



MCUXpresso SDK Documentation

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This documentation contains information specific to the mcimx93qsb board.

Chapter 1

MCIMX93-QSB

1.1 Overview



MCU device and part on board is shown below:

- Device: MIMX9322
- PartNumber: MIMX9322CVXXM

1.2 Getting Started with MCUXpresso SDK Package

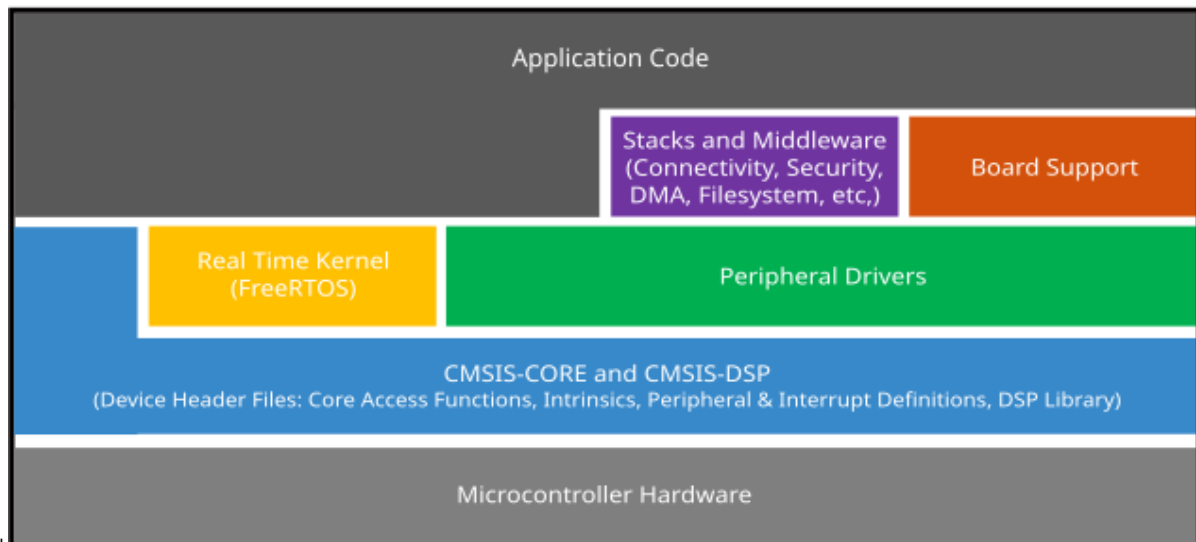
1.2.1 Getting Started with Package

Overview

The NXP MCUXpresso software and tools offer comprehensive development solutions designed to optimize, ease and help accelerate embedded system development of applications based on general purpose, crossover and Bluetooth-enabled MCUs from NXP. The MCUXpresso SDK includes a flexible set of peripheral drivers designed to speed up and simplify development of embedded applications. Along with the peripheral drivers, the MCUXpresso SDK provides an extensive and rich set of example applications covering everything from basic peripheral use case examples to demo applications. The MCUXpresso SDK also contains optional RTOS integrations such as FreeRTOS and Azure RTOS, and device stack to support rapid development on devices.

For supported toolchain versions, see *MCUXpresso SDK Release Notes for MCIMX93-QSB (document MCUXSDKMCIMX93QSB RN)*.

For the latest version of this and other MCUXpresso SDK documents, see the MCUXpresso SDK homepage [MCUXpresso-SDK: Software Development Kit for MCUXpresso](#).



MCUXpresso SDK board support folders

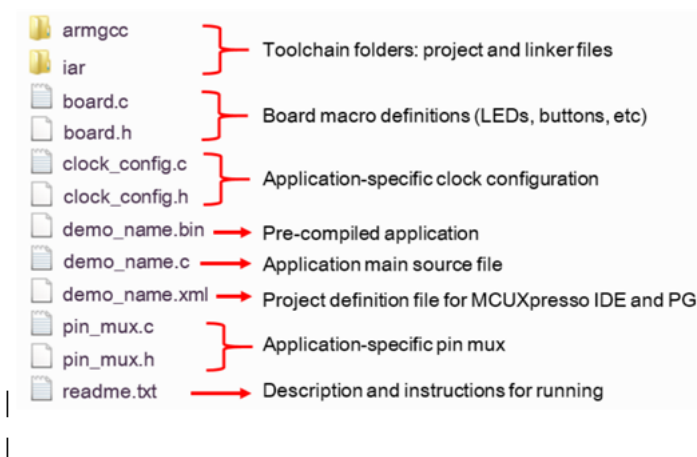
MCUXpresso SDK board support provides example applications for NXP development and evaluation boards for Arm Cortex-M cores. Board support packages are found inside of the top level boards folder, and each supported board has its own folder (MCUXpresso SDK package can support multiple boards). Within each `<board_name>` folder there are various sub-folders to classify the type of examples they contain. These include (but are not limited to):

- `cmsis_driver_examples`: Simple applications intended to concisely illustrate how to use CMSIS drivers.
- `demo_apps`: Full-featured applications intended to highlight key functionality and use cases of the target MCU. These applications typically use multiple MCU peripherals and may leverage stacks and middleware.
- `driver_examples`: Simple applications intended to concisely illustrate how to use the MCUXpresso SDK's peripheral drivers for a single use case.
- `rtos_examples`: Basic FreeRTOS OS examples showcasing the use of various RTOS objects (semaphores, queues, and so on) and interfacing with the MCUXpresso SDK's RTOS drivers
- `multicore_examples`: Simple applications intended to concisely illustrate how to use middleware/multicore stack.

Example application structure This section describes how the various types of example applications interact with the other components in the MCUXpresso SDK. To get a comprehensive understanding of all MCUXpresso SDK components and folder structure, see *MCUXpresso SDK API Reference Manual*.

Each `<board_name>` folder in the boards directory contains a comprehensive set of examples that are relevant to that specific piece of hardware. Although we use the `hello_world` example (part of the `demo_apps` folder), the same general rules apply to any type of example in the `<board_name>` folder.

In the `hello_world` application folder you see the following contents:



All files in the application folder are specific to that example, so it is easy to copy and paste an existing example to start developing a custom application based on a project provided in the MCUXpresso SDK.

Parent topic: [MCUXpresso SDK board support folders](#)

Locating example application source files When opening an example application in any of the supported IDEs, a variety of source files are referenced. The MCUXpresso SDK devices folder is the central component to all example applications. It means the examples reference the same source files and, if one of these files is modified, it could potentially impact the behavior of other examples.

The main areas of the MCUXpresso SDK tree used in all example applications are:

- devices/<device_name>: The device's CMSIS header file, MCUXpresso SDK feature file and a few other files
- devices/<device_name>/cmsis_drivers: All the CMSIS drivers for your specific MCU
- devices/<device_name>/drivers: All of the peripheral drivers for your specific MCU
- devices/<device_name>/<tool_name>: Toolchain-specific startup code, including vector table definitions
- devices/<device_name>/utilities: Items such as the debug console that are used by many of the example applications
- devices/<device_name>/project_template: Project template used in CMSIS PACK new project creation

For examples containing an RTOS, there are references to the appropriate source code. RTOSes are in the `rtos` folder. The core files of each of these are shared, so modifying one could have potential impacts on other projects that depend on that file.

Parent topic: [MCUXpresso SDK board support folders](#)

Toolchain introduction

The MCUXpresso SDK release for i.MX 93 includes the build system to be used with some toolchains. In this chapter, the toolchain support is presented and detailed.

Compiler/Debugger The MCUXpresso SDK i.MX 93 release supports building and debugging with the toolchains listed in Table 1.

The user can choose the appropriate one for development.

For supported toolchain versions, see MCUXpresso SDK Release Notes for MCIMX93-QSB (*document: MCUXSDKMCIMX93QSB RN*).

- Arm GCC + SEGGER J-Link GDB Server. This is a command line tool option and it supports both Windows OS and Linux OS.
- IAR Embedded Workbench for Arm and SEGGER J-Link software. The IAR Embedded Workbench is an IDE integrated with editor, compiler, debugger, and other components. The SEGGER J-Link software provides the driver for the J-Link Plus debugger probe and supports the device to attach, debug, and download.

Com- piler/Debugger	Supported host OS	Debug probe	Tool website
ArmGCC/J-Link GDB server	Windows OS/Linux OS	J-Link Plus	developer.arm.com/open-source/gnu-toolchain/gnu-rm

www.segger.com

| | IAR/J-Link | Windows OS | J-Link Plus | www.iar.com

www.segger.com

|

Download the corresponding tools for the specific host OS from the website.

Note:

- To support i.MX 93, the patch for IAR and Segger J-Link must be installed. To download, navigate to https://www.nxp.com/webapp/Download?colCode=SDK_MX93_3RDPARTY_PATCH&appType=license

Parent topic: [Toolchain introduction](#)

Run a demo application using IAR

This section describes the steps required to build, run, and debug example applications provided in the MCUXpresso SDK. The `hello_world` demo application targeted for the i.MX 93 QSB hardware platform is used as an example, although these steps can be applied to any example application in the MCUXpresso SDK.

Build an example application Perform the following steps to build the `hello_world` example application.

1. Open the desired demo application workspace. Most example application workspace files can be located using the following path:

```
<install_dir>/boards/<board_name>/<example_type>/<application_name>/iar
```

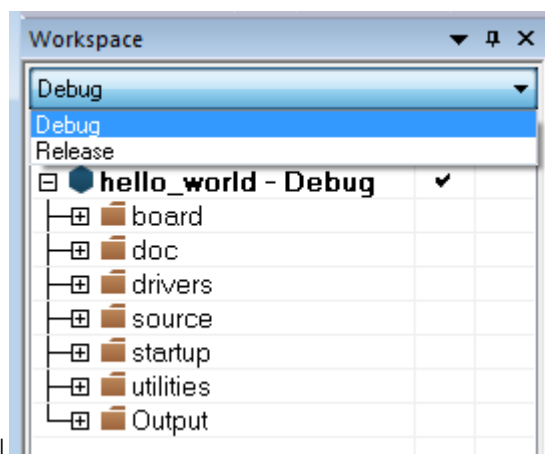
Using the i.MX 93 QSB hardware platform as an example, the `hello_world` workspace is located in:

```
<install_dir>/boards/mcimx93qsb/demo_apps/hello_world/iar/hello_world.eww
```

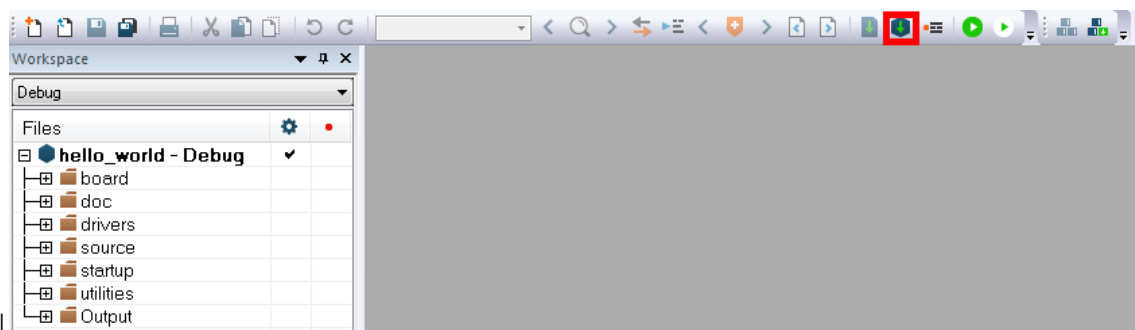
Other example applications may have additional folders in their path.

2. Select the desired build target from the drop-down menu.

For this example, select **hello_world – debug**.



3. To build the demo application, click **Make**, highlighted in red in Figure 2.

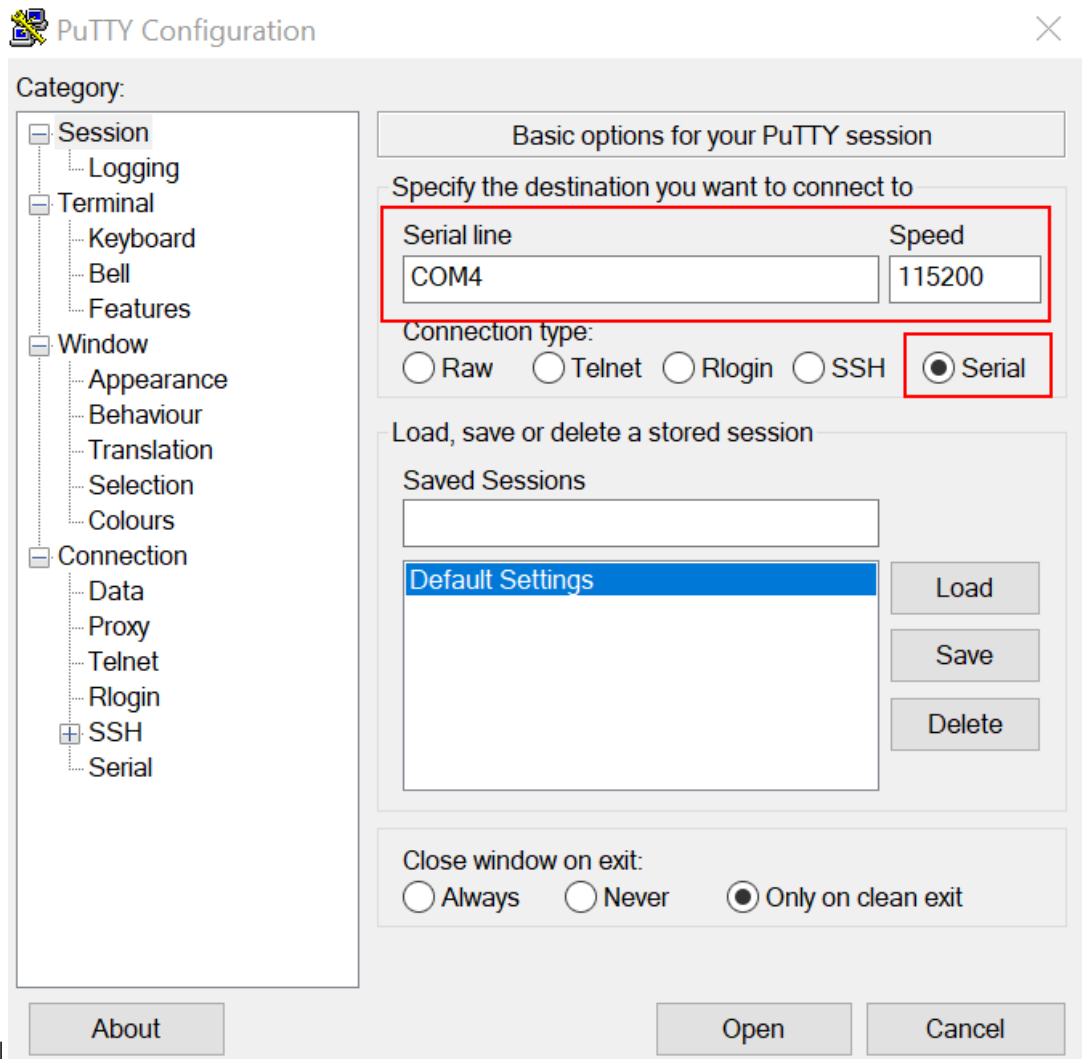


4. The build completes without errors.

Parent topic: [Run a demo application using IAR](#)

Run an example application To download and run the application, perform these steps:

1. This board supports the J-Link PLUS debug probe. Before using it, install SEGGER J-Link software, as per the requirement listed in [Toolchain introduction](#).
2. Connect the development platform to your PC via USB cable between the DBG USB connector and the PC USB connector.
3. Connect 12 V ~ 20 V power supply and J-Link Plus to the device.
4. Switch SW601[1:4] to the M core boot and ensure that the image is not available on the boot source. For example, 0b1011 for MicroSD boot. Keep the SD slot empty.
5. Open the terminal application on the PC, such as PuTTY or TeraTerm, connect to the debug COM port, see [How to determine COM port](#), and configure the terminal with these settings:
 1. 115,200 baud rate
 2. No parity
 3. 8 data bits
 4. 1 stop bit

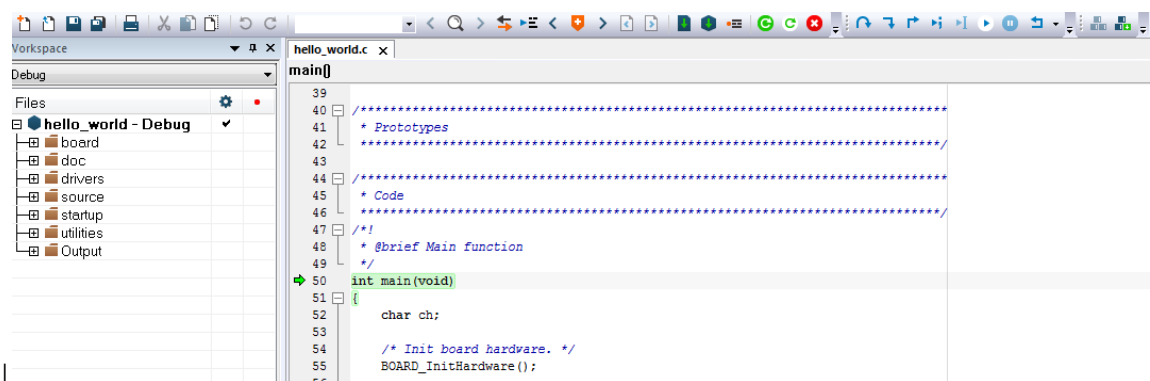


6. Power on the board.

7. In IAR, click **Download and Debug** to download the application to the target.



8. The application then downloads to the target and automatically runs to the `main()` function.



9. Run the code by clicking **Go** to start the application.



10. The `hello_world` application is now running and a banner is displayed on the terminal. If the application does not run or the banner is not displayed, check your terminal settings and connections.



****Note:**** If the software is already running on the M core, the debugger loading image into TCM may get
 ↳ HardFault or a data verification issue. NXP recommends you to follow the steps above to use the debugger.
 ↳ Repowering the board is required to restart the debugger.

Parent topic: [Run a demo application using IAR](#)

Run a demo using ARMGCC / VSCODE

This section describes the steps to run an example application from the SDK archive using the ARMGCC / VSCODE toolchain.

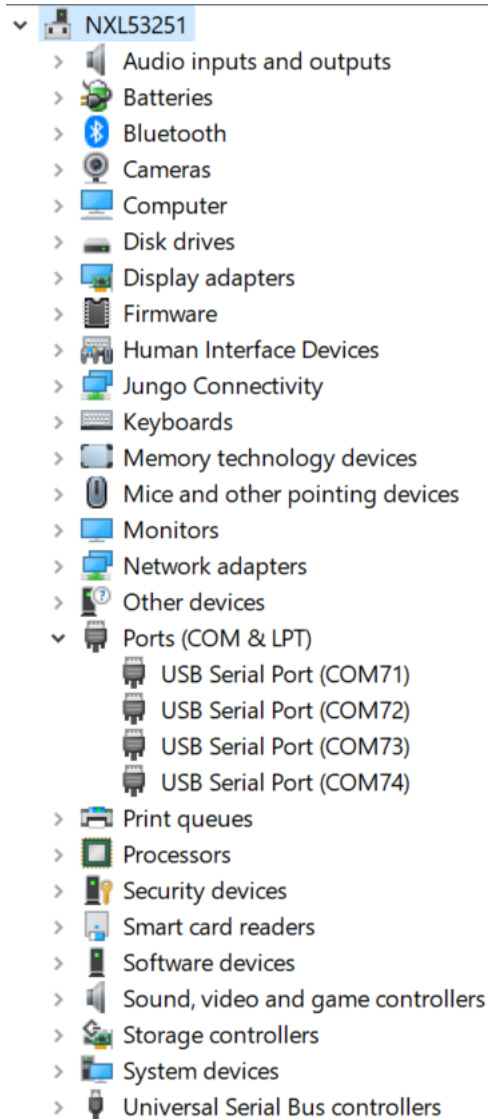
Refer to the [running a demo using MCUXpresso VSC](#) section for detailed instructions on setting up and configuring your project in Visual Studio Code.

Refer to the [CLI](#) section for detailed instructions on building and running your project from the command line.

Running an application by U-Boot

This section describes the steps to write a bootable SDK bin file to TCM with the prebuilt U-Boot image for the i.MX processor. The following steps describe how to use the U-Boot:

1. Connect the **DEBUG UART** slot on the board to your PC through the USB cable. The Windows OS installs the USB driver automatically, and the Ubuntu OS finds the serial devices as well.
2. On Windows OS, open the device manager, find **USB serial Port in Ports (COM & LPT)**. Assume that the ports are COM71 - COM74. COM73 is for the debug message from the Cortex-A55 and COM74 is for the Cortex-M33. The port number is allocated randomly, so opening both is beneficial for development. On Ubuntu OS, find the TTY device with name `/dev/ttyUSB*` to determine your debug port. Similar to Windows OS, opening both is beneficial for development.



3. Build the application (for example, `hello_world`) to get the bin file (`hello_world.bin`).
4. Prepare an SD card with the prebuilt Linux BSP flashed and copy bin file (`hello_world.bin`) into the SD card.
5. Insert the SD card to the target board. Make sure to switch SW601[1:4] is configured to MicroSD A core boot 0b0011.
6. Open your preferred serial terminals for the serial devices, setting the speed to 115200 bps, 8 data bits, 1 stop bit (115200, 8N1), no parity, then power on the board.
7. Power on the board and hit any key to stop autoboot in the A55 terminal.
8. Enter to U-Boot command line mode. You can then write the image and run it from TCM with the following commands:
 - `fatload mmc 1:1 80000000 hello_world.bin; cp.b 0x80000000 0x201e0000 0x10000;`
 - `bootaux 0x1ffe0000 0`
9. The `hello_world` application is now running and a banner is displayed on the M33 terminal. If this is not true, check your terminal settings and connections.



Program flash.bin to SD/eMMC with UUU

This section describes the steps to use the UUU to run the example applications provided in the MCUXpresso SDK. Download the flash.bin to emmc/sd with UUU. The hello_world demo application targeted for the i.MX 93 hardware platform is used as an example, although these steps can be applied to any example application in the MCUXpresso SDK.

Set up environment This section contains the steps to install the necessary components required to build and run a MCUXpresso SDK demo application, as supported by the MCUXpresso SDK.

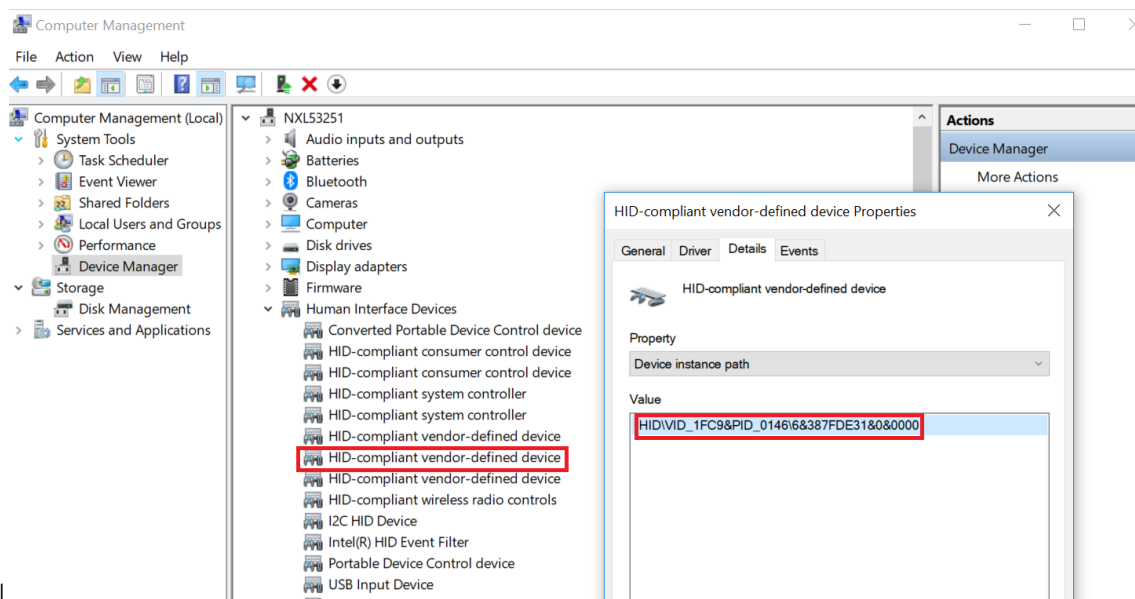
Download the Universal Upgrade Utility The Universal Upgrade Utility (UUU) is an upgraded version of MfgTool. It is a command line tool that aims at installing the bootloader to various storage including SD, QSPI, and so on, for i.MX series devices with ease.

The tool can be accessed from corresponding Linux BSP release. Download uuu.exe for Windows OS, or download UUU for Linux. Configure the path so that the executable can later be called anywhere in the command line.

Parent topic:Set up environment

Switch to Download mode The board needs to be in Download mode for UUU to download images:

1. Set the board boot mode to Download mode [SW601[1:4] = 0011].
2. Connect the development platform to your PC via USB cable between the DBG USB connector and the PC USB connector.
3. Connect the USB port to PC USB connector for downloading.
4. The PC recognizes the i.MX 93 device as (VID:PID)=(1FC9:0146), as shown in Figure 1.



Parent topic:Set up environment

Parent topic:[Program flash.bin to SD/eMMC with UUU](#)

Build an example application The following steps guide you through opening the `hello_world` example application. These steps may change slightly for other example applications, as some of these applications may have additional layers of folders in their paths.

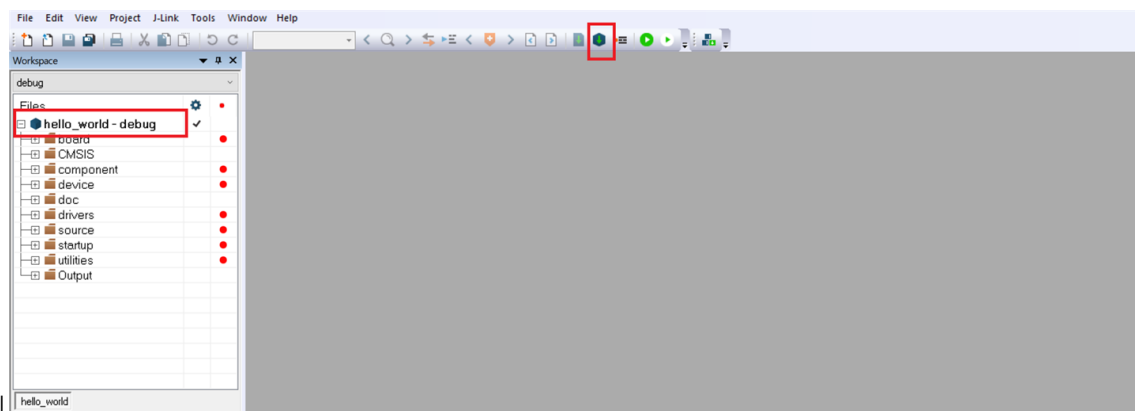
1. If not already done, open the desired demo application workspace. Most example application workspace files can be located using the following path:

```
<install_dir>/boards/<board_name>/<example_type>/<application_name>/iar
```

Using the i.MX 93 QSB board as an example, the workspace is located in:

```
<install_dir>/boards/mcimx93qsb/demo_apps/hello_world/iar/hello_world.eww
```

2. Select the desired build target from the drop-down. For this example, select **hello_world – debug**.
3. To build the demo application, click **Make**.

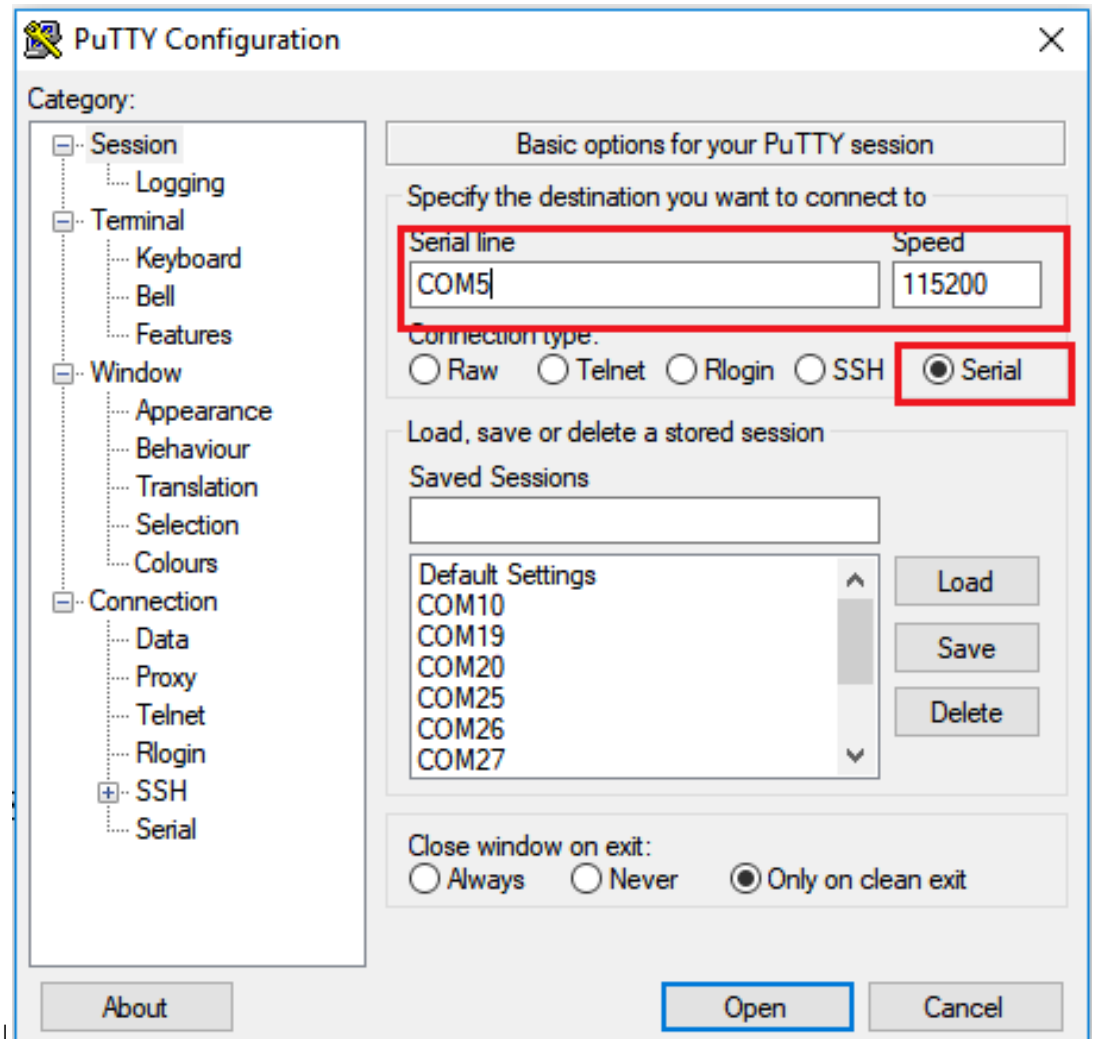


4. The build completes without errors.

Parent topic:[Program flash.bin to SD/eMMC with UUU](#)

Run an example application To download and run the application via UUU, perform these steps:

1. Connect the development platform to your PC via USB cable between the DBG USB connector and the PC. It provides console output while using UUU.
2. Connect the USB port connector and the PC. It provides the data path for UUU.
3. Open the terminal application on the PC, such as PuTTY or TeraTerm, and connect to the debug COM port (to determine the COM port number, see [How to determine COM port](#)). Configure the terminal with these settings:
 1. 115200 baud rate
 2. No parity
 3. 8 data bits



4. 1 stop bit

4. Get the boot images and the imx-mkimage source repository from corresponding Linux BSP release. The boot images required to be put into imx-mkimage/i.MX9 are:
 - u-boot-imx93-9x9-lpddr4-qsb.bin-sd (rename to u-boot.bin)
 - u-boot-spl.bin-imx93-9x9-lpddr4-qsb-sd (rename to u-boot-spl.bin)
 - bl31-imx93.bin (rename to bl31.bin)
 - mx93a1-ahab-container.img

- lpddr4_dmem_1d_v202201.bin
 - lpddr4_dmem_2d_v202201.bin
 - lpddr4_imem_1d_v202201.bin
 - lpddr4_imem_2d_v202201.bin
5. Copy binary generated by IAR build into imx-mkimage/i.MX9, and rename it to m33_image.bin.
 6. Make flash.bin with imx-mkimage.

make SOC=iMX9 REV=A1 flash_singleboot_m33 (for single boot mode)

or

make SOC=iMX9 REV=A1 flash_lpboot (for low power boot mode)

7. Power on the board.

8. Type the UUU command to the flash image.

uuu -b emmc flash.bin (for single boot on eMMC)

uuu -b sd flash.bin (for single boot on SD)

For low power boot, a single boot flash.bin is needed besides the target flash.bin.

uuu -b emmc <singleboot flash.bin> flash.bin (for lowpower boot on eMMC)

uuu -b sd <singleboot flash.bin> flash.bin (for lowpower boot on SD)

The UUU puts the platform into fast boot mode and automatically flashes the target boot-loader to emmc/sd. The command line and fast boot console is as shown in Figure 2.

```

switch to partitions #0, OK
mmc0(part 0) is current device
flash target is MMC:0
Net:
Warning: ethernet@428a0000 MAC addresses don't match:
Address in ROM is      01:02:03:04:05:06
Address in environment is 36:e5:5c:42:fa:e5

Warning: ethernet@42890000 MAC addresses don't match:
Address in ROM is      01:02:03:04:05:06
Address in environment is be:8a:6c:54:c1:5a
eth0: ethernet@42890000 [PRIME], eth1: ethernet@428a0000
Fastboot: Normal
Normal Boot
Hit any key to stop autoboot: 0
=> fastboot 0
Failed to configure default pinctrl
switch to partitions #0, OK
mmc0(part 0) is current device
Starting download of 1014784 bytes
.....
downloading of 1014784 bytes finished
writing to partition 'bootloader'
Initializing 'bootloader'
switch to partitions #1, OK
mmc0(part 1) is current device
Writing 'bootloader'

MMC write: dev # 0, block # 0, count 1982 ... 1982 blocks written: OK
Writing 'bootloader' DONE!

CTRL-A Z for help | 115200 8N1 | NOR | Minicom 2.7.1 | VT102 | Offline | ttyUSB4
sudo uuu -b emmc flash.bin
uuu (Universal Update Utility) for nxp imx chips -- libuuu_1.4.224-0-g70d1e85
Success 1 Failure 0

1:141 7/ 7 [Done] FB: Done
nxf49783@biwen:/mnt/home/nxf49783/logs/imx/imx93/imx93evk/verify_rpmsg$

```

9. Then, power off the board and change the boot mode to the corresponding one.

- For single-boot mode:
 - when boot device is emmc, then $SW601[1:4] = 0010$;
 - when boot device is sd, then $SW601[1:4] = 0011$.
- For low-power boot mode:
 - when boot device is emmc, then $SW601[1:4] = 1010$;
 - when boot device is sd, then $SW601[1:4] = 1011$.

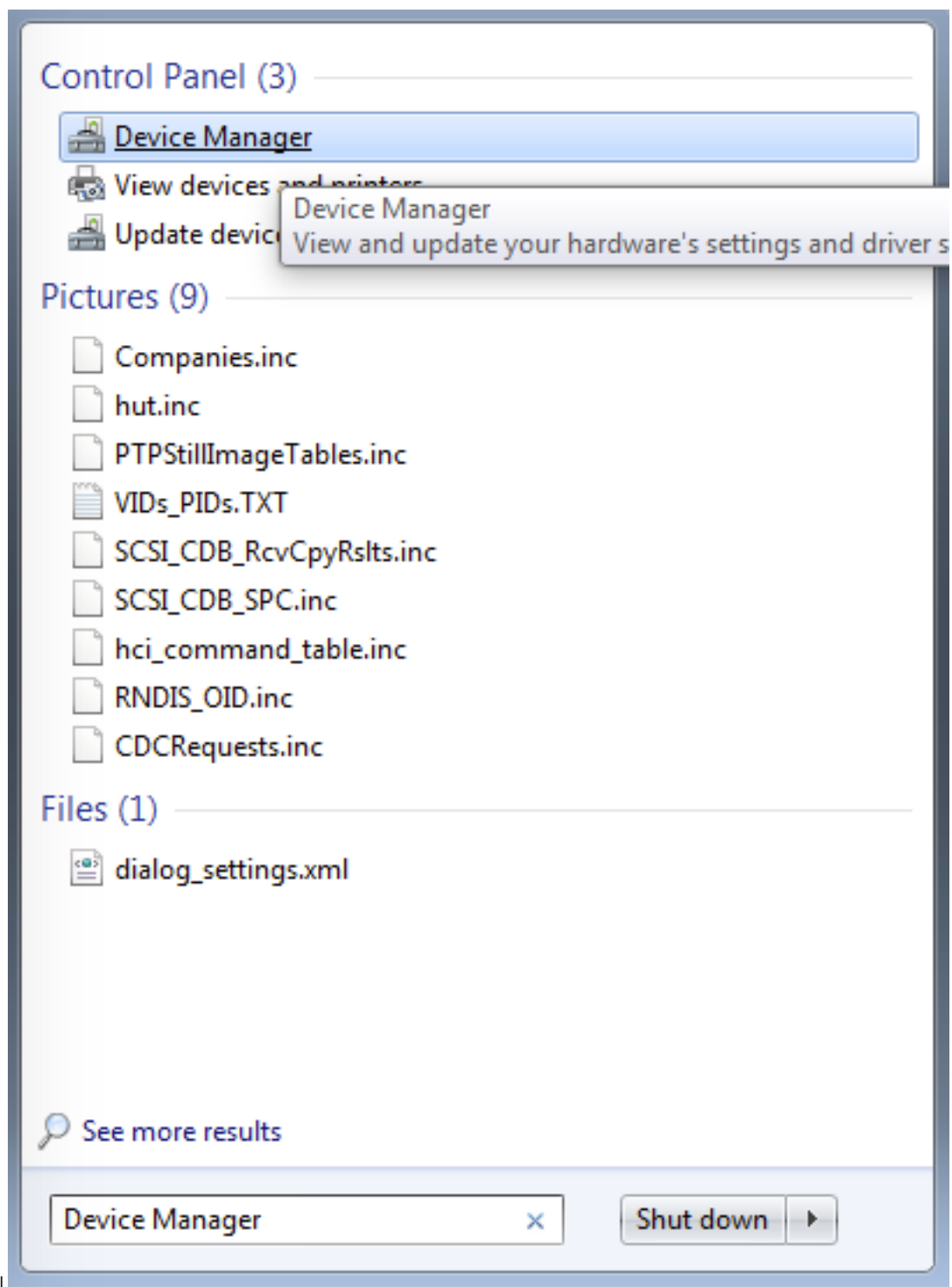
10. Power on the board again.

Parent topic: [Program flash.bin to SD/eMMC with UUU](#)

How to determine COM port

This section describes the steps necessary to determine the debug COM port number of your NXP hardware development platform.

1. To determine the COM port, open the Windows operating system Device Manager. This can be achieved by going to the Windows operating system Start menu and typing **Device Manager** in the search bar, as shown in *Figure 1*.



2. In the **Device Manager**, expand the **Ports (COM & LPT)** section to view the available ports. Depending on the NXP board you're using, the COM port can be named differently.

1. **USB-UART interface**



1.3 Getting Started with MCUXpresso SDK GitHub

1.3.1 Getting Started with MCUXpresso SDK Repository

Welcome to the **GitHub Repository SDK Guide**. This documentation provides instructions for setting up and working with the MCUXpresso SDK distributed in a **multi-repository model**. The SDK is distributed across multiple GitHub repositories and managed using the **Zephyr West** tool, enabling modular development and streamlined workflows.

Overview

The GitHub Repository SDK approach offers:

- **Modular Structure:** Multiple repositories for flexibility and scalability.
- **Zephyr West Integration:** Simplified repository management and synchronization.
- **Cross-Platform Support:** Designed for MCUXpresso SDK development environments.

Benefits of the Multi-Repository Approach

- **Scalability:** Easily add or update components without impacting the entire SDK.
- **Collaboration:** Enables distributed development across teams and repositories.
- **Version Control:** Independent versioning for components ensures better stability.
- **Automation:** Zephyr West simplifies dependency handling and repository synchronization.

Setup and Configuration

Follow these steps to prepare your development environment:

Development Tools Installation This guide explains how to install the essential tools for development with the MCUXpresso SDK.

Quick Start: Automated Installation (Recommended) The **MCUXpresso Installer** is the fastest way to get started. It automatically installs all the basic tools you need.

1. **Download the MCUXpresso Installer** from: [Dependency-Installation](#)
2. **Run the installer** and select “**MCUXpresso SDK Developer**” from the menu
3. **Click Install** and let it handle everything automatically

Manual Installation If you prefer to install tools manually or need specific versions, follow these steps:

Essential Tools

Git - Version Control **What it does:** Manages code versions and downloads SDK repositories from GitHub.

Installation:

- Visit git-scm.com
- Download for your operating system
- Run installer with default settings
- **Important:** Make sure “Add Git to PATH” is selected during installation

Setup:

```
git config --global user.name "Your Name"
git config --global user.email "youremail@example.com"
```

Python - Scripting Environment **What it does:** Runs build scripts and SDK tools.

Installation:

- Install Python **3.10 or newer** from python.org
- **Important:** Check “Add Python to PATH” during installation

West - SDK Management Tool **What it does:** Manages SDK repositories and provides build commands. The west tool is developed by the Zephyr project for managing multiple repositories.

Installation:

```
pip install -U west
```

Minimum version: 1.2.0 or newer

Build System Tools

CMake - Build Configuration **What it does:** Configures how your projects are built.

Recommended version: 3.30.0 or newer

Installation:

- **Windows:** Download .msi installer from cmake.org/download
- **Linux:** Use package manager or download from cmake.org
- **macOS:** Use Homebrew (brew install cmake) or download from cmake.org

Ninja - Fast Build System **What it does:** Compiles your code quickly.

Minimum version: 1.12.1 or newer

Installation:

- **Windows:** Usually included, or download from ninja-build.org
- **Linux:** sudo apt install ninja-build or download binary
- **macOS:** brew install ninja or download binary

Ruby - IDE Project Generation (Optional) **What it does:** Generates project files for IDEs like IAR and Keil.

When needed: Only if you want to use traditional IDEs instead of VS Code.

Installation: Follow the Ruby environment setup guide

Compiler Toolchains Choose and install the compiler toolchain you want to use:

Toolchain	Best For	Download Link	Environment Variable
ARM GCC (Recommended)	Most users, free	ARM GCC Toolchain	ARMGCC_DIR
IAR EWARM	Professional development	IAR Systems	IAR_DIR
Keil MDK ARM Compiler	ARM ecosystem Advanced optimization	ARM Developer ARM Developer	MDK_DIR ARMCLANG_DIR

Setting Up Environment Variables After toolchain installation, set an environment variable so the build system locates it:

Windows:

```
# Example for ARM GCC installed in C:\armgcc
setx ARMGCC_DIR "C:\armgcc"
```

Linux/macOS:

```
# Add to ~/.bashrc or ~/.zshrc
export ARMGCC_DIR="/usr" # or your installation path
```

Verify Your Installation After installation, verify everything works by opening a terminal/command prompt and running these commands:

```
# Check each tool - you should see version numbers
git --version
python --version
west --version
cmake --version
ninja --version
arm-none-eabi-gcc --version # (if using ARM GCC)
```

Troubleshooting Installation Issues **“Command not found” errors:**

- The tool isn’t in your system PATH
- **Solution:** Add the installation directory to your PATH environment variable

Python/pip issues:

- Try using python3 and pip3 instead of python and pip
- On Windows, run the Command Prompt as an Administrator

Slow downloads:

- Add timeout option: `pip install -U west --default-timeout=1000`
- Use alternative mirror: `pip install -U west -i https://pypi.tuna.tsinghua.edu.cn/simple`

GitHub Repository Setup This guide explains how to initialize your MCUXpresso SDK workspace from GitHub repositories using the west tool. The GitHub Repository SDK uses multiple repositories hosted on GitHub to provide modular, flexible development.

Prerequisites Verify the requirements:

System Requirements:

- Python 3.8 or later
- Git 2.25 or later
- CMake 3.20 or later
- Build tools for your target platform

Verification Commands:

```
python --version # Should show 3.8+
git --version    # Should show 2.25+
cmake --version  # Should show 3.20+
west --version   # Should show west tool installation
```

Workspace Initialization The GitHub Repository SDK uses the Zephyr west tool to manage multiple repositories containing different SDK components.

Step 1: Initialize Workspace Create and initialize your SDK workspace from GitHub:

Get the latest SDK from main branch:

```
west init -m https://github.com/nxp-mcuxpresso/mcuxsdk-manifests.git mcuxpresso-sdk
```

Get SDK at specific revision:

```
west init -m https://github.com/nxp-mcuxpresso/mcuxsdk-manifests.git mcuxpresso-sdk --mr {revision}
```

Note: Replace {revision} with the desired release tag, such as v25.09.00

Step 2: Choose Your Repository Update Strategy Navigate to the SDK workspace:

```
cd mcuxpresso-sdk
```

The west tool manages multiple GitHub repositories containing different SDK components. You have two options for downloading:

Option A: Download All Repositories (Complete SDK) Download all SDK repositories for comprehensive development:

```
west update
```

This command downloads all the repositories defined in the manifest from GitHub. Initial download takes several minutes and requires ~7 GB of disk space.

Best for:

- Exploring the complete SDK
- Multi-board development projects
- Comprehensive middleware evaluation

Option B: Targeted Repository Download (Recommended) Download only repositories needed for your specific board or device to save time and disk space:

```
# For specific board development
west update_board --set board your_board_name

# For specific device family development
west update_board --set device your_device_name

# List available repositories before downloading
west update_board --set board your_board_name --list-repo
```

Best for:

- Single board development
- Faster setup and reduced disk usage
- Focused development workflows

Examples:

```
# Update only repositories for FRDM-MCXW23 board
west update_board --set board frdm-mcxw23

# Update only repositories for MCXW23 device family
west update_board --set device mcxw23
```

Step 3: Verify Installation Confirm successful setup:

```
# Verify workspace structure
ls -la
# Should show: manifests/ and mcuxsdk/ directories

# Test build system
west list_project -p examples/demo_apps/hello_world
# Should display available build configurations
```

Advanced Repository Management The west extension command `update_board` provides advanced repository management capabilities for optimized workspace setup with GitHub repositories.

Board-Specific Setup Update only repositories required for a specific board:

```
# Update only repositories for specific board, e.g., frdm-mcxw23
west update_board --set board frdm-mcxw23

# List available repositories for the board before updating
west update_board --set board frdm-mcxw23 --list-repo
```

Device-Specific Setup Update only repositories required for a specific device family:

```
# Update only repositories for specific device, e.g., MCXW235
west update_board --set device mcxw23

# List available repositories for the device family
west update_board --set device mcxw23 --list-repo
```

Custom Configuration For advanced users who want to create custom repository combinations:

```
# Use custom configuration file
west update_board --set custom path/to/custom-config.yml

# Generate custom configuration template
cp manifests/boards/custom.yml.template my-custom-config.yml
```

Benefits of Targeted Setup Reduced Download Size

- Download only components needed for your target board or device
- Significantly faster initial setup for focused development
- Typical reduction from 7 GB to 2GB

Optimized Workspace

- Cleaner workspace with relevant components only
- Reduced disk space usage
- Faster repository operations

Flexible Development

- Switch between different board configurations easily
- Maintain separate workspaces for different projects
- Include optional components as needed

Repository Information Before setting up your workspace, you can explore what repositories are available:

```
# Display repository information in console
west update_board --set board frdm-mcxw23 --list-repo

# Export repository information to YAML file for reference
west update_board --set board frdm-mcxw23 --list-repo -o board-repos.yml
```

This command lists all the available repositories with descriptions and outlines the included components in the workspace.

Package Generation (Optional) The `update_board` command can also generate ZIP packages for offline distribution:

```
# Generate board-specific SDK package
west update_board --set board frdm-mcxw23 -o frdm-mcxw23-sdk.zip
```

Note: Package generation is primarily intended for creating custom SDK distributions. For regular development, use the workspace update commands without the `-o` option.

Workspace Management

Updating Your Workspace Keep your SDK current with latest updates from GitHub:

For Complete SDK Workspace:

```
# Update manifest repository
cd manifests
git pull

# Update all component repositories
cd ..
west update
```

For Targeted Workspace:

```
# Update manifest repository
cd manifests
git pull

# Update board-specific repositories
cd ..
west update_board --set board your_board_name
```

Workspace Status Check workspace synchronization status:

```
# Show status of all repositories
west status

# Show detailed information about repositories
west list
```

Troubleshooting Network Issues:

- Use `west update --keep-descendants` for partial failures
- Configure Git credentials for private repositories
- Check firewall settings for Git protocol access

Permission Issues:

- Ensure write permissions in workspace directory
- Run commands without `sudo`/administrator privileges
- Verify Git SSH key configuration for authenticated access

Disk Space:

- Full SDK workspace requires approximately 7-8 GB
- Targeted workspace typically requires 1-2 GB
- Use board-specific setup to reduce workspace size

Repository Management Issues:

- Verify board/device names match available configurations
- Check that custom YAML files follow the correct template format
- Use `--list-repo` to verify available repositories before setup

Next Steps With your workspace initialized:

1. Review [Workspace Structure](#) to understand the layout
2. Build your first project with [First Build Guide](#)
3. Explore [Development Workflows MCUXpresso VSCode](#) or [Development Workflows Command Line](#) for the details on project setup and execution

For advanced repository management, see the [west tool documentation](#).

Explore SDK Structure and Content

Learn about the organization of the SDK and its components:

SDK Architecture Overview The MCUXpresso SDK uses a modular architecture where software components are distributed across multiple repositories hosted on GitHub and managed through the west tool. This approach provides flexibility, maintainability, and enables selective component inclusion.

Repository Organization Based on the manifest structure, the SDK consists of four main repository categories:

Manifest Repository The manifest repo (mcuxsdk-manifests) contains the west.yml manifest file that tracks all other repositories in the SDK.

Base Repositories Recorded in submanifests/base.yml and loaded in the root west.yml manifest file. These are the foundational repositories that build the SDK:

- **Devices:** MCU-specific support packages
- **Examples:** Demonstration applications and code samples
- **Boards:** Board support packages

Middleware Repositories Recorded in the submanifests/middleware subdirectory, categorized according to functionality:

- **Connectivity:** Networking stacks, USB, and communication protocols
- **Security:** Cryptographic libraries and secure boot components
- **Wireless:** Bluetooth, IEEE 802.15.4, and other wireless protocols
- **Graphics:** Display drivers and UI frameworks
- **Audio:** Audio processing and voice recognition libraries
- **Machine Learning:** AI inference engines and neural network libraries
- **Safety:** IEC60730B safety libraries
- **Motor Control:** Motor control and real-time control libraries

Internal Repositories Recorded in submanifests/internal.yml and grouped into the “bifrost” group. These are only visible to NXP internal developers and hosted on NXP internal git servers.

Repository Hosting Public repositories are hosted on GitHub under these organizations:

- [nxp-mcuxpresso](#)
- [NXP](#)
- [nxp-zephyr](#)

Internal repositories are hosted on NXP's private Git infrastructure.

Benefits of This Architecture **Selective Integration:** Projects include only required components, reducing memory footprint and build complexity.

Independent Versioning: Each component maintains its own release cycle and version control.

Community Collaboration: Public repositories accept community contributions through standard Git workflows.

Scalable Maintenance: Component owners can update their repositories without affecting the entire SDK.

Workspace Management The west tool manages repository synchronization, version tracking, and workspace updates. All repositories are checked out under the `mcuxsdk/` directory with their designated paths defined in the manifest files.

Workspace Structure After you initialize your SDK workspace, it creates a specific directory structure that organizes all SDK components. This structure is identical for both GitHub Repository SDK and Repository-Layout SDK Package.

Top-Level Organization

```
your-sdk-workspace/  
  manifests/      # West manifest repository  
  mcuxsdk/        # Main SDK content
```

The `mcuxsdk/` directory serves as your primary working directory and contains all the SDK components.

SDK Component Layout Based on the actual SDK structure, the main directories include:

Directory	Contents	Purpose
arch/	Architecture-specific files	ARM CMSIS, build configurations
cmake/	Build system modules	CMake configuration and build rules
compo	Software components	Reusable software libraries and utilities
devices	Device support packages	MCU-specific headers, startup code, linker scripts
drivers	Peripheral drivers	Hardware abstraction layer for MCU peripherals
examp	Sample applications	Demonstration code and reference implementations
middle	Optional software stacks	Networking, graphics, security, and other libraries
rtos/	Operating system support	FreeRTOS integration
scripts	Build and utility scripts	West extensions and development tools
svd	Svd files for devices, this is optional because of large size. Customers run <code>west manifest config group.filter +optional</code> and <code>west update mcux-soc-svd</code> to get this folder.	

Example Organization Examples follow a two-tier structure separating common code from board-specific implementations:

Common Example Files

```
examples/demo_apps/hello_world/
  CMakeLists.txt      # Build configuration
  example.yml         # Example metadata
  hello_world.c       # Application source code
  Kconfig             # Configuration options
  readme.md           # General documentation
```

Board-Specific Files

```
examples/_boards/your_board/demo_apps/hello_world/
  app.h               # Board specific application header
  example_board_readme.md # Board specific documentation
  hardware_init.c     # Board specific hardware initialization
  pin_mux.c           # Pin multiplexing configuration
  pin_mux.h           # Pin multiplexing header definitions
  hello_world.bin     # Pre-built binary for quick testing
  hello_world.mex     # MCUXpresso Config Tools project file
  prj.conf            # Board specific Kconfig configuration
  reconfig.cmake      # Board specific cmake configuration overrides
```

Device Support Structure Device support is organized hierarchically by MCU family:

```

devices/
  MCX/          # MCU portfolio
  MCXW/         # MCU family
  MCXW235/      # Specific device
  MCXW235.h     # Device register definitions
  drivers/      # Device-specific drivers
  gcc/          # GNU toolchain files
  iar/          # IAR toolchain files
  mcuxpresso/   # MCUXpresso IDE files
  startup_MCXW235.c # Startup and vector table
  system_MCXW235.c # System initialization

```

Middleware Organization Middleware components are categorized by functionality and maintained in separate repositories. Based on the manifest files, common middleware categories include:

- **Connectivity:** USB, TCP/IP, industrial protocols
- **Security:** Cryptographic libraries, secure boot
- **Wireless:** Bluetooth, IEEE 802.15.4, Wi-Fi
- **Graphics:** Display drivers, UI frameworks
- **Audio:** Processing libraries, voice recognition
- **Machine Learning:** Inference engines, neural networks
- **Safety:** IEC60730B safety libraries
- **Motor Control:** Motor control and real-time control libraries

Documentation Structure SDK documentation is distributed across multiple locations:

- docs/ - Core SDK documentation and build infrastructure
- Component repositories - API documentation and integration guides
- Board directories - Hardware-specific setup instructions

For complete documentation, refer to the [online documentation](#).

Understanding Example Structure Each example has **two README files**:

1. General README: examples/demo_apps/hello_world/readme.md

- What the example does
- General functionality description
- Common usage information

2. Board-Specific README: examples/_boards/{board_name}/demo_apps/hello_world/example_board_readme.md

- Board-specific setup instructions
- Hardware connections required
- Board-specific behavior notes

Tip: Always check both readme files - start with the general one, then read the board-specific one for detailed setup.

Development Workflows

Get started with building and running projects:

Building Your First Project This guide explains how to build and run your first SDK example project using the west build system. This applies to both GitHub Repository SDK and Repository-Layout SDK Package.

Prerequisites

- GitHub Repository SDK workspace initialized OR Repository-Layout SDK Package extracted
- Development board connected via USB
- Build tools installed per [Installation Guide](#)

Understanding Board Support Use the west extension to discover available examples for your board:

```
west list_project -p examples/demo_apps/hello_world
```

This shows all supported build configurations. You can filter by toolchain:

```
west list_project -p examples/demo_apps/hello_world -t armgcc
```

Basic Build Process

Simple Build Build the hello_world example with default settings:

```
west build -b your_board examples/demo_apps/hello_world
```

The default toolchain is armgcc, and the build system will select the first debug target as default if no config is specified.

Specifying Configuration

```
# Release build
west build -b your_board examples/demo_apps/hello_world --config release
```

```
# Debug build (default)
west build -b your_board examples/demo_apps/hello_world --config debug
```

Alternative Toolchains

```
# IAR toolchain
west build -b your_board examples/demo_apps/hello_world --toolchain iar
```

```
# Other toolchains as supported by the example
```


Multicore Applications For multicore devices, specify the core ID:

```
west build -b evkbmimxrt1170 examples/demo_apps/hello_world --toolchain iar -Dcore_id=cm7 --config ↵
↵ flexspi_nor_debug
```

For multicore projects using sysbuild:

```
west build -b evkbmimxrt1170 --sysbuild ./examples/multicore_examples/hello_world/primary -Dcore_
↵ id=cm7 --config flexspi_nor_debug --toolchain=armgcc -p always
```

Flash an Application Flash the built application to your board:

```
west flash -r linkserver
```

Debug Start a debug session:

```
west debug -r linkserver
```

Common Build Options

Clean Build Force a complete rebuild:

```
west build -b your_board examples/demo_apps/hello_world -p always
```

Dry Run See the commands that get executed without running them:

```
west build -b your_board examples/demo_apps/hello_world --dry-run
```

Device Variants For boards supporting multiple device variants:

```
west build -b your_board examples/demo_apps/hello_world --device DEVICE_PART_NUMBER --config ↵
↵ release
```

Project Configuration

CMake Configuration Only Run configuration without building:

```
west build -b your_board examples/demo_apps/hello_world -Dcore_id=cm7 --cmake-only -p
```

Interactive Configuration Launch the configuration GUI:

```
west build -t guiconfig
```

Troubleshooting

Build Failures Use pristine builds to resolve dependency issues:

```
west build -b your_board examples/demo_apps/hello_world -p always
```

Getting Help View the help information for west build:

```
west build -h
```

Check Supported Configurations To see available configuration options and board targets for an example, refer to the below command:

```
west list_project -p examples/demo_apps/hello_world
```

Next Steps

- Explore other examples in the SDK
- Learn about [Command Line Development](#) for advanced options
- Try [VS Code Development](#) for integrated development
- Refer [Workspace Structure](#) to understand the SDK layout

MCUXpresso for VS Code Development This guide covers using MCUXpresso for VS Code extension to build, debug, and develop SDK applications with an integrated development environment.

Prerequisites

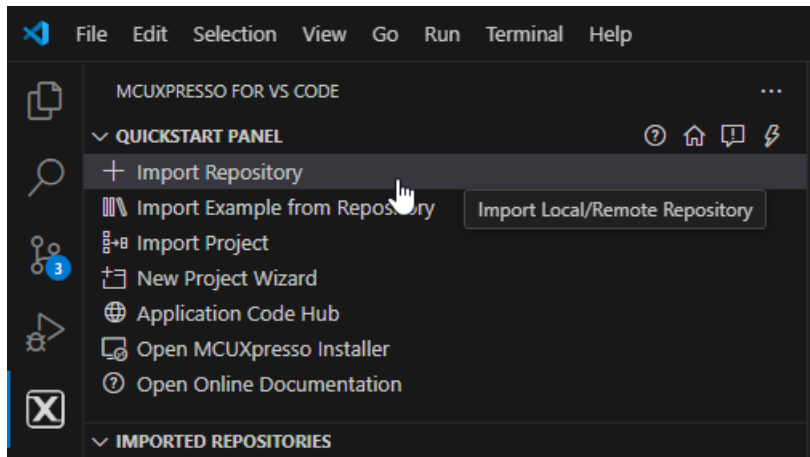
- SDK workspace initialized (GitHub Repository SDK or Repository-Layout SDK Package)
- Development tools installed per [Installation Guide](#)
- Visual Studio Code installed
- MCUXpresso for VS Code extension installed

Extension Installation

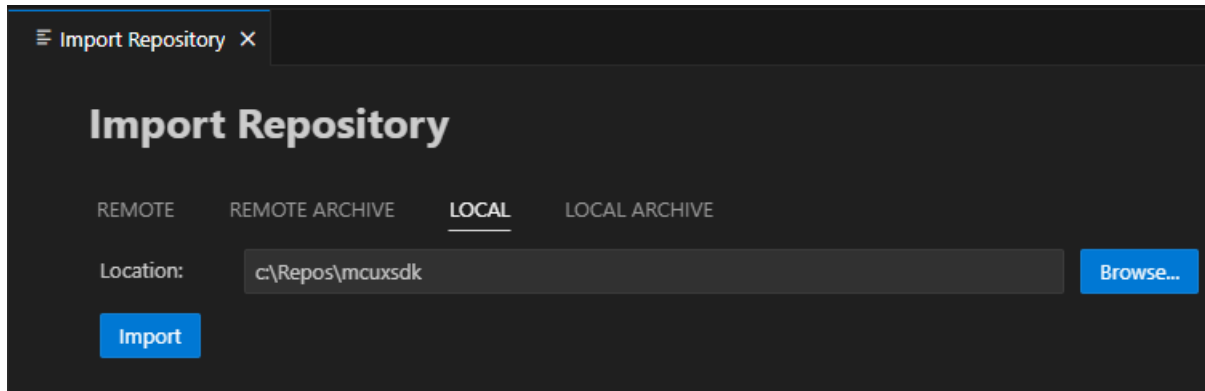
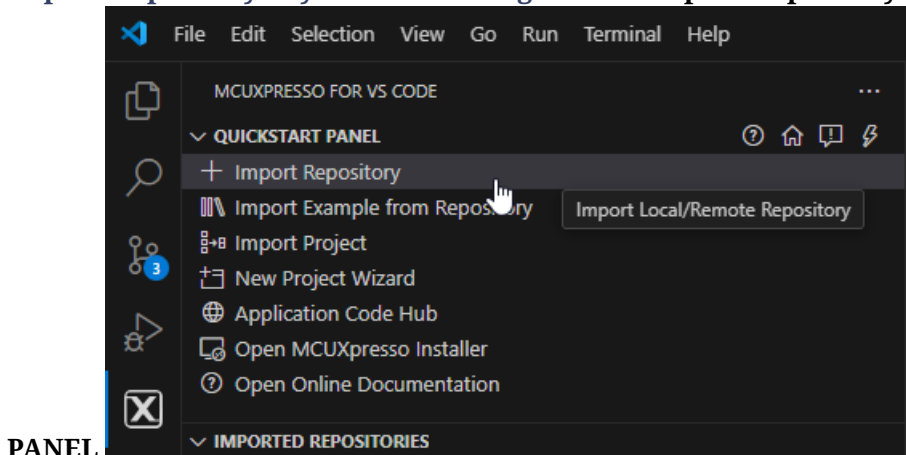
Install MCUXpresso for VS Code The MCUXpresso for VS Code extension provides integrated development capabilities for MCUXpresso SDK projects. Refer to the [MCUXpresso for VS Code Wiki](#) for detailed installation and setup instructions.

SDK Import and Setup

Import Methods The SDK can be imported in several ways. The MCUXpresso for VS Code extension supports both GitHub Repository SDK and Repository-Layout SDK Package distributions.

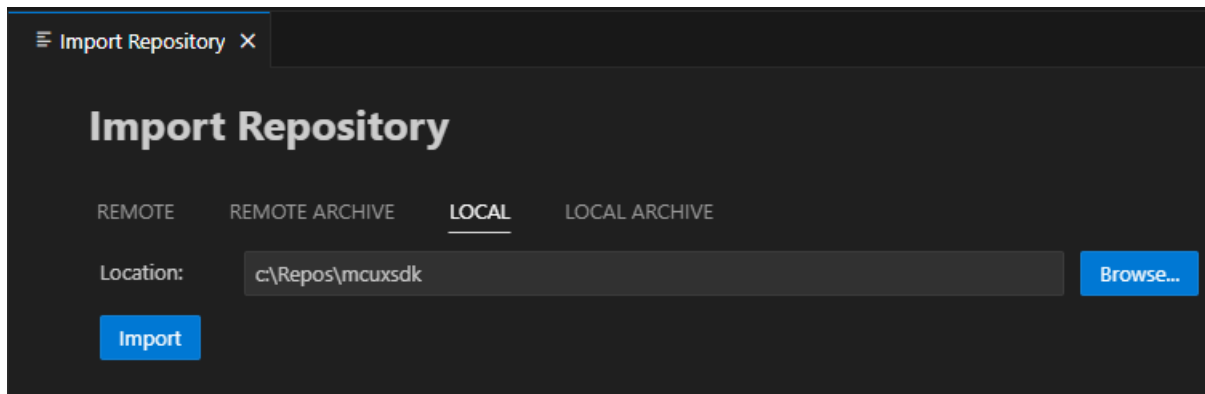
Import GitHub Repository SDK Click **Import Repository** from the **QUICKSTART PANEL**

Note: You can import the SDK in several ways. Refer to [MCUXpresso for VS Code Wiki](#) for details. Select **Local** if you've already obtained the SDK according to [setting up the repo](#). Select your location and click **Import**.

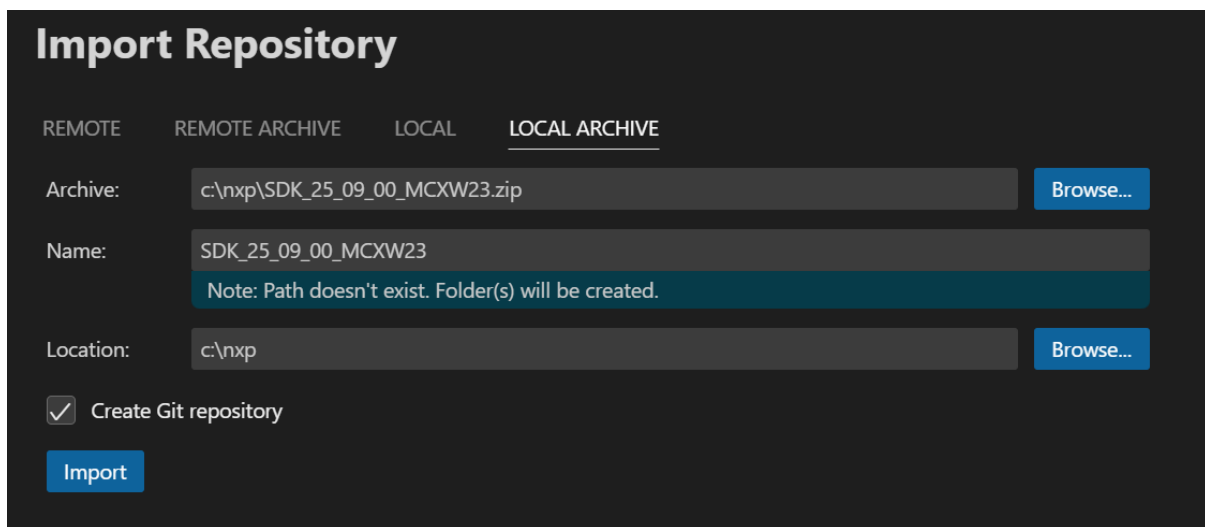
**Import Repository-Layout SDK Package** Click **Import Repository** from the **QUICKSTART**

PANEL

Select **Local** if you've already unzipped the Repository-Layout SDK Package. Select your location and click **Import**.



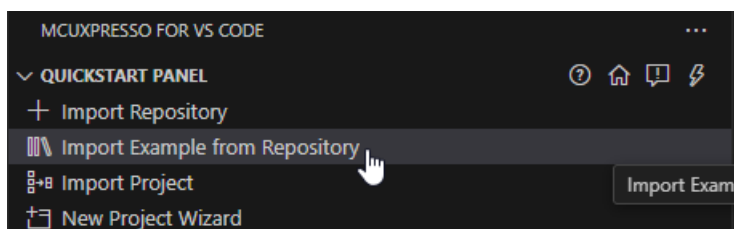
Else if the SDK is ZIP archive, select **Local Archive**, browse to the downloaded SDK ZIP file, fill the link of expect location, then click **Import**.



Building Example Applications

Import Example Project

1. Click **Import Example from Repository** from the **QUICKSTART PANEL**



2. Configure project settings:
 - **MCUXpresso SDK:** Select your imported SDK
 - **Arm GNU Toolchain:** Choose toolchain
 - **Board:** Select your target development board
 - **Template:** Choose example category
 - **Application:** Select specific example (e.g., hello_world)
 - **App type:** Choose between Repository applications or Freestanding applications

3. Click **Import**

Import Example from Repository

Import Example from Repository

Repository:
c:\Repos\mcuxsdk (MCUXpresso SDK Repository)

Toolchain:
(Arm GNU Toolchain 13.2.rel1 (Build arm-13.7)) 13.2.1 20231009 (C:\NXP\MCUXpressoIDE_24.

Board:
FRDM-MCXC444


FRDM-MCXC444

Template:
demo_apps/hello_world

The HelloWorld demo prints the "Hello World" string to the terminal using the SDK UART drivers and repeat what user input. The purpose of this demo is to show how to use the UART, and to provide a simple project for debugging and further development.
Please refer to [README](#) file for more details.

App type:
Freestanding application

Name:
frdmmcxc444_hello_world

Location:
c:\nxp_examples
Browse...

Note: Path doesn't exist. Folder(s) will be created.

☐ Open readme file after project is imported

Import

Application Types Repository Applications:

- Located inside the MCUXpresso SDK
- Integrated with SDK workspace

Freestanding Applications:

- Imported to user-defined location
- Independent of SDK location

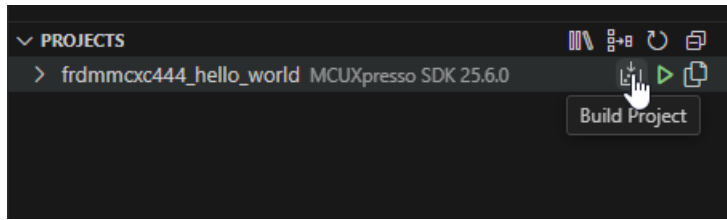
Trust Confirmation VS Code will prompt you to confirm if the imported files are trusted. Click **Yes** to proceed.

Building Projects

Build Process

1. Navigate to **PROJECTS** view

2. Find your project
3. Click the **Build Project** icon

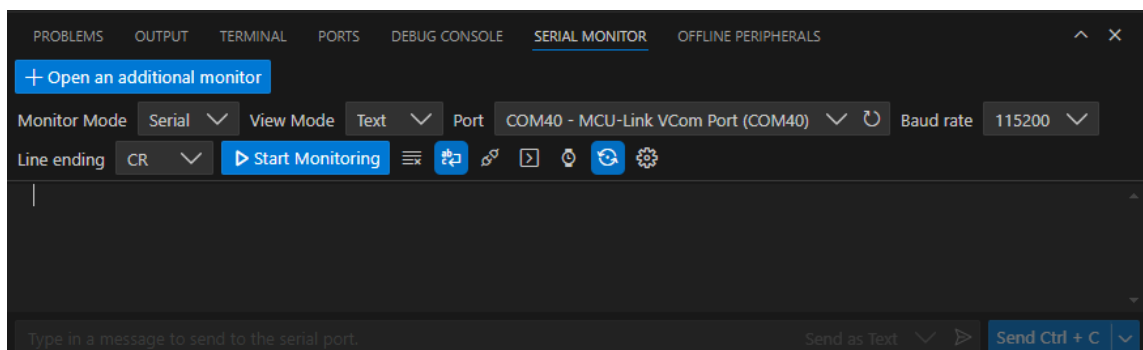


The integrated terminal will display build output at the bottom of the VS Code window.

Running and Debugging

Serial Monitor Setup

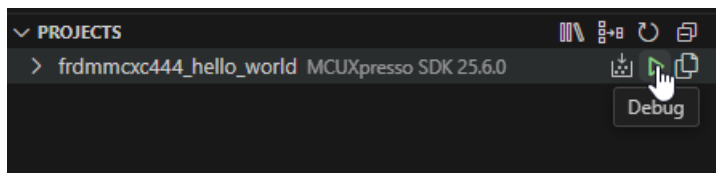
1. Open **Serial Monitor** from VS Code's integrated terminal



2. Configure serial settings:
 - **VCom Port:** Select port for your device
 - **Baud Rate:** Set to 115200

Debug Session

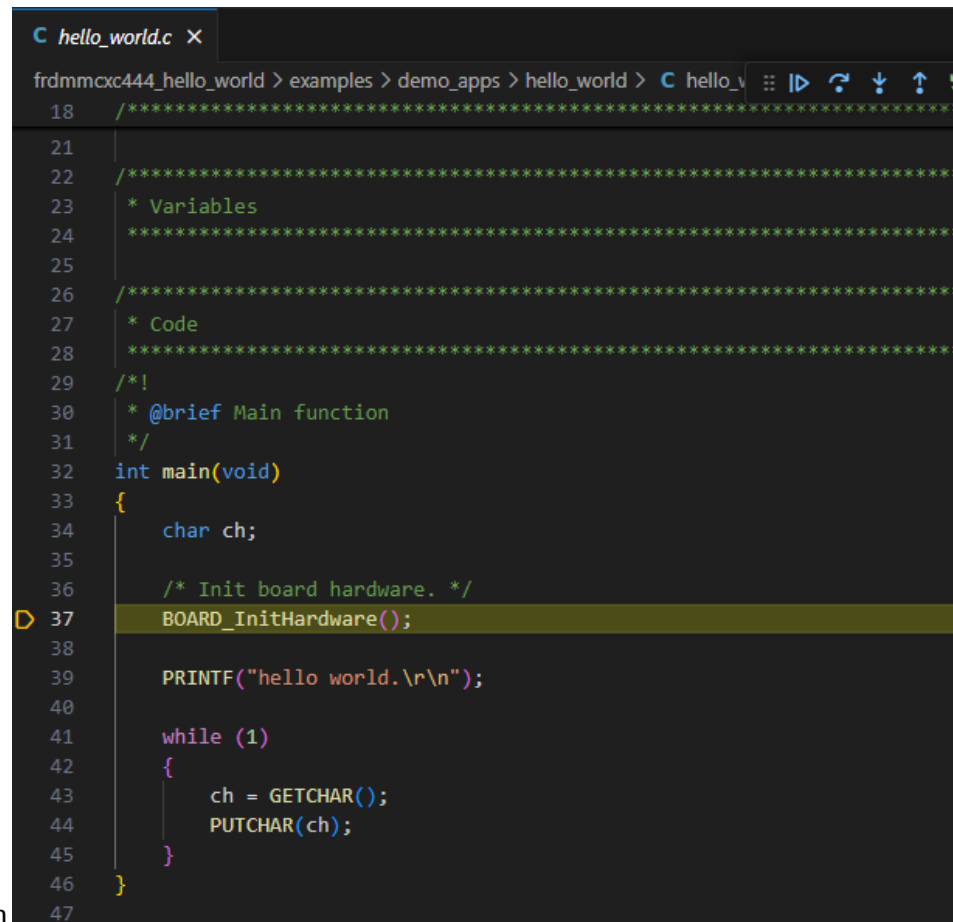
1. Navigate to **PROJECTS** view
2. Click the play button to initiate a debug session



The debug session will begin with debug controls initially at the top of the interface.

Debug Controls Use the debug controls to manage execution:

- **Continue:** Resume code execution
- **Step controls:** Navigate through code



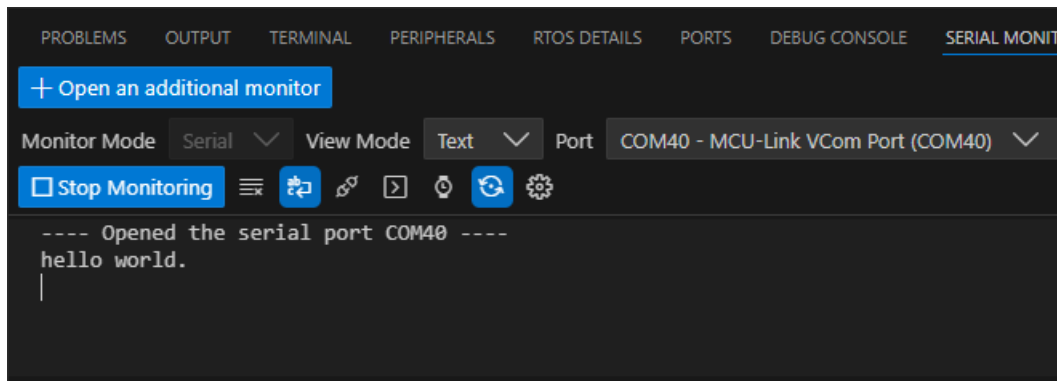
```

C hello_world.c x
frdm-mxc444_hello_world > examples > demo_apps > hello_world > C hello_w
18  /*****
21
22  /*****
23  * Variables
24  *****/
25
26  /*****
27  * Code
28  *****/
29  /*!
30  * @brief Main function
31  */
32  int main(void)
33  {
34      char ch;
35
36      /* Init board hardware. */
37      BOARD_InitHardware();
38
39      PRINTF("hello world.\r\n");
40
41      while (1)
42      {
43          ch = GETCHAR();
44          PUTCHAR(ch);
45      }
46  }
47

```

- **Stop:** Terminate debug session

Monitor Output Observe application output in the **Serial Monitor** to verify correct operation.



Debug Probe Support For comprehensive information on debug probe support and configuration, refer to the [MCUXpresso for VS Code Wiki DebugK](#) section.

Project Configuration

Workspace Management The extension integrates with the MCUXpresso SDK workspace structure, providing access to:

- Example applications
- Board configurations

- Middleware components
- Build system integration

Multi-Project Support The PROJECTS view allows management of multiple imported projects within the same workspace.

Troubleshooting

Import Issues SDK not detected:

- Verify SDK workspace is properly initialized
- Ensure all required repositories are updated
- Check SDK manifest files are present

Project import failures:

- Confirm board support exists for selected example
- Verify toolchain installation
- Check example compatibility with selected board

Build Problems Build failures:

- Check integrated terminal for error messages
- Verify all dependencies are installed
- Ensure toolchain is properly configured

Debug Issues Debug session fails:

- Verify board connection via USB
- Check debug probe drivers are installed
- Confirm build completed successfully

Serial monitor problems:

- Verify correct VCom port selection
- Check baud rate configuration (115200)
- Ensure board drivers are installed

Integration with Command Line MCUXpresso for VS Code integrates with the underlying west build system, allowing seamless integration with command line workflows described in [Command Line Development](#).

Advanced Features

Project Types The extension supports both repository-based and freestanding project types, providing flexibility in project organization and SDK integration.

Build System Integration The extension leverages the MCUXpresso SDK build system, providing access to all build configurations and options available through command line tools.

Next Steps

- Explore additional examples in the SDK
- Review [Command Line Development](#) for advanced build options
- Refer [MCUXpresso for VS Code Wiki](#) for detailed documentation
- Learn about [SDK Architecture](#) for better understanding of the development environment

Command Line Development This guide covers developing with the MCUXpresso SDK using command line tools and the west build system. This workflow applies to both GitHub Repository SDK and Repository-Layout SDK Package distributions.

Prerequisites

- GitHub Repository SDK workspace initialized OR Repository-Layout SDK Package extracted
- Development tools installed per [Installation Guide](#)
- Target board connected via USB

Understanding Board Support Use the west extension to discover available examples for your board:

```
west list _project -p examples/demo_apps/hello_world
```

This shows all supported build configurations. You can filter by toolchain:

```
west list _project -p examples/demo_apps/hello_world -t armgcc
```

Basic Build Commands

Standard Build Process Build with default settings (armgcc toolchain, first debug config):

```
west build -b your_board examples/demo_apps/hello_world
```

Specifying Build Configuration

```
# Release build
west build -b your_board examples/demo_apps/hello_world --config release

# Debug build with specific toolchain
west build -b your_board examples/demo_apps/hello_world --toolchain iar --config debug
```

Multicore Applications For multicore devices, specify the core ID:

```
west build -b evkbmimxrt1170 examples/demo_apps/hello_world --toolchain iar -Dcore_id=cm7 --config ↵
↵ flexspi_nor_debug
```

For multicore projects using sysbuild:

```
west build -b evkbmimxrt1170 --sysbuild ./examples/multicore_examples/hello_world/primary -Dcore_↵id=cm7 --config flexspi_nor_debug --toolchain=armgcc -p always
```

Shield Support For boards with shields:

```
west build -b mimxrt700evk --shield a8974 examples/issdk_examples/sensors/fxls8974cf/fxls8974cf_poll -↵Dcore_id=cm33_core0
```

Advanced Build Options

Clean Builds Force a complete rebuild:

```
west build -b your_board examples/demo_apps/hello_world -p always
```

Dry Run See what commands would be executed:

```
west build -b your_board examples/demo_apps/hello_world --dry-run
```

Device Variants For boards supporting multiple device variants:

```
west build -b your_board examples/demo_apps/hello_world --device MK22F12810 --config release
```

Project Configuration

CMake Configuration Only Run configuration without building:

```
west build -b evkbmimxrt1170 examples/demo_apps/hello_world -Dcore_id=cm7 --cmake-only -p
```

Interactive Configuration Launch the configuration GUI:

```
west build -t guiconfig
```

Flashing and Debugging

Flash Application Flash the built application to your board:

```
west flash -r linkserver
```

Debug Session Start a debugging session:

```
west debug -r linkserver
```

IDE Project Generation Generate IDE project files for traditional IDEs:

```
# Generate IAR project
west build -b evkbmimxrt1170 examples/demo_apps/hello_world --toolchain iar -Dcore_id=cm7 --config_
↪ flexspi_nor_debug -p always -t guiproject
```

IDE project files are generated in `mcuxsdk/build/<toolchain>` folder.

Note: Ruby installation is required for IDE project generation. See [Installation Guide](#) for setup instructions.

Troubleshooting

Build Failures Use pristine builds to resolve dependency issues:

```
west build -b your_board examples/demo_apps/hello_world -p always
```

Toolchain Issues Verify environment variables are set correctly:

```
# Check ARM GCC
echo $ARMGCC_DIR
arm-none-eabi-gcc --version

# Check IAR (if using)
echo $IAR_DIR
```

Getting Help Display help information:

```
west build -h
west flash -h
west debug -h
```

Check Supported Configurations If unsure about supported options for an example:

```
west list_project -p examples/demo_apps/hello_world
```

Best Practices

Project Organization

- Keep custom projects outside the SDK tree
- Use version control for your application code
- Document any SDK modifications

Build Efficiency

- Use `-p always` for clean builds when troubleshooting
- Leverage `--dry-run` to understand build processes
- Use specific configs and toolchains to reduce build time

Development Workflow

1. Start with existing examples closest to your requirements
2. Copy and modify rather than building from scratch
3. Test with hello_world before moving to complex examples
4. Use configuration tools for pin muxing and clock setup

Next Steps

- Explore [VS Code Development](#) for integrated development experience
- Review [Workspace Structure](#) to understand SDK organization
- Refer build system documentation for advanced configurations

Using MCUXpresso Config Tools MCUXpresso Config tools provide a user-friendly way to configure hardware initialization of your projects. This guide explains the basic workflow with the MCUXpresso SDK west build system and the Config Tools.

Prerequisites

- GitHub Repository SDK workspace initialized OR Repository-Layout SDK Package extracted
- MCUXpresso Config Tools standalone installed (version 25.09 or above)
- MCUXpresso SDK Project that can be successfully built

Board Files MCUXpresso Config Tools generate source files for the board. These files include pin_mux.c/h and clock_config.c/h. The files contain initialization code functions that reflect the hardware configuration in the Config Tools. Within the SDK codebase, these files are specific for the board and either shared by multiple example projects or specific for one example. Open or import the configuration from the SDK project in the Config Tools and customize the settings to match the custom board or specific project use case and regenerate the code. See *User Guide for MCUXpresso Config Tools (Desktop)* (document [GSMCUXCTUG](#)) for details.

Note: When opening the configuration for SDK example projects, the board files may be shared across multiple examples. To ensure a separate copy of the board configuration files exists, create a freestanding project with copied board files.

Visual Studio Code To open the configuration in Visual Studio Code, use the context menu for the project to access Config Tools. See [MCUXpresso Extension Documentation](#) for details. Otherwise, use the manual workflow described in detail in the following section.

Manual Workflow Use the following steps:

1. Before using Config Tools, run the west command to get the project information for Config Tools from the SDK project files, for example:

```
west cfg_project_info -b lpcxpresso55s69 ...mcuxsdk/examples/demo_apps/hello_world/ -Dcore_
↪ id=cm33_core0
```

This results in the creation of the project information json file that is searched by the config tools when the configuration is created. The parameters of the command should match the build parameters that will be used for the project.

2. Launch the MCUXpresso Config Tools and in the **Start development** wizard, select **Create a new configuration based on the existing IDE/Toolchain project**. Select the created “cfg_tools” subfolder as a project folder (for example: ...mcuxsdk/examples/demo_apps/hello_world/cfg_tools/).

Updating the SDK West project **Note:** Updating project is supported with Config Tools V25.12 or newer only.

Changes in the Config tools generated source code modules may require adjustments to the toolchain project to ensure a successful build. These changes may mean, for example, adding the newly generated files, adding include paths, required drivers, or other SDK components. This section describes how to manually resolve the changes needed in the project within the toolchain projects based on the SDK project managed by the West tool.

After the configuration in the Config Tools is finished, write updated files to the disk using the ‘Update Code’ command. The written files include a json file with the required changes for the toolchain project.

To resolve the changes in the project in the terminal, launch the west command that updates the project. For example:

```
west cfg_resolve -b lpcxpresso55s69 ...mcuxsdk/examples/demo_apps/hello_world/ -Dcore_id=cm33_core0
```

This command updates the appropriate cmake and kconfig files to address the changes. After this, the application can be built.

Note: The `cfg_resolve` command supports additional arguments. Launch the `west cfg_resolve -h` command to get the list and description.

1.4 Release Notes

1.4.1 MCUXpresso SDK Release Notes

Overview

The MCUXpresso SDK is a comprehensive software enablement package designed to simplify and accelerate application development with Arm Cortex-M-based devices from NXP, including its general purpose, crossover and Bluetooth-enabled MCUs. MCUXpresso SW and Tools for DSC further extends the SDK support to current 32-bit Digital Signal Controllers. The MCUXpresso SDK includes production-grade software with integrated RTOS (optional), integrated enabling software technologies (stacks and middleware), reference software, and more.

In addition to working seamlessly with the MCUXpresso IDE, the MCUXpresso SDK also supports and provides example projects for various toolchains. The Development tools chapter in the associated Release Notes provides details about toolchain support for your board. Support for the MCUXpresso Config Tools allows easy cloning of existing SDK examples and demos, allowing users to leverage the existing software examples provided by the SDK for their own projects.

Underscoring our commitment to high quality, the MCUXpresso SDK is MISRA compliant and checked with Coverity static analysis tools. For details on MCUXpresso SDK, see [MCUXpresso-SDK: Software Development Kit for MCUXpresso](#).

MCUXpresso SDK

As part of the MCUXpresso software and tools, MCUXpresso SDK is the evolution of Kinetis SDK, includes support for LPC, DSC, PN76, and i.MX System-on-Chip (SoC). The same drivers, APIs, and

middleware are still available with support for Kinetis, LPC, DSC, and i.MX silicon. The MCUXpresso SDK adds support for the MCUXpresso IDE, an Eclipse-based toolchain that works with all MCUXpresso SDKs. Easily import your SDK into the new toolchain to access to all of the available components, examples, and demos for your target silicon. In addition to the MCUXpresso IDE, support for the MCUXpresso Config Tools allows easy cloning of existing SDK examples and demos, allowing users to leverage the existing software examples provided by the SDK for their own projects.

In order to maintain compatibility with legacy Freescale code, the filenames and source code in MCUXpresso SDK containing the legacy Freescale prefix FSL has been left as is. The FSL prefix has been redefined as the NXP Foundation Software Library.

Development tools

The MCUXpresso SDK was tested with following development tools. Same versions or above are recommended.

- IAR Embedded Workbench for Arm, version is 9.60.4
- MCUXpresso for VS Code v25.09
- GCC Arm Embedded Toolchain 14.2.x

Supported development systems

This release supports board and devices listed in following table. The board and devices in bold were tested in this release.

De- velop- ment boards	MCU devices			
MCIMX93 QSB	MIMX9311CVXXM,	MIMX9311DVXXM,	MIMX9311XVXXM,	MIMX9312CVXXM, MIMX9312DVXXM, MIMX9312XVXXM, MIMX9321CVXXM, MIMX9321DVXXM, MIMX9321XVXXM, MIMX9322CVXXM , MIMX9322DVXXM, MIMX9322XVXXM

MCUXpresso SDK release package

The MCUXpresso SDK release package content is aligned with the silicon subfamily it supports. This includes the boards, CMSIS, devices, middleware, and RTOS support.

Device support The device folder contains the whole software enablement available for the specific System-on-Chip (SoC) subfamily. This folder includes clock-specific implementation, device register header files, device register feature header files, and the system configuration source files. Included with the standard SoC support are folders containing peripheral drivers, toolchain support, and a standard debug console. The device-specific header files provide a direct access to the microcontroller peripheral registers. The device header file provides an overall SoC memory mapped register definition. The folder also includes the feature header file for each peripheral on the microcontroller. The toolchain folder contains the startup code and linker files for each supported toolchain. The startup code efficiently transfers the code execution to the main() function.

Board support The boards folder provides the board-specific demo applications, driver examples, and middleware examples.

Demo application and other examples The demo applications demonstrate the usage of the peripheral drivers to achieve a system level solution. Each demo application contains a readme file that describes the operation of the demo and required setup steps. The driver examples demonstrate the capabilities of the peripheral drivers. Each example implements a common use case to help demonstrate the driver functionality.

RTOS

FreeRTOS Real-time operating system for microcontrollers from Amazon

Middleware

CMSIS DSP Library The MCUXpresso SDK is shipped with the standard CMSIS development pack, including the prebuilt libraries.

VoiceSpot VoiceSpot is a highly accurate, small memory and MIPS profile wake word engine supporting custom voice trigger words and phrases. MCUXpresso SDK version of VoiceSpot is trained to “Hey NXP” wake word only and has 25 hour trial timeout.

TinyCBOR Concise Binary Object Representation (CBOR) Library

PKCS#11 The PKCS#11 standard specifies an application programming interface (API), called “Cryptoki,” for devices that hold cryptographic information and perform cryptographic functions. Cryptoki follows a simple object based approach, addressing the goals of technology independence (any kind of device) and resource sharing (multiple applications accessing multiple devices), presenting to applications a common, logical view of the device called a “cryptographic token”.

Multicore Multicore Software Development Kit

eIQ The package contains several example applications using the eIQ TensorFlow Lite for Microcontrollers library.

eIQ machine learning SDK containing:

- Arm CMSIS-NN library (neural network kernels optimized for Cortex-M cores)
- Inference engines:
 - TensorFlow Lite Micro
 - DeepView RT
- Example code for TensorFlow Lite Micro, Glow, and DeepView RT

lwIP The lwIP TCP/IP stack is pre-integrated with MCUXpresso SDK and runs on top of the MCUXpresso SDK Ethernet driver with Ethernet-capable devices/boards.

For details, see the *lwIP TCPIP Stack and MCUXpresso SDK Integration User’s Guide* (document MCUXSDKLWIPUG).

lwIP is a small independent implementation of the TCP/IP protocol suite.

llhttp HTTP parser llhttp

FreeMASTER FreeMASTER communication driver for 32-bit platforms.

Release contents

Provides an overview of the MCUXpresso SDK release package contents and locations.

Deliverable	Location
Boards	INSTALL_DIR/boards
Demo Applications	INSTALL_DIR/boards/<board_name>/demo_apps
Driver Examples	INSTALL_DIR/boards/<board_name>/driver_examples
eIQ examples	INSTALL_DIR/boards/<board_name>/eiq_examples
Board Project Template for MCUXpresso IDE NPW	INSTALL_DIR/boards/<board_name>/project_template
Driver, SoC header files, extension header files and feature header files, utilities	INSTALL_DIR/devices/<device_name>
CMSIS drivers	INSTALL_DIR/devices/<device_name>/cmsis_drivers
Peripheral drivers	INSTALL_DIR/devices/<device_name>/drivers
Toolchain linker files and startup code	INSTALL_DIR/devices/<device_name>/<toolchain_name>
Utilities such as debug console	INSTALL_DIR/devices/<device_name>/utilities
Device Project Template for MCUXpresso IDE NPW	INSTALL_DIR/devices/<device_name>/project_template
CMSIS Arm Cortex-M header files, DSP library source	INSTALL_DIR/CMSIS
Components and board device drivers	INSTALL_DIR/components
RTOS	INSTALL_DIR/rtos
Release Notes, Getting Started Document and other documents	INSTALL_DIR/docs
Tools such as shared cmake files	INSTALL_DIR/tools
Middleware	INSTALL_DIR/middleware

Known Issues

This section lists the known issues, limitations, and/or workarounds.

eDMA examples accessing AIPS peripheral bridge memory must run through U-Boot loading method

Non-secure access to Arm IP Bus (AIPS) must be configured in Trusted Resource Domain Control (TRDC) for enhanced direct memory access (eDMA) controller. Due to the limitation that Sentinel ROM can release TRDC only once, such examples must run through U-Boot loading method after Trusted Firmware-A (TF-A) configuring TRDC.

To make low-power boot mode work for only M core in such example, you need to implement the request of the TRDC release and configure TRDC. However, it will break the single boot mode with TF-A/Linux BSP.

The following eDMA examples need access to AIPS.

- cmsis_lpi2c_edma_b2b_transfer_master
- cmsis_lpi2c_edma_b2b_transfer_slave
- cmsis_lpuart_edma_transfer
- flexcan_loopback_edma_transfer
- lpi2c_edma_b2b_transfer_master

- lpi2c_edma_b2b_transfer_slave
- lpuart_edma_transfer
- pdm_edma_transfer
- sai_edma_transfer

Examples `hello_world_ns`, `secure_faults_ns`, and `secure_faults_trdc_ns` have incorrect library path in GUI projects

When the affected examples are generated as GUI projects, the library linking the secure and non-secure worlds has an incorrect path set. This causes linking errors during project compilation.

Examples: `hello_world_ns`, `hello_world_s`, `secure_faults_ns`, `secure_faults_s`, `secure_faults_trdc_ns`, `secure_faults_trdc_s`

Affected toolchains: mdk, iar

Workaround: In the IDE project settings for the non-secure (`_ns`) project, find the linked library (named `hello_world_s_CMSE_lib.o`, or similar, depending on the example project) and replace the path to the library with `<build_directory>/<secure_world_project_folder>/<IDE>/`, replacing the subdirectory names with the build directory, the secure world project name, and IDE name.

1.5 ChangeLog

1.5.1 MCUXpresso SDK Changelog

Board Support Files

`board`

[25.06.00]

- Initial version

`clock_config`

[25.06.00]

- Initial version

`pin_mux`

[25.06.00]

- Initial version

CACHE XCACHE

[2.0.4]

- Improvements
 - Add memory barrier when enabling/disabling cache.

[2.0.3]

- Bug Fixes
 - Fixed CERT INT30-C violations.

[2.0.2]

- Bug Fixes
 - Updated `XCACHE_InvalidateCacheByRange()`, `XCACHE_CleanCacheByRange()`, `XCACHE_CleanInvalidateCacheByRange()` in case of startAddr equal to endAddr.

[2.0.1]

- Improvements
 - Check input parameter “size_byte” must be larger than 0.

[2.0.0]

- Initial version.
-

COMMON

[2.6.3]

- Bug Fixes
 - Fixed build issue of CMSIS PACK BSP example caused by CMSIS 6.1 issue.

[2.6.2]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule for implicit conversions in boolean contexts

[2.6.1]

- Improvements
 - Support Cortex M23.

[2.6.0]

- Bug Fixes
 - Fix CERT-C violations.

[2.5.0]

- New Features
 - Added new APIs `InitCriticalSectionMeasurementContext`, `DisableGlobalIRQEx` and `EnableGlobalIRQEx` so that user can measure the execution time of the protected sections.

[2.4.3]

- Improvements
 - Enable irq's that mount under `irqsteer` interrupt extender.

[2.4.2]

- Improvements
 - Add the macros to convert peripheral address to secure address or non-secure address.

[2.4.1]

- Improvements
 - Improve for the macro redefinition error when integrated with `zephyr`.

[2.4.0]

- New Features
 - Added `EnableIRQWithPriority`, `IRQ_SetPriority`, and `IRQ_ClearPendingIRQ` for ARM.
 - Added `MSDK_EnableCpuCycleCounter`, `MSDK_GetCpuCycleCount` for ARM.

[2.3.3]

- New Features
 - Added `NETC` into status group.

[2.3.2]

- Improvements
 - Make driver `aarch64` compatible

[2.3.1]

- Bug Fixes
 - Fixed `MAKE_VERSION` overflow on 16-bit platforms.

[2.3.0]

- Improvements
 - Split the driver to common part and CPU architecture related part.

[2.2.10]

- Bug Fixes
 - Fixed the ATOMIC macros build error in cpp files.

[2.2.9]

- Bug Fixes
 - Fixed MISRA C-2012 issue, 5.6, 5.8, 8.4, 8.5, 8.6, 10.1, 10.4, 17.7, 21.3.
 - Fixed SDK_Malloc issue that not allocate memory with required size.

[2.2.8]

- Improvements
 - Included stddef.h header file for MDK tool chain.
- New Features:
 - Added atomic modification macros.

[2.2.7]

- Other Change
 - Added MECC status group definition.

[2.2.6]

- Other Change
 - Added more status group definition.
- Bug Fixes
 - Undef __VECTOR_TABLE to avoid duplicate definition in cmsis_clang.h

[2.2.5]

- Bug Fixes
 - Fixed MISRA C-2012 rule-15.5.

[2.2.4]

- Bug Fixes
 - Fixed MISRA C-2012 rule-10.4.

[2.2.3]

- New Features
 - Provided better accuracy of SDK_DelayAtLeastUs with DWT, use macro SDK_DELAY_USE_DWT to enable this feature.
 - Modified the Cortex-M7 delay count divisor based on latest tests on RT series boards, this setting lets result be closer to actual delay time.

[2.2.2]

- New Features
 - Added include RTE_Components.h for CMSIS pack RTE.

[2.2.1]

- Bug Fixes
 - Fixed violation of MISRA C-2012 Rule 3.1, 10.1, 10.3, 10.4, 11.6, 11.9.

[2.2.0]

- New Features
 - Moved SDK_DelayAtLeastUs function from clock driver to common driver.

[2.1.4]

- New Features
 - Added OTFAD into status group.

[2.1.3]

- Bug Fixes
 - MISRA C-2012 issue fixed.
 - * Fixed the rule: rule-10.3.

[2.1.2]

- Improvements
 - Add SUPPRESS_FALL_THROUGH_WARNING() macro for the usage of suppressing fallthrough warning.

[2.1.1]

- Bug Fixes
 - Deleted and optimized repeated macro.

[2.1.0]

- New Features
 - Added IRQ operation for XCC toolchain.
 - Added group IDs for newly supported drivers.

[2.0.2]

- Bug Fixes
 - MISRA C-2012 issue fixed.
 - * Fixed the rule: rule-10.4.

[2.0.1]

- Improvements
 - Removed the implementation of LPC8XX Enable/DisableDeepSleepIRQ() function.
 - Added new feature macro switch “FSL_FEATURE_HAS_NO_NONCACHEABLE_SECTION” for specific SoCs which have no noncacheable sections, that helps avoid an unnecessary complex in link file and the startup file.
 - Updated the align(x) to **attribute**(aligned(x)) to support MDK v6 armclang compiler.

[2.0.0]

- Initial version.
-

EDMA

[2.10.9]

- Bug Fixes
 - Add new api EDMA_TcdInit to avoid destroying code logic by reordering blocks in the toolchain.

[2.10.8]

- Bug Fixes
 - Fixed coverity issues with CERT INT30-C, CERT INT31-C compliance.
 - Fixed incorrect enabling of preemption capability issue.

[2.10.7]

- Improvements
 - Add condition to fix build warnings(array subscript 4 is above array bounds of ‘edma_handle_t *[4][64]’)
- Bug Fixes
 - Fixed the EDMA header index retrieval error caused by done bit calculation mistake issue.

[2.10.6]

- Improvements
 - Add macro FSL_FEATURE_EDMA_HAS_EDMA_TCD_CLOCK_ENABLE to enable tcd clocks in EDMA_Init function.

[2.10.5]

- Bug Fixes
 - Fixed memory convert would convert NULL as zero address issue.

[2.10.4]

- Improvements
 - Add new MP register macros to ensure compatibility with different devices.
 - Add macro `DMA_CHANNEL_ARRAY_STEPn` to adapt to complex addressing of edma tcd registers.

[2.10.3]

- Bug Fixes
 - Clear interrupt status flags in `EDMA_CreateHandle` to avoid triggering interrupt by mistake.

[2.10.2]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 10.3.

[2.10.1]

- Bug Fixes
 - Fixed `EDMA_GetRemainingMajorLoopCount` may return wrong value issue.
 - Fixed violations of the MISRA C-2012 rules 13.5, 10.4.

[2.10.0]

- Improvements
 - Modify the structures `edma_core_mp_t`, `edma_core_channel_t`, `edma_core_tcd_t` to adapt to edma5.
 - Add TCD register macro to facilitate confirmation of tcd type.
 - Modify the mask macro to a fixed value.
 - Add `EDMA_TCD_TYPE` macro to determine edma tcd type.
 - Add extension API to the following API to determine edma tcd type.
 - * `EDMA_ConfigChannelSoftwareTCD` -> `EDMA_ConfigChannelSoftwareTCDExt`
 - * `EDMA_TcdReset` -> `EDMA_TcdResetExt`
 - * `EDMA_TcdSetTransferConfig` -> `EDMA_TcdSetTransferConfigExt`
 - * `EDMA_TcdSetMinorOffsetConfig` -> `EDMA_TcdSetMinorOffsetConfigExt`
 - * `EDMA_TcdSetChannelLink` -> `EDMA_TcdSetChannelLinkExt`
 - * `EDMA_TcdSetBandWidth` -> `EDMA_TcdSetBandWidthExt`
 - * `EDMA_TcdSetModulo` -> `EDMA_TcdSetModuloExt`
 - * `EDMA_TcdEnableAutoStopRequest` -> `EDMA_TcdEnableAutoStopRequestExt`
 - * `EDMA_TcdEnableInterrupts` -> `EDMA_TcdEnableInterruptsExt`
 - * `EDMA_TcdDisableInterrupts` -> `EDMA_TcdDisableInterruptsExt`
 - * `EDMA_TcdSetMajorOffsetConfig` -> `EDMA_TcdSetMajorOffsetConfigExt`

[2.9.2]

- Improvements
 - Remove tcd alignment check in API that is low level and does not necessarily use scatter/gather mode.

[2.9.1]

- Bug Fixes
 - Deinit channel request source before set channel mux.

[2.9.0]

- Improvements
 - Release peripheral from reset if necessary in init function.
- Bug Fixes
 - Fixed the variable type definition error issue.
 - Fixed doxygen warning.
 - Fixed violations of MISRA C-2012 rule 18.1.

[2.8.1]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 10.3

[2.8.0]

- Improvements
 - Added feature FSL_FEATURE_EDMA_HAS_NO_CH_SBR_SEC to separate DMA without SEC bitfield.

[2.7.1]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 10.3, 10.4, 11.6, 11.8, 14.3,.

[2.7.0]

- Improvements
 - Use more accurate DMA instance based feature macros.
- New Features
 - Add new APIs EDMA_PrepareTransferTCD and EDMA_SubmitTransferTCD, which support EDMA transfer using TCD.

[2.6.0]

- Improvements
 - Modify the type of parameter channelRequestSource from dma_request_source_t to int32_t in the EDMA_SetChannelMux.

[2.5.3]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 10.3, 10.4, 11.6, 20.7, 12.2, 20.9, 5.3, 10.8, 8.4, 9.3.

[2.5.2]

- Improvements
 - Applied ERRATA 51327.

[2.5.1]

- Bug Fixes
 - Fixed the EDMA_ResetChannel function cannot reset channel DONE/ERROR status.

[2.5.0]

- Improvements
 - Added feature FSL_FEATURE_EDMA_HAS_NO_SBR_ATTR_BIT to separate DMA without ATTR bitfield.
 - Added api EDMA_GetChannelSystemBusInformation to gets the channel identification and attribute information on the system bus interface.
- Bug Fixes
 - Fixed the ESG bit not set in scatter gather mode issue.
 - Fixed the DREQ bit configuration missed in single transfer issue.
 - Cleared the interrupt status before invoke callback to avoid miss interrupt issue.
 - Removed disableRequestAfterMajorLoopComplete from edma_transfer_config_t structure as driver will handle it.
 - Fixed the channel mux configuration not compatible issue.
 - Fixed the out of bound access in function EDMA_DriverIRQHandler.

[2.4.4]

- Bug Fixes
 - Fixed comments by replacing STCD with TCD
 - Fixed the TCD overwrite issue when submit transfer request in the callback if there is a active TCD in hardware.

[2.4.3]

- Improvements
 - Added FSL_FEATURE_MEMORY_HAS_ADDRESS_OFFSET to convert the address between system mapped address and dma quick access address.
- Bug Fixes
 - Fixed the wrong tcd done count calculated in first TCD interrupt for the non scatter gather case.

[2.4.2]

- Bug Fixes
 - Fixed the wrong tcd done count calculated in first TCD interrupt by correct the initial value of the header.
 - Fixed violations of MISRA C-2012 rule 10.3, 10.4.

[2.4.1]

- Bug Fixes
 - Added clear CITER and BITER registers in `EDMA_AbortTransfer` to make sure the TCD registers in a correct state for next calling of `EDMA_SubmitTransfer`.
 - Removed the clear DONE status for ESG not enabled case to avoid DONE bit cleared unexpectedly.

[2.4.0]

- Improvements
 - Added api `EDMA_EnableContinuousChannelLinkMode` to support continuous link mode.
 - Added apis `EDMA_SetMajorOffsetConfig/EDMA_TcdSetMajorOffsetConfig` to support major loop address offset feature.
 - Added api `EDMA_EnableChannelMinorLoopMapping` for minor loop offset feature.
 - Removed the redundant IRQ Handler in edma driver.

[2.3.2]

- Improvements
 - Fixed HIS ccm issue in function `EDMA_PrepareTransferConfig`.
 - Fixed violations of MISRA C-2012 rule 11.6, 10.7, 10.3, 18.1.
- Bug Fixes
 - Added ACTIVE & BITER & CITER bitfields to determine the channel status to fixed the issue of the transfer request cannot submit by function `EDMA_SubmitTransfer` when channel is idle.

[2.3.1]

- Improvements
 - Added source/destination address alignment check.
 - Added driver IRQ handler support for multi DMA instance in one SOC.

[2.3.0]

- Improvements
 - Added new api `EDMA_PrepareTransferConfig` to allow different configurations of width and offset.
- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 10.4, 10.1.

- Fixed the Coverity issue regarding out-of-bounds write.

[2.2.0]

- Improvements
 - Added peripheral-to-peripheral support in EDMA driver.

[2.1.9]

- Bug Fixes
 - Fixed MISRA issue: Rule 10.7 and 10.8 in function `EDMA_DisableChannelInterrupts` and `EDMA_SubmitTransfer`.
 - Fixed MISRA issue: Rule 10.7 in function `EDMA_EnableAsyncRequest`.

[2.1.8]

- Bug Fixes
 - Fixed incorrect channel preemption base address used in `EDMA_SetChannelPreemptionConfig` API which causes incorrect configuration of the channel preemption register.

[2.1.7]

- Bug Fixes
 - Fixed incorrect transfer size setting.
 - * Added 8 bytes transfer configuration and feature for RT series;
 - * Added feature to support 16 bytes transfer for Kinetis.
 - Fixed the issue that `EDMA_HandleIRQ` would go to incorrect branch when TCD was not used and callback function not registered.

[2.1.6]

- Bug Fixes
 - Fixed KW3X MISRA Issue.
 - * Rule 14.4, 10.8, 10.4, 10.7, 10.1, 10.3, 13.5, and 13.2.
- Improvements
 - Cleared the IRQ handler unavailable for specific platform with macro `FSL_FEATURE_EDMA_MODULE_CHANNEL_IRQ_ENTRY_SHARED_OFFSET`.

[2.1.5]

- Improvements
 - Improved EDMA IRQ handler to support half interrupt feature.

[2.1.4]

- Bug Fixes
 - Cleared enabled request, status during EDMA_Init for the case that EDMA is halted before reinitialization.

[2.1.3]

- Bug Fixes
 - Added clear DONE bit in IRQ handler to avoid overwrite TCD issue.
 - Optimized above solution for the case that transfer request occurs in callback.

[2.1.2]

- Improvements
 - Added interface to get next TCD address.
 - Added interface to get the unused TCD number.

[2.1.1]

- Improvements
 - Added documentation for eDMA data flow when scatter/gather is implemented for the EDMA_HandleIRQ API.
 - Updated and corrected some related comments in the EDMA_HandleIRQ API and edma_handle_t struct.

[2.1.0]

- Improvements
 - Changed the EDMA_GetRemainingBytes API into EDMA_GetRemainingMajorLoopCount due to eDMA IP limitation (see API comments/note for further details).

[2.0.5]

- Improvements
 - Added pubweak DriverIRQHandler for K32H844P (16 channels shared).

[2.0.4]

- Improvements
 - Added support for SoCs with multiple eDMA instances.
 - Added pubweak DriverIRQHandler for KL28T DMA1 and MCIMX7U5_M4.

[2.0.3]

- Bug Fixes
 - Fixed the incorrect pubweak IRQHandler name issue, which caused re-definition build errors when client set his/her own IRQHandler, by changing the 32-channel IRQHandler name to DriverIRQHandler.

[2.0.2]

- Bug Fixes
 - Fixed incorrect minorLoopBytes type definition in `_edma_transfer_config` struct, and defined minorLoopBytes as `uint32_t` instead of `uint16_t`.

[2.0.1]

- Bug Fixes
 - Fixed the eDMA callback issue (which did not check valid status) in `EDMA_HandleIRQ` API.

[2.0.0]

- Initial version.
-

ENET**[2.11.0]**

- New Features
 - Added function `ENET_Ptp1588JumpTimer` which adjusts the ENET PTP 1588 timer by jumping a relative time difference. Compared to `ENET_Ptp1588SetTimer`, this function yields more accurate results when the relative time difference between the PTP clock and the target clock is known.

[2.10.1]

- Bug Fixes
 - Fixed WAKEUP interrupt not being handled.

[2.10.0]

- New Features
 - Added function `ENET_Ptp1588GetChannelCaptureValue` to read last captured time from PTP 1588 timer.

[2.9.3]

- Bug Fixes
 - Fixed `ENET_Ptp1588GetTimer` incorrect timestamps when timer wraps occur after nanosecond capture:
 - * Now only increments second field when nanosecond value is less than half a second

[2.9.2]

- Bug Fixes
 - RGMII mode is (temporarily) disabled before selecting between 10/100-Mbit/s and 1000-Mbit/s modes of operation. The bit RGMII_EN of RCR register must not be set while changing ECR register's speed bit, otherwise there is a possibility of ENET IP ending in an incorrect state.

[2.9.1]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 8.4, 10.4.

[2.9.0]

- Bug Fixes
 - Enabled collection of transfer statistics, so the function ENET_GetStatistics does not always return zeroes.
- New Features
 - Added new function ENET_EnableStatistics to enable/disable collection of transfer statistics.
 - Added new function ENET_ResetStatistics to reset transfer statistics.
- Improvements
 - Renamed the function ENET_ResetHareware to ENET_ResetHardware.

[2.8.0]

- New Features
 - Added the function to reset hardware on certain devices.

[2.7.1]

- Bug Fixes
 - Fixed the issue that free wrong buffer address when one frame stores in multiple buffers and memory pool is not enough to allocate these buffers to receive one complete frame.

[2.7.0]

- Improvements
 - Deleted deprecated zero copy Tx/Rx functions and set callback function which can be configured in ENET_Init.
 - Moved the Rx zero copy buffer allocation to Rx BD initialization function to reduce unnecessary looping code.
- Bug Fixes
 - Fixed the issue that predefined Rx buffers which should not be used when enabling Rx zero copy are still be handled by cache operation, it causes hardfault on some platforms.

- Fixed the issue that zero-copy Rx function doesn't check Rx length of 0 in the BD with EMPTY bit is 0, it may occur in the corner case reported by customer. Not sure how it turns out, consider it as an ENET IP issue and drop this abnormal BD.

[2.6.3]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 11.6.

[2.6.2]

- Improvements
 - Changed ENET1_MAC0_Rx_Tx_Done0_DriverIRQHandler/ENET1_MAC0_Rx_Tx_Done1_DriverIRQHandler to ENET1_MAC0_Rx_Tx_Done1_DriverIRQHandler/ENET1_MAC0_Rx_Tx_Done2_DriverIRQHandler which represent ring 1 and ring 2.

[2.6.1]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 10.3, 10.4, 10.7, 11.6, 11.8.

[2.6.0]

- Improvements
 - Added MDIO access wrapper APIs for ease of use.
 - Fixed the build warning introduced by 64-bit compatibility patch.

[2.5.4]

- Improvements
 - Made the driver compatible with 64-bit platforms.

[2.5.3]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 11.6.

[2.5.2]

- Improvements
 - Updated the TXIC/RXIC register handling code according to the new header file.

[2.5.1]

- Bug Fixes
 - Fixed document typo.

[2.5.0]

- Bug Fixes
 - Fixed the SendFrame/SendFrameZeroCopy functions issue with scattered buffers.
 - Updated the formula of MDC calculation.
 - Used a feature macro to distinguish the old IP design from the new design, because old IP design always reads a value zero from ATCR->CAPTURE bit. For old IP, driver calculates and wait the necessary delay cycles after setting ATCR->CAPTURE then gets the timestamp value.
- New Features
 - Added new zero copy Tx/Rx function.
 - New zero copy Tx function combines scattered and contiguous Tx buffer in one API, it also supports more Tx features which buffer descriptor supports but previous Tx function doesn't support.
 - New zero copy Rx function use dynamic buffer mechanism and simpler interface.
- Improvements
 - Corrected the interrupt handler for PTP timestamp IRQ and PTP1588 event IRQ since platform difference.
 - Added missing IRQ handlers for PTP1588 events on some platforms.
 - Corrected the max Tx frame length verification, it will not depend on a fixed macro. The ENET_FRAME_MAX_FRAMELEN is only an default value for driver, application can configure it. Driver calculates the limitation with the max frame length in register which may takes extended 4 or 8 bytes VLAN tag if VLAN/SVLAN enables.
 - Deleted deprecated Clause 45 read/write legacy APIs.

[2.4.3]

- Improvements
 - Aligned the IRQ handler name with header file.

[2.4.2]

- Bug Fixes
 - Fixed the MISRA issue of speculative out-of-bounds access.

[2.4.1]

- Bug Fixes
 - Fixed the PTP time capture issue.

[2.4.0]

- Improvements
 - Exposed API ENET_ReclaimTxDescriptor for user application to reclaim tx descriptors in their application.
 - Added counter to record multicast hash conflict in struct _enet_handle, improved the situation that one multicast group could be left by other conflict multicast address left operation.

- Improved concurrent usage of relaim and send frame operation.

[2.3.4]

- Bug Fixes
 - Fixed the issue that interrupt handler only checks the interrupt event flag but not checks interrupt mask flag.

[2.3.3]

- Bug Fixes
 - Fixed the issue that some compilers may choose the memcpy with 4-bit aligned address limitation due to the type of address pointer is 'unsigned int *', the data address doesn't have to be 4-bit aligned.

[2.3.2]

- New Features
 - Added the feature that ENET driver can be used in the platform which integrates both 10/100M and 1G ENET IP.
 - Deleted duplicated code about ARM errata 838869 in first/second level IRQ handler.

[2.3.1]

- Improvements
 - Added function pointer checking in IRQ handler to make sure code can be used even it runs into the interrupt when the second level interrupt handler is NULL.

[2.3.0]

- Bug Fixes
 - Fixed the issue that clause 45 MDIO read/write API doesn't check the transmission over status between two transmissions.
 - Fixed violations of the MISRA C-2012 rules 2.2,10.3,10.4,10.7,11.6,11.8,13.5,14.4,15.7,17.7.
- New Features
 - Added APIs to support send/receive frame with Zero-Copy.
- Improvements
 - Separated the clock configuration from module configuration when init and deinit.
 - Added functions to set second level interrupt handler.
 - Provided new function to get 1588 timer count without disabling interrupt.
 - Improved timestamp controlling, deleted all old timestamp management APIs and data structures.
 - Merged the single/multiple ring(s) APIs, now these APIs can handle both.
 - Used base and index to control buffer descriptor, aligned with qos and lpc enet driver.

[2.2.6]

- Bug Fixes
 - Updated MII speed formula referring to the manual.

[2.2.5]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 10.1, 10.3, 10.4, 10.6, 10.7, 11.6, 11.9, 13.5, 14.4, 16.4, 17.7, 21.15, 3.1, 8.4.
 - Changed to use `ARRAY_SIZE(s_enetBases)` as the array size for `s_ENETHandle`, fixed the hardfault issue for using some ENET instance when `ARRAY_SIZE(s_enetBases)` is not same as `FSL_FEATURE_SOC_ENET_COUNT`.

[2.2.4]

- Improvements
 - Added call to Data Synchronization Barrier instruction before activating Tx/Rx buffer descriptor to ensure previous data update is completed.
 - Improved `ENET_TransmitIRQHandler` to store timestamps for multiple transmit buffer descriptors.
 - Bug Fixes
 - Fixed the issue that `ENET_Ptp1588GetTimer` did not handle the timer wrap situation.

[2.2.3]

- Improvements
 - Improved data buffer cache maintenance in the ENET driver.

[2.2.2]

- New Features
 - Added APIs for extended multi-ring support.
 - Added the AVB configure API for extended AVB feature support.

[2.2.1]

- Improvements
 - Changed the input data pointer attribute to `const` in `ENET_SendFrame()`.

[2.1.1]

- New Features
 - Added the extended MDIO IEEE802.3 Clause 45 MDIO format SMI command APIs.
 - Added the extended interrupt coalescing feature.
- Improvements
 - Combined all storage operations in the `ENET_Init` to `ENET_SetHandler` API.

[2.0.1]

- Bug Fixes
 - Used direct transmit busy check when doing data transmit.
- Miscellaneous Changes
 - Updated IRQ handler work flow.
 - Changed the TX/RX interrupt macro from kENET_RxByteInterrupt to kENET_RxBufferInterrupt, from kENET_TxByteInterrupt to kENET_TxBufferInterrupt.
 - Deleted unnecessary parameters in ENET handler.

[2.0.0]

- Initial version.
-

ENET_QOS

[2.7.2]

- Bug Fixes
 - Not disabling ENET_QOS_ConfigureRxParser function when compiled for EMAC, as the MTL_RXP_INDIRECT_ACC_DATA register is writeable now.

[2.7.1]

- Bug Fixes
 - Fixed writing after DMA_CH array on platforms with smaller number of channels (EMAC).

[2.7.0]

- New features
 - The driver can work with EMAC IP now. EMAC is similar to ENET_QOS but doesn't support 100 % of its features.

[2.6.5]

- Bug Fixes
 - Fixed ENET_QOS_GetMacAddr address byte order not matching ENET_QOS_SetMacAddr.

[2.6.4]

- Improvements
 - ENET_QOS_SetMII returns success or failure status now (related to i.MX RT1170 errata ERR050539 - ENET_QOS doesn't support RMII 10Mbps mode).
- Bug Fixes
 - Fixed the MISRA C-2012 issue rule 14.3.

[2.6.3]

- Bug Fixes
 - Fixed the issue that ENET_QOS_GetRxFrame, ENET_QOS_ReadFrame and ENET_QOS_DropFrame did not properly restart the receiving once it stopped.

[2.6.2]

- Bug Fixes
 - Fixed the issue that free wrong buffer address when one frame stores in multiple buffers and memory pool is not enough to allocate these buffers to receive one complete frame.

[2.6.1]

- Bug Fixes
 - Fixed the issue that ENET_QOS_ReadFrame doesn't check timestamp available bit before check the context BD bit, it makes software update extra BD. If DMA receives new frame to this BD before software update, software will lose this frame.

[2.6.0]

- New features
 - Added hardware checksum acceleration support.

[2.5.3]

- Bug Fixes
 - Fixed the MISRA issue rule 14.3, 5.3.

[2.5.2]

- Bug Fixes
 - Fixed the issue that ENET_QOS_Init reset the MDIO setting of ENET_QOS_SetSML.

[2.5.1]

- Improvements
 - Supported RMII mode.

[2.5.0]

- Improvements
 - Added MDIO access wrapper APIs for ease of use.

[2.4.1]

- Improvements
 - Supported cache control.
 - Supported BD address conversion to system address.
 - Make driver aarch64 compatible
- Bug Fixes
 - Fixed the issue that driver internal interface ENET_QOS_DropFrame drops all frames in whole BD ring rather than one frame as design. Impact case: 1. Rx drop occurs in zero copy Rx API ENET_QOS_GetRxFrame. 2. Call ENET_QOS_ReadFrame with data pointer is NULL, driver will drop all Rx frames.

[2.4.0]

- New features
 - Added MDIO IEEE802.3 Clause 45 access support.
 - Added get statistics API to get some statistical data in transfer.
 - Added new APIs to support zero copy Rx.
 - Fixed the MISRA issue rule 8.4, 8.6.

[2.3.0]

- Improvements
 - Added counter to record multicast hash conflict in struct _enet_handle, improved the situation that one multicast group could be left by other conflict multicast address left operation.
- Bug Fixes
 - Updated txDirtyRing maintenance in reclaim and send frame process, allow txDirtyRing to be overwritten.
 - Disabled carrier sensing in full duplex mode configuration in ethernet initialization
 - Fixed 1588 sub-second calculate issue.

[2.2.2]

- Bug Fixes
 - Fixed the issue that ENET_QOS_SetupTxDescriptor didn't handle the DMA access address mapping for SoCs have feature FSL_FEATURE_MEMORY_HAS_ADDRESS_OFFSET.
 - Fixed MISRA 2012 violations detected in examples build.

[2.2.1]

- Bug Fixes
 - Fixed MISRA 2012 violations, fixed doxygen warning.
 - Fixed the issue that cache invalidate to invalid converted memory address in ENET_QOS_ReadFrame for SoCs have feature FSL_FEATURE_MEMORY_HAS_ADDRESS_OFFSET.

[2.2.0]

- Removed the ptp time data ring management, below structures and APIs are removed:
 - structure `enet_qos_ptp_time_data_t`
 - structure `enet_qos_ptp_time_data_ring_t`
 - API `ENET_QOS_GetRxFrameTime`
 - API `ENET_QOS_GetTxFrameTime`
- Added API for GCL list read and AVB configuration
 - `ENET_QOS_EstReadGcl`
 - `ENET_QOS_AVBConfigure`
- Improved driver for PTP system time configuration, timestamp read.
- Added IRQ lock and memory barrier instruction for descriptor operation.
- Fixed MISRA 2012 violations

[2.1.1]

- Bug Fixes
 - Fixed the bug that data pointer is not converted to local memory address in the call to `ENET_QOS_Ptp1588ParseFrame`.

[2.1.0]

- New feature
 - Update driver to support feature `FSL_FEATURE_MEMORY_HAS_ADDRESS_OFFSET` which convert buffer address to visible address for DMA.
 - Require user to provide implementation for `ENET_QOS_SetSYSControl` API, which set the PHY interface and enable clock generation for IP.

[2.0.0]

- Initial version.
-

FLEXCAN

[2.14.5]

- Improvements
 - Make API `FLEXCAN_GetFDMailboxOffset` **public**.
 - Add API `FLEXCAN_SetMbID` and `FLEXCAN_SetFDMbID` to configure Message Buffer ID individually.
- Bug Fixes
 - Fixed violations of the CERT INT30-C INT31-C.
 - Fixed violations of the CERT ARR30-C.

[2.14.4]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 8.4, 10.1, 10.4, 18.1.

[2.14.3]

- Improvements
 - Add unhandled interrupt events check for following API:
 - * FLEXCAN_MbHandleIRQ
 - * FLEXCAN_EhancedRxFifoHandleIRQ
- Bug Fixes
 - Remove FLEXCAN_MemoryErrorHandleIRQ on some platform without memory error interrupt.
 - Add conditional compile for CTRL2[ISOCANFDEN] because some platform do not have this bit.

[2.14.2]

- Improvements
 - Add Coverage Justification for uncovered code.
 - Adjust API FLEXCAN_TransferAbortReceive order.
 - Update FLEXCAN_Enable to enter Freeze Mode first when enter Disable mode on some platform.
 - Added while loop timeout for following API:
 - * FLEXCAN_EnterFreezeMode
 - * FLEXCAN_ExitFreezeMode
 - * FLEXCAN_Enable
 - * FLEXCAN_Reset
 - * FLEXCAN_TransferSendBlocking
 - * FLEXCAN_TransferReceiveBlocking
 - * FLEXCAN_TransferFDSendBlocking
 - * FLEXCAN_TransferFDReceiveBlocking
 - * FLEXCAN_TransferReceiveFifoBlocking
 - * FLEXCAN_TransferReceiveEnhancedFifoBlocking
- Bug Fixes
 - Remove remote frame feature in CANFD mode because there is no remote frame in the CANFD format.
 - Remove legacy Rx FIFO disabled branch in FLEXCAN_SubHandlerForLegacyRxFIFO and FLEXCAN_SubHandlerForDataTransferred.

[2.14.1]

- Bug Fixes
 - Fixed register IMASK2-4 IFLAG2-4 HR_TIME_STAMP_n access issue on FlexCAN instances with different number of MBs.
 - Fixed bit field MBDSR1-3 access issue on FlexCAN instances with different number of MBs.
- Improvements
 - Unified following API as same parameter and return value type:
 - * FLEXCAN_GetMbStatusFlags
 - * FLEXCAN_ClearMbStatusFlags
 - * FLEXCAN_EnableMbInterrupts
 - * FLEXCAN_DisableMbInterrupts
 - Add workaround for ERR050443 and ERR052403.
 - Update message buffer read process in API FLEXCAN_ReadRxMb and FLEXCAN_ReadFDRxMb to make critical section as short as possible.
 - Simplify API FLEXCAN_DriverDataIRQHandler implementation by remove parameter type.

[2.14.0]

- Improvements
 - Support external time tick feature.
 - Support high resolution timestamp feature.
 - Enter Freeze Mode first when enter Disable Mode on some platform.
 - Add feature macro for Pretended Networking because some FlexCAN instance do not have this feature.
 - Add feature macro for enhanced Rx FIFO because some FlexCAN instance do not have this feature.
 - Add new FlexCAN IRQ Handler FLEXCAN_DriverDataIRQHandler and FLEXCAN_DriverEventIRQHandler. These IRQ Handlers are used on soc which FlexCAN interrupts are grouped by specific function and assigned to different vector.
 - Update macro FLEXCAN_WAKE_UP_FLAG and FLEXCAN_PNWAKE_UP_FLAG to simplify code.
 - Replace macro FSL_FEATURE_FLEXCAN_HAS_NO_WAKMSK_SUPPORT with FSL_FEATURE_FLEXCAN_HAS_NO_SLFWAK_SUPPORT.
 - Replace macro FSL_FEATURE_FLEXCAN_HAS_NO_WAKSRC_SUPPORT with FSL_FEATURE_FLEXCAN_HAS_GLITCH_FILTER.
- Bug Fixes
 - Fixed wrong interrupt and status flag helper macro in enumeration flexcan_flags and API FLEXCAN_DisableInterrupts.
 - Fixed interrupt flag helper macro typo issue.
 - Remove flags which will be unassociated with interrupt in macro FLEXCAN_MEMORY_ERROR_INT_FLAG.
 - Remove flags which will be unassociated with interrupt in macro FLEXCAN_ERROR_AND_STATUS_INT_FLAG.

- Fixed array out-of-bounds access when read enhanced Rx FIFO.

[2.13.1]

- Improvements
 - Conditionally compile interrupt handling code to solve the problem of using this driver on CPU cores that do not support interrupts.

[2.13.0]

- Improvements
 - Support payload endianness selection feature.

[2.12.0]

- Improvements
 - Support automatic Remote Response feature.
 - Add API FLEXCAN_SetRemoteResponseMbConfig() to configure automatic Remote Response mailbox.

[2.11.8]

- Improvements
 - Synchronize flexcan driver update on s32z platform.

[2.11.7]

- Bug Fixes
 - Fixed FLEXCAN_TransferReceiveEnhancedFifoEDMA() compatibility with edma5.

[2.11.6]

- Bug Fixes
 - Fixed ERRATA_9595 FLEXCAN_EnterFreezeMode() may result to bus fault on some platform.

[2.11.5]

- Bug Fixes
 - Fixed flexcan_memset() crash under high optimization compilation.

[2.11.4]

- Improvements
 - Update CANFD max bitrate to 10Mbps on MCXNx3x and MCXNx4x.
 - Release peripheral from reset if necessary in init function.

[2.11.3]

- Bug Fixes
 - Fixed FLEXCAN_TransferReceiveEnhancedFifoEDMA() compile error with DMA3.

[2.11.2]

- Bug Fixes
 - Fixed bug that timestamp in flexcan_handle_t not updated when RX overflow happens.

[2.11.1]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 10.1.

[2.11.0]

- Bug Fixes
 - Fixed wrong base address argument in FLEXCAN2 IRQ Handler.
- Improvements
 - Add API to determine if the instance supports CAN FD mode at run time.

[2.10.1]

- Bug Fixes
 - Fixed HIS CCM issue.
 - Fixed RTOS issue by adding protection to read-modify-write operations on interrupt enable/disable API.

[2.10.0]

- Improvements
 - Update driver to make it able to support devices which has more than 64 8bytes MBs.
 - Update CAN FD transfer APIs to make them set/get edl bit according to frame content, which can make them compatible with classic CAN.

[2.9.2]

- Bug Fixes
 - Fixed the issue that FLEXCAN_CheckUnhandleInterruptEvents() can't detecting the exist enhanced RX FIFO interrupt status.
 - Fixed the issue that FLEXCAN_ReadPNWakeUpMB() does not return fail even no existing valid wake-up frame.
 - Fixed the issue that FLEXCAN_ReadEnhancedRxFifo() may clear bits other than the data available bit.
 - Fixed violations of the MISRA C-2012 rules 10.4, 10.8.
- Improvements

- Return `kStatus_FLEXCAN_RxFifoDisabled` instead of `kStatus_Fail` when read FIFO fail during IRQ handler.
- Remove unreachable code from timing calculates APIs.
- Update Enhanced Rx FIFO handler to make it deal with underflow/overflow status first.

[2.9.1]

- Bug Fixes
 - Fixed the issue that `FLEXCAN_TransferReceiveEnhancedFifoBlocking()` API clearing Fifo data available flag more than once.
 - Fixed the issue that entering `FLEXCAN_SubHandlerForEnhancedRxFifo()` even if Enhanced Rx fifo interrupts are not enabled.
 - Fixed the issue that `FLEXCAN_TransferReceiveEnhancedFifoEDMA()` update handle even if previous Rx FIFO receive not finished.
 - Fixed the issue that `FLEXCAN_SetEnhancedRxFifoConfig()` not configure the `ER_FCR[NFE]` bits to the correct value.
 - Fixed the issue that `FLEXCAN_ReceiveFifoEDMACallback()` can't differentiate between Rx fifo and enhanced rx fifo.
 - Fixed the issue that `FLEXCAN_TransferHandleIRQ()` can't report Legacy Rx FIFO warning status.

[2.9.0]

- Improvements
- Add public set bit rate API to make driver easier to use.
- Update Legacy Rx FIFO transfer APIs to make it support received multiple frames during one API call.
- Optimized `FLEXCAN_SubHandlerForDataTransferred()` API in interrupt handling to reduce the probability of packet loss.

[2.8.7]

- Improvements
- Initialized the EDMA configuration structure in the FLEXCAN EDMA driver.

[2.8.6]

- Bug Fixes
- Fix Coverity overrun issues in `fsl_flexcan_edma` driver.

[2.8.5]

- Improvements
 - Make driver aarch64 compatible.

[2.8.4]

- Bug Fixes
 - Fixed FlexCan_Errata_6032 to disable all interrupts.

[2.8.3]

- Bug Fixes
 - Fixed an issue with the FLEXCAN_EnableInterrupts and FLEXCAN_DisableInterrupts interrupt enable bits in the CTRL1 register.

[2.8.2]

- Bug Fixes
 - Fixed errors in timing calculations and simplify the calculation process.
 - Fixed issue of CBT and FDCBT register may write failure.

[2.8.1]

- Bug Fixes
 - Fixed the issue of CAN FD three sampling points.
 - Added macro to support the devices that no MCR[SUPV] bit.
 - Remove unnecessary clear WMB operations.

[2.8.0]

- Improvements
 - Update config configuration.
 - * Added enableSupervisorMode member to support enable/disable Supervisor mode.
 - Simplified the algorithm in CAN FD improved timing APIs.

[2.7.1]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 10.3, 10.7.

[2.7.0]

- Improvements
 - Update config configuration.
 - * Added enablePretendededeNetworking member to support enable/disable Pretended Networking feature.
 - * Added enableTransceiverDelayMeasure member to support enable/disable Transceiver Delay MeasurementPretended feature.
 - * Added bitRate/bitRateFD member to work as baudRate/baudRateFD member union.
 - Rename all “baud” in code or comments to “bit” to align with the CAN spec.

- Added Pretended Networking mode related APIs.
 - * FLEXCAN_SetPNConfig
 - * FLEXCAN_GetPNMatchCount
 - * FLEXCAN_ReadPNWakeUpMB
- Added support for Enhanced Rx FIFO.
- Removed independent memory error interrupt/status APIs and put all interrupt/status control operation into FLEXCAN_EnableInterrupts/FLEXCAN_DisableInterrupts and FLEXCAN_GetStatusFlags/FLEXCAN_ClearStatusFlags APIs.
- Update improved timing APIs to make it calculate improved timing according to CiA doc recommended.
 - * FLEXCAN_CalculateImprovedTimingValues.
 - * FLEXCAN_FDCalculateImprovedTimingValues.
- Update FLEXCAN_SetBitRate/FLEXCAN_SetFDBitRate to added the use of enhanced timing registers.

[2.6.2]

- Improvements
 - Add CANFD frame data length enumeration.

[2.6.1]

- Bug Fixes
 - Fixed the issue of not fully initializing memory in FLEXCAN_Reset() API.

[2.6.0]

- Improvements
 - Enable CANFD ISO mode in FLEXCAN_FDInit API.
 - Enable the transceiver delay compensation feature when enable FD operation and set bitrate switch.
 - Implementation memory error control in FLEXCAN_Init API.
 - Improve FLEXCAN_FDCalculateImprovedTimingValues API to get same value for FPRESDIV and PRES DIV.
 - Added memory error configuration for user.
 - * enableMemoryErrorControl
 - * enableNonCorrectableErrorEnterFreeze
 - Added memory error related APIs.
 - * FLEXCAN_GetMemoryErrorReportStatus
 - * FLEXCAN_GetMemoryErrorStatusFlags
 - * FLEXCAN_ClearMemoryErrorStatusFlags
 - * FLEXCAN_EnableMemoryErrorInterrupts
 - * FLEXCAN_DisableMemoryErrorInterrupts
- Bug Fixes

- Fixed the issue of sent duff CAN frame after call FLEXCAN_FDInit() API.

[2.5.2]

- Bug Fixes
 - Fixed the code error issue and simplified the algorithm in improved timing APIs.
 - * The bit field in CTRL1 register couldn't calculate higher ideal SP, we set it as the lowest one(75%)
 - FLEXCAN_CalculateImprovedTimingValues
 - FLEXCAN_FDCalculateImprovedTimingValues
 - Fixed MISRA-C 2012 Rule 17.7 and 14.4.
- Improvements
 - Pass ESRStatus to callback function when kStatus_FLEXCAN_ErrorStatus is coming.

[2.5.1]

- Bug Fixes
 - Fixed the non-divisible case in improved timing APIs.
 - * FLEXCAN_CalculateImprovedTimingValues
 - * FLEXCAN_FDCalculateImprovedTimingValues

[2.5.0]

- Bug Fixes
 - MISRA C-2012 issue check.
 - * Fixed rules, containing: rule-10.1, rule-10.3, rule-10.4, rule-10.7, rule-10.8, rule-11.8, rule-12.2, rule-13.4, rule-14.4, rule-15.5, rule-15.6, rule-15.7, rule-16.4, rule-17.3, rule-5.8, rule-8.3, rule-8.5.
 - Fixed the issue that API FLEXCAN_SetFDRxMbConfig lacks inactive message buff.
 - Fixed the issue of Pa082 warning.
 - Fixed the issue of dead lock in the function of interruption handler.
 - Fixed the issue of Legacy Rx Fifo EDMA transfer data fail in evkmimxrt1060 and evk-mimxrt1064.
 - Fixed the issue of setting CANFD Bit Rate Switch.
 - Fixed the issue of operating unknown pointer risk.
 - * when used the pointer "handle->mbFrameBuf[mbIdx]" to update the timestamp in a short-live TX frame, the frame pointer became as unknown, the action of operating it would result in program stack destroyed.
 - Added assert to check current CAN clock source affected by other clock gates in current device.
 - * In some chips, CAN clock sources could be selected by CCM. But for some clock sources affected by other clock gates, if user insisted on using that clock source, they had to open these gates at the same time. However, they should take into consideration the power consumption issue at system level. In RT10xx chips, CAN clock source 2 was affected by the clock gate of lpuart1. ERRATA ID: (ERR050235 in CCM).

- Improvements

- Implementation for new FLEXCAN with ECC feature able to exit Freeze mode.
- Optimized the function of interruption handler.
- Added two APIs for FLEXCAN EDMA driver.
 - * FLEXCAN_PrepareTransfConfiguration
 - * FLEXCAN_StartTransferDatafromRxFIFO
- Added new API for FLEXCAN driver.
 - * FLEXCAN_GetTimeStamp
 - For TX non-blocking API, we wrote the frame into mailbox only, so no need to register TX frame address to the pointer, and the timestamp could be updated into the new global variable handle->timestamp[mbIdx], the FLEXCAN driver provided a new API for user to get it by handle and index number after TX DONE Success.
 - * FLEXCAN_EnterFreezeMode
 - * FLEXCAN_ExitFreezeMode
- Added new configuration for user.
 - * disableSelfReception
 - * enableListenOnlyMode
- Renamed the two clock source enum macros based on CLKSRC bit field value directly.
 - * The CLKSRC bit value had no property about Oscillator or Peripheral type in lots of devices, it acted as two different clock input source only, but the legacy enum macros name contained such property, that misled user to select incorrect CAN clock source.
- Created two new enum macros for the FLEXCAN driver.
 - * kFLEXCAN_ClkSrc0
 - * kFLEXCAN_ClkSrc1
- Deprecated two legacy enum macros for the FLEXCAN driver.
 - * kFLEXCAN_ClkSrcOsc
 - * kFLEXCAN_ClkSrcPeri
- Changed the process flow for Remote request frame response..
 - * Created a new enum macro for the FLEXCAN driver.
 - kStatus_FLEXCAN_RxRemote
- Changed the process flow for kFLEXCAN_StateRxRemote state in the interrupt handler.
 - * Should the TX frame not register to the pointer of frame handle, interrupt handler would not be able to read the remote response frame from the mail box to ram, so user should read the frame by manual from mail box after a complete remote frame transfer.

[2.4.0]

- Bug Fixes

- MISRA C-2012 issue check.

- * Fixed rules, containing: rule-12.1, rule-17.7, rule-16.4, rule-11.9, rule-8.4, rule-14.4, rule-10.8, rule-10.4, rule-10.3, rule-10.7, rule-10.1, rule-11.6, rule-13.5, rule-11.3, rule-8.3, rule-12.2 and rule-16.1.
- Fixed the issue that CANFD transfer data fail when bus baudrate is 30Khz.
- Fixed the issue that ERR009595 does not follow the ERRATA document.
- Fixed code error for ERR006032 work around solution.
- Fixed the Coverity issue of BAD_SHIFT in FLEXCAN.
- Fixed the Repo build warning issue for variable without initial.
- Improvements
 - Fixed the run fail issue of FlexCAN RemoteRequest UT Case.
 - Implementation all TX and RX transferring Timestamp used in FlexCAN demos.
 - Fixed the issue of UT Test Fail for CANFD payload size changed from 64BperMB to 8PerMB.
 - Implementation for improved timing API by baud rate.

[2.3.2]

- Improvements
 - Implementation for ERR005959.
 - Implementation for ERR005829.
 - Implementation for ERR006032.

[2.3.1]

- Bug Fixes
 - Added correct handle when kStatus_FLEXCAN_TxSwitchToRx is coming.

[2.3.0]

- Improvements
 - Added self-wakeup support for STOP mode in the interrupt handling.

[2.2.3]

- Bug Fixes
 - Fixed the issue of CANFD data phase's bit rate not set as expected.

[2.2.2]

- Improvements
 - Added a time stamp feature and enable it in the interrupt_transfer example.

[2.2.1]

- Improvements
 - Separated CANFD initialization API.
 - In the interrupt handling, fix the issue that the user cannot use the normal CAN API when with an FD.

[2.2.0]

- Improvements
 - Added `FSL_FEATURE_FLEXCAN_HAS_SUPPORT_ENGINE_CLK_SEL_REMOVE` feature to support SoCs without CAN Engine Clock selection in FlexCAN module.
 - Added FlexCAN Serial Clock Operation to support i.MX SoCs.

[2.1.0]

- Bug Fixes
 - Corrected the spelling error in the function name `FLEXCAN_XXX()`.
 - Moved Freeze Enable/Disable setting from `FLEXCAN_Enter/ExitFreezeMode()` to `FLEXCAN_Init()`.
 - Corrected wrong helper macro values.
- Improvements
 - Hid `FLEXCAN_Reset()` from user.
 - Used `NDEBUG` macro to wrap `FLEXCAN_IsMbOccupied()` function instead of `DEBUG` macro.

[2.0.0]

- Initial version.
-

FLEXCAN_EDMA**[2.12.1]**

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 18.1.

[2.12.0]

- Improvements
 - Support high resolution timestamp feature in enhanced Rx FIFO EDMA.
 - Add feature macro for enhanced Rx FIFO because some FlexCAN instance do not have this feature.
- Bug Fixes
 - Fixed array out-of-bounds access when read enhanced Rx FIFO in EDMA.

[2.11.7]

- Refer FLEXCAN driver change log 2.7.0 to 2.11.7
-

FLEXIO

[2.3.0]

- Improvements
 - Supported platforms which don't have DOZE mode control.
 - Added more pin control functions.

[2.2.3]

- Improvements
 - Adapter the FLEXIO driver to platforms which don't have system level interrupt controller, such as NVIC.

[2.2.2]

- Improvements
 - Release peripheral from reset if necessary in init function.

[2.2.1]

- Improvements
 - Added doxygen index parameter comment in FLEXIO_SetClockMode.

[2.2.0]

- New Features
 - Added new APIs to support FlexIO pin register.

[2.1.0]

- Improvements
 - Added API FLEXIO_SetClockMode to set flexio channel counter and source clock.

[2.0.4]

- Bug Fixes
 - Fixed MISRA 8.4 issues.

[2.0.3]

- Bug Fixes
 - Fixed MISRA 10.4 issues.

[2.0.2]

- Improvements
 - Split FLEXIO component which combines all flexio/flexio_uart/flexio_i2c/flexio_i2s drivers into several components: FlexIO component, flexio_uart component, flexio_i2c_master component, and flexio_i2s component.
- Bug Fixes
 - Fixed MISRA issues
 - * Fixed rules 10.1, 10.3, 10.4, 10.7, 11.6, 11.9, 14.4, 17.7.

[2.0.1]

- Bug Fixes
 - Fixed the dozen mode configuration error in FLEXIO_Init API. For enableInDoze = true, the configuration should be 0; for enableInDoze = false, the configuration should be 1.
-

FLEXIO_I2C**[2.6.2]**

- Improvements
 - Added timeout for while loop in FLEXIO_I2C_MasterTransferBlocking().
- Bug Fixes
 - Fixed build issues related to I2C_RETRY_TIMES.

[2.6.1]

- Bug Fixes
 - Fixed coverity issues

[2.6.0]

- Improvements
 - Supported platforms which don't have DOZE mode control.

[2.5.1]

- Improvements
 - Conditionally compile interrupt handling code to solve the problem of using this driver on CPU cores that do not support interrupts.

[2.5.0]

- Improvements
 - Split some functions, fixed CCM problem in file fsl_flexio_i2c_master.c.

[2.4.0]

- Improvements
 - Added delay of 1 clock cycle in FLEXIO_I2C_MasterTransferRunStateMachine to ensure that bus would be idle before next transfer if master is nacked.
 - Fixed issue that the restart setup time is less than the time in I2C spec by adding delay of 1 clock cycle before restart signal.

[2.3.0]

- Improvements
 - Used 3 timers instead of 2 to support transfer which is more than 14 bytes in single transfer.
 - Improved FLEXIO_I2C_MasterTransferGetCount so that the API can check whether the transfer is still in progress.
- Bug Fixes
 - Fixed MISRA 10.4 issues.

[2.2.0]

- New Features
 - Added timeout mechanism when waiting certain state in transfer API.
 - Added an API for checking bus pin status.
- Bug Fixes
 - Fixed COVERITY issue of useless call in FLEXIO_I2C_MasterTransferRunStateMachine.
 - Fixed MISRA issues
 - * Fixed rules 10.1, 10.3, 10.4, 10.7, 11.6, 11.9, 14.4, 17.7.
 - Added codes in FLEXIO_I2C_MasterTransferCreateHandle to clear pending NVIC IRQ, disable internal IRQs before enabling NVIC IRQ.
 - Modified code so that during master's nonblocking transfer the start and slave address are sent after interrupts being enabled, in order to avoid potential issue of sending the start and slave address twice.

[2.1.7]

- Bug Fixes
 - Fixed the issue that FLEXIO_I2C_MasterTransferBlocking did not wait for STOP bit sent.
 - Fixed COVERITY issue of useless call in FLEXIO_I2C_MasterTransferRunStateMachine.
 - Fixed the issue that I2C master did not check whether bus was busy before transfer.

[2.1.6]

- Bug Fixes
 - Fixed the issue that I2C Master transfer APIs(blocking/non-blocking) did not support the situation of master transfer with subaddress and transfer data size being zero, which means no data followed the subaddress.

[2.1.5]

- Improvements
 - Unified component full name to FLEXIO I2C Driver.

[2.1.4]

- Bug Fixes
 - The following modifications support FlexIO using multiple instances:
 - * Removed FLEXIO_Reset API in module Init APIs.
 - * Updated module Deinit APIs to reset the shifter/timer config instead of disabling module/clock.
 - * Updated module Enable APIs to only support enable operation.

[2.1.3]

- Improvements
 - Changed the prototype of FLEXIO_I2C_MasterInit to return kStatus_Success if initialized successfully or to return kStatus_InvalidArgument if “(srcClock_Hz / masterConfig->baudRate_Bps) / 2 - 1” exceeds 0xFFU.

[2.1.2]

- Bug Fixes
 - Fixed the FLEXIO I2C issue where the master could not receive data from I2C slave in high baudrate.
 - Fixed the FLEXIO I2C issue where the master could not receive NAK when master sent non-existent addr.
 - Fixed the FLEXIO I2C issue where the master could not get transfer count successfully.
 - Fixed the FLEXIO I2C issue where the master could not receive data successfully when sending data first.
 - Fixed the Dozen mode configuration error in FLEXIO_I2C_MasterInit API. For enableInDoze = true, the configuration should be 0; for enableInDoze = false, the configuration should be 1.
 - Fixed the issue that FLEXIO_I2C_MasterTransferBlocking API called FLEXIO_I2C_MasterTransferCreateHandle, which lead to the s_flexioHandle/s_flexioIsr/s_flexioType variable being written. Then, if calling FLEXIO_I2C_MasterTransferBlocking API multiple times, the s_flexioHandle/s_flexioIsr/s_flexioType variable would not be written any more due to it being out of range. This lead to the following situation: NonBlocking transfer APIs could not work due to the fail of register IRQ.

[2.1.1]

- Bug Fixes
 - Implemented the FLEXIO_I2C_MasterTransferBlocking API which is defined in header file but has no implementation in the C file.

[2.1.0]

- New Features
 - Added Transfer prefix in transactional APIs.
 - Added transferSize in handle structure to record the transfer size.
-

FLEXIO_I2S

[2.2.2]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 12.4.

[2.2.1]

- Improvements
 - Conditionally compile interrupt handling code to solve the problem of using this driver on CPU cores that do not support interrupts.

[2.2.0]

- New Features
 - Added timeout mechanism when waiting certain state in transfer API.
- Bug Fixes
 - Fixed IAR Pa082 warnings.
 - Fixed violations of the MISRA C-2012 rules 10.4, 14.4, 11.8, 11.9, 10.1, 17.7, 11.6, 10.3, 10.7.

[2.1.6]

- Bug Fixes
 - Added reset flexio before flexio i2s init to make sure flexio status is normal.

[2.1.5]

- Bug Fixes
 - Fixed the issue that I2S driver used hard code for bitwidth setting.

[2.1.4]

- Improvements
 - Unified component's full name to FLEXIO I2S (DMA/EDMA) driver.

[2.1.3]

- Bug Fixes
 - The following modifications support FLEXIO using multiple instances:
 - * Removed FLEXIO_Reset API in module Init APIs.
 - * Updated module Deinit APIs to reset the shifter/timer config instead of disabling module/clock.
 - * Updated module Enable APIs to only support enable operation.

[2.1.2]

- New Features
 - Added configure items for all pin polarity and data valid polarity.
 - Added default configure for pin polarity and data valid polarity.

[2.1.1]

- Bug Fixes
 - Fixed FlexIO I2S RX data read error and eDMA address error.
 - Fixed FlexIO I2S slave timer compare setting error.

[2.1.0]

- New Features
 - Added Transfer prefix in transactional APIs.
 - Added transferSize in handle structure to record the transfer size.
-

FLEXIO_I2S_EDMA**[2.1.9]**

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 12.4.

[2.1.8]

- Improvements
 - Applied EDMA ERRATA 51327.
-

FLEXIO_SPI**[2.4.3]**

- Improvements
 - Make SPI_RETRY_TIMES configurable by CONFIG_SPI_RETRY_TIMES.

[2.4.2]

- Bug Fixes
 - Fixed FLEXIO_SPI_MasterTransferBlocking and FLEXIO_SPI_MasterTransferNonBlocking issue in CS continuous mode, the CS might not be continuous.

[2.4.1]

- Bug Fixes
 - Fixed coverity issues

[2.4.0]

- Improvements
 - Supported platforms which don't have DOZE mode control.

[2.3.5]

- Improvements
 - Conditionally compile interrupt handling code to solve the problem of using this driver on CPU cores that do not support interrupts.

[2.3.4]

- Bug Fixes
 - Fixed the txData from void * to const void * in transmit API

[2.3.3]

- Bugfixes
 - Fixed cs-continuous mode.

[2.3.2]

- Improvements
 - Changed FLEXIO_SPI_DUMMYDATA to 0x00.

[2.3.1]

- Bugfixes
 - Fixed IRQ SHIFTBUF overrun issue when one FLEXIO instance used as multiple SPIs.

[2.3.0]

- New Features
 - Supported FLEXIO_SPI slave transfer with continuous master CS signal and CPHA=0.
 - Supported FLEXIO_SPI master transfer with continuous CS signal.
 - Support 32 bit transfer width.
- Bug Fixes

- Fixed wrong timer compare configuration for dma/edma transfer.
- Fixed wrong byte order of rx data if transfer width is 16 bit, since the we use shifter buffer bit swapped/byte swapped register to read in received data, so the high byte should be read from the high bits of the register when MSB.

[2.2.1]

- Bug Fixes
 - Fixed bug in FLEXIO_SPI_MasterTransferAbortEDMA that when aborting EDMA transfer EDMA_AbortTransfer should be used rather than EDMA_StopTransfer.

[2.2.0]

- Improvements
 - Added timeout mechanism when waiting certain states in transfer driver.
- Bug Fixes
 - Fixed MISRA 10.4 issues.
 - Added codes in FLEXIO_SPI_MasterTransferCreateHandle and FLEXIO_SPI_SlaveTransferCreateHandle to clear pending NVIC IRQ before enabling NVIC IRQ, to fix issue of pending IRQ interfering the on-going process.

[2.1.3]

- Improvements
 - Unified component full name to FLEXIO SPI(DMA/EDMA) Driver.
- Bug Fixes
 - Fixed MISRA issues
 - * Fixed rules 10.1, 10.3, 10.4, 10.7, 11.6, 11.9, 14.4, 17.7.

[2.1.2]

- Bug Fixes
 - The following modification support FlexIO using multiple instances:
 - * Removed FLEXIO_Reset API in module Init APIs.
 - * Updated module Deinit APIs to reset the shifter/timer config instead of disabling module/clock.
 - * Updated module Enable APIs to only support enable operation.

[2.1.1]

- Bug Fixes
 - Fixed bug where FLEXIO SPI transfer data is in 16 bit per frame mode with eDMA.
 - Fixed bug when FLEXIO SPI works in eDMA and interrupt mode with 16-bit per frame and Lsbfirst.
 - Fixed the Dozen mode configuration error in FLEXIO_SPI_MasterInit/FLEXIO_SPI_SlaveInit API. For enableInDoze = true, the configuration should be 0; for enableInDoze = false, the configuration should be 1.

- Improvements
 - Added `#ifndef/#endif` to allow users to change the default TX value at compile time.

[2.1.0]

- New Features
 - Added Transfer prefix in transactional APIs.
 - Added `transferSize` in handle structure to record the transfer size.
 - Bug Fixes
 - Fixed the error register address return for 16-bit data write in `FLEXIO_SPI_GetTxDataRegisterAddress`.
 - Provided independent `IRQHandler`/transfer APIs for Master and slave to fix the baudrate limit issue.
-

FLEXIO_UART

[2.6.4]

- Improvements
 - Make `UART_RETRY_TIMES` configurable by `CONFIG_UART_RETRY_TIMES`.

[2.6.3]

- Bug Fixes
 - Fixed coverity issues

[2.6.2]

- Bug Fixes
 - Fixed coverity issues

[2.6.1]

- Improvements
 - Improve baudrate calculation method, to support higher frequency FlexIO clock source.

[2.6.0]

- Improvements
 - Supported platforms which don't have DOZE mode control.

[2.5.1]

- Improvements
 - Conditionally compile interrupt handling code to solve the problem of using this driver on CPU cores that do not support interrupts.

[2.5.0]

- Improvements
 - Added API FLEXIO_UART_FlushShifters to flush UART fifo.

[2.4.0]

- Improvements
 - Use separate data for TX and RX in flexio_uart_transfer_t.
- Bug Fixes
 - Fixed bug that when ring buffer is used, if some data is received in ring buffer first before calling FLEXIO_UART_TransferReceiveNonBlocking, the received data count returned by FLEXIO_UART_TransferGetReceiveCount is wrong.

[2.3.0]

- Improvements
 - Added check for baud rate's accuracy that returns kStatus_FLEXIO_UART_BaudrateNotSupport when the best achieved baud rate is not within 3% error of configured baud rate.
- Bug Fixes
 - Added codes in FLEXIO_UART_TransferCreateHandle to clear pending NVIC IRQ before enabling NVIC IRQ, to fix issue of pending IRQ interfering the on-going process.

[2.2.0]

- Improvements
 - Added timeout mechanism when waiting for certain states in transfer driver.
- Bug Fixes
 - Fixed MISRA 10.4 issues.

[2.1.6]

- Bug Fixes
 - Fixed IAR Pa082 warnings.
 - Fixed MISRA issues
 - * Fixed rules 10.1, 10.3, 10.4, 10.7, 11.6, 11.9, 14.4, 17.7.

[2.1.5]

- Improvements
 - Triggered user callback after all the data in ringbuffer were received in FLEXIO_UART_TransferReceiveNonBlocking.

[2.1.4]

- Improvements
 - Unified component full name to FLEXIO UART(DMA/EDMA) Driver.

[2.1.3]

- Bug Fixes
 - The following modifications support FLEXIO using multiple instances:
 - * Removed FLEXIO_Reset API in module Init APIs.
 - * Updated module Deinit APIs to reset the shifter/timer configuration instead of disabling module and clock.
 - * Updated module Enable APIs to only support enable operation.

[2.1.2]

- Bug Fixes
 - Fixed the transfer count calculation issue in FLEXIO_UART_TransferGetReceiveCount, FLEXIO_UART_TransferGetSendCount, FLEXIO_UART_TransferGetReceiveCountDMA, FLEXIO_UART_TransferGetSendCountDMA, FLEXIO_UART_TransferGetReceiveCountEDMA and FLEXIO_UART_TransferGetSendCountEDMA.
 - Fixed the Dozen mode configuration error in FLEXIO_UART_Init API. For enableInDoze = true, the configuration should be 0; for enableInDoze = false, the configuration should be 1.
 - Added code to report errors if the user sets a too-low-baudrate which FLEXIO cannot reach.
 - Disabled FLEXIO_UART receive interrupt instead of all NVICs when reading data from ring buffer. If ring buffer is used, receive nonblocking will disable all NVIC interrupts to protect the ring buffer. This had negative effects on other IPs using interrupt.

[2.1.1]

- Bug Fixes
 - Changed the API name FLEXIO_UART_StopRingBuffer to FLEXIO_UART_TransferStopRingBuffer to align with the definition in C file.

[2.1.0]

- New Features
 - Added Transfer prefix in transactional APIs.
 - Added txSize/rxSize in handle structure to record the transfer size.
- Bug Fixes
 - Added an error handle to handle the situation that data count is zero or data buffer is NULL.

FLEXIO_UART_EDMA

[2.3.1]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules.

[2.3.0]

- Refer FLEXIO_UART driver change log to 2.3.0
-

FLEXSPI

[2.8.1]

- Improvements
 - Updated the LUT configuration parameter checking with flexible way to adapt different Socs.

[2.8.0]

- Bug Fixes
 - Introduced the **disableAhbReadResume** field in the flexspi_config_t structure to provide control over the AHBCR[RESUMEDISABLE] register bit.
 - Implemented a workaround for hardware erratum ERR052733 by setting the default value of **disableAhbReadResume** to **true**.
 - Fixed issue in FLEXSPI_TransferHandleIRQ where the transfer completion was incorrectly signaled despite pending read/write operations.
- New Features
 - Introduced a new function(FLEXSPI_UpdateAhbBuffersSettings) that allows users to update the AHB buffer configuration after the FLEXSPI module has been initialized

[2.7.0]

- New Features
 - Added new API to support address remapping.

[2.6.4]

- Improvements
 - Added new macro “FSL_SDK_ENABLE_FLEXSPI_RESET_CONTROL” to support driver level reset control.

[2.6.3]

- Bug Fixes
 - Fixed an issue which cause IPCR1[IPAREN] cleared by mistake.

[2.6.2]

- Bug Fixes
 - Wait Bus IDLE before operation of FLEXSPI_SoftwareReset(), FLEXSPI_TransferBlocking() and FLEXSPI_TransferNonBlocking().

[2.6.1]

- Bug Fixes
 - Updated code of reset peripheral.
 - Updated FLEXSPI_UpdateLUT() to check if input lut address is not in Flexspi AMBA region.
 - Updated FLEXSPI_Init() to check if input AHB buffer size exceeded maximum AHB size.

[2.6.0]

- New Features
 - Added new API to set AHB memory-mapped flash base address.
 - Added support of DLLxCR[REFPHASEGAP] bit field, it is recommended to set it as 0x2 if DLL calibration is enabled.

[2.5.1]

- Bugfixes
 - Fixed handling of W1C bits in the INTR register
 - Removed FIFO resets from FLEXSPI_CheckAndClearError
 - FLEXSPI_TransferBlocking is observing IPCMDDONE and then fetches the final status of the transfer
 - Fixed issue that FLEXSPI2_DriverIRQHandler not defined.

[2.5.0]

- Improvements
 - Supported word un-aligned access for write/read blocking/non-blocking API functions.
 - Fixed dead loop issue in DLL update function when using FRO clock source.
 - Fixed violations of the MISRA C-2012 Rule 10.3.

[2.4.0]

- Improvements
 - Isolated IP command parallel mode and AHB command parallel mode using feature MACRO.
 - Supported new column address shift feature for external memory.

[2.3.5]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 Rule 14.2.

[2.3.4]

- Bug Fixes
 - Updated flexspi_config_t structure and FlexSPI_Init to support new feature FSL_FEATURE_FLEXSPI_HAS_NO_MCR0_CONBINATION.

[2.3.3]

- Bug Fixes
 - Removed feature `FSL_FEATURE_FLEXSPI_DQS_DELAY_PS` for DLL delay setting. Changed to use feature `FSL_FEATURE_FLEXSPI_DQS_DELAY_MIN` to set slave delay target as 0 for DLL enable and clock frequency higher than 100MHz.

[2.3.2]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 Rule 8.4, 8.5, 10.1, 10.3, 10.4, 11.6 and 14.4.

[2.3.1]

- Bug Fixes
 - Wait for bus to be idle before using it as access to external flash with new setting in `FLEXSPI_SetFlashConfig()` API.
 - Fixed the potential buffer overread and Tx FIFO overwrite issue in `FLEXSPI_WriteBlocking`.

[2.3.0]

- New Features
 - Added new API `FLEXSPI_UpdateDllValue` for users to update DLL value after updating flexspi root clock.
 - Corrected grammatical issues for comments.
 - Added support for new feature `FSL_FEATURE_FLEXSPI_DQS_DELAY_PS` in DLL configuration.

[2.2.2]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 Rule 10.1, 10.3 and 10.4.
 - Updated `_flexspi_command` from named enumerator into anonymous enumerator.

[2.2.1]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 Rule 10.1, 10.3, 10.4, 10.8, 11.9, 14.4, 15.7, 16.4, 17.7, 7.3.
 - Fixed IAR build warning Pe167.
 - Fixed the potential buffer overwrite and Rx FIFO overread issue in `FLEXSPI_ReadBlocking`.

[2.2.0]

- Bug Fixes
 - Fixed flag name typos: kFLEXSPI_IpTxFifoWatermarkEmpltyFlag to kFLEXSPI_IpTxFifoWatermarkEmptyFlag; kFLEXSPI_IpCommandExcutionDoneFlag to kFLEXSPI_IpCommandExecutionDoneFlag.
 - Fixed comments typos such as sequencen->sequence, levle->level.
 - Fixed FLSHCR2[ARDSEQID] field clean issue.
 - Updated flexspi_config_t structure and FlexSPI_Init to support new feature FSL_FEATURE_FLEXSPI_HAS_NO_MCR0_ATDFEN and FSL_FEATURE_FLEXSPI_HAS_NO_MCR0_ARDFEN.
 - Updated flexspi_flags_t structure to support new feature FSL_FEATURE_FLEXSPI_HAS_INTEN_AHBBUSERROREN.

[2.1.1]

- Improvements
 - Defaulted enable prefetch for AHB RX buffer configuration in FLEXSPI_GetDefaultConfig, which is align with the reset value in AHBRXBUFxCR0.
 - Added software workaround for ERR011377 in FLEXSPI_SetFlashConfig; added some delay after DLL lock status set to ensure correct data read/write.

[2.1.0]

- New Features
 - Added new API FLEXSPI_UpdateRxSampleClock for users to update read sample clock source after initialization.
 - Added reset peripheral operation in FLEXSPI_Init if required.

[2.0.5]

- Bug Fixes
 - Fixed FLEXSPI_UpdateLUT cannot do partial update issue.

[2.0.4]

- Bug Fixes
 - Reset flash size to zero for all ports in FLEXSPI_Init; fixed the possible out-of-range flash access with no error reported.

[2.0.3]

- Bug Fixes
 - Fixed AHB receive buffer size configuration issue. The FLEXSPI_AHBRXBUFCR0_BUFSZ field should configure 64 bits size, and currently the AHB receive buffer size is in bytes which means 8-bit, so the correct configuration should be config->ahbConfig.buffer[i].bufferSize / 8.

[2.0.2]

- New Features
 - Supported DQS write mask enable/disable feature during set FLEXSPI configuration.
 - Provided new API FLEXSPI_TransferUpdateSizeEDMA for users to update eDMA transfer size(SSIZE/DSIZE) per DMA transfer.
- Bug Fixes
 - Fixed invalid operation of FLEXSPI_Init to enable AHB bus Read Access to IP RX FIFO.
 - Fixed incorrect operation of FLEXSPI_Init to configure IP TX FIFO watermark.

[2.0.1]

- Bug Fixes
 - Fixed the flag clear issue and AHB read Command index configuration issue in FLEXSPI_SetFlashConfig.
 - Updated FLEXSPI_UpdateLUT function to update LUT table from any index instead of previous command index.
 - Added bus idle wait in FLEXSPI_SetFlashConfig and FLEXSPI_UpdateLUT to ensure bus is idle before any change to FlexSPI controller.
 - Updated interrupt API FLEXSPI_TransferNonBlocking and interrupt handle flow FLEXSPI_TransferHandleIRQ.
 - Updated eDMA API FLEXSPI_TransferEDMA.

[2.0.0]

- Initial version.
-

FLEXSPI EDMA Driver**[2.3.3]**

- Bug Fixes
 - Fixed FLEXSPI_TransferEDMA bug that, the DMA channel not configured correctly when using kFLEXSPI_Read.

[2.3.2]

- Bug Fixes
 - Fixed the bug that internal variable s_edmaPrivateHandle overflows when using FlexSPI2.

[2.0.2]

- New Features
 - Provided new API FLEXSPI_TransferUpdateSizeEDMA for users to update eDMA transfer size(SSIZE/DSIZE) per DMA transfer.

[2.0.0]

- Initial version.
-

I3C

[2.14.3]

- Improvements
 - Fixed Coverity CERT-C violations.
 - Used I3C_RSTS instead of I3C special feature macro.
 - Adapted the driver to support new platform.

[2.14.2]

- Improvements
 - Added timeout for ENTDAAs process API.
 - Added build system macro to control the timeout setting.

[2.14.1]

- Improvements
 - Split the function I3C_MasterTransferBlocking to meet the HIS-CCM requirement.

[2.14.0]

- Improvements
 - Added the choice to set fast start header with push-pull speed when all targets addresses have MSB 0 instead of forcing to set it.
 - Deleted duplicated busy check in I3C_MasterStart function.

[2.13.1]

- Bug Fixes
 - Disabled Rx auto-termination in repeated start interrupt event while transfer API doesn't enable it.
 - Waited the completion event after loading all Tx data in Tx FIFO.
- Improvements
 - Conditionally compile interrupt handling code to solve the problem of using this driver on CPU cores that do not support interrupts.

[2.13.0]

- New features
 - Added the hot-join support for I3C bus initialization API.
- Bug Fixes
 - Set read termination with START at the same time in case unknown issue.
 - Set MCTRL[TYPE] as 0 for DDR force exit.
- Improvements
 - Added the API to reset device count assigned by ENTDAAs.
 - Provided the method to set global macro I3C_MAX_DEVCNT to determine how many device addresses ENTDAAs can allocate at one time.
 - Initialized target management static array based on instance number for the case that multiple instances are used at the same time.

[2.12.0]

- Improvements
 - Added the slow clock parameter for Controller initialization function to calculate accurate timeout.
- Bug Fixes
 - Fixed the issue that BAMATCH field can't be 0. BAMATCH should be 1 for 1MHz slow clock.

[2.11.1]

- Bug Fixes
 - Fixed the issue that interrupt API transmits extra byte when subaddress and data size are null.
 - Fixed the slow clock calculation issue.

[2.11.0]

- New features
 - Added the START/ReSTART SCL delay setting for the Soc which supports this feature.
- Bug Fixes
 - Fixed the issue that ENTDAAs process waits Rx pending flag which causes problem when Rx watermark isn't 0. Just check the Rx FIFO count.

[2.10.8]

- Improvements
 - Support more instances.

[2.10.7]

- Improvements
 - Fixed the potential compile warning.

[2.10.6]

- New features
 - Added the I3C private read/write with 0x7E address as start.

[2.10.5]

- New features
 - Added I3C HDR-DDR transfer support.

[2.10.4]

- Improvements
 - Added one more option for master to not set RDTERM when doing I3C Common Command Code transfer.

[2.10.3]

- Improvements
 - Masked the slave IBI/MR/HJ request functions with feature macro.

[2.10.2]

- Bug Fixes
 - Added workaround for errata ERR051617: I3C working with I2C mode creates the unintended Repeated START before actual STOP on some platforms.

[2.10.1]

- Bug Fixes
 - Fixed the issue that DAA function doesn't wait until all Rx data is read out from FIFO after master control done flag is set.
 - Fixed the issue that DAA function could return directly although the disabled interrupts are not enabled back.

[2.10.0]

- New features
 - Added I3C extended IBI data support.

[2.9.0]

- Improvements
 - Added adaptive termination for master blocking transfer. Set termination with start signal when receiving bytes less than 256.

[2.8.2]

- Improvements
 - Fixed the build warning due to armgcc strict check.

[2.8.1]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 17.7.

[2.8.0]

- Improvements
 - Added API `I3C_MasterProcessDAASpecifiedBaudrate` for temporary baud rate adjustment when I3C master assigns dynamic address.

[2.7.1]

- Bug Fixes
 - Fixed the issue that I3C slave handle STOP event before finishing data transmission.

[2.7.0]

- Fixed the CCM problem in file `fsl_i3c.c`.
- Fixed the `FSL_FEATURE_I3C_HAS_NO_SCONFIG_IDRAND` usage issue in `I3C_GetDefaultConfig` and `I3C_Init`.

[2.6.0]

- Fixed the `FSL_FEATURE_I3C_HAS_NO_SCONFIG_IDRAND` usage issue in `fsl_i3c.h`.
- Changed some static functions in `fsl_i3c.c` as non-static and define the functions in `fsl_i3c.h` to make I3C DMA driver reuse:
 - `I3C_GetIBIType`
 - `I3C_GetIBIAddress`
 - `I3C_SlaveCheckAndClearError`
- Changed the handle pointer parameter in IRQ related functions to void * type to make it reuse in I3C DMA driver.
- Added new API `I3C_SlaveRequestIBIWithSingleData` for slave to request single data byte, this API could be used regardless slave is working in non-blocking interrupt or non-blocking dma.
- Added new API `I3C_MasterGetDeviceListAfterDAA` for master application to get the device information list built up in DAA process.

[2.5.4]

- Improved I3C driver to avoid setting state twice in the `SendCommandState` of `I3C_RunTransferStateMachine`.
- Fixed MISRA violation of rule 20.9.
- Fixed the issue that `I3C_MasterEmitRequest` did not use Type I3C SDR.

[2.5.3]

- Updated driver for new feature `FSL_FEATURE_I3C_HAS_NO_SCONFIG_BAMATCH` and `FSL_FEATURE_I3C_HAS_NO_SCONFIG_IDRAND`.

[2.5.2]

- Updated driver for new feature FSL_FEATURE_I3C_HAS_NO_MERRWARN_TERM.
- Fixed the issue that call to I3C_MasterTransferBlocking API did not generate STOP signal when NAK status was returned.

[2.5.1]

- Improved the receive terminate size setting for interrupt transfer read, now it's set at beginning of transfer if the receive size is less than 256 bytes.

[2.5.0]

- Added new API I3C_MasterRepeatedStartWithRxSize to send repeated start signal with receive terminate size specified.
- Fixed the status used in I3C_RunTransferStateMachine, changed to use pending interrupts as status to be handled in the state machine.
- Fixed MISRA 2012 violation of rule 10.3, 10.7.

[2.4.0]

- Bug Fixes
 - Fixed kI3C_SlaveMatchedFlag interrupt is not properly handled in I3C_SlaveTransferHandleIRQ when it comes together with interrupt kI3C_SlaveBusStartFlag.
 - Fixed the inaccurate I2C baudrate calculation in I3C_MasterSetBaudRate.
 - Added new API I3C_MasterGetIBIRules to get registered IBI rules.
 - Added new variable isReadTerm in struct i3c_master_handle for transfer state routine to check if MCTRL.RDTERM is configured for read transfer.
 - Changed to emit Auto IBI in transfer state routine for slave start flag assertion.
 - Fixed the slave maxWriteLength and maxReadLength does not be configured into SMAXLIMITS register issue.
 - Fixed incorrect state for IBI in I3C master interrupt transfer IRQ handle routine.
 - Added isHotJoin in i3c_slave_config_t to request hot-join event during slave init.

[2.3.2]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 8.4, 17.7.
 - Fixed incorrect HotJoin event index in I3C_GetIBIType.

[2.3.1]

- Bug Fixes
 - Fixed the issue that call of I3C_MasterTransferBlocking/I3C_MasterTransferNonBlocking fails for the case which receive length 1 byte of data.
 - Fixed the issue that STOP signal is not sent when NAK status is detected during execution of I3C_MasterTransferBlocking function.

[2.3.0]

- Improvements
 - Added I3C common driver APIs to initialize I3C with both master and slave configuration.
 - Updated I3C master transfer callback to function set structure to include callback invoke for IBI event and slave2master event.
 - Updated I3C master non-blocking transfer model and always enable the interrupts to be able to re-act to the slave start event and handle slave IBI.

[2.2.0]

- Bug Fixes
 - Fixed the issue that I3C transfer size limit to 255 bytes.

[2.1.2]

- Bug Fixes
 - Reset default hkeep value to kI3C_MasterHighKeeperNone in I3C_MasterGetDefaultConfig

[2.1.1]

- Bug Fixes
 - Fixed incorrect FIFO reset operation in I3C Master Transfer APIs.
 - Fixed i3c slave IRQ handler issue, slave transmit could be underrun because tx FIFO is not filled in time right after start flag detected.

[2.1.0]

- Added definitions and APIs for I3C slave functionality, updated previous I3C APIs to support I3C functionality.

[2.0.0]

- Initial version.
-

I3C_EDMA**[2.2.12]**

- Bug Fixes
 - Fixed the issue that EDMA transfer configuration use wrong parameter.

[2.2.11]

- Improvements
 - Fixed Coverity CERT-C violations.

[2.2.10]

- Bug Fixes
 - Fixed the issue that slave start event is cleared when it has not been handled.
- Added
 - Supported I3C HDR-DDR transfer with EDMA.
- Changed
 - Used linked EDMA to transfer all I3C subaddress and data without handling of intermediate states, simplifying code logic.
 - Prepare DMA before I3C START to ensure there's no time delay between START and transmitting data.
 - Added the MCTRLDONE flag check after START and STOP request to ensure all states are handled properly.

[2.2.9]

- Bug Fixes
 - Fixed MISRA issue rule 11.3.
 - Added the master control done flag waiting code after STOP in case the bus is not idle when transfer function finishes.

[2.2.8]

- Improvements
 - Removed I3C IRQ handler calling in the EDMA callback. Previously driver doesn't use the END byte which can trigger the STOP interrupt for controller sending and receiving, now let I3C event handler deal with all I3C events.
- Bug Fixes
 - Fixed the bug that the END type Tx register is not used when command length or data length is one byte.

[2.2.7]

- Bug Fixes
 - Fixed MISRA issue rule 11.6.

[2.2.6]

- New features
 - Added the I3C private read/write with 0x7E address as start.

[2.2.5]

- Improvements
 - Added the workaround for RT1180 I3C EDMA issue ERR052086.

[2.2.4]

- Bug Fixes
 - Fixed the issue that I3C master sends the last byte data without using the END type register.

[2.2.3]

- Bug Fixes
 - Fixed issue that slave pollutes the last byte when Tx FIFO may be full.

[2.2.2]

- Bug Fixes
 - Fixed I3C MISRA issue rule 10.4, 11.3.

[2.2.1]

- Bug Fixes
 - Fixed the issue that I3C slave send the last byte data without using the END type register.
- Improvements
 - There's no need to reserve two bytes FIFO for DMA transfer which is for IP issue workaround.

[2.2.0]

- Improvements
 - Deleted legacy IBI data request code.

[2.1.0]

- Bug Fixes
 - Fixed MISRA issue rule 8.4, 8.6, 11.8.

[2.0.1]

- Bug Fixes
 - Fixed MISRA issue rule 9.1.

[2.0.0]

- Initial version.
-

LPI2C

[2.6.3]

- Bug Fixes
 - Fixed static analysis identified issues.

[2.6.2]

- Improvements
 - Added timeout for while loop in LPI2C_TransferStateMachineSendCommand().

[2.6.1]

- Bug Fixes
 - Fixed coverity issues.

[2.6.0]

- New Feature
 - Added common IRQ handler entry LPI2C_DriverIRQHandler.

[2.5.7]

- Improvements
 - Added support for separated IRQ handlers.

[2.5.6]

- Improvements
 - Conditionally compile interrupt handling code to solve the problem of using this driver on CPU cores that do not support interrupts.

[2.5.5]

- Bug Fixes
 - Fixed LPI2C_SlaveInit() - allow to disable SDA/SCL glitch filter.

[2.5.4]

- Bug Fixes
 - Fixed LPI2C_MasterTransferBlocking() - the return value was sometime affected by call of LPI2C_MasterStop().

[2.5.3]

- Improvements
 - Added handler for LPI2C7 and LPI2C8.

[2.5.2]

- Bug Fixes
 - Fixed ERR051119 to ignore the nak flag when IGNACK=1 in LPI2C_MasterCheckAndClearError.

[2.5.1]

- Bug Fixes
 - Added bus stop incase of bus stall in LPI2C_MasterTransferBlocking.
- Improvements
 - Release peripheral from reset if necessary in init function.

[2.5.0]

- New Features
 - Added new function LPI2C_SlaveEnableAckStall to enable or disable ACKSTALL.

[2.4.1]

- Improvements
 - Before master transfer with transactional APIs, enable master function while disable slave function and vise versa for slave transfer to avoid the one affecting the other.

[2.4.0]

- Improvements
 - Split some functions, fixed CCM problem in file fsl_lpi2c.c.
- Bug Fixes
 - Fixed bug in LPI2C_MasterInit that the MCFGR2's value set in LPI2C_MasterSetBaudRate may be overwritten by mistake.

[2.3.2]

- Improvements
 - Initialized the EDMA configuration structure in the LPI2C EDMA driver.

[2.3.1]

- Improvements
 - Updated LPI2C_GetCyclesForWidth to add the parameter of minimum cycle, because for master SDA/SCL filter, master bus idle/pin low timeout and slave SDA/SCL filter configuration, 0 means disabling the feature and cannot be used.
- Bug Fixes
 - Fixed bug in LPI2C_SlaveTransferHandleIRQ that when restart detect event happens the transfer structure should not be cleared.
 - Fixed bug in LPI2C_RunTransferStateMachine, that when only slave address is transferred or there is still data remaining in tx FIFO the last byte's nack cannot be ignored.

- Fixed bug in slave filter doze enable, that when FILTDZ is set it means disable rather than enable.
- Fixed bug in the usage of LPI2C_GetCyclesForWidth. First its return value cannot be used directly to configure the slave FILTSDA, FILTSCL, DATAVD or CLKHOLD, because the real cycle width for them should be FILTSDA+3, FILTSCL+3, FILTSCL+DATAVD+3 and CLKHOLD+3. Second when cycle period is not affected by the prescaler value, prescaler value should be passed as 0 rather than 1.
- Fixed wrong default setting for LPI2C slave. If enabling the slave tx SCL stall, then the default clock hold time should be set to 250ns according to I2C spec for 100kHz standard mode baudrate.
- Fixed bug that before pushing command to the tx FIFO the FIFO occupation should be checked first in case FIFO overflow.

[2.3.0]

- New Features
 - Supported reading more than 256 bytes of data in one transfer as master.
 - Added API LPI2C_GetInstance.
- Bug Fixes
 - Fixed bug in LPI2C_MasterTransferAbortEDMA, LPI2C_MasterTransferAbort and LPI2C_MasterTransferHandleIRQ that before sending stop signal whether master is active and whether stop signal has been sent should be checked, to make sure no FIFO error or bus error will be caused.
 - Fixed bug in LPI2C master EDMA transactional layer that the bus error cannot be caught and returned by user callback, by monitoring bus error events in interrupt handler.
 - Fixed bug in LPI2C_GetCyclesForWidth that the parameter used to calculate clock cycle should be $2^{\text{prescaler}}$ rather than prescaler.
 - Fixed bug in LPI2C_MasterInit that timeout value should be configured after baudrate, since the timeout calculation needs prescaler as parameter which is changed during baudrate configuration.
 - Fixed bug in LPI2C_MasterTransferHandleIRQ and LPI2C_RunTransferStateMachine that when master writes with no stop signal, need to first make sure no data remains in the tx FIFO before finishes the transfer.

[2.2.0]

- Bug Fixes
 - Fixed issue that the SCL high time, start hold time and stop setup time do not meet I2C specification, by changing the configuration of data valid delay, setup hold delay, clock high and low parameters.
 - MISRA C-2012 issue fixed.
 - * Fixed rule 8.4, 13.5, 17.7, 20.8.

[2.1.12]

- Bug Fixes
 - Fixed MISRA advisory 15.5 issues.

[2.1.11]

- Bug Fixes
 - Fixed the bug that, during master non-blocking transfer, after the last byte is sent/received, the `kLPI2C_MasterNackDetectFlag` is expected, so master should not check and clear `kLPI2C_MasterNackDetectFlag` when `remainingBytes` is zero, in case FIFO is emptied when stop command has not been sent yet.
 - Fixed the bug that, during non-blocking transfer slave may nack master while master is busy filling tx FIFO, and NDF may not be handled properly.

[2.1.10]

- Bug Fixes
 - MISRA C-2012 issue fixed.
 - * Fixed rule 10.3, 14.4, 15.5.
 - Fixed unaligned access issue in `LPI2C_RunTransferStateMachine`.
 - Fixed uninitialized variable issue in `LPI2C_MasterTransferHandleIRQ`.
 - Used linked TCD to disable tx and enable rx in read operation to fix the issue that for platform sharing the same DMA request with tx and rx, during LPI2C read operation if interrupt with higher priority happened exactly after command was sent and before tx disabled, potentially both tx and rx could trigger dma and cause trouble.
 - Fixed MISRA issues.
 - * Fixed rules 10.1, 10.3, 10.4, 11.6, 11.9, 14.4, 17.7.
 - Fixed the `waitTimes` variable not re-assignment issue for each byte read.
- New Features
 - Added the `IRQHandler` for LPI2C5 and LPI2C6 instances.
- Improvements
 - Updated the `LPI2C_WAIT_TIMEOUT` macro to unified name `I2C_RETRY_TIMES`.

[2.1.9]

- Bug Fixes
 - Fixed Coverity issue of unchecked return value in `I2C_RTOS_Transfer`.
 - Fixed Coverity issue of operands did not affect the result in `LPI2C_SlaveReceive` and `LPI2C_SlaveSend`.
 - Removed STOP signal wait when NAK detected.
 - Cleared slave repeat start flag before transmission started in `LPI2C_SlaveSend/LPI2C_SlaveReceive`. The issue was that `LPI2C_SlaveSend/LPI2C_SlaveReceive` did not handle with the reserved repeat start flag. This caused the next slave to send a break, and the master was always in the receive data status, but could not receive data.

[2.1.8]

- Bug Fixes
 - Fixed the transfer issue with `LPI2C_MasterTransferNonBlocking`, `kLPI2C_TransferNoStopFlag`, with the wait transfer done through callback in a way of not doing a blocking transfer.

- Fixed the issue that STOP signal did not appear in the bus when NAK event occurred.

[2.1.7]

- Bug Fixes
 - Cleared the stopflag before transmission started in LPI2C_SlaveSend/LPI2C_SlaveReceive. The issue was that LPI2C_SlaveSend/LPI2C_SlaveReceive did not handle with the reserved stop flag and caused the next slave to send a break, and the master always stayed in the receive data status but could not receive data.

[2.1.6]

- Bug Fixes
 - Fixed driver MISRA build error and C++ build error in LPI2C_MasterSend and LPI2C_SlaveSend.
 - Reset FIFO in LPI2C Master Transfer functions to avoid any byte still remaining in FIFO during last transfer.
 - Fixed the issue that LPI2C_MasterStop did not return the correct NAK status in the bus for second transfer to the non-existing slave address.

[2.1.5]

- Bug Fixes
 - Extended the Driver IRQ handler to support LPI2C4.
 - Changed to use ARRAY_SIZE(kLpi2cBases) instead of FEATURE COUNT to decide the array size for handle pointer array.

[2.1.4]

- Bug Fixes
 - Fixed the LPI2C_MasterTransferEDMA receive issue when LPI2C shared same request source with TX/RX DMA request. Previously, the API used scatter-gather method, which handled the command transfer first, then the linked TCD which was pre-set with the receive data transfer. The issue was that the TX DMA request and the RX DMA request were both enabled, so when the DMA finished the first command TCD transfer and handled the receive data TCD, the TX DMA request still happened due to empty TX FIFO. The result was that the RX DMA transfer would start without waiting on the expected RX DMA request.
 - Fixed the issue by enabling IntMajor interrupt for the command TCD and checking if there was a linked TCD to disable the TX DMA request in LPI2C_MasterEDMACallback API.

[2.1.3]

- Improvements
 - Added LPI2C_WATI_TIMEOUT macro to allow the user to specify the timeout times for waiting flags in functional API and blocking transfer API.
 - Added LPI2C_MasterTransferBlocking API.

[2.1.2]

- Bug Fixes
 - In LPI2C_SlaveTransferHandleIRQ, reset the slave status to idle when stop flag was detected.

[2.1.1]

- Bug Fixes
 - Disabled the auto-stop feature in eDMA driver. Previously, the auto-stop feature was enabled at transfer when transferring with stop flag. Since transfer was without stop flag and the auto-stop feature was enabled, when starting a new transfer with stop flag, the stop flag would be sent before the new transfer started, causing unsuccessful sending of the start flag, so the transfer could not start.
 - Changed default slave configuration with address stall false.

[2.1.0]

- Improvements
 - API name changed:
 - * LPI2C_MasterTransferCreateHandle -> LPI2C_MasterCreateHandle.
 - * LPI2C_MasterTransferGetCount -> LPI2C_MasterGetTransferCount.
 - * LPI2C_MasterTransferAbort -> LPI2C_MasterAbortTransfer.
 - * LPI2C_MasterTransferHandleIRQ -> LPI2C_MasterHandleInterrupt.
 - * LPI2C_SlaveTransferCreateHandle -> LPI2C_SlaveCreateHandle.
 - * LPI2C_SlaveTransferGetCount -> LPI2C_SlaveGetTransferCount.
 - * LPI2C_SlaveTransferAbort -> LPI2C_SlaveAbortTransfer.
 - * LPI2C_SlaveTransferHandleIRQ -> LPI2C_SlaveHandleInterrupt.

[2.0.0]

- Initial version.
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LPI2C_EDMA

[2.4.6]

- Bug Fixes
 - Fixed static analysis identified issues.

[2.4.5]

- Improvements
 - Added condition to IRQ handler to check whether the interrupt is enabled - kLPI2C_MasterTxReadyFlag.

[2.4.4]

- Improvements
 - Added support for 2KB data transfer

[2.4.3]

- Improvements
 - Added support for separated IRQ handlers.

[2.4.2]

- Improvements
 - Add EDMA ext API to accommodate more types of EDMA.

[2.4.1]

- Refer LPI2C driver change log 2.0.0 to 2.4.1
-

LPIT

[2.1.3]

- Bug Fixes
 - Fixed doxygen generation warnings.

[2.1.2]

- Bug Fixes
 - Fix CERT INT31-C issues.

[2.1.1]

- Improvements
 - Release peripheral from reset if necessary in init function.

[2.1.0]

- Improvements
 - Add new function LPIT_SetTimerValue to set timeout period.

[2.0.2]

- Improvements
 - Improved LPIT_SetTimerPeriod implementation, configure timeout value with LPIT ticks minus 1 generate more correct interval.
 - Added timeout value configuration check for LPIT_SetTimerPeriod, at least input 3 ticks for calling LPIT_SetTimerPeriod.
- Bug Fixes
 - Fixed MISRA C-2012 rule 17.7 violations.

[2.0.1]

- Bug Fixes
 - MISRA C-2012 issue fixed.
 - * Fixed rules, containing: rule-10.3, rule-14.4, rule-15.5.

[2.0.0]

- Initial version.
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LPSPI**[2.7.4]**

- Bug Fixes
 - Clear WIDTH bits from the TCR register before writing a new value in LPSPI_MasterTransferBlocking().

[2.7.3]

- Improvements
 - Added timeout for while loop in LPSPI_MasterTransferWriteAllTxData().
 - Make SPI_RETRY_TIMES configurable by CONFIG_SPI_RETRY_TIMES.

[2.7.2]

- Bug Fixes
 - Fixed coverity issues.

[2.7.1]

- Bug Fixes
 - Workaround for errata ERR050607
 - Workaround for errata ERR010655

[2.7.0]

- New Feature
 - Added common IRQ handler entry LPSPi_DriverIRQHandler.

[2.6.10]

- Improvements
 - Conditionally compile interrupt handling code to solve the problem of using this driver on CPU cores that do not support interrupts.

[2.6.9]

- Bug Fixes
 - Fixed reading of TCR register
 - Workaround for errata ERR050606

[2.6.8]

- Bug Fixes
 - Fixed build error when SPI_RETRY_TIMES is defined to non-zero value.

[2.6.7]

- Bug Fixes
 - Fixed the txData from void * to const void * in transmit API _lpspi_master_handle and _lpspi_slave_handle.

[2.6.6]

- Bug Fixes
 - Added LPSPi register init in LPSPi_MasterInit incase of LPSPi register exist.

[2.6.5]

- Improvements
 - Introduced FSL_FEATURE_LPSPi_HAS_NO_PCSCFG and FSL_FEATURE_LPSPi_HAS_NO_MULTI_WIDTH for conditional compile.
 - Release peripheral from reset if necessary in init function.

[2.6.4]

- Bug Fixes
 - Added LPSPi6_DriverIRQHandler for LPSPi6 instance.

[2.6.3]

- Hot Fixes
 - Added macro switch in function LPSPi_Enable about ERRATA051472.

[2.6.2]

- Bug Fixes
 - Disabled lpspi before LPSPI_MasterSetBaudRate incase of LPSPI opened.

[2.6.1]

- Bug Fixes
 - Fixed return value while calling LPSPI_WaitTxFifoEmpty in function LPSPI_MasterTransferNonBlocking.

[2.6.0]

- Feature
 - Added the new feature of multi-IO SPI .

[2.5.3]

- Bug Fixes
 - Fixed 3-wire txmask of handle vaule reentrant issue.

[2.5.2]

- Bug Fixes
 - Workaround for errata ERR051588 by clearing FIFO after transmit underrun occurs.

[2.5.1]

- Bug Fixes
 - Workaround for errata ERR050456 by resetting the entire module using LPSPI_CR[RST] bit.

[2.5.0]

- Bug Fixes
 - Workaround for errata ERR011097 to wait the TX FIFO to go empty when writing TCR register and TCR[TXMSK] value is 1.
 - Added API LPSPI_WaitTxFifoEmpty for wait the txfifo to go empty.

[2.4.7]

- Bug Fixes
 - Fixed bug that the SR[REF] would assert if software disabled or enabled the LPSPI module in LPSPI_Enable.

[2.4.6]

- Improvements
 - Moved the configuration of registers for the 3-wire lpspi mode to the LPSPI_MasterInit and LPSPI_SlaveInit function.

[2.4.5]

- Improvements
 - Improved LPSPI_MasterTransferBlocking send performance when frame size is 1-byte.

[2.4.4]

- Bug Fixes
 - Fixed LPSPI_MasterGetDefaultConfig incorrect default inter-transfer delay calculation.

[2.4.3]

- Bug Fixes
 - Fixed bug that the ISR response speed is too slow on some platforms, resulting in the first transmission of overflow, Set proper RX watermarks to reduce the ISR response times.

[2.4.2]

- Bug Fixes
 - Fixed bug that LPSPI_MasterTransferBlocking will modify the parameter txbuff and rxbuff pointer.

[2.4.1]

- Bug Fixes
 - Fixed bug that LPSPI_SlaveTransferNonBlocking can't detect RX error.

[2.4.0]

- Improvements
 - Split some functions, fixed CCM problem in file fsl_lpspi.c.

[2.3.1]

- Improvements
 - Initialized the EDMA configuration structure in the LPSPI EDMA driver.
- Bug Fixes
 - Fixed bug that function LPSPI_MasterTransferBlocking should return after the transfer complete flag is set to make sure the PCS is re-asserted.

[2.3.0]

- New Features
 - Supported the master configuration of sampling the input data using a delayed clock to improve slave setup time.

[2.2.1]

- Bug Fixes
 - Fixed bug in LPSPI_SetPCSContinuous when disabling PCS continuous mode.

[2.2.0]

- Bug Fixes
 - Fixed bug in 3-wire polling and interrupt transfer that the received data is not correct and the PCS continuous mode is not working.

[2.1.0]

- Improvements
 - Improved LPSPI_SlaveTransferHandleIRQ to fill up TX FIFO instead of write one data to TX register which improves the slave transmit performance.
 - Added new functional APIs LPSPI_SelectTransferPCS and LPSPI_SetPCSContinuous to support changing PCS selection and PCS continuous mode.
- Bug Fixes
 - Fixed bug in non-blocking and EDMA transfer APIs that kStatus_InvalidArgument is returned if user configures 3-wire mode and full-duplex transfer at the same time, but transfer state is already set to kLPSPI_Busy by mistake causing following transfer can not start.
 - Fixed bug when LPSPI slave using EDMA way to transfer, tx should be masked when tx data is null, otherwise in 3-wire mode which tx/rx use the same pin, the received data will be interfered.

[2.0.5]

- Improvements
 - Added timeout mechanism when waiting certain states in transfer driver.
- Bug Fixes
 - Fixed the bug that LPSPI can not transfer large data using EDMA.
 - Fixed MISRA 17.7 issues.
 - Fixed variable overflow issue introduced by MISRA fix.
 - Fixed issue that rxFifoMaxBytes should be calculated according to transfer width rather than FIFO width.
 - Fixed issue that completion flag was not cleared after transfer completed.

[2.0.4]

- Bug Fixes
 - Fixed in LPSPI_MasterTransferBlocking that master rxfifo may overflow in stall condition.
 - Eliminated IAR Pa082 warnings.
 - Fixed MISRA issues.
 - * Fixed rules 10.1, 10.3, 10.4, 10.6, 11.9, 14.2, 14.4, 15.7, 17.7.

[2.0.3]

- Bug Fixes
 - Removed LPSPI_Reset from LPSPI_MasterInit and LPSPI_SlaveInit, because this API may glitch the slave select line. If needed, call this function manually.

[2.0.2]

- New Features
 - Added dummy data set up API to allow users to configure the dummy data to be transferred.
 - Enabled the 3-wire mode, SIN and SOUT pins can be configured as input/output pin.

[2.0.1]

- Bug Fixes
 - Fixed the bug that the clock source should be divided by the PRESCALE setting in LPSPI_MasterSetDelayTimes function.
 - Fixed the bug that LPSPI_MasterTransferBlocking function would hang in some corner cases.
- Optimization
 - Added #ifndef/#endif to allow user to change the default TX value at compile time.

[2.0.0]

- Initial version.
-

LPSPI_EDMA

[2.4.9]

- Improvements
 - Removed unused code from LPSPI_SeparateEdmaReadData().

[2.4.8]

- Improvements
 - Added timeout for while loop in EDMA_LpspiMasterCallback() and EDMA_LpspiSlaveCallback().

[2.4.7]

- Bug Fixes
 - Add macro LPSPI_ALIGN_TCD_SIZE_MASK to align an address to edma_tcd_t size.

[2.4.6]

- Improvements
 - Increased transmit FIFO watermark to ensure whole transmit FIFO will be used during data transfer.

[2.4.5]

- Bug Fixes
 - Fixed reading of TCR register
 - Workaround for errata ERR050606

[2.4.4]

- Improvements
 - Add EDMA ext API to accommodate more types of EDMA.

[2.4.3]

- Improvements
 - Supported 32K bytes transmit in DMA, improve the max datasize in LP-SPI_MasterTransferEDMALite.

[2.4.2]

- Improvements
 - Added callback status in EDMA_LpspiMasterCallback and EDMA_LpspiSlaveCallback to check transferDone.

[2.4.1]

- Improvements
 - Add the TXMSK wait after TCR setting.

[2.4.0]

- Improvements
 - Separated LPSPI_MasterTransferEDMA functions to LP-SPI_MasterTransferPrepareEDMA and LPSPI_MasterTransferEDMALite to optimize the process of transfer.
-

LPTMR**[2.2.1]**

- Bug Fixes
 - Fix CERT INT31-C issues.

[2.2.0]

- Improvements
 - Updated `lptmr_prescaler_clock_select_t`, only define the valid options.

[2.1.1]

- Improvements
 - Updated the characters from “PTMR” to “LPTMR” in “FSL_FEATURE_PTMR_HAS_NO_PRESCALER_CLOCK_SOURCE_1_SUPPORT” feature definition.

[2.1.0]

- Improvements
 - Implement for some special devices’ not supporting for all clock sources.
- Bug Fixes
 - Fixed issue when accessing CMR register.

[2.0.2]

- Bug Fixes
 - Fixed MISRA-2012 issues.
 - * Rule 10.1.

[2.0.1]

- Improvements
 - Updated the LPTMR driver to support 32-bit CNR and CMR registers in some devices.

[2.0.0]

- Initial version.
-

LPUART

[2.10.0]

- New Feature
 - Added support to configure RTS watermark.

[2.9.4]

- Improvements
 - Merged duplicate code.

[2.9.3]

- Improvements
 - Added timeout for while loops in LPUART_Deinit().

[2.9.2]

- Bug Fixes
 - Fixed coverity issues.

[2.9.1]

- Bug Fixes
 - Fixed coverity issues.

[2.9.0]

- New Feature
 - Added support for swap TXD and RXD pins.
 - Added common IRQ handler entry LPUART_DriverIRQHandler.

[2.8.3]

- Improvements
 - Conditionally compile interrupt handling code to solve the problem of using this driver on CPU cores that do not support interrupts.

[2.8.2]

- Bug Fix
 - Fixed the bug that LPUART_TransferEnable16Bit controled by wrong feature macro.

[2.8.1]

- Bug Fixes
 - Fixed issue for MISRA-2012 check.
 - * Fixed rule-5.3, rule-5.8, rule-10.4, rule-11.3, rule-11.8.

[2.8.0]

- Improvements
 - Added support of DATA register for 9bit or 10bit data transmit in write and read API. Such as: LPUART_WriteBlocking16bit, LPUART_ReadBlocking16bit, LPUART_TransferEnable16Bit, LPUART_WriteNonBlocking16bit, LPUART_ReadNonBlocking16bit.

[2.7.7]

- Bug Fixes
 - Fixed the bug that baud rate calculation overflow when srcClock_Hz is 528MHz.

[2.7.6]

- Bug Fixes
 - Fixed LPUART_EnableInterrupts and LPUART_DisableInterrupts bug that blocks if the LPUART address doesn't support exclusive access.

[2.7.5]

- Improvements
 - Release peripheral from reset if necessary in init function.

[2.7.4]

- Improvements
 - Added support for atomic register accessing in LPUART_EnableInterrupts and LPUART_DisableInterrupts.

[2.7.3]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 15.7.

[2.7.2]

- Bug Fix
 - Fixed the bug that the OSR calculation error when lpuart init and lpuart set baud rate.

[2.7.1]

- Improvements
 - Added support for LPUART_BASE_PTRS_NS in security mode in file fsl_lpuart.c.

[2.7.0]

- Improvements
 - Split some functions, fixed CCM problem in file fsl_lpuart.c.

[2.6.0]

- Bug Fixes
 - Fixed bug that when there are multiple lpuart instance, unable to support different ISR.

[2.5.3]

- Bug Fixes
 - Fixed comments by replacing unused status flags kLPUART_NoiseErrorInRxDataRegFlag and kLPUART_ParityErrorInRxDataRegFlag with kLPUART_NoiseErrorFlag and kLPUART_ParityErrorFlag.

[2.5.2]

- Bug Fixes
 - Fixed bug that when setting watermark for TX or RX FIFO, the value may exceed the maximum limit.
- Improvements
 - Added check in LPUART_TransferDMAHandleIRQ and LPUART_TransferEdmaHandleIRQ to ensure if user enables any interrupts other than transfer complete interrupt, the dma transfer is not terminated by mistake.

[2.5.1]

- Improvements
 - Use separate data for TX and RX in lpuart_transfer_t.
- Bug Fixes
 - Fixed bug that when ring buffer is used, if some data is received in ring buffer first before calling LPUART_TransferReceiveNonBlocking, the received data count returned by LPUART_TransferGetReceiveCount is wrong.

[2.5.0]

- Bug Fixes
 - Added missing interrupt enable masks kLPUART_Match1InterruptEnable and kLPUART_Match2InterruptEnable.
 - Fixed bug in LPUART_EnableInterrupts, LPUART_DisableInterrupts and LPUART_GetEnabledInterrupts that the BAUD[LBKDIE] bit field should be soc specific.
 - Fixed bug in LPUART_TransferHandleIRQ that idle line interrupt should be disabled when rx data size is zero.
 - Deleted unused status flags kLPUART_NoiseErrorInRxDataRegFlag and kLPUART_ParityErrorInRxDataRegFlag, since firstly their function are the same as kLPUART_NoiseErrorFlag and kLPUART_ParityErrorFlag, secondly to obtain them one data word must be read out thus interfering with the receiving process.
 - Fixed bug in LPUART_GetStatusFlags that the STAT[LBKDIF], STAT[MA1F] and STAT[MA2F] should be soc specific.
 - Fixed bug in LPUART_ClearStatusFlags that tx/rx FIFO is reset by mistake when clearing flags.
 - Fixed bug in LPUART_TransferHandleIRQ that while clearing idle line flag the other bits should be masked in case other status bits be cleared by accident.
 - Fixed bug of race condition during LPUART transfer using transactional APIs, by disabling and re-enabling the global interrupt before and after critical operations on interrupt enable register.
 - Fixed DMA/eDMA transfer blocking issue by enabling tx idle interrupt after DMA/eDMA transmission finishes.
- New Features
 - Added APIs LPUART_GetRxFifoCount/LPUART_GetTxFifoCount to get rx/tx FIFO data count.
 - Added APIs LPUART_SetRxFifoWatermark/LPUART_SetTxFifoWatermark to set rx/tx FIFO water mark.

[2.4.1]

- Bug Fixes
 - Fixed MISRA advisory 17.7 issues.

[2.4.0]

- New Features
 - Added APIs to configure 9-bit data mode, set slave address and send address.

[2.3.1]

- Bug Fixes
 - Fixed MISRA advisory 15.5 issues.

[2.3.0]

- Improvements
 - Modified LPUART_TransferHandleIRQ so that txState will be set to idle only when all data has been sent out to bus.
 - Modified LPUART_TransferGetSendCount so that this API returns the real byte count that LPUART has sent out rather than the software buffer status.
 - Added timeout mechanism when waiting for certain states in transfer driver.

[2.2.8]

- Bug Fixes
 - Fixed issue for MISRA-2012 check.
 - * Fixed rule-10.3, rule-14.4, rule-15.5.
 - Eliminated Pa082 warnings by assigning volatile variables to local variables and using local variables instead.
 - Fixed MISRA issues.
 - * Fixed rules 10.1, 10.3, 10.4, 10.8, 14.4, 11.6, 17.7.
- Improvements
 - Added check for kLPUART_TransmissionCompleteFlag in LPUART_WriteBlocking, LPUART_TransferHandleIRQ, LPUART_TransferSendDMACallback and LPUART_SendEDMACallback to ensure all the data would be sent out to bus.
 - Rounded up the calculated sbr value in LPUART_SetBaudRate and LPUART_Init to achieve more accurate baudrate setting. Changed osr from uint32_t to uint8_t since osr's biggest value is 31.
 - Modified LPUART_ReadBlocking so that if more than one receiver errors occur, all status flags will be cleared and the most severe error status will be returned.

[2.2.7]

- Bug Fixes
 - Fixed issue for MISRA-2012 check.
 - * Fixed rule-12.1, rule-17.7, rule-14.4, rule-13.3, rule-14.4, rule-10.4, rule-10.8, rule-10.3, rule-10.7, rule-10.1, rule-11.6, rule-13.5, rule-11.3, rule-13.2, rule-8.3.

[2.2.6]

- Bug Fixes
 - Fixed the issue of register's being in repeated reading status while dealing with the IRQ routine.

[2.2.5]

- Bug Fixes
 - Do not set or clear the TIE/RIE bits when using LPUART_EnableTxDMA and LPUART_EnableRxDMA.

[2.2.4]

- Improvements
 - Added hardware flow control function support.
 - Added idle-line-detecting feature in LPUART_TransferNonBlocking function. If an idle line is detected, a callback is triggered with status kStatus_LPUART_IdleLineDetected returned. This feature may be useful when the received Bytes is less than the expected received data size. Before triggering the callback, data in the FIFO (if has FIFO) is read out, and no interrupt will be disabled, except for that the receive data size reaches 0.
 - Enabled the RX FIFO watermark function. With the idle-line-detecting feature enabled, users can set the watermark value to whatever you want (should be less than the RX FIFO size). Data is received and a callback will be triggered when data receive ends.

[2.2.3]

- Improvements
 - Changed parameter type in LPUART_RTOS_Init struct from rtos_lpuart_config to lpuart_rtos_config_t.
- Bug Fixes
 - Disabled LPUART receive interrupt instead of all NVICs when reading data from ring buffer. Otherwise when the ring buffer is used, receive nonblocking method will disable all NVICs to protect the ring buffer. This may has a negative effect on other IPs that are using the interrupt.

[2.2.2]

- Improvements
 - Added software reset feature support.
 - Added software reset API in LPUART_Init.

[2.2.1]

- Improvements
 - Added separate RX/TX IRQ number support.

[2.2.0]

- Improvements
 - Added support of 7 data bits and MSB.

[2.1.1]

- Improvements
 - Removed unnecessary check of event flags and assert in LPUART_RTOS_Receive.
 - Added code to always wait for RX event flag in LPUART_RTOS_Receive.

[2.1.0]

- Improvements
 - Update transactional APIs.
-

LPUART_EDMA

[2.4.0]

- Refer LPUART driver change log 2.1.0 to 2.4.0
-

MCM

[2.2.0]

- Improvements
 - Support platforms with less features.

[2.1.0]

- Others
 - Remove byteID from mcm_lmem_fault_attribute_t for document update.

[2.0.0]

- Initial version.
-

MIPI_DSI

[2.1.0]

- Bug Fixes
 - Fixed typo in member of `dsi_transfer_t` structure. The `sendDscCmd` and `dscCmd` shall be `sendDcsCmd` and `dcsCmd`.

[2.0.3]

- Improvements
 - Supported `DSI_ConfigDphy` api.
 - Supported `DSI_EnableVpgEnMode` to config the video mode pattern generator.

[2.0.2]

- Improvements
 - More precise calculation of the values of `m` & `n`.
 - Lookup table method to obtain DPHY-related parameters based on bandwidth.

[2.0.1]

- Bug Fixes.
 - Fixed MISRA C-2012 issues: 10.1, 10.3, 10.4, 10.8, 21.15

[2.0.0]

- Initial version.
-

MU

[2.8.1]

- Bug Fixes
 - Avoid incorrect `MU_BUSY_POLL_COUNT` macro use.

[2.8.0]

- New Features
 - Added `MU1_BUSY_POLL_COUNT` parameter to prevent infinite polling loops in MU operations.
 - Added timeout mechanism to all polling loops in MU driver code.
- Improvements
 - Updated function signatures to return status codes for better error handling:
 - * Changed `MU_ResetBothSides` to return `status_t` instead of void
 - * Updated `MU_SendMsg` to return `status_t` for timeout indication
 - * Added new function `MU_ReceiveMsgTimeout()` to include timeout mechanism.

- Enhanced documentation across all functions to clarify timeout behavior and return values.

[2.7.0]

- New Features
 - Added API MU_GetRxStatusFlags.

[2.6.0]

- New Features
 - Added API MU_GetInterruptsPending.

[2.5.1]

- Bug Fixes
 - Fixed the bug that MU_TriggerGeneralPurposeInterrupts and MU_TriggerInterrupts may trigger previous triggered general purpose interrupts again by mistake.

[2.5.0]

- New Features
 - Supported more than 4 general purpose interrupts.
 - Added separate APIs for general purpose interrupts.

[2.4.0]

- Improvements
 - Supported the case that some features only available with specific instances. These features include Hardware Reset, Boot Peer Core, Hold Reset. When using the features with instances which don't support them, driver will report error.

[2.3.3]

- Improvements
 - Release peripheral from reset if necessary in init function.

[2.3.2]

- Improvements
 - Supported platforms which don't have CCR0[RSTH], CCR0[CLKE], CCR0[HR], CCR0[HRM].

[2.3.1]

- Bug Fixes
 - Fixed build error for platforms which have CCR0[RSTH], but no CCR0[NMI].

[2.3.0]

- New features
 - Added support for i.MX RT7xx.

[2.2.1]

- Bug Fixes
 - Fixed issue that MU_GetInstance() is defined but never used.

[2.2.0]

- New features
 - Added support for i.MX RT118x.
- Bug Fixes
 - Fixed general purpose interrupt bug.
- Other Changes
 - Change _mu_interrupt_trigger item value.

[2.1.2]

- Bug Fixes
 - Fixed bug that general purpose interrupt can't be configured.

[2.1.1]

- Bug Fixes
 - Fixed MISRA C-2012 issues.

[2.1.0]

- Improvements
 - Added new enum mu_msg_reg_index_t.

[2.0.0]

- Initial version.
-

OTFAD**[2.1.4]**

- Bug fixes
 - Fixed MISRA 2012 issue: 10.1.

[2.1.3]

- Bug fixes
 - Fixed the error that waiting for both FLEXSPI AHB idle and SEQ idle.

[2.1.2]

- Bug fixes
 - Fixed MISRA 2012 issue: 10.4.

[2.1.1]

- Improvements:
 - Hided some bits in CR and SR registers for selected platforms.
 - Fixed doxygen issues.

[2.1.0]

- Improvements:
 - Used boolean type to define 1-bit field concepts.

[2.0.0]

- Initial version.
-

PDM

[2.9.3]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 10.1, 10.3, 10.4, 10.5, 10.6, 10.7, 10.8, 12.4.

[2.9.2]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 10.1, 10.3, 10.4, 10.5, 10.6, 10.7, 10.8, 12.4.

[2.9.1]

- Bug Fixes
 - Fixed the issue that the driver still enters the interrupt after disabling clock.

[2.9.0]

- Improvements
- Added feature `FSL_FEATURE_PDM_HAS_DECIMATION_FILTER_BYPASS` to config `CTRL_2[DEC_BYPASS]` field.
- Modify code to make the OSR value is not limited to 16.

[2.8.1]

- Improvements
- Added feature `FSL_FEATURE_PDM_HAS_NO_DOZEN` to handle nonexistent `CTRL_1[DOZEN]` field.

[2.8.0]

- Improvements
- Added feature `FSL_FEATURE_PDM_HAS_NO_HWVAD` to remove the support of hardware voice activity detector.
- Added feature `FSL_FEATURE_PDM_HAS_NO_FILTER_BUFFER` to remove the support of `FIR_RDY` bitfield in `STAT` register.

[2.7.4]

- Bug Fixes
 - Fixed driver can not determine the specific float number of clock divider.
 - Fixed `PDM_ValidateSrcClockRate` calculates PDM channel in wrong method issue.

[2.7.3]

- Improvements
- Added feature `FSL_FEATURE_PDM_HAS_NO_VADEF` to remove the support of `VADEF` bitfield in `VAD0_STAT` register.

[2.7.2]

- Improvements
- Added feature `FSL_FEATURE_PDM_HAS_NO_MINIMUM_CLKDIV` to decide whether the minimum clock frequency division is required.

[2.7.1]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 8.4, 10.3, 10.1, 10.4, 14.4

[2.7.0]

- Improvements
 - Added api `PDM_EnableHwvadInterruptCallback` to support handle hwvad IRQ in PDM driver.
 - Corrected the sample rate configuration for non high quality mode.
 - Added api `PDM_SetChannelGain` to support adjust the channel gain.

[2.6.0]

- Improvements
 - Added new features `FSL_FEATURE_PDM_HAS_STATUS_LOW_FREQ`/`FSL_FEATURE_PDM_HAS_DC_OUT`

[2.5.0]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 8.4, 16.5, 10.4, 10.3, 10.1, 11.9, 17.7, 10.6, 14.4, 11.8, 11.6.

[2.4.1]

- Bug Fixes
 - Fixed MDK 66-D warning in pdm driver.

[2.4.0]

- Improvements
 - Added api PDM_TransferSetChannelConfig/PDM_ReadFifo to support read different width data.
 - Added feature FSL_FEATURE_PDM_HAS_RANGE_CTRL and api PDM_ClearRangeStatus/PDM_GetRangeStatus for range register.
- Bug Fixes
 - Fixed violation of MISRA C-2012 Rule 14.4, 10.3, 10.4.

[2.3.0]

- Improvements
 - Enabled envelope/energy voice detect mode by adding apis PDM_SetHwvadInEnvelopeBasedMode/PDM_SetHwvadInEnergyBasedMode.
 - Added feature FSL_FEATURE_PDM_CHANNEL_NUM for different SOC.

[2.2.1]

- Bug Fixes
 - Fixed violation of MISRA C-2012 Rule 10.1, 10.3, 10.4, 10.6, 10.7, 11.3, 11.8, 14.4, 17.7, 18.4.
 - Added medium quality mode support in function PDM_SetSampleRateConfig.

[2.2.0]

- Improvements
 - Added api PDM_SetSampleRateConfig to improve user experience and marked api PDM_SetSampleRate as deprecated.

[2.1.1]

- Improvements
 - Used new SDMA API SDMA_SetDoneConfig instead of SDMA_EnableSwDone for PDM SDMA driver.

[2.1.0]

- Improvements
 - Added software buffer queue for transactional API.

[2.0.1]

- Improvements
 - Improved HWVAD feature.

[2.0.0]

- Initial version.
-

PDM_EDMA**[2.6.5]**

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 10.1, 10.3, 10.4, 10.5, 10.6, 10.7, 10.8.

[2.6.4]

- Improvements
 - Add handling for runtime change of number of linked transfers

[2.6.3]

- Improvements
 - Add EDMA ext API to accommodate more types of EDMA.

[2.6.2]

- Improvements
 - Add macro `MCUX_SDK_PDM_EDMA_PDM_ENABLE_INTERNAL` to let the user decide whether to enable it when calling `PDM_TransferReceiveEDMA`.

[2.6.1]

- Bug Fixes
 - Fixed violation of MISRA C-2012 Rule 10.3, 10.4.

[2.6.0]

- Improvements
 - Updated api `PDM_TransferReceiveEDMA` to support channel block interleave transfer.
 - Added new api `PDM_TransferSetMultiChannelInterleaveType` to support channel interleave type configurations.

[2.5.0]

- Refer PDM driver change log 2.1.0 to 2.5.0
-

RGPIO

[2.2.0]

- Added RGPIO_GetPinDirection() API to get the current direction of a RGPIO pin.
- Added FGPIO_GetPinDirection() API to get the current direction of a FGPIO pin.

[2.1.0]

- New feature:
 - Added API RGPIO_EnablePortInput()
 - Added API RGPIO_SetPinInterruptConfig()
 - Added API RGPIO_GetPinsInterruptFlags()
 - Added API RGPIO_ClearPinsInterruptFlags()

[2.0.3]

- Improvements:
 - Enhanced FGPIO_PinInit to enable clock internally.

[2.0.2]

- Bug fix
 - MISRA C-2012 issue fixed.
 - * Fix rules, containing: rule-10.3, rule-14.4, rule-15.5.

[2.0.1]

- API Interface Change:
 - Refined naming of API while keep all original APIs with marking them as deprecated. The original API will be removed in the next release. The main change is to update API with prefix of _PinXXX() and _PortXXX().

[2.0.0]

- Initial version.
-

SAI

[2.4.10]

- Improvements
 - Allow enabling/disabling implicit channel configuration.
 - Allow NULL FIFO watermark.
- Bug Fixes
 - Fix compilation warnings when asserts are disabled

[2.4.9]

- Added Errata ERR051421 workaround.

[2.4.8]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 10.1, 10.3, 10.4, 10.5, 10.6, 10.7, 10.8, 12.4.

[2.4.7]

- Added conditional support for bit clock swap feature
- Added common IRQ handler entry SAI_DriverIRQHandler.

[2.4.6]

- Bug Fixes
 - Fixed the IAR build warning.

[2.4.5]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 10.1, 10.3, 10.4, 10.5, 10.6, 10.7, 10.8, 12.4.

[2.4.4]

- Bug Fixes
 - Fixed enumeration sai_fifo_combine_t - add RX configuration.

[2.4.3]

- Bug Fixes
 - Fixed enumeration sai_fifo_combine_t value configuration issue.

[2.4.2]

- Improvements
 - Release peripheral from reset if necessary in init function.

[2.4.1]

- Bug Fixes
 - Fixed bitWidth incorrectly assigned issue.

[2.4.0]

- Improvements
 - Removed deprecated APIs.

[2.3.8]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 10.4.

[2.3.7]

- Improvements
 - Change feature “FSL_FEATURE_SAI_FIFO_COUNT” to “FSL_FEATURE_SAI_HAS_FIFO”.
 - Added feature “FSL_FEATURE_SAI_FIFO_COUNTn(x)” to align SAI fifo count function with IP in function

[2.3.6]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 5.6.

[2.3.5]

- Improvements
 - Make driver to be aarch64 compatible.

[2.3.4]

- Bug Fixes
 - Corrected the fifo combine feature macro used in driver.

[2.3.3]

- Bug Fixes
 - Added bit clock polarity configuration when sai act as slave.
 - Fixed out of bound access coverity issue.
 - Fixed violations of MISRA C-2012 rule 10.3, 10.4.

[2.3.2]

- Bug Fixes
 - Corrected the frame sync configuration when sai act as slave.

[2.3.1]

- Bug Fixes
 - Corrected the peripheral name in function SAI0_DriverIRQHandler.
 - Fixed violations of MISRA C-2012 rule 17.7.

[2.3.0]

- Bug Fixes
 - Fixed the build error caused by the SOC has no fifo feature.

[2.2.3]

- Bug Fixes
 - Corrected the peripheral name in function SAI0_DriverIRQHandler.

[2.2.2]

- Bug Fixes
 - Fixed the issue of MISRA 2004 rule 9.3.
 - Fixed sign-compare warning.
 - Fixed the PA082 build warning.
 - Fixed sign-compare warning.
 - Fixed violations of MISRA C-2012 rule 10.3,17.7,10.4,8.4,10.7,10.8,14.4,17.7,11.6,10.1,10.6,8.4,14.3,16.4,18.2.
 - Allow to reset Rx or Tx FIFO pointers only when Rx or Tx is disabled.
- Improvements
 - Added 24bit raw audio data width support in sai sdma driver.
 - Disabled the interrupt/DMA request in the SAI_Init to avoid generates unexpected sai FIFO requests.

[2.2.1]

- Improvements
 - Added mclk post divider support in function SAI_SetMasterClockDivider.
 - Removed useless configuration code in SAI_RxSetSerialDataConfig.
- Bug Fixes
 - Fixed the SAI SDMA driver build issue caused by the wrong structure member name used in the function SAI_TransferRxSetConfigSDMA/SAI_TransferTxSetConfigSDMA.
 - Fixed BAD BIT SHIFT OPERATION issue caused by the FSL_FEATURE_SAI_CHANNEL_COUNTn.
 - Applied ERR05144: not set FCONT = 1 when TMR > 0, otherwise the TX may not work.

[2.2.0]

- Improvements
 - Added new APIs for parameters collection and simplified user interfaces:
 - * SAI_Init
 - * SAI_SetMasterClockConfig
 - * SAI_TxSetBitClockRate
 - * SAI_TxSetSerialDataConfig
 - * SAI_TxSetFrameSyncConfig
 - * SAI_TxSetFifoConfig
 - * SAI_TxSetBitclockConfig
 - * SAI_TxSetConfig
 - * SAI_TxSetTransferConfig
 - * SAI_RxSetBitClockRate
 - * SAI_RxSetSerialDataConfig
 - * SAI_RxSetFrameSyncConfig
 - * SAI_RxSetFifoConfig
 - * SAI_RxSetBitclockConfig
 - * SAI_RXSetConfig
 - * SAI_RxSetTransferConfig
 - * SAI_GetClassicI2SConfig
 - * SAI_GetLeftJustifiedConfig
 - * SAI_GetRightJustifiedConfig
 - * SAI_GetTDMConfig

[2.1.9]

- Improvements
 - Improved SAI driver comment for clock polarity.
 - Added enumeration for SAI for sample inputs on different edges.
 - Changed FSL_FEATURE_SAI_CHANNEL_COUNT to FSL_FEATURE_SAI_CHANNEL_COUNTn(base) for the difference between the different SAI instances.
- Added new APIs:
 - SAI_TxSetBitClockDirection
 - SAI_RxSetBitClockDirection
 - SAI_RxSetFrameSyncDirection
 - SAI_TxSetFrameSyncDirection

[2.1.8]

- Improvements
 - Added feature macro test for the sync mode2 and mode 3.
 - Added feature macro test for masterClockHz in sai_transfer_format_t.

[2.1.7]

- Improvements
 - Added feature macro test for the mclkSource member in sai_config_t.
 - Changed “FSL_FEATURE_SAI5_SAI6_SHARE_IRQ” to “FSL_FEATURE_SAI_SAI5_SAI6_SHARE_IRQ”.
 - Added #ifndef #endif check for SAI_XFER_QUEUE_SIZE to allow redefinition.
- Bug Fixes
 - Fixed build error caused by feature macro test for mclkSource.

[2.1.6]

- Improvements
 - Added feature macro test for mclkSourceClockHz check.
 - Added bit clock source name for general devices.
- Bug Fixes
 - Fixed incorrect channel numbers setting while calling RX/TX set format together.

[2.1.5]

- Bug Fixes
 - Corrected SAI3 driver IRQ handler name.
 - Added I2S4/5/6 IRQ handler.
 - Added base in handler structure to support different instances sharing one IRQ number.
- New Features
 - Updated SAI driver for MCR bit MICS.
 - Added 192 KHZ/384 KHZ in the sample rate enumeration.
 - Added multi FIFO interrupt/SDMA transfer support for TX/RX.
 - Added an API to read/write multi FIFO data in a blocking method.
 - Added bclk bypass support when bclk is same with mclk.

[2.1.4]

- New Features
 - Added an API to enable/disable auto FIFO error recovery in platforms that support this feature.
 - Added an API to set data packing feature in platforms which support this feature.

[2.1.3]

- New Features
 - Added feature to make I2S frame sync length configurable according to bitWidth.

[2.1.2]

- Bug Fixes
 - Added 24-bit support for SAI eDMA transfer. All data shall be 32 bits for send/receive, as eDMA cannot directly handle 3-Byte transfer.

[2.1.1]

- Improvements
 - Reduced code size while not using transactional API.

[2.1.0]

- Improvements
 - API name changes:
 - * SAI_GetSendRemainingBytes -> SAI_GetSentCount.
 - * SAI_GetReceiveRemainingBytes -> SAI_GetReceivedCount.
 - * All names of transactional APIs were added with “Transfer” prefix.
 - * All transactional APIs use base and handle as input parameter.
 - * Unified the parameter names.
- Bug Fixes
 - Fixed WLC bug while reading TCSR/RCSR registers.
 - Fixed MOE enable flow issue. Moved MOE enable after MICS settings in SAI_TxInit/SAI_RxInit.

[2.0.0]

- Initial version.
-

SAI_EDMA

[2.7.3]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 10.1, 10.3, 10.4, 10.5, 10.6, 10.7, 10.8, 12.4.

[2.7.2]

- Improvements
 - Add macros `MCUX_SDK_SAI_EDMA_TX_ENABLE_INTERNAL` and `MCUX_SDK_SAI_EDMA_RX_ENABLE_INTERNAL` to let the user decide whether to enable SAI when calling `SAI_TransferSendEDMA/SAI_TransferReceiveEDMA`.

[2.7.1]

- Improvements
 - Add EDMA ext API to accommodate more types of EDMA.

[2.7.0]

- Improvements
 - Updated api SAI_TransferReceiveEDMA to support voice channel block interleave transfer.
 - Updated api SAI_TransferSendEDMA to support voice channel block interleave transfer.
 - Added new api SAI_TransferSetInterleaveType to support channel interleave type configurations.

[2.6.0]

- Improvements
 - Removed deprecated APIs.

[2.5.1]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 20.7.

[2.5.0]

- Improvements
 - Added new api SAI_TransferSendLoopEDMA/SAI_TransferReceiveLoopEDMA to support loop transfer.
 - Added multi sai channel transfer support.

[2.4.0]

- Improvements
 - Added new api SAI_TransferGetValidTransferSlotsEDMA which can be used to get valid transfer slot count in the sai edma transfer queue.
 - Deprecated the api SAI_TransferRxSetFormatEDMA and SAI_TransferTxSetFormatEDMA.
- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 10.3,10.4.

[2.3.2]

- Refer SAI driver change log 2.1.0 to 2.3.2

SAR_ADC

[2.3.0]

- New Feature
 - Added new feature macro a for compatibility with ADCs on some platforms where some instances do not support group3.

[2.2.0]

- New Feature
 - Added new features to compatible with new platforms.

[2.1.1]

- Improvement
 - Change ADC sample rate phase duration default value from 0x08 to 0x14.

[2.1.0]

- New Feature
 - Added ADC_StopConvChain function to support stop scan in normal conversion scan operation mode.

[2.0.3]

- Bug Fixes
 - Fixed the array name usage error in function ADC_GetInstance.

[2.0.2]

- Bug Fixes
 - Fixed MISRA issues.

[2.0.1]

- Bug Fixes
 - Fixed the bug that when calling function ADC_EnableWdgThresholdInt() in function ADC_SetAnalogWdgConfig(), the parameter was passed incorrectly.

[2.0.0]

- Initial version.
-

SEMA42

[2.1.1]

- Improvements
 - Updated SEMA42_TryLock function to avoid unsigned integer operations wrap issue.

[2.1.0]

- New Features
 - Added SEMA42_BUSY_POLL_COUNT parameter to prevent infinite polling loops in SEMA42 operations.
 - Added timeout mechanism to all polling loops in SEMA42 driver code.
- Improvements
 - Updated SEMA42_Lock function to return status_t instead of void for better error handling.
 - Enhanced documentation to clarify timeout behavior and return values.

[2.0.4]

- Improvements
 - Release peripheral from reset if necessary in init function.

[2.0.3]

- Improvements
 - Changed to implement SEMA42_Lock base on SEMA42_TryLock.

[2.0.2]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 17.7.

[2.0.1]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 10.3, 10.4, 14.4, 18.1.

[2.0.0]

- Initial version.
-

TMU**[2.1.0]**

- New feature.
 - Supported rising & falling temp rate critical threshold.
 - Supported polling function to avoid the temp sudden jump issue.

[2.0.0]

- Initial version.
 - This module was first developed on i.MX 93.
-

TPM

[2.4.1]

- Improvements
 - Add Coverage Justification for uncovered code.

[2.4.0]

- New Feature
 - Added while loop timeout for MOD CnV CnSC and SC register write sequence.
 - Change the return type from void to status_t for following API:
 - * TPM_DisableChannel
 - * TPM_EnableChannel
 - * TPM_SetupOutputCompare
 - * TPM_SetTimerPeriod
 - * TPM_StopTimer

[2.3.6]

- Bug Fixes
 - Fixed CERT INT30-C INT31-C issue for TPM_SetupDualEdgeCapture.

[2.3.5]

- New Feature
 - Added IRQ handler entry for TPM2.

[2.3.4]

- New Feature
 - Added common IRQ handler entry TPM_DriverIRQHandler.

[2.3.3]

- Improvements
 - Conditionally compile interrupt handling code to solve the problem of using this driver on CPU cores that do not support interrupts.

[2.3.2]

- Bug Fixes
 - Fixed ERR008085 TPM writing the TPMx_MOD or TPMx_CnV registers more than once may fail when the timer is disabled.

[2.3.1]

- Bug Fixes
 - Fixed compilation error when macro `FSL_SDK_DISABLE_DRIVER_CLOCK_CONTROL` is 1.

[2.3.0]

- Improvements
 - Create callback feature for TPM match and timer overflow interrupts.

[2.2.4]

- Improvements
 - Add feature macros(`FSL_FEATURE_TPM_HAS_GLOBAL_TIME_BASE_EN`, `FSL_FEATURE_TPM_HAS_GLOBAL_TIME_BASE_SYNC`).

[2.2.3]

- Improvements
 - Release peripheral from reset if necessary in init function.

[2.2.2]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 10.4.

[2.2.1]

- Bug Fixes
 - Fixed CCM issue by splitting function from `TPM_SetupPwm()` function to reduce function complexity.
 - Fixed violations of MISRA C-2012 rule 17.7.

[2.2.0]

- Improvements
 - Added `TPM_SetChannelPolarity` to support select channel input/output polarity.
 - Added `TPM_EnableChannelExtTrigger` to support enable external trigger input to be used by channel.
 - Added `TPM_CalculateCounterClkDiv` to help calculates the counter clock prescaler.
 - Added `TPM_GetChannelValue` to support get TPM channel value.
 - Added new TPM configuration.
 - * `syncGlobalTimeBase`
 - * `extTriggerPolarity`
 - * `chnlPolarity`
 - Added new PWM signal configuration.

- * secPauseLevel

- Bug Fixes
 - Fixed TPM_SetupPwm can't configure 0% combined PWM issues.

[2.1.1]

- Improvements
 - Add feature macro for PWM pause level select feature.

[2.1.0]

- Improvements
 - Added TPM_EnableChannel and TPM_DisableChannel APIs.
 - Added new PWM signal configuration.
 - * pauseLevel - Support select output level when counter first enabled or paused.
 - * enableComplementary - Support enable/disable generate complementary PWM signal.
 - * deadTimeValue - Support deadtime insertion for each pair of channels in combined PWM mode.
- Bug Fixes
 - Fixed issues about channel MSnB:MSnA and ELSnB:ELSnA bit fields and CnV register change request acknowledgement. Writes to these bits are ignored when the interval between successive writes is less than the TPM clock period.

[2.0.8]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 10.1, 10.4, 10.7 and 14.4.

[2.0.7]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 10.4 and 17.7.

[2.0.6]

- Bug Fixes
 - Fixed Out-of-bounds issue.

[2.0.5]

- Bug Fixes
 - Fixed MISRA-2012 rules.
 - * Rule 10.6, 10.7

[2.0.4]

- Bug Fixes
 - Fixed ERR050050 in functions TPM_SetupPwm/TPM_UpdatePwmDutycycle. When TPM was configured in EPWM mode as PS = 0, the compare event was missed on the first reload/overflow after writing 1 to the CnV register.

[2.0.3]

- Bug Fixes
 - MISRA-2012 issue fixed.
 - * Fixed rules: rule-12.1, rule-17.7, rule-16.3, rule-14.4, rule-1.3, rule-10.4, rule-10.3, rule-10.7, rule-10.1, rule-10.6, and rule-18.1.

[2.0.2]

- Bug Fixes
 - Fixed issues in functions TPM_SetupPwm/TPM_UpdateChnlEdgeLevelSelect/TPM_SetupInputCapture/TPM_SetupOutputCompare/TPM_SetupDualEdgeCapture, wait acknowledgement when the channel is disabled.

[2.0.1]

- Bug Fixes
 - Fixed TPM_UpdateChnlEdgeLevelSelect ACK wait issue.
 - Fixed the issue that TPM_SetupdualEdgeCapture could not set FILTER register.
 - Fixed TPM_UpdateChnlEdgeLevelSelect ACK wait issue.

[2.0.0]

- Initial version.
-

TRDC**[2.2.2]**

- Improvements
 - Update APIs to check whether the memory access configuration can be updated.
 - Update APIs to mask the MRC address since only high 18 bits are valid.

[2.2.1]

- Bug Fixes:
 - Fix MISRA violations.

[2.2.0]

- New Features:
 - Supported SoCs that do not have all TRDC modules.

[2.1.0]

- Bug Fixes:
 - Fix MISRA violations.
 - Fixed wrong operation of domain mask in TRDC_MbcNseClearAll and TRDC_MrcDomainNseClear.

[2.0.0]

- Initial version.
-

TSTMR

[2.1.0]

- New Features
 - Support configured clock frequency.
 - Add TSTMR_Init and TSTMR_init APIs.
- Improvements
 - Change TSTMR_DelayUs from static inline function to normal function.

[2.0.4]

- Bugfix
 - Fix MISRA C-2012 Rule 10.4 and 14.4 issues.

[2.0.3]

- Bugfix
 - Fix CERT INT30-C that Unsigned integer operation TSTMR_ReadTimeStamp(base) - startTime may wrap.

[2.0.2]

- Improvements
 - Support 24MHz clock source.
- Bugfix
 - Fix MISRA C-2012 Rule 10.4 issue.
 - Read of TSTMR HIGH must follow TSTMR LOW atomically: require masking interrupt around 2 LSB / MSB accesses.

[2.0.1]

- Bugfix
 - Restrict to read with 32-bit accesses only.
 - Restrict that TSTMR LOW read occurs first, followed by the TSTMR HIGH read.

[2.0.0]

- Initial version.
-

WDOG32**[2.2.1]**

- Bug Fixes
 - Fix CERT INT31-C that the bool value shall be converted to unsigned int 0 or 1 then passed to registers.
 - Fix MISRA 2012 20.3 violation.

[2.2.0]

- Improvements
 - Added while loop timeout config value for WDOG32 reconfiguration and unlock sequence.
 - Change the return type of WDOG32_Init, WDOG32_Deinit and WDOG32_Unlock from void to status_t.

[2.1.0]

- Improvements
 - Release peripheral from reset if necessary in init function.

[2.0.4]

- Improvements
 - To ensure that the reconfiguration is inside 128 bus clocks unlock window, put all reconfiguration APIs in quick access code section.

[2.0.3]

- Bug Fixes
 - Fixed the noncompliance issue of the reference document.
 - * Waited until for new configuration to take effect by checking the RCS bit field.
 - * Waited until for registers to be unlocked by checking the ULK bit field.
- Improvements
 - Added 128 bus clocks delay ensures a smooth transition before restarting the counter with the new configuration when there is no RCS status bit.

[2.0.2]

- Bug Fixes
 - MISRA C-2012 issue fixed.
 - * Fixed rules, containing: rule-10.3, rule-14.4, rule-15.5.
 - Fixed the issue of the inseparable process interrupted by other interrupt source.
 - * WDOG32_Refresh

[2.0.1]

- Bug Fixes
 - WDOG must be configured within its configuration time period.
 - * Added WDOG32_Init API to quick access section.
 - * Defined register variable in WDOG32_Init API.

[2.0.0]

- Initial version.
-

1.6 Driver API Reference Manual

This section provides a link to the Driver API RM, detailing available drivers and their usage to help you integrate hardware efficiently.

[MIMX9322](#)

1.7 Middleware Documentation

Find links to detailed middleware documentation for key components. While not all onboard middleware is covered, this serves as a useful reference for configuration and development.

1.7.1 Multicore

[Multicore SDK](#)

1.7.2 FreeMASTER

[freemaster](#)

1.7.3 FreeRTOS

[FreeRTOS](#)

1.7.4 lwIP

lwIP

Chapter 2

MIMX9322

2.1 eDMA: Enhanced Direct Memory Access (eDMA) Controller Driver

void EDMA_Init(*EDMA_Type* *base, const *edma_config_t* *config)

Initializes the eDMA peripheral.

This function ungates the eDMA clock and configures the eDMA peripheral according to the configuration structure. All emda enabled request will be cleared in this function.

Note: This function enables the minor loop map feature.

Parameters

- base – eDMA peripheral base address.
- config – A pointer to the configuration structure, see “edma_config_t”.

void EDMA_Deinit(*EDMA_Type* *base)

Deinitializes the eDMA peripheral.

This function gates the eDMA clock.

Parameters

- base – eDMA peripheral base address.

void EDMA_InstallTCD(*EDMA_Type* *base, uint32_t channel, *edma_tcd_t* *tcd)

Push content of TCD structure into hardware TCD register.

Parameters

- base – EDMA peripheral base address.
- channel – EDMA channel number.
- tcd – Point to TCD structure.

void EDMA_GetDefaultConfig(*edma_config_t* *config)

Gets the eDMA default configuration structure.

This function sets the configuration structure to default values. The default configuration is set to the following values.

```
config.enableContinuousLinkMode = false;
config.enableHaltOnError = true;
config.enableRoundRobinArbitration = false;
config.enableDebugMode = false;
```

Parameters

- config – A pointer to the eDMA configuration structure.

```
void EDMA__InitChannel(EDMA_Type *base, uint32_t channel, edma_channel_config_t
                      *channelConfig)
```

EDMA Channel initialization.

Parameters

- base – eDMA4 peripheral base address.
- channel – eDMA4 channel number.
- channelConfig – pointer to user's eDMA4 channel config structure, see *edma_channel_config_t* for detail.

```
static inline void EDMA__SetChannelMemoryAttribute(EDMA_Type *base, uint32_t channel,
                                                    edma_channel_memory_attribute_t
                                                    writeAttribute,
                                                    edma_channel_memory_attribute_t
                                                    readAttribute)
```

Set channel memory attribute.

Parameters

- base – eDMA4 peripheral base address.
- channel – eDMA4 channel number.
- writeAttribute – Attributes associated with a write transaction.
- readAttribute – Attributes associated with a read transaction.

```
static inline void EDMA__SetChannelSignExtension(EDMA_Type *base, uint32_t channel, uint8_t
                                                  position)
```

Set channel sign extension.

Parameters

- base – eDMA4 peripheral base address.
- channel – eDMA4 channel number.
- position – A non-zero value specifying the sign extend bit position. If 0, sign extension is disabled.

```
static inline void EDMA__SetChannelSwapSize(EDMA_Type *base, uint32_t channel,
                                             edma_channel_swap_size_t swapSize)
```

Set channel swap size.

Parameters

- base – eDMA4 peripheral base address.
- channel – eDMA4 channel number.
- swapSize – Swap occurs with respect to the specified transfer size. If 0, swap is disabled.

```
static inline void EDMA_SetChannelAccessType(EDMA_Type *base, uint32_t channel,  
                                             edma_channel_access_type_t  
                                             channelAccessType)
```

Set channel access type.

Parameters

- base – eDMA4 peripheral base address.
- channel – eDMA4 channel number.
- channelAccessType – eDMA4's transactions type on the system bus when the channel is active.

```
static inline void EDMA_SetChannelMux(EDMA_Type *base, uint32_t channel, uint32_t  
                                     channelRequestSource)
```

Set channel request source.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.
- channelRequestSource – eDMA hardware service request source for the channel. User need to use the `dma_request_source_t` type as the input parameter. Note that devices may use other enum type to express dma request source and User can find it in SOC header or `fsl_edma_soc.h`.

```
static inline uint32_t EDMA_GetChannelSystemBusInformation(EDMA_Type *base, uint32_t  
                                                         channel)
```

Gets the channel identification and attribute information on the system bus interface.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.

Returns

The mask of the channel system bus information. Users need to use the `_edma_channel_sys_bus_info` type to decode the return variables.

```
static inline void EDMA_EnableChannelMasterIDReplication(EDMA_Type *base, uint32_t  
                                                         channel, bool enable)
```

Set channel master ID replication.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.
- enable – true is enable, false is disable.

```
static inline void EDMA_SetChannelSecurityLevel(EDMA_Type *base, uint32_t channel,  
                                                edma_channel_security_level_t level)
```

Set channel security level.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.
- level – security level.

```
static inline void EDMA_SetChannelProtectionLevel(EDMA_Type *base, uint32_t channel,  
                                                edma_channel_protection_level_t level)
```

Set channel security level.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.
- level – security level.

```
void EDMA_ResetChannel(EDMA_Type *base, uint32_t channel)
```

Sets all TCD registers to default values.

This function sets TCD registers for this channel to default values.

Note: This function must not be called while the channel transfer is ongoing or it causes unpredictable results.

Note: This function enables the auto stop request feature.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.

```
void EDMA_SetTransferConfig(EDMA_Type *base, uint32_t channel, const  
                           edma_transfer_config_t *config, edma_tcd_t *nextTcd)
```

Configures the eDMA transfer attribute.

This function configures the transfer attribute, including source address, destination address, transfer size, address offset, and so on. It also configures the scatter gather feature if the user supplies the TCD address. Example:

```
edma_transfer_t config;  
edma_tcd_t tcd;  
config.srcAddr = ..;  
config.destAddr = ..;  
...  
EDMA_SetTransferConfig(DMA0, channel, &config, &tcd);
```

Note: If nextTcd is not NULL, it means scatter gather feature is enabled and DREQ bit is cleared in the previous transfer configuration, which is set in the EDMA_ResetChannel.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.
- config – Pointer to eDMA transfer configuration structure.
- nextTcd – Point to TCD structure. It can be NULL if users do not want to enable scatter/gather feature.

```
void EDMA_SetMinorOffsetConfig(EDMA_Type *base, uint32_t channel, const  
                              edma_minor_offset_config_t *config)
```

Configures the eDMA minor offset feature.

The minor offset means that the signed-extended value is added to the source address or destination address after each minor loop.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.
- config – A pointer to the minor offset configuration structure.

```
void EDMA_SetChannelPreemptionConfig(EDMA_Type *base, uint32_t channel, const  
                                     edma_channel_preemption_config_t *config)
```

Configures the eDMA channel preemption feature.

This function configures the channel preemption attribute and the priority of the channel.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number
- config – A pointer to the channel preemption configuration structure.

```
void EDMA_SetChannelLink(EDMA_Type *base, uint32_t channel, edma_channel_link_type_t  
                        type, uint32_t linkedChannel)
```

Sets the channel link for the eDMA transfer.

This function configures either the minor link or the major link mode. The minor link means that the channel link is triggered every time CITER decreases by 1. The major link means that the channel link is triggered when the CITER is exhausted.

Note: Users should ensure that DONE flag is cleared before calling this interface, or the configuration is invalid.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.
- type – A channel link type, which can be one of the following:
 - kEDMA_LinkNone
 - kEDMA_MinorLink
 - kEDMA_MajorLink
- linkedChannel – The linked channel number.

```
void EDMA_SetBandWidth(EDMA_Type *base, uint32_t channel, edma_bandwidth_t  
                      bandwidth)
```

Sets the bandwidth for the eDMA transfer.

Because the eDMA processes the minor loop, it continuously generates read/write sequences until the minor count is exhausted. The bandwidth forces the eDMA to stall after the completion of each read/write access to control the bus request bandwidth seen by the crossbar switch.

Parameters

- base – eDMA peripheral base address.

- channel – eDMA channel number.
- bandWidth – A bandwidth setting, which can be one of the following:
 - kEDMABandwidthStallNone
 - kEDMABandwidthStall4Cycle
 - kEDMABandwidthStall8Cycle

```
void EDMA__SetModulo(EDMA_Type *base, uint32_t channel, edma_modulo_t srcModulo,  
                    edma_modulo_t destModulo)
```

Sets the source modulo and the destination modulo for the eDMA transfer.

This function defines a specific address range specified to be the value after (SADDR + SOFF)/(DADDR + DOFF) calculation is performed or the original register value. It provides the ability to implement a circular data queue easily.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.
- srcModulo – A source modulo value.
- destModulo – A destination modulo value.

```
static inline void EDMA__EnableAutoStopRequest(EDMA_Type *base, uint32_t channel, bool  
                                              enable)
```

Enables an auto stop request for the eDMA transfer.

If enabling the auto stop request, the eDMA hardware automatically disables the hardware channel request.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.
- enable – The command to enable (true) or disable (false).

```
void EDMA__EnableChannelInterrupts(EDMA_Type *base, uint32_t channel, uint32_t mask)
```

Enables the interrupt source for the eDMA transfer.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.
- mask – The mask of interrupt source to be set. Users need to use the defined `edma_interrupt_enable_t` type.

```
void EDMA__DisableChannelInterrupts(EDMA_Type *base, uint32_t channel, uint32_t mask)
```

Disables the interrupt source for the eDMA transfer.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.
- mask – The mask of the interrupt source to be set. Use the defined `edma_interrupt_enable_t` type.

```
void EDMA_SetMajorOffsetConfig(EDMA_Type *base, uint32_t channel, int32_t sourceOffset,  
                               int32_t destOffset)
```

Configures the eDMA channel TCD major offset feature.

Adjustment value added to the source address at the completion of the major iteration count

Parameters

- base – eDMA peripheral base address.
- channel – edma channel number.
- sourceOffset – source address offset will be applied to source address after major loop done.
- destOffset – destination address offset will be applied to source address after major loop done.

```
void EDMA_ConfigChannelSoftwareTCD(edma_tcd_t *tcd, const edma_transfer_config_t  
                                   *transfer)
```

Sets TCD fields according to the user's channel transfer configuration structure, *edma_transfer_config_t*.

@Note This API only supports EDMA4 TCD type. It can be used to support all types with extension API *EDMA_ConfigChannelSoftwareTCDExt*

Application should be careful about the TCD pool buffer storage class,

- For the platform has cache, the software TCD should be put in non cache section
- The TCD pool buffer should have a consistent storage class.

Note: This function enables the auto stop request feature.

Parameters

- tcd – Pointer to the TCD structure.
- transfer – channel transfer configuration pointer.

```
void EDMA_TcdReset(edma_tcd_t *tcd)
```

Sets all fields to default values for the TCD structure.

@Note This API only supports EDMA4 TCD type. It can be used to support all types with extension API *EDMA_TcdResetExt*

This function sets all fields for this TCD structure to default value.

Note: This function enables the auto stop request feature.

Parameters

- tcd – Pointer to the TCD structure.

```
void EDMA_TcdSetTransferConfig(edma_tcd_t *tcd, const edma_transfer_config_t *config,  
                               edma_tcd_t *nextTcd)
```

Configures the eDMA TCD transfer attribute.

@Note This API only supports EDMA4 TCD type. It can be used to support all types with extension API *EDMA_TcdSetTransferConfigExt*

The TCD is a transfer control descriptor. The content of the TCD is the same as the hardware TCD registers. The TCD is used in the scatter-gather mode. This function configures the TCD transfer attribute, including source address, destination address, transfer size, address

offset, and so on. It also configures the scatter gather feature if the user supplies the next TCD address. Example:

```
edma_transfer_t config = {  
...  
}  
edma_tcd_t tcd __aligned(32);  
edma_tcd_t nextTcd __aligned(32);  
EDMA_TcdSetTransferConfig(&tcd, &config, &nextTcd);
```

Note: TCD address should be 32 bytes aligned or it causes an eDMA error.

Note: If the nextTcd is not NULL, the scatter gather feature is enabled and DREQ bit is cleared in the previous transfer configuration, which is set in the EDMA_TcdReset.

Parameters

- tcd – Pointer to the TCD structure.
- config – Pointer to eDMA transfer configuration structure.
- nextTcd – Pointer to the next TCD structure. It can be NULL if users do not want to enable scatter/gather feature.

```
void EDMA_TcdSetMinorOffsetConfig(edma_tcd_t *tcd, const edma_minor_offset_config_t  
                                *config)
```

Configures the eDMA TCD minor offset feature.

@Note This API only supports EDMA4 TCD type. It can be used to support all types with extension API EDMA_TcdSetMinorOffsetConfigExt

A minor offset is a signed-extended value added to the source address or a destination address after each minor loop.

Parameters

- tcd – A point to the TCD structure.
- config – A pointer to the minor offset configuration structure.

```
void EDMA_TcdSetChannelLink(edma_tcd_t *tcd, edma_channel_link_type_t type, uint32_t  
                           linkedChannel)
```

Sets the channel link for the eDMA TCD.

@Note This API only supports EDMA4 TCD type. It can be used to support all types with extension API EDMA_TcdSetChannelLinkExt

This function configures either a minor link or a major link. The minor link means the channel link is triggered every time CITER decreases by 1. The major link means that the channel link is triggered when the CITER is exhausted.

Note: Users should ensure that DONE flag is cleared before calling this interface, or the configuration is invalid.

Parameters

- tcd – Point to the TCD structure.
- type – Channel link type, it can be one of:
 - kEDMA_LinkNone

- kEDMA_MinorLink
- kEDMA_MajorLink
- linkedChannel – The linked channel number.

static inline void EDMA_TcdSetBandWidth(*edma_tcd_t* *tcd, *edma_bandwidth_t* bandWidth)

Sets the bandwidth for the eDMA TCD.

@Note This API only supports EDMA4 TCD type. It can be used to support all types with extension API EDMA_TcdSetBandWidthExt

Because the eDMA processes the minor loop, it continuously generates read/write sequences until the minor count is exhausted. The bandwidth forces the eDMA to stall after the completion of each read/write access to control the bus request bandwidth seen by the crossbar switch.

Parameters

- tcd – A pointer to the TCD structure.
- bandWidth – A bandwidth setting, which can be one of the following:
 - kEDMABandwidthStallNone
 - kEDMABandwidthStall4Cycle
 - kEDMABandwidthStall8Cycle

void EDMA_TcdSetModulo(*edma_tcd_t* *tcd, *edma_modulo_t* srcModulo, *edma_modulo_t* destModulo)

Sets the source modulo and the destination modulo for the eDMA TCD.

@Note This API only supports EDMA4 TCD type. It can be used to support all types with extension API EDMA_TcdSetModuloExt

This function defines a specific address range specified to be the value after (SADDR + SOFF)/(DADDR + DOFF) calculation is performed or the original register value. It provides the ability to implement a circular data queue easily.

Parameters

- tcd – A pointer to the TCD structure.
- srcModulo – A source modulo value.
- destModulo – A destination modulo value.

static inline void EDMA_TcdEnableAutoStopRequest(*edma_tcd_t* *tcd, bool enable)

Sets the auto stop request for the eDMA TCD.

@Note This API only supports EDMA4 TCD type. It can be used to support all types with extension API EDMA_TcdEnableAutoStopRequestExt

If enabling the auto stop request, the eDMA hardware automatically disables the hardware channel request.

Parameters

- tcd – A pointer to the TCD structure.
- enable – The command to enable (true) or disable (false).

void EDMA_TcdEnableInterrupts(*edma_tcd_t* *tcd, uint32_t mask)

Enables the interrupt source for the eDMA TCD.

@Note This API only supports EDMA4 TCD type. It can be used to support all types with extension API EDMA_TcdEnableInterruptsExt

Parameters

- `tcd` – Point to the TCD structure.
- `mask` – The mask of interrupt source to be set. Users need to use the defined `edma_interrupt_enable_t` type.

`void EDMA__TcdDisableInterrupts(edma_tcd_t *tcd, uint32_t mask)`

Disables the interrupt source for the eDMA TCD.

@Note This API only supports EDMA4 TCD type. It can be used to support all types with extension API `EDMA__TcdDisableInterruptsExt`

Parameters

- `tcd` – Point to the TCD structure.
- `mask` – The mask of interrupt source to be set. Users need to use the defined `edma_interrupt_enable_t` type.

`void EDMA__TcdSetMajorOffsetConfig(edma_tcd_t *tcd, int32_t sourceOffset, int32_t destOffset)`

Configures the eDMA TCD major offset feature.

@Note This API only supports EDMA4 TCD type. It can be used to support all types with extension API `EDMA__TcdSetMajorOffsetConfigExt`

Adjustment value added to the source address at the completion of the major iteration count

Parameters

- `tcd` – A point to the TCD structure.
- `sourceOffset` – source address offset will be applied to source address after major loop done.
- `destOffset` – destination address offset will be applied to source address after major loop done.

`void EDMA__ConfigChannelSoftwareTCDExt(EDMA_Type *base, edma_tcd_t *tcd, const edma_transfer_config_t *transfer)`

Sets TCD fields according to the user's channel transfer configuration structure, `edma_transfer_config_t`.

Application should be careful about the TCD pool buffer storage class,

- For the platform has cache, the software TCD should be put in non cache section
- The TCD pool buffer should have a consistent storage class.

Note: This function enables the auto stop request feature.

Parameters

- `base` – eDMA peripheral base address.
- `tcd` – Pointer to the TCD structure.
- `transfer` – channel transfer configuration pointer.

`void EDMA__TcdResetExt(EDMA_Type *base, edma_tcd_t *tcd)`

Sets all fields to default values for the TCD structure.

This function sets all fields for this TCD structure to default value.

Note: This function enables the auto stop request feature.

Parameters

- base – eDMA peripheral base address.
- tcd – Pointer to the TCD structure.

```
void EDMA_TcdSetTransferConfigExt(EDMA_Type *base, edma_tcd_t *tcd, const
                                edma_transfer_config_t *config, edma_tcd_t *nextTcd)
```

Configures the eDMA TCD transfer attribute.

The TCD is a transfer control descriptor. The content of the TCD is the same as the hardware TCD registers. The TCD is used in the scatter-gather mode. This function configures the TCD transfer attribute, including source address, destination address, transfer size, address offset, and so on. It also configures the scatter gather feature if the user supplies the next TCD address. Example:

```
edma_transfer_t config = {
...
}
edma_tcd_t tcd __aligned(32);
edma_tcd_t nextTcd __aligned(32);
EDMA_TcdSetTransferConfig(&tcd, &config, &nextTcd);
```

Note: TCD address should be 32 bytes aligned or it causes an eDMA error.

Note: If the nextTcd is not NULL, the scatter gather feature is enabled and DREQ bit is cleared in the previous transfer configuration, which is set in the EDMA_TcdReset.

Parameters

- base – eDMA peripheral base address.
- tcd – Pointer to the TCD structure.
- config – Pointer to eDMA transfer configuration structure.
- nextTcd – Pointer to the next TCD structure. It can be NULL if users do not want to enable scatter/gather feature.

```
void EDMA_TcdSetMinorOffsetConfigExt(EDMA_Type *base, edma_tcd_t *tcd, const
                                     edma_minor_offset_config_t *config)
```

Configures the eDMA TCD minor offset feature.

A minor offset is a signed-extended value added to the source address or a destination address after each minor loop.

Parameters

- base – eDMA peripheral base address.
- tcd – A point to the TCD structure.
- config – A pointer to the minor offset configuration structure.

```
void EDMA_TcdSetChannelLinkExt(EDMA_Type *base, edma_tcd_t *tcd,
                              edma_channel_link_type_t type, uint32_t linkedChannel)
```

Sets the channel link for the eDMA TCD.

This function configures either a minor link or a major link. The minor link means the channel link is triggered every time CITER decreases by 1. The major link means that the channel link is triggered when the CITER is exhausted.

Note: Users should ensure that DONE flag is cleared before calling this interface, or the configuration is invalid.

Parameters

- base – eDMA peripheral base address.
- tcd – Point to the TCD structure.
- type – Channel link type, it can be one of:
 - kEDMA_LinkNone
 - kEDMA_MinorLink
 - kEDMA_MajorLink
- linkedChannel – The linked channel number.

```
static inline void EDMA__TcdSetBandWidthExt(EDMA_Type *base, edma_tcd_t *tcd,  
                                             edma_bandwidth_t bandWidth)
```

Sets the bandwidth for the eDMA TCD.

Because the eDMA processes the minor loop, it continuously generates read/write sequences until the minor count is exhausted. The bandwidth forces the eDMA to stall after the completion of each read/write access to control the bus request bandwidth seen by the crossbar switch.

Parameters

- base – eDMA peripheral base address.
- tcd – A pointer to the TCD structure.
- bandWidth – A bandwidth setting, which can be one of the following:
 - kEDMABandwidthStallNone
 - kEDMABandwidthStall4Cycle
 - kEDMABandwidthStall8Cycle

```
void EDMA__TcdSetModuloExt(EDMA_Type *base, edma_tcd_t *tcd, edma_modulo_t srcModulo,  
                          edma_modulo_t destModulo)
```

Sets the source modulo and the destination modulo for the eDMA TCD.

This function defines a specific address range specified to be the value after (SADDR + SOFF)/(DADDR + DOFF) calculation is performed or the original register value. It provides the ability to implement a circular data queue easily.

Parameters

- base – eDMA peripheral base address.
- tcd – A pointer to the TCD structure.
- srcModulo – A source modulo value.
- destModulo – A destination modulo value.

```
static inline void EDMA__TcdEnableAutoStopRequestExt(EDMA_Type *base, edma_tcd_t *tcd,  
                                                    bool enable)
```

Sets the auto stop request for the eDMA TCD.

If enabling the auto stop request, the eDMA hardware automatically disables the hardware channel request.

Parameters

- base – eDMA peripheral base address.
- tcd – A pointer to the TCD structure.
- enable – The command to enable (true) or disable (false).

void EDMA__TcdEnableInterruptsExt(*EDMA_Type* *base, *edma_tcd_t* *tcd, uint32_t mask)

Enables the interrupt source for the eDMA TCD.

Parameters

- base – eDMA peripheral base address.
- tcd – Point to the TCD structure.
- mask – The mask of interrupt source to be set. Users need to use the defined *edma_interrupt_enable_t* type.

void EDMA__TcdDisableInterruptsExt(*EDMA_Type* *base, *edma_tcd_t* *tcd, uint32_t mask)

Disables the interrupt source for the eDMA TCD.

Parameters

- base – eDMA peripheral base address.
- tcd – Point to the TCD structure.
- mask – The mask of interrupt source to be set. Users need to use the defined *edma_interrupt_enable_t* type.

void EDMA__TcdSetMajorOffsetConfigExt(*EDMA_Type* *base, *edma_tcd_t* *tcd, int32_t sourceOffset, int32_t destOffset)

Configures the eDMA TCD major offset feature.

Adjustment value added to the source address at the completion of the major iteration count

Parameters

- base – eDMA peripheral base address.
- tcd – A point to the TCD structure.
- sourceOffset – source address offset will be applied to source address after major loop done.
- destOffset – destination address offset will be applied to source address after major loop done.

static inline void EDMA__EnableChannelRequest(*EDMA_Type* *base, uint32_t channel)

Enables the eDMA hardware channel request.

This function enables the hardware channel request.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.

static inline void EDMA__DisableChannelRequest(*EDMA_Type* *base, uint32_t channel)

Disables the eDMA hardware channel request.

This function disables the hardware channel request.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.

static inline void EDMA_TriggerChannelStart(*EDMA_Type* *base, uint32_t channel)

Starts the eDMA transfer by using the software trigger.

This function starts a minor loop transfer.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.

uint32_t EDMA_GetRemainingMajorLoopCount(*EDMA_Type* *base, uint32_t channel)

Gets the remaining major loop count from the eDMA current channel TCD.

This function checks the TCD (Task Control Descriptor) status for a specified eDMA channel and returns the number of major loop count that has not finished.

Note: 1. This function can only be used to get unfinished major loop count of transfer without the next TCD, or it might be inaccuracy.

- a. The unfinished/remaining transfer bytes cannot be obtained directly from registers while the channel is running. Because to calculate the remaining bytes, the initial NBYTES configured in DMA_TCDn_NBYTES_MLNO register is needed while the eDMA IP does not support getting it while a channel is active. In another word, the NBYTES value reading is always the actual (decrementing) NBYTES value the dma_engine is working with while a channel is running. Consequently, to get the remaining transfer bytes, a software-saved initial value of NBYTES (for example copied before enabling the channel) is needed. The formula to calculate it is shown below: RemainingBytes = RemainingMajorLoopCount * NBYTES(initially configured)
-

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.

Returns

Major loop count which has not been transferred yet for the current TCD.

static inline uint32_t EDMA_GetErrorStatusFlags(*EDMA_Type* *base)

Gets the eDMA channel error status flags.

Parameters

- base – eDMA peripheral base address.

Returns

The mask of error status flags. Users need to use the `_edma_error_status_flags` type to decode the return variables.

uint32_t EDMA_GetChannelStatusFlags(*EDMA_Type* *base, uint32_t channel)

Gets the eDMA channel status flags.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.

Returns

The mask of channel status flags. Users need to use the `_edma_channel_status_flags` type to decode the return variables.

`void EDMA_ClearChannelStatusFlags(EDMA_Type *base, uint32_t channel, uint32_t mask)`
 Clears the eDMA channel status flags.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.
- mask – The mask of channel status to be cleared. Users need to use the defined `_edma_channel_status_flags` type.

`status_t EDMA_CreateHandle(edma_handle_t *handle, EDMA_Type *base, uint32_t channel)`
 Creates the eDMA handle.

This function is called if using the transactional API for eDMA. This function initializes the internal state of the eDMA handle.

Parameters

- handle – eDMA handle pointer. The eDMA handle stores callback function and parameters.
- base – eDMA peripheral base address.
- channel – eDMA channel number.

Return values

- `kStatus_Success` –
- `kStatus_InvalidArgument` –

`void EDMA_InstallTCDMemory(edma_handle_t *handle, edma_tcd_t *tcdPool, uint32_t tcdSize)`
 Installs the TCDs memory pool into the eDMA handle.

This function is called after the `EDMA_CreateHandle` to use scatter/gather feature. This function shall only be used while users need to use scatter gather mode. Scatter gather mode enables EDMA to load a new transfer control block (tcd) in hardware, and automatically reconfigure that DMA channel for a new transfer. Users need to prepare tcd memory and also configure tcds using interface `EDMA_SubmitTransfer`.

Parameters

- handle – eDMA handle pointer.
- tcdPool – A memory pool to store TCDs. It must be 32 bytes aligned.
- tcdSize – The number of TCD slots.

`void EDMA_SetCallback(edma_handle_t *handle, edma_callback callback, void *userData)`
 Installs a callback function for the eDMA transfer.

This callback is called in the eDMA IRQ handler. Use the callback to do something after the current major loop transfer completes. This function will be called every time one tcd finished transfer.

Parameters

- handle – eDMA handle pointer.
- callback – eDMA callback function pointer.
- userData – A parameter for the callback function.

`void EDMA_PrepareTransferConfig(edma_transfer_config_t *config, void *srcAddr, uint32_t srcWidth, int16_t srcOffset, void *destAddr, uint32_t destWidth, int16_t destOffset, uint32_t bytesEachRequest, uint32_t transferBytes)`

Prepares the eDMA transfer structure configurations.

This function prepares the transfer configuration structure according to the user input.

Note: The data address and the data width must be consistent. For example, if the SRC is 4 bytes, the source address must be 4 bytes aligned, or it results in source address error (SAE). User can check if 128 bytes support is available for specific instance by FSL_FEATURE_EDMA_INSTANCE_SUPPORT_128_BYTES_TRANSFERn.

Parameters

- config – The user configuration structure of type `edma_transfer_t`.
- srcAddr – eDMA transfer source address.
- srcWidth – eDMA transfer source address width(bytes).
- srcOffset – source address offset.
- destAddr – eDMA transfer destination address.
- destWidth – eDMA transfer destination address width(bytes).
- destOffset – destination address offset.
- bytesEachRequest – eDMA transfer bytes per channel request.
- transferBytes – eDMA transfer bytes to be transferred.

```
void EDMA__PrepareTransfer(edma_transfer_config_t *config, void *srcAddr, uint32_t srcWidth,  
                           void *destAddr, uint32_t destWidth, uint32_t bytesEachRequest,  
                           uint32_t transferBytes, edma_transfer_type_t type)
```

Prepares the eDMA transfer structure.

This function prepares the transfer configuration structure according to the user input.

Note: The data address and the data width must be consistent. For example, if the SRC is 4 bytes, the source address must be 4 bytes aligned, or it results in source address error (SAE).

Parameters

- config – The user configuration structure of type `edma_transfer_t`.
- srcAddr – eDMA transfer source address.
- srcWidth – eDMA transfer source address width(bytes).
- destAddr – eDMA transfer destination address.
- destWidth – eDMA transfer destination address width(bytes).
- bytesEachRequest – eDMA transfer bytes per channel request.
- transferBytes – eDMA transfer bytes to be transferred.
- type – eDMA transfer type.

```
void EDMA__PrepareTransferTCD(edma_handle_t *handle, edma_tcd_t *tcd, void *srcAddr,  
                             uint32_t srcWidth, int16_t srcOffset, void *destAddr, uint32_t  
                             destWidth, int16_t destOffset, uint32_t bytesEachRequest,  
                             uint32_t transferBytes, edma_tcd_t *nextTcd)
```


Prepares the eDMA transfer content descriptor.

This function prepares the transfer content descriptor structure according to the user input.

Note: The data address and the data width must be consistent. For example, if the SRC is 4 bytes, the source address must be 4 bytes aligned, or it results in source address error (SAE).

Parameters

- `handle` – eDMA handle pointer.
- `tcd` – Pointer to eDMA transfer content descriptor structure.
- `srcAddr` – eDMA transfer source address.
- `srcWidth` – eDMA transfer source address width(bytes).
- `srcOffset` – source address offset.
- `destAddr` – eDMA transfer destination address.
- `destWidth` – eDMA transfer destination address width(bytes).
- `destOffset` – destination address offset.
- `bytesEachRequest` – eDMA transfer bytes per channel request.
- `transferBytes` – eDMA transfer bytes to be transferred.
- `nextTcd` – eDMA transfer linked TCD address.

status_t EDMA_SubmitTransferTCD(*edma_handle_t* *handle, *edma_tcd_t* *tcd)

Submits the eDMA transfer content descriptor.

This function submits the eDMA transfer request according to the transfer content descriptor. In scatter gather mode, call this function will add a configured tcd to the circular list of tcd pool. The tcd pools is setup by call function EDMA_InstallTCDMemory before.

Typical user case:

a. submit single transfer

```
edma_tcd_t tcd;
EDMA_PrepareTransferTCD(handle, &tcd, ...)
EDMA_SubmitTransferTCD(handle, tcd)
EDMA_StartTransfer(handle)
```

b. submit static link transfer,

```
edma_tcd_t tcd[2];
EDMA_PrepareTransferTCD(handle, &tcd[0], ...)
EDMA_PrepareTransferTCD(handle, &tcd[1], ...)
EDMA_SubmitTransferTCD(handle, &tcd[0])
EDMA_StartTransfer(handle)
```

c. submit dynamic link transfer

```
edma_tcd_t tcdpool[2];
EDMA_InstallTCDMemory(&g_DMA_Handle, tcdpool, 2);
edma_tcd_t tcd;
EDMA_PrepareTransferTCD(handle, tcd, ...)
EDMA_SubmitTransferTCD(handle, tcd)
EDMA_PrepareTransferTCD(handle, tcd, ...)
```

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```
EDMA_SubmitTransferTCD(handle, tcd)
EDMA_StartTransfer(handle)
```

d. submit loop transfer

```
edma_tcd_t tcd[2];
EDMA_PrepareTransferTCD(handle, &tcd[0], ..., &tcd[1])
EDMA_PrepareTransferTCD(handle, &tcd[1], ..., &tcd[0])
EDMA_SubmitTransferTCD(handle, &tcd[0])
EDMA_StartTransfer(handle)
```

Parameters

- handle – eDMA handle pointer.
- tcd – Pointer to eDMA transfer content descriptor structure.

Return values

- kStatus_EDMA_Success – It means submit transfer request succeed.
- kStatus_EDMA_QueueFull – It means TCD queue is full. Submit transfer request is not allowed.
- kStatus_EDMA_Busy – It means the given channel is busy, need to submit request later.

status_t EDMA_SubmitTransfer(*edma_handle_t* *handle, const *edma_transfer_config_t* *config)

Submits the eDMA transfer request.

This function submits the eDMA transfer request according to the transfer configuration structure. In scatter gather mode, call this function will add a configured tcd to the circular list of tcd pool. The tcd pools is setup by call function EDMA_InstallTCMemory before.

Parameters

- handle – eDMA handle pointer.
- config – Pointer to eDMA transfer configuration structure.

Return values

- kStatus_EDMA_Success – It means submit transfer request succeed.
- kStatus_EDMA_QueueFull – It means TCD queue is full. Submit transfer request is not allowed.
- kStatus_EDMA_Busy – It means the given channel is busy, need to submit request later.

status_t EDMA_SubmitLoopTransfer(*edma_handle_t* *handle, *edma_transfer_config_t* *transfer, *uint32_t* transferLoopCount)

Submits the eDMA scatter gather transfer configurations.

The function is target for submit loop transfer request, the ring transfer request means that the transfer request TAIL is link to HEAD, such as, A->B->C->D->A, or A->A

To use the ring transfer feature, the application should allocate several transfer object, such as

```
edma_channel_transfer_config_t transfer[2];
EDMA_TransferSubmitLoopTransfer(psHandle, &transfer, 2U);
```

Then eDMA driver will link transfer[0] and transfer[1] to each other

Note: Application should check the return value of this function to avoid transfer request submit failed

Parameters

- `handle` – eDMA handle pointer
- `transfer` – pointer to user's eDMA channel configure structure, see `edma_channel_transfer_config_t` for detail
- `transferLoopCount` – the count of the transfer ring, if loop count is 1, that means that the one will link to itself.

Return values

- `kStatus_Success` – It means submit transfer request succeed
- `kStatus_EDMA_Busy` – channel is in busy status
- `kStatus_InvalidArgument` – Invalid Argument

`void EDMA_StartTransfer(edma_handle_t *handle)`

eDMA starts transfer.

This function enables the channel request. Users can call this function after submitting the transfer request or before submitting the transfer request.

Parameters

- `handle` – eDMA handle pointer.

`void EDMA_StopTransfer(edma_handle_t *handle)`

eDMA stops transfer.

This function disables the channel request to pause the transfer. Users can call `EDMA_StartTransfer()` again to resume the transfer.

Parameters

- `handle` – eDMA handle pointer.

`void EDMA_AbortTransfer(edma_handle_t *handle)`

eDMA aborts transfer.

This function disables the channel request and clear transfer status bits. Users can submit another transfer after calling this API.

Parameters

- `handle` – DMA handle pointer.

`static inline uint32_t EDMA_GetUnusedTCDNumber(edma_handle_t *handle)`

Get unused TCD slot number.

This function gets current tcd index which is run. If the TCD pool pointer is NULL, it will return 0.

Parameters

- `handle` – DMA handle pointer.

Returns

The unused tcd slot number.

`static inline uint32_t EDMA_GetNextTCDAddress(edma_handle_t *handle)`

Get the next tcd address.

This function gets the next tcd address. If this is last TCD, return 0.

Parameters

- handle – DMA handle pointer.

Returns

The next TCD address.

void EDMA_HandleIRQ(*edma_handle_t* *handle)

eDMA IRQ handler for the current major loop transfer completion.

This function clears the channel major interrupt flag and calls the callback function if it is not NULL.

Note: For the case using TCD queue, when the major iteration count is exhausted, additional operations are performed. These include the final address adjustments and reloading of the BITER field into the CITER. Assertion of an optional interrupt request also occurs at this time, as does a possible fetch of a new TCD from memory using the scatter/gather address pointer included in the descriptor (if scatter/gather is enabled).

For instance, when the time interrupt of TCD[0] happens, the TCD[1] has already been loaded into the eDMA engine. As sga and sga_index are calculated based on the DLAST_SGA bitfield lies in the TCD_CSR register, the sga_index in this case should be 2 (DLAST_SGA of TCD[1] stores the address of TCD[2]). Thus, the “tcdUsed” updated should be (tcdUsed - 2U) which indicates the number of TCDs can be loaded in the memory pool (because TCD[0] and TCD[1] have been loaded into the eDMA engine at this point already.).

For the last two continuous ISRs in a scatter/gather process, they both load the last TCD (The last ISR does not load a new TCD) from the memory pool to the eDMA engine when major loop completes. Therefore, ensure that the header and tcdUsed updated are identical for them. tcdUsed are both 0 in this case as no TCD to be loaded.

See the “eDMA basic data flow” in the eDMA Functional description section of the Reference Manual for further details.

Parameters

- handle – eDMA handle pointer.

void EDMA_TcdInit(*EDMA_Type* *base, *edma_tcd_t* *tcdRegs)

Initialize all fields to 0 for the TCD structure.

This function initialize all fields for this TCD structure to 0.

Parameters

- base – eDMA peripheral base address.
- tcd – Pointer to the TCD structure.

FSL_EDMA_DRIVER_VERSION

eDMA driver version

Version 2.10.9.

_edma_transfer_status eDMA transfer status

Values:

enumerator kStatus_EDMA_QueueFull

TCD queue is full.

enumerator kStatus_EDMA_Busy

Channel is busy and can't handle the transfer request.

enum _edma_transfer_size

eDMA transfer configuration

Values:

enumerator kEDMA_TransferSize1Bytes

Source/Destination data transfer size is 1 byte every time

enumerator kEDMA_TransferSize2Bytes

Source/Destination data transfer size is 2 bytes every time

enumerator kEDMA_TransferSize4Bytes

Source/Destination data transfer size is 4 bytes every time

enumerator kEDMA_TransferSize8Bytes

Source/Destination data transfer size is 8 bytes every time

enumerator kEDMA_TransferSize16Bytes

Source/Destination data transfer size is 16 bytes every time

enumerator kEDMA_TransferSize32Bytes

Source/Destination data transfer size is 32 bytes every time

enumerator kEDMA_TransferSize64Bytes

Source/Destination data transfer size is 64 bytes every time

enumerator kEDMA_TransferSize128Bytes

Source/Destination data transfer size is 128 bytes every time

enum _edma_modulo

eDMA modulo configuration

Values:

enumerator kEDMA_ModuloDisable

Disable modulo

enumerator kEDMA_Modulo2bytes

Circular buffer size is 2 bytes.

enumerator kEDMA_Modulo4bytes

Circular buffer size is 4 bytes.

enumerator kEDMA_Modulo8bytes

Circular buffer size is 8 bytes.

enumerator kEDMA_Modulo16bytes

Circular buffer size is 16 bytes.

enumerator kEDMA_Modulo32bytes

Circular buffer size is 32 bytes.

enumerator kEDMA_Modulo64bytes

Circular buffer size is 64 bytes.

enumerator kEDMA_Modulo128bytes

Circular buffer size is 128 bytes.

enumerator kEDMA_Modulo256bytes

Circular buffer size is 256 bytes.

enumerator kEDMA_Modulo512bytes

Circular buffer size is 512 bytes.

enumerator kEDMA_Modulo1Kbytes
Circular buffer size is 1 K bytes.

enumerator kEDMA_Modulo2Kbytes
Circular buffer size is 2 K bytes.

enumerator kEDMA_Modulo4Kbytes
Circular buffer size is 4 K bytes.

enumerator kEDMA_Modulo8Kbytes
Circular buffer size is 8 K bytes.

enumerator kEDMA_Modulo16Kbytes
Circular buffer size is 16 K bytes.

enumerator kEDMA_Modulo32Kbytes
Circular buffer size is 32 K bytes.

enumerator kEDMA_Modulo64Kbytes
Circular buffer size is 64 K bytes.

enumerator kEDMA_Modulo128Kbytes
Circular buffer size is 128 K bytes.

enumerator kEDMA_Modulo256Kbytes
Circular buffer size is 256 K bytes.

enumerator kEDMA_Modulo512Kbytes
Circular buffer size is 512 K bytes.

enumerator kEDMA_Modulo1Mbytes
Circular buffer size is 1 M bytes.

enumerator kEDMA_Modulo2Mbytes
Circular buffer size is 2 M bytes.

enumerator kEDMA_Modulo4Mbytes
Circular buffer size is 4 M bytes.

enumerator kEDMA_Modulo8Mbytes
Circular buffer size is 8 M bytes.

enumerator kEDMA_Modulo16Mbytes
Circular buffer size is 16 M bytes.

enumerator kEDMA_Modulo32Mbytes
Circular buffer size is 32 M bytes.

enumerator kEDMA_Modulo64Mbytes
Circular buffer size is 64 M bytes.

enumerator kEDMA_Modulo128Mbytes
Circular buffer size is 128 M bytes.

enumerator kEDMA_Modulo256Mbytes
Circular buffer size is 256 M bytes.

enumerator kEDMA_Modulo512Mbytes
Circular buffer size is 512 M bytes.

enumerator kEDMA_Modulo1Gbytes
Circular buffer size is 1 G bytes.

enumerator kEDMA_Modulo2Gbytes
Circular buffer size is 2 G bytes.

enum __edma_bandwidth
Bandwidth control.

Values:

enumerator kEDMA_BandwidthStallNone
No eDMA engine stalls.

enumerator kEDMA_BandwidthStall4Cycle
eDMA engine stalls for 4 cycles after each read/write.

enumerator kEDMA_BandwidthStall8Cycle
eDMA engine stalls for 8 cycles after each read/write.

enum __edma_channel_link_type
Channel link type.

Values:

enumerator kEDMA_LinkNone
No channel link

enumerator kEDMA_MinorLink
Channel link after each minor loop

enumerator kEDMA_MajorLink
Channel link while major loop count exhausted

_edma_channel_status_flags eDMA channel status flags.

Values:

enumerator kEDMA_DoneFlag
DONE flag, set while transfer finished, CITER value exhausted

enumerator kEDMA_ErrorFlag
eDMA error flag, an error occurred in a transfer

enumerator kEDMA_InterruptFlag
eDMA interrupt flag, set while an interrupt occurred of this channel

_edma_error_status_flags eDMA channel error status flags.

Values:

enumerator kEDMA_DestinationBusErrorFlag
Bus error on destination address

enumerator kEDMA_SourceBusErrorFlag
Bus error on the source address

enumerator kEDMA_ScatterGatherErrorFlag
Error on the Scatter/Gather address, not 32byte aligned.

enumerator kEDMA_NbytesErrorFlag
NBYTES/CITER configuration error

enumerator kEDMA_DestinationOffsetErrorFlag
Destination offset not aligned with destination size

enumerator kEDMA_DestinationAddressErrorFlag
Destination address not aligned with destination size

enumerator kEDMA_SourceOffsetErrorFlag
Source offset not aligned with source size

enumerator kEDMA_SourceAddressErrorFlag
Source address not aligned with source size

enumerator kEDMA_ErrorChannelFlag
Error channel number of the cancelled channel number

enumerator kEDMA_TransferCanceledFlag
Transfer cancelled

enumerator kEDMA_ValidFlag
No error occurred, this bit is 0. Otherwise, it is 1.

_edma_interrupt_enable eDMA interrupt source

Values:

enumerator kEDMA_ErrorInterruptEnable
Enable interrupt while channel error occurs.

enumerator kEDMA_MajorInterruptEnable
Enable interrupt while major count exhausted.

enumerator kEDMA_HalfInterruptEnable
Enable interrupt while major count to half value.

enum _edma_transfer_type

eDMA transfer type

Values:

enumerator kEDMA_MemoryToMemory
Transfer from memory to memory

enumerator kEDMA_PeripheralToMemory
Transfer from peripheral to memory

enumerator kEDMA_MemoryToPeripheral
Transfer from memory to peripheral

enumerator kEDMA_PeripheralToPeripheral
Transfer from Peripheral to peripheral

enum edma_channel_memory_attribute

eDMA channel memory attribute

Values:

enumerator kEDMA_ChannelNoWriteNoReadNoCacheNoBuffer
No write allocate, no read allocate, non-cacheable, non-bufferable.

enumerator kEDMA_ChannelNoWriteNoReadNoCacheBufferable
No write allocate, no read allocate, non-cacheable, bufferable.

enumerator kEDMA_ChannelNoWriteNoReadCacheableNoBuffer
No write allocate, no read allocate, cacheable, non-bufferable.

enumerator kEDMA_ChannelNoWriteNoReadCacheableBufferable

No write allocate, no read allocate, cacheable, bufferable.

enumerator kEDMA_ChannelNoWriteReadNoCacheNoBuffer

No write allocate, read allocate, non-cacheable, non-bufferable.

enumerator kEDMA_ChannelNoWriteReadNoCacheBufferable

No write allocate, read allocate, non-cacheable, bufferable.

enumerator kEDMA_ChannelNoWriteReadCacheableNoBuffer

No write allocate, read allocate, cacheable, non-bufferable.

enumerator kEDMA_ChannelNoWriteReadCacheableBufferable

No write allocate, read allocate, cacheable, bufferable.

enumerator kEDMA_ChannelWriteNoReadNoCacheNoBuffer

write allocate, no read allocate, non-cacheable, non-bufferable.

enumerator kEDMA_ChannelWriteNoReadNoCacheBufferable

write allocate, no read allocate, non-cacheable, bufferable.

enumerator kEDMA_ChannelWriteNoReadCacheableNoBuffer

write allocate, no read allocate, cacheable, non-bufferable.

enumerator kEDMA_ChannelWriteNoReadCacheableBufferable

write allocate, no read allocate, cacheable, bufferable.

enumerator kEDMA_ChannelWriteReadNoCacheNoBuffer

write allocate, read allocate, non-cacheable, non-bufferable.

enumerator kEDMA_ChannelWriteReadNoCacheBufferable

write allocate, read allocate, non-cacheable, bufferable.

enumerator kEDMA_ChannelWriteReadCacheableNoBuffer

write allocate, read allocate, cacheable, non-bufferable.

enumerator kEDMA_ChannelWriteReadCacheableBufferable

write allocate, read allocate, cacheable, bufferable.

enum _edma_channel_swap_size

eDMA4 channel swap size

Values:

enumerator kEDMA_ChannelSwapDisabled

Swap is disabled.

enumerator kEDMA_ChannelReadWith8bitSwap

Swap occurs with respect to the read 8bit.

enumerator kEDMA_ChannelReadWith16bitSwap

Swap occurs with respect to the read 16bit.

enumerator kEDMA_ChannelReadWith32bitSwap

Swap occurs with respect to the read 32bit.

enumerator kEDMA_ChannelWriteWith8bitSwap

Swap occurs with respect to the write 8bit.

enumerator kEDMA_ChannelWriteWith16bitSwap

Swap occurs with respect to the write 16bit.

enumerator kEDMA_ChannelWriteWith32bitSwap

Swap occurs with respect to the write 32bit.

eDMA channel system bus information, `_edma_channel_sys_bus_info`

Values:

enumerator kEDMA_PrivilegedAccessLevel

Privileged Access Level for DMA transfers. 0b - User protection level; 1b - Privileged protection level.

enumerator kEDMA_MasterId

DMA's master ID when channel is active and master ID replication is enabled.

enum `_edma_channel_access_type`

eDMA4 channel access type

Values:

enumerator kEDMA_ChannelDataAccess

Data access for eDMA4 transfers.

enumerator kEDMA_ChannelInstructionAccess

Instruction access for eDMA4 transfers.

enum `_edma_channel_protection_level`

eDMA4 channel protection level

Values:

enumerator kEDMA_ChannelProtectionLevelUser

user protection level for eDMA transfers.

enumerator kEDMA_ChannelProtectionLevelPrivileged

Privileged protection level eDMA transfers.

enum `_edma_channel_security_level`

eDMA4 channel security level

Values:

enumerator kEDMA_ChannelSecurityLevelNonSecure

non secure level for eDMA transfers.

enumerator kEDMA_ChannelSecurityLevelSecure

secure level for eDMA transfers.

typedef enum `_edma_transfer_size` `edma_transfer_size_t`

eDMA transfer configuration

typedef enum `_edma_modulo` `edma_modulo_t`

eDMA modulo configuration

typedef enum `_edma_bandwidth` `edma_bandwidth_t`

Bandwidth control.

typedef enum `_edma_channel_link_type` `edma_channel_link_type_t`

Channel link type.

typedef enum `_edma_transfer_type` `edma_transfer_type_t`

eDMA transfer type

```
typedef struct _edma_channel_Preemption_config edma_channel_Preemption_config_t
    eDMA channel priority configuration
```

```
typedef struct _edma_minor_offset_config edma_minor_offset_config_t
    eDMA minor offset configuration
```

```
typedef enum edma_channel_memory_attribute edma_channel_memory_attribute_t
    eDMA channel memory attribute
```

```
typedef enum _edma_channel_swap_size edma_channel_swap_size_t
    eDMA4 channel swap size
```

```
typedef enum _edma_channel_access_type edma_channel_access_type_t
    eDMA4 channel access type
```

```
typedef enum _edma_channel_protection_level edma_channel_protection_level_t
    eDMA4 channel protection level
```

```
typedef enum _edma_channel_security_level edma_channel_security_level_t
    eDMA4 channel security level
```

```
typedef struct _edma_channel_config edma_channel_config_t
    eDMA4 channel configuration
```

```
typedef edma_core_tcd_t edma_tcd_t
    eDMA TCD.
```

This structure is same as TCD register which is described in reference manual, and is used to configure the scatter/gather feature as a next hardware TCD.

```
typedef struct _edma_transfer_config edma_transfer_config_t
    edma4 channel transfer configuration
```

The transfer configuration structure support full feature configuration of the transfer control descriptor.

1.To perform a simple transfer, below members should be initialized at least .srcAddr - source address .dstAddr - destination address .srcWidthOfEachTransfer - data width of source address .dstWidthOfEachTransfer - data width of destination address, normally it should be as same as srcWidthOfEachTransfer .bytesEachRequest - bytes to be transferred in each DMA request .totalBytes - total bytes to be transferred .srcOffsetOfEachTransfer - offset value in bytes unit to be applied to source address as each source read is completed .dstOffsetOfEachTransfer - offset value in bytes unit to be applied to destination address as each destination write is completed enableChannelRequest - channel request can be enabled together with transfer configure submission

2.The transfer configuration structure also support advance feature: Programmable source/destination address range(MODULO) Programmable minor loop offset Programmable major loop offset Programmable channel chain feature Programmable channel transfer control descriptor link feature

Note: User should pay attention to the transfer size alignment limitation

- the bytesEachRequest should align with the srcWidthOfEachTransfer and the dstWidthOfEachTransfer that is to say bytesEachRequest % srcWidthOfEachTransfer should be 0
- the srcOffsetOfEachTransfer and dstOffsetOfEachTransfer must be aligne with transfer width
- the totalBytes should align with the bytesEachRequest

- d. the srcAddr should align with the srcWidthOfEachTransfer
 - e. the dstAddr should align with the dstWidthOfEachTransfer
 - f. the srcAddr should align with srcAddrModulo if modulo feature is enabled
 - g. the dstAddr should align with dstAddrModulo if modulo feature is enabled If anyone of above condition can not be satisfied, the edma4 interfaces will generate assert error.
-

typedef struct *_edma_config* edma_config_t

eDMA global configuration structure.

typedef void (*edma_callback)(struct *_edma_handle* *handle, void *userData, bool transferDone, uint32_t tcds)

Define callback function for eDMA.

This callback function is called in the EDMA interrupt handle. In normal mode, run into callback function means the transfer users need is done. In scatter gather mode, run into callback function means a transfer control block (tcd) is finished. Not all transfer finished, users can get the finished tcd numbers using interface EDMA_GetUnusedTCDNumber.

Param handle

EDMA handle pointer, users shall not touch the values inside.

Param userData

The callback user parameter pointer. Users can use this parameter to involve things users need to change in EDMA callback function.

Param transferDone

If the current loaded transfer done. In normal mode it means if all transfer done. In scatter gather mode, this parameter shows is the current transfer block in EDMA register is done. As the load of core is different, it will be different if the new tcd loaded into EDMA registers while this callback called. If true, it always means new tcd still not loaded into registers, while false means new tcd already loaded into registers.

Param tcds

How many tcds are done from the last callback. This parameter only used in scatter gather mode. It tells user how many tcds are finished between the last callback and this.

typedef struct *_edma_handle* edma_handle_t

eDMA transfer handle structure

FSL_EDMA_DRIVER_EDMA4

eDMA driver name

EDMA_ALLOCATE_TCD(name, number)

Macro used for allocate edma TCD.

DMA_DCHPRI_INDEX(channel)

Compute the offset unit from DCHPRI3.

struct *_edma_channel_Preemption_config*

#include <fsl_edma.h> eDMA channel priority configuration

Public Members

bool enableChannelPreemption

If true: a channel can be suspended by other channel with higher priority

bool enablePreemptAbility

If true: a channel can suspend other channel with low priority

uint8_t channelPriority

Channel priority

struct __edma__minor_offset_config

#include <fsl_edma.h> eDMA minor offset configuration

Public Members

bool enableSrcMinorOffset

Enable(true) or Disable(false) source minor loop offset.

bool enableDestMinorOffset

Enable(true) or Disable(false) destination minor loop offset.

uint32_t minorOffset

Offset for a minor loop mapping.

struct __edma__channel_config

#include <fsl_edma.h> eDMA4 channel configuration

Public Members

edma_channel_preemption_config_t channelPreemptionConfig

channel preemption configuration

edma_channel_memory_attribute_t channelReadMemoryAttribute

channel memory read attribute configuration

edma_channel_memory_attribute_t channelWriteMemoryAttribute

channel memory write attribute configuration

edma_channel_swap_size_t channelSwapSize

channel swap size configuration

edma_channel_access_type_t channelAccessType

channel access type configuration

uint8_t channelDataSignExtensionBitPosition

channel data sign extension bit position configuration

uint32_t channelRequestSource

hardware service request source for the channel

bool enableMasterIDReplication

enable master ID replication

edma_channel_security_level_t securityLevel

security level

edma_channel_protection_level_t protectionLevel

protection level

struct __edma__transfer_config

#include <fsl_edma.h> edma4 channel transfer configuration

The transfer configuration structure support full feature configuration of the transfer control descriptor.

1.To perform a simple transfer, below members should be initialized at least .srcAddr - source address .dstAddr - destination address .srcWidthOfEachTransfer - data width of source address .dstWidthOfEachTransfer - data width of destination address, normally it should be as same as srcWidthOfEachTransfer .bytesEachRequest - bytes to be transferred in each DMA request .totalBytes - total bytes to be transferred .srcOffsetOfEachTransfer - offset value in bytes unit to be applied to source address as each source read is completed .dstOffsetOfEachTransfer - offset value in bytes unit to be applied to destination address as each destination write is completed enablchannelRequest - channel request can be enabled together with transfer configure submission

2.The transfer configuration structure also support advance feature: Programmable source/destination address range(MODULO) Programmable minor loop offset Programmable major loop offset Programmable channel chain feature Programmable channel transfer control descriptor link feature

Note: User should pay attention to the transfer size alignment limitation

- a. the bytesEachRequest should align with the srcWidthOfEachTransfer and the dstWidthOfEachTransfer that is to say $\text{bytesEachRequest} \% \text{srcWidthOfEachTransfer}$ should be 0
 - b. the srcOffsetOfEachTransfer and dstOffsetOfEachTransfer must be aligne with transfer width
 - c. the totalBytes should align with the bytesEachRequest
 - d. the srcAddr should align with the srcWidthOfEachTransfer
 - e. the dstAddr should align with the dstWidthOfEachTransfer
 - f. the srcAddr should align with srcAddrModulo if modulo feature is enabled
 - g. the dstAddr should align with dstAddrModulo if modulo feature is enabled If anyone of above condition can not be satisfied, the edma4 interfaces will generate assert error.
-

Public Members

uint32_t srcAddr

Source data address.

uint32_t destAddr

Destination data address.

edma_transfer_size_t srcTransferSize

Source data transfer size.

edma_transfer_size_t destTransferSize

Destination data transfer size.

int16_t srcOffset

Sign-extended offset value in byte unit applied to the current source address to form the next-state value as each source read is completed

int16_t destOffset

Sign-extended offset value in byte unit applied to the current destination address to form the next-state value as each destination write is completed.

uint32_t minorLoopBytes

bytes in each minor loop or each request range: 1 - ($2^{30} - 1$) when minor loop mapping is enabled range: 1 - ($2^{10} - 1$) when minor loop mapping is enabled and source or dest minor loop offset is enabled range: 1 - ($2^{32} - 1$) when minor loop mapping is disabled

uint32_t majorLoopCounts

minor loop counts in each major loop, should be 1 at least for each transfer range: (0 - ($2^{15} - 1$)) when minor loop channel link is disabled range: (0 - ($2^9 - 1$)) when minor loop channel link is enabled total bytes in a transfer = minorLoopCountsEachMajorLoop * bytesEachMinorLoop

uint16_t enabledInterruptMask

channel interrupt to enable, can be OR'ed value of _edma_interrupt_enable

edma_modulo_t srcAddrModulo

source circular data queue range

int32_t srcMajorLoopOffset

source major loop offset

edma_modulo_t dstAddrModulo

destination circular data queue range

int32_t dstMajorLoopOffset

destination major loop offset

bool enableSrcMinorLoopOffset

enable source minor loop offset

bool enableDstMinorLoopOffset

enable dest minor loop offset

int32_t minorLoopOffset

burst offset, the offset will be applied after minor loop update

bool enableChannelMajorLoopLink

channel link when major loop complete

uint32_t majorLoopLinkChannel

major loop link channel number

bool enableChannelMinorLoopLink

channel link when minor loop complete

uint32_t minorLoopLinkChannel

minor loop link channel number

edma_tcd_t *linkTCD

pointer to the link transfer control descriptor

struct _edma_config

#include <fsl_edma.h> eDMA global configuration structure.

Public Members

bool enableContinuousLinkMode

Enable (true) continuous link mode. Upon minor loop completion, the channel activates again if that channel has a minor loop channel link enabled and the link channel is itself.

bool enableMasterIdReplication

Enable (true) master ID replication. If Master ID replication is disabled, the privileged protection level (supervisor mode) for eDMA4 transfers is used.

bool enableGlobalChannelLink

Enable(true) channel linking is available and controlled by each channel's link settings.

bool enableHaltOnError

Enable (true) transfer halt on error. Any error causes the HALT bit to set. Subsequently, all service requests are ignored until the HALT bit is cleared.

bool enableDebugMode

Enable(true) eDMA4 debug mode. When in debug mode, the eDMA4 stalls the start of a new channel. Executing channels are allowed to complete.

bool enableRoundRobinArbitration

Enable(true) channel linking is available and controlled by each channel's link settings.

edma_channel_config_t *channelConfig[1]

channel preemption configuration

struct *_edma_handle*

#include <fsl_edma.h> eDMA transfer handle structure

Public Members

edma_callback callback

Callback function for major count exhausted.

void *userData

Callback function parameter.

EDMA_ChannelType *channelBase

eDMA peripheral channel base address.

EDMA_Type *base

eDMA peripheral base address

EDMA_TCDType *tcdBase

eDMA peripheral tcd base address.

edma_tcd_t *tcdPool

Pointer to memory stored TCDs.

uint32_t channel

eDMA channel number.

volatile int8_t header

The first TCD index. Should point to the next TCD to be loaded into the eDMA engine.

volatile int8_t tail

The last TCD index. Should point to the next TCD to be stored into the memory pool.

volatile int8_t tcdUsed

The number of used TCD slots. Should reflect the number of TCDs can be used/loaded in the memory.

volatile int8_t tcdSize

The total number of TCD slots in the queue.

2.2 eDMA core Driver

```
enum _edma_tcd_type
    eDMA tcd flag type
    Values:
    enumerator kEDMA_EDMA4Flag
        Data access for eDMA4 transfers.
    enumerator kEDMA_EDMA5Flag
        Instruction access for eDMA4 transfers.
typedef struct _edma_core_mp edma_core_mp_t
    edma core channel struture definition
typedef struct _edma_core_channel edma_core_channel_t
    edma core channel struture definition
typedef enum _edma_tcd_type edma_tcd_type_t
    eDMA tcd flag type
typedef struct _edma5_core_tcd edma5_core_tcd_t
    edma5 core TCD struture definition
typedef struct _edma4_core_tcd edma4_core_tcd_t
    edma4 core TCD struture definition
typedef struct _edma_core_tcd edma_core_tcd_t
    edma core TCD struture definition
typedef edma_core_channel_t EDMA_ChannelType
    EDMA typedef.
typedef edma_core_tcd_t EDMA_TCDType
typedef void EDMA_Type
DMA_CORE_MP_CSR_EDBG_MASK
DMA_CORE_MP_CSR_ERCA_MASK
DMA_CORE_MP_CSR_HAE_MASK
DMA_CORE_MP_CSR_HALT_MASK
DMA_CORE_MP_CSR_GCLC_MASK
DMA_CORE_MP_CSR_GMRC_MASK
DMA_CORE_MP_CSR_EDBG(x)
DMA_CORE_MP_CSR_ERCA(x)
DMA_CORE_MP_CSR_HAE(x)
DMA_CORE_MP_CSR_HALT(x)
DMA_CORE_MP_CSR_GCLC(x)
DMA_CORE_MP_CSR_GMRC(x)
DMA_CSR_INTMAJOR_MASK
```

DMA_CSR_INTHALF_MASK
DMA_CSR_DREQ_MASK
DMA_CSR_ESG_MASK
DMA_CSR_BWC_MASK
DMA_CSR_BWC(x)
DMA_CSR_START_MASK
DMA_CITER_ELINKNO_CITER_MASK
DMA_BITER_ELINKNO_BITER_MASK
DMA_CITER_ELINKNO_CITER_SHIFT
DMA_CITER_ELINKYES_CITER_MASK
DMA_CITER_ELINKYES_CITER_SHIFT
DMA_ATTR_SMOD_MASK
DMA_ATTR_DMOD_MASK
DMA_CITER_ELINKNO_ELINK_MASK
DMA_CSR_MAJORELINK_MASK
DMA_BITER_ELINKYES_ELINK_MASK
DMA_CITER_ELINKYES_ELINK_MASK
DMA_CSR_MAJORLINKCH_MASK
DMA_BITER_ELINKYES_LINKCH_MASK
DMA_CITER_ELINKYES_LINKCH_MASK
DMA_NBYTES_MLOFFYES_MLOFF_MASK
DMA_NBYTES_MLOFFYES_DMLOE_MASK
DMA_NBYTES_MLOFFYES_SMLOE_MASK
DMA_NBYTES_MLOFFNO_NBYTES_MASK
DMA_ATTR_DMOD(x)
DMA_ATTR_SMOD(x)
DMA_BITER_ELINKYES_LINKCH(x)
DMA_CITER_ELINKYES_LINKCH(x)
DMA_NBYTES_MLOFFYES_MLOFF(x)
DMA_NBYTES_MLOFFYES_DMLOE(x)
DMA_NBYTES_MLOFFYES_SMLOE(x)
DMA_NBYTES_MLOFFNO_NBYTES(x)
DMA_NBYTES_MLOFFYES_NBYTES(x)

DMA_ATTR_DSIZE(x)
DMA_ATTR_SSIZE(x)
DMA_CSR_DREQ(x)
DMA_CSR_MAJORLINKCH(x)
DMA_CH_MATTR_WCACHE(x)
DMA_CH_MATTR_RCACHE(x)
DMA_CH_CSR_SIGNEXT_MASK
DMA_CH_CSR_SIGNEXT_SHIFT
DMA_CH_CSR_SWAP_MASK
DMA_CH_CSR_SWAP_SHIFT
DMA_CH_SBR_INSTR_MASK
DMA_CH_SBR_INSTR_SHIFT
DMA_CH_SBR_EMI_MASK
DMA_CH_SBR_EMI_SHIFT
DMA_CH_MUX_SOURCE(x)
DMA_ERR_DBE_FLAG
 DMA error flag.
DMA_ERR_SBE_FLAG
DMA_ERR_SGE_FLAG
DMA_ERR_NCE_FLAG
DMA_ERR_DOE_FLAG
DMA_ERR_DAE_FLAG
DMA_ERR_SOE_FLAG
DMA_ERR_SAE_FLAG
DMA_ERR_ERRCHAN_FLAG
DMA_ERR_ECX_FLAG
DMA_ERR_FLAG
DMA_CLEAR_DONE_STATUS(base, channel)
 get/clear DONE bit
DMA_GET_DONE_STATUS(base, channel)
DMA_ENABLE_ERROR_INT(base, channel)
 enable/disable error interrupt
DMA_DISABLE_ERROR_INT(base, channel)
DMA_CLEAR_ERROR_STATUS(base, channel)
 get/clear error status

DMA_GET_ERROR_STATUS(base, channel)
DMA_CLEAR_INT_STATUS(base, channel)
 get/clear INT status
DMA_GET_INT_STATUS(base, channel)
DMA_ENABLE_MAJOR_INT(base, channel)
 enable/dsiable MAJOR/HALF INT
DMA_ENABLE_HALF_INT(base, channel)
DMA_DISABLE_MAJOR_INT(base, channel)
DMA_DISABLE_HALF_INT(base, channel)
EDMA_TCD_ALIGN_SIZE
 EDMA tcd align size.
EDMA_CORE_BASE(base)
 EDMA base address convert macro.
EDMA_MP_BASE(base)
EDMA_CHANNEL_BASE(base, channel)
EDMA_TCD_BASE(base, channel)
EDMA_TCD_TYPE(x)
 EDMA TCD type macro.
EDMA_TCD_SADDR(tcd, flag)
 EDMA TCD address convert macro.
EDMA_TCD_SOFF(tcd, flag)
EDMA_TCD_ATTR(tcd, flag)
EDMA_TCD_NBYTES(tcd, flag)
EDMA_TCD_SLAST(tcd, flag)
EDMA_TCD_DADDR(tcd, flag)
EDMA_TCD_DOFF(tcd, flag)
EDMA_TCD_CITER(tcd, flag)
EDMA_TCD_DLAST_SGA(tcd, flag)
EDMA_TCD_CSR(tcd, flag)
EDMA_TCD_BITER(tcd, flag)
struct _edma_core_mp
 #include <fsl_edma_core.h> edma core channel struture definition

Public Members

__IO uint32_t MP_CSR
 Channel Control and Status, array offset: 0x10000, array step: 0x10000

```
__IO uint32_t MP_ES
    Channel Error Status, array offset: 0x10004, array step: 0x10000
struct __edma_core_channel
    #include <fsl_edma_core.h> edma core channel struture definition
```

Public Members

```
__IO uint32_t CH_CSR
    Channel Control and Status, array offset: 0x10000, array step: 0x10000
__IO uint32_t CH_ES
    Channel Error Status, array offset: 0x10004, array step: 0x10000
__IO uint32_t CH_INT
    Channel Interrupt Status, array offset: 0x10008, array step: 0x10000
__IO uint32_t CH_SBR
    Channel System Bus, array offset: 0x1000C, array step: 0x10000
__IO uint32_t CH_PRI
    Channel Priority, array offset: 0x10010, array step: 0x10000
struct __edma5_core_tcd
    #include <fsl_edma_core.h> edma5 core TCD struture definition
```

Public Members

```
__IO uint32_t SADDR
    SADDR register, used to save source address
__IO uint32_t SADDR_HIGH
    SADDR HIGH register, used to save source address
__IO uint16_t SOFF
    SOFF register, save offset bytes every transfer
__IO uint16_t ATTR
    ATTR register, source/destination transfer size and modulo
__IO uint32_t NBYTES
    Nbytes register, minor loop length in bytes
__IO uint32_t SLAST
    SLAST register
__IO uint32_t SLAST_SDA_HIGH
    SLAST SDA HIGH register
__IO uint32_t DADDR
    DADDR register, used for destination address
__IO uint32_t DADDR_HIGH
    DADDR HIGH register, used for destination address
__IO uint32_t DLAST_SGA
    DLASTSGA register, next tcd address used in scatter-gather mode
__IO uint32_t DLAST_SGA_HIGH
    DLASTSGA HIGH register, next tcd address used in scatter-gather mode
```

```
__IO uint16_t DOFF
    DOFF register, used for destination offset
__IO uint16_t CITER
    CITER register, current minor loop numbers, for unfinished minor loop.
__IO uint16_t CSR
    CSR register, for TCD control status
__IO uint16_t BITER
    BITER register, begin minor loop count.
uint8_t RESERVED[16]
    Aligned 64 bytes
struct _edma4_core_tcd
    #include <fsl_edma_core.h> edma4 core TCD struture definition
```

Public Members

```
__IO uint32_t SADDR
    SADDR register, used to save source address
__IO uint16_t SOFF
    SOFF register, save offset bytes every transfer
__IO uint16_t ATTR
    ATTR register, source/destination transfer size and modulo
__IO uint32_t NBYTES
    Nbytes register, minor loop length in bytes
__IO uint32_t SLAST
    SLAST register
__IO uint32_t DADDR
    DADDR register, used for destination address
__IO uint16_t DOFF
    DOFF register, used for destination offset
__IO uint16_t CITER
    CITER register, current minor loop numbers, for unfinished minor loop.
__IO uint32_t DLAST_SGA
    DLASTSGA register, next tcd address used in scatter-gather mode
__IO uint16_t CSR
    CSR register, for TCD control status
__IO uint16_t BITER
    BITER register, begin minor loop count.
struct _edma_core_tcd
    #include <fsl_edma_core.h> edma core TCD struture definition
union MP_REGS
```

Public Members

```
struct _edma_core_mp EDMA5_REG
```

```
struct EDMA5_REG
```

Public Members

```
__IO uint32_t MP_INT_LOW
```

Channel Control and Status, array offset: 0x10008, array step: 0x10000

```
__IO uint32_t MP_INT_HIGH
```

Channel Control and Status, array offset: 0x1000C, array step: 0x10000

```
__IO uint32_t MP_HRS_LOW
```

Channel Control and Status, array offset: 0x10010, array step: 0x10000

```
__IO uint32_t MP_HRS_HIGH
```

Channel Control and Status, array offset: 0x10014, array step: 0x10000

```
__IO uint32_t MP_STOPCH
```

Channel Control and Status, array offset: 0x10020, array step: 0x10000

```
__IO uint32_t MP_SSR_LOW
```

Channel Control and Status, array offset: 0x10030, array step: 0x10000

```
__IO uint32_t MP_SSR_HIGH
```

Channel Control and Status, array offset: 0x10034, array step: 0x10000

```
__IO uint32_t CH_GRPRI [64]
```

Channel Control and Status, array offset: 0x10100, array step: 0x10000

```
__IO uint32_t CH_MUX [64]
```

Channel Control and Status, array offset: 0x10200, array step: 0x10000

```
__IO uint32_t CH_PROT [64]
```

Channel Control and Status, array offset: 0x10400, array step: 0x10000

```
union CH_REGS
```

Public Members

```
struct _edma_core_channel EDMA5_REG
```

```
struct _edma_core_channel EDMA4_REG
```

```
struct EDMA5_REG
```

Public Members

```
__IO uint32_t CH_MATTR
```

Memory Attributes Register, array offset: 0x10018, array step: 0x8000

```
struct EDMA4_REG
```

Public Members

`__IO uint32_t CH_MUX`
Channel Multiplexor Configuration, array offset: 0x10014, array step: 0x10000

`__IO uint16_t CH_MATTR`
Memory Attributes Register, array offset: 0x10018, array step: 0x8000

`union TCD_REGS`

Public Members

`edma4_core_tcd_t edma4_tcd`

2.3 eDMA soc Driver

2.4 ENET: Ethernet MAC Driver

`void ENET_GetDefaultConfig(enet_config_t *config)`

Gets the ENET default configuration structure.

The purpose of this API is to get the default ENET MAC controller configure structure for `ENET_Init()`. User may use the initialized structure unchanged in `ENET_Init()`, or modify some fields of the structure before calling `ENET_Init()`. Example:

```
enet_config_t config;
ENET_GetDefaultConfig(&config);
```

Parameters

- `config` – The ENET mac controller configuration structure pointer.

`status_t ENET_Up(ENET_Type *base, enet_handle_t *handle, const enet_config_t *config, const enet_buffer_config_t *bufferConfig, uint8_t *macAddr, uint32_t srcClock_Hz)`

Initializes the ENET module.

This function initializes the module with the ENET configuration.

Note: ENET has two buffer descriptors legacy buffer descriptors and enhanced IEEE 1588 buffer descriptors. The legacy descriptor is used by default. To use the IEEE 1588 feature, use the enhanced IEEE 1588 buffer descriptor by defining “`ENET_ENHANCEDBUFFERDESCRIPTOR_MODE`” and calling `ENET_Ptp1588Configure()` to configure the 1588 feature and related buffers after calling `ENET_Up()`.

Parameters

- `base` – ENET peripheral base address.
- `handle` – ENET handler pointer.
- `config` – ENET mac configuration structure pointer. The “`enet_config_t`” type mac configuration return from `ENET_GetDefaultConfig` can be used directly. It is also possible to verify the Mac configuration using other methods.

- `bufferConfig` – ENET buffer configuration structure pointer. The buffer configuration should be prepared for ENET Initialization. It is the start address of “ringNum” `enet_buffer_config` structures. To support added multi-ring features in some soc and compatible with the previous enet driver version. For single ring supported, this `bufferConfig` is a buffer configure structure pointer; for multi-ring supported and used case, this `bufferConfig` pointer should be a buffer configure structure array pointer.
- `macAddr` – ENET mac address of Ethernet device. This MAC address should be provided.
- `srcClock_Hz` – The internal module clock source for MII clock.

Return values

- `kStatus_Success` – Succeed to initialize the ethernet driver.
- `kStatus_ENET_InitMemoryFail` – Init fails since buffer memory is not enough.

`status_t` ENET_Init(`ENET_Type` *base, `enet_handle_t` *handle, const `enet_config_t` *config, const `enet_buffer_config_t` *bufferConfig, `uint8_t` *macAddr, `uint32_t` srcClock_Hz)

Initializes the ENET module.

This function ungates the module clock and initializes it with the ENET configuration.

Note: ENET has two buffer descriptors legacy buffer descriptors and enhanced IEEE 1588 buffer descriptors. The legacy descriptor is used by default. To use the IEEE 1588 feature, use the enhanced IEEE 1588 buffer descriptor by defining “ENET_ENHANCEDBUFFERDESCRIPTOR_MODE” and calling `ENET_Ptp1588Configure()` to configure the 1588 feature and related buffers after calling `ENET_Init()`.

Parameters

- `base` – ENET peripheral base address.
- `handle` – ENET handler pointer.
- `config` – ENET mac configuration structure pointer. The “`enet_config_t`” type mac configuration return from `ENET_GetDefaultConfig` can be used directly. It is also possible to verify the Mac configuration using other methods.
- `bufferConfig` – ENET buffer configuration structure pointer. The buffer configuration should be prepared for ENET Initialization. It is the start address of “ringNum” `enet_buffer_config` structures. To support added multi-ring features in some soc and compatible with the previous enet driver version. For single ring supported, this `bufferConfig` is a buffer configure structure pointer; for multi-ring supported and used case, this `bufferConfig` pointer should be a buffer configure structure array pointer.
- `macAddr` – ENET mac address of Ethernet device. This MAC address should be provided.
- `srcClock_Hz` – The internal module clock source for MII clock.

Return values

- `kStatus_Success` – Succeed to initialize the ethernet driver.
- `kStatus_ENET_InitMemoryFail` – Init fails since buffer memory is not enough.

void ENET_Down(ENET_Type *base)

Stops the ENET module.

This function disables the ENET module.

Parameters

- base – ENET peripheral base address.

void ENET_Deinit(ENET_Type *base)

Deinitializes the ENET module.

This function gates the module clock, clears ENET interrupts, and disables the ENET module.

Parameters

- base – ENET peripheral base address.

static inline void ENET_Reset(ENET_Type *base)

Resets the ENET module.

This function restores the ENET module to reset state. Note that this function sets all registers to reset state. As a result, the ENET module can't work after calling this function.

Parameters

- base – ENET peripheral base address.

void ENET_SetMII(ENET_Type *base, *enet_mii_speed_t* speed, *enet_mii_duplex_t* duplex)

Sets the ENET MII speed and duplex.

This API is provided to dynamically change the speed and duplex for MAC.

Parameters

- base – ENET peripheral base address.
- speed – The speed of the RMII mode.
- duplex – The duplex of the RMII mode.

void ENET_SetSMI(ENET_Type *base, uint32_t srcClock_Hz, bool isPreambleDisabled)

Sets the ENET SMI(serial management interface)- MII management interface.

Parameters

- base – ENET peripheral base address.
- srcClock_Hz – This is the ENET module clock frequency. See clock distribution.
- isPreambleDisabled – The preamble disable flag.
 - true Enables the preamble.
 - false Disables the preamble.

static inline bool ENET_GetSMI(ENET_Type *base)

Gets the ENET SMI- MII management interface configuration.

This API is used to get the SMI configuration to check whether the MII management interface has been set.

Parameters

- base – ENET peripheral base address.

Returns

The SMI setup status true or false.

```
static inline uint32_t ENET_ReadSMIData(ENET_Type *base)
```

Reads data from the PHY register through an SMI interface.

Parameters

- base – ENET peripheral base address.

Returns

The data read from PHY

```
static inline void ENET_StartSMIWrite(ENET_Type *base, uint8_t phyAddr, uint8_t regAddr,  
                                     enet_mii_write_t operation, uint16_t data)
```

Sends the MDIO IEEE802.3 Clause 22 format write command.

After calling this function, need to check whether the transmission is over then do next MDIO operation. For ease of use, encapsulated ENET_MDIOWrite() can be called. For customized requirements, implement with combining separated APIs.

Parameters

- base – ENET peripheral base address.
- phyAddr – The PHY address. Range from 0 ~ 31.
- regAddr – The PHY register address. Range from 0 ~ 31.
- operation – The write operation.
- data – The data written to PHY.

```
static inline void ENET_StartSMIRead(ENET_Type *base, uint8_t phyAddr, uint8_t regAddr,  
                                    enet_mii_read_t operation)
```

Sends the MDIO IEEE802.3 Clause 22 format read command.

After calling this function, need to check whether the transmission is over then do next MDIO operation. For ease of use, encapsulated ENET_MDIORead() can be called. For customized requirements, implement with combining separated APIs.

Parameters

- base – ENET peripheral base address.
- phyAddr – The PHY address. Range from 0 ~ 31.
- regAddr – The PHY register address. Range from 0 ~ 31.
- operation – The read operation.

```
status_t ENET_MDIOWrite(ENET_Type *base, uint8_t phyAddr, uint8_t regAddr, uint16_t data)
```

MDIO write with IEEE802.3 Clause 22 format.

Parameters

- base – ENET peripheral base address.
- phyAddr – The PHY address. Range from 0 ~ 31.
- regAddr – The PHY register. Range from 0 ~ 31.
- data – The data written to PHY.

Returns

kStatus_Success MDIO access succeeds.

Returns

kStatus_Timeout MDIO access timeout.

```
status_t ENET_MDIORead(ENET_Type *base, uint8_t phyAddr, uint8_t regAddr, uint16_t  
                      *pData)
```

MDIO read with IEEE802.3 Clause 22 format.

Parameters

- base – ENET peripheral base address.
- phyAddr – The PHY address. Range from 0 ~ 31.
- regAddr – The PHY register. Range from 0 ~ 31.
- pData – The data read from PHY.

Returns

kStatus_Success MDIO access succeeds.

Returns

kStatus_Timeout MDIO access timeout.

```
static inline void ENET_StartExtC45SMIWriteReg(ENET_Type *base, uint8_t portAddr, uint8_t  
                                              devAddr, uint16_t regAddr)
```

Sends the MDIO IEEE802.3 Clause 45 format write register command.

After calling this function, need to check whether the transmission is over then do next MDIO operation. For ease of use, encapsulated ENET_MDIOC45Write()/ENET_MDIOC45Read() can be called. For customized requirements, implement with combining separated APIs.

Parameters

- base – ENET peripheral base address.
- portAddr – The MDIO port address(PHY address).
- devAddr – The device address.
- regAddr – The PHY register address.

```
static inline void ENET_StartExtC45SMIWriteData(ENET_Type *base, uint8_t portAddr, uint8_t  
                                              devAddr, uint16_t data)
```

Sends the MDIO IEEE802.3 Clause 45 format write data command.

After calling this function, need to check whether the transmission is over then do next MDIO operation. For ease of use, encapsulated ENET_MDIOC45Write() can be called. For customized requirements, implement with combining separated APIs.

Parameters

- base – ENET peripheral base address.
- portAddr – The MDIO port address(PHY address).
- devAddr – The device address.
- data – The data written to PHY.

```
static inline void ENET_StartExtC45SMIReadData(ENET_Type *base, uint8_t portAddr, uint8_t  
                                              devAddr)
```

Sends the MDIO IEEE802.3 Clause 45 format read data command.

After calling this function, need to check whether the transmission is over then do next MDIO operation. For ease of use, encapsulated ENET_MDIOC45Read() can be called. For customized requirements, implement with combining separated APIs.

Parameters

- base – ENET peripheral base address.
- portAddr – The MDIO port address(PHY address).

- devAddr – The device address.

status_t ENET_MDIOC45Write(ENET_Type *base, uint8_t portAddr, uint8_t devAddr, uint16_t regAddr, uint16_t data)

MDIO write with IEEE802.3 Clause 45 format.

Parameters

- base – ENET peripheral base address.
- portAddr – The MDIO port address(PHY address).
- devAddr – The device address.
- regAddr – The PHY register address.
- data – The data written to PHY.

Returns

kStatus_Success MDIO access succeeds.

Returns

kStatus_Timeout MDIO access timeout.

status_t ENET_MDIOC45Read(ENET_Type *base, uint8_t portAddr, uint8_t devAddr, uint16_t regAddr, uint16_t *pData)

MDIO read with IEEE802.3 Clause 45 format.

Parameters

- base – ENET peripheral base address.
- portAddr – The MDIO port address(PHY address).
- devAddr – The device address.
- regAddr – The PHY register address.
- pData – The data read from PHY.

Returns

kStatus_Success MDIO access succeeds.

Returns

kStatus_Timeout MDIO access timeout.

static inline void ENET_SetRGMIIClockDelay(ENET_Type *base, bool txEnabled, bool rxEnabled)

Control the usage of the delayed tx/rx RGMII clock.

Parameters

- base – ENET peripheral base address.
- txEnabled – Enable or disable to generate the delayed version of RGMII_TXC.
- rxEnabled – Enable or disable to use the delayed version of RGMII_RXC.

void ENET_SetMacAddr(ENET_Type *base, uint8_t *macAddr)

Sets the ENET module Mac address.

Parameters

- base – ENET peripheral base address.
- macAddr – The six-byte Mac address pointer. The pointer is allocated by application and input into the API.

```
void ENET_GetMacAddr(ENET_Type *base, uint8_t *macAddr)
```

Gets the ENET module Mac address.

Parameters

- base – ENET peripheral base address.
- macAddr – The six-byte Mac address pointer. The pointer is allocated by application and input into the API.

```
void ENET_AddMulticastGroup(ENET_Type *base, uint8_t *address)
```

Adds the ENET device to a multicast group.

Parameters

- base – ENET peripheral base address.
- address – The six-byte multicast group address which is provided by application.

```
void ENET_LeaveMulticastGroup(ENET_Type *base, uint8_t *address)
```

Moves the ENET device from a multicast group.

Parameters

- base – ENET peripheral base address.
- address – The six-byte multicast group address which is provided by application.

```
static inline void ENET_ActiveRead(ENET_Type *base)
```

Activates frame reception for multiple rings.

This function is to active the enet read process.

Note: This must be called after the MAC configuration and state are ready. It must be called after the ENET_Init(). This should be called when the frame reception is required.

Parameters

- base – ENET peripheral base address.

```
static inline void ENET_EnableSleepMode(ENET_Type *base, bool enable)
```

Enables/disables the MAC to enter sleep mode. This function is used to set the MAC enter sleep mode. When entering sleep mode, the magic frame wakeup interrupt should be enabled to wake up MAC from the sleep mode and reset it to normal mode.

Parameters

- base – ENET peripheral base address.
- enable – True enable sleep mode, false disable sleep mode.

```
static inline void ENET_GetAccelFunction(ENET_Type *base, uint32_t *txAccelOption, uint32_t *rxAccelOption)
```

Gets ENET transmit and receive accelerator functions from MAC controller.

Parameters

- base – ENET peripheral base address.
- txAccelOption – The transmit accelerator option. The “enet_tx_accelerator_t” is recommended to be used to as the mask to get the exact the accelerator option.

- rxAccelOption – The receive accelerator option. The “enet_rx_accelerator_t” is recommended to be used to as the mask to get the exact the accelerator option.

static inline void ENET_EnableInterrupts(ENET_Type *base, uint32_t mask)

Enables the ENET interrupt.

This function enables the ENET interrupt according to the provided mask. The mask is a logical OR of enumeration members. See enet_interrupt_enable_t. For example, to enable the TX frame interrupt and RX frame interrupt, do the following.

```
ENET_EnableInterrupts(ENET, kENET_TxFrameInterrupt | kENET_RxFrameInterrupt);
```

Parameters

- base – ENET peripheral base address.
- mask – ENET interrupts to enable. This is a logical OR of the enumeration enet_interrupt_enable_t.

static inline void ENET_DisableInterrupts(ENET_Type *base, uint32_t mask)

Disables the ENET interrupt.

This function disables the ENET interrupts according to the provided mask. The mask is a logical OR of enumeration members. See enet_interrupt_enable_t. For example, to disable the TX frame interrupt and RX frame interrupt, do the following.

```
ENET_DisableInterrupts(ENET, kENET_TxFrameInterrupt | kENET_RxFrameInterrupt);
```

Parameters

- base – ENET peripheral base address.
- mask – ENET interrupts to disable. This is a logical OR of the enumeration enet_interrupt_enable_t.

static inline uint32_t ENET_GetInterruptStatus(ENET_Type *base)

Gets the ENET interrupt status flag.

Parameters

- base – ENET peripheral base address.

Returns

The event status of the interrupt source. This is the logical OR of members of the enumeration enet_interrupt_enable_t.

static inline void ENET_ClearInterruptStatus(ENET_Type *base, uint32_t mask)

Clears the ENET interrupt events status flag.

This function clears enabled ENET interrupts according to the provided mask. The mask is a logical OR of enumeration members. See the enet_interrupt_enable_t. For example, to clear the TX frame interrupt and RX frame interrupt, do the following.

```
ENET_ClearInterruptStatus(ENET, kENET_TxFrameInterrupt | kENET_RxFrameInterrupt);
```

Parameters

- base – ENET peripheral base address.
- mask – ENET interrupt source to be cleared. This is the logical OR of members of the enumeration enet_interrupt_enable_t.

void ENET_SetRxISRHandler(ENET_Type *base, *enet_isr_t* ISRHandler)

Set the second level Rx IRQ handler.

Parameters

- base – ENET peripheral base address.
- ISRHandler – The handler to install.

void ENET_SetTxISRHandler(ENET_Type *base, *enet_isr_t* ISRHandler)

Set the second level Tx IRQ handler.

Parameters

- base – ENET peripheral base address.
- ISRHandler – The handler to install.

void ENET_SetErrISRHandler(ENET_Type *base, *enet_isr_t* ISRHandler)

Set the second level Err IRQ handler.

Parameters

- base – ENET peripheral base address.
- ISRHandler – The handler to install.

void ENET_GetRxErrBeforeReadFrame(*enet_handle_t* *handle, *enet_data_error_stats_t* *eErrorStatic, uint8_t ringId)

Gets the error statistics of a received frame for ENET specified ring.

This API must be called after the ENET_GetRxFrameSize and before the ENET_ReadFrame(). If the ENET_GetRxFrameSize returns kStatus_ENET_RxFrameError, the ENET_GetRxErrBeforeReadFrame can be used to get the exact error statistics. This is an example.

```
status = ENET_GetRxFrameSize(&g_handle, &length, 0);
if (status == kStatus_ENET_RxFrameError)
{
    Comments: Get the error information of the received frame.
    ENET_GetRxErrBeforeReadFrame(&g_handle, &eErrStatic, 0);
    Comments: update the receive buffer.
    ENET_ReadFrame(EXAMPLE_ENET, &g_handle, NULL, 0);
}
```

Parameters

- handle – The ENET handler structure pointer. This is the same handler pointer used in the ENET_Init.
- eErrorStatic – The error statistics structure pointer.
- ringId – The ring index, range from 0 ~ (FSL_FEATURE_ENET_INSTANCE_QUEUEEn(x) - 1).

void ENET_EnableStatistics(ENET_Type *base, bool enable)

Enables/disables collection of transfer statistics.

Note that this function does not reset any of the already collected data, use the function ENET_ResetStatistics to clear the transfer statistics if needed.

Parameters

- base – ENET peripheral base address.
- enable – True enable statistics collection, false disable statistics collection.

void ENET_GetStatistics(ENET_Type *base, *enet_transfer_stats_t* *statistics)

Gets transfer statistics.

Copies the actual value of hardware counters into the provided structure. Calling this function does not reset the counters in hardware.

Parameters

- base – ENET peripheral base address.
- statistics – The statistics structure pointer.

void ENET_ResetStatistics(ENET_Type *base)

Resets transfer statistics.

Sets the value of hardware transfer counters to zero.

Parameters

- base – ENET peripheral base address.

status_t ENET_GetRxFramSize(*enet_handle_t* *handle, uint32_t *length, uint8_t ringId)

Gets the size of the read frame for specified ring.

This function gets a received frame size from the ENET buffer descriptors.

Note: The FCS of the frame is automatically removed by MAC and the size is the length without the FCS. After calling ENET_GetRxFramSize, ENET_ReadFrame() should be called to receive frame and update the BD if the result is not “kStatus_ENET_RxFrameEmpty”.

Parameters

- handle – The ENET handler structure. This is the same handler pointer used in the ENET_Init.
- length – The length of the valid frame received.
- ringId – The ring index or ring number.

Return values

- kStatus_ENET_RxFrameEmpty – No frame received. Should not call ENET_ReadFrame to read frame.
- kStatus_ENET_RxFrameError – Data error happens. ENET_ReadFrame should be called with NULL data and NULL length to update the receive buffers.
- kStatus_Success – Receive a frame Successfully then the ENET_ReadFrame should be called with the right data buffer and the captured data length input.

status_t ENET_ReadFrame(ENET_Type *base, *enet_handle_t* *handle, uint8_t *data, uint32_t length, uint8_t ringId, uint32_t *ts)

Reads a frame from the ENET device. This function reads a frame (both the data and the length) from the ENET buffer descriptors. User can get timestamp through ts pointer if the ts is not NULL.

Note: It doesn't store the timestamp in the receive timestamp queue. The ENET_GetRxFramSize should be used to get the size of the prepared data buffer. This API uses memcpy to copy data from DMA buffer to application buffer; 4 bytes aligned data buffer in 32 bits platforms provided by user may let compiler use optimization instruction to reduce time consumption. This is an example:

```
uint32_t length;
enet_handle_t g_handle;
Comments: Get the received frame size firstly.
status = ENET_GetRxFramSize(&g_handle, &length, 0);
if (length != 0)
{
    Comments: Allocate memory here with the size of "length"
    uint8_t *data = memory allocate interface;
    if (!data)
    {
        ENET_ReadFrame(ENET, &g_handle, NULL, 0, 0, NULL);
        Comments: Add the console warning log.
    }
    else
    {
        status = ENET_ReadFrame(ENET, &g_handle, data, length, 0, NULL);
        Comments: Call stack input API to deliver the data to stack
    }
}
else if (status == kStatus_ENET_RxFrameError)
{
    Comments: Update the received buffer when a error frame is received.
    ENET_ReadFrame(ENET, &g_handle, NULL, 0, 0, NULL);
}
```

Parameters

- base – ENET peripheral base address.
- handle – The ENET handler structure. This is the same handler pointer used in the ENET_Init.
- data – The data buffer provided by user to store the frame which memory size should be at least "length".
- length – The size of the data buffer which is still the length of the received frame.
- ringId – The ring index or ring number.
- ts – The timestamp address to store received timestamp.

Returns

The execute status, successful or failure.

status_t ENET_SendFrame(ENET_Type *base, *enet_handle_t* *handle, const uint8_t *data, uint32_t length, uint8_t ringId, bool tsFlag, void *context)

Transmits an ENET frame for specified ring.

Note: The CRC is automatically appended to the data. Input the data to send without the CRC. This API uses memcpy to copy data from DMA buffer to application buffer, 4 bytes aligned data buffer in 32 bits platforms provided by user may let compiler use optimization instruction to reduce time consumption.

Parameters

- base – ENET peripheral base address.
- handle – The ENET handler pointer. This is the same handler pointer used in the ENET_Init.
- data – The data buffer provided by user to send.

- `length` – The length of the data to send.
- `ringId` – The ring index or ring number.
- `tsFlag` – Timestamp enable flag.
- `context` – Used by user to handle some events after transmit over.

Return values

- `kStatus_Success` – Send frame succeed.
- `kStatus_ENET_TxFrameBusy` – Transmit buffer descriptor is busy under transmission. The transmit busy happens when the data send rate is over the MAC capacity. The waiting mechanism is recommended to be added after each call return with `kStatus_ENET_TxFrameBusy`.

`status_t` ENET_SetTxReclaim(*enet_handle_t* *handle, bool isEnabled, uint8_t ringId)

Enable or disable tx descriptors reclaim mechanism.

Note: This function must be called when no pending send frame action. Set enable if you want to reclaim context or timestamp in interrupt.

Parameters

- `handle` – The ENET handler pointer. This is the same handler pointer used in the `ENET_Init`.
- `isEnabled` – Enable or disable flag.
- `ringId` – The ring index or ring number.

Return values

- `kStatus_Success` – Succeed to enable/disable Tx reclaim.
- `kStatus_Fail` – Fail to enable/disable Tx reclaim.

`void` ENET_ReclaimTxDescriptor(*ENET_Type* *base, *enet_handle_t* *handle, uint8_t ringId)

Reclaim tx descriptors. This function is used to update the tx descriptor status and store the tx timestamp when the 1588 feature is enabled. This is called by the transmit interrupt IRQ handler after the complete of a frame transmission.

Parameters

- `base` – ENET peripheral base address.
- `handle` – The ENET handler pointer. This is the same handler pointer used in the `ENET_Init`.
- `ringId` – The ring index or ring number.

`status_t` ENET_GetRxFrame(*ENET_Type* *base, *enet_handle_t* *handle, *enet_rx_frame_struct_t* *rxFrame, uint8_t ringId)

Receives one frame in specified BD ring with zero copy.

This function uses the user-defined allocation and free callbacks. Every time application gets one frame through this function, driver stores the buffer address(es) in `enet_buffer_struct_t` and allocate new buffer(s) for the BD(s). If there's no memory buffer in the pool, this function drops current one frame to keep the Rx frame in BD ring is as fresh as possible.

Note: Application must provide a memory pool including at least BD number + n buffers in order for this function to work properly, because each BD must always take one buffer while driver is running, then other extra n buffer(s) can be taken by application. Here n

is the $\text{ceil}(\text{max\_frame\_length}(\text{set by RCR}) / \text{bd\_rx\_size}(\text{set by MRBR}))$. Application must also provide an array structure in `rxFrame->rxBuffArray` with `n` index to receive one complete frame in any case.

Parameters

- `base` – ENET peripheral base address.
- `handle` – The ENET handler pointer. This is the same handler pointer used in the `ENET_Init`.
- `rxFrame` – The received frame information structure provided by user.
- `ringId` – The ring index or ring number.

Return values

- `kStatus_Success` – Succeed to get one frame and allocate new memory for Rx buffer.
- `kStatus_ENET_RxFrameEmpty` – There's no Rx frame in the BD.
- `kStatus_ENET_RxFrameError` – There's issue in this receiving.
- `kStatus_ENET_RxFrameDrop` – There's no new buffer memory for BD, drop this frame.

`status_t` `ENET_StartTxFrame(ENET_Type *base, enet_handle_t *handle, enet_tx_frame_struct_t *txFrame, uint8_t ringId)`

Sends one frame in specified BD ring with zero copy.

This function supports scattered buffer transmit, user needs to provide the buffer array.

Note: Tx reclaim should be enabled to ensure the Tx buffer ownership can be given back to application after Tx is over.

Parameters

- `base` – ENET peripheral base address.
- `handle` – The ENET handler pointer. This is the same handler pointer used in the `ENET_Init`.
- `txFrame` – The Tx frame structure.
- `ringId` – The ring index or ring number.

Return values

- `kStatus_Success` – Succeed to send one frame.
- `kStatus_ENET_TxFrameBusy` – The BD is not ready for Tx or the reclaim operation still not finishes.
- `kStatus_ENET_TxFrameOverLen` – The Tx frame length is over max ethernet frame length.

`void` `ENET_TransmitIRQHandler(ENET_Type *base, enet_handle_t *handle)`

The transmit IRQ handler.

Parameters

- `base` – ENET peripheral base address.
- `handle` – The ENET handler pointer.

`void ENET_ReceiveIRQHandler(ENET_Type *base, enet_handle_t *handle)`

The receive IRQ handler.

Parameters

- base – ENET peripheral base address.
- handle – The ENET handler pointer.

`void ENET_ErrorIRQHandler(ENET_Type *base, enet_handle_t *handle)`

Some special IRQ handler including the error, mii, wakeup irq handler.

Parameters

- base – ENET peripheral base address.
- handle – The ENET handler pointer.

`void ENET_Ptp1588IRQHandler(ENET_Type *base)`

the common IRQ handler for the 1588 irq handler.

This is used for the 1588 timer interrupt.

Parameters

- base – ENET peripheral base address.

`void ENET_CommonFrame0IRQHandler(ENET_Type *base)`

the common IRQ handler for the tx/rx/error etc irq handler.

This is used for the combined tx/rx/error interrupt for single/mutli-ring (frame 0).

Parameters

- base – ENET peripheral base address.

`FSL_ENET_DRIVER_VERSION`

Defines the driver version.

`ENET_BUFFDESCRIPTOR_RX_EMPTY_MASK`

Empty bit mask.

`ENET_BUFFDESCRIPTOR_RX_SOFTOWNER1_MASK`

Software owner one mask.

`ENET_BUFFDESCRIPTOR_RX_WRAP_MASK`

Next buffer descriptor is the start address.

`ENET_BUFFDESCRIPTOR_RX_SOFTOWNER2_Mask`

Software owner two mask.

`ENET_BUFFDESCRIPTOR_RX_LAST_MASK`

Last BD of the frame mask.

`ENET_BUFFDESCRIPTOR_RX_MISS_MASK`

Received because of the promiscuous mode.

`ENET_BUFFDESCRIPTOR_RX_BROADCAST_MASK`

Broadcast packet mask.

`ENET_BUFFDESCRIPTOR_RX_MULTICAST_MASK`

Multicast packet mask.

`ENET_BUFFDESCRIPTOR_RX_LENVIOLATE_MASK`

Length violation mask.

ENET_BUFFDESCRIPTOR_RX_NOOCTET_MASK

Non-octet aligned frame mask.

ENET_BUFFDESCRIPTOR_RX_CRC_MASK

CRC error mask.

ENET_BUFFDESCRIPTOR_RX_OVERRUN_MASK

FIFO overrun mask.

ENET_BUFFDESCRIPTOR_RX_TRUNC_MASK

Frame is truncated mask.

ENET_BUFFDESCRIPTOR_TX_READY_MASK

Ready bit mask.

ENET_BUFFDESCRIPTOR_TX_SOFTOWNER1_MASK

Software owner one mask.

ENET_BUFFDESCRIPTOR_TX_WRAP_MASK

Wrap buffer descriptor mask.

ENET_BUFFDESCRIPTOR_TX_SOFTOWNER2_MASK

Software owner two mask.

ENET_BUFFDESCRIPTOR_TX_LAST_MASK

Last BD of the frame mask.

ENET_BUFFDESCRIPTOR_TX_TRANSMITCRC_MASK

Transmit CRC mask.

ENET_FRAME_MAX_FRAMELEN

Default maximum Ethernet frame size without VLAN tag.

ENET_FRAME_VLAN_TAGLEN

Ethernet single VLAN tag size.

ENET_FRAME_CRC_LEN

CRC size in a frame.

ENET_FRAME_TX_LEN_LIMITATION(x)

ENET_FIFO_MIN_RX_FULL

ENET minimum receive FIFO full.

ENET_RX_MIN_BUFFERSIZE

ENET minimum buffer size.

ENET_PHY_MAXADDRESS

Maximum PHY address.

ENET_TX_INTERRUPT

Enet Tx interrupt flag.

ENET_RX_INTERRUPT

Enet Rx interrupt flag.

ENET_TS_INTERRUPT

Enet timestamp interrupt flag.

ENET_ERR_INTERRUPT

Enet error interrupt flag.

Defines the status return codes for transaction.

Values:

enumerator kStatus_ENET_InitMemoryFail
Init fails since buffer memory is not enough.

enumerator kStatus_ENET_RxFrameError
A frame received but data error happen.

enumerator kStatus_ENET_RxFrameFail
Failed to receive a frame.

enumerator kStatus_ENET_RxFrameEmpty
No frame arrive.

enumerator kStatus_ENET_RxFrameDrop
Rx frame is dropped since no buffer memory.

enumerator kStatus_ENET_TxFrameOverLen
Tx frame over length.

enumerator kStatus_ENET_TxFrameBusy
Tx buffer descriptors are under process.

enumerator kStatus_ENET_TxFrameFail
Transmit frame fail.

enum _enet_mii_mode

Defines the MII/RMII/RGMII mode for data interface between the MAC and the PHY.

Values:

enumerator kENET_MiiMode
MII mode for data interface.

enumerator kENET_RmiiMode
RMII mode for data interface.

enumerator kENET_RgmiiMode
RGMII mode for data interface.

enum _enet_mii_speed

Defines the 10/100/1000 Mbps speed for the MII data interface.

Notice: “kENET_MiiSpeed1000M” only supported when mii mode is “kENET_RgmiiMode”.

Values:

enumerator kENET_MiiSpeed10M
Speed 10 Mbps.

enumerator kENET_MiiSpeed100M
Speed 100 Mbps.

enumerator kENET_MiiSpeed1000M
Speed 1000M bps.

enum _enet_mii_duplex

Defines the half or full duplex for the MII data interface.

Values:

enumerator kENET_MiiHalfDuplex

Half duplex mode.

enumerator kENET_MiiFullDuplex

Full duplex mode.

enum _enet_mii_write

Define the MII opcode for normal MDIO_CLAUSES_22 Frame.

Values:

enumerator kENET_MiiWriteNoCompliant

Write frame operation, but not MII-compliant.

enumerator kENET_MiiWriteValidFrame

Write frame operation for a valid MII management frame.

enum _enet_mii_read

Defines the read operation for the MII management frame.

Values:

enumerator kENET_MiiReadValidFrame

Read frame operation for a valid MII management frame.

enumerator kENET_MiiReadNoCompliant

Read frame operation, but not MII-compliant.

enum _enet_mii_extend_opcode

Define the MII opcode for extended MDIO_CLAUSES_45 Frame.

Values:

enumerator kENET_MiiAddrWrite_C45

Address Write operation.

enumerator kENET_MiiWriteFrame_C45

Write frame operation for a valid MII management frame.

enumerator kENET_MiiReadFrame_C45

Read frame operation for a valid MII management frame.

enum _enet_special_control_flag

Defines a special configuration for ENET MAC controller.

These control flags are provided for special user requirements. Normally, these control flags are unused for ENET initialization. For special requirements, set the flags to macSpecialConfig in the enet_config_t. The kENET_ControlStoreAndFwdDisable is used to disable the FIFO store and forward. FIFO store and forward means that the FIFO read/send is started when a complete frame is stored in TX/RX FIFO. If this flag is set, configure rxFifoFullThreshold and txFifoWatermark in the enet_config_t.

Values:

enumerator kENET_ControlFlowControlEnable

Enable ENET flow control: pause frame.

enumerator kENET_ControlRxPayloadCheckEnable

Enable ENET receive payload length check.

enumerator kENET_ControlRxPadRemoveEnable

Padding is removed from received frames.

enumerator kENET_ControlRxBroadCastRejectEnable

Enable broadcast frame reject.

enumerator kENET_ControlMacAddrInsert

Enable MAC address insert.

enumerator kENET_ControlStoreAndFwdDisable

Enable FIFO store and forward.

enumerator kENET_ControlSMIPreambleDisable

Enable SMI preamble.

enumerator kENET_ControlPromiscuousEnable

Enable promiscuous mode.

enumerator kENET_ControlMIILoopEnable

Enable ENET MII loop back.

enumerator kENET_ControlVLANTagEnable

Enable normal VLAN (single vlan tag).

enumerator kENET_ControlSVLANEnable

Enable S-VLAN.

enumerator kENET_ControlVLANUseSecondTag

Enable extracting the second vlan tag for further processing.

enum _enet_interrupt_enable

List of interrupts supported by the peripheral. This enumeration uses one-bit encoding to allow a logical OR of multiple members. Members usually map to interrupt enable bits in one or more peripheral registers.

Values:

enumerator kENET_BabrInterrupt

Babbling receive error interrupt source

enumerator kENET_BabtInterrupt

Babbling transmit error interrupt source

enumerator kENET_GraceStopInterrupt

Graceful stop complete interrupt source

enumerator kENET_TxFrameInterrupt

TX FRAME interrupt source

enumerator kENET_TxBufferInterrupt

TX BUFFER interrupt source

enumerator kENET_RxFrameInterrupt

RX FRAME interrupt source

enumerator kENET_RxBufferInterrupt

RX BUFFER interrupt source

enumerator kENET_MiiInterrupt

MII interrupt source

enumerator kENET_EBusERInterrupt

Ethernet bus error interrupt source

enumerator kENET_LateCollisionInterrupt

Late collision interrupt source

enumerator kENET_RetryLimitInterrupt
Collision Retry Limit interrupt source

enumerator kENET_UnderrunInterrupt
Transmit FIFO underrun interrupt source

enumerator kENET_PayloadRxInterrupt
Payload Receive error interrupt source

enumerator kENET_WakeupInterrupt
WAKEUP interrupt source

enumerator kENET_TsAvailInterrupt
TS AVAIL interrupt source for PTP

enumerator kENET_TsTimerInterrupt
TS WRAP interrupt source for PTP

enum _enet_event

Defines the common interrupt event for callback use.

Values:

enumerator kENET_RxEvent
Receive event.

enumerator kENET_TxEvent
Transmit event.

enumerator kENET_ErrEvent
Error event: BABR/BABT/EBERR/LC/RL/UN/PLR .

enumerator kENET_WakeUpEvent
Wake up from sleep mode event.

enumerator kENET_TimeStampEvent
Time stamp event.

enumerator kENET_TimeStampAvailEvent
Time stamp available event.

enum _enet_idle_slope

Defines certain idle slope for bandwidth fraction.

Values:

enumerator kENET_IdleSlope1
The bandwidth fraction is about 0.002.

enumerator kENET_IdleSlope2
The bandwidth fraction is about 0.003.

enumerator kENET_IdleSlope4
The bandwidth fraction is about 0.008.

enumerator kENET_IdleSlope8
The bandwidth fraction is about 0.02.

enumerator kENET_IdleSlope16
The bandwidth fraction is about 0.03.

enumerator kENET_IdleSlope32
The bandwidth fraction is about 0.06.

enumerator kENET_IdleSlope64

The bandwidth fraction is about 0.11.

enumerator kENET_IdleSlope128

The bandwidth fraction is about 0.20.

enumerator kENET_IdleSlope256

The bandwidth fraction is about 0.33.

enumerator kENET_IdleSlope384

The bandwidth fraction is about 0.43.

enumerator kENET_IdleSlope512

The bandwidth fraction is about 0.50.

enumerator kENET_IdleSlope640

The bandwidth fraction is about 0.56.

enumerator kENET_IdleSlope768

The bandwidth fraction is about 0.60.

enumerator kENET_IdleSlope896

The bandwidth fraction is about 0.64.

enumerator kENET_IdleSlope1024

The bandwidth fraction is about 0.67.

enumerator kENET_IdleSlope1152

The bandwidth fraction is about 0.69.

enumerator kENET_IdleSlope1280

The bandwidth fraction is about 0.71.

enumerator kENET_IdleSlope1408

The bandwidth fraction is about 0.73.

enumerator kENET_IdleSlope1536

The bandwidth fraction is about 0.75.

enum _enet_tx_accelerator

Defines the transmit accelerator configuration.

Note that the hardware does not insert ICMPv6 protocol checksums as mentioned in errata ERR052152.

Values:

enumerator kENET_TxAccelIsShift16Enabled

Transmit FIFO shift-16.

enumerator kENET_TxAccelIpCheckEnabled

Insert IP header checksum.

enumerator kENET_TxAccelProtoCheckEnabled

Insert protocol checksum (TCP, UDP, ICMPv4).

enum _enet_rx_accelerator

Defines the receive accelerator configuration.

Note that the hardware does not validate ICMPv6 protocol checksums as mentioned in errata ERR052152.

Values:

enumerator `kENET_RxAccelPadRemoveEnabled`

Padding removal for short IP frames.

enumerator `kENET_RxAccelIpCheckEnabled`

Discard with wrong IP header checksum.

enumerator `kENET_RxAccelProtoCheckEnabled`

Discard with wrong protocol checksum (TCP, UDP, ICMPv4).

enumerator `kENET_RxAccelMacCheckEnabled`

Discard with Mac layer errors.

enumerator `kENET_RxAccelIsShift16Enabled`

Receive FIFO shift-16.

typedef enum `_enet_mii_mode` `enet_mii_mode_t`

Defines the MII/RMII/RGMII mode for data interface between the MAC and the PHY.

typedef enum `_enet_mii_speed` `enet_mii_speed_t`

Defines the 10/100/1000 Mbps speed for the MII data interface.

Notice: “`kENET_MiiSpeed1000M`” only supported when mii mode is “`kENET_RgmiiMode`”.

typedef enum `_enet_mii_duplex` `enet_mii_duplex_t`

Defines the half or full duplex for the MII data interface.

typedef enum `_enet_mii_write` `enet_mii_write_t`

Define the MII opcode for normal MDIO_CLAUSES_22 Frame.

typedef enum `_enet_mii_read` `enet_mii_read_t`

Defines the read operation for the MII management frame.

typedef enum `_enet_mii_extend_opcode` `enet_mii_extend_opcode`

Define the MII opcode for extended MDIO_CLAUSES_45 Frame.

typedef enum `_enet_special_control_flag` `enet_special_control_flag_t`

Defines a special configuration for ENET MAC controller.

These control flags are provided for special user requirements. Normally, these control flags are unused for ENET initialization. For special requirements, set the flags to `macSpecialConfig` in the `enet_config_t`. The `kENET_ControlStoreAndFwdDisable` is used to disable the FIFO store and forward. FIFO store and forward means that the FIFO read/send is started when a complete frame is stored in TX/RX FIFO. If this flag is set, configure `rxFifoFullThreshold` and `txFifoWatermark` in the `enet_config_t`.

typedef enum `_enet_interrupt_enable` `enet_interrupt_enable_t`

List of interrupts supported by the peripheral. This enumeration uses one-bit encoding to allow a logical OR of multiple members. Members usually map to interrupt enable bits in one or more peripheral registers.

typedef enum `_enet_event` `enet_event_t`

Defines the common interrupt event for callback use.

typedef enum `_enet_idle_slope` `enet_idle_slope_t`

Defines certain idle slope for bandwidth fraction.

typedef enum `_enet_tx_accelerator` `enet_tx_accelerator_t`

Defines the transmit accelerator configuration.

Note that the hardware does not insert ICMPv6 protocol checksums as mentioned in errata ERR052152.

`typedef enum _enet_rx_accelerator enet_rx_accelerator_t`

Defines the receive accelerator configuration.

Note that the hardware does not validate ICMPv6 protocol checksums as mentioned in errata ERR052152.

`typedef struct _enet_rx_bd_struct enet_rx_bd_struct_t`

Defines the receive buffer descriptor structure for the little endian system.

`typedef struct _enet_tx_bd_struct enet_tx_bd_struct_t`

Defines the enhanced transmit buffer descriptor structure for the little endian system.

`typedef struct _enet_data_error_stats enet_data_error_stats_t`

Defines the ENET data error statistics structure.

`typedef struct _enet_rx_frame_error enet_rx_frame_error_t`

Defines the Rx frame error structure.

`typedef struct _enet_transfer_stats enet_transfer_stats_t`

Defines the ENET transfer statistics structure.

`typedef struct enet_frame_info enet_frame_info_t`

Defines the frame info structure.

`typedef struct _enet_tx_dirty_ring enet_tx_dirty_ring_t`

Defines the ENET transmit dirty addresses ring/queue structure.

`typedef void (*enet_rx_alloc_callback_t)(ENET_Type *base, void *userData, uint8_t ringId)`

Defines the ENET Rx memory buffer alloc function pointer.

`typedef void (*enet_rx_free_callback_t)(ENET_Type *base, void *buffer, void *userData, uint8_t ringId)`

Defines the ENET Rx memory buffer free function pointer.

`typedef struct _enet_buffer_config enet_buffer_config_t`

Defines the receive buffer descriptor configuration structure.

Note that for the internal DMA requirements, the buffers have a corresponding alignment requirements.

- a. The aligned receive and transmit buffer size must be evenly divisible by ENET_BUFF_ALIGNMENT. when the data buffers are in cacheable region when cache is enabled, all those size should be aligned to the maximum value of “ENET_BUFF_ALIGNMENT” and the cache line size.
- b. The aligned transmit and receive buffer descriptor start address must be at least 64 bit aligned. However, it's recommended to be evenly divisible by ENET_BUFF_ALIGNMENT. buffer descriptors should be put in non-cacheable region when cache is enabled.
- c. The aligned transmit and receive data buffer start address must be evenly divisible by ENET_BUFF_ALIGNMENT. Receive buffers should be continuous with the total size equal to “rxBdNumber * rxBuffSizeAlign”. Transmit buffers should be continuous with the total size equal to “txBdNumber * txBuffSizeAlign”. when the data buffers are in cacheable region when cache is enabled, all those size should be aligned to the maximum value of “ENET_BUFF_ALIGNMENT” and the cache line size.

`typedef struct _enet_intcoalesce_config enet_intcoalesce_config_t`

Defines the interrupt coalescing configure structure.

`typedef struct _enet_avb_config enet_avb_config_t`

Defines the ENET AVB Configure structure.

This is used for to configure the extended ring 1 and ring 2.

- a. The classification match format is $(CMP3 \ll 12) \mid (CMP2 \ll 8) \mid (CMP1 \ll 4) \mid CMP0$. composed of four 3-bit compared VLAN priority field $cmp0 \sim cmp3$, $cm0 \sim cmp3$ are used in parallel.

If CMP1,2,3 are not unused, please set them to the same value as CMP0.

- a. The idleSlope is used to calculate the Band Width fraction, $BW \text{ fraction} = 1 / (1 + 512/idleSlope)$. For avb configuration, the BW fraction of Class 1 and Class 2 combined must not exceed 0.75.

```
typedef struct _enet_handle enet_handle_t
```

```
typedef void (*enet_callback_t)(ENET_Type *base, enet_handle_t *handle, enet_event_t event,
enet_frame_info_t *frameInfo, void *userData)
```

ENET callback function.

```
typedef struct _enet_config enet_config_t
```

Defines the basic configuration structure for the ENET device.

Note:

- a. macSpecialConfig is used for a special control configuration, A logical OR of “enet_special_control_flag_t”. For a special configuration for MAC, set this parameter to 0.
- b. txWatermark is used for a cut-through operation. It is in steps of 64 bytes: 0/1 - 64 bytes written to TX FIFO before transmission of a frame begins. 2 - 128 bytes written to TX FIFO 3 - 192 bytes written to TX FIFO The maximum of txWatermark is 0x2F - 4032 bytes written to TX FIFO txWatermark allows minimizing the transmit latency to set the txWatermark to 0 or 1 or for larger bus access latency 3 or larger due to contention for the system bus.
- c. rxFifoFullThreshold is similar to the txWatermark for cut-through operation in RX. It is in 64-bit words. The minimum is ENET_FIFO_MIN_RX_FULLL and the maximum is 0xFF. If the end of the frame is stored in FIFO and the frame size is smaller than the txWatermark, the frame is still transmitted. The rule is the same for rxFifoFullThreshold in the receive direction.
- d. When “kENET_ControlFlowControlEnable” is set in the macSpecialConfig, ensure that the pauseDuration, rxFifoEmptyThreshold, and rxFifoStatEmptyThreshold are set for flow control enabled case.
- e. When “kENET_ControlStoreAndFwdDisabled” is set in the macSpecialConfig, ensure that the rxFifoFullThreshold and txFifoWatermark are set for store and forward disable.
- f. The rxAccelerConfig and txAccelerConfig default setting with 0 - accelerator are disabled. The “enet_tx_accelerator_t” and “enet_rx_accelerator_t” are recommended to be used to enable the transmit and receive accelerator. After the accelerators are enabled, the store and forward feature should be enabled. As a result, kENET_ControlStoreAndFwdDisabled should not be set.
- g. The intCoalesceCfg can be used in the rx or tx enabled cases to decrease the CPU loading.

```
typedef struct _enet_tx_bd_ring enet_tx_bd_ring_t
```

Defines the ENET transmit buffer descriptor ring/queue structure.

```
typedef struct _enet_rx_bd_ring enet_rx_bd_ring_t
```

Defines the ENET receive buffer descriptor ring/queue structure.

```
typedef struct _enet_buffer_struct enet_buffer_struct_t
```

```
typedef struct _enet_rx_frame_attribute_struct enet_rx_frame_attribute_t
```

```
typedef struct _enet_rx_frame_struct enet_rx_frame_struct_t
```

```
typedef struct _enet_tx_frame_struct enet_tx_frame_struct_t
```

```
typedef void (*enet_isr_t)(ENET_Type *base, enet_handle_t *handle)
```

Define interrupt IRQ handler.

```
const clock_ip_name_t s_enetClock[]
```

Pointers to enet clocks for each instance.

```
const clock_ip_name_t s_enetExtraClock[]
```

```
uint32_t ENET_GetInstance(ENET_Type *base)
```

Get the ENET instance from peripheral base address.

Parameters

- base – ENET peripheral base address.

Returns

ENET instance.

```
ENET_BUFFDESCRIPTOR_RX_ERR_MASK
```

Defines the receive error status flag mask.

```
struct _enet_rx_bd_struct
```

#include <fsl_enet.h> Defines the receive buffer descriptor structure for the little endian system.

Public Members

```
uint16_t length
```

Buffer descriptor data length.

```
uint16_t control
```

Buffer descriptor control and status.

```
uint32_t buffer
```

Data buffer pointer.

```
struct _enet_tx_bd_struct
```

#include <fsl_enet.h> Defines the enhanced transmit buffer descriptor structure for the little endian system.

Public Members

```
uint16_t length
```

Buffer descriptor data length.

```
uint16_t control
```

Buffer descriptor control and status.

```
uint32_t buffer
```

Data buffer pointer.

```
struct _enet_data_error_stats
```

#include <fsl_enet.h> Defines the ENET data error statistics structure.

Public Members

uint32_t statsRxLenGreaterErr
Receive length greater than RCR[MAX_FL].

uint32_t statsRxAlignErr
Receive non-octet alignment/

uint32_t statsRxFcsErr
Receive CRC error.

uint32_t statsRxOverRunErr
Receive over run.

uint32_t statsRxTruncateErr
Receive truncate.

struct __enet_rx_frame_error
#include <fsl_enet.h> Defines the Rx frame error structure.

Public Members

bool statsRxTruncateErr
Receive truncate.

bool statsRxOverRunErr
Receive over run.

bool statsRxFcsErr
Receive CRC error.

bool statsRxAlignErr
Receive non-octet alignment.

bool statsRxLenGreaterErr
Receive length greater than RCR[MAX_FL].

struct __enet_transfer_stats
#include <fsl_enet.h> Defines the ENET transfer statistics structure.

Public Members

uint32_t statsRxFrameCount
Rx frame number.

uint32_t statsRxFrameOk
Good Rx frame number.

uint32_t statsRxCrcErr
Rx frame number with CRC error.

uint32_t statsRxAlignErr
Rx frame number with alignment error.

uint32_t statsRxDropInvalidSFD
Dropped frame number due to invalid SFD.

uint32_t statsRxFifoOverflowErr
Rx FIFO overflow count.

uint32_t statsTxFrameCount

Tx frame number.

uint32_t statsTxFrameOk

Good Tx frame number.

uint32_t statsTxCrcAlignErr

The transmit frame is error.

uint32_t statsTxFifoUnderRunErr

Tx FIFO underrun count.

struct enet_frame_info

#include <fsl_enet.h> Defines the frame info structure.

Public Members

void *context

User specified data

struct __enet_tx_dirty_ring

#include <fsl_enet.h> Defines the ENET transmit dirty addresses ring/queue structure.

Public Members

enet_frame_info_t *txDirtyBase

Dirty buffer descriptor base address pointer.

uint16_t txGenIdx

tx generate index.

uint16_t txConsumIdx

tx consume index.

uint16_t txRingLen

tx ring length.

bool isFull

tx ring is full flag.

struct __enet_buffer_config

#include <fsl_enet.h> Defines the receive buffer descriptor configuration structure.

Note that for the internal DMA requirements, the buffers have a corresponding alignment requirements.

- a. The aligned receive and transmit buffer size must be evenly divisible by ENET_BUFF_ALIGNMENT. when the data buffers are in cacheable region when cache is enabled, all those size should be aligned to the maximum value of "ENET_BUFF_ALIGNMENT" and the cache line size.
- b. The aligned transmit and receive buffer descriptor start address must be at least 64 bit aligned. However, it's recommended to be evenly divisible by ENET_BUFF_ALIGNMENT. buffer descriptors should be put in non-cacheable region when cache is enabled.
- c. The aligned transmit and receive data buffer start address must be evenly divisible by ENET_BUFF_ALIGNMENT. Receive buffers should be continuous with the total size equal to "rxBdNumber * rxBuffSizeAlign". Transmit buffers should be continuous with the total size equal to "txBdNumber * txBuffSizeAlign". when the data buffers are in cacheable region when cache is enabled, all those size should be aligned to the maximum value of "ENET_BUFF_ALIGNMENT" and the cache line size.

Public Members

uint16_t rxBdNumber

Receive buffer descriptor number.

uint16_t txBdNumber

Transmit buffer descriptor number.

uint16_t rxBuffSizeAlign

Aligned receive data buffer size.

uint16_t txBuffSizeAlign

Aligned transmit data buffer size.

volatile *enet_rx_bd_struct_t* *rxBdStartAddrAlign

Aligned receive buffer descriptor start address: should be non-cacheable.

volatile *enet_tx_bd_struct_t* *txBdStartAddrAlign

Aligned transmit buffer descriptor start address: should be non-cacheable.

uint8_t *rxBufferAlign

Receive data buffer start address.

uint8_t *txBufferAlign

Transmit data buffer start address.

bool rxMaintainEnable

Receive buffer cache maintain.

bool txMaintainEnable

Transmit buffer cache maintain.

enet_frame_info_t *txFrameInfo

Transmit frame information start address.

struct __enet_intcoalesce_config

#include <fsl_enet.h> Defines the interrupt coalescing configure structure.

Public Members

uint8_t txCoalesceFrameCount[1]

Transmit interrupt coalescing frame count threshold.

uint16_t txCoalesceTimeCount[1]

Transmit interrupt coalescing timer count threshold.

uint8_t rxCoalesceFrameCount[1]

Receive interrupt coalescing frame count threshold.

uint16_t rxCoalesceTimeCount[1]

Receive interrupt coalescing timer count threshold.

struct __enet_avb_config

#include <fsl_enet.h> Defines the ENET AVB Configure structure.

This is used for to configure the extended ring 1 and ring 2.

- a. The classification match format is $(CMP3 \ll 12) \mid (CMP2 \ll 8) \mid (CMP1 \ll 4) \mid CMP0$. composed of four 3-bit compared VLAN priority field cmp0~cmp3, cm0 ~ cmp3 are used in parallel.

If CMP1,2,3 are not unused, please set them to the same value as CMP0.

- a. The idleSlope is used to calculate the Band Width fraction, $BW \text{ fraction} = 1 / (1 + 512/\text{idleSlope})$. For avb configuration, the BW fraction of Class 1 and Class 2 combined must not exceed 0.75.

Public Members

uint16_t rxClassifyMatch[1 - 1]

The classification match value for the ring.

enet_idle_slope_t idleSlope[1 - 1]

The idle slope for certian bandwidth fraction.

struct _enet_config

#include <fsl_enet.h> Defines the basic configuration structure for the ENET device.

Note:

- a. macSpecialConfig is used for a special control configuration, A logical OR of “enet_special_control_flag_t”. For a special configuration for MAC, set this parameter to 0.
- b. txWatermark is used for a cut-through operation. It is in steps of 64 bytes: 0/1 - 64 bytes written to TX FIFO before transmission of a frame begins. 2 - 128 bytes written to TX FIFO 3 - 192 bytes written to TX FIFO The maximum of txWatermark is 0x2F - 4032 bytes written to TX FIFO txWatermark allows minimizing the transmit latency to set the txWatermark to 0 or 1 or for larger bus access latency 3 or larger due to contention for the system bus.
- c. rxFifoFullThreshold is similar to the txWatermark for cut-through operation in RX. It is in 64-bit words. The minimum is ENET_FIFO_MIN_RX_FULL and the maximum is 0xFF. If the end of the frame is stored in FIFO and the frame size is smaller than the txWatermark, the frame is still transmitted. The rule is the same for rxFifoFullThreshold in the receive direction.
- d. When “kENET_ControlFlowControlEnable” is set in the macSpecialConfig, ensure that the pauseDuration, rxFifoEmptyThreshold, and rxFifoStatEmptyThreshold are set for flow control enabled case.
- e. When “kENET_ControlStoreAndFwdDisabled” is set in the macSpecialConfig, ensure that the rxFifoFullThreshold and txFifoWatermark are set for store and forward disable.
- f. The rxAccelerConfig and txAccelerConfig default setting with 0 - accelerator are disabled. The “enet_tx_accelerator_t” and “enet_rx_accelerator_t” are recommended to be used to enable the transmit and receive accelerator. After the accelerators are enabled, the store and forward feature should be enabled. As a result, kENET_ControlStoreAndFwdDisabled should not be set.
- g. The intCoalesceCfg can be used in the rx or tx enabled cases to decrease the CPU loading.

Public Members

uint32_t macSpecialConfig

Mac special configuration. A logical OR of “enet_special_control_flag_t”.

uint32_t interrupt

Mac interrupt source. A logical OR of “enet_interrupt_enable_t”.

uint16_t rxMaxFrameLen

Receive maximum frame length.

enet_mii_mode_t miiMode

MII mode.

enet_mii_speed_t miiSpeed

MII Speed.

enet_mii_duplex_t miiDuplex

MII duplex.

uint8_t rxAccelerConfig

Receive accelerator, A logical OR of “enet_rx_accelerator_t”.

uint8_t txAccelerConfig

Transmit accelerator, A logical OR of “enet_rx_accelerator_t”.

uint16_t pauseDuration

For flow control enabled case: Pause duration.

uint8_t rxFifoEmptyThreshold

For flow control enabled case: when RX FIFO level reaches this value, it makes MAC generate XOFF pause frame.

uint8_t rxFifoStatEmptyThreshold

For flow control enabled case: number of frames in the receive FIFO, independent of size, that can be accept. If the limit is reached, reception continues and a pause frame is triggered.

uint8_t rxFifoFullThreshold

For store and forward disable case, the data required in RX FIFO to notify the MAC receive ready status.

uint8_t txFifoWatermark

For store and forward disable case, the data required in TX FIFO before a frame transmit start.

enet_intcoalesce_config_t *intCoalesceCfg

If the interrupt coalescence is not required in the ring n(0,1,2), please set to NULL.

uint8_t ringNum

Number of used rings. default with 1 — single ring.

enet_rx_alloc_callback_t rxBuffAlloc

Callback function to alloc memory, must be provided for zero-copy Rx.

enet_rx_free_callback_t rxBuffFree

Callback function to free memory, must be provided for zero-copy Rx.

enet_callback_t callback

General callback function.

void *userData

Callback function parameter.

struct __enet_tx_bd_ring

#include <fsl_enet.h> Defines the ENET transmit buffer descriptor ring/queue structure.

Public Members

volatile *enet_tx_bd_struct_t* *txBdBase

Buffer descriptor base address pointer.

uint16_t txGenIdx

The current available transmit buffer descriptor pointer.

uint16_t txConsumIdx

Transmit consume index.

volatile uint16_t txDescUsed

Transmit descriptor used number.

uint16_t txRingLen

Transmit ring length.

struct __enet_rx_bd_ring

#include <fsl_enet.h> Defines the ENET receive buffer descriptor ring/queue structure.

Public Members

volatile *enet_rx_bd_struct_t* *rxBdBase

Buffer descriptor base address pointer.

uint16_t rxGenIdx

The current available receive buffer descriptor pointer.

uint16_t rxRingLen

Receive ring length.

struct __enet_handle

#include <fsl_enet.h> Defines the ENET handler structure.

Public Members

enet_rx_bd_ring_t rxBdRing[1]

Receive buffer descriptor.

enet_tx_bd_ring_t txBdRing[1]

Transmit buffer descriptor.

uint16_t rxBuffSizeAlign[1]

Receive buffer size alignment.

uint16_t txBuffSizeAlign[1]

Transmit buffer size alignment.

bool rxMaintainEnable[1]

Receive buffer cache maintain.

bool txMaintainEnable[1]

Transmit buffer cache maintain.

uint8_t ringNum

Number of used rings.

enet_callback_t callback

Callback function.

void *userData

Callback function parameter.

enet_tx_dirty_ring_t txDirtyRing[1]

Ring to store tx frame information.

bool txReclaimEnable[1]

Tx reclaim enable flag.

enet_rx_alloc_callback_t rxBuffAlloc

Callback function to alloc memory for zero copy Rx.

enet_rx_free_callback_t rxBuffFree

Callback function to free memory for zero copy Rx.

uint8_t multicastCount[64]

Multicast collisions counter

uint32_t enetClock

The clock of enet peripheral, to caculate core cycles for PTP timestamp.

uint32_t tsDelayCount

The count of core cycles for PTP timestamp capture delay.

struct __enet_buffer_struct

#include <fsl_enet.h>

Public Members

void *buffer

The buffer store the whole or partial frame.

uint16_t length

The byte length of this buffer.

struct __enet_rx_frame_attribute_struct

#include <fsl_enet.h>

Public Members

bool promiscuous

This frame is received because of promiscuous mode.

struct __enet_rx_frame_struct

#include <fsl_enet.h>

Public Members

enet_buffer_struct_t *rxBuffArray

Rx frame buffer structure.

uint16_t totLen

Rx frame total length.

enet_rx_frame_attribute_t rxAttribute

Rx frame attribute structure.

enet_rx_frame_error_t rxFrameError

Rx frame error.

struct __enet_tx_frame_struct

#include <fsl_enet.h>

Public Members

enet_buffer_struct_t *txBuffArray

Tx frame buffer structure.

uint32_t txBuffNum

Buffer number of this Tx frame.

void *context

Driver reclaims and gives it in Tx over callback, usually store network packet header.

2.5 EQOS-TSN: Ethernet QoS with TSN Driver

2.6 Enet_qos_qos

void ENET_QOS_GetDefaultConfig(*enet_qos_config_t* *config)

Gets the ENET default configuration structure.

The purpose of this API is to get the default ENET configure structure for ENET_QOS_Init(). User may use the initialized structure unchanged in ENET_QOS_Init(), or modify some fields of the structure before calling ENET_QOS_Init(). Example:

```
enet_qos_config_t config;
ENET_QOS_GetDefaultConfig(&config);
```

Parameters

- config – The ENET mac controller configuration structure pointer.

status_t ENET_QOS_Up(ENET_QOS_Type *base, const *enet_qos_config_t* *config, uint8_t *macAddr, uint8_t macCount, uint32_t refclkSrc_Hz)

Initializes the ENET module.

This function initializes it with the ENET basic configuration.

Parameters

- base – ENET peripheral base address.
- config – ENET mac configuration structure pointer. The “enet_qos_config_t” type mac configuration return from ENET_QOS_GetDefaultConfig can be used directly. It is also possible to verify the Mac configuration using other methods.
- macAddr – Pointer to ENET mac address array of Ethernet device. This MAC address should be provided.
- macCount – Count of macAddr in the ENET mac address array
- refclkSrc_Hz – ENET input reference clock.

status_t ENET_QOS_Init(ENET_QOS_Type *base, const *enet_qos_config_t* *config, uint8_t *macAddr, uint8_t macCount, uint32_t refclkSrc_Hz)

Initializes the ENET module.

This function ungates the module clock and initializes it with the ENET basic configuration.

Parameters

- base – ENET peripheral base address.

- `config` – ENET mac configuration structure pointer. The “enet_qos_config_t” type mac configuration return from `ENET_QOS_GetDefaultConfig` can be used directly. It is also possible to verify the Mac configuration using other methods.
- `macAddr` – Pointer to ENET mac address array of Ethernet device. This MAC address should be provided.
- `macCount` – Count of `macAddr` in the ENET mac address array
- `refclkSrc_Hz` – ENET input reference clock.

`void ENET_QOS_Down(ENET_QOS_Type *base)`

Stops the ENET module.

This function disables the ENET module.

Parameters

- `base` – ENET peripheral base address.

`void ENET_QOS_Deinit(ENET_QOS_Type *base)`

Deinitializes the ENET module.

This function gates the module clock and disables the ENET module.

Parameters

- `base` – ENET peripheral base address.

`uint32_t ENET_QOS_GetInstance(ENET_QOS_Type *base)`

Get the ENET instance from peripheral base address.

Parameters

- `base` – ENET peripheral base address.

Returns

ENET instance.

`status_t ENET_QOS_DescriptorInit(ENET_QOS_Type *base, enet_qos_config_t *config, enet_qos_buffer_config_t *bufferConfig)`

Initialize for all ENET descriptors.

Note: This function is do all tx/rx descriptors initialization. Because this API read all interrupt registers first and then set the interrupt flag for all descriptors, if the interrupt register is set. so the descriptor initialization should be called after `ENET_QOS_Init()`, `ENET_QOS_EnableInterrupts()` and `ENET_QOS_CreateHandle()`(if transactional APIs are used).

Parameters

- `base` – ENET peripheral base address.
- `config` – The configuration for ENET.
- `bufferConfig` – All buffers configuration.

`status_t ENET_QOS_RxBufferAllocAll(ENET_QOS_Type *base, enet_qos_handle_t *handle)`

Allocates Rx buffers for all BDs. It's used for zero copy Rx. In zero copy Rx case, Rx buffers are dynamic. This function will populate initial buffers in all BDs for receiving. Then `ENET_QOS_GetRxFrame()` is used to get Rx frame with zero copy, it will allocate new buffer to replace the buffer in BD taken by application application should free those buffers after they're used.

Note: This function should be called after ENET_QOS_CreateHandler() and buffer allocating callback function should be ready.

Parameters

- `base` – ENET_QOS peripheral base address.
- `handle` – The ENET_QOS handler structure. This is the same handler pointer used in the ENET_QOS_Init.

void ENET_QOS_RxBufferFreeAll(ENET_QOS_Type *base, *enet_qos_handle_t* *handle)

Frees Rx buffers in all BDs. It's used for zero copy Rx. In zero copy Rx case, Rx buffers are dynamic. This function will free left buffers in all BDs.

Parameters

- `base` – ENET_QOS peripheral base address.
- `handle` – The ENET_QOS handler structure. This is the same handler pointer used in the ENET_QOS_Init.

void ENET_QOS_StartRxTx(ENET_QOS_Type *base, uint8_t txRingNum, uint8_t rxRingNum)

Starts the ENET rx/tx. This function enable the tx/rx and starts the rx/tx DMA. This shall be set after ENET initialization and before starting to receive the data.

Note: This must be called after all the ENET initialization. And should be called when the ENET receive/transmit is required.

Parameters

- `base` – ENET peripheral base address.
- `rxRingNum` – The number of the used rx rings. It shall not be larger than the ENET_QOS_RING_NUM_MAX(2). If the ringNum is set with 1, the ring 0 will be used.
- `txRingNum` – The number of the used tx rings. It shall not be larger than the ENET_QOS_RING_NUM_MAX(2). If the ringNum is set with 1, the ring 0 will be used.

status_t ENET_QOS_SetMII(ENET_QOS_Type *base, *enet_qos_mii_speed_t* speed, *enet_qos_mii_duplex_t* duplex)

Sets the ENET MII speed and duplex.

This API is provided to dynamically change the speed and duplex for MAC.

Parameters

- `base` – ENET peripheral base address.
- `speed` – The speed of the RMII mode.
- `duplex` – The duplex of the RMII mode.

Returns

`kStatus_Success` The ENET MII speed and duplex has been set successfully.

Returns

`kStatus_InvalidArgument` Could not set the desired ENET MII speed and duplex combination.

```
void ENET_QOS_SetSMI(ENET_QOS_Type *base, uint32_t csrClock_Hz)
```

Sets the ENET SMI(serial management interface)- MII management interface.

Parameters

- base – ENET peripheral base address.
- csrClock_Hz – CSR clock frequency in HZ

```
static inline bool ENET_QOS_IsSMIBusy(ENET_QOS_Type *base)
```

Checks if the SMI is busy.

Parameters

- base – ENET peripheral base address.

Returns

The status of MII Busy status.

```
static inline uint16_t ENET_QOS_ReadSMIData(ENET_QOS_Type *base)
```

Reads data from the PHY register through SMI interface.

Parameters

- base – ENET peripheral base address.

Returns

The data read from PHY

```
void ENET_QOS_StartSMIWrite(ENET_QOS_Type *base, uint8_t phyAddr, uint8_t regAddr,  
                           uint16_t data)
```

Sends the MDIO IEEE802.3 Clause 22 format write command. After send command, user needs to check whether the transmission is over with ENET_QOS_IsSMIBusy().

Parameters

- base – ENET peripheral base address.
- phyAddr – The PHY address.
- regAddr – The PHY register address.
- data – The data written to PHY.

```
void ENET_QOS_StartSMIRead(ENET_QOS_Type *base, uint8_t phyAddr, uint8_t regAddr)
```

Sends the MDIO IEEE802.3 Clause 22 format read command. After send command, user needs to check whether the transmission is over with ENET_QOS_IsSMIBusy().

Parameters

- base – ENET peripheral base address.
- phyAddr – The PHY address.
- regAddr – The PHY register address.

```
void ENET_QOS_StartExtC45SMIWrite(ENET_QOS_Type *base, uint8_t portAddr, uint8_t  
                                  devAddr, uint16_t regAddr, uint16_t data)
```

Sends the MDIO IEEE802.3 Clause 45 format write command. After send command, user needs to check whether the transmission is over with ENET_QOS_IsSMIBusy().

Parameters

- base – ENET peripheral base address.
- portAddr – The MDIO port address(PHY address).
- devAddr – The device address.
- regAddr – The PHY register address.

- data – The data written to PHY.

```
void ENET_QOS_StartExtC45SMIRRead(ENET_QOS_Type *base, uint8_t portAddr, uint8_t  
devAddr, uint16_t regAddr)
```

Sends the MDIO IEEE802.3 Clause 45 format read command. After send command, user needs to check whether the transmission is over with ENET_QOS_IsSMIBusy().

Parameters

- base – ENET peripheral base address.
- portAddr – The MDIO port address(PHY address).
- devAddr – The device address.
- regAddr – The PHY register address.

```
status_t ENET_QOS_MDIOWrite(ENET_QOS_Type *base, uint8_t phyAddr, uint8_t regAddr,  
uint16_t data)
```

MDIO write with IEEE802.3 MDIO Clause 22 format.

Parameters

- base – ENET peripheral base address.
- phyAddr – The PHY address.
- regAddr – The PHY register.
- data – The data written to PHY.

Returns

kStatus_Success MDIO access succeeds.

Returns

kStatus_Timeout MDIO access timeout.

```
status_t ENET_QOS_MDIOWrite(ENET_QOS_Type *base, uint8_t phyAddr, uint8_t regAddr,  
uint16_t *pData)
```

MDIO read with IEEE802.3 MDIO Clause 22 format.

Parameters

- base – ENET peripheral base address.
- phyAddr – The PHY address.
- regAddr – The PHY register.
- pData – The data read from PHY.

Returns

kStatus_Success MDIO access succeeds.

Returns

kStatus_Timeout MDIO access timeout.

```
status_t ENET_QOS_MDIOWrite(ENET_QOS_Type *base, uint8_t portAddr, uint8_t devAddr,  
uint16_t regAddr, uint16_t data)
```

MDIO write with IEEE802.3 Clause 45 format.

Parameters

- base – ENET peripheral base address.
- portAddr – The MDIO port address(PHY address).
- devAddr – The device address.
- regAddr – The PHY register address.

- data – The data written to PHY.

Returns

kStatus_Success MDIO access succeeds.

Returns

kStatus_Timeout MDIO access timeout.

status_t ENET_QOS_MDIOC45Read(ENET_QOS_Type *base, uint8_t portAddr, uint8_t devAddr, uint16_t regAddr, uint16_t *pData)

MDIO read with IEEE802.3 Clause 45 format.

Parameters

- base – ENET peripheral base address.
- portAddr – The MDIO port address(PHY address).
- devAddr – The device address.
- regAddr – The PHY register address.
- pData – The data read from PHY.

Returns

kStatus_Success MDIO access succeeds.

Returns

kStatus_Timeout MDIO access timeout.

static inline void ENET_QOS_SetMacAddr(ENET_QOS_Type *base, uint8_t *macAddr, uint8_t index)

Sets the ENET module Mac address.

Parameters

- base – ENET peripheral base address.
- macAddr – The six-byte Mac address pointer. The pointer is allocated by application and input into the API.
- index – Configure macAddr to MAC_ADDRESS[index] register.

void ENET_QOS_GetMacAddr(ENET_QOS_Type *base, uint8_t *macAddr, uint8_t index)

Gets the ENET module Mac address.

Parameters

- base – ENET peripheral base address.
- macAddr – The six-byte Mac address pointer. The pointer is allocated by application and input into the API.
- index – Get macAddr from MAC_ADDRESS[index] register.

void ENET_QOS_AddMulticastGroup(ENET_QOS_Type *base, uint8_t *address)

Adds the ENET_QOS device to a multicast group.

Parameters

- base – ENET_QOS peripheral base address.
- address – The six-byte multicast group address which is provided by application.

void ENET_QOS_LeaveMulticastGroup(ENET_QOS_Type *base, uint8_t *address)

Moves the ENET_QOS device from a multicast group.

Parameters

- base – ENET_QOS peripheral base address.

- address – The six-byte multicast group address which is provided by application.

static inline void ENET_QOS_AcceptAllMulticast(ENET_QOS_Type *base)

Enable ENET device to accept all multicast frames.

Parameters

- base – ENET peripheral base address.

static inline void ENET_QOS_RejectAllMulticast(ENET_QOS_Type *base)

ENET device reject to accept all multicast frames.

Parameters

- base – ENET peripheral base address.

void ENET_QOS_EnterPowerDown(ENET_QOS_Type *base, uint32_t *wakeFilter)

Set the MAC to enter into power down mode. the remote power wake up frame and magic frame can wake up the ENET from the power down mode.

Parameters

- base – ENET peripheral base address.
- wakeFilter – The wakeFilter provided to configure the wake up frame filter. Set the wakeFilter to NULL is not required. But if you have the filter requirement, please make sure the wakeFilter pointer shall be eight continuous 32-bits configuration.

static inline void ENET_QOS_ExitPowerDown(ENET_QOS_Type *base)

Set the MAC to exit power down mode. Exit from the power down mode and recover to normal work mode.

Parameters

- base – ENET peripheral base address.

status_t ENET_QOS_EnableRxParser(ENET_QOS_Type *base, bool enable)

Enable/Disable Rx parser, please notice that for enable/disable Rx Parser, should better disable Receive first.

Parameters

- base – ENET_QOS peripheral base address.
- enable – Enable/Disable Rx parser function

Return values

- kStatus_Success – Configure rx parser success.
- kStatus_ENET_QOS_Timeout – Poll status flag timeout.

void ENET_QOS_EnableInterrupts(ENET_QOS_Type *base, uint32_t mask)

Enables the ENET DMA and MAC interrupts.

This function enables the ENET interrupt according to the provided mask. The mask is a logical OR of enet_qos_dma_interrupt_enable_t and enet_qos_mac_interrupt_enable_t. For example, to enable the dma and mac interrupt, do the following.

```
ENET_QOS_EnableInterrupts(ENET, kENET_QOS_DmaRx | kENET_QOS_DmaTx | kENET_QOS_MacPmt);
```

Parameters

- base – ENET peripheral base address.

- mask – ENET interrupts to enable. This is a logical OR of both enumeration :: `enet_qos_dma_interrupt_enable_t` and `enet_qos_mac_interrupt_enable_t`.

`void ENET_QOS_DisableInterrupts(ENET_QOS_Type *base, uint32_t mask)`

Disables the ENET DMA and MAC interrupts.

This function disables the ENET interrupt according to the provided mask. The mask is a logical OR of `enet_qos_dma_interrupt_enable_t` and `enet_qos_mac_interrupt_enable_t`. For example, to disable the dma and mac interrupt, do the following.

```
ENET_QOS_DisableInterrupts(ENET, kENET_QOS_DmaRx | kENET_QOS_DmaTx | kENET_
↪QOS_MacPmt);
```

Parameters

- base – ENET peripheral base address.
- mask – ENET interrupts to disables. This is a logical OR of both enumeration :: `enet_qos_dma_interrupt_enable_t` and `enet_qos_mac_interrupt_enable_t`.

`static inline uint32_t ENET_QOS_GetDmaInterruptStatus(ENET_QOS_Type *base, uint8_t channel)`

Gets the ENET DMA interrupt status flag.

Parameters

- base – ENET peripheral base address.
- channel – The DMA Channel. Shall not be larger than `ENET_QOS_RING_NUM_MAX`.

Returns

The event status of the interrupt source. This is the logical OR of members of the enumeration :: `enet_qos_dma_interrupt_enable_t`.

`static inline void ENET_QOS_ClearDmaInterruptStatus(ENET_QOS_Type *base, uint8_t channel, uint32_t mask)`

Clear the ENET DMA interrupt status flag.

Parameters

- base – ENET peripheral base address.
- channel – The DMA Channel. Shall not be larger than `ENET_QOS_RING_NUM_MAX`.
- mask – The interrupt status to be cleared. This is the logical OR of members of the enumeration :: `enet_qos_dma_interrupt_enable_t`.

`static inline uint32_t ENET_QOS_GetMacInterruptStatus(ENET_QOS_Type *base)`

Gets the ENET MAC interrupt status flag.

Parameters

- base – ENET peripheral base address.

Returns

The event status of the interrupt source. Use the enum in `enet_qos_mac_interrupt_enable_t` and right shift `ENET_QOS_MACINT_ENUM_OFFSET` to mask the returned value to get the exact interrupt status.

```
void ENET_QOS_ClearMacInterruptStatus(ENET_QOS_Type *base, uint32_t mask)
```

Clears the ENET mac interrupt events status flag.

This function clears enabled ENET interrupts according to the provided mask. The mask is a logical OR of enumeration members. See the `enet_qos_mac_interrupt_enable_t`. For example, to clear the TX frame interrupt and RX frame interrupt, do the following.

```
ENET_QOS_ClearMacInterruptStatus(ENET, kENET_QOS_MacPmt);
```

Parameters

- `base` – ENET peripheral base address.
- `mask` – ENET interrupt source to be cleared. This is the logical OR of members of the enumeration `:: enet_qos_mac_interrupt_enable_t`.

```
static inline bool ENET_QOS_IsTxDescriptorDmaOwn(enet_qos_tx_bd_struct_t *txDesc)
```

Get the tx descriptor DMA Own flag.

Parameters

- `txDesc` – The given tx descriptor.

Return values

True – the dma own tx descriptor, false application own tx descriptor.

```
void ENET_QOS_SetupTxDescriptor(enet_qos_tx_bd_struct_t *txDesc, void *buffer1, uint32_t bytes1, void *buffer2, uint32_t bytes2, uint32_t framelen, bool intEnable, bool tsEnable, enet_qos_desc_flag flag, uint8_t slotNum)
```

Setup a given tx descriptor. This function is a low level functional API to setup or prepare a given tx descriptor.

Note: This must be called after all the ENET initialization. And should be called when the ENET receive/transmit is required. Transmit buffers are ‘zero-copy’ buffers, so the buffer must remain in memory until the packet has been fully transmitted. The buffers should be free or queued in the transmit interrupt irq handler.

Parameters

- `txDesc` – The given tx descriptor.
- `buffer1` – The first buffer address in the descriptor.
- `bytes1` – The bytes in the fist buffer.
- `buffer2` – The second buffer address in the descriptor.
- `bytes2` – The bytes in the second buffer.
- `framelen` – The length of the frame to be transmitted.
- `intEnable` – Interrupt enable flag.
- `tsEnable` – The timestamp enable.
- `flag` – The flag of this tx descriptor, `enet_qos_desc_flag`.
- `slotNum` – The slot num used for AV only.

```
static inline void ENET_QOS_UpdateTxDescriptorTail(ENET_QOS_Type *base, uint8_t channel, uint32_t txDescTailAddrAlign)
```

Update the tx descriptor tail pointer. This function is a low level functional API to update the the tx descriptor tail. This is called after you setup a new tx descriptor to update the tail pointer to make the new descriptor accessible by DMA.

Parameters

- base – ENET peripheral base address.
- channel – The tx DMA channel.
- txDescTailAddrAlign – The new tx tail pointer address.

```
static inline void ENET_QOS_UpdateRxDescriptorTail(ENET_QOS_Type *base, uint8_t channel,  
                                                    uint32_t rxDescTailAddrAlign)
```

Update the rx descriptor tail pointer. This function is a low level functional API to update the the rx descriptor tail. This is called after you setup a new rx descriptor to update the tail pointer to make the new descriptor accessible by DMA and to anouse the rx poll command for DMA.

Parameters

- base – ENET peripheral base address.
- channel – The rx DMA channel.
- rxDescTailAddrAlign – The new rx tail pointer address.

```
static inline uint32_t ENET_QOS_GetRxDescriptor(enet_qos_rx_bd_struct_t *rxDesc)
```

Gets the context in the ENET rx descriptor. This function is a low level functional API to get the the status flag from a given rx descriptor.

Note: This must be called after all the ENET initialization. And should be called when the ENET receive/transmit is required.

Parameters

- rxDesc – The given rx descriptor.

Return values

The – RDES3 regions for write-back format rx buffer descriptor.

```
void ENET_QOS_UpdateRxDescriptor(enet_qos_rx_bd_struct_t *rxDesc, void *buffer1, void  
                                *buffer2, bool intEnable, bool doubleBuffEnable)
```

Updates the buffers and the own status for a given rx descriptor. This function is a low level functional API to Updates the buffers and the own status for a given rx descriptor.

Note: This must be called after all the ENET initialization. And should be called when the ENET receive/transmit is required.

Parameters

- rxDesc – The given rx descriptor.
- buffer1 – The first buffer address in the descriptor.
- buffer2 – The second buffer address in the descriptor.
- intEnable – Interrupt enable flag.
- doubleBuffEnable – The double buffer enable flag.

```
status_t ENET_QOS_ConfigureRxParser(ENET_QOS_Type *base, enet_qos_rxp_config_t  
                                    *rxpConfig, uint16_t entryCount)
```

Configure flexible rx parser.

This function is used to configure the flexible rx parser table.

Parameters

- base – ENET peripheral base address..
- rxpConfig – The rx parser configuration pointer.
- entryCount – The rx parser entry count.

Return values

- kStatus_Success – Configure rx parser success.
- kStatus_ENET_QOS_Timeout – Poll status flag timeout.

status_t ENET_QOS_ReadRxParser(ENET_QOS_Type *base, *enet_qos_rxp_config_t* *rxpConfig, uint16_t entryIndex)

Read flexible rx parser configuration at specified index.

This function is used to read flexible rx parser configuration at specified index.

Parameters

- base – ENET peripheral base address..
- rxpConfig – The rx parser configuration pointer.
- entryIndex – The rx parser entry index to read, start from 0.

Return values

- kStatus_Success – Configure rx parser success.
- kStatus_ENET_QOS_Timeout – Poll status flag timeout.

status_t ENET_QOS_EstProgramGcl(ENET_QOS_Type *base, *enet_qos_est_gcl_t* *gcl, uint32_t ptpClk_Hz)

Program Gate Control List.

This function is used to program the Enhanced Scheduled Transmission. (IEEE802.1Qbv)

Parameters

- base – ENET peripheral base address..
- gcl – Pointer to the Gate Control List structure.
- ptpClk_Hz – frequency of the PTP clock.

status_t ENET_QOS_EstReadGcl(ENET_QOS_Type *base, *enet_qos_est_gcl_t* *gcl, uint32_t listLen, bool hwList)

Read Gate Control List.

This function is used to read the Enhanced Scheduled Transmission list. (IEEE802.1Qbv)

Parameters

- base – ENET peripheral base address..
- gcl – Pointer to the Gate Control List structure.
- listLen – length of the provided opList array in gcl structure.
- hwList – Boolean if True read HW list, false read SW list.

static inline void ENET_QOS_FpeEnable(ENET_QOS_Type *base)

Enable Frame Preemption.

This function is used to enable frame preemption. (IEEE802.1Qbu)

Parameters

- base – ENET peripheral base address..

```
static inline void ENET_QOS_FpeDisable(ENET_QOS_Type *base)
```

Disable Frame Preemption.

This function is used to disable frame preemption. (IEEE802.1Qbu)

Parameters

- base – ENET peripheral base address..

```
static inline void ENET_QOS_FpeConfigPreemptable(ENET_QOS_Type *base, uint8_t  
queueMask)
```

Configure preemptable transmit queues.

This function is used to configure the preemptable queues. (IEEE802.1Qbu)

Parameters

- base – ENET peripheral base address..
- queueMask – bitmask representing queues to set in preemptable mode. The N-th bit represents the queue N.

```
void ENET_QOS_AVBConfigure(ENET_QOS_Type *base, const enet_qos_cbs_config_t *config,  
uint8_t queueIndex)
```

Sets the ENET AVB feature.

ENET_QOS AVB feature configuration, set transmit bandwidth. This API is called when the AVB feature is required.

Parameters

- base – ENET_QOS peripheral base address.
- config – The ENET_QOS AVB feature configuration structure.
- queueIndex – ENET_QOS queue index.

```
void ENET_QOS_GetStatistics(ENET_QOS_Type *base, enet_qos_transfer_stats_t *statistics)
```

Gets statistical data in transfer.

Parameters

- base – ENET_QOS peripheral base address.
- statistics – The statistics structure pointer.

```
void ENET_QOS_CreateHandler(ENET_QOS_Type *base, enet_qos_handle_t *handle,  
enet_qos_config_t *config, enet_qos_buffer_config_t  
*bufferConfig, enet_qos_callback_t callback, void *userData)
```

Create ENET Handler.

This is a transactional API and it's provided to store all data which are needed during the whole transactional process. This API should not be used when you use functional APIs to do data tx/rx. This is function will store many data/flag for transactional use, so all configure API such as ENET_QOS_Init(), ENET_QOS_DescriptorInit(), ENET_QOS_EnableInterrupts() etc.

Note: as our transactional transmit API use the zero-copy transmit buffer. so there are two thing we emphasize here:

- a. tx buffer free/requeue for application should be done in the tx interrupt handler. Please set callback: kENET_QOS_TxIntEvent with tx buffer free/requeue process APIs.
 - b. the tx interrupt is forced to open.
-

Parameters

- base – ENET peripheral base address.
- handle – ENET handler.
- config – ENET configuration.
- bufferConfig – ENET buffer configuration.
- callback – The callback function.
- userData – The application data.

status_t ENET_QOS_GetRxFramSize(ENET_QOS_Type *base, *enet_qos_handle_t* *handle, uint32_t *length, uint8_t channel)

Gets the size of the read frame. This function gets a received frame size from the ENET buffer descriptors.

Note: The FCS of the frame is automatically removed by MAC and the size is the length without the FCS. After calling ENET_QOS_GetRxFramSize, ENET_QOS_ReadFrame() should be called to update the receive buffers. If the result is not “kStatus_ENET_QOS_RxFramEmpty”.

Parameters

- base – ENET peripheral base address.
- handle – The ENET handler structure. This is the same handler pointer used in the ENET_QOS_Init.
- length – The length of the valid frame received.
- channel – The DMAC channel for the rx.

Return values

- kStatus_ENET_QOS_RxFramEmpty – No frame received. Should not call ENET_QOS_ReadFrame to read frame.
- kStatus_ENET_QOS_RxFramError – Data error happens. ENET_QOS_ReadFrame should be called with NULL data and NULL length to update the receive buffers.
- kStatus_Success – Receive a frame Successfully then the ENET_QOS_ReadFrame should be called with the right data buffer and the captured data length input.

status_t ENET_QOS_ReadFrame(ENET_QOS_Type *base, *enet_qos_handle_t* *handle, uint8_t *data, uint32_t length, uint8_t channel, *enet_qos_ptp_time_t* *ts)

Reads a frame from the ENET device. This function reads a frame from the ENET DMA descriptors. The ENET_QOS_GetRxFramSize should be used to get the size of the prepared data buffer. For example use rx dma channel 0:

```
uint32_t length;
enet_qos_handle_t g_handle;
status = ENET_QOS_GetRxFramSize(&g_handle, &length, 0);
if (length != 0)
{
    uint8_t *data = memory allocate interface;
    if (!data)
    {
        ENET_QOS_ReadFrame(ENET, &g_handle, NULL, 0, 0);
    }
}
```

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```
    }
    else
    {
        status = ENET_QOS_ReadFrame(ENET, &g_handle, data, length, 0);
    }
}
else if (status == kStatus_ENET_QOS_RxFrameError)
{
    ENET_QOS_ReadFrame(ENET, &g_handle, NULL, 0, 0);
}
```

Parameters

- base – ENET peripheral base address.
- handle – The ENET handler structure. This is the same handler pointer used in the ENET_QOS_Init.
- data – The data buffer provided by user to store the frame which memory size should be at least “length”.
- length – The size of the data buffer which is still the length of the received frame.
- channel – The rx DMA channel. shall not be larger than 2.
- ts – Pointer to the structure enet_qos_ptp_time_t to save frame timestamp.

Returns

The execute status, successful or failure.

status_t ENET_QOS_SendFrame(ENET_QOS_Type *base, *enet_qos_handle_t* *handle, uint8_t *data, uint32_t length, uint8_t channel, bool isNeedTs, void *context, *enet_qos_tx_offload_t* txOffloadOps)

Transmits an ENET frame.

Note: The CRC is automatically appended to the data. Input the data to send without the CRC.

Parameters

- base – ENET peripheral base address.
- handle – The ENET handler pointer. This is the same handler pointer used in the ENET_QOS_Init.
- data – The data buffer provided by user to be send.
- length – The length of the data to be send.
- channel – Channel to send the frame, same with queue index.
- isNeedTs – True to enable timestamp save for the frame
- context – pointer to user context to be kept in the tx dirty frame information.
- txOffloadOps – The Tx frame checksum offload option.

Return values

- kStatus_Success – Send frame succeed.

- `kStatus_ENET_QOS_TxFrameBusy` – Transmit buffer descriptor is busy under transmission. The transmit busy happens when the data send rate is over the MAC capacity. The waiting mechanism is recommended to be added after each call return with `kStatus_ENET_QOS_TxFrameBusy`.

`void ENET_QOS_ReclaimTxDescriptor(ENET_QOS_Type *base, enet_qos_handle_t *handle, uint8_t channel)`

Reclaim tx descriptors. This function is used to update the tx descriptor status and store the tx timestamp when the 1588 feature is enabled. This is called by the transmit interrupt IRQ handler after the complete of a frame transmission.

Parameters

- `base` – ENET peripheral base address.
- `handle` – The ENET handler pointer. This is the same handler pointer used in the `ENET_QOS_Init`.
- `channel` – The tx DMA channel.

`void ENET_QOS_CommonIRQHandler(ENET_QOS_Type *base, enet_qos_handle_t *handle)`

The ENET IRQ handler.

Parameters

- `base` – ENET peripheral base address.
- `handle` – The ENET handler pointer.

`void ENET_QOS_SetISRHandler(ENET_QOS_Type *base, enet_qos_isr_t ISRHandler)`

Set the second level IRQ handler, allow user to overwrite the default second level weak IRQ handler.

Parameters

- `base` – ENET peripheral base address.
- `ISRHandler` – The handler to install.

`status_t ENET_QOS_Ptp1588CorrectTimerInCoarse(ENET_QOS_Type *base, enet_qos_systime_op operation, uint32_t second, uint32_t nanosecond)`

Correct the ENET PTP 1588 timer in coarse method.

Parameters

- `base` – ENET peripheral base address.
- `operation` – The system time operation, refer to “`enet_qos_systime_op`”
- `second` – The correction second.
- `nanosecond` – The correction nanosecond.

`status_t ENET_QOS_Ptp1588CorrectTimerInFine(ENET_QOS_Type *base, uint32_t addend)`

Correct the ENET PTP 1588 timer in fine method.

Note: Should take refer to the chapter “System time correction” and see the description for the “fine correction method”.

Parameters

- `base` – ENET peripheral base address.
- `addend` – The addend value to be set in the fine method

```
static inline uint32_t ENET_QOS_Ptp1588GetAddend(ENET_QOS_Type *base)
```

Get the ENET Time stamp current addend value.

Parameters

- base – ENET peripheral base address.

Returns

The addend value.

```
void ENET_QOS_Ptp1588GetTimerNoIRQDisable(ENET_QOS_Type *base, uint64_t *second,  
                                           uint32_t *nanosecond)
```

Gets the current ENET time from the PTP 1588 timer without IRQ disable.

Parameters

- base – ENET peripheral base address.
- second – The PTP 1588 system timer second.
- nanosecond – The PTP 1588 system timer nanosecond. For the unit of the nanosecond is 1ns. so the nanosecond is the real nanosecond.

```
static inline status_t ENET_Ptp1588PpsControl(ENET_QOS_Type *base,  
                                              enet_qos_ptp_pps_instance_t instance,  
                                              enet_qos_ptp_pps_trgt_mode_t trgtMode,  
                                              enet_qos_ptp_pps_cmd_t cmd)
```

Sets the ENET PTP 1588 PPS control. All channels operate in flexible PPS output mode.

Parameters

- base – ENET peripheral base address.
- instance – The ENET QOS PTP PPS instance.
- trgtMode – The target time register mode.
- cmd – The target flexible PPS output control command.

```
status_t ENET_QOS_Ptp1588PpsSetTrgtTime(ENET_QOS_Type *base,  
                                         enet_qos_ptp_pps_instance_t instance, uint32_t  
                                         seconds, uint32_t nanoseconds)
```

Sets the ENET QOS PTP 1588 PPS target time registers.

Parameters

- base – ENET QOS peripheral base address.
- instance – The ENET QOS PTP PPS instance.
- seconds – The target seconds.
- nanoseconds – The target nanoseconds.

```
static inline void ENET_QOS_Ptp1588PpsSetWidth(ENET_QOS_Type *base,  
                                              enet_qos_ptp_pps_instance_t instance,  
                                              uint32_t width)
```

Sets the ENET QOS PTP 1588 PPS output signal interval.

Parameters

- base – ENET QOS peripheral base address.
- instance – The ENET QOS PTP PPS instance.
- width – Signal Width. It is stored in terms of number of units of sub-second increment value. The width value must be lesser than interval value.

```
static inline void ENET_QOS_Ptp1588PpsSetInterval(ENET_QOS_Type *base,
                                                enet_qos_ptp_pps_instance_t instance,
                                                uint32_t interval)
```

Sets the ENET QOS PTP 1588 PPS output signal width.

Parameters

- base – ENET QOS peripheral base address.
- instance – The ENET QOS PTP PPS instance.
- interval – Signal Interval. It is stored in terms of number of units of sub-second increment value.

```
void ENET_QOS_Ptp1588GetTimer(ENET_QOS_Type *base, uint64_t *second, uint32_t
                             *nanosecond)
```

Gets the current ENET time from the PTP 1588 timer.

Parameters

- base – ENET peripheral base address.
- second – The PTP 1588 system timer second.
- nanosecond – The PTP 1588 system timer nanosecond. For the unit of the nanosecond is 1ns.so the nanosecond is the real nanosecond.

```
void ENET_QOS_GetTxFrame(enet_qos_handle_t *handle, enet_qos_frame_info_t *txFrame,
                        uint8_t channel)
```

Gets the time stamp of the transmit frame.

This function is used for PTP stack to get the timestamp captured by the ENET driver.

Parameters

- handle – The ENET handler pointer.This is the same state pointer used in ENET_QOS_Init.
- txFrame – Input parameter, pointer to *enet_qos_frame_info_t* for saving read out frame information.
- channel – Channel for searching the tx frame.

```
status_t ENET_QOS_GetRxFrame(ENET_QOS_Type *base, enet_qos_handle_t *handle,
                             enet_qos_rx_frame_struct_t *rxFrame, uint8_t channel)
```

Receives one frame in specified BD ring with zero copy.

This function will use the user-defined allocate and free callback. Every time application gets one frame through this function, driver will allocate new buffers for the BDs whose buffers have been taken by application.

Note: This function will drop current frame and update related BDs as available for DMA if new buffers allocating fails. Application must provide a memory pool including at least BD number + 1 buffers(+2 if enable double buffer) to make this function work normally. If user calls this function in Rx interrupt handler, be careful that this function makes Rx BD ready with allocating new buffer(normal) or updating current BD(out of memory). If there's always new Rx frame input, Rx interrupt will be triggered forever. Application need to disable Rx interrupt according to specific design in this case.

Parameters

- base – ENET peripheral base address.
- handle – The ENET handler pointer. This is the same handler pointer used in the ENET_Init.

- rxFrame – The received frame information structure provided by user.
- channel – Channel for searching the rx frame.

Return values

- kStatus_Success – Succeed to get one frame and allocate new memory for Rx buffer.
- kStatus_ENET_QOS_RxFrameEmpty – There's no Rx frame in the BD.
- kStatus_ENET_QOS_RxFrameError – There's issue in this receiving.
- kStatus_ENET_QOS_RxFrameDrop – There's no new buffer memory for BD, drop this frame.

FSL_ENET_QOS_DRIVER_VERSION

Defines the driver version.

ENET_QOS_RXDESCRIP_RD_BUFF1VALID_MASK

Defines for read format.

Buffer1 address valid.

ENET_QOS_RXDESCRIP_RD_BUFF2VALID_MASK

Buffer2 address valid.

ENET_QOS_RXDESCRIP_RD_IOC_MASK

Interrupt enable on complete.

ENET_QOS_RXDESCRIP_RD_OWN_MASK

Own bit.

ENET_QOS_RXDESCRIP_WR_ERR_MASK

Defines for write back format.

ENET_QOS_RXDESCRIP_WR_PYLOAD_MASK

ENET_QOS_RXDESCRIP_WR_PTPMSGTYPE_MASK

ENET_QOS_RXDESCRIP_WR_PTPTYPE_MASK

ENET_QOS_RXDESCRIP_WR_PTPVERSION_MASK

ENET_QOS_RXDESCRIP_WR_PTPTSA_MASK

ENET_QOS_RXDESCRIP_WR_PACKETLEN_MASK

ENET_QOS_RXDESCRIP_WR_ERRSUM_MASK

ENET_QOS_RXDESCRIP_WR_TYPE_MASK

ENET_QOS_RXDESCRIP_WR_DE_MASK

ENET_QOS_RXDESCRIP_WR_RE_MASK

ENET_QOS_RXDESCRIP_WR_OE_MASK

ENET_QOS_RXDESCRIP_WR_RWT_MASK

ENET_QOS_RXDESCRIP_WR_GP_MASK

ENET_QOS_RXDESCRIP_WR_CRC_MASK

ENET_QOS_RXDESCRIP_WR_RS0V_MASK

ENET_QOS_RXDESCRIP_WR_RS1V_MASK

ENET_QOS_RXDESCRIP_WR_RS2V_MASK
ENET_QOS_RXDESCRIP_WR_LD_MASK
ENET_QOS_RXDESCRIP_WR_FD_MASK
ENET_QOS_RXDESCRIP_WR_CTXT_MASK
ENET_QOS_RXDESCRIP_WR_OWN_MASK
ENET_QOS_RXDESCRIP_WR_SA_FAILURE_MASK
ENET_QOS_RXDESCRIP_WR_DA_FAILURE_MASK
ENET_QOS_TXDESCRIP_RD_BL1_MASK

Defines for read format.

ENET_QOS_TXDESCRIP_RD_BL2_MASK
ENET_QOS_TXDESCRIP_RD_BL1(n)
ENET_QOS_TXDESCRIP_RD_BL2(n)
ENET_QOS_TXDESCRIP_RD_TTSE_MASK
ENET_QOS_TXDESCRIP_RD_IOC_MASK
ENET_QOS_TXDESCRIP_RD_FL_MASK
ENET_QOS_TXDESCRIP_RD_FL(n)
ENET_QOS_TXDESCRIP_RD_CIC(n)
ENET_QOS_TXDESCRIP_RD_TSE_MASK
ENET_QOS_TXDESCRIP_RD_SLOT(n)
ENET_QOS_TXDESCRIP_RD_SAIC(n)
ENET_QOS_TXDESCRIP_RD_CPC(n)
ENET_QOS_TXDESCRIP_RD_LDFD(n)
ENET_QOS_TXDESCRIP_RD_LD_MASK
ENET_QOS_TXDESCRIP_RD_FD_MASK
ENET_QOS_TXDESCRIP_RD_CTXT_MASK
ENET_QOS_TXDESCRIP_RD_OWN_MASK
ENET_QOS_TXDESCRIP_WB_TTSS_MASK

Defines for write back format.

ENET_QOS_ABNORM_INT_MASK
ENET_QOS_NORM_INT_MASK
ENET_QOS_RING_NUM_MAX
The Maximum number of tx/rx descriptor rings.
ENET_QOS_FRAME_MAX_FRAMELEN
Default maximum Ethernet frame size.

ENET_QOS_FCS_LEN

Ethernet FCS length.

ENET_QOS_ADDR_ALIGNMENT

Recommended Ethernet buffer alignment.

ENET_QOS_BUFF_ALIGNMENT

Receive buffer alignment shall be 4bytes-aligned.

ENET_QOS_MTL_RXFIFOSIZE

The rx fifo size.

ENET_QOS_MTL_TXFIFOSIZE

The tx fifo size.

ENET_QOS_MACINT_ENUM_OFFSET

The offset for mac interrupt in enum type.

ENET_QOS_RXP_ENTRY_COUNT

RXP table entry count, implied by FRPES in MAC_HW_FEATURE3

ENET_QOS_RXP_BUFFER_SIZE

RXP Buffer size, implied by FRPBS in MAC_HW_FEATURE3

ENET_QOS_EST_WID

Width of the time interval in Gate Control List

ENET_QOS_EST_DEP

Maximum depth of Gate Control List

Defines the status return codes for transaction.

Values:

enumerator kStatus_ENET_QOS_InitMemoryFail

Init fails since buffer memory is not enough.

enumerator kStatus_ENET_QOS_RxFrameError

A frame received but data error happen.

enumerator kStatus_ENET_QOS_RxFrameFail

Failed to receive a frame.

enumerator kStatus_ENET_QOS_RxFrameEmpty

No frame arrive.

enumerator kStatus_ENET_QOS_RxFrameDrop

Rx frame is dropped since no buffer memory.

enumerator kStatus_ENET_QOS_TxFrameBusy

Transmit descriptors are under process.

enumerator kStatus_ENET_QOS_TxFrameFail

Transmit frame fail.

enumerator kStatus_ENET_QOS_TxFrameOverLen

Transmit oversize.

enumerator kStatus_ENET_QOS_Est_SwListBusy

SW Gcl List not yet processed by HW.

enumerator kStatus_ENET_QOS_Est_SwListWriteAbort
SW Gcl List write aborted .

enumerator kStatus_ENET_QOS_Est_InvalidParameter
Invalid parameter in Gcl List .

enumerator kStatus_ENET_QOS_Est_BtrError
Base Time Error when loading list.

enumerator kStatus_ENET_QOS_TrgtBusy
Target time register busy.

enumerator kStatus_ENET_QOS_Timeout
Target time register busy.

enumerator kStatus_ENET_QOS_PpsBusy
Pps command busy.

enum _enet_qos_mii_mode
Defines the MII/RGMII mode for data interface between the MAC and the PHY.

Values:

enumerator kENET_QOS_MiiMode
MII mode for data interface.

enumerator kENET_QOS_RgmiiMode
RGMII mode for data interface.

enumerator kENET_QOS_RmiiMode
RMII mode for data interface.

enum _enet_qos_mii_speed
Defines the 10/100/1000 Mbps speed for the MII data interface.

Values:

enumerator kENET_QOS_MiiSpeed10M
Speed 10 Mbps.

enumerator kENET_QOS_MiiSpeed100M
Speed 100 Mbps.

enumerator kENET_QOS_MiiSpeed1000M
Speed 1000 Mbps.

enumerator kENET_QOS_MiiSpeed2500M
Speed 2500 Mbps.

enum _enet_qos_mii_duplex
Defines the half or full duplex for the MII data interface.

Values:

enumerator kENET_QOS_MiiHalfDuplex
Half duplex mode.

enumerator kENET_QOS_MiiFullDuplex
Full duplex mode.

enum _enet_qos_mii_normal_opcode
Define the MII opcode for normal MDIO_CLAUSES_22 Frame.

Values:

enumerator kENET_QOS_MiiWriteFrame

Write frame operation for a valid MII management frame.

enumerator kENET_QOS_MiiReadFrame

Read frame operation for a valid MII management frame.

enum _enet_qos_dma_burstlen

Define the DMA maximum transmit burst length.

Values:

enumerator kENET_QOS_BurstLen1

DMA burst length 1.

enumerator kENET_QOS_BurstLen2

DMA burst length 2.

enumerator kENET_QOS_BurstLen4

DMA burst length 4.

enumerator kENET_QOS_BurstLen8

DMA burst length 8.

enumerator kENET_QOS_BurstLen16

DMA burst length 16.

enumerator kENET_QOS_BurstLen32

DMA burst length 32.

enumerator kENET_QOS_BurstLen64

DMA burst length 64. eight times enabled.

enumerator kENET_QOS_BurstLen128

DMA burst length 128. eight times enabled.

enumerator kENET_QOS_BurstLen256

DMA burst length 256. eight times enabled.

enum _enet_qos_desc_flag

Define the flag for the descriptor.

Values:

enumerator kENET_QOS_MiddleFlag

It's a middle descriptor of the frame.

enumerator kENET_QOS_LastFlagOnly

It's the last descriptor of the frame.

enumerator kENET_QOS_FirstFlagOnly

It's the first descriptor of the frame.

enumerator kENET_QOS_FirstLastFlag

It's the first and last descriptor of the frame.

enum _enet_qos_systime_op

Define the system time adjust operation control.

Values:

enumerator kENET_QOS_SystimeAdd

System time add to.

enumerator kENET_QOS_SystimeSubtract
System time subtract.

enum _enet_qos_ts_rollover_type
Define the system time rollover control.

Values:

enumerator kENET_QOS_BinaryRollover
System time binary rollover.

enumerator kENET_QOS_DigitalRollover
System time digital rollover.

enum _enet_qos_special_config
Defines some special configuration for ENET.

These control flags are provided for special user requirements. Normally, there is no need to set these control flags for ENET initialization. But if you have some special requirements, set the flags to specialControl in the enet_qos_config_t.

Note: “kENET_QOS_StoreAndForward” is recommended to be set.

Values:

enumerator kENET_QOS_DescDoubleBuffer
The double buffer is used in the tx/rx descriptor.

enumerator kENET_QOS_StoreAndForward
The rx/tx store and forward enable.

enumerator kENET_QOS_PromiscuousEnable
The promiscuous enabled.

enumerator kENET_QOS_FlowControlEnable
The flow control enabled.

enumerator kENET_QOS_BroadCastRxDisable
The broadcast disabled.

enumerator kENET_QOS_MulticastAllEnable
All multicast are passed.

enumerator kENET_QOS_8023AS2KPacket
8023as support for 2K packets.

enumerator kENET_QOS_HashMulticastEnable
The multicast packets are filtered through hash table.

enumerator kENET_QOS_RxChecksumOffloadEnable
The Rx checksum offload enabled.

enum _enet_qos_dma_interrupt_enable
List of DMA interrupts supported by the ENET interrupt. This enumeration uses one-bit encoding to allow a logical OR of multiple members.

Values:

enumerator kENET_QOS_DmaTx
Tx interrupt.

enumerator kENET_QOS_DmaTxStop

Tx stop interrupt.

enumerator kENET_QOS_DmaTxBuffUnavail

Tx buffer unavailable.

enumerator kENET_QOS_DmaRx

Rx interrupt.

enumerator kENET_QOS_DmaRxBuffUnavail

Rx buffer unavailable.

enumerator kENET_QOS_DmaRxStop

Rx stop.

enumerator kENET_QOS_DmaRxWatchdogTimeout

Rx watchdog timeout.

enumerator kENET_QOS_DmaEarlyTx

Early transmit.

enumerator kENET_QOS_DmaEarlyRx

Early receive.

enumerator kENET_QOS_DmaBusErr

Fatal bus error.

enum _enet_qos_mac_interrupt_enable

List of mac interrupts supported by the ENET interrupt. This enumeration uses one-bit encoding to allow a logical OR of multiple members.

Values:

enumerator kENET_QOS_MacTimestamp

enum _enet_qos_event

Defines the common interrupt event for callback use.

Values:

enumerator kENET_QOS_RxIntEvent

Receive interrupt event.

enumerator kENET_QOS_TxIntEvent

Transmit interrupt event.

enumerator kENET_QOS_WakeUpIntEvent

Wake up interrupt event.

enumerator kENET_QOS_TimeStampIntEvent

Time stamp interrupt event.

enum _enet_qos_queue_mode

Define the MTL mode for multiple queues/rings.

Values:

enumerator kENET_QOS_AVB_Mode

Enable queue in AVB mode.

enumerator kENET_QOS_DCB_Mode

Enable queue in DCB mode.

enum _enet_qos_mtl_multiqueue_txsche

Define the MTL tx scheduling algorithm for multiple queues/rings.

Values:

enumerator kENET_QOS_txWeightRR

Tx weight round-robin.

enumerator kENET_QOS_txWeightFQ

Tx weight fair queuing.

enumerator kENET_QOS_txDefictWeightRR

Tx deficit weighted round-robin.

enumerator kENET_QOS_txStrPrio

Tx strict priority.

enum _enet_qos_mtl_multiqueue_rxsche

Define the MTL rx scheduling algorithm for multiple queues/rings.

Values:

enumerator kENET_QOS_rxStrPrio

Rx strict priority, Queue 0 has the lowest priority.

enumerator kENET_QOS_rxWeightStrPrio

Weighted Strict Priority.

enum _enet_qos_mtl_rxqueueuemap

Define the MTL rx queue and DMA channel mapping.

Values:

enumerator kENET_QOS_StaticDiretMap

The received fame in rx Qn(n = 0,1) directly map to dma channel n.

enumerator kENET_QOS_DynamicMap

The received frame in rx Qn(n = 0,1) map to the dma channel m(m = 0,1) related with the same Mac.

enum _enet_qos_rx_queue_route

Defines the package type for receive queue routing.

Values:

enumerator kENET_QOS_PacketNoQ

enumerator kENET_QOS_PacketAVCPQ

enumerator kENET_QOS_PacketPTPQ

enumerator kENET_QOS_PacketUPQ

enumerator kENET_QOS_PacketMCBCQ

enum _enet_qos_ptp_event_type

Defines the ENET PTP message related constant.

Values:

enumerator kENET_QOS_PtpEventMsgType

PTP event message type.

enumerator kENET_QOS_PtpSrcPortIdLen

PTP message sequence id length.

enumerator kENET_QOS_PtpEventPort
PTP event port number.

enumerator kENET_QOS_PtpGnrlPort
PTP general port number.

enum _enet_qos_ptp_pps_instance
Defines the PPS instance numbers.

Values:

enumerator kENET_QOS_PtpPpsInstance0
PPS instance 0.

enumerator kENET_QOS_PtpPpsInstance1
PPS instance 1.

enumerator kENET_QOS_PtpPpsInstance2
PPS instance 2.

enumerator kENET_QOS_PtpPpsInstance3
PPS instance 3.

enum _enet_qos_ptp_pps_trgt_mode
Defines the Target Time register mode.

Values:

enumerator kENET_QOS_PtpPpsTrgtModeOnlyInt
Only interrupts.

enumerator kENET_QOS_PtpPpsTrgtModeIntSt
Both interrupt and output signal.

enumerator kENET_QOS_PtpPpsTrgtModeOnlySt
Only output signal.

enum _enet_qos_ptp_pps_cmd
Defines commands for ppscmd register.

Values:

enumerator kENET_QOS_PtpPpsCmdNC
No Command.

enumerator kENET_QOS_PtpPpsCmdSSP
Start Single Pulse.

enumerator kENET_QOS_PtpPpsCmdSPT
Start Pulse Train.

enumerator kENET_QOS_PtpPpsCmdCS
Cancel Start.

enumerator kENET_QOS_PtpPpsCmdSPTAT
Stop Pulse Train At Time.

enumerator kENET_QOS_PtpPpsCmdSPTI
Stop Pulse Train Immediately.

enumerator kENET_QOS_PtpPpsCmdCSPT
Cancel Stop Pulse Train.

enum _enet_qos_ets_list_length

Defines the enumeration of ETS list length.

Values:

enumerator kENET_QOS_Ets_List_64

List length of 64

enumerator kENET_QOS_Ets_List_128

List length of 128

enumerator kENET_QOS_Ets_List_256

List length of 256

enumerator kENET_QOS_Ets_List_512

List length of 512

enumerator kENET_QOS_Ets_List_1024

List length of 1024

enum _enet_qos_ets_gccr_addr

Defines the enumeration of ETS gate control address.

Values:

enumerator kENET_QOS_Ets_btr_low

BTR Low

enumerator kENET_QOS_Ets_btr_high

BTR High

enumerator kENET_QOS_Ets_ctr_low

CTR Low

enumerator kENET_QOS_Ets_ctr_high

CTR High

enumerator kENET_QOS_Ets_ter

TER

enumerator kENET_QOS_Ets_llr

LLR

enum _enet_qos_rxp_dma_chn

Defines the enumeration of DMA channel used for rx parser entry.

Values:

enumerator kENET_QOS_Rxp_DMACHn0

DMA Channel 0 used for RXP entry match

enumerator kENET_QOS_Rxp_DMACHn1

DMA Channel 1 used for RXP entry match

enumerator kENET_QOS_Rxp_DMACHn2

DMA Channel 2 used for RXP entry match

enumerator kENET_QOS_Rxp_DMACHn3

DMA Channel 3 used for RXP entry match

enumerator kENET_QOS_Rxp_DMACHn4

DMA Channel 4 used for RXP entry match

enum *_enet_qos_tx_offload*

Define the Tx checksum offload options.

Values:

enumerator *kENET_QOS_TxOffloadDisable*

Disable Tx checksum offload.

enumerator *kENET_QOS_TxOffloadIPHeader*

Enable IP header checksum calculation and insertion.

enumerator *kENET_QOS_TxOffloadIPHeaderPlusPayload*

Enable IP header and payload checksum calculation and insertion.

enumerator *kENET_QOS_TxOffloadAll*

Enable IP header, payload and pseudo header checksum calculation and insertion.

typedef enum *_enet_qos_mii_mode* *enet_qos_mii_mode_t*

Defines the MII/RGMII mode for data interface between the MAC and the PHY.

typedef enum *_enet_qos_mii_speed* *enet_qos_mii_speed_t*

Defines the 10/100/1000 Mbps speed for the MII data interface.

typedef enum *_enet_qos_mii_duplex* *enet_qos_mii_duplex_t*

Defines the half or full duplex for the MII data interface.

typedef enum *_enet_qos_mii_normal_opcode* *enet_qos_mii_normal_opcode*

Define the MII opcode for normal MDIO_CLAUSES_22 Frame.

typedef enum *_enet_qos_dma_burstlen* *enet_qos_dma_burstlen*

Define the DMA maximum transmit burst length.

typedef enum *_enet_qos_desc_flag* *enet_qos_desc_flag*

Define the flag for the descriptor.

typedef enum *_enet_qos_systime_op* *enet_qos_systime_op*

Define the system time adjust operation control.

typedef enum *_enet_qos_ts_rollover_type* *enet_qos_ts_rollover_type*

Define the system time rollover control.

typedef enum *_enet_qos_special_config* *enet_qos_special_config_t*

Defines some special configuration for ENET.

These control flags are provided for special user requirements. Normally, there is no need to set this control flags for ENET initialization. But if you have some special requirements, set the flags to specialControl in the *enet_qos_config_t*.

Note: “*kENET_QOS_StoreAndForward*” is recommended to be set.

typedef enum *_enet_qos_dma_interrupt_enable* *enet_qos_dma_interrupt_enable_t*

List of DMA interrupts supported by the ENET interrupt. This enumeration uses one-bit encoding to allow a logical OR of multiple members.

typedef enum *_enet_qos_mac_interrupt_enable* *enet_qos_mac_interrupt_enable_t*

List of mac interrupts supported by the ENET interrupt. This enumeration uses one-bit encoding to allow a logical OR of multiple members.

typedef enum *_enet_qos_event* *enet_qos_event_t*

Defines the common interrupt event for callback use.

```
typedef enum _enet_qos_queue_mode enet_qos_queue_mode_t
```

Define the MTL mode for multiple queues/rings.

```
typedef enum _enet_qos_mtl_multiqueue_txsche enet_qos_mtl_multiqueue_txsche
```

Define the MTL tx scheduling algorithm for multiple queues/rings.

```
typedef enum _enet_qos_mtl_multiqueue_rxsche enet_qos_mtl_multiqueue_rxsche
```

Define the MTL rx scheduling algorithm for multiple queues/rings.

```
typedef enum _enet_qos_mtl_rxqueuemap enet_qos_mtl_rxqueuemap_t
```

Define the MTL rx queue and DMA channel mapping.

```
typedef enum _enet_qos_rx_queue_route enet_qos_rx_queue_route_t
```

Defines the package type for receive queue routing.

```
typedef enum _enet_qos_ptp_event_type enet_qos_ptp_event_type_t
```

Defines the ENET PTP message related constant.

```
typedef enum _enet_qos_ptp_pps_instance enet_qos_ptp_pps_instance_t
```

Defines the PPS instance numbers.

```
typedef enum _enet_qos_ptp_pps_trgt_mode enet_qos_ptp_pps_trgt_mode_t
```

Defines the Target Time register mode.

```
typedef enum _enet_qos_ptp_pps_cmd enet_qos_ptp_pps_cmd_t
```

Defines commands for ppscmd register.

```
typedef enum _enet_qos_ets_list_length enet_qos_ets_list_length_t
```

Defines the enumeration of ETS list length.

```
typedef enum _enet_qos_ets_gccr_addr enet_qos_ets_gccr_addr_t
```

Defines the enumeration of ETS gate control address.

```
typedef enum _enet_qos_rxp_dma_chn enet_qos_rxp_dma_chn_t
```

Defines the enumeration of DMA channel used for rx parser entry.

```
typedef enum _enet_qos_tx_offload enet_qos_tx_offload_t
```

Define the Tx checksum offload options.

```
typedef struct _enet_qos_rx_bd_struct enet_qos_rx_bd_struct_t
```

Defines the receive descriptor structure has the read-format and write-back format structure. They both has the same size with different region definition. so we define the read-format region as the receive descriptor structure Use the read-format region mask bits in the descriptor initialization Use the write-back format region mask bits in the receive data process.

```
typedef struct _enet_qos_tx_bd_struct enet_qos_tx_bd_struct_t
```

Defines the transmit descriptor structure has the read-format and write-back format structure. They both has the same size with different region definition. so we define the read-format region as the transmit descriptor structure Use the read-format region mask bits in the descriptor initialization Use the write-back format region mask bits in the transmit data process.

```
typedef struct _enet_qos_tx_bd_config_struct enet_qos_tx_bd_config_struct_t
```

Defines the Tx BD configuration structure.

```
typedef struct _enet_qos_ptp_time enet_qos_ptp_time_t
```

Defines the ENET PTP time stamp structure.

```
typedef struct enet_qos_frame_info enet_qos_frame_info_t
```

Defines the frame info structure.

```
typedef struct _enet_qos_tx_dirty_ring enet_qos_tx_dirty_ring_t
```

Defines the ENET transmit dirty addresses ring/queue structure.

```
typedef struct _enet_qos_ptp_config enet_qos_ptp_config_t
```

Defines the ENET PTP configuration structure.

```
typedef struct _enet_qos_est_gate_op enet_qos_est_gate_op_t
```

Defines the EST gate operation structure.

```
typedef struct _enet_qos_est_gcl enet_qos_est_gcl_t
```

Defines the EST gate control list structure.

```
typedef struct _enet_qos_rxp_config enet_qos_rxp_config_t
```

Defines the ENET_QOS Rx parser configuration structure.

```
typedef struct _enet_qos_buffer_config enet_qos_buffer_config_t
```

Defines the buffer descriptor configure structure.

Note:

- a. The receive and transmit descriptor start address pointer and tail pointer must be word-aligned.
 - b. The recommended minimum tx/rx ring length is 4.
 - c. The tx/rx descriptor tail address shall be the address pointer to the address just after the end of the last last descriptor. because only the descriptors between the start address and the tail address will be used by DMA.
 - d. The descriptor address is the start address of all used contiguous memory. for example, the rxDescStartAddrAlign is the start address of rxRingLen contiguous descriptor memories for rx descriptor ring 0.
 - e. The “*rxBufferstartAddr” is the first element of rxRingLen (2*rxRingLen for double buffers) rx buffers. It means the *rxBufferStartAddr is the rx buffer for the first descriptor the *rxBufferStartAddr + 1 is the rx buffer for the second descriptor or the rx buffer for the second buffer in the first descriptor. so please make sure the rxBufferStartAddr is the address of a rxRingLen or 2*rxRingLen array.
-

```
typedef struct _enet_qos_cbs_config enet_qos_cbs_config_t
```

Defines the CBS configuration for queue.

```
typedef struct enet_qos_tx_queue_config enet_qos_queue_tx_config_t
```

Defines the queue configuration structure.

```
typedef struct enet_qos_rx_queue_config enet_qos_queue_rx_config_t
```

Defines the queue configuration structure.

```
typedef struct enet_qos_multiqueue_config enet_qos_multiqueue_config_t
```

Defines the configuration when multi-queue is used.

```
typedef void (*enet_qos_rx_alloc_callback_t)(ENET_QOS_Type *base, void *userData, uint8_t channel)
```

Defines the Rx memory buffer alloc function pointer.

```
typedef void (*enet_qos_rx_free_callback_t)(ENET_QOS_Type *base, void *buffer, void *userData, uint8_t channel)
```

Defines the Rx memory buffer free function pointer.

```
typedef struct _enet_qos_config enet_qos_config_t
```

Defines the basic configuration structure for the ENET device.

Note: Default the signal queue is used so the “*multiqueueCfg” is set default with NULL. Set the pointer with a valid configuration pointer if the multiple queues are required. If multiple queue is enabled, please make sure the buffer configuration for all are prepared also.

```
typedef struct _enet_qos_handle enet_qos_handle_t
```

```
typedef void (*enet_qos_callback_t)(ENET_QOS_Type *base, enet_qos_handle_t *handle,
enet_qos_event_t event, uint8_t channel, void *userData)
```

ENET callback function.

```
typedef struct _enet_qos_tx_bd_ring enet_qos_tx_bd_ring_t
```

Defines the ENET transmit buffer descriptor ring/queue structure.

```
typedef struct _enet_qos_rx_bd_ring enet_qos_rx_bd_ring_t
```

Defines the ENET receive buffer descriptor ring/queue structure.

```
typedef struct _enet_qos_state enet_qos_state_t
```

Defines the ENET state structure.

Note: The structure contains saved state for the instance. It could be stored in *enet_qos_handle_t*, but that's used only with the transactional API.

```
typedef struct _enet_qos_buffer_struct enet_qos_buffer_struct_t
```

Defines the frame buffer structure.

```
typedef struct _enet_qos_rx_frame_error enet_qos_rx_frame_error_t
```

Defines the Rx frame error structure.

```
typedef struct _enet_qos_rx_frame_attribute_struct enet_qos_rx_frame_attribute_t
```

```
typedef struct _enet_qos_rx_frame_struct enet_qos_rx_frame_struct_t
```

Defines the Rx frame data structure.

```
typedef struct _enet_qos_transfer_stats enet_qos_transfer_stats_t
```

Defines the ENET QOS transfer statistics structure.

```
typedef void (*enet_qos_isr_t)(ENET_QOS_Type *base, enet_qos_handle_t *handle)
```

```
const clock_ip_name_t s_enetqosClock[]
```

Pointers to enet clocks for each instance.

```
void ENET_QOS_SetSYSControl(enet_qos_mii_mode_t miiMode)
```

Set ENET system configuration.

Note: User needs to provide the implementation because the implementation is SoC specific. This function set the phy selection and enable clock. It should be called before any other ethernet operation.

Parameters

- *miiMode* – The MII/RGMII/RMII mode for interface between the phy and Ethernet.

```
void ENET_QOS_EnableClock(bool enable)
```

Enable/Disable ENET qos clock.

Note: User needs to provide the implementation because the implementation is SoC specific. This function should be called before config RMII mode.

```
struct __enet_qos_rx_bd_struct
```

#include <fsl_enet_qos.h> Defines the receive descriptor structure has the read-format and write-back format structure. They both has the same size with different region definition. so we define the read-format region as the receive descriptor structure Use the read-format region mask bits in the descriptor initialization Use the write-back format region mask bits in the receive data process.

Public Members

```
__IO uint32_t buff1Addr
```

Buffer 1 address

```
__IO uint32_t reserved
```

Reserved

```
__IO uint32_t buff2Addr
```

Buffer 2 or next descriptor address

```
__IO uint32_t control
```

Buffer 1/2 byte counts and control

```
struct __enet_qos_tx_bd_struct
```

#include <fsl_enet_qos.h> Defines the transmit descriptor structure has the read-format and write-back format structure. They both has the same size with different region definition. so we define the read-format region as the transmit descriptor structure Use the read-format region mask bits in the descriptor initialization Use the write-back format region mask bits in the transmit data process.

Public Members

```
__IO uint32_t buff1Addr
```

Buffer 1 address

```
__IO uint32_t buff2Addr
```

Buffer 2 address

```
__IO uint32_t buffLen
```

Buffer 1/2 byte counts

```
__IO uint32_t controlStat
```

TDES control and status word

```
struct __enet_qos_tx_bd_config_struct
```

#include <fsl_enet_qos.h> Defines the Tx BD configuration structure.

Public Members

```
void *buffer1
```

The first buffer address in the descriptor.

uint32_t bytes1

The bytes in the first buffer.

void *buffer2

The second buffer address in the descriptor.

uint32_t bytes2

The bytes in the second buffer.

uint32_t framelen

The length of the frame to be transmitted.

bool intEnable

Interrupt enable flag.

bool tsEnable

The timestamp enable.

enet_qos_tx_offload_t txOffloadOps

The Tx checksum offload option.

enet_qos_desc_flag flag

The flag of this tx descriptor, see “enet_qos_desc_flag”.

struct _enet_qos_ptp_time

#include <fsl_enet_qos.h> Defines the ENET PTP time stamp structure.

Public Members

uint64_t second

Second.

uint32_t nanosecond

Nanosecond.

struct enet_qos_frame_info

#include <fsl_enet_qos.h> Defines the frame info structure.

Public Members

void *context

User specified data, could be buffer address for free

bool isTsAvail

Flag indicates timestamp available status

enet_qos_ptp_time_t timeStamp

Timestamp of frame

struct _enet_qos_tx_dirty_ring

#include <fsl_enet_qos.h> Defines the ENET transmit dirty addresses ring/queue structure.

Public Members

enet_qos_frame_info_t *txDirtyBase

Dirty buffer descriptor base address pointer.

uint16_t txGenIdx

tx generate index.

uint16_t txConsumIdx
tx consume index.

uint16_t txRingLen
tx ring length.

bool isFull
tx ring is full flag, add this parameter to avoid waste one element.

struct __enet_qos_ptp_config
#include <fsl_enet_qos.h> Defines the ENET PTP configuration structure.

Public Members

bool fineUpdateEnable
Use the fine update.

uint32_t defaultAddend
Default addend value when fine update is enable, could be $2^{32} / (\text{refClk\_Hz} / \text{ENET\_QOS\_MICRSECS\_ONESECOND} / \text{ENET\_QOS\_SYSTIME\_REQUIRED\_CLK\_MHZ})$.

bool ptp1588V2Enable
The desired system time frequency. Must be lower than reference clock. (Only used with fine correction method). ptp 1588 version 2 is used.

enet_qos_ts_rollover_type tsRollover
1588 time nanosecond rollover.

struct __enet_qos_est_gate_op
#include <fsl_enet_qos.h> Defines the EST gate operation structure.

struct __enet_qos_est_gcl
#include <fsl_enet_qos.h> Defines the EST gate control list structure.

Public Members

bool enable
Enable or disable EST

uint64_t cycleTime
Base Time 32 bits seconds 32 bits nanoseconds

uint32_t extTime
Cycle Time 32 bits seconds 32 bits nanoseconds

uint32_t numEntries
Time Extension 32 bits seconds 32 bits nanoseconds

enet_qos_est_gate_op_t *opList
Number of entries

struct __enet_qos_rxp_config
#include <fsl_enet_qos.h> Defines the ENET_QOS Rx parser configuration structure.

Public Members

uint32_t matchEnable
4-byte match data used for comparing with incoming packet

uint8_t acceptFrame

When matchEnable is set to 1, the matchData is used for comparing

uint8_t rejectFrame

When acceptFrame = 1 and data is matched, the frame will be sent to DMA channel

uint8_t inverseMatch

When rejectFrame = 1 and data is matched, the frame will be dropped

uint8_t nextControl

Inverse match

uint8_t reserved

Next instruction indexing control

uint8_t frameOffset

Reserved control fields

uint8_t okIndex

Frame offset in the packet data to be compared for match, in terms of 4 bytes.

uint8_t dmaChannel

Memory Index to be used next.

uint32_t reserved2

The DMA channel enet_qos_rxp_dma_chn_t used for receiving the frame when frame match and acceptFrame = 1

struct _enet_qos_buffer_config

#include <fsl_enet_qos.h> Defines the buffer descriptor configure structure.

Note:

- The receive and transmit descriptor start address pointer and tail pointer must be word-aligned.
 - The recommended minimum tx/rx ring length is 4.
 - The tx/rx descriptor tail address shall be the address pointer to the address just after the end of the last last descriptor. because only the descriptors between the start address and the tail address will be used by DMA.
 - The descriptor address is the start address of all used contiguous memory. for example, the rxDescStartAddrAlign is the start address of rxRingLen contiguous descriptor memories for rx descriptor ring 0.
 - The “*rxBufferstartAddr” is the first element of rxRingLen (2*rxRingLen for double buffers) rx buffers. It means the *rxBufferStartAddr is the rx buffer for the first descriptor the *rxBufferStartAddr + 1 is the rx buffer for the second descriptor or the rx buffer for the second buffer in the first descriptor. so please make sure the rxBufferStartAddr is the address of a rxRingLen or 2*rxRingLen array.
-

Public Members

uint8_t rxRingLen

The length of receive buffer descriptor ring.

uint8_t txRingLen

The length of transmit buffer descriptor ring.

enet_qos_tx_bd_struct_t *txDescStartAddrAlign

Aligned transmit descriptor start address.

enet_qos_tx_bd_struct_t *txDescTailAddrAlign

Aligned transmit descriptor tail address.

enet_qos_frame_info_t *txDirtyStartAddr

Start address of the dirty tx frame information.

enet_qos_rx_bd_struct_t *rxDescStartAddrAlign

Aligned receive descriptor start address.

enet_qos_rx_bd_struct_t *rxDescTailAddrAlign

Aligned receive descriptor tail address.

uint32_t *rxBufferStartAddr

Start address of the rx buffers.

uint32_t rxBuffSizeAlign

Aligned receive data buffer size.

bool rxBuffNeedMaintain

Whether receive data buffer need cache maintain.

struct _enet_qos_cbs_config

#include <fsl_enet_qos.h> Defines the CBS configuration for queue.

Public Members

uint16_t sendSlope

Send slope configuration.

uint16_t idleSlope

Idle slope configuration.

uint32_t highCredit

High credit.

uint32_t lowCredit

Low credit.

struct enet_qos_tx_queue_config

#include <fsl_enet_qos.h> Defines the queue configuration structure.

Public Members

enet_qos_queue_mode_t mode

tx queue mode configuration.

uint32_t weight

Refer to the MTL TxQ Quantum Weight register.

uint32_t priority

Refer to Transmit Queue Priority Mapping register.

enet_qos_cbs_config_t *cbsConfig

CBS configuration if queue use AVB mode.

struct enet_qos_rx_queue_config

#include <fsl_enet_qos.h> Defines the queue configuration structure.

Public Members

enet_qos_queue_mode_t mode
rx queue mode configuration.

uint8_t mapChannel
tx queue map dma channel.

uint32_t priority
Rx queue priority.

enet_qos_rx_queue_route_t packetRoute
Receive packet routing.

struct *enet_qos_multiqueue_config*
#include <fsl_enet_qos.h> Defines the configuration when multi-queue is used.

Public Members

enet_qos_dma_burstlen burstLen
Burst len for the multi-queue.

uint8_t txQueueUse
Used Tx queue count.

enet_qos_mtl_multiqueue_txsche mtltxSche
Transmit schedule for multi-queue.

enet_qos_queue_tx_config_t txQueueConfig[ENET_QOS_DMA_CH_COUNT]
Tx Queue configuration.

uint8_t rxQueueUse
Used Rx queue count.

enet_qos_mtl_multiqueue_rxsche mtlrxSche
Receive schedule for multi-queue.

enet_qos_queue_rx_config_t rxQueueConfig[ENET_QOS_DMA_CH_COUNT]
Rx Queue configuration.

struct *_enet_qos_config*
#include <fsl_enet_qos.h> Defines the basic configuration structure for the ENET device.

Note: Default the signal queue is used so the “*multiqueueCfg” is set default with NULL. Set the pointer with a valid configuration pointer if the multiple queues are required. If multiple queue is enabled, please make sure the buffer configuration for all are prepared also.

Public Members

uint16_t specialControl
The logic or of *enet_qos_special_config_t*

enet_qos_multiqueue_config_t *multiqueueCfg
Use multi-queue.

enet_qos_mii_mode_t miiMode
MII mode.

enet_qos_mii_speed_t miiSpeed

MII Speed.

enet_qos_mii_duplex_t miiDuplex

MII duplex.

uint16_t pauseDuration

Used in the tx flow control frame, only valid when kENET_QOS_FlowControlEnable is set.

enet_qos_ptp_config_t *ptpConfig

PTP 1588 feature configuration

uint32_t csrClock_Hz

CSR clock frequency in HZ.

enet_qos_rx_alloc_callback_t rxBuffAlloc

Callback to alloc memory, must be provided for zero-copy Rx.

enet_qos_rx_free_callback_t rxBuffFree

Callback to free memory, must be provided for zero-copy Rx.

struct *_enet_qos_tx_bd_ring*

#include <fsl_enet_qos.h> Defines the ENET transmit buffer descriptor ring/queue structure.

Public Members

enet_qos_tx_bd_struct_t *txBdBase

Buffer descriptor base address pointer.

uint16_t txGenIdx

tx generate index.

uint16_t txConsumIdx

tx consume index.

volatile *uint16_t* txDescUsed

tx descriptor used number.

uint16_t txRingLen

tx ring length.

struct *_enet_qos_rx_bd_ring*

#include <fsl_enet_qos.h> Defines the ENET receive buffer descriptor ring/queue structure.

Public Members

enet_qos_rx_bd_struct_t *rxBdBase

Buffer descriptor base address pointer.

uint16_t rxGenIdx

The current available receive buffer descriptor pointer.

uint16_t rxRingLen

Receive ring length.

uint32_t rxBuffSizeAlign

Receive buffer size.

struct *_enet_qos_handle*

#include <fsl_enet_qos.h> Defines the ENET handler structure.

Public Members

`uint8_t txQueueUse`
Used tx queue count.

`uint8_t rxQueueUse`
Used rx queue count.

`bool doubleBuffEnable`
The double buffer is used in the descriptor.

`bool rxintEnable`
Rx interrupt enabled.

`bool rxMaintainEnable[ENET_QOS_DMA_CH_COUNT]`
Rx buffer cache maintain enabled.

`enet_qos_rx_bd_ring_t rxBdRing[ENET_QOS_DMA_CH_COUNT]`
Receive buffer descriptor.

`enet_qos_tx_bd_ring_t txBdRing[ENET_QOS_DMA_CH_COUNT]`
Transmit buffer descriptor.

`enet_qos_tx_dirty_ring_t txDirtyRing[ENET_QOS_DMA_CH_COUNT]`
Transmit dirty buffers addresses.

`uint32_t *rxBufferStartAddr[ENET_QOS_DMA_CH_COUNT]`
Rx buffer start address for reInitialize.

`enet_qos_callback_t callback`
Callback function.

`void *userData`
Callback function parameter.

`uint8_t multicastCount[64]`
Multicast collisions counter

`enet_qos_rx_alloc_callback_t rxBuffAlloc`
Callback to alloc memory, must be provided for zero-copy Rx.

`enet_qos_rx_free_callback_t rxBuffFree`
Callback to free memory, must be provided for zero-copy Rx.

`struct __enet_qos_state`
#include <fsl_enet_qos.h> Defines the ENET state structure.

Note: The structure contains saved state for the instance. It could be stored in `enet_qos_handle_t`, but that's used only with the transactional API.

Public Members

`enet_qos_mii_mode_t miiMode`
MII mode.

`struct __enet_qos_buffer_struct`
#include <fsl_enet_qos.h> Defines the frame buffer structure.

Public Members

void *buffer

The buffer store the whole or partial frame.

uint16_t length

The byte length of this buffer.

struct _enet_qos_rx_frame_error

#include <fsl_enet_qos.h> Defines the Rx frame error structure.

Public Members

bool rxDstAddrFilterErr

Destination Address Filter Fail.

bool rxSrcAddrFilterErr

SA Address Filter Fail.

bool rxDribbleErr

Dribble error.

bool rxReceiveErr

Receive error.

bool rxOverflowErr

Receive over flow.

bool rxWatchDogErr

Watch dog timeout.

bool rxGaintPacketErr

Receive gaint packet.

bool rxCrcErr

Receive CRC error.

struct _enet_qos_rx_frame_attribute_struct

#include <fsl_enet_qos.h>

Public Members

bool isTsAvail

Rx frame timestamp is available or not.

enet_qos_ptp_time_t timestamp

The nanosecond part timestamp of this Rx frame.

struct _enet_qos_rx_frame_struct

#include <fsl_enet_qos.h> Defines the Rx frame data structure.

Public Members

enet_qos_buffer_struct_t *rxBuffArray

Rx frame buffer structure.

uint16_t totLen

Rx frame total length.

enet_qos_rx_frame_attribute_t rxAttribute
Rx frame attribute structure.

enet_qos_rx_frame_error_t rxFrameError
Rx frame error.

struct *_enet_qos_transfer_stats*
#include <fsl_enet_qos.h> Defines the ENET QOS transfer statistics structure.

Public Members

uint32_t statsRxFrameCount
Rx frame number.

uint32_t statsRxCrcErr
Rx frame number with CRC error.

uint32_t statsRxAlignErr
Rx frame number with alignment error.

uint32_t statsRxLengthErr
Rx frame length field doesn't equal to packet size.

uint32_t statsRxFifoOverflowErr
Rx FIFO overflow count.

uint32_t statsTxFrameCount
Tx frame number.

uint32_t statsTxFifoUnderRunErr
Tx FIFO underrun count.

2.7 FGPIO Driver

2.8 FlexCAN: Flex Controller Area Network Driver

2.9 FlexCAN Driver

bool FLEXCAN_IsInstanceHasFDMode(CAN_Type *base)
Determine whether the FlexCAN instance support CAN FD mode at run time.

Note: Use this API only if different soc parts share the SOC part name macro define. Otherwise, a different SOC part name can be used to determine at compile time whether the FlexCAN instance supports CAN FD mode or not. If need use this API to determine if CAN FD mode is supported, the FLEXCAN_Init function needs to be executed first, and then call this API and use the return to value determines whether to supports CAN FD mode, if return true, continue calling FLEXCAN_FDInit to enable CAN FD mode.

Parameters

- base – FlexCAN peripheral base address.

Returns

return TRUE if instance support CAN FD mode, FALSE if instance only support classic CAN (2.0) mode.

uint32_t FLEXCAN_GetFDMailboxOffset(CAN_Type *base, uint8_t mbIdx)

Get Mailbox offset number by dword.

This function gets the offset number of the specified mailbox. Mailbox is not consecutive between memory regions when payload is not 8 bytes so need to calculate the specified mailbox address. For example, in the first memory region, MB[0].CS address is 0x4002_4080. For 32 bytes payload frame, the second mailbox is $((1/12)*512 + 1\%12*40)/4 = 10$, meaning 10 dword after the 0x4002_4080, which is actually the address of mailbox MB[1].CS.

Parameters

- base – FlexCAN peripheral base address.
- mbIdx – Mailbox index.

Returns

Mailbox address offset in word.

status_t FLEXCAN_EnterFreezeMode(CAN_Type *base)

Enter FlexCAN Freeze Mode.

This function makes the FlexCAN work under Freeze Mode.

Parameters

- base – FlexCAN peripheral base address.

Returns

kStatus_Success Enter Freeze Mode successful kStatus_Timeout Timeout when wait for Freeze Mode Acknowledge

status_t FLEXCAN_ExitFreezeMode(CAN_Type *base)

Exit FlexCAN Freeze Mode.

This function makes the FlexCAN leave Freeze Mode.

Parameters

- base – FlexCAN peripheral base address.

Returns

kStatus_Success Enter Freeze Mode successful kStatus_Timeout Timeout when wait for Freeze Mode Acknowledge

uint32_t FLEXCAN_GetInstance(CAN_Type *base)

Get the FlexCAN instance from peripheral base address.

Parameters

- base – FlexCAN peripheral base address.

Returns

FlexCAN instance.

bool FLEXCAN_CalculateImprovedTimingValues(CAN_Type *base, uint32_t bitRate, uint32_t sourceClock_Hz, flexcan_timing_config_t *pTimingConfig)

Calculates the improved timing values by specific bit Rates for classical CAN.

This function use to calculates the Classical CAN timing values according to the given bit rate. The Calculated timing values will be set in CTRL1/CBT/ENCBT register. The calculation is based on the recommendation of the CiA 301 v4.2.0 and previous version document.

Parameters

- base – FlexCAN peripheral base address.
- bitRate – The classical CAN speed in bps defined by user, should be less than or equal to 1Mbps.

- sourceClock_Hz – The Source clock frequency in Hz.
- pTimingConfig – Pointer to the FlexCAN timing configuration structure.

Returns

TRUE if timing configuration found, FALSE if failed to find configuration.

void FLEXCAN_Init(CAN_Type *base, const *flexcan_config_t* *pConfig, uint32_t sourceClock_Hz)
Initializes a FlexCAN instance.

This function initializes the FlexCAN module with user-defined settings. This example shows how to set up the *flexcan_config_t* parameters and how to call the FLEXCAN_Init function by passing in these parameters.

```
flexcan_config_t flexcanConfig;
flexcanConfig.clkSrc      = kFLEXCAN_ClkSrc0;
flexcanConfig.bitRate     = 1000000U;
flexcanConfig.maxMbNum    = 16;
flexcanConfig.enableLoopBack = false;
flexcanConfig.enableSelfWakeup = false;
flexcanConfig.enableIndividMask = false;
flexcanConfig.enableDoze    = false;
flexcanConfig.disableSelfReception = false;
flexcanConfig.enableListenOnlyMode = false;
flexcanConfig.timingConfig = timingConfig;
FLEXCAN_Init(CAN0, &flexcanConfig, 4000000UL);
```

Parameters

- base – FlexCAN peripheral base address.
- pConfig – Pointer to the user-defined configuration structure.
- sourceClock_Hz – FlexCAN Protocol Engine clock source frequency in Hz.

bool FLEXCAN_FDCalculateImprovedTimingValues(CAN_Type *base, uint32_t bitRate, uint32_t bitRateFD, uint32_t sourceClock_Hz, *flexcan_timing_config_t* *pTimingConfig)

Calculates the improved timing values by specific bit rates for CANFD.

This function use to calculates the CANFD timing values according to the given nominal phase bit rate and data phase bit rate. The Calculated timing values will be set in CBT/ENCBT and FDCBT/EDCBT registers. The calculation is based on the recommendation of the CiA 1301 v1.0.0 document.

Parameters

- base – FlexCAN peripheral base address.
- bitRate – The CANFD bus control speed in bps defined by user.
- bitRateFD – The CAN FD data phase speed in bps defined by user. Equal to bitRate means disable bit rate switching.
- sourceClock_Hz – The Source clock frequency in Hz.
- pTimingConfig – Pointer to the FlexCAN timing configuration structure.

Returns

TRUE if timing configuration found, FALSE if failed to find configuration

void FLEXCAN_FDInit(CAN_Type *base, const *flexcan_config_t* *pConfig, uint32_t sourceClock_Hz, *flexcan_mb_size_t* dataSize, bool brs)

Initializes a FlexCAN instance.

This function initializes the FlexCAN module with user-defined settings. This example shows how to set up the `flexcan_config_t` parameters and how to call the `FLEXCAN_FDIInit` function by passing in these parameters.

```
flexcan_config_t flexcanConfig;
flexcanConfig.clkSrc      = kFLEXCAN_ClkSrc0;
flexcanConfig.bitRate     = 1000000U;
flexcanConfig.bitRateFD   = 2000000U;
flexcanConfig.maxMbNum    = 16;
flexcanConfig.enableLoopBack = false;
flexcanConfig.enableSelfWakeup = false;
flexcanConfig.enableIndividMask = false;
flexcanConfig.disableSelfReception = false;
flexcanConfig.enableListenOnlyMode = false;
flexcanConfig.enableDoze = false;
flexcanConfig.timingConfig = timingConfig;
FLEXCAN_FDIInit(CAN0, &flexcanConfig, 8000000UL, kFLEXCAN_16BperMB, true);
```

Parameters

- `base` – FlexCAN peripheral base address.
- `pConfig` – Pointer to the user-defined configuration structure.
- `sourceClock_Hz` – FlexCAN Protocol Engine clock source frequency in Hz.
- `dataSize` – FlexCAN Message Buffer payload size. The actual transmitted or received CAN FD frame data size needs to be less than or equal to this value.
- `brs` – True if bit rate switch is enabled in FD mode.

`void FLEXCAN_Deinit(CAN_Type *base)`

De-initializes a FlexCAN instance.

This function disables the FlexCAN module clock and sets all register values to the reset value.

Parameters

- `base` – FlexCAN peripheral base address.

`void FLEXCAN_GetDefaultConfig(flexcan_config_t *pConfig)`

Gets the default configuration structure.

This function initializes the FlexCAN configuration structure to default values. The default values are as follows. `flexcanConfig->clkSrc = kFLEXCAN_ClkSrc0; flexcanConfig->bitRate = 1000000U; flexcanConfig->bitRateFD = 2000000U; flexcanConfig->maxMbNum = 16; flexcanConfig->enableLoopBack = false; flexcanConfig->enableSelfWakeup = false; flexcanConfig->enableIndividMask = false; flexcanConfig->disableSelfReception = false; flexcanConfig->enableListenOnlyMode = false; flexcanConfig->enableDoze = false; flexcanConfig->enablePretendedNetwork = false; flexcanConfig->enableMemoryErrorControl = true; flexcanConfig->enableNonCorrectableErrorEnterFreeze = true; flexcanConfig->enableTransceiverDelayMeasure = true; flexcanConfig->enableRemoteRequestFrameStored = true; flexcanConfig->payloadEndianness = kFLEXCAN_bigEndian; flexcanConfig.timingConfig = timingConfig;`

Parameters

- `pConfig` – Pointer to the FlexCAN configuration structure.

`void FLEXCAN_SetTimingConfig(CAN_Type *base, const flexcan_timing_config_t *pConfig)`

Sets the FlexCAN classical CAN protocol timing characteristic.

This function gives user settings to classical CAN or CAN FD nominal phase timing characteristic. The function is for an experienced user. For less experienced users, call the FLEXCAN_SetBitRate() instead.

Note: Calling FLEXCAN_SetTimingConfig() overrides the bit rate set in FLEXCAN_Init() or FLEXCAN_SetBitRate().

Parameters

- base – FlexCAN peripheral base address.
- pConfig – Pointer to the timing configuration structure.

status_t FLEXCAN_SetBitRate(CAN_Type *base, uint32_t sourceClock_Hz, uint32_t bitRate_Bps)

Set bit rate of FlexCAN classical CAN frame or CAN FD frame nominal phase.

This function set the bit rate of classical CAN frame or CAN FD frame nominal phase base on FLEXCAN_CalculateImprovedTimingValues() API calculated timing values.

Note: Calling FLEXCAN_SetBitRate() overrides the bit rate set in FLEXCAN_Init().

Parameters

- base – FlexCAN peripheral base address.
- sourceClock_Hz – Source Clock in Hz.
- bitRate_Bps – Bit rate in Bps.

Returns

kStatus_Success - Set CAN baud rate (only Nominal phase) successfully.

void FLEXCAN_SetFDTimingConfig(CAN_Type *base, const *flexcan_timing_config_t* *pConfig)

Sets the FlexCAN CANFD data phase timing characteristic.

This function gives user settings to CANFD data phase timing characteristic. The function is for an experienced user. For less experienced users, call the FLEXCAN_SetFDBitRate() to set both Nominal/Data bit Rate instead.

Note: Calling FLEXCAN_SetFDTimingConfig() overrides the data phase bit rate set in FLEXCAN_FDInit()/FLEXCAN_SetFDBitRate().

Parameters

- base – FlexCAN peripheral base address.
- pConfig – Pointer to the timing configuration structure.

status_t FLEXCAN_SetFDBitRate(CAN_Type *base, uint32_t sourceClock_Hz, uint32_t bitRateN_Bps, uint32_t bitRateD_Bps)

Set bit rate of FlexCAN FD frame.

This function set the baud rate of FLEXCAN FD base on FLEXCAN_FDCalculateImprovedTimingValues() API calculated timing values.

Parameters

- base – FlexCAN peripheral base address.
- sourceClock_Hz – Source Clock in Hz.
- bitRateN_Bps – Nominal bit Rate in Bps.

- bitRateD_Bps – Data bit Rate in Bps.

Returns

kStatus_Success - Set CAN FD bit rate (include Nominal and Data phase) successfully.

void FLEXCAN_SetRxMbGlobalMask(CAN_Type *base, uint32_t mask)

Sets the FlexCAN receive message buffer global mask.

This function sets the global mask for the FlexCAN message buffer in a matching process. The configuration is only effective when the Rx individual mask is disabled in the FLEXCAN_Init().

Parameters

- base – FlexCAN peripheral base address.
- mask – Rx Message Buffer Global Mask value.

void FLEXCAN_SetRxFifoGlobalMask(CAN_Type *base, uint32_t mask)

Sets the FlexCAN receive FIFO global mask.

This function sets the global mask for FlexCAN FIFO in a matching process.

Parameters

- base – FlexCAN peripheral base address.
- mask – Rx Fifo Global Mask value.

void FLEXCAN_SetRxIndividualMask(CAN_Type *base, uint8_t maskIdx, uint32_t mask)

Sets the FlexCAN receive individual mask.

This function sets the individual mask for the FlexCAN matching process. The configuration is only effective when the Rx individual mask is enabled in the FLEXCAN_Init(). If the Rx FIFO is disabled, the individual mask is applied to the corresponding Message Buffer. If the Rx FIFO is enabled, the individual mask for Rx FIFO occupied Message Buffer is applied to the Rx Filter with the same index. Note that only the first 32 individual masks can be used as the Rx FIFO filter mask.

Parameters

- base – FlexCAN peripheral base address.
- maskIdx – The Index of individual Mask.
- mask – Rx Individual Mask value.

void FLEXCAN_SetTxMbConfig(CAN_Type *base, uint8_t mbIdx, bool enable)

Configures a FlexCAN transmit message buffer.

This function aborts the previous transmission, cleans the Message Buffer, and configures it as a Transmit Message Buffer.

Parameters

- base – FlexCAN peripheral base address.
- mbIdx – The Message Buffer index.
- enable – Enable/disable Tx Message Buffer.
 - true: Enable Tx Message Buffer.
 - false: Disable Tx Message Buffer.

```
void FLEXCAN_SetRxMbConfig(CAN_Type *base, uint8_t mbIdx, const flexcan_rx_mb_config_t
                          *pRxMbConfig, bool enable)
```

Configures a FlexCAN Receive Message Buffer.

This function cleans a FlexCAN build-in Message Buffer and configures it as a Receive Message Buffer. User should invoke this API when CTRL2[RRS]=1. When CTRL2[RRS]=1, frame's ID is compared to the IDs of the receive mailboxes with the CODE field configured as kFLEXCAN_RxMbEmpty, kFLEXCAN_RxMbFull or kFLEXCAN_RxMbOverrun. Message buffer will store the remote frame in the same fashion of a data frame. No automatic remote response frame will be generated. User need to setup another message buffer to respond remote request.

Parameters

- base – FlexCAN peripheral base address.
- mbIdx – The Message Buffer index.
- pRxMbConfig – Pointer to the FlexCAN Message Buffer configuration structure.
- enable – Enable/disable Rx Message Buffer.
 - true: Enable Rx Message Buffer.
 - false: Disable Rx Message Buffer.

```
static inline void FLEXCAN_SetMbID(CAN_Type *base, uint8_t mbIdx, uint32_t id)
```

Configures a FlexCAN Message Buffer identifier.

Parameters

- base – FlexCAN peripheral base address.
- mbIdx – The Message Buffer index.
- id – CAN Message Buffer Identifier, should use FLEXCAN_ID_EXT() or FLEXCAN_ID_STD() macro.

```
void FLEXCAN_SetFDTxMbConfig(CAN_Type *base, uint8_t mbIdx, bool enable)
```

Configures a FlexCAN transmit message buffer.

This function aborts the previous transmission, cleans the Message Buffer, and configures it as a Transmit Message Buffer.

Parameters

- base – FlexCAN peripheral base address.
- mbIdx – The Message Buffer index.
- enable – Enable/disable Tx Message Buffer.
 - true: Enable Tx Message Buffer.
 - false: Disable Tx Message Buffer.

```
void FLEXCAN_SetFDRxMbConfig(CAN_Type *base, uint8_t mbIdx, const
                             flexcan_rx_mb_config_t *pRxMbConfig, bool enable)
```

Configures a FlexCAN Receive Message Buffer.

This function cleans a FlexCAN build-in Message Buffer and configures it as a Receive Message Buffer.

Parameters

- base – FlexCAN peripheral base address.
- mbIdx – The Message Buffer index.

- pRxMbConfig – Pointer to the FlexCAN Message Buffer configuration structure.
- enable – Enable/disable Rx Message Buffer.
 - true: Enable Rx Message Buffer.
 - false: Disable Rx Message Buffer.

static inline void FLEXCAN_SetFDMbID(CAN_Type *base, uint8_t mbIdx, uint32_t id)
Configures a FlexCAN Message Buffer identifier.

Parameters

- base – FlexCAN peripheral base address.
- mbIdx – The Message Buffer index.
- id – CAN Message Buffer Identifier, should use FLEXCAN_ID_EXT() or FLEXCAN_ID_STD() macro.

void FLEXCAN_SetRemoteResponseMbConfig(CAN_Type *base, uint8_t mbIdx, const
flexcan_frame_t *pFrame)

Configures a FlexCAN Remote Response Message Buffer.

User should invoke this API when CTRL2[RRS]=0. When CTRL2[RRS]=0, frame's ID is compared to the IDs of the receive mailboxes with the CODE field configured as kFLEXCAN_RxMbRanswer. If there is a matching ID, then this mailbox content will be transmitted as response. The received remote request frame is not stored in receive buffer. It is only used to trigger a transmission of a frame in response.

Parameters

- base – FlexCAN peripheral base address.
- mbIdx – The Message Buffer index.
- pFrame – Pointer to CAN message frame structure for response.

void FLEXCAN_SetRxFifoConfig(CAN_Type *base, const flexcan_rx_fifo_config_t *pRxFifoConfig,
bool enable)

Configures the FlexCAN Legacy Rx FIFO.

This function configures the FlexCAN Rx FIFO with given configuration.

Note: Legacy Rx FIFO only can receive classic CAN message.

Parameters

- base – FlexCAN peripheral base address.
- pRxFifoConfig – Pointer to the FlexCAN Legacy Rx FIFO configuration structure. Can be NULL when enable parameter is false.
- enable – Enable/disable Legacy Rx FIFO.
 - true: Enable Legacy Rx FIFO.
 - false: Disable Legacy Rx FIFO.

void FLEXCAN_SetEnhancedRxFifoConfig(CAN_Type *base, const
flexcan_enhanced_rx_fifo_config_t *pConfig, bool
enable)

Configures the FlexCAN Enhanced Rx FIFO.

This function configures the Enhanced Rx FIFO with given configuration.

Note: Enhanced Rx FIFO support receive classic CAN or CAN FD messages, Legacy Rx FIFO and Enhanced Rx FIFO cannot be enabled at the same time.

Parameters

- base – FlexCAN peripheral base address.
- pConfig – Pointer to the FlexCAN Enhanced Rx FIFO configuration structure. Can be NULL when enable parameter is false.
- enable – Enable/disable Enhanced Rx FIFO.
 - true: Enable Enhanced Rx FIFO.
 - false: Disable Enhanced Rx FIFO.

```
void FLEXCAN_SetPNConfig(CAN_Type *base, const flexcan_pn_config_t *pConfig)
```

Configures the FlexCAN Pretended Networking mode.

This function configures the FlexCAN Pretended Networking mode with given configuration.

Parameters

- base – FlexCAN peripheral base address.
- pConfig – Pointer to the FlexCAN Rx FIFO configuration structure.

```
static inline uint64_t FLEXCAN_GetStatusFlags(CAN_Type *base)
```

Gets the FlexCAN module interrupt flags.

This function gets all FlexCAN status flags. The flags are returned as the logical OR value of the enumerators `_flexcan_flags`. To check the specific status, compare the return value with enumerators in `_flexcan_flags`.

Parameters

- base – FlexCAN peripheral base address.

Returns

FlexCAN status flags which are ORed by the enumerators in the `_flexcan_flags`.

```
static inline void FLEXCAN_ClearStatusFlags(CAN_Type *base, uint64_t mask)
```

Clears status flags with the provided mask.

This function clears the FlexCAN status flags with a provided mask. An automatically cleared flag can't be cleared by this function.

Parameters

- base – FlexCAN peripheral base address.
- mask – The status flags to be cleared, it is logical OR value of `_flexcan_flags`.

```
static inline void FLEXCAN_GetBusErrCount(CAN_Type *base, uint8_t *txErrBuf, uint8_t *rxErrBuf)
```

Gets the FlexCAN Bus Error Counter value.

This function gets the FlexCAN Bus Error Counter value for both Tx and Rx direction. These values may be needed in the upper layer error handling.

Parameters

- base – FlexCAN peripheral base address.
- txErrBuf – Buffer to store Tx Error Counter value.
- rxErrBuf – Buffer to store Rx Error Counter value.

```
static inline uint64_t FLEXCAN_GetMbStatusFlags(CAN_Type *base, uint64_t mask)
```

Gets the FlexCAN low 64 Message Buffer interrupt flags.

This function gets the interrupt flags of a given Message Buffers.

Parameters

- `base` – FlexCAN peripheral base address.
- `mask` – The ORed FlexCAN Message Buffer mask.

Returns

The status of given Message Buffers.

```
static inline uint64_t FLEXCAN_GetHigh64MbStatusFlags(CAN_Type *base, uint64_t mask)
```

Gets the FlexCAN High 64 Message Buffer interrupt flags.

Valid only if the number of available MBs exceeds 64.

Parameters

- `base` – FlexCAN peripheral base address.
- `mask` – The ORed FlexCAN Message Buffer mask.

Returns

The status of given Message Buffers.

```
static inline void FLEXCAN_ClearMbStatusFlags(CAN_Type *base, uint64_t mask)
```

Clears the FlexCAN low 64 Message Buffer interrupt flags.

This function clears the interrupt flags of a given Message Buffers.

Parameters

- `base` – FlexCAN peripheral base address.
- `mask` – The ORed FlexCAN Message Buffer mask.

```
static inline void FLEXCAN_ClearHigh64MbStatusFlags(CAN_Type *base, uint64_t mask)
```

Clears the FlexCAN High 64 Message Buffer interrupt flags.

Valid only if the number of available MBs exceeds 64.

Parameters

- `base` – FlexCAN peripheral base address.
- `mask` – The ORed FlexCAN Message Buffer mask.

```
void FLEXCAN_GetMemoryErrorReportStatus(CAN_Type *base,  
                                         flexcan_memory_error_report_status_t  
                                         *errorStatus)
```

Gets the FlexCAN Memory Error Report registers status.

This function gets the FlexCAN Memory Error Report registers status.

Parameters

- `base` – FlexCAN peripheral base address.
- `errorStatus` – Pointer to FlexCAN Memory Error Report registers status structure.

```
static inline uint8_t FLEXCAN_GetPNMatchCount(CAN_Type *base)
```

Gets the FlexCAN Number of Matches when in Pretended Networking.

This function gets the number of times a given message has matched the predefined filtering criteria for ID and/or PL before a wakeup event.

Parameters

- base – FlexCAN peripheral base address.

Returns

The number of received wake up messages.

```
static inline uint32_t FLEXCAN_GetEnhancedFifoDataCount(CAN_Type *base)
```

Gets the number of FlexCAN Enhanced Rx FIFO available frames.

This function gets the number of CAN messages stored in the Enhanced Rx FIFO.

Parameters

- base – FlexCAN peripheral base address.

Returns

The number of available CAN messages stored in the Enhanced Rx FIFO.

```
static inline void FLEXCAN_EnableInterrupts(CAN_Type *base, uint64_t mask)
```

Enables FlexCAN interrupts according to the provided mask.

This function enables the FlexCAN interrupts according to the provided mask. The mask is a logical OR of enumeration members, see `_flexcan_interrupt_enable`.

Parameters

- base – FlexCAN peripheral base address.
- mask – The interrupts to enable. Logical OR of `_flexcan_interrupt_enable`.

```
static inline void FLEXCAN_DisableInterrupts(CAN_Type *base, uint64_t mask)
```

Disables FlexCAN interrupts according to the provided mask.

This function disables the FlexCAN interrupts according to the provided mask. The mask is a logical OR of enumeration members, see `_flexcan_interrupt_enable`.

Parameters

- base – FlexCAN peripheral base address.
- mask – The interrupts to disable. Logical OR of `_flexcan_interrupt_enable`.

```
static inline void FLEXCAN_EnableMbInterrupts(CAN_Type *base, uint64_t mask)
```

Enables FlexCAN low 64 Message Buffer interrupts.

This function enables the interrupts of given Message Buffers.

Parameters

- base – FlexCAN peripheral base address.
- mask – The ORed FlexCAN Message Buffer mask.

```
static inline void FLEXCAN_EnableHigh64MbInterrupts(CAN_Type *base, uint64_t mask)
```

Enables FlexCAN high 64 Message Buffer interrupts.

Valid only if the number of available MBs exceeds 64.

Parameters

- base – FlexCAN peripheral base address.
- mask – The ORed FlexCAN Message Buffer mask.

```
static inline void FLEXCAN_DisableMbInterrupts(CAN_Type *base, uint64_t mask)
```

Disables FlexCAN low 64 Message Buffer interrupts.

This function disables the interrupts of given Message Buffers.

Parameters

- base – FlexCAN peripheral base address.

- mask – The ORed FlexCAN Message Buffer mask.

static inline void FLEXCAN_DisableHigh64MbInterrupts(CAN_Type *base, uint64_t mask)

Disables FlexCAN high 64 Message Buffer interrupts.

Valid only if the number of available MBs exceeds 64.

Parameters

- base – FlexCAN peripheral base address.
- mask – The ORed FlexCAN Message Buffer mask.

void FLEXCAN_EnableRxFifoDMA(CAN_Type *base, bool enable)

Enables or disables the FlexCAN Rx FIFO DMA request.

This function enables or disables the DMA feature of FlexCAN build-in Rx FIFO.

Parameters

- base – FlexCAN peripheral base address.
- enable – true to enable, false to disable.

static inline uintptr_t FLEXCAN_GetRxFifoHeadAddr(CAN_Type *base)

Gets the Rx FIFO Head address.

This function returns the FlexCAN Rx FIFO Head address, which is mainly used for the DMA/eDMA use case.

Parameters

- base – FlexCAN peripheral base address.

Returns

FlexCAN Rx FIFO Head address.

static inline *status_t* FLEXCAN_Enable(CAN_Type *base, bool enable)

Enables or disables the FlexCAN module operation.

This function enables or disables the FlexCAN module.

Parameters

- base – FlexCAN base pointer.
- enable – true to enable, false to disable.

Returns

kStatus_Success Enable FlexCAN module successful
kStatus_Timeout Timeout when wait for Low-Power Mode Acknowledge

status_t FLEXCAN_WriteTxMb(CAN_Type *base, uint8_t mbIdx, const *flexcan_frame_t* *pTxFrame)

Writes a FlexCAN Message to the Transmit Message Buffer.

This function writes a CAN Message to the specified Transmit Message Buffer and changes the Message Buffer state to start CAN Message transmit. After that the function returns immediately.

Parameters

- base – FlexCAN peripheral base address.
- mbIdx – The FlexCAN Message Buffer index.
- pTxFrame – Pointer to CAN message frame to be sent.

Return values

- kStatus_Success -- Write Tx Message Buffer Successfully.

- `kStatus_Fail` – Tx Message Buffer is currently in use.

`status_t FLEXCAN_ReadRxMb(CAN_Type *base, uint8_t mbIdx, flexcan_frame_t *pRxFrame)`

Reads a FlexCAN Message from Receive Message Buffer.

This function reads a CAN message from a specified Receive Message Buffer. The function fills a receive CAN message frame structure with just received data and activates the Message Buffer again. The function returns immediately.

Parameters

- `base` – FlexCAN peripheral base address.
- `mbIdx` – The FlexCAN Message Buffer index.
- `pRxFrame` – Pointer to CAN message frame structure for reception.

Return values

- `kStatus_Success` – Rx Message Buffer is full and has been read successfully.
- `kStatus_FLEXCAN_RxOverflow` – Rx Message Buffer is already overflowed and has been read successfully.
- `kStatus_Fail` – Rx Message Buffer is empty.

`status_t FLEXCAN_WriteFDTxMb(CAN_Type *base, uint8_t mbIdx, const flexcan_fd_frame_t *pTxFrame)`

Writes a FlexCAN FD Message to the Transmit Message Buffer.

This function writes a CAN FD Message to the specified Transmit Message Buffer and changes the Message Buffer state to start CAN FD Message transmit. After that the function returns immediately.

Parameters

- `base` – FlexCAN peripheral base address.
- `mbIdx` – The FlexCAN FD Message Buffer index.
- `pTxFrame` – Pointer to CAN FD message frame to be sent.

Return values

- `kStatus_Success` – Write Tx Message Buffer Successfully.
- `kStatus_Fail` – Tx Message Buffer is currently in use.

`status_t FLEXCAN_ReadFDRxMb(CAN_Type *base, uint8_t mbIdx, flexcan_fd_frame_t *pRxFrame)`

Reads a FlexCAN FD Message from Receive Message Buffer.

This function reads a CAN FD message from a specified Receive Message Buffer. The function fills a receive CAN FD message frame structure with just received data and activates the Message Buffer again. The function returns immediately.

Parameters

- `base` – FlexCAN peripheral base address.
- `mbIdx` – The FlexCAN FD Message Buffer index.
- `pRxFrame` – Pointer to CAN FD message frame structure for reception.

Return values

- `kStatus_Success` – Rx Message Buffer is full and has been read successfully.
- `kStatus_FLEXCAN_RxOverflow` – Rx Message Buffer is already overflowed and has been read successfully.
- `kStatus_Fail` – Rx Message Buffer is empty.

status_t FLEXCAN_ReadRxFifo(CAN_Type *base, *flexcan_frame_t* *pRxFrame)

Reads a FlexCAN Message from Legacy Rx FIFO.

This function reads a CAN message from the FlexCAN Legacy Rx FIFO.

Parameters

- base – FlexCAN peripheral base address.
- pRxFrame – Pointer to CAN message frame structure for reception.

Return values

- kStatus_Success – Read Message from Rx FIFO successfully.
- kStatus_Fail – Rx FIFO is not enabled.

status_t FLEXCAN_ReadEnhancedRxFifo(CAN_Type *base, *flexcan_fd_frame_t* *pRxFrame)

Reads a FlexCAN Message from Enhanced Rx FIFO.

This function reads a CAN or CAN FD message from the FlexCAN Enhanced Rx FIFO.

Parameters

- base – FlexCAN peripheral base address.
- pRxFrame – Pointer to CAN FD message frame structure for reception.

Return values

- kStatus_Success – Read Message from Rx FIFO successfully.
- kStatus_Fail – Rx FIFO is not enabled.

status_t FLEXCAN_ReadPNWakeUpMB(CAN_Type *base, uint8_t mbIdx, *flexcan_frame_t* *pRxFrame)

Reads a FlexCAN Message from Wake Up MB.

This function reads a CAN message from the FlexCAN Wake up Message Buffers. There are four Wake up Message Buffers (WMBs) used to store incoming messages in Pretended Networking mode. The WMB index indicates the arrival order. The last message is stored in WMB3.

Parameters

- base – FlexCAN peripheral base address.
- pRxFrame – Pointer to CAN message frame structure for reception.
- mbIdx – The FlexCAN Wake up Message Buffer index. Range in 0x0 ~ 0x3.

Return values

- kStatus_Success – Read Message from Wake up Message Buffer successfully.
- kStatus_Fail – Wake up Message Buffer has no valid content.

status_t FLEXCAN_TransferFDSendBlocking(CAN_Type *base, uint8_t mbIdx, *flexcan_fd_frame_t* *pTxFrame)

Performs a polling send transaction on the CAN bus.

Note: A transfer handle does not need to be created before calling this API.

Parameters

- base – FlexCAN peripheral base pointer.
- mbIdx – The FlexCAN FD Message Buffer index.

- pTxFrame – Pointer to CAN FD message frame to be sent.

Return values

- kStatus__Success – - Write Tx Message Buffer Successfully.
- kStatus__Fail – - Tx Message Buffer is currently in use.
- kStatus__Timeout – - Failed to send frames within specific time.

status_t FLEXCAN__TransferFDReceiveBlocking(CAN_Type *base, uint8_t mbIdx,
flexcan_fd_frame_t *pRxFrame)

Performs a polling receive transaction on the CAN bus.

Note: A transfer handle does not need to be created before calling this API.

Parameters

- base – FlexCAN peripheral base pointer.
- mbIdx – The FlexCAN FD Message Buffer index.
- pRxFrame – Pointer to CAN FD message frame structure for reception.

Return values

- kStatus__Success – - Rx Message Buffer is full and has been read successfully.
- kStatus_FLEXCAN__RxOverflow – - Rx Message Buffer is already overflowed and has been read successfully.
- kStatus__Fail – - Rx Message Buffer is empty.
- kStatus__Timeout – - Failed to receive frames within specific time.

status_t FLEXCAN__TransferFDSendNonBlocking(CAN_Type *base, flexcan_handle_t *handle,
flexcan_mb_transfer_t *pMbXfer)

Sends a message using IRQ.

This function sends a message using IRQ. This is a non-blocking function, which returns right away. When messages have been sent out, the send callback function is called.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.
- pMbXfer – FlexCAN FD Message Buffer transfer structure. See the flexcan_mb_transfer_t.

Return values

- kStatus__Success – Start Tx Message Buffer sending process successfully.
- kStatus__Fail – Write Tx Message Buffer failed.
- kStatus_FLEXCAN__TxBusy – Tx Message Buffer is in use.

status_t FLEXCAN__TransferFDReceiveNonBlocking(CAN_Type *base, flexcan_handle_t *handle,
flexcan_mb_transfer_t *pMbXfer)

Receives a message using IRQ.

This function receives a message using IRQ. This is non-blocking function, which returns right away. When the message has been received, the receive callback function is called.

Parameters

- base – FlexCAN peripheral base address.

- handle – FlexCAN handle pointer.
- pMbXfer – FlexCAN FD Message Buffer transfer structure. See the `flexcan_mb_transfer_t`.

Return values

- `kStatus_Success` – - Start Rx Message Buffer receiving process successfully.
- `kStatus_FLEXCAN_RxBusy` – - Rx Message Buffer is in use.

```
void FLEXCAN_TransferFDAbortSend(CAN_Type *base, flexcan_handle_t *handle, uint8_t mbIdx)
```

Aborts the interrupt driven message send process.

This function aborts the interrupt driven message send process.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.
- mbIdx – The FlexCAN FD Message Buffer index.

```
void FLEXCAN_TransferFDAbortReceive(CAN_Type *base, flexcan_handle_t *handle, uint8_t mbIdx)
```

Aborts the interrupt driven message receive process.

This function aborts the interrupt driven message receive process.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.
- mbIdx – The FlexCAN FD Message Buffer index.

```
status_t FLEXCAN_TransferSendBlocking(CAN_Type *base, uint8_t mbIdx, flexcan_frame_t *pTxFrame)
```

Performs a polling send transaction on the CAN bus.

Note: A transfer handle does not need to be created before calling this API.

Parameters

- base – FlexCAN peripheral base pointer.
- mbIdx – The FlexCAN Message Buffer index.
- pTxFrame – Pointer to CAN message frame to be sent.

Return values

- `kStatus_Success` – - Write Tx Message Buffer Successfully.
- `kStatus_Fail` – - Tx Message Buffer is currently in use.
- `kStatus_Timeout` – - Failed to send frames within specific time.

```
status_t FLEXCAN_TransferReceiveBlocking(CAN_Type *base, uint8_t mbIdx, flexcan_frame_t *pRxFrame)
```

Performs a polling receive transaction on the CAN bus.

Note: A transfer handle does not need to be created before calling this API.

Parameters

- base – FlexCAN peripheral base pointer.
- mbIdx – The FlexCAN Message Buffer index.
- pRxFrame – Pointer to CAN message frame structure for reception.

Return values

- kStatus_Success – Rx Message Buffer is full and has been read successfully.
- kStatus_FLEXCAN_RxOverflow – Rx Message Buffer is already overflowed and has been read successfully.
- kStatus_Fail – Rx Message Buffer is empty.
- kStatus_Timeout – Failed to receive frames within specific time.

status_t FLEXCAN_TransferReceiveFifoBlocking(CAN_Type *base, *flexcan_frame_t* *pRxFrame)
 Performs a polling receive transaction from Legacy Rx FIFO on the CAN bus.

Note: A transfer handle does not need to be created before calling this API.

Parameters

- base – FlexCAN peripheral base pointer.
- pRxFrame – Pointer to CAN message frame structure for reception.

Return values

- kStatus_Success – Read Message from Rx FIFO successfully.
- kStatus_Fail – Rx FIFO is not enabled.
- kStatus_Timeout – Failed to receive frames within specific time.

status_t FLEXCAN_TransferReceiveEnhancedFifoBlocking(CAN_Type *base, *flexcan_fd_frame_t* *pRxFrame)

Performs a polling receive transaction from Enhanced Rx FIFO on the CAN bus.

Note: A transfer handle does not need to be created before calling this API.

Parameters

- base – FlexCAN peripheral base pointer.
- pRxFrame – Pointer to CAN FD message frame structure for reception.

Return values

- kStatus_Success – Read Message from Rx FIFO successfully.
- kStatus_Fail – Rx FIFO is not enabled.
- kStatus_Timeout – Failed to receive frames within specific time.

void FLEXCAN_TransferCreateHandle(CAN_Type *base, *flexcan_handle_t* *handle, *flexcan_transfer_callback_t* callback, void *userData)

Initializes the FlexCAN handle.

This function initializes the FlexCAN handle, which can be used for other FlexCAN transactional APIs. Usually, for a specified FlexCAN instance, call this API once to get the initialized handle.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.
- callback – The callback function.
- userData – The parameter of the callback function.

status_t FLEXCAN__TransferSendNonBlocking(CAN_Type *base, *flexcan_handle_t* *handle, *flexcan_mb_transfer_t* *pMbXfer)

Sends a message using IRQ.

This function sends a message using IRQ. This is a non-blocking function, which returns right away. When messages have been sent out, the send callback function is called.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.
- pMbXfer – FlexCAN Message Buffer transfer structure. See the *flexcan_mb_transfer_t*.

Return values

- kStatus_Success – Start Tx Message Buffer sending process successfully.
- kStatus_Fail – Write Tx Message Buffer failed.
- kStatus_FLEXCAN__TxBusy – Tx Message Buffer is in use.

status_t FLEXCAN__TransferReceiveNonBlocking(CAN_Type *base, *flexcan_handle_t* *handle, *flexcan_mb_transfer_t* *pMbXfer)

Receives a message using IRQ.

This function receives a message using IRQ. This is non-blocking function, which returns right away. When the message has been received, the receive callback function is called.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.
- pMbXfer – FlexCAN Message Buffer transfer structure. See the *flexcan_mb_transfer_t*.

Return values

- kStatus_Success – Start Rx Message Buffer receiving process successfully.
- kStatus_FLEXCAN__RxBusy – Rx Message Buffer is in use.

status_t FLEXCAN__TransferReceiveFifoNonBlocking(CAN_Type *base, *flexcan_handle_t* *handle, *flexcan_fifo_transfer_t* *pFifoXfer)

Receives a message from Rx FIFO using IRQ.

This function receives a message using IRQ. This is a non-blocking function, which returns right away. When all messages have been received, the receive callback function is called.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.
- pFifoXfer – FlexCAN Rx FIFO transfer structure. See the *flexcan_fifo_transfer_t*.

Return values

- `kStatus_Success` -- Start Rx FIFO receiving process successfully.
- `kStatus_FLEXCAN_RxFifoBusy` -- Rx FIFO is currently in use.

`status_t FLEXCAN_TransferGetReceiveFifoCount(CAN_Type *base, flexcan_handle_t *handle, size_t *count)`

Gets the Legacy Rx Fifo transfer status during a interrupt non-blocking receive.

Parameters

- `base` – FlexCAN peripheral base address.
- `handle` – FlexCAN handle pointer.
- `count` – Number of CAN messages receive so far by the non-blocking transaction.

Return values

- `kStatus_InvalidArgument` – `count` is Invalid.
- `kStatus_Success` – Successfully return the count.

`status_t FLEXCAN_TransferReceiveEnhancedFifoNonBlocking(CAN_Type *base, flexcan_handle_t *handle, flexcan_fifo_transfer_t *pFifoXfer)`

Receives a message from Enhanced Rx FIFO using IRQ.

This function receives a message using IRQ. This is a non-blocking function, which returns right away. When all messages have been received, the receive callback function is called.

Parameters

- `base` – FlexCAN peripheral base address.
- `handle` – FlexCAN handle pointer.
- `pFifoXfer` – FlexCAN Rx FIFO transfer structure. See the ref `flexcan_fifo_transfer_t`.

Return values

- `kStatus_Success` -- Start Rx FIFO receiving process successfully.
- `kStatus_FLEXCAN_RxFifoBusy` -- Rx FIFO is currently in use.

`static inline status_t FLEXCAN_TransferGetReceiveEnhancedFifoCount(CAN_Type *base, flexcan_handle_t *handle, size_t *count)`

Gets the Enhanced Rx Fifo transfer status during a interrupt non-blocking receive.

Parameters

- `base` – FlexCAN peripheral base address.
- `handle` – FlexCAN handle pointer.
- `count` – Number of CAN messages receive so far by the non-blocking transaction.

Return values

- `kStatus_InvalidArgument` – `count` is Invalid.
- `kStatus_Success` – Successfully return the count.

`uint32_t FLEXCAN_GetTimeStamp(flexcan_handle_t *handle, uint8_t mbIdx)`

Gets the detail index of Mailbox's Timestamp by handle.

Then function can only be used when calling non-blocking Data transfer (TX/RX) API, After TX/RX data transfer done (User can get the status by handler's callback

function), we can get the detail index of Mailbox's timestamp by handle, Detail non-blocking data transfer API (TX/RX) contain. -FLEXCAN_TransferSendNonBlocking -FLEXCAN_TransferFDSendNonBlocking -FLEXCAN_TransferReceiveNonBlocking -FLEXCAN_TransferFDReceiveNonBlocking -FLEXCAN_TransferReceiveFifoNonBlocking

Parameters

- handle – FlexCAN handle pointer.
- mbIdx – The FlexCAN Message Buffer index.

Return values

the – index of mailbox 's timestamp stored in the handle.

```
static inline uint32_t FLEXCAN_GetHighResolutionTimeStamp(CAN_Type *base, uint8_t mbIdx)
```

```
void FLEXCAN_TransferAbortSend(CAN_Type *base, flexcan_handle_t *handle, uint8_t mbIdx)
```

Aborts the interrupt driven message send process.

This function aborts the interrupt driven message send process.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.
- mbIdx – The FlexCAN Message Buffer index.

```
void FLEXCAN_TransferAbortReceive(CAN_Type *base, flexcan_handle_t *handle, uint8_t mbIdx)
```

Aborts the interrupt driven message receive process.

This function aborts the interrupt driven message receive process.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.
- mbIdx – The FlexCAN Message Buffer index.

```
void FLEXCAN_TransferAbortReceiveFifo(CAN_Type *base, flexcan_handle_t *handle)
```

Aborts the interrupt driven message receive from Rx FIFO process.

This function aborts the interrupt driven message receive from Rx FIFO process.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.

```
void FLEXCAN_TransferAbortReceiveEnhancedFifo(CAN_Type *base, flexcan_handle_t *handle)
```

Aborts the interrupt driven message receive from Enhanced Rx FIFO process.

This function aborts the interrupt driven message receive from Enhanced Rx FIFO process.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.

```
void FLEXCAN_TransferHandleIRQ(CAN_Type *base, flexcan_handle_t *handle)
```

FlexCAN IRQ handle function.

This function handles the FlexCAN Error, the Message Buffer, and the Rx FIFO IRQ request.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.

void FLEXCAN_MbHandleIRQ(CAN_Type *base, flexcan_handle_t *handle, uint32_t startMbIdx, uint32_t endMbIdx)

FlexCAN Message Buffer IRQ handle function.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.
- startMbIdx – First Message Buffer to handle.
- endMbIdx – Last Message Buffer to handle.

void FLEXCAN_EhancedRxFifoHandleIRQ(CAN_Type *base, flexcan_handle_t *handle)

FlexCAN Enhanced Rx FIFO IRQ handle function.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.

void FLEXCAN_BusoffErrorHandleIRQ(CAN_Type *base, flexcan_handle_t *handle)

FlexCAN Bus Off, Error and Warning IRQ handle function.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.

void FLEXCAN_PNWakeUpHandleIRQ(CAN_Type *base, flexcan_handle_t *handle)

FlexCAN Pretended Networking Wake-up IRQ handle function.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.

void FLEXCAN_MemoryErrorHandleIRQ(CAN_Type *base, flexcan_handle_t *handle)

FlexCAN Memory Error IRQ handle function.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.

FSL_FLEXCAN_DRIVER_VERSION

FlexCAN driver version.

FlexCAN transfer status.

Values:

enumerator kStatus_FLEXCAN_TxBusy

Tx Message Buffer is Busy.

enumerator kStatus_FLEXCAN_TxIdle

Tx Message Buffer is Idle.

enumerator kStatus_FLEXCAN_TxSwitchToRx

Remote Message is send out and Message buffer changed to Receive one.

enumerator kStatus_FLEXCAN_RxBusy
Rx Message Buffer is Busy.

enumerator kStatus_FLEXCAN_RxIdle
Rx Message Buffer is Idle.

enumerator kStatus_FLEXCAN_RxOverflow
Rx Message Buffer is Overflowed.

enumerator kStatus_FLEXCAN_RxFifoBusy
Rx Message FIFO is Busy.

enumerator kStatus_FLEXCAN_RxFifoIdle
Rx Message FIFO is Idle.

enumerator kStatus_FLEXCAN_RxFifoOverflow
Rx Message FIFO is overflowed.

enumerator kStatus_FLEXCAN_RxFifoWarning
Rx Message FIFO is almost overflowed.

enumerator kStatus_FLEXCAN_RxFifoDisabled
Rx Message FIFO is disabled during reading.

enumerator kStatus_FLEXCAN_ErrorStatus
FlexCAN Module Error and Status.

enumerator kStatus_FLEXCAN_WakeUp
FlexCAN is waken up from STOP mode.

enumerator kStatus_FLEXCAN_UnHandled
UnHandled Interrupt asserted.

enumerator kStatus_FLEXCAN_RxRemote
Rx Remote Message Received in Mail box.

enumerator kStatus_FLEXCAN_RxFifoUnderflow
Enhanced Rx Message FIFO is underflow.

enumerator kStatus_FLEXCAN_MemoryError
FlexCAN Memory Error.

enum _flexcan_frame_format
FlexCAN frame format.

Values:

enumerator kFLEXCAN_FrameFormatStandard
Standard frame format attribute.

enumerator kFLEXCAN_FrameFormatExtend
Extend frame format attribute.

enum _flexcan_frame_type
FlexCAN frame type.

Values:

enumerator kFLEXCAN_FrameTypeData
Data frame type attribute.

enumerator kFLEXCAN_FrameTypeRemote
Remote frame type attribute.

enum `_flexcan_clock_source`
FlexCAN clock source.

Deprecated:

Do not use the `kFLEXCAN_ClkSrcOs`. It has been superceded `kFLEXCAN_ClkSrc0`

Do not use the `kFLEXCAN_ClkSrcPeri`. It has been superceded `kFLEXCAN_ClkSrc1`

Values:

enumerator `kFLEXCAN_ClkSrcOsc`

FlexCAN Protocol Engine clock from Oscillator.

enumerator `kFLEXCAN_ClkSrcPeri`

FlexCAN Protocol Engine clock from Peripheral Clock.

enumerator `kFLEXCAN_ClkSrc0`

FlexCAN Protocol Engine clock selected by user as SRC == 0.

enumerator `kFLEXCAN_ClkSrc1`

FlexCAN Protocol Engine clock selected by user as SRC == 1.

enum `_flexcan_wake_up_source`
FlexCAN wake up source.

Values:

enumerator `kFLEXCAN_WakeupSrcUnfiltered`

FlexCAN uses unfiltered Rx input to detect edge.

enumerator `kFLEXCAN_WakeupSrcFiltered`

FlexCAN uses filtered Rx input to detect edge.

enum `_flexcan_endianness`
FlexCAN payload endianness.

Values:

enumerator `kFLEXCAN_bigEndian`

Transmit frame with MSB first, receive frame with big-endian format.

enumerator `kFLEXCAN_littleEndian`

Transmit frame with LSB first, receive frame with little-endian format.

enum `_flexcan_MB_timestamp_base`
FlexCAN timebase used for capturing 16-bit TIME_STAMP field of message buffer.

Values:

enumerator `kFLEXCAN_CANTimer`

FlexCAN free-running timer.

enumerator `kFLEXCAN_Lower16bitsHRTimer`

Lower 16 bits of high-resolution on-chip timer.

enumerator `kFLEXCAN_Upper16bitsHRTimer`

Upper 16 bits of high-resolution on-chip timer.

enum `_flexcan_capture_point`
FlexCAN capture point of 32-bit high resolution timebase during a CAN frame.

Values:

enumerator kFLEXCAN_CANFrameID2ndBit

Second bit of identifier field of any frame is on the CAN bus. HR_TIME_STAMPn register will not capture 32-bit counter value.

enumerator kFLEXCAN_CANFrameEnd

End of the CAN frame.

enumerator kFLEXCAN_CANFrameStart

Start of the CAN frame.

enumerator kFLEXCAN_CANFDFrameRes

Start of frame for classical CAN frames; res bit for CAN FD frames.

enum _flexcan_rx_fifo_filter_type

FlexCAN Rx Fifo Filter type.

Values:

enumerator kFLEXCAN_RxFifoFilterTypeA

One full ID (standard and extended) per ID Filter element.

enumerator kFLEXCAN_RxFifoFilterTypeB

Two full standard IDs or two partial 14-bit ID slices per ID Filter Table element.

enumerator kFLEXCAN_RxFifoFilterTypeC

Four partial 8-bit Standard or extended ID slices per ID Filter Table element.

enumerator kFLEXCAN_RxFifoFilterTypeD

All frames rejected.

enum _flexcan_mb_size

FlexCAN Message Buffer Payload size.

Values:

enumerator kFLEXCAN_8BperMB

Selects 8 bytes per Message Buffer.

enumerator kFLEXCAN_16BperMB

Selects 16 bytes per Message Buffer.

enumerator kFLEXCAN_32BperMB

Selects 32 bytes per Message Buffer.

enumerator kFLEXCAN_64BperMB

Selects 64 bytes per Message Buffer.

enum _flexcan_fd_frame_length

FlexCAN CAN FD frame supporting data length (available DLC values).

For Tx, when the Data size corresponding to DLC value stored in the MB selected for transmission is larger than the MB Payload size, FlexCAN adds the necessary number of bytes with constant 0xCC pattern to complete the expected DLC. For Rx, when the Data size corresponding to DLC value received from the CAN bus is larger than the MB Payload size, the high order bytes that do not fit the Payload size will lose.

Values:

enumerator kFLEXCAN_0BperFrame

Frame contains 0 valid data bytes.

enumerator kFLEXCAN_1BperFrame

Frame contains 1 valid data bytes.

enumerator kFLEXCAN_2BperFrame
Frame contains 2 valid data bytes.

enumerator kFLEXCAN_3BperFrame
Frame contains 3 valid data bytes.

enumerator kFLEXCAN_4BperFrame
Frame contains 4 valid data bytes.

enumerator kFLEXCAN_5BperFrame
Frame contains 5 valid data bytes.

enumerator kFLEXCAN_6BperFrame
Frame contains 6 valid data bytes.

enumerator kFLEXCAN_7BperFrame
Frame contains 7 valid data bytes.

enumerator kFLEXCAN_8BperFrame
Frame contains 8 valid data bytes.

enumerator kFLEXCAN_12BperFrame
Frame contains 12 valid data bytes.

enumerator kFLEXCAN_16BperFrame
Frame contains 16 valid data bytes.

enumerator kFLEXCAN_20BperFrame
Frame contains 20 valid data bytes.

enumerator kFLEXCAN_24BperFrame
Frame contains 24 valid data bytes.

enumerator kFLEXCAN_32BperFrame
Frame contains 32 valid data bytes.

enumerator kFLEXCAN_48BperFrame
Frame contains 48 valid data bytes.

enumerator kFLEXCAN_64BperFrame
Frame contains 64 valid data bytes.

enum _flexcan_efifo_dma_per_read_length
FlexCAN Enhanced Rx Fifo DMA transfer per read length enumerations.

Values:

enumerator kFLEXCAN_1WordPerRead
Transfer 1 32-bit words (CS).

enumerator kFLEXCAN_2WordPerRead
Transfer 2 32-bit words (CS + ID).

enumerator kFLEXCAN_3WordPerRead
Transfer 3 32-bit words (CS + ID + 1~4 bytes data).

enumerator kFLEXCAN_4WordPerRead
Transfer 4 32-bit words (CS + ID + 5~8 bytes data).

enumerator kFLEXCAN_5WordPerRead
Transfer 5 32-bit words (CS + ID + 9~12 bytes data).

enumerator kFLEXCAN_6WordPerRead

Transfer 6 32-bit words (CS + ID + 13~16 bytes data).

enumerator kFLEXCAN_7WordPerRead

Transfer 7 32-bit words (CS + ID + 17~20 bytes data).

enumerator kFLEXCAN_8WordPerRead

Transfer 8 32-bit words (CS + ID + 21~24 bytes data).

enumerator kFLEXCAN_9WordPerRead

Transfer 9 32-bit words (CS + ID + 25~28 bytes data).

enumerator kFLEXCAN_10WordPerRead

Transfer 10 32-bit words (CS + ID + 29~32 bytes data).

enumerator kFLEXCAN_11WordPerRead

Transfer 11 32-bit words (CS + ID + 33~36 bytes data).

enumerator kFLEXCAN_12WordPerRead

Transfer 12 32-bit words (CS + ID + 37~40 bytes data).

enumerator kFLEXCAN_13WordPerRead

Transfer 13 32-bit words (CS + ID + 41~44 bytes data).

enumerator kFLEXCAN_14WordPerRead

Transfer 14 32-bit words (CS + ID + 45~48 bytes data).

enumerator kFLEXCAN_15WordPerRead

Transfer 15 32-bit words (CS + ID + 49~52 bytes data).

enumerator kFLEXCAN_16WordPerRead

Transfer 16 32-bit words (CS + ID + 53~56 bytes data).

enumerator kFLEXCAN_17WordPerRead

Transfer 17 32-bit words (CS + ID + 57~60 bytes data).

enumerator kFLEXCAN_18WordPerRead

Transfer 18 32-bit words (CS + ID + 61~64 bytes data).

enumerator kFLEXCAN_19WordPerRead

Transfer 19 32-bit words (CS + ID + 64 bytes data + ID HIT).

enumerator kFLEXCAN_20WordPerRead

Transfer 20 32-bit words (CS + ID + 64 bytes data + ID HIT + HR timestamp).

enum _flexcan_rx_fifo_priority

FlexCAN Enhanced/Legacy Rx FIFO priority.

The matching process starts from the Rx MB(or Enhanced/Legacy Rx FIFO) with higher priority. If no MB(or Enhanced/Legacy Rx FIFO filter) is satisfied, the matching process goes on with the Enhanced/Legacy Rx FIFO(or Rx MB) with lower priority.

Values:

enumerator kFLEXCAN_RxFifoPrioLow

Matching process start from Rx Message Buffer first.

enumerator kFLEXCAN_RxFifoPrioHigh

Matching process start from Enhanced/Legacy Rx FIFO first.

enum _flexcan_interrupt_enable

FlexCAN interrupt enable enumerations.

This provides constants for the FlexCAN interrupt enable enumerations for use in the FlexCAN functions.

Note: FlexCAN Message Buffers and Legacy Rx FIFO interrupts not included in.

Values:

enumerator kFLEXCAN_BusOffInterruptEnable

Bus Off interrupt, use bit 15.

enumerator kFLEXCAN_ErrorInterruptEnable

CAN Error interrupt, use bit 14.

enumerator kFLEXCAN_TxWarningInterruptEnable

Tx Warning interrupt, use bit 11.

enumerator kFLEXCAN_RxWarningInterruptEnable

Rx Warning interrupt, use bit 10.

enumerator kFLEXCAN_FDErrorInterruptEnable

CAN FD Error interrupt, use bit 31.

enumerator kFLEXCAN_PNMatchWakeUpInterruptEnable

PN Match Wake Up interrupt, use high word bit 17.

enumerator kFLEXCAN_PNTimeoutWakeUpInterruptEnable

PN Timeout Wake Up interrupt, use high word bit 16. Enhanced Rx FIFO Underflow interrupt, use high word bit 31.

enumerator kFLEXCAN_ERxFifoUnderflowInterruptEnable

Enhanced Rx FIFO Overflow interrupt, use high word bit 30.

enumerator kFLEXCAN_ERxFifoOverflowInterruptEnable

Enhanced Rx FIFO Watermark interrupt, use high word bit 29.

enumerator kFLEXCAN_ERxFifoWatermarkInterruptEnable

Enhanced Rx FIFO Data Available interrupt, use high word bit 28.

enumerator kFLEXCAN_ERxFifoDataAvlInterruptEnable

enumerator kFLEXCAN_HostAccessNCErrInterruptEnable

Host Access With Non-Correctable Errors interrupt, use high word bit 0.

enumerator kFLEXCAN_FlexCanAccessNCErrInterruptEnable

FlexCAN Access With Non-Correctable Errors interrupt, use high word bit 2.

enumerator kFLEXCAN_HostOrFlexCanCErrInterruptEnable

Host or FlexCAN Access With Correctable Errors interrupt, use high word bit 3.

enum _flexcan_flags

FlexCAN status flags.

This provides constants for the FlexCAN status flags for use in the FlexCAN functions.

Note: The CPU read action clears the bits corresponding to the FLEXCAN_ErrorFlag macro, therefore user need to read status flags and distinguish which error is occur using _flexcan_error_flags enumerations.

Values:

enumerator kFLEXCAN_ErrorOverrunFlag
Error Overrun Status.

enumerator kFLEXCAN_FDErrorIntFlag
CAN FD Error Interrupt Flag.

enumerator kFLEXCAN_BusoffDoneIntFlag
Bus Off process completed Interrupt Flag.

enumerator kFLEXCAN_SynchFlag
CAN Synchronization Status.

enumerator kFLEXCAN_TxWarningIntFlag
Tx Warning Interrupt Flag.

enumerator kFLEXCAN_RxWarningIntFlag
Rx Warning Interrupt Flag.

enumerator kFLEXCAN_IdleFlag
FlexCAN In IDLE Status.

enumerator kFLEXCAN_FaultConfinementFlag
FlexCAN Fault Confinement State.

enumerator kFLEXCAN_TransmittingFlag
FlexCAN In Transmission Status.

enumerator kFLEXCAN_ReceivingFlag
FlexCAN In Reception Status.

enumerator kFLEXCAN_BusOffIntFlag
Bus Off Interrupt Flag.

enumerator kFLEXCAN_ErrorIntFlag
CAN Error Interrupt Flag.

enumerator kFLEXCAN_ErrorFlag

enumerator kFLEXCAN_PNMatchIntFlag
PN Matching Event Interrupt Flag.

enumerator kFLEXCAN_PNTimeoutIntFlag
PN Timeout Event Interrupt Flag.

enumerator kFLEXCAN_ERxFifoUnderflowIntFlag
Enhanced Rx FIFO underflow Interrupt Flag.

enumerator kFLEXCAN_ERxFifoOverflowIntFlag
Enhanced Rx FIFO overflow Interrupt Flag.

enumerator kFLEXCAN_ERxFifoWatermarkIntFlag
Enhanced Rx FIFO watermark Interrupt Flag.

enumerator kFLEXCAN_ERxFifoDataAvlIntFlag
Enhanced Rx FIFO data available Interrupt Flag.

enumerator kFLEXCAN_ERxFifoEmptyFlag
Enhanced Rx FIFO empty status.

enumerator kFLEXCAN_ERxFifoFullFlag
Enhanced Rx FIFO full status.

enumerator kFLEXCAN_HostAccessNonCorrectableErrorIntFlag
Host Access With Non-Correctable Error Interrupt Flag.

enumerator kFLEXCAN_FlexCanAccessNonCorrectableErrorIntFlag
FlexCAN Access With Non-Correctable Error Interrupt Flag.

enumerator kFLEXCAN_CorrectableErrorIntFlag
Correctable Error Interrupt Flag.

enumerator kFLEXCAN_HostAccessNonCorrectableErrorOverrunFlag
Host Access With Non-Correctable Error Interrupt Overrun Flag.

enumerator kFLEXCAN_FlexCanAccessNonCorrectableErrorOverrunFlag
FlexCAN Access With Non-Correctable Error Interrupt Overrun Flag.

enumerator kFLEXCAN_CorrectableErrorOverrunFlag
Correctable Error Interrupt Overrun Flag.

enumerator kFLEXCAN_AllMemoryErrorIntFlag
All Memory Error Interrupt Flags.

enumerator kFLEXCAN_AllMemoryErrorFlag
All Memory Error Flags.

enum _flexcan_error_flags
FlexCAN error status flags.

The FlexCAN Error Status enumerations is used to report current error of the FlexCAN bus. This enumerations should be used with KFLEXCAN_ErrorFlag in _flexcan_flags enumerations to determine which error is generated.

Values:

enumerator kFLEXCAN_FDStuffingError
Stuffing Error.

enumerator kFLEXCAN_FDFormError
Form Error.

enumerator kFLEXCAN_FDCrcError
Cyclic Redundancy Check Error.

enumerator kFLEXCAN_FDBit0Error
Unable to send dominant bit.

enumerator kFLEXCAN_FDBit1Error
Unable to send recessive bit.

enumerator kFLEXCAN_TxErrorWarningFlag
Tx Error Warning Status.

enumerator kFLEXCAN_RxErrorWarningFlag
Rx Error Warning Status.

enumerator kFLEXCAN_StuffingError
Stuffing Error.

enumerator kFLEXCAN_FormError
Form Error.

enumerator kFLEXCAN_CrcError
Cyclic Redundancy Check Error.

enumerator kFLEXCAN_AckError

Received no ACK on transmission.

enumerator kFLEXCAN_Bit0Error

Unable to send dominant bit.

enumerator kFLEXCAN_Bit1Error

Unable to send recessive bit.

FlexCAN Legacy Rx FIFO status flags.

The FlexCAN Legacy Rx FIFO Status enumerations are used to determine the status of the Rx FIFO. Because Rx FIFO occupy the MB0 ~ MB7 (Rx Fifo filter also occupies more Message Buffer space), Rx FIFO status flags are mapped to the corresponding Message Buffer status flags.

Values:

enumerator kFLEXCAN_RxFifoOverflowFlag

Rx FIFO overflow flag.

enumerator kFLEXCAN_RxFifoWarningFlag

Rx FIFO almost full flag.

enumerator kFLEXCAN_RxFifoFrameAvlFlag

Frames available in Rx FIFO flag.

enum _flexcan_memory_error_type

FlexCAN Memory Error Type.

Values:

enumerator kFLEXCAN_CorrectableError

The memory error is correctable which means on bit error.

enumerator kFLEXCAN_NonCorrectableError

The memory error is non-correctable which means two bit errors.

enum _flexcan_memory_access_type

FlexCAN Memory Access Type.

Values:

enumerator kFLEXCAN_MoveOutFlexCanAccess

The memory error was detected during move-out FlexCAN access.

enumerator kFLEXCAN_MoveInAccess

The memory error was detected during move-in FlexCAN access.

enumerator kFLEXCAN_TxArbitrationAccess

The memory error was detected during Tx Arbitration FlexCAN access.

enumerator kFLEXCAN_RxMatchingAccess

The memory error was detected during Rx Matching FlexCAN access.

enumerator kFLEXCAN_MoveOutHostAccess

The memory error was detected during Rx Matching Host (CPU) access.

enum _flexcan_byte_error_syndrome

FlexCAN Memory Error Byte Syndrome.

Values:

enumerator kFLEXCAN_NoError

No bit error in this byte.

enumerator kFLEXCAN_ParityBits0Error

Parity bit 0 error in this byte.

enumerator kFLEXCAN_ParityBits1Error

Parity bit 1 error in this byte.

enumerator kFLEXCAN_ParityBits2Error

Parity bit 2 error in this byte.

enumerator kFLEXCAN_ParityBits3Error

Parity bit 3 error in this byte.

enumerator kFLEXCAN_ParityBits4Error

Parity bit 4 error in this byte.

enumerator kFLEXCAN_DataBits0Error

Data bit 0 error in this byte.

enumerator kFLEXCAN_DataBits1Error

Data bit 1 error in this byte.

enumerator kFLEXCAN_DataBits2Error

Data bit 2 error in this byte.

enumerator kFLEXCAN_DataBits3Error

Data bit 3 error in this byte.

enumerator kFLEXCAN_DataBits4Error

Data bit 4 error in this byte.

enumerator kFLEXCAN_DataBits5Error

Data bit 5 error in this byte.

enumerator kFLEXCAN_DataBits6Error

Data bit 6 error in this byte.

enumerator kFLEXCAN_DataBits7Error

Data bit 7 error in this byte.

enumerator kFLEXCAN_AllZeroError

All-zeros non-correctable error in this byte.

enumerator kFLEXCAN_AllOneError

All-ones non-correctable error in this byte.

enumerator kFLEXCAN_NonCorrectableErrors

Non-correctable error in this byte.

enum _flexcan_pn_match_source

FlexCAN Pretended Networking match source selection.

Values:

enumerator kFLEXCAN_PNMatSrcID

Message match with ID filtering.

enumerator kFLEXCAN_PNMatSrcIDAndData

Message match with ID filtering and payload filtering.

enum *flexcan_pn_match_mode*

FlexCAN Pretended Networking mode match type.

Values:

enumerator kFLEXCAN_PNMatModeEqual

Match upon ID/Payload contents against an exact target value.

enumerator kFLEXCAN_PNMatModeGreater

Match upon an ID/Payload value greater than or equal to a specified target value.

enumerator kFLEXCAN_PNMatModeSmaller

Match upon an ID/Payload value smaller than or equal to a specified target value.

enumerator kFLEXCAN_PNMatModeRange

Match upon an ID/Payload value inside a range, greater than or equal to a specified lower limit, and smaller than or equal to a specified upper limit

typedef enum *flexcan_frame_format* flexcan_frame_format_t

FlexCAN frame format.

typedef enum *flexcan_frame_type* flexcan_frame_type_t

FlexCAN frame type.

typedef enum *flexcan_clock_source* flexcan_clock_source_t

FlexCAN clock source.

Deprecated:

Do not use the kFLEXCAN_ClkSrcOs. It has been superceded kFLEXCAN_ClkSrc0

Do not use the kFLEXCAN_ClkSrcPeri. It has been superceded kFLEXCAN_ClkSrc1

typedef enum *flexcan_wake_up_source* flexcan_wake_up_source_t

FlexCAN wake up source.

typedef enum *flexcan_endianness* flexcan_endianness_t

FlexCAN payload endianness.

typedef enum *flexcan_MB_timestamp_base* flexcan_MB_timestamp_base_t

FlexCAN timebase used for capturing 16-bit TIME_STAMP field of message buffer.

typedef enum *flexcan_capture_point* flexcan_capture_point_t

FlexCAN capture point of 32-bit high resolution timebase during a CAN frame.

typedef enum *flexcan_rx_fifo_filter_type* flexcan_rx_fifo_filter_type_t

FlexCAN Rx Fifo Filter type.

typedef enum *flexcan_mb_size* flexcan_mb_size_t

FlexCAN Message Buffer Payload size.

typedef enum *flexcan_efifo_dma_per_read_length* flexcan_efifo_dma_per_read_length_t

FlexCAN Enhanced Rx Fifo DMA transfer per read length enumerations.

typedef enum *flexcan_rx_fifo_priority* flexcan_rx_fifo_priority_t

FlexCAN Enhanced/Legacy Rx FIFO priority.

The matching process starts from the Rx MB(or Enhanced/Legacy Rx FIFO) with higher priority. If no MB(or Enhanced/Legacy Rx FIFO filter) is satisfied, the matching process goes on with the Enhanced/Legacy Rx FIFO(or Rx MB) with lower priority.

typedef enum *flexcan_memory_error_type* flexcan_memory_error_type_t

FlexCAN Memory Error Type.

typedef enum *_flexcan_memory_access_type* flexcan_memory_access_type_t
FlexCAN Memory Access Type.

typedef enum *_flexcan_byte_error_syndrome* flexcan_byte_error_syndrome_t
FlexCAN Memory Error Byte Syndrome.

typedef struct *_flexcan_memory_error_report_status* flexcan_memory_error_report_status_t
FlexCAN memory error register status structure.

This structure contains the memory access properties that caused a memory error access. It is used as the parameter of FLEXCAN_GetMemoryErrorReportStatus() function. And user can use FLEXCAN_GetMemoryErrorReportStatus to get the status of the last memory error access.

typedef struct *_flexcan_frame* flexcan_frame_t
FlexCAN message frame structure.

typedef struct *_flexcan_fd_frame* flexcan_fd_frame_t
CAN FD message frame structure.

The CAN FD message supporting up to sixty four bytes can be used for a data frame, depending on the length selected for the message buffers. The length should be a enumeration member, see *_flexcan_fd_frame_length*.

typedef struct *_flexcan_timing_config* flexcan_timing_config_t
FlexCAN protocol timing characteristic configuration structure.

typedef struct *_flexcan_config* flexcan_config_t
FlexCAN module configuration structure.

Deprecated:

Do not use the baudRate. It has been superceded bitRate

Do not use the baudRateFD. It has been superceded bitRateFD

typedef struct *_flexcan_rx_mb_config* flexcan_rx_mb_config_t
FlexCAN Receive Message Buffer configuration structure.

This structure is used as the parameter of FLEXCAN_SetRxMbConfig() function. The FLEXCAN_SetRxMbConfig() function is used to configure FlexCAN Receive Message Buffer. The function abort previous receiving process, clean the Message Buffer and activate the Rx Message Buffer using given Message Buffer setting.

typedef enum *_flexcan_pn_match_source* flexcan_pn_match_source_t
FlexCAN Pretended Networking match source selection.

typedef enum *_flexcan_pn_match_mode* flexcan_pn_match_mode_t
FlexCAN Pretended Networking mode match type.

typedef struct *_flexcan_pn_config* flexcan_pn_config_t
FlexCAN Pretended Networking configuration structure.

This structure is used as the parameter of FLEXCAN_SetPNConfig() function. The FLEXCAN_SetPNConfig() function is used to configure FlexCAN Networking work mode.

typedef struct *_flexcan_rx_fifo_config* flexcan_rx_fifo_config_t
FlexCAN Legacy Rx FIFO configuration structure.

typedef struct *_flexcan_enhanced_rx_fifo_std_id_filter* flexcan_enhanced_rx_fifo_std_id_filter_t
FlexCAN Enhanced Rx FIFO Standard ID filter element structure.

`typedef struct flexcan_enhanced_rx_fifo_ext_id_filter flexcan_enhanced_rx_fifo_ext_id_filter_t`
FlexCAN Enhanced Rx FIFO Extended ID filter element structure.

`typedef struct flexcan_enhanced_rx_fifo_config flexcan_enhanced_rx_fifo_config_t`
FlexCAN Enhanced Rx FIFO configuration structure.

`typedef struct flexcan_mb_transfer flexcan_mb_transfer_t`
FlexCAN Message Buffer transfer.

`typedef struct flexcan_fifo_transfer flexcan_fifo_transfer_t`
FlexCAN Rx FIFO transfer.

`typedef struct flexcan_handle flexcan_handle_t`
FlexCAN handle structure definition.

`typedef void (*flexcan_transfer_callback_t)(CAN_Type *base, flexcan_handle_t *handle, status_t status, uint64_t result, void *userData)`

`FLEXCAN_WAIT_TIMEOUT`

`FLEXCAN_POLLING_TIMEOUT`
Max loops to wait for polling transfer.

`FLEXCAN_MODULE_TIMEOUT`
Max loops to wait for FlexCAN register access complete.

`DLC_LENGTH_DECODE(dlc)`
FlexCAN frame length helper macro.

`FLEXCAN_ID_STD(id)`
FlexCAN Frame ID helper macro.
Standard Frame ID helper macro.

`FLEXCAN_ID_EXT(id)`
Extend Frame ID helper macro.

`FLEXCAN_RX_MB_STD_MASK(id, rtr, ide)`
FlexCAN Rx Message Buffer Mask helper macro.
Standard Rx Message Buffer Mask helper macro.

`FLEXCAN_RX_MB_EXT_MASK(id, rtr, ide)`
Extend Rx Message Buffer Mask helper macro.

`FLEXCAN_RX_FIFO_STD_MASK_TYPE_A(id, rtr, ide)`
FlexCAN Legacy Rx FIFO Mask helper macro.
Standard Rx FIFO Mask helper macro Type A helper macro.

`FLEXCAN_RX_FIFO_STD_MASK_TYPE_B_HIGH(id, rtr, ide)`
Standard Rx FIFO Mask helper macro Type B upper part helper macro.

`FLEXCAN_RX_FIFO_STD_MASK_TYPE_B_LOW(id, rtr, ide)`
Standard Rx FIFO Mask helper macro Type B lower part helper macro.

`FLEXCAN_RX_FIFO_STD_MASK_TYPE_C_HIGH(id)`
Standard Rx FIFO Mask helper macro Type C upper part helper macro.

`FLEXCAN_RX_FIFO_STD_MASK_TYPE_C_MID_HIGH(id)`
Standard Rx FIFO Mask helper macro Type C mid-upper part helper macro.

`FLEXCAN_RX_FIFO_STD_MASK_TYPE_C_MID_LOW(id)`
Standard Rx FIFO Mask helper macro Type C mid-lower part helper macro.

`FLEXCAN_RX_FIFO_STD_MASK_TYPE_C_LOW(id)`
Standard Rx FIFO Mask helper macro Type C lower part helper macro.

`FLEXCAN_RX_FIFO_EXT_MASK_TYPE_A(id, rtr, ide)`
Extend Rx FIFO Mask helper macro Type A helper macro.

`FLEXCAN_RX_FIFO_EXT_MASK_TYPE_B_HIGH(id, rtr, ide)`
Extend Rx FIFO Mask helper macro Type B upper part helper macro.

`FLEXCAN_RX_FIFO_EXT_MASK_TYPE_B_LOW(id, rtr, ide)`
Extend Rx FIFO Mask helper macro Type B lower part helper macro.

`FLEXCAN_RX_FIFO_EXT_MASK_TYPE_C_HIGH(id)`
Extend Rx FIFO Mask helper macro Type C upper part helper macro.

`FLEXCAN_RX_FIFO_EXT_MASK_TYPE_C_MID_HIGH(id)`
Extend Rx FIFO Mask helper macro Type C mid-upper part helper macro.

`FLEXCAN_RX_FIFO_EXT_MASK_TYPE_C_MID_LOW(id)`
Extend Rx FIFO Mask helper macro Type C mid-lower part helper macro.

`FLEXCAN_RX_FIFO_EXT_MASK_TYPE_C_LOW(id)`
Extend Rx FIFO Mask helper macro Type C lower part helper macro.

`FLEXCAN_RX_FIFO_STD_FILTER_TYPE_A(id, rtr, ide)`
FlexCAN Rx FIFO Filter helper macro.
Standard Rx FIFO Filter helper macro Type A helper macro.

`FLEXCAN_RX_FIFO_STD_FILTER_TYPE_B_HIGH(id, rtr, ide)`
Standard Rx FIFO Filter helper macro Type B upper part helper macro.

`FLEXCAN_RX_FIFO_STD_FILTER_TYPE_B_LOW(id, rtr, ide)`
Standard Rx FIFO Filter helper macro Type B lower part helper macro.

`FLEXCAN_RX_FIFO_STD_FILTER_TYPE_C_HIGH(id)`
Standard Rx FIFO Filter helper macro Type C upper part helper macro.

`FLEXCAN_RX_FIFO_STD_FILTER_TYPE_C_MID_HIGH(id)`
Standard Rx FIFO Filter helper macro Type C mid-upper part helper macro.

`FLEXCAN_RX_FIFO_STD_FILTER_TYPE_C_MID_LOW(id)`
Standard Rx FIFO Filter helper macro Type C mid-lower part helper macro.

`FLEXCAN_RX_FIFO_STD_FILTER_TYPE_C_LOW(id)`
Standard Rx FIFO Filter helper macro Type C lower part helper macro.

`FLEXCAN_RX_FIFO_EXT_FILTER_TYPE_A(id, rtr, ide)`
Extend Rx FIFO Filter helper macro Type A helper macro.

`FLEXCAN_RX_FIFO_EXT_FILTER_TYPE_B_HIGH(id, rtr, ide)`
Extend Rx FIFO Filter helper macro Type B upper part helper macro.

`FLEXCAN_RX_FIFO_EXT_FILTER_TYPE_B_LOW(id, rtr, ide)`
Extend Rx FIFO Filter helper macro Type B lower part helper macro.

`FLEXCAN_RX_FIFO_EXT_FILTER_TYPE_C_HIGH(id)`
Extend Rx FIFO Filter helper macro Type C upper part helper macro.

`FLEXCAN_RX_FIFO_EXT_FILTER_TYPE_C_MID_HIGH(id)`
Extend Rx FIFO Filter helper macro Type C mid-upper part helper macro.

`FLEXCAN_RX_FIFO_EXT_FILTER_TYPE_C_MID_LOW(id)`

Extend Rx FIFO Filter helper macro Type C mid-lower part helper macro.

`FLEXCAN_RX_FIFO_EXT_FILTER_TYPE_C_LOW(id)`

Extend Rx FIFO Filter helper macro Type C lower part helper macro.

`ENHANCED_RX_FIFO_FSC(x)`

FlexCAN Enhanced Rx FIFO Filter and Mask helper macro.

`RTR_STD_HIGH(x)`

`RTR_STD_LOW(x)`

`RTR_EXT(x)`

`ID_STD_LOW(id)`

`ID_STD_HIGH(id)`

`ID_EXT(id)`

`FLEXCAN_ENHANCED_RX_FIFO_STD_MASK_AND_FILTER(id, rtr, id_mask, rtr_mask)`

Standard ID filter element with filter + mask scheme.

`FLEXCAN_ENHANCED_RX_FIFO_STD_FILTER_WITH_RANGE(id_upper, rtr, id_lower,
rtr_mask)`

Standard ID filter element with filter range.

`FLEXCAN_ENHANCED_RX_FIFO_STD_TWO_FILTERS(id1, rtr1, id2, rtr2)`

Standard ID filter element with two filters without masks.

`FLEXCAN_ENHANCED_RX_FIFO_EXT_MASK_AND_FILTER_LOW(id, rtr)`

Extended ID filter element with filter + mask scheme low word.

`FLEXCAN_ENHANCED_RX_FIFO_EXT_MASK_AND_FILTER_HIGH(id_mask, rtr_mask)`

Extended ID filter element with filter + mask scheme high word.

`FLEXCAN_ENHANCED_RX_FIFO_EXT_FILTER_WITH_RANGE_LOW(id_upper, rtr)`

Extended ID filter element with range scheme low word.

`FLEXCAN_ENHANCED_RX_FIFO_EXT_FILTER_WITH_RANGE_HIGH(id_lower, rtr_mask)`

Extended ID filter element with range scheme high word.

`FLEXCAN_ENHANCED_RX_FIFO_EXT_TWO_FILTERS_LOW(id2, rtr2)`

Extended ID filter element with two filters without masks low word.

`FLEXCAN_ENHANCED_RX_FIFO_EXT_TWO_FILTERS_HIGH(id1, rtr1)`

Extended ID filter element with two filters without masks high word.

`FLEXCAN_PN_STD_MASK(id, rtr)`

FlexCAN Pretended Networking ID Mask helper macro.

Standard Rx Message Buffer Mask helper macro.

`FLEXCAN_PN_EXT_MASK(id, rtr)`

Extend Rx Message Buffer Mask helper macro.

`FLEXCAN_PN_INT_MASK(x)`

FlexCAN interrupt/status flag helper macro.

`FLEXCAN_PN_INT_UNMASK(x)`

`FLEXCAN_PN_STATUS_MASK(x)`

FLEXCAN_PN_STATUS_UNMASK(x)

FLEXCAN_EFIFO_INT_MASK(x)

FLEXCAN_EFIFO_INT_UNMASK(x)

FLEXCAN_EFIFO_STATUS_MASK(x)

FLEXCAN_EFIFO_STATUS_UNMASK(x)

FLEXCAN_MECR_INT_MASK(x)

FLEXCAN_MECR_INT_UNMASK(x)

FLEXCAN_MECR_STATUS_MASK(x)

FLEXCAN_MECR_STATUS_UNMASK(x)

FLEXCAN_ERROR_AND_STATUS_INT_FLAG

FLEXCAN_PNWAKE_UP_FLAG

FLEXCAN_WAKE_UP_FLAG

FLEXCAN_MEMORY_ERROR_INT_FLAG

FLEXCAN_ENHANCED_RX_FIFO_INT_FLAG

FlexCAN Enhanced Rx FIFO base address helper macro.

E_RX_FIFO(base)

FLEXCAN_CALLBACK(x)

FlexCAN transfer callback function.

The FlexCAN transfer callback returns a value from the underlying layer. If the status equals to `kStatus_FLEXCAN_ErrorStatus`, the result parameter is the Content of FlexCAN status register which can be used to get the working status(or error status) of FlexCAN module. If the status equals to other FlexCAN Message Buffer transfer status, the result is the index of Message Buffer that generate transfer event. If the status equals to other FlexCAN Message Buffer transfer status, the result is meaningless and should be Ignored.

struct flexcan_memory_error_report_status

#include <fsl_flexcan.h> FlexCAN memory error register status structure.

This structure contains the memory access properties that caused a memory error access. It is used as the parameter of `FLEXCAN_GetMemoryErrorReportStatus()` function. And user can use `FLEXCAN_GetMemoryErrorReportStatus` to get the status of the last memory error access.

Public Members

flexcan_memory_error_type_t errorType

The type of memory error that giving rise to the report.

flexcan_memory_access_type_t accessType

The type of memory access that giving rise to the memory error.

uint16_t accessAddress

The address where memory error detected.

uint32_t errorData

The raw data word read from memory with error.

struct _flexcan_frame

#include <fsl_flexcan.h> FlexCAN message frame structure.

struct _flexcan_fd_frame

#include <fsl_flexcan.h> CAN FD message frame structure.

The CAN FD message supporting up to sixty four bytes can be used for a data frame, depending on the length selected for the message buffers. The length should be a enumeration member, see _flexcan_fd_frame_length.

Public Members

uint32_t idhit

Note: ID HIT offset is changed dynamically according to data length code (DLC), when DLC is 15, they will be located below. Using FLEXCAN_FixEnhancedRxFifoFrameIdHit API is recommended to ensure this idhit value is correct. CAN Enhanced Rx FIFO filter hit id (This value is only used in Enhanced Rx FIFO receive mode).

uint32_t hrtimestamp

Note: HR timestamp offset is changed dynamically according to data length code (DLC). External 32-bit on-chip timer high-resolution timestamp.

struct _flexcan_timing_config

#include <fsl_flexcan.h> FlexCAN protocol timing characteristic configuration structure.

Public Members

uint32_t preDivider

Classic CAN or CAN FD nominal phase bit rate prescaler.

uint32_t rJumpwidth

Classic CAN or CAN FD nominal phase Re-sync Jump Width.

uint32_t phaseSeg1

Classic CAN or CAN FD nominal phase Segment 1.

uint32_t phaseSeg2

Classic CAN or CAN FD nominal phase Segment 2.

uint32_t propSeg

Classic CAN or CAN FD nominal phase Propagation Segment.

uint32_t fpreDivider

CAN FD data phase bit rate prescaler.

uint32_t frJumpwidth

CAN FD data phase Re-sync Jump Width.

uint32_t fphaseSeg1

CAN FD data phase Phase Segment 1.

uint32_t fphaseSeg2

CAN FD data phase Phase Segment 2.

uint32_t fpropSeg

CAN FD data phase Propagation Segment.

struct __flexcan_config

#include <fsl_flexcan.h> FlexCAN module configuration structure.

Deprecated:

Do not use the baudRate. It has been superceded bitRate

Do not use the baudRateFD. It has been superceded bitRateFD

Public Members

flexcan_clock_source_t clkSrc

Clock source for FlexCAN Protocol Engine.

flexcan_wake_up_source_t wakeupSrc

Wake up source selection.

uint8_t maxMbNum

The maximum number of Message Buffers used by user.

bool enableLoopBack

Enable or Disable Loop Back Self Test Mode.

bool enableTimerSync

Enable or Disable Timer Synchronization.

bool enableIndividMask

Enable or Disable Rx Individual Mask and Queue feature.

bool disableSelfReception

Enable or Disable Self Reflection.

bool enableListenOnlyMode

Enable or Disable Listen Only Mode.

bool enableDoze

Enable or Disable Doze Mode.

bool enablePretendedeNetworking

Enable or Disable the Pretended Networking mode.

bool enableMemoryErrorControl

Enable or Disable the memory errors detection and correction mechanism.

bool enableNonCorrectableErrorEnterFreeze

Enable or Disable Non-Correctable Errors In FlexCAN Access Put Device In Freeze Mode.

bool enableTransceiverDelayMeasure

Enable or Disable the transceiver delay measurement, when it is enabled, then the secondary sample point position is determined by the sum of the transceiver delay measurement plus the enhanced TDC offset.

bool enableRemoteRequestFrameStored

true: Store Remote Request Frame in the same fashion of data frame. false: Generate an automatic Remote Response Frame.

flexcan_endianness_t payloadEndianness

Selects the byte order for the payload of transmit and receive frames, see *flexcan_endianness_t*.

bool enableExternalTimeTick

true: External time tick clocks the free-running timer. false: FlexCAN bit clock clocks the free-running timer.

flexcan_MB_timestamp_base_t captureTimeBase

Timebase of message buffer 16-bit TIME_STAMP field.

flexcan_capture_point_t capturePoint

Point in time when 32-bit timebase is captured during CAN frame.

struct *_flexcan_rx_mb_config*

#include <fsl_flexcan.h> FlexCAN Receive Message Buffer configuration structure.

This structure is used as the parameter of FLEXCAN_SetRxMbConfig() function. The FLEXCAN_SetRxMbConfig() function is used to configure FlexCAN Receive Message Buffer. The function abort previous receiving process, clean the Message Buffer and activate the Rx Message Buffer using given Message Buffer setting.

Public Members

uint32_t id

CAN Message Buffer Frame Identifier, should be set using FLEXCAN_ID_EXT() or FLEXCAN_ID_STD() macro.

flexcan_frame_format_t format

CAN Frame Identifier format(Standard of Extend).

flexcan_frame_type_t type

CAN Frame Type(Data or Remote for classical CAN only).

struct *_flexcan_pn_config*

#include <fsl_flexcan.h> FlexCAN Pretended Networking configuration structure.

This structure is used as the parameter of FLEXCAN_SetPNConfig() function. The FLEXCAN_SetPNConfig() function is used to configure FlexCAN Networking work mode.

Public Members

bool enableTimeout

Enable or Disable timeout event trigger wakeup.

uint16_t timeoutValue

The timeout value that generates a wakeup event, the counter timer is incremented based on 64 times the CAN Bit Time unit.

bool enableMatch

Enable or Disable match event trigger wakeup.

flexcan_pn_match_source_t matchSrc

Selects the match source (ID and/or data match) to trigger wakeup.

uint8_t matchNum

The number of times a given message must match the predefined ID and/or data before generating a wakeup event, range in 0x1 ~ 0xFF.

flexcan_pn_match_mode_t idMatchMode

The ID match type.

flexcan_pn_match_mode_t dataMatchMode

The data match type.

uint32_t idLower

The ID target values 1 which used either for ID match “equal to”, “smaller than”, “greater than” comparisons, or as the lower limit value in ID match “range detection”.

uint32_t idUpper

The ID target values 2 which used only as the upper limit value in ID match “range detection” or used to store the ID mask in “equal to”.

uint8_t lengthLower

The lower limit for length of data bytes which used only in data match “range detection”. Range in 0x0 ~ 0x8.

uint8_t lengthUpper

The upper limit for length of data bytes which used only in data match “range detection”. Range in 0x0 ~ 0x8.

struct *_flexcan_rx_fifo_config*

#include <fsl_flexcan.h> FlexCAN Legacy Rx FIFO configuration structure.

Public Members

uint32_t *idFilterTable

Pointer to the FlexCAN Legacy Rx FIFO identifier filter table.

uint8_t idFilterNum

The FlexCAN Legacy Rx FIFO Filter elements quantity.

flexcan_rx_fifo_filter_type_t idFilterType

The FlexCAN Legacy Rx FIFO Filter type.

flexcan_rx_fifo_priority_t priority

The FlexCAN Legacy Rx FIFO receive priority.

struct *_flexcan_enhanced_rx_fifo_std_id_filter*

#include <fsl_flexcan.h> FlexCAN Enhanced Rx FIFO Standard ID filter element structure.

Public Members

uint32_t filterType

FlexCAN internal Free-Running Counter Time Stamp.

uint32_t rtr1

CAN FD frame data length code (DLC), range see *_flexcan_fd_frame_length*, When the length <= 8, it equal to the data length, otherwise the number of valid frame data is not equal to the length value. user can use *DLC_LENGTH_DECODE(length)* macro to get the number of valid data bytes.

uint32_t std1

CAN Frame Type(DATA or REMOTE).

uint32_t rtr2

CAN Frame Identifier(STD or EXT format).

uint32_t std2

Substitute Remote request.

struct flexcan_enhanced_rx_fifo_ext_id_filter

#include <fsl_flexcan.h> FlexCAN Enhanced Rx FIFO Extended ID filter element structure.

Public Members

uint32_t filterType

FlexCAN internal Free-Running Counter Time Stamp.

uint32_t rtr1

CAN FD frame data length code (DLC), range see flexcan_fd_frame_length, When the length <= 8, it equal to the data length, otherwise the number of valid frame data is not equal to the length value. user can use DLC_LENGTH_DECODE(length) macro to get the number of valid data bytes.

uint32_t std1

CAN Frame Type(DATA or REMOTE).

uint32_t rtr2

CAN Frame Identifier(STD or EXT format).

uint32_t std2

Substitute Remote request.

struct flexcan_enhanced_rx_fifo_config

#include <fsl_flexcan.h> FlexCAN Enhanced Rx FIFO configuration structure.

Public Members

uint32_t *idFilterTable

Pointer to the FlexCAN Enhanced Rx FIFO identifier filter table, each table member occupies 32 bit word, table size should be equal to idFilterNum. There are two types of Enhanced Rx FIFO filter elements that can be stored in table : extended-ID filter element (1 word, occupies 1 table members) and standard-ID filter element (2 words, occupies 2 table members), the extended-ID filter element needs to be placed in front of the table.

uint8_t idFilterPairNum

idFilterPairNum is the Enhanced Rx FIFO identifier filter element pair numbers, each pair of filter elements occupies 2 words and can consist of one extended ID filter element or two standard ID filter elements.

uint8_t extendIdFilterNum

The number of extended ID filter element items in the FlexCAN enhanced Rx FIFO identifier filter table, each extended-ID filter element occupies 2 words, extendIdFilterNum need less than or equal to idFilterPairNum.

uint8_t fifoWatermark

(fifoWatermark + 1) is the minimum number of CAN messages stored in the Enhanced RX FIFO which can trigger FIFO watermark interrupt or a DMA request.

flexcan_efifo_dma_per_read_length_t dmaPerReadLength

Define the length of each read of the Enhanced RX FIFO element by the DAM, see flexcan_fd_frame_length.

flexcan_rx_fifo_priority_t priority

The FlexCAN Enhanced Rx FIFO receive priority.

struct *_flexcan_mb_transfer*

#include <fsl_flexcan.h> FlexCAN Message Buffer transfer.

Public Members

flexcan_frame_t *frame

The buffer of CAN Message to be transfer.

uint8_t mbIdx

The index of Message buffer used to transfer Message.

struct *_flexcan_fifo_transfer*

#include <fsl_flexcan.h> FlexCAN Rx FIFO transfer.

Public Members

flexcan_fd_frame_t *framefd

The buffer of CAN Message to be received from Enhanced Rx FIFO.

flexcan_frame_t *frame

The buffer of CAN Message to be received from Legacy Rx FIFO.

size_t frameNum

Number of CAN Message need to be received from Legacy or Enhanced Rx FIFO.

struct *_flexcan_handle*

#include <fsl_flexcan.h> FlexCAN handle structure.

Public Members

flexcan_transfer_callback_t callback

Callback function.

void *userData

FlexCAN callback function parameter.

flexcan_frame_t *volatile mbFrameBuf[CAN_WORD1_COUNT]

The buffer for received CAN data from Message Buffers.

flexcan_fd_frame_t *volatile mbFDFrameBuf[CAN_WORD1_COUNT]

The buffer for received CAN FD data from Message Buffers.

flexcan_frame_t *volatile rxFifoFrameBuf

The buffer for received CAN data from Legacy Rx FIFO.

flexcan_fd_frame_t *volatile rxFifoFDFrameBuf

The buffer for received CAN FD data from Enhanced Rx FIFO.

size_t rxFifoFrameNum

The number of CAN messages remaining to be received from Legacy or Enhanced Rx FIFO.

size_t rxFifoTransferTotalNum

Total CAN Message number need to be received from Legacy or Enhanced Rx FIFO.

volatile uint8_t mbState[CAN_WORD1_COUNT]

Message Buffer transfer state.

volatile uint8_t rxFifoState

Rx FIFO transfer state.

volatile uint32_t timestamp[CAN_WORD1_COUNT]

Mailbox transfer timestamp.

struct byteStatus

Public Members

bool byteIsRead

The byte n (0~3) was read or not. The type of error and which bit in byte (n) is affected by the error.

struct __unnamed18__

Public Members

uint32_t timestamp

FlexCAN internal Free-Running Counter Time Stamp.

uint32_t length

CAN frame data length in bytes (Range: 0~8).

uint32_t type

CAN Frame Type(DATA or REMOTE).

uint32_t format

CAN Frame Identifier(STD or EXT format).

uint32_t __pad0__

Reserved.

uint32_t idhit

CAN Rx FIFO filter hit id(This value is only used in Rx FIFO receive mode).

struct __unnamed20__

Public Members

uint32_t id

CAN Frame Identifier, should be set using FLEXCAN_ID_EXT() or FLEXCAN_ID_STD() macro.

uint32_t __pad0__

Reserved.

union __unnamed22__

Public Members

struct _flexcan_frame

struct _flexcan_frame

struct __unnamed24__

Public Members

uint32_t dataWord0
CAN Frame payload word0.

uint32_t dataWord1
CAN Frame payload word1.

struct ____unnamed26____

Public Members

uint8_t dataByte3
CAN Frame payload byte3.

uint8_t dataByte2
CAN Frame payload byte2.

uint8_t dataByte1
CAN Frame payload byte1.

uint8_t dataByte0
CAN Frame payload byte0.

uint8_t dataByte7
CAN Frame payload byte7.

uint8_t dataByte6
CAN Frame payload byte6.

uint8_t dataByte5
CAN Frame payload byte5.

uint8_t dataByte4
CAN Frame payload byte4.

struct ____unnamed28____

Public Members

uint32_t timestamp
FlexCAN internal Free-Running Counter Time Stamp.

uint32_t length
CAN FD frame data length code (DLC), range see `_flexcan_fd_frame_length`, When the length <= 8, it equal to the data length, otherwise the number of valid frame data is not equal to the length value. user can use `DLC_LENGTH_DECODE(length)` macro to get the number of valid data bytes.

uint32_t type
CAN Frame Type(DATA only).

uint32_t format
CAN Frame Identifier(STD or EXT format).

uint32_t srr
Substitute Remote request.

uint32_t esi
Error State Indicator.

uint32_t brs

Bit Rate Switch.

uint32_t edl

Extended Data Length.

struct ____unnamed30____

Public Members

uint32_t id

CAN Frame Identifier, should be set using FLEXCAN_ID_EXT() or FLEXCAN_ID_STD() macro.

uint32_t ____pad0____

Reserved.

union ____unnamed32____

Public Members

struct __flexcan__fd__frame

struct __flexcan__fd__frame

struct ____unnamed34____

Public Members

uint32_t dataWord[16]

CAN FD Frame payload, 16 double word maximum.

struct ____unnamed36____

Public Members

uint8_t dataByte3

CAN Frame payload byte3.

uint8_t dataByte2

CAN Frame payload byte2.

uint8_t dataByte1

CAN Frame payload byte1.

uint8_t dataByte0

CAN Frame payload byte0.

uint8_t dataByte7

CAN Frame payload byte7.

uint8_t dataByte6

CAN Frame payload byte6.

uint8_t dataByte5

CAN Frame payload byte5.

```
uint8_t dataByte4
    CAN Frame payload byte4.
union __unnamed38__
```

Public Members

```
struct __flexcan__config
struct __flexcan__config
struct __unnamed40__
```

Public Members

```
uint32_t baudRate
    FlexCAN bit rate in bps, for classical CAN or CANFD nominal phase.
uint32_t baudRateFD
    FlexCAN FD bit rate in bps, for CANFD data phase.
struct __unnamed42__
```

Public Members

```
uint32_t bitRate
    FlexCAN bit rate in bps, for classical CAN or CANFD nominal phase.
uint32_t bitRateFD
    FlexCAN FD bit rate in bps, for CANFD data phase.
union __unnamed44__
```

Public Members

```
struct __flexcan__pn_config
    < The data target values 1 which used either for data match “equal to”, “smaller than”,
    “greater than” comparisons, or as the lower limit value in data match “range
    detection”.
struct __flexcan__pn_config
struct __unnamed48__
    < The data target values 1 which used either for data match “equal to”, “smaller than”,
    “greater than” comparisons, or as the lower limit value in data match “range
    detection”.
```

Public Members

```
uint32_t lowerWord0
    CAN Frame payload word0.
uint32_t lowerWord1
    CAN Frame payload word1.
struct __unnamed50__
```

Public Members

uint8_t lowerByte3
CAN Frame payload byte3.

uint8_t lowerByte2
CAN Frame payload byte2.

uint8_t lowerByte1
CAN Frame payload byte1.

uint8_t lowerByte0
CAN Frame payload byte0.

uint8_t lowerByte7
CAN Frame payload byte7.

uint8_t lowerByte6
CAN Frame payload byte6.

uint8_t lowerByte5
CAN Frame payload byte5.

uint8_t lowerByte4
CAN Frame payload byte4.

union __unnamed46__

Public Members

struct __flexcan_pn_config

< The data target values 2 which used only as the upper limit value in data match “range detection” or used to store the data mask in “equal to”.

struct __flexcan_pn_config

struct __unnamed52__

< The data target values 2 which used only as the upper limit value in data match “range detection” or used to store the data mask in “equal to”.

Public Members

uint32_t upperWord0
CAN Frame payload word0.

uint32_t upperWord1
CAN Frame payload word1.

struct __unnamed54__

Public Members

uint8_t upperByte3
CAN Frame payload byte3.

```
uint8_t upperByte2
    CAN Frame payload byte2.
uint8_t upperByte1
    CAN Frame payload byte1.
uint8_t upperByte0
    CAN Frame payload byte0.
uint8_t upperByte7
    CAN Frame payload byte7.
uint8_t upperByte6
    CAN Frame payload byte6.
uint8_t upperByte5
    CAN Frame payload byte5.
uint8_t upperByte4
    CAN Frame payload byte4.
```

2.10 FlexCAN eDMA Driver

```
void FLEXCAN__TransferCreateHandleEDMA(CAN_Type *base, flexcan_edma_handle_t *handle,
                                         flexcan_edma_transfer_callback_t callback, void
                                         *userData, edma_handle_t *rxFifoEdmaHandle)
```

Initializes the FlexCAN handle, which is used in transactional functions.

Parameters

- *base* – FlexCAN peripheral base address.
- *handle* – Pointer to *flexcan_edma_handle_t* structure.
- *callback* – The callback function.
- *userData* – The parameter of the callback function.
- *rxFifoEdmaHandle* – User-requested DMA handle for Rx FIFO DMA transfer.

```
void FLEXCAN__PrepareTransfConfiguration(CAN_Type *base, flexcan_fifo_transfer_t *pFifoXfer,
                                         edma_transfer_config_t *pEdmaConfig)
```

Prepares the eDMA transfer configuration for FLEXCAN Legacy RX FIFO.

This function prepares the eDMA transfer configuration structure according to FLEXCAN Legacy RX FIFO.

Parameters

- *base* – FlexCAN peripheral base address.
- *pFifoXfer* – FlexCAN Rx FIFO EDMA transfer structure, see *flexcan_fifo_transfer_t*.
- *pEdmaConfig* – The user configuration structure of type *edma_transfer_t*.

```
status_t FLEXCAN__StartTransferDatafromRxFIFO(CAN_Type *base, flexcan_edma_handle_t
                                                *handle, edma_transfer_config_t
                                                *pEdmaConfig)
```

Start Transfer Data from the FLEXCAN Legacy Rx FIFO using eDMA.

This function to Update edma transfer configuration and Start eDMA transfer

Parameters

- base – FlexCAN peripheral base address.
- handle – Pointer to flexcan_edma_handle_t structure.
- pEdmaConfig – The user configuration structure of type edma_transfer_t.

Return values

- kStatus__Success – if succeed, others failed.
- kStatus_FLEXCAN_RxFifoBusy – Previous transfer ongoing.

status_t FLEXCAN_TransferReceiveFifoEDMA(CAN_Type *base, flexcan_edma_handle_t *handle, flexcan_fifo_transfer_t *pFifoXfer)

Receives the CAN Message from the Legacy Rx FIFO using eDMA.

This function receives the CAN Message using eDMA. This is a non-blocking function, which returns right away. After the CAN Message is received, the receive callback function is called.

Parameters

- base – FlexCAN peripheral base address.
- handle – Pointer to flexcan_edma_handle_t structure.
- pFifoXfer – FlexCAN Rx FIFO EDMA transfer structure, see flexcan_fifo_transfer_t.

Return values

- kStatus__Success – if succeed, others failed.
- kStatus_FLEXCAN_RxFifoBusy – Previous transfer ongoing.

status_t FLEXCAN_TransferGetReceiveFifoCountEMDA(CAN_Type *base, flexcan_edma_handle_t *handle, size_t *count)

Gets the Legacy Rx Fifo transfer status during a interrupt non-blocking receive.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.
- count – Number of CAN messages receive so far by the non-blocking transaction.

Return values

- kStatus_InvalidArgument – count is Invalid.
- kStatus__Success – Successfully return the count.

void FLEXCAN_TransferAbortReceiveFifoEDMA(CAN_Type *base, flexcan_edma_handle_t *handle)

Aborts the receive Legacy/Enhanced Rx FIFO process which used eDMA.

This function aborts the receive Legacy/Enhanced Rx FIFO process which used eDMA.

Parameters

- base – FlexCAN peripheral base address.
- handle – Pointer to flexcan_edma_handle_t structure.

status_t FLEXCAN_TransferReceiveEnhancedFifoEDMA(CAN_Type *base, flexcan_edma_handle_t *handle, flexcan_fifo_transfer_t *pFifoXfer)

Receives the CAN FD Message from the Enhanced Rx FIFO using eDMA.

This function receives the CAN FD Message using eDMA. This is a non-blocking function, which returns right away. After the CAN Message is received, the receive callback function is called.

Parameters

- `base` – FlexCAN peripheral base address.
- `handle` – Pointer to `flexcan_edma_handle_t` structure.
- `pFifoXfer` – FlexCAN Rx FIFO EDMA transfer structure, see `flexcan_fifo_transfer_t`.

Return values

- `kStatus_Success` – if succeed, others failed.
- `kStatus_FLEXCAN_RxFifoBusy` – Previous transfer ongoing.

```
static inline status_t FLEXCAN_TransferGetReceiveEnhancedFifoCountEMDA(CAN_Type *base,
                                                                    flex-
                                                                    can_edma_handle_t
                                                                    *handle, size_t
                                                                    *count)
```

Gets the Enhanced Rx Fifo transfer status during a interrupt non-blocking receive.

Parameters

- `base` – FlexCAN peripheral base address.
- `handle` – FlexCAN handle pointer.
- `count` – Number of CAN messages receive so far by the non-blocking transaction.

Return values

- `kStatus_InvalidArgument` – count is Invalid.
- `kStatus_Success` – Successfully return the count.

FSL_FLEXCAN_EDMA_DRIVER_VERSION

FlexCAN EDMA driver version.

```
typedef struct flexcan_edma_handle flexcan_edma_handle_t
```

```
typedef void (*flexcan_edma_transfer_callback_t)(CAN_Type *base, flexcan_edma_handle_t
*handle, status_t status, void *userData)
```

FlexCAN transfer callback function.

```
struct flexcan_edma_handle
```

```
#include <fsl_flexcan_edma.h> FlexCAN eDMA handle.
```

Public Members

`flexcan_edma_transfer_callback_t` callback
Callback function.

`void *userData`

FlexCAN callback function parameter.

`edma_handle_t *rxFifoEdmaHandle`

The EDMA handler for Rx FIFO.

volatile uint8_t rxFifoState

Rx FIFO transfer state.

size_t frameNum

The number of messages that need to be received.

flexcan_fd_frame_t *framefd

Point to the buffer of CAN Message to be received from Enhanced Rx FIFO.

2.11 FlexIO: FlexIO Driver

2.12 FlexIO Driver

void FLEXIO_GetDefaultConfig(*flexio_config_t* *userConfig)

Gets the default configuration to configure the FlexIO module. The configuration can used directly to call the FLEXIO_Configure().

Example:

```
flexio_config_t config;
FLEXIO_GetDefaultConfig(&config);
```

Parameters

- userConfig – pointer to flexio_config_t structure

void FLEXIO_Init(FLEXIO_Type *base, const *flexio_config_t* *userConfig)

Configures the FlexIO with a FlexIO configuration. The configuration structure can be filled by the user or be set with default values by FLEXIO_GetDefaultConfig().

Example

```
flexio_config_t config = {
    .enableFlexio = true,
    .enableInDoze = false,
    .enableInDebug = true,
    .enableFastAccess = false
};
FLEXIO_Configure(base, &config);
```

Parameters

- base – FlexIO peripheral base address
- userConfig – pointer to flexio_config_t structure

void FLEXIO_Deinit(FLEXIO_Type *base)

Gates the FlexIO clock. Call this API to stop the FlexIO clock.

Note: After calling this API, call the FLEXIO_Init to use the FlexIO module.

Parameters

- base – FlexIO peripheral base address

```
uint32_t FLEXIO_GetInstance(FLEXIO_Type *base)
```

Get instance number for FLEXIO module.

Parameters

- base – FLEXIO peripheral base address.

```
void FLEXIO_Reset(FLEXIO_Type *base)
```

Resets the FlexIO module.

Parameters

- base – FlexIO peripheral base address

```
static inline void FLEXIO_Enable(FLEXIO_Type *base, bool enable)
```

Enables the FlexIO module operation.

Parameters

- base – FlexIO peripheral base address
- enable – true to enable, false to disable.

```
static inline uint32_t FLEXIO_ReadPinInput(FLEXIO_Type *base)
```

Reads the input data on each of the FlexIO pins.

Parameters

- base – FlexIO peripheral base address

Returns

FlexIO pin input data

```
static inline uint8_t FLEXIO_GetShifterState(FLEXIO_Type *base)
```

Gets the current state pointer for state mode use.

Parameters

- base – FlexIO peripheral base address

Returns

current State pointer

```
void FLEXIO_SetShifterConfig(FLEXIO_Type *base, uint8_t index, const flexio_shifter_config_t *shifterConfig)
```

Configures the shifter with the shifter configuration. The configuration structure covers both the SHIFTCTL and SHIFTCFG registers. To configure the shifter to the proper mode, select which timer controls the shifter to shift, whether to generate start bit/stop bit, and the polarity of start bit and stop bit.

Example

```
flexio_shifter_config_t config = {
    .timerSelect = 0,
    .timerPolarity = kFLEXIO_ShifterTimerPolarityOnPositive,
    .pinConfig = kFLEXIO_PinConfigOpenDrainOrBidirection,
    .pinPolarity = kFLEXIO_PinActiveLow,
    .shifterMode = kFLEXIO_ShifterModeTransmit,
    .inputSource = kFLEXIO_ShifterInputFromPin,
    .shifterStop = kFLEXIO_ShifterStopBitHigh,
    .shifterStart = kFLEXIO_ShifterStartBitLow
};
FLEXIO_SetShifterConfig(base, &config);
```

Parameters

- base – FlexIO peripheral base address

- index – Shifter index
- shifterConfig – Pointer to flexio_shifter_config_t structure

```
void FLEXIO_SetTimerConfig(FLEXIO_Type *base, uint8_t index, const flexio_timer_config_t *timerConfig)
```

Configures the timer with the timer configuration. The configuration structure covers both the TIMCTL and TIMCFG registers. To configure the timer to the proper mode, select trigger source for timer and the timer pin output and the timing for timer.

Example

```
flexio_timer_config_t config = {  
    .triggerSelect = FLEXIO_TIMER_TRIGGER_SEL_SHIFThSTAT(0),  
    .triggerPolarity = kFLEXIO_TimerTriggerPolarityActiveLow,  
    .triggerSource = kFLEXIO_TimerTriggerSourceInternal,  
    .pinConfig = kFLEXIO_PinConfigOpenDrainOrBidirection,  
    .pinSelect = 0,  
    .pinPolarity = kFLEXIO_PinActiveHigh,  
    .timerMode = kFLEXIO_TimerModeDual8BitBaudBit,  
    .timerOutput = kFLEXIO_TimerOutputZeroNotAffectedByReset,  
    .timerDecrement = kFLEXIO_TimerDecSrcOnFlexIOClockShiftTimerOutput,  
    .timerReset = kFLEXIO_TimerResetOnTimerPinEqualToTimerOutput,  
    .timerDisable = kFLEXIO_TimerDisableOnTimerCompare,  
    .timerEnable = kFLEXIO_TimerEnableOnTriggerHigh,  
    .timerStop = kFLEXIO_TimerStopBitEnableOnTimerDisable,  
    .timerStart = kFLEXIO_TimerStartBitEnabled  
};  
FLEXIO_SetTimerConfig(base, &config);
```

Parameters

- base – FlexIO peripheral base address
- index – Timer index
- timerConfig – Pointer to the flexio_timer_config_t structure

```
static inline void FLEXIO_SetClockMode(FLEXIO_Type *base, uint8_t index,  
                                       flexio_timer_decrement_source_t clocksource)
```

This function set the value of the prescaler on flexio channels.

Parameters

- base – Pointer to the FlexIO simulated peripheral type.
- index – Timer index
- clocksource – Set clock value

```
static inline void FLEXIO_EnableShifterStatusInterrupts(FLEXIO_Type *base, uint32_t mask)
```

Enables the shifter status interrupt. The interrupt generates when the corresponding SSF is set.

Note: For multiple shifter status interrupt enable, for example, two shifter status enable, can calculate the mask by using ((1 « shifter index0) | (1 « shifter index1))

Parameters

- base – FlexIO peripheral base address
- mask – The shifter status mask which can be calculated by (1 « shifter index)

static inline void FLEXIO_DisableShifterStatusInterrupts(FLEXIO_Type *base, uint32_t mask)

Disables the shifter status interrupt. The interrupt won't generate when the corresponding SSF is set.

Note: For multiple shifter status interrupt enable, for example, two shifter status enable, can calculate the mask by using $((1 \ll \text{shifter index0}) \mid (1 \ll \text{shifter index1}))$

Parameters

- base – FlexIO peripheral base address
- mask – The shifter status mask which can be calculated by $(1 \ll \text{shifter index})$

static inline void FLEXIO_EnableShifterErrorInterrupts(FLEXIO_Type *base, uint32_t mask)

Enables the shifter error interrupt. The interrupt generates when the corresponding SEF is set.

Note: For multiple shifter error interrupt enable, for example, two shifter error enable, can calculate the mask by using $((1 \ll \text{shifter index0}) \mid (1 \ll \text{shifter index1}))$

Parameters

- base – FlexIO peripheral base address
- mask – The shifter error mask which can be calculated by $(1 \ll \text{shifter index})$

static inline void FLEXIO_DisableShifterErrorInterrupts(FLEXIO_Type *base, uint32_t mask)

Disables the shifter error interrupt. The interrupt won't generate when the corresponding SEF is set.

Note: For multiple shifter error interrupt enable, for example, two shifter error enable, can calculate the mask by using $((1 \ll \text{shifter index0}) \mid (1 \ll \text{shifter index1}))$

Parameters

- base – FlexIO peripheral base address
- mask – The shifter error mask which can be calculated by $(1 \ll \text{shifter index})$

static inline void FLEXIO_EnableTimerStatusInterrupts(FLEXIO_Type *base, uint32_t mask)

Enables the timer status interrupt. The interrupt generates when the corresponding SSF is set.

Note: For multiple timer status interrupt enable, for example, two timer status enable, can calculate the mask by using $((1 \ll \text{timer index0}) \mid (1 \ll \text{timer index1}))$

Parameters

- base – FlexIO peripheral base address
- mask – The timer status mask which can be calculated by $(1 \ll \text{timer index})$

static inline void FLEXIO_DisableTimerStatusInterrupts(FLEXIO_Type *base, uint32_t mask)
Disables the timer status interrupt. The interrupt won't generate when the corresponding SSF is set.

Note: For multiple timer status interrupt enable, for example, two timer status enable, can calculate the mask by using $((1 \ll \text{timer index0}) | (1 \ll \text{timer index1}))$

Parameters

- base – FlexIO peripheral base address
- mask – The timer status mask which can be calculated by $(1 \ll \text{timer index})$

static inline uint32_t FLEXIO_GetShifterStatusFlags(FLEXIO_Type *base)

Gets the shifter status flags.

Parameters

- base – FlexIO peripheral base address

Returns

Shifter status flags

static inline void FLEXIO_ClearShifterStatusFlags(FLEXIO_Type *base, uint32_t mask)

Clears the shifter status flags.

Note: For clearing multiple shifter status flags, for example, two shifter status flags, can calculate the mask by using $((1 \ll \text{shifter index0}) | (1 \ll \text{shifter index1}))$

Parameters

- base – FlexIO peripheral base address
- mask – The shifter status mask which can be calculated by $(1 \ll \text{shifter index})$

static inline uint32_t FLEXIO_GetShifterErrorFlags(FLEXIO_Type *base)

Gets the shifter error flags.

Parameters

- base – FlexIO peripheral base address

Returns

Shifter error flags

static inline void FLEXIO_ClearShifterErrorFlags(FLEXIO_Type *base, uint32_t mask)

Clears the shifter error flags.

Note: For clearing multiple shifter error flags, for example, two shifter error flags, can calculate the mask by using $((1 \ll \text{shifter index0}) | (1 \ll \text{shifter index1}))$

Parameters

- base – FlexIO peripheral base address
- mask – The shifter error mask which can be calculated by $(1 \ll \text{shifter index})$

```
static inline uint32_t FLEXIO_GetTimerStatusFlags(FLEXIO_Type *base)
```

Gets the timer status flags.

Parameters

- base – FlexIO peripheral base address

Returns

Timer status flags

```
static inline void FLEXIO_ClearTimerStatusFlags(FLEXIO_Type *base, uint32_t mask)
```

Clears the timer status flags.

Note: For clearing multiple timer status flags, for example, two timer status flags, can calculate the mask by using $((1 \ll \text{timer index0}) | (1 \ll \text{timer index1}))$

Parameters

- base – FlexIO peripheral base address
- mask – The timer status mask which can be calculated by $(1 \ll \text{timer index})$

```
static inline void FLEXIO_EnableShifterStatusDMA(FLEXIO_Type *base, uint32_t mask, bool enable)
```

Enables/disables the shifter status DMA. The DMA request generates when the corresponding SSF is set.

Note: For multiple shifter status DMA enables, for example, calculate the mask by using $((1 \ll \text{shifter index0}) | (1 \ll \text{shifter index1}))$

Parameters

- base – FlexIO peripheral base address
- mask – The shifter status mask which can be calculated by $(1 \ll \text{shifter index})$
- enable – True to enable, false to disable.

```
uint32_t FLEXIO_GetShifterBufferAddress(FLEXIO_Type *base, flexio_shifter_buffer_type_t type, uint8_t index)
```

Gets the shifter buffer address for the DMA transfer usage.

Parameters

- base – FlexIO peripheral base address
- type – Shifter type of `flexio_shifter_buffer_type_t`
- index – Shifter index

Returns

Corresponding shifter buffer index

```
status_t FLEXIO_RegisterHandleIRQ(void *base, void *handle, flexio_isr_t isr)
```

Registers the handle and the interrupt handler for the FlexIO-simulated peripheral.

Parameters

- base – Pointer to the FlexIO simulated peripheral type.
- handle – Pointer to the handler for FlexIO simulated peripheral.
- isr – FlexIO simulated peripheral interrupt handler.

Return values

- `kStatus_Success` – Successfully create the handle.
- `kStatus_OutOfRange` – The FlexIO type/handle/ISR table out of range.

`status_t` FLEXIO_UnregisterHandleIRQ(void *base)

Unregisters the handle and the interrupt handler for the FlexIO-simulated peripheral.

Parameters

- `base` – Pointer to the FlexIO simulated peripheral type.

Return values

- `kStatus_Success` – Successfully create the handle.
- `kStatus_OutOfRange` – The FlexIO type/handle/ISR table out of range.

static inline void FLEXIO_ClearPortOutput(FLEXIO_Type *base, uint32_t mask)

Sets the output level of the multiple FLEXIO pins to the logic 0.

Parameters

- `base` – FlexIO peripheral base address
- `mask` – FLEXIO pin number mask

static inline void FLEXIO_SetPortOutput(FLEXIO_Type *base, uint32_t mask)

Sets the output level of the multiple FLEXIO pins to the logic 1.

Parameters

- `base` – FlexIO peripheral base address
- `mask` – FLEXIO pin number mask

static inline void FLEXIO_TogglePortOutput(FLEXIO_Type *base, uint32_t mask)

Reverses the current output logic of the multiple FLEXIO pins.

Parameters

- `base` – FlexIO peripheral base address
- `mask` – FLEXIO pin number mask

static inline void FLEXIO_PinWrite(FLEXIO_Type *base, uint32_t pin, uint8_t output)

Sets the output level of the FLEXIO pins to the logic 1 or 0.

Parameters

- `base` – FlexIO peripheral base address
- `pin` – FLEXIO pin number.
- `output` – FLEXIO pin output logic level.
 - 0: corresponding pin output low-logic level.
 - 1: corresponding pin output high-logic level.

static inline void FLEXIO_EnablePinOutput(FLEXIO_Type *base, uint32_t pin)

Enables the FLEXIO output pin function.

Parameters

- `base` – FlexIO peripheral base address
- `pin` – FLEXIO pin number.


```
static inline uint32_t FLEXIO_PinRead(FLEXIO_Type *base, uint32_t pin)
```

Reads the current input value of the FLEXIO pin.

Parameters

- base – FlexIO peripheral base address
- pin – FLEXIO pin number.

Return values

FLEXIO – port input value

- 0: corresponding pin input low-logic level.
- 1: corresponding pin input high-logic level.

```
static inline uint32_t FLEXIO_GetPinStatus(FLEXIO_Type *base, uint32_t pin)
```

Gets the FLEXIO input pin status.

Parameters

- base – FlexIO peripheral base address
- pin – FLEXIO pin number.

Return values

FLEXIO – port input status

- 0: corresponding pin input capture no status.
- 1: corresponding pin input capture rising or falling edge.

```
static inline void FLEXIO_SetPinLevel(FLEXIO_Type *base, uint8_t pin, bool level)
```

Sets the FLEXIO output pin level.

Parameters

- base – FlexIO peripheral base address
- pin – FlexIO pin number.
- level – FlexIO output pin level to set, can be either 0 or 1.

```
static inline bool FLEXIO_GetPinOverride(const FLEXIO_Type *const base, uint8_t pin)
```

Gets the enabled status of a FLEXIO output pin.

Parameters

- base – FlexIO peripheral base address
- pin – FlexIO pin number.

Return values

FlexIO – port enabled status

- 0: corresponding output pin is in disabled state.
- 1: corresponding output pin is in enabled state.

```
static inline void FLEXIO_ConfigPinOverride(FLEXIO_Type *base, uint8_t pin, bool enabled)
```

Enables or disables a FLEXIO output pin.

Parameters

- base – FlexIO peripheral base address
- pin – Flexio pin number.
- enabled – Enable or disable the FlexIO pin.

static inline void FLEXIO_ClearPortStatus(FLEXIO_Type *base, uint32_t mask)

Clears the multiple FLEXIO input pins status.

Parameters

- base – FlexIO peripheral base address
- mask – FLEXIO pin number mask

FSL_FLEXIO_DRIVER_VERSION

FlexIO driver version.

enum __flexio_timer_trigger_polarity

Define time of timer trigger polarity.

Values:

enumerator kFLEXIO_TimerTriggerPolarityActiveHigh
Active high.

enumerator kFLEXIO_TimerTriggerPolarityActiveLow
Active low.

enum __flexio_timer_trigger_source

Define type of timer trigger source.

Values:

enumerator kFLEXIO_TimerTriggerSourceExternal
External trigger selected.

enumerator kFLEXIO_TimerTriggerSourceInternal
Internal trigger selected.

enum __flexio_pin_config

Define type of timer/shifter pin configuration.

Values:

enumerator kFLEXIO_PinConfigOutputDisabled
Pin output disabled.

enumerator kFLEXIO_PinConfigOpenDrainOrBidirection
Pin open drain or bidirectional output enable.

enumerator kFLEXIO_PinConfigBidirectionOutputData
Pin bidirectional output data.

enumerator kFLEXIO_PinConfigOutput
Pin output.

enum __flexio_pin_polarity

Definition of pin polarity.

Values:

enumerator kFLEXIO_PinActiveHigh
Active high.

enumerator kFLEXIO_PinActiveLow
Active low.

enum __flexio_timer_mode

Define type of timer work mode.

Values:

enumerator kFLEXIO__TimerModeDisabled
Timer Disabled.

enumerator kFLEXIO__TimerModeDual8BitBaudBit
Dual 8-bit counters baud/bit mode.

enumerator kFLEXIO__TimerModeDual8BitPWM
Dual 8-bit counters PWM mode.

enumerator kFLEXIO__TimerModeSingle16Bit
Single 16-bit counter mode.

enumerator kFLEXIO__TimerModeDual8BitPWMLow
Dual 8-bit counters PWM Low mode.

enum _flexio_timer_output
Define type of timer initial output or timer reset condition.
Values:

enumerator kFLEXIO__TimerOutputOneNotAffectedByReset
Logic one when enabled and is not affected by timer reset.

enumerator kFLEXIO__TimerOutputZeroNotAffectedByReset
Logic zero when enabled and is not affected by timer reset.

enumerator kFLEXIO__TimerOutputOneAffectedByReset
Logic one when enabled and on timer reset.

enumerator kFLEXIO__TimerOutputZeroAffectedByReset
Logic zero when enabled and on timer reset.

enum _flexio_timer_decrement_source
Define type of timer decrement.
Values:

enumerator kFLEXIO__TimerDecSrcOnFlexIOClockShiftTimerOutput
Decrement counter on FlexIO clock, Shift clock equals Timer output.

enumerator kFLEXIO__TimerDecSrcOnTriggerInputShiftTimerOutput
Decrement counter on Trigger input (both edges), Shift clock equals Timer output.

enumerator kFLEXIO__TimerDecSrcOnPinInputShiftPinInput
Decrement counter on Pin input (both edges), Shift clock equals Pin input.

enumerator kFLEXIO__TimerDecSrcOnTriggerInputShiftTriggerInput
Decrement counter on Trigger input (both edges), Shift clock equals Trigger input.

enum _flexio_timer_reset_condition
Define type of timer reset condition.
Values:

enumerator kFLEXIO__TimerResetNever
Timer never reset.

enumerator kFLEXIO__TimerResetOnTimerPinEqualToTimerOutput
Timer reset on Timer Pin equal to Timer Output.

enumerator kFLEXIO__TimerResetOnTimerTriggerEqualToTimerOutput
Timer reset on Timer Trigger equal to Timer Output.

enumerator kFLEXIO__TimerResetOnTimerPinRisingEdge

Timer reset on Timer Pin rising edge.

enumerator kFLEXIO__TimerResetOnTimerTriggerRisingEdge

Timer reset on Trigger rising edge.

enumerator kFLEXIO__TimerResetOnTimerTriggerBothEdge

Timer reset on Trigger rising or falling edge.

enum _flexio_timer_disable_condition

Define type of timer disable condition.

Values:

enumerator kFLEXIO__TimerDisableNever

Timer never disabled.

enumerator kFLEXIO__TimerDisableOnPreTimerDisable

Timer disabled on Timer N-1 disable.

enumerator kFLEXIO__TimerDisableOnTimerCompare

Timer disabled on Timer compare.

enumerator kFLEXIO__TimerDisableOnTimerCompareTriggerLow

Timer disabled on Timer compare and Trigger Low.

enumerator kFLEXIO__TimerDisableOnPinBothEdge

Timer disabled on Pin rising or falling edge.

enumerator kFLEXIO__TimerDisableOnPinBothEdgeTriggerHigh

Timer disabled on Pin rising or falling edge provided Trigger is high.

enumerator kFLEXIO__TimerDisableOnTriggerFallingEdge

Timer disabled on Trigger falling edge.

enum _flexio_timer_enable_condition

Define type of timer enable condition.

Values:

enumerator kFLEXIO__TimerEnabledAlways

Timer always enabled.

enumerator kFLEXIO__TimerEnableOnPrevTimerEnable

Timer enabled on Timer N-1 enable.

enumerator kFLEXIO__TimerEnableOnTriggerHigh

Timer enabled on Trigger high.

enumerator kFLEXIO__TimerEnableOnTriggerHighPinHigh

Timer enabled on Trigger high and Pin high.

enumerator kFLEXIO__TimerEnableOnPinRisingEdge

Timer enabled on Pin rising edge.

enumerator kFLEXIO__TimerEnableOnPinRisingEdgeTriggerHigh

Timer enabled on Pin rising edge and Trigger high.

enumerator kFLEXIO__TimerEnableOnTriggerRisingEdge

Timer enabled on Trigger rising edge.

enumerator kFLEXIO__TimerEnableOnTriggerBothEdge

Timer enabled on Trigger rising or falling edge.

enum _flexio_timer_stop_bit_condition

Define type of timer stop bit generate condition.

Values:

enumerator kFLEXIO_TimerStopBitDisabled

Stop bit disabled.

enumerator kFLEXIO_TimerStopBitEnableOnTimerCompare

Stop bit is enabled on timer compare.

enumerator kFLEXIO_TimerStopBitEnableOnTimerDisable

Stop bit is enabled on timer disable.

enumerator kFLEXIO_TimerStopBitEnableOnTimerCompareDisable

Stop bit is enabled on timer compare and timer disable.

enum _flexio_timer_start_bit_condition

Define type of timer start bit generate condition.

Values:

enumerator kFLEXIO_TimerStartBitDisabled

Start bit disabled.

enumerator kFLEXIO_TimerStartBitEnabled

Start bit enabled.

enum _flexio_timer_output_state

FlexIO as PWM channel output state.

Values:

enumerator kFLEXIO_PwmLow

The output state of PWM channel is low

enumerator kFLEXIO_PwmHigh

The output state of PWM channel is high

enum _flexio_shifter_timer_polarity

Define type of timer polarity for shifter control.

Values:

enumerator kFLEXIO_ShifterTimerPolarityOnPositive

Shift on positive edge of shift clock.

enumerator kFLEXIO_ShifterTimerPolarityOnNegative

Shift on negative edge of shift clock.

enum _flexio_shifter_mode

Define type of shifter working mode.

Values:

enumerator kFLEXIO_ShifterDisabled

Shifter is disabled.

enumerator kFLEXIO_ShifterModeReceive

Receive mode.

enumerator kFLEXIO_ShifterModeTransmit

Transmit mode.

enumerator kFLEXIO__ShifterModeMatchStore

Match store mode.

enumerator kFLEXIO__ShifterModeMatchContinuous

Match continuous mode.

enumerator kFLEXIO__ShifterModeState

SHIFTBUF contents are used for storing programmable state attributes.

enumerator kFLEXIO__ShifterModeLogic

SHIFTBUF contents are used for implementing programmable logic look up table.

enum _flexio_shifter_input_source

Define type of shifter input source.

Values:

enumerator kFLEXIO__ShifterInputFromPin

Shifter input from pin.

enumerator kFLEXIO__ShifterInputFromNextShifterOutput

Shifter input from Shifter N+1.

enum _flexio_shifter_stop_bit

Define of STOP bit configuration.

Values:

enumerator kFLEXIO__ShifterStopBitDisable

Disable shifter stop bit.

enumerator kFLEXIO__ShifterStopBitLow

Set shifter stop bit to logic low level.

enumerator kFLEXIO__ShifterStopBitHigh

Set shifter stop bit to logic high level.

enum _flexio_shifter_start_bit

Define type of START bit configuration.

Values:

enumerator kFLEXIO__ShifterStartBitDisabledLoadDataOnEnable

Disable shifter start bit, transmitter loads data on enable.

enumerator kFLEXIO__ShifterStartBitDisabledLoadDataOnShift

Disable shifter start bit, transmitter loads data on first shift.

enumerator kFLEXIO__ShifterStartBitLow

Set shifter start bit to logic low level.

enumerator kFLEXIO__ShifterStartBitHigh

Set shifter start bit to logic high level.

enum _flexio_shifter_buffer_type

Define FlexIO shifter buffer type.

Values:

enumerator kFLEXIO__ShifterBuffer

Shifter Buffer N Register.

enumerator kFLEXIO__ShifterBufferBitSwapped

Shifter Buffer N Bit Byte Swapped Register.

enumerator kFLEXIO__ShifterBufferByteSwapped
Shifter Buffer N Byte Swapped Register.

enumerator kFLEXIO__ShifterBufferBitByteSwapped
Shifter Buffer N Bit Swapped Register.

enumerator kFLEXIO__ShifterBufferNibbleByteSwapped
Shifter Buffer N Nibble Byte Swapped Register.

enumerator kFLEXIO__ShifterBufferHalfWordSwapped
Shifter Buffer N Half Word Swapped Register.

enumerator kFLEXIO__ShifterBufferNibbleSwapped
Shifter Buffer N Nibble Swapped Register.

enum _flexio_gpio_direction
FLEXIO gpio direction definition.

Values:

enumerator kFLEXIO__DigitalInput
Set current pin as digital input

enumerator kFLEXIO__DigitalOutput
Set current pin as digital output

enum _flexio_pin_input_config
FLEXIO gpio input config.

Values:

enumerator kFLEXIO__InputInterruptDisabled
Interrupt request is disabled.

enumerator kFLEXIO__InputInterruptEnable
Interrupt request is enable.

enumerator kFLEXIO__FlagRisingEdgeEnable
Input pin flag on rising edge.

enumerator kFLEXIO__FlagFallingEdgeEnable
Input pin flag on falling edge.

typedef enum _flexio_timer_trigger_polarity flexio_timer_trigger_polarity_t
Define time of timer trigger polarity.

typedef enum _flexio_timer_trigger_source flexio_timer_trigger_source_t
Define type of timer trigger source.

typedef enum _flexio_pin_config flexio_pin_config_t
Define type of timer/shifter pin configuration.

typedef enum _flexio_pin_polarity flexio_pin_polarity_t
Definition of pin polarity.

typedef enum _flexio_timer_mode flexio_timer_mode_t
Define type of timer work mode.

typedef enum _flexio_timer_output flexio_timer_output_t
Define type of timer initial output or timer reset condition.

typedef enum _flexio_timer_decrement_source flexio_timer_decrement_source_t
Define type of timer decrement.

typedef enum *_flexio_timer_reset_condition* flexio_timer_reset_condition_t

Define type of timer reset condition.

typedef enum *_flexio_timer_disable_condition* flexio_timer_disable_condition_t

Define type of timer disable condition.

typedef enum *_flexio_timer_enable_condition* flexio_timer_enable_condition_t

Define type of timer enable condition.

typedef enum *_flexio_timer_stop_bit_condition* flexio_timer_stop_bit_condition_t

Define type of timer stop bit generate condition.

typedef enum *_flexio_timer_start_bit_condition* flexio_timer_start_bit_condition_t

Define type of timer start bit generate condition.

typedef enum *_flexio_timer_output_state* flexio_timer_output_state_t

FlexIO as PWM channel output state.

typedef enum *_flexio_shifter_timer_polarity* flexio_shifter_timer_polarity_t

Define type of timer polarity for shifter control.

typedef enum *_flexio_shifter_mode* flexio_shifter_mode_t

Define type of shifter working mode.

typedef enum *_flexio_shifter_input_source* flexio_shifter_input_source_t

Define type of shifter input source.

typedef enum *_flexio_shifter_stop_bit* flexio_shifter_stop_bit_t

Define of STOP bit configuration.

typedef enum *_flexio_shifter_start_bit* flexio_shifter_start_bit_t

Define type of START bit configuration.

typedef enum *_flexio_shifter_buffer_type* flexio_shifter_buffer_type_t

Define FlexIO shifter buffer type.

typedef struct *_flexio_config* flexio_config_t

Define FlexIO user configuration structure.

typedef struct *_flexio_timer_config* flexio_timer_config_t

Define FlexIO timer configuration structure.

typedef struct *_flexio_shifter_config* flexio_shifter_config_t

Define FlexIO shifter configuration structure.

typedef enum *_flexio_gpio_direction* flexio_gpio_direction_t

FLEXIO gpio direction definition.

typedef enum *_flexio_pin_input_config* flexio_pin_input_config_t

FLEXIO gpio input config.

typedef struct *_flexio_gpio_config* flexio_gpio_config_t

The FLEXIO pin configuration structure.

Each pin can only be configured as either an output pin or an input pin at a time. If configured as an input pin, use inputConfig param. If configured as an output pin, use outputLogic.

typedef void (*flexio_isr_t)(void *base, void *handle)

typedef for FlexIO simulated driver interrupt handler.

FLEXIO_Type *const s_flexioBases[]

Pointers to flexio bases for each instance.


```
const clock_ip_name_t s_flexioClocks[]
```

Pointers to flexio clocks for each instance.

```
void FLEXIO_SetPinConfig(FLEXIO_Type *base, uint32_t pin, flexio_gpio_config_t *config)
```

Configure a FLEXIO pin used by the board.

To Config the FLEXIO PIN, define a pin configuration, as either input or output, in the user file. Then, call the FLEXIO_SetPinConfig() function.

This is an example to define an input pin or an output pin configuration.

```
Define a digital input pin configuration,
flexio_gpio_config_t config =
{
    kFLEXIO_DigitalInput,
    0U,
    kFLEXIO_FlagRisingEdgeEnable | kFLEXIO_InputInterruptEnable,
}
Define a digital output pin configuration,
flexio_gpio_config_t config =
{
    kFLEXIO_DigitalOutput,
    0U,
    0U
}
```

Parameters

- base – FlexIO peripheral base address
- pin – FLEXIO pin number.
- config – FLEXIO pin configuration pointer.

```
FLEXIO_TIMER_TRIGGER_SEL_PININPUT(x)
```

Calculate FlexIO timer trigger.

```
FLEXIO_TIMER_TRIGGER_SEL_SHIFtnSTAT(x)
```

```
FLEXIO_TIMER_TRIGGER_SEL_TIMn(x)
```

```
struct _flexio_config_
```

#include <fsl_flexio.h> Define FlexIO user configuration structure.

Public Members

```
bool enableFlexio
```

Enable/disable FlexIO module

```
bool enableInDoze
```

Enable/disable FlexIO operation in doze mode

```
bool enableInDebug
```

Enable/disable FlexIO operation in debug mode

```
bool enableFastAccess
```

Enable/disable fast access to FlexIO registers, fast access requires the FlexIO clock to be at least twice the frequency of the bus clock.

```
struct _flexio_timer_config
```

#include <fsl_flexio.h> Define FlexIO timer configuration structure.

Public Members

`uint32_t triggerSelect`

The internal trigger selection number using MACROs.

`flexio_timer_trigger_polarity_t triggerPolarity`

Trigger Polarity.

`flexio_timer_trigger_source_t triggerSource`

Trigger Source, internal (see 'trgsel') or external.

`flexio_pin_config_t pinConfig`

Timer Pin Configuration.

`uint32_t pinSelect`

Timer Pin number Select.

`flexio_pin_polarity_t pinPolarity`

Timer Pin Polarity.

`flexio_timer_mode_t timerMode`

Timer work Mode.

`flexio_timer_output_t timerOutput`

Configures the initial state of the Timer Output and whether it is affected by the Timer reset.

`flexio_timer_decrement_source_t timerDecrement`

Configures the source of the Timer decrement and the source of the Shift clock.

`flexio_timer_reset_condition_t timerReset`

Configures the condition that causes the timer counter (and optionally the timer output) to be reset.

`flexio_timer_disable_condition_t timerDisable`

Configures the condition that causes the Timer to be disabled and stop decrementing.

`flexio_timer_enable_condition_t timerEnable`

Configures the condition that causes the Timer to be enabled and start decrementing.

`flexio_timer_stop_bit_condition_t timerStop`

Timer STOP Bit generation.

`flexio_timer_start_bit_condition_t timerStart`

Timer STRAT Bit generation.

`uint32_t timerCompare`

Value for Timer Compare N Register.

`struct _flexio_shifter_config`

`#include <fsl_flexio.h>` Define FlexIO shifter configuration structure.

Public Members

`uint32_t timerSelect`

Selects which Timer is used for controlling the logic/shift register and generating the Shift clock.

`flexio_shifter_timer_polarity_t timerPolarity`

Timer Polarity.

flexio_pin_config_t pinConfig
Shifter Pin Configuration.

uint32_t pinSelect
Shifter Pin number Select.

flexio_pin_polarity_t pinPolarity
Shifter Pin Polarity.

flexio_shifter_mode_t shifterMode
Configures the mode of the Shifter.

uint32_t parallelWidth
Configures the parallel width when using parallel mode.

flexio_shifter_input_source_t inputSource
Selects the input source for the shifter.

flexio_shifter_stop_bit_t shifterStop
Shifter STOP bit.

flexio_shifter_start_bit_t shifterStart
Shifter START bit.

struct __flexio_gpio_config

#include <fsl_flexio.h> The FLEXIO pin configuration structure.

Each pin can only be configured as either an output pin or an input pin at a time. If configured as an input pin, use inputConfig param. If configured as an output pin, use outputLogic.

Public Members

flexio_gpio_direction_t pinDirection
FLEXIO pin direction, input or output

uint8_t outputLogic
Set a default output logic, which has no use in input

uint8_t inputConfig
Set an input config

2.13 FlexIO eDMA I2S Driver

```
void FLEXIO_I2S_TransferTxCreateHandleEDMA(FLEXIO_I2S_Type *base,
                                           flexio_i2s_edma_handle_t *handle,
                                           flexio_i2s_edma_callback_t callback, void
                                           *userData, edma_handle_t *dmaHandle)
```

Initializes the FlexIO I2S eDMA handle.

This function initializes the FlexIO I2S master DMA handle which can be used for other FlexIO I2S master transactional APIs. Usually, for a specified FlexIO I2S instance, call this API once to get the initialized handle.

Parameters

- base – FlexIO I2S peripheral base address.
- handle – FlexIO I2S eDMA handle pointer.

- callback – FlexIO I2S eDMA callback function called while finished a block.
- userData – User parameter for callback.
- dmaHandle – eDMA handle for FlexIO I2S. This handle is a static value allocated by users.

```
void FLEXIO_I2S_TransferRxCreateHandleEDMA(FLEXIO_I2S_Type *base,  
                                           flexio_i2s_edma_handle_t *handle,  
                                           flexio_i2s_edma_callback_t callback, void  
                                           *userData, edma_handle_t *dmaHandle)
```

Initializes the FlexIO I2S Rx eDMA handle.

This function initializes the FlexIO I2S slave DMA handle which can be used for other FlexIO I2S master transactional APIs. Usually, for a specified FlexIO I2S instance, call this API once to get the initialized handle.

Parameters

- base – FlexIO I2S peripheral base address.
- handle – FlexIO I2S eDMA handle pointer.
- callback – FlexIO I2S eDMA callback function called while finished a block.
- userData – User parameter for callback.
- dmaHandle – eDMA handle for FlexIO I2S. This handle is a static value allocated by users.

```
void FLEXIO_I2S_TransferSetFormatEDMA(FLEXIO_I2S_Type *base, flexio_i2s_edma_handle_t  
                                       *handle, flexio_i2s_format_t *format, uint32_t  
                                       srcClock_Hz)
```

Configures the FlexIO I2S Tx audio format.

Audio format can be changed in run-time of FlexIO I2S. This function configures the sample rate and audio data format to be transferred. This function also sets the eDMA parameter according to format.

Parameters

- base – FlexIO I2S peripheral base address.
- handle – FlexIO I2S eDMA handle pointer
- format – Pointer to FlexIO I2S audio data format structure.
- srcClock_Hz – FlexIO I2S clock source frequency in Hz, it should be 0 while in slave mode.

```
status_t FLEXIO_I2S_TransferSendEDMA(FLEXIO_I2S_Type *base, flexio_i2s_edma_handle_t  
                                       *handle, flexio_i2s_transfer_t *xfer)
```

Performs a non-blocking FlexIO I2S transfer using DMA.

Note: This interface returned immediately after transfer initiates. Users should call FLEXIO_I2S_GetTransferStatus to poll the transfer status and check whether the FlexIO I2S transfer is finished.

Parameters

- base – FlexIO I2S peripheral base address.
- handle – FlexIO I2S DMA handle pointer.
- xfer – Pointer to DMA transfer structure.

Return values

- `kStatus__Success` – Start a FlexIO I2S eDMA send successfully.
- `kStatus__InvalidArgument` – The input arguments is invalid.
- `kStatus__TxBusy` – FlexIO I2S is busy sending data.

`status_t` FLEXIO_I2S_TransferReceiveEDMA(*FLEXIO_I2S_Type* *base, *flexio_i2s_edma_handle_t* *handle, *flexio_i2s_transfer_t* *xfer)

Performs a non-blocking FlexIO I2S receive using eDMA.

Note: This interface returned immediately after transfer initiates. Users should call `FLEXIO_I2S_GetReceiveRemainingBytes` to poll the transfer status and check whether the FlexIO I2S transfer is finished.

Parameters

- base – FlexIO I2S peripheral base address.
- handle – FlexIO I2S DMA handle pointer.
- xfer – Pointer to DMA transfer structure.

Return values

- `kStatus__Success` – Start a FlexIO I2S eDMA receive successfully.
- `kStatus__InvalidArgument` – The input arguments is invalid.
- `kStatus__RxBusy` – FlexIO I2S is busy receiving data.

`void` FLEXIO_I2S_TransferAbortSendEDMA(*FLEXIO_I2S_Type* *base, *flexio_i2s_edma_handle_t* *handle)

Aborts a FlexIO I2S transfer using eDMA.

Parameters

- base – FlexIO I2S peripheral base address.
- handle – FlexIO I2S DMA handle pointer.

`void` FLEXIO_I2S_TransferAbortReceiveEDMA(*FLEXIO_I2S_Type* *base, *flexio_i2s_edma_handle_t* *handle)

Aborts a FlexIO I2S receive using eDMA.

Parameters

- base – FlexIO I2S peripheral base address.
- handle – FlexIO I2S DMA handle pointer.

`status_t` FLEXIO_I2S_TransferGetSendCountEDMA(*FLEXIO_I2S_Type* *base, *flexio_i2s_edma_handle_t* *handle, *size_t* *count)

Gets the remaining bytes to be sent.

Parameters

- base – FlexIO I2S peripheral base address.
- handle – FlexIO I2S DMA handle pointer.
- count – Bytes sent.

Return values

- `kStatus__Success` – Succeed get the transfer count.

- `kStatus_NoTransferInProgress` – There is not a non-blocking transaction currently in progress.

`status_t` FLEXIO_I2S_TransferGetReceiveCountEDMA(*FLEXIO_I2S_Type* *base, *flexio_i2s_edma_handle_t* *handle, *size_t* *count)

Get the remaining bytes to be received.

Parameters

- `base` – FlexIO I2S peripheral base address.
- `handle` – FlexIO I2S DMA handle pointer.
- `count` – Bytes received.

Return values

- `kStatus_Success` – Succeed get the transfer count.
- `kStatus_NoTransferInProgress` – There is not a non-blocking transaction currently in progress.

FSL_FLEXIO_I2S_EDMA_DRIVER_VERSION

FlexIO I2S EDMA driver version 2.1.9.

`typedef struct _flexio_i2s_edma_handle` *flexio_i2s_edma_handle_t*

`typedef void (*flexio_i2s_edma_callback_t)(FLEXIO_I2S_Type *base, flexio_i2s_edma_handle_t *handle, status_t status, void *userData)`

FlexIO I2S eDMA transfer callback function for finish and error.

`struct _flexio_i2s_edma_handle`

`#include <fsl_flexio_i2s_edma.h>` FlexIO I2S DMA transfer handle, users should not touch the content of the handle.

Public Members

edma_handle_t *dmaHandle

DMA handler for FlexIO I2S send

uint8_t bytesPerFrame

Bytes in a frame

uint8_t nbytes

eDMA minor byte transfer count initially configured.

uint32_t state

Internal state for FlexIO I2S eDMA transfer

flexio_i2s_edma_callback_t callback

Callback for users while transfer finish or error occurred

void *userData

User callback parameter

edma_tcd_t tcd[(4U) + 1U]

TCD pool for eDMA transfer.

flexio_i2s_transfer_t queue[(4U)]

Transfer queue storing queued transfer.

size_t transferSize[(4U)]

Data bytes need to transfer

volatile uint8_t queueUser

Index for user to queue transfer.

volatile uint8_t queueDriver

Index for driver to get the transfer data and size

2.14 FlexIO eDMA SPI Driver

```
status_t FLEXIO_SPI_MasterTransferCreateHandleEDMA(FLEXIO_SPI_Type *base,
                                                    flexio_spi_master_edma_handle_t
                                                    *handle,
                                                    flexio_spi_master_edma_transfer_callback_t
                                                    callback, void *userData,
                                                    edma_handle_t *txHandle,
                                                    edma_handle_t *rxHandle)
```

Initializes the FlexIO SPI master eDMA handle.

This function initializes the FlexIO SPI master eDMA handle which can be used for other FlexIO SPI master transactional APIs. For a specified FlexIO SPI instance, call this API once to get the initialized handle.

Parameters

- base – Pointer to FLEXIO_SPI_Type structure.
- handle – Pointer to flexio_spi_master_edma_handle_t structure to store the transfer state.
- callback – SPI callback, NULL means no callback.
- userData – callback function parameter.
- txHandle – User requested eDMA handle for FlexIO SPI RX eDMA transfer.
- rxHandle – User requested eDMA handle for FlexIO SPI TX eDMA transfer.

Return values

- kStatus_Success – Successfully create the handle.
- kStatus_OutOfRange – The FlexIO SPI eDMA type/handle table out of range.

```
status_t FLEXIO_SPI_MasterTransferEDMA(FLEXIO_SPI_Type *base,
                                         flexio_spi_master_edma_handle_t *handle,
                                         flexio_spi_transfer_t *xfer)
```

Performs a non-blocking FlexIO SPI transfer using eDMA.

Note: This interface returns immediately after transfer initiates. Call FLEXIO_SPI_MasterGetTransferCountEDMA to poll the transfer status and check whether the FlexIO SPI transfer is finished.

Parameters

- base – Pointer to FLEXIO_SPI_Type structure.
- handle – Pointer to flexio_spi_master_edma_handle_t structure to store the transfer state.
- xfer – Pointer to FlexIO SPI transfer structure.

Return values

- `kStatus__Success` – Successfully start a transfer.
- `kStatus__InvalidArgument` – Input argument is invalid.
- `kStatus_FLEXIO_SPI_Busy` – FlexIO SPI is not idle, is running another transfer.

```
void FLEXIO_SPI_MasterTransferAbortEDMA(FLEXIO_SPI_Type *base,  
                                         flexio_spi_master_edma_handle_t *handle)
```

Aborts a FlexIO SPI transfer using eDMA.

Parameters

- `base` – Pointer to `FLEXIO_SPI_Type` structure.
- `handle` – FlexIO SPI eDMA handle pointer.

```
status_t FLEXIO_SPI_MasterTransferGetCountEDMA(FLEXIO_SPI_Type *base,  
                                                flexio_spi_master_edma_handle_t *handle,  
                                                size_t *count)
```

Gets the number of bytes transferred so far using FlexIO SPI master eDMA.

Parameters

- `base` – Pointer to `FLEXIO_SPI_Type` structure.
- `handle` – FlexIO SPI eDMA handle pointer.
- `count` – Number of bytes transferred so far by the non-blocking transaction.

```
static inline void FLEXIO_SPI_SlaveTransferCreateHandleEDMA(FLEXIO_SPI_Type *base,  
                                                           flexio_spi_slave_edma_handle_t  
                                                           *handle,  
                                                           flexio_spi_slave_edma_transfer_callback_t  
                                                           callback, void *userData,  
                                                           edma_handle_t *txHandle,  
                                                           edma_handle_t *rxHandle)
```

Initializes the FlexIO SPI slave eDMA handle.

This function initializes the FlexIO SPI slave eDMA handle.

Parameters

- `base` – Pointer to `FLEXIO_SPI_Type` structure.
- `handle` – Pointer to `flexio_spi_slave_edma_handle_t` structure to store the transfer state.
- `callback` – SPI callback, NULL means no callback.
- `userData` – callback function parameter.
- `txHandle` – User requested eDMA handle for FlexIO SPI TX eDMA transfer.
- `rxHandle` – User requested eDMA handle for FlexIO SPI RX eDMA transfer.

```
status_t FLEXIO_SPI_SlaveTransferEDMA(FLEXIO_SPI_Type *base,  
                                       flexio_spi_slave_edma_handle_t *handle,  
                                       flexio_spi_transfer_t *xfer)
```

Performs a non-blocking FlexIO SPI transfer using eDMA.

Note: This interface returns immediately after transfer initiates. Call `FLEXIO_SPI_SlaveGetTransferCountEDMA` to poll the transfer status and check whether the FlexIO SPI transfer is finished.

Parameters

- base – Pointer to FLEXIO_SPI_Type structure.
- handle – Pointer to flexio_spi_slave_edma_handle_t structure to store the transfer state.
- xfer – Pointer to FlexIO SPI transfer structure.

Return values

- kStatus_Success – Successfully start a transfer.
- kStatus_InvalidArgument – Input argument is invalid.
- kStatus_FLEXIO_SPI_Busy – FlexIO SPI is not idle, is running another transfer.

```
static inline void FLEXIO_SPI_SlaveTransferAbortEDMA(FLEXIO_SPI_Type *base,
                                                    flexio_spi_slave_edma_handle_t
                                                    *handle)
```

Aborts a FlexIO SPI transfer using eDMA.

Parameters

- base – Pointer to FLEXIO_SPI_Type structure.
- handle – Pointer to flexio_spi_slave_edma_handle_t structure to store the transfer state.

```
static inline status_t FLEXIO_SPI_SlaveTransferGetCountEDMA(FLEXIO_SPI_Type *base,
                                                           flexio_spi_slave_edma_handle_t
                                                           *handle, size_t *count)
```

Gets the number of bytes transferred so far using FlexIO SPI slave eDMA.

Parameters

- base – Pointer to FLEXIO_SPI_Type structure.
- handle – FlexIO SPI eDMA handle pointer.
- count – Number of bytes transferred so far by the non-blocking transaction.

FSL_FLEXIO_SPI_EDMA_DRIVER_VERSION

FlexIO SPI EDMA driver version.

```
typedef struct flexio_spi_master_edma_handle flexio_spi_master_edma_handle_t
typedef for flexio_spi_master_edma_handle_t in advance.
```

```
typedef flexio_spi_master_edma_handle_t flexio_spi_slave_edma_handle_t
Slave handle is the same with master handle.
```

```
typedef void (*flexio_spi_master_edma_transfer_callback_t)(FLEXIO_SPI_Type *base,
                                                           flexio_spi_master_edma_handle_t *handle, status_t status, void *userData)
```

FlexIO SPI master callback for finished transmit.

```
typedef void (*flexio_spi_slave_edma_transfer_callback_t)(FLEXIO_SPI_Type *base,
                                                           flexio_spi_slave_edma_handle_t *handle, status_t status, void *userData)
```

FlexIO SPI slave callback for finished transmit.

```
struct flexio_spi_master_edma_handle
```

#include <fsl_flexio_spi_edma.h> FlexIO SPI eDMA transfer handle, users should not touch the content of the handle.

Public Members

`size_t` transferSize
Total bytes to be transferred.

`uint8_t` nbytes
eDMA minor byte transfer count initially configured.

`bool` txInProgress
Send transfer in progress

`bool` rxInProgress
Receive transfer in progress

`edma_handle_t` *txHandle
DMA handler for SPI send

`edma_handle_t` *rxHandle
DMA handler for SPI receive

`flexio_spi_master_edma_transfer_callback_t` callback
Callback for SPI DMA transfer

`void` *userData
User Data for SPI DMA callback

2.15 FlexIO eDMA UART Driver

`status_t` FLEXIO_UART_TransferCreateHandleEDMA(*FLEXIO_UART_Type* *base,
 flexio_uart_edma_handle_t *handle,
 flexio_uart_edma_transfer_callback_t
 callback, void *userData, *edma_handle_t*
 *txEdmaHandle, *edma_handle_t*
 *rxEdmaHandle)

Initializes the UART handle which is used in transactional functions.

Parameters

- base – Pointer to *FLEXIO_UART_Type*.
- handle – Pointer to *flexio_uart_edma_handle_t* structure.
- callback – The callback function.
- userData – The parameter of the callback function.
- rxEdmaHandle – User requested DMA handle for RX DMA transfer.
- txEdmaHandle – User requested DMA handle for TX DMA transfer.

Return values

- `kStatus_Success` – Successfully create the handle.
- `kStatus_OutOfRange` – The FlexIO SPI eDMA type/handle table out of range.

`status_t` FLEXIO_UART_TransferSendEDMA(*FLEXIO_UART_Type* *base,
 flexio_uart_edma_handle_t *handle,
 flexio_uart_transfer_t *xfer)

Sends data using eDMA.

This function sends data using eDMA. This is a non-blocking function, which returns right away. When all data is sent out, the send callback function is called.

Parameters

- base – Pointer to FLEXIO_UART_Type
- handle – UART handle pointer.
- xfer – UART eDMA transfer structure, see flexio_uart_transfer_t.

Return values

- kStatus_Success – if succeed, others failed.
- kStatus_FLEXIO_UART_TxBusy – Previous transfer on going.

```
status_t FLEXIO_UART_TransferReceiveEDMA(FLEXIO_UART_Type *base,  
                                         flexio_uart_edma_handle_t *handle,  
                                         flexio_uart_transfer_t *xfer)
```

Receives data using eDMA.

This function receives data using eDMA. This is a non-blocking function, which returns right away. When all data is received, the receive callback function is called.

Parameters

- base – Pointer to FLEXIO_UART_Type
- handle – Pointer to flexio_uart_edma_handle_t structure
- xfer – UART eDMA transfer structure, see flexio_uart_transfer_t.

Return values

- kStatus_Success – if succeed, others failed.
- kStatus_UART_RxBusy – Previous transfer on going.

```
void FLEXIO_UART_TransferAbortSendEDMA(FLEXIO_UART_Type *base,  
                                       flexio_uart_edma_handle_t *handle)
```

Aborts the sent data which using eDMA.

This function aborts sent data which using eDMA.

Parameters

- base – Pointer to FLEXIO_UART_Type
- handle – Pointer to flexio_uart_edma_handle_t structure

```
void FLEXIO_UART_TransferAbortReceiveEDMA(FLEXIO_UART_Type *base,  
                                          flexio_uart_edma_handle_t *handle)
```

Aborts the receive data which using eDMA.

This function aborts the receive data which using eDMA.

Parameters

- base – Pointer to FLEXIO_UART_Type
- handle – Pointer to flexio_uart_edma_handle_t structure

```
status_t FLEXIO_UART_TransferGetSendCountEDMA(FLEXIO_UART_Type *base,  
                                              flexio_uart_edma_handle_t *handle,  
                                              size_t *count)
```

Gets the number of bytes sent out.

This function gets the number of bytes sent out.

Parameters

- base – Pointer to FLEXIO_UART_Type
- handle – Pointer to flexio_uart_edma_handle_t structure
- count – Number of bytes sent so far by the non-blocking transaction.

Return values

- `kStatus_NoTransferInProgress` – transfer has finished or no transfer in progress.
- `kStatus_Success` – Successfully return the count.

`status_t FLEXIO_UART_TransferGetReceiveCountEDMA(FLEXIO_UART_Type *base, flexio_uart_edma_handle_t *handle, size_t *count)`

Gets the number of bytes received.

This function gets the number of bytes received.

Parameters

- `base` – Pointer to `FLEXIO_UART_Type`
- `handle` – Pointer to `flexio_uart_edma_handle_t` structure
- `count` – Number of bytes received so far by the non-blocking transaction.

Return values

- `kStatus_NoTransferInProgress` – transfer has finished or no transfer in progress.
- `kStatus_Success` – Successfully return the count.

`FSL_FLEXIO_UART_EDMA_DRIVER_VERSION`

FlexIO UART EDMA driver version.

`typedef struct flexio_uart_edma_handle flexio_uart_edma_handle_t`

`typedef void (*flexio_uart_edma_transfer_callback_t)(FLEXIO_UART_Type *base, flexio_uart_edma_handle_t *handle, status_t status, void *userData)`

UART transfer callback function.

`struct flexio_uart_edma_handle`

`#include <fsl_flexio_uart_edma.h>` UART eDMA handle.

Public Members

`flexio_uart_edma_transfer_callback_t` callback

Callback function.

`void *userData`

UART callback function parameter.

`size_t txDataSizeAll`

Total bytes to be sent.

`size_t rxDataSizeAll`

Total bytes to be received.

`edma_handle_t *txEdmaHandle`

The eDMA TX channel used.

`edma_handle_t *rxEdmaHandle`

The eDMA RX channel used.

`uint8_t nbytes`

eDMA minor byte transfer count initially configured.

volatile uint8_t txState
TX transfer state.

volatile uint8_t rxState
RX transfer state

2.16 FlexIO I2C Master Driver

status_t FLEXIO_I2C_CheckForBusyBus(*FLEXIO_I2C_Type* *base)

Make sure the bus isn't already pulled down.

Check the FLEXIO pin status to see whether either of SDA and SCL pin is pulled down.

Parameters

- base – Pointer to FLEXIO_I2C_Type structure..

Return values

- kStatus_Success –
- kStatus_FLEXIO_I2C_Busy –

status_t FLEXIO_I2C_MasterInit(*FLEXIO_I2C_Type* *base, *flexio_i2c_master_config_t* *masterConfig, uint32_t srcClock_Hz)

Ungates the FlexIO clock, resets the FlexIO module, and configures the FlexIO I2C hardware configuration.

Example

```
FLEXIO_I2C_Type base = {
    .flexioBase = FLEXIO,
    .SDAPinIndex = 0,
    .SCLPinIndex = 1,
    .shifterIndex = {0,1},
    .timerIndex = {0,1}
};
flexio_i2c_master_config_t config = {
    .enableInDoze = false,
    .enableInDebug = true,
    .enableFastAccess = false,
    .baudRate_Bps = 100000
};
FLEXIO_I2C_MasterInit(base, &config, srcClock_Hz);
```

Parameters

- base – Pointer to FLEXIO_I2C_Type structure.
- masterConfig – Pointer to flexio_i2c_master_config_t structure.
- srcClock_Hz – FlexIO source clock in Hz.

Return values

- kStatus_Success – Initialization successful
- kStatus_InvalidArgument – The source clock exceed upper range limitation

void FLEXIO_I2C_MasterDeinit(*FLEXIO_I2C_Type* *base)

De-initializes the FlexIO I2C master peripheral. Calling this API Resets the FlexIO I2C master shifer and timer config, module can't work unless the FLEXIO_I2C_MasterInit is called.

Parameters

- base – pointer to FLEXIO_I2C_Type structure.

void FLEXIO_I2C_MasterGetDefaultConfig(*flexio_i2c_master_config_t* *masterConfig)

Gets the default configuration to configure the FlexIO module. The configuration can be used directly for calling the FLEXIO_I2C_MasterInit().

Example:

```
flexio_i2c_master_config_t config;  
FLEXIO_I2C_MasterGetDefaultConfig(&config);
```

Parameters

- masterConfig – Pointer to flexio_i2c_master_config_t structure.

static inline void FLEXIO_I2C_MasterEnable(*FLEXIO_I2C_Type* *base, bool enable)

Enables/disables the FlexIO module operation.

Parameters

- base – Pointer to FLEXIO_I2C_Type structure.
- enable – Pass true to enable module, false does not have any effect.

uint32_t FLEXIO_I2C_MasterGetStatusFlags(*FLEXIO_I2C_Type* *base)

Gets the FlexIO I2C master status flags.

Parameters

- base – Pointer to FLEXIO_I2C_Type structure

Returns

Status flag, use status flag to AND `_flexio_i2c_master_status_flags` can get the related status.

void FLEXIO_I2C_MasterClearStatusFlags(*FLEXIO_I2C_Type* *base, uint32_t mask)

Clears the FlexIO I2C master status flags.

Parameters

- base – Pointer to FLEXIO_I2C_Type structure.
- mask – Status flag. The parameter can be any combination of the following values:
 - kFLEXIO_I2C_RxFullFlag
 - kFLEXIO_I2C_ReceiveNakFlag

void FLEXIO_I2C_MasterEnableInterrupts(*FLEXIO_I2C_Type* *base, uint32_t mask)

Enables the FlexIO i2c master interrupt requests.

Parameters

- base – Pointer to FLEXIO_I2C_Type structure.
- mask – Interrupt source. Currently only one interrupt request source:
 - kFLEXIO_I2C_TransferCompleteInterruptEnable

void FLEXIO_I2C_MasterDisableInterrupts(*FLEXIO_I2C_Type* *base, uint32_t mask)

Disables the FlexIO I2C master interrupt requests.

Parameters

- base – Pointer to FLEXIO_I2C_Type structure.
- mask – Interrupt source.

```
void FLEXIO_I2C_MasterSetBaudRate(FLEXIO_I2C_Type *base, uint32_t baudRate_Bps,  
                                uint32_t srcClock_Hz)
```

Sets the FlexIO I2C master transfer baudrate.

Parameters

- base – Pointer to *FLEXIO_I2C_Type* structure
- baudRate_Bps – the baud rate value in HZ
- srcClock_Hz – source clock in HZ

```
void FLEXIO_I2C_MasterStart(FLEXIO_I2C_Type *base, uint8_t address, flexio_i2c_direction_t  
                           direction)
```

Sends START + 7-bit address to the bus.

Note: This API should be called when the transfer configuration is ready to send a START signal and 7-bit address to the bus. This is a non-blocking API, which returns directly after the address is put into the data register but the address transfer is not finished on the bus. Ensure that the *kFLEXIO_I2C_RxFullFlag* status is asserted before calling this API.

Parameters

- base – Pointer to *FLEXIO_I2C_Type* structure.
- address – 7-bit address.
- direction – transfer direction. This parameter is one of the values in *flexio_i2c_direction_t*:
 - *kFLEXIO_I2C_Write*: Transmit
 - *kFLEXIO_I2C_Read*: Receive

```
void FLEXIO_I2C_MasterStop(FLEXIO_I2C_Type *base)
```

Sends the stop signal on the bus.

Parameters

- base – Pointer to *FLEXIO_I2C_Type* structure.

```
void FLEXIO_I2C_MasterRepeatedStart(FLEXIO_I2C_Type *base)
```

Sends the repeated start signal on the bus.

Parameters

- base – Pointer to *FLEXIO_I2C_Type* structure.

```
void FLEXIO_I2C_MasterAbortStop(FLEXIO_I2C_Type *base)
```

Sends the stop signal when transfer is still on-going.

Parameters

- base – Pointer to *FLEXIO_I2C_Type* structure.

```
void FLEXIO_I2C_MasterEnableAck(FLEXIO_I2C_Type *base, bool enable)
```

Configures the sent ACK/NAK for the following byte.

Parameters

- base – Pointer to *FLEXIO_I2C_Type* structure.
- enable – True to configure send ACK, false configure to send NAK.

status_t FLEXIO_I2C_MasterSetTransferCount(*FLEXIO_I2C_Type* *base, uint16_t count)

Sets the number of bytes to be transferred from a start signal to a stop signal.

Note: Call this API before a transfer begins because the timer generates a number of clocks according to the number of bytes that need to be transferred.

Parameters

- base – Pointer to FLEXIO_I2C_Type structure.
- count – Number of bytes need to be transferred from a start signal to a re-start/stop signal

Return values

- kStatus_Success – Successfully configured the count.
- kStatus_InvalidArgument – Input argument is invalid.

static inline void FLEXIO_I2C_MasterWriteByte(*FLEXIO_I2C_Type* *base, uint32_t data)

Writes one byte of data to the I2C bus.

Note: This is a non-blocking API, which returns directly after the data is put into the data register but the data transfer is not finished on the bus. Ensure that the TxEmptyFlag is asserted before calling this API.

Parameters

- base – Pointer to FLEXIO_I2C_Type structure.
- data – a byte of data.

static inline uint8_t FLEXIO_I2C_MasterReadByte(*FLEXIO_I2C_Type* *base)

Reads one byte of data from the I2C bus.

Note: This is a non-blocking API, which returns directly after the data is read from the data register. Ensure that the data is ready in the register.

Parameters

- base – Pointer to FLEXIO_I2C_Type structure.

Returns

data byte read.

status_t FLEXIO_I2C_MasterWriteBlocking(*FLEXIO_I2C_Type* *base, const uint8_t *txBuff, uint8_t txSize)

Sends a buffer of data in bytes.

Note: This function blocks via polling until all bytes have been sent.

Parameters

- base – Pointer to FLEXIO_I2C_Type structure.
- txBuff – The data bytes to send.
- txSize – The number of data bytes to send.

Return values

- kStatus_Success – Successfully write data.
- kStatus_FLEXIO_I2C_Nak – Receive NAK during writing data.
- kStatus_FLEXIO_I2C_Timeout – Timeout polling status flags.

status_t FLEXIO_I2C_MasterReadBlocking(*FLEXIO_I2C_Type* *base, uint8_t *rxBuff, uint8_t rxSize)

Receives a buffer of bytes.

Note: This function blocks via polling until all bytes have been received.

Parameters

- base – Pointer to FLEXIO_I2C_Type structure.
- rxBuff – The buffer to store the received bytes.
- rxSize – The number of data bytes to be received.

Return values

- kStatus_Success – Successfully read data.
- kStatus_FLEXIO_I2C_Timeout – Timeout polling status flags.

status_t FLEXIO_I2C_MasterTransferBlocking(*FLEXIO_I2C_Type* *base,
flexio_i2c_master_transfer_t *xfer)

Performs a master polling transfer on the I2C bus.

Note: The API does not return until the transfer succeeds or fails due to receiving NAK.

Parameters

- base – pointer to FLEXIO_I2C_Type structure.
- xfer – pointer to flexio_i2c_master_transfer_t structure.

Returns

status of status_t.

status_t FLEXIO_I2C_MasterTransferCreateHandle(*FLEXIO_I2C_Type* *base,
flexio_i2c_master_handle_t *handle,
flexio_i2c_master_transfer_callback_t
callback, void *userData)

Initializes the I2C handle which is used in transactional functions.

Parameters

- base – Pointer to FLEXIO_I2C_Type structure.
- handle – Pointer to flexio_i2c_master_handle_t structure to store the transfer state.
- callback – Pointer to user callback function.
- userData – User param passed to the callback function.

Return values

- kStatus_Success – Successfully create the handle.
- kStatus_OutOfRange – The FlexIO type/handle/isr table out of range.

```
status_t FLEXIO_I2C_MasterTransferNonBlocking(FLEXIO_I2C_Type *base,  
                                              flexio_i2c_master_handle_t *handle,  
                                              flexio_i2c_master_transfer_t *xfer)
```

Performs a master interrupt non-blocking transfer on the I2C bus.

Note: The API returns immediately after the transfer initiates. Call `FLEXIO_I2C_MasterTransferGetCount` to poll the transfer status to check whether the transfer is finished. If the return status is not `kStatus_FLEXIO_I2C_Busy`, the transfer is finished.

Parameters

- base – Pointer to `FLEXIO_I2C_Type` structure
- handle – Pointer to `flexio_i2c_master_handle_t` structure which stores the transfer state
- xfer – pointer to `flexio_i2c_master_transfer_t` structure

Return values

- `kStatus_Success` – Successfully start a transfer.
- `kStatus_FLEXIO_I2C_Busy` – FlexIO I2C is not idle, is running another transfer.

```
status_t FLEXIO_I2C_MasterTransferGetCount(FLEXIO_I2C_Type *base,  
                                           flexio_i2c_master_handle_t *handle, size_t  
                                           *count)
```

Gets the master transfer status during a interrupt non-blocking transfer.

Parameters

- base – Pointer to `FLEXIO_I2C_Type` structure.
- handle – Pointer to `flexio_i2c_master_handle_t` structure which stores the transfer state.
- count – Number of bytes transferred so far by the non-blocking transaction.

Return values

- `kStatus_InvalidArgument` – count is Invalid.
- `kStatus_NoTransferInProgress` – There is not a non-blocking transaction currently in progress.
- `kStatus_Success` – Successfully return the count.

```
void FLEXIO_I2C_MasterTransferAbort(FLEXIO_I2C_Type *base, flexio_i2c_master_handle_t  
                                   *handle)
```

Aborts an interrupt non-blocking transfer early.

Note: This API can be called at any time when an interrupt non-blocking transfer initiates to abort the transfer early.

Parameters

- base – Pointer to `FLEXIO_I2C_Type` structure
- handle – Pointer to `flexio_i2c_master_handle_t` structure which stores the transfer state

void FLEXIO_I2C_MasterTransferHandleIRQ(void *i2cType, void *i2cHandle)

Master interrupt handler.

Parameters

- i2cType – Pointer to FLEXIO_I2C_Type structure
- i2cHandle – Pointer to flexio_i2c_master_transfer_t structure

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FlexIO I2C transfer status.

Values:

enumerator kStatus_FLEXIO_I2C_Busy

I2C is busy doing transfer.

enumerator kStatus_FLEXIO_I2C_Idle

I2C is busy doing transfer.

enumerator kStatus_FLEXIO_I2C_Nak

NAK received during transfer.

enumerator kStatus_FLEXIO_I2C_Timeout

Timeout polling status flags.

enum _flexio_i2c_master_interrupt

Define FlexIO I2C master interrupt mask.

Values:

enumerator kFLEXIO_I2C_TxEmptyInterruptEnable

Tx buffer empty interrupt enable.

enumerator kFLEXIO_I2C_RxFullInterruptEnable

Rx buffer full interrupt enable.

enum _flexio_i2c_master_status_flags

Define FlexIO I2C master status mask.

Values:

enumerator kFLEXIO_I2C_TxEmptyFlag

Tx shifter empty flag.

enumerator kFLEXIO_I2C_RxFullFlag

Rx shifter full/Transfer complete flag.

enumerator kFLEXIO_I2C_ReceiveNakFlag

Receive NAK flag.

enum _flexio_i2c_direction

Direction of master transfer.

Values:

enumerator kFLEXIO_I2C_Write

Master send to slave.

enumerator kFLEXIO_I2C_Read

Master receive from slave.

typedef enum _flexio_i2c_direction flexio_i2c_direction_t

Direction of master transfer.

```
typedef struct _flexio_i2c_type FLEXIO_I2C_Type
    Define FlexIO I2C master access structure typedef.
typedef struct _flexio_i2c_master_config flexio_i2c_master_config_t
    Define FlexIO I2C master user configuration structure.
typedef struct _flexio_i2c_master_transfer flexio_i2c_master_transfer_t
    Define FlexIO I2C master transfer structure.
typedef struct _flexio_i2c_master_handle flexio_i2c_master_handle_t
    FlexIO I2C master handle typedef.
typedef void (*flexio_i2c_master_transfer_callback_t)(FLEXIO_I2C_Type *base,
flexio_i2c_master_handle_t *handle, status_t status, void *userData)
    FlexIO I2C master transfer callback typedef.
I2C_RETRY_TIMES
    Retry times for waiting flag.
struct _flexio_i2c_type
    #include <fsl_flexio_i2c_master.h> Define FlexIO I2C master access structure typedef.
```

Public Members

```
FLEXIO_Type *flexioBase
    FlexIO base pointer.
uint8_t SDAPinIndex
    Pin select for I2C SDA.
uint8_t SCLPinIndex
    Pin select for I2C SCL.
uint8_t shifterIndex[2]
    Shifter index used in FlexIO I2C.
uint8_t timerIndex[3]
    Timer index used in FlexIO I2C.
uint32_t baudrate
    Master transfer baudrate, used to calculate delay time.
struct _flexio_i2c_master_config
    #include <fsl_flexio_i2c_master.h> Define FlexIO I2C master user configuration structure.
```

Public Members

```
bool enableMaster
    Enables the FlexIO I2C peripheral at initialization time.
bool enableInDoze
    Enable/disable FlexIO operation in doze mode.
bool enableInDebug
    Enable/disable FlexIO operation in debug mode.
bool enableFastAccess
    Enable/disable fast access to FlexIO registers, fast access requires the FlexIO clock to
    be at least twice the frequency of the bus clock.
```

uint32_t baudRate_Bps
Baud rate in Bps.

struct _flexio_i2c_master_transfer
#include <fsl_flexio_i2c_master.h> Define FlexIO I2C master transfer structure.

Public Members

uint32_t flags
Transfer flag which controls the transfer, reserved for FlexIO I2C.

uint8_t slaveAddress
7-bit slave address.

flexio_i2c_direction_t direction
Transfer direction, read or write.

uint32_t subaddress
Sub address. Transferred MSB first.

uint8_t subaddressSize
Size of sub address.

uint8_t volatile *data
Transfer buffer.

volatile size_t dataSize
Transfer size.

struct _flexio_i2c_master_handle
#include <fsl_flexio_i2c_master.h> Define FlexIO I2C master handle structure.

Public Members

flexio_i2c_master_transfer_t transfer
FlexIO I2C master transfer copy.

size_t transferSize
Total bytes to be transferred.

uint8_t state
Transfer state maintained during transfer.

flexio_i2c_master_transfer_callback_t completionCallback
Callback function called at transfer event. Callback function called at transfer event.

void *userData
Callback parameter passed to callback function.

bool needRestart
Whether master needs to send re-start signal.

2.17 FlexIO I2S Driver

void FLEXIO_I2S_Init(*FLEXIO_I2S_Type* *base, const *flexio_i2s_config_t* *config)

Initializes the FlexIO I2S.

This API configures FlexIO pins and shifter to I2S and configures the FlexIO I2S with a configuration structure. The configuration structure can be filled by the user, or be set with default values by FLEXIO_I2S_GetDefaultConfig().

Note: This API should be called at the beginning of the application to use the FlexIO I2S driver. Otherwise, any access to the FlexIO I2S module can cause hard fault because the clock is not enabled.

Parameters

- base – FlexIO I2S base pointer
- config – FlexIO I2S configure structure.

void FLEXIO_I2S_GetDefaultConfig(*flexio_i2s_config_t* *config)

Sets the FlexIO I2S configuration structure to default values.

The purpose of this API is to get the configuration structure initialized for use in FLEXIO_I2S_Init(). Users may use the initialized structure unchanged in FLEXIO_I2S_Init() or modify some fields of the structure before calling FLEXIO_I2S_Init().

Parameters

- config – pointer to master configuration structure

void FLEXIO_I2S_Deinit(*FLEXIO_I2S_Type* *base)

De-initializes the FlexIO I2S.

Calling this API resets the FlexIO I2S shifter and timer config. After calling this API, call the FLEXIO_I2S_Init to use the FlexIO I2S module.

Parameters

- base – FlexIO I2S base pointer

static inline void FLEXIO_I2S_Enable(*FLEXIO_I2S_Type* *base, bool enable)

Enables/disables the FlexIO I2S module operation.

Parameters

- base – Pointer to FLEXIO_I2S_Type
- enable – True to enable, false dose not have any effect.

uint32_t FLEXIO_I2S_GetStatusFlags(*FLEXIO_I2S_Type* *base)

Gets the FlexIO I2S status flags.

Parameters

- base – Pointer to FLEXIO_I2S_Type structure

Returns

Status flag, which are ORed by the enumerators in the `_flexio_i2s_status_flags`.

void FLEXIO_I2S_EnableInterrupts(*FLEXIO_I2S_Type* *base, uint32_t mask)

Enables the FlexIO I2S interrupt.

This function enables the FlexIO UART interrupt.

Parameters

- base – Pointer to FLEXIO_I2S_Type structure
- mask – interrupt source

```
void FLEXIO_I2S_DisableInterrupts(FLEXIO_I2S_Type *base, uint32_t mask)
```

Disables the FlexIO I2S interrupt.

This function enables the FlexIO UART interrupt.

Parameters

- base – pointer to *FLEXIO_I2S_Type* structure
- mask – interrupt source

```
static inline void FLEXIO_I2S_TxEnableDMA(FLEXIO_I2S_Type *base, bool enable)
```

Enables/disables the FlexIO I2S Tx DMA requests.

Parameters

- base – FlexIO I2S base pointer
- enable – True means enable DMA, false means disable DMA.

```
static inline void FLEXIO_I2S_RxEnableDMA(FLEXIO_I2S_Type *base, bool enable)
```

Enables/disables the FlexIO I2S Rx DMA requests.

Parameters

- base – FlexIO I2S base pointer
- enable – True means enable DMA, false means disable DMA.

```
static inline uint32_t FLEXIO_I2S_TxGetDataRegisterAddress(FLEXIO_I2S_Type *base)
```

Gets the FlexIO I2S send data register address.

This function returns the I2S data register address, mainly used by DMA/eDMA.

Parameters

- base – Pointer to *FLEXIO_I2S_Type* structure

Returns

FlexIO i2s send data register address.

```
static inline uint32_t FLEXIO_I2S_RxGetDataRegisterAddress(FLEXIO_I2S_Type *base)
```

Gets the FlexIO I2S receive data register address.

This function returns the I2S data register address, mainly used by DMA/eDMA.

Parameters

- base – Pointer to *FLEXIO_I2S_Type* structure

Returns

FlexIO i2s receive data register address.

```
void FLEXIO_I2S_MasterSetFormat(FLEXIO_I2S_Type *base, flexio_i2s_format_t *format,  
                                uint32_t srcClock_Hz)
```

Configures the FlexIO I2S audio format in master mode.

Audio format can be changed in run-time of FlexIO I2S. This function configures the sample rate and audio data format to be transferred.

Parameters

- base – Pointer to *FLEXIO_I2S_Type* structure
- format – Pointer to FlexIO I2S audio data format structure.
- srcClock_Hz – I2S master clock source frequency in Hz.

```
void FLEXIO_I2S_SlaveSetFormat(FLEXIO_I2S_Type *base, flexio_i2s_format_t *format)
```

Configures the FlexIO I2S audio format in slave mode.

Audio format can be changed in run-time of FlexIO I2S. This function configures the sample rate and audio data format to be transferred.

Parameters

- base – Pointer to *FLEXIO_I2S_Type* structure
- format – Pointer to FlexIO I2S audio data format structure.

```
status_t FLEXIO_I2S_WriteBlocking(FLEXIO_I2S_Type *base, uint8_t bitWidth, uint8_t *txData,  
                                size_t size)
```

Sends data using a blocking method.

Note: This function blocks via polling until data is ready to be sent.

Parameters

- base – FlexIO I2S base pointer.
- bitWidth – How many bits in a audio word, usually 8/16/24/32 bits.
- txData – Pointer to the data to be written.
- size – Bytes to be written.

Return values

- kStatus_Success – Successfully write data.
- kStatus_FLEXIO_I2C_Timeout – Timeout polling status flags.

```
static inline void FLEXIO_I2S_WriteData(FLEXIO_I2S_Type *base, uint8_t bitWidth, uint32_t  
                                       data)
```

Writes data into a data register.

Parameters

- base – FlexIO I2S base pointer.
- bitWidth – How many bits in a audio word, usually 8/16/24/32 bits.
- data – Data to be written.

```
status_t FLEXIO_I2S_ReadBlocking(FLEXIO_I2S_Type *base, uint8_t bitWidth, uint8_t *rxData,  
                                size_t size)
```

Receives a piece of data using a blocking method.

Note: This function blocks via polling until data is ready to be sent.

Parameters

- base – FlexIO I2S base pointer
- bitWidth – How many bits in a audio word, usually 8/16/24/32 bits.
- rxData – Pointer to the data to be read.
- size – Bytes to be read.

Return values

- kStatus_Success – Successfully read data.

- `kStatus_FLEXIO_I2C_Timeout` – Timeout polling status flags.

`static inline uint32_t FLEXIO_I2S_ReadData(FLEXIO_I2S_Type *base)`

Reads a data from the data register.

Parameters

- `base` – FlexIO I2S base pointer

Returns

Data read from data register.

`void FLEXIO_I2S_TransferTxCreateHandle(FLEXIO_I2S_Type *base, flexio_i2s_handle_t *handle, flexio_i2s_callback_t callback, void *userData)`

Initializes the FlexIO I2S handle.

This function initializes the FlexIO I2S handle which can be used for other FlexIO I2S transactional APIs. Call this API once to get the initialized handle.

Parameters

- `base` – Pointer to `FLEXIO_I2S_Type` structure
- `handle` – Pointer to `flexio_i2s_handle_t` structure to store the transfer state.
- `callback` – FlexIO I2S callback function, which is called while finished a block.
- `userData` – User parameter for the FlexIO I2S callback.

`void FLEXIO_I2S_TransferSetFormat(FLEXIO_I2S_Type *base, flexio_i2s_handle_t *handle, flexio_i2s_format_t *format, uint32_t srcClock_Hz)`

Configures the FlexIO I2S audio format.

Audio format can be changed at run-time of FlexIO I2S. This function configures the sample rate and audio data format to be transferred.

Parameters

- `base` – Pointer to `FLEXIO_I2S_Type` structure.
- `handle` – FlexIO I2S handle pointer.
- `format` – Pointer to audio data format structure.
- `srcClock_Hz` – FlexIO I2S bit clock source frequency in Hz. This parameter should be 0 while in slave mode.

`void FLEXIO_I2S_TransferRxCreateHandle(FLEXIO_I2S_Type *base, flexio_i2s_handle_t *handle, flexio_i2s_callback_t callback, void *userData)`

Initializes the FlexIO I2S receive handle.

This function initializes the FlexIO I2S handle which can be used for other FlexIO I2S transactional APIs. Call this API once to get the initialized handle.

Parameters

- `base` – Pointer to `FLEXIO_I2S_Type` structure.
- `handle` – Pointer to `flexio_i2s_handle_t` structure to store the transfer state.
- `callback` – FlexIO I2S callback function, which is called while finished a block.
- `userData` – User parameter for the FlexIO I2S callback.

status_t FLEXIO_I2S_TransferSendNonBlocking(*FLEXIO_I2S_Type* *base, *flexio_i2s_handle_t* *handle, *flexio_i2s_transfer_t* *xfer)

Performs an interrupt non-blocking send transfer on FlexIO I2S.

Note: The API returns immediately after transfer initiates. Call FLEXIO_I2S_GetRemainingBytes to poll the transfer status and check whether the transfer is finished. If the return status is 0, the transfer is finished.

Parameters

- base – Pointer to FLEXIO_I2S_Type structure.
- handle – Pointer to flexio_i2s_handle_t structure which stores the transfer state
- xfer – Pointer to flexio_i2s_transfer_t structure

Return values

- kStatus_Success – Successfully start the data transmission.
- kStatus_FLEXIO_I2S_TxBusy – Previous transmission still not finished, data not all written to TX register yet.
- kStatus_InvalidArgument – The input parameter is invalid.

status_t FLEXIO_I2S_TransferReceiveNonBlocking(*FLEXIO_I2S_Type* *base, *flexio_i2s_handle_t* *handle, *flexio_i2s_transfer_t* *xfer)

Performs an interrupt non-blocking receive transfer on FlexIO I2S.

Note: The API returns immediately after transfer initiates. Call FLEXIO_I2S_GetRemainingBytes to poll the transfer status to check whether the transfer is finished. If the return status is 0, the transfer is finished.

Parameters

- base – Pointer to FLEXIO_I2S_Type structure.
- handle – Pointer to flexio_i2s_handle_t structure which stores the transfer state
- xfer – Pointer to flexio_i2s_transfer_t structure

Return values

- kStatus_Success – Successfully start the data receive.
- kStatus_FLEXIO_I2S_RxBusy – Previous receive still not finished.
- kStatus_InvalidArgument – The input parameter is invalid.

void FLEXIO_I2S_TransferAbortSend(*FLEXIO_I2S_Type* *base, *flexio_i2s_handle_t* *handle)

Aborts the current send.

Note: This API can be called at any time when interrupt non-blocking transfer initiates to abort the transfer in a early time.

Parameters

- base – Pointer to FLEXIO_I2S_Type structure.

- handle – Pointer to flexio_i2s_handle_t structure which stores the transfer state

void FLEXIO_I2S_TransferAbortReceive(*FLEXIO_I2S_Type* *base, *flexio_i2s_handle_t* *handle)
Aborts the current receive.

Note: This API can be called at any time when interrupt non-blocking transfer initiates to abort the transfer in a early time.

Parameters

- base – Pointer to FLEXIO_I2S_Type structure.
- handle – Pointer to flexio_i2s_handle_t structure which stores the transfer state

status_t FLEXIO_I2S_TransferGetSendCount(*FLEXIO_I2S_Type* *base, *flexio_i2s_handle_t* *handle, *size_t* *count)

Gets the remaining bytes to be sent.

Parameters

- base – Pointer to FLEXIO_I2S_Type structure.
- handle – Pointer to flexio_i2s_handle_t structure which stores the transfer state
- count – Bytes sent.

Return values

- kStatus_Success – Succeed get the transfer count.
- kStatus_NoTransferInProgress – There is not a non-blocking transaction currently in progress.

status_t FLEXIO_I2S_TransferGetReceiveCount(*FLEXIO_I2S_Type* *base, *flexio_i2s_handle_t* *handle, *size_t* *count)

Gets the remaining bytes to be received.

Parameters

- base – Pointer to FLEXIO_I2S_Type structure.
- handle – Pointer to flexio_i2s_handle_t structure which stores the transfer state
- count – Bytes recieved.

Return values

- kStatus_Success – Succeed get the transfer count.
- kStatus_NoTransferInProgress – There is not a non-blocking transaction currently in progress.

Returns

count Bytes received.

void FLEXIO_I2S_TransferTxHandleIRQ(void *i2sBase, void *i2sHandle)

Tx interrupt handler.

Parameters

- i2sBase – Pointer to FLEXIO_I2S_Type structure.
- i2sHandle – Pointer to flexio_i2s_handle_t structure

void FLEXIO_I2S_TransferRxHandleIRQ(void *i2sBase, void *i2sHandle)

Rx interrupt handler.

Parameters

- i2sBase – Pointer to FLEXIO_I2S_Type structure.
- i2sHandle – Pointer to flexio_i2s_handle_t structure.

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FlexIO I2S transfer status.

Values:

enumerator kStatus_FLEXIO_I2S_Idle

FlexIO I2S is in idle state

enumerator kStatus_FLEXIO_I2S_TxBusy

FlexIO I2S Tx is busy

enumerator kStatus_FLEXIO_I2S_RxBusy

FlexIO I2S Rx is busy

enumerator kStatus_FLEXIO_I2S_Error

FlexIO I2S error occurred

enumerator kStatus_FLEXIO_I2S_QueueFull

FlexIO I2S transfer queue is full.

enumerator kStatus_FLEXIO_I2S_Timeout

FlexIO I2S timeout polling status flags.

enum flexio_i2s_master_slave

Master or slave mode.

Values:

enumerator kFLEXIO_I2S_Master

Master mode

enumerator kFLEXIO_I2S_Slave

Slave mode

_flexio_i2s_interrupt_enable Define FlexIO FlexIO I2S interrupt mask.

Values:

enumerator kFLEXIO_I2S_TxDataRegEmptyInterruptEnable

Transmit buffer empty interrupt enable.

enumerator kFLEXIO_I2S_RxDataRegFullInterruptEnable

Receive buffer full interrupt enable.

_flexio_i2s_status_flags Define FlexIO FlexIO I2S status mask.

Values:

enumerator kFLEXIO_I2S_TxDataRegEmptyFlag

Transmit buffer empty flag.

enumerator kFLEXIO_I2S_RxDataRegFullFlag
Receive buffer full flag.

enum _flexio_i2s_sample_rate
Audio sample rate.

Values:

enumerator kFLEXIO_I2S_SampleRate8KHz
Sample rate 8000Hz

enumerator kFLEXIO_I2S_SampleRate11025Hz
Sample rate 11025Hz

enumerator kFLEXIO_I2S_SampleRate12KHz
Sample rate 12000Hz

enumerator kFLEXIO_I2S_SampleRate16KHz
Sample rate 16000Hz

enumerator kFLEXIO_I2S_SampleRate22050Hz
Sample rate 22050Hz

enumerator kFLEXIO_I2S_SampleRate24KHz
Sample rate 24000Hz

enumerator kFLEXIO_I2S_SampleRate32KHz
Sample rate 32000Hz

enumerator kFLEXIO_I2S_SampleRate44100Hz
Sample rate 44100Hz

enumerator kFLEXIO_I2S_SampleRate48KHz
Sample rate 48000Hz

enumerator kFLEXIO_I2S_SampleRate96KHz
Sample rate 96000Hz

enum _flexio_i2s_word_width
Audio word width.

Values:

enumerator kFLEXIO_I2S_WordWidth8bits
Audio data width 8 bits

enumerator kFLEXIO_I2S_WordWidth16bits
Audio data width 16 bits

enumerator kFLEXIO_I2S_WordWidth24bits
Audio data width 24 bits

enumerator kFLEXIO_I2S_WordWidth32bits
Audio data width 32 bits

typedef struct _flexio_i2s_type FLEXIO_I2S_Type
Define FlexIO I2S access structure typedef.

typedef enum _flexio_i2s_master_slave flexio_i2s_master_slave_t
Master or slave mode.

typedef struct _flexio_i2s_config flexio_i2s_config_t
FlexIO I2S configure structure.

```
typedef struct _flexio_i2s_format flexio_i2s_format_t
    FlexIO I2S audio format, FlexIO I2S only support the same format in Tx and Rx.
typedef enum _flexio_i2s_sample_rate flexio_i2s_sample_rate_t
    Audio sample rate.
typedef enum _flexio_i2s_word_width flexio_i2s_word_width_t
    Audio word width.
typedef struct _flexio_i2s_transfer flexio_i2s_transfer_t
    Define FlexIO I2S transfer structure.
typedef struct _flexio_i2s_handle flexio_i2s_handle_t
typedef void (*flexio_i2s_callback_t)(FLEXIO_I2S_Type *base, flexio_i2s_handle_t *handle,
status_t status, void *userData)
    FlexIO I2S xfer callback prototype.
I2S__RETRY_TIMES
    Retry times for waiting flag.
FLEXIO_I2S_XFER_QUEUE_SIZE
    FlexIO I2S transfer queue size, user can refine it according to use case.
struct _flexio_i2s_type
    #include <fsl_flexio_i2s.h> Define FlexIO I2S access structure typedef.
```

Public Members

```
FLEXIO_Type *flexioBase
    FlexIO base pointer
uint8_t txPinIndex
    Tx data pin index in FlexIO pins
uint8_t rxPinIndex
    Rx data pin index
uint8_t bclkPinIndex
    Bit clock pin index
uint8_t fsPinIndex
    Frame sync pin index
uint8_t txShifterIndex
    Tx data shifter index
uint8_t rxShifterIndex
    Rx data shifter index
uint8_t bclkTimerIndex
    Bit clock timer index
uint8_t fsTimerIndex
    Frame sync timer index
struct _flexio_i2s_config
    #include <fsl_flexio_i2s.h> FlexIO I2S configure structure.
```

Public Members

bool enableI2S

Enable FlexIO I2S

flexio_i2s_master_slave_t masterSlave

Master or slave

flexio_pin_polarity_t txPinPolarity

Tx data pin polarity, active high or low

flexio_pin_polarity_t rxPinPolarity

Rx data pin polarity

flexio_pin_polarity_t bclkPinPolarity

Bit clock pin polarity

flexio_pin_polarity_t fsPinPolarity

Frame sync pin polarity

flexio_shifter_timer_polarity_t txTimerPolarity

Tx data valid on bclk rising or falling edge

flexio_shifter_timer_polarity_t rxTimerPolarity

Rx data valid on bclk rising or falling edge

struct *_flexio_i2s_format*

#include <fsl_flexio_i2s.h> FlexIO I2S audio format, FlexIO I2S only support the same format in Tx and Rx.

Public Members

uint8_t bitWidth

Bit width of audio data, always 8/16/24/32 bits

uint32_t sampleRate_Hz

Sample rate of the audio data

struct *_flexio_i2s_transfer*

#include <fsl_flexio_i2s.h> Define FlexIO I2S transfer structure.

Public Members

uint8_t *data

Data buffer start pointer

size_t dataSize

Bytes to be transferred.

struct *_flexio_i2s_handle*

#include <fsl_flexio_i2s.h> Define FlexIO I2S handle structure.

Public Members

uint32_t state

Internal state

flexio_i2s_callback_t callback

Callback function called at transfer event

`void *userData`
 Callback parameter passed to callback function

`uint8_t bitWidth`
 Bit width for transfer, 8/16/24/32bits

`flexio_i2s_transfer_t queue[(4U)]`
 Transfer queue storing queued transfer

`size_t transferSize[(4U)]`
 Data bytes need to transfer

`volatile uint8_t queueUser`
 Index for user to queue transfer

`volatile uint8_t queueDriver`
 Index for driver to get the transfer data and size

2.18 FlexIO SPI Driver

`void FLEXIO_SPI_MasterInit(FLEXIO_SPI_Type *base, flexio_spi_master_config_t *masterConfig, uint32_t srcClock_Hz)`

Ungates the FlexIO clock, resets the FlexIO module, configures the FlexIO SPI master hardware, and configures the FlexIO SPI with FlexIO SPI master configuration. The configuration structure can be filled by the user, or be set with default values by the `FLEXIO_SPI_MasterGetDefaultConfig()`.

Example

```
FLEXIO_SPI_Type spiDev = {
    .flexioBase = FLEXIO,
    .SDOPinIndex = 0,
    .SDIPinIndex = 1,
    .SCKPinIndex = 2,
    .CSnPinIndex = 3,
    .shifterIndex = {0,1},
    .timerIndex = {0,1}
};
flexio_spi_master_config_t config = {
    .enableMaster = true,
    .enableInDoze = false,
    .enableInDebug = true,
    .enableFastAccess = false,
    .baudRate_Bps = 500000,
    .phase = kFLEXIO_SPI_ClockPhaseFirstEdge,
    .direction = kFLEXIO_SPI_MsbFirst,
    .dataMode = kFLEXIO_SPI_8BitMode
};
FLEXIO_SPI_MasterInit(&spiDev, &config, srcClock_Hz);
```

Note: 1.FlexIO SPI master only support CPOL = 0, which means clock inactive low. 2.For FlexIO SPI master, the input valid time is 1.5 clock cycles, for slave the output valid time is 2.5 clock cycles. So if FlexIO SPI master communicates with other spi IPs, the maximum baud rate is FlexIO clock frequency divided by 2*2=4. If FlexIO SPI master communicates with FlexIO SPI slave, the maximum baud rate is FlexIO clock frequency divided by (1.5+2.5)*2=8.

Parameters

- base – Pointer to the FLEXIO_SPI_Type structure.
- masterConfig – Pointer to the flexio_spi_master_config_t structure.
- srcClock_Hz – FlexIO source clock in Hz.

void FLEXIO_SPI_MasterDeinit(*FLEXIO_SPI_Type* *base)

Resets the FlexIO SPI timer and shifter config.

Parameters

- base – Pointer to the FLEXIO_SPI_Type.

void FLEXIO_SPI_MasterGetDefaultConfig(*flexio_spi_master_config_t* *masterConfig)

Gets the default configuration to configure the FlexIO SPI master. The configuration can be used directly by calling the FLEXIO_SPI_MasterConfigure(). Example:

```
flexio_spi_master_config_t masterConfig;
FLEXIO_SPI_MasterGetDefaultConfig(&masterConfig);
```

Parameters

- masterConfig – Pointer to the flexio_spi_master_config_t structure.

void FLEXIO_SPI_SlaveInit(*FLEXIO_SPI_Type* *base, *flexio_spi_slave_config_t* *slaveConfig)

Ungates the FlexIO clock, resets the FlexIO module, configures the FlexIO SPI slave hardware configuration, and configures the FlexIO SPI with FlexIO SPI slave configuration. The configuration structure can be filled by the user, or be set with default values by the FLEXIO_SPI_SlaveGetDefaultConfig().

Note: 1. Only one timer is needed in the FlexIO SPI slave. As a result, the second timer index is ignored. 2. FlexIO SPI slave only support CPOL = 0, which means clock inactive low. 3. For FlexIO SPI master, the input valid time is 1.5 clock cycles, for slave the output valid time is 2.5 clock cycles. So if FlexIO SPI slave communicates with other spi IPs, the maximum baud rate is FlexIO clock frequency divided by $3 \times 2 = 6$. If FlexIO SPI slave communicates with FlexIO SPI master, the maximum baud rate is FlexIO clock frequency divided by $(1.5 + 2.5) \times 2 = 8$. Example

```
FLEXIO_SPI_Type spiDev = {
    .flexioBase = FLEXIO,
    .SDOPinIndex = 0,
    .SDIPinIndex = 1,
    .SCKPinIndex = 2,
    .CSnPinIndex = 3,
    .shifterIndex = {0,1},
    .timerIndex = {0}
};
flexio_spi_slave_config_t config = {
    .enableSlave = true,
    .enableInDoze = false,
    .enableInDebug = true,
    .enableFastAccess = false,
    .phase = kFLEXIO_SPI_ClockPhaseFirstEdge,
    .direction = kFLEXIO_SPI_MsbFirst,
    .dataMode = kFLEXIO_SPI_8BitMode
};
FLEXIO_SPI_SlaveInit(&spiDev, &config);
```

Parameters

- base – Pointer to the FLEXIO_SPI_Type structure.
- slaveConfig – Pointer to the flexio_spi_slave_config_t structure.

void FLEXIO_SPI_SlaveDeinit(*FLEXIO_SPI_Type* *base)

Gates the FlexIO clock.

Parameters

- base – Pointer to the FLEXIO_SPI_Type.

void FLEXIO_SPI_SlaveGetDefaultConfig(*flexio_spi_slave_config_t* *slaveConfig)

Gets the default configuration to configure the FlexIO SPI slave. The configuration can be used directly for calling the FLEXIO_SPI_SlaveConfigure(). Example:

```
flexio_spi_slave_config_t slaveConfig;  
FLEXIO_SPI_SlaveGetDefaultConfig(&slaveConfig);
```

Parameters

- slaveConfig – Pointer to the flexio_spi_slave_config_t structure.

uint32_t FLEXIO_SPI_GetStatusFlags(*FLEXIO_SPI_Type* *base)

Gets FlexIO SPI status flags.

Parameters

- base – Pointer to the FLEXIO_SPI_Type structure.

Returns

status flag; Use the status flag to AND the following flag mask and get the status.

- kFLEXIO_SPI_TxEmptyFlag
- kFLEXIO_SPI_RxEmptyFlag

void FLEXIO_SPI_ClearStatusFlags(*FLEXIO_SPI_Type* *base, uint32_t mask)

Clears FlexIO SPI status flags.

Parameters

- base – Pointer to the FLEXIO_SPI_Type structure.
- mask – status flag The parameter can be any combination of the following values:
 - kFLEXIO_SPI_TxEmptyFlag
 - kFLEXIO_SPI_RxEmptyFlag

void FLEXIO_SPI_EnableInterrupts(*FLEXIO_SPI_Type* *base, uint32_t mask)

Enables the FlexIO SPI interrupt.

This function enables the FlexIO SPI interrupt.

Parameters

- base – Pointer to the FLEXIO_SPI_Type structure.
- mask – interrupt source. The parameter can be any combination of the following values:
 - kFLEXIO_SPI_RxFullInterruptEnable
 - kFLEXIO_SPI_TxEmptyInterruptEnable

```
void FLEXIO_SPI_DisableInterrupts(FLEXIO_SPI_Type *base, uint32_t mask)
```

Disables the FlexIO SPI interrupt.

This function disables the FlexIO SPI interrupt.

Parameters

- base – Pointer to the *FLEXIO_SPI_Type* structure.
- mask – interrupt source The parameter can be any combination of the following values:
 - kFLEXIO_SPI_RxFullInterruptEnable
 - kFLEXIO_SPI_TxEmptyInterruptEnable

```
void FLEXIO_SPI_EnableDMA(FLEXIO_SPI_Type *base, uint32_t mask, bool enable)
```

Enables/disables the FlexIO SPI transmit DMA. This function enables/disables the FlexIO SPI Tx DMA, which means that asserting the kFLEXIO_SPI_TxEmptyFlag does/doesn't trigger the DMA request.

Parameters

- base – Pointer to the *FLEXIO_SPI_Type* structure.
- mask – SPI DMA source.
- enable – True means enable DMA, false means disable DMA.

```
static inline uint32_t FLEXIO_SPI_GetTxDataRegisterAddress(FLEXIO_SPI_Type *base,  
                                                         flexio_spi_shift_direction_t  
                                                         direction)
```

Gets the FlexIO SPI transmit data register address for MSB first transfer.

This function returns the SPI data register address, which is mainly used by DMA/eDMA.

Parameters

- base – Pointer to the *FLEXIO_SPI_Type* structure.
- direction – Shift direction of MSB first or LSB first.

Returns

FlexIO SPI transmit data register address.

```
static inline uint32_t FLEXIO_SPI_GetRxDataRegisterAddress(FLEXIO_SPI_Type *base,  
                                                         flexio_spi_shift_direction_t  
                                                         direction)
```

Gets the FlexIO SPI receive data register address for the MSB first transfer.

This function returns the SPI data register address, which is mainly used by DMA/eDMA.

Parameters

- base – Pointer to the *FLEXIO_SPI_Type* structure.
- direction – Shift direction of MSB first or LSB first.

Returns

FlexIO SPI receive data register address.

```
static inline void FLEXIO_SPI_Enable(FLEXIO_SPI_Type *base, bool enable)
```

Enables/disables the FlexIO SPI module operation.

Parameters

- base – Pointer to the *FLEXIO_SPI_Type*.
- enable – True to enable, false does not have any effect.

```
void FLEXIO_SPI_MasterSetBaudRate(FLEXIO_SPI_Type *base, uint32_t baudRate_Bps,  
                                uint32_t srcClockHz)
```

Sets baud rate for the FlexIO SPI transfer, which is only used for the master.

Parameters

- base – Pointer to the *FLEXIO_SPI_Type* structure.
- baudRate_Bps – Baud Rate needed in Hz.
- srcClockHz – SPI source clock frequency in Hz.

```
static inline void FLEXIO_SPI_WriteData(FLEXIO_SPI_Type *base, flexio_spi_shift_direction_t  
                                       direction, uint32_t data)
```

Writes one byte of data, which is sent using the MSB method.

Note: This is a non-blocking API, which returns directly after the data is put into the data register but the data transfer is not finished on the bus. Ensure that the TxEmptyFlag is asserted before calling this API.

Parameters

- base – Pointer to the *FLEXIO_SPI_Type* structure.
- direction – Shift direction of MSB first or LSB first.
- data – 8/16/32 bit data.

```
static inline uint32_t FLEXIO_SPI_ReadData(FLEXIO_SPI_Type *base,  
                                           flexio_spi_shift_direction_t direction)
```

Reads 8 bit/16 bit data.

Note: This is a non-blocking API, which returns directly after the data is read from the data register. Ensure that the RxFullFlag is asserted before calling this API.

Parameters

- base – Pointer to the *FLEXIO_SPI_Type* structure.
- direction – Shift direction of MSB first or LSB first.

Returns

8 bit/16 bit data received.

```
status_t FLEXIO_SPI_WriteBlocking(FLEXIO_SPI_Type *base, flexio_spi_shift_direction_t  
                                  direction, const uint8_t *buffer, size_t size)
```

Sends a buffer of data bytes.

Note: This function blocks using the polling method until all bytes have been sent.

Parameters

- base – Pointer to the *FLEXIO_SPI_Type* structure.
- direction – Shift direction of MSB first or LSB first.
- buffer – The data bytes to send.
- size – The number of data bytes to send.

Return values

- kStatus_Success – Successfully create the handle.
- kStatus_FLEXIO_SPI_Timeout – The transfer timed out and was aborted.

status_t FLEXIO_SPI_ReadBlocking(*FLEXIO_SPI_Type* *base, *flexio_spi_shift_direction_t* direction, *uint8_t* *buffer, *size_t* size)

Receives a buffer of bytes.

Note: This function blocks using the polling method until all bytes have been received.

Parameters

- base – Pointer to the FLEXIO_SPI_Type structure.
- direction – Shift direction of MSB first or LSB first.
- buffer – The buffer to store the received bytes.
- size – The number of data bytes to be received.

Return values

- kStatus_Success – Successfully create the handle.
- kStatus_FLEXIO_SPI_Timeout – The transfer timed out and was aborted.

status_t FLEXIO_SPI_MasterTransferBlocking(*FLEXIO_SPI_Type* *base, *flexio_spi_transfer_t* *xfer)

Receives a buffer of bytes.

Note: This function blocks via polling until all bytes have been received.

Parameters

- base – pointer to FLEXIO_SPI_Type structure
- xfer – FlexIO SPI transfer structure, see flexio_spi_transfer_t.

Return values

- kStatus_Success – Successfully create the handle.
- kStatus_FLEXIO_SPI_Timeout – The transfer timed out and was aborted.

void FLEXIO_SPI_FlushShifters(*FLEXIO_SPI_Type* *base)

Flush tx/rx shifters.

Parameters

- base – Pointer to the FLEXIO_SPI_Type structure.

status_t FLEXIO_SPI_MasterTransferCreateHandle(*FLEXIO_SPI_Type* *base, *flexio_spi_master_handle_t* *handle, *flexio_spi_master_transfer_callback_t* callback, *void* *userData)

Initializes the FlexIO SPI Master handle, which is used in transactional functions.

Parameters

- base – Pointer to the FLEXIO_SPI_Type structure.
- handle – Pointer to the flexio_spi_master_handle_t structure to store the transfer state.
- callback – The callback function.

- `userData` – The parameter of the callback function.

Return values

- `kStatus_Success` – Successfully create the handle.
- `kStatus_OutOfRange` – The FlexIO type/handle/ISR table out of range.

`status_t` FLEXIO_SPI_MasterTransferNonBlocking(*FLEXIO_SPI_Type* *base,
 flexio_spi_master_handle_t *handle,
 flexio_spi_transfer_t *xfer)

Master transfer data using IRQ.

This function sends data using IRQ. This is a non-blocking function, which returns right away. When all data is sent out/received, the callback function is called.

Parameters

- `base` – Pointer to the `FLEXIO_SPI_Type` structure.
- `handle` – Pointer to the `flexio_spi_master_handle_t` structure to store the transfer state.
- `xfer` – FlexIO SPI transfer structure. See `flexio_spi_transfer_t`.

Return values

- `kStatus_Success` – Successfully start a transfer.
- `kStatus_InvalidArgument` – Input argument is invalid.
- `kStatus_FLEXIO_SPI_Busy` – SPI is not idle, is running another transfer.

`void` FLEXIO_SPI_MasterTransferAbort(*FLEXIO_SPI_Type* *base, *flexio_spi_master_handle_t*
 *handle)

Aborts the master data transfer, which used IRQ.

Parameters

- `base` – Pointer to the `FLEXIO_SPI_Type` structure.
- `handle` – Pointer to the `flexio_spi_master_handle_t` structure to store the transfer state.

`status_t` FLEXIO_SPI_MasterTransferGetCount(*FLEXIO_SPI_Type* *base,
 flexio_spi_master_handle_t *handle, *size_t*
 *count)

Gets the data transfer status which used IRQ.

Parameters

- `base` – Pointer to the `FLEXIO_SPI_Type` structure.
- `handle` – Pointer to the `flexio_spi_master_handle_t` structure to store the transfer state.
- `count` – Number of bytes transferred so far by the non-blocking transaction.

Return values

- `kStatus_InvalidArgument` – count is Invalid.
- `kStatus_Success` – Successfully return the count.

`void` FLEXIO_SPI_MasterTransferHandleIRQ(*void* *spiType, *void* *spiHandle)

FlexIO SPI master IRQ handler function.

Parameters

- `spiType` – Pointer to the `FLEXIO_SPI_Type` structure.

- spiHandle – Pointer to the flexio_spi_master_handle_t structure to store the transfer state.

```
status_t FLEXIO_SPI_SlaveTransferCreateHandle(FLEXIO_SPI_Type *base,
                                              flexio_spi_slave_handle_t *handle,
                                              flexio_spi_slave_transfer_callback_t callback,
                                              void *userData)
```

Initializes the FlexIO SPI Slave handle, which is used in transactional functions.

Parameters

- base – Pointer to the FLEXIO_SPI_Type structure.
- handle – Pointer to the flexio_spi_slave_handle_t structure to store the transfer state.
- callback – The callback function.
- userData – The parameter of the callback function.

Return values

- kStatus__Success – Successfully create the handle.
- kStatus__OutOfRange – The FlexIO type/handle/ISR table out of range.

```
status_t FLEXIO_SPI_SlaveTransferNonBlocking(FLEXIO_SPI_Type *base,
                                              flexio_spi_slave_handle_t *handle,
                                              flexio_spi_transfer_t *xfer)
```

Slave transfer data using IRQ.

This function sends data using IRQ. This is a non-blocking function, which returns right away. When all data is sent out/received, the callback function is called.

Parameters

- handle – Pointer to the flexio_spi_slave_handle_t structure to store the transfer state.
- base – Pointer to the FLEXIO_SPI_Type structure.
- xfer – FlexIO SPI transfer structure. See flexio_spi_transfer_t.

Return values

- kStatus__Success – Successfully start a transfer.
- kStatus__InvalidArgument – Input argument is invalid.
- kStatus__FLEXIO_SPI_Busy – SPI is not idle; it is running another transfer.

```
static inline void FLEXIO_SPI_SlaveTransferAbort(FLEXIO_SPI_Type *base,
                                                flexio_spi_slave_handle_t *handle)
```

Aborts the slave data transfer which used IRQ, share same API with master.

Parameters

- base – Pointer to the FLEXIO_SPI_Type structure.
- handle – Pointer to the flexio_spi_slave_handle_t structure to store the transfer state.

```
static inline status_t FLEXIO_SPI_SlaveTransferGetCount(FLEXIO_SPI_Type *base,
                                                        flexio_spi_slave_handle_t *handle,
                                                        size_t *count)
```

Gets the data transfer status which used IRQ, share same API with master.

Parameters

- base – Pointer to the FLEXIO_SPI_Type structure.

- `handle` – Pointer to the `flexio_spi_slave_handle_t` structure to store the transfer state.
- `count` – Number of bytes transferred so far by the non-blocking transaction.

Return values

- `kStatus_InvalidArgument` – `count` is Invalid.
- `kStatus_Success` – Successfully return the count.

`void FLEXIO_SPI_SlaveTransferHandleIRQ(void *spiType, void *spiHandle)`

FlexIO SPI slave IRQ handler function.

Parameters

- `spiType` – Pointer to the `FLEXIO_SPI_Type` structure.
- `spiHandle` – Pointer to the `flexio_spi_slave_handle_t` structure to store the transfer state.

`FSL_FLEXIO_SPI_DRIVER_VERSION`

FlexIO SPI driver version.

Error codes for the FlexIO SPI driver.

Values:

enumerator `kStatus_FLEXIO_SPI_Busy`

FlexIO SPI is busy.

enumerator `kStatus_FLEXIO_SPI_Idle`

SPI is idle

enumerator `kStatus_FLEXIO_SPI_Error`

FlexIO SPI error.

enumerator `kStatus_FLEXIO_SPI_Timeout`

FlexIO SPI timeout polling status flags.

enum `_flexio_spi_clock_phase`

FlexIO SPI clock phase configuration.

Values:

enumerator `kFLEXIO_SPI_ClockPhaseFirstEdge`

First edge on SPSCCK occurs at the middle of the first cycle of a data transfer.

enumerator `kFLEXIO_SPI_ClockPhaseSecondEdge`

First edge on SPSCCK occurs at the start of the first cycle of a data transfer.

enum `_flexio_spi_shift_direction`

FlexIO SPI data shifter direction options.

Values:

enumerator `kFLEXIO_SPI_MsbFirst`

Data transfers start with most significant bit.

enumerator `kFLEXIO_SPI_LsbFirst`

Data transfers start with least significant bit.

enum `_flexio_spi_data_bitcount_mode`

FlexIO SPI data length mode options.

Values:

enumerator kFLEXIO_SPI_8BitMode
8-bit data transmission mode.

enumerator kFLEXIO_SPI_16BitMode
16-bit data transmission mode.

enumerator kFLEXIO_SPI_32BitMode
32-bit data transmission mode.

enum _flexio_spi_interrupt_enable
Define FlexIO SPI interrupt mask.

Values:

enumerator kFLEXIO_SPI_TxEmptyInterruptEnable
Transmit buffer empty interrupt enable.

enumerator kFLEXIO_SPI_RxFullInterruptEnable
Receive buffer full interrupt enable.

enum _flexio_spi_status_flags
Define FlexIO SPI status mask.

Values:

enumerator kFLEXIO_SPI_TxBufferEmptyFlag
Transmit buffer empty flag.

enumerator kFLEXIO_SPI_RxBufferFullFlag
Receive buffer full flag.

enum _flexio_spi_dma_enable
Define FlexIO SPI DMA mask.

Values:

enumerator kFLEXIO_SPI_TxDmaEnable
Tx DMA request source

enumerator kFLEXIO_SPI_RxDmaEnable
Rx DMA request source

enumerator kFLEXIO_SPI_DmaAllEnable
All DMA request source

enum _flexio_spi_transfer_flags
Define FlexIO SPI transfer flags.

Note: Use kFLEXIO_SPI_csContinuous and one of the other flags to OR together to form the transfer flag.

Values:

enumerator kFLEXIO_SPI_8bitMsb
FlexIO SPI 8-bit MSB first

enumerator kFLEXIO_SPI_8bitLsb
FlexIO SPI 8-bit LSB first

enumerator kFLEXIO_SPI_16bitMsb
FlexIO SPI 16-bit MSB first

enumerator kFLEXIO_SPI_16bitLsb
FlexIO SPI 16-bit LSB first

enumerator kFLEXIO_SPI_32bitMsb
FlexIO SPI 32-bit MSB first

enumerator kFLEXIO_SPI_32bitLsb
FlexIO SPI 32-bit LSB first

enumerator kFLEXIO_SPI_csContinuous
Enable the CS signal continuous mode

typedef enum *_flexio_spi_clock_phase* flexio_spi_clock_phase_t
FlexIO SPI clock phase configuration.

typedef enum *_flexio_spi_shift_direction* flexio_spi_shift_direction_t
FlexIO SPI data shifter direction options.

typedef enum *_flexio_spi_data_bitcount_mode* flexio_spi_data_bitcount_mode_t
FlexIO SPI data length mode options.

typedef struct *_flexio_spi_type* FLEXIO_SPI_Type
Define FlexIO SPI access structure typedef.

typedef struct *_flexio_spi_master_config* flexio_spi_master_config_t
Define FlexIO SPI master configuration structure.

typedef struct *_flexio_spi_slave_config* flexio_spi_slave_config_t
Define FlexIO SPI slave configuration structure.

typedef struct *_flexio_spi_transfer* flexio_spi_transfer_t
Define FlexIO SPI transfer structure.

typedef struct *_flexio_spi_master_handle* flexio_spi_master_handle_t
typedef for flexio_spi_master_handle_t in advance.

typedef *flexio_spi_master_handle_t* flexio_spi_slave_handle_t
Slave handle is the same with master handle.

typedef void (*flexio_spi_master_transfer_callback_t)(FLEXIO_SPI_Type *base,
flexio_spi_master_handle_t *handle, *status_t* status, void *userData)
FlexIO SPI master callback for finished transmit.

typedef void (*flexio_spi_slave_transfer_callback_t)(FLEXIO_SPI_Type *base,
flexio_spi_slave_handle_t *handle, *status_t* status, void *userData)
FlexIO SPI slave callback for finished transmit.

FLEXIO_SPI_DUMMYDATA
FlexIO SPI dummy transfer data, the data is sent while txData is NULL.

SPI_RETRY_TIMES
Retry times for waiting flag.

FLEXIO_SPI_XFER_DATA_FORMAT(flag)
Get the transfer data format of width and bit order.

struct *_flexio_spi_type*
#include <fsl_flexio_spi.h> Define FlexIO SPI access structure typedef.

Public Members

FLEXIO_Type *flexioBase

FlexIO base pointer.

uint8_t SDOPinIndex

Pin select for data output. To set SDO pin in Hi-Z state, user needs to mux the pin as GPIO input and disable all pull up/down in application.

uint8_t SDIPinIndex

Pin select for data input.

uint8_t SCKPinIndex

Pin select for clock.

uint8_t CSnPinIndex

Pin select for enable.

uint8_t shifterIndex[2]

Shifter index used in FlexIO SPI.

uint8_t timerIndex[2]

Timer index used in FlexIO SPI.

struct _flexio_spi_master_config

#include <fsl_flexio_spi.h> Define FlexIO SPI master configuration structure.

Public Members

bool enableMaster

Enable/disable FlexIO SPI master after configuration.

bool enableInDoze

Enable/disable FlexIO operation in doze mode.

bool enableInDebug

Enable/disable FlexIO operation in debug mode.

bool enableFastAccess

Enable/disable fast access to FlexIO registers, fast access requires the FlexIO clock to be at least twice the frequency of the bus clock.

uint32_t baudRate_Bps

Baud rate in Bps.

flexio_spi_clock_phase_t phase

Clock phase.

flexio_spi_data_bitcount_mode_t dataMode

8bit or 16bit mode.

struct _flexio_spi_slave_config

#include <fsl_flexio_spi.h> Define FlexIO SPI slave configuration structure.

Public Members

bool enableSlave

Enable/disable FlexIO SPI slave after configuration.

bool enableInDoze

Enable/disable FlexIO operation in doze mode.

bool enableInDebug

Enable/disable FlexIO operation in debug mode.

bool enableFastAccess

Enable/disable fast access to FlexIO registers, fast access requires the FlexIO clock to be at least twice the frequency of the bus clock.

flexio_spi_clock_phase_t phase

Clock phase.

flexio_spi_data_bitcount_mode_t dataMode

8bit or 16bit mode.

struct *_flexio_spi_transfer*

#include <fsl_flexio_spi.h> Define FlexIO SPI transfer structure.

Public Members

const uint8_t *txData

Send buffer.

uint8_t *rxData

Receive buffer.

size_t dataSize

Transfer bytes.

uint8_t flags

FlexIO SPI control flag, MSB first or LSB first.

struct *_flexio_spi_master_handle*

#include <fsl_flexio_spi.h> Define FlexIO SPI handle structure.

Public Members

const uint8_t *txData

Transfer buffer.

uint8_t *rxData

Receive buffer.

size_t transferSize

Total bytes to be transferred.

volatile size_t txRemainingBytes

Send data remaining in bytes.

volatile size_t rxRemainingBytes

Receive data remaining in bytes.

volatile uint32_t state

FlexIO SPI internal state.

uint8_t bytePerFrame

SPI mode, 2bytes or 1byte in a frame

flexio_spi_shift_direction_t direction

Shift direction.

flexio_spi_master_transfer_callback_t callback

FlexIO SPI callback.

void *userData

Callback parameter.

bool isCsContinuous

Is current transfer using CS continuous mode.

uint32_t timer1Cfg

TIMER1 TIMCFG regiser value backup.

2.19 FlexIO UART Driver

status_t FLEXIO_UART_Init(*FLEXIO_UART_Type* *base, const *flexio_uart_config_t* *userConfig, uint32_t srcClock_Hz)

Ungates the FlexIO clock, resets the FlexIO module, configures FlexIO UART hardware, and configures the FlexIO UART with FlexIO UART configuration. The configuration structure can be filled by the user or be set with default values by FLEXIO_UART_GetDefaultConfig().

Example

```
FLEXIO_UART_Type base = {
    .flexioBase = FLEXIO,
    .TxPinIndex = 0,
    .RxPinIndex = 1,
    .shifterIndex = {0,1},
    .timerIndex = {0,1}
};
flexio_uart_config_t config = {
    .enableInDoze = false,
    .enableInDebug = true,
    .enableFastAccess = false,
    .baudRate_Bps = 115200U,
    .bitCountPerChar = 8
};
FLEXIO_UART_Init(base, &config, srcClock_Hz);
```

Parameters

- base – Pointer to the FLEXIO_UART_Type structure.
- userConfig – Pointer to the flexio_uart_config_t structure.
- srcClock_Hz – FlexIO source clock in Hz.

Return values

- kStatus_Success – Configuration success.
- kStatus_FLEXIO_UART_BaudrateNotSupport – Baudrate is not supported for current clock source frequency.

void FLEXIO_UART_Deinit(*FLEXIO_UART_Type* *base)

Resets the FlexIO UART shifter and timer config.

Note: After calling this API, call the FLEXIO_UART_Init to use the FlexIO UART module.

Parameters

- base – Pointer to FLEXIO_UART_Type structure

void FLEXIO_UART_GetDefaultConfig(*flexio_uart_config_t* *userConfig)

Gets the default configuration to configure the FlexIO UART. The configuration can be used directly for calling the FLEXIO_UART_Init(). Example:

```
flexio_uart_config_t config;  
FLEXIO_UART_GetDefaultConfig(&userConfig);
```

Parameters

- userConfig – Pointer to the flexio_uart_config_t structure.

uint32_t FLEXIO_UART_GetStatusFlags(*FLEXIO_UART_Type* *base)

Gets the FlexIO UART status flags.

Parameters

- base – Pointer to the FLEXIO_UART_Type structure.

Returns

FlexIO UART status flags.

void FLEXIO_UART_ClearStatusFlags(*FLEXIO_UART_Type* *base, uint32_t mask)

Gets the FlexIO UART status flags.

Parameters

- base – Pointer to the FLEXIO_UART_Type structure.
- mask – Status flag. The parameter can be any combination of the following values:
 - kFLEXIO_UART_TxDataRegEmptyFlag
 - kFLEXIO_UART_RxEmptyFlag
 - kFLEXIO_UART_RxOverRunFlag

void FLEXIO_UART_EnableInterrupts(*FLEXIO_UART_Type* *base, uint32_t mask)

Enables the FlexIO UART interrupt.

This function enables the FlexIO UART interrupt.

Parameters

- base – Pointer to the FLEXIO_UART_Type structure.
- mask – Interrupt source.

void FLEXIO_UART_DisableInterrupts(*FLEXIO_UART_Type* *base, uint32_t mask)

Disables the FlexIO UART interrupt.

This function disables the FlexIO UART interrupt.

Parameters

- base – Pointer to the FLEXIO_UART_Type structure.
- mask – Interrupt source.

static inline uint32_t FLEXIO_UART_GetTxDataRegisterAddress(*FLEXIO_UART_Type* *base)

Gets the FlexIO UART transmit data register address.

This function returns the UART data register address, which is mainly used by DMA/eDMA.

Parameters

- base – Pointer to the FLEXIO_UART_Type structure.

Returns

FlexIO UART transmit data register address.

```
static inline uint32_t FLEXIO_UART_GetRxDataRegisterAddress(FLEXIO_UART_Type *base)
```

Gets the FlexIO UART receive data register address.

This function returns the UART data register address, which is mainly used by DMA/eDMA.

Parameters

- base – Pointer to the FLEXIO_UART_Type structure.

Returns

FlexIO UART receive data register address.

```
static inline void FLEXIO_UART_EnableTxDMA(FLEXIO_UART_Type *base, bool enable)
```

Enables/disables the FlexIO UART transmit DMA. This function enables/disables the FlexIO UART Tx DMA, which means asserting the kFLEXIO_UART_TxDataRegEmptyFlag does/doesn't trigger the DMA request.

Parameters

- base – Pointer to the FLEXIO_UART_Type structure.
- enable – True to enable, false to disable.

```
static inline void FLEXIO_UART_EnableRxDMA(FLEXIO_UART_Type *base, bool enable)
```

Enables/disables the FlexIO UART receive DMA. This function enables/disables the FlexIO UART Rx DMA, which means asserting kFLEXIO_UART_RxDataRegFullFlag does/doesn't trigger the DMA request.

Parameters

- base – Pointer to the FLEXIO_UART_Type structure.
- enable – True to enable, false to disable.

```
static inline void FLEXIO_UART_Enable(FLEXIO_UART_Type *base, bool enable)
```

Enables/disables the FlexIO UART module operation.

Parameters

- base – Pointer to the FLEXIO_UART_Type.
- enable – True to enable, false does not have any effect.

```
static inline void FLEXIO_UART_WriteByte(FLEXIO_UART_Type *base, const uint8_t *buffer)
```

Writes one byte of data.

Note: This is a non-blocking API, which returns directly after the data is put into the data register. Ensure that the TxEmptyFlag is asserted before calling this API.

Parameters

- base – Pointer to the FLEXIO_UART_Type structure.
- buffer – The data bytes to send.

```
static inline void FLEXIO_UART_ReadByte(FLEXIO_UART_Type *base, uint8_t *buffer)
```

Reads one byte of data.

Note: This is a non-blocking API, which returns directly after the data is read from the data register. Ensure that the RxFullFlag is asserted before calling this API.

Parameters

- base – Pointer to the FLEXIO_UART_Type structure.
- buffer – The buffer to store the received bytes.

status_t FLEXIO_UART_WriteBlocking(*FLEXIO_UART_Type* *base, const uint8_t *txData, size_t txSize)

Sends a buffer of data bytes.

Note: This function blocks using the polling method until all bytes have been sent.

Parameters

- base – Pointer to the FLEXIO_UART_Type structure.
- txData – The data bytes to send.
- txSize – The number of data bytes to send.

Return values

- kStatus_FLEXIO_UART_Timeout – Transmission timed out and was aborted.
- kStatus_Success – Successfully wrote all data.

status_t FLEXIO_UART_ReadBlocking(*FLEXIO_UART_Type* *base, uint8_t *rxData, size_t rxSize)

Receives a buffer of bytes.

Note: This function blocks using the polling method until all bytes have been received.

Parameters

- base – Pointer to the FLEXIO_UART_Type structure.
- rxData – The buffer to store the received bytes.
- rxSize – The number of data bytes to be received.

Return values

- kStatus_FLEXIO_UART_Timeout – Transmission timed out and was aborted.
- kStatus_Success – Successfully received all data.

status_t FLEXIO_UART_TransferCreateHandle(*FLEXIO_UART_Type* *base, *flexio_uart_handle_t* *handle, *flexio_uart_transfer_callback_t* callback, void *userData)

Initializes the UART handle.

This function initializes the FlexIO UART handle, which can be used for other FlexIO UART transactional APIs. Call this API once to get the initialized handle.

The UART driver supports the “background” receiving, which means that users can set up a RX ring buffer optionally. Data received is stored into the ring buffer even when the user doesn’t call the FLEXIO_UART_TransferReceiveNonBlocking() API. If there is already data received in the ring buffer, users can get the received data from the ring buffer directly. The ring buffer is disabled if passing NULL as ringBuffer.

Parameters

- base – to FLEXIO_UART_Type structure.

- `handle` – Pointer to the `flexio_uart_handle_t` structure to store the transfer state.
- `callback` – The callback function.
- `userData` – The parameter of the callback function.

Return values

- `kStatus_Success` – Successfully create the handle.
- `kStatus_OutOfRange` – The FlexIO type/handle/ISR table out of range.

```
void FLEXIO_UART_TransferStartRingBuffer(FLEXIO_UART_Type *base, flexio_uart_handle_t
                                         *handle, uint8_t *ringBuffer, size_t
                                         ringBufferSize)
```

Sets up the RX ring buffer.

This function sets up the RX ring buffer to a specific UART handle.

When the RX ring buffer is used, data received is stored into the ring buffer even when the user doesn't call the `UART_ReceiveNonBlocking()` API. If there is already data received in the ring buffer, users can get the received data from the ring buffer directly.

Note: When using the RX ring buffer, one byte is reserved for internal use. In other words, if `ringBufferSize` is 32, only 31 bytes are used for saving data.

Parameters

- `base` – Pointer to the `FLEXIO_UART_Type` structure.
- `handle` – Pointer to the `flexio_uart_handle_t` structure to store the transfer state.
- `ringBuffer` – Start address of ring buffer for background receiving. Pass `NULL` to disable the ring buffer.
- `ringBufferSize` – Size of the ring buffer.

```
void FLEXIO_UART_TransferStopRingBuffer(FLEXIO_UART_Type *base, flexio_uart_handle_t
                                         *handle)
```

Aborts the background transfer and uninstalls the ring buffer.

This function aborts the background transfer and uninstalls the ring buffer.

Parameters

- `base` – Pointer to the `FLEXIO_UART_Type` structure.
- `handle` – Pointer to the `flexio_uart_handle_t` structure to store the transfer state.

```
status_t FLEXIO_UART_TransferSendNonBlocking(FLEXIO_UART_Type *base,
                                              flexio_uart_handle_t *handle,
                                              flexio_uart_transfer_t *xfer)
```

Transmits a buffer of data using the interrupt method.

This function sends data using an interrupt method. This is a non-blocking function, which returns directly without waiting for all data to be written to the TX register. When all data is written to the TX register in ISR, the FlexIO UART driver calls the callback function and passes the `kStatus_FLEXIO_UART_TxIdle` as status parameter.

Note: The `kStatus_FLEXIO_UART_TxIdle` is passed to the upper layer when all data is written to the TX register. However, it does not ensure that all data is sent out.

Parameters

- `base` – Pointer to the `FLEXIO_UART_Type` structure.
- `handle` – Pointer to the `flexio_uart_handle_t` structure to store the transfer state.
- `xfer` – FlexIO UART transfer structure. See `flexio_uart_transfer_t`.

Return values

- `kStatus_Success` – Successfully starts the data transmission.
- `kStatus_UART_TxBusy` – Previous transmission still not finished, data not written to the TX register.

```
void FLEXIO_UART_TransferAbortSend(FLEXIO_UART_Type *base, flexio_uart_handle_t *handle)
```

Aborts the interrupt-driven data transmit.

This function aborts the interrupt-driven data sending. Get the `remainBytes` to find out how many bytes are still not sent out.

Parameters

- `base` – Pointer to the `FLEXIO_UART_Type` structure.
- `handle` – Pointer to the `flexio_uart_handle_t` structure to store the transfer state.

```
status_t FLEXIO_UART_TransferGetSendCount(FLEXIO_UART_Type *base, flexio_uart_handle_t *handle, size_t *count)
```

Gets the number of bytes sent.

This function gets the number of bytes sent driven by interrupt.

Parameters

- `base` – Pointer to the `FLEXIO_UART_Type` structure.
- `handle` – Pointer to the `flexio_uart_handle_t` structure to store the transfer state.
- `count` – Number of bytes sent so far by the non-blocking transaction.

Return values

- `kStatus_NoTransferInProgress` – transfer has finished or no transfer in progress.
- `kStatus_Success` – Successfully return the count.

```
status_t FLEXIO_UART_TransferReceiveNonBlocking(FLEXIO_UART_Type *base, flexio_uart_handle_t *handle, flexio_uart_transfer_t *xfer, size_t *receivedBytes)
```

Receives a buffer of data using the interrupt method.

This function receives data using the interrupt method. This is a non-blocking function, which returns without waiting for all data to be received. If the RX ring buffer is used and not empty, the data in ring buffer is copied and the parameter `receivedBytes` shows how many bytes are copied from the ring buffer. After copying, if the data in ring buffer is not enough to read, the receive request is saved by the UART driver. When new data arrives, the receive request is serviced first. When all data is received, the UART driver notifies the upper layer through a callback function and passes the status parameter `kStatus_UART_RxIdle`. For example, if the upper layer needs 10 bytes but there are only 5 bytes in the ring buffer, the 5 bytes are copied to `xfer->data`. This function returns with the parameter `receivedBytes` set to 5. For the last 5 bytes, newly arrived data is saved from the

xfer->data[5]. When 5 bytes are received, the UART driver notifies upper layer. If the RX ring buffer is not enabled, this function enables the RX and RX interrupt to receive data to xfer->data. When all data is received, the upper layer is notified.

Parameters

- base – Pointer to the FLEXIO_UART_Type structure.
- handle – Pointer to the flexio_uart_handle_t structure to store the transfer state.
- xfer – UART transfer structure. See flexio_uart_transfer_t.
- receivedBytes – Bytes received from the ring buffer directly.

Return values

- kStatus__Success – Successfully queue the transfer into the transmit queue.
- kStatus_FLEXIO_UART_RxBusy – Previous receive request is not finished.

```
void FLEXIO_UART_TransferAbortReceive(FLEXIO_UART_Type *base, flexio_uart_handle_t *handle)
```

Aborts the receive data which was using IRQ.

This function aborts the receive data which was using IRQ.

Parameters

- base – Pointer to the FLEXIO_UART_Type structure.
- handle – Pointer to the flexio_uart_handle_t structure to store the transfer state.

```
status_t FLEXIO_UART_TransferGetReceiveCount(FLEXIO_UART_Type *base,  
                                              flexio_uart_handle_t *handle, size_t *count)
```

Gets the number of bytes received.

This function gets the number of bytes received driven by interrupt.

Parameters

- base – Pointer to the FLEXIO_UART_Type structure.
- handle – Pointer to the flexio_uart_handle_t structure to store the transfer state.
- count – Number of bytes received so far by the non-blocking transaction.

Return values

- kStatus_NoTransferInProgress – transfer has finished or no transfer in progress.
- kStatus__Success – Successfully return the count.

```
void FLEXIO_UART_TransferHandleIRQ(void *uartType, void *uartHandle)
```

FlexIO UART IRQ handler function.

This function processes the FlexIO UART transmit and receives the IRQ request.

Parameters

- uartType – Pointer to the FLEXIO_UART_Type structure.
- uartHandle – Pointer to the flexio_uart_handle_t structure to store the transfer state.

void FLEXIO_UART_FlushShifters(*FLEXIO_UART_Type* *base)

Flush tx/rx shifters.

Parameters

- base – Pointer to the FLEXIO_UART_Type structure.

FSL_FLEXIO_UART_DRIVER_VERSION

FlexIO UART driver version.

Error codes for the UART driver.

Values:

enumerator kStatus_FLEXIO_UART_TxBusy

Transmitter is busy.

enumerator kStatus_FLEXIO_UART_RxBusy

Receiver is busy.

enumerator kStatus_FLEXIO_UART_TxIdle

UART transmitter is idle.

enumerator kStatus_FLEXIO_UART_RxIdle

UART receiver is idle.

enumerator kStatus_FLEXIO_UART_ERROR

ERROR happens on UART.

enumerator kStatus_FLEXIO_UART_RxRingBufferOverrun

UART RX software ring buffer overrun.

enumerator kStatus_FLEXIO_UART_RxHardwareOverrun

UART RX receiver overrun.

enumerator kStatus_FLEXIO_UART_Timeout

UART times out.

enumerator kStatus_FLEXIO_UART_BaudrateNotSupport

Baudrate is not supported in current clock source

enum _flexio_uart_bit_count_per_char

FlexIO UART bit count per char.

Values:

enumerator kFLEXIO_UART_7BitsPerChar

7-bit data characters

enumerator kFLEXIO_UART_8BitsPerChar

8-bit data characters

enumerator kFLEXIO_UART_9BitsPerChar

9-bit data characters

enum _flexio_uart_interrupt_enable

Define FlexIO UART interrupt mask.

Values:

enumerator kFLEXIO_UART_TxDataRegEmptyInterruptEnable

Transmit buffer empty interrupt enable.

```

    enumerator kFLEXIO_UART_RxDataRegFullInterruptEnable
        Receive buffer full interrupt enable.

enum _flexio_uart_status_flags
    Define FlexIO UART status mask.

    Values:

    enumerator kFLEXIO_UART_TxDataRegEmptyFlag
        Transmit buffer empty flag.

    enumerator kFLEXIO_UART_RxDataRegFullFlag
        Receive buffer full flag.

    enumerator kFLEXIO_UART_RxOverRunFlag
        Receive buffer over run flag.

typedef enum _flexio_uart_bit_count_per_char flexio_uart_bit_count_per_char_t
    FlexIO UART bit count per char.

typedef struct _flexio_uart_type FLEXIO_UART_Type
    Define FlexIO UART access structure typedef.

typedef struct _flexio_uart_config flexio_uart_config_t
    Define FlexIO UART user configuration structure.

typedef struct _flexio_uart_transfer flexio_uart_transfer_t
    Define FlexIO UART transfer structure.

typedef struct _flexio_uart_handle flexio_uart_handle_t

typedef void (*flexio_uart_transfer_callback_t)(FLEXIO_UART_Type *base, flexio_uart_handle_t
*handle, status_t status, void *userData)
    FlexIO UART transfer callback function.

UART_RETRY_TIMES
    Retry times for waiting flag.

struct _flexio_uart_type
    #include <fsl_flexio_uart.h> Define FlexIO UART access structure typedef.

```

Public Members

```

FLEXIO_Type *flexioBase
    FlexIO base pointer.

uint8_t TxPinIndex
    Pin select for UART_Tx.

uint8_t RxPinIndex
    Pin select for UART_Rx.

uint8_t shifterIndex[2]
    Shifter index used in FlexIO UART.

uint8_t timerIndex[2]
    Timer index used in FlexIO UART.

struct _flexio_uart_config
    #include <fsl_flexio_uart.h> Define FlexIO UART user configuration structure.

```

Public Members

`bool enableUart`
Enable/disable FlexIO UART TX & RX.

`bool enableInDoze`
Enable/disable FlexIO operation in doze mode

`bool enableInDebug`
Enable/disable FlexIO operation in debug mode

`bool enableFastAccess`
Enable/disable fast access to FlexIO registers, fast access requires the FlexIO clock to be at least twice the frequency of the bus clock.

`uint32_t baudRate_Bps`
Baud rate in Bps.

`flexio_uart_bit_count_per_char_t bitCountPerChar`
number of bits, 7/8/9 -bit

`struct _flexio_uart_transfer`
#include <fsl_flexio_uart.h> Define FlexIO UART transfer structure.

Public Members

`size_t dataSize`
Transfer size

`struct _flexio_uart_handle`
#include <fsl_flexio_uart.h> Define FLEXIO UART handle structure.

Public Members

`const uint8_t *volatile txData`
Address of remaining data to send.

`volatile size_t txDataSize`
Size of the remaining data to send.

`uint8_t *volatile rxData`
Address of remaining data to receive.

`volatile size_t rxDataSize`
Size of the remaining data to receive.

`size_t txDataSizeAll`
Total bytes to be sent.

`size_t rxDataSizeAll`
Total bytes to be received.

`uint8_t *rxRingBuffer`
Start address of the receiver ring buffer.

`size_t rxRingBufferSize`
Size of the ring buffer.

`volatile uint16_t rxRingBufferHead`
Index for the driver to store received data into ring buffer.

`volatile uint16_t rxRingBufferTail`
Index for the user to get data from the ring buffer.

`flexio_uart_transfer_callback_t callback`
Callback function.

`void *userData`
UART callback function parameter.

`volatile uint8_t txState`
TX transfer state.

`volatile uint8_t rxState`
RX transfer state

`union __unnamed105__`

Public Members

`uint8_t *data`
The buffer of data to be transfer.

`uint8_t *rxData`
The buffer to receive data.

`const uint8_t *txData`
The buffer of data to be sent.

2.20 FLEXSPI: Flexible Serial Peripheral Interface Driver

`uint32_t FLEXSPI_GetInstance(FLEXSPI_Type *base)`
Get the instance number for FLEXSPI.

Parameters

- `base` – FLEXSPI base pointer.

`status_t FLEXSPI_CheckAndClearError(FLEXSPI_Type *base, uint32_t status)`
Check and clear IP command execution errors.

Parameters

- `base` – FLEXSPI base pointer.
- `status` – interrupt status.

`void FLEXSPI_Init(FLEXSPI_Type *base, const flexspi_config_t *config)`
Initializes the FLEXSPI module and internal state.

This function enables the clock for FLEXSPI and also configures the FLEXSPI with the input configure parameters. Users should call this function before any FLEXSPI operations.

Parameters

- `base` – FLEXSPI peripheral base address.
- `config` – FLEXSPI configure structure.

void FLEXSPI_GetDefaultConfig(*flexspi_config_t* *config)

Gets default settings for FLEXSPI.

Parameters

- config – FLEXSPI configuration structure.

void FLEXSPI_Deinit(FLEXSPI_Type *base)

Deinitializes the FLEXSPI module.

Clears the FLEXSPI state and FLEXSPI module registers.

Parameters

- base – FLEXSPI peripheral base address.

void FLEXSPI_UpdateDllValue(FLEXSPI_Type *base, *flexspi_device_config_t* *config,
flexspi_port_t port)

Update FLEXSPI DLL value depending on currently flexspi root clock.

Parameters

- base – FLEXSPI peripheral base address.
- config – Flash configuration parameters.
- port – FLEXSPI Operation port.

void FLEXSPI_SetFlashConfig(FLEXSPI_Type *base, *flexspi_device_config_t* *config,
flexspi_port_t port)

Configures the connected device parameter.

This function configures the connected device relevant parameters, such as the size, command, and so on. The flash configuration value cannot have a default value. The user needs to configure it according to the connected device.

Parameters

- base – FLEXSPI peripheral base address.
- config – Flash configuration parameters.
- port – FLEXSPI Operation port.

void FLEXSPI_SoftwareReset(FLEXSPI_Type *base)

Software reset for the FLEXSPI logic.

This function sets the software reset flags for both AHB and buffer domain and resets both AHB buffer and also IP FIFOs.

Parameters

- base – FLEXSPI peripheral base address.

static inline void FLEXSPI_Enable(FLEXSPI_Type *base, bool enable)

Enables or disables the FLEXSPI module.

Parameters

- base – FLEXSPI peripheral base address.
- enable – True means enable FLEXSPI, false means disable.

void FLEXSPI_UpdateAhbBuffersSettings(FLEXSPI_Type *base, *flexspi_ahbBuffers_ctrl_t*
**ptrAhbBufferCtrl*)

Update all AHB buffers' settings, including buffer size, master ID.

Parameters

- base – FLEXSPI peripheral base address.

- ptrAhbBufferCtrl – Pointer to structure flexspi_ahbBuffers_ctrl_t which store all AHB buffers' settings.

static inline void FLEXSPI_EnableInterrupts(FLEXSPI_Type *base, uint32_t mask)

Enables the FLEXSPI interrupts.

Parameters

- base – FLEXSPI peripheral base address.
- mask – FLEXSPI interrupt source.

static inline void FLEXSPI_DisableInterrupts(FLEXSPI_Type *base, uint32_t mask)

Disable the FLEXSPI interrupts.

Parameters

- base – FLEXSPI peripheral base address.
- mask – FLEXSPI interrupt source.

static inline void FLEXSPI_EnableTxDMA(FLEXSPI_Type *base, bool enable)

Enables or disables FLEXSPI IP Tx FIFO DMA requests.

Parameters

- base – FLEXSPI peripheral base address.
- enable – Enable flag for transmit DMA request. Pass true for enable, false for disable.

static inline void FLEXSPI_EnableRxDMA(FLEXSPI_Type *base, bool enable)

Enables or disables FLEXSPI IP Rx FIFO DMA requests.

Parameters

- base – FLEXSPI peripheral base address.
- enable – Enable flag for receive DMA request. Pass true for enable, false for disable.

static inline uint32_t FLEXSPI_GetTxFifoAddress(FLEXSPI_Type *base)

Gets FLEXSPI IP tx fifo address for DMA transfer.

Parameters

- base – FLEXSPI peripheral base address.

Return values

The – tx fifo address.

static inline uint32_t FLEXSPI_GetRxFifoAddress(FLEXSPI_Type *base)

Gets FLEXSPI IP rx fifo address for DMA transfer.

Parameters

- base – FLEXSPI peripheral base address.

Return values

The – rx fifo address.

static inline void FLEXSPI_ResetFifos(FLEXSPI_Type *base, bool txFifo, bool rxFifo)

Clears the FLEXSPI IP FIFO logic.

Parameters

- base – FLEXSPI peripheral base address.
- txFifo – Pass true to reset TX FIFO.
- rxFifo – Pass true to reset RX FIFO.

```
static inline void FLEXSPI_GetFifoCounts(FLEXSPI_Type *base, size_t *txCount, size_t
                                         *rxCount)
```

Gets the valid data entries in the FLEXSPI FIFOs.

Parameters

- base – FLEXSPI peripheral base address.
- txCount – **[out]** Pointer through which the current number of bytes in the transmit FIFO is returned. Pass NULL if this value is not required.
- rxCount – **[out]** Pointer through which the current number of bytes in the receive FIFO is returned. Pass NULL if this value is not required.

```
static inline uint32_t FLEXSPI_GetInterruptStatusFlags(FLEXSPI_Type *base)
```

Get the FLEXSPI interrupt status flags.

Parameters

- base – FLEXSPI peripheral base address.

Return values

interrupt – status flag, use status flag to AND flexspi_flags_t could get the related status.

```
static inline void FLEXSPI_ClearInterruptStatusFlags(FLEXSPI_Type *base, uint32_t mask)
```

Get the FLEXSPI interrupt status flags.

Parameters

- base – FLEXSPI peripheral base address.
- mask – FLEXSPI interrupt source.

```
static inline flexspi_arb_command_source_t FLEXSPI_GetArbitratorCommandSource(FLEXSPI_Type
                                                                              *base)
```

Gets the trigger source of current command sequence granted by arbitrator.

Parameters

- base – FLEXSPI peripheral base address.

Return values

trigger – source of current command sequence.

```
static inline flexspi_ip_error_code_t FLEXSPI_GetIPCommandErrorCode(FLEXSPI_Type *base,
                                                                    uint8_t *index)
```

Gets the error code when IP command error detected.

Parameters

- base – FLEXSPI peripheral base address.
- index – Pointer to a uint8_t type variable to receive the sequence index when error detected.

Return values

error – code when IP command error detected.

```
static inline flexspi_ahb_error_code_t FLEXSPI_GetAHBCommandErrorCode(FLEXSPI_Type
                                                                      *base, uint8_t
                                                                      *index)
```

Gets the error code when AHB command error detected.

Parameters

- base – FLEXSPI peripheral base address.

- `index` – Pointer to a `uint8_t` type variable to receive the sequence index when error detected.

Return values

`error` – code when AHB command error detected.

```
static inline bool FLEXSPI_GetBusIdleStatus(FLEXSPI_Type *base)
```

Returns whether the bus is idle.

Parameters

- `base` – FLEXSPI peripheral base address.

Return values

- `true` – Bus is idle.
- `false` – Bus is busy.

```
void FLEXSPI_UpdateRxSampleClock(FLEXSPI_Type *base, flexspi_read_sample_clock_t  
                                clockSource)
```

Update read sample clock source.

Parameters

- `base` – FLEXSPI peripheral base address.
- `clockSource` – `clockSource` of type `flexspi_read_sample_clock_t`

```
void FLEXSPI_UpdateLUT(FLEXSPI_Type *base, uint32_t index, const uint32_t *cmd, uint32_t  
                      count)
```

Updates the LUT table.

Parameters

- `base` – FLEXSPI peripheral base address.
- `index` – From which index start to update. It could be any index of the LUT table, which also allows user to update command content inside a command. Each command consists of up to 8 instructions and occupy 4*32-bit memory.
- `cmd` – Command sequence array.
- `count` – Number of sequences.

```
static inline void FLEXSPI_WriteData(FLEXSPI_Type *base, uint32_t data, uint8_t fifoIndex)
```

Writes data into FIFO.

Parameters

- `base` – FLEXSPI peripheral base address
- `data` – The data bytes to send
- `fifoIndex` – Destination fifo index.

```
static inline uint32_t FLEXSPI_ReadData(FLEXSPI_Type *base, uint8_t fifoIndex)
```

Receives data from data FIFO.

Parameters

- `base` – FLEXSPI peripheral base address
- `fifoIndex` – Source fifo index.

Returns

The data in the FIFO.

status_t FLEXSPI_WriteBlocking(FLEXSPI_Type *base, uint8_t *buffer, size_t size)

Sends a buffer of data bytes using blocking method.

Note: This function blocks via polling until all bytes have been sent.

Parameters

- base – FLEXSPI peripheral base address
- buffer – The data bytes to send
- size – The number of data bytes to send

Return values

- kStatus_Success – write success without error
- kStatus_FLEXSPI_SequenceExecutionTimeout – sequence execution timeout
- kStatus_FLEXSPI_IpCommandSequenceError – IP command sequence error detected
- kStatus_FLEXSPI_IpCommandGrantTimeout – IP command grant timeout detected

status_t FLEXSPI_ReadBlocking(FLEXSPI_Type *base, uint8_t *buffer, size_t size)

Receives a buffer of data bytes using a blocking method.

Note: This function blocks via polling until all bytes have been sent.

Parameters

- base – FLEXSPI peripheral base address
- buffer – The data bytes to send
- size – The number of data bytes to receive

Return values

- kStatus_Success – read success without error
- kStatus_FLEXSPI_SequenceExecutionTimeout – sequence execution timeout
- kStatus_FLEXSPI_IpCommandSequenceError – IP command sequence error detected
- kStatus_FLEXSPI_IpCommandGrantTimeout – IP command grant timeout detected

status_t FLEXSPI_TransferBlocking(FLEXSPI_Type *base, *flexspi_transfer_t* *xfer)

Execute command to transfer a buffer data bytes using a blocking method.

Parameters

- base – FLEXSPI peripheral base address
- xfer – pointer to the transfer structure.

Return values

- kStatus_Success – command transfer success without error

- `kStatus_FLEXSPI_SequenceExecutionTimeout` – sequence execution timeout
- `kStatus_FLEXSPI_IpCommandSequenceError` – IP command sequence error detected
- `kStatus_FLEXSPI_IpCommandGrantTimeout` – IP command grant timeout detected

`void FLEXSPI_TransferCreateHandle(FLEXSPI_Type *base, flexspi_handle_t *handle, flexspi_transfer_callback_t callback, void *userData)`

Initializes the FLEXSPI handle which is used in transactional functions.

Parameters

- `base` – FLEXSPI peripheral base address.
- `handle` – pointer to `flexspi_handle_t` structure to store the transfer state.
- `callback` – pointer to user callback function.
- `userData` – user parameter passed to the callback function.

`status_t FLEXSPI_TransferNonBlocking(FLEXSPI_Type *base, flexspi_handle_t *handle, flexspi_transfer_t *xfer)`

Performs a interrupt non-blocking transfer on the FLEXSPI bus.

Note: Calling the API returns immediately after transfer initiates. The user needs to call `FLEXSPI_GetTransferCount` to poll the transfer status to check whether the transfer is finished. If the return status is not `kStatus_FLEXSPI_Busy`, the transfer is finished. For `FLEXSPI_Read`, the `dataSize` should be multiple of rx watermark level, or FLEXSPI could not read data properly.

Parameters

- `base` – FLEXSPI peripheral base address.
- `handle` – pointer to `flexspi_handle_t` structure which stores the transfer state.
- `xfer` – pointer to `flexspi_transfer_t` structure.

Return values

- `kStatus_Success` – Successfully start the data transmission.
- `kStatus_FLEXSPI_Busy` – Previous transmission still not finished.

`status_t FLEXSPI_TransferGetCount(FLEXSPI_Type *base, flexspi_handle_t *handle, size_t *count)`

Gets the master transfer status during a interrupt non-blocking transfer.

Parameters

- `base` – FLEXSPI peripheral base address.
- `handle` – pointer to `flexspi_handle_t` structure which stores the transfer state.
- `count` – Number of bytes transferred so far by the non-blocking transaction.

Return values

- `kStatus_InvalidArgument` – count is Invalid.
- `kStatus_Success` – Successfully return the count.

void FLEXSPI_TransferAbort(FLEXSPI_Type *base, *flexspi_handle_t* *handle)

Aborts an interrupt non-blocking transfer early.

Note: This API can be called at any time when an interrupt non-blocking transfer initiates to abort the transfer early.

Parameters

- base – FLEXSPI peripheral base address.
- handle – pointer to *flexspi_handle_t* structure which stores the transfer state

void FLEXSPI_TransferHandleIRQ(FLEXSPI_Type *base, *flexspi_handle_t* *handle)

Master interrupt handler.

Parameters

- base – FLEXSPI peripheral base address.
- handle – pointer to *flexspi_handle_t* structure.

FSL_FLEXSPI_DRIVER_VERSION

FLEXSPI driver version.

Status structure of FLEXSPI.

Values:

enumerator kStatus_FLEXSPI_Busy

FLEXSPI is busy

enumerator kStatus_FLEXSPI_SequenceExecutionTimeout

Sequence execution timeout error occurred during FLEXSPI transfer.

enumerator kStatus_FLEXSPI_IpCommandSequenceError

IP command Sequence execution timeout error occurred during FLEXSPI transfer.

enumerator kStatus_FLEXSPI_IpCommandGrantTimeout

IP command grant timeout error occurred during FLEXSPI transfer.

CMD definition of FLEXSPI, use to form LUT instruction, *_flexspi_command*.

Values:

enumerator kFLEXSPI_Command_STOP

Stop execution, deassert CS.

enumerator kFLEXSPI_Command_SDR

Transmit Command code to Flash, using SDR mode.

enumerator kFLEXSPI_Command_RADDR_SDR

Transmit Row Address to Flash, using SDR mode.

enumerator kFLEXSPI_Command_CADDR_SDR

Transmit Column Address to Flash, using SDR mode.

enumerator kFLEXSPI_Command_MODE1_SDR

Transmit 1-bit Mode bits to Flash, using SDR mode.

enumerator kFLEXSPI_Command_MODE2_SDR
Transmit 2-bit Mode bits to Flash, using SDR mode.

enumerator kFLEXSPI_Command_MODE4_SDR
Transmit 4-bit Mode bits to Flash, using SDR mode.

enumerator kFLEXSPI_Command_MODE8_SDR
Transmit 8-bit Mode bits to Flash, using SDR mode.

enumerator kFLEXSPI_Command_WRITE_SDR
Transmit Programming Data to Flash, using SDR mode.

enumerator kFLEXSPI_Command_READ_SDR
Receive Read Data from Flash, using SDR mode.

enumerator kFLEXSPI_Command_LEARN_SDR
Receive Read Data or Preamble bit from Flash, SDR mode.

enumerator kFLEXSPI_Command_DATSZ_SDR
Transmit Read/Program Data size (byte) to Flash, SDR mode.

enumerator kFLEXSPI_Command_DUMMY_SDR
Leave data lines undriven by FlexSPI controller.

enumerator kFLEXSPI_Command_DUMMY_RWDS_SDR
Leave data lines undriven by FlexSPI controller, dummy cycles decided by RWDS.

enumerator kFLEXSPI_Command_DDR
Transmit Command code to Flash, using DDR mode.

enumerator kFLEXSPI_Command_RADDR_DDR
Transmit Row Address to Flash, using DDR mode.

enumerator kFLEXSPI_Command_CADDR_DDR
Transmit Column Address to Flash, using DDR mode.

enumerator kFLEXSPI_Command_MODE1_DDR
Transmit 1-bit Mode bits to Flash, using DDR mode.

enumerator kFLEXSPI_Command_MODE2_DDR
Transmit 2-bit Mode bits to Flash, using DDR mode.

enumerator kFLEXSPI_Command_MODE4_DDR
Transmit 4-bit Mode bits to Flash, using DDR mode.

enumerator kFLEXSPI_Command_MODE8_DDR
Transmit 8-bit Mode bits to Flash, using DDR mode.

enumerator kFLEXSPI_Command_WRITE_DDR
Transmit Programming Data to Flash, using DDR mode.

enumerator kFLEXSPI_Command_READ_DDR
Receive Read Data from Flash, using DDR mode.

enumerator kFLEXSPI_Command_LEARN_DDR
Receive Read Data or Preamble bit from Flash, DDR mode.

enumerator kFLEXSPI_Command_DATSZ_DDR
Transmit Read/Program Data size (byte) to Flash, DDR mode.

enumerator kFLEXSPI_Command_DUMMY_DDR
Leave data lines undriven by FlexSPI controller.

enumerator kFLEXSPI_Command_DUMMY_RWDS_DDR

Leave data lines undriven by FlexSPI controller, dummy cycles decided by RWDS.

enumerator kFLEXSPI_Command_JUMP_ON_CS

Stop execution, deassert CS and save operand[7:0] as the instruction start pointer for next sequence

enum _flexspi_pad

pad definition of FLEXSPI, use to form LUT instruction.

Values:

enumerator kFLEXSPI_1PAD

Transmit command/address and transmit/receive data only through DATA0/DATA1.

enumerator kFLEXSPI_2PAD

Transmit command/address and transmit/receive data only through DATA[1:0].

enumerator kFLEXSPI_4PAD

Transmit command/address and transmit/receive data only through DATA[3:0].

enumerator kFLEXSPI_8PAD

Transmit command/address and transmit/receive data only through DATA[7:0].

enum _flexspi_flags

FLEXSPI interrupt status flags.

Values:

enumerator kFLEXSPI_SequenceExecutionTimeoutFlag

Sequence execution timeout.

enumerator kFLEXSPI_AhbBusErrorFlag

AHB Bus error flag.

enumerator kFLEXSPI_SckStoppedBecauseTxEmptyFlag

SCK is stopped during command sequence because Async TX FIFO empty.

enumerator kFLEXSPI_SckStoppedBecauseRxFullFlag

SCK is stopped during command sequence because Async RX FIFO full.

enumerator kFLEXSPI_IpTxFifoWatermarkEmptyFlag

IP TX FIFO WaterMark empty.

enumerator kFLEXSPI_IpRxFifoWatermarkAvailableFlag

IP RX FIFO WaterMark available.

enumerator kFLEXSPI_AhbCommandSequenceErrorFlag

AHB triggered Command Sequences Error.

enumerator kFLEXSPI_IpCommandSequenceErrorFlag

IP triggered Command Sequences Error.

enumerator kFLEXSPI_AhbCommandGrantTimeoutFlag

AHB triggered Command Sequences Grant Timeout.

enumerator kFLEXSPI_IpCommandGrantTimeoutFlag

IP triggered Command Sequences Grant Timeout.

enumerator kFLEXSPI_IpCommandExecutionDoneFlag

IP triggered Command Sequences Execution finished.

enumerator kFLEXSPI_AllInterruptFlags

All flags.

enum _flexspi_read_sample_clock

FLEXSPI sample clock source selection for Flash Reading.

Values:

enumerator kFLEXSPI_ReadSampleClkLoopbackInternally

Dummy Read strobe generated by FlexSPI Controller and loopback internally.

enumerator kFLEXSPI_ReadSampleClkLoopbackFromDqsPad

Dummy Read strobe generated by FlexSPI Controller and loopback from DQS pad.

enumerator kFLEXSPI_ReadSampleClkLoopbackFromSckPad

SCK output clock and loopback from SCK pad.

enumerator kFLEXSPI_ReadSampleClkExternalInputFromDqsPad

Flash provided Read strobe and input from DQS pad.

enum _flexspi_cs_interval_cycle_unit

FLEXSPI interval unit for flash device select.

Values:

enumerator kFLEXSPI_CsIntervalUnit1SckCycle

Chip selection interval: CSINTERVAL * 1 serial clock cycle.

enumerator kFLEXSPI_CsIntervalUnit256SckCycle

Chip selection interval: CSINTERVAL * 256 serial clock cycle.

enum _flexspi_ahb_write_wait_unit

FLEXSPI AHB wait interval unit for writing.

Values:

enumerator kFLEXSPI_AhbWriteWaitUnit2AhbCycle

AWRWAIT unit is 2 ahb clock cycle.

enumerator kFLEXSPI_AhbWriteWaitUnit8AhbCycle

AWRWAIT unit is 8 ahb clock cycle.

enumerator kFLEXSPI_AhbWriteWaitUnit32AhbCycle

AWRWAIT unit is 32 ahb clock cycle.

enumerator kFLEXSPI_AhbWriteWaitUnit128AhbCycle

AWRWAIT unit is 128 ahb clock cycle.

enumerator kFLEXSPI_AhbWriteWaitUnit512AhbCycle

AWRWAIT unit is 512 ahb clock cycle.

enumerator kFLEXSPI_AhbWriteWaitUnit2048AhbCycle

AWRWAIT unit is 2048 ahb clock cycle.

enumerator kFLEXSPI_AhbWriteWaitUnit8192AhbCycle

AWRWAIT unit is 8192 ahb clock cycle.

enumerator kFLEXSPI_AhbWriteWaitUnit32768AhbCycle

AWRWAIT unit is 32768 ahb clock cycle.

enum _flexspi_ip_error_code

Error Code when IP command Error detected.

Values:

enumerator kFLEXSPI_IpCmdErrorNoError

No error.

enumerator kFLEXSPI_IpCmdErrorJumpOnCsInIpCmd
IP command with JMP_ON_CS instruction used.

enumerator kFLEXSPI_IpCmdErrorUnknownOpCode
Unknown instruction opcode in the sequence.

enumerator kFLEXSPI_IpCmdErrorSdrDummyInDdrSequence
Instruction DUMMY_SDR/DUMMY_RWDS_SDR used in DDR sequence.

enumerator kFLEXSPI_IpCmdErrorDdrDummyInSdrSequence
Instruction DUMMY_DDR/DUMMY_RWDS_DDR used in SDR sequence.

enumerator kFLEXSPI_IpCmdErrorInvalidAddress
Flash access start address exceed the whole flash address range (A1/A2/B1/B2).

enumerator kFLEXSPI_IpCmdErrorSequenceExecutionTimeout
Sequence execution timeout.

enumerator kFLEXSPI_IpCmdErrorFlashBoundaryAcrosss
Flash boundary crossed.

enum _flexspi_ahb_error_code
Error Code when AHB command Error detected.

Values:

enumerator kFLEXSPI_AhbCmdErrorNoError
No error.

enumerator kFLEXSPI_AhbCmdErrorJumpOnCsInWriteCmd
AHB Write command with JMP_ON_CS instruction used in the sequence.

enumerator kFLEXSPI_AhbCmdErrorUnknownOpCode
Unknown instruction opcode in the sequence.

enumerator kFLEXSPI_AhbCmdErrorSdrDummyInDdrSequence
Instruction DUMMY_SDR/DUMMY_RWDS_SDR used in DDR sequence.

enumerator kFLEXSPI_AhbCmdErrorDdrDummyInSdrSequence
Instruction DUMMY_DDR/DUMMY_RWDS_DDR used in SDR sequence.

enumerator kFLEXSPI_AhbCmdSequenceExecutionTimeout
Sequence execution timeout.

enum _flexspi_port
FLEXSPI operation port select.

Values:

enumerator kFLEXSPI_PortA1
Access flash on A1 port.

enumerator kFLEXSPI_PortA2
Access flash on A2 port.

enumerator kFLEXSPI_PortCount

enum _flexspi_arb_command_source
Trigger source of current command sequence granted by arbitrator.

Values:

enumerator kFLEXSPI_AhbReadCommand

enumerator kFLEXSPI_AhbWriteCommand

enumerator kFLEXSPI_IpCommand

enumerator kFLEXSPI_SuspendedCommand

enum _flexspi_command_type

Command type.

Values:

enumerator kFLEXSPI_Command

FlexSPI operation: Only command, both TX and Rx buffer are ignored.

enumerator kFLEXSPI_Config

FlexSPI operation: Configure device mode, the TX fifo size is fixed in LUT.

enumerator kFLEXSPI_Read

enumerator kFLEXSPI_Write

typedef enum _flexspi_pad flexspi_pad_t

pad definition of FLEXSPI, use to form LUT instruction.

typedef enum _flexspi_flags flexspi_flags_t

FLEXSPI interrupt status flags.

typedef enum _flexspi_read_sample_clock flexspi_read_sample_clock_t

FLEXSPI sample clock source selection for Flash Reading.

typedef enum _flexspi_cs_interval_cycle_unit flexspi_cs_interval_cycle_unit_t

FLEXSPI interval unit for flash device select.

typedef enum _flexspi_ahb_write_wait_unit flexspi_ahb_write_wait_unit_t

FLEXSPI AHB wait interval unit for writing.

typedef enum _flexspi_ip_error_code flexspi_ip_error_code_t

Error Code when IP command Error detected.

typedef enum _flexspi_ahb_error_code flexspi_ahb_error_code_t

Error Code when AHB command Error detected.

typedef enum _flexspi_port flexspi_port_t

FLEXSPI operation port select.

typedef enum _flexspi_arb_command_source flexspi_arb_command_source_t

Trigger source of current command sequence granted by arbitrator.

typedef enum _flexspi_command_type flexspi_command_type_t

Command type.

typedef struct _flexspi_ahbBuffer_config flexspi_ahbBuffer_config_t

typedef struct _flexspi_ahbBuffers_ctrl flexspi_ahbBuffers_ctrl_t

Structure to control all AHB buffers.

typedef struct _flexspi_config flexspi_config_t

FLEXSPI configuration structure.

typedef struct _flexspi_device_config flexspi_device_config_t

External device configuration items.

typedef struct _flexspi_transfer flexspi_transfer_t

Transfer structure for FLEXSPI.

```
typedef struct _flexspi_handle flexspi_handle_t

typedef void (*flexspi_transfer_callback_t)(FLEXSPI_Type *base, flexspi_handle_t *handle,
status_t status, void *userData)
    FLEXSPI transfer callback function.

typedef struct _flexspi_addr_map_config flexspi_addr_map_config_t
    Address mapping configuration structure.

FSL_FEATURE_FLEXSPI_AHB_BUFFER_COUNT

FLEXSPI_LUT_SEQ(cmd0, pad0, op0, cmd1, pad1, op1)
    Formula to form FLEXSPI instructions in LUT table.

struct _flexspi_ahbBuffer_config
    #include <fsl_flexspi.h>
```

Public Members

```
uint8_t priority
    This priority for AHB Master Read which this AHB RX Buffer is assigned.

uint8_t masterIndex
    AHB Master ID the AHB RX Buffer is assigned.

uint16_t bufferSize
    AHB buffer size in byte.

bool enablePrefetch
    AHB Read Prefetch Enable for current AHB RX Buffer corresponding Master, allows
    prefetch disable/enable separately for each master.

struct _flexspi_ahbBuffers_ctrl
    #include <fsl_flexspi.h> Structure to control all AHB buffers.
```

Public Members

```
flexspi_ahbBuffer_config_t buffer[FSL_FEATURE_FLEXSPI_AHB_BUFFER_COUNTn(0)]
    Configurations of all AHB buffers.

struct _flexspi_config
    #include <fsl_flexspi.h> FLEXSPI configuration structure.
```

Public Members

```
flexspi_read_sample_clock_t rxSampleClock
    Sample Clock source selection for Flash Reading.

bool enableSckFreeRunning
    Enable/disable SCK output free-running.

bool enableDoze
    Enable/disable doze mode support.

bool enableHalfSpeedAccess
    Enable/disable divide by 2 of the clock for half speed commands.

flexspi_read_sample_clock_t rxSampleClockPortB
    Sample Clock source_b selection for Flash Reading.
```

bool rxSampleClockDiff

Sample Clock source or source_b selection for Flash Reading.

bool enableSameConfigForAll

Enable/disable same configuration for all connected devices when enabled, same configuration in FLASHA1CRx is applied to all.

uint16_t seqTimeoutCycle

Timeout wait cycle for command sequence execution, timeout after ahbGrantTimeoutCycle*1024 serial root clock cycles.

uint8_t ipGrantTimeoutCycle

Timeout wait cycle for IP command grant, timeout after ipGrantTimeoutCycle*1024 AHB clock cycles.

uint8_t txWatermark

FLEXSPI IP transmit watermark value.

uint8_t rxWatermark

FLEXSPI receive watermark value.

struct _flexspi_device_config

#include <fsl_flexspi.h> External device configuration items.

Public Members

uint32_t flexspiRootClk

FLEXSPI serial root clock.

bool isSck2Enabled

FLEXSPI use SCK2.

uint32_t flashSize

Flash size in KByte.

bool addressShift

Address shift.

flexspi_cs_interval_cycle_unit_t CSIntervalUnit

CS interval unit, 1 or 256 cycle.

uint16_t CSInterval

CS line assert interval, multiply CS interval unit to get the CS line assert interval cycles.

uint8_t CSHoldTime

CS line hold time.

uint8_t CSSetupTime

CS line setup time.

uint8_t dataValidTime

Data valid time for external device.

uint8_t columnSpace

Column space size.

bool enableWordAddress

If enable word address.

uint8_t AWRSeqIndex

Sequence ID for AHB write command.

uint8_t AWRSeqNumber

Sequence number for AHB write command.

uint8_t ARDSeqIndex

Sequence ID for AHB read command.

uint8_t ARDSeqNumber

Sequence number for AHB read command.

flexspi_ahb_write_wait_unit_t AHBWriteWaitUnit

AHB write wait unit.

uint16_t AHBWriteWaitInterval

AHB write wait interval, multiply AHB write interval unit to get the AHB write wait cycles.

bool enableWriteMask

Enable/Disable FLEXSPI drive DQS pin as write mask when writing to external device.

bool isFroClockSource

Is FRO clock source or not.

struct *_flexspi_transfer*

#include <fsl_flexspi.h> Transfer structure for FLEXSPI.

Public Members

uint32_t deviceAddress

Operation device address.

flexspi_port_t port

Operation port.

flexspi_command_type_t cmdType

Execution command type.

uint8_t seqIndex

Sequence ID for command.

uint8_t SeqNumber

Sequence number for command.

uint32_t *data

Data buffer.

size_t dataSize

Data size in bytes.

struct *_flexspi_handle*

#include <fsl_flexspi.h> Transfer handle structure for FLEXSPI.

Public Members

uint32_t state

Internal state for FLEXSPI transfer

uint8_t *data

Data buffer.

size_t dataSize

Remaining Data size in bytes.

size_t transferTotalSize

Total Data size in bytes.

flexspi_transfer_callback_t completionCallback

Callback for users while transfer finish or error occurred

void *userData

FLEXSPI callback function parameter.

struct *_flexspi_addr_map_config*

#include <fsl_flexspi.h> Address mapping configuration structure.

Public Members

uint32_t addrStart

Remapping start address.

uint32_t addrEnd

Remapping end address.

uint32_t addrOffset

Address offset.

bool remapEnable

Enable address remapping.

struct ahbConfig

Public Members

uint8_t ahbGrantTimeoutCycle

Timeout wait cycle for AHB command grant, timeout after ahbGrantTimeoutCycle*1024 AHB clock cycles.

uint16_t ahbBusTimeoutCycle

Timeout wait cycle for AHB read/write access, timeout after ahbBusTimeoutCycle*1024 AHB clock cycles.

uint8_t resumeWaitCycle

Wait cycle for idle state before suspended command sequence resume, timeout after ahbBusTimeoutCycle AHB clock cycles.

bool disableAhbReadResume

True: Suspended AHB read prefetch does not resume once aborted; **False:** Suspended AHB read prefetch resumes when AHB is IDLE.

flexspi_ahbBuffer_config_t buffer[FSL_FEATURE_FLEXSPI_AHB_BUFFER_COUNTn(0)]

AHB buffer size.

bool enableClearAHBBufferOpt

Enable/disable automatically clean AHB RX Buffer and TX Buffer when FLEXSPI returns STOP mode ACK.

bool enableReadAddressOpt

Enable/disable remove AHB read burst start address alignment limitation. when enable, there is no AHB read burst start address alignment limitation.

bool enableAHBPrefetch

Enable/disable AHB read prefetch feature, when enabled, FLEXSPI will fetch more data than current AHB burst.

bool enableAHBBufferable

Enable/disable AHB bufferable write access support, when enabled, FLEXSPI return before waiting for command execution finished.

bool enableAHBCachable

Enable AHB bus cachable read access support.

2.21 FLEXSPI eDMA Driver

```
void FLEXSPI_TransferCreateHandleEDMA(FLEXSPI_Type *base, flexspi_edma_handle_t
                                     *handle, flexspi_edma_callback_t callback, void
                                     *userData, edma_handle_t *txDmaHandle,
                                     edma_handle_t *rxDmaHandle)
```

Initializes the FLEXSPI handle for transfer which is used in transactional functions and set the callback.

Parameters

- base – FLEXSPI peripheral base address
- handle – Pointer to flexspi_edma_handle_t structure
- callback – FLEXSPI callback, NULL means no callback.
- userData – User callback function data.
- txDmaHandle – User requested DMA handle for TX DMA transfer.
- rxDmaHandle – User requested DMA handle for RX DMA transfer.

```
void FLEXSPI_TransferUpdateSizeEDMA(FLEXSPI_Type *base, flexspi_edma_handle_t *handle,
                                    flexspi_edma_transfer_nsize_t nsize)
```

Update FLEXSPI EDMA transfer source data transfer size(SSIZE) and destination data transfer size(DSIZE).

See also:

flexspi_edma_transfer_nsize_t.

Parameters

- base – FLEXSPI peripheral base address
- handle – Pointer to flexspi_edma_handle_t structure
- nsize – FLEXSPI DMA transfer data transfer size(SSIZE/DSIZE), by default the size is kFLEXPSI_EDMAAnSize1Bytes(one byte).

```
status_t FLEXSPI_TransferEDMA(FLEXSPI_Type *base, flexspi_edma_handle_t *handle,
                              flexspi_transfer_t *xfer)
```

Transfers FLEXSPI data using an eDMA non-blocking method.

This function writes/receives data to/from the FLEXSPI transmit/receive FIFO. This function is non-blocking.

Parameters

- base – FLEXSPI peripheral base address.

- `handle` – Pointer to `flexspi_edma_handle_t` structure
- `xfer` – FLEXSPI transfer structure.

Return values

- `kStatus_FLEXSPI_Busy` – FLEXSPI is busy transfer.
- `kStatus_InvalidArgument` – The watermark configuration is invalid, the watermark should be power of 2 to do successfully EDMA transfer.
- `kStatus_Success` – FLEXSPI successfully start edma transfer.

`void FLEXSPI_TransferAbortEDMA(FLEXSPI_Type *base, flexspi_edma_handle_t *handle)`

Aborts the transfer data using eDMA.

This function aborts the transfer data using eDMA.

Parameters

- `base` – FLEXSPI peripheral base address.
- `handle` – Pointer to `flexspi_edma_handle_t` structure

`status_t FLEXSPI_TransferGetTransferCountEDMA(FLEXSPI_Type *base, flexspi_edma_handle_t *handle, size_t *count)`

Gets the transferred counts of transfer.

Parameters

- `base` – FLEXSPI peripheral base address.
- `handle` – Pointer to `flexspi_edma_handle_t` structure.
- `count` – Bytes transfer.

Return values

- `kStatus_Success` – Succeed get the transfer count.
- `kStatus_NoTransferInProgress` – There is not a non-blocking transaction currently in progress.

`FSL_FLEXSPI_EDMA_DRIVER_VERSION`

FLEXSPI EDMA driver version.

`enum flexspi_edma_ntransfer_size`

eDMA transfer configuration

Values:

enumerator `kFLEXPSI_EDMAAnSize1Bytes`

Source/Destination data transfer size is 1 byte every time

enumerator `kFLEXPSI_EDMAAnSize2Bytes`

Source/Destination data transfer size is 2 bytes every time

enumerator `kFLEXPSI_EDMAAnSize4Bytes`

Source/Destination data transfer size is 4 bytes every time

enumerator `kFLEXPSI_EDMAAnSize8Bytes`

Source/Destination data transfer size is 8 bytes every time

enumerator `kFLEXPSI_EDMAAnSize32Bytes`

Source/Destination data transfer size is 32 bytes every time

`typedef struct flexspi_edma_handle flexspi_edma_handle_t`

```
typedef void (*flexspi_edma_callback_t)(FLEXSPI_Type *base, flexspi_edma_handle_t *handle,
status_t status, void *userData)
```

FLEXSPI eDMA transfer callback function for finish and error.

```
typedef enum _flexspi_edma_ntransfer_size flexspi_edma_transfer_nsize_t
    eDMA transfer configuration
```

```
struct _flexspi_edma_handle
```

#include <fsl_flexspi_edma.h> FLEXSPI DMA transfer handle, users should not touch the content of the handle.

Public Members

edma_handle_t *txDmaHandle

eDMA handler for FLEXSPI Tx.

edma_handle_t *rxDmaHandle

eDMA handler for FLEXSPI Rx.

size_t transferSize

Bytes need to transfer.

flexspi_edma_transfer_nsize_t nsize

eDMA SSIZE/DSIZE in each transfer.

uint8_t nbytes

eDMA minor byte transfer count initially configured.

uint8_t count

The transfer data count in a DMA request.

uint32_t state

Internal state for FLEXSPI eDMA transfer.

flexspi_edma_callback_t completionCallback

A callback function called after the eDMA transfer is finished.

void *userData

User callback parameter

2.22 I3C: I3C Driver

FSL_I3C_DRIVER_VERSION

I3C driver version.

I3C status return codes.

Values:

enumerator kStatus_I3C_Busy

The master is already performing a transfer.

enumerator kStatus_I3C_Idle

The slave driver is idle.

enumerator kStatus_I3C_Nak

The slave device sent a NAK in response to an address.

enumerator kStatus_I3C_WriteAbort

The slave device sent a NAK in response to a write.

enumerator kStatus_I3C_Term

The master terminates slave read.

enumerator kStatus_I3C_HdrParityError

Parity error from DDR read.

enumerator kStatus_I3C_CrcError

CRC error from DDR read.

enumerator kStatus_I3C_ReadFifoError

Read from M/SRDATA register when FIFO empty.

enumerator kStatus_I3C_WriteFifoError

Write to M/SWDATA register when FIFO full.

enumerator kStatus_I3C_MsgError

Message SDR/DDR mismatch or read/write message in wrong state

enumerator kStatus_I3C_InvalidReq

Invalid use of request.

enumerator kStatus_I3C_Timeout

The module has stalled too long in a frame.

enumerator kStatus_I3C_SlaveCountExceed

The I3C slave count has exceed the definition in I3C_MAX_DEVCNT.

enumerator kStatus_I3C_IBIWon

The I3C slave event IBI or MR or HJ won the arbitration on a header address.

enumerator kStatus_I3C_OverrunError

Slave internal from-bus buffer/FIFO overrun.

enumerator kStatus_I3C_UnderrunError

Slave internal to-bus buffer/FIFO underrun

enumerator kStatus_I3C_UnderrunNak

Slave internal from-bus buffer/FIFO underrun and NACK error

enumerator kStatus_I3C_InvalidStart

Slave invalid start flag

enumerator kStatus_I3C_SdrParityError

SDR parity error

enumerator kStatus_I3C_S0S1Error

S0 or S1 error

enum _i3c_hdr_mode

I3C HDR modes.

Values:

enumerator kI3C_HDRModeNone

enumerator kI3C_HDRModeDDR

enumerator kI3C_HDRModeTSP

enumerator kI3C_HDRModeTSL

```
typedef enum _i3c_hdr_mode i3c_hdr_mode_t
```

I3C HDR modes.

```
typedef struct _i3c_device_info i3c_device_info_t
```

I3C device information.

```
I3C_RETRY_TIMES
```

Max loops to wait for I3C operation status complete.

This is the maximum number of loops to wait for I3C operation status complete. If set to 0, it will wait indefinitely.

```
I3C_MAX_DEVCNT
```

```
I3C_IBI_BUFF_SIZE
```

```
struct _i3c_device_info
```

```
#include <fsl_i3c.h> I3C device information.
```

Public Members

```
uint8_t dynamicAddr
```

Device dynamic address.

```
uint8_t staticAddr
```

Static address.

```
uint8_t dcr
```

Device characteristics register information.

```
uint8_t bcr
```

Bus characteristics register information.

```
uint16_t vendorID
```

Device vendor ID(manufacture ID).

```
uint32_t partNumber
```

Device part number info

```
uint16_t maxReadLength
```

Maximum read length.

```
uint16_t maxWriteLength
```

Maximum write length.

```
uint8_t hdrMode
```

Support hdr mode, could be OR logic in `i3c_hdr_mode`.

2.23 I3C Common Driver

```
typedef struct _i3c_config i3c_config_t
```

Structure with settings to initialize the I3C module, could both initialize master and slave functionality.

This structure holds configuration settings for the I3C peripheral. To initialize this structure to reasonable defaults, call the `I3C_GetDefaultConfig()` function and pass a pointer to your configuration structure instance.

The configuration structure can be made constant so it resides in flash.

```
uint32_t I3C_GetInstance(I3C_Type *base)
```

Get which instance current I3C is used.

Parameters

- `base` – The I3C peripheral base address.

```
void I3C_GetDefaultConfig(i3c_config_t *config)
```

Provides a default configuration for the I3C peripheral, the configuration covers both master functionality and slave functionality.

This function provides the following default configuration for I3C:

```
config->enableMaster          = kI3C_MasterCapable;
config->disableTimeout        = false;
config->hKeep                  = kI3C_MasterHighKeeperNone;
config->enableOpenDrainStop    = true;
config->enableOpenDrainHigh    = true;
config->baudRate_Hz.i2cBaud    = 400000U;
config->baudRate_Hz.i3cPushPullBaud = 12500000U;
config->baudRate_Hz.i3cOpenDrainBaud = 2500000U;
config->masterDynamicAddress   = 0x0AU;
config->slowClock_Hz           = 1000000U;
config->enableSlave            = true;
config->vendorID                = 0x11BU;
config->enableRandomPart       = false;
config->partNumber              = 0;
config->dcr                     = 0;
config->bcr = 0;
config->hdrMode                 = (uint8_t)kI3C_HDRModeDDR;
config->nakAllRequest           = false;
config->ignoreS0S1Error        = false;
config->offline                 = false;
config->matchSlaveStartStop    = false;
```

After calling this function, you can override any settings in order to customize the configuration, prior to initializing the common I3C driver with `I3C_Init()`.

Parameters

- `config` – **[out]** User provided configuration structure for default values. Refer to `i3c_config_t`.

```
void I3C_Init(I3C_Type *base, const i3c_config_t *config, uint32_t sourceClock_Hz)
```

Initializes the I3C peripheral. This function enables the peripheral clock and initializes the I3C peripheral as described by the user provided configuration. This will initialize both the master peripheral and slave peripheral so that I3C module could work as pure master, pure slave or secondary master, etc. A software reset is performed prior to configuration.

Parameters

- `base` – The I3C peripheral base address.
- `config` – User provided peripheral configuration. Use `I3C_GetDefaultConfig()` to get a set of defaults that you can override.
- `sourceClock_Hz` – Frequency in Hertz of the I3C functional clock. Used to calculate the baud rate divisors, filter widths, and timeout periods.

```
struct _i3c_config
```

`#include <fsl_i3c.h>` Structure with settings to initialize the I3C module, could both initialize master and slave functionality.

This structure holds configuration settings for the I3C peripheral. To initialize this structure to reasonable defaults, call the `I3C_GetDefaultConfig()` function and pass a pointer to your configuration structure instance.

The configuration structure can be made constant so it resides in flash.

Public Members

i3c_master_enable_t enableMaster

Enable master mode.

bool disableTimeout

Whether to disable timeout to prevent the ERRWARN.

i3c_master_hkeep_t hKeep

High keeper mode setting.

bool enableOpenDrainStop

Whether to emit open-drain speed STOP.

bool enableOpenDrainHigh

Enable Open-Drain High to be 1 PPBAUD count for i3c messages, or 1 ODBAUD.

i3c_baudrate_hz_t baudRate_Hz

Desired baud rate settings.

i3c_start_scl_delay_t startSclDelay

I3C SCL delay after START.

i3c_start_scl_delay_t restartSclDelay

I3C SCL delay after Repeated START.

uint8_t masterDynamicAddress

Main master dynamic address configuration.

uint32_t maxWriteLength

Maximum write length.

uint32_t maxReadLength

Maximum read length.

bool enableSlave

Whether to enable slave.

uint8_t staticAddr

Static address.

uint16_t vendorID

Device vendor ID(manufacture ID).

uint32_t partNumber

Device part number info

uint8_t dcr

Device characteristics register information.

uint8_t bcr

Bus characteristics register information.

uint8_t hdrMode

Support hdr mode, could be OR logic in enumeration:i3c_hdr_mode_t.

bool nakAllRequest

Whether to reply NAK to all requests except broadcast CCC.

`bool ignoreS0S1Error`

Whether to ignore S0/S1 error in SDR mode.

`bool offline`

Whether to wait 60 us of bus quiet or HDR request to ensure slave track SDR mode safely.

`bool matchSlaveStartStop`

Whether to assert start/stop status only the time slave is addressed.

2.24 I3C Master Driver

`void I3C_MasterGetDefaultConfig(i3c_master_config_t *masterConfig)`

Provides a default configuration for the I3C master peripheral.

This function provides the following default configuration for the I3C master peripheral:

```
masterConfig->enableMaster      = kI3C_MasterOn;
masterConfig->disableTimeout    = false;
masterConfig->hKeep             = kI3C_MasterHighKeeperNone;
masterConfig->enableOpenDrainStop = true;
masterConfig->enableOpenDrainHigh = true;
masterConfig->baudRate_Hz       = 100000U;
masterConfig->busType            = kI3C_TypeI2C;
```

After calling this function, you can override any settings in order to customize the configuration, prior to initializing the master driver with `I3C_MasterInit()`.

Parameters

- `masterConfig` – **[out]** User provided configuration structure for default values. Refer to `i3c_master_config_t`.

`void I3C_MasterInit(I3C_Type *base, const i3c_master_config_t *masterConfig, uint32_t sourceClock_Hz)`

Initializes the I3C master peripheral.

This function enables the peripheral clock and initializes the I3C master peripheral as described by the user provided configuration. A software reset is performed prior to configuration.

Parameters

- `base` – The I3C peripheral base address.
- `masterConfig` – User provided peripheral configuration. Use `I3C_MasterGetDefaultConfig()` to get a set of defaults that you can override.
- `sourceClock_Hz` – Frequency in Hertz of the I3C functional clock. Used to calculate the baud rate divisors, filter widths, and timeout periods.

`void I3C_MasterDeinit(I3C_Type *base)`

Deinitializes the I3C master peripheral.

This function disables the I3C master peripheral and gates the clock. It also performs a software reset to restore the peripheral to reset conditions.

Parameters

- `base` – The I3C peripheral base address.

status_t I3C_MasterCheckAndClearError(I3C_Type *base, uint32_t status)

status_t I3C_MasterWaitForCtrlDone(I3C_Type *base, bool waitIdle)

status_t I3C_CheckForBusyBus(I3C_Type *base)

static inline void I3C_MasterEnable(I3C_Type *base, *i3c_master_enable_t* enable)

Set I3C module master mode.

Parameters

- base – The I3C peripheral base address.
- enable – Enable master mode.

void I3C_SlaveGetDefaultConfig(*i3c_slave_config_t* *slaveConfig)

Provides a default configuration for the I3C slave peripheral.

This function provides the following default configuration for the I3C slave peripheral:

```
slaveConfig->enableslave      = true;
```

After calling this function, you can override any settings in order to customize the configuration, prior to initializing the slave driver with I3C_SlaveInit().

Parameters

- slaveConfig – **[out]** User provided configuration structure for default values. Refer to *i3c_slave_config_t*.

void I3C_SlaveInit(I3C_Type *base, const *i3c_slave_config_t* *slaveConfig, uint32_t slowClock_Hz)

Initializes the I3C slave peripheral.

This function enables the peripheral clock and initializes the I3C slave peripheral as described by the user provided configuration.

Parameters

- base – The I3C peripheral base address.
- slaveConfig – User provided peripheral configuration. Use I3C_SlaveGetDefaultConfig() to get a set of defaults that you can override.
- slowClock_Hz – Frequency in Hertz of the I3C slow clock. Used to calculate the bus match condition values. If FSL_FEATURE_I3C_HAS_NO_SCONFIG_BAMATCH defines as 1, this parameter is useless.

void I3C_SlaveDeinit(I3C_Type *base)

Deinitializes the I3C slave peripheral.

This function disables the I3C slave peripheral and gates the clock.

Parameters

- base – The I3C peripheral base address.

static inline void I3C_SlaveEnable(I3C_Type *base, bool isEnabled)

Enable/Disable Slave.

Parameters

- base – The I3C peripheral base address.
- isEnabled – Enable or disable.


```
static inline uint32_t I3C_MasterGetStatusFlags(I3C_Type *base)
```

Gets the I3C master status flags.

A bit mask with the state of all I3C master status flags is returned. For each flag, the corresponding bit in the return value is set if the flag is asserted.

See also:

`_i3c_master_flags`

Parameters

- `base` – The I3C peripheral base address.

Returns

State of the status flags:

- 1: related status flag is set.
- 0: related status flag is not set.

```
static inline void I3C_MasterClearStatusFlags(I3C_Type *base, uint32_t statusMask)
```

Clears the I3C master status flag state.

The following status register flags can be cleared:

- `kI3C_MasterSlaveStartFlag`
- `kI3C_MasterControlDoneFlag`
- `kI3C_MasterCompleteFlag`
- `kI3C_MasterArbitrationWonFlag`
- `kI3C_MasterSlave2MasterFlag`

Attempts to clear other flags has no effect.

See also:

`_i3c_master_flags`.

Parameters

- `base` – The I3C peripheral base address.
- `statusMask` – A bitmask of status flags that are to be cleared. The mask is composed of `_i3c_master_flags` enumerators OR'd together. You may pass the result of a previous call to `I3C_MasterGetStatusFlags()`.

```
static inline uint32_t I3C_MasterGetErrorStatusFlags(I3C_Type *base)
```

Gets the I3C master error status flags.

A bit mask with the state of all I3C master error status flags is returned. For each flag, the corresponding bit in the return value is set if the flag is asserted.

See also:

`_i3c_master_error_flags`

Parameters

- `base` – The I3C peripheral base address.

Returns

State of the error status flags:

- 1: related status flag is set.
- 0: related status flag is not set.

```
static inline void I3C_MasterClearErrorStatusFlags(I3C_Type *base, uint32_t statusMask)
```

Clears the I3C master error status flag state.

See also:

`_i3c_master_error_flags`.

Parameters

- `base` – The I3C peripheral base address.
- `statusMask` – A bitmask of error status flags that are to be cleared. The mask is composed of `_i3c_master_error_flags` enumerators OR'd together. You may pass the result of a previous call to `I3C_MasterGetStatusFlags()`.

```
i3c_master_state_t I3C_MasterGetState(I3C_Type *base)
```

Gets the I3C master state.

Parameters

- `base` – The I3C peripheral base address.

Returns

I3C master state.

```
static inline uint32_t I3C_SlaveGetStatusFlags(I3C_Type *base)
```

Gets the I3C slave status flags.

A bit mask with the state of all I3C slave status flags is returned. For each flag, the corresponding bit in the return value is set if the flag is asserted.

See also:

`_i3c_slave_flags`

Parameters

- `base` – The I3C peripheral base address.

Returns

State of the status flags:

- 1: related status flag is set.
- 0: related status flag is not set.

```
static inline void I3C_SlaveClearStatusFlags(I3C_Type *base, uint32_t statusMask)
```

Clears the I3C slave status flag state.

The following status register flags can be cleared:

- `kI3C_SlaveBusStartFlag`
- `kI3C_SlaveMatchedFlag`
- `kI3C_SlaveBusStopFlag`

Attempts to clear other flags has no effect.

See also:

`_i3c_slave_flags`.

Parameters

- `base` – The I3C peripheral base address.
- `statusMask` – A bitmask of status flags that are to be cleared. The mask is composed of `_i3c_slave_flags` enumerators OR'd together. You may pass the result of a previous call to `I3C_SlaveGetStatusFlags()`.

```
static inline uint32_t I3C_SlaveGetErrorStatusFlags(I3C_Type *base)
```

Gets the I3C slave error status flags.

A bit mask with the state of all I3C slave error status flags is returned. For each flag, the corresponding bit in the return value is set if the flag is asserted.

See also:

`_i3c_slave_error_flags`

Parameters

- `base` – The I3C peripheral base address.

Returns

State of the error status flags:

- 1: related status flag is set.
- 0: related status flag is not set.

```
static inline void I3C_SlaveClearErrorStatusFlags(I3C_Type *base, uint32_t statusMask)
```

Clears the I3C slave error status flag state.

See also:

`_i3c_slave_error_flags`.

Parameters

- `base` – The I3C peripheral base address.
- `statusMask` – A bitmask of error status flags that are to be cleared. The mask is composed of `_i3c_slave_error_flags` enumerators OR'd together. You may pass the result of a previous call to `I3C_SlaveGetErrorStatusFlags()`.

```
i3c_slave_activity_state_t I3C_SlaveGetActivityState(I3C_Type *base)
```

Gets the I3C slave state.

Parameters

- `base` – The I3C peripheral base address.

Returns

I3C slave activity state, refer `i3c_slave_activity_state_t`.

```
status_t I3C_SlaveCheckAndClearError(I3C_Type *base, uint32_t status)
```

static inline void I3C_MasterEnableInterrupts(I3C_Type *base, uint32_t interruptMask)

Enables the I3C master interrupt requests.

All flags except kI3C_MasterBetweenFlag and kI3C_MasterNackDetectFlag can be enabled as interrupts.

Parameters

- base – The I3C peripheral base address.
- interruptMask – Bit mask of interrupts to enable. See `_i3c_master_flags` for the set of constants that should be OR'd together to form the bit mask.

static inline void I3C_MasterDisableInterrupts(I3C_Type *base, uint32_t interruptMask)

Disables the I3C master interrupt requests.

All flags except kI3C_MasterBetweenFlag and kI3C_MasterNackDetectFlag can be enabled as interrupts.

Parameters

- base – The I3C peripheral base address.
- interruptMask – Bit mask of interrupts to disable. See `_i3c_master_flags` for the set of constants that should be OR'd together to form the bit mask.

static inline uint32_t I3C_MasterGetEnabledInterrupts(I3C_Type *base)

Returns the set of currently enabled I3C master interrupt requests.

Parameters

- base – The I3C peripheral base address.

Returns

A bitmask composed of `_i3c_master_flags` enumerators OR'd together to indicate the set of enabled interrupts.

static inline uint32_t I3C_MasterGetPendingInterrupts(I3C_Type *base)

Returns the set of pending I3C master interrupt requests.

Parameters

- base – The I3C peripheral base address.

Returns

A bitmask composed of `_i3c_master_flags` enumerators OR'd together to indicate the set of pending interrupts.

static inline void I3C_SlaveEnableInterrupts(I3C_Type *base, uint32_t interruptMask)

Enables the I3C slave interrupt requests.

Only below flags can be enabled as interrupts.

- kI3C_SlaveBusStartFlag
- kI3C_SlaveMatchedFlag
- kI3C_SlaveBusStopFlag
- kI3C_SlaveRxReadyFlag
- kI3C_SlaveTxReadyFlag
- kI3C_SlaveDynamicAddrChangedFlag
- kI3C_SlaveReceivedCCCFlag
- kI3C_SlaveErrorFlag
- kI3C_SlaveHDRCommandMatchFlag

- kI3C_SlaveCCCHandledFlag
- kI3C_SlaveEventSentFlag

Parameters

- base – The I3C peripheral base address.
- interruptMask – Bit mask of interrupts to enable. See `_i3c_slave_flags` for the set of constants that should be OR'd together to form the bit mask.

static inline void I3C_SlaveDisableInterrupts(I3C_Type *base, uint32_t interruptMask)

Disables the I3C slave interrupt requests.

Only below flags can be disabled as interrupts.

- kI3C_SlaveBusStartFlag
- kI3C_SlaveMatchedFlag
- kI3C_SlaveBusStopFlag
- kI3C_SlaveRxReadyFlag
- kI3C_SlaveTxReadyFlag
- kI3C_SlaveDynamicAddrChangedFlag
- kI3C_SlaveReceivedCCCFlag
- kI3C_SlaveErrorFlag
- kI3C_SlaveHDRCommandMatchFlag
- kI3C_SlaveCCCHandledFlag
- kI3C_SlaveEventSentFlag

Parameters

- base – The I3C peripheral base address.
- interruptMask – Bit mask of interrupts to disable. See `_i3c_slave_flags` for the set of constants that should be OR'd together to form the bit mask.

static inline uint32_t I3C_SlaveGetEnabledInterrupts(I3C_Type *base)

Returns the set of currently enabled I3C slave interrupt requests.

Parameters

- base – The I3C peripheral base address.

Returns

A bitmask composed of `_i3c_slave_flags` enumerators OR'd together to indicate the set of enabled interrupts.

static inline uint32_t I3C_SlaveGetPendingInterrupts(I3C_Type *base)

Returns the set of pending I3C slave interrupt requests.

Parameters

- base – The I3C peripheral base address.

Returns

A bitmask composed of `_i3c_slave_flags` enumerators OR'd together to indicate the set of pending interrupts.

```
static inline void I3C_MasterEnableDMA(I3C_Type *base, bool enableTx, bool enableRx,  
                                     uint32_t width)
```

Enables or disables I3C master DMA requests.

Parameters

- base – The I3C peripheral base address.
- enableTx – Enable flag for transmit DMA request. Pass true for enable, false for disable.
- enableRx – Enable flag for receive DMA request. Pass true for enable, false for disable.
- width – DMA read/write unit in bytes.

```
static inline uint32_t I3C_MasterGetTxFifoAddress(I3C_Type *base, uint32_t width)
```

Gets I3C master transmit data register address for DMA transfer.

Parameters

- base – The I3C peripheral base address.
- width – DMA read/write unit in bytes.

Returns

The I3C Master Transmit Data Register address.

```
static inline uint32_t I3C_MasterGetRxFifoAddress(I3C_Type *base, uint32_t width)
```

Gets I3C master receive data register address for DMA transfer.

Parameters

- base – The I3C peripheral base address.
- width – DMA read/write unit in bytes.

Returns

The I3C Master Receive Data Register address.

```
static inline void I3C_SlaveEnableDMA(I3C_Type *base, bool enableTx, bool enableRx, uint32_t  
                                     width)
```

Enables or disables I3C slave DMA requests.

Parameters

- base – The I3C peripheral base address.
- enableTx – Enable flag for transmit DMA request. Pass true for enable, false for disable.
- enableRx – Enable flag for receive DMA request. Pass true for enable, false for disable.
- width – DMA read/write unit in bytes.

```
static inline uint32_t I3C_SlaveGetTxFifoAddress(I3C_Type *base, uint32_t width)
```

Gets I3C slave transmit data register address for DMA transfer.

Parameters

- base – The I3C peripheral base address.
- width – DMA read/write unit in bytes.

Returns

The I3C Slave Transmit Data Register address.

```
static inline uint32_t I3C_SlaveGetRxFifoAddress(I3C_Type *base, uint32_t width)
```

Gets I3C slave receive data register address for DMA transfer.

Parameters

- *base* – The I3C peripheral base address.
- *width* – DMA read/write unit in bytes.

Returns

The I3C Slave Receive Data Register address.

```
static inline void I3C_MasterSetWatermarks(I3C_Type *base, i3c_tx_trigger_level_t txLvl,
                                           i3c_rx_trigger_level_t rxLvl, bool flushTx, bool
                                           flushRx)
```

Sets the watermarks for I3C master FIFOs.

Parameters

- *base* – The I3C peripheral base address.
- *txLvl* – Transmit FIFO watermark level. The `kI3C_MasterTxReadyFlag` flag is set whenever the number of words in the transmit FIFO reaches *txLvl*.
- *rxLvl* – Receive FIFO watermark level. The `kI3C_MasterRxReadyFlag` flag is set whenever the number of words in the receive FIFO reaches *rxLvl*.
- *flushTx* – true if TX FIFO is to be cleared, otherwise TX FIFO remains unchanged.
- *flushRx* – true if RX FIFO is to be cleared, otherwise RX FIFO remains unchanged.

```
static inline void I3C_MasterGetFifoCounts(I3C_Type *base, size_t *rxCount, size_t *txCount)
```

Gets the current number of bytes in the I3C master FIFOs.

Parameters

- *base* – The I3C peripheral base address.
- *txCount* – **[out]** Pointer through which the current number of bytes in the transmit FIFO is returned. Pass NULL if this value is not required.
- *rxCount* – **[out]** Pointer through which the current number of bytes in the receive FIFO is returned. Pass NULL if this value is not required.

```
static inline void I3C_SlaveSetWatermarks(I3C_Type *base, i3c_tx_trigger_level_t txLvl,
                                           i3c_rx_trigger_level_t rxLvl, bool flushTx, bool
                                           flushRx)
```

Sets the watermarks for I3C slave FIFOs.

Parameters

- *base* – The I3C peripheral base address.
- *txLvl* – Transmit FIFO watermark level. The `kI3C_SlaveTxReadyFlag` flag is set whenever the number of words in the transmit FIFO reaches *txLvl*.
- *rxLvl* – Receive FIFO watermark level. The `kI3C_SlaveRxReadyFlag` flag is set whenever the number of words in the receive FIFO reaches *rxLvl*.
- *flushTx* – true if TX FIFO is to be cleared, otherwise TX FIFO remains unchanged.
- *flushRx* – true if RX FIFO is to be cleared, otherwise RX FIFO remains unchanged.

```
static inline void I3C_SlaveGetFifoCounts(I3C_Type *base, size_t *rxCount, size_t *txCount)
```

Gets the current number of bytes in the I3C slave FIFOs.

Parameters

- *base* – The I3C peripheral base address.
- *txCount* – **[out]** Pointer through which the current number of bytes in the transmit FIFO is returned. Pass NULL if this value is not required.
- *rxCount* – **[out]** Pointer through which the current number of bytes in the receive FIFO is returned. Pass NULL if this value is not required.

```
void I3C_MasterSetBaudRate(I3C_Type *base, const i3c_baudrate_hz_t *baudRate_Hz, uint32_t sourceClock_Hz)
```

Sets the I3C bus frequency for master transactions.

The I3C master is automatically disabled and re-enabled as necessary to configure the baud rate. Do not call this function during a transfer, or the transfer is aborted.

Parameters

- *base* – The I3C peripheral base address.
- *baudRate_Hz* – Pointer to structure of requested bus frequency in Hertz.
- *sourceClock_Hz* – I3C functional clock frequency in Hertz.

```
static inline bool I3C_MasterGetBusIdleState(I3C_Type *base)
```

Returns whether the bus is idle.

Requires the master mode to be enabled.

Parameters

- *base* – The I3C peripheral base address.

Return values

- *true* – Bus is busy.
- *false* – Bus is idle.

```
status_t I3C_MasterStartWithRxSize(I3C_Type *base, i3c_bus_type_t type, uint8_t address, i3c_direction_t dir, uint8_t rxSize)
```

Sends a START signal and slave address on the I2C/I3C bus, receive size is also specified in the call.

This function is used to initiate a new master mode transfer. First, the bus state is checked to ensure that another master is not occupying the bus. Then a START signal is transmitted, followed by the 7-bit address specified in the *address* parameter. Note that this function does not actually wait until the START and address are successfully sent on the bus before returning.

Parameters

- *base* – The I3C peripheral base address.
- *type* – The bus type to use in this transaction.
- *address* – 7-bit slave device address, in bits [6:0].
- *dir* – Master transfer direction, either *kI3C_Read* or *kI3C_Write*. This parameter is used to set the R/w bit (bit 0) in the transmitted slave address.
- *rxSize* – Read terminate size for the followed read transfer, limit to 255 bytes.

Return values

- `kStatus_Success` – START signal and address were successfully enqueued in the transmit FIFO.
- `kStatus_I3C_Busy` – Another master is currently utilizing the bus.

`status_t I3C_MasterStart(I3C_Type *base, i3c_bus_type_t type, uint8_t address, i3c_direction_t dir)`

Sends a START signal and slave address on the I2C/I3C bus.

This function is used to initiate a new master mode transfer. First, the bus state is checked to ensure that another master is not occupying the bus. Then a START signal is transmitted, followed by the 7-bit address specified in the *address* parameter. Note that this function does not actually wait until the START and address are successfully sent on the bus before returning.

Parameters

- *base* – The I3C peripheral base address.
- *type* – The bus type to use in this transaction.
- *address* – 7-bit slave device address, in bits [6:0].
- *dir* – Master transfer direction, either `kI3C_Read` or `kI3C_Write`. This parameter is used to set the R/w bit (bit 0) in the transmitted slave address.

Return values

- `kStatus_Success` – START signal and address were successfully enqueued in the transmit FIFO.
- `kStatus_I3C_Busy` – Another master is currently utilizing the bus.

`status_t I3C_MasterRepeatedStartWithRxSize(I3C_Type *base, i3c_bus_type_t type, uint8_t address, i3c_direction_t dir, uint8_t rxSize)`

Sends a repeated START signal and slave address on the I2C/I3C bus, receive size is also specified in the call.

This function is used to send a Repeated START signal when a transfer is already in progress. Like `I3C_MasterStart()`, it also sends the specified 7-bit address. Call this API also configures the read terminate size for the following read transfer. For example, set the *rxSize* = 2, the following read transfer will be terminated after two bytes of data received. Write transfer will not be affected by the *rxSize* configuration.

Note: This function exists primarily to maintain compatible APIs between I3C and I2C drivers, as well as to better document the intent of code that uses these APIs.

Parameters

- *base* – The I3C peripheral base address.
- *type* – The bus type to use in this transaction.
- *address* – 7-bit slave device address, in bits [6:0].
- *dir* – Master transfer direction, either `kI3C_Read` or `kI3C_Write`. This parameter is used to set the R/w bit (bit 0) in the transmitted slave address.
- *rxSize* – Read terminate size for the followed read transfer, limit to 255 bytes.

Return values

`kStatus_Success` – Repeated START signal and address were successfully enqueued in the transmit FIFO.

```
static inline status_t I3C_MasterRepeatedStart(I3C_Type *base, i3c_bus_type_t type, uint8_t  
                                              address, i3c_direction_t dir)
```

Sends a repeated START signal and slave address on the I2C/I3C bus.

This function is used to send a Repeated START signal when a transfer is already in progress. Like I3C_MasterStart(), it also sends the specified 7-bit address.

Note: This function exists primarily to maintain compatible APIs between I3C and I2C drivers, as well as to better document the intent of code that uses these APIs.

Parameters

- *base* – The I3C peripheral base address.
- *type* – The bus type to use in this transaction.
- *address* – 7-bit slave device address, in bits [6:0].
- *dir* – Master transfer direction, either kI3C_Read or kI3C_Write. This parameter is used to set the R/w bit (bit 0) in the transmitted slave address.

Return values

kStatus_Success – Repeated START signal and address were successfully enqueued in the transmit FIFO.

```
status_t I3C_MasterSend(I3C_Type *base, const void *txBuff, size_t txSize, uint32_t flags)
```

Performs a polling send transfer on the I2C/I3C bus.

Sends up to *txSize* number of bytes to the previously addressed slave device. The slave may reply with a NAK to any byte in order to terminate the transfer early. If this happens, this function returns kStatus_I3C_Nak.

Parameters

- *base* – The I3C peripheral base address.
- *txBuff* – The pointer to the data to be transferred.
- *txSize* – The length in bytes of the data to be transferred.
- *flags* – Bit mask of options for the transfer. See enumeration *_i3c_master_transfer_flags* for available options.

Return values

- kStatus_Success – Data was sent successfully.
- kStatus_I3C_Busy – Another master is currently utilizing the bus.
- kStatus_I3C_Timeout – The module has stalled too long in a frame.
- kStatus_I3C_Nak – The slave device sent a NAK in response to an address.
- kStatus_I3C_WriteAbort – The slave device sent a NAK in response to a write.
- kStatus_I3C_MsgError – Message SDR/DDR mismatch or read/write message in wrong state.
- kStatus_I3C_WriteFifoError – Write to M/SWDATAB register when FIFO full.
- kStatus_I3C_InvalidReq – Invalid use of request.

```
status_t I3C_MasterReceive(I3C_Type *base, void *rxBuff, size_t rxSize, uint32_t flags)
```

Performs a polling receive transfer on the I2C/I3C bus.

Parameters

- `base` – The I3C peripheral base address.
- `rxBuff` – The pointer to the data to be transferred.
- `rxSize` – The length in bytes of the data to be transferred.
- `flags` – Bit mask of options for the transfer. See enumeration `_i3c_master_transfer_flags` for available options.

Return values

- `kStatus_Success` – Data was received successfully.
- `kStatus_I3C_Busy` – Another master is currently utilizing the bus.
- `kStatus_I3C_Timeout` – The module has stalled too long in a frame.
- `kStatus_I3C_Term` – The master terminates slave read.
- `kStatus_I3C_HdrParityError` – Parity error from DDR read.
- `kStatus_I3C_CrcError` – CRC error from DDR read.
- `kStatus_I3C_MsgError` – Message SDR/DDR mismatch or read/write message in wrong state.
- `kStatus_I3C_ReadFifoError` – Read from M/SRDATAB register when FIFO empty.
- `kStatus_I3C_InvalidReq` – Invalid use of request.

`status_t I3C_MasterStop(I3C_Type *base)`

Sends a STOP signal on the I2C/I3C bus.

This function does not return until the STOP signal is seen on the bus, or an error occurs.

Parameters

- `base` – The I3C peripheral base address.

Return values

- `kStatus_Success` – The STOP signal was successfully sent on the bus and the transaction terminated.
- `kStatus_I3C_Busy` – Another master is currently utilizing the bus.
- `kStatus_I3C_Timeout` – The module has stalled too long in a frame.
- `kStatus_I3C_InvalidReq` – Invalid use of request.

`void I3C_MasterEmitRequest(I3C_Type *base, i3c_bus_request_t masterReq)`

I3C master emit request.

Parameters

- `base` – The I3C peripheral base address.
- `masterReq` – I3C master request of type `i3c_bus_request_t`

`static inline void I3C_MasterEmitIBIResponse(I3C_Type *base, i3c_ibi_response_t ibiResponse)`

I3C master emit request.

Parameters

- `base` – The I3C peripheral base address.
- `ibiResponse` – I3C master emit IBI response of type `i3c_ibi_response_t`

```
void I3C_MasterRegisterIBI(I3C_Type *base, i3c_register_ibi_addr_t *ibiRule)
```

I3C master register IBI rule.

Parameters

- base – The I3C peripheral base address.
- ibiRule – Pointer to ibi rule description of type `i3c_register_ibi_addr_t`

```
void I3C_MasterGetIBIRules(I3C_Type *base, i3c_register_ibi_addr_t *ibiRule)
```

I3C master get IBI rule.

Parameters

- base – The I3C peripheral base address.
- ibiRule – Pointer to store the read out ibi rule description.

```
i3c_ibi_type_t I3C_GetIBIType(I3C_Type *base)
```

I3C master get IBI Type.

Parameters

- base – The I3C peripheral base address.

Return values

`i3c_ibi_type_t` – Type of `i3c_ibi_type_t`.

```
static inline uint8_t I3C_GetIBIAddress(I3C_Type *base)
```

I3C master get IBI Address.

Parameters

- base – The I3C peripheral base address.

Return values

The – 8-bit IBI address.

```
status_t I3C_MasterProcessDAASpecifiedBaudrate(I3C_Type *base, uint8_t *addressList, uint32_t  
count, i3c_master_daa_baudrate_t  
*daaBaudRate)
```

Performs a DAA in the i3c bus with specified temporary baud rate.

Parameters

- base – The I3C peripheral base address.
- addressList – The pointer for address list which is used to do DAA.
- count – The address count in the address list.
- daaBaudRate – The temporary baud rate in DAA process, NULL for using initial setting. The initial setting is set back between the completion of the DAA and the return of this function.

Return values

- `kStatus_Success` – The transaction was started successfully.
- `kStatus_I3C_Busy` – Either another master is currently utilizing the bus, or a non-blocking transaction is already in progress.
- `kStatus_I3C_SlaveCountExceed` – The I3C slave count has exceed the definition in `I3C_MAX_DEVCNT`.

```
static inline status_t I3C_MasterProcessDAA(I3C_Type *base, uint8_t *addressList, uint32_t  
count)
```

Performs a DAA in the i3c bus.

Parameters

- `base` – The I3C peripheral base address.
- `addressList` – The pointer for address list which is used to do DAA.
- `count` – The address count in the address list. The initial setting is set back between the completion of the DAA and the return of this function.

Return values

- `kStatus_Success` – The transaction was started successfully.
- `kStatus_I3C_Busy` – Either another master is currently utilizing the bus, or a non-blocking transaction is already in progress.
- `kStatus_I3C_SlaveCountExceed` – The I3C slave count has exceed the definition in `I3C_MAX_DEVCNT`.

i3c_device_info_t *I3C_MasterGetDeviceListAfterDAA(I3C_Type *base, uint8_t *count)

Get device information list after DAA process is done.

Parameters

- `base` – The I3C peripheral base address.
- `count` – **[out]** The pointer to store the available device count.

Returns

Pointer to the *i3c_device_info_t* array.

void I3C_MasterClearDeviceCount(I3C_Type *base)

Clear the global device count which represents current devices number on the bus. When user resets all dynamic addresses on the bus, should call this API.

Parameters

- `base` – The I3C peripheral base address.

status_t I3C_MasterTransferBlocking(I3C_Type *base, *i3c_master_transfer_t* *transfer)

Performs a master polling transfer on the I2C/I3C bus.

Note: The API does not return until the transfer succeeds or fails due to error happens during transfer.

Parameters

- `base` – The I3C peripheral base address.
- `transfer` – Pointer to the transfer structure.

Return values

- `kStatus_Success` – Data was received successfully.
- `kStatus_I3C_Busy` – Another master is currently utilizing the bus.
- `kStatus_I3C_IBIWon` – The I3C slave event IBI or MR or HJ won the arbitration on a header address.
- `kStatus_I3C_Timeout` – The module has stalled too long in a frame.
- `kStatus_I3C_Nak` – The slave device sent a NAK in response to an address.
- `kStatus_I3C_WriteAbort` – The slave device sent a NAK in response to a write.
- `kStatus_I3C_Term` – The master terminates slave read.
- `kStatus_I3C_HdrParityError` – Parity error from DDR read.

- `kStatus_I3C_CrcError` – CRC error from DDR read.
- `kStatus_I3C_MsgError` – Message SDR/DDR mismatch or read/write message in wrong state.
- `kStatus_I3C_ReadFifoError` – Read from M/SRDATAB register when FIFO empty.
- `kStatus_I3C_WriteFifoError` – Write to M/SWDATAB register when FIFO full.
- `kStatus_I3C_InvalidReq` – Invalid use of request.

`status_t I3C_SlaveSend(I3C_Type *base, const void *txBuff, size_t txSize)`

Performs a polling send transfer on the I3C bus.

Parameters

- `base` – The I3C peripheral base address.
- `txBuff` – The pointer to the data to be transferred.
- `txSize` – The length in bytes of the data to be transferred.

Returns

Error or success status returned by API.

`status_t I3C_SlaveReceive(I3C_Type *base, void *rxBuff, size_t rxSize)`

Performs a polling receive transfer on the I3C bus.

Parameters

- `base` – The I3C peripheral base address.
- `rxBuff` – The pointer to the data to be transferred.
- `rxSize` – The length in bytes of the data to be transferred.

Returns

Error or success status returned by API.

`void I3C_MasterTransferCreateHandle(I3C_Type *base, i3c_master_handle_t *handle, const i3c_master_transfer_callback_t *callback, void *userData)`

Creates a new handle for the I3C master non-blocking APIs.

The creation of a handle is for use with the non-blocking APIs. Once a handle is created, there is not a corresponding destroy handle. If the user wants to terminate a transfer, the `I3C_MasterTransferAbort()` API shall be called.

Note: The function also enables the NVIC IRQ for the input I3C. Need to notice that on some SoCs the I3C IRQ is connected to INTMUX, in this case user needs to enable the associated INTMUX IRQ in application.

Parameters

- `base` – The I3C peripheral base address.
- `handle` – **[out]** Pointer to the I3C master driver handle.
- `callback` – User provided pointer to the asynchronous callback function.
- `userData` – User provided pointer to the application callback data.

`status_t I3C_MasterTransferNonBlocking(I3C_Type *base, i3c_master_handle_t *handle, i3c_master_transfer_t *transfer)`

Performs a non-blocking transaction on the I2C/I3C bus.

Parameters

- base – The I3C peripheral base address.
- handle – Pointer to the I3C master driver handle.
- transfer – The pointer to the transfer descriptor.

Return values

- kStatus__Success – The transaction was started successfully.
- kStatus_I3C_Busy – Either another master is currently utilizing the bus, or a non-blocking transaction is already in progress.

status_t I3C_MasterTransferGetCount(I3C_Type *base, *i3c_master_handle_t* *handle, *size_t* *count)

Returns number of bytes transferred so far.

Parameters

- base – The I3C peripheral base address.
- handle – Pointer to the I3C master driver handle.
- count – **[out]** Number of bytes transferred so far by the non-blocking transaction.

Return values

- kStatus__Success –
- kStatus_NoTransferInProgress – There is not a non-blocking transaction currently in progress.

void I3C_MasterTransferAbort(I3C_Type *base, *i3c_master_handle_t* *handle)

Terminates a non-blocking I3C master transmission early.

Note: It is not safe to call this function from an IRQ handler that has a higher priority than the I3C peripheral's IRQ priority.

Parameters

- base – The I3C peripheral base address.
- handle – Pointer to the I3C master driver handle.

void I3C_MasterTransferHandleIRQ(I3C_Type *base, *void* *intHandle)

Reusable routine to handle master interrupts.

Note: This function does not need to be called unless you are reimplementing the non-blocking API's interrupt handler routines to add special functionality.

Parameters

- base – The I3C peripheral base address.
- intHandle – Pointer to the I3C master driver handle.

enum _i3c_master_flags

I3C master peripheral flags.

The following status register flags can be cleared:

- kI3C_MasterSlaveStartFlag

- kI3C_MasterControlDoneFlag
- kI3C_MasterCompleteFlag
- kI3C_MasterArbitrationWonFlag
- kI3C_MasterSlave2MasterFlag

All flags except kI3C_MasterBetweenFlag and kI3C_MasterNackDetectFlag can be enabled as interrupts.

Note: These enums are meant to be OR'd together to form a bit mask.

Values:

enumerator kI3C_MasterBetweenFlag

Between messages/DAA's flag

enumerator kI3C_MasterNackDetectFlag

NACK detected flag

enumerator kI3C_MasterSlaveStartFlag

Slave request start flag

enumerator kI3C_MasterControlDoneFlag

Master request complete flag

enumerator kI3C_MasterCompleteFlag

Transfer complete flag

enumerator kI3C_MasterRxReadyFlag

Rx data ready in Rx buffer flag

enumerator kI3C_MasterTxReadyFlag

Tx buffer ready for Tx data flag

enumerator kI3C_MasterArbitrationWonFlag

Header address won arbitration flag

enumerator kI3C_MasterErrorFlag

Error occurred flag

enumerator kI3C_MasterSlave2MasterFlag

Switch from slave to master flag

enumerator kI3C_MasterClearFlags

enum _i3c_master_error_flags

I3C master error flags to indicate the causes.

Note: These enums are meant to be OR'd together to form a bit mask.

Values:

enumerator kI3C_MasterErrorNackFlag

Slave NACKed the last address

enumerator kI3C_MasterErrorWriteAbortFlag

Slave NACKed the write data

enumerator kI3C_MasterErrorParityFlag

Parity error from DDR read

enumerator kI3C_MasterErrorCrcFlag

CRC error from DDR read

enumerator kI3C_MasterErrorReadFlag

Read from MRDATAB register when FIFO empty

enumerator kI3C_MasterErrorWriteFlag

Write to MWDATAB register when FIFO full

enumerator kI3C_MasterErrorMsgFlag

Message SDR/DDR mismatch or read/write message in wrong state

enumerator kI3C_MasterErrorInvalidReqFlag

Invalid use of request

enumerator kI3C_MasterErrorTimeoutFlag

The module has stalled too long in a frame

enumerator kI3C_MasterAllErrorFlags

All error flags

enum _i3c_master_state

I3C working master state.

Values:

enumerator kI3C_MasterStateIdle

Bus stopped.

enumerator kI3C_MasterStateSlvReq

Bus stopped but slave holding SDA low.

enumerator kI3C_MasterStateMsgSdr

In SDR Message mode from using MWMSG_SDR.

enumerator kI3C_MasterStateNormAct

In normal active SDR mode.

enumerator kI3C_MasterStateDdr

In DDR Message mode.

enumerator kI3C_MasterStateDaa

In ENTDAAs mode.

enumerator kI3C_MasterStateIbiAck

Waiting on IBI ACK/NACK decision.

enumerator kI3C_MasterStateIbiRcv

Receiving IBI.

enum _i3c_master_enable

I3C master enable configuration.

Values:

enumerator kI3C_MasterOff

Master off.

enumerator kI3C_MasterOn

Master on.

enumerator kI3C_MasterCapable

Master capable.

enum `_i3c_master_hkeep`

I3C high keeper configuration.

Values:

enumerator `kI3C_MasterHighKeeperNone`

Use PUR to hold SCL high.

enumerator `kI3C_MasterHighKeeperWiredIn`

Use pin_HK controls.

enumerator `kI3C_MasterPassiveSDA`

Hi-Z for Bus Free and hold SDA.

enumerator `kI3C_MasterPassiveSDASCL`

Hi-Z both for Bus Free, and can Hi-Z SDA for hold.

enum `_i3c_bus_request`

Emits the requested operation when doing in pieces vs. by message.

Values:

enumerator `kI3C_RequestNone`

No request.

enumerator `kI3C_RequestEmitStartAddr`

Request to emit start and address on bus.

enumerator `kI3C_RequestEmitStop`

Request to emit stop on bus.

enumerator `kI3C_RequestIbiAckNack`

Manual IBI ACK or NACK.

enumerator `kI3C_RequestProcessDAA`

Process DAA.

enumerator `kI3C_RequestForceExit`

Request to force exit.

enumerator `kI3C_RequestAutoIbi`

Hold in stopped state, but Auto-emit START,7E.

enum `_i3c_bus_type`

Bus type with EmitStartAddr.

Values:

enumerator `kI3C_TypeI3CSdr`

SDR mode of I3C.

enumerator `kI3C_TypeI2C`

Standard i2c protocol.

enumerator `kI3C_TypeI3CDdr`

HDR-DDR mode of I3C.

enum `_i3c_ibi_response`

IBI response.

Values:

enumerator `kI3C_IbiRespAck`

ACK with no mandatory byte.

enumerator kI3C_IbiRespNack
NACK.

enumerator kI3C_IbiRespAckMandatory
ACK with mandatory byte.

enumerator kI3C_IbiRespManual
Reserved.

enum _i3c_ibi_type
IBI type.

Values:

enumerator kI3C_IbiNormal
In-band interrupt.

enumerator kI3C_IbiHotJoin
slave hot join.

enumerator kI3C_IbiMasterRequest
slave master ship request.

enum _i3c_ibi_state
IBI state.

Values:

enumerator kI3C_IbiReady
In-band interrupt ready state, ready for user to handle.

enumerator kI3C_IbiDataBuffNeed
In-band interrupt need data buffer for data receive.

enumerator kI3C_IbiAckNackPending
In-band interrupt Ack/Nack pending for decision.

enum _i3c_direction
Direction of master and slave transfers.

Values:

enumerator kI3C_Write
Master transmit.

enumerator kI3C_Read
Master receive.

enum _i3c_tx_trigger_level
Watermark of TX int/dma trigger level.

Values:

enumerator kI3C_TxTriggerOnEmpty
Trigger on empty.

enumerator kI3C_TxTriggerUntilOneQuarterOrLess
Trigger on 1/4 full or less.

enumerator kI3C_TxTriggerUntilOneHalfOrLess
Trigger on 1/2 full or less.

enumerator kI3C_TxTriggerUntilOneLessThanFull
Trigger on 1 less than full or less.

enum _i3c_rx_trigger_level

Watermark of RX int/dma trigger level.

Values:

enumerator kI3C_RxTriggerOnNotEmpty

Trigger on not empty.

enumerator kI3C_RxTriggerUntilOneQuarterOrMore

Trigger on 1/4 full or more.

enumerator kI3C_RxTriggerUntilOneHalfOrMore

Trigger on 1/2 full or more.

enumerator kI3C_RxTriggerUntilThreeQuarterOrMore

Trigger on 3/4 full or more.

enum _i3c_rx_term_ops

I3C master read termination operations.

Values:

enumerator kI3C_RxTermDisable

Master doesn't terminate read, used for CCC transfer.

enumerator kI3C_RxAutoTerm

Master auto terminate read after receiving specified bytes(<=255).

enumerator kI3C_RxTermLastByte

Master terminates read at any time after START, no length limitation.

enum _i3c_start_scl_delay

I3C start SCL delay options.

Values:

enumerator kI3C_NoDelay

No delay.

enumerator kI3C_IncreaseSclHalfPeriod

Increases SCL clock period by 1/2.

enumerator kI3C_IncreaseSclOnePeriod

Increases SCL clock period by 1.

enumerator kI3C_IncreaseSclOneAndHalfPeriod

Increases SCL clock period by 1 1/2

enum _i3c_master_transfer_flags

Transfer option flags.

Note: These enumerations are intended to be OR'd together to form a bit mask of options for the `_i3c_master_transfer::flags` field.

Values:

enumerator kI3C_TransferDefaultFlag

Transfer starts with a start signal, stops with a stop signal.

enumerator kI3C_TransferNoStartFlag

Don't send a start condition, address, and sub address

enumerator `kI3C_TransferRepeatedStartFlag`
Send a repeated start condition

enumerator `kI3C_TransferNoStopFlag`
Don't send a stop condition.

enumerator `kI3C_TransferWordsFlag`
Transfer in words, else transfer in bytes.

enumerator `kI3C_TransferDisableRxTermFlag`
Disable Rx termination. Note: It's for I3C CCC transfer.

enumerator `kI3C_TransferRxAutoTermFlag`
Set Rx auto-termination. Note: It's adaptive based on Rx size(<=255 bytes) except in `I3C_MasterReceive`.

enumerator `kI3C_TransferStartWithBroadcastAddr`
Start transfer with 0x7E, then read/write data with device address.

typedef enum `_i3c_master_state` `i3c_master_state_t`
I3C working master state.

typedef enum `_i3c_master_enable` `i3c_master_enable_t`
I3C master enable configuration.

typedef enum `_i3c_master_hkeep` `i3c_master_hkeep_t`
I3C high keeper configuration.

typedef enum `_i3c_bus_request` `i3c_bus_request_t`
Emits the requested operation when doing in pieces vs. by message.

typedef enum `_i3c_bus_type` `i3c_bus_type_t`
Bus type with `EmitStartAddr`.

typedef enum `_i3c_ibi_response` `i3c_ibi_response_t`
IBI response.

typedef enum `_i3c_ibi_type` `i3c_ibi_type_t`
IBI type.

typedef enum `_i3c_ibi_state` `i3c_ibi_state_t`
IBI state.

typedef enum `_i3c_direction` `i3c_direction_t`
Direction of master and slave transfers.

typedef enum `_i3c_tx_trigger_level` `i3c_tx_trigger_level_t`
Watermark of TX int/dma trigger level.

typedef enum `_i3c_rx_trigger_level` `i3c_rx_trigger_level_t`
Watermark of RX int/dma trigger level.

typedef enum `_i3c_rx_term_ops` `i3c_rx_term_ops_t`
I3C master read termination operations.

typedef enum `_i3c_start_scl_delay` `i3c_start_scl_delay_t`
I3C start SCL delay options.

typedef struct `_i3c_register_ibi_addr` `i3c_register_ibi_addr_t`
Structure with setting master IBI rules and slave registry.

typedef struct `_i3c_baudrate` `i3c_baudrate_hz_t`
Structure with I3C baudrate settings.

```
typedef struct _i3c_master_daa_baudrate i3c_master_daa_baudrate_t
```

I3C DAA baud rate configuration.

```
typedef struct _i3c_master_config i3c_master_config_t
```

Structure with settings to initialize the I3C master module.

This structure holds configuration settings for the I3C peripheral. To initialize this structure to reasonable defaults, call the I3C_MasterGetDefaultConfig() function and pass a pointer to your configuration structure instance.

The configuration structure can be made constant so it resides in flash.

```
typedef struct _i3c_master_transfer i3c_master_transfer_t
```

```
typedef struct _i3c_master_handle i3c_master_handle_t
```

```
typedef struct _i3c_master_transfer_callback i3c_master_transfer_callback_t
```

i3c master callback functions.

```
typedef void (*i3c_master_isr_t)(I3C_Type *base, void *handle)
```

Typedef for master interrupt handler.

```
struct _i3c_register_ibi_addr
```

#include <fsl_i3c.h> Structure with setting master IBI rules and slave registry.

Public Members

uint8_t address[5]
Address array for registry.

bool i3cFastStart
Allow the START header to run as push-pull speed if all dynamic addresses take MSB 0.

bool ibiHasPayload
Whether the address array has mandatory IBI byte.

```
struct _i3c_baudrate
```

#include <fsl_i3c.h> Structure with I3C baudrate settings.

Public Members

uint32_t i2cBaud
Desired I2C baud rate in Hertz.

uint32_t i3cPushPullBaud
Desired I3C push-pull baud rate in Hertz.

uint32_t i3cOpenDrainBaud
Desired I3C open-drain baud rate in Hertz.

```
struct _i3c_master_daa_baudrate
```

#include <fsl_i3c.h> I3C DAA baud rate configuration.

Public Members

uint32_t sourceClock_Hz
FCLK, function clock in Hertz.

uint32_t i3cPushPullBaud

Desired I3C push-pull baud rate in Hertz.

uint32_t i3cOpenDrainBaud

Desired I3C open-drain baud rate in Hertz.

struct __i3c_master_config

#include <fsl_i3c.h> Structure with settings to initialize the I3C master module.

This structure holds configuration settings for the I3C peripheral. To initialize this structure to reasonable defaults, call the I3C_MasterGetDefaultConfig() function and pass a pointer to your configuration structure instance.

The configuration structure can be made constant so it resides in flash.

Public Members

i3c_master_enable_t enableMaster

Enable master mode.

bool disableTimeout

Whether to disable timeout to prevent the ERRWARN.

i3c_master_hkeep_t hKeep

High keeper mode setting.

bool enableOpenDrainStop

Whether to emit open-drain speed STOP.

bool enableOpenDrainHigh

Enable Open-Drain High to be 1 PPBAUD count for i3c messages, or 1 ODBAUD.

i3c_baudrate_hz_t baudRate_Hz

Desired baud rate settings.

i3c_start_scl_delay_t startSclDelay

I3C SCL delay after START.

i3c_start_scl_delay_t restartSclDelay

I3C SCL delay after Repeated START.

struct __i3c_master_transfer_callback

#include <fsl_i3c.h> i3c master callback functions.

Public Members

void (*slave2Master)(I3C_Type *base, void *userData)

Transfer complete callback

void (*ibiCallback)(I3C_Type *base, i3c_master_handle_t *handle, i3c_ibi_type_t ibiType, i3c_ibi_state_t ibiState)

IBI event callback

void (*transferComplete)(I3C_Type *base, i3c_master_handle_t *handle, status_t completionStatus, void *userData)

Transfer complete callback

struct __i3c_master_transfer

#include <fsl_i3c.h> Non-blocking transfer descriptor structure.

This structure is used to pass transaction parameters to the I3C_MasterTransferNonBlocking() API.

Public Members

`uint32_t` flags
Bit mask of options for the transfer. See enumeration `_i3c_master_transfer_flags` for available options. Set to 0 or `kI3C_TransferDefaultFlag` for normal transfers.

`uint8_t` slaveAddress
The 7-bit slave address.

`i3c_direction_t` direction
Either `kI3C_Read` or `kI3C_Write`.

`uint32_t` subaddress
Sub address. Transferred MSB first.

`size_t` subaddressSize
Length of sub address to send in bytes. Maximum size is 4 bytes.

`void *`data
Pointer to data to transfer.

`size_t` dataSize
Number of bytes to transfer.

`i3c_bus_type_t` busType
bus type.

`i3c_ibi_response_t` ibiResponse
ibi response during transfer.

`struct _i3c_master_handle`
`#include <fsl_i3c.h>` Driver handle for master non-blocking APIs.

Note: The contents of this structure are private and subject to change.

Public Members

`uint8_t` state
Transfer state machine current state.

`uint32_t` remainingBytes
Remaining byte count in current state.

`i3c_rx_term_ops_t` rxTermOps
Read termination operation.

`i3c_master_transfer_t` transfer
Copy of the current transfer info.

`uint8_t` ibiAddress
Slave address which request IBI.

`uint8_t *`ibiBuff
Pointer to IBI buffer to keep ibi bytes.

`size_t` ibiPayloadSize
IBI payload size.

`i3c_ibi_type_t` ibiType
IBI type.

i3c_master_transfer_callback_t callback

Callback functions pointer.

void *userData

Application data passed to callback.

2.25 I3C Master DMA Driver

```
void I3C_MasterTransferCreateHandleEDMA(I3C_Type *base, i3c_master_edma_handle_t
                                         *handle, const i3c_master_edma_callback_t
                                         *callback, void *userData, edma_handle_t
                                         *rxDmaHandle, edma_handle_t *txDmaHandle)
```

Create a new handle for the I3C master DMA APIs.

The creation of a handle is for use with the DMA APIs. Once a handle is created, there is not a corresponding destroy handle. If the user wants to terminate a transfer, the `I3C_MasterTransferAbortDMA()` API shall be called.

For devices where the I3C send and receive DMA requests are OR'd together, the *txDmaHandle* parameter is ignored and may be set to NULL.

Parameters

- base – The I3C peripheral base address.
- handle – Pointer to the I3C master driver handle.
- callback – User provided pointer to the asynchronous callback function.
- userData – User provided pointer to the application callback data.
- rxDmaHandle – Handle for the DMA receive channel. Created by the user prior to calling this function.
- txDmaHandle – Handle for the DMA transmit channel. Created by the user prior to calling this function.

```
status_t I3C_MasterTransferEDMA(I3C_Type *base, i3c_master_edma_handle_t *handle,
                                i3c_master_transfer_t *transfer)
```

Performs a non-blocking DMA-based transaction on the I3C bus.

The callback specified when the *handle* was created is invoked when the transaction has completed.

Parameters

- base – The I3C peripheral base address.
- handle – Pointer to the I3C master driver handle.
- transfer – The pointer to the transfer descriptor.

Return values

- kStatus_Success – The transaction was started successfully.
- kStatus_I3C_Busy – Either another master is currently utilizing the bus, or another DMA transaction is already in progress.

```
status_t I3C_MasterTransferGetCountEDMA(I3C_Type *base, i3c_master_edma_handle_t *handle,
                                         size_t *count)
```

Returns number of bytes transferred so far.

Parameters

- base – The I3C peripheral base address.

- `handle` – Pointer to the I3C master driver handle.
- `count` – **[out]** Number of bytes transferred so far by the non-blocking transaction.

Return values

- `kStatus__Success` –
- `kStatus__NoTransferInProgress` – There is not a DMA transaction currently in progress.

`void I3C_MasterTransferAbortEDMA(I3C_Type *base, i3c_master_edma_handle_t *handle)`

Terminates a non-blocking I3C master transmission early.

Note: It is not safe to call this function from an IRQ handler that has a higher priority than the DMA peripheral's IRQ priority.

Parameters

- `base` – The I3C peripheral base address.
- `handle` – Pointer to the I3C master driver handle.

`void I3C_MasterTransferEDMAHandleIRQ(I3C_Type *base, void *i3cHandle)`

Reusable routine to handle master interrupts.

Note: This function does not need to be called unless you are reimplementing the non-blocking API's interrupt handler routines to add special functionality.

Parameters

- `base` – The I3C peripheral base address.
- `i3cHandle` – Pointer to the I3C master DMA driver handle.

`typedef struct _i3c_master_edma_handle i3c_master_edma_handle_t`

`typedef struct _i3c_master_edma_callback i3c_master_edma_callback_t`
i3c master callback functions.

`struct _i3c_master_edma_callback`
`#include <fsl_i3c_edma.h>` i3c master callback functions.

Public Members

`void (*slave2Master)(I3C_Type *base, void *userData)`

Target asks for controller request.

`void (*ibiCallback)(I3C_Type *base, i3c_master_edma_handle_t *handle, i3c_ibi_type_t ibiType, i3c_ibi_state_t ibiState)`

IBI event callback.

`void (*transferComplete)(I3C_Type *base, i3c_master_edma_handle_t *handle, status_t status, void *userData)`

Transfer complete callback.

```
struct _i3c_master_edma_handle
#include <fsl_i3c_edma.h> Driver handle for master EDMA APIs.
```

Note: The contents of this structure are private and subject to change.

Public Members

I3C_Type *base
I3C base pointer.

uint8_t state
Transfer state machine current state.

uint32_t transferCount
Indicates progress of the transfer

uint8_t subaddressBuffer[4]
Saving subaddress command.

uint8_t subaddressCount
Saving command count.

i3c_master_transfer_t transfer
Copy of the current transfer info.

i3c_master_edma_callback_t callback
Callback function pointer.

void *userData
Application data passed to callback.

edma_handle_t *rxDmaHandle
Handle for receive DMA channel.

edma_handle_t *txDmaHandle
Handle for transmit DMA channel.

bool ibiFlag
IBIWON flag.

uint8_t ibiAddress
Slave address which request IBI.

uint8_t *ibiBuff
Pointer to IBI buffer to keep ibi bytes.

size_t ibiPayloadSize
IBI payload size.

i3c_ibi_type_t ibiType
IBI type.

status_t result
Transfer result.

2.26 I3C Slave Driver

`void I3C_SlaveGetDefaultConfig(i3c_slave_config_t *slaveConfig)`

Provides a default configuration for the I3C slave peripheral.

This function provides the following default configuration for the I3C slave peripheral:

```
slaveConfig->enableSlave = true;
```

After calling this function, you can override any settings in order to customize the configuration, prior to initializing the slave driver with `I3C_SlaveInit()`.

Parameters

- `slaveConfig` – **[out]** User provided configuration structure for default values. Refer to `i3c_slave_config_t`.

`void I3C_SlaveInit(I3C_Type *base, const i3c_slave_config_t *slaveConfig, uint32_t slowClock_Hz)`

Initializes the I3C slave peripheral.

This function enables the peripheral clock and initializes the I3C slave peripheral as described by the user provided configuration.

Parameters

- `base` – The I3C peripheral base address.
- `slaveConfig` – User provided peripheral configuration. Use `I3C_SlaveGetDefaultConfig()` to get a set of defaults that you can override.
- `slowClock_Hz` – Frequency in Hertz of the I3C slow clock. Used to calculate the bus match condition values. If `FSL_FEATURE_I3C_HAS_NO_SCONFIG_BAMATCH` defines as 1, this parameter is useless.

`void I3C_SlaveDeinit(I3C_Type *base)`

Deinitializes the I3C slave peripheral.

This function disables the I3C slave peripheral and gates the clock.

Parameters

- `base` – The I3C peripheral base address.

`static inline void I3C_SlaveEnable(I3C_Type *base, bool isEnabled)`

Enable/Disable Slave.

Parameters

- `base` – The I3C peripheral base address.
- `isEnabled` – Enable or disable.

`static inline uint32_t I3C_SlaveGetStatusFlags(I3C_Type *base)`

Gets the I3C slave status flags.

A bit mask with the state of all I3C slave status flags is returned. For each flag, the corresponding bit in the return value is set if the flag is asserted.

See also:

`_i3c_slave_flags`

Parameters

- `base` – The I3C peripheral base address.

Returns

State of the status flags:

- 1: related status flag is set.
- 0: related status flag is not set.

```
static inline void I3C_SlaveClearStatusFlags(I3C_Type *base, uint32_t statusMask)
```

Clears the I3C slave status flag state.

The following status register flags can be cleared:

- `kI3C_SlaveBusStartFlag`
- `kI3C_SlaveMatchedFlag`
- `kI3C_SlaveBusStopFlag`

Attempts to clear other flags has no effect.

See also:

`_i3c_slave_flags`.

Parameters

- `base` – The I3C peripheral base address.
- `statusMask` – A bitmask of status flags that are to be cleared. The mask is composed of `_i3c_slave_flags` enumerators OR'd together. You may pass the result of a previous call to `I3C_SlaveGetStatusFlags()`.

```
static inline uint32_t I3C_SlaveGetErrorStatusFlags(I3C_Type *base)
```

Gets the I3C slave error status flags.

A bit mask with the state of all I3C slave error status flags is returned. For each flag, the corresponding bit in the return value is set if the flag is asserted.

See also:

`_i3c_slave_error_flags`

Parameters

- `base` – The I3C peripheral base address.

Returns

State of the error status flags:

- 1: related status flag is set.
- 0: related status flag is not set.

```
static inline void I3C_SlaveClearErrorStatusFlags(I3C_Type *base, uint32_t statusMask)
```

Clears the I3C slave error status flag state.

See also:

`_i3c_slave_error_flags`.

Parameters

- `base` – The I3C peripheral base address.

- `statusMask` – A bitmask of error status flags that are to be cleared. The mask is composed of `_i3c_slave_error_flags` enumerators OR'd together. You may pass the result of a previous call to `I3C_SlaveGetErrorStatusFlags()`.

`i3c_slave_activity_state_t` `I3C_SlaveGetActivityState(I3C_Type *base)`

Gets the I3C slave state.

Parameters

- `base` – The I3C peripheral base address.

Returns

I3C slave activity state, refer `i3c_slave_activity_state_t`.

`status_t` `I3C_SlaveCheckAndClearError(I3C_Type *base, uint32_t status)`

`static inline void` `I3C_SlaveEnableInterrupts(I3C_Type *base, uint32_t interruptMask)`

Enables the I3C slave interrupt requests.

Only below flags can be enabled as interrupts.

- `kI3C_SlaveBusStartFlag`
- `kI3C_SlaveMatchedFlag`
- `kI3C_SlaveBusStopFlag`
- `kI3C_SlaveRxReadyFlag`
- `kI3C_SlaveTxReadyFlag`
- `kI3C_SlaveDynamicAddrChangedFlag`
- `kI3C_SlaveReceivedCCCFlag`
- `kI3C_SlaveErrorFlag`
- `kI3C_SlaveHDRCommandMatchFlag`
- `kI3C_SlaveCCCHandledFlag`
- `kI3C_SlaveEventSentFlag`

Parameters

- `base` – The I3C peripheral base address.
- `interruptMask` – Bit mask of interrupts to enable. See `_i3c_slave_flags` for the set of constants that should be OR'd together to form the bit mask.

`static inline void` `I3C_SlaveDisableInterrupts(I3C_Type *base, uint32_t interruptMask)`

Disables the I3C slave interrupt requests.

Only below flags can be disabled as interrupts.

- `kI3C_SlaveBusStartFlag`
- `kI3C_SlaveMatchedFlag`
- `kI3C_SlaveBusStopFlag`
- `kI3C_SlaveRxReadyFlag`
- `kI3C_SlaveTxReadyFlag`
- `kI3C_SlaveDynamicAddrChangedFlag`
- `kI3C_SlaveReceivedCCCFlag`
- `kI3C_SlaveErrorFlag`
- `kI3C_SlaveHDRCommandMatchFlag`

- kI3C_SlaveCCCHandledFlag
- kI3C_SlaveEventSentFlag

Parameters

- base – The I3C peripheral base address.
- interruptMask – Bit mask of interrupts to disable. See `_i3c_slave_flags` for the set of constants that should be OR'd together to form the bit mask.

static inline uint32_t I3C_SlaveGetEnabledInterrupts(I3C_Type *base)

Returns the set of currently enabled I3C slave interrupt requests.

Parameters

- base – The I3C peripheral base address.

Returns

A bitmask composed of `_i3c_slave_flags` enumerators OR'd together to indicate the set of enabled interrupts.

static inline uint32_t I3C_SlaveGetPendingInterrupts(I3C_Type *base)

Returns the set of pending I3C slave interrupt requests.

Parameters

- base – The I3C peripheral base address.

Returns

A bitmask composed of `_i3c_slave_flags` enumerators OR'd together to indicate the set of pending interrupts.

static inline void I3C_SlaveEnableDMA(I3C_Type *base, bool enableTx, bool enableRx, uint32_t width)

Enables or disables I3C slave DMA requests.

Parameters

- base – The I3C peripheral base address.
- enableTx – Enable flag for transmit DMA request. Pass true for enable, false for disable.
- enableRx – Enable flag for receive DMA request. Pass true for enable, false for disable.
- width – DMA read/write unit in bytes.

static inline uint32_t I3C_SlaveGetTxFifoAddress(I3C_Type *base, uint32_t width)

Gets I3C slave transmit data register address for DMA transfer.

Parameters

- base – The I3C peripheral base address.
- width – DMA read/write unit in bytes.

Returns

The I3C Slave Transmit Data Register address.

static inline uint32_t I3C_SlaveGetRxFifoAddress(I3C_Type *base, uint32_t width)

Gets I3C slave receive data register address for DMA transfer.

Parameters

- base – The I3C peripheral base address.
- width – DMA read/write unit in bytes.

Returns

The I3C Slave Receive Data Register address.

```
static inline void I3C_SlaveSetWatermarks(I3C_Type *base, i3c_tx_trigger_level_t txLvl,  
                                         i3c_rx_trigger_level_t rxLvl, bool flushTx, bool  
                                         flushRx)
```

Sets the watermarks for I3C slave FIFOs.

Parameters

- *base* – The I3C peripheral base address.
- *txLvl* – Transmit FIFO watermark level. The `kI3C_SlaveTxReadyFlag` flag is set whenever the number of words in the transmit FIFO reaches *txLvl*.
- *rxLvl* – Receive FIFO watermark level. The `kI3C_SlaveRxReadyFlag` flag is set whenever the number of words in the receive FIFO reaches *rxLvl*.
- *flushTx* – true if TX FIFO is to be cleared, otherwise TX FIFO remains unchanged.
- *flushRx* – true if RX FIFO is to be cleared, otherwise RX FIFO remains unchanged.

```
static inline void I3C_SlaveGetFifoCounts(I3C_Type *base, size_t *rxCount, size_t *txCount)
```

Gets the current number of bytes in the I3C slave FIFOs.

Parameters

- *base* – The I3C peripheral base address.
- *txCount* – **[out]** Pointer through which the current number of bytes in the transmit FIFO is returned. Pass NULL if this value is not required.
- *rxCount* – **[out]** Pointer through which the current number of bytes in the receive FIFO is returned. Pass NULL if this value is not required.

```
status_t I3C_SlaveSend(I3C_Type *base, const void *txBuff, size_t txSize)
```

Performs a polling send transfer on the I3C bus.

Parameters

- *base* – The I3C peripheral base address.
- *txBuff* – The pointer to the data to be transferred.
- *txSize* – The length in bytes of the data to be transferred.

Returns

Error or success status returned by API.

```
status_t I3C_SlaveReceive(I3C_Type *base, void *rxBuff, size_t rxSize)
```

Performs a polling receive transfer on the I3C bus.

Parameters

- *base* – The I3C peripheral base address.
- *rxBuff* – The pointer to the data to be transferred.
- *rxSize* – The length in bytes of the data to be transferred.

Returns

Error or success status returned by API.

```
void I3C_SlaveTransferCreateHandle(I3C_Type *base, i3c_slave_handle_t *handle,  
                                  i3c_slave_transfer_callback_t callback, void *userData)
```


Creates a new handle for the I3C slave non-blocking APIs.

The creation of a handle is for use with the non-blocking APIs. Once a handle is created, there is not a corresponding destroy handle. If the user wants to terminate a transfer, the I3C_SlaveTransferAbort() API shall be called.

Note: The function also enables the NVIC IRQ for the input I3C. Need to notice that on some SoCs the I3C IRQ is connected to INTMUX, in this case user needs to enable the associated INTMUX IRQ in application.

Parameters

- base – The I3C peripheral base address.
- handle – **[out]** Pointer to the I3C slave driver handle.
- callback – User provided pointer to the asynchronous callback function.
- userData – User provided pointer to the application callback data.

status_t I3C_SlaveTransferNonBlocking(I3C_Type *base, i3c_slave_handle_t *handle, uint32_t eventMask)

Starts accepting slave transfers.

Call this API after calling I2C_SlaveInit() and I3C_SlaveTransferCreateHandle() to start processing transactions driven by an I2C master. The slave monitors the I2C bus and pass events to the callback that was passed into the call to I3C_SlaveTransferCreateHandle(). The callback is always invoked from the interrupt context.

The set of events received by the callback is customizable. To do so, set the *eventMask* parameter to the OR'd combination of i3c_slave_transfer_event_t enumerators for the events you wish to receive. The kI3C_SlaveTransmitEvent and kI3C_SlaveReceiveEvent events are always enabled and do not need to be included in the mask. Alternatively, you can pass 0 to get a default set of only the transmit and receive events that are always enabled. In addition, the kI3C_SlaveAllEvents constant is provided as a convenient way to enable all events.

Parameters

- base – The I3C peripheral base address.
- handle – Pointer to struct: i3c_slave_handle structure which stores the transfer state.
- eventMask – Bit mask formed by OR'ing together i3c_slave_transfer_event_t enumerators to specify which events to send to the callback. Other accepted values are 0 to get a default set of only the transmit and receive events, and kI3C_SlaveAllEvents to enable all events.

Return values

- kStatus_Success – Slave transfers were successfully started.
- kStatus_I3C_Busy – Slave transfers have already been started on this handle.

status_t I3C_SlaveTransferGetCount(I3C_Type *base, i3c_slave_handle_t *handle, size_t *count)

Gets the slave transfer status during a non-blocking transfer.

Parameters

- base – The I3C peripheral base address.
- handle – Pointer to i2c_slave_handle_t structure.

- `count` – **[out]** Pointer to a value to hold the number of bytes transferred. May be NULL if the count is not required.

Return values

- `kStatus__Success` –
- `kStatus__NoTransferInProgress` –

`void I3C_SlaveTransferAbort(I3C_Type *base, i3c_slave_handle_t *handle)`
Aborts the slave non-blocking transfers.

Note: This API could be called at any time to stop slave for handling the bus events.

Parameters

- `base` – The I3C peripheral base address.
- `handle` – Pointer to struct: `_i3c_slave_handle` structure which stores the transfer state.

`void I3C_SlaveTransferHandleIRQ(I3C_Type *base, void *intHandle)`
Reusable routine to handle slave interrupts.

Note: This function does not need to be called unless you are reimplementing the non blocking API's interrupt handler routines to add special functionality.

Parameters

- `base` – The I3C peripheral base address.
- `intHandle` – Pointer to struct: `_i3c_slave_handle` structure which stores the transfer state.

`enum _i3c_slave_flags`
I3C slave peripheral flags.

The following status register flags can be cleared:

- `kI3C_SlaveBusStartFlag`
- `kI3C_SlaveMatchedFlag`
- `kI3C_SlaveBusStopFlag`

Only below flags can be enabled as interrupts.

- `kI3C_SlaveBusStartFlag`
- `kI3C_SlaveMatchedFlag`
- `kI3C_SlaveBusStopFlag`
- `kI3C_SlaveRxReadyFlag`
- `kI3C_SlaveTxReadyFlag`
- `kI3C_SlaveDynamicAddrChangedFlag`
- `kI3C_SlaveReceivedCCCFlag`
- `kI3C_SlaveErrorFlag`
- `kI3C_SlaveHDRCommandMatchFlag`
- `kI3C_SlaveCCCHandledFlag`

- kI3C_SlaveEventSentFlag

Note: These enums are meant to be OR'd together to form a bit mask.

Values:

enumerator kI3C_SlaveNotStopFlag

Slave status not stop flag

enumerator kI3C_SlaveMessageFlag

Slave status message, indicating slave is listening to the bus traffic or responding

enumerator kI3C_SlaveRequiredReadFlag

Slave status required, either is master doing SDR read from slave, or is IBI pushing out.

enumerator kI3C_SlaveRequiredWriteFlag

Slave status request write, master is doing SDR write to slave, except slave in ENTDAAMode

enumerator kI3C_SlaveBusDAAModeFlag

I3C bus is in ENTDAAMode

enumerator kI3C_SlaveBusHDRModeFlag

I3C bus is in HDR mode

enumerator kI3C_SlaveBusStartFlag

Start/Re-start event is seen since the bus was last cleared

enumerator kI3C_SlaveMatchedFlag

Slave address(dynamic/static) matched since last cleared

enumerator kI3C_SlaveBusStopFlag

Stop event is seen since the bus was last cleared

enumerator kI3C_SlaveRxReadyFlag

Rx data ready in rx buffer flag

enumerator kI3C_SlaveTxReadyFlag

Tx buffer ready for Tx data flag

enumerator kI3C_SlaveDynamicAddrChangedFlag

Slave dynamic address has been assigned, re-assigned, or lost

enumerator kI3C_SlaveReceivedCCCFlag

Slave received Common command code

enumerator kI3C_SlaveErrorFlag

Error occurred flag

enumerator kI3C_SlaveHDRCommandMatchFlag

High data rate command match

enumerator kI3C_SlaveCCCHandledFlag

Slave received Common command code is handled by I3C module

enumerator kI3C_SlaveEventSentFlag

Slave IBI/P2P/MR/HJ event has been sent

enumerator kI3C_SlaveIbiDisableFlag

Slave in band interrupt is disabled.

enumerator kI3C_SlaveMasterRequestDisabledFlag

Slave master request is disabled.

enumerator kI3C_SlaveHotJoinDisabledFlag

Slave Hot-Join is disabled.

enumerator kI3C_SlaveClearFlags

All flags which are cleared by the driver upon starting a transfer.

enumerator kI3C_SlaveAllIrqFlags

enum _i3c_slave_error_flags

I3C slave error flags to indicate the causes.

Note: These enums are meant to be OR'd together to form a bit mask.

Values:

enumerator kI3C_SlaveErrorOverrunFlag

Slave internal from-bus buffer/FIFO overrun.

enumerator kI3C_SlaveErrorUnderrunFlag

Slave internal to-bus buffer/FIFO underrun

enumerator kI3C_SlaveErrorUnderrunNakFlag

Slave internal from-bus buffer/FIFO underrun and NACK error

enumerator kI3C_SlaveErrorTermFlag

Terminate error from master

enumerator kI3C_SlaveErrorInvalidStartFlag

Slave invalid start flag

enumerator kI3C_SlaveErrorSdrParityFlag

SDR parity error

enumerator kI3C_SlaveErrorHdrParityFlag

HDR parity error

enumerator kI3C_SlaveErrorHdrCRCFlag

HDR-DDR CRC error

enumerator kI3C_SlaveErrorS0S1Flag

S0 or S1 error

enumerator kI3C_SlaveErrorOverreadFlag

Over-read error

enumerator kI3C_SlaveErrorOverwriteFlag

Over-write error

enum _i3c_slave_event

I3C slave.event.

Values:

enumerator kI3C_SlaveEventNormal

Normal mode.

enumerator kI3C_SlaveEventIBI

In band interrupt event.

enumerator kI3C_SlaveEventMasterReq

Master request event.

enumerator kI3C_SlaveEventHotJoinReq

Hot-join event.

enum _i3c_slave_activity_state

I3C slave.activity state.

Values:

enumerator kI3C_SlaveNoLatency

Normal bus operation

enumerator kI3C_SlaveLatency1Ms

1ms of latency.

enumerator kI3C_SlaveLatency100Ms

100ms of latency.

enumerator kI3C_SlaveLatency10S

10s latency.

enum _i3c_slave_transfer_event

Set of events sent to the callback for non blocking slave transfers.

These event enumerations are used for two related purposes. First, a bit mask created by OR'ing together events is passed to I3C_SlaveTransferNonBlocking() in order to specify which events to enable. Then, when the slave callback is invoked, it is passed the current event through its *transfer* parameter.

Note: These enumerations are meant to be OR'd together to form a bit mask of events.

Values:

enumerator kI3C_SlaveAddressMatchEvent

Received the slave address after a start or repeated start.

enumerator kI3C_SlaveTransmitEvent

Callback is requested to provide data to transmit (slave-transmitter role).

enumerator kI3C_SlaveReceiveEvent

Callback is requested to provide a buffer in which to place received data (slave-receiver role).

enumerator kI3C_SlaveRequiredTransmitEvent

Callback is requested to provide a buffer in which to place received data (slave-receiver role).

enumerator kI3C_SlaveStartEvent

A start/repeated start was detected.

enumerator kI3C_SlaveHDRCommandMatchEvent

Slave Match HDR Command.

enumerator kI3C_SlaveCompletionEvent

A stop was detected, completing the transfer.

enumerator kI3C_SlaveRequestSentEvent

Slave request event sent.

enumerator `kI3C_SlaveReceivedCCCEvent`

Slave received CCC event, need to handle by application.

enumerator `kI3C_SlaveAllEvents`

Bit mask of all available events.

typedef enum `_i3c_slave_event` `i3c_slave_event_t`

I3C slave.event.

typedef enum `_i3c_slave_activity_state` `i3c_slave_activity_state_t`

I3C slave.activity state.

typedef struct `_i3c_slave_config` `i3c_slave_config_t`

Structure with settings to initialize the I3C slave module.

This structure holds configuration settings for the I3C peripheral. To initialize this structure to reasonable defaults, call the `I3C_SlaveGetDefaultConfig()` function and pass a pointer to your configuration structure instance.

The configuration structure can be made constant so it resides in flash.

typedef enum `_i3c_slave_transfer_event` `i3c_slave_transfer_event_t`

Set of events sent to the callback for non blocking slave transfers.

These event enumerations are used for two related purposes. First, a bit mask created by OR'ing together events is passed to `I3C_SlaveTransferNonBlocking()` in order to specify which events to enable. Then, when the slave callback is invoked, it is passed the current event through its *transfer* parameter.

Note: These enumerations are meant to be OR'd together to form a bit mask of events.

typedef struct `_i3c_slave_transfer` `i3c_slave_transfer_t`

I3C slave transfer structure.

typedef struct `_i3c_slave_handle` `i3c_slave_handle_t`

typedef void (*`i3c_slave_transfer_callback_t`)(`I3C_Type` *base, `i3c_slave_transfer_t` *transfer, void *userData)

Slave event callback function pointer type.

This callback is used only for the slave non-blocking transfer API. To install a callback, use the `I3C_SlaveSetCallback()` function after you have created a handle.

Param base

Base address for the I3C instance on which the event occurred.

Param transfer

Pointer to transfer descriptor containing values passed to and/or from the callback.

Param userData

Arbitrary pointer-sized value passed from the application.

typedef void (*`i3c_slave_isr_t`)(`I3C_Type` *base, void *handle)

Typedef for slave interrupt handler.

struct `_i3c_slave_config`

`#include <fsl_i3c.h>` Structure with settings to initialize the I3C slave module.

This structure holds configuration settings for the I3C peripheral. To initialize this structure to reasonable defaults, call the `I3C_SlaveGetDefaultConfig()` function and pass a pointer to your configuration structure instance.

The configuration structure can be made constant so it resides in flash.

Public Members

`bool enableSlave`
Whether to enable slave.

`uint8_t staticAddr`
Static address.

`uint16_t vendorID`
Device vendor ID(manufacture ID).

`uint32_t partNumber`
Device part number info

`uint8_t dcr`
Device characteristics register information.

`uint8_t bcr`
Bus characteristics register information.

`uint8_t hdrMode`
Support hdr mode, could be OR logic in enumeration:`i3c_hdr_mode_t`.

`bool nakAllRequest`
Whether to reply NAK to all requests except broadcast CCC.

`bool ignoreS0S1Error`
Whether to ignore S0/S1 error in SDR mode.

`bool offline`
Whether to wait 60 us of bus quiet or HDR request to ensure slave track SDR mode safely.

`bool matchSlaveStartStop`
Whether to assert start/stop status only the time slave is addressed.

`uint32_t maxWriteLength`
Maximum write length.

`uint32_t maxReadLength`
Maximum read length.

`struct __i3c_slave_transfer`
#include <fsl_i3c.h> I3C slave transfer structure.

Public Members

`uint32_t event`
Reason the callback is being invoked.

`uint8_t *txData`
Transfer buffer

`size_t txDataSize`
Transfer size

`uint8_t *rxData`
Transfer buffer

`size_t rxDataSize`
Transfer size

status_t completionStatus

Success or error code describing how the transfer completed. Only applies for *kI3C_SlaveCompletionEvent*.

size_t transferredCount

Number of bytes actually transferred since start or last repeated start.

struct *_i3c_slave_handle*

#include <fsl_i3c.h> I3C slave handle structure.

Note: The contents of this structure are private and subject to change.

Public Members

i3c_slave_transfer_t transfer

I3C slave transfer copy.

bool isBusy

Whether transfer is busy.

bool wasTransmit

Whether the last transfer was a transmit.

uint32_t eventMask

Mask of enabled events.

uint32_t transferredCount

Count of bytes transferred.

i3c_slave_transfer_callback_t callback

Callback function called at transfer event.

void *userData

Callback parameter passed to callback.

size_t txFifoSize

Tx Fifo size

2.27 I3C Slave DMA Driver

```
void I3C_SlaveTransferCreateHandleEDMA(I3C_Type *base, i3c_slave_edma_handle_t *handle,
                                       i3c_slave_edma_callback_t callback, void *userData,
                                       edma_handle_t *rxDmaHandle, edma_handle_t
                                       *txDmaHandle)
```

Create a new handle for the I3C slave DMA APIs.

The creation of a handle is for use with the DMA APIs. Once a handle is created, there is not a corresponding destroy handle. If the user wants to terminate a transfer, the *I3C_SlaveTransferAbortDMA()* API shall be called.

For devices where the I3C send and receive DMA requests are OR'd together, the *txDmaHandle* parameter is ignored and may be set to NULL.

Parameters

- base – The I3C peripheral base address.
- handle – Pointer to the I3C slave driver handle.

- `callback` – User provided pointer to the asynchronous callback function.
- `userData` – User provided pointer to the application callback data.
- `rxDmaHandle` – Handle for the DMA receive channel. Created by the user prior to calling this function.
- `txDmaHandle` – Handle for the DMA transmit channel. Created by the user prior to calling this function.

```
status_t I3C_SlaveTransferEDMA(I3C_Type *base, i3c_slave_edma_handle_t *handle,  
                              i3c_slave_edma_transfer_t *transfer, uint32_t eventMask)
```

Prepares for a non-blocking DMA-based transaction on the I3C bus.

The API will do DMA configuration according to the input transfer descriptor, and the data will be transferred when there's bus master requesting transfer from/to this slave. So the timing of call to this API need be aligned with master application to ensure the transfer is executed as expected. Callback specified when the *handle* was created is invoked when the transaction has completed.

Parameters

- `base` – The I3C peripheral base address.
- `handle` – Pointer to the I3C slave driver handle.
- `transfer` – The pointer to the transfer descriptor.
- `eventMask` – Bit mask formed by OR'ing together `i3c_slave_transfer_event_t` enumerators to specify which events to send to the callback. The transmit and receive events is not allowed to be enabled.

Return values

- `kStatus_Success` – The transaction was started successfully.
- `kStatus_I3C_Busy` – Either another master is currently utilizing the bus, or another DMA transaction is already in progress.
- `kStatus_Fail` – The transaction can't be set.

```
void I3C_SlaveTransferAbortEDMA(I3C_Type *base, i3c_slave_edma_handle_t *handle)
```

Abort a slave edma non-blocking transfer in a early time.

Parameters

- `base` – I3C peripheral base address
- `handle` – pointer to `i3c_slave_edma_handle_t` structure

```
void I3C_SlaveTransferEDMAHandleIRQ(I3C_Type *base, void *i3CHandle)
```

Reusable routine to handle slave interrupts.

Note: This function does not need to be called unless you are reimplementing the non-blocking API's interrupt handler routines to add special functionality.

Parameters

- `base` – The I3C peripheral base address.
- `i3CHandle` – Pointer to the I3C slave DMA driver handle.

```
typedef struct _i3c_slave_edma_handle i3c_slave_edma_handle_t
```

```
typedef struct _i3c_slave_edma_transfer i3c_slave_edma_transfer_t  
I3C slave transfer structure.
```

```
typedef void (*i3c_slave_edma_callback_t)(I3C_Type *base, i3c_slave_edma_transfer_t *transfer, void *userData)
```

Slave event callback function pointer type.

This callback is used only for the slave DMA transfer API.

Param base

Base address for the I3C instance on which the event occurred.

Param handle

Pointer to slave DMA transfer handle.

Param transfer

Pointer to transfer descriptor containing values passed to and/or from the callback.

Param userData

Arbitrary pointer-sized value passed from the application.

```
struct _i3c_slave_edma_transfer
```

#include <fsl_i3c_edma.h> I3C slave transfer structure.

Public Members

uint32_t event

Reason the callback is being invoked.

uint8_t *txData

Transfer buffer

size_t txDataSize

Transfer size

uint8_t *rxData

Transfer buffer

size_t rxDataSize

Transfer size

status_t completionStatus

Success or error code describing how the transfer completed. Only applies for kI3C_SlaveCompletionEvent.

```
struct _i3c_slave_edma_handle
```

#include <fsl_i3c_edma.h> I3C slave edma handle structure.

Note: The contents of this structure are private and subject to change.

Public Members

I3C_Type *base

I3C base pointer.

i3c_slave_edma_transfer_t transfer

I3C slave transfer copy.

bool isBusy

Whether transfer is busy.

`bool` `wasTransmit`
Whether the last transfer was a transmit.

`bool` `isDdrMode`
Whether this is HDR-DDR transfer.

`uint32_t` `eventMask`
Mask of enabled events.

`i3c_slave_edma_callback_t` `callback`
Callback function called at transfer event.

`edma_handle_t` `*rxDmaHandle`
Handle for receive DMA channel.

`edma_handle_t` `*txDmaHandle`
Handle for transmit DMA channel.

`void` `*userData`
Callback parameter passed to callback.

2.28 Common Driver

`FSL_COMMON_DRIVER_VERSION`
common driver version.

`DEBUG_CONSOLE_DEVICE_TYPE_NONE`
No debug console.

`DEBUG_CONSOLE_DEVICE_TYPE_UART`
Debug console based on UART.

`DEBUG_CONSOLE_DEVICE_TYPE_LPUART`
Debug console based on LPUART.

`DEBUG_CONSOLE_DEVICE_TYPE_LPSCI`
Debug console based on LPSCI.

`DEBUG_CONSOLE_DEVICE_TYPE_USBCDC`
Debug console based on USBCDC.

`DEBUG_CONSOLE_DEVICE_TYPE_FLEXCOMM`
Debug console based on FLEXCOMM.

`DEBUG_CONSOLE_DEVICE_TYPE_IUART`
Debug console based on i.MX UART.

`DEBUG_CONSOLE_DEVICE_TYPE_VUSART`
Debug console based on LPC_VUSART.

`DEBUG_CONSOLE_DEVICE_TYPE_MINI_USART`
Debug console based on LPC_USART.

`DEBUG_CONSOLE_DEVICE_TYPE_SWO`
Debug console based on SWO.

`DEBUG_CONSOLE_DEVICE_TYPE_QSCI`
Debug console based on QSCI.

MIN(*a*, *b*)

Computes the minimum of *a* and *b*.

MAX(*a*, *b*)

Computes the maximum of *a* and *b*.

UINT16_MAX

Max value of uint16_t type.

UINT32_MAX

Max value of uint32_t type.

SDK_ATOMIC_LOCAL_ADD(*addr*, *val*)

Add value *val* from the variable at address *address*.

SDK_ATOMIC_LOCAL_SUB(*addr*, *val*)

Subtract value *val* to the variable at address *address*.

SDK_ATOMIC_LOCAL_SET(*addr*, *bits*)

Set the bits specifiled by *bits* to the variable at address *address*.

SDK_ATOMIC_LOCAL_CLEAR(*addr*, *bits*)

Clear the bits specifiled by *bits* to the variable at address *address*.

SDK_ATOMIC_LOCAL_TOGGLE(*addr*, *bits*)

Toggle the bits specifiled by *bits* to the variable at address *address*.

SDK_ATOMIC_LOCAL_CLEAR_AND_SET(*addr*, *clearBits*, *setBits*)

For the variable at address *address*, clear the bits specifiled by *clearBits* and set the bits specifiled by *setBits*.

SDK_ATOMIC_LOCAL_COMPARE_AND_SET(*addr*, *expected*, *newValue*)

For the variable at address *address*, check whether the value equal to *expected*. If value same as *expected* then update *newValue* to address and return **true** , else return **false** .

SDK_ATOMIC_LOCAL_TEST_AND_SET(*addr*, *newValue*)

For the variable at address *address*, set as *newValue* value and return old value.

USEC_TO_COUNT(*us*, *clockFreqInHz*)

Macro to convert a microsecond period to raw count value

COUNT_TO_USEC(*count*, *clockFreqInHz*)

Macro to convert a raw count value to microsecond

MSEC_TO_COUNT(*ms*, *clockFreqInHz*)

Macro to convert a millisecond period to raw count value

COUNT_TO_MSEC(*count*, *clockFreqInHz*)

Macro to convert a raw count value to millisecond

SDK_ISR_EXIT_BARRIER

SDK_ALIGN(*var*, *alignbytes*)

Macro to define a variable with *alignbytes* alignment

SDK_SIZEALIGN(*var*, *alignbytes*)

Macro to define a variable with L1 d-cache line size alignment

Macro to define a variable with L2 cache line size alignment

Macro to change a value to a given size aligned value (rounded up)

SDK_SIZEALIGN_UP(var, alignbytes)

Macro to change a value to a given size aligned value (rounded up), the wrapper of SDK_SIZEALIGN

SDK_SIZEALIGN_DOWN(var, alignbytes)

Macro to change a value to a given size aligned value (rounded down)

SDK_IS_ALIGNED(var, alignbytes)

Macro to check if a value is aligned to a given size

AT_NONCACHEABLE_SECTION(var)

Define a variable *var*, and place it in non-cacheable section.

AT_NONCACHEABLE_SECTION_ALIGN(var, alignbytes)

Define a variable *var*, and place it in non-cacheable section, the start address of the variable is aligned to *alignbytes*.

AT_NONCACHEABLE_SECTION_INIT(var)

Define a variable *var* with initial value, and place it in non-cacheable section.

AT_NONCACHEABLE_SECTION_ALIGN_INIT(var, alignbytes)

Define a variable *var* with initial value, and place it in non-cacheable section, the start address of the variable is aligned to *alignbytes*.

AT_CACHE_LINE_SECTION(var)

Define a variable *var*, which is cache line size aligned and be placed in CacheLineData section.

AT_CACHE_LINE_SECTION_INIT(var)

Define a variable *var* with initial value, which is cache line size aligned and be placed in CacheLineData.init section.

AT_QUICKACCESS_SECTION_CODE(func)

Place function in a section which can be accessed quickly by core.

AT_QUICKACCESS_SECTION_DATA(var)

Place data in a section which can be accessed quickly by core.

AT_QUICKACCESS_SECTION_DATA_ALIGN(var, alignbytes)

Place data in a section which can be accessed quickly by core, and the variable address is set to align with *alignbytes*.

MCUX_RAMFUNC

Function attribute to place function in RAM. For example, to place function *my_func* in ram, use like:

```
MCUX_RAMFUNC my_func
```

RAMFUNCTION_SECTION_CODE(func)

Place function in ram.

enum __status_groups

Status group numbers.

Values:

enumerator kStatusGroup_Generic

Group number for generic status codes.

enumerator kStatusGroup_FLASH

Group number for FLASH status codes.

enumerator kStatusGroup_LPSPi
Group number for LPSPi status codes.

enumerator kStatusGroup_FLEXIO_SPI
Group number for FLEXIO SPI status codes.

enumerator kStatusGroup_DSPI
Group number for DSPI status codes.

enumerator kStatusGroup_FLEXIO_UART
Group number for FLEXIO UART status codes.

enumerator kStatusGroup_FLEXIO_I2C
Group number for FLEXIO I2C status codes.

enumerator kStatusGroup_LPI2C
Group number for LPI2C status codes.

enumerator kStatusGroup_UART
Group number for UART status codes.

enumerator kStatusGroup_I2C
Group number for I2C status codes.

enumerator kStatusGroup_LPSCI
Group number for LPSCI status codes.

enumerator kStatusGroup_LPUART
Group number for LPUART status codes.

enumerator kStatusGroup_SPI
Group number for SPI status code.

enumerator kStatusGroup_XRDC
Group number for XRDC status code.

enumerator kStatusGroup_SEMA42
Group number for SEMA42 status code.

enumerator kStatusGroup_SDHC
Group number for SDHC status code

enumerator kStatusGroup_SDMMC
Group number for SDMMC status code

enumerator kStatusGroup_SAI
Group number for SAI status code

enumerator kStatusGroup_MCG
Group number for MCG status codes.

enumerator kStatusGroup_SCG
Group number for SCG status codes.

enumerator kStatusGroup_SDSPI
Group number for SDSPI status codes.

enumerator kStatusGroup_FLEXIO_I2S
Group number for FLEXIO I2S status codes

enumerator kStatusGroup_FLEXIO_MCULCD
Group number for FLEXIO LCD status codes

enumerator kStatusGroup_FLASHIAP
Group number for FLASHIAP status codes

enumerator kStatusGroup_FLEXCOMM_I2C
Group number for FLEXCOMM I2C status codes

enumerator kStatusGroup_I2S
Group number for I2S status codes

enumerator kStatusGroup_IUART
Group number for IUART status codes

enumerator kStatusGroup_CSI
Group number for CSI status codes

enumerator kStatusGroup_MIPI_DSI
Group number for MIPI DSI status codes

enumerator kStatusGroup_SDRAMC
Group number for SDRAMC status codes.

enumerator kStatusGroup_POWER
Group number for POWER status codes.

enumerator kStatusGroup_ENET
Group number for ENET status codes.

enumerator kStatusGroup_PHY
Group number for PHY status codes.

enumerator kStatusGroup_TRGMUX
Group number for TRGMUX status codes.

enumerator kStatusGroup_SMARTCARD
Group number for SMARTCARD status codes.

enumerator kStatusGroup_LMEM
Group number for LMEM status codes.

enumerator kStatusGroup_QSPI
Group number for QSPI status codes.

enumerator kStatusGroup_DMA
Group number for DMA status codes.

enumerator kStatusGroup_EDMA
Group number for EDMA status codes.

enumerator kStatusGroup_DMAMGR
Group number for DMAMGR status codes.

enumerator kStatusGroup_FLEXCAN
Group number for FlexCAN status codes.

enumerator kStatusGroup_LTC
Group number for LTC status codes.

enumerator kStatusGroup_FLEXIO_CAMERA
Group number for FLEXIO CAMERA status codes.

enumerator kStatusGroup_LPC_SPI
Group number for LPC_SPI status codes.

enumerator kStatusGroup_LPC_USART
Group number for LPC_USART status codes.

enumerator kStatusGroup_DMIC
Group number for DMIC status codes.

enumerator kStatusGroup_SDIF
Group number for SDIF status codes.

enumerator kStatusGroup_SPIFI
Group number for SPIFI status codes.

enumerator kStatusGroup_OTP
Group number for OTP status codes.

enumerator kStatusGroup_MCAN
Group number for MCAN status codes.

enumerator kStatusGroup_CAAM
Group number for CAAM status codes.

enumerator kStatusGroup_ECSPI
Group number for ECSPI status codes.

enumerator kStatusGroup_USDHC
Group number for USDHC status codes.

enumerator kStatusGroup_LPC_I2C
Group number for LPC_I2C status codes.

enumerator kStatusGroup_DCP
Group number for DCP status codes.

enumerator kStatusGroup_MSCAN
Group number for MSCAN status codes.

enumerator kStatusGroup_ESAI
Group number for ESAI status codes.

enumerator kStatusGroup_FLEXSPI
Group number for FLEXSPI status codes.

enumerator kStatusGroup_MMDC
Group number for MMDC status codes.

enumerator kStatusGroup_PDM
Group number for MIC status codes.

enumerator kStatusGroup_SDMA
Group number for SDMA status codes.

enumerator kStatusGroup_ICS
Group number for ICS status codes.

enumerator kStatusGroup_SPDIF
Group number for SPDIF status codes.

enumerator kStatusGroup_LPC_MINISPI
Group number for LPC_MINISPI status codes.

enumerator kStatusGroup_HASHCRYPT
Group number for Hashcrypt status codes

enumerator kStatusGroup_LPC_SPI_SSP
Group number for LPC_SPI_SSP status codes.

enumerator kStatusGroup_I3C
Group number for I3C status codes

enumerator kStatusGroup_LPC_I2C_1
Group number for LPC_I2C_1 status codes.

enumerator kStatusGroup_NOTIFIER
Group number for NOTIFIER status codes.

enumerator kStatusGroup_DebugConsole
Group number for debug console status codes.

enumerator kStatusGroup_SEMC
Group number for SEMC status codes.

enumerator kStatusGroup_ApplicationRangeStart
Starting number for application groups.

enumerator kStatusGroup_IAP
Group number for IAP status codes

enumerator kStatusGroup_SFA
Group number for SFA status codes

enumerator kStatusGroup_SPC
Group number for SPC status codes.

enumerator kStatusGroup_PUF
Group number for PUF status codes.

enumerator kStatusGroup_TOUCH_PANEL
Group number for touch panel status codes

enumerator kStatusGroup_VBAT
Group number for VBAT status codes

enumerator kStatusGroup_XSPI
Group number for XSPI status codes

enumerator kStatusGroup_PNGDEC
Group number for PNGDEC status codes

enumerator kStatusGroup_JPEGDEC
Group number for JPEGDEC status codes

enumerator kStatusGroup_AUDMIX
Group number for AUDMIX status codes

enumerator kStatusGroup_HAL_GPIO
Group number for HAL GPIO status codes.

enumerator kStatusGroup_HAL_UART
Group number for HAL UART status codes.

enumerator kStatusGroup_HAL_TIMER
Group number for HAL TIMER status codes.

enumerator kStatusGroup_HAL_SPI
Group number for HAL SPI status codes.

enumerator `kStatusGroup_HAL_I2C`
Group number for HAL I2C status codes.

enumerator `kStatusGroup_HAL_FLASH`
Group number for HAL FLASH status codes.

enumerator `kStatusGroup_HAL_PWM`
Group number for HAL PWM status codes.

enumerator `kStatusGroup_HAL_RNG`
Group number for HAL RNG status codes.

enumerator `kStatusGroup_HAL_I2S`
Group number for HAL I2S status codes.

enumerator `kStatusGroup_HAL_ADC_SENSOR`
Group number for HAL ADC SENSOR status codes.

enumerator `kStatusGroup_TIMERMANAGER`
Group number for TiMER MANAGER status codes.

enumerator `kStatusGroup_SERIALMANAGER`
Group number for SERIAL MANAGER status codes.

enumerator `kStatusGroup_LED`
Group number for LED status codes.

enumerator `kStatusGroup_BUTTON`
Group number for BUTTON status codes.

enumerator `kStatusGroup_EXTERN_EEPROM`
Group number for EXTERN EEPROM status codes.

enumerator `kStatusGroup_SHELL`
Group number for SHELL status codes.

enumerator `kStatusGroup_MEM_MANAGER`
Group number for MEM MANAGER status codes.

enumerator `kStatusGroup_LIST`
Group number for List status codes.

enumerator `kStatusGroup_OSA`
Group number for OSA status codes.

enumerator `kStatusGroup_COMMON_TASK`
Group number for Common task status codes.

enumerator `kStatusGroup_MSG`
Group number for messaging status codes.

enumerator `kStatusGroup_SDK_OCOTP`
Group number for OCOTP status codes.

enumerator `kStatusGroup_SDK_FLEXSPINOR`
Group number for FLEXSPINOR status codes.

enumerator `kStatusGroup_CODEC`
Group number for codec status codes.

enumerator `kStatusGroup_ASRC`
Group number for codec status ASRC.

enumerator kStatusGroup_OTFAD
Group number for codec status codes.

enumerator kStatusGroup_SDIO SLV
Group number for SDIO SLV status codes.

enumerator kStatusGroup_MECC
Group number for MECC status codes.

enumerator kStatusGroup_ENET_QOS
Group number for ENET_QOS status codes.

enumerator kStatusGroup_LOG
Group number for LOG status codes.

enumerator kStatusGroup_I3CBUS
Group number for I3CBUS status codes.

enumerator kStatusGroup_QSCI
Group number for QSCI status codes.

enumerator kStatusGroup_ELE MU
Group number for ELE MU status codes.

enumerator kStatusGroup_QUEUE DSPI
Group number for QSPI status codes.

enumerator kStatusGroup_POWER_MANAGER
Group number for POWER_MANAGER status codes.

enumerator kStatusGroup_IPED
Group number for IPED status codes.

enumerator kStatusGroup_ELS_PKC
Group number for ELS PKC status codes.

enumerator kStatusGroup_CSS_PKC
Group number for CSS PKC status codes.

enumerator kStatusGroup_HOSTIF
Group number for HOSTIF status codes.

enumerator kStatusGroup_CLIF
Group number for CLIF status codes.

enumerator kStatusGroup_BMA
Group number for BMA status codes.

enumerator kStatusGroup_NETC
Group number for NETC status codes.

enumerator kStatusGroup_ELE
Group number for ELE status codes.

enumerator kStatusGroup_GLIKEY
Group number for GLIKEY status codes.

enumerator kStatusGroup_AON_POWER
Group number for AON_POWER status codes.

enumerator kStatusGroup_AON_COMMON
Group number for AON_COMMON status codes.

enumerator kStatusGroup_ENDAT3

Group number for ENDAT3 status codes.

enumerator kStatusGroup_HIPERFACE

Group number for HIPERFACE status codes.

enumerator kStatusGroup_NPX

Group number for NPX status codes.

enumerator kStatusGroup_ELA_CSEC

Group number for ELA_CSEC status codes.

enumerator kStatusGroup_FLEXIO_T_FORMAT

Group number for T-format status codes.

enumerator kStatusGroup_FLEXIO_A_FORMAT

Group number for A-format status codes.

enumerator kStatusGroup_LPC_QSPI

Group number for LPC QSPI status codes.

Generic status return codes.

Values:

enumerator kStatus_Success

Generic status for Success.

enumerator kStatus_Fail

Generic status for Fail.

enumerator kStatus_ReadOnly

Generic status for read only failure.

enumerator kStatus_OutOfRange

Generic status for out of range access.

enumerator kStatus_InvalidArgument

Generic status for invalid argument check.

enumerator kStatus_Timeout

Generic status for timeout.

enumerator kStatus_NoTransferInProgress

Generic status for no transfer in progress.

enumerator kStatus_Busy

Generic status for module is busy.

enumerator kStatus_NoData

Generic status for no data is found for the operation.

typedef int32_t status_t

Type used for all status and error return values.

void *SDK_Malloc(size_t size, size_t alignbytes)

Allocate memory with given alignment and aligned size.

This is provided to support the dynamically allocated memory used in cache-able region.

Parameters

- size – The length required to malloc.

- alignbytes – The alignment size.

Return values

The – allocated memory.

void SDK_Free(void *ptr)

Free memory.

Parameters

- ptr – The memory to be release.

void SDK_DelayAtLeastUs(uint32_t delayTime_us, uint32_t coreClock_Hz)

Delay at least for some time. Please note that, this API uses while loop for delay, different run-time environments make the time not precise, if precise delay count was needed, please implement a new delay function with hardware timer.

Parameters

- delayTime_us – Delay time in unit of microsecond.
- coreClock_Hz – Core clock frequency with Hz.

static inline *status_t* EnableIRQ(IRQn_Type interrupt)

Enable specific interrupt.

Enable LEVEL1 interrupt. For some devices, there might be multiple interrupt levels. For example, there are NVIC and intmux. Here the interrupts connected to NVIC are the LEVEL1 interrupts, because they are routed to the core directly. The interrupts connected to intmux are the LEVEL2 interrupts, they are routed to NVIC first then routed to core.

This function only enables the LEVEL1 interrupts. The number of LEVEL1 interrupts is indicated by the feature macro FSL_FEATURE_NUMBER_OF_LEVEL1_INT_VECTORS.

Parameters

- interrupt – The IRQ number.

Return values

- kStatus_Success – Interrupt enabled successfully
- kStatus_Fail – Failed to enable the interrupt

static inline *status_t* DisableIRQ(IRQn_Type interrupt)

Disable specific interrupt.

Disable LEVEL1 interrupt. For some devices, there might be multiple interrupt levels. For example, there are NVIC and intmux. Here the interrupts connected to NVIC are the LEVEL1 interrupts, because they are routed to the core directly. The interrupts connected to intmux are the LEVEL2 interrupts, they are routed to NVIC first then routed to core.

This function only disables the LEVEL1 interrupts. The number of LEVEL1 interrupts is indicated by the feature macro FSL_FEATURE_NUMBER_OF_LEVEL1_INT_VECTORS.

Parameters

- interrupt – The IRQ number.

Return values

- kStatus_Success – Interrupt disabled successfully
- kStatus_Fail – Failed to disable the interrupt

static inline *status_t* EnableIRQWithPriority(IRQn_Type interrupt, uint8_t priNum)

Enable the IRQ, and also set the interrupt priority.

Only handle LEVEL1 interrupt. For some devices, there might be multiple interrupt levels. For example, there are NVIC and intmux. Here the interrupts connected to NVIC are the

LEVEL1 interrupts, because they are routed to the core directly. The interrupts connected to intmux are the LEVEL2 interrupts, they are routed to NVIC first then routed to core.

This function only handles the LEVEL1 interrupts. The number of LEVEL1 interrupts is indicated by the feature macro FSL_FEATURE_NUMBER_OF_LEVEL1_INT_VECTORS.

Parameters

- interrupt – The IRQ to Enable.
- priNum – Priority number set to interrupt controller register.

Return values

- kStatus_Success – Interrupt priority set successfully
- kStatus_Fail – Failed to set the interrupt priority.

```
static inline status_t IRQ_SetPriority(IRQn_Type interrupt, uint8_t priNum)
```

Set the IRQ priority.

Only handle LEVEL1 interrupt. For some devices, there might be multiple interrupt levels. For example, there are NVIC and intmux. Here the interrupts connected to NVIC are the LEVEL1 interrupts, because they are routed to the core directly. The interrupts connected to intmux are the LEVEL2 interrupts, they are routed to NVIC first then routed to core.

This function only handles the LEVEL1 interrupts. The number of LEVEL1 interrupts is indicated by the feature macro FSL_FEATURE_NUMBER_OF_LEVEL1_INT_VECTORS.

Parameters

- interrupt – The IRQ to set.
- priNum – Priority number set to interrupt controller register.

Return values

- kStatus_Success – Interrupt priority set successfully
- kStatus_Fail – Failed to set the interrupt priority.

```
static inline status_t IRQ_ClearPendingIRQ(IRQn_Type interrupt)
```

Clear the pending IRQ flag.

Only handle LEVEL1 interrupt. For some devices, there might be multiple interrupt levels. For example, there are NVIC and intmux. Here the interrupts connected to NVIC are the LEVEL1 interrupts, because they are routed to the core directly. The interrupts connected to intmux are the LEVEL2 interrupts, they are routed to NVIC first then routed to core.

This function only handles the LEVEL1 interrupts. The number of LEVEL1 interrupts is indicated by the feature macro FSL_FEATURE_NUMBER_OF_LEVEL1_INT_VECTORS.

Parameters

- interrupt – The flag which IRQ to clear.

Return values

- kStatus_Success – Interrupt priority set successfully
- kStatus_Fail – Failed to set the interrupt priority.

```
static inline uint32_t DisableGlobalIRQ(void)
```

Disable the global IRQ.

Disable the global interrupt and return the current primask register. User is required to provided the primask register for the EnableGlobalIRQ().

Returns

Current primask value.

`static inline void EnableGlobalIRQ(uint32_t primask)`

Enable the global IRQ.

Set the primask register with the provided primask value but not just enable the primask. The idea is for the convenience of integration of RTOS. some RTOS get its own management mechanism of primask. User is required to use the EnableGlobalIRQ() and DisableGlobalIRQ() in pair.

Parameters

- `primask` – value of primask register to be restored. The primask value is supposed to be provided by the DisableGlobalIRQ().

`static inline bool _SDK_AtomicLocalCompareAndSet(uint32_t *addr, uint32_t expected, uint32_t newValue)`

`static inline uint32_t _SDK_AtomicTestAndSet(uint32_t *addr, uint32_t newValue)`

`FSL_DRIVER_TRANSFER_DOUBLE_WEAK_IRQ`

Macro to use the default weak IRQ handler in drivers.

`MAKE_STATUS(group, code)`

Construct a status code value from a group and code number.

`MAKE_VERSION(major, minor, bugfix)`

Construct the version number for drivers.

The driver version is a 32-bit number, for both 32-bit platforms(such as Cortex M) and 16-bit platforms(such as DSC).

Unused		Major Version				Minor Version				Bug Fix	
31	25	24	17	16	9	8	0				

`ARRAY_SIZE(x)`

Computes the number of elements in an array.

`UINT64_H(X)`

Macro to get upper 32 bits of a 64-bit value

`UINT64_L(X)`

Macro to get lower 32 bits of a 64-bit value

`SUPPRESS_FALL_THROUGH_WARNING()`

For switch case code block, if case section ends without “break;” statement, there will be fallthrough warning with compiler flag -Wextra or -Wimplicit-fallthrough=n when using armgcc. To suppress this warning, “SUPPRESS_FALL_THROUGH_WARNING();” need to be added at the end of each case section which misses “break;”statement.

`MSDK_REG_SECURE_ADDR(x)`

Convert the register address to the one used in secure mode.

`MSDK_REG_NONSECURE_ADDR(x)`

Convert the register address to the one used in non-secure mode.

`MSDK_HAS_DWT_CYCCNT`

The chip supports DWT CYCCNT or not.

`MSDK_INVALID_IRQ_HANDLER`

Invalid IRQ handler address.

2.29 LPI2C: Low Power Inter-Integrated Circuit Driver

`void LPI2C_DriverIRQHandler(uint32_t instance)`

LPI2C driver IRQ handler common entry.

This function provides the common IRQ request entry for LPI2C.

Parameters

- `instance` – LPI2C instance.

`FSL_LPI2C_DRIVER_VERSION`

LPI2C driver version.

LPI2C status return codes.

Values:

enumerator `kStatus_LPI2C_Busy`

The master is already performing a transfer.

enumerator `kStatus_LPI2C_Idle`

The slave driver is idle.

enumerator `kStatus_LPI2C_Nak`

The slave device sent a NAK in response to a byte.

enumerator `kStatus_LPI2C_FifoError`

FIFO under run or overrun.

enumerator `kStatus_LPI2C_BitError`

Transferred bit was not seen on the bus.

enumerator `kStatus_LPI2C_ArbitrationLost`

Arbitration lost error.

enumerator `kStatus_LPI2C_PinLowTimeout`

SCL or SDA were held low longer than the timeout.

enumerator `kStatus_LPI2C_NoTransferInProgress`

Attempt to abort a transfer when one is not in progress.

enumerator `kStatus_LPI2C_DmaRequestFail`

DMA request failed.

enumerator `kStatus_LPI2C_Timeout`

Timeout polling status flags.

`IRQn_Type const kLpi2cMasterIrqs[]`

Array to map LPI2C instance number to IRQ number, used internally for LPI2C master interrupt and EDMA transactional APIs.

`IRQn_Type const kLpi2cSlaveIrqs[]`

`lpi2c_master_isr_t s_lpi2cMasterIsr`

Pointer to master IRQ handler for each instance, used internally for LPI2C master interrupt and EDMA transactional APIs.

`void *s_lpi2cMasterHandle[]`

Pointers to master handles for each instance, used internally for LPI2C master interrupt and EDMA transactional APIs.


```
uint32_t LPI2C_GetInstance(LPI2C_Type *base)
```

Returns an instance number given a base address.

If an invalid base address is passed, debug builds will assert. Release builds will just return instance number 0.

Parameters

- `base` – The LPI2C peripheral base address.

Returns

LPI2C instance number starting from 0.

```
I2C_RETRY_TIMES
```

Retry times for waiting flag.

2.30 LPI2C Master Driver

```
void LPI2C_MasterGetDefaultConfig(lpi2c_master_config_t *masterConfig)
```

Provides a default configuration for the LPI2C master peripheral.

This function provides the following default configuration for the LPI2C master peripheral:

```
masterConfig->enableMaster      = true;
masterConfig->debugEnable       = false;
masterConfig->ignoreAck         = false;
masterConfig->pinConfig         = kLPI2C_2PinOpenDrain;
masterConfig->baudRate_Hz       = 100000U;
masterConfig->busIdleTimeout_ns = 0;
masterConfig->pinLowTimeout_ns  = 0;
masterConfig->sdaGlitchFilterWidth_ns = 0;
masterConfig->sclGlitchFilterWidth_ns = 0;
masterConfig->hostRequest.enable = false;
masterConfig->hostRequest.source  = kLPI2C_HostRequestExternalPin;
masterConfig->hostRequest.polarity = kLPI2C_HostRequestPinActiveHigh;
```

After calling this function, you can override any settings in order to customize the configuration, prior to initializing the master driver with `LPI2C_MasterInit()`.

Parameters

- `masterConfig` – **[out]** User provided configuration structure for default values. Refer to `lpi2c_master_config_t`.

```
void LPI2C_MasterInit(LPI2C_Type *base, const lpi2c_master_config_t *masterConfig, uint32_t
sourceClock_Hz)
```

Initializes the LPI2C master peripheral.

This function enables the peripheral clock and initializes the LPI2C master peripheral as described by the user provided configuration. A software reset is performed prior to configuration.

Parameters

- `base` – The LPI2C peripheral base address.
- `masterConfig` – User provided peripheral configuration. Use `LPI2C_MasterGetDefaultConfig()` to get a set of defaults that you can override.
- `sourceClock_Hz` – Frequency in Hertz of the LPI2C functional clock. Used to calculate the baud rate divisors, filter widths, and timeout periods.

`void LPI2C_MasterDeinit(LPI2C_Type *base)`

Deinitializes the LPI2C master peripheral.

This function disables the LPI2C master peripheral and gates the clock. It also performs a software reset to restore the peripheral to reset conditions.

Parameters

- `base` – The LPI2C peripheral base address.

`void LPI2C_MasterConfigureDataMatch(LPI2C_Type *base, const lpi2c_data_match_config_t *matchConfig)`

Configures LPI2C master data match feature.

Parameters

- `base` – The LPI2C peripheral base address.
- `matchConfig` – Settings for the data match feature.

`status_t LPI2C_MasterCheckAndClearError(LPI2C_Type *base, uint32_t status)`

Convert provided flags to status code, and clear any errors if present.

Parameters

- `base` – The LPI2C peripheral base address.
- `status` – Current status flags value that will be checked.

Return values

- `kStatus_Success` –
- `kStatus_LPI2C_PinLowTimeout` –
- `kStatus_LPI2C_ArbitrationLost` –
- `kStatus_LPI2C_Nak` –
- `kStatus_LPI2C_FifoError` –

`status_t LPI2C_CheckForBusyBus(LPI2C_Type *base)`

Make sure the bus isn't already busy.

A busy bus is allowed if we are the one driving it.

Parameters

- `base` – The LPI2C peripheral base address.

Return values

- `kStatus_Success` –
- `kStatus_LPI2C_Busy` –

`static inline void LPI2C_MasterReset(LPI2C_Type *base)`

Performs a software reset.

Restores the LPI2C master peripheral to reset conditions.

Parameters

- `base` – The LPI2C peripheral base address.

`static inline void LPI2C_MasterEnable(LPI2C_Type *base, bool enable)`

Enables or disables the LPI2C module as master.

Parameters

- `base` – The LPI2C peripheral base address.
- `enable` – Pass true to enable or false to disable the specified LPI2C as master.

```
static inline uint32_t LPI2C_MasterGetStatusFlags(LPI2C_Type *base)
```

Gets the LPI2C master status flags.

A bit mask with the state of all LPI2C master status flags is returned. For each flag, the corresponding bit in the return value is set if the flag is asserted.

See also:

`_lpi2c_master_flags`

Parameters

- `base` – The LPI2C peripheral base address.

Returns

State of the status flags:

- 1: related status flag is set.
- 0: related status flag is not set.

```
static inline void LPI2C_MasterClearStatusFlags(LPI2C_Type *base, uint32_t statusMask)
```

Clears the LPI2C master status flag state.

The following status register flags can be cleared:

- `kLPI2C_MasterEndOfPacketFlag`
- `kLPI2C_MasterStopDetectFlag`
- `kLPI2C_MasterNackDetectFlag`
- `kLPI2C_MasterArbitrationLostFlag`
- `kLPI2C_MasterFifoErrFlag`
- `kLPI2C_MasterPinLowTimeoutFlag`
- `kLPI2C_MasterDataMatchFlag`

Attempts to clear other flags has no effect.

See also:

`_lpi2c_master_flags`.

Parameters

- `base` – The LPI2C peripheral base address.
- `statusMask` – A bitmask of status flags that are to be cleared. The mask is composed of `_lpi2c_master_flags` enumerators OR'd together. You may pass the result of a previous call to `LPI2C_MasterGetStatusFlags()`.

```
static inline void LPI2C_MasterEnableInterrupts(LPI2C_Type *base, uint32_t interruptMask)
```

Enables the LPI2C master interrupt requests.

All flags except `kLPI2C_MasterBusyFlag` and `kLPI2C_MasterBusBusyFlag` can be enabled as interrupts.

Parameters

- `base` – The LPI2C peripheral base address.
- `interruptMask` – Bit mask of interrupts to enable. See `_lpi2c_master_flags` for the set of constants that should be OR'd together to form the bit mask.

```
static inline void LPI2C_MasterDisableInterrupts(LPI2C_Type *base, uint32_t interruptMask)
```

Disables the LPI2C master interrupt requests.

All flags except kLPI2C_MasterBusyFlag and kLPI2C_MasterBusBusyFlag can be enabled as interrupts.

Parameters

- base – The LPI2C peripheral base address.
- interruptMask – Bit mask of interrupts to disable. See `_lpi2c_master_flags` for the set of constants that should be OR'd together to form the bit mask.

```
static inline uint32_t LPI2C_MasterGetEnabledInterrupts(LPI2C_Type *base)
```

Returns the set of currently enabled LPI2C master interrupt requests.

Parameters

- base – The LPI2C peripheral base address.

Returns

A bitmask composed of `_lpi2c_master_flags` enumerators OR'd together to indicate the set of enabled interrupts.

```
static inline void LPI2C_MasterEnableDMA(LPI2C_Type *base, bool enableTx, bool enableRx)
```

Enables or disables LPI2C master DMA requests.

Parameters

- base – The LPI2C peripheral base address.
- enableTx – Enable flag for transmit DMA request. Pass true for enable, false for disable.
- enableRx – Enable flag for receive DMA request. Pass true for enable, false for disable.

```
static inline uint32_t LPI2C_MasterGetTxFifoAddress(LPI2C_Type *base)
```

Gets LPI2C master transmit data register address for DMA transfer.

Parameters

- base – The LPI2C peripheral base address.

Returns

The LPI2C Master Transmit Data Register address.

```
static inline uint32_t LPI2C_MasterGetRxFifoAddress(LPI2C_Type *base)
```

Gets LPI2C master receive data register address for DMA transfer.

Parameters

- base – The LPI2C peripheral base address.

Returns

The LPI2C Master Receive Data Register address.

```
static inline void LPI2C_MasterSetWatermarks(LPI2C_Type *base, size_t txWords, size_t rxWords)
```

Sets the watermarks for LPI2C master FIFOs.

Parameters

- base – The LPI2C peripheral base address.
- txWords – Transmit FIFO watermark value in words. The kLPI2C_MasterTxReadyFlag flag is set whenever the number of words in the transmit FIFO is equal or less than *txWords*. Writing a value equal or greater than the FIFO size is truncated.

- `rxWords` – Receive FIFO watermark value in words. The `kLPI2C_MasterRxReadyFlag` flag is set whenever the number of words in the receive FIFO is greater than `rxWords`. Writing a value equal or greater than the FIFO size is truncated.

```
static inline void LPI2C_MasterGetFifoCounts(LPI2C_Type *base, size_t *rxCount, size_t *txCount)
```

Gets the current number of words in the LPI2C master FIFOs.

Parameters

- `base` – The LPI2C peripheral base address.
- `txCount` – **[out]** Pointer through which the current number of words in the transmit FIFO is returned. Pass NULL if this value is not required.
- `rxCount` – **[out]** Pointer through which the current number of words in the receive FIFO is returned. Pass NULL if this value is not required.

```
void LPI2C_MasterSetBaudRate(LPI2C_Type *base, uint32_t sourceClock_Hz, uint32_t baudRate_Hz)
```

Sets the I2C bus frequency for master transactions.

The LPI2C master is automatically disabled and re-enabled as necessary to configure the baud rate. Do not call this function during a transfer, or the transfer is aborted.

Note: Please note that the second parameter is the clock frequency of LPI2C module, the third parameter means user configured bus baudrate, this implementation is different from other I2C drivers which use baudrate configuration as second parameter and source clock frequency as third parameter.

Parameters

- `base` – The LPI2C peripheral base address.
- `sourceClock_Hz` – LPI2C functional clock frequency in Hertz.
- `baudRate_Hz` – Requested bus frequency in Hertz.

```
static inline bool LPI2C_MasterGetBusIdleState(LPI2C_Type *base)
```

Returns whether the bus is idle.

Requires the master mode to be enabled.

Parameters

- `base` – The LPI2C peripheral base address.

Return values

- `true` – Bus is busy.
- `false` – Bus is idle.

```
status_t LPI2C_MasterStart(LPI2C_Type *base, uint8_t address, lpi2c_direction_t dir)
```

Sends a START signal and slave address on the I2C bus.

This function is used to initiate a new master mode transfer. First, the bus state is checked to ensure that another master is not occupying the bus. Then a START signal is transmitted, followed by the 7-bit address specified in the *address* parameter. Note that this function does not actually wait until the START and address are successfully sent on the bus before returning.

Parameters

- `base` – The LPI2C peripheral base address.

- `address` – 7-bit slave device address, in bits [6:0].
- `dir` – Master transfer direction, either `kLPI2C_Read` or `kLPI2C_Write`. This parameter is used to set the R/w bit (bit 0) in the transmitted slave address.

Return values

- `kStatus_Success` – START signal and address were successfully enqueued in the transmit FIFO.
- `kStatus_LPI2C_Busy` – Another master is currently utilizing the bus.

```
static inline status_t LPI2C_MasterRepeatedStart(LPI2C_Type *base, uint8_t address,  
                                                lpi2c_direction_t dir)
```

Sends a repeated START signal and slave address on the I2C bus.

This function is used to send a Repeated START signal when a transfer is already in progress. Like `LPI2C_MasterStart()`, it also sends the specified 7-bit address.

Note: This function exists primarily to maintain compatible APIs between LPI2C and I2C drivers, as well as to better document the intent of code that uses these APIs.

Parameters

- `base` – The LPI2C peripheral base address.
- `address` – 7-bit slave device address, in bits [6:0].
- `dir` – Master transfer direction, either `kLPI2C_Read` or `kLPI2C_Write`. This parameter is used to set the R/w bit (bit 0) in the transmitted slave address.

Return values

- `kStatus_Success` – Repeated START signal and address were successfully enqueued in the transmit FIFO.
- `kStatus_LPI2C_Busy` – Another master is currently utilizing the bus.

```
status_t LPI2C_MasterSend(LPI2C_Type *base, void *txBuff, size_t txSize)
```

Performs a polling send transfer on the I2C bus.

Sends up to `txSize` number of bytes to the previously addressed slave device. The slave may reply with a NAK to any byte in order to terminate the transfer early. If this happens, this function returns `kStatus_LPI2C_Nak`.

Parameters

- `base` – The LPI2C peripheral base address.
- `txBuff` – The pointer to the data to be transferred.
- `txSize` – The length in bytes of the data to be transferred.

Return values

- `kStatus_Success` – Data was sent successfully.
- `kStatus_LPI2C_Busy` – Another master is currently utilizing the bus.
- `kStatus_LPI2C_Nak` – The slave device sent a NAK in response to a byte.
- `kStatus_LPI2C_FifoError` – FIFO under run or over run.
- `kStatus_LPI2C_ArbitrationLost` – Arbitration lost error.
- `kStatus_LPI2C_PinLowTimeout` – SCL or SDA were held low longer than the timeout.

status_t LPI2C_MasterReceive(LPI2C_Type *base, void *rxBuff, size_t rxSize)

Performs a polling receive transfer on the I2C bus.

Parameters

- base – The LPI2C peripheral base address.
- rxBuff – The pointer to the data to be transferred.
- rxSize – The length in bytes of the data to be transferred.

Return values

- kStatus_Success – Data was received successfully.
- kStatus_LPI2C_Busy – Another master is currently utilizing the bus.
- kStatus_LPI2C_Nak – The slave device sent a NAK in response to a byte.
- kStatus_LPI2C_FifoError – FIFO under run or overrun.
- kStatus_LPI2C_ArbitrationLost – Arbitration lost error.
- kStatus_LPI2C_PinLowTimeout – SCL or SDA were held low longer than the timeout.

status_t LPI2C_MasterStop(LPI2C_Type *base)

Sends a STOP signal on the I2C bus.

This function does not return until the STOP signal is seen on the bus, or an error occurs.

Parameters

- base – The LPI2C peripheral base address.

Return values

- kStatus_Success – The STOP signal was successfully sent on the bus and the transaction terminated.
- kStatus_LPI2C_Busy – Another master is currently utilizing the bus.
- kStatus_LPI2C_Nak – The slave device sent a NAK in response to a byte.
- kStatus_LPI2C_FifoError – FIFO under run or overrun.
- kStatus_LPI2C_ArbitrationLost – Arbitration lost error.
- kStatus_LPI2C_PinLowTimeout – SCL or SDA were held low longer than the timeout.

status_t LPI2C_MasterTransferBlocking(LPI2C_Type *base, *lpi2c_master_transfer_t* *transfer)

Performs a master polling transfer on the I2C bus.

Note: The API does not return until the transfer succeeds or fails due to error happens during transfer.

Parameters

- base – The LPI2C peripheral base address.
- transfer – Pointer to the transfer structure.

Return values

- kStatus_Success – Data was received successfully.
- kStatus_LPI2C_Busy – Another master is currently utilizing the bus.
- kStatus_LPI2C_Nak – The slave device sent a NAK in response to a byte.

- kStatus_LPI2C_FifoError – FIFO under run or overrun.
- kStatus_LPI2C_ArbitrationLost – Arbitration lost error.
- kStatus_LPI2C_PinLowTimeout – SCL or SDA were held low longer than the timeout.

```
void LPI2C_MasterTransferCreateHandle(LPI2C_Type *base, lpi2c_master_handle_t *handle,  
                                     lpi2c_master_transfer_callback_t callback, void  
                                     *userData)
```

Creates a new handle for the LPI2C master non-blocking APIs.

The creation of a handle is for use with the non-blocking APIs. Once a handle is created, there is not a corresponding destroy handle. If the user wants to terminate a transfer, the LPI2C_MasterTransferAbort() API shall be called.

Note: The function also enables the NVIC IRQ for the input LPI2C. Need to notice that on some SoCs the LPI2C IRQ is connected to INTMUX, in this case user needs to enable the associated INTMUX IRQ in application.

Parameters

- base – The LPI2C peripheral base address.
- handle – **[out]** Pointer to the LPI2C master driver handle.
- callback – User provided pointer to the asynchronous callback function.
- userData – User provided pointer to the application callback data.

```
status_t LPI2C_MasterTransferNonBlocking(LPI2C_Type *base, lpi2c_master_handle_t *handle,  
                                         lpi2c_master_transfer_t *transfer)
```

Performs a non-blocking transaction on the I2C bus.

Parameters

- base – The LPI2C peripheral base address.
- handle – Pointer to the LPI2C master driver handle.
- transfer – The pointer to the transfer descriptor.

Return values

- kStatus_Success – The transaction was started successfully.
- kStatus_LPI2C_Busy – Either another master is currently utilizing the bus, or a non-blocking transaction is already in progress.

```
status_t LPI2C_MasterTransferGetCount(LPI2C_Type *base, lpi2c_master_handle_t *handle,  
                                       size_t *count)
```

Returns number of bytes transferred so far.

Parameters

- base – The LPI2C peripheral base address.
- handle – Pointer to the LPI2C master driver handle.
- count – **[out]** Number of bytes transferred so far by the non-blocking transaction.

Return values

- kStatus_Success –
- kStatus_NoTransferInProgress – There is not a non-blocking transaction currently in progress.

`void LPI2C_MasterTransferAbort(LPI2C_Type *base, lpi2c_master_handle_t *handle)`

Terminates a non-blocking LPI2C master transmission early.

Note: It is not safe to call this function from an IRQ handler that has a higher priority than the LPI2C peripheral's IRQ priority.

Parameters

- `base` – The LPI2C peripheral base address.
- `handle` – Pointer to the LPI2C master driver handle.

`void LPI2C_MasterTransferHandleIRQ(LPI2C_Type *base, void *lpi2cMasterHandle)`

Reusable routine to handle master interrupts.

Note: This function does not need to be called unless you are reimplementing the non-blocking API's interrupt handler routines to add special functionality.

Parameters

- `base` – The LPI2C peripheral base address.
- `lpi2cMasterHandle` – Pointer to the LPI2C master driver handle.

`enum _lpi2c_master_flags`

LPI2C master peripheral flags.

The following status register flags can be cleared:

- `kLPI2C_MasterEndOfPacketFlag`
- `kLPI2C_MasterStopDetectFlag`
- `kLPI2C_MasterNackDetectFlag`
- `kLPI2C_MasterArbitrationLostFlag`
- `kLPI2C_MasterFifoErrFlag`
- `kLPI2C_MasterPinLowTimeoutFlag`
- `kLPI2C_MasterDataMatchFlag`

All flags except `kLPI2C_MasterBusyFlag` and `kLPI2C_MasterBusBusyFlag` can be enabled as interrupts.

Note: These enums are meant to be OR'd together to form a bit mask.

Values:

enumerator `kLPI2C_MasterTxReadyFlag`

Transmit data flag

enumerator `kLPI2C_MasterRxReadyFlag`

Receive data flag

enumerator `kLPI2C_MasterEndOfPacketFlag`

End Packet flag

enumerator `kLPI2C_MasterStopDetectFlag`

Stop detect flag

enumerator kLPI2C_MasterNackDetectFlag
NACK detect flag

enumerator kLPI2C_MasterArbitrationLostFlag
Arbitration lost flag

enumerator kLPI2C_MasterFifoErrFlag
FIFO error flag

enumerator kLPI2C_MasterPinLowTimeoutFlag
Pin low timeout flag

enumerator kLPI2C_MasterDataMatchFlag
Data match flag

enumerator kLPI2C_MasterBusyFlag
Master busy flag

enumerator kLPI2C_MasterBusBusyFlag
Bus busy flag

enumerator kLPI2C_MasterClearFlags
All flags which are cleared by the driver upon starting a transfer.

enumerator kLPI2C_MasterIrqFlags
IRQ sources enabled by the non-blocking transactional API.

enumerator kLPI2C_MasterErrorFlags
Errors to check for.

enum _lpi2c_direction
Direction of master and slave transfers.
Values:

enumerator kLPI2C_Write
Master transmit.

enumerator kLPI2C_Read
Master receive.

enum _lpi2c_master_pin_config
LPI2C pin configuration.
Values:

enumerator kLPI2C_2PinOpenDrain
LPI2C Configured for 2-pin open drain mode

enumerator kLPI2C_2PinOutputOnly
LPI2C Configured for 2-pin output only mode (ultra-fast mode)

enumerator kLPI2C_2PinPushPull
LPI2C Configured for 2-pin push-pull mode

enumerator kLPI2C_4PinPushPull
LPI2C Configured for 4-pin push-pull mode

enumerator kLPI2C_2PinOpenDrainWithSeparateSlave
LPI2C Configured for 2-pin open drain mode with separate LPI2C slave

enumerator kLPI2C_2PinOutputOnlyWithSeparateSlave
LPI2C Configured for 2-pin output only mode(ultra-fast mode) with separate LPI2C slave

enumerator kLPI2C_2PinPushPullWithSeparateSlave
LPI2C Configured for 2-pin push-pull mode with separate LPI2C slave

enumerator kLPI2C_4PinPushPullWithInvertedOutput
LPI2C Configured for 4-pin push-pull mode(inverted outputs)

enum _lpi2c_host_request_source
LPI2C master host request selection.

Values:

enumerator kLPI2C_HostRequestExternalPin
Select the LPI2C_HREQ pin as the host request input

enumerator kLPI2C_HostRequestInputTrigger
Select the input trigger as the host request input

enum _lpi2c_host_request_polarity
LPI2C master host request pin polarity configuration.

Values:

enumerator kLPI2C_HostRequestPinActiveLow
Configure the LPI2C_HREQ pin active low

enumerator kLPI2C_HostRequestPinActiveHigh
Configure the LPI2C_HREQ pin active high

enum _lpi2c_data_match_config_mode
LPI2C master data match configuration modes.

Values:

enumerator kLPI2C_MatchDisabled
LPI2C Match Disabled

enumerator kLPI2C_1stWordEqualsM0OrM1
LPI2C Match Enabled and 1st data word equals MATCH0 OR MATCH1

enumerator kLPI2C_AnyWordEqualsM0OrM1
LPI2C Match Enabled and any data word equals MATCH0 OR MATCH1

enumerator kLPI2C_1stWordEqualsM0And2ndWordEqualsM1
LPI2C Match Enabled and 1st data word equals MATCH0, 2nd data equals MATCH1

enumerator kLPI2C_AnyWordEqualsM0AndNextWordEqualsM1
LPI2C Match Enabled and any data word equals MATCH0, next data equals MATCH1

enumerator kLPI2C_1stWordAndM1EqualsM0AndM1
LPI2C Match Enabled and 1st data word and MATCH0 equals MATCH0 and MATCH1

enumerator kLPI2C_AnyWordAndM1EqualsM0AndM1
LPI2C Match Enabled and any data word and MATCH0 equals MATCH0 and MATCH1

enum _lpi2c_master_transfer_flags
Transfer option flags.

Note: These enumerations are intended to be OR'd together to form a bit mask of options for the _lpi2c_master_transfer::flags field.

Values:

enumerator `kLPI2C_TransferDefaultFlag`

Transfer starts with a start signal, stops with a stop signal.

enumerator `kLPI2C_TransferNoStartFlag`

Don't send a start condition, address, and sub address

enumerator `kLPI2C_TransferRepeatedStartFlag`

Send a repeated start condition

enumerator `kLPI2C_TransferNoStopFlag`

Don't send a stop condition.

typedef enum `_lpi2c_direction` `lpi2c_direction_t`

Direction of master and slave transfers.

typedef enum `_lpi2c_master_pin_config` `lpi2c_master_pin_config_t`

LPI2C pin configuration.

typedef enum `_lpi2c_host_request_source` `lpi2c_host_request_source_t`

LPI2C master host request selection.

typedef enum `_lpi2c_host_request_polarity` `lpi2c_host_request_polarity_t`

LPI2C master host request pin polarity configuration.

typedef struct `_lpi2c_master_config` `lpi2c_master_config_t`

Structure with settings to initialize the LPI2C master module.

This structure holds configuration settings for the LPI2C peripheral. To initialize this structure to reasonable defaults, call the `LPI2C_MasterGetDefaultConfig()` function and pass a pointer to your configuration structure instance.

The configuration structure can be made constant so it resides in flash.

typedef enum `_lpi2c_data_match_config_mode` `lpi2c_data_match_config_mode_t`

LPI2C master data match configuration modes.

typedef struct `_lpi2c_match_config` `lpi2c_data_match_config_t`

LPI2C master data match configuration structure.

typedef struct `_lpi2c_master_transfer` `lpi2c_master_transfer_t`

LPI2C master descriptor of the transfer.

typedef struct `_lpi2c_master_handle` `lpi2c_master_handle_t`

LPI2C master handle of the transfer.

typedef void (*`lpi2c_master_transfer_callback_t`)(`LPI2C_Type` *`base`, `lpi2c_master_handle_t` *`handle`, `status_t` `completionStatus`, void *`userData`)

Master completion callback function pointer type.

This callback is used only for the non-blocking master transfer API. Specify the callback you wish to use in the call to `LPI2C_MasterTransferCreateHandle()`.

Param base

The LPI2C peripheral base address.

Param handle

Pointer to the LPI2C master driver handle.

Param completionStatus

Either `kStatus_Success` or an error code describing how the transfer completed.

Param userData

Arbitrary pointer-sized value passed from the application.

```
typedef void (*lpi2c_master_isr_t)(LPI2C_Type *base, void *handle)
```

Typedef for master interrupt handler, used internally for LPI2C master interrupt and EDMA transactional APIs.

```
struct _lpi2c_master_config
```

#include <fsl_lpi2c.h> Structure with settings to initialize the LPI2C master module.

This structure holds configuration settings for the LPI2C peripheral. To initialize this structure to reasonable defaults, call the LPI2C_MasterGetDefaultConfig() function and pass a pointer to your configuration structure instance.

The configuration structure can be made constant so it resides in flash.

Public Members

bool enableMaster

Whether to enable master mode.

bool enableDoze

Whether master is enabled in doze mode.

bool debugEnable

Enable transfers to continue when halted in debug mode.

bool ignoreAck

Whether to ignore ACK/NACK.

lpi2c_master_pin_config_t pinConfig

The pin configuration option.

uint32_t baudRate_Hz

Desired baud rate in Hertz.

uint32_t busIdleTimeout_ns

Bus idle timeout in nanoseconds. Set to 0 to disable.

uint32_t pinLowTimeout_ns

Pin low timeout in nanoseconds. Set to 0 to disable.

uint8_t sdaGlitchFilterWidth_ns

Width in nanoseconds of glitch filter on SDA pin. Set to 0 to disable.

uint8_t sclGlitchFilterWidth_ns

Width in nanoseconds of glitch filter on SCL pin. Set to 0 to disable.

struct *_lpi2c_master_config* hostRequest

Host request options.

```
struct _lpi2c_match_config
```

#include <fsl_lpi2c.h> LPI2C master data match configuration structure.

Public Members

lpi2c_data_match_config_mode_t matchMode

Data match configuration setting.

bool rxDataMatchOnly

When set to true, received data is ignored until a successful match.

uint32_t match0

Match value 0.

uint32_t match1

Match value 1.

struct _lpi2c_master_transfer

#include <fsl_lpi2c.h> Non-blocking transfer descriptor structure.

This structure is used to pass transaction parameters to the LPI2C_MasterTransferNonBlocking() API.

Public Members

uint32_t flags

Bit mask of options for the transfer. See enumeration _lpi2c_master_transfer_flags for available options. Set to 0 or kLPI2C_TransferDefaultFlag for normal transfers.

uint16_t slaveAddress

The 7-bit slave address.

lpi2c_direction_t direction

Either kLPI2C_Read or kLPI2C_Write.

uint32_t subaddress

Sub address. Transferred MSB first.

size_t subaddressSize

Length of sub address to send in bytes. Maximum size is 4 bytes.

void *data

Pointer to data to transfer.

size_t dataSize

Number of bytes to transfer.

struct _lpi2c_master_handle

#include <fsl_lpi2c.h> Driver handle for master non-blocking APIs.

Note: The contents of this structure are private and subject to change.

Public Members

uint8_t state

Transfer state machine current state.

uint16_t remainingBytes

Remaining byte count in current state.

uint8_t *buf

Buffer pointer for current state.

uint16_t commandBuffer[6]

LPI2C command sequence. When all 6 command words are used: Start&addr&write[1 word] + subaddr[4 words] + restart&addr&read[1 word]

lpi2c_master_transfer_t transfer

Copy of the current transfer info.

lpi2c_master_transfer_callback_t completionCallback

Callback function pointer.

void *userData

Application data passed to callback.

struct hostRequest

Public Members

bool enable

Enable host request.

lpi2c_host_request_source_t source

Host request source.

lpi2c_host_request_polarity_t polarity

Host request pin polarity.

2.31 LPI2C Master DMA Driver

```
void LPI2C_MasterCreateEDMAHandle(LPI2C_Type *base, lpi2c_master_edma_handle_t *handle,
                                   edma_handle_t *rxDmaHandle, edma_handle_t
                                   *txDmaHandle, lpi2c_master_edma_transfer_callback_t
                                   callback, void *userData)
```

Create a new handle for the LPI2C master DMA APIs.

The creation of a handle is for use with the DMA APIs. Once a handle is created, there is not a corresponding destroy handle. If the user wants to terminate a transfer, the LPI2C_MasterTransferAbortEDMA() API shall be called.

For devices where the LPI2C send and receive DMA requests are OR'd together, the *txDmaHandle* parameter is ignored and may be set to NULL.

Parameters

- base – The LPI2C peripheral base address.
- handle – **[out]** Pointer to the LPI2C master driver handle.
- rxDmaHandle – Handle for the eDMA receive channel. Created by the user prior to calling this function.
- txDmaHandle – Handle for the eDMA transmit channel. Created by the user prior to calling this function.
- callback – User provided pointer to the asynchronous callback function.
- userData – User provided pointer to the application callback data.

```
status_t LPI2C_MasterTransferEDMA(LPI2C_Type *base, lpi2c_master_edma_handle_t *handle,
                                   lpi2c_master_transfer_t *transfer)
```

Performs a non-blocking DMA-based transaction on the I2C bus.

The callback specified when the *handle* was created is invoked when the transaction has completed.

Parameters

- base – The LPI2C peripheral base address.
- handle – Pointer to the LPI2C master driver handle.
- transfer – The pointer to the transfer descriptor.

Return values

- `kStatus_Success` – The transaction was started successfully.
- `kStatus_LPI2C_Busy` – Either another master is currently utilizing the bus, or another DMA transaction is already in progress.

`status_t` LPI2C_MasterTransferGetCountEDMA(LPI2C_Type *base, *lpi2c_master_edma_handle_t* *handle, size_t *count)

Returns number of bytes transferred so far.

Parameters

- `base` – The LPI2C peripheral base address.
- `handle` – Pointer to the LPI2C master driver handle.
- `count` – **[out]** Number of bytes transferred so far by the non-blocking transaction.

Return values

- `kStatus_Success` –
- `kStatus_NoTransferInProgress` – There is not a DMA transaction currently in progress.

`status_t` LPI2C_MasterTransferAbortEDMA(LPI2C_Type *base, *lpi2c_master_edma_handle_t* *handle)

Terminates a non-blocking LPI2C master transmission early.

Note: It is not safe to call this function from an IRQ handler that has a higher priority than the eDMA peripheral's IRQ priority.

Parameters

- `base` – The LPI2C peripheral base address.
- `handle` – Pointer to the LPI2C master driver handle.

Return values

- `kStatus_Success` – A transaction was successfully aborted.
- `kStatus_LPI2C_Idle` – There is not a DMA transaction currently in progress.

`typedef struct _lpi2c_master_edma_handle` `lpi2c_master_edma_handle_t`
LPI2C master EDMA handle of the transfer.

`typedef void (*lpi2c_master_edma_transfer_callback_t)`(LPI2C_Type *base, *lpi2c_master_edma_handle_t* *handle, `status_t` completionStatus, void *userData)

Master DMA completion callback function pointer type.

This callback is used only for the non-blocking master transfer API. Specify the callback you wish to use in the call to `LPI2C_MasterCreateEDMAHandle()`.

Param base

The LPI2C peripheral base address.

Param handle

Handle associated with the completed transfer.

Param completionStatus

Either `kStatus_Success` or an error code describing how the transfer completed.

Param userData

Arbitrary pointer-sized value passed from the application.

```
struct _lpi2c_master_edma_handle
```

#include <fsl_lpi2c_edma.h> Driver handle for master DMA APIs.

Note: The contents of this structure are private and subject to change.

Public Members

```
LPI2C_Type *base
```

LPI2C base pointer.

```
bool isBusy
```

Transfer state machine current state.

```
uint8_t nbytes
```

eDMA minor byte transfer count initially configured.

```
uint16_t commandBuffer[20]
```

LPI2C command sequence. When all 10 command words are used:
Start&addr&write[1 word] + subaddr[4 words] + restart&addr&read[1 word] +
receive&Size[4 words]

```
lpi2c_master_transfer_t transfer
```

Copy of the current transfer info.

```
lpi2c_master_edma_transfer_callback_t completionCallback
```

Callback function pointer.

```
void *userData
```

Application data passed to callback.

```
edma_handle_t *rx
```

Handle for receive DMA channel.

```
edma_handle_t *tx
```

Handle for transmit DMA channel.

```
edma_tcd_t tcds[3]
```

Software TCD. Three are allocated to provide enough room to align to 32-bytes.

2.32 LPI2C Slave Driver

```
void LPI2C_SlaveGetDefaultConfig(lpi2c_slave_config_t *slaveConfig)
```

Provides a default configuration for the LPI2C slave peripheral.

This function provides the following default configuration for the LPI2C slave peripheral:

```
slaveConfig->enableSlave      = true;
slaveConfig->address0         = 0U;
slaveConfig->address1         = 0U;
slaveConfig->addressMatchMode = kLPI2C_MatchAddress0;
slaveConfig->filterDozeEnable  = true;
slaveConfig->filterEnable      = true;
slaveConfig->enableGeneralCall = false;
slaveConfig->sclStall.enableAck = false;
```

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```

slaveConfig->sclStall.enableTx      = true;
slaveConfig->sclStall.enableRx      = true;
slaveConfig->sclStall.enableAddress = true;
slaveConfig->ignoreAck              = false;
slaveConfig->enableReceivedAddressRead = false;
slaveConfig->sdaGlitchFilterWidth_ns = 0;
slaveConfig->sclGlitchFilterWidth_ns = 0;
slaveConfig->dataValidDelay_ns      = 0;
slaveConfig->clockHoldTime_ns       = 0;

```

After calling this function, override any settings to customize the configuration, prior to initializing the master driver with `LPI2C_SlaveInit()`. Be sure to override at least the *address0* member of the configuration structure with the desired slave address.

Parameters

- `slaveConfig` – **[out]** User provided configuration structure that is set to default values. Refer to `lpi2c_slave_config_t`.

```
void LPI2C__SlaveInit(LPI2C_Type *base, const lpi2c_slave_config_t *slaveConfig, uint32_t
                    sourceClock_Hz)
```

Initializes the LPI2C slave peripheral.

This function enables the peripheral clock and initializes the LPI2C slave peripheral as described by the user provided configuration.

Parameters

- `base` – The LPI2C peripheral base address.
- `slaveConfig` – User provided peripheral configuration. Use `LPI2C_SlaveGetDefaultConfig()` to get a set of defaults that you can override.
- `sourceClock_Hz` – Frequency in Hertz of the LPI2C functional clock. Used to calculate the filter widths, data valid delay, and clock hold time.

```
void LPI2C__SlaveDeinit(LPI2C_Type *base)
```

Deinitializes the LPI2C slave peripheral.

This function disables the LPI2C slave peripheral and gates the clock. It also performs a software reset to restore the peripheral to reset conditions.

Parameters

- `base` – The LPI2C peripheral base address.

```
static inline void LPI2C__SlaveReset(LPI2C_Type *base)
```

Performs a software reset of the LPI2C slave peripheral.

Parameters

- `base` – The LPI2C peripheral base address.

```
static inline void LPI2C__SlaveEnable(LPI2C_Type *base, bool enable)
```

Enables or disables the LPI2C module as slave.

Parameters

- `base` – The LPI2C peripheral base address.
- `enable` – Pass true to enable or false to disable the specified LPI2C as slave.

```
static inline uint32_t LPI2C_SlaveGetStatusFlags(LPI2C_Type *base)
```

Gets the LPI2C slave status flags.

A bit mask with the state of all LPI2C slave status flags is returned. For each flag, the corresponding bit in the return value is set if the flag is asserted.

See also:

`_lpi2c_slave_flags`

Parameters

- `base` – The LPI2C peripheral base address.

Returns

State of the status flags:

- 1: related status flag is set.
- 0: related status flag is not set.

```
static inline void LPI2C_SlaveClearStatusFlags(LPI2C_Type *base, uint32_t statusMask)
```

Clears the LPI2C status flag state.

The following status register flags can be cleared:

- `kLPI2C_SlaveRepeatedStartDetectFlag`
- `kLPI2C_SlaveStopDetectFlag`
- `kLPI2C_SlaveBitErrFlag`
- `kLPI2C_SlaveFifoErrFlag`

Attempts to clear other flags has no effect.

See also:

`_lpi2c_slave_flags`.

Parameters

- `base` – The LPI2C peripheral base address.
- `statusMask` – A bitmask of status flags that are to be cleared. The mask is composed of `_lpi2c_slave_flags` enumerators OR'd together. You may pass the result of a previous call to `LPI2C_SlaveGetStatusFlags()`.

```
static inline void LPI2C_SlaveEnableInterrupts(LPI2C_Type *base, uint32_t interruptMask)
```

Enables the LPI2C slave interrupt requests.

All flags except `kLPI2C_SlaveBusyFlag` and `kLPI2C_SlaveBusBusyFlag` can be enabled as interrupts.

Parameters

- `base` – The LPI2C peripheral base address.
- `interruptMask` – Bit mask of interrupts to enable. See `_lpi2c_slave_flags` for the set of constants that should be OR'd together to form the bit mask.

```
static inline void LPI2C_SlaveDisableInterrupts(LPI2C_Type *base, uint32_t interruptMask)
```

Disables the LPI2C slave interrupt requests.

All flags except `kLPI2C_SlaveBusyFlag` and `kLPI2C_SlaveBusBusyFlag` can be enabled as interrupts.

Parameters

- `base` – The LPI2C peripheral base address.
- `interruptMask` – Bit mask of interrupts to disable. See `_lpi2c_slave_flags` for the set of constants that should be OR'd together to form the bit mask.

```
static inline uint32_t LPI2C_SlaveGetEnabledInterrupts(LPI2C_Type *base)
```

Returns the set of currently enabled LPI2C slave interrupt requests.

Parameters

- `base` – The LPI2C peripheral base address.

Returns

A bitmask composed of `_lpi2c_slave_flags` enumerators OR'd together to indicate the set of enabled interrupts.

```
static inline void LPI2C_SlaveEnableDMA(LPI2C_Type *base, bool enableAddressValid, bool enableRx, bool enableTx)
```

Enables or disables the LPI2C slave peripheral DMA requests.

Parameters

- `base` – The LPI2C peripheral base address.
- `enableAddressValid` – Enable flag for the address valid DMA request. Pass true for enable, false for disable. The address valid DMA request is shared with the receive data DMA request.
- `enableRx` – Enable flag for the receive data DMA request. Pass true for enable, false for disable.
- `enableTx` – Enable flag for the transmit data DMA request. Pass true for enable, false for disable.

```
static inline bool LPI2C_SlaveGetBusIdleState(LPI2C_Type *base)
```

Returns whether the bus is idle.

Requires the slave mode to be enabled.

Parameters

- `base` – The LPI2C peripheral base address.

Return values

- `true` – Bus is busy.
- `false` – Bus is idle.

```
static inline void LPI2C_SlaveTransmitAck(LPI2C_Type *base, bool ackOrNack)
```

Transmits either an ACK or NAK on the I2C bus in response to a byte from the master.

Use this function to send an ACK or NAK when the `kLPI2C_SlaveTransmitAckFlag` is asserted. This only happens if you enable the `sclStall.enableAck` field of the `lpi2c_slave_config_t` configuration structure used to initialize the slave peripheral.

Parameters

- `base` – The LPI2C peripheral base address.
- `ackOrNack` – Pass true for an ACK or false for a NAK.

```
static inline void LPI2C_SlaveEnableAckStall(LPI2C_Type *base, bool enable)
```

Enables or disables ACKSTALL.

When enables ACKSTALL, software can transmit either an ACK or NAK on the I2C bus in response to a byte from the master.

Parameters

- base – The LPI2C peripheral base address.
- enable – True will enable ACKSTALL, false will disable ACKSTALL.

static inline uint32_t LPI2C_SlaveGetReceivedAddress(LPI2C_Type *base)

Returns the slave address sent by the I2C master.

This function should only be called if the kLPI2C_SlaveAddressValidFlag is asserted.

Parameters

- base – The LPI2C peripheral base address.

Returns

The 8-bit address matched by the LPI2C slave. Bit 0 contains the R/w direction bit, and the 7-bit slave address is in the upper 7 bits.

status_t LPI2C_SlaveSend(LPI2C_Type *base, void *txBuff, size_t txSize, size_t *actualTxSize)

Performs a polling send transfer on the I2C bus.

Parameters

- base – The LPI2C peripheral base address.
- txBuff – The pointer to the data to be transferred.
- txSize – The length in bytes of the data to be transferred.
- actualTxSize – **[out]**

Returns

Error or success status returned by API.

status_t LPI2C_SlaveReceive(LPI2C_Type *base, void *rxBuff, size_t rxSize, size_t *actualRxSize)

Performs a polling receive transfer on the I2C bus.

Parameters

- base – The LPI2C peripheral base address.
- rxBuff – The pointer to the data to be transferred.
- rxSize – The length in bytes of the data to be transferred.
- actualRxSize – **[out]**

Returns

Error or success status returned by API.

void LPI2C_SlaveTransferCreateHandle(LPI2C_Type *base, lpi2c_slave_handle_t *handle, lpi2c_slave_transfer_callback_t callback, void *userData)

Creates a new handle for the LPI2C slave non-blocking APIs.

The creation of a handle is for use with the non-blocking APIs. Once a handle is created, there is not a corresponding destroy handle. If the user wants to terminate a transfer, the LPI2C_SlaveTransferAbort() API shall be called.

Note: The function also enables the NVIC IRQ for the input LPI2C. Need to notice that on some SoCs the LPI2C IRQ is connected to INTMUX, in this case user needs to enable the associated INTMUX IRQ in application.

Parameters

- base – The LPI2C peripheral base address.
- handle – **[out]** Pointer to the LPI2C slave driver handle.

- `callback` – User provided pointer to the asynchronous callback function.
- `userData` – User provided pointer to the application callback data.

`status_t` LPI2C_SlaveTransferNonBlocking(LPI2C_Type *base, *lpi2c_slave_handle_t* *handle, uint32_t eventMask)

Starts accepting slave transfers.

Call this API after calling `I2C_SlaveInit()` and `LPI2C_SlaveTransferCreateHandle()` to start processing transactions driven by an I2C master. The slave monitors the I2C bus and pass events to the callback that was passed into the call to `LPI2C_SlaveTransferCreateHandle()`. The callback is always invoked from the interrupt context.

The set of events received by the callback is customizable. To do so, set the *eventMask* parameter to the OR'd combination of `lpi2c_slave_transfer_event_t` enumerators for the events you wish to receive. The `kLPI2C_SlaveTransmitEvent` and `kLPI2C_SlaveReceiveEvent` events are always enabled and do not need to be included in the mask. Alternatively, you can pass 0 to get a default set of only the transmit and receive events that are always enabled. In addition, the `kLPI2C_SlaveAllEvents` constant is provided as a convenient way to enable all events.

Parameters

- `base` – The LPI2C peripheral base address.
- `handle` – Pointer to `lpi2c_slave_handle_t` structure which stores the transfer state.
- `eventMask` – Bit mask formed by OR'ing together `lpi2c_slave_transfer_event_t` enumerators to specify which events to send to the callback. Other accepted values are 0 to get a default set of only the transmit and receive events, and `kLPI2C_SlaveAllEvents` to enable all events.

Return values

- `kStatus__Success` – Slave transfers were successfully started.
- `kStatus_LPI2C_Busy` – Slave transfers have already been started on this handle.

`status_t` LPI2C_SlaveTransferGetCount(LPI2C_Type *base, *lpi2c_slave_handle_t* *handle, size_t *count)

Gets the slave transfer status during a non-blocking transfer.

Parameters

- `base` – The LPI2C peripheral base address.
- `handle` – Pointer to `i2c_slave_handle_t` structure.
- `count` – **[out]** Pointer to a value to hold the number of bytes transferred. May be NULL if the count is not required.

Return values

- `kStatus__Success` –
- `kStatus_NoTransferInProgress` –

`void` LPI2C_SlaveTransferAbort(LPI2C_Type *base, *lpi2c_slave_handle_t* *handle)

Aborts the slave non-blocking transfers.

Note: This API could be called at any time to stop slave for handling the bus events.

Parameters

- `base` – The LPI2C peripheral base address.
- `handle` – Pointer to `lpi2c_slave_handle_t` structure which stores the transfer state.

`void LPI2C_SlaveTransferHandleIRQ(LPI2C_Type *base, lpi2c_slave_handle_t *handle)`

Reusable routine to handle slave interrupts.

Note: This function does not need to be called unless you are reimplementing the non blocking API's interrupt handler routines to add special functionality.

Parameters

- `base` – The LPI2C peripheral base address.
- `handle` – Pointer to `lpi2c_slave_handle_t` structure which stores the transfer state.

`enum _lpi2c_slave_flags`

LPI2C slave peripheral flags.

The following status register flags can be cleared:

- `kLPI2C_SlaveRepeatedStartDetectFlag`
- `kLPI2C_SlaveStopDetectFlag`
- `kLPI2C_SlaveBitErrFlag`
- `kLPI2C_SlaveFifoErrFlag`

All flags except `kLPI2C_SlaveBusyFlag` and `kLPI2C_SlaveBusBusyFlag` can be enabled as interrupts.

Note: These enumerations are meant to be OR'd together to form a bit mask.

Values:

enumerator `kLPI2C_SlaveTxReadyFlag`

Transmit data flag

enumerator `kLPI2C_SlaveRxReadyFlag`

Receive data flag

enumerator `kLPI2C_SlaveAddressValidFlag`

Address valid flag

enumerator `kLPI2C_SlaveTransmitAckFlag`

Transmit ACK flag

enumerator `kLPI2C_SlaveRepeatedStartDetectFlag`

Repeated start detect flag

enumerator `kLPI2C_SlaveStopDetectFlag`

Stop detect flag

enumerator `kLPI2C_SlaveBitErrFlag`

Bit error flag

enumerator `kLPI2C_SlaveFifoErrFlag`

FIFO error flag

enumerator kLPI2C_SlaveAddressMatch0Flag

Address match 0 flag

enumerator kLPI2C_SlaveAddressMatch1Flag

Address match 1 flag

enumerator kLPI2C_SlaveGeneralCallFlag

General call flag

enumerator kLPI2C_SlaveBusyFlag

Master busy flag

enumerator kLPI2C_SlaveBusBusyFlag

Bus busy flag

enumerator kLPI2C_SlaveClearFlags

All flags which are cleared by the driver upon starting a transfer.

enumerator kLPI2C_SlaveIrqFlags

IRQ sources enabled by the non-blocking transactional API.

enumerator kLPI2C_SlaveErrorFlags

Errors to check for.

enum _lpi2c_slave_address_match

LPI2C slave address match options.

Values:

enumerator kLPI2C_MatchAddress0

Match only address 0.

enumerator kLPI2C_MatchAddress0OrAddress1

Match either address 0 or address 1.

enumerator kLPI2C_MatchAddress0ThroughAddress1

Match a range of slave addresses from address 0 through address 1.

enum _lpi2c_slave_transfer_event

Set of events sent to the callback for non blocking slave transfers.

These event enumerations are used for two related purposes. First, a bit mask created by OR'ing together events is passed to LPI2C_SlaveTransferNonBlocking() in order to specify which events to enable. Then, when the slave callback is invoked, it is passed the current event through its *transfer* parameter.

Note: These enumerations are meant to be OR'd together to form a bit mask of events.

Values:

enumerator kLPI2C_SlaveAddressMatchEvent

Received the slave address after a start or repeated start.

enumerator kLPI2C_SlaveTransmitEvent

Callback is requested to provide data to transmit (slave-transmitter role).

enumerator kLPI2C_SlaveReceiveEvent

Callback is requested to provide a buffer in which to place received data (slave-receiver role).

enumerator kLPI2C_SlaveTransmitAckEvent

Callback needs to either transmit an ACK or NACK.

enumerator kLPI2C_SlaveRepeatedStartEvent

A repeated start was detected.

enumerator kLPI2C_SlaveCompletionEvent

A stop was detected, completing the transfer.

enumerator kLPI2C_SlaveAllEvents

Bit mask of all available events.

typedef enum *_lpi2c_slave_address_match* lpi2c_slave_address_match_t

LPI2C slave address match options.

typedef struct *_lpi2c_slave_config* lpi2c_slave_config_t

Structure with settings to initialize the LPI2C slave module.

This structure holds configuration settings for the LPI2C slave peripheral. To initialize this structure to reasonable defaults, call the LPI2C_SlaveGetDefaultConfig() function and pass a pointer to your configuration structure instance.

The configuration structure can be made constant so it resides in flash.

typedef enum *_lpi2c_slave_transfer_event* lpi2c_slave_transfer_event_t

Set of events sent to the callback for non blocking slave transfers.

These event enumerations are used for two related purposes. First, a bit mask created by OR'ing together events is passed to LPI2C_SlaveTransferNonBlocking() in order to specify which events to enable. Then, when the slave callback is invoked, it is passed the current event through its *transfer* parameter.

Note: These enumerations are meant to be OR'd together to form a bit mask of events.

typedef struct *_lpi2c_slave_transfer* lpi2c_slave_transfer_t

LPI2C slave transfer structure.

typedef struct *_lpi2c_slave_handle* lpi2c_slave_handle_t

LPI2C slave handle structure.

typedef void (*lpi2c_slave_transfer_callback_t)(LPI2C_Type *base, lpi2c_slave_transfer_t *transfer, void *userData)

Slave event callback function pointer type.

This callback is used only for the slave non-blocking transfer API. To install a callback, use the LPI2C_SlaveSetCallback() function after you have created a handle.

Param base

Base address for the LPI2C instance on which the event occurred.

Param transfer

Pointer to transfer descriptor containing values passed to and/or from the callback.

Param userData

Arbitrary pointer-sized value passed from the application.

struct *_lpi2c_slave_config*

#include <fsl_lpi2c.h> Structure with settings to initialize the LPI2C slave module.

This structure holds configuration settings for the LPI2C slave peripheral. To initialize this structure to reasonable defaults, call the LPI2C_SlaveGetDefaultConfig() function and pass a pointer to your configuration structure instance.

The configuration structure can be made constant so it resides in flash.

Public Members

`bool enableSlave`
Enable slave mode.

`uint8_t address0`
Slave's 7-bit address.

`uint8_t address1`
Alternate slave 7-bit address.

`lpi2c_slave_address_match_t addressMatchMode`
Address matching options.

`bool filterDozeEnable`
Enable digital glitch filter in doze mode.

`bool filterEnable`
Enable digital glitch filter.

`bool enableGeneralCall`
Enable general call address matching.

`struct _lpi2c_slave_config sclStall`
SCL stall enable options.

`bool ignoreAck`
Continue transfers after a NACK is detected.

`bool enableReceivedAddressRead`
Enable reading the address received address as the first byte of data.

`uint32_t sdaGlitchFilterWidth_ns`
Width in nanoseconds of the digital filter on the SDA signal. Set to 0 to disable.

`uint32_t sclGlitchFilterWidth_ns`
Width in nanoseconds of the digital filter on the SCL signal. Set to 0 to disable.

`uint32_t dataValidDelay_ns`
Width in nanoseconds of the data valid delay.

`uint32_t clockHoldTime_ns`
Width in nanoseconds of the clock hold time.

`struct _lpi2c_slave_transfer`
#include <fsl_lpi2c.h> LPI2C slave transfer structure.

Public Members

`lpi2c_slave_transfer_event_t event`
Reason the callback is being invoked.

`uint8_t receivedAddress`
Matching address send by master.

`uint8_t *data`
Transfer buffer

`size_t dataSize`
Transfer size

status_t completionStatus

Success or error code describing how the transfer completed. Only applies for kLPI2C_SlaveCompletionEvent.

size_t transferredCount

Number of bytes actually transferred since start or last repeated start.

struct *_lpi2c_slave_handle*

#include <fsl_lpi2c.h> LPI2C slave handle structure.

Note: The contents of this structure are private and subject to change.

Public Members

lpi2c_slave_transfer_t transfer

LPI2C slave transfer copy.

bool isBusy

Whether transfer is busy.

bool wasTransmit

Whether the last transfer was a transmit.

uint32_t eventMask

Mask of enabled events.

uint32_t transferredCount

Count of bytes transferred.

lpi2c_slave_transfer_callback_t callback

Callback function called at transfer event.

void *userData

Callback parameter passed to callback.

struct sclStall

Public Members

bool enableAck

Enables SCL clock stretching during slave-transmit address byte(s) and slave-receiver address and data byte(s) to allow software to write the Transmit ACK Register before the ACK or NACK is transmitted. Clock stretching occurs when transmitting the 9th bit. When enableAckSCLStall is enabled, there is no need to set either enableRxDataSCLStall or enableAddressSCLStall.

bool enableTx

Enables SCL clock stretching when the transmit data flag is set during a slave-transmit transfer.

bool enableRx

Enables SCL clock stretching when receive data flag is set during a slave-receive transfer.

bool enableAddress

Enables SCL clock stretching when the address valid flag is asserted.

2.33 LPIT: Low-Power Interrupt Timer

`void LPIT_Init(LPIT_Type *base, const lpit_config_t *config)`

Ungates the LPIT clock and configures the peripheral for a basic operation.

This function issues a software reset to reset all channels and registers except the Module Control register.

Note: This API should be called at the beginning of the application using the LPIT driver.

Parameters

- `base` – LPIT peripheral base address.
- `config` – Pointer to the user configuration structure.

`void LPIT_Deinit(LPIT_Type *base)`

Disables the module and gates the LPIT clock.

Parameters

- `base` – LPIT peripheral base address.

`void LPIT_GetDefaultConfig(lpit_config_t *config)`

Fills in the LPIT configuration structure with default settings.

The default values are:

```
config->enableRunInDebug = false;  
config->enableRunInDoze = false;
```

Parameters

- `config` – Pointer to the user configuration structure.

`status_t LPIT_SetupChannel(LPIT_Type *base, lpit_chnl_t channel, const lpit_chnl_params_t *chnlSetup)`

Sets up an LPIT channel based on the user's preference.

This function sets up the operation mode to one of the options available in the enumeration `lpit_timer_modes_t`. It sets the trigger source as either internal or external, trigger selection and the timers behaviour when a timeout occurs. It also chains the timer if a prior timer if requested by the user.

Parameters

- `base` – LPIT peripheral base address.
- `channel` – Channel that is being configured.
- `chnlSetup` – Configuration parameters.

`static inline void LPIT_EnableInterrupts(LPIT_Type *base, uint32_t mask)`

Enables the selected PIT interrupts.

Parameters

- `base` – LPIT peripheral base address.
- `mask` – The interrupts to enable. This is a logical OR of members of the enumeration `lpit_interrupt_enable_t`

static inline void LPIT_DisableInterrupts(LPIT_Type *base, uint32_t mask)

Disables the selected PIT interrupts.

Parameters

- base – LPIT peripheral base address.
- mask – The interrupts to enable. This is a logical OR of members of the enumeration `lpit_interrupt_enable_t`

static inline uint32_t LPIT_GetEnabledInterrupts(LPIT_Type *base)

Gets the enabled LPIT interrupts.

Parameters

- base – LPIT peripheral base address.

Returns

The enabled interrupts. This is the logical OR of members of the enumeration `lpit_interrupt_enable_t`

static inline uint32_t LPIT_GetStatusFlags(LPIT_Type *base)

Gets the LPIT status flags.

Parameters

- base – LPIT peripheral base address.

Returns

The status flags. This is the logical OR of members of the enumeration `lpit_status_flags_t`

static inline void LPIT_ClearStatusFlags(LPIT_Type *base, uint32_t mask)

Clears the LPIT status flags.

Parameters

- base – LPIT peripheral base address.
- mask – The status flags to clear. This is a logical OR of members of the enumeration `lpit_status_flags_t`

static inline void LPIT_SetTimerPeriod(LPIT_Type *base, *lpit_chnl_t* channel, uint32_t ticks)

Sets the timer period in units of count.

Timers begin counting down from the value set by this function until it reaches 0, at which point it generates an interrupt and loads this register value again. Writing a new value to this register does not restart the timer. Instead, the value is loaded after the timer expires.

Note: User can call the utility macros provided in `fsl_common.h` to convert to ticks.

Parameters

- base – LPIT peripheral base address.
- channel – Timer channel number.
- ticks – Timer period in units of ticks.

static inline void LPIT_SetTimerValue(LPIT_Type *base, *lpit_chnl_t* channel, uint32_t ticks)

Sets the timer period in units of count.

In the Dual 16-bit Periodic Counter mode, the counter will load and then the lower 16-bits will decrement down to zero, which will assert the output pre-trigger. The upper 16-bits will then decrement down to zero, which will negate the output pre-trigger and set the timer interrupt flag.

Note: Set TVAL register to 0 or 1 is invalid in compare mode.

Parameters

- base – LPIT peripheral base address.
- channel – Timer channel number.
- ticks – Timer period in units of ticks.

static inline uint32_t LPIT_GetCurrentTimerCount(LPIT_Type *base, *lpit_chnl_t* channel)

Reads the current timer counting value.

This function returns the real-time timer counting value, in a range from 0 to a timer period.

Note: User can call the utility macros provided in `fsl_common.h` to convert ticks to microseconds or milliseconds.

Parameters

- base – LPIT peripheral base address.
- channel – Timer channel number.

Returns

Current timer counting value in ticks.

static inline void LPIT_StartTimer(LPIT_Type *base, *lpit_chnl_t* channel)

Starts the timer counting.

After calling this function, timers load the period value and count down to 0. When the timer reaches 0, it generates a trigger pulse and sets the timeout interrupt flag.

Parameters

- base – LPIT peripheral base address.
- channel – Timer channel number.

static inline void LPIT_StopTimer(LPIT_Type *base, *lpit_chnl_t* channel)

Stops the timer counting.

Parameters

- base – LPIT peripheral base address.
- channel – Timer channel number.

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enum *_lpit_chnl*

List of LPIT channels.

Note: Actual number of available channels is SoC-dependent

Values:

enumerator kLPIT_Chnl_0

LPIT channel number 0

enumerator kLPIT_Chnl_1

LPIT channel number 1

enumerator kLPIT_Chnl_2

LPIT channel number 2

enumerator kLPIT_Chnl_3

LPIT channel number 3

enum _lpit_timer_modes

Mode options available for the LPIT timer.

Values:

enumerator kLPIT_PeriodicCounter

Use the all 32-bits, counter loads and decrements to zero

enumerator kLPIT_DualPeriodicCounter

Counter loads, lower 16-bits decrement to zero, then upper 16-bits decrement

enumerator kLPIT_TriggerAccumulator

Counter loads on first trigger and decrements on each trigger

enumerator kLPIT_InputCapture

Counter loads with 0xFFFFFFFF, decrements to zero. It stores the inverse of the current value when a input trigger is detected

enum _lpit_trigger_select

Trigger options available.

This is used for both internal and external trigger sources. The actual trigger options available is SoC-specific, user should refer to the reference manual.

Values:

enumerator kLPIT_Trigger_TimerChn0

Channel 0 is selected as a trigger source

enumerator kLPIT_Trigger_TimerChn1

Channel 1 is selected as a trigger source

enumerator kLPIT_Trigger_TimerChn2

Channel 2 is selected as a trigger source

enumerator kLPIT_Trigger_TimerChn3

Channel 3 is selected as a trigger source

enumerator kLPIT_Trigger_TimerChn4

Channel 4 is selected as a trigger source

enumerator kLPIT_Trigger_TimerChn5

Channel 5 is selected as a trigger source

enumerator kLPIT_Trigger_TimerChn6

Channel 6 is selected as a trigger source

enumerator kLPIT_Trigger_TimerChn7

Channel 7 is selected as a trigger source

enumerator kLPIT_Trigger_TimerChn8

Channel 8 is selected as a trigger source

enumerator kLPIT_Trigger_TimerChn9

Channel 9 is selected as a trigger source

enumerator kLPIT_Trigger_TimerChn10

Channel 10 is selected as a trigger source

enumerator kLPIT_Trigger_TimerChn11

Channel 11 is selected as a trigger source

enumerator kLPIT_Trigger_TimerChn12

Channel 12 is selected as a trigger source

enumerator kLPIT_Trigger_TimerChn13

Channel 13 is selected as a trigger source

enumerator kLPIT_Trigger_TimerChn14

Channel 14 is selected as a trigger source

enumerator kLPIT_Trigger_TimerChn15

Channel 15 is selected as a trigger source

enum _lpit_trigger_source

Trigger source options available.

Values:

enumerator kLPIT_TriggerSource_External

Use external trigger input

enumerator kLPIT_TriggerSource_Internal

Use internal trigger

enum _lpit_interrupt_enable

List of LPIT interrupts.

Note: Number of timer channels are SoC-specific. See the SoC Reference Manual.

Values:

enumerator kLPIT_Channel0TimerInterruptEnable

Channel 0 Timer interrupt

enumerator kLPIT_Channel1TimerInterruptEnable

Channel 1 Timer interrupt

enumerator kLPIT_Channel2TimerInterruptEnable

Channel 2 Timer interrupt

enumerator kLPIT_Channel3TimerInterruptEnable

Channel 3 Timer interrupt

enum _lpit_status_flags

List of LPIT status flags.

Note: Number of timer channels are SoC-specific. See the SoC Reference Manual.

Values:

enumerator kLPIT_Channel0TimerFlag

Channel 0 Timer interrupt flag

enumerator kLPIT_Channel1TimerFlag

Channel 1 Timer interrupt flag

enumerator kLPIT_Channel2TimerFlag

Channel 2 Timer interrupt flag

enumerator kLPIT_Channel3TimerFlag

Channel 3 Timer interrupt flag

typedef enum *_lpit_chnl* lpit_chnl_t

List of LPIT channels.

Note: Actual number of available channels is SoC-dependent

typedef enum *_lpit_timer_modes* lpit_timer_modes_t

Mode options available for the LPIT timer.

typedef enum *_lpit_trigger_select* lpit_trigger_select_t

Trigger options available.

This is used for both internal and external trigger sources. The actual trigger options available is SoC-specific, user should refer to the reference manual.

typedef enum *_lpit_trigger_source* lpit_trigger_source_t

Trigger source options available.

typedef enum *_lpit_interrupt_enable* lpit_interrupt_enable_t

List of LPIT interrupts.

Note: Number of timer channels are SoC-specific. See the SoC Reference Manual.

typedef enum *_lpit_status_flags* lpit_status_flags_t

List of LPIT status flags.

Note: Number of timer channels are SoC-specific. See the SoC Reference Manual.

typedef struct *_lpit_chnl_params* lpit_chnl_params_t

Structure to configure the channel timer.

typedef struct *_lpit_config* lpit_config_t

LPIT configuration structure.

This structure holds the configuration settings for the LPIT peripheral. To initialize this structure to reasonable defaults, call the LPIT_GetDefaultConfig() function and pass a pointer to the configuration structure instance.

The configuration structure can be made constant so as to reside in flash.

static void LPIT_ResetStateDelay(void)

Short wait for LPIT state reset.

After clear or set LPIT_EN, there should be delay longer than 4 LPIT functional clock.

static inline void LPIT_Reset(LPIT_Type *base)

Performs a software reset on the LPIT module.

This resets all channels and registers except the Module Control Register.

Parameters

- base – LPIT peripheral base address.

LPIT_RESET_STATE_DELAY

Delay used in LPIT_Reset.

The macro value should be larger than $4 * \text{core clock} / \text{LPIT peripheral clock}$.

struct __lpit_chnl_params

#include <fsl_lpit.h> Structure to configure the channel timer.

Public Members

bool chainChannel

true: Timer chained to previous timer; false: Timer not chained

lpit_timer_modes_t timerMode

Timers mode of operation.

lpit_trigger_select_t triggerSelect

Trigger selection for the timer

lpit_trigger_source_t triggerSource

Decides if we use external or internal trigger.

bool enableReloadOnTrigger

true: Timer reloads when a trigger is detected; false: No effect

bool enableStopOnTimeout

true: Timer will stop after timeout; false: does not stop after timeout

bool enableStartOnTrigger

true: Timer starts when a trigger is detected; false: decrement immediately

struct __lpit_config

#include <fsl_lpit.h> LPIT configuration structure.

This structure holds the configuration settings for the LPIT peripheral. To initialize this structure to reasonable defaults, call the LPIT_GetDefaultConfig() function and pass a pointer to the configuration structure instance.

The configuration structure can be made constant so as to reside in flash.

Public Members

bool enableRunInDebug

true: Timers run in debug mode; false: Timers stop in debug mode

bool enableRunInDoze

true: Timers run in doze mode; false: Timers stop in doze mode

2.34 LPSPI: Low Power Serial Peripheral Interface

2.35 LPSPI Peripheral driver

void LPSPI_MasterInit(LPSPI_Type *base, const *lpspi_master_config_t* *masterConfig, uint32_t srcClock_Hz)

Initializes the LPSPI master.

Parameters

- base – LPSPI peripheral address.
- masterConfig – Pointer to structure `lpspi_master_config_t`.
- srcClock_Hz – Module source input clock in Hertz

void LPSPI_MasterGetDefaultConfig(*lpspi_master_config_t* *masterConfig)

Sets the `lpspi_master_config_t` structure to default values.

This API initializes the configuration structure for LPSPI_MasterInit(). The initialized structure can remain unchanged in LPSPI_MasterInit(), or can be modified before calling the LPSPI_MasterInit(). Example:

```
lpspi_master_config_t masterConfig;
LPSPI_MasterGetDefaultConfig(&masterConfig);
```

Parameters

- masterConfig – pointer to `lpspi_master_config_t` structure

void LPSPI_SlaveInit(LPSPI_Type *base, const *lpspi_slave_config_t* *slaveConfig)

LPSPI slave configuration.

Parameters

- base – LPSPI peripheral address.
- slaveConfig – Pointer to a structure `lpspi_slave_config_t`.

void LPSPI_SlaveGetDefaultConfig(*lpspi_slave_config_t* *slaveConfig)

Sets the `lpspi_slave_config_t` structure to default values.

This API initializes the configuration structure for LPSPI_SlaveInit(). The initialized structure can remain unchanged in LPSPI_SlaveInit() or can be modified before calling the LPSPI_SlaveInit(). Example:

```
lpspi_slave_config_t slaveConfig;
LPSPI_SlaveGetDefaultConfig(&slaveConfig);
```

Parameters

- slaveConfig – pointer to `lpspi_slave_config_t` structure.

void LPSPI_Deinit(LPSPI_Type *base)

De-initializes the LPSPI peripheral. Call this API to disable the LPSPI clock.

Parameters

- base – LPSPI peripheral address.

void LPSPI_Reset(LPSPI_Type *base)

Restores the LPSPI peripheral to reset state. Note that this function sets all registers to reset state. As a result, the LPSPI module can't work after calling this API.

Parameters

- base – LPSPI peripheral address.

uint32_t LPSPI_GetInstance(LPSPI_Type *base)

Get the LPSPI instance from peripheral base address.

Parameters

- base – LPSPI peripheral base address.

Returns

LPSPI instance.

```
static inline void LPSPI_Enable(LPSPI_Type *base, bool enable)
```

Enables the LPSPI peripheral and sets the MCR MDIS to 0.

Parameters

- base – LPSPI peripheral address.
- enable – Pass true to enable module, false to disable module.

```
static inline uint32_t LPSPI_GetStatusFlags(LPSPI_Type *base)
```

Gets the LPSPI status flag state.

Parameters

- base – LPSPI peripheral address.

Returns

The LPSPI status(in SR register).

```
static inline uint8_t LPSPI_GetTxFifoSize(LPSPI_Type *base)
```

Gets the LPSPI Tx FIFO size.

Parameters

- base – LPSPI peripheral address.

Returns

The LPSPI Tx FIFO size.

```
static inline uint8_t LPSPI_GetRxFifoSize(LPSPI_Type *base)
```

Gets the LPSPI Rx FIFO size.

Parameters

- base – LPSPI peripheral address.

Returns

The LPSPI Rx FIFO size.

```
static inline uint32_t LPSPI_GetTxFifoCount(LPSPI_Type *base)
```

Gets the LPSPI Tx FIFO count.

Parameters

- base – LPSPI peripheral address.

Returns

The number of words in the transmit FIFO.

```
static inline uint32_t LPSPI_GetRxFifoCount(LPSPI_Type *base)
```

Gets the LPSPI Rx FIFO count.

Parameters

- base – LPSPI peripheral address.

Returns

The number of words in the receive FIFO.

```
static inline void LPSPI_ClearStatusFlags(LPSPI_Type *base, uint32_t statusFlags)
```

Clears the LPSPI status flag.

This function clears the desired status bit by using a write-1-to-clear. The user passes in the base and the desired status flag bit to clear. The list of status flags is defined in the `_lpspi_flags`. Example usage:

```
LPSPI_ClearStatusFlags(base, kLPSPI_TxDataRequestFlag|kLPSPI_RxDataReadyFlag);
```

Parameters

- base – LPSPI peripheral address.
- statusFlags – The status flag used from type `_lpspi_flags`.

static inline uint32_t LPSPI_GetTcr(LPSPI_Type *base)

static inline void LPSPI_EnableInterrupts(LPSPI_Type *base, uint32_t mask)

Enables the LPSPI interrupts.

This function configures the various interrupt masks of the LPSPI. The parameters are base and an interrupt mask. Note that, for Tx fill and Rx FIFO drain requests, enabling the interrupt request disables the DMA request.

```
LPSPI_EnableInterrupts(base, kLPSPI_TxInterruptEnable | kLPSPI_RxInterruptEnable );
```

Parameters

- base – LPSPI peripheral address.
- mask – The interrupt mask; Use the enum `_lpspi_interrupt_enable`.

static inline void LPSPI_DisableInterrupts(LPSPI_Type *base, uint32_t mask)

Disables the LPSPI interrupts.

```
LPSPI_DisableInterrupts(base, kLPSPI_TxInterruptEnable | kLPSPI_RxInterruptEnable );
```

Parameters

- base – LPSPI peripheral address.
- mask – The interrupt mask; Use the enum `_lpspi_interrupt_enable`.

static inline void LPSPI_EnableDMA(LPSPI_Type *base, uint32_t mask)

Enables the LPSPI DMA request.

This function configures the Rx and Tx DMA mask of the LPSPI. The parameters are base and a DMA mask.

```
LPSPI_EnableDMA(base, kLPSPI_TxDmaEnable | kLPSPI_RxDmaEnable);
```

Parameters

- base – LPSPI peripheral address.
- mask – The interrupt mask; Use the enum `_lpspi_dma_enable`.

static inline void LPSPI_DisableDMA(LPSPI_Type *base, uint32_t mask)

Disables the LPSPI DMA request.

This function configures the Rx and Tx DMA mask of the LPSPI. The parameters are base and a DMA mask.

```
SPI_DisableDMA(base, kLPSPI_TxDmaEnable | kLPSPI_RxDmaEnable);
```

Parameters

- base – LPSPI peripheral address.
- mask – The interrupt mask; Use the enum `_lpspi_dma_enable`.

static inline uint32_t LPSPI_GetTxRegisterAddress(LPSPI_Type *base)

Gets the LPSPI Transmit Data Register address for a DMA operation.

This function gets the LPSPI Transmit Data Register address because this value is needed for the DMA operation. This function can be used for either master or slave mode.

Parameters

- base – LPSPI peripheral address.

Returns

The LPSPI Transmit Data Register address.

```
static inline uint32_t LPSPI_GetRxRegisterAddress(LPSPI_Type *base)
```

Gets the LPSPI Receive Data Register address for a DMA operation.

This function gets the LPSPI Receive Data Register address because this value is needed for the DMA operation. This function can be used for either master or slave mode.

Parameters

- base – LPSPI peripheral address.

Returns

The LPSPI Receive Data Register address.

```
bool LPSPI_CheckTransferArgument(LPSPI_Type *base, lpspi_transfer_t *transfer, bool isEdma)
```

Check the argument for transfer .

Parameters

- base – LPSPI peripheral address.
- transfer – the transfer struct to be used.
- isEdma – True to check for EDMA transfer, false to check interrupt non-blocking transfer

Returns

Return true for right and false for wrong.

```
static inline void LPSPI_SetMasterSlaveMode(LPSPI_Type *base, lpspi_master_slave_mode_t mode)
```

Configures the LPSPI for either master or slave.

Note that the CFGR1 should only be written when the LPSPI is disabled (LPSPIx_CR_MEN = 0).

Parameters

- base – LPSPI peripheral address.
- mode – Mode setting (master or slave) of type lpspi_master_slave_mode_t.

```
static inline void LPSPI_SelectTransferPCS(LPSPI_Type *base, lpspi_which_pcs_t select)
```

Configures the peripheral chip select used for the transfer.

Parameters

- base – LPSPI peripheral address.
- select – LPSPI Peripheral Chip Select (PCS) configuration.

```
static inline void LPSPI_SetPCSContinuous(LPSPI_Type *base, bool IsContinuous)
```

Set the PCS signal to continuous or uncontinuous mode.

Note: In master mode, continuous transfer will keep the PCS asserted at the end of the frame size, until a command word is received that starts a new frame. So PCS must be set back to uncontinuous when transfer finishes. In slave mode, when continuous transfer is enabled, the LPSPI will only transmit the first frame size bits, after that the LPSPI will transmit received data back (assuming a 32-bit shift register).

Parameters

- base – LPSPI peripheral address.
- IsContinuous – True to set the transfer PCS to continuous mode, false to set to uncontinuous mode.

static inline bool LPSPI_IsMaster(LPSPI_Type *base)

Returns whether the LPSPI module is in master mode.

Parameters

- base – LPSPI peripheral address.

Returns

Returns true if the module is in master mode or false if the module is in slave mode.

static inline void LPSPI_FlushFifo(LPSPI_Type *base, bool flushTxFifo, bool flushRxFifo)

Flushes the LPSPI FIFOs.

Parameters

- base – LPSPI peripheral address.
- flushTxFifo – Flushes (true) the Tx FIFO, else do not flush (false) the Tx FIFO.
- flushRxFifo – Flushes (true) the Rx FIFO, else do not flush (false) the Rx FIFO.

static inline void LPSPI_SetFifoWatermarks(LPSPI_Type *base, uint32_t txWater, uint32_t rxWater)

Sets the transmit and receive FIFO watermark values.

This function allows the user to set the receive and transmit FIFO watermarks. The function does not compare the watermark settings to the FIFO size. The FIFO watermark should not be equal to or greater than the FIFO size. It is up to the higher level driver to make this check.

Parameters

- base – LPSPI peripheral address.
- txWater – The TX FIFO watermark value. Writing a value equal or greater than the FIFO size is truncated.
- rxWater – The RX FIFO watermark value. Writing a value equal or greater than the FIFO size is truncated.

static inline void LPSPI_SetAllPcsPolarity(LPSPI_Type *base, uint32_t mask)

Configures all LPSPI peripheral chip select polarities simultaneously.

Note that the CFGR1 should only be written when the LPSPI is disabled (LPSPIx_CR_MEN = 0).

This is an example: PCS0 and PCS1 set to active low and other PCSs set to active high. Note that the number of PCS is device-specific.

```
LPSPI_SetAllPcsPolarity(base, kLPSPI_Pcs0ActiveLow | kLPSPI_Pcs1ActiveLow);
```

Parameters

- base – LPSPI peripheral address.
- mask – The PCS polarity mask; Use the enum `_lpspi_pcs_polarity`.

static inline void LPSPI_SetFrameSize(LPSPI_Type *base, uint32_t frameSize)

Configures the frame size.

The minimum frame size is 8-bits and the maximum frame size is 4096-bits. If the frame size is less than or equal to 32-bits, the word size and frame size are identical. If the frame

size is greater than 32-bits, the word size is 32-bits for each word except the last (the last word contains the remainder bits if the frame size is not divisible by 32). The minimum word size is 2-bits. A frame size of 33-bits (or similar) is not supported.

Note 1: The transmit command register should be initialized before enabling the LPSPI in slave mode, although the command register does not update until after the LPSPI is enabled. After it is enabled, the transmit command register should only be changed if the LPSPI is idle.

Note 2: The transmit and command FIFO is a combined FIFO that includes both transmit data and command words. That means the TCR register should be written to when the Tx FIFO is not full.

Parameters

- base – LPSPI peripheral address.
- frameSize – The frame size in number of bits.

```
uint32_t LPSPI_MasterSetBaudRate(LPSPI_Type *base, uint32_t baudRate_Bps, uint32_t  
                                srcClock_Hz, uint32_t *tcrPrescaleValue)
```

Sets the LPSPI baud rate in bits per second.

This function takes in the desired bitsPerSec (baud rate) and calculates the nearest possible baud rate without exceeding the desired baud rate and returns the calculated baud rate in bits-per-second. It requires the caller to provide the frequency of the module source clock (in Hertz). Note that the baud rate does not go into effect until the Transmit Control Register (TCR) is programmed with the prescale value. Hence, this function returns the prescale tcrPrescaleValue parameter for later programming in the TCR. The higher level peripheral driver should alert the user of an out of range baud rate input.

Note that the LPSPI module must first be disabled before configuring this. Note that the LPSPI module must be configured for master mode before configuring this.

Parameters

- base – LPSPI peripheral address.
- baudRate_Bps – The desired baud rate in bits per second.
- srcClock_Hz – Module source input clock in Hertz.
- tcrPrescaleValue – The TCR prescale value needed to program the TCR.

Returns

The actual calculated baud rate. This function may also return a “0” if the LPSPI is not configured for master mode or if the LPSPI module is not disabled.

```
void LPSPI_MasterSetDelayScaler(LPSPI_Type *base, uint32_t scaler, lpspi_delay_type_t  
                                whichDelay)
```

Manually configures a specific LPSPI delay parameter (module must be disabled to change the delay values).

This function configures the following: SCK to PCS delay, or PCS to SCK delay, or The configurations must occur between the transfer delay.

The delay names are available in type *lpspi_delay_type_t*.

The user passes the desired delay along with the delay value. This allows the user to directly set the delay values if they have pre-calculated them or if they simply wish to manually increment the value.

Note that the LPSPI module must first be disabled before configuring this. Note that the LPSPI module must be configured for master mode before configuring this.

Parameters

- base – LPSPI peripheral address.

- `scaler` – The 8-bit delay value 0x00 to 0xFF (255).
- `whichDelay` – The desired delay to configure, must be of type `lpspi_delay_type_t`.

```
uint32_t LPSPI_MasterSetDelayTimes(LPSPI_Type *base, uint32_t delayTimeInNanoSec,
                                   lpspi_delay_type_t whichDelay, uint32_t srcClock_Hz)
```

Calculates the delay based on the desired delay input in nanoseconds (module must be disabled to change the delay values).

This function calculates the values for the following: SCK to PCS delay, or PCS to SCK delay, or The configurations must occur between the transfer delay.

The delay names are available in type `lpspi_delay_type_t`.

The user passes the desired delay and the desired delay value in nano-seconds. The function calculates the value needed for the desired delay parameter and returns the actual calculated delay because an exact delay match may not be possible. In this case, the closest match is calculated without going below the desired delay value input. It is possible to input a very large delay value that exceeds the capability of the part, in which case the maximum supported delay is returned. It is up to the higher level peripheral driver to alert the user of an out of range delay input.

Note that the LPSPI module must be configured for master mode before configuring this. And note that the `delayTime = LPSPI_clockSource / (PRESCALE * Delay_scaler)`.

Parameters

- `base` – LPSPI peripheral address.
- `delayTimeInNanoSec` – The desired delay value in nano-seconds.
- `whichDelay` – The desired delay to configuration, which must be of type `lpspi_delay_type_t`.
- `srcClock_Hz` – Module source input clock in Hertz.

Returns

actual Calculated delay value in nano-seconds.

```
static inline void LPSPI_WriteData(LPSPI_Type *base, uint32_t data)
```

Writes data into the transmit data buffer.

This function writes data passed in by the user to the Transmit Data Register (TDR). The user can pass up to 32-bits of data to load into the TDR. If the frame size exceeds 32-bits, the user has to manage sending the data one 32-bit word at a time. Any writes to the TDR result in an immediate push to the transmit FIFO. This function can be used for either master or slave modes.

Parameters

- `base` – LPSPI peripheral address.
- `data` – The data word to be sent.

```
static inline uint32_t LPSPI_ReadData(LPSPI_Type *base)
```

Reads data from the data buffer.

This function reads the data from the Receive Data Register (RDR). This function can be used for either master or slave mode.

Parameters

- `base` – LPSPI peripheral address.

Returns

The data read from the data buffer.

```
void LPSPI_SetDummyData(LPSPI_Type *base, uint8_t dummyData)
```

Set up the dummy data.

Parameters

- `base` – LPSPI peripheral address.
- `dummyData` – Data to be transferred when tx buffer is NULL. Note: This API has no effect when LPSPI in slave interrupt mode, because driver will set the TXMSK bit to 1 if txData is NULL, no data is loaded from transmit FIFO and output pin is tristated.

```
void LPSPI_MasterTransferCreateHandle(LPSPI_Type *base, lpspi_master_handle_t *handle,  
                                     lpspi_master_transfer_callback_t callback, void  
                                     *userData)
```

Initializes the LPSPI master handle.

This function initializes the LPSPI handle, which can be used for other LPSPI transactional APIs. Usually, for a specified LPSPI instance, call this API once to get the initialized handle.

Parameters

- `base` – LPSPI peripheral address.
- `handle` – LPSPI handle pointer to `lpspi_master_handle_t`.
- `callback` – DSPI callback.
- `userData` – callback function parameter.

```
status_t LPSPI_MasterTransferBlocking(LPSPI_Type *base, lpspi_transfer_t *transfer)
```

LPSPI master transfer data using a polling method.

This function transfers data using a polling method. This is a blocking function, which does not return until all transfers have been completed.

Note: The transfer data size should be integer multiples of `bytesPerFrame` if `bytesPerFrame` is less than or equal to 4. For `bytesPerFrame` greater than 4: The transfer data size should be equal to `bytesPerFrame` if the `bytesPerFrame` is not integer multiples of 4. Otherwise, the transfer data size can be an integer multiple of `bytesPerFrame`.

Parameters

- `base` – LPSPI peripheral address.
- `transfer` – pointer to `lpspi_transfer_t` structure.

Returns

status of `status_t`.

```
status_t LPSPI_MasterTransferNonBlocking(LPSPI_Type *base, lpspi_master_handle_t *handle,  
                                         lpspi_transfer_t *transfer)
```

LPSPI master transfer data using an interrupt method.

This function transfers data using an interrupt method. This is a non-blocking function, which returns right away. When all data is transferred, the callback function is called.

Note: The transfer data size should be integer multiples of `bytesPerFrame` if `bytesPerFrame` is less than or equal to 4. For `bytesPerFrame` greater than 4: The transfer data size should be equal to `bytesPerFrame` if the `bytesPerFrame` is not integer multiples of 4. Otherwise, the transfer data size can be an integer multiple of `bytesPerFrame`.

Parameters

- `base` – LPSPI peripheral address.
- `handle` – pointer to `lpspi_master_handle_t` structure which stores the transfer state.

- transfer – pointer to `lpspi_transfer_t` structure.

Returns

status of `status_t`.

`status_t` LPSPI_MasterTransferGetCount(LPSPI_Type *base, *lpspi_master_handle_t* *handle, size_t *count)

Gets the master transfer remaining bytes.

This function gets the master transfer remaining bytes.

Parameters

- base – LPSPI peripheral address.
- handle – pointer to `lpspi_master_handle_t` structure which stores the transfer state.
- count – Number of bytes transferred so far by the non-blocking transaction.

Returns

status of `status_t`.

void LPSPI_MasterTransferAbort(LPSPI_Type *base, *lpspi_master_handle_t* *handle)

LPSPI master abort transfer which uses an interrupt method.

This function aborts a transfer which uses an interrupt method.

Parameters

- base – LPSPI peripheral address.
- handle – pointer to `lpspi_master_handle_t` structure which stores the transfer state.

void LPSPI_MasterTransferHandleIRQ(LPSPI_Type *base, *lpspi_master_handle_t* *handle)

LPSPI Master IRQ handler function.

This function processes the LPSPI transmit and receive IRQ.

Parameters

- base – LPSPI peripheral address.
- handle – pointer to `lpspi_master_handle_t` structure which stores the transfer state.

void LPSPI_SlaveTransferCreateHandle(LPSPI_Type *base, *lpspi_slave_handle_t* *handle, *lpspi_slave_transfer_callback_t* callback, void *userData)

Initializes the LPSPI slave handle.

This function initializes the LPSPI handle, which can be used for other LPSPI transactional APIs. Usually, for a specified LPSPI instance, call this API once to get the initialized handle.

Parameters

- base – LPSPI peripheral address.
- handle – LPSPI handle pointer to `lpspi_slave_handle_t`.
- callback – DSPI callback.
- userData – callback function parameter.

`status_t` LPSPI_SlaveTransferNonBlocking(LPSPI_Type *base, *lpspi_slave_handle_t* *handle, *lpspi_transfer_t* *transfer)

LPSPI slave transfer data using an interrupt method.

This function transfer data using an interrupt method. This is a non-blocking function, which returns right away. When all data is transferred, the callback function is called.

Note: The transfer data size should be integer multiples of bytesPerFrame if bytesPerFrame is less than or equal to 4. For bytesPerFrame greater than 4: The transfer data size should be equal to bytesPerFrame if the bytesPerFrame is not an integer multiple of 4. Otherwise, the transfer data size can be an integer multiple of bytesPerFrame.

Parameters

- base – LPSPI peripheral address.
- handle – pointer to `lpspi_slave_handle_t` structure which stores the transfer state.
- transfer – pointer to `lpspi_transfer_t` structure.

Returns

status of `status_t`.

`status_t` LPSPI_SlaveTransferGetCount(LPSPI_Type *base, *lpspi_slave_handle_t* *handle, size_t *count)

Gets the slave transfer remaining bytes.

This function gets the slave transfer remaining bytes.

Parameters

- base – LPSPI peripheral address.
- handle – pointer to `lpspi_slave_handle_t` structure which stores the transfer state.
- count – Number of bytes transferred so far by the non-blocking transaction.

Returns

status of `status_t`.

`void` LPSPI_SlaveTransferAbort(LPSPI_Type *base, *lpspi_slave_handle_t* *handle)

LPSPI slave aborts a transfer which uses an interrupt method.

This function aborts a transfer which uses an interrupt method.

Parameters

- base – LPSPI peripheral address.
- handle – pointer to `lpspi_slave_handle_t` structure which stores the transfer state.

`void` LPSPI_SlaveTransferHandleIRQ(LPSPI_Type *base, *lpspi_slave_handle_t* *handle)

LPSPI Slave IRQ handler function.

This function processes the LPSPI transmit and receives an IRQ.

Parameters

- base – LPSPI peripheral address.
- handle – pointer to `lpspi_slave_handle_t` structure which stores the transfer state.

`bool` LPSPI_WaitTxFifoEmpty(LPSPI_Type *base)

Wait for tx FIFO to be empty.

This function wait the tx fifo empty

Parameters

- base – LPSPI peripheral address.

Returns

true for the tx FIFO is ready, false is not.

void LPSPI_DriverIRQHandler(uint32_t instance)

LPSPI driver IRQ handler common entry.

This function provides the common IRQ request entry for LPSPI.

Parameters

- instance – LPSPI instance.

FSL_LPSPI_DRIVER_VERSION

LPSPI driver version.

Status for the LPSPI driver.

Values:

enumerator kStatus_LPSPI_Busy

LPSPI transfer is busy.

enumerator kStatus_LPSPI_Error

LPSPI driver error.

enumerator kStatus_LPSPI_Idle

LPSPI is idle.

enumerator kStatus_LPSPI_OutOfRange

LPSPI transfer out Of range.

enumerator kStatus_LPSPI_Timeout

LPSPI timeout polling status flags.

enum _lpspi_flags

LPSPI status flags in SPIx_SR register.

Values:

enumerator kLPSPI_TxDataRequestFlag

Transmit data flag

enumerator kLPSPI_RxDataReadyFlag

Receive data flag

enumerator kLPSPI_WordCompleteFlag

Word Complete flag

enumerator kLPSPI_FrameCompleteFlag

Frame Complete flag

enumerator kLPSPI_TransferCompleteFlag

Transfer Complete flag

enumerator kLPSPI_TransmitErrorFlag

Transmit Error flag (FIFO underrun)

enumerator kLPSPI_ReceiveErrorFlag

Receive Error flag (FIFO overrun)

enumerator kLPSPI_DataMatchFlag

Data Match flag

enumerator kLPSPI_ModuleBusyFlag

Module Busy flag

enumerator kLPSPI_AllStatusFlag

Used for clearing all w1c status flags

enum _lpspi_interrupt_enable

LPSPI interrupt source.

Values:

enumerator kLPSPI_TxInterruptEnable

Transmit data interrupt enable

enumerator kLPSPI_RxInterruptEnable

Receive data interrupt enable

enumerator kLPSPI_WordCompleteInterruptEnable

Word complete interrupt enable

enumerator kLPSPI_FrameCompleteInterruptEnable

Frame complete interrupt enable

enumerator kLPSPI_TransferCompleteInterruptEnable

Transfer complete interrupt enable

enumerator kLPSPI_TransmitErrorInterruptEnable

Transmit error interrupt enable(FIFO underrun)

enumerator kLPSPI_ReceiveErrorInterruptEnable

Receive Error interrupt enable (FIFO overrun)

enumerator kLPSPI_DataMatchInterruptEnable

Data Match interrupt enable

enumerator kLPSPI_AllInterruptEnable

All above interrupts enable.

enum _lpspi_dma_enable

LPSPI DMA source.

Values:

enumerator kLPSPI_TxDmaEnable

Transmit data DMA enable

enumerator kLPSPI_RxDmaEnable

Receive data DMA enable

enum _lpspi_master_slave_mode

LPSPI master or slave mode configuration.

Values:

enumerator kLPSPI_Master

LPSPI peripheral operates in master mode.

enumerator kLPSPI_Slave

LPSPI peripheral operates in slave mode.

enum _lpspi_which_pcs_config

LPSPI Peripheral Chip Select (PCS) configuration (which PCS to configure).

Values:

enumerator kLPSPI_Pcs0

PCS[0]

enumerator kLPSPI_Pcs1
PCS[1]

enumerator kLPSPI_Pcs2
PCS[2]

enumerator kLPSPI_Pcs3
PCS[3]

enum __lpspi_pcs_polarity_config
LPSPI Peripheral Chip Select (PCS) Polarity configuration.
Values:

enumerator kLPSPI_PcsActiveHigh
PCS Active High (idles low)

enumerator kLPSPI_PcsActiveLow
PCS Active Low (idles high)

enum __lpspi_pcs_polarity
LPSPI Peripheral Chip Select (PCS) Polarity.
Values:

enumerator kLPSPI_Pcs0ActiveLow
Pcs0 Active Low (idles high).

enumerator kLPSPI_Pcs1ActiveLow
Pcs1 Active Low (idles high).

enumerator kLPSPI_Pcs2ActiveLow
Pcs2 Active Low (idles high).

enumerator kLPSPI_Pcs3ActiveLow
Pcs3 Active Low (idles high).

enumerator kLPSPI_PcsAllActiveLow
Pcs0 to Pcs5 Active Low (idles high).

enum __lpspi_clock_polarity
LPSPI clock polarity configuration.
Values:

enumerator kLPSPI_ClockPolarityActiveHigh
CPOL=0. Active-high LPSPI clock (idles low)

enumerator kLPSPI_ClockPolarityActiveLow
CPOL=1. Active-low LPSPI clock (idles high)

enum __lpspi_clock_phase
LPSPI clock phase configuration.
Values:

enumerator kLPSPI_ClockPhaseFirstEdge
CPHA=0. Data is captured on the leading edge of the SCK and changed on the following edge.

enumerator kLPSPI_ClockPhaseSecondEdge
CPHA=1. Data is changed on the leading edge of the SCK and captured on the following edge.

enum `_lpspi_shift_direction`

LPSPi data shifter direction options.

Values:

enumerator `kLPSPi_MsbFirst`

Data transfers start with most significant bit.

enumerator `kLPSPi_LsbFirst`

Data transfers start with least significant bit.

enum `_lpspi_host_request_select`

LPSPi Host Request select configuration.

Values:

enumerator `kLPSPi_HostReqExtPin`

Host Request is an ext pin.

enumerator `kLPSPi_HostReqInternalTrigger`

Host Request is an internal trigger.

enum `_lpspi_match_config`

LPSPi Match configuration options.

Values:

enumerator `kLPSPi_MatchDisabled`

LPSPi Match Disabled.

enumerator `kLPSPi_1stWordEqualsM0orM1`

LPSPi Match Enabled.

enumerator `kLPSPi_AnyWordEqualsM0orM1`

LPSPi Match Enabled.

enumerator `kLPSPi_1stWordEqualsM0and2ndWordEqualsM1`

LPSPi Match Enabled.

enumerator `kLPSPi_AnyWordEqualsM0andNxtWordEqualsM1`

LPSPi Match Enabled.

enumerator `kLPSPi_1stWordAndM1EqualsM0andM1`

LPSPi Match Enabled.

enumerator `kLPSPi_AnyWordAndM1EqualsM0andM1`

LPSPi Match Enabled.

enum `_lpspi_pin_config`

LPSPi pin (SDO and SDI) configuration.

Values:

enumerator `kLPSPi_SdiInSdoOut`

LPSPi SDI input, SDO output.

enumerator `kLPSPi_SdiInSdiOut`

LPSPi SDI input, SDI output.

enumerator `kLPSPi_SdoInSdoOut`

LPSPi SDO input, SDO output.

enumerator `kLPSPi_SdoInSdiOut`

LPSPi SDO input, SDI output.

enum _lpspi_data_out_config

LPSPi data output configuration.

Values:

enumerator kLpspiDataOutRetained

Data out retains last value when chip select is de-asserted

enumerator kLpspiDataOutTristate

Data out is tristated when chip select is de-asserted

enum _lpspi_transfer_width

LPSPi transfer width configuration.

Values:

enumerator kLPSPi_SingleBitXfer

1-bit shift at a time, data out on SDO, in on SDI (normal mode)

enumerator kLPSPi_TwoBitXfer

2-bits shift out on SDO/SDI and in on SDO/SDI

enumerator kLPSPi_FourBitXfer

4-bits shift out on SDO/SDI/PCS[3:2] and in on SDO/SDI/PCS[3:2]

enum _lpspi_delay_type

LPSPi delay type selection.

Values:

enumerator kLPSPi_PcsToSck

PCS-to-SCK delay.

enumerator kLPSPi_LastSckToPcs

Last SCK edge to PCS delay.

enumerator kLPSPi_BetweenTransfer

Delay between transfers.

enum _lpspi_transfer_config_flag_for_master

Use this enumeration for LPSPi master transfer configFlags.

Values:

enumerator kLPSPi_MasterPcs0

LPSPi master PCS shift macro , internal used. LPSPi master transfer use PCS0 signal

enumerator kLPSPi_MasterPcs1

LPSPi master PCS shift macro , internal used. LPSPi master transfer use PCS1 signal

enumerator kLPSPi_MasterPcs2

LPSPi master PCS shift macro , internal used. LPSPi master transfer use PCS2 signal

enumerator kLPSPi_MasterPcs3

LPSPi master PCS shift macro , internal used. LPSPi master transfer use PCS3 signal

enumerator kLPSPi_MasterPcsContinuous

Is PCS signal continuous

enumerator kLPSPi_MasterByteSwap

Is master swap the byte. For example, when want to send data 1 2 3 4 5 6 7 8 (suppose you set lpspi_shift_direction_t to MSB).

- i. If you set bitPerFrame = 8 , no matter the kLPSPi_MasterByteSwapyou flag is used or not, the waveform is 1 2 3 4 5 6 7 8.

- ii. If you set bitPerFrame = 16 : (1) the waveform is 2 1 4 3 6 5 8 7 if you do not use the kLPSPi_MasterByteSwap flag. (2) the waveform is 1 2 3 4 5 6 7 8 if you use the kLPSPi_MasterByteSwap flag.
- iii. If you set bitPerFrame = 32 : (1) the waveform is 4 3 2 1 8 7 6 5 if you do not use the kLPSPi_MasterByteSwap flag. (2) the waveform is 1 2 3 4 5 6 7 8 if you use the kLPSPi_MasterByteSwap flag.

enum _lpspi_transfer_config_flag_for_slave

Use this enumeration for LPSPi slave transfer configFlags.

Values:

enumerator kLPSPi_SlavePcs0

LPSPi slave PCS shift macro , internal used. LPSPi slave transfer use PCS0 signal

enumerator kLPSPi_SlavePcs1

LPSPi slave PCS shift macro , internal used. LPSPi slave transfer use PCS1 signal

enumerator kLPSPi_SlavePcs2

LPSPi slave PCS shift macro , internal used. LPSPi slave transfer use PCS2 signal

enumerator kLPSPi_SlavePcs3

LPSPi slave PCS shift macro , internal used. LPSPi slave transfer use PCS3 signal

enumerator kLPSPi_SlaveByteSwap

Is slave swap the byte. For example, when want to send data 1 2 3 4 5 6 7 8 (suppose you set lpspi_shift_direction_t to MSB).

- i. If you set bitPerFrame = 8 , no matter the kLPSPi_SlaveByteSwap flag is used or not, the waveform is 1 2 3 4 5 6 7 8.
- ii. If you set bitPerFrame = 16 : (1) the waveform is 2 1 4 3 6 5 8 7 if you do not use the kLPSPi_SlaveByteSwap flag. (2) the waveform is 1 2 3 4 5 6 7 8 if you use the kLPSPi_SlaveByteSwap flag.
- iii. If you set bitPerFrame = 32 : (1) the waveform is 4 3 2 1 8 7 6 5 if you do not use the kLPSPi_SlaveByteSwap flag. (2) the waveform is 1 2 3 4 5 6 7 8 if you use the kLPSPi_SlaveByteSwap flag.

enum _lpspi_transfer_state

LPSPi transfer state, which is used for LPSPi transactional API state machine.

Values:

enumerator kLPSPi_Idle

Nothing in the transmitter/receiver.

enumerator kLPSPi_Busy

Transfer queue is not finished.

enumerator kLPSPi_Error

Transfer error.

typedef enum _lpspi_master_slave_mode lpspi_master_slave_mode_t

LPSPi master or slave mode configuration.

typedef enum _lpspi_which_pcs_config lpspi_which_pcs_t

LPSPi Peripheral Chip Select (PCS) configuration (which PCS to configure).

typedef enum _lpspi_pcs_polarity_config lpspi_pcs_polarity_config_t

LPSPi Peripheral Chip Select (PCS) Polarity configuration.

```
typedef enum _lpspi_clock_polarity lpspi_clock_polarity_t
    LPSPI clock polarity configuration.
typedef enum _lpspi_clock_phase lpspi_clock_phase_t
    LPSPI clock phase configuration.
typedef enum _lpspi_shift_direction lpspi_shift_direction_t
    LPSPI data shifter direction options.
typedef enum _lpspi_host_request_select lpspi_host_request_select_t
    LPSPI Host Request select configuration.
typedef enum _lpspi_match_config lpspi_match_config_t
    LPSPI Match configuration options.
typedef enum _lpspi_pin_config lpspi_pin_config_t
    LPSPI pin (SDO and SDI) configuration.
typedef enum _lpspi_data_out_config lpspi_data_out_config_t
    LPSPI data output configuration.
typedef enum _lpspi_transfer_width lpspi_transfer_width_t
    LPSPI transfer width configuration.
typedef enum _lpspi_delay_type lpspi_delay_type_t
    LPSPI delay type selection.
typedef struct _lpspi_master_config lpspi_master_config_t
    LPSPI master configuration structure.
typedef struct _lpspi_slave_config lpspi_slave_config_t
    LPSPI slave configuration structure.
typedef struct _lpspi_master_handle lpspi_master_handle_t
    Forward declaration of the _lpspi_master_handle typedefs.
typedef struct _lpspi_slave_handle lpspi_slave_handle_t
    Forward declaration of the _lpspi_slave_handle typedefs.
typedef void (*lpspi_master_transfer_callback_t)(LPSPi_Type *base, lpspi_master_handle_t
*handle, status_t status, void *userData)
    Master completion callback function pointer type.
    Param base
        LPSPI peripheral address.
    Param handle
        Pointer to the handle for the LPSPI master.
    Param status
        Success or error code describing whether the transfer is completed.
    Param userData
        Arbitrary pointer-dataSized value passed from the application.
typedef void (*lpspi_slave_transfer_callback_t)(LPSPi_Type *base, lpspi_slave_handle_t *handle,
status_t status, void *userData)
    Slave completion callback function pointer type.
    Param base
        LPSPI peripheral address.
    Param handle
        Pointer to the handle for the LPSPI slave.
```

Param status

Success or error code describing whether the transfer is completed.

Param userData

Arbitrary pointer-dataSized value passed from the application.

`typedef struct _lpspi_transfer lpspi_transfer_t`

LPSPI master/slave transfer structure.

`volatile uint8_t g_lpspiDummyData[]`

Global variable for dummy data value setting.

`LPSPI_DUMMY_DATA`

LPSPI dummy data if no Tx data.

Dummy data used for tx if there is not txData.

`SPI_RETRY_TIMES`

Retry times for waiting flag.

`LPSPI_MASTER_PCS_SHIFT`

LPSPI master PCS shift macro , internal used.

`LPSPI_MASTER_PCS_MASK`

LPSPI master PCS shift macro , internal used.

`LPSPI_SLAVE_PCS_SHIFT`

LPSPI slave PCS shift macro , internal used.

`LPSPI_SLAVE_PCS_MASK`

LPSPI slave PCS shift macro , internal used.

`struct _lpspi_master_config`

`#include <fsl_lpspi.h>` LPSPI master configuration structure.

Public Members

`uint32_t baudRate`

Baud Rate for LPSPI.

`uint32_t bitsPerFrame`

Bits per frame, minimum 8, maximum 4096.

`lpspi_clock_polarity_t cpol`

Clock polarity.

`lpspi_clock_phase_t cpha`

Clock phase.

`lpspi_shift_direction_t direction`

MSB or LSB data shift direction.

`uint32_t pcsToSckDelayInNanoSec`

PCS to SCK delay time in nanoseconds, setting to 0 sets the minimum delay. It sets the boundary value if out of range.

`uint32_t lastSckToPcsDelayInNanoSec`

Last SCK to PCS delay time in nanoseconds, setting to 0 sets the minimum delay. It sets the boundary value if out of range.

uint32_t betweenTransferDelayInNanoSec

After the SCK delay time with nanoseconds, setting to 0 sets the minimum delay. It sets the boundary value if out of range.

lpspi_which_pcs_t whichPcs

Desired Peripheral Chip Select (PCS).

lpspi_pcs_polarity_config_t pcsActiveHighOrLow

Desired PCS active high or low

lpspi_pin_config_t pinCfg

Configures which pins are used for input and output data during single bit transfers.

lpspi_data_out_config_t dataOutConfig

Configures if the output data is tristated between accesses (LPSPI_PCS is negated).

bool enableInputDelay

Enable master to sample the input data on a delayed SCK. This can help improve slave setup time. Refer to device data sheet for specific time length.

struct __lpspi_slave_config

#include <fsl_lpspi.h> LPSPI slave configuration structure.

Public Members

uint32_t bitsPerFrame

Bits per frame, minimum 8, maximum 4096.

lpspi_clock_polarity_t cpol

Clock polarity.

lpspi_clock_phase_t cpha

Clock phase.

lpspi_shift_direction_t direction

MSB or LSB data shift direction.

lpspi_which_pcs_t whichPcs

Desired Peripheral Chip Select (pcs)

lpspi_pcs_polarity_config_t pcsActiveHighOrLow

Desired PCS active high or low

lpspi_pin_config_t pinCfg

Configures which pins are used for input and output data during single bit transfers.

lpspi_data_out_config_t dataOutConfig

Configures if the output data is tristated between accesses (LPSPI_PCS is negated).

struct __lpspi_transfer

#include <fsl_lpspi.h> LPSPI master/slave transfer structure.

Public Members

const uint8_t *txData

Send buffer.

uint8_t *rxData

Receive buffer.

volatile size_t dataSize

Transfer bytes.

uint32_t configFlags

Transfer transfer configuration flags. Set from `_lpspi_transfer_config_flag_for_master` if the transfer is used for master or `_lpspi_transfer_config_flag_for_slave` enumeration if the transfer is used for slave.

struct `_lpspi_master_handle`

#include <fsl_lpspi.h> LPSPI master transfer handle structure used for transactional API.

Public Members

volatile bool isPcsContinuous

Is PCS continuous in transfer.

volatile bool writeTcrInIsr

A flag that whether should write TCR in ISR.

volatile bool isByteSwap

A flag that whether should byte swap.

volatile bool isTxMask

A flag that whether TCR[TXMSK] is set.

volatile uint16_t bytesPerFrame

Number of bytes in each frame

volatile uint16_t frameSize

Backup of TCR[FRAMESZ]

volatile uint8_t fifoSize

FIFO dataSize.

volatile uint8_t rxWatermark

Rx watermark.

volatile uint8_t bytesEachWrite

Bytes for each write TDR.

volatile uint8_t bytesEachRead

Bytes for each read RDR.

const uint8_t *volatile txData

Send buffer.

uint8_t *volatile rxData

Receive buffer.

volatile size_t txRemainingByteCount

Number of bytes remaining to send.

volatile size_t rxRemainingByteCount

Number of bytes remaining to receive.

volatile uint32_t writeRegRemainingTimes

Write TDR register remaining times.

volatile uint32_t readRegRemainingTimes

Read RDR register remaining times.

uint32_t totalByteCount

Number of transfer bytes

uint32_t txBuffIfNull

Used if the txData is NULL.

volatile uint8_t state

LPSPi transfer state , _lpspi_transfer_state.

lpspi_master_transfer_callback_t callback

Completion callback.

void *userData

Callback user data.

struct _lpspi_slave_handle

#include <fsl_lpspi.h> LPSPi slave transfer handle structure used for transactional API.

Public Members

volatile bool isByteSwap

A flag that whether should byte swap.

volatile uint8_t fifoSize

FIFO dataSize.

volatile uint8_t rxWatermark

Rx watermark.

volatile uint8_t bytesEachWrite

Bytes for each write TDR.

volatile uint8_t bytesEachRead

Bytes for each read RDR.

const uint8_t *volatile txData

Send buffer.

uint8_t *volatile rxData

Receive buffer.

volatile size_t txRemainingByteCount

Number of bytes remaining to send.

volatile size_t rxRemainingByteCount

Number of bytes remaining to receive.

volatile uint32_t writeRegRemainingTimes

Write TDR register remaining times.

volatile uint32_t readRegRemainingTimes

Read RDR register remaining times.

uint32_t totalByteCount

Number of transfer bytes

volatile uint8_t state

LPSPi transfer state , _lpspi_transfer_state.

volatile uint32_t errorCount

Error count for slave transfer.

lpspi_slave_transfer_callback_t callback

Completion callback.

void *userData

Callback user data.

2.36 LPSPI eDMA Driver

FSL_LPSPI_EDMA_DRIVER_VERSION

LPSPI EDMA driver version.

DMA_MAX_TRANSFER_COUNT

DMA max transfer size.

typedef struct *lpspi_master_edma_handle* lpspi_master_edma_handle_t

Forward declaration of the *lpspi_master_edma_handle* typedefs.

typedef struct *lpspi_slave_edma_handle* lpspi_slave_edma_handle_t

Forward declaration of the *lpspi_slave_edma_handle* typedefs.

typedef void (*lpspi_master_edma_transfer_callback_t)(LPSPI_Type *base,
lpspi_master_edma_handle_t *handle, *status_t* status, void *userData)

Completion callback function pointer type.

Param base

LPSPI peripheral base address.

Param handle

Pointer to the handle for the LPSPI master.

Param status

Success or error code describing whether the transfer completed.

Param userData

Arbitrary pointer-dataSized value passed from the application.

typedef void (*lpspi_slave_edma_transfer_callback_t)(LPSPI_Type *base,
lpspi_slave_edma_handle_t *handle, *status_t* status, void *userData)

Completion callback function pointer type.

Param base

LPSPI peripheral base address.

Param handle

Pointer to the handle for the LPSPI slave.

Param status

Success or error code describing whether the transfer completed.

Param userData

Arbitrary pointer-dataSized value passed from the application.

void LPSPI_MasterTransferCreateHandleEDMA(LPSPI_Type *base, *lpspi_master_edma_handle_t*
*handle, *lpspi_master_edma_transfer_callback_t*
callback, void *userData, *edma_handle_t*
*edmaRxRegToRxDataHandle, *edma_handle_t*
*edmaTxDataToTxRegHandle)

Initializes the LPSPI master eDMA handle.

This function initializes the LPSPI eDMA handle which can be used for other LPSPI transactional APIs. Usually, for a specified LPSPI instance, call this API once to get the initialized handle.

Note that the LPSPI eDMA has a separated (Rx and Tx as two sources) or shared (Rx and Tx are the same source) DMA request source. (1) For a separated DMA request source, enable and set the Rx DMAMUX source for `edmaRxRegToRxDataHandle` and Tx DMAMUX source for `edmaTxDataToTxRegHandle`. (2) For a shared DMA request source, enable and set the Rx/Tx DMAMUX source for `edmaRxRegToRxDataHandle`.

Parameters

- `base` – LPSPI peripheral base address.
- `handle` – LPSPI handle pointer to `lpspi_master_edma_handle_t`.
- `callback` – LPSPI callback.
- `userData` – callback function parameter.
- `edmaRxRegToRxDataHandle` – `edmaRxRegToRxDataHandle` pointer to `edma_handle_t`.
- `edmaTxDataToTxRegHandle` – `edmaTxDataToTxRegHandle` pointer to `edma_handle_t`.

status_t LPSPI_MasterTransferEDMA(LPSPI_Type *base, *lpspi_master_edma_handle_t* *handle, *lpspi_transfer_t* *transfer)

LPSPI master transfer data using eDMA.

This function transfers data using eDMA. This is a non-blocking function, which returns right away. When all data is transferred, the callback function is called.

Note: The transfer data size should be an integer multiple of `bytesPerFrame` if `bytesPerFrame` is less than or equal to 4. For `bytesPerFrame` greater than 4: The transfer data size should be equal to `bytesPerFrame` if the `bytesPerFrame` is not an integer multiple of 4. Otherwise, the transfer data size can be an integer multiple of `bytesPerFrame`.

Parameters

- `base` – LPSPI peripheral base address.
- `handle` – pointer to `lpspi_master_edma_handle_t` structure which stores the transfer state.
- `transfer` – pointer to `lpspi_transfer_t` structure.

Returns

status of `status_t`.

status_t LPSPI_MasterTransferPrepareEDMALite(LPSPI_Type *base, *lpspi_master_edma_handle_t* *handle, *uint32_t* configFlags)

LPSPI master config transfer parameter while using eDMA.

This function is preparing to transfer data using eDMA, work with `LPSPI_MasterTransferEDMALite`.

Parameters

- `base` – LPSPI peripheral base address.
- `handle` – pointer to `lpspi_master_edma_handle_t` structure which stores the transfer state.
- `configFlags` – transfer configuration flags. `_lpspi_transfer_config_flag_for_master`.

Return values

- `kStatus_Success` – Execution successfully.
- `kStatus_LPSPI_Busy` – The LPSPI device is busy.

Returns

Indicates whether LPSPI master transfer was successful or not.

status_t LPSPI_MasterTransferEDMALite(LPSPI_Type *base, *lpspi_master_edma_handle_t* *handle, *lpspi_transfer_t* *transfer)

LPSPI master transfer data using eDMA without configs.

This function transfers data using eDMA. This is a non-blocking function, which returns right away. When all data is transferred, the callback function is called.

Note: This API is only for transfer through DMA without configuration. Before calling this API, you must call LPSPI_MasterTransferPrepareEDMALite to configure it once. The transfer data size should be an integer multiple of bytesPerFrame if bytesPerFrame is less than or equal to 4. For bytesPerFrame greater than 4: The transfer data size should be equal to bytesPerFrame if the bytesPerFrame is not an integer multiple of 4. Otherwise, the transfer data size can be an integer multiple of bytesPerFrame.

Parameters

- base – LPSPI peripheral base address.
- handle – pointer to *lpspi_master_edma_handle_t* structure which stores the transfer state.
- transfer – pointer to *lpspi_transfer_t* structure, config field is not used.

Return values

- kStatus_Success – Execution successfully.
- kStatus_LPSPI_Busy – The LPSPI device is busy.
- kStatus_InvalidArgument – The transfer structure is invalid.

Returns

Indicates whether LPSPI master transfer was successful or not.

void LPSPI_MasterTransferAbortEDMA(LPSPI_Type *base, *lpspi_master_edma_handle_t* *handle)

LPSPI master aborts a transfer which is using eDMA.

This function aborts a transfer which is using eDMA.

Parameters

- base – LPSPI peripheral base address.
- handle – pointer to *lpspi_master_edma_handle_t* structure which stores the transfer state.

status_t LPSPI_MasterTransferGetCountEDMA(LPSPI_Type *base, *lpspi_master_edma_handle_t* *handle, *size_t* *count)

Gets the master eDMA transfer remaining bytes.

This function gets the master eDMA transfer remaining bytes.

Parameters

- base – LPSPI peripheral base address.
- handle – pointer to *lpspi_master_edma_handle_t* structure which stores the transfer state.
- count – Number of bytes transferred so far by the EDMA transaction.

Returns

status of *status_t*.

```
void LPSPI_SlaveTransferCreateHandleEDMA(LPSPI_Type *base, lpspi_slave_edma_handle_t
                                         *handle, lpspi_slave_edma_transfer_callback_t
                                         callback, void *userData, edma_handle_t
                                         *edmaRxRegToRxDataHandle, edma_handle_t
                                         *edmaTxDataToTxRegHandle)
```

Initializes the LPSPI slave eDMA handle.

This function initializes the LPSPI eDMA handle which can be used for other LPSPI transactional APIs. Usually, for a specified LPSPI instance, call this API once to get the initialized handle.

Note that LPSPI eDMA has a separated (Rx and Tx as two sources) or shared (Rx and Tx as the same source) DMA request source.

(1) For a separated DMA request source, enable and set the Rx DMAMUX source for *edmaRxRegToRxDataHandle* and Tx DMAMUX source for *edmaTxDataToTxRegHandle*. (2) For a shared DMA request source, enable and set the Rx/Rx DMAMUX source for *edmaRxRegToRxDataHandle*.

Parameters

- *base* – LPSPI peripheral base address.
- *handle* – LPSPI handle pointer to *lpspi_slave_edma_handle_t*.
- *callback* – LPSPI callback.
- *userData* – callback function parameter.
- *edmaRxRegToRxDataHandle* – *edmaRxRegToRxDataHandle* pointer to *edma_handle_t*.
- *edmaTxDataToTxRegHandle* – *edmaTxDataToTxRegHandle* pointer to *edma_handle_t*.

```
status_t LPSPI_SlaveTransferEDMA(LPSPI_Type *base, lpspi_slave_edma_handle_t *handle,
                                  lpspi_transfer_t *transfer)
```

LPSPI slave transfers data using eDMA.

This function transfers data using eDMA. This is a non-blocking function, which return right away. When all data is transferred, the callback function is called.

Note: The transfer data size should be an integer multiple of *bytesPerFrame* if *bytesPerFrame* is less than or equal to 4. For *bytesPerFrame* greater than 4: The transfer data size should be equal to *bytesPerFrame* if the *bytesPerFrame* is not an integer multiple of 4. Otherwise, the transfer data size can be an integer multiple of *bytesPerFrame*.

Parameters

- *base* – LPSPI peripheral base address.
- *handle* – pointer to *lpspi_slave_edma_handle_t* structure which stores the transfer state.
- *transfer* – pointer to *lpspi_transfer_t* structure.

Returns

status of *status_t*.

```
void LPSPI_SlaveTransferAbortEDMA(LPSPI_Type *base, lpspi_slave_edma_handle_t *handle)
```

LPSPI slave aborts a transfer which is using eDMA.

This function aborts a transfer which is using eDMA.

Parameters

- *base* – LPSPI peripheral base address.

- `handle` – pointer to `lpspi_slave_edma_handle_t` structure which stores the transfer state.

`status_t` LPSPI_SlaveTransferGetCountEDMA(LPSPI_Type *base, *lpspi_slave_edma_handle_t* *handle, `size_t` *count)

Gets the slave eDMA transfer remaining bytes.

This function gets the slave eDMA transfer remaining bytes.

Parameters

- `base` – LPSPI peripheral base address.
- `handle` – pointer to `lpspi_slave_edma_handle_t` structure which stores the transfer state.
- `count` – Number of bytes transferred so far by the eDMA transaction.

Returns

status of `status_t`.

`struct _lpspi_master_edma_handle`

#include <fsl_lpspi_edma.h> LPSPI master eDMA transfer handle structure used for transactional API.

Public Members

`volatile bool` `isPcsContinuous`

Is PCS continuous in transfer.

`volatile bool` `isByteSwap`

A flag that whether should byte swap.

`volatile uint8_t` `fifoSize`

FIFO dataSize.

`volatile uint8_t` `rxWatermark`

Rx watermark.

`volatile uint8_t` `bytesEachWrite`

Bytes for each write TDR.

`volatile uint8_t` `bytesEachRead`

Bytes for each read RDR.

`volatile uint8_t` `bytesLastRead`

Bytes for last read RDR.

`volatile bool` `isThereExtraRxBytes`

Is there extra RX byte.

`const uint8_t *volatile` `txData`

Send buffer.

`uint8_t *volatile` `rxData`

Receive buffer.

`volatile size_t` `txRemainingByteCount`

Number of bytes remaining to send.

`volatile size_t` `rxRemainingByteCount`

Number of bytes remaining to receive.

`volatile uint32_t writeRegRemainingTimes`
Write TDR register remaining times.

`volatile uint32_t readRegRemainingTimes`
Read RDR register remaining times.

`uint32_t totalByteCount`
Number of transfer bytes

`edma_tcd_t *lastTimeTCD`
Pointer to the lastTime TCD

`bool isMultiDMATransmit`
Is there multi DMA transmit

`volatile uint8_t dmaTransmitTime`
DMA Transfer times.

`uint32_t lastTimeDataBytes`
DMA transmit last Time data Bytes

`uint32_t dataBytesEveryTime`
Bytes in a time for DMA transfer, default is DMA_MAX_TRANSFER_COUNT

`edma_transfer_config_t transferConfigRx`
Config of DMA rx channel.

`edma_transfer_config_t transferConfigTx`
Config of DMA tx channel.

`uint32_t txBuffIfNull`
Used if there is not txData for DMA purpose.

`uint32_t rxBuffIfNull`
Used if there is not rxData for DMA purpose.

`uint32_t transmitCommand`
Used to write TCR for DMA purpose.

`volatile uint8_t state`
LPSPI transfer state , `_lpspi_transfer_state`.

`uint8_t nbytes`
eDMA minor byte transfer count initially configured.

`lpspi_master_edma_transfer_callback_t callback`
Completion callback.

`void *userData`
Callback user data.

`edma_handle_t *edmaRxRegToRxDataHandle`
edma_handle_t handle point used for RxReg to RxData buff

`edma_handle_t *edmaTxDataToTxRegHandle`
edma_handle_t handle point used for TxData to TxReg buff

`edma_tcd_t lpspiSoftwareTCD[3]`
SoftwareTCD, internal used

`struct _lpspi_slave_edma_handle`
`#include <fsl_lpspi_edma.h>` LPSPI slave eDMA transfer handle structure used for transactional API.

Public Members

volatile bool isByteSwap

A flag that whether should byte swap.

volatile uint8_t fifoSize

FIFO dataSize.

volatile uint8_t rxWatermark

Rx watermark.

volatile uint8_t bytesEachWrite

Bytes for each write TDR.

volatile uint8_t bytesEachRead

Bytes for each read RDR.

volatile uint8_t bytesLastRead

Bytes for last read RDR.

volatile bool isThereExtraRxBytes

Is there extra RX byte.

uint8_t nbytes

eDMA minor byte transfer count initially configured.

const uint8_t *volatile txData

Send buffer.

uint8_t *volatile rxData

Receive buffer.

volatile size_t txRemainingByteCount

Number of bytes remaining to send.

volatile size_t rxRemainingByteCount

Number of bytes remaining to receive.

volatile uint32_t writeRegRemainingTimes

Write TDR register remaining times.

volatile uint32_t readRegRemainingTimes

Read RDR register remaining times.

uint32_t totalByteCount

Number of transfer bytes

uint32_t txBuffIfNull

Used if there is not txData for DMA purpose.

uint32_t rxBuffIfNull

Used if there is not rxData for DMA purpose.

volatile uint8_t state

LPSPi transfer state.

uint32_t errorCount

Error count for slave transfer.

lpspi_slave_edma_transfer_callback_t callback

Completion callback.

`void *userData`

Callback user data.

`edma_handle_t *edmaRxRegToRxDataHandle`

`edma_handle_t` handle point used for RxReg to RxData buff

`edma_handle_t *edmaTxDataToTxRegHandle`

`edma_handle_t` handle point used for TxData to TxReg

`edma_tcd_t` `lpspiSoftwareTCD[2]`

SoftwareTCD, internal used

2.37 LPTMR: Low-Power Timer

`void LPTMR_Init(LPTMR_Type *base, const lptmr_config_t *config)`

Ungates the LPTMR clock and configures the peripheral for a basic operation.

Note: This API should be called at the beginning of the application using the LPTMR driver.

Parameters

- `base` – LPTMR peripheral base address
- `config` – A pointer to the LPTMR configuration structure.

`void LPTMR_Deinit(LPTMR_Type *base)`

Gates the LPTMR clock.

Parameters

- `base` – LPTMR peripheral base address

`void LPTMR_GetDefaultConfig(lptmr_config_t *config)`

Fills in the LPTMR configuration structure with default settings.

The default values are as follows.

```
config->timerMode = kLPTMR_TimerModeTimeCounter;
config->pinSelect = kLPTMR_PinSelectInput_0;
config->pinPolarity = kLPTMR_PinPolarityActiveHigh;
config->enableFreeRunning = false;
config->bypassPrescaler = true;
config->prescalerClockSource = kLPTMR_PrescalerClock_1;
config->value = kLPTMR_Prescale_Glitch_0;
```

Parameters

- `config` – A pointer to the LPTMR configuration structure.

`static inline void LPTMR_EnableInterrupts(LPTMR_Type *base, uint32_t mask)`

Enables the selected LPTMR interrupts.

Parameters

- `base` – LPTMR peripheral base address
- `mask` – The interrupts to enable. This is a logical OR of members of the enumeration `lptmr_interrupt_enable_t`

static inline void LPTMR_DisableInterrupts(LPTMR_Type *base, uint32_t mask)

Disables the selected LPTMR interrupts.

Parameters

- base – LPTMR peripheral base address
- mask – The interrupts to disable. This is a logical OR of members of the enumeration `lptmr_interrupt_enable_t`.

static inline uint32_t LPTMR_GetEnabledInterrupts(LPTMR_Type *base)

Gets the enabled LPTMR interrupts.

Parameters

- base – LPTMR peripheral base address

Returns

The enabled interrupts. This is the logical OR of members of the enumeration `lptmr_interrupt_enable_t`

static inline uint32_t LPTMR_GetStatusFlags(LPTMR_Type *base)

Gets the LPTMR status flags.

Parameters

- base – LPTMR peripheral base address

Returns

The status flags. This is the logical OR of members of the enumeration `lptmr_status_flags_t`

static inline void LPTMR_ClearStatusFlags(LPTMR_Type *base, uint32_t mask)

Clears the LPTMR status flags.

Parameters

- base – LPTMR peripheral base address
- mask – The status flags to clear. This is a logical OR of members of the enumeration `lptmr_status_flags_t`.

static inline void LPTMR_SetTimerPeriod(LPTMR_Type *base, uint32_t ticks)

Sets the timer period in units of count.

Timers counts from 0 until it equals the count value set here. The count value is written to the CMR register.

Note:

- a. The TCF flag is set with the CNR equals the count provided here and then increments.
 - b. Call the utility macros provided in the `fsl_common.h` to convert to ticks.
-

Parameters

- base – LPTMR peripheral base address
- ticks – A timer period in units of ticks

static inline uint32_t LPTMR_GetCurrentTimerCount(LPTMR_Type *base)

Reads the current timer counting value.

This function returns the real-time timer counting value in a range from 0 to a timer period.

Note: Call the utility macros provided in the `fsl_common.h` to convert ticks to usec or msec.

Parameters

- base – LPTMR peripheral base address

Returns

The current counter value in ticks

static inline void LPTMR_StartTimer(LPTMR_Type *base)

Starts the timer.

After calling this function, the timer counts up to the CMR register value. Each time the timer reaches the CMR value and then increments, it generates a trigger pulse and sets the timeout interrupt flag. An interrupt is also triggered if the timer interrupt is enabled.

Parameters

- base – LPTMR peripheral base address

static inline void LPTMR_StopTimer(LPTMR_Type *base)

Stops the timer.

This function stops the timer and resets the timer's counter register.

Parameters

- base – LPTMR peripheral base address

FSL_LPTMR_DRIVER_VERSION

Driver Version

enum _lptmr_pin_select

LPTMR pin selection used in pulse counter mode.

Values:

enumerator kLPTMR_PinSelectInput_0

Pulse counter input 0 is selected

enumerator kLPTMR_PinSelectInput_1

Pulse counter input 1 is selected

enumerator kLPTMR_PinSelectInput_2

Pulse counter input 2 is selected

enumerator kLPTMR_PinSelectInput_3

Pulse counter input 3 is selected

enum _lptmr_pin_polarity

LPTMR pin polarity used in pulse counter mode.

Values:

enumerator kLPTMR_PinPolarityActiveHigh

Pulse Counter input source is active-high

enumerator kLPTMR_PinPolarityActiveLow

Pulse Counter input source is active-low

enum _lptmr_timer_mode

LPTMR timer mode selection.

Values:

enumerator kLPTMR_TimerModeTimeCounter

Time Counter mode

enumerator kLPTMR_TimerModePulseCounter
Pulse Counter mode

enum _lptmr_prescaler_glitch_value
LPTMR prescaler/glitch filter values.

Values:

enumerator kLPTMR_Prescale_Glitch_0
Prescaler divide 2, glitch filter does not support this setting

enumerator kLPTMR_Prescale_Glitch_1
Prescaler divide 4, glitch filter 2

enumerator kLPTMR_Prescale_Glitch_2
Prescaler divide 8, glitch filter 4

enumerator kLPTMR_Prescale_Glitch_3
Prescaler divide 16, glitch filter 8

enumerator kLPTMR_Prescale_Glitch_4
Prescaler divide 32, glitch filter 16

enumerator kLPTMR_Prescale_Glitch_5
Prescaler divide 64, glitch filter 32

enumerator kLPTMR_Prescale_Glitch_6
Prescaler divide 128, glitch filter 64

enumerator kLPTMR_Prescale_Glitch_7
Prescaler divide 256, glitch filter 128

enumerator kLPTMR_Prescale_Glitch_8
Prescaler divide 512, glitch filter 256

enumerator kLPTMR_Prescale_Glitch_9
Prescaler divide 1024, glitch filter 512

enumerator kLPTMR_Prescale_Glitch_10
Prescaler divide 2048 glitch filter 1024

enumerator kLPTMR_Prescale_Glitch_11
Prescaler divide 4096, glitch filter 2048

enumerator kLPTMR_Prescale_Glitch_12
Prescaler divide 8192, glitch filter 4096

enumerator kLPTMR_Prescale_Glitch_13
Prescaler divide 16384, glitch filter 8192

enumerator kLPTMR_Prescale_Glitch_14
Prescaler divide 32768, glitch filter 16384

enumerator kLPTMR_Prescale_Glitch_15
Prescaler divide 65536, glitch filter 32768

enum _lptmr_prescaler_clock_select
LPTMR prescaler/glitch filter clock select.

Note: Clock connections are SoC-specific

Values:

enum `_lptmr_interrupt_enable`

List of the LPTMR interrupts.

Values:

enumerator `kLPTMR_TimerInterruptEnable`

Timer interrupt enable

enum `_lptmr_status_flags`

List of the LPTMR status flags.

Values:

enumerator `kLPTMR_TimerCompareFlag`

Timer compare flag

typedef enum `_lptmr_pin_select` `lptmr_pin_select_t`

LPTMR pin selection used in pulse counter mode.

typedef enum `_lptmr_pin_polarity` `lptmr_pin_polarity_t`

LPTMR pin polarity used in pulse counter mode.

typedef enum `_lptmr_timer_mode` `lptmr_timer_mode_t`

LPTMR timer mode selection.

typedef enum `_lptmr_prescaler_glitch_value` `lptmr_prescaler_glitch_value_t`

LPTMR prescaler/glitch filter values.

typedef enum `_lptmr_prescaler_clock_select` `lptmr_prescaler_clock_select_t`

LPTMR prescaler/glitch filter clock select.

Note: Clock connections are SoC-specific

typedef enum `_lptmr_interrupt_enable` `lptmr_interrupt_enable_t`

List of the LPTMR interrupts.

typedef enum `_lptmr_status_flags` `lptmr_status_flags_t`

List of the LPTMR status flags.

typedef struct `_lptmr_config` `lptmr_config_t`

LPTMR config structure.

This structure holds the configuration settings for the LPTMR peripheral. To initialize this structure to reasonable defaults, call the `LPTMR_GetDefaultConfig()` function and pass a pointer to your configuration structure instance.

The configuration struct can be made constant so it resides in flash.

static inline void `LPTMR_EnableTimerDMA(LPTMR_Type *base, bool enable)`

Enable or disable timer DMA request.

Parameters

- `base` – base LPTMR peripheral base address
- `enable` – Switcher of timer DMA feature. “true” means to enable, “false” means to disable.

struct `_lptmr_config`

`#include <fsl_lptmr.h>` LPTMR config structure.

This structure holds the configuration settings for the LPTMR peripheral. To initialize this structure to reasonable defaults, call the `LPTMR_GetDefaultConfig()` function and pass a pointer to your configuration structure instance.

The configuration struct can be made constant so it resides in flash.

Public Members

lptmr_timer_mode_t timerMode

Time counter mode or pulse counter mode

lptmr_pin_select_t pinSelect

LPTMR pulse input pin select; used only in pulse counter mode

lptmr_pin_polarity_t pinPolarity

LPTMR pulse input pin polarity; used only in pulse counter mode

bool enableFreeRunning

True: enable free running, counter is reset on overflow False: counter is reset when the compare flag is set

bool bypassPrescaler

True: bypass prescaler; false: use clock from prescaler

lptmr_prescaler_clock_select_t prescalerClockSource

LPTMR clock source

lptmr_prescaler_glitch_value_t value

Prescaler or glitch filter value

2.38 LPUART: Low Power Universal Asynchronous Receiver/Transmitter Driver

2.39 LPUART Driver

static inline void LPUART_SoftwareReset(LPUART_Type *base)

Resets the LPUART using software.

This function resets all internal logic and registers except the Global Register. Remains set until cleared by software.

Parameters

- base – LPUART peripheral base address.

status_t LPUART_Init(LPUART_Type *base, const *lpuart_config_t* *config, uint32_t srcClock_Hz)

Initializes an LPUART instance with the user configuration structure and the peripheral clock.

This function configures the LPUART module with user-defined settings. Call the LPUART_GetDefaultConfig() function to configure the configuration structure and get the default configuration. The example below shows how to use this API to configure the LPUART.

```
lpuart_config_t lpuartConfig;
lpuartConfig.baudRate_Bps = 115200U;
lpuartConfig.parityMode = kLPUART_ParityDisabled;
lpuartConfig.dataBitsCount = kLPUART_EightDataBits;
lpuartConfig.isMsb = false;
lpuartConfig.stopBitCount = kLPUART_OneStopBit;
lpuartConfig.txFifoWatermark = 0;
```

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```
lpuartConfig.rxFifoWatermark = 1;
LPUART_Init(LPUART1, &lpuartConfig, 20000000U);
```

Parameters

- base – LPUART peripheral base address.
- config – Pointer to a user-defined configuration structure.
- srcClock_Hz – LPUART clock source frequency in HZ.

Return values

- kStatus_LPUART_BaudrateNotSupport – Baudrate is not support in current clock source.
- kStatus_Success – LPUART initialize succeed

status_t LPUART_Deinit(LPUART_Type *base)

Deinitializes a LPUART instance.

This function waits for transmit to complete, disables TX and RX, and disables the LPUART clock.

Parameters

- base – LPUART peripheral base address.

Return values

- kStatus_Success – Deinit is success.
- kStatus_LPUART_Timeout – Timeout during deinit.

void LPUART_GetDefaultConfig(*lpuart_config_t* *config)

Gets the default configuration structure.

This function initializes the LPUART configuration structure to a default value. The default values are: lpuartConfig->baudRate_Bps = 115200U; lpuartConfig->parityMode = kLPUART_ParityDisabled; lpuartConfig->dataBitsCount = kLPUART_EightDataBits; lpuartConfig->isMsb = false; lpuartConfig->stopBitCount = kLPUART_OneStopBit; lpuartConfig->txFifoWatermark = 0; lpuartConfig->rxFifoWatermark = 1; lpuartConfig->rxIdleType = kLPUART_IdleTypeStartBit; lpuartConfig->rxIdleConfig = kLPUART_IdleCharacter1; lpuartConfig->enableTx = false; lpuartConfig->enableRx = false;

Parameters

- config – Pointer to a configuration structure.

status_t LPUART_SetBaudRate(LPUART_Type *base, uint32_t baudRate_Bps, uint32_t srcClock_Hz)

Sets the LPUART instance baudrate.

This function configures the LPUART module baudrate. This function is used to update the LPUART module baudrate after the LPUART module is initialized by the LPUART_Init.

```
LPUART_SetBaudRate(LPUART1, 115200U, 20000000U);
```

Parameters

- base – LPUART peripheral base address.
- baudRate_Bps – LPUART baudrate to be set.
- srcClock_Hz – LPUART clock source frequency in HZ.

Return values

- kStatus_LPUART_BaudrateNotSupport – Baudrate is not supported in the current clock source.
- kStatus_Success – Set baudrate succeeded.

void LPUART_Enable9bitMode(LPUART_Type *base, bool enable)

Enable 9-bit data mode for LPUART.

This function set the 9-bit mode for LPUART module. The 9th bit is not used for parity thus can be modified by user.

Parameters

- base – LPUART peripheral base address.
- enable – true to enable, false to disable.

static inline void LPUART_SetMatchAddress(LPUART_Type *base, uint16_t address1, uint16_t address2)

Set the LPUART address.

This function configures the address for LPUART module that works as slave in 9-bit data mode. One or two address fields can be configured. When the address field's match enable bit is set, the frame it receives with MSB being 1 is considered as an address frame, otherwise it is considered as data frame. Once the address frame matches one of slave's own addresses, this slave is addressed. This address frame and its following data frames are stored in the receive buffer; otherwise the frames will be discarded. To un-address a slave, just send an address frame with unmatched address.

Note: Any LPUART instance joined in the multi-slave system can work as slave. The position of the address mark is the same as the parity bit when parity is enabled for 8 bit and 9 bit data formats.

Parameters

- base – LPUART peripheral base address.
- address1 – LPUART slave address1.
- address2 – LPUART slave address2.

static inline void LPUART_EnableMatchAddress(LPUART_Type *base, bool match1, bool match2)

Enable the LPUART match address feature.

Parameters

- base – LPUART peripheral base address.
- match1 – true to enable match address1, false to disable.
- match2 – true to enable match address2, false to disable.

static inline void LPUART_SetRxFifoWatermark(LPUART_Type *base, uint8_t water)

Sets the rx FIFO watermark.

Parameters

- base – LPUART peripheral base address.
- water – Rx FIFO watermark.

static inline void LPUART_SetTxFifoWatermark(LPUART_Type *base, uint8_t water)

Sets the tx FIFO watermark.

Parameters

- base – LPUART peripheral base address.
- water – Tx FIFO watermark.

static inline void LPUART_TransferEnable16Bit(*lpuart_handle_t* *handle, bool enable)

Sets the LPUART using 16bit transmit, only for 9bit or 10bit mode.

This function Enable 16bit Data transmit in *lpuart_handle_t*.

Parameters

- handle – LPUART handle pointer.
- enable – true to enable, false to disable.

uint32_t LPUART_GetStatusFlags(LPUART_Type *base)

Gets LPUART status flags.

This function gets all LPUART status flags. The flags are returned as the logical OR value of the enumerators *_lpuart_flags*. To check for a specific status, compare the return value with enumerators in the *_lpuart_flags*. For example, to check whether the TX is empty:

```
if (kLPUART_TxDataRegEmptyFlag & LPUART_GetStatusFlags(LPUART1))
{
    ...
}
```

Parameters

- base – LPUART peripheral base address.

Returns

LPUART status flags which are Ored by the enumerators in the *_lpuart_flags*.

status_t LPUART_ClearStatusFlags(LPUART_Type *base, uint32_t mask)

Clears status flags with a provided mask.

This function clears LPUART status flags with a provided mask. Automatically cleared flags can't be cleared by this function. Flags that can only cleared or set by hardware are: *kLPUART_TxDataRegEmptyFlag*, *kLPUART_TransmissionCompleteFlag*, *kLPUART_RxDataRegFullFlag*, *kLPUART_RxActiveFlag*, *kLPUART_NoiseErrorFlag*, *kLPUART_ParityErrorFlag*, *kLPUART_TxFifoEmptyFlag*, *kLPUART_RxFifoEmptyFlag* Note: This API should be called when the Tx/Rx is idle, otherwise it takes no effects.

Parameters

- base – LPUART peripheral base address.
- mask – the status flags to be cleared. The user can use the enumerators in the *_lpuart_status_flag_t* to do the OR operation and get the mask.

Return values

- *kStatus_LPUART_FlagCannotClearManually* – The flag can't be cleared by this function but it is cleared automatically by hardware.
- *kStatus_Success* – Status in the mask are cleared.

Returns

0 succeed, others failed.

void LPUART_EnableInterrupts(LPUART_Type *base, uint32_t mask)

Enables LPUART interrupts according to a provided mask.

This function enables the LPUART interrupts according to a provided mask. The mask is a logical OR of enumeration members. See the *_lpuart_interrupt_enable*. This examples shows how to enable TX empty interrupt and RX full interrupt:

```
LPUART_EnableInterrupts(LPUART1, kLPUART_TxDataRegEmptyInterruptEnable | kLPUART_
↳ RxDataRegFullInterruptEnable);
```

Parameters

- base – LPUART peripheral base address.
- mask – The interrupts to enable. Logical OR of `_lpuart_interrupt_enable`.

`void LPUART_DisableInterrupts(LPUART_Type *base, uint32_t mask)`

Disables LPUART interrupts according to a provided mask.

This function disables the LPUART interrupts according to a provided mask. The mask is a logical OR of enumeration members. See `_lpuart_interrupt_enable`. This example shows how to disable the TX empty interrupt and RX full interrupt:

```
LPUART_DisableInterrupts(LPUART1, kLPUART_TxDataRegEmptyInterruptEnable | kLPUART_
↳ RxDataRegFullInterruptEnable);
```

Parameters

- base – LPUART peripheral base address.
- mask – The interrupts to disable. Logical OR of `_lpuart_interrupt_enable`.

`uint32_t LPUART_GetEnabledInterrupts(LPUART_Type *base)`

Gets enabled LPUART interrupts.

This function gets the enabled LPUART interrupts. The enabled interrupts are returned as the logical OR value of the enumerators `_lpuart_interrupt_enable`. To check a specific interrupt enable status, compare the return value with enumerators in `_lpuart_interrupt_enable`. For example, to check whether the TX empty interrupt is enabled:

```
uint32_t enabledInterrupts = LPUART_GetEnabledInterrupts(LPUART1);

if (kLPUART_TxDataRegEmptyInterruptEnable & enabledInterrupts)
{
    ...
}
```

Parameters

- base – LPUART peripheral base address.

Returns

LPUART interrupt flags which are logical OR of the enumerators in `_lpuart_interrupt_enable`.

`static inline uintptr_t LPUART_GetDataRegisterAddress(LPUART_Type *base)`

Gets the LPUART data register address.

This function returns the LPUART data register address, which is mainly used by the DMA/eDMA.

Parameters

- base – LPUART peripheral base address.

Returns

LPUART data register addresses which are used both by the transmitter and receiver.

static inline void LPUART_EnableTxDMA(LPUART_Type *base, bool enable)

Enables or disables the LPUART transmitter DMA request.

This function enables or disables the transmit data register empty flag, STAT[TDRE], to generate DMA requests.

Parameters

- base – LPUART peripheral base address.
- enable – True to enable, false to disable.

static inline void LPUART_EnableRxDMA(LPUART_Type *base, bool enable)

Enables or disables the LPUART receiver DMA.

This function enables or disables the receiver data register full flag, STAT[RDRF], to generate DMA requests.

Parameters

- base – LPUART peripheral base address.
- enable – True to enable, false to disable.

uint32_t LPUART_GetInstance(LPUART_Type *base)

Get the LPUART instance from peripheral base address.

Parameters

- base – LPUART peripheral base address.

Returns

LPUART instance.

static inline void LPUART_EnableTx(LPUART_Type *base, bool enable)

Enables or disables the LPUART transmitter.

This function enables or disables the LPUART transmitter.

Parameters

- base – LPUART peripheral base address.
- enable – True to enable, false to disable.

static inline void LPUART_EnableRx(LPUART_Type *base, bool enable)

Enables or disables the LPUART receiver.

This function enables or disables the LPUART receiver.

Parameters

- base – LPUART peripheral base address.
- enable – True to enable, false to disable.

static inline void LPUART_WriteByte(LPUART_Type *base, uint8_t data)

Writes to the transmitter register.

This function writes data to the transmitter register directly. The upper layer must ensure that the TX register is empty or that the TX FIFO has room before calling this function.

Parameters

- base – LPUART peripheral base address.
- data – Data write to the TX register.

static inline uint8_t LPUART_ReadByte(LPUART_Type *base)

Reads the receiver register.

This function reads data from the receiver register directly. The upper layer must ensure that the receiver register is full or that the RX FIFO has data before calling this function.

Parameters

- base – LPUART peripheral base address.

Returns

Data read from data register.

static inline uint8_t LPUART_GetRxFifoCount(LPUART_Type *base)

Gets the rx FIFO data count.

Parameters

- base – LPUART peripheral base address.

Returns

rx FIFO data count.

static inline uint8_t LPUART_GetTxFifoCount(LPUART_Type *base)

Gets the tx FIFO data count.

Parameters

- base – LPUART peripheral base address.

Returns

tx FIFO data count.

void LPUART_SendAddress(LPUART_Type *base, uint8_t address)

Transmit an address frame in 9-bit data mode.

Parameters

- base – LPUART peripheral base address.
- address – LPUART slave address.

status_t LPUART_WriteBlocking(LPUART_Type *base, const uint8_t *data, size_t length)

Writes to the transmitter register using a blocking method.

This function polls the transmitter register, first waits for the register to be empty or TX FIFO to have room, and writes data to the transmitter buffer, then waits for the data to be sent out to the bus.

Parameters

- base – LPUART peripheral base address.
- data – Start address of the data to write.
- length – Size of the data to write.

Return values

- kStatus_LPUART_Timeout – Transmission timed out and was aborted.
- kStatus_Success – Successfully wrote all data.

status_t LPUART_WriteBlocking16bit(LPUART_Type *base, const uint16_t *data, size_t length)

Writes to the transmitter register using a blocking method in 9bit or 10bit mode.

Note: This function only support 9bit or 10bit transfer. Please make sure only 10bit of data is valid and other bits are 0.

Parameters

- base – LPUART peripheral base address.
- data – Start address of the data to write.
- length – Size of the data to write.

Return values

- kStatus_LPUART_Timeout – Transmission timed out and was aborted.
- kStatus_Success – Successfully wrote all data.

status_t LPUART_ReadBlocking(LPUART_Type *base, uint8_t *data, size_t length)

Reads the receiver data register using a blocking method.

This function polls the receiver register, waits for the receiver register full or receiver FIFO has data, and reads data from the TX register.

Parameters

- base – LPUART peripheral base address.
- data – Start address of the buffer to store the received data.
- length – Size of the buffer.

Return values

- kStatus_LPUART_RxHardwareOverrun – Receiver overrun happened while receiving data.
- kStatus_LPUART_NoiseError – Noise error happened while receiving data.
- kStatus_LPUART_FramingError – Framing error happened while receiving data.
- kStatus_LPUART_ParityError – Parity error happened while receiving data.
- kStatus_LPUART_Timeout – Transmission timed out and was aborted.
- kStatus_Success – Successfully received all data.

status_t LPUART_ReadBlocking16bit(LPUART_Type *base, uint16_t *data, size_t length)

Reads the receiver data register in 9bit or 10bit mode.

Note: This function only support 9bit or 10bit transfer.

Parameters

- base – LPUART peripheral base address.
- data – Start address of the buffer to store the received data by 16bit, only 10bit is valid.
- length – Size of the buffer.

Return values

- kStatus_LPUART_RxHardwareOverrun – Receiver overrun happened while receiving data.
- kStatus_LPUART_NoiseError – Noise error happened while receiving data.
- kStatus_LPUART_FramingError – Framing error happened while receiving data.

- `kStatus_LPUART_ParityError` – Parity error happened while receiving data.
- `kStatus_LPUART_Timeout` – Transmission timed out and was aborted.
- `kStatus_Success` – Successfully received all data.

```
void LPUART__TransferCreateHandle(LPUART_Type *base, lpuart_handle_t *handle,  
                                lpuart_transfer_callback_t callback, void *userData)
```

Initializes the LPUART handle.

This function initializes the LPUART handle, which can be used for other LPUART transactional APIs. Usually, for a specified LPUART instance, call this API once to get the initialized handle.

The LPUART driver supports the “background” receiving, which means that user can set up an RX ring buffer optionally. Data received is stored into the ring buffer even when the user doesn’t call the `LPUART_TransferReceiveNonBlocking()` API. If there is already data received in the ring buffer, the user can get the received data from the ring buffer directly. The ring buffer is disabled if passing `NULL` as `ringBuffer`.

Parameters

- `base` – LPUART peripheral base address.
- `handle` – LPUART handle pointer.
- `callback` – Callback function.
- `userData` – User data.

```
status_t LPUART__TransferSendNonBlocking(LPUART_Type *base, lpuart_handle_t *handle,  
                                         lpuart_transfer_t *xfer)
```

Transmits a buffer of data using the interrupt method.

This function send data using an interrupt method. This is a non-blocking function, which returns directly without waiting for all data written to the transmitter register. When all data is written to the TX register in the ISR, the LPUART driver calls the callback function and passes the `kStatus_LPUART_TxIdle` as `status` parameter.

Note: The `kStatus_LPUART_TxIdle` is passed to the upper layer when all data are written to the TX register. However, there is no check to ensure that all the data sent out. Before disabling the TX, check the `kLPUART_TransmissionCompleteFlag` to ensure that the transmit is finished.

Parameters

- `base` – LPUART peripheral base address.
- `handle` – LPUART handle pointer.
- `xfer` – LPUART transfer structure, see `lpuart_transfer_t`.

Return values

- `kStatus_Success` – Successfully start the data transmission.
- `kStatus_LPUART_TxBusy` – Previous transmission still not finished, data not all written to the TX register.
- `kStatus_InvalidArgument` – Invalid argument.

```
void LPUART__TransferStartRingBuffer(LPUART_Type *base, lpuart_handle_t *handle, uint8_t  
                                     *ringBuffer, size_t ringBufferSize)
```

Sets up the RX ring buffer.

This function sets up the RX ring buffer to a specific UART handle.

When the RX ring buffer is used, data received is stored into the ring buffer even when the user doesn't call the `UART_TransferReceiveNonBlocking()` API. If there is already data received in the ring buffer, the user can get the received data from the ring buffer directly.

Note: When using RX ring buffer, one byte is reserved for internal use. In other words, if `ringBufferSize` is 32, then only 31 bytes are used for saving data.

Parameters

- `base` – LPUART peripheral base address.
- `handle` – LPUART handle pointer.
- `ringBuffer` – Start address of ring buffer for background receiving. Pass `NULL` to disable the ring buffer.
- `ringBufferSize` – size of the ring buffer.

`void LPUART__TransferStopRingBuffer(LPUART_Type *base, lpuart_handle_t *handle)`

Aborts the background transfer and uninstalls the ring buffer.

This function aborts the background transfer and uninstalls the ring buffer.

Parameters

- `base` – LPUART peripheral base address.
- `handle` – LPUART handle pointer.

`size_t LPUART__TransferGetRxRingBufferLength(LPUART_Type *base, lpuart_handle_t *handle)`

Get the length of received data in RX ring buffer.

Parameters

- `base` – LPUART peripheral base address.
- `handle` – LPUART handle pointer.

Returns

Length of received data in RX ring buffer.

`void LPUART__TransferAbortSend(LPUART_Type *base, lpuart_handle_t *handle)`

Aborts the interrupt-driven data transmit.

This function aborts the interrupt driven data sending. The user can get the `remainBtyes` to find out how many bytes are not sent out.

Parameters

- `base` – LPUART peripheral base address.
- `handle` – LPUART handle pointer.

`status_t LPUART__TransferGetSendCount(LPUART_Type *base, lpuart_handle_t *handle, uint32_t *count)`

Gets the number of bytes that have been sent out to bus.

This function gets the number of bytes that have been sent out to bus by an interrupt method.

Parameters

- `base` – LPUART peripheral base address.

- `handle` – LPUART handle pointer.
- `count` – Send bytes count.

Return values

- `kStatus_NoTransferInProgress` – No send in progress.
- `kStatus_InvalidArgument` – Parameter is invalid.
- `kStatus_Success` – Get successfully through the parameter `count`;

`status_t` LPUART_TransferReceiveNonBlocking(LPUART_Type *base, *lpuart_handle_t* *handle, *lpuart_transfer_t* *xfer, `size_t` *receivedBytes)

Receives a buffer of data using the interrupt method.

This function receives data using an interrupt method. This is a non-blocking function which returns without waiting to ensure that all data are received. If the RX ring buffer is used and not empty, the data in the ring buffer is copied and the parameter `receivedBytes` shows how many bytes are copied from the ring buffer. After copying, if the data in the ring buffer is not enough for read, the receive request is saved by the LPUART driver. When the new data arrives, the receive request is serviced first. When all data is received, the LPUART driver notifies the upper layer through a callback function and passes a status parameter `kStatus_UART_RxIdle`. For example, the upper layer needs 10 bytes but there are only 5 bytes in ring buffer. The 5 bytes are copied to `xfer->data`, which returns with the parameter `receivedBytes` set to 5. For the remaining 5 bytes, the newly arrived data is saved from `xfer->data[5]`. When 5 bytes are received, the LPUART driver notifies the upper layer. If the RX ring buffer is not enabled, this function enables the RX and RX interrupt to receive data to `xfer->data`. When all data is received, the upper layer is notified.

Parameters

- `base` – LPUART peripheral base address.
- `handle` – LPUART handle pointer.
- `xfer` – LPUART transfer structure, see `uart_transfer_t`.
- `receivedBytes` – Bytes received from the ring buffer directly.

Return values

- `kStatus_Success` – Successfully queue the transfer into the transmit queue.
- `kStatus_LPUART_RxBusy` – Previous receive request is not finished.
- `kStatus_InvalidArgument` – Invalid argument.

`void` LPUART_TransferAbortReceive(LPUART_Type *base, *lpuart_handle_t* *handle)

Aborts the interrupt-driven data receiving.

This function aborts the interrupt-driven data receiving. The user can get the `remainBytes` to find out how many bytes not received yet.

Parameters

- `base` – LPUART peripheral base address.
- `handle` – LPUART handle pointer.

`status_t` LPUART_TransferGetReceiveCount(LPUART_Type *base, *lpuart_handle_t* *handle, `uint32_t` *count)

Gets the number of bytes that have been received.

This function gets the number of bytes that have been received.

Parameters

- `base` – LPUART peripheral base address.

- handle – LPUART handle pointer.
- count – Receive bytes count.

Return values

- kStatus_NoTransferInProgress – No receive in progress.
- kStatus_InvalidArgument – Parameter is invalid.
- kStatus_Success – Get successfully through the parameter count;

void LPUART_TransferHandleIRQ(LPUART_Type *base, void *irqHandle)
LPUART IRQ handle function.

This function handles the LPUART transmit and receive IRQ request.

Parameters

- base – LPUART peripheral base address.
- irqHandle – LPUART handle pointer.

void LPUART_TransferHandleErrorIRQ(LPUART_Type *base, void *irqHandle)
LPUART Error IRQ handle function.

This function handles the LPUART error IRQ request.

Parameters

- base – LPUART peripheral base address.
- irqHandle – LPUART handle pointer.

void LPUART_DriverIRQHandler(uint32_t instance)
LPUART driver IRQ handler common entry.

This function provides the common IRQ request entry for LPUART.

Parameters

- instance – LPUART instance.

FSL_LPUART_DRIVER_VERSION
LPUART driver version.

Error codes for the LPUART driver.

Values:

enumerator kStatus_LPUART_TxBusy
TX busy

enumerator kStatus_LPUART_RxBusy
RX busy

enumerator kStatus_LPUART_TxIdle
LPUART transmitter is idle.

enumerator kStatus_LPUART_RxIdle
LPUART receiver is idle.

enumerator kStatus_LPUART_TxWatermarkTooLarge
TX FIFO watermark too large

enumerator kStatus_LPUART_RxWatermarkTooLarge
RX FIFO watermark too large

enumerator kStatus_LPUART_FlagCannotClearManually

Some flag can't manually clear

enumerator kStatus_LPUART_Error

Error happens on LPUART.

enumerator kStatus_LPUART_RxRingBufferOverrun

LPUART RX software ring buffer overrun.

enumerator kStatus_LPUART_RxHardwareOverrun

LPUART RX receiver overrun.

enumerator kStatus_LPUART_NoiseError

LPUART noise error.

enumerator kStatus_LPUART_FramingError

LPUART framing error.

enumerator kStatus_LPUART_ParityError

LPUART parity error.

enumerator kStatus_LPUART_BaudrateNotSupport

Baudrate is not support in current clock source

enumerator kStatus_LPUART_IdleLineDetected

IDLE flag.

enumerator kStatus_LPUART_Timeout

LPUART times out.

enum _lpuart_parity_mode

LPUART parity mode.

Values:

enumerator kLPUART_ParityDisabled

Parity disabled

enumerator kLPUART_ParityEven

Parity enabled, type even, bit setting: PE | PT = 10

enumerator kLPUART_ParityOdd

Parity enabled, type odd, bit setting: PE | PT = 11

enum _lpuart_data_bits

LPUART data bits count.

Values:

enumerator kLPUART_EightDataBits

Eight data bit

enumerator kLPUART_SevenDataBits

Seven data bit

enum _lpuart_stop_bit_count

LPUART stop bit count.

Values:

enumerator kLPUART_OneStopBit

One stop bit

enumerator kLPUART_TwoStopBit
Two stop bits

enum _lpuart_transmit_cts_source
LPUART transmit CTS source.

Values:

enumerator kLPUART_CtsSourcePin
CTS resource is the LPUART_CTS pin.

enumerator kLPUART_CtsSourceMatchResult
CTS resource is the match result.

enum _lpuart_transmit_cts_config
LPUART transmit CTS configure.

Values:

enumerator kLPUART_CtsSampleAtStart
CTS input is sampled at the start of each character.

enumerator kLPUART_CtsSampleAtIdle
CTS input is sampled when the transmitter is idle

enum _lpuart_idle_type_select
LPUART idle flag type defines when the receiver starts counting.

Values:

enumerator kLPUART_IdleTypeStartBit
Start counting after a valid start bit.

enumerator kLPUART_IdleTypeStopBit
Start counting after a stop bit.

enum _lpuart_idle_config
LPUART idle detected configuration. This structure defines the number of idle characters that must be received before the IDLE flag is set.

Values:

enumerator kLPUART_IdleCharacter1
the number of idle characters.

enumerator kLPUART_IdleCharacter2
the number of idle characters.

enumerator kLPUART_IdleCharacter4
the number of idle characters.

enumerator kLPUART_IdleCharacter8
the number of idle characters.

enumerator kLPUART_IdleCharacter16
the number of idle characters.

enumerator kLPUART_IdleCharacter32
the number of idle characters.

enumerator kLPUART_IdleCharacter64
the number of idle characters.

enumerator kLPUART_IdleCharacter128
the number of idle characters.

enum _lpuart_interrupt_enable

LPUART interrupt configuration structure, default settings all disabled.

This structure contains the settings for all LPUART interrupt configurations.

Values:

enumerator kLPUART_LinBreakInterruptEnable
LIN break detect. bit 7

enumerator kLPUART_RxActiveEdgeInterruptEnable
Receive Active Edge. bit 6

enumerator kLPUART_TxDataRegEmptyInterruptEnable
Transmit data register empty. bit 23

enumerator kLPUART_TransmissionCompleteInterruptEnable
Transmission complete. bit 22

enumerator kLPUART_RxDataRegFullInterruptEnable
Receiver data register full. bit 21

enumerator kLPUART_IdleLineInterruptEnable
Idle line. bit 20

enumerator kLPUART_RxOverrunInterruptEnable
Receiver Overrun. bit 27

enumerator kLPUART_NoiseErrorInterruptEnable
Noise error flag. bit 26

enumerator kLPUART_FramingErrorInterruptEnable
Framing error flag. bit 25

enumerator kLPUART_ParityErrorInterruptEnable
Parity error flag. bit 24

enumerator kLPUART_Match1InterruptEnable
Parity error flag. bit 15

enumerator kLPUART_Match2InterruptEnable
Parity error flag. bit 14

enumerator kLPUART_TxFifoOverflowInterruptEnable
Transmit FIFO Overflow. bit 9

enumerator kLPUART_RxFifoUnderflowInterruptEnable
Receive FIFO Underflow. bit 8

enumerator kLPUART_AllInterruptEnable

enum _lpuart_flags

LPUART status flags.

This provides constants for the LPUART status flags for use in the LPUART functions.

Values:

enumerator kLPUART_TxDataRegEmptyFlag
Transmit data register empty flag, sets when transmit buffer is empty. bit 23

enumerator `kLPUART_TransmissionCompleteFlag`

Transmission complete flag, sets when transmission activity complete. bit 22

enumerator `kLPUART_RxDataRegFullFlag`

Receive data register full flag, sets when the receive data buffer is full. bit 21

enumerator `kLPUART_IdleLineFlag`

Idle line detect flag, sets when idle line detected. bit 20

enumerator `kLPUART_RxOverrunFlag`

Receive Overrun, sets when new data is received before data is read from receive register. bit 19

enumerator `kLPUART_NoiseErrorFlag`

Receive takes 3 samples of each received bit. If any of these samples differ, noise flag sets. bit 18

enumerator `kLPUART_FramingErrorFlag`

Frame error flag, sets if logic 0 was detected where stop bit expected. bit 17

enumerator `kLPUART_ParityErrorFlag`

If parity enabled, sets upon parity error detection. bit 16

enumerator `kLPUART_LinBreakFlag`

LIN break detect interrupt flag, sets when LIN break char detected and LIN circuit enabled. bit 31

enumerator `kLPUART_RxActiveEdgeFlag`

Receive pin active edge interrupt flag, sets when active edge detected. bit 30

enumerator `kLPUART_RxActiveFlag`

Receiver Active Flag (RAF), sets at beginning of valid start. bit 24

enumerator `kLPUART_DataMatch1Flag`

The next character to be read from `LPUART_DATA` matches MA1. bit 15

enumerator `kLPUART_DataMatch2Flag`

The next character to be read from `LPUART_DATA` matches MA2. bit 14

enumerator `kLPUART_TxFifoEmptyFlag`

TXEMPT bit, sets if transmit buffer is empty. bit 7

enumerator `kLPUART_RxFifoEmptyFlag`

RXEMPT bit, sets if receive buffer is empty. bit 6

enumerator `kLPUART_TxFifoOverflowFlag`

TXOF bit, sets if transmit buffer overflow occurred. bit 1

enumerator `kLPUART_RxFifoUnderflowFlag`

RXUF bit, sets if receive buffer underflow occurred. bit 0

enumerator `kLPUART_AllClearFlags`

enumerator `kLPUART_AllFlags`

typedef enum *lpuart_parity_mode* lpuart_parity_mode_t

LPUART parity mode.

typedef enum *lpuart_data_bits* lpuart_data_bits_t

LPUART data bits count.

typedef enum *lpuart_stop_bit_count* lpuart_stop_bit_count_t

LPUART stop bit count.

typedef enum *_lpuart_transmit_cts_source* lpuart_transmit_cts_source_t
LPUART transmit CTS source.

typedef enum *_lpuart_transmit_cts_config* lpuart_transmit_cts_config_t
LPUART transmit CTS configure.

typedef enum *_lpuart_idle_type_select* lpuart_idle_type_select_t
LPUART idle flag type defines when the receiver starts counting.

typedef enum *_lpuart_idle_config* lpuart_idle_config_t
LPUART idle detected configuration. This structure defines the number of idle characters that must be received before the IDLE flag is set.

typedef struct *_lpuart_config* lpuart_config_t
LPUART configuration structure.

typedef struct *_lpuart_transfer* lpuart_transfer_t
LPUART transfer structure.

typedef struct *_lpuart_handle* lpuart_handle_t

typedef void (*lpuart_transfer_callback_t)(LPUART_Type *base, *lpuart_handle_t* *handle, *status_t* status, void *userData)
LPUART transfer callback function.

typedef void (*lpuart_isr_t)(LPUART_Type *base, void *handle)

void *s_lpuartHandle[]

const IRQn_Type s_lpuartTxIRQ[]

lpuart_isr_t s_lpuartIsr[]

UART_RETRY_TIMES
Retry times for waiting flag.

struct _lpuart_config
#include <fsl_lpuart.h> LPUART configuration structure.

Public Members

uint32_t baudRate_Bps
LPUART baud rate

lpuart_parity_mode_t parityMode
Parity mode, disabled (default), even, odd

lpuart_data_bits_t dataBitsCount
Data bits count, eight (default), seven

bool isMsb
Data bits order, LSB (default), MSB

lpuart_stop_bit_count_t stopBitCount
Number of stop bits, 1 stop bit (default) or 2 stop bits

uint8_t txFifoWatermark
TX FIFO watermark

uint8_t rxFifoWatermark
RX FIFO watermark

`bool enableRxRTS`
RX RTS enable

`bool enableTxCTS`
TX CTS enable

`lpuart_transmit_cts_source_t txCtsSource`
TX CTS source

`lpuart_transmit_cts_config_t txCtsConfig`
TX CTS configure

`uint8_t rtsWatermark`
RTS watermark

`lpuart_idle_type_select_t rxIdleType`
RX IDLE type.

`lpuart_idle_config_t rxIdleConfig`
RX IDLE configuration.

`bool enableTx`
Enable TX

`bool enableRx`
Enable RX

`bool swapTxdRxd`
Swap TXD and RXD pins

`struct __lpuart_transfer`
#include <fsl_lpuart.h> LPUART transfer structure.

Public Members

`size_t dataSize`
The byte count to be transfer.

`struct __lpuart_handle`
#include <fsl_lpuart.h> LPUART handle structure.

Public Members

`volatile size_t txDataSize`
Size of the remaining data to send.

`size_t txDataSizeAll`
Size of the data to send out.

`volatile size_t rxDataSize`
Size of the remaining data to receive.

`size_t rxDataSizeAll`
Size of the data to receive.

`size_t rxRingBufferSize`
Size of the ring buffer.

`volatile uint16_t rxRingBufferHead`
Index for the driver to store received data into ring buffer.

volatile uint16_t rxRingBufferTail

Index for the user to get data from the ring buffer.

lpuart_transfer_callback_t callback

Callback function.

void *userData

LPUART callback function parameter.

volatile uint8_t txState

TX transfer state.

volatile uint8_t rxState

RX transfer state.

bool isSevenDataBits

Seven data bits flag.

bool is16bitData

16bit data bits flag, only used for 9bit or 10bit data

union ____unnamed65____

Public Members

uint8_t *data

The buffer of data to be transfer.

uint8_t *rxData

The buffer to receive data.

uint16_t *rxData16

The buffer to receive data.

const uint8_t *txData

The buffer of data to be sent.

const uint16_t *txData16

The buffer of data to be sent.

union ____unnamed67____

Public Members

const uint8_t *volatile txData

Address of remaining data to send.

const uint16_t *volatile txData16

Address of remaining data to send.

union ____unnamed69____

Public Members

uint8_t *volatile rxData

Address of remaining data to receive.

uint16_t *volatile rxData16

Address of remaining data to receive.

union ____unnamed71____

Public Members

`uint8_t *rxRingBuffer`

Start address of the receiver ring buffer.

`uint16_t *rxRingBuffer16`

Start address of the receiver ring buffer.

2.40 LPUART eDMA Driver

```
void LPUART__TransferCreateHandleEDMA(LPUART_Type *base, lpuart_edma_handle_t *handle,
                                     lpuart_edma_transfer_callback_t callback, void
                                     *userData, edma_handle_t *txEdmaHandle,
                                     edma_handle_t *rxEdmaHandle)
```

Initializes the LPUART handle which is used in transactional functions.

Note: This function disables all LPUART interrupts.

Parameters

- `base` – LPUART peripheral base address.
- `handle` – Pointer to `lpuart_edma_handle_t` structure.
- `callback` – Callback function.
- `userData` – User data.
- `txEdmaHandle` – User requested DMA handle for TX DMA transfer.
- `rxEdmaHandle` – User requested DMA handle for RX DMA transfer.

```
status_t LPUART__SendEDMA(LPUART_Type *base, lpuart_edma_handle_t *handle,
                          lpuart_transfer_t *xfer)
```

Sends data using eDMA.

This function sends data using eDMA. This is a non-blocking function, which returns right away. When all data is sent, the send callback function is called.

Parameters

- `base` – LPUART peripheral base address.
- `handle` – LPUART handle pointer.
- `xfer` – LPUART eDMA transfer structure. See `lpuart_transfer_t`.

Return values

- `kStatus_Success` – if succeed, others failed.
- `kStatus_LPUART_TxBusy` – Previous transfer on going.
- `kStatus_InvalidArgument` – Invalid argument.

```
status_t LPUART__ReceiveEDMA(LPUART_Type *base, lpuart_edma_handle_t *handle,
                              lpuart_transfer_t *xfer)
```

Receives data using eDMA.

This function receives data using eDMA. This is non-blocking function, which returns right away. When all data is received, the receive callback function is called.

Parameters

- `base` – LPUART peripheral base address.
- `handle` – Pointer to `lpuart_edma_handle_t` structure.
- `xfer` – LPUART eDMA transfer structure, see `lpuart_transfer_t`.

Return values

- `kStatus__Success` – if succeed, others fail.
- `kStatus__LPUART_RxBusy` – Previous transfer ongoing.
- `kStatus__InvalidArgument` – Invalid argument.

`void LPUART__TransferAbortSendEDMA(LPUART_Type *base, lpuart_edma_handle_t *handle)`
Aborts the sent data using eDMA.

This function aborts the sent data using eDMA.

Parameters

- `base` – LPUART peripheral base address.
- `handle` – Pointer to `lpuart_edma_handle_t` structure.

`void LPUART__TransferAbortReceiveEDMA(LPUART_Type *base, lpuart_edma_handle_t *handle)`
Aborts the received data using eDMA.

This function aborts the received data using eDMA.

Parameters

- `base` – LPUART peripheral base address.
- `handle` – Pointer to `lpuart_edma_handle_t` structure.

`status_t LPUART__TransferGetSendCountEDMA(LPUART_Type *base, lpuart_edma_handle_t *handle, uint32_t *count)`

Gets the number of bytes written to the LPUART TX register.

This function gets the number of bytes written to the LPUART TX register by DMA.

Parameters

- `base` – LPUART peripheral base address.
- `handle` – LPUART handle pointer.
- `count` – Send bytes count.

Return values

- `kStatus__NoTransferInProgress` – No send in progress.
- `kStatus__InvalidArgument` – Parameter is invalid.
- `kStatus__Success` – Get successfully through the parameter `count`;

`status_t LPUART__TransferGetReceiveCountEDMA(LPUART_Type *base, lpuart_edma_handle_t *handle, uint32_t *count)`

Gets the number of received bytes.

This function gets the number of received bytes.

Parameters

- `base` – LPUART peripheral base address.
- `handle` – LPUART handle pointer.
- `count` – Receive bytes count.

Return values

- `kStatus_NoTransferInProgress` – No receive in progress.
- `kStatus_InvalidArgument` – Parameter is invalid.
- `kStatus_Success` – Get successfully through the parameter count;

`void LPUART_TransferEdmaHandleIRQ(LPUART_Type *base, void *lpuartEdmaHandle)`

LPUART eDMA IRQ handle function.

This function handles the LPUART tx complete IRQ request and invoke user callback. It is not set to static so that it can be used in user application.

Note: This function is used as default IRQ handler by double weak mechanism. If user's specific IRQ handler is implemented, make sure this function is invoked in the handler.

Parameters

- `base` – LPUART peripheral base address.
- `lpuartEdmaHandle` – LPUART handle pointer.

`FSL_LPUART_EDMA_DRIVER_VERSION`

LPUART EDMA driver version.

`typedef struct _lpuart_edma_handle lpuart_edma_handle_t`

`typedef void (*lpuart_edma_transfer_callback_t)(LPUART_Type *base, lpuart_edma_handle_t *handle, status_t status, void *userData)`

LPUART transfer callback function.

`struct _lpuart_edma_handle`

`#include <fsl_lpuart_edma.h>` LPUART eDMA handle.

Public Members

`lpuart_edma_transfer_callback_t` callback

Callback function.

`void *userData`

LPUART callback function parameter.

`size_t rxDataSizeAll`

Size of the data to receive.

`size_t txDataSizeAll`

Size of the data to send out.

`edma_handle_t *txEdmaHandle`

The eDMA TX channel used.

`edma_handle_t *rxEdmaHandle`

The eDMA RX channel used.

`uint8_t nbytes`

eDMA minor byte transfer count initially configured.

`volatile uint8_t txState`

TX transfer state.

`volatile uint8_t rxState`

RX transfer state

2.41 MCM: Miscellaneous Control Module

FSL_MCM_DRIVER_VERSION

MCM driver version.

Enum _mcm_interrupt_flag. Interrupt status flag mask. .

Values:

enumerator kMCM_CacheWriteBuffer
Cache Write Buffer Error Enable.

enumerator kMCM_ParityError
Cache Parity Error Enable.

enumerator kMCM_FPUInvalidOperation
FPU Invalid Operation Interrupt Enable.

enumerator kMCM_FPUDivideByZero
FPU Divide-by-zero Interrupt Enable.

enumerator kMCM_FPUOverflow
FPU Overflow Interrupt Enable.

enumerator kMCM_FPUUnderflow
FPU Underflow Interrupt Enable.

enumerator kMCM_FPUInexact
FPU Inexact Interrupt Enable.

enumerator kMCM_FPUInputDenormalInterrupt
FPU Input Denormal Interrupt Enable.

typedef union *_mcm_buffer_fault_attribute* mcm_buffer_fault_attribute_t
The union of buffer fault attribute.

typedef union *_mcm_lmem_fault_attribute* mcm_lmem_fault_attribute_t
The union of LMEM fault attribute.

static inline void MCM_EnableCrossbarRoundRobin(MCM_Type *base, bool enable)
Enables/Disables crossbar round robin.

Parameters

- base – MCM peripheral base address.
- enable – Used to enable/disable crossbar round robin.
 - **true** Enable crossbar round robin.
 - **false** disable crossbar round robin.

static inline void MCM_EnableInterruptStatus(MCM_Type *base, uint32_t mask)
Enables the interrupt.

Parameters

- base – MCM peripheral base address.
- mask – Interrupt status flags mask(_mcm_interrupt_flag).

static inline void MCM_DisableInterruptStatus(MCM_Type *base, uint32_t mask)
Disables the interrupt.

Parameters

- base – MCM peripheral base address.
- mask – Interrupt status flags mask(`mcm_interrupt_flag`).

static inline uint16_t MCM_GetInterruptStatus(MCM_Type *base)
Gets the Interrupt status .

Parameters

- base – MCM peripheral base address.

static inline void MCM_ClearCacheWriteBufferErrorStatus(MCM_Type *base)
Clears the Interrupt status .

Parameters

- base – MCM peripheral base address.

static inline uint32_t MCM_GetBufferFaultAddress(MCM_Type *base)
Gets buffer fault address.

Parameters

- base – MCM peripheral base address.

static inline void MCM_GetBufferFaultAttribute(MCM_Type *base, *mcm_buffer_fault_attribute_t*
*bufferfault)

Gets buffer fault attributes.

Parameters

- base – MCM peripheral base address.
- bufferfault – Structure to store the result.

static inline uint32_t MCM_GetBufferFaultData(MCM_Type *base)
Gets buffer fault data.

Parameters

- base – MCM peripheral base address.

static inline void MCM_LimitCodeCachePeripheralWriteBuffering(MCM_Type *base, bool enable)
Limit code cache peripheral write buffering.

Parameters

- base – MCM peripheral base address.
- enable – Used to enable/disable limit code cache peripheral write buffering.
 - **true** Enable limit code cache peripheral write buffering.
 - **false** disable limit code cache peripheral write buffering.

static inline void MCM_BypassFixedCodeCacheMap(MCM_Type *base, bool enable)
Bypass fixed code cache map.

Parameters

- base – MCM peripheral base address.
- enable – Used to enable/disable bypass fixed code cache map.
 - **true** Enable bypass fixed code cache map.
 - **false** disable bypass fixed code cache map.

static inline void MCM_EnableCodeBusCache(MCM_Type *base, bool enable)

Enables/Disables code bus cache.

Parameters

- base – MCM peripheral base address.
- enable – Used to disable/enable code bus cache.
 - **true** Enable code bus cache.
 - **false** disable code bus cache.

static inline void MCM_ForceCodeCacheToNoAllocation(MCM_Type *base, bool enable)

Force code cache to no allocation.

Parameters

- base – MCM peripheral base address.
- enable – Used to force code cache to allocation or no allocation.
 - **true** Force code cache to no allocation.
 - **false** Force code cache to allocation.

static inline void MCM_EnableCodeCacheWriteBuffer(MCM_Type *base, bool enable)

Enables/Disables code cache write buffer.

Parameters

- base – MCM peripheral base address.
- enable – Used to enable/disable code cache write buffer.
 - **true** Enable code cache write buffer.
 - **false** Disable code cache write buffer.

static inline void MCM_ClearCodeBusCache(MCM_Type *base)

Clear code bus cache.

Parameters

- base – MCM peripheral base address.

static inline void MCM_EnablePcParityFaultReport(MCM_Type *base, bool enable)

Enables/Disables PC Parity Fault Report.

Parameters

- base – MCM peripheral base address.
- enable – Used to enable/disable PC Parity Fault Report.
 - **true** Enable PC Parity Fault Report.
 - **false** disable PC Parity Fault Report.

static inline void MCM_EnablePcParity(MCM_Type *base, bool enable)

Enables/Disables PC Parity.

Parameters

- base – MCM peripheral base address.
- enable – Used to enable/disable PC Parity.
 - **true** Enable PC Parity.
 - **false** disable PC Parity.

```
static inline void MCM_LockConfigState(MCM_Type *base)
```

Lock the configuration state.

Parameters

- base – MCM peripheral base address.

```
static inline void MCM_EnableCacheParityReporting(MCM_Type *base, bool enable)
```

Enables/Disables cache parity reporting.

Parameters

- base – MCM peripheral base address.
- enable – Used to enable/disable cache parity reporting.
 - **true** Enable cache parity reporting.
 - **false** disable cache parity reporting.

```
static inline uint32_t MCM_GetLmemFaultAddress(MCM_Type *base)
```

Gets LMEM fault address.

Parameters

- base – MCM peripheral base address.

```
static inline void MCM_GetLmemFaultAttribute(MCM_Type *base, mcm_lmem_fault_attribute_t *lmemFault)
```

Get LMEM fault attributes.

Parameters

- base – MCM peripheral base address.
- lmemFault – Structure to store the result.

```
static inline uint64_t MCM_GetLmemFaultData(MCM_Type *base)
```

Gets LMEM fault data.

Parameters

- base – MCM peripheral base address.

```
MCM_LMFATR_TYPE_MASK
```

```
MCM_LMFATR_MODE_MASK
```

```
MCM_LMFATR_BUFF_MASK
```

```
MCM_LMFATR_CACH_MASK
```

```
MCM_ISCR_STAT_MASK
```

```
FSL_COMPONENT_ID
```

```
union _mcm_buffer_fault_attribute
```

#include <fsl_mcm.h> The union of buffer fault attribute.

Public Members

```
uint32_t attribute
```

Indicates the faulting attributes, when a properly-enabled cache write buffer error interrupt event is detected.

```
struct _mcm_buffer_fault_attribute._mcm_buffer_fault_attribut attribute__memory
```

```
struct _mcm_buffer_fault_attribut
#include <fsl_mcm.h>
```

Public Members

uint32_t busErrorDataAccessType

Indicates the type of cache write buffer access.

uint32_t busErrorPrivilegeLevel

Indicates the privilege level of the cache write buffer access.

uint32_t busErrorSize

Indicates the size of the cache write buffer access.

uint32_t busErrorAccess

Indicates the type of system bus access.

uint32_t busErrorMasterID

Indicates the crossbar switch bus master number of the captured cache write buffer bus error.

uint32_t busErrorOverrun

Indicates if another cache write buffer bus error is detected.

union _mcm_lmem_fault_attribute

#include <fsl_mcm.h> The union of LMEM fault attribute.

Public Members

uint32_t attribute

Indicates the attributes of the LMEM fault detected.

struct _mcm_lmem_fault_attribute._mcm_lmem_fault_attribut attribute_memory

```
struct _mcm_lmem_fault_attribut
#include <fsl_mcm.h>
```

Public Members

uint32_t parityFaultProtectionSignal

Indicates the features of parity fault protection signal.

uint32_t parityFaultMasterSize

Indicates the parity fault master size.

uint32_t parityFaultWrite

Indicates the parity fault is caused by read or write.

uint32_t backdoorAccess

Indicates the LMEM access fault is initiated by core access or backdoor access.

uint32_t parityFaultSyndrome

Indicates the parity fault syndrome.

uint32_t overrun

Indicates the number of faultss.

2.42 Mipi_dsi

`void DSI_Init(MIPI_DSI_Type *base, dsi_config_t *config)`

Initializes the MIPI DSI host with the user configuration.

This function initializes the MIPI DSI host with the configuration, it should be called before other MIPI DSI driver functions.

Parameters

- `base` – MIPI DSI host peripheral base address.
- `config` – Pointer to the user configuration structure.

`void DSI_Deinit(MIPI_DSI_Type *base)`

Deinitializes an MIPI DSI host.

This function should be called after all bother MIPI DSI driver functions.

Parameters

- `base` – MIPI DSI host peripheral base address.

`void DSI_GetDefaultConfig(dsi_config_t *config)`

Gets the default configuration to initialize the MIPI DSI host.

The default value is:

```
config->mode = kDSI_CommandMode;
config->packageFlags = kDSI_DpiEnableAll;
config->enableNoncontinuousClk = true;
config->HsRxDeviceReady_ByteClk = 0U;
config->lpRxDeviceReady_ByteClk = 0U;
config->HsTxDeviceReady_ByteClk = 0U;
config->lpTxDeviceReady_ByteClk = 0U;
```

Parameters

- `config` – Pointer to a user-defined configuration structure.

`uint32_t DSI_DphyGetPlldivider(uint32_t *m, uint32_t *n, uint32_t refClkFreq_Hz, uint32_t desiredOutFreq_Hz)`

Calculates the D-PHY PLL dividers to generate the desired output frequency.

The phy byte clock frequency(byte count per second) is generated by multiplying the ref-ClkFreq_Hz, the formula is as follows, m & n is configured by mediamix control block.

$\text{desiredOutFreq\_Hz} = \text{refClkFreq\_Hz} * (M + 2) / (N + 1)$. M: 62 ~ 625 N: 0 ~ 15

Parameters

- `m` – Control of the feedback multiplication ratio.
- `n` – Control of the input frequency division ratio.
- `refClkFreq_Hz` – The D-PHY input reference clock frequency (REF_CLK).
- `desiredOutFreq_Hz` – Desired PLL output frequency.

Returns

The actually output frequency using the returned dividers. If can not find suitable dividers, return 0.

`status_t DSI_PowerUp(MIPI_DSI_Type *base)`

Power up the DSI.

Parameters

- base – MIPI DSI host peripheral base address.

Return values

- kStatus_Success – Data transfer finished with no error.
- kStatus_Timeout – Transfer failed because of timeout.

```
static inline void DSI_PowerDown(MIPI_DSI_Type *base)
```

Power down the DSI.

Parameters

- base – MIPI DSI host peripheral base address.

```
static inline void DSI_EnableInterrupts(MIPI_DSI_Type *base, uint32_t intGroup1, uint32_t  
intGroup2)
```

Enable the interrupts.

The interrupts to enable are passed in as OR'ed mask value of _dsi_interrupt.

Parameters

- base – MIPI DSI host peripheral base address.
- intGroup1 – Interrupts to enable in group 1.
- intGroup2 – Interrupts to enable in group 2.

```
static inline void DSI_DisableInterrupts(MIPI_DSI_Type *base, uint32_t intGroup1, uint32_t  
intGroup2)
```

Disable the interrupts.

The interrupts to disable are passed in as OR'ed mask value of _dsi_interrupt.

Parameters

- base – MIPI DSI host peripheral base address.
- intGroup1 – Interrupts to disable in group 1.
- intGroup2 – Interrupts to disable in group 2.

```
static inline void DSI_GetAndClearInterruptStatus(MIPI_DSI_Type *base, uint32_t *intGroup1,  
uint32_t *intGroup2)
```

Get and clear the interrupt status.

Parameters

- base – MIPI DSI host peripheral base address.
- intGroup1 – Group 1 interrupt status.
- intGroup2 – Group 2 interrupt status.

```
void DSI_SetDpiConfig(MIPI_DSI_Type *base, const dsi_dpi_config_t *config, uint8_t laneNum)
```

Configure the DPI interface.

This function sets the DPI interface configuration, it should be used in video mode.

Parameters

- base – MIPI DSI host peripheral base address.
- config – Pointer to the DPI interface configuration.
- laneNum – How many lanes in use.


```
void DSI_SetCommandModeConfig(MIPI_DSI_Type *base, const dsi_command_config_t *config,
                             uint32_t phyByteClkFreq_Hz)
```

Configures the command mode configuration.

This function configures the timeout values for DSI command mode.

Parameters

- base – MIPI DSI host peripheral base address.
- config – Pointer to the command mode configuration structure.
- phyByteClkFreq_Hz – Byte clock frequency in each lane.

```
static inline void DSI_EnableCommandMode(MIPI_DSI_Type *base, bool enable)
```

Enables the command mode.

This function configures the timeout values for DSI command mode.

Parameters

- base – MIPI DSI host peripheral base address.
- enable – true to enable command mode and disable video mode, vise versa.

```
static inline void DSI_EnableVpgEnMode(MIPI_DSI_Type *base, bool enable)
```

Enables the VPG mode.

This function configures video mode pattern generator.

Parameters

- base – MIPI DSI host peripheral base address.
- enable – true to enable video mode pattern generator.

```
void DSI_GetDefaultDphyConfig(dsi_dphy_config_t *config, uint32_t phyByteClkFreq_Hz, uint8_t
                             laneNum)
```

Gets the default D-PHY configuration.

Gets the default D-PHY configuration, the timing parameters are set according to D-PHY specification. User can use the configuration directly, or change the parameters according device specific requirements.

Parameters

- config – Pointer to the D-PHY configuration.
- phyByteClkFreq_Hz – Byte clock frequency in each lane.
- laneNum – How may lanes in use.

```
void DSI_InitDphy(MIPI_DSI_Type *base, const dsi_dphy_config_t *config)
```

Initializes the D-PHY.

This function configures the D-PHY timing and setups the D-PHY PLL based on user configuration. The default configuration can be obtained by calling the function DSI_GetDefaultDphyConfig.

Parameters

- base – MIPI DSI host peripheral base address.
- config – Pointer to the D-PHY configuration.

```
void DSI_SetPacketControl(MIPI_DSI_Type *base, uint8_t flags)
```

Configures the APB packet to send.

This function configures the next APB packet transfer feature. After configuration, user can write the payload by calling DSI_WriteTxPayload then call DSI_WriteTxHeader to start the transfer or just call DSI_WriteTxHeader alone if it is a short packet.

Parameters

- base – MIPI DSI host peripheral base address.
- flags – The transfer control flags, see `ref_dsi_transfer_flags`.

```
void DSI_WriteTxHeader(MIPI_DSI_Type *base, uint16_t wordCount, uint8_t virtualChannel,  
                      dsi_tx_data_type_t dataType)
```

Writes tx header to command FIFO. This will trigger the packet transfer.

Parameters

- base – MIPI DSI host peripheral base address.
- wordCount – For long packet, this is the byte count of the payload. For short packet, this is $(data1 \ll 8) | data0$.
- virtualChannel – Virtual channel.
- dataType – The packet data type, (DI).

```
void DSI_WriteTxPayload(MIPI_DSI_Type *base, const uint8_t *payload, uint16_t payloadSize)
```

Fills the long APB packet payload.

Write the long packet payload to TX FIFO.

Parameters

- base – MIPI DSI host peripheral base address.
- payload – Pointer to the payload.
- payloadSize – Payload size in byte.

```
void DSI_WriteTxPayloadExt(MIPI_DSI_Type *base, const uint8_t *payload, uint16_t  
                          payloadSize, bool sendDcsCmd, uint8_t dcsCmd)
```

Writes payload data to generic payload FIFO.

Write the long packet payload to TX FIFO. This function could be used in two ways

- a. Include the DCS command in the 1st byte of payload. In this case, the DCS command is the first byte of payload. The parameter `sendDcsCmd` is set to false, the `dcsCmd` is not used. This function is the same as `DSI_WriteTxPayload` when used in this way.
- b. The DCS command is not in payload, but specified by parameter `dcsCmd`. In this case, the parameter `sendDcsCmd` is set to true, the `dcsCmd` is the DCS command to send. The payload is sent after `dcsCmd`.

Parameters

- base – MIPI DSI host peripheral base address.
- payload – Pointer to the payload.
- payloadSize – Payload size in byte.
- sendDcsCmd – If set to true, the DCS command is specified by `dcsCmd`, otherwise the DCS command is included in the payload.
- dcsCmd – The DCS command to send, only used when `sendDCSCmd` is true.

```
void DSI_ReadRxData(MIPI_DSI_Type *base, uint8_t *payload, uint16_t payloadSize)
```

Reads the long APB packet payload.

Read the long packet payload from RX FIFO. This function reads directly from RX FIFO status. Upper layer should make sure the whole rx packet has been received.

Parameters

- base – MIPI DSI host peripheral base address.
- payload – Pointer to the payload buffer.
- payloadSize – Payload size in byte.

status_t DSI_TransferBlocking(MIPI_DSI_Type *base, *dsi_transfer_t* *xfer)

APB data transfer using blocking method.

Perform APB data transfer using blocking method. This function waits until all data send or received, or timeout happens.

Parameters

- base – MIPI DSI host peripheral base address.
- xfer – Pointer to the transfer structure.

Return values

- kStatus_Success – Data transfer finished with no error.
- kStatus_Timeout – Transfer failed because of timeout.
- kStatus_DSI_RxDataError – RX data error, user could use ref DSI_GetRxErrorStatus to check the error details.
- kStatus_DSI_PhyError – PHY error detected during transfer.
- kStatus_DSI_ErrorReportReceived – Error Report packet received, user could use ref DSI_GetAndClearHostStatus to check the error report status.
- kStatus_DSI_NotSupported – Transfer format not supported.
- kStatus_DSI_Fail – Transfer failed for other reasons.

uint16_t Pll_Set_Hs_Freqrange(*uint32_t* bnd_width)

Lookup table method to obtain HS frequency range of operation selection override.

Parameters

- bnd_width – band width frequency in Hz

Returns

the *hsfreqrange_ovr*[6:0] value based on band width frequency in hz.

uint16_t Pll_Set_Pll_Prop_Param(*uint32_t* pll_freq_sel)

Lookup table method to obtain PLL Proportional Charge Pump control.

Parameters

- pll_freq_sel – PLL frequency in Mhz

Returns

the *pll_prop_cntrl_rw*[5:0] value based on video Pll frequency in Mhz.

uint16_t Pll_Set_Sr_Osc_Freq_Target(*uint32_t* pll_freq_sel)

Lookup table method to obtain DDL target oscillation frequency.

Parameters

- pll_freq_sel – PLL frequency in Mhz

Returns

the *sr_osc_freq_target*[11:0] value based on video Pll frequency in Mhz.

uint32_t Pll_Set_Pll_Vco_Freq(*uint32_t* pll_freq_sel)

calculate VCO frequency.

Parameters

- pll_freq_sel – PLL frequency in Hz

Returns

the vco_freq_clk value

uint16_t Pll_Set_Pll_Vco_Param(uint32_t pll_freq_sel)

Lookup table method to obtain VCO parameter.

Parameters

- pll_freq_sel – PLL frequency in Mhz

Returns

the pll_vco_cntrl_ovr_rw[5:0] value based on video Pll frequency in Mhz. If can not find suitable value, return default value 63.

void DSI_ConfigDphy(MIPI_DSI_Type *base, uint32_t phyRefClkFreq_Hz, uint32_t dataRateFreq_Hz)

config to set Dphy.

Parameters

- phyRefClkFreq_Hz – Dphy reference clock frequency in Hz
- dataRateFreq_Hz – line rate clock frequency.

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Error codes for the MIPI DSI driver.

Values:

enumerator kStatus_DSI_Busy

DSI is busy.

enumerator kStatus_DSI_EccMultiBitError

Multibit ECC error detected in rx packet.

enumerator kStatus_DSI_CrcError

CRC error detected in rx packet.

enumerator kStatus_DSI_PacketSizeError

Rx packet size error.

enumerator kStatus_DSI_EotMissingError

Received transmission does not end with an EoT packet.

enumerator kStatus_DSI_ErrorReportReceived

Error report package received.

enumerator kStatus_DSI_NotSupported

The transfer type not supported.

enumerator kStatus_DSI_PhyError

Physical layer error.

Status and interrupt mask of acknowledge error sent by device caused by host, belongs to interrupt group1. INT_ST0 bit0-bit15.

Values:

enumerator kDSI_ErrorReportSot

SoT error detected in device's acknowledge error report.

enumerator kDSI_ErrorReportSotSync

SoT Sync error detected in device's acknowledge error report.

enumerator kDSI_ErrorReportEotSync

EoT Sync error detected in device's acknowledge error report.

enumerator kDSI_ErrorReportEscEntryCmd

Escape Mode Entry Command error detected in device's acknowledge error report.

enumerator kDSI_ErrorReportLpSync

Low-power Transmit Sync error detected in device's acknowledge error report.

enumerator kDSI_ErrorReportPeriphTo

Peripheral Timeout error detected in device's acknowledge error report.

enumerator kDSI_ErrorReportFalseControl

False Control error detected in device's acknowledge error report.

enumerator kDSI_ErrorReportDeviceSpecific1

The deice specific error detected in device's acknowledge error report.

enumerator kDSI_ErrorReportEccOneBit

Single-bit ECC error detected in device's acknowledge error report.

enumerator kDSI_ErrorReportEccMultiBit

Muiti-bit ECC error detected in device's acknowledge error report.

enumerator kDSI_ErrorReportChecksum

Checksum error detected in device's acknowledge error report.

enumerator kDSI_ErrorReportDataTypeUnrecognized

DSI data type not recognized error detected in device's acknowledge error report.

enumerator kDSI_ErrorReportVcIdInvalid

Virtual channel ID invalid error detected in device's acknowledge error report.

enumerator kDSI_ErrorReportTxLengthInvalid

Invalid transmission length error detected in device's acknowledge error report.

enumerator kDSI_ErrorReportDeviceSpecific2

The deice specific error detected in device's acknowledge error report.

enumerator kDSI_ErrorReportProtocolViolation

Protocol violation error detected in device's acknowledge error report.

enumerator kDSI_ErrorReportAll

Status and interrupt mask of error in phy layer, belongs to interrupt group1. INT_ST0 bit16-bit20.

Values:

enumerator kDSI_PhyErrorEscEntry

Escape entry error from Lane 0.

enumerator kDSI_PhyErrorLpSync

Low-power data transmission synchronization error from Lane 0.

enumerator kDSI_PhyErrorControl

Control error from Lane 0.

enumerator kDSI_PhyErrorLp0Connection

LP0 connection error from Lane 0.

enumerator kDSI_PhyErrorLp1Connection

LP1 connection error from Lane 0.

enumerator kDSI_PhyErrorAll

Timeout error interrupt and status, belongs to interrupt group2. INT_ST1 bit0-bit6.

Values:

enumerator kDSI_TimeoutErrorHtx

High Speed forward TX timeout detected.

enumerator kDSI_TimeoutErrorLrx

Reverse Low power data receive timeout detected.

Host receive packet error status, belongs to interrupt group2. INT_ST1 bit0-bit6.

Values:

enumerator kDSI_RxErrorEccOneBit

ECC single bit error detected.

enumerator kDSI_RxErrorEccMultiBit

ECC multi bit error detected.

enumerator kDSI_RxErrorCrc

CRC error detected.

enumerator kDSI_RxErrorPacketSize

Packet size error detected.

enumerator kDSI_RxErrorEotMissing

Host receives a transmission that does not end with an EoT packet.

enumerator kDSI_RxErrorAll

Host receive error status, belongs to interrupt group2. INT_ST1 bit7-bit12 bit19?

Values:

enumerator kDSI_DpiPayloadFifoOverflow

During a DPI pixel line storage, the payload FIFO overflow occurs.

enumerator kDSI_GenericCommandFifoOverflow

System writes a command through the Generic interface while FIFO is full causing overflow.

enumerator kDSI_GenericPayloadFifoOverflow

System writes a payload data through the Generic interface while FIFO is full causing payload FIFO overflow.

enumerator kDSI_GenericPayloadFifoUnderflow

System writes the packet header before the packet payload is completed loaded into the payload FIFO during a packet build causing payload FIFO underflow.

enumerator kDSI_GenericReadFifoUnderflow

System requests data before it is fully received causing underflow.

enumerator kDSI_GenericReadFifoOverflow

The Read FIFO size is not correctly dimensioned for the max rx packet size causing generic read FIFO overflow.

`_dsi_dpi_package_flag` Flags for DPI package composition.

Values:

enumerator `kDSI_DpiEnableEotpTxHs`

Enables the EoTp transmission in high-speed.

enumerator `kDSI_DpiEnableEotpRx`

Enables the EoTp reception.

enumerator `kDSI_DpiEnableBta`

Enables the Bus Turn-Around (BTA) request.

enumerator `kDSI_DpiEnableEcc`

Enables the ECC reception, error correction, and reporting.

enumerator `kDSI_DpiEnableCrc`

Enables the CRC reception and error reporting.

enumerator `kDSI_DpiEnableEotpTxLp`

Enables the EoTp transmission in low-power.

enumerator `kDSI_DpiEnableAll`

enum `_dsi_operation_mode`

MIPI DSI operation mode.

Values:

enumerator `kDSI_VideoMode`

Video mode.

enumerator `kDSI_CommandMode`

Command mode.

enum `_dsi_dpi_color_coding`

MIPI DPI interface color coding.

Values:

enumerator `kDSI_DpiRGB16Bit`

16-bit configuration 1. RGB565: XXXXXXXX_RRRRRGGG_GGGBBBBB.

enumerator `kDSI_DpiRGB16BitLoose0`

16-bit configuration 2. RGB565: XXXRRRRR_XXGGGGGG_XXXBBBBB.

enumerator `kDSI_DpiRGB16BitLoose1`

16-bit configuration 3. RGB565: XXRRRRRX_XXGGGGGG_XXBBBBBX.

enumerator `kDSI_DpiRGB18Bit`

18-bit configuration 1. RGB666: XXXXXXRR_RRRRGGGG_GGBBBBBB.

enumerator `kDSI_DpiRGB18BitLoose`

18-bit configuration 2. RGB666: XXRRRRRR_XXGGGGGG_XXBBBBBB.

enumerator `kDSI_DpiRGB24Bit`

24-bit configuration. RGB888: RRRRRRRR_GGGGGGGG_BBBBBBBB.

enumerator `kDSI_DpiYCbCr20Bit`

20-bit configuration. YCbCr422 loosely packed.
 Cle1: YYYYYYYY_YYXXCbCbCbCb_CbCbCbCbCbCbXX,
 YYYYYYYY_YYXXCrCrCrCr_CrCrCrCrCrCrXX.

Cy-
Cycle2:

enumerator kDSI_DpiYCbCr24Bit

24-bit configuration. YCbCr422: CyCle1: YYYYYYYY_YYYYCbCbCbCb_CbCbCbCbCbCbCbCb,
Cycle2: YYYYYYYY_YYYYCrCrCrCr_CrCrCrCrCrCrCrCr.

enumerator kDSI_DpiYCbCr16Bit

16-bit configuration. YCbCr422 loosely packed. Cy-
Cle1: YYYYYYYY_YYXXCbCbCbCb_CbCbCbCbCbCbXX, Cycle2:
YYYYYYY_XXXXCrCrCrCr_CrCrCrCrXXXX.

enumerator kDSI_DpiRGB30Bit

30-bit configuration. RGB10.10.10: XXXRRRRR_RRRRGGGG_GGGGGGBB_BBBBBBBB.

enumerator kDSI_DpiRGB36Bit

36-bit configuration. RGB12.12.12. CyCle1: XXXXXXRR_RRRRRRRR_RRGGGGGG, Cy-
cle2: XXXXXXGG_GGGGBBBB_BBBBBBBB.

enumerator kDSI_DpiYCbCr12Bit

12-bit configuration. YCbCr420: CyCle1: Y1Y1Y1Y1Y1Y1Y1_Y0Y0Y0Y0Y0Y0Y0_CbCbCbCbCbCbCbCb
Cycle2: Y1Y1Y1Y1Y1Y1Y1Y1_Y0Y0Y0Y0Y0Y0Y0Y0_CrCrCrCrCrCrCrCr.

enumerator kDSI_DpiDcs24Bit

24-bit configuration with no specific coding.

_dsi_dpi_polarity_flag Flags for DPI signal polarity.

Values:

enumerator kDSI_DpiDataEnableActiveHigh

Data enable pin active high.

enumerator kDSI_DpiVsyncActiveHigh

VSYNC active high.

enumerator kDSI_DpiHsyncActiveHigh

HSYNC active high.

enumerator kDSI_DpiShutDownActiveHigh

Shutdown pin active high.

enumerator kDSI_DpiColorModeActiveHigh

Color mode pin active high.

enumerator kDSI_DpiDataEnableActiveLow

Data enable pin active low.

enumerator kDSI_DpiVsyncActiveLow

VSYNC active low.

enumerator kDSI_DpiHsyncActiveLow

HSYNC active low.

enumerator kDSI_DpiShutDownActiveLow

Shutdown pin active low.

enumerator kDSI_DpiColorModeActiveLow

Color mode pin active low.

enum _dsi_video_mode

DSI video mode.

Values:

enumerator kDSI_DpiNonBurstWithSyncPulse
Non-Burst mode with Sync Pulses.

enumerator kDSI_DpiNonBurstWithSyncEvent
Non-Burst mode with Sync Events.

enumerator kDSI_DpiBurst
Burst mode.

enum _dsi_video_pattern

Values:

enumerator kDSI_PatternDisable
Color bar pattern mode disabled.

enumerator kDSI_PatternVertical
Color bar pattern mode displayed vertically.

enumerator kDSI_PatternHorizontal
Color bar pattern mode displayed horizontally.

enum _dsi_tx_data_type

DSI TX data type.

Values:

enumerator kDSI_TxDataVsyncStart
V Sync start.

enumerator kDSI_TxDataVsyncEnd
V Sync end.

enumerator kDSI_TxDataHsyncStart
H Sync start.

enumerator kDSI_TxDataHsyncEnd
H Sync end.

enumerator kDSI_TxDataEoTp
End of transmission packet.

enumerator kDSI_TxDataCmOff
Color mode off.

enumerator kDSI_TxDataCmOn
Color mode on.

enumerator kDSI_TxDataShutDownPeriph
Shut down peripheral.

enumerator kDSI_TxDataTurnOnPeriph
Turn on peripheral.

enumerator kDSI_TxDataGenShortWrNoParam
Generic Short WRITE, no parameters.

enumerator kDSI_TxDataGenShortWrOneParam
Generic Short WRITE, one parameter.

enumerator kDSI_TxDataGenShortWrTwoParam
Generic Short WRITE, two parameter.

enumerator kDSI_TxDataGenShortRdNoParam
Generic Short READ, no parameters.

enumerator kDSI_TxDataGenShortRdOneParam
Generic Short READ, one parameter.

enumerator kDSI_TxDataGenShortRdTwoParam
Generic Short READ, two parameter.

enumerator kDSI_TxDataDcsShortWrNoParam
DCS Short WRITE, no parameters.

enumerator kDSI_TxDataDcsShortWrOneParam
DCS Short WRITE, one parameter.

enumerator kDSI_TxDataDcsShortRdNoParam
DCS Short READ, no parameters.

enumerator kDSI_TxDataSetMaxReturnPktSize
Set the Maximum Return Packet Size.

enumerator kDSI_TxDataNull
Null Packet, no data.

enumerator kDSI_TxDataBlanking
Blanking Packet, no data.

enumerator kDSI_TxDataGenLongWr
Generic long write.

enumerator kDSI_TxDataDcsLongWr
DCS Long Write/write_LUT Command Packet.

enumerator kDSI_TxDataLooselyPackedPixel20BitYCbCr
Loosely Packed Pixel Stream, 20-bit YCbCr, 4:2:2 Format.

enumerator kDSI_TxDataPackedPixel24BitYCbCr
Packed Pixel Stream, 24-bit YCbCr, 4:2:2 Format.

enumerator kDSI_TxDataPackedPixel16BitYCbCr
Packed Pixel Stream, 16-bit YCbCr, 4:2:2 Format.

enumerator kDSI_TxDataPackedPixel30BitRGB
Packed Pixel Stream, 30-bit RGB, 10-10-10 Format.

enumerator kDSI_TxDataPackedPixel36BitRGB
Packed Pixel Stream, 36-bit RGB, 12-12-12 Format.

enumerator kDSI_TxDataPackedPixel12BitYCrCb
Packed Pixel Stream, 12-bit YCbCr, 4:2:0 Format.

enumerator kDSI_TxDataPackedPixel16BitRGB
Packed Pixel Stream, 16-bit RGB, 5-6-5 Format.

enumerator kDSI_TxDataPackedPixel18BitRGB
Packed Pixel Stream, 18-bit RGB, 6-6-6 Format.

enumerator kDSI_TxDataLooselyPackedPixel18BitRGB
Loosely Packed Pixel Stream, 18-bit RGB, 6-6-6 Format.

enumerator kDSI_TxDataPackedPixel24BitRGB
Packed Pixel Stream, 24-bit RGB, 8-8-8 Format.

enum `_dsi_rx_data_type`

DSI RX data type.

Values:

enumerator `kDSI_RxDataAckAndErrorReport`

Acknowledge and Error Report

enumerator `kDSI_RxDataEoTp`

End of Transmission packet.

enumerator `kDSI_RxDataGenShortRdResponseOneByte`

Generic Short READ Response, 1 byte returned.

enumerator `kDSI_RxDataGenShortRdResponseTwoByte`

Generic Short READ Response, 2 byte returned.

enumerator `kDSI_RxDataGenLongRdResponse`

Generic Long READ Response.

enumerator `kDSI_RxDataDcsLongRdResponse`

DCS Long READ Response.

enumerator `kDSI_RxDataDcsShortRdResponseOneByte`

DCS Short READ Response, 1 byte returned.

enumerator `kDSI_RxDataDcsShortRdResponseTwoByte`

DCS Short READ Response, 2 byte returned.

`_dsi_transfer_flags` DSI transfer control flags.

Values:

enumerator `kDSI_TransferUseLowPower`

Use low power or not.

enumerator `kDSI_TransferPerformBTA`

Perform BTA or not at the end of a frame.

typedef enum `_dsi_operation_mode` `dsi_operation_mode_t`

MIPI DSI operation mode.

typedef struct `_dsi_config` `dsi_config_t`

MIPI DSI controller configuration.

typedef enum `_dsi_dpi_color_coding` `dsi_dpi_color_coding_t`

MIPI DPI interface color coding.

typedef enum `_dsi_video_mode` `dsi_video_mode_t`

DSI video mode.

typedef enum `_dsi_video_pattern` `dsi_video_pattern_t`

typedef struct `_dsi_dpi_config` `dsi_dpi_config_t`

MIPI DSI controller DPI interface configuration.

typedef struct `_dsi_command_config` `dsi_command_config_t`

MIPI DSI command mode configuration.

typedef struct `_dsi_dphy_config` `dsi_dphy_config_t`

MIPI DSI D-PHY configuration.

```
typedef enum _dsi_tx_data_type dsi_tx_data_type_t
```

DSI TX data type.

```
typedef enum _dsi_rx_data_type dsi_rx_data_type_t
```

DSI RX data type.

```
typedef struct _dsi_transfer dsi_transfer_t
```

Structure for the data transfer.

```
uint32_t DSI_GetInstance(MIPI_DSI_Type *base)
```

Gets the MIPI DSI host controller instance from peripheral base address.

Parameters

- base – MIPI DSI peripheral base address.

Returns

MIPI DSI instance.

TX_DPHY_TX_PLL_1

TX_DPHY_TX_PLL_5

TX_DPHY_TX_PLL_9

TX_DPHY_TX_PLL_13

TX_DPHY_TX_PLL_17

TX_DPHY_TX_PLL_22

TX_DPHY_TX_PLL_23

TX_DPHY_TX_PLL_24

TX_DPHY_TX_PLL_25

TX_DPHY_TX_PLL_27

TX_DPHY_TX_PLL_28

TX_DPHY_TX_PLL_29

TX_DPHY_TX_PLL_30

TX_DPHY_TX_PLL_31

TX_DPHY_TX_CB_0

TX_DPHY_TX_CB_1

TX_DPHY_TX_CB_2

TX_DPHY_TX_SLEW_5

TX_DPHY_TX_SLEW_6

TX_DPHY_TX_SLEW_7

TX_DPHY_TX_CLK_TERMLOWCAP

```
struct _dsi_config
```

#include <fsl_mipi_dsi.h> MIPI DSI controller configuration.

Public Members*dsi_operation_mode_t* mode

DSI operation mode. MODE_CFG[cmd_video_mode]

uint8_t packageFlags

OR'ed value of _dsi_dpi_package_flag that controls DPI package composition. PCK-HDL_CFG

bool enableNoncontinuousClk

Enables the automatic mechanism to stop providing clock in the clock lane when time allows. LPCLK_CTRL[auto_clklane_ctrl]

uint16_t HsRxDeviceReady_ByteClk

The min time the display device takes to process high-speed read from master before it can continue doing other stuff. The timer starts when D-PHY enters stop state and measured in lane byte clock. HS_RD_TO_CNT[hs_rd_to_cnt]

uint16_t lpRxDeviceReady_ByteClk

The min time the display device takes to process low-power read from master before it can continue doing other stuff. The timer starts when D-PHY enters stop state and measured in lane byte clock. LP_RD_TO_CNT[lp_rd_to_cnt]

uint16_t HsTxDeviceReady_ByteClk

The min time the display device takes to process high-speed write from master before it can continue doing other stuff. The timer starts when D-PHY enters stop state and measured in lane byte clock. HS_WR_TO_CNT[hs_wr_to_cnt]

uint16_t lpTxDeviceReady_ByteClk

The min time the display device takes to process low-power write from master before it can continue doing other stuff. The timer starts when D-PHY enters stop state and measured in lane byte clock. LP_WR_TO_CNT[lp_wr_to_cnt]

struct _dsi_dpi_config

#include <fsl_mipi_dsi.h> MIPI DSI controller DPI interface configuration.

Public Members

uint8_t virtualChannel

Virtual channel. DPI_VCID[dpi_vcid]

dsi_dpi_color_coding_t colorCoding

DPI color coding. DPI_COLOR_CODING

uint8_t polarityFlags

OR'ed value of _dsi_dpi_polarity_flag that controls signal polarity. DPI_CFG_POL

bool enablelpSwitch

Enable return to low-power inside the VSA/VBP/VFP/VACT/HBP/HFP period when timing allows. VID_MODE_CFG[bit8-13]

bool enableAck

Enable the request for an acknowledge response at the end of a frame. VID_MODE_CFG[frame_bta_ack_en]

dsi_video_mode_t videoMode

Video mode. VID_MODE_CFG[vid_mode_type]

uint16_t pixelPayloadSize

Color bar pattern. VID_MODE_CFG[vpg_orientation][vpg_en][vpg_mode=0] The number of pixels in a single video packet. For 18-bit not loosely packed data types, this number must be a multiple of 4, for YCbCr data types, it must be a multiple of 2. Recommended to set to the line size (in pixels). VID_PKT_SIZE

uint16_t vsw

Number of lines in vertical sync width. VID_VSA_LINES

uint16_t vbp

Number of lines in vertical back porch. VID_VBP_LINES

uint16_t vfp

Number of lines in vertical front porch. VID_VFP_LINES

uint16_t panelHeight

Number of lines in vertical active area. VID_VACTIVE_LINES

uint16_t hsw

Horizontal sync width, in dpi pixel clock. VID_HSA_TIME

uint16_t hbp

Horizontal back porch, in dpi pixel clock. VID_HBP_TIME

uint16_t hfp

Horizontal front porch, in dpi pixel clock. VID_HLINE_TIME = (hsw+hbp+hfp+width)

struct __dsi_command_config

#include <fsl_mipi_dsi.h> MIPI DSI command mode configuration.

Public Members

uint32_t escClkFreq_Hz

Escape clock frequency in Hz.

uint16_t lpRxTo_Ns

Timeout value that triggers a low-power reception timeout contention detection. TO_CNT_CFG[lprx_to_cnt]

uint16_t hsTxTo_Ns

Timeout value that triggers a high-speed transmission timeout contention detection. In non-burst mode, the time should be larger than 1.1 times of one frame data transmission time, in burst mode it should be one line. TO_CNT_CFG[hstx_to_cnt]

uint16_t btaTo_Ns

The time period for which MIPI DSI host keeps the link still after completing a Bus Turnaround. BTA_TO_CNT[bta_to_cnt]

struct __dsi_dphy_config

#include <fsl_mipi_dsi.h> MIPI DSI D-PHY configuration.

Public Members

uint8_t numLanes

Number of lanes. The value range is from 1-4, lane 0-3. PHY_IF_CFG[n_lanes]

uint8_t tStopState_ByteClk

Minimum time that the PHY controller stays in stop state before a HS transmission. TODO in what unit? PHY_IF_CFG[phy_stop_wait_time]

uint16_t tClkHs2Lp_ByteClk

Maximum time that the D-PHY clock lane takes to go from high-speed to low-power in lane byte clock. PHY_TMR_LPCLK_CFG[phy_clkhs2lp_time]

uint16_t tClkLp2Hs_ByteClk

Maximum time that the D-PHY clock lane takes to go from low-power to high-speed in lane byte clock. PHY_TMR_LPCLK_CFG[phy_clklp2hs_time]

uint16_t tDataHs2Lp_ByteClk

Maximum time that the D-PHY data lane takes to go from high-speed to low-power in lane byte clock. PHY_TMR_CFG[phy_hs2lp_time]

uint16_t tDataLp2Hs_ByteClk

Maximum time that the D-PHY data lane takes to go from low-power to high-speed in lane byte clock. PHY_TMR_CFG[phy_lp2hs_time]

uint16_t maxRead_ByteClk

Maximum time required to perform a read command in lane byte clock. PHY_TMR_RD_CFG[max_rd_time]

struct _dsi_transfer

#include <fsl_mipi_dsi.h> Structure for the data transfer.

Public Members

uint8_t virtualChannel

Virtual channel.

dsi_tx_data_type_t txDataType

TX data type.

uint8_t flags

Flags to control the transfer, see _dsi_transfer_flags.

const uint8_t *txData

The TX data buffer.

uint8_t *rxData

The TX data buffer.

uint16_t txDataSize

Size of the TX data.

uint16_t rxDataSize

Size of the RX data.

bool sendDcsCmd

If set to true, the DCS command is specified by dcsCmd, otherwise the DCS command is included in the txData.

uint8_t dcsCmd

The DCS command to send, only valid when sendDcsCmd is true.

2.43 MIPI_DSI: MIPI DSI Host Controller

2.44 MU: Messaging Unit

uint32_t MU_GetInstance(MU_Type *base)

Get the MU instance index.

Parameters

- base – MU peripheral base address.

Returns

MU instance index.

void MU_Init(MU_Type *base)

Initializes the MU module.

This function enables the MU clock only.

Parameters

- base – MU peripheral base address.

void MU_Deinit(MU_Type *base)

De-initializes the MU module.

This function disables the MU clock only.

Parameters

- base – MU peripheral base address.

static inline void MU_SendMsgNonBlocking(MU_Type *base, uint32_t regIndex, uint32_t msg)

Writes a message to the TX register.

This function writes a message to the specific TX register. It does not check whether the TX register is empty or not. The upper layer should make sure the TX register is empty before calling this function. This function can be used in ISR for better performance.

```
while (!(kMU_Tx0EmptyFlag & MU_GetStatusFlags(base))) { } Wait for TX0 register empty.  
MU_SendMsgNonBlocking(base, kMU_MsgReg0, MSG_VAL); Write message to the TX0 register.
```

Parameters

- base – MU peripheral base address.
- regIndex – TX register index, see `mu_msg_reg_index_t`.
- msg – Message to send.

status_t MU_SendMsg(MU_Type *base, uint32_t regIndex, uint32_t msg)

Blocks to send a message.

This function waits until the TX register is empty and sends the message. If `MU1_BUSY_POLL_COUNT` is defined and non-zero, the function will timeout after the specified number of polling iterations and returns `kStatus_Timeout`.

Parameters

- base – MU peripheral base address.
- regIndex – MU message register, see `mu_msg_reg_index_t`.
- msg – Message to send.

Return values

- `kStatus_Success` – Message sent successfully.
- `kStatus_Timeout` – Timeout occurred while waiting for TX register to be empty.

Returns

status_t


```
static inline uint32_t MU_ReceiveMsgNonBlocking(MU_Type *base, uint32_t regIndex)
```

Reads a message from the RX register.

This function reads a message from the specific RX register. It does not check whether the RX register is full or not. The upper layer should make sure the RX register is full before calling this function. This function can be used in ISR for better performance.

```
uint32_t msg;
while (!(kMU_Rx0FullFlag & MU_GetStatusFlags(base)))
{
    } Wait for the RX0 register full.

msg = MU_ReceiveMsgNonBlocking(base, kMU_MsgReg0); Read message from RX0 register.
```

Parameters

- base – MU peripheral base address.
- regIndex – RX register index, see `mu_msg_reg_index_t`.

Returns

The received message.

```
status_t MU_ReceiveMsgTimeout(MU_Type *base, uint32_t regIndex, uint32_t *readValue)
```

Blocks to receive a message with timeout protection.

This function waits until the RX register is full and receives the message. If `MU1_BUSY_POLL_COUNT` is defined and non-zero, the function will timeout after the specified number of polling iterations and return `kStatus_Timeout`.

This function provides the same blocking behavior as `MU_ReceiveMsg()` but with additional timeout protection to prevent system hangs if the other core becomes unresponsive or if hardware issues occur.

Note: Both `MU_ReceiveMsg()` and `MU_ReceiveMsgTimeout()` are blocking functions. The difference is that this function includes timeout protection while `MU_ReceiveMsg()` waits indefinitely.

Parameters

- base – MU peripheral base address.
- regIndex – RX register index, see `mu_msg_reg_index_t`.
- readValue – Pointer to store the received message.

Return values

- `kStatus_Success` – Message received successfully.
- `kStatus_InvalidArgument` – Invalid readValue pointer.
- `kStatus_Timeout` – Timeout occurred while waiting for RX register to be full.

Returns

`status_t`

```
uint32_t MU_ReceiveMsg(MU_Type *base, uint32_t regIndex)
```

Blocks to receive a message (infinite wait, no timeout protection).

This function waits until the RX register is full and receives the message. This function will wait indefinitely until a message is received.

Note: Both `MU_ReceiveMsg()` and `MU_ReceiveMsgTimeout()` are blocking functions. The difference is that `MU_ReceiveMsgTimeout()` includes timeout protection while this function waits indefinitely.

Warning: This function does not include timeout protection and may cause system hangs if the other core becomes unresponsive. For applications requiring timeout protection, use `MU_ReceiveMsgTimeout()` instead.

Parameters

- `base` – MU peripheral base address.
- `regIndex` – RX register index, see `mu_msg_reg_index_t`.

Returns

The received message.

`static inline void MU_SetFlagsNonBlocking(MU_Type *base, uint32_t flags)`

Sets the 3-bit MU flags reflect on the other MU side.

This function sets the 3-bit MU flags directly. Every time the 3-bit MU flags are changed, the status flag `kMU_FlagsUpdatingFlag` asserts indicating the 3-bit MU flags are updating to the other side. After the 3-bit MU flags are updated, the status flag `kMU_FlagsUpdatingFlag` is cleared by hardware. During the flags updating period, the flags cannot be changed. The upper layer should make sure the status flag `kMU_FlagsUpdatingFlag` is cleared before calling this function.

```
while (kMU_FlagsUpdatingFlag & MU_GetStatusFlags(base))
{
    } Wait for previous MU flags updating.
MU_SetFlagsNonBlocking(base, 0U); Set the mU flags.
```

Parameters

- `base` – MU peripheral base address.
- `flags` – The 3-bit MU flags to set.

`status_t MU_SetFlags(MU_Type *base, uint32_t flags)`

brief Blocks setting the 3-bit MU flags reflect on the other MU side.

This function blocks setting the 3-bit MU flags. Every time the 3-bit MU flags are changed, the status flag `kMU_FlagsUpdatingFlag` asserts indicating the 3-bit MU flags are updating to the other side. After the 3-bit MU flags are updated, the status flag `kMU_FlagsUpdatingFlag` is cleared by hardware. During the flags updating period, the flags cannot be changed. This function waits for the MU status flag `kMU_FlagsUpdatingFlag` cleared and sets the 3-bit MU flags.

If `MU1_BUSY_POLL_COUNT` is defined and non-zero, the function will timeout after the specified number of polling iterations and return `kStatus_Timeout`.

return `status_t` `retval` `kStatus_Success` Flags were set successfully. `retval` `kStatus_Timeout` Timeout occurred while waiting for flags to update.

Parameters

- `base` – MU peripheral base address.
- `flags` – The 3-bit MU flags to set.

static inline uint32_t MU_GetFlags(MU_Type *base)

Gets the current value of the 3-bit MU flags set by the other side.

This function gets the current 3-bit MU flags on the current side.

Parameters

- base – MU peripheral base address.

Returns

flags Current value of the 3-bit flags.

uint32_t MU_GetStatusFlags(MU_Type *base)

Gets the MU status flags.

This function returns the bit mask of the MU status flags. See `_mu_status_flags`.

```
uint32_t flags;
flags = MU_GetStatusFlags(base); Get all status flags.
if (kMU_Tx0EmptyFlag & flags)
{
    The TX0 register is empty. Message can be sent.
    MU_SendMsgNonBlocking(base, kMU_MsgReg0, MSG0_VAL);
}
if (kMU_Tx1EmptyFlag & flags)
{
    The TX1 register is empty. Message can be sent.
    MU_SendMsgNonBlocking(base, kMU_MsgReg1, MSG1_VAL);
}
```

If there are more than 4 general purpose interrupts, use `MU_GetGeneralPurposeStatusFlags`.

Parameters

- base – MU peripheral base address.

Returns

Bit mask of the MU status flags, see `_mu_status_flags`.

static inline uint32_t MU_GetInterruptsPending(MU_Type *base)

Gets the MU IRQ pending status of enabled interrupts.

This function returns the bit mask of the pending MU IRQs of enabled interrupts. Only these flags are checked. `kMU_Tx0EmptyFlag` `kMU_Tx1EmptyFlag` `kMU_Tx2EmptyFlag` `kMU_Tx3EmptyFlag` `kMU_Rx0FullFlag` `kMU_Rx1FullFlag` `kMU_Rx2FullFlag` `kMU_Rx3FullFlag` `kMU_GenInt0Flag` `kMU_GenInt1Flag` `kMU_GenInt2Flag` `kMU_GenInt3Flag`

Parameters

- base – MU peripheral base address.

Returns

Bit mask of the MU IRQs pending.

static inline void MU_ClearStatusFlags(MU_Type *base, uint32_t flags)

Clears the specific MU status flags.

This function clears the specific MU status flags. The flags to clear should be passed in as bit mask. See `_mu_status_flags`.

```
Clear general interrupt 0 and general interrupt 1 pending flags.
MU_ClearStatusFlags(base, kMU_GenInt0Flag | kMU_GenInt1Flag);
```

If there are more than 4 general purpose interrupts, use `MU_ClearGeneralPurposeStatusFlags`.

Parameters

- base – MU peripheral base address.
- flags – Bit mask of the MU status flags. See `_mu_status_flags`. Only the following flags can be cleared by software (if applicable for particular device), other flags are cleared by hardware:
 - `kMU_GenInt0Flag`
 - `kMU_GenInt1Flag`
 - `kMU_GenInt2Flag`
 - `kMU_GenInt3Flag`
 - `kMU_MuResetInterruptFlag`
 - `kMU_OtherSideEnterRunInterruptFlag`
 - `kMU_OtherSideEnterHaltInterruptFlag`
 - `kMU_OtherSideEnterWaitInterruptFlag`
 - `kMU_OtherSideEnterStopInterruptFlag`
 - `kMU_OtherSideEnterPowerDownInterruptFlag`
 - `kMU_ResetAssertInterruptFlag`
 - `kMU_HardwareResetInterruptFlag`

`static inline void MU_EnableInterrupts(MU_Type *base, uint32_t interrupts)`

Enables the specific MU interrupts.

This function enables the specific MU interrupts. The interrupts to enable should be passed in as bit mask. See `_mu_interrupt_enable`.

Enable general interrupt 0 and TX0 empty interrupt.
`MU_EnableInterrupts(base, kMU_GenInt0InterruptEnable | kMU_Tx0EmptyInterruptEnable);`

If there are more than 4 general purpose interrupts, use `MU_EnableGeneralPurposeInterrupts`.

Parameters

- base – MU peripheral base address.
- interrupts – Bit mask of the MU interrupts. See `_mu_interrupt_enable`.

`static inline void MU_DisableInterrupts(MU_Type *base, uint32_t interrupts)`

Disables the specific MU interrupts.

This function disables the specific MU interrupts. The interrupts to disable should be passed in as bit mask. See `_mu_interrupt_enable`.

Disable general interrupt 0 and TX0 empty interrupt.
`MU_DisableInterrupts(base, kMU_GenInt0InterruptEnable | kMU_Tx0EmptyInterruptEnable);`

If there are more than 4 general purpose interrupts, use `MU_DisableGeneralPurposeInterrupts`.

Parameters

- base – MU peripheral base address.
- interrupts – Bit mask of the MU interrupts. See `_mu_interrupt_enable`.

`status_t MU_TriggerInterrupts(MU_Type *base, uint32_t interrupts)`

Triggers interrupts to the other core.

This function triggers the specific interrupts to the other core. The interrupts to trigger are passed in as bit mask. See `_mu_interrupt_trigger`. The MU should not trigger an interrupt to the other core when the previous interrupt has not been processed by the other core. This function checks whether the previous interrupts have been processed. If not, it returns an error.

```
if (kStatus_Success != MU_TriggerInterrupts(base, kMU_GenInt0InterruptTrigger | kMU_
↪ GenInt2InterruptTrigger))
{
    Previous general purpose interrupt 0 or general purpose interrupt 2
    has not been processed by the other core.
}
```

If there are more than 4 general purpose interrupts, use `MU_TriggerGeneralPurposeInterrupts`.

Parameters

- `base` – MU peripheral base address.
- `interrupts` – Bit mask of the interrupts to trigger. See `_mu_interrupt_trigger`.

Return values

- `kStatus_Success` – Interrupts have been triggered successfully.
- `kStatus_Fail` – Previous interrupts have not been accepted.

`static inline void MU_EnableGeneralPurposeInterrupts(MU_Type *base, uint32_t interrupts)`

Enables the MU general purpose interrupts.

This function enables the MU general purpose interrupts. The interrupts to enable should be passed in as bit mask of `mu_general_purpose_interrupt_t`. The function `MU_EnableInterrupts` only support general interrupt 0~3, this function supports all general interrupts.

For example, to enable general purpose interrupt 0 and 3, use like this:

```
MU_EnableGeneralPurposeInterrupts(MU, kMU_GeneralPurposeInterrupt0 | kMU_
↪ GeneralPurposeInterrupt3);
```

Parameters

- `base` – MU peripheral base address.
- `interrupts` – Bit mask of the MU general purpose interrupts, see `mu_general_purpose_interrupt_t`.

`static inline void MU_DisableGeneralPurposeInterrupts(MU_Type *base, uint32_t interrupts)`

Disables the MU general purpose interrupts.

This function disables the MU general purpose interrupts. The interrupts to disable should be passed in as bit mask of `mu_general_purpose_interrupt_t`. The function `MU_DisableInterrupts` only support general interrupt 0~3, this function supports all general interrupts.

For example, to disable general purpose interrupt 0 and 3, use like this:

```
MU_EnableGeneralPurposeInterrupts(MU, kMU_GeneralPurposeInterrupt0 | kMU_
↪ GeneralPurposeInterrupt3);
```

Parameters

- base – MU peripheral base address.
- interrupts – Bit mask of the MU general purpose interrupts. see `mu_general_purpose_interrupt_t`.

static inline uint32_t MU_GetGeneralPurposeStatusFlags(MU_Type *base)

Gets the MU general purpose interrupt status flags.

This function returns the bit mask of the MU general purpose interrupt status flags. `MU_GetStatusFlags` can only get general purpose interrupt status 0~3, this function can get all general purpose interrupts status.

This example shows to check whether general purpose interrupt 0 and 3 happened.

```
uint32_t flags;
flags = MU_GetGeneralPurposeStatusFlags(base);
if (kMU_GeneralPurposeInterrupt0 & flags)
{
}
if (kMU_GeneralPurposeInterrupt3 & flags)
{
}
```

Parameters

- base – MU peripheral base address.

Returns

Bit mask of the MU general purpose interrupt status flags.

static inline void MU_ClearGeneralPurposeStatusFlags(MU_Type *base, uint32_t flags)

Clear the MU general purpose interrupt status flags.

This function clears the specific MU general purpose interrupt status flags. The flags to clear should be passed in as bit mask. `mu_general_purpose_interrupt_t_mu_status_flags`.

Example to clear general purpose interrupt 0 and general interrupt 1 pending flags.

```
MU_ClearGeneralPurposeStatusFlags(base, kMU_GeneralPurposeInterrupt0 | kMU_
↪GeneralPurposeInterrupt1);
```

Parameters

- base – MU peripheral base address.
- flags – Bit mask of the MU general purpose interrupt status flags. See `mu_general_purpose_interrupt_t`.

static inline uint32_t MU_GetRxStatusFlags(MU_Type *base)

Return the RX status flags in reverse numerical order.

This function return the RX status flags in reverse order. Note: RFn bits of SR[3-0](mu status register) are mapped in ascending numerical order: RF0 -> SR[0] RF1 -> SR[1] RF2 -> SR[2] RF3 -> SR[3] This function will return these bits in reverse numerical order(RF3->RF1) to comply with `MU_GetRxStatusFlags()` of mu driver. See `MU_GetRxStatusFlags()` from `drivers/mu/fsl_mu.h`

```
status_reg = MU_GetRxStatusFlags(base);
```

Parameters

- base – MU peripheral base address.

Returns

MU RX status flags in reverse order

status_t MU_TriggerGeneralPurposeInterrupts(MU_Type *base, uint32_t interrupts)

Triggers general purpose interrupts to the other core.

This function triggers the specific general purpose interrupts to the other core. The interrupts to trigger are passed in as bit mask. See `mu_general_purpose_interrupt_t`. The MU should not trigger an interrupt to the other core when the previous interrupt has not been processed by the other core. This function checks whether the previous interrupts have been processed. If not, it returns an error.

```
status_t status;
status = MU_TriggerGeneralPurposeInterrupts(base, kMU_GeneralPurposeInterrupt0 | kMU_
↪GeneralPurposeInterrupt2);

if (kStatus_Success != status)
{
    Previous general purpose interrupt 0 or general purpose interrupt 2
    has not been processed by the other core.
}
```

Parameters

- `base` – MU peripheral base address.
- `interrupts` – Bit mask of the interrupts to trigger. See `mu_general_purpose_interrupt_t`.

Return values

- `kStatus_Success` – Interrupts have been triggered successfully.
- `kStatus_Fail` – Previous interrupts have not been accepted.

void MU_BootOtherCore(MU_Type *base, mu_core_boot_mode_t mode)

Boots the other core.

This function boots the other core with a boot configuration.

Parameters

- `base` – MU peripheral base address.
- `mode` – The other core boot mode.

void MU_HoldOtherCoreReset(MU_Type *base)

Holds the other core reset.

This function causes the other core to be held in reset following any reset event.

Parameters

- `base` – MU peripheral base address.

static inline status_t MU_ResetBothSides(MU_Type *base)

Resets the MU for both A side and B side.

This function resets the MU for both A side and B side. Before reset, it is recommended to interrupt processor B, because this function may affect the ongoing processor B programs.

If `MU1_BUSY_POLL_COUNT` is defined and non-zero, the function will timeout after the specified number of polling iterations if waiting for the other side to come out of reset takes too long.

Note: For some platforms, only MU side A could use this function, check reference manual for details.

Parameters

- base – MU peripheral base address.

Return values

- kStatus_Success – The MU was reset successfully.
- kStatus_Timeout – Timeout occurred while waiting for the other side to come out of reset.

Returns

status_t

status_t MU_HardwareResetOtherCore(MU_Type *base, bool waitReset, bool holdReset, mu_core_boot_mode_t bootMode)

Hardware reset the other core.

This function resets the other core, the other core could mask the hardware reset by calling MU_MaskHardwareReset. The hardware reset mask feature is only available for some platforms. This function could be used together with MU_BootOtherCore to control the other core reset workflow.

If MU1_BUSY_POLL_COUNT is defined and non-zero, the function will timeout after the specified number of polling iterations and return kStatus_Timeout if waiting for the other core to enter or exit reset takes too long.

Example 1: Reset the other core, and no hold reset

```
MU_HardwareResetOtherCore(MU_A, true, false, bootMode);
```

In this example, the core at MU side B will reset with the specified boot mode.

Example 2: Reset the other core and hold it, then boot the other core later. Here the other core enters reset, and the reset is hold

```
MU_HardwareResetOtherCore(MU_A, true, true, modeDontCare);
```

Current core boot the other core when necessary.

```
MU_BootOtherCore(MU_A, bootMode);
```

Note: The feature waitReset, holdReset, and bootMode might be not supported for some platforms. waitReset is only available for platforms that FSL_FEATURE_MU_NO_CORE_STATUS not defined as 1 and FSL_FEATURE_MU_HAS_RESET_ASSERT_INT not defined as 0. holdReset is only available for platforms that FSL_FEATURE_MU_HAS_RSTH not defined as 0. bootMode is only available for platforms that FSL_FEATURE_MU_HAS_BOOT not defined as 0.

Parameters

- base – MU peripheral base address.
- waitReset – Wait the other core enters reset. Only work when there is CSSR0[RAIP].
 - true: Wait until the other core enters reset, if the other core has masked the hardware reset, then this function will be blocked.
 - false: Don't wait the reset.
- holdReset – Hold the other core reset or not. Only work when there is CCR0[RSTH].

- true: Hold the other core in reset, this function returns directly when the other core enters reset.
- false: Don't hold the other core in reset, this function waits until the other core out of reset.
- bootMode – Boot mode of the other core, if holdReset is true, this parameter is useless.

Return values

- kStatus_Success – The other core was reset successfully.
- kStatus_Timeout – Timeout occurred while waiting for the other core to enter or exit reset.

Returns

status_t

FSL_MU_DRIVER_VERSION

MU driver version.

enum _mu_status_flags

MU status flags.

Values:

enumerator kMU_Tx0EmptyFlag

TX0 empty.

enumerator kMU_Tx1EmptyFlag

TX1 empty.

enumerator kMU_Tx2EmptyFlag

TX2 empty.

enumerator kMU_Tx3EmptyFlag

TX3 empty.

enumerator kMU_Rx0FullFlag

RX0 full.

enumerator kMU_Rx1FullFlag

RX1 full.

enumerator kMU_Rx2FullFlag

RX2 full.

enumerator kMU_Rx3FullFlag

RX3 full.

enumerator kMU_GenInt0Flag

General purpose interrupt 0 pending.

enumerator kMU_GenInt1Flag

General purpose interrupt 1 pending.

enumerator kMU_GenInt2Flag

General purpose interrupt 2 pending.

enumerator kMU_GenInt3Flag

General purpose interrupt 3 pending.

enumerator kMU_RxFullPendingFlag

Any RX full flag is pending.

enumerator kMU__TxEmptyPendingFlag

Any TX empty flag is pending.

enumerator kMU__GenIntPendingFlag

Any general interrupt flag is pending.

enumerator kMU__EventPendingFlag

MU event pending.

enumerator kMU__FlagsUpdatingFlag

MU flags update is on-going.

enumerator kMU__MuInResetFlag

MU of any side is in reset.

enumerator kMU__MuResetInterruptFlag

The other side initializes MU reset.

enum __mu_interrupt_enable

MU interrupt source to enable.

Values:

enumerator kMU__Tx0EmptyInterruptEnable

TX0 empty.

enumerator kMU__Tx1EmptyInterruptEnable

TX1 empty.

enumerator kMU__Tx2EmptyInterruptEnable

TX2 empty.

enumerator kMU__Tx3EmptyInterruptEnable

TX3 empty.

enumerator kMU__Rx0FullInterruptEnable

RX0 full.

enumerator kMU__Rx1FullInterruptEnable

RX1 full.

enumerator kMU__Rx2FullInterruptEnable

RX2 full.

enumerator kMU__Rx3FullInterruptEnable

RX3 full.

enumerator kMU__GenInt0InterruptEnable

General purpose interrupt 0.

enumerator kMU__GenInt1InterruptEnable

General purpose interrupt 1.

enumerator kMU__GenInt2InterruptEnable

General purpose interrupt 2.

enumerator kMU__GenInt3InterruptEnable

General purpose interrupt 3.

enumerator kMU__MuResetInterruptEnable

The other side initializes MU reset.

enum `_mu_interrupt_trigger`

MU interrupt that could be triggered to the other core.

Values:

enumerator `kMU_GenInt0InterruptTrigger`

General purpose interrupt 0.

enumerator `kMU_GenInt1InterruptTrigger`

General purpose interrupt 1.

enumerator `kMU_GenInt2InterruptTrigger`

General purpose interrupt 2.

enumerator `kMU_GenInt3InterruptTrigger`

General purpose interrupt 3.

enum `_mu_msg_reg_index`

MU message register index.

Values:

enumerator `kMU_MsgReg0`

Message register 0.

enumerator `kMU_MsgReg1`

Message register 1.

enumerator `kMU_MsgReg2`

Message register 2.

enumerator `kMU_MsgReg3`

Message register 3.

enum `_mu_general_purpose_interrupt`

MU general purpose interrupts.

Values:

enumerator `kMU_GeneralPurposeInterrupt0`

General purpose interrupt 0

enumerator `kMU_GeneralPurposeInterrupt1`

General purpose interrupt 1

enumerator `kMU_GeneralPurposeInterrupt2`

General purpose interrupt 2

enumerator `kMU_GeneralPurposeInterrupt3`

General purpose interrupt 3

typedef enum `_mu_msg_reg_index` `mu_msg_reg_index_t`

MU message register index.

typedef enum `_mu_general_purpose_interrupt` `mu_general_purpose_interrupt_t`

MU general purpose interrupts.

`MU_CORE_INTR(intr)`

`MU_MISC_INTR(intr)`

`MU_TX_INTR(intr)`

`MU_RX_INTR(intr)`

MU_GI_INTR(*intr*)
MU_GET_CORE_INTR(*intrs*)
MU_GET_TX_INTR(*intrs*)
MU_GET_RX_INTR(*intrs*)
MU_GET_GI_INTR(*intrs*)
MU_CORE_FLAG(*flag*)
MU_STAT_FLAG(*flag*)
MU_TX_FLAG(*flag*)
MU_RX_FLAG(*flag*)
MU_GI_FLAG(*flag*)
MU_GET_CORE_FLAG(*flags*)
MU_GET_STAT_FLAG(*flags*)
MU_GET_TX_FLAG(*flags*)
MU_GET_RX_FLAG(*flags*)
MU_GET_GI_FLAG(*flags*)
MU1_BUSY_POLL_COUNT

Maximum polling iterations for MU waiting loops.

This parameter defines the maximum number of iterations for any polling loop in the MU code before timing out and returning an error.

It applies to all waiting loops in MU driver, such as waiting for TX register to be empty or waiting for RX register to be full.

This is a count of loop iterations, not a time-based value.

If defined as 0, polling loops will continue indefinitely until their exit condition is met, which could potentially cause the system to hang if a core becomes unresponsive.

2.45 OTFAD: On The Fly AES-128 Decryption Driver

void OTFAD_GetDefaultConfig(*otfad_config_t* **config*)

OTFAD module initialization function.

Parameters

- *config* – OTFAD configuration.

void OTFAD_Init(OTFAD_Type **base*, const *otfad_config_t* **config*)

OTFAD module initialization function.

Parameters

- *base* – OTFAD base address.
- *config* – OTFAD configuration.

void OTFAD_Deinit(OTFAD_Type **base*)

Deinitializes the OTFAD.

```
static inline uint32_t OTFAD_GetOperateMode(OTFAD_Type *base)
```

OTFAD module get operate mode.

Parameters

- base – OTFAD base address.

```
static inline uint32_t OTFAD_GetStatus(OTFAD_Type *base)
```

OTFAD module get status.

Parameters

- base – OTFAD base address.

```
status_t OTFAD_SetEncryptionConfig(OTFAD_Type *base, const otfad_encryption_config_t  
*config)
```

OTFAD module set encryption configuration.

Note: if enable keyblob process, the first 256 bytes external memory is use for keyblob data, so this region shouldn't be in OTFAD region.

Parameters

- base – OTFAD base address.
- config – encryption configuration.

```
status_t OTFAD_GetEncryptionConfig(OTFAD_Type *base, otfad_encryption_config_t *config)
```

OTFAD module get encryption configuration.

Note: if enable keyblob process, the first 256 bytes external memory is use for keyblob data, so this region shouldn't be in OTFAD region.

Parameters

- base – OTFAD base address.
- config – encryption configuration.

```
status_t OTFAD_HitDetermination(OTFAD_Type *base, uint32_t address, uint8_t *contextIndex)
```

OTFAD module do hit determination.

Parameters

- base – OTFAD base address.
- address – the physical address space assigned to the QuadSPI(FlexSPI) module.
- contextIndex – hitted context region index.

Returns

status, such as kStatus_Success or kStatus_OTFAD_ResRegAccessMode.

```
FSL_OTFAD_DRIVER_VERSION
```

Driver version.

Status codes for the OTFAD driver.

Values:

enumerator kStatus_OTFAD_ResRegAccessMode

Restricted register mode

enumerator kStatus_OTFAD_AddressError

End address less than start address

enumerator kStatus_OTFAD_RegionOverlap

the OTFAD does not support any form of memory region overlap, for system accesses that hit in multiple contexts or no contexts, the fetched data is simply bypassed

enumerator kStatus_OTFAD_RegionMiss

For accesses that hit in a single context, but not the selected one

OTFAD context type.

Values:

enumerator kOTFAD_Context_0

context 0

enumerator kOTFAD_Context_1

context 1

enumerator kOTFAD_Context_2

context 2

enumerator kOTFAD_Context_3

context 3

OTFAD operate mode.

Values:

enumerator kOTFAD_NRM

Normal Mode

enumerator kOTFAD_SVM

Security Violation Mode

enumerator kOTFAD_LDM

Logically Disabled Mode

typedef struct *_otfad_encryption_config* otfad_encryption_config_t

OTFAD encryption configuration structure.

typedef struct *_otfad_config* otfad_config_t

OTFAD configuration structure.

struct *_otfad_encryption_config*

#include <fsl_otfad.h> OTFAD encryption configuration structure.

Public Members

bool valid

The context is valid or not

bool AESdecryption

AES decryption enable

uint8_t readOnly

read write attribute for the entire set of context registers

uint8_t contextIndex
 OTFAD context index

uint32_t startAddr
 Start address

uint32_t endAddr
 End address

uint32_t key[4]
 Encryption key

uint32_t counter[2]
 Encryption counter

struct __otfad_config
 #include <fsl_otfad.h> OTFAD configuration structure.

Public Members

bool forceSVM
 Force entry into SVM after a write

bool forceLDM
 Force entry into LDM after a write

bool restrictedRegAccess
 Restricted register access enable

bool enableOTFAD
 OTFAD has decryption enabled

2.46 PDM: Microphone Interface

2.47 PDM Driver

void PDM_Init(PDM_Type *base, const *pdm_config_t* *config)

Initializes the PDM peripheral.

Ungates the PDM clock, resets the module, and configures PDM with a configuration structure. The configuration structure can be custom filled or set with default values by PDM_GetDefaultConfig().

Note: This API should be called at the beginning of the application to use the PDM driver. Otherwise, accessing the PDM module can cause a hard fault because the clock is not enabled.

Parameters

- base – PDM base pointer
- config – PDM configuration structure.

`void PDM_Deinit(PDM_Type *base)`

De-initializes the PDM peripheral.

This API gates the PDM clock. The PDM module can't operate unless PDM_Init is called to enable the clock.

Parameters

- base – PDM base pointer

`static inline void PDM_Reset(PDM_Type *base)`

Resets the PDM module.

Parameters

- base – PDM base pointer

`static inline void PDM_Enable(PDM_Type *base, bool enable)`

Enables/disables PDM interface.

Parameters

- base – PDM base pointer
- enable – True means PDM interface is enabled, false means PDM interface is disabled.

`static inline void PDM_EnableDebugMode(PDM_Type *base, bool enable)`

Enables/disables debug mode for PDM. The PDM interface cannot enter debug mode once in Disable/Low Leakage or Low Power mode.

Parameters

- base – PDM base pointer
- enable – True means PDM interface enter debug mode, false means PDM interface in normal mode.

`static inline void PDM_EnableInDebugMode(PDM_Type *base, bool enable)`

Enables/disables PDM interface in debug mode.

Parameters

- base – PDM base pointer
- enable – True means PDM interface is enabled debug mode, false means PDM interface is disabled after after completing the current frame in debug mode.

`static inline void PDM_EnterLowLeakageMode(PDM_Type *base, bool enable)`

Enables/disables PDM interface disable/Low Leakage mode.

Parameters

- base – PDM base pointer
- enable – True means PDM interface is in disable/low leakage mode, False means PDM interface is in normal mode.

`static inline void PDM_EnableChannel(PDM_Type *base, uint8_t channel, bool enable)`

Enables/disables the PDM channel.

Parameters

- base – PDM base pointer
- channel – PDM channel number need to enable or disable.
- enable – True means enable PDM channel, false means disable.


```
void PDM_SetChannelConfig(PDM_Type *base, uint32_t channel, const pdm_channel_config_t
                        *config)
```

PDM one channel configurations.

Parameters

- base – PDM base pointer
- config – PDM channel configurations.
- channel – channel number. after completing the current frame in debug mode.

```
status_t PDM_SetSampleRateConfig(PDM_Type *base, uint32_t sourceClock_HZ, uint32_t
                                sampleRate_HZ)
```

PDM set sample rate.

Note: This function is depend on the configuration of the PDM and PDM channel, so the correct call sequence is

```
PDM_Init(base, pdmConfig)
PDM_SetChannelConfig(base, channel, &channelConfig)
PDM_SetSampleRateConfig(base, source, sampleRate)
```

Parameters

- base – PDM base pointer
- sourceClock_HZ – PDM source clock frequency.
- sampleRate_HZ – PDM sample rate.

```
status_t PDM_SetSampleRate(PDM_Type *base, uint32_t enableChannelMask,
                            pdm_df_quality_mode_t qualityMode, uint8_t osr, uint32_t clkDiv)
```

PDM set sample rate.

Deprecated:

Do not use this function. It has been superceded by PDM_SetSampleRateConfig

Parameters

- base – PDM base pointer
- enableChannelMask – PDM channel enable mask.
- qualityMode – quality mode.
- osr – cic oversample rate
- clkDiv – clock divider

```
uint32_t PDM_GetInstance(PDM_Type *base)
```

Get the instance number for PDM.

Parameters

- base – PDM base pointer.

```
static inline uint32_t PDM_GetStatus(PDM_Type *base)
```

Gets the PDM internal status flag. Use the Status Mask in `_pdm_internal_status` to get the status value needed.

Parameters

- base – PDM base pointer

Returns

PDM status flag value.

```
static inline uint32_t PDM_GetFifoStatus(PDM_Type *base)
```

Gets the PDM FIFO status flag. Use the Status Mask in `_pdm_fifo_status` to get the status value needed.

Parameters

- base – PDM base pointer

Returns

FIFO status.

```
static inline uint32_t PDM_GetRangeStatus(PDM_Type *base)
```

Gets the PDM Range status flag. Use the Status Mask in `_pdm_range_status` to get the status value needed.

Parameters

- base – PDM base pointer

Returns

output status.

```
static inline void PDM_ClearStatus(PDM_Type *base, uint32_t mask)
```

Clears the PDM Tx status.

Parameters

- base – PDM base pointer
- mask – State mask. It can be a combination of the status between `kPDM_StatusFrequencyLow` and `kPDM_StatusCh7FifoDataAvaliable`.

```
static inline void PDM_ClearFIFOStatus(PDM_Type *base, uint32_t mask)
```

Clears the PDM Tx status.

Parameters

- base – PDM base pointer
- mask – State mask. It can be a combination of the status in `_pdm_fifo_status`.

```
static inline void PDM_ClearRangeStatus(PDM_Type *base, uint32_t mask)
```

Clears the PDM range status.

Parameters

- base – PDM base pointer
- mask – State mask. It can be a combination of the status in `_pdm_range_status`.

```
void PDM_EnableInterrupts(PDM_Type *base, uint32_t mask)
```

Enables the PDM interrupt requests.

Parameters

- base – PDM base pointer
- mask – interrupt source The parameter can be a combination of the following sources if defined.
 - `kPDM_ErrorInterruptEnable`
 - `kPDM_FIFOInterruptEnable`

```
static inline void PDM_DisableInterrupts(PDM_Type *base, uint32_t mask)
```

Disables the PDM interrupt requests.

Parameters

- base – PDM base pointer
- mask – interrupt source The parameter can be a combination of the following sources if defined.
 - kPDM_ErrorInterruptEnable
 - kPDM_FIFOInterruptEnable

```
static inline void PDM_EnableDMA(PDM_Type *base, bool enable)
```

Enables/disables the PDM DMA requests.

Parameters

- base – PDM base pointer
- enable – True means enable DMA, false means disable DMA.

```
static inline uint32_t PDM_GetDataRegisterAddress(PDM_Type *base, uint32_t channel)
```

Gets the PDM data register address.

This API is used to provide a transfer address for the PDM DMA transfer configuration.

Parameters

- base – PDM base pointer.
- channel – Which data channel used.

Returns

data register address.

```
void PDM_ReadFifo(PDM_Type *base, uint32_t startChannel, uint32_t channelNums, void  
                 *buffer, size_t size, uint32_t dataWidth)
```

PDM read fifo.

Note: : This function support 16 bit only for IP version that only supports 16bit.

Parameters

- base – PDM base pointer.
- startChannel – start channel number.
- channelNums – total enabled channelnums.
- buffer – received buffer address.
- size – number of samples to read.
- dataWidth – sample width.

```
void PDM_SetChannelGain(PDM_Type *base, uint32_t channel, pdm_df_output_gain_t gain)
```

Set the PDM channel gain.

Please note for different quality mode, the valid gain value is different, reference RM for detail.

Parameters

- base – PDM base pointer.
- channel – PDM channel index.

- gain – channel gain, the register gain value range is 0 - 15.

```
void PDM_TransferCreateHandle(PDM_Type *base, pdm_handle_t *handle,  
                             pdm_transfer_callback_t callback, void *userData)
```

Initializes the PDM handle.

This function initializes the handle for the PDM transactional APIs. Call this function once to get the handle initialized.

Parameters

- base – PDM base pointer.
- handle – PDM handle pointer.
- callback – Pointer to the user callback function.
- userData – User parameter passed to the callback function.

```
status_t PDM_TransferSetChannelConfig(PDM_Type *base, pdm_handle_t *handle, uint32_t  
                                     channel, const pdm_channel_config_t *config, uint32_t  
                                     format)
```

PDM set channel transfer config.

Parameters

- base – PDM base pointer.
- handle – PDM handle pointer.
- channel – PDM channel.
- config – channel config.
- format – data format, support data width configurations, *pdm_data_width*.

Return values

kStatus_PDM_ChannelConfig_Failed – or *kStatus_Success*.

```
status_t PDM_TransferReceiveNonBlocking(PDM_Type *base, pdm_handle_t *handle,  
                                         pdm_transfer_t *xfer)
```

Performs an interrupt non-blocking receive transfer on PDM.

Note: This API returns immediately after the transfer initiates. Call the *PDM_RxGetTransferStatusIRQ* to poll the transfer status and check whether the transfer is finished. If the return status is not *kStatus_PDM_Busy*, the transfer is finished.

Parameters

- base – PDM base pointer
- handle – Pointer to the *pdm_handle_t* structure which stores the transfer state.
- xfer – Pointer to the *pdm_transfer_t* structure.

Return values

- *kStatus_Success* – Successfully started the data receive.
- *kStatus_PDM_Busy* – Previous receive still not finished.

```
void PDM_TransferAbortReceive(PDM_Type *base, pdm_handle_t *handle)
```

Aborts the current IRQ receive.

Note: This API can be called when an interrupt non-blocking transfer initiates to abort the transfer early.

Parameters

- base – PDM base pointer
- handle – Pointer to the `pdm_handle_t` structure which stores the transfer state.

`void PDM_TransferHandleIRQ(PDM_Type *base, pdm_handle_t *handle)`

Tx interrupt handler.

Parameters

- base – PDM base pointer.
- handle – Pointer to the `pdm_handle_t` structure.

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PDM return status.

Values:

enumerator `kStatus_PDM_Busy`

PDM is busy.

enumerator `kStatus_PDM_CLK_LOW`

PDM clock frequency low

enumerator `kStatus_PDM_FIFO_ERROR`

PDM FIFO underrun or overflow

enumerator `kStatus_PDM_QueueFull`

PDM FIFO underrun or overflow

enumerator `kStatus_PDM_Idle`

PDM is idle

enumerator `kStatus_PDM_Output_ERROR`

PDM is output error

enumerator `kStatus_PDM_ChannelConfig_Failed`

PDM channel config failed

enum `_pdm_interrupt_enable`

The PDM interrupt enable flag.

Values:

enumerator `kPDM_ErrorInterruptEnable`

PDM channel error interrupt enable.

enumerator `kPDM_FIFOInterruptEnable`

PDM channel FIFO interrupt

enum `_pdm_internal_status`

The PDM status.

Values:

enumerator kPDM_StatusDfBusyFlag
Decimation filter is busy processing data

enumerator kPDM_StatusFrequencyLow
Mic app clock frequency not high enough

enumerator kPDM_StatusCh0FifoDataAvaliable
channel 0 fifo data reached watermark level

enumerator kPDM_StatusCh1FifoDataAvaliable
channel 1 fifo data reached watermark level

enumerator kPDM_StatusCh2FifoDataAvaliable
channel 2 fifo data reached watermark level

enumerator kPDM_StatusCh3FifoDataAvaliable
channel 3 fifo data reached watermark level

enum _pdm_channel_enable_mask

PDM channel enable mask.

Values:

enumerator kPDM_EnableChannel0
channgel 0 enable mask

enumerator kPDM_EnableChannel1
channgel 1 enable mask

enumerator kPDM_EnableChannel2
channgel 2 enable mask

enumerator kPDM_EnableChannel3
channgel 3 enable mask

enumerator kPDM_EnableChannelAll

enum _pdm_fifo_status

The PDM fifo status.

Values:

enumerator kPDM_FifoStatusUnderflowCh0
channel0 fifo status underflow

enumerator kPDM_FifoStatusUnderflowCh1
channel1 fifo status underflow

enumerator kPDM_FifoStatusUnderflowCh2
channel2 fifo status underflow

enumerator kPDM_FifoStatusUnderflowCh3
channel3 fifo status underflow

enumerator kPDM_FifoStatusOverflowCh0
channel0 fifo status overflow

enumerator kPDM_FifoStatusOverflowCh1
channel1 fifo status overflow

enumerator kPDM_FifoStatusOverflowCh2
channel2 fifo status overflow

enumerator kPDM_FifoStatusOverflowCh3
channel3 fifo status overflow

enum __pdm_range_status

The PDM output status.

Values:

enumerator kPDM_RangeStatusUnderFlowCh0
channel0 range status underflow

enumerator kPDM_RangeStatusUnderFlowCh1
channel1 range status underflow

enumerator kPDM_RangeStatusUnderFlowCh2
channel2 range status underflow

enumerator kPDM_RangeStatusUnderFlowCh3
channel3 range status underflow

enumerator kPDM_RangeStatusOverFlowCh0
channel0 range status overflow

enumerator kPDM_RangeStatusOverFlowCh1
channel1 range status overflow

enumerator kPDM_RangeStatusOverFlowCh2
channel2 range status overflow

enumerator kPDM_RangeStatusOverFlowCh3
channel3 range status overflow

enum __pdm_dc_removal

PDM DC removal configurations.

Values:

enumerator kPDM_DcRemovalCutOff20Hz
DC removal cut off 20HZ

enumerator kPDM_DcRemovalCutOff13Hz
DC removal cut off 13.3HZ

enumerator kPDM_DcRemovalCutOff40Hz
DC removal cut off 40HZ

enumerator kPDM_DcRemovalBypass
DC removal bypass

enum __pdm_df_quality_mode

PDM decimation filter quality mode.

Values:

enumerator kPDM_QualityModeMedium
quality mode medium

enumerator kPDM_QualityModeHigh
quality mode high

enumerator kPDM_QualityModeLow
quality mode low

enumerator kPDM_QualityModeVeryLow0
quality mode very low0

enumerator kPDM_QualityModeVeryLow1
quality mode very low1

enumerator kPDM_QualityModeVeryLow2
quality mode very low2

enum __pdm_qulaity__mode_k_factor
PDM quality mode K factor.

Values:

enumerator kPDM_QualityModeHighKFactor
high quality mode K factor = 1 / 2

enumerator kPDM_QualityModeMediumKFactor
medium/very low0 quality mode K factor = 2 / 2

enumerator kPDM_QualityModeLowKFactor
low/very low1 quality mode K factor = 4 / 2

enumerator kPDM_QualityModeVeryLow2KFactor
very low2 quality mode K factor = 8 / 2

enum __pdm_df_output_gain
PDM decimation filter output gain.

Values:

enumerator kPDM_DfOutputGain0
Decimation filter output gain 0

enumerator kPDM_DfOutputGain1
Decimation filter output gain 1

enumerator kPDM_DfOutputGain2
Decimation filter output gain 2

enumerator kPDM_DfOutputGain3
Decimation filter output gain 3

enumerator kPDM_DfOutputGain4
Decimation filter output gain 4

enumerator kPDM_DfOutputGain5
Decimation filter output gain 5

enumerator kPDM_DfOutputGain6
Decimation filter output gain 6

enumerator kPDM_DfOutputGain7
Decimation filter output gain 7

enumerator kPDM_DfOutputGain8
Decimation filter output gain 8

enumerator kPDM_DfOutputGain9
Decimation filter output gain 9

enumerator kPDM_DfOutputGain10
Decimation filter output gain 10


```

    enumerator kPDM_DfOutputGain11
        Decimation filter output gain 11
    enumerator kPDM_DfOutputGain12
        Decimation filter output gain 12
    enumerator kPDM_DfOutputGain13
        Decimation filter output gain 13
    enumerator kPDM_DfOutputGain14
        Decimation filter output gain 14
    enumerator kPDM_DfOutputGain15
        Decimation filter output gain 15
enum __pdm_data_width
    PDM data width.
    Values:
    enumerator kPDM_DataWwidth24
        PDM data width 24bit
    enumerator kPDM_DataWwidth32
        PDM data width 32bit
typedef enum __pdm_dc_removal pdm_dc_removal_t
    PDM DC remover configurations.
typedef enum __pdm_df_quality_mode pdm_df_quality_mode_t
    PDM decimation filter quality mode.
typedef enum __pdm_df_output_gain pdm_df_output_gain_t
    PDM decimation filter output gain.
typedef struct __pdm_channel_config pdm_channel_config_t
    PDM channel configurations.
typedef struct __pdm_config pdm_config_t
    PDM user configuration structure.
typedef struct __pdm_transfer pdm_transfer_t
    PDM SDMA transfer structure.
typedef struct __pdm_handle pdm_handle_t
    PDM handle.
typedef void (*pdm_transfer_callback_t)(PDM_Type *base, pdm_handle_t *handle, status_t
status, void *userData)
    PDM transfer callback prototype.
PDM_XFER_QUEUE_SIZE
    PDM XFER QUEUE SIZE.
struct __pdm_channel_config
    #include <fsl_pdm.h> PDM channel configurations.

```

Public Members

```

pdm_dc_removal_t outputCutOffFreq
    PDM output DC remover cut off frequency

```

pdm_df_output_gain_t gain
Decimation Filter Output Gain

struct __pdm_config
#include <fsl_pdm.h> PDM user configuration structure.

Public Members

bool enableDoze
This module will enter disable/low leakage mode if DOZEN is active with ipg_doze is asserted

bool enableFilterBypass
Switchable bypass path for the decimation filter

uint8_t fifoWatermark
Watermark value for FIFO

pdm_df_quality_mode_t qualityMode
Quality mode

uint8_t cicOverSampleRate
CIC filter over sampling rate

struct __pdm_transfer
#include <fsl_pdm.h> PDM SDMA transfer structure.

Public Members

volatile uint8_t *data
Data start address to transfer.

volatile size_t dataSize
Total Transfer bytes size.

struct __pdm_handle
#include <fsl_pdm.h> PDM handle structure.

Public Members

uint32_t state
Transfer status

pdm_transfer_callback_t callback
Callback function called at transfer event

void *userData
Callback parameter passed to callback function

pdm_transfer_t pdmQueue[(4U)]
Transfer queue storing queued transfer

size_t transferSize[(4U)]
Data bytes need to transfer

volatile uint8_t queueUser
Index for user to queue transfer

`volatile uint8_t queueDriver`
Index for driver to get the transfer data and size

`uint32_t format`
data format

`uint8_t watermark`
Watermark value

`uint8_t startChannel`
end channel

`uint8_t channelNums`
Enabled channel number

2.48 PDM EDMA Driver

`void PDM_TransferInstallEDMATCDMemory(pdm_edma_handle_t *handle, void *tcdAddr, size_t tcdNum)`

Install EDMA descriptor memory.

Parameters

- `handle` – Pointer to EDMA channel transfer handle.
- `tcdAddr` – EDMA head descriptor address.
- `tcdNum` – EDMA link descriptor address.

`void PDM_TransferCreateHandleEDMA(PDM_Type *base, pdm_edma_handle_t *handle, pdm_edma_callback_t callback, void *userData, edma_handle_t *dmaHandle)`

Initializes the PDM Rx eDMA handle.

This function initializes the PDM slave DMA handle, which can be used for other PDM master transactional APIs. Usually, for a specified PDM instance, call this API once to get the initialized handle.

Parameters

- `base` – PDM base pointer.
- `handle` – PDM eDMA handle pointer.
- `callback` – Pointer to user callback function.
- `userData` – User parameter passed to the callback function.
- `dmaHandle` – eDMA handle pointer, this handle shall be static allocated by users.

`void PDM_TransferSetMultiChannelInterleaveType(pdm_edma_handle_t *handle, pdm_edma_multi_channel_interleave_t multiChannelInterleaveType)`

Initializes the multi PDM channel interleave type.

This function initializes the PDM DMA handle member `interleaveType`, it shall be called only when application would like to use type `kPDM_EDMAMultiChannelInterleavePerChannelBlock`, since the default `interleaveType` is `kPDM_EDMAMultiChannelInterleavePerChannelSample` always

Parameters

- `handle` – PDM eDMA handle pointer.

- multiChannelInterleaveType – Multi channel interleave type.

```
void PDM_TransferSetChannelConfigEDMA(PDM_Type *base, pdm_edma_handle_t *handle,
                                       uint32_t channel, const pdm_channel_config_t
                                       *config)
```

Configures the PDM channel.

Parameters

- base – PDM base pointer.
- handle – PDM eDMA handle pointer.
- channel – channel index.
- config – pdm channel configurations.

```
status_t PDM_TransferReceiveEDMA(PDM_Type *base, pdm_edma_handle_t *handle,
                                  pdm_edma_transfer_t *xfer)
```

Performs a non-blocking PDM receive using eDMA.

Mcaro MCUX_SDK_PDM_EDMA_PDM_ENABLE_INTERNAL can control whether PDM is enabled internally or externally.

- a. Scatter gather case: This function support dynamic scatter gather and static scatter gather, a. for the dynamic scatter gather case: Application should call PDM_TransferReceiveEDMA function continuously to make sure new receive request is submit before the previous one finish. b. for the static scatter gather case: Application should use the link transfer feature and make sure a loop link transfer is provided, such as:

```
pdm_edma_transfer_t pdmXfer[2] =
{
    {
        .data = s_buffer,
        .dataSize = BUFFER_SIZE,
        .linkTransfer = &pdmXfer[1],
    },
    {
        .data = &s_buffer[BUFFER_SIZE],
        .dataSize = BUFFER_SIZE,
        .linkTransfer = &pdmXfer[0]
    },
};
```

- b. Multi channel case: This function support receive multi pdm channel data, for example, if two channel is requested,

```
PDM_TransferSetChannelConfigEDMA(DEMO_PDM, &s_pdmRxHandle_0, DEMO_PDM_
↳ENABLE_CHANNEL_0, &channelConfig);
PDM_TransferSetChannelConfigEDMA(DEMO_PDM, &s_pdmRxHandle_0, DEMO_PDM_
↳ENABLE_CHANNEL_1, &channelConfig);
PDM_TransferReceiveEDMA(DEMO_PDM, &s_pdmRxHandle_0, pdmXfer);
```

The output data will be formatted as below if handle->interleaveType =

Note: This interface returns immediately after the transfer initiates. Call the PDM_GetReceiveRemainingBytes to poll the transfer status and check whether the PDM transfer is finished.

`void PDM_TransferTerminateReceiveEDMA(PDM_Type *base, pdm_edma_handle_t *handle)`
 Terminate all PDM receive.

This function will clear all transfer slots buffered in the pdm queue. If users only want to abort the current transfer slot, please call `PDM_TransferAbortReceiveEDMA`.

Parameters

- base – PDM base pointer.
- handle – PDM eDMA handle pointer.

`void PDM_TransferAbortReceiveEDMA(PDM_Type *base, pdm_edma_handle_t *handle)`
 Aborts a PDM receive using eDMA.

This function only aborts the current transfer slots, the other transfer slots' information still kept in the handler. If users want to terminate all transfer slots, just call `PDM_TransferTerminateReceiveEDMA`.

Parameters

- base – PDM base pointer
- handle – PDM eDMA handle pointer.

`status_t PDM_TransferGetReceiveCountEDMA(PDM_Type *base, pdm_edma_handle_t *handle, size_t *count)`

Gets byte count received by PDM.

Parameters

- base – PDM base pointer
- handle – PDM eDMA handle pointer.
- count – Bytes count received by PDM.

Return values

- `kStatus_Success` – Succeed get the transfer count.
- `kStatus_NoTransferInProgress` – There is no non-blocking transaction in progress.

`FSL_PDM_EDMA_DRIVER_VERSION`
 Version 2.6.5

`enum _pdm_edma_multi_channel_interleave`
 pdm multi channel interleave type

Values:

enumerator `kPDM_EDMAMultiChannelInterleavePerChannelSample`

enumerator `kPDM_EDMAMultiChannelInterleavePerChannelBlock`

`typedef struct _pdm_edma_handle` `pdm_edma_handle_t`
 PDM edma handler.

`typedef enum _pdm_edma_multi_channel_interleave` `pdm_edma_multi_channel_interleave_t`
 pdm multi channel interleave type

`typedef struct _pdm_edma_transfer` `pdm_edma_transfer_t`
 PDM edma transfer.

`typedef void (*pdm_edma_callback_t)(PDM_Type *base, pdm_edma_handle_t *handle, status_t status, void *userData)`

PDM eDMA transfer callback function for finish and error.

MCUX_SDK_PDM_EDMA_PDM_ENABLE_INTERNAL

the PDM enable position When calling PDM_TransferReceiveEDMA

struct __pdm_edma_transfer

#include <fsl_pdm_edma.h> PDM edma transfer.

Public Members

volatile uint8_t *data

Data start address to transfer.

volatile size_t dataSize

Total Transfer bytes size.

struct *_pdm_edma_transfer* *linkTransfer

linked transfer configurations

struct __pdm_edma_handle

#include <fsl_pdm_edma.h> PDM DMA transfer handle, users should not touch the content of the handle.

Public Members

edma_handle_t *dmaHandle

DMA handler for PDM send

uint8_t count

The transfer data count in a DMA request

uint32_t receivedBytes

total transfer count

uint32_t state

Internal state for PDM eDMA transfer

pdm_edma_callback_t callback

Callback for users while transfer finish or error occurs

bool isLoopTransfer

loop transfer

void *userData

User callback parameter

edma_tcd_t *tcd

TCD pool for eDMA transfer.

uint32_t tcdNum

TCD number

uint32_t tcdUser

Index for user to queue transfer.

uint32_t tcdDriver

Index for driver to get the transfer data and size

volatile uint32_t tcdUsedNum

Index for user to queue transfer.

pdm_edma_multi_channel_interleave_t interleaveType
multi channel transfer interleave type

uint8_t endChannel
The last enabled channel

uint8_t channelNums
total channel numbers

2.49 RGPIO: Rapid General-Purpose Input/Output Driver

FSL_RGPIODRIVER_VERSION

RGPIO driver version 2.2.0.

enum _rgpio_pin_direction

RGPIO direction definition.

Values:

enumerator kRGPIO_DigitalInput

Set current pin as digital input

enumerator kRGPIO_DigitalOutput

Set current pin as digital output

enum _rgpio_checker_attribute

RGPIO checker attribute.

Values:

enumerator kRGPIO_UsernonsecureRWUsersecureRWPrivilegedsecureRW

User nonsecure:Read+Write; User Secure:Read+Write; Privileged Secure:Read+Write

enumerator kRGPIO_UsernonsecureRUsersecureRWPrivilegedsecureRW

User nonsecure:Read; User Secure:Read+Write; Privileged Secure:Read+Write

enumerator kRGPIO_UsernonsecureNUsersecureRWPrivilegedsecureRW

User nonsecure:None; User Secure:Read+Write; Privileged Secure:Read+Write

enumerator kRGPIO_UsernonsecureRUsersecureRPrivilegedsecureRW

User nonsecure:Read; User Secure:Read; Privileged Secure:Read+Write

enumerator kRGPIO_UsernonsecureNUsersecureRPrivilegedsecureRW

User nonsecure:None; User Secure:Read; Privileged Secure:Read+Write

enumerator kRGPIO_UsernonsecureNUsersecureNPrivilegedsecureRW

User nonsecure:None; User Secure:None; Privileged Secure:Read+Write

enumerator kRGPIO_UsernonsecureNUsersecureNPrivilegedsecureR

User nonsecure:None; User Secure:None; Privileged Secure:Read

enumerator kRGPIO_UsernonsecureNUsersecureNPrivilegedsecureN

User nonsecure:None; User Secure:None; Privileged Secure:None

enumerator kRGPIO_IgnoreAttributeCheck

Ignores the attribute check

enum _rgpio_interrupt_sel

Configures the interrupt generation condition.

Values:

enumerator kRGPIO_InterruptOutput0
Interrupt/DMA request/trigger output 0.

enumerator kRGPIO_InterruptOutput1
Interrupt/DMA request/trigger output 1.

enumerator kRGPIO_InterruptOutput2
Interrupt/DMA request/trigger output 2.

enumerator kRGPIO_InterruptOutput3
Interrupt/DMA request/trigger output 3.

enum _rgpio_interrupt_config
Configures the interrupt generation condition.

Values:

enumerator kRGPIO_InterruptOrDMADisabled
Interrupt/DMA request is disabled.

enumerator kRGPIO_DMARisingEdge
DMA request on rising edge.

enumerator kRGPIO_DMAFallingEdge
DMA request on falling edge.

enumerator kRGPIO_DMAEitherEdge
DMA request on either edge.

enumerator kRGPIO_FlagRisingEdge
Flag sets on rising edge.

enumerator kRGPIO_FlagFallingEdge
Flag sets on falling edge.

enumerator kRGPIO_FlagEitherEdge
Flag sets on either edge.

enumerator kRGPIO_InterruptLogicZero
Interrupt when logic zero.

enumerator kRGPIO_InterruptRisingEdge
Interrupt on rising edge.

enumerator kRGPIO_InterruptFallingEdge
Interrupt on falling edge.

enumerator kRGPIO_InterruptEitherEdge
Interrupt on either edge.

enumerator kRGPIO_InterruptLogicOne
Interrupt when logic one.

enumerator kRGPIO_ActiveHighTriggerOutputEnable
Enable active high-trigger output.

enumerator kRGPIO_ActiveLowTriggerOutputEnable
Enable active low-trigger output.

typedef enum _rgpio_pin_direction rgpio_pin_direction_t
RGPIO direction definition.


```
typedef enum _rgpio_checker_attribute rgpio_checker_attribute_t
```

RGPIO checker attribute.

```
typedef enum _rgpio_interrupt_sel rgpio_interrupt_sel_t
```

Configures the interrupt generation condition.

```
typedef enum _rgpio_interrupt_config rgpio_interrupt_config_t
```

Configures the interrupt generation condition.

```
typedef struct _rgpio_pin_config rgpio_pin_config_t
```

The RGPIO pin configuration structure.

Each pin can only be configured as either an output pin or an input pin at a time. If configured as an input pin, leave the outputConfig unused. Note that in some use cases, the corresponding port property should be configured in advance with the PORT_SetPinConfig().

```
struct _rgpio_pin_config
```

#include <fsl_rgpio.h> The RGPIO pin configuration structure.

Each pin can only be configured as either an output pin or an input pin at a time. If configured as an input pin, leave the outputConfig unused. Note that in some use cases, the corresponding port property should be configured in advance with the PORT_SetPinConfig().

Public Members

```
rgpio_pin_direction_t pinDirection
```

RGPIO direction, input or output

```
uint8_t outputLogic
```

Set a default output logic, which has no use in input

2.50 RGPIO Driver

```
void RGPIO_PinInit(RGPIO_Type *base, uint32_t pin, const rgpio_pin_config_t *config)
```

Initializes a RGPIO pin used by the board.

To initialize the RGPIO, define a pin configuration, as either input or output, in the user file. Then, call the RGPIO_PinInit() function.

This is an example to define an input pin or an output pin configuration.

```
Define a digital input pin configuration,
rgpio_pin_config_t config =
{
    kRGPIO_DigitalInput,
    0,
}
Define a digital output pin configuration,
rgpio_pin_config_t config =
{
    kRGPIO_DigitalOutput,
    0,
}
```

Parameters

- base – RGPIO peripheral base pointer (RGPIOA, RGPIOB, RGPIOC, and so on.)
- pin – RGPIO port pin number

- config – RGPIO pin configuration pointer

uint32_t RGPIO_GetInstance(RGPIO_Type *base)

Gets the RGPIO instance according to the RGPIO base.

Parameters

- base – RGPIO peripheral base pointer(PTA, PTB, PTC, etc.)

Return values

RGPIO – instance

static inline *rgpio_pin_direction_t* RGPIO_GetPinDirection(RGPIO_Type *base, uint32_t pin)

Gets the current direction of a RGPIO pin.

Parameters

- base – RGPIO peripheral base pointer (RGPIOA, RGPIOB, RGPIOC, and so on.)
- pin – RGPIO port pin number

Return values

RGPIO – pin direction

- kRGPIO_DigitalInput: pin is configured as digital input.
- kRGPIO_DigitalOutput: pin is configured as digital output.

static inline void RGPIO_PinWrite(RGPIO_Type *base, uint32_t pin, uint8_t output)

Sets the output level of the multiple RGPIO pins to the logic 1 or 0.

Parameters

- base – RGPIO peripheral base pointer (RGPIOA, RGPIOB, RGPIOC, and so on.)
- pin – RGPIO pin number
- output – RGPIO pin output logic level.
 - 0: corresponding pin output low-logic level.
 - 1: corresponding pin output high-logic level.

static inline void RGPIO_WritePinOutput(RGPIO_Type *base, uint32_t pin, uint8_t output)

Sets the output level of the multiple RGPIO pins to the logic 1 or 0.

Deprecated:

Do not use this function. It has been superceded by RGPIO_PinWrite.

static inline void RGPIO_PortSet(RGPIO_Type *base, uint32_t mask)

Sets the output level of the multiple RGPIO pins to the logic 1.

Parameters

- base – RGPIO peripheral base pointer (RGPIOA, RGPIOB, RGPIOC, and so on.)
- mask – RGPIO pin number macro

static inline void RGPIO_SetPinsOutput(RGPIO_Type *base, uint32_t mask)

Sets the output level of the multiple RGPIO pins to the logic 1.

Deprecated:

Do not use this function. It has been superceded by RGPIO_PortSet.

static inline void RGPIO_PortClear(RGPIO_Type *base, uint32_t mask)

Sets the output level of the multiple RGPIO pins to the logic 0.

Parameters

- base – RGPIO peripheral base pointer (RGPIOA, RGPIOB, RGPIOC, and so on.)
- mask – RGPIO pin number macro

static inline void RGPIO_ClearPinsOutput(RGPIO_Type *base, uint32_t mask)

Sets the output level of the multiple RGPIO pins to the logic 0.

Deprecated:

Do not use this function. It has been superceded by RGPIO_PortClear.

Parameters

- base – RGPIO peripheral base pointer (RGPIOA, RGPIOB, RGPIOC, and so on.)
- mask – RGPIO pin number macro

static inline void RGPIO_PortToggle(RGPIO_Type *base, uint32_t mask)

Reverses the current output logic of the multiple RGPIO pins.

Parameters

- base – RGPIO peripheral base pointer (RGPIOA, RGPIOB, RGPIOC, and so on.)
- mask – RGPIO pin number macro

static inline void RGPIO_TogglePinsOutput(RGPIO_Type *base, uint32_t mask)

Reverses the current output logic of the multiple RGPIO pins.

Deprecated:

Do not use this function. It has been superceded by RGPIO_PortToggle.

static inline uint32_t RGPIO_PinRead(RGPIO_Type *base, uint32_t pin)

Reads the current input value of the RGPIO port.

Parameters

- base – RGPIO peripheral base pointer (RGPIOA, RGPIOB, RGPIOC, and so on.)
- pin – RGPIO pin number

Return values

RGPIO – port input value

- 0: corresponding pin input low-logic level.
- 1: corresponding pin input high-logic level.

static inline uint32_t RGPIO_ReadPinInput(RGPIO_Type *base, uint32_t pin)

Reads the current input value of the RGPIO port.

Deprecated:

Do not use this function. It has been superceded by RGPIO_PinRead.

```
static inline void RGPIO__EnablePortInput(RGPIO_Type *base, uint32_t mask, bool enable)
```

Parameters

- base – RGPIO peripheral base pointer (RGPIOA, RGPIOB, RGPIOC, and so on.)
- mask – RGPIO pin number mask
- enable – RGPIO digital input enable/disable flag.

```
void RGPIO__CheckAttributeBytes(RGPIO_Type *base, rgpio_checker_attribute_t attribute)
```

The RGPIO module supports a device-specific number of data ports, organized as 32-bit words. Each 32-bit data port includes a GACR register, which defines the byte-level attributes required for a successful access to the RGPIO programming model. The attribute controls for the 4 data bytes in the GACR follow a standard little endian data convention.

Parameters

- base – RGPIO peripheral base pointer (RGPIOA, RGPIOB, RGPIOC, and so on.)
- mask – RGPIO pin number macro

```
static inline void RGPIO__SetPinInterruptConfig(RGPIO_Type *base, uint32_t pin,  
                                                rgpio_interrupt_sel_t sel,  
                                                rgpio_interrupt_config_t config)
```

Configures the gpio pin interrupt/DMA request.

Parameters

- base – RGPIO peripheral base pointer.
- pin – RGPIO pin number.
- sel – RGPIO pin interrupt selection(0-3).
- config – RGPIO pin interrupt configuration.

```
static inline void __SetMultipleInterruptPinsConfig(RGPIO_Type *base, uint32_t mask,  
                                                  rgpio_interrupt_sel_t sel,  
                                                  rgpio_interrupt_config_t config)
```

Sets the gpio interrupt configuration in ICR register for multiple pins.

Parameters

- base – RGPIO peripheral base pointer (RGPIOA, RGPIOB, RGPIOC, and so on.)
- mask – RGPIO pin number macro.
- sel – RGPIO pin interrupt selection(0-3).
- config – RGPIO pin interrupt configuration.

```
static inline uint32_t RGPIO__GetPinsInterruptFlags(RGPIO_Type *base, rgpio_interrupt_sel_t sel)
```

Reads the whole gpio status flag.

If a pin is configured to generate the DMA request, the corresponding flag is cleared automatically at the completion of the requested DMA transfer. Otherwise, the flag remains set until a logic one is written to that flag. If configured for a level sensitive interrupt that remains asserted, the flag is set again immediately.

Parameters

- base – RGPIO peripheral base pointer.
- sel – RGPIO pin interrupt selection(0-3).

Returns

Current gpio interrupt status flags, for example, 0x00010001 means the pin 0 and 16 have the interrupt.

```
static inline void RGPIO_ClearPinsInterruptFlags(RGPIO_Type *base, rgpio_interrupt_sel_t sel,
                                                uint32_t mask)
```

Clears the multiple pin interrupt status flag.

Parameters

- base – RGPIO peripheral base pointer.
- sel – RGPIO pin interrupt selection(0-3).
- mask – RGPIO pin number macro.

2.51 SAI: Serial Audio Interface

2.52 SAI Driver

```
void SAI_Init(I2S_Type *base)
```

Initializes the SAI peripheral.

This API gates the SAI clock. The SAI module can't operate unless SAI_Init is called to enable the clock.

Parameters

- base – SAI base pointer.

```
void SAI_Deinit(I2S_Type *base)
```

De-initializes the SAI peripheral.

This API gates the SAI clock. The SAI module can't operate unless SAI_TxInit or SAI_RxInit is called to enable the clock.

Parameters

- base – SAI base pointer.

```
void SAI_TxReset(I2S_Type *base)
```

Resets the SAI Tx.

This function enables the software reset and FIFO reset of SAI Tx. After reset, clear the reset bit.

Parameters

- base – SAI base pointer

```
void SAI_RxReset(I2S_Type *base)
```

Resets the SAI Rx.

This function enables the software reset and FIFO reset of SAI Rx. After reset, clear the reset bit.

Parameters

- base – SAI base pointer

```
void SAI_TxEnable(I2S_Type *base, bool enable)
```

Enables/disables the SAI Tx.

Parameters

- base – SAI base pointer.
- enable – True means enable SAI Tx, false means disable.

void SAI_RxEnable(I2S_Type *base, bool enable)

Enables/disables the SAI Rx.

Parameters

- base – SAI base pointer.
- enable – True means enable SAI Rx, false means disable.

static inline void SAI_TxSetBitClockDirection(I2S_Type *base, *sai_master_slave_t* masterSlave)

Set Rx bit clock direction.

Select bit clock direction, master or slave.

Parameters

- base – SAI base pointer.
- masterSlave – reference *sai_master_slave_t*.

static inline void SAI_RxSetBitClockDirection(I2S_Type *base, *sai_master_slave_t* masterSlave)

Set Rx bit clock direction.

Select bit clock direction, master or slave.

Parameters

- base – SAI base pointer.
- masterSlave – reference *sai_master_slave_t*.

static inline void SAI_RxSetFrameSyncDirection(I2S_Type *base, *sai_master_slave_t* masterSlave)

Set Rx frame sync direction.

Select frame sync direction, master or slave.

Parameters

- base – SAI base pointer.
- masterSlave – reference *sai_master_slave_t*.

static inline void SAI_TxSetFrameSyncDirection(I2S_Type *base, *sai_master_slave_t* masterSlave)

Set Tx frame sync direction.

Select frame sync direction, master or slave.

Parameters

- base – SAI base pointer.
- masterSlave – reference *sai_master_slave_t*.

void SAI_TxSetBitClockRate(I2S_Type *base, uint32_t sourceClockHz, uint32_t sampleRate, uint32_t bitWidth, uint32_t channelNumbers)

Transmitter bit clock rate configurations.

Parameters

- base – SAI base pointer.
- sourceClockHz – Bit clock source frequency.
- sampleRate – Audio data sample rate.
- bitWidth – Audio data bitWidth.
- channelNumbers – Audio channel numbers.

```
void SAI_RxSetBitClockRate(I2S_Type *base, uint32_t sourceClockHz, uint32_t sampleRate,  
                           uint32_t bitWidth, uint32_t channelNumbers)
```

Receiver bit clock rate configurations.

Parameters

- base – SAI base pointer.
- sourceClockHz – Bit clock source frequency.
- sampleRate – Audio data sample rate.
- bitWidth – Audio data bitWidth.
- channelNumbers – Audio channel numbers.

```
void SAI_TxSetBitclockConfig(I2S_Type *base, sai_master_slave_t masterSlave, sai_bit_clock_t  
                             *config)
```

Transmitter Bit clock configurations.

Parameters

- base – SAI base pointer.
- masterSlave – master or slave.
- config – bit clock other configurations, can be NULL in slave mode.

```
void SAI_RxSetBitclockConfig(I2S_Type *base, sai_master_slave_t masterSlave, sai_bit_clock_t  
                             *config)
```

Receiver Bit clock configurations.

Parameters

- base – SAI base pointer.
- masterSlave – master or slave.
- config – bit clock other configurations, can be NULL in slave mode.

```
void SAI_SetMasterClockConfig(I2S_Type *base, sai_master_clock_t *config)
```

Master clock configurations.

Parameters

- base – SAI base pointer.
- config – master clock configurations.

```
void SAI_TxSetFifoConfig(I2S_Type *base, sai_fifo_t *config)
```

SAI transmitter fifo configurations.

Parameters

- base – SAI base pointer.
- config – fifo configurations.

```
void SAI_RxSetFifoConfig(I2S_Type *base, sai_fifo_t *config)
```

SAI receiver fifo configurations.

Parameters

- base – SAI base pointer.
- config – fifo configurations.

```
void SAI_TxSetFrameSyncConfig(I2S_Type *base, sai_master_slave_t masterSlave,  
                             sai_frame_sync_t *config)
```

SAI transmitter Frame sync configurations.

Parameters

- base – SAI base pointer.
- masterSlave – master or slave.
- config – frame sync configurations, can be NULL in slave mode.

```
void SAI_RxSetFrameSyncConfig(I2S_Type *base, sai_master_slave_t masterSlave,  
                             sai_frame_sync_t *config)
```

SAI receiver Frame sync configurations.

Parameters

- base – SAI base pointer.
- masterSlave – master or slave.
- config – frame sync configurations, can be NULL in slave mode.

```
void SAI_TxSetSerialDataConfig(I2S_Type *base, sai_serial_data_t *config)
```

SAI transmitter Serial data configurations.

Parameters

- base – SAI base pointer.
- config – serial data configurations.

```
void SAI_RxSetSerialDataConfig(I2S_Type *base, sai_serial_data_t *config)
```

SAI receiver Serial data configurations.

Parameters

- base – SAI base pointer.
- config – serial data configurations.

```
void SAI_TxSetConfig(I2S_Type *base, sai_transceiver_t *config)
```

SAI transmitter configurations.

Parameters

- base – SAI base pointer.
- config – transmitter configurations.

```
void SAI_RxSetConfig(I2S_Type *base, sai_transceiver_t *config)
```

SAI receiver configurations.

Parameters

- base – SAI base pointer.
- config – receiver configurations.

```
void SAI_GetClassicI2SConfig(sai_transceiver_t *config, sai_word_width_t bitWidth,  
                             sai_mono_stereo_t mode, uint32_t saiChannelMask)
```

Get classic I2S mode configurations.

Parameters

- config – transceiver configurations.
- bitWidth – audio data bitWidth.
- mode – audio data channel.

- `saiChannelMask` – mask value of the channel to be enable.

```
void SAI_GetLeftJustifiedConfig(sai_transceiver_t *config, sai_word_width_t bitWidth,
                               sai_mono_stereo_t mode, uint32_t saiChannelMask)
```

Get left justified mode configurations.

Parameters

- `config` – transceiver configurations.
- `bitWidth` – audio data bitWidth.
- `mode` – audio data channel.
- `saiChannelMask` – mask value of the channel to be enable.

```
void SAI_GetRightJustifiedConfig(sai_transceiver_t *config, sai_word_width_t bitWidth,
                                 sai_mono_stereo_t mode, uint32_t saiChannelMask)
```

Get right justified mode configurations.

Parameters

- `config` – transceiver configurations.
- `bitWidth` – audio data bitWidth.
- `mode` – audio data channel.
- `saiChannelMask` – mask value of the channel to be enable.

```
void SAI_GetTDMConfig(sai_transceiver_t *config, sai_frame_sync_len_t frameSyncWidth,
                     sai_word_width_t bitWidth, uint32_t dataWordNum, uint32_t
                     saiChannelMask)
```

Get TDM mode configurations.

Parameters

- `config` – transceiver configurations.
- `frameSyncWidth` – length of frame sync.
- `bitWidth` – audio data word width.
- `dataWordNum` – word number in one frame.
- `saiChannelMask` – mask value of the channel to be enable.

```
void SAI_GetDSPConfig(sai_transceiver_t *config, sai_frame_sync_len_t frameSyncWidth,
                     sai_word_width_t bitWidth, sai_mono_stereo_t mode, uint32_t
                     saiChannelMask)
```

Get DSP mode configurations.

DSP/PCM MODE B configuration flow for TX. RX is similiar but uses `SAI_RxSetConfig` instead of `SAI_TxSetConfig`:

```
SAI_GetDSPConfig(config, kSAI_FrameSyncLenOneBitClk, bitWidth, kSAI_Stereo, channelMask)
SAI_TxSetConfig(base, config)
```

Note: DSP mode is also called PCM mode which support MODE A and MODE B, DSP/PCM MODE A configuration flow. RX is similiar but uses `SAI_RxSetConfig` instead of `SAI_TxSetConfig`:

```
SAI_GetDSPConfig(config, kSAI_FrameSyncLenOneBitClk, bitWidth, kSAI_Stereo, channelMask)
config->frameSync.frameSyncEarly = true;
SAI_TxSetConfig(base, config)
```

Parameters

- config – transceiver configurations.
- frameSyncWidth – length of frame sync.
- bitWidth – audio data bitWidth.
- mode – audio data channel.
- saiChannelMask – mask value of the channel to enable.

```
static inline uint32_t SAI_TxGetStatusFlag(I2S_Type *base)
```

Gets the SAI Tx status flag state.

Parameters

- base – SAI base pointer

Returns

SAI Tx status flag value. Use the Status Mask to get the status value needed.

```
static inline void SAI_TxClearStatusFlags(I2S_Type *base, uint32_t mask)
```

Clears the SAI Tx status flag state.

Parameters

- base – SAI base pointer
- mask – State mask. It can be a combination of the following source if defined:
 - kSAI_WordStartFlag
 - kSAI_SyncErrorFlag
 - kSAI_FIFOErrorFlag

```
static inline uint32_t SAI_RxGetStatusFlag(I2S_Type *base)
```

Gets the SAI Tx status flag state.

Parameters

- base – SAI base pointer

Returns

SAI Rx status flag value. Use the Status Mask to get the status value needed.

```
static inline void SAI_RxClearStatusFlags(I2S_Type *base, uint32_t mask)
```

Clears the SAI Rx status flag state.

Parameters

- base – SAI base pointer
- mask – State mask. It can be a combination of the following sources if defined.
 - kSAI_WordStartFlag
 - kSAI_SyncErrorFlag
 - kSAI_FIFOErrorFlag

```
void SAI_TxSoftwareReset(I2S_Type *base, sai_reset_type_t resetType)
```

Do software reset or FIFO reset .

FIFO reset means clear all the data in the FIFO, and make the FIFO pointer both to 0. Software reset means clear the Tx internal logic, including the bit clock, frame count etc. But

software reset will not clear any configuration registers like TCR1~TCR5. This function will also clear all the error flags such as FIFO error, sync error etc.

Parameters

- base – SAI base pointer
- resetType – Reset type, FIFO reset or software reset

void SAI_RxSoftwareReset(I2S_Type *base, *sai_reset_type_t* resetType)

Do software reset or FIFO reset .

FIFO reset means clear all the data in the FIFO, and make the FIFO pointer both to 0. Software reset means clear the Rx internal logic, including the bit clock, frame count etc. But software reset will not clear any configuration registers like RCR1~RCR5. This function will also clear all the error flags such as FIFO error, sync error etc.

Parameters

- base – SAI base pointer
- resetType – Reset type, FIFO reset or software reset

void SAI_TxSetChannelFIFOMask(I2S_Type *base, uint8_t mask)

Set the Tx channel FIFO enable mask.

Parameters

- base – SAI base pointer
- mask – Channel enable mask, 0 means all channel FIFO disabled, 1 means channel 0 enabled, 3 means both channel 0 and channel 1 enabled.

void SAI_RxSetChannelFIFOMask(I2S_Type *base, uint8_t mask)

Set the Rx channel FIFO enable mask.

Parameters

- base – SAI base pointer
- mask – Channel enable mask, 0 means all channel FIFO disabled, 1 means channel 0 enabled, 3 means both channel 0 and channel 1 enabled.

void SAI_TxSetDataOrder(I2S_Type *base, *sai_data_order_t* order)

Set the Tx data order.

Parameters

- base – SAI base pointer
- order – Data order MSB or LSB

void SAI_RxSetDataOrder(I2S_Type *base, *sai_data_order_t* order)

Set the Rx data order.

Parameters

- base – SAI base pointer
- order – Data order MSB or LSB

void SAI_TxSetBitClockPolarity(I2S_Type *base, *sai_clock_polarity_t* polarity)

Set the Tx data order.

Parameters

- base – SAI base pointer
- polarity –

void SAI_RxSetBitClockPolarity(I2S_Type *base, *sai_clock_polarity_t* polarity)

Set the Rx data order.

Parameters

- base – SAI base pointer
- polarity –

void SAI_TxSetFrameSyncPolarity(I2S_Type *base, *sai_clock_polarity_t* polarity)

Set the Tx data order.

Parameters

- base – SAI base pointer
- polarity –

void SAI_RxSetFrameSyncPolarity(I2S_Type *base, *sai_clock_polarity_t* polarity)

Set the Rx data order.

Parameters

- base – SAI base pointer
- polarity –

void SAI_TxSetFIFOPacking(I2S_Type *base, *sai_fifo_packing_t* pack)

Set Tx FIFO packing feature.

Parameters

- base – SAI base pointer.
- pack – FIFO pack type. It is element of *sai_fifo_packing_t*.

void SAI_RxSetFIFOPacking(I2S_Type *base, *sai_fifo_packing_t* pack)

Set Rx FIFO packing feature.

Parameters

- base – SAI base pointer.
- pack – FIFO pack type. It is element of *sai_fifo_packing_t*.

static inline void SAI_TxSetFIFOErrorContinue(I2S_Type *base, bool isEnabled)

Set Tx FIFO error continue.

FIFO error continue mode means SAI will keep running while FIFO error occurred. If this feature not enabled, SAI will hang and users need to clear FEF flag in TCSR register.

Parameters

- base – SAI base pointer.
- isEnabled – Is FIFO error continue enabled, true means enable, false means disable.

static inline void SAI_RxSetFIFOErrorContinue(I2S_Type *base, bool isEnabled)

Set Rx FIFO error continue.

FIFO error continue mode means SAI will keep running while FIFO error occurred. If this feature not enabled, SAI will hang and users need to clear FEF flag in RCSR register.

Parameters

- base – SAI base pointer.
- isEnabled – Is FIFO error continue enabled, true means enable, false means disable.

```
static inline void SAI_TxEnableInterrupts(I2S_Type *base, uint32_t mask)
```

Enables the SAI Tx interrupt requests.

Parameters

- `base` – SAI base pointer
- `mask` – interrupt source The parameter can be a combination of the following sources if defined.
 - `kSAI_WordStartInterruptEnable`
 - `kSAI_SyncErrorInterruptEnable`
 - `kSAI_FIFOWarningInterruptEnable`
 - `kSAI_FIFORequestInterruptEnable`
 - `kSAI_FIFOErrorInterruptEnable`

```
static inline void SAI_RxEnableInterrupts(I2S_Type *base, uint32_t mask)
```

Enables the SAI Rx interrupt requests.

Parameters

- `base` – SAI base pointer
- `mask` – interrupt source The parameter can be a combination of the following sources if defined.
 - `kSAI_WordStartInterruptEnable`
 - `kSAI_SyncErrorInterruptEnable`
 - `kSAI_FIFOWarningInterruptEnable`
 - `kSAI_FIFORequestInterruptEnable`
 - `kSAI_FIFOErrorInterruptEnable`

```
static inline void SAI_TxDisableInterrupts(I2S_Type *base, uint32_t mask)
```

Disables the SAI Tx interrupt requests.

Parameters

- `base` – SAI base pointer
- `mask` – interrupt source The parameter can be a combination of the following sources if defined.
 - `kSAI_WordStartInterruptEnable`
 - `kSAI_SyncErrorInterruptEnable`
 - `kSAI_FIFOWarningInterruptEnable`
 - `kSAI_FIFORequestInterruptEnable`
 - `kSAI_FIFOErrorInterruptEnable`

```
static inline void SAI_RxDisableInterrupts(I2S_Type *base, uint32_t mask)
```

Disables the SAI Rx interrupt requests.

Parameters

- `base` – SAI base pointer
- `mask` – interrupt source The parameter can be a combination of the following sources if defined.
 - `kSAI_WordStartInterruptEnable`
 - `kSAI_SyncErrorInterruptEnable`

- kSAI_FIFOWarningInterruptEnable
- kSAI_FIFORequestInterruptEnable
- kSAI_FIFOErrorInterruptEnable

static inline void SAI_TxEnableDMA(I2S_Type *base, uint32_t mask, bool enable)

Enables/disables the SAI Tx DMA requests.

Parameters

- base – SAI base pointer
- mask – DMA source The parameter can be combination of the following sources if defined.
 - kSAI_FIFOWarningDMAEnable
 - kSAI_FIFORequestDMAEnable
- enable – True means enable DMA, false means disable DMA.

static inline void SAI_RxEnableDMA(I2S_Type *base, uint32_t mask, bool enable)

Enables/disables the SAI Rx DMA requests.

Parameters

- base – SAI base pointer
- mask – DMA source The parameter can be a combination of the following sources if defined.
 - kSAI_FIFOWarningDMAEnable
 - kSAI_FIFORequestDMAEnable
- enable – True means enable DMA, false means disable DMA.

static inline uintptr_t SAI_TxGetDataRegisterAddress(I2S_Type *base, uint32_t channel)

Gets the SAI Tx data register address.

This API is used to provide a transfer address for the SAI DMA transfer configuration.

Parameters

- base – SAI base pointer.
- channel – Which data channel used.

Returns

data register address.

static inline uintptr_t SAI_RxGetDataRegisterAddress(I2S_Type *base, uint32_t channel)

Gets the SAI Rx data register address.

This API is used to provide a transfer address for the SAI DMA transfer configuration.

Parameters

- base – SAI base pointer.
- channel – Which data channel used.

Returns

data register address.

void SAI_WriteBlocking(I2S_Type *base, uint32_t channel, uint32_t bitWidth, uint8_t *buffer, uint32_t size)

Sends data using a blocking method.

Note: This function blocks by polling until data is ready to be sent.

Parameters

- base – SAI base pointer.
- channel – Data channel used.
- bitWidth – How many bits in an audio word; usually 8/16/24/32 bits.
- buffer – Pointer to the data to be written.
- size – Bytes to be written.

```
void SAI_WriteMultiChannelBlocking(I2S_Type *base, uint32_t channel, uint32_t channelMask,  
                                  uint32_t bitWidth, uint8_t *buffer, uint32_t size)
```

Sends data to multi channel using a blocking method.

Note: This function blocks by polling until data is ready to be sent.

Parameters

- base – SAI base pointer.
- channel – Data channel used.
- channelMask – channel mask.
- bitWidth – How many bits in an audio word; usually 8/16/24/32 bits.
- buffer – Pointer to the data to be written.
- size – Bytes to be written.

```
static inline void SAI_WriteData(I2S_Type *base, uint32_t channel, uint32_t data)
```

Writes data into SAI FIFO.

Parameters

- base – SAI base pointer.
- channel – Data channel used.
- data – Data needs to be written.

```
void SAI_ReadBlocking(I2S_Type *base, uint32_t channel, uint32_t bitWidth, uint8_t *buffer,  
                     uint32_t size)
```

Receives data using a blocking method.

Note: This function blocks by polling until data is ready to be sent.

Parameters

- base – SAI base pointer.
- channel – Data channel used.
- bitWidth – How many bits in an audio word; usually 8/16/24/32 bits.
- buffer – Pointer to the data to be read.
- size – Bytes to be read.

```
void SAI_ReadMultiChannelBlocking(I2S_Type *base, uint32_t channel, uint32_t channelMask,  
                                uint32_t bitWidth, uint8_t *buffer, uint32_t size)
```

Receives multi channel data using a blocking method.

Note: This function blocks by polling until data is ready to be sent.

Parameters

- base – SAI base pointer.
- channel – Data channel used.
- channelMask – channel mask.
- bitWidth – How many bits in an audio word; usually 8/16/24/32 bits.
- buffer – Pointer to the data to be read.
- size – Bytes to be read.

```
static inline uint32_t SAI_ReadData(I2S_Type *base, uint32_t channel)
```

Reads data from the SAI FIFO.

Parameters

- base – SAI base pointer.
- channel – Data channel used.

Returns

Data in SAI FIFO.

```
void SAI_TransferTxCreateHandle(I2S_Type *base, sai_handle_t *handle, sai_transfer_callback_t  
                              callback, void *userData)
```

Initializes the SAI Tx handle.

This function initializes the Tx handle for the SAI Tx transactional APIs. Call this function once to get the handle initialized.

Parameters

- base – SAI base pointer
- handle – SAI handle pointer.
- callback – Pointer to the user callback function.
- userData – User parameter passed to the callback function

```
void SAI_TransferRxCreateHandle(I2S_Type *base, sai_handle_t *handle, sai_transfer_callback_t  
                              callback, void *userData)
```

Initializes the SAI Rx handle.

This function initializes the Rx handle for the SAI Rx transactional APIs. Call this function once to get the handle initialized.

Parameters

- base – SAI base pointer.
- handle – SAI handle pointer.
- callback – Pointer to the user callback function.
- userData – User parameter passed to the callback function.

`void SAI_TransferTxSetConfig(I2S_Type *base, sai_handle_t *handle, sai_transceiver_t *config)`
SAI transmitter transfer configurations.

This function initializes the Tx, include bit clock, frame sync, master clock, serial data and fifo configurations.

Parameters

- base – SAI base pointer.
- handle – SAI handle pointer.
- config – transmitter configurations.

`void SAI_TransferRxSetConfig(I2S_Type *base, sai_handle_t *handle, sai_transceiver_t *config)`
SAI receiver transfer configurations.

This function initializes the Rx, include bit clock, frame sync, master clock, serial data and fifo configurations.

Parameters

- base – SAI base pointer.
- handle – SAI handle pointer.
- config – receiver configurations.

`status_t SAI_TransferSendNonBlocking(I2S_Type *base, sai_handle_t *handle, sai_transfer_t *xfer)`

Performs an interrupt non-blocking send transfer on SAI.

Note: This API returns immediately after the transfer initiates. Call the `SAI_TxGetTransferStatusIRQ` to poll the transfer status and check whether the transfer is finished. If the return status is not `kStatus_SAI_Busy`, the transfer is finished.

Parameters

- base – SAI base pointer.
- handle – Pointer to the `sai_handle_t` structure which stores the transfer state.
- xfer – Pointer to the `sai_transfer_t` structure.

Return values

- `kStatus_Success` – Successfully started the data receive.
- `kStatus_SAI_TxBusy` – Previous receive still not finished.
- `kStatus_InvalidArgument` – The input parameter is invalid.

`status_t SAI_TransferReceiveNonBlocking(I2S_Type *base, sai_handle_t *handle, sai_transfer_t *xfer)`

Performs an interrupt non-blocking receive transfer on SAI.

Note: This API returns immediately after the transfer initiates. Call the `SAI_RxGetTransferStatusIRQ` to poll the transfer status and check whether the transfer is finished. If the return status is not `kStatus_SAI_Busy`, the transfer is finished.

Parameters

- base – SAI base pointer

- `handle` – Pointer to the `sai_handle_t` structure which stores the transfer state.
- `xfer` – Pointer to the `sai_transfer_t` structure.

Return values

- `kStatus_Success` – Successfully started the data receive.
- `kStatus_SAI_RxBusy` – Previous receive still not finished.
- `kStatus_InvalidArgument` – The input parameter is invalid.

`status_t` SAI_TransferGetSendCount(I2S_Type *base, *sai_handle_t* *handle, size_t *count)

Gets a set byte count.

Parameters

- `base` – SAI base pointer.
- `handle` – Pointer to the `sai_handle_t` structure which stores the transfer state.
- `count` – Bytes count sent.

Return values

- `kStatus_Success` – Succeed get the transfer count.
- `kStatus_NoTransferInProgress` – There is not a non-blocking transaction currently in progress.

`status_t` SAI_TransferGetReceiveCount(I2S_Type *base, *sai_handle_t* *handle, size_t *count)

Gets a received byte count.

Parameters

- `base` – SAI base pointer.
- `handle` – Pointer to the `sai_handle_t` structure which stores the transfer state.
- `count` – Bytes count received.

Return values

- `kStatus_Success` – Succeed get the transfer count.
- `kStatus_NoTransferInProgress` – There is not a non-blocking transaction currently in progress.

`void` SAI_TransferAbortSend(I2S_Type *base, *sai_handle_t* *handle)

Aborts the current send.

Note: This API can be called any time when an interrupt non-blocking transfer initiates to abort the transfer early.

Parameters

- `base` – SAI base pointer.
- `handle` – Pointer to the `sai_handle_t` structure which stores the transfer state.

void SAI_TransferAbortReceive(I2S_Type *base, sai_handle_t *handle)

Aborts the current IRQ receive.

Note: This API can be called when an interrupt non-blocking transfer initiates to abort the transfer early.

Parameters

- base – SAI base pointer
- handle – Pointer to the sai_handle_t structure which stores the transfer state.

void SAI_TransferTerminateSend(I2S_Type *base, sai_handle_t *handle)

Terminate all SAI send.

This function will clear all transfer slots buffered in the sai queue. If users only want to abort the current transfer slot, please call SAI_TransferAbortSend.

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.

void SAI_TransferTerminateReceive(I2S_Type *base, sai_handle_t *handle)

Terminate all SAI receive.

This function will clear all transfer slots buffered in the sai queue. If users only want to abort the current transfer slot, please call SAI_TransferAbortReceive.

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.

void SAI_TransferTxHandleIRQ(I2S_Type *base, sai_handle_t *handle)

Tx interrupt handler.

Parameters

- base – SAI base pointer.
- handle – Pointer to the sai_handle_t structure.

void SAI_TransferRxHandleIRQ(I2S_Type *base, sai_handle_t *handle)

Tx interrupt handler.

Parameters

- base – SAI base pointer.
- handle – Pointer to the sai_handle_t structure.

void SAI_DriverIRQHandler(uint32_t instance)

SAI driver IRQ handler common entry.

This function provides the common IRQ request entry for SAI.

Parameters

- instance – SAI instance.

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`_sai_status_t`, SAI return status.

Values:

enumerator `kStatus_SAI_TxBusy`

SAI Tx is busy.

enumerator `kStatus_SAI_RxBusy`

SAI Rx is busy.

enumerator `kStatus_SAI_TxError`

SAI Tx FIFO error.

enumerator `kStatus_SAI_RxError`

SAI Rx FIFO error.

enumerator `kStatus_SAI_QueueFull`

SAI transfer queue is full.

enumerator `kStatus_SAI_TxIdle`

SAI Tx is idle

enumerator `kStatus_SAI_RxIdle`

SAI Rx is idle

`_sai_channel_mask`, sai channel mask value, actual channel numbers is depend soc specific

Values:

enumerator `kSAI_Channel0Mask`

channel 0 mask value

enumerator `kSAI_Channel1Mask`

channel 1 mask value

enumerator `kSAI_Channel2Mask`

channel 2 mask value

enumerator `kSAI_Channel3Mask`

channel 3 mask value

enumerator `kSAI_Channel4Mask`

channel 4 mask value

enumerator `kSAI_Channel5Mask`

channel 5 mask value

enumerator `kSAI_Channel6Mask`

channel 6 mask value

enumerator `kSAI_Channel7Mask`

channel 7 mask value

enum `_sai_protocol`

Define the SAI bus type.

Values:

enumerator `kSAI_BusLeftJustified`

Uses left justified format.

enumerator kSAI_BusRightJustified
Uses right justified format.

enumerator kSAI_BusI2S
Uses I2S format.

enumerator kSAI_BusPCMA
Uses I2S PCM A format.

enumerator kSAI_BusPCMB
Uses I2S PCM B format.

enum _sai_master_slave
Master or slave mode.

Values:

enumerator kSAI_Master
Master mode include bclk and frame sync

enumerator kSAI_Slave
Slave mode include bclk and frame sync

enumerator kSAI_Bclk_Master_FrameSync_Slave
bclk in master mode, frame sync in slave mode

enumerator kSAI_Bclk_Slave_FrameSync_Master
bclk in slave mode, frame sync in master mode

enum _sai_mono_stereo
Mono or stereo audio format.

Values:

enumerator kSAI_Stereo
Stereo sound.

enumerator kSAI_MonoRight
Only Right channel have sound.

enumerator kSAI_MonoLeft
Only left channel have sound.

enum _sai_data_order
SAI data order, MSB or LSB.

Values:

enumerator kSAI_DataLSB
LSB bit transferred first

enumerator kSAI_DataMSB
MSB bit transferred first

enum _sai_clock_polarity
SAI clock polarity, active high or low.

Values:

enumerator kSAI_PolarityActiveHigh
Drive outputs on rising edge

enumerator kSAI_PolarityActiveLow
Drive outputs on falling edge

enumerator kSAI_SampleOnFallingEdge

Sample inputs on falling edge

enumerator kSAI_SampleOnRisingEdge

Sample inputs on rising edge

enum _sai_sync_mode

Synchronous or asynchronous mode.

Values:

enumerator kSAI_ModeAsync

Asynchronous mode

enumerator kSAI_ModeSync

Synchronous mode (with receiver or transmit)

enumerator kSAI_ModeSyncWithOtherTx

Synchronous with another SAI transmit

enumerator kSAI_ModeSyncWithOtherRx

Synchronous with another SAI receiver

enum _sai_bclk_source

Bit clock source.

Values:

enumerator kSAI_BclkSourceBusclk

Bit clock using bus clock

enumerator kSAI_BclkSourceMclkOption1

Bit clock MCLK option 1

enumerator kSAI_BclkSourceMclkOption2

Bit clock MCLK option2

enumerator kSAI_BclkSourceMclkOption3

Bit clock MCLK option3

enumerator kSAI_BclkSourceMclkDiv

Bit clock using master clock divider

enumerator kSAI_BclkSourceOtherSai0

Bit clock from other SAI device

enumerator kSAI_BclkSourceOtherSai1

Bit clock from other SAI device

_sai_interrupt_enable_t, The SAI interrupt enable flag

Values:

enumerator kSAI_WordStartInterruptEnable

Word start flag, means the first word in a frame detected

enumerator kSAI_SyncErrorInterruptEnable

Sync error flag, means the sync error is detected

enumerator kSAI_FIFOWarningInterruptEnable

FIFO warning flag, means the FIFO is empty

enumerator kSAI_FIFOErrorInterruptEnable
FIFO error flag

enumerator kSAI_FIFORequestInterruptEnable
FIFO request, means reached watermark

_sai_dma_enable_t, The DMA request sources

Values:

enumerator kSAI_FIFOWarningDMAEnable
FIFO warning caused by the DMA request

enumerator kSAI_FIFORequestDMAEnable
FIFO request caused by the DMA request

_sai_flags, The SAI status flag

Values:

enumerator kSAI_WordStartFlag
Word start flag, means the first word in a frame detected

enumerator kSAI_SyncErrorFlag
Sync error flag, means the sync error is detected

enumerator kSAI_FIFOErrorFlag
FIFO error flag

enumerator kSAI_FIFORequestFlag
FIFO request flag.

enumerator kSAI_FIFOWarningFlag
FIFO warning flag

enum _sai_reset_type

The reset type.

Values:

enumerator kSAI_ResetTypeSoftware
Software reset, reset the logic state

enumerator kSAI_ResetTypeFIFO
FIFO reset, reset the FIFO read and write pointer

enumerator kSAI_ResetAll
All reset.

enum _sai_fifo_packing

The SAI packing mode The mode includes 8 bit and 16 bit packing.

Values:

enumerator kSAI_FifoPackingDisabled
Packing disabled

enumerator kSAI_FifoPacking8bit
8 bit packing enabled

enumerator kSAI_FifoPacking16bit
16bit packing enabled

enum _sai_sample_rate

Audio sample rate.

Values:

enumerator kSAI_SampleRate8KHz

Sample rate 8000 Hz

enumerator kSAI_SampleRate11025Hz

Sample rate 11025 Hz

enumerator kSAI_SampleRate12KHz

Sample rate 12000 Hz

enumerator kSAI_SampleRate16KHz

Sample rate 16000 Hz

enumerator kSAI_SampleRate22050Hz

Sample rate 22050 Hz

enumerator kSAI_SampleRate24KHz

Sample rate 24000 Hz

enumerator kSAI_SampleRate32KHz

Sample rate 32000 Hz

enumerator kSAI_SampleRate44100Hz

Sample rate 44100 Hz

enumerator kSAI_SampleRate48KHz

Sample rate 48000 Hz

enumerator kSAI_SampleRate96KHz

Sample rate 96000 Hz

enumerator kSAI_SampleRate192KHz

Sample rate 192000 Hz

enumerator kSAI_SampleRate384KHz

Sample rate 384000 Hz

enum _sai_word_width

Audio word width.

Values:

enumerator kSAI_WordWidth8bits

Audio data width 8 bits

enumerator kSAI_WordWidth16bits

Audio data width 16 bits

enumerator kSAI_WordWidth24bits

Audio data width 24 bits

enumerator kSAI_WordWidth32bits

Audio data width 32 bits

enum _sai_data_pin_state

sai data pin state definition

Values:

enumerator kSAI_DataPinStateTriState

transmit data pins are tri-stated when slots are masked or channels are disabled

enumerator kSAI_DataPinStateOutputZero

transmit data pins are never tri-stated and will output zero when slots are masked or channel disabled

enum _sai_fifo_combine

sai fifo combine mode definition

Values:

enumerator kSAI_FifoCombineDisabled

sai TX/RX fifo combine mode disabled

enumerator kSAI_FifoCombineModeEnabledOnRead

sai TX fifo combine mode enabled on FIFO reads

enumerator kSAI_FifoCombineModeEnabledOnWrite

sai TX fifo combine mode enabled on FIFO write

enumerator kSAI_RxFifoCombineModeEnabledOnWrite

sai RX fifo combine mode enabled on FIFO write

enumerator kSAI_RXFifoCombineModeEnabledOnRead

sai RX fifo combine mode enabled on FIFO reads

enumerator kSAI_FifoCombineModeEnabledOnReadWrite

sai TX/RX fifo combined mode enabled on FIFO read/writes

enum _sai_transceiver_type

sai transceiver type

Values:

enumerator kSAI_Transmitter

sai transmitter

enumerator kSAI_Receiver

sai receiver

enum _sai_frame_sync_len

sai frame sync len

Values:

enumerator kSAI_FrameSyncLenOneBitClk

1 bit clock frame sync len for DSP mode

enumerator kSAI_FrameSyncLenPerWordWidth

Frame sync length decided by word width

typedef enum _sai_protocol sai_protocol_t

Define the SAI bus type.

typedef enum _sai_master_slave sai_master_slave_t

Master or slave mode.

typedef enum _sai_mono_stereo sai_mono_stereo_t

Mono or stereo audio format.

typedef enum _sai_data_order sai_data_order_t

SAI data order, MSB or LSB.

`typedef enum _sai_clock_polarity sai_clock_polarity_t`
SAI clock polarity, active high or low.

`typedef enum _sai_sync_mode sai_sync_mode_t`
Synchronous or asynchronous mode.

`typedef enum _sai_bclk_source sai_bclk_source_t`
Bit clock source.

`typedef enum _sai_reset_type sai_reset_type_t`
The reset type.

`typedef enum _sai_fifo_packing sai_fifo_packing_t`
The SAI packing mode The mode includes 8 bit and 16 bit packing.

`typedef struct _sai_config sai_config_t`
SAI user configuration structure.

`typedef enum _sai_sample_rate sai_sample_rate_t`
Audio sample rate.

`typedef enum _sai_word_width sai_word_width_t`
Audio word width.

`typedef enum _sai_data_pin_state sai_data_pin_state_t`
sai data pin state definition

`typedef enum _sai_fifo_combine sai_fifo_combine_t`
sai fifo combine mode definition

`typedef enum _sai_transceiver_type sai_transceiver_type_t`
sai transceiver type

`typedef enum _sai_frame_sync_len sai_frame_sync_len_t`
sai frame sync len

`typedef struct _sai_transfer_format sai_transfer_format_t`
sai transfer format

`typedef struct _sai_master_clock sai_master_clock_t`
master clock configurations

`typedef struct _sai_fifo sai_fifo_t`
sai fifo configurations

`typedef struct _sai_bit_clock sai_bit_clock_t`
sai bit clock configurations

`typedef struct _sai_frame_sync sai_frame_sync_t`
sai frame sync configurations

`typedef struct _sai_serial_data sai_serial_data_t`
sai serial data configurations

`typedef struct _sai_transceiver sai_transceiver_t`
sai transceiver configurations

`typedef struct _sai_transfer sai_transfer_t`
SAI transfer structure.

`typedef struct _sai_handle sai_handle_t`

```
typedef void (*sai_transfer_callback_t)(I2S_Type *base, sai_handle_t *handle, status_t status, void *userData)
```

SAI transfer callback prototype.

MCUX_SDK_SAI_ALLOW_NULL_FIFO_WATERMARK

Used to control whether SAI_RxSetFifoConfig()/SAI_TxSetFifoConfig() allows a NULL FIFO watermark.

If this macro is set to 0 then SAI_RxSetFifoConfig()/SAI_TxSetFifoConfig() will set the watermark to half of the FIFO's depth if passed a NULL watermark.

MCUX_SDK_SAI_DISABLE_IMPLICIT_CHAN_CONFIG

Disable implicit channel data configuration within SAI_TxSetConfig()/SAI_RxSetConfig().

Use this macro to control whether SAI_RxSetConfig()/SAI_TxSetConfig() will attempt to implicitly configure the channel data. By channel data we mean the startChannel, channelMask, endChannel, and channelNums fields from the sai_transciever_t structure. By default, SAI_TxSetConfig()/SAI_RxSetConfig() will attempt to compute these fields, which may not be desired in cases where the user wants to set them before the call to said functions.

SAI_XFER_QUEUE_SIZE

SAI transfer queue size, user can refine it according to use case.

FSL_SAI_HAS_FIFO_EXTEND_FEATURE

sai fifo feature

struct __sai_config

#include <fsl_sai.h> SAI user configuration structure.

Public Members

sai_protocol_t protocol

Audio bus protocol in SAI

sai_sync_mode_t syncMode

SAI sync mode, control Tx/Rx clock sync

bool mclkOutputEnable

Master clock output enable, true means master clock divider enabled

sai_bclk_source_t bclkSource

Bit Clock source

sai_master_slave_t masterSlave

Master or slave

struct __sai_transfer_format

#include <fsl_sai.h> sai transfer format

Public Members

uint32_t sampleRate_Hz

Sample rate of audio data

uint32_t bitWidth

Data length of audio data, usually 8/16/24/32 bits

sai_mono_stereo_t stereo

Mono or stereo

uint32_t masterClockHz

Master clock frequency in Hz

uint8_t watermark

Watermark value

uint8_t channel

Transfer start channel

uint8_t channelMask

enabled channel mask value, reference `_sai_channel_mask`

uint8_t endChannel

end channel number

uint8_t channelNums

Total enabled channel numbers

sai_protocol_t protocol

Which audio protocol used

bool isFrameSyncCompact

True means Frame sync length is configurable according to bitWidth, false means frame sync length is 64 times of bit clock.

struct `_sai_master_clock`

#include <fsl_sai.h> master clock configurations

Public Members

bool mclkOutputEnable

master clock output enable

uint32_t mclkHz

target mclk frequency

uint32_t mclkSourceClkHz

mclk source frequency

struct `_sai_fifo`

#include <fsl_sai.h> sai fifo configurations

Public Members

bool fifoContinueOnError

fifo continues when error occur

sai_fifo_combine_t fifoCombine

fifo combine mode

sai_fifo_packing_t fifoPacking

fifo packing mode

uint8_t fifoWatermark

fifo watermark

struct `_sai_bit_clock`

#include <fsl_sai.h> sai bit clock configurations

Public Members

bool bclkSrcSwap

bit clock source swap

bool bclkInputDelay

bit clock actually used by the transmitter is delayed by the pad output delay, this has effect of decreasing the data input setup time, but increasing the data output valid time

.

sai_clock_polarity_t bclkPolarity

bit clock polarity

sai_bclk_source_t bclkSource

bit Clock source

struct *_sai_frame_sync*

#include <fsl_sai.h> sai frame sync configurations

Public Members

uint8_t frameSyncWidth

frame sync width in number of bit clocks

bool frameSyncEarly

TRUE is frame sync assert one bit before the first bit of frame FALSE is frame sync assert with the first bit of the frame

bool frameSyncGenerateOnDemand

internal frame sync is generated when FIFO waring flag is clear

sai_clock_polarity_t frameSyncPolarity

frame sync polarity

struct *_sai_serial_data*

#include <fsl_sai.h> sai serial data configurations

Public Members

sai_data_pin_state_t dataMode

sai data pin state when slots masked or channel disabled

sai_data_order_t dataOrder

configure whether the LSB or MSB is transmitted first

uint8_t dataWord0Length

configure the number of bits in the first word in each frame

uint8_t dataWordNLength

configure the number of bits in the each word in each frame, except the first word

uint8_t dataWordLength

used to record the data length for dma transfer

uint8_t dataFirstBitShifted

Configure the bit index for the first bit transmitted for each word in the frame

uint8_t dataWordNum

configure the number of words in each frame

uint32_t dataMaskedWord
 configure whether the transmit word is masked

struct _sai_transceiver
 #include <fsl_sai.h> sai transceiver configurations

Public Members

sai_serial_data_t serialData
 serial data configurations

sai_frame_sync_t frameSync
 ws configurations

sai_bit_clock_t bitClock
 bit clock configurations

sai_fifo_t fifo
 fifo configurations

sai_master_slave_t masterSlave
 transceiver is master or slave

sai_sync_mode_t syncMode
 transceiver sync mode

uint8_t startChannel
 Transfer start channel

uint8_t channelMask
 enabled channel mask value, reference _sai_channel_mask

uint8_t endChannel
 end channel number

uint8_t channelNums
 Total enabled channel numbers

struct _sai_transfer
 #include <fsl_sai.h> SAI transfer structure.

Public Members

uint8_t *data
 Data start address to transfer.

size_t dataSize
 Transfer size.

struct _sai_handle
 #include <fsl_sai.h> SAI handle structure.

Public Members

I2S_Type *base
 base address

uint32_t state
 Transfer status

sai_transfer_callback_t callback
Callback function called at transfer event

void *userData
Callback parameter passed to callback function

uint8_t bitWidth
Bit width for transfer, 8/16/24/32 bits

uint8_t channel
Transfer start channel

uint8_t channelMask
enabled channel mask value, refernece *_sai_channel_mask*

uint8_t endChannel
end channel number

uint8_t channelNums
Total enabled channel numbers

sai_transfer_t saiQueue[(4U)]
Transfer queue storing queued transfer

size_t transferSize[(4U)]
Data bytes need to transfer

volatile uint8_t queueUser
Index for user to queue transfer

volatile uint8_t queueDriver
Index for driver to get the transfer data and size

uint8_t watermark
Watermark value

2.53 SAI EDMA Driver

```
void SAI_TransferTxCreateHandleEDMA(I2S_Type *base, sai_edma_handle_t *handle,  
                                   sai_edma_callback_t callback, void *userData,  
                                   edma_handle_t *txDmaHandle)
```

Initializes the SAI eDMA handle.

This function initializes the SAI master DMA handle, which can be used for other SAI master transactional APIs. Usually, for a specified SAI instance, call this API once to get the initialized handle.

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.
- callback – Pointer to user callback function.
- userData – User parameter passed to the callback function.
- txDmaHandle – eDMA handle pointer; this handle shall be static allocated by users.

```
void SAI_TransferRxCreateHandleEDMA(I2S_Type *base, sai_edma_handle_t *handle,
                                   sai_edma_callback_t callback, void *userData,
                                   edma_handle_t *rxDmaHandle)
```

Initializes the SAI Rx eDMA handle.

This function initializes the SAI slave DMA handle, which can be used for other SAI master transactional APIs. Usually, for a specified SAI instance, call this API once to get the initialized handle.

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.
- callback – Pointer to user callback function.
- userData – User parameter passed to the callback function.
- rxDmaHandle – eDMA handle pointer, this handle shall be static allocated by users.

```
void SAI_TransferSetInterleaveType(sai_edma_handle_t *handle, sai_edma_interleave_t
                                   interleaveType)
```

Initializes the SAI interleave type.

This function initializes the SAI DMA handle member interleaveType, it shall be called only when application would like to use type kSAI_EDMAInterleavePerChannelBlock, since the default interleaveType is kSAI_EDMAInterleavePerChannelSample always

Parameters

- handle – SAI eDMA handle pointer.
- interleaveType – Multi channel interleave type.

```
void SAI_TransferTxSetConfigEDMA(I2S_Type *base, sai_edma_handle_t *handle,
                                 sai_transceiver_t *saiConfig)
```

Configures the SAI Tx.

Note: SAI eDMA supports data transfer in a multiple SAI channels if the FIFO Combine feature is supported. To activate the multi-channel transfer enable SAI channels by filling the channelMask of sai_transceiver_t with the corresponding values of _sai_channel_mask enum, enable the FIFO Combine mode by assigning kSAI_FifoCombineModeEnabledOnWrite to the fifoCombine member of sai_fifo_combine_t which is a member of sai_transceiver_t. This is an example of multi-channel data transfer configuration step.

```
sai_transceiver_t config;
SAI_GetClassicI2SConfig(&config, kSAI_WordWidth16bits, kSAI_Stereo, kSAI_Channel0Mask|kSAI_
↪Channel1Mask);
config.fifo.fifoCombine = kSAI_FifoCombineModeEnabledOnWrite;
SAI_TransferTxSetConfigEDMA(I2S0, &edmaHandle, &config);
```

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.
- saiConfig – sai configurations.


```
void SAI_TransferRxSetConfigEDMA(I2S_Type *base, sai_edma_handle_t *handle,
                                sai_transceiver_t *saiConfig)
```

Configures the SAI Rx.

Note: SAI eDMA supports data transfer in a multiple SAI channels if the FIFO Combine feature is supported. To activate the multi-channel transfer enable SAI channels by filling the channelMask of sai_transceiver_t with the corresponding values of _sai_channel_mask enum, enable the FIFO Combine mode by assigning kSAI_FifoCombineModeEnabledOnRead to the fifoCombine member of sai_fifo_combine_t which is a member of sai_transceiver_t. This is an example of multi-channel data transfer configuration step.

```
sai_transceiver_t config;
SAI_GetClassicI2SConfig(&config, kSAI_WordWidth16bits, kSAI_Stereo, kSAI_Channel0Mask|kSAI_
↪Channel1Mask);
config.fifo.fifoCombine = kSAI_FifoCombineModeEnabledOnRead;
SAI_TransferRxSetConfigEDMA(I2S0, &edmaHandle, &config);
```

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.
- saiConfig – sai configurations.

```
status_t SAI_TransferSendEDMA(I2S_Type *base, sai_edma_handle_t *handle, sai_transfer_t
                                *xfer)
```

Performs a non-blocking SAI transfer using DMA.

This function support multi channel transfer,

- for the sai IP support fifo combine mode, application should enable the fifo combine mode, no limitation on channel numbers
- for the sai IP not support fifo combine mode, sai edma provide another solution which using EDMA modulo feature, but support 2 or 4 channels only.

Note: This interface returns immediately after the transfer initiates. Call SAI_GetTransferStatus to poll the transfer status and check whether the SAI transfer is finished.

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.
- xfer – Pointer to the DMA transfer structure.

Return values

- kStatus__Success – Start a SAI eDMA send successfully.
- kStatus__InvalidArgument – The input argument is invalid.
- kStatus__TxBusy – SAI is busy sending data.

status_t SAI_TransferReceiveEDMA(I2S_Type *base, *sai_edma_handle_t* *handle, *sai_transfer_t* *xfer)

Performs a non-blocking SAI receive using eDMA.

This function support multi channel transfer,

- a. for the sai IP support fifo combine mode, application should enable the fifo combine mode, no limitation on channel numbers
- b. for the sai IP not support fifo combine mode, sai edma provide another solution which using EDMA modulo feature, but support 2 or 4 channels only.

Note: This interface returns immediately after the transfer initiates. Call the SAI_GetReceiveRemainingBytes to poll the transfer status and check whether the SAI transfer is finished.

Parameters

- base – SAI base pointer
- handle – SAI eDMA handle pointer.
- xfer – Pointer to DMA transfer structure.

Return values

- kStatus_Success – Start a SAI eDMA receive successfully.
- kStatus_InvalidArgument – The input argument is invalid.
- kStatus_RxBusy – SAI is busy receiving data.

status_t SAI_TransferSendLoopEDMA(I2S_Type *base, *sai_edma_handle_t* *handle, *sai_transfer_t* *xfer, uint32_t loopTransferCount)

Performs a non-blocking SAI loop transfer using eDMA.

Once the loop transfer start, application can use function SAI_TransferAbortSendEDMA to stop the loop transfer.

Note: This function support loop transfer only,such as A->B->...->A, application must be aware of that the more counts of the loop transfer, then more tcd memory required, as the function use the tcd pool in *sai_edma_handle_t*, so application could redefine the SAI_XFER_QUEUE_SIZE to determine the proper TCD pool size. This function support one sai channel only.

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.
- xfer – Pointer to the DMA transfer structure, should be a array with elements counts >=1(loopTransferCount).
- loopTransferCount – the counts of xfer array.

Return values

- kStatus_Success – Start a SAI eDMA send successfully.
- kStatus_InvalidArgument – The input argument is invalid.

```
status_t SAI_TransferReceiveLoopEDMA(I2S_Type *base, sai_edma_handle_t *handle,
                                     sai_transfer_t *xfer, uint32_t loopTransferCount)
```

Performs a non-blocking SAI loop transfer using eDMA.

Once the loop transfer start, application can use function SAI_TransferAbortReceiveEDMA to stop the loop transfer.

Note: This function support loop transfer only, such as A->B->...->A, application must be aware of that the more counts of the loop transfer, then more tcd memory required, as the function use the tcd pool in *sai_edma_handle_t*, so application could redefine the SAI_XFER_QUEUE_SIZE to determine the proper TCD pool size. This function support one *sai* channel only.

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.
- xfer – Pointer to the DMA transfer structure, should be a array with elements counts >=1(loopTransferCount).
- loopTransferCount – the counts of xfer array.

Return values

- *kStatus_Success* – Start a SAI eDMA receive successfully.
- *kStatus_InvalidArgument* – The input argument is invalid.

```
void SAI_TransferTerminateSendEDMA(I2S_Type *base, sai_edma_handle_t *handle)
```

Terminate all SAI send.

This function will clear all transfer slots buffered in the *sai* queue. If users only want to abort the current transfer slot, please call SAI_TransferAbortSendEDMA.

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.

```
void SAI_TransferTerminateReceiveEDMA(I2S_Type *base, sai_edma_handle_t *handle)
```

Terminate all SAI receive.

This function will clear all transfer slots buffered in the *sai* queue. If users only want to abort the current transfer slot, please call SAI_TransferAbortReceiveEDMA.

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.

```
void SAI_TransferAbortSendEDMA(I2S_Type *base, sai_edma_handle_t *handle)
```

Aborts a SAI transfer using eDMA.

This function only aborts the current transfer slots, the other transfer slots' information still kept in the handler. If users want to terminate all transfer slots, just call SAI_TransferTerminateSendEDMA.

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.

`void SAI_TransferAbortReceiveEDMA(I2S_Type *base, sai_edma_handle_t *handle)`

Aborts a SAI receive using eDMA.

This function only aborts the current transfer slots, the other transfer slots' information still kept in the handler. If users want to terminate all transfer slots, just call `SAI_TransferTerminateReceiveEDMA`.

Parameters

- `base` – SAI base pointer
- `handle` – SAI eDMA handle pointer.

`status_t SAI_TransferGetSendCountEDMA(I2S_Type *base, sai_edma_handle_t *handle, size_t *count)`

Gets byte count sent by SAI.

Parameters

- `base` – SAI base pointer.
- `handle` – SAI eDMA handle pointer.
- `count` – Bytes count sent by SAI.

Return values

- `kStatus_Success` – Succeed get the transfer count.
- `kStatus_NoTransferInProgress` – There is no non-blocking transaction in progress.

`status_t SAI_TransferGetReceiveCountEDMA(I2S_Type *base, sai_edma_handle_t *handle, size_t *count)`

Gets byte count received by SAI.

Parameters

- `base` – SAI base pointer
- `handle` – SAI eDMA handle pointer.
- `count` – Bytes count received by SAI.

Return values

- `kStatus_Success` – Succeed get the transfer count.
- `kStatus_NoTransferInProgress` – There is no non-blocking transaction in progress.

`uint32_t SAI_TransferGetValidTransferSlotsEDMA(I2S_Type *base, sai_edma_handle_t *handle)`

Gets valid transfer slot.

This function can be used to query the valid transfer request slot that the application can submit. It should be called in the critical section, that means the application could call it in the corresponding callback function or disable IRQ before calling it in the application, otherwise, the returned value may not correct.

Parameters

- `base` – SAI base pointer
- `handle` – SAI eDMA handle pointer.

Return values

`valid` – slot count that application submit.

`FSL_SAI_EDMA_DRIVER_VERSION`

Version 2.7.3

enum *_sai_edma_interleave*
sai interleave type

Values:

enumerator kSAI_EDMAInterleavePerChannelSample

enumerator kSAI_EDMAInterleavePerChannelBlock

typedef struct *sai_edma_handle* sai_edma_handle_t

typedef void (*sai_edma_callback_t)(I2S_Type *base, *sai_edma_handle_t* *handle, *status_t* status, void *userData)

SAI eDMA transfer callback function for finish and error.

typedef enum *_sai_edma_interleave* sai_edma_interleave_t
sai interleave type

MCUX_SDK_SAI_EDMA_RX_ENABLE_INTERNAL

the SAI enable position When calling SAI_TransferReceiveEDMA

MCUX_SDK_SAI_EDMA_TX_ENABLE_INTERNAL

the SAI enable position When calling SAI_TransferSendEDMA

struct sai_edma_handle

#include <fsl_sai_edma.h> SAI DMA transfer handle, users should not touch the content of the handle.

Public Members

edma_handle_t *dmaHandle

DMA handler for SAI send

uint8_t nbytes

eDMA minor byte transfer count initially configured.

uint8_t bytesPerFrame

Bytes in a frame

uint8_t channelMask

Enabled channel mask value, reference *_sai_channel_mask*

uint8_t channelNums

total enabled channel nums

uint8_t channel

Which data channel

uint8_t count

The transfer data count in a DMA request

uint32_t state

Internal state for SAI eDMA transfer

sai_edma_callback_t callback

Callback for users while transfer finish or error occurs

void *userData

User callback parameter

uint8_t tcd[(((4U) + 1U) * sizeof(*edma_tcd_t*))]

TCD pool for eDMA transfer.

sai_transfer_t saiQueue[(4U)]
Transfer queue storing queued transfer.

size_t transferSize[(4U)]
Data bytes need to transfer

sai_edma_interleave_t interleaveType
Transfer interleave type

volatile uint8_t queueUser
Index for user to queue transfer.

volatile uint8_t queueDriver
Index for driver to get the transfer data and size

2.54 SAR_ADC: SAR_ADC Module

void ADC_GetDefaultConfig(*adc_config_t* *config)

This function is used to get available predefined configurations for the ADC initialization.

Parameters

- *config* – Pointer to the ADC configuration structure, please refer to *adc_config_t* for details.

void ADC_Init(*ADC_Type* *base, const *adc_config_t* *config)

This function is used to initialize the ADC.

Parameters

- *base* – ADC peripheral base address.
- *config* – Pointer to the ADC configuration structure, please refer to *adc_config_t* for details.

void ADC_Deinit(*ADC_Type* *base)

This function is used to de-initialize the ADC.

Parameters

- *base* – ADC peripheral base address.

static inline void ADC_SetPowerDownMode(*ADC_Type* *base, *bool* enable)

This function is used to enter or exit power-down mode.

After the release of the reset, the ADC analog module will be kept in power-down mode by default. The power-down mode can be set anytime. However, ADC can enter the power-down mode successfully only after completion of an ongoing conversion (if there is one). In scan mode, the ongoing operation should be aborted manually before or after switching mode. If the power-down mode is entered by setting MCR[PWDN], the process running in the previous mode must be restarted manually (by setting the appropriate START bit in the MCR register) after exiting power-down mode.

Note: After setting the ADC mode, it is recommended to use the function *ADC_GetAdcState* to query whether the ADC has correctly entered the mode.

Parameters

- *base* – ADC peripheral base address.
- *enable* – Indicates whether to enter or exit power-down mode.

- **true** Request to enter power-down mode.
- **false** When ADC status is in power-down mode (MSR[ADCSTATUS] = 001b), start ADC transition to IDLE mode.

static inline void ADC_SetOperatingClock(ADC_Type *base, *adc_clock_frequency_t* clockSelect)

This function is used to select the ADC operating clock.

Note: Needs to enter power-down mode before changing the ADC internal operating clock.

Parameters

- base – ADC peripheral base address.
- clockSelect – ADC clock frequency selection, please refer to *adc_clock_frequency_t* for details.

static inline *adc_state_t* ADC_GetAdcState(ADC_Type *base)

This function is used to get the ADC state.

Parameters

- base – ADC peripheral base address.

Returns

ADC state, for possible states, please refer to *adc_state_t* for details.

static inline bool ADC_CheckAutoClockOffEnabled(ADC_Type *base)

This function is used to check whether the ADC auto clock-off feature has been enabled or not.

Parameters

- base – ADC peripheral base address.

Returns

ADC auto clock-off feature status.

- **true** Auto clock-off feature has been enabled.
- **false** Auto clock-off feature has not been enabled.

static inline uint8_t ADC_GetCurrentConvertedChannelId(ADC_Type *base)

This function is used to get the ID of the channel that is currently being converted.

Parameters

- base – ADC peripheral base address.

Returns

ADC channel ID that is currently being converted.

static inline bool ADC_CheckSelfTestConvInProgress(ADC_Type *base)

This function is used to check whether the self-test conversion is in process or not.

Parameters

- base – ADC peripheral base address.

Returns

Self-test conversion status.

- **true** Self-test conversion is in process.
- **false** Self-test conversion is not in process.

static inline bool ADC_CheckInjectConvInProgress(ADC_Type *base)

This function is used to check whether the inject conversion is in process or not.

Parameters

- base – ADC peripheral base address.

Returns

Inject conversion status.

- **true** Inject conversion is in process.
- **false** Inject conversion is not in process.

static inline bool ADC_CheckInjectConvAborted(ADC_Type *base)

This function is used to check whether the inject conversion has been aborted or not.

Parameters

- base – ADC peripheral base address.

Returns

Inject conversion abort status.

- **true** Injected conversion has been aborted.
- **false** Injected conversion has not been aborted.

static inline bool ADC_CheckNormalConvInProgress(ADC_Type *base)

This function is used to check whether the normal conversion is in process or not.

Parameters

- base – ADC peripheral base address.

Returns

Normal conversion status.

- **true** Normal conversion is in process.
- **false** Normal conversion is not in process.

static inline bool ADC_CheckCalibrationBusy(ADC_Type *base)

This function is used to check whether the ADC is executing calibration or ready for use.

Parameters

- base – ADC peripheral base address.

Returns

Calibration process status.

- **true** ADC is busy in a calibration process.
- **false** ADC is ready for use.

static inline bool ADC_CheckCalibrationFailed(ADC_Type *base)

This function is used to check whether the calibration has failed or passed.

Note: When the user clears the calibration failed status and then reads the status, it will display the calibration passed. At this time, the calibration may not be successful. The user must read the MSR[CALBUSY] bit by function ADC_CheckCalibrationBusy to perform a double check.

Returns

Normal conversion status.

- **true** Calibration failed.

- **false** Calibration passed (must be checked with CALBUSY = 0b).

static inline void ADC_ClearCalibrationFailedFlag(ADC_Type *base)

This function is used to clear the flag of calibration.

Parameters

- base – ADC peripheral base address.

static inline bool ADC_CheckCalibrationSuccessful(ADC_Type *base)

This function is used to check whether the calibration is successful or not.

Parameters

- base – ADC peripheral base address.

Returns

Normal conversion status.

- **true** Calibrated or calibration successful.
- **false** Uncalibrated or calibration unsuccessful.

void ADC_SetConvChainConfig(ADC_Type *base, const *adc_chain_config_t* *config)

This function is used to configure the chain.

Parameters

- base – ADC peripheral base address.
- config – Pointer to the chain configuration structure, please refer to *adc_chain_config_t* for details.

static inline void ADC_EnableSpecificChannelNormalConv(ADC_Type *base, uint8_t
channelIndex)

This function is used to enable the specific ADC channel to execute normal conversion.

Parameters

- base – ADC peripheral base address.
- channelIndex – Channel index to enable the normal conversion.

static inline void ADC_DisableSpecificChannelNormalConv(ADC_Type *base, uint8_t
channelIndex)

This function is used to disable the specific ADC channel to execute the normal conversion.

Parameters

- base – ADC peripheral base address.
- channelIndex – Channel index to disable the normal conversion.

static inline void ADC_EnableSpecificChannelInjectConv(ADC_Type *base, uint8_t channelIndex)

This function is used to enable the specific ADC channel to execute the inject conversion.

Parameters

- base – ADC peripheral base address.
- channelIndex – Channel index to enable the inject conversion.

static inline void ADC_DisableSpecificChannelInjectConv(ADC_Type *base, uint8_t channelIndex)

This function is used to disable the specific ADC channel to execute the inject conversion.

Parameters

- base – ADC peripheral base address.
- channelIndex – Channel index to disable the inject conversion.

```
static inline void ADC_SetConvMode(ADC_Type *base, adc_conv_mode_t convMode)
```

This function is used to set the ADC conversion mode.

Note: Before setting the conversion mode, users need to check whether the ADC is in the idle status through the function `ADC_GetAdcState`.

Parameters

- `base` – ADC peripheral base address.
- `convMode` – ADC conversion mode, please refer to `adc_conv_mode_t` for details.

```
static inline void ADC_StartConvChain(ADC_Type *base, adc_conv_mode_t convMode)
```

This function is used to start the ADC conversion chain to execute the conversion.

Note: Normal conversion supports two conversion modes, one is one-shot conversion mode, and the other is scan conversion mode. Normal conversion should usually be used to convert analog samples most of the time in an application, unless there is a special need. Inject conversion has a higher priority than normal conversion and it runs in one-shot mode only, it can be started in IDLE condition or when normal conversion is in process.

Parameters

- `base` – ADC peripheral base address.
- `convMode` – Pointer to the ADC conversion chain, please refer to `adc_conv_mode_t` for details.

```
static inline void ADC_StopConvChain(ADC_Type *base)
```

This function is used to stop scan in normal conversion scan operation mode.

Note: In scan operation mode, the `MCR[NSTART]` field remains high after setting. Clearing this field in scan operation mode causes the current chain conversion to finish, then stop the scan.

Parameters

- `base` – ADC peripheral base address.

```
static inline void ADC_AbortCurrentConvChain(ADC_Type *base)
```

This function is used to abort the conversion chain.

Abort the current chain of conversions by setting `MCR[ABORTCHAIN]`. In that case, the behavior of the ADC depends on `MCR[MODE]` (one-shot/scan conversion modes). In one-shot mode, `MSR[NSTART]` is automatically reset together with `MCR[ABORTCHAIN]`, an end-of-chain interrupt is not generated in the case of an abort chain. In scan mode, a new chain is started. The end-of-conversion interrupt of the current aborted conversion is not generated but an end-of-chain interrupt is generated.

Note: Setting this field in an IDLE state (for example, no normal/inject conversion is in process) has no effect. In this case, the `MCR[ABORTCHAIN]` field is reset immediately.

Parameters

- `base` – ADC peripheral base address.

```
static inline void ADC_AbortCurrentConv(ADC_Type *base)
```

This function is used to abort the conversion channel.

Abort the current conversion and immediately start the conversion of the next channel of the chain. In the case of an abort operation, MSR[NSTART/JSTART] remains set if not in the last channel of the chain, and MCR[ABORT] is reset as soon as the channel is aborted. The end-of-conversion interrupt corresponds to the aborted channel is not generated. This behavior is true for normal or inject conversion modes. If the last channel of a chain is aborted, and the end-of-chain is reported, then an end-of-chain interrupt will be generated.

Note: This conversion can not abort while the self-test channel conversion is in process.

Parameters

- base – ADC peripheral base address.

```
static inline void ADC_EnableConvInt(ADC_Type *base, uint32_t mask)
```

This function is used to enable the ADC end-of-conversion and end-of-chain interrupts.

Parameters

- base – ADC peripheral base address.
- mask – Mask value to enable the ADC end-of-conversion and end-of-chain interrupts, please refer to `_adc_conv_int_enable` for details.

```
static inline void ADC_DisableConvInt(ADC_Type *base, uint32_t mask)
```

This function is used to disable the ADC end-of-conversion and end-of-chain interrupts.

Parameters

- base – ADC peripheral base address.
- mask – Mask value to disable the ADC end-of-conversion and end-of-chain interrupts, please refer to `_adc_conv_int_enable` for details.

```
static inline uint32_t ADC_GetConvIntStatus(ADC_Type *base)
```

This function is used to get the ADC end-of-conversion and end-of-chain interrupts status.

Parameters

- base – ADC peripheral base address.

Returns

ADC end-of-conversion and end-of-chain interrupts status mask.

```
static inline void ADC_ClearConvIntStatus(ADC_Type *base, uint32_t mask)
```

This function is used to clear the ADC end-of-conversion and end-of-chain interrupts status.

Parameters

- base – ADC peripheral base address.
- mask – Mask value for flags to be cleared, please refer to `_adc_conv_int_flag` for details.

```
static inline void ADC_EnableSpecificConvChannelInt(ADC_Type *base, uint8_t channelIndex)
```

This function is used to enable the specific ADC channel end-of-conversion interrupt.

Note: This function can only turn on the interrupt of a specific channel, if the interrupt occurs, the user also needs to turn on the global end-of-conversion interrupt by using function `ADC_EnableConvInt`

Parameters

- base – ADC peripheral base address.
- channelIndex – Channel index to enable the end-of-conversion interrupt.

```
static inline void ADC_DisableSpecificConvChannelInt(ADC_Type *base, uint8_t channelIndex)
```

This function is used to disable the specific ADC channel end-of-conversion interrupt.

Parameters

- base – ADC peripheral base address.
- channelIndex – Channel index to disable the end-of-conversion interrupt.

```
static inline bool ADC_CheckSpecificConvChannelInt(ADC_Type *base, uint8_t channelIndex)
```

This function is used to check whether the specific conversion channel's end-of-conversion interrupt has been occurred.

Parameters

- base – ADC peripheral base address.
- channelIndex – Channel index to check the end-of-conversion interrupt status.

Returns

Channel end-of-conversion interrupt status flag of the specific channel.

- **true** Channel end-of-conversion interrupt has been occurred.
- **false** Channel end-of-conversion interrupt has not been occurred.

```
static inline void ADC_ClearSpecificConvChannelInt(ADC_Type *base, uint8_t channelIndex)
```

This function is used to clear specific channel end-of-conversion interrupt flag.

Parameters

- base – ADC peripheral base address.
- channelIndex – Channel index to clear the end-of-conversion interrupt flag.

```
static inline void ADC_EnableDmaTransfer(ADC_Type *base)
```

This function is used to enable the DMA transfer function.

Note: This function is a master switch used to control whether the data converted by the ADC is transmitted through DMA. If the user configures DMA to transmit the conversion data of the channel during the chain channel configuration process, then the main switch of the DMA transmission must be turned on, otherwise, data transmission cannot be performed.

Parameters

- base – ADC peripheral base address.

```
static inline void ADC_DisableDmaTransfer(ADC_Type *base)
```

This function is used to disable the DMA transfer function.

Parameters

- base – ADC peripheral base address.

```
static inline void ADC_EnableSpecificConvChannelDmaTransfer(ADC_Type *base, uint8_t  
                                                           channelIndex)
```

This function is used to enable the specific ADC conversion channel's DMA transfer function.

Note: This function can only turn on the DMA transfer of a specific channel, before using the DMA transfer, the user needs to turn on the global DMA transfer by using the function `ADC_EnableDmaTransfer`.

Parameters

- `base` – ADC peripheral base address.
- `channelIndex` – Channel index to enable the DMA transfer function.

```
static inline void ADC__DisableSpecificConvChannelDmaTransfer(ADC_Type *base, uint8_t
                                                             channelIndex)
```

This function is used to disable the specific ADC conversion channel's DMA transfer function.

Parameters

- `base` – ADC peripheral base address.
- `channelIndex` – Channel index to disable the DMA transfer function.

```
static inline void ADC__EnableSpecificConvChannelPresample(ADC_Type *base, uint8_t
                                                           channelIndex)
```

This function is used to enable the specific ADC conversion channel's pre-sample function.

Parameters

- `base` – ADC peripheral base address.
- `channelIndex` – Channel index to enable the pre-sample function.

```
static inline void ADC__DisableSpecificConvChannelPresample(ADC_Type *base, uint8_t
                                                            channelIndex)
```

This function is used to disable the specific ADC conversion channel's pre-sample function.

Parameters

- `base` – ADC peripheral base address.
- `channelIndex` – Channel index to disable the pre-sample function.

```
void ADC_SetAnalogWdgConfig(ADC_Type *base, const adc_wdg_config_t *config)
```

This function is used to configure the analog watchdog.

The analog watchdogs are used to monitor the conversion result to see if it is within defined limits, specified by a higher and a lower threshold value. After the conversion of the selected channel, a comparison is performed between the converted value and the threshold values. If the converted value is outside the threshold values, then a corresponding threshold violation interrupt is generated.

Parameters

- `base` – ADC peripheral base address.
- `config` – Pointer to the analog watchdog configuration structure, please refer to `adc_wdg_config_t` for details.

```
static inline void ADC__EnableSpecificConvChannelAnalogWdg(ADC_Type *base, uint8_t
                                                            channelIndex)
```

This function is used to enable the specific ADC conversion channel's analog watchdog function.

Parameters

- `base` – ADC peripheral base address.

- `channelIndex` – Conversion channel index to enable the analog watchdog function.

```
static inline void ADC__DisableSpecificConvChannelAnalogWdg(ADC_Type *base, uint8_t  
                                                           channelIndex)
```

This function is used to disable the specific ADC conversion channel's analog watchdog function.

Parameters

- `base` – ADC peripheral base address.
- `channelIndex` – Conversion channel index to disable the analog watchdog function.

```
static inline bool ADC__CheckSpecificConvChannelOutOfRange(ADC_Type *base, uint8_t  
                                                           channelIndex)
```

This function is used to check whether the specific conversion channel's converted data is out of range.

Parameters

- `base` – ADC peripheral base address.
- `channelIndex` – Channel index to check the converted data out of range status.

Returns

Converted data out of range status of the specific conversion channel.

- **true** Channel converted data is out of range.
- **false** Channel converted data is in range.

```
static inline void ADC__ClearSpecificConvChannelOutOfRange(ADC_Type *base, uint8_t  
                                                           channelIndex)
```

This function is used to clear the specific conversion channel's converted data out-of-range flag.

Parameters

- `base` – ADC peripheral base address.
- `channelIndex` – Channel index to clear the converted data out of range flag.

```
static inline void ADC__EnableWdgThresholdInt(ADC_Type *base, uint32_t mask)
```

This function is used to enable the analog watchdog threshold low or/and high interrupts.

Parameters

- `base` – ADC peripheral base address.
- `mask` – Mask value to enable the analog watchdog threshold low or/and high interrupts, please refer to `_adc_wdg_threshold_int_enable` for details.

```
static inline void ADC__DisableWdgThresholdInt(ADC_Type *base, uint32_t mask)
```

This function is used to disable the analog watchdog threshold low or/and high interrupts.

Parameters

- `base` – ADC peripheral base address.
- `mask` – Mask value to disable the analog watchdog threshold low or/and high interrupts, please refer to `_adc_wdg_threshold_int_enable` for details.

```
static inline uint32_t ADC__GetWdgThresholdIntStatus(ADC_Type *base)
```

This function is used to get the analog watchdog threshold interrupts status.

Parameters

- `base` – ADC peripheral base address.

Returns

Analog watchdog threshold interrupts status mask.

```
static inline void ADC_ClearWdgThresholdIntStatus(ADC_Type *base, uint32_t mask)
```

This function is used to clear the analog watchdog threshold low or/and high interrupts status.

Parameters

- `base` – ADC peripheral base address.
- `mask` – Mask value for flags to be cleared, please refer to `_adc_wdg_threshold_int_flag` for details.

```
bool ADC_DoCalibration(ADC_Type *base, const adc_calibration_config_t *config)
```

This function is used to do the calibration.

The calibration is used to reduce or eliminate the various errors. In the calibration process, the calibration values for offset, gain, and capacitor mismatch are obtained. These calibration values (except gain calibration) are used in a result post-processing step to reduce or eliminate the various errors contribution effects. The gain calibration is used during the sample phase to define the additional charge to be loaded in order to compensate for the gain failure. Calibration must be performed after every power-up reset and whenever required in runtime operation. It is also recommended to run calibration if the operating conditions (particularly `VrefH`) change. Never apply functional reset during the calibration process. If applied, calibration must be rerun after exiting a reset condition; otherwise, the calibration-generated values and conversion results may be unspecified.

Note: This function executes a calibration sequence, it is recommended to run this sequence before using the ADC converter. The maximum clock frequency for the calibration is 40 MHz. Before calling this function, the user needs to ensure that the input clock is within 40MHz. The results of individual steps are also updated in the CALSTAT register (CALSTAT[STAT_n]). The result of the last failed step is dynamically updated in the same register.

Parameters

- `base` – ADC peripheral base address.
- `config` – Pointer to the calibration configuration structure, please refer to `adc_calibration_config_t` for details.

Returns

Status whether calibration is running passed or failed.

- **true** Calibration successful.
- **false** Calibration unsuccessful.

```
void ADC_SetUserOffsetAndGainConfig(ADC_Type *base, const adc_user_offset_gain_config_t *config)
```

This function is used to configure the user gain and offset.

Parameters

- `base` – ADC peripheral base address.
- `config` – Pointer to the user offset and gain configuration structure, please refer to `adc_user_offset_gain_config_t` for details.

void ADC_SetSelfTestConfig(ADC_Type *base, const *adc_self_test_config_t* *config)

This function is used to configure the ADC self-test.

The self-test is used to check at regular intervals whether ADC is operating correctly. When self-test is enabled, ADC automatically checks its components and flags any errors it finds. The test can be enabled to check the supply voltage (VDD), reference voltage (VrefH), and calibrated values.

Note: Before calling this function, please ensure the functional conversion is one-shot conversion mode normal conversion type and the operating clock are equal to bus frequency. ADC self-test should be run with MCR[ADCLKSE] bit set to 1. Self-test with ADCLKSE bit set to 0 can give erroneous results.

Parameters

- base – ADC peripheral base address.
- config – Pointer to the self-test configuration structure, please refer to *adc_self_test_config_t* for details.

void ADC_SetSelfTestWdgConfig(ADC_Type *base, const *adc_self_test_wdg_config_t* *config)

This function is used to configure the ADC self-test watchdog.

Parameters

- base – ADC peripheral base address.
- config – Pointer to the self-test watchdog configuration structure, please refer to *adc_self_test_wdg_config_t* for details.

void ADC_GetCalibrationLastFailedTestResult(ADC_Type *base, int16_t *result)

This function is used to get the test result for the last failed test.

Parameters

- base – ADC peripheral base address.
- result – Points to a 16-bit signed variable, and it is used to store the test result for the last failing test.

static inline uint16_t ADC_GetCalibrationStepsStatus(ADC_Type *base)

This function is used to get the status of the calibration steps.

Note: The status of calibration steps (step 0 to step 12) is stored in the CALSTAT register, and only the lower 12 bits are available in the returned result.

Parameters

- base – ADC peripheral base address.

Returns

ADC self-test interrupt status mask.

static inline void ADC_EnableSelfTest(ADC_Type *base)

This function is used to enable the ADC self-test.

Decides whether to enable the ADC self-test. The self-test test is enabled by setting STCR2[EN], this field must be set before starting normal conversion and should not be changed while the conversion is in process. This field should only be reset after the end-of-conversion of the last self-test channel has been received.

Note: ADC self-test should be run with MCR[ADCLKSE] bit set to 1. Self-test with ADCLKSE bit set to 0 can give erroneous results. In the case of Inject Conversion mode, test channel conversion is not performed. It is performed only during normal conversions.

Parameters

- base – ADC peripheral base address.

```
static inline void ADC_DisableSelfTest(ADC_Type *base)
```

This function is used to disable the ADC self-test.

Parameters

- base – ADC peripheral base address.

```
static inline void ADC_EnableSelfTestWdgThreshold(ADC_Type *base,  
                                                  adc_self_test_wdg_threshold_t wdgID)
```

This function is used to enable the ADC self-test watchdog threshold for algorithm S step 0/1/2 and algorithm C.

The user can pass `kADC_SelfTestWdgThresholdForAlgSStep0` as parameter 'wdgID' to enable the self-test watchdog threshold function for algorithm S step 0; pass `kADC_SelfTestWdgThresholdForAlgSStep1Integer` as parameter 'wdgID' to enable the self-test watchdog threshold function for algorithm S step 1; pass `kADC_SelfTestWdgThresholdForAlgSStep2` as parameter 'wdgID' to enable the self-test watchdog threshold function for algorithm S step 2; pass `kADC_SelfTestWdgThresholdForAlgCStep0` as parameter 'wdgID' to enable the self-test watchdog threshold function for algorithm C; Other enumerations in `adc_self_test_wdg_threshold_t` have no use.

Parameters

- base – ADC peripheral base address.
- wdgID – Watchdog threshold index to enable, please refer to `adc_self_test_wdg_threshold_t` for details.

```
static inline void ADC_DisableSelfTestWdgThreshold(ADC_Type *base,  
                                                  adc_self_test_wdg_threshold_t wdgID)
```

This function is used to disable the ADC self-test watchdog threshold for algorithm S step 0/1/2 and algorithm C.

The user can pass `kADC_SelfTestWdgThresholdForAlgSStep0` as parameter 'wdgID' to disable the self-test watchdog threshold function for algorithm S step 0; pass `kADC_SelfTestWdgThresholdForAlgSStep1Integer` as parameter 'wdgID' to disable the self-test watchdog threshold function for algorithm S step 1; pass `kADC_SelfTestWdgThresholdForAlgSStep2` as parameter 'wdgID' to disable the self-test watchdog threshold function for algorithm S step 2; pass `kADC_SelfTestWdgThresholdForAlgCStep0` as parameter 'wdgID' to disable the self-test watchdog threshold function for algorithm C; Other enumerations in `adc_self_test_wdg_threshold_t` have no use.

Parameters

- base – ADC peripheral base address.
- wdgID – Watchdog threshold index to disable, please refer to `adc_self_test_wdg_threshold_t` for details.

```
static inline void ADC_EnableSelfTestWdgTimer(ADC_Type *base, adc_alg_type_t  
                                              wdgTimerType)
```

This function is used to enable the ADC self-test watchdog timer for algorithm S or/and algorithm C.

The user can pass `kADC_SelfTestForAlgS` as parameter 'wdgTimerType' to enable the watchdog timer for algorithm S; pass `kADC_SelfTestForAlgC` as parameter 'wdgTimerType' to enable the watchdog timer for algorithm C; pass `kADC_SelfTestForAlgSAndC` as parameter 'wdgTimerType' to enable the watchdog timer for algorithm S and C.

Parameters

- `base` – ADC peripheral base address.
- `wdgTimerType` – Watchdog timer type to enable, please refer to `adc_alg_type_t` for details.

```
static inline void ADC_DisableSelfTestWdgTimer(ADC_Type *base, adc_alg_type_t
                                              wdgTimerType)
```

This function is used to disable the ADC self-test watchdog timer.

The user can pass `kADC_SelfTestForAlgS` as parameter 'wdgTimerType' to disable the watchdog timer for algorithm S; pass `kADC_SelfTestForAlgC` as parameter 'wdgTimerType' to disable the watchdog timer for algorithm C; pass `kADC_SelfTestForAlgSAndC` as parameter 'wdgTimerType' to disable the watchdog timer for algorithm S and C.

Parameters

- `base` – ADC peripheral base address.
- `wdgTimerType` – Watchdog timer type to disable, please refer to `adc_alg_type_t` for details.

```
static inline void ADC_SetSelfTestWdgTimerVal(ADC_Type *base, adc_wdg_timer_val_t
                                              wdgTimerVal)
```

This function is used to set the ADC self-test watchdog timer value.

Parameters

- `base` – ADC peripheral base address.
- `wdgTimerVal` – Watchdog timer value, please refer to `adc_wdg_timer_val_t` for details.

```
static inline uint16_t ADC_GetSelfTestChannelConvFailedData(ADC_Type *base,
                                                            adc_self_test_wdg_threshold_t
                                                            type)
```

This function is used to get the ADC self-test channel converted data when `ERR_S0/ERR_S1_INTEGER/ERR_S1_FRACTION/ERR_S2/ERR_C` occurred.

Note: The user can pass `kADC_SelfTestWdgThresholdForAlgSStep0` as parameter 'type' to get the converted data when `ERR_S0` occurred; pass `kADC_SelfTestWdgThresholdForAlgSStep1Integer` as parameter 'type' to get the converted data when `ERR_S1_INTEGER` occurred; pass `kADC_SelfTestWdgThresholdForAlgSStep1Fraction` as parameter 'type' to get the converted data when `ERR_S1_FRACTION` occurred; pass `kADC_SelfTestWdgThresholdForAlgSStep2` as parameter 'type' to get the converted data when `ERR_S2` occurred; pass `kADC_SelfTestWdgThresholdForAlgCStep0` as parameter 'type' to get the converted data when `ERR_C` occurred; Other enumerations in `adc_self_test_wdg_threshold_t` have no use.

Parameters

- `base` – ADC peripheral base address.
- `type` – Watchdog threshold index to get the ADC self-test channel converted data, please refer to `adc_self_test_wdg_threshold_t` for details.

```
static inline void ADC_EnableSelfTestInt(ADC_Type *base, uint32_t mask)
```

This function is used to enable the ADC self-test-related interrupts.

Note: Watchdog timer feature is applicable only for scan operation mode and not for one-shot operation mode.

Parameters

- `base` – ADC peripheral base address.
- `mask` – Mask value to enable the ADC self-test related interrupts, please refer to `_adc_self_test_int_enable` for details.

```
static inline void ADC_DisableSelfTestInt(ADC_Type *base, uint32_t mask)
```

This function is used to disable the ADC self-test interrupt.

Parameters

- `base` – ADC peripheral base address.
- `mask` – Mask value to disable the ADC self-test related interrupts, please refer to `_adc_self_test_int_enable` for details.

```
static inline uint32_t ADC_GetSelfTestIntStatus(ADC_Type *base)
```

This function is used to get the ADC self-test interrupts status.

Parameters

- `base` – ADC peripheral base address.

Returns

ADC self-test related interrupts status mask.

```
static inline void ADC_ClearSelfTestIntStatus(ADC_Type *base, uint32_t mask)
```

This function is used to clear the ADC self-test interrupts status.

Parameters

- `base` – ADC peripheral base address.
- `mask` – Mask value for flags to be cleared, please refer to `_adc_self_test_int_flag` for details.

```
bool ADC_GetChannelConvResult(ADC_Type *base, adc_conv_result_t *result, uint8_t  
                             channelIndex)
```

This function is used to get the specific ADC channel's conversion result.

CDR[VALID] indicates whether a new conversion is available, this field is automatically reset to 0 when the data is read. CDR[OVERW] Indicates whether the previous conversion data was overwritten without having been read, in which case the overwritten data is lost.

Parameters

- `base` – SAR ADC peripheral base address.
- `result` – Pointer to SAR ADC channels conversion result structure, please refer to `adc_conv_result_t` for details.
- `channelIndex` – Channel index to get the conversion result.

Returns

Indicates whether the acquisition of the specific channel conversion result is successful or not.

- **true** Obtaining the specific channel conversion result successfully, and the conversion result is stored in the input parameter result.

- **false** Obtaining the specific channel conversion result failed.

bool ADC_GetSelfTestChannelConvData(ADC_Type *base, *adc_self_test_conv_result_t* *result)

This function is used to get the test channel converted data when algorithm S step 0, algorithm S step 2, or algorithm C step executes.

Parameters

- *base* – ADC peripheral base address.
- *result* – Pointer to the SAR ADC self-test channel conversion result structure, please refer to *adc_self_test_conv_result_t* for details.

Returns

Indicates whether the acquisition of the self-test channel conversion result is successful or not.

- **true** Obtaining the self-test channel conversion result successfully, and the conversion result is stored in the input parameter 'result'.
- **false** Obtaining the self-test channel conversion result failed.

bool ADC_GetSelfTestChannelConvDataForAlgSStep1(ADC_Type *base,
adc_self_test_conv_result_t *result)

This function is used to get the test channel converted data when algorithm S step 1 executes.

Parameters

- *base* – ADC peripheral base address.
- *result* – Pointer to the SAR ADC self-test channel conversion result structure, please refer to *adc_self_test_conv_result_t* for details.

Returns

Indicates whether the acquisition of the self-test channel conversion result is successful or not.

- **true** Obtaining the self-test channel conversion result successfully, and the conversion result is stored in the input parameter 'result'.
- **false** Obtaining the self-test channel conversion result failed.

FSL_SAR_ADC_DRIVER_VERSION

SAR ADC driver version 2.3.0.

enum _adc_conv_int_enable

This enumeration provides the mask for the ADC end-of-conversion and end-of-chain interrupts enabling.

Values:

enumerator kADC_NormalConvChainEndIntEnable

Enable end of normal chain conversion interrupt.

enumerator kADC_NormalConvEndIntEnable

Enable end of normal conversion interrupt.

enumerator kADC_InjectConvChainEndIntEnable

Enable end of inject chain conversion interrupt.

enumerator kADC_InjectConvEndIntEnable

Enable end of inject conversion interrupt.

enum _adc_wdg_threshold_int_enable

This enumeration provides the mask for the ADC analog watchdog threshold interrupts enabling.

Values:

enumerator kADC__wdg0LowThresholdIntEnable
Enable watchdog 0 low threshold interrupt.

enumerator kADC__wdg0HighThresholdIntEnable
Enable watchdog 0 high threshold interrupt.

enumerator kADC__wdg1LowThresholdIntEnable
Enable watchdog 1 low threshold interrupt.

enumerator kADC__wdg1HighThresholdIntEnable
Enable watchdog 1 high threshold interrupt.

enumerator kADC__wdg2LowThresholdIntEnable
Enable watchdog 2 low threshold interrupt.

enumerator kADC__wdg2HighThresholdIntEnable
Enable watchdog 2 high threshold interrupt.

enumerator kADC__wdg3LowThresholdIntEnable
Enable watchdog 3 low threshold interrupt.

enumerator kADC__wdg3HighThresholdIntEnable
Enable watchdog 3 high threshold interrupt.

enumerator kADC__wdg4LowThresholdIntEnable
Enable watchdog 4 low threshold interrupt.

enumerator kADC__wdg4HighThresholdIntEnable
Enable watchdog 4 high threshold interrupt.

enumerator kADC__wdg5LowThresholdIntEnable
Enable watchdog 5 low threshold interrupt.

enumerator kADC__wdg5HighThresholdIntEnable
Enable watchdog 5 high threshold interrupt.

enumerator kADC__wdg6LowThresholdIntEnable
Enable watchdog 6 low threshold interrupt.

enumerator kADC__wdg6HighThresholdIntEnable
Enable watchdog 6 high threshold interrupt.

enumerator kADC__wdg7LowThresholdIntEnable
Enable watchdog 7 low threshold interrupt.

enumerator kADC__wdg7HighThresholdIntEnable
Enable watchdog 7 high threshold interrupt.

enum _adc_self_test_int_enable

This enumeration provides the mask for the ADC self-test related interrupts enabling.

Values:

enumerator kADC__AlgSStep0ErrIntEnable
Enable self-test algorithm S step0 error interrupt.

enumerator kADC__AlgSStep1ErrIntEnable
Enable self-test algorithm S step1 error interrupt.

enumerator kADC__AlgSStep2ErrIntEnable
Enable self-test algorithm S step2 error interrupt.

enumerator kADC__AlgCErrIntEnable
Enable self-test algorithm C error interrupt.

enumerator kADC__AlgSEndIntEnable
Enable self-test algorithm S end interrupt.

enumerator kADC__AlgCEndIntEnable
Enable self-test algorithm C end interrupt.

enumerator kADC__ConvEndIntEnable
Enable self-test conversion end interrupt.

enumerator kADC__WdgTimeErrIntEnable
Enable watchdog time error interrupt.

enumerator kADC__WdgSequenceErrIntEnable
Enable watchdog sequence error interrupt.

enum _adc_conv_int_flag

This enumeration provides the mask for the ADC end-of-conversion and end-of-chain interrupts flag.

Values:

enumerator kADC__NormalConvChainEndIntFlag
Indicates whether the end of normal chain conversion interrupt has occurred.

enumerator kADC__NormalConvEndIntFlag
Indicates whether the end of conversion interrupt has occurred.

enumerator kADC__InjectConvChainEndIntFlag
Indicates whether the end of inject chain conversion interrupt has occurred.

enumerator kADC__InjectConvEndIntFlag
Indicates whether the end of inject conversion interrupt has occurred.

enum _adc_wdg_threshold_int_flag

This enumeration provides the mask for the ADC analog watchdog threshold interrupts flag.

Values:

enumerator kADC__wdg0LowThresholdIntFlag
Indicates whether the watchdog 0 low threshold interrupt has occurred.

enumerator kADC__wdg0HighThresholdIntFlag
Indicates whether the watchdog 0 high threshold interrupt has occurred.

enumerator kADC__wdg1LowThresholdIntFlag
Indicates whether the watchdog 1 low threshold interrupt has occurred.

enumerator kADC__wdg1HighThresholdIntFlag
Indicates whether the watchdog 1 high threshold interrupt has occurred.

enumerator kADC__wdg2LowThresholdIntFlag
Indicates whether the watchdog 2 low threshold interrupt has occurred.

enumerator kADC__wdg2HighThresholdIntFlag
Indicates whether the watchdog 2 high threshold interrupt has occurred.

enumerator kADC__wdg3LowThresholdIntFlag

Indicates whether the watchdog 3 low threshold interrupt has occurred.

enumerator kADC__wdg3HighThresholdIntFlag

Indicates whether the watchdog 3 high threshold interrupt has occurred.

enumerator kADC__wdg4LowThresholdIntFlag

Indicates whether the watchdog 4 low threshold interrupt has occurred.

enumerator kADC__wdg4HighThresholdIntFlag

Indicates whether the watchdog 4 high threshold interrupt has occurred.

enumerator kADC__wdg5LowThresholdIntFlag

Indicates whether the watchdog 5 low threshold interrupt has occurred.

enumerator kADC__wdg5HighThresholdIntFlag

Indicates whether the watchdog 5 high threshold interrupt has occurred.

enumerator kADC__wdg6LowThresholdIntFlag

Indicates whether the watchdog 6 low threshold interrupt has occurred.

enumerator kADC__wdg6HighThresholdIntFlag

Indicates whether the watchdog 6 high threshold interrupt has occurred.

enumerator kADC__wdg7LowThresholdIntFlag

Indicates whether the watchdog 7 low threshold interrupt has occurred.

enumerator kADC__wdg7HighThresholdIntFlag

Indicates whether the watchdog 7 high threshold interrupt has occurred.

enum _adc_self_test_int_flag

This enumeration provides the mask for the ADC self-test-related interrupts flag.

Values:

enumerator kADC__AlgSStep0ErrIntFlag

Indicates whether the self-test algorithm S step0 error interrupt has occurred.

enumerator kADC__AlgSStep1ErrIntFlag

Indicates whether the self-test algorithm S step1 error interrupt has occurred.

enumerator kADC__AlgSStep2ErrIntFlag

Indicates whether the self-test algorithm S step2 error interrupt has occurred.

enumerator kADC__AlgCErrIntFlag

Indicates whether the self-test algorithm C error interrupt has occurred.

enumerator kADC__AlgSEndIntFlag

Indicates whether the algorithm S end interrupt has completed.

enumerator kADC__AlgCEndIntFlag

Indicates whether the algorithm C end interrupt has completed.

enumerator kADC__SelfTestConvEndIntFlag

Indicates whether the self-test end-of-conversion interrupt has completed.

enumerator kADC__OverWriteErrIntFlag

Indicates whether the overwrite error interrupt has occurred.

enumerator kADC__WdgTimeErrIntFlag

Indicates whether the watchdog time error interrupt has occurred.

enumerator kADC_WdgSequenceErrIntFlag

Indicates whether the watchdog sequence error interrupt has occurred.

enum _adc_ext_trig

This enumeration provides the selection of the ADC external trigger type.

Values:

enumerator kADC_ExtTrigDisable

Normal trigger input does not start a conversion.

enumerator kADC_ExtTrigFallingEdge

Normal trigger (falling edge) input starts a conversion.

enumerator kADC_ExtTrigRisingEdge

Normal trigger (rising edge) input starts a conversion.

enum _adc_state

This enumeration provides the selection of the ADC state.

Values:

enumerator kADC_AdcIdle

Indicates the ADC is in the IDLE state.

enumerator kADC_AdcPowerdown

Indicates the ADC is in the power-down state.

enumerator kADC_AdcWait

Indicates the ADC is in the wait state.

enumerator kADC_AdcBusyInCalibration

Indicates the ADC is in the calibration busy state.

enumerator kADC_AdcSample

Indicates the ADC is in the sample state.

enumerator kADC_AdcConv

Indicates the ADC is in the conversion state.

enum _adc_conv_mode

This enumeration provides the selection of the ADC conversion mode, including normal conversion one-shot mode, normal conversion scan mode, and inject conversion one-shot mode.

Values:

enumerator kADC_NormalConvOneShotMode

Normal conversion one-shot mode.

enumerator kADC_NormalConvScanMode

Normal conversion scan mode.

enumerator kADC_InjectConvOneShotMode

Inject conversion one-shot mode.

enum _adc_clock_frequency

This enumeration provides the selection of the ADC operating clock frequency, including half-bus frequency and full bus frequency.

Values:

enumerator kADC_HalfBusFrequency

Half of bus clock frequency.

enumerator kADC_FullBusFrequency
Equal to bus clock frequency.

enum _adc_conv_data_align

This enumeration provides the selection of the ADC conversion data alignment, including the right alignment and left alignment.

Values:

enumerator kADC_ConvDataRightAlign
Conversion data is right aligned.

enumerator kADC_ConvDataLeftAlign
Conversion data is left aligned.

enum _adc_presample_voltage_src

This enumeration provides the selection of the ADC internal analog input voltage sources for pre-sample, including DVDD0P8/2, AVDD1P8/4, VREFL_1p8 and VREFH_1p8.

Values:

enumerator kADC_PresampleVoltageSrcVREL
Use VREL as pre-sample voltage source.

enumerator kADC_PresampleVoltageSrcVREH
Use VREH as pre-sample voltage source.

enum _adc_dma_request_clear_src

This enumeration provides the selection of the DMA request clear sources, including clear by acknowledgment from the DMA controller and clear on a read of the data register.

Values:

enumerator kADC_DMAResultClearByAck
DMA request cleared by acknowledgment from DMA controller.

enumerator kADC_DMAResultClearOnRead
DMA request cleared on a read of the data register.

enum _adc_average_sample_numbers

This enumeration provides the selection of the ADC calibration averaging sample numbers, including 16, 32, 128, and 512 averaging samples.

Values:

enumerator kADC_AverageSampleNumbers16
Use 16 averaging samples during calibration.

enumerator kADC_AverageSampleNumbers32
Use 32 averaging samples during calibration.

enumerator kADC_AverageSampleNumbers128
Use 128 averaging samples during calibration.

enumerator kADC_AverageSampleNumbers512
Use 512 averaging samples during calibration.

enum _adc_sample_time

This enumeration provides the selection of the ADC sample time of calibration conversions, including 22, 8, 16 and 32 cycles of ADC_CLK.

Values:

enumerator kADC_SampleTime22

Use 22 cycles of ADC_CLK as sample time of calibration conversions.

enumerator kADC_SampleTime8

Use 8 cycles of ADC_CLK as sample time of calibration conversions.

enumerator kADC_SampleTime16

Use 16 cycles of ADC_CLK as sample time of calibration conversions.

enumerator kADC_SampleTime32

Use 32 cycles of ADC_CLK as sample time of calibration conversions.

enum _adc_wdg_threshold_int

This enumeration provides the selection of the ADC analog watchdog threshold low and high interrupt enable.

Values:

enumerator kADC_LowHighThresholdIntDisable

Enable the ADC analog watchdog low and high threshold interrupts.

enumerator kADC_LowThresholdIntEnable

Enable the ADC analog watchdog low threshold interrupt.

enumerator kADC_HighThresholdIntEnable

Enable the ADC analog watchdog high threshold interrupt.

enumerator kADC_LowHighThresholdIntEnable

Enable the ADC analog watchdog low and high threshold interrupts.

enum _adc_alg_type

This enumeration provides the selection of the ADC self-test algorithm type, including algorithm S, algorithm C and algorithm S and C.

Note: The meaning of enumeration member 'kADC_SelfTestForAlgSAndC' in different conversion modes is different, in the one-shot conversion mode, it means executing algorithm S; in the scan conversion mode, it means executing algorithm S and C.

Values:

enumerator kADC_SelfTestForAlgS

Use algorithm S for self-test.

enumerator kADC_SelfTestForAlgC

Use algorithm C for self-test.

enumerator kADC_SelfTestForAlgSAndC

Use algorithm S for one-shot conversion mode self-test, use algorithm S and algorithm C for scan conversion mode self-test.

enum _adc_self_test_wdg_threshold

This enumeration provides the selection of the ADC self-test watchdog thresholds for algorithm S step 0 - 2, and watchdog thresholds for algorithm C step 0 and step x (x = 1 - 11).

Values:

enumerator kADC_SelfTestWdgThresholdForAlgSStep0

Self-test watchdog threshold for the algorithm S step 0.

enumerator kADC_SelfTestWdgThresholdForAlgSStep1

Self-test watchdog threshold for the algorithm S step 1 fraction part.

enumerator kADC_SelfTestWdgThresholdForAlgSStep2

Self-test watchdog threshold for the algorithm S step 2.

enumerator kADC_SelfTestWdgThresholdForAlgCStep0

Self-test watchdog threshold for the algorithm C step 0.

enumerator kADC_SelfTestWdgThresholdForAlgCStepx

Self-test watchdog threshold for the algorithm C step x.

enum _adc_wdg_timer_val

This enumeration provides the selection of the ADC self-test watchdog timer value, including 0.1ms, 0.5ms, 1ms, 2ms, 5ms, 10ms, 20ms and 50ms.

Values:

enumerator kADC_SelfTestWdgTimerVal0

0.1ms ((0008h × Prescaler) cycles at 80 MHz).

enumerator kADC_SelfTestWdgTimerVal1

0.5ms ((0027h × Prescaler) cycles at 80 MHz).

enumerator kADC_SelfTestWdgTimerVal2

1ms ((004Eh × Prescaler) cycles at 80 MHz).

enumerator kADC_SelfTestWdgTimerVal3

2ms ((009Ch × Prescaler) cycles at 80 MHz).

enumerator kADC_SelfTestWdgTimerVal4

5ms ((0187h × Prescaler) cycles at 80 MHz).

enumerator kADC_SelfTestWdgTimerVal5

10ms ((030Dh × Prescaler) cycles at 80 MHz).

enumerator kADC_SelfTestWdgTimerVal6

20ms ((061Ah × Prescaler) cycles at 80 MHz).

enumerator kADC_SelfTestWdgTimerVal7

50ms ((0F42h × Prescaler) cycles at 80 MHz).

typedef enum _adc_ext_trig adc_ext_trig_t

This enumeration provides the selection of the ADC external trigger type.

typedef enum _adc_state adc_state_t

This enumeration provides the selection of the ADC state.

typedef enum _adc_conv_mode adc_conv_mode_t

This enumeration provides the selection of the ADC conversion mode, including normal conversion one-shot mode, normal conversion scan mode, and inject conversion one-shot mode.

typedef enum _adc_clock_frequency adc_clock_frequency_t

This enumeration provides the selection of the ADC operating clock frequency, including half-bus frequency and full bus frequency.

typedef enum _adc_conv_data_align adc_conv_data_align_t

This enumeration provides the selection of the ADC conversion data alignment, including the right alignment and left alignment.

typedef enum _adc_presample_voltage_src adc_presample_voltage_src_t

This enumeration provides the selection of the ADC internal analog input voltage sources for pre-sample, including DVDD0P8/2, AVDD1P8/4, VREFL_1p8 and VREFH_1p8.

typedef enum *_adc_dma_request_clear_src* adc_dma_request_clear_src_t

This enumeration provides the selection of the DMA request clear sources, including clear by acknowledgment from the DMA controller and clear on a read of the data register.

typedef enum *_adc_average_sample_numbers* adc_average_sample_numbers_t

This enumeration provides the selection of the ADC calibration averaging sample numbers, including 16, 32, 128, and 512 averaging samples.

typedef enum *_adc_sample_time* adc_sample_time_t

This enumeration provides the selection of the ADC sample time of calibration conversions, including 22, 8, 16 and 32 cycles of ADC_CLK.

typedef enum *_adc_wdg_threshold_int* adc_wdg_threshold_int_t

This enumeration provides the selection of the ADC analog watchdog threshold low and high interrupt enable.

typedef enum *_adc_alg_type* adc_alg_type_t

This enumeration provides the selection of the ADC self-test algorithm type, including algorithm S, algorithm C and algorithm S and C.

Note: The meaning of enumeration member 'kADC_SelfTestForAlgSAndC' in different conversion modes is different, in the one-shot conversion mode, it means executing algorithm S; in the scan conversion mode, it means executing algorithm S and C.

typedef enum *_adc_self_test_wdg_threshold* adc_self_test_wdg_threshold_t

This enumeration provides the selection of the ADC self-test watchdog thresholds for algorithm S step 0 - 2, and watchdog thresholds for algorithm C step 0 and step x (x = 1 - 11).

typedef enum *_adc_wdg_timer_val* adc_wdg_timer_val_t

This enumeration provides the selection of the ADC self-test watchdog timer value, including 0.1ms, 0.5ms, 1ms, 2ms, 5ms, 10ms, 20ms and 50ms.

typedef struct *_adc_config* adc_config_t

This structure is used to configure the ADC module.

typedef struct *_adc_channel_config* adc_channel_config_t

This structure is used to configure the ADC conversion channel.

typedef struct *_adc_chain_config* adc_chain_config_t

This structure is used to configure the ADC conversion chain.

typedef struct *_adc_wdg_config* adc_wdg_config_t

This structure is used to configure the ADC analog watchdog.

typedef struct *_adc_calibration_config* adc_calibration_config_t

This structure is used to configure the ADC calibration.

typedef struct *_adc_user_offset_gain_config* adc_user_offset_gain_config_t

This structure is used to configure the ADC user offset and gain.

typedef struct *_adc_self_test_config* adc_self_test_config_t

This structure is used to configure the ADC self-test.

typedef struct *_adc_self_test_wdg_config* adc_self_test_wdg_config_t

This structure is used to configure the ADC self-test watchdog for algorithm steps.

Note: The algorithm S step 2 only has the 'LowThrsholdVal'.

```
typedef struct _adc_conv_result adc_conv_result_t
```

This structure is used to save the result information when obtaining the conversion result.

```
typedef struct _adc_self_test_conv_result adc_self_test_conv_result_t
```

This structure is used to save the result information when obtaining the self-test channel conversion result.

Note: The member ‘convData’ is used to store self-test channel conversion results. Only when executing step 1 of algorithm S, member ‘convDataFraction’ will be used to store the fractional part data. When executing other algorithms, this member will not be used.

ADC_GROUP_COUNTS

ADC_THRESHOLD_COUNTS

ADC_SELF_TEST_THRESHOLD_COUNTS

GET_REGINDEX(channelIndex)

GET_BITINDEX(channelIndex)

REGISTER_READWRITE(baseRegister, shiftIndex)

REGISTER_READONLY(baseRegister, shiftIndex)

NCMR_IO(base, registerIndex)

JCMR_IO(base, registerIndex)

PSR_IO(base, registerIndex)

DMAR_IO(base, registerIndex)

CWSELR_IO(base, registerIndex)

CWENR_IO(base, registerIndex)

CIMR_IO(base, registerIndex)

CEOCFR_IO(base, registerIndex)

AWORR_IO(base, registerIndex)

STAWR_IO(base, registerIndex)

CEOCFR_I(base, registerIndex)

AWORR_I(base, registerIndex)

CDR_I(base, registerIndex)

WDG_SELECT_MASK(shiftIndex)

WDG_SELECT_SHIFT(shiftIndex)

WDG_SELECT(val, shiftIndex)

ADC_CDR_VALID_MASK

ADC_CDR_VALID_SHIFT

ADC_CDR_OVERW_MASK

ADC_CDR_OVERW_SHIFT
ADC_CDR_RESULT_MASK
ADC_CDR_RESULT_SHIFT
ADC_CDR_CDATA_MASK
ADC_CDR_CDATA_SHIFT
ADC_STAWR_AWDE_MASK
ADC_STAWR_THRL_MASK
ADC_STAWR_THRL_SHIFT
ADC_STAWR_THRL(val)
ADC_STAWR_THRH_MASK
ADC_STAWR_THRH_SHIFT
ADC_STAWR_THRH(val)
ADC_CALSTAT_MAX
ADC_CALSTAT_SIGN

struct _adc_config

#include <fsl_sar_adc.h> This structure is used to configure the ADC module.

Public Members

bool enableAutoClockOff

Decides whether to enable the ADC auto clock-off function, when set to true, the internal ADC clock is automatically switched off during IDLE mode to reduce power consumption (without going into power-down mode).

bool enableOverWrite

Decides whether to enable the latest conversion to overwrite the current value in the data registers.

bool enableConvertPresampleVal

Decides whether to convert the pre-sampled value, if enabled, pre-sampling is followed by the conversion, sampling will be bypassed and conversion of the pre-sampled data will be done.

adc_ext_trig_t extTrig

Specifies whether the normal trigger (with trigger type) input starts a conversion.

adc_conv_data_align_t convDataAlign

Selects the conversion data alignment.

adc_clock_frequency_t clockFrequency

Selects the ADC clock frequency.

adc_dma_request_clear_src_t dmaRequestClearSrc

Selects DMA request clear source.

adc_presample_voltage_src_t presampleVoltageSrc[1]

Selects analog input voltages for group 0 (corresponding to channel 0 to channel 31) and group 32 (corresponding to channel 32 to channel 63) pre-sampling.

uint8_t samplePhaseDuration[1]

Sets the sample phase duration in terms of the ADC controller clock for group 0 (corresponding to channel 0 to channel 31) and group 32 (corresponding to channel 32 to channel 63), the minimum acceptable value is 8, configuring to a value lower than 8 sets the sample period to 8 cycles.

struct __adc_channel_config

#include <fsl_sar_adc.h> This structure is used to configure the ADC conversion channel.

Public Members

uint8_t channelIndex

Sets the conversion channel index.

bool enableInt

Decides Whether to enable the interrupt function of the current conversion channel.

bool enablePresample

Decides whether to enable the pre-sample function of the current conversion channel.

bool enableDmaTransfer

Decides whether to enable the DMA transfer function of the current conversion channel.

bool enableWdg

Decides whether to enable the analog watchdog function of the current conversion channel.

uint8_t wdgIndex

Indicates which analog watchdog to provide the low and high threshold value.

struct __adc_chain_config

#include <fsl_sar_adc.h> This structure is used to configure the ADC conversion chain.

Public Members

adc_conv_mode_t convMode

Selects conversion mode.

bool enableGlobalChannelConvEndInt

Global control function to determine whether to enable the interrupt function of conversion channels.

bool enableChainConvEndInt

Decides whether to enable the current chain end-of-conversion interrupt.

uint8_t channelCount

Indicates the channel counts.

adc_channel_config_t *channelConfig

Chain channels configuration.

struct __adc_wdg_config

#include <fsl_sar_adc.h> This structure is used to configure the ADC analog watchdog.

Public Members

uint8_t wdgIndex

Indicates the analog watchdog index

adc_wdg_threshold_int_t wdgThresholdInt

Selects watchdog threshold low or/and high interrupt to enable/disable.

uint16_t lowThresholdVal

Sets the ADC analog watchdog low threshold value.

uint16_t highThresholdVal

Sets the ADC analog watchdog high threshold value.

struct _adc_calibration_config

#include <fsl_sar_adc.h> This structure is used to configure the ADC calibration.

Public Members

bool enableAverage

Decides whether to enable averaging of calibration time.

adc_sample_time_t sampleTime

Selects sample time of calibration conversions.

adc_average_sample_numbers_t averageSampleNumbers

Selects calibration averaging sample numbers.

struct _adc_user_offset_gain_config

#include <fsl_sar_adc.h> This structure is used to configure the ADC user offset and gain.

Public Members

int8_t userOffset

Sets user defined gain value.

int16_t userGain

Sets user defined offset value.

struct _adc_self_test_config

#include <fsl_sar_adc.h> This structure is used to configure the ADC self-test.

Public Members

adc_alg_type_t algType

Selects the self-test algorithm.

uint8_t algSteps

Sets the self-test algorithm steps, it should be programmed to zero in scan mode.

uint8_t algSSamplePhaseDuration

Sets the self-test algorithm S conversion sampling phase duration.

uint8_t algCSamplePhaseDuration

Sets the self-test algorithm C conversion sampling phase duration.

uint8_t baudRate

Sets the baud rate for the selected algorithm in scan mode, must write to this field before enabling a self-test channel.

struct _adc_self_test_wdg_config

#include <fsl_sar_adc.h> This structure is used to configure the ADC self-test watchdog for algorithm steps.

Note: The algorithm S step 2 only has the 'LowThrsholdVal'.

Public Members

adc_self_test_wdg_threshold_t wdgThresholdId

Indicates the self-test watchdog index

uint16_t lowThrsholdVal

Sets the self-test watchdog low threshold value.

uint16_t highThrsholdVal

Sets the self-test watchdog high threshold value.

struct _adc_conv_result

#include <fsl_sar_adc.h> This structure is used to save the result information when obtaining the conversion result.

Public Members

bool overWrittenFlag

Indicates when conversion data was overwritten by a newer result, the new data is written or discarded according to MCR[OWREN].

uint8_t convMode

Indicates the mode of conversion for the corresponding channel.

uint16_t convData

Stores the conversion data corresponding to the internal channel.

struct _adc_self_test_conv_result

#include <fsl_sar_adc.h> This structure is used to save the result information when obtaining the self-test channel conversion result.

Note: The member 'convData' is used to store self-test channel conversion results. Only when executing step 1 of algorithm S, member 'convDataFraction' will be used to store the fractional part data. When executing other algorithms, this member will not be used.

Public Members

bool overWrittenFlag

Indicates when conversion data is overwritten by a newer result.

uint16_t convData

Stores the conversion data corresponding to the internal self-test channel.

uint16_t convDataFraction

This field is only used to store the fractional part conversion result.

2.55 SEMA42: Hardware Semaphores Driver

FSL_SEMA42_DRIVER_VERSION

SEMA42 driver version.

SEMA42 status return codes.

Values:

enumerator kStatus_SEMA42_Busy

SEMA42 gate has been locked by other processor.

enumerator kStatus_SEMA42_Reseting

SEMA42 gate resetting is ongoing.

enum _sema42_gate_status

SEMA42 gate lock status.

Values:

enumerator kSEMA42_Unlocked

The gate is unlocked.

enumerator kSEMA42_LockedByProc0

The gate is locked by processor 0.

enumerator kSEMA42_LockedByProc1

The gate is locked by processor 1.

enumerator kSEMA42_LockedByProc2

The gate is locked by processor 2.

enumerator kSEMA42_LockedByProc3

The gate is locked by processor 3.

enumerator kSEMA42_LockedByProc4

The gate is locked by processor 4.

enumerator kSEMA42_LockedByProc5

The gate is locked by processor 5.

enumerator kSEMA42_LockedByProc6

The gate is locked by processor 6.

enumerator kSEMA42_LockedByProc7

The gate is locked by processor 7.

enumerator kSEMA42_LockedByProc8

The gate is locked by processor 8.

enumerator kSEMA42_LockedByProc9

The gate is locked by processor 9.

enumerator kSEMA42_LockedByProc10

The gate is locked by processor 10.

enumerator kSEMA42_LockedByProc11

The gate is locked by processor 11.

enumerator kSEMA42_LockedByProc12

The gate is locked by processor 12.

enumerator kSEMA42_LockedByProc13

The gate is locked by processor 13.

enumerator kSEMA42_LockedByProc14

The gate is locked by processor 14.

typedef enum *_sema42_gate_status* sema42_gate_status_t
SEMA42 gate lock status.

void SEMA42_Init(SEMA42_Type *base)

Initializes the SEMA42 module.

This function initializes the SEMA42 module. It only enables the clock but does not reset the gates because the module might be used by other processors at the same time. To reset the gates, call either SEMA42_ResetGate or SEMA42_ResetAllGates function.

Parameters

- base – SEMA42 peripheral base address.

void SEMA42_Deinit(SEMA42_Type *base)

De-initializes the SEMA42 module.

This function de-initializes the SEMA42 module. It only disables the clock.

Parameters

- base – SEMA42 peripheral base address.

status_t SEMA42_TryLock(SEMA42_Type *base, uint8_t gateNum, uint8_t procNum)

Tries to lock the SEMA42 gate.

This function tries to lock the specific SEMA42 gate. If the gate has been locked by another processor, this function returns an error code.

Parameters

- base – SEMA42 peripheral base address.
- gateNum – Gate number to lock.
- procNum – Current processor number.

Return values

- kStatus_Success – Lock the sema42 gate successfully.
- kStatus_SEMA42_Busy – Sema42 gate has been locked by another processor.

status_t SEMA42_Lock(SEMA42_Type *base, uint8_t gateNum, uint8_t procNum)

Locks the SEMA42 gate.

This function locks the specific SEMA42 gate. If the gate has been locked by other processors, this function waits until it is unlocked and then lock it.

If SEMA42_BUSY_POLL_COUNT is defined and non-zero, the function will timeout after the specified number of polling iterations and return kStatus_Timeout.

Parameters

- base – SEMA42 peripheral base address.
- gateNum – Gate number to lock.
- procNum – Current processor number.

Return values

- kStatus_Success – The gate was successfully locked.

- `kStatus_Timeout` – Timeout occurred while waiting for the gate to be unlocked.

Returns

`status_t`

`static inline void SEMA42_Unlock(SEMA42_Type *base, uint8_t gateNum)`

Unlocks the SEMA42 gate.

This function unlocks the specific SEMA42 gate. It only writes unlock value to the SEMA42 gate register. However, it does not check whether the SEMA42 gate is locked by the current processor or not. As a result, if the SEMA42 gate is not locked by the current processor, this function has no effect.

Parameters

- `base` – SEMA42 peripheral base address.
- `gateNum` – Gate number to unlock.

`static inline sema42_gate_status_t SEMA42_GetGateStatus(SEMA42_Type *base, uint8_t gateNum)`

Gets the status of the SEMA42 gate.

This function checks the lock status of a specific SEMA42 gate.

Parameters

- `base` – SEMA42 peripheral base address.
- `gateNum` – Gate number.

Returns

status Current status.

`status_t SEMA42_ResetGate(SEMA42_Type *base, uint8_t gateNum)`

Resets the SEMA42 gate to an unlocked status.

This function resets a SEMA42 gate to an unlocked status.

Parameters

- `base` – SEMA42 peripheral base address.
- `gateNum` – Gate number.

Return values

- `kStatus_Success` – SEMA42 gate is reset successfully.
- `kStatus_SEMA42_Reseting` – Some other reset process is ongoing.

`static inline status_t SEMA42_ResetAllGates(SEMA42_Type *base)`

Resets all SEMA42 gates to an unlocked status.

This function resets all SEMA42 gate to an unlocked status.

Parameters

- `base` – SEMA42 peripheral base address.

Return values

- `kStatus_Success` – SEMA42 is reset successfully.
- `kStatus_SEMA42_Reseting` – Some other reset process is ongoing.

`SEMA42_GATE_NUM_RESET_ALL`

The number to reset all SEMA42 gates.

SEMA42_GATE_n(base, n)

SEMA42 gate n register address.

The SEMA42 gates are sorted in the order 3, 2, 1, 0, 7, 6, 5, 4, ... not in the order 0, 1, 2, 3, 4, 5, 6, 7, ... The macro SEMA42_GATE_n gets the SEMA42 gate based on the gate index.

The input gate index is XOR'ed with 3U: $0 \wedge 3 = 3$ $1 \wedge 3 = 2$ $2 \wedge 3 = 1$ $3 \wedge 3 = 0$ $4 \wedge 3 = 7$ $5 \wedge 3 = 6$ $6 \wedge 3 = 5$ $7 \wedge 3 = 4$...

SEMA42_BUSY_POLL_COUNT

Maximum polling iterations for SEMA42 waiting loops.

This parameter defines the maximum number of iterations for any polling loop in the SEMA42 driver code before timing out and returning an error.

It applies to all waiting loops in SEMA42 driver, such as waiting for a gate to be unlocked, waiting for a reset to complete, or waiting for a resource to become available.

This is a count of loop iterations, not a time-based value.

If defined as 0, polling loops will continue indefinitely until their exit condition is met, which could potentially cause the system to hang if hardware doesn't respond or if a resource is never released.

2.56 TMU: Thermal Management Unit Driver

enum __tmu_monitor_site

TMU monitor site.

Values:

enumerator kTMU_MonitorSite0

TMU monitoring site 0.

enum __tmu_interrupt_enable

TMU interrupt enable.

Values:

enumerator kTMU_ImmediateTemperatureInterruptEnable

Immediate temperature threshold exceeded interrupt enable.

enumerator kTMU_AverageTemperatureInterruptEnable

Average temperature threshold exceeded interrupt enable.

enumerator kTMU_AverageTemperatureCriticalInterruptEnable

Average temperature critical threshold exceeded interrupt enable.

enumerator kTMU_RisingTemperatureCriticalInterruptEnable

Rising temperature critical threshold exceeded interrupt enable.

enumerator kTMU_FallingTemperatureCriticalInterruptEnable

Falling temperature critical threshold exceeded interrupt enable.

enum __tmu_interrupt_status_flags

TMU interrupt status flags.

Values:

enumerator kTMU_ImmediateTemperatureStatusFlags

Immediate temperature threshold exceeded(IHTT).

enumerator kTMU__AverageTemperatureStatusFlags

Average temperature threshold exceeded(AHTT).

enumerator kTMU__AverageTemperatureCriticalStatusFlags

Average temperature critical threshold exceeded.(AHTCT)

enumerator kTMU__RisingTemperatureCriticalStatusFlags

Rising temperature critical threshold exceeded.(RTRCT)

enumerator kTMU__FallingTemperatureCriticalStatusFlags

Falling temperature critical threshold exceeded.(FTRCT)

enum __tmu_status_flags

TMU status flags.

Values:

enumerator kTMU__IntervalExceededStatusFlags

Monitoring interval exceeded. The time required to perform measurement of all monitored sites has exceeded the monitoring interval as defined by TMTMIR.

enumerator kTMU__OutOfLowRangeStatusFlags

Out-of-range low temperature measurement detected. A temperature sensor detected a temperature reading below the lowest measurable temperature of 0 °C.

enumerator kTMU__OutOfHighRangeStatusFlags

Out-of-range high temperature measurement detected. A temperature sensor detected a temperature reading above the highest measurable temperature of 160 °C.

enum __tmu_average_low_pass_filter

Average low pass filter setting.

Values:

enumerator kTMU__AverageLowPassFilter1_0

Average low pass filter = 1.

enumerator kTMU__AverageLowPassFilter0_5

Average low pass filter = 0.5.

enumerator kTMU__AverageLowPassFilter0_25

Average low pass filter = 0.25.

enumerator kTMU__AverageLowPassFilter0_125

Average low pass filter = 0.125.

typedef struct *tmu_threshold_config* tmu_threshold_config_t

configuration for TMU threshold.

typedef struct *tmu_interrupt_status* tmu_interrupt_status_t

TMU interrupt status.

typedef enum *tmu_average_low_pass_filter* tmu_average_low_pass_filter_t

Average low pass filter setting.

typedef struct *tmu_config* tmu_config_t

Configuration for TMU module.

void TMU_Init(TMU_Type *base, const *tmu_config_t* *config)

Enable the access to TMU registers and Initialize TMU module.

Parameters

- base – TMU peripheral base address.

- `config` – Pointer to configuration structure. Refer to “`tmu_config_t`” structure.

`void TMU_Deinit(TMU_Type *base)`

De-initialize TMU module and Disable the access to DCDC registers.

Parameters

- `base` – TMU peripheral base address.

`void TMU_GetDefaultConfig(tmu_config_t *config)`

Gets the default configuration for TMU.

This function initializes the user configuration structure to default value. The default value are:

Example:

```
config->monitorInterval = 0U;
config->monitorSiteSelection = 0U;
config->averageLPF = kTMU_AverageLowPassFilter1_0;
```

Parameters

- `config` – Pointer to TMU configuration structure.

`static inline void TMU_Enable(TMU_Type *base, bool enable)`

Enable/Disable the TMU module.

Parameters

- `base` – TMU peripheral base address.
- `enable` – Switcher to enable/disable TMU.

`static inline void TMU_EnableInterrupts(TMU_Type *base, uint32_t mask)`

Enable the TMU interrupts.

Parameters

- `base` – TMU peripheral base address.
- `mask` – The interrupt mask. Refer to “`_tmu_interrupt_enable`” enumeration.

`static inline void TMU_DisableInterrupts(TMU_Type *base, uint32_t mask)`

Disable the TMU interrupts.

Parameters

- `base` – TMU peripheral base address.
- `mask` – The interrupt mask. Refer to “`_tmu_interrupt_enable`” enumeration.

`void TMU_GetInterruptStatusFlags(TMU_Type *base, tmu_interrupt_status_t *status)`

Get interrupt status flags.

Parameters

- `base` – TMU peripheral base address.
- `status` – The pointer to interrupt status structure. Record the current interrupt status. Please refer to “`tmu_interrupt_status_t`” structure.

`void TMU_ClearInterruptStatusFlags(TMU_Type *base, uint32_t mask)`

Clear interrupt status flags and corresponding interrupt critical site capture register.

Parameters

- `base` – TMU peripheral base address.
- `mask` – The mask of interrupt status flags. Refer to “`_tmu_interrupt_status_flags`” enumeration.

`static inline uint32_t TMU_GetStatusFlags(TMU_Type *base)`

Get TMU status flags.

Parameters

- `base` – TMU peripheral base address.

Returns

The mask of status flags. Refer to “`_tmu_status_flags`” enumeration.

`status_t TMU_GetHighestTemperature(TMU_Type *base, uint32_t *temperature)`

Get the highest temperature reached for any enabled monitored site within the temperature sensor range.

Parameters

- `base` – TMU peripheral base address.
- `temperature` – Highest temperature recorded in degrees Celsius by any enabled monitored site.

Return values

- `kStatus_Success` – Temperature reading is valid.
- `kStatus_Fail` – Temperature reading is not valid due to no measured temperature within the sensor range of 0-160 °C for an enabled monitored site.

Returns

Execution status.

`status_t TMU_GetLowestTemperature(TMU_Type *base, uint32_t *temperature)`

Get the lowest temperature reached for any enabled monitored site within the temperature sensor range.

Parameters

- `base` – TMU peripheral base address.
- `temperature` – Lowest temperature recorded in degrees Celsius by any enabled monitored site.

Return values

- `kStatus_Success` – Temperature reading is valid.
- `kStatus_Fail` – Temperature reading is not valid due to no measured temperature within the sensor range of 0-160 °C for an enabled monitored site.

Returns

Execution status.

`status_t TMU_GetImmediateTemperature(TMU_Type *base, float *temperature)`

Get the last immediate temperature at site `n`. The site must be part of the list of enabled monitored sites as defined by `monitorSiteSelection` in “`tmu_config_t`” structure.

Parameters

- base – TMU peripheral base address.
- temperature – Last immediate temperature reading at site 0.

Return values

- kStatus_Success – Temperature reading is valid.
- kStatus_Fail – Temperature reading is not valid because temperature out of sensor range or first measurement still pending.

Returns

Execution status.

status_t TMU_GetAverageTemperature(TMU_Type *base, uint32_t *temperature)

Get the last average temperature at site n. The site must be part of the list of enabled monitored sites as defined by monitorSiteSelection in “tmu_config_t” structure.

Parameters

- base – TMU peripheral base address.
- temperature – Last average temperature reading at site 0.

Return values

- kStatus_Success – Temperature reading is valid.
- kStatus_Fail – Temperature reading is not valid because temperature out of sensor range or first measurement still pending.

Returns

Execution status.

void TMU_SetHighTemperatureThreshold(TMU_Type *base, const *tmu_threshold_config_t* *config)

Configure the high temperature threshold value and enable/disable relevant threshold.

Parameters

- base – TMU peripheral base address.
- config – Pointer to configuration structure. Refer to “tmu_threshold_config_t” structure.

FSL_TMU_DRIVER_VERSION

TMU driver version.

Version 2.1.0.

struct *_tmu_threshold_config*

#include <fsl_tmu.h> configuration for TMU threshold.

Public Members

bool immediateThresholdEnable

Enable high temperature immediate threshold.

bool averageThresholdEnable

Enable high temperature average threshold.

bool averageCriticalThresholdEnable

Enable high temperature average critical threshold.

bool risingCriticalThresholdEnable

Enable rising temperature rate critical threshold.

bool fallingCriticalThresoldEnable

Enable rising temperature rate critical threshold.

uint8_t immediateThresoldValue

Range:0U-160U. Valid when corresponding thresold is enabled. High temperature immediate threshold value. Determines the current upper temperature threshold, for anyenabled monitored site.

uint8_t averageThresoldValue

Range:0U-160U. Valid when corresponding thresold is enabled. High temperature average threshold value. Determines the average upper temperature threshold, for any enabled monitored site.

uint8_t averageCriticalThresoldValue

Range:0U-160U. Valid when corresponding thresold is enabled. High temperature average critical threshold value. Determines the average upper critical temperature threshold, for any enabled monitored site.

uint8_t risingfallingCriticalThresoldValue

Range:0U-160U. Valid when corresponding thresold is enabled. Rising temperature rate critical threshold value. Determines the rising upper critical temperature threshold, for any enabled monitored site.

struct _tmu_interrupt_status

#include <fsl_tmu.h> TMU interrupt status.

Public Members

uint32_t interruptDetectMask

The mask of interrupt status flags. Refer to “_tmu_interrupt_status_flags” enumeration.

uint16_t immediateInterruptsSiteMask

The mask of the temperature sensor site associated with a detected IHTT event. Please refer to “_tmu_monitor_site” enumeration.

uint16_t averageInterruptsSiteMask

The mask of the temperature sensor site associated with a detected AHTT event. Please refer to “_tmu_monitor_site” enumeration.

uint16_t averageCriticalInterruptsSiteMask

The mask of the temperature sensor site associated with a detected AHTCT event. Please refer to “_tmu_monitor_site” enumeration.

uint16_t risingCriticalInterruptsSiteMask

The mask of the temperature sensor site associated with a detected RTRCT event. Please refer to “_tmu_monitor_site” enumeration.

uint16_t fallingCriticalInterruptsSiteMask

The mask of the temperature sensor site associated with a detected FTRCT event. Please refer to “_tmu_monitor_site” enumeration.

struct _tmu_config

#include <fsl_tmu.h> Configuration for TMU module.

Public Members

uint8_t monitorInterval

Temperature monitoring interval in seconds. Please refer to specific table in RM.

uint16_t monitorSiteSelection

By setting the select bit for a temperature sensor site, it is enabled and included in all monitoring functions. If no site is selected, site 0 is monitored by default. Refer to “_tmu_monitor_site” enumeration. Please look up relevant table in reference manual.

tmu_average_low_pass_filter_t averageLPF

The average temperature is calculated as: $ALPF \times \text{Current\_Temp} + (1 - ALPF) \times \text{Average\_Temp}$. For proper operation, this field should only change when monitoring is disabled.

2.57 TPM: Timer PWM Module

uint32_t TPM_GetInstance(TPM_Type *base)

Gets the instance from the base address.

Parameters

- base – TPM peripheral base address

Returns

The TPM instance

void TPM_Init(TPM_Type *base, const tpm_config_t *config)

Ungates the TPM clock and configures the peripheral for basic operation.

Note: This API should be called at the beginning of the application using the TPM driver.

Parameters

- base – TPM peripheral base address
- config – Pointer to user's TPM config structure.

void TPM_Deinit(TPM_Type *base)

Stops the counter and gates the TPM clock.

Parameters

- base – TPM peripheral base address

void TPM_GetDefaultConfig(tpm_config_t *config)

Fill in the TPM config struct with the default settings.

The default values are:

```
config->prescale = kTPM_Prescale_Divide_1;
config->useGlobalTimeBase = false;
config->syncGlobalTimeBase = false;
config->dozeEnable = false;
config->dbgMode = false;
config->enableReloadOnTrigger = false;
config->enableStopOnOverflow = false;
config->enableStartOnTrigger = false;
#if FSL_FEATURE_TPM_HAS_PAUSE_COUNTER_ON_TRIGGER
config->enablePauseOnTrigger = false;
#endif
config->triggerSelect = kTPM_Trigger_Select_0;
#if FSL_FEATURE_TPM_HAS_EXTERNAL_TRIGGER_SELECTION
config->triggerSource = kTPM_TriggerSource_External;
config->extTriggerPolarity = kTPM_ExtTrigger_Active_High;
```

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```
#endif
#if defined(FSL_FEATURE_TPM_HAS_POL) && FSL_FEATURE_TPM_HAS_POL
    config->chnlPolarity = 0U;
#endif
```

Parameters

- config – Pointer to user's TPM config structure.

tpm_clock_prescale_t TPM_CalculateCounterClkDiv(TPM_Type *base, uint32_t
counterPeriod_Hz, uint32_t srcClock_Hz)

Calculates the counter clock prescaler.

This function calculates the values for SC[PS].

return Calculated clock prescaler value.

Parameters

- base – TPM peripheral base address
- counterPeriod_Hz – The desired frequency in Hz which corresponding to the time when the counter reaches the mod value
- srcClock_Hz – TPM counter clock in Hz

static inline void TPM_Reset(TPM_Type *base)

Performs a software reset on the TPM module.

Reset all internal logic and registers, except the Global Register. Remains set until cleared by software.

Note: TPM software reset is available on certain SoC's only

Parameters

- base – TPM peripheral base address

status_t TPM_SetupPwm(TPM_Type *base, const *tpm_chnl_pwm_signal_param_t* *chnlParams,
uint8_t numOfChnls, *tpm_pwm_mode_t* mode, uint32_t pwmFreq_Hz,
uint32_t srcClock_Hz)

Configures the PWM signal parameters.

User calls this function to configure the PWM signals period, mode, dutycycle and edge. Use this function to configure all the TPM channels that will be used to output a PWM signal

Parameters

- base – TPM peripheral base address
- chnlParams – Array of PWM channel parameters to configure the channel(s)
- numOfChnls – Number of channels to configure, this should be the size of the array passed in
- mode – PWM operation mode, options available in enumeration *tpm_pwm_mode_t*
- pwmFreq_Hz – PWM signal frequency in Hz
- srcClock_Hz – TPM counter clock in Hz

Returns

kStatus_Success PWM setup successful kStatus_Error PWM setup failed kStatus_Timeout PWM setup timeout when write register CnV or MOD

status_t TPM_UpdatePwmDutycycle(TPM_Type *base, *tpm_chnl_t* chnlNumber, *tpm_pwm_mode_t* currentPwmMode, uint8_t dutyCyclePercent)

Update the duty cycle of an active PWM signal.

Parameters

- base – TPM peripheral base address
- chnlNumber – The channel number. In combined mode, this represents the channel pair number
- currentPwmMode – The current PWM mode set during PWM setup
- dutyCyclePercent – New PWM pulse width, value should be between 0 to 100 0=inactive signal(0% duty cycle)... 100=active signal (100% duty cycle)

Returns

kStatus_Success if the PWM setup was successful, kStatus_Error on failure

void TPM_UpdateChnlEdgeLevelSelect(TPM_Type *base, *tpm_chnl_t* chnlNumber, uint8_t level)

Update the edge level selection for a channel.

Note: When the TPM has PWM pause level select feature (FSL_FEATURE_TPM_HAS_PAUSE_LEVEL_SELECT = 1), the PWM output cannot be turned off by selecting the output level. In this case, must use TPM_DisableChannel API to close the PWM output.

Parameters

- base – TPM peripheral base address
- chnlNumber – The channel number
- level – The level to be set to the ELSnB:ELSnA field; valid values are 00, 01, 10, 11. See the appropriate SoC reference manual for details about this field.

static inline uint8_t TPM_GetChannelControlBits(TPM_Type *base, *tpm_chnl_t* chnlNumber)

Get the channel control bits value (mode, edge and level bit fields).

This function disable the channel by clear all mode and level control bits.

Parameters

- base – TPM peripheral base address
- chnlNumber – The channel number

Returns

The control bits value. This is the logical OR of members of the enumeration *tpm_chnl_control_bit_mask_t*.

static inline *status_t* TPM_DisableChannel(TPM_Type *base, *tpm_chnl_t* chnlNumber)

Disable the channel.

This function disable the channel by clear all mode and level control bits.

Parameters

- base – TPM peripheral base address
- chnlNumber – The channel number

Returns

kStatus_Success PWM setup successful kStatus_Timeout PWM setup timeout when write register CnSC

```
static inline status_t TPM_EnableChannel(TPM_Type *base, tpm_chnl_t chnlNumber, uint8_t control)
```

Enable the channel according to mode and level configs.

This function enable the channel output according to input mode/level config parameters.

Parameters

- base – TPM peripheral base address
- chnlNumber – The channel number
- control – The control bits value. This is the logical OR of members of the enumeration *tpm_chnl_control_bit_mask_t*.

Returns

kStatus_Success PWM setup successful kStatus_Timeout PWM setup timeout when write register CnSC

```
void TPM_SetupInputCapture(TPM_Type *base, tpm_chnl_t chnlNumber, tpm_input_capture_edge_t captureMode)
```

Enables capturing an input signal on the channel using the function parameters.

When the edge specified in the captureMode argument occurs on the channel, the TPM counter is captured into the CnV register. The user has to read the CnV register separately to get this value.

Parameters

- base – TPM peripheral base address
- chnlNumber – The channel number
- captureMode – Specifies which edge to capture

```
status_t TPM_SetupOutputCompare(TPM_Type *base, tpm_chnl_t chnlNumber, tpm_output_compare_mode_t compareMode, uint32_t compareValue)
```

Configures the TPM to generate timed pulses.

When the TPM counter matches the value of compareVal argument (this is written into CnV reg), the channel output is changed based on what is specified in the compareMode argument.

Parameters

- base – TPM peripheral base address
- chnlNumber – The channel number
- compareMode – Action to take on the channel output when the compare condition is met
- compareValue – Value to be programmed in the CnV register.

Returns

kStatus_Success PWM setup successful kStatus_Timeout PWM setup timeout when write register CnV

```
void TPM_SetupDualEdgeCapture(TPM_Type *base, tpm_chnl_t chnlPairNumber, const tpm_dual_edge_capture_param_t *edgeParam, uint32_t filterValue)
```

Configures the dual edge capture mode of the TPM.

This function allows to measure a pulse width of the signal on the input of channel of a channel pair. The filter function is disabled if the filterVal argument passed is zero.

Parameters

- base – TPM peripheral base address
- chnlPairNumber – The TPM channel pair number; options are 0, 1, 2, 3
- edgeParam – Sets up the dual edge capture function
- filterValue – Filter value, specify 0 to disable filter.

```
void TPM_SetupQuadDecode(TPM_Type *base, const tpm_phase_params_t *phaseAParams,  
                        const tpm_phase_params_t *phaseBParams,  
                        tpm_quad_decode_mode_t quadMode)
```

Configures the parameters and activates the quadrature decode mode.

Parameters

- base – TPM peripheral base address
- phaseAParams – Phase A configuration parameters
- phaseBParams – Phase B configuration parameters
- quadMode – Selects encoding mode used in quadrature decoder mode

```
static inline void TPM_SetChannelPolarity(TPM_Type *base, tpm_chnl_t chnlNumber, bool  
                                         enable)
```

Set the input and output polarity of each of the channels.

Parameters

- base – TPM peripheral base address
- chnlNumber – The channel number
- enable – true: Set the channel polarity to active high; false: Set the channel polarity to active low;

```
static inline void TPM_EnableChannelExtTrigger(TPM_Type *base, tpm_chnl_t chnlNumber, bool  
                                              enable)
```

Enable external trigger input to be used by channel.

In input capture mode, configures the trigger input that is used by the channel to capture the counter value. In output compare or PWM mode, configures the trigger input used to modulate the channel output. When modulating the output, the output is forced to the channel initial value whenever the trigger is not asserted.

Note: No matter how many external trigger sources there are, only input trigger 0 and 1 are used. The even numbered channels share the input trigger 0 and the odd numbered channels share the second input trigger 1.

Parameters

- base – TPM peripheral base address
- chnlNumber – The channel number
- enable – true: Configures trigger input 0 or 1 to be used by channel; false: Trigger input has no effect on the channel

```
void TPM_EnableInterrupts(TPM_Type *base, uint32_t mask)
```

Enables the selected TPM interrupts.

Parameters

- `base` – TPM peripheral base address
- `mask` – The interrupts to enable. This is a logical OR of members of the enumeration `tpm_interrupt_enable_t`

`void TPM_DisableInterrupts(TPM_Type *base, uint32_t mask)`

Disables the selected TPM interrupts.

Parameters

- `base` – TPM peripheral base address
- `mask` – The interrupts to disable. This is a logical OR of members of the enumeration `tpm_interrupt_enable_t`

`uint32_t TPM_GetEnabledInterrupts(TPM_Type *base)`

Gets the enabled TPM interrupts.

Parameters

- `base` – TPM peripheral base address

Returns

The enabled interrupts. This is the logical OR of members of the enumeration `tpm_interrupt_enable_t`

`void TPM_RegisterCallback(TPM_Type *base, tpm_callback_t callback)`

Register callback.

If channel or overflow interrupt is enabled by the user, then a callback can be registered which will be invoked when the interrupt is triggered.

Parameters

- `base` – TPM peripheral base address
- `callback` – Callback function

`void TPM_DriverIRQHandler(uint32_t instance)`

TPM driver IRQ handler common entry.

This function provides the common IRQ request entry for TPM.

Parameters

- `instance` – TPM instance.

`static inline uint32_t TPM_GetChannelValue(TPM_Type *base, tpm_chnl_t chnlNumber)`

Gets the TPM channel value.

Note: The TPM channel value contain the captured TPM counter value for the input modes or the match value for the output modes.

Parameters

- `base` – TPM peripheral base address
- `chnlNumber` – The channel number

Returns

The channle CnV regisyer value.

`static inline uint32_t TPM_GetStatusFlags(TPM_Type *base)`

Gets the TPM status flags.

Parameters

- `base` – TPM peripheral base address

Returns

The status flags. This is the logical OR of members of the enumeration `tpm_status_flags_t`

```
static inline void TPM_ClearStatusFlags(TPM_Type *base, uint32_t mask)
```

Clears the TPM status flags.

Parameters

- `base` – TPM peripheral base address
- `mask` – The status flags to clear. This is a logical OR of members of the enumeration `tpm_status_flags_t`

```
static inline status_t TPM_SetTimerPeriod(TPM_Type *base, uint32_t ticks)
```

Sets the timer period in units of ticks.

Timers counts from 0 until it equals the count value set here. The count value is written to the MOD register.

Note:

- This API allows the user to use the TPM module as a timer. Do not mix usage of this API with TPM's PWM setup API's.
 - Call the utility macros provided in the `fsl_common.h` to convert usec or msec to ticks.
-

Parameters

- `base` – TPM peripheral base address
- `ticks` – A timer period in units of ticks, which should be equal or greater than 1.

Returns

`kStatus_Success` PWM setup successful
`kStatus_Timeout` PWM setup timeout when write register CnSC

```
static inline uint32_t TPM_GetCurrentTimerCount(TPM_Type *base)
```

Reads the current timer counting value.

This function returns the real-time timer counting value in a range from 0 to a timer period.

Note: Call the utility macros provided in the `fsl_common.h` to convert ticks to usec or msec.

Parameters

- `base` – TPM peripheral base address

Returns

The current counter value in ticks

```
static inline void TPM_StartTimer(TPM_Type *base, tpm_clock_source_t clockSource)
```

Starts the TPM counter.

Parameters

- `base` – TPM peripheral base address
- `clockSource` – TPM clock source; once clock source is set the counter will start running

static inline *status_t* TPM_StopTimer(TPM_Type *base)

Stops the TPM counter.

Parameters

- base – TPM peripheral base address

Returns

kStatus_Success PWM setup successful
kStatus_Timeout PWM setup timeout
when write register CnSC

FSL_TPM_DRIVER_VERSION

TPM driver version 2.4.0.

enum *_tpm_chnl*

List of TPM channels.

Note: Actual number of available channels is SoC dependent

Values:

enumerator kTPM_Chnl_0
TPM channel number 0

enumerator kTPM_Chnl_1
TPM channel number 1

enumerator kTPM_Chnl_2
TPM channel number 2

enumerator kTPM_Chnl_3
TPM channel number 3

enumerator kTPM_Chnl_4
TPM channel number 4

enumerator kTPM_Chnl_5
TPM channel number 5

enumerator kTPM_Chnl_6
TPM channel number 6

enumerator kTPM_Chnl_7
TPM channel number 7

enum *_tpm_pwm_mode*

TPM PWM operation modes.

Values:

enumerator kTPM_EdgeAlignedPwm
Edge aligned PWM

enumerator kTPM_CenterAlignedPwm
Center aligned PWM

enumerator kTPM_CombinedPwm
Combined PWM (Edge-aligned, center-aligned, or asymmetrical PWMs can be obtained in combined mode using different software configurations)

enum _tpm_pwm_level_select

TPM PWM output pulse mode: high-true, low-true or no output.

Note: When the TPM has PWM pause level select feature, the PWM output cannot be turned off by selecting the output level. In this case, the channel must be closed to close the PWM output.

Values:

enumerator kTPM_HighTrue

High true pulses

enumerator kTPM_LowTrue

Low true pulses

enum _tpm_pwm_pause_level_select

TPM PWM output when first enabled or paused: set or clear.

Values:

enumerator kTPM_ClearOnPause

Clear Output when counter first enabled or paused.

enumerator kTPM_SetOnPause

Set Output when counter first enabled or paused.

enum _tpm_chnl_control_bit_mask

List of TPM channel modes and level control bit mask.

Values:

enumerator kTPM_ChnlELSnAMask

Channel ELSA bit mask.

enumerator kTPM_ChnlELSnBMask

Channel ELSE bit mask.

enumerator kTPM_ChnlMSAMask

Channel MSA bit mask.

enumerator kTPM_ChnlMSBMask

Channel MSB bit mask.

enum _tpm_trigger_select

Trigger sources available.

This is used for both internal & external trigger sources (external trigger sources available in certain SoC's)

Note: The actual trigger sources available is SoC-specific.

Values:

enumerator kTPM_Trigger_Select_0

enumerator kTPM_Trigger_Select_1

enumerator kTPM_Trigger_Select_2

enumerator kTPM_Trigger_Select_3

enumerator kTPM_Trigger_Select_4
enumerator kTPM_Trigger_Select_5
enumerator kTPM_Trigger_Select_6
enumerator kTPM_Trigger_Select_7
enumerator kTPM_Trigger_Select_8
enumerator kTPM_Trigger_Select_9
enumerator kTPM_Trigger_Select_10
enumerator kTPM_Trigger_Select_11
enumerator kTPM_Trigger_Select_12
enumerator kTPM_Trigger_Select_13
enumerator kTPM_Trigger_Select_14
enumerator kTPM_Trigger_Select_15

enum _tpm_trigger_source

Trigger source options available.

Note: This selection is available only on some SoC's. For SoC's without this selection, the only trigger source available is internal trigger.

Values:

enumerator kTPM_TriggerSource_External

Use external trigger input

enumerator kTPM_TriggerSource_Internal

Use internal trigger (channel pin input capture)

enum _tpm_ext_trigger_polarity

External trigger source polarity.

Note: Selects the polarity of the external trigger source.

Values:

enumerator kTPM_ExtTrigger_Active_High

External trigger input is active high

enumerator kTPM_ExtTrigger_Active_Low

External trigger input is active low

enum _tpm_output_compare_mode

TPM output compare modes.

Values:

enumerator kTPM_NoOutputSignal

No channel output when counter reaches CnV

enumerator kTPM_ToggleOnMatch

Toggle output

enumerator kTPM_ClearOnMatch

Clear output

enumerator kTPM_SetOnMatch

Set output

enumerator kTPM_HighPulseOutput

Pulse output high

enumerator kTPM_LowPulseOutput

Pulse output low

enum _tpm_input_capture_edge

TPM input capture edge.

Values:

enumerator kTPM_RisingEdge

Capture on rising edge only

enumerator kTPM_FallingEdge

Capture on falling edge only

enumerator kTPM_RiseAndFallEdge

Capture on rising or falling edge

enum _tpm_quad_decode_mode

TPM quadrature decode modes.

Note: This mode is available only on some SoC's.

Values:

enumerator kTPM_QuadPhaseEncode

Phase A and Phase B encoding mode

enumerator kTPM_QuadCountAndDir

Count and direction encoding mode

enum _tpm_phase_polarity

TPM quadrature phase polarities.

Values:

enumerator kTPM_QuadPhaseNormal

Phase input signal is not inverted

enumerator kTPM_QuadPhaseInvert

Phase input signal is inverted

enum _tpm_clock_source

TPM clock source selection.

Values:

enumerator kTPM_SystemClock

System clock

enumerator kTPM_ExternalClock

External TPM_EXTCLK pin clock

enumerator kTPM_ExternalInputTriggerClock
Selected external input trigger clock

enum _tpm_clock_prescale
TPM prescale value selection for the clock source.

Values:

enumerator kTPM_Prescale_Divide_1
Divide by 1

enumerator kTPM_Prescale_Divide_2
Divide by 2

enumerator kTPM_Prescale_Divide_4
Divide by 4

enumerator kTPM_Prescale_Divide_8
Divide by 8

enumerator kTPM_Prescale_Divide_16
Divide by 16

enumerator kTPM_Prescale_Divide_32
Divide by 32

enumerator kTPM_Prescale_Divide_64
Divide by 64

enumerator kTPM_Prescale_Divide_128
Divide by 128

enum _tpm_interrupt_enable
List of TPM interrupts.

Values:

enumerator kTPM_Chnl0InterruptEnable
Channel 0 interrupt.

enumerator kTPM_Chnl1InterruptEnable
Channel 1 interrupt.

enumerator kTPM_Chnl2InterruptEnable
Channel 2 interrupt.

enumerator kTPM_Chnl3InterruptEnable
Channel 3 interrupt.

enumerator kTPM_Chnl4InterruptEnable
Channel 4 interrupt.

enumerator kTPM_Chnl5InterruptEnable
Channel 5 interrupt.

enumerator kTPM_Chnl6InterruptEnable
Channel 6 interrupt.

enumerator kTPM_Chnl7InterruptEnable
Channel 7 interrupt.

enumerator kTPM_TimeOverflowInterruptEnable
Time overflow interrupt.

enum *_tpm_status_flags*

List of TPM flags.

Values:

enumerator *kTPM_Chnl0Flag*

Channel 0 flag

enumerator *kTPM_Chnl1Flag*

Channel 1 flag

enumerator *kTPM_Chnl2Flag*

Channel 2 flag

enumerator *kTPM_Chnl3Flag*

Channel 3 flag

enumerator *kTPM_Chnl4Flag*

Channel 4 flag

enumerator *kTPM_Chnl5Flag*

Channel 5 flag

enumerator *kTPM_Chnl6Flag*

Channel 6 flag

enumerator *kTPM_Chnl7Flag*

Channel 7 flag

enumerator *kTPM_TimeOverflowFlag*

Time overflow flag

typedef enum *_tpm_chnl* *tpm_chnl_t*

List of TPM channels.

Note: Actual number of available channels is SoC dependent

typedef enum *_tpm_pwm_mode* *tpm_pwm_mode_t*

TPM PWM operation modes.

typedef enum *_tpm_pwm_level_select* *tpm_pwm_level_select_t*

TPM PWM output pulse mode: high-true, low-true or no output.

Note: When the TPM has PWM pause level select feature, the PWM output cannot be turned off by selecting the output level. In this case, the channel must be closed to close the PWM output.

typedef enum *_tpm_pwm_pause_level_select* *tpm_pwm_pause_level_select_t*

TPM PWM output when first enabled or paused: set or clear.

typedef enum *_tpm_chnl_control_bit_mask* *tpm_chnl_control_bit_mask_t*

List of TPM channel modes and level control bit mask.

typedef struct *_tpm_chnl_pwm_signal_param* *tpm_chnl_pwm_signal_param_t*

Options to configure a TPM channel's PWM signal.

typedef enum *_tpm_trigger_select* tpm_trigger_select_t

Trigger sources available.

This is used for both internal & external trigger sources (external trigger sources available in certain SoC's)

Note: The actual trigger sources available is SoC-specific.

typedef enum *_tpm_trigger_source* tpm_trigger_source_t

Trigger source options available.

Note: This selection is available only on some SoC's. For SoC's without this selection, the only trigger source available is internal trigger.

typedef enum *_tpm_ext_trigger_polarity* tpm_ext_trigger_polarity_t

External trigger source polarity.

Note: Selects the polarity of the external trigger source.

typedef enum *_tpm_output_compare_mode* tpm_output_compare_mode_t

TPM output compare modes.

typedef enum *_tpm_input_capture_edge* tpm_input_capture_edge_t

TPM input capture edge.

typedef struct *_tpm_dual_edge_capture_param* tpm_dual_edge_capture_param_t

TPM dual edge capture parameters.

Note: This mode is available only on some SoC's.

typedef enum *_tpm_quad_decode_mode* tpm_quad_decode_mode_t

TPM quadrature decode modes.

Note: This mode is available only on some SoC's.

typedef enum *_tpm_phase_polarity* tpm_phase_polarity_t

TPM quadrature phase polarities.

typedef struct *_tpm_phase_param* tpm_phase_params_t

TPM quadrature decode phase parameters.

typedef enum *_tpm_clock_source* tpm_clock_source_t

TPM clock source selection.

typedef enum *_tpm_clock_prescale* tpm_clock_prescale_t

TPM prescale value selection for the clock source.

typedef struct *_tpm_config* tpm_config_t

TPM config structure.

This structure holds the configuration settings for the TPM peripheral. To initialize this structure to reasonable defaults, call the `TPM_GetDefaultConfig()` function and pass a pointer to your config structure instance.

The config struct can be made const so it resides in flash


```
typedef enum _tpm_interrupt_enable tpm_interrupt_enable_t
```

List of TPM interrupts.

```
typedef enum _tpm_status_flags tpm_status_flags_t
```

List of TPM flags.

```
typedef void (*tpm_callback_t)(TPM_Type *base)
```

TPM callback function pointer.

Param base

TPM peripheral base address.

```
TPM_TIMEOUT
```

Max loops to wait for writing register.

When writing MOD CnV CnSC and SC register, driver will wait until register is updated. This parameter defines how many loops to check completion before return timeout. If defined as 0, driver will wait forever until completion.

```
TPM_MAX_COUNTER_VALUE(x)
```

Help macro to get the max counter value.

```
struct _tpm_chnl_pwm_signal_param
```

#include <fsl_tpm.h> Options to configure a TPM channel's PWM signal.

Public Members

```
tpm_chnl_t chnlNumber
```

TPM channel to configure. In combined mode (available in some SoC's), this represents the channel pair number

```
tpm_pwm_pause_level_select_t pauseLevel
```

PWM output level when counter first enabled or paused

```
tpm_pwm_level_select_t level
```

PWM output active level select

```
uint8_t dutyCyclePercent
```

PWM pulse width, value should be between 0 to 100 0=inactive signal(0% duty cycle)... 100=always active signal (100% duty cycle)

```
uint8_t firstEdgeDelayPercent
```

Used only in combined PWM mode to generate asymmetrical PWM. Specifies the delay to the first edge in a PWM period. If unsure, leave as 0. Should be specified as percentage of the PWM period, (dutyCyclePercent + firstEdgeDelayPercent) value should be not greater than 100.

```
bool enableComplementary
```

Used only in combined PWM mode. true: The combined channels output complementary signals; false: The combined channels output same signals;

```
tpm_pwm_pause_level_select_t secPauseLevel
```

Used only in combined PWM mode. Define the second channel output level when counter first enabled or paused

```
uint8_t deadTimeValue[2]
```

The dead time value for channel n and n+1 in combined complementary PWM mode. Deadtime insertion is disabled when this value is zero, otherwise deadtime insertion for channel n/n+1 is configured as (deadTimeValue * 4) clock cycles. deadTimeValue's available range is 0 ~ 15.

struct `_tpm_dual_edge_capture_param`
#include <fsl_tpm.h> TPM dual edge capture parameters.

Note: This mode is available only on some SoC's.

Public Members

bool enableSwap
true: Use channel n+1 input, channel n input is ignored; false: Use channel n input, channel n+1 input is ignored

tpm_input_capture_edge_t currChanEdgeMode
Input capture edge select for channel n

tpm_input_capture_edge_t nextChanEdgeMode
Input capture edge select for channel n+1

struct `_tpm_phase_param`
#include <fsl_tpm.h> TPM quadrature decode phase parameters.

Public Members

uint32_t phaseFilterVal
Filter value, filter is disabled when the value is zero

tpm_phase_polarity_t phasePolarity
Phase polarity

struct `_tpm_config`
#include <fsl_tpm.h> TPM config structure.

This structure holds the configuration settings for the TPM peripheral. To initialize this structure to reasonable defaults, call the `TPM_GetDefaultConfig()` function and pass a pointer to your config structure instance.

The config struct can be made const so it resides in flash

Public Members

tpm_clock_prescale_t prescale
Select TPM clock prescale value

bool useGlobalTimeBase
true: The TPM channels use an external global time base (the local counter still use for generate overflow interrupt and DMA request); false: All TPM channels use the local counter as their timebase

bool syncGlobalTimeBase
true: The TPM counter is synchronized to the global time base; false: disabled

tpm_trigger_select_t triggerSelect
Input trigger to use for controlling the counter operation

tpm_trigger_source_t triggerSource
Decides if we use external or internal trigger.

tpm_ext_trigger_polarity_t extTriggerPolarity

when using external trigger source, need selects the polarity of it.

bool enableDoze

true: TPM counter is paused in doze mode; false: TPM counter continues in doze mode

bool enableDebugMode

true: TPM counter continues in debug mode; false: TPM counter is paused in debug mode

bool enableReloadOnTrigger

true: TPM counter is reloaded on trigger; false: TPM counter not reloaded

bool enableStopOnOverflow

true: TPM counter stops after overflow; false: TPM counter continues running after overflow

bool enableStartOnTrigger

true: TPM counter only starts when a trigger is detected; false: TPM counter starts immediately

bool enablePauseOnTrigger

true: TPM counter will pause while trigger remains asserted; false: TPM counter continues running

uint8_t chnlPolarity

Defines the input/output polarity of the channels in POL register

2.58 TRDC: Trusted Resource Domain Controller

void TRDC__Init(TRDC_Type *base)

Initializes the TRDC module.

This function enables the TRDC clock.

Parameters

- base – TRDC peripheral base address.

void TRDC__Deinit(TRDC_Type *base)

De-initializes the TRDC module.

This function disables the TRDC clock.

Parameters

- base – TRDC peripheral base address.

static inline uint8_t TRDC__GetCurrentMasterDomainId(TRDC_Type *base)

Gets the domain ID of the current bus master.

Parameters

- base – TRDC peripheral base address.

Returns

Domain ID of current bus master.

void TRDC__GetHardwareConfig(TRDC_Type *base, *trdc_hardware_config_t* *config)

Gets the TRDC hardware configuration.

This function gets the TRDC hardware configurations, including number of bus masters, number of domains, number of MRCs and number of PACs.

Parameters

- base – TRDC peripheral base address.
- config – Pointer to the structure to get the configuration.

```
static inline void TRDC_SetDacGlobalValid(TRDC_Type *base)
```

Sets the TRDC DAC(Domain Assignment Controllers) global valid.

Once enabled, it will remain enabled until next reset.

Parameters

- base – TRDC peripheral base address.

```
static inline void TRDC_LockMasterDomainAssignment(TRDC_Type *base, uint8_t master, uint8_t regNum)
```

Locks the bus master domain assignment register.

This function locks the master domain assignment. After it is locked, the register can't be changed until next reset.

Parameters

- base – TRDC peripheral base address.
- master – Which master to configure, refer to `trdcx_master_t` in processor header file, x is trdc instance.
- regNum – Which register to configure, processor master can have more than one register for the MDAC configuration.
- assignIndex – Which assignment register to lock.

```
static inline void TRDC_SetMasterDomainAssignmentValid(TRDC_Type *base, uint8_t master, uint8_t regNum, bool valid)
```

Sets the master domain assignment as valid or invalid.

This function sets the master domain assignment as valid or invalid.

Parameters

- base – TRDC peripheral base address.
- master – Which master to configure.
- regNum – Which register to configure, processor master can have more than one register for the MDAC configuration.
- assignIndex – Index for the domain assignment register.
- valid – True to set valid, false to set invalid.

```
void TRDC_GetDefaultProcessorDomainAssignment(trdc_processor_domain_assignment_t *domainAssignment)
```

Gets the default master domain assignment for the processor bus master.

This function gets the default master domain assignment for the processor bus master. It should only be used for the processor bus masters, such as CORE0. This function sets the assignment as follows:

```
assignment->domainId      = 0U;  
assignment->domainIdSelect = kTRDC_DidMda;  
assignment->lock           = 0U;
```

Parameters

- domainAssignment – Pointer to the assignment structure.

```
void TRDC_GetDefaultNonProcessorDomainAssignment(trdc_non_processor_domain_assignment_t
                                                *domainAssignment)
```

Gets the default master domain assignment for non-processor bus master.

This function gets the default master domain assignment for non-processor bus master. It should only be used for the non-processor bus masters, such as DMA. This function sets the assignment as follows:

```
assignment->domainId      = 0U;
assignment->privilegeAttr  = kTRDC_ForceUser;
assignment->secureAttr     = kTRDC_ForceSecure;
assignment->bypassDomainId = 0U;
assignment->lock           = 0U;
```

Parameters

- domainAssignment – Pointer to the assignment structure.

```
void TRDC_SetProcessorDomainAssignment(TRDC_Type *base, uint8_t master, uint8_t regNum,
                                       const trdc_processor_domain_assignment_t
                                       *domainAssignment)
```

Sets the processor bus master domain assignment.

This function sets the processor master domain assignment as valid. One bus master might have multiple domain assignment registers. The parameter `assignIndex` specifies which assignment register to set.

Example: Set domain assignment for core 0.

```
trdc_processor_domain_assignment_t processorAssignment;

TRDC_GetDefaultProcessorDomainAssignment(&processorAssignment);

processorAssignment.domainId = 0;
processorAssignment.xxx      = xxx;
TRDC_SetMasterDomainAssignment(TRDC, &processorAssignment);
```

Parameters

- base – TRDC peripheral base address.
- master – Which master to configure, refer to `trdc_master_t` in processor header file.
- regNum – Which register to configure, processor master can have more than one register for the MDAC configuration.
- domainAssignment – Pointer to the assignment structure.

```
void TRDC_SetNonProcessorDomainAssignment(TRDC_Type *base, uint8_t master, const
                                          trdc_non_processor_domain_assignment_t
                                          *domainAssignment)
```

Sets the non-processor bus master domain assignment.

This function sets the non-processor master domain assignment as valid. One bus master might have multiple domain assignment registers. The parameter `assignIndex` specifies which assignment register to set.

Example: Set domain assignment for DMA0.

```
trdc_non_processor_domain_assignment_t nonProcessorAssignment;

TRDC_GetDefaultNonProcessorDomainAssignment(&nonProcessorAssignment);
```

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```

nonProcessorAssignment.domainId = 1;
nonProcessorAssignment.xxx      = xxx;

TRDC_SetMasterDomainAssignment(TRDC, kTrdcMasterDma0, 0U, &nonProcessorAssignment);

```

Parameters

- base – TRDC peripheral base address.
- master – Which master to configure, refer to `trdc_master_t` in processor header file.
- domainAssignment – Pointer to the assignment structure.

```
static inline uint64_t TRDC_GetActiveMasterPidMap(TRDC_Type *base)
```

Gets the bit map of the bus master(s) that is(are) sourcing a PID register.

This function sets the non-processor master domain assignment as valid.

Parameters

- base – TRDC peripheral base address.

Returns

the bit map of the master(s). Bit 1 sets indicates bus master 1.

```
void TRDC_SetPid(TRDC_Type *base, uint8_t master, const trdc_pid_config_t *pidConfig)
```

Sets the current Process identifier(PID) for processor core.

Each processor has a corresponding process identifier (PID) which can be used to group tasks into different domains. Secure privileged software saves and restores the PID as part of any context switch. This data structure defines an array of 32-bit values, one per MDA module, that define the PID. Since this register resource is only applicable to processor cores, the data structure is typically sparsely populated. The `HWCFG[2-3]` registers provide a bitmap of the implemented PIDn registers. This data structure is indexed using the corresponding MDA instance number. Depending on the operating clock domain of each DAC instance, there may be optional information stored in the corresponding PIDm register to properly implement the LK2 = 2 functionality.

Parameters

- base – TRDC peripheral base address.
- master – Which processor master to configure, refer to `trdc_master_t` in processor header file.
- pidConfig – Pointer to the configuration structure.

```
void TRDC_GetDefaultIDAUConfig(trdc_idau_config_t *idauConfiguration)
```

Gets the default IDAU(Implementation-Defined Attribution Unit) configuration.

```

config->lockSecureVTOR   = false;
config->lockNonsecureVTOR = false;
config->lockSecureMPU     = false;
config->lockNonsecureMPU  = false;
config->lockSAU           = false;

```

Parameters

- domainAssignment – Pointer to the configuration structure.

```
void TRDC_SetIDAU(TRDC_Type *base, const trdc_idau_config_t *idauConfiguration)
```

Sets the IDAU(Implementation-Defined Attribution Unit) control configuration.

Example: Lock the secure and non-secure MPU registers.

```
trdc_idau_config_t idauConfiguration;

TRDC_GetDefaultIDAUConfig(&idauConfiguration);

idauConfiguration.lockSecureMPU = true;
idauConfiguration.lockNonsecureMPU = true;
TRDC_SetIDAU(TRDC, &idauConfiguration);
```

Parameters

- base – TRDC peripheral base address.
- domainAssignment – Pointer to the configuration structure.

static inline void TRDC_EnableFlashLogicalWindow(TRDC_Type *base, bool enable)

Enables/disables the FLW(flash logical window) function.

Parameters

- base – TRDC peripheral base address.
- enable – True to enable, false to disable.

static inline void TRDC_LockFlashLogicalWindow(TRDC_Type *base)

Locks FLW registers. Once locked the registers can not be updated until next reset.

Parameters

- base – TRDC peripheral base address.

static inline uint32_t TRDC_GetFlashLogicalWindowPbase(TRDC_Type *base)

Gets the FLW physical base address.

Parameters

- base – TRDC peripheral base address.

Returns

Physical address of the FLW function.

static inline void TRDC_GetSetFlashLogicalWindowSize(TRDC_Type *base, uint16_t size)

Sets the FLW size.

Parameters

- base – TRDC peripheral base address.
- size – Size of the FLW in unit of 32k bytes.

void TRDC_GetDefaultFlashLogicalWindowConfig(*trdc_flw_config_t* *flwConfiguration)

Gets the default FLW(Flash Logical Window) configuration.

```
config->blockCount = false;
config->arrayBaseAddr = false;
config->lock = false;
config->enable = false;
```

Parameters

- flwConfiguration – Pointer to the configuration structure.

void TRDC_SetFlashLogicalWindow(TRDC_Type *base, const *trdc_flw_config_t* *flwConfiguration)

Sets the FLW function's configuration.

```
trdc_flw_config_t flwConfiguration;  
  
TRDC_GetDefaultIDAUConfig(&flwConfiguration);  
  
flwConfiguration.blockCount = 32U;  
flwConfiguration.arrayBaseAddr = 0xFFFFFFFF;  
TRDC_SetIDAU(TRDC, &flwConfiguration);
```

Parameters

- base – TRDC peripheral base address.
- flwConfiguration – Pointer to the configuration structure.

status_t TRDC_GetAndClearFirstDomainError(TRDC_Type *base, *trdc_domain_error_t* *error)

Gets and clears the first domain error of the current domain.

This function gets the first access violation information for the current domain and clears the pending flag. There might be multiple access violations pending for the current domain. This function only processes the first error.

Parameters

- base – TRDC peripheral base address.
- error – Pointer to the error information.

Returns

If the access violation is captured, this function returns the *kStatus_Success*. The error information can be obtained from the parameter error. If no access violation is captured, this function returns the *kStatus_NoData*.

status_t TRDC_GetAndClearFirstSpecificDomainError(TRDC_Type *base, *trdc_domain_error_t* *error, *uint8_t* domainId)

Gets and clears the first domain error of the specific domain.

This function gets the first access violation information for the specific domain and clears the pending flag. There might be multiple access violations pending for the current domain. This function only processes the first error.

Parameters

- base – TRDC peripheral base address.
- error – Pointer to the error information.
- domainId – The error of which domain to get and clear.

Returns

If the access violation is captured, this function returns the *kStatus_Success*. The error information can be obtained from the parameter error. If no access violation is captured, this function returns the *kStatus_NoData*.

static inline void TRDC_SetMrcGlobalValid(TRDC_Type *base)

Sets the TRDC MRC(Memory Region Checkers) global valid.

Once enabled, it will remain enabled until next reset.

Parameters

- base – TRDC peripheral base address.

static inline *uint8_t* TRDC_GetMrcRegionNumber(TRDC_Type *base, *uint8_t* mrcIdx)

Gets the TRDC MRC(Memory Region Checkers) region number valid.

Parameters

- base – TRDC peripheral base address.

Returns

the region number of the given MRC instance

```
void TRDC_MrcSetMemoryAccessConfig(TRDC_Type *base, const
                                   trdc_memory_access_control_config_t *config, uint8_t
                                   mrcIdx, uint8_t regIdx)
```

Sets the memory access configuration for one of the access control register of one MRC.

Example: Enable the secure operations and lock the configuration for MRC0 region 1.

```
trdc_memory_access_control_config_t config;

config.securePrivX = true;
config.securePrivW = true;
config.securePrivR = true;
config.lock = true;
TRDC_SetMrcMemoryAccess(TRDC, &config, 0, 1);
```

Parameters

- base – TRDC peripheral base address.
- config – Pointer to the configuration structure.
- mrcIdx – MRC index.
- regIdx – Register number.

```
void TRDC_MrcEnableDomainNseUpdate(TRDC_Type *base, uint8_t mrcIdx, uint16_t
                                   domianMask, bool enable)
```

Enables the update of the selected domians.

After the domians' update are enabled, their regions' NSE bits can be set or clear.

Parameters

- base – TRDC peripheral base address.
- mrcIdx – MRC index.
- domianMask – Bit mask of the domains to be enabled.
- enable – True to enable, false to disable.

```
void TRDC_MrcRegionNseSet(TRDC_Type *base, uint8_t mrcIdx, uint16_t regionMask)
```

Sets the NSE bits of the selected regions for domains.

This function sets the NSE bits for the selected regions for the domains whose update are enabled.

Parameters

- base – TRDC peripheral base address.
- mrcIdx – MRC index.
- regionMask – Bit mask of the regions whose NSE bits to set.

```
void TRDC_MrcRegionNseClear(TRDC_Type *base, uint8_t mrcIdx, uint16_t regionMask)
```

Clears the NSE bits of the selected regions for domains.

This function clears the NSE bits for the selected regions for the domains whose update are enabled.

Parameters

- base – TRDC peripheral base address.
- mrcIdx – MRC index.

- `regionMask` – Bit mask of the regions whose NSE bits to clear.

`void TRDC_MrcDomainNseClear(TRDC_Type *base, uint8_t mrcIdx, uint16_t domainMask)`

Clears the NSE bits for all the regions of the selected domains.

This function clears the NSE bits for all regions of selected domains whose update are enabled.

Parameters

- `base` – TRDC peripheral base address.
- `mrcIdx` – MRC index.
- `domainMask` – Bit mask of the domains whose NSE bits to clear.

`void TRDC_MrcSetRegionDescriptorConfig(TRDC_Type *base, const trdc_mrc_region_descriptor_config_t *config)`

Sets the configuration for one of the region descriptor per domain per MRC instance.

This function sets the configuration for one of the region descriptor, including the start and end address of the region, memory access control policy and valid.

Parameters

- `base` – TRDC peripheral base address.
- `config` – Pointer to region descriptor configuration structure.

`static inline void TRDC_SetMbcGlobalValid(TRDC_Type *base)`

Sets the TRDC MBC(Memory Block Checkers) global valid.

Once enabled, it will remain enabled until next reset.

Parameters

- `base` – TRDC peripheral base address.

`void TRDC_GetMbcHardwareConfig(TRDC_Type *base, trdc_slave_memory_hardware_config_t *config, uint8_t mbcIdx, uint8_t slvIdx)`

Gets the hardware configuration of the one of two slave memories within each MBC(memory block checker).

Parameters

- `base` – TRDC peripheral base address.
- `config` – Pointer to the structure to get the configuration.
- `mbcIdx` – MBC number.
- `slvIdx` – Slave number.

`void TRDC_MbcSetNseUpdateConfig(TRDC_Type *base, const trdc_mbc_nse_update_config_t *config, uint8_t mbcIdx)`

Sets the NSR update configuration for one of the MBC instance.

After set the NSE configuration, the configured memory area can be update by NSE set/clear.

Parameters

- `base` – TRDC peripheral base address.
- `config` – Pointer to NSE update configuration structure.
- `mbcIdx` – MBC index.

`void TRDC_MbcWordNseSet(TRDC_Type *base, uint8_t mbcIdx, uint32_t bitMask)`

Sets the NSE bits of the selected configuration words according to NSE update configuration.

This function sets the NSE bits of the word for the configured region, memory.

Parameters

- base – TRDC peripheral base address.
- mbcIdx – MBC index.
- bitMask – Mask of the bits whose NSE bits to set.

void TRDC__MbcWordNseClear(TRDC_Type *base, uint8_t mbcIdx, uint32_t bitMask)

Clears the NSE bits of the selected configuration words according to NSE update configuration.

This function sets the NSE bits of the word for the configured regio, memory.

Parameters

- base – TRDC peripheral base address.
- mbcIdx – MBC index.
- bitMask – Mask of the bits whose NSE bits to clear.

void TRDC__MbcNseClearAll(TRDC_Type *base, uint8_t mbcIdx, uint16_t domainMask, uint8_t slave)

Clears all configuration words' NSE bits of the selected domain and memory.

Parameters

- base – TRDC peripheral base address.
- mbcIdx – MBC index.
- domainMask – Mask of the domains whose NSE bits to clear, 0b110 means clear domain 1&2.
- slaveMask – Mask of the slaves whose NSE bits to clear, 0x11 means clear all slave 0&1's NSE bits.

void TRDC__MbcSetMemoryAccessConfig(TRDC_Type *base, const *trdc_memory_access_control_config_t* *config, uint8_t mbcIdx, uint8_t rgdIdx)

Sets the memory access configuration for one of the region descriptor of one MBC.

Example: Enable the secure operations and lock the configuration for MRC0 region 1.

```
trdc_memory_access_control_config_t config;

config.securePrivX = true;
config.securePrivW = true;
config.securePrivR = true;
config.lock = true;
TRDC_SetMbcMemoryAccess(TRDC, &config, 0, 1);
```

Parameters

- base – TRDC peripheral base address.
- config – Pointer to the configuration structure.
- mbcIdx – MBC index.
- rgdIdx – Region descriptor number.

void TRDC__MbcSetMemoryBlockConfig(TRDC_Type *base, const *trdc_mbc_memory_block_config_t* *config)

Sets the configuration for one of the memory block per domain per MBC instance.

This function sets the configuration for one of the memory block, including the memory access control policy and nse enable.

Parameters

- base – TRDC peripheral base address.
- config – Pointer to memory block configuration structure.

enum `_trdc_did_sel`

TRDC domain ID select method, the register bit `TRDC_MDA_W0_0_DFMT0[DIDS]`, used for domain hit evaluation.

Values:

enumerator `kTRDC_DidMda`

Use `MDAn[2:0]` as DID.

enumerator `kTRDC_DidInput`

Use the input DID (`DID_in`) as DID.

enumerator `kTRDC_DidMdaAndInput`

Use `MDAn[2]` concatenated with `DID_in[1:0]` as DID.

enumerator `kTRDC_DidReserved`

Reserved.

enum `_trdc_secure_attr`

TRDC secure attribute, the register bit `TRDC_MDA_W0_0_DFMT0[SA]`, used for bus master domain assignment.

Values:

enumerator `kTRDC_ForceSecure`

Force the bus attribute for this master to secure.

enumerator `kTRDC_ForceNonSecure`

Force the bus attribute for this master to non-secure.

enumerator `kTRDC_MasterSecure`

Use the bus master's secure/nonsecure attribute directly.

enumerator `kTRDC_MasterSecure1`

Use the bus master's secure/nonsecure attribute directly.

enum `_trdc_pid_domain_hit_config`

The configuration of domain hit evaluation of PID.

Values:

enumerator `kTRDC_pidDomainHitNone0`

No PID is included in the domain hit evaluation.

enumerator `kTRDC_pidDomainHitNone1`

No PID is included in the domain hit evaluation.

enumerator `kTRDC_pidDomainHitInclusive`

The PID is included in the domain hit evaluation when $(PID \ \& \ \sim PIDM)$.

enumerator `kTRDC_pidDomainHitExclusive`

The PID is included in the domain hit evaluation when $\sim(PID \ \& \ \sim PIDM)$.

enum `_trdc_privilege_attr`

TRDC privileged attribute, the register bit `TRDC_MDA_W0_x_DFMT1[PA]`, used for non-processor bus master domain assignment.

Values:

enumerator kTRDC_ForceUser

Force the bus attribute for this master to user.

enumerator kTRDC_ForcePrivilege

Force the bus attribute for this master to privileged.

enumerator kTRDC_MasterPrivilege

Use the bus master's attribute directly.

enumerator kTRDC_MasterPrivilege1

Use the bus master's attribute directly.

enum _trdc_pid_lock

PID lock configuration.

Values:

enumerator kTRDC_PidUnlocked0

The PID value can be updated by any secure privileged write.

enumerator kTRDC_PidUnlocked1

The PID value can be updated by any secure privileged write.

enumerator kTRDC_PidUnlocked2

The PID value can be updated by any secure privileged write from the bus master that first configured this register.

enumerator kTRDC_PidLocked

The PID value is locked until next reset.

enum _trdc_controller

TRDC controller definition for domain error check. Each TRDC instance may have different MRC or MBC count, call TRDC_GetHardwareConfig to get the actual count.

Values:

enumerator kTRDC_MemBlockController0

Memory block checker 0.

enumerator kTRDC_MemBlockController1

Memory block checker 1.

enumerator kTRDC_MemBlockController2

Memory block checker 2.

enumerator kTRDC_MemBlockController3

Memory block checker 3.

enumerator kTRDC_MemRegionChecker0

Memory region checker 0.

enumerator kTRDC_MemRegionChecker1

Memory region checker 1.

enumerator kTRDC_MemRegionChecker2

Memory region checker 2.

enumerator kTRDC_MemRegionChecker3

Memory region checker 3.

enumerator kTRDC_MemRegionChecker4

Memory region checker 4.

enumerator kTRDC_MemRegionChecker5

Memory region checker 5.

enumerator kTRDC_MemRegionChecker6

Memory region checker 6.

enum _trdc_error_state

TRDC domain error state	definition	TRDC_MBCn_DERR_W1[EST]	or
TRDC_MRCn_DERR_W1[EST].			

Values:

enumerator kTRDC_ErrorStateNone

No access violation detected.

enumerator kTRDC_ErrorStateNone1

No access violation detected.

enumerator kTRDC_ErrorStateSingle

Single access violation detected.

enumerator kTRDC_ErrorStateMulti

Multiple access violation detected.

enum _trdc_error_attr

TRDC domain error attribute	definition	TRDC_MBCn_DERR_W1[EATR]	or
TRDC_MRCn_DERR_W1[EATR].			

Values:

enumerator kTRDC_ErrorSecureUserInst

Secure user mode, instruction fetch access.

enumerator kTRDC_ErrorSecureUserData

Secure user mode, data access.

enumerator kTRDC_ErrorSecurePrivilegeInst

Secure privileged mode, instruction fetch access.

enumerator kTRDC_ErrorSecurePrivilegeData

Secure privileged mode, data access.

enumerator kTRDC_ErrorNonSecureUserInst

NonSecure user mode, instruction fetch access.

enumerator kTRDC_ErrorNonSecureUserData

NonSecure user mode, data access.

enumerator kTRDC_ErrorNonSecurePrivilegeInst

NonSecure privileged mode, instruction fetch access.

enumerator kTRDC_ErrorNonSecurePrivilegeData

NonSecure privileged mode, data access.

enum _trdc_error_type

TRDC domain error access type definition TRDC_DERR_W1_n[ERW].

Values:

enumerator kTRDC_ErrorTypeRead

Error occurs on read reference.

enumerator kTRDC_ErrorTypeWrite

Error occurs on write reference.

enum _trdc_region_descriptor

The region descriptor enumeration, used to form a mask to set/clear the NSE bits for one or several regions.

Values:

enumerator kTRDC_RegionDescriptor0

Region descriptor 0.

enumerator kTRDC_RegionDescriptor1

Region descriptor 1.

enumerator kTRDC_RegionDescriptor2

Region descriptor 2.

enumerator kTRDC_RegionDescriptor3

Region descriptor 3.

enumerator kTRDC_RegionDescriptor4

Region descriptor 4.

enumerator kTRDC_RegionDescriptor5

Region descriptor 5.

enumerator kTRDC_RegionDescriptor6

Region descriptor 6.

enumerator kTRDC_RegionDescriptor7

Region descriptor 7.

enumerator kTRDC_RegionDescriptor8

Region descriptor 8.

enumerator kTRDC_RegionDescriptor9

Region descriptor 9.

enumerator kTRDC_RegionDescriptor10

Region descriptor 10.

enumerator kTRDC_RegionDescriptor11

Region descriptor 11.

enumerator kTRDC_RegionDescriptor12

Region descriptor 12.

enumerator kTRDC_RegionDescriptor13

Region descriptor 13.

enumerator kTRDC_RegionDescriptor14

Region descriptor 14.

enumerator kTRDC_RegionDescriptor15

Region descriptor 15.

enum _trdc_MRC_domain

The MRC domain enumeration, used to form a mask to enable/disable the update or clear all NSE bits of one or several domains.

Values:

enumerator kTRDC_MrcDomain0

Domain 0.

enumerator kTRDC_MrcDomain1

Domain 1.

enumerator kTRDC_MrcDomain2

Domain 2.

enumerator kTRDC_MrcDomain3

Domain 3.

enumerator kTRDC_MrcDomain4

Domain 4.

enumerator kTRDC_MrcDomain5

Domain 5.

enumerator kTRDC_MrcDomain6

Domain 6.

enumerator kTRDC_MrcDomain7

Domain 7.

enumerator kTRDC_MrcDomain8

Domain 8.

enumerator kTRDC_MrcDomain9

Domain 9.

enumerator kTRDC_MrcDomain10

Domain 10.

enumerator kTRDC_MrcDomain11

Domain 11.

enumerator kTRDC_MrcDomain12

Domain 12.

enumerator kTRDC_MrcDomain13

Domain 13.

enumerator kTRDC_MrcDomain14

Domain 14.

enumerator kTRDC_MrcDomain15

Domain 15.

enum _trdc_MBC_domain

The MBC domain enumeration, used to form a mask to enable/disable the update or clear NSE bits of one or several domains.

Values:

enumerator kTRDC_MbcDomain0

Domain 0.

enumerator kTRDC_MbcDomain1

Domain 1.

enumerator kTRDC_MbcDomain2

Domain 2.

enumerator kTRDC_MbcDomain3

Domain 3.

enumerator kTRDC_MbcDomain4
Domain 4.

enumerator kTRDC_MbcDomain5
Domain 5.

enumerator kTRDC_MbcDomain6
Domain 6.

enumerator kTRDC_MbcDomain7
Domain 7.

enum _trdc_MBC_memory

The MBC slave memory enumeration, used to form a mask to enable/disable the update or clear NSE bits of one or several memory block.

Values:

enumerator kTRDC_MbcSlaveMemory0
Memory 0.

enumerator kTRDC_MbcSlaveMemory1
Memory 1.

enumerator kTRDC_MbcSlaveMemory2
Memory 2.

enumerator kTRDC_MbcSlaveMemory3
Memory 3.

enum _trdc_MBC_bit

The MBC bit enumeration, used to form a mask to set/clear configured words' NSE.

Values:

enumerator kTRDC_MbcBit0
Bit 0.

enumerator kTRDC_MbcBit1
Bit 1.

enumerator kTRDC_MbcBit2
Bit 2.

enumerator kTRDC_MbcBit3
Bit 3.

enumerator kTRDC_MbcBit4
Bit 4.

enumerator kTRDC_MbcBit5
Bit 5.

enumerator kTRDC_MbcBit6
Bit 6.

enumerator kTRDC_MbcBit7
Bit 7.

enumerator kTRDC_MbcBit8
Bit 8.

enumerator kTRDC_MbcBit9
Bit 9.

enumerator kTRDC_MbcBit10
Bit 10.

enumerator kTRDC_MbcBit11
Bit 11.

enumerator kTRDC_MbcBit12
Bit 12.

enumerator kTRDC_MbcBit13
Bit 13.

enumerator kTRDC_MbcBit14
Bit 14.

enumerator kTRDC_MbcBit15
Bit 15.

enumerator kTRDC_MbcBit16
Bit 16.

enumerator kTRDC_MbcBit17
Bit 17.

enumerator kTRDC_MbcBit18
Bit 18.

enumerator kTRDC_MbcBit19
Bit 19.

enumerator kTRDC_MbcBit20
Bit 20.

enumerator kTRDC_MbcBit21
Bit 21.

enumerator kTRDC_MbcBit22
Bit 22.

enumerator kTRDC_MbcBit23
Bit 23.

enumerator kTRDC_MbcBit24
Bit 24.

enumerator kTRDC_MbcBit25
Bit 25.

enumerator kTRDC_MbcBit26
Bit 26.

enumerator kTRDC_MbcBit27
Bit 27.

enumerator kTRDC_MbcBit28
Bit 28.

enumerator kTRDC_MbcBit29
Bit 29.

enumerator kTRDC_MbcBit30
Bit 30.

enumerator kTRDC_MbcBit31

Bit 31.

typedef struct *_trdc_hardware_config* trdc_hardware_config_t

TRDC hardware configuration.

typedef struct *_trdc_slave_memory_hardware_config* trdc_slave_memory_hardware_config_t

Hardware configuration of the two slave memories within each MBC(memory block checker).

typedef enum *_trdc_did_sel* trdc_did_sel_t

TRDC domain ID select method, the register bit TRDC_MDA_W0_0_DFMT0[DIDS], used for domain hit evaluation.

typedef enum *_trdc_secure_attr* trdc_secure_attr_t

TRDC secure attribute, the register bit TRDC_MDA_W0_0_DFMT0[SA], used for bus master domain assignment.

typedef enum *_trdc_pid_domain_hit_config* trdc_pid_domain_hit_config_t

The configuration of domain hit evaluation of PID.

typedef struct *_trdc_processor_domain_assignment* trdc_processor_domain_assignment_t

Domain assignment for the processor bus master.

typedef enum *_trdc_privilege_attr* trdc_privilege_attr_t

TRDC privileged attribute, the register bit TRDC_MDA_W0_x_DFMT1[PA], used for non-processor bus master domain assignment.

typedef struct *_trdc_non_processor_domain_assignment*

trdc_non_processor_domain_assignment_t

Domain assignment for the non-processor bus master.

typedef enum *_trdc_pid_lock* trdc_pid_lock_t

PID lock configuration.

typedef struct *_trdc_pid_config* trdc_pid_config_t

Process identifier(PID) configuration for processor cores.

typedef struct *_trdc_idau_config* trdc_idau_config_t

IDAU(Implementation-Defined Attribution Unit) configuration for TZ-M function control.

typedef struct *_trdc_flw_config* trdc_flw_config_t

FLW(Flash Logical Window) configuration.

typedef enum *_trdc_controller* trdc_controller_t

TRDC controller definition for domain error check. Each TRDC instance may have different MRC or MBC count, call TRDC_GetHardwareConfig to get the actual count.

typedef enum *_trdc_error_state* trdc_error_state_t

TRDC domain error state definition TRDC_MBCn_DERR_W1[EST] or TRDC_MRCn_DERR_W1[EST].

typedef enum *_trdc_error_attr* trdc_error_attr_t

TRDC domain error attribute definition TRDC_MBCn_DERR_W1[EATR] or TRDC_MRCn_DERR_W1[EATR].

typedef enum *_trdc_error_type* trdc_error_type_t

TRDC domain error access type definition TRDC_DERR_W1_n[ERW].

typedef struct *_trdc_domain_error* trdc_domain_error_t

TRDC domain error definition.

```
typedef struct _trdc_memory_access_control_config trdc_memory_access_control_config_t
```

Memory access control configuration for MBC/MRC.

```
typedef struct _trdc_mrc_region_descriptor_config trdc_mrc_region_descriptor_config_t
```

The configuration of each region descriptor per domain per MRC instance.

```
typedef struct _trdc_mbc_nse_update_config trdc_mbc_nse_update_config_t
```

The configuration of MBC NSE update.

```
typedef struct _trdc_mbc_memory_block_config trdc_mbc_memory_block_config_t
```

The configuration of each memory block per domain per MBC instance.

```
FSL_TRDC_DRIVER_VERSION
```

```
struct _trdc_hardware_config
```

#include <fsl_trdc.h> TRDC hardware configuration.

Public Members

uint8_t masterNumber

Number of bus masters.

uint8_t domainNumber

Number of domains.

uint8_t mbcNumber

Number of MBCs.

uint8_t mrcNumber

Number of MRCs.

```
struct _trdc_slave_memory_hardware_config
```

#include <fsl_trdc.h> Hardware configuration of the two slave memories within each MBC(memory block checker).

Public Members

uint32_t blockNum

Number of blocks.

uint32_t blockSize

Block size.

```
struct _trdc_processor_domain_assignment
```

#include <fsl_trdc.h> Domain assignment for the processor bus master.

Public Members

uint32_t domainId

Domain ID.

uint32_t domainIdSelect

Domain ID select method, see `trdc_did_sel_t`.

uint32_t pidDomainHitConfig

The configuration of the domain hit evaluation for PID, see `trdc_pid_domain_hit_config_t`.

uint32_t pidMask

The mask combined with PID, so multiple PID can be included as part of the domain hit determination. Set to 0 to disable.

uint32_t secureAttr

Secure attribute, see trdc_secure_attr_t.

uint32_t pid

The process identifier, combined with pidMask to form the domain hit determination.

uint32_t __pad0__

Reserved.

uint32_t lock

Lock the register.

uint32_t __pad1__

Reserved.

struct __trdc_non_processor_domain_assignment

#include <fsl_trdc.h> Domain assignment for the non-processor bus master.

Public Members

uint32_t domainId

Domain ID.

uint32_t privilegeAttr

Privileged attribute, see trdc_privilege_attr_t.

uint32_t secureAttr

Secure attribute, see trdc_secure_attr_t.

uint32_t bypassDomainId

Bypass domain ID.

uint32_t __pad0__

Reserved.

uint32_t lock

Lock the register.

uint32_t __pad1__

Reserved.

struct __trdc_pid_config

#include <fsl_trdc.h> Process identifier(PID) configuration for processor cores.

Public Members

uint32_t pid

The process identifier of the executing task. The highest bit can be used to define secure/nonsecure attribute of the task.

uint32_t __pad0__

Reserved.

uint32_t lock

How to lock the register, see trdc_pid_lock_t.

uint32_t __pad1__
Reserved.

struct __trdc_idau_config
#include <fsl_trdc.h> IDAU(Implementation-Defined Attribution Unit) configuration for TZ-M function control.

Public Members

uint32_t __pad0__
Reserved.

uint32_t lockSecureVTOR
Disable writes to secure VTOR(Vector Table Offset Register).

uint32_t lockNonsecureVTOR
Disable writes to non-secure VTOR, Application interrupt and Reset Control Registers.

uint32_t lockSecureMPU
Disable writes to secure MPU(Memory Protection Unit) from software or from a debug agent connected to the processor in Secure state.

uint32_t lockNonsecureMPU
Disable writes to non-secure MPU(Memory Protection Unit) from software or from a debug agent connected to the processor.

uint32_t lockSAU
Disable writes to SAU(Security Attribution Unit) registers.

uint32_t __pad1__
Reserved.

struct __trdc_flw_config
#include <fsl_trdc.h> FLW(Flash Logical Window) configuration.

Public Members

uint16_t blockCount
Block count of the Flash Logic Window in 32KByte blocks.

uint32_t arrayBaseAddr
Flash array base address of the Flash Logical Window.

bool lock
Disable writes to FLW registers.

bool enable
Enable FLW function.

struct __trdc_domain_error
#include <fsl_trdc.h> TRDC domain error definition.

Public Members

trdc_controller_t controller
Which controller captured access violation.

uint32_t address

Access address that generated access violation.

trdc_error_state_t errorState

Error state.

trdc_error_attr_t errorAttr

Error attribute.

trdc_error_type_t errorType

Error type.

uint8_t errorPort

Error port.

uint8_t domainId

Domain ID.

uint8_t slaveMemoryIdx

The slave memory index. Only apply when violation in MBC.

struct _trdc_memory_access_control_config

#include <fsl_trdc.h> Memory access control configuration for MBC/MRC.

Public Members

uint32_t nonsecureUsrX

Allow nonsecure user execute access.

uint32_t nonsecureUsrW

Allow nonsecure user write access.

uint32_t nonsecureUsrR

Allow nonsecure user read access.

uint32_t __pad0__

Reserved.

uint32_t nonsecurePrivX

Allow nonsecure privilege execute access.

uint32_t nonsecurePrivW

Allow nonsecure privilege write access.

uint32_t nonsecurePrivR

Allow nonsecure privilege read access.

uint32_t __pad1__

Reserved.

uint32_t secureUsrX

Allow secure user execute access.

uint32_t secureUsrW

Allow secure user write access.

uint32_t secureUsrR

Allow secure user read access.

uint32_t __pad2__

Reserved.

uint32_t securePrivX

Allownsecure privilege execute access.

uint32_t securePrivW

Allownsecure privilege write access.

uint32_t securePrivR

Allownsecure privilege read access.

uint32_t __pad3__

Reserved.

uint32_t lock

Lock the configuration until next reset, only apply to access control register 0.

struct _trdc_mrc_region_descriptor_config

#include <fsl_trdc.h> The configuration of each region descriptor per domain per MRC instance.

Public Members

uint8_t memoryAccessControlSelect

Select one of the 8 access control policies for this region, for access cotrol policies see trdc_memory_access_control_config_t.

uint32_t startAddr

Physical start address.

bool valid

Lock the register.

bool nseEnable

Enable non-secure accesses and disable secure accesses.

uint32_t endAddr

Physical start address.

uint8_t mrcIdx

The index of the MRC for this configuration to take effect.

uint8_t domainIdx

The index of the domain for this configuration to take effect.

uint8_t regionIdx

The index of the region for this configuration to take effect.

struct _trdc_mbc_nse_update_config

#include <fsl_trdc.h> The configuration of MBC NSE update.

Public Members

uint32_t __pad0__

Reserved.

uint32_t wordIdx

MBC configuration word index to be updated.

uint32_t __pad1__

Reserved.

uint32_t memorySelect

Bit mask of the selected memory to be updated. _trdc_MBC_memory.

uint32_t __pad2__

Reserved.

uint32_t domainSelect

Bit mask of the selected domain to be updated. _trdc_MBC_domain.

uint32_t __pad3__

Reserved.

uint32_t autoIncrement

Whether to increment the word index after current word is updated using this configuration.

struct _trdc_mbc_memory_block_config

#include <fsl_trdc.h> The configuration of each memory block per domain per MBC instance.

Public Members

uint32_t memoryAccessControlSelect

Select one of the 8 access control policies for this memory block, for access control policies see trdc_memory_access_control_config_t.

uint32_t nseEnable

Enable non-secure accesses and disable secure accesses.

uint32_t mbcIdx

The index of the MBC for this configuration to take effect.

uint32_t domainIdx

The index of the domain for this configuration to take effect.

uint32_t slaveMemoryIdx

The index of the slave memory for this configuration to take effect.

uint32_t memoryBlockIdx

The index of the memory block for this configuration to take effect.

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typedef struct *_TRDC_General_Type* TRDC__General__Type

TRDC general configuration register definition.

typedef struct *_TRDC_FLW_Type* TRDC__FLW__Type

TRDC flash logical control register definition.

typedef struct *_TRDC_DomainError_Type* TRDC__DomainError__Type

TRDC domain error register definition.

typedef struct *_TRDC_DomainAssignment_Type* TRDC__DomainAssignment__Type

TRDC master domain assignment register definition.

typedef struct *_TRDC_MBC_Type* TRDC__MBC__Type

TRDC MBC control register definition.

```
typedef struct _TRDC_MRC_Type TRDC_MRC_Type
    TRDC MRC control register definition. MRC_DOM0_RGD_W[region][word].
TRDC_GENERAL_BASE(base)
    TRDC base address convert macro.
TRDC_FLW_BASE(base)
TRDC_DOMAIN_ERROR_BASE(base)
TRDC_DOMAIN_ASSIGNMENT_BASE(base)
TRDC_MBC_BASE(base, instance)
TRDC_MRC_BASE(base, instance)
struct _TRDC_General_Type
    #include <fsl_trdc_core.h> TRDC general configuration register definition.
```

Public Members

```
__IO uint32_t TRDC_CR
    TRDC Register, offset: 0x0
__I uint32_t TRDC_HWCFG0
    TRDC Hardware Configuration Register 0, offset: 0xF0
__I uint32_t TRDC_HWCFG1
    TRDC Hardware Configuration Register 1, offset: 0xF4
__I uint32_t TRDC_HWCFG2
    TRDC Hardware Configuration Register 2, offset: 0xF8
__I uint32_t TRDC_HWCFG3
    TRDC Hardware Configuration Register 3, offset: 0xFC
__I uint8_t DACFG [8]
    Domain Assignment Configuration Register, array offset: 0x100, array step: 0x1
__IO uint32_t TRDC_IDAU_CR
    TRDC IDAU Control Register, offset: 0x1C0
struct _TRDC_FLW_Type
    #include <fsl_trdc_core.h> TRDC flash logical control register definition.
```

Public Members

```
__IO uint32_t TRDC_FLW_CTL
    TRDC FLW Control, offset: 0x1E0
__I uint32_t TRDC_FLW_PBASE
    TRDC FLW Physical Base, offset: 0x1E4
__IO uint32_t TRDC_FLW_ABASE
    TRDC FLW Array Base, offset: 0x1E8
__IO uint32_t TRDC_FLW_BCNT
    TRDC FLW Block Count, offset: 0x1EC
struct _TRDC_DomainError_Type
    #include <fsl_trdc_core.h> TRDC domain error register definition.
```

Public Members

```

__IO uint32_t TRDC_FDID
    TRDC Fault Domain ID, offset: 0x1FC

__IO uint32_t TRDC_DERRLOC [16]
    TRDC Domain Error Location Register, array offset: 0x200, array step: 0x4

struct _TRDC_DomainAssignment_Type
    #include <fsl_trdc_core.h> TRDC master domain assignment register definition.

```

Public Members

```

__IO uint32_t PID [8]
    Process Identifier, array offset: 0x700, array step: 0x4

struct _TRDC_MBC_Type
    #include <fsl_trdc_core.h> TRDC MBC control register definition.

```

Public Members

```

__IO uint32_t MBC_MEM_GLBCFG [4]
    MBC Global Configuration Register, array offset: 0x10000, array step: index*0x2000,
    index2*0x4

__IO uint32_t MBC_NSE_BLK_INDEX
    MBC NonSecure Enable Block Index, array offset: 0x10010, array step: 0x2000

__O uint32_t MBC_NSE_BLK_SET
    MBC NonSecure Enable Block Set, array offset: 0x10014, array step: 0x2000

__O uint32_t MBC_NSE_BLK_CLR
    MBC NonSecure Enable Block Clear, array offset: 0x10018, array step: 0x2000

__O uint32_t MBC_NSE_BLK_CLR_ALL
    MBC NonSecure Enable Block Clear All, array offset: 0x1001C, array step: 0x2000

__IO uint32_t MBC_MEMN_GLBAC [8]
    MBC Global Access Control, array offset: 0x10020, array step: index*0x2000, in-
    dex2*0x4

__IO uint32_t MBC_DOM0_MEM0_BLK_CFG_W [64]
    MBC Memory Block Configuration Word, array offset: 0x10040, array step: in-
    dex*0x2000, index2*0x4

__IO uint32_t MBC_DOM0_MEM0_BLK_NSE_W [16]
    MBC Memory Block NonSecure Enable Word, array offset: 0x10140, array step: in-
    dex*0x2000, index2*0x4

__IO uint32_t MBC_DOM0_MEM1_BLK_CFG_W [8]
    MBC Memory Block Configuration Word, array offset: 0x10180, array step: in-
    dex*0x2000, index2*0x4

__IO uint32_t MBC_DOM0_MEM1_BLK_NSE_W [2]
    MBC Memory Block NonSecure Enable Word, array offset: 0x101A0, array step: in-
    dex*0x2000, index2*0x4

__IO uint32_t MBC_DOM0_MEM2_BLK_CFG_W [8]
    MBC Memory Block Configuration Word, array offset: 0x101A8, array step: in-
    dex*0x2000, index2*0x4

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- ___IO uint32_t MBC_DOM0_MEM2_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x101C8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM0_MEM3_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x101D0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM0_MEM3_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x101F0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM1_MEM0_BLK_CFG_W [64]
MBC Memory Block Configuration Word, array offset: 0x10240, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM1_MEM0_BLK_NSE_W [16]
MBC Memory Block NonSecure Enable Word, array offset: 0x10340, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM1_MEM1_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x10380, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM1_MEM1_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x103A0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM1_MEM2_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x103A8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM1_MEM2_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x103C8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM1_MEM3_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x103D0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM1_MEM3_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x103F0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM2_MEM0_BLK_CFG_W [64]
MBC Memory Block Configuration Word, array offset: 0x10440, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM2_MEM0_BLK_NSE_W [16]
MBC Memory Block NonSecure Enable Word, array offset: 0x10540, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM2_MEM1_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x10580, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM2_MEM1_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x105A0, array step: index*0x2000, index2*0x4

- ___IO uint32_t MBC_DOM2_MEM2_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x105A8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM2_MEM2_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x105C8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM2_MEM3_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x105D0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM2_MEM3_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x105F0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM3_MEM0_BLK_CFG_W [64]
MBC Memory Block Configuration Word, array offset: 0x10640, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM3_MEM0_BLK_NSE_W [16]
MBC Memory Block NonSecure Enable Word, array offset: 0x10740, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM3_MEM1_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x10780, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM3_MEM1_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x107A0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM3_MEM2_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x107A8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM3_MEM2_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x107C8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM3_MEM3_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x107D0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM3_MEM3_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x107F0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM4_MEM0_BLK_CFG_W [64]
MBC Memory Block Configuration Word, array offset: 0x10840, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM4_MEM0_BLK_NSE_W [16]
MBC Memory Block NonSecure Enable Word, array offset: 0x10940, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM4_MEM1_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x10980, array step: index*0x2000, index2*0x4

- ___IO uint32_t MBC_DOM4_MEM1_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x109A0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM4_MEM2_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x109A8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM4_MEM2_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x109C8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM4_MEM3_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x109D0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM4_MEM3_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x109F0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM5_MEM0_BLK_CFG_W [64]
MBC Memory Block Configuration Word, array offset: 0x10A40, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM5_MEM0_BLK_NSE_W [16]
MBC Memory Block NonSecure Enable Word, array offset: 0x10B40, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM5_MEM1_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x10B80, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM5_MEM1_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x10BA0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM5_MEM2_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x10BA8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM5_MEM2_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x10BC8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM5_MEM3_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x10BD0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM5_MEM3_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x10BF0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM6_MEM0_BLK_CFG_W [64]
MBC Memory Block Configuration Word, array offset: 0x10C40, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM6_MEM0_BLK_NSE_W [16]
MBC Memory Block NonSecure Enable Word, array offset: 0x10D40, array step: index*0x2000, index2*0x4

- ___IO uint32_t MBC_DOM6_MEM1_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x10D80, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM6_MEM1_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x10DA0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM6_MEM2_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x10DA8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM6_MEM2_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x10DC8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM6_MEM3_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x10DD0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM6_MEM3_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x10DF0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM7_MEM0_BLK_CFG_W [64]
MBC Memory Block Configuration Word, array offset: 0x10E40, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM7_MEM0_BLK_NSE_W [16]
MBC Memory Block NonSecure Enable Word, array offset: 0x10F40, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM7_MEM1_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x10F80, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM7_MEM1_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x10FA0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM7_MEM2_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x10FA8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM7_MEM2_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x10FC8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM7_MEM3_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x10FD0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM7_MEM3_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x10FF0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM8_MEM0_BLK_CFG_W [64]
MBC Memory Block Configuration Word, array offset: 0x11040, array step: index*0x2000, index2*0x4

- ___IO uint32_t MBC_DOM8_MEM0_BLK_NSE_W [16]
MBC Memory Block NonSecure Enable Word, array offset: 0x11140, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM8_MEM1_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x11180, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM8_MEM1_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x111A0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM8_MEM2_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x111A8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM8_MEM2_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x111C8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM8_MEM3_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x111D0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM8_MEM3_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x111F0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM9_MEM0_BLK_CFG_W [64]
MBC Memory Block Configuration Word, array offset: 0x11240, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM9_MEM0_BLK_NSE_W [16]
MBC Memory Block NonSecure Enable Word, array offset: 0x11340, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM9_MEM1_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x11380, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM9_MEM1_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x113A0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM9_MEM2_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x113A8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM9_MEM2_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x113C8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM9_MEM3_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x113D0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM9_MEM3_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x113F0, array step: index*0x2000, index2*0x4

- ___IO uint32_t MBC_DOM10_MEM0_BLK_CFG_W [64]
MBC Memory Block Configuration Word, array offset: 0x11440, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM10_MEM0_BLK_NSE_W [16]
MBC Memory Block NonSecure Enable Word, array offset: 0x11540, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM10_MEM1_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x11580, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM10_MEM1_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x115A0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM10_MEM2_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x115A8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM10_MEM2_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x115C8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM10_MEM3_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x115D0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM10_MEM3_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x115F0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM11_MEM0_BLK_CFG_W [64]
MBC Memory Block Configuration Word, array offset: 0x11640, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM11_MEM0_BLK_NSE_W [16]
MBC Memory Block NonSecure Enable Word, array offset: 0x11740, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM11_MEM1_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x11780, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM11_MEM1_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x117A0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM11_MEM2_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x117A8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM11_MEM2_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x117C8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM11_MEM3_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x117D0, array step: index*0x2000, index2*0x4

__IO uint32_t MBC_DOM11_MEM3_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x117F0, array step: index*0x2000, index2*0x4

__IO uint32_t MBC_DOM12_MEM0_BLK_CFG_W [64]
MBC Memory Block Configuration Word, array offset: 0x11840, array step: index*0x2000, index2*0x4

__IO uint32_t MBC_DOM12_MEM0_BLK_NSE_W [16]
MBC Memory Block NonSecure Enable Word, array offset: 0x11940, array step: index*0x2000, index2*0x4

__IO uint32_t MBC_DOM12_MEM1_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x11980, array step: index*0x2000, index2*0x4

__IO uint32_t MBC_DOM12_MEM1_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x119A0, array step: index*0x2000, index2*0x4

__IO uint32_t MBC_DOM12_MEM2_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x119A8, array step: index*0x2000, index2*0x4

__IO uint32_t MBC_DOM12_MEM2_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x119C8, array step: index*0x2000, index2*0x4

__IO uint32_t MBC_DOM12_MEM3_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x119D0, array step: index*0x2000, index2*0x4

__IO uint32_t MBC_DOM12_MEM3_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x119F0, array step: index*0x2000, index2*0x4

__IO uint32_t MBC_DOM13_MEM0_BLK_CFG_W [64]
MBC Memory Block Configuration Word, array offset: 0x11A40, array step: index*0x2000, index2*0x4

__IO uint32_t MBC_DOM13_MEM0_BLK_NSE_W [16]
MBC Memory Block NonSecure Enable Word, array offset: 0x11B40, array step: index*0x2000, index2*0x4

__IO uint32_t MBC_DOM13_MEM1_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x11B80, array step: index*0x2000, index2*0x4

__IO uint32_t MBC_DOM13_MEM1_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x11BA0, array step: index*0x2000, index2*0x4

__IO uint32_t MBC_DOM13_MEM2_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x11BA8, array step: index*0x2000, index2*0x4

__IO uint32_t MBC_DOM13_MEM2_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x11BC8, array step: index*0x2000, index2*0x4

- ___IO uint32_t MBC_DOM13_MEM3_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x11BD0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM13_MEM3_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x11BF0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM14_MEM0_BLK_CFG_W [64]
MBC Memory Block Configuration Word, array offset: 0x11C40, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM14_MEM0_BLK_NSE_W [16]
MBC Memory Block NonSecure Enable Word, array offset: 0x11D40, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM14_MEM1_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x11D80, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM14_MEM1_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x11DA0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM14_MEM2_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x11DA8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM14_MEM2_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x11DC8, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM14_MEM3_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x11DD0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM14_MEM3_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x11DF0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM15_MEM0_BLK_CFG_W [64]
MBC Memory Block Configuration Word, array offset: 0x11E40, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM15_MEM0_BLK_NSE_W [16]
MBC Memory Block NonSecure Enable Word, array offset: 0x11F40, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM15_MEM1_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x11F80, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM15_MEM1_BLK_NSE_W [2]
MBC Memory Block NonSecure Enable Word, array offset: 0x11FA0, array step: index*0x2000, index2*0x4
- ___IO uint32_t MBC_DOM15_MEM2_BLK_CFG_W [8]
MBC Memory Block Configuration Word, array offset: 0x11FA8, array step: index*0x2000, index2*0x4

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__IO uint32_t MBC_DOM15_MEM2_BLK_NSE_W [2]
    MBC Memory Block NonSecure Enable Word, array offset: 0x11FC8, array step: index*0x2000, index2*0x4

__IO uint32_t MBC_DOM15_MEM3_BLK_CFG_W [8]
    MBC Memory Block Configuration Word, array offset: 0x11FD0, array step: index*0x2000, index2*0x4

__IO uint32_t MBC_DOM15_MEM3_BLK_NSE_W [2]
    MBC Memory Block NonSecure Enable Word, array offset: 0x11FF0, array step: index*0x2000, index2*0x4

struct _TRDC_MRC_Type
#include <fsl_trdc_core.h>    TRDC    MRC    control    register    definition.
MRC_DOM0_RGD_W[region][word].
```

Public Members

```
__I uint32_t MRC_GLBCFG
    MRC Global Configuration Register, array offset: 0x14000, array step: 0x1000

__IO uint32_t MRC_NSE_RGN_INDIRECT
    MRC NonSecure Enable Region Indirect, array offset: 0x14010, array step: 0x1000

__O uint32_t MRC_NSE_RGN_SET
    MRC NonSecure Enable Region Set, array offset: 0x14014, array step: 0x1000

__O uint32_t MRC_NSE_RGN_CLR
    MRC NonSecure Enable Region Clear, array offset: 0x14018, array step: 0x1000

__O uint32_t MRC_NSE_RGN_CLR_ALL
    MRC NonSecure Enable Region Clear All, array offset: 0x1401C, array step: 0x1000

__IO uint32_t MRC_GLBAC [8]
    MRC Global Access Control, array offset: 0x14020, array step: index*0x1000, index2*0x4

__IO uint32_t MRC_DOM0_RGD_W [16][2]
    MRC Region Descriptor Word 0..MRC Region Descriptor Word 1, array offset: 0x14040, array step: index*0x1000, index2*0x8, index3*0x4

__IO uint32_t MRC_DOM0_RGD_NSE
    MRC Region Descriptor NonSecure Enable, array offset: 0x140C0, array step: 0x1000

__IO uint32_t MRC_DOM1_RGD_W [16][2]
    MRC Region Descriptor Word 0..MRC Region Descriptor Word 1, array offset: 0x14140, array step: index*0x1000, index2*0x8, index3*0x4

__IO uint32_t MRC_DOM1_RGD_NSE
    MRC Region Descriptor NonSecure Enable, array offset: 0x141C0, array step: 0x1000

__IO uint32_t MRC_DOM2_RGD_W [16][2]
    MRC Region Descriptor Word 0..MRC Region Descriptor Word 1, array offset: 0x14240, array step: index*0x1000, index2*0x8, index3*0x4

__IO uint32_t MRC_DOM2_RGD_NSE
    MRC Region Descriptor NonSecure Enable, array offset: 0x142C0, array step: 0x1000

__IO uint32_t MRC_DOM3_RGD_W [16][2]
    MRC Region Descriptor Word 0..MRC Region Descriptor Word 1, array offset: 0x14340, array step: index*0x1000, index2*0x8, index3*0x4
```

```

__IO uint32_t MRC_DOM3_RGD_NSE
    MRC Region Descriptor NonSecure Enable, array offset: 0x143C0, array step: 0x1000

__IO uint32_t MRC_DOM4_RGD_W [16][2]
    MRC Region Descriptor Word 0..MRC Region Descriptor Word 1, array offset: 0x14440,
    array step: index*0x1000, index2*0x8, index3*0x4

__IO uint32_t MRC_DOM4_RGD_NSE
    MRC Region Descriptor NonSecure Enable, array offset: 0x144C0, array step: 0x1000

__IO uint32_t MRC_DOM5_RGD_W [16][2]
    MRC Region Descriptor Word 0..MRC Region Descriptor Word 1, array offset: 0x14540,
    array step: index*0x1000, index2*0x8, index3*0x4

__IO uint32_t MRC_DOM5_RGD_NSE
    MRC Region Descriptor NonSecure Enable, array offset: 0x145C0, array step: 0x1000

__IO uint32_t MRC_DOM6_RGD_W [16][2]
    MRC Region Descriptor Word 0..MRC Region Descriptor Word 1, array offset: 0x14640,
    array step: index*0x1000, index2*0x8, index3*0x4

__IO uint32_t MRC_DOM6_RGD_NSE
    MRC Region Descriptor NonSecure Enable, array offset: 0x146C0, array step: 0x1000

__IO uint32_t MRC_DOM7_RGD_W [16][2]
    MRC Region Descriptor Word 0..MRC Region Descriptor Word 1, array offset: 0x14740,
    array step: index*0x1000, index2*0x8, index3*0x4

__IO uint32_t MRC_DOM7_RGD_NSE
    MRC Region Descriptor NonSecure Enable, array offset: 0x147C0, array step: 0x1000

__IO uint32_t MRC_DOM8_RGD_W [16][2]
    MRC Region Descriptor Word 0..MRC Region Descriptor Word 1, array offset: 0x14840,
    array step: index*0x1000, index2*0x8, index3*0x4

__IO uint32_t MRC_DOM8_RGD_NSE
    MRC Region Descriptor NonSecure Enable, array offset: 0x148C0, array step: 0x1000

__IO uint32_t MRC_DOM9_RGD_W [16][2]
    MRC Region Descriptor Word 0..MRC Region Descriptor Word 1, array offset: 0x14940,
    array step: index*0x1000, index2*0x8, index3*0x4

__IO uint32_t MRC_DOM9_RGD_NSE
    MRC Region Descriptor NonSecure Enable, array offset: 0x149C0, array step: 0x1000

__IO uint32_t MRC_DOM10_RGD_W [16][2]
    MRC Region Descriptor Word 0..MRC Region Descriptor Word 1, array offset: 0x14A40,
    array step: index*0x1000, index2*0x8, index3*0x4

__IO uint32_t MRC_DOM10_RGD_NSE
    MRC Region Descriptor NonSecure Enable, array offset: 0x14AC0, array step: 0x1000

__IO uint32_t MRC_DOM11_RGD_W [16][2]
    MRC Region Descriptor Word 0..MRC Region Descriptor Word 1, array offset: 0x14B40,
    array step: index*0x1000, index2*0x8, index3*0x4

__IO uint32_t MRC_DOM11_RGD_NSE
    MRC Region Descriptor NonSecure Enable, array offset: 0x14BC0, array step: 0x1000

__IO uint32_t MRC_DOM12_RGD_W [16][2]
    MRC Region Descriptor Word 0..MRC Region Descriptor Word 1, array offset: 0x14C40,
    array step: index*0x1000, index2*0x8, index3*0x4

```

```
__IO uint32_t MRC_DOM12_RGD_NSE
    MRC Region Descriptor NonSecure Enable, array offset: 0x14CC0, array step: 0x1000
__IO uint32_t MRC_DOM13_RGD_W [16][2]
    MRC Region Descriptor Word 0..MRC Region Descriptor Word 1, array offset: 0x14D40,
    array step: index*0x1000, index2*0x8, index3*0x4
__IO uint32_t MRC_DOM13_RGD_NSE
    MRC Region Descriptor NonSecure Enable, array offset: 0x14DC0, array step: 0x1000
__IO uint32_t MRC_DOM14_RGD_W [16][2]
    MRC Region Descriptor Word 0..MRC Region Descriptor Word 1, array offset: 0x14E40,
    array step: index*0x1000, index2*0x8, index3*0x4
__IO uint32_t MRC_DOM14_RGD_NSE
    MRC Region Descriptor NonSecure Enable, array offset: 0x14EC0, array step: 0x1000
__IO uint32_t MRC_DOM15_RGD_W [16][2]
    MRC Region Descriptor Word 0..MRC Region Descriptor Word 1, array offset: 0x14F40,
    array step: index*0x1000, index2*0x8, index3*0x4
__IO uint32_t MRC_DOM15_RGD_NSE
    MRC Region Descriptor NonSecure Enable, array offset: 0x14FC0, array step: 0x1000
struct MBC_DERR
```

Public Members

```
__I uint32_t W0
    MBC Domain Error Word0 Register, array offset: 0x400, array step: 0x10
__I uint32_t W1
    MBC Domain Error Word1 Register, array offset: 0x404, array step: 0x10
__O uint32_t W3
    MBC Domain Error Word3 Register, array offset: 0x40C, array step: 0x10
struct MRC_DERR
```

Public Members

```
__I uint32_t W0
    MRC Domain Error Word0 Register, array offset: 0x480, array step: 0x10
__I uint32_t W1
    MRC Domain Error Word1 Register, array offset: 0x484, array step: 0x10
__O uint32_t W3
    MRC Domain Error Word3 Register, array offset: 0x48C, array step: 0x10
union __unnamed95__
```

Public Members

```
struct _TRDC_DomainAssignment_Type MDA_DFMT0[8]
struct _TRDC_DomainAssignment_Type MDA_DFMT1[8]
struct MDA_DFMT0
```

Public Members

__IO uint32_t MDA_W_DFMT0 [8]

DAC Master Domain Assignment Register, array offset: 0x800, array step: index*0x20, index2*0x4

struct MDA_DFMT1

Public Members

__IO uint32_t MDA_W_DFMT1 [1]

DAC Master Domain Assignment Register, array offset: 0x800, array step: index*0x20, index2*0x4

2.60 TSTMR: Timestamp Timer Driver

void TSTMR_Init(TSTMR_Type *base)

Init TSTMR.

This function initializes the TSTMR module.

Parameters

- base – TSTMR peripheral base address.

void TSTMR_Deinit(TSTMR_Type *base)

Deinit TSTMR.

This function deinitializes the TSTMR module.

Parameters

- base – TSTMR peripheral base address.

FSL_TSTMR_DRIVER_VERSION

Version 2.1.0

static inline uint64_t TSTMR_ReadTimeStamp(TSTMR_Type *base)

Reads the time stamp.

This function reads the low and high registers and returns the 56-bit free running counter value. This can be read by software at any time to determine the software ticks. TSTMR registers can be read with 32-bit accesses only. The TSTMR LOW read should occur first, followed by the TSTMR HIGH read.

Parameters

- base – TSTMR peripheral base address.

Returns

The 56-bit time stamp value.

void TSTMR_DelayUs(TSTMR_Type *base, uint64_t delayInUs)

Delays for a specified number of microseconds.

This function repeatedly reads the timestamp register and waits for the user-specified delay value.

Parameters

- base – TSTMR peripheral base address.
- delayInUs – Delay value in microseconds.

2.61 WDOG32: 32-bit Watchdog Timer

`void WDOG32_GetDefaultConfig(wdog32_config_t *config)`

Initializes the WDOG32 configuration structure.

This function initializes the WDOG32 configuration structure to default values. The default values are:

```
wdog32Config->enableWdog32 = true;
wdog32Config->clockSource = kWDOG32_ClockSource1;
wdog32Config->prescaler = kWDOG32_ClockPrescalerDivide1;
wdog32Config->workMode.enableWait = true;
wdog32Config->workMode.enableStop = false;
wdog32Config->workMode.enableDebug = false;
wdog32Config->testMode = kWDOG32_TestModeDisabled;
wdog32Config->enableUpdate = true;
wdog32Config->enableInterrupt = false;
wdog32Config->enableWindowMode = false;
wdog32Config->windowValue = 0U;
wdog32Config->timeoutValue = 0xFFFFU;
```

See also:

`wdog32_config_t`

Parameters

- `config` – Pointer to the WDOG32 configuration structure.

`status_t WDOG32_Init(WDOG_Type *base, const wdog32_config_t *config)`

Initializes the WDOG32 module.

This function initializes the WDOG32. To reconfigure the WDOG32 without forcing a reset first, `enableUpdate` must be set to true in the configuration.

Example:

```
wdog32_config_t config;
WDOG32_GetDefaultConfig(&config);
config.timeoutValue = 0x7ffU;
config.enableUpdate = true;
WDOG32_Init(wdog_base,&config);
```

Note: If there is errata ERR010536 (FSL_FEATURE_WDOG_HAS_ERRATA_010536 defined as 1), then after calling this function, user need delay at least 4 LPO clock cycles before accessing other WDOG32 registers.

Parameters

- `base` – WDOG32 peripheral base address.
- `config` – The configuration of the WDOG32.

Return values

- `kStatus_Success` – The initialization was successful
- `kStatus_Timeout` – The initialization timed out

status_t WDOG32_Deinit(WDOG_Type *base)

De-initializes the WDOG32 module.

This function shuts down the WDOG32. Ensure that the WDOG_CS.UPDATE is 1, which means that the register update is enabled.

Parameters

- base – WDOG32 peripheral base address.

Return values

- kStatus_Success – The de-initialization was successful
- kStatus_Timeout – The de-initialization timed out

status_t WDOG32_Unlock(WDOG_Type *base)

Unlocks the WDOG32 register written.

This function unlocks the WDOG32 register written.

Before starting the unlock sequence and following the configuration, disable the global interrupts. Otherwise, an interrupt could effectively invalidate the unlock sequence and the WCT may expire. After the configuration finishes, re-enable the global interrupts.

Parameters

- base – WDOG32 peripheral base address

Return values

- kStatus_Success – The unlock sequence was successful
- kStatus_Timeout – The unlock sequence timed out

void WDOG32_Enable(WDOG_Type *base)

Enables the WDOG32 module.

This function writes a value into the WDOG_CS register to enable the WDOG32. The WDOG_CS register is a write-once register. Please check the enableUpdate is set to true for calling WDOG32_Init to do wdog initialize. Before call the re-configuration APIs, ensure that the WCT window is still open and this register has not been written in this WCT while the function is called.

Parameters

- base – WDOG32 peripheral base address.

void WDOG32_Disable(WDOG_Type *base)

Disables the WDOG32 module.

This function writes a value into the WDOG_CS register to disable the WDOG32. The WDOG_CS register is a write-once register. Please check the enableUpdate is set to true for calling WDOG32_Init to do wdog initialize. Before call the re-configuration APIs, ensure that the WCT window is still open and this register has not been written in this WCT while the function is called.

Parameters

- base – WDOG32 peripheral base address

void WDOG32_EnableInterrupts(WDOG_Type *base, uint32_t mask)

Enables the WDOG32 interrupt.

This function writes a value into the WDOG_CS register to enable the WDOG32 interrupt. The WDOG_CS register is a write-once register. Please check the enableUpdate is set to true for calling WDOG32_Init to do wdog initialize. Before call the re-configuration APIs, ensure that the WCT window is still open and this register has not been written in this WCT while the function is called.

Parameters

- base – WDOG32 peripheral base address.
- mask – The interrupts to enable. The parameter can be a combination of the following source if defined:
 - kWDOG32_InterruptEnable

`void WDOG32_DisableInterrupts(WDOG_Type *base, uint32_t mask)`

Disables the WDOG32 interrupt.

This function writes a value into the WDOG_CS register to disable the WDOG32 interrupt. The WDOG_CS register is a write-once register. Please check the enableUpdate is set to true for calling WDOG32_Init to do wdog initialize. Before call the re-configuration APIs, ensure that the WCT window is still open and this register has not been written in this WCT while the function is called.

Parameters

- base – WDOG32 peripheral base address.
- mask – The interrupts to disabled. The parameter can be a combination of the following source if defined:
 - kWDOG32_InterruptEnable

`static inline uint32_t WDOG32_GetStatusFlags(WDOG_Type *base)`

Gets the WDOG32 all status flags.

This function gets all status flags.

Example to get the running flag:

```
uint32_t status;  
status = WDOG32_GetStatusFlags(wdog_base) & kWDOG32_RunningFlag;
```

See also:

`_wdog32_status_flags_t`

- true: related status flag has been set.
- false: related status flag is not set.

Parameters

- base – WDOG32 peripheral base address

Returns

State of the status flag: asserted (true) or not-asserted (false).

`void WDOG32_ClearStatusFlags(WDOG_Type *base, uint32_t mask)`

Clears the WDOG32 flag.

This function clears the WDOG32 status flag.

Example to clear an interrupt flag:

```
WDOG32_ClearStatusFlags(wdog_base, kWDOG32_InterruptFlag);
```

Parameters

- base – WDOG32 peripheral base address.
- mask – The status flags to clear. The parameter can be any combination of the following values:
 - kWDOG32_InterruptFlag

`void WDOG32_SetTimeoutValue(WDOG_Type *base, uint16_t timeoutCount)`

Sets the WDOG32 timeout value.

This function writes a timeout value into the WDOG_TOVAL register. The WDOG_TOVAL register is a write-once register. To ensure the reconfiguration fits the timing of WCT, unlock function will be called inline.

Parameters

- `base` – WDOG32 peripheral base address
- `timeoutCount` – WDOG32 timeout value, count of WDOG32 clock ticks.

`void WDOG32_SetWindowValue(WDOG_Type *base, uint16_t windowValue)`

Sets the WDOG32 window value.

This function writes a window value into the WDOG_WIN register. The WDOG_WIN register is a write-once register. Please check the `enableUpdate` is set to true for calling `WDOG32_Init` to do wdog initialize. Before call the re-configuration APIs, ensure that the WCT window is still open and this register has not been written in this WCT while the function is called.

Parameters

- `base` – WDOG32 peripheral base address.
- `windowValue` – WDOG32 window value.

`static inline void WDOG32_Refresh(WDOG_Type *base)`

Refreshes the WDOG32 timer.

This function feeds the WDOG32. This function should be called before the Watchdog timer is in timeout. Otherwise, a reset is asserted.

Parameters

- `base` – WDOG32 peripheral base address

`static inline uint16_t WDOG32_GetCounterValue(WDOG_Type *base)`

Gets the WDOG32 counter value.

This function gets the WDOG32 counter value.

Parameters

- `base` – WDOG32 peripheral base address.

Returns

Current WDOG32 counter value.

`WDOG_FIRST_WORD_OF_UNLOCK`

First word of unlock sequence

`WDOG_SECOND_WORD_OF_UNLOCK`

Second word of unlock sequence

`WDOG_FIRST_WORD_OF_REFRESH`

First word of refresh sequence

`WDOG_SECOND_WORD_OF_REFRESH`

Second word of refresh sequence

`FSL_WDOG32_DRIVER_VERSION`

WDOG32 driver version.

enum `_wdog32_clock_source`

Max loops to wait for WDOG32 unlock sequence complete.

This is the maximum number of loops to wait for the wdog32 unlock sequence to complete. If set to 0, it will wait indefinitely until the unlock sequence is complete.

Max loops to wait for WDOG32 reconfiguration complete.

This is the maximum number of loops to wait for the wdog32 reconfiguration to complete. If set to 0, it will wait indefinitely until the reconfiguration is complete.

Describes WDOG32 clock source.

Values:

enumerator `kWDOG32_ClockSource0`

Clock source 0

enumerator `kWDOG32_ClockSource1`

Clock source 1

enumerator `kWDOG32_ClockSource2`

Clock source 2

enumerator `kWDOG32_ClockSource3`

Clock source 3

enum `_wdog32_clock_prescaler`

Describes the selection of the clock prescaler.

Values:

enumerator `kWDOG32_ClockPrescalerDivide1`

Divided by 1

enumerator `kWDOG32_ClockPrescalerDivide256`

Divided by 256

enum `_wdog32_test_mode`

Describes WDOG32 test mode.

Values:

enumerator `kWDOG32_TestModeDisabled`

Test Mode disabled

enumerator `kWDOG32_UserModeEnabled`

User Mode enabled

enumerator `kWDOG32_LowByteTest`

Test Mode enabled, only low byte is used

enumerator `kWDOG32_HighByteTest`

Test Mode enabled, only high byte is used

enum `_wdog32_interrupt_enable_t`

WDOG32 interrupt configuration structure.

This structure contains the settings for all of the WDOG32 interrupt configurations.

Values:

enumerator `kWDOG32_InterruptEnable`

Interrupt is generated before forcing a reset

enum `_wdog32_status_flags_t`

WDOG32 status flags.

This structure contains the WDOG32 status flags for use in the WDOG32 functions.

Values:

enumerator `kWDOG32_RunningFlag`

Running flag, set when WDOG32 is enabled

enumerator `kWDOG32_InterruptFlag`

Interrupt flag, set when interrupt occurs

typedef enum `_wdog32_clock_source` `wdog32_clock_source_t`

Max loops to wait for WDOG32 unlock sequence complete.

This is the maximum number of loops to wait for the wdog32 unlock sequence to complete. If set to 0, it will wait indefinitely until the unlock sequence is complete.

Max loops to wait for WDOG32 reconfiguration complete.

This is the maximum number of loops to wait for the wdog32 reconfiguration to complete. If set to 0, it will wait indefinitely until the reconfiguration is complete.

Describes WDOG32 clock source.

typedef enum `_wdog32_clock_prescaler` `wdog32_clock_prescaler_t`

Describes the selection of the clock prescaler.

typedef struct `_wdog32_work_mode` `wdog32_work_mode_t`

Defines WDOG32 work mode.

typedef enum `_wdog32_test_mode` `wdog32_test_mode_t`

Describes WDOG32 test mode.

typedef struct `_wdog32_config` `wdog32_config_t`

Describes WDOG32 configuration structure.

struct `_wdog32_work_mode`

#include <fsl_wdog32.h> Defines WDOG32 work mode.

Public Members

bool `enableWait`

Enables or disables WDOG32 in wait mode

bool `enableStop`

Enables or disables WDOG32 in stop mode

bool `enableDebug`

Enables or disables WDOG32 in debug mode

struct `_wdog32_config`

#include <fsl_wdog32.h> Describes WDOG32 configuration structure.

Public Members

bool `enableWdog32`

Enables or disables WDOG32

`wdog32_clock_source_t` `clockSource`

Clock source select

wdog32_clock_prescaler_t prescaler

Clock prescaler value

wdog32_work_mode_t workMode

Configures WDOG32 work mode in debug stop and wait mode

wdog32_test_mode_t testMode

Configures WDOG32 test mode

bool enableUpdate

Update write-once register enable

bool enableInterrupt

Enables or disables WDOG32 interrupt

bool enableWindowMode

Enables or disables WDOG32 window mode

uint16_t windowValue

Window value

uint16_t timeoutValue

Timeout value

2.62 CACHE: CACHE Memory Controller

uint32_t XCACHE_GetInstanceByAddr(uint32_t address)

brief Returns an instance number given physical memory address.

param address The physical memory address.

Returns

XCACHE instance number starting from 0.

void XCACHE_EnableCache(XCACHE_Type *base)

Enables the cache.

Parameters

- base – XCACHE peripheral base address.

void XCACHE_DisableCache(XCACHE_Type *base)

Disables the cache.

Parameters

- base – XCACHE peripheral base address.

void XCACHE_InvalidateCache(XCACHE_Type *base)

Invalidates the cache.

Parameters

- base – XCACHE peripheral base address.

void XCACHE_InvalidateCacheByRange(uint32_t address, uint32_t size_byte)

Invalidates cache by range.

Note: Address and size should be aligned to “XCACHE_LINESIZE_BYTE”. The startAddr here will be forced to align to XCACHE_LINESIZE_BYTE if startAddr is not aligned. For the size_byte, application should make sure the alignment or make sure the right operation order if the size_byte is not aligned.

Parameters

- address – The physical address of cache.
- size_byte – size of the memory to be invalidated, should be larger than 0, better to align with cache line size.

```
void XCACHE_CleanCache(XCACHE_Type *base)
```

Cleans the cache.

Parameters

- base – XCACHE peripheral base address.

```
void XCACHE_CleanCacheByRange(uint32_t address, uint32_t size_byte)
```

Cleans cache by range.

Note: Address and size should be aligned to “XCACHE_LINESIZE_BYTE”. The startAddr here will be forced to align to XCACHE_LINESIZE_BYTE if startAddr is not aligned. For the size_byte, application should make sure the alignment or make sure the right operation order if the size_byte is not aligned.

Parameters

- address – The physical address of cache.
- size_byte – size of the memory to be cleaned, should be larger than 0, better to align with cache line size.

```
void XCACHE_CleanInvalidateCache(XCACHE_Type *base)
```

Cleans and invalidates the cache.

Parameters

- base – XCACHE peripheral base address.

```
void XCACHE_CleanInvalidateCacheByRange(uint32_t address, uint32_t size_byte)
```

Cleans and invalidate cache by range.

Note: Address and size should be aligned to “XCACHE_LINESIZE_BYTE”. The startAddr here will be forced to align to XCACHE_LINESIZE_BYTE if startAddr is not aligned. For the size_byte, application should make sure the alignment or make sure the right operation order if the size_byte is not aligned.

Parameters

- address – The physical address of cache.
- size_byte – size of the memory to be Cleaned and Invalidated, should be larger than 0, better to align with cache line size.

```
static inline void ICACHE_InvalidateByRange(uint32_t address, uint32_t size_byte)
```

Invalidates instruction cache by range.

Note: Address and size should be aligned to XCACHE_LINESIZE_BYTE due to the cache operation unit FSL_FEATURE_XCACHE_LINESIZE_BYTE. The startAddr here will be forced to align to the cache line size if startAddr is not aligned. For the size_byte, application should make sure the alignment or make sure the right operation order if the size_byte is not aligned.

Parameters

- address – The physical address.
- size_byte – size of the memory to be invalidated, should be larger than 0, better to align with cache line size.

static inline void DCACHE_InvalidateByRange(uint32_t address, uint32_t size_byte)

Invalidates data cache by range.

Note: Address and size should be aligned to XCACHE_LINESIZE_BYTE due to the cache operation unit FSL_FEATURE_XCACHE_LINESIZE_BYTE. The startAddr here will be forced to align to the cache line size if startAddr is not aligned. For the size_byte, application should make sure the alignment or make sure the right operation order if the size_byte is not aligned.

Parameters

- address – The physical address.
- size_byte – size of the memory to be invalidated, should be larger than 0, better to align with cache line size.

static inline void DCACHE_CleanByRange(uint32_t address, uint32_t size_byte)

Clean data cache by range.

Note: Address and size should be aligned to XCACHE_LINESIZE_BYTE due to the cache operation unit FSL_FEATURE_XCACHE_LINESIZE_BYTE. The startAddr here will be forced to align to the cache line size if startAddr is not aligned. For the size_byte, application should make sure the alignment or make sure the right operation order if the size_byte is not aligned.

Parameters

- address – The physical address.
- size_byte – size of the memory to be cleaned, should be larger than 0, better to align with cache line size.

static inline void DCACHE_CleanInvalidateByRange(uint32_t address, uint32_t size_byte)

Cleans and Invalidates data cache by range.

Note: Address and size should be aligned to XCACHE_LINESIZE_BYTE due to the cache operation unit FSL_FEATURE_XCACHE_LINESIZE_BYTE. The startAddr here will be forced to align to the cache line size if startAddr is not aligned. For the size_byte, application should make sure the alignment or make sure the right operation order if the size_byte is not aligned.

Parameters

- address – The physical address.
- size_byte – size of the memory to be Cleaned and Invalidated, should be larger than 0, better to align with cache line size.

FSL_CACHE_DRIVER_VERSION

cache driver version.

XCACHE_LINESIZE_BYTE

cache line size.

Chapter 3

Middleware

3.1 Connectivity

3.1.1 lwIP

This is the NXP fork of the [lwIP networking stack](#).

- For details about changes and additions made by NXP, see CHANGELOG.
- For details about the NXP porting layer, see *The NXP lwIP Port*.
- For usage and API of lwIP, use official documentation at <http://www.nongnu.org/lwip/>.

The NXP lwIP Port

Below is description of possible settings of the port layer and an overview of a few helper functions.

The best place for redefinition of any mentioned macro is `lwipopts.h`.

The declaration of every mentioned function is in `ethernetif.h`. Please check the doxygen comments of those functions before.

Link state Physical link state (up/down) and its speed and duplex must be read out from PHY over MDIO bus. Especially link information is useful for lwIP stack so it can for example send DHCP discovery immediately when a link becomes up.

To simplify this port layer offers a function `ethernetif_probe_link()` which reads those data from PHY and forwards them into lwIP stack.

In almost all examples this function is called every `ETH_LINK_POLLING_INTERVAL_MS` (1500ms) by a function `probe_link_cyclic()`.

By setting `ETH_LINK_POLLING_INTERVAL_MS` to 0 polling will be disabled. On FreeRTOS, `probe_link_cyclic()` will be then called on an interrupt generated by PHY. GPIO port and pin for the interrupt line must be set in the `ethernetifConfig` struct passed to `ethernetif_init()`. On bare metal interrupts are not supported right now.

Rx task To improve the reaction time of the app, reception of packets is done in a dedicated task. The rx task stack size can be set by `ETH_RX_TASK_STACK_SIZE` macro, its priority by `ETH_RX_TASK_PRIO`.

If you want to save memory you can set reception to be done in an interrupt by setting `ETH_DO_RX_IN_SEPARATE_TASK` macro to 0.

Disabling Rx interrupt when out of buffers If `ETH_DISABLE_RX_INT_WHEN_OUT_OF_BUFFERS` is set to 1, then when the port gets out of Rx buffers, Rx enet interrupt will be disabled for a particular controller. Everytime Rx buffer is freed, Rx interrupt will be enabled.

This prevents your app from never getting out of Rx interrupt when the network is flooded with traffic.

`ETH_DISABLE_RX_INT_WHEN_OUT_OF_BUFFERS` is by default turned on, on FreeRTOS and off on bare metal.

Limit the number of packets read out from the driver at once on bare metal. You may define macro `ETH_MAX_RX_PKTS_AT_ONCE` to limit the number of received packets read out from the driver at once.

In case of heavy Rx traffic, lowering this number improves the realtime behaviour of an app. Increasing improves Rx throughput.

Setting it to value < 1 or not defining means “no limit”.

Helper functions If your application needs to wait for the link to become up you can use one of the following functions:

- `ethernetif_wait_linkup()` - Blocks until the link on the passed netif is not up.
- `ethernetif_wait_linkup_array()` - Blocks until the link on at least one netif from the passed list of netifs becomes up.

If your app needs to wait for the IPv4 address on a particular netif to become different than “ANY” address (255.255.255.255) function `ethernetif_wait_ipv4_valid()` does this.

3.2 Motor Control

3.2.1 FreeMASTER

Communication Driver User Guide

Introduction

What is FreeMASTER? FreeMASTER is a PC-based application developed by NXP for NXP customers. It is a versatile tool usable as a real-time monitor, visualization tool, and a graphical control panel of embedded applications based on the NXP processing units.

This document describes the embedded-side software driver which implements an interface between the application and the host PC. The interface covers the following communication:

- **Serial** UART communication either over plain RS232 interface or more typically over a USB-to-Serial either external or built in a debugger probe.
- **USB** direct connection to target microcontroller
- **CAN bus**
- **TCP/IP network** wired or WiFi
- **Segger J-Link RTT**

- JTAG debug port communication
- ...and all of the above also using a **Zephyr** generic drivers.

The driver also supports so-called “packet-driven BDM” interface which enables a protocol-based communication over a debugging port. The BDM stands for Background Debugging Module and its physical implementation is different on each platform. Some platforms leverage a semi-standard JTAG interface, other platforms provide a custom implementation called BDM. Regardless of the name, this debugging interface enables non-intrusive access to the memory space while the target CPU is running. For basic memory read and write operations, there is no communication driver required on the target when communicating with the host PC. Use this driver to get more advanced FreeMASTER protocol features over the BDM interface. The driver must be configured for the packet-driven BDM mode, in which the host PC uses the debugging interface to write serial command frames directly to the target memory buffer. The same method is then used to read response frames from that memory buffer.

Similar to “packet-driven BDM”, the FreeMASTER also supports a communication over [J-Link RTT](<https://www.segger.com/products/debug-probes/j-link/technology/about-real-time-transfer/>) interface defined by SEGGER Microcontroller GmbH for ARM CortexM-based microcontrollers. This method also uses JTAG physical interface and enables high-speed real time communication to run over the same channel as used for application debugging.

Driver version 3 This document describes version 3 of the FreeMASTER Communication Driver. This version features the implementation of the new Serial Protocol, which significantly extends the features and security of its predecessor. The new protocol internal number is v4 and its specification is available in the documentation accompanying the driver code.

Driver V3 is deployed to modern 32-bit MCU platforms first, so the portfolio of supported platforms is smaller than for the previous V2 versions. It is recommended to keep using the V2 driver for legacy platforms, such as S08, S12, ColdFire, or Power Architecture. Reach out to [FreeMASTER community](#) or to the local NXP representative with requests for more information or to port the V3 driver to legacy MCU devices.

Thanks to a layered approach, the new driver simplifies the porting of the driver to new UART, CAN or networking communication interfaces significantly. Users are encouraged to port the driver to more NXP MCU platforms and contribute the code back to NXP for integration into future releases. Existing code and low-level driver layers may be used as an example when porting to new targets.

Note: Using the FreeMASTER tool and FreeMASTER Communication Driver is only allowed in systems based on NXP microcontroller or microprocessor unit. Use with non-NXP MCU platforms is **not permitted** by the license terms.

Target platforms The driver implementation uses the following abstraction mechanisms which simplify driver porting and supporting new communication modules:

- **General CPU Platform** (see source code in the `src/platforms` directory). The code in this layer is only specific to native data type sizes and CPU architectures (for example; alignment-aware memory copy routines). This driver version brings two generic implementations of 32-bit platforms supporting both little-endian and big-endian architectures. There are also implementations customized for the 56F800E family of digital signal controllers and S12Z MCUs. **Zephyr** is treated as a specific CPU platform as it brings unified user configuration (Kconfig) and generic hardware device drivers. With Zephyr, the transport layer and low-level communication layers described below are configured automatically using Kconfig and Device Tree technologies.
- **Transport Communication Layer** - The Serial, CAN, Networking, PD-BDM, and other methods of transport logic are implemented as a driver layer called FMSTR_TRANSPORT with a uniform API. A support of the Network transport also extends single-client modes of operation which are native for Serial, USB and CAN by a concept of multiple client sessions.

- **Low-level Communication Driver** - Each type of transport further defines a low-level API used to access the physical communication module. For example, the Serial transport defines a character-oriented API implemented by different serial communication modules like UART, LPUART, USART, and also USB-CDC. Similarly, the CAN transport defines a message-oriented API implemented by the FlexCAN or MCAN modules. Moreover, there are multiple different implementations for the same kind of communication peripherals. The difference between the implementation is in the way the low-level hardware registers are accessed. The *mcuxsdk* folder contains implementations which use MCUXpresso SDK drivers. These drivers should be used in applications based on the NXP MCUXpresso SDK. The “ampsdk” drivers target automotive-specific MCUs and their respective SDKs. The “dreg” implementations use a plain C-language access to hardware register addresses which makes it a universal and the most portable solution. In this case, users are encouraged to add more drivers for other communication modules or other respective SDKs and contribute the code back to NXP for integration.

The low-level drivers defined for the Networking transport enable datagram-oriented UDP and stream TCP communication. This implementation is demonstrated using the lwIP software stack but shall be portable to other TCP/IP stacks. It may sound surprisingly, but also the Segger J-Link RTT communication driver is linked to the Networking transport (RTT is stream oriented communication handled similarly to TCP).

Replacing existing drivers For all supported platforms, the driver described in this document replaces the V2 implementation and also older driver implementations that were available separately for individual platforms (PC Master SCI drivers).

Clocks, pins, and peripheral initialization The FreeMASTER communication driver is only responsible for runtime processing of the communication and must be integrated with an user application code to function properly. The user application code is responsible for general initialization of clock sources, pin multiplexers, and peripheral registers related to the communication speed. Such initialization should be done before calling the `FMSTR_Init` function.

It is recommended to develop the user application using one of the Software Development Kits (SDKs) available from third parties or directly from NXP, such as MCUXpresso SDK, MCUXpresso IDE, and related tools. This approach simplifies the general configuration process significantly.

MCUXpresso SDK The MCUXpresso SDK is a software package provided by NXP which contains the device initialization code, linker files, and software drivers with example applications for the NXP family of MCUs. The MCUXpresso Config Tools may be used to generate the clock-setup and pin-multiplexer setup code suitable for the selected processor.

The MCUXpresso SDK also contains this FreeMASTER communication driver as a “middleware” component which may be downloaded along with the example applications from <https://mcuxpresso.nxp.com/en/welcome>.

MCUXpresso SDK on GitHub The FreeMASTER communication driver is also released as one of the middleware components of the MCUXpresso SDK on the GitHub. This release enables direct integration of the FreeMASTER source code Git repository into a target applications including Zephyr applications.

Related links:

- [The official FreeMASTER middleware repository.](#)
- [Online version of this document](#)

FreeMASTER in Zephyr The FreeMASTER middleware repository can be used with MCUXpresso SDK as well as a Zephyr module. Zephyr-specific samples which include examples of Kconfig and Device Tree configurations for Serial, USB and Network communications are available in separate repository. West manifest in this sample repository fetches the full Zephyr package including the FreeMASTER middleware repository used as a Zephyr module.

Example applications

MCUX SDK Example applications There are several example applications available for each supported MCU platform.

- **fmstr_uart** demonstrates a plain serial transmission, typically connecting to a computer's physical or virtual COM port. The typical transmission speed is 115200 bps.
- **fmstr_can** demonstrates CAN bus communication. This requires a suitable CAN interface connected to the computer and interconnected with the target MCU using a properly terminated CAN bus. The typical transmission speed is 500 kbps. A FreeMASTER-over-CAN communication plug-in must be used.
- **fmstr_usb_cdc** uses an on-chip USB controller to implement a CDC communication class. It is connected directly to a computer's USB port and creates a virtual COM port device. The typical transmission speed is above 1 Mbps.
- **fmstr_net** demonstrates the Network communication over UDP or TCP protocol. Existing examples use lwIP stack to implement the communication, but in general, it shall be possible to use any other TCP/IP stack to achieve the same functionality.
- **fmstr_wifi** is the fmstr_net application modified to use a WiFi network interface instead of a wired Ethernet connection.
- **fmstr_rtt** demonstrates the communication over SEGGER J-Link RTT interface. Both fmstr_net and fmstr_rtt examples require the FreeMASTER TCP/UDP communication plug-in to be used on the PC host side.
- **fmstr_eonce** uses the real-time data unit on the JTAG EOnCE module of the 56F800E family to implement pseudo-serial communication over the JTAG port. The typical transmission speed is around 10 kbps. This communication requires FreeMASTER JTAG/EOnCE communication plug-in.
- **fmstr_pdbdm** uses JTAG or BDM debugging interface to access the target RAM directly while the CPU is running. Note that such approach can be used with any MCU application, even without any special driver code. The computer reads from and writes into the RAM directly without CPU intervention. The Packet-Driven BDM (PD-BDM) communication uses the same memory access to exchange command and response frames. With PD-BDM, the FreeMASTER tool is able to go beyond basic memory read/write operations and accesses also advanced features like Recorder, TSA, or Pipes. The typical transmission speed is around 10 kbps. A PD-BDM communication plug-in must be used in FreeMASTER and configured properly for the selected debugging interface. Note that this communication cannot be used while a debugging interface is used by a debugger session.
- **fmstr_any** is a special example application which demonstrates how the NXP MCUXpresso Config Tools can be used to configure pins, clocks, peripherals, interrupts, and even the FreeMASTER "middleware" driver features in a graphical and user friendly way. The user can switch between the Serial, CAN, and other ways of communication and generate the required initialization code automatically.

Zephyr sample applications Zephyr sample applications demonstrate Kconfig and Device Tree configuration which configure the FreeMASTER middleware module for a selected communication option (Serial, CAN, Network or RTT).

Refer to *readme.md* files in each sample directory for description of configuration options required to implement FreeMASTER connectivity.

Description

This section shows how to add the FreeMASTER Communication Driver into application and how to configure the connection to the FreeMASTER visualization tool.

Features The FreeMASTER driver implements the FreeMASTER protocol V4 and provides the following features which may be accessed using the FreeMASTER visualization tool:

- Read/write access to any memory location on the target.
- Optional password protection of the read, read/write, and read/write/flash access levels.
- Atomic bit manipulation on the target memory (bit-wise write access).
- Optimal size-aligned access to memory which is also suitable to access the peripheral register space.
- Oscilloscope access—real-time access to target variables. The sample rate may be limited by the communication speed.
- Recorder— access to the fast transient recorder running on the board as a part of the FreeMASTER driver. The sample rate is only limited by the MCU CPU speed. The length of the data recorded depends on the amount of available memory.
- Multiple instances of Oscilloscopes and Recorders without the limitation of maximum number of variables.
- Application commands—high-level message delivery from the PC to the application.
- TSA tables—describing the data types, variables, files, or hyperlinks exported by the target application. The TSA newly supports also non-memory mapped resources like external EEPROM or SD Card files.
- Pipes—enabling the buffered stream-oriented data exchange for a general-purpose terminal-like communication, diagnostic data streaming, or other data exchange.

The FreeMASTER driver features:

- Full FreeMASTER protocol V4 implementation with a new V4 style of CRC used.
- Layered approach supporting Serial, CAN, Network, PD-BDM, and other transports.
- Layered low-level Serial transport driver architecture enabling to select UART, LPUART, USART, and other physical implementations of serial interfaces, including USB-CDC.
- Layered low-level CAN transport driver architecture enabling to select FlexCAN, msCAN, MCAN, and other physical implementations of the CAN interface.
- Layered low-level Networking transport enabling to select TCP, UDP or J-Link RTT communication.
- TSA support to write-protect memory regions or individual variables and to deny the access to the unsafe memory.
- The pipe callback handlers are invoked whenever new data is available for reading from the pipe.
- Two Serial Single-Wire modes of operation are enabled. The “external” mode has the RX and TX shorted on-board. The “true” single-wire mode interconnects internally when the MCU or UART modules support it.

The following sections briefly describe all FreeMASTER features implemented by the driver. See the PC-based FreeMASTER User Manual for more details on how to use the features to monitor, tune, or control an embedded application.

Board Detection The FreeMASTER protocol V4 defines the standard set of configuration values which the host PC tool reads to identify the target and to access other target resources properly. The configuration includes the following parameters:

- Version of the driver and the version of the protocol implemented.
- MTU as the Maximum size of the Transmission Unit (for example; communication buffer size).
- Application name, description, and version strings.
- Application build date and time as a string.
- Target processor byte ordering (little/big endian).
- Protection level that requires password authentication.
- Number of the Recorder and Oscilloscope instances.
- RAM Base Address for optimized memory access commands.

Memory Read This basic feature enables the host PC to read any data memory location by specifying the address and size of the required memory area. The device response frame must be shorter than the MTU to fit into the outgoing communication buffer. To read a device memory of any size, the host uses the information retrieved during the Board Detection and splits the large-block request to multiple partial requests.

The driver uses size-aligned operations to read the target memory (for example; uses proper read-word instruction when an address is aligned to 4 bytes).

Memory Write Similarly to the Memory Read operation, the Memory Write feature enables to write to any RAM memory location on the target device. A single write command frame must be shorter than the MTU to fit into the target communication buffer. Larger requests must be split into smaller ones.

The driver uses size-aligned operations to write to the target memory (for example; uses proper write-word instruction when an address is aligned to 4 bytes).

Masked Memory Write To implement the write access to a single bit or a group of bits of target variables, the Masked Memory Write feature is available in the FreeMASTER protocol and it is supported by the driver using the Read-Modify-Write approach.

Be careful when writing to bit fields of volatile variables that are also modified in an application interrupt. The interrupt may be serviced in the middle of a read-modify-write operation and it may cause data corruption.

Oscilloscope The protocol and driver enables any number of variables to be read at once with a single request from the host. This feature is called Oscilloscope and the FreeMASTER tool uses it to display a real-time graph of variable values.

The driver can be configured to support any number of Oscilloscope instances and enable simultaneously running graphs to be displayed on the host computer screen.

Recorder The protocol enables the host to select target variables whose values are then periodically recorded into a dedicated on-board memory buffer. After such data sampling stops (either on a host request or by evaluating a threshold-crossing condition), the data buffer is downloaded to the host and displayed as a graph. The data sampling rate is not limited by the speed of the communication line, so it enables displaying the variable transitions in a very high resolution.

The driver can be configured to support multiple Recorder instances and enable multiple recorder graphs to be displayed on the host screen. Having multiple recorders also enables setting the recording point differently for each instance. For example; one instance may be recording data in a general timer interrupt while another instance may record at a specific control algorithm time in the PWM interrupt.

TSA With the TSA feature, data types and variables can be described directly in the application source code. Such information is later provided to the FreeMASTER tool which may use it instead of reading symbol data from the application ELF executable file.

The information is encoded as so-called TSA tables which become direct part of the application code. The TSA tables contain descriptors of variables that shall be visible to the host tool. The descriptors can describe the memory areas by specifying the address and size of the memory block or more conveniently using the C variable names directly. Different set of TSA descriptors can be used to encode information about the structure types, unions, enumerations, or arrays.

The driver also supports special types of TSA table entries to describe user resources like external EEPROM and SD Card files, memory-mapped files, virtual directories, web URL hyperlinks, and constant enumerations.

TSA Safety When the TSA is enabled in the application, the TSA Safety can be enabled and validate the memory accesses directly by the embedded-side driver. When the TSA Safety is turned on, any memory request received from the host is validated and accepted only if it belongs to a TSA-described object. The TSA entries can be declared as Read-Write or Read-Only so that the driver can actively deny the write access to the Read-Only objects.

Application commands The Application Commands are high-level messages that can be delivered from the PC Host to the embedded application for further processing. The embedded application can either poll the status, or be called back when a new Application Command arrives to be processed. After the embedded application acknowledges that the command is handled, the host receives the Result Code and reads the other return data from memory. Both the Application Commands and the Result Codes are specific to a given application and it is user's responsibility to define them. The FreeMASTER protocol and the FreeMASTER driver only implement the delivery channel and a set of API calls to enable the Application Command processing in general.

Pipes The Pipes enable buffered and stream-oriented data exchange between the PC Host and the target application. Any pipe can be written to and read from at both ends (either on the PC or the MCU). The data transmission is acknowledged using the special FreeMASTER protocol commands. It is guaranteed that the data bytes are delivered from the writer to the reader in a proper order and without losses.

Serial single-wire operation The MCU Serial Communication Driver natively supports normal dual-wire operation. Because the protocol is half-duplex only, the driver can also operate in two single-wire modes:

- “External” single-wire operation where the Receiver and Transmitter pins are shorted on the board. This mode is supported by default in the MCU driver because the Receiver and Transmitter units are enabled or disabled whenever needed. It is also easy to extend this operation for the RS485 communication.

- “True” single-wire mode which uses only a single pin and the direction switching is made by the UART module. This mode of operation must be enabled by defining the FMSTR_SERIAL_SINGLEWIRE configuration option.

Multi-session support With networking interface it is possible for multiple clients to access the target MCU simultaneously. Reading and writing of target memory is processed atomically so there is no risk of data corruption. The state-full resources such as Recorders or Oscilloscopes are locked to a client session upon first use and access is denied to other clients until lock is released..

Zephyr-specific

Dedicated communication task FreeMASTER communication may run isolated in a dedicated task. The task automates the FMSTR_Init and FMSTR_Poll calls together with periodic activities enabling the FreeMASTER UI to fetch information about tasks and CPU utilization. The task can be started automatically or manually, and it must be assigned a priority to be able to react on interrupts and other communication events. Refer to Zephyr FreeMASTER sample applications which all use this communication task.

Zephyr shell and logging over FreeMASTER pipe FreeMASTER implements a shell backend which may use FreeMASTER pipe as a I/O terminal and logging output. Refer to Zephyr FreeMASTER sample applications which all use this feature.

Automatic TSA tables TSA tables can be declared as “automatic” in Zephyr which make them automatically registered in the table list. This may be very useful when there are many TSA tables or when the tables are defined in different (often unrelated) libraries linked together. In this case user does not need to build a list of all tables manually.

Driver files The driver source files can be found in a top-level src folder, further divided into the sub-folders:

- **src/platforms** platform-specific folder—one folder exists for each supported processor platform (for example; 32-bit Little Endian platform). Each such folder contains a platform header file with data types and a code which implements the potentially platform-specific operations, such as aligned memory access.
- **src/common** folder—contains the common driver source files shared by the driver for all supported platforms. All the .c files must be added to the project, compiled, and linked together with the application.
 - *freemaster.h* - master driver header file, which declares the common data types, macros, and prototypes of the FreeMASTER driver API functions.
 - *freemaster_cfg.h.example* - this file can serve as an example of the FreeMASTER driver configuration file. Save this file into a project source code folder and rename it to *freemaster_cfg.h*. The FreeMASTER driver code includes this file to get the project-specific configuration options and to optimize the compilation of the driver.
 - *freemaster_defcfg.h* - defines the default values for each FreeMASTER configuration option if the option is not set in the *freemaster_cfg.h* file.
 - *freemaster_protocol.h* - defines the FreeMASTER protocol constants used internally by the driver.
 - *freemaster_protocol.c* - implements the FreeMASTER protocol decoder and handles the basic Get Configuration Value, Memory Read, and Memory Write commands.

- *freemaster_rec.c* - handles the Recorder-specific commands and implements the Recorder sampling and triggering routines. When the Recorder is disabled by the FreeMASTER driver configuration file, this file only compiles to empty API functions.
- *freemaster_scope.c* - handles the Oscilloscope-specific commands. If the Oscilloscope is disabled by the FreeMASTER driver configuration file, this file compiles as void.
- *freemaster_pipes.c* - implements the Pipes functionality when the Pipes feature is enabled.
- *freemaster_appcmd.c* - handles the communication commands used to deliver and execute the Application Commands within the context of the embedded application. When the Application Commands are disabled by the FreeMASTER driver configuration file, this file only compiles to empty API functions.
- *freemaster_tsa.c* - handles the commands specific to the TSA feature. This feature enables the FreeMASTER host tool to obtain the TSA memory descriptors declared in the embedded application. If the TSA is disabled by the FreeMASTER driver configuration file, this file compiles as void.
- *freemaster_tsa.h* - contains the declaration of the macros used to define the TSA memory descriptors. This file is indirectly included into the user application code (via *freemaster.h*).
- *freemaster_sha.c* - implements the SHA-1 hash code used in the password authentication algorithm.
- *freemaster_private.h* - contains the declarations of functions and data types used internally in the driver. It also contains the C pre-processor statements to perform the compile-time verification of the user configuration provided in the *freemaster_cfg.h* file.
- *freemaster_serial.c* - implements the serial protocol logic including the CRC, FIFO queuing, and other communication-related operations. This code calls the functions of the low-level communication driver indirectly via a character-oriented API exported by the specific low-level driver.
- *freemaster_serial.h* - defines the low-level character-oriented Serial API.
- *freemaster_can.c* - implements the CAN protocol logic including the CAN message preparation, signalling using the first data byte in the CAN frame, and other communication-related operations. This code calls the functions of the low-level communication driver indirectly via a message-oriented API exported by the specific low-level driver.
- *freemaster_can.h* - defines the low-level message-oriented CAN API.
- *freemaster_net.c* - implements the Network protocol transport logic including multiple session management code.
- *freemaster_net.h* - definitions related to the Network transport.
- *freemaster_pdbdm.c* - implements the packet-driven BDM communication buffer and other communication-related operations.
- *freemaster_utils.c* - aligned memory copy routines, circular buffer management and other utility functions
- *freemaster_utils.h* - definitions related to utility code.
- **src/drivers/[sdk]/serial** - contains the code related to the serial communication implemented using one of the supported SDK frameworks.
 - *freemaster_serial_XXX.c* and *.h* - implement low-level access to the communication peripheral registers. Different files exist for the UART, LPUART, USART, and other kinds of Serial communication modules.

- ***src/drivers/[sdk]/can*** - contains the code related to the serial communication implemented using one of the supported SDK frameworks.
 - *freemaster_XXX.c* and *.h* - implement low-level access to the communication peripheral registers. Different files exist for the FlexCAN, msCAN, MCAN, and other kinds of CAN communication modules.
- ***src/drivers/[sdk]/network*** - contains low-level code adapting the FreeMASTER Network transport to an underlying TCP/IP or RTT stack.
 - *freemaster_net_lwip_tcp.c* and *_udp.c* - default networking implementation of TCP and UDP transports using lwIP stack.
 - *freemaster_net_segger_rtt.c* - implementation of network transport using Segger J-Link RTT interface

Driver configuration The driver is configured using a single header file (*freemaster_cfg.h*). Create this file and save it together with other project source files before compiling the driver code. All FreeMASTER driver source files include the *freemaster_cfg.h* file and use the macros defined here for the conditional and parameterized compilation. The C compiler must locate the configuration file when compiling the driver files. Typically, it can be achieved by putting this file into a folder where the other project-specific included files are stored.

As a starting point to create the configuration file, get the *freemaster_cfg.h.example* file, rename it to *freemaster_cfg.h*, and save it into the project area.

Note: It is NOT recommended to leave the *freemaster_cfg.h* file in the FreeMASTER driver source code folder. The configuration file must be placed at a project-specific location, so that it does not affect the other applications that use the same driver.

Configurable items This section describes the configuration options which can be defined in *freemaster_cfg.h*.

Interrupt modes

```
#define FMSTR_LONG_INTR    [0|1]
#define FMSTR_SHORT_INTR   [0|1]
#define FMSTR_POLL_DRIVEN [0|1]
```

Value Type boolean (0 or 1)

Description Exactly one of the three macros must be defined to non-zero. The others must be defined to zero or left undefined. The non-zero-defined constant selects the interrupt mode of the driver. See [Driver interrupt modes](#).

- FMSTR_LONG_INTR — long interrupt mode
- FMSTR_SHORT_INTR — short interrupt mode
- FMSTR_POLL_DRIVEN — poll-driven mode

Note: Some options may not be supported by all communication interfaces. For example, the FMSTR_SHORT_INTR option is not supported by the USB_CDC interface.

Protocol transport

```
#define FMSTR_TRANSPORT [identifier]
```

Value Type Driver identifiers are structure instance names defined in FreeMASTER source code. Specify one of existing instances to make use of the protocol transport.

Description Use one of the pre-defined constants, as implemented by the FreeMASTER code. The current driver supports the following transports:

- **FMSTR_SERIAL** - serial communication protocol
- **FMSTR_CAN** - using CAN communication
- **FMSTR_PDBDM** - using packet-driven BDM communication
- **FMSTR_NET** - network communication using TCP or UDP protocol

Serial transport This section describes configuration parameters used when serial transport is used:

```
#define FMSTR_TRANSPORT FMSTR_SERIAL
```

FMSTR_SERIAL_DRV Select what low-level driver interface will be used when implementing the Serial communication.

```
#define FMSTR_SERIAL_DRV [identifier]
```

Value Type Driver identifiers are structure instance names defined in FreeMASTER drivers code. Specify one of existing serial driver instances.

Description When using MCUXpresso SDK, use one of the following constants (see */drivers/mcuxsdk/serial* implementation):

- **FMSTR_SERIAL_MCUX_UART** - UART driver
- **FMSTR_SERIAL_MCUX_LPUART** - LPUART driver
- **FMSTR_SERIAL_MCUX_USART** - USART driver
- **FMSTR_SERIAL_MCUX_MINIUSART** - miniUSART driver
- **FMSTR_SERIAL_MCUX_QSCI** - DSC QSCI driver
- **FMSTR_SERIAL_MCUX_USB** - USB/CDC class driver (also see code in the */support/mcuxsdk_usb* folder)
- **FMSTR_SERIAL_56F800E_EONCE** - DSC JTAG EOnCE driver

Other SDKs or BSPs may define custom low-level driver interface structure which may be used as **FMSTR_SERIAL_DRV**. For example:

- **FMSTR_SERIAL_DREG_UART** - demonstrates the low-level interface implemented without the MCUXpresso SDK and using direct access to peripheral registers.

FMSTR_SERIAL_BASE

```
#define FMSTR_SERIAL_BASE [address|symbol]
```

Value Type Optional address value (numeric or symbolic)

Description Specify the base address of the UART, LPUART, USART, or other serial peripheral module to be used for the communication. This value is not defined by default. User application should call `FMSTR_SetSerialBaseAddress()` to select the peripheral module.

FMSTR_COMM_BUFFER_SIZE

```
#define FMSTR_COMM_BUFFER_SIZE [number]
```

Value Type 0 or a value in range 32...255

Description Specify the size of the communication buffer to be allocated by the driver. Default value, which suits all driver features, is used when this option is defined as 0.

FMSTR_COMM_QUEUE_SIZE

```
#define FMSTR_COMM_QUEUE_SIZE [number]
```

Value Type Value in range 0...255

Description Specify the size of the FIFO receiver queue used to quickly receive and store characters in the `FMSTR_SHORT_INTR` interrupt mode. The default value is 32 B.

FMSTR_SERIAL_SINGLEWIRE

```
#define FMSTR_SERIAL_SINGLEWIRE [0|1]
```

Value Type Boolean 0 or 1.

Description Set to non-zero to enable the “True” single-wire mode which uses a single MCU pin to communicate. The low-level driver enables the pin direction switching when the MCU peripheral supports it.

CAN Bus transport This section describes configuration parameters used when CAN transport is used:

```
#define FMSTR_TRANSPORT FMSTR_CAN
```

FMSTR_CAN_DRV Select what low-level driver interface will be used when implementing the CAN communication.

```
#define FMSTR_CAN_DRV [identifier]
```

Value Type Driver identifiers are structure instance names defined in FreeMASTER drivers code. Specify one of existing CAN driver instances.

Description When using MCUXpresso SDK, use one of the following constants (see */drivers/mcuxsdk/can implementation*):

- **FMSTR_CAN_MCUX_FLEXCAN** - FlexCAN driver
- **FMSTR_CAN_MCUX_MCAN** - MCAN driver
- **FMSTR_CAN_MCUX_MSCAN** - msCAN driver
- **FMSTR_CAN_MCUX_DSCFLEXCAN** - DSC FlexCAN driver
- **FMSTR_CAN_MCUX_DSCMSCAN** - DSC msCAN driver

Other SDKs or BSPs may define the custom low-level driver interface structure which may be used as FMSTR_CAN_DRV.

FMSTR_CAN_BASE

```
#define FMSTR_CAN_BASE [address|symbol]
```

Value Type Optional address value (numeric or symbolic)

Description Specify the base address of the FlexCAN, msCAN, or other CAN peripheral module to be used for the communication. This value is not defined by default. User application should call FMSTR_SetCanBaseAddress() to select the peripheral module.

FMSTR_CAN_CMDID

```
#define FMSTR_CAN_CMDID [number]
```

Value Type CAN identifier (11-bit or 29-bit number)

Description CAN message identifier used for FreeMASTER commands (direction from PC Host tool to target application). When declaring 29-bit identifier, combine the numeric value with FMSTR_CAN_EXTID bit. Default value is 0x7AA.

FMSTR_CAN_RSPID

```
#define FMSTR_CAN_RSPID [number]
```

Value Type CAN identifier (11-bit or 29-bit number)

Description CAN message identifier used for responding messages (direction from target application to PC Host tool). When declaring 29-bit identifier, combine the numeric value with FMSTR_CAN_EXTID bit. Note that both *CMDID* and *RSPID* values may be the same. Default value is 0x7AA.

FMSTR_FLEXCAN_TXMB

```
#define FMSTR_FLEXCAN_TXMB [number]
```

Value Type Number in range of 0..N where N is number of CAN message-buffers supported by HW module.

Description Only used when the FlexCAN low-level driver is used. Define the FlexCAN message buffer for CAN frame transmission. Default value is 0.

FMSTR_FLEXCAN_RXMB

```
#define FMSTR_FLEXCAN_RXMB [number]
```

Value Type Number in range of 0..N where N is number of CAN message-buffers supported by HW module.

Description Only used when the FlexCAN low-level driver is used. Define the FlexCAN message buffer for CAN frame reception. Note that the FreeMASTER driver may also operate with a common message buffer used by both TX and RX directions. Default value is 1.

Network transport This section describes configuration parameters used when Network transport is used:

```
#define FMSTR_TRANSPORT FMSTR_NET
```

FMSTR_NET_DRV Select network interface implementation.

```
#define FMSTR_NET_DRV [identifier]
```

Value Type Identifiers are structure instance names defined in FreeMASTER drivers code. Specify one of existing NET driver instances.

Description When using MCUXpresso SDK, use one of the following constants (see */drivers/mcuxsdk/network implementation*):

- **FMSTR_NET_LWIP_TCP** - TCP communication using lwIP stack
- **FMSTR_NET_LWIP_UDP** - UDP communication using lwIP stack
- **FMSTR_NET_SEGGER_RTT** - Communication using SEGGER J-Link RTT interface

Other SDKs or BSPs may define the custom networking interface which may be used as FMSTR_CAN_DRV.

Add another row below:

FMSTR_NET_PORT

```
#define FMSTR_NET_PORT [number]
```

Value Type TCP or UDP port number (short integer)

Description Specifies the server port number used by TCP or UDP protocols.

FMSTR_NET_BLOCKING_TIMEOUT

```
#define FMSTR_NET_BLOCKING_TIMEOUT [number]
```

Value Type Timeout as number of milliseconds

Description This value specifies a timeout in milliseconds for which the network socket operations may block the execution inside *FMSTR_Poll*. This may be set high (e.g. 250) when a dedicated RTOS task is used to handle FreeMASTER protocol polling. Set to a lower value when the polling task is also responsible for other operations. Set to 0 to attempt to use non-blocking socket operations.

FMSTR_NET_AUTODISCOVERY

```
#define FMSTR_NET_AUTODISCOVERY [0|1]
```

Value Type Boolean 0 or 1.

Description This option enables the FreeMASTER driver to use a separate UDP socket to broadcast auto-discovery messages to network. This helps the FreeMASTER tool to discover the target device address, port and protocol options.

Debugging options

FMSTR_DISABLE

```
#define FMSTR_DISABLE [0|1]
```

Value Type boolean (0 or 1)

Description Define as non-zero to disable all FreeMASTER features, exclude the driver code from build, and compile all its API functions empty. This may be useful to remove FreeMASTER without modifying any application source code. Default value is 0 (false).

FMSTR_DEBUG_TX

```
#define FMSTR_DEBUG_TX [0|1]
```

Value Type Boolean 0 or 1.

Description Define as non-zero to enable the driver to periodically transmit test frames out on the selected communication interface (SCI or CAN). With the debug transmission enabled, it is simpler to detect problems in the baudrate or other communication configuration settings.

The test frames are transmitted until the first valid command frame is received from the PC Host tool. The test frame is a valid error status frame, as defined by the protocol format. On the serial line, the test frame consists of three printable characters (+©W) which are easy to capture using the serial terminal tools.

This feature requires the FMSTR_Poll() function to be called periodically. Default value is 0 (false).

FMSTR_APPLICATION_STR

```
#define FMSTR_APPLICATION_STR
```

Value Type String.

Description Name of the application visible in FreeMASTER host application.

Memory access**FMSTR_USE_READMEM**

```
#define FMSTR_USE_READMEM [0|1]
```

Value Type Boolean 0 or 1.

Description Define as non-zero to implement the Memory Read command and enable FreeMASTER to have read access to memory and variables. The access can be further restricted by using a TSA feature.
Default value is 1 (true).

FMSTR_USE_WRITEMEM

```
#define FMSTR_USE_WRITEMEM [0|1]
```

Value Type Boolean 0 or 1.

Description Define as non-zero to implement the Memory Write command.
The default value is 1 (true).

Oscilloscope options**FMSTR_USE_SCOPE**

```
#define FMSTR_USE_SCOPE [number]
```

Value Type Integer number.

Description Number of Oscilloscope instances to be supported. Set to 0 to disable the Oscilloscope feature.
Default value is 0.

FMSTR_MAX_SCOPE_VARS

```
#define FMSTR_MAX_SCOPE_VARS [number]
```

Value Type Integer number larger than 2.

Description Number of variables to be supported by each Oscilloscope instance.
Default value is 8.

Recorder options

FMSTR_USE_RECORDER

```
#define FMSTR_USE_RECORDER [number]
```

Value Type Integer number.

Description Number of Recorder instances to be supported. Set to 0 to disable the Recorder feature.
Default value is 0.

FMSTR_REC_BUFF_SIZE

```
#define FMSTR_REC_BUFF_SIZE [number]
```

Value Type Integer number larger than 2.

Description Defines the size of the memory buffer used by the Recorder instance #0.
Default: not defined, user shall call 'FMSTR_RecorderCreate()' API function to specify this parameter in run time.

FMSTR_REC_TIMEBASE

```
#define FMSTR_REC_TIMEBASE [time specification]
```

Value Type Number (nanoseconds time).

Description Defines the base sampling rate in nanoseconds (sampling speed) Recorder instance #0.

Use one of the following macros:

- FMSTR_REC_BASE_SECONDS(x)
- FMSTR_REC_BASE_MILLISEC(x)
- FMSTR_REC_BASE_MICROSEC(x)
- FMSTR_REC_BASE_NANOSEC(x)

Default: not defined, user shall call 'FMSTR_RecorderCreate()' API function to specify this parameter in run time.

FMSTR_REC_FLOAT_TRIG

```
#define FMSTR_REC_FLOAT_TRIG [0|1]
```

Value Type Boolean 0 or 1.

Description Define as non-zero to implement the floating-point triggering. Be aware that floating-point triggering may grow the code size by linking the floating-point standard library. Default value is 0 (false).

Application Commands options

FMSTR_USE_APPCMD

```
#define FMSTR_USE_APPCMD [0|1]
```

Value Type Boolean 0 or 1.

Description Define as non-zero to implement the Application Commands feature. Default value is 0 (false).

FMSTR_APPCMD_BUFF_SIZE

```
#define FMSTR_APPCMD_BUFF_SIZE [size]
```

Value Type Numeric buffer size in range 1..255

Description The size of the Application Command data buffer allocated by the driver. The buffer stores the (optional) parameters of the Application Command which waits to be processed.

FMSTR_MAX_APPCMD_CALLS

```
#define FMSTR_MAX_APPCMD_CALLS [number]
```

Value Type Number in range 0..255

Description The number of different Application Commands that can be assigned a callback handler function using FMSTR_RegisterAppCmdCall(). Default value is 0.

TSA options

FMSTR_USE_TSA

```
#define FMSTR_USE_TSA [0|1]
```

Value Type Boolean 0 or 1.

Description Enable the FreeMASTER TSA feature to be used. With this option enabled, the TSA tables defined in the applications are made available to the FreeMASTER host tool. Default value is 0 (false).

FMSTR_USE_TSA_SAFETY

```
#define FMSTR_USE_TSA_SAFETY [0|1]
```

Value Type Boolean 0 or 1.

Description Enable the memory access validation in the FreeMASTER driver. With this option, the host tool is not able to access the memory which is not described by at least one TSA descriptor. Also a write access is denied for objects defined as read-only in TSA tables. Default value is 0 (false).

FMSTR_USE_TSA_INROM

```
#define FMSTR_USE_TSA_INROM [0|1]
```

Value Type Boolean 0 or 1.

Description Declare all TSA descriptors as *const*, which enables the linker to put the data into the flash memory. The actual result depends on linker settings or the linker commands used in the project. Default value is 0 (false).

FMSTR_USE_TSA_DYNAMIC

```
#define FMSTR_USE_TSA_DYNAMIC [0|1]
```

Value Type Boolean 0 or 1.

Description Enable runtime-defined TSA entries to be added to the TSA table by the FMSTR_SetUpTsaBuff() and FMSTR_TsaAddVar() functions. Default value is 0 (false).

Pipes options

FMSTR_USE_PIPES

```
#define FMSTR_USE_PIPES [0|1]
```

Value Type Boolean 0 or 1.

Description Enable the FreeMASTER Pipes feature to be used. Default value is 0 (false).

FMSTR_MAX_PIPES_COUNT

```
#define FMSTR_MAX_PIPES_COUNT [number]
```

Value Type Number in range 1..63.

Description The number of simultaneous pipe connections to support. The default value is 1.

Driver interrupt modes To implement the communication, the FreeMASTER driver handles the Serial or CAN module's receive and transmit requests. Use the *freemaster_cfg.h* configuration file to select whether the driver processes the communication automatically in the interrupt service routine handler or if it only polls the status of the module (typically during the application idle time).

This section describes each of the interrupt mode in more details.

Completely Interrupt-Driven operation Activated using:

```
#define FMSTR_LONG_INTR 1
```

In this mode, both the communication and the FreeMASTER protocol decoding is done in the *FMSTR_SerialIsr*, *FMSTR_CanIsr*, or other interrupt service routine. Because the protocol execution may be a lengthy task (especially with the TSA-Safety enabled) it is recommended to use this mode only if the interrupt prioritization scheme is possible in the application and the FreeMASTER interrupt is assigned to a lower (the lowest) priority.

In this mode, the application code must register its own interrupt handler for all interrupt vectors related to the selected communication interface and call the *FMSTR_SerialIsr* or *FMSTR_CanIsr* functions from that handler.

Mixed Interrupt and Polling Modes Activated using:

```
#define FMSTR_SHORT_INTR 1
```

In this mode, the communication processing time is split between the interrupt routine and the main application loop or task. The raw communication is handled by the *FMSTR_SerialIsr*, *FMSTR_CanIsr*, or other interrupt service routine, while the protocol decoding and execution is handled by the *FMSTR_Poll* routine. Call *FMSTR_Poll* during the idle time in the application main loop.

The interrupt processing in this mode is relatively fast and deterministic. Upon a serial-receive event, the received character is only placed into a FIFO-like queue and it is not further processed. Upon a CAN receive event, the received frame is stored into a receive buffer. When transmitting, the characters are fetched from the prepared transmit buffer.

In this mode, the application code must register its own interrupt handler for all interrupt vectors related to the selected communication interface and call the *FMSTR_SerialIsr* or *FMSTR_CanIsr* functions from that handler.

When the serial interface is used as the serial communication interface, ensure that the *FMSTR_Poll* function is called at least once per *N* character time periods. *N* is the length of the FreeMASTER FIFO queue (*FMSTR_COMM_QUEUE_SIZE*) and the character time is the time needed to transmit or receive a single byte over the SCI line.

Completely Poll-driven

```
#define FMSTR_POLL_DRIVEN 1
```

In this mode, both the communication and the FreeMASTER protocol decoding are done in the *FMSTR_Poll* routine. No interrupts are needed and the *FMSTR_SerialIsr*, *FMSTR_CanIsr*, and similar handlers compile to an empty code.

When using this mode, ensure that the *FMSTR_Poll* function is called by the application at least once per the serial “character time” which is the time needed to transmit or receive a single character.

In the latter two modes (*FMSTR_SHORT_INTR* and *FMSTR_POLL_DRIVEN*), the protocol handling takes place in the *FMSTR_Poll* routine. An application interrupt can occur in the middle of the Read Memory or Write Memory commands’ execution and corrupt the variable being accessed by the FreeMASTER driver. In these two modes, some issues or glitches may occur when using FreeMASTER to visualize or monitor volatile variables modified in interrupt servicing code.

The same issue may appear even in the full interrupt mode (*FMSTR_LONG_INTR*), if volatile variables are modified in the interrupt code with a priority higher than the priority of the communication interrupt.

Data types Simple portability was one of the main requirements when writing the FreeMASTER driver. This is why the driver code uses the privately-declared data types and the vast majority of the platform-dependent code is separated in the platform-dependent source files. The data types used in the driver API are all defined in the platform-specific header file.

To prevent name conflicts with the symbols used in the application, all data types, macros, and functions have the *FMSTR_* prefix. The only global variables used in the driver are the transport and low-level API structures exported from the driver-implementation layer to upper layers. Other than that, all private variables are declared as static and named using the *fmstr_* prefix.

Communication interface initialization The FreeMASTER driver does not perform neither the initialization nor the configuration of the peripheral module that it uses to communicate. It is the application startup code responsibility to configure the communication module before the FreeMASTER driver is initialized by the *FMSTR_Init* call.

When the Serial communication module is used as the FreeMASTER communication interface, configure the UART receive and transmit pins, the serial communication baud rate, parity (no-parity), the character length (eight bits), and the number of stop bits (one) before initializing the FreeMASTER driver. For either the long or the short interrupt modes of the driver (see *Driver interrupt modes*), configure the interrupt controller and register an application-specific interrupt handler for all interrupt sources related to the selected serial peripheral module. Call the *FMSTR_SerialIsr* function from the application handler.

When a CAN module is used as the FreeMASTER communication interface, configure the CAN receive and transmit pins and the CAN module bit rate before initializing the FreeMASTER driver. For either the long or the short interrupt modes of the driver (see *Driver interrupt modes*), configure the interrupt controller and register an application-specific interrupt handler for all interrupt sources related to the selected CAN peripheral module. Call the *FMSTR_CanIsr* function from the application handler.

Note: It is not necessary to enable or unmask the serial nor the CAN interrupts before initializing the FreeMASTER driver. The driver enables or disables the interrupts and communication lines, as required during runtime.

FreeMASTER Recorder calls When using the FreeMASTER Recorder in the application (*FMSTR_USE_RECORDER* > 0), call the *FMSTR_RecorderCreate* function early after *FMSTR_Init* to set

up each recorder instance to be used in the application. Then call the FMSTR_Recorder function periodically in the code where the data recording should occur. A typical place to call the Recorder routine is at the timer or PWM interrupts, but it can be anywhere else. The example applications provided together with the driver code call the FMSTR_Recorder in the main application loop.

In applications where FMSTR_Recorder is called periodically with a constant period, specify the period in the Recorder configuration structure before calling FMSTR_RecorderCreate. This setting enables the PC Host FreeMASTER tool to display the X-axis of the Recorder graph properly scaled for the time domain.

Driver usage Start using or evaluating FreeMASTER by opening some of the example applications available in the driver setup package.

Follow these steps to enable the basic FreeMASTER connectivity in the application:

- Make sure that all *.c files of the FreeMASTER driver from the *src/common/platforms/[your_platform]* folder are a part of the project. See [Driver files](#) for more details.
- Configure the FreeMASTER driver by creating or editing the *freemaster_cfg.h* file and by saving it into the application project directory. See [Driver configuration](#) for more details.
- Include the *freemaster.h* file into any application source file that makes the FreeMASTER API calls.
- Initialize the Serial or CAN modules. Set the baud rate, parity, and other parameters of the communication. Do not enable the communication interrupts in the interrupt mask registers.
- For the FMSTR_LONG_INTR and FMSTR_SHORT_INTR modes, install the application-specific interrupt routine and call the FMSTR_SerialIsr or FMSTR_CanIsr functions from this handler.
- Call the FMSTR_Init function early on in the application initialization code.
- Call the FMSTR_RecorderCreate functions for each Recorder instance to enable the Recorder feature.
- In the main application loop, call the FMSTR_Poll API function periodically when the application is idle.
- For the FMSTR_SHORT_INTR and FMSTR_LONG_INTR modes, enable the interrupts globally so that the interrupts can be handled by the CPU.

Communication troubleshooting The most common problem that causes communication issues is a wrong baud rate setting or a wrong pin multiplexer setting of the target MCU. When a communication between the PC Host running FreeMASTER and the target MCU cannot be established, try enabling the FMSTR_DEBUG_TX option in the *freemaster_cfg.h* file and call the FMSTR_Poll function periodically in the main application task loop.

With this feature enabled, the FreeMASTER driver periodically transmits a test frame through the Serial or CAN lines. Use a logic analyzer or an oscilloscope to monitor the signals at the communication pins of the CPU device to examine whether the bit rate and signal polarity are configured properly.

Driver API

This section describes the driver Application Programmers' Interface (API) needed to initialize and use the FreeMASTER serial communication driver.

Control API There are three key functions to initialize and use the driver.

FMSTR_Init

Prototype

```
FMSTR_BOOL FMSTR_Init(void);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_protocol.c*

Description This function initializes the internal variables of the FreeMASTER driver and enables the communication interface. This function does not change the configuration of the selected communication module. The hardware module must be initialized before the *FMSTR_Init* function is called.

A call to this function must occur before calling any other FreeMASTER driver API functions.

FMSTR_Poll

Prototype

```
void FMSTR_Poll(void);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_protocol.c*

Description In the poll-driven or short interrupt modes, this function handles the protocol decoding and execution (see *Driver interrupt modes*). In the poll-driven mode, this function also handles the communication interface with the PC. Typically, the *FMSTR_Poll* function is called during the “idle” time in the main application task loop.

To prevent the receive data overflow (loss) on a serial interface, make sure that the *FMSTR_Poll* function is called at least once per the time calculated as:

$N * T_{char}$

where:

- N is equal to the length of the receive FIFO queue (configured by the *FMSTR_COMM_QUEUE_SIZE* macro). N is 1 for the poll-driven mode.
- T_{char} is the character time, which is the time needed to transmit or receive a single byte over the SCI line.

Note: In the long interrupt mode, this function typically compiles as an empty function and can still be called. It is worthwhile to call this function regardless of the interrupt mode used in the application. This approach enables a convenient switching between the different interrupt modes only by changing the configuration macros in the *freemaster_cfg.h* file.

FMSTR_SerialIsr / FMSTR_CanIsr

Prototype

```
void FMSTR_SerialIsr(void);
void FMSTR_CanIsr(void);
```

- Declaration: *freemaster.h*
- Implementation: *hw-specific low-level driver C file*

Description This function contains the interrupt-processing code of the FreeMASTER driver. In long or short interrupt modes (see [Driver interrupt modes](#)), this function must be called from the application interrupt service routine registered for the communication interrupt vector. On platforms where the communication module uses multiple interrupt vectors, the application should register a handler for all vectors and call this function at each interrupt.

Note: In a poll-driven mode, this function is compiled as an empty function and does not have to be used.

Recorder API

FMSTR_RecorderCreate

Prototype

```
FMSTR_BOOL FMSTR_RecorderCreate(FMSTR_INDEX recIndex, FMSTR_REC_BUFF* buffCfg);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_rec.c*

Description This function registers a recorder instance and enables it to be used by the PC Host tool. Call this function for all recorder instances from 0 to the maximum number defined by the FMSTR_USE_RECORDER configuration option (minus one). An exception to this requirement is the recorder of instance 0 which may be automatically configured by FMSTR_Init when the *freemaster_cfg.h* configuration file defines the *FMSTR_REC_BUFF_SIZE* and *FMSTR_REC_TIMEBASE* options.

For more information, see [Configurable items](#).

FMSTR_Recorder

Prototype

```
void FMSTR_Recorder(FMSTR_INDEX recIndex);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_rec.c*

Description This function takes a sample of the variables being recorded using the FreeMASTER Recorder instance *recIndex*. If the selected Recorder is not active when the *FMSTR_Recorder* function is being called, the function returns immediately. When the Recorder is active, the values of the variables being recorded are copied into the recorder buffer and the trigger conditions are evaluated.

If a trigger condition is satisfied, the Recorder enters the post-trigger mode, where it counts down the follow-up samples (number of *FMSTR_Recorder* function calls) and de-activates the Recorder when the required post-trigger samples are finished.

The *FMSTR_Recorder* function is typically called in the timer or PWM interrupt service routines. This function can also be called in the application main loop (for testing purposes).

FMSTR_RecorderTrigger

Prototype

```
void FMSTR_RecorderTrigger(FMSTR_INDEX recIndex);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_rec.c*

Description This function forces the Recorder trigger condition to happen, which causes the Recorder to be automatically deactivated after the post-trigger samples are sampled. Use this function in the application code for programmatic control over the Recorder triggering. This can be useful when a more complex triggering conditions need to be used.

Fast Recorder API The Fast Recorder feature is not available in the FreeMASTER driver version 3. This feature was heavily dependent on the target platform and it was only available for the 56F8xxxx DSCs.

TSA Tables When the TSA is enabled in the FreeMASTER driver configuration file (by setting the *FMSTR_USE_TSA* macro to a non-zero value), it defines the so-called TSA tables in the application. This section describes the macros that must to be used to define the TSA tables.

There can be any number of TSA tables spread across the application source files. There must be always exactly one TSA Table List defined, which informs the FreeMASTER driver about the active TSA tables.

When there is at least one TSA table and one TSA Table List defined in the application, the TSA information automatically appears in the FreeMASTER symbols list. The symbols can then be used to create FreeMASTER variables for visualization or control.

TSA table definition The TSA table describes the static or global variables together with their address, size, type, and access-protection information. If the TSA-described variables are of a structure type, the TSA table may also describe this type and provide an access to the individual structure members of the variable.

The TSA table definition begins with the *FMSTR_TSA_TABLE_BEGIN* macro with a *table_id* identifying the table. The *table_id* shall be a valid C-language symbol.

```
FMSTR_TSA_TABLE_BEGIN(table_id)
```

After this opening macro, the TSA descriptors are placed using these macros:

```
/* Adding variable descriptors */
FMSTR_TSA_RW_VAR(name, type) /* read/write variable entry */
FMSTR_TSA_RO_VAR(name, type) /* read-only variable entry */

/* Description of complex data types */
FMSTR_TSA_STRUCT(struct_name) /* structure or union type entry */
```

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```
FMSTR_TSA_MEMBER(struct_name, member_name, type) /* structure member entry */

/* Memory blocks */
FMSTR_TSA_RW_MEM(name, type, address, size) /* read/write memory block */
FMSTR_TSA_RO_MEM(name, type, address, size) /* read-only memory block */
```

The table is closed using the FMSTR_TSA_TABLE_END macro:

```
FMSTR_TSA_TABLE_END()
```

TSA descriptor parameters The TSA descriptor macros accept these parameters:

- *name* — variable name. The variable must be defined before the TSA descriptor references it.
- *type* — variable or member type. Only one of the pre-defined type constants may be used (see below).
- *struct_name* — structure type name. The type must be defined (typedef) before the TSA descriptor references it.
- *member_name* — structure member name.

Note: The structure member descriptors (FMSTR_TSA_MEMBER) must immediately follow the parent structure descriptor (FMSTR_TSA_STRUCT) in the table.

Note: To write-protect the variables in the FreeMASTER driver (FMSTR_TSA_RO_VAR), enable the TSA-Safety feature in the configuration file.

TSA variable types The table lists *type* identifiers which can be used in TSA descriptors:

Constant	Description
FMSTR_TSA_UINTn	Unsigned integer type of size <i>n</i> bits (n=8,16,32,64)
FMSTR_TSA_SINTn	Signed integer type of size <i>n</i> bits (n=8,16,32,64)
FMSTR_TSA_FRACn	Fractional number of size <i>n</i> bits (n=16,32,64).
FMSTR_TSA_FRAC_Q(<i>m,n</i>)	Signed fractional number in general Q form (m+n+1 total bits)
FMSTR_TSA_FRAC_UQ(<i>m,n</i>)	Unsigned fractional number in general UQ form (m+n total bits)
FMSTR_TSA_FLOAT	4-byte standard IEEE floating-point type
FMSTR_TSA_DOUBLE	8-byte standard IEEE floating-point type
FMSTR_TSA_POINTER	Generic pointer type defined (platform-specific 16 or 32 bit)
FM-STR_TSA_USERTYPE(<i>name</i>)	Structure or union type declared with FMSTR_TSA_STRUCT record

TSA table list There shall be exactly one TSA Table List in the application. The list contains one entry for each TSA table defined anywhere in the application.

The TSA Table List begins with the FMSTR_TSA_TABLE_LIST_BEGIN macro and continues with the TSA table entries for each table.

```
FMSTR_TSA_TABLE_LIST_BEGIN()

FMSTR_TSA_TABLE(table_id)
FMSTR_TSA_TABLE(table_id2)
FMSTR_TSA_TABLE(table_id3)
...
```

The list is closed with the `FMSTR_TSA_TABLE_LIST_END` macro:

```
FMSTR_TSA_TABLE_LIST_END()
```

TSA Active Content entries FreeMASTER v2.0 and higher supports TSA Active Content, enabling the TSA tables to describe the memory-mapped files, virtual directories, and URL hyperlinks. FreeMASTER can access such objects similarly to accessing the files and folders on the local hard drive.

With this set of TSA entries, the FreeMASTER pages can be embedded directly into the target MCU flash and accessed by FreeMASTER directly over the communication line. The HTML-coded pages rendered inside the FreeMASTER window can access the TSA Active Content resources using a special URL referencing the *fmstr:* protocol.

This example provides an overview of the supported TSA Active Content entries:

```
FMSTR_TSA_TABLE_BEGIN(files_and_links)

/* Directory entry applies to all subsequent MEMFILE entries */
FMSTR_TSA_DIRECTORY("/text_files") /* entering a new virtual directory */

/* The readme.txt file will be accessible at the fmstr://text_files/readme.txt URL */
FMSTR_TSA_MEMFILE("readme.txt", readme_txt, sizeof(readme_txt)) /* memory-mapped file */

/* Files can also be specified with a full path so the DIRECTORY entry does not apply */
FMSTR_TSA_MEMFILE("/index.htm", index, sizeof(index)) /* memory-mapped file */
FMSTR_TSA_MEMFILE("/prj/demo.pmp", demo_pmp, sizeof(demo_pmp)) /* memory-mapped file */

/* Hyperlinks can point to a local MEMFILE object or to the Internet */
FMSTR_TSA_HREF("Board's Built-in Welcome Page", "/index.htm")
FMSTR_TSA_HREF("FreeMASTER Home Page", "http://www.nxp.com/freemaster")

/* Project file links simplify opening the projects from any URLs */
FMSTR_TSA_PROJECT("Demonstration Project (embedded)", "/prj/demo.pmp")
FMSTR_TSA_PROJECT("Full Project (online)", "http://mycompany.com/prj/demo.pmp")

FMSTR_TSA_TABLE_END()
```

TSA API

FMSTR_SetUpTsaBuff

Prototype

```
FMSTR_BOOL FMSTR_SetUpTsaBuff(FMSTR_ADDR buffAddr, FMSTR_SIZE buffSize);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_tsa.c*

Arguments

- *buffAddr* [in] - address of the memory buffer for the dynamic TSA table
- *buffSize* [in] - size of the memory buffer which determines the maximum number of TSA entries to be added in the runtime

Description This function must be used to assign the RAM memory buffer to the TSA subsystem when FMSTR_USE_TSA_DYNAMIC is enabled. The memory buffer is then used to store the TSA entries added dynamically to the runtime TSA table using the FMSTR_TsaAddVar function call. The runtime TSA table is processed by the FreeMASTER PC Host tool along with all static tables as soon as the communication port is open.

The size of the memory buffer determines the number of TSA entries that can be added dynamically. Depending on the MCU platform, one TSA entry takes either 8 or 16 bytes.

FMSTR_TsaAddVar

Prototype

```
FMSTR_BOOL FMSTR_TsaAddVar(FMSTR_TSATBL_STRPTR tsaName, FMSTR_TSATBL_STRPTR ↵
↵ tsaType,
    FMSTR_TSATBL_VOIDPTR varAddr, FMSTR_SIZE32 varSize,
    FMSTR_SIZE flags);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_tsa.c*

Arguments

- *tsaName* [in] - name of the object
- *tsaType* [in] - name of the object type
- *varAddr* [in] - address of the object
- *varSize* [in] - size of the object
- *flags* [in] - access flags; a combination of these values:
 - FMSTR_TSA_INFO_RO_VAR — read-only memory-mapped object (typically a variable)
 - FMSTR_TSA_INFO_RW_VAR — read/write memory-mapped object
 - FMSTR_TSA_INFO_NON_VAR — other entry, describing structure types, structure members, enumerations, and other types

Description This function can be called only when the dynamic TSA table is enabled by the FMSTR_USE_TSA_DYNAMIC configuration option and when the FMSTR_SetUpTsaBuff function call is made to assign the dynamic TSA table memory. This function adds an entry into the dynamic TSA table. It can be used to register a read-only or read/write memory object or describe an item of the user-defined type.

See [TSA table definition](#) for more details about the TSA table entries.

Application Commands API

FMSTR_GetAppCmd

Prototype

```
FMSTR_APPCMD_CODE FMSTR_GetAppCmd(void);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_appcmd.c*

Description This function can be used to detect if there is an Application Command waiting to be processed by the application. If no command is pending, this function returns the FMSTR_APPCMDRESULT_NOCMD constant. Otherwise, this function returns the code of the Application Command that must be processed. Use the FMSTR_AppCmdAck call to acknowledge the Application Command after it is processed and to return the appropriate result code to the host.

The FMSTR_GetAppCmd function does not report the commands for which a callback handler function exists. If the FMSTR_GetAppCmd function is called when a callback-registered command is pending (and before it is actually processed by the callback function), this function returns FMSTR_APPCMDRESULT_NOCMD.

FMSTR_GetAppCmdData

Prototype

```
FMSTR_APPCMD_PDATA FMSTR_GetAppCmdData(FMSTR_SIZE* dataLen);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_appcmd.c*

Arguments

- *dataLen* [out] - pointer to the variable that receives the length of the data available in the buffer. It can be NULL when this information is not needed.

Description This function can be used to retrieve the Application Command data when the application determines that an Application Command is pending (see [FMSTR_GetAppCmd](#)).

There is just a single buffer to hold the Application Command data (the buffer length is FMSTR_APPCMD_BUFF_SIZE bytes). If the data are to be used in the application after the command is processed by the FMSTR_AppCmdAck call, copy the data out to a private buffer.

FMSTR_AppCmdAck

Prototype

```
void FMSTR_AppCmdAck(FMSTR_APPCMD_RESULT resultCode);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_appcmd.c*

Arguments

- *resultCode* [in] - the result code which is to be returned to FreeMASTER

Description This function is used when the Application Command processing finishes in the application. The resultCode passed to this function is returned back to the host and the driver is re-initialized to expect the next Application Command.

After this function is called and before the next Application Command arrives, the return value of the FMSTR_GetAppCmd function is FMSTR_APPCMDRESULT_NOCMD.

FMSTR_AppCmdSetResponseData

Prototype

```
void FMSTR_AppCmdSetResponseData(FMSTR_ADDR resultDataAddr, FMSTR_SIZE resultDataLen);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_appcmd.c*

Arguments

- *resultDataAddr* [in] - pointer to the data buffer that is to be copied to the Application Command data buffer
- *resultDataLen* [in] - length of the data to be copied. It must not exceed the FMSTR_APPCMD_BUFF_SIZE value.

Description This function can be used before the Application Command processing finishes, when there are data to be returned back to the PC.

The response data buffer is copied into the Application Command data buffer, from where it is accessed when the host requires it. Do not use FMSTR_GetAppCmdData and the data buffer after FMSTR_AppCmdSetResponseData is called.

Note: The current version of FreeMASTER does not support the Application Command response data.

FMSTR_RegisterAppCmdCall

Prototype

```
FMSTR_BOOL FMSTR_RegisterAppCmdCall(FMSTR_APPCMD_CODE appCmdCode, FMSTR_
↳PAPPCMDFUNC callbackFunc);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_appcmd.c*

Arguments

- *appCmdCode* [in] - the Application Command code for which the callback is to be registered
- *callbackFunc* [in] - pointer to the callback function that is to be registered. Use NULL to unregister a callback registered previously with this Application Command.

Return value This function returns a non-zero value when the callback function was successfully registered or unregistered. It can return zero when trying to register a callback function for more than FMSTR_MAX_APPCMD_CALLS different Application Commands.

Description This function can be used to register the given function as a callback handler for the Application Command. The Application Command is identified using single-byte code. The callback function is invoked automatically by the FreeMASTER driver when the protocol decoder obtains a request to get the application command result code.

The prototype of the callback function is

```
FMSTR_APPCMD_RESULT HandlerFunction(FMSTR_APPCMD_CODE nAppcmd,
FMSTR_APPCMD_PDATA pData, FMSTR_SIZE nDataLen);
```

Where:

- *nAppcmd* -Application Command code
- *pData* —points to the Application Command data received (if any)
- *nDataLen* —information about the Application Command data length

The return value of the callback function is used as the Application Command Result Code and returned to FreeMASTER.

Note: The FMSTR_MAX_APPCMD_CALLS configuration macro defines how many different Application Commands may be handled by a callback function. When FMSTR_MAX_APPCMD_CALLS is undefined or defined as zero, the FMSTR_RegisterAppCmdCall function always fails.

Pipes API

FMSTR_PipeOpen

Prototype

```
FMSTR_HPIPE FMSTR_PipeOpen(FMSTR_PIPE_PORT pipePort, FMSTR_PPIPEFUNC pipeCallback,  
FMSTR_ADDR pipeRxBuff, FMSTR_PIPE_SIZE pipeRxSize,  
FMSTR_ADDR pipeTxBuff, FMSTR_PIPE_SIZE pipeTxSize,  
FMSTR_U8 type, const FMSTR_CHAR *name);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_pipes.c*

Arguments

- *pipePort* [in] - port number that identifies the pipe for the client
- *pipeCallback* [in] - pointer to the callback function that is called whenever a pipe data status changes
- *pipeRxBuff* [in] - address of the receive memory buffer
- *pipeRxSize* [in] - size of the receive memory buffer
- *pipeTxBuff* [in] - address of the transmit memory buffer
- *pipeTxSize* [in] - size of the transmit memory buffer
- *type* [in] - a combination of FMSTR_PIPE_MODE_XXX and FMSTR_PIPE_SIZE_XXX constants describing primary pipe data format and usage. This type helps FreeMASTER decide how to access the pipe by default. Optional, use 0 when undetermined.
- *name* [in] - user name of the pipe port. This name is visible to the FreeMASTER user when creating the graphical pipe interface.

Description This function initializes a new pipe and makes it ready to accept or send the data to the PC Host client. The receive memory buffer is used to store the received data before they are read out by the FMSTR_PipeRead call. When this buffer gets full, the PC Host client denies the data transmission into this pipe until there is enough free space again. The transmit memory buffer is used to store the data transmitted by the application to the PC Host client using the FMSTR_PipeWrite call. The transmit buffer can get full when the PC Host is disconnected or when it is slow in receiving and reading out the pipe data.

The function returns the pipe handle which must be stored and used in the subsequent calls to manage the pipe object.

The callback function (if specified) is called whenever new data are received through the pipe and available for reading. This callback is also called when the data waiting in the transmit buffer are successfully pushed to the PC Host and the transmit buffer free space increases. The prototype of the callback function provided by the user application must be as follows. The *PipeHandler* name is only a placeholder and must be defined by the application.

```
void PipeHandler(FMSTR_HPIPE pipeHandle);
```

FMSTR_PipeClose

Prototype

```
void FMSTR_PipeClose(FMSTR_HPIPE pipeHandle);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_pipes.c*

Arguments

- *pipeHandle* [in] - pipe handle returned from the FMSTR_PipeOpen function call

Description This function de-initializes the pipe object. No data can be received or sent on the pipe after this call.

FMSTR_PipeWrite

Prototype

```
FMSTR_PIPE_SIZE FMSTR_PipeWrite(FMSTR_HPIPE pipeHandle, FMSTR_ADDR pipeData,  
FMSTR_PIPE_SIZE pipeDataLen, FMSTR_PIPE_SIZE writeGranularity);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_pipes.c*

Arguments

- *pipeHandle* [in] - pipe handle returned from the FMSTR_PipeOpen function call
- *pipeData* [in] - address of the data to be written
- *pipeDataLen* [in] - length of the data to be written
- *writeGranularity* [in] - size of the minimum unit of data which is to be written

Description This function puts the user-specified data into the pipe's transmit memory buffer and schedules it for transmission. This function returns the number of bytes that were successfully written into the buffer. This number may be smaller than the number of the requested bytes if there is not enough free space in the transmit buffer.

The *writeGranularity* argument can be used to split the data into smaller chunks, each of the size given by the *writeGranularity* value. The FMSTR_PipeWrite function writes as many data chunks as possible into the transmit buffer and does not attempt to write an incomplete chunk.

This feature can prove to be useful to avoid the intermediate caching when writing an array of integer values or other multi-byte data items. When making the `nGranularity` value equal to the `nLength` value, all data are considered as one chunk which is either written successfully as a whole or not at all. The `nGranularity` value of 0 or 1 disables the data-chunk approach.

FMSTR_PipeRead

Prototype

```
FMSTR_PIPE_SIZE FMSTR_PipeRead(FMSTR_HPIPE pipeHandle, FMSTR_ADDR pipeData,  
    FMSTR_PIPE_SIZE pipeDataLen, FMSTR_PIPE_SIZE readGranularity);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_pipes.c*

Arguments

- *pipeHandle* [in] - pipe handle returned from the `FMSTR_PipeOpen` function call
- *pipeData* [in] - address of the data buffer to be filled with the received data
- *pipeDataLen* [in] - length of the data to be read
- *readGranularity* [in] - size of the minimum unit of data which is to be read

Description This function copies the data received from the pipe from its receive buffer to the user buffer for further processing. The function returns the number of bytes that were successfully copied to the buffer. This number may be smaller than the number of the requested bytes if there is not enough data bytes available in the receive buffer.

The `readGranularity` argument can be used to copy the data in larger chunks in the same way as described in the `FMSTR_PipeWrite` function.

API data types This section describes the data types used in the FreeMASTER driver. The information provided here can be useful when modifying or porting the FreeMASTER Communication Driver to new NXP platforms.

Note: The licensing conditions prohibit use of FreeMASTER and the FreeMASTER Communication Driver with non-NXP MPU or MCU products.

Public common types The table below describes the public data types used in the FreeMASTER driver API calls. The data types are declared in the *freemaster.h* header file.

Type name	Description
<i>FM-STR_ADDR</i> For example, this type is defined as long integer on the 56F8xxx platform where the 24-bit addresses must be supported, but the C-pointer may be only 16 bits wide in some compiler configurations.	Data type used to hold the memory address. On most platforms, this is normally a C-pointer, but it may also be a pure integer type.
<i>FM-STR_SIZE</i> It is required that this type is unsigned and at least 16 bits wide integer.	Data type used to hold the memory block size.
<i>FM-STR_BOOL</i> This type is used only in zero/non-zero conditions in the driver code.	Data type used as a general boolean type.
<i>FM-STR_APPCM</i> Generally, this is an unsigned 8-bit value.	Data type used to hold the Application Command code.
<i>FM-STR_APPCM</i> Generally, this is an unsigned 8-bit value.	Data type used to create the Application Command data buffer.
<i>FM-STR_APPCM</i> Generally, this is an unsigned 8-bit value.	Data type used to hold the Application Command result code.

Public TSA types The table describes the TSA-specific public data types. These types are declared in the *freemaster_tsa.h* header file, which is included in the user application indirectly by the *freemaster.h* file.

<i>FM-STR_TSA_TII</i>	Data type used to hold a descriptor index in the TSA table or a table index in the list of TSA tables. By default, this is defined as <i>FM-STR_SIZE</i> .
<i>FM-STR_TSA_TS</i>	Data type used to hold a memory block size, as used in the TSA descriptors. By default, this is defined as <i>FM-STR_SIZE</i> .

Public Pipes types The table describes the data types used by the FreeMASTER Pipes API:

<i>FM-STR_HPIPE</i>	Pipe handle that identifies the open-pipe object. Generally, this is a pointer to a void type.
<i>FM-STR_PIPE_PC</i>	Integer type required to hold at least 7 bits of data. Generally, this is an unsigned 8-bit or 16-bit type.
<i>FM-STR_PIPE_SI</i>	Integer type required to hold at least 16 bits of data. This is used to store the data buffer sizes.
<i>FM-STR_PPIPEF</i>	Pointer to the pipe handler function. See FM-STR_PipeOpen for more details.

Internal types The table describes the data types used internally by the FreeMASTER driver. The data types are declared in the platform-specific header file and they are not available in the application code.

<i>FMSTR_U8</i>	The smallest memory entity.
On the vast majority of platforms, this is an unsigned 8-bit integer.	
On the 56F8xx DSP platform, this is defined as an unsigned 16-bit integer.	
<i>FMSTR_U16</i>	Unsigned 16-bit integer.
<i>FMSTR_U32</i>	Unsigned 32-bit integer.
<i>FMSTR_S8</i>	Signed 8-bit integer.
<i>FMSTR_S16</i>	Signed 16-bit integer.
<i>FMSTR_S32</i>	Signed 32-bit integer.
<i>FMSTR_FLOAT</i>	4-byte standard IEEE floating-point type.
<i>FMSTR_FLAGS</i>	Data type forming a union with a structure of flag bit-fields.
<i>FMSTR_SIZE8</i>	Data type holding a general size value, at least 8 bits wide.
<i>FMSTR_INDEX</i>	General for-loop index. Must be signed, at least 16 bits wide.
<i>FMSTR_BCHR</i>	A single character in the communication buffer.
Typically, this is an 8-bit unsigned integer, except for the DSP platforms where it is a 16-bit integer.	
<i>FMSTR_BPTR</i>	A pointer to the communication buffer (an array of <i>FMSTR_BCHR</i>).

Document references

Links

- This document online: <https://mcuxpresso.nxp.com/mcuxsdk/latest/html/middleware/freemaster/doc/index.html>

- FreeMASTER tool home: www.nxp.com/freemaster
- FreeMASTER community area: community.nxp.com/community/freemaster
- FreeMASTER GitHub code repo: <https://github.com/nxp-mcuxpresso/mcux-freemaster>
- MCUXpresso SDK home: www.nxp.com/mcuxpresso
- MCUXpresso SDK builder: mcuxpresso.nxp.com/en

Documents

- *FreeMASTER Usage Serial Driver Implementation* (document [AN4752](#))
- *Integrating FreeMASTER Time Debugging Tool With CodeWarrior For Microcontrollers v10.X Project* (document [AN4771](#))
- *Flash Driver Library For MC56F847xx And MC56F827xx DSC Family* (document [AN4860](#))

Revision history This Table summarizes the changes done to this document since the initial release.

Revision	Date	Description
1.0	03/2006	Limited initial release
2.0	09/2007	Updated for FreeMASTER version. New Freescale document template used.
2.1	12/2007	Added description of the new Fast Recorder feature and its API.
2.2	04/2010	Added support for MPC56xx platform, Added new API for use CAN interface.
2.3	04/2011	Added support for Kxx Kinetis platform and MQX operating system.
2.4	06/2011	Serial driver update, adds support for USB CDC interface.
2.5	08/2011	Added Packet Driven BDM interface.
2.7	12/2013	Added FLEXCAN32 interface, byte access and isr callback configuration option.
2.8	06/2014	Removed obsolete license text, see the software package content for up-to-date license.
2.9	03/2015	Update for driver version 1.8.2 and 1.9: FreeMASTER Pipes, TSA Active Content, LIN Transport Layer support, DEBUG-TX communication troubleshooting, Kinetis SDK support.
3.0	08/2016	Update for driver version 2.0: Added support for MPC56xx, MPC57xx, KEAxx and S32Kxx platforms. New NXP document template as well as new license agreement used. added MCAN interface. Folders structure at the installation destination was rearranged.
4.0	04/2019	Update for driver released as part of FreeMASTER v3.0 and MCUXpresso SDK 2.6. Updated to match new V4 serial communication protocol and new configuration options. This version of the document removes substantial portion of outdated information related to S08, S12, ColdFire, Power and other legacy platforms.
4.1	04/2020	Minor update for FreeMASTER driver included in MCUXpresso SDK 2.8.
4.2	09/2020	Added example applications description and information about the MCUXpresso Config Tools. Fixed the pipe-related API description.
4.3	10/2024	Added description of Network and Segger J-Link RTT interface configuration. Accompanying the MCUXpresso SDK version 24.12.00.
4.4	04/2025	Added Zephyr-specific information. Accompanying the MCUXpresso SDK version 25.06.00.

3.3 MultiCore

3.3.1 Multicore SDK

Multicore Software Development Kit (MCSDK) is a Software Development Kit that provides comprehensive software support for NXP dual/multicore devices. The MCSDK is combined with the MCUXpresso SDK to make the software framework for easy development of multicore applications.

Multicore SDK (MCSDK) Release Notes

Overview These are the release notes for the NXP Multicore Software Development Kit (MCSDK) version 25.12.00.

This software package contains components for efficient work with multicore devices as well as for the multiprocessor communication.

What is new

- eRPC [CHANGELOG](#)
- RPPmsg-Lite [CHANGELOG](#)
- MCMgr [CHANGELOG](#)
- Supported evaluation boards (multicore examples):
 - LPCXpresso55S69
 - FRDM-K32L3A6
 - MIMXRT1170-EVKB
 - MIMXRT1160-EVK
 - MIMXRT1180-EVK
 - MCX-N5XX-EVK
 - MCX-N9XX-EVK
 - FRDM-MCXN947
 - MIMXRT700-EVK
 - KW47-EVK
 - KW47-LOC
 - FRDM-MCXW72
 - MCX-W72-EVK
 - FRDM-IMXRT1186
- Supported evaluation boards (multiprocessor examples):
 - LPCXpresso55S36
 - FRDM-K22F
 - FRDM-K32L2B
 - MIMXRT685-EVK
 - MIMXRT1170-EVKB
 - MIMXRT1180
 - FRDM-MCXN236
 - FRDM-MCXC242
 - FRDM-MCXC444
 - MCX-N9XX-EVK
 - FRDM-MCXN947
 - MIMXRT700-EVK
 - FRDM-IMXRT1186

Development tools The Multicore SDK (MCSDK) was compiled and tested with development tools referred in: [Development tools](#)

Release contents This table describes the release contents. Not all MCUXpresso SDK packages contain the whole set of these components.

Deliverable	Location
Multicore SDK location	<MCUXpressoSDK_install_dir>/middleware/multicore/
Documentation	<MCSDK_dir>/mcuxsdk-doc/
Embedded Remote Procedure Call component	<MCSDK_dir>/erpc/
Multicore Manager component	<MCSDK_dir>/mcmgr/
RPMsg-Lite	<MCSDK_dir>/rpmsg_lite/
Multicore demo applications	<MCUXpressoSDK_install_dir>/examples/multicore_examples/
Multiprocessor demo applications	<MCUXpressoSDK_install_dir>/examples/multiprocessor_examples/

Multicore SDK release overview Together, the Multicore SDK (MCSDK) and the MCUXpresso SDK (SDK) form a framework for the development of software for NXP multicore devices. The MCSDK release consists of the following elementary software components for multicore:

- Embedded Remote Procedure Call (eRPC)
- Multicore Manager (MCMGR) - included just in SDK for multicore devices
- Remote Processor Messaging - Lite (RPMsg-Lite) - included just in SDK for multicore devices

The MCSDK is also accompanied with documentation and several multicore and multiprocessor demo applications.

Demo applications The multicore demo applications demonstrate the usage of the MCSDK software components on supported multicore development boards.

The following multicore demo applications are located together with other MCUXpresso SDK examples in

the <MCUXpressoSDK_install_dir>/examples/multicore_examples subdirectories.

- erpc_matrix_multiply_mu
- erpc_matrix_multiply_mu_rtos
- erpc_matrix_multiply_rpmsg
- erpc_matrix_multiply_rpmsg_rtos
- erpc_two_way_rpc_rpmsg_rtos
- freertos_message_buffers
- hello_world
- multicore_manager
- rpmsg_lite_pingpong
- rpmsg_lite_pingpong_rtos
- rpmsg_lite_pingpong_dsp
- rpmsg_lite_pingpong_tzm

The eRPC multicore component can be leveraged for inter-processor communication and remote procedure calls between SoCs / development boards.

The following multiprocessor demo applications are located together with other MCUXpresso SDK examples in

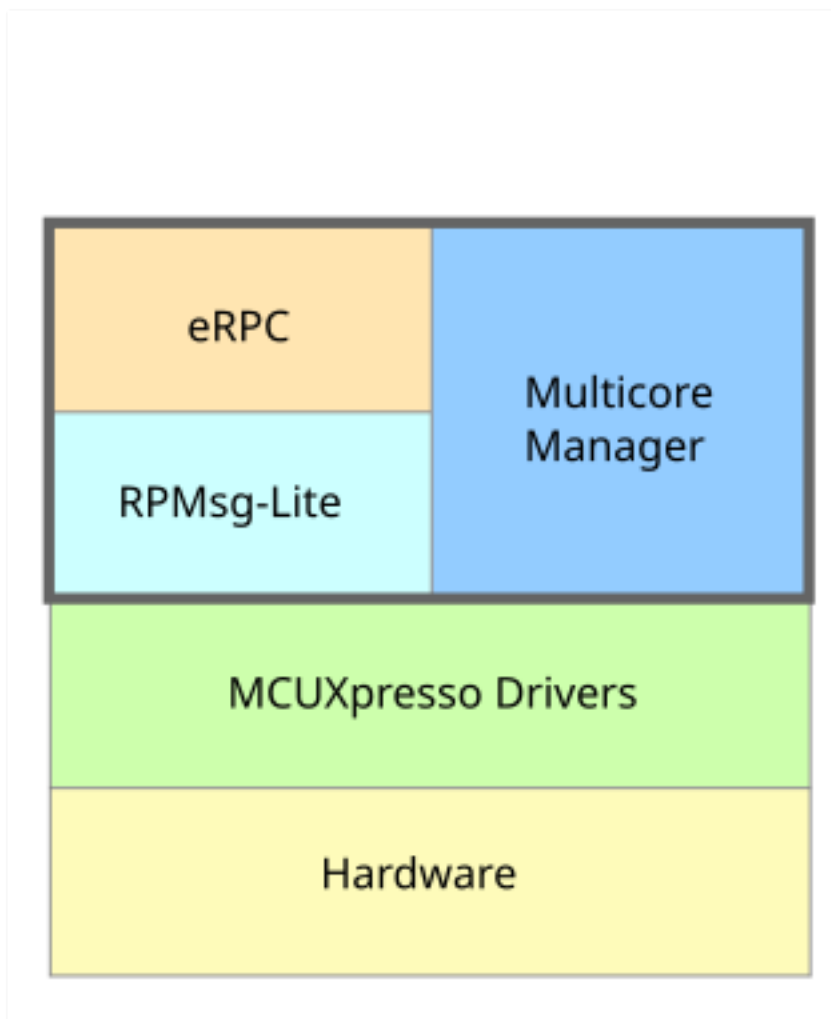
the <MCUXpressoSDK_install_dir>/examples/multiprocessor_examples subdirectories.

- erpc_client_matrix_multiply_spi
- erpc_server_matrix_multiply_spi
- erpc_client_matrix_multiply_uart
- erpc_server_matrix_multiply_uart
- erpc_server_dac_adc
- erpc_remote_control

Getting Started with Multicore SDK (MCSDK)

Overview Multicore Software Development Kit (MCSDK) is a Software Development Kit that provides comprehensive software support for NXP dual/multicore devices. The MCSDK is combined with the MCUXpresso SDK to make the software framework for easy development of multicore applications.

The following figure highlights the layers and main software components of the MCSDK.

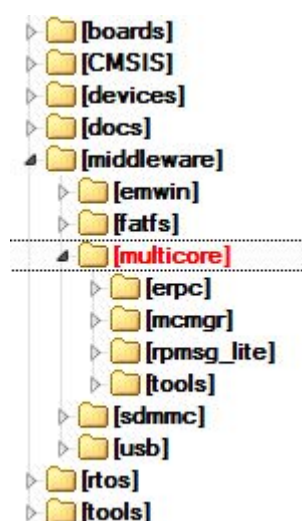


All the MCSDK-related files are located in `<MCUXpressoSDK_install_dir>/middleware/multicore` folder.

For supported toolchain versions, see the *Multicore SDK v25.12.00 Release Notes* (document MCS-DKRN). For the latest version of this and other MCSDK documents, visit www.nxp.com.

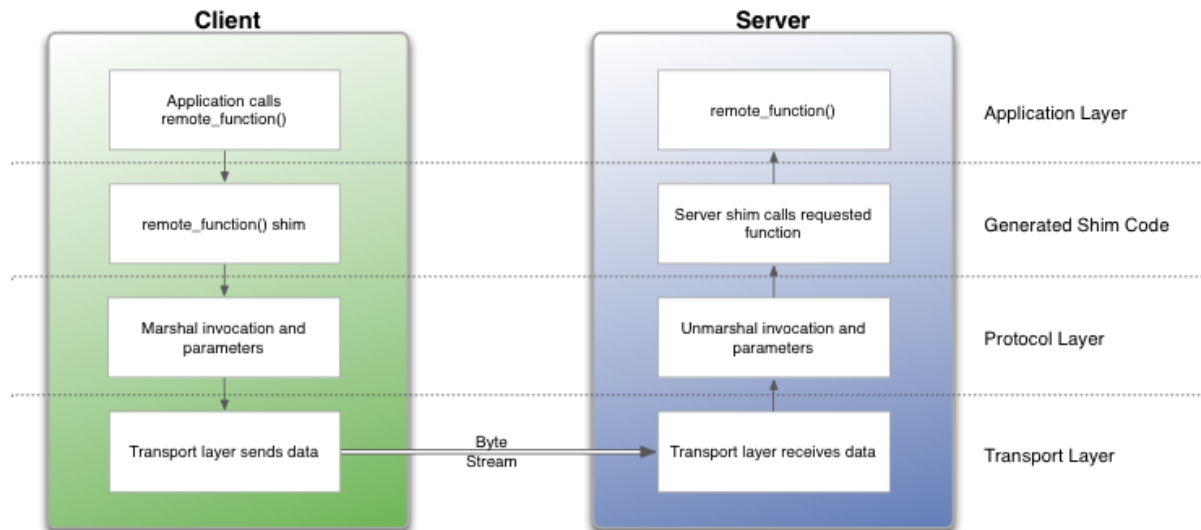
Multicore SDK (MCSDK) components The MCSDK consists of the following software components:

- **Embedded Remote Procedure Call (eRPC):** This component is a combination of a library and code generator tool that implements a transparent function call interface to remote services (running on a different core).
- **Multicore Manager (MCMGR):** This library maintains information about all cores and starts up secondary/auxiliary cores.
- **Remote Processor Messaging - Lite (RPMsg-Lite):** Inter-Processor Communication library.



Embedded Remote Procedure Call (eRPC) The Embedded Remote Procedure Call (eRPC) is the RPC system created by NXP. The RPC is a mechanism used to invoke a software routine on a remote system via a simple local function call.

When a remote function is called by the client, the function's parameters and an identifier for the called routine are marshaled (or serialized) into a stream of bytes. This byte stream is transported to the server through a communications channel (IPC, TPC/IP, UART, and so on). The server unmarshals the parameters, determines which function was invoked, and calls it. If the function returns a value, it is marshaled and sent back to the client.



RPC implementations typically use a combination of a tool (erpcgen) and IDL (interface definition language) file to generate source code to handle the details of marshaling a function's parameters and building the data stream.

Main eRPC features:

- Scalable from BareMetal to Linux OS - configurable memory and threading policies.
- Focus on embedded systems - intrinsic support for C, modular, and lightweight implementation.
- Abstracted transport interface - RPMsg is the primary transport for multicore, UART, or SPI-based solutions can be used for multichip.

The eRPC library is located in the `<MCUXpressoSDK_install_dir>/middleware/multicore/erpc` folder. For detailed information about the eRPC, see the documentation available in the `<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/doc` folder.

Multicore Manager (MCMGR) The Multicore Manager (MCMGR) software library provides a number of services for multicore systems.

The main MCMGR features:

- Maintains information about all cores in system.
- Secondary/auxiliary cores startup and shutdown.
- Remote core monitoring and event handling.

The MCMGR library is located in the `<MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr` folder. For detailed information about the MCMGR library, see the documentation available in the `<MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr/doc` folder.

Remote Processor Messaging Lite (RPMsg-Lite) RPMsg-Lite is a lightweight implementation of the RPMsg protocol. The RPMsg protocol defines a standardized binary interface used to communicate between multiple cores in a heterogeneous multicore system. Compared to the legacy OpenAMP implementation, RPMsg-Lite offers a code size reduction, API simplification, and improved modularity.

The main RPMsg protocol features:

- Shared memory interprocessor communication.
- Virtio-based messaging bus.
- Application-defined messages sent between endpoints.

- Portable to different environments/platforms.
- Available in upstream Linux OS.

The RPMsg-Lite library is located in the `<MCUXpressoSDK_install_dir>/middleware/multicore/rpmsg-lite` folder. For detailed information about the RPMsg-Lite, see the RPMsg-Lite User's Guide located in the `<MCUXpressoSDK_install_dir>/middleware/multicore/rpmsg_lite/doc` folder.

MCSDK demo applications Multicore and multiprocessor example applications are stored together with other MCUXpresso SDK examples, in the dedicated multicore subfolder.

Location	Folder
Multicore example projects	<code><MCUXpressoSDK_install_dir>/examples/multicore_examples/<application_name>/</code>
Multiprocessor example projects	<code><MCUXpressoSDK_install_dir>/examples/multiprocessor_examples/<application_name>/</code>

See the *Getting Started with MCUXpresso SDK* (document MCUXSDKGSUG) and *Getting Started with MCUXpresso SDK for XXX Derivatives* documents for more information about the MCUXpresso SDK example folder structure and the location of individual files that form the example application projects. These documents also contain information about building, running, and debugging multicore demo applications in individual supported IDEs. Each example application also contains a readme file that describes the operation of the example and required setup steps.

Inter-Processor Communication (IPC) levels The MCSDK provides several mechanisms for Inter-Processor Communication (IPC). Particular ways and levels of IPC are described in this chapter.

IPC using low-level drivers

The NXP multicore SoCs are equipped with peripheral modules dedicated for data exchange between individual cores. They deal with the Mailbox peripheral for LPC parts and the Messaging Unit (MU) peripheral for Kinetis and i.MX parts. The common attribute of both modules is the ability to provide a means of IPC, allowing multiple CPUs to share resources and communicate with each other in a simple manner.

The most lightweight method of IPC uses the MCUXpresso SDK low-level drivers for these peripherals. Using the Mailbox/MU driver API functions, it is possible to pass a value from core to core via the dedicated registers (could be a scalar or a pointer to shared memory) and also to trigger inter-core interrupts for notifications.

For details about individual driver API functions, see the MCUXpresso SDK API Reference Manual of the specific multicore device. The MCUXpresso SDK is accompanied with the RPMsg-Lite documentation that shows how to use this API in multicore applications.

Messaging mechanism

On top of Mailbox/MU drivers, a messaging system can be implemented, allowing messages to send between multiple endpoints created on each of the CPUs. The RPMsg-Lite library of the MCSDK provides this ability and serves as the preferred MCUXpresso SDK messaging library. It implements ring buffers in shared memory for messages exchange without the need of a locking mechanism.

The RPMsg-Lite provides the abstraction layer and can be easily ported to different multicore platforms and environments (Operating Systems). The advantages of such a messaging system are ease of use (there is no need to study behavior of the used underlying hardware) and smooth application code portability between platforms due to unified messaging API.

However, this costs several kB of code and data memory. The MCUXpresso SDK is accompanied by the RPMsg-Lite documentation and several multicore examples. You can also obtain the latest RPMsg-Lite code from the GitHub account github.com/nxp-mcuxpresso/rpmsg-lite.

Remote procedure calls

To facilitate the IPC even more and to allow the remote functions invocation, the remote procedure call mechanism can be implemented. The eRPC of the MCSDK serves for these purposes and allows the ability to invoke a software routine on a remote system via a simple local function call. Utilizing different transport layers, it is possible to communicate between individual cores of multicore SoCs (via RPMsg-Lite) or between separate processors (via SPI, UART, or TCP/IP). The eRPC is mostly applicable to the MPU parts with enough of memory resources like i.MX parts.

The eRPC library allows you to export existing C functions without having to change their prototypes (in most cases). It is accompanied by the code generator tool that generates the shim code for serialization and invocation based on the IDL file with definitions of data types and remote interfaces (API).

If the communicating peer is running as a Linux OS user-space application, the generated code can be either in C/C++ or Python.

Using the eRPC simplifies the access to services implemented on individual cores. This way, the following types of applications running on dedicated cores can be easily interfaced:

- Communication stacks (USB, Thread, Bluetooth Low Energy, Zigbee)
- Sensor aggregation/fusion applications
- Encryption algorithms
- Virtual peripherals

The eRPC is publicly available from the following GitHub account: github.com/EmbeddedRPC/erpc. Also, the MCUXpresso SDK is accompanied by the eRPC code and several multicore and multiprocessor eRPC examples.

The mentioned IPC levels demonstrate the scalability of the Multicore SDK library. Based on application needs, different IPC techniques can be used. It depends on the complexity, required speed, memory resources, system design, and so on. The MCSDK brings users the possibility for quick and easy development of multicore and multiprocessor applications.

Changelog Multicore SDK

All notable changes to this project will be documented in this file.

The format is based on [Keep a Changelog](#), and this project adheres to [Semantic Versioning](#).

[25.12.00]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.14.0
 - eRPC generator (erpcgen) v1.14.0
 - Multicore Manager (MCMgr) v5.0.2
 - RPMsg-Lite v5.3.0

[25.09.00]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.14.0

- eRPC generator (erpcgen) v1.14.0
- Multicore Manager (MCMgr) v5.0.1
- RPSMsg-Lite v5.2.1

[25.06.00]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.14.0
 - eRPC generator (erpcgen) v1.14.0
 - Multicore Manager (MCMgr) v5.0.0
 - RPSMsg-Lite v5.2.0

[25.03.00]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.13.0
 - eRPC generator (erpcgen) v1.13.0
 - Multicore Manager (MCMgr) v4.1.7
 - RPSMsg-Lite v5.1.4

[24.12.00]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.13.0
 - eRPC generator (erpcgen) v1.13.0
 - Multicore Manager (MCMgr) v4.1.6
 - RPSMsg-Lite v5.1.3

[2.16.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.13.0
 - eRPC generator (erpcgen) v1.13.0
 - Multicore Manager (MCMgr) v4.1.5
 - RPSMsg-Lite v5.1.2

[2.15.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.12.0
 - eRPC generator (erpcgen) v1.12.0
 - Multicore Manager (MCMgr) v4.1.5
 - RPSMsg-Lite v5.1.1

[2.14.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.11.0
 - eRPC generator (erpcgen) v1.11.0
 - Multicore Manager (MCMgr) v4.1.4
 - RPSMsg-Lite v5.1.0

[2.13.0_imxrt1180a0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.10.0
 - eRPC generator (erpcgen) v1.10.0
 - Multicore Manager (MCMgr) v4.1.3
 - RPSMsg-Lite v5.0.0

[2.13.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.10.0
 - eRPC generator (erpcgen) v1.10.0
 - Multicore Manager (MCMgr) v4.1.3
 - RPSMsg-Lite v5.0.0

[2.12.0_imx93]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.9.1
 - eRPC generator (erpcgen) v1.9.1
 - Multicore Manager (MCMgr) v4.1.2
 - RPSMsg-Lite v4.0.1

[2.12.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.9.1
 - eRPC generator (erpcgen) v1.9.1
 - Multicore Manager (MCMgr) v4.1.2
 - RPSMsg-Lite v4.0.0

[2.11.1]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.9.0
 - eRPC generator (erpcgen) v1.9.0
 - Multicore Manager (MCMgr) v4.1.1
 - RPSMsg-Lite v3.2.1

[2.11.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.9.0
 - eRPC generator (erpcgen) v1.9.0
 - Multicore Manager (MCMgr) v4.1.1
 - RPSMsg-Lite v3.2.0

[2.10.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.8.1
 - eRPC generator (erpcgen) v1.8.1
 - Multicore Manager (MCMgr) v4.1.1
 - RPSMsg-Lite v3.1.2

[2.9.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.8.0
 - eRPC generator (erpcgen) v1.8.0
 - Multicore Manager (MCMgr) v4.1.1
 - RPSMsg-Lite v3.1.1

[2.8.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.7.4
 - eRPC generator (erpcgen) v1.7.4
 - Multicore Manager (MCMgr) v4.1.0
 - RPSMsg-Lite v3.1.0

[2.7.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.7.3
 - eRPC generator (erpcgen) v1.7.3
 - Multicore Manager (MCMgr) v4.1.0
 - RPSMsg-Lite v3.0.0

[2.6.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.7.2
 - eRPC generator (erpcgen) v1.7.2
 - Multicore Manager (MCMgr) v4.0.3
 - RPSMsg-Lite v2.2.0

[2.5.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.7.1
 - eRPC generator (erpcgen) v1.7.1
 - Multicore Manager (MCMgr) v4.0.2
 - RPSMsg-Lite v2.0.2

[2.4.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.7.0
 - eRPC generator (erpcgen) v1.7.0
 - Multicore Manager (MCMgr) v4.0.1
 - RPSMsg-Lite v2.0.1

[2.3.1]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.6.0
 - eRPC generator (erpcgen) v1.6.0
 - Multicore Manager (MCMgr) v4.0.0
 - RPSMsg-Lite v1.2.0

[2.3.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.5.0
 - eRPC generator (erpcgen) v1.5.0
 - Multicore Manager (MCMgr) v3.0.0
 - RPMMsg-Lite v1.2.0

[2.2.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.4.0
 - eRPC generator (erpcgen) v1.4.0
 - Multicore Manager (MCMgr) v2.0.1
 - RPMMsg-Lite v1.1.0

[2.1.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.3.0
 - eRPC generator (erpcgen) v1.3.0

[2.0.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.2.0
 - eRPC generator (erpcgen) v1.2.0
 - Multicore Manager (MCMgr) v2.0.0
 - RPMMsg-Lite v1.0.0

[1.1.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.1.0
 - Multicore Manager (MCMgr) v1.1.0
 - Open-AMP / RPMMsg based on SHA1 ID 44b5f3c0a6458f3cf80 rev01

[1.0.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.0.0
 - Multicore Manager (MCMgr) v1.0.0
 - Open-AMP / RPMMsg based on SHA1 ID 44b5f3c0a6458f3cf80 rev00

Multicore SDK Components

RPMSG-Lite

MCUXpresso SDK : mcuxsdk-middleware-rpmsg-lite

Overview This repository is for MCUXpresso SDK RPMSG-Lite middleware delivery and it contains RPMSG-Lite component officially provided in NXP MCUXpresso SDK. This repository is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository [mcuxsdk](#) for the complete delivery of MCUXpresso SDK to be able to build and run RPMSG-Lite examples that are based on mcux-sdk-middleware-rpmsg-lite component.

Documentation Overall details can be reviewed here: [MCUXpresso SDK Online Documentation](#)

Visit [RPMSG-Lite - Documentation](#) to review details on the contents in this sub-repo.

For Further API documentation, please look at [doxygen documentation](#)

Setup Instructions on how to install the MCUXpresso SDK provided from GitHub via west manifest [Getting Started with SDK - Detailed Installation Instructions](#)

Contribution We welcome and encourage the community to submit patches directly to the rpmsg-lite project placed on github. Contributing can be managed via pull-requests. Before a pull-request is created the code should be tested and properly formatted.

RPMSG-Lite This documentation describes the RPMsg-Lite component, which is a lightweight implementation of the Remote Processor Messaging (RPMsg) protocol. The RPMsg protocol defines a standardized binary interface used to communicate between multiple cores in a heterogeneous multicore system.

Compared to the RPMsg implementation of the Open Asymmetric Multi Processing (OpenAMP) framework (<https://github.com/OpenAMP/open-amp>), the RPMsg-Lite offers a code size reduction, API simplification, and improved modularity. On smaller Cortex-M0+ based systems, it is recommended to use RPMsg-Lite.

The RPMsg-Lite is an open-source component developed by NXP Semiconductors and released under the BSD-compatible license.

For overview please read RPMSG-Lite VirtIO Overview.

For RPMSG-Lite Design Considerations please read RPMSG-Lite Design Considerations.

Motivation to create RPMsg-Lite There are multiple reasons why RPMsg-Lite was developed. One reason is the need for the small footprint of the RPMsg protocol-compatible communication component, another reason is the simplification of extensive API of OpenAMP RPMsg implementation.

RPMsg protocol was not documented, and its only definition was given by the Linux Kernel and legacy OpenAMP implementations. This has changed with [1] which is a standardization protocol allowing multiple different implementations to coexist and still be mutually compatible.

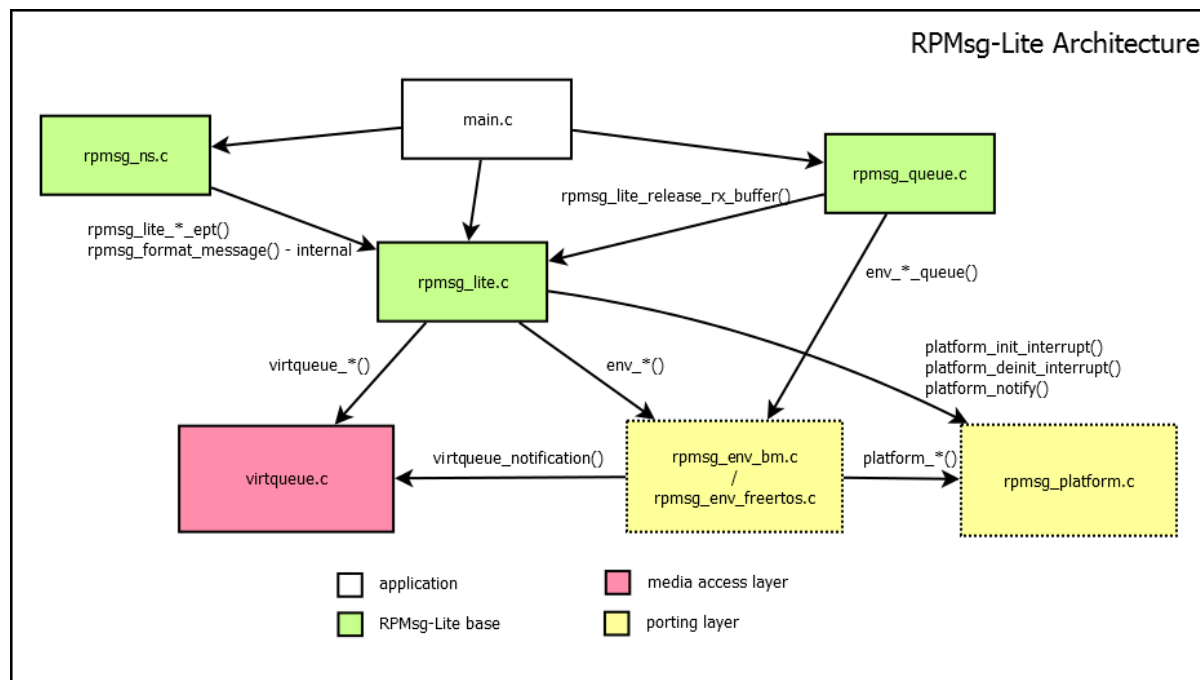
Small MCU-based systems often do not implement dynamic memory allocation. The creation of static API in RPMsg-Lite enables another reduction of resource usage. Not only does the dynamic allocation adds another 5 KB of code size, but also communication is slower and less deterministic, which is a property introduced by dynamic memory. The following table shows some rough comparison data between the OpenAMP RPMsg implementation and new RPMsg-Lite implementation:

Component / Configuration	Flash [B]	RAM [B]
OpenAMP RPMsg / Release (reference)	5547	456 + dynamic
RPMsg-Lite / Dynamic API, Release	3462	56 + dynamic
Relative Difference [%]	~62.4%	~12.3%
RPMsg-Lite / Static API (no malloc), Release	2926	352
Relative Difference [%]	~52.7%	~77.2%

Implementation The implementation of RPMsg-Lite can be divided into three sub-components, from which two are optional. The core component is situated in `rpmsg_lite.c`. Two optional components are used to implement a blocking receive API (in `rpmsg_queue.c`) and dynamic “named” endpoint creation and deletion announcement service (in `rpmsg_ns.c`).

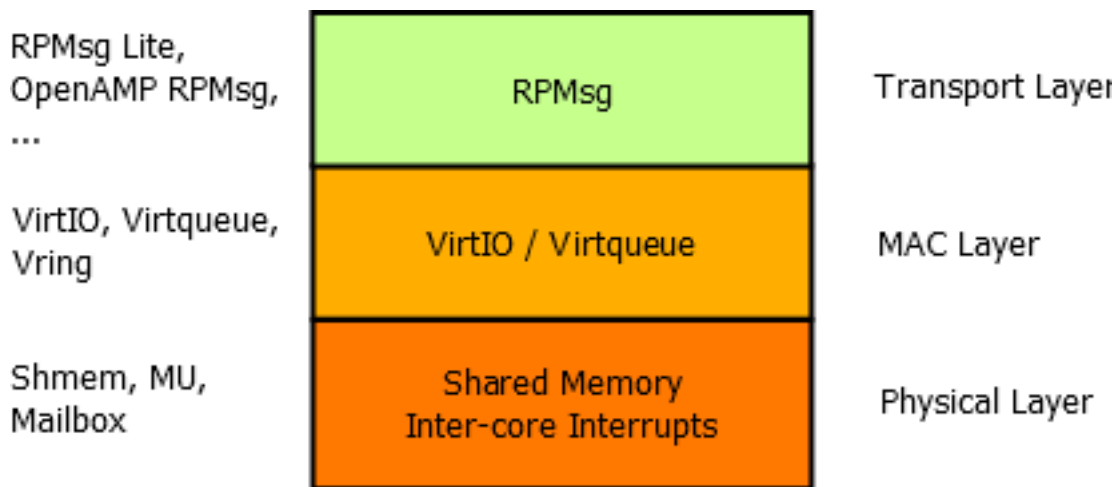
The actual “media access” layer is implemented in `virtqueue.c`, which is one of the few files shared with the OpenAMP implementation. This layer mainly defines the shared memory model, and internally defines used components such as `vring` or `virtqueue`.

The porting layer is split into two sub-layers: the environment layer and the platform layer. The first sublayer is to be implemented separately for each environment. (The bare metal environment already exists and is implemented in `rpmsg_env_bm.c`, and the FreeRTOS environment is implemented in `rpmsg_env_freertos.c` etc.) Only the source file, which matches the used environment, is included in the target application project. The second sublayer is implemented in `rpmsg_platform.c` and defines low-level functions for interrupt enabling, disabling, and triggering mainly. The situation is described in the following figure:



RPMsg-Lite core sub-component This subcomponent implements a blocking send API and callback-based receive API. The RPMsg protocol is part of the transport layer. This is realized by using so-called endpoints. Each endpoint can be assigned a different receive callback function.

However, it is important to notice that the callback is executed in an interrupt environment in current design. Therefore, certain actions like memory allocation are discouraged to execute in the callback. The following figure shows the role of RPMsg in an ISO/OSI-like layered model:



Queue sub-component (optional) This subcomponent is optional and requires implementation of the `env_*_queue()` functions in the environment porting layer. It uses a blocking receive API, which is common in RTOS-environments. It supports both copy and nocopy blocking receive functions.

Name Service sub-component (optional) This subcomponent is a minimum implementation of the name service which is present in the Linux Kernel implementation of RPMsg. It allows the communicating node both to send announcements about “named” endpoint (in other words, channel) creation or deletion and to receive these announcement taking any user-defined action in an application callback. The endpoint address used to receive name service announcements is arbitrarily fixed to be 53 (0x35).

Usage The application should put the `/rpmmsg_lite/lib/include` directory to the include path and in the application, include either the `rpmmsg_lite.h` header file, or optionally also include the `rpmmsg_queue.h` and/or `rpmmsg_ns.h` files. Both porting sublayers should be provided for you by NXP, but if you plan to use your own RTOS, all you need to do is to implement your own environment layer (in other words, `rpmmsg_env_myrtos.c`) and to include it in the project build.

The initialization of the stack is done by calling the `rpmmsg_lite_master_init()` on the master side and the `rpmmsg_lite_remote_init()` on the remote side. This initialization function must be called prior to any RPMsg-Lite API call. After the init, it is wise to create a communication endpoint, otherwise communication is not possible. This can be done by calling the `rpmmsg_lite_create_ept()` function. It optionally accepts a last argument, where an internal context of the endpoint is created, just in case the `RL_USE_STATIC_API` option is set to 1. If not, the stack internally calls `env_alloc()` to allocate dynamic memory for it. In case a callback-based receiving is to be used, an ISR-callback is registered to each new endpoint with user-defined callback data pointer. If a blocking receive is desired (in case of RTOS environment), the `rpmmsg_queue_create()` function must be called before calling `rpmmsg_lite_create_ept()`. The queue handle is passed to the endpoint creation function as a callback data argument and the callback function is set to `rpmmsg_queue_rx_cb()`. Then, it is possible to use `rpmmsg_queue_receive()` function to listen on a queue object for incoming messages. The `rpmmsg_lite_send()` function is used to send messages to the other side.

The RPMsg-Lite also implements no-copy mechanisms for both sending and receiving operations. These methods require specifics that have to be considered when used in an application.

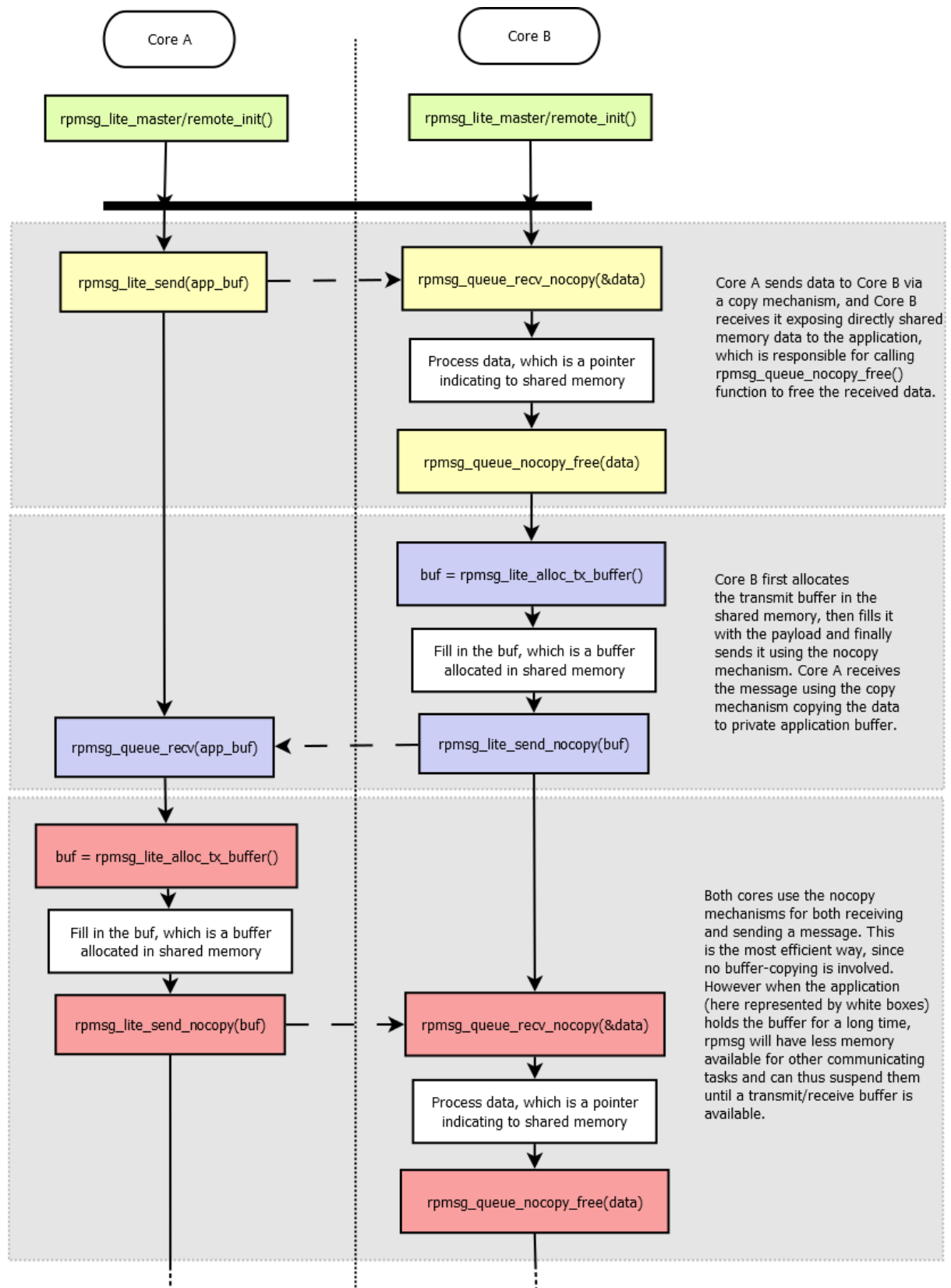
no-copy-send mechanism: This mechanism allows sending messages without the cost for copying data from the application buffer to the RPMsg/virtio buffer in the shared memory. The sequence of no-copy sending steps to be performed is as follows:

- Call the `rpmmsg_lite_alloc_tx_buffer()` function to get the virtio buffer and provide the buffer pointer to the application.
- Fill the data to be sent into the pre-allocated virtio buffer. Ensure that the filled data does not exceed the buffer size (provided as the `rpmmsg_lite_alloc_tx_buffer()` size output parameter).
- Call the `rpmmsg_lite_send_nocopy()` function to send the message to the destination endpoint. Consider the cache functionality and the virtio buffer alignment. See the `rpmmsg_lite_send_nocopy()` function description below.

no-copy-receive mechanism: This mechanism allows reading messages without the cost for copying data from the virtio buffer in the shared memory to the application buffer. The sequence of no-copy receiving steps to be performed is as follows:

- Call the `rpmmsg_queue_rcv_nocopy()` function to get the virtio buffer pointer to the received data.
- Read received data directly from the shared memory.
- Call the `rpmmsg_queue_nocopy_free()` function to release the virtio buffer and to make it available for the next data transfer.

The user is responsible for destroying any RPMsg-Lite objects he has created in case of deinitialization. In order to do this, the function `rpmmsg_queue_destroy()` is used to destroy a queue, `rpmmsg_lite_destroy_ept()` is used to destroy an endpoint and finally, `rpmmsg_lite_deinit()` is used to deinitialize the RPMsg-Lite intercore communication stack. Deinitialize all endpoints using a queue before deinitializing the queue. Otherwise, you are actively invalidating the used queue handle, which is not allowed. RPMsg-Lite does not check this internally, since its main aim is to be lightweight.



Examples RPMsg_Lite multicore examples are part of NXP MCUXpressoSDK packages. Visit <https://mcuxpresso.nxp.com> to configure, build and download these packages. To get the board list with multicore support (RPMsg_Lite included) use filtering based on Middleware and search for 'multicore' string. Once the selected package with the multicore middleware is downloaded,

see

<MCUXpressoSDK_install_dir>/boards/<board_name>/multicore_examples for RPMMsg_Lite multicore examples with 'rpmmsg_lite_' name prefix.

Another way of getting NXP MCUXpressoSDK RPMMsg_Lite multicore examples is using the [mcuxsdk-manifests](#) Github repo. Follow the description how to use the West tool to clone and update the mcuxsdk-manifests repo in [readme section](#). Once done the armgcc rpmmsg_lite examples can be found in

mcuxsdk/examples/_<board_name>/multicore_examples

You can use the evkmimxrt1170 as the board_name for instance. Similar to MCUXpressoSDK packages the RPMMsg_Lite examples use the 'rpmmsg_lite_' name prefix.

Notes

Environment layers implementation Several environment layers are provided in lib/rpmmsg_lite/porting/environment folder. Not all of them are fully tested however. Here is the list of environment layers that passed testing:

- rpmmsg_env_bm.c
- rpmmsg_env_freertos.c
- rpmmsg_env_xos.c
- rpmmsg_env_threadx.c

The rest of environment layers has been created and used in some experimental projects, it has been running well at the time of creation but due to the lack of unit testing there is no guarantee it is still fully functional.

Shared memory configuration It is important to correctly initialize/configure the shared memory for data exchange in the application. The shared memory must be accessible from both the master and the remote core and it needs to be configured as Non-Cacheable memory. Dedicated shared memory section in linker file is also a good practise, it is recommended to use linker files from MCUXpressoSDK packages for NXP devices based applications. It needs to be ensured no other application part/component is unintentionally accessing this part of memory.

Configuration options The RPMMsg-Lite can be configured at the compile time. The default configuration is defined in the rpmmsg_default_config.h header file. This configuration can be customized by the user by including rpmmsg_config.h file with custom settings. The following table summarizes all possible RPMMsg-Lite configuration options.

Config- uration option	De- fault value	Usage
RL_MS_PE (1)		Delay in milliseconds used in non-blocking API functions for polling.
RL_BUFEE (496)		Size of the buffer payload, it must be more than 1 byte, and has to be word align (including rpmsg header size 16 bytes), if not it will be aligned up
RL_BUFEE (2)		Number of the buffers, it must be power of two (2, 4, ...)
RL_API_H (1)		Zero-copy API functions enabled/disabled.
RL_USE_S' (0)		Static API functions (no dynamic allocation) enabled/disabled.
RL_USE_D (0)		Memory cache management of shared memory. Use in case of data cache is enabled for shared memory.
RL_CLEAF (0)		Clearing used buffers before returning back to the pool of free buffers enabled/disabled.
RL_USE_M (0)		When enabled IPC interrupts are managed by the Multicore Manager (IPC interrupts router), when disabled RPMsg-Lite manages IPC interrupts by itself.
RL_USE_E (0)		When enabled the environment layer uses its own context. Required for some environments (QNX). The default value is 0 (no context, saves some RAM).
RL_DEBU (0)		When enabled buffer pointers passed to <code>rpmsg_lite_send_nocopy()</code> and <code>rpmsg_lite_release_rx_buffer()</code> functions (enabled by <code>RL_API_HAS_ZEROCOPY</code> config) are checked to avoid passing invalid buffer pointer. The default value is 0 (disabled). Do not use in RPMsg-Lite to Linux configuration.
RL_ALLOV (0)		When enabled the opposite side is notified each time received buffers are consumed and put into the queue of available buffers. Enable this option in RPMsg-Lite to Linux configuration to allow unblocking of the Linux blocking send. The default value is 0 (RPMsg-Lite to RPMsg-Lite communication).
RL_ALLOV (0)		It allows to define custom shared memory configuration and replacing the shared memory related global settings from <code>rpmsg_config.h</code> . This is useful when multiple instances are running in parallel but different shared memory arrangement (vring size & alignment, buffers size & count) is required. The default value is 0 (all RPMsg_Lite instances use the same shared memory arrangement as defined by common config macros).
RL_ASSER	see rpmsg	Assert implementation.

How to format rpmsg-lite code To format code, use the application developed by Google, named *clang-format*. This tool is part of the [llvm](#) project. Currently, the clang-format 10.0.0 version is used for rpmsg-lite. The set of style settings used for clang-format is defined in the `.clang-format` file, placed in a root of the rpmsg-lite directory where Python script `run_clang_format.py` can be executed. This script executes the application named *clang-format.exe*. You need to have the path of this application in the OS's environment path, or you need to change the script.

References

[1] M. Novak, M. Cingel, **Lockless Shared Memory Based Multicore Communication Protocol**
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Changelog RPMSG-Lite All notable changes to this project will be documented in this file. The format is based on [Keep a Changelog](#), and this project adheres to [Semantic Versioning](#).

[v5.3.0]**Added**

- RT700 porting layer added support to send rpmsg messages between CM33_0 <-> Hifi1 and CM33_1 <-> Hifi4 cores.
- Add new platform macro `RL_PLATFORM_MAX_ISR_COUNT` this will set number of IRQ count per platform. This macro is then used in environment layers to set `isr_table` size where irq handles are registered. It size should match the bit length of `VQ_ID` so all combinations can fit into table.
- Unit tests updated to improve code coverage, new unit tests added covering static allocations in rtos environment layers.

Fixed

- `virtio.h` removed `typedef uint8_t boolean` and in its place use standard C99 `bool` type to avoid potential type conflicts.
- `env_acquire_sync_lock()` and `env_release_sync_lock()` synchronization primitives removed
- Kconfig consolidation, when `RL_ALLOW_CUSTOM_SHMEM_CONFIG` enabled the `platform_get_custom_shmem_config()` function needs to be implemented in platform layer to provide custom shared memory configuration for RPMsg-Lite instance.

v5.2.1**Added**

- Doc added RPMSG-Lite VirtIO Overview
- Doc added RPMSG-Lite Design Considerations
- Added `frdmimxrt1186` unit testing

Changed

- Remove limitation that `RL_BUFFER_SIZE` needs to be power of 2. It just has to be more than 16 bytes, e.g. 16 bytes of rpmsg header and payload size at least 1 byte and word aligned, if not it will be aligned up.

Fixed

- Fixed CERT-C INT31-C violation in `platform_notify` function in `rpmsg_platform.c` for `imxrt700_m33`, `imxrt700_hifi4`, `imxrt700_hifi1` platforms

v5.2.0**Added**

- Add MCXL20 porting layer and unit testing
- New utility macro `RL_CALCULATE_BUFFER_COUNT_DOWN_SAFE` to safely determine maximum buffer count within shared memory while preventing integer underflow.
- RT700 platform add support for MCMGR in DSPs

Changed

- Change `rpmsg_platform.c` to support new MCMGR API
- Improved input validation in initialization functions to properly handle insufficient memory size conditions.
- Refactored repeated buffer count calculation pattern for better code maintainability.
- To make sure that remote has already registered IRQ there is required App level IPC mechanism to notify master about it

Fixed

- Fixed `env_wait_for_link_up` function to handle timeout in link state checks for baremetal and qnx environment, `RL_BLOCK` mode can be used to wait indefinitely.
- Fixed CERT-C INT31-C violation by adding compile-time check to ensure `RL_PLATFORM_HIGHEST_LINK_ID` remains within safe range for 16-bit casting in virtqueue ID creation.
- Fixed CERT-C INT30-C violations by adding protection against unsigned integer underflow in shared memory calculations, specifically in `shmem_length - (uint32_t)RL_VRING_OVERHEAD` and `shmem_length - 2U * shmem_config.vring_size` expressions.
- Fixed CERT INT31-C violation in `platform_interrupt_disable()` and similar functions by replacing unsafe cast from `uint32_t` to `int32_t` with a return of 0 constant.
- Fixed unsigned integer underflow in `rpmsg_lite_alloc_tx_buffer()` where subtracting header size from buffer size could wrap around if buffer was too small, potentially leading to incorrect buffer sizing.
- Fixed CERT-C INT31-C violation in `rpmsg_lite.c` where `size` parameter was cast from `uint32_t` to `uint16_t` without proper validation.
 - Applied consistent masking approach to both `size` and `flags` parameters: `(uint16_t)(value & 0xFFFFU)`.
 - This fix prevents potential data loss when `size` values exceed 65535.
- Fixed CERT INT31-C violation in `env_memset` functions by explicitly converting `int32_t` values to unsigned char using bit masking. This prevents potential data loss or misinterpretation when passing values outside the unsigned char range (0-255) to the standard `memset()` function.
- Fixed CERT-C INT31-C violations in RPMsg-Lite environment porting: Added validation checks for signed-to-unsigned integer conversions to prevent data loss and misinterpretation.
 - `rpmsg_env_freertos.c`: Added validation before converting `int32_t` to `UBaseType_t`.
 - `rpmsg_env_qnx.c`: Fixed format string and added validation before assigning to `mqstat` fields.
 - `rpmsg_env_threadx.c`: Added validation to prevent integer overflow and negative values.
 - `rpmsg_env_xos.c`: Added range checking before casting to `uint16_t`.
 - `rpmsg_env_zephyr.c`: Added validation before passing values to `k_msgq_init`.
- Fixed a CERT INT31-C compliance issue in `env_get_current_queue_size()` function where an unsigned queue count was cast to a signed `int32_t` without proper validation, which could lead to lost or misinterpreted data if queue size exceeded `INT32_MAX`.
- Fixed CERT INT31-C violation in `rpmsg_platform.c` where `memcmp()` return value (signed int) was compared with unsigned constant without proper type handling.

- Fixed CERT INT31-C violation in `rpmsg_platform.c` where casting from `uint32_t` to `uint16_t` could potentially result in data loss. Changed length variable type from `uint16_t` to `uint32_t` to properly handle memory address differences without truncation.
- Fixed potential integer overflow in `env_sleep_msec()` function in ThreadX environment implementation by rearranging calculation order in the sleep duration formula.
- Fixed CERT-C INT31-C violation in RPMsg-Lite where bitwise NOT operations on integer constants were performed in signed integer context before being cast to unsigned. This could potentially lead to misinterpreted data on `imx943` platform.
- Added `RL_MAX_BUFFER_COUNT` (32768U) and `RL_MAX_VRING_ALIGN` (65536U) limit to ensure alignment values cannot contribute to integer overflow
- Fixed CERT INT31-C violation in `vring_need_event()`, added cast to `uint16_t` for each operand.

v5.1.4 - 27-Mar-2025

Added

- Add KW43B43 porting layer

Changed

- Doxygen bump to version 1.9.6

v5.1.3 - 13-Jan-2025

Added

- Memory cache management of shared memory. Enable with `#define RL_USE_DCACHE (1)` in `rpmsg_config.h` in case of data cache is used.
- Cmake/Kconfig support added.
- Porting layers for `imx95`, `imxrt700`, `mcmxw71x`, `mcmxw72x`, `kw47b42` added.

v5.1.2 - 08-Jul-2024

Changed

- Zephyr-related changes.
- Minor Misra corrections.

v5.1.1 - 19-Jan-2024

Added

- Test suite provided.
- Zephyr support added.

Changed

- Minor changes in platform and env. layers, minor test code updates.

v5.1.0 - 02-Aug-2023

Added

- RPMMsg-Lite: Added aarch64 support.

Changed

- RPMMsg-Lite: Increased the queue size to (2 * RL_BUFFER_COUNT) to cover zero copy cases.
- Code formatting using LLVM16.

Fixed

- Resolved issues in ThreadX env. layer implementation.

v5.0.0 - 19-Jan-2023

Added

- Timeout parameter added to `rpmmsg_lite_wait_for_link_up` API function.

Changed

- Improved debug check buffers implementation - instead of checking the pointer fits into shared memory check the presence in the VirtIO ring descriptors list.
- VRING_SIZE is set based on number of used buffers now (as calculated in `vring_init`) - updated for all platforms that are not communicating to Linux rpmmsg counterpart.

Fixed

- Fixed wrong RL_VRING_OVERHEAD macro comment in platform.h files
- Misra corrections.

v4.0.0 - 20-Jun-2022

Added

- Added support for custom shared memory arrangement per the RPMMsg_Lite instance.
- Introduced new `rpmmsg_lite_wait_for_link_up()` API function - this allows to avoid using busy loops in rtos environments, GitHub PR [#21](#).

Changed

- Adjusted `rpmmsg_lite_is_link_up()` to return RL_TRUE/RL_FALSE.

v3.2.0 - 17-Jan-2022**Added**

- Added support for i.MX8 MP multicore platform.

Changed

- Improved static allocations - allow OS-specific objects being allocated statically, GitHub PR [#14](#).
- Aligned rpmsg_env_xos.c and some platform layers to latest static allocation support.

Fixed

- Minor Misra and typo corrections, GitHub PR [#19](#), [#20](#).

v3.1.2 - 16-Jul-2021**Added**

- Addressed MISRA 21.6 rule violation in rpmsg_env.h (use SDK's PRINTF in MCUXpressoSDK examples, otherwise stdio printf is used).
- Added environment layers for XOS.
- Added support for i.MX RT500, i.MX RT1160 and i.MX RT1170 multicore platforms.

Fixed

- Fixed incorrect description of the rpmsg_lite_get_endpoint_from_addr function.

Changed

- Updated RL_BUFFER_COUNT documentation (issue [#10](#)).
- Updated imxrt600_hifi4 platform layer.

v3.1.1 - 15-Jan-2021**Added**

- Introduced RL_ALLOW_CONSUMED_BUFFERS_NOTIFICATION config option to allow opposite side notification sending each time received buffers are consumed and put into the queue of available buffers.
- Added environment layers for Threadx.
- Added support for i.MX8QM multicore platform.

Changed

- Several MISRA C-2012 violations addressed.

v3.1.0 - 22-Jul-2020

Added

- Added support for several new multicore platforms.

Fixed

- MISRA C-2012 violations fixed (7.4).
- Fixed missing lock in `rpmsg_lite_rx_callback()` for QNX env.
- Correction of `rpmsg_lite_instance` structure members description.
- Address -Waddress-of-packed-member warnings in GCC9.

Changed

- Clang update to v10.0.0, code re-formatted.

v3.0.0 - 20-Dec-2019

Added

- Added support for several new multicore platforms.

Fixed

- MISRA C-2012 violations fixed, incl. data types consolidation.
- Code formatted.

v2.2.0 - 20-Mar-2019

Added

- Added configuration macro `RL_DEBUG_CHECK_BUFFERS`.
- Several MISRA violations fixed.
- Added environment layers for QNX and Zephyr.
- Allow environment context required for some environment (controlled by the `RL_USE_ENVIRONMENT_CONTEXT` configuration macro).
- Data types consolidation.

v1.1.0 - 28-Apr-2017

Added

- Supporting i.MX6SX and i.MX7D MPU platforms.
- Supporting LPC5411x MCU platform.
- Baremetal and FreeRTOS support.
- Support of copy and zero-copy transfer.
- Support of static API (without dynamic allocations).

Multicore Manager

MCUXpresso SDK : mcuxsdk-middleware-mcmgr (Multicore Manager)

Overview This repository is for MCUXpresso SDK Multicore Manager middleware delivery and it contains Multicore Manager component officially provided in NXP MCUXpresso SDK. This repository is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository [mcuxsdk](#) for the complete delivery of MCUXpresso SDK to be able to build and run Multicore Manager examples that are based on mcux-sdk-middleware-mcmgr component.

Documentation Overall details can be reviewed here: [MCUXpresso SDK Online Documentation](#)

Visit [Multicore Manager - Documentation](#) to review details on the contents in this sub-repo.

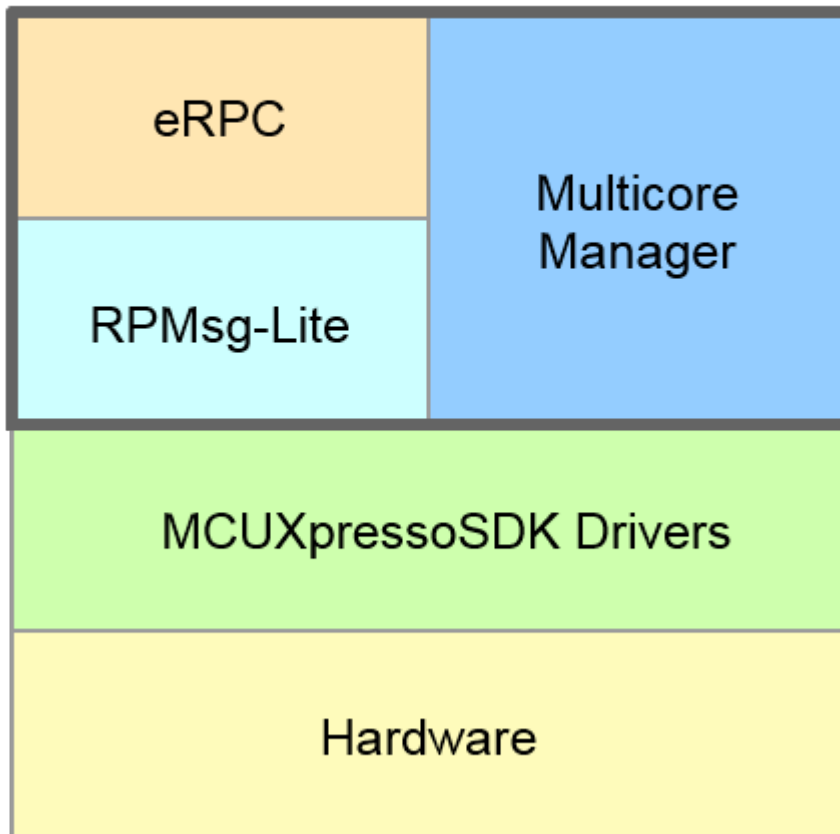
For Further API documentation, please look at [doxygen documentation](#)

Setup Instructions on how to install the MCUXpresso SDK provided from GitHub via west manifest [Getting Started with SDK - Detailed Installation Instructions](#)

Contribution We welcome and encourage the community to submit patches directly to the mcmgr project placed on github. Contributing can be managed via pull-requests. Before a pull-request is created the code should be tested and properly formatted.

Multicore Manager (MCMGR) The Multicore Manager (MCMGR) software library provides a number of services for multicore systems. This library is distributed as a part of the Multicore SDK (MCSDK). Together, the MCSDK and the MCUXpresso SDK (SDK) form a framework for development of software for NXP multicore devices.

The MCMGR component is located in the <MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr directory.



The Multicore Manager provides the following major functions:

- Maintains information about all cores in system.
- Secondary/auxiliary core(s) startup and shutdown.
- Remote core monitoring and event handling.

Usage of the MCMGR software component The main use case of MCMGR is the secondary/auxiliary core start. This functionality is performed by the public API function.

Example of MCMGR usage to start secondary core:

```
#include "mcmgr.h"

void main()
{
    /* Initialize MCMGR - low level multicore management library.
       Call this function as close to the reset entry as possible,
       (into the startup sequence) to allow CoreUp event triggering. */
    MCMGR_EarlyInit();

    /* Initialize MCMGR, install generic event handlers */
    MCMGR_Init();
}
```

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```

/* Boot secondary core application from the CORE1_BOOT_ADDRESS, pass "1" as startup data,
↳ starting synchronously. */
MCMGR_StartCore(kMCMGR_Core1, CORE1_BOOT_ADDRESS, 1, kMCMGR_Start_Synchronous);
.
.
.
/* Stop secondary core execution. */
MCMGR_StopCore(kMCMGR_Core1);
}

```

Some platforms allow stopping and re-starting the secondary core application again, using the MCMGR_StopCore / MCMGR_StartCore API calls. It is necessary to ensure the initially loaded image is not corrupted before re-starting, especially if it deals with the RAM target. Cache coherence has to be considered/ensured as well.

It could also happen that the secondary core application stops running correctly and the primary core application does not know about that situation. Therefore, it is beneficial to implement a mechanism for core health monitoring. The *test_heartbeat* unit test can serve as an example how to ensure that: secondary core could periodically send heartbeat signals to the primary core using MCMGR_TriggerEvent() API to indicate that it is alive and functioning properly.

Another important MCMGR feature is the ability for remote core monitoring and handling of events such as reset, exception, and application events. Application-specific callback functions for events are registered by the MCMGR_RegisterEvent() API. Triggering these events is done using the MCMGR_TriggerEvent() API. mcmgr_event_type_t enums all possible event types.

An example of MCMGR usage for remote core monitoring and event handling. Code for the primary side:

```

#include "mcmgr.h"

#define APP_RPMSG_READY_EVENT_DATA (1)
#define APP_NUMBER_OF_CORES (2)
#define APP_SECONDARY_CORE kMCMGR_Core1

/* Callback function registered via the MCMGR_RegisterEvent() and triggered by MCMGR_TriggerEvent()
↳ called on the secondary core side */
void RPSMsgRemoteReadyEventHandler(mcmgr_core_t coreNum, uint16_t eventData, void *context)
{
    uint16_t *data = &((uint16_t *)context)[coreNum];

    *data = eventData;
}

void main()
{
    uint16_t RPSMsgRemoteReadyEventData[NUMBER_OF_CORES] = {0};

    /* Initialize MCMGR - low level multicore management library.
       Call this function as close to the reset entry as possible,
       (into the startup sequence) to allow CoreUp event triggering. */
    MCMGR_EarlyInit();

    /* Initialize MCMGR, install generic event handlers */
    MCMGR_Init();

    /* Register the application event before starting the secondary core */
    MCMGR_RegisterEvent(kMCMGR_RemoteApplicationEvent, RPSMsgRemoteReadyEventHandler, (void
↳ *)RPSMsgRemoteReadyEventData);

```

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```
/* Boot secondary core application from the CORE1_BOOT_ADDRESS, pass rpmsg_lite_base address,
↳as startup data, starting synchronously. */
MCMGR_StartCore(APP_SECONDARY_CORE, CORE1_BOOT_ADDRESS, (uint32_t)rpmsg_lite_
↳base, kMCMGR_Start_Synchronous);

/* Wait until the secondary core application signals the rpmsg remote has been initialized and is ready to
↳communicate. */
while(APP_RPMSG_READY_EVENT_DATA != RPSMsgRemoteReadyEventData[APP_SECONDARY_
↳CORE]) {};
.
.
.
}
```

Code for the secondary side:

```
#include "mcmgr.h"

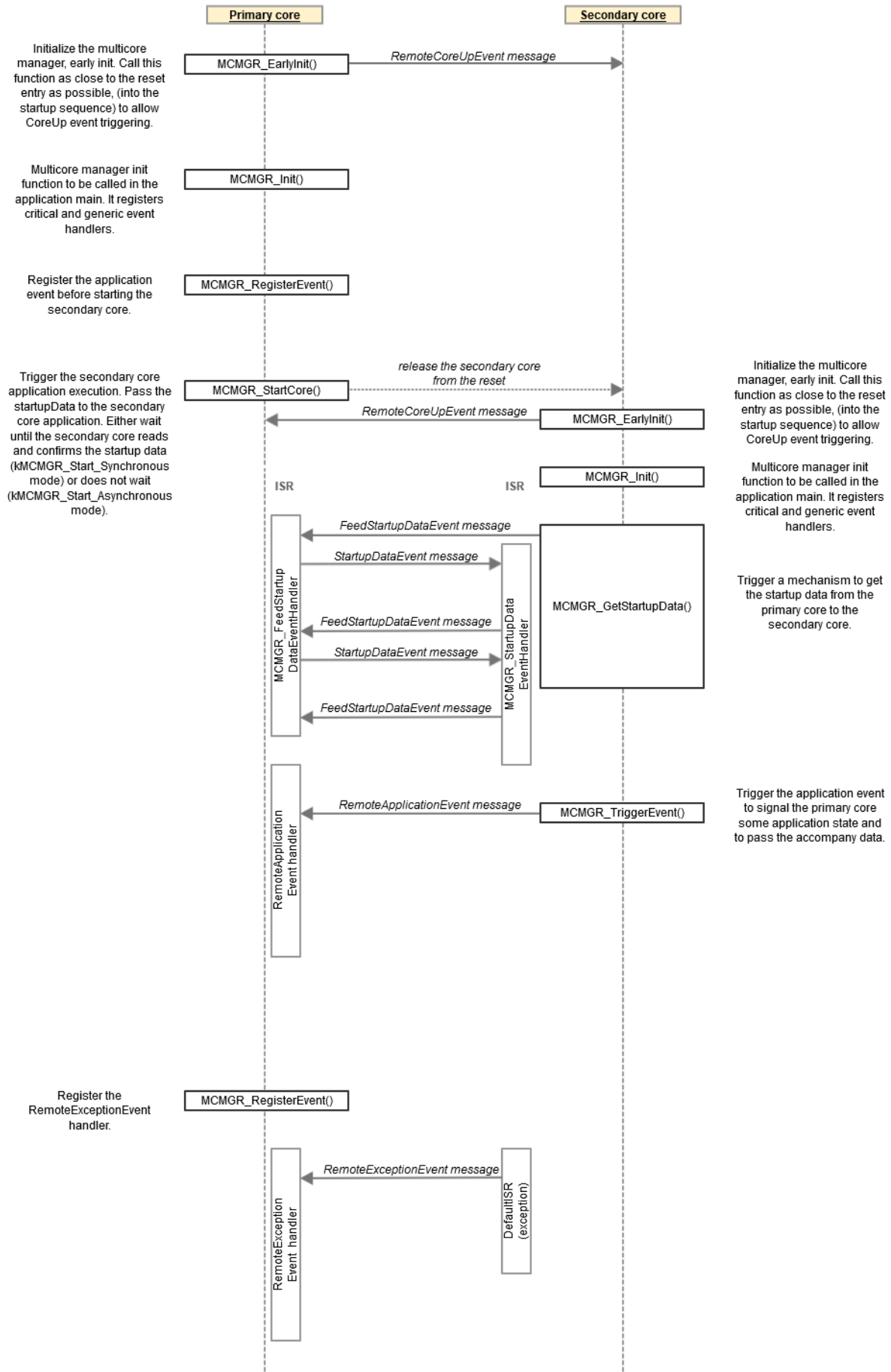
#define APP_RPMSG_READY_EVENT_DATA (1)

void main()
{
    /* Initialize MCMGR - low level multicore management library.
       Call this function as close to the reset entry as possible,
       (into the startup sequence) to allow CoreUp event triggering. */
    MCMGR_EarlyInit();

    /* Initialize MCMGR, install generic event handlers */
    MCMGR_Init();
    .
    .
    .

    /* Signal the to other core that we are ready by triggering the event and passing the APP_RPMSG_
    ↳READY_EVENT_DATA */
    MCMGR_TriggerEvent(kMCMGR_Core0, kMCMGR_RemoteApplicationEvent, APP_RPMSG_
    ↳READY_EVENT_DATA);
    .
    .
    .
}
```

MCMGR Data Exchange Diagram The following picture shows how the handshakes are supposed to work between the two cores in the MCMGR software.



Changelog Multicore Manager All notable changes to this project will be documented in this file.

The format is based on [Keep a Changelog](#), and this project adheres to [Semantic Versioning](#).

[v5.0.2]

Added

- Added gcov options and configs to support mcmgr code coverage
- Added new test_weak_mu_isr testcase for devices with MU peripheral
- Added new test_heartbeat testcase showing heartbeat mechanism between primary and secondary cores using the MCMGR

v5.0.1

Added

- Added frdmimxrt1186 unit testing

Changed

- [KW43] Rename core#1 reset control register

Fixed

- Added CX flag into CMakeLists.txt to allow c++ build compatibility.
- Fix path to mcmgr headers directory in doxyfile

v5.0.0

Added

- Added MCMGR_BUSY_POLL_COUNT macro to prevent infinite polling loops in MCMGR operations.
- Implemented timeout mechanism for all polling loops in MCMGR code.
- Added support to handle more then two cores. Breaking API change by adding parameter coreNum specifying core number in functions bellow.
 - MCMGR_GetStartupData(uint32_t *startupData, mcmgr_core_t coreNum)
 - MCMGR_TriggerEvent(mcmgr_event_type_t type, uint16_t eventData, mcmgr_core_t coreNum)
 - MCMGR_TriggerEventForce(mcmgr_event_type_t type, uint16_t eventData, mcmgr_core_t coreNum)
 - typedef void (*mcmgr_event_callback_t)(uint16_t data, void *context, mcmgr_core_t coreNum);

When registering the event with function `MCMGR_RegisterEvent()` user now needs to provide `callbackData` pointer to array of elements per every core in system (see README.md for example). In case of systems with only two cores the `coreNum` in callback can be ignored as events can arrive only from one core. Please see Porting guide for more details: `Porting-GuideTo_v5.md`

- Updated all porting files to support new MCMGR API.
- Added new platform specific include file `mcmgr_platform.h`. It will contain common platform specific macros that can be then used in `mcmgr` and application. e.g. platform core count `MCMGR_CORECOUNT` 4.
- Move all header files to new `inc` directory.
- Added new platform-specific include files `inc/platform/<platform_name>/mcmgr_platform.h`.

Added

- Add MCXL20 porting layer and unit testing

v4.1.7

Fixed

- `mcmgr_stop_core_internal()` function now returns `kStatus_MCMGR_NotImplemented` status code instead of `kStatus_MCMGR_Success` when device does not support stop of secondary core. Ports affected: `kw32w1`, `kw45b41`, `kw45b42`, `mcxw716`, `mcxw727`.

[v4.1.6]

Added

- Multicore Manager moved to standalone repository.
- Add porting layers for `imxrt700`, `mcmxw727`, `kw47b42`.
- New `MCMGR_ProcessDeferredRxIsr()` API added.

[v4.1.5]

Added

- Add notification into `MCMGR_EarlyInit` and `mcmgr_early_init_internal` functions to avoid using uninitialized data in their implementations.

[v4.1.4]

Fixed

- Avoid calling tx isr callbacks when respective Messaging Unit Transmit Interrupt Enable flag is not set in the CR/TCR register.
- Messaging Unit RX and status registers are cleared after the initialization.

[v4.1.3]

Added

- Add porting layers for imxrt1180.

Fixed

- mu_isr() updated to avoid calling tx isr callbacks when respective Transmit Interrupt Enable flag is not set in the CR/TCR register.
- mcmgr_mu_internal.c code adaptation to new supported SoCs.

[v4.1.2]

Fixed

- Update mcmgr_stop_core_internal() implementations to set core state to kMCMGR_ResetCoreState.

[v4.1.0]

Fixed

- Code adjustments to address MISRA C-2012 Rules

[v4.0.3]

Fixed

- Documentation updated to describe handshaking in a graphic form.
- Minor code adjustments based on static analysis tool findings

[v4.0.2]

Fixed

- Align porting layers to the updated MCUXpressoSDK feature files.

[v4.0.1]

Fixed

- Code formatting, removed unused code

[v4.0.0]

Added

- Add new MCMGR_TriggerEventForce() API.

[v3.0.0]

Removed

- Removed MCMGR_LoadApp(), MCMGR_MapAddress() and MCMGR_SignalReady()

Modified

- Modified MCMGR_GetStartupData()

Added

- Added MCMGR_EarlyInit(), MCMGR_RegisterEvent() and MCMGR_TriggerEvent()
- Added the ability for remote core monitoring and event handling

[v2.0.1]

Fixed

- Updated to be Misra compliant.

[v2.0.0]

Added

- Support for lpcxpresso54114 board.

[v1.1.0]

Fixed

- Ported to KSDK 2.0.0.

[v1.0.0]

Added

- Initial release.

eRPC

MCUXpresso SDK : mcuxsdk-middleware-erpc

Overview This repository is for MCUXpresso SDK eRPC middleware delivery and it contains eRPC component officially provided in NXP MCUXpresso SDK. This repository is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository [mcuxsdk](#) for the complete delivery of MCUXpresso SDK to be able to build and run eRPC examples that are based on mcux-sdk-middleware-erpc component.

Documentation Overall details can be reviewed here: [MCUXpresso SDK Online Documentation](#)

Visit [eRPC - Documentation](#) to review details on the contents in this sub-repo.

Setup Instructions on how to install the MCUXpresso SDK provided from GitHub via west manifest [Getting Started with SDK - Detailed Installation Instructions](#)

Contribution We welcome and encourage the community to submit patches directly to the eRPC project placed on github. Contributing can be managed via pull-requests. Before a pull-request is created the code should be tested and properly formatted.

eRPC

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** Installing for Python*

- *Known issues and limitations*
- *Code providing*

About

eRPC (Embedded RPC) is an open source Remote Procedure Call (RPC) system for multichip embedded systems and heterogeneous multicore SoCs.

Unlike other modern RPC systems, such as the excellent [Apache Thrift](#), eRPC distinguishes itself by being designed for tightly coupled systems, using plain C for remote functions, and having a small code size (<5kB). It is not intended for high performance distributed systems over a network.

eRPC does not force upon you any particular API style. It allows you to export existing C functions, without having to change their prototypes. (There are limits, of course.) And although the internal infrastructure is written in C++, most users will be able to use only the simple C setup APIs shown in the examples below.

A code generator tool called `erpcgen` is included. It accepts input IDL files, having an `.erpc` extension, that have definitions of your data types and remote interfaces, and generates the shim code that handles serialization and invocation. `erpcgen` can generate either C/C++ or Python code.

Example `.erpc` file:

```
// Define a data type.
enum LEDName { kRed, kGreen, kBlue }

// An interface is a logical grouping of functions.
interface IO {
    // Simple function declaration with an empty reply.
    set_led(LEDName whichLed, bool onOrOff) -> void
}
```

Client side usage:

```
void example_client(void) {
    erpc_transport_t transport;
    erpc_mbf_t message_buffer_factory;
    erpc_client_t client_manager;

    /* Init eRPC client infrastructure */
    transport = erpc_transport_cmsis_uart_init(Driver_USART0);
    message_buffer_factory = erpc_mbf_dynamic_init();
    client_manager = erpc_client_init(transport, message_buffer_factory);

    /* init eRPC client IO service */
    initIO_client(client_manager);

    // Now we can call the remote function to turn on the green LED.
    set_led(kGreen, true);

    /* deinit objects */
    deinitIO_client();
    erpc_client_deinit(client_manager);
    erpc_mbf_dynamic_deinit(message_buffer_factory);
}
```

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```

    erpc_transport_tcp_deinit(transport);
}

void example_client(void) {
    erpc_transport_t transport;
    erpc_mbf_t message_buffer_factory;
    erpc_client_t client_manager;

    /* Init eRPC client infrastructure */
    transport = erpc_transport_cmsis_uart_init(Driver_USART0);
    message_buffer_factory = erpc_mbf_dynamic_init();
    client_manager = erpc_client_init(transport, message_buffer_factory);

    /* scope for client service */
    {
        /* init eRPC client IO service */
        IO_client client(client_manager);

        // Now we can call the remote function to turn on the green LED.
        client.set_led(kGreen, true);
    }

    /* deinit objects */
    erpc_client_deinit(client_manager);
    erpc_mbf_dynamic_deinit(message_buffer_factory);
    erpc_transport_tcp_deinit(transport);
}

```

Server side usage:

```

// Implement the remote function.
void set_led(LEDName whichLed, bool onOrOff) {
    // implementation goes here
}

void example_server(void) {
    erpc_transport_t transport;
    erpc_mbf_t message_buffer_factory;
    erpc_server_t server;
    erpc_service_t service = create_IO_service();

    /* Init eRPC server infrastructure */
    transport = erpc_transport_cmsis_uart_init(Driver_USART0);
    message_buffer_factory = erpc_mbf_dynamic_init();
    server = erpc_server_init(transport, message_buffer_factory);

    /* add custom service implementation to the server */
    erpc_add_service_to_server(server, service);

    // Run the server.
    erpc_server_run();

    /* deinit objects */
    destroy_IO_service(service);
    erpc_server_deinit(server);
    erpc_mbf_dynamic_deinit(message_buffer_factory);
    erpc_transport_tcp_deinit(transport);
}

```

```

// Implement the remote function.
class IO : public IO_interface

```

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```

{
    /* eRPC call definition */
    void set_led(LEDName whichLed, bool onOrOff) override {
        // implementation goes here
    }
}

void example_server(void) {
    erpc_transport_t transport;
    erpc_mbf_t message_buffer_factory;
    erpc_server_t server;
    IO IOImpl;
    IO_service io(&IOImpl);

    /* Init eRPC server infrastructure */
    transport = erpc_transport_cmsis_uart_init(Driver_USART0);
    message_buffer_factory = erpc_mbf_dynamic_init();
    server = erpc_server_init(transport, message_buffer_factory);

    /* add custom service implementation to the server */
    erpc_add_service_to_server(server, &io);

    /* poll for requests */
    erpc_status_t err = server.run();

    /* deinit objects */
    erpc_server_deinit(server);
    erpc_mbf_dynamic_deinit(message_buffer_factory);
    erpc_transport_tcp_deinit(transport);
}

```

A number of transports are supported, and new transport classes are easy to write.

Supported transports can be found in *erpc/erpc_c/transport* folder. E.g:

- CMSIS UART
- NXP Kinetis SPI and DSPI
- POSIX and Windows serial port
- TCP/IP (mostly for testing)
- NXP RPMsg-Lite / RPMsg TTY
- SPIdev Linux
- USB CDC
- NXP Messaging Unit

eRPC is available with an unrestrictive BSD 3-clause license. See the [LICENSE file](#) for the full license text.

Releases [eRPC releases](#)

Edge releases Edge releases can be found on [eRPC CircleCI](#) webpage. Choose build of interest, then platform target and choose ARTIFACTS tab. Here you can find binary application from chosen build.

Documentation Documentation is in the wiki section.

eRPC Infrastructure documentation

Examples Example IDL is available in the *examples/* folder.

Plenty of eRPC multicore and multiprocessor examples can be also found in NXP MCUXpressoSDK packages. Visit <https://mcuxpresso.nxp.com> to configure, build and download these packages.

To get the board list with multicore support (eRPC included) use filtering based on Middleware and search for 'multicore' string. Once the selected package with the multicore middleware is downloaded, see

<MCUXpressoSDK_install_dir>/boards/<board_name>/multicore_examples for eRPC multicore examples (RPMsg_Lite or Messaging Unit transports used) or

<MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples for eRPC multiprocessor examples (UART or SPI transports used).

eRPC examples use the 'erpc_' name prefix.

Another way of getting NXP MCUXpressoSDK eRPC multicore and multiprocessor examples is using the [mcux-sdk](#) Github repo. Follow the description how to use the West tool to clone and update the mcuxsdk repo in [readme Overview section](#). Once done the armgcc eRPC examples can be found in

mcuxsdk/examples/<board_name>/multicore_examples or in

mcuxsdk/examples/<board_name>/multiprocessor_examples folders.

You can use the evkmimxrt1170 as the board_name for instance. Similar to MCUXpressoSDK packages the eRPC examples use the 'erpc_' name prefix.

References This section provides links to interesting erpc-based projects, articles, blogs or guides:

- [erpc \(EmbeddedRPC\) getting started notes](#)
- [ERPC Linux Local Environment Construction and Use](#)
- [The New Wio Terminal eRPC Firmware](#)

Directories *doc* - Documentation.

doxygen - Configuration and support files for running Doxygen over the eRPC C++ infrastructure and erpcgen code.

erpc_c - Holds C/C++ infrastructure for eRPC. This is the code you will include in your application.

erpc_python - Holds Python version of the eRPC infrastructure.

erpcgen - Holds source code for erpcgen and makefiles or project files to build erpcgen on Windows, Linux, and OS X.

erpcsniffer - Holds source code for erpcsniffer application.

examples - Several example IDL files.

mk - Contains common makefiles for building eRPC components.

test - Client/server tests. These tests verify the entire communications path from client to server and back.

utilities - Holds utilities which bring additional benefit to eRPC apps developers.

Building and installing These build instructions apply to host PCs and embedded Linux. For bare metal or RTOS embedded environments, you should copy the *erpc_c* directory into your application sources.

CMake and KConfig build:

It builds a static library of the eRPC C/C++ infrastructure, the `erpcgen` executable, and optionally the unit tests and examples.

CMake is compatible with gcc and clang. On Windows local MingGW downloaded by *script* can be used.

Make build:

It builds a static library of the eRPC C/C++ infrastructure, the `erpcgen` executable, and optionally the unit tests.

The makefiles are compatible with gcc or clang on Linux, OS X, and Cygwin. A Windows build of erpcgen using Visual Studio is also available in the *erpcgen/VisualStudio_v14* directory. There is also an Xcode project file in the *erpcgen* directory, which can be used to build erpcgen for OS X.

Requirements erPC now support building **erpcgen**, **erpc_lib**, **tests** and **C examples** using CMake.

Requirements when using CMake:

- **CMake** (minimal version 3.20.0)
- Generator - **Make, Ninja, ...**
- **C/C++ compiler** - **GCC, CLANG, ...**
- **Binson** - <https://www.gnu.org/software/bison/>
- **Flex** - <https://github.com/westes/flex/>

Requirements when using Make:

- **Make**
- **C/C++ compiler - GCC, CLANG, ...**
- **Binson** - <https://www.gnu.org/software/bison/>
- **Flex** - <https://github.com/westes/flex/>

Windows Related steps to build **erpcgen** using **Visual Studio** are described in `erpcgen/VisualStudio v14/readme erpcgen.txt`.

To install MinGW, Bison, Flex locally on Windows:

```
./install_dependencies.ps1
* ^^^
#### Linux
^^^ bash
./install_dependencies.sh
```

Mandatory for case, when build for different architecture is needed

- gcc-multilib, g++-multilib

Mac OS X

```
./install_dependencies.sh
```

Building

CMake and KConfig eRPC use CMake and KConfig to configure and build eRPC related targets. KConfig can be edited by *prj.conf* or *menuconfig* when building.

Generate project, config and build. In *erpc/* execute:

```
cmake -B ./build # in erpc/build generate cmake project
cmake --build ./build --target menuconfig # Build menuconfig and configure erpcgen, erpc_lib, tests and
↳examples
cmake --build ./build # Build all selected target from prj.conf/menuconfig
```

****CMake will use the system's default compilers and generator**

If you want to use Windows and locally installed MinGW, use *CMake preset* :

```
cmake --preset mingw64 # Generate project in ./build using mingw64's make and compilers
cmake --build ./build --target menuconfig # Build menuconfig and configure erpcgen, erpc_lib, tests and
↳examples
cmake --build ./build # Build all selected target from prj.conf/menuconfig
```

Make To build the library and erpcgen, run from the repo root directory:

```
make
```

To install the library, erpcgen, and include files, run:

```
make install
```

You may need to `sudo` the `make install`.

By default this will install into `/usr/local`. If you want to install elsewhere, set the `PREFIX` environment variable. Example for installing into `/opt`:

```
make install PREFIX=/opt
```

List of top level Makefile targets:

- `erpc`: build the `liberpc.a` static library
- `erpcgen`: build the `erpcgen` tool
- `erpcsniffer`: build the sniffer tool
- `test`: build the unit tests under the *test* directory
- `all`: build all of the above
- `install`: install `liberpc.a`, `erpcgen`, and include files

eRPC code is validated with respect to the C++ 11 standard.

Installing for Python To install the Python infrastructure for eRPC see instructions in the *erpc python readme*.

Known issues and limitations

- Static allocations controlled by the `ERPC_ALLOCATION_POLICY` config macro are not fully supported yet, i.e. not all erpc objects can be allocated statically now. It deals with the ongoing process and the full static allocations support will be added in the future.

Code providing Repository on Github contains two main branches: **main** and **develop**. Code is developed on **develop** branch. Release version is created via merging **develop** branch into **main** branch.

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eRPC Getting Started

Overview This *Getting Started User Guide* shows software developers how to use Remote Procedure Calls (RPC) in embedded multicore microcontrollers (eRPC).

The eRPC documentation is located in the `<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/doc` folder.

Create an eRPC application This section describes a generic way to create a client/server eRPC application:

1. **Design the eRPC application:** Decide which data types are sent between applications, and define functions that send/receive this data.
2. **Create the IDL file:** The IDL file contains information about data types and functions used in an eRPC application, and is written in the IDL language.
3. **Use the eRPC generator tool:** This tool takes an IDL file and generates the shim code for the client and the server-side applications.
4. **Create an eRPC application:**
 1. Create two projects, where one project is for the client side (primary core) and the other project is for the server side (secondary core).
 2. Add generated files for the client application to the client project, and add generated files for the server application to the server project.
 3. Add infrastructure files.
 4. Add user code for client and server applications.
 5. Set the client and server project options.
5. **Run the eRPC application:** Run both the server and the client applications. Make sure that the server has been run before the client request was sent.

A specific example follows in the next section.

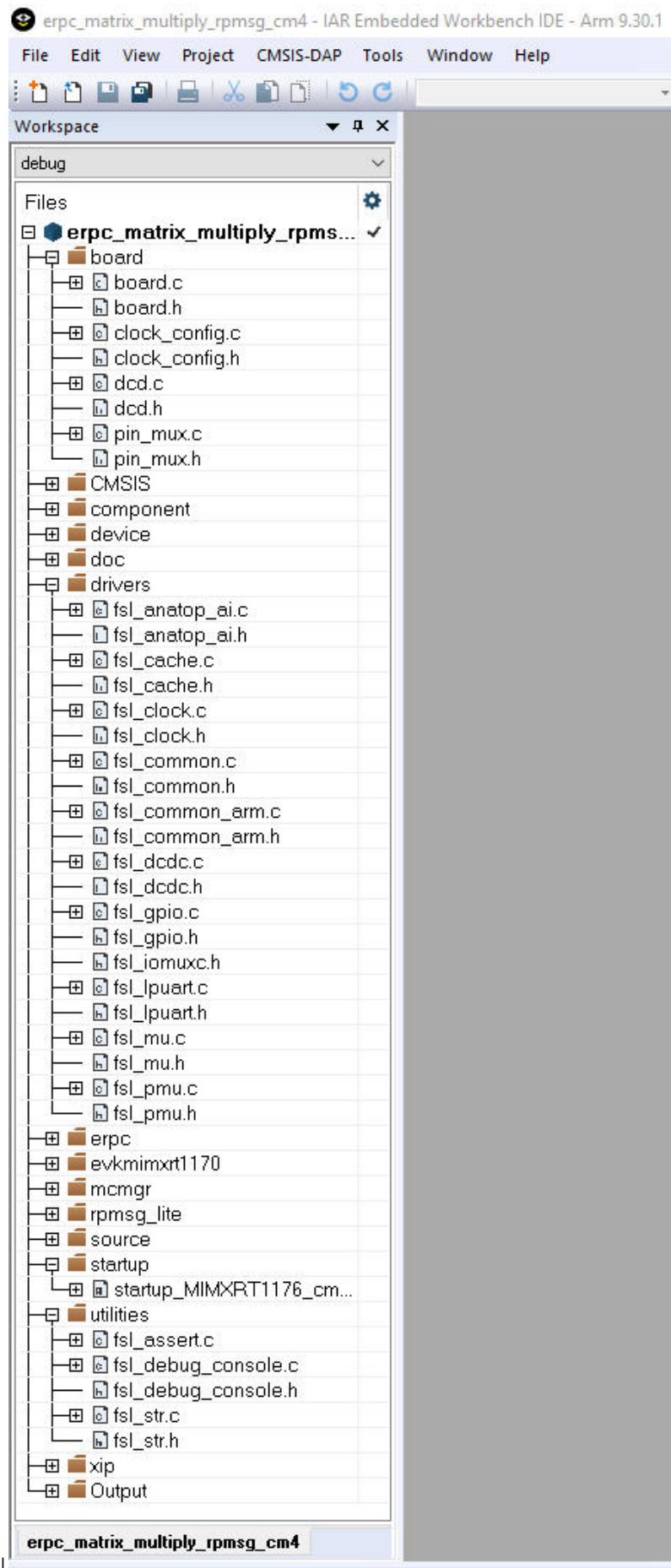
Multicore server application The “Matrix multiply” eRPC server project is located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg/cm4/iar`

The project files for the eRPC server have the `_cm4` suffix.

Server project basic source files The startup files, board-related settings, peripheral drivers, and utilities belong to the basic project source files and form the skeleton of all MCUXpresso SDK applications. These source files are located in:

- `<MCUXpressoSDK_install_dir>/devices/<device>`
- `<MCUXpressoSDK_install_dir>/boards/<board_name>/multicore_examples/<example_name>/`



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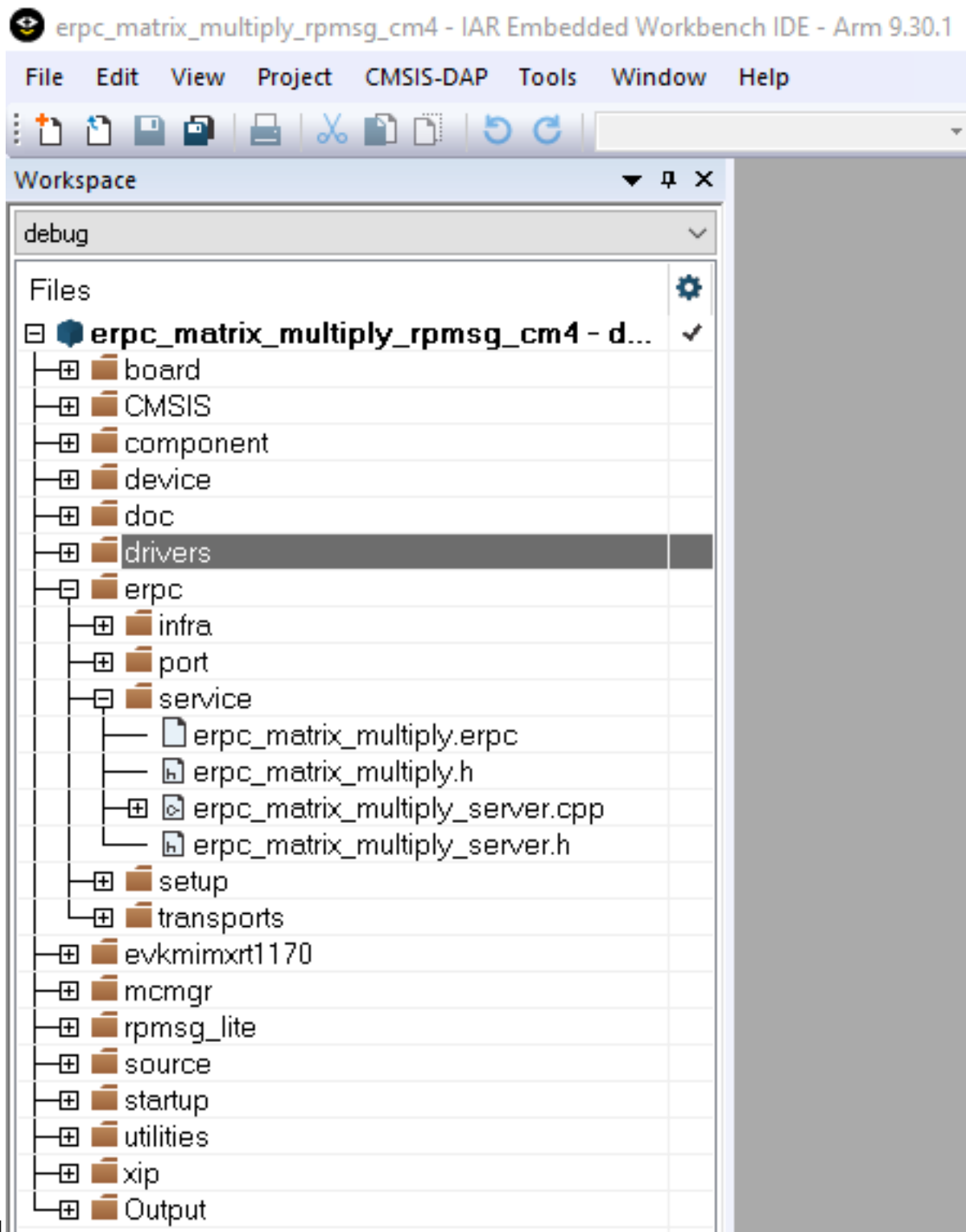
Parent topic:Multicore server application

Server related generated files The server-related generated files are:

- erpc__matric__multiply.h
- erpc__matrix__multiply__server.h
- erpc__matrix__multiply__server.cpp

The server-related generated files contain the shim code for functions and data types declared in the IDL file. These files also contain functions for the identification of client requested functions, data deserialization, calling requested function's implementations, and data serialization and return, if requested by the client. These shim code files can be found in the following folder:

<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/



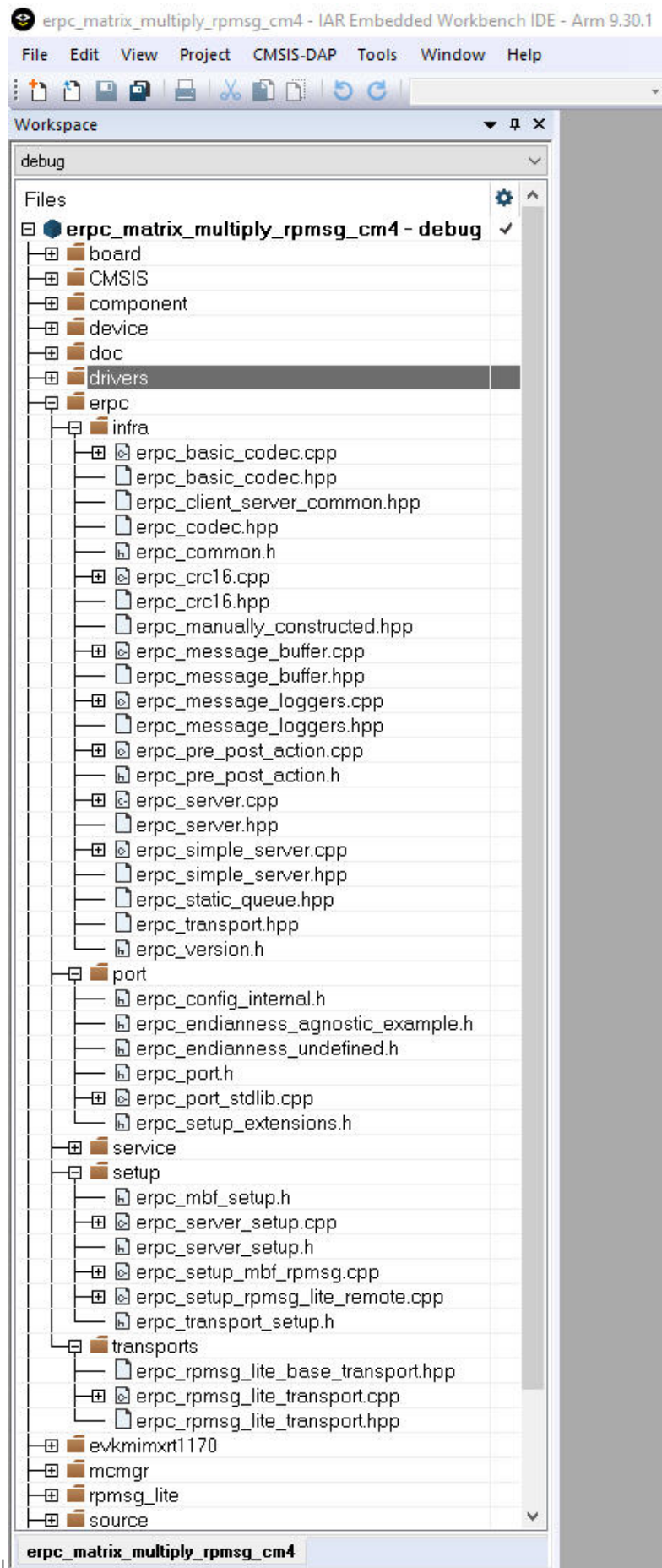
Parent topic: Multicore server application

Server infrastructure files The eRPC infrastructure files are located in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/erpc_c`

The **erpc_c** folder contains files for creating eRPC client and server applications in the C/C++ language. These files are distributed into subfolders.

- The **infra** subfolder contains C++ infrastructure code used to build server and client applications.
 - Four files, `erpc_server.hpp`, `erpc_server.cpp`, `erpc_simple_server.hpp`, and `erpc_simple_server.cpp`, are used for running the eRPC server on the server-side applications. The simple server is currently the only implementation of the server, and its role is to catch client requests, identify and call requested functions, and send data back when requested.
 - Three files (`erpc_codec.hpp`, `erpc_basic_codec.hpp`, and `erpc_basic_codec.cpp`) are used for codecs. Currently, the basic codec is the initial and only implementation of the codecs.
 - The `erpc_common.hpp` file is used for common eRPC definitions, typedefs, and enums.
 - The `erpc_manually_constructed.hpp` file is used for allocating static storage for the used objects.
 - Message buffer files are used for storing serialized data: `erpc_message_buffer.h` and `erpc_message_buffer.cpp`.
 - The `erpc_transport.h` file defines the abstract interface for transport layer.
- The **port** subfolder contains the eRPC porting layer to adapt to different environments.
 - `erpc_port.h` file contains definition of `erpc_malloc()` and `erpc_free()` functions.
 - `erpc_port_stdlib.cpp` file ensures adaptation to `stdlib`.
 - `erpc_config_internal.h` internal erpc configuration file.
- The **setup** subfolder contains a set of plain C APIs that wrap the C++ infrastructure, providing client and server init and deinit routines that greatly simplify eRPC usage in C-based projects. No knowledge of C++ is required to use these APIs.
 - The `erpc_server_setup.h` and `erpc_server_setup.cpp` files need to be added into the “Matrix multiply” example project to demonstrate the use of C-wrapped functions in this example.
 - The `erpc_transport_setup.h` and `erpc_setup_rpmsg_lite_remote.cpp` files need to be added into the project in order to allow the C-wrapped function for transport layer setup.
 - The `erpc_mbf_setup.h` and `erpc_setup_mbf_rpmsg.cpp` files need to be added into the project in order to allow message buffer factory usage.
- The **transports** subfolder contains transport classes for the different methods of communication supported by eRPC. Some transports are applicable only to host PCs, while others are applicable only to embedded or multicore systems. Most transports have corresponding client and server setup functions in the setup folder.
 - RPMsg-Lite is used as the transport layer for the communication between cores, `erpc_rpmsg_lite_base_transport.hpp`, `erpc_rpmsg_lite_transport.hpp`, and `erpc_rpmsg_lite_transport.cpp` files need to be added into the server project.



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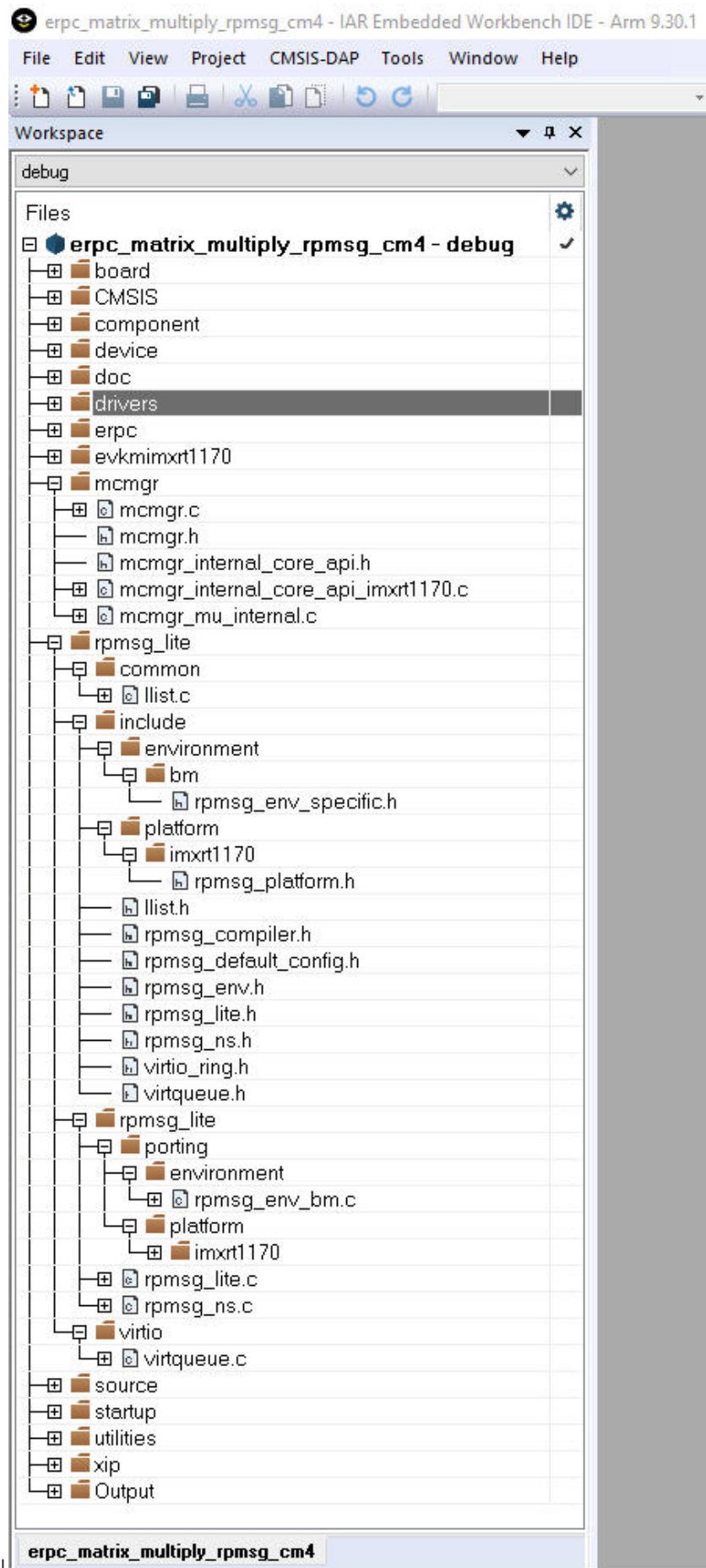
Parent topic: Multicore server application

Server multicore infrastructure files Because of the RPMsg-Lite (transport layer), it is also necessary to include RPMsg-Lite related files, which are in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/rpmsg_lite/`

The multicore example applications also use the Multicore Manager software library to control the secondary core startup and shutdown. These source files are located in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr/`



|

Parent topic: Multicore server application

Server user code The server's user code is stored in the `main_core1.c` file, located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg/cm4`

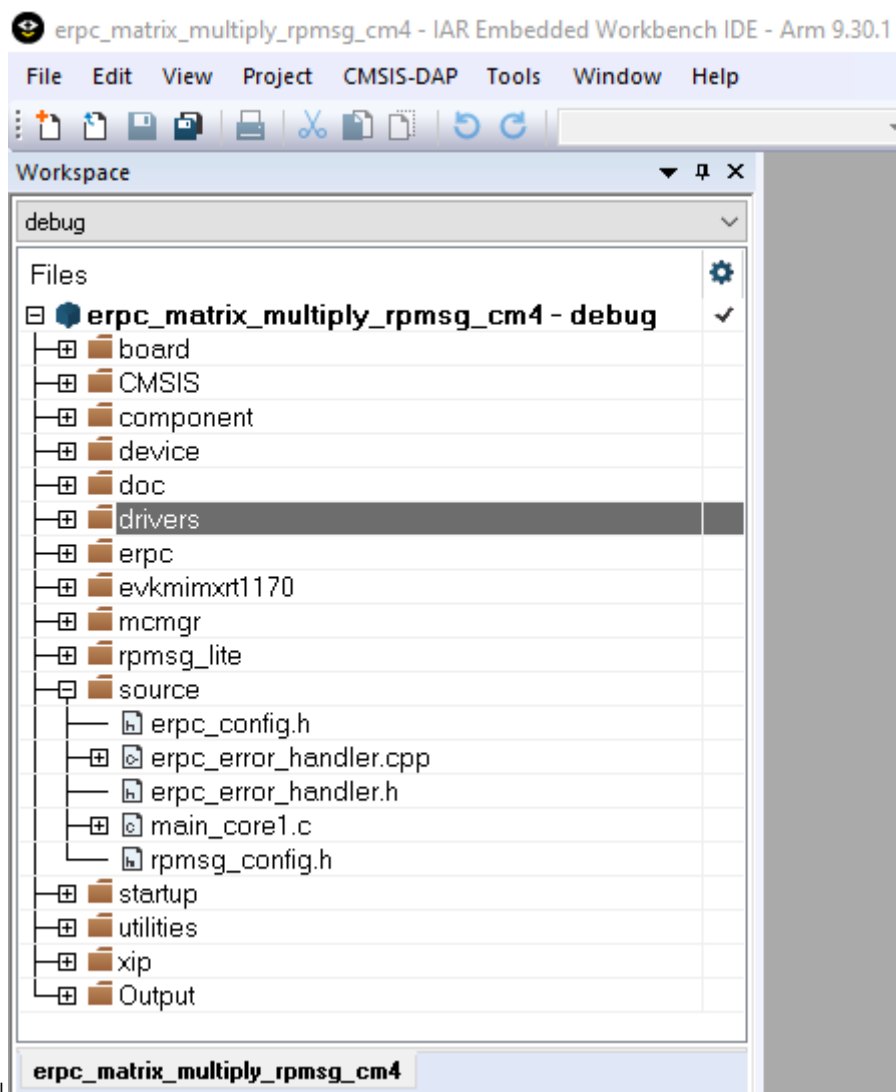
The `main_core1.c` file contains two functions:

- The **main()** function contains the code for the target board and eRPC server initialization. After the initialization, the matrix multiply service is added and the eRPC server waits for client's requests in the while loop.
- The **erpcMatrixMultiply()** function is the user implementation of the eRPC function defined in the IDL file.
- There is the possibility to write the application-specific eRPC error handler. The eRPC error handler of the matrix multiply application is implemented in the `erpc_error_handler.h` and `erpc_error_handler.cpp` files.

The eRPC-relevant code is captured in the following code snippet:

```
/* erpcMatrixMultiply function user implementation */
void erpcMatrixMultiply(const Matrix *matrix1, const Matrix *matrix2, Matrix *result_matrix)
{
    ...
}
int main()
{
    ...
    /* RPSMsg-Lite transport layer initialization */
    erpc_transport_t transport;
    transport = erpc_transport_rpmsg_lite_remote_init(src, dst, (void*)startupData,
    ERPC_TRANSPORT_RPMSG_LITE_LINK_ID, SignalReady, NULL);
    ...
    /* MessageBufferFactory initialization */
    erpc_mbf_t message_buffer_factory;
    message_buffer_factory = erpc_mbf_rpmsg_init(transport);
    ...
    /* eRPC server side initialization */
    erpc_server_t server;
    server = erpc_server_init(transport, message_buffer_factory);
    ...
    /* Adding the service to the server */
    erpc_service_t service = create_MatrixMultiplyService_service();
    erpc_add_service_to_server(server, service);
    ...
    while (1)
    {
        /* Process eRPC requests */
        erpc_status_t status = erpc_server_poll(server);
        /* handle error status */
        if (status != kErpcStatus_Success)
        {
            /* print error description */
            erpc_error_handler(status, 0);
            ...
        }
        ...
    }
}
```

Except for the application main file, there are configuration files for the RPMsg-Lite (rpmsg_config.h) and eRPC (erpc_config.h), located in the `<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg` folder.



Parent topic:Multicore server application

Parent topic:[Create an eRPC application](#)

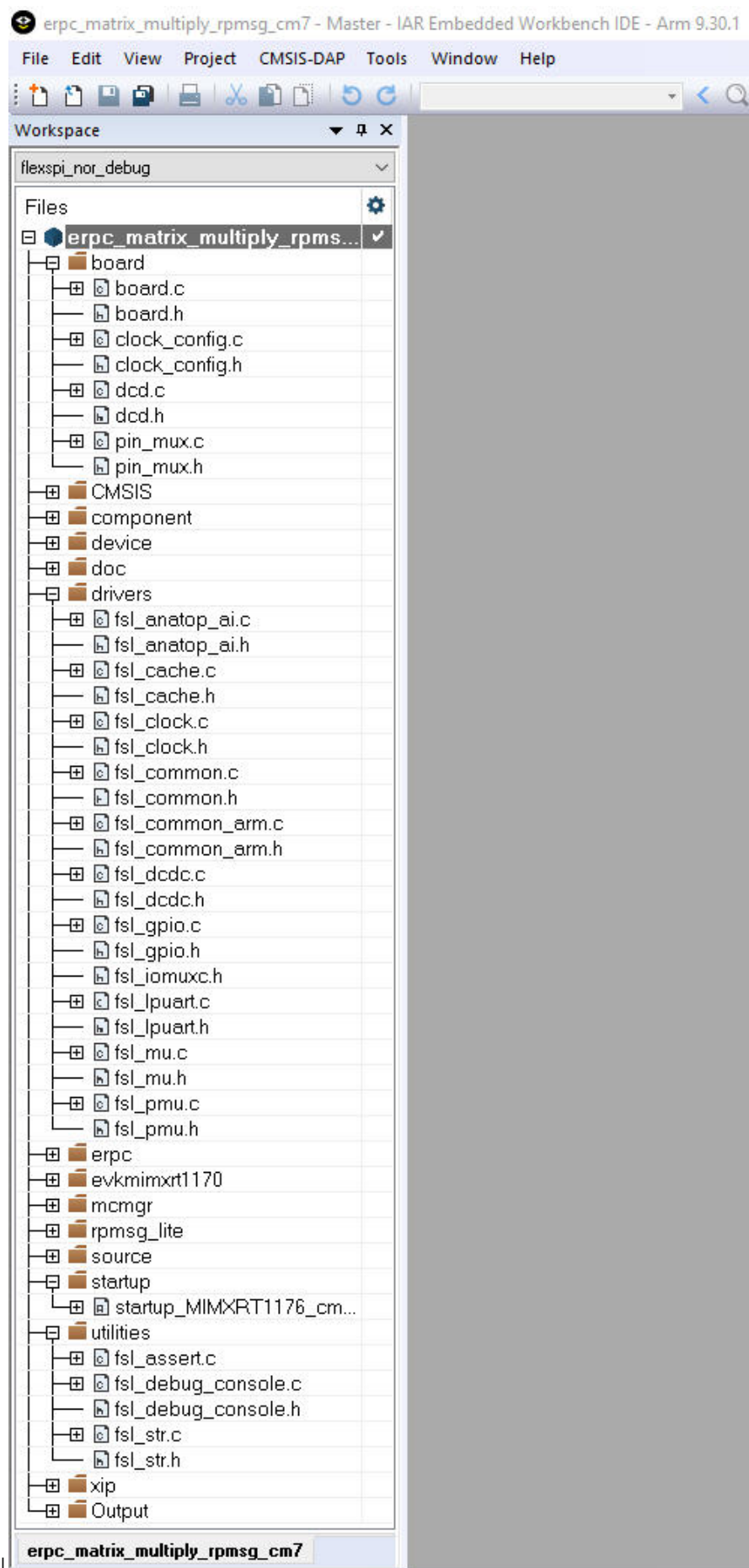
Multicore client application The “Matrix multiply” eRPC client project is located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg/cm7/iar`

Project files for the eRPC client have the `_cm7` suffix.

Client project basic source files The startup files, board-related settings, peripheral drivers, and utilities belong to the basic project source files and form the skeleton of all MCUXpresso SDK applications. These source files are located in the following folders:

- `<MCUXpressoSDK_install_dir>/devices/<device>`
- `<MCUXpressoSDK_install_dir>/boards/<board_name>/multicore_examples/<example_name>/`



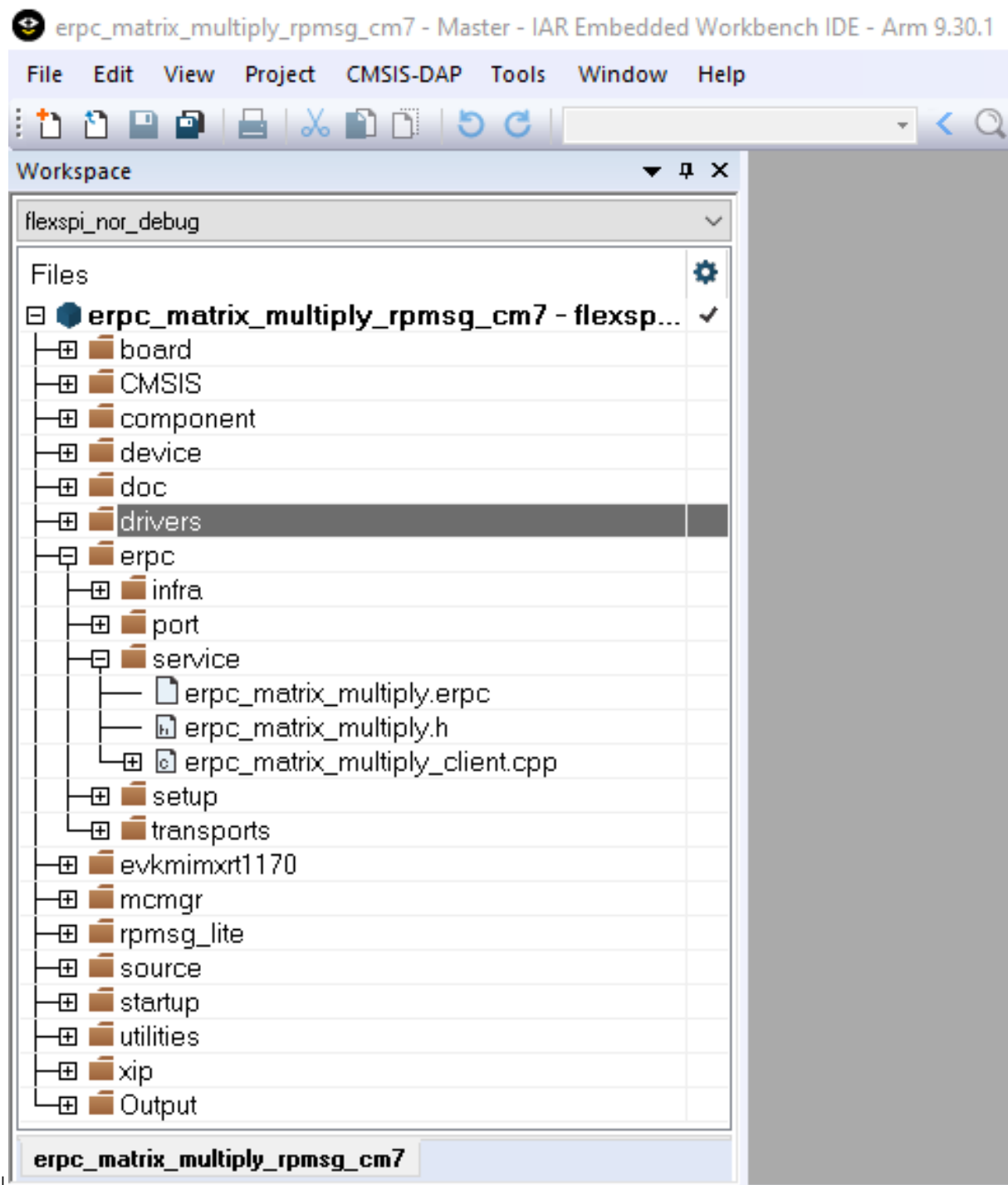
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Parent topic:Multicore client application

Client-related generated files The client-related generated files are:

- erpc__matric__multiply.h
- erpc__matrix__multiply__client.cpp

These files contain the shim code for the functions and data types declared in the IDL file. These functions also call methods for codec initialization, data serialization, performing eRPC requests, and de-serializing outputs into expected data structures (if return values are expected). These shim code files can be found in the `<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/service/` folder.



Parent topic:Multicore client application

Client infrastructure files The eRPC infrastructure files are located in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/erpc_c`

The **erpc_c** folder contains files for creating eRPC client and server applications in the C/C++ language. These files are distributed into subfolders.

- The **infra** subfolder contains C++ infrastructure code used to build server and client applications.

- Two files, `erpc_client_manager.h` and `erpc_client_manager.cpp`, are used for managing the client-side application. The main purpose of the client files is to create, perform, and release eRPC requests.
- Three files (`erpc_codec.hpp`, `erpc_basic_codec.hpp`, and `erpc_basic_codec.cpp`) are used for codecs. Currently, the basic codec is the initial and only implementation of the codecs.
- `erpc_common.h` file is used for common eRPC definitions, typedefs, and enums.
- `erpc_manually_constructed.hpp` file is used for allocating static storage for the used objects.
- Message buffer files are used for storing serialized data: `erpc_message_buffer.hpp` and `erpc_message_buffer.cpp`.
- `erpc_transport.hpp` file defines the abstract interface for transport layer.

The **port** subfolder contains the eRPC porting layer to adapt to different environments.

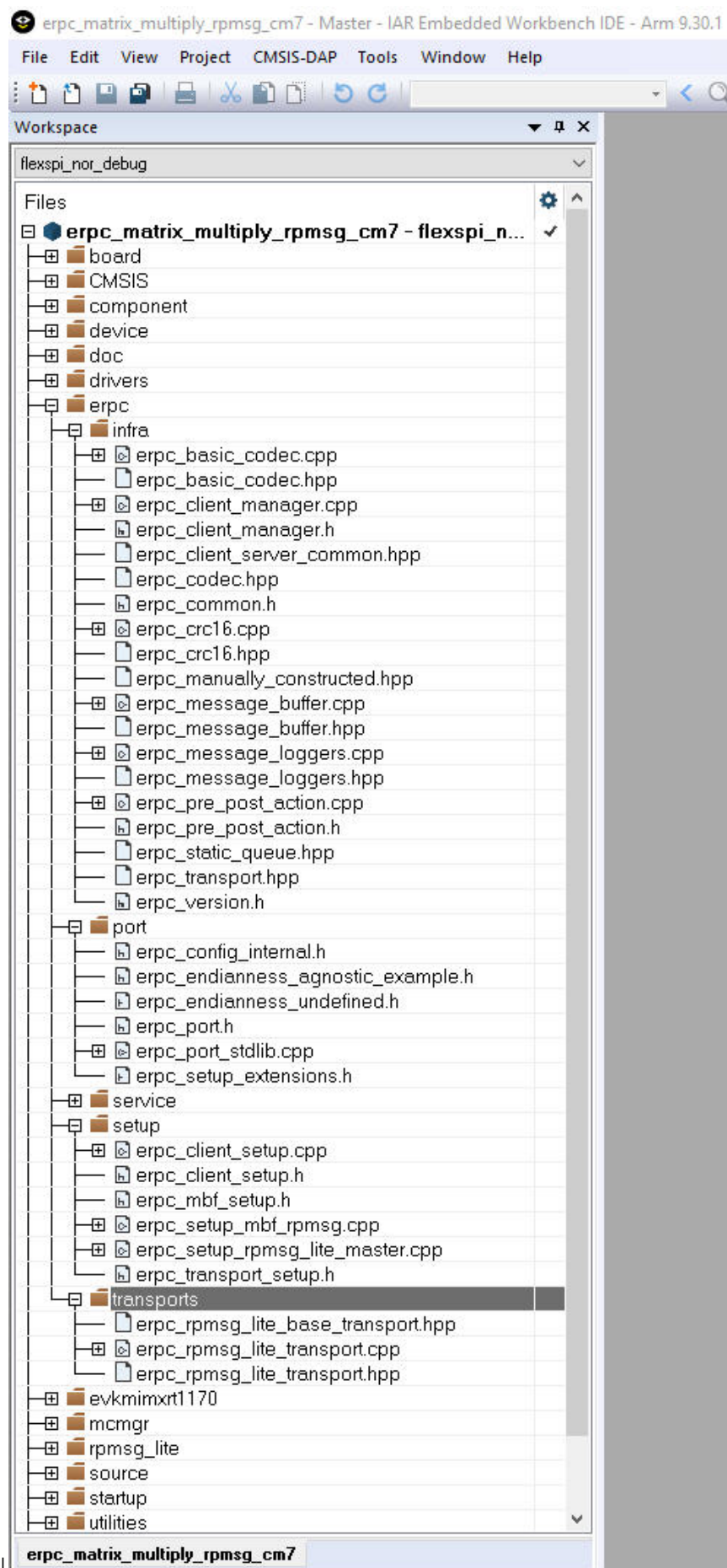
- `erpc_port.h` file contains definition of `erpc_malloc()` and `erpc_free()` functions.
- `erpc_port_stdlib.cpp` file ensures adaptation to `stdlib`.
- `erpc_config_internal.h` internal eRPC configuration file.

The **setup** subfolder contains a set of plain C APIs that wrap the C++ infrastructure, providing client and server init and deinit routines that greatly simplify eRPC usage in C-based projects. No knowledge of C++ is required to use these APIs.

- `erpc_client_setup.h` and `erpc_client_setup.cpp` files needs to be added into the “Matrix multiply” example project to demonstrate the use of C-wrapped functions in this example.
- `erpc_transport_setup.h` and `erpc_setup_rpmsg_lite_master.cpp` files needs to be added into the project in order to allow C-wrapped function for transport layer setup.
- `erpc_mbf_setup.h` and `erpc_setup_mbf_rpmsg.cpp` files needs to be added into the project in order to allow message buffer factory usage.

The **transports** subfolder contains transport classes for the different methods of communication supported by eRPC. Some transports are applicable only to host PCs, while others are applicable only to embedded or multicore systems. Most transports have corresponding client and server setup functions, in the setup folder.

- RPMsg-Lite is used as the transport layer for the communication between cores, `erpc_rpmsg_lite_base_transport.hpp`, `erpc_rpmsg_lite_transport.hpp`, and `erpc_rpmsg_lite_transport.cpp` files needs to be added into the client project.



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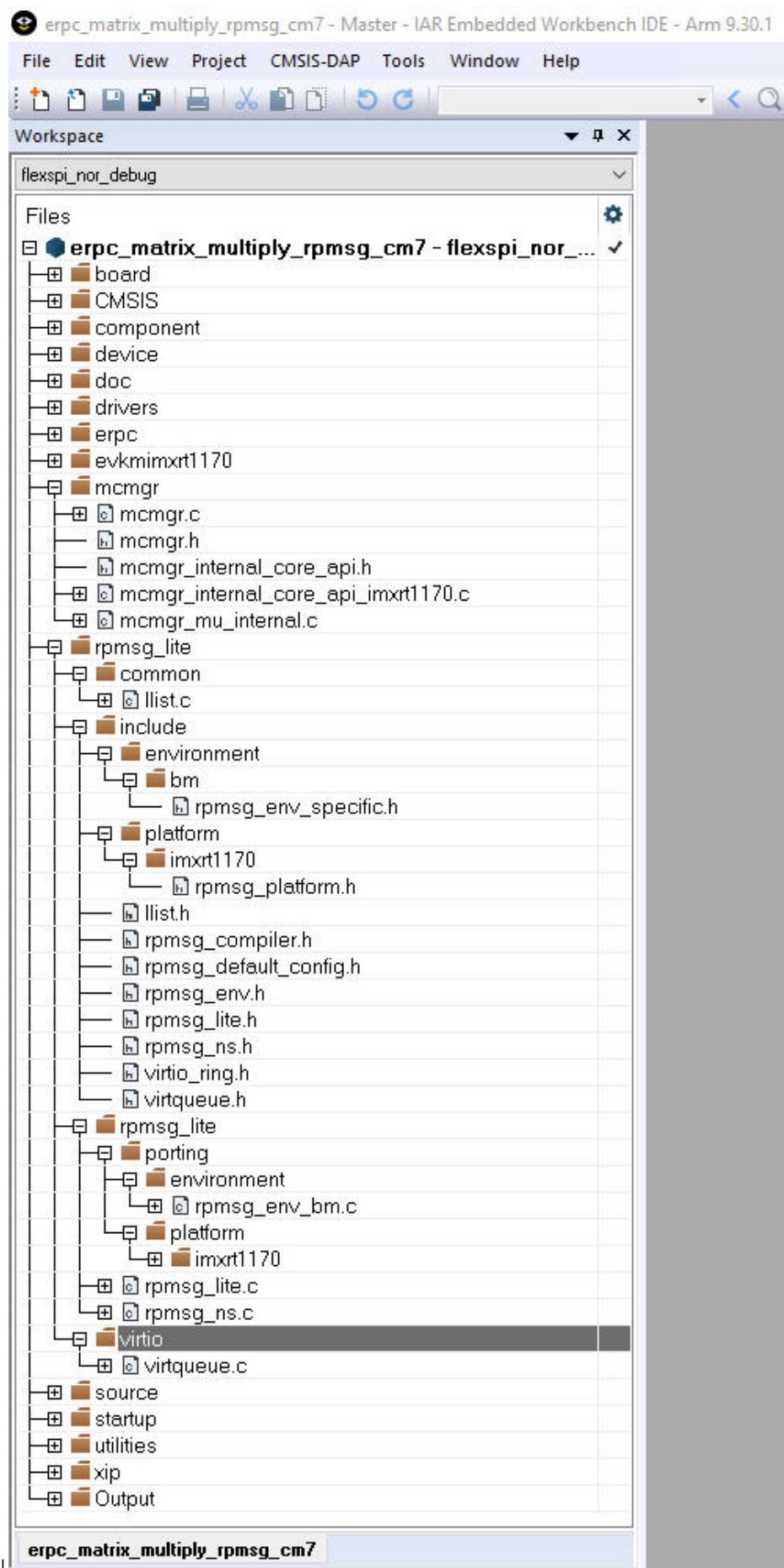
Parent topic: Multicore client application

Client multicore infrastructure files Because of the RPSMsg-Lite (transport layer), it is also necessary to include RPSMsg-Lite related files, which are in the following folder:

<MCUXpressoSDK_install_dir>/middleware/multicore/rpsmsg_lite/

The multicore example applications also use the Multicore Manager software library to control the secondary core startup and shutdown. These source files are located in the following folder:

<MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr/



Parent topic: Multicore client application

Client user code The client's user code is stored in the main_core0.c file, located in the following folder:

<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_example/erpc_matrix_multiply_rpmsg/cm7

The main_core0.c file contains the code for target board and eRPC initialization.

- After initialization, the secondary core is released from reset.
- When the secondary core is ready, the primary core initializes two matrix variables.
- The erpcMatrixMultiply eRPC function is called to issue the eRPC request and get the result.

It is possible to write the application-specific eRPC error handler. The eRPC error handler of the matrix multiply application is implemented in erpc_error_handler.h and erpc_error_handler.cpp files.

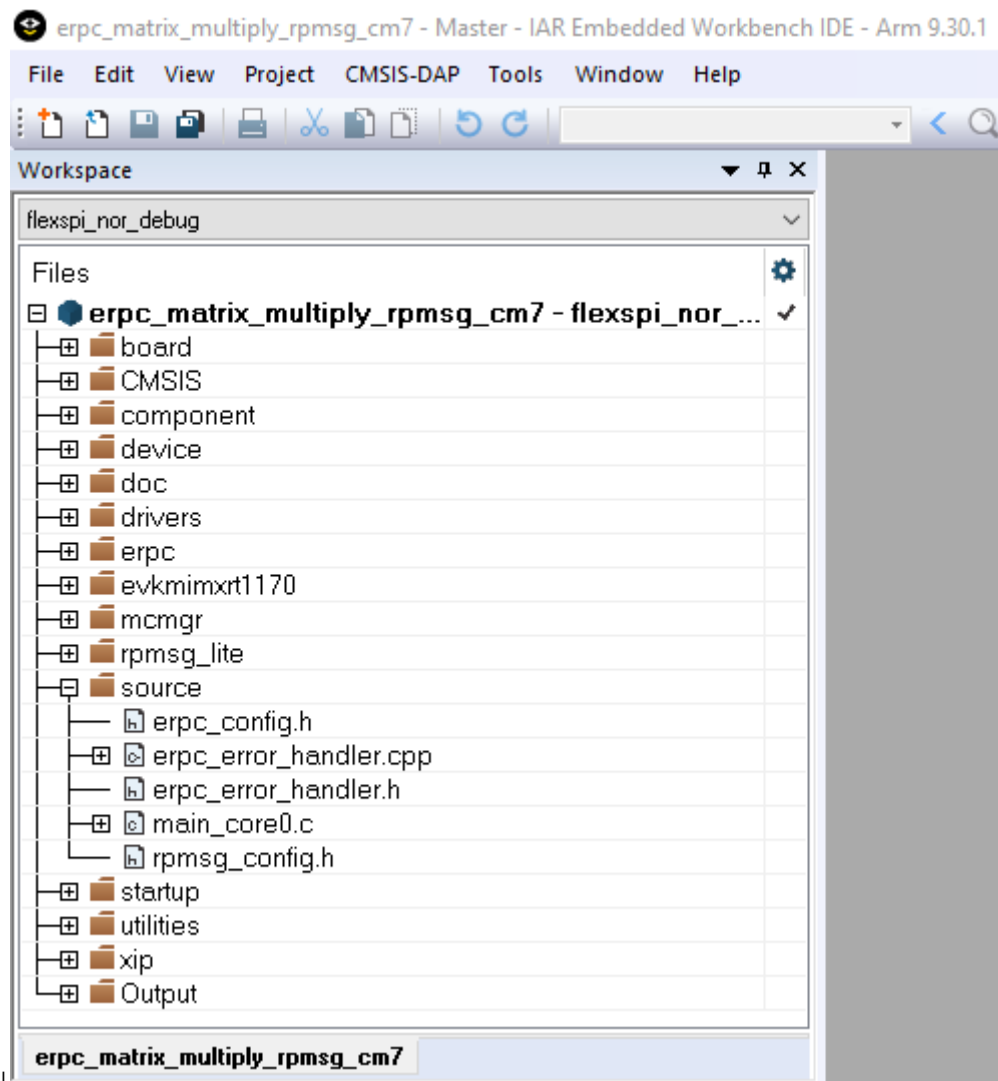
The matrix multiplication can be issued repeatedly, when pressing a software board button.

The eRPC-relevant code is captured in the following code snippet:

```
...
extern bool g_erpc_error_occurred;
...
/* Declare matrix arrays */
Matrix matrix1 = {0}, matrix2 = {0}, result_matrix = {0};
...
/* RPMsg-Lite transport layer initialization */
erpc_transport_t transport;
transport = erpc_transport_rpmsg_lite_master_init(src, dst,
ERPC_TRANSPORT_RPMSG_LITE_LINK_ID);
...
/* MessageBufferFactory initialization */
erpc_mbf_t message_buffer_factory;
message_buffer_factory = erpc_mbf_rpmsg_init(transport);
...
/* eRPC client side initialization */
erpc_client_t client;
client = erpc_client_init(transport, message_buffer_factory);
...
/* Set default error handler */
erpc_client_set_error_handler(client, erpc_error_handler);
...
while (1)
{
    /* Invoke the erpcMatrixMultiply function */
    erpcMatrixMultiply(matrix1, matrix2, result_matrix);
    ...
    /* Check if some error occurred in eRPC */
    if (g_erpc_error_occurred)
    {
        /* Exit program loop */
        break;
    }
    ...
}
```

Except for the application main file, there are configuration files for the RPMsg-Lite (rpmsg_config.h) and eRPC (erpc_config.h), located in the following folder:

<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg



Parent topic: Multicore client application

Parent topic: [Create an eRPC application](#)

Multiprocessor server application The “Matrix multiply” eRPC server project for multiprocessor applications is located in the `<MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_server_matrix_multiply_<transport_layer>` folder.

Most of the multiprocessor application setup is the same as for the multicore application. The multiprocessor server application requires server-related generated files (server shim code), server infrastructure files, and the server user code. There is no need for server multicore infrastructure files (MCMGR and RPMs-Lite). The RPMs-Lite transport layer is replaced either by SPI or UART transports. The following table shows the required transport-related files per each transport type.

SPI	<eRPC base directory>/erpc_c/setup/erpc_setup_(d)spi_slave.cpp
	<eRPC base directory>/erpc_c/transports/erpc_(d)spi_slave_transport.hpp
	<eRPC base directory>/erpc_c/transports/erpc_(d)spi_slave_transport.cpp
UART	<eRPC base directory>/erpc_c/setup/erpc_setup_uart_cmsis.cpp

<eRPC base directory>/erpc_c/transport/erpc_uart_cmsis_transport.hpp

<eRPC base directory>/erpc_c/transport/erpc_uart_cmsis_transport.cpp

|

Server user code The server's user code is stored in the main_server.c file, located in the <MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_server_matrix_multiply_<transport_layer>/ folder.

The eRPC-relevant code with UART as a transport is captured in the following code snippet:

```
/* erpcMatrixMultiply function user implementation */
void erpcMatrixMultiply(Matrix matrix1, Matrix matrix2, Matrix result_matrix)
{
    ...
}
int main()
{
    ...
    /* UART transport layer initialization, ERPC_DEMO_UART is the structure of CMSIS UART driver
    ↪operations */
    erpc_transport_t transport;
    transport = erpc_transport_cmsis_uart_init((void *)&ERPC_DEMO_UART);
    ...
    /* MessageBufferFactory initialization */
    erpc_mbf_t message_buffer_factory;
    message_buffer_factory = erpc_mbf_dynamic_init();
    ...
    /* eRPC server side initialization */
    erpc_server_t server;
    server = erpc_server_init(transport, message_buffer_factory);
    ...
    /* Adding the service to the server */
    erpc_service_t service = create_MatrixMultiplyService_service();
    erpc_add_service_to_server(server, service);
    ...
    while (1)
    {
        /* Process eRPC requests */
        erpc_status_t status = erpc_server_poll(server)
        /* handle error status */
        if (status != kErpcStatus_Success)
        {
            /* print error description */
            erpc_error_handler(status, 0);
            ...
        }
        ...
    }
}
```

Parent topic:Multiprocessor server application

Multiprocessor client application The “Matrix multiply” eRPC client project for multiprocessor applications is located in the <MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_client_matrix_multiply_<transport_layer>/iar/ folder.

Most of the multiprocessor application setup is the same as for the multicore application. The multiprocessor server application requires client-related generated files (server shim code),

client infrastructure files, and the client user code. There is no need for client multicore infrastructure files (MCMGR and RPSMsg-Lite). The RPSMsg-Lite transport layer is replaced either by SPI or UART transports. The following table shows the required transport-related files per each transport type.

SPI	<eRPC base directory>/erpc_c/setup/erpc_setup_(d)spi_master.cpp
<eRPC base directory>/erpc_c/	transports/ erpc_(d)spi_master_transport.hpp
<eRPC base directory>/erpc_c/	transports/ erpc_(d)spi_master_transport.cpp
UART	<eRPC base directory>/erpc_c/setup/erpc_setup_uart_cmsis.cpp
<eRPC base directory>/erpc_c/	transports/erpc_uart_cmsis_transport.hpp
<eRPC base directory>/erpc_c/	transports/erpc_uart_cmsis_transport.cpp

Client user code The client's user code is stored in the `main_client.c` file, located in the `<MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_client_matrix_multiply_<transport_layer>/` folder.

The eRPC-relevant code with UART as a transport is captured in the following code snippet:

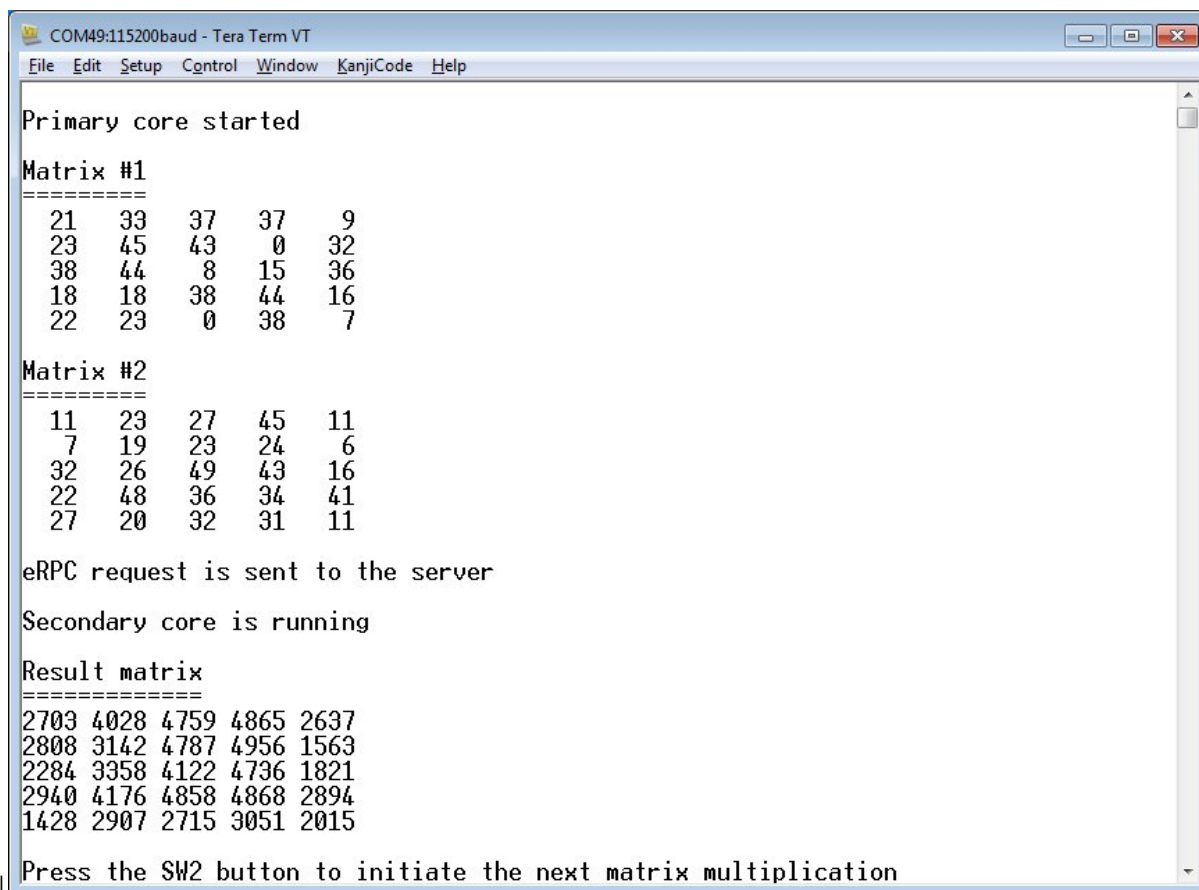
```
...
extern bool g_erpc_error_occurred;
...
/* Declare matrix arrays */
Matrix matrix1 = {0}, matrix2 = {0}, result_matrix = {0};
...
/* UART transport layer initialization, ERPC_DEMO_UART is the structure of CMSIS UART driver
↳operations */
erpc_transport_t transport;
transport = erpc_transport_cmsis_uart_init((void *)&ERPC_DEMO_UART);
...
/* MessageBufferFactory initialization */
erpc_mbf_t message_buffer_factory;
message_buffer_factory = erpc_mbf_dynamic_init();
...
/* eRPC client side initialization */
erpc_client_t client;
client = erpc_client_init(transport,message_buffer_factory);
...
/* Set default error handler */
erpc_client_set_error_handler(client, erpc_error_handler);
...
while (1)
{
    /* Invoke the erpcMatrixMultiply function */
    erpcMatrixMultiply(matrix1, matrix2, result_matrix);
    ...
    /* Check if some error occurred in eRPC */
    if (g_erpc_error_occurred)
    {
        /* Exit program loop */
        break;
    }
    ...
}
```

Parent topic:Multiprocessor client application

Parent topic:Multiprocessor server application

Parent topic:[Create an eRPC application](#)

Running the eRPC application Follow the instructions in *Getting Started with MCUXpresso SDK* (document MCUXSDKGSUG) (located in the <MCUXpressoSDK_install_dir>/docs folder), to load both the primary and the secondary core images into the on-chip memory, and then effectively debug the dual-core application. After the application is running, the serial console should look like:



```

COM49:115200baud - Tera Term VT
File Edit Setup Control Window KanjiCode Help

Primary core started

Matrix #1
=====
 21  33  37  37   9
 23  45  43   0  32
 38  44   8  15  36
 18  18  38  44  16
 22  23   0  38   7

Matrix #2
=====
 11  23  27  45  11
  7  19  23  24   6
 32  26  49  43  16
 22  48  36  34  41
 27  20  32  31  11

eRPC request is sent to the server

Secondary core is running

Result matrix
=====
2703 4028 4759 4865 2637
2808 3142 4787 4956 1563
2284 3358 4122 4736 1821
2940 4176 4858 4868 2894
1428 2907 2715 3051 2015

Press the SW2 button to initiate the next matrix multiplication

```

For multiprocessor applications that are running between PC and the target evaluation board or between two boards, follow the instructions in the accompanied example readme files that provide details about the proper board setup and the PC side setup (Python).

Parent topic:[Create an eRPC application](#)

Parent topic:[eRPC example](#)

eRPC example This section shows how to create an example eRPC application called “Matrix multiply”, which implements one eRPC function (matrix multiply) with two function parameters (two matrices). The client-side application calls this eRPC function, and the server side performs the multiplication of received matrices. The server side then returns the result.

For example, use the NXP MIMXRT1170-EVK board as the target dual-core platform, and the IAR Embedded Workbench for ARM (EWARM) as the target IDE for developing the eRPC example.

- The primary core (CM7) runs the eRPC client.
- The secondary core (CM4) runs the eRPC server.
- RPMsg-Lite (Remote Processor Messaging Lite) is used as the eRPC transport layer.

The “Matrix multiply” application can be also run in the multi-processor setup. In other words, the eRPC client running on one SoC communicates with the eRPC server that runs on another SoC, utilizing different transport channels. It is possible to run the board-to-PC example (PC as the eRPC server and a board as the eRPC client, and vice versa) and also the board-to-board example. These multiprocessor examples are prepared for selected boards only.

| Multicore application source and project files | `<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore/`
| Multiprocessor application source and project files | `<MCUXpressoSDK_install_dir>/boards/<board_name>/multi`
`<MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_server_matrix_multiply_<tr`
| | eRPC source files | `<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/` | | RPLite
source files | `<MCUXpressoSDK_install_dir>/middleware/multicore/rplite/`

Designing the eRPC application The matrix multiply application is based on calling single eRPC function that takes 2 two-dimensional arrays as input and returns matrix multiplication results as another 2 two-dimensional array. The IDL file syntax supports arrays with the dimension length set by the number only (in the current eRPC implementation). Because of this, a variable is declared in the IDL dedicated to store information about matrix dimension length, and to allow easy maintenance of the user and server code.

For a simple use of the two-dimensional array, the alias name (new type definition) for this data type has been declared in the IDL. Declaring this alias name ensures that the same data type can be used across the client and server applications.

Parent topic: [eRPC example](#)

Creating the IDL file The created IDL file is located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/`

The created IDL file contains the following code:

```
program erpc_matrix_multiply
/*! This const defines the matrix size. The value has to be the same as the
Matrix array dimension. Do not forget to re-generate the erpc code once the
matrix size is changed in the erpc file */
const int32 matrix_size = 5;
/*! This is the matrix array type. The dimension has to be the same as the
matrix size const. Do not forget to re-generate the erpc code once the
matrix size is changed in the erpc file */
type Matrix = int32[matrix_size][matrix_size];
interface MatrixMultiplyService {
erpcMatrixMultiply(in Matrix matrix1, in Matrix matrix2, out Matrix result_matrix) ->
void
}
```

Details:

- The IDL file starts with the program name (*erpc_matrix_multiply*), and this program name is used in the naming of all generated outputs.
- The declaration and definition of the constant variable named *matrix_size* follows next. The *matrix_size* variable is used for passing information about the length of matrix dimensions to the client/server user code.
- The alias name for the two-dimensional array type (*Matrix*) is declared.
- The interface group *MatrixMultiplyService* is located at the end of the IDL file. This interface group contains only one function declaration *erpcMatrixMultiply*.
- As shown above, the function’s declaration contains three parameters of *Matrix* type: *matrix1* and *matrix2* are input parameters, while *result_matrix* is the output parameter. Additionally, the returned data type is declared as *void*.

When writing the IDL file, the following order of items is recommended:

1. Program name at the top of the IDL file.
2. New data types and constants declarations.
3. Declarations of interfaces and functions at the end of the IDL file.

Parent topic: [eRPC example](#)

Using the eRPC generator tool | Windows OS | `<MCUXpressoSDK_install_dir>/middleware/multicore/tools/erpcgen/Linux_x64`
 | Linux OS | `<MCUXpressoSDK_install_dir>/middleware/multicore/tools/erpcgen/Linux_x86`
 | Mac OS | `<MCUXpressoSDK_install_dir>/middleware/multicore/tools/erpcgen/Mac`

The files for the “Matrix multiply” example are pre-generated and already a part of the application projects. The following section describes how they have been created.

- The easiest way to create the shim code is to copy the erpcgen application to the same folder where the IDL file (*.erpc) is located; then run the following command:

```
erpcgen <IDL_file>.erpc
```

- In the “Matrix multiply” example, the command should look like:

```
erpcgen erpc_matrix_multiply.erpc
```

Additionally, another method to create the shim code is to execute the eRPC application using input commands:

- “-?”/”—help” – Shows supported commands.
- “-o <filePath>”/”—output<filePath>” – Sets the output directory.

For example,

```
<path_to_erpcgen>/erpcgen -o <path_to_output>  
<path_to_IDL>/<IDL_file_name>.erpc
```

For the “Matrix multiply” example, when the command is executed from the default erpcgen location, it looks like:

```
erpcgen -o  
../../../../boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/service  
../../../../boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/service/erpc_matrix_mu
```

In both cases, the following four files are generated into the `<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/service` folder:

- erpc_matrix_multiply.h
- erpc_matrix_multiply_client.cpp
- erpc_matrix_multiply_server.h
- erpc_matrix_multiply_server.cpp

For multiprocessor examples, the eRPC file and pre-generated files can be found in the `<MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_common/erpc_matrix_multiply/service` folder.

For Linux OS users:

- Do not forget to set the permissions for the eRPC generator application.
- Run the application as `./erpcgen...` instead of as `erpcgen ....`

Parent topic: [eRPC example](#)

Create an eRPC application This section describes a generic way to create a client/server eRPC application:

1. **Design the eRPC application:** Decide which data types are sent between applications, and define functions that send/receive this data.
2. **Create the IDL file:** The IDL file contains information about data types and functions used in an eRPC application, and is written in the IDL language.
3. **Use the eRPC generator tool:** This tool takes an IDL file and generates the shim code for the client and the server-side applications.
4. **Create an eRPC application:**
 1. Create two projects, where one project is for the client side (primary core) and the other project is for the server side (secondary core).
 2. Add generated files for the client application to the client project, and add generated files for the server application to the server project.
 3. Add infrastructure files.
 4. Add user code for client and server applications.
 5. Set the client and server project options.
5. **Run the eRPC application:** Run both the server and the client applications. Make sure that the server has been run before the client request was sent.

A specific example follows in the next section.

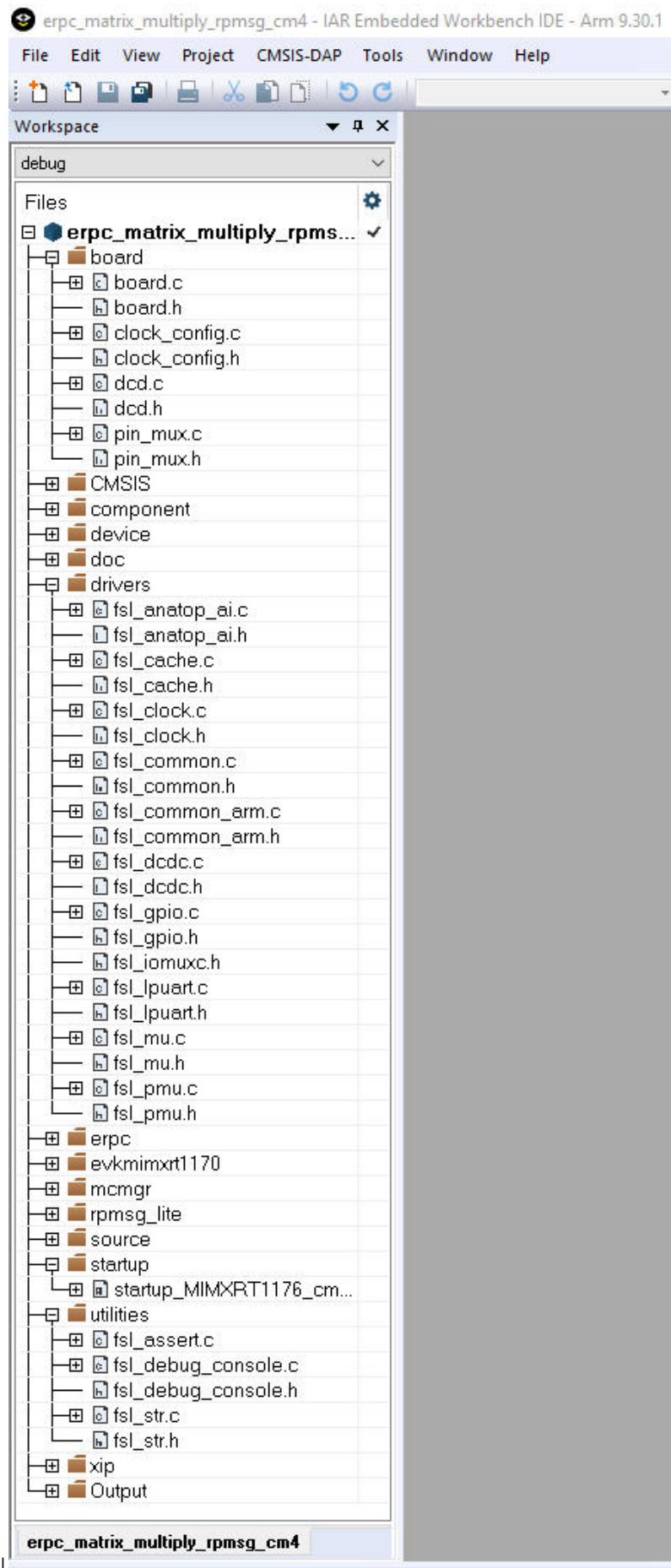
Multicore server application The “Matrix multiply” eRPC server project is located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmmsg/cm4/iar`

The project files for the eRPC server have the `_cm4` suffix.

Server project basic source files The startup files, board-related settings, peripheral drivers, and utilities belong to the basic project source files and form the skeleton of all MCUXpresso SDK applications. These source files are located in:

- `<MCUXpressoSDK_install_dir>/devices/<device>`
- `<MCUXpressoSDK_install_dir>/boards/<board_name>/multicore_examples/<example_name>/`



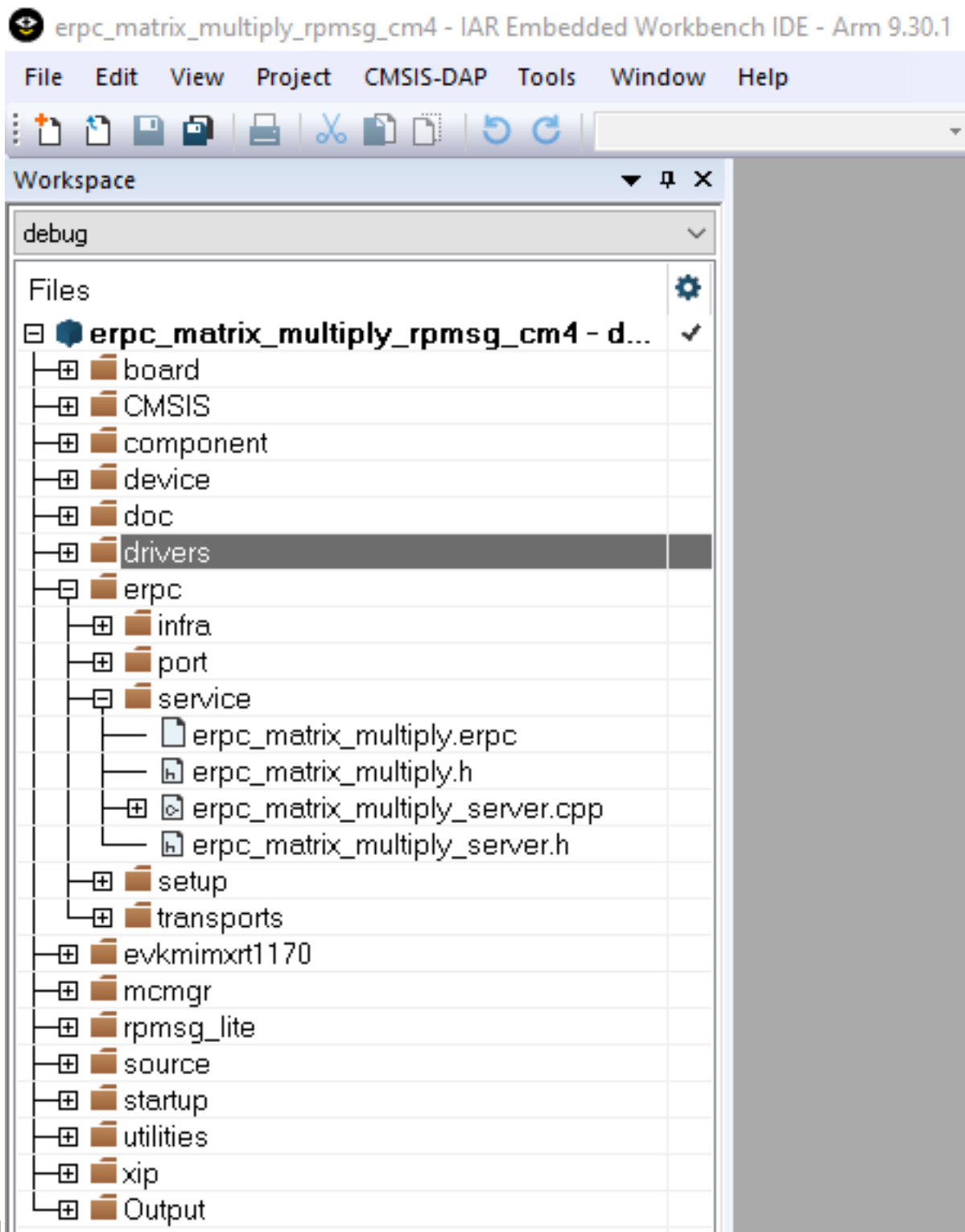
|

Parent topic: Multicore server application**Server related generated files** The server-related generated files are:

- erpc__matric__multiply.h
- erpc__matrix__multiply__server.h
- erpc__matrix__multiply__server.cpp

The server-related generated files contain the shim code for functions and data types declared in the IDL file. These files also contain functions for the identification of client requested functions, data deserialization, calling requested function's implementations, and data serialization and return, if requested by the client. These shim code files can be found in the following folder:

<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/



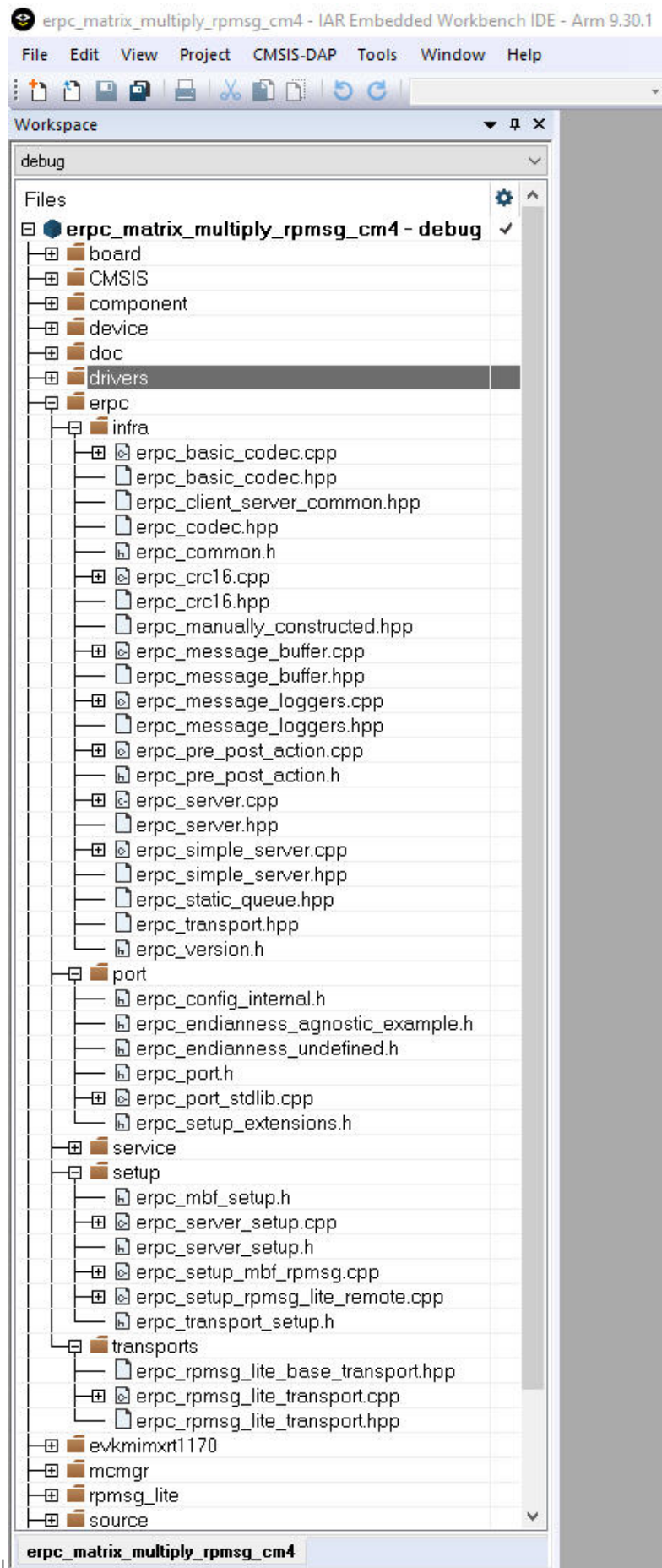
Parent topic: Multicore server application

Server infrastructure files The eRPC infrastructure files are located in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/erpc_c`

The **erpc_c** folder contains files for creating eRPC client and server applications in the C/C++ language. These files are distributed into subfolders.

- The **infra** subfolder contains C++ infrastructure code used to build server and client applications.
 - Four files, `erpc_server.hpp`, `erpc_server.cpp`, `erpc_simple_server.hpp`, and `erpc_simple_server.cpp`, are used for running the eRPC server on the server-side applications. The simple server is currently the only implementation of the server, and its role is to catch client requests, identify and call requested functions, and send data back when requested.
 - Three files (`erpc_codec.hpp`, `erpc_basic_codec.hpp`, and `erpc_basic_codec.cpp`) are used for codecs. Currently, the basic codec is the initial and only implementation of the codecs.
 - The `erpc_common.hpp` file is used for common eRPC definitions, typedefs, and enums.
 - The `erpc_manually_constructed.hpp` file is used for allocating static storage for the used objects.
 - Message buffer files are used for storing serialized data: `erpc_message_buffer.h` and `erpc_message_buffer.cpp`.
 - The `erpc_transport.h` file defines the abstract interface for transport layer.
- The **port** subfolder contains the eRPC porting layer to adapt to different environments.
 - `erpc_port.h` file contains definition of `erpc_malloc()` and `erpc_free()` functions.
 - `erpc_port_stdlib.cpp` file ensures adaptation to `stdlib`.
 - `erpc_config_internal.h` internal erpc configuration file.
- The **setup** subfolder contains a set of plain C APIs that wrap the C++ infrastructure, providing client and server init and deinit routines that greatly simplify eRPC usage in C-based projects. No knowledge of C++ is required to use these APIs.
 - The `erpc_server_setup.h` and `erpc_server_setup.cpp` files need to be added into the “Matrix multiply” example project to demonstrate the use of C-wrapped functions in this example.
 - The `erpc_transport_setup.h` and `erpc_setup_rpmsg_lite_remote.cpp` files need to be added into the project in order to allow the C-wrapped function for transport layer setup.
 - The `erpc_mbf_setup.h` and `erpc_setup_mbf_rpmsg.cpp` files need to be added into the project in order to allow message buffer factory usage.
- The **transports** subfolder contains transport classes for the different methods of communication supported by eRPC. Some transports are applicable only to host PCs, while others are applicable only to embedded or multicore systems. Most transports have corresponding client and server setup functions in the setup folder.
 - RPMsg-Lite is used as the transport layer for the communication between cores, `erpc_rpmsg_lite_base_transport.hpp`, `erpc_rpmsg_lite_transport.hpp`, and `erpc_rpmsg_lite_transport.cpp` files need to be added into the server project.



|

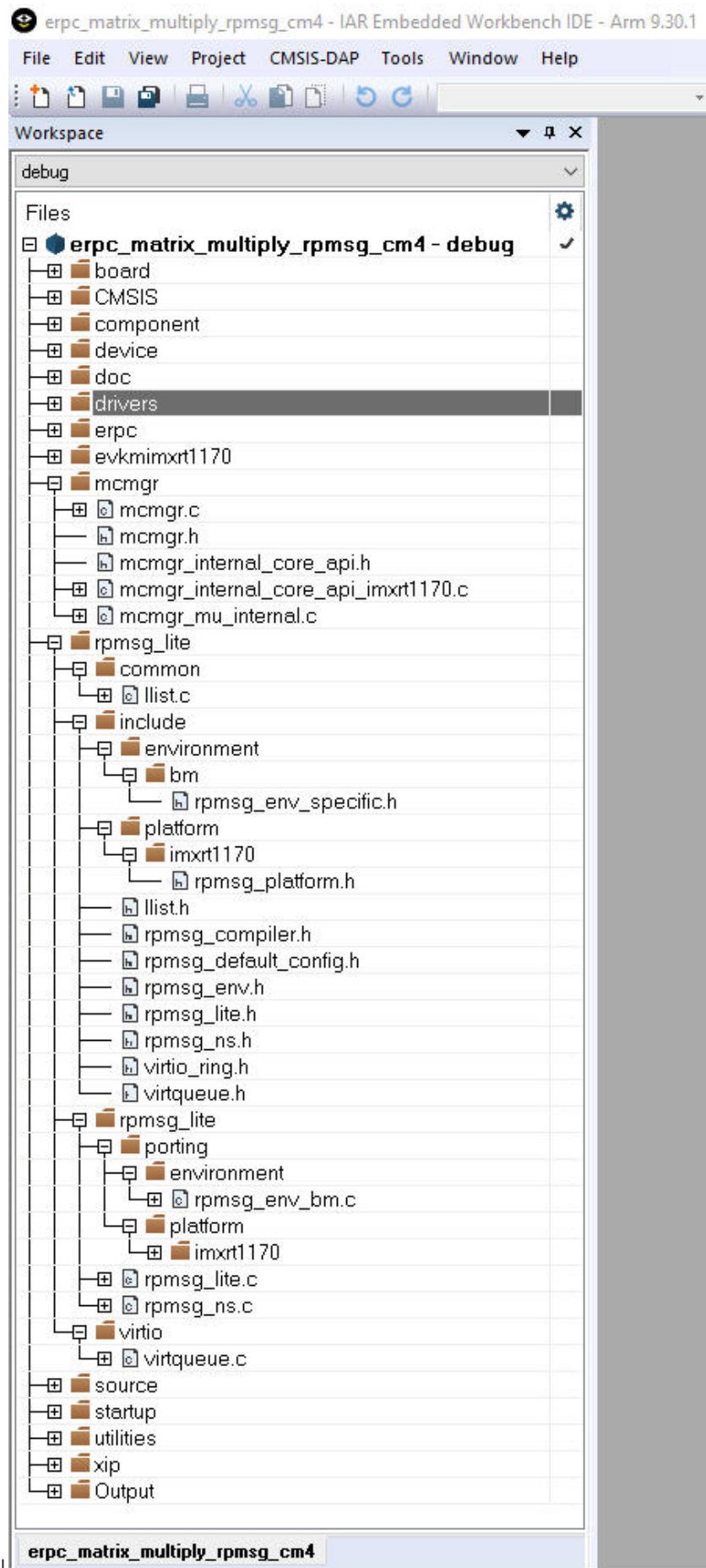
Parent topic: Multicore server application

Server multicore infrastructure files Because of the RPMsg-Lite (transport layer), it is also necessary to include RPMsg-Lite related files, which are in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/rpmsg_lite/`

The multicore example applications also use the Multicore Manager software library to control the secondary core startup and shutdown. These source files are located in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr/`



|

Parent topic: Multicore server application

Server user code The server's user code is stored in the `main_core1.c` file, located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg/cm4`

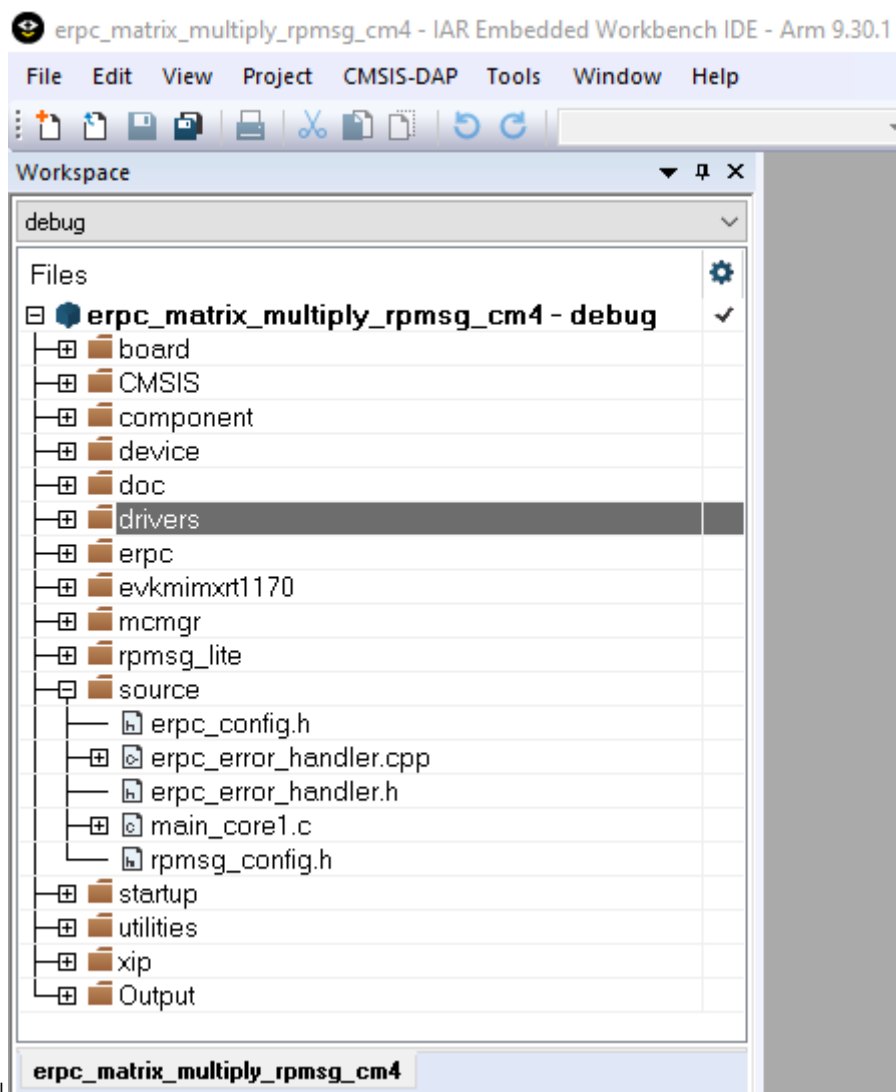
The `main_core1.c` file contains two functions:

- The **main()** function contains the code for the target board and eRPC server initialization. After the initialization, the matrix multiply service is added and the eRPC server waits for client's requests in the while loop.
- The **erpcMatrixMultiply()** function is the user implementation of the eRPC function defined in the IDL file.
- There is the possibility to write the application-specific eRPC error handler. The eRPC error handler of the matrix multiply application is implemented in the `erpc_error_handler.h` and `erpc_error_handler.cpp` files.

The eRPC-relevant code is captured in the following code snippet:

```
/* erpcMatrixMultiply function user implementation */
void erpcMatrixMultiply(const Matrix *matrix1, const Matrix *matrix2, Matrix *result_matrix)
{
    ...
}
int main()
{
    ...
    /* RPSMsg-Lite transport layer initialization */
    erpc_transport_t transport;
    transport = erpc_transport_rpmsg_lite_remote_init(src, dst, (void*)startupData,
    ERPC_TRANSPORT_RPMSG_LITE_LINK_ID, SignalReady, NULL);
    ...
    /* MessageBufferFactory initialization */
    erpc_mbf_t message_buffer_factory;
    message_buffer_factory = erpc_mbf_rpmsg_init(transport);
    ...
    /* eRPC server side initialization */
    erpc_server_t server;
    server = erpc_server_init(transport, message_buffer_factory);
    ...
    /* Adding the service to the server */
    erpc_service_t service = create_MatrixMultiplyService_service();
    erpc_add_service_to_server(server, service);
    ...
    while (1)
    {
        /* Process eRPC requests */
        erpc_status_t status = erpc_server_poll(server);
        /* handle error status */
        if (status != kErpcStatus_Success)
        {
            /* print error description */
            erpc_error_handler(status, 0);
            ...
        }
        ...
    }
}
```

Except for the application main file, there are configuration files for the RPMsg-Lite (`rpmsg_config.h`) and eRPC (`erpc_config.h`), located in the `<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg` folder.



Parent topic:Multicore server application

Parent topic:[Create an eRPC application](#)

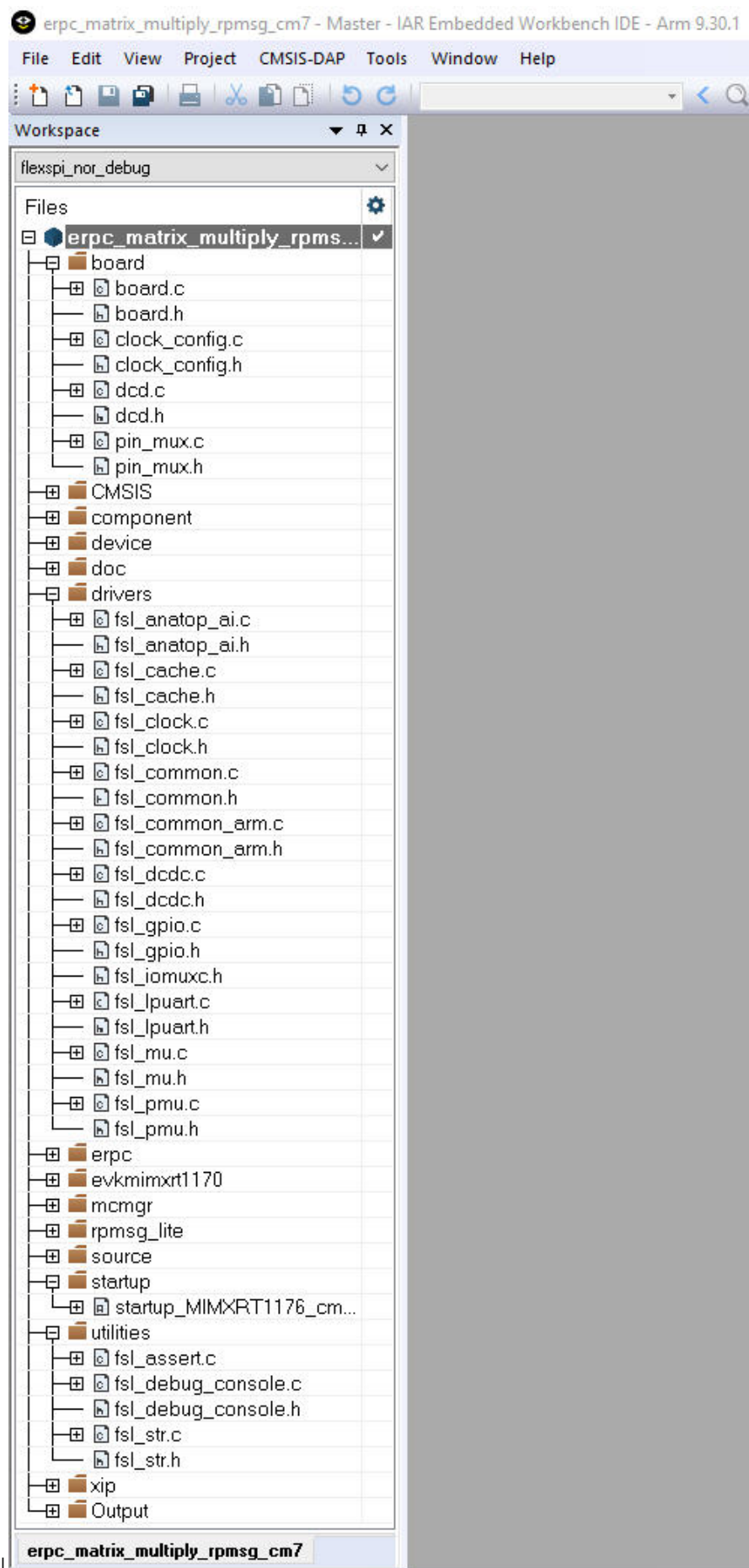
Multicore client application The “Matrix multiply” eRPC client project is located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg/cm7/iar`

Project files for the eRPC client have the `_cm7` suffix.

Client project basic source files The startup files, board-related settings, peripheral drivers, and utilities belong to the basic project source files and form the skeleton of all MCUXpresso SDK applications. These source files are located in the following folders:

- `<MCUXpressoSDK_install_dir>/devices/<device>`
- `<MCUXpressoSDK_install_dir>/boards/<board_name>/multicore_examples/<example_name>/`



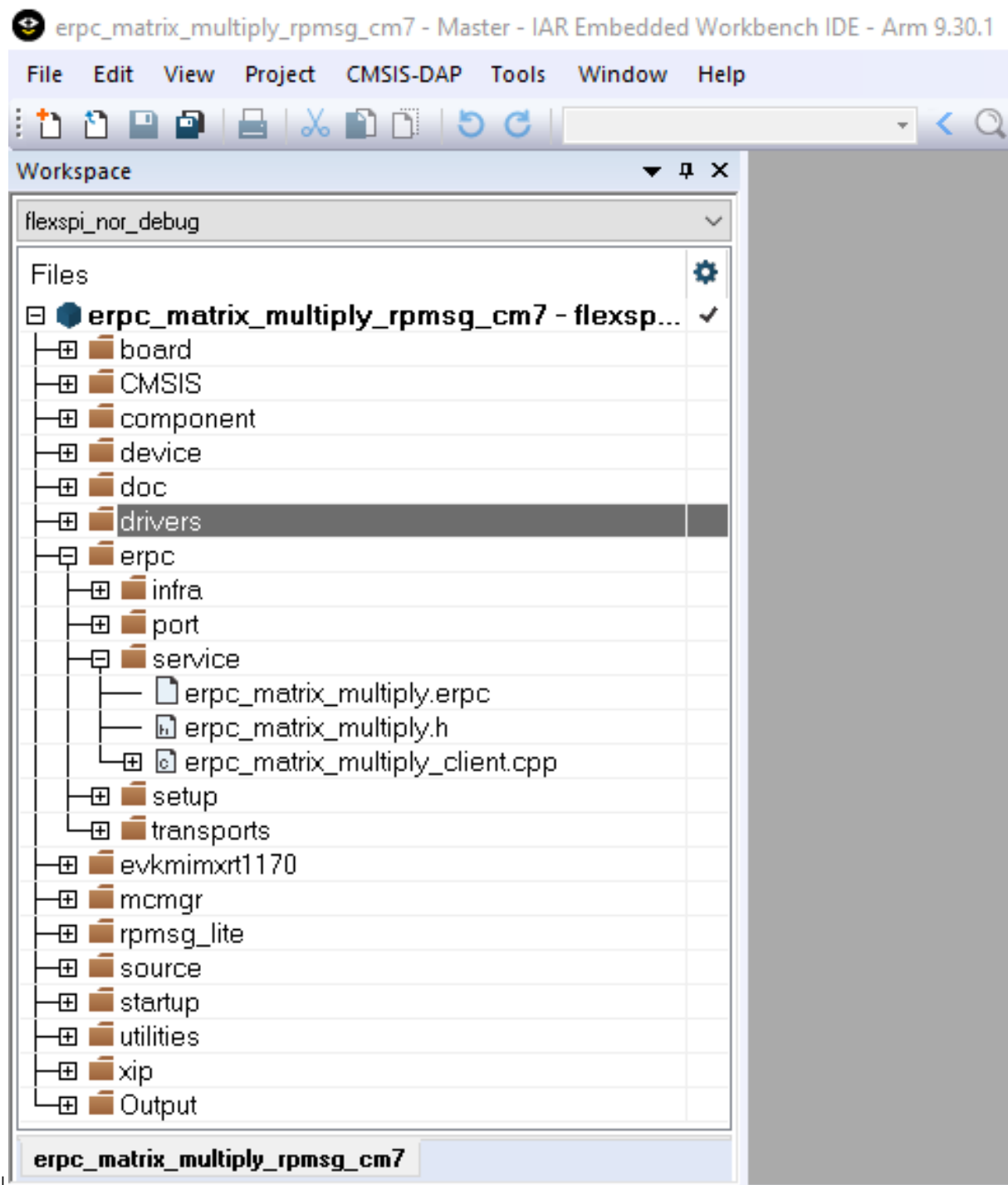
|

Parent topic: Multicore client application

Client-related generated files The client-related generated files are:

- `erpc__matric__multiply.h`
- `erpc__matrix__multiply__client.cpp`

These files contain the shim code for the functions and data types declared in the IDL file. These functions also call methods for codec initialization, data serialization, performing eRPC requests, and de-serializing outputs into expected data structures (if return values are expected). These shim code files can be found in the `<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/service/` folder.



Parent topic:Multicore client application

Client infrastructure files The eRPC infrastructure files are located in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/erpc_c`

The **erpc_c** folder contains files for creating eRPC client and server applications in the C/C++ language. These files are distributed into subfolders.

- The **infra** subfolder contains C++ infrastructure code used to build server and client applications.

- Two files, `erpc_client_manager.h` and `erpc_client_manager.cpp`, are used for managing the client-side application. The main purpose of the client files is to create, perform, and release eRPC requests.
- Three files (`erpc_codec.hpp`, `erpc_basic_codec.hpp`, and `erpc_basic_codec.cpp`) are used for codecs. Currently, the basic codec is the initial and only implementation of the codecs.
- `erpc_common.h` file is used for common eRPC definitions, typedefs, and enums.
- `erpc_manually_constructed.hpp` file is used for allocating static storage for the used objects.
- Message buffer files are used for storing serialized data: `erpc_message_buffer.hpp` and `erpc_message_buffer.cpp`.
- `erpc_transport.hpp` file defines the abstract interface for transport layer.

The **port** subfolder contains the eRPC porting layer to adapt to different environments.

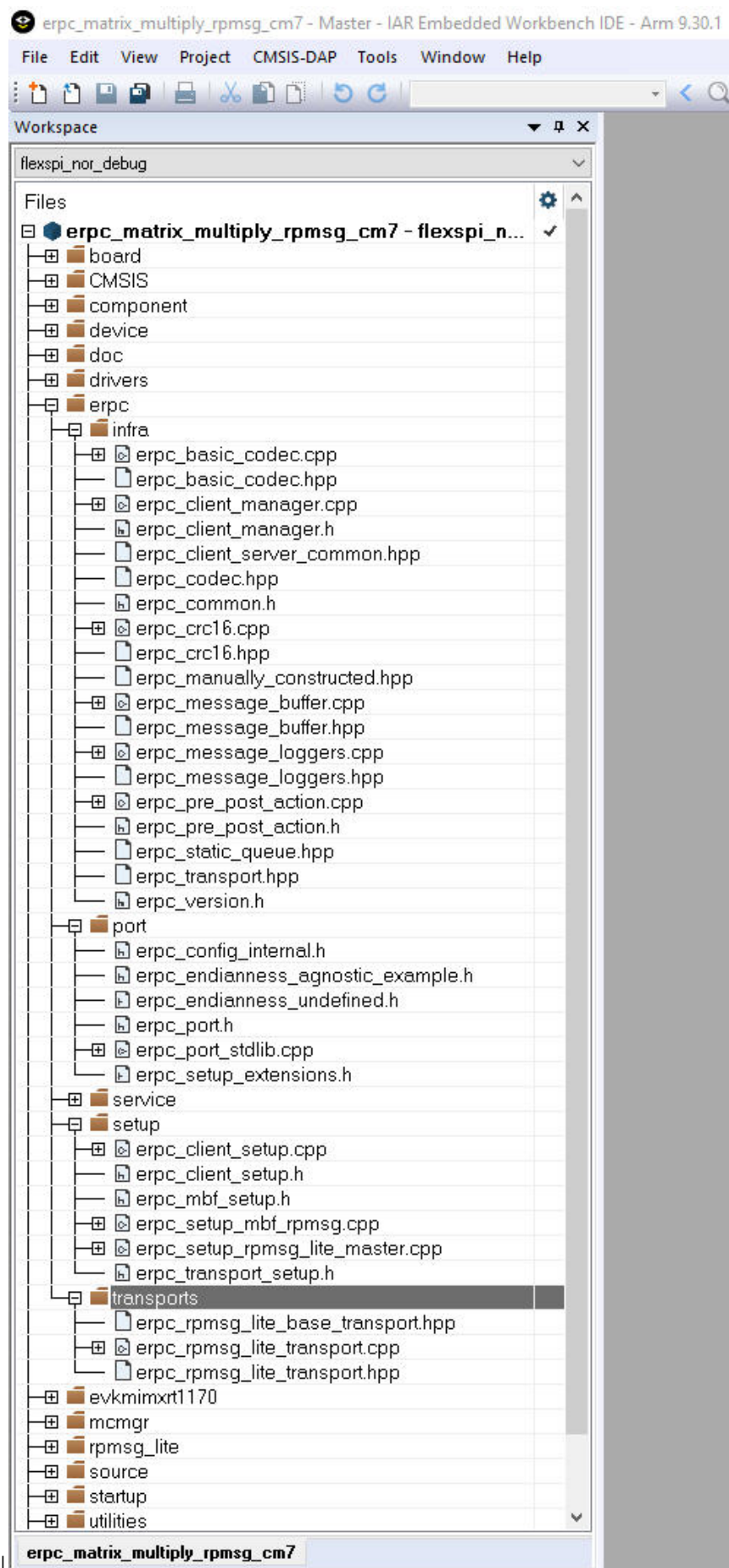
- `erpc_port.h` file contains definition of `erpc_malloc()` and `erpc_free()` functions.
- `erpc_port_stdlib.cpp` file ensures adaptation to `stdlib`.
- `erpc_config_internal.h` internal eRPC configuration file.

The **setup** subfolder contains a set of plain C APIs that wrap the C++ infrastructure, providing client and server init and deinit routines that greatly simplify eRPC usage in C-based projects. No knowledge of C++ is required to use these APIs.

- `erpc_client_setup.h` and `erpc_client_setup.cpp` files needs to be added into the “Matrix multiply” example project to demonstrate the use of C-wrapped functions in this example.
- `erpc_transport_setup.h` and `erpc_setup_rpmsg_lite_master.cpp` files needs to be added into the project in order to allow C-wrapped function for transport layer setup.
- `erpc_mbf_setup.h` and `erpc_setup_mbf_rpmsg.cpp` files needs to be added into the project in order to allow message buffer factory usage.

The **transports** subfolder contains transport classes for the different methods of communication supported by eRPC. Some transports are applicable only to host PCs, while others are applicable only to embedded or multicore systems. Most transports have corresponding client and server setup functions, in the setup folder.

- RPMsg-Lite is used as the transport layer for the communication between cores, `erpc_rpmsg_lite_base_transport.hpp`, `erpc_rpmsg_lite_transport.hpp`, and `erpc_rpmsg_lite_transport.cpp` files needs to be added into the client project.



|

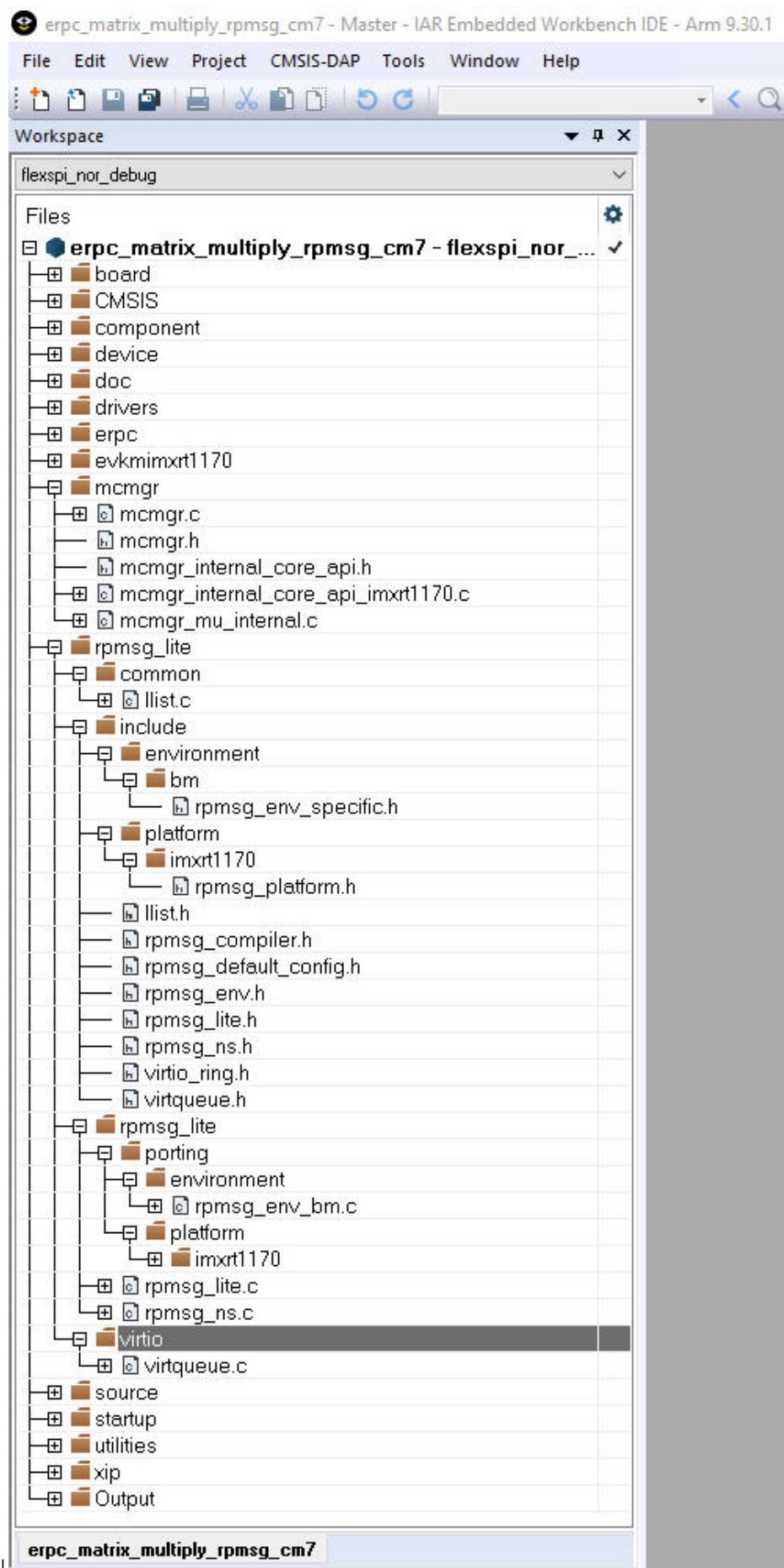
Parent topic: Multicore client application

Client multicore infrastructure files Because of the RPSMsg-Lite (transport layer), it is also necessary to include RPSMsg-Lite related files, which are in the following folder:

<MCUXpressoSDK_install_dir>/middleware/multicore/rpsmsg_lite/

The multicore example applications also use the Multicore Manager software library to control the secondary core startup and shutdown. These source files are located in the following folder:

<MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr/



Parent topic:Multicore client application

Client user code The client's user code is stored in the main_core0.c file, located in the following folder:

<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_example/erpc_matrix_multiply_rpmsg/cm7

The main_core0.c file contains the code for target board and eRPC initialization.

- After initialization, the secondary core is released from reset.
- When the secondary core is ready, the primary core initializes two matrix variables.
- The erpcMatrixMultiply eRPC function is called to issue the eRPC request and get the result.

It is possible to write the application-specific eRPC error handler. The eRPC error handler of the matrix multiply application is implemented in erpc_error_handler.h and erpc_error_handler.cpp files.

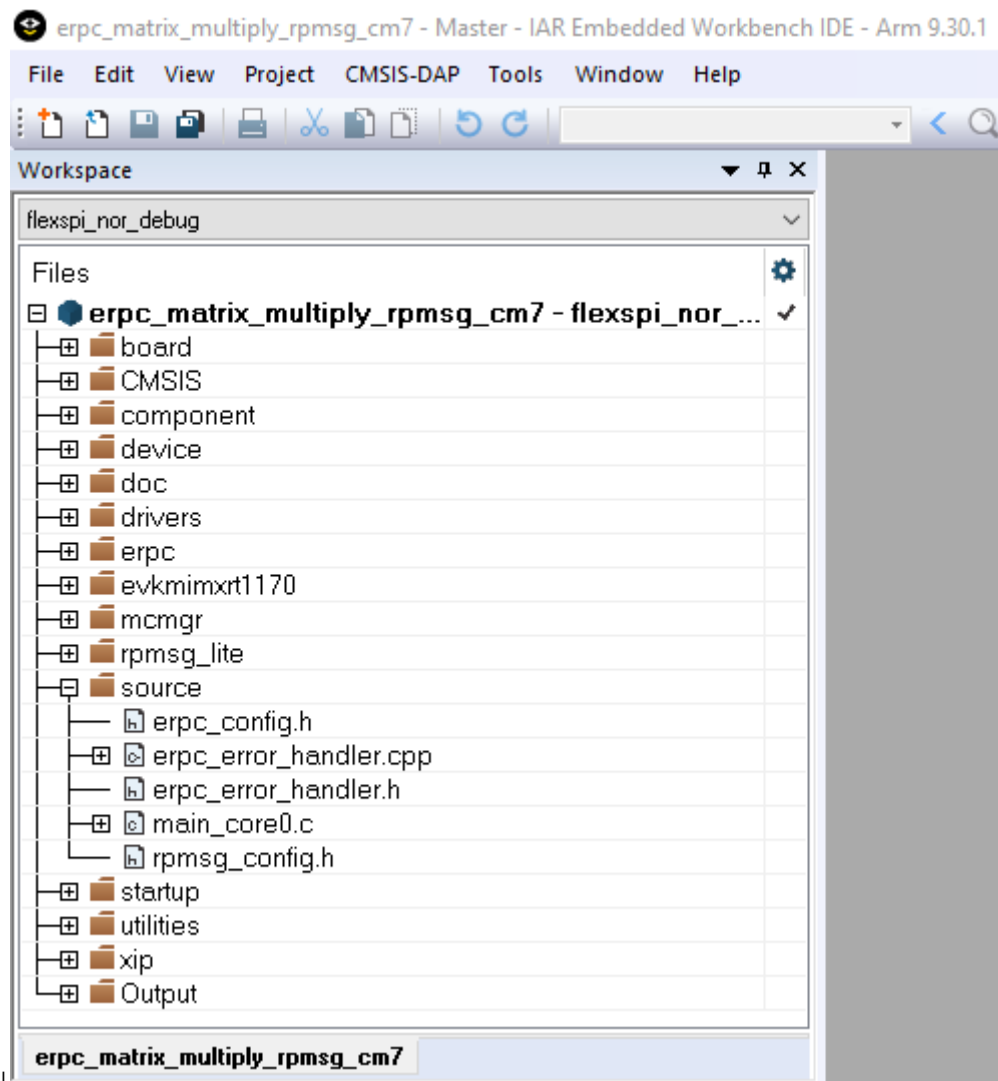
The matrix multiplication can be issued repeatedly, when pressing a software board button.

The eRPC-relevant code is captured in the following code snippet:

```
...
extern bool g_erpc_error_occurred;
...
/* Declare matrix arrays */
Matrix matrix1 = {0}, matrix2 = {0}, result_matrix = {0};
...
/* RPMsg-Lite transport layer initialization */
erpc_transport_t transport;
transport = erpc_transport_rpmsg_lite_master_init(src, dst,
ERPC_TRANSPORT_RPMSG_LITE_LINK_ID);
...
/* MessageBufferFactory initialization */
erpc_mbf_t message_buffer_factory;
message_buffer_factory = erpc_mbf_rpmsg_init(transport);
...
/* eRPC client side initialization */
erpc_client_t client;
client = erpc_client_init(transport, message_buffer_factory);
...
/* Set default error handler */
erpc_client_set_error_handler(client, erpc_error_handler);
...
while (1)
{
    /* Invoke the erpcMatrixMultiply function */
    erpcMatrixMultiply(matrix1, matrix2, result_matrix);
    ...
    /* Check if some error occurred in eRPC */
    if (g_erpc_error_occurred)
    {
        /* Exit program loop */
        break;
    }
    ...
}
```

Except for the application main file, there are configuration files for the RPMsg-Lite (rpmsg_config.h) and eRPC (erpc_config.h), located in the following folder:

<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg



Parent topic: Multicore client application

Parent topic: [Create an eRPC application](#)

Multiprocessor server application The “Matrix multiply” eRPC server project for multiprocessor applications is located in the `<MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_server_matrix_multiply_<transport_layer>` folder.

Most of the multiprocessor application setup is the same as for the multicore application. The multiprocessor server application requires server-related generated files (server shim code), server infrastructure files, and the server user code. There is no need for server multicore infrastructure files (MCMGR and RPMsg-Lite). The RPMsg-Lite transport layer is replaced either by SPI or UART transports. The following table shows the required transport-related files per each transport type.

SPI	<eRPC base directory>/erpc_c/setup/erpc_setup_(d)spi_slave.cpp
	<eRPC base directory>/erpc_c/transports/erpc_(d)spi_slave_transport.hpp
	<eRPC base directory>/erpc_c/transports/erpc_(d)spi_slave_transport.cpp
UART	<eRPC base directory>/erpc_c/setup/erpc_setup_uart_cmsis.cpp

<eRPC base directory>/erpc_c/transport/erpc_uart_cmsis_transport.hpp

<eRPC base directory>/erpc_c/transport/erpc_uart_cmsis_transport.cpp

|

Server user code The server's user code is stored in the main_server.c file, located in the <MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_server_matrix_multiply_<transport_layer>/ folder.

The eRPC-relevant code with UART as a transport is captured in the following code snippet:

```
/* erpcMatrixMultiply function user implementation */
void erpcMatrixMultiply(Matrix matrix1, Matrix matrix2, Matrix result_matrix)
{
    ...
}
int main()
{
    ...
    /* UART transport layer initialization, ERPC_DEMO_UART is the structure of CMSIS UART driver
    ↪operations */
    erpc_transport_t transport;
    transport = erpc_transport_cmsis_uart_init((void *)&ERPC_DEMO_UART);
    ...
    /* MessageBufferFactory initialization */
    erpc_mbf_t message_buffer_factory;
    message_buffer_factory = erpc_mbf_dynamic_init();
    ...
    /* eRPC server side initialization */
    erpc_server_t server;
    server = erpc_server_init(transport, message_buffer_factory);
    ...
    /* Adding the service to the server */
    erpc_service_t service = create_MatrixMultiplyService_service();
    erpc_add_service_to_server(server, service);
    ...
    while (1)
    {
        /* Process eRPC requests */
        erpc_status_t status = erpc_server_poll(server)
        /* handle error status */
        if (status != kErpcStatus_Success)
        {
            /* print error description */
            erpc_error_handler(status, 0);
            ...
        }
        ...
    }
}
```

Parent topic:Multiprocessor server application

Multiprocessor client application The “Matrix multiply” eRPC client project for multiprocessor applications is located in the <MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_client_matrix_multiply_<transport_layer>/iar/ folder.

Most of the multiprocessor application setup is the same as for the multicore application. The multiprocessor server application requires client-related generated files (server shim code),

client infrastructure files, and the client user code. There is no need for client multicore infrastructure files (MCMGR and RPSMsg-Lite). The RPSMsg-Lite transport layer is replaced either by SPI or UART transports. The following table shows the required transport-related files per each transport type.

SPI	<eRPC base directory>/erpc_c/setup/erpc_setup_(d)spi_master.cpp
<eRPC base directory>/erpc_c/	transports/ erpc_(d)spi_master_transport.hpp
<eRPC base directory>/erpc_c/	transports/ erpc_(d)spi_master_transport.cpp
UART	<eRPC base directory>/erpc_c/setup/erpc_setup_uart_cmsis.cpp
<eRPC base directory>/erpc_c/	transports/erpc_uart_cmsis_transport.hpp
<eRPC base directory>/erpc_c/	transports/erpc_uart_cmsis_transport.cpp

Client user code The client's user code is stored in the `main_client.c` file, located in the `<MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_client_matrix_multiply_<transport_layer>/` folder.

The eRPC-relevant code with UART as a transport is captured in the following code snippet:

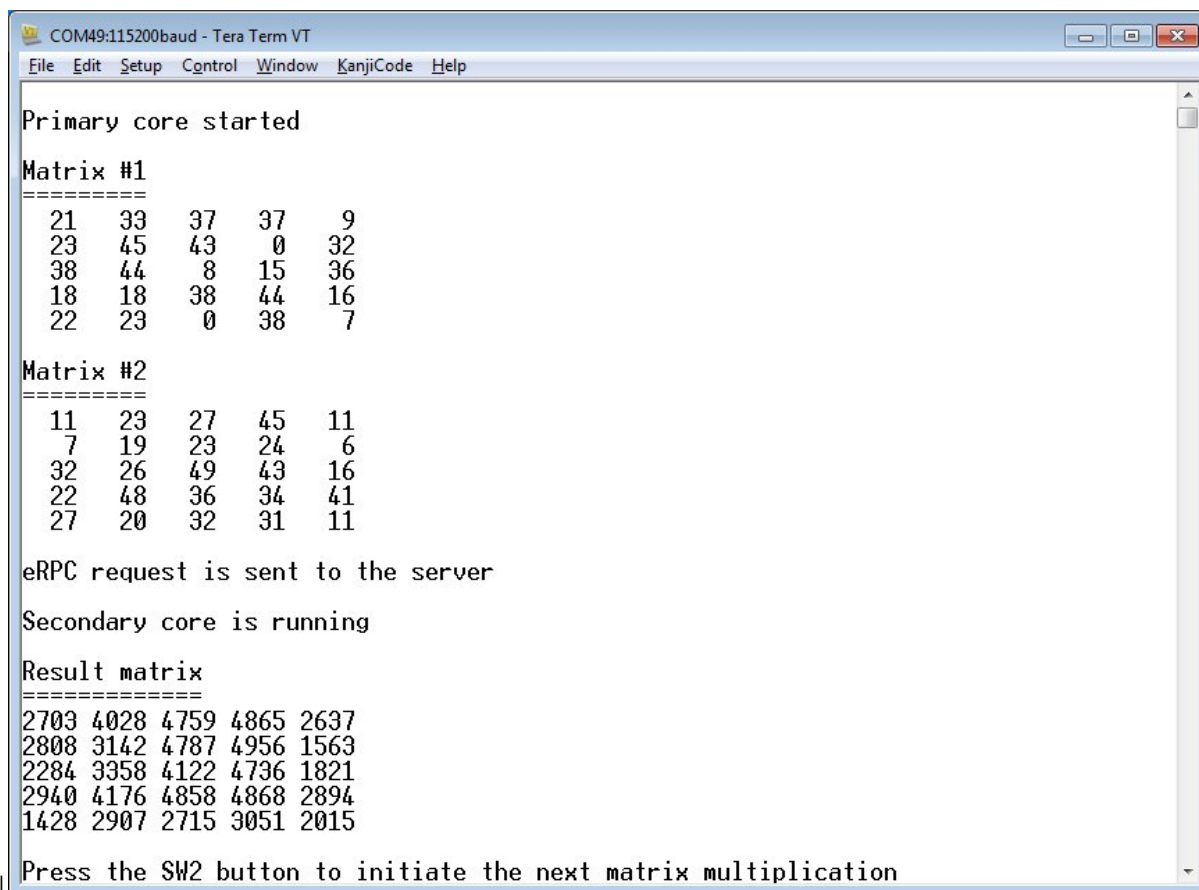
```
...
extern bool g_erpc_error_occurred;
...
/* Declare matrix arrays */
Matrix matrix1 = {0}, matrix2 = {0}, result_matrix = {0};
...
/* UART transport layer initialization, ERPC_DEMO_UART is the structure of CMSIS UART driver
↳operations */
erpc_transport_t transport;
transport = erpc_transport_cmsis_uart_init((void *)&ERPC_DEMO_UART);
...
/* MessageBufferFactory initialization */
erpc_mbf_t message_buffer_factory;
message_buffer_factory = erpc_mbf_dynamic_init();
...
/* eRPC client side initialization */
erpc_client_t client;
client = erpc_client_init(transport,message_buffer_factory);
...
/* Set default error handler */
erpc_client_set_error_handler(client, erpc_error_handler);
...
while (1)
{
    /* Invoke the erpcMatrixMultiply function */
    erpcMatrixMultiply(matrix1, matrix2, result_matrix);
    ...
    /* Check if some error occurred in eRPC */
    if (g_erpc_error_occurred)
    {
        /* Exit program loop */
        break;
    }
    ...
}
```

Parent topic:Multiprocessor client application

Parent topic:Multiprocessor server application

Parent topic:[Create an eRPC application](#)

Running the eRPC application Follow the instructions in *Getting Started with MCUXpresso SDK* (document MCUXSDKGSUG) (located in the <MCUXpressoSDK_install_dir>/docs folder), to load both the primary and the secondary core images into the on-chip memory, and then effectively debug the dual-core application. After the application is running, the serial console should look like:



```

COM49:115200baud - Tera Term VT
File Edit Setup Control Window KanjiCode Help

Primary core started

Matrix #1
=====
 21  33  37  37   9
 23  45  43   0  32
 38  44   8  15  36
 18  18  38  44  16
 22  23   0  38   7

Matrix #2
=====
 11  23  27  45  11
  7  19  23  24   6
 32  26  49  43  16
 22  48  36  34  41
 27  20  32  31  11

eRPC request is sent to the server

Secondary core is running

Result matrix
=====
2703 4028 4759 4865 2637
2808 3142 4787 4956 1563
2284 3358 4122 4736 1821
2940 4176 4858 4868 2894
1428 2907 2715 3051 2015

Press the SW2 button to initiate the next matrix multiplication

```

For multiprocessor applications that are running between PC and the target evaluation board or between two boards, follow the instructions in the accompanied example readme files that provide details about the proper board setup and the PC side setup (Python).

Parent topic:[Create an eRPC application](#)

Parent topic:[eRPC example](#)

Other uses for an eRPC implementation The eRPC implementation is generic, and its use is not limited to just embedded applications. When creating an eRPC application outside the embedded world, the same principles apply. For example, this manual can be used to create an eRPC application for a PC running the Linux operating system. Based on the used type of transport medium, existing transport layers can be used, or new transport layers can be implemented.

For more information and erpc updates see the github.com/EmbeddedRPC.

Note about the source code in the document Example code shown in this document has the following copyright and BSD-3-Clause license:

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Changelog eRPC All notable changes to this project will be documented in this file.

The format is based on [Keep a Changelog](#), and this project adheres to [Semantic Versioning](#).

Unreleased

Added

Fixed

- Python code of the eRPC infrastructure was updated to match the proper python code style, add type annotations and improve readability.

1.14.0

Added

- Added Cmake/Kconfig support.
- Made java code jdk11 compliant, GitHub PR #432.
- Added imxrt1186 support into mu transport layer.
- erpcgen: Added assert for listType before usage, GitHub PR #406.

Fixed

- eRPC: Sources reformatted.
- erpc: Fixed typo in semaphore get (mutex -> semaphore), and write it can fail in case of timeout, GitHub PR #446.
- erpc: Free the arbitrated client token from client manager, GitHub PR #444.

- erpc: Fixed Makefile, install the erpc_simple_server header, GitHub PR #447.
- erpc_python: Fixed possible AttributeError and OSError on calling TCPTransport.close(), GitHub PR #438.
- Examples and tests consolidated.

1.13.0

Added

- erpc: Add BSD-3 license to endianness agnostic files, GitHub PR #417.
- eRPC: Add new Zephyr-related transports (zephyr_uart, zephyr_mbox).
- eRPC: Add new Zephyr-related examples.

Fixed

- eRPC,erpcgen: Fixing/improving markdown files, GitHub PR #395.
- eRPC: Fix Python client TCPTransports not being able to close, GitHub PR #390.
- eRPC,erpcgen: Align switch brackets, GitHub PR #396.
- erpc: Fix zephyr uart transport, GitHub PR #410.
- erpc: UART ZEPHYR Transport stop to work after a few transactions when using USB-CDC resolved, GitHub PR #420.

Removed

- eRPC,erpcgen: Remove cstbool library, GitHub PR #403.

1.12.0

Added

- eRPC: Add dynamic/static option for transport init, GitHub PR #361.
- eRPC,erpcgen: Winsock2 support, GitHub PR #365.
- eRPC,erpcgen: Feature/support multiple clients, GitHub PR #271.
- eRPC,erpcgen: Feature/buffer head - Framed transport header data stored in Message-Buffer, GitHub PR #378.
- eRPC,erpcgen: Add experimental Java support.

Fixed

- eRPC: Fix receive error value for spidev, GitHub PR #363.
- eRPC: UartTransport::init adaptation to changed driver.
- eRPC: Fix typo in assert, GitHub PR #371.
- eRPC,erpcgen: Move enums to enum classes, GitHub PR #379.
- eRPC: Fixed rpmsg tty transport to work with serial transport, GitHub PR #373.

1.11.0

Fixed

- eRPC: Makefiles update, GitHub PR #301.
- eRPC: Resolving warnings in Python, GitHub PR #325.
- eRPC: Python3.8 is not ready for usage of typing.Any type, GitHub PR #325.
- eRPC: Improved codec function to use reference instead of address, GitHub PR #324.
- eRPC: Fix NULL check for pending client creation, GitHub PR #341.
- eRPC: Replace sprintf with snprintf, GitHub PR #343.
- eRPC: Use MU_SendMsg blocking call in MU transport.
- eRPC: New LPSPI and LPI2C transport layers.
- eRPC: Freeing static objects, GitHub PR #353.
- eRPC: Fixed casting in deinit functions, GitHub PR #354.
- eRPC: Align LIBUSB_SIO.GetNumPorts API use with libusb_sio python module v. 2.1.11.
- erpcgen: Renamed temp variable to more generic one, GitHub PR #321.
- erpcgen: Add check that string read is not more than max length, GitHub PR #328.
- erpcgen: Move to g++ in pytest, GitHub PR #335.
- erpcgen: Use build=release for make, GitHub PR #334.
- erpcgen: Removed boost dependency, GitHub PR #346.
- erpcgen: Mingw support, GitHub PR #344.
- erpcgen: VS build update, GitHub PR #347.
- erpcgen: Modified name for common types macro scope, GitHub PR #337.
- erpcgen: Fixed memcpy for template, GitHub PR #352.
- eRPC,erpcgen: Change default build target to release + adding artefacts, GitHub PR #334.
- eRPC,erpcgen: Remove redundant includes, GitHub PR #338.
- eRPC,erpcgen: Many minor code improvements, GitHub PR #323.

1.10.0

Fixed

- eRPC: MU transport layer switched to blocking MU_SendMsg() API use.

1.10.0

Added

- eRPC: Add TCP_NODELAY option to python, GitHub PR #298.

Fixed

- eRPC: MUPort adaptation to new supported SoCs.
- eRPC: Simplifying CI with installing dependencies using shell script, GitHub PR #267.
- eRPC: Using event for waiting for sock connection in TCP python server, formatting python code, C specific includes, GitHub PR #269.
- eRPC: Endianness agnostic update, GitHub PR #276.
- eRPC: Assertion added for functions which are returning status on freeing memory, GitHub PR #277.
- eRPC: Fixed closing arbitrator server in unit tests, GitHub PR #293.
- eRPC: Makefile updated to reflect the correct header names, GitHub PR #295.
- eRPC: Compare value length to used length() in reading data from message buffer, GitHub PR #297.
- eRPC: Replace EXPECT_TRUE with EXPECT_EQ in unit tests, GitHub PR #318.
- eRPC: Adapt rpmsg_lite based transports to changed rpmsg_lite_wait_for_link_up() API parameters.
- eRPC, erpcgen: Better distinguish which file can and cannot be linked by C linker, GitHub PR #266.
- eRPC, erpcgen: Stop checking if pointer is NULL before sending it to the erpc_free function, GitHub PR #275.
- eRPC, erpcgen: Changed api to count with more interfaces, GitHub PR #304.
- erpcgen: Check before reading from heap the buffer boundaries, GitHub PR #287.
- erpcgen: Several fixes for tests and CI, GitHub PR #289.
- erpcgen: Refactoring erpcgen code, GitHub PR #302.
- erpcgen: Fixed assigning const value to enum, GitHub PR #309.
- erpcgen: Enable runTesttest_enumErrorCode_allDirection, serialize enums as int32 instead of uint32.

1.9.1

Fixed

- eRPC: Construct the USB CDC transport, rather than a client, GitHub PR #220.
- eRPC: Fix premature import of package, causing failure when attempting installation of Python library in a clean environment, GitHub PR #38, #226.
- eRPC: Improve python detection in make, GitHub PR #225.
- eRPC: Fix several warnings with deprecated call in pytest, GitHub PR #227.
- eRPC: Fix freeing union members when only default need be freed, GitHub PR #228.
- eRPC: Fix making test under Linux, GitHub PR #229.
- eRPC: Assert costumizing, GitHub PR #148.
- eRPC: Fix corrupt clientList bug in TransportArbitrator, GitHub PR #199.
- eRPC: Fix build issue when invoking g++ with -Wno-error=free-nonheap-object, GitHub PR #233.
- eRPC: Fix inout cases, GitHub PR #237.

- eRPC: Remove ERPC_PRE_POST_ACTION dependency on return type, GitHub PR #238.
- eRPC: Adding NULL to ptr when codec function failed, fixing memcpy when fail is present during deserialization, GitHub PR #253.
- eRPC: MessageBuffer usage improvement, GitHub PR #258.
- eRPC: Get rid of serial and enum34 dependency (enum34 is in python3 since 3.4 (from 2014)), GitHub PR #247.
- eRPC: Several MISRA violations addressed.
- eRPC: Fix timeout for Freertos semaphore, GitHub PR #251.
- eRPC: Use of rpmsg_lite_wait_for_link_up() in rpmsg_lite based transports, GitHub PR #223.
- eRPC: Fix codec nullptr dereferencing, GitHub PR #264.
- erpcgen: Fix two syntax errors in erpcgen Python output related to non-encapsulated unions, improved test for union, GitHub PR #206, #224.
- erpcgen: Fix serialization of list/binary types, GitHub PR #240.
- erpcgen: Fix empty list parsing, GitHub PR #72.
- erpcgen: Fix templates for malloc errors, GitHub PR #110.
- erpcgen: Get rid of encapsulated union declarations in global scale, improve enum usage in unions, GitHub PR #249, #250.
- erpcgen: Fix compile error:UniqueIdChecker.cpp:156:104:'sort' was not declared, GitHub PR #265.

1.9.0

Added

- eRPC: Allow used LIBUSBSIO device index being specified from the Python command line argument.

Fixed

- eRPC: Improving template usage, GitHub PR #153.
- eRPC: run_clang_format.py cleanup, GitHub PR #177.
- eRPC: Build TCP transport setup code into liberpc, GitHub PR #179.
- eRPC: Fix multiple definitions of g_client error, GitHub PR #180.
- eRPC: Fix memset past end of buffer in erpc_setup_mbf_static.cpp, GitHub PR #184.
- eRPC: Fix deprecated error with newer pytest version, GitHub PR #203.
- eRPC, erpcgen: Static allocation support and usage of rpmsg static FreeRTOSs related API, GitHub PR #168, #169.
- erpcgen: Remove redundant module imports in erpcgen, GitHub PR #196.

1.8.1

Added

- eRPC: New i2c_slave_transport transport introduced.

Fixed

- eRPC: Fix misra erpc c, GitHub PR #158.
- eRPC: Allow conditional compilation of message_loggers and pre_post_action.
- eRPC: (D)SPI slave transports updated to avoid busy loops in rtos environments.
- erpcgen: Re-implement EnumMember::hasValue(), GitHub PR #159.
- erpcgen: Fixing several misra issues in shim code, erpcgen and unit tests updated, GitHub PR #156.
- erpcgen: Fix bison file, GitHub PR #156.

1.8.0

Added

- eRPC: Support win32 thread, GitHub PR #108.
- eRPC: Add mbed support for malloc() and free(), GitHub PR #92.
- eRPC: Introduced pre and post callbacks for eRPC call, GitHub PR #131.
- eRPC: Introduced new USB CDC transport.
- eRPC: Introduced new Linux spidev-based transport.
- eRPC: Added formatting extension for VSC, GitHub PR #134.
- erpcgen: Introduce ustring type for unsigned char and force cast to char*, GitHub PR #125.

Fixed

- eRPC: Update makefile.
- eRPC: Fixed warnings and error with using MessageLoggers, GitHub PR #127.
- eRPC: Extend error msg for python server service handle function, GitHub PR #132.
- eRPC: Update CMSIS UART transport layer to avoid busy loops in rtos environments, introduce semaphores.
- eRPC: SPI transport update to allow usage without handshaking GPIO.
- eRPC: Native _WIN32 erpc serial transport and threading.
- eRPC: Arbitrator deadlock fix, TCP transport updated, TCP setup functions introduced, GitHub PR #121.
- eRPC: Update of matrix_multiply.py example: Add -serial and -baud argument, GitHub PR #137.
- eRPC: Update of .clang-format, GitHub PR #140.
- eRPC: Update of erpc_framed_transport.cpp: return error if received message has zero length, GitHub PR #141.
- eRPC, erpcgen: Fixed error messages produced by -Wall -Wextra -Wshadow -pedantic-errors compiler flags, GitHub PR #136, #139.
- eRPC, erpcgen: Core re-formatted using Clang version 10.
- erpcgen: Enable deallocation in server shim code when callback/function pointer used as out parameter in IDL.
- erpcgen: Removed '\$' character from generated symbol name in '_\$union' suffix, GitHub PR #103.

- erpcgen: Resolved mismatch between C++ and Python for callback index type, GitHub PR #111.
- erpcgen: Python generator improvements, GitHub PR #100, #118.
- erpcgen: Fixed error messages produced by -Wall -Wextra -Wshadow -pedantic-errors compiler flags, GitHub PR #136.

1.7.4

Added

- eRPC: Support MU transport unit testing.
- eRPC: Adding mbed os support.

Fixed

- eRPC: Unit test code updated to handle service add and remove operations.
- eRPC: Several MISRA issues in rpmsg-based transports addressed.
- eRPC: Fixed Linux/TCP acceptance tests in release target.
- eRPC: Minor documentation updates, code formatting.
- erpcgen: Whitespace removed from C common header template.

1.7.3

Fixed

- eRPC: Improved the test_callbacks logic to be more understandable and to allow requested callback execution on the server side.
- eRPC: TransportArbitrator::prepareClientReceive modified to avoid incorrect return value type.
- eRPC: The ClientManager and the ArbitratedClientManager updated to avoid performing client requests when the previous serialization phase fails.
- erpcgen: Generate the shim code for destroy of statically allocated services.

1.7.2

Added

- eRPC: Add missing doxygen comments for transports.

Fixed

- eRPC: Improved support of const types.
- eRPC: Fixed Mac build.
- eRPC: Fixed serializing python list.
- eRPC: Documentation update.

1.7.1

Fixed

- eRPC: Fixed semaphore in static message buffer factory.
- erpcgen: Fixed MU received error flag.
- erpcgen: Fixed tcp transport.

1.7.0

Added

- eRPC: List names are based on their types. Names are more deterministic.
- eRPC: Service objects are as a default created as global static objects.
- eRPC: Added missing doxygen comments.
- eRPC: Added support for 64bit numbers.
- eRPC: Added support of program language specific annotations.

Fixed

- eRPC: Improved code size of generated code.
- eRPC: Generating crc value is optional.
- eRPC: Fixed CMSIS Uart driver. Removed dependency on KSDK.
- eRPC: Forbid users use reserved words.
- eRPC: Removed outByref for function parameters.
- eRPC: Optimized code style of callback functions.

1.6.0

Added

- eRPC: Added @nullable support for scalar types.

Fixed

- eRPC: Improved code size of generated code.
- eRPC: Improved eRPC nested calls.
- eRPC: Improved eRPC list length variable serialization.

1.5.0

Added

- eRPC: Added support for unions type non-wrapped by structure.
- eRPC: Added callbacks support.
- eRPC: Added support @external annotation for functions.
- eRPC: Added support @name annotation.
- eRPC: Added Messaging Unit transport layer.
- eRPC: Added RPMSG Lite RTOS TTY transport layer.
- eRPC: Added version verification and IDL version verification between eRPC code and eRPC generated shim code.
- eRPC: Added support of shared memory pointer.
- eRPC: Added annotation to forbid generating const keyword for function parameters.
- eRPC: Added python matrix multiply example.
- eRPC: Added nested call support.
- eRPC: Added struct member “byref” option support.
- eRPC: Added support of forward declarations of structures
- eRPC: Added Python RPMsg Multiendpoint kernel module support
- eRPC: Added eRPC sniffer tool

1.4.0

Added

- eRPC: New RPMsg-Lite Zero Copy (RPMsgZC) transport layer.

Fixed

- eRPC: win_flex_bison.zip for windows updated.
- eRPC: Use one codec (instead of inCodec outCodec).

[1.3.0]

Added

- eRPC: New annotation types introduced (@length, @max_length, ...).
- eRPC: Support for running both erpc client and erpc server on one side.
- eRPC: New transport layers for (LP)UART, (D)SPI.
- eRPC: Error handling support.

[1.2.0]

Added

- eRPC source directory organization changed.
- Many eRPC improvements.

[1.1.0]

Added

- Multicore SDK 1.1.0 ported to KSDK 2.0.0.

[1.0.0]

Added

- Initial Release

Chapter 4

RTOS

4.1 FreeRTOS

4.1.1 FreeRTOS kernel

Open source RTOS kernel for small devices.

[FreeRTOS kernel for MCUXpresso SDK Readme](#)

[FreeRTOS kernel for MCUXpresso SDK ChangeLog](#)

[FreeRTOS kernel Readme](#)

4.1.2 FreeRTOS drivers

This is set of NXP provided FreeRTOS reentrant bus drivers.

4.1.3 backoffalgorithm

Algorithm for calculating exponential backoff with jitter for network retry attempts.

[Readme](#)

4.1.4 corehttp

C language HTTP client library designed for embedded platforms.

4.1.5 corejson

JSON parser.

Readme

4.1.6 coremqtt

MQTT publish/subscribe messaging library.

4.1.7 corepkcs11

PKCS #11 key management library.

Readme

4.1.8 freertos-plus-tcp

Open source RTOS FreeRTOS Plus TCP.

Readme