MCUXpresso SDK Documentation

Release 25.09.00-pvw2

NXP
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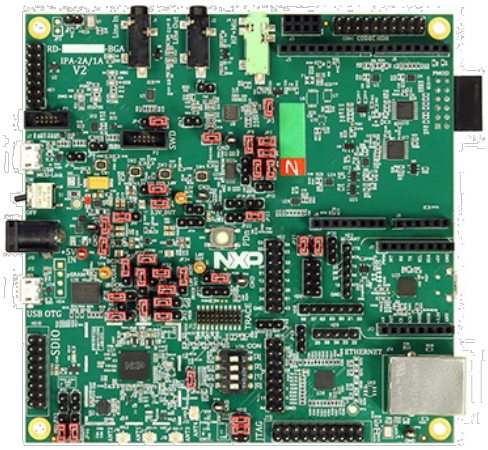
Table of contents

This documentation contains information specific to the rdrw612bga board.

Chapter 1

RD-RW612-BGA

1.1 Overview



MCU device and part on board is shown below:

- Device: RW612
- PartNumber: RW612ETA2I

1.2 Getting Started with MCUXpresso SDK Package

1.2.1 Getting Started with Package

- Overview
- MCUXpresso SDK board support package folders
  - Example application structure
  - Locating example application source files
- Run a demo using MCUXpresso IDE
  - Select the workspace location
  - Build an example application
  - Run an example application
- Run a demo application using IAR

  - Build an example application
  - Run an example application
  - IAR RAM debugging notes
- Run a demo using Arm GCC
  - Set up toolchain
    - Install GCC ARM Embedded tool chain
    - Install MinGW
    - Add a new system environment variable for ARMGCC_DIR
    - Install CMake
  - Build a demo application
  - Run a demo application
- Run a demo using Keil MDK/µVision
  - Install CMSIS device pack
  - Build an example application
  - Run an example application
- MCUXpresso IDE New Project Wizard
- How to determine COM port
- How to define IRQ handler in CPP files
- Default debug interfaces
- Updating debugger firmware
  - Updating OpenSDA firmware
  - Updating MCU-Link firmware

1.3 Getting Started with MCUXpresso SDK GitHub

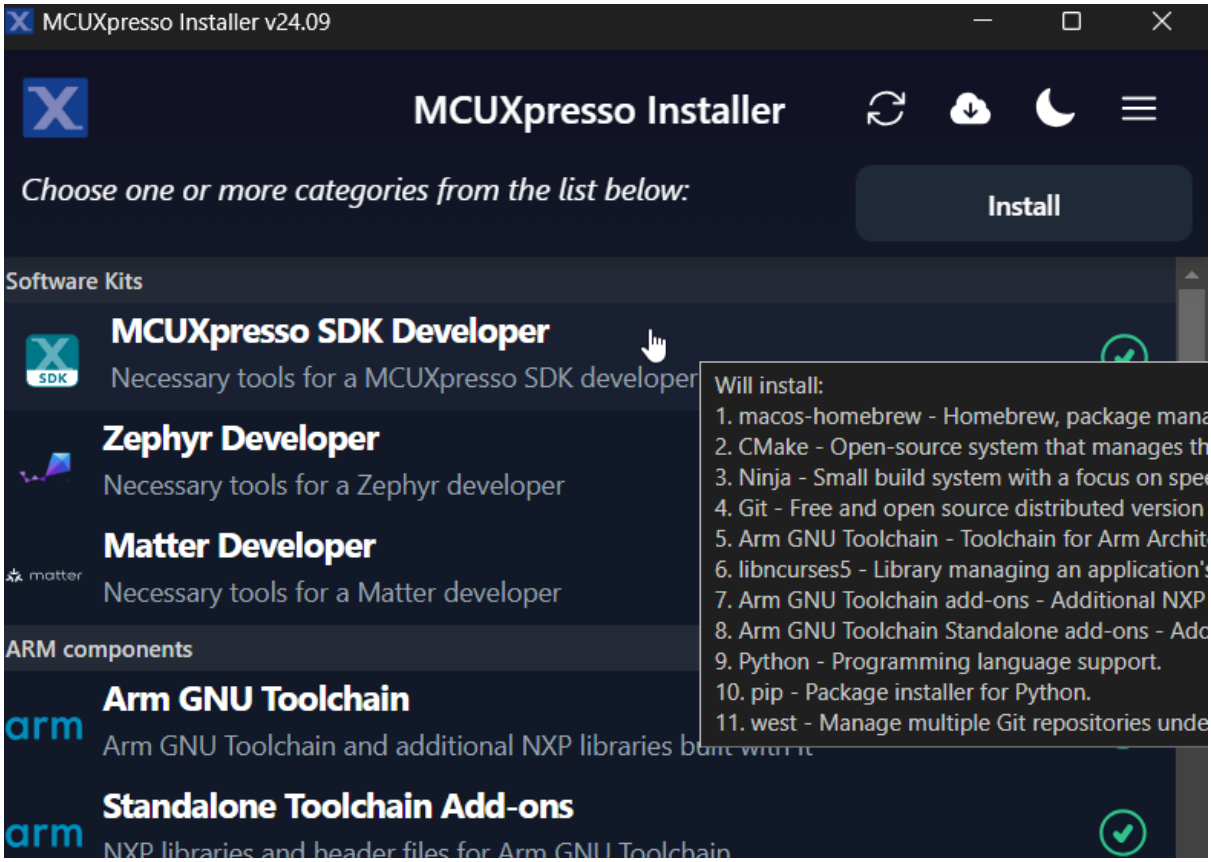
1.3.1 Getting Started with MCUXpresso SDK Repository

Installation

NOTE

If the installation instruction asks/selects whether to have the tool installation path added to the PATH variable, agree/select the choice. This option ensures that the tool can be used in any terminal in any path. *Verify the installation* after each tool installation.

Install Prerequisites with MCUXpresso Installer The MCUXpresso Installer offers a quick and easy way to install the basic tools needed. The MCUXpresso Installer can be obtained from https://github.com/nxp-mcuxpresso/vscode-for-mcux/wiki/Dependency-Installation. The MCUXpresso Installer is an automated installation process, simply select MCUXpresso SDK Developer from the menu and click install. If you prefer to install the basic tools manually, refer to the next section.



Alternative: Manual Installation

Basic tools

Git Git is a free and open source distributed version control system. Git is designed to handle everything from small to large projects with speed and efficiency. To install Git, visit the official Git website. Download the appropriate version(you may use the latest one) for your operating system (Windows, macOS, Linux). Then run the installer and follow the installation instructions.

User `git --version` to check the version if you have a version installed.

Then configure your username and email using the commands:

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

Python Install python 3.10 or latest. Follow the Python Download guide.

Use `python --version` to check the version if you have a version installed.

West Please use the west version equal or greater than 1.2.0

```
# Note: you can add option '--default-timeout=1000' if you meet connection issue. Or you may set a different␣
↪source using option '-i'.
# for example, in China you could try: pip install -U west -i https://pypi.tuna.tsinghua.edu.cn/simple
pip install -U west
```

Build And Configuration System

CMake It is strongly recommended to use CMake version equal or later than 3.30.0. You can get latest CMake distributions from the official CMake download page.

For Windows, you can directly use the .msi installer like cmake-3.31.4-windows-x86_64.msi to install.

For Linux, CMake can be installed using the system package manager or by getting binaries from the official CMake download page.

After installation, you can use cmake --version to check the version.

Ninja Please use the ninja version equal or later than 1.12.1.

By default, Windows comes with the Ninja program. If the default Ninja version is too old, you can directly download the ninja binary and register the ninja executor location path into your system path variable to work.

For Linux, you can use your system package manager or you can directly download the ninja binary to work.

After installation, you can use ninja --version to check the version.

Kconfig MCUXpresso SDK uses Kconfig python implementation. We customize it based on our needs and integrate it into our build and configuration system. The Kconfiglib sources are placed under mcuxsdk/scripts/kconfig folder.

Please make sure *python* environment is setup ready then you can use the Kconfig.

Ruby Our build system supports IDE project generation for iar, mdk, codewarrior and xtensa to provide OOBE from build to debug. This feature is implemented with ruby. You can follow the guide ruby environment setup to setup the ruby environment. Since we provide a built-in portable ruby, it is just a simple one cmd installation.

If you only work with CLI, you can skip this step.

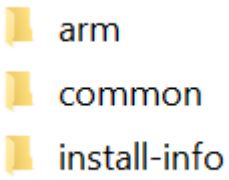
Toolchain MCUXpresso SDK supports all mainstream toolchains for embedded development. You can install your used or interested toolchains following the guides.

Toolchain	Download and Installation Guide	Note
Armgcc	Arm GNU Toolchain Install Guide	ARMGCC is default toolchain
IAR	IAR Installation and Licensing quick reference guide	
MDK	MDK Installation	
Armclang	Installing Arm Compiler for Embedded	
Zephyr	Zephyr SDK	
Codewarrior	NXP CodeWarrior	
Xtensa	Tensilica Tools	
NXP S32Compiler RISC-V Zen-V	NXP Website	

After you have installed the toolchains, register them in the system environment variables. This will allow the west build to recognize them:

Toolchain	Environment Variable	Example	Cmd Line Argument
Armgcc	ARMGCC_DIR	C:\armgcc for windows/usr for Linux. Typically arm-none-eabi-* is installed under /usr/bin	–toolchain armgcc
IAR	IAR_DIR	C:\iar\ewarm-9.60.3 for Windows/opt/iarsystems/bxarm-9.60.3 for Linux	–toolchain iar
MDK	MDK_DIR	C:\Keil_v5 for Windows.MDK IDE is not officially supported with Linux.	–toolchain mdk
Armclang	ARMCLANG_DIR	C:\ArmCompilerforEmbedded6.22 for Windows/opt/ArmCompilerforEmbedded6.21 for Linux	–toolchain mdk
Zephyr	ZEPHYR_SDK	c:\NXP\zephyr-sdk-<version> for windows/opt/zephyr-sdk-<version> for Linux	–toolchain zephyr
CodeWarrior	CW_DIR	C:\Freescale\CW MCU v11.2 for windowsCodeWarrior is not supported with Linux	–toolchain codewarrior
Xtensa	XCC_DIR	C:\xtensa\XtDevTools\install\tools\RI-2023.11-win32\XtensaTools for windows/opt/xtensa/XtDevTools/install/tools/RI-2023.11-Linux/XtensaTools for Linux	–toolchain xtensa
NXP S32Compiler RISC-V Zen-V	RISCVLLVM_DIR	C:\riscv-llvm-win32_b298_b298_2024.08.12 for Windows/opt/riscv-llvm-Linux-x64_b298_b298_2024.08.12 for Linux	–toolchain riscvllvm

- The <toolchain>_DIR is the root installation folder, not the binary location folder. For IAR, it is directory containing following installation folders:



- MDK IDE using armclang toolchain only officially supports Windows. In Linux, please directly use armclang toolchain by setting ARMCLANG_DIR. In Windows, since most Keil users will install MDK IDE instead of standalone armclang toolchain, the MDK_DIR has higher priority than ARMCLANG_DIR.
- For Xtensa toolchain, please set the XTENSA_CORE environment variable. Here's an example list:

Device Core	XTENSA_CORE
RT500 fusion1	nxp_rt500_RI23_11_newlib
RT600 hifi4	nxp_rt600_RI23_11_newlib
RT700 hifi1	rt700_hifi1_RI23_11_nlib
RT700 hifi4	t700_hifi4_RI23_11_nlib
i.MX8ULP fusion1	fusion_nxp02_dsp_prod

- In Windows, the short path is used in environment variables. If any toolchain is using the long path, you can open a command window from the toolchain folder and use below command to get the short path: for %i in (.) do echo %~fsi

Tool installation check Once installed, open a terminal or command prompt and type the associated command to verify the installation.

If you see the version number, you have successfully installed the tool. Else, check whether the tool's installation path is added into the PATH variable. You can add the installation path to the PATH with the commands below:

- Windows: Open command prompt or powershell, run below command to show the user PATH variable.

```
reg query HKEY_CURRENT_USER\Environment /v PATH
```

The tool installation path should be C:\Users\xxx\AppData\Local\Programs\Git\cmd. If the path is not seen in the output from above, append the path value to the PATH variable with the command below:

```
reg add HKEY_CURRENT_USER\Environment /v PATH /d "%PATH%;C:\Users\xxx\AppData\
↪Local\Programs\Git\cmd"
```

Then close the command prompt or powershell and verify the tool command again.

- Linux:
  1. Open the $HOME/.bashrc file using a text editor, such as vim.
  2. Go to the end of the file.
  3. Add the line which appends the tool installation path to the PATH variable and export PATH at the end of the file. For example, export PATH="/Directory1:$PATH".
  4. Save and exit.
  5. Execute the script with source .bashrc or reboot the system to make the changes live. To verify the changes, run echo $PATH.
- macOS:
  1. Open the $HOME/.bash_profile file using a text editor, such as nano.
  2. Go to the end of the file.
  3. Add the line which appends the tool installation path to the PATH variable and export PATH at the end of the file. For example, export PATH="/Directory1:$PATH".
  4. Save and exit.
  5. Execute the script with source .bash_profile or reboot the system to make the changes live. To verify the changes, run echo $PATH.

Get MCUXpresso SDK Repo

Establish SDK Workspace To get the MCUXpresso SDK repository, use the west tool to clone the manifest repository and checkout all the west projects.

```
# Initialize west with the manifest repository
west init -m https://github.com/nxp-mcuxpresso/mcuxsdk-manifests/ mcuxpresso-sdk

# Update the west projects
cd mcuxpresso-sdk
west update

# Allow the usage of west extensions provided by MCUXpresso SDK
west config commands.allow_extensions true
```

Install Python Dependency(If do tool installation manually) To create a Python virtual environment in the west workspace core repo directory mcuxsdk, follow these steps:

1. Navigate to the core directory:

   ```
   cd mcuxsdk
   ```

2. [Optional] Create and activate the virtual environment: If you don't want to use the python virtual environment, skip this step. **We strongly suggest you use venv to avoid conflicts with other projects using python.**

   ```
   python -m venv .venv

   # For Linux/MacOS
   source .venv/bin/activate

   # For Windows
   .\.venv\Scripts\activate
   # If you are using powershell and see the issue that the activate script cannot be run.
   # You may fix the issue by opening the powershell as administrator and run below command:
   powershell Set-ExecutionPolicy RemoteSigned
   # then run above activate command again.
   ```

   Once activated, your shell will be prefixed with (.venv). The virtual environment can be deactivated at any time by running deactivate command.

   Remember to activate the virtual environment every time you start working in this directory. If you are using some modern shell like zsh, there are some powerful plugins to help you auto switch venv among workspaces. For example, zsh-autoswitch-virtualenv.

3. Install the required Python packages:

   ```
   # Note: you can add option '--default-timeout=1000' if you meet connection issue. Or you may set a␣
   ↪different source using option '-i'.
   # for example, in China you could try: pip3 install -r mcuxsdk/scripts/requirements.txt -i https://pypi.
   ↪tuna.tsinghua.edu.cn/simple
   pip install -r scripts/requirements.txt
   ```

Explore Contents

This section helps you build basic understanding of current fundamental project content and guides you how to build and run the provided example project in whole SDK delivery.

Folder View The whole MCUXpresso SDK project, after you have done the west init and west update operations follow the guideline at *Getting Started Guide*, have below folder structure:

Folder	Description
manifests	Manifest repo, contains the manifest file to initialize and update the west workspace.
mcuxsdk	The MCUXpresso SDK source code, examples, middleware integration and script files.

All the projects record in the Manifest repo are checked out to the folder mcuxsdk/, the layout of mcuxsdk folder is shown as below:

Folder	Description
arch	Arch related files such as ARM CMSIS core files, RISC-V files and the build files related to the architecture.
cmake	The cmake modules, files which organize the build system.
components	Software components.
devices	Device support package which categorized by device series. For each device, header file, feature file, startup file and linker files are provided, also device specific drivers are included.
docs	Documentation source and build configuration for this sphinx built online documentation.
drivers	Peripheral drivers.
examples	Various demos and examples, support files on different supported boards. For each board support, there are board configuration files.
middleware	Middleware components integrated into SDK.
rtos	Rtos components integrated into SDK.
scripts	Script files for the west extension command and build system support.
svd	Svd files for devices, this is optional because of large size. Customers run west manifest config group.filter +optional and west update mcux-soc-svd to get this folder.

Examples Project The examples project is part of the whole SDK delivery, and locates in the folder mcuxsdk/examples of west workspace.

Examples files are placed in folder of <example_category>, these examples include (but are not limited to)

- demo_apps: Basic demo set to start using SDK, including hello_world and led_blinky.
- driver_examples: Simple applications that show how to use the peripheral drivers for a single use case. These applications typically only use a single peripheral but there are cases where multiple peripherals are used (for example, SPI transfer using DMA).

Board porting layers are placed in folder of _boards/<board_name> which aims at providing the board specific parts for examples code mentioned above.

Run a demo using MCUXpresso for VS Code

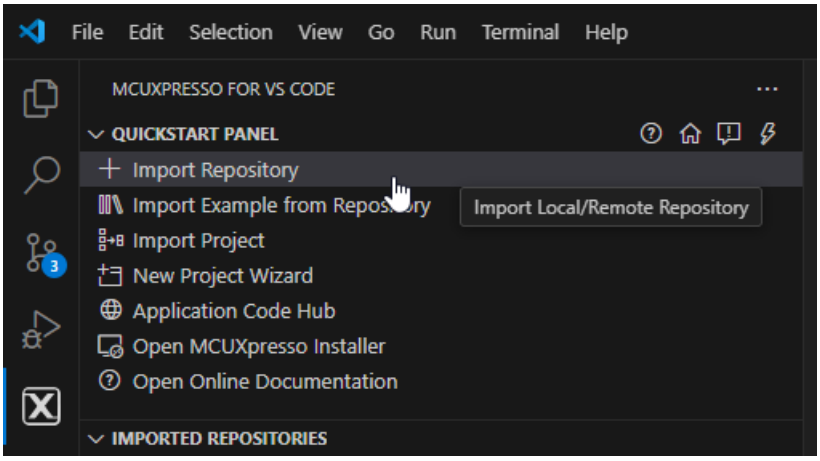
This section explains how to configure MCUXpresso for VS Code to build, run, and debug example applications. This guide uses the hello_world demo application as an example. However, these

steps can be applied to any example application in the MCUXpresso SDK.

Build an example application This section assumes that the user has already obtained the SDK as outlined in *Get MCUXpresso SDK Repo*.

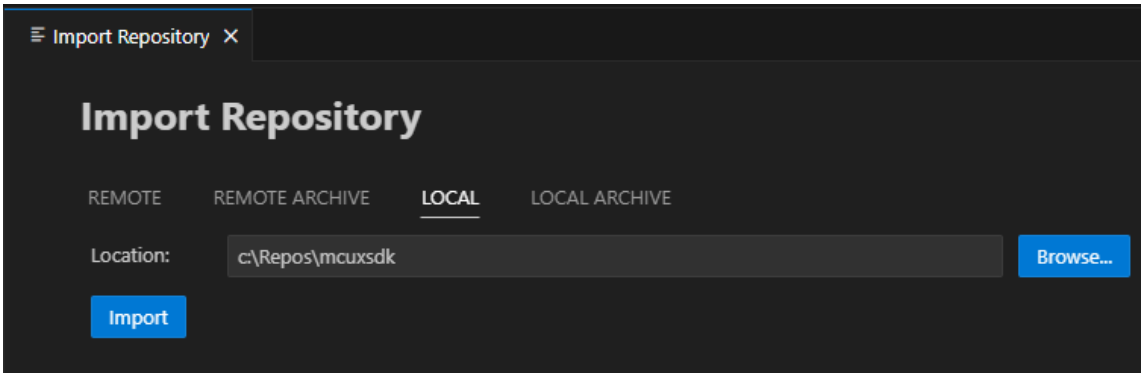
To build an example application:

1. Import the SDK into your workspace. Click **Import Repository** from the **QUICKSTART PANEL**.

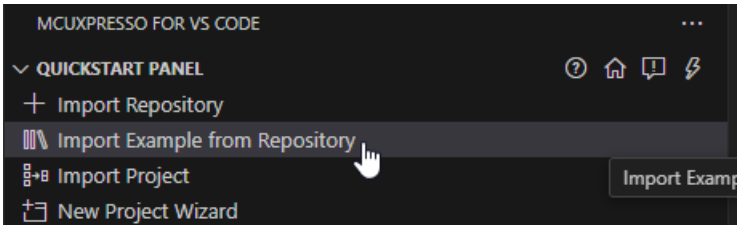


Note: You can import the SDK in several ways. Refer to MCUXpresso for VS Code Wiki for details.

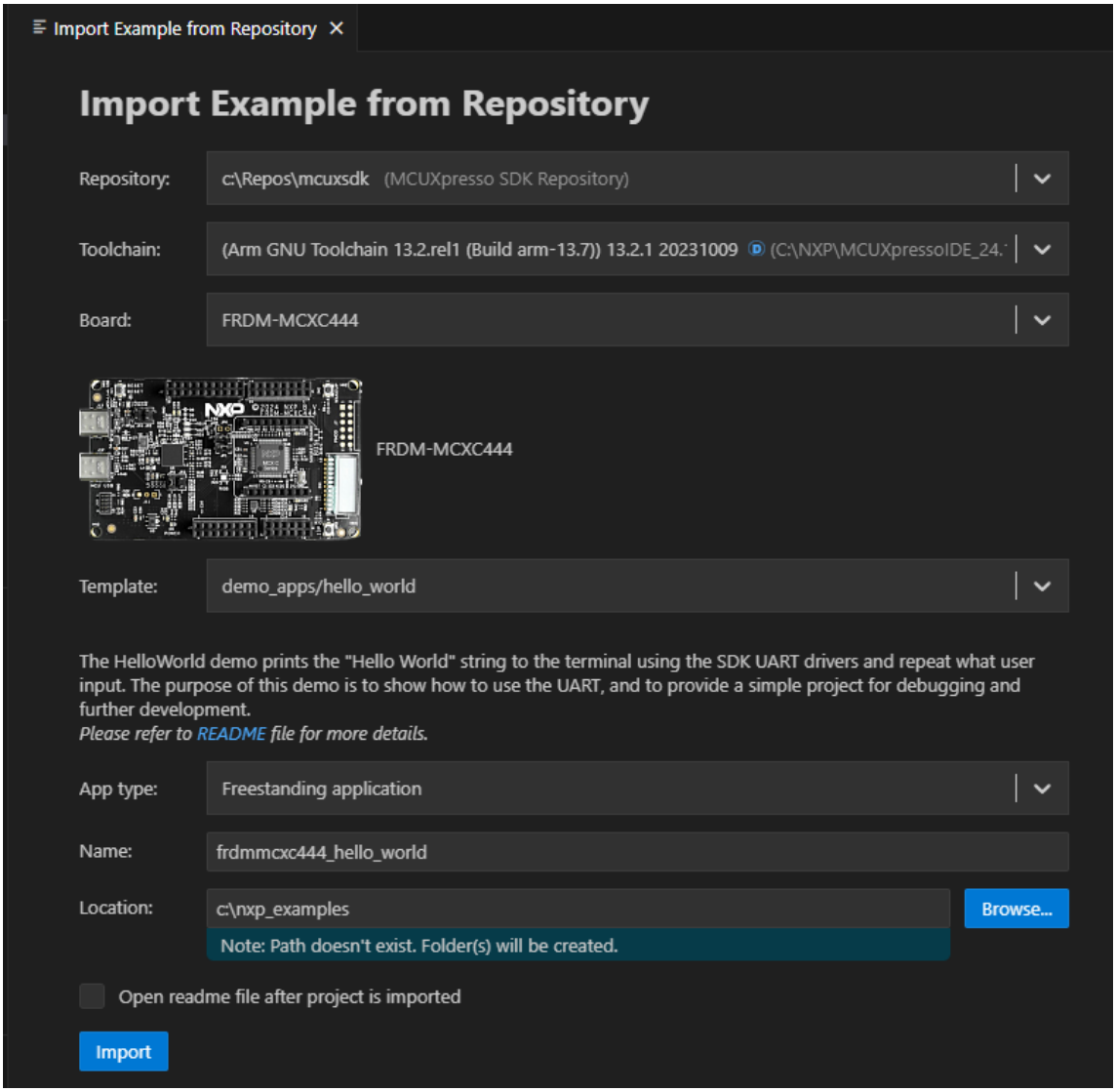
Select **Local** if you've already obtained the SDK as seen in *Get MCUXpresso SDK Repo*. Select your location and click **Import**.



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

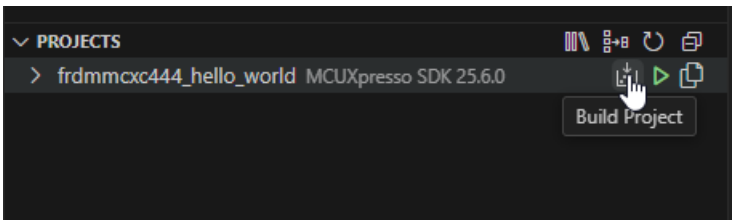


In the dropdown menu, select the MCUXpresso SDK, the Arm GNU Toolchain, your board, template, and application type. Click **Import**.

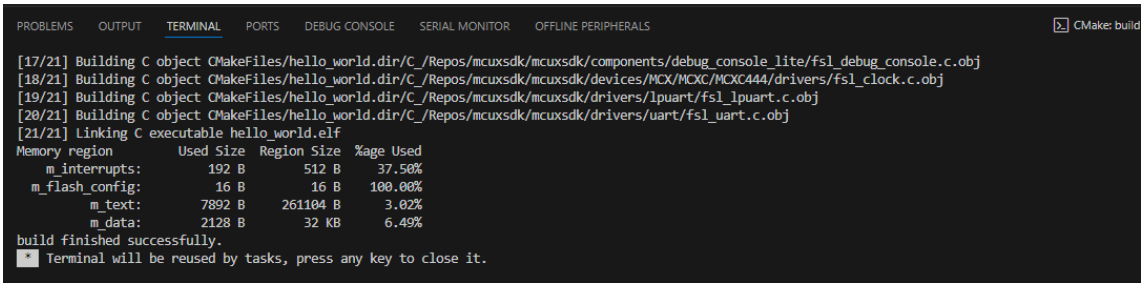


Note: The MCUXpresso SDK projects can be imported as **Repository applications** or **Freestanding applications**. The difference between the two is the import location. Projects imported as Repository examples will be located inside the MCUXpresso SDK, whereas Freestanding examples can be imported to a user-defined location. Select between these by designating your selection in the **App type** dropdown menu.

3. VS Code will prompt you to confirm if the imported files are trusted. Click **Yes**.
4. Navigate to the **PROJECTS** view. Find your project and click the **Build Project** icon.

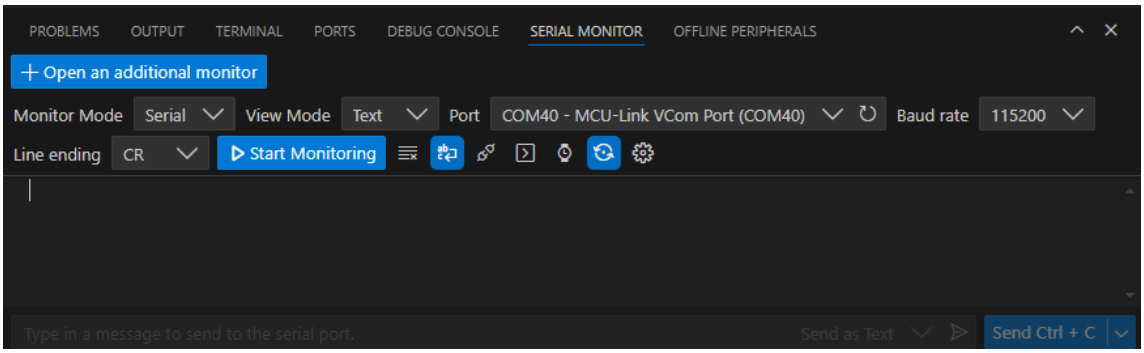


The integrated terminal will open at the bottom and will display the build output.

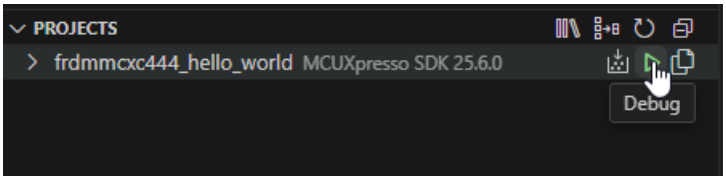


Run an example application **Note:** for full details on MCUXpresso for VS Code debug probe support, see MCUXpresso for VS Code Wiki.

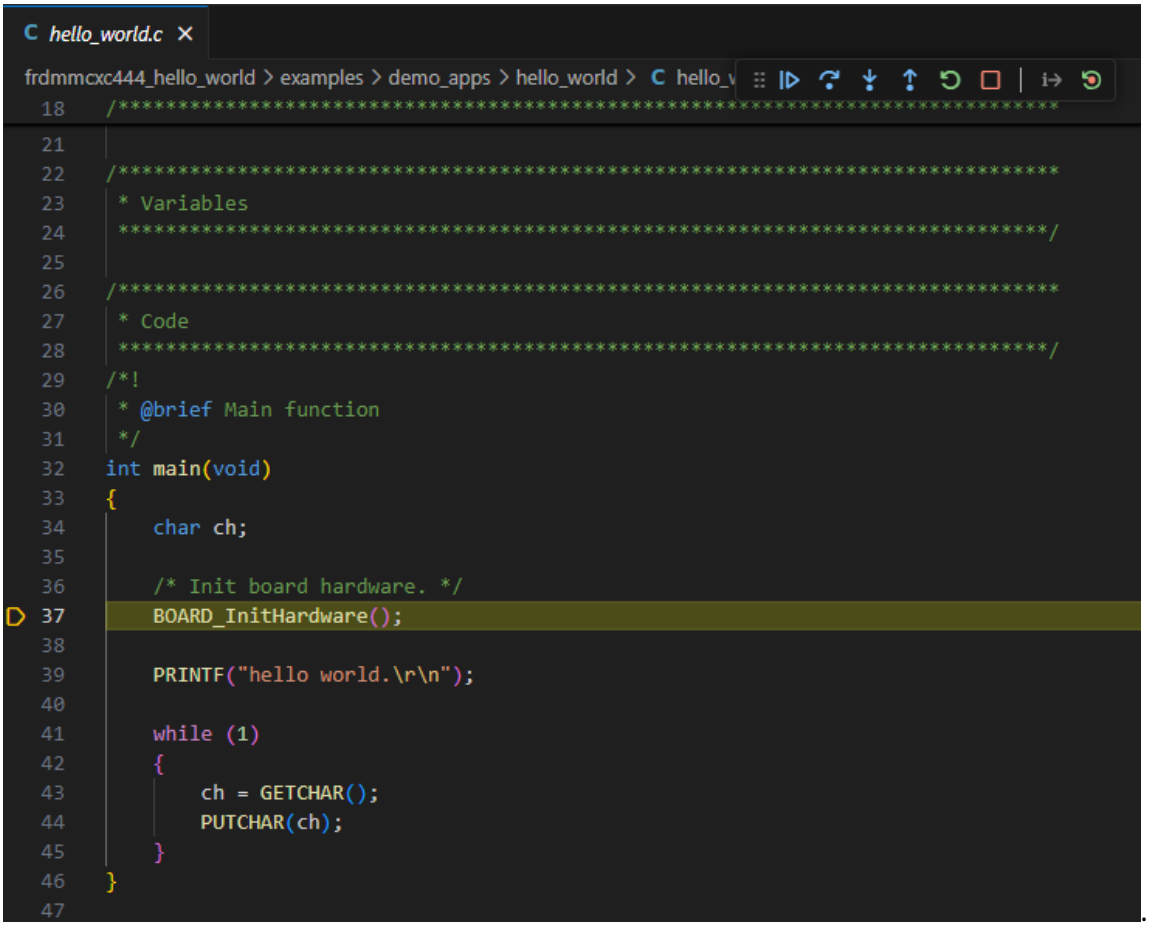
1. Open the **Serial Monitor** from the VS Code's integrated terminal. Select the VCom Port for your device and set the baud rate to 115200.



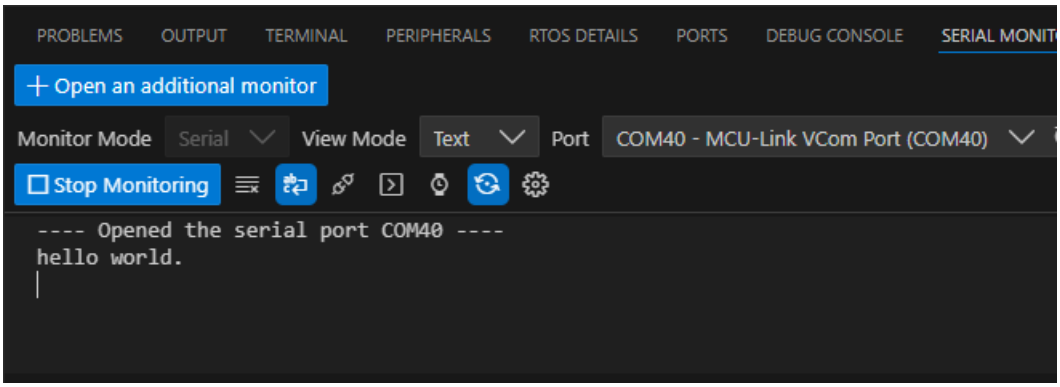
2. Navigate to the **PROJECTS** view and click the play button to initiate a debug session.



The debug session will begin. The debug controls are initially at the top.



3. Click **Continue** on the debug controls to resume execution of the code. Observe the output on the **Serial Monitor**.



Running a demo using ARMGCC CLI/IAR/MDK

Supported Boards Use the west extension `west list_project` to understand the board support scope for a specified example. All supported build command will be listed in output:

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

INFO: [  1][west build -p always examples/demo_apps/hello_world --toolchain armgcc --config release -b
↪evk9mimx8ulp -Dcore_id=cm33]
INFO: [  2][west build -p always examples/demo_apps/hello_world --toolchain armgcc --config release -b
↪evkbimxrt1050]
INFO: [  3][west build -p always examples/demo_apps/hello_world --toolchain armgcc --config release -b
```

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```
↪evkbmimxrt1060]
INFO: [  4][west build -p always examples/demo_apps/hello_world --toolchain armgcc --config release -b␣
↪evkbmimxrt1170 -Dcore_id=cm4]
INFO: [  5][west build -p always examples/demo_apps/hello_world --toolchain armgcc --config release -b␣
↪evkbmimxrt1170 -Dcore_id=cm7]
INFO: [  6][west build -p always examples/demo_apps/hello_world --toolchain armgcc --config release -b␣
↪evkcmimxrt1060]
INFO: [  7][west build -p always examples/demo_apps/hello_world --toolchain armgcc --config release -b␣
↪evkmcimx7ulp]
...
```

The supported toolchains and build targets for an example are decided by the example-self example.yml and board example.yml, please refer Example Toolchains and Targets for more details.

Build the project Use west build -h to see help information for west build command. Compared to zephyr's west build, MCUXpresso SDK's west build command provides following additional options for mcux examples:

- --toolchain: specify the toolchain for this build, default armgcc.
- --config: value for CMAKE_BUILD_TYPE. If not provided, build system will get all the example supported build targets and use the first debug target as the default one. Please refer Example Toolchains and Targets for more details about example supported build targets.

Here are some typical usages for generating a SDK example:

```
# Generate example with default settings, default used device is the mainset MK22F51212
west build -b frdmk22f examples/demo_apps/hello_world

# Just print cmake commands, do not execute it
west build -b frdmk22f examples/demo_apps/hello_world --dry-run

# Generate example with other toolchain like iar, default armgcc
west build -b frdmk22f examples/demo_apps/hello_world --toolchain iar

# Generate example with other config type
west build -b frdmk22f examples/demo_apps/hello_world --config release

# Generate example with other devices with --device
west build -b frdmk22f examples/demo_apps/hello_world --device MK22F12810 --config release
```

For multicore devices, you shall specify the corresponding core id by passing the command line argument -Dcore_id. For example

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

For shield, please use the --shield to specify the shield to run, like

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

Sysbuild(System build) To support multicore project building, we ported Sysbuild from Zephyr. It supports combine multiple projects for compilation. You can build all projects by adding --sysbuild for main application. For example:

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

For more details, please refer to System build.

Config a Project Example in MCUXpresso SDK is configured and tested with pre-defined configuration. You can follow steps blow to change the configuration.

1. Run cmake configuration

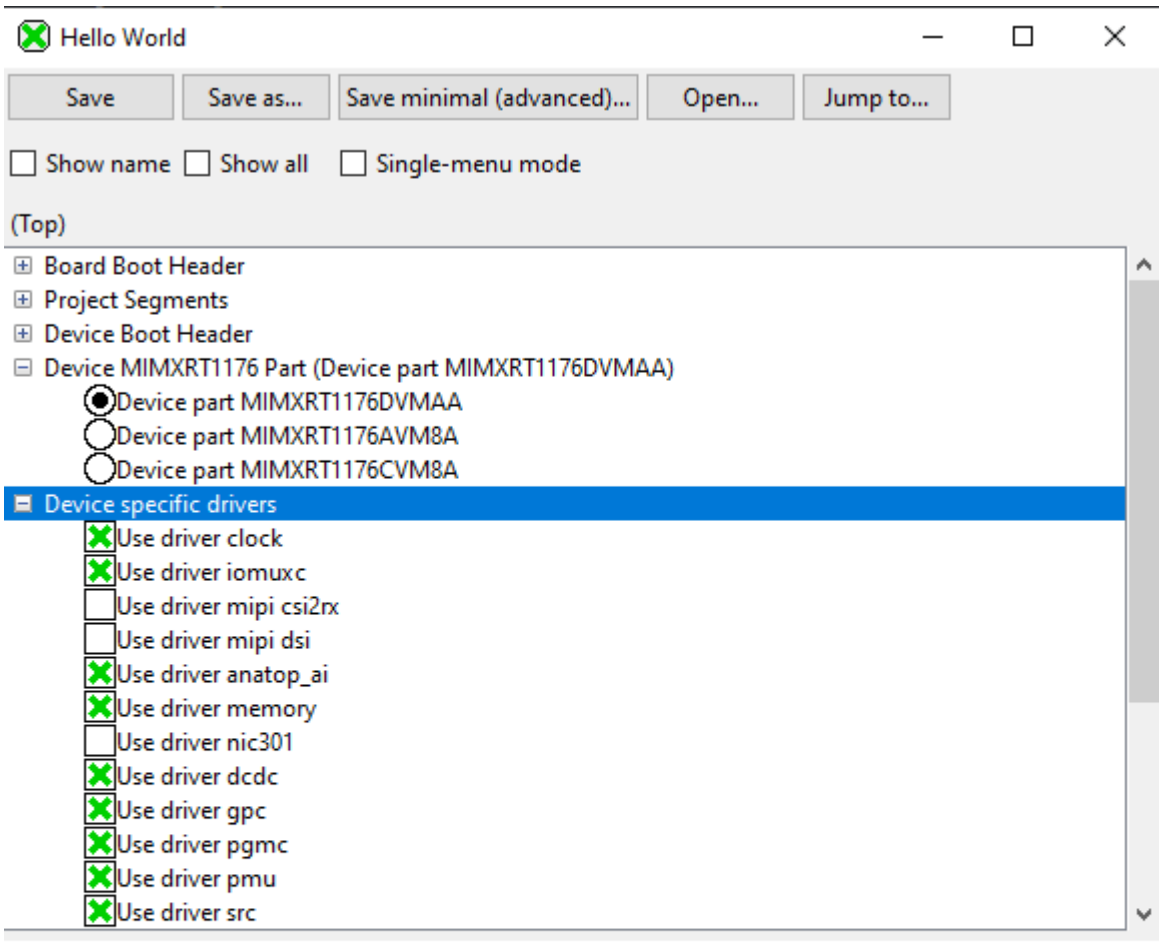
```
west build -b evkbmimxrt1170 examples/demo_apps/hello_world -Dcore_id=cm7 --cmake-only -p
```

Please note the project will be built without `--cmake-only` parameter.

2. Run guiconfig target

```
west build -t guiconfig
```

Then you will get the Kconfig GUI launched, like




```
Kconfig definition, with parent deps. propagated to 'depends on'
===============================================================

At D:/sdk_next/mcuxsdk\devices\../devices/RT/RT1170/MIMXRT1176\drivers/Kconfig:5
Included via D:/sdk_next/mcuxsdk/examples/demo_apps/hello_world/Kconfig:6 ->
D:/sdk_next/mcuxsdk/Kconfig.mcuxpresso:9 -> D:/sdk_next/mcuxsdk\devices/Kconfig:1
-> D:/sdk_next/mcuxsdk\devices\../devices/RT/RT1170/MIMXRT1176/Kconfig:8
Menu path: (Top)

menu "Device specific drivers"
```

You can reconfigure the project by selecting/deselecting Kconfig options.

After saving and closing the Kconfig GUI, you can directly run `west build` to build with the new configuration.

Flash ***Note***: Please refer Flash and Debug The Example to enable west flash/debug support.

Flash the hello_world example:

```
west flash -r linkserver
```

Debug Start a gdb interface by following command:

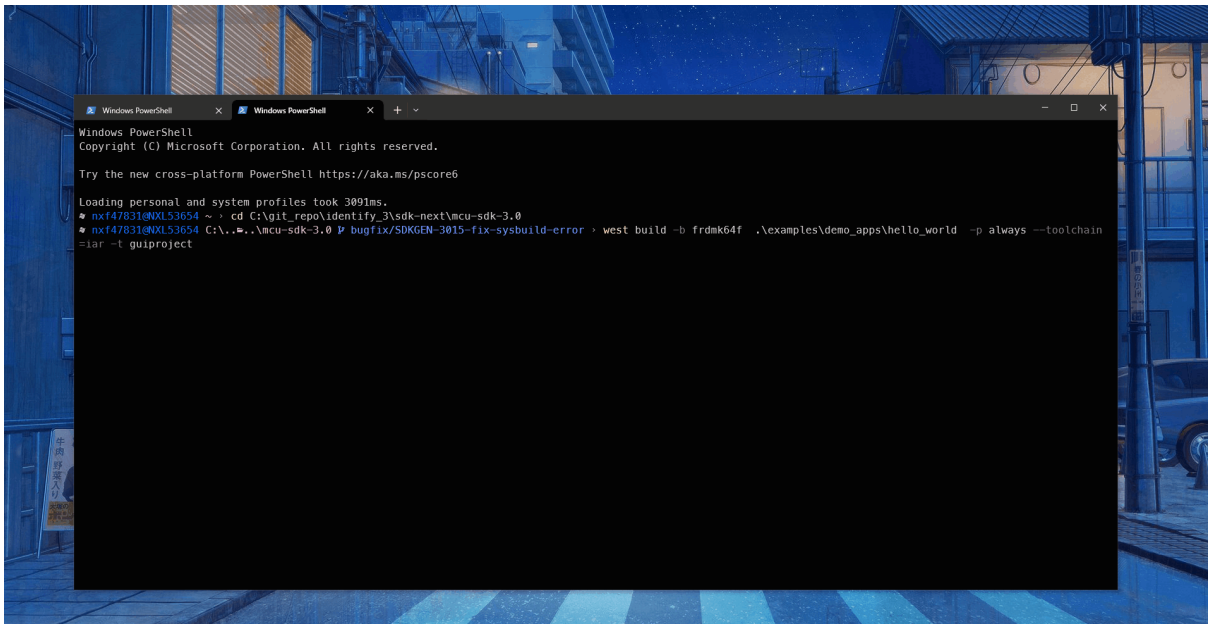
```
west debug -r linkserver
```

Work with IDE Project The above build functionalities are all with CLI. If you want to use the toolchain IDE to work to enjoy the better user experience especially for debugging or you are already used to develop with IDEs like IAR, MDK, Xtensa and CodeWarrior in the embedded world, you can play with our IDE project generation functionality.

This is the cmd to generate the evkbmimxrt1170 hello_world IAR IDE project files.

```
west build -b evkbmimxrt1170 examples/demo_apps/hello_world --toolchain iar -Dcore_id=cm7 --config␣
↪flexspi_nor_debug -p always -t guiproject
```

By default, the IDE project files are generated in mcuxsdk/build/<toolchain> folder, you can open the project file with the IDE tool to work:



Note, please follow the *Installation* to setup the environment especially make sure that *ruby* has been installed.

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.

- MCUXpresso IDE, Rev. 25.06.xx
- IAR Embedded Workbench for Arm, version is 9.60.4
- Keil MDK, version is 5.41
- MCUXpresso for VS Code v25.06
- 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.

Development boards	MCU devices
RD-RW612-BGA	RW610ETA2I, RW610HNA2I, RW610UKA2I, **RW612ETA2I**, RW612HNA2I, RW612UKA2I

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.

memfault-firmware-sdk memfault-firmware-sdk

Wireless Connectivity Framework The Connectivity Framework is a software component that provides hardware abstraction modules to the upper layer connectivity stacks and components. It also provides a list of services and APIs, such as, Low power, Over the Air (OTA) Firmware update, File System, Security, Sensors, Serial Connectivity Interface (FSCI), and others. The Connectivity Framework modules are located in the *middleware|wireless|framework SDK* folder.

wpa_supplicant-rtos NXP Wi-Fi WPA Supplicant

Wireless EdgeFast Bluetooth PAL For more information, see the MCUXpresso SDK EdgeFast Bluetooth Protocol Abstraction Layer User's Guide.

Ethermind BT/BLE Stack nxp_bt_ble_stack

coreHTTP coreHTTP

NXP Wi-Fi The MCUXpresso SDK provides driver for NXP Wi-Fi external modules. The Wi-Fi driver is integrated with LWIP TCPIP stack and demonstrated with several network applications (iperf and AWS IoT).

For more information, see Getting Started with NXP based Wireless Modules and i.MX RT Platform Running on RTOS (document: UM11441).

USB Type-C PD Stack See the *MCUXpresso SDK USB Type-C PD Stack User's Guide* (document MCUXSDKUSBPDUG) for more information

USB Host, Device, OTG Stack See the MCUXpresso SDK USB Stack User's Guide (document MCUXSDKUSBSUG) for more information.

TinyCBOR Concise Binary Object Representation (CBOR) Library

TF-M Trusted Firmware - M Library

PSA Test Suite Arm Platform Security Architecture Test Suite

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".

NXP IoT Agent NXP IoT Agent

MCU Boot Open source MCU Bootloader.

mbedTLS mbedtls SSL/TLS library v3.x

mbedTLS mbedtls SSL/TLS library v2.x

Voice Seeker (no AEC) VoiceSeeker is a multi-microphone voice control audio front-end signal processing solution. VoiceSeeker is not featuring acoustic echo cancellation (AEC).

Voice intelligent technology library Voice Intelligent Technology (VIT) Library provides wake word and voice command engine for voice control

Audio Voice components Audio Voice components for MCU

Maestro Audio Framework for MCU Maestro Audio Framework library for MCU

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.

LVGL LVGL Open Source Graphics Library

llhttp HTTP parser llhttp

LittleFS LittleFS filesystem stack

FreeMASTER FreeMASTER communication driver for 32-bit platforms.

File systemFatfs The FatFs file system is integrated with the MCUXpresso SDK and can be used to access either the SD card or the USB memory stick when the SD card driver or the USB Mass Storage Device class implementation is used.

emWin The MCUXpresso SDK is pre-integrated with the SEGGER emWin GUI middleware. The AppWizard provides developers and designers with a flexible tool to create stunning user interface applications, without writing any code.

cJSON Ultralightweight JSON parser in ANSI C

AWS IoT Amazon Web Service (AWS) IoT Core SDK.

NXP PSA CRYPTO DRIVER PSA crypto driver for crypto library integration via driver wrappers

NXP ELS PKC ELS PKC crypto library

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_nam
Utilities such as debug console	INSTALL_DIR/devices/<device_name>/utilities
Device Project Template for MCUXpresso IDE NPW	INSTALL_DIR/devices/<device_name>/project_templat
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.

Low speed devices not supported

The host examples cannot support low-speed devices.

IAR cannot debug RAM application with J-Link

Currently, IAR will call J-Link reset after the application is downloaded to SRAM, but such operation will cause SRAM data lost.

Here is a workaround to avoid real reset, with the cost of no any reset during the debugging, and hardware status uncleared.

1. Build and debug IAR project once and see the settings folder created.
2. Create the _.JLinkScript file in the settings folder with the following contents.

```
void ResetTarget(void) {
JLINK_TARGET_Halt();
}
```

3. Debug the project again and now it can work.

usb_device_mtp example cannot boot on Keil MDK µVision

After reset, the usb_device_mtp and usb_device_mtp_lite examples cannot boot successfully when using Keil MDK µVision. Adding the *–predefine="-DXIP_BOOT_HEADER_ENABLE=1"* into **Options for target** > **Linker** > **Misc controls** can fix this issue.

Log output may be mixed in shell/hfp example

When multiple tasks print the log, the serial port terminal output has the probability to appear mixed.

Example mbedtls_benchmark may hang on some targets on devices with ELS acceleration

Some targets of ELS accelerated devices may experience runtime issues when run with the default configuration of the mbedtls_benchmark application.

Examples: mbedtls_benchmark

Affected toolchains: All

TF-M secure and EL2GO examples incorrect path in "Download extra image" with iar and mdk IDEs with Kex package

TF-M secure and EL2GO examples are missing the target path for ns binary in "extra download image" with iar and mdk IDEs

Examples: tfm_demo_s, tfm_psatest_s, tfm_regression_s, tfm_secureboot_s, el2go_agent_s, el2go_blob_test_s, el2go_import_blob_s, el2go_mqtt_demo_s **Affected toolchains**: mdk, iar **Affected platforms**: mcxn5xxevk, frdmmcxn947, mcxn9xxevk, rdrw612bga, frdmrw612 **Workaround**: There are two ways 1.) Flash secure and non secure bins via Jlink or SPSDK after the build with IDE and providing with correct paths of secure and non-secure binaries. or 2.) Add {target} debug/release in path of "Download extra image" for iar and for MDK in xxx_flashdownload.ini file.

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

CNS_ACOMP

[2.0.1]

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

[2.0.0]

- Initial version.

CNS_ADC

[2.2.1]

- Improvements
  - Fixed CERT-C issues.

[2.2.0]

- Improvements
  - Updated cns adc trigger sources.
  - Migrated cns adc trigger sources enumeration from cns_adc.h to device.h
  - Reserved single-end mode channel 15, differential mode channel 5, and channel 15.

[2.1.0]

- Bug Fixes
  - Fixed temperature measurement error, and provided 'enableChop' member to control the ADC chop.

[2.0.2]

- Bug Fixes
  - Fixed ADC scan channel misconfiguration issue.
  - Fixed violation of MISRA C-2012 rule 10.1 and rule 10.4.
- Improvements
  - Added new member "enableInputBufferChop" into "adc_config_t" to enable/disable input buffer chopper.

[2.0.1]

- Bug Fixes
  - Fixed MISRA-2012 rules.
    - Rule 14.2, rule 10.3.

[2.0.0]

- Initial version.

CACHE64

[2.0.11]

- Bug Fixes
  - Fixed CERT INT30-C violations: check and guarantee address plus size is equal or smaller than UINT32_MAX.

[2.0.10]

- Improvements
  - Updated CACHE64_InvalidateCacheByRange(), CACHE64_CleanCacheByRange() and CACHE64_CleanInvalidateCacheByRange() to support some platforms that multiple regions in the memory map are remapped to create a continuous address space.

[2.0.9]

- Improvements
  - Removed assert(false) in CACHE64_GetInstanceByAddr.

[2.0.8]

- Improvements
  - Updated function CACHE64_GetInstanceByAddr() to support some devices that provide alias of cacheable memory section.

[2.0.7]

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

[2.0.6]

- Bug Fixes
  - Fixed overflow for CACHE64_GetInstanceByAddr()/CACHE64_CleanCacheByRange()/CACHE64_Invalid
    APIs.

[2.0.5]

- Improvement
  - Made use of FSL_FEATURE_CACHE64_CTRL_HAS_NO_WRITE_BUF feature

[2.0.4]

- Improvement
  - Disable cache policy feature on SoC without CACHE64_POLSEL IP.
- Bug Fixes
  - Fixed doxygen issue.

[2.0.3]

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

[2.0.2]

- Bug Fixes
  - Fixed violations of the MISRA C-2012 Rule 10.1, 10.3, 10.4 and 14.4.
  - Fixed doxygen issue.

[2.0.1]

- Improvements
  - Moved CLCR register configuration out of the while loop, it's unnecessary to repeat this operation.

[2.0.0]

- Initial version.

CDOG

[2.1.3]

- Re-design multiple instance IRQs and Clocks
- Add fix for RESTART command errata

[2.1.2]

- Support multiple IRQs
- Fix default CONTROL values

[2.1.1]

- Remove bit CONTROL[CONTROL_CTRL].

[2.1.0]

- Rename CWT to CDOG.

[2.0.2]

- Fix MISRA-2012 issues.

[2.0.1]

- Fix doxygen issues.

[2.0.0]

- Initial version.

CLOCK

[2.3.2]

- Fixed MSG issues. No function change.

[2.3.1]

- Updated code according to new header file. No function change.

[2.3.0]

- Added CLOCK_GetFreq() API
- Removed DTRNG flag wait in clock API to avoid unconditional delay. DTRNG will be reloaded in crypto init function.

[2.2.0]

- Added els_gdet clock source enumeration
- Fixed kMAIN_CLK_to_DMIC_CLK value

[2.1.4]

- Added noinline attribute to CLOCK_Delay() to work around compiler optimization issue

[2.1.3]

- Added delay for DTRNG busy flag before disabling T3 256M

[2.1.2]

- Renamed kCLOCK_Css/kCLOCK_CssApb to kCLOCK_Els/kCLOCK_ElsApb

[2.1.1]

- Added ANA_GRP XTL power control in USB PHY API

[2.1.0]

- Added USIM_CLOCKS macro
- Added CLOCK_DisableUsbhsPhyClock API

[2.0.1]

- Moved g_clkinFreq and g_mclkinFreq inside extern “C”

[2.0.0]

- initial version.

COMMON

[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 irqs 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.

CRC

[2.1.1]

- Fix MISRA issue.

[2.1.0]

- Add CRC_WriteSeed function.

[2.0.2]

- Fix MISRA issue.

[2.0.1]

- Fixed KPSDK-13362. MDK compiler issue when writing to WR_DATA with -O3 optimize for time.

[2.0.0]

- Initial version.

CTIMER

[2.3.3]

- Bug Fixes
  - Fix CERT INT30-C INT31-C issue.
  - Make API CTIMER_SetupPwm and CTIMER_UpdatePwmDutycycle return fail if pulse width register overflow.

[2.3.2]

- Bug Fixes
  - Clear unexpected DMA request generated by RESET_PeripheralReset in API CTIMER_Init to avoid trigger DMA by mistake.

[2.3.1]

- Bug Fixes
  - MISRA C-2012 issue fixed: rule 10.7 and 12.2.

[2.3.0]

- Improvements
  - Added the CTIMER_SetPrescale(), CTIMER_GetCaptureValue(), CTIMER_EnableResetMatchChannel(), CTIMER_EnableStopMatchChannel(), CTIMER_EnableRisingEdgeCapture(), CTIMER_EnableFallingEdgeCapture(), CTIMER_SetShadowValue(),APIs Interface to reduce code complexity.

[2.2.2]

- Bug Fixes
  - Fixed SetupPwm() API only can use match 3 as period channel issue.

[2.2.1]

- Bug Fixes
  - Fixed use specified channel to setting the PWM period in SetupPwmPeriod() API.
  - Fixed Coverity Out-of-bounds issue.

[2.2.0]

- Improvements
  - Updated three API Interface to support Users to flexibly configure the PWM period and PWM output.
- Bug Fixes
  - MISRA C-2012 issue fixed: rule 8.4.

[2.1.0]

- Improvements
  - Added the CTIMER_GetOutputMatchStatus() API Interface.
  - Added feature macro for FSL_FEATURE_CTIMER_HAS_NO_CCR_CAP2 and FSL_FEATURE_CTIMER_HAS_NO_IR_CR2INT.

[2.0.3]

- Bug Fixes
  - MISRA C-2012 issue fixed: rule 10.3, 10.4, 10.6, 10.7 and 11.9.

[2.0.2]

- New Features
  - Added new API "CTIMER_GetTimerCountValue" to get the current timer count value.
  - Added a control macro to enable/disable the RESET and CLOCK code in current driver.
  - Added a new feature macro to update the API of CTimer driver for lpc8n04.

[2.0.1]

- Improvements
  - API Interface Change
    - Changed API interface by adding CTIMER_SetupPwmPeriod API and CTIMER_UpdatePwmPulsePeriod API, which both can set up the right PWM with high resolution.

[2.0.0]

- Initial version.

CNS_DAC

[2.1.1]

- Improvements
  - Fixed CERT-C issues.

[2.1.0]

- Improvements
  - Updated cns dac trigger sources.
  - Migrated cns dac trigger sources enumeration from cns_dac.h to device.h

[2.0.1]

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

[2.0.0]

- Initial version.

LPC_DMA

[2.5.3]

- Improvements
  - Add assert in DMA_SetChannelXferConfig to prevent XFERCOUNT value overflow.

[2.5.2]

- Bug Fixes
  - Use separate “SET” and “CLR” registers to modify shared registers for all channels, in case of thread-safe issue.

[2.5.1]

- Bug Fixes
  - Fixed violation of the MISRA C-2012 rule 11.6.

[2.5.0]

- Improvements
  - Added a new api DMA_SetChannelXferConfig to set DMA xfer config.

[2.4.4]

- Bug Fixes
  - Fixed the issue that DMA_IRQHandle might generate redundant callbacks.
  - Fixed the issue that DMA driver cannot support channel bigger then 32.
  - Fixed violation of the MISRA C-2012 rule 13.5.

[2.4.3]

- Improvements
  - Added features FSL_FEATURE_DMA_DESCRIPTOR_ALIGN_SIZEn/FSL_FEATURE_DMA0_DESCRIPTOR_A to support the descriptor align size not constant in the two instances.

[2.4.2]

- Bug Fixes
  - Fixed violation of the MISRA C-2012 rule 8.4.

[2.4.1]

- Bug Fixes
  - Fixed violations of the MISRA C-2012 rules 5.7, 8.3.

[2.4.0]

- Improvements
  - Added new APIs DMA_LoadChannelDescriptor/DMA_ChannelIsBusy to support polling transfer case.
- Bug Fixes
  - Added address alignment check for descriptor source and destination address.
  - Added DMA_ALLOCATE_DATA_TRANSFER_BUFFER for application buffer allocation.
  - Fixed the sign-compare warning.
  - Fixed violations of the MISRA C-2012 rules 18.1, 10.4, 11.6, 10.7, 14.4, 16.3, 20.7, 10.8, 16.1, 17.7, 10.3, 3.1, 18.1.

[2.3.0]

- Bug Fixes
  - Removed DMA_HandleIRQ prototype definition from header file.
  - Added DMA_IRQHandle prototype definition in header file.

[2.2.5]

- Improvements
  - Added new API DMA_SetupChannelDescriptor to support configuring wrap descriptor.
  - Added wrap support in function DMA_SubmitChannelTransfer.

[2.2.4]

- Bug Fixes
  - Fixed the issue that macro DMA_CHANNEL_CFER used wrong parameter to calculate DSTINC.

[2.2.3]

- Bug Fixes
  - Improved DMA driver Deinit function for correct logic order.
- Improvements
  - Added API DMA_SubmitChannelTransferParameter to support creating head descriptor directly.
  - Added API DMA_SubmitChannelDescriptor to support ping pong transfer.
  - Added macro DMA_ALLOCATE_HEAD_DESCRIPTOR/DMA_ALLOCATE_LINK_DESCRIPTOR to simplify DMA descriptor allocation.

[2.2.2]

- Bug Fixes
  - Do not use software trigger when hardware trigger is enabled.

[2.2.1]

- Bug Fixes
  - Fixed Coverity issue.

[2.2.0]

- Improvements
  - Changed API DMA_SetupDMADescriptor to non-static.
  - Marked APIs below as deprecated.
    - DMA_PrepareTransfer.
    - DMA_Submit transfer.
  - Added new APIs as below:
    - DMA_SetChannelConfig.
    - DMA_PrepareChannelTransfer.
    - DMA_InstallDescriptorMemory.
    - DMA_SubmitChannelTransfer.
    - DMA_SetChannelConfigValid.
    - DMA_DoChannelSoftwareTrigger.
    - DMA_LoadChannelTransferConfig.

[2.0.1]

- Improvements
  - Added volatile for DMA descriptor member xfercfg to avoid optimization.

[2.0.0]

- Initial version.

DMIC

[2.3.3]

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

[2.3.2]

- New Features
  - Supported 4 channels in driver.

[2.3.1]

- Bug Fixes
  - Fixed the issue that DMIC_EnableChannelDma and DMIC_EnableChannelFifo did not clean relevant bits.

[2.3.0]

- Improvements
  - Added new apis DMIC_ResetChannelDecimator/DMIC_EnableChannelGlobalSync/DMIC_DisableChann

[2.2.1]

- Bug Fixes
  - Fixed violations of the MISRA C-2012 rules 14.4, 17.7, 10.4, 10.3, 10.8, 14.3.

[2.2.0]

- Bug Fixes
  - Corrected the usage of feature FSL_FEATURE_DMIC_IO_HAS_NO_BYPASS.

[2.1.1]

- Improvements
  - Added feature FSL_FEATURE_DMIC_HAS_NO_IOCFG for IOCFG register.

[2.1.0]

- New Features
  - Added API DMIC_EnbleChannelInterrupt/DMIC_EnbleChannelDma to replace API DMIC_SetOperationMode.
  - Added API DMIC_SetIOCFG and marked DMIC_ConfigIO as deprecated.
  - Added API DMIC_EnableChannelSignExtend to support sign extend feature.

[2.0.5]

- Improvements
  - Changed some parameters' value of DMIC_FifoChannel API, such as enable, resetn, and trig_level. This is not possible for the current code logic, so it improves the DMIC_FifoChannel logic and fixes incorrect math logic.

[2.0.4]

- Bug Fixes
  - Fixed the issue that DMIC DMA driver(ver2.0.3) did not support calling DMIC_TransferReceiveDMA in DMA callback as it did before version 2.0.3. But calling DMIC_TransferReceiveDMA in callback is not recommended.

[2.0.3]

- New Features
- Supported linked transfer in DMIC DMA driver.
- Added new API DMIC_EnableChannelFifo/DMIC_DoFifoReset/DMIC_InstallDMADescriptor.

[2.0.2]

- New Features
  - Supported more channels in driver.

[2.0.1]

- New Features
  - Added a control macro to enable/disable the RESET and CLOCK code in current driver.

[2.0.0]

- Initial version.

DMIC_DMA

[2.4.1]

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

[2.4.0]

- Bug Fixes
  - Fixed the issue that DMIC_TransferAbortReceiveDMA can not disable dmic and dma request issue.

[2.3.1]

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

[2.3.0]

- Refer DMIC driver change log 2.0.1 to 2.3.0

ENET

[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_DriverIRQHan 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 caculates 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 featrues 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 caculates 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 relaim 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 interupt 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.

FLEXCOMM

[2.0.2]

- Bug Fixes
  - Fixed typos in FLEXCOMM15_DriverIRQHandler().
  - Fixed MISRA issues.
    - Fixed rules 10.1, 10.3, 10.4, 10.7, 10.8, 11.3, 11.6, 11.8, 11.9, 13.5.
- Improvements
  - Added instance calculation in FLEXCOMM16_DriverIRQHandler() to align with Flexcomm 14 and 15.

[2.0.1]

- Improvements
  - Added more IRQHandler code in drivers to adapt new devices.

[2.0.0]

- Initial version.

FLEXSPI

[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 DMA Driver

[2.2.1]

- Bug Fixes
  - Fixed violations of the MISRA C-2012 Rule 10.1, 10.3, 10.4, 10.8.

[2.2.0]

- Bug Fixes
  - Fixed violations of the MISRA C-2012 Rule 10.1, 10.3.
- New Features
  - Updated name of FLEXSPI_TransferGetTransferCountDMA API.

[2.1.1]

- New Features
  - Updated driver to support feature FSL_FEATURE_FLEXSPI_DMA_MULTIPLE_DES.

[2.1.0]

- Bug Fixes
  - Updated enumaration flexspi_dma_transfer_nsize_t and remove the unsupported items.
- New Features
  - Updated driver for deprecating the multiple linked descriptors inside FLEXSPI_TransferDMA, only up to one linked descriptor is needed according to hardware update.

[2.0.0]

- Initial version.

FMEAS

[2.1.1]

- Bug Fixes
  - MISRA C-2012 issues fixed: rule 10.4, rule 10.8.

[2.1.0]

- Updated "FMEAS_GetFrequency","FMEAS_StartMeasure","FMEAS_IsMeasureComplete" API and add definition to match ASYNC_SYSCON.

[2.0.0]

- Initial version ported from LPCOpen.

GDMA

[2.0.3]

- Bug Fixes
  - Fixed MISRA C-2012 violation.

[2.0.2]

- Improvements
  - Changed to use FSL_FEATURE_GDMA_CHANNEL_NUM defined by feature header.

[2.0.1]

- Bug Fixes
  - Fixed MISRA C-2012 violation.

[2.0.0]

- Initial version.

GPIO

[2.1.7]

- Improvements
  - Enhanced GPIO_PinInit to enable clock internally.

[2.1.6]

- Bug Fixes
  - Clear bit before set it within GPIO_SetPinInterruptConfig() API.

[2.1.5]

- Bug Fixes
  - Fixed violations of the MISRA C-2012 rules 3.1, 10.6, 10.7, 17.7.

[2.1.4]

- Improvements
  - Added API GPIO_PortGetInterruptStatus to retrieve interrupt status for whole port.
  - Corrected typos in header file.

[2.1.3]

- Improvements
  - Updated “GPIO_PinInit” API. If it has DIRCLR and DIRSET registers, use them at set 1 or clean 0.

[2.1.2]

- Improvements
  - Removed deprecated APIs.

[2.1.1]

- Improvements
  - API interface changes:
    * Refined naming of APIs while keeping all original APIs, marking them as deprecated. Original APIs will be removed in next release. The mainin change is updating APIs with prefix of _PinXXX() and _PorortXXX

[2.1.0]

- New Features
  - Added GPIO initialize API.

[2.0.0]

- Initial version.

I2C

[2.3.3]

- Bug Fixes
  - Fixed violations of the MISRA C-2012 rules 10.1.
  - Fixed issue that if master only sends address without data during I2C interrupt transfer, address nack cannot be detected.

[2.3.2]

- Improvement
  - Enable or disable timeout option according to enableTimeout.
- Bug Fixes
  - Fixed timeout value calculation error.
  - Fixed bug that the interrupt transfer cannot recover from the timeout error.

[2.3.1]

- Improvement
  - 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.
- Bug Fixes
  - Fixed bug in I2C_SlaveEnable that the slave enable/disable should not affect the other register bits.

[2.3.0]

- Improvement
  - Added new return codes kStatus_I2C_EventTimeout and kStatus_I2C_SclLowTimeout, and added the check for event timeout and SCL timeout in I2C master transfer.
  - Fixed bug in slave transfer that the address match event should be invoked before not after slave transmit/receive event.

[2.2.0]

- New Features
  - Added enumeration _i2c_status_flags to include all previous master and slave status flags, and added missing status flags.
  - Modified I2C_GetStatusFlags to get all I2C flags.
  - Added API I2C_ClearStatusFlags to clear all clearable flags not just master flags.
  - Modified master transactional APIs to enable bus event timeout interrupt during transfer, to avoid glitch on bus causing transfer hangs indefinitely.
- Bug Fixes
  - Fixed bug that status flags and interrupt enable masks share the same enumerations by adding enumeration _i2c_interrupt_enable for all master and slave interrupt sources.

[2.1.0]

- Bug Fixes
  - Fixed bug that during master transfer, when master is nacked during slave probing or sending subaddress, the return status should be kStatus_I2C_Addr_Nak rather than kStatus_I2C_Nak.
- Bug Fixes
  - Fixed MISRA issues.
    - Fixed rules 10.1, 10.4, 13.5.
- New Features
  - Added macro I2C_MASTER_TRANSMIT_IGNORE_LAST_NACK, so that user can configure whether to ignore the last byte being nacked by slave during master transfer.

[2.0.8]

- Bug Fixes
  - Fixed I2C_MasterSetBaudRate issue that MSTSCLLOW and MSTSCLHIGH are incorrect when MSTTIME is odd.

[2.0.7]

- Bug Fixes
  - Two dividers, CLKDIV and MSTTIME are used to configure baudrate. According to reference manual, in order to generate 400kHz baudrate, the clock frequency after CLKDIV must be less than 2mHz. Fixed the bug that, the clock frequency after CLKDIV may be larger than 2mHz using the previous calculation method.
  - Fixed MISRA 10.1 issues.
  - Fixed wrong baudrate calculation when feature FSL_FEATURE_I2C_PREPCLKFRG_8MHZ is enabled.

[2.0.6]

- New Features
  - Added master timeout self-recovery support for feature FSL_FEATURE_I2C_TIMEOUT_RECOVERY.

- Bug Fixes
  - Eliminated IAR Pa082 warning.
  - Fixed MISRA issues.
    - Fixed rules 10.1, 10.3, 10.4, 10.7, 10.8, 11.3, 11.6, 11.8, 11.9, 13.5.

[2.0.5]

- Bug Fixes
  - Fixed wrong assignment for datasize in I2C_InitTransferStateMachineDMA.
  - Fixed wrong working flow in I2C_RunTransferStateMachineDMA to ensure master can work in no start flag and no stop flag mode.
  - Fixed wrong working flow in I2C_RunTransferStateMachine and added kReceiveDataBeginState in _i2c_transfer_states to ensure master can work in no start flag and no stop flag mode.
  - Fixed wrong handle state in I2C_MasterTransferDMAHandleIRQ. After all the data has been transfered or nak is returned, handle state should be changed to idle.
- Improvements
  - Rounded up the calculated divider value in I2C_MasterSetBaudRate.

[2.0.4]

- Improvements
  - Updated the I2C_WATI_TIMEOUT macro to unified name I2C_RETRY_TIMES
  - Updated the “I2C_MasterSetBaudRate” API to support baudrate configuration for feature QN9090.
- Bug Fixes
  - Fixed build warnning caused by uninitialized variable.
  - Fixed COVERITY issue of unchecked return value in I2C_RTOS_Transfer.

[2.0.3]

- Improvements
  - Unified the component full name to FLEXCOMM I2C(DMA/FREERTOS) driver.

[2.0.2]

- Improvements
  - In slave IRQ:
    1. Changed slave receive process to first set the I2C_SLVCTL_SLVCONTINUE_MASK to acknowledge the received data, then do data receive.
    2. Improved slave transmit process to set the I2C_SLVCTL_SLVCONTINUE_MASK immediately after writing the data.

[2.0.1]

- Improvements
  - Added I2C_WATI_TIMEOUT macro to allow users to specify the timeout times for waiting flags in functional API and blocking transfer API.

[2.0.0]

- Initial version.

I2S

[2.3.2]

- Bug Fixes
  - Fixed warning for comparison between pointer and integer.

[2.3.1]

- Bug Fixes
  - Updated the value of TX/RX software transfer state machine after transfer contents are submitted to avoid race condition.

[2.3.0]

- Improvements
  - Added api I2S_InstallDMADescriptorMemory/I2S_TransferSendLoopDMA/I2S_TransferReceiveLoopD to support loop transfer.
  - Added api I2S_EmptyTxFifo to support blocking flush tx fifo.
  - Updated api I2S_TransferAbortDMA by removed the blocking flush tx fifo from this function.
- Bug Fixes
  - Removed the while loop in abort transfer function to fix the dead loop issue under specific user case.

[2.2.2]

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

[2.2.1]

- Improvements
  - Added feature FSL_FEATURE_FLEXCOMM_INSTANCE_I2S_SUPPORT_SECONDARY_CHANNELn for the SOC has parts of instance support secondary channel.
- Bug Fixes
  - Added volatile statement for the state variable of i2s_handle and enable the mainline channel pair before enable interrupt to avoid the issue of code excution reordering which may cause the interrupt generated unexpectedly.

[2.2.0]

- Improvements
  - Added 8/16/24 bits mono data format transfer support in I2S driver.
  - Added new apis I2S_SetBitClockRate.
- Bug Fixes
  - Fixed the PA082 build warning.
  - Fixed the sign-compare warning.
  - Fixed violations of the MISRA C-2012 rules 10.4, 10.8, 11.9, 10.1, 11.3, 13.5, 11.8, 10.3, 10.7.
  - Fixed the Operand don't affect result Coverity issue.

[2.1.0]

- Improvements
  - Added a feature for the FLEXCOMM which supports I2S and has interconnection with DMIC.
  - Used a feature to control PDMDATA instead of I2S_CFG1_PDMDATA.
  - Added member bytesPerFrame in i2s_dma_handle_t, used for DMA transfer width configure, instead of using sizeof(uint32_t) hardcode.
  - Used the macro provided by DMA driver to define the I2S DMA descriptor.
- Bug Fixes
  - Fixed the issue that I2S DMA driver always generated duplicate callback.

[2.0.3]

- New Features
  - Added a feature to remove configuration for the second channel on LPC51U68.

[2.0.2]

- New Features
  - Added ENABLE_IRQ handle after register I2S interrupt handle.

[2.0.1]

- Improvements
  - Unified the component full name to FLEXCOMM I2S (DMA) driver.

[2.0.0]

- Initial version.

I2S_BRIDGE

[2.0.0]

- initial version

I2S_DMA

[2.3.3]

- Bug Fixes
  - Fixed data size limit does not match the macro DMA_MAX_TRANSFER_BYTES issue.

[2.3.2]

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

[2.3.1]

- Refer I2S driver change log 2.0.1 to 2.3.1

IMU

[2.2.0]

- New Features
  - Added IMU_BUSY_POLL_COUNT parameter to prevent infinite polling loops in IMU operations.
  - Added timeout mechanism to all polling loops in IMU driver code.
- Improvements
  - Enhanced error handling in blocking functions to return timeout status.
  - Updated documentation to clarify timeout behavior and return values.
  - Added IMU_ERR_TIMEOUT error code for timeout conditions.

[2.1.1]

- Bug Fixes
  - Fix MISRA C-2012 violations.
  - Fixed IMU_GetStatusFlags bug that returns wrong RX FIFO status.

[2.1.0]

- Improvements:
  - Updated API prototype, remove CIU2_Type from parameters.

[2.0.0]

- Initial version.

INPUTMUX

[2.0.9]

- Improvements
  - Use INPUTMUX_CLOCKS to initialize the inputmux module clock to adapt to multiple inputmux instances.
  - Modify the API base type from INPUTMUX_Type to void.

[2.0.8]

- Improvements
  - Updated a feature macro usage for function INPUTMUX_EnableSignal.

[2.0.7]

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

[2.0.6]

- Bug Fixes
  - Fixed the documentation wrong in API INPUTMUX_AttachSignal.

[2.0.5]

- Bug Fixes
  - Fixed build error because some devices has no sct.

[2.0.4]

- Bug Fixes
  - Fixed violations of the MISRA C-2012 rule 10.4, 12.2 in INPUTMUX_EnableSignal() function.

[2.0.3]

- Bug Fixes
  - Fixed violations of the MISRA C-2012 rules 10.4, 10.7, 12.2.

[2.0.2]

- Bug Fixes
  - Fixed violations of the MISRA C-2012 rules 10.4, 12.2.

[2.0.1]

- Support channel mux setting in INPUTMUX_EnableSignal().

[2.0.0]

- Initial version.

IO_MUX

[2.2.2]

- Fixed MSG issues. No function change.

[2.2.1]

- Fixed component id.

[2.2.0]

- Update io_mux signals according to data sheet.

[2.1.2]

- Fixed misra issues

[2.1.1]

- Added driver strength configuration

[2.1.0]

- Added IO_MUX_SetPinOutLevelInSleep API
- Added IO_MUX_SetRfPinOutLevelInSleep API
- Added capture pulse macro IO_MUX_AON_CAPTURE

[2.0.0]

- initial version.

IPED

[1.0.1]

- Fixed component id.

[1.0.0]

- initial version

ITRC

[2.0.0]

- Initial version.

LCDIC

[2.2.0]

- New Features
  - Add software timeout when waiting for CMD done.

[2.1.0]

- New Features
  - Add seperate APIs for send and receive data in non-blocking way.
- Others
  - Return error status when sending or receiving data larger than 0x40000, current driver doesn't support this.

[2.0.3]

- Bug Fixes
  - Fixed potential issue that clock may not be send out when sending data array.

[2.0.2]

- Bug Fixes
  - Fixed build error with MDK 5.37.

[2.0.1]

- Bug Fixes
  - Added delay after setting LCDIC_EN to make sure LCDIC is out of reset.

[2.0.0]

- Initial version.

LCDIC_DMA

[2.1.0]

- New Features
  - Add seperate APIs for send and receive data.
- Others
  - Return error status when sending or receiving data larger than 0x40000, current driver doesn't support this.

[2.0.0]

- Initial version.

MRT

[2.0.5]

- Bug Fixes
  - Fixed CERT INT31-C violations.

[2.0.4]

- Improvements
  - Don't reset MRT when there is not system level MRT reset functions.

[2.0.3]

- Bug Fixes
  - Fixed violations of MISRA C-2012 rule 10.1 and 10.4.
  - Fixed the wrong count value assertion in MRT_StartTimer API.

[2.0.2]

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

[2.0.1]

- Added control macro to enable/disable the RESET and CLOCK code in current driver.

[2.0.0]

- Initial version.

OCOTP

[2.2.3]

- Fixed MSG issues. No function change.

[2.2.2]

- Fixed component id.

[2.2.1]

- Removed reset on OTP init and deinit to keep OTP configuration on boot.

[2.2.0]

- Added OCOTP_ReadPackage() API
- Exposed OCOTP_ReadSocOtp() API

[2.1.0]

- Added OCOTP_ReadSVC() API.
- Avoid access OTP register before busy wait in OCOTP_OtpFuseRead()

[2.0.1]

- Fixed an misra issue 10.1

[2.0.0]

- initial version.

OSTIMER

[2.2.5]

- Improvements
  - Support binary encoded ostimer.

[2.2.4]

- Bug Fixes
  - Fixed CERT INT31-C violations.

[2.2.3]

- Improvements
  - Disable and clear pending interrupts before disabling the OSTIMER clock to avoid interrupts being executed when the clock is already disabled.

[2.2.2]

- Improvements
  - Support devices with different OSTIMER instance name.

[2.2.1]

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

[2.2.0]

- Improvements
  - Move the PMC operation out of the OSTIMER driver to board specific files.
  - Added low level APIs to control OSTIMER MATCH and interrupt.

[2.1.2]

- Bug Fixes
  - Fixed MISRA-2012 rule 10.8.

[2.1.1]

- Bug Fixes
  - removes the suffix 'n' for some register names and bit fields' names
- Improvements
  - Added HW CODE GRAY feature supported by CODE GRAY in SYSCTRL register group.

[2.1.0]

- Bug Fixes
  - Added a workaround to fix the issue that no interrupt was reported when user set smaller period.
  - Fixed violation of MISRA C-2012 rule 10.3 and 11.9.
- Improvements
  - Added return value for the two APIs to set match value.
    - OSTIMER_SetMatchRawValue
    - OSTIMER_SetMatchValue

[2.0.3]

- Bug Fixes
  - Fixed violation of MISRA C-2012 rule 10.3, 14.4, 17.7.

[2.0.2]

- Improvements
  - Added support for OSTIMER0

[2.0.1]

- Improvements
  - Removed the software reset function out of the initialization API.
  - Enabled interrupt directly instead of enabling deep sleep interrupt. Users need to enable the deep sleep interrupt in application code if needed.

[2.0.0]

- Initial version.

PINT

[2.2.0]

- Fixed
  - Fixed the issue that clear interrupt flag when it's not handled. This causes events to be lost.
- Changed
  - Used one callback for one PINT instance. It's unnecessary to provide different callbacks for all PINT events.

[2.1.13]

- Improvements
  - Added instance array for PINT to adapt more devices.
  - Used release reset instead of reset PINT which may clear other related registers out of PINT.

[2.1.12]

- Bug Fixes
  - Fixed coverity issue.

[2.1.11]

- Bug Fixes
  - Fixed MISRA C-2012 rule 10.7 violation.

[2.1.10]

- New Features
  - Added the driver support for MCXN10 platform with combined interrupt handler.

[2.1.9]

- Bug Fixes
  - Fixed MISRA-2012 rule 8.4.

[2.1.8]

- Bug Fixes
  - Fixed MISRA-2012 rule 10.1 rule 10.4 rule 10.8 rule 18.1 rule 20.9.

[2.1.7]

- Improvements
  - Added fully support for the SECPINT, making it can be used just like PINT.

[2.1.6]

- Bug Fixes
  - Fixed the bug of not enabling common pint clock when enabling security pint clock.

[2.1.5]

- Bug Fixes
  - Fixed issue for MISRA-2012 check.
    - Fixed rule 10.1 rule 10.3 rule 10.4 rule 10.8 rule 14.4.
  - Changed interrupt init order to make pin interrupt configuration more reasonable.

[2.1.4]

- Improvements
  - Added feature to control distinguish PINT/SECPINT relevant interrupt/clock configurations for PINT_Init and PINT_Deinit API.
  - Swapped the order of clearing PIN interrupt status flag and clearing pending NVIC interrupt in PINT_EnableCallback and PINT_EnableCallbackByIndex function.
  - Bug Fixes
    - Fixed build issue caused by incorrect macro definitions.

[2.1.3]

- Bug fix:
  - Updated PINT_PinInterruptClrStatus to clear PINT interrupt status when the bit is asserted and check whether was triggered by edge-sensitive mode.
  - Write 1 to IST corresponding bit will clear interrupt status only in edge-sensitive mode and will switch the active level for this pin in level-sensitive mode.
  - Fixed MISRA c-2012 rule 10.1, rule 10.6, rule 10.7.
  - Added FSL_FEATURE_SECPINT_NUMBER_OF_CONNECTED_OUTPUTS to distinguish IRQ relevant array definitions for SECPINT/PINT on lpc55s69 board.
  - Fixed PINT driver c++ build error and remove index offset operation.

[2.1.2]

- Improvement:
  - Improved way of initialization for SECPINT/PINT in PINT_Init API.

[2.1.1]

- Improvement:
  - Enabled secure pint interrupt and add secure interrupt handle.

[2.1.0]

- Added PINT_EnableCallbackByIndex/PINT_DisableCallbackByIndex APIs to enable/disable callback by index.

[2.0.2]

- Added control macro to enable/disable the RESET and CLOCK code in current driver.

[2.0.1]

- Bug fix:
  - Updated PINT driver to clear interrupt only in Edge sensitive.

[2.0.0]

- Initial version.

POWER

[2.5.3]

- Fixed MSG issues. No function change.

[2.5.2]

- Updated code according to new header file. No function change.

[2.5.1]

- Added new SVC trim equation for new samples

[2.5.0]

- Added Power_InitLoadGdetCfg() API
- Added bool return value for POWER_EnableGDetVSensors()

[2.4.0]

- Added POWER_TrimSvc() API
- Added pack parameter to POWER_InitVoltage() API
- Moved POWER_DelayUs() to execute in SRAM
- Added barriar around WFI
- Tweaked SVC table
- Fixed POWER_GetResetCause() to get correct cause

[2.3.0]

- Added POWER_SetPowerSwitchCallback() API
- Added POWER_InitVoltage() API
- Remove PMIP_BUCK_LVL configuration from POWER_InitPowerConfig().
- Fixed a potential compiling issue in Power_Delay()

[2.2.0]

- Added POWER_DisableGDetVSensors() API
- Added POWER_EnableGDetVSensors() API
- Added GDET/VSensor setting around PM2 PM3

[2.1.1]

- Renamed kPOWER_Pm2MemPuCss to kPOWER_Pm2MemPuEls
- Supported PM3 wakeup on A1 device

[2.1.0]

- Added PM3 wakeup support for A1 device.
- Added POWER_ConfigCauInSleep() API. Remove pm3CauPd field from power_sleep_config_t structure.
- Added power_init_config_t parameter in POWER_InitPowerConfig() API.

[2.0.1]

- Improved power performance
- Added return value for POWER_EnterPowerMode()

[2.0.0]

- initial version.

POWERQUAD

[2.2.0]

- New Features
  - Added new API PQ_Arctan2Fixed.

[2.1.1]

- Bug Fixes
  - Remove PQ_WaitDone from PQ_ArctanFixed and PQ_ArctanhFixed because it is unnecessary.

[2.1.0]

- Improvements
  - Fixed typo issue for biquad related function name.
  - Changed operator from “%” into “&” to reduce heavy cycle for biquad functions.

[2.0.5]

- Improvements
  - Added a note in driver for FIR that powerquad has a hardware limitation, when using it for FIR increment calculation, the address of pSrc needs to be a continuous address.

[2.0.4]

- Improvements
  - Supported the platforms which don’t have PowerQuad clock and reset control.

[2.0.3]

- Bug Fixes
  - Fixed violations of the MISRA C-2012 rules 8.4, 10.1, 10.3, 10.4, 10.6, and so on.

[2.0.2]

- Bug Fixes
  - Fixed array size issue in fsl_powerquad_data.h file.
  - Fixed vector function pipeline issue.

[2.0.1]

- Bug Fixes
  - Fixed build error in C++ mode.

[2.0.0]

- Initial version.

RESET

[2.1.1]

- Corrected XX_RSTS definitions.
- Removed USDHC_RSTS.

[2.1.0]

- Added RESET_ReleasePeripheralReset() API

[2.0.3]

- Renamed CSS(Crypto subsystem) related macros to ELS(Edge lock security)

[2.0.2]

- Added USIM_RSTS macro

[2.0.1]

- Added kCSS_GDET_REF_RST_SHIFT_RSTn

[2.0.0]

- initial version.

ROMAPI

[2.0.0]

- initial version for A0.

RTC

[2.2.0]

- New Features
  - Created new APIs for the RTC driver.
    - RTC_EnableSubsecCounter
    - RTC_GetSubsecValue

[2.1.3]

- Bug Fixes
  - Fixed issue that RTC_GetWakeupCount may return wrong value.

[2.1.2]

- Bug Fixes
  - MISRA C-2012 issue fixed: rule 10.1, 10.4 and 10.7.

[2.1.1]

- Bug Fixes
  - MISRA C-2012 issue fixed: rule 10.3 and 11.9.

[2.1.0]

- Bug Fixes
  - Created new APIs for the RTC driver.
    - RTC_EnableTimer
    - RTC_EnableWakeUpTimerInterruptFromDPD
    - RTC_EnableAlarmTimerInterruptFromDPD
    - RTC_EnableWakeupTimer
    - RTC_GetEnabledWakeupTimer
    - RTC_SetSecondsTimerMatch
    - RTC_GetSecondsTimerMatch
    - RTC_SetSecondsTimerCount
    - RTC_GetSecondsTimerCount
  - deprecated legacy APIs for the RTC driver.
    - RTC_StartTimer
    - RTC_StopTimer
    - RTC_EnableInterrupts
    - RTC_DisableInterrupts
    - RTC_GetEnabledInterrupts

[2.0.0]

- Initial version.

SCTIMER

[2.5.1]

- Bug Fixes
  - Fixed bug in SCTIMER_SetupCaptureAction: When kSCTIMER_Counter_H is selected, events 12-15 and capture registers 12-15 CAPn_H field can't be used.

[2.5.0]

- Improvements
  - Add SCTIMER_GetCaptureValue API to get capture value in capture registers.

[2.4.9]

- Improvements
  - Supported platforms which don't have system level SCTIMER reset.

[2.4.8]

- Bug Fixes
  - Fixed the issue that the SCTIMER_UpdatePwmDutycycle() can't writes MATCH_H bit and RELOADn_H.

[2.4.7]

- Bug Fixes
  - Fixed the issue that the SCTIMER_UpdatePwmDutycycle() can't configure 100% duty cycle PWM.

[2.4.6]

- Bug Fixes
  - Fixed the issue where the H register was not written as a word along with the L register.
  - Fixed the issue that the SCTIMER_SetCOUNTValue() is not configured with high 16 bits in unify mode.

[2.4.5]

- Bug Fixes
  - Fix SCT_EV_STATE_STATEMSKn macro build error.

[2.4.4]

- Bug Fixes
  - Fix MISRA C-2012 issue 10.8.

[2.4.3]

- Bug Fixes
  - Fixed the wrong way of writing CAPCTRL and REGMODE registers in SCTIMER_SetupCaptureAction.

[2.4.2]

- Bug Fixes
  - Fixed SCTIMER_SetupPwm 100% duty cycle issue.

[2.4.1]

- Bug Fixes
  - Fixed the issue that MATCHn_H bit and RELOADn_H bit could not be written.

[2.4.0]

[2.3.0]

- Bug Fixes
  - Fixed the potential overflow issue of pulseperiod variable in SCTIMER_SetupPwm/SCTIMER_UpdatePwmDutycycle API.
  - Fixed the issue of SCTIMER_CreateAndScheduleEvent API does not correctly work with 32 bit unified counter.
  - Fixed the issue of position of clear counter operation in SCTIMER_Init API.
- Improvements
  - Update SCTIMER_SetupPwm/SCTIMER_UpdatePwmDutycycle to support generate 0% and 100% PWM signal.
  - Add SCTIMER_SetupEventActiveDirection API to configure event activity direction.
  - Update SCTIMER_StartTimer/SCTIMER_StopTimer API to support start/stop low counter and high counter at the same time.
  - Add SCTIMER_SetCounterState/SCTIMER_GetCounterState API to write/read counter current state value.
  - Update APIs to make it meaningful.
    - SCTIMER_SetEventInState
    - SCTIMER_ClearEventInState
    - SCTIMER_GetEventInState

[2.2.0]

- Improvements
  - Updated for 16-bit register access.

[2.1.3]

- Bug Fixes
  - Fixed the issue of uninitialized variables in SCTIMER_SetupPwm.
  - Fixed the issue that the Low 16-bit and high 16-bit work independently in SCTIMER driver.
- Improvements
  - Added an enumerable macro of unify counter for user.
    - kSCTIMER_Counter_U
  - Created new APIs for the RTC driver.
    - SCTIMER_SetupStateLdMethodAction
    - SCTIMER_SetupNextStateActionwithLdMethod
    - SCTIMER_SetCOUNTValue
    - SCTIMER_GetCOUNTValue
    - SCTIMER_SetEventInState
    - SCTIMER_ClearEventInState
    - SCTIMER_GetEventInState
  - Deprecated legacy APIs for the RTC driver.

    * SCTIMER_SetupNextStateAction

[2.1.2]

- Bug Fixes
  - MISRA C-2012 issue fixed: rule 10.3, 10.4, 10.6, 10.7, 11.9, 14.2 and 15.5.

[2.1.1]

- Improvements
  - Updated the register and macro names to align with the header of devices.

[2.1.0]

- Bug Fixes
  - Fixed issue where SCT application level Interrupt handler function is occupied by SCT driver.
  - Fixed issue where wrong value for INSYNC field inside SCTIMER_Init function.
  - Fixed issue to change Default value for INSYNC field inside SCTIMER_GetDefaultConfig.

[2.0.1]

- New Features
  - Added control macro to enable/disable the RESET and CLOCK code in current driver.

[2.0.0]

- Initial version.

SDU

[1.0.0]

- Initial version.

SMARTCARD

[2.3.0]

- New features:
  - Added support for USIM

[2.2.2]

- Bug fix:
  - Fixed MISRA C-2012 rule 10.4.

[2.2.1]

- Bug fix:
  - Fixed IAR warnings Pa082 in smartcard_emvsim
  - Fixed MISRA issues
  - Fixed rules 10.1, 10.3, 10.4, 10.6, 10.7, 10.8, 14.4, 16.1, 16.3, 16.4, 17.7

[2.2.0]

- New features:
  - Updated to use RX/TX FIFO

[2.1.2]

- Provided time delay function which works in microseconds.
- Bug fix:
  - Changed event to semaphore in RTOS driver (KPSDK-11634).
  - Added check if de-initialized variables are not null iSMARTCARD_RTOS_Deinit() (KPSDK-8788).
  - Changed deactivation sequence iSMARTCARD_PHY_TDA8035_Deactivate() to properly stop the clockPOSCR-35).
  - Fixed timing issue with VSEL0/1 signals in smartcard TDA803driver (KPSDK-10160)

[2.1.1]

- New features:
  - Added default phy interface selection into smartcard RTOS drivers (KPSDK-9063).
  - Replaced smartcard_phy_ncn8025 driver by smartcard_phy_tda8035.
- Bug fix:
  - Fixed protocol timers activation sequences in smartcard_emvsim and smartcard_phy_tda8035 drivers during emvl1 pre-certification tests (KPSDK-9170, KPSDK-9556).

[2.1.0]

- Initial version.

SPI

[2.3.2]

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

[2.3.1]

- Improvements
  - Changed SPI_DUMMYDATA to 0x00.

[2.3.0]

- Update version.

[2.2.2]

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

[2.2.1]

- Bug Fixes
  - Fixed MISRA 2012 10.4 issue.
  - Added code to clear FIFOs before transfer using DMA.

[2.2.0]

- Bug Fixes
  - Fixed bug that slave gets stuck during interrupt transfer.

[2.1.1]

- Improvements
  - Added timeout mechanism when waiting certain states in transfer driver.
- Bug Fixes
  - Fixed MISRA 10.1, 5.7 issues.

[2.1.0]

- Bug Fixes
  - Fixed Coverity issue of incrementing null pointer in SPI_TransferHandleIRQInternal.
  - Eliminated IAR Pa082 warnings.
  - Fixed MISRA issues.
    - Fixed rules 10.1, 10.3, 10.4, 10.7, 10.8, 11.3, 11.6, 11.8, 11.9, 13.5.
- New Features
  - Modified the definition of SPI_SSELPOL_MASK to support the socs that have only 3 SSEL pins.

[2.0.4]

- Bug Fixes
  - Fixed the bug of using read only mode in DMA transfer. In DMA transfer mode, if transfer->txData is NULL, code attempts to read data from the address of 0x0 for configuring the last frame.
  - Fixed wrong assignment of handle->state. During transfer handle->state should be kSPI_Busy rather than kStatus_SPI_Busy.
- Improvements
  - Rounded up the calculated divider value in SPI_MasterSetBaud.

[2.0.3]

- Improvements
  - Added “SPI_FIFO_DEPTH(base)” with more definition.

[2.0.2]

- Improvements
  - Unified the component full name to FLEXCOMM SPI(DMA/FREERTOS) driver.

[2.0.1]

- Changed the data buffer from uint32_t to uint8_t which matches the real applications for SPI DMA driver.
- Added dummy data setup API to allow users to configure the dummy data to be transferred.
- Added new APIs for half-duplex transfer function. Users can not only send and receive data by one API in polling/interrupt/DMA way, but choose either to transmit first or to receive first. Besides, the PCS pin can be configured as assert status in transmission (between transmit and receive) by setting the isPcsAssertInTransfer to true.

[2.0.0]

- Initial version.

SPI_DMA

[2.2.1]

- Bug Fixes
  - Fixed MISRA 2012 11.6 issue..

[2.2.0]

- Improvements
  - Supported dataSize larger than 1024 data transmit.

TRNG

[2.0.18]

- Bug fix:
  - TRNG health checks now done in software on RT5xx and RT6xx.

[2.0.17]

- New features:
  - Add support for RT700.

[2.0.16]

- Improvements:
  - Added support for Dual oscillator mode.

[2.0.15]

- Other changes:
  - Changed TRNG_USER_CONFIG_DEFAULT_XXX values according to latest reccomended by design team.

[2.0.14]

- New features:
  - Add support for RW610 and RW612.

[2.0.13]

- Bug fix:
  - After deepsleep it might return error, added clearing bits in TRNG_GetRandomData() and generating new entropy.
  - Modified reloading entropy in TRNG_GetRandomData(), for some data length it doesn't reloading entropy correctly.

[2.0.12]

- Bug fix:
  - For KW34A4_SERIES, KW35A4_SERIES, KW36A4_SERIES set TRNG_USER_CONFIG_DEFAULT_OSC_DIV to kTRNG_RingOscDiv8.

[2.0.11]

- Bug fix:
  - Add clearing pending errors in TRNG_Init().

[2.0.10]

- Bug Fix:
  - Fixed doxygen issues.

[2.0.9]

- Bug Fix:
  - Fix HIS_CCM metrics issues.

[2.0.8]

- Bug fix:
  - For K32L2A41A_SERIES set TRNG_USER_CONFIG_DEFAULT_OSC_DIV to kTRNG_RingOscDiv4.

[2.0.7]

- Bug fix:
  - Fix MISRA 2004 issue rule 12.5.

[2.0.6]

- Bug fix:
  - For KW35Z4_SERIES set TRNG_USER_CONFIG_DEFAULT_OSC_DIV to kTRNG_RingOscDiv8.

[2.0.5]

- Improvements:
  - For FRQMIN, FRQMAX and OSCDIV, add possibility to use device specific preprocessor macro to define default value in TRNG user configuration structure.

[2.0.4]

- Bug Fix:
  - Fix MISRA-2012 issues.
    - Rule 10.1, rule 10.3, rule 13.5, rule 16.1.

[2.0.3]

- Improvements:
  - update TRNG_Init to restart new entropy generation.

[2.0.2]

- Improvements:
  - fix MISRA issues
    - Rule 14.4.

[2.0.1]

- New features:
  - Set default OSCDIV for Kinetis devices KL8x and KL28Z.
- Other changes:
  - Changed default OSCDIV for K81 to divide by 2.

[2.0.0]

- Initial version.

USART

[2.8.5]

- Bug Fixes
  - Fixed race condition during call of USART_EnableTxDMA and USART_EnableRxDMA.

[2.8.4]

- Bug Fixes
  - Fixed exclusive access in USART_TransferReceiveNonBlocking and USART_TransferSendNonBlocking.

[2.8.3]

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

[2.8.2]

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

[2.8.1]

- Bug Fixes
  - Fixed the Baud Rate Generator(BRG) configuration in 32kHz mode.

[2.8.0]

- New Features
  - Added the rx timeout interrupts and status flags of bus status.
  - Added new rx timeout configuration item in usart_config_t.
  - Added API USART_SetRxTimeoutConfig for rx timeout configuration.
- Improvements
  - When the calculated baudrate cannot meet user's configuration, lower OSR value is allewed to use.

[2.7.0]

- New Features
  - Added the missing interrupts and status flags of bus status.
  - Added the check of tx error, noise error framing error and parity error in interrupt handler.

[2.6.0]

- Improvements
  - Used separate data for TX and RX in usart_transfer_t.
- Bug Fixes
  - Fixed bug that when ring buffer is used, if some data is received in ring buffer first before calling USART_TransferReceiveNonBlocking, the received data count returned by USART_TransferGetReceiveCount is wrong.
- New Features
  - Added missing API USART_TransferGetSendCountDMA get send count using DMA.

[2.5.0]

- New Features
  - Added APIs USART_GetRxFifoCount/USART_GetTxFifoCount to get rx/tx FIFO data count.
  - Added APIs USART_SetRxFifoWatermark/USART_SetTxFifoWatermark to set rx/tx FIFO water mark.
- Bug Fixes
  - Fixed DMA transfer blocking issue by enabling tx idle interrupt after DMA transmission finishes.

[2.4.0]

- New Features
  - Modified usart_config_t, USART_Init and USART_GetDefaultConfig APIs so that the hardware flow control can be enabled during module initialization.
- Bug Fixes
  - Fixed MISRA 10.4 violation.

[2.3.1]

- Bug Fixes
  - Fixed bug that operation on INTENSET, INTENCLR, FIFOINTENSET and FIFOINTENCLR should use bitwise operation not ‘or’ operation.
  - Fixed bug that if rx interrupt occurrs before TX interrupt is enabled and after txDataSize is configured, the data will be sent early by mistake, thus TX interrupt will be enabled after data is sent out.
- Improvements

  - Added check for baud rate's accuracy that returns kStatus_USART_BaudrateNotSupport when the best achieved baud rate is not within 3% error of configured baud rate.

[2.3.0]

- New Features
  - Added APIs to configure 9-bit data mode, set slave address and send address.
  - Modified USART_TransferReceiveNonBlocking and USART_TransferHandleIRQ to use 9-bit mode in multi-slave system.

[2.2.0]

- New Features
  - Added the feature of supporting USART working at 32 kHz clocking mode.
- Improvements
  - Modified USART_TransferHandleIRQ so that txState will be set to idle only when all data has been sent out to bus.
  - Modified USART_TransferGetSendCount so that this API returns the real byte count that USART has sent out rather than the software buffer status.
  - Added timeout mechanism when waiting for certain states in transfer driver.
- Bug Fixes
  - Fixed MISRA 10.1 issues.
  - Fixed bug that operation on INTENSET, INTENCLR, FIFOINTENSET and FIFOINTENCLR should use bitwise operation not 'or' operation.
  - Fixed bug that if rx interrupt occurrs before TX interrupt is enabled and after txDataSize is configured, the data will be sent early by mistake, thus TX interrupt will be enabled after data is sent out.

[2.1.1]

- Improvements
  - Added check for transmitter idle in USART_TransferHandleIRQ and USART_TransferSendDMACallback to ensure all the data would be sent out to bus.
  - Modified USART_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.
- Bug Fixes
  - Eliminated IAR Pa082 warnings.
  - Fixed MISRA issues.
    - Fixed rules 10.1, 10.3, 10.4, 10.7, 10.8, 11.3, 11.6, 11.8, 11.9, 13.5.

[2.1.0]

- New Features
  - Added features to allow users to configure the USART to synchronous transfer(master and slave) mode.
- Bug Fixes

  - Modified USART_SetBaudRate to get more acurate configuration.

[2.0.3]

- New Features
  - Added new APIs to allow users to enable the CTS which determines whether CTS is used for flow control.

[2.0.2]

- Bug Fixes
  - Fixed the bug where transfer abort APIs could not disable the interrupts. The FIFOINTENSET register should not be used to disable the interrupts, so use the FIFOINTENCLR register instead.

[2.0.1]

- Improvements
  - Unified the component full name to FLEXCOMM USART (DMA/FREERTOS) driver.

[2.0.0]

- Initial version.

USART_DMA

[2.6.0]

- Refer USART driver change log 2.0.1 to 2.6.0

UTICK

[2.0.5]

- Improvements
  - Improved for SOC RW610.

[2.0.4]

- Bug Fixes
  - Fixed compile fail issue of no-supporting PD configuration in utick driver.

[2.0.3]

- Bug Fixes
  - Fixed violations of MISRA C-2012 rules: 8.4, 14.4, 17.7

[2.0.2]

- Added new feature definition macro to enable/disable power control in drivers for some devices have no power control function.

[2.0.1]

- Added control macro to enable/disable the CLOCK code in current driver.

[2.0.0]

- Initial version.

WWDT

[2.1.9]

- Bug Fixes
  - Fixed violation of the MISRA C-2012 rule 10.4.

[2.1.8]

- Improvements
  - Updated the "WWDT_Init" API to add wait operation. Which can avoid the TV value read by CPU still be 0xFF (reset value) after WWDT_Init function returns.

[2.1.7]

- Bug Fixes
  - Fixed the issue that the watchdog reset event affected the system from PMC.
  - Fixed the issue of setting watchdog WDPROTECT field without considering the backwards compatibility.
  - Fixed the issue of clearing bit fields by mistake in the function of WWDT_ClearStatusFlags.

[2.1.5]

- Bug Fixes
  - deprecated a unusable API in WWWDT driver.
    - WWDT_Disable

[2.1.4]

- Bug Fixes
  - Fixed violation of the MISRA C-2012 rules Rule 10.1, 10.3, 10.4 and 11.9.
  - Fixed the issue of the inseparable process interrupted by other interrupt source.
    - WWDT_Init

[2.1.3]

- Bug Fixes
  - Fixed legacy issue when initializing the MOD register.

[2.1.2]

- Improvements
  - Updated the “WWDT_ClearStatusFlags” API and “WWDT_GetStatusFlags” API to match QN9090. WDTOF is not set in case of WD reset. Get info from PMC instead.

[2.1.1]

- New Features
  - Added new feature definition macro for devices which have no LCOK control bit in MOD register.
  - Implemented delay/retry in WWDT driver.

[2.1.0]

- Improvements
  - Added new parameter in configuration when initializing WWDT module. This parameter, which must be set, allows the user to deliver the WWDT clock frequency.

[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.

RW612

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 Wireless Connectivity Framework

framework

1.7.2 MCU Boot

mcuboot_opensource

1.7.3 Audio Voice components

Audio Voice Components

1.7.4 Maestro Audio Framework for MCU

Maestro Audio Framework

1.7.5 FreeMASTER

freemaster

1.7.6 AWS IoT

AWS IoT

1.7.7 NXP Wi-Fi

Wi-Fi

1.7.8 FreeRTOS

FreeRTOS

1.7.9 Wireless EdgeFast Bluetooth PAL

edgefast_bluetooth

1.7.10 lwIP

lwIP

1.7.11 File systemFatfs

FatFs

Chapter 2

RW612

2.1 ACOMP: Analog Comparator

void ACOMP_Init(ACOMP_Type *base, const *acomp_config_t* *config)

Initializes the module, including warm up time, response mode, inactive value and so on.

Parameters

- base – ACOMP peripheral base address.
- config – The pointer to the structure acomp_config_t.

void ACOMP_GetDefaultConfig(*acomp_config_t* *config)

Gets the default configuration of ACOMP module.

```
config->id = kACOMP_Acomp0;
config->enable = false;
config->warmupTime = kACOMP_WarmUpTime1us;
config->responseMode = kACOMP_SlowResponseMode;
config->inactiveValue = kACOMP_ResultLogicLow;
config->intTrigType = kACOMP_HighLevelTrig;
config->edgeDetectTrigSrc = kACOMP_EdgePulseDis;
config->outPinMode = kACOMP_PinOutDisable;
config->posInput = NULL;
config->negInput = NULL;
```

Parameters

- config – The pointer to the structure acomp_config_t.

void ACOMP_Deinit(ACOMP_Type *base)

De-initializes the module.

Parameters

- base – ACOMP peripheral base address.

void ACOMP_SetInputConfig(ACOMP_Type *base, *acomp_comparator_id_t* id, const *acomp_positive_input_config_t* *posInput, const *acomp_negative_input_config_t* *negInput)

Configures selected comparator's inputs, inclduing input channel and hysteresis level.

Parameters

- base – ACOMP peripheral base address.

- id – The selected acomp comparator's id, please refer to acomp_comparator_id_t.
- posInput – The configuration of selected comparator's positive input, please refer to acomp_positive_input_config_t.
- negInput – The configuration of selected comparator's negative input, please refer to acomp_negative_input_config_t.

static inline void ACOMP_DoSoftwareReset(ACOMP_Type *base, *acomp_comparator_id_t* id)

Does software reset to the selected ACOMP module.

Parameters

- base – ACOMP peripheral base address.
- id – The selected acomp comparator's id, please refer to acomp_comparator_id_t.

static inline void ACOMP_Enable(ACOMP_Type *base, *acomp_comparator_id_t* id, bool enable)

Enables/Disables ACOMP module.

Parameters

- base – ACOMP peripheral base address.
- id – The selected acomp comparator's id, please refer to acomp_comparator_id_t.
- enable – Used to enable/disable module.
  - **true** Enable comparator instance.
  - **false** Disable comparator instance.

static inline void ACOMP_ResetClockDivider(ACOMP_Type *base)

Resets clock divider.

Parameters

- base – ACOMP peripheral base address.

static inline *acomp_result_logic_status_t* ACOMP_GetResult(ACOMP_Type *base, *acomp_comparator_id_t* id)

Gets the selected acomp conversion result.

Parameters

- base – ACOMP peripheral base address.
- id – The selected acomp comparator's id, please refer to acomp_comparator_id_t.

Returns

The result of the selected acomp instance.

static inline void ACOMP_EnableInterrupts(ACOMP_Type *base, uint32_t interruptMask)

ACOMP Interrupt Control Interfaces.

Enables interrupts, including acomp0 asynchronized interrupt, acomp0 synchronized interrupt, acomp1 asynchronized interrupt, and acomp1 synchronized interrupt.

Parameters

- base – ACOMP peripheral base address.
- interruptMask – The OR'ed value of the interrupts to be enabled, please refer to _acomp_interrupt_enable.

static inline void ACOMP_DisableInterrupt(ACOMP_Type *base, uint32_t interruptMask)

Disables interrupts, including acomp0 asynchronized interrupt, acomp0 synchronized interrupt, acomp1 asynchronized interrupt, and acomp1 synchronized interrupt.

Parameters

- base – ACOMP peripheral base address.
- interruptMask – The OR'ed value of the interrupts to be disabled, please refer to _acomp_interrupt_enable.

uint32_t ACOMP_GetStatusFlags(ACOMP_Type *base)

ACOMP Status Flag Interfaces.

Gets status flags, such as ACOMP0 active status flags, ACOMP1 active status flags, and so on.

Parameters

- base – ACOMP peripheral base address.

Returns

The OR'ed value ACOMP status flags, please refer to _acomp_status_flags for details.

static inline void ACOMP_ClearStatusFlags(ACOMP_Type *base, uint32_t statusFlagMask)

Clears status flags that can be cleared by software.

Note: Only kACOMP_Acomp0OutInterruptFlag, kACOMP_Acomp0OutAInterruptFlag, kACOMP_Acomp1OutInterruptFlag, and kACOMP_Acomp1OutAInterruptFlag can be cleared by software.

Parameters

- base – ACOMP peripheral base address.
- statusFlagMask – The OR'ed value of the status flags that can be cleared.

enum _acomp_interrupt_enable

The enumeration of interrupts, including ACOMP0 synchrnized output interrupt, ACOMP0 asynchrnized output interrupt, ACOMP1 synchrnized output interrupt, and ACOMP1 asynchrnized output interrupt.

Values:

enumerator kACOMP_Out0InterruptEnable

ACOMP0 synchrnized output interrupt enable.

enumerator kACOMP_OutA0InterruptEnable

ACOMP0 asynchrnized output interrupt enable.

enumerator kACOMP_Out1InterruptEnable

ACOMP1 synchrnized output interrupt enable.

enumerator kACOMP_OutA1InterruptEnable

ACOMP1 asynchrnized output interrupt enable.

enum _acomp_status_flags

The enumeration of status flags, including ACOMP0 active staus flag, ACOMP1 active status flag, and so on.

Values:

enumerator kACOMP_Acomp0ActiveFlag

ACOMP0 active status flag, if this flag is set it means the ACOMP0 is active.

enumerator kACOMP_Acomp0OutInterruptFlag

ACOMP0 Synchronized output interrupt flags, this flag is set when ACOMP0 synchronized output changes from 0 to 1 and the corresponding interrupt is enabled.

enumerator kACOMP_Acomp0OutAInterruptFlag

ACOMP0 Asynchronized output interrupt flags, this flag is set when ACOMP0 asynchronized output changes from 0 to 1 and the corresponding interrupt is enabled.

enumerator kACOMP_Acomp0RawOutInterruptFlag

ACOMP0 raw synchroized output interrrupt flags.

enumerator kACOMP_Acomp0RawOutAInterruptFlag

ACOMP0 raw asynchroized output interrupt flags.

enumerator kACOMP_Acomp1ActiveFlag

ACOMP1 active status flag, if this flag is set it means the ACOMP0 is active.

enumerator kACOMP_Acomp1OutInterruptFlag

ACOMP1 Synchronized output interrupt flags, this flag is set when ACOMP1 synchronized output changes from 0 to 1 and the corresponding interrupt is enabled.

enumerator kACOMP_Acomp1OutAInterruptFlag

ACOMP1 Asynchronized output interrupt flags, this flag is set when ACOMP1 asynchronized output changes from 0 to 1 and the corresponding interrupt is enabled.

enumerator kACOMP_Acomp1RawOutInterruptFlag

ACOMP1 raw synchroized output interrrupt flags.

enumerator kACOMP_Acomp1RawOutAInterruptFlag

ACOMP1 raw asynchroized output interrupt flags.

enum _acomp_result_logic_status

ACOMP result logical status Type definition.

Values:

enumerator kACOMP_ResultLogicLow

The comparsion result is high logic.

enumerator kACOMP_ResultLogicHigh

The comparsion result is low logic.

enum _acomp_comparator_id

ACOMP comparator id.

Values:

enumerator kACOMP_Acomp0

Index for ACOMP0

enumerator kACOMP_Acomp1

Index for ACOMP1

enum _acomp_warm_up_time

The enumeration of wave up time.

Values:

enumerator kACOMP_WarmUpTime1us

Set wave-up time as 1us.

enumerator kACOMP_WarmUpTime2us

Set wave-up time as 2us.

enumerator kACOMP_WarmUpTime4us
Set wave-up time as 4us.

enumerator kACOMP_WarmUpTime8us
Set wave-up time as 8us.

enum _acomp_response_mode
The enumeration of response mode. The response mode will affect the delay from input to output.

Values:

enumerator kACOMP_SlowResponseMode
Slow response mode also called power mode 1.

enumerator kACOMP_MediumResponseMode
Medium response mode also called power mode 2.

enumerator kACOMP_FastResponseMode
Fast response mode also called power mode 3.

enum _acomp_interrupt_trigger_type
ACOMP interrupt trigger type definition.

Values:

enumerator kACOMP_LowLevelTrig
Low level trigger interrupt.

enumerator kACOMP_HighLevelTrig
High level trigger interrupt.

enumerator kACOMP_FallingEdgeTrig
Falling edge trigger interrupt.

enumerator kACOMP_RisingEdgeTrig
Rising edge trigger interrupt.

enum _acomp_edge_pulse_trig_source
ACOMP edge pule trigger source type definition.

Values:

enumerator kACOMP_EdgePulseDis
edge pulse function is disable

enumerator kACOMP_EdgePulseRising
Rising edge can trigger edge pulse

enumerator kACOMP_EdgePulseFalling
Falling edge can trigger edge pulse

enumerator kACOMP_EdgePulseBothEdge
Both edge can trigger edge pulse

enum _acomp_pin_out_type
ACOMP synchronous/asynchronous output type to pin.

Values:

enumerator kACOMP_PinOutSyn
Enable ACOMP synchronous pin output

enumerator kACOMP_PinOutAsyn
Enable ACOMP asynchronous pin output

enumerator kACOMP_PinOutSynInverted
Enable ACOMP inverted synchronous pin output

enumerator kACOMP_PinOutAsynInverted
Enable ACOMP inverted asynchronous pin output

enumerator kACOMP_PinOutDisable
Diable ACOMP pin output

enum _acomp_positive_channel
ACOMP positive channel enumeration.

Values:

enumerator kACOMP_PosCh0
ACOMP Channel0 selection

enumerator kACOMP_PosCh1
ACOMP Channel1 selection

enumerator kACOMP_PosCh2
ACOMP Channel2 selection

enumerator kACOMP_PosCh3
ACOMP Channel3 selection

enumerator kACOMP_PosCh4
ACOMP Channel4 selection

enumerator kACOMP_PosCh5
ACOMP Channel5 selection

enumerator kACOMP_PosCh6
ACOMP Channel6 selection

enumerator kACOMP_PosCh7
ACOMP Channel7 selection

enumerator kACOMP_PosChDACA
DACA selection

enumerator kACOMP_PosChDACB
DACB selection

enum _acomp_negative_channel
ACOMP negative channel enumeration.

Values:

enumerator kACOMP_NegCh0
ACOMP Channel0 selection

enumerator kACOMP_NegCh1
ACOMP Channel1 selection

enumerator kACOMP_NegCh2
ACOMP Channel2 selection

enumerator kACOMP_NegCh3
ACOMP Channel3 selection

enumerator kACOMP_NegCh4
ACOMP Channel4 selection

enumerator kACOMP_NegCh5
ACOMP Channel5 selection

enumerator kACOMP_NegCh6
ACOMP Channel6 selection

enumerator kACOMP_NegCh7
ACOMP Channel7 selection

enumerator kACOMP_NegChDACA
DACA selection

enumerator kACOMP_NegChDACB
DACB selection

enumerator kACOMP_NegChVREF1P2
Vref1p2 selection

enumerator kACOMP_NegChAVSS
AVSS selection

enumerator kACOMP_NegChVIO_0P25
VIO Scaling factor 0.25

enumerator kACOMP_NegChVIO_0P50
VIO Scaling factor 0.50

enumerator kACOMP_NegChVIO_0P75
VIO Scaling factor 0.75

enumerator kACOMP_NegChVIO_1P00
VIO Scaling factor 1.00

enum _acomp_input_hysteresis
ACOMP hysteresis level enumeration.

Values:

enumerator kACOMP_Hyster0MV
Hysteresis level = 0mv

enumerator kACOMP_Hyster10MV
Hysteresis level = 10mv

enumerator kACOMP_Hyster20MV
Hysteresis level = 20mv

enumerator kACOMP_Hyster30MV
Hysteresis level = 30mv

enumerator kACOMP_Hyster40MV
Hysteresis level = 40mv

enumerator kACOMP_Hyster50MV
Hysteresis level = 50mv

enumerator kACOMP_Hyster60MV
Hysteresis level = 60mv

enumerator kACOMP_Hyster70MV
Hysteresis level = 70mv

typedef enum *_acomp_result_logic_status* acomp_result_logic_status_t
ACOMP result logical status Type definition.

typedef enum *_acomp_comparator_id* acomp_comparator_id_t
ACOMP comparator id.

typedef enum *_acomp_warm_up_time* acomp_warm_up_time_t
The enumeration of wave up time.

typedef enum *_acomp_response_mode* acomp_response_mode_t
The enumeration of response mode. The response mode will affect the delay from input to output.

typedef enum *_acomp_interrupt_trigger_type* acomp_interrupt_trigger_type_t
ACOMP interrupt trigger type definition.

typedef enum *_acomp_edge_pulse_trig_source* acomp_edge_pulse_trig_source_t
ACOMP edge pule trigger source type definition.

typedef enum *_acomp_pin_out_type* acomp_pin_out_type_t
ACOMP synchronous/asynchronous output type to pin.

typedef enum *_acomp_positive_channel* acomp_positive_channel_t
ACOMP positive channel enumeration.

typedef enum *_acomp_negative_channel* acomp_negative_channel_t
ACOMP negative channel enumeration.

typedef enum *_acomp_input_hysteresis* acomp_input_hysteresis_t
ACOMP hysteresis level enumeration.

typedef struct *_acomp_positive_input_config* acomp_positive_input_config_t
The configuration of positive input, including channel selection and hysteresis level.

typedef struct *_acomp_negative_input_config* acomp_negative_input_config_t
The configuration of negative input, including channel selection and hysteresis level.

typedef struct *_acomp_config* acomp_config_t
The configure structure of acomp, including warm up time, response mode and so on.

FSL_ACOMP_DRIVER_VERSION
ACOMP driver version.

Version 2.0.1.

ACOMP_REG_ADDR(startAddr, id)
The macro to get the address based on start address and acomp id.

ACOMP_REG_CONST_ADDR(startAddr, id)

ACOMP_GET_REG_VAL(startAddr, id)
The macro to get register value based on start address and acomp id.

ACOMP_GET_REG_CONST_VAL(startAddr, id)

ACOMP_SET_REG_BIT(startAddr, id, val)
Sets register's bit field.

ACOMP_CLEAR_REG_BIT(startAddr, id, val)
Clears register's bit field.

struct _acomp_positive_input_config

#include <fsl_acomp.h> The configuration of positive input, including channel selection and hysteresis level.

Public Members

acomp_positive_channel_t channel

Positive input channel selection, please refer to acomp_positive_channel_t.

acomp_input_hysteresis_t hysterLevel

Positive hysteresis voltage level selection, please refer to acomp_input_hysteresis_t.

struct _acomp_negative_input_config

#include <fsl_acomp.h> The configuration of negative input, including channel selection and hysteresis level.

Public Members

acomp_negative_channel_t channel

Negative input channel selection, please refer to acomp_negative_channel_t.

acomp_input_hysteresis_t hysterLevel

Negative hystersis voltage level selection, please refer to acomp_input_hysteresis_t.

struct _acomp_config

#include <fsl_acomp.h> The configure structure of acomp, including warm up time, response mode and so on.

Public Members

acomp_comparator_id_t id

The id of comparator, please refer to acomp_comparator_id_t.

bool enable

Enable/Disable the selected ACOMP.

- **true** Enable the selected ACOMP.
- **false** Disable the selected ACOMP.

acomp_warm_up_time_t warmupTime

Configure warm-up time, please refer to acomp_warm_up_time_t.

acomp_response_mode_t responseMode

Configure responde mode(power mode), please refer to acomp_response_mode_t for details.

acomp_interrupt_trigger_type_t intTrigType

Select interrupt trigger type, please refer to acomp_interrupt_trigger_type_t.

acomp_result_logic_status_t inactiveValue

Configure output value for inactive state.

acomp_edge_pulse_trig_source_t edgeDetectTrigSrc

Config edge detect trigger source, please refer to acomp_edge_pulse_trig_source_t.

acomp_pin_out_type_t outPinMode

Config the output pin mode, please refer to acomp_pin_out_type_t for details.

const *acomp_positive_input_config_t* *posInput

The pointer to the configuration structure of positive input, please refer to acomp_positive_input_config_t.

const *acomp_negative_input_config_t* *negInput

The pointer to the configuration structure of negative input, please refer to acomp_positive_input_config_t.

2.2 ADC: Analog Digital Converter

void ADC_Init(ADC_Type *base, const *adc_config_t* *config)

Initialize ADC module, including clock divider, power mode, and so on.

Parameters

- base – ADC peripheral base address.
- config – The pointer to the structure adc_config_t.

void ADC_GetDefaultConfig(*adc_config_t* *config)

Get default configuration.

```
config->clockDivider = kADC_ClockDivider1;
config->powerMode = kADC_PowerModeFullBiasingCurrent;
config->resolution = kADC_Resolution12Bit;
config->warmupTime = kADC_WarmUpTime16us;
config->vrefSource = kADC_Vref1P2V;
config->inputMode = kADC_InputSingleEnded;
config->conversionMode = kADC_ConversionContinuous;
config->scanLength = kADC_ScanLength_1;
config->averageLength = kADC_AverageNone;
config->triggerSource = kADC_TriggerSourceSoftware;
config->inputGain = kADC_InputGain1;
config->enableInputGainBuffer = false;
config->resultWidth = kADC_ResultWidth16;
config->fifoThreshold = kADC_FifoThresholdData1;
config->enableDMA = false;
config->enableADC = false;
```

Parameters

- config – The Pointer to the structure adc_config_t.

void ADC_Deinit(ADC_Type *base)

De-initialize the ADC module.

Parameters

- base – ADC peripheral base address.

static inline void ADC_DoSoftwareReset(ADC_Type *base)

Reset the whole ADC block.

Parameters

- base – ADC peripheral base address.

static inline void ADC_SelectAnalogPortionPowerMode(ADC_Type *base, *adc_analog_portion_power_mode_t* powerMode)

Select ADC analog portion power mode.

Parameters

- base – ADC peripheral base address.
- powerMode – The power mode to be set, please refer to adc_analog_portion_power_mode_t.

status_t ADC_DoAutoCalibration(ADC_Type *base, *adc_calibration_ref_t* calVref)

Do automatic calibration measurement.

Note: After auto calibrate successful, user can invoke ADC_GetAutoCalibrationData() to get self offset calibration value and self gain calibration value.

Parameters

- base – ADC peripheral base address.
- calVref – The inpul reference channel for gain calibration, please refer to adc_calibration_ref_t for details.

Return values

- kStatus_Success – Auto calibrate successfully.
- kStatus_Fail – Auto calibrate failure.

static inline void ADC_GetAutoCalibrationData(ADC_Type *base, uint16_t *offsetCal, uint16_t *gainCal)

Get the ADC automatic calibration data.

Parameters

- base – ADC peripheral base address.
- offsetCal – Self offset calibration data pointer, evaluate NULL if not requried.
- gainCal – Self gain calibration data pointer, evaluate NULL if not requried.

static inline void ADC_ResetAutoCalibrationData(ADC_Type *base)

Reset the automatic calibration data.

Parameters

- base – ADC peripheral base address.

static inline void ADC_DoUserCalibration(ADC_Type *base, uint16_t offsetCal, uint16_t gainCal)

Do user defined calibration.

Parameters

- base – ADC peripheral base address.
- offsetCal – User defined offset calibration data.
- gainCal – User defined gain calibration date.

static inline void ADC_EnableTemperatureSensor(ADC_Type *base, bool enable)

Enable/disable temperature sensor.

Note: This function is useful only when the channel source is temperature sensor.

Parameters

- base – ADC peripheral base address.

- enable – Used to enable/disable temperature sensor.
  - **true** Enable temperature sensor.
  - **false** Disable temperature sensor.

static inline void ADC_SetTemperatureSensorMode(ADC_Type *base, *adc_temperature_sensor_mode_t* tSensorMode)

Set temperature sensor mode, available selections are internal diode mode and external diode mode.

Parameters

- base – ADC peripheral base address.
- tSensorMode – The temperature sensor mode to be set, please refer to adc_temperature_sensor_mode_t.

static inline void ADC_EnableAudio(ADC_Type *base, bool enable)

Enable/disable audio PGA and decimation rate select.

Parameters

- base – ADC peripheral base address.
- enable – Used to enable/disable audio PGA and decimation rate select.
  - **true** Enable audio PGA and decimation rate select.
  - **false** Disable audio PGA and decimation rate select.

static inline void ADC_SetAudioPGAVoltageGain(ADC_Type *base, *adc_audio_pga_voltage_gain_t* voltageGain)

Set audio PGA voltage gain.

Parameters

- base – ADC peripheral base address.
- voltageGain – The selected audio PGA voltage gain, please refer to adc_audio_pga_voltage_gain_t.

void ADC_ConfigAudioVoiceLevel(ADC_Type *base, bool enableDetect, *adc_audio_voice_level_t* voiceLevel)

Configure audio voice level.

Parameters

- base – ADC peripheral base address.
- enableDetect – Used to enable/disable voice level detection.
  - **true** Enable voice level detection.
  - **false** Disable voice level detection.
- voiceLevel – Selected voice level, please refer to adc_audio_voice_level_t.

void ADC_SetScanChannel(ADC_Type *base, *adc_scan_channel_t* scanChannel, *adc_channel_source_t* channelSource)

Set scan channel mux source.

Parameters

- base – ADC peripheral base address.
- scanChannel – The selected channel, please refer to adc_scan_channel_t for details.

- channelSource – The mux source to be set to the selected channel, please refer to adc_channel_source_t for details.

static inline void ADC_DoSoftwareTrigger(ADC_Type *base)

If trigger mode is selected as software trigger, invoking this function to start conversion.

Note: This API will also clear the FIFO.

Parameters

- base – ADC peripheral base address.

static inline void ADC_StopConversion(ADC_Type *base)

Invoke this function to stop conversion.

Parameters

- base – ADC peripheral base address.

static inline uint32_t ADC_GetConversionResult(ADC_Type *base)

Get the 32-bit width packed ADC conversion result.

Parameters

- base – ADC peripheral base address.

Returns

32-bit width packed ADC conversion result.

static inline uint8_t ADC_GetFifoDataCount(ADC_Type *base)

Get the ADC FIFO data count.

Parameters

- base – ADC peripheral base address.

Returns

ADC FIFO data count.

static inline void ADC_EnableInterrupts(ADC_Type *base, uint32_t interruptMask)

Enable interrupts, such as conversion data ready interrupt, gain correction saturation interrupt, FIFO under run interrupt, and so on.

Parameters

- base – ADC peripheral base address.
- interruptMask – The interrupts to be enabled, should be the OR'ed value of _adc_interrupt_enable.

static inline void ADC_DisableInterrupts(ADC_Type *base, uint32_t interruptMask)

Disable interrupts, such as conversion data ready interrupt, gain correction saturation interrupt, FIFO under run interrupt, and so on.

Parameters

- base – ADC peripheral base address.
- interruptMask – The interrupts to be disabled, should be the OR'ed value of _adc_interrupt_enable.

uint32_t ADC_GetStatusFlags(ADC_Type *base)

Get status flags, including interrupt flags, raw flags, and so on.

Parameters

- base – ADC peripheral base address.

Returns

The OR'ed value of ADC status flags, please refer to _adc_status_flags for details.

static inline void ADC_ClearStatusFlags(ADC_Type *base, uint32_t statusFlagsMask)

Clear status flags.

Note: Only interrupt flags and raw flags can be cleared.

Parameters

- base – ADC peripheral base address.
- statusFlagsMask – The OR'ed value of status flags to be cleared, please refer to _adc_status_flags for details.

enum _adc_interrupt_enable

The enumeration of interrupts, this enumeration can be used to enable/disable interrupts.

Values:

enumerator kADC_DataReadyInterruptEnable

Conversion data ready interrupt.

enumerator kADC_GainSaturationInterruptEnable

Gain correction saturation interrupt

enumerator kADC_OffsetSaturationInterruptEnable

Offset correction saturation interupt enable.

enumerator kADC_NegativeSaturationInterruptEnable

ADC data negative side saturation interrupt enable.

enumerator kADC_PositiveSaturationInterruptEnable

ADC data positive side saturation interrupt enable.

enumerator kADC_FifoOverrunInterruptEnable

FIFO overrun interrupt enable.

enumerator kADC_FifoUnderrunInterruptEnable

FIFO underrun interrupt enable.

enum _adc_status_flags

The enumeration of adc status flags, including interrupt flags, raw flags, and so on.

Note: The raw flags will be captured regardless the interrupt mask. Both interrupt flags and raw flags can be cleared.

Values:

enumerator kADC_DataReadyInterruptFlag

Conversion Data Ready interrupt flag.

enumerator kADC_GainSaturationInterruptFlag

Gain correction saturation interrupt flag.

enumerator kADC_OffsetSaturationInterruptFlag

Offset correction saturation interupt flag.

enumerator kADC_NegativeSaturationInterruptFlag
ADC data negative side saturation interrupt flag.

enumerator kADC_PositiveSaturationInterruptFlag
ADC data positive side saturation interrupt flag.

enumerator kADC_FifoOverrunInterruptFlag
FIFO overrun interrupt flag.

enumerator kADC_FifoUnderrunInterruptFlag
FIFO underrun interrupt flag.

enumerator kADC_DataReadyRawFlag
Conversion data ready raw flag, this flag will be captured regardless the interrupt mask.

enumerator kADC_GainSaturationRawFlag
Gain correction saturation raw flag, this flag will be captured regardless the interrupt mask.

enumerator kADC_OffsetSaturationRawFlag
Offset correction saturation raw flag, this flag will be captured regardless the interrupt mask.

enumerator kADC_NegativeSaturationRawFlag
ADC data negative side saturation raw flag, this flag will be captured regardless the interrupt mask.

enumerator kADC_PositiveSaturationRawFlag
ADC data positive side saturation raw flag, this flag will be captured regardless the interrupt mask.

enumerator kADC_FifoOverrunRawFlag
FIFO overrun raw flag, this flag will be captured regardless the interrupt mask.

enumerator kADC_FifoUnderrunRawFlag
FIFO underrun interrupt mask, this flag will be captured regardless the interrupt mask.

enumerator kADC_ActiveStatusFlag
ADC conversion active status flag.

enumerator kADC_FIFONotEmptyStatusFlag
FIFO not empty status flag.

enumerator kADC_FifoFullStatusFlag
FIFO full status flag.

enum _adc_clock_divider
ADC clock divider ratio type.

Values:

enumerator kADC_ClockDivider1
Clock divider ratio is 1

enumerator kADC_ClockDivider2
Clock divider ratio is 2

enumerator kADC_ClockDivider3
Clock divider ratio is 3

enumerator kADC_ClockDivider4
Clock divider ratio is 4

enumerator kADC_ClockDivider5
Clock divider ratio is 5

enumerator kADC_ClockDivider6
Clock divider ratio is 6

enumerator kADC_ClockDivider7
Clock divider ratio is 7

enumerator kADC_ClockDivider8
Clock divider ratio is 8

enumerator kADC_ClockDivider9
Clock divider ratio is 9

enumerator kADC_ClockDivider10
Clock divider ratio is 10

enumerator kADC_ClockDivider11
Clock divider ratio is 11

enumerator kADC_ClockDivider12
Clock divider ratio is 12

enumerator kADC_ClockDivider13
Clock divider ratio is 13

enumerator kADC_ClockDivider14
Clock divider ratio is 14

enumerator kADC_ClockDivider15
Clock divider ratio is 15

enumerator kADC_ClockDivider16
Clock divider ratio is 16

enumerator kADC_ClockDivider17
Clock divider ratio is 17

enumerator kADC_ClockDivider18
Clock divider ratio is 18

enumerator kADC_ClockDivider19
Clock divider ratio is 19

enumerator kADC_ClockDivider20
Clock divider ratio is 20

enumerator kADC_ClockDivider21
Clock divider ratio is 21

enumerator kADC_ClockDivider22
Clock divider ratio is 22

enumerator kADC_ClockDivider23
Clock divider ratio is 23

enumerator kADC_ClockDivider24
Clock divider ratio is 24

enumerator kADC_ClockDivider25
Clock divider ratio is 25

enumerator kADC_ClockDivider26
Clock divider ratio is 26

enumerator kADC_ClockDivider27
Clock divider ratio is 27

enumerator kADC_ClockDivider28
Clock divider ratio is 28

enumerator kADC_ClockDivider29
Clock divider ratio is 29

enumerator kADC_ClockDivider30
Clock divider ratio is 30

enumerator kADC_ClockDivider31
Clock divider ratio is 31

enumerator kADC_ClockDivider32
Clock divider ratio is 32

enum _adc_analog_portion_power_mode
ADC analog portion low-power mode selection.

Values:

enumerator kADC_PowerModeFullBiasingCurrent
Full biasing current.

enumerator kADC_PowerModeHalfBiasingCurrent
Half biasing current.

enum _adc_resolution
ADC resolution type.

Values:

enumerator kADC_Resolution12Bit
12-bit resolution

enumerator kADC_Resolution14Bit
14-bit resolution

enumerator kADC_Resolution16Bit
16-bit resolution

enumerator kADC_Resolution16BitAudio
16-bit resolution for audio application

enum _adc_warm_up_time
The enumeration of adc warm up time, the ADC warm-up state can also bypassed.

Values:

enumerator kADC_WarmUpTime1us
ADC warm-up time is 1 us.

enumerator kADC_WarmUpTime2us
ADC warm-up time is 2 us.

enumerator kADC_WarmUpTime3us
ADC warm-up time is 3 us.

enumerator kADC_WarmUpTime4us
ADC warm-up time is 4 us.

enumerator kADC_WarmUpTime5us
ADC warm-up time is 5 us.

enumerator kADC_WarmUpTime6us
ADC warm-up time is 6 us.

enumerator kADC_WarmUpTime7us
ADC warm-up time is 7 us.

enumerator kADC_WarmUpTime8us
ADC warm-up time is 8 us.

enumerator kADC_WarmUpTime9us
ADC warm-up time is 9 us.

enumerator kADC_WarmUpTime10us
ADC warm-up time is 10 us.

enumerator kADC_WarmUpTime11us
ADC warm-up time is 11 us.

enumerator kADC_WarmUpTime12us
ADC warm-up time is 12 us.

enumerator kADC_WarmUpTime13us
ADC warm-up time is 13 us.

enumerator kADC_WarmUpTime14us
ADC warm-up time is 14 us.

enumerator kADC_WarmUpTime15us
ADC warm-up time is 15 us.

enumerator kADC_WarmUpTime16us
ADC warm-up time is 16 us.

enumerator kADC_WarmUpTime17us
ADC warm-up time is 17 us.

enumerator kADC_WarmUpTime18us
ADC warm-up time is 18 us.

enumerator kADC_WarmUpTime19us
ADC warm-up time is 19 us.

enumerator kADC_WarmUpTime20us
ADC warm-up time is 20 us.

enumerator kADC_WarmUpTime21us
ADC warm-up time is 21 us.

enumerator kADC_WarmUpTime22us
ADC warm-up time is 22 us.

enumerator kADC_WarmUpTime23us
ADC warm-up time is 23 us.

enumerator kADC_WarmUpTime24us
ADC warm-up time is 24 us.

enumerator kADC_WarmUpTime25us
ADC warm-up time is 25 us.

enumerator kADC_WarmUpTime26us
ADC warm-up time is 26 us.

enumerator kADC_WarmUpTime27us
ADC warm-up time is 27 us.

enumerator kADC_WarmUpTime28us
ADC warm-up time is 28 us.

enumerator kADC_WarmUpTime29us
ADC warm-up time is 29 us.

enumerator kADC_WarmUpTime30us
ADC warm-up time is 30 us.

enumerator kADC_WarmUpTime31us
ADC warm-up time is 31 us.

enumerator kADC_WarmUpTime32us
ADC warm-up time is 32 us.

enumerator kADC_WarmUpStateBypass
ADC warm-up state bypassed.

enum _adc_vref_source
ADC voltage reference source type.

Values:

enumerator kADC_Vref1P8V
Internal 1.8V reference

enumerator kADC_Vref1P2V
Internal 1.2V reference

enumerator kADC_VrefExternal
External single-ended reference though ADC_CH3

enumerator kADC_VrefInternal1P2V
Internal 1.2V reference with cap filter though ADC_CH3

enum _adc_input_mode
ADC input mode type.

Values:

enumerator kADC_InputSingleEnded
Single-ended mode

enumerator kADC_InputDifferential
Differential mode

enum _adc_conversion_mode
ADC conversion mode type.

Values:

enumerator kADC_ConversionOneShot
One shot mode

enumerator kADC_ConversionContinuous
Continuous mode

enum _adc_scan_length
ADC scan length type.

Values:

enumerator kADC_ScanLength_1
Scan length is 1

enumerator kADC_ScanLength_2
Scan length is 2

enumerator kADC_ScanLength_3
Scan length is 3

enumerator kADC_ScanLength_4
Scan length is 4

enumerator kADC_ScanLength_5
Scan length is 5

enumerator kADC_ScanLength_6
Scan length is 6

enumerator kADC_ScanLength_7
Scan length is 7

enumerator kADC_ScanLength_8
Scan length is 8

enumerator kADC_ScanLength_9
Scan length is 9

enumerator kADC_ScanLength_10
Scan length is 10

enumerator kADC_ScanLength_11
Scan length is 11

enumerator kADC_ScanLength_12
Scan length is 12

enumerator kADC_ScanLength_13
Scan length is 13

enumerator kADC_ScanLength_14
Scan length is 14

enumerator kADC_ScanLength_15
Scan length is 15

enumerator kADC_ScanLength_16
Scan length is 16

enum _adc_average_length
ADC average length type.

Values:

enumerator kADC_AverageNone
Average length: no average

enumerator kADC_Average2
Average length: 2

enumerator kADC_Average4
Average length: 4

enumerator kADC_Average8
Average length: 8

enumerator kADC_Average16
Average length: 16

enum _adc_input_gain
ADC input buffer gain type.

Values:

enumerator kADC_InputGain0P5
Input buffer gain is 0.5

enumerator kADC_InputGain1
Input buffer gain is 1

enumerator kADC_InputGain2
Input buffer gain is 2

enum _adc_result_width
ADC result width type.

Values:

enumerator kADC_ResultWidth16
16-bit final result buffer width

enumerator kADC_ResultWidth32
32-bit final result buffer width

enum _adc_fifo_threshold
The threshold of FIFO.

Values:

enumerator kADC_FifoThresholdData1
FIFO Threshold is 1 data.

enumerator kADC_FifoThresholdData4
FIFO Threshold is 4 data.

enumerator kADC_FifoThresholdData8
FIFO Threshold is 8 data.

enumerator kADC_FifoThresholdData16
FIFO Threshold is 16 data.

enum _adc_calibration_ref
ADC calibration voltage reference type.

Values:

enumerator kADC_CalibrationVrefInternal
Internal vref as input for calibration

enumerator kADC_CalibrationVrefExternal
External vref as input for calibration

enum _adc_scan_channel
ADC scan channel type.

Values:

enumerator kADC_ScanChannel0
Scan channel 0

enumerator kADC_ScanChannel1
Scan channel 1

enumerator kADC_ScanChannel2
Scan channel 2

enumerator kADC_ScanChannel3
Scan channel 3

enumerator kADC_ScanChannel4
Scan channel 4

enumerator kADC_ScanChannel5
Scan channel 5

enumerator kADC_ScanChannel6
Scan channel 6

enumerator kADC_ScanChannel7
Scan channel 7

enumerator kADC_ScanChannel8
Scan channel 8

enumerator kADC_ScanChannel9
Scan channel 9

enumerator kADC_ScanChannel10
Scan channel 10

enumerator kADC_ScanChannel11
Scan channel 11

enumerator kADC_ScanChannel12
Scan channel 12

enumerator kADC_ScanChannel13
Scan channel 13

enumerator kADC_ScanChannel14
Scan channel 14

enumerator kADC_ScanChannel15
Scan channel 15

enum _adc_channel_source
ADC channel source type.

Values:

enumerator kADC_CH0
Single-ended mode, channel[0] and vssa

enumerator kADC_CH1
Single-ended mode, channel[1] and vssa

enumerator kADC_CH2
Single-ended mode, channel[2] and vssa

enumerator kADC_CH3
Single-ended mode, channel[3] and vssa

enumerator kADC_CH4
Single-ended mode, channel[4] and vssa

enumerator kADC_CH5
Single-ended mode, channel[5] and vssa

enumerator kADC_CH6
Single-ended mode, channel[6] and vssa

enumerator kADC_CH7
Single-ended mode, channel[7] and vssa

enumerator kADC_VBATS
Single-ended mode, vbat_s and vssa

enumerator kADC_VREF
Single-ended mode, vref_12 and vssa

enumerator kADC_DACA
Single-ended mode, daca and vssa

enumerator kADC_DACB
Single-ended mode, dacb and vssa

enumerator kADC_VSSA
Single-ended mode, vssa and vssa

enumerator kADC_CH0_CH1
Differential mode, channel[0] and channel[1]

enumerator kADC_CH2_CH3
Differential mode, channel[2] and channel[3]

enumerator kADC_CH4_CH5
Differential mode, channel[4] and channel[5]

enumerator kADC_CH6_CH7
Differential mode, channel[6] and channel[7]

enumerator kADC_DACA_DACB
Differential mode, daca and dacb

enum _adc_temperature_sensor_mode
Temperature sensor mode, including internal diode mode and external diode mode.

Values:

enumerator kADC_TSensorExternal
External diode mode.

enum _adc_audio_pga_voltage_gain
ADC audio pga gain type.

Values:

enumerator kADC_AudioGain4
Audio pga gain is 4

enumerator kADC_AudioGain8
Audio pga gain is 8

enumerator kADC_AudioGain16
Audio pga gain is 16

enumerator kADC_AudioGain32
Audio pga gain is 32

enum _adc_audio_voice_level
ADC audio voice level selection.

Values:

enumerator kADC_VoiceLevel0
Input voice level >+255LSB or <-256LSB

enumerator kADC_VoiceLevel1
Input voice level >+511LSB or <-512LSB

enumerator kADC_VoiceLevel2
Input voice level >+1023LSB or <-1024LSB

enumerator kADC_VoiceLevel3
Input voice level >+2047LSB or <-2048LSB

typedef enum *_adc_clock_divider* adc_clock_divider_t
ADC clock divider ratio type.

typedef enum *_adc_analog_portion_power_mode* adc_analog_portion_power_mode_t
ADC analog portion low-power mode selection.

typedef enum *_adc_resolution* adc_resolution_t
ADC resolution type.

typedef enum *_adc_warm_up_time* adc_warm_up_time_t
The enumeration of adc warm up time, the ADC warm-up state can also bypassed.

typedef enum *_adc_vref_source* adc_vref_source_t
ADC voltage reference source type.

typedef enum *_adc_input_mode* adc_input_mode_t
ADC input mode type.

typedef enum *_adc_conversion_mode* adc_conversion_mode_t
ADC conversion mode type.

typedef enum *_adc_scan_length* adc_scan_length_t
ADC scan length type.

typedef enum *_adc_average_length* adc_average_length_t
ADC average length type.

typedef enum *_adc_input_gain* adc_input_gain_t
ADC input buffer gain type.

typedef enum *_adc_result_width* adc_result_width_t
ADC result width type.

typedef enum *_adc_fifo_threshold* adc_fifo_threshold_t
The threshold of FIFO.

typedef enum *_adc_calibration_ref* adc_calibration_ref_t
ADC calibration voltage reference type.

typedef enum *_adc_scan_channel* adc_scan_channel_t
ADC scan channel type.

typedef enum *_adc_channel_source* adc_channel_source_t
ADC channel source type.

typedef enum *_adc_temperature_sensor_mode* adc_temperature_sensor_mode_t
Temperature sensor mode, including internal diode mode and external diode mode.

typedef enum *_adc_audio_pga_voltage_gain* adc_audio_pga_voltage_gain_t
ADC audio pga gain type.

typedef enum *_adc_audio_voice_level* adc_audio_voice_level_t
ADC audio voice level selection.

typedef struct *_adc_config* adc_config_t
The structure of adc options, including clock divider, power mode, and so on.

FSL_ADC_DRIVER_VERSION
ADC driver version.

Version 2.2.1.

struct _adc_config
#include <fsl_adc.h> The structure of adc options, including clock divider, power mode, and so on.

Public Members

adc_clock_divider_t clockDivider
Analog 64M clock division ratio, please refer to adc_clock_divider_t.

adc_resolution_t resolution
Configure ADC resolution, please refer to adc_resolution_t.

adc_warm_up_time_t warmupTime
Configure warm-up time.

adc_vref_source_t vrefSource
Configure voltage reference source, please refer to adc_vref_source_t.

adc_input_mode_t inputMode
Configure input mode, such as kADC_InputSingleEnded or kADC_InputDifferential.

adc_conversion_mode_t conversionMode
Configure convrsion mode, such as kADC_ConversionOneShot or kADC_ConversionContinuous.

adc_scan_length_t scanLength
Configure the length of scan, please refer to adc_scan_length_t.

adc_average_length_t averageLength
Configure hardware average number, please refer to adc_average_length_t

adc_trigger_source_t triggerSource
: Configure trigger source, the trigger source can be divided into hardware trigger and software trigger, please refer to adc_trigger_source_t for details.

adc_input_gain_t inputGain
: Configure ADC input buffer gain, please refer to adc_input_gain_t.

bool enableInputGainBuffer
: Enable/Disable input gain buffer.
  - **true** Enable input gain buffer.
  - **false** Disable input gain buffer.

bool enableInputBufferChop
: Enable/Disable input buffer chopper:
  - **true** Enable input buffer chopper;
  - **false** Disable input buffer chopper.

bool enableChop
: Enable/Disable the ADC chopper:
  - **true** Enable the chopper;
  - **false** Disable the chopper.

adc_result_width_t resultWidth
: Select result FIFO data packed format, please refer to adc_result_width_t.

adc_fifo_threshold_t fifoThreshold
: Configure FIFO threshold, please refer to adc_fifo_threshold_t.

bool enableDMA
: Enable/Disable DMA reqeust.
  - **true** Enable DMA request.
  - **false** Disable DMA request.

bool enableADC
: Enable/Disable ADC module.
  - **true** Enable ADC module.
  - **false** Disable ADC module.

2.3 CACHE: CACHE Memory Controller

uint32_t CACHE64_GetInstance(CACHE64_POLSEL_Type *base)
: Returns an instance number given peripheral base address.

  Parameters
  - base – The peripheral base address.

  Returns
  CACHE64_POLSEL instance number starting from 0.

uint32_t CACHE64_GetInstanceByAddr(uint32_t address)
: brief Returns an instance number given physical memory address.

  param address The physical memory address.

Returns
CACHE64_CTRL instance number starting from 0.

status_t CACHE64_Init(CACHE64_POLSEL_Type *base, const *cache64_config_t* *config)

Initializes an CACHE64 instance with the user configuration structure.

This function configures the CACHE64 module with user-defined settings. Call the CACHE64_GetDefaultConfig() function to configure the configuration structure and get the default configuration.

Parameters

- base – CACHE64_POLSEL peripheral base address.
- config – Pointer to a user-defined configuration structure.

Return values
kStatus_Success – CACHE64 initialize succeed

void CACHE64_GetDefaultConfig(*cache64_config_t* *config)

Gets the default configuration structure.

This function initializes the CACHE64 configuration structure to a default value. The default values are first region covers whole cacheable area, and policy set to write back.

Parameters

- config – Pointer to a configuration structure.

void CACHE64_EnableCache(CACHE64_CTRL_Type *base)

Enables the cache.

Parameters

- base – CACHE64_CTRL peripheral base address.

void CACHE64_DisableCache(CACHE64_CTRL_Type *base)

Disables the cache.

Parameters

- base – CACHE64_CTRL peripheral base address.

void CACHE64_InvalidateCache(CACHE64_CTRL_Type *base)

Invalidates the cache.

Parameters

- base – CACHE64_CTRL peripheral base address.

void CACHE64_InvalidateCacheByRange(uint32_t address, uint32_t size_byte)

Invalidates cache by range.

Note: Address and size should be aligned to “CACHE64_LINESIZE_BYTE”. The startAddr here will be forced to align to CACHE64_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.

void CACHE64_CleanCache(CACHE64_CTRL_Type *base)

Cleans the cache.

Parameters

- base – CACHE64_CTRL peripheral base address.

void CACHE64_CleanCacheByRange(uint32_t address, uint32_t size_byte)

Cleans cache by range.

Note: Address and size should be aligned to "CACHE64_LINESIZE_BYTE". The startAddr here will be forced to align to CACHE64_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.

void CACHE64_CleanInvalidateCache(CACHE64_CTRL_Type *base)

Cleans and invalidates the cache.

Parameters

- base – CACHE64_CTRL peripheral base address.

void CACHE64_CleanInvalidateCacheByRange(uint32_t address, uint32_t size_byte)

Cleans and invalidate cache by range.

Note: Address and size should be aligned to "CACHE64_LINESIZE_BYTE". The startAddr here will be forced to align to CACHE64_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.

void CACHE64_EnableWriteBuffer(CACHE64_CTRL_Type *base, bool enable)

Enables/disables the write buffer.

Parameters

- base – CACHE64_CTRL peripheral base address.
- enable – The enable or disable flag. true - enable the write buffer. false - disable the write buffer.

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 CACHE64_LINESIZE_BYTE due to the cache operation unit FSL_FEATURE_CACHE64_CTRL_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.

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 CACHE64_LINESIZE_BYTE due to the cache operation unit FSL_FEATURE_CACHE64_CTRL_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.

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 CACHE64_LINESIZE_BYTE due to the cache operation unit FSL_FEATURE_CACHE64_CTRL_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.

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 CACHE64_LINESIZE_BYTE due to the cache operation unit FSL_FEATURE_CACHE64_CTRL_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.

FSL_CACHE_DRIVER_VERSION

cache driver version.

enum _cache64_policy

Level 2 cache controller way size.

Values:

enumerator kCACHE64_PolicyNonCacheable

Non-cacheable

enumerator kCACHE64_PolicyWriteThrough

Write through

enumerator kCACHE64_PolicyWriteBack

Write back

typedef enum *_cache64_policy* cache64_policy_t

Level 2 cache controller way size.

typedef struct *_cache64_config* cache64_config_t

CACHE64 configuration structure.

CACHE64_LINESIZE_BYTE

cache line size.

CACHE64_REGION_NUM

cache region number.

CACHE64_REGION_ALIGNMENT

cache region alignment.

struct _cache64_config

#include <fsl_cache.h> CACHE64 configuration structure.

Public Members

uint32_t boundaryAddr[(3U) - 1]

< The cache controller can divide whole memory into 3 regions. Boundary address is the FlexSPI internal address (start from 0) instead of system address (start from FlexSPI AMBA base) to split adjacent regions and must be 1KB aligned. The boundary address itself locates in upper region. Cacheable policy for each region.

2.4 CDOG

status_t CDOG_Init(CDOG_Type *base, *cdog_config_t* *conf)

Initialize CDOG.

This function initializes CDOG block and setting.

Parameters

- base – CDOG peripheral base address
- conf – CDOG configuration structure

Returns

Status of the init operation

void CDOG_Deinit(CDOG_Type *base)

Deinitialize CDOG.

This function deinitializes CDOG secure counter.

Parameters

- base – CDOG peripheral base address

void CDOG_GetDefaultConfig(*cdog_config_t* *conf)

Sets the default configuration of CDOG.

This function initialize CDOG config structure to default values.

Parameters

- conf – CDOG configuration structure

void CDOG_Stop(CDOG_Type *base, uint32_t stop)

Stops secure counter and instruction timer.

This function stops instruction timer and secure counter. This also change state od CDOG to IDLE.

Parameters

- base – CDOG peripheral base address
- stop – expected value which will be compared with value of secure counter

void CDOG_Start(CDOG_Type *base, uint32_t reload, uint32_t start)

Sets secure counter and instruction timer values.

This function sets value in RELOAD and START registers for instruction timer and secure counter

Parameters

- base – CDOG peripheral base address
- reload – reload value
- start – start value

void CDOG_Check(CDOG_Type *base, uint32_t check)

Checks secure counter.

This function compares stop value in handler with secure counter value by writting to RELOAD refister.

Parameters

- base – CDOG peripheral base address
- check – expected (stop) value

void CDOG_Set(CDOG_Type *base, uint32_t stop, uint32_t reload, uint32_t start)

Sets secure counter and instruction timer values.

This function sets value in STOP, RELOAD and START registers for instruction timer and secure counter.

Parameters

- base – CDOG peripheral base address
- stop – expected value which will be compared with value of secure counter
- reload – reload value for instruction timer
- start – start value for secure timer

void CDOG_Add(CDOG_Type *base, uint32_t add)

Add value to secure counter.

This function add specified value to secure counter.

Parameters

- base – CDOG peripheral base address.
- add – Value to be added.

void CDOG_Add1(CDOG_Type *base)

Add 1 to secure counter.

This function add 1 to secure counter.

Parameters

- base – CDOG peripheral base address.

void CDOG_Add16(CDOG_Type *base)

Add 16 to secure counter.

This function add 16 to secure counter.

Parameters

- base – CDOG peripheral base address.

void CDOG_Add256(CDOG_Type *base)

Add 256 to secure counter.

This function add 256 to secure counter.

Parameters

- base – CDOG peripheral base address.

void CDOG_Sub(CDOG_Type *base, uint32_t sub)

brief Substract value to secure counter

This function substract specified value to secure counter.

param base CDOG peripheral base address. param sub Value to be substracted.

void CDOG_Sub1(CDOG_Type *base)

Substract 1 from secure counter.

This function substract specified 1 from secure counter.

Parameters

- base – CDOG peripheral base address.

void CDOG_Sub16(CDOG_Type *base)

Substract 16 from secure counter.

This function substract specified 16 from secure counter.

Parameters

- base – CDOG peripheral base address.

void CDOG_Sub256(CDOG_Type *base)

Substract 256 from secure counter.

This function substract specified 256 from secure counter.

Parameters

- base – CDOG peripheral base address.

void CDOG_WritePersistent(CDOG_Type *base, uint32_t value)

Set the CDOG persistent word.

Parameters

- base – CDOG peripheral base address.
- value – The value to be written.

uint32_t CDOG_ReadPersistent(CDOG_Type *base)

Get the CDOG persistent word.

Parameters

- base – CDOG peripheral base address.

Returns

The persistent word.

FSL_CDOG_DRIVER_VERSION

Defines CDOG driver version 2.1.3.

Change log:

- Version 2.1.3
  - Re-design multiple instance IRQs and Clocks
  - Add fix for RESTART command errata
- Version 2.1.2
  - Support multiple IRQs
  - Fix default CONTROL values
- Version 2.1.1
  - Remove bit CONTROL[CONTROL_CTRL]
- Version 2.1.0
  - Rename CWT to CDOG
- Version 2.0.2
  - Fix MISRA-2012 issues
- Version 2.0.1
  - Fix doxygen issues
- Version 2.0.0
  - initial version

enum ___cdog__debug__Action__ctrl__enum

Values:

enumerator kCDOG_DebugHaltCtrl_Run

enumerator kCDOG_DebugHaltCtrl_Pause

enum ___cdog__irq__pause__ctrl__enum

Values:

enumerator kCDOG_IrqPauseCtrl_Run

enumerator kCDOG_IrqPauseCtrl_Pause

enum ___cdog__fault__ctrl__enum

Values:

enumerator kCDOG_FaultCtrl_EnableReset

enumerator kCDOG_FaultCtrl_EnableInterrupt

enumerator kCDOG_FaultCtrl_NoAction

enum ___code_lock_ctrl_enum

Values:

enumerator kCDOG_LockCtrl_Lock

enumerator kCDOG_LockCtrl_Unlock

typedef uint32_t secure_counter_t

SC_ADD(add)

SC_ADD1

SC_ADD16

SC_ADD256

SC_SUB(sub)

SC_SUB1

SC_SUB16

SC_SUB256

SC_CHECK(val)

struct cdog_config_t

#include <fsl_cdog.h>

2.5 Clock Driver

enum _clock_name

Clock name used to get clock frequency.

Values:

enumerator kCLOCK_CoreSysClk

Core clock (aka HCLK)

enumerator kCLOCK_BusClk

Bus clock (AHB/APB clock, aka HCLK)

enumerator kCLOCK_MclkClk

MCLK, to MCLK pin

enum _clock_ip_name

Peripheral clock name difinition used for clock gate.

Values:

enumerator kCLOCK_IpInvalid

enumerator kCLOCK_TcpuMciClk

enumerator kCLOCK_TcpuMciFlexspiClk

enumerator kCLOCK_TddrMciEnetClk

enumerator kCLOCK_TddrMciFlexspiClk

enumerator kCLOCK_T3PllMciIrcClk

enumerator kCLOCK_T3PllMci256mClk

enumerator kCLOCK_T3PllMci213mClk

enumerator kCLOCK_T3PllMciFlexspiClk

enumerator kCLOCK_RefClkSys

enumerator kCLOCK_RefClkTcpu

enumerator kCLOCK_RefClkTddr

enumerator kCLOCK_RefClkAud

enumerator kCLOCK_RefClkUsb

enumerator kCLOCK_RefClkCauSlp

enumerator kCLOCK_Cpu

enumerator kCLOCK_Matrix

enumerator kCLOCK_Romcp

enumerator kCLOCK_PowerQuad

enumerator kCLOCK_Pkc

enumerator kCLOCK_Els

enumerator kCLOCK_Puf

enumerator kCLOCK_Flexspi

enumerator kCLOCK_Hpu

enumerator kCLOCK_Usb

enumerator kCLOCK_Sct

enumerator kCLOCK_AonMem

enumerator kCLOCK_Gdma

enumerator kCLOCK_Dma0

enumerator kCLOCK_Dma1

enumerator kCLOCK_Sdio

enumerator kCLOCK_ElsApb

enumerator kCLOCK_SdioSlv

enumerator kCLOCK_Gau

enumerator kCLOCK_Otp

enumerator kCLOCK_SecureGpio

enumerator kCLOCK_EnetIpg

enumerator kCLOCK_EnetIpgS

enumerator kCLOCK_Trng

enumerator kCLOCK_Utick

enumerator kCLOCK_Wwdt0

enumerator kCLOCK_Usim

enumerator kCLOCK_Itrc

enumerator kCLOCK_FreeMrt

enumerator kCLOCK_Lcdic

enumerator kCLOCK_Flexcomm0

enumerator kCLOCK_Flexcomm1

enumerator kCLOCK_Flexcomm2

enumerator kCLOCK_Flexcomm3

enumerator kCLOCK_Flexcomm14

enumerator kCLOCK_Dmic0

enumerator kCLOCK_OsEventTimer

enumerator kCLOCK_HsGpio0

enumerator kCLOCK_HsGpio1

enumerator kCLOCK_Crc

enumerator kCLOCK_Freqme

enumerator kCLOCK_Ct32b0

enumerator kCLOCK_Ct32b1

enumerator kCLOCK_Ct32b2

enumerator kCLOCK_Ct32b3

enumerator kCLOCK_Ct32b4

enumerator kCLOCK_Pmu

enumerator kCLOCK_Rtc

enumerator kCLOCK_Mrt

enumerator kCLOCK_Pint

enumerator kCLOCK_InputMux

enum _clock_attach_id

Peripheral clock source selection definition.

Values:

enumerator kXTAL_to_SYSOSC_CLK

enumerator kCLKIN_to_SYSOSC_CLK

enumerator kNONE_to_SYSOSC_CLK

enumerator kSYSOSC_to_MAIN_CLK

enumerator kFFRO_DIV4_to_MAIN_CLK

enumerator kLPOSC_to_MAIN_CLK

enumerator kFFRO_to_MAIN_CLK

enumerator kSFRO_to_MAIN_CLK

enumerator kMAIN_PLL_to_MAIN_CLK

enumerator kCLK32K_to_MAIN_CLK

enumerator kMAIN_CLK_to_FLEXSPI_CLK

enumerator kT3PLL_MCI_FLEXSPI_to_FLEXSPI_CLK

enumerator kAUX0_PLL_to_FLEXSPI_CLK

enumerator kTCPU_MCI_FLEXSPI_to_FLEXSPI_CLK

enumerator kAUX1_PLL_to_FLEXSPI_CLK

enumerator kTDDR_MCI_FLEXSPI_to_FLEXSPI_CLK

enumerator kT3PLL_MCI_256M_to_FLEXSPI_CLK

enumerator kNONE_to_FLEXSPI_CLK

enumerator kMAIN_CLK_to_SCT_CLK

enumerator kMAIN_PLL_to_SCT_CLK

enumerator kAUX0_PLL_to_SCT_CLK

enumerator kFFRO_to_SCT_CLK

enumerator kAUX1_PLL_to_SCT_CLK

enumerator kAUDIO_PLL_to_SCT_CLK

enumerator kNONE_to_SCT_CLK

enumerator kLPOSC_to_UTICK_CLK

enumerator kMAIN_CLK_to_UTICK_CLK

enumerator kNONE_to_UTICK_CLK

enumerator kLPOSC_to_WDT0_CLK

enumerator kMAIN_CLK_to_WDT0_CLK

enumerator kNONE_to_WDT0_CLK

enumerator kSYSTICK_DIV_to_SYSTICK_CLK

enumerator kLPOSC_to_SYSTICK_CLK

enumerator kCLK32K_to_SYSTICK_CLK

enumerator kSFRO_to_SYSTICK_CLK

enumerator kNONE_to_SYSTICK_CLK

enumerator kMAIN_CLK_to_USIM_CLK

enumerator kAUDIO_PLL_to_USIM_CLK

enumerator kFFRO_to_USIM_CLK

enumerator kNONE_to_USIM_CLK

enumerator kMAIN_CLK_to_LCD_CLK

enumerator kT3PLL_MCI_FLEXSPI_to_LCD_CLK

enumerator kTCPU_MCI_FLEXSPI_to_LCD_CLK

enumerator kTDDR_MCI_FLEXSPI_to_LCD_CLK

enumerator kNONE_to_LCD_CLK

enumerator kMAIN_CLK_to_GAU_CLK

enumerator kT3PLL_MCI_256M_to_GAU_CLK

enumerator kAVPLL_CH2_to_GAU_CLK

enumerator kNONE_to_GAU_CLK

enumerator kT3PLL_MCI_256M_to_ELS_GDET

enumerator kELS_128M_to_ELS_GDET

enumerator kELS_64M_to_ELS_GDET

enumerator kOTP_FUSE_32M_to_ELS_GDET

enumerator kNONE_to_ELS_GDET

enumerator kLPOSC_to_OSTIMER_CLK

enumerator kCLK32K_to_OSTIMER_CLK

enumerator kHCLK_to_OSTIMER_CLK

enumerator kMAIN_CLK_to_OSTIMER_CLK

enumerator kNONE_to_OSTIMER_CLK

enumerator kSFRO_to_FLEXCOMM0

enumerator kFFRO_to_FLEXCOMM0

enumerator kAUDIO_PLL_to_FLEXCOMM0

enumerator kMCLK_IN_to_FLEXCOMM0

enumerator kFRG_to_FLEXCOMM0

enumerator kNONE_to_FLEXCOMM0

enumerator kSFRO_to_FLEXCOMM1

enumerator kFFRO_to_FLEXCOMM1

enumerator kAUDIO_PLL_to_FLEXCOMM1

enumerator kMCLK_IN_to_FLEXCOMM1

enumerator kFRG_to_FLEXCOMM1

enumerator kNONE_to_FLEXCOMM1

enumerator kSFRO_to_FLEXCOMM2

enumerator kFFRO_to_FLEXCOMM2

enumerator kAUDIO_PLL_to_FLEXCOMM2

enumerator kMCLK_IN_to_FLEXCOMM2

enumerator kFRG_to_FLEXCOMM2

enumerator kNONE_to_FLEXCOMM2

enumerator kSFRO_to_FLEXCOMM3

enumerator kFFRO_to_FLEXCOMM3

enumerator kAUDIO_PLL_to_FLEXCOMM3

enumerator kMCLK_IN_to_FLEXCOMM3

enumerator kFRG_to_FLEXCOMM3

enumerator kNONE_to_FLEXCOMM3

enumerator kSFRO_to_FLEXCOMM14

enumerator kFFRO_to_FLEXCOMM14

enumerator kAUDIO_PLL_to_FLEXCOMM14

enumerator kMCLK_IN_to_FLEXCOMM14

enumerator kFRG_to_FLEXCOMM14

enumerator kNONE_to_FLEXCOMM14

enumerator kSFRO_to_DMIC_CLK

enumerator kFFRO_to_DMIC_CLK

enumerator kAUDIO_PLL_to_DMIC_CLK

enumerator kMCLK_IN_to_DMIC_CLK

enumerator kLPOSC_to_DMIC_CLK

enumerator kCLK32K_to_DMIC_CLK

enumerator kMAIN_CLK_to_DMIC_CLK

enumerator kNONE_to_DMIC_CLK

enumerator kMAIN_CLK_to_CTIMER0

enumerator kSFRO_to_CTIMER0

enumerator kFFRO_to_CTIMER0

enumerator kAUDIO_PLL_to_CTIMER0

enumerator kMCLK_IN_to_CTIMER0

enumerator kLPOSC_to_CTIMER0

enumerator kNONE_to_CTIMER0

enumerator kMAIN_CLK_to_CTIMER1

enumerator kSFRO_to_CTIMER1

enumerator kFFRO_to_CTIMER1

enumerator kAUDIO_PLL_to_CTIMER1

enumerator kMCLK_IN_to_CTIMER1

enumerator kLPOSC_to_CTIMER1

enumerator kNONE_to_CTIMER1

enumerator kMAIN_CLK_to_CTIMER2

enumerator kSFRO_to_CTIMER2

enumerator kFFRO_to_CTIMER2

enumerator kAUDIO_PLL_to_CTIMER2

enumerator kMCLK_IN_to_CTIMER2

enumerator kLPOSC_to_CTIMER2

enumerator kNONE_to_CTIMER2

enumerator kMAIN_CLK_to_CTIMER3

enumerator kSFRO_to_CTIMER3

enumerator kFFRO_to_CTIMER3

enumerator kAUDIO_PLL_to_CTIMER3

enumerator kMCLK_IN_to_CTIMER3

enumerator kLPOSC_to_CTIMER3

enumerator kNONE_to_CTIMER3

enumerator kFFRO_to_MCLK_CLK

enumerator kAUDIO_PLL_to_MCLK_CLK

enumerator kMAIN_CLK_to_MCLK_CLK

enumerator kNONE_to_MCLK_CLK

enumerator kSFRO_to_CLKOUT

enumerator kSYSOSC_to_CLKOUT

enumerator kLPOSC_to_CLKOUT

enumerator kFFRO_to_CLKOUT

enumerator kMAIN_CLK_to_CLKOUT

enumerator kREFCLK_SYS_to_CLKOUT

enumerator kAVPLL_CH2_to_CLKOUT

enumerator kMAIN_PLL_to_CLKOUT

enumerator kAUX0_PLL_to_CLKOUT

enumerator kAUX1_PLL_to_CLKOUT

enumerator kAUDIO_PLL_to_CLKOUT

enumerator kCLK32K_to_CLKOUT

enumerator kTCPU_MCI_FLEXSPI_to_CLKOUT

enumerator kTDDR_MCI_FLEXSPI_to_CLKOUT

enumerator kT3PLL_MCI_FLEXSPI_to_CLKOUT

enumerator kT3PLL_MCI_256M_to_CLKOUT

enumerator kCAU_SLP_REF_CLK_to_CLKOUT

enumerator kTDDR_MCI_ENET_to_CLKOUT

enumerator kNONE_to_CLKOUT

enumerator kRC32K_to_CLK32K

enumerator kXTAL32K_to_CLK32K

enumerator kNCO32K_to_CLK32K

enum _clock_div_name

Clock divider definition.

Values:

enumerator kCLOCK_DivMainPllClk

enumerator kCLOCK_DivAux0PllClk

enumerator kCLOCK_DivAux1PllClk

enumerator kCLOCK_DivSysCpuAhbClk

enumerator kCLOCK_DivPfc1Clk

enumerator kCLOCK_DivFlexspiClk

enumerator kCLOCK_DivSctClk

enumerator kCLOCK_DivUsbHsFclk

enumerator kCLOCK_DivSystickClk

enumerator kCLOCK_DivLcdClk

enumerator kCLOCK_DivGauClk

enumerator kCLOCK_DivUsimClk

enumerator kCLOCK_DivPmuFclk

enumerator kCLOCK_DivAudioPllClk

enumerator kCLOCK_DivPllFrgClk

enumerator kCLOCK_DivDmicClk

enumerator kCLOCK_DivMclkClk

enumerator kCLOCK_DivClockOut

enum clock_tcpu_flexspi_div_t

TCPU PLL divider for tcpu_mci_flexspi_clk.

Values:

enumerator kCLOCK_TcpuFlexspiDiv12

Divided by 12

enumerator kCLOCK_TcpuFlexspiDiv11

Divided by 11

enumerator kCLOCK_TcpuFlexspiDiv10

Divided by 10

enumerator kCLOCK_TcpuFlexspiDiv9

Divided by 9

enum clock_tddr_flexspi_div_t

TDDR PLL divider for tddr_mci_flexspi_clk.

Values:

enumerator kCLOCK_TddrFlexspiDiv11

Divided by 11

enumerator kCLOCK_TddrFlexspiDiv10

Divided by 10

enumerator kCLOCK_TddrFlexspiDiv9

Divided by 9

enumerator kCLOCK_TddrFlexspiDiv8

Divided by 8

enum clock_t3_mci_irc_config_t

T3 PLL IRC configuration.

Values:

enumerator kCLOCK_T3MciIrc60m

T3 MCI IRC 59.53MHz

enumerator kCLOCK_T3MciIrc48m

T3 MCI IRC 48.30MHz

enum clock_avpll_ch_freq_t

AVPLL channel1 frequency configuration.

Values:

enumerator kCLOCK_AvPllChUnchanged

AVPLL channel frequency unchanged.

enumerator kCLOCK_AvPllChFreq2p048m

AVPLL channel frequency 2.048MHz

enumerator kCLOCK_AvPllChFreq4p096m

AVPLL channel frequency 4.096MHz

enumerator kCLOCK_AvPllChFreq6p144m
AVPLL channel frequency 6.144MHz

enumerator kCLOCK_AvPllChFreq8p192m
AVPLL channel frequency 8.192MHz

enumerator kCLOCK_AvPllChFreq11p2896m
AVPLL channel frequency 11.2896MHz

enumerator kCLOCK_AvPllChFreq12m
AVPLL channel frequency 12MHz

enumerator kCLOCK_AvPllChFreq12p288m
AVPLL channel frequency 12.288MHz

enumerator kCLOCK_AvPllChFreq24p576m
AVPLL channel frequency 24.576MHz

enumerator kCLOCK_AvPllChFreq64m
AVPLL channel frequency 64MHz

enumerator kCLOCK_AvPllChFreq98p304m
AVPLL channel frequency 98.304MHz

typedef enum *_clock_name* clock_name_t
Clock name used to get clock frequency.

typedef enum *_clock_ip_name* clock_ip_name_t
Peripheral clock name difinition used for clock gate.

typedef enum *_clock_attach_id* clock_attach_id_t
Peripheral clock source selection definition.

typedef enum *_clock_div_name* clock_div_name_t
Clock divider definition.

typedef struct *_clock_frg_clk_config* clock_frg_clk_config_t
PLL configuration for FRG.

volatile uint32_t g_clkinFreq
External CLK_IN pin clock frequency (clkin) clock frequency.

The CLK_IN pin (clkin) clock frequency in Hz, when the clock is setup, use the function CLOCK_SetClkinFreq to set the value in to clock driver. For example, if CLK_IN is 16MHz,

```
CLOCK_SetClkinFreq(16000000);
```

volatile uint32_t g_mclkinFreq
External MCLK IN clock frequency.

The MCLK in (mclk_in) PIN clock frequency in Hz, when the clock is setup, use the function CLOCK_SetMclkInFreq to set the value in to clock driver. For example, if mclk_In is 16MHz,

```
CLOCK_SetMclkInFreq(16000000);
```

uint32_t CLOCK_GetT3PllMciIrcClkFreq(void)
Return Frequency of t3pll_mci_48_60m_irc.

Returns
Frequency of t3pll_mci_48_60m_irc

uint32_t CLOCK_GetT3PllMci213mClkFreq(void)

Return Frequency of t3pll_mci_213p3m.

Returns

Frequency of t3pll_mci_213p3m

uint32_t CLOCK_GetT3PllMci256mClkFreq(void)

Return Frequency of t3pll_mci_256m.

Returns

Frequency of t3pll_mci_256m

uint32_t CLOCK_GetT3PllMciFlexspiClkFreq(void)

Return Frequency of t3pll_mci_flexspi_clk.

Returns

Frequency of t3pll_mci_flexspi_clk

uint32_t CLOCK_GetTcpuMciClkFreq(void)

Return Frequency of tcpu_mci_clk.

Returns

Frequency of tcpu_mci_clk

uint32_t CLOCK_GetTcpuMciFlexspiClkFreq(void)

Return Frequency of tcpu_mci_flexspi_clk.

Returns

Frequency of tcpu_mci_flexspi_clk

uint32_t CLOCK_GetTddrMciFlexspiClkFreq(void)

Return Frequency of tddr_mci_flexspi_clk.

Returns

Frequency of tddr_mci_flexspi_clk

uint32_t CLOCK_GetTddrMciEnetClkFreq(void)

Return Frequency of tddr_mci_enet_clk.

Returns

Frequency of tddr_mci_enet_clk

void CLOCK_EnableClock(*clock_ip_name_t* clk)

Enable the clock for specific IP.

Parameters

- clk – Which clock to enable, see clock_ip_name_t.

void CLOCK_DisableClock(*clock_ip_name_t* clk)

Disable the clock for specific IP.

Parameters

- clk – Which clock to disable, see clock_ip_name_t.

void CLOCK_AttachClk(*clock_attach_id_t* connection)

Configure the clock selection muxes.

Parameters

- connection – : Clock to be configured.

void CLOCK_SetClkDiv(*clock_div_name_t* name, uint32_t divider)

Setup clock dividers.

Parameters

- name – : Clock divider name
- divider – : Value to be divided.

uint32_t CLOCK_GetFreq(*clock_name_t* clockName)

Return Frequency of selected clock.

Returns
Frequency of selected clock

uint32_t CLOCK_GetFRGClock(uint32_t id)

Return Input frequency for the Fractional baud rate generator.

Returns
Input Frequency for FRG

void CLOCK_SetFRGClock(const *clock_frg_clk_config_t* *config)

Set output of the Fractional baud rate generator.

Parameters

- config – : Configuration to set to FRGn clock.

uint32_t CLOCK_GetFFroFreq(void)

Return Frequency of FFRO.

Returns
Frequency of FFRO

uint32_t CLOCK_GetSFroFreq(void)

Return Frequency of SFRO.

Returns
Frequency of SFRO

uint32_t CLOCK_GetAvPllCh1Freq(void)

Return Frequency of AUDIO PLL (AVPLL CH1)

Returns
Frequency of AUDIO PLL

uint32_t CLOCK_GetAvPllCh2Freq(void)

Return Frequency of AVPLL CH2.

Returns
Frequency of AVPLL CH2

uint32_t CLOCK_GetMainClkFreq(void)

Return Frequency of main clk.

Returns
Frequency of main clk

uint32_t CLOCK_GetCoreSysClkFreq(void)

Return Frequency of core/bus clk.

Returns
Frequency of core/bus clk

uint32_t CLOCK_GetSystickClkFreq(void)

Return Frequency of systick clk.

Returns
Frequency of systick clk

static inline uint32_t CLOCK_GetSysOscFreq(void)

Return Frequency of sys osc Clock.

Returns

Frequency of sys osc Clock. Or CLK_IN pin frequency.

static inline uint32_t CLOCK_GetMclkInClkFreq(void)

Return Frequency of MCLK Input Clock.

Returns

Frequency of MCLK input Clock.

static inline uint32_t CLOCK_GetLpOscFreq(void)

Return Frequency of LPOSC.

Returns

Frequency of LPOSC

static inline uint32_t CLOCK_GetClk32KFreq(void)

Return Frequency of CLK_32K.

Returns

Frequency of 32KHz osc

void CLOCK_EnableXtal32K(bool enable)

Enables and disables 32KHz XTAL.

Parameters

- enable – : true to enable 32k XTAL clock, false to disable clock

void CLOCK_EnableRtc32K(bool enable)

Enables and disables RTC 32KHz.

Parameters

- enable – : true to enable 32k RTC clock, false to disable clock

static inline void CLOCK_SetClkinFreq(uint32_t freq)

Set the CLKIN (CLKIN pin) frequency based on GPIO4 input.

Parameters

- freq – : The CLK_IN pin input clock frequency in Hz.

static inline void CLOCK_SetMclkinFreq(uint32_t freq)

Set the MCLK in (mclk_in) clock frequency based on board setting.

Parameters

- freq – : The MCLK input clock frequency in Hz.

uint32_t CLOCK_GetDmicClkFreq(void)

Return Frequency of DMIC clk.

Returns

Frequency of DMIC clk

uint32_t CLOCK_GetLcdClkFreq(void)

Return Frequency of LCD clk.

Returns

Frequency of LCD clk

uint32_t CLOCK_GetWdtClkFreq(void)

Return Frequency of WDT clk.

Returns
Frequency of WDT clk

uint32_t CLOCK_GetMclkClkFreq(void)

Return Frequency of mclk.

Returns
Frequency of mclk clk

uint32_t CLOCK_GetSctClkFreq(void)

Return Frequency of sct.

Returns
Frequency of sct clk

uint32_t CLOCK_GetFlexCommClkFreq(uint32_t id)

Return Frequency of Flexcomm functional Clock.

Parameters

- id – : flexcomm index to get frequency.

Returns
Frequency of Flexcomm functional Clock

uint32_t CLOCK_GetCTimerClkFreq(uint32_t id)

Return Frequency of CTimer Clock.

Parameters

- id – : ctimer index to get frequency.

Returns
Frequency of CTimer Clock

uint32_t CLOCK_GetUtickClkFreq(void)

Return Frequency of Utick Clock.

Returns
Frequency of Utick Clock

uint32_t CLOCK_GetFlexspiClkFreq(void)

Return Frequency of Flexspi Clock.

Returns
Frequency of Flexspi.

uint32_t CLOCK_GetUsimClkFreq(void)

Return Frequency of USIM Clock.

Returns
Frequency of USIM.

uint32_t CLOCK_GetGauClkFreq(void)

Return Frequency of GAU Clock.

Returns
Frequency of GAU.

uint32_t CLOCK_GetOSTimerClkFreq(void)

Return Frequency of OSTimer Clock.

Returns
Frequency of OSTimer.

uint32_t CLOCK_InitTcpuRefClk(uint32_t targetHz, *clock_tcpu_flexspi_div_t* div)

Initialize TCPU FVCO to target frequency. For 40MHz XTAL, FVCO ranges from 3000MHz to 3840MHz. For 38.4MHz XTAL, FVCO ranges from 2995.2MHz to 3840MHz.

Parameters

- targetHz – : Target FVCO frequency in Hz.
- div – : Divider for tcpu_mci_flexspi_clk.

Returns

Actual FVCO frequency in Hz.

void CLOCK_DeinitTcpuRefClk(void)

Deinit the TCPU reference clock.

void CLOCK_InitTddrRefClk(*clock_tddr_flexspi_div_t* div)

Initialize the TDDR reference clock.

Parameters

- div – : Divider for tddr_mci_flexspi_clk.

void CLOCK_DeinitTddrRefClk(void)

Deinit the TDDR reference clock.

void CLOCK_InitT3RefClk(*clock_t3_mci_irc_config_t* cnfg)

Initialize the T3 reference clock.

Parameters

- cnfg – : t3pll_mci_48_60m_irc clock configuration

void CLOCK_DeinitT3RefClk(void)

Deinit the T3 reference clock.

void CLOCK_InitAvPll(const *clock_avpll_config_t* *cnfg)

Initialize the AVPLL. Both channel 1 and 2 are enabled.

Parameters

- cnfg – : AVPLL clock configuration

void CLOCK_DeinitAvPll(void)

Deinit the AVPLL. All channels are disabled.

void CLOCK_ConfigAvPllCh(*clock_avpll_ch_freq_t* ch1Freq, *clock_avpll_ch_freq_t* ch2Freq, bool enableCali)

Update the AVPLL channel configuration. Enable/Disable state keeps unchanged.

Parameters

- ch1Freq – : Channel 1 frequency to set.
- ch2Freq – : Channel 2 frequency to set.
- enableCali – : Enable AVPLL calibration.

void CLOCK_EnableAvPllCh(bool enableCh1, bool enableCh2, bool enableCali)

Enable the AVPLL channel.

Parameters

- enableCh1 – : Enable AVPLL channel1, channel unchanged on false.
- enableCh2 – : Enable AVPLL channel2, channel unchanged on false.
- enableCali – : Enable AVPLL calibration.

void CLOCK_DisableAvPllCh(bool disableCh1, bool disableCh2)
Disable the AVPLL.

Parameters

- disableCh1 – : Disable AVPLL channel1, channel unchanged on false.
- disableCh2 – : Disable AVPLL channel2, channel unchanged on false.

void CLOCK_EnableUsbhsPhyClock(void)
Enable USB HS PHY PLL clock.

This function enables USB HS PHY PLL clock.

void CLOCK_DisableUsbhsPhyClock(void)
Disable USB HS PHY PLL clock.

This function disables USB HS PHY PLL clock.

FSL_CLOCK_DRIVER_VERSION
CLOCK driver version 2.3.2.

SDK_DEVICE_MAXIMUM_CPU_CLOCK_FREQUENCY

GPIO_CLOCKS
Clock ip name array for GPIO.

CACHE64_CLOCKS
Clock ip name array for CACHE64.

FLEXSPI_CLOCKS
Clock ip name array for FLEXSPI.

FLEXCOMM_CLOCKS
Clock ip name array for FLEXCOMM.

USART_CLOCKS
Clock ip name array for LPUART.

I2C_CLOCKS
Clock ip name array for I2C.

SPI_CLOCKS
Clock ip name array for SPI.

ACOMP_CLOCKS
Clock ip name array for ACOMP.

ADC_CLOCKS
Clock ip name array for ADC.

DAC_CLOCKS
Clock ip name array for DAC.

LCDIC_CLOCKS
Clock ip name array for LCDIC.

DMA_CLOCKS
Clock ip name array for DMA.

DMIC_CLOCKS
Clock ip name array for DMIC.

ENET_CLOCKS
Clock ip name array for ENET.

ENET_EXTRA_CLOCKS
: Extra clock ip name array for ENET.

POWERQUAD_CLOCKS
: Clock ip name array for Powerquad.

OSTIMER_CLOCKS
: Clock ip name array for OSTimer.

CTIMER_CLOCKS
: Clock ip name array for CT32B.

UTICK_CLOCKS
: Clock ip name array for UTICK.

MRT_CLOCKS
: Clock ip name array for MRT.

SCT_CLOCKS
: Clock ip name array for SCT.

RTC_CLOCKS
: Clock ip name array for RTC.

WWDT_CLOCKS
: Clock ip name array for WWDT.

TRNG_CLOCKS
: Clock ip name array for TRNG.

USIM_CLOCKS
: Clock ip name array for USIM.

CLK_GATE_REG_OFFSET_SHIFT
: Clock gate name used for CLOCK_EnableClock/CLOCK_DisableClock.

CLK_GATE_REG_OFFSET_MASK

CLK_GATE_BIT_SHIFT_SHIFT

CLK_GATE_BIT_SHIFT_MASK

CLK_GATE_DEFINE(reg_offset, bit_shift)

CLK_GATE_ABSTRACT_REG_OFFSET(x)

CLK_GATE_ABSTRACT_BITS_SHIFT(x)

CLK_CTL0_PSCCTL0

CLK_CTL0_PSCCTL1

CLK_CTL0_PSCCTL2

CLK_CTL1_PSCCTL0

CLK_CTL1_PSCCTL1

CLK_CTL1_PSCCTL2

SYS_CLK_GATE_FLAG_MASK

SYS_CLK_GATE_DEFINE(bit_shift)

SYS_CLK_GATE_BIT_MASK(x)

CLKCTL0_TUPLE_MUXA(reg, choice)

CLKCTL0_TUPLE_MUXB(reg, choice)

CLKCTL1_TUPLE_FLAG_MASK

CLKCTL1_TUPLE_MUXA(reg, choice)

CLKCTL1_TUPLE_MUXB(reg, choice)

CLKCTL_TUPLE_REG(base, tuple)

CLKCTL_TUPLE_SEL(tuple)

CLKOUT_TUPLE_MUX_AVAIL

CLKOUT_TUPLE_MUX(ch0, ch1, ch2)

PMU_TUPLE_MUX_AVAIL

PMU_TUPLE_MUX(reg, choice)

PMU_TUPLE_REG(base, tuple)

PMU_TUPLE_SEL(tuple)

Values:

enumerator kCLOCK_FrgMainClk
: Main System clock

enumerator kCLOCK_FrgPllDiv
: Main pll clock divider

enumerator kCLOCK_FrgSFro
: 16MHz FRO

enumerator kCLOCK_FrgFFro
: FRO48/60

uint8_t num
: FRG clock

enum *_clock_frg_clk_config* sfg_clock_src

uint8_t divider
: Denominator of the fractional divider.

uint8_t mult
: Numerator of the fractional divider.

clock_avpll_ch_freq_t ch1Freq
: AVPLL channel 1 frequency configuration

clock_avpll_ch_freq_t ch2Freq
: AVPLL channel 2 frequency configuration

bool enableCali
: Enable calibration

FSL_SDK_DISABLE_DRIVER_CLOCK_CONTROL

Configure whether driver controls clock.

When set to 0, peripheral drivers will enable clock in initialize function and disable clock in de-initialize function. When set to 1, peripheral driver will not control the clock, application could control the clock out of the driver.

Note: All drivers share this feature switcher. If it is set to 1, application should handle clock enable and disable for all drivers.

---

struct _clock_frg_clk_config

#include <fsl_clock.h> PLL configuration for FRG.

struct clock_avpll_config_t

#include <fsl_clock.h> AVPLL configuration.

2.6 CRC: Cyclic Redundancy Check Driver

FSL_CRC_DRIVER_VERSION

CRC driver version. Version 2.1.1.

Current version: 2.1.1

Change log:

- Version 2.0.0
  - initial version
- Version 2.0.1
  - add explicit type cast when writing to WR_DATA
- Version 2.0.2
  - Fix MISRA issue
- Version 2.1.0
  - Add CRC_WriteSeed function
- Version 2.1.1
  - Fix MISRA issue

enum _crc_polynomial

CRC polynomials to use.

Values:

enumerator kCRC_Polynomial_CRC_CCITT

x^16+x^12+x^5+1

enumerator kCRC_Polynomial_CRC_16

x^16+x^15+x^2+1

enumerator kCRC_Polynomial_CRC_32

x^32+x^26+x^23+x^22+x^16+x^12+x^11+x^10+x^8+x^7+x^5+x^4+x^2+x+1

typedef enum *_crc_polynomial* crc_polynomial_t

CRC polynomials to use.

typedef struct *_crc_config* crc_config_t

CRC protocol configuration.

This structure holds the configuration for the CRC protocol.

void CRC_Init(CRC_Type *base, const *crc_config_t* *config)

Enables and configures the CRC peripheral module.

This functions enables the CRC peripheral clock in the LPC SYSCON block. It also configures the CRC engine and starts checksum computation by writing the seed.

Parameters

- base – CRC peripheral address.
- config – CRC module configuration structure.

static inline void CRC_Deinit(CRC_Type *base)

Disables the CRC peripheral module.

This functions disables the CRC peripheral clock in the LPC SYSCON block.

Parameters

- base – CRC peripheral address.

void CRC_Reset(CRC_Type *base)

resets CRC peripheral module.

Parameters

- base – CRC peripheral address.

void CRC_WriteSeed(CRC_Type *base, uint32_t seed)

Write seed to CRC peripheral module.

Parameters

- base – CRC peripheral address.
- seed – CRC Seed value.

void CRC_GetDefaultConfig(*crc_config_t* *config)

Loads default values to CRC protocol configuration structure.

Loads default values to CRC protocol configuration structure. The default values are:

```
config->polynomial = kCRC_Polynomial_CRC_CCITT;
config->reverseIn = false;
config->complementIn = false;
config->reverseOut = false;
config->complementOut = false;
config->seed = 0xFFFFU;
```

Parameters

- config – CRC protocol configuration structure

void CRC_GetConfig(CRC_Type *base, *crc_config_t* *config)

Loads actual values configured in CRC peripheral to CRC protocol configuration structure.

The values, including seed, can be used to resume CRC calculation later.

Parameters

- base – CRC peripheral address.
- config – CRC protocol configuration structure

void CRC_WriteData(CRC_Type *base, const uint8_t *data, size_t dataSize)

Writes data to the CRC module.

Writes input data buffer bytes to CRC data register.

Parameters

- base – CRC peripheral address.
- data – Input data stream, MSByte in data[0].
- dataSize – Size of the input data buffer in bytes.

static inline uint32_t CRC_Get32bitResult(CRC_Type *base)

Reads 32-bit checksum from the CRC module.

Reads CRC data register.

Parameters

- base – CRC peripheral address.

Returns

final 32-bit checksum, after configured bit reverse and complement operations.

static inline uint16_t CRC_Get16bitResult(CRC_Type *base)

Reads 16-bit checksum from the CRC module.

Reads CRC data register.

Parameters

- base – CRC peripheral address.

Returns

final 16-bit checksum, after configured bit reverse and complement operations.

CRC_DRIVER_USE_CRC16_CCITT_FALSE_AS_DEFAULT

Default configuration structure filled by CRC_GetDefaultConfig(). Uses CRC-16/CCITT-FALSE as default.

struct _crc_config

#include <fsl_crc.h> CRC protocol configuration.

This structure holds the configuration for the CRC protocol.

Public Members

crc_polynomial_t polynomial

CRC polynomial.

bool reverseIn

Reverse bits on input.

bool complementIn

Perform 1's complement on input.

bool reverseOut

Reverse bits on output.

bool complementOut

Perform 1's complement on output.

uint32_t seed

Starting checksum value.

2.7 CTIMER: Standard counter/timers

void CTIMER_Init(CTIMER_Type *base, const *ctimer_config_t* *config)

Ungates the clock and configures the peripheral for basic operation.

Note: This API should be called at the beginning of the application before using the driver.

Parameters

- base – Ctimer peripheral base address
- config – Pointer to the user configuration structure.

void CTIMER_Deinit(CTIMER_Type *base)

Gates the timer clock.

Parameters

- base – Ctimer peripheral base address

void CTIMER_GetDefaultConfig(*ctimer_config_t* *config)

Fills in the timers configuration structure with the default settings.

The default values are:

```
config->mode = kCTIMER_TimerMode;
config->input = kCTIMER_Capture_0;
config->prescale = 0;
```

Parameters

- config – Pointer to the user configuration structure.

status_t CTIMER_SetupPwmPeriod(CTIMER_Type *base, const *ctimer_match_t* pwmPeriodChannel, *ctimer_match_t* matchChannel, uint32_t pwmPeriod, uint32_t pulsePeriod, bool enableInt)

Configures the PWM signal parameters.

Enables PWM mode on the match channel passed in and will then setup the match value and other match parameters to generate a PWM signal. This function can manually assign the specified channel to set the PWM cycle.

Note: When setting PWM output from multiple output pins, all should use the same PWM period

---

Parameters

- base – Ctimer peripheral base address
- pwmPeriodChannel – Specify the channel to control the PWM period
- matchChannel – Match pin to be used to output the PWM signal
- pwmPeriod – PWM period match value
- pulsePeriod – Pulse width match value
- enableInt – Enable interrupt when the timer value reaches the match value of the PWM pulse, if it is 0 then no interrupt will be generated.

Returns

kStatus_Success on success kStatus_Fail If matchChannel is equal to pwmPeriodChannel; this channel is reserved to set the PWM cycle If PWM pulse width register value is larger than 0xFFFFFFFF.

status_t CTIMER_SetupPwm(CTIMER_Type *base, const *ctimer_match_t* pwmPeriodChannel, *ctimer_match_t* matchChannel, uint8_t dutyCyclePercent, uint32_t pwmFreq_Hz, uint32_t srcClock_Hz, bool enableInt)

Configures the PWM signal parameters.

Enables PWM mode on the match channel passed in and will then setup the match value and other match parameters to generate a PWM signal. This function can manually assign the specified channel to set the PWM cycle.

Note: When setting PWM output from multiple output pins, all should use the same PWM frequency. Please use CTIMER_SetupPwmPeriod to set up the PWM with high resolution.

Parameters

- base – Ctimer peripheral base address
- pwmPeriodChannel – Specify the channel to control the PWM period
- matchChannel – Match pin to be used to output the PWM signal
- dutyCyclePercent – PWM pulse width; the value should be between 0 to 100
- pwmFreq_Hz – PWM signal frequency in Hz
- srcClock_Hz – Timer counter clock in Hz
- enableInt – Enable interrupt when the timer value reaches the match value of the PWM pulse, if it is 0 then no interrupt will be generated.

static inline void CTIMER_UpdatePwmPulsePeriod(CTIMER_Type *base, *ctimer_match_t* matchChannel, uint32_t pulsePeriod)

Updates the pulse period of an active PWM signal.

Parameters

- base – Ctimer peripheral base address
- matchChannel – Match pin to be used to output the PWM signal
- pulsePeriod – New PWM pulse width match value

status_t CTIMER_UpdatePwmDutycycle(CTIMER_Type *base, const *ctimer_match_t* pwmPeriodChannel, *ctimer_match_t* matchChannel, uint8_t dutyCyclePercent)

Updates the duty cycle of an active PWM signal.

Note: Please use CTIMER_SetupPwmPeriod to update the PWM with high resolution. This function can manually assign the specified channel to set the PWM cycle.

Parameters

- base – Ctimer peripheral base address
- pwmPeriodChannel – Specify the channel to control the PWM period
- matchChannel – Match pin to be used to output the PWM signal
- dutyCyclePercent – New PWM pulse width; the value should be between 0 to 100

Returns
kStatus_Success on success kStatus_Fail If PWM pulse width register value is larger than 0xFFFFFFFF.

static inline void CTIMER_EnableInterrupts(CTIMER_Type *base, uint32_t mask)

Enables the selected Timer interrupts.

Parameters

- base – Ctimer peripheral base address
- mask – The interrupts to enable. This is a logical OR of members of the enumeration ctimer_interrupt_enable_t

static inline void CTIMER_DisableInterrupts(CTIMER_Type *base, uint32_t mask)

Disables the selected Timer interrupts.

Parameters

- base – Ctimer peripheral base address
- mask – The interrupts to enable. This is a logical OR of members of the enumeration ctimer_interrupt_enable_t

static inline uint32_t CTIMER_GetEnabledInterrupts(CTIMER_Type *base)

Gets the enabled Timer interrupts.

Parameters

- base – Ctimer peripheral base address

Returns
The enabled interrupts. This is the logical OR of members of the enumeration ctimer_interrupt_enable_t

static inline uint32_t CTIMER_GetStatusFlags(CTIMER_Type *base)

Gets the Timer status flags.

Parameters

- base – Ctimer peripheral base address

Returns
The status flags. This is the logical OR of members of the enumeration ctimer_status_flags_t

static inline void CTIMER_ClearStatusFlags(CTIMER_Type *base, uint32_t mask)

Clears the Timer status flags.

Parameters

- base – Ctimer peripheral base address
- mask – The status flags to clear. This is a logical OR of members of the enumeration ctimer_status_flags_t

static inline void CTIMER_StartTimer(CTIMER_Type *base)

Starts the Timer counter.

Parameters

- base – Ctimer peripheral base address

static inline void CTIMER_StopTimer(CTIMER_Type *base)

Stops the Timer counter.

Parameters

- base – Ctimer peripheral base address

FSL_CTIMER_DRIVER_VERSION
Version 2.3.3

enum _ctimer_capture_channel
List of Timer capture channels.

Values:

enumerator kCTIMER_Capture_0
Timer capture channel 0

enumerator kCTIMER_Capture_1
Timer capture channel 1

enumerator kCTIMER_Capture_3
Timer capture channel 3

enum _ctimer_capture_edge
List of capture edge options.

Values:

enumerator kCTIMER_Capture_RiseEdge
Capture on rising edge

enumerator kCTIMER_Capture_FallEdge
Capture on falling edge

enumerator kCTIMER_Capture_BothEdge
Capture on rising and falling edge

enum _ctimer_match
List of Timer match registers.

Values:

enumerator kCTIMER_Match_0
Timer match register 0

enumerator kCTIMER_Match_1
Timer match register 1

enumerator kCTIMER_Match_2
Timer match register 2

enumerator kCTIMER_Match_3
Timer match register 3

enum _ctimer_external_match
List of external match.

Values:

enumerator kCTIMER_External_Match_0
External match 0

enumerator kCTIMER_External_Match_1
External match 1

enumerator kCTIMER_External_Match_2
External match 2

enumerator kCTIMER_External_Match_3
External match 3

enum _ctimer_match_output_control
List of output control options.

Values:

enumerator kCTIMER_Output_NoAction
No action is taken

enumerator kCTIMER_Output_Clear
Clear the EM bit/output to 0

enumerator kCTIMER_Output_Set
Set the EM bit/output to 1

enumerator kCTIMER_Output_Toggle
Toggle the EM bit/output

enum _ctimer_timer_mode
List of Timer modes.

Values:

enumerator kCTIMER_TimerMode

enumerator kCTIMER_IncreaseOnRiseEdge

enumerator kCTIMER_IncreaseOnFallEdge

enumerator kCTIMER_IncreaseOnBothEdge

enum _ctimer_interrupt_enable
List of Timer interrupts.

Values:

enumerator kCTIMER_Match0InterruptEnable
Match 0 interrupt

enumerator kCTIMER_Match1InterruptEnable
Match 1 interrupt

enumerator kCTIMER_Match2InterruptEnable
Match 2 interrupt

enumerator kCTIMER_Match3InterruptEnable
Match 3 interrupt

enum _ctimer_status_flags
List of Timer flags.

Values:

enumerator kCTIMER_Match0Flag
Match 0 interrupt flag

enumerator kCTIMER_Match1Flag
Match 1 interrupt flag

enumerator kCTIMER_Match2Flag
Match 2 interrupt flag

enumerator kCTIMER_Match3Flag
Match 3 interrupt flag

enum ctimer_callback_type_t

Callback type when registering for a callback. When registering a callback an array of function pointers is passed the size could be 1 or 8, the callback type will tell that.

Values:

enumerator kCTIMER_SingleCallback

Single Callback type where there is only one callback for the timer. based on the status flags different channels needs to be handled differently

enumerator kCTIMER_MultipleCallback

Multiple Callback type where there can be 8 valid callbacks, one per channel. for both match/capture

typedef enum *_ctimer_capture_channel* ctimer_capture_channel_t

List of Timer capture channels.

typedef enum *_ctimer_capture_edge* ctimer_capture_edge_t

List of capture edge options.

typedef enum *_ctimer_match* ctimer_match_t

List of Timer match registers.

typedef enum *_ctimer_external_match* ctimer_external_match_t

List of external match.

typedef enum *_ctimer_match_output_control* ctimer_match_output_control_t

List of output control options.

typedef enum *_ctimer_timer_mode* ctimer_timer_mode_t

List of Timer modes.

typedef enum *_ctimer_interrupt_enable* ctimer_interrupt_enable_t

List of Timer interrupts.

typedef enum *_ctimer_status_flags* ctimer_status_flags_t

List of Timer flags.

typedef void (*ctimer_callback_t)(uint32_t flags)

typedef struct *_ctimer_match_config* ctimer_match_config_t

Match configuration.

This structure holds the configuration settings for each match register.

typedef struct *_ctimer_config* ctimer_config_t

Timer configuration structure.

This structure holds the configuration settings for the Timer peripheral. To initialize this structure to reasonable defaults, call the CTIMER_GetDefaultConfig() function and pass a pointer to the configuration structure instance.

The configuration structure can be made constant so as to reside in flash.

void CTIMER_SetupMatch(CTIMER_Type *base, *ctimer_match_t* matchChannel, const *ctimer_match_config_t* *config)

Setup the match register.

User configuration is used to setup the match value and action to be taken when a match occurs.

Parameters

- base – Ctimer peripheral base address
- matchChannel – Match register to configure

- config – Pointer to the match configuration structure

uint32_t CTIMER_GetOutputMatchStatus(CTIMER_Type *base, uint32_t matchChannel)

Get the status of output match.

This function gets the status of output MAT, whether or not this output is connected to a pin. This status is driven to the MAT pins if the match function is selected via IOCON. 0 = LOW. 1 = HIGH.

Parameters

- base – Ctimer peripheral base address
- matchChannel – External match channel, user can obtain the status of multiple match channels at the same time by using the logic of "|" enumeration ctimer_external_match_t

Returns

The mask of external match channel status flags. Users need to use the _ctimer_external_match type to decode the return variables.

void CTIMER_SetupCapture(CTIMER_Type *base, *ctimer_capture_channel_t* capture, *ctimer_capture_edge_t* edge, bool enableInt)

Setup the capture.

Parameters

- base – Ctimer peripheral base address
- capture – Capture channel to configure
- edge – Edge on the channel that will trigger a capture
- enableInt – Flag to enable channel interrupts, if enabled then the registered call back is called upon capture

static inline uint32_t CTIMER_GetTimerCountValue(CTIMER_Type *base)

Get the timer count value from TC register.

Parameters

- base – Ctimer peripheral base address.

Returns

return the timer count value.

void CTIMER_RegisterCallBack(CTIMER_Type *base, *ctimer_callback_t* *cb_func, *ctimer_callback_type_t* cb_type)

Register callback.

This function configures CTimer Callback in following modes:

- Single Callback: cb_func should be pointer to callback function pointer For example: ctimer_callback_t ctimer_callback = pwm_match_callback; CTIMER_RegisterCallBack(CTIMER, &ctimer_callback, kCTIMER_SingleCallback);
- Multiple Callback: cb_func should be pointer to array of callback function pointers Each element corresponds to Interrupt Flag in IR register. For example: ctimer_callback_t ctimer_callback_table[] = { ctimer_match0_callback, NULL, NULL, ctimer_match3_callback, NULL, NULL, NULL, NULL}; CTIMER_RegisterCallBack(CTIMER, &ctimer_callback_table[0], kCTIMER_MultipleCallback);

Parameters

- base – Ctimer peripheral base address
- cb_func – Pointer to callback function pointer

- cb_type – callback function type, singular or multiple

static inline void CTIMER_Reset(CTIMER_Type *base)

Reset the counter.

The timer counter and prescale counter are reset on the next positive edge of the APB clock.

Parameters

- base – Ctimer peripheral base address

static inline void CTIMER_SetPrescale(CTIMER_Type *base, uint32_t prescale)

Setup the timer prescale value.

Specifies the maximum value for the Prescale Counter.

Parameters

- base – Ctimer peripheral base address
- prescale – Prescale value

static inline uint32_t CTIMER_GetCaptureValue(CTIMER_Type *base, *ctimer_capture_channel_t* capture)

Get capture channel value.

Get the counter/timer value on the corresponding capture channel.

Parameters

- base – Ctimer peripheral base address
- capture – Select capture channel

Returns

The timer count capture value.

static inline void CTIMER_EnableResetMatchChannel(CTIMER_Type *base, *ctimer_match_t* match, bool enable)

Enable reset match channel.

Set the specified match channel reset operation.

Parameters

- base – Ctimer peripheral base address
- match – match channel used
- enable – Enable match channel reset operation.

static inline void CTIMER_EnableStopMatchChannel(CTIMER_Type *base, *ctimer_match_t* match, bool enable)

Enable stop match channel.

Set the specified match channel stop operation.

Parameters

- base – Ctimer peripheral base address.
- match – match channel used.
- enable – Enable match channel stop operation.

static inline void CTIMER_EnableMatchChannelReload(CTIMER_Type *base, *ctimer_match_t* match, bool enable)

Enable reload channel falling edge.

Enable the specified match channel reload match shadow value.

Parameters

- base – Ctimer peripheral base address.
- match – match channel used.
- enable – Enable .

static inline void CTIMER_EnableRisingEdgeCapture(CTIMER_Type *base, *ctimer_capture_channel_t* capture, bool enable)

Enable capture channel rising edge.

Sets the specified capture channel for rising edge capture.

Parameters

- base – Ctimer peripheral base address.
- capture – capture channel used.
- enable – Enable rising edge capture.

static inline void CTIMER_EnableFallingEdgeCapture(CTIMER_Type *base, *ctimer_capture_channel_t* capture, bool enable)

Enable capture channel falling edge.

Sets the specified capture channel for falling edge capture.

Parameters

- base – Ctimer peripheral base address.
- capture – capture channel used.
- enable – Enable falling edge capture.

static inline void CTIMER_SetShadowValue(CTIMER_Type *base, *ctimer_match_t* match, uint32_t matchvalue)

Set the specified match shadow channel.

Parameters

- base – Ctimer peripheral base address.
- match – match channel used.
- matchvalue – Reload the value of the corresponding match register.

struct _ctimer_match_config

#include <fsl_ctimer.h> Match configuration.

This structure holds the configuration settings for each match register.

Public Members

uint32_t matchValue

This is stored in the match register

bool enableCounterReset

true: Match will reset the counter false: Match will not reser the counter

bool enableCounterStop

true: Match will stop the counter false: Match will not stop the counter

ctimer_match_output_control_t outControl
Action to be taken on a match on the EM bit/output

bool outPinInitState
Initial value of the EM bit/output

bool enableInterrupt
true: Generate interrupt upon match false: Do not generate interrupt on match

struct _ctimer_config
#include <fsl_ctimer.h> Timer configuration structure.

This structure holds the configuration settings for the Timer peripheral. To initialize this structure to reasonable defaults, call the CTIMER_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

ctimer_timer_mode_t mode
Timer mode

ctimer_capture_channel_t input
Input channel to increment the timer, used only in timer modes that rely on this input signal to increment TC

uint32_t prescale
Prescale value

2.8 DAC: Digital Analog Converter

void DAC_Init(DAC_Type *base, const *dac_config_t* *config)
Initializes DAC module, including set reference voltage source, set conversion range, and set output voltage range.

Parameters

- base – DAC peripheral base address.
- config – Pointer to the structure which in type of dac_config_t.

void DAC_GetDefaultConfig(*dac_config_t* *config)
Gets the default configurations of DAC module.

```
config->conversionRate = kDAC_ConversionRate62P5KHZ;
config->refSource = kDAC_ReferenceInternalVoltageSource;
config->rangeSelect = kDAC_RangeLarge;
```

Parameters

- config – Pointer to the structure which in the type of dac_config_t.

void DAC_Deinit(DAC_Type *base)
De-initializes the DAC module, including reset clock divider, reset each channel, and so on.

Parameters

- base – DAC peripheral base address.

void DAC_SetChannelConfig(DAC_Type *base, uint32_t channelMask, const *dac_channel_config_t* *channelConfig)

Configures the DAC channels, including enable channel conversion, set wave type, set timing mode, and so on.

Parameters

- base – DAC peripheral base address.
- channelMask – The mask of channel, can be the OR'ed value of dac_channel_id_t.
- channelConfig – The pointer of structure which in the type of dac_channel_config_t.

static inline void DAC_ResetChannel(DAC_Type *base, uint32_t channelMask)

Does software reset for the selected DAC channels.

Parameters

- base – DAC peripheral base address.
- channelMask – The mask of channel to be reset, should be the OR'ed value of dac_channel_id_t.

static inline void DAC_EnableChannelConversion(DAC_Type *base, uint32_t channelMask, bool enable)

Enables/Disables selected channel conversion.

Note: To enable/disable the conversions of both channels, invoking this API with the parameter **channelMask** set as **kDAC_ChannelA**|**kDAC_ChannelB** .

Parameters

- base – DAC peripheral base address.
- channelMask – The mask of channel to be reset, can be the OR'ed value of dac_channel_id_t.
- enable – Enable/Disable channel conversion.
  - **true** Enable selected channels' conversion.
  - **false** Disable selected channels' conversion.

static inline void DAC_SetChannelOutMode(DAC_Type *base, uint32_t channelMask, *dac_channel_output_t* outMode)

Sets channels out mode, including kDAC_ChannelOutputInternal and kDAC_ChannelOutputPad.

Parameters

- base – DAC peripheral base address.
- channelMask – The mask of channel, can be the OR'ed value of dac_channel_id_t.
- outMode – The out mode of selected channels, please refer to dac_channel_output_t for details.

static inline void DAC_EnableChannelTriggerMode(DAC_Type *base, uint32_t channelMask, bool enable)

Enables/Disables channels trigger mode.

Note: To enable/disable the trigger mode of both two channels, invoking this API with the parameter **channelMask** set as **kDAC_ChannelA|kDAC_ChannelB** .

Parameters

- base – DAC peripheral base address.
- channelMask – The mask of channel, can be the OR'ed value of dac_channel_id_t.
- enable – Enable/Disable channel trigger mode.
  - **true** Channels' conversion triggered by external event enabled.
  - **false** Channels' conversion trigged by external event disabled.

static inline void DAC_SetChannelTrigSource(DAC_Type *base, uint32_t channelMask, dac_channel_trigger_source_t trigSource)

Sets channels trigger source.

Note: To set the same trigger source to both two channels, invoking this API with the parameter **channelMask** set as **kDAC_ChannelA|kDAC_ChannelB** .

Parameters

- base – DAC peripheral base address.
- channelMask – The mask of channel, can be the OR'ed value of dac_channel_id_t.
- trigSource – The selected trigger source, please refer to dac_channel_trigger_source_t for details.

static inline void DAC_SetChannelTrigType(DAC_Type *base, uint32_t channelMask, *dac_channel_trigger_type_t* trigType)

Sets channels trigger type, such as rising edge trigger, falling edge trigger, or both edge trigger.

Note: To set the same trigger type to both two channels, invoking this API with the parameter **channelMask** set as **kDAC_ChannelA|kDAC_ChannelB** .

Parameters

- base – DAC peripheral base address.
- channelMask – The mask of channel, can be the OR'ed value of dac_channel_id_t;
- trigType – The selected trigger type, please refer to dac_channel_trigger_type_t;

static inline void DAC_SetChannelTimingMode(DAC_Type *base, uint32_t channelMask, *dac_channel_timing_mode_t* timingMode)

Sets channels timing mode, including not-timing related or timing related.

Note: To the same timing mode to both two channels, invoking this API with the parameter **channelMask** set as **kDAC_ChannelA|kDAC_ChannelB** .

Parameters

- base – DAC peripheral base address.
- channelMask – The mask of channel, can be the OR'ed value of dac_channel_id_t.
- timingMode – The selected timing mode, please refer to dac_channel_timing_mode_t for details.

static inline void DAC_EnableChannelDMA(DAC_Type *base, uint32_t channelMask, bool enable)

Enables/Disables channels DMA.

Parameters

- base – DAC peripheral base address.
- channelMask – The mask of channel, can be the OR'ed value of dac_channel_id_t.
- enable – Enable/Disable channel DMA data transfer.
  - **true** DMA data transfer enabled.
  - **false** DMA data transfer disabled.

static inline void DAC_SetChannelWaveType(DAC_Type *base, uint32_t channelMask, *dac_channel_wave_type_t* waveType)

Sets channels wave type, such as sine, noise, or triangle.

Note: To set the same wave type to both channel, invoking this API with the parameter **channelMask** set as **kDAC_ChannelA|kDAC_ChannelB** .

Parameters

- base – DAC peripheral base address.
- channelMask – The mask of channel, should be the OR'ed value of dac_channel_id_t.
- waveType – The wave type to set, please refer to dac_channel_wave_type_t.

static inline void DAC_SetChannelData(DAC_Type *base, uint32_t channelMask, uint16_t data)

Sets DAC channels data.

Note: To set the same data to both channel, invoking this API with the parameter **channelMask** set as **kDAC_ChannelA|kDAC_ChannelB** .

Parameters

- base – DAC peripheral base address.
- channelMask – The mask of channel, can be the OR'ed value of dac_channel_id_t.
- data –

void DAC_SetTriangleConfig(DAC_Type *base, const *dac_triangle_config_t* *triangleConfig)

Configures the options of triangle waveform.

Note: This API should be invoked to set the options of triangle waveform when channel A's output wave type is selected as kDAC_WaveTriangle.

Parameters

- base – DAC peripheral base address.
- triangleConfig – The pointer of structure which in the type of dac_triangle_config_t.

static inline void DAC_EnableInterrupts(DAC_Type *base, uint32_t interruptMask)

Enables interrupts, such as channel A data ready interupt, channel A timeout interrupt, and so on.

Parameters

- base – DAC peripheral base address.
- interruptMask – The or'ed value of the interrupts to be enabled, please refer to _dac_interrupt_enable.

static inline void DAC_DisableInterrupts(DAC_Type *base, uint32_t interruptMask)

Disables interrupts, such as channel B data ready interrupt, channel B timeout interrupt, and so on.

Parameters

- base – DAC peripheral base address.
- interruptMask – The or'ed value of the interrupts to be disabled, please refer to _dac_interrupt_enable.

static inline uint32_t DAC_GetStatusFlags(DAC_Type *base)

Gets the status flags, including interrupt status flags, raw status flags, and conversion status flags.

Parameters

- base – DAC peripheral base address.

Returns

The mask of status flags, please refer to _dac_status_flags.

static inline void DAC_ClearStatusFlags(DAC_Type *base, uint32_t statusFlagsMask)

Clears the interrups status flags, such as channel A data ready interrupt flag, channel B data ready interrupt flag, and so on.

Parameters

- base – DAC peripheral base address.
- statusFlagsMask – The mask of the status flags to be cleared, please refer to _dac_status_flags.

enum _dac_interrupt_enable

The enumeration of interrupts that DAC support.

Values:

enumerator kDAC_ChannelAReadyInterruptEnable

Enable channel A data ready interrupt.

enumerator kDAC_ChannelBReadyInterruptEnable

Enable channel B data ready interrupt.

enumerator kDAC_ChannelATimeoutInterruptEnable
Enable channel A time out interrupt.

enumerator kDAC_ChannelBTimeoutInterruptEnable
Enable channel B time out interrupt.

enumerator kDAC_TriangleOverflowInterruptEnable
Enable triangle overflow interrupt.

enum _dac_status_flags
The enumeration of DAC status flags, including interrupt status flags, raw status flags, and conversion status flags.

Note: The interrupt status flags can only be asserted upon both enabling and happening of related interrupts. Comparatively, the raw status flags will be asserted as long as related events happen regardless of whether related interrupts are enabled or not.

Note: Only interrupt status flags can be cleared mannually.

Values:

enumerator kDAC_ChannelADataReadyInterruptFlag
Channel A data ready.

enumerator kDAC_ChannelBDataReadyInterruptFlag
Channel B data ready.

enumerator kDAC_ChannelATimeoutInterruptFlag
Channel A time out.

enumerator kDAC_ChannelBTimeoutInterruptFlag
Channel B time out.

enumerator kDAC_TriangleOverflowInterruptFlag
Triangle overflow.

enumerator kDAC_RawChannelADataReadyFlag
Channel A data ready raw.

enumerator kDAC_RawChannelBDataReadyFlag
Channel B data ready raw.

enumerator kDAC_RawChannelATimeoutFlag
Channel A timeout raw.

enumerator kDAC_RawChannelBTimeoutFlag
Channel B timeout raw.

enumerator kDAC_RawTriangleOverflowFlag
Triangle overflow raw.

enumerator kDAC_ChannelAConversionCompleteFlag
Channel A conversion complete.

enumerator kDAC_ChannelBConversionCompleteFlag
Channel B conversion complete.

enum _dac_channel_id

The enumeration of dac channels, including channel A and channel B.

Values:

enumerator kDAC_ChannelA

enumerator kDAC_ChannelB

enum _dac_conversion_rate

The enumeration of dac converion rate, including 62.5 KHz, 125 KHz, 250 KHz, and 500 KHz.

Values:

enumerator kDAC_ConversionRate62P5KHZ

DAC Conversion Rate selects as 62.5 KHz.

enumerator kDAC_ConversionRate125KHZ

DAC Conversion Rate selects as 125 KHz.

enumerator kDAC_ConversionRate250KHZ

DAC Conversion Rate selects as 250 KHz.

enumerator kDAC_ConversionRate500KHZ

DAC Conversion Rate selects as 500 KHz.

enum _dac_reference_voltage_source

The enumeration of dac reference voltage source.

Values:

enumerator kDAC_ReferenceInternalVoltageSource

Select internal voltage reference.

enumerator kDAC_ReferenceExternalVoltageSource

Select external voltage reference.

enum _dac_output_voltage_range

The enumeration of dac output voltage range.

Values:

enumerator kDAC_RangeSmall

DAC output small range.

enumerator kDAC_RangeMiddle

DAC output middle range.

enumerator kDAC_RangeLarge

DAC output large range.

enum _dac_channel_output

The enumeration of dac channel's output mode.

Values:

enumerator kDAC_ChannelOutputInternal

Enable internal output but disable output to pad

enumerator kDAC_ChannelOutputPAD

Enable output to pad but disable internal output

enum _dac_channel_trigger_type

The enumeration of dac channel's trigger type, including rising edge trigger, falling edge trigger, and both edge triggers.

Values:

enumerator kDAC_RisingEdgeTrigger

Rising edge trigger.

enumerator kDAC_FallingEdgeTrigger

Failing edge trigger.

enumerator kDAC_BothEdgeTrigger

Rising and Failing edge trigger.

enum _dac_channel_timing_mode

The enumeration of dac channel timing mode.

Values:

enumerator kDAC_NonTimingCorrelated

DAC non-timing-correlated mode.

enumerator kDAC_TimingCorrelated

DAC timing-correlated mode.

enum _dac_channel_wave_type

The enumerator of channel output wave type, please note that not all wave types are effective to A and B channel.

Values:

enumerator kDAC_WaveNormal

No predefined waveform, effective to A or B channel

enumerator kDAC_WaveTriangle

Triangle wave, effective only to A channel

enumerator kDAC_WaveSine

Sine wave, effective only to A channel

enumerator kDAC_WaveNoiseDifferential

Noise wave, effective only to A channel; Differential mode, one's complemental code from A data, effective only to B channel

enum _dac_triangle_mamp

DAC triangle maximum amplitude type.

Values:

enumerator kDAC_TriangleAmplitude63

DAC triangle amplitude 63 lsb

enumerator kDAC_TriangleAmplitude127

DAC triangle amplitude 127 lsb

enumerator kDAC_TriangleAmplitude191

DAC triangle amplitude 191 lsb

enumerator kDAC_TriangleAmplitude255

DAC triangle amplitude 255 lsb

enumerator kDAC_TriangleAmplitude319

DAC triangle amplitude 319 lsb

enumerator kDAC_TriangleAmplitude383
DAC triangle amplitude 383 lsb

enumerator kDAC_TriangleAmplitude447
DAC triangle amplitude 447 lsb

enumerator kDAC_TriangleAmplitude511
DAC triangle amplitude 511 lsb

enumerator kDAC_TriangleAmplitude575
DAC triangle amplitude 575 lsb

enumerator kDAC_TriangleAmplitude639
DAC triangle amplitude 639 lsb

enumerator kDAC_TriangleAmplitude703
DAC triangle amplitude 703 lsb

enumerator kDAC_TriangleAmplitude767
DAC triangle amplitude 767 lsb

enumerator kDAC_TriangleAmplitude831
DAC triangle amplitude 831 lsb

enumerator kDAC_TriangleAmplitude895
DAC triangle amplitude 895 lsb

enumerator kDAC_TriangleAmplitude959
DAC triangle amplitude 959 lsb

enumerator kDAC_TriangleAmplitude1023
DAC triangle amplitude 1023 lsb

enum _dac_triangle_step_size
DAC triangle step size type.

Values:

enumerator kDAC_TriangleStepSize1
DAC triangle step size 1 lsb

enumerator kDAC_TriangleStepSize3
DAC triangle step size 3 lsb

enumerator kDAC_TriangleStepSize15
DAC triangle step size 15 lsb

enumerator kDAC_TriangleStepSize511
DAC triangle step size 511 lsb

enum _dac_triangle_waveform_type
DAC triangle waveform type.

Values:

enumerator kDAC_TriangleFull
DAC full triangle waveform

enumerator kDAC_TriangleHalf
DAC half triangle waveform

typedef enum *_dac_channel_id* dac_channel_id_t
The enumeration of dac channels, including channel A and channel B.

typedef enum *_dac_conversion_rate* dac_conversion_rate_t

The enumeration of dac converion rate, including 62.5 KHz, 125 KHz, 250 KHz, and 500 KHz.

typedef enum *_dac_reference_voltage_source* dac_reference_voltage_source_t

The enumeration of dac reference voltage source.

typedef enum *_dac_output_voltage_range* dac_output_voltage_range_t

The enumeration of dac output voltage range.

typedef enum *_dac_channel_output* dac_channel_output_t

The enumeration of dac channel's output mode.

typedef enum *_dac_channel_trigger_type* dac_channel_trigger_type_t

The enumeration of dac channel's trigger type, including rising edge trigger, falling edge trigger, and both edge triggers.

typedef enum *_dac_channel_timing_mode* dac_channel_timing_mode_t

The enumeration of dac channel timing mode.

typedef enum *_dac_channel_wave_type* dac_channel_wave_type_t

The enumerator of channel output wave type, please note that not all wave types are effective to A and B channel.

typedef enum *_dac_triangle_mamp* dac_triangle_mamp_t

DAC triangle maximum amplitude type.

typedef enum *_dac_triangle_step_size* dac_triangle_step_size_t

DAC triangle step size type.

typedef enum *_dac_triangle_waveform_type* dac_triangle_waveform_type_t

DAC triangle waveform type.

typedef struct *_dac_config* dac_config_t

The structure of dac module basic configuration, including conversion rate, output range, and reference voltage source.

typedef struct *_dac_channel_config* dac_channel_config_t

The structure of dac channel configuration, such as trigger type, wave type, timing mode, and so on.

typedef struct *_dac_triangle_config* dac_triangle_config_t

The structure of triangle waveform, including maximum value, minimum value, step size, and so on.

FSL_DAC_DRIVER_VERSION

DAC driver version.

Version 2.1.1.

IS_DAC_CHANNEL_A_WAVE(CH_WAVE)

DAC channel A wave mode check.

IS_DAC_CHANNEL_B_WAVE(CH_WAVE)

DAC channel B wave mode check.

struct _dac_config

#include <fsl_dac.h> The structure of dac module basic configuration, including conversion rate, output range, and reference voltage source.

Public Members

dac_conversion_rate_t conversionRate

Configure DAC conversion rate, please refer to dac_conversion_rate_t.

dac_reference_voltage_source_t refSource

Configure DAC vref source, please refer to dac_reference_voltage_source_t.

dac_output_voltage_range_t rangeSelect

Configure DAC channel output range, please refer to dac_output_voltage_range_t.

struct __dac__channel__config

#include <fsl_dac.h> The structure of dac channel configuration, such as trigger type, wave type, timing mode, and so on.

Public Members

bool enableConversion

Enable/Disable selected channel's conversion.

- **true** Enable selected channel's conversion.
- **false** Disable selected channel's conversion.

dac_channel_output_t outMode

Configure channel output mode, please refer to dac_channel_output_t

bool enableDMA

Enable/Disable channel DAM data transfer.

- **true** DMA data transfer enabled.
- **false** DMA data transfer disabled.

bool enableTrigger

Enable/Disable external event trigger.

dac_channel_trigger_type_t triggerType

Configure the channel trigger type, please refer to dac_channel_trigger_type_t.

dac_channel_trigger_source_t triggerSource

Configure DAC channel trigger source, please refer to dac_channel_trigger_source_t.

dac_channel_timing_mode_t timingMode

Configure channel timing mode, please refer to dac_channel_timing_mode_t.

dac_channel_wave_type_t waveType

Configure wave type for the selected channel, please refer to dac_channel_wave_type_t.

struct __dac__triangle__config

#include <fsl_dac.h> The structure of triangle waveform, including maximum value, minimum value, step size, and so on.

Public Members

dac_triangle_mamp_t triangleMamp

Configure triangle maximum value.

dac_triangle_step_size_t triangleStepSize

Configure triangle step size.

dac_triangle_waveform_type_t triangleWaveform
Configure triangle waveform type.

uint32_t triangleBase
Configure triangle minimum value.

2.9 DMA: Direct Memory Access Controller Driver

void DMA_Init(DMA_Type *base)
Initializes DMA peripheral.

This function enable the DMA clock, set descriptor table and enable DMA peripheral.

Parameters

- base – DMA peripheral base address.

void DMA_Deinit(DMA_Type *base)
Deinitializes DMA peripheral.

This function gates the DMA clock.

Parameters

- base – DMA peripheral base address.

void DMA_InstallDescriptorMemory(DMA_Type *base, void *addr)
Install DMA descriptor memory.

This function used to register DMA descriptor memory for linked transfer, a typical case is ping pong transfer which will request more than one DMA descriptor memory space, althrough current DMA driver has a default DMA descriptor buffer, but it support one DMA descriptor for one channel only.

Parameters

- base – DMA base address.
- addr – DMA descriptor address

static inline bool DMA_ChannelIsActive(DMA_Type *base, uint32_t channel)
Return whether DMA channel is processing transfer.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

Returns
True for active state, false otherwise.

static inline bool DMA_ChannelIsBusy(DMA_Type *base, uint32_t channel)
Return whether DMA channel is busy.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

Returns
True for busy state, false otherwise.

static inline void DMA_EnableChannelInterrupts(DMA_Type *base, uint32_t channel)

Enables the interrupt source for the DMA transfer.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

static inline void DMA_DisableChannelInterrupts(DMA_Type *base, uint32_t channel)

Disables the interrupt source for the DMA transfer.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

static inline void DMA_EnableChannel(DMA_Type *base, uint32_t channel)

Enable DMA channel.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

static inline void DMA_DisableChannel(DMA_Type *base, uint32_t channel)

Disable DMA channel.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

static inline void DMA_EnableChannelPeriphRq(DMA_Type *base, uint32_t channel)

Set PERIPHREQEN of channel configuration register.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

static inline void DMA_DisableChannelPeriphRq(DMA_Type *base, uint32_t channel)

Get PERIPHREQEN value of channel configuration register.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

Returns

True for enabled PeriphRq, false for disabled.

void DMA_ConfigureChannelTrigger(DMA_Type *base, uint32_t channel, *dma_channel_trigger_t* *trigger)

Set trigger settings of DMA channel.

Deprecated:

Do not use this function. It has been superceded by DMA_SetChannelConfig.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

- trigger – trigger configuration.

void DMA_SetChannelConfig(DMA_Type *base, uint32_t channel, *dma_channel_trigger_t* *trigger, bool isPeriph)

set channel config.

This function provide a interface to configure channel configuration reisters.

Parameters

- base – DMA base address.
- channel – DMA channel number.
- trigger – channel configurations structure.
- isPeriph – true is periph request, false is not.

static inline uint32_t DMA_SetChannelXferConfig(bool reload, bool clrTrig, bool intA, bool intB, uint8_t width, uint8_t srcInc, uint8_t dstInc, uint32_t bytes)

DMA channel xfer transfer configurations.

Parameters

- reload – true is reload link descriptor after current exhaust, false is not
- clrTrig – true is clear trigger status, wait software trigger, false is not
- intA – enable interruptA
- intB – enable interruptB
- width – transfer width
- srcInc – source address interleave size
- dstInc – destination address interleave size
- bytes – transfer bytes

Returns

The vaule of xfer config

uint32_t DMA_GetRemainingBytes(DMA_Type *base, uint32_t channel)

Gets the remaining bytes of the current DMA descriptor transfer.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

Returns

The number of bytes which have not been transferred yet.

static inline void DMA_SetChannelPriority(DMA_Type *base, uint32_t channel, *dma_priority_t* priority)

Set priority of channel configuration register.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.
- priority – Channel priority value.

static inline *dma_priority_t* DMA_GetChannelPriority(DMA_Type *base, uint32_t channel)

Get priority of channel configuration register.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

Returns

Channel priority value.

static inline void DMA_SetChannelConfigValid(DMA_Type *base, uint32_t channel)

Set channel configuration valid.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

static inline void DMA_DoChannelSoftwareTrigger(DMA_Type *base, uint32_t channel)

Do software trigger for the channel.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.

static inline void DMA_LoadChannelTransferConfig(DMA_Type *base, uint32_t channel, uint32_t xfer)

Load channel transfer configurations.

Parameters

- base – DMA peripheral base address.
- channel – DMA channel number.
- xfer – transfer configurations.

void DMA_CreateDescriptor(*dma_descriptor_t* *desc, *dma_xfercfg_t* *xfercfg, void *srcAddr, void *dstAddr, void *nextDesc)

Create application specific DMA descriptor to be used in a chain in transfer.

Deprecated:

Do not use this function. It has been superceded by DMA_SetupDescriptor.

Parameters

- desc – DMA descriptor address.
- xfercfg – Transfer configuration for DMA descriptor.
- srcAddr – Address of last item to transmit
- dstAddr – Address of last item to receive.
- nextDesc – Address of next descriptor in chain.

void DMA_SetupDescriptor(*dma_descriptor_t* *desc, uint32_t xfercfg, void *srcStartAddr, void *dstStartAddr, void *nextDesc)

setup dma descriptor

Note: This function do not support configure wrap descriptor.

Parameters

- desc – DMA descriptor address.
- xfercfg – Transfer configuration for DMA descriptor.
- srcStartAddr – Start address of source address.
- dstStartAddr – Start address of destination address.
- nextDesc – Address of next descriptor in chain.

void DMA_SetupChannelDescriptor(*dma_descriptor_t* *desc, uint32_t xfercfg, void *srcStartAddr, void *dstStartAddr, void *nextDesc, *dma_burst_wrap_t* wrapType, uint32_t burstSize)

setup dma channel descriptor

Note: This function support configure wrap descriptor.

Parameters

- desc – DMA descriptor address.
- xfercfg – Transfer configuration for DMA descriptor.
- srcStartAddr – Start address of source address.
- dstStartAddr – Start address of destination address.
- nextDesc – Address of next descriptor in chain.
- wrapType – burst wrap type.
- burstSize – burst size, reference _dma_burst_size.

void DMA_LoadChannelDescriptor(DMA_Type *base, uint32_t channel, *dma_descriptor_t* *descriptor)

load channel transfer decriptor.

This function can be used to load desscriptor to driver internal channel descriptor that is used to start DMA transfer, the head descriptor table is defined in DMA driver, it is useful for the case:

a. for the polling transfer, application can allocate a local descriptor memory table to prepare a descriptor firstly and then call this api to load the configured descriptor to driver descriptor table.

```
DMA_Init(DMA0);
DMA_EnableChannel(DMA0, DEMO_DMA_CHANNEL);
DMA_SetupDescriptor(desc, xferCfg, s_srcBuffer, &s_destBuffer[0], NULL);
DMA_LoadChannelDescriptor(DMA0, DEMO_DMA_CHANNEL, (dma_descriptor_t *)desc);
DMA_DoChannelSoftwareTrigger(DMA0, DEMO_DMA_CHANNEL);
while(DMA_ChannelIsBusy(DMA0, DEMO_DMA_CHANNEL))
{}
```

Parameters

- base – DMA base address.
- channel – DMA channel.
- descriptor – configured DMA descriptor.

void DMA_AbortTransfer(*dma_handle_t* *handle)

Abort running transfer by handle.

This function aborts DMA transfer specified by handle.

Parameters

- handle – DMA handle pointer.

void DMA_CreateHandle(*dma_handle_t* *handle, DMA_Type *base, uint32_t channel)

Creates the DMA handle.

This function is called if using transaction API for DMA. This function initializes the internal state of DMA handle.

Parameters

- handle – DMA handle pointer. The DMA handle stores callback function and parameters.
- base – DMA peripheral base address.
- channel – DMA channel number.

void DMA_SetCallback(*dma_handle_t* *handle, *dma_callback* callback, void *userData)

Installs a callback function for the DMA transfer.

This callback is called in DMA IRQ handler. Use the callback to do something after the current major loop transfer completes.

Parameters

- handle – DMA handle pointer.
- callback – DMA callback function pointer.
- userData – Parameter for callback function.

void DMA_PrepareTransfer(*dma_transfer_config_t* *config, void *srcAddr, void *dstAddr, uint32_t byteWidth, uint32_t transferBytes, *dma_transfer_type_t* type, void *nextDesc)

Prepares the DMA transfer structure.

Deprecated:

Do not use this function. It has been superceded by DMA_PrepareChannelTransfer. 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, so the source address must be 4 bytes aligned, or it shall result in source address error(SAE).

Parameters

- config – The user configuration structure of type dma_transfer_t.
- srcAddr – DMA transfer source address.
- dstAddr – DMA transfer destination address.
- byteWidth – DMA transfer destination address width(bytes).
- transferBytes – DMA transfer bytes to be transferred.
- type – DMA transfer type.
- nextDesc – Chain custom descriptor to transfer.

void DMA_PrepareChannelTransfer(*dma_channel_config_t* *config, void *srcStartAddr, void *dstStartAddr, uint32_t xferCfg, *dma_transfer_type_t* type, *dma_channel_trigger_t* *trigger, void *nextDesc)

Prepare channel transfer configurations.

This function used to prepare channel transfer configurations.

Parameters

- config – Pointer to DMA channel transfer configuration structure.
- srcStartAddr – source start address.
- dstStartAddr – destination start address.
- xferCfg – xfer configuration, user can reference DMA_CHANNEL_XFER about to how to get xferCfg value.
- type – transfer type.
- trigger – DMA channel trigger configurations.
- nextDesc – address of next descriptor.

status_t DMA_SubmitTransfer(*dma_handle_t* *handle, *dma_transfer_config_t* *config)

Submits the DMA transfer request.

Deprecated:

Do not use this function. It has been superceded by DMA_SubmitChannelTransfer.

This function submits the DMA transfer request according to the transfer configuration structure. If the user submits the transfer request repeatedly, this function packs an unprocessed request as a TCD and enables scatter/gather feature to process it in the next time.

Parameters

- handle – DMA handle pointer.
- config – Pointer to DMA transfer configuration structure.

Return values

- kStatus_DMA_Success – It means submit transfer request succeed.
- kStatus_DMA_QueueFull – It means TCD queue is full. Submit transfer request is not allowed.
- kStatus_DMA_Busy – It means the given channel is busy, need to submit request later.

void DMA_SubmitChannelTransferParameter(*dma_handle_t* *handle, uint32_t xferCfg, void *srcStartAddr, void *dstStartAddr, void *nextDesc)

Submit channel transfer paramter directly.

This function used to configue channel head descriptor that is used to start DMA transfer, the head descriptor table is defined in DMA driver, it is useful for the case:

a. for the single transfer, application doesn't need to allocate descriptor table, the head descriptor can be used for it.

```
DMA_SetChannelConfig(base, channel, trigger, isPeriph);
DMA_CreateHandle(handle, base, channel)
DMA_SubmitChannelTransferParameter(handle, DMA_CHANNEL_XFER(reload, clrTrig,␣
↪intA, intB, width, srcInc, dstInc,
bytes), srcStartAddr, dstStartAddr, NULL);
DMA_StartTransfer(handle)
```

b. for the linked transfer, application should responsible for link descriptor, for example, if 4 transfer is required, then application should prepare three descriptor table with macro , the head descriptor in driver can be used for the first transfer descriptor.

```
  define link descriptor table in application with macro
  DMA_ALLOCATE_LINK_DESCRIPTOR(nextDesc[3]);

  DMA_SetupDescriptor(nextDesc0,  DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width,
↪ srcInc, dstInc, bytes),
srcStartAddr, dstStartAddr, nextDesc1);
  DMA_SetupDescriptor(nextDesc1,  DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width,
↪ srcInc, dstInc, bytes),
srcStartAddr, dstStartAddr, nextDesc2);
  DMA_SetupDescriptor(nextDesc2,  DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width,
↪ srcInc, dstInc, bytes),
srcStartAddr, dstStartAddr, NULL);
  DMA_SetChannelConfig(base, channel, trigger, isPeriph);
  DMA_CreateHandle(handle, base, channel)
  DMA_SubmitChannelTransferParameter(handle, DMA_CHANNEL_XFER(reload, clrTrig,␣
↪intA, intB, width, srcInc, dstInc,
bytes), srcStartAddr, dstStartAddr, nextDesc0);
  DMA_StartTransfer(handle);
```

Parameters

- handle – Pointer to DMA handle.
- xferCfg – xfer configuration, user can reference DMA_CHANNEL_XFER about to how to get xferCfg value.
- srcStartAddr – source start address.
- dstStartAddr – destination start address.
- nextDesc – address of next descriptor.

void DMA_SubmitChannelDescriptor(*dma_handle_t* *handle, *dma_descriptor_t* *descriptor)

Submit channel descriptor.

This function used to configue channel head descriptor that is used to start DMA transfer, the head descriptor table is defined in DMA driver, this functiono is typical for the ping pong case:

a. for the ping pong case, application should responsible for the descriptor, for example, application should prepare two descriptor table with macro.

```
  define link descriptor table in application with macro
  DMA_ALLOCATE_LINK_DESCRIPTOR(nextDesc[2]);

  DMA_SetupDescriptor(nextDesc0,  DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width,
↪ srcInc, dstInc, bytes),
srcStartAddr, dstStartAddr, nextDesc1);
  DMA_SetupDescriptor(nextDesc1,  DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width,
↪ srcInc, dstInc, bytes),
srcStartAddr, dstStartAddr, nextDesc0);
  DMA_SetChannelConfig(base, channel, trigger, isPeriph);
  DMA_CreateHandle(handle, base, channel)
  DMA_SubmitChannelDescriptor(handle,  nextDesc0);
  DMA_StartTransfer(handle);
```

Parameters

- handle – Pointer to DMA handle.
- descriptor – descriptor to submit.

status_t DMA_SubmitChannelTransfer(*dma_handle_t* *handle, *dma_channel_config_t* *config)

Submits the DMA channel transfer request.

This function submits the DMA transfer request according to the transfer configuration structure. If the user submits the transfer request repeatedly, this function packs an unprocessed request as a TCD and enables scatter/gather feature to process it in the next time. It is used for the case:

a. for the single transfer, application doesn't need to allocate descriptor table, the head descriptor can be used for it.

```
DMA_CreateHandle(handle, base, channel)
DMA_PrepareChannelTransfer(config,srcStartAddr,dstStartAddr,xferCfg,type,trigger,NULL);
DMA_SubmitChannelTransfer(handle, config)
DMA_StartTransfer(handle)
```

b. for the linked transfer, application should responsible for link descriptor, for example, if 4 transfer is required, then application should prepare three descriptor table with macro , the head descriptor in driver can be used for the first transfer descriptor.

```
  define link descriptor table in application with macro
  DMA_ALLOCATE_LINK_DESCRIPTOR(nextDesc);
  DMA_SetupDescriptor(nextDesc0,  DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width,
↪ srcInc, dstInc, bytes),
srcStartAddr, dstStartAddr, nextDesc1);
  DMA_SetupDescriptor(nextDesc1,  DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width,
↪ srcInc, dstInc, bytes),
srcStartAddr, dstStartAddr, nextDesc2);
  DMA_SetupDescriptor(nextDesc2,  DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width,
↪ srcInc, dstInc, bytes),
srcStartAddr, dstStartAddr, NULL);
  DMA_CreateHandle(handle, base, channel)
  DMA_PrepareChannelTransfer(config,srcStartAddr,dstStartAddr,xferCfg,type,trigger,
↪nextDesc0);
  DMA_SubmitChannelTransfer(handle, config)
  DMA_StartTransfer(handle)
```

c. for the ping pong case, application should responsible for link descriptor, for example, application should prepare two descriptor table with macro , the head descriptor in driver can be used for the first transfer descriptor.

```
  define link descriptor table in application with macro
  DMA_ALLOCATE_LINK_DESCRIPTOR(nextDesc);

  DMA_SetupDescriptor(nextDesc0,  DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width,
↪ srcInc, dstInc, bytes),
srcStartAddr, dstStartAddr, nextDesc1);
  DMA_SetupDescriptor(nextDesc1,  DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width,
↪ srcInc, dstInc, bytes),
srcStartAddr, dstStartAddr, nextDesc0);
  DMA_CreateHandle(handle, base, channel)
  DMA_PrepareChannelTransfer(config,srcStartAddr,dstStartAddr,xferCfg,type,trigger,
↪nextDesc0);
  DMA_SubmitChannelTransfer(handle, config)
  DMA_StartTransfer(handle)
```

Parameters

- handle – DMA handle pointer.
- config – Pointer to DMA transfer configuration structure.

Return values

- kStatus_DMA_Success – It means submit transfer request succeed.
- kStatus_DMA_QueueFull – It means TCD queue is full. Submit transfer request is not allowed.
- kStatus_DMA_Busy – It means the given channel is busy, need to submit request later.

void DMA_StartTransfer(*dma_handle_t* *handle)

DMA start transfer.

This function enables the channel request. User can call this function after submitting the transfer request It will trigger transfer start with software trigger only when hardware trigger is not used.

Parameters

- handle – DMA handle pointer.

void DMA_IRQHandle(DMA_Type *base)

DMA IRQ handler for descriptor transfer complete.

This function clears the channel major interrupt flag and call the callback function if it is not NULL.

Parameters

- base – DMA base address.

FSL_DMA_DRIVER_VERSION

DMA driver version.

Version 2.5.3.

_dma_transfer_status DMA transfer status

Values:

enumerator kStatus_DMA_Busy

Channel is busy and can't handle the transfer request.

_dma_addr_interleave_size dma address interleave size

Values:

enumerator kDMA_AddressInterleave0xWidth

dma source/destination address no interleave

enumerator kDMA_AddressInterleave1xWidth

dma source/destination address interleave 1xwidth

enumerator kDMA_AddressInterleave2xWidth

dma source/destination address interleave 2xwidth

enumerator kDMA_AddressInterleave4xWidth

dma source/destination address interleave 3xwidth

_dma_transfer_width dma transfer width

Values:

enumerator kDMA_Transfer8BitWidth

dma channel transfer bit width is 8 bit

enumerator kDMA_Transfer16BitWidth
dma channel transfer bit width is 16 bit

enumerator kDMA_Transfer32BitWidth
dma channel transfer bit width is 32 bit

enum _dma_priority
DMA channel priority.

Values:

enumerator kDMA_ChannelPriority0
Highest channel priority - priority 0

enumerator kDMA_ChannelPriority1
Channel priority 1

enumerator kDMA_ChannelPriority2
Channel priority 2

enumerator kDMA_ChannelPriority3
Channel priority 3

enumerator kDMA_ChannelPriority4
Channel priority 4

enumerator kDMA_ChannelPriority5
Channel priority 5

enumerator kDMA_ChannelPriority6
Channel priority 6

enumerator kDMA_ChannelPriority7
Lowest channel priority - priority 7

enum _dma_int
DMA interrupt flags.

Values:

enumerator kDMA_IntA
DMA interrupt flag A

enumerator kDMA_IntB
DMA interrupt flag B

enumerator kDMA_IntError
DMA interrupt flag error

enum _dma_trigger_type
DMA trigger type.

Values:

enumerator kDMA_NoTrigger
Trigger is disabled

enumerator kDMA_LowLevelTrigger
Low level active trigger

enumerator kDMA_HighLevelTrigger
High level active trigger

enumerator kDMA_FallingEdgeTrigger
Falling edge active trigger

enumerator kDMA_RisingEdgeTrigger
Rising edge active trigger

_dma_burst_size DMA burst size

Values:

enumerator kDMA_BurstSize1
burst size 1 transfer

enumerator kDMA_BurstSize2
burst size 2 transfer

enumerator kDMA_BurstSize4
burst size 4 transfer

enumerator kDMA_BurstSize8
burst size 8 transfer

enumerator kDMA_BurstSize16
burst size 16 transfer

enumerator kDMA_BurstSize32
burst size 32 transfer

enumerator kDMA_BurstSize64
burst size 64 transfer

enumerator kDMA_BurstSize128
burst size 128 transfer

enumerator kDMA_BurstSize256
burst size 256 transfer

enumerator kDMA_BurstSize512
burst size 512 transfer

enumerator kDMA_BurstSize1024
burst size 1024 transfer

enum _dma_trigger_burst
DMA trigger burst.

Values:

enumerator kDMA_SingleTransfer
Single transfer

enumerator kDMA_LevelBurstTransfer
Burst transfer driven by level trigger

enumerator kDMA_EdgeBurstTransfer1
Perform 1 transfer by edge trigger

enumerator kDMA_EdgeBurstTransfer2
Perform 2 transfers by edge trigger

enumerator kDMA_EdgeBurstTransfer4
Perform 4 transfers by edge trigger

enumerator kDMA_EdgeBurstTransfer8
Perform 8 transfers by edge trigger

enumerator kDMA_EdgeBurstTransfer16
Perform 16 transfers by edge trigger

enumerator kDMA_EdgeBurstTransfer32
Perform 32 transfers by edge trigger

enumerator kDMA_EdgeBurstTransfer64
Perform 64 transfers by edge trigger

enumerator kDMA_EdgeBurstTransfer128
Perform 128 transfers by edge trigger

enumerator kDMA_EdgeBurstTransfer256
Perform 256 transfers by edge trigger

enumerator kDMA_EdgeBurstTransfer512
Perform 512 transfers by edge trigger

enumerator kDMA_EdgeBurstTransfer1024
Perform 1024 transfers by edge trigger

enum _dma_burst_wrap
DMA burst wrapping.

Values:

enumerator kDMA_NoWrap
Wrapping is disabled

enumerator kDMA_SrcWrap
Wrapping is enabled for source

enumerator kDMA_DstWrap
Wrapping is enabled for destination

enumerator kDMA_SrcAndDstWrap
Wrapping is enabled for source and destination

enum _dma_transfer_type
DMA transfer type.

Values:

enumerator kDMA_MemoryToMemory
Transfer from memory to memory (increment source and destination)

enumerator kDMA_PeripheralToMemory
Transfer from peripheral to memory (increment only destination)

enumerator kDMA_MemoryToPeripheral
Transfer from memory to peripheral (increment only source)

enumerator kDMA_StaticToStatic
Peripheral to static memory (do not increment source or destination)

typedef struct *_dma_descriptor* dma_descriptor_t
DMA descriptor structure.

typedef struct *_dma_xfercfg* dma_xfercfg_t
DMA transfer configuration.

typedef enum *_dma_priority* dma_priority_t
DMA channel priority.

typedef enum *_dma_int* dma_irq_t
DMA interrupt flags.

typedef enum *_dma_trigger_type* dma_trigger_type_t
DMA trigger type.

typedef enum *_dma_trigger_burst* dma_trigger_burst_t
DMA trigger burst.

typedef enum *_dma_burst_wrap* dma_burst_wrap_t
DMA burst wrapping.

typedef enum *_dma_transfer_type* dma_transfer_type_t
DMA transfer type.

typedef struct *_dma_channel_trigger* dma_channel_trigger_t
DMA channel trigger.

typedef struct *_dma_channel_config* dma_channel_config_t
DMA channel trigger.

typedef struct *_dma_transfer_config* dma_transfer_config_t
DMA transfer configuration.

typedef void (*dma_callback)(struct *_dma_handle* *handle, void *userData, bool transferDone, uint32_t intmode)
Define Callback function for DMA.

typedef struct *_dma_handle* dma_handle_t
DMA transfer handle structure.

DMA_MAX_TRANSFER_COUNT
DMA max transfer size.

FSL_FEATURE_DMA_LINK_DESCRIPTOR_ALIGN_SIZE
DMA channel numbers.

DMA head link descriptor table align size

DMA_ALLOCATE_HEAD_DESCRIPTORS(name, number)
DMA head descriptor table allocate macro To simplify user interface, this macro will help allocate descriptor memory, user just need to provide the name and the number for the allocate descriptor.

Parameters

- name – Allocate decriptor name.
- number – Number of descriptor to be allocated.

DMA_ALLOCATE_HEAD_DESCRIPTORS_AT_NONCACHEABLE(name, number)
DMA head descriptor table allocate macro at noncacheable section To simplify user interface, this macro will help allocate descriptor memory at noncacheable section, user just need to provide the name and the number for the allocate descriptor.

Parameters

- name – Allocate decriptor name.
- number – Number of descriptor to be allocated.

DMA_ALLOCATE_LINK_DESCRIPTORS(name, number)

DMA link descriptor table allocate macro To simplify user interface, this macro will help allocate descriptor memory, user just need to provide the name and the number for the allocate descriptor.

Parameters

- name – Allocate decriptor name.
- number – Number of descriptor to be allocated.

DMA_ALLOCATE_LINK_DESCRIPTORS_AT_NONCACHEABLE(name, number)

DMA link descriptor table allocate macro at noncacheable section To simplify user interface, this macro will help allocate descriptor memory at noncacheable section, user just need to provide the name and the number for the allocate descriptor.

Parameters

- name – Allocate decriptor name.
- number – Number of descriptor to be allocated.

DMA_ALLOCATE_DATA_TRANSFER_BUFFER(name, width)

DMA transfer buffer address need to align with the transfer width.

DMA_CHANNEL_GROUP(channel)

DMA_CHANNEL_INDEX(base, channel)

DMA_COMMON_REG_GET(base, channel, reg)

DMA linked descriptor address algin size.

DMA_COMMON_CONST_REG_GET(base, channel, reg)

DMA_COMMON_REG_SET(base, channel, reg, value)

DMA_DESCRIPTOR_END_ADDRESS(start, inc, bytes, width)

DMA descriptor end address calculate.

Parameters

- start – start address
- inc – address interleave size
- bytes – transfer bytes
- width – transfer width

DMA_CHANNEL_XFER(reload, clrTrig, intA, intB, width, srcInc, dstInc, bytes)

struct _dma_descriptor

#include <fsl_dma.h> DMA descriptor structure.

Public Members

volatile uint32_t xfercfg

Transfer configuration

void *srcEndAddr

Last source address of DMA transfer

void *dstEndAddr

Last destination address of DMA transfer

void *linkToNextDesc
Address of next DMA descriptor in chain

struct _dma_xfercfg
#include <fsl_dma.h> DMA transfer configuration.

Public Members

bool valid
Descriptor is ready to transfer

bool reload
Reload channel configuration register after current descriptor is exhausted

bool swtrig
Perform software trigger. Transfer if fired when 'valid' is set

bool clrtrig
Clear trigger

bool intA
Raises IRQ when transfer is done and set IRQA status register flag

bool intB
Raises IRQ when transfer is done and set IRQB status register flag

uint8_t byteWidth
Byte width of data to transfer

uint8_t srcInc
Increment source address by 'srcInc' x 'byteWidth'

uint8_t dstInc
Increment destination address by 'dstInc' x 'byteWidth'

uint16_t transferCount
Number of transfers

struct _dma_channel_trigger
#include <fsl_dma.h> DMA channel trigger.

Public Members

dma_trigger_type_t type
Select hardware trigger as edge triggered or level triggered.

dma_trigger_burst_t burst
Select whether hardware triggers cause a single or burst transfer.

dma_burst_wrap_t wrap
Select wrap type, source wrap or dest wrap, or both.

struct _dma_channel_config
#include <fsl_dma.h> DMA channel trigger.

Public Members

void *srcStartAddr
: Source data address

void *dstStartAddr
: Destination data address

void *nextDesc
: Chain custom descriptor

uint32_t xferCfg
: channel transfer configurations

dma_channel_trigger_t *trigger
: DMA trigger type

bool isPeriph
: select the request type

struct __dma__transfer__config
: *#include <fsl_dma.h>* DMA transfer configuration.

Public Members

uint8_t *srcAddr
: Source data address

uint8_t *dstAddr
: Destination data address

uint8_t *nextDesc
: Chain custom descriptor

dma_xfercfg_t xfercfg
: Transfer options

bool isPeriph
: DMA transfer is driven by peripheral

struct __dma__handle
: *#include <fsl_dma.h>* DMA transfer handle structure.

Public Members

dma_callback callback
: Callback function. Invoked when transfer of descriptor with interrupt flag finishes

void *userData
: Callback function parameter

DMA_Type *base
: DMA peripheral base address

uint8_t channel
: DMA channel number

2.10 DMIC: Digital Microphone

2.11 DMIC DMA Driver

status_t DMIC_TransferCreateHandleDMA(DMIC_Type *base, *dmic_dma_handle_t* *handle, *dmic_dma_transfer_callback_t* callback, void *userData, *dma_handle_t* *rxDmaHandle)

Initializes the DMIC handle which is used in transactional functions.

Parameters

- base – DMIC peripheral base address.
- handle – Pointer to dmic_dma_handle_t structure.
- callback – Callback function.
- userData – User data.
- rxDmaHandle – User-requested DMA handle for RX DMA transfer.

status_t DMIC_TransferReceiveDMA(DMIC_Type *base, *dmic_dma_handle_t* *handle, *dmic_transfer_t* *xfer, uint32_t channel)

Receives data using DMA.

This function receives data using DMA. This is a non-blocking function, which returns right away. When all data is received, the receive callback function is called.

Parameters

- base – USART peripheral base address.
- handle – Pointer to usart_dma_handle_t structure.
- xfer – DMIC DMA transfer structure. See dmic_transfer_t.
- channel – DMIC start channel number.

Return values

kStatus_Success –

void DMIC_TransferAbortReceiveDMA(DMIC_Type *base, *dmic_dma_handle_t* *handle)

Aborts the received data using DMA.

This function aborts the received data using DMA.

Parameters

- base – DMIC peripheral base address
- handle – Pointer to dmic_dma_handle_t structure

status_t DMIC_TransferGetReceiveCountDMA(DMIC_Type *base, *dmic_dma_handle_t* *handle, uint32_t *count)

Get the number of bytes that have been received.

This function gets the number of bytes that have been received.

Parameters

- base – DMIC peripheral base address.
- handle – DMIC 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 DMIC_InstallDMADescriptorMemory(*dmic_dma_handle_t* *handle, void *linkAddr, size_t linkNum)

Install DMA descriptor memory.

This function used to register DMA descriptor memory for linked transfer, a typical case is ping pong transfer which will request more than one DMA descriptor memory space, it should be called after DMIC_TransferCreateHandleDMA. User should be take care about the address of DMA descriptor pool which required align with 16BYTE at least.

Parameters

- handle – Pointer to DMA channel transfer handle.
- linkAddr – DMA link descriptor address.
- linkNum – DMA link descriptor number.

FSL_DMIC_DMA_DRIVER_VERSION

DMIC DMA driver version 2.4.1.

typedef struct *_dmic_transfer* dmic_transfer_t

DMIC transfer structure.

typedef struct *_dmic_dma_handle* dmic_dma_handle_t

typedef void (*dmic_dma_transfer_callback_t)(DMIC_Type *base, *dmic_dma_handle_t* *handle, *status_t* status, void *userData)

DMIC transfer callback function.

struct _dmic_transfer

#include <fsl_dmic_dma.h> DMIC transfer structure.

Public Members

void *data

The buffer of data to be transfer.

uint8_t dataWidth

DMIC support 16bit/32bit

size_t dataSize

The byte count to be transfer.

uint8_t dataAddrInterleaveSize

destination address interleave size

struct *_dmic_transfer* *linkTransfer

use to support link transfer

struct _dmic_dma_handle

#include <fsl_dmic_dma.h> DMIC DMA handle.

Public Members

DMIC_Type *base

DMIC peripheral base address.

dma_handle_t *rxDmaHandle
The DMA RX channel used.

dmic_dma_transfer_callback_t callback
Callback function.

void *userData
DMIC callback function parameter.

size_t transferSize
Size of the data to receive.

volatile uint8_t state
Internal state of DMIC DMA transfer

uint32_t channel
DMIC channel used.

bool isChannelValid
DMIC channel initialization flag

dma_descriptor_t *desLink
descriptor pool pointer

size_t linkNum
number of descriptor in descriptors pool

2.12 DMIC Driver

uint32_t DMIC_GetInstance(DMIC_Type *base)
Get the DMIC instance from peripheral base address.

Parameters

- base – DMIC peripheral base address.

Returns
DMIC instance.

void DMIC_Init(DMIC_Type *base)
Turns DMIC Clock on.

Parameters

- base – : DMIC base

Returns
Nothing

void DMIC_DeInit(DMIC_Type *base)
Turns DMIC Clock off.

Parameters

- base – : DMIC base

Returns
Nothing

void DMIC_SetOperationMode(DMIC_Type *base, *operation_mode_t* mode)
Set DMIC operating mode.

Deprecated:

Do not use this function. It has been superceded by DMIC_EnableChannelInterrupt, DMIC_EnableChannelDma.

Parameters

- base – : The base address of DMIC interface
- mode – : DMIC mode

Returns

Nothing

void DMIC_Use2fs(DMIC_Type *base, bool use2fs)

Configure Clock scaling.

Parameters

- base – : The base address of DMIC interface
- use2fs – : clock scaling

Returns

Nothing

void DMIC_CfgChannelDc(DMIC_Type *base, *dmic_channel_t* channel, *dc_removal_t* dc_cut_level, uint32_t post_dc_gain_reduce, bool saturate16bit)

Configure DMIC channel.

Parameters

- base – : The base address of DMIC interface
- channel – : DMIC channel
- dc_cut_level – : dc_removal_t, Cut off Frequency
- post_dc_gain_reduce – : Fine gain adjustment in the form of a number of bits to downshift.
- saturate16bit – : If selects 16-bit saturation.

static inline void DMIC_EnableChannelSignExtend(DMIC_Type *base, *dmic_channel_t* channel, bool enable)

Enbale channel sign extend which allows processing of 24bit audio data on 32bit machines.

Parameters

- base – : The base address of DMIC interface
- channel – : DMIC channel
- enable – : true is enable sign extend, false is disable sign extend

void DMIC_ConfigChannel(DMIC_Type *base, *dmic_channel_t* channel, *stereo_side_t* side, *dmic_channel_config_t* *channel_config)

Configure DMIC channel.

Parameters

- base – : The base address of DMIC interface
- channel – : DMIC channel
- side – : stereo_side_t, choice of left or right
- channel_config – : Channel configuration

Returns

Nothing

void DMIC_EnableChannnel(DMIC_Type *base, uint32_t channelmask)

Enable a particualr channel.

Parameters

- base – : The base address of DMIC interface
- channelmask – reference _dmic_channel_mask

Returns

Nothing

void DMIC_FifoChannel(DMIC_Type *base, uint32_t channel, uint32_t trig_level, uint32_t enable, uint32_t resetn)

Configure fifo settings for DMIC channel.

Parameters

- base – : The base address of DMIC interface
- channel – : DMIC channel
- trig_level – : FIFO trigger level
- enable – : FIFO level
- resetn – : FIFO reset

Returns

Nothing

static inline void DMIC_EnableChannelInterrupt(DMIC_Type *base, *dmic_channel_t* channel, bool enable)

Enable a particualr channel interrupt request.

Parameters

- base – : The base address of DMIC interface
- channel – : Channel selection
- enable – : true is enable, false is disable

static inline void DMIC_EnableChannelDma(DMIC_Type *base, *dmic_channel_t* channel, bool enable)

Enable a particualr channel dma request.

Parameters

- base – : The base address of DMIC interface
- channel – : Channel selection
- enable – : true is enable, false is disable

static inline void DMIC_EnableChannelFifo(DMIC_Type *base, *dmic_channel_t* channel, bool enable)

Enable a particualr channel fifo.

Parameters

- base – : The base address of DMIC interface
- channel – : Channel selection
- enable – : true is enable, false is disable

static inline void DMIC_DoFifoReset(DMIC_Type *base, *dmic_channel_t* channel)

Channel fifo reset.

Parameters

- base – : The base address of DMIC interface
- channel – : Channel selection

static inline uint32_t DMIC_FifoGetStatus(DMIC_Type *base, uint32_t channel)

Get FIFO status.

Parameters

- base – : The base address of DMIC interface
- channel – : DMIC channel

Returns

FIFO status

static inline void DMIC_FifoClearStatus(DMIC_Type *base, uint32_t channel, uint32_t mask)

Clear FIFO status.

Parameters

- base – : The base address of DMIC interface
- channel – : DMIC channel
- mask – : Bits to be cleared

Returns

FIFO status

static inline uint32_t DMIC_FifoGetData(DMIC_Type *base, uint32_t channel)

Get FIFO data.

Parameters

- base – : The base address of DMIC interface
- channel – : DMIC channel

Returns

FIFO data

static inline uint32_t DMIC_FifoGetAddress(DMIC_Type *base, uint32_t channel)

Get FIFO address.

Parameters

- base – : The base address of DMIC interface
- channel – : DMIC channel

Returns

FIFO data

void DMIC_ResetChannelDecimator(DMIC_Type *base, uint32_t channelMask, bool reset)

DMIC channel Decimator reset.

Parameters

- base – : The base address of DMIC interface
- channelMask – : DMIC channel mask, reference _dmic_channel_mask
- reset – : true is reset decimator, false is release decimator.

static inline void DMIC_EnableChannelGlobalSync(DMIC_Type *base, uint32_t channelMask, uint32_t syncCounter)

Enable DMIC channel global sync function.

Parameters

- base – : The base address of DMIC interface
- channelMask – : DMIC channel mask, reference _dmic_channel_mask
- syncCounter – :sync counter will trigger a pulse whenever count reaches CCOUNTVAL. If CCOUNTVAL is set to 0, there will be a pulse on every cycle

static inline void DMIC_DisableChannelGlobalSync(DMIC_Type *base, uint32_t channelMask)

Disbale DMIC channel global sync function.

Parameters

- base – : The base address of DMIC interface
- channelMask – : DMIC channel mask, reference _dmic_channel_mask

void DMIC_EnableIntCallback(DMIC_Type *base, *dmic_callback_t* cb)

Enable callback.

This function enables the interrupt for the selected DMIC peripheral. The callback function is not enabled until this function is called.

Parameters

- base – Base address of the DMIC peripheral.
- cb – callback Pointer to store callback function.

Return values

None. –

void DMIC_DisableIntCallback(DMIC_Type *base, *dmic_callback_t* cb)

Disable callback.

This function disables the interrupt for the selected DMIC peripheral.

Parameters

- base – Base address of the DMIC peripheral.
- cb – callback Pointer to store callback function..

Return values

None. –

static inline void DMIC_SetGainNoiseEstHwvad(DMIC_Type *base, uint32_t value)

Sets the gain value for the noise estimator.

Parameters

- base – DMIC base pointer
- value – gain value for the noise estimator.

Return values

None. –

static inline void DMIC_SetGainSignalEstHwvad(DMIC_Type *base, uint32_t value)

Sets the gain value for the signal estimator.

Parameters

- base – DMIC base pointer
- value – gain value for the signal estimator.

Return values
None. –

static inline void DMIC_SetFilterCtrlHwvad(DMIC_Type *base, uint32_t value)

Sets the hwvad filter cutoff frequency parameter.

Parameters

- base – DMIC base pointer
- value – cut off frequency value.

Return values
None. –

static inline void DMIC_SetInputGainHwvad(DMIC_Type *base, uint32_t value)

Sets the input gain of hwvad.

Parameters

- base – DMIC base pointer
- value – input gain value for hwvad.

Return values
None. –

static inline void DMIC_CtrlClrIntrHwvad(DMIC_Type *base, bool st10)

Clears hwvad internal interrupt flag.

Parameters

- base – DMIC base pointer
- st10 – bit value.

Return values
None. –

static inline void DMIC_FilterResetHwvad(DMIC_Type *base, bool rstt)

Resets hwvad filters.

Parameters

- base – DMIC base pointer
- rstt – Reset bit value.

Return values
None. –

static inline uint16_t DMIC_GetNoiseEnvlpEst(DMIC_Type *base)

Gets the value from output of the filter z7.

Parameters

- base – DMIC base pointer

Return values
output – of filter z7.

void DMIC_HwvadEnableIntCallback(DMIC_Type *base, *dmic_hwvad_callback_t* vadcb)

Enable hwvad callback.

This function enables the hwvad interrupt for the selected DMIC peripheral. The callback function is not enabled until this function is called.

Parameters

- base – Base address of the DMIC peripheral.

- vadcb – callback Pointer to store callback function.

Return values
None. –

void DMIC_HwvadDisableIntCallback(DMIC_Type *base, *dmic_hwvad_callback_t* vadcb)

Disable callback.

This function disables the hwvad interrupt for the selected DMIC peripheral.

Parameters

- base – Base address of the DMIC peripheral.
- vadcb – callback Pointer to store callback function..

Return values
None. –

FSL_DMIC_DRIVER_VERSION

DMIC driver version 2.3.3.

_dmic_status DMIC transfer status.

Values:

enumerator kStatus_DMIC_Busy
DMIC is busy

enumerator kStatus_DMIC_Idle
DMIC is idle

enumerator kStatus_DMIC_OverRunError
DMIC over run Error

enumerator kStatus_DMIC_UnderRunError
DMIC under run Error

enum _operation_mode

DMIC different operation modes.

Values:

enumerator kDMIC_OperationModeInterrupt
Interrupt mode

enumerator kDMIC_OperationModeDma
DMA mode

enum _stereo_side

DMIC left/right values.

Values:

enumerator kDMIC_Left
Left Stereo channel

enumerator kDMIC_Right
Right Stereo channel

enum pdm_div_t

DMIC Clock pre-divider values.

Values:

enumerator kDMIC_PdmDiv1
DMIC pre-divider set in divide by 1

enumerator kDMIC_PdmDiv2
DMIC pre-divider set in divide by 2

enumerator kDMIC_PdmDiv3
DMIC pre-divider set in divide by 3

enumerator kDMIC_PdmDiv4
DMIC pre-divider set in divide by 4

enumerator kDMIC_PdmDiv6
DMIC pre-divider set in divide by 6

enumerator kDMIC_PdmDiv8
DMIC pre-divider set in divide by 8

enumerator kDMIC_PdmDiv12
DMIC pre-divider set in divide by 12

enumerator kDMIC_PdmDiv16
DMIC pre-divider set in divide by 16

enumerator kDMIC_PdmDiv24
DMIC pre-divider set in divide by 24

enumerator kDMIC_PdmDiv32
DMIC pre-divider set in divide by 32

enumerator kDMIC_PdmDiv48
DMIC pre-divider set in divide by 48

enumerator kDMIC_PdmDiv64
DMIC pre-divider set in divide by 64

enumerator kDMIC_PdmDiv96
DMIC pre-divider set in divide by 96

enumerator kDMIC_PdmDiv128
DMIC pre-divider set in divide by 128

enum _compensation
Pre-emphasis Filter coefficient value for 2FS and 4FS modes.

Values:

enumerator kDMIC_CompValueZero
Compensation 0

enumerator kDMIC_CompValueNegativePoint16
Compensation -0.16

enumerator kDMIC_CompValueNegativePoint15
Compensation -0.15

enumerator kDMIC_CompValueNegativePoint13
Compensation -0.13

enum _dc_removal
DMIC DC filter control values.

Values:

enumerator kDMIC_DcNoRemove
Flat response no filter

enumerator kDMIC_DcCut155
Cut off Frequency is 155 Hz

enumerator kDMIC_DcCut78
Cut off Frequency is 78 Hz

enumerator kDMIC_DcCut39
Cut off Frequency is 39 Hz

enum _dmic_channel
DMIC Channel number.

Values:

enumerator kDMIC_Channel0
DMIC channel 0

enumerator kDMIC_Channel1
DMIC channel 1

enumerator kDMIC_ChannelMAX
Maximum number of DMIC channels

_dmic_channel_mask DMIC Channel mask.

Values:

enumerator kDMIC_EnableChannel0
DMIC channel 0 mask

enumerator kDMIC_EnableChannel1
DMIC channel 1 mask

enum _dmic_phy_sample_rate
DMIC and decimator sample rates.

Values:

enumerator kDMIC_PhyFullSpeed
Decimator gets one sample per each chosen clock edge of PDM interface

enumerator kDMIC_PhyHalfSpeed
PDM clock to Microphone is halved, decimator receives each sample twice

typedef enum *_operation_mode* operation_mode_t
DMIC different operation modes.

typedef enum *_stereo_side* stereo_side_t
DMIC left/right values.

typedef enum *_compensation* compensation_t
Pre-emphasis Filter coefficient value for 2FS and 4FS modes.

typedef enum *_dc_removal* dc_removal_t
DMIC DC filter control values.

typedef enum *_dmic_channel* dmic_channel_t
DMIC Channel number.

typedef enum *_dmic_phy_sample_rate* dmic_phy_sample_rate_t
DMIC and decimator sample rates.

typedef struct *_dmic_channel_config* dmic_channel_config_t
DMIC Channel configuration structure.

typedef void (*dmic_callback_t)(void)
DMIC Callback function.

typedef void (*dmic_hwvad_callback_t)(void)
HWVAD Callback function.

struct _dmic_channel_config
#include <fsl_dmic.h> DMIC Channel configuration structure.

Public Members

pdm_div_t divhfclk
DMIC Clock pre-divider values

uint32_t osr
oversampling rate(CIC decimation rate) for PCM

uint32_t gainshft
4FS PCM data gain control

compensation_t preac2coef
Pre-emphasis Filter coefficient value for 2FS

compensation_t preac4coef
Pre-emphasis Filter coefficient value for 4FS

dc_removal_t dc_cut_level
DMIC DC filter control values.

uint32_t post_dc_gain_reduce
Fine gain adjustment in the form of a number of bits to downshift

dmic_phy_sample_rate_t sample_rate
DMIC and decimator sample rates

bool saturate16bit
Selects 16-bit saturation. 0 means results roll over if out range and do not saturate. 1 means if the result overflows, it saturates at 0xFFFF for positive overflow and 0x8000 for negative overflow.

bool enableSignExtend
sign extend feature which allows processing of 24bit audio data on 32bit machine

2.13 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_ResetHardware(void)

Resets the ENET hardware.

This function resets ENET related resources in the hardware.

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 dulpex 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_QUEUEn(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_GetRxFrameSize(*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_GetRxFrameSize, 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_GetRxFrameSize 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_GetRxFrameSize(&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 isEnable, 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.
- isEnable – 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 interupt 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 ceil(max_frame_length(set by RCR) / bd_rx_size(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 finishs.
- 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_LENVLIOLATE_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_SOFTOWENER1_MASK
: Software owner one mask.

ENET_BUFFDESCRIPTOR_TX_WRAP_MASK
: Wrap buffer descriptor mask.

ENET_BUFFDESCRIPTOR_TX_SOFTOWENER2_MASK
: Software owner two mask.

ENET_BUFFDESCRIPTOR_TX_LAST_MASK
: Last BD of the frame mask.

ENET_BUFFDESCRIPTOR_TX_TRANMITCRC_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 « 12) | (CMP2 « 8) | (CMP1 « 4) | 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 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_FULL and the maximum is

0xFF. If the end of the frame is stored in FIFO and the frame size if 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 decrese 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 « 12) | (CMP2 « 8) | (CMP1 « 4) | 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 fraction = 1 / (1 + 512/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 if 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 decrese 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 coalsecence 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

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.

2.14 FLEXCOMM: FLEXCOMM Driver

2.15 FLEXCOMM Driver

FSL_FLEXCOMM_DRIVER_VERSION
FlexCOMM driver version 2.0.2.

enum FLEXCOMM_PERIPH_T
FLEXCOMM peripheral modes.

Values:

enumerator FLEXCOMM_PERIPH_NONE
No peripheral

enumerator FLEXCOMM_PERIPH_USART
USART peripheral

enumerator FLEXCOMM_PERIPH_SPI
SPI Peripheral

enumerator FLEXCOMM_PERIPH_I2C
I2C Peripheral

enumerator FLEXCOMM_PERIPH_I2S_TX
I2S TX Peripheral

enumerator FLEXCOMM_PERIPH_I2S_RX
I2S RX Peripheral

typedef void (*flexcomm_irq_handler_t)(void *base, void *handle)
Typedef for interrupt handler.

IRQn_Type const kFlexcommIrqs[]
Array with IRQ number for each FLEXCOMM module.

uint32_t FLEXCOMM_GetInstance(void *base)
Returns instance number for FLEXCOMM module with given base address.

status_t FLEXCOMM_Init(void *base, *FLEXCOMM_PERIPH_T* periph)
Initializes FLEXCOMM and selects peripheral mode according to the second parameter.

void FLEXCOMM_SetIRQHandler(void *base, *flexcomm_irq_handler_t* handler, void *flexcommHandle)
Sets IRQ handler for given FLEXCOMM module. It is used by drivers register IRQ handler according to FLEXCOMM mode.

2.16 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 void FLEXSPI_GetDataLearningPhase(FLEXSPI_Type *base, uint8_t *portAPhase, uint8_t *portBPhase)

Gets the sampling clock phase selection after Data Learning.

Parameters

- base – FLEXSPI peripheral base address.
- portAPhase – Pointer to a uint8_t type variable to receive the selected clock phase on PORTA.
- portBPhase – Pointer to a uint8_t type variable to receive the selected clock phase on PORTB.

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 sequencen 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_AhbBusTimeoutFlag
AHB Bus timeout.

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_DataLearningFailedFlag
Data learning failed.

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_PortB1
Access flash on B1 port.

enumerator kFLEXSPI_PortB2
Access flash on B2 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 enableCombination
Enable/disable combining PORT A and B Data Pins (SIOA[3:0] and SIOB[3:0]) to support Flash Octal mode.

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 enableSckBDiffOpt
Enable/disable SCKB pad use as SCKA differential clock output, when enable, Port B flash access is not available.

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 ahbGrantTimeoutCyle*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.

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 ahbGrantTimeoutCyle*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.

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.

2.17 FLEXSPI DMA Driver

void FLEXSPI_TransferCreateHandleDMA(FLEXSPI_Type *base, *flexspi_dma_handle_t* *handle, *flexspi_dma_callback_t* callback, void *userData, *dma_handle_t* *txDmaHandle, *dma_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_dma_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_TransferUpdateSizeDMA(FLEXSPI_Type *base, *flexspi_dma_handle_t* *handle, *flexspi_dma_transfer_nsize_t* nsize)

Update FLEXSPI DMA transfer source data transfer size(SSIZE) and destination data transfer size(DSIZE).

See also:

flexspi_dma_transfer_nsize_t .

Parameters

- base – FLEXSPI peripheral base address
- handle – Pointer to flexspi_dma_handle_t structure
- nsize – FLEXSPI DMA transfer data transfer size(SSIZE/DSIZE), by default the size is kFLEXPSI_DMAnSize1Bytes(one byte).

status_t FLEXSPI_TransferDMA(FLEXSPI_Type *base, *flexspi_dma_handle_t* *handle, *flexspi_transfer_t* *xfer)

Transfers FLEXSPI data using an dma 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_dma_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 DMA transfer.
- kStatus_Success – FLEXSPI successfully start dma transfer.

void FLEXSPI_TransferAbortDMA(FLEXSPI_Type *base, *flexspi_dma_handle_t* *handle)

Aborts the transfer data using dma.

This function aborts the transfer data using dma.

Parameters

- base – FLEXSPI peripheral base address.
- handle – Pointer to flexspi_dma_handle_t structure

status_t FLEXSPI_TransferGetTransferCountDMA(FLEXSPI_Type *base, *flexspi_dma_handle_t* *handle, size_t *count)

Gets the transferred counts of transfer.

Parameters

- base – FLEXSPI peripheral base address.
- handle – Pointer to flexspi_dma_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_DMA_DRIVER_VERSION

FLEXSPI DMA driver version 2.2.1.

enum _flexspi_dma_ntransfer_size

dma transfer configuration

Values:

enumerator kFLEXPSI_DMAnSize1Bytes

Source/Destination data transfer size is 1 byte every time

enumerator kFLEXPSI_DMAnSize2Bytes

Source/Destination data transfer size is 2 bytes every time

enumerator kFLEXPSI_DMAnSize4Bytes

Source/Destination data transfer size is 4 bytes every time

typedef struct *_flexspi_dma_handle* flexspi_dma_handle_t

typedef void (*flexspi_dma_callback_t)(FLEXSPI_Type *base, *flexspi_dma_handle_t* *handle, *status_t* status, void *userData)

FLEXSPI dma transfer callback function for finish and error.

typedef enum *_flexspi_dma_ntransfer_size* flexspi_dma_transfer_nsize_t

dma transfer configuration

struct _flexspi_dma_handle

#include <fsl_flexspi_dma.h> FLEXSPI DMA transfer handle, users should not touch the content of the handle.

Public Members

dma_handle_t *txDmaHandle

dma handler for FLEXSPI Tx.

dma_handle_t *rxDmaHandle

dma handler for FLEXSPI Rx.

size_t transferSize

Bytes need to transfer.

flexspi_dma_transfer_nsize_t nsize

dma SSIZE/DSIZE in each transfer.

uint8_t nbytes

dma minor byte transfer count initially configured.

uint8_t count

The transfer data count in a DMA request.

uint32_t state

Internal state for FLEXSPI dma transfer.

flexspi_dma_callback_t completionCallback

A callback function called after the dma transfer is finished.

void *userData
User callback parameter

2.18 FMEAS: Frequency Measure Driver

static inline void FMEAS_StartMeasure(*FMEAS_SYSCON_Type* *base)
Starts a frequency measurement cycle.

Parameters

- base – : SYSCON peripheral base address.

static inline bool FMEAS_IsMeasureComplete(*FMEAS_SYSCON_Type* *base)
Indicates when a frequency measurement cycle is complete.

Parameters

- base – : SYSCON peripheral base address.

Returns
true if a measurement cycle is active, otherwise false.

uint32_t FMEAS_GetFrequency(*FMEAS_SYSCON_Type* *base, uint32_t refClockRate)
Returns the computed value for a frequency measurement cycle.

Parameters

- base – : SYSCON peripheral base address.
- refClockRate – : Reference clock rate used during the frequency measurement cycle.

Returns
Frequency in Hz.

FSL_FMEAS_DRIVER_VERSION
Defines LPC Frequency Measure driver version 2.1.1.

typedef FREQME_Type FMEAS_SYSCON_Type

FMEAS_SYSCON_FREQMECTRL_CAPVAL_MASK

FMEAS_SYSCON_FREQMECTRL_CAPVAL_SHIFT

FMEAS_SYSCON_FREQMECTRL_CAPVAL

FMEAS_SYSCON_FREQMECTRL_PROG_MASK

FMEAS_SYSCON_FREQMECTRL_PROG_SHIFT

FMEAS_SYSCON_FREQMECTRL_PROG

2.19 GDMA: General DMA(GDMA) Driver

void GDMA_Init(GDMA_Type *base)
Initializes GDMA peripheral.

It ungates the GDMA access clock, after this function, the GDMA module is ready to be used.

Parameters

- base – GDMA peripheral base address.

void GDMA_Deinit(GDMA_Type *base)

Deinitializes GDMA peripheral.

Parameters

- base – GDMA peripheral base address.

static inline void GDMA_SetChannelSourceAddress(GDMA_Type *base, uint8_t channel, uint32_t addr)

Set GDMA channel source address.

Parameters

- base – GDMA peripheral base address.
- channel – GDMA channel number.
- addr – Source address.

static inline void GDMA_SetChannelDestAddress(GDMA_Type *base, uint8_t channel, uint32_t addr)

Set GDMA channel destination address.

Parameters

- base – GDMA peripheral base address.
- channel – GDMA channel number.
- addr – Destination address.

static inline void GDMA_StartChannel(GDMA_Type *base, uint8_t channel)

Start GDMA channel to work.

Parameters

- base – GDMA peripheral base address.
- channel – GDMA channel number.

static inline void GDMA_StopChannel(GDMA_Type *base, uint8_t channel)

Stop GDMA channel.

Parameters

- base – GDMA peripheral base address.
- channel – GDMA channel number.

static inline bool GDMA_IsChannelBusy(GDMA_Type *base, uint8_t channel)

Return whether GDMA channel is processing transfer.

When GDMA_StopChannel is called, if the channel is on service, it does not stop immediately, application could call this API to check whether the channel is stopped.

Parameters

- base – GDMA peripheral base address.
- channel – GDMA channel number.

Returns

True if the channel is busy, false if not.

static inline void GDMA_EnableChannelInterrupts(GDMA_Type *base, uint8_t channel, uint32_t interrupts)

Enables the interrupt for the GDMA transfer.

Parameters

- base – GDMA peripheral base address.

- channel – GDMA channel number.
- interrupts – The interrupts to enable, it is OR'ed value of _gdma_interrupt_enable.

static inline void GDMA_DisableChannelInterrupts(GDMA_Type *base, uint8_t channel, uint32_t interrupts)

Disables the interrupt for the GDMA transfer.

Parameters

- base – GDMA peripheral base address.
- channel – GDMA channel number.
- interrupts – The interrupts to disable, it is OR'ed value of _gdma_interrupt_enable.

static inline uint32_t GDMA_GetChannelInterruptFlags(GDMA_Type *base, uint8_t channel)

Get the GDMA channel interrupt flags.

Parameters

- base – GDMA peripheral base address.
- channel – GDMA channel number.

Returns

The interrupt flags, it is OR'ed value of _gdma_interrupt_flags.

static inline void GDMA_ClearChannelInterruptFlags(GDMA_Type *base, uint8_t channel, uint32_t flags)

Clear the GDMA channel interrupt flags.

The kGDMA_ChannelInterruptFlag is OR'ed status of all other unmasked interrupt flags, it could not be clear directly, it should be cleared by clear all other flags.

Parameters

- base – GDMA peripheral base address.
- channel – GDMA channel number.
- flags – The interrupt flags to clear, it is OR'ed value of _gdma_interrupt_flags.

static inline uint32_t GDMA_GetChannelFinishedDescriptorNumber(GDMA_Type *base, uint8_t channel)

Get the number of finished descriptor.

The counter increases when an item of descriptor is done in linklist mode.

Parameters

- base – GDMA peripheral base address.
- channel – GDMA channel number.

Returns

Number of finished descriptor.

static inline void GDMA_ClearChannelFinishedDescriptorNumber(GDMA_Type *base, uint8_t channel)

Clear the number of finished descriptor.

Parameters

- base – GDMA peripheral base address.
- channel – GDMA channel number.

static inline void GDMA_SetChannelPriority(GDMA_Type *base, uint8_t channel, *gdma_priority_t* priority)

Set priority of channel.

Parameters

- base – GDMA peripheral base address.
- channel – GDMA channel number.
- priority – Channel priority value.

status_t GDMA_SetChannelTransferConfig(GDMA_Type *base, uint8_t channel, const *gdma_channel_xfer_config_t* *config)

Set channel transfer configuration..

This function configures the channel transfer, after configured, GDMA_StartChannel could be called to start the transfer.

This function must be called when previous transfer finished. Application can use GDMA_IsChannelBusy to check whether the channel has finished the previous work.

Note: The transfer configuration must follow the requirements:

- SRCBSIZE * SRCWIDTH == DESTBSIZE * DESTWIDTH
- If wrap not used, the address should align with WIDTH
- If wrap used, the address should align with WIDTH * BURST_SIZE.

Parameters

- base – GDMA base address.
- channel – GDMA channel number. @config Pointer to the transfer configuration.

Return values

- kStatus_Fail – GDMA is busy with previous transfer.
- kStatus_Success – Configuration set successfully.
- kStatus_InvalidArgument – Configuration wrong.

void GDMA_CreateHandle(*gdma_handle_t* *handle, GDMA_Type *base, uint8_t channel)

Creates the GDMA handle.

This function is called if using transaction API for GDMA. This function initializes the internal state of GDMA handle.

Parameters

- handle – GDMA handle pointer. It stores callback function and parameters.
- base – GDMA peripheral base address.
- channel – GDMA channel number.

void GDMA_SetCallback(*gdma_handle_t* *handle, *gdma_callback_t* callback, void *userData)

Installs a callback function for the GDMA transfer.

This callback is called in GDMA IRQ handler to inform user the interrupt status.

Parameters

- handle – GDMA handle pointer.
- callback – GDMA callback function pointer.

- userData – Parameter for callback function.

status_t GDMA_SubmitTransfer(*gdma_handle_t* *handle, *gdma_channel_xfer_config_t* *config)

Submits the GDMA channel transfer request.

After this function, user could call GDMA_StartTransfer to start GDMA transfer.

This function must be called when previous transfer finished. Application can use GDMA_IsChannelBusy to check whether the channel has finished the previous work.

Note: The transfer configuration must follow the requirements:

- SRCBSIZE * SRCWIDTH == DESTBSIZE * DESTWIDTH
- If wrap not used, the address should align with WIDTH
- If wrap used, the address should align with WIDTH * BURST_SIZE.

Parameters

- handle – GDMA handle pointer.
- config – Pointer to GDMA transfer configuration structure.

Return values

- kStatus_Fail – GDMA is busy with previous transfer.
- kStatus_Success – Configuration set successfully.
- kStatus_InvalidArgument – Configuration wrong.

void GDMA_StartTransfer(*gdma_handle_t* *handle)

GDMA start transfer.

User can call this function after GDMA_SubmitTransfer.

Parameters

- handle – GDMA handle pointer.

void GDMA_AbortTransfer(*gdma_handle_t* *handle)

Abort running transfer by handle.

When this function is called, if the channel is on service, it only stops when service finished.

Parameters

- handle – GDMA handle pointer.

void GDMA_IRQHandle(GDMA_Type *base)

GDMA IRQ handler.

This function checks all GDMA channel interrupts and inform application the interrupt flags through user registered callback.

Parameters

- base – GDMA peripheral.

FSL_GDMA_DRIVER_VERSION

enum _gdma_transfer_width

GDMA transfer width.

Values:

enumerator kGDMA_TransferWidth1Byte
1 byte.

enumerator kGDMA_TransferWidth2Byte
2 bytes.

enumerator kGDMA_TransferWidth4Byte
4 bytes.

enum _gdma_burst_size
GDMA burst size.

Values:

enumerator kGDMA_BurstSize1
Burst 1.

enumerator kGDMA_BurstSize4
Burst 4.

enumerator kGDMA_BurstSize8
Burst 8.

enumerator kGDMA_BurstSize16
Burst 16.

enumerator kGDMA_BurstSizeWrap4
Wrap 4.

enumerator kGDMA_BurstSizeWrap8
Wrap 8.

enumerator kGDMA_BurstSizeWrap16
Wrap 16.

enum _gdma_ahb_prot
GDMA AHB HPROT flags. .

Values:

enumerator kGDMA_ProtUserMode
The access is in user mode.

enumerator kGDMA_ProtPrevilegedMode
The access is in previleged mode.

enumerator kGDMA_ProtUnbufferable
The access is not bufferable.

enumerator kGDMA_ProtBufferable
The access is bufferable.

enumerator kGDMA_ProtUncacheable
The access is not cacheable.

enumerator kGDMA_ProtCacheable
The access is cacheable.

enum _gdma_priority
GDMA channel priority.

Values:

enumerator kGDMA_ChannelPriority0
Lowest channel priority - priority 0

enumerator kGDMA_ChannelPriority1
Channel priority 1

enumerator kGDMA_ChannelPriority2
Channel priority 2

enumerator kGDMA_ChannelPriority3
Channel priority 3

enumerator kGDMA_ChannelPriority4
Channel priority 4

enumerator kGDMA_ChannelPriority5
Channel priority 5

enumerator kGDMA_ChannelPriority6
Channel priority 6

enumerator kGDMA_ChannelPriority7
Channel priority 7

enumerator kGDMA_ChannelPriority8
Channel priority 8

enumerator kGDMA_ChannelPriority9
Channel priority 9

enumerator kGDMA_ChannelPriority10
Channel priority 10

enumerator kGDMA_ChannelPriority11
Channel priority 11

enumerator kGDMA_ChannelPriority12
Channel priority 12

enumerator kGDMA_ChannelPriority13
Channel priority 13

enumerator kGDMA_ChannelPriority14
Channel priority 14

enumerator kGDMA_ChannelPriority15
Highest channel priority - priority 15

enum _gdma_interrupt_enable
GDMA interrupts to enable .

Values:

enumerator kGDMA_DescriptorTransferDoneInterruptEnable
Descriptor transfer done interrupt. This happens when the descriptor is configured to generate interrupt when transfer done.

enumerator kGDMA_AddressErrorInterruptEnable
Channel source or destination address is not aligned to corresponding transfer width.

enumerator kGDMA_BusErrorInterruptEnable
AHB bus interrupt.

enumerator kGDMA_TransferDoneInterruptEnable
DMA transfer done interrupt.

enumerator kGDMA_BlockTransferDoneInterruptEnable
DMA block single/burst transfer done interrupt.

enumerator kGDMA_AllInterruptEnable
All interrupt enable.

enum _gdma_interrupt_flags
GDMA interrupt status flags. .

Values:

enumerator kGDMA_DescriptorTransferDoneFlag
Descriptor transfer done interrupt. This happens when the descriptor is configured to generate interrupt when transfer done.

enumerator kGDMA_ChannelInterruptFlag
OR of the content of the respective unmasked interrupt of channel.

enumerator kGDMA_AddressErrorFlag
Channel source or destination address is not aligned to corresponding transfer width.

enumerator kGDMA_BusErrorFlag
AHB bus interrupt.

enumerator kGDMA_TransferDoneFlag
DMA transfer done interrupt.

enumerator kGDMA_BlockTransferDoneFlag
DMA block single/burst transfer done interrupt.

enumerator kGDMA_AllInterruptFlag
All interrupt flags.

typedef enum *_gdma_transfer_width* gdma_transfer_width_t
GDMA transfer width.

typedef enum *_gdma_burst_size* gdma_burst_size_t
GDMA burst size.

typedef enum *_gdma_priority* gdma_priority_t
GDMA channel priority.

typedef struct *_gdma_channel_xfer_config* gdma_channel_xfer_config_t
GDMA channel transfer configuration.

Note: The transfer configuration must follow the requirements:

- SRCBSIZE * SRCWIDTH == DESTBSIZE * DESTWIDTH
- If wrap not used, the address should align with WIDTH
- If wrap used, the address should align with WIDTH * BURST_SIZE.

---

typedef void (*gdma_callback_t)(struct *_gdma_handle* *handle, void *userData, uint32_t interrupts)

Define Callback function for GDMA.

handle: Pointer to the GDMA driver handle. userData: The userData registered using GDMA_SetCallback. interrupts: The interrupts flags of the specific channel.

typedef struct *_gdma_handle* gdma_handle_t

GDMA transfer handle structure.

gdma_descriptor_t

struct ___ALIGNED (16) _gdma_descriptor

GDMA channel link list descriptor structure.

GDMA_DESC_LLI(linkListAddr, stopAfterDescFinished, enableDescInterrupt)

Macro for GDMA link list descriptor LLI.

This macro constructs gdma_descriptor_t::lli.

Parameters

- linkListAddr – Address of next link list descriptor item.
- stopAfterDescFinished – Stop or not after this descriptor transfer done.
- enableDescInterrupt – Generate interrupt after this descriptor transfer done.

GDMA_DESC_CTRL(ahbProt, srcAddrInc, destAddrInc, srcWidth, destWidth, srcBurstSize, destBurstSize, length)

struct _gdma_channel_xfer_config

#include <fsl_gdma.h> GDMA channel transfer configuration.

Note: The transfer configuration must follow the requirements:

- SRCBSIZE * SRCWIDTH == DESTBSIZE * DESTWIDTH
- If wrap not used, the address should align with WIDTH
- If wrap used, the address should align with WIDTH * BURST_SIZE.

Public Members

uint32_t srcAddr

Source data address

uint32_t destAddr

Destination data address

uint8_t ahbProt

GDMA AHB HPROT flags, it could be OR'ed value of _gdma_ahb_prot.

gdma_burst_size_t srcBurstSize

Source address burst size.

gdma_burst_size_t destBurstSize

Destination address burst size.

gdma_transfer_width_t srcWidth

Source transfer width.

gdma_transfer_width_t destWidth

Destination transfer width.

bool srcAddrInc

Increase source address on each successive access.

bool destAddrInc
: Increase destination address on each successive access.

uint16_t transferLen
: Transfer length in bytes, max value is 8 * 1024 - 1, should align with transfer size.

bool enableLinkList
: Enable link list or not.

bool enableDescInterrupt
: Generate interrupt when descriptor transfer finished, only used when enableLinkList is true.

bool stopAfterDescFinished
: Stop channel when descriptor transfer finished, only used when enableLinkList is true.

uint32_t linkListAddr
: Link list address, only used when enableLinkList is true.

struct __gdma_handle
: *#include <fsl_gdma.h>* GDMA transfer handle structure.

Public Members

GDMA_Type *gdma
: GDMA peripheral base address

uint8_t channel
: GDMA channel number

gdma_callback_t callback
: Callback function. Invoked interrupt happens.

void *userData
: Callback function parameter

2.20 I2C: Inter-Integrated Circuit Driver

2.21 I2C DMA Driver

void I2C_MasterTransferCreateHandleDMA(I2C_Type *base, *i2c_master_dma_handle_t* *handle, *i2c_master_dma_transfer_callback_t* callback, void *userData, *dma_handle_t* *dmaHandle)

Init the I2C handle which is used in transactional functions.

Parameters

- base – I2C peripheral base address
- handle – pointer to i2c_master_dma_handle_t structure
- callback – pointer to user callback function
- userData – user param passed to the callback function
- dmaHandle – DMA handle pointer

status_t I2C_MasterTransferDMA(I2C_Type *base, *i2c_master_dma_handle_t* *handle, *i2c_master_transfer_t* *xfer)

Performs a master dma non-blocking transfer on the I2C bus.

Parameters

- base – I2C peripheral base address
- handle – pointer to i2c_master_dma_handle_t structure
- xfer – pointer to transfer structure of i2c_master_transfer_t

Return values

- kStatus_Success – Sucessully complete the data transmission.
- kStatus_I2C_Busy – Previous transmission still not finished.
- kStatus_I2C_Timeout – Transfer error, wait signal timeout.
- kStatus_I2C_ArbitrationLost – Transfer error, arbitration lost.
- kStataus_I2C_Nak – Transfer error, receive Nak during transfer.

status_t I2C_MasterTransferGetCountDMA(I2C_Type *base, *i2c_master_dma_handle_t* *handle, size_t *count)

Get master transfer status during a dma non-blocking transfer.

Parameters

- base – I2C peripheral base address
- handle – pointer to i2c_master_dma_handle_t structure
- count – Number of bytes transferred so far by the non-blocking transaction.

void I2C_MasterTransferAbortDMA(I2C_Type *base, *i2c_master_dma_handle_t* *handle)

Abort a master dma non-blocking transfer in a early time.

Parameters

- base – I2C peripheral base address
- handle – pointer to i2c_master_dma_handle_t structure

FSL_I2C_DMA_DRIVER_VERSION

I2C DMA driver version.

typedef struct *_i2c_master_dma_handle* i2c_master_dma_handle_t

I2C master dma handle typedef.

typedef void (*i2c_master_dma_transfer_callback_t)(I2C_Type *base, *i2c_master_dma_handle_t* *handle, *status_t* status, void *userData)

I2C master dma transfer callback typedef.

typedef void (*flexcomm_i2c_dma_master_irq_handler_t)(I2C_Type *base, *i2c_master_dma_handle_t* *handle)

Typedef for master dma handler.

I2C_MAX_DMA_TRANSFER_COUNT

Maximum lenght of single DMA transfer (determined by capability of the DMA engine)

struct _i2c_master_dma_handle

#include <fsl_i2c_dma.h> I2C master dma transfer structure.

Public Members

uint8_t state
Transfer state machine current state.

uint32_t transferCount
Indicates progress of the transfer

uint32_t remainingBytesDMA
Remaining byte count to be transferred using DMA.

uint8_t *buf
Buffer pointer for current state.

bool checkAddrNack
Whether to check the nack signal is detected during addressing.

dma_handle_t *dmaHandle
The DMA handler used.

i2c_master_transfer_t transfer
Copy of the current transfer info.

i2c_master_dma_transfer_callback_t completionCallback
Callback function called after dma transfer finished.

void *userData
Callback parameter passed to callback function.

2.22 I2C Driver

FSL_I2C_DRIVER_VERSION
I2C driver version.

I2C status return codes.

Values:

enumerator kStatus_I2C_Busy
The master is already performing a transfer.

enumerator kStatus_I2C_Idle
The slave driver is idle.

enumerator kStatus_I2C_Nak
The slave device sent a NAK in response to a byte.

enumerator kStatus_I2C_InvalidParameter
Unable to proceed due to invalid parameter.

enumerator kStatus_I2C_BitError
Transferred bit was not seen on the bus.

enumerator kStatus_I2C_ArbitrationLost
Arbitration lost error.

enumerator kStatus_I2C_NoTransferInProgress
Attempt to abort a transfer when one is not in progress.

enumerator kStatus_I2C_DmaRequestFail
DMA request failed.

enumerator kStatus_I2C_StartStopError
Start and stop error.

enumerator kStatus_I2C_UnexpectedState
Unexpected state.

enumerator kStatus_I2C_Timeout
Timeout when waiting for I2C master/slave pending status to set to continue transfer.

enumerator kStatus_I2C_Addr_Nak
NAK received for Address

enumerator kStatus_I2C_EventTimeout
Timeout waiting for bus event.

enumerator kStatus_I2C_SclLowTimeout
Timeout SCL signal remains low.

enum _i2c_status_flags
I2C status flags.

Note: These enums are meant to be OR'd together to form a bit mask.

Values:

enumerator kI2C_MasterPendingFlag
The I2C module is waiting for software interaction. bit 0

enumerator kI2C_MasterArbitrationLostFlag
The arbitration of the bus was lost. There was collision on the bus. bit 4

enumerator kI2C_MasterStartStopErrorFlag
There was an error during start or stop phase of the transaction. bit 6

enumerator kI2C_MasterIdleFlag
The I2C master idle status. bit 5

enumerator kI2C_MasterRxReadyFlag
The I2C master rx ready status. bit 1

enumerator kI2C_MasterTxReadyFlag
The I2C master tx ready status. bit 2

enumerator kI2C_MasterAddrNackFlag
The I2C master address nack status. bit 7

enumerator kI2C_MasterDataNackFlag
The I2C master data nack status. bit 3

enumerator kI2C_SlavePendingFlag
The I2C module is waiting for software interaction. bit 8

enumerator kI2C_SlaveNotStretching
Indicates whether the slave is currently stretching clock (0 = yes, 1 = no). bit 11

enumerator kI2C_SlaveSelected
Indicates whether the slave is selected by an address match. bit 14

enumerator kI2C_SaveDeselected
Indicates that slave was previously deselected (deselect event took place, w1c). bit 15

enumerator kI2C_SlaveAddressedFlag
One of the I2C slave's 4 addresses is matched. bit 22

enumerator kI2C_SlaveReceiveFlag
Slave receive data available. bit 9

enumerator kI2C_SlaveTransmitFlag
Slave data can be transmitted. bit 10

enumerator kI2C_SlaveAddress0MatchFlag
Slave address0 match. bit 20

enumerator kI2C_SlaveAddress1MatchFlag
Slave address1 match. bit 12

enumerator kI2C_SlaveAddress2MatchFlag
Slave address2 match. bit 13

enumerator kI2C_SlaveAddress3MatchFlag
Slave address3 match. bit 21

enumerator kI2C_MonitorReadyFlag
The I2C monitor ready interrupt. bit 16

enumerator kI2C_MonitorOverflowFlag
The monitor data overrun interrupt. bit 17

enumerator kI2C_MonitorActiveFlag
The monitor is active. bit 18

enumerator kI2C_MonitorIdleFlag
The monitor idle interrupt. bit 19

enumerator kI2C_EventTimeoutFlag
The bus event timeout interrupt. bit 24

enumerator kI2C_SclTimeoutFlag
The SCL timeout interrupt. bit 25

enumerator kI2C_MasterAllClearFlags

enumerator kI2C_SlaveAllClearFlags

enumerator kI2C_CommonAllClearFlags

enum _i2c_interrupt_enable
I2C interrupt enable.

Note: These enums are meant to be OR'd together to form a bit mask.

Values:

enumerator kI2C_MasterPendingInterruptEnable
The I2C master communication pending interrupt.

enumerator kI2C_MasterArbitrationLostInterruptEnable
The I2C master arbitration lost interrupt.

enumerator kI2C_MasterStartStopErrorInterruptEnable
The I2C master start/stop timing error interrupt.

enumerator kI2C_SlavePendingInterruptEnable
The I2C slave communication pending interrupt.

enumerator kI2C_SlaveNotStretchingInterruptEnable
The I2C slave not streching interrupt, deep-sleep mode can be entered only when this interrupt occurs.

enumerator kI2C_SlaveDeselectedInterruptEnable
The I2C slave deselection interrupt.

enumerator kI2C_MonitorReadyInterruptEnable
The I2C monitor ready interrupt.

enumerator kI2C_MonitorOverflowInterruptEnable
The monitor data overrun interrupt.

enumerator kI2C_MonitorIdleInterruptEnable
The monitor idle interrupt.

enumerator kI2C_EventTimeoutInterruptEnable
The bus event timeout interrupt.

enumerator kI2C_SclTimeoutInterruptEnable
The SCL timeout interrupt.

enumerator kI2C_MasterAllInterruptEnable

enumerator kI2C_SlaveAllInterruptEnable

enumerator kI2C_CommonAllInterruptEnable

I2C_RETRY_TIMES
Retry times for waiting flag.

I2C_MASTER_TRANSMIT_IGNORE_LAST_NACK
Whether to ignore the nack signal of the last byte during master transmit.

I2C_STAT_MSTCODE_IDLE
Master Idle State Code

I2C_STAT_MSTCODE_RXREADY
Master Receive Ready State Code

I2C_STAT_MSTCODE_TXREADY
Master Transmit Ready State Code

I2C_STAT_MSTCODE_NACKADR
Master NACK by slave on address State Code

I2C_STAT_MSTCODE_NACKDAT
Master NACK by slave on data State Code

I2C_STAT_SLVST_ADDR

I2C_STAT_SLVST_RX

I2C_STAT_SLVST_TX

2.23 I2C Master Driver

void I2C_MasterGetDefaultConfig(*i2c_master_config_t* *masterConfig)

Provides a default configuration for the I2C master peripheral.

This function provides the following default configuration for the I2C master peripheral:

```
masterConfig->enableMaster            = true;
masterConfig->baudRate_Bps            = 100000U;
masterConfig->enableTimeout           = false;
```

After calling this function, you can override any settings in order to customize the configuration, prior to initializing the master driver with I2C_MasterInit().

Parameters

- masterConfig – **[out]** User provided configuration structure for default values. Refer to i2c_master_config_t.

void I2C_MasterInit(I2C_Type *base, const *i2c_master_config_t* *masterConfig, uint32_t srcClock_Hz)

Initializes the I2C master peripheral.

This function enables the peripheral clock and initializes the I2C master peripheral as described by the user provided configuration. A software reset is performed prior to configuration.

Parameters

- base – The I2C peripheral base address.
- masterConfig – User provided peripheral configuration. Use I2C_MasterGetDefaultConfig() to get a set of defaults that you can override.
- srcClock_Hz – Frequency in Hertz of the I2C functional clock. Used to calculate the baud rate divisors, filter widths, and timeout periods.

void I2C_MasterDeinit(I2C_Type *base)

Deinitializes the I2C master peripheral.

This function disables the I2C master peripheral and gates the clock. It also performs a software reset to restore the peripheral to reset conditions.

Parameters

- base – The I2C peripheral base address.

uint32_t I2C_GetInstance(I2C_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 I2C peripheral base address.

Returns

I2C instance number starting from 0.

static inline void I2C_MasterReset(I2C_Type *base)

Performs a software reset.

Restores the I2C master peripheral to reset conditions.

Parameters

- base – The I2C peripheral base address.

static inline void I2C_MasterEnable(I2C_Type *base, bool enable)

Enables or disables the I2C module as master.

Parameters

- base – The I2C peripheral base address.
- enable – Pass true to enable or false to disable the specified I2C as master.

uint32_t I2C_GetStatusFlags(I2C_Type *base)

Gets the I2C status flags.

A bit mask with the state of all I2C status flags is returned. For each flag, the corresponding bit in the return value is set if the flag is asserted.

See also:

_i2c_status_flags.

Parameters

- base – The I2C 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 I2C_ClearStatusFlags(I2C_Type *base, uint32_t statusMask)

Clears the I2C status flag state.

Refer to kI2C_CommonAllClearStatusFlags, kI2C_MasterAllClearStatusFlags and kI2C_SlaveAllClearStatusFlags to see the clearable flags. Attempts to clear other flags has no effect.

See also:

_i2c_status_flags, _i2c_master_status_flags and _i2c_slave_status_flags.

Parameters

- base – The I2C peripheral base address.
- statusMask – A bitmask of status flags that are to be cleared. The mask is composed of the members in kI2C_CommonAllClearStatusFlags, kI2C_MasterAllClearStatusFlags and kI2C_SlaveAllClearStatusFlags. You may pass the result of a previous call to I2C_GetStatusFlags().

static inline void I2C_MasterClearStatusFlags(I2C_Type *base, uint32_t statusMask)

Clears the I2C master status flag state.

Deprecated:

Do not use this function. It has been superceded by I2C_ClearStatusFlags The following status register flags can be cleared:

- kI2C_MasterArbitrationLostFlag
- kI2C_MasterStartStopErrorFlag

Attempts to clear other flags has no effect.

See also:

_i2c_status_flags.

Parameters

- base – The I2C peripheral base address.
- statusMask – A bitmask of status flags that are to be cleared. The mask is composed of _i2c_status_flags enumerators OR'd together. You may pass the result of a previous call to I2C_GetStatusFlags().

static inline void I2C_EnableInterrupts(I2C_Type *base, uint32_t interruptMask)

Enables the I2C interrupt requests.

Parameters

- base – The I2C peripheral base address.
- interruptMask – Bit mask of interrupts to enable. See _i2c_interrupt_enable for the set of constants that should be OR'd together to form the bit mask.

static inline void I2C_DisableInterrupts(I2C_Type *base, uint32_t interruptMask)

Disables the I2C interrupt requests.

Parameters

- base – The I2C peripheral base address.
- interruptMask – Bit mask of interrupts to disable. See _i2c_interrupt_enable for the set of constants that should be OR'd together to form the bit mask.

static inline uint32_t I2C_GetEnabledInterrupts(I2C_Type *base)

Returns the set of currently enabled I2C interrupt requests.

Parameters

- base – The I2C peripheral base address.

Returns

A bitmask composed of _i2c_interrupt_enable enumerators OR'd together to indicate the set of enabled interrupts.

void I2C_MasterSetBaudRate(I2C_Type *base, uint32_t baudRate_Bps, uint32_t srcClock_Hz)

Sets the I2C bus frequency for master transactions.

The I2C 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 I2C peripheral base address.
- srcClock_Hz – I2C functional clock frequency in Hertz.
- baudRate_Bps – Requested bus frequency in bits per second.

void I2C_MasterSetTimeoutValue(I2C_Type *base, uint8_t timeout_Ms, uint32_t srcClock_Hz)

Sets the I2C bus timeout value.

If the SCL signal remains low or bus does not have event longer than the timeout value, kI2C_SclTimeoutFlag or kI2C_EventTimeoutFlag is set. This can indicete the bus is held by slave or any fault occurs to the I2C module.

Parameters

- base – The I2C peripheral base address.
- timeout_Ms – Timeout value in millisecond.
- srcClock_Hz – I2C functional clock frequency in Hertz.

static inline bool I2C_MasterGetBusIdleState(I2C_Type *base)

Returns whether the bus is idle.

Requires the master mode to be enabled.

Parameters

- base – The I2C peripheral base address.

Return values

- true – Bus is busy.
- false – Bus is idle.

status_t I2C_MasterStart(I2C_Type *base, uint8_t address, *i2c_direction_t* direction)

Sends a START on the I2C bus.

This function is used to initiate a new master mode transfer by sending the START signal. The slave address is sent following the I2C START signal.

Parameters

- base – I2C peripheral base pointer
- address – 7-bit slave device address.
- direction – Master transfer directions(transmit/receive).

Return values

- kStatus_Success – Successfully send the start signal.
- kStatus_I2C_Busy – Current bus is busy.

status_t I2C_MasterStop(I2C_Type *base)

Sends a STOP signal on the I2C bus.

Return values

- kStatus_Success – Successfully send the stop signal.
- kStatus_I2C_Timeout – Send stop signal failed, timeout.

static inline *status_t* I2C_MasterRepeatedStart(I2C_Type *base, uint8_t address, *i2c_direction_t* direction)

Sends a REPEATED START on the I2C bus.

Parameters

- base – I2C peripheral base pointer
- address – 7-bit slave device address.
- direction – Master transfer directions(transmit/receive).

Return values

- kStatus_Success – Successfully send the start signal.
- kStatus_I2C_Busy – Current bus is busy but not occupied by current I2C master.

status_t I2C_MasterWriteBlocking(I2C_Type *base, const void *txBuff, size_t txSize, uint32_t flags)

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_I2C_Nak.

Parameters

- base – The I2C peripheral base address.
- txBuff – The pointer to the data to be transferred.
- txSize – The length in bytes of the data to be transferred.
- flags – Transfer control flag to control special behavior like suppressing start or stop, for normal transfers use kI2C_TransferDefaultFlag

Return values

- kStatus_Success – Data was sent successfully.
- kStatus_I2C_Busy – Another master is currently utilizing the bus.
- kStatus_I2C_Nak – The slave device sent a NAK in response to a byte.
- kStatus_I2C_ArbitrationLost – Arbitration lost error.

status_t I2C_MasterReadBlocking(I2C_Type *base, void *rxBuff, size_t rxSize, uint32_t flags)

Performs a polling receive transfer on the I2C bus.

Parameters

- base – The I2C peripheral base address.
- rxBuff – The pointer to the data to be transferred.
- rxSize – The length in bytes of the data to be transferred.
- flags – Transfer control flag to control special behavior like suppressing start or stop, for normal transfers use kI2C_TransferDefaultFlag

Return values

- kStatus_Success – Data was received successfully.
- kStatus_I2C_Busy – Another master is currently utilizing the bus.
- kStatus_I2C_Nak – The slave device sent a NAK in response to a byte.
- kStatus_I2C_ArbitrationLost – Arbitration lost error.

status_t I2C_MasterTransferBlocking(I2C_Type *base, *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 arbitration lost or receiving a NAK.

Parameters

- base – I2C peripheral base address.
- xfer – Pointer to the transfer structure.

Return values

- kStatus_Success – Successfully complete the data transmission.
- kStatus_I2C_Busy – Previous transmission still not finished.

- kStatus_I2C_Timeout – Transfer error, wait signal timeout.
- kStatus_I2C_ArbitrationLost – Transfer error, arbitration lost.
- kStataus_I2C_Nak – Transfer error, receive NAK during transfer.
- kStataus_I2C_Addr_Nak – Transfer error, receive NAK during addressing.

void I2C_MasterTransferCreateHandle(I2C_Type *base, *i2c_master_handle_t* *handle, *i2c_master_transfer_callback_t* callback, void *userData)

Creates a new handle for the I2C 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 I2C_MasterTransferAbort() API shall be called.

Parameters

- base – The I2C peripheral base address.
- handle – **[out]** Pointer to the I2C master driver handle.
- callback – User provided pointer to the asynchronous callback function.
- userData – User provided pointer to the application callback data.

status_t I2C_MasterTransferNonBlocking(I2C_Type *base, *i2c_master_handle_t* *handle, *i2c_master_transfer_t* *xfer)

Performs a non-blocking transaction on the I2C bus.

Parameters

- base – The I2C peripheral base address.
- handle – Pointer to the I2C master driver handle.
- xfer – The pointer to the transfer descriptor.

Return values

- kStatus_Success – The transaction was started successfully.
- kStatus_I2C_Busy – Either another master is currently utilizing the bus, or a non-blocking transaction is already in progress.

status_t I2C_MasterTransferGetCount(I2C_Type *base, *i2c_master_handle_t* *handle, size_t *count)

Returns number of bytes transferred so far.

Parameters

- base – The I2C peripheral base address.
- handle – Pointer to the I2C master driver handle.
- count – **[out]** Number of bytes transferred so far by the non-blocking transaction.

Return values

- kStatus_Success –
- kStatus_I2C_Busy –

status_t I2C_MasterTransferAbort(I2C_Type *base, *i2c_master_handle_t* *handle)

Terminates a non-blocking I2C master transmission early.

Note: It is not safe to call this function from an IRQ handler that has a higher priority than the I2C peripheral's IRQ priority.

Parameters

- base – The I2C peripheral base address.
- handle – Pointer to the I2C master driver handle.

Return values

- kStatus_Success – A transaction was successfully aborted.
- kStatus_I2C_Timeout – Timeout during polling for flags.

void I2C_MasterTransferHandleIRQ(I2C_Type *base, *i2c_master_handle_t* *handle)

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 I2C peripheral base address.
- handle – Pointer to the I2C master driver handle.

enum _i2c_direction

Direction of master and slave transfers.

Values:

enumerator kI2C_Write

Master transmit.

enumerator kI2C_Read

Master receive.

enum _i2c_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 _i2c_master_transfer::flags field.

Values:

enumerator kI2C_TransferDefaultFlag

Transfer starts with a start signal, stops with a stop signal.

enumerator kI2C_TransferNoStartFlag

Don't send a start condition, address, and sub address

enumerator kI2C_TransferRepeatedStartFlag

Send a repeated start condition

enumerator kI2C_TransferNoStopFlag

Don't send a stop condition.

enum _i2c_transfer_states

States for the state machine used by transactional APIs.

Values:

enumerator kIdleState

enumerator kTransmitSubaddrState

enumerator kTransmitDataState

enumerator kReceiveDataBeginState

enumerator kReceiveDataState

enumerator kReceiveLastDataState

enumerator kStartState

enumerator kStopState

enumerator kWaitForCompletionState

typedef enum *_i2c_direction* i2c_direction_t

Direction of master and slave transfers.

typedef struct *_i2c_master_config* i2c_master_config_t

Structure with settings to initialize the I2C master module.

This structure holds configuration settings for the I2C peripheral. To initialize this structure to reasonable defaults, call the I2C_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 *_i2c_master_transfer* i2c_master_transfer_t

I2C master transfer typedef.

typedef struct *_i2c_master_handle* i2c_master_handle_t

I2C master handle typedef.

typedef void (*i2c_master_transfer_callback_t)(I2C_Type *base, *i2c_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 I2C_MasterTransferCreateHandle().

Param base
The I2C peripheral base address.

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 i2c_master_config

#include <fsl_i2c.h> Structure with settings to initialize the I2C master module.

This structure holds configuration settings for the I2C peripheral. To initialize this structure to reasonable defaults, call the I2C_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.

uint32_t baudRate_Bps
: Desired baud rate in bits per second.

bool enableTimeout
: Enable internal timeout function.

uint8_t timeout_Ms
: Event timeout and SCL low timeout value.

struct _i2c_master_transfer
: *#include <fsl_i2c.h>* Non-blocking transfer descriptor structure.

This structure is used to pass transaction parameters to the I2C_MasterTransferNonBlocking() API.

Public Members

uint32_t flags
: Bit mask of options for the transfer. See enumeration _i2c_master_transfer_flags for available options. Set to 0 or kI2C_TransferDefaultFlag for normal transfers.

uint8_t slaveAddress
: The 7-bit slave address.

i2c_direction_t direction
: Either kI2C_Read or kI2C_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 _i2c_master_handle
: *#include <fsl_i2c.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 transferCount
: Indicates progress of the transfer

uint32_t remainingBytes
: Remaining byte count in current state.

uint8_t *buf
: Buffer pointer for current state.

bool checkAddrNack

Whether to check the nack signal is detected during addressing.

i2c_master_transfer_t transfer

Copy of the current transfer info.

i2c_master_transfer_callback_t completionCallback

Callback function pointer.

void *userData

Application data passed to callback.

2.24 I2C Slave Driver

void I2C_SlaveGetDefaultConfig(*i2c_slave_config_t* *slaveConfig)

Provides a default configuration for the I2C slave peripheral.

This function provides the following default configuration for the I2C slave peripheral:

```
slaveConfig->enableSlave = true;
slaveConfig->address0.disable = false;
slaveConfig->address0.address = 0u;
slaveConfig->address1.disable = true;
slaveConfig->address2.disable = true;
slaveConfig->address3.disable = true;
slaveConfig->busSpeed = kI2C_SlaveStandardMode;
```

After calling this function, override any settings to customize the configuration, prior to initializing the master driver with I2C_SlaveInit(). Be sure to override at least the *address0.address* 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 i2c_slave_config_t.

status_t I2C_SlaveInit(I2C_Type *base, const *i2c_slave_config_t* *slaveConfig, uint32_t srcClock_Hz)

Initializes the I2C slave peripheral.

This function enables the peripheral clock and initializes the I2C slave peripheral as described by the user provided configuration.

Parameters

- base – The I2C peripheral base address.
- slaveConfig – User provided peripheral configuration. Use I2C_SlaveGetDefaultConfig() to get a set of defaults that you can override.
- srcClock_Hz – Frequency in Hertz of the I2C functional clock. Used to calculate CLKDIV value to provide enough data setup time for master when slave stretches the clock.

void I2C_SlaveSetAddress(I2C_Type *base, *i2c_slave_address_register_t* addressRegister, uint8_t address, bool addressDisable)

Configures Slave Address n register.

This function writes new value to Slave Address register.

Parameters

- base – The I2C peripheral base address.

- addressRegister – The module supports multiple address registers. The parameter determines which one shall be changed.
- address – The slave address to be stored to the address register for matching.
- addressDisable – Disable matching of the specified address register.

void I2C_SlaveDeinit(I2C_Type *base)

Deinitializes the I2C slave peripheral.

This function disables the I2C slave peripheral and gates the clock. It also performs a software reset to restore the peripheral to reset conditions.

Parameters

- base – The I2C peripheral base address.

static inline void I2C_SlaveEnable(I2C_Type *base, bool enable)

Enables or disables the I2C module as slave.

Parameters

- base – The I2C peripheral base address.
- enable – True to enable or flase to disable.

static inline void I2C_SlaveClearStatusFlags(I2C_Type *base, uint32_t statusMask)

Clears the I2C status flag state.

The following status register flags can be cleared:

- slave deselected flag

Attempts to clear other flags has no effect.

See also:

_i2c_slave_flags.

Parameters

- base – The I2C peripheral base address.
- statusMask – A bitmask of status flags that are to be cleared. The mask is composed of _i2c_slave_flags enumerators OR'd together. You may pass the result of a previous call to I2C_SlaveGetStatusFlags().

status_t I2C_SlaveWriteBlocking(I2C_Type *base, const uint8_t *txBuff, size_t txSize)

Performs a polling send transfer on the I2C bus.

The function executes blocking address phase and blocking data phase.

Parameters

- base – The I2C peripheral base address.
- txBuff – The pointer to the data to be transferred.
- txSize – The length in bytes of the data to be transferred.

Returns

kStatus_Success Data has been sent.

Returns

kStatus_Fail Unexpected slave state (master data write while master read from slave is expected).

status_t I2C_SlaveReadBlocking(I2C_Type *base, uint8_t *rxBuff, size_t rxSize)

Performs a polling receive transfer on the I2C bus.

The function executes blocking address phase and blocking data phase.

Parameters

- base – The I2C peripheral base address.
- rxBuff – The pointer to the data to be transferred.
- rxSize – The length in bytes of the data to be transferred.

Returns

kStatus_Success Data has been received.

Returns

kStatus_Fail Unexpected slave state (master data read while master write to slave is expected).

void I2C_SlaveTransferCreateHandle(I2C_Type *base, *i2c_slave_handle_t* *handle, *i2c_slave_transfer_callback_t* callback, void *userData)

Creates a new handle for the I2C 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 I2C_SlaveTransferAbort() API shall be called.

Parameters

- base – The I2C peripheral base address.
- handle – **[out]** Pointer to the I2C slave driver handle.
- callback – User provided pointer to the asynchronous callback function.
- userData – User provided pointer to the application callback data.

status_t I2C_SlaveTransferNonBlocking(I2C_Type *base, *i2c_slave_handle_t* *handle, uint32_t eventMask)

Starts accepting slave transfers.

Call this API after calling I2C_SlaveInit() and I2C_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 I2C_SlaveTransferCreateHandle(). The callback is always invoked from the interrupt context.

If no slave Tx transfer is busy, a master read from slave request invokes kI2C_SlaveTransmitEvent callback. If no slave Rx transfer is busy, a master write to slave request invokes kI2C_SlaveReceiveEvent callback.

The set of events received by the callback is customizable. To do so, set the *eventMask* parameter to the OR'd combination of i2c_slave_transfer_event_t enumerators for the events you wish to receive. The kI2C_SlaveTransmitEvent and kI2C_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 kI2C_SlaveAllEvents constant is provided as a convenient way to enable all events.

Parameters

- base – The I2C peripheral base address.
- handle – Pointer to i2c_slave_handle_t structure which stores the transfer state.

- eventMask – Bit mask formed by OR'ing together i2c_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 kI2C_SlaveAllEvents to enable all events.

Return values

- kStatus_Success – Slave transfers were successfully started.
- kStatus_I2C_Busy – Slave transfers have already been started on this handle.

status_t I2C_SlaveSetSendBuffer(I2C_Type *base, volatile *i2c_slave_transfer_t* *transfer, const void *txData, size_t txSize, uint32_t eventMask)

Starts accepting master read from slave requests.

The function can be called in response to kI2C_SlaveTransmitEvent callback to start a new slave Tx transfer from within the transfer callback.

The set of events received by the callback is customizable. To do so, set the *eventMask* parameter to the OR'd combination of i2c_slave_transfer_event_t enumerators for the events you wish to receive. The kI2C_SlaveTransmitEvent and kI2C_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 kI2C_SlaveAllEvents constant is provided as a convenient way to enable all events.

Parameters

- base – The I2C peripheral base address.
- transfer – Pointer to i2c_slave_transfer_t structure.
- txData – Pointer to data to send to master.
- txSize – Size of txData in bytes.
- eventMask – Bit mask formed by OR'ing together i2c_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 kI2C_SlaveAllEvents to enable all events.

Return values

- kStatus_Success – Slave transfers were successfully started.
- kStatus_I2C_Busy – Slave transfers have already been started on this handle.

status_t I2C_SlaveSetReceiveBuffer(I2C_Type *base, volatile *i2c_slave_transfer_t* *transfer, void *rxData, size_t rxSize, uint32_t eventMask)

Starts accepting master write to slave requests.

The function can be called in response to kI2C_SlaveReceiveEvent callback to start a new slave Rx transfer from within the transfer callback.

The set of events received by the callback is customizable. To do so, set the *eventMask* parameter to the OR'd combination of i2c_slave_transfer_event_t enumerators for the events you wish to receive. The kI2C_SlaveTransmitEvent and kI2C_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 kI2C_SlaveAllEvents constant is provided as a convenient way to enable all events.

Parameters

- base – The I2C peripheral base address.

- transfer – Pointer to i2c_slave_transfer_t structure.
- rxData – Pointer to data to store data from master.
- rxSize – Size of rxData in bytes.
- eventMask – Bit mask formed by OR'ing together i2c_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 kI2C_SlaveAllEvents to enable all events.

Return values

- kStatus_Success – Slave transfers were successfully started.
- kStatus_I2C_Busy – Slave transfers have already been started on this handle.

static inline uint32_t I2C_SlaveGetReceivedAddress(I2C_Type *base, volatile *i2c_slave_transfer_t* *transfer)

Returns the slave address sent by the I2C master.

This function should only be called from the address match event callback kI2C_SlaveAddressMatchEvent.

Parameters

- base – The I2C peripheral base address.
- transfer – The I2C slave transfer.

Returns

The 8-bit address matched by the I2C slave. Bit 0 contains the R/w direction bit, and the 7-bit slave address is in the upper 7 bits.

void I2C_SlaveTransferAbort(I2C_Type *base, *i2c_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 I2C peripheral base address.
- handle – Pointer to i2c_slave_handle_t structure which stores the transfer state.

Return values

- kStatus_Success –
- kStatus_I2C_Idle –

status_t I2C_SlaveTransferGetCount(I2C_Type *base, *i2c_slave_handle_t* *handle, size_t *count)

Gets the slave transfer remaining bytes during a interrupt non-blocking transfer.

Parameters

- base – I2C base pointer.
- handle – pointer to i2c_slave_handle_t structure.
- 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 I2C_SlaveTransferHandleIRQ(I2C_Type *base, *i2c_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 I2C peripheral base address.
- handle – Pointer to i2c_slave_handle_t structure which stores the transfer state.

enum _i2c_slave_address_register

I2C slave address register.

Values:

enumerator kI2C_SlaveAddressRegister0

Slave Address 0 register.

enumerator kI2C_SlaveAddressRegister1

Slave Address 1 register.

enumerator kI2C_SlaveAddressRegister2

Slave Address 2 register.

enumerator kI2C_SlaveAddressRegister3

Slave Address 3 register.

enum _i2c_slave_address_qual_mode

I2C slave address match options.

Values:

enumerator kI2C_QualModeMask

The SLVQUAL0 field (qualAddress) is used as a logical mask for matching address0.

enumerator kI2C_QualModeExtend

The SLVQUAL0 (qualAddress) field is used to extend address 0 matching in a range of addresses.

enum _i2c_slave_bus_speed

I2C slave bus speed options.

Values:

enumerator kI2C_SlaveStandardMode

enumerator kI2C_SlaveFastMode

enumerator kI2C_SlaveFastModePlus

enumerator kI2C_SlaveHsMode

enum _i2c_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 I2C_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 kI2C_SlaveAddressMatchEvent
Received the slave address after a start or repeated start.

enumerator kI2C_SlaveTransmitEvent
Callback is requested to provide data to transmit (slave-transmitter role).

enumerator kI2C_SlaveReceiveEvent
Callback is requested to provide a buffer in which to place received data (slave-receiver role).

enumerator kI2C_SlaveCompletionEvent
All data in the active transfer have been consumed.

enumerator kI2C_SlaveDeselectedEvent
The slave function has become deselected (SLVSEL flag changing from 1 to 0.

enumerator kI2C_SlaveAllEvents
Bit mask of all available events.

enum _i2c_slave_fsm
I2C slave software finite state machine states.

Values:

enumerator kI2C_SlaveFsmAddressMatch

enumerator kI2C_SlaveFsmReceive

enumerator kI2C_SlaveFsmTransmit

typedef enum *_i2c_slave_address_register* i2c_slave_address_register_t
I2C slave address register.

typedef struct *_i2c_slave_address* i2c_slave_address_t
Data structure with 7-bit Slave address and Slave address disable.

typedef enum *_i2c_slave_address_qual_mode* i2c_slave_address_qual_mode_t
I2C slave address match options.

typedef enum *_i2c_slave_bus_speed* i2c_slave_bus_speed_t
I2C slave bus speed options.

typedef struct *_i2c_slave_config* i2c_slave_config_t
Structure with settings to initialize the I2C slave module.

This structure holds configuration settings for the I2C slave peripheral. To initialize this structure to reasonable defaults, call the I2C_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 *_i2c_slave_transfer_event* i2c_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 I2C_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 *_i2c_slave_handle* i2c_slave_handle_t

I2C slave handle typedef.

typedef struct *_i2c_slave_transfer* i2c_slave_transfer_t

I2C slave transfer structure.

typedef void (*i2c_slave_transfer_callback_t)(I2C_Type *base, volatile *i2c_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 I2C_SlaveSetCallback() function after you have created a handle.

Param base
Base address for the I2C 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 enum *_i2c_slave_fsm* i2c_slave_fsm_t

I2C slave software finite state machine states.

typedef void (*flexcomm_i2c_master_irq_handler_t)(I2C_Type *base, *i2c_master_handle_t* *handle)

Typedef for master interrupt handler.

typedef void (*flexcomm_i2c_slave_irq_handler_t)(I2C_Type *base, *i2c_slave_handle_t* *handle)

Typedef for slave interrupt handler.

struct _i2c_slave_address

#include <fsl_i2c.h> Data structure with 7-bit Slave address and Slave address disable.

Public Members

uint8_t address

7-bit Slave address SLVADR.

bool addressDisable

Slave address disable SADISABLE.

struct _i2c_slave_config

#include <fsl_i2c.h> Structure with settings to initialize the I2C slave module.

This structure holds configuration settings for the I2C slave peripheral. To initialize this structure to reasonable defaults, call the I2C_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

i2c_slave_address_t address0

Slave's 7-bit address and disable.

i2c_slave_address_t address1
: Alternate slave 7-bit address and disable.

i2c_slave_address_t address2
: Alternate slave 7-bit address and disable.

i2c_slave_address_t address3
: Alternate slave 7-bit address and disable.

i2c_slave_address_qual_mode_t qualMode
: Qualify mode for slave address 0.

uint8_t qualAddress
: Slave address qualifier for address 0.

i2c_slave_bus_speed_t busSpeed
: Slave bus speed mode. If the slave function stretches SCL to allow for software response, it must provide sufficient data setup time to the master before releasing the stretched clock. This is accomplished by inserting one clock time of CLKDIV at that point. The busSpeed value is used to configure CLKDIV such that one clock time is greater than the tSU;DAT value noted in the I2C bus specification for the I2C mode that is being used. If the busSpeed mode is unknown at compile time, use the longest data setup time kI2C_SlaveStandardMode (250 ns)

bool enableSlave
: Enable slave mode.

struct __i2c__slave__transfer
: *#include <fsl_i2c.h>* I2C slave transfer structure.

Public Members

i2c_slave_handle_t *handle
: Pointer to handle that contains this transfer.

i2c_slave_transfer_event_t event
: Reason the callback is being invoked.

uint8_t receivedAddress
: Matching address send by master. 7-bits plus R/nW bit0

uint32_t eventMask
: Mask of enabled events.

uint8_t *rxData
: Transfer buffer for receive data

const uint8_t *txData
: Transfer buffer for transmit data

size_t txSize
: Transfer size

size_t rxSize
: Transfer size

size_t transferredCount
: Number of bytes transferred during this transfer.

status_t completionStatus

Success or error code describing how the transfer completed. Only applies for kI2C_SlaveCompletionEvent.

struct _i2c_slave_handle

#include <fsl_i2c.h> I2C slave handle structure.

Note: The contents of this structure are private and subject to change.

Public Members

volatile *i2c_slave_transfer_t* transfer

I2C slave transfer.

volatile bool isBusy

Whether transfer is busy.

volatile *i2c_slave_fsm_t* slaveFsm

slave transfer state machine.

i2c_slave_transfer_callback_t callback

Callback function called at transfer event.

void *userData

Callback parameter passed to callback.

2.25 I2S: I2S Driver

2.26 I2S_BRIDGE: I2S bridging and signal sharing configuration

enum _i2s_bridge_share_set_index

I2S Bridge share set.

Values:

enumerator kI2S_BRIDGE_OriginalSignal

Original FLEXCOMM I2S signals

enumerator kI2S_BRIDGE_ShareSet0

share set 0 signals

enumerator kI2S_BRIDGE_ShareSet1

share set 1 signals

enum _i2s_bridge_signal

I2S signal.

Values:

enumerator kI2S_BRIDGE_SignalSCK

SCK signal

enumerator kI2S_BRIDGE_SignalWS

WS signal

enumerator kI2S_BRIDGE_SignalDataIn
Data in signal

enumerator kI2S_BRIDGE_SignalDataOut
Data out signal

enum _i2s_bridge_share_src
I2S signal source.

Values:

enumerator kI2S_BRIDGE_Flexcomm0
Shared signal comes from FLEXCOMM0

enumerator kI2S_BRIDGE_Flexcomm1
Shared signal comes from FLEXCOMM1

enumerator kI2S_BRIDGE_Flexcomm2
Shared signal comes from FLEXCOMM2

enumerator kI2S_BRIDGE_Flexcomm3
Shared signal comes from FLEXCOMM3

enum _i2s_bridge_dataout_mask
I2S Bridge shared data out mask.

Values:

enumerator kI2S_BRIDGE_Flexcomm0DataOut
FLEXCOMM0 DATAOUT Output Enable

enumerator kI2S_BRIDGE_Flexcomm1DataOut
FLEXCOMM1 DATAOUT Output Enable

enumerator kI2S_BRIDGE_Flexcomm2DataOut
FLEXCOMM2 DATAOUT Output Enable

enumerator kI2S_BRIDGE_Flexcomm3DataOut
FLEXCOMM3 DATAOUT Output Enable

typedef enum *_i2s_bridge_signal* i2s_bridge_signal_t
I2S signal.

FSL_I2S_BRIDGE_DRIVER_VERSION
Group I2S Bridge driver version for SDK.

Version 2.0.0.

void I2S_BRIDGE_SetFlexcommShareSet(uint32_t flexCommIndex, uint32_t sckSet, uint32_t wsSet, uint32_t dataInSet, uint32_t dataOutSet)
I2S Bridge share set selection for flexcomm instance.

Parameters

- flexCommIndex – index of flexcomm, refer to RM for supported FLEXCOMM instances.
- sckSet – share set for sck, refer to _i2s_bridge_share_set_index
- wsSet – share set for ws, refer to _i2s_bridge_share_set_index
- dataInSet – share set for data in, refer to _i2s_bridge_share_set_index
- dataOutSet – share set for data out, refer to _i2s_bridge_share_set_index

void I2S_BRIDGE_SetFlexcommSignalShareSet(uint32_t flexCommIndex, *i2s_bridge_signal_t* signal, uint32_t set)

I2S Bridge share set selection for a separate signal.

Parameters

- flexCommIndex – index of flexcomm, refer to RM for supported FLEXCOMM instances.
- signal – The signal need to be configured.
- set – share set for the signal, refer to _i2s_bridge_share_set_index

void I2S_BRIDGE_SetShareSetSrc(uint32_t setIndex, uint32_t sckShareSrc, uint32_t wsShareSrc, uint32_t dataInShareSrc, uint32_t dataOutShareSrc)

I2S Bridge share set source configure.

Parameters

- setIndex – index of share set, refer _i2s_bridge_share_set_index
- sckShareSrc – sck source for this share set, refer to _i2s_bridge_share_src
- wsShareSrc – ws source for this share set, refer to _i2s_bridge_share_src
- dataInShareSrc – data in source for this share set, refer to _i2s_bridge_share_src
- dataOutShareSrc – data out source for this share set, refer to _i2s_bridge_dataout_mask

void I2S_BRIDGE_SetShareSignalSrc(uint32_t setIndex, *i2s_bridge_signal_t* signal, uint32_t shareSrc)

I2S Bridge shared signal source selection for a share set.

Parameters

- setIndex – index of share set, refer to _i2s_bridge_share_set_index
- signal – the shared signal to be configured
- shareSrc – the signal selection, refer to _i2s_bridge_share_src.

2.27 I2S DMA Driver

void I2S_TxTransferCreateHandleDMA(I2S_Type *base, *i2s_dma_handle_t* *handle, *dma_handle_t* *dmaHandle, *i2s_dma_transfer_callback_t* callback, void *userData)

Initializes handle for transfer of audio data.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.
- dmaHandle – pointer to dma handle structure.
- callback – function to be called back when transfer is done or fails.
- userData – pointer to data passed to callback.

status_t I2S_TxTransferSendDMA(I2S_Type *base, *i2s_dma_handle_t* *handle, *i2s_transfer_t* transfer)

Begins or queue sending of the given data.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.
- transfer – data buffer.

Return values

- kStatus_Success –
- kStatus_I2S_Busy – if all queue slots are occupied with unsent buffers.

void I2S_TransferAbortDMA(I2S_Type *base, *i2s_dma_handle_t* *handle)

Aborts transfer of data.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.

void I2S_RxTransferCreateHandleDMA(I2S_Type *base, *i2s_dma_handle_t* *handle, *dma_handle_t* *dmaHandle, *i2s_dma_transfer_callback_t* callback, void *userData)

Initializes handle for reception of audio data.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.
- dmaHandle – pointer to dma handle structure.
- callback – function to be called back when transfer is done or fails.
- userData – pointer to data passed to callback.

status_t I2S_RxTransferReceiveDMA(I2S_Type *base, *i2s_dma_handle_t* *handle, *i2s_transfer_t* transfer)

Begins or queue reception of data into given buffer.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.
- transfer – data buffer.

Return values

- kStatus_Success –
- kStatus_I2S_Busy – if all queue slots are occupied with buffers which are not full.

void I2S_DMACallback(*dma_handle_t* *handle, void *userData, bool transferDone, uint32_t tcds)

Invoked from DMA interrupt handler.

Parameters

- handle – pointer to DMA handle structure.
- userData – argument for user callback.
- transferDone – if transfer was done.
- tcds –

void I2S_TransferInstallLoopDMADescriptorMemory(*i2s_dma_handle_t* *handle, void *dmaDescriptorAddr, size_t dmaDescriptorNum)

Install DMA descriptor memory for loop transfer only.

This function used to register DMA descriptor memory for the i2s loop dma transfer.

It must be callbed before I2S_TransferSendLoopDMA/I2S_TransferReceiveLoopDMA and after I2S_RxTransferCreateHandleDMA/I2S_TxTransferCreateHandleDMA.

User should be take care about the address of DMA descriptor pool which required align with 16BYTE at least.

Parameters

- handle – Pointer to i2s DMA transfer handle.
- dmaDescriptorAddr – DMA descriptor start address.
- dmaDescriptorNum – DMA descriptor number.

status_t I2S_TransferSendLoopDMA(I2S_Type *base, *i2s_dma_handle_t* *handle, *i2s_transfer_t* *xfer, uint32_t loopTransferCount)

Send link transfer data using DMA.

This function receives data using DMA. This is a non-blocking function, which returns right away. When all data is received, the receive callback function is called.

This function support loop transfer, such as A->B->...->A, the loop transfer chain will be converted into a chain of descriptor and submit to dma. Application must be aware of that the more counts of the loop transfer, then more DMA descriptor memory required, user can use function I2S_InstallDMADescriptorMemory to register the dma descriptor memory.

As the DMA support maximum 1024 transfer count, so application must be aware of that this transfer function support maximum 1024 samples in each transfer, otherwise assert error or error status will be returned. Once the loop transfer start, application can use function I2S_TransferAbortDMA to stop the loop transfer.

Parameters

- base – I2S peripheral base address.
- handle – Pointer to usart_dma_handle_t structure.
- xfer – I2S DMA transfer structure. See i2s_transfer_t.
- loopTransferCount – loop count

Return values

kStatus_Success –

status_t I2S_TransferReceiveLoopDMA(I2S_Type *base, *i2s_dma_handle_t* *handle, *i2s_transfer_t* *xfer, uint32_t loopTransferCount)

Receive link transfer data using DMA.

This function receives data using DMA. This is a non-blocking function, which returns right away. When all data is received, the receive callback function is called.

This function support loop transfer, such as A->B->...->A, the loop transfer chain will be converted into a chain of descriptor and submit to dma. Application must be aware of that the more counts of the loop transfer, then more DMA descriptor memory required, user can use function I2S_InstallDMADescriptorMemory to register the dma descriptor memory.

As the DMA support maximum 1024 transfer count, so application must be aware of that this transfer function support maximum 1024 samples in each transfer, otherwise assert error or error status will be returned. Once the loop transfer start, application can use function I2S_TransferAbortDMA to stop the loop transfer.

Parameters

- base – I2S peripheral base address.
- handle – Pointer to usart_dma_handle_t structure.
- xfer – I2S DMA transfer structure. See i2s_transfer_t.
- loopTransferCount – loop count

Return values

kStatus_Success –

FSL_I2S_DMA_DRIVER_VERSION

I2S DMA driver version 2.3.3.

typedef struct *_i2s_dma_handle* i2s_dma_handle_t

Members not to be accessed / modified outside of the driver.

typedef void (*i2s_dma_transfer_callback_t)(I2S_Type *base, *i2s_dma_handle_t* *handle, *status_t* completionStatus, void *userData)

Callback function invoked from DMA API on completion.

Param base
I2S base pointer.

Param handle
pointer to I2S transaction.

Param completionStatus
status of the transaction.

Param userData
optional pointer to user arguments data.

struct _i2s_dma_handle

#include <fsl_i2s_dma.h> i2s dma handle

Public Members

uint32_t state

Internal state of I2S DMA transfer

uint8_t bytesPerFrame

bytes per frame

i2s_dma_transfer_callback_t completionCallback

Callback function pointer

void *userData

Application data passed to callback

dma_handle_t *dmaHandle

DMA handle

volatile *i2s_transfer_t* i2sQueue[(4U)]

Transfer queue storing transfer buffers

volatile uint8_t queueUser

Queue index where user's next transfer will be stored

volatile uint8_t queueDriver

Queue index of buffer actually used by the driver

dma_descriptor_t *i2sLoopDMADescriptor
descriptor pool pointer

size_t i2sLoopDMADescriptorNum
number of descriptor in descriptors pool

2.28 I2S Driver

void I2S_TxInit(I2S_Type *base, const *i2s_config_t* *config)

Initializes the FLEXCOMM peripheral for I2S transmit functionality.

Ungates the FLEXCOMM clock and configures the module for I2S transmission using a configuration structure. The configuration structure can be custom filled or set with default values by I2S_TxGetDefaultConfig().

Note: This API should be called at the beginning of the application to use the I2S driver.

Parameters

- base – I2S base pointer.
- config – pointer to I2S configuration structure.

void I2S_RxInit(I2S_Type *base, const *i2s_config_t* *config)

Initializes the FLEXCOMM peripheral for I2S receive functionality.

Ungates the FLEXCOMM clock and configures the module for I2S receive using a configuration structure. The configuration structure can be custom filled or set with default values by I2S_RxGetDefaultConfig().

Note: This API should be called at the beginning of the application to use the I2S driver.

Parameters

- base – I2S base pointer.
- config – pointer to I2S configuration structure.

void I2S_TxGetDefaultConfig(*i2s_config_t* *config)

Sets the I2S Tx configuration structure to default values.

This API initializes the configuration structure for use in I2S_TxInit(). The initialized structure can remain unchanged in I2S_TxInit(), or it can be modified before calling I2S_TxInit(). Example:

```
i2s_config_t config;
I2S_TxGetDefaultConfig(&config);
```

Default values:

```
config->masterSlave = kI2S_MasterSlaveNormalMaster;
config->mode = kI2S_ModeI2sClassic;
config->rightLow = false;
config->leftJust = false;
config->pdmData = false;
config->sckPol = false;
config->wsPol = false;
```

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```
config->divider = 1;
config->oneChannel = false;
config->dataLength = 16;
config->frameLength = 32;
config->position = 0;
config->watermark = 4;
config->txEmptyZero = true;
config->pack48 = false;
```

Parameters

- config – pointer to I2S configuration structure.

void I2S_RxGetDefaultConfig(*i2s_config_t* *config)

Sets the I2S Rx configuration structure to default values.

This API initializes the configuration structure for use in I2S_RxInit(). The initialized structure can remain unchanged in I2S_RxInit(), or it can be modified before calling I2S_RxInit(). Example:

```
i2s_config_t config;
I2S_RxGetDefaultConfig(&config);
```

Default values:

```
config->masterSlave = kI2S_MasterSlaveNormalSlave;
config->mode = kI2S_ModeI2sClassic;
config->rightLow = false;
config->leftJust = false;
config->pdmData = false;
config->sckPol = false;
config->wsPol = false;
config->divider = 1;
config->oneChannel = false;
config->dataLength = 16;
config->frameLength = 32;
config->position = 0;
config->watermark = 4;
config->txEmptyZero = false;
config->pack48 = false;
```

Parameters

- config – pointer to I2S configuration structure.

void I2S_Deinit(I2S_Type *base)

De-initializes the I2S peripheral.

This API gates the FLEXCOMM clock. The I2S module can't operate unless I2S_TxInit or I2S_RxInit is called to enable the clock.

Parameters

- base – I2S base pointer.

void I2S_SetBitClockRate(I2S_Type *base, uint32_t sourceClockHz, uint32_t sampleRate, uint32_t bitWidth, uint32_t channelNumbers)

Transmitter/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 I2S_TxTransferCreateHandle(I2S_Type *base, *i2s_handle_t* *handle, *i2s_transfer_callback_t* callback, void *userData)

Initializes handle for transfer of audio data.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.
- callback – function to be called back when transfer is done or fails.
- userData – pointer to data passed to callback.

status_t I2S_TxTransferNonBlocking(I2S_Type *base, *i2s_handle_t* *handle, *i2s_transfer_t* transfer)

Begins or queue sending of the given data.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.
- transfer – data buffer.

Return values

- kStatus_Success –
- kStatus_I2S_Busy – if all queue slots are occupied with unsent buffers.

void I2S_TxTransferAbort(I2S_Type *base, *i2s_handle_t* *handle)

Aborts sending of data.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.

void I2S_RxTransferCreateHandle(I2S_Type *base, *i2s_handle_t* *handle, *i2s_transfer_callback_t* callback, void *userData)

Initializes handle for reception of audio data.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.
- callback – function to be called back when transfer is done or fails.
- userData – pointer to data passed to callback.

status_t I2S_RxTransferNonBlocking(I2S_Type *base, *i2s_handle_t* *handle, *i2s_transfer_t* transfer)

Begins or queue reception of data into given buffer.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.
- transfer – data buffer.

Return values

- kStatus_Success –
- kStatus_I2S_Busy – if all queue slots are occupied with buffers which are not full.

void I2S_RxTransferAbort(I2S_Type *base, *i2s_handle_t* *handle)

Aborts receiving of data.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.

status_t I2S_TransferGetCount(I2S_Type *base, *i2s_handle_t* *handle, size_t *count)

Returns number of bytes transferred so far.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.
- count – **[out]** number of bytes transferred so far by the non-blocking transaction.

Return values

- kStatus_Success –
- kStatus_NoTransferInProgress – there is no non-blocking transaction currently in progress.

status_t I2S_TransferGetErrorCount(I2S_Type *base, *i2s_handle_t* *handle, size_t *count)

Returns number of buffer underruns or overruns.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.
- count – **[out]** number of transmit errors encountered so far by the non-blocking transaction.

Return values

- kStatus_Success –
- kStatus_NoTransferInProgress – there is no non-blocking transaction currently in progress.

static inline void I2S_Enable(I2S_Type *base)

Enables I2S operation.

Parameters

- base – I2S base pointer.

void I2S_EnableSecondaryChannel(I2S_Type *base, uint32_t channel, bool oneChannel, uint32_t position)

Enables I2S secondary channel.

Parameters

- base – I2S base pointer.
- channel – seondary channel channel number, reference _i2s_secondary_channel.

- oneChannel – true is treated as single channel, functionality left channel for this pair.
- position – define the location within the frame of the data, should not bigger than 0x1FFU.

static inline void I2S_DisableSecondaryChannel(I2S_Type *base, uint32_t channel)

Disables I2S secondary channel.

Parameters

- base – I2S base pointer.
- channel – seondary channel channel number, reference _i2s_secondary_channel.

static inline void I2S_Disable(I2S_Type *base)

Disables I2S operation.

Parameters

- base – I2S base pointer.

static inline void I2S_EnableInterrupts(I2S_Type *base, uint32_t interruptMask)

Enables I2S FIFO interrupts.

Parameters

- base – I2S base pointer.
- interruptMask – bit mask of interrupts to enable. See i2s_flags_t for the set of constants that should be OR'd together to form the bit mask.

static inline void I2S_DisableInterrupts(I2S_Type *base, uint32_t interruptMask)

Disables I2S FIFO interrupts.

Parameters

- base – I2S base pointer.
- interruptMask – bit mask of interrupts to enable. See i2s_flags_t for the set of constants that should be OR'd together to form the bit mask.

static inline uint32_t I2S_GetEnabledInterrupts(I2S_Type *base)

Returns the set of currently enabled I2S FIFO interrupts.

Parameters

- base – I2S base pointer.

Returns

A bitmask composed of i2s_flags_t enumerators OR'd together to indicate the set of enabled interrupts.

status_t I2S_EmptyTxFifo(I2S_Type *base)

Flush the valid data in TX fifo.

Parameters

- base – I2S base pointer.

Returns

kStatus_Fail empty TX fifo failed, kStatus_Success empty tx fifo success.

void I2S_TxHandleIRQ(I2S_Type *base, *i2s_handle_t* *handle)

Invoked from interrupt handler when transmit FIFO level decreases.

Parameters

- base – I2S base pointer.

- handle – pointer to handle structure.

void I2S_RxHandleIRQ(I2S_Type *base, *i2s_handle_t* *handle)

Invoked from interrupt handler when receive FIFO level decreases.

Parameters

- base – I2S base pointer.
- handle – pointer to handle structure.

FSL_I2S_DRIVER_VERSION

I2S driver version 2.3.2.

_i2s_status I2S status codes.

Values:

enumerator kStatus_I2S_BufferComplete

Transfer from/into a single buffer has completed

enumerator kStatus_I2S_Done

All buffers transfers have completed

enumerator kStatus_I2S_Busy

Already performing a transfer and cannot queue another buffer

enum _i2s_flags

I2S flags.

Note: These enums are meant to be OR'd together to form a bit mask.

Values:

enumerator kI2S_TxErrorFlag

TX error interrupt

enumerator kI2S_TxLevelFlag

TX level interrupt

enumerator kI2S_RxErrorFlag

RX error interrupt

enumerator kI2S_RxLevelFlag

RX level interrupt

enum _i2s_master_slave

Master / slave mode.

Values:

enumerator kI2S_MasterSlaveNormalSlave

Normal slave

enumerator kI2S_MasterSlaveWsSyncMaster

WS synchronized master

enumerator kI2S_MasterSlaveExtSckMaster

Master using existing SCK

enumerator kI2S_MasterSlaveNormalMaster

Normal master

enum _i2s_mode

I2S mode.

Values:

enumerator kI2S_ModeI2sClassic

I2S classic mode

enumerator kI2S_ModeDspWs50

DSP mode, WS having 50% duty cycle

enumerator kI2S_ModeDspWsShort

DSP mode, WS having one clock long pulse

enumerator kI2S_ModeDspWsLong

DSP mode, WS having one data slot long pulse

_i2s_secondary_channel I2S secondary channel.

Values:

enumerator kI2S_SecondaryChannel1

secondary channel 1

enumerator kI2S_SecondaryChannel2

secondary channel 2

enumerator kI2S_SecondaryChannel3

secondary channel 3

typedef enum *_i2s_flags* i2s_flags_t

I2S flags.

Note: These enums are meant to be OR'd together to form a bit mask.

typedef enum *_i2s_master_slave* i2s_master_slave_t

Master / slave mode.

typedef enum *_i2s_mode* i2s_mode_t

I2S mode.

typedef struct *_i2s_config* i2s_config_t

I2S configuration structure.

typedef struct *_i2s_transfer* i2s_transfer_t

Buffer to transfer from or receive audio data into.

typedef struct *_i2s_handle* i2s_handle_t

Transactional state of the intialized transfer or receive I2S operation.

typedef void (*i2s_transfer_callback_t)(I2S_Type *base, *i2s_handle_t* *handle, *status_t* completionStatus, void *userData)

Callback function invoked from transactional API on completion of a single buffer transfer.

Param base
I2S base pointer.

Param handle
pointer to I2S transaction.

Param completionStatus
status of the transaction.

Param userData
optional pointer to user arguments data.

I2S_NUM_BUFFERS
Number of buffers .

struct _i2s_config
#include <fsl_i2s.h> I2S configuration structure.

Public Members

i2s_master_slave_t masterSlave
Master / slave configuration

i2s_mode_t mode
I2S mode

bool rightLow
Right channel data in low portion of FIFO

bool leftJust
Left justify data in FIFO

bool pdmData
Data source is the D-Mic subsystem

bool sckPol
SCK polarity

bool wsPol
WS polarity

uint16_t divider
Flexcomm function clock divider (1 - 4096)

bool oneChannel
true mono, false stereo

uint8_t dataLength
Data length (4 - 32)

uint16_t frameLength
Frame width (4 - 512)

uint16_t position
Data position in the frame

uint8_t watermark
FIFO trigger level

bool txEmptyZero
Transmit zero when buffer becomes empty or last item

bool pack48
Packing format for 48-bit data (false - 24 bit values, true - alternating 32-bit and 16-bit values)

struct _i2s_transfer
#include <fsl_i2s.h> Buffer to transfer from or receive audio data into.

Public Members

uint8_t *data
: Pointer to data buffer.

size_t dataSize
: Buffer size in bytes.

struct __i2s_handle
: *#include <fsl_i2s.h>* Members not to be accessed / modified outside of the driver.

Public Members

volatile uint32_t state
: State of transfer

i2s_transfer_callback_t completionCallback
: Callback function pointer

void *userData
: Application data passed to callback

bool oneChannel
: true mono, false stereo

uint8_t dataLength
: Data length (4 - 32)

bool pack48
: Packing format for 48-bit data (false - 24 bit values, true - alternating 32-bit and 16-bit values)

uint8_t watermark
: FIFO trigger level

bool useFifo48H
: When dataLength 17-24: true use FIFOWR48H, false use FIFOWR

volatile *i2s_transfer_t* i2sQueue[(4U)]
: Transfer queue storing transfer buffers

volatile uint8_t queueUser
: Queue index where user's next transfer will be stored

volatile uint8_t queueDriver
: Queue index of buffer actually used by the driver

volatile uint32_t errorCount
: Number of buffer underruns/overruns

volatile uint32_t transferCount
: Number of bytes transferred

2.29 IMU: Inter CPU Messaging Unit

status_t IMU_Init(imu_link_t link)

Initializes the IMU module.

This function sets IMU to initialized state, including:

- Flush the send FIFO.
- Unlock the send FIFO.
- Set the water mark to (IMU_MAX_MSG_FIFO_WATER_MARK)
- Flush the receive FIFO.

If IMU_BUSY_POLL_COUNT is defined and non-zero, the function will timeout after the specified number of polling iterations and return kStatus_Timeout if flushing the receive FIFO takes too long.

Parameters

- link – IMU link.

Return values

- kStatus_Success – The IMU was initialized successfully.
- kStatus_InvalidArgument – Invalid link parameter.
- kStatus_Timeout – Timeout occurred while flushing the receive FIFO.

Returns

status_t

void IMU_Deinit(imu_link_t link)

De-initializes the IMU module.

Parameters

- link – IMU link.

static inline void IMU_WriteMsg(imu_link_t link, uint32_t msg)

Write one message to TX FIFO.

This function writes message to the TX FIFO, user need to make sure there is empty space in the TX FIFO, and TX FIFO not locked before calling this function.

Parameters

- link – IMU link.
- msg – The message to send.

static inline uint32_t IMU_ReadMsg(imu_link_t link)

Read one message from RX FIFO.

User need to make sure there is available message in the RX FIFO.

Parameters

- link – IMU link.

Returns

The message.

int32_t IMU_SendMsgsBlocking(imu_link_t link, const uint32_t *msgs, int32_t msgCount, bool lockSendFifo)

Blocking to send messages.

This function blocks until all messages have been filled to TX FIFO.

- If the TX FIFO is locked, this function returns IMU_ERR_TX_FIFO_LOCKED.
- If TX FIFO not locked, this function waits the available empty slot in TX FIFO, and fills the message to TX FIFO.
- To lock TX FIFO after filling all messages, set lockSendFifo to true.

If IMU_BUSY_POLL_COUNT is defined and non-zero, the function will timeout after the specified number of polling iterations and return IMU_ERR_TIMEOUT if waiting for FIFO space takes too long.

Parameters

- link – IMU link.
- msgs – The messages to send.
- msgCount – Message count, one message is a 32-bit word.
- lockSendFifo – If set to true, the TX FIFO is locked after all messages filled to TX FIFO.

Returns

If TX FIFO is locked, this function returns IMU_ERR_TX_FIFO_LOCKED. If a timeout occurs while waiting for FIFO space, it returns IMU_ERR_TIMEOUT. Otherwise, this function returns the actual message count sent out, which equals msgCount because this function is blocking until all messages have been filled into TX FIFO or a timeout occurs.

int32_t IMU_TrySendMsgs(imu_link_t link, const uint32_t *msgs, int32_t msgCount, bool lockSendFifo)

Try to send messages.

This function is similar with IMU_SendMsgsBlocking, the difference is, this function tries to send as many as possible, if there is not enough empty slot in TX FIFO, this function fills messages to available empty slots and returns how many messages have been filled.

- If the TX FIFO is locked, this function returns IMU_ERR_TX_FIFO_LOCKED.
- If TX FIFO not locked, this function fills messages to TX FIFO empty slot, and returns how many messages have been filled.
- If lockSendFifo is set to true, TX FIFO is locked after all messages have been filled to TX FIFO. In other word, TX FIFO is locked if the function return value equals msgCount, when lockSendFifo set to true.

Parameters

- link – IMU link.
- msgs – The messages to send.
- msgCount – Message count, one message is a 32-bit word.
- lockSendFifo – If set to true, the TX FIFO is locked after all messages filled to TX FIFO.

Returns

If TX FIFO is locked, this function returns IMU_ERR_TX_FIFO_LOCKED, otherwise, this function returns the actual message count sent out.

int32_t IMU_TryReceiveMsgs(imu_link_t link, uint32_t *msgs, int32_t desiredMsgCount, bool *needAckLock)

Try to receive messages.

This function tries to read messages from RX FIFO. It reads the messages already exists in RX FIFO and returns the actual read count.

- If the RX FIFO has enough messages, this function reads the messages and returns.
- If the RX FIFO does not have enough messages, this function the messages in RX FIFO and returns the actual read count.
- During message reading, if RX FIFO is empty and locked, in this case peer CPU will not send message until current CPU send lock ack message. Then this function returns the message count actually received, and sets needAckLock to true to inform upper layer.

Parameters

- link – IMU link.
- msgs – The buffer to read messages.
- desiredMsgCount – Desired read count, one message is a 32-bit word.
- needAckLock – Upper layer should always check this value. When this is set to true by this function, upper layer should send lock ack message to peer CPU.

Returns

Count of messages actually received.

int32_t IMU_ReceiveMsgsBlocking(imu_link_t link, uint32_t *msgs, int32_t desiredMsgCount, bool *needAckLock)

Blocking to receive messages.

This function blocks until all desired messages have been received or the RX FIFO is locked.

- If the RX FIFO has enough messages, this function reads the messages and returns.
- If the RX FIFO does not have enough messages, this function waits for the new messages.
- During message reading, if RX FIFO is empty and locked, in this case peer CPU will not send message until current CPU send lock ack message. Then this function returns the message count actually received, and sets needAckLock to true to inform upper layer.

Parameters

- link – IMU link.
- msgs – The buffer to read messages.
- desiredMsgCount – Desired read count, one message is a 32-bit word.
- needAckLock – Upper layer should always check this value. When this is set to true by this function, upper layer should send lock ack message to peer CPU.

Returns

Count of messages actually received.

int32_t IMU_SendMsgPtrBlocking(imu_link_t link, uint32_t msgPtr, bool lockSendFifo)

Blocking to send messages pointer.

Compared with IMU_SendMsgsBlocking, this function fills message pointer to TX FIFO, but not the message content.

This function blocks until the message pointer is filled to TX FIFO.

- If the TX FIFO is locked, this function returns IMU_ERR_TX_FIFO_LOCKED.
- If TX FIFO not locked, this function waits the available empty slot in TX FIFO, and fills the message pointer to TX FIFO.
- To lock TX FIFO after filling the message pointer, set lockSendFifo to true.

If IMU_BUSY_POLL_COUNT is defined and non-zero, the function will timeout after the specified number of polling iterations and return IMU_ERR_TIMEOUT if waiting for FIFO space takes too long.

Parameters

- link – IMU link.
- msgPtr – The buffer pointer to message to send.
- lockSendFifo – If set to true, the TX FIFO is locked after message pointer filled to TX FIFO.

Returns

If TX FIFO is locked, this function returns IMU_ERR_TX_FIFO_LOCKED. If a timeout occurs while waiting for FIFO space, it returns IMU_ERR_TIMEOUT. Otherwise, this function returns 0 to indicate success.

static inline void IMU_LockSendFifo(imu_link_t link, bool lock)

Lock or unlock the TX FIFO.

Parameters

- link – IMU link.
- lock – Use true to lock the FIFO, use false to unlock.

void IMU_FlushSendFifo(imu_link_t link)

Flush the send FIFO.

Flush all messages in send FIFO.

Parameters

- link – IMU link.

static inline void IMU_SetSendFifoWaterMark(imu_link_t link, uint8_t waterMark)

Set send FIFO warter mark.

The warter mark must be less than IMU_MAX_MSG_FIFO_WATER_MARK, i.e. 0 < waterMark <= IMU_MAX_MSG_FIFO_WATER_MARK.

Parameters

- link – IMU link.
- waterMark – Send FIFO warter mark.

static inline uint32_t IMU_GetReceivedMsgCount(imu_link_t link)

Get the message count in receive FIFO.

Parameters

- link – IMU link.

Returns

The message count in receive FIFO.

static inline uint32_t IMU_GetSendFifoEmptySpace(imu_link_t link)

Get the empty slot in send FIFO.

Parameters

- link – IMU link.

Returns
The empty slot count in send FIFO.

uint32_t IMU_GetStatusFlags(imu_link_t link)
Gets the IMU status flags.

Parameters
- link – IMU link.

Returns
Bit mask of the IMU status flags, see _imu_status_flags.

static inline void IMU_ClearPendingInterrupts(imu_link_t link, uint32_t mask)
Clear the IMU IRQ.

Parameters
- link – IMU link.
- mask – Bit mask of the interrupts to clear, see _imu_interrupts.

FSL_IMU_DRIVER_VERSION
IMU driver version.

enum _imu_status_flags
IMU status flags. .

Values:

enumerator kIMU_TxFifoEmpty

enumerator kIMU_TxFifoFull

enumerator kIMU_TxFifoAlmostFull

enumerator kIMU_TxFifoLocked

enumerator kIMU_RxFifoEmpty

enumerator kIMU_RxFifoFull

enumerator kIMU_RxFifoAlmostFull

enumerator kIMU_RxFifoLocked

enum _imu_interrupts
IMU interrupt. .

Values:

enumerator kIMU_RxMsgReadyInterrupt

enumerator kIMU_TxFifoSpaceAvailableInterrupt

IMU_MSG_FIFO_STATUS_MSG_FIFO_LOCKED_MASK

IMU_MSG_FIFO_STATUS_MSG_FIFO_ALMOST_FULL_MASK

IMU_MSG_FIFO_STATUS_MSG_FIFO_FULL_MASK

IMU_MSG_FIFO_STATUS_MSG_FIFO_EMPTY_MASK

IMU_MSG_FIFO_STATUS_MSG_COUNT_MASK

IMU_MSG_FIFO_STATUS_MSG_COUNT_SHIFT

IMU_MSG_FIFO_STATUS_WR_PTR_MASK

IMU_MSG_FIFO_STATUS_WR_PTR_SHIFT

IMU_MSG_FIFO_STATUS_RD_PTR_MASK

IMU_MSG_FIFO_STATUS_RD_PTR_SHIFT

IMU_MSG_FIFO_CNTL_MSG_RDY_INT_CLR_MASK

IMU_MSG_FIFO_CNTL_SP_AV_INT_CLR_MASK

IMU_MSG_FIFO_CNTL_FIFO_FLUSH_MASK

IMU_MSG_FIFO_CNTL_WAIT_FOR_ACK_MASK

IMU_MSG_FIFO_CNTL_FIFO_FULL_WATERMARK_MASK

IMU_MSG_FIFO_CNTL_FIFO_FULL_WATERMARK_SHIFT

IMU_MSG_FIFO_CNTL_FIFO_FULL_WATERMARK(x)

IMU_WR_MSG(link, msg)

IMU_RD_MSG(link)

IMU_RX_FIFO_LOCKED(link)

IMU_TX_FIFO_LOCKED(link)

IMU_TX_FIFO_ALMOST_FULL(link)

IMU_RX_FIFO_EMPTY(link)
: Get Rx FIFO empty status.

IMU_LOCK_TX_FIFO(link)

IMU_UNLOCK_TX_FIFO(link)

IMU_RX_FIFO_MSG_COUNT(link)

IMU_TX_FIFO_MSG_COUNT(link)

IMU_RX_FIFO_MSG_COUNT_FROM_STATUS(rxFifoStatus)

IMU_RX_FIFO_LOCKED_FROM_STATUS(rxFifoStatus)

IMU_TX_FIFO_STATUS(link)

IMU_RX_FIFO_STATUS(link)

IMU_TX_FIFO_CNTL(link)

IMU_ERR_TX_FIFO_LOCKED
: IMU driver returned error value.

IMU_ERR_TIMEOUT
: IMU driver returned error value timeout.

IMU_MSG_FIFO_MAX_COUNT
: Maximum message numbers in FIFO.

IMU_MAX_MSG_FIFO_WATER_MARK
: Maximum message FIFO warter mark.

IMU_FIFO_SW_WRAPAROUND(ptr)

IMU_WR_PTR(link)

IMU_RD_PTR(link)

IMU_BUSY_POLL_COUNT

Maximum polling iterations for IMU waiting loops.

This parameter defines the maximum number of iterations for any polling loop in the IMU driver code before timing out and returning an error.

It applies to all waiting loops in IMU driver.

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 sensors don't respond or if communication interfaces fail.

struct IMU_Type

#include <fsl_imu.h> IMU register structure.

2.30 INPUTMUX: Input Multiplexing Driver

FSL_INPUTMUX_DRIVER_VERSION

Group interrupt driver version for SDK.

enum _inputmux_connection_t

INPUTMUX connections type.

Values:

enumerator kINPUTMUX_Gpio3Inp0ToSct0

SCT INMUX.

enumerator kINPUTMUX_Gpio4Inp1ToSct0

enumerator kINPUTMUX_Gpio22Inp2ToSct0

enumerator kINPUTMUX_Gpio23Inp3ToSct0

enumerator kINPUTMUX_Gpio26Inp4ToSct0

enumerator kINPUTMUX_Gpio27Inp5ToSct0

enumerator kINPUTMUX_Gpio35Inp6ToSct0

enumerator kINPUTMUX_Gpio36Inp7ToSct0

enumerator kINPUTMUX_Ctimer0Mat0ToSct0

enumerator kINPUTMUX_Ctimer1Mat0ToSct0

enumerator kINPUTMUX_Ctimer2Mat0ToSct0

enumerator kINPUTMUX_Ctimer3Mat0ToSct0

enumerator kINPUTMUX_GpioIntBmatchToSct0

enumerator kINPUTMUX_SharedI2s0SclkToSct0

enumerator kINPUTMUX_SharedI2s1SclkToSct0

enumerator kINPUTMUX_SharedI2s0WsToSct0

enumerator kINPUTMUX_SharedI2s1WsToSct0

enumerator kINPUTMUX_MclkToSct0

enumerator kINPUTMUX_ArmTxevToSct0

enumerator kINPUTMUX_DebugHaltedToSct0

Pin Interrupt.

enumerator kINPUTMUX_GpioPort0Pin0ToPintsel

enumerator kINPUTMUX_GpioPort0Pin1ToPintsel

enumerator kINPUTMUX_GpioPort0Pin2ToPintsel

enumerator kINPUTMUX_GpioPort0Pin3ToPintsel

enumerator kINPUTMUX_GpioPort0Pin4ToPintsel

enumerator kINPUTMUX_GpioPort0Pin5ToPintsel

enumerator kINPUTMUX_GpioPort0Pin6ToPintsel

enumerator kINPUTMUX_GpioPort0Pin7ToPintsel

enumerator kINPUTMUX_GpioPort0Pin8ToPintsel

enumerator kINPUTMUX_GpioPort0Pin9ToPintsel

enumerator kINPUTMUX_GpioPort0Pin10ToPintsel

enumerator kINPUTMUX_GpioPort0Pin11ToPintsel

enumerator kINPUTMUX_GpioPort0Pin12ToPintsel

enumerator kINPUTMUX_GpioPort0Pin13ToPintsel

enumerator kINPUTMUX_GpioPort0Pin14ToPintsel

enumerator kINPUTMUX_GpioPort0Pin15ToPintsel

enumerator kINPUTMUX_GpioPort0Pin16ToPintsel

enumerator kINPUTMUX_GpioPort0Pin17ToPintsel

enumerator kINPUTMUX_GpioPort0Pin18ToPintsel

enumerator kINPUTMUX_GpioPort0Pin19ToPintsel

enumerator kINPUTMUX_GpioPort0Pin20ToPintsel

enumerator kINPUTMUX_GpioPort0Pin21ToPintsel

enumerator kINPUTMUX_GpioPort0Pin22ToPintsel

enumerator kINPUTMUX_GpioPort0Pin23ToPintsel

enumerator kINPUTMUX_GpioPort0Pin24ToPintsel

enumerator kINPUTMUX_GpioPort0Pin25ToPintsel

enumerator kINPUTMUX_GpioPort0Pin26ToPintsel

enumerator kINPUTMUX_GpioPort0Pin27ToPintsel

enumerator kINPUTMUX_GpioPort0Pin28ToPintsel

enumerator kINPUTMUX_GpioPort0Pin29ToPintsel

enumerator kINPUTMUX_GpioPort0Pin30ToPintsel

enumerator kINPUTMUX_GpioPort0Pin31ToPintsel

enumerator kINPUTMUX_GpioPort1Pin0ToPintsel

enumerator kINPUTMUX_GpioPort1Pin1ToPintsel

enumerator kINPUTMUX_GpioPort1Pin2ToPintsel

enumerator kINPUTMUX_GpioPort1Pin3ToPintsel

enumerator kINPUTMUX_GpioPort1Pin4ToPintsel

enumerator kINPUTMUX_GpioPort1Pin5ToPintsel

enumerator kINPUTMUX_GpioPort1Pin6ToPintsel

enumerator kINPUTMUX_GpioPort1Pin7ToPintsel

enumerator kINPUTMUX_GpioPort1Pin8ToPintsel

enumerator kINPUTMUX_GpioPort1Pin9ToPintsel

enumerator kINPUTMUX_GpioPort1Pin10ToPintsel

enumerator kINPUTMUX_GpioPort1Pin11ToPintsel

enumerator kINPUTMUX_GpioPort1Pin12ToPintsel

enumerator kINPUTMUX_GpioPort1Pin13ToPintsel

enumerator kINPUTMUX_GpioPort1Pin14ToPintsel

enumerator kINPUTMUX_GpioPort1Pin15ToPintsel

enumerator kINPUTMUX_GpioPort1Pin16ToPintsel

enumerator kINPUTMUX_GpioPort1Pin17ToPintsel

enumerator kINPUTMUX_GpioPort1Pin18ToPintsel

enumerator kINPUTMUX_GpioPort1Pin19ToPintsel

enumerator kINPUTMUX_GpioPort1Pin20ToPintsel

enumerator kINPUTMUX_GpioPort1Pin21ToPintsel

enumerator kINPUTMUX_GpioPort1Pin22ToPintsel

enumerator kINPUTMUX_GpioPort1Pin23ToPintsel

enumerator kINPUTMUX_GpioPort1Pin24ToPintsel

enumerator kINPUTMUX_GpioPort1Pin25ToPintsel

enumerator kINPUTMUX_GpioPort1Pin26ToPintsel

enumerator kINPUTMUX_GpioPort1Pin27ToPintsel

enumerator kINPUTMUX_GpioPort1Pin28ToPintsel

enumerator kINPUTMUX_GpioPort1Pin29ToPintsel

enumerator kINPUTMUX_GpioPort1Pin30ToPintsel

enumerator kINPUTMUX_GpioPort1Pin31ToPintsel

Frequency measure.

enumerator kINPUTMUX_SysoscToFreqmeas

enumerator kINPUTMUX_SfroToFreqmeas

enumerator kINPUTMUX_FfroToFreqmeas

enumerator kINPUTMUX_LposcToFreqmeas

enumerator kINPUTMUX_Xtal32kToFreqmeas

enumerator kINPUTMUX_C0FrHclkToFreqmeas

enumerator kINPUTMUX_FreqmeGpioClkInToFreqmeas

enumerator kINPUTMUX_T3pllMcuFlexspiClkToFreqmeas

enumerator kINPUTMUX_TddrMcuFlexspiClkToFreqmeas

enumerator kINPUTMUX_TddrMcuEnetClkToFreqmeas

enumerator kINPUTMUX_TcpuMcuFlexspiClkToFreqmeas

enumerator kINPUTMUX_Nco32kToFreqmeas

enumerator kINPUTMUX_PmuFclkToFreqmeas

enumerator kINPUTMUX_Osc32kClk1hzToFreqmeas

enumerator kINPUTMUX_Osc32kClk1khzToFreqmeas

enumerator kINPUTMUX_LcdFclkToFreqmeas

enumerator kINPUTMUX_Flexcomm0FclkToFreqmeas

enumerator kINPUTMUX_DmicFclkToFreqmeas

enumerator kINPUTMUX_Flexspi0FclkToFreqmeas

enumerator kINPUTMUX_TcpuMcuClkToFreqmeas

enumerator kINPUTMUX_AvpllCh2ClkoutToFreqmeas

CTmier0 capture input mux.

enumerator kINPUTMUX_Gpio0Inp0ToTimer0CaptureChannels

enumerator kINPUTMUX_Gpio1Inp1ToTimer0CaptureChannels

enumerator kINPUTMUX_Gpio12Inp2ToTimer0CaptureChannels

enumerator kINPUTMUX_Gpio13Inp3ToTimer0CaptureChannels

enumerator kINPUTMUX_Gpio14Inp4ToTimer0CaptureChannels

enumerator kINPUTMUX_Gpio21Inp5ToTimer0CaptureChannels

enumerator kINPUTMUX_Gpio24Inp6ToTimer0CaptureChannels

enumerator kINPUTMUX_Gpio25Inp7ToTimer0CaptureChannels

enumerator kINPUTMUX_Gpio37Inp8ToTimer0CaptureChannels

enumerator kINPUTMUX_Gpio38Inp9ToTimer0CaptureChannels

enumerator kINPUTMUX_Gpio39Inp10ToTimer0CaptureChannels

enumerator kINPUTMUX_Gpio51Inp11ToTimer0CaptureChannels

enumerator kINPUTMUX_Gpio52Inp12ToTimer0CaptureChannels

enumerator kINPUTMUX_Gpio53Inp13ToTimer0CaptureChannels

enumerator kINPUTMUX_Gpio54Inp14ToTimer0CaptureChannels

enumerator kINPUTMUX_SharedI2s0WsToTimer0CaptureChannels

enumerator kINPUTMUX_SharedI2s1WsToTimer0CaptureChannels

enumerator kINPUTMUX_BtuHostTrigger0ToTimer0CaptureChannels

enumerator kINPUTMUX_BtuHostTrigger1ToTimer0CaptureChannels

enumerator kINPUTMUX_BtuHostTrigger2ToTimer0CaptureChannels

enumerator kINPUTMUX_FlexcommDmaDone0ToTimer0CaptureChannels

enumerator kINPUTMUX_FlexcommDmaDone1ToTimer0CaptureChannels

enumerator kINPUTMUX_FlexcommDmaCmpltDone0ToTimer0CaptureChannels

enumerator kINPUTMUX_FlexcommDmaCmpltDone1ToTimer0CaptureChannels

CTmier1 capture input mux.

enumerator kINPUTMUX_Gpio0Inp0ToTimer1CaptureChannels

enumerator kINPUTMUX_Gpio1Inp1ToTimer1CaptureChannels

enumerator kINPUTMUX_Gpio12Inp2ToTimer1CaptureChannels

enumerator kINPUTMUX_Gpio13Inp3ToTimer1CaptureChannels

enumerator kINPUTMUX_Gpio14Inp4ToTimer1CaptureChannels

enumerator kINPUTMUX_Gpio21Inp5ToTimer1CaptureChannels

enumerator kINPUTMUX_Gpio24Inp6ToTimer1CaptureChannels

enumerator kINPUTMUX_Gpio25Inp7ToTimer1CaptureChannels

enumerator kINPUTMUX_Gpio37Inp8ToTimer1CaptureChannels

enumerator kINPUTMUX_Gpio38Inp9ToTimer1CaptureChannels

enumerator kINPUTMUX_Gpio39Inp10ToTimer1CaptureChannels

enumerator kINPUTMUX_Gpio51Inp11ToTimer1CaptureChannels

enumerator kINPUTMUX_Gpio52Inp12ToTimer1CaptureChannels

enumerator kINPUTMUX_Gpio53Inp13ToTimer1CaptureChannels

enumerator kINPUTMUX_Gpio54Inp14ToTimer1CaptureChannels

enumerator kINPUTMUX_SharedI2s0WsToTimer1CaptureChannels

enumerator kINPUTMUX_SharedI2s1WsToTimer1CaptureChannels

enumerator kINPUTMUX_EnetToTimer1CaptureChannels

enumerator kINPUTMUX_BtuHostTrigger0ToTimer1CaptureChannels

enumerator kINPUTMUX_BtuHostTrigger1ToTimer1CaptureChannels

enumerator kINPUTMUX_BtuHostTrigger2ToTimer1CaptureChannels

CTmier2 capture input mux.

enumerator kINPUTMUX_Gpio0Inp0ToTimer2CaptureChannels

enumerator kINPUTMUX_Gpio1Inp1ToTimer2CaptureChannels

enumerator kINPUTMUX_Gpio12Inp2ToTimer2CaptureChannels

enumerator kINPUTMUX_Gpio13Inp3ToTimer2CaptureChannels

enumerator kINPUTMUX_Gpio14Inp4ToTimer2CaptureChannels

enumerator kINPUTMUX_Gpio21Inp5ToTimer2CaptureChannels

enumerator kINPUTMUX_Gpio24Inp6ToTimer2CaptureChannels

enumerator kINPUTMUX_Gpio25Inp7ToTimer2CaptureChannels

enumerator kINPUTMUX_Gpio37Inp8ToTimer2CaptureChannels

enumerator kINPUTMUX_Gpio38Inp9ToTimer2CaptureChannels

enumerator kINPUTMUX_Gpio39Inp10ToTimer2CaptureChannels

enumerator kINPUTMUX_Gpio51Inp11ToTimer2CaptureChannels

enumerator kINPUTMUX_Gpio52Inp12ToTimer2CaptureChannels

enumerator kINPUTMUX_Gpio53Inp13ToTimer2CaptureChannels

enumerator kINPUTMUX_Gpio54Inp14ToTimer2CaptureChannels

enumerator kINPUTMUX_SharedI2s0WsToTimer2CaptureChannels

enumerator kINPUTMUX_SharedI2s1WsToTimer2CaptureChannels

enumerator kINPUTMUX_BtuHostTrigger0ToTimer2CaptureChannels

enumerator kINPUTMUX_BtuHostTrigger1ToTimer2CaptureChannels

enumerator kINPUTMUX_BtuHostTrigger2ToTimer2CaptureChannels

enumerator kINPUTMUX_FlexcommDmaDone0ToTimer2CaptureChannels

enumerator kINPUTMUX_FlexcommDmaDone1ToTimer2CaptureChannels

enumerator kINPUTMUX_FlexcommDmaCmpltDone0ToTimer2CaptureChannels

enumerator kINPUTMUX_FlexcommDmaCmpltDone1ToTimer2CaptureChannels

CTmier3 capture input mux.

enumerator kINPUTMUX_Gpio0Inp0ToTimer3CaptureChannels

enumerator kINPUTMUX_Gpio1Inp1ToTimer3CaptureChannels

enumerator kINPUTMUX_Gpio12Inp2ToTimer3CaptureChannels

enumerator kINPUTMUX_Gpio13Inp3ToTimer3CaptureChannels

enumerator kINPUTMUX_Gpio14Inp4ToTimer3CaptureChannels

enumerator kINPUTMUX_Gpio21Inp5ToTimer3CaptureChannels

enumerator kINPUTMUX_Gpio24Inp6ToTimer3CaptureChannels

enumerator kINPUTMUX_Gpio25Inp7ToTimer3CaptureChannels

enumerator kINPUTMUX_Gpio37Inp8ToTimer3CaptureChannels

enumerator kINPUTMUX_Gpio38Inp9ToTimer3CaptureChannels

enumerator kINPUTMUX_Gpio39Inp10ToTimer3CaptureChannels

enumerator kINPUTMUX_Gpio51Inp11ToTimer3CaptureChannels

enumerator kINPUTMUX_Gpio52Inp12ToTimer3CaptureChannels

enumerator kINPUTMUX_Gpio53Inp13ToTimer3CaptureChannels

enumerator kINPUTMUX_Gpio54Inp14ToTimer3CaptureChannels

enumerator kINPUTMUX_SharedI2s0WsToTimer3CaptureChannels

enumerator kINPUTMUX_SharedI2s1WsToTimer3CaptureChannels

enumerator kINPUTMUX_BtuHostTrigger0ToTimer3CaptureChannels

enumerator kINPUTMUX_BtuHostTrigger1ToTimer3CaptureChannels

enumerator kINPUTMUX_BtuHostTrigger2ToTimer3CaptureChannels
DMA0 ITRIG.

enumerator kINPUTMUX_NsGpioPint0ToDma0

enumerator kINPUTMUX_NsGpioPint1ToDma0

enumerator kINPUTMUX_NsGpioPint2ToDma0

enumerator kINPUTMUX_NsGpioPint3ToDma0

enumerator kINPUTMUX_Ctimer0M0ToDma0

enumerator kINPUTMUX_Ctimer0M1ToDma0

enumerator kINPUTMUX_Ctimer1M0ToDma0

enumerator kINPUTMUX_Ctimer1M1ToDma0

enumerator kINPUTMUX_Ctimer2M0ToDma0

enumerator kINPUTMUX_Ctimer2M1ToDma0

enumerator kINPUTMUX_Ctimer3M0ToDma0

enumerator kINPUTMUX_Ctimer3M1ToDma0

enumerator kINPUTMUX_Dma0TrigOutAToDma0

enumerator kINPUTMUX_Dma0TrigOutBToDma0

enumerator kINPUTMUX_Dma0TrigOutCToDma0

enumerator kINPUTMUX_Dma0TrigOutDToDma0

enumerator kINPUTMUX_Sct0Dmac0ToDma0

enumerator kINPUTMUX_Sct0Dmac1ToDma0

enumerator kINPUTMUX_EnetMac0DmaReq0ToDma0

enumerator kINPUTMUX_EnetMac0DmaReq1ToDma0

enumerator kINPUTMUX_UsimDmaRxSingleToDma0

enumerator kINPUTMUX_UsimDmaTxSingleToDma0

enumerator kINPUTMUX_GauGpadc0DmaSingleToDma0

enumerator kINPUTMUX_GauGpadc1DmaSingleToDma0

enumerator kINPUTMUX_GauGpdacaDmaSingleToDma0

enumerator kINPUTMUX_GauGpdacbDmaSingleToDma0

enumerator kINPUTMUX_FlexspiRxToDma0

enumerator kINPUTMUX_FlexspiTxToDma0

enumerator kINPUTMUX_LcdRxRegToDmaSingleToDma0

enumerator kINPUTMUX_LcdTxRegToDmaSingleToDma0
DMA1 ITRIG.

enumerator kINPUTMUX_NsGpioPint0ToDma1

enumerator kINPUTMUX_NsGpioPint1ToDma1

enumerator kINPUTMUX_NsGpioPint2ToDma1

enumerator kINPUTMUX_NsGpioPint3ToDma1

enumerator kINPUTMUX_Ctimer0M0ToDma1

enumerator kINPUTMUX_Ctimer0M1ToDma1

enumerator kINPUTMUX_Ctimer1M0ToDma1

enumerator kINPUTMUX_Ctimer1M1ToDma1

enumerator kINPUTMUX_Ctimer2M0ToDma1

enumerator kINPUTMUX_Ctimer2M1ToDma1

enumerator kINPUTMUX_Ctimer3M0ToDma1

enumerator kINPUTMUX_Ctimer3M1ToDma1

enumerator kINPUTMUX_Dma1TrigOutAToDma1

enumerator kINPUTMUX_Dma1TrigOutBToDma1

enumerator kINPUTMUX_Dma1TrigOutCToDma1

enumerator kINPUTMUX_Dma1TrigOutDToDma1

enumerator kINPUTMUX_Sct0Dmac0ToDma1

enumerator kINPUTMUX_Sct0Dmac1ToDma1

enumerator kINPUTMUX_EnetMac0DmaReq0ToDma1

enumerator kINPUTMUX_EnetMac0DmaReq1ToDma1

enumerator kINPUTMUX_UsimDmaRxSingleToDma1

enumerator kINPUTMUX_UsimDmaTxSingleToDma1

enumerator kINPUTMUX_GauGpadc0DmaSingleToDma1

enumerator kINPUTMUX_GauGpadc1DmaSingleToDma1

enumerator kINPUTMUX_GauGpdacaDmaSingleToDma1

enumerator kINPUTMUX_GauGpdacbDmaSingleToDma1

enumerator kINPUTMUX_FlexspiRxToDma1

enumerator kINPUTMUX_FlexspiTxToDma1

enumerator kINPUTMUX_LcdRxRegToDmaSingleToDma1

enumerator kINPUTMUX_LcdTxRegToDmaSingleToDma1

DMA0 OTRIG.

enumerator kINPUTMUX_Dma0OtrigChannel0ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel1ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel2ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel3ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel4ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel5ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel6ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel7ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel8ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel9ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel10ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel11ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel12ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel13ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel14ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel15ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel16ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel17ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel18ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel19ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel20ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel21ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel22ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel23ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel24ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel25ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel26ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel27ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel28ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel29ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel30ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel31ToTriginChannels

enumerator kINPUTMUX_Dma0OtrigChannel32ToTriginChannels
DMA1 OTRIG.

enumerator kINPUTMUX_Dma1OtrigChannel0ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel1ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel2ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel3ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel4ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel5ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel6ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel7ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel8ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel9ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel10ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel11ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel12ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel13ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel14ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel15ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel16ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel17ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel18ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel19ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel20ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel21ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel22ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel23ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel24ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel25ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel26ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel27ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel28ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel29ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel30ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel31ToTriginChannels

enumerator kINPUTMUX_Dma1OtrigChannel32ToTriginChannels

enum _inputmux_signal_t

INPUTMUX signal enable/disable type.

Values:

enumerator kINPUTMUX_Dmac0InputTriggerPint0Ena

DMA0 input trigger source enable.

enumerator kINPUTMUX_Dmac0InputTriggerPint1Ena

enumerator kINPUTMUX_Dmac0InputTriggerPint2Ena

enumerator kINPUTMUX_Dmac0InputTriggerPint3Ena

enumerator kINPUTMUX_Dmac0InputTriggerCtimer0M0Ena

enumerator kINPUTMUX_Dmac0InputTriggerCtimer0M1Ena

enumerator kINPUTMUX_Dmac0InputTriggerCtimer1M0Ena

enumerator kINPUTMUX_Dmac0InputTriggerCtimer1M1Ena

enumerator kINPUTMUX_Dmac0InputTriggerCtimer2M0Ena

enumerator kINPUTMUX_Dmac0InputTriggerCtimer2M1Ena

enumerator kINPUTMUX_Dmac0InputTriggerCtimer3M0Ena

enumerator kINPUTMUX_Dmac0InputTriggerCtimer3M1Ena

enumerator kINPUTMUX_Dmac0InputTriggerDma0OutAEna

enumerator kINPUTMUX_Dmac0InputTriggerDma0OutBEna

enumerator kINPUTMUX_Dmac0InputTriggerDma0OutCEna

enumerator kINPUTMUX_Dmac0InputTriggerDma0OutDEna

enumerator kINPUTMUX_Dmac0InputTriggerSct0Dmac0Ena

enumerator kINPUTMUX_Dmac0InputTriggerSct0Dmac1Ena

enumerator kINPUTMUX_Dmac0InputTriggerEnetMac0DmaReq0Ena

enumerator kINPUTMUX_Dmac0InputTriggerEnetMac0DmaReq1Ena

enumerator kINPUTMUX_Dmac0InputTriggerUsimDmaRxSingleEna

enumerator kINPUTMUX_Dmac0InputTriggerUsimDmaTxSingleEna

enumerator kINPUTMUX_Dmac0InputTriggerGauGpadc0DmaSingleEna

enumerator kINPUTMUX_Dmac0InputTriggerGauGpadc1DmaSingleEna

enumerator kINPUTMUX_Dmac0InputTriggerGauGpdacaDmaSingleEna

enumerator kINPUTMUX_Dmac0InputTriggerGauGpdacbDmaSingleEna

enumerator kINPUTMUX_Dmac0InputTriggerFlexspiRxEna

enumerator kINPUTMUX_Dmac0InputTriggerFlexspiTxEna

enumerator kINPUTMUX_Dmac0InputTriggerLcdRxRegToDmaSingleEna

enumerator kINPUTMUX_Dmac0InputTriggerLcdTxRegToDmaSingleEna

DMA1 input trigger source enable.

enumerator kINPUTMUX_Dmac1InputTriggerPint0Ena

enumerator kINPUTMUX_Dmac1InputTriggerPint1Ena

enumerator kINPUTMUX_Dmac1InputTriggerPint2Ena

enumerator kINPUTMUX_Dmac1InputTriggerPint3Ena

enumerator kINPUTMUX_Dmac1InputTriggerCtimer0M0Ena

enumerator kINPUTMUX_Dmac1InputTriggerCtimer0M1Ena

enumerator kINPUTMUX_Dmac1InputTriggerCtimer1M0Ena

enumerator kINPUTMUX_Dmac1InputTriggerCtimer1M1Ena

enumerator kINPUTMUX_Dmac1InputTriggerCtimer2M0Ena

enumerator kINPUTMUX_Dmac1InputTriggerCtimer2M1Ena

enumerator kINPUTMUX_Dmac1InputTriggerCtimer3M0Ena

enumerator kINPUTMUX_Dmac1InputTriggerCtimer3M1Ena

enumerator kINPUTMUX_Dmac1InputTriggerDma1OutAEna

enumerator kINPUTMUX_Dmac1InputTriggerDma1OutBEna

enumerator kINPUTMUX_Dmac1InputTriggerDma1OutCEna

enumerator kINPUTMUX_Dmac1InputTriggerDma1OutDEna

enumerator kINPUTMUX_Dmac1InputTriggerSct0Dmac0Ena

enumerator kINPUTMUX_Dmac1InputTriggerSct0Dmac1Ena

enumerator kINPUTMUX_Dmac1InputTriggerEnetMac0DmaReq0Ena

enumerator kINPUTMUX_Dmac1InputTriggerEnetMac0DmaReq1Ena

enumerator kINPUTMUX_Dmac1InputTriggerUsimDmaRxSingleEna

enumerator kINPUTMUX_Dmac1InputTriggerUsimDmaTxSingleEna

enumerator kINPUTMUX_Dmac1InputTriggerGauGpadc0DmaSingleEna

enumerator kINPUTMUX_Dmac1InputTriggerGauGpadc1DmaSingleEna

enumerator kINPUTMUX_Dmac1InputTriggerGauGpdacaDmaSingleEna

enumerator kINPUTMUX_Dmac1InputTriggerGauGpdacbDmaSingleEna

enumerator kINPUTMUX_Dmac1InputTriggerFlexspiRxEna

enumerator kINPUTMUX_Dmac1InputTriggerFlexspiTxEna

enumerator kINPUTMUX_Dmac1InputTriggerLcdRxRegToDmaSingleEna

enumerator kINPUTMUX_Dmac1InputTriggerLcdTxRegToDmaSingleEna
DMA0 REQ signal.

enumerator kINPUTMUX_Flexcomm0RxToDmac0Ch0RequestEna

enumerator kINPUTMUX_Flexcomm0TxToDmac0Ch1RequestEna

enumerator kINPUTMUX_Flexcomm1RxToDmac0Ch2RequestEna

enumerator kINPUTMUX_Flexcomm1TxToDmac0Ch3RequestEna

enumerator kINPUTMUX_Flexcomm2RxToDmac0Ch4RequestEna

enumerator kINPUTMUX_Flexcomm2TxToDmac0Ch5RequestEna

enumerator kINPUTMUX_Flexcomm3RxToDmac0Ch6RequestEna

enumerator kINPUTMUX_Flexcomm3TxToDmac0Ch7RequestEna

enumerator kINPUTMUX_Dmic0Ch0ToDmac0Ch16RequestEna

enumerator kINPUTMUX_Dmic0Ch1ToDmac0Ch17RequestEna

enumerator kINPUTMUX_Dmic0Ch2ToDmac0Ch18RequestEna

enumerator kINPUTMUX_Dmic0Ch3ToDmac0Ch19RequestEna

enumerator kINPUTMUX_Flexcomm14RxToDmac0Ch26RequestEna

enumerator kINPUTMUX_Flexcomm14TxToDmac0Ch27RequestEna
DMA1 REQ signal.

enumerator kINPUTMUX_Flexcomm0RxToDmac1Ch0RequestEna

enumerator kINPUTMUX_Flexcomm0TxToDmac1Ch1RequestEna

enumerator kINPUTMUX_Flexcomm1RxToDmac1Ch2RequestEna

enumerator kINPUTMUX_Flexcomm1TxToDmac1Ch3RequestEna

enumerator kINPUTMUX_Flexcomm2RxToDmac1Ch4RequestEna

enumerator kINPUTMUX_Flexcomm2TxToDmac1Ch5RequestEna

enumerator kINPUTMUX_Flexcomm3RxToDmac1Ch6RequestEna

enumerator kINPUTMUX_Flexcomm3TxToDmac1Ch7RequestEna

enumerator kINPUTMUX_Dmic0Ch0ToDmac1Ch16RequestEna

enumerator kINPUTMUX_Dmic0Ch1ToDmac1Ch17RequestEna

enumerator kINPUTMUX_Dmic0Ch2ToDmac1Ch18RequestEna

enumerator kINPUTMUX_Dmic0Ch3ToDmac1Ch19RequestEna

enumerator kINPUTMUX_Flexcomm14RxToDmac1Ch26RequestEna

enumerator kINPUTMUX_Flexcomm14TxToDmac1Ch27RequestEna

typedef enum *_inputmux_connection_t* inputmux_connection_t

INPUTMUX connections type.

typedef enum *_inputmux_signal_t* inputmux_signal_t

INPUTMUX signal enable/disable type.

void INPUTMUX_Init(void *base)

Initialize INPUTMUX peripheral.

This function enables the INPUTMUX clock.

Parameters

- base – Base address of the INPUTMUX peripheral.

Return values

None. –

void INPUTMUX_AttachSignal(void *base, uint32_t index, *inputmux_connection_t* connection)

Attaches a signal.

This function attaches multiplexed signals from INPUTMUX to target signals. For example, to attach GPIO PORT0 Pin 5 to PINT peripheral, do the following:

```
INPUTMUX_AttachSignal(INPUTMUX, 2, kINPUTMUX_GpioPort0Pin5ToPintsel);
```

In this example, INTMUX has 8 registers for PINT, PINT_SEL0~PINT_SEL7. With parameter index specified as 2, this function configures register PINT_SEL2.

Parameters

- base – Base address of the INPUTMUX peripheral.
- index – The serial number of destination register in the group of INPUTMUX registers with same name.
- connection – Applies signal from source signals collection to target signal.

Return values

None. –

void INPUTMUX_EnableSignal(void *base, *inputmux_signal_t* signal, bool enable)

Enable/disable a signal.

This function gates the INPUTPMUX clock.

Parameters

- base – Base address of the INPUTMUX peripheral.
- signal – Enable signal register id and bit offset.
- enable – Selects enable or disable.

Return values

None. –

void INPUTMUX_Deinit(void *base)

Deinitialize INPUTMUX peripheral.

This function disables the INPUTMUX clock.

Parameters

- base – Base address of the INPUTMUX peripheral.

Return values

None. –

SCT0_PMUX_ID

Periphinmux IDs.

SHSGPIO_PMUX_ID

PINTSEL_PMUX_ID

DMA0_ITRIG_PMUX_ID

DMA0_OTRIG_PMUX_ID

DMA1_ITRIG_PMUX_ID

DMA1_OTRIG_PMUX_ID

CT32BIT0_CAP_PMUX_ID

CT32BIT1_CAP_PMUX_ID

CT32BIT2_CAP_PMUX_ID

CT32BIT3_CAP_PMUX_ID

FREQMEAS_PMUX_ID

DMA0_REQ_ENA0_ID

DMA1_REQ_ENA0_ID

DMA0_ITRIG_EN0_ID

DMA0_ITRIG_EN1_ID

DMA1_ITRIG_EN0_ID

DMA1_ITRIG_EN1_ID

ENA_SHIFT

PMUX_SHIFT

2.31 IO_MUX Driver

enum io_mux_pin_config_t

IO MUX pin configuration. Bit [1:0] for pull configuration Bit [3:2] for drive strength configuration.

Values:

enumerator IO_MUX_PinConfigNoPullDriveWeakest

enumerator IO_MUX_PinConfigNoPullDriveWeak

enumerator IO_MUX_PinConfigNoPullDriveStrong

enumerator IO_MUX_PinConfigNoPullDriveStrongest

enumerator IO_MUX_PinConfigPullUpDriveWeakest

enumerator IO_MUX_PinConfigPullUpDriveWeak

enumerator IO_MUX_PinConfigPullUpDriveStrong

enumerator IO_MUX_PinConfigPullUpDriveStrongest

enumerator IO_MUX_PinConfigPullDownDriveWeakest

enumerator IO_MUX_PinConfigPullDownDriveWeak

enumerator IO_MUX_PinConfigPullDownDriveStrong

enumerator IO_MUX_PinConfigPullDownDriveStrongest

enumerator IO_MUX_PinConfigNoPull

enumerator IO_MUX_PinConfigPullUp

enumerator IO_MUX_PinConfigPullDown

enum io_mux_sleep_pin_level_t

IO MUX sleep pin level.

Values:

enumerator IO_MUX_SleepPinLevelLow

enumerator IO_MUX_SleepPinLevelHigh

enumerator IO_MUX_SleepPinLevelUnchanged

IO_MUX_GPIO_FC_MASK(gpio, fcIdx, fcMsk)

IO_MUX_SGPIO_FLAG(mask)

IO_MUX_GPIO_FLAG(mask)

IO_MUX_FC_OFFSET(mask)

IO_MUX_FC_MASK(mask)

IO_MUX_CTIMER_MASK(inMsk, outMsk)

IO_MUX_CTIMER_IN_MASK(mask)

IO_MUX_CTIMER_OUT_MASK(mask)

IO_MUX_SCTIMER_MASK(inMsk, outMsk)

IO_MUX_FC0_USART_SCK

IO_MUX_FC0_USART_DATA

IO_MUX_FC0_USART_CMD

IO_MUX_FC0_I2C_2_3

IO_MUX_FC0_I2S

IO_MUX_FC0_I2S_DATA

IO_MUX_FC0_SPI_SS0

IO_MUX_FC1_USART_SCK

IO_MUX_FC1_USART_DATA

IO_MUX_FC1_USART_CMD

IO_MUX_FC1_I2C_8_9

IO_MUX_FC1_I2S

IO_MUX_FC1_I2S_DATA

IO_MUX_FC1_SPI_SS0

IO_MUX_FC2_USART_SCK

IO_MUX_FC2_USART_DATA

IO_MUX_FC2_USART_CMD

IO_MUX_FC2_I2C_13_14

IO_MUX_FC2_I2C_16_17

IO_MUX_FC2_I2S

IO_MUX_FC2_I2S_DATA

IO_MUX_FC2_SPI_SS0

IO_MUX_FC3_USART_SCK

IO_MUX_FC3_USART_DATA

IO_MUX_FC3_USART_CMD

IO_MUX_FC3_I2C_24_26

IO_MUX_FC3_I2C_19_20

IO_MUX_FC3_I2S

IO_MUX_FC3_I2S_DATA

IO_MUX_FC3_SPI_SS0

IO_MUX_FC14_USART_SCK

IO_MUX_FC14_USART_DATA

IO_MUX_FC14_USART_CMD

IO_MUX_FC14_I2C_56_57

IO_MUX_FC14_I2S

IO_MUX_FC14_I2S_DATA

IO_MUX_FC14_SPI_SS0

IO_MUX_QUAD_SPI_FLASH

IO_MUX_QUAD_SPI_PSRAM

IO_MUX_PDM

IO_MUX_USB

IO_MUX_SCT_OUT_0

IO_MUX_SCT_OUT_1

IO_MUX_SCT_OUT_8

IO_MUX_SCT_OUT_4

IO_MUX_SCT_OUT_5

IO_MUX_SCT_OUT_6

IO_MUX_SCT_OUT_7

IO_MUX_SCT_OUT_9

IO_MUX_SCT_IN_0

IO_MUX_SCT_IN_1

IO_MUX_SCT_IN_2

IO_MUX_SCT_IN_3

IO_MUX_SCT_IN_4

IO_MUX_SCT_IN_5

IO_MUX_SCT_IN_6

IO_MUX_SCT_IN_7

IO_MUX_CT0_MAT0_OUT

IO_MUX_CT0_MAT1_OUT

IO_MUX_CT0_MAT2_OUT

IO_MUX_CT0_MAT3_OUT

IO_MUX_CT1_MAT0_OUT

IO_MUX_CT1_MAT1_OUT

IO_MUX_CT1_MAT2_OUT

IO_MUX_CT1_MAT3_OUT

IO_MUX_CT2_MAT0_OUT

IO_MUX_CT2_MAT1_OUT

IO_MUX_CT2_MAT2_OUT

IO_MUX_CT2_MAT3_OUT

IO_MUX_CT3_MAT0_OUT

IO_MUX_CT3_MAT1_OUT

IO_MUX_CT3_MAT2_OUT

IO_MUX_CT_INP0

IO_MUX_CT_INP1

IO_MUX_CT_INP2

IO_MUX_CT_INP3

IO_MUX_CT_INP4

IO_MUX_CT_INP5

IO_MUX_CT_INP6

IO_MUX_CT_INP7

IO_MUX_CT_INP8

IO_MUX_CT_INP9

IO_MUX_CT_INP10

IO_MUX_CT_INP11

IO_MUX_CT_INP12

IO_MUX_CT_INP13

IO_MUX_CT_INP14

IO_MUX_MCLK

IO_MUX_UTICK

IO_MUX_USIM

IO_MUX_LCD_8080

IO_MUX_LCD_SPI

IO_MUX_FREQ_GPIO_CLK

IO_MUX_GPIO_INT_BMATCH

IO_MUX_GAU_TRIGGER0

IO_MUX_ACOMP0_GPIO_OUT

IO_MUX_ACOMP0_EDGE_PULSE

IO_MUX_ACOMP1_GPIO_OUT

IO_MUX_ACOMP1_EDGE_PULSE

IO_MUX_GAU_TRIGGER1

IO_MUX_SDIO

IO_MUX_ENET_CLK

IO_MUX_ENET_RX

IO_MUX_ENET_TX

IO_MUX_ENET_MDIO

IO_MUX_ENET_TIMER0

IO_MUX_ENET_TIMER1

IO_MUX_ENET_TIMER2

IO_MUX_ENET_TIMER3

IO_MUX_CLKIN_FRM_PD

IO_MUX_GPIO0

IO_MUX_GPIO1

IO_MUX_GPIO2

IO_MUX_GPIO3

IO_MUX_GPIO4

IO_MUX_GPIO5

IO_MUX_GPIO6

IO_MUX_GPIO7

IO_MUX_GPIO8

IO_MUX_GPIO9

IO_MUX_GPIO10

IO_MUX_GPIO11

IO_MUX_GPIO12

IO_MUX_GPIO13

IO_MUX_GPIO14

IO_MUX_GPIO15

IO_MUX_GPIO16

IO_MUX_GPIO17

IO_MUX_GPIO18

IO_MUX_GPIO19

IO_MUX_GPIO20

IO_MUX_GPIO21

IO_MUX_GPIO22

IO_MUX_GPIO23

IO_MUX_GPIO24

IO_MUX_GPIO25

IO_MUX_GPIO26

IO_MUX_GPIO27

IO_MUX_GPIO28

IO_MUX_GPIO29

IO_MUX_GPIO30

IO_MUX_GPIO31

IO_MUX_GPIO32

IO_MUX_GPIO33

IO_MUX_GPIO34

IO_MUX_GPIO35

IO_MUX_GPIO36

IO_MUX_GPIO37

IO_MUX_GPIO38

IO_MUX_GPIO39

IO_MUX_GPIO40

IO_MUX_GPIO41

IO_MUX_GPIO42

IO_MUX_GPIO43

IO_MUX_GPIO44

IO_MUX_GPIO45

IO_MUX_GPIO46

IO_MUX_GPIO47

IO_MUX_GPIO48

IO_MUX_GPIO49

IO_MUX_GPIO50

IO_MUX_GPIO51

IO_MUX_GPIO52

IO_MUX_GPIO53

IO_MUX_GPIO54

IO_MUX_GPIO55

IO_MUX_GPIO56

IO_MUX_GPIO57

IO_MUX_GPIO58

IO_MUX_GPIO59

IO_MUX_GPIO60

IO_MUX_GPIO61

IO_MUX_GPIO62

IO_MUX_GPIO63

IO_MUX_SGPIO0

IO_MUX_SGPIO1

IO_MUX_SGPIO2

IO_MUX_SGPIO3

IO_MUX_SGPIO4

IO_MUX_SGPIO5

IO_MUX_SGPIO6

IO_MUX_SGPIO7

IO_MUX_SGPIO8

IO_MUX_SGPIO9

IO_MUX_SGPIO10

IO_MUX_SGPIO11

IO_MUX_SGPIO12

IO_MUX_SGPIO13

IO_MUX_SGPIO14

IO_MUX_SGPIO15

IO_MUX_SGPIO16

IO_MUX_SGPIO17

IO_MUX_SGPIO18

IO_MUX_SGPIO19

IO_MUX_SGPIO20

IO_MUX_SGPIO21

IO_MUX_SGPIO22

IO_MUX_SGPIO23

IO_MUX_SGPIO24

IO_MUX_SGPIO25

IO_MUX_SGPIO26

IO_MUX_SGPIO27

IO_MUX_SGPIO28

IO_MUX_SGPIO29

IO_MUX_SGPIO30

IO_MUX_SGPIO31

IO_MUX_AON_CAPTURE

static inline void IO_MUX_SetPinMux(uint32_t pinLowMask, uint32_t pinHighMask, uint32_t gpioFcSetMask, uint32_t gpioFcClrMask, uint32_t fselSetMask, uint32_t fselClrMask, uint32_t ctimerSetMask, uint32_t ctimerClrMask, uint32_t sctimerSetMask, uint32_t sctimerClrMask)

Sets the IO_MUX pin mux mode.

This is an example to set the GPIO2/GPIO3 as the Flexcomm0 UART RX/TX:

```
IO_MUX_SetPinMux(IO_MUX_FC0_USART_DATA);
```

This is an example to set the GPIO6/GPIO10 as Flexcomm1 I2C SDA/SCL:

```
IO_MUX_SetPinMux(IO_MUX_FC1_I2C_6_10);
```

Note: The parameters can be filled with the pin function ID macros.

Parameters

- pinLowMask – The GPIO0-31 pins mask.
- pinHighMask – The GPIO32-63 pins mask.
- gpioFcSetMask – The GPIO and Flexcomm registers mask to set, defined by IO_MUX_GPIO_FC_MASK()
- gpioFcClrMask – The GPIO and Flexcomm registers mask to clear, defined by IO_MUX_GPIO_FC_MASK()
- fselSetMask – The FSEL register mask to set
- fselClrMask – The FSEL register mask to clear
- ctimerSetMask – The C_TIMER_IN/C_TIMER_OUT register mask to set, defined by IO_MUX_CTIMER_MASK()
- ctimerClrMask – The C_TIMER_IN/C_TIMER_OUT register mask to clear, defined by IO_MUX_CTIMER_MASK()
- sctimerSetMask – The SC_TIMER register mask to set
- sctimerClrMask – The SC_TIMER register mask to clear

static inline void IO_MUX_SetPinConfig(uint32_t pin, *io_mux_pin_config_t* config)

Sets the IO_MUX pin mux pull up/down configuartion.

This is an example to set the GPIO2 pin to pull down:

```
IO_MUX_SetPinConfig(2U, IO_MUX_PinConfigPullDown);
```

Parameters

- pin – The GPIO pin index to config.
- config – The pull up/down setting for the pin.

static inline void IO_MUX_SetPinOutLevelInSleep(uint32_t pin, *io_mux_sleep_pin_level_t* level)

Sets IO output level in sleep mode. If level set to IO_MUX_SleepPinLevelUnchanged, the IO configuration is same as the active mode.

This is an example to set the GPIO2 pin to output high during sleep:

```
IO_MUX_SetPinOutLevelInSleep(2U, IO_MUX_SleepPinLevelHigh);
```

Parameters

- pin – The GPIO pin index to config.
- level – Output level in sleep.

static inline void IO_MUX_SetRfPinOutLevelInSleep(uint32_t pin, *io_mux_sleep_pin_level_t* level)

Sets RF Switch Pin 0-3 output level in sleep mode. If level set to IO_MUX_SleepPinLevelUnchanged, the IO configuration is same as the active mode.

This is an example to set the RF_CNTL0 pin to output low during sleep:

```
IO_MUX_SetRfPinOutLevelInSleep(0U, IO_MUX_SleepPinLevelLow);
```

Parameters

- pin – The RF Switch pin index to config.
- level – Output level in sleep.

FSL_IO_MUX_DRIVER_VERSION

IO_MUX driver version 2.2.2.

FSL_COMPONENT_ID

2.32 IPED Driver

enum _iped_status

Values:

enumerator kStatus_IPED_RegionIsLocked

typedef uint32_t iped_region_t

typedef uint32_t iped_prince_rounds_t

static inline void IPED_EncryptEnable(FLEXSPI_Type *base)

Enable data encryption.

This function enables IPED on-the-fly data encryption.

Parameters

- base – IPED peripheral address.

static inline void IPED_EncryptDisable(FLEXSPI_Type *base)

Disable data encryption.

This function disables IPED on-the-fly data encryption.

Parameters

- base – IPED peripheral address.

static inline void IPED_SetLock(FLEXSPI_Type *base, *iped_region_t* region)

Locks access for specified region registers or data mask register.

This function sets lock on specified region.

Parameters

- base – IPED peripheral address.
- region – number to lock

static inline bool IPED_IsRegionLocked(FLEXSPI_Type *base, *iped_region_t* region)

Gets info whether IPED region is locked.

Parameters

- base – IPED peripheral address.
- region – Selection of the IPED region to be queried.

status_t IPED_SetRegionEnable(FLEXSPI_Type *base, *iped_region_t* region, bool enable)

Enable encryption for a specific IPED region encryption.

Parameters

- base – IPED peripheral address.
- region – Selection of the IPED region to be enabled.

static inline bool IPED_IsRegionEnabled(FLEXSPI_Type *base, *iped_region_t* region)

Gets info whether IPED region encryption is enabled.

Parameters

- base – IPED peripheral address.
- region – Selection of the IPED region to be queried.

status_t IPED_SetRegionAddressRange(FLEXSPI_Type *base, *iped_region_t* region, uint32_t start_address, uint32_t end_address)

Sets IPED region address range.

This function configures IPED region address range.

Parameters

- base – IPED peripheral address.
- region – Selection of the IPED region to be configured.
- start_address – Start address for region.
- end_address – End address for region.

void IPED_GetRegionAddressRange(FLEXSPI_Type *base, *iped_region_t* region, uint32_t *start_address, uint32_t *end_address)

Gets IPED region base address.

This function reads current start and end address settings for selected region.

Parameters

- base – IPED peripheral address.
- region – Selection of the IPED region to be configured.
- start_address – Start address for region.
- end_address – End address for region.

void IPED_SetRegionIV(FLEXSPI_Type *base, *iped_region_t* region, const uint8_t iv[8])

Sets the IPED region IV.

This function sets specified AES IV for the given region.

Parameters

- base – IPED peripheral address.
- region – Selection of the IPED region to be configured.
- iv – 64-bit AES IV in little-endian byte order.

void IPED_GetRegionIV(FLEXSPI_Type *base, *iped_region_t* region, uint8_t iv[8])

Gets the IPED region IV.

This function gets specified AES IV for the given region.

Parameters

- base – IPED peripheral address.
- region – Selection of the IPED region to be configured.
- iv – 64-bit AES IV in little-endian byte order.

void IPED_SetRegionAAD(FLEXSPI_Type *base, *iped_region_t* region, const uint8_t aad[8])

Sets the IPED region AAD.

This function sets specified AES AAD for the given region.

Parameters

- base – IPED peripheral address.
- region – Selection of the IPED region to be configured.
- iv – 64-bit AES AAD in little-endian byte order.

void IPED_GetRegionAAD(FLEXSPI_Type *base, *iped_region_t* region, uint8_t aad[8])

Gets the IPED region AAD.

This function gets specified AES AAD for the given region.

Parameters

- base – IPED peripheral address.
- region – Selection of the IPED region to be configured.
- iv – 64-bit AES AAD in little-endian byte order.

static inline void IPED_SetPrinceRounds(FLEXSPI_Type *base, *iped_prince_rounds_t* rounds)

Sets the number of rounds used for PRINCE.

Parameters

- base – IPED peripheral address.
- rounds – Number of PRINCE rounds used during encryption/decryption

static inline *iped_prince_rounds_t* IPED_GetPrinceRounds(FLEXSPI_Type *base)

Gets the number of rounds used for PRINCE.

Parameters

- base – IPED peripheral address.
- rounds – Number of PRINCE rounds used during encryption/decryption

FSL_IPED_DRIVER_VERSION

IPED driver version for RW61x. Version 1.0.0.

- Version 1.0.1
  - Initial version

kIPED_Region0

IPED region 0

kIPED_Region1

IPED region 1

kIPED_Region2

IPED region 2

kIPED_Region3

IPED region 3

kIPED_Region4

IPED region 4

kIPED_Region5

IPED region 5

kIPED_Region6

IPED region 6

kIPED_Region7

IPED region 7

kIPED_Region8

IPED region 8

kIPED_Region9

IPED region 9

kIPED_Region10

IPED region 10

kIPED_Region11

IPED region 11

kIPED_Region12

IPED region 12

kIPED_Region13

IPED region 13

kIPED_Region14

IPED region 14

kIPED_Region15
IPED region 15

kIPED_PrinceRounds12

kIPED_PrinceRounds22

IPED_REGION_COUNT
IPED region count.

IPED_RW_ENABLE_VAL

IPED_RW_DISABLE_VAL

IPED_CTX_REG_OFFSET

2.33 Intrusion and Tamper Response Controller

2.34 ITRC

status_t ITRC_SetActionToEvent(ITRC_Type *base, *itrc_out_signals_t* out, *itrc_in_signals_t* in, *itrc_lock_t* lock, *itrc_enable_t* enable)

Set ITRC Action to Event.

This function sets input Event signal to corresponding output Action response signal.

Parameters

- base – ITRC peripheral base address
- out – ITRC OUT signal action
- in – ITRC IN signal event
- lock – if set locks INx_SEL configuration. This can be cleared only by PMC Core reset.
- enable – if set input Event will be selected for output Action, otherwise disable (if not already locked).

Returns
kStatus_Success if success, kStatus_InvalidArgument otherwise

void ITRC_SetSWEvent0(ITRC_Type *base)

Trigger ITRC SW Event 0.

This funciton set SW_EVENT0 register with value !=0 which triggers ITRC SW Event 0.

Parameters

- base – ITRC peripheral base address

void ITRC_SetSWEvent1(ITRC_Type *base)

Trigger ITRC SW Event 1.

This funciton set SW_EVENT1 register with value !=0 which triggers ITRC SW Event 1.

Parameters

- base – ITRC peripheral base address

bool ITRC_GetInEventStatus(ITRC_Type *base, *itrc_in_signals_t* event)

Get ITRC input event status.

This function returns ITRC status corresponding to provided input event.

Parameters

- base – ITRC peripheral base address
- event – represents input event to get from STATUS register (see ITRC_STATUS_INx)

Returns

boolean TRUE if corresponding event occured FALSE otherwise

bool ITRC_GetOutActionStatus(ITRC_Type *base, *itrc_out_signals_t* action)

Get ITRC output action status.

This function returns ITRC register output status.

Parameters

- base – ITRC peripheral base address
- action – represents output action to get from STATUS register (see ITRC_STATUS_OUTx)

Returns

boolean TRUE if corresponding action occured FALSE otherwise

status_t ITRC_ClearInEventStatus(ITRC_Type *base, *itrc_in_signals_t* event)

Clear In ITRC status.

This function clears corresponding ITRC event or action in input STATUS register.

Parameters

- base – ITRC peripheral base address
- event – represents input event in STATUS register to be cleared (see ITRC_STATUS_INx)

Returns

kStatus_Success if success, kStatus_InvalidArgument otherwise

status_t ITRC_ClearOutActionStatus(ITRC_Type *base, *itrc_out_signals_t* action)

Clear Out ITRC status.

This function clears corresponding ITRC event or action in output STATUS register.

Parameters

- base – ITRC peripheral base address
- action – represents output action in STATUS register to be cleared (see OUTx_STATUS)

Returns

kStatus_Success if success, kStatus_InvalidArgument otherwise

status_t ITRC_ClearAllStatus(ITRC_Type *base)

Clear All ITRC status.

This function clears all event and action status.

Parameters

- base – ITRC peripheral base address

Returns

kStatus_Success if success

status_t ITRC_Init(ITRC_Type *base)

Initialize ITRC.

This function initializes ITRC by enabling IRQ.

Parameters

- base – ITRC peripheral base address
- conf – ITRC configuration structure

Returns

Status of the init operation

void ITRC_Deinit(ITRC_Type *base)

Deinitialize ITRC.

This function deinitializes ITRC by disabling IRQ.

Parameters

- base – ITRC peripheral base address

FSL_ITRC_DRIVER_VERSION

Defines ITRC driver version 2.0.0.

Change log:

- Version 2.0.0
  - Initial version.

typedef uint32_t itrc_in_signals_t

ITRC input events.

typedef uint32_t itrc_out_signals_t

ITRC output actions.

typedef uint32_t itrc_lock_t

ITRC lock/unlock.

typedef uint32_t itrc_enable_t

ITRC enable/disable.

void ITRC_DriverIRQHandler(void)

ITRC_INPUT_SIGNALS_NUM

kITRC_CauTemeprature

kITRC_PmipTemperature

kITRC_VddCore

kITRC_Vdd18

kITRC_Vdd33

kITRC_VddCoreGlitch

kITRC_AnalogSensor

kITRC_Ahb

kITRC_Cwd

kITRC_Css

kITRC_Pkc

kITRC_Otp

kITRC_Prince

kITRC_ClockGlitch

kITRC_SecurityIP

kITRC_Trng

kITRC_PmipGlitch

kITRC_PmipVddCoreGlitch

kITRC_TcpuPll

kITRC_T3Pll

kITRC_SwEvent0

kITRC_SwEvent1

kITRC_Irq

kITRC_ChipReset

kITRC_Unlock

kITRC_Lock

kITRC_Enable

kITRC_Disable

IN_STATUS0_EVENTS_MASK

IN_STATUS1_EVENTS_MASK

OUT_ACTIONS_MASK

ITRC

2.35 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_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

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*.

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 UART 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_SDIOSLV
Group number for SDIOSLV 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_ELEMU
Group number for ELEMU status codes.

enumerator kStatusGroup_QUEUEDSPI
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.

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 wil 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_INVALID_IRQ_HANDLER

Invalid IRQ handler address.

2.36 LCDIC Driver

status_t LCDIC_Init(LCDIC_Type *base, const *lcdic_config_t* *config)

Initialize the LCDIC.

This function initializes the LCDIC to work, it configues the LCDIC according to the configue structure and enables the module. After calling this function, the peripheral is ready to work.

Parameters

- base – LCDIC peripheral base address.

Return values

kStatus_Success – Initialize successfully.

void LCDIC_Deinit(LCDIC_Type *base)

De-initialize the LCDIC.

This function disables the LCDIC, and disables peripheral clock if necessary.

Parameters

- base – LCDIC peripheral base address.

void LCDIC_GetDefaultConfig(*lcdic_config_t* *config)

Get the default configuration for to initialize the LCDIC.

The default configuration value is:

```
config->mode        = kLCDIC_3WireSPI;
config->endian      = kLCDIC_BigEndian;
config->rxThreshold = kLCDIC_RxThreshold0Word;
config->txThreshold = kLCDIC_TxThreshold3Word;

config->timerRatio0 = 8;
config->timerRatio1 = 9;

config->resetPulseWidth_Timer0 = 20;
config->resetSequence          = 0;
config->resetSequencePulseNum  = 1;
config->resetPolarity          = kLCDIC_ResetActiveLow;

config->i8080CtrlFlags = kLCDIC_I8080_CsActiveLow | kLCDIC_I8080_DcCmdLow | kLCDIC_
↪I8080_RdActiveLow |
                         kLCDIC_I8080_WrActiveLow | kLCDIC_I8080_CsEnableIdleOff;

config->csWaitTime              = 2;
config->csSetupTime             = 2;
config->csHoldTime              = 2;
config->dcSetupTime             = 2;
config->dcHoldTime              = 2;
config->writeDataSetupTime      = 2;
config->writeDataHoldTime       = 2;
config->writeEnableActiveWidth  = 6;
config->writeEnableInactiveWidth = 6;
config->readEnableActiveWidth   = 15;
config->readEnableInactiveWidth  = 15;

config->spiCtrlFlags =
   kLCDIC_SPI_MsbFirst | kLCDIC_SPI_ClkActiveHigh | kLCDIC_SPI_ClkPhaseFirstEdge |␣
↪kLCDIC_SPI_DcCmdLow;

config->teTimeoutTime_Timer1  = 16;
config->teSyncWaitTime_Timer1 = 0;

config->cmdShortTimeout_Timer0 = 1;
config->cmdLongTimeout_Timer1  = 16;
```

Parameters

- config – Pointer to the LCDIC configuration.

void LCDIC_ResetState(LCDIC_Type *base)

Reset the LCDIC.

This function resets the LCDIC state. After calling this function, all data in TX_FIFO and RX_FIFO will be cleared and all transactions on LCD interface will restart despite of formal status.

The configurations will not be reset.

Parameters

- base – LCDIC peripheral base address.

static inline void LCDIC_EnableInterrupts(LCDIC_Type *base, uint32_t interrupts)

Enables LCDIC interrupts.

Parameters

- base – LCDIC peripheral base address.
- interrupts – The interrupts to enable, pass in as OR'ed value of _lcdic_interrupt.

static inline void LCDIC_DisableInterrupts(LCDIC_Type *base, uint32_t interrupts)

Disable LCDIC interrupts.

Parameters

- base – LCDIC peripheral base address.
- interrupts – The interrupts to disable, pass in as OR'ed value of _lcdic_interrupt.

static inline uint32_t LCDIC_GetInterruptStatus(LCDIC_Type *base)

Get LCDIC interrupt pending status.

Note: The interrupt must be enabled, otherwise the interrupt flags will not assert.

Parameters

- base – LCDIC peripheral base address.

Returns

The interrupt pending status.

static inline uint32_t LCDIC_GetInterruptRawStatus(LCDIC_Type *base)

Get LCDIC raw interrupt status.

This function gets the raw interrupt pending flags, it is not affected by interrupt enabled status.

Parameters

- base – LCDIC peripheral base address.

Returns

The raw interrupt status.

static inline void LCDIC_ClearInterruptStatus(LCDIC_Type *base, uint32_t interrupts)

Clear LCDIC interrupt status.

Parameters

- base – LCDIC peripheral base address.
- interrupts – The interrupt status to clear , pass in as OR'ed value of _lcdic_interrupt.

static inline uint32_t LCDIC_GetStatusFlags(LCDIC_Type *base)

Get LCDIC status flags.

Note: The interval between two times calling this function shall be larger than one LCDIC function clock.

Parameters

- base – LCDIC peripheral base address.

Returns

The status flags, it is OR'ed value of _lcdic_flags.

static inline uint32_t LCDIC_GetProcessingTrxCmd(LCDIC_Type *base)

Get current on-going LCDIC TRX-CMD.

Note: The interval between two times calling this function shall be larger than one LCDIC function clock.

Parameters

- base – LCDIC peripheral base address.

Returns

The TRX-CMD on-going.

static inline void LCDIC_SetTxThreshold(LCDIC_Type *base, *lcdic_tx_threshold_t* threshold)

Set TX FIFO threshold.

Parameters

- base – LCDIC peripheral base address.
- threshold – TX threshold.

static inline void LCDIC_SetRxThreshold(LCDIC_Type *base, *lcdic_rx_threshold_t* threshold)

Set RX FIFO threshold.

Parameters

- base – LCDIC peripheral base address.
- threshold – RX threshold.

status_t LCDIC_WriteTxFifoBlocking(LCDIC_Type *base, const uint32_t *data, uint32_t dataLen_Word)

Write the TX FIFO using blocking way.

This function waits for empty slot in TX FIFO and fill the data to TX FIFO.

Parameters

- base – LCDIC peripheral base address.
- data – Data to send, the data length must be dividable by 4.
- dataLen_Word – Data length in word.

Return values

- kStatus_Success – Write successfully.
- kStatus_Timeout – Timeout happened.

status_t LCDIC_ReadRxFifoBlocking(LCDIC_Type *base, uint32_t *data, uint32_t dataLen_Word)

Read the RX FIFO using blocking way.

This function waits for valid data in RX FIFO and read them.

Parameters

- base – LCDIC peripheral base address.
- data – Array for received data, the data length must be dividable by 4.
- dataLen_Word – Data length in word.

Return values

- kStatus_Success – Read successfully.
- kStatus_Timeout – Timeout happened.

static inline void LCDIC_SendResetSequence(LCDIC_Type *base)

Send reset sequence to the reset pin.

The function sends reset to reset pin, to reset the external panel. The reset sequence parameters are configued by lcdic_config_t.

Parameters

- base – LCDIC peripheral base address.

void LCDIC_SetResetSequenceDoneCallback(*lcdic_reset_done_callback_t* callback)

Set the callback called when reset sequence sent done.

Parameters

- callback – The callback to set.

static inline void LCDIC_EnableDMA(LCDIC_Type *base, bool enable)

Enable or disable to trigger DMA.

Parameters

- base – LCDIC peripheral base address.
- enable – Use true to enable, false to disable.

status_t LCDIC_SendCommandBlocking(LCDIC_Type *base, uint8_t cmd)

Send command using blocking way.

This function sends out command and waits until send finished.

Parameters

- base – LCDIC peripheral base address.
- cmd – Command to send.

Return values

kStatus_Success – Command sent successfully.

status_t LCDIC_SendRepeatDataBlocking(LCDIC_Type *base, const *lcdic_repeat_tx_xfer_t* *xfer)

Send repeat data using blocking way.

This function sends out command and the repeat data, then waits until send finished or timeout happened.

Parameters

- base – LCDIC peripheral base address.
- xfer – Pointer to the transfer configuration.

Return values

- kStatus_Success – Sent successfully.
- kStatus_Timeout – Timeout happened.
- kStatus_InvalidArgument – Invalid argument.

status_t LCDIC_SendDataArrayBlocking(LCDIC_Type *base, const *lcdic_tx_xfer_t* *xfer)

Send data array using blocking way.

This function sends out command and the data array, then waits until send finished or timeout happened.

Parameters

- base – LCDIC peripheral base address.
- xfer – Pointer to the transfer configuration.

Return values

- kStatus_Success – Sent successfully.
- kStatus_Timeout – Timeout happened.
- kStatus_InvalidArgument – Invalid argument.

status_t LCDIC_ReadDataArrayBlocking(LCDIC_Type *base, const *lcdic_rx_xfer_t* *xfer)

Read data array using blocking way.

This function sends out command and read the data array, then waits until send finished or timeout happened.

Parameters

- base – LCDIC peripheral base address.
- xfer – Pointer to the transfer configuration.

Return values

- kStatus_Success – Sent successfully.
- kStatus_Timeout – Timeout happened.
- kStatus_InvalidArgument – Invalid argument.

status_t LCDC_TransferBlocking(LCDIC_Type *base, const *lcdic_xfer_t* *xfer)

LCDIC data transfer using blocking way.

This function sends command only, or sends repeat data, or sends data array, or reads data array based on the transfer structure. It uses blocking way, only returns when transfer successed or failed.

Parameters

- base – LCDIC peripheral base address.
- xfer – Pointer to the transfer configuration.

Return values

- kStatus_Success – Sent successfully.
- kStatus_Timeout – Timeout happened.
- kStatus_InvalidArgument – Invalid argument.

status_t LCDIC_TransferCreateHandle(LCDIC_Type *base, *lcdic_handle_t* *handle, *lcdic_transfer_callback_t* callback, void *userData)

Initializes the LCDIC driver handle, which is used in transactional functions.

Parameters

- base – LCDIC peripheral base address.
- handle – Pointer to the lcdic_handle_t structure to store the transfer state.
- callback – The callback function.
- userData – The parameter of the callback function.

Return values

kStatus_Success – Successfully created the handle.

status_t LCDIC_TransferNonBlocking(LCDIC_Type *base, *lcdic_handle_t* *handle, *lcdic_xfer_t* *xfer)

Transfer data using IRQ.

This function transfer data using IRQ. This is a non-blocking function, which returns right away. When all data is sent out/received, or timeout happened, the callback function is called.

Parameters

- base – LCDIC peripheral base address.
- handle – Pointer to the lcdic_handle_t structure to store the transfer state.
- xfer – LCDIC transfer structure.

Return values

- kStatus_Success – Successfully start a transfer.
- kStatus_InvalidArgument – Input argument is invalid.
- kStatus_Busy – LCDIC driver is busy with another transfer.

status_t LCDIC_SendCommandNonBlocking(LCDIC_Type *base, *lcdic_handle_t* *handle, uint8_t cmd)

Send command using interrupt-driven way.

Parameters

- base – LCDIC peripheral base address.
- handle – Pointer to the lcdic_handle_t structure to store the transfer state.
- cmd – Command to send.

Return values

- kStatus_Success – Command sent successfully.
- kStatus_Busy – LCDIC driver is busy with another transfer.

status_t LCDIC_SendRepeatDataNonBlocking(LCDIC_Type *base, *lcdic_handle_t* *handle, const *lcdic_repeat_tx_xfer_t* *xfer)

Send repeat data using interrupt-driven way.

Parameters

- base – LCDIC peripheral base address.
- handle – Pointer to the lcdic_handle_t structure to store the transfer state.
- xfer – LCDIC transfer structure.

Return values

- kStatus_Success – Successfully start a transfer.
- kStatus_InvalidArgument – Input argument is invalid.
- kStatus_Busy – LCDIC driver is busy with another transfer.

status_t LCDIC_SendDataArrayNonBlocking(LCDIC_Type *base, *lcdic_handle_t* *handle, const *lcdic_tx_xfer_t* *xfer)

Send data array using interrupt-driven way.

Parameters

- base – LCDIC peripheral base address.
- handle – Pointer to the lcdic_handle_t structure to store the transfer state.
- xfer – LCDIC transfer structure.

Return values

- kStatus_Success – Successfully start a transfer.

- kStatus_InvalidArgument – Input argument is invalid.
- kStatus_Busy – LCDIC driver is busy with another transfer.

status_t LCDIC_ReadDataArrayNonBlocking(LCDIC_Type *base, *lcdic_handle_t* *handle, const *lcdic_rx_xfer_t* *xfer)

Read data array using interrupt-driven way.

Parameters

- base – LCDIC peripheral base address.
- handle – Pointer to the lcdic_handle_t structure to store the transfer state.
- xfer – LCDIC transfer structure.

Return values

- kStatus_Success – Successfully start a transfer.
- kStatus_InvalidArgument – Input argument is invalid.
- kStatus_Busy – LCDIC driver is busy with another transfer.

void LCDIC_TransferHandleIRQ(LCDIC_Type *base, void *handle)

LCDIC IRQ handler function.

IRQ handler to work with LCDIC_TransferNonBlocking.

Parameters

- base – LCDIC peripheral base address.
- handle – Pointer to the lcdic_handle_t structure to store the transfer state.

void LCDIC_TransferInstallIRQHandler(uint32_t instance, void *handle, *lcdic_transfer_irq_handler_t* handler)

Install the IRQ handler.

Install IRQ handler for specific instance.

Parameters

- instance – LCDIC instance.
- handle – Driver handle, it will be used as IRQ handler parameter.
- handler – IRQ handler to instance.

uint32_t LCDIC_GetInstance(LCDIC_Type *base)

Get the instance from the base address.

Parameters

- base – LCDIC peripheral base address

Returns

The LCDIC module instance

IRQn_Type LCDIC_GetIRQn(uint32_t instance)

Get IRQn for specific instance.

Parameters

- instance – LCDIC instance.

Returns

The LCDIC IRQn.

uint32_t LCDIC_FillByteToWord(const uint8_t *bytes, uint8_t len)

Get data from byte array, and fill to 4-byte word.

LCDIC data registers only accept 4-byte data, but the user passed data might be not 4-byte size aligned. This function is used to construct the unaligned part to a word, to write to LCDIC register.

Parameters

- bytes – The byte array.
- len – Length of the byte array.

Returns

The construct word.

void LCDIC_ExtractByteFromWord(uint32_t word, uint8_t *bytes, uint8_t len)

Get data from 4-byte, and fill to byte array.

LCDIC data registers only accept 4-byte data, but the user passed data might be not 4-byte size aligned. This function is used to get desired bytes from the word read from LCDIC register, and save to the user data array.

Parameters

- word – Word data read from LCDIC register.
- bytes – The byte array.
- len – Length of the byte array.

status_t LCDIC_PrepareSendCommand(LCDIC_Type *base, uint8_t cmd)

Prepare the command sending.

Fill the TRX command and command to TX FIFO, after calling this function, user should wait for transfer done by checking status or IRQ.

Parameters

- base – LCDIC peripheral base address.
- cmd – Command to send.

Return values

kStatus_Success – Operation successed.

status_t LCDIC_PrepareSendRepeatData(LCDIC_Type *base, const *lcdic_repeat_tx_xfer_t* *xfer)

Prepare the repeat data sending.

Fill the required data to TX FIFO, after calling this function, user should wait for transfer done by checking status or IRQ.

Parameters

- base – LCDIC peripheral base address.
- xfer – Transfer structure.

Return values

- kStatus_Success – Operation successed.
- kStatus_InvalidArgument – Invalid argument.

status_t LCDIC_PrepareSendDataArray(LCDIC_Type *base, const *lcdic_tx_xfer_t* *xfer, uint32_t *xferSizeWordAligned, uint8_t *xferSizeWordUnaligned, uint32_t *wordUnalignedData)

Prepare sending data array.

Fill the required command data to TX FIFO, after calling this function, user should fill the xfer->txData to TX FIFO based on FIFO status.

Parameters

- base – LCDIC peripheral base address.
- xfer – Transfer structure.
- xferSizeWordAligned – The word size aligned part of the transfer data.
- xferSizeWordUnaligned – The word size unaligned part of the transfer data.
- wordUnalignedData – Word to save the word size unaligned data, it should be sent after all word size aligned data write finished.

Return values

- kStatus_Success – Operation successed.
- kStatus_InvalidArgument – Invalid argument.

status_t LCDIC_PrepareReadDataArray(LCDIC_Type *base, const *lcdic_rx_xfer_t* *xfer, uint32_t *xferSizeWordAligned, uint8_t *xferSizeWordUnaligned)

Prepare reading data array.

Fill the required command data to TX FIFO, after calling this function, user should read RX FIFO to xfer->rxData based on FIFO status.

Parameters

- base – LCDIC peripheral base address.
- xfer – Transfer structure.
- xferSizeWordAligned – The word size aligned part of the transfer data.
- xferSizeWordUnaligned – The word size unaligned part of the transfer data.

Return values

- kStatus_Success – Operation successed.
- kStatus_InvalidArgument – Invalid argument.

FSL_LCDIC_DRIVER_VERSION

enum _lcdic_mode

LCDIC mode.

Values:

enumerator kLCDIC_3WireSPI

3-wire SPI mode.

enumerator kLCDIC_4WireSPI

4-wire SPI mode.

enumerator kLCDIC_I8080

I8080 mode.

enum _lcdic_endian

LCDIC byte order data endian.

Values:

enumerator kLCDIC_BigEndian

Big endian.

enumerator kLCDIC_LittleEndian

Little endian.

enum _lcdic_rx_threshold

LCDIC RX FIFO threshold.

RX threshold interrupt happens if the occupied word number in RX FIFO is bigger than the threshold value.

Values:

enumerator kLCDIC_RxThreshold0Word

0 word.

enumerator kLCDIC_RxThreshold1Word

1 word.

enum _lcdic_tx_threshold

LCDIC TX FIFO threshold.

TX threshold interrupt happens if the empty word number in TX FIFO is bigger than the threshold value.

Values:

enumerator kLCDIC_TxThreshold0Word

0 word.

enumerator kLCDIC_TxThreshold1Word

1 word.

enumerator kLCDIC_TxThreshold2Word

2 word.

enumerator kLCDIC_TxThreshold3Word

3 word.

enumerator kLCDIC_TxThreshold4Word

4 word.

enumerator kLCDIC_TxThreshold5Word

5 word.

enumerator kLCDIC_TxThreshold6Word

6 word.

enumerator kLCDIC_TxThreshold7Word

7 word.

enum _lcdic_reset_polarity

LCDIC reset signal polarity.

Values:

enumerator kLCDIC_ResetActiveLow

Active low.

enumerator kLCDIC_ResetActiveHigh

Active high.

LCDIC I8080 control flags. .

Values:

enumerator kLCDIC_I8080_CsActiveLow

CS active low.

enumerator kLCDIC_I8080_CsActiveHigh
CS active high.

enumerator kLCDIC_I8080_DcCmdLow
DC 0 means command, while 1 means data.

enumerator kLCDIC_I8080_DcCmdHigh
DC 1 means command, while 0 means data.

enumerator kLCDIC_I8080_RdActiveLow
RD active low.

enumerator kLCDIC_I8080_RdActiveHigh
RD active high.

enumerator kLCDIC_I8080_WrActiveLow
WR active low.

enumerator kLCDIC_I8080_WrActiveHigh
WR active high.

enumerator kLCDIC_I8080_CsEnableIdleOff
CS off while no transmission.

enumerator kLCDIC_I8080_CsEnableDcSwitchOff
CS off while DC switches.

LCDIC SPI mode control flags. .

Values:

enumerator kLCDIC_SPI_MsbFirst
MSB(bit 7) sent and received first.

enumerator kLCDIC_SPI_LsbFirst
LSB(bit 0) sent and received first.

enumerator kLCDIC_SPI_ClkActiveHigh
CPOL=0. Clock active-high (idle low)

enumerator kLCDIC_SPI_ClkActiveLow
CPOL=1. Clock active-low (idle high)

enumerator kLCDIC_SPI_ClkPhaseFirstEdge
CPHA=0. Data sample at first clock edge.

enumerator kLCDIC_SPI_ClkPhaseSecondEdge
CPHA=1. Data sample at second clock edge.

enumerator kLCDIC_SPI_DcCmdLow
DC 0 means command, while 1 means data.

enumerator kLCDIC_SPI_DcCmdHigh
DC 1 means command, while 0 means data.

enum _lcdic_interrupt
LCDIC interrupts.

Values:

enumerator kLCDIC_ResetDoneInterrupt

enumerator kLCDIC_CmdDoneInterrupt

enumerator kLCDIC_CmdTimeoutInterrupt

enumerator kLCDIC_TeTimeoutInterrupt

enumerator kLCDIC_TxOverflowInterrupt

enumerator kLCDIC_TxThresholdInterrupt

enumerator kLCDIC_RxUnderflowInterrupt

enumerator kLCDIC_RxThresholdInterrupt

enumerator kLCDIC_AllInterrupt
All interrupts.

LCDIC status flags. .

Values:

enumerator kLCDIC_IdleFlag

enumerator kLCDIC_TxThresholdFlag

enumerator kLCDIC_TxFullFlag

enumerator kLCDIC_RxThresholdFlag

enumerator kLCDIC_RxEmptyFlag

enumerator kLCDIC_AllFlag
All flags.

LCDIC TE sync mode .

Values:

enumerator kLCDIC_TeNoSync
Don't need to sync.

enumerator kLCDIC_TeRisingEdgeSync
Sync to TE rising edge.

enumerator kLCDIC_TeFallingEdgeSync
Sync to TE falling edge.

LCDIC TRX command timeout mode .

Values:

enumerator kLCDIC_ShortTimeout
Using short timeout.

enumerator kLCDIC_LongTimeout
Using long timeout.

LCDIC data format .

Values:

enumerator kLCDIC_DataFormatByte
Byte.

enumerator kLCDIC_DataFormatHalfWord
Half word (2-byte).

enumerator kLCDIC_DataFormatWord
Word (4-byte).

LCDIC data or command .

Values:

enumerator kLCDIC_Command
Command.

enumerator kLCDIC_Data
Data.

LCDIC TX or RX .

Values:

enumerator kLCDIC_RX
RX

enumerator kLCDIC_TX
TX.

enum lcdic_xfer_mode_t
LCDIC transfer mode.

Values:

enumerator kLCDIC_XferCmdOnly
Only send command.

enumerator kLCDIC_XferSendRepeatData
Send repeat data.

enumerator kLCDIC_XferSendDataArray
Send data array.

enumerator kLCDIC_XferReceiveDataArray
Receive data array.

typedef enum *_lcdic_mode* lcdic_mode_t
LCDIC mode.

typedef enum *_lcdic_endian* lcdic_endian_t
LCDIC byte order data endian.

typedef enum *_lcdic_rx_threshold* lcdic_rx_threshold_t
LCDIC RX FIFO threshold.

RX threshold interrupt happens if the occupied word number in RX FIFO is bigger than the threshold value.

typedef enum *_lcdic_tx_threshold* lcdic_tx_threshold_t
LCDIC TX FIFO threshold.

TX threshold interrupt happens if the empty word number in TX FIFO is bigger than the threshold value.

typedef enum *_lcdic_reset_polarity* lcdic_reset_polarity_t

LCDIC reset signal polarity.

typedef struct *_lcdic_config* lcdic_config_t

LCDIC configuration.

typedef union *_lcdic_trx_cmd* lcdic_trx_cmd_t

LCDIC TRX command.

typedef struct *_lcdic_repeat_tx_xfer* lcdic_repeat_tx_xfer_t

LCDIC repeat data TX transfer structure.

typedef struct *_lcdic_tx_xfer* lcdic_tx_xfer_t

LCDIC data array TX transfer structure.

typedef struct *_lcdic_rx_xfer* lcdic_rx_xfer_t

LCDIC data array RX transfer structure.

typedef struct *_lcdic_xfer* lcdic_xfer_t

LCDIC transfer structure.

typedef struct *_lcdic_handle* lcdic_handle_t

typedef void (*lcdic_transfer_callback_t)(LCDIC_Type *base, *lcdic_handle_t* *handle, *status_t* status, void *userData)

LCDIC transfer callback function.

The status is kStatus_Success when transfer finished successfully, it is kStatus_Timeout when timeout happened.

typedef void (*lcdic_transfer_irq_handler_t)(LCDIC_Type *base, void *handle)

Typedef for transactional APIs IRQ handler.

typedef void (*lcdic_reset_done_callback_t)(LCDIC_Type *base)

Typedef for reset sequence sent done callback.

LCDIC_RESET_STATE_DELAY

Delay used in LCDIC_ResetState.

This should be larger than 5 * core clock / LCDIC function clock.

LCDIC_WAIT_CMD_DONE_TIMEOUT

How many loops the driver will wait when waiting for command execution done.

LCDIC hardware provides command timeout (kLCDIC_CmdTimeoutInterrupt) and TE timeout feature (kLCDIC_TeTimeoutInterrupt). When LCDIC driver waits for a command finish, it checks the hardware timeout flags, and returns directly when timeout occurs.

Besides the hardware timeout, LCDIC driver provides a software timeout feature, macro LCDIC_WAIT_CMD_DONE_TIMEOUT defines how many times will LCDIC driver check the hardware flags while waiting for command execution done. If kLCDIC_CmdDoneInterrupt, kLCDIC_CmdTimeoutInterrupt, and kLCDIC_TeTimeoutInterrupt flags are not set after LCDIC_WAIT_CMD_DONE_TIMEOUT times check, LCDIC driver will return kStatus_Timeout.

Define LCDIC_WAIT_CMD_DONE_TIMEOUT as 0 will disable this software timeout feature.

LCDIC_MAX_BYTE_PER_TRX

struct _lcdic_config

#include <fsl_lcdic.h> LCDIC configuration.

Public Members

lcdic_mode_t mode
LCDIC work mode.

lcdic_endian_t endian
Data endian.

lcdic_rx_threshold_t rxThreshold
RX FIFO threshold.

lcdic_tx_threshold_t txThreshold
TX FIFO threshold.

uint8_t timerRatio0
Valid range: 0~15. freq(timer0) = freq(lcdic_clk) / (2 ^ timerRatio0).

uint8_t timerRatio1
Valid range: 0~15. freq(timer1) = freq(timer0) / (2 ^ timerRatio1).

uint8_t resetPulseWidth_Timer0
Reset pulse width, in the unit of timer0 period. Valid range 1 ~ 64.

uint8_t resetSequence
Reset sequence, it is a 8-bit value sent to reset pin from LSB.

uint8_t resetSequencePulseNum
Reset sequence pulse number, valid range is 1 ~ 8.

lcdic_reset_polarity_t resetPolarity
Reset signal polarity.

uint8_t i8080CtrlFlags
I8080 control flags, it is OR'ed value of _lcdic_i8080_ctrl_flags.

uint8_t csWaitTime
Minimum CS inactive pulse width. T(csw)=T(lcdic_clk)*csWaitTime, valid range 0-7.

uint8_t csSetupTime
Minimum CS setup time before WR/RD. T(css)=T(lcdic_clk)*csSetupTime, valid range 0-255.

uint8_t csHoldTime
Minimum CS hold time after WR/RD. T(csh)=T(lcdic_clk)*csHoldTime, valid range 0-7.

uint8_t dcSetupTime
Minimum DC setup time before WR/RD/CS. T(dcs)=T(lcdic_clk)*dsSetupTime, valid range 0-7.

uint8_t dcHoldTime
Minimum DC hold time after WR/RD/CS. T(dch)=T(lcdic_clk)*dsHoldTime, valid range 0-7.

uint8_t writeDataSetupTime
Minimum write data setup time after WR active. T(wdh)=T(lcdic_clk)*writeDataSetupTime, valid range 0-7.

uint8_t writeDataHoldTime
Minimum write data setup time before WR active. T(wds)=T(lcdic_clk)*writeDataHoldTime, valid range 0-7.

uint8_t writeEnableActiveWidth
: Minmum write enable active pulse width. T(waw)=T(lcdic_clk)*writeEnableActiveWidth, valid range 0-63.

uint8_t writeEnableInactiveWidth
: Minmum write enable inactive pulse width. T(wiw)=T(lcdic_clk)*writeEnableInactiveWidth, valid range 0-63.

uint8_t readEnableActiveWidth
: Minmum read enable active pulse width. T(raw)=T(lcdic_clk)*readEnableActiveWidth, valid range 0-255.

uint8_t readEnableInactiveWidth
: Minmum read enable inactive pulse width. T(riw)=T(lcdic_clk)*readEnableInactiveWidth, valid range 0-255.

uint8_t spiCtrlFlags
: SPI control flags, it is OR'ed value of _lcdic_spi_ctrl_flags.

uint8_t teTimeoutTime_Timer1
: Tearing effect timeout time. T(te_to)=T(timer1)*teTimeoutTime_Timer1.

uint8_t teSyncWaitTime_Timer1
: Tearing effect signal synchronization wait time. T(tew)=T(timer1)*teSyncWaitTime_Timer1.

uint8_t cmdShortTimeout_Timer0
: Command short timeout. T(cmd_short_to)=T(timer0)*cmdShortTimeout_Timer0.

uint8_t cmdLongTimeout_Timer1
: Command long timeout. T(cmd_long_to)=T(timer1)*cmdLongTimeout_Timer1.

union __lcdic_trx_cmd
: *#include <fsl_lcdic.h>* LCDIC TRX command.

Public Members

struct *_lcdic_trx_cmd* bits

uint32_t u32

struct __lcdic_repeat_tx_xfer
: *#include <fsl_lcdic.h>* LCDIC repeat data TX transfer structure.

Public Members

uint8_t cmd
: Command.

uint8_t teSyncMode
: TE sync mode, see _lcdic_te_sync_mode.

uint8_t trxTimeoutMode
: TRX command timeout mode, see _lcdic_trx_timeout_mode.

uint8_t dataFormat
: Data format, see _lcdic_data_format.

uint32_t dataLen
: Data length.

uint32_t txRepeatData
The repeat data.

struct _lcdic_tx_xfer
#include <fsl_lcdic.h> LCDIC data array TX transfer structure.

Public Members

uint8_t cmd
Command.

uint8_t teSyncMode
TE sync mode, see _lcdic_te_sync_mode.

uint8_t trxTimeoutMode
TRX command timeout mode, see _lcdic_trx_timeout_mode.

uint8_t dataFormat
Data format, see _lcdic_data_format.

uint32_t dataLen
Data length.

const uint8_t *txData
The data to send.

struct _lcdic_rx_xfer
#include <fsl_lcdic.h> LCDIC data array RX transfer structure.

Public Members

uint8_t cmd
Command.

uint8_t dummyCount
Dummy cycle between TX and RX, only used for SPI mode.

uint8_t trxTimeoutMode
TRX command timeout mode, see _lcdic_trx_timeout_mode.

uint8_t dataFormat
Data format, see _lcdic_data_format.

uint32_t dataLen
Data length.

uint8_t *rxData
Pointer to the data receive array.

struct _lcdic_xfer
#include <fsl_lcdic.h> LCDIC transfer structure.

Public Members

lcdic_xfer_mode_t mode
Transfer mode.

struct _lcdic_handle
#include <fsl_lcdic.h> LCDIC handle structure.

Public Members

volatile bool xferInProgress
: Transfer in progress.

lcdic_xfer_mode_t xferMode
: On-going transfer mode.

lcdic_transfer_callback_t callback
: Callback function.

void *userData
: LCDIC callback function parameter.

uint32_t xferSizeWordAligned
: 4-byte aligned part of the transfer size.

uint8_t xferSizeWordUnaligned
: 4-byte unaligned part of the transfer size.

uint32_t tmpData
: Temp data for driver internal use.

struct bits

Public Members

uint32_t dataLen
: Data length in bytes, transfered byte is dataLen + 1.

uint32_t dummyCount
: Dummy cycle count between TX and RX (for SPI only).

uint32_t useAutoRepeat
: Use auto repeat mode or not.

uint32_t teSyncMode
: TE sync mode, see _lcdic_te_sync_mode.

uint32_t trxTimeoutMode
: TRX command timeout mode, see _lcdic_trx_timeout_mode.

uint32_t dataFormat
: Data format, see _lcdic_data_format.

uint32_t enableCmdDoneInt
: Enable command done interrupt or not.

uint32_t cmdOrData
: Command or data, see _lcdic_dc.

uint32_t trx
: TX or TX, see _lcdic_trx.

union ___unnamed36___

Public Members

uint8_t cmdToSendOnly
: Command to send in mode kLCDIC_XferCmdOnly.

lcdic_repeat_tx_xfer_t repeatTxXfer
For mode kLCDIC_XferSendRepeatData.

lcdic_tx_xfer_t txXfer
For mode kLCDIC_XferSendDataArray.

lcdic_rx_xfer_t rxXfer
For mode kLCDIC_XferReceiveDataArray.

union ___unnamed38___

Public Members

const uint8_t *txData
Data array to send.

uint8_t *rxData
RX data array.

2.37 LCDIC DMA Driver

status_t LCDIC_TransferCreateHandleDMA(LCDIC_Type *base, *lcdic_dma_handle_t* *handle, *lcdic_dma_callback_t* callback, void *userData, *dma_handle_t* *txDmaHandle, *dma_handle_t* *rxDmaHandle, *dma_descriptor_t* dmaDesc[2])

Initialize the LCDIC DMA handle.

This function initializes the LCDIC DMA handle which can be used for other LCDIC transactional APIs. Usually, for a specified LCDIC instance, user need only call this API once to get the initialized handle.

Parameters

- base – LCDIC peripheral base address.
- handle – LCDIC handle pointer.
- callback – User callback function called at the end of a transfer.
- userData – User data for callback.
- txDmaHandle – DMA handle pointer for LCDIC Tx, the handle shall be static allocated by users.
- rxDmaHandle – DMA handle pointer for LCDIC Rx, the handle shall be static allocated by users.
- dmaDesc – User allocated dma descriptor, it should be in non-cacheable region and 16-byte aligned.

status_t LCDIC_TransferDMA(LCDIC_Type *base, *lcdic_dma_handle_t* *handle, const *lcdic_xfer_t* *xfer)

Perform a non-blocking LCDIC transfer using DMA.

This function returned immediately after transfer initiates, monitor the transfer done by callback.

Parameters

- base – LCDIC peripheral base address.
- handle – LCDIC DMA handle pointer.

- xfer – Pointer to dma transfer structure.

Return values

- kStatus_Success – Successfully start a transfer.
- kStatus_InvalidArgument – Input argument is invalid.
- kStatus_Busy – LCDIC is not idle, is running another transfer.

status_t LCDIC_SendDataArrayDMA(LCDIC_Type *base, *lcdic_dma_handle_t* *handle, const *lcdic_tx_xfer_t* *xfer)

Send data array using DMA.

Parameters

- base – LCDIC peripheral base address.
- handle – Pointer to the lcdic_handle_t structure to store the transfer state.
- xfer – LCDIC transfer structure.

Return values

- kStatus_Success – Successfully start a transfer.
- kStatus_InvalidArgument – Input argument is invalid.
- kStatus_Busy – LCDIC driver is busy with another transfer.

status_t LCDIC_ReadDataArrayDMA(LCDIC_Type *base, *lcdic_dma_handle_t* *handle, const *lcdic_rx_xfer_t* *xfer)

Read data array using DMA.

Parameters

- base – LCDIC peripheral base address.
- handle – Pointer to the lcdic_handle_t structure to store the transfer state.
- xfer – LCDIC transfer structure.

Return values

- kStatus_Success – Successfully start a transfer.
- kStatus_InvalidArgument – Input argument is invalid.
- kStatus_Busy – LCDIC driver is busy with another transfer.

void LCDIC_TransferHandleIRQDMA(LCDIC_Type *base, void *handle)

LCDIC IRQ handler function work with DMA transactional APIs.

IRQ handler to work with LCDIC_TransferDMA.

Parameters

- base – LCDIC peripheral base address.
- handle – Pointer to the lcdic_dma_handle_t structure to store the transfer state.

FSL_LCDIC_DMA_DRIVER_VERSION

typedef struct *_lcdic_dma_handle* lcdic_dma_handle_t

typedef void (*lcdic_dma_callback_t)(LCDIC_Type *base, *lcdic_dma_handle_t* *handle, *status_t* status, void *userData)

LCDIC DMA callback called at the end of transfer.

struct __lcdic_dma_handle

#include <fsl_lcdic_dma.h> LCDIC DMA transfer handle, users should not touch the content of the handle.

Public Members

volatile bool xferInProgress

Transfer in progress

lcdic_xfer_mode_t xferMode

On-going transfer mode.

dma_handle_t *txDmaHandle

DMA handler for send

dma_handle_t *rxDmaHandle

DMA handler for receive

lcdic_dma_callback_t callback

Callback when transfer finished.

void *userData

User Data for callback

uint32_t xferSizeWordAligned

4-byte size aligned part or the transfer data size.

uint8_t xferSizeWordUnaligned

4-byte size unaligned part of the transfer data size.

uint8_t rxSizeWordUnaligned

Same as xferSizeWordUnaligned, it is only used for RX.

uint32_t tmpData

To save temporary data during transfer.

dma_descriptor_t *dmaDesc

Pointer to two DMA descriptor, should be 16-byte aligned.

union ___unnamed25___

Public Members

const uint8_t *txData

Pointer to the TX data.

uint8_t *rxData

Pointer to the RX data.

2.38 LCDIC: LCD Interface Controller

2.39 GPIO: General Purpose I/O

void GPIO_PortInit(GPIO_Type *base, uint32_t port)

Initializes the GPIO peripheral.

This function ungates the GPIO clock.

Parameters

- base – GPIO peripheral base pointer.
- port – GPIO port number.

void GPIO_PinInit(GPIO_Type *base, uint32_t port, uint32_t pin, const *gpio_pin_config_t* *config)

Initializes a GPIO pin used by the board.

To initialize the GPIO, define a pin configuration, either input or output, in the user file. Then, call the GPIO_PinInit() function.

This is an example to define an input pin or output pin configuration:

```
Define a digital input pin configuration,
gpio_pin_config_t config =
{
  kGPIO_DigitalInput,
  0,
}
Define a digital output pin configuration,
gpio_pin_config_t config =
{
  kGPIO_DigitalOutput,
  0,
}
```

Parameters

- base – GPIO peripheral base pointer(Typically GPIO)
- port – GPIO port number
- pin – GPIO pin number
- config – GPIO pin configuration pointer

static inline void GPIO_PinWrite(GPIO_Type *base, uint32_t port, uint32_t pin, uint8_t output)

Sets the output level of the one GPIO pin to the logic 1 or 0.

Parameters

- base – GPIO peripheral base pointer(Typically GPIO)
- port – GPIO port number
- pin – GPIO pin number
- output – GPIO pin output logic level.
  - 0: corresponding pin output low-logic level.
  - 1: corresponding pin output high-logic level.

static inline uint32_t GPIO_PinRead(GPIO_Type *base, uint32_t port, uint32_t pin)

Reads the current input value of the GPIO PIN.

Parameters

- base – GPIO peripheral base pointer(Typically GPIO)
- port – GPIO port number
- pin – GPIO pin number

Return values

GPIO – port input value

- 0: corresponding pin input low-logic level.
- 1: corresponding pin input high-logic level.

FSL_GPIO_DRIVER_VERSION

LPC GPIO driver version.

enum _gpio_pin_direction

LPC GPIO direction definition.

Values:

enumerator kGPIO_DigitalInput

Set current pin as digital input

enumerator kGPIO_DigitalOutput

Set current pin as digital output

enum _gpio_pin_enable_mode

GPIO Pin Interrupt enable mode.

Values:

enumerator kGPIO_PinIntEnableLevel

Generate Pin Interrupt on level mode

enumerator kGPIO_PinIntEnableEdge

Generate Pin Interrupt on edge mode

enum _gpio_pin_enable_polarity

GPIO Pin Interrupt enable polarity.

Values:

enumerator kGPIO_PinIntEnableHighOrRise

Generate Pin Interrupt on high level or rising edge

enumerator kGPIO_PinIntEnableLowOrFall

Generate Pin Interrupt on low level or falling edge

enum _gpio_interrupt_index

LPC GPIO interrupt index definition.

Values:

enumerator kGPIO_InterruptA

Set current pin as interrupt A

enumerator kGPIO_InterruptB

Set current pin as interrupt B

typedef enum *_gpio_pin_direction* gpio_pin_direction_t

LPC GPIO direction definition.

typedef struct *_gpio_pin_config* gpio_pin_config_t

The GPIO pin configuration structure.

Every pin can only be configured as either output pin or input pin at a time. If configured as a input pin, then leave the outputConfig unused.

typedef enum *_gpio_pin_enable_mode* gpio_pin_enable_mode_t

GPIO Pin Interrupt enable mode.

typedef enum *_gpio_pin_enable_polarity* gpio_pin_enable_polarity_t
GPIO Pin Interrupt enable polarity.

typedef enum *_gpio_interrupt_index* gpio_interrupt_index_t
LPC GPIO interrupt index definition.

typedef struct *_gpio_interrupt_config* gpio_interrupt_config_t
Configures the interrupt generation condition.

static inline void GPIO_PortSet(GPIO_Type *base, uint32_t port, uint32_t mask)
Sets the output level of the multiple GPIO pins to the logic 1.

Parameters

- base – GPIO peripheral base pointer(Typically GPIO)
- port – GPIO port number
- mask – GPIO pin number macro

static inline void GPIO_PortClear(GPIO_Type *base, uint32_t port, uint32_t mask)
Sets the output level of the multiple GPIO pins to the logic 0.

Parameters

- base – GPIO peripheral base pointer(Typically GPIO)
- port – GPIO port number
- mask – GPIO pin number macro

static inline void GPIO_PortToggle(GPIO_Type *base, uint32_t port, uint32_t mask)
Reverses current output logic of the multiple GPIO pins.

Parameters

- base – GPIO peripheral base pointer(Typically GPIO)
- port – GPIO port number
- mask – GPIO pin number macro

GPIO_PIN_INT_LEVEL

GPIO_PIN_INT_EDGE

PINT_PIN_INT_HIGH_OR_RISE_TRIGGER

PINT_PIN_INT_LOW_OR_FALL_TRIGGER

struct __gpio_pin_config
#include <fsl_gpio.h> The GPIO pin configuration structure.

Every pin can only be configured as either output pin or input pin at a time. If configured as a input pin, then leave the outputConfig unused.

Public Members

gpio_pin_direction_t pinDirection
GPIO direction, input or output

uint8_t outputLogic
Set default output logic, no use in input

struct __gpio_interrupt_config
#include <fsl_gpio.h> Configures the interrupt generation condition.

2.40 MRT: Multi-Rate Timer

void MRT_Init(MRT_Type *base, const *mrt_config_t* *config)

Ungates the MRT clock and configures the peripheral for basic operation.

Note: This API should be called at the beginning of the application using the MRT driver.

Parameters

- base – Multi-Rate timer peripheral base address
- config – Pointer to user's MRT config structure. If MRT has MULTITASK bit field in MODCFG reigster, param config is useless.

void MRT_Deinit(MRT_Type *base)

Gate the MRT clock.

Parameters

- base – Multi-Rate timer peripheral base address

static inline void MRT_GetDefaultConfig(*mrt_config_t* *config)

Fill in the MRT config struct with the default settings.

The default values are:

```
config->enableMultiTask = false;
```

Parameters

- config – Pointer to user's MRT config structure.

static inline void MRT_SetupChannelMode(MRT_Type *base, *mrt_chnl_t* channel, const *mrt_timer_mode_t* mode)

Sets up an MRT channel mode.

Parameters

- base – Multi-Rate timer peripheral base address
- channel – Channel that is being configured.
- mode – Timer mode to use for the channel.

static inline void MRT_EnableInterrupts(MRT_Type *base, *mrt_chnl_t* channel, uint32_t mask)

Enables the MRT interrupt.

Parameters

- base – Multi-Rate timer peripheral base address
- channel – Timer channel number
- mask – The interrupts to enable. This is a logical OR of members of the enumeration mrt_interrupt_enable_t

static inline void MRT_DisableInterrupts(MRT_Type *base, *mrt_chnl_t* channel, uint32_t mask)

Disables the selected MRT interrupt.

Parameters

- base – Multi-Rate timer peripheral base address
- channel – Timer channel number

- mask – The interrupts to disable. This is a logical OR of members of the enumeration mrt_interrupt_enable_t

static inline uint32_t MRT_GetEnabledInterrupts(MRT_Type *base, *mrt_chnl_t* channel)

Gets the enabled MRT interrupts.

Parameters

- base – Multi-Rate timer peripheral base address
- channel – Timer channel number

Returns

The enabled interrupts. This is the logical OR of members of the enumeration mrt_interrupt_enable_t

static inline uint32_t MRT_GetStatusFlags(MRT_Type *base, *mrt_chnl_t* channel)

Gets the MRT status flags.

Parameters

- base – Multi-Rate timer peripheral base address
- channel – Timer channel number

Returns

The status flags. This is the logical OR of members of the enumeration mrt_status_flags_t

static inline void MRT_ClearStatusFlags(MRT_Type *base, *mrt_chnl_t* channel, uint32_t mask)

Clears the MRT status flags.

Parameters

- base – Multi-Rate timer peripheral base address
- channel – Timer channel number
- mask – The status flags to clear. This is a logical OR of members of the enumeration mrt_status_flags_t

void MRT_UpdateTimerPeriod(MRT_Type *base, *mrt_chnl_t* channel, uint32_t count, bool immediateLoad)

Used to update the timer period in units of count.

The new value will be immediately loaded or will be loaded at the end of the current time interval. For one-shot interrupt mode the new value will be immediately loaded.

Note: User can call the utility macros provided in fsl_common.h to convert to ticks

---

Parameters

- base – Multi-Rate timer peripheral base address
- channel – Timer channel number
- count – Timer period in units of ticks
- immediateLoad – true: Load the new value immediately into the TIMER register; false: Load the new value at the end of current timer interval

static inline uint32_t MRT_GetCurrentTimerCount(MRT_Type *base, *mrt_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 usec or msec

Parameters

- base – Multi-Rate timer peripheral base address
- channel – Timer channel number

Returns

Current timer counting value in ticks

static inline void MRT_StartTimer(MRT_Type *base, *mrt_chnl_t* channel, uint32_t count)

Starts the timer counting.

After calling this function, timers load period value, counts down to 0 and depending on the timer mode it will either load the respective start value again or stop.

Note: User can call the utility macros provided in fsl_common.h to convert to ticks

Parameters

- base – Multi-Rate timer peripheral base address
- channel – Timer channel number.
- count – Timer period in units of ticks. Count can contain the LOAD bit, which control the force load feature.

static inline void MRT_StopTimer(MRT_Type *base, *mrt_chnl_t* channel)

Stops the timer counting.

This function stops the timer from counting.

Parameters

- base – Multi-Rate timer peripheral base address
- channel – Timer channel number.

static inline uint32_t MRT_GetIdleChannel(MRT_Type *base)

Find the available channel.

This function returns the lowest available channel number.

Parameters

- base – Multi-Rate timer peripheral base address

static inline void MRT_ReleaseChannel(MRT_Type *base, *mrt_chnl_t* channel)

Release the channel when the timer is using the multi-task mode.

In multi-task mode, the INUSE flags allow more control over when MRT channels are released for further use. The user can hold on to a channel acquired by calling MRT_GetIdleChannel() for as long as it is needed and release it by calling this function. This removes the need to ask for an available channel for every use.

Parameters

- base – Multi-Rate timer peripheral base address
- channel – Timer channel number.

FSL_MRT_DRIVER_VERSION

enum _mrt_chnl

List of MRT channels.

Values:

enumerator kMRT_Channel_0

MRT channel number 0

enumerator kMRT_Channel_1

MRT channel number 1

enumerator kMRT_Channel_2

MRT channel number 2

enumerator kMRT_Channel_3

MRT channel number 3

enum _mrt_timer_mode

List of MRT timer modes.

Values:

enumerator kMRT_RepeatMode

Repeat Interrupt mode

enumerator kMRT_OneShotMode

One-shot Interrupt mode

enumerator kMRT_OneShotStallMode

One-shot stall mode

enum _mrt_interrupt_enable

List of MRT interrupts.

Values:

enumerator kMRT_TimerInterruptEnable

Timer interrupt enable

enum _mrt_status_flags

List of MRT status flags.

Values:

enumerator kMRT_TimerInterruptFlag

Timer interrupt flag

enumerator kMRT_TimerRunFlag

Indicates state of the timer

typedef enum *_mrt_chnl* mrt_chnl_t

List of MRT channels.

typedef enum *_mrt_timer_mode* mrt_timer_mode_t

List of MRT timer modes.

typedef enum *_mrt_interrupt_enable* mrt_interrupt_enable_t

List of MRT interrupts.

typedef enum *_mrt_status_flags* mrt_status_flags_t

List of MRT status flags.

typedef struct *_mrt_config* mrt_config_t

MRT configuration structure.

This structure holds the configuration settings for the MRT peripheral. To initialize this structure to reasonable defaults, call the MRT_GetDefaultConfig() function and pass a pointer to your config structure instance.

The config struct can be made const so it resides in flash

struct _mrt_config

#include <fsl_mrt.h> MRT configuration structure.

This structure holds the configuration settings for the MRT peripheral. To initialize this structure to reasonable defaults, call the MRT_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

bool enableMultiTask

true: Timers run in multi-task mode; false: Timers run in hardware status mode

2.41 This type defines status return values used by NBOOT functions that are not easily disturbed by Fault Attacks

kStatus_NBOOT_Success

Operation completed successfully.

kStatus_NBOOT_Fail

Operation failed.

kStatus_NBOOT_InvalidArgument

Invalid argument passed to the function.

kStatus_NBOOT_RequestTimeout

Operation timed out.

kStatus_NBOOT_KeyNotLoaded

The requested key is not loaded.

kStatus_NBOOT_AuthFail

Authentication failed.

kStatus_NBOOT_OperationNotAvaialable

Operation not available on this HW.

kStatus_NBOOT_KeyNotAvailable

Key is not avaialble.

kStatus_NBOOT_IvCounterOverflow

Overflow of IV counter (PRINCE/IPED).

kStatus_NBOOT_SelftestFail

FIPS self-test failure.

kStatus_NBOOT_InvalidDataFormat

Invalid data format for example antipole

kStatus_NBOOT_IskCertUserDataTooBig
: Size of User data in ISK certificate is greater than 96 bytes

kStatus_NBOOT_IskCertSignatureOffsetTooSmall
: Signature offset in ISK certificate is smaller than expected

kStatus_NBOOT_MemcpyFail
: Unexpected error detected during nboot_memcpy()

NXPCLCSS_HASH_RTF_OUTPUT_SIZE
: Size of run-time fingerprint appended to the hash in pDigest in bytes, if #NXPCLCSS_HASH_RTF_OUTPUT_ENABLE was specified.

NXPCLHASH_WA_SIZE_MAX

2.42 OCOTP Driver

OTP Status Group.

Values:

enumerator kStatusGroup_OtpGroup

OTP Error Status definitions.

Values:

enumerator kStatus_OTP_InvalidAddress
: Invalid OTP address

enumerator kStatus_OTP_Timeout
: OTP operation time out

status_t OCOTP_OtpInit(void)
: Initialize OTP controller.

  This function enables OTP Controller clock.

  Returns
  : kStatus_Success

status_t OCOTP_OtpDeinit(void)
: De-Initialize OTP controller.

  This functin disables OTP Controller Clock.

  Returns
  : kStatus_Success

status_t OCOTP_OtpFuseRead(uint32_t addr, uint32_t *data)
: Read Fuse value from OTP Fuse Block.

  This function read fuse data from OTP Fuse block to specified data buffer.

  Parameters

  - addr – Fuse address
  - data – Buffer to hold the data read from OTP Fuse block

Returns

kStatus_Success - Data read from OTP Fuse block successfully kStatus_OTP_Timeout - OTP read timeout kStatus_InvalidArgument - data pointer is invalid

status_t OCOTP_ReadSocOtp(uint64_t *data, uint32_t tag)

Read Fuse line with specific tag value from SoC OTP.

This function read Fuse line with specific tag value from SoC OTP to specified data buffer.

Parameters

- data – Buffer to hold the data read from SoC OTP
- tag – Tag value to match

Returns

kStatus_Success - Data read from SoC OTP successfully kStatus_Fail - Data read from SoC OTP failed, or cannot find the tag kStatus_InvalidArgument - data pointer is invalid

status_t OCOTP_ReadUniqueID(uint8_t *uid, uint32_t *idLen)

Read unique ID from OTP Fuse Block.

This function read unique ID from OTP Fuse block to specified data buffer.

Parameters

- uid – The buffer to store unique ID, buffer byte length is FSL_OCOTP_UID_LENGTH.
- idLen[in/out] – The unique ID byte length. Set the length to read, return the length read out.

Returns

kStatus_Success - Data read from OTP Fuse block successfully kStatus_OTP_Timeout - OTP read timeout kStatus_InvalidArgument - data pointer is invalid

status_t OCOTP_ReadSVC(uint64_t *svc)

Read Static Voltage Compansation from SOC OTP.

This function read SVC from OTP Fuse block to specified data buffer.

Parameters

- svc – The buffer to store SVC.

Returns

kStatus_Success - Data read from SOC OTP successfully kStatus_Fail - SOC OTP read failure

status_t OCOTP_ReadPackage(uint32_t *pack)

Read package type from SOC OTP.

Parameters

- pack – The buffer to store package type.

Returns

kStatus_Success - Data read from SOC OTP successfully kStatus_Fail - SOC OTP read failure

FSL_OCOTP_DRIVER_VERSION

OCOTP driver version 2.2.3.

FSL_OCOTP_UID_LENGTH

OCOTP unique ID length.

2.43 OSTIMER: OS Event Timer Driver

void OSTIMER_Init(OSTIMER_Type *base)

Initializes an OSTIMER by turning its bus clock on.

void OSTIMER_Deinit(OSTIMER_Type *base)

Deinitializes a OSTIMER instance.

This function shuts down OSTIMER bus clock

Parameters

- base – OSTIMER peripheral base address.

uint64_t OSTIMER_GrayToDecimal(uint64_t gray)

Translate the value from gray-code to decimal.

Parameters

- gray – The gray value input.

Returns

The decimal value.

static inline uint64_t OSTIMER_DecimalToGray(uint64_t dec)

Translate the value from decimal to gray-code.

Parameters

- dec – The decimal value.

Returns

The gray code of the input value.

uint32_t OSTIMER_GetStatusFlags(OSTIMER_Type *base)

Get OSTIMER status Flags.

This returns the status flag. Currently, only match interrupt flag can be got.

Parameters

- base – OSTIMER peripheral base address.

Returns

status register value

void OSTIMER_ClearStatusFlags(OSTIMER_Type *base, uint32_t mask)

Clear Status Interrupt Flags.

This clears intrrupt status flag. Currently, only match interrupt flag can be cleared.

Parameters

- base – OSTIMER peripheral base address.
- mask – Clear bit mask.

Returns

none

status_t OSTIMER_SetMatchRawValue(OSTIMER_Type *base, uint64_t count, *ostimer_callback_t* cb)

Set the match raw value for OSTIMER.

This function will set a match value for OSTIMER with an optional callback. And this callback will be called while the data in dedicated pair match register is equals to the value of central EVTIMER. Please note that, the data format may be gray-code, if so, please using OSTIMER_SetMatchValue().

Parameters

- base – OSTIMER peripheral base address.
- count – OSTIMER timer match value.(Value may be gray-code format)
- cb – OSTIMER callback (can be left as NULL if none, otherwise should be a void func(void)).

Return values

- kStatus_Success – - Set match raw value and enable interrupt Successfully.
- kStatus_Fail – - Set match raw value fail.

status_t OSTIMER_SetMatchValue(OSTIMER_Type *base, uint64_t count, *ostimer_callback_t* cb)

Set the match value for OSTIMER.

This function will set a match value for OSTIMER with an optional callback. And this callback will be called while the data in dedicated pair match register is equals to the value of central OS TIMER.

Parameters

- base – OSTIMER peripheral base address.
- count – OSTIMER timer match value.(Value is decimal format, and this value will be translate to Gray code in API if the IP counter is gray encoded.)
- cb – OSTIMER callback (can be left as NULL if none, otherwise should be a void func(void)).

Return values

- kStatus_Success – - Set match value and enable interrupt Successfully.
- kStatus_Fail – - Set match value fail.

static inline void OSTIMER_SetMatchRegister(OSTIMER_Type *base, uint64_t value)

Set value to OSTIMER MATCH register directly.

This function writes the input value to OSTIMER MATCH register directly, it does not touch any other registers. Note that, the data format is gray-code. The function OSTIMER_DecimalToGray could convert decimal value to gray code.

Parameters

- base – OSTIMER peripheral base address.
- value – OSTIMER timer match value (Value is gray-code format).

static inline uint64_t OSTIMER_GetMatchRegister(OSTIMER_Type *base)

Get the match value from OSTIMER.

This function will get the match value from OSTIMER. The value of timer match is gray code format.

Parameters

- base – OSTIMER peripheral base address.

Returns

Value of match register, data format is gray code.

static inline uint64_t OSTIMER_GetMatchValue(OSTIMER_Type *base)

Get the match value from OSTIMER.

This function will get a match value from OSTIMER.

Parameters

- base – OSTIMER peripheral base address.

Returns
Value of match register.

static inline void OSTIMER_EnableMatchInterrupt(OSTIMER_Type *base)

Enable the OSTIMER counter match interrupt.

Enable the timer counter match interrupt. The interrupt happens when OSTIMER counter matches the value in MATCH registers.

Parameters

- base – OSTIMER peripheral base address.

static inline void OSTIMER_DisableMatchInterrupt(OSTIMER_Type *base)

Disable the OSTIMER counter match interrupt.

Disable the timer counter match interrupt. The interrupt happens when OSTIMER counter matches the value in MATCH registers.

Parameters

- base – OSTIMER peripheral base address.

static inline uint64_t OSTIMER_GetCurrentTimerRawValue(OSTIMER_Type *base)

Get current timer raw count value from OSTIMER.

This function will get the timer count value from OS timer register. The raw value of timer count may be gray code format.

Parameters

- base – OSTIMER peripheral base address.

Returns
Raw value of OSTIMER, may be gray code format.

uint64_t OSTIMER_GetCurrentTimerValue(OSTIMER_Type *base)

Get current timer count value from OSTIMER.

This function will get a decimal timer count value. If the RAW value of timer count is gray code format, it will be translated to decimal data internally.

Parameters

- base – OSTIMER peripheral base address.

Returns
Value of OSTIMER which will be formated to decimal value.

static inline uint64_t OSTIMER_GetCaptureRawValue(OSTIMER_Type *base)

Get the capture value from OSTIMER.

This function will get a captured value from OSTIMER. The Raw value of timer capture may be gray code format.

Parameters

- base – OSTIMER peripheral base address.

Returns
Raw value of capture register, data format may be gray code.

uint64_t OSTIMER_GetCaptureValue(OSTIMER_Type *base)

Get the capture value from OSTIMER.

This function will get a capture decimal-value from OSTIMER. If the RAW value of timer count is gray code format, it will be translated to decimal data internally.

Parameters

- base – OSTIMER peripheral base address.

Returns
Value of capture register, data format is decimal.

void OSTIMER_HandleIRQ(OSTIMER_Type *base, *ostimer_callback_t* cb)

OS timer interrupt Service Handler.

This function handles the interrupt and refers to the callback array in the driver to callback user (as per request in OSTIMER_SetMatchValue()). if no user callback is scheduled, the interrupt will simply be cleared.

Parameters

- base – OS timer peripheral base address.
- cb – callback scheduled for this instance of OS timer

Returns
none

FSL_OSTIMER_DRIVER_VERSION

OSTIMER driver version.

enum _ostimer_flags

OSTIMER status flags.

Values:

enumerator kOSTIMER_MatchInterruptFlag

Match interrupt flag bit, sets if the match value was reached.

typedef void (*ostimer_callback_t)(void)

ostimer callback function.

2.44 PINT: Pin Interrupt and Pattern Match Driver

FSL_PINT_DRIVER_VERSION

enum _pint_pin_enable

PINT Pin Interrupt enable type.

Values:

enumerator kPINT_PinIntEnableNone

Do not generate Pin Interrupt

enumerator kPINT_PinIntEnableRiseEdge

Generate Pin Interrupt on rising edge

enumerator kPINT_PinIntEnableFallEdge

Generate Pin Interrupt on falling edge

enumerator kPINT_PinIntEnableBothEdges

Generate Pin Interrupt on both edges

enumerator kPINT_PinIntEnableLowLevel

Generate Pin Interrupt on low level

enumerator kPINT_PinIntEnableHighLevel

Generate Pin Interrupt on high level

enum _pint_int

PINT Pin Interrupt type.

Values:

enumerator kPINT_PinInt0

Pin Interrupt 0

enum _pint_pmatch_input_src

PINT Pattern Match bit slice input source type.

Values:

enumerator kPINT_PatternMatchInp0Src

Input source 0

enumerator kPINT_PatternMatchInp1Src

Input source 1

enumerator kPINT_PatternMatchInp2Src

Input source 2

enumerator kPINT_PatternMatchInp3Src

Input source 3

enumerator kPINT_PatternMatchInp4Src

Input source 4

enumerator kPINT_PatternMatchInp5Src

Input source 5

enumerator kPINT_PatternMatchInp6Src

Input source 6

enumerator kPINT_PatternMatchInp7Src

Input source 7

enumerator kPINT_SecPatternMatchInp0Src

Input source 0

enumerator kPINT_SecPatternMatchInp1Src

Input source 1

enum _pint_pmatch_bslice

PINT Pattern Match bit slice type.

Values:

enumerator kPINT_PatternMatchBSlice0

Bit slice 0

enum _pint_pmatch_bslice_cfg

PINT Pattern Match configuration type.

Values:

enumerator kPINT_PatternMatchAlways

Always Contributes to product term match

enumerator kPINT_PatternMatchStickyRise

Sticky Rising edge

enumerator kPINT_PatternMatchStickyFall

Sticky Falling edge

enumerator kPINT_PatternMatchStickyBothEdges
Sticky Rising or Falling edge

enumerator kPINT_PatternMatchHigh
High level

enumerator kPINT_PatternMatchLow
Low level

enumerator kPINT_PatternMatchNever
Never contributes to product term match

enumerator kPINT_PatternMatchBothEdges
Either rising or falling edge

typedef enum *_pint_pin_enable* pint_pin_enable_t
PINT Pin Interrupt enable type.

typedef enum *_pint_int* pint_pin_int_t
PINT Pin Interrupt type.

typedef enum *_pint_pmatch_input_src* pint_pmatch_input_src_t
PINT Pattern Match bit slice input source type.

typedef enum *_pint_pmatch_bslice* pint_pmatch_bslice_t
PINT Pattern Match bit slice type.

typedef enum *_pint_pmatch_bslice_cfg* pint_pmatch_bslice_cfg_t
PINT Pattern Match configuration type.

typedef struct *_pint_status* pint_status_t
PINT event status.

typedef void (*pint_cb_t)(*pint_pin_int_t* pintr, *pint_status_t* *status)
PINT Callback function.

typedef struct *_pint_pmatch_cfg* pint_pmatch_cfg_t

void PINT_Init(PINT_Type *base)
Initialize PINT peripheral.

This function initializes the PINT peripheral and enables the clock.

Parameters

- base – Base address of the PINT peripheral.

Return values
None. –

void PINT_SetCallback(PINT_Type *base, *pint_cb_t* callback)
Set PINT callback.

This function set the callback for PINT interupt handler.

Parameters

- base – Base address of the PINT peripheral.
- callback – Callback.

Return values
None. –

void PINT_PinInterruptConfig(PINT_Type *base, *pint_pin_int_t* intr, *pint_pin_enable_t* enable)

Configure PINT peripheral pin interrupt.

This function configures a given pin interrupt.

Parameters

- base – Base address of the PINT peripheral.
- intr – Pin interrupt.
- enable – Selects detection logic.

Return values

None. –

void PINT_PinInterruptGetConfig(PINT_Type *base, *pint_pin_int_t* pintr, *pint_pin_enable_t* *enable)

Get PINT peripheral pin interrupt configuration.

This function returns the configuration of a given pin interrupt.

Parameters

- base – Base address of the PINT peripheral.
- pintr – Pin interrupt.
- enable – Pointer to store the detection logic.

Return values

None. –

void PINT_PinInterruptClrStatus(PINT_Type *base, *pint_pin_int_t* pintr)

Clear Selected pin interrupt status only when the pin was triggered by edge-sensitive.

This function clears the selected pin interrupt status.

Parameters

- base – Base address of the PINT peripheral.
- pintr – Pin interrupt.

Return values

None. –

static inline uint32_t PINT_PinInterruptGetStatus(PINT_Type *base, *pint_pin_int_t* pintr)

Get Selected pin interrupt status.

This function returns the selected pin interrupt status.

Parameters

- base – Base address of the PINT peripheral.
- pintr – Pin interrupt.

Return values

status – = 0 No pin interrupt request. = 1 Selected Pin interrupt request active.

void PINT_PinInterruptClrStatusAll(PINT_Type *base)

Clear all pin interrupts status only when pins were triggered by edge-sensitive.

This function clears the status of all pin interrupts.

Parameters

- base – Base address of the PINT peripheral.

Return values

None. –

static inline uint32_t PINT_PinInterruptGetStatusAll(PINT_Type *base)

Get all pin interrupts status.

This function returns the status of all pin interrupts.

Parameters

- base – Base address of the PINT peripheral.

Return values

status – Each bit position indicates the status of corresponding pin interrupt. = 0 No pin interrupt request. = 1 Pin interrupt request active.

static inline void PINT_PinInterruptClrFallFlag(PINT_Type *base, *pint_pin_int_t* pintr)

Clear Selected pin interrupt fall flag.

This function clears the selected pin interrupt fall flag.

Parameters

- base – Base address of the PINT peripheral.
- pintr – Pin interrupt.

Return values

None. –

static inline uint32_t PINT_PinInterruptGetFallFlag(PINT_Type *base, *pint_pin_int_t* pintr)

Get selected pin interrupt fall flag.

This function returns the selected pin interrupt fall flag.

Parameters

- base – Base address of the PINT peripheral.
- pintr – Pin interrupt.

Return values

flag – = 0 Falling edge has not been detected. = 1 Falling edge has been detected.

static inline void PINT_PinInterruptClrFallFlagAll(PINT_Type *base)

Clear all pin interrupt fall flags.

This function clears the fall flag for all pin interrupts.

Parameters

- base – Base address of the PINT peripheral.

Return values

None. –

static inline uint32_t PINT_PinInterruptGetFallFlagAll(PINT_Type *base)

Get all pin interrupt fall flags.

This function returns the fall flag of all pin interrupts.

Parameters

- base – Base address of the PINT peripheral.

Return values

flags – Each bit position indicates the falling edge detection of the corresponding pin interrupt. 0 Falling edge has not been detected. = 1 Falling edge has been detected.

static inline void PINT_PinInterruptClrRiseFlag(PINT_Type *base, *pint_pin_int_t* pintr)

Clear Selected pin interrupt rise flag.

This function clears the selected pin interrupt rise flag.

Parameters

- base – Base address of the PINT peripheral.
- pintr – Pin interrupt.

Return values

None. –

static inline uint32_t PINT_PinInterruptGetRiseFlag(PINT_Type *base, *pint_pin_int_t* pintr)

Get selected pin interrupt rise flag.

This function returns the selected pin interrupt rise flag.

Parameters

- base – Base address of the PINT peripheral.
- pintr – Pin interrupt.

Return values

flag – = 0 Rising edge has not been detected. = 1 Rising edge has been detected.

static inline void PINT_PinInterruptClrRiseFlagAll(PINT_Type *base)

Clear all pin interrupt rise flags.

This function clears the rise flag for all pin interrupts.

Parameters

- base – Base address of the PINT peripheral.

Return values

None. –

static inline uint32_t PINT_PinInterruptGetRiseFlagAll(PINT_Type *base)

Get all pin interrupt rise flags.

This function returns the rise flag of all pin interrupts.

Parameters

- base – Base address of the PINT peripheral.

Return values

flags – Each bit position indicates the rising edge detection of the corresponding pin interrupt. 0 Rising edge has not been detected. = 1 Rising edge has been detected.

void PINT_PatternMatchConfig(PINT_Type *base, *pint_pmatch_bslice_t* bslice, *pint_pmatch_cfg_t* *cfg)

Configure PINT pattern match.

This function configures a given pattern match bit slice.

Parameters

- base – Base address of the PINT peripheral.
- bslice – Pattern match bit slice number.
- cfg – Pointer to bit slice configuration.

Return values

None. –

void PINT_PatternMatchGetConfig(PINT_Type *base, *pint_pmatch_bslice_t* bslice, *pint_pmatch_cfg_t* *cfg)

Get PINT pattern match configuration.

This function returns the configuration of a given pattern match bit slice.

Parameters

- base – Base address of the PINT peripheral.
- bslice – Pattern match bit slice number.
- cfg – Pointer to bit slice configuration.

Return values

None. –

static inline uint32_t PINT_PatternMatchGetStatus(PINT_Type *base, *pint_pmatch_bslice_t* bslice)

Get pattern match bit slice status.

This function returns the status of selected bit slice.

Parameters

- base – Base address of the PINT peripheral.
- bslice – Pattern match bit slice number.

Return values

status – = 0 Match has not been detected. = 1 Match has been detected.

static inline uint32_t PINT_PatternMatchGetStatusAll(PINT_Type *base)

Get status of all pattern match bit slices.

This function returns the status of all bit slices.

Parameters

- base – Base address of the PINT peripheral.

Return values

status – Each bit position indicates the match status of corresponding bit slice. = 0 Match has not been detected. = 1 Match has been detected.

uint32_t PINT_PatternMatchResetDetectLogic(PINT_Type *base)

Reset pattern match detection logic.

This function resets the pattern match detection logic if any of the product term is matching.

Parameters

- base – Base address of the PINT peripheral.

Return values

pmstatus – Each bit position indicates the match status of corresponding bit slice. = 0 Match was detected. = 1 Match was not detected.

static inline void PINT_PatternMatchEnable(PINT_Type *base)

Enable pattern match function.

This function enables the pattern match function.

Parameters

- base – Base address of the PINT peripheral.

Return values

None. –

static inline void PINT_PatternMatchDisable(PINT_Type *base)

Disable pattern match function.

This function disables the pattern match function.

Parameters

- base – Base address of the PINT peripheral.

Return values

None. –

static inline void PINT_PatternMatchEnableRXEV(PINT_Type *base)

Enable RXEV output.

This function enables the pattern match RXEV output.

Parameters

- base – Base address of the PINT peripheral.

Return values

None. –

static inline void PINT_PatternMatchDisableRXEV(PINT_Type *base)

Disable RXEV output.

This function disables the pattern match RXEV output.

Parameters

- base – Base address of the PINT peripheral.

Return values

None. –

void PINT_EnableCallback(PINT_Type *base)

Enable callback.

This function enables the interrupt for the selected PINT peripheral. Although the pin(s) are monitored as soon as they are enabled, the callback function is not enabled until this function is called.

Parameters

- base – Base address of the PINT peripheral.

Return values

None. –

void PINT_DisableCallback(PINT_Type *base)

Disable callback.

This function disables the interrupt for the selected PINT peripheral. Although the pins are still being monitored but the callback function is not called.

Parameters

- base – Base address of the peripheral.

Return values

None. –

void PINT_Deinit(PINT_Type *base)

Deinitialize PINT peripheral.

This function disables the PINT clock.

Parameters

- base – Base address of the PINT peripheral.

Return values
None. –

void PINT_EnableCallbackByIndex(PINT_Type *base, *pint_pin_int_t* pintIdx)
enable callback by pin index.

This function enables callback by pin index instead of enabling all pins.

Parameters

- base – Base address of the peripheral.
- pintIdx – pin index.

Return values
None. –

void PINT_DisableCallbackByIndex(PINT_Type *base, *pint_pin_int_t* pintIdx)
disable callback by pin index.

This function disables callback by pin index instead of disabling all pins.

Parameters

- base – Base address of the peripheral.
- pintIdx – pin index.

Return values
None. –

PINT_USE_LEGACY_CALLBACK

PININT_BITSLICE_SRC_START

PININT_BITSLICE_SRC_MASK

PININT_BITSLICE_CFG_START

PININT_BITSLICE_CFG_MASK

PININT_BITSLICE_ENDP_MASK

PINT_PIN_INT_LEVEL

PINT_PIN_INT_EDGE

PINT_PIN_INT_FALL_OR_HIGH_LEVEL

PINT_PIN_INT_RISE

PINT_PIN_RISE_EDGE

PINT_PIN_FALL_EDGE

PINT_PIN_BOTH_EDGE

PINT_PIN_LOW_LEVEL

PINT_PIN_HIGH_LEVEL

struct _pint_status
#include <fsl_pint.h> PINT event status.

struct _pint_pmatch_cfg
#include <fsl_pint.h>

2.45 Power Driver

enum _power_wakeup_edge

Pin edge for wakeup.

Values:

enumerator kPOWER_WakeupEdgeLow

Wakeup on pin low level.

enumerator kPOWER_WakeupEdgeHigh

Wakeup on pin high level.

enum _power_wakeup_pin

Wakeup pin.

Values:

enumerator kPOWER_WakeupPin0

Wakeup0 pin.

enumerator kPOWER_WakeupPin1

Wakeup1 pin.

enum _power_reset_cause

Reset cause.

Values:

enumerator kPOWER_ResetCauseSysResetReq

CM33 system soft reset request.

enumerator kPOWER_ResetCauseLockup

CM33 locked up.

enumerator kPOWER_ResetCauseWdt

Watchdog timer.

enumerator kPOWER_ResetCauseApResetReq

Debug mailbox reset.

enumerator kPOWER_ResetCauseCodeWdt

Code watchdog timer.

enumerator kPOWER_ResetCauseItrc

ITRC_CHIP reset.

enumerator kPOWER_ResetCauseResetB

sw_resetb_scantest reset.

enumerator kPOWER_ResetCauseAll

All reset causes. Used in POWER_ClearResetCause().

enum _power_reset_source

Reset source.

Values:

enumerator kPOWER_ResetSourceSysResetReq

CM33 system soft reset request.

enumerator kPOWER_ResetSourceLockup

CM33 locked up.

enumerator kPOWER_ResetSourceWdt
Watchdog timer.

enumerator kPOWER_ResetSourceApResetReq
Debug mailbox reset.

enumerator kPOWER_ResetSourceCodeWdt
Code watchdog timer.

enumerator kPOWER_ResetSourceItrc
ITRC_CHIP reset.

enumerator kPOWER_ResetSourceAll
All reset sources.

enum _pm2_mem_pu_bits
PM2 mem power up bits definition.

Values:

enumerator kPOWER_Pm2MemPuEnet

enumerator kPOWER_Pm2MemPuSdio

enumerator kPOWER_Pm2MemPuOtp

enumerator kPOWER_Pm2MemPuRom

enumerator kPOWER_Pm2MemPuFlexspi

enumerator kPOWER_Pm2MemPuPq

enumerator kPOWER_Pm2MemPuPkc

enumerator kPOWER_Pm2MemPuEls

enumerator kPOWER_Pm2MemPuAon1

enumerator kPOWER_Pm2MemPuAon0

enumerator kPOWER_Pm2MemPuSram18

enumerator kPOWER_Pm2MemPuSram17

enumerator kPOWER_Pm2MemPuSram16

enumerator kPOWER_Pm2MemPuSram15

enumerator kPOWER_Pm2MemPuSram14

enumerator kPOWER_Pm2MemPuSram13

enumerator kPOWER_Pm2MemPuSram12

enumerator kPOWER_Pm2MemPuSram11

enumerator kPOWER_Pm2MemPuSram10

enumerator kPOWER_Pm2MemPuSram9

enumerator kPOWER_Pm2MemPuSram8

enumerator kPOWER_Pm2MemPuSram7

enumerator kPOWER_Pm2MemPuSram6

enumerator kPOWER_Pm2MemPuSram5

enumerator kPOWER_Pm2MemPuSram4

enumerator kPOWER_Pm2MemPuSram3

enumerator kPOWER_Pm2MemPuSram2

enumerator kPOWER_Pm2MemPuSram1

enumerator kPOWER_Pm2MemPuSram0

enumerator kPOWER_Pm2MemPuAll

enum _pm2_ana_pu_bits

PM2 ana power up bits definition.

Values:

enumerator kPOWER_Pm2AnaPuT3

enumerator kPOWER_Pm2AnaPuTcpuTop

enumerator kPOWER_Pm2AnaPuTddrTop

enumerator kPOWER_Pm2AnaPuAnaTop

enumerator kPOWER_Pm2AnaPuGau

enumerator kPOWER_Pm2AnaPuUsb

enumerator kPOWER_Pm2AnaPuAvpll

enumerator kPOWER_Pm2AnaPuAll

enum _clk_gate_bits

clock gate bits definition

Values:

enumerator kPOWER_ClkGateTddrMciEnet

enumerator kPOWER_ClkGateAll

enum _clk_pm3_buck_bits

PM3 buck control bits definition.

Values:

enumerator kPOWER_Pm3Buck18

1: Use normal buck18 level in PM3. 0: Use sleep buck18 level in PM3

enumerator kPOWER_Pm3Buck11

1: Use normal buck11 level in PM3. 0: Use sleep buck11 level in PM3

enumerator kPOWER_Pm3BuckAll

enum _capt_slow_pulse_width

Capture slow pulse width.

Values:

enumerator kPOWER_CaptSlowPulseWidth1

enumerator kPOWER_CaptSlowPulseWidth2

enumerator kPOWER_CaptSlowPulseWidth3

enumerator kPOWER_CaptSlowPulseWidth4

enumerator kPOWER_CaptSlowPulseWidth5

enumerator kPOWER_CaptSlowPulseWidth6

enumerator kPOWER_CaptSlowPulseWidth7

enum _capt_slow_pulse_edge

Capture slow pulse edge.

Values:

enumerator kPOWER_CaptSlowPulseEdgeRising

enumerator kPOWER_CaptSlowPulseEdgeFalling

enumerator kPOWER_CaptSlowPulseEdgeAny

typedef enum *_power_wakeup_edge* power_wakeup_edge_t

Pin edge for wakeup.

typedef enum *_power_wakeup_pin* power_wakeup_pin_t

Wakeup pin.

typedef enum *_power_reset_cause* power_reset_cause_t

Reset cause.

typedef enum *_power_reset_source* power_reset_source_t

Reset source.

typedef enum *_capt_slow_pulse_width* capt_slow_pulse_width_t

Capture slow pulse width.

typedef enum *_capt_slow_pulse_edge* capt_slow_pulse_edge_t

Capture slow pulse edge.

typedef void (*capt_pulse_timer_callback_t)(void *param)

Capture timer callback function.

Param param
: User parameter for callback.

typedef void (*power_switch_callback_t)(uint32_t mode, void *param)

Power mode switch callback function.

Param mode
: Power mode to switch.

Param param
: User parameter for callback.

typedef struct *_power_init_config* power_init_config_t

Init configuration.

typedef struct *_power_sleep_config* power_sleep_config_t

Sleep configuration.

typedef struct *_power_gdet_data* power_gdet_data_t

Glitch detector configuration.

typedef bool (*power_load_gdet_cfg)(*power_gdet_data_t* *data)

Glitch detector configuration load function.

___STATIC_INLINE void POWER_EnableResetSource (uint32_t source)

Enable system reset source.

Parameters

- source – : A bitmask of of power_reset_source_t

___STATIC_INLINE void POWER_DisableResetSource (uint32_t source)

Disable system reset source.

Parameters

- source – : A bitmask of of power_reset_source_t

___STATIC_INLINE uint32_t POWER_GetResetCause (void)

Get last reset cause.

Returns

Or'ed cause of power_reset_cause_t

___STATIC_INLINE void POWER_ClearResetCause (uint32_t cause)

Clear last reset cause.

Parameters

- cause – : A bitmask of of power_reset_cause_t

___STATIC_INLINE void POWER_ConfigWakeupPin (power_wakeup_pin_t pin, power_wakeup_edge_t edge)

Configure pin edge for wakeup.

Parameters

- pin – : Wakeup pin
- edge – : Pin level for wakeup

bool POWER_GetWakeupStatus(IRQn_Type irq)

Check if IRQ is the wakeup source.

Parameters

- irq – : IRQ number

Returns

true if IRQ is the wakeup source, false otherwise.

void POWER_ClearWakeupStatus(IRQn_Type irq)

Clear wakeup status.

Parameters

- irq – : IRQ number

void POWER_EnableWakeup(IRQn_Type irq)

Enable the Wakeup interrupt.

Parameters

- irq – : IRQ number

void POWER_DisableWakeup(IRQn_Type irq)

Disable the Wakeup interrupts.

Parameters

- irq – : IRQ number

AT_QUICKACCESS_SECTION_CODE (void POWER_SetSleepMode(uint32_t mode))

Set power mode on idle.

Parameters

- mode – : 0 ~ 4 stands for PM0 ~ PM4.

__STATIC_INLINE uint32_t POWER_GetWakenMode (void)

Get power mode waken up from.

Returns

Power mode.

void POWER_GetCurrentSleepConfig(*power_sleep_config_t* *config)

Get current sleep configuration.

Parameters

- config – : Pointer to config structure to save current config.

void POWER_InitPowerConfig(const *power_init_config_t* *config)

Initialize power configuration.

Parameters

- config – : Pointer to init config structure.

void POWER_ConfigCauInSleep(bool pdCau)

Configure CAU_SOC_SLP_REF_GEN_CLK on/off status in SoC sleep mode.

Parameters

- pdCau – : true for clock off; false for clock on.

void POWER_SetPowerSwitchCallback(*power_switch_callback_t* pre, void *preParam,
power_switch_callback_t post, void *postParam)

Set power mode switch callback. The callbacks are called with interrupt disabled.

Parameters

- pre – : Function called before power mode switch
- preParam – : User parameter for pre callback
- post – : Function called after power mode switch
- postParam – : User parameter for post callback

AT_QUICKACCESS_SECTION_CODE (bool POWER_EnterPowerMode(uint32_t mode,
const power_sleep_config_t *config))

Switch system into certain power mode.

Parameters

- mode – : 0 ~ 4 stands for PM0 ~ PM4.
- config – : Sleep configuration on PM2-PM4.

Returns

True for success, else failure.

void POWER_PowerOnWlan(void)

Power on WLAN.

void POWER_PowerOffWlan(void)

Power off WLAN.

___STATIC_INLINE void PMU_EnableWlanWakeup (uint8_t wlWakeup)

Enable MCI wakeup WLAN.

Parameters

- wlWakeup – : 8 bits wakeup mask

___STATIC_INLINE void PMU_DisableWlanWakeup (uint8_t wlWakeup)

Disable MCI wakeup WLAN.

Parameters

- wlWakeup – : 8 bits wakeup mask

void POWER_PowerOnBle(void)

Power on BLE.

void POWER_PowerOffBle(void)

Power off BLE.

___STATIC_INLINE void PMU_EnableBleWakeup (uint8_t bleWakeup)

Enable MCI wakeup BLE.

Parameters

- bleWakeup – : 8 bits wakeup mask

___STATIC_INLINE void PMU_DisableBleWakeup (uint8_t bleWakeup)

Disable MCI wakeup BLE.

Parameters

- bleWakeup – : 8 bits wakeup mask

void POWER_PowerOnGau(void)

Power on GAU.

void POWER_PowerOffGau(void)

Power off GAU.

void POWER_EnableCaptSlowPulseTimer(*capt_slow_pulse_width_t* width, *capt_slow_pulse_edge_t* edge, uint32_t timeout, *capt_pulse_timer_callback_t* cb, void *param)

Enable capture slow pulse timer with 32768Hz clock source.

Parameters

- width – : input capture filter width in cycles
- edge – : trigger condition of counter
- timeout – : timer expire counter which will trigger callback
- callback – : callback function on timer expire
- param – : callback parameter

void POWER_EnableCaptFastPulseTimer(uint32_t timeout, *capt_pulse_timer_callback_t* cb, void *param)

Enable capture fast pulse timer with 3.84/4MHz clock source.

Parameters

- timeout – : timer expire counter which will trigger callback
- callback – : callback function on timer expire
- param – : callback parameter

void POWER_DisableCaptPulseTimer(void)

Disable capture pulse timer.

void POWER_InitVoltage(uint32_t dro, uint32_t pack)

Configure power rail voltage and LVD/HVD threshold.

Parameters

- dro – : trim value from fuse.
- pack – : Device package type: 0 - QFN, 1 - CSP, 2 - BGA

void Power_InitLoadGdetCfg(*power_load_gdet_cfg* loadFunc, const *power_gdet_data_t* *data, uint32_t pack)

Initialize glitch detector configuration.

Parameters

- loadFunc – : function pointer to the GDET load configuration.
- data – : GDET config data loaded from fuse.
- pack – : Device package type: 0 - QFN, 1 - CSP, 2 - BGA

AT_QUICKACCESS_SECTION_CODE (void POWER_DisableGDetVSensors(void))

Disable GDET and VSensors.

AT_QUICKACCESS_SECTION_CODE (bool POWER_EnableGDetVSensors(void))

Enable GDET and VSensors.

Returns

True for success, else failure.

uint32_t POWER_TrimSvc(uint32_t gdetTrim, uint32_t pack)

Apply SVC GDC equation and get the SVC trim configuration.

Parameters

- gdetTrim – : GDET trim value from fuse.
- pack – : Device package type: 0 - QFN, 1 - CSP, 2 - BGA

FSL_POWER_DRIVER_VERSION

POWER driver version 2.5.3.

bool iBuck

true: VCORE and AVDD18 supplied from iBuck; false: supplied from external DCDC.

bool gateCauRefClk

true: CAU_SOC_SLP_REF_GEN_CLK gated; false: CAU_SOC_SLP_REF_GEN_CLK on.

uint32_t pm2MemPuCfg

Modules to keep powered on in PM2 mode. Logical OR of the enums in _pm2_mem_pu_bits.

uint32_t pm2AnaPuCfg

Ana to keep powered on in PM2 mode. Logical OR of the enums in _pm2_ana_pu_bits.

uint32_t clkGate

Source clock gate control. Logical OR of the enums in _clk_gate_bits.

uint32_t memPdCfg

PMU MEM_CFG: Power Down memory configuration. Bit0-5 for PM3, bit8 for PM4. bit0: ram0-5 384KB bit1: ram6 64KB bit2: ram7 64KB bit3: ram8-9 128KB bit4: ram10-13 256KB bit5: ram14-18 320KB. bit8: aon mem higher 8KB

uint32_t pm3BuckCfg
PMIP BUCK control in PM3 mode. Logical OR of the enums in _clk_pm3_buck_bits.

uint32_t CFG[6]

uint32_t TRIM0

struct __power_init_config
#include <fsl_power.h> Init configuration.

struct __power_sleep_config
#include <fsl_power.h> Sleep configuration.

struct __power_gdet_data
#include <fsl_power.h> Glitch detector configuration.

2.46 POWERQUAD: PowerQuad hardware accelerator

void PQ_GetDefaultConfig(*pq_config_t* *config)
Get default configuration.

This function initializes the POWERQUAD configuration structure to a default value. FORMAT register field definitions Bits[15:8] scaler (for scaled 'q31' formats) Bits[5:4] external format. 00b=q15, 01b=q31, 10b=float Bits[1:0] internal format. 00b=q15, 01b=q31, 10b=float POWERQUAD->INAFORMAT = (config->inputAPrescale « 8U) | (config->inputAFormat « 4U) | config->machineFormat

For all Powerquad operations internal format must be float (with the only exception being the FFT related functions, ie FFT/IFFT/DCT/IDCT which must be set to q31). The default values are: config->inputAFormat = kPQ_Float; config->inputAPrescale = 0; config->inputBFormat = kPQ_Float; config->inputBPrescale = 0; config->outputFormat = kPQ_Float; config->outputPrescale = 0; config->tmpFormat = kPQ_Float; config->tmpPrescale = 0; config->machineFormat = kPQ_Float; config->tmpBase = 0xE0000000;

Parameters

- config – Pointer to "pq_config_t" structure.

void PQ_SetConfig(POWERQUAD_Type *base, const *pq_config_t* *config)
Set configuration with format/prescale.

Parameters

- base – POWERQUAD peripheral base address
- config – Pointer to "pq_config_t" structure.

static inline void PQ_SetCoprocessorScaler(POWERQUAD_Type *base, const *pq_prescale_t* *prescale)
set coprocessor scaler for coprocessor instructions, this function is used to set output saturation and scaleing for input/output.

Parameters

- base – POWERQUAD peripheral base address
- prescale – Pointer to "pq_prescale_t" structure.

void PQ_Init(POWERQUAD_Type *base)
Initializes the POWERQUAD module.

Parameters

- base – POWERQUAD peripheral base address.

void PQ_Deinit(POWERQUAD_Type *base)

De-initializes the POWERQUAD module.

Parameters

- base – POWERQUAD peripheral base address.

void PQ_SetFormat(POWERQUAD_Type *base, *pq_computationengine_t* engine, *pq_format_t* format)

Set format for non-coprecessor instructions.

Parameters

- base – POWERQUAD peripheral base address
- engine – Computation engine
- format – Data format

static inline void PQ_WaitDone(POWERQUAD_Type *base)

Wait for the completion.

Parameters

- base – POWERQUAD peripheral base address

static inline void PQ_LnF32(float *pSrc, float *pDst)

Processing function for the floating-point natural log.

Parameters

- *pSrc – points to the block of input data. The range of the input value is (0 +INFINITY).
- *pDst – points to the block of output data

static inline void PQ_InvF32(float *pSrc, float *pDst)

Processing function for the floating-point reciprocal.

Parameters

- *pSrc – points to the block of input data. The range of the input value is non-zero.
- *pDst – points to the block of output data

static inline void PQ_SqrtF32(float *pSrc, float *pDst)

Processing function for the floating-point square-root.

Parameters

- *pSrc – points to the block of input data. The range of the input value is [0 +INFINITY).
- *pDst – points to the block of output data

static inline void PQ_InvSqrtF32(float *pSrc, float *pDst)

Processing function for the floating-point inverse square-root.

Parameters

- *pSrc – points to the block of input data. The range of the input value is (0 +INFINITY).
- *pDst – points to the block of output data

static inline void PQ_EtoxF32(float *pSrc, float *pDst)

Processing function for the floating-point natural exponent.

Parameters

- *pSrc – points to the block of input data. The range of the input value is (-INFINITY +INFINITY).
- *pDst – points to the block of output data

static inline void PQ_EtonxF32(float *pSrc, float *pDst)

Processing function for the floating-point natural exponent with negative parameter.

Parameters

- *pSrc – points to the block of input data. The range of the input value is (-INFINITY +INFINITY).
- *pDst – points to the block of output data

static inline void PQ_SinF32(float *pSrc, float *pDst)

Processing function for the floating-point sine.

Parameters

- *pSrc – points to the block of input data. The input value is in radians, the range is (-INFINITY +INFINITY).
- *pDst – points to the block of output data

static inline void PQ_CosF32(float *pSrc, float *pDst)

Processing function for the floating-point cosine.

Parameters

- *pSrc – points to the block of input data. The input value is in radians, the range is (-INFINITY +INFINITY).
- *pDst – points to the block of output data

static inline void PQ_BiquadF32(float *pSrc, float *pDst)

Processing function for the floating-point biquad.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data

static inline void PQ_DivF32(float *x1, float *x2, float *pDst)

Processing function for the floating-point division.

Get x1 / x2.

Parameters

- x1 – x1
- x2 – x2
- *pDst – points to the block of output data

static inline void PQ_Biquad1F32(float *pSrc, float *pDst)

Processing function for the floating-point biquad.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data

static inline int32_t PQ_LnFixed(int32_t val)

Processing function for the fixed natural log.

Parameters

- val – value to be calculated. The range of the input value is (0 +INFINITY).

Returns
returns ln(val).

static inline int32_t PQ_InvFixed(int32_t val)

Processing function for the fixed reciprocal.

Parameters

- val – value to be calculated. The range of the input value is non-zero.

Returns
returns inv(val).

static inline uint32_t PQ_SqrtFixed(uint32_t val)

Processing function for the fixed square-root.

Parameters

- val – value to be calculated. The range of the input value is [0 +INFINITY).

Returns
returns sqrt(val).

static inline int32_t PQ_InvSqrtFixed(int32_t val)

Processing function for the fixed inverse square-root.

Parameters

- val – value to be calculated. The range of the input value is (0 +INFINITY).

Returns
returns 1/sqrt(val).

static inline int32_t PQ_EtoxFixed(int32_t val)

Processing function for the Fixed natural exponent.

Parameters

- val – value to be calculated. The range of the input value is (-INFINITY +INFINITY).

Returns
returns etox^(val).

static inline int32_t PQ_EtonxFixed(int32_t val)

Processing function for the fixed natural exponent with negative parameter.

Parameters

- val – value to be calculated. The range of the input value is (-INFINITY +INFINITY).

Returns
returns etonx^(val).

static inline int32_t PQ_SinQ31(int32_t val)

Processing function for the fixed sine.

Parameters

- val – value to be calculated. The input value is [-1, 1] in Q31 format, which means [-pi, pi].

Returns
returns sin(val).

static inline int16_t PQ_SinQ15(int16_t val)

Processing function for the fixed sine.

Parameters

- val – value to be calculated. The input value is [-1, 1] in Q15 format, which means [-pi, pi].

Returns

returns sin(val).

static inline int32_t PQ_CosQ31(int32_t val)

Processing function for the fixed cosine.

Parameters

- val – value to be calculated. The input value is [-1, 1] in Q31 format, which means [-pi, pi].

Returns

returns cos(val).

static inline int16_t PQ_CosQ15(int16_t val)

Processing function for the fixed sine.

Parameters

- val – value to be calculated. The input value is [-1, 1] in Q15 format, which means [-pi, pi].

Returns

returns sin(val).

static inline int32_t PQ_BiquadFixed(int32_t val)

Processing function for the fixed biquad.

Parameters

- val – value to be calculated

Returns

returns biquad(val).

void PQ_VectorLnF32(float *pSrc, float *pDst, int32_t length)

Processing function for the floating-point vectorised natural log.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorInvF32(float *pSrc, float *pDst, int32_t length)

Processing function for the floating-point vectorised reciprocal.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorSqrtF32(float *pSrc, float *pDst, int32_t length)

Processing function for the floating-point vectorised square-root.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorInvSqrtF32(float *pSrc, float *pDst, int32_t length)

Processing function for the floating-point vectorised inverse square-root.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorEtoxF32(float *pSrc, float *pDst, int32_t length)

Processing function for the floating-point vectorised natural exponent.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorEtonxF32(float *pSrc, float *pDst, int32_t length)

Processing function for the floating-point vectorised natural exponent with negative parameter.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorSinF32(float *pSrc, float *pDst, int32_t length)

Processing function for the floating-point vectorised sine.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorCosF32(float *pSrc, float *pDst, int32_t length)

Processing function for the floating-point vectorised cosine.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorLnFixed32(int32_t *pSrc, int32_t *pDst, int32_t length)

Processing function for the Q31 vectorised natural log.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorInvFixed32(int32_t *pSrc, int32_t *pDst, int32_t length)

Processing function for the Q31 vectorised reciprocal.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorSqrtFixed32(int32_t *pSrc, int32_t *pDst, int32_t length)

Processing function for the 32-bit integer vectorised square-root.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorInvSqrtFixed32(int32_t *pSrc, int32_t *pDst, int32_t length)

Processing function for the 32-bit integer vectorised inverse square-root.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorEtoxFixed32(int32_t *pSrc, int32_t *pDst, int32_t length)

Processing function for the 32-bit integer vectorised natural exponent.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorEtonxFixed32(int32_t *pSrc, int32_t *pDst, int32_t length)

Processing function for the 32-bit integer vectorised natural exponent with negative parameter.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorSinQ15(int16_t *pSrc, int16_t *pDst, int32_t length)

Processing function for the Q15 vectorised sine.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorCosQ15(int16_t *pSrc, int16_t *pDst, int32_t length)

Processing function for the Q15 vectorised cosine.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorSinQ31(int32_t *pSrc, int32_t *pDst, int32_t length)

Processing function for the Q31 vectorised sine.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorCosQ31(int32_t *pSrc, int32_t *pDst, int32_t length)

Processing function for the Q31 vectorised cosine.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorLnFixed16(int16_t *pSrc, int16_t *pDst, int32_t length)

Processing function for the 16-bit integer vectorised natural log.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorInvFixed16(int16_t *pSrc, int16_t *pDst, int32_t length)

Processing function for the 16-bit integer vectorised reciprocal.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorSqrtFixed16(int16_t *pSrc, int16_t *pDst, int32_t length)

Processing function for the 16-bit integer vectorised square-root.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorInvSqrtFixed16(int16_t *pSrc, int16_t *pDst, int32_t length)

Processing function for the 16-bit integer vectorised inverse square-root.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorEtoxFixed16(int16_t *pSrc, int16_t *pDst, int32_t length)

Processing function for the 16-bit integer vectorised natural exponent.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorEtonxFixed16(int16_t *pSrc, int16_t *pDst, int32_t length)

Processing function for the 16-bit integer vectorised natural exponent with negative parameter.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block of input data.

void PQ_VectorBiquadDf2F32(float *pSrc, float *pDst, int32_t length)

Processing function for the floating-point vectorised biquad direct form II.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block size of input data.

void PQ_VectorBiquadDf2Fixed32(int32_t *pSrc, int32_t *pDst, int32_t length)

Processing function for the 32-bit integer vectorised biquad direct form II.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block size of input data

void PQ_VectorBiquadDf2Fixed16(int16_t *pSrc, int16_t *pDst, int32_t length)

Processing function for the 16-bit integer vectorised biquad direct form II.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block size of input data

void PQ_VectorBiquadCascadeDf2F32(float *pSrc, float *pDst, int32_t length)

Processing function for the floating-point vectorised biquad direct form II.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block size of input data

void PQ_VectorBiquadCascadeDf2Fixed32(int32_t *pSrc, int32_t *pDst, int32_t length)

Processing function for the 32-bit integer vectorised biquad direct form II.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block size of input data

void PQ_VectorBiquadCascadeDf2Fixed16(int16_t *pSrc, int16_t *pDst, int32_t length)

Processing function for the 16-bit integer vectorised biquad direct form II.

Parameters

- *pSrc – points to the block of input data
- *pDst – points to the block of output data
- length – the block size of input data

int32_t PQ_ArctanFixed(POWERQUAD_Type *base, int32_t x, int32_t y, *pq_cordic_iter_t* iteration)

Processing function for the fixed inverse trigonometric.

Get the inverse tangent, the behavior is like c function atan.

Note: The sum of x and y should not exceed the range of int32_t.

Note: Larger input number gets higher output accuracy, for example the arctan(0.5), the result of PQ_ArctanFixed(POWERQUAD, 100000, 200000, kPQ_Iteration_24) is more accurate than PQ_ArctanFixed(POWERQUAD, 1, 2, kPQ_Iteration_24).

Parameters

- base – POWERQUAD peripheral base address
- x – value of opposite
- y – value of adjacent
- iteration – iteration times

Returns

The return value is in the range of -2^26 to 2^26, which means -pi/2 to pi/2.

int32_t PQ_ArctanhFixed(POWERQUAD_Type *base, int32_t x, int32_t y, *pq_cordic_iter_t* iteration)

Processing function for the fixed inverse trigonometric.

Note: The sum of x and y should not exceed the range of int32_t.

Note: Larger input number gets higher output accuracy, for example the arctanh(0.5), the result of PQ_ArctanhFixed(POWERQUAD, 100000, 200000, kPQ_Iteration_24) is more accurate than PQ_ArctanhFixed(POWERQUAD, 1, 2, kPQ_Iteration_24).

Parameters

- base – POWERQUAD peripheral base address
- x – value of opposite
- y – value of adjacent
- iteration – iteration times

Returns
The return value is radians, 2^27 means pi. The range is -1.118 to 1.118 radians.

int32_t PQ_Arctan2Fixed(POWERQUAD_Type *base, int32_t x, int32_t y, *pq_cordic_iter_t* iteration)

Processing function for the fixed inverse trigonometric.

Get the inverse tangent, it calculates the angle in radians for the quadrant. The behavior is like c function atan2.

Note: The sum of x and y should not exceed the range of int32_t.

Note: Larger input number gets higher output accuracy, for example the arctan(0.5), the result of PQ_Arctan2Fixed(POWERQUAD, 100000, 200000, kPQ_Iteration_24) is more accurate than PQ_Arctan2Fixed(POWERQUAD, 1, 2, kPQ_Iteration_24).

Parameters

- base – POWERQUAD peripheral base address
- x – value of opposite
- y – value of adjacent
- iteration – iteration times

Returns
The return value is in the range of -2^27 to 2^27, which means -pi to pi.

static inline int32_t PQ_Biquad1Fixed(int32_t val)

Processing function for the fixed biquad.

Parameters

- val – value to be calculated

Returns
returns biquad(val).

void PQ_TransformCFFT(POWERQUAD_Type *base, uint32_t length, void *pData, void *pResult)

Processing function for the complex FFT.

Parameters

- base – POWERQUAD peripheral base address
- length – number of input samples
- pData – input data
- pResult – output data.

void PQ_TransformRFFT(POWERQUAD_Type *base, uint32_t length, void *pData, void *pResult)

Processing function for the real FFT.

Parameters

- base – POWERQUAD peripheral base address
- length – number of input samples
- pData – input data

- pResult – output data.

void PQ_TransformIFFT(POWERQUAD_Type *base, uint32_t length, void *pData, void *pResult)

Processing function for the inverse complex FFT.

Parameters

- base – POWERQUAD peripheral base address
- length – number of input samples
- pData – input data
- pResult – output data.

void PQ_TransformCDCT(POWERQUAD_Type *base, uint32_t length, void *pData, void *pResult)

Processing function for the complex DCT.

Parameters

- base – POWERQUAD peripheral base address
- length – number of input samples
- pData – input data
- pResult – output data.

void PQ_TransformRDCT(POWERQUAD_Type *base, uint32_t length, void *pData, void *pResult)

Processing function for the real DCT.

Parameters

- base – POWERQUAD peripheral base address
- length – number of input samples
- pData – input data
- pResult – output data.

void PQ_TransformIDCT(POWERQUAD_Type *base, uint32_t length, void *pData, void *pResult)

Processing function for the inverse complex DCT.

Parameters

- base – POWERQUAD peripheral base address
- length – number of input samples
- pData – input data
- pResult – output data.

void PQ_BiquadBackUpInternalState(POWERQUAD_Type *base, int32_t biquad_num, *pq_biquad_state_t* *state)

Processing function for backup biquad context.

Parameters

- base – POWERQUAD peripheral base address
- biquad_num – biquad side
- state – point to states.

void PQ_BiquadRestoreInternalState(POWERQUAD_Type *base, int32_t biquad_num, *pq_biquad_state_t* *state)

Processing function for restore biquad context.

Parameters

- base – POWERQUAD peripheral base address
- biquad_num – biquad side
- state – point to states.

void PQ_BiquadCascadeDf2Init(*pq_biquad_cascade_df2_instance* *S, uint8_t numStages, *pq_biquad_state_t* *pState)

Initialization function for the direct form II Biquad cascade filter.

Parameters

- *S – **[inout]** points to an instance of the filter data structure.
- numStages – **[in]** number of 2nd order stages in the filter.
- *pState – **[in]** points to the state buffer.

void PQ_BiquadCascadeDf2F32(const *pq_biquad_cascade_df2_instance* *S, float *pSrc, float *pDst, uint32_t blockSize)

Processing function for the floating-point direct form II Biquad cascade filter.

Parameters

- *S – **[in]** points to an instance of the filter data structure.
- *pSrc – **[in]** points to the block of input data.
- *pDst – **[out]** points to the block of output data
- blockSize – **[in]** number of samples to process.

void PQ_BiquadCascadeDf2Fixed32(const *pq_biquad_cascade_df2_instance* *S, int32_t *pSrc, int32_t *pDst, uint32_t blockSize)

Processing function for the Q31 direct form II Biquad cascade filter.

Parameters

- *S – **[in]** points to an instance of the filter data structure.
- *pSrc – **[in]** points to the block of input data.
- *pDst – **[out]** points to the block of output data
- blockSize – **[in]** number of samples to process.

void PQ_BiquadCascadeDf2Fixed16(const *pq_biquad_cascade_df2_instance* *S, int16_t *pSrc, int16_t *pDst, uint32_t blockSize)

Processing function for the Q15 direct form II Biquad cascade filter.

Parameters

- *S – **[in]** points to an instance of the filter data structure.
- *pSrc – **[in]** points to the block of input data.
- *pDst – **[out]** points to the block of output data
- blockSize – **[in]** number of samples to process.

void PQ_FIR(POWERQUAD_Type *base, const void *pAData, int32_t ALength, const void *pBData, int32_t BLength, void *pResult, uint32_t opType)

Processing function for the FIR.

Parameters

- base – POWERQUAD peripheral base address
- pAData – the first input sequence
- ALength – number of the first input sequence
- pBData – the second input sequence
- BLength – number of the second input sequence
- pResult – array for the output data
- opType – operation type, could be PQ_FIR_FIR, PQ_FIR_CONVOLUTION, PQ_FIR_CORRELATION.

void PQ_FIRIncrement(POWERQUAD_Type *base, int32_t ALength, int32_t BLength, int32_t xOffset)

Processing function for the incremental FIR. This function can be used after pq_fir() for incremental FIR operation when new x data are available.

Parameters

- base – POWERQUAD peripheral base address
- ALength – number of input samples
- BLength – number of taps
- xOffset – offset for number of input samples

void PQ_MatrixAddition(POWERQUAD_Type *base, uint32_t length, void *pAData, void *pBData, void *pResult)

Processing function for the matrix addition.

Parameters

- base – POWERQUAD peripheral base address
- length – rows and cols for matrix. LENGTH register configuration: LENGTH[23:16] = M2 cols LENGTH[15:8] = M1 cols LENGTH[7:0] = M1 rows This could be constructed using macro POWERQUAD_MAKE_MATRIX_LEN.
- pAData – input matrix A
- pBData – input matrix B
- pResult – array for the output data.

void PQ_MatrixSubtraction(POWERQUAD_Type *base, uint32_t length, void *pAData, void *pBData, void *pResult)

Processing function for the matrix subtraction.

Parameters

- base – POWERQUAD peripheral base address
- length – rows and cols for matrix. LENGTH register configuration: LENGTH[23:16] = M2 cols LENGTH[15:8] = M1 cols LENGTH[7:0] = M1 rows This could be constructed using macro POWERQUAD_MAKE_MATRIX_LEN.
- pAData – input matrix A
- pBData – input matrix B
- pResult – array for the output data.

void PQ_MatrixMultiplication(POWERQUAD_Type *base, uint32_t length, void *pAData, void *pBData, void *pResult)

Processing function for the matrix multiplication.

Parameters

- base – POWERQUAD peripheral base address
- length – rows and cols for matrix. LENGTH register configuration: LENGTH[23:16] = M2 cols LENGTH[15:8] = M1 cols LENGTH[7:0] = M1 rows This could be constructed using macro POWERQUAD_MAKE_MATRIX_LEN.
- pAData – input matrix A
- pBData – input matrix B
- pResult – array for the output data.

void PQ_MatrixProduct(POWERQUAD_Type *base, uint32_t length, void *pAData, void *pBData, void *pResult)

Processing function for the matrix product.

Parameters

- base – POWERQUAD peripheral base address
- length – rows and cols for matrix. LENGTH register configuration: LENGTH[23:16] = M2 cols LENGTH[15:8] = M1 cols LENGTH[7:0] = M1 rows This could be constructed using macro POWERQUAD_MAKE_MATRIX_LEN.
- pAData – input matrix A
- pBData – input matrix B
- pResult – array for the output data.

void PQ_VectorDotProduct(POWERQUAD_Type *base, uint32_t length, void *pAData, void *pBData, void *pResult)

Processing function for the vector dot product.

Parameters

- base – POWERQUAD peripheral base address
- length – length of vector
- pAData – input vector A
- pBData – input vector B
- pResult – array for the output data.

void PQ_MatrixInversion(POWERQUAD_Type *base, uint32_t length, void *pData, void *pTmpData, void *pResult)

Processing function for the matrix inverse.

Parameters

- base – POWERQUAD peripheral base address
- length – rows and cols for matrix. LENGTH register configuration: LENGTH[23:16] = M2 cols LENGTH[15:8] = M1 cols LENGTH[7:0] = M1 rows This could be constructed using macro POWERQUAD_MAKE_MATRIX_LEN.
- pData – input matrix

- pTmpData – input temporary matrix, pTmpData length not less than pData lenght and 1024 words is sufficient for the largest supported matrix.
- pResult – array for the output data, round down for fixed point.

void PQ_MatrixTranspose(POWERQUAD_Type *base, uint32_t length, void *pData, void *pResult)

Processing function for the matrix transpose.

Parameters

- base – POWERQUAD peripheral base address
- length – rows and cols for matrix. LENGTH register configuration: LENGTH[23:16] = M2 cols LENGTH[15:8] = M1 cols LENGTH[7:0] = M1 rows This could be constructed using macro POWERQUAD_MAKE_MATRIX_LEN.
- pData – input matrix
- pResult – array for the output data.

void PQ_MatrixScale(POWERQUAD_Type *base, uint32_t length, float misc, const void *pData, void *pResult)

Processing function for the matrix scale.

Parameters

- base – POWERQUAD peripheral base address
- length – rows and cols for matrix. LENGTH register configuration: LENGTH[23:16] = M2 cols LENGTH[15:8] = M1 cols LENGTH[7:0] = M1 rows This could be constructed using macro POWERQUAD_MAKE_MATRIX_LEN.
- misc – scaling parameters
- pData – input matrix
- pResult – array for the output data.

FSL_POWERQUAD_DRIVER_VERSION

Version.

enum pq_computationengine_t

powerquad computation engine

Values:

enumerator kPQ_CP_PQ

Math engine.

enumerator kPQ_CP_MTX

Matrix engine.

enumerator kPQ_CP_FFT

FFT engine.

enumerator kPQ_CP_FIR

FIR engine.

enumerator kPQ_CP_CORDIC

CORDIC engine.

enum pq_format_t

powerquad data structure format type

Values:

enumerator kPQ_16Bit

Int16 Fixed point.

enumerator kPQ_32Bit

Int32 Fixed point.

enumerator kPQ_Float

Float point.

enum pq_cordic_iter_t

CORDIC iteration.

Values:

enumerator kPQ_Iteration_8

Iterate 8 times.

enumerator kPQ_Iteration_16

Iterate 16 times.

enumerator kPQ_Iteration_24

Iterate 24 times.

typedef struct *_pq_biquad_param* pq_biquad_param_t

Struct to save biquad parameters.

typedef struct *_pq_biquad_state* pq_biquad_state_t

Struct to save biquad state.

typedef union *_pq_float* pq_float_t

Conversion between integer and float type.

PQ_VectorBiqaudDf2F32

PQ_VectorBiqaudDf2Fixed32

PQ_VectorBiqaudDf2Fixed16

PQ_VectorBiqaudCascadeDf2F32

PQ_VectorBiqaudCascadeDf2Fixed32

PQ_VectorBiqaudCascadeDf2Fixed16

PQ_Vector8BiqaudDf2CascadeF32

PQ_Vector8BiqaudDf2CascadeFixed32

PQ_Vector8BiqaudDf2CascadeFixed16

PQ_FLOAT32

PQ_FIXEDPT

CP_PQ

CP_MTX

CP_FFT

CP_FIR

CP_CORDIC

PQ_TRANS

PQ_TRIG

PQ_BIQUAD

PQ_TRANS_FIXED

PQ_TRIG_FIXED

PQ_BIQUAD_FIXED

PQ_INV

PQ_LN

PQ_SQRT

PQ_INVSQRT

PQ_ETOX

PQ_ETONX

PQ_DIV

PQ_SIN

PQ_COS

PQ_BIQ0_CALC

PQ_BIQ1_CALC

PQ_COMP0_ONLY

PQ_COMP1_ONLY

CORDIC_ITER(**x**)

CORDIC_MIU(**x**)

CORDIC_T(**x**)

CORDIC_ARCTAN

CORDIC_ARCTANH

INST_BUSY

PQ_ERRSTAT_OVERFLOW

PQ_ERRSTAT_NAN

PQ_ERRSTAT_FIXEDOVERFLOW

PQ_ERRSTAT_UNDERFLOW

PQ_TRANS_CFFT

PQ_TRANS_IFFT

PQ_TRANS_CDCT

PQ_TRANS_IDCT

PQ_TRANS_RFFT

PQ_TRANS_RDCT

PQ_MTX_SCALE

PQ_MTX_MULT

PQ_MTX_ADD

PQ_MTX_INV

PQ_MTX_PROD

PQ_MTX_SUB

PQ_VEC_DOTP

PQ_MTX_TRAN

PQ_FIR_FIR

PQ_FIR_CONVOLUTION

PQ_FIR_CORRELATION

PQ_FIR_INCREMENTAL

_pq_ln0(**x**)

_pq_inv0(**x**)

_pq_sqrt0(**x**)

_pq_invsqrt0(**x**)

_pq_etox0(**x**)

_pq_etonx0(**x**)

_pq_sin0(**x**)

_pq_cos0(**x**)

_pq_biquad0(**x**)

_pq_ln_fx0(**x**)

_pq_inv_fx0(**x**)

_pq_sqrt_fx0(**x**)

_pq_invsqrt_fx0(**x**)

_pq_etox_fx0(**x**)

_pq_etonx_fx0(**x**)

_pq_sin_fx0(**x**)

_pq_cos_fx0(**x**)

__pq__biquad0__fx(**x**)

__pq__div0(**x**)

__pq__div1(**x**)

__pq__ln1(**x**)

__pq__inv1(**x**)

__pq__sqrt1(**x**)

__pq__invsqrt1(**x**)

__pq__etox1(**x**)

__pq__etonx1(**x**)

__pq__sin1(**x**)

__pq__cos1(**x**)

__pq__biquad1(**x**)

__pq__ln__fx1(**x**)

__pq__inv__fx1(**x**)

__pq__sqrt__fx1(**x**)

__pq__invsqrt__fx1(**x**)

__pq__etox__fx1(**x**)

__pq__etonx__fx1(**x**)

__pq__sin__fx1(**x**)

__pq__cos__fx1(**x**)

__pq__biquad1__fx(**x**)

__pq__readMult0()

__pq__readAdd0()

__pq__readMult1()

__pq__readAdd1()

__pq__readMult0__fx()

__pq__readAdd0__fx()

__pq__readMult1__fx()

__pq__readAdd1__fx()

PQ__LN__INF
: Parameter used for vector ln(x)

PQ__INV__INF
: Parameter used for vector 1/x

PQ__SQRT__INF
: Parameter used for vector sqrt(x)

PQ_ISQRT_INF
: Parameter used for vector 1/sqrt(x)

PQ_ETOX_INF
: Parameter used for vector e^x

PQ_ETONX_INF
: Parameter used for vector e^(-x)

PQ_SIN_INF
: Parameter used for vector sin(x)

PQ_COS_INF
: Parameter used for vector cos(x)

PQ_RUN_OPCODE_R3_R2(BATCH_OPCODE, BATCH_MACHINE)

PQ_RUN_OPCODE_R5_R4(BATCH_OPCODE, BATCH_MACHINE)

PQ_RUN_OPCODE_R7_R6(BATCH_OPCODE, BATCH_MACHINE)

PQ_Vector8_FP(middle, last, BATCH_OPCODE, DOUBLE_READ_ADDERS, BATCH_MACHINE)

PQ_RUN_OPCODE_R2_R3(BATCH_OPCODE, BATCH_MACHINE)

PQ_RUN_OPCODE_R4_R5(BATCH_OPCODE, BATCH_MACHINE)

PQ_RUN_OPCODE_R6_R7(BATCH_OPCODE, BATCH_MACHINE)

PQ_Vector8_FX(middle, last, BATCH_OPCODE, DOUBLE_READ_ADDERS, BATCH_MACHINE)

PQ_Initiate_Vector_Func(pSrc, pDst)
: Start 32-bit data vector calculation.

  Start the vector calculation, the input data could be float, int32_t or Q31.

  Parameters

  - pSrc – Pointer to the source data.
  - pDst – Pointer to the destination data.

PQ_End_Vector_Func()
: End vector calculation.

  This function should be called after vector calculation.

PQ_StartVector(PSRC, PDST, LENGTH)
: Start 32-bit data vector calculation.

  Start the vector calculation, the input data could be float, int32_t or Q31.

  Parameters

  - PSRC – Pointer to the source data.
  - PDST – Pointer to the destination data.
  - LENGTH – Number of the data, must be multiple of 8.

PQ_StartVectorFixed16(PSRC, PDST, LENGTH)
: Start 16-bit data vector calculation.

  Start the vector calculation, the input data could be int16_t. This function should be use with PQ_Vector8Fixed16.

  Parameters

  - PSRC – Pointer to the source data.

- PDST – Pointer to the destination data.
- LENGTH – Number of the data, must be multiple of 8.

PQ_StartVectorQ15(PSRC, PDST, LENGTH)

Start Q15-bit data vector calculation.

Start the vector calculation, the input data could be Q15. This function should be use with PQ_Vector8Q15. This function is dedicate for SinQ15/CosQ15 vector calculation. Because PowerQuad only supports Q31 Sin/Cos fixed function, so the input Q15 data is left shift 16 bits first, after Q31 calculation, the output data is right shift 16 bits.

Parameters

- PSRC – Pointer to the source data.
- PDST – Pointer to the destination data.
- LENGTH – Number of the data, must be multiple of 8.

PQ_EndVector()

End vector calculation.

This function should be called after vector calculation.

PQ_Vector8F32(BATCH_OPCODE, DOUBLE_READ_ADDERS, BATCH_MACHINE)

Float data vector calculation.

Float data vector calculation, the input data should be float. The parameter could be PQ_LN_INF, PQ_INV_INF, PQ_SQRT_INF, PQ_ISQRT_INF, PQ_ETOX_INF, PQ_ETONX_INF. For example, to calculate sqrt of a vector, use like this:

```
#define VECTOR_LEN 8
float input[VECTOR_LEN] = {1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0};
float output[VECTOR_LEN];

PQ_StartVector(input, output, VECTOR_LEN);
PQ_Vector8F32(PQ_SQRT_INF);
PQ_EndVector();
```

PQ_Vector8Fixed32(BATCH_OPCODE, DOUBLE_READ_ADDERS, BATCH_MACHINE)

Fixed 32bits data vector calculation.

Float data vector calculation, the input data should be 32-bit integer. The parameter could be PQ_LN_INF, PQ_INV_INF, PQ_SQRT_INF, PQ_ISQRT_INF, PQ_ETOX_INF, PQ_ETONX_INF. PQ_SIN_INF, PQ_COS_INF. When this function is used for sin/cos calculation, the input data should be in the format Q1.31. For example, to calculate sqrt of a vector, use like this:

```
#define VECTOR_LEN 8
int32_t input[VECTOR_LEN] = {1, 4, 9, 16, 25, 36, 49, 64};
int32_t output[VECTOR_LEN];

PQ_StartVector(input, output, VECTOR_LEN);
PQ_Vector8F32(PQ_SQRT_INF);
PQ_EndVector();
```

PQ_Vector8Fixed16(BATCH_OPCODE, DOUBLE_READ_ADDERS, BATCH_MACHINE)

Fixed 32bits data vector calculation.

Float data vector calculation, the input data should be 16-bit integer. The parameter could be PQ_LN_INF, PQ_INV_INF, PQ_SQRT_INF, PQ_ISQRT_INF, PQ_ETOX_INF, PQ_ETONX_INF. For example, to calculate sqrt of a vector, use like this:

```
#define VECTOR_LEN 8
int16_t input[VECTOR_LEN] = {1, 4, 9, 16, 25, 36, 49, 64};
int16_t output[VECTOR_LEN];

PQ_StartVector(input, output, VECTOR_LEN);
PQ_Vector8F32(PQ_SQRT_INF);
PQ_EndVector();
```

PQ_Vector8Q15(BATCH_OPCODE, DOUBLE_READ_ADDERS, BATCH_MACHINE)

Q15 data vector calculation.

Q15 data vector calculation, this function should only be used for sin/cos Q15 calculation, and the coprocessor output prescaler must be set to 31 before this function. This function loads Q15 data and left shift 16 bits, calculate and right shift 16 bits, then stores to the output array. The input range -1 to 1 means -pi to pi. For example, to calculate sin of a vector, use like this:

```
#define VECTOR_LEN 8
int16_t input[VECTOR_LEN] = {...}
int16_t output[VECTOR_LEN];
const pq_prescale_t prescale =
{
    .inputPrescale = 0,
    .outputPrescale = 31,
    .outputSaturate = 0
};

PQ_SetCoprocessorScaler(POWERQUAD, const pq_prescale_t *prescale);

PQ_StartVectorQ15(pSrc, pDst, length);
PQ_Vector8Q15(PQ_SQRT_INF);
PQ_EndVector();
```

PQ_DF2_Vector8_FP(middle, last)

Float data vector biquad direct form II calculation.

Biquad filter, the input and output data are float data. Biquad side 0 is used. Example:

```
#define VECTOR_LEN 16
float input[VECTOR_LEN] = {1024.0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0};
float output[VECTOR_LEN];
pq_biquad_state_t state =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

PQ_BiquadRestoreInternalState(POWERQUAD, 0, &state);

PQ_Initiate_Vector_Func(pSrc,pDst);
PQ_DF2_Vector8_FP(false,false);
PQ_DF2_Vector8_FP(true,true);
PQ_End_Vector_Func();
```

PQ_DF2_Vector8_FX(middle, last)

Fixed data vector biquad direct form II calculation.

Biquad filter, the input and output data are fixed data. Biquad side 0 is used. Example:

```
#define VECTOR_LEN 16
int32_t input[VECTOR_LEN] = {1024, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0};
int32_t output[VECTOR_LEN];
pq_biquad_state_t state =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

PQ_BiquadRestoreInternalState(POWERQUAD, 0, &state);

PQ_Initiate_Vector_Func(pSrc,pDst);
PQ_DF2_Vector8_FX(false,false);
PQ_DF2_Vector8_FX(true,true);
PQ_End_Vector_Func();
```

PQ_Vector8BiquadDf2F32()

Float data vector biquad direct form II calculation.

Biquad filter, the input and output data are float data. Biquad side 0 is used. Example:

```
#define VECTOR_LEN 8
float input[VECTOR_LEN] = {1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0};
float output[VECTOR_LEN];
pq_biquad_state_t state =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

PQ_BiquadRestoreInternalState(POWERQUAD, 0, &state);

PQ_StartVector(input, output, VECTOR_LEN);
PQ_Vector8BiquadDf2F32();
PQ_EndVector();
```

PQ_Vector8BiquadDf2Fixed32()

Fixed 32-bit data vector biquad direct form II calculation.

Biquad filter, the input and output data are Q31 or 32-bit integer. Biquad side 0 is used. Example:

```
#define VECTOR_LEN 8
int32_t input[VECTOR_LEN] = {1, 2, 3, 4, 5, 6, 7, 8};
int32_t output[VECTOR_LEN];
pq_biquad_state_t state =
{
    .param =
    {
```

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```
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

PQ_BiquadRestoreInternalState(POWERQUAD, 0, &state);

PQ_StartVector(input, output, VECTOR_LEN);
PQ_Vector8BiquadDf2Fixed32();
PQ_EndVector();
```

PQ_Vector8BiquadDf2Fixed16()

Fixed 16-bit data vector biquad direct form II calculation.

Biquad filter, the input and output data are Q15 or 16-bit integer. Biquad side 0 is used. Example:

```
#define VECTOR_LEN 8
int16_t input[VECTOR_LEN] = {1, 2, 3, 4, 5, 6, 7, 8};
int16_t output[VECTOR_LEN];
pq_biquad_state_t state =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

PQ_BiquadRestoreInternalState(POWERQUAD, 0, &state);

PQ_StartVector(input, output, VECTOR_LEN);
PQ_Vector8BiquadDf2Fixed16();
PQ_EndVector();
```

PQ_DF2_Cascade_Vector8_FP(middle, last)

Float data vector direct form II biquad cascade filter.

The input and output data are float data. The data flow is input -> biquad side 1 -> biquad side 0 -> output.

```
#define VECTOR_LEN 16
float input[VECTOR_LEN] = {1024.0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0};
float output[VECTOR_LEN];
pq_biquad_state_t state0 =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};
```

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```
pq_biquad_state_t state1 =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

PQ_BiquadRestoreInternalState(POWERQUAD, 0, &state0);
PQ_BiquadRestoreInternalState(POWERQUAD, 1, &state1);

PQ_Initiate_Vector_Func(pSrc, pDst);
PQ_DF2_Cascade_Vector8_FP(false, false);
PQ_DF2_Cascade_Vector8_FP(true, true);
PQ_End_Vector_Func();
```

PQ_DF2_Cascade_Vector8_FX(middle, last)

Fixed data vector direct form II biquad cascade filter.

The input and output data are fixed data. The data flow is input -> biquad side 1 -> biquad side 0 -> output.

```
#define VECTOR_LEN 16
int32_t input[VECTOR_LEN] = {1024.0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0};
int32_t output[VECTOR_LEN];
pq_biquad_state_t state0 =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

pq_biquad_state_t state1 =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

PQ_BiquadRestoreInternalState(POWERQUAD, 0, &state0);
PQ_BiquadRestoreInternalState(POWERQUAD, 1, &state1);

PQ_Initiate_Vector_Func(pSrc, pDst);
PQ_DF2_Cascade_Vector8_FX(false, false);
PQ_DF2_Cascade_Vector8_FX(true, true);
PQ_End_Vector_Func();
```

PQ_Vector8BiquadDf2CascadeF32()

Float data vector direct form II biquad cascade filter.

The input and output data are float data. The data flow is input -> biquad side 1 -> biquad side 0 -> output.

```
#define VECTOR_LEN 8
float input[VECTOR_LEN] = {1, 2, 3, 4, 5, 6, 7, 8};
float output[VECTOR_LEN];
pq_biquad_state_t state0 =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

pq_biquad_state_t state1 =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

PQ_BiquadRestoreInternalState(POWERQUAD, 0, &state0);
PQ_BiquadRestoreInternalState(POWERQUAD, 1, &state1);

PQ_StartVector(input, output, VECTOR_LEN);
PQ_Vector8BiquadDf2CascadeF32();
PQ_EndVector();
```

PQ_Vector8BiquadDf2CascadeFixed32()

Fixed 32-bit data vector direct form II biquad cascade filter.

The input and output data are fixed 32-bit data. The data flow is input -> biquad side 1 -> biquad side 0 -> output.

```
#define VECTOR_LEN 8
int32_t input[VECTOR_LEN] = {1, 2, 3, 4, 5, 6, 7, 8};
int32_t output[VECTOR_LEN];
pq_biquad_state_t state0 =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

pq_biquad_state_t state1 =
{
```

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```
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

PQ_BiquadRestoreInternalState(POWERQUAD, 0, &state0);
PQ_BiquadRestoreInternalState(POWERQUAD, 1, &state1);

PQ_StartVector(input, output, VECTOR_LEN);
PQ_Vector8BiquadDf2CascadeFixed32();
PQ_EndVector();
```

PQ_Vector8BiquadDf2CascadeFixed16()

Fixed 16-bit data vector direct form II biquad cascade filter.

The input and output data are fixed 16-bit data. The data flow is input -> biquad side 1 -> biquad side 0 -> output.

```
#define VECTOR_LEN 8
int32_t input[VECTOR_LEN] = {1, 2, 3, 4, 5, 6, 7, 8};
int32_t output[VECTOR_LEN];
pq_biquad_state_t state0 =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

pq_biquad_state_t state1 =
{
    .param =
    {
        .a_1 = xxx,
        .a_2 = xxx,
        .b_0 = xxx,
        .b_1 = xxx,
        .b_2 = xxx,
    },
};

PQ_BiquadRestoreInternalState(POWERQUAD, 0, &state0);
PQ_BiquadRestoreInternalState(POWERQUAD, 1, &state1);

PQ_StartVector(input, output, VECTOR_LEN);
PQ_Vector8BiquadDf2CascadeFixed16();
PQ_EndVector();
```

POWERQUAD_MAKE_MATRIX_LEN(mat1Row, mat1Col, mat2Col)

Make the length used for matrix functions.

PQ_Q31_2_FLOAT(x)

Convert Q31 to float.

PQ__Q15__2__FLOAT(x)

Convert Q15 to float.

struct pq__prescale__t

#include <fsl_powerquad.h> Coprocessor prescale.

Public Members

int8_t inputPrescale

Input prescale.

int8_t outputPrescale

Output prescale.

int8_t outputSaturate

Output saturate at n bits, for example 0x11 is 8 bit space, the value will be truncated at +127 or -128.

struct pq__config__t

#include <fsl_powerquad.h> powerquad data structure format

Public Members

pq_format_t inputAFormat

Input A format.

int8_t inputAPrescale

Input A prescale, for example 1.5 can be 1.5*2^n if you scale by 'shifting' ('scaling' by a factor of n).

pq_format_t inputBFormat

Input B format.

int8_t inputBPrescale

Input B prescale.

pq_format_t outputFormat

Out format.

int8_t outputPrescale

Out prescale.

pq_format_t tmpFormat

Temp format.

int8_t tmpPrescale

Temp prescale.

pq_format_t machineFormat

Machine format.

uint32_t *tmpBase

Tmp base address.

struct __pq__biquad__param

#include <fsl_powerquad.h> Struct to save biquad parameters.

Public Members

float v__n__1
: v[n-1], set to 0 when initialization.

float v__n
: v[n], set to 0 when initialization.

float a__1
: a[1]

float a__2
: a[2]

float b__0
: b[0]

float b__1
: b[1]

float b__2
: b[2]

struct __pq__biquad__state
: *#include <fsl_powerquad.h>* Struct to save biquad state.

Public Members

pq_biquad_param_t param
: Filter parameter.

uint32_t compreg
: Internal register, set to 0 when initialization.

struct pq__biquad__cascade__df2__instance
: *#include <fsl_powerquad.h>* Instance structure for the direct form II Biquad cascade filter.

Public Members

uint8_t numStages
: Number of 2nd order stages in the filter.

pq_biquad_state_t *pState
: Points to the array of state coefficients.

union __pq__float
: *#include <fsl_powerquad.h>* Conversion between integer and float type.

Public Members

float floatX
: Float type.

uint32_t integerX
: Unsigned interger type.

2.47 Reset Driver

enum _RSTCTL_RSTn

Enumeration for peripheral reset control bits.

Defines the enumeration for peripheral reset control bits in RSTCLTx registers

Values:

enumerator kPOWERQUAD_RST_SHIFT_RSTn
POWERQUAD reset control

enumerator kPKC_RST_SHIFT_RSTn
PKC reset control

enumerator kELS_RST_SHIFT_RSTn
ELS reset control

enumerator kPUF_RST_SHIFT_RSTn
Physical unclonable function reset control

enumerator kFLEXSPI_RST_SHIFT_RSTn
FLEXSPI reset control

enumerator kHPU_RST_SHIFT_RSTn
HPU reset control

enumerator kUSB_RST_SHIFT_RSTn
USB reset control

enumerator kSCT_RST_SHIFT_RSTn
Standard ctimers reset control

enumerator kAON_MEM_RST_SHIFT_RSTn
AON MEM reset control

enumerator kGDMA_RST_SHIFT_RSTn
GDMA reset control

enumerator kDMA0_RST_SHIFT_RSTn
DMA0 reset control

enumerator kDMA1_RST_SHIFT_RSTn
DMA1 reset control

enumerator kSDIO_RST_SHIFT_RSTn
SDIO reset control

enumerator kELS_APB_RST_SHIFT_RSTn
ELS_APB reset control

enumerator kELS_GDET_REF_RST_SHIFT_RSTn
ELS_GDET_REF_RST reset control

enumerator kSDIO_SLV_SHIFT_RSTn
SDIO_SLV reset control

enumerator kGAU_RST_SHIFT_RSTn
GAU reset control

enumerator kOTP_RST_SHIFT_RSTn
OTP reset control

enumerator kSECURE_GPIO_RST_SHIFT_RSTn
Security GPIO reset control

enumerator kENET_IPG_RST_SHIFT_RSTn
ENET_IPG reset control

enumerator kENET_IPG_S_RST_SHIFT_RSTn
ENET_IPG_S reset control

enumerator kTRNG_RST_SHIFT_RSTn
TRNG reset control

enumerator kUTICK_RST_SHIFT_RSTn
Micro-tick timer reset control

enumerator kWWDT_RST_SHIFT_RSTn
Windowed Watchdog timer reset control

enumerator kUSIM_RST_SHIFT_RSTn
USIM reset control

enumerator kFREEMRT_RST_SHIFT_RSTn
FREEMRT reset control

enumerator kLCDIC_RST_SHIFT_RSTn
LCDIC reset control

enumerator kFC0_RST_SHIFT_RSTn
Flexcomm Interface 0 reset control

enumerator kFC1_RST_SHIFT_RSTn
Flexcomm Interface 1 reset control

enumerator kFC2_RST_SHIFT_RSTn
Flexcomm Interface 2 reset control

enumerator kFC3_RST_SHIFT_RSTn
Flexcomm Interface 3 reset control

enumerator kFC14_RST_SHIFT_RSTn
Flexcomm Interface 14 reset control

enumerator kDMIC_RST_SHIFT_RSTn
Digital microphone interface reset control

enumerator kOSEVENT_TIMER_RST_SHIFT_RSTn
Osevent Timer reset control

enumerator kHSGPIO0_RST_SHIFT_RSTn
HSGPIO 0 reset control

enumerator kHSGPIO1_RST_SHIFT_RSTn
HSGPIO 1 reset control

enumerator kCRC_RST_SHIFT_RSTn
CRC reset control

enumerator kFREQME_RST_SHIFT_RSTn
Frequency Measure reset control

enumerator kCT32B0_RST_SHIFT_RSTn
CT32B0 reset control

enumerator kCT32B1_RST_SHIFT_RSTn
CT32B1 reset control

enumerator kCT32B2_RST_SHIFT_RSTn
CT32B3 reset control

enumerator kCT32B3_RST_SHIFT_RSTn
CT32B4 reset control

enumerator kCT32B4_RST_SHIFT_RSTn
CT32B4 reset control

enumerator kMRT_RST_SHIFT_RSTn
Multi-rate timer (MRT) reset control

enumerator kPINT_RST_SHIFT_RSTn
GPIO_INT reset control

enumerator kINPUTMUX_RST_SHIFT_RSTn
PMUX reset control

typedef enum *_RSTCTL_RSTn* RSTCTL_RSTn_t
Enumeration for peripheral reset control bits.

Defines the enumeration for peripheral reset control bits in RSTCLTx registers

typedef *RSTCTL_RSTn_t* reset_ip_name_t
IP reset handle.

void RESET_SetPeripheralReset(*reset_ip_name_t* peripheral)
Assert reset to peripheral.

Asserts reset signal to specified peripheral module.

Parameters

- peripheral – Assert reset to this peripheral. The enum argument contains encoding of reset register and reset bit position in the reset register.

void RESET_ClearPeripheralReset(*reset_ip_name_t* peripheral)
Clear reset to peripheral.

Clears reset signal to specified peripheral module, allows it to operate.

Parameters

- peripheral – Clear reset to this peripheral. The enum argument contains encoding of reset register and reset bit position in the reset register.

void RESET_PeripheralReset(*reset_ip_name_t* peripheral)
Reset peripheral module.

Reset peripheral module.

Parameters

- peripheral – Peripheral to reset. The enum argument contains encoding of reset register and reset bit position in the reset register.

static inline void RESET_ReleasePeripheralReset(*reset_ip_name_t* peripheral)
Release peripheral module.

Release peripheral module.

Parameters

- peripheral – Peripheral to release. The enum argument contains encoding of reset register and reset bit position in the reset register.

FSL_RESET_DRIVER_VERSION
reset driver version 2.1.1.

RST_CTL0_PSCCTL0
Reset control registers index.

RST_CTL0_PSCCTL1

RST_CTL0_PSCCTL2

RST_CTL1_PSCCTL0

RST_CTL1_PSCCTL1

RST_CTL1_PSCCTL2

CRC_RSTS
Array initializers with peripheral reset bits

DMA_RSTS_N

DMIC_RSTS

FLEXCOMM_RSTS

GPIO_RSTS_N

MRT_RSTS

PINT_RSTS

SCT_RSTS

CTIMER_RSTS

USB_RSTS

UTICK_RSTS

WWDT_RSTS

OSTIMER_RSTS

POWERQUAD_RSTS

PUF_RSTS

TRNG_RSTS

USIM_RSTS

ENET_RSTS

2.48 RTC: Real Time Clock

void RTC_Init(RTC_Type *base)
Un-gate the RTC clock and enable the RTC oscillator.

Note: This API should be called at the beginning of the application using the RTC driver.

Parameters

- base – RTC peripheral base address

static inline void RTC_Deinit(RTC_Type *base)

Stop the timer and gate the RTC clock.

Parameters

- base – RTC peripheral base address

status_t RTC_SetDatetime(RTC_Type *base, const *rtc_datetime_t* *datetime)

Set the RTC date and time according to the given time structure.

The RTC counter must be stopped prior to calling this function as writes to the RTC seconds register will fail if the RTC counter is running.

Parameters

- base – RTC peripheral base address
- datetime – Pointer to structure where the date and time details to set are stored

Returns

kStatus_Success: Success in setting the time and starting the RTC kStatus_InvalidArgument: Error because the datetime format is incorrect

void RTC_GetDatetime(RTC_Type *base, *rtc_datetime_t* *datetime)

Get the RTC time and stores it in the given time structure.

Parameters

- base – RTC peripheral base address
- datetime – Pointer to structure where the date and time details are stored.

status_t RTC_SetAlarm(RTC_Type *base, const *rtc_datetime_t* *alarmTime)

Set the RTC alarm time.

The function checks whether the specified alarm time is greater than the present time. If not, the function does not set the alarm and returns an error.

Parameters

- base – RTC peripheral base address
- alarmTime – Pointer to structure where the alarm time is stored.

Returns

kStatus_Success: success in setting the RTC alarm kStatus_InvalidArgument: Error because the alarm datetime format is incorrect kStatus_Fail: Error because the alarm time has already passed

void RTC_GetAlarm(RTC_Type *base, *rtc_datetime_t* *datetime)

Return the RTC alarm time.

Parameters

- base – RTC peripheral base address
- datetime – Pointer to structure where the alarm date and time details are stored.

static inline void RTC_EnableWakeupTimer(RTC_Type *base, bool enable)

Enable the RTC wake-up timer (1KHZ).

After calling this function, the RTC driver will use/un-use the RTC wake-up (1KHZ) at the same time.

Parameters

- base – RTC peripheral base address
- enable – Use/Un-use the RTC wake-up timer.
  - true: Use RTC wake-up timer at the same time.
  - false: Un-use RTC wake-up timer, RTC only use the normal seconds timer by default.

static inline uint32_t RTC_GetEnabledWakeupTimer(RTC_Type *base)

Get the enabled status of the RTC wake-up timer (1KHZ).

Parameters

- base – RTC peripheral base address

Returns

The enabled status of RTC wake-up timer (1KHZ).

static inline void RTC_EnableSubsecCounter(RTC_Type *base, bool enable)

Enable the RTC Sub-second counter (32KHZ).

Note: Only enable sub-second counter after RTC_ENA bit has been set to 1.

Parameters

- base – RTC peripheral base address
- enable – Enable/Disable RTC sub-second counter.
  - true: Enable RTC sub-second counter.
  - false: Disable RTC sub-second counter.

static inline uint32_t RTC_GetSubsecValue(const RTC_Type *base)

A read of 32KHZ sub-seconds counter.

Parameters

- base – RTC peripheral base address

Returns

Current value of the SUBSEC register

static inline void RTC_EnableWakeUpTimerInterruptFromDPD(RTC_Type *base, bool enable)

Enable the wake-up timer interrupt from deep power down mode.

Parameters

- base – RTC peripheral base address
- enable – Enable/Disable wake-up timer interrupt from deep power down mode.
  - true: Enable wake-up timer interrupt from deep power down mode.
  - false: Disable wake-up timer interrupt from deep power down mode.

static inline void RTC_EnableAlarmTimerInterruptFromDPD(RTC_Type *base, bool enable)

Enable the alarm timer interrupt from deep power down mode.

Parameters

- base – RTC peripheral base address
- enable – Enable/Disable alarm timer interrupt from deep power down mode.
  - true: Enable alarm timer interrupt from deep power down mode.

– false: Disable alarm timer interrupt from deep power down mode.

static inline void RTC_EnableInterrupts(RTC_Type *base, uint32_t mask)

Enables the selected RTC interrupts.

Deprecated:

Do not use this function. It has been superceded by RTC_EnableAlarmTimerInterruptFromDPD and RTC_EnableWakeUpTimerInterruptFromDPD

Parameters

- base – RTC peripheral base address
- mask – The interrupts to enable. This is a logical OR of members of the enumeration rtc_interrupt_enable_t

static inline void RTC_DisableInterrupts(RTC_Type *base, uint32_t mask)

Disables the selected RTC interrupts.

Deprecated:

Do not use this function. It has been superceded by RTC_EnableAlarmTimerInterruptFromDPD and RTC_EnableWakeUpTimerInterruptFromDPD

Parameters

- base – RTC peripheral base address
- mask – The interrupts to enable. This is a logical OR of members of the enumeration rtc_interrupt_enable_t

static inline uint32_t RTC_GetEnabledInterrupts(RTC_Type *base)

Get the enabled RTC interrupts.

Deprecated:

Do not use this function. It will be deleted in next release version.

Parameters

- base – RTC peripheral base address

Returns

The enabled interrupts. This is the logical OR of members of the enumeration rtc_interrupt_enable_t

static inline uint32_t RTC_GetStatusFlags(RTC_Type *base)

Get the RTC status flags.

Parameters

- base – RTC peripheral base address

Returns

The status flags. This is the logical OR of members of the enumeration rtc_status_flags_t

static inline void RTC_ClearStatusFlags(RTC_Type *base, uint32_t mask)

Clear the RTC status flags.

Parameters

- base – RTC peripheral base address

- mask – The status flags to clear. This is a logical OR of members of the enumeration rtc_status_flags_t

static inline void RTC_EnableTimer(RTC_Type *base, bool enable)

Enable the RTC timer counter.

After calling this function, the RTC inner counter increments once a second when only using the RTC seconds timer (1hz), while the RTC inner wake-up timer countdown once a millisecond when using RTC wake-up timer (1KHZ) at the same time. RTC timer contain two timers, one is the RTC normal seconds timer, the other one is the RTC wake-up timer, the RTC enable bit is the master switch for the whole RTC timer, so user can use the RTC seconds (1HZ) timer independly, but they can't use the RTC wake-up timer (1KHZ) independently.

Parameters

- base – RTC peripheral base address
- enable – Enable/Disable RTC Timer counter.
  - true: Enable RTC Timer counter.
  - false: Disable RTC Timer counter.

static inline void RTC_StartTimer(RTC_Type *base)

Starts the RTC time counter.

Deprecated:

Do not use this function. It has been superceded by RTC_EnableTimer

After calling this function, the timer counter increments once a second provided SR[TOF] or SR[TIF] are not set.

Parameters

- base – RTC peripheral base address

static inline void RTC_StopTimer(RTC_Type *base)

Stops the RTC time counter.

Deprecated:

Do not use this function. It has been superceded by RTC_EnableTimer

RTC's seconds register can be written to only when the timer is stopped.

Parameters

- base – RTC peripheral base address

FSL_RTC_DRIVER_VERSION

Version 2.2.0

enum _rtc_interrupt_enable

List of RTC interrupts.

Values:

enumerator kRTC_AlarmInterruptEnable

Alarm interrupt.

enumerator kRTC_WakeupInterruptEnable

Wake-up interrupt.

enum _rtc_status_flags

List of RTC flags.

Values:

enumerator kRTC_AlarmFlag

Alarm flag

enumerator kRTC_WakeupFlag

1kHz wake-up timer flag

typedef enum *_rtc_interrupt_enable* rtc_interrupt_enable_t

List of RTC interrupts.

typedef enum *_rtc_status_flags* rtc_status_flags_t

List of RTC flags.

typedef struct *_rtc_datetime* rtc_datetime_t

Structure is used to hold the date and time.

static inline void RTC_SetSecondsTimerMatch(RTC_Type *base, uint32_t matchValue)

Set the RTC seconds timer (1HZ) MATCH value.

Parameters

- base – RTC peripheral base address
- matchValue – The value to be set into the RTC MATCH register

static inline uint32_t RTC_GetSecondsTimerMatch(RTC_Type *base)

Read actual RTC seconds timer (1HZ) MATCH value.

Parameters

- base – RTC peripheral base address

Returns

The actual RTC seconds timer (1HZ) MATCH value.

static inline void RTC_SetSecondsTimerCount(RTC_Type *base, uint32_t countValue)

Set the RTC seconds timer (1HZ) COUNT value.

Parameters

- base – RTC peripheral base address
- countValue – The value to be loaded into the RTC COUNT register

static inline uint32_t RTC_GetSecondsTimerCount(RTC_Type *base)

Read the actual RTC seconds timer (1HZ) COUNT value.

Parameters

- base – RTC peripheral base address

Returns

The actual RTC seconds timer (1HZ) COUNT value.

static inline void RTC_SetWakeupCount(RTC_Type *base, uint16_t wakeupValue)

Enable the RTC wake-up timer (1KHZ) and set countdown value to the RTC WAKE register.

Parameters

- base – RTC peripheral base address
- wakeupValue – The value to be loaded into the WAKE register in RTC wake-up timer (1KHZ).

static inline uint16_t RTC_GetWakeupCount(RTC_Type *base)

Read the actual value from the WAKE register value in RTC wake-up timer (1KHZ)

Read the WAKE register twice and compare the result, if the value match,the time can be used.

Parameters

- base – RTC peripheral base address

Returns

The actual value of the WAKE register value in RTC wake-up timer (1KHZ).

static inline void RTC_Reset(RTC_Type *base)

Perform a software reset on the RTC module.

This resets all RTC registers to their reset value. The bit is cleared by software explicitly clearing it.

Parameters

- base – RTC peripheral base address

struct _rtc_datetime

#include <fsl_rtc.h> Structure is used to hold the date and time.

Public Members

uint16_t year

Range from 1970 to 2099.

uint8_t month

Range from 1 to 12.

uint8_t day

Range from 1 to 31 (depending on month).

uint8_t hour

Range from 0 to 23.

uint8_t minute

Range from 0 to 59.

uint8_t second

Range from 0 to 59.

2.49 Sbloader

enum _bl_status_groups

Values:

enumerator kStatusGroup_SBLoader

enum _sbloader_status

Values:

enumerator kStatusRomLdrSectionOverrun

enumerator kStatusRomLdrSignature

enumerator kStatusRomLdrSectionLength

enumerator kStatusRomLdrUnencryptedOnly

enumerator kStatusRomLdrEOFReached

enumerator kStatusRomLdrChecksum

enumerator kStatusRomLdrCrc32Error

enumerator kStatusRomLdrUnknownCommand

enumerator kStatusRomLdrIdNotFound

enumerator kStatusRomLdrDataUnderrun

enumerator kStatusRomLdrJumpReturned

enumerator kStatusRomLdrCallFailed

enumerator kStatusRomLdrKeyNotFound

enumerator kStatusRomLdrSecureOnly

enumerator kStatusRomLdrResetReturned

enumerator kStatusRomLdrRollbackBlocked

enumerator kStatusRomLdrInvalidSectionMacCount

enumerator kStatusRomLdrUnexpectedCommand

enumerator kStatusRomLdrBadSBKEK

enumerator kStatusRomLdrPendingJumpCommand

enum _sectionType

sb3 section definitions

section type

Values:

enumerator kSectionNone

enumerator kSectionDataRange

enumerator kSectionDiffUpdate

enumerator kSectionDDRConfig

enumerator kSectionRegister

Values:

enumerator kFwVerChk_Id_none

enumerator kFwVerChk_Id_nonsecure

enumerator kFwVerChk_Id_secure

enum _loader_command_sb3

Values:

enumerator kSB3_CmdInvalid

enumerator kSB3_CmdErase

enumerator kSB3_CmdLoad

enumerator kSB3_CmdExecute

enumerator kSB3_CmdCall

enumerator kSB3_CmdProgramFuse

enumerator kSB3_CmdProgramIFR

enumerator kSB3_CmdLoadCmac

enumerator kSB3_CmdCopy

enumerator kSB3_CmdLoadHashLocking

enumerator kSB3_CmdLoadKeyBlob

enumerator kSB3_CmdConfigMem

enumerator kSB3_CmdFillMem

enumerator kSB3_CmdFwVerCheck

typedef uint8_t chunk_v3_t[16]

typedef struct *_ldr_buf* ldr_buf_t

typedef struct *_ldr_Context_v3* ldr_Context_v3_t

typedef *status_t* (*pLdrFnc_v3_t)(*ldr_Context_v3_t* *content)
Function pointer definition for all loader action functions.

typedef enum *_sectionType* section_type_t
sb3 section definitions

section type

typedef struct *range_header* sb3_data_range_header_t
section data range structure

typedef struct *range_header_expansion* sb3_data_range_expansion_t

typedef struct *copy_memory_expansion* sb3_copy_memory_expansion_t

typedef struct *copy* sb3_copy_memory_t

typedef struct *load_keyblob* sb3_load_keyblob_t

typedef struct *fill_memory_expansion* sb3_fill_memory_expansion_t

typedef struct *fill_memory* sb3_fill_memory_t

typedef struct *config_memory* sb3_config_memory_t

typedef struct *fw_ver_check* sb3_fw_ver_check_t

typedef struct *section_header* sb3_section_header_t
sb3 DATA section header format

typedef enum *_loader_command_sb3* sb3_cmd_t

SB3_BYTES_PER_CHUNK
Defines the number of bytes in a cipher block (chunk). This is dictated by the encryption algorithm.

SB3_DATA_RANGE_HEADER_FLAGS_ERASE_MASK

SB3_DATA_RANGE_HEADER_FLAGS_LOAD_MASK

SB3_DATA_RANGE_HEADER_TAG

SB3_DATA_ALIGNMENT_SIZE_IN_BYTE

SB3_LOAD_KEY_BLOB_OTP_MASK

SBLOADER_V3_CMD_SET_ALL
: The all of the allowed command.

SBLOADER_V3_CMD_SET_IN_ISP_MODE
: The allowed command set in ISP mode.

SBLOADER_V3_CMD_SET_IN_REC_MODE
: The allowed command set in recovery mode.

SBLOADER_V3_CMD_SET_IN_SEC_ATE_MODE
: The allowed command set in secure ATE mode.

SB3_DATA_BUFFER_SIZE_IN_BYTE

struct _ldr_buf
: *#include <fsl_sbloader_v3.h>*

struct range_header
: *#include <fsl_sbloader_v3.h>* section data range structure

struct range_header_expansion
: *#include <fsl_sbloader_v3.h>*

struct copy_memory_expansion
: *#include <fsl_sbloader_v3.h>*

struct copy
: *#include <fsl_sbloader_v3.h>*

struct load_keyblob
: *#include <fsl_sbloader_v3.h>*

struct fill_memory_expansion
: *#include <fsl_sbloader_v3.h>*

struct fill_memory
: *#include <fsl_sbloader_v3.h>*

struct config_memory
: *#include <fsl_sbloader_v3.h>*

struct fw_ver_check
: *#include <fsl_sbloader_v3.h>*

struct section_header
: *#include <fsl_sbloader_v3.h>* sb3 DATA section header format

struct _ldr_Context_v3
: *#include <fsl_sbloader_v3.h>* Loader context definition.

Public Members

pLdrFnc_v3_t Action
pointer to loader action function

uint32_t block_size
size of each block in bytes

uint32_t block_data_size
data size in bytes (NBOOT_SB3_CHUNK_SIZE_IN_BYTES)

uint32_t block_data_total
data max size in bytes (block_size * data_size

uint32_t block_buffer_size
block0 and block size

uint32_t processedBlocks
will be used for both block0 and blockx

bool in_data_block
data block offset in a block.

in progress of handling a data block within a block

bool in_data_section
in progress of handling a data section within a data block

bool in_data_range
in progress of handling a data range within a data section

uint32_t commandSet
support command set during sb file handling

uint8_t data_buffer[(*MAX*(128, NBOOT_KEY_BLOB_SIZE_IN_BYTE_MAX))]
temporary data buffer

uint8_t fuse_cmd_buffer[32 * 4]
used for fuse command

bool do_firmware_load
special handling for firmware loading ourside normal memory regions

2.50 SCTimer: SCTimer/PWM (SCT)

status_t SCTIMER_Init(SCT_Type *base, const *sctimer_config_t* *config)
Ungates the SCTimer clock and configures the peripheral for basic operation.

Note: This API should be called at the beginning of the application using the SCTimer driver.

Parameters

- base – SCTimer peripheral base address
- config – Pointer to the user configuration structure.

Returns
kStatus_Success indicates success; Else indicates failure.

void SCTIMER_Deinit(SCT_Type *base)

Gates the SCTimer clock.

Parameters

- base – SCTimer peripheral base address

void SCTIMER_GetDefaultConfig(*sctimer_config_t* *config)

Fills in the SCTimer configuration structure with the default settings.

The default values are:

```
config->enableCounterUnify = true;
config->clockMode = kSCTIMER_System_ClockMode;
config->clockSelect = kSCTIMER_Clock_On_Rise_Input_0;
config->enableBidirection_l = false;
config->enableBidirection_h = false;
config->prescale_l = 0U;
config->prescale_h = 0U;
config->outInitState = 0U;
config->inputsync  = 0xFU;
```

Parameters

- config – Pointer to the user configuration structure.

status_t SCTIMER_SetupPwm(SCT_Type *base, const *sctimer_pwm_signal_param_t* *pwmParams, *sctimer_pwm_mode_t* mode, uint32_t pwmFreq_Hz, uint32_t srcClock_Hz, uint32_t *event)

Configures the PWM signal parameters.

Call this function to configure the PWM signal period, mode, duty cycle, and edge. This function will create 2 events; one of the events will trigger on match with the pulse value and the other will trigger when the counter matches the PWM period. The PWM period event is also used as a limit event to reset the counter or change direction. Both events are enabled for the same state. The state number can be retrieved by calling the function SCTIMER_GetCurrentStateNumber(). The counter is set to operate as one 32-bit counter (unify bit is set to 1). The counter operates in bi-directional mode when generating a center-aligned PWM.

Note: When setting PWM output from multiple output pins, they all should use the same PWM mode i.e all PWM's should be either edge-aligned or center-aligned. When using this API, the PWM signal frequency of all the initialized channels must be the same. Otherwise all the initialized channels' PWM signal frequency is equal to the last call to the API's pwmFreq_Hz.

Parameters

- base – SCTimer peripheral base address
- pwmParams – PWM parameters to configure the output
- mode – PWM operation mode, options available in enumeration sctimer_pwm_mode_t
- pwmFreq_Hz – PWM signal frequency in Hz
- srcClock_Hz – SCTimer counter clock in Hz
- event – Pointer to a variable where the PWM period event number is stored

Returns

kStatus_Success on success kStatus_Fail If we have hit the limit in terms of number of events created or if an incorrect PWM dutycylce is passed in.

void SCTIMER_UpdatePwmDutycycle(SCT_Type *base, *sctimer_out_t* output, uint8_t dutyCyclePercent, uint32_t event)

Updates the duty cycle of an active PWM signal.

Before calling this function, the counter is set to operate as one 32-bit counter (unify bit is set to 1).

Parameters

- base – SCTimer peripheral base address
- output – The output to configure
- dutyCyclePercent – New PWM pulse width; the value should be between 1 to 100
- event – Event number associated with this PWM signal. This was returned to the user by the function SCTIMER_SetupPwm().

static inline void SCTIMER_EnableInterrupts(SCT_Type *base, uint32_t mask)

Enables the selected SCTimer interrupts.

Parameters

- base – SCTimer peripheral base address
- mask – The interrupts to enable. This is a logical OR of members of the enumeration sctimer_interrupt_enable_t

static inline void SCTIMER_DisableInterrupts(SCT_Type *base, uint32_t mask)

Disables the selected SCTimer interrupts.

Parameters

- base – SCTimer peripheral base address
- mask – The interrupts to enable. This is a logical OR of members of the enumeration sctimer_interrupt_enable_t

static inline uint32_t SCTIMER_GetEnabledInterrupts(SCT_Type *base)

Gets the enabled SCTimer interrupts.

Parameters

- base – SCTimer peripheral base address

Returns

The enabled interrupts. This is the logical OR of members of the enumeration sctimer_interrupt_enable_t

static inline uint32_t SCTIMER_GetStatusFlags(SCT_Type *base)

Gets the SCTimer status flags.

Parameters

- base – SCTimer peripheral base address

Returns

The status flags. This is the logical OR of members of the enumeration sctimer_status_flags_t

static inline void SCTIMER_ClearStatusFlags(SCT_Type *base, uint32_t mask)

Clears the SCTimer status flags.

Parameters

- base – SCTimer peripheral base address
- mask – The status flags to clear. This is a logical OR of members of the enumeration sctimer_status_flags_t

static inline void SCTIMER_StartTimer(SCT_Type *base, uint32_t countertoStart)

Starts the SCTimer counter.

Note: In 16-bit mode, we can enable both Counter_L and Counter_H, In 32-bit mode, we only can select Counter_U.

Parameters

- base – SCTimer peripheral base address
- countertoStart – The SCTimer counters to enable. This is a logical OR of members of the enumeration sctimer_counter_t.

static inline void SCTIMER_StopTimer(SCT_Type *base, uint32_t countertoStop)

Halts the SCTimer counter.

Parameters

- base – SCTimer peripheral base address
- countertoStop – The SCTimer counters to stop. This is a logical OR of members of the enumeration sctimer_counter_t.

status_t SCTIMER_CreateAndScheduleEvent(SCT_Type *base, *sctimer_event_t* howToMonitor, uint32_t matchValue, uint32_t whichIO, *sctimer_counter_t* whichCounter, uint32_t *event)

Create an event that is triggered on a match or IO and schedule in current state.

This function will configure an event using the options provided by the user. If the event type uses the counter match, then the function will set the user provided match value into a match register and put this match register number into the event control register. The event is enabled for the current state and the event number is increased by one at the end. The function returns the event number; this event number can be used to configure actions to be done when this event is triggered.

Parameters

- base – SCTimer peripheral base address
- howToMonitor – Event type; options are available in the enumeration sctimer_interrupt_enable_t
- matchValue – The match value that will be programmed to a match register
- whichIO – The input or output that will be involved in event triggering. This field is ignored if the event type is “match only”
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.
- event – Pointer to a variable where the new event number is stored

Returns

kStatus_Success on success kStatus_Error if we have hit the limit in terms of number of events created or if we have reached the limit in terms of number of match registers

void SCTIMER_ScheduleEvent(SCT_Type *base, uint32_t event)

Enable an event in the current state.

This function will allow the event passed in to trigger in the current state. The event must be created earlier by either calling the function SCTIMER_SetupPwm() or function SCTIMER_CreateAndScheduleEvent() .

Parameters

- base – SCTimer peripheral base address
- event – Event number to enable in the current state

status_t SCTIMER_IncreaseState(SCT_Type *base)

Increase the state by 1.

All future events created by calling the function SCTIMER_ScheduleEvent() will be enabled in this new state.

Parameters

- base – SCTimer peripheral base address

Returns

kStatus_Success on success kStatus_Error if we have hit the limit in terms of states used

uint32_t SCTIMER_GetCurrentState(SCT_Type *base)

Provides the current state.

User can use this to set the next state by calling the function SCTIMER_SetupNextStateAction().

Parameters

- base – SCTimer peripheral base address

Returns

The current state

static inline void SCTIMER_SetCounterState(SCT_Type *base, *sctimer_counter_t* whichCounter, uint32_t state)

Set the counter current state.

The function is to set the state variable bit field of STATE register. Writing to the STATE_L, STATE_H, or unified register is only allowed when the corresponding counter is halted (HALT bits are set to 1 in the CTRL register).

Parameters

- base – SCTimer peripheral base address
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.
- state – The counter current state number (only support range from 0~31).

static inline uint16_t SCTIMER_GetCounterState(SCT_Type *base, *sctimer_counter_t* whichCounter)

Get the counter current state value.

The function is to get the state variable bit field of STATE register.

Parameters

- base – SCTimer peripheral base address
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.

Returns

The the counter current state value.

status_t SCTIMER_SetupCaptureAction(SCT_Type *base, *sctimer_counter_t* whichCounter, uint32_t *captureRegister, uint32_t event)

Setup capture of the counter value on trigger of a selected event.

Parameters

- base – SCTimer peripheral base address
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.
- captureRegister – Pointer to a variable where the capture register number will be returned. User can read the captured value from this register when the specified event is triggered.
- event – Event number that will trigger the capture

Returns

kStatus_Success on success kStatus_Error if we have hit the limit in terms of number of match/capture registers available

void SCTIMER_SetCallback(SCT_Type *base, *sctimer_event_callback_t* callback, uint32_t event)

Receive noticification when the event trigger an interrupt.

If the interrupt for the event is enabled by the user, then a callback can be registered which will be invoked when the event is triggered

Parameters

- base – SCTimer peripheral base address
- event – Event number that will trigger the interrupt
- callback – Function to invoke when the event is triggered

static inline void SCTIMER_SetupStateLdMethodAction(SCT_Type *base, uint32_t event, bool fgLoad)

Change the load method of transition to the specified state.

Change the load method of transition, it will be triggered by the event number that is passed in by the user.

Parameters

- base – SCTimer peripheral base address
- event – Event number that will change the method to trigger the state transition
- fgLoad – The method to load highest-numbered event occurring for that state to the STATE register.
  - true: Load the STATEV value to STATE when the event occurs to be the next state.
  - false: Add the STATEV value to STATE when the event occurs to be the next state.

static inline void SCTIMER_SetupNextStateActionwithLdMethod(SCT_Type *base, uint32_t nextState, uint32_t event, bool fgLoad)

Transition to the specified state with Load method.

This transition will be triggered by the event number that is passed in by the user, the method decide how to load the highest-numbered event occurring for that state to the STATE register.

Parameters

- base – SCTimer peripheral base address
- nextState – The next state SCTimer will transition to
- event – Event number that will trigger the state transition

- fgLoad – The method to load the highest-numbered event occurring for that state to the STATE register.
  - true: Load the STATEV value to STATE when the event occurs to be the next state.
  - false: Add the STATEV value to STATE when the event occurs to be the next state.

static inline void SCTIMER_SetupNextStateAction(SCT_Type *base, uint32_t nextState, uint32_t event)

Transition to the specified state.

Deprecated:

Do not use this function. It has been superceded by SCTIMER_SetupNextStateActionwithLdMethod

This transition will be triggered by the event number that is passed in by the user.

Parameters

- base – SCTimer peripheral base address
- nextState – The next state SCTimer will transition to
- event – Event number that will trigger the state transition

static inline void SCTIMER_SetupEventActiveDirection(SCT_Type *base, *sctimer_event_active_direction_t* activeDirection, uint32_t event)

Setup event active direction when the counters are operating in BIDIR mode.

Parameters

- base – SCTimer peripheral base address
- activeDirection – Event generation active direction, see sctimer_event_active_direction_t.
- event – Event number that need setup the active direction.

static inline void SCTIMER_SetupOutputSetAction(SCT_Type *base, uint32_t whichIO, uint32_t event)

Set the Output.

This output will be set when the event number that is passed in by the user is triggered.

Parameters

- base – SCTimer peripheral base address
- whichIO – The output to set
- event – Event number that will trigger the output change

static inline void SCTIMER_SetupOutputClearAction(SCT_Type *base, uint32_t whichIO, uint32_t event)

Clear the Output.

This output will be cleared when the event number that is passed in by the user is triggered.

Parameters

- base – SCTimer peripheral base address
- whichIO – The output to clear
- event – Event number that will trigger the output change

void SCTIMER_SetupOutputToggleAction(SCT_Type *base, uint32_t whichIO, uint32_t event)

Toggle the output level.

This change in the output level is triggered by the event number that is passed in by the user.

Parameters

- base – SCTimer peripheral base address
- whichIO – The output to toggle
- event – Event number that will trigger the output change

static inline void SCTIMER_SetupCounterLimitAction(SCT_Type *base, *sctimer_counter_t* whichCounter, uint32_t event)

Limit the running counter.

The counter is limited when the event number that is passed in by the user is triggered.

Parameters

- base – SCTimer peripheral base address
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.
- event – Event number that will trigger the counter to be limited

static inline void SCTIMER_SetupCounterStopAction(SCT_Type *base, *sctimer_counter_t* whichCounter, uint32_t event)

Stop the running counter.

The counter is stopped when the event number that is passed in by the user is triggered.

Parameters

- base – SCTimer peripheral base address
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.
- event – Event number that will trigger the counter to be stopped

static inline void SCTIMER_SetupCounterStartAction(SCT_Type *base, *sctimer_counter_t* whichCounter, uint32_t event)

Re-start the stopped counter.

The counter will re-start when the event number that is passed in by the user is triggered.

Parameters

- base – SCTimer peripheral base address
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.
- event – Event number that will trigger the counter to re-start

static inline void SCTIMER_SetupCounterHaltAction(SCT_Type *base, *sctimer_counter_t* whichCounter, uint32_t event)

Halt the running counter.

The counter is disabled (halted) when the event number that is passed in by the user is triggered. When the counter is halted, all further events are disabled. The HALT condition can only be removed by calling the SCTIMER_StartTimer() function.

Parameters

- base – SCTimer peripheral base address

- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.
- event – Event number that will trigger the counter to be halted

static inline void SCTIMER_SetupDmaTriggerAction(SCT_Type *base, uint32_t dmaNumber, uint32_t event)

Generate a DMA request.

DMA request will be triggered by the event number that is passed in by the user.

Parameters

- base – SCTimer peripheral base address
- dmaNumber – The DMA request to generate
- event – Event number that will trigger the DMA request

static inline void SCTIMER_SetCOUNTValue(SCT_Type *base, *sctimer_counter_t* whichCounter, uint32_t value)

Set the value of counter.

The function is to set the value of Count register, Writing to the COUNT_L, COUNT_H, or unified register is only allowed when the corresponding counter is halted (HALT bits are set to 1 in the CTRL register).

Parameters

- base – SCTimer peripheral base address
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.
- value – the counter value update to the COUNT register.

static inline uint32_t SCTIMER_GetCOUNTValue(SCT_Type *base, *sctimer_counter_t* whichCounter)

Get the value of counter.

The function is to read the value of Count register, software can read the counter registers at any time..

Parameters

- base – SCTimer peripheral base address
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.

Returns

The value of counter selected.

static inline void SCTIMER_SetEventInState(SCT_Type *base, uint32_t event, uint32_t state)

Set the state mask bit field of EV_STATE register.

Parameters

- base – SCTimer peripheral base address
- event – The EV_STATE register be set.
- state – The state value in which the event is enabled to occur.

static inline void SCTIMER_ClearEventInState(SCT_Type *base, uint32_t event, uint32_t state)

Clear the state mask bit field of EV_STATE register.

Parameters

- base – SCTimer peripheral base address

- event – The EV_STATE register be clear.
- state – The state value in which the event is disabled to occur.

static inline bool SCTIMER_GetEventInState(SCT_Type *base, uint32_t event, uint32_t state)

Get the state mask bit field of EV_STATE register.

Note: This function is to check whether the event is enabled in a specific state.

Parameters

- base – SCTimer peripheral base address
- event – The EV_STATE register be read.
- state – The state value.

Returns

The the state mask bit field of EV_STATE register.

- true: The event is enable in state.
- false: The event is disable in state.

static inline uint32_t SCTIMER_GetCaptureValue(SCT_Type *base, *sctimer_counter_t* whichCounter, uint8_t capChannel)

Get the value of capture register.

This function returns the captured value upon occurrence of the events selected by the corresponding Capture Control registers occurred.

Parameters

- base – SCTimer peripheral base address
- whichCounter – SCTimer counter to use. In 16-bit mode, we can select Counter_L and Counter_H, In 32-bit mode, we can select Counter_U.
- capChannel – SCTimer capture register of capture channel.

Returns

The SCTimer counter value at which this register was last captured.

void SCTIMER_EventHandleIRQ(SCT_Type *base)

SCTimer interrupt handler.

Parameters

- base – SCTimer peripheral base address.

FSL_SCTIMER_DRIVER_VERSION

Version

enum _sctimer_pwm_mode

SCTimer PWM operation modes.

Values:

enumerator kSCTIMER_EdgeAlignedPwm

Edge-aligned PWM

enumerator kSCTIMER_CenterAlignedPwm

Center-aligned PWM

enum _sctimer_counter

SCTimer counters type.

Values:

enumerator kSCTIMER_Counter_L

16-bit Low counter.

enumerator kSCTIMER_Counter_H

16-bit High counter.

enumerator kSCTIMER_Counter_U

32-bit Unified counter.

enum _sctimer_input

List of SCTimer input pins.

Values:

enumerator kSCTIMER_Input_0

SCTIMER input 0

enumerator kSCTIMER_Input_1

SCTIMER input 1

enumerator kSCTIMER_Input_2

SCTIMER input 2

enumerator kSCTIMER_Input_3

SCTIMER input 3

enumerator kSCTIMER_Input_4

SCTIMER input 4

enumerator kSCTIMER_Input_5

SCTIMER input 5

enumerator kSCTIMER_Input_6

SCTIMER input 6

enumerator kSCTIMER_Input_7

SCTIMER input 7

enum _sctimer_out

List of SCTimer output pins.

Values:

enumerator kSCTIMER_Out_0

SCTIMER output 0

enumerator kSCTIMER_Out_1

SCTIMER output 1

enumerator kSCTIMER_Out_2

SCTIMER output 2

enumerator kSCTIMER_Out_3

SCTIMER output 3

enumerator kSCTIMER_Out_4

SCTIMER output 4

enumerator kSCTIMER_Out_5
SCTIMER output 5

enumerator kSCTIMER_Out_6
SCTIMER output 6

enumerator kSCTIMER_Out_7
SCTIMER output 7

enumerator kSCTIMER_Out_8
SCTIMER output 8

enumerator kSCTIMER_Out_9
SCTIMER output 9

enum _sctimer_pwm_level_select
SCTimer PWM output pulse mode: high-true, low-true or no output.

Values:

enumerator kSCTIMER_LowTrue
Low true pulses

enumerator kSCTIMER_HighTrue
High true pulses

enum _sctimer_clock_mode
SCTimer clock mode options.

Values:

enumerator kSCTIMER_System_ClockMode
System Clock Mode

enumerator kSCTIMER_Sampled_ClockMode
Sampled System Clock Mode

enumerator kSCTIMER_Input_ClockMode
SCT Input Clock Mode

enumerator kSCTIMER_Asynchronous_ClockMode
Asynchronous Mode

enum _sctimer_clock_select
SCTimer clock select options.

Values:

enumerator kSCTIMER_Clock_On_Rise_Input_0
Rising edges on input 0

enumerator kSCTIMER_Clock_On_Fall_Input_0
Falling edges on input 0

enumerator kSCTIMER_Clock_On_Rise_Input_1
Rising edges on input 1

enumerator kSCTIMER_Clock_On_Fall_Input_1
Falling edges on input 1

enumerator kSCTIMER_Clock_On_Rise_Input_2
Rising edges on input 2

enumerator kSCTIMER_Clock_On_Fall_Input_2
Falling edges on input 2

enumerator kSCTIMER_Clock_On_Rise_Input_3
Rising edges on input 3

enumerator kSCTIMER_Clock_On_Fall_Input_3
Falling edges on input 3

enumerator kSCTIMER_Clock_On_Rise_Input_4
Rising edges on input 4

enumerator kSCTIMER_Clock_On_Fall_Input_4
Falling edges on input 4

enumerator kSCTIMER_Clock_On_Rise_Input_5
Rising edges on input 5

enumerator kSCTIMER_Clock_On_Fall_Input_5
Falling edges on input 5

enumerator kSCTIMER_Clock_On_Rise_Input_6
Rising edges on input 6

enumerator kSCTIMER_Clock_On_Fall_Input_6
Falling edges on input 6

enumerator kSCTIMER_Clock_On_Rise_Input_7
Rising edges on input 7

enumerator kSCTIMER_Clock_On_Fall_Input_7
Falling edges on input 7

enum _sctimer_conflict_resolution
SCTimer output conflict resolution options.

Specifies what action should be taken if multiple events dictate that a given output should be both set and cleared at the same time

Values:

enumerator kSCTIMER_ResolveNone
No change

enumerator kSCTIMER_ResolveSet
Set output

enumerator kSCTIMER_ResolveClear
Clear output

enumerator kSCTIMER_ResolveToggle
Toggle output

enum _sctimer_event_active_direction
List of SCTimer event generation active direction when the counters are operating in BIDIR mode.

Values:

enumerator kSCTIMER_ActiveIndependent
This event is triggered regardless of the count direction.

enumerator kSCTIMER_ActiveInCountUp
This event is triggered only during up-counting when BIDIR = 1.

enumerator kSCTIMER_ActiveInCountDown
This event is triggered only during down-counting when BIDIR = 1.

enum _sctimer_event
List of SCTimer event types.

Values:

enumerator kSCTIMER_InputLowOrMatchEvent

enumerator kSCTIMER_InputRiseOrMatchEvent

enumerator kSCTIMER_InputFallOrMatchEvent

enumerator kSCTIMER_InputHighOrMatchEvent

enumerator kSCTIMER_MatchEventOnly

enumerator kSCTIMER_InputLowEvent

enumerator kSCTIMER_InputRiseEvent

enumerator kSCTIMER_InputFallEvent

enumerator kSCTIMER_InputHighEvent

enumerator kSCTIMER_InputLowAndMatchEvent

enumerator kSCTIMER_InputRiseAndMatchEvent

enumerator kSCTIMER_InputFallAndMatchEvent

enumerator kSCTIMER_InputHighAndMatchEvent

enumerator kSCTIMER_OutputLowOrMatchEvent

enumerator kSCTIMER_OutputRiseOrMatchEvent

enumerator kSCTIMER_OutputFallOrMatchEvent

enumerator kSCTIMER_OutputHighOrMatchEvent

enumerator kSCTIMER_OutputLowEvent

enumerator kSCTIMER_OutputRiseEvent

enumerator kSCTIMER_OutputFallEvent

enumerator kSCTIMER_OutputHighEvent

enumerator kSCTIMER_OutputLowAndMatchEvent

enumerator kSCTIMER_OutputRiseAndMatchEvent

enumerator kSCTIMER_OutputFallAndMatchEvent

enumerator kSCTIMER_OutputHighAndMatchEvent

enum _sctimer_interrupt_enable
List of SCTimer interrupts.

Values:

enumerator kSCTIMER_Event0InterruptEnable
Event 0 interrupt

enumerator kSCTIMER_Event1InterruptEnable
Event 1 interrupt

enumerator kSCTIMER_Event2InterruptEnable
Event 2 interrupt

enumerator kSCTIMER_Event3InterruptEnable
Event 3 interrupt

enumerator kSCTIMER_Event4InterruptEnable
Event 4 interrupt

enumerator kSCTIMER_Event5InterruptEnable
Event 5 interrupt

enumerator kSCTIMER_Event6InterruptEnable
Event 6 interrupt

enumerator kSCTIMER_Event7InterruptEnable
Event 7 interrupt

enumerator kSCTIMER_Event8InterruptEnable
Event 8 interrupt

enumerator kSCTIMER_Event9InterruptEnable
Event 9 interrupt

enumerator kSCTIMER_Event10InterruptEnable
Event 10 interrupt

enumerator kSCTIMER_Event11InterruptEnable
Event 11 interrupt

enumerator kSCTIMER_Event12InterruptEnable
Event 12 interrupt

enum _sctimer_status_flags
List of SCTimer flags.

Values:

enumerator kSCTIMER_Event0Flag
Event 0 Flag

enumerator kSCTIMER_Event1Flag
Event 1 Flag

enumerator kSCTIMER_Event2Flag
Event 2 Flag

enumerator kSCTIMER_Event3Flag
Event 3 Flag

enumerator kSCTIMER_Event4Flag
Event 4 Flag

enumerator kSCTIMER_Event5Flag
Event 5 Flag

enumerator kSCTIMER_Event6Flag
Event 6 Flag

enumerator kSCTIMER_Event7Flag
Event 7 Flag

enumerator kSCTIMER_Event8Flag
Event 8 Flag

enumerator kSCTIMER_Event9Flag
Event 9 Flag

enumerator kSCTIMER_Event10Flag
Event 10 Flag

enumerator kSCTIMER_Event11Flag
Event 11 Flag

enumerator kSCTIMER_Event12Flag
Event 12 Flag

enumerator kSCTIMER_BusErrorLFlag
Bus error due to write when L counter was not halted

enumerator kSCTIMER_BusErrorHFlag
Bus error due to write when H counter was not halted

typedef enum *_sctimer_pwm_mode* sctimer_pwm_mode_t
SCTimer PWM operation modes.

typedef enum *_sctimer_counter* sctimer_counter_t
SCTimer counters type.

typedef enum *_sctimer_input* sctimer_input_t
List of SCTimer input pins.

typedef enum *_sctimer_out* sctimer_out_t
List of SCTimer output pins.

typedef enum *_sctimer_pwm_level_select* sctimer_pwm_level_select_t
SCTimer PWM output pulse mode: high-true, low-true or no output.

typedef struct *_sctimer_pwm_signal_param* sctimer_pwm_signal_param_t
Options to configure a SCTimer PWM signal.

typedef enum *_sctimer_clock_mode* sctimer_clock_mode_t
SCTimer clock mode options.

typedef enum *_sctimer_clock_select* sctimer_clock_select_t
SCTimer clock select options.

typedef enum *_sctimer_conflict_resolution* sctimer_conflict_resolution_t
SCTimer output conflict resolution options.

Specifies what action should be taken if multiple events dictate that a given output should be both set and cleared at the same time

typedef enum *_sctimer_event_active_direction* sctimer_event_active_direction_t
List of SCTimer event generation active direction when the counters are operating in BIDIR mode.

typedef enum *_sctimer_event* sctimer_event_t
List of SCTimer event types.

typedef void (*sctimer_event_callback_t)(void)
SCTimer callback typedef.

typedef enum *_sctimer_interrupt_enable* sctimer_interrupt_enable_t

List of SCTimer interrupts.

typedef enum *_sctimer_status_flags* sctimer_status_flags_t

List of SCTimer flags.

typedef struct *_sctimer_config* sctimer_config_t

SCTimer configuration structure.

This structure holds the configuration settings for the SCTimer peripheral. To initialize this structure to reasonable defaults, call the SCTMR_GetDefaultConfig() function and pass a pointer to the configuration structure instance.

The configuration structure can be made constant so as to reside in flash.

SCT_EV_STATE_STATEMSKn(x)

struct _sctimer_pwm_signal_param

#include <fsl_sctimer.h> Options to configure a SCTimer PWM signal.

Public Members

sctimer_out_t output

The output pin to use to generate the PWM signal

sctimer_pwm_level_select_t level

PWM output active level select.

uint8_t dutyCyclePercent

PWM pulse width, value should be between 0 to 100 0 = always inactive signal (0% duty cycle) 100 = always active signal (100% duty cycle).

struct _sctimer_config

#include <fsl_sctimer.h> SCTimer configuration structure.

This structure holds the configuration settings for the SCTimer peripheral. To initialize this structure to reasonable defaults, call the SCTMR_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 enableCounterUnify

true: SCT operates as a unified 32-bit counter; false: SCT operates as two 16-bit counters. User can use the 16-bit low counter and the 16-bit high counters at the same time; for Hardware limit, user can not use unified 32-bit counter and any 16-bit low/high counter at the same time.

sctimer_clock_mode_t clockMode

SCT clock mode value

sctimer_clock_select_t clockSelect

SCT clock select value

bool enableBidirection_l

true: Up-down count mode for the L or unified counter false: Up count mode only for the L or unified counter

bool enableBidirection_h

true: Up-down count mode for the H or unified counter false: Up count mode only for the H or unified counter. This field is used only if the enableCounterUnify is set to false

uint8_t prescale_l

Prescale value to produce the L or unified counter clock

uint8_t prescale_h

Prescale value to produce the H counter clock. This field is used only if the enableCounterUnify is set to false

uint8_t outInitState

Defines the initial output value

uint8_t inputsync

SCT INSYNC value, INSYNC field in the CONFIG register, from bit9 to bit 16. it is used to define synchronization for input N: bit 9 = input 0 bit 10 = input 1 bit 11 = input 2 bit 12 = input 3 All other bits are reserved (bit13 ~bit 16). How User to set the the value for the member inputsync. IE: delay for input0, and input 1, bypasses for input 2 and input 3 MACRO definition in user level. #define INPUTSYNC0 (0U) #define INPUTSYNC1 (1U) #define INPUTSYNC2 (2U) #define INPUTSYNC3 (3U) User Code. sctimerInfo.inputsync = (1 « INPUTSYNC2) | (1 « INPUTSYNC3);

2.51 Sdioslv_sdu_driver

enum _sdioslv_status

SDIO status.

Values:

enumerator kStatus_SDIOSLV_CmdPending

previous command is under working.

enumerator kStatus_SDIOSLV_SendFull

all data slots are occupied.

enumerator kStatus_SDIOSLV_FuncEnabled

function enabled

enumerator kStatus_SDIOSLV_FuncDisabled

function disabled

enumerator kStatus_SDIOSLV_FuncSuspended

function suspended

enumerator kStatus_SDIOSLV_FuncResumed

function resumed

enumerator kStatus_SDIOSLV_FuncSendComplete

function send complete

enumerator kStatus_SDIOSLV_FuncReadComplete

function read complete

enumerator kStatus_SDIOSLV_FuncRequestBuffer

function request read buffer

enum _sdioslv_int_cpu_num

SDIO card function number.

Values:

enumerator kSDIOSLV_INT_CPUNum1

sdio interrupt to CPU1

enumerator kSDIOSLV_INT_CPUNum2

sdio interrupt to CPU2

enumerator kSDIOSLV_INT_CPUNum3

sdio interrupt to CPU3

enum _sdioslv_func_num

SDIO card function number.

Values:

enumerator kSDIOSLV_FunctionNum1

sdio function1

enumerator kSDIOSLV_FunctionNum2

sdio function2

enumerator kSDIOSLV_FunctionNum3

sdio function3

enumerator kSDIOSLV_FunctionNum4

sdio function4

enumerator kSDIOSLV_FunctionNum5

sdio function5

enumerator kSDIOSLV_FunctionNum6

sdio function6

enumerator kSDIOSLV_FunctionNum7

sdio function7

enum _sdioslv_port_num

SDIO port number (per function)

Values:

enumerator kSDIOSLV_DataPortNum0

sdio dataport0

enumerator kSDIOSLV_DataPortNum1

sdio dataport1

enumerator kSDIOSLV_DataPortNum2

sdio dataport2

enumerator kSDIOSLV_DataPortNum3

sdio dataport3

enumerator kSDIOSLV_DataPortNum4

sdio dataport4

enumerator kSDIOSLV_DataPortNum5

sdio dataport5

enumerator kSDIOSLV_DataPortNum6
sdio dataport6

enumerator kSDIOSLV_DataPortNum7
sdio dataport7

enumerator kSDIOSLV_DataPortNum8
sdio dataport8

enumerator kSDIOSLV_DataPortNum9
sdio dataport9

enumerator kSDIOSLV_DataPortNum10
sdio dataport10

enumerator kSDIOSLV_DataPortNum11
sdio dataport11

enumerator kSDIOSLV_DataPortNum12
sdio dataport12

enumerator kSDIOSLV_DataPortNum13
sdio dataport13

enumerator kSDIOSLV_DataPortNum14
sdio dataport14

enumerator kSDIOSLV_DataPortNum15
sdio dataport15

enumerator kSDIOSLV_DataPortNum16
sdio dataport16

enumerator kSDIOSLV_DataPortNum17
sdio dataport17

enumerator kSDIOSLV_DataPortNum18
sdio dataport18

enumerator kSDIOSLV_DataPortNum19
sdio dataport19

enumerator kSDIOSLV_DataPortNum20
sdio dataport20

enumerator kSDIOSLV_DataPortNum21
sdio dataport21

enumerator kSDIOSLV_DataPortNum22
sdio dataport22

enumerator kSDIOSLV_DataPortNum23
sdio dataport23

enumerator kSDIOSLV_DataPortNum24
sdio dataport24

enumerator kSDIOSLV_DataPortNum25
sdio dataport25

enumerator kSDIOSLV_DataPortNum26
sdio dataport26

enumerator kSDIOSLV_DataPortNum27
sdio dataport27

enumerator kSDIOSLV_DataPortNum28
sdio dataport28

enumerator kSDIOSLV_DataPortNum29
sdio dataport29

enumerator kSDIOSLV_DataPortNum30
sdio dataport30

enumerator kSDIOSLV_DataPortNum31
sdio dataport31

enumerator kSDIOSLV_CmdPortNum0
sdio cmdport0

enum _sdioslv_bus_speed
SDIO Bus Speed.

Values:

enumerator kSDIOSLV_SDR12_MODE
SDR12 mode => 25Mhz

enumerator kSDIOSLV_SDR25_MODE
SDR25 mode => 50Mhz

enumerator kSDIOSLV_SDR50_MODE
SDR50 mode => 100Mhz

enumerator kSDIOSLV_SDR104_MODE
SDR104 mode => 208Mhz

enum _sdioslv_scratch_group
Scratch register group.

Values:

enumerator kSDIOSLV_ScratchGroup0
sdio scratch1 in FW18 0xnD4 n:1..7 16 bits

enumerator kSDIOSLV_ScratchGroup1
sdio scratch2 in FW18 0xnB0 n:1..7 16 bits

enumerator kSDIOSLV_ScratchGroup2
sdio scratch group 2 in SDU 0xnE8 n:1..7 32 bits

enumerator kSDIOSLV_ScratchGroup3
sdio scratch group 3 in SDU 0xnEC n:1..7 32 bits

enumerator kSDIOSLV_ScratchGroup4
sdio scratch group 4 in SDU 0xnF0 n:1..7 32 bits

enumerator kSDIOSLV_ScratchGroup5
sdio scratch group 5 in SDU 0xnF4 n:1..7 32 bits

enumerator kSDIOSLV_ScratchGroup6
sdio scratch group 6 in SDU 0xnF8 n:1..7 32 bits

enumerator kSDIOSLV_ScratchGroup7
sdio scratch group 7 in SDU 0xnFC n:1..7 32 bits

enum _sdioslv_scratch_offset

Scratch register offset in a group.

Values:

enumerator kSDIOSLV_ScratchOffset0

sdio scratchoffset0

enumerator kSDIOSLV_ScratchOffset1

sdio scratchoffset1

enumerator kSDIOSLV_ScratchOffset3

sdio scratchoffset2

enumerator kSDIOSLV_ScratchOffset4

sdio scratchoffset3

typedef enum *_sdioslv_int_cpu_num* sdioslv_int_cpu_num_t

SDIO card function number.

typedef enum *_sdioslv_func_num* sdioslv_func_t

SDIO card function number.

typedef enum *_sdioslv_port_num* sdioslv_port_t

SDIO port number (per function)

typedef enum *_sdioslv_bus_speed* sdioslv_bus_speed_t

SDIO Bus Speed.

typedef enum *_sdioslv_scratch_group* sdioslv_scratch_group_t

Scratch register group.

typedef enum *_sdioslv_scratch_offset* sdioslv_scratch_offset_t

Scratch register offset in a group.

typedef struct *_sdioslv_sdu_regmap* sdioslv_sdu_regmap_t

SDU register map version 4.

typedef void (*sdioslv_cis_table_callback_t)(const uint32_t SDU_BASE)

SDIO CIS table callback.

typedef struct *sdio_slave_config* sdio_slave_config_t

Data structure to configure SDIO handle for specific function.

FSL_SDIOSLV_SDU_DRIVER_VERSION

Driver version 1.0.0.

void SDIOSLV_Init0(void)

SDIOSLV Init0.

Call this API to Init SDIOSLV phase0.

Parameters

- void – None.

Return values

void – None.

status_t SDIOSLV_Init1(SDU_FN_CARD_Type *base, *sdio_slave_config_t* *config)

SDIOSLV Init1.

Call this API to Init SDIOSLV phase1.

Parameters

- base – FN FSR pointer.
- config – Configure for SDIO Slave.

Return values

- kStatus_Success – command is ready to be sent to host driver.
- kStatus_InvalidArgument – Invalid argument.

status_t SDIOSLV_SendCmdNonBlocking(*sdioslv_sdu_regmap_t* *regmap, uint8_t *data_addr, uint16_t data_len)

SDIOSLV send command.

Call this API to send command to host driver. The callback is always invoked from theinterrupt context.

Parameters

- regmap – FN FSR pointer.
- data_addr – Data Address.
- data_len – Data Length.

Return values

- kStatus_Success – command is ready to be sent to host driver.
- kStatus_InvalidArgument – Invalid argument.

status_t SDIOSLV_RefillCmdBuffer(*sdioslv_sdu_regmap_t* *regmap, uint8_t *data_addr)

SDIOSLV provide command buffer.

Call this API to provide receive command buffer to SDU driver.

Parameters

- regmap – FN FSR pointer.
- data_addr – Data Address.
- data_len – Data Length.

Return values

- kStatus_Success – buffer refill sucessfully.
- kStatus_Fail – fail to refill buffer.

status_t SDIOSLV_SendDataNonBlocking(*sdioslv_sdu_regmap_t* *regmap, *sdioslv_port_t* tx_port, uint8_t *data_addr, uint16_t data_len)

SDIOSLV send data transfer.

Call this API to send data to host driver. The callback is always invoked from theinterrupt context.

Parameters

- regmap – FN FSR pointer.
- port – Data Port.
- data_addr – Data Address.
- data_len – Data Length.

Return values

- kStatus_Success – buffer is added to data slot with problem.
- kStatus_InvalidArgument – Invalid argument.
- kStatus_SDIOSLV_SendFull – all data slots are occupied, application

status_t SDIOSLV_RefillDataBuffer(*sdioslv_sdu_regmap_t* *regmap, *sdioslv_port_t* port, uint8_t *data_addr)

SDIOSLV provide receive data buffer.

Call this API to provide receive data buffer to SDU driver.

Parameters

- regmap – FN FSR pointer.
- port – Data Port.
- data_addr – Data Address.
- data_len – Data Length.

Return values

- kStatus_Success – refill buffer sucessfully.
- kStatus_Fail – fail to refill buffer.

sdioslv_bus_speed_t SDIOSLV_GetBusSpeed(void)

Get SDIO bus speed selection.

Call this API to get current bus speed selected for SDIO.

Parameters

- void – None.

Return values

sdioslv_bus_speed_t – Bus speed selected for SDIO.

uint32_t SDIOSLV_GetBlockSize(uint8_t fn_num)

Get SDIO the block size in FBR.

For block mode, block size equals to block size in FBR.

Parameters

- handle – Created by SDIOSLV_CreateHanle().

Return values

the – block size in FBR.

status_t SDIOSLV_ReadScratchRegister(*sdioslv_func_t* fun_num, *sdioslv_scratch_group_t* group, *sdioslv_scratch_offset_t* offset, uint8_t *value)

SDIOSLV read scratch register of SDU.

Call this API to read scratch register of SDU (based on group and offset).

Parameters

- fun_num – Specify which function.
- group – Specify which group scratch register.
- offset – Specify offset of the scratch group.
- value – Value read from the register.

Return values

- kStatus_Success – read sucessfully.
- kStatus_Fail – fail to read.

status_t SDIOSLV_WriteScratchRegister(*sdioslv_func_t* fun_num, *sdioslv_scratch_group_t* group, *sdioslv_scratch_offset_t* offset, uint8_t value)

SDIOSLV write value to scratch register of SDU.

Call this API to write value to scratch register of SDU (based on group and offset).

Parameters

- fun_num – Specify which function.
- group – Specify which group scratch register.
- offset – Specify offset of the scratch group.
- value – Value write to the register.

Return values

- kStatus_Success – write sucessfully.
- kStatus_Fail – fail to write.

uint32_t HostToCardEvent
0x100/200.../700

uint32_t HostIntCause
0x104/204.../704

uint32_t HostIntMask
0x108/208.../708

uint32_t HostIntStatus
0x10C/20C.../70C

uint32_t RdBitMap
0x110/210.../710

uint32_t WrBitMap
0x114/214.../714

uint16_t RdLen[32]
0x118/218.../718

uint8_t HostTransferStatus
0x158/258.../758

uint8_t FunctionCardIntMsk
0x159/259.../759

uint8_t Card_Q_PTR_RANGE0
0x15A/25A.../75A

uint8_t Card_Q_PTR_RANGE1
0x15B/25B.../75B

uint16_t CardToHostEvent
0x15C/25C.../75C

uint8_t reserved2[2]

uint32_t CardIntMask
0x160/260.../760

uint32_t CardIntStatus
0x164/264.../764

uint32_t CardIntMode
0x168/268.../768

uint32_t SqReadBase
0x16C/26C.../76C

uint32_t SqWriteBase
0x170/270.../770

uint8_t RdIdx
0x174/274.../774

uint8_t WrIdx
0x175/275.../775

uint8_t Reserved6[2]
0x176/276.../776

uint8_t Card_APU_SLP_RDY_EN
0x178/278.../778

uint8_t Reserved7[3]

uint8_t Card_HOST_ERR_WKUP_EN
0x17C/27C.../77C

uint8_t Reserved8[3]

uint8_t HOST_ERR_CMD0
0x180/280.../780

uint8_t HOST_ERR_CMD1
0x181/281.../781

uint8_t HOST_ERR_CMD2
0x182/282.../782

uint8_t HOST_ERR_CMD3
0x183/283.../783

uint8_t HOST_ERR_CMD4
0x184/284.../784

uint8_t HOST_ERR_CMD5
0x185/285.../785

uint8_t Reserved9[2]

uint32_t PktWrBitmapClr
0x188/288.../788

uint32_t PktRdBitmapClr
0x18C/28C.../78C

uint32_t HostIntActMskEn
0x190/290.../790

uint32_t HostIntActMskClr
0x194/294.../794

uint32_t HostIntActMskStat
0x198/298.../798

uint32_t CardIntActMskEn
0x19C/29C.../79C

uint32_t CardIntActMskClr
0x1A0/2A0.../7A0

uint32_t CardIntActMskStat
0x1A4/2A4.../7A4

uint32_t TestbusBitSelect
0x1A8/2A8.../7A8

uint32_t TestbusBitSelect1
0x1AC/2AC.../7AC

uint16_t Scratch2
0x1B0/2B0.../7B0

uint8_t Scratch[6]
0x1B2/2B2.../7B2

uint32_t CmdPortSqWriteBase
0x1B8/2B8.../7B8

uint32_t CmdPortSqReadBase
0x1BC/2BC.../7BC

uint16_t CmdPortRdLen
0x1C0/2C0.../7C0

uint16_t Reserved10
0x1C2/2C2.../7C2

uint32_t CmdPortConfig
0x1C4/2C4.../7C4

uint8_t ChipRev
0x1C8/2C8.../7C8

uint8_t reserved11

uint8_t SDUMinorIPRev
0x1CA/2CA.../7CA

uint8_t SDUMajorIPRev
0x1CB/2CB.../7CB

uint32_t Card_PKT_END_RADDR
0x1CC/2CC.../7CC

uint32_t Card_PKT_END_WADDR
0x1D0/2D0.../7D0

uint16_t Scratch1
0x1D4/2D4.../7D4

uint8_t Ocr2
0x1D6/2D6.../7D6

uint8_t Config
0x1D7/2D7.../7D7

uint32_t Config2
: 0x1D8/2D8.../7D8

uint32_t Debug
: 0x1DC/2DC.../7DC

uint32_t DmaAddr
: 0x1E0/2E0.../7E0

uint8_t IoPort[3]
: 0x1E4/2E4.../7E4

uint8_t fun_num
: SDIO function number (1..7).

sdioslv_int_cpu_num_t cpu_num
: Specify interrupt should be generated to which CPU

uint8_t used_port_num
: How many data ports are used inside this function

uint8_t cmd_tx_format
: Command Tx length format. 0: no tx_len, 1: 2 bytes, 2: 3 bytes

uint8_t cmd_rd_format
: Command Rx length format. 0: blk_num * blk_size, 1: CMD_PORT_RD_LEN

uint8_t data_tx_format
: Data Tx length format. 0: no tx_len, 1: 2 bytes, 2: 3 bytes

uint8_t data_rd_format
: Data Rx length format. 0: blk_num * blk_size, 1: PORT_RD_LEN[15:0], 2: PORT1_RD_LEN[7:0] && PORT0_RD_LEN[15:0]

sdioslv_cis_table_callback_t cis_table_callback
: Callback function for initializing the CIS table.

SDU_INT_CPU_NUM

SDU_USED_FUN_NUM

SDU_USED_PORT_NUM

SDU_MAX_FUNCTION_NUM
: Maximum functions supported by SDU.

SDU_MAX_PORT_NUM
: Maximum data ports supported by SDU per function.

sdu_fbr_fnN_base(FN)

sdu_fbr_fnN_fn_code(FN)

sdu_fbr_fnN_fn_code_code_HI

sdu_fbr_fnN_fn_code_code_LO

SDU_REGS8(x)
: MACRO used to access register of SDU.

SDU_READ_REGS8(reg, val)
: MACRO used to read SDU register.

SDU_WRITE_REGS8(reg, val)
: MACRO used to write SDU register.

SDU_REGS8_SETBITS(reg, val)
: MACRO used to set bits of SDU register.

SDU_REGS8_CLRBITS(reg, val)
: MACRO used to clear bits of SDU register.

SDU_SCRATCH2_OFFSET0_ADDR
: Address of scratch register (group 2, offset 0) within function.

SDU_SDIO_CFG_BASE
: SDU SDIO configuration base (SDU_FN0_CARD_BASE defined in device)

SDIO_CCR_FUNC_OFFSET
: Address offset of CCR between two functions.

SDIO_IO_ENABLE
: SDIO I/O Enable.

SDIO_FUNC0_BSS
: SDIO Bus Speed Select.

SDIO_FUNC0_BSS_SUPPORT_MASK

SDIO_FUNC0_BSS_MODE_BIT

SDIO_FUNC0_BSS_MODE_MASK

SDIO_CCR_FUNC0_CARD_INT_MSK
: Interrupt mask register for function 0.

SDIO_CCR_HOST_DnLdReStart
: Bit Def. Host Transfer Status (HostTransferStatus)

SDIO_CCR_HOST_UpLdReStart

SDIO_CCR_HOST_DnLdCRC_err

SDIO_CCR_CS_DnLdRdy
: Bit Def. Card To Host Interrupt Event (CardToHostEvent)

SDIO_CCR_CS_UpLdRdy

SDIO_CCR_CS_ReadCISRdy

SDIO_CCR_CS_CmdUpLdRdy

SDIO_CCR_CS_CmdDnLdRdy

SDIO_CCR_CIM_DnLdOvr
: Bit Def. Card Interrupt Mask (CardIntMask)

SDIO_CCR_CIM_UpLdOvr

SDIO_CCR_CIM_Abort

SDIO_CCR_CIM_PwrDn

SDIO_CCR_CIM_PwrUp

SDIO_CCR_CIM_CmdUpLdOvr

SDIO_CCR_CIM_CmdDnLdOvr

SDIO_CCR_CIM_MASK

SDIO_CCR_CIC_DnLdOvr

Bit Def. Card Interrupt Status (CardIntStatus)

SDIO_CCR_CIC_UpLdOvr

SDIO_CCR_CIC_Abort

SDIO_CCR_CIC_PwrDn

SDIO_CCR_CIC_PwrUp

SDIO_CCR_CIC_CmdUpLdOvr

SDIO_CCR_CIC_CmdDnLdOvr

SDIO_CCR_CIC_ALL

SDIO_CCR_CIC_MASK

CARD_INT_MODE_MSK

Bit Def. Default setting ISR bit clear after read (CardIntMode)

CMD_TX_LEN_BIT_OFFSET

Bit Def. Command port configuration register (CmdPortConfig)

CMD_RD_LEN_BIT_OFFSET

CONFIG2_ASYNC_INT

Bit Def. Config2 register (Config2)

CONFIG2_CMD53_NEW_MODE

CONFIG2_DNLD_RDY_AUTO_RESET

CONFIG2_UPLD_RDY_AUTO_RESET

CONFIG2_TX_LEN_BIT_OFFSET

CONFIG2_RD_LEN_BIT_OFFSET

CONFIG2_DEFAULT_SETTING

struct _sdioslv_sdu_regmap

#include <fsl_sdioslv_sdu.h> SDU register map version 4.

struct sdio_slave_config

#include <fsl_sdioslv_sdu.h> Data structure to configure SDIO handle for specific function.

2.52 Smart Card

FSL_SMARTCARD_DRIVER_VERSION

Smart card driver version 2.3.0.

Smart card Error codes.

Values:

enumerator kStatus_SMARTCARD_Success
Transfer ends successfully

enumerator kStatus_SMARTCARD_TxBusy
Transmit in progress

enumerator kStatus_SMARTCARD_RxBusy
Receiving in progress

enumerator kStatus_SMARTCARD_NoTransferInProgress
No transfer in progress

enumerator kStatus_SMARTCARD_Timeout
Transfer ends with time-out

enumerator kStatus_SMARTCARD_Initialized
Smart card driver is already initialized

enumerator kStatus_SMARTCARD_PhyInitialized
Smart card PHY drive is already initialized

enumerator kStatus_SMARTCARD_CardNotActivated
Smart card is not activated

enumerator kStatus_SMARTCARD_InvalidInput
Function called with invalid input arguments

enumerator kStatus_SMARTCARD_OtherError
Some other error occur

enum _smartcard_control
Control codes for the Smart card protocol timers and misc.

Values:

enumerator kSMARTCARD_EnableADT

enumerator kSMARTCARD_DisableADT

enumerator kSMARTCARD_EnableGTV

enumerator kSMARTCARD_DisableGTV

enumerator kSMARTCARD_ResetWWT

enumerator kSMARTCARD_EnableWWT

enumerator kSMARTCARD_DisableWWT

enumerator kSMARTCARD_ResetCWT

enumerator kSMARTCARD_EnableCWT

enumerator kSMARTCARD_DisableCWT

enumerator kSMARTCARD_ResetBWT

enumerator kSMARTCARD_EnableBWT

enumerator kSMARTCARD_DisableBWT

enumerator kSMARTCARD_EnableInitDetect

enumerator kSMARTCARD_EnableAnack

enumerator kSMARTCARD_DisableAnack

enumerator kSMARTCARD_ConfigureBaudrate

enumerator kSMARTCARD_SetupATRMode

enumerator kSMARTCARD_SetupT0Mode

enumerator kSMARTCARD_SetupT1Mode

enumerator kSMARTCARD_EnableReceiverMode

enumerator kSMARTCARD_DisableReceiverMode

enumerator kSMARTCARD_EnableTransmitterMode

enumerator kSMARTCARD_DisableTransmitterMode

enumerator kSMARTCARD_ResetWaitTimeMultiplier

enum _smartcard_card_voltage_class

Defines Smart card interface voltage class values.

Values:

enumerator kSMARTCARD_VoltageClassUnknown

enumerator kSMARTCARD_VoltageClassA5_0V

enumerator kSMARTCARD_VoltageClassB3_3V

enumerator kSMARTCARD_VoltageClassC1_8V

enum _smartcard_transfer_state

Defines Smart card I/O transfer states.

Values:

enumerator kSMARTCARD_IdleState

enumerator kSMARTCARD_WaitingForTSState

enumerator kSMARTCARD_InvalidTSDetecetedState

enumerator kSMARTCARD_ReceivingState

enumerator kSMARTCARD_TransmittingState

enum _smartcard_reset_type

Defines Smart card reset types.

Values:

enumerator kSMARTCARD_ColdReset

enumerator kSMARTCARD_WarmReset

enumerator kSMARTCARD_NoColdReset

enumerator kSMARTCARD_NoWarmReset

enum _smartcard_transport_type

Defines Smart card transport protocol types.

Values:

enumerator kSMARTCARD_T0Transport

enumerator kSMARTCARD_T1Transport

enum _smartcard_parity_type

Defines Smart card data parity types.

Values:

enumerator kSMARTCARD_EvenParity

enumerator kSMARTCARD_OddParity

enum _smartcard_card_convention

Defines data Convention format.

Values:

enumerator kSMARTCARD_DirectConvention

enumerator kSMARTCARD_InverseConvention

enum _smartcard_interface_control

Defines Smart card interface IC control types.

Values:

enumerator kSMARTCARD_InterfaceSetVcc

enumerator kSMARTCARD_InterfaceSetClockToResetDelay

enumerator kSMARTCARD_InterfaceReadStatus

enum _smartcard_direction

Defines transfer direction.

Values:

enumerator kSMARTCARD_Receive

enumerator kSMARTCARD_Transmit

typedef enum *_smartcard_control* smartcard_control_t

Control codes for the Smart card protocol timers and misc.

typedef enum *_smartcard_card_voltage_class* smartcard_card_voltage_class_t

Defines Smart card interface voltage class values.

typedef enum *_smartcard_transfer_state* smartcard_transfer_state_t

Defines Smart card I/O transfer states.

typedef enum *_smartcard_reset_type* smartcard_reset_type_t

Defines Smart card reset types.

typedef enum *_smartcard_transport_type* smartcard_transport_type_t

Defines Smart card transport protocol types.

typedef enum *_smartcard_parity_type* smartcard_parity_type_t

Defines Smart card data parity types.

typedef enum *_smartcard_card_convention* smartcard_card_convention_t

Defines data Convention format.

typedef enum *_smartcard_interface_control* smartcard_interface_control_t

Defines Smart card interface IC control types.

typedef enum *_smartcard_direction* smartcard_direction_t
Defines transfer direction.

typedef void (*smartcard_interface_callback_t)(void *smartcardContext, void *param)
Smart card interface interrupt callback function type.

typedef void (*smartcard_transfer_callback_t)(void *smartcardContext, void *param)
Smart card transfer interrupt callback function type.

typedef void (*smartcard_time_delay_t)(uint32_t us)
Time Delay function used to passive waiting using RTOS [us].

typedef struct *_smartcard_card_params* smartcard_card_params_t
Defines card-specific parameters for Smart card driver.

typedef struct *_smartcard_timers_state* smartcard_timers_state_t
Smart card defines the state of the EMV timers in the Smart card driver.

typedef struct *_smartcard_interface_config* smartcard_interface_config_t
Defines user specified configuration of Smart card interface.

typedef struct *_smartcard_xfer* smartcard_xfer_t
Defines user transfer structure used to initialize transfer.

typedef struct *_smartcard_context* smartcard_context_t
Runtime state of the Smart card driver.

SMARTCARD_INIT_DELAY_CLOCK_CYCLES
Smart card global define which specify number of clock cycles until initial 'TS' character has to be received.

SMARTCARD_EMV_ATR_DURATION_ETU
Smart card global define which specify number of clock cycles during which ATR string has to be received.

SMARTCARD_TS_DIRECT_CONVENTION
Smart card specification initial TS character definition of direct convention.

SMARTCARD_TS_INVERSE_CONVENTION
Smart card specification initial TS character definition of inverse convention.

struct _smartcard_card_params
#include <fsl_smartcard.h> Defines card-specific parameters for Smart card driver.

Public Members

uint16_t Fi
4 bits Fi - clock rate conversion integer

uint8_t fMax
Maximum Smart card frequency in MHz

uint8_t WI
8 bits WI - work wait time integer

uint8_t Di
4 bits DI - baud rate divisor

uint8_t BWI
4 bits BWI - block wait time integer

uint8_t CWI
: 4 bits CWI - character wait time integer

uint8_t BGI
: 4 bits BGI - block guard time integer

uint8_t GTN
: 8 bits GTN - extended guard time integer

uint8_t IFSC
: Indicates IFSC value of the card

uint8_t modeNegotiable
: Indicates if the card acts in negotiable or a specific mode.

uint8_t currentD
: 4 bits DI - current baud rate divisor

uint8_t status
: Indicates smart card status

bool t0Indicated
: Indicates ff T=0 indicated in TD1 byte

bool t1Indicated
: Indicates if T=1 indicated in TD2 byte

bool atrComplete
: Indicates whether the ATR received from the card was complete or not

bool atrValid
: Indicates whether the ATR received from the card was valid or not

bool present
: Indicates if a smart card is present

bool active
: Indicates if the smart card is activated

bool faulty
: Indicates whether smart card/interface is faulty

smartcard_card_convention_t convention
: Card convention, kSMARTCARD_DirectConvention for direct convention, kSMARTCARD_InverseConvention for inverse convention

struct __smartcard__timers__state
: *#include <fsl_smartcard.h>* Smart card defines the state of the EMV timers in the Smart card driver.

Public Members

volatile bool adtExpired
: Indicates whether ADT timer expired

volatile bool wwtExpired
: Indicates whether WWT timer expired

volatile bool cwtExpired
: Indicates whether CWT timer expired

volatile bool bwtExpired
: Indicates whether BWT timer expired

volatile bool initCharTimerExpired
: Indicates whether reception timer for initialization character (TS) after the RST has expired

struct _smartcard_interface_config
: *#include <fsl_smartcard.h>* Defines user specified configuration of Smart card interface.

Public Members

uint32_t smartCardClock
: Smart card interface clock [Hz]

uint32_t clockToResetDelay
: Indicates clock to RST apply delay [smart card clock cycles]

uint8_t clockModule
: Smart card clock module number

uint8_t clockModuleChannel
: Smart card clock module channel number

uint8_t clockModuleSourceClock
: Smart card clock module source clock [e.g., BusClk]

smartcard_card_voltage_class_t vcc
: Smart card voltage class

uint8_t controlPort
: Smart card PHY control port instance

uint8_t controlPin
: Smart card PHY control pin instance

uint8_t irqPort
: Smart card PHY Interrupt port instance

uint8_t irqPin
: Smart card PHY Interrupt pin instance

uint8_t resetPort
: Smart card reset port instance

uint8_t resetPin
: Smart card reset pin instance

uint8_t vsel0Port
: Smart card PHY Vsel0 control port instance

uint8_t vsel0Pin
: Smart card PHY Vsel0 control pin instance

uint8_t vsel1Port
: Smart card PHY Vsel1 control port instance

uint8_t vsel1Pin
: Smart card PHY Vsel1 control pin instance

uint8_t dataPort
Smart card PHY data port instance

uint8_t dataPin
Smart card PHY data pin instance

uint8_t dataPinMux
Smart card PHY data pin mux option

uint8_t tsTimerId
Numerical identifier of the External HW timer for Initial character detection

struct _smartcard_xfer
#include <fsl_smartcard.h> Defines user transfer structure used to initialize transfer.

Public Members

smartcard_direction_t direction
Direction of communication. (RX/TX)

uint8_t *buff
The buffer of data.

size_t size
The number of transferred units.

struct _smartcard_context
#include <fsl_smartcard.h> Runtime state of the Smart card driver.

Public Members

void *base
Smart card module base address

smartcard_direction_t direction
Direction of communication. (RX/TX)

uint8_t *xBuff
The buffer of data being transferred.

volatile size_t xSize
The number of bytes to be transferred.

volatile bool xIsBusy
True if there is an active transfer.

uint8_t txFifoEntryCount
Number of data word entries in transmit FIFO.

uint8_t rxFifoThreshold
The max value of the receiver FIFO threshold.

smartcard_interface_callback_t interfaceCallback
Callback to invoke after interface IC raised interrupt.

smartcard_transfer_callback_t transferCallback
Callback to invoke after transfer event occur.

void *interfaceCallbackParam
Interface callback parameter pointer.

void *transferCallbackParam
Transfer callback parameter pointer.

smartcard_time_delay_t timeDelay
Function which handles time delay defined by user or RTOS.

smartcard_reset_type_t resetType
Indicates whether a Cold reset or Warm reset was requested.

smartcard_transport_type_t tType
Indicates current transfer protocol (T0 or T1)

volatile *smartcard_transfer_state_t* transferState
Indicates the current transfer state

smartcard_timers_state_t timersState
Indicates the state of different protocol timers used in driver

smartcard_card_params_t cardParams
Smart card parameters(ATR and current) and interface slots states(ATR and current)

uint8_t IFSD
Indicates the terminal IFSD

smartcard_parity_type_t parity
Indicates current parity even/odd

volatile bool rxtCrossed
Indicates whether RXT thresholds has been crossed

volatile bool txtCrossed
Indicates whether TXT thresholds has been crossed

volatile bool wtxRequested
Indicates whether WTX has been requested or not

volatile bool parityError
Indicates whether a parity error has been detected

uint8_t statusBytes[2]
Used to store Status bytes SW1, SW2 of the last executed card command response

smartcard_interface_config_t interfaceConfig
Smart card interface configuration structure

bool abortTransfer
Used to abort transfer.

2.53 Smart Card PHY Driver

void SMARTCARD_PHY_GetDefaultConfig(*smartcard_interface_config_t* *config)
Fills in the configuration structure with default values.

Parameters

- config – The Smart card user configuration structure which contains configuration structure of type smartcard_interface_config_t. Function fill in members: clockToResetDelay = 42000, vcc = kSmartcardVoltageClassB3_3V, with default values.

status_t SMARTCARD_PHY_Init(void *base, *smartcard_interface_config_t* const *config, uint32_t srcClock_Hz)

Initializes a Smart card interface instance.

Parameters

- base – The Smart card peripheral base address.
- config – The user configuration structure of type smartcard_interface_config_t. Call the function SMARTCARD_PHY_GetDefaultConfig() to fill the configuration structure.
- srcClock_Hz – Smart card clock generation module source clock.

Return values

kStatus_SMARTCARD_Success – or kStatus_SMARTCARD_OtherError in case of error.

void SMARTCARD_PHY_Deinit(void *base, *smartcard_interface_config_t* const *config)

De-initializes a Smart card interface, stops the Smart card clock, and disables the VCC.

Parameters

- base – The Smart card peripheral module base address.
- config – The user configuration structure of type smartcard_interface_config_t.

status_t SMARTCARD_PHY_Activate(void *base, *smartcard_context_t* *context, *smartcard_reset_type_t* resetType)

Activates the Smart card IC.

Parameters

- base – The Smart card peripheral module base address.
- context – A pointer to a Smart card driver context structure.
- resetType – type of reset to be performed, possible values = kSmartcardColdReset, kSmartcardWarmReset

Return values

kStatus_SMARTCARD_Success – or kStatus_SMARTCARD_OtherError in case of error.

status_t SMARTCARD_PHY_Deactivate(void *base, *smartcard_context_t* *context)

De-activates the Smart card IC.

Parameters

- base – The Smart card peripheral module base address.
- context – A pointer to a Smart card driver context structure.

Return values

kStatus_SMARTCARD_Success – or kStatus_SMARTCARD_OtherError in case of error.

status_t SMARTCARD_PHY_Control(void *base, *smartcard_context_t* *context, *smartcard_interface_control_t* control, uint32_t param)

Controls the Smart card interface IC.

Parameters

- base – The Smart card peripheral module base address.
- context – A pointer to a Smart card driver context structure.
- control – A interface command type.

- param – Integer value specific to control type

Return values

kStatus_SMARTCARD_Success – or kStatus_SMARTCARD_OtherError in case of error.

SMARTCARD_ATR_DURATION_ADJUSTMENT

Smart card definition which specifies the adjustment number of clock cycles during which an ATR string has to be received.

SMARTCARD_INIT_DELAY_CLOCK_CYCLES_ADJUSTMENT

Smart card definition which specifies the adjustment number of clock cycles until an initial 'TS' character has to be received.

2.54 Smart Card PHY USIM W

2.55 Smart Card USIM Driver

void SMARTCARD_USIM_GetDefaultConfig(*smartcard_card_params_t* *cardParams)

Fills in the smartcard_card_params structure with default values according to the EMV 4.3 specification.

Parameters

- cardParams – The configuration structure of type smartcard_interface_config_t. Function fill in members: Fi = 372; Di = 1; currentD = 1; WI = 0x0A; GTN = 0x00; with default values.

status_t SMARTCARD_USIM_Init(USIM_Type *base, *smartcard_context_t* *context, uint32_t srcClock_Hz)

Initializes an USIM peripheral for the Smart card/ISO-7816 operation.

This function un-gates the USIM clock, initializes the module to EMV default settings, configures the IRQ, enables the module-level interrupt to the core and, initializes the driver context.

Parameters

- base – The USIM peripheral base address.
- context – A pointer to the smart card driver context structure.
- srcClock_Hz – Smart card clock generation module source clock.

Returns

An error code or kStatus_SMARTCARD_Success.

void SMARTCARD_USIM_Deinit(USIM_Type *base)

This function disables the USIM interrupts, disables the transmitter and receiver, flushes the FIFOs, and gates USIM clock in SIM.

Parameters

- base – The USIM module base address.

int32_t SMARTCARD_USIM_GetTransferRemainingBytes(USIM_Type *base, *smartcard_context_t* *context)

Returns whether the previous USIM transfer has finished.

When performing an async transfer, call this function to ascertain the context of the current transfer: in progress (or busy) or complete (success). If the transfer is still in progress, the user can obtain the number of words that have not been transferred.

Parameters

- base – The USIM module base address.
- context – A pointer to a smart card driver context structure.

Returns
The number of bytes not transferred.

status_t SMARTCARD_USIM_AbortTransfer(USIM_Type *base, *smartcard_context_t* *context)

Terminates an asynchronous USIM transfer early.

During an async USIM transfer, the user can terminate the transfer early if the transfer is still in progress.

Parameters

- base – The USIM peripheral address.
- context – A pointer to a smart card driver context structure.

Returns
kStatus_SMARTCARD_Success The transmit abort was successful.

Returns
kStatus_SMARTCARD_NoTransmitInProgress No transmission is currently in progress.

status_t SMARTCARD_USIM_TransferNonBlocking(USIM_Type *base, *smartcard_context_t* *context, *smartcard_xfer_t* *xfer)

Transfer data using interrupts.

A non-blocking (also known as asynchronous) function means that the function returns immediately after initiating the transfer function. The application has to get the transfer status to see when the transfer is complete. In other words, after calling the non-blocking (asynchronous) transfer function, the application must get the transfer status to check if the transmit is completed or not.

Parameters

- base – The USIM peripheral base address.
- context – A pointer to a smart card driver context structure.
- xfer – A pointer to the smart card transfer structure where the linked buffers and sizes are stored.

Returns
An error code or kStatus_SMARTCARD_Success.

status_t SMARTCARD_USIM_Control(USIM_Type *base, *smartcard_context_t* *context, *smartcard_control_t* control, uint32_t param)

Controls the USIM module per different user request.

Parameters

- base – The USIM peripheral base address.
- context – A pointer to a smart card driver context structure.
- control – Control type.
- param – Integer value of specific to control command.

Returns
kStatus_SMARTCARD_Success in success.

Returns
kStatus_SMARTCARD_OtherError in case of error.

void SMARTCARD_USIM_IRQHandler(USIM_Type *base, *smartcard_context_t* *context)

Handles USIM module interrupts.

Parameters

- base – The USIM peripheral base address.
- context – A pointer to a smart card driver context structure.

void SMARTCARD_USIM_TSExpiryCallback(USIM_Type *base, *smartcard_context_t* *context)

Handles initial TS character timer time-out event.

Parameters

- base – The USIM peripheral base address.
- context – A pointer to a Smart card driver context structure.

void SMARTCARD_USIM_TimerStart(uint32_t time)

Initializes timer with input period, enable interrupt and start counter.

Parameters

- time – The time period.

enum _usim_rx_fifo_trigger_level

USIM Rx FIFO receiver trigger level enumeration.

Values:

enumerator kUSIM_1ByteOrMore

1 byte or more in the RX-FIFO can trigger receiver data ready interrupt.

enumerator kUSIM_4ByteOrMore

4 byte or more in the RX-FIFO can trigger receiver data ready interrupt.

enumerator kUSIM_8ByteOrMore

8 byte or more in the RX-FIFO can trigger receiver data ready interrupt.

enumerator kUSIM_12ByteOrMore

12 byte or more in the RX-FIFO can trigger receiver data ready interrupt.

typedef enum *_usim_rx_fifo_trigger_level* usim_rx_fifo_trigger_level_t

USIM Rx FIFO receiver trigger level enumeration.

SMARTCARD_Control(base, handle, control, param)

SMARTCARD_TransferNonBlocking(base, handle, xfer)

SMARTCARD_Init(base, handle, sourceClockHz)

SMARTCARD_Deinit(base)

SMARTCARD_GetTransferRemainingBytes(base, handle)

SMARTCARD_AbortTransfer(base, handle)

SMARTCARD_EMV_RX_NACK_THRESHOLD

EMV RX NACK interrupt generation threshold.

SMARTCARD_EMV_TX_NACK_THRESHOLD

EMV TX NACK interrupt generation threshold.

SMARTCARD_T0_CWT_ADJUSTMENT

Smart card T0 Character Wait Timer adjustment value.

SMARTCARD_T1_CWT_ADJUSTMENT
: Smart card T1 Character Wait Timer adjustment value.

SMARTCARD_T0_BWT_ADJUSTMENT
: Smart card T0 Block Wait Timer adjustment value.

SMARTCARD_T1_BWT_ADJUSTMENT
: Smart card T1 Block Wait Timer adjustment value.

SMARTCARD_MAX_RX_TRIGGER_LEVEL
: Rx FIFO max receive trigger level.

USIM_FIND_RX_FIFO_TRIGGER_LEVEL(x)
: USIM Find max Rx FIFO receiver trigger level according to bytes numbers.

2.56 SPI: Serial Peripheral Interface Driver

2.57 SPI DMA Driver

status_t SPI_MasterTransferCreateHandleDMA(SPI_Type *base, *spi_dma_handle_t* *handle, *spi_dma_callback_t* callback, void *userData, *dma_handle_t* *txHandle, *dma_handle_t* *rxHandle)

Initialize the SPI master DMA handle.

This function initializes the SPI master DMA handle which can be used for other SPI master transactional APIs. Usually, for a specified SPI instance, user need only call this API once to get the initialized handle.

Parameters

- base – SPI peripheral base address.
- handle – SPI handle pointer.
- callback – User callback function called at the end of a transfer.
- userData – User data for callback.
- txHandle – DMA handle pointer for SPI Tx, the handle shall be static allocated by users.
- rxHandle – DMA handle pointer for SPI Rx, the handle shall be static allocated by users.

status_t SPI_MasterTransferDMA(SPI_Type *base, *spi_dma_handle_t* *handle, *spi_transfer_t* *xfer)

Perform a non-blocking SPI transfer using DMA.

Note: This interface returned immediately after transfer initiates, users should call SPI_GetTransferStatus to poll the transfer status to check whether SPI transfer finished.

Parameters

- base – SPI peripheral base address.
- handle – SPI DMA handle pointer.
- xfer – Pointer to dma transfer structure.

Return values

- kStatus_Success – Successfully start a transfer.
- kStatus_InvalidArgument – Input argument is invalid.
- kStatus_SPI_Busy – SPI is not idle, is running another transfer.

status_t SPI_MasterHalfDuplexTransferDMA(SPI_Type *base, *spi_dma_handle_t* *handle, *spi_half_duplex_transfer_t* *xfer)

Transfers a block of data using a DMA method.

This function using polling way to do the first half transimission and using DMA way to do the srcond half transimission, the transfer mechanism is half-duplex. When do the second half transimission, code will return right away. When all data is transferred, the callback function is called.

Parameters

- base – SPI base pointer
- handle – A pointer to the spi_master_dma_handle_t structure which stores the transfer state.
- xfer – A pointer to the spi_half_duplex_transfer_t structure.

Returns

status of status_t.

static inline *status_t* SPI_SlaveTransferCreateHandleDMA(SPI_Type *base, *spi_dma_handle_t* *handle, *spi_dma_callback_t* callback, void *userData, *dma_handle_t* *txHandle, *dma_handle_t* *rxHandle)

Initialize the SPI slave DMA handle.

This function initializes the SPI slave DMA handle which can be used for other SPI master transactional APIs. Usually, for a specified SPI instance, user need only call this API once to get the initialized handle.

Parameters

- base – SPI peripheral base address.
- handle – SPI handle pointer.
- callback – User callback function called at the end of a transfer.
- userData – User data for callback.
- txHandle – DMA handle pointer for SPI Tx, the handle shall be static allocated by users.
- rxHandle – DMA handle pointer for SPI Rx, the handle shall be static allocated by users.

static inline *status_t* SPI_SlaveTransferDMA(SPI_Type *base, *spi_dma_handle_t* *handle, *spi_transfer_t* *xfer)

Perform a non-blocking SPI transfer using DMA.

Note: This interface returned immediately after transfer initiates, users should call SPI_GetTransferStatus to poll the transfer status to check whether SPI transfer finished.

Parameters

- base – SPI peripheral base address.
- handle – SPI DMA handle pointer.

- xfer – Pointer to dma transfer structure.

Return values

- kStatus_Success – Successfully start a transfer.
- kStatus_InvalidArgument – Input argument is invalid.
- kStatus_SPI_Busy – SPI is not idle, is running another transfer.

void SPI_MasterTransferAbortDMA(SPI_Type *base, *spi_dma_handle_t* *handle)

Abort a SPI transfer using DMA.

Parameters

- base – SPI peripheral base address.
- handle – SPI DMA handle pointer.

status_t SPI_MasterTransferGetCountDMA(SPI_Type *base, *spi_dma_handle_t* *handle, size_t *count)

Gets the master DMA transfer remaining bytes.

This function gets the master DMA transfer remaining bytes.

Parameters

- base – SPI peripheral base address.
- handle – A pointer to the spi_dma_handle_t structure which stores the transfer state.
- count – A number of bytes transferred by the non-blocking transaction.

Returns

status of status_t.

static inline void SPI_SlaveTransferAbortDMA(SPI_Type *base, *spi_dma_handle_t* *handle)

Abort a SPI transfer using DMA.

Parameters

- base – SPI peripheral base address.
- handle – SPI DMA handle pointer.

static inline *status_t* SPI_SlaveTransferGetCountDMA(SPI_Type *base, *spi_dma_handle_t* *handle, size_t *count)

Gets the slave DMA transfer remaining bytes.

This function gets the slave DMA transfer remaining bytes.

Parameters

- base – SPI peripheral base address.
- handle – A pointer to the spi_dma_handle_t structure which stores the transfer state.
- count – A number of bytes transferred by the non-blocking transaction.

Returns

status of status_t.

FSL_SPI_DMA_DRIVER_VERSION

SPI DMA driver version 2.1.1.

typedef struct *_spi_dma_handle* spi_dma_handle_t

typedef void (*spi_dma_callback_t)(SPI_Type *base, *spi_dma_handle_t* *handle, *status_t* status, void *userData)

SPI DMA callback called at the end of transfer.

struct _spi_dma_handle

#include <fsl_spi_dma.h> SPI DMA transfer handle, users should not touch the content of the handle.

Public Members

volatile bool txInProgress

Send transfer finished

volatile bool rxInProgress

Receive transfer finished

uint8_t bytesPerFrame

Bytes in a frame for SPI transfer

uint8_t lastwordBytes

The Bytes of lastword for master

dma_handle_t *txHandle

DMA handler for SPI send

dma_handle_t *rxHandle

DMA handler for SPI receive

spi_dma_callback_t callback

Callback for SPI DMA transfer

void *userData

User Data for SPI DMA callback

uint32_t state

Internal state of SPI DMA transfer

size_t transferSize

Bytes need to be transfer

uint32_t instance

Index of SPI instance

const uint8_t *txNextData

The pointer of next time tx data

const uint8_t *txEndData

The pointer of end of data

uint8_t *rxNextData

The pointer of next time rx data

uint8_t *rxEndData

The pointer of end of rx data

uint32_t dataBytesEveryTime

Bytes in a time for DMA transfer, default is DMA_MAX_TRANSFER_COUNT

2.58 SPI Driver

FSL_SPI_DRIVER_VERSION
SPI driver version.

enum _spi_xfer_option
SPI transfer option.

Values:

enumerator kSPI_FrameDelay
A delay may be inserted, defined in the DLY register.

enumerator kSPI_FrameAssert
SSEL will be deasserted at the end of a transfer

enum _spi_shift_direction
SPI data shifter direction options.

Values:

enumerator kSPI_MsbFirst
Data transfers start with most significant bit.

enumerator kSPI_LsbFirst
Data transfers start with least significant bit.

enum _spi_clock_polarity
SPI clock polarity configuration.

Values:

enumerator kSPI_ClockPolarityActiveHigh
Active-high SPI clock (idles low).

enumerator kSPI_ClockPolarityActiveLow
Active-low SPI clock (idles high).

enum _spi_clock_phase
SPI clock phase configuration.

Values:

enumerator kSPI_ClockPhaseFirstEdge
First edge on SCK occurs at the middle of the first cycle of a data transfer.

enumerator kSPI_ClockPhaseSecondEdge
First edge on SCK occurs at the start of the first cycle of a data transfer.

enum _spi_txfifo_watermark
txFIFO watermark values

Values:

enumerator kSPI_TxFifo0
SPI tx watermark is empty

enumerator kSPI_TxFifo1
SPI tx watermark at 1 item

enumerator kSPI_TxFifo2
SPI tx watermark at 2 items

enumerator kSPI_TxFifo3
SPI tx watermark at 3 items

enumerator kSPI_TxFifo4
SPI tx watermark at 4 items

enumerator kSPI_TxFifo5
SPI tx watermark at 5 items

enumerator kSPI_TxFifo6
SPI tx watermark at 6 items

enumerator kSPI_TxFifo7
SPI tx watermark at 7 items

enum __spi__rxfifo__watermark
rxFIFO watermark values

Values:

enumerator kSPI_RxFifo1
SPI rx watermark at 1 item

enumerator kSPI_RxFifo2
SPI rx watermark at 2 items

enumerator kSPI_RxFifo3
SPI rx watermark at 3 items

enumerator kSPI_RxFifo4
SPI rx watermark at 4 items

enumerator kSPI_RxFifo5
SPI rx watermark at 5 items

enumerator kSPI_RxFifo6
SPI rx watermark at 6 items

enumerator kSPI_RxFifo7
SPI rx watermark at 7 items

enumerator kSPI_RxFifo8
SPI rx watermark at 8 items

enum __spi__data__width
Transfer data width.

Values:

enumerator kSPI_Data4Bits
4 bits data width

enumerator kSPI_Data5Bits
5 bits data width

enumerator kSPI_Data6Bits
6 bits data width

enumerator kSPI_Data7Bits
7 bits data width

enumerator kSPI_Data8Bits
8 bits data width

enumerator kSPI_Data9Bits
9 bits data width

enumerator kSPI_Data10Bits
10 bits data width

enumerator kSPI_Data11Bits
11 bits data width

enumerator kSPI_Data12Bits
12 bits data width

enumerator kSPI_Data13Bits
13 bits data width

enumerator kSPI_Data14Bits
14 bits data width

enumerator kSPI_Data15Bits
15 bits data width

enumerator kSPI_Data16Bits
16 bits data width

enum _spi_ssel
Slave select.

Values:

enumerator kSPI_Ssel0
Slave select 0

enumerator kSPI_Ssel1
Slave select 1

enumerator kSPI_Ssel2
Slave select 2

enumerator kSPI_Ssel3
Slave select 3

enum _spi_spol
ssel polarity

Values:

enumerator kSPI_Spol0ActiveHigh

enumerator kSPI_Spol1ActiveHigh

enumerator kSPI_Spol3ActiveHigh

enumerator kSPI_SpolActiveAllHigh

enumerator kSPI_SpolActiveAllLow

SPI transfer status.

Values:

enumerator kStatus_SPI_Busy
SPI bus is busy

enumerator kStatus_SPI_Idle
SPI is idle

enumerator kStatus_SPI_Error
SPI error

enumerator kStatus_SPI_BaudrateNotSupport
Baudrate is not support in current clock source

enumerator kStatus_SPI_Timeout
SPI timeout polling status flags.

enum _spi_interrupt_enable
SPI interrupt sources.

Values:

enumerator kSPI_RxLvlIrq
Rx level interrupt

enumerator kSPI_TxLvlIrq
Tx level interrupt

enum _spi_statusflags
SPI status flags.

Values:

enumerator kSPI_TxEmptyFlag
txFifo is empty

enumerator kSPI_TxNotFullFlag
txFifo is not full

enumerator kSPI_RxNotEmptyFlag
rxFIFO is not empty

enumerator kSPI_RxFullFlag
rxFIFO is full

typedef enum *_spi_xfer_option* spi_xfer_option_t
SPI transfer option.

typedef enum *_spi_shift_direction* spi_shift_direction_t
SPI data shifter direction options.

typedef enum *_spi_clock_polarity* spi_clock_polarity_t
SPI clock polarity configuration.

typedef enum *_spi_clock_phase* spi_clock_phase_t
SPI clock phase configuration.

typedef enum *_spi_txfifo_watermark* spi_txfifo_watermark_t
txFIFO watermark values

typedef enum *_spi_rxfifo_watermark* spi_rxfifo_watermark_t
rxFIFO watermark values

typedef enum *_spi_data_width* spi_data_width_t
Transfer data width.

typedef enum *_spi_ssel* spi_ssel_t
Slave select.

typedef enum *_spi_spol* spi_spol_t

ssel polarity

typedef struct *_spi_delay_config* spi_delay_config_t

SPI delay time configure structure. Note: The DLY register controls several programmable delays related to SPI signalling, it stands for how many SPI clock time will be inserted. The maxinun value of these delay time is 15.

typedef struct *_spi_master_config* spi_master_config_t

SPI master user configure structure.

typedef struct *_spi_slave_config* spi_slave_config_t

SPI slave user configure structure.

typedef struct *_spi_transfer* spi_transfer_t

SPI transfer structure.

typedef struct *_spi_half_duplex_transfer* spi_half_duplex_transfer_t

SPI half-duplex(master only) transfer structure.

typedef struct *_spi_config* spi_config_t

Internal configuration structure used in 'spi' and 'spi_dma' driver.

typedef struct *_spi_master_handle* spi_master_handle_t

Master handle type.

typedef *spi_master_handle_t* spi_slave_handle_t

Slave handle type.

typedef void (*spi_master_callback_t)(SPI_Type *base, *spi_master_handle_t* *handle, *status_t* status, void *userData)

SPI master callback for finished transmit.

typedef void (*spi_slave_callback_t)(SPI_Type *base, *spi_slave_handle_t* *handle, *status_t* status, void *userData)

SPI slave callback for finished transmit.

typedef void (*flexcomm_spi_master_irq_handler_t)(SPI_Type *base, *spi_master_handle_t* *handle)

Typedef for master interrupt handler.

typedef void (*flexcomm_spi_slave_irq_handler_t)(SPI_Type *base, *spi_slave_handle_t* *handle)

Typedef for slave interrupt handler.

volatile uint8_t s_dummyData[]

SPI default SSEL COUNT.

Global variable for dummy data value setting.

SPI_DUMMYDATA

SPI dummy transfer data, the data is sent while txBuff is NULL.

SPI_RETRY_TIMES

Retry times for waiting flag.

SPI_DATA(n)

SPI_CTRLMASK

SPI_ASSERTNUM_SSEL(n)

SPI_DEASSERTNUM_SSEL(n)

SPI_DEASSERT_ALL

SPI_FIFOWR_FLAGS_MASK

SPI_FIFOTRIG_TXLVL_GET(base)

SPI_FIFOTRIG_RXLVL_GET(base)

struct _spi_delay_config

#include <fsl_spi.h> SPI delay time configure structure. Note: The DLY register controls several programmable delays related to SPI signalling, it stands for how many SPI clock time will be inserted. The maxinun value of these delay time is 15.

Public Members

uint8_t preDelay

Delay between SSEL assertion and the beginning of transfer.

uint8_t postDelay

Delay between the end of transfer and SSEL deassertion.

uint8_t frameDelay

Delay between frame to frame.

uint8_t transferDelay

Delay between transfer to transfer.

struct _spi_master_config

#include <fsl_spi.h> SPI master user configure structure.

Public Members

bool enableLoopback

Enable loopback for test purpose

bool enableMaster

Enable SPI at initialization time

spi_clock_polarity_t polarity

Clock polarity

spi_clock_phase_t phase

Clock phase

spi_shift_direction_t direction

MSB or LSB

uint32_t baudRate_Bps

Baud Rate for SPI in Hz

spi_data_width_t dataWidth

Width of the data

spi_ssel_t sselNum

Slave select number

spi_spol_t sselPol

Configure active CS polarity

uint8_t txWatermark
txFIFO watermark

uint8_t rxWatermark
rxFIFO watermark

spi_delay_config_t delayConfig
Delay configuration.

struct __spi__slave__config
#include <fsl_spi.h> SPI slave user configure structure.

Public Members

bool enableSlave
Enable SPI at initialization time

spi_clock_polarity_t polarity
Clock polarity

spi_clock_phase_t phase
Clock phase

spi_shift_direction_t direction
MSB or LSB

spi_data_width_t dataWidth
Width of the data

spi_spol_t sselPol
Configure active CS polarity

uint8_t txWatermark
txFIFO watermark

uint8_t rxWatermark
rxFIFO watermark

struct __spi__transfer
#include <fsl_spi.h> SPI transfer structure.

Public Members

const uint8_t *txData
Send buffer

uint8_t *rxData
Receive buffer

uint32_t configFlags
Additional option to control transfer, spi_xfer_option_t.

size_t dataSize
Transfer bytes

struct __spi__half__duplex__transfer
#include <fsl_spi.h> SPI half-duplex(master only) transfer structure.

Public Members

const uint8_t *txData
: Send buffer

uint8_t *rxData
: Receive buffer

size_t txDataSize
: Transfer bytes for transmit

size_t rxDataSize
: Transfer bytes

uint32_t configFlags
: Transfer configuration flags, spi_xfer_option_t.

bool isPcsAssertInTransfer
: If PCS pin keep assert between transmit and receive. true for assert and false for de-assert.

bool isTransmitFirst
: True for transmit first and false for receive first.

struct __spi__config
: *#include <fsl_spi.h>* Internal configuration structure used in 'spi' and 'spi_dma' driver.

struct __spi__master__handle
: *#include <fsl_spi.h>* SPI transfer handle structure.

Public Members

const uint8_t *volatile txData
: Transfer buffer

uint8_t *volatile rxData
: Receive buffer

volatile size_t txRemainingBytes
: Number of data to be transmitted [in bytes]

volatile size_t rxRemainingBytes
: Number of data to be received [in bytes]

volatile int8_t toReceiveCount
: The number of data expected to receive in data width. Since the received count and sent count should be the same to complete the transfer, if the sent count is x and the received count is y, toReceiveCount is x-y.

size_t totalByteCount
: A number of transfer bytes

volatile uint32_t state
: SPI internal state

spi_master_callback_t callback
: SPI callback

void *userData
: Callback parameter

uint8_t dataWidth
: Width of the data [Valid values: 1 to 16]

uint8_t sselNum
: Slave select number to be asserted when transferring data [Valid values: 0 to 3]

uint32_t configFlags
: Additional option to control transfer

uint8_t txWatermark
: txFIFO watermark

uint8_t rxWatermark
: rxFIFO watermark

2.59 TRNG: True Random Number Generator

FSL_TRNG_DRIVER_VERSION
: TRNG driver version 2.0.18.

Current version: 2.0.18

Change log:

- version 2.0.18
  - TRNG health checks now done in software on RT5xx and RT6xx.
- version 2.0.17
  - Added support for RT700.
- version 2.0.16
  - Added support for Dual oscillator mode.
- version 2.0.15
  - Changed TRNG_USER_CONFIG_DEFAULT_XXX values according to latest reccomended by design team.
- version 2.0.14
  - add support for RW610 and RW612
- version 2.0.13
  - After deepsleep it might return error, added clearing bits in TRNG_GetRandomData() and generating new entropy.
  - Modified reloading entropy in TRNG_GetRandomData(), for some data length it doesn't reloading entropy correctly.
- version 2.0.12
  - For KW34A4_SERIES, KW35A4_SERIES, KW36A4_SERIES set TRNG_USER_CONFIG_DEFAULT_OSC_DIV to kTRNG_RingOscDiv8.
- version 2.0.11
  - Add clearing pending errors in TRNG_Init().
- version 2.0.10
  - Fixed doxygen issues.
- version 2.0.9

  - Fix HIS_CCM metrics issues.
- version 2.0.8
  - For K32L2A41A_SERIES set TRNG_USER_CONFIG_DEFAULT_OSC_DIV to kTRNG_RingOscDiv4.
- version 2.0.7
  - Fix MISRA 2004 issue rule 12.5.
- version 2.0.6
  - For KW35Z4_SERIES set TRNG_USER_CONFIG_DEFAULT_OSC_DIV to kTRNG_RingOscDiv8.
- version 2.0.5
  - Add possibility to define default TRNG configuration by device specific preprocessor macros for FRQMIN, FRQMAX and OSCDIV.
- version 2.0.4
  - Fix MISRA-2012 issues.
- Version 2.0.3
  - update TRNG_Init to restart entropy generation
- Version 2.0.2
  - fix MISRA issues
- Version 2.0.1
  - add support for KL8x and KL28Z
  - update default OSCDIV for K81 to divide by 2

enum _trng_sample_mode

TRNG sample mode. Used by trng_config_t.

Values:

enumerator kTRNG_SampleModeVonNeumann

Use von Neumann data in both Entropy shifter and Statistical Checker.

enumerator kTRNG_SampleModeRaw

Use raw data into both Entropy shifter and Statistical Checker.

enumerator kTRNG_SampleModeVonNeumannRaw

Use von Neumann data in Entropy shifter. Use raw data into Statistical Checker.

enum _trng_clock_mode

TRNG clock mode. Used by trng_config_t.

Values:

enumerator kTRNG_ClockModeRingOscillator

Ring oscillator is used to operate the TRNG (default).

enumerator kTRNG_ClockModeSystem

System clock is used to operate the TRNG. This is for test use only, and indeterminate results may occur.

enum _trng_ring_osc_div

TRNG ring oscillator divide. Used by trng_config_t.

Values:

enumerator kTRNG_RingOscDiv0
Ring oscillator with no divide

enumerator kTRNG_RingOscDiv2
Ring oscillator divided-by-2.

enumerator kTRNG_RingOscDiv4
Ring oscillator divided-by-4.

enumerator kTRNG_RingOscDiv8
Ring oscillator divided-by-8.

enum trng_oscillator_mode_t
TRNG oscillator mode . Used by trng_config_t.

Values:

enumerator kTRNG_SingleOscillatorModeOsc1
Single oscillator mode, using OSC1 (default)

enumerator kTRNG_DualOscillatorMode
Dual oscillator mode

enumerator kTRNG_SingleOscillatorModeOsc2
Single oscillator mode, using OSC2

typedef enum *_trng_sample_mode* trng_sample_mode_t
TRNG sample mode. Used by trng_config_t.

typedef enum *_trng_clock_mode* trng_clock_mode_t
TRNG clock mode. Used by trng_config_t.

typedef enum *_trng_ring_osc_div* trng_ring_osc_div_t
TRNG ring oscillator divide. Used by trng_config_t.

typedef enum *trng_oscillator_mode_t* trng_oscillator_mode_t
TRNG oscillator mode . Used by trng_config_t.

typedef struct *_trng_statistical_check_limit* trng_statistical_check_limit_t
Data structure for definition of statistical check limits. Used by trng_config_t.

typedef struct *_trng_user_config* trng_config_t
Data structure for the TRNG initialization.

This structure initializes the TRNG by calling the TRNG_Init() function. It contains all TRNG configurations.

status_t TRNG_GetDefaultConfig(*trng_config_t* *userConfig)
Initializes the user configuration structure to default values.

This function initializes the configuration structure to default values. The default values are platform dependent.

Parameters

- userConfig – User configuration structure.

Returns
If successful, returns the kStatus_TRNG_Success. Otherwise, it returns an error.

status_t TRNG_Init(TRNG_Type *base, const *trng_config_t* *userConfig)
Initializes the TRNG.

This function initializes the TRNG. When called, the TRNG entropy generation starts immediately.

Parameters

- base – TRNG base address
- userConfig – Pointer to the initialization configuration structure.

Returns

If successful, returns the kStatus_TRNG_Success. Otherwise, it returns an error.

void TRNG_Deinit(TRNG_Type *base)

Shuts down the TRNG.

This function shuts down the TRNG.

Parameters

- base – TRNG base address.

status_t TRNG_GetRandomData(TRNG_Type *base, void *data, size_t dataSize)

Gets random data.

This function gets random data from the TRNG.

Parameters

- base – TRNG base address.
- data – Pointer address used to store random data.
- dataSize – Size of the buffer pointed by the data parameter.

Returns

random data

struct __trng_statistical_check_limit

#include <fsl_trng.h> Data structure for definition of statistical check limits. Used by trng_config_t.

Public Members

uint32_t maximum

Maximum limit.

int32_t minimum

Minimum limit.

struct __trng_user_config

#include <fsl_trng.h> Data structure for the TRNG initialization.

This structure initializes the TRNG by calling the TRNG_Init() function. It contains all TRNG configurations.

Public Members

bool lock

Disable programmability of TRNG registers.

trng_clock_mode_t clockMode

Clock mode used to operate TRNG.

trng_ring_osc_div_t ringOscDiv

Ring oscillator divide used by TRNG.

trng_sample_mode_t sampleMode

Sample mode of the TRNG ring oscillator.

trng_oscillator_mode_t oscillatorMode

TRNG oscillator mode .

trng_ring_osc_div_t ringOsc2Div

Divider used for Ring oscillator 2.

uint16_t entropyDelay

Entropy Delay. Defines the length (in system clocks) of each Entropy sample taken.

uint16_t sampleSize

Sample Size. Defines the total number of Entropy samples that will be taken during Entropy generation.

uint16_t sparseBitLimit

Sparse Bit Limit which defines the maximum number of consecutive samples that may be discarded before an error is generated. This limit is used only for during von Neumann sampling (enabled by TRNG_HAL_SetSampleMode()). Samples are discarded if two consecutive raw samples are both 0 or both 1. If this discarding occurs for a long period of time, it indicates that there is insufficient Entropy.

uint8_t retryCount

Retry count. It defines the number of times a statistical check may fails during the TRNG Entropy Generation before generating an error.

uint8_t longRunMaxLimit

Largest allowable number of consecutive samples of all 1, or all 0, that is allowed during the Entropy generation.

trng_statistical_check_limit_t monobitLimit

Maximum and minimum limits for statistical check of number of ones/zero detected during entropy generation.

trng_statistical_check_limit_t runBit1Limit

Maximum and minimum limits for statistical check of number of runs of length 1 detected during entropy generation.

trng_statistical_check_limit_t runBit2Limit

Maximum and minimum limits for statistical check of number of runs of length 2 detected during entropy generation.

trng_statistical_check_limit_t runBit3Limit

Maximum and minimum limits for statistical check of number of runs of length 3 detected during entropy generation.

trng_statistical_check_limit_t runBit4Limit

Maximum and minimum limits for statistical check of number of runs of length 4 detected during entropy generation.

trng_statistical_check_limit_t runBit5Limit

Maximum and minimum limits for statistical check of number of runs of length 5 detected during entropy generation.

trng_statistical_check_limit_t runBit6PlusLimit

Maximum and minimum limits for statistical check of number of runs of length 6 or more detected during entropy generation.

trng_statistical_check_limit_t pokerLimit

Maximum and minimum limits for statistical check of “Poker Test”.

trng_statistical_check_limit_t frequencyCountLimit

Maximum and minimum limits for statistical check of entropy sample frequency count.

2.60 USART: Universal Synchronous/Asynchronous Receiver/Transmitter Driver

2.61 USART DMA Driver

status_t USART_TransferCreateHandleDMA(USART_Type *base, *usart_dma_handle_t* *handle, *usart_dma_transfer_callback_t* callback, void *userData, *dma_handle_t* *txDmaHandle, *dma_handle_t* *rxDmaHandle)

Initializes the USART handle which is used in transactional functions.

Parameters

- base – USART peripheral base address.
- handle – Pointer to usart_dma_handle_t structure.
- callback – Callback function.
- userData – User data.
- txDmaHandle – User-requested DMA handle for TX DMA transfer.
- rxDmaHandle – User-requested DMA handle for RX DMA transfer.

status_t USART_TransferSendDMA(USART_Type *base, *usart_dma_handle_t* *handle, *usart_transfer_t* *xfer)

Sends data using DMA.

This function sends data using DMA. This is a non-blocking function, which returns right away. When all data is sent, the send callback function is called.

Parameters

- base – USART peripheral base address.
- handle – USART handle pointer.
- xfer – USART DMA transfer structure. See usart_transfer_t.

Return values

- kStatus_Success – if succeed, others failed.
- kStatus_USART_TxBusy – Previous transfer on going.
- kStatus_InvalidArgument – Invalid argument.

status_t USART_TransferReceiveDMA(USART_Type *base, *usart_dma_handle_t* *handle, *usart_transfer_t* *xfer)

Receives data using DMA.

This function receives data using DMA. This is a non-blocking function, which returns right away. When all data is received, the receive callback function is called.

Parameters

- base – USART peripheral base address.
- handle – Pointer to usart_dma_handle_t structure.

- xfer – USART DMA transfer structure. See usart_transfer_t.

Return values

- kStatus_Success – if succeed, others failed.
- kStatus_USART_RxBusy – Previous transfer on going.
- kStatus_InvalidArgument – Invalid argument.

void USART_TransferAbortSendDMA(USART_Type *base, *usart_dma_handle_t* *handle)

Aborts the sent data using DMA.

This function aborts send data using DMA.

Parameters

- base – USART peripheral base address
- handle – Pointer to usart_dma_handle_t structure

void USART_TransferAbortReceiveDMA(USART_Type *base, *usart_dma_handle_t* *handle)

Aborts the received data using DMA.

This function aborts the received data using DMA.

Parameters

- base – USART peripheral base address
- handle – Pointer to usart_dma_handle_t structure

status_t USART_TransferGetReceiveCountDMA(USART_Type *base, *usart_dma_handle_t* *handle, uint32_t *count)

Get the number of bytes that have been received.

This function gets the number of bytes that have been received.

Parameters

- base – USART peripheral base address.
- handle – USART 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;

status_t USART_TransferGetSendCountDMA(USART_Type *base, *usart_dma_handle_t* *handle, uint32_t *count)

Get the number of bytes that have been sent.

This function gets the number of bytes that have been sent.

Parameters

- base – USART peripheral base address.
- handle – USART handle pointer.
- count – Sent bytes count.

Return values

- kStatus_NoTransferInProgress – No receive in progress.
- kStatus_InvalidArgument – Parameter is invalid.

- kStatus_Success – Get successfully through the parameter count;

FSL_USART_DMA_DRIVER_VERSION
USART dma driver version.

typedef struct *_usart_dma_handle* usart_dma_handle_t

typedef void (*usart_dma_transfer_callback_t)(USART_Type *base, *usart_dma_handle_t* *handle, *status_t* status, void *userData)
UART transfer callback function.

struct _usart_dma_handle
#include <fsl_usart_dma.h> UART DMA handle.

Public Members

USART_Type *base
UART peripheral base address.

usart_dma_transfer_callback_t callback
Callback function.

void *userData
UART callback function parameter.

size_t rxDataSizeAll
Size of the data to receive.

size_t txDataSizeAll
Size of the data to send out.

dma_handle_t *txDmaHandle
The DMA TX channel used.

dma_handle_t *rxDmaHandle
The DMA RX channel used.

volatile uint8_t txState
TX transfer state.

volatile uint8_t rxState
RX transfer state

2.62 USART Driver

status_t USART_Init(USART_Type *base, const *usart_config_t* *config, uint32_t srcClock_Hz)
Initializes a USART instance with user configuration structure and peripheral clock.

This function configures the USART module with the user-defined settings. The user can configure the configuration structure and also get the default configuration by using the USART_GetDefaultConfig() function. Example below shows how to use this API to configure USART.

```
usart_config_t usartConfig;
usartConfig.baudRate_Bps = 115200U;
usartConfig.parityMode = kUSART_ParityDisabled;
usartConfig.stopBitCount = kUSART_OneStopBit;
USART_Init(USART1, &usartConfig, 20000000U);
```

Parameters

- base – USART peripheral base address.
- config – Pointer to user-defined configuration structure.
- srcClock_Hz – USART clock source frequency in HZ.

Return values

- kStatus_USART_BaudrateNotSupport – Baudrate is not support in current clock source.
- kStatus_InvalidArgument – USART base address is not valid
- kStatus_Success – Status USART initialize succeed

void USART_CalcTimeoutConfig(uint32_t target_us, uint8_t *rxTimeoutPrescaler, uint32_t *rxTimeoutcounter, uint32_t srcClock_Hz)

Calculate the USART instance RX timeout prescaler and counter.

This function for calculate the USART RXFIFO timeout config. This function is used to calculate suitable prescaler and counter for target_us.

```
usart_config_t config;
config.rxWatermark                  = kUSART_RxFifo2;
config.rxTimeout.enable             = true;
config.rxTimeout.resetCounterOnEmpty  = true;
config.rxTimeout.resetCounterOnReceive = true;
USART_CalcTimeoutConfig(200U, &config.rxTimeout.prescaler, &config.rxTimeout.counter,
                        CLOCK_GetFreq(kCLOCK_BusClk));
```

Parameters

- target_us – Time for rx timeout unit us.
- rxTimeoutPrescaler – The prescaler to be setted after function.
- rxTimeoutcounter – The counter to be setted after function.
- srcClock_Hz – The clockSrc for rx timeout.

void USART_SetRxTimeoutConfig(USART_Type *base, const *usart_rx_timeout_config* *config)

Sets the USART instance RX timeout config.

This function configures the USART RXFIFO timeout config. This function is used to config the USART RXFIFO timeout config after the USART module is initialized by the USART_Init.

Parameters

- base – USART peripheral base address.
- config – pointer to receive timeout configuration structure.

void USART_Deinit(USART_Type *base)

Deinitializes a USART instance.

This function waits for TX complete, disables TX and RX, and disables the USART clock.

Parameters

- base – USART peripheral base address.

void USART_GetDefaultConfig(*usart_config_t* *config)

Gets the default configuration structure.

This function initializes the USART configuration structure to a default value. The default values are: usartConfig->baudRate_Bps = 115200U; usartConfig->parityMode =

kUSART_ParityDisabled; usartConfig->stopBitCount = kUSART_OneStopBit; usartConfig->bitCountPerChar = kUSART_8BitsPerChar; usartConfig->loopback = false; usartConfig->enableTx = false; usartConfig->enableRx = false;

Parameters

- config – Pointer to configuration structure.

status_t USART_SetBaudRate(USART_Type *base, uint32_t baudrate_Bps, uint32_t srcClock_Hz)

Sets the USART instance baud rate.

This function configures the USART module baud rate. This function is used to update the USART module baud rate after the USART module is initialized by the USART_Init.

```
USART_SetBaudRate(USART1, 115200U, 20000000U);
```

Parameters

- base – USART peripheral base address.
- baudrate_Bps – USART baudrate to be set.
- srcClock_Hz – USART clock source frequency in HZ.

Return values

- kStatus_USART_BaudrateNotSupport – Baudrate is not support in current clock source.
- kStatus_Success – Set baudrate succeed.
- kStatus_InvalidArgument – One or more arguments are invalid.

status_t USART_Enable32kMode(USART_Type *base, uint32_t baudRate_Bps, bool enableMode32k, uint32_t srcClock_Hz)

Enable 32 kHz mode which USART uses clock from the RTC oscillator as the clock source.

Please note that in order to use a 32 kHz clock to operate USART properly, the RTC oscillator and its 32 kHz output must be manully enabled by user, by calling RTC_Init and setting SYSCON_RTCOSCCTRL_EN bit to 1. And in 32kHz clocking mode the USART can only work at 9600 baudrate or at the baudrate that 9600 can evenly divide, eg: 4800, 3200.

Parameters

- base – USART peripheral base address.
- baudRate_Bps – USART baudrate to be set..
- enableMode32k – true is 32k mode, false is normal mode.
- srcClock_Hz – USART clock source frequency in HZ.

Return values

- kStatus_USART_BaudrateNotSupport – Baudrate is not support in current clock source.
- kStatus_Success – Set baudrate succeed.
- kStatus_InvalidArgument – One or more arguments are invalid.

void USART_Enable9bitMode(USART_Type *base, bool enable)

Enable 9-bit data mode for USART.

This function set the 9-bit mode for USART module. The 9th bit is not used for parity thus can be modified by user.

Parameters

- base – USART peripheral base address.

- enable – true to enable, false to disable.

static inline void USART_SetMatchAddress(USART_Type *base, uint8_t address)

Set the USART slave address.

This function configures the address for USART module that works as slave in 9-bit data mode. When the address detection is enabled, the frame it receices with MSB being 1 is considered as an address frame, otherwise it is considered as data frame. Once the address frame matches 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 USART 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 – USART peripheral base address.
- address – USART slave address.

static inline void USART_EnableMatchAddress(USART_Type *base, bool match)

Enable the USART match address feature.

Parameters

- base – USART peripheral base address.
- match – true to enable match address, false to disable.

static inline uint32_t USART_GetStatusFlags(USART_Type *base)

Get USART status flags.

This function get all USART status flags, the flags are returned as the logical OR value of the enumerators _usart_flags. To check a specific status, compare the return value with enumerators in _usart_flags. For example, to check whether the TX is empty:

```
if (kUSART_TxFifoNotFullFlag & USART_GetStatusFlags(USART1))
{
    ...
}
```

Parameters

- base – USART peripheral base address.

Returns

USART status flags which are ORed by the enumerators in the _usart_flags.

static inline void USART_ClearStatusFlags(USART_Type *base, uint32_t mask)

Clear USART status flags.

This function clear supported USART status flags. The mask is a logical OR of enumeration members. See kUSART_AllClearFlags. For example:

```
USART_ClearStatusFlags(USART1, kUSART_TxError | kUSART_RxError)
```

Parameters

- base – USART peripheral base address.
- mask – status flags to be cleared.

static inline void USART_EnableInterrupts(USART_Type *base, uint32_t mask)

Enables USART interrupts according to the provided mask.

This function enables the USART interrupts according to the provided mask. The mask is a logical OR of enumeration members. See _usart_interrupt_enable. For example, to enable TX empty interrupt and RX full interrupt:

```
USART_EnableInterrupts(USART1, kUSART_TxLevelInterruptEnable | kUSART_
↪RxLevelInterruptEnable);
```

Parameters

- base – USART peripheral base address.
- mask – The interrupts to enable. Logical OR of _usart_interrupt_enable.

static inline void USART_DisableInterrupts(USART_Type *base, uint32_t mask)

Disables USART interrupts according to a provided mask.

This function disables the USART interrupts according to a provided mask. The mask is a logical OR of enumeration members. See _usart_interrupt_enable. This example shows how to disable the TX empty interrupt and RX full interrupt:

```
USART_DisableInterrupts(USART1, kUSART_TxLevelInterruptEnable | kUSART_
↪RxLevelInterruptEnable);
```

Parameters

- base – USART peripheral base address.
- mask – The interrupts to disable. Logical OR of _usart_interrupt_enable.

static inline uint32_t USART_GetEnabledInterrupts(USART_Type *base)

Returns enabled USART interrupts.

This function returns the enabled USART interrupts.

Parameters

- base – USART peripheral base address.

static inline void USART_EnableTxDMA(USART_Type *base, bool enable)

Enable DMA for Tx.

static inline void USART_EnableRxDMA(USART_Type *base, bool enable)

Enable DMA for Rx.

static inline void USART_EnableCTS(USART_Type *base, bool enable)

Enable CTS. This function will determine whether CTS is used for flow control.

Parameters

- base – USART peripheral base address.
- enable – Enable CTS or not, true for enable and false for disable.

static inline void USART_EnableContinuousSCLK(USART_Type *base, bool enable)

Continuous Clock generation. By default, SCLK is only output while data is being transmitted in synchronous mode. Enable this funciton, SCLK will run continuously in synchronous mode, allowing characters to be received on Un_RxD independently from transmission on Un_TXD).

Parameters

- base – USART peripheral base address.

- enable – Enable Continuous Clock generation mode or not, true for enable and false for disable.

static inline void USART_EnableAutoClearSCLK(USART_Type *base, bool enable)

Enable Continuous Clock generation bit auto clear. While enable this cuntion, the Continuous Clock bit is automatically cleared when a complete character has been received. This bit is cleared at the same time.

Parameters

- base – USART peripheral base address.
- enable – Enable auto clear or not, true for enable and false for disable.

static inline void USART_SetRxFifoWatermark(USART_Type *base, uint8_t water)

Sets the rx FIFO watermark.

Parameters

- base – USART peripheral base address.
- water – Rx FIFO watermark.

static inline void USART_SetTxFifoWatermark(USART_Type *base, uint8_t water)

Sets the tx FIFO watermark.

Parameters

- base – USART peripheral base address.
- water – Tx FIFO watermark.

static inline void USART_WriteByte(USART_Type *base, uint8_t data)

Writes to the FIFOWR register.

This function writes data to the txFIFO directly. The upper layer must ensure that txFIFO has space for data to write before calling this function.

Parameters

- base – USART peripheral base address.
- data – The byte to write.

static inline uint8_t USART_ReadByte(USART_Type *base)

Reads the FIFORD register directly.

This function reads data from the rxFIFO directly. The upper layer must ensure that the rxFIFO is not empty before calling this function.

Parameters

- base – USART peripheral base address.

Returns

The byte read from USART data register.

static inline uint8_t USART_GetRxFifoCount(USART_Type *base)

Gets the rx FIFO data count.

Parameters

- base – USART peripheral base address.

Returns

rx FIFO data count.

static inline uint8_t USART_GetTxFifoCount(USART_Type *base)

Gets the tx FIFO data count.

Parameters

- base – USART peripheral base address.

Returns

tx FIFO data count.

void USART_SendAddress(USART_Type *base, uint8_t address)

Transmit an address frame in 9-bit data mode.

Parameters

- base – USART peripheral base address.
- address – USART slave address.

status_t USART_WriteBlocking(USART_Type *base, const uint8_t *data, size_t length)

Writes to the TX register using a blocking method.

This function polls the TX register, waits for the TX register to be empty or for the TX FIFO to have room and writes data to the TX buffer.

Parameters

- base – USART peripheral base address.
- data – Start address of the data to write.
- length – Size of the data to write.

Return values

- kStatus_USART_Timeout – Transmission timed out and was aborted.
- kStatus_InvalidArgument – Invalid argument.
- kStatus_Success – Successfully wrote all data.

status_t USART_ReadBlocking(USART_Type *base, uint8_t *data, size_t length)

Read RX data register using a blocking method.

This function polls the RX register, waits for the RX register to be full or for RX FIFO to have data and read data from the TX register.

Parameters

- base – USART peripheral base address.
- data – Start address of the buffer to store the received data.
- length – Size of the buffer.

Return values

- kStatus_USART_FramingError – Receiver overrun happened while receiving data.
- kStatus_USART_ParityError – Noise error happened while receiving data.
- kStatus_USART_NoiseError – Framing error happened while receiving data.
- kStatus_USART_RxError – Overflow or underflow rxFIFO happened.
- kStatus_USART_Timeout – Transmission timed out and was aborted.
- kStatus_Success – Successfully received all data.

status_t USART_TransferCreateHandle(USART_Type *base, *usart_handle_t* *handle, *usart_transfer_callback_t* callback, void *userData)

Initializes the USART handle.

This function initializes the USART handle which can be used for other USART transactional APIs. Usually, for a specified USART instance, call this API once to get the initialized handle.

Parameters

- base – USART peripheral base address.
- handle – USART handle pointer.
- callback – The callback function.
- userData – The parameter of the callback function.

status_t USART_TransferSendNonBlocking(USART_Type *base, *usart_handle_t* *handle, *usart_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 the IRQ handler, the USART driver calls the callback function and passes the kStatus_USART_TxIdle as status parameter.

Parameters

- base – USART peripheral base address.
- handle – USART handle pointer.
- xfer – USART transfer structure. See usart_transfer_t.

Return values

- kStatus_Success – Successfully start the data transmission.
- kStatus_USART_TxBusy – Previous transmission still not finished, data not all written to TX register yet.
- kStatus_InvalidArgument – Invalid argument.

void USART_TransferStartRingBuffer(USART_Type *base, *usart_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 USART handle.

When the RX ring buffer is used, data received are stored into the ring buffer even when the user doesn't call the USART_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 the 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 – USART peripheral base address.
- handle – USART handle pointer.
- ringBuffer – Start address of the ring buffer for background receiving. Pass NULL to disable the ring buffer.
- ringBufferSize – size of the ring buffer.

void USART_TransferStopRingBuffer(USART_Type *base, *usart_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 – USART peripheral base address.
- handle – USART handle pointer.

size_t USART_TransferGetRxRingBufferLength(*usart_handle_t* *handle)

Get the length of received data in RX ring buffer.

Parameters

- handle – USART handle pointer.

Returns

Length of received data in RX ring buffer.

void USART_TransferAbortSend(USART_Type *base, *usart_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 still not sent out.

Parameters

- base – USART peripheral base address.
- handle – USART handle pointer.

status_t USART_TransferGetSendCount(USART_Type *base, *usart_handle_t* *handle, uint32_t *count)

Get 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 interrupt method.

Parameters

- base – USART peripheral base address.
- handle – USART 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 USART_TransferReceiveNonBlocking(USART_Type *base, *usart_handle_t* *handle, *usart_transfer_t* *xfer, size_t *receivedBytes)

Receives a buffer of data using an interrupt method.

This function receives data using an 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 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 to read, the receive request is saved by the USART driver. When the new data arrives, the receive request is serviced first. When all data is received, the USART driver notifies the upper layer through a callback function and passes the status parameter kStatus_USART_RxIdle. For example, the upper layer needs 10 bytes but there are only 5 bytes in the ring buffer. The 5 bytes are copied to the xfer->data and this function returns with the parameter receivedBytes set to 5. For the left 5 bytes, newly arrived data is saved

from the xfer->data[5]. When 5 bytes are received, the USART 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 the xfer->data. When all data is received, the upper layer is notified.

Parameters

- base – USART peripheral base address.
- handle – USART handle pointer.
- xfer – USART transfer structure, see usart_transfer_t.
- receivedBytes – Bytes received from the ring buffer directly.

Return values

- kStatus_Success – Successfully queue the transfer into transmit queue.
- kStatus_USART_RxBusy – Previous receive request is not finished.
- kStatus_InvalidArgument – Invalid argument.

void USART_TransferAbortReceive(USART_Type *base, *usart_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 – USART peripheral base address.
- handle – USART handle pointer.

status_t USART_TransferGetReceiveCount(USART_Type *base, *usart_handle_t* *handle, uint32_t *count)

Get the number of bytes that have been received.

This function gets the number of bytes that have been received.

Parameters

- base – USART peripheral base address.
- handle – USART 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 USART_TransferHandleIRQ(USART_Type *base, *usart_handle_t* *handle)

USART IRQ handle function.

This function handles the USART transmit and receive IRQ request.

Parameters

- base – USART peripheral base address.
- handle – USART handle pointer.

FSL_USART_DRIVER_VERSION

USART driver version.

Error codes for the USART driver.

Values:

enumerator kStatus_USART_TxBusy
Transmitter is busy.

enumerator kStatus_USART_RxBusy
Receiver is busy.

enumerator kStatus_USART_TxIdle
USART transmitter is idle.

enumerator kStatus_USART_RxIdle
USART receiver is idle.

enumerator kStatus_USART_TxError
Error happens on txFIFO.

enumerator kStatus_USART_RxError
Error happens on rxFIFO.

enumerator kStatus_USART_RxRingBufferOverrun
Error happens on rx ring buffer

enumerator kStatus_USART_NoiseError
USART noise error.

enumerator kStatus_USART_FramingError
USART framing error.

enumerator kStatus_USART_ParityError
USART parity error.

enumerator kStatus_USART_BaudrateNotSupport
Baudrate is not support in current clock source

enum _usart_sync_mode
USART synchronous mode.

Values:

enumerator kUSART_SyncModeDisabled
Asynchronous mode.

enumerator kUSART_SyncModeSlave
Synchronous slave mode.

enumerator kUSART_SyncModeMaster
Synchronous master mode.

enum _usart_parity_mode
USART parity mode.

Values:

enumerator kUSART_ParityDisabled
Parity disabled

enumerator kUSART_ParityEven
Parity enabled, type even, bit setting: PE|PT = 10

enumerator kUSART_ParityOdd
Parity enabled, type odd, bit setting: PE|PT = 11

enum _usart_stop_bit_count
USART stop bit count.

Values:

enumerator kUSART_OneStopBit
One stop bit

enumerator kUSART_TwoStopBit
Two stop bits

enum _usart_data_len
USART data size.

Values:

enumerator kUSART_7BitsPerChar
Seven bit mode

enumerator kUSART_8BitsPerChar
Eight bit mode

enum _usart_clock_polarity
USART clock polarity configuration, used in sync mode.

Values:

enumerator kUSART_RxSampleOnFallingEdge
Un_RXD is sampled on the falling edge of SCLK.

enumerator kUSART_RxSampleOnRisingEdge
Un_RXD is sampled on the rising edge of SCLK.

enum _usart_txfifo_watermark
txFIFO watermark values

Values:

enumerator kUSART_TxFifo0
USART tx watermark is empty

enumerator kUSART_TxFifo1
USART tx watermark at 1 item

enumerator kUSART_TxFifo2
USART tx watermark at 2 items

enumerator kUSART_TxFifo3
USART tx watermark at 3 items

enumerator kUSART_TxFifo4
USART tx watermark at 4 items

enumerator kUSART_TxFifo5
USART tx watermark at 5 items

enumerator kUSART_TxFifo6
USART tx watermark at 6 items

enumerator kUSART_TxFifo7
USART tx watermark at 7 items

enum _usart_rxfifo_watermark

rxFIFO watermark values

Values:

enumerator kUSART_RxFifo1

USART rx watermark at 1 item

enumerator kUSART_RxFifo2

USART rx watermark at 2 items

enumerator kUSART_RxFifo3

USART rx watermark at 3 items

enumerator kUSART_RxFifo4

USART rx watermark at 4 items

enumerator kUSART_RxFifo5

USART rx watermark at 5 items

enumerator kUSART_RxFifo6

USART rx watermark at 6 items

enumerator kUSART_RxFifo7

USART rx watermark at 7 items

enumerator kUSART_RxFifo8

USART rx watermark at 8 items

enum _usart_interrupt_enable

USART interrupt configuration structure, default settings all disabled.

Values:

enumerator kUSART_TxErrorInterruptEnable

enumerator kUSART_RxErrorInterruptEnable

enumerator kUSART_TxLevelInterruptEnable

enumerator kUSART_RxLevelInterruptEnable

enumerator kUSART_TxIdleInterruptEnable

Transmitter idle.

enumerator kUSART_CtsChangeInterruptEnable

Change in the state of the CTS input.

enumerator kUSART_RxBreakChangeInterruptEnable

Break condition asserted or deasserted.

enumerator kUSART_RxStartInterruptEnable

Rx start bit detected.

enumerator kUSART_FramingErrorInterruptEnable

Framing error detected.

enumerator kUSART_ParityErrorInterruptEnable

Parity error detected.

enumerator kUSART_NoiseErrorInterruptEnable

Noise error detected.

enumerator kUSART_AutoBaudErrorInterruptEnable
Auto baudrate error detected.

enumerator kUSART_RxTimeoutInterruptEnable
Receive timeout detected.

enumerator kUSART_AllInterruptEnables

enum _usart_flags
USART status flags.

This provides constants for the USART status flags for use in the USART functions.

Values:

enumerator kUSART_TxError
TXERR bit, sets if TX buffer is error

enumerator kUSART_RxError
RXERR bit, sets if RX buffer is error

enumerator kUSART_TxFifoEmptyFlag
TXEMPTY bit, sets if TX buffer is empty

enumerator kUSART_TxFifoNotFullFlag
TXNOTFULL bit, sets if TX buffer is not full

enumerator kUSART_RxFifoNotEmptyFlag
RXNOEMPTY bit, sets if RX buffer is not empty

enumerator kUSART_RxFifoFullFlag
RXFULL bit, sets if RX buffer is full

enumerator kUSART_RxIdleFlag
Receiver idle.

enumerator kUSART_TxIdleFlag
Transmitter idle.

enumerator kUSART_CtsAssertFlag
CTS signal high.

enumerator kUSART_CtsChangeFlag
CTS signal changed interrupt status.

enumerator kUSART_BreakDetectFlag
Break detected. Self cleared when rx pin goes high again.

enumerator kUSART_BreakDetectChangeFlag
Break detect change interrupt flag. A change in the state of receiver break detection.

enumerator kUSART_RxStartFlag
Rx start bit detected interrupt flag.

enumerator kUSART_FramingErrorFlag
Framing error interrupt flag.

enumerator kUSART_ParityErrorFlag
parity error interrupt flag.

enumerator kUSART_NoiseErrorFlag
Noise error interrupt flag.

enumerator kUSART_AutobaudErrorFlag
Auto baudrate error interrupt flag, caused by the baudrate counter timeout before the end of start bit.

enumerator kUSART_RxTimeoutFlag
RXTIMEOUT bit, sets if RX FIFO Timeout.

enumerator kUSART_AllClearFlags

typedef enum *_usart_sync_mode* usart_sync_mode_t
USART synchronous mode.

typedef enum *_usart_parity_mode* usart_parity_mode_t
USART parity mode.

typedef enum *_usart_stop_bit_count* usart_stop_bit_count_t
USART stop bit count.

typedef enum *_usart_data_len* usart_data_len_t
USART data size.

typedef enum *_usart_clock_polarity* usart_clock_polarity_t
USART clock polarity configuration, used in sync mode.

typedef enum *_usart_txfifo_watermark* usart_txfifo_watermark_t
txFIFO watermark values

typedef enum *_usart_rxfifo_watermark* usart_rxfifo_watermark_t
rxFIFO watermark values

typedef struct *_usart_rx_timeout_config* usart_rx_timeout_config
USART receive timeout configuration structure.

typedef struct *_usart_config* usart_config_t
USART configuration structure.

typedef struct *_usart_transfer* usart_transfer_t
USART transfer structure.

typedef struct *_usart_handle* usart_handle_t

typedef void (*usart_transfer_callback_t)(USART_Type *base, *usart_handle_t* *handle, *status_t* status, void *userData)
USART transfer callback function.

typedef void (*flexcomm_usart_irq_handler_t)(USART_Type *base, *usart_handle_t* *handle)
Typedef for usart interrupt handler.

uint32_t USART_GetInstance(USART_Type *base)
Returns instance number for USART peripheral base address.

USART_FIFOTRIG_TXLVL_GET(base)

USART_FIFOTRIG_RXLVL_GET(base)

UART_RETRY_TIMES
Retry times for waiting flag.

Defining to zero means to keep waiting for the flag until it is assert/deassert in blocking transfer, otherwise the program will wait until the UART_RETRY_TIMES counts down to 0, if the flag still remains unchanged then program will return kStatus_USART_Timeout. It is not advised to use this macro in formal application to prevent any hardware error because the actual wait period is affected by the compiler and optimization.

struct __usart__rx__timeout__config

#include <fsl_usart.h> USART receive timeout configuration structure.

Public Members

bool enable
: Enable RX timeout

bool resetCounterOnEmpty
: Enable RX timeout counter reset when RX FIFO becames empty.

bool resetCounterOnReceive
: Enable RX timeout counter reset when RX FIFO receives data from the transmitter side.

uint32_t counter
: RX timeout counter

uint8_t prescaler
: RX timeout prescaler

struct __usart__config

#include <fsl_usart.h> USART configuration structure.

Public Members

uint32_t baudRate_Bps
: USART baud rate

usart_parity_mode_t parityMode
: Parity mode, disabled (default), even, odd

usart_stop_bit_count_t stopBitCount
: Number of stop bits, 1 stop bit (default) or 2 stop bits

usart_data_len_t bitCountPerChar
: Data length - 7 bit, 8 bit

bool loopback
: Enable peripheral loopback

bool enableRx
: Enable RX

bool enableTx
: Enable TX

bool enableContinuousSCLK
: USART continuous Clock generation enable in synchronous master mode.

bool enableMode32k
: USART uses 32 kHz clock from the RTC oscillator as the clock source.

bool enableHardwareFlowControl
: Enable hardware control RTS/CTS

usart_txfifo_watermark_t txWatermark
: txFIFO watermark

usart_rxfifo_watermark_t rxWatermark
: rxFIFO watermark

usart_sync_mode_t syncMode
Transfer mode select - asynchronous, synchronous master, synchronous slave.

usart_clock_polarity_t clockPolarity
Selects the clock polarity and sampling edge in synchronous mode.

usart_rx_timeout_config rxTimeout
rx timeout configuration

struct __usart__transfer
#include <fsl_usart.h> USART transfer structure.

Public Members

size_t dataSize
The byte count to be transfer.

struct __usart__handle
#include <fsl_usart.h> USART 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.

size_t txDataSizeAll
Size of the data to send out.

uint8_t *volatile rxData
Address of remaining data to receive.

volatile size_t rxDataSize
Size of the remaining data to receive.

size_t rxDataSizeAll
Size of the data to receive.

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.

usart_transfer_callback_t callback
Callback function.

void *userData
USART callback function parameter.

volatile uint8_t txState
TX transfer state.

volatile uint8_t rxState
RX transfer state

uint8_t txWatermark
txFIFO watermark

uint8_t rxWatermark
rxFIFO watermark

union ___unnamed50___

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.

2.63 UTICK: MictoTick Timer Driver

void UTICK_Init(UTICK_Type *base)
Initializes an UTICK by turning its bus clock on.

void UTICK_Deinit(UTICK_Type *base)
Deinitializes a UTICK instance.

This function shuts down Utick bus clock

Parameters

- base – UTICK peripheral base address.

uint32_t UTICK_GetStatusFlags(UTICK_Type *base)
Get Status Flags.

This returns the status flag

Parameters

- base – UTICK peripheral base address.

Returns
status register value

void UTICK_ClearStatusFlags(UTICK_Type *base)
Clear Status Interrupt Flags.

This clears intr status flag

Parameters

- base – UTICK peripheral base address.

Returns
none

void UTICK_SetTick(UTICK_Type *base, *utick_mode_t* mode, uint32_t count, *utick_callback_t* cb)

Starts UTICK.

This function starts a repeat/onetime countdown with an optional callback

Parameters

- base – UTICK peripheral base address.
- mode – UTICK timer mode (ie kUTICK_onetime or kUTICK_repeat)
- count – UTICK timer mode (ie kUTICK_onetime or kUTICK_repeat)
- cb – UTICK callback (can be left as NULL if none, otherwise should be a void func(void))

Returns

none

void UTICK_HandleIRQ(UTICK_Type *base, *utick_callback_t* cb)

UTICK Interrupt Service Handler.

This function handles the interrupt and refers to the callback array in the driver to callback user (as per request in UTICK_SetTick()). if no user callback is scheduled, the interrupt will simply be cleared.

Parameters

- base – UTICK peripheral base address.
- cb – callback scheduled for this instance of UTICK

Returns

none

FSL_UTICK_DRIVER_VERSION

UTICK driver version 2.0.5.

enum _utick_mode

UTICK timer operational mode.

Values:

enumerator kUTICK_Onetime

Trigger once

enumerator kUTICK_Repeat

Trigger repeatedly

typedef enum *_utick_mode* utick_mode_t

UTICK timer operational mode.

typedef void (*utick_callback_t)(void)

UTICK callback function.

2.64 WWDT: Windowed Watchdog Timer Driver

void WWDT_GetDefaultConfig(*wwdt_config_t* *config)

Initializes WWDT configure structure.

This function initializes the WWDT configure structure to default value. The default value are:

```
config->enableWwdt = true;
config->enableWatchdogReset = false;
config->enableWatchdogProtect = false;
config->enableLockOscillator = false;
config->windowValue = 0xFFFFFFU;
config->timeoutValue = 0xFFFFFFU;
config->warningValue = 0;
```

See also:

wwdt_config_t

Parameters

- config – Pointer to WWDT config structure.

void WWDT_Init(WWDT_Type *base, const *wwdt_config_t* *config)

Initializes the WWDT.

This function initializes the WWDT. When called, the WWDT runs according to the configuration.

Example:

```
wwdt_config_t config;
WWDT_GetDefaultConfig(&config);
config.timeoutValue = 0x7ffU;
WWDT_Init(wwdt_base,&config);
```

Parameters

- base – WWDT peripheral base address
- config – The configuration of WWDT

void WWDT_Deinit(WWDT_Type *base)

Shuts down the WWDT.

This function shuts down the WWDT.

Parameters

- base – WWDT peripheral base address

static inline void WWDT_Enable(WWDT_Type *base)

Enables the WWDT module.

This function write value into WWDT_MOD register to enable the WWDT, it is a write-once bit; once this bit is set to one and a watchdog feed is performed, the watchdog timer will run permanently.

Parameters

- base – WWDT peripheral base address

static inline void WWDT_Disable(WWDT_Type *base)

Disables the WWDT module.

Deprecated:

Do not use this function. It will be deleted in next release version, for once the bit field of WDEN written with a 1, it can not be re-written with a 0.

This function write value into WWDT_MOD register to disable the WWDT.

Parameters

- base – WWDT peripheral base address

static inline uint32_t WWDT_GetStatusFlags(WWDT_Type *base)

Gets all WWDT status flags.

This function gets all status flags.

Example for getting Timeout Flag:

```
uint32_t status;
status = WWDT_GetStatusFlags(wwdt_base) & kWWDT_TimeoutFlag;
```

Parameters

- base – WWDT peripheral base address

Returns

The status flags. This is the logical OR of members of the enumeration _wwdt_status_flags_t

void WWDT_ClearStatusFlags(WWDT_Type *base, uint32_t mask)

Clear WWDT flag.

This function clears WWDT status flag.

Example for clearing warning flag:

```
WWDT_ClearStatusFlags(wwdt_base, kWWDT_WarningFlag);
```

Parameters

- base – WWDT peripheral base address
- mask – The status flags to clear. This is a logical OR of members of the enumeration _wwdt_status_flags_t

static inline void WWDT_SetWarningValue(WWDT_Type *base, uint32_t warningValue)

Set the WWDT warning value.

The WDWARNINT register determines the watchdog timer counter value that will generate a watchdog interrupt. When the watchdog timer counter is no longer greater than the value defined by WARNINT, an interrupt will be generated after the subsequent WDCLK.

Parameters

- base – WWDT peripheral base address
- warningValue – WWDT warning value.

static inline void WWDT_SetTimeoutValue(WWDT_Type *base, uint32_t timeoutCount)

Set the WWDT timeout value.

This function sets the timeout value. Every time a feed sequence occurs the value in the TC register is loaded into the Watchdog timer. Writing a value below 0xFF will cause 0xFF to be loaded into the TC register. Thus the minimum time-out interval is TWDCLK*256*4. If enableWatchdogProtect flag is true in wwdt_config_t config structure, any attempt to change the timeout value before the watchdog counter is below the warning and window values will cause a watchdog reset and set the WDTOF flag.

Parameters

- base – WWDT peripheral base address
- timeoutCount – WWDT timeout value, count of WWDT clock tick.

static inline void WWDT_SetWindowValue(WWDT_Type *base, uint32_t windowValue)

Sets the WWDT window value.

The WINDOW register determines the highest TV value allowed when a watchdog feed is performed. If a feed sequence occurs when timer value is greater than the value in WINDOW, a watchdog event will occur. To disable windowing, set windowValue to 0xFFFFFF (maximum possible timer value) so windowing is not in effect.

Parameters

- base – WWDT peripheral base address
- windowValue – WWDT window value.

void WWDT_Refresh(WWDT_Type *base)

Refreshes the WWDT timer.

This function feeds the WWDT. This function should be called before WWDT timer is in timeout. Otherwise, a reset is asserted.

Parameters

- base – WWDT peripheral base address

FSL_WWDT_DRIVER_VERSION

Defines WWDT driver version.

WWDT_FIRST_WORD_OF_REFRESH

First word of refresh sequence

WWDT_SECOND_WORD_OF_REFRESH

Second word of refresh sequence

enum _wwdt_status_flags_t

WWDT status flags.

This structure contains the WWDT status flags for use in the WWDT functions.

Values:

enumerator kWWDT_TimeoutFlag

Time-out flag, set when the timer times out

enumerator kWWDT_WarningFlag

Warning interrupt flag, set when timer is below the value WDWARNINT

typedef struct *_wwdt_config* wwdt_config_t

Describes WWDT configuration structure.

struct _wwdt_config

#include <fsl_wwdt.h> Describes WWDT configuration structure.

Public Members

bool enableWwdt

Enables or disables WWDT

bool enableWatchdogReset

true: Watchdog timeout will cause a chip reset false: Watchdog timeout will not cause a chip reset

bool enableWatchdogProtect

true: Enable watchdog protect i.e timeout value can only be changed after counter is below warning & window values false: Disable watchdog protect; timeout value can be changed at any time

uint32_t windowValue

Window value, set this to 0xFFFFFF if windowing is not in effect

uint32_t timeoutValue

Timeout value

uint32_t warningValue

Watchdog time counter value that will generate a warning interrupt. Set this to 0 for no warning

uint32_t clockFreq_Hz

Watchdog clock source frequency.

Chapter 3

Middleware

3.1 Boot

3.1.1 MCUXpresso SDK : mcuxsdk-middleware-mcuboot_opensource

Overview

This repository is a fork of MCUboot (https://github.com/mcu-tools/mcuboot) for MCUXpresso SDK delivery and it contains the components 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-manifests) for the complete delivery of MCUXpresso SDK.

Documentation

Overall details can be reviewed here: MCUXpresso SDK Online Documentation

Visit MCUboot - 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

Contributions are not currently accepted. If the intended contribution is not related to NXP specific code, consider contributing directly to the upstream MCUboot project. Once this MCUboot fork is synchronized with the upstream project, such contributions will end up here as well. If the intended contribution is a bugfix or improvement for NXP porting layer or for code added or modified by NXP, please open an issue or contact NXP support.

NXP Fork

This fork of MCUboot contains specific modifications and enhancements for NXP MCUXpresso SDK integration.

See *changelog* for details.

3.1.2 MCUboot

This is MCUboot version 2.2.0

MCUboot is a secure bootloader for 32-bits microcontrollers. It defines a common infrastructure for the bootloader and the system flash layout on microcontroller systems, and provides a secure bootloader that enables easy software upgrade.

MCUboot is not dependent on any specific operating system and hardware and relies on hardware porting layers from the operating system it works with. Currently, MCUboot works with the following operating systems and SoCs:

- Zephyr
- Apache Mynewt
- Apache NuttX
- RIOT
- Mbed OS
- Espressif
- Cypress/Infineon

RIOT is supported only as a boot target. We will accept any new port contributed by the community once it is good enough.

MCUboot How-tos

See the following pages for instructions on using MCUboot with different operating systems and SoCs:

- Zephyr
- Apache Mynewt
- Apache NuttX
- RIOT
- Mbed OS
- Espressif
- *Cypress/Infineon*

There are also instructions for the *Simulator*.

Roadmap

The issues being planned and worked on are tracked using GitHub issues. To give your input, visit MCUboot GitHub Issues.

Source files

You can find additional documentation on the bootloader in the source files. For more information, use the following links:

- boot/bootutil - The core of the bootloader itself.
- boot/boot_serial - Support for serial upgrade within the bootloader itself.
- boot/zephyr - Port of the bootloader to Zephyr.
- boot/mynewt - Bootloader application for Apache Mynewt.
- boot/nuttx - Bootloader application and port of MCUboot interfaces for Apache NuttX.
- boot/mbed - Port of the bootloader to Mbed OS.
- boot/espressif - Bootloader application and MCUboot port for Espressif SoCs.
- boot/cypress - Bootloader application and MCUboot port for Cypress/Infineon SoCs.
- imgtool - A tool to securely sign firmware images for booting by MCUboot.
- sim - A bootloader simulator for testing and regression.

Joining the project

Developers are welcome!

Use the following links to join or see more about the project:

- Our developer mailing list
- Our Discord channel Get your invite

3.2 Cloud

3.2.1 AWS IoT

Device Shadow Library

AWS IoT Device Shadow library The AWS IoT Device Shadow library enables you to store and retrieve the current state (the "shadow") of every registered device. The device's shadow is a persistent, virtual representation of your device that you can interact with from AWS IoT Core even if the device is offline. The device state is captured as its "shadow" within a JSON document. The device can send commands over MQTT to get, update and delete its latest state as well as receive notifications over MQTT about changes in its state. Each device's shadow is uniquely identified by the name of the corresponding "thing", a representation of a specific device or logical entity on the AWS Cloud. See Managing Devices with AWS IoT for more information on IoT "thing". More details about AWS IoT Device Shadow can be found in AWS IoT documentation. This library is distributed under the *MIT Open Source License*.

Note: From v1.1.0 release onwards, you can used named shadow, a feature of the AWS IoT Device Shadow service that allows you to create multiple shadows for a single IoT device.

This library has gone through code quality checks including verification that no function has a GNU Complexity score over 8, and checks against deviations from mandatory rules in the MISRA coding standard. Deviations from the MISRA C:2012 guidelines are documented under *MISRA Deviations*. This library has also undergone both static code analysis from Coverity static analysis, and validation of memory safety through the CBMC automated reasoning tool.

See memory requirements for this library here.

AWS IoT Device Shadow v1.3.0 source code is part of the FreeRTOS 202210.00 LTS release.

AWS IoT Device Shadow v1.0.2 source code is part of the FreeRTOS 202012.00 LTS release.

AWS IoT Device Shadow Config File The AWS IoT Device Shadow library exposes configuration macros that are required for building the library. A list of all the configurations and their default values are defined in *shadow_config_defaults.h*. To provide custom values for the configuration macros, a custom config file named shadow_config.h can be provided by the user application to the library.

By default, a shadow_config.h custom config is required to build the library. To disable this requirement and build the library with default configuration values, provide SHADOW_DO_NOT_USE_CUSTOM_CONFIG as a compile time preprocessor macro.

Building the Library The *shadowFilePaths.cmake* file contains the information of all source files and the header include path required to build the AWS IoT Device Shadow library.

As mentioned in the *previous section*, either a custom config file (i.e. shadow_config.h) OR the SHADOW_DO_NOT_USE_CUSTOM_CONFIG macro needs to be provided to build the AWS IoT Device Shadow library.

For a CMake example of building the AWS IoT Device Shadow library with the shadowFilePaths.cmake file, refer to the coverity_analysis library target in *test/CMakeLists.txt* file.

Building Unit Tests

Checkout CMock Submodule By default, the submodules in this repository are configured with update=none in *.gitmodules* to avoid increasing clone time and disk space usage of other repositories (like amazon-freertos that submodules this repository).

To build unit tests, the submodule dependency of CMock is required. Use the following command to clone the submodule:

```
git submodule update --checkout --init --recursive --test/unit-test/CMock
```

Platform Prerequisites

- For building the library, **CMake 3.13.0** or later and a **C90 compiler**.
- For running unit tests, **Ruby 2.0.0** or later is additionally required for the CMock test framework (that we use).
- For running the coverage target, **gcov** and **lcov** are additionally required.

Steps to build unit tests

1. Go to the root directory of this repository. (Make sure that the **CMock** submodule is cloned as described *above*.)
2. Run the *cmake* command: cmake -S test -B build

3. Run this command to build the library and unit tests: `make -C build all`
4. The generated test executables will be present in `build/bin/tests` folder.
5. Run `cd build && ctest` to execute all tests and view the test run summary.

CBMC To learn more about CBMC and proofs specifically, review the training material here.

The `test/cbmc/proofs` directory contains CBMC proofs.

In order to run these proofs you will need to install CBMC and other tools by following the instructions here.

Reference examples Please refer to the demos of the AWS IoT Device Shadow library in the following locations for reference examples on POSIX and FreeRTOS platforms:

Platform	Location	Transport Interface Implementation (for coreMQTT stack)
POSIX	AWS IoT Device SDK for Embedded C	POSIX sockets for TCP/IP and OpenSSL for TLS stack
FreeRTOS	FreeRTOS/FreeRTOS	FreeRTOS+TCP for TCP/IP and mbedTLS for TLS stack
FreeRTOS	FreeRTOS AWS Reference Integrations	Based on Secure Sockets Abstraction

Documentation

Existing Documentation For pre-generated documentation, please see the documentation linked in the locations below:

Location
AWS IoT Device SDK for Embedded C
FreeRTOS.org

Note that the latest included version of IoT Device Shadow library may differ across repositories.

Generating documentation The Doxygen references were created using Doxygen version 1.9.2. To generate the Doxygen pages, please run the following command from the root of this repository:

```
doxygen docs/doxygen/config.doxyfile
```

Contributing See *CONTRIBUTING.md* for information on contributing.

Device Defender Library

AWS IoT Device Defender Library The Device Defender library enables you to send device metrics to the AWS IoT Device Defender Service. This library also supports custom metrics, a feature that helps you monitor operational health metrics that are unique to your fleet or use case. For example, you can define a new metric to monitor the memory usage or CPU usage

on your devices. This library has no dependencies on any additional libraries other than the standard C library, and therefore, can be used with any MQTT client library. This library is distributed under the *MIT Open Source License*.

This library has gone through code quality checks including verification that no function has a GNU Complexity score over 8, and checks against deviations from mandatory rules in the MISRA coding standard. Deviations from the MISRA C:2012 guidelines are documented under *MISRA Deviations*. This library has also undergone static code analysis using Coverity static analysis, and validation of memory safety through the CBMC automated reasoning tool.

See memory requirements for this library *here*.

AWS IoT Device Defender v1.3.0 source code is part of the FreeRTOS 202210.00 LTS release.

AWS IoT Device Defender v1.1.0 source code is part of the FreeRTOS 202012.01 LTS release.

AWS IoT Device Defender Client Config File The AWS IoT Device Defender Client Library exposes build configuration macros that are required for building the library. A list of all the configurations and their default values are defined in *defender_config_defaults.h*. To provide custom values for the configuration macros, a config file named defender_config.h can be provided by the application to the library.

By default, a defender_config.h config file is required to build the library. To disable this requirement and build the library with default configuration values, provide DEFENDER_DO_NOT_USE_CUSTOM_CONFIG as a compile time preprocessor macro.

Thus, the Device Defender client library can be built by either:

- Defining a defender_config.h file in the application, and adding it to the include directories list of the library.

OR

- Defining the DEFENDER_DO_NOT_USE_CUSTOM_CONFIG preprocessor macro for the library build.

Building the Library The *defenderFilePaths.cmake* file contains the information of all source files and the header include paths required to build the Device Defender client library.

As mentioned in the previous section, either a custom config file (i.e. defender_config.h) or DEFENDER_DO_NOT_USE_CUSTOM_CONFIG macro needs to be provided to build the Device Defender client library.

For a CMake example of building the Device Defender client library with the defenderFilePaths.cmake file, refer to the coverity_analysis library target in *test/CMakeLists.txt* file.

Building Unit Tests

Platform Prerequisites

- For running unit tests:
  - **C90 compiler** like gcc.
  - **CMake 3.13.0 or later**.
  - **Ruby 2.0.0 or later** is additionally required for the CMock test framework (that we use).
- For running the coverage target, **gcov** and **lcov** are additionally required.

Steps to build Unit Tests

1. Go to the root directory of this repository.
2. Run the *cmake* command: `cmake -S test -B build -DBUILD_CLONE_SUBMODULES=ON`.
3. Run this command to build the library and unit tests: `make -C build all`.
4. The generated test executables will be present in `build/bin/tests` folder.
5. Run `cd build && ctest` to execute all tests and view the test run summary.

CBMC To learn more about CBMC and proofs specifically, review the training material here.

The `test/cbmc/proofs` directory contains CBMC proofs.

In order to run these proofs you will need to install CBMC and other tools by following the instructions here.

Reference examples The AWS IoT Embedded C-SDK repository contains a demo showing the use of AWS IoT Device Defender Client Library here on a POSIX platform.

Documentation

Existing documentation For pre-generated documentation, please see the documentation linked in the locations below:

Location
AWS IoT Device SDK for Embedded C
FreeRTOS.org

Note that the latest included version of the AWS IoT Device Defender library may differ across repositories.

Generating documentation The Doxygen references were created using Doxygen version 1.9.2. To generate the Doxygen pages, please run the following command from the root of this repository:

```
doxygen docs/doxygen/config.doxyfile
```

Contributing See *CONTRIBUTING.md* for information on contributing.

Jobs Library

README

AWS IoT Jobs library The AWS IoT Jobs library helps you notify connected IoT devices of a pending Job. A Job can be used to manage your fleet of devices, update firmware and security certificates on your devices, or perform administrative tasks such as restarting devices and performing diagnostics. It interacts with the AWS IoT Jobs service using MQTT, a lightweight publish-subscribe protocol. This library provides a convenience API to compose and recognize the MQTT topic strings used by the Jobs service. The library is written in C compliant with ISO C90 and MISRA C:2012, and is distributed under the *MIT Open Source License*.

This library has gone through code quality checks including verification that no function has a GNU Complexity score over 8, and checks against deviations from mandatory rules in the MISRA coding standard . Deviations from the MISRA C:2012 guidelines are documented under *MISRA Deviations*. This library has also undergone both static code analysis from Coverity, and validation of memory safety with the CBMC bounded model checker.

See memory requirements for this library *here*.

AWS IoT Jobs v1.3.0 source code is part of the FreeRTOS 202210.00 LTS release.

AWS IoT Jobs v1.1.0 source code is part of the FreeRTOS 202012.01 LTS release.

Building the Jobs library A compiler that supports **C90 or later** such as *gcc* is required to build the library.

Given an application in a file named `example.c`, *gcc* can be used like so:

```
gcc -I source/include example.c source/jobs.c -o example
```

gcc can also produce an object file to be linked later:

```
gcc -I source/include -c source/jobs.c
```

CBMC To learn more about CBMC and proofs specifically, review the training material here.

The `test/cbmc/proofs` directory contains CBMC proofs.

In order to run these proofs you will need to install CBMC and other tools by following the instructions here.

Reference example The AWS IoT Device SDK for Embedded C repository contains a demo using the jobs library on a POSIX platform. https://github.com/aws/aws-iot-device-sdk-embedded-C/tree/main/demos/jobs/jobs_demo_mosquitto

Documentation

Existing Documentation For pre-generated documentation, please see the documentation linked in the locations below:

Location
AWS IoT Device SDK for Embedded C
FreeRTOS.org

Note that the latest included version of the AWS IoT Jobs library may differ across repositories.

Generating Documentation The Doxygen references were created using Doxygen version 1.9.2. To generate the Doxygen pages, please run the following command from the root of this repository:

```
doxygen docs/doxygen/config.doxyfile
```

Building unit tests

Checkout Unity Submodule By default, the submodules in this repository are configured with `update=none` in *.gitmodules* to avoid increasing clone time and disk space usage of other repositories that submodule this repository.

To build unit tests, the submodule dependency of Unity is required. Use the following command to clone the submodule:

```
git submodule update --checkout --init --recursive --test/unit-test/Unity
```

Platform Prerequisites

- For running unit tests
  - C90 compiler like gcc
  - CMake 3.13.0 or later
  - Ruby 2.0.0 or later is additionally required for the Unity test framework (that we use).
- For running the coverage target, lcov is additionally required.

Steps to build Unit Tests

1. Go to the root directory of this repository. (Make sure that the **Unity** submodule is cloned as described *above*.)
2. Create build directory: `mkdir build && cd build`
3. Run *cmake* while inside build directory: `cmake -S ../test`
4. Run this command to build the library and unit tests: `make all`
5. The generated test executables will be present in `build/bin/tests` folder.
6. Run `ctest` to execute all tests and view the test run summary.

Contributing See *CONTRIBUTING.md* for information on contributing.

Over-the-air Update Library

AWS IoT Over-the-air Update Library The OTA library enables you to manage the notification of a newly available update, download the update, and perform cryptographic verification of the firmware update. Using the library, you can logically separate firmware updates from the application running on your devices. The OTA library can share a network connection with the application, saving memory in resource-constrained devices. In addition, the OTA library lets you define application-specific logic for testing, committing, or rolling back a firmware update. The library supports different application protocols like Message Queuing Telemetry Transport (MQTT) and Hypertext Transfer Protocol (HTTP), and provides various configuration options you can fine tune depending on network type and conditions. This library is distributed under the *MIT Open Source License*.

This library has gone through code quality checks including verification that no function has a GNU Complexity score over 8. This library has also undergone static code analysis from Coverity static analysis.

See memory requirements for this library *here*.

AWS IoT Over-the-air Update Library v3.4.0 source code is part of the FreeRTOS 202210.00 LTS release.

AWS IoT Over-the-air Update Library v3.3.0 source code is part of the FreeRTOS 202012.01 LTS release.

AWS IoT Over-the-air Updates Config File The AWS IoT Over-the-air Updates library exposes configuration macros that are required for building the library. A list of all the configurations and their default values are defined in *ota_config_defaults.h*. To provide custom values for the configuration macros, a custom config file named ota_config.h can be provided by the user application to the library.

By default, a ota_config.h custom config is required to build the library. To disable this requirement and build the library with default configuration values, provide OTA_DO_NOT_USE_CUSTOM_CONFIG as a compile time preprocessor macro.

Building the Library The *otaFilePaths.cmake* file contains the information of all source files and the header include paths required to build the AWS IoT Over-the-air Updates library.

As mentioned in the previous section, either a custom config file (i.e. ota_config.h) OR the OTA_DO_NOT_USE_CUSTOM_CONFIG macro needs to be provided to build the AWS IoT Over-the-air Updates library.

For a CMake example of building the AWS IoT Over-the-air Updates library with the otaFilePaths.cmake file, refer to the coverity_analysis library target in the *test/CMakeLists.txt* file.

Building Unit Tests

Checkout CMock Submodule By default, the submodules in this repository are configured with update=none in *.gitmodules* to avoid increasing clone time and disk space usage of other repositories (like AWS IoT Device SDK for Embedded C that submodules this repository).

To build unit tests, the submodule dependency of CMock is required. Use the following command to clone the submodule:

```
git submodule update --checkout --init --recursive test/unit-test/CMock
```

Platform Prerequisites

- For building the library, **CMake 3.13.0** or later and a **C90 compiler**.
- For running unit tests, **Ruby 2.0.0** or later is additionally required for the CMock test framework (that we use).
- For running the coverage target, **gcov** and **lcov** are additionally required.

Steps to build unit tests

1. Go to the root directory of this repository. (Make sure that the **CMock** submodule is cloned as described *above*.)
2. Run the *cmake* command: cmake -S test -B build

3. Run this command to build the library and unit tests: `make -C build all`
4. The generated test executables will be present in `build/bin/tests` folder.
5. Run `cd build && ctest` to execute all tests and view the test run summary.

Migration Guide

How to migrate from v2.0.0 (Release Candidate) to v3.4.0 The following table lists equivalent API function signatures in v2.0.0 (Release Candidate) and v3.4.0 declared in *ota.h*

v2.0.0 (Release Candidate)	v3.4.0	Notes
`OtaState_t OTA_Shutdown( uint32_t ticksToWait );`	`OtaState_t OTA_Shutdown( uint32_t ticksToWait, uint8_t unsubscribeFlag );`	`unsubscribeFlag` indicates if unsubscribe operations should be performed from the job topics when shutdown is called. Set this as 1 to unsubscribe, 0 otherwise.

How to migrate from version 1.0.0 to version 3.4.0 for OTA applications Refer to OTA Migration document for the summary of updates to the API. Migration document for OTA PAL also provides a summary of updates required for upgrading the OTA-PAL to work with v3.4.0 of the library.

Porting In order to support AWS IoT Over-the-air Updates on your device, it is necessary to provide the following components:

1. Port for the OTA Portable Abstraction Layer (PAL).
2. OS Interface
3. MQTT Interface

For enabling data transfer over HTTP dataplane the following component should also be provided:

1. HTTP Interface

NOTE When using OTA over HTTP dataplane, MQTT is required for control plane operations and should also be provided.

CBMC To learn more about CBMC and proofs specifically, review the training material here.

The `test/cbmc/proofs` directory contains CBMC proofs.

In order to run these proofs you will need to install CBMC and other tools by following the instructions here.

Reference examples Please refer to the demos of the AWS IoT Over-the-air Updates library in the following location for reference examples on POSIX and FreeRTOS:

Platform	Location
POSIX	AWS IoT Device SDK for Embedded C
FreeRTOS	FreeRTOS/FreeRTOS
FreeRTOS	FreeRTOS AWS Reference Integrations

Documentation

Existing Documentation For pre-generated documentation, please see the documentation linked in the locations below:

Location
AWS IoT Device SDK for Embedded C
FreeRTOS.org

Note that the latest included version of coreMQTT may differ across repositories.

Generating documentation The Doxygen references were created using Doxygen version 1.9.2. To generate the Doxygen pages, please run the following command from the root of this repository:

```
doxygen docs/doxygen/config.doxyfile
```

Contributing See *CONTRIBUTING.md* for information on contributing.

3.3 Connectivity

3.3.1 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.

3.4 File System

3.4.1 FatFs

MCUXpresso SDK : mcuxsdk-middleware-fatfs

Overview This repository is for FatFs middleware delivery and it contains the components 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-manifests) for the complete delivery of MCUXpresso SDK.

Documentation Overall details can be reviewed here: MCUXpresso SDK Online Documentation

Visit FatFs - 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 Contributions are not currently accepted. Guidelines to contribute will be posted in the future.

Repo Specific Content This is MCUXpresso SDK fork of FatFs (FAT file system created by ChaN). Official documentation is available at http://elm-chan.org/fsw/ff/

MCUXpresso version is extending original content by following hardware specific porting layers:

- mmc_disk
- nand_disk
- ram_disk
- sd_disk
- sdspi_disk
- usb_disk

Changelog FatFs

All notable changes to this project will be documented in this file.

The format is based on Keep a Changelog

[R0.15_rev0]

- Upgraded to version 0.15
- Applied patches from http://elm-chan.org/fsw/ff/patches.html

[R0.14b_rev1]

- Applied patches from http://elm-chan.org/fsw/ff/patches.html

[R0.14b_rev0]

- Upgraded to version 0.14b

[R0.14a_rev0]

- Upgraded to version 0.14a
- Applied patch ff14a_p1.diff and ff14a_p2.diff

[R0.14_rev0]

- Upgraded to version 0.14
- Applied patch ff14_p1.diff and ff14_p2.diff

[R0.13c_rev0]

- Upgraded to version 0.13c
- Applied patches ff_13c_p1.diff,ff_13c_p2.diff, ff_13c_p3.diff and ff_13c_p4.diff.

[R0.13b_rev0]

- Upgraded to version 0.13b

[R0.13a_rev0]

- Upgraded to version 0.13a. Added patch ff_13a_p1.diff.

[R0.12c_rev1]

- Add NAND disk support.

[R0.12c_rev0]

- Upgraded to version 0.12c and applied patches ff_12c_p1.diff and ff_12c_p2.diff.

[R0.12b_rev0]

- Upgraded to version 0.12b.

[R0.11a]

- Added glue functions for low-level drivers (SDHC, SDSPI, RAM, MMC). Modified diskio.c.
- Added RTOS wrappers to make FatFs thread safe. Modified syscall.c.
- Renamed ffconf.h to ffconf_template.h. Each application should contain its own ffconf.h.
- Included ffconf.h into diskio.c to enable the selection of physical disk from ffconf.h by macro definition.
- Conditional compilation of physical disk interfaces in diskio.c.

3.5 Motor Control

3.5.1 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 spplications 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_RQUEUE_SIZE

```
#define FMSTR_COMM_RQUEUE_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_RQUEUE_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 * Tchar*

where:

- *N* is equal to the length of the receive FIFO queue (configured by the FMSTR_COMM_RQUEUE_SIZE macro). *N* is 1 for the poll-driven mode.
- *Tchar* 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-langiage 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_UINT*n*	Unsigned integer type of size *n* bits (n=8,16,32,64)
FMSTR_TSA_SINT*n*	Signed integer type of size *n* bits (n=8,16,32,64)
FMSTR_TSA_FRAC*n*	Fractional number of size *n* bits (n=16,32,64).
FMSTR_TSA_FRAC_Q(*m,n*)	Signed fractional number in general Q form (m+n+1 total bits)
FMSTR_TSA_FRAC_UQ(*m,n*)	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)
FMSTR_TSA_USERTYPE(*name*)	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
FMSTR_ADDR	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.
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.	
FMSTR_SIZE	Data type used to hold the memory block size.
It is required that this type is unsigned and at least 16 bits wide integer.	
FMSTR_BOOL	Data type used as a general boolean type.
This type is used only in zero/non-zero conditions in the driver code.	
FMSTR_APPCM	Data type used to hold the Application Command code.
Generally, this is an unsigned 8-bit value.	
FMSTR_APPCM	Data type used to create the Application Command data buffer.
Generally, this is an unsigned 8-bit value.	
FMSTR_APPCM	Data type used to hold the Application Command result code.
Generally, this is an unsigned 8-bit value.	

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.

FMSTR_TSA_TII	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 FMSTR_SIZE.	
FMSTR_TSA_TS	Data type used to hold a memory block size, as used in the TSA descriptors.
By default, this is defined as FMSTR_SIZE.	

Public Pipes types The table describes the data types used by the FreeMASTER Pipes API:

FMSTR_HPIPE	Pipe handle that identifies the open-pipe object.
Generally, this is a pointer to a void type.	
FMSTR_PIPE_P(	Integer type required to hold at least 7 bits of data.
Generally, this is an unsigned 8-bit or 16-bit type.	
FMSTR_PIPE_SI	Integer type required to hold at least 16 bits of data.
This is used to store the data buffer sizes.	
FMSTR_PPIPEF	Pointer to the pipe handler function.
See *FMSTR_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.

FMSTR_U8	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.
FMSTR_U16	Unsigned 16-bit integer.
FMSTR_U32	Unsigned 32-bit integer.
FMSTR_S8	Signed 8-bit integer.
FMSTR_S16	Signed 16-bit integer.
FMSTR_S32	Signed 32-bit integer.
FMSTR_FLOAT	4-byte standard IEEE floating-point type.
FMSTR_FLAGS	Data type forming a union with a structure of flag bit-fields.
FMSTR_SIZE8	Data type holding a general size value, at least 8 bits wide.
FMSTR_INDEX	General for-loop index. Must be signed, at least 16 bits wide.
FMSTR_BCHR	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.
FMSTR_BPTR	A pointer to the communication buffer (an array of FMSTR_BCHR).

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.

3.6 Multimedia

3.6.1 Audio Voice

Audio Voice Components

MCUXpresso SDK : audio-voice-components

Overview This repository is for MCUXpresso SDK audio-voice-components middleware delivery and it contains the components 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-manifests) for the complete delivery of MCUXpresso SDK.

Documentation Overall details can be reviewed here: MCUXpresso SDK Online Documentation

Visit Audio Voice Components - 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 Contributions are not currently accepted. Guidelines to contribute will be posted in the future.

Overview This repository allows users to add additional functionality to the Maestro Audio framework. This structure is designed for integration with Maestro and is not intended for standalone use. For information on the use of individual components, please refer to the Maestro programmer's guide.

This repository acts as Zephyr module, to be able to use these libraries in Zephyr build system.

Content

- *asrc* - Libraries and public files of Asynchronous Sample Rate Converter, version 1.0.0
- *ssrc* - Libraries and public files of Synchronous Sample Rate Converter, version 1.0.0
- *opus* - Source files of Opus decoder and encoder, version 1.3.1
- *opusfile* - Source files for Opus streams in the Ogg container, version 0.12
- *ogg* - Source files of Ogg container, version 1.3.5
- *decoders* - Libraries and public files of following audio decoders:
  - *aac* - AAC decoder, version 1.0.0
  - *flac* - FLAC decoder, version 1.0.0
  - *mp3* - MP3 decoder, version 1.0.0
  - *wav* - WAV decoder, version 1.0.0
- zephyr/ - Files allowing usage of the libraries in Zephyr build

Following table contains information about libraries and source files availability:

Asynchronous Sample Rate Converter The Asynchronous Sample Rate Converter (ASRC) software module compensates the drift between two mono audio signals. This is not a frequency converter and so the nominal signal frequency is the same before and after the ASRC. More details about ASRC are available in the User Guide, which is located in asrc\doc\.

Synchronous Sample Rate Converter The Synchronous Sample Rate Converter (SSRC) software module converts an audio signal (mono or stereo) with a certain sampling frequency to an audio signal with another sampling frequency. More details about SSRC are available in the *User Guide*.

Opus For Opus decoder and encoder documentation please see following link: opus.

Opus File The Opus File provides a API for decoding and basic manipulation of Opus streams in Ogg container and depends on *Opus* and *Ogg* libraries. For Opus File documentation please see following link: opusfile.

Ogg Container For Ogg container documentation please see following link: ogg.

Decoders Each decoder contains libraries for supported processor and toolchain (see table above), corresponding Public API file and documentation folder.

AAC For decoder features please see *aacdec*, for API Usage please see *aacd_ug*.

FLAC For decoder features please see *flacdec*, for API Usage please see *flacd_ug*.

MP3 For decoder features please see *mp3dec*, for API Usage please see *mp3d_ug*.

WAV For decoder features please see *wavdec*, for API Usage please see *wavd_ug*.

Zephyr build To add library into the Zephyr build, add CONFIG_NXP_AUDIO_VOICE_COMPONENTS_* for specific libraries into your prj.conf. For all configuration options, see *zephyr/Kconfig*.

List of supported libraries in Zephyr:

- Decoders:
  - AAC
  - FLAC
  - MP3
  - FLAC
  - OPUS
- Encoders
  - OPUS

AAC decoder

AAC decoder features

- The AAC decoder implementation supports the following:
- Supported profile : AAC-LC
- Sampling rate : 8 kHz, 11.025 kHz, 12 kHz, 16 kHz, 22.05 kHz, 24 kHz, 32 kHz, 44.1 kHz, 48 kHz
- Channel : stereo and mono
- Bits per samples : 16 bit
- Container format : (MPEG-2 Style)AAC transport format - ADTS and ADIF.

Specification and reference

Performance

Memory information The memory usage of the decoder in bytes is:

- Code/flash = 26332 + 19264 = 45596
- Data/RAM = 26832

Section	Size
.text	26332
.ro & .const	19264
.bss	26832

CPU usage

- CPU core clock in MHz: 20.97.

Track type	Duration of track in second	Frame size in bytes	Performance MIPS of codec (in MHz)
48 kHz, stereo	38 s	4096	12.2 MHz

API Usage of AAC Decoder

Overview

- This section describes the integration steps to call AAC decoder APIs by the application code. During each step, the used data structures and functions are explained. All CCI public APIs are defined in aac_cci.h header file. This file is located at \decoders\aac.

Configuration

Build Options AAC Decoder library is built with the following defined/enabled macros.

- There is no macro or define used to build the AAC decoder.

Buffer Allocation

- The AAC decoder does not perform dynamic memory allocation. The application calls the function AACDecoderGetMemorySize() to get the decoder memory requirements. This function must be called before all other decoder functions are invoked.
- The application first gets the required memory size for the decoder, then allocates memory for the decoder structures. Structures contain Main Decoder parameters and decoder information parameters.
- This function populates the required memory for the decoder and returns the required memory size in bytes.

Initialization

- AACDecoderInit() function must be called before decode API. This API allocates the memory to decoder main structure and also initializes the decoder main structure parameters.
- It also registers the call back functions to the decoder, which is used by the decoder to read or seek the input stream.

Decoding

- AACDecoderDecode() function is main decoding API of the decoder. This API decodes the encoded input stream and fills the PCM output samples into decoder output PCM buffer.
- This API gives the information about the number of samples produced by the decoder and also provides the pointer to the decoder output PCM samples buffer.

Seeking

- AACDecoderSeek() function calculates the actual frame boundary align offset from the unalign seek offset and returns the actual seek offset. It also resets the decoder internal states and variables.

Callback Usage All the callback functions are assigned to the respective pointers before the codec initialization is called. Callback APIs are described below.

Read Callback API AAC Decoder read call back API reads the bytes from the input stream and fills them into decoder internal bit stream buffer. It returns the number of bytes read from the input stream.

Seek Callback API This call back API is for the seek operation.

Get File Position Callback API This call back API gives the current file position.

FLAC decoder

FLAC decoder features

- The FLAC decoder implementation support the following:
- Sampling rate: 8 kHz, 11.05 kHz, 12 kHz, 16 kHz, 22.05 kHz, 32 kHz, 44.1 kHz, and 48 kHz.
- Channel : stereo and mono
- Bits per samples : 16 bits

Specification and reference

Official website

- FLAC lossless audio codec is at https://xiph.org/flac.

Inbound licensing

- For licensing information please refer to FLAC's official website: https://xiph.org/flac/license.html.

Performance

Memory information The memory usage of the decoder in bytes is:

- Code/flash = 15744 + 2080 = 17824
- Data/RAM = 27936

Section	Size
.text	15744
.ro & .const	2080
.bss	27936

CPU usage

- Output frame size: 16384 bytes.
- CPU core clock in MHz: 20.97.

Track type	Duration of track in second	Performance MIPS of codec (in MHz)
48 kHz, stereo	76 s	30.7 MHz
32 kHz, stereo	76 s	20.3 MHz
8 kHz, stereo	37 s	5.34 MHz

Following test cases are performed:

- Audio format listening test
- Audio quality test

For all above test cases, test tracks are played through the end without any distortion, glitching, hanging, or crashing.

API Usage of FLAC Decoder

Overview

- This section describes the integration steps to call FLAC decoder APIs by the application code. During each step the used data structures and functions are explained. All cci public APIs are defined in flac_cci.h header file. This file is located at \decoders\flac\include.

Configuration

Build Options

- SUPPORT_16_BITS_ONLY :- This macro is used to enable 16bits per sample flac decoder.
- *ASM* :- This macro is used to enable ARM assembly macros for 24bits per sample flac decoder.

Buffer Allocation

- The FLAC decoder does not perform dynamic memory allocation. The application calls the function FLACDecoderGetMemorySize() to get the decoder memory requirements. This function must be called before all other decoder functions are invoked.
- The application first gets the required memory size for the decoder and then allocates memory for the decoder structures. Structures contain Main Decoder parameters and decoder information parameters.
- This function populates the required memory for the decoder and returns the required memory size in bytes.

Initialization

- FLACDecoderInit() function must be called before decode API. This API allocates the memory to decoder main structure and also initializes the decoder main structure parameters.
- It also registers the call back functions to the decoder, which will be used by decoder to read or to seek the input stream.

Decoding

- FLACDecoderDecode() function is main decoding API of the decoder. This API decodes the encoded input stream and fills the PCM output samples into decoder output PCM buffer.
- This API gives the information about the number of samples produced by the decoder and also provides the pointer to the decoder output PCM samples buffer.

Seeking

- FLACDecoderSeek() function calculates the actual frame boundary align offset from the unalign seek offset and returns the actual seek offset. It also resets the decoder internal states and variables.

Callback Usage All the callback functions will be assigned to the respective pointers before the codec initialization is called. Callback APIs are described below.

Read Callback API FLAC Decoder read call back API reads the bytes from the input stream and fills them into decoder internal bit stream buffer. It returns the number of bytes read from the input stream.

Seek Callback API This call back API is for the seek operation.

Get File Position Callback API This call back API gives the current file position.

MP3 decoder

MP3 decoder features

- MP3 decoder supports mpeg-1, mpeg-2, mpeg-2.5.
- All MP3 features supported , including joint stereo, mid-side stereo, intensity stereo, and dual channel.
- Supported sampling rate: 8 kHz, 11.025 kHz, 12 kHz, 16 kHz, 22.05 kHz, 24 kHz, 32 kHz, 44.1 kHz and 48 kHz.
- Supported channel: stereo and mono
- Supported bits per samples: 16 bit
- Supported bit rate: 8, 16, 24, 32, 40, 48, 56, 64, 80, 96, 112, 128, 144, 160, 176, 192, 224, 256, 320, 384, 416, and 448.

Performance

Memory information The memory usage of the decoder (data obtained from IAR compiler) in bytes is:

- Code/flash = 26884 + 18372 = 45256
- RAM = 16200

Section	Size
.text	26884
.ro & .const	18372
.bss	16200

CPU usage The performance of the decoder was measured using the real hardware platform (RT1060).

- CPU core clock in MHz: 600.

Track type	Duration of track in second	Frame size in bytes	Performance MIPS of codec (in MHz)
320 Kbps, 44.1 kHz, stereo	358 s	2304	~24 MHz
192 Kbps, 48 kHz, stereo	10 s	2304	~18 MHz

API Usage of MP3 Decoder

Overview

- This section describes the integration steps to call MP3 decoder APIs by the application code. During each step the used data structures and functions are explained. All cci public APIs are defined in mp3_cci.h header file. This file is located at \decoders\mp3.

Configuration

Build Options MP3 Decoder library is built with the following defined/enabled macros.

- There is no macro or define used to build the MP3 decoder.

Buffer Allocation

- The MP3 decoder does not perform dynamic memory allocation. The application calls the function MP3DecoderGetMemorySize() to get the decoder memory requirements. This function must be called before all other decoder functions are invoked.
- The application first gets the required memory size for the decoder and then allocates memory for the decoder structures. Structures contain Main Decoder parameters and decoder information parameters.
- This function populates the required memory for the decoder and returns the required memory size in bytes.

Initialization

- MP3DecoderInit() function must be called before decode API. This API allocates the memory to decoder main structure and also initializes the decoder main structure parameters.
- It also registers the call back functions to the decoder, which will be used by decoder to read or to seek the input stream.

Decoding

- MP3DecoderDecode() function is main decoding API of the decoder. This API decodes the encoded input stream and fills the PCM output samples into decoder output PCM buffer.
- This API gives the information about the number of samples produced by the decoder and also provides the pointer to the decoder output PCM samples buffer.

Seeking

- MP3DecoderSeek() function calculates the actual frame boundary align offset from the unalign seek offset and returns the actual seek offset. It also resets the decoder internal states and variables.

Callback Usage All the callback functions will be assigned to the respective pointers before the codec initialization is called. Callback APIs are described below.

Read Callback API MP3 Decoder read call back API reads the bytes from the input stream and fills them into decoder internal bit stream buffer. It returns the number of bytes read from the input stream.

Seek Callback API This call back API is for the seek operation.

Get File Position Callback API This call back API gives the current file position.

WAV decoder

WAV decoder features

- The WAV decoder implementation support the following:
- Sampling rate: 8 kHz, 11.025kHz, 16 kHz, 22.05 kHz, 32 kHz, 44.1 kHz, and 48 kHz.
- Channel: stereo and mono
- PCM format with 8/16/24 bits per sample.

Performance

Memory information The memory usage of the decoder in bytes is:

- Code/flash = 6260 + 342 = 6602
- Data/RAM = 16 + 20696 = 20712

Section	Size
.text	6260
.ro & .const	342
.bss	20696
.data	16

CPU usage The performance of the decoder was measured using the decoder standalone unit test.

- CPU core clock in MHz: 20.97 MHz.

Track type	Duration of track in second	Frame size in bytes	Performance MIPS of codec (in MHz)
48 kHz, stereo, PCM	12 s	4096	9.68 MHz

Following test cases were performed:

- Audio format listening test
- Audio quality test

For all above test cases, test tracks are played through the end without any distortion, glitching, hanging, or crashing.

API Usage of WAV Decoder

Overview

- This section describes the integration steps to call MP3 decoder APIs by the application code. During each step the used data structures and functions are explained. All cci public APIs are defined in wav_cci.h header file. This file is located at \decoders\wav.

Configuration

Build Options WAV Decoder library is built with the following defined/enabled macros.

- There is no macro or define used to build the WAV decoder.

Buffer Allocation

- The WAV decoder does not perform dynamic memory allocation. The application calls the function WAVDecoderGetMemorySize() to get the decoder memory requirements. This function must be called before all other decoder functions are invoked.
- The application first gets the required memory size for the decoder and then allocates memory for the decoder structures. Structures contain Main Decoder parameters and decoder information parameters.
- This function populates the required memory for the decoder and returns the required memory size in bytes.

Initialization

- WAVDecoderInit() function must be called before decode API. This API allocates the memory to decoder main structure and also initializes the decoder main structure parameters.
- It also registers the call back functions to the decoder, which will be used by decoder to read or to seek the input stream.

Decoding

- WAVDecoderDecode() function is main decoding API of the decoder. This API decodes the encoded input stream and fills the PCM output samples into decoder output PCM buffer.
- This API gives the information about the number of samples produced by the decoder and also provides the pointer to the decoder output PCM samples buffer.

Seeking

- WAVDecoderSeek() function calculates the actual frame boundary align offset from the unalign seek offset and returns the actual seek offset. It also resets the decoder internal states and variables.

Callback Usage All the callback functions will be assigned to the respective pointers before the codec initialization is called. Callback APIs are described below.

Read Callback API WAV Decoder read call back API reads the bytes from the input stream and fills them into decoder internal bit stream buffer. It returns the number of bytes read from the input stream.

Seek Callback API This call back API is for the seek operation.

Get File Position Callback API This call back API gives the current file position.

Synchronous Sample Rate Converter

Introduction The Synchronous Sample Rate Converter (SSRC) software module converts a mono or stereo audio signal with a certain sampling frequency to an audio signal with a different sampling frequency. The sample rate converter works synchronously, meaning that input and output sampling rates are exactly known for a mutual clock reference.

To accomplish a professional sampling conversion quality and minimal system footprint, the SRC SW module contains highly optimized components.

The SSRC module supports the following features.

- Multiple instances of the sample rate converter can run at the same time.
- Supported sampling frequencies: 32 kHz, 44.1 kHz, and 48 kHz plus the halves and the quarters of these three sample rates. The input and output sample rates are freely selectable out of the supported sampling rates
- Selectable Mono/Stereo Input/Output.
- Selectable quality level: high quality/ very high quality.

Acronyms *Table 1* lists the acronyms used in this document.

Acror	Description
Fs	Sampling Frequency
Fs-LOW(	Lowest sample rate used for the conversion **Note:** Input sample rate for up sampling and the output sample rate for down sampling
FsIN	Input sample rate
FsOU	Output sample rate
MIPS	Million Instructions Per Second
SSRC	Synchronous sample rate converter
THD+	Total Harmonic Distortion plus Noise **Note:** The THD+N is defined as the total power of the unwanted signal divided by the power of the wanted signal. The wanted signal is defined as a full scale, 1 kHz sine wave.

Parent topic:*Introduction*

Performance figures The Total Harmonic Distortion Plus Noise (THD+N) of the converted signals is below - 76 (high-quality mode) and - 85 (very high-quality mode) for signal frequencies below 0.45*FsLOW (=90 % of the Nyquist range of the lowest sample clock)

Table 1 and *Table 2* give the THD+N performance (FsIN on the vertical axis and FsOUT on the horizontal axis) for the two supported quality levels. The numbers in the tables give the worst-case THD+N measured for signal frequencies below 0.45*FsLOW. For each conversion ratio, 100 THD+N measurements were executed with signal frequencies linearly spread over the complete Nyquist range.

FsIN/ FsOUT	8000	11025	12000	16000	22050	24000	32000	44100	48000
8000	-92.1	-79.7	-80.1	-80.1	-79.6	-80.2	-79.4	-79.1	-79.2
11025	-79	-92.9	-80	-79.9	-80.2	-79.8	-79.9	-79.5	-78.9
12000	-79	-79.2	-92.7	-80.1	-79.8	-80.3	-79.8	-79.8	-79.5
16000	-81.7	-78.8	-80.2	-93	-78.3	-77.7	-78.3	-78.3	-77.9
22050	-77.5	-81.8	-78.2	-79	-93	-79.9	-79.8	-80.3	-79.9
24000	-77.4	-77.9	-81.2	-79.1	-79.2	-92.5	-80.1	-79.8	-79.9
32000	-81	-77.5	-78.9	-81.2	-78.7	-80.1	-92.9	-79.7	-79.2
44100	-79.1	-81.2	-76.7	-77.8	-82	-78.2	-79.1	-93	-79.7
48000	-78.7	-78.8	-81.1	-77.6	-77.9	-81.8	-79.1	-79.3	-93

FsIN/ FsOUT	8000	11025	12000	16000	22050	24000	32000	44100	48000
8000	-92.1	-86.6	-88.6	-91.5	-86.4	-89	-89.7	-89.3	-89.3
11025	-89.1	-92.9	-86.3	-86.3	-91.6	-86.3	-86.5	-89.7	-89.3
12000	-91.4	-88.4	-92.7	-89.6	-86.6	-91.5	-86.8	-86.6	-89.7
16000	-93.1	-88.4	-90.4	-93	-86.6	-88.8	-91.5	-86.5	-89.4
22050	-90.7	-93.5	-89.7	-89.3	-93	-86.5	-86.3	-91.5	-86.6
24000	-93.8	-90.5	-93.5	-91.7	-88.4	-92.5	-89.7	-86.6	-91.5
32000	-93.8	-91	-91.2	-93.3	-88.4	-90.5	-92.9	-86.7	-89
44100	-93.7	-93.6	-91.5	-90.6	-93.8	-89.8	-89.3	-93	-86.5
48000	-94.1	-92.6	-94	-94	-90.1	-93.7	-91.8	-88.4	-93

Parent topic:*Introduction*

Resource usage This section lists the memory and processing requirements for the SSRC module.

Memory requirements The following are the memory requirements for the SSRC module.

Memory item	Size in bytes
Instance memory (persistent)	548
Scratch memory (non-persistent)	15.536 *1*
Program memory for Arm9E and XScale	14k
Program memory for Arm7	15k

Parent topic: Resource usage

1 Worst case number for I/O buffers of 40 ms. If smaller I/O buffers are used, this number is smaller. The required scratch memory is roughly equal to 2 times the buffer size on the highest sample rate.

Processing requirements The following tables give the MIPS performance of the SSRC module. The cycles are measured with zero wait state memory and for I/O buffers of 40 ms.

Note: The user processing 32-bit processing must refer to the very high-quality MIPS results.

On Arm7 and Arm9

FsIN / FsOUT	8000	11025	12000	16000	22050	24000	32000	44100	48000
8000	0.13	4.77	5.17	1.84	6.75	7.33	3.55	9.1	9.89
11025	5.42	0.18	5.58	6.84	2.53	7.75	9.71	4.89	10.31
12000	5.85	6.39	0.2	7.01	8.97	2.76	9.89	12.94	5.32
16000	1.69	7.74	7.99	0.26	9.54	10.33	3.68	13.5	14.65
22050	7.2	2.33	10.09	10.83	0.36	11.17	13.67	5.07	15.49
24000	7.79	8.33	2.53	11.7	12.78	0.39	14.03	17.94	5.51
32000	3.12	10.32	10.58	3.38	15.48	15.98	0.52	19.08	20.66
44100	9.96	4.3	13.65	14.4	4.65	20.18	21.67	0.72	22.34
48000	10.8	11.34	4.68	15.58	16.67	5.06	23.4	25.56	0.78

FsIN / FsOUT	8000	11025	12000	16000	22050	24000	32000	44100	48000
8000	0.07	7.71	8.24	2.28	10.5	11.28	4.41	13.44	14.48
11025	8.19	0.1	8.96	11.04	3.14	12	15.09	6.08	15.2
12000	8.76	9.52	0.1	11.3	14.48	3.41	15.36	20.07	6.61
16000	2.14	11.73	12.01	0.14	15.41	16.48	4.55	21	22.56
22050	10.78	2.94	15.39	16.38	0.19	17.92	22.08	6.27	24
24000	11.57	12.34	3.2	17.51	19.04	0.21	22.61	28.97	6.83
32000	4.19	15.48	15.77	4.27	23.46	24.01	0.28	30.83	32.96
44100	14.78	5.77	20.56	21.56	5.89	30.77	32.75	0.38	35.83
48000	15.92	16.7	6.28	23.15	24.69	6.41	35.02	38.08	0.42

FsIN / FsOUT	8000	11025	12000	16000	22050	24000	32000	44100	48000
8000	0.13	13.61	14.52	4.43	19.03	20.43	8.8	25.06	26.99
11025	14.85	0.18	15.91	19.47	6.1	21.82	27.35	12.13	28.38
12000	15.84	17.36	0.2	19.97	25.4	6.64	27.85	36.26	13.21
16000	4.25	21.24	21.79	0.26	27.22	29.03	8.86	38.07	40.85
22050	20.02	5.85	27.72	29.7	0.36	31.81	38.94	12.2	43.63
24000	21.45	22.98	6.37	31.68	34.71	0.39	39.94	50.8	13.28
32000	8.39	28.74	29.29	8.5	42.48	43.58	0.52	54.43	58.07
44100	28.11	11.57	38.05	40.03	11.71	55.43	59.4	0.72	63.62
48000	30.19	31.71	12.59	42.9	45.96	12.74	63.36	69.42	0.78

Parent topic: Processing requirements

On Arm9e and XScale

FsIN / FsOUT	8000	11025	12000	16000	22050	24000	32000	44100	48000
8000	0.03	1.14	1.25	0.54	1.95	2.14	1.04	3.85	4.23
11025	1.31	0.05	1.36	1.62	0.75	2.23	2.78	1.44	4.38
12000	1.43	1.57	0.05	1.68	2.13	0.82	2.84	3.72	1.57
16000	0.5	1.86	1.93	0.07	2.27	2.5	1.09	3.9	4.29
22050	2.19	0.69	2.42	2.61	0.1	2.72	3.24	1.5	4.46
24000	2.4	2.52	0.75	2.86	3.15	0.1	3.35	4.25	1.63
32000	0.92	3.12	3.18	1.01	3.72	3.86	0.14	4.55	4.99
44100	4.28	1.27	4.15	4.37	1.39	4.83	5.23	0.19	5.43
48000	4.7	4.9	1.39	4.8	5.03	1.51	5.72	6.3	0.21

FsIN / FsOUT	8000	11025	12000	16000	22050	24000	32000	44100	48000
8000	0.06	1.87	2.02	1.07	3.09	3.36	2.07	6.09	6.63
11025	2.27	0.09	2.25	2.66	1.47	3.56	4.4	2.85	7.01
12000	2.45	2.76	0.09	2.75	3.43	1.6	4.5	5.83	3.1
16000	0.99	3.23	3.36	0.13	3.73	4.05	2.14	6.17	6.72
22050	3.69	1.36	4.14	4.55	0.17	4.51	5.31	2.95	7.13
24000	4.01	4.28	1.48	4.9	5.51	0.19	5.51	6.85	3.21
32000	1.83	5.26	5.39	1.98	6.46	6.71	0.25	7.47	8.09
44100	7.22	2.52	6.94	7.38	2.72	8.27	9.1	0.35	9.02
48000	7.85	8.33	2.74	8.02	8.57	2.97	9.81	11.03	0.38

FsIN / FsOUT	8000	11025	12000	16000	22050	24000	32000	44100	48000
8000	0.03	1.21	1.33	0.61	2.08	2.29	1.17	4.1	4.51
11025	1.47	0.05	1.44	1.72	0.84	2.38	2.97	1.61	4.66
12000	1.62	1.76	0.05	1.78	2.26	0.91	3.03	3.98	1.75
16000	0.55	2.1	2.17	0.07	2.42	2.65	1.22	4.16	4.57
22050	2.49	0.76	2.73	2.95	0.1	2.88	3.45	1.68	4.75
24000	2.75	2.86	0.83	3.23	3.52	0.1	3.56	4.53	1.83
32000	1	3.56	3.63	1.11	4.2	4.34	0.14	4.84	5.3
44100	4.86	1.38	4.74	4.98	1.53	5.46	5.89	0.19	5.75
48000	5.38	5.55	1.5	5.5	5.71	1.66	6.47	7.05	0.21

FsIN / FsOUT	8000	11025	12000	16000	22050	24000	32000	44100	48000
8000	0.06	2.11	2.29	1.2	3.55	3.86	2.31	6.99	7.61
11025	2.62	0.09	2.52	3.01	1.66	4.07	5.07	3.19	8
12000	2.85	3.15	0.09	3.11	3.9	1.81	5.17	6.75	3.47
16000	1.09	3.73	3.85	0.13	4.22	4.57	2.41	7.1	7.72
22050	4.32	1.5	4.79	5.23	0.17	5.05	6.02	3.32	8.15
24000	4.74	4.99	1.64	5.69	6.3	0.19	6.22	7.8	3.61
32000	1.98	6.18	6.3	2.18	7.45	7.71	0.25	8.44	9.14
44100	8.43	2.72	8.18	8.64	3.01	9.59	10.47	0.35	10.1
48000	9.26	9.66	2.97	9.49	9.97	3.27	11.39	12.59	0.38

Parent topic: Processing requirements

On Cortex-A8 for worst case of 48000 Hz to 44100 Hz

Mode	MIPs
Mono at High Quality	3.13
Stereo at High Quality	3.61
Mono at Very High Quality	4.13
Stereo at Very High Quality	6.52

Parent topic: Processing requirements

Parent topic: Resource usage

Parent topic:*Introduction*

Application programmers interface (API) This section describes the application programming interface (API) libraries of the SSRC module.

Type definitions This section describes the type definitions of the SSRC module.

Types for allocation of instance and scratch memory The instance memory is the memory that contains the state of one instance of the SSRC module. Multiple instances of the SSRC module can exist, each with it is own instance memory. S memory is the memory that is only used temporarily by the process function of the SSRC module. This memory can be used as scratch memory by any other function running in the same thread as the SSRC module. Different threads cannot share the scratch memories.

The application must allocate both the instance and the scratch memory. The SSRC module does not allocate memory.

There is a data type available for both the instance and the scratch memory, namely SSRC_Instance_t and SSRC_Scratch_t. The instance type is defined as structures of the correct size in the SSRC header file. Both the instance and the scratch memory must be 4 bytes aligned.

Parent topic: Type definitions

LVM_Fs_en **Definition:**

```
typedef enum
{
    LVM_FS_8000    = 0,
    LVM_FS_11025   = 1,
    LVM_FS_12000   = 2,
    LVM_FS_16000   = 3,
    LVM_FS_22050   = 4,
    LVM_FS_24000   = 5,
    LVM_FS_32000   = 6,
    LVM_FS_44100   = 7,
    LVM_FS_48000   = 8
} LVM_Fs_en;
```

Description:

Used to pass the input and the output sample rate to the SSRC.

Parent topic: Type definitions

LVM_Format_en **Definition:**

```
typedef enum
{
    LVM_STEREO          = 0,
    LVM_MONOINSTEREO    = 1,
    LVM_MONO            = 2
} LVM_Format_en;
```

Description:

The LVM_Format_en enumerated type is used to set the value of the SSRC data format.

The SSRC supports input data in two formats Mono and Stereo. For an input buffer of NumSamples = N (meaning N sample pairs for Stereo and MonoInStereo or N samples for Mono), the format of data in the buffer is as listed in *Table 1*:

Sample Number	Stereo	MonoInStereo	Mono
0	Left(0)	Mono(0)	Mono(0)
1	Right(0)	Mono(0)	Mono(1)
2	Left(1)	Mono(1)	Mono(2)
3	Right(1)	Mono(1)	Mono(3)
4	Left(2)	Mono(2)	Mono(4)
“	“	“	“
“	“	“	“
N-2	Left(N/2-1)	Mono(N/2-1)	Mono(N-2)
N-1	Right(N/2-1)	Mono(N/2-1)	Mono(N-1)
N	Left(N/2)	Mono(N/2)	Not Used
N+1	Right(N/2)	Mono(N/2)	Not Used
N+2	Left(N/2+1)	Mono(N/2+1)	Not Used
N+3	Right(N/2+1)	Mono(N/2+1)	Not Used
“	“	“	Not Used
“	“	“	Not Used
2*N-2	Left(N-1)	Mono(N-1)	Not Used

Parent topic: Type definitions

SSRC_Quality_en **Definition:**

```
typedef enum
{
    SSRC_QUALITY_HIGH           = 0,
    SSRC_QUALITY_VERY_HIGH      = 1,
    SSRC_QUALITY_DUMMY          = LVM_MAXENUM
} SSRC_Quality_en;
```

Description:

Used to select the quality level of the SSRC. For details, see Performance figures. Selecting the highest-quality level, comes with a cost in the SSRC processing requirements. Therefore, it should only be done for critical applications.

Parent topic: Type definitions

Instance parameters **Definition:**

```
typedef struct
{
    SSRC_Quality_en     Quality;
    LVM_Fs_en           SSRC_Fs_In;
    LVM_Fs_en           SSRC_Fs_Out;
    LVM_Format_en       SSRC_NrOfChannels;
    short               NrSamplesIn;
    short               NrSamplesOut;
} SSRC_Params_t;
```

Description:

Used to pass the SSRC instance parameters to the SSRC module. It is a structure that contains the members for input sample rate, output sample rate, the number of channels, and the number of samples on the input and output audio stream.

Parent topic: Type definitions

Nr of samples mode **Definition:**

```
typedef enum
{
    SSRC_NR_SAMPLES_DEFAULT     = 0,
    SSRC_NR_SAMPLES_MIN         = 1,
    SSRC_NR_SAMPLES_DUMMY       = LVM_MAXENUM
} SSRC_NR_SAMPLES_MODE_en;
```

Description:

The SSRC_NR_SAMPLES_MODE_en enumerated type specifies the two different modes that can be used to retrieve the number of samples using the SSRC_GetNrSamples function.

Parent topic: Type definitions

Function return status **Definition:**

```
typedef enum
{
    SSRC_OK                     = 0,
    SSRC_INVALID_FS             = 1,
    SSRC_INVALID_NR_CHANNELS    = 2,
    SSRC_NULL_POINTER           = 3,
    SSRC_WRONG_NR_SAMPLES       = 4,
    SSRC_ALLINGMENT_ERROR       = 5,
    SSRC_INVALID_MODE           = 6,
    SSRC_INVALID_VALUE          = 7,
    SSRC_ALLINGMENT_ERROR       = 8,
    LVXXX_RETURNSTATUS_DUMMY = LVM_MAXENUM
} SSRC_ReturnStatus_en;
```

Description:

The SSRC_ReturnStatus_en enumerated type specifies the different error codes returned by the API functions. For the exact meaning, see the individual function descriptions.

Parent topic: Type definitions

Parent topic:*Application programmers interface (API)*

Functions

This section lists all the API functions of the SSRC module and explains their parameters.

SSRC_GetNrSamples **Prototype:**

```
SSRC_ReturnStatus_en SSRC_GetNrSamples
  (SSRC_NR_SAMPLES_MODE_en  Mode,
   SSRC_Params_t*           pSSRC_Params );
```

Description:

This function retrieves the number of samples or sample pairs for stereo used as an input and as an output of the SSRC module.

Nam	Type	Description
Mod	SSRC_N	There are two modes: - SSRC_NR_SAMPLES_DEFAULT: In this mode, the function returns the number of samples for 40 ms blocks - SSRC_NR_SAMPLES_MIN: the function returns the minimal number of samples supported for this conversion ratio. The SSRC_Init function accepts each integer multiple of this ratio. Formula: blocksize (ms) = 1/gcd(Fs_In,Fs_Out)
pSSF	SSRC_Pa	Pointer to the instance parameters. The application fills in the values of the input sample rate, the output sample rate, and the number of channels. Based on this input, the SSRC_GetNrSamples fills in the values for the number of samples for the input and the output audio stream.

Returns:

SSRC_OK	When the function call succeeds.
SSRC_INVALID_FS	When the requested input or output sampling rates are invalid.
SSRC_INVALID_NR_CHANN	When the channel format is not equal to LVM_MONO or LVM_STEREO.
SSRC_NULL_POINTER	When pSSRC_Params is a NULL pointer.
SSRC_INVALID_MODE	When mode is not a valid setting.

Note: The SSRC_GetNrSamples function returns the values from the following tables. Instead of calling the SSRC_GetNrSamples function, use the values from these tables directly.

Sample rate	Nr of samples
8000	320
11025	441
12000	480
16000	640
22050	882
24000	960
32000	1280
44100	1764
48000	1920

In/Out	8000	11025	12000	16000	22050	24000	32000	44100	48000
8000	11	320441	23	12	160441	13	14	80441	16
11025	441320	11	147160	441640	12	147320	4411280	14	147640
12000	32	160147	11	34	80147	12	38	40147	14
16000	21	640441	43	11	320441	23	12	160441	13
22050	441160	21	14780	441320	11	147160	441640	12	147320
24000	31	320147	21	32	160147	11	34	80147	12
32000	41	1280441	83	21	640441	43	11	320441	23
44100	44180	41	14740	441160	21	14780	441320	11	147160
48000	61	640147	41	31	320147	21	32	160147	11

Parent topic: Functions

SSRC_GetScratchSize **Prototype:**

```
SSRC_ReturnStatus_en SSRC_GetScratchSize
  (SSRC_Params_t*     pSSRC_Params,
   LVM_INT32*         pScratchSize );
```

Description:

This function retrieves the scratch size for a given conversion ratio and for given buffer sizes at the input and at the output.

Name	Type	Description
pSSRC_Par	SSRC_Param	Pointer to the instance parameters. All members should have a valid value.
pScratch-Size	LVM_INT32*	Pointer to the scratch size. The SSRC_GetScratchSize function fills in the correct value (in bytes).

|

Returns:

SSRC_OK	When the function call succeeds.
SSRC_INVALID_FS	When the requested input or output sampling rates are invalid.
SSRC_INVALID_NR_CHANN	When the channel format is not equal to LVM_MONO or LVM_STEREO.
SSRC_NULL_POINTER	When pSSRC_Params or pScratchSize is a NULL pointer.
SSRC_WRONG_NR_SAMPLI	When the number of samples on the input or on the output are incorrect.

Parent topic: Functions

SSRC_Init Prototype:

```
SSRC_ReturnStatus_en SSRC_Init
  (SSRC_Instance_t* pSSRC_Instance,
   SSRC_Scratch_t*  pSSRC_Scratch,
   SSRC_Params_t*   pSSRC_Params,
   LVM_INT16**      ppInputInScratch,
   LVM_INT16**      ppOutputInScratch);
```

Description:

The SSRC_Init function initializes an instance of the SSRC module.

Name	Type	Description
pSSRC_	SSRC_	Pointer to the instance of the SSRC. This application must allocate the memory before calling the SSRC_Init function.
pSSRC_	SSRC_	Pointer to the scratch memory. The pointer is saved inside the instance and is used by the SSRC_Process function. The application must allocate the scratch memory before calling the SSRC_Init function.
pSSRC_	SSRC_	Pointer to the instance parameters.
ppInputInScratch	LVM_I	The SSRC module can be called with the input samples located in scratch. This pointer points to a location that holds the pointer to the location in the scratch memory that can be used to store the input samples. For example, to save memory.
ppOutputInScratch	LVM_I	The SSRC module can store the output samples in the scratch memory. This pointer points to a location that holds the pointer to the location in the scratch memory that can be used to store the output samples. For example, to save memory.

Returns:

SSRC_OK	When the function call succeeds.
SSRC_INVALID_FS	When the requested input or output sampling rates are invalid.
SSRC_INVALID_NR_CHANN	When the channel format is not equal to LVM_MONO or LVM_STEREO.
SSRC_NULL_POINTER	When pSSRC_Params or pScratchSize is a NULL pointer.
SSRC_WRONG_NR_SAMPLI	When the number of samples on the input or on the output are incorrect.
SSRC_ALIGNMENT_ERROR	When the instance memory or the scratch memory is not 4 bytes aligned.

Parent topic: Functions

SSRC_SetGains **Prototype:**

```
SSRC_ReturnStatus_en SSRC_SetGains
  (SSRC_Instance_t* pSSRC_Instance,
   LVM_Mode_en      bHeadroomGainEnabled,
   LVM_Mode_en      bOutputGainEnabled,
   LVM_INT16        OutputGain);
```

Description:

This function sets headroom gain and the post gain of the SSRC. The SSRC_SetGains function is an optional function that should be used only in rare cases. Preferably, use the default settings.

Name	Type	Description
pSSRC	SSRC_	Pointer to the instance of the SSRC.
bHeadroomGainEnabled	LVM_	Parameter to enable or disable the headroom gain of the SSRC. The default value is LVM_MODE_ON. LVM_MODE_OFF can be used if it can be guaranteed that the input level is below - 6 in all cases (the default headroom is -6 dB).
bOutputGainEnabled	LVM_	Parameter to enable or disable the output gain. The default value is LVM_MODE_ON.
OutputGain	LVM_	The value of the output gain. The output gain is a linear gain value. 0x7FFF is equal to +6 dB and 0x0000 corresponds to -inf dB. By default, a 3 dB gain is applied (OutputGain = 23197), resulting in an overall gain of -3 dB (-6 dB headroom +3 dB output gain). Unit Q format Data Range Default value Linear gain Q1.14 [0;32767] 23197

Returns:

SSRC_OK	When the function call succeeds
SSRC_NULL_POINT	When pSSRC_Instance is a NULL pointer
SSRC_INVALID_MO	Wrong value used for the bHeadroomGainEnabled or the OutputGainEnabled parameters.
SSRC_INVALID_VAI	When OutputGain is out of the range [0;32767].

Parent topic: Functions

SSRC_Process **Prototype:**

```
SSRC_ReturnStatus_en SSRC_Process
  (SSRC_Instance_t* pSSRC_Instance,
   LVM_INT16*       pSSRC_AudioIn,
   LVM_INT16*       pSSRC_AudioOut);
```

Description:

Process function for the SSRC module. The function takes pointers as input and output audio buffers.

The sample format used for the input and output buffers is 16-bit little-endian. Stereo buffers are interleaved (L1, R1, L2, R2, and so on), mono buffers are deinterleaved (L1, L2, and so on).

Name	Type	Description
pSSRC_Instance	SSRC_Instance_t*	Pointer to the instance of the SSRC.
pSSRC_AudioIn	LVM_INT16*	Pointer to the input samples.
pSSRC_AudioOut	LVM_INT16*	Pointer to the output samples.

Returns:

SSRC_OK	When the function call succeeds.
SSRC_NULL_POINTEI	When one of pSSRC_Instance, pSSRC_AudioIn, or pSSRC_AudioOut is NULL.

Parent topic: Functions

SSRC_Process_D32 Prototype:

```
SSRC_ReturnStatus_en SSRC_Process_D32
  (SSRC_Instance_t* pSSRC_Instance,
   LVM_INT32*       pSSRC_AudioIn,
   LVM_INT32*       pSSRC_AudioOut);
```

Description:

Process function for the SSRC module. The function takes pointers as input and output audio buffers.

The sample format used for the input and output buffers is 32-bit little-endian. Stereo buffers are interleaved (L1, R1, L2, R2, and so on), mono buffers are deinterleaved (L1, L2, and so on).

Name	Type	Description
pSSRC_Instance	SSRC_Instance_t*	Pointer to the instance of the SSRC.
pSSRC_AudioIn	LVM_INT32*	Pointer to the input samples.
pSSRC_AudioOut	LVM_INT32*	Pointer to the output samples.

Returns:

|SSRC_OK|When the function call succeeds.| |SSRC_NULL_POINTER|When one of pSSRC_Instance, pSSRC_AudioIn, or pSSRC_AudioOut is NULL.|

Parent topic: Functions

Parent topic:*Application programmers interface (API)*

Dynamic function usage

This chapter explains how and when the SSRC functions are or can be used.

Define the number of samples to be used on input and output

Call the function SSRC_GetNrSamples. Each integer multiple of the returned number of samples can be used.

Parent topic: Dynamic function usage

Allocate scratch memory

To calculate the required size of the scratch memory, call the SSRC_GetScratchSize function. Allocate memory for the returned size.

Parent topic: Dynamic function usage

Initialize the SSRC instance

Call the SSRC_Init function.

Parent topic: Dynamic function usage

Process samples The SSRC_Process function can now be called any number of times.

Parent topic: Dynamic function usage

Destroy the SSRC instance When the processing is completed, the allocated memory for the instance and the scratch can be freed.

Parent topic: Dynamic function usage

Parent topic:*Application programmers interface (API)*

Reentrancy None of the SSRC functions are re-entrant.

Parent topic:*Application programmers interface (API)*

Additional user information This section provides information on the Attenuation of the signal and Notes on integration.

Attenuation of the signal When a fully saturated or clipped input is applied to an SRC module, the aliases after the sample rate conversion, although sufficiently suppressed, can still result in a clipped output. To prevent clipped output, the output of the SSRC module is by default attenuated with 3 dB. Although not advised, this gain value can be changed using the SSRC_SetGains function.

Parent topic:*Additional user information*

Notes on integration Although the sample rate converter module works with audio signals on different sampling rates, it is a synchronous module. The module takes a block of input samples, consumes the input completely, and produces a full buffer with output samples. As a result, the SSRC only accepts a limited number of input and output block sizes. To flush last, incomplete, block of an audio stream, the block is padded with zeros until it is full before the SSRC processes it.

Parent topic:*Additional user information*

Example application The source code of the example application can be found in the .\EX_APP\APP_FileIO\SRC directory of the release package. The .\EX_APP\APP_FileIO\MAKE directory contains a make file that can be used to build the example application. When building the application, an executable is generated in the .\EX_APP\APP_FileIO\EXE directory.

The example application takes as command-line input parameters:

1. The path toward the input PCM file. It assumes raw 16 bit signed little-endian put. Stereo input samples should be interleaved (L1, L2 R1, R2,...), mono samples should be deinterleaved (L1, L2, and so on).
2. The path toward the output PCM file.
3. The input sample rate.
4. The output sample rate.
5. The channel format (mono or stereo).

Integration test A correct integration of the SSRC module can be verified in two ways.

- Bit accurate test
- THD+N measurement

Bit accurate test The TestFiles directory of the release package contains a test input (sampled at 44,100 Hz) and several expected output files (sample rates from 8000 Hz to 48,000 Hz). If the same test input file is applied to the SRC after integration in the target platform, the output is bit accurate with the expected output file that matches the output-sample rate

Parent topic:*Integration test*

THD+N measurement Produce a swept sine and feed it through the SSRC module. Do a THD+N measurement on the obtained output signal. The THD+N of the converted signals should be below - 77 in the interval [0 - 0.45] FsLOW.

Parent topic:*Integration test*

Maestro Audio Framework

MCUXpresso SDK : Maestro

Overview This repository is for MCUXpresso SDK maestro middleware delivery and it contains the components 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-manifests) for the complete delivery of MCUXpresso SDK.

Documentation Overall details can be reviewed here: MCUXpresso SDK Online Documentation

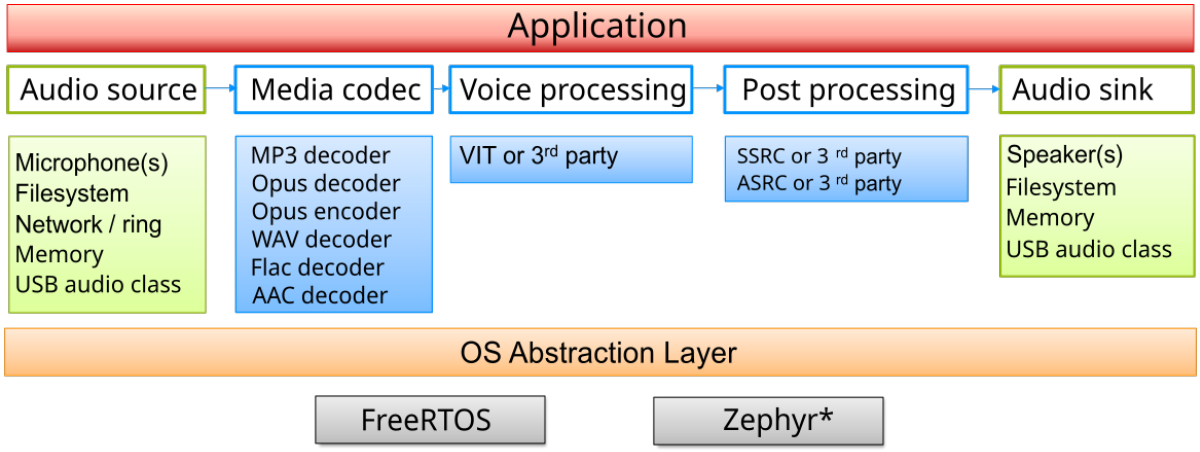
Visit Maestro - Documentation to review details on the contents in this sub-repo.

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 Maestro project placed on github. Contributing can be managed via pull-requests.

Introduction Maestro audio framework intends to enable chaining of basic audio processing blocks, called *elements*. These blocks then form stream processing objects, called *pipeline*. This pipeline can be used for multiple audio processing use cases.

The processing blocks can include (but are not limited to) different audio sources (for example file or microphone), decoders or encoders, filters or effects, and audio sinks. Framework overview is depicted in the following picture:



*not all elements and libraries are supported in Zephyr port. For more information, see *Maestro on Zephyr*

The Maestro audio framework is an open-source component developed by NXP Semiconductors and released under the BSD-compatible license. It is running on RTOS (Zephyr or FreeRTOS), abstracted by OSA layer.

For detailed description of the audio Maestro framework, please refer to the *programmer's guide*.

To see what is new, see *changelog*.

Maestro on Zephyr Getting started guide and further information for Maestro on Zephyr may be found *here*.

Maestro on FreeRTOS Maestro on FreeRTOS is supported in NXP's SDK. To get started, see mcuxsdk doc.

Supported examples The current version of the Maestro audio framework supports several optional *features*, some of which are used in these examples:

- *maestro_playback*
- *maestro_record*
- *maestro_usb_mic*
- *maestro_usb_speaker*
- *maestro_sync*

The examples can be found in the **audio_examples** folder of the desired board. The demo applications are based on FreeRTOS and use multiple tasks to form the application functionality.

Example applications overview To set up the audio framework properly, it is necessary to create a streamer with streamer_create API. It is also essential to set up the desired hardware peripherals using the functions described in streamer_pcm.h. The Maestro example projects consist of several files regarding the audio framework. The initial file is main.c with code to create multiple tasks. For features including SD card (in the maestro_playback examples, reading a file from SD card is supported and in maestro_record writing to SD card is currently supported) the APP_SDCARD_Task is created. The command prompt and connected functionalities are handled by APP_Shell_Task.

One of the most important parts of the configuration is the streamer_pcm.c where the initialization of the hardware peripherals, input and output buffer management can be found. For further information please see also streamer_pcm.h

In the Maestro USB examples (maestro_usb_mic and maestro_usb_speaker), the USB configuration is located in the usb_device_descriptor.c, audio_microphone.c and audio_speaker.c files. For further information please see also usb_device_descriptor.h, audio_microphone.h and audio_speaker.h.

In order to be able to get the messages from the audio framework, it is necessary to create a thread for receiving the messages from the streamer, which is usually called a Message Task. The message thread is placed in the app_streamer.c file, reads the streamer message queue, and reacts to the following messages:

- STREAM_MSG_ERROR - stops the streamer and exits the message thread
- STREAM_MSG_EOS - stops the streamer and exits the message thread
- STREAM_MSG_UPDATE_DURATION - prints info about the stream duration
- STREAM_MSG_UPDATE_POSITION - prints info about current stream position
- STREAM_MSG_CLOSE_TASK - exits the message thread

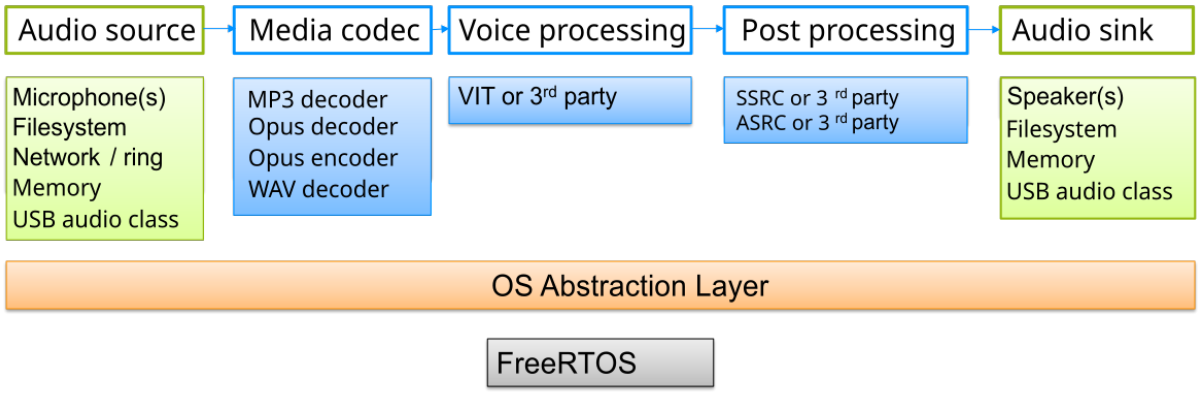
File structure

Folder	Description
src	Maestro audio framework sources
src/inc	Maestro include files
src/core	Maestro core sources
src/cci	Common decoder interface sources
src/cei	Common encoder interface sources
src/elements	Maestro elements sources
src/devices	External audio devices implementation (audio source & audio sink elements)
src/utils	Helper utilities utilized by Maestro
docs	Generated documentation
doxygen	Documentation sources
components	Glue for audio libraries, so they can be used in elements
tests	Maestro tests
zephyr/	Zephyr related files
zephyr/samples/	Zephyr samples
zephyr/tests/	Zephyr tests
zephyr/audioTracks/	Audio tracks for testing
zephyr/wrappers/	Zephyr NXP SDK Wrappers
zephyr/doc/	Zephyr documentation configuration for Sphinx
zephyr/scripts/	Zephyr helper scripts, mostly for testing

Maestro Audio Framework Programmer's Guide

Introduction Maestro audio framework provides instruments for playback and capture of different audio streams. In order to do that the framework uses API for creating various audio and voice pipelines with the support of media and track information. This document describes the framework in its detail, and the usage of API for pipeline creation using different elements. The framework needs an operating system in order to create different tasks for audio processing and communication with the application.

Architecture overview A high-level block diagram of the streamer used in Maestro is shown below. An element is the most important class of objects in the streamer (see streamer_element.c). A chain of elements will be created and linked together when a *pipeline* is created. Data flows through this chain of elements in form of data buffers. An element has one specific function, which can be the reading of data from a file, decoding of this data, or outputting this data to a sink device. By chaining together several such elements, a pipeline is created that can do a specific task, for example, the playback.



Pipeline

The pipeline is created within the streamer_create API using the streamer_create_pipeline call. In the example applications provided in the MCUXpresso SDK the pipeline is created in the app_streamer.c file. In order to create a pipeline user needs to provide a PipelineElements structure consisting of array of element indexes ElementIndex and the number of elements in the pipeline. Then the pipeline is built automatically and user can specify the properties of the elements using the streamer_set_property API. All the element properties can be found in the streamer_element_properties.h file.

The streamer can handle up to two pipelines within a single task. The first pipeline with index 0 can be created using the streamer_create function as described above. Then the streamer_create_pipeline function should be used to create the second pipeline (pipeline with index 1). An example creation can be found in the app_streamer.c file in the *maestro_sync_example*. Both pipelines are processed sequentially, so after the first pipeline is processed, the second pipeline is processed.

After the pipeline is sucessfully created, all elements and entire pipeline are in STATE_NULL state. A user can start the streamer by setting the pipeline state to STATE_PLAYING using the streamer_set_state function. The pipeline can also be paused or stopped using the same function. Use the STATE_PAUSED to pause and use STATE_NULL to stop. The function changes the state of each element that is in the pipeline in turn, and after all the elements have obtained the desired state, the state of entire pipeline is changed.

Elements The current version of the Maestro framework supports several types of elements (StreamElementType). In each pipeline should be used one source element (elements with the _SRC suffix) and one sink element (elements with the _SINK suffix). A decoder, encoder or audio_proc element can be connected between these two elements. The audio_proc element can be used more than once within the same pipeline.

Each element type (StreamElementType) has several functions that are determined by a unique element index (ElementIndex). These indexes are used to create a pipeline, and each element index can only be used once in the same pipeline. The type_lookup_table shows which StreamElementType supports which ElementIndex.

Each element index (ElementIndex) has its own properties and a list of these properties can be found in the streamer_element_properties.h file. These properties are divided into groups and each group is identified by a property mask (e.g. for speaker it is PROP_SPEAKER_MASK). Then the property_lookup_table in the streamer_msg.c file determines which property group relates to

which element index (ElementIndex). When an element is created and added to the pipeline, its properties are set to their defalut values. Default values can be seen in the initialization function of a particular element. The initialization functions are specified in the element_list array in the streamer_element.c file (e.g. for the audio_proc element it is the audio_proc_init_element function). The user can get the value of the property using the streamer_get_property function or change its value using the streamer_set_property function.

The source code of the elements can be found in the middleware\audio_voice\maestro\src\elements\ folder.

Add a new element type The user can add a new element type (StreamElementType) to the Maestro audio framework. For this, the following steps need to be done.

- Add a new element type to the StreamElementType enum type in the streamer_api.h.
- Create a new *.c and *.h files for the new element type in the middleware\audio_voice\maestro\src\elements\ folder. All necessary structures and functions (functions for src pads, sink pads and element itself) needs to be defined in these files. Inspiration can be found in other elements.
- Link the initialization function to the element type in the element_list array in the streamer_element.c file. To do this, a new definition that enables the element needs to be created (e.g. there is a STREAMER_ENABLE_AUDIO_PROC definition for the audio_proc element).
- Associate the newly created element type with an element index (ElementIndex) by adding a new pair to the type_lookup_table in the streamer.c file.
- If the user wants to use the newly created element in an application, the definiton that enables the element must be defined at the project level.

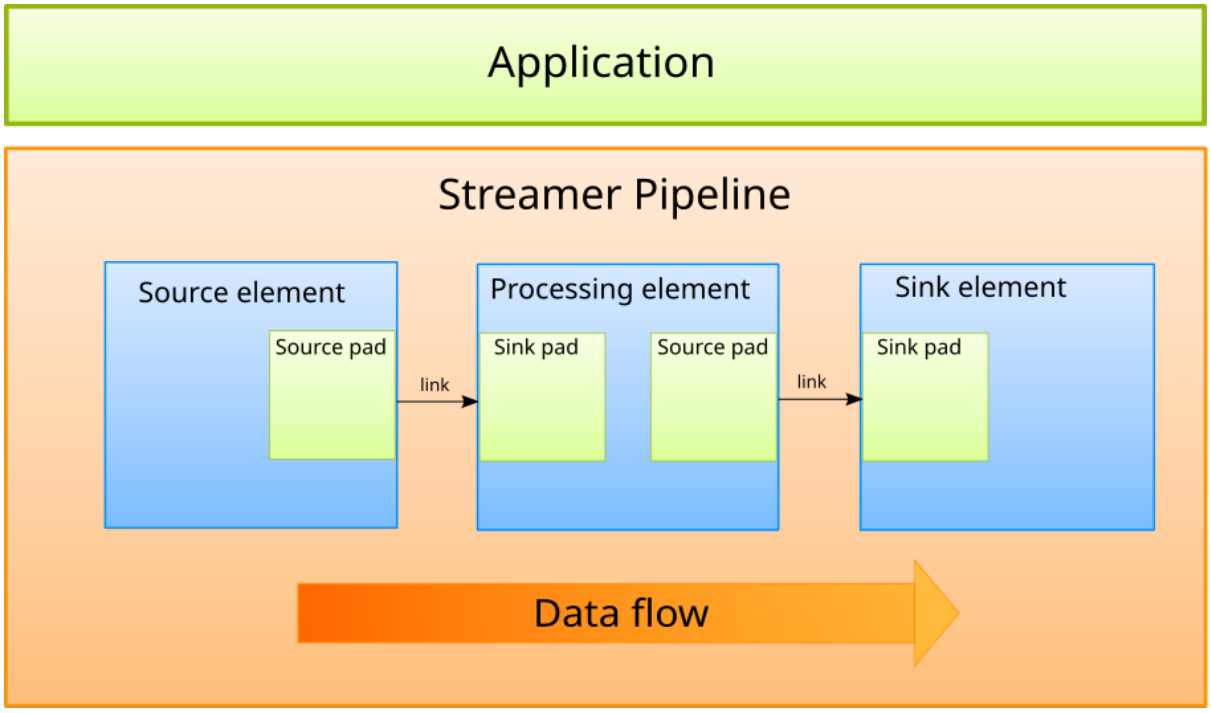
Mostly the user doesn't need to create a new element type, but just create an element index.

Add a new element index To create a new element index in the Maestro audio framework, follow these steps:

- Add a new element index to the ElementIndex enum type in the streamer_api.h.
- Create the required properties for the newly created element index in the streamer_element_properties.h file.
- Associate the newly created property group with newly created element index by adding a new pair to the property_lookup_table in the streamer_msg.c file.
- Associate the newly created element index with an element type (StreamElementType) by adding a new pair to the type_lookup_table in the streamer.c file.
- Add support for the created properties to functions of the associated element type. These functions are defined in files that correspond to a particular element type. The files are located in the middleware\audio_voice\maestro\src\elements\ folder.

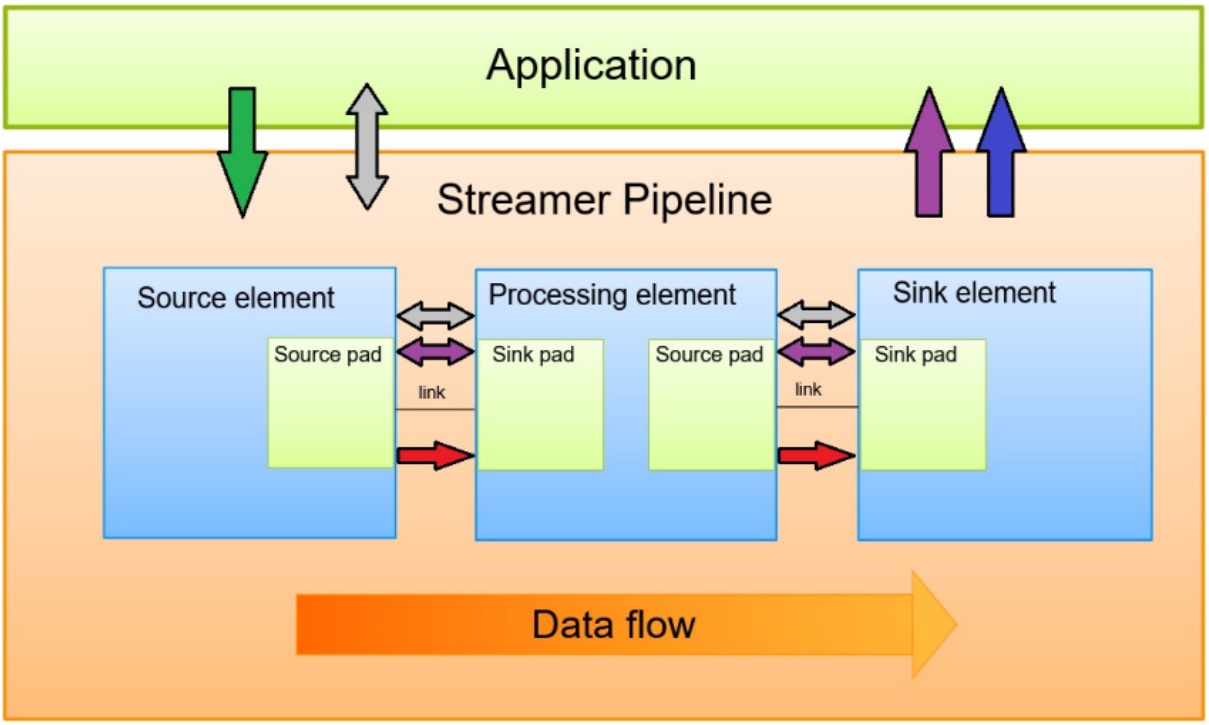
It is important to know that each element type (StreamElementType) can be associated with more than one element index (ElementIndex), but each element index (ElementIndex) can be associated with only one element type (StreamElementType).

Pads Pads are elements' inputs and outputs. A pad can be viewed as a "plug" or "port" on an element where links may be made with other elements, and through which data can flow to or from those elements. Data flows out of an element through a source pad, and elements accept incoming data through a sink pad. Source and sink elements have only source and sink pads, respectively. For detailed information about pads, please see the API reference from pad.c.



Internal communication The streamer (the core of the framework) provides several mechanisms for communication and data exchange between the application, a pipeline, and pipeline elements:

- Buffers are objects for passing streaming data between elements in the pipeline. Buffers always travel from sources to sinks (downstream).
- Messages are objects sent from the application to the streamer task to construct, configure, and control a streamer pipeline.
- Callbacks are used to transmit information such as errors, tags, state changes, etc. from the pipeline and elements to the application.
- Events are objects sent between elements. Events can travel upstream and downstream. Events may also be sent to the application
- Queries allow applications to request information such as duration or current playback position from the pipeline. Elements can also use queries to request information from their peer elements (such as the file size or duration). They can be used both ways within a pipeline, but upstream queries are more common



Decoders and encoders Maestro framework uses a common codec interface for decoding purposes and a common encoder interface for encoding. Those interfaces encapsulate the usage of specific codecs. Reference codecs are available in audio-voice-components repository which should be in \middleware\audio_voice\components\ folder.

Common codec interface The Common Codec Interface is the intended interface for all used **decoders**. The framework will integrate a CCI decoder element into the streamer to interface with all decoders.

Using the CCI to interface with Metadata

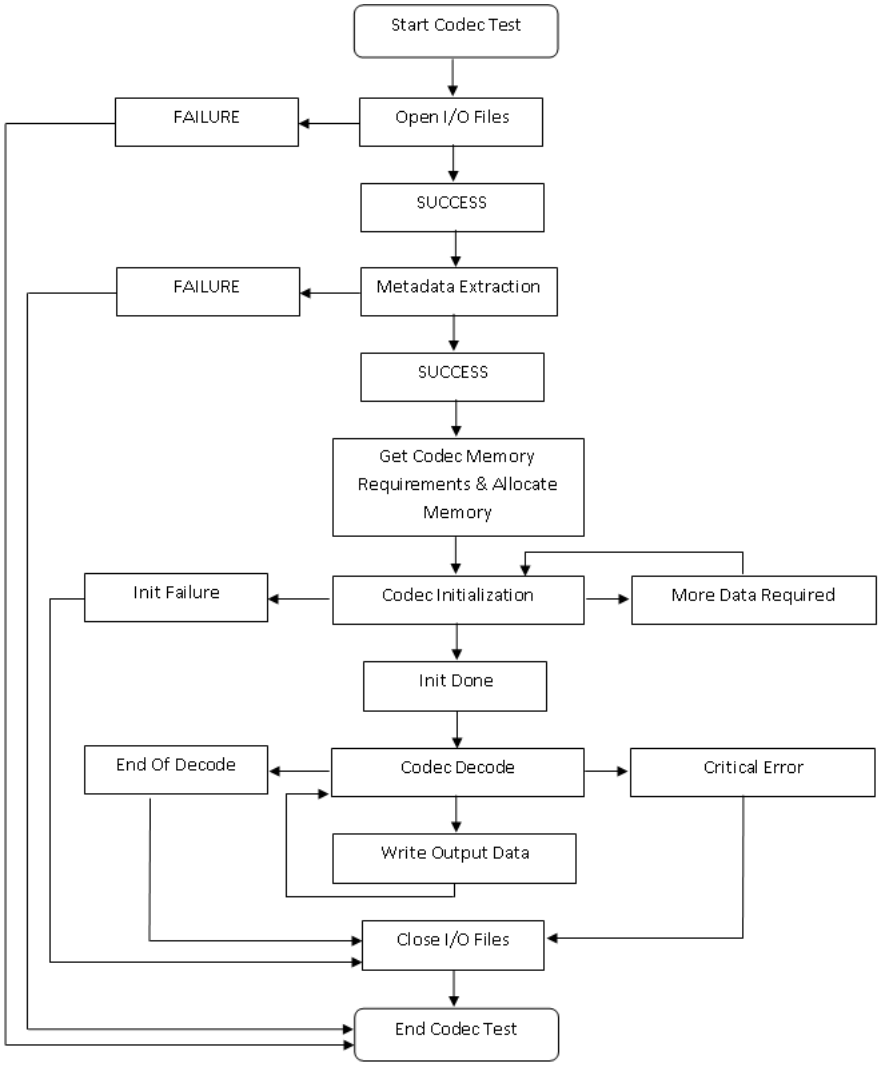
- cci_extract_meta_data must be called before any other Codec Interface APIs. This API extracts the metadata information of the codec and fills this information in the file_meta_data_t structure. The file_meta_data_t structure must be allocated by the application.
- This function first extracts the input file extension and based on that it calls the specific codec's metadata extraction function. If it finds an invalid extension or unsupported extension then it returns with META_DATA_FILE_NOT_SUPPORTED code for any unsupported file format.
- If this API finds the valid metadata then it returns with META_DATA_FOUND code. If this API does not find any metadata information then it returns with META_DATA_NOT_FOUND code. It also returns with META_DATA_FILE_NOT_SUPPORTED code for any unsupported file format.

Using the CCI to interface with Decoders

- codec_get_mem_info gets the memory requirement based on the specific decoder stream type. It returns the size in bytes of the specific codec. The user of the decoders must allocate memory of this size and this memory is used by the initialization API. The user or application must pass this allocated memory pointer to the init API.

- codec_init must be called before the codec's decode API. This API calls the codec-specific initialization function based on the codec stream type. This API allocates the memory to the codec main structure and also initializes the codec main structure parameters. It also registers the call back functions to the codec which will be used by the codec to read or seek the input stream.
- codec_decode is the main decoding API of the codec. This API calls the codec-specific decoding function based on the codec stream type. This API decodes the input raw stream and fills the PCM output samples into codec output PCM buffer. This API gives the information about the number of samples produced by the codec and also gives the pointer of the codec output PCM samples buffer.
- codec_get_pcm_samples must be called after the codec's decode API. This API calls the codec specific Get PCM Sample API based on the codec stream type. This API gets the PCM samples from the codec in constant block size and fills them into the output PCM buffer. It returns the number of samples get from the codec and also gives the pointer of the output PCM buffer.
- codec_reset calls the codec specific reset API base on stream type and resets the codec.
- codec_seek accepts the seek bytes offset converted from the time by application. This API calls the decoder's internal seek API to calculate the actual seek offset which frame boundary aligns. This API returns the actual seek offset.

The basic sequence to use a decoder with the CCI is shown below:



Adding new decoders to the CCI This section explains how to integrate a new decoder in the Common Codec Interface. The CCI assumes the decoder library to be used is in the \middleware\audio_voice\audiocomponents\decoders*decoder*\libs\ folder of the maestro framework. The CCI is just a wrapper around a specific implementation. The decoder is expected to be extended as needed to meet the APIs described above.

- Register Decoder Top level APIs in Common Codec Interface
  - Place the decoder lib in libs folder.
  - Add prototypes of the decoder top level APIs in codec_interface.h file (located at maestro\src\cci\inc\ folder).
  - In codec_interface.c file (located at maestro\src\cci\src\), add top level Decoder APIs in decoder function table.
  - Pseudo code for this is as described below.

```
const codec_interface_function_table_t g_codec_function_table[STREAM_TYPE_COUNT] = {
#ifdef VORBIS_CODEC
    {
        &VORBISDecoderGetMemorySize,
        &VORBISDecoderInit,
        &VORBISDecoderDecode,
        NULL,
        NULL,
        &VORBISDecoderSeek,
        &VORBISDecoderGetIOFrameSize,
    },
#else
    {
        NULL,
        NULL,
        NULL,
        NULL,
        NULL,
        NULL,
        NULL,
    }
#endif
};
```

- Enable or Disable Decoder
  - Define VORBIS_CODEC macro in audio_cfg.h file.
  - Comment this macro if you want to disable VORBIS Decoder otherwise keep it defined in order to enable the decoder.
- Add Extract Metadata API for the decoder
  - Add extract metadata API source file for the decoder at streamer/cci/metadata/src/vorbis folder.
  - Add this code in extract metadata lib project space.
  - Build the extract metadata lib and copy that lib to libs folder.
  - Add the desired stream type into ccidec_extract_meta_data API (in codecextractmetadata.c file) to call VORBIS Decoder extract metadata API.
- Add stream type of the new decoder in the stream type enum audio_stream_type_t in codec_interface_public_api.h
  - Stream type of the decoder in stream type enum and decoder APIs in decoder function table must be in the same sequence.

Common encoder interface Please see the following section about the *cei*.

Maestro performance

Memory information The memory usage of the framework components using reference codecs (data obtained from GNU ARM compiler) in bytes is:

text	data	bss	component
48790	2752	4	aac decoder
4348	16400	212	asrc
15512	0	4	flac decoder
76462	16	5013	maestro
34211	0	4	mp3 decoder
211974	0	0	opus
65446	0	4	ssrc
5850	16	12	wav decoder

Maestro framework uses dynamic allocation of audio buffers. The total amount of memory allocated for the pipeline depends on the following parameters:

- Number of elements in the pipeline
- Element types
- Audio stream properties
  - Sampling rate
  - Bit width
  - Channel number
  - Frame size

CPU usage The performance of the pipeline was measured using the real hardware platform (RT1060).

- CPU core clock in MHz: 600.

Pipeline type	Performance MIPS of pipeline (in MHz)
audio source -> audio sink	~10.26 MHz
audio source -> file sink	~9.84 MHz
file source (8-channel PCM) -> audio sink	~16.5 MHz

For performance details about the supported codecs please see audio-voice-components repository documentation.

CEI encoder The Maestro streamer contains an element adapting an extensible set of audio encoders in the form of functions conforming to the CEI (Common Encoder Interface). This element enables the user to choose and configure a suitable encoder at runtime.

Header files CEI itself and the CEI encoders are using following header files, in which you may be interested:

- cei.h - contains types used by the element itself and an encoder implementing the CEI
- cei_enctypes.h - contains a list of possible encoders and types used for interfacing with a CEI encoder
- cei_table.h - contains a table of functions implementing integrated CEI encoders

Instantiating the element This element's index is ELEMENT_ENCODER_INDEX and its type is TYPE_ELEMENT_ENCODER, as defined in streamer_api.h. It has one source pad (data input) and one sink pad (data output). It is initialized like any other element, meaning that it is instantiated and inserted into the pipeline using the create_element, add_element_pipeline and link_elements functions. Inversely, for destroying the element, the unlink_elements, remove_element_pipeline and destroy_element are used. This element alone does not depend on any additional software layers other than these required by the Maestro streamer itself, so no pre-initialization before this element instantiation is necessary.

Element properties Use Maestro streamer property API (streamer_set_property and streamer_get_property) for setting or getting these. The constants are defined in streamer_element_properties.h.

- PROP_ENCODER_CHUNK_SIZE
  - **Synopsis:** Determines the length of a chunk pulled from the sibling of the source pad and essentially influences the size of allocated buffers. If the actual amount of data pulled is smaller, the rest is zero-filled.
  - **Type:** unsigned 32-bit integer
  - **Default value:** 1920
  - **Constraints:**
    - Must be bigger than zero, otherwise STREAM_ERR_INVALID_ARGS is returned.
    - Cannot be changed if the actual encoder has been created. If done so, STREAM_ERR_ELEMENT_BAD_STATUS is returned.
- PROP_ENCODER_TYPE
  - **Synopsis:** Determines the exact encoder (CEI implementation) to be used.
  - **Type:** CeiEncoderType (cei_enctypes.h)
  - **Default value:** CEIENC_LAST
  - **Constraints:**
    - Must not be equal to CEIENC_LAST, otherwise STREAM_ERR_INVALID_ARGS will be returned.
    - Selected encoder must be implemented, otherwise STREAM_ERR_INVALID_ARGS will be returned.
    - Cannot be changed if the actual encoder has been created. If done so, STREAM_ERR_ELEMENT_BAD_STATUS will be returned.
  - **Behaviour influenced:** The encoder element process function will return FLOW_ERROR if this property isn't set.
- PROP_ENCODER_CONFIG
  - **Synopsis:** Determines encoder-specific configuration (application, bitrate, ...).
  - **Type:** Pointer to the encoder-specific configuration structure.

  - **Default value:** Determined by the encoder.
  - **Constraints**:
    * The encoder has to be configurable. If it is not, STREAM_ERR_ERR_GENERAL will be returned on any access.
    * The structure has to conform to the encoder requirements. If the encoder returns an error code, STREAM_ERR_GENERAL will be returned.

- PROP_ENCODER_BITSTREAMINFO
  - **Synopsis:** Specifies information about the incoming bitstream (sample rate, sample depth, ...).
  - **Type:** Pointer to CeiBitstreamInfo (cei_enctypes.h).
  - **Default value:**

```
(CeiBitstreamInfo) {
    .sample_rate = 0,
    .num_channels = 0,
    .endian = AF_LITTLE_ENDIAN,
    .sign = TRUE,
    .sample_size = 0,
    .interleaved = TRUE
}
```

  - **Constraints:**
    * Cannot be changed if the actual encoder has been created. If done so, STREAM_ERR_ELEMENT_BAD_STATUS will be returned.
    * As of now, only bitstreams containing 16-bit interleaved (if 2 or more channels will be encoded) samples are supported. If anything else was set to the sample_size and interleaved members, STREAM_ERR_INVALID_ARGS will be returned.
  - **Behaviour influenced:**
    * Given the characteristics of some elements available, different packets of data (header and payload, referred to as "chunk" above) may be pulled by this element. Each packet can contain a different header, which may or may not contain useful information about the bitstream. If a packet with the AudioPacketHeader (todofile.h) is pulled at first and any other iteration of the streamer pipeline, the bitstream parameters configured by this property are implicitly available and are not expected to be specified by the user. Other packet header types (such as RawPacketHeader) don't contain any bitstream parameters and require the user to specify the parameters manually using this property. Failure to do so will result in the element's process function returning FLOW_ERROR. Same situation will occur if a packet with the AudioPacketHeader is received and its contents differ from the already acquired bitstream parameters.
    * As of now, CEI is defined to work with 16-bit signed little-endian (s16le) samples, which are interleaved if the bitstream contains more than one channels. This element handles endianness and unsigned to signed conversion.

CEI definition - implementing your own encoder The CEI defines following function pointer types:

- CeiFnGetMemorySize: Returns number of bytes required for encoder state for a given number of channels.
- CeiFnEncoderInit: Initialize an encoder for a given sample rate and channel count.
- CeiFnEncoderGetConfig: Copy current or default configuration to a given structure pointer.

- CeiFnEncoderSetConfig: Configure the encoder from a given structure pointer.
- CeiFnEncode: Encode a given buffer to a given output buffer.

Detailed descriptions of function behaviour, parameters and expected return values are available as docblocks in the cei.h file.

Each encoder is implemented as a set of pointers pointing to functions conforming to these types, grouped in the CeiEncoderFunctions structure. Specifying the CeiEncoderGetConfig fnGetConfig and CeiFnEncoderSetConfig fnSetConfig members is optional, as an encoder does not have to be configurable. If so desired, specify NULL. Implementation of the remaining functions is mandatory, however. If at least one of these functions isn't implemented and NULL is specified instead, the encoder will be considered as not implemented.

To register an implemented encoder with the element, add a new entry to the CeiEncoderType enum and add the CeiEncoderFunctions struct value to the table CeiEncoderFunctions ceiEncTable[] located in the cei_table.h header file. Note and match the order of items in that table, as a CeiEncoderType value is used as an index. Same goes for the size_t ceiEncConfigSizeTable[]. If configuration is not applicable, specify 0 at the appropriate index. If configuration is applicable, describe the configuration structure in the cei_enctypes.h header file and add its size to that table.

Maestro playback example

Table of content

Overview The Maestro playback example demonstrates audio processing on the ARM cortex core utilizing the Maestro Audio Framework library.

The application is controlled by commands from a shell interface using serial console and the audio files are read from the SD card.

Depending on target platform or development board there are different modes and features of the demo supported.

- **Standard** - The mode demonstrates playback of encoded files from an SD card with up to 2 channels, up to 48 kHz sample rate and up to 16 bit width. This mode is enabled by default.
- **Multi-channel** - The mode demonstrates playback of raw PCM files from an SD card with 2 or 8 channels, 96kHz sample rate and 32 bit width. The decoders and synchronous sample rate converter are not supported in this mode. The Multi-channel mode is only supported on selected platforms, see the table below. The *Example configuration* section contains information on how to enable it.

As shown in the table below, the application is supported on several development boards and each development board may have certain limitations, some development boards may also require hardware modifications or allow to use of an audio expansion board. Therefore, please check the supported features and *Hardware modifications* or *Example configuration* sections before running the demo.

Limitations:

- Note:
  - *LPCXPresso55s69* - MCUXpresso IDE project default debug console is semihost
- Decoder:
  - **AAC:**
    - The reference decoder is supported only in the MCUXpresso IDE and ARMGCC.
  - **FLAC:**
    - *LPCXpresso55s69* - When playing FLAC audio files with too small frame size (block size), the audio output may be distorted because the board is not fast enough.
  - **OPUS:**
    - *LPCXpresso55s69* - The decoder is disabled due to insufficient memory may be distorted because the board is not fast enough.
- Sample rate converter:
  - **SSRC:**
    - *LPCXpresso55s69* - When a memory allocation ERROR occurs, it is necessary to disable the SSRC element due to insufficient memory.

Known issues:

- Decoder:
  - **MP3:**
    - The reference decoder has issues with some of the files. One of the channels can be sometimes distorted or missing parts of the signal.
  - **OPUS:**
    - The decoder doesn't support all the combinations of frame sizes and sample rates. The application might crash when playing an unspupported file.

More information about supported features can be found on the *Supported features* page.

Hardware requirements

- Desired development board
- Micro USB cable
- Headphones with 3.5 mm stereo jack
- SD card with supported audio files
- Personal computer
- Optional:
  - Audio expansion board AUD-EXP-42448 (REV B)

Hardware modifications Some development boards need some hardware modifications to run the application. If the development board is not listed here, its default setting is required.

- *EVKB-MIMXRT1170:*
  1. Please remove below resistors if on board wifi chip is not DNP:
     - R228, R229, R232, R234
  2. Please make sure R136 is weld for GPIO card detect.

Preparation

1. Connect a micro USB cable between the PC host and the debug USB port on the development board.
2. Open a serial terminal with the following settings:
   - 115200 baud rate
   - 8 data bits
   - No parity
   - One stop bit
   - No flow control
3. Download the program to the target board.
4. Insert the headphones into the Line-Out connector (headphone jack) on the development board.
5. Either press the reset button on your development board or launch the debugger in your IDE to begin running the demo.

Running the demo When the example runs successfully, you should see similar output on the serial terminal as below:

```
**********************************
Maestro audio playback demo start
**********************************

[APP_Main_Task] started

Copyright  2022  NXP
[APP_SDCARD_Task] start
[APP_Shell_Task] start

>> [APP_SDCARD_Task] SD card drive mounted
```

Type help to see the command list. Similar description will be displayed on serial console (*If multi-channel playback mode is enabled, the description is slightly different*):

```
>> help

"help": List all the registered commands

"exit": Exit program

"version": Display component versions

"file": Perform audio file decode and playback

  USAGE: file [stop|pause|volume|seek|play|list|info]
```

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```
stop              Stops actual playback.
pause             Pause actual track or resume if already paused.
volume <volume>   Set volume. The volume can be set from 0 to 100.
seek <seek_time>  Seek currently paused track. Seek time is absolute time in milliseconds.
play <filename>   Select audio track to play.
list              List audio files available on mounted SD card.
info              Prints playback info.
```

Details of commands can be found *here*.

Example configuration The example can be configured by user. Before configuration, please check the *table* to see if the feature is supported on the development board.

- **Enable Multi-channel mode:**
  - Add the MULTICHANNEL_EXAMPLE symbol to preprocessor defines on project level.
  - Connect AUD-EXP-42448 (see the point below).
- **Connect AUD-EXP-42448:**
  - *EVKC-MIMXRT1060:*
    1. Disconnect the power supply for safety reasons.
    2. Insert AUD-EXP-42448 into J19 to be able to use the CS42448 codec for multichannel output.
    3. Uninstall J99.
    4. Set the DEMO_CODEC_WM8962 macro to 0 in the app_definitions.h file
    5. Set the DEMO_CODEC_CS42448 macro to 1 in the app_definitions.h file.

Functionality The file play <filename> command calls the STREAMER_file_Create or STREAMER_PCM_Create function from the app_streamer.c file depending on the selected mode.

- When the *Standard* mode is enabled, the command calls the STREAMER_file_Create function that creates a pipeline with the following elements:
  - ELEMENT_FILE_SRC_INDEX
  - ELEMENT_DECODER_INDEX
  - ELEMENT_SRC_INDEX (If SSRC_PROC is defined)
  - ELEMENT_SPEAKER_INDEX
- When the *Multi-channel* mode is enabled, the command calls STREAMER_PCM_Create function, which creates a pipeline with the following elements:
  - ELEMENT_FILE_SRC_INDEX (PCM format only)
  - ELEMENT_SPEAKER_INDEX
  - *Note:*
    * If the input file is an 8 channel PCM file, output to all 8 channels is available. The properties of the PCM file are set in the app_streamer.c file using file source properties sent to the streamer:
      - PROP_FILESRC_SET_SAMPLE_RATE - default value is 96000 [Hz]
      - PROP_FILESRC_SET_NUM_CHANNELS - default value is 8
      - PROP_FILESRC_SET_BIT_WIDTH - default value is 32

Playback itself can be started with the STREAMER_Start function.

Each of the elements has several properties that can be accessed using the streamer_get_property or streamer_set_property function. These properties allow a user to change the values of the appropriate elements. The list of properties can be found in streamer_element_properties.h. See the example of setting property value in the following piece of code from the app_streamer.c file:

```
ELEMENT_PROPERTY_T prop;

EXT_PROCESS_DESC_T ssrc_proc = {SSRC_Proc_Init, SSRC_Proc_Execute, SSRC_Proc_Deinit,␣
↪&get_app_data()->proc_args};

prop.prop = PROP_SRC_PROC_FUNCPTR;
prop.val  = (uintptr_t)&ssrc_proc;

if (streamer_set_property(streamer, 0, prop, true) != 0)
{
    return -1;
}

prop.prop = PROP_AUDIOSINK_SET_VOLUME;
prop.val  = volume;
streamer_set_property(streamer, 0, prop, true);
```

Some of the predefined values can be found in the streamer_api.h.

States The application can be in 3 different states:

- Idle
- Running
- Paused

In each state, each command can have a different behavior. For more information, see *Commands in detail* section.

Commands in detail The applicatin is controlled by commands from the shell interface and the available commands for the selected mode can be displayed using the help command. Commands are processed in the cmd.c file.

- *help, version*
- *file stop*
- *file pause*
- *file volume <volume>*
- *file seek <seek_time>*
- *file play <filename>*
- *file list*
- *file info*

Legend for diagrams:

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
```

```
    classDef error fill:#F54D4D

    A((State)):::state
    B{Condition}:::condition
    C[Error message]:::error
    D[Process function]:::function
```

help, version

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    A((Idle)):::state --> D[Write help or version]:::function
    B((Running)):::state --> D
    C((Paused)):::state --> D
    D-->E((No state
    change)):::state
```

file stop

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    B((Idle)):::state --> B
    C((Running)):::state -->E((Idle)):::state
    D((Paused)):::state -->E
```

file pause

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    B((Idle)):::state --> B
    C((Running)):::state -->E((Paused)):::state
    D((Paused)):::state -->F((Running)):::state
```

file volume <volume>

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    B((Idle)):::state --> M[Error: Play a track first]:::error
    C((Running)):::state --> G{Volume
    parameter
```

```
empty?}:::condition
D((Paused)):::state --> G
G -- Yes -->H[Error: Enter volume parameter]:::error
G -- No -->I{Volume
in range?}:::condition
I -- No -->J[Error: invalid value]:::error
I -- Yes -->K[Set volume]:::function
J --> L((No state
change)):::state
K --> L
H--> L
```

file seek <seek_time> The seek argument is only supported in the Standard mode.

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    B((Idle)):::state --> E[Error: First select
    an audio track to play]:::error
    E-->B
    C((Running)):::state --> F[Error: First
    pause the track]:::error
    F --> C
    D((Paused)):::state --> G{Seek
    parameter
    empty?}:::condition
    G --No --> H{AAC file?}:::condition
    G --Yes --> I[Error: Enter
    a seek time value]:::error
    I-->N((Paused)):::state;
    H --Yes -->J[Error: The AAC decoder
    does not support
    the seek command]:::error
    J-->N
    H --No -->K{Seek
    parameter
    positive?}:::condition
    K --No -->L[Error: The seek
    time must be
    a positive value]:::error
    L-->N
    K --Yes -->M[Seek the file]:::function
    M-->N
```

file play <filename>

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    C((Running)):::state --> Z[Error: First stop
    current track]:::error
```

```
D((Paused)):::state --> Z
B((Idle)):::state --> E{SD Card
inserted?}:::condition
E -- No -->F[Error: Insert SD
card]:::error
E -- Yes -->G{File
name
empty?}:::condition
G -- Yes -->H[Error: Enter
file name]:::error
G -- No -->I{File exists?}:::condition
I -- No -->O[Error: File
doesn't exist]:::error
I -- Yes -->J{Supported
format?}:::condition
J -- Yes -->K[Play the track]:::function
J -- No -->L[Error: Unsupported
file]:::error
K -->M((Running)):::state
L --> W((No state
change)):::state
O --> W
H --> W
F --> W
Z --> W
```

file list

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    B((Idle)):::state --> G{SD Card
    inserted?}:::condition
    C((Running)):::state --> G
    D((Paused)):::state --> G
    G -- Yes -->H[List supported files]:::function
    G -- No -->I[Error: Insert SD card]:::error
    I --> J((No state
    change)):::state
    H --> J
```

file info

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    B((Idle)):::state -->E[Write file info]:::function
    C((Running)):::state -->E
    D((Paused)):::state -->E
    E --> F((No state
        change)):::state
```

Processing Time Typical streamer pipeline execution times and their individual elements for the EVKC-MIMXRT1060 development board are presented in the following tables. The time spent on output buffers is not included in the traversal measurements. However, file reading time is accounted for. In the case of the WAV codec, the audio file was accessed in every pipeline run. Therefore, during each run, the file was read from the SD card. However, for the MP3 codec, where data must be processed in complete MP3 frames, the file was not read in every run. Instead, it was read periodically only when the codec buffer did not contain a complete frame of data.

For further details, please refer to the *Processing Time* document.

WAV	streamer	file_src	codec	SSRC_proc	speaker
48kHz	1.1 ms	850 µs	150 µs	70 µs	40 µs
44kHz	1.75 ms	850 µs	180 µs	670 µs	40 µs

MP3	streamer	file_src	codec	SSRC_proc	speaker
48 kHz with file read	2.9 ms	2.3 µs	450 µs	60 µs	50 µs
48 kHz without file read	0.5 ms	x	400 µs	40 µs	40 µs
44 kHz with file read	3.2 ms	2.3 µs	440 µs	400 µs	50 µs
44 kHz without file read	0.9 ms	x	440 µs	390 µs	40 µs

Maestro record example

Table of content

Overview The Maestro record example demonstrates audio processing on the ARM cortex core utilizing the Maestro Audio Framework library.

The application is controlled by commands from a shell interface using serial console.

Depending on target platform or development board there are different modes and features of the demo supported.

- **Loopback** - The application demonstrates a loopback from the microphone to the speaker without any audio processing. Mono, stereo or multichannel mode can be used, depending on the hardware, see *table* below.
- **File recording** - The application takes audio samples from the microphone inputs and stores them to an SD card as an PCM file. The PCM file has following parameters:

  - Mono and stereo : 2 channels, 16kHz, 16bit width
  - Multi-channel (AUD-EXP-42448): 6 channels, 16kHz, 32bit width
- **Voice control** - The application takes audio samples from the microphone input and uses the VIT library to recognize wake words and voice commands. If a wake word or a voice command is recognized, the application write it to the serial terminal.
- **Encoding** - The application takes PCM samples from memory and sends them to the Opus encoder. The encoded data is stored in memory and compared to a reference. The result of the comparison is finally written into the serial terminal.

As shown in the table below, the application is supported on several development boards, and each development board may have certain limitations, some development boards may also require hardware modifications or allow to use of an audio expansion board. Therefore, please check the supported features and *Hardware modifications* or *Example configuration* sections before running the demo.

Limitations:

- Note:
  - *LPCXPresso55s69* - MCUXpresso IDE project default debug console is semihost
- Addition labraries
  - **VIT:**
    - The VIT is supported only in the MCUXpresso IDE and ARMGCC.
    - *LPCXpresso55s69* - The VIT is disabled by default due to insufficient memory. To enable it, see the *Example configuration* section.
    - *EVK-MCXN5XX* - Some VIT models can't fit into memory. In order to free some space it is necessary to disable SD card handling and opus encoder. To disable it, see the *Example configuration* section.
  - **VoiceSeeker:**
    - The VoiceSeeker is supported only in the MCUXpresso IDE and ARMGCC.
- Encoder
  - **OPUS:**
    - *LPCXpresso55s69* - The encoder is not supported due to insufficient memory.
- The File recording mode is not supported on *RW612BGA* development board due to missing SD card slot.

Known issues:

- *EVKB-MIMXRT1170* - After several tens of runs (the number of runs is not deterministic), the development board restarts because a power-up sequence is detected on the RESET pin (due to a voltage drop).

More information about supported features can be found on the *Supported features* page.

Hardware requirements

- Desired development board
- Micro USB cable
- Headphones with 3.5 mm stereo jack
- Personal computer
- Optional:
  - SD card for file output

  - Audio expansion board AUD-EXP-42448 (REV B)
- *LPCXpresso55s69:*
  - Source of sound with 3.5 mm stereo jack connector

Hardware modifications Some development boards need some hardware modifications to run the application. If the development board is not listed here, its default setting is required.

- *EVKB-MIMXRT1170:*
  1. Please remove below resistors if on board wifi chip is not DNP:
     - R228, R229, R232, R234
  2. Please make sure R136 is weld for GPIO card detect.
- *EVK-MCXN5XX:*
  - Short: JP7 2-3, JP8 2-3, JP10 2-3, JP11 2-3
- *RW612BGA:*
  - Connect: JP50; Disconnect JP9, JP11

Preparation

1. Connect a micro USB cable between the PC host and the debug USB port on the development board
2. Open a serial terminal with the following settings:
   - 115200 baud rate
   - 8 data bits
   - No parity
   - One stop bit
   - No flow control
3. Download the program to the target board.
4. Insert the headphones into the Line-Out connector (headphone jack) on the development board.
5. *LPCXpresso55s69:*
   - Insert source of sound to audio Line-In connector (headphone jack) on the development board.
6. Either press the reset button on your development board or launch the debugger in your IDE to begin running the demo.

Running the demo When the example runs successfully, you should see similar output on the serial terminal as below:

```
******************************
Maestro audio record demo start
******************************

Copyright 2022 NXP
[APP_SDCARD_Task] start
[APP_Shell_Task] start

>> [APP_SDCARD_Task] SD card drive mounted
```

Type help to see the command list. Similar description will be displayed on serial console:

```
>> help

"help": List all the registered commands

"exit": Exit program

"version": Display component versions

"record_mic": Record MIC audio and perform one (or more) of following actions:
- playback on codec
- perform VoiceSeeker processing
- perform voice recognition (VIT)
- store samples to a file.

USAGE: record_mic [audio|file|<file_name>|vit] 20 [<language>]
The number defines length of recording in seconds.

Please see the project defined symbols for the languages supported.
Then specify one of: en/cn/de/es/fr/it/ja/ko/pt/tr as the language parameter.
For voice recognition say supported WakeWord and in 3s frame supported command.
Please note that this VIT demo is near-field and uses 1 on-board microphone.

NOTES: This command returns to shell after the recording is finished.
       To store samples to a file, the "file" option can be used to create a file
       with a predefined name, or any file name (without whitespaces) can be specified
       instead of the "file" option.

"opus_encode": Initializes the streamer with the Opus memory-to-memory pipeline and
encodes a hardcoded buffer.
```

Details of commands can be found *here*.

Example configuration The example can be configured by user. There are several options how to configure the example settings, depending on the environment. For configuration using west and Kconfig, please follow the instructions here. Before configuration, please check the *table* to see if the feature is supported on the development board.

- **Connect AUD-EXP-42448:**
  - *EVKC-MIMXRT1060:*
    1. Disconnect the power supply for safety reasons.
    2. Insert AUD-EXP-42448 into J19 to be able to use the CS42448 codec for multichannel output.
    3. Uninstall J99.
    4. Set the DEMO_CODEC_WM8962 macro to 0 in the app_definitions.h file
    5. Set the DEMO_CODEC_CS42448 macro to 1 in the app_definitions.h file.
    6. Enable VoiceSeeker, see point bellow.
  - *Note:*
    * The audio stream is as follows:
      - Stereo INPUT 1 (J12) -> LINE 1&2 OUTPUT (J6)
      - Stereo INPUT 2 (J15) -> LINE 3&4 OUTPUT (J7)
      - MIC1 & MIC2 (P1, P2) -> LINE 5&6 OUTPUT (J8)
      - Insert the headphones into the different line outputs to hear the inputs.

        - To use the Stereo INPUT 1, 2, connect an audio source LINE IN jack.

- **Enable VoiceSeeker:**
  - On some development boards the VoiceSeeker is enabled by default, see the *table* above.
  - If more than one channel is used and VIT is enabled, the VoiceSeeker that combines multiple channels into one must be used, as VIT can only work with mono signal.
  - Using MCUXPresso IDE:
    - It is necessary to add VOICE_SEEKER_PROC symbol to preprocessor defines on project level:
      - (Project -> Properties -> C/C++ Build -> Settings -> MCU C Compiler -> Preprocessor)
  - Using Kconfig:
    - Enable the VoiceSeeker in the guiconfig using MCUX_PRJSEG_middleware.audio_voice.components.voice_seeker
- **Enable VIT:**
  - *LPCXpresso55s69 and MCX-N5XX:*
    - In MCUXPresso IDE (SDK package):
      1. Remove SD_ENABLED and STREAMER_ENABLE_FILE_SINK symbols from preprocessor defines on project level.
      2. Add VIT_PROC symbol to preprocessor defines on project level:
         - (Project -> Properties -> C/C++ Build -> Settings -> MCU C Compiler -> Preprocessor)
    - In armgcc in SDK package:
      1. Remove SD_ENABLED and STREAMER_ENABLE_FILE_SINK symbols from preprocessor defines in flags.cmake file.
      2. Remove OPUS_ENCODE=1 and STREAMER_ENABLE_ENCODER preprocessor defines in flags.cmake file.
      3. Add VIT_PROC symbol to preprocessor defines in flags.cmake file.
      4. Remove sdmmc_config.c,.h files from CMakeLists.txt file.
    - In Kconfig:
      1. Disable File sink MCUX_COMPONENT_middleware.audio_voice.maestro.element.file_sink.enable
      2. Make sure SD card support is disabled MCUX_COMPONENT_middleware.sdmmc.sd and MCUX_COMPONENT_middleware.sdmmc.host.usdhc
      3. Make sure sdmmc_config files (.c, .h) is excluded from project build
         - remove mcux_add_source function that adds the sources in reconfig.cmake in maestro_record/cm33_core0 folder
      4. Disable fatfs MCUX_COMPONENT_middleware.fatfs and MCUX_COMPONENT_middleware.fatfs.sd
      5. Disable file utils MCUX_COMPONENT_middleware.audio_voice.maestro.file_utils.enable
      6. Make sure Opus encoder is disabled MCUX_COMPONENT_middleware.audio_voice.maestro.element.encoder.opus.enable
      7. Make sure VIT_PROC symbol is defined

        - remove mcux_remove_macro function that removes the VIT_PROC preprocessor definition in reconfig.cmake in maestro_record folder

    8. Make sure VIT processing is enabled MCUX_PRJSEG_middleware.audio_voice.components.vit

- **VIT model generation:**
  - For custom VIT model generation (defining own wake words and voice commands) please use https://vit.nxp.com/
- **Disable SD card handling:**
  - In MCUXPresso IDE:
    - Remove SD_ENABLED and STREAMER_ENABLE_FILE_SINK symbols from preprocessor defines on project level:
      - (Project -> Properties -> C/C++ Build -> Settings -> MCU C Compiler -> Preprocessor)
  - In armgcc in SDK package:
    - Remove SD_ENABLED and STREAMER_ENABLE_FILE_SINK symbols from preprocessor defines in flags.cmake file.
  - In Kconfig:
    1. Disable File sink MCUX_COMPONENT_middleware.audio_voice.maestro.element.file_sink.enable
    2. Make sure SD card support is disabled MCUX_COMPONENT_middleware.sdmmc.sd

Functionality The record_mic or opus_encode command calls the STREAMER_mic_Create or STREAMER_opusmem2mem_Create function from the app_streamer.c file depending on the selected mode.

- When the *Loopback* mode is selected, the command calls the STREAMER_mic_Create function that creates a pipeline with the following elements:
  - ELEMENT_MICROPHONE_INDEX
  - ELEMENT_SPEAKER_INDEX
- When the *File recording* mode is selected, the command calls the STREAMER_mic_Create function that creates a pipeline with the following elements: - ELEMENT_MICROPHONE_INDEX - ELEMENT_FILE_SINK_INDEX
- When the *Voice control* mode is selected, the command calls the STREAMER_mic_Create function that creates a pipeline with the following elements: - ELEMENT_MICROPHONE_INDEX - ELEMENT_VOICESEEKER_INDEX (If VOICE_SEEKER_PROC is defined) - ELEMENT_VIT_INDEX
- When the Encoding mode is selected, the command calls the STREAMER_opusmem2mem_Create function that creates a pipeline with the following elements: - ELEMENT_MEM_SRC_INDEX - ELEMENT_ENCODER_INDEX - ELEMENT_MEM_SINK_INDEX

Recording itself can be started with the STREAMER_Start function.

Each of the elements has several properties that can be accessed using the streamer_get_property or streamer_set_property function. These properties allow a user to change the values of the appropriate elements. The list of properties can be found in streamer_element_properties.h. See the example of setting property value in the following piece of code from the app_streamer.c file:

```
    ELEMENT_PROPERTY_T prop;

    prop.prop = PROP_MICROPHONE_SET_NUM_CHANNELS;
    prop.val  = DEMO_MIC_CHANNEL_NUM;
    streamer_set_property(handle->streamer, 0, prop, true);

    prop.prop = PROP_MICROPHONE_SET_BITS_PER_SAMPLE;
    prop.val  = DEMO_AUDIO_BIT_WIDTH;
    streamer_set_property(handle->streamer, 0, prop, true);

    prop.prop = PROP_MICROPHONE_SET_FRAME_MS;
    prop.val  = DEMO_MIC_FRAME_SIZE;
    streamer_set_property(handle->streamer, 0, prop, true);

    prop.prop = PROP_MICROPHONE_SET_SAMPLE_RATE;
    prop.val  = DEMO_AUDIO_SAMPLE_RATE;
    streamer_set_property(handle->streamer, 0, prop, true);
```

Some of the predefined values can be found in the streamer_api.h.

States The application can be in 2 different states:

- Idle
- Running

Commands in detail

- *help, version*
- *record_mic audio <time>*
- *record_mic file <time>*
- *record_mic <file_name> <time>*
- *record_mic vit <time> <language>*
- *opus_encode*

Legend for diagrams:

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    A((State)):::state
    B{Condition}:::condition
    C[Error message]:::error
    D[Process function]:::function
```

help, version

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    A((Idle)):::state --> C[Write help or version]:::function
```

```
B((Running)):::state --> C
C --> E((No state
change)):::state
```

record_mic audio <time>

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    B((Idle)):::state --> D{time
    > 0 ?}:::condition
    D -- Yes --> F[recording]:::function
    D -- No --> E[Error: Record length
    must be greater than 0]:::error
    E --> B
    F --> C((Running)):::state
    C -->G{time
    expired?}:::condition
    G -- No --> C
    G -- Yes --> B
```

record_mic file <time>/record_mic <file_name> <time>

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    B((Idle)):::state --> C{time
    > 0 ?}:::condition
    C -- Yes --> D{SD card
    inserted?}:::condition
    C -- No --> E[Error: Record length
    must be greater than 0]:::error
    E --> B
    D -- Yes --> G{Custom
    file name?}:::condition
    G -- Yes --> H[Create custom
    file name]:::function
    G -- No --> I[Create default
    file name]:::function
    H --> J[Recording]:::function
    I --> J
    J --> K((Running)):::state
    K -->L{time
    expired?}:::condition
    L -- No --> K
    L -- Yes --> B
    D -- No --> F[Error: Insert SD
    card first]:::error
    F --> B
```

record_mic vit <time> <language>

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    B((Idle)):::state --> C{time
    > 0 ?}:::condition
    C -- Yes --> E{Selected
    language?}:::condition
    C -- No --> D[Error: Record length
    must be greater than 0]:::error
    D --> B
    E -- Yes --> G{Supported
    language?}:::condition
    E -- No --> F[Error: Language
    not selected]:::error
    F -->B
    G -- Yes -->I[Recording with
    voice recognition]:::function
    G -- No -->H[Error: Language not supported]:::error
    H --> B
    I --> J((Running)):::state
    J -->K{time
    expired?}:::condition
    K -- No --> J
    K -- Yes --> B
```

opus_encode

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    B((Idle)):::state -->C[Encode file]:::function
    C -->D[Check result]:::function
    D -->B
```

Processing Time Typical execution times of the streamer pipeline for the EVKC-MIMXRT1060 development board are detailed in the following table. The duration spent on output buffers and reading from the microphone is excluded from traversal measurements. Three measured pipelines were considered. The first involves a loopback from microphone to speaker, supporting both mono and stereo configurations. The second pipeline is a mono voice control setup, comprising microphone and VIT blocks. The final pipeline is a stereo voice control setup, integrating microphone, voice seeker, and VIT blocks.

For further details of execution times on individual elements, please refer to the *Processing Time* document.

	streamer
microphone -> speaker 1 channel	40 µs
microphone -> speaker 2 channels	115 µs
microphone -> VIT	7.4 ms
microphone -> voice seeker -> VIT	9.9 ms

Maestro sync example

Table of content

Overview The Maestro sync example demonstrates the use of synchronous pipelines (Tx and Rx in this case) processing in a single streamer task on the ARM cortex core utilizing the Maestro Audio Framework library.

The application is controlled by commands from a shell interface using serial console.

The feature is useful for testing the latency of the pipeline or implementing algorithms requiring reference signals such as echo cancellation. The VoiceSeeker library available in this example is not featuring AEC (Acoustic Echo Cancellation), but NXP is offering it in the premium version of the library. More information about the premium version can be found at VoiceSeeker. page. The demo uses two pipelines running synchronously in a single streamer task:

1. Playback (Tx) pipeline:
    - Playback of audio data in PCM format stored in flash memory to the audio Line-Out connector (speaker).
2. Recording (Rx) pipline:
    - Record audio data using a microphone.
    - VoiceSeeker processing.
    - Wake words + voice commands recognition.
    - Save the VoiceSeeker output to the voiceseeker_output.pcm file on the SD card.

As shown in the table below, the application is supported on several development boards, and each development board may have certain limitations, some development boards may also require hardware modifications or allow to use of an audio expansion board. Therefore, please check the supported features and *Hardware modifications* or *Example configuration* sections before running the demo.

Limitations:

- Addition labraries
  - **VIT:**
    * The VIT is supported only in the MCUXpresso IDE.
  - **VoiceSeeker:**
    * The VoiceSeeker is supported only in the MCUXpresso IDE.

Known issues:

- No known issues.

More information about supported features can be found on the *Supported features* page.

Hardware requirements

- Desired development board
- Micro USB cable
- Speaker with 3.5 mm stereo jack
- Personal computer
- Optional:
  - SD card for file output

Hardware modifications Some development boards need some hardware modifications to run the application. If the development board is not listed here, its default setting is required.

- *EVKC-MIMXRT1060:*
  1. Please make sure resistors below are removed to be able to use SD-Card.
     - R368, R347, R349, R365, R363
  2. Please Make sure J99 is installed.

Preparation

1. Connect a micro USB cable between the PC host and the debug USB port on the development board
2. Open a serial terminal with the following settings:
   - 115200 baud rate
   - 8 data bits
   - No parity
   - One stop bit
   - No flow control
3. Download the program to the target board.
4. Insert the speaker into the Line-Out connector (headphone jack) on the development board.
5. *Optional:* Insert an SD card into the SD card slot to record to the VoiceSeeker output.
6. Either press the reset button on your development board or launch the debugger in your IDE to begin running the demo.

Running the demo When the example runs successfully, you should see similar output on the serial terminal as below:

```
****************************
Maestro audio sync demo start
****************************

Copyright 2022 NXP
[APP_SDCARD_Task] start
[APP_Shell_Task] start

>> [APP_SDCARD_Task] SD card drive mounted
```

Type help to see the command list. Similar description will be displayed on serial console:

```
>> help

"help": List all the registered commands

"exit": Exit program

"version": Display component versions

"start [nosdcard]": Starts a streamer task.
            - Initializes the streamer with the Memory->Speaker pipeline and with
              the Microphone->VoiceSeeker->VIT->SDcard pipeline.
            - Runs repeatedly until stop command.
    nosdcard - Doesn't use SD card to store data.

"stop": Stops a running streamer:

"debug [on|off]": Starts / stops debugging.
              - Starts / stops saving VoiceSeeker input data (reference and microphone data)
                to SDRAM.
              - After the stop command, this data is transferred to the SD card.
```

Details of commands can be found *here*.

Example configuration The example can be configured by user. Before configuration, please check the *table* to see if the feature is supported on the development board.

- **Enable the premium version of VoiceSeeker:**
  - The premium version of the VoiceSeeker library with AEC is API compatible with this example.
  - To get the premium version, please visit VoiceSeeker page.
  - The following steps are required to run this example with the VoiceSeeker&AEC library.
    - Link the voiceseeker.a library instead of voiceseeker_no_aec.a.
    - Set the RDSP_ENABLE_AEC definition to 1U in the voiceseeker.h file
- **VIT model generation:**
  - For custom VIT model generation (defining own wake words and voice commands) please use https://vit.nxp.com/

Functionality The start <nosdcard> command calls the STREAMER_Create function from the app_streamer.c file that creates pipelines with the following elements:

- Playback pipeline:

  - ELEMENT_MEM_SRC_INDEX
  - ELEMENT_SPEAKER_INDEX
- Record pipeline:
  - ELEMENT_MICROPHONE_INDEX
  - ELEMENT_VOICESEEKER_INDEX
  - ELEMENT_VIT_PROC_INDEX
  - ELEMENT_FILE_SINK_INDEX (If the nosdcard argument is not used)

Processing itself can be started with the STREAMER_Start function.

Each of the elements has several properties that can be accessed using the streamer_get_property or streamer_set_property function. These properties allow a user to change the values of the appropriate elements. The list of properties can be found in streamer_element_properties.h. See the example of setting property value in the following piece of code from the app_streamer.c file:

```
ELEMENT_PROPERTY_T prop;

MEMSRC_SET_BUFFER_T buf;
buf.location = (int8_t *)TESTAUDIO_DATA;
buf.size     = TESTAUDIO_LEN;

prop.prop = PROP_MEMSRC_SET_BUFF;
prop.val  = (uintptr_t)&buf;
if (STREAM_OK != streamer_set_property(handle->streamer, 0, prop, true))
{
    return kStatus_Fail;
}

prop.prop = PROP_MEMSRC_SET_MEM_TYPE;
prop.val  = AUDIO_DATA;
if (STREAM_OK != streamer_set_property(handle->streamer, 0, prop, true))
{
    return kStatus_Fail;
}

prop.prop = PROP_MEMSRC_SET_SAMPLE_RATE;
prop.val  = DEMO_SAMPLE_RATE;
if (STREAM_OK != streamer_set_property(handle->streamer, 0, prop, true))
{
    return kStatus_Fail;
}
```

Some of the predefined values can be found in the streamer_api.h.

States The application can be in 2 different states:

- Idle
- Running

Commands in detail

- *help, version*
- *start [nosdcard]*
- *stop*
- *debug [on|off]*

Legend for diagrams:

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    A((State)):::state
    B{Condition}:::condition
    C[Error message]:::error
    D[Process function]:::function
```

help, version

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    A((Idle)):::state --> C[Write help or version]:::function
    B((Running)):::state --> C
    C --> E((No state
    change)):::state
```

start [nosdcard]

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    A((Idle)):::state --> B{nosdcard
    parameter?}:::condition
    B -- Yes --> CH[Playing to Line-out and
    recording]:::function
    CH --> L((Running)):::state
    B -- No --> C{Is SD card
    inserted?}:::condition
    C -- Yes --> E[Playing to Line-out and
    recording to SD card]:::function
    E --> F((Running)):::state
    F --> G{Debugging
    is enabled?}:::condition
    G -- No --> F
    G -- Yes --> H[Save reference and
    microphone data to SDRAM]:::function
    H --> F
    C -- No --> D[Error: Insert SD
card first]:::error
    D --> A
    J((Running)):::state --> K[Error: The streamer task is
    already running]:::error
    K --> J
```

stop

flowchart TD
classDef function fill:#69CA00
classDef condition fill:#0EAFE0
classDef state fill:#F9B500
classDef error fill:#F54D4D

A((Idle)):::state --> A
B((Running)):::state --> C{Is debugging
enabled?}:::condition
C --Yes -->E[Copy reference and
microphone data to
the SD card]:::function
E --> G((Idle)):::state
C -- No --> G

debug [on|off]

flowchart TD
classDef function fill:#69CA00
classDef condition fill:#0EAFE0
classDef state fill:#F9B500
classDef error fill:#F54D4D

A((Idle)):::state --> B[Error: First, start
the streamer task]:::error
C((Running)):::state --> D{Any
parameter?}:::condition
D -- Yes --> F{Started with
nosdcard
parameter?}:::condition
F -- No --> H[Set debugging]:::function
H --> C
F --Yes --> G[Error: Debugging cannot be used]:::error
G --> C
D -- No --> E[Error: Use the parameter
either on or off]:::error
E --> C

Maestro USB microphone example

Table of content

Overview The Maestro USB microphone example demonstrates audio processing on the ARM cortex core utilizing the Maestro Audio Framework library.

The application is controlled by commands from a shell interface using serial console.

The development board will be enumerated as a USB audio class 2.0 device on the USB host. The application takes audio samples from the microphone inputs and sends them to the USB host via the USB bus. User will see the volume levels obtained from the USB host but this is only an example application. To leverage the volume values, the demo has to be modified.

As shown in the table below, the application is supported on several development boards, and each development board may have certain limitations, some development boards may also require hardware modifications or allow to use of an audio expansion board. Therefore, please check the supported features and *Hardware modifications* or *Example configuration* sections before running the demo.

Limitations:

- *Note:*
  1. When connected to MacBook, change the PCM format from (0x02,0x00,) to (0x01,0x00,) in the g_config_descriptor[CONFIG_DESC_SIZE] in the usb_descriptor.c file. Otherwise, it can't be enumerated and noise is present when recording with the QuickTime player because the sampling frequency and bit resolution do not match.
  2. When device functionality is changed, please uninstall the previous PC driver to make sure the device with changed functionality can run normally.
  3. If you're having audio problems on Windows 10 for recorder, please disable signal enhancement as the following if it is enabled and have a try again.

Known issues:

- No known issues.

More information about supported features can be found on the *Supported features* page.

Hardware requirements

- Desired development board
- 2x Micro USB cable
- Personal Computer
- *LPCXpresso55s69:*
  - Source of sound with 3.5 mm stereo jack connector

Hardware modifications Some development boards need some hardware modifications to run the application. If the development board is not listed here, its default setting is required.

Preparation

1. Connect the first micro USB cable between the PC host and the debug USB port on the development board
2. Open a serial terminal with the following settings:
   - 115200 baud rate
   - 8 data bits
   - No parity
   - One stop bit

- No flow control

3. Download the program to the target board.
4. *LPCXpresso55s69:*
   - Insert source of sound to Audio Line-In connector (headphone jack) on the development board.
5. Connect the second micro USB cable between the PC host and the USB port on the development board.
6. Either press the reset button on your development board or launch the debugger in your IDE to begin running the demo.

Running the demo When the example runs successfully, you should see similar output on the serial terminal as below:

```
**************************************************
Maestro audio USB microphone solutions demo start
**************************************************

Copyright 2022 NXP
[APP_Shell_Task] start

>> usb_mic -1

Starting maestro usb microphone application
The application will run until the board restarts
[STREAMER] Message Task started
Starting recording
[STREAMER] start usb microphone
Set Cur Volume : 1f00
```

Type help to see the command list. Similar description will be displayed on serial console:

```
>> help

"help": List all the registered commands

"exit": Exit program

"version": Display component versions

"usb_mic": Record MIC audio and playback to the USB port as an audio 2.0
        microphone device.

  USAGE: usb_mic <seconds>
    <seconds> Time in seconds how long the application should run.
              When you enter a negative number the application will
              run until the board restarts.
  EXAMPLE:  The application will run for 20 seconds: usb_mic 20
```

Details of commands can be found *here*.

Example configuration The example only supports one mode and do not support any additional libraries, so the example can't be configured by user.

Functionality The usb_mic command calls the STREAMER_mic_Create function from the app_streamer.cfile that creates pipeline with the following elements: - ELEMENT_MICROPHONE_INDEX - ELEMENT_USB_SINK_INDEX

Recording itself can be started with the STREAMER_Start function.

Each of the elements has several properties that can be accessed using the streamer_get_property or streamer_set_property function. These properties allow a user to change the values of the appropriate elements. The list of properties can be found in streamer_element_properties.h. See the example of setting property value in the following piece of code from the app_streamer.c file:

```
ELEMENT_PROPERTY_T prop;

prop.prop = PROP_MICROPHONE_SET_SAMPLE_RATE;
prop.val  = AUDIO_SAMPLING_RATE;

streamer_set_property(handle->streamer, 0, prop, true);

prop.prop = PROP_MICROPHONE_SET_NUM_CHANNELS;
prop.val  = 1;

streamer_set_property(handle->streamer, 0, prop, true);

prop.prop = PROP_MICROPHONE_SET_FRAME_MS;
prop.val  = 1;

streamer_set_property(handle->streamer, 0, prop, true);
```

Some of the predefined values can be found in the streamer_api.h.

States The application can be in 2 different states:

- Idle
- Running

Commands in detail

- *help, version*
- *usb_mic <seconds>*

Legend for diagrams:

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    A((State)):::state
    B{Condition}:::condition
    C[Error message]:::error
    D[Process function]:::function
```

help, version

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    A((Idle)):::state --> C[Write help or version]:::function
    B((Running)):::state --> C
```

```
C --> E((No state
change)):::state
```

usb_mic <seconds>

```
flowchart TD
    classDef function fill:#c6d22c
    classDef condition fill:#7cb2de
    classDef state fill:#fcb415
    classDef error fill:#FF999C

    B((Idle)):::state -->C{seconds
    == 0?}:::condition
    C -- No --> E{seconds
    < 0?}:::condition
    C -- Yes --> D[Error: Incorrect
    command parameter]:::error
    D -->B
    E -- Yes --> G[recording]:::function
    G --> H((Running)):::state
    H --> H
    E -- No --> F[recording]:::function
    F --> I((Running)):::state
    I --> J{seconds
    expired?}:::condition
    J -- No -->I
    J -- Yes --> B
```

Maestro USB speaker example

Table of content

Overview The Maestro USB speaker example demonstrates audio processing on the ARM cortex core utilizing the Maestro Audio Framework library.

The application is controlled by commands from a shell interface using serial console.

The development board will be enumerated as a USB audio class 2.0 device on the USB host. The application takes audio samples from the USB host and sends them to the audio Line-Out port. User will see the volume levels obtained from the USB host but this is only an example application. To leverage the volume values, the demo has to be modified.

Depending on target platform or development board there are different modes and features of the demo supported.

- **Standard** - The mode demonstrates playback with up to 2 channels, up to 48 kHz sample rate and up to 16 bit width. This mode is enabled by default.
- **Multi-Channel** - In this mode the device is enumerated as a UAC 5.1. This mode is disabled by default. See the *Example configuration* section to see how to enable the mode.
  - When playing an 5.1 audio file, the example sends only the front-left and front-right channels to the audio Line-Out port (the other channels are ignored), since this example only supports on-board codecs with stereo audio output.

As shown in the table below, the application is supported on several development boards, and each development board may have certain limitations, some development boards may also require hardware modifications or allow to use of an audio expansion board. Therefore, please check the supported features and *Hardware modifications* or *Example configuration* sections before running the demo.

Limitations:

- *Note:*
  - If the USB device audio speaker example uses an ISO IN feedback endpoint, please attach the device to a host like PC which supports feedback function. Otherwise, there might be attachment issue or other problems.

Known issues:

- No known issues.

More information about supported features can be found on the *Supported features* page.

Hardware requirements

- Desired development board
- 2x Micro USB cable
- Personal Computer
- Headphones with 3.5 mm stereo jack

Hardware modifications Some development boards need some hardware modifications to run the application. If the development board is not listed here, its default setting is required.

Preparation

1. Connect the first micro USB cable between the PC host and the debug USB port on the development board
2. Open a serial terminal with the following settings:
   - 115200 baud rate
   - 8 data bits
   - No parity
   - One stop bit
   - No flow control
3. Download the program to the target board.
4. Connect the second micro USB cable between the PC host and the USB port on the development board.

5. Insert the headphones into Line-Out connector (headphone jack) on the development board.
6. Either press the reset button on your development board or launch the debugger in your IDE to begin running the demo.

Running the demo When the example runs successfully, you should see similar output on the serial terminal as below:

```
**********************************************
Maestro audio USB speaker solutions demo start
**********************************************

Copyright 2022 NXP
[APP_Shell_Task] start

>> usb_speaker -1

Starting maestro usb speaker application
The application will run until the board restarts
[STREAMER] Message Task started
Starting playing
[STREAMER] start usb speaker
Set Cur Volume : fbd5
```

Type help to see the command list. Similar description will be displayed on serial console:

```
>> help

"help": List all the registered commands

"exit": Exit program

"version": Display component versions

"usb_speaker": Play data from the USB port as an audio 2.0
               speaker device.

 USAGE:      usb_speaker <seconds>
  <seconds>  Time in seconds how long the application should run.
             When you enter a negative number the application will
             run until the board restarts.
  EXAMPLE:   The application will run for 20 seconds: usb_speaker 20
```

Details of commands can be found *here*.

Example configuration The example can be configured by user. Before configuration, please check the *table* to see if the feature is supported on the development board.

- **Enable Multi-channel mode:**
  - The feature can be enabled by set the USB_AUDIO_CHANNEL5_1 macro to 1U in the usb_device_descriptor.h file.
  - *Note:* When device functionality is changed, such as UAC 5.1, please uninstall the previous PC driver to make sure the device with changed functionality can run normally.

Functionality The Usb_speaker command calls the STREAMER_speaker_Create function from the app_streamer.cfile that creates pipeline with the following elements: - ELEMENT_USB_SRC_INDEX - ELEMENT_SPEAKER_INDEX

Playback itself can be started with the STREAMER_Start function.

Each of the elements has several properties that can be accessed using the streamer_get_property or streamer_set_property function. These properties allow a user to change the values of the appropriate elements. The list of properties can be found in streamer_element_properties.h. See the example of setting property value in the following piece of code from the app_streamer.c file:

```
ELEMENT_PROPERTY_T prop;

prop.prop = PROP_USB_SRC_SET_SAMPLE_RATE;
prop.val  = AUDIO_SAMPLING_RATE;

streamer_set_property(handle->streamer, 0, prop, true);

prop.prop = PROP_USB_SRC_SET_NUM_CHANNELS;
prop.val  = 2;

streamer_set_property(handle->streamer, 0, prop, true);

prop.prop = PROP_USB_SRC_SET_FRAME_MS;
prop.val  = 1;

streamer_set_property(handle->streamer, 0, prop, true);
```

Some of the predefined values can be found in the streamer_api.h.

States The application can be in 2 different states:

- Idle
- Running

Commands in detail

- *help, version*
- *usb_speaker <seconds>*

Legend for diagrams:

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    A((State)):::state
    B{Condition}:::condition
    C[Error message]:::error
    D[Process function]:::function
```

help, version

```
flowchart TD
    classDef function fill:#69CA00
    classDef condition fill:#0EAFE0
    classDef state fill:#F9B500
    classDef error fill:#F54D4D

    A((Idle)):::state --> C[Write help or version]:::function
    B((Running)):::state --> C
```

```
C --> E((No state
change)):::state
```

usb_speaker <seconds>

```
flowchart TD
    classDef function fill:#c6d22c
    classDef condition fill:#7cb2de
    classDef state fill:#fcb415
    classDef error fill:#FF999C

    B((Idle)):::state -->C{Duration
    == 0?}:::condition
    C -- No --> E{Duration
    < 0?}:::condition
    C -- Yes --> D[Error: Incorrect
    command parameter]:::error
    D -->B
    E -- Yes --> G[playing]:::function
    G --> H((Running)):::state
    H --> H
    E -- No --> F[playing]:::function
    F --> I((Running)):::state
    I --> J{Duration
    expired?}:::condition
    J -- No -->I
    J -- Yes --> B
```

Supported features The current version of the audio framework supports several optional features. These can be limited to some MCU cores or development boards variants. More information about support can be found on the specific example page:

- *maestro_playback*
- *maestro_record*
- *maestro_usb_mic*
- *maestro_usb_speaker*
- *maestro_sync*

Some features are delivered as prebuilt library and the binaries can be found in the \middleware\audio_voice\components*component*\libs folder. The source code of some features can be found in the \middleware\audio_voice\maestro\src folder.

Decoders Supported decoders and its options are:

Decoder	Sample rates [kHz]	Number of channels	Bit depth
AAC	8, 11.025, 12, 16, 22.05, 24, 32, 44.1, 48	1, 2 (mono/stereo)	16
FLAC	8, 11.025, 12, 16, 22.05, 32, 44.1, 48	1, 2 (mono/stereo)	16
MP3	8, 11.025, 12, 16, 22.05, 24, 32, 44.1, 48	1, 2 (mono/stereo)	16
OPUS	8, 16, 24, 48	1, 2 (mono/stereo)	16
WAV	8, 11.025, 16, 22.05, 32, 44.1, 48	1, 2 (mono/stereo)	8, 16, 24

For more details about the reference decoders please see audio-voice-components repository documentation \middleware\audio_voice\components\.

Encoders

- **OPUS encoder** - The current verion of the audio framework only supports a OPUS encoder. For more details about the encoder please see the following link.

Sample rate converters

- **SSRC** - Synchronous sample rate converter. More details about SSRC are available in the User Guide, which is located in middleware\audio_voice\components\ssrc\doc\.
- **ASRC** - Asynchronous sample rate converter is not used in our examples, but it is part of the maestro middleware and can be enabled. To enable ASRC, the maestro_framework_asrc and CMSIS_DSP_Library_Source components must be added to the project. Furthermore, it is necessary to switch from Redlib to Newlib (semihost) library and add a platform definition to the project (e.g. for RT1170: PLATFORM_RT1170_CORTEXM7). Supported platforms can be found in the PL_platformTypes.h file. More details about ASRC are available in the User Guide, which is located in middleware\audio_voice\components\asrc\doc\.

Additional libraries

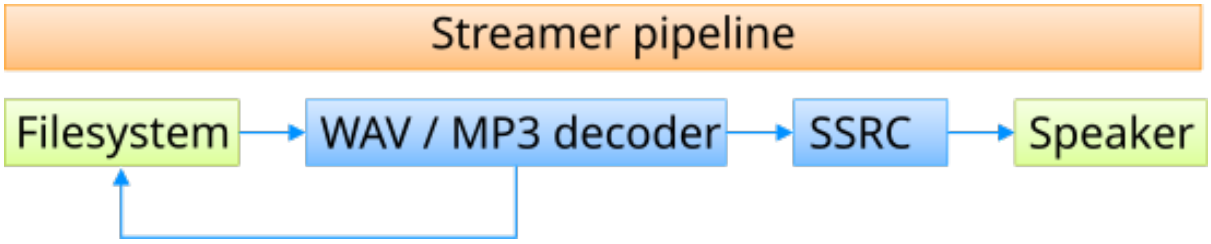
- **VIT** - Voice Intelligent Technology (VIT) Wake Word and Voice Command Engines provide free, ready to use voice UI enablement for developers. It enables customer-defined wake words and commands using free online tools. More details about VIT are available in the VIT package, which is located in middleware\audio_voice\components\vit\{platform}\Doc\(depending on the platform) or via following link.
- **VoiceSeeker** - VoiceSeeker is a multi-microphone voice control audio front-end signal processing solution. More details about VoiceSeeker are available in the VoiceSeeker package, which is located in middleware\audio_voice\components\voice_seeker\{platform}\Doc\(depending on the platform) or via following link.

Processing Time

Table of content

The individual time measurements were conducted using a logic analyzer by monitoring changes in the GPIO port levels on the EVKC-MIMXRT1060 development board. These measurements were executed for each individual pipeline run, capturing the timing at each corresponding element, and, when relevant, the interconnections between these elements.

Maestro playback example For the Maestro playback example the following reference audio file was used: test_48khz_16bit_2ch.wav. In this example, the pipeline depicted in the diagram was considered. Media codecs WAV and MP3 were taken into account. To compare the times spent on the SSRC block, sampling rates for both codecs were selected: 44.1 kHz and 48 kHz.



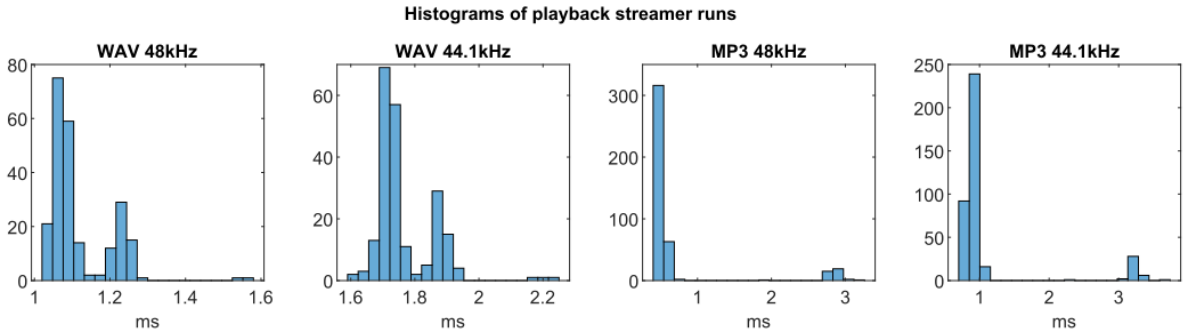
The measurement of streamer pipeline run started at the beginning of streamer_process_pipelines(): streamer.c and ended in the function streamer_pcm_write(): streamer_pcm.c just before the output buffer.

In the scenario involving the WAV codec, the audio file was accessed in every iteration of the streamer pipeline. Meaning, during each run, the file was read directly from the SD card. However, in the case of the MP3 codec, where data processing necessitates complete MP3 frames, the file wasn't read during every run. Rather, it was accessed periodically, triggered when the codec buffer lacked a complete MP3 frame of data. The total time spent on codec processing varies significantly depending on the type and implementation of the codec. For certain types of codecs, like FLAC, there may be multiple file accesses during a single pipeline run. The provided values are specific to the reference implementation. For details about the codecs please see see audio-voice-components documentation middleware\audio_voice\components\.

The duration of the streamer pipeline illustrates that with a sampling frequency of 48 kHz, there is no resampling occurring at the SSRC element. Consequently, the overall pipeline time is lower than in the case of 44.1 kHz audio, where resampling takes place.

To enhance comprehension of the system's behavior, histograms of the pipeline run times and its elements are included. The greater time variance with the MP3 codec is precisely due to the absence of file reads in every run. In clusters with shorter times, there are no file accesses, while in clusters with longer times, file reads occur. This indicates that the majority of runs do not involve file access.

	WAV 48 kHz	WAV 44 kHz	MP3 48 kHz file read	MP3 48 kHz w/o file read	MP3 44 kHz file read	MP3 44 kHz w/o file read
mean	1.11 ms	1.76 ms	2.87 ms	0.51 ms	3.22 ms	0.89 ms
min	1.03 ms	1.60 ms	2.74 ms	0.41 ms	2.33 ms	0.74 ms
max	1.29 ms	2.23 ms	3.24 ms	1.83 ms	3.73 ms	1.12 ms



Time on each element In the tables and histograms below, the timings for individual elements and their connections are provided. Given that the file reading function was invoked during the codec's operation, the tables for individual elements display the total time on the codec element, the time on the codec element before the file read, and the time on the codec element after the file read. The individual blocks in the tables are as follows:

- **streamer** - total time of one pipeline run without time on output buffers
- **codec start** - time on decoder before file read
- **codec end** - time on decoder after file read
- **codec total** - codec_start+codec_end
- **file_src** - file reading time
- **SSRC_proc** - time on SSRC element
- **audio_sink** - time on audio sink without ouput buffers

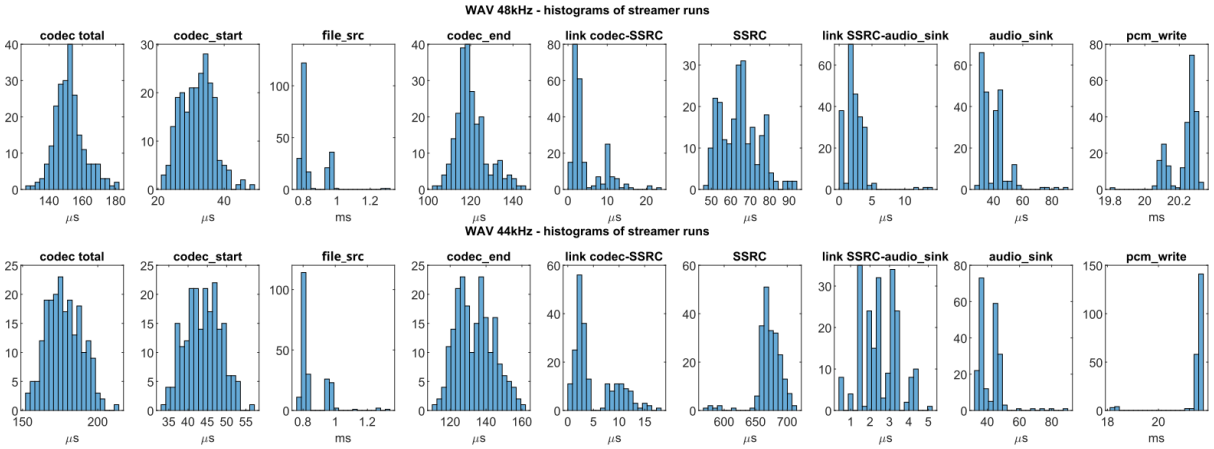
- **pcm_write** - time on output buffers
- **link** - time on element links

The start times of the time intervals for individual blocks and their respective links were measured by altering the GPIO pin level in the following functions:

- **streamer** - streamer_process_pipelines():streamer.c
- **codec** - decoder_sink_pad_process_handler():decoder_pads.c
- **file_src** - filesrc_read():file_src_rtos.c
- **SSRC_proc** - SSRC_Proc_Execute():ssrc_proc.c
- **audio_sink** - audiosink_sink_pad_chain_handler():audio_sink.c
- **pcm_write** - streamer_pcm_write():streamer_pcm.c
- **link** - pad_push():pad.c

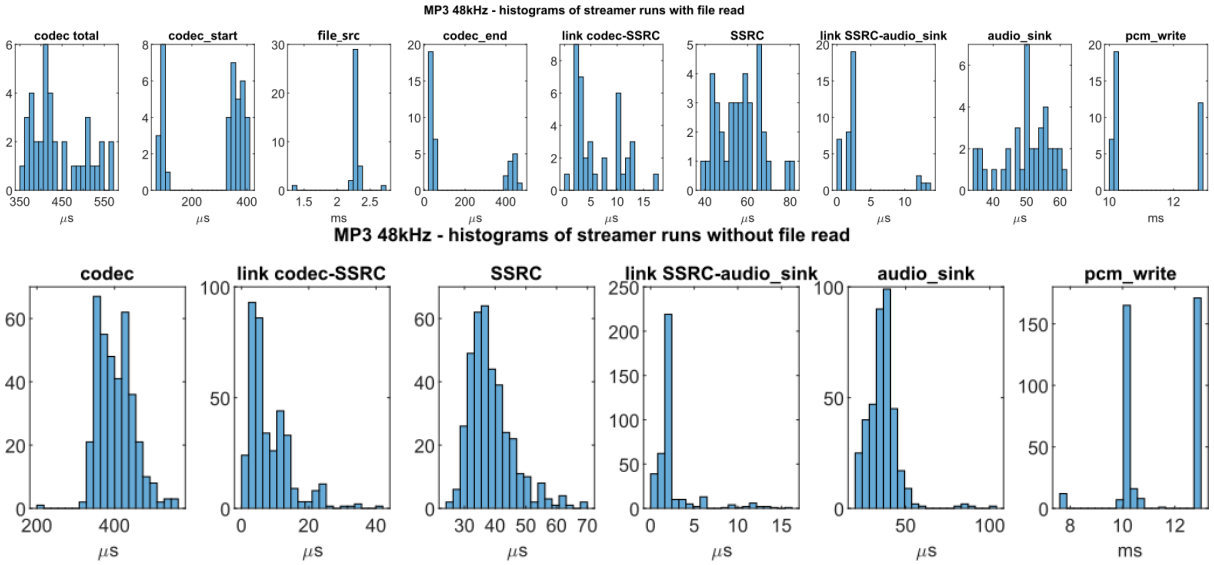
WAV 48kHz	strean	codec total	codec start	file_sr	codec end	link codec-SSRC	SSRC_p	link SSRC-audio_sink	au-dio_sin	pcm_write
mean	1.119 ms	152 µs	31 µs	0.843 ms	120 µs	5 µs	64 µs	2 µs	40 µs	20.228 ms
min	1.026 ms	125 µs	21 µs	0.773 ms	104 µs	<1 µs	47 µs	<1 µs	30 µs	19.805 ms
max	1.290 ms	193 µs	49 µs	1.311 ms	144 µs	23 µs	93 µs	14 µs	91 µs	20.324 ms

WAV 44kHz	strean	codec total	codec start	file_sr	codec end	link codec-SSRC	SSRC_p	link SSRC-audio_sink	au-dio_sin	pcm_write
mean	1.765 ms	178 µs	44 µs	0.853 ms	134 µs	5 µs	671 µs	3 µs	42 µs	21.472 ms
min	1.604 ms	145 µs	33 µs	0.770 ms	112 µs	<1 µs	574 µs	<1 µs	33 µs	18.163 ms
max	2.233 ms	218 µs	57 µs	1.335 ms	161 µs	18 µs	715 µs	5 µs	89 µs	21.746 ms



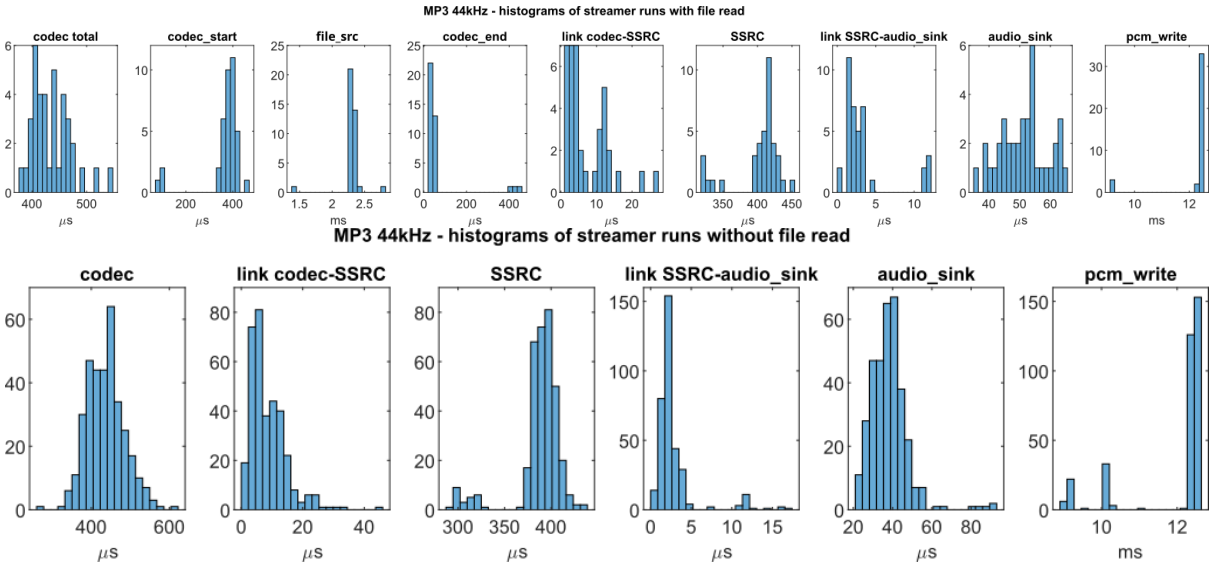
MP3 48 kHz w/ file read	strear	codec total	codec start	file_sr	codec end	link codec-SSRC	SSRC_l	link SSRC-audio_sink	au-dio_sir	pcm_write
mean	2.871 ms	441 µs	279 µs	2.271 ms	162 µs	6 µs	56 µs	3 µs	50 µs	11.019 ms
min	2.739 ms	353 µs	74 µs	1.353 ms	26 µs	<1 µs	40 µs	<1 µs	34 µs	10.091 ms
max	3.244 ms	570 µs	409 µs	2.728 ms	467 µs	18 µs	80 µs	14 µs	62 µs	12.910 ms

MP3 48 kHz w/o file read	strear	codec total	codec start	file_s	codec end	link codec-SSRC	SSRC_l	link SSRC-audio_sink	au-dio_sir	pcm_write
mean	0.508 ms	403 µs	x	x	x	8 µs	39 µs	3 µs	36 µs	11.326 ms
min	0.407 ms	208 µs	x	x	x	<1 µs	25 µs	<1 µs	21 µs	7.715 ms
max	1.834 ms	563 µs	x	x	x	41 µs	69 µs	16 µs	104 µs	12.941 ms

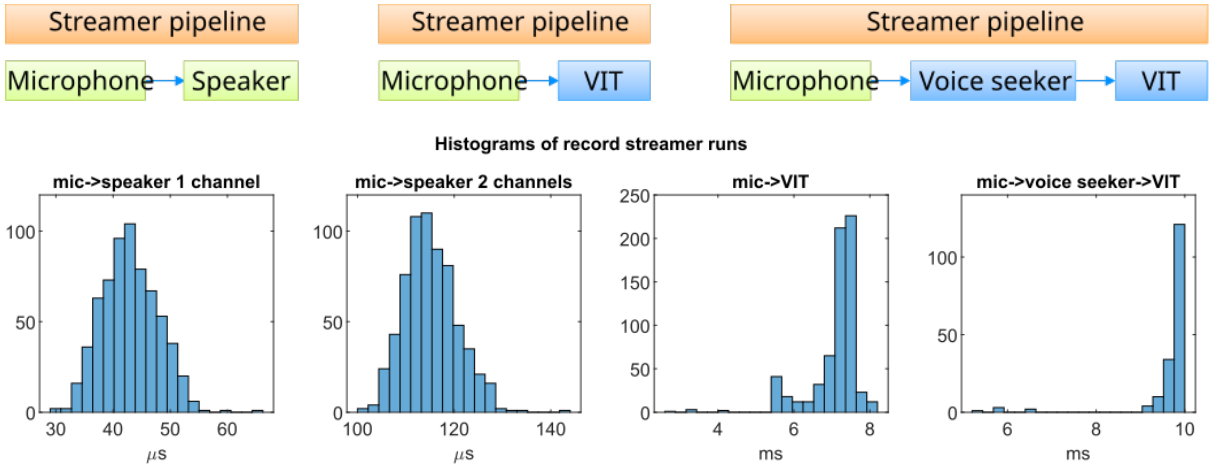


MP3 44 kHz w/ file read	strear	codec total	codec start	file_sr	codec end	link codec-SSRC	SSRC_l	link SSRC-audio_sink	au-dio_sir	pcm_write
mean	3.217 ms	436 µs	367 µs	2.300 ms	66 µs	7 µs	403 µs	3 µs	51 µs	12.188 ms
min	2.329 ms	383 µs	73 µs	1.411 ms	26 µs	2 µs	318 µs	<1 µs	35 µs	9.119 ms
max	3.726 ms	547 µs	464 µs	2.801 ms	441 µs	27 µs	454 µs	12 µs	65 µs	12.529 ms

MP3 44 kHz w/o file read	strear	codec total	codec start	file_s	codec end	link codec-SSRC	SSRC_l	link SSRC-audio_sink	au-dio_sir	pcm_write
mean	0.891 ms	437 µs	x	x	x	9 µs	388 µs	3 µs	38 µs	11.934 ms
min	0.738 ms	268 µs	x	x	x	<1 µs	290 µs	<1 µs	22 µs	8.964 ms
max	1.115 ms	620 µs	x	x	x	45 µs	438 µs	17 µs	92 µs	12.624 ms



Maestro record example Typical execution times of the streamer pipeline and its individual elements for the EVKC-MIMXRT1060 development board are detailed in the following tables. The duration spent on output buffers and reading from the microphone is excluded from traversal measurements. Three measured pipelines are depicted in the figure below. The first involves a loopback from microphone to speaker, supporting both mono and stereo configurations. The second pipeline is a mono voice control setup, comprising microphone and VIT blocks. The final pipeline is a stereo voice control setup, integrating microphone, voice seeker, and VIT blocks. The measurement of streamer pipeline run started at the beginning of streamer_process_pipelines():streamer.c and ended in the function streamer_pcm_write(): streamer_pcm.c just before the output buffer.



The individual blocks in the tables are as follows:

- **streamer** - total time of one pipeline run without time on output buffers and without time reading from the microphone
- **audio_src_start** - time on audio src before reading from the microphone
- **audio_src_end** - time on audio src after reading from the microphone
- **pcm_read** - reading from the microphone
- **voiceseeker** - time on voice seeker element
- **vit** - time on VIT element
- **audio_sink** - time on audio sink without ouput buffers
- **pcm_write** - time on output buffers
- **link** - time on element links

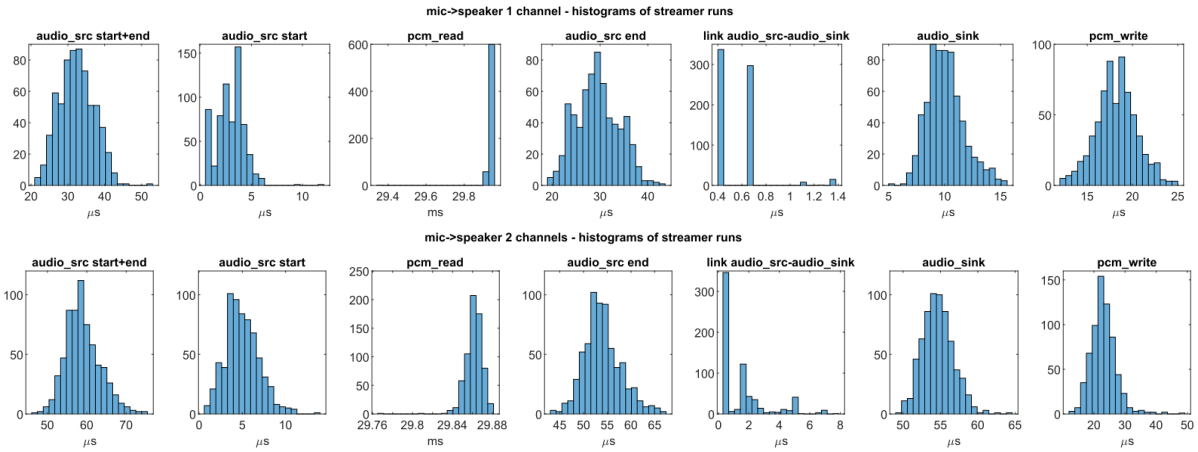
The start times of the time intervals for individual blocks and their respective links were measured by altering the GPIO pin level in the following functions:

- **streamer** - streamer_process_pipelines():streamer.c
- **audio_src** - audiosrc_src_process():audio_src.c
- **pcm_read** - streamer_pcm_read():streamer_pcm.c
- **voiceseeker** - audio_proc_sink_pad_chain_handler():audio_proc.c
- **vit** - vitsink_sink_pad_chain_handler():vit_sink.c
- **audio_sink** - audiosink_sink_pad_chain_handler():audio_sink.c
- **pcm_write** - streamer_pcm_write():streamer_pcm.c
- **link** - pad_push():pad.c

Pipeline Microphone -> Speaker

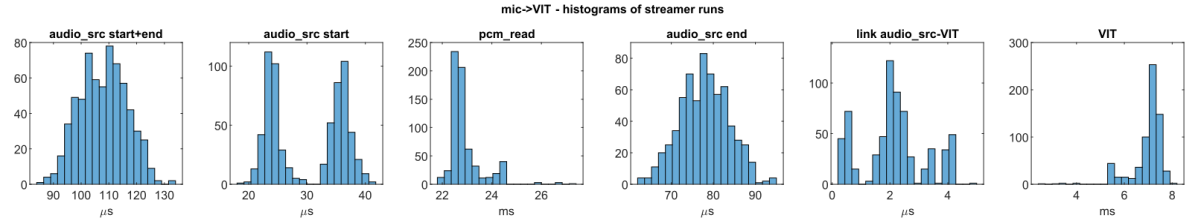
microphone -> speaker mono	stream	audio_src_sta	pcm_re	audio_src_er	link audio_src-audio_sink	audio_sink	pcm_write
mean	43 µs	3 µs	29.938 ms	29 µs	<1 µs	10 µs	18 µs
min	26 µs	<1 µs	29.350 ms	19 µs	<1 µs	5 µs	12 µs
max	72 µs	12 µs	29.957 ms	44 µs	1 µs	15 µs	25 µs

microphone -> speaker stereo	stream	audio_src_sta	pcm_re	audio_src_er	link audio_src-audio_sink	audio_sink	pcm_write
mean	115 µs	5 µs	29.861 ms	54 µs	2 µs	55 µs	23 µs
min	94 µs	<1 µs	29.768 ms	43 µs	<1 µs	50 µs	12 µs
max	154 µs	14 µs	29.880 ms	67 µs	8 µs	65 µs	49 µs



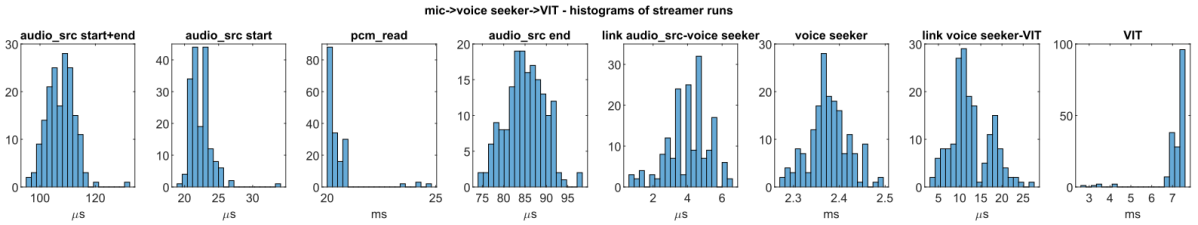
Pipeline Microphone -> VIT

microphone -> VIT	streamer	audio_src_start	pcm_read	audio_src_end	link audio_src-vit	vit
mean	7.380 ms	30 µs	22.624 ms	78 µs	2 µs	7.261 ms
min	2.641 ms	10 µs	2.2265 ms	58 µs	<1 µs	2.559 ms
max	7.780 ms	42 µs	2.7341 ms	94 µs	5 µs	7.624 ms



Pipeline Microphone -> Voice seeker -> VIT

microphone -> voice seeker -> VIT	stream	audio_src_s	pcm_r	audio_src_	link audio_src-voiceseeker	voice-seeker	link voiceseeke vit	vit
mean	9.916 ms	22 µs	20.084 ms	84 µs	4 µs	2.386 ms	13 µs	7.407 ms
min	4.983 ms	19 µs	19.738 ms	72 µs	<1 µs	2.228 ms	2 µs	2.662 ms
max	10.423 ms	34 µs	24.777 ms	100 µs	7 µs	2.522 ms	31 µs	7.729 ms



Maestro on Zephyr

- Based on and tested with Zephyr version, given by tag v4.0.0
- Tested with Zephyr SDK version 16.4
- To see the pre-built documentation, see: README.html. Also see the *documentation section*.

Maestro sample for recording data from microphone to RAM

Description This sample records data from microphone (alias dmic0 in devicetree) and stores them to a buffer in RAM.

Currently one PDM channel with fixed 16 kHz sample rate and 16 bit sample width is supported.

For configuration options, see Kconfig and prj.conf.

User Input/Output

- Input:

  None.

- Output:

  UART Output:

  - Demo result: OK if everything went OK
  - Demo result: FAIL otherwise

Supported platforms Currently tested for:

- RD_RW612_BGA.

Maestro voice detection sample using VIT

Description Records data from microphone (alias dmic0 in devicetree) and detects voice commands from selected language model. Detected commands are printed via UART.

Language model may be changed via Kconfig using CONFIG_MAESTRO_EXAMPLE_VIT_LANGUAGE selection. For other configuration options, see example's Kconfig and prj.conf.

This project requires an NXP board supported by the VIT library.

The example has to be modified if a new board needs to be added. Please create an issue in that case.

User Input/Output

- Input:

  None.

- Output:

  UART Output:

  - List of voice commands the model can detect (printed immediately after start)
  - <Specific voice command> if voice command was detected
  - Demo result: FAIL otherwise

Dependencies

- VIT library: https://www.nxp.com/design/design-center/software/embedded-software/voice-intelligent-technology-wake-word-and-voice-command-engines:VOICE-INTELLIGENT-TECHNOLOGY

Supported platforms Currently tested for:

- RD_RW612_BGA.

Maestro decoder sample

Description Tests and demonstrates decoder functionality in Maestro pipeline.

Supported decoders:

- MP3
- WAV
- AAC
- FLAC
- OPUS with OGG envelop
- (RAW OPUS - TBD)

Data Input:

- Prepared encoded audio data (part of Maestro repository, folder `zephyr/audioTracks`)
- Prepared decoded audio data (RAW PCM format, part of Maestro repository, folder `zephyr/audioTracks`)

Function:

1. Loads encoded data into source buffer stored in RAM
2. Decodes audio data using selected decoder and stores data in RAM
3. Compares prepared data with decoded data to check if its the same
4. Prints `Demo result: OK` or `Demo result: FAIL` via UART

User Input/Output

- Input:

  None

- Output:

  UART Output

  - `Demo result: OK` if everything went OK
  - `Demo result: FAIL` otherwise

Dependencies

- Audio voice component library (pulled in by Maestro's west), containing Decoder libraries

Configuration

- See prj.conf for user input sections
  - Selecting decoder may be done by enabling CONFIG_MAESTRO_EXAMPLE_DECODER_SELECTED in prj.conf file. When no decoder is selected, default one (WAV) is used instead.
  - System settings should be modified (stack size, heap size) based on selected decoder and system capabilities/requirements in prj.conf.
- For other configuration options, see example's Kconfig and prj.conf.

Supported platforms Currently tested for:

- RD_RW612_BGA - Working decoders: FLAC, WAV, OPUS OGG

Maestro encoder sample

Description Tests and demonstrates encoder functionality in Maestro pipeline.

Supported encoders:

- OPUS with OGG envelop - TBD
- RAW OPUS - TBD

Input:

- Prepared decoded audio data (RAW PCM format, part of Maestro repository)
- Prepared encoded audio data (part of Maestro repository)

Function:

1. Loads RAW data into source buffer stored in RAM
2. Encodes audio data using selected encoder and stores data in RAM
3. Compares prepared data with decoded data if same
4. Prints Demo result: OK or Demo result: FAIL via UART

Dependencies

- Audio voice component library (pulled in by Maestro's west), containing Encoder libraries

User Input/Output Input:

- None

Output:

- UART Output
  - Demo result: OK if everything went OK
  - Demo result: FAIL otherwise

Configuration

- See prj.conf for user input sections
  - Selecting encoder may be done by enabling CONFIG_MAESTRO_EXAMPLE_ENCODER_SELECTED in prj.conf file. When no encoder is selected, default one (OPUS) is used instead.
  - System settings should be modified (stack size, heap size) based on selected encoder and system capabilities/requirements in prj.conf file.
- For other configuration options, see example's Kconfig and prj.conf.

Supported platforms Currently tested for:

- RD_RW612_BGA - Working encoders: None.

Maestro mem2mem sample

Description Tests basic memory to memory pipeline.

Function:

1. Moves generated data with fixed size of 256B from memory source to memory sink.
2. Compares copied data to check if they're the same.
3. Returns Demo result: OK or Demo result: FAIL via UART.

Maestro environment setup Follow these steps to set up a Maestro development environment on your machine.

1. If you haven't already, please follow this guide to set up a Zephyr development environment and its dependencies first:
   - Cmake
   - Python
   - Devicetree compiler
   - West
   - Zephyr SDK bundle

2. Get Maestro. You can pick either of the options listed below. If you need help deciding which option is the best fit for your needs, please see the *FAQ*.

   - Freestanding Maestro - This option pulls in only Maestro's necessary dependencies.

     Run:

     ```
     1. west init -m <maestro repository url> --mr <revision> --mf west-freestanding.yml
     ↪<foldername>
     2. cd <foldername>
     3. west update
     ```

   - Maestro as a Zephyr module

     To include Maestro into Zephyr, update Zephyr's west.yml file:

     ```
     projects:
     name: maestro
     url: <maestro repository url>
     revision: <revision with Zephyr support>
     path: modules/audio/maestro
     import: west.yml
     ```

     Then run west update maestro command.

Build and run Maestro example These steps will guide you through building and running Maestro samples. You can use either the command line utilizing Zephyr's powerful west tool or you can use VS Code's GUI. Detailed steps for both options are listed below.

Using command line See Zephyr's Building, Flashing and Debugging guide if you aren't familiar with it yet.

1. To **build** a project, run:

   ```
   west build -b <board> -d <output build directory> <path to example> -p
   ```

   For example, this compiles VIT example for rd_rw612_bga board:

   ```
   1. cd maestro/zephyr
   2. west build -b rd_rw612_bga -d build samples/vit -p
   ```

2. To **run** a project, run:

   ```
   west flash -d <directory>
   ```

   e.g.:

   ```
   west flash -d build
   ```

3. To **debug** a project, run:

   ```
   west debug -d <directory>
   ```

   e.g.:

   ```
   west debug -d build
   ```

Using MCUXpresso for VS Code For this you have to have NXP's MCUXpresso for VS Code extension installed.

1. Import your topdir as a repository to MCUXPresso for VS Code:

- Open the MCUXpresso Extension. In the *Quickstart Panel* click *Import Repository*.
- In the displayed menu click *LOCAL* tab and select the folder location of your *topdir*.
- Click *Import*.
- The repository is successfully added to the *Installed Repositories* view once the import is successful.

2. To import any project from the imported repository:
   - In the *Quickstart Panel* click *Import Example from Repository*.
   - For **Repository** select *your imported* repository.
   - For **Zephyr SDK** the installed Zephyr SDK is selected automatically. If not, select one.
   - For **Board** select your board (*make sure* you've selected the *correct* revision).
   - For **Template** select the folder path to your project.
   - Click the *Create* button.
3. Build the project by clicking the *Build Selected* icon (displayed on hover) in the extension's *Projects* view. After the build, the debug console window displays the memory usage (or compiler errors if any).
4. Debug the project by clicking the *Debug* (play) icon (displayed on hover) in the extension's *Projects* view.
5. The execution will pause. To continue execution click *Continue* on the debug options.
6. In the *SERIAL MONITOR* tab of your console panel, the application prints the Zephyr boot banner during startup and then prints the test results.

Folder structure

```
maestro/
    ...
    zephyr/              All Zephyr related files
      samples/           Sample examples
      tests/             Tests
      audioTracks/       Audio tracks for testing
      doc/               Documentation configuration for Sphinx
      wrappers/          NXP SDK Wrappers
      scripts/           Helper scripts, mostly for testing
      module.yml         Defines module name, Cmake and Kconfig locations
      CMakeList.txt      Defines module's build process
      Kconfig            Defines module's configuration
      osa/               Deprecated. OSA port for Zephyr
      ...
```

Supported elements and libraries Here is the list of all features currently supported in Maestro on Zephyr. Our goal is to support all features in Maestro on Zephyr that are already supported in Maestro on NXP's SDK and to extend them further.

Supported elements:

- Memory source
- Memory sink
- Audio source
- Audio sink
- Process sink

- Decoder
- Encoder

Supported decoders:

- WAV
- MP3
- FLAC
- OPUS OGG
- AAC

Supported encoders:

- OPUS RAW

Supported libraries:

- VIT

Examples support All included examples use UART as output. Examples are located in zephyr/tests and zephyr/samples directories.

List of included examples:

- *Maestro sample for recording data from microphone to RAM*
- *Maestro voice detection sample using VIT*
- *Maestro encoder sample*
- *Maestro decoder sample*
- *Maestro mem2mem sample*

Examples support for specific boards:

Example	RDRW612BGA	LPCx-presso55s69	MIMXRT1060EVKE	MIMXRT1170EVKB
Record	YES	TO BE TESTED	TO BE TESTED	TO BE TESTED
VIT	YES	TO BE TESTED	TO BE TESTED	TO BE TESTED
Encoder	In progress: OPUS RAW	TO BE TESTED	TO BE TESTED	TO BE TESTED
Decoder	YES - WAV, FLAC, OPUS OGG	TO BE TESTED	TO BE TESTED	TO BE TESTED
Mem2mem	YES	TO BE TESTED	TO BE TESTED	TO BE TESTED

Creating your own example There are two ways to create your own example - you can either one of the included examples as a reference or you can create your own example from scratch by hand.

When creating your own example from scratch, set CONFIG_MAESTRO_AUDIO_FRAMEWORK=y in your prj.conf file. Then you can start enabling specific elements by setting CONFIG_MAESTRO_ELEMENT_<NAME>_ENABLE=y.

However, the recommended way to edit config options is to open gui-config (or menuconfig) by calling west build -t guiconfig. Then you can use the graphical interface to interactively turn on/off the features you need.

Documentation Please note, Maestro documentation is under reconstruction. It is currently mixing several tools and formats.

To see the pre-generated Maestro Zephyr documentation, see zephyr/doc/doc/README.html

To generate the Zephyr documentation, go under zephyr/doc folder and execute make html. Sphinx version sphinx-build 8.1.3 must be installed. Open doc/doc/html/README.hml afterwards.

To see Maestro core documentation, go to the Maestro top directory and see README.md.

FAQ

1. Should I choose the freestanding version of Maestro or should integrate it into my west instead?
    - Freestanding version of Maestro pulls in all the dependencies it needs including Zephyr itself.
    - Integrating it as a module is easier if you already have your Zephyr environment set up.

Maestro Audio Framework changelog

2.0.0 (newest)

- Added Zephyr port, see *Zephyr README*.
    - Possible to use standalone version, pulling its own Zephyr and dependencies
    - Possible to import it as a module in your Zephyr project
- Changed build system - newly uses Kconfig and Cmake
- Supports NXP MCUXSDK (previously 2.x)
- Changed folder structure and names to improve readability (description may be found in *README*)
- Removed audio libraries and placed into audio-voice-components repository
- Added libraries are pulled into the build via Kconfig and Cmake
- Changed Maestro library core - minor changes

1.8.0

- New platforms support: MCX-N5XX-EVK, FRDMMCXN236 and RD-RW612-BGA
- Fixed compilation warnings
- Documentation improvements and updates
    - Added section with processing time information
    - Added application state diagrams
- Various updates and fixes

1.7.0

- Removed EAP support for future SDK releases
- Created new API for audio_sink and audio_src to support USB source, sink
- ASRC library integrated
- License changed to BSD 3-Clause
- Improved pipeline creation API
- Fixed compilation warnings in Opus
- Various other improvements and bug fixes

1.6.0

- Up to 2 parallel pipelines supported
- Synchronous Sample Rate Converter support Added
- Various improvements and bug fixes

1.5.0

- Enabled switching from 2 to 4 channel output during processing
- PadReturn type has been replaced by FlowReturn
- Support of AAC, WAV, FLAC decoders
- Renamed eap element to audio_proc element
- Added audio_proc to VIT pipeline to support VoiceSeeker
- Minor bug fixes

1.4.0

- Use Opusfile lib for Ogg Opus decoder
- Refactor code, fix issues found in unit tests
- Various bug fixes

1.3.0

- Make Maestro framework open source (except mp3 and wav decoder)
- Refactor code, remove unused parts, add comments

1.2.0

- Unified buffering in audio source, audio sink
- Various improvements and bug fixes

1.0_rev0

- Initial version of framework with support for Cortex-M7 platforms

3.7 Wireless

3.7.1 NXP Wireless Framework and Stacks

Wireless Framework

Wireless Connectivity Framework Connectivity Framework repository provides both connectivity platform enablement with hardware abstraction layer and a set of Services for NXP connectivity stacks : BLE, Zigbee, OpenThread, Matter.

The connectivity framework repository consists of:

- Common folder to common header files for minimal type definition to be used in the repo
- Platform folder used for platform enablement with Hardware abstraction:
  - platform/include: common API header files used by several platforms
  - platform/common: common code for several platforms
  - specifics platform folders , See below the supported platform list
  - platform/../configs folder: configuration files for framework repository and other middlewares (rpmsg, mbedTls, etc.._)
- Services folder
- Zephyr folder for zephyr modules integrated in mcux SDK
- clang formatting script and script folder to format appropriately the source files of the repo

Supported platforms The following devices/platforms are supported in platform folder for connectivity applications:

- kw45x, k32w1x, mcxw71x, under wireless_mcu, kw45_k32w1_mcxw71 folders.
- kw47x, mcxw72x families under wireless_mcu, kw47_mcxw72, kw47_mcxw72_nbu folders.
- rw61x
- RT1060 and RT1170 for Matter
- Other RT devices such as i.MX RT595s

Supported services The supported services are provided for connectivity stacks and their demo application, and are usually dependent on PLATFORM API implementation:

- DBG: Light Debug Module, currently a stubbed header file
- FSCI: Framework Serial Communication Interface between BLE host stack and upper layer located on an other core/device
- FunctionLib: wrapper to toolchain memory manipulation functions (memcpy, memcmp, etc) or use its own implementation for code size reduction
- HWParameters: Store Factory hardware parameters and Application parameters in Flash or IFR
- LowPower: wrapper of SDK power manager for connectivity applications
- ModuleInfo: Store and handle connectivity component versions
- NVM: NXP proprietary File System used for KW45, KW47 automotive devices and RT1060/RT1170 platform for Matter

- OtaSupport: Handle OTA binary writes into internal or external flash.
- SecLib and RNG: Crypto and Random Number generator functions. It supports several ports:
  - Software algorithms
  - Secure subsystem interface to an HW enclave
  - MbedTls 2.x interface
- Sensors: Provides service for Battery and temperature measurements
- SFC: Smart Frequency Calibration to be run from KW47/MCXW71 from NBU core. Matter related modules:
- OTW: Over The Wire module for External Transceiver firmware update from RT platforms
- FactoryDataProvider to be used for Matter

Supported Zephyr modules integration in mcux SDK Connectivity framework provides integration and port layers to the following Zephyr Modules located into zephyr/subsys:

- NVS: Zephyr File System used by Matter and Zigbee
- Settings: Over layer module that allows to store keys into NVS File System used by Matter Port layer and required libraries for these zephyr modules are located in port and lib folder in zephyr directory

Connectivity framework CHANGELOG

7.0.3 revB mcux SDK 25.09.00

Major Changes

- [wireless_mcu] Adjusted default value of BOARD_RADIO_DOMAIN_WAKE_UP_DELAY from 0x16 to 0x10 to address stability issues observed with the previous setting. This change enhances system reliability but will reduce low-power performance.

Minor Changes (bug fixes)

- [Common] Added MDK compatibility for the errno framework header.
- [mcxw23] Implemented missing PLATFORM_OtaClearBootInterface() API.
- [mcxw23] Refactored fwk_platform.c to separate BLE-specific logic into fwk_platform_ble.c.
- [OTA] Corrected definition of gEepromParams_WriteAlignment_c flag for mcxw23
- [OTA] Enabled calling OTA_GetImgState() prior to OTA_Initialize().
- [wireless_mcu] Fixed PLATFORM_IsExternalFlashSectorBlank() to check the entire sector instead of just one page.
- [mcxw23] Added support for OTA using external flash.
- [mcxw23] Introduced PLATFORM_GetRadioIdleDuration32K() to estimate time until next radio event.
- [OTA] Removed gUseInternalStorageLink_d linker flag definition when external OTA storage is used.
- [mcxw23] Extended CopyAndReboot() to support external flash OTA.

- [wireless_mcu] Resolved counter wrap issue in PLATFORM_GetDeltaTimeStamp().
- [kw43_mcxw70] Defined LPTMR frequency constants in fwk_platform_definitions.h.
- [kw47_mcxw72] Updated shared memory allocation for RPMsg adapter.
- [mcxw23] Implement PLATFORM_IsExternalFlashBusy() API.
- [kw45_mcxw71][kw47_mcxw72] Moved RAM bank definitions from the connectivity framework to device-specific definitions.

7.0.3 revA mcux SDK 25.09.00

Major Changes

- [wireless_nbu] Enhanced XTAL32M trimming handling: updates are applied when requested by the application core and the NBU enters low-power mode, ensuring no interference from ongoing radio activity. Introduced new APIs to lock (PLATFORM_LockXtal32MTrim()) and unlock XTAL32M (PLATFORM_UnlockXtal32MTrim()) trimming updates using a counter-based mechanism. Also added a reset API (PLATFORM_ResetContext()) for platform-specific variables (currently limited to the trimming lock).
- [wireless_mcu] Introduced a new API, PLATFORM_SetLdoCoreNormalDriveVoltage(), to enable support for NBU clock frequency at 64 MHz, as required by BLE channel sounding applications.
- [wireless_mcu][wireless_nbu] Increased delayLpoCycle default from 2 to 3 to address link layer instabilities in low-power NBU use cases. Adjusted BOARD_RADIO_DOMAIN_WAKE_UP_DELAY from 0x10 to 0x16 to balance power consumption and stability. NBU may malfunction if delayLpoCycle (or BOARD_LL_32MHz_WAKEUP_ADVANCE_HSLOT) is set to 2 while BOARD_RADIO_DOMAIN_WAKE_UP_DELAY is 0x16.

Minor Changes (bug fixes)

- [WorkQ] Increased stack size when RNG use mbedtls port and coverage is enabled.
- [FSCI] Resolved an issue where messages remained unprocessed in the queue by ensuring OSA_EventSet() is triggered when pending messages are detected.
- [OTA] Fixed a bug in in OTA_PullImageChunk() that prevented retrieval of data previously received via OTA_PushImageChunk() when still buffered in RAM during posted operations.
- [OTA] Various MISRA and coverity fixes.
- [mcxw23] Fixed an unused variable warning in PLATFORM_RegisterNbuTemperatureRequestEventCb() API.
- [SFC] Remove obsolete flag gNbuJtagCapability.
- [wireless_mcu] Introduced new API PLATFORM_GetRadioIdleDuration32K(). Deprecated PLATFORM_CheckNextBleConnectivityActivity() API.
- [mcxw23] Aligned platform-specific implementations with the corresponding prototypes defined in wireless_mcu.
- [DBG] Cleaned up fwk_fault_handler.c.

7.0.2 RFP mcux SDK 25.06.00

Major Changes

- [wireless_mcu][wireless_nbu] Introduced PLATFORM_Get32KTimeStamp() API, available on platforms that support it.
- [RNG] Switched to using a workqueue for scheduling seed generation tasks.
- [Sensors] Integrated workqueue to trigger temperature readings on periodic timer expirations.
- [wireless_nbu] Removed outdated configuration files from wireless_nbu/configs.
- [SecLib_RNG][PSA] Added a PSA-compliant implementation for SecLib_RNG. This is an experimental feature and should be used with caution.
- [wireless_mcu][wireless_nbu] Implemented PLATFORM_SendNBUXtal32MTrim() API to transmit XTAL32M trimming values to the NBU.

Minor Changes (bug fixes)

- [MWS] Migrated the Mobile Wireless Standard (MWS) service to the public repository. This service manages coexistence between connectivity protocols such as BLE, 802.15.4, and GenFSK.
- [HWParameter][NVM][SecLib_RNG][Sensors] Addressed various MISRA compliance issues across multiple modules.
- [Sensors] Applied a filtering mechanism to temperature data measured by the application core before forwarding it to the NBU, improving data reliability.
- [Common] Relocated the GetPowerOfTwoShift() function to a shared module for broader accessibility across components.
- [RNG] Resolved inconsistencies in RNG behavior when using the fsl_adapter_rng HAL by aligning it with other API implementations.
- [SecLib] Updated the AES CMAC block counter in AES_128_CMAC() and AES_128_CMAC_LsbFirstInput() to support data segments larger than 4KB.
- [SecLib] Utilized sss_sscp_key_object_free() with kSSS_keyObjFree_KeysStoreDefragment to avoid key allocation failures.
- [MCXW23] Removed redundant NVIC_SetPriority() call for the ctimer IRQ in the platform file, as it's already handled by the driver.
- [WorkQ] Increased workqueue stack size to accommodate RNG usage with mbedtls.
- [wireless_mcu][ot] Suppressed chip revision transmission when operating with nbu_15_4.
- [platform][mflash] Ensured proper address alignment for external flash reads in PLATFORM_ReadExternalFlash() when required by platform constraints.
- [RNG] Corrected reseed flag behavior in RNG_GetPseudoRandomData() after reaching gRngMaxRequests_d threshold.
- [platform][mflash] Fixed uninitialized variable issue in PLATFORM_ReadExternalFlash().
- [platform][wireless_nbu] Fixed an issue on KW47 where PLATFORM_InitFro192M incorrectly reads IFR1 from a hardcoded flash address (0x48000), leading to unstable FRO192M trimming. The function is now conditionally compiled for KW45 only.

7.0.2 revB mcux SDK 25.06.00

Major Changes

- [RNG][wireless_mcu][wireless_nbu] Rework RNG seeding on NBU request
- [wireless_mcu] [LowPower] Add gPlatformEnableFro6MCalLowpower_d macro to enable FRO6M frequency verification on exit of Low Power
  - add PLATFORM_StartFro6MCalibration() and PLATFORM_EndFro6MCalibration() new function for FRO6M calibration (6MHz or 2Mhz) on wake-up from low power mode.
  - Enabled by default in fwk_config.h
- [wireless_nbu][LowPower] Clear pending interrupt status of the systick before going in low-power - Reduce NBU active time
- [wireless_nbu] Fix impossibility to go to WFI in combo mode (15.4/BLE)
- [wireless_mcu] Implement XTAL32M temperature compensation mechanism. 2 new APIs:
  - PLATFORM_RegisterXtal32MTempCompLut(): register the temperature compensation table for XTAL32M.
  - PLATFORM_CalibrateXtal32M(): apply XTAL32M temperature compensation depending on current temperature.
- [Sensors][wireless_mcu] Add support for periodic temperature measurement. new API:
  - SENSORS_TriggerTemperatureMeasurementUnsafe(): to be called from Interrupt masked critical section, from ISR or when scheduler is stopped
- [SFC] Change default maximal ppm target of the SFC algorithm from 200 to 360ppm. Impact the SFC algorith of kw45 and mcxw71 platforms, 360ppm was already the default setting for kw47 and mcxw72 platforms

Minor Changes (bug fixes)

- [DBG] Fix FWK_DBG_PERF_DWT_CYCLE_CNT_STOP macro
- [wireless_nbu] Add gPlatformIsNbu_d compile Macro set to 1
- [wireless_nbu][ics] gFwkSrvHostChipRevision_c can be processed in the system workqueue
- [kw45_mcxw71][kw47_mcxw72]
  - Remove LTC dependency from platform in kconfig
  - gPlatformShutdownEccRamInLowPower moved from fwk_platform_definition.h to fwk_confg.h as this is a configuration flag.
- [wireless_mcu][sensors] Rework and remove unnecessary ADC APIs
- [wireless_nbu] Add PLATFORM_GetMCUUid() function from Chip UID
- [SecLib] Change AES_MMO_BlockUpdate() function from private to public for zigbee.

7.0.2 revA mcux SDK 25.06.00 Supported platforms:

- Same as 25.03.00 release

Major Changes

- [KW45/MCXW71] HW parameters placement now located in IFR section. Flash storage is not longer used:
  - Compilation: Macro gHwParamsProdDataPlacement_c changed from gHwParamsProdDataMainFlash2IfrMode_c to gHwParamsProdDataIfrMode_c

- [KW47] NBU: Add new fwk_platform_dcdc.[ch] files to allow DCDC stepping by using SPC high power mode. This requires new API in board_dcdc.c files. Please refer to new compilation MACROs gBoardDcdcRampTrim_c and gBoardDcdcEnableHighPowerModeOnNbu_d in board_platform.h files located in kw47evk, kw47loc, frdmmcxw72 board folders.
- [KW45/MCXW71/KW47/MCXW72] Trigger an interrupt each time App core calls PLATFORM_RemoteActiveReq() to access NBU power domain in order to restart NBU core for domain low power process

Minor Changes (bug fixes)

Services

- [SecLib_RNG]
  - Rename mSecLibMutexId mutex to mSecLibSssMutexId in SecLib_sss.c
  - Remove MEM_TRACKING flag from RNG.c
  - Implement port to fsl_adapter_rng.h API using gRngUseRngAdapter_c compil Macro from RNG.c
  - Add support for BLE debug Keys in SecLi and SecLin_sss.c with gSecLibUseBleDebugKeys_d - for Debug only
- [FSCI] Add queue mechanism to prevent corruption of FSCI global variableAllow the application to override the trig sample number parameter when gFsciOverRpmsg_c is set to 1
- [DBG][btsnoop] Add a mechanism to dump raw HCI data via UART using SBTSNOOP_MODE_RAW
- [OTA]
  - OtaInternalFlash.c: Take into account chunks smaller than a flash phrase worth
  - fwk_platform_ot.c: dependencies and include files to gpio, port, pin_mux removed

Platform specific

- [kw45_mcxw71][kw47_mcxw72]
  - fwk_platform_reset.h : add compil Macro gUseResetByLvdForce_c and gUseResetByDeepPowerDown_c to avoid compile the code if not supported on some platforms
  - New compile Flag gPlatformHasNbu_d
  - Rework FRO32K notification service for MISRA fix

7.0.1 RFP mcux SDK 25.03.00 Supported platforms:

- KW45x, KW47x, MCXW71, MCXW72, K32W1x
- RW61x
- RT595, RT1060, RT1170
- MCXW23

Minor Changes (bug fixes)

- [General] Various MISRA/Coverity fixes in framework: NVM, RNG, LowPower, SecLib and platform files

Services

- [SecLib_RNG] fix return status from RNG_GetTrueRandomNumber() function: return correctly gRngSuccess_d when RNG_entropy_func() function is successful
- [SFC] Allow the application to override the trig sample number parameter
- [Settings] Re-define the framework settings API name to avoid double definition when gSettingsRedefineApiName_c flag is defined

Platform specific

- [wireless_mcu] fwk_platform_sensors update :
  - Enable temperature measurement over ADC ISR
  - Enable temperature handling requested by NBU
- [wireless_mcu] fwk_platform_lcl coex config update for KW45
- [kw47_mcxw72] Change the default ppm_target of SFC algorithm from 200 to 360ppm

7.0.1 revB mcux SDK 25.03.00 Supported platforms:

- KW45x, KW47x, MCXW71, MCXW72, K32W1x
- RW61x
- RT595, RT1060, RT1170
- MCXW23

Minor Changes (bug fixes)

General

- [General] Various MISRA/Coverity fixes in framework: NVM, RNG, LowPower, FunctionLib and platform files

Services

- [SecLib_RNG] AES-CBC evolution:
  - added AES_CBC_Decrypt() API for sw, SSS and mbedtls variants.
  - Made AES-CBC SW implementation reentrant avoiding use of static storage of AES block.
  - fixed SSS version to update Initialization Vector within SecLib, simplifying caller's implementation.
  - modified AES_128_CBC_Encrypt_And_Pad() so as to avoid the constraint mandating that 16 byte headroom be available at end of input buffer.
- [SecLib_RNG] RNG modifications:
  - RNG_GetPseudoRandomData() could return 0 in some error cases where caller expected a negative status.
    - Explicited RNG error codes
    - Added argument checks for all APIs and return gRngBadArguments_d (-2) when wrong

    - added checks of RNG initalization and return gRngNotInitialized_d (-3) when not done
    - fixed correcteness of RNG_GetPrngFunc() and RNG_GetPrngContext() relative to API description.
    - Added RNG_DeInit() function mostly for test and coverage purposes.
    - Improved RNG description in README.md
    - Unified the APIs behaviour between mbedtls and non mbedtls variants.
  - RNG/mbedtls : Prevent RNG_Init() from corrupting RNG entropy context if called more than once.
  - RNG/mbedtls: fixed RNG_GetTrueRandomNumber() to return a proper mbedtls_entropy_func() result.
  - Use defragmetation option when freeing key object in SecLib_sss to avoid leak in S200 memory
  - Add new API ECP256_IsKeyValid() to check whether a public key is valid
- [OtaSupport] Update return status to OTA_Flash_Success when success at the end of InternalFlash_WriteData() and InternalFlash_FlushWriteBuffer() APIs
- [WorQ] Implementing a simple workqueue service to the framework
- [SFC] Keep using immediate measurement for some measurement before switching to configuration trig to confirm the calibration made
- [DBG] Adding modules to framework DBG :
  - sbtsnoop
  - SWO
- [Common] Fix HAL_CTZ and HAL_RBIT IAR versions
- [LowPower] Fix wrong tick error calculation in case of infinite timeout
- [Settings] Add new macro gSettingsRedefineApiName_c to avoid multiple definition of settings API when using connectivity framework repo

Platform specific

- [KW47/MCXW72] Change xtal cload default value from 4 to 8 in order to increase the precision of the link layer timebase in NBU
- [wireless_mcu] [wireless_nbu] Use new WorkQ service to process framework intercore messages
- [rw61x] Fix HCI message sending failure in some corner case by releasing controller wakes up after that the host has send its HCI message
- [MCXW23] Adding the initial support of MCXW23 into the framework

7.0.0 mcux SDK 24.12.00 Supported platforms:

- KW45x, KW47x, MCXW71, MCXW72, K32W1x
- RW61x
- RT595, RT1060, RT1170

Minor Changes (bug fixes)

Platform specific

- [RW61X]
  - Add MCUX_COMPONENT_middleware.wireless.framework.platform.rng to the platform to fix a warning at generation
  - Retrieve IEEE 64 bits address from OTP memory
- [KW45x, MCXW71x, KW47x, MCXW72x]
  - Ignore the secure bit from RAM addresses when comparing used ram bank in bank retention mechanism
  - Add gPlatformNbuDebugGpioDAccessEnabled_d Compile Macro (enabled by default). Can be used to disable the NBU debug capability using IOs in case Trustzone is enabled ("PLATFORM_InitNbu()' code executed from unsecure world).
  - Fix in NBU firmware when sending ICS messages gFwkSrvNbuApiRequest_c (from controller_api.h API functions)

Services

- [OTA]
  - Add choice name to OtaSupport flash selection in Kconfig
- [NVM]
  - Add gNvmErasePartitionWhenFlashing_c feature support to gcc toolchain
- [SecLib_RNG]
  - Misra fixes

7.0.0 revB mcux SDK 24.12.00 Supported platforms: KW45x, KW47x, MCXW71, MCXW72, K32W1x, RW61x, RT595, RT1060, RT1170

Major Changes (User Applications may be impacted)

- mcux github support with cmake/Kconfig from sdk3 user shall now use CmakeLists.txt and Kconfig files from root folder. Compilation should be done using west build command. In order to see the Framework Kconfig, use command >west build -t guiconfig
- Board files and linker scripts moved to examples repository

Bugfixes

- [platform lowpower]
  - Entering Deep down power mode will no longer call PLATFORM_EnterPowerDown(). This API is now called only when going to Power down mode

Platform specific

- [KW47/MCXW72]: Early access release only
  - Deep sleep power mode not fully tested. User can experiment deep sleep and deep down modes using low power reference design applications
  - XTAL32K-less support using FRO32K not tested
- [KW45/MCXW71/K32W148]

  - Deep sleep mode is supported. Power down mode is supported in low power reference design applications as experimental only
  - XTAL32K-less support using FRO32K is experimental - FRO32K notifications callback is debug only and should not be used for mass production firmware builds

Minor Changes (no impact on application)

- Overall folder restructuring for SDK3
  - [Platform]:
    * Rename platform_family from connected_mcu/nbu to wireless_mcu/nbu
    * platform family have now a dedicated fwk_config.h, rpmsg_config.h and SecLib_mbedtls_config.h
  - [Services]
    * Move all framework services in a common directory “services/”

7.0.0 revA: KW45/KW47/MCX W71/MCX W72/K32W148

Experimental Features only

- Power down on application power domain: Some tests have shown some failure. Power consumption higher than Deep Sleep. => This feature is not fully supported in this release
- XTAL32K less board with FRO32K support: Some additional stress tests are under progress.
- FRO32K notifications callback is for debug only and shall not be used for production. User shall not execute long processing (such as PRINTF) as it is executed in ISR context.

Main Changes

- Cmake/Kconfig support for SDK3.0
- [Sensors] API renaming:
  - SENSORS_InitAdc() renamed to SENSORS_Init()
  - SENSORS_DeinitAdc() remamed to SENSORS_Deinit()
- [HWparams]
  - Repair PROD_DATA sector in case of ECC error (implies loss of previous contents of sector)
- [NVM] Linker script modification for armgcc whenever gNvTableKeptInRam_d option is used:
  - placement of NVM_TABLE_RW in data initialized section, providing start and end address symbols. For details see NVM_Interface.h comments.
- [OtaSupport]
  - OTA_Initialize(): now transitions the image state from RunCandidate to Permanent if not done by the application. OTA module shall always be initialized on a Permanent image, this change ensures it is the case.
  - OTA_MakeHeadRoomForNextBlock(): now erases the OTA partition up to the image total size (rounded to the sector) if known.

Minor changes

- [Platform]
  - Updated macro values: -kw47: BOARD_32MHZ_XTAL_CDAC_VALUE from 12U to 16U, BOARD_32MHZ_XTAL_ISEL_VALUE from 7U to 11U, BOARD_32KHZ_XTAL_CLOAD_DEFAULT from 8U to 4U, BOARD_32KHZ_XTAL_COARSE_ADJ_DEFAULT from 1U to 3U
    * MCX W72 (low-power reference design applications only): BOARD_32MHZ_XTAL_CDAC_VALUE from 12U to 10U, BOARD_32MHZ_XTAL_ISEL_VALUE from 7U to 11U, BOARD_32KHZ_XTAL_CLOAD_DEFAULT from 8U to 4U, BOARD_32KHZ_XTAL_COARSE_ADJ_DEFAULT from 1U to 3U
  - New PLATFORM_RegisterNbuTemperatureRequestEventCb() API: register a function callback when NBU request new temperature measurement. API provides the interval request for the temperature measurement
  - Update PLATFORM_IsNbuStarted() API to return true only if the NBU firmware has been started.
- [platform lowpower]
  - Move RAM layout values in fwk_platform_definition.h and update RAM retention API for KW47/MCXW72

Bugfixes

- [OtaSupport]
  - OTA_MakeHeadRoomForNextBlock(): fixed a case where the function could try to erase outside the OTA partition range.

6.2.4: KW45/K32W1x/MCXW71/RX61x SDK 2.16.100 This release does not contain the changes from 6.2.3 release.

This release contains changes from 6.2.2 release.

Main Change

- armgcc support for Cmake sdk2 support and VS code integration

Minor changes

- [NBU]
  - Optimize some critical sections on nbu firmware
- [Platform]
  - Optimize PLATFORM_RemoteActiveReq() execution time.

6.2.3: KW47 EAR1.0 Initial Connectivity Framework enablement for KW47 EAR1.0 support.

New features

- OpenNBU feature : nbu_ble project is available for modification and building

Supported features

- Deep sleep mode

Unsuported features

- Power down mode
- FRO32K support (XTAL32K less boards)

Main changes

- [NBU]
  - LPTMR2 available and TimerManager initialization with Compile Macro: gPlatformUseLptmr_d
  - NBU can now have access to GPIOD
  - SW RNG and SW SecLib ported to NBU (Software implementation only)
- [RNG]
  - Obsoleted API removed : FWK_RNG_DEPRECATED_API
  - RNG can be built without SecLib for NBU, using gRngUseSecLib_d in fwk_config.h
  - Some API updates:
    - RNG_IsReseedneeded() renamed to RNG_IsReseedNeeded,
    - RNG_TriggerReseed() renamed to RNG_NotifyReseedNeeded(),
    - RNG_SetSeed() and RNG_SetExternalSeed() return status code.
  - Optimized Linear Congruential modulus computation to reduce cycle count.

Minor changes

- [NVM]
  - Optimize NvIsRecordErased() procedure for faster garbage collection
  - MISRA fix : Remove externs and weaks from NVM module - Make RNG and timer manager dependencies conditional
- [Platform]
  - Allow the debugger to wakeup the KW47/MCXW72 target

6.2.2: KW45/K32W1 MR6 SDK 2.16.000 Experimental Features only:

- Power down on application power domain : Some tests have shown some failure. Power consumption higher than Deep Sleep. => This feature is not fully supported in this release
- XTAL32K less board with FRO32K support : Some additional stress tests are under progress.
- FRO32K notifications callback is for debug only and shall not be used for production. User shall not execute long processing (such as PRINTF) as it is executed in ISR context.

Changes

- [Board] Support for freedom board FRDM-MCX W7X
- [HWparams]
  - Support for location of HWParameters and Application Factory Data IFR in IFR1
  - Default is still to use HWparams in Flash to keep backward compatibility
- [RNG]: API updates:
  - New APIS RNG_IsReseedneeded(), RNG_SetSeed() to provide See to PRNG on NBU/App core - See BluetoothLEHost_ProcessIdleTask() in app_conn.c
  - New APIs RNG_SetExternalSeed() : User can provide external seed. Typically used on NBU firmrware for App core to set a seed to RNG. RNG_TriggerReseed() : Not required on App core. Used on NBU only.
- [NVS] Wear statistics counters added - Fix nvs_file_stat() function
- [NVM] fix Nv_Shutdown() API
- [SecLib] New feature AES MMO supported for Zigbee

6.2.2: RW61x RFP4 SDK 2.16.000

- [Platform] Support Zigbee stack
- [OTA] Add support for RW61x OTA with remap feature.
  - Required modifications to prevent direct access to flash logical addresses when remap is active.
  - Image trailers expected at different offset with remap enabled (see gPlatformMcuBootUseRemap_d in fwk_config.h)
  - fixed image state assessment procedure when in RunCandidate.
- [NVS] Wear statistics counters added
- [SecLib] New feature AES MMO supported for Zigbee
- [Misra] various fixes

6.2.1: KW45/K32W1 MR5 SDK 2.15.000 Experimental Features only:

- Power down on application power domain : Some tests have shown some failure. This feature is not fully supported in this release
- XTAL32K less board with FRO32K support : Some additional stress tests are under progress. Timing variation of the timebase are being analyzed

Major changes

- [RNG]: API updates
  - New compile flag to keep deprecated API: FWK_RNG_DEPRECATED_API
  - change return error code to int type for RNG_Init(), RNG_ReInit()
  - New APIs RNG_GetTrueRandomNumber(), RNG_GetPseudoRandomData()
- [Platform]
  - fwk_platform_sensors
    - Change default temperature value from -1 to 999999 when unknown

  - fwk_platform_genfsk
    - rename from platform_genfsk.c/h to fwk_platform_genfsk.c/h
  - platform family
    - Rename the framework platform folder from kw45_k32w1 to connected_mcu to support other platform from the same family
  - fwk_platform_intflash
    - Moved from fwk_platform files to the new fwk_platform_intflash files the internal flash dependant API
- [NBU]
  - BOARD_LL_32MHz_WAKEUP_ADVANCE_HSLOT changed from 2 to 3 by default
  - BOARD_RADIO_DOMAIN_WAKE_UP_DELAY changed from 0x10 to 0x0F
- [gcc linker]
  - Exclude k32w1_nbu_ble_15_4_dyn.bin from .data section

Minor Changes

- [Platform]
  - PLATFORM_GetTimeStamp(0 has an important fix for reading the Timestamp in TSTMR0
  - New API PLATFORM_TerminateCrypto(), PLATFORM_ResetCrypto() called from SecLib for lowpower exit
  - Fix when enable fro debug callback on nbu
- [DBG]
  - SWO
    - Add new files fwk_debug_swo.c/h to use SWO for debug purpose
    - Two new flags has been added:
      - BOARD_DBG_SWO_CORE_FUNNEL to chose on which core you want to use SWO
      - BOARD_DBG_SWO_PIN_ENABLE to enable SWO on a pin
- [NVS]
  - Add support of NVS and Settings in framework
- [NBU]
  - Fix power down issues and reduce critical section on NBU side:
    - new API PLATFORM_RemoteActiveReqWithoutDelay() called from NBU functions where waiting delay is not required
    - Increase delay needed in power down for OEM part to request the SOC to be active
    - Remove unnecessary code to PLATFORM_RemoteActiveReqWithoutDelay() from PLATFORM_HciRpmsgRxCallback()
    - Improve nbu memory allocation failure debug messages
- [SDK]
  - Multicore: remove critical section in HAL_RpmsgSendTimeout() (only required in FPGA HDI mode)
  - Flash drivers: update for ECC detection

- [Platform]
  - fwk_platform_sensors
    - Fix temperature reporting to NBU
  - fwk_platform_extflash
    - Align .c and .h prototype of PLATFORM_ExternalFlashAreaIsBlank() function
- [NVM]
  - Keep Mutex in NvModuleDeInit(). In Bare metal OS, Mutex can not be destroyed
  - New API NvRegisterEccFaultNotificationCb() to register Notification callback when Ecc error happens in FileSystem
- [MISRA] fixes
  - SecLib_sss.c: ECDH_P256_ComputeDhKey()
  - fwk_platform_extflash.c: PLATFORM_IsExternalFlashPageBlank()
  - fwk_fs_abstraction.c: Various fixes
- [HWparams]
  - Fix on if condition when gHwParamsProdDataPlacementLegacy2IfrMode_c mode is selected
- [OTA]
  - Enable gOtaCheckEccFaults_d by default to avoid bus in case of ECC error during OTA
  - Fix OTA partition overflow during OTA stop and resume transfer
- [BOARD]
  - Place code button or led specific under correct defines in board_comp.c/h
  - Bring back MACROs BOARD_INITRFSWITCHCONTROLPINS in pin_mux header file of the loc board
- [SecLib]
  - Add some undefinition in SecLib_mbedtls_config as new dependency has been added in mbedtls repo:
    - MBEDTLS_SSL_CBC_RECORD_SPLITTING, MBEDTLS_SSL_PROTO_TLS1, MBEDTLS_SSL_PROTO_TLS1_1
- [FRO32K]
  - FRO32K notification callback PLATFORM_FroDebugCallback_t() has new parameter to report he fro_trim value
  - maxCalibrationIntervalMs value can be provided to NBU using PLATFORM_FwkSrvSetRfSfcConfig()
- [Sensors]
  - fix: PLATFORM_GetTemperatureValue() shall have NBU started to send temperature to NBU

6.2.1: RW61x RFP3

- [NVS]
  - Add support of NVS and Settings in framework
- [MISRA] fixes
  - board_lp.c BOARD_UninitDebugConsole() and BOARD_ReinitDebugConsole()

  - fwk_platform_ble.c: Various fixes
- [OTA]
  - Fix OTA partition overflow during OTA stop and resume transfer

6.2.0: RT1060/RT1170 SDK2.15 Major

6.1.8: KW45/K32W1 MR4

- [BOARD PLATFORM]
  - Move gBoardUseFro32k_d to board_platform.h file
  - Offer the possibility to change the source clock accuracy to gain in power consumption
- [BOARD LP]
  - Move PLATFORM_SetRamBanksRetained() at end of BOARD_EnterLowPowerCb() in case a memory allocation is done previously in this function
  - fix low power, increase BOARD_RADIO_DOMAIN_WAKE_UP_DELAY from 0 to 0x10 - Skip this delay when App requesting NBU wakeup
- [PLATFORM]
  - fwk_platform_ble.c/h: New timestamp API that returns the difference between the current value of the LL clock and the argument of the function
  - fwk_platform.c/h:
    * New PLATFORM_EnableEccFaultsAPI_d compile flag: Enable APIs for interception of ECC Fault in bus fault handler
    * New gInterceptEccBusFaults_d compile flag: Provide FaultRecovery() demo code for bus fault handler to Intercept bus fault from Flash Ecc error
- [LOC]
  - Incorrect behavior for set_dtest_page (DqTEST11 overridden)
  - Fix SW1 button wake able on Localization board
  - Fix yellow led not properly initialized
  - Format localization pin_mux.c/h files
- [Inter Core]
  - Affect values to enumeration giving the inter core service message ids
  - Shared memory settings shared between both cores
  - Add callback to register when NBU has unrecoverable Radio issue
- [NVM]
  - Add NV_STORAGE_MAX_SECTORS, NV_STORAGE_SIZE as linker symbol for alignment with other toolchain
  - ECC detection and recovery. New gNvSalvageFromEccFault_d and gNvVerifyReadBackAfterProgram_d compile flags. Please refer to ECC Fault detection section in README.md file located in NVM folder
- [OTA]
  - Prevent bus fault in case of ECC error when reading back OTA_CFR update status (disable by default)
- [SecLib]

  - Shared mutex for RNG and SecLib as they share same hardware resource
- [Key storage]
  - Fix to ignore the garbage at the end of buffers
  - Detect when buffers are too small in KS_AddKey() functions
- [FileCache]
  - Fix deadlock in Filecache FC_Process()
- [SDK]
  - Applications: remove definition of stack location and use default from linker script, fix warmboot stack in freertos at 0x20004000
  - Memory Manager Light:
    * fix Null pointer harfault when MEM_STATISTICS_INTERNAL enable
    * Fix MemReinitBank() on wakeup from lowpower when Ecc banks are turned off

6.1.7: KW45/K32W1 MR3

- [OTA]
  - New API OTA_SetNewImageFlagWithOffset()
  - Fix StorageBitmapSize calculation
  - OTA clean up: Removed OTA_ValidateImage()
- [Low Power]
  - New linker Symbol m_lowpower_flag_start in linker file.
    * Flag is used to indicate NBU that Application domain goes to power down mode. Keep this flag to 0 if only Deep sleep is supported
    * This flag will be set to 1 if Application domain goes to power down mode
  - Re-introduce PWR_AllowDeviceToSleep()/PWR_DisallowDeviceToSleep(), PWR_IsDeviceAllowedToSleep() API
  - Implement tick compensation mechanism for idle hook in a dedicated freertos utils file fwk_freertos_utils.[ch], new functions: FWK_PreIdleHookTickCompensation() and FWK_PostIdleHookTickCompensation
  - Rework timestamping on K4W1
    * PLATFORM_GetMaxTimeStamp() based on TSTMR
    * Rename PLATFORM_GetTimestamp() to PLATFORM_GetTimeStamp()
    * Update PLATFORM_Delay(): Rework to use TSTMR instead of LPTMR for platform_delay
    * Update PLATFORM_WaitTimeout(): Fixed a bug in PLATFORM_WaitTimeout() related to timer wrap
    * Add PLATFORM_IsTimeoutExpired() API
  - Fix race condition in PWR_EnterLowPower(), masking interrupts in case not done at upper layer
  - Low power timer split in new files fwk_platform_lowpower_timer.[ch]
  - New PWR_systicks_bm.c file for bare metal usage: implement SysTick suspend/resume functionality, New weak PWR_SysTicksLowPowerInit()
- [FRO32K]

  - Improve FRO32K calibration in NBU
  - create PLATFORM_InitFro32K() to initialize FRO32K instead of XTAL32K (to be called from hardware_init())
  - update FRO32K README.md file in SFC module
  - Debug:
  - Add Notification callback feature for SFC module FRO32K
  - Linker script update to support m_sfc_log_start in SMU2
- [SecLib]
  - Remove gSecLibSssUseEncryptedKeys_d compile option, split Secure/Unsecure APIs
  - RNG update to use same mutex than SecLib
  - Fix AES_128_CBC_Encrypt_And_Pad length
  - Implement RNG_ReInit() for lowpower
  - Fix issue in ECDH_P256_GenerateKeys() when waking up from power down
  - Call CRYPTO_ELEMU_reset() from SecLib_reInit() for power down support
- [BOARD]
  - Create new board_platform.h file for all Board characteristics settings (32Mhz XTAL, 32KHZ XTAL, etc..)
  - TM_EnterLowpower() TM_EnterLowpower() to be called from LP callbacks
  - Support Localization boards, Only BUTTON0 supported
    * New compile flag BOARD_LOCALIZATION_REVISION_SUPPORT
    * New pin_mux.[ch] files
  - Offer the possibility to override CDAC and ISEL 32MHz settings before the initialization of the crystal in board_platform.h
    * new BOARD_32MHZ_XTAL_CDAC_VALUE, BOARD_32MHZ_XTAL_ISEL_VALUE
    * BOARD_32MHZ_XTAL_TRIM_DEFAULT obsoleted
- [NVM file system]
  - Look ahead in pending save queue - Avoid consuming space to save outdated record
  - Fix NVM gNvDualImageSupport feature in NvIsRecordCopied
- [Inter Core]
  - Change PLATFORM_NbuApiReq() API return parameters granularity from uint32 to uint8
  - MAX_VARIANT_SZ change from 20 to 25
  - Set lp wakeup delay to 0 to reduce time of execution on host side, NBU waits XTAL to be ready before starting execution
  - Update inter core config rpmsg_config.h
  - Add timeout to while loops that relies on hardware in RemoteActiveReq(), Application can register Callbacks when timeout
  - Return non-0 status when calling PLATFORM_FwkSrvSendPacket when NBU non started
  - Let PLATFORM_GetNbuInfo return -10 if response not received on timeout - Doxygen platform_ics APIs
- [HW params]

  - New compile Macro for HW params placement in IFR - Save 8K in FLash: gHwParamsProdDataPlacement_c . 3 modes:
  - Legacy placement, move from legacy to IFR, IFR only placement
  - New compile Macro for Application data to be stored with HW params (in shared flash sector): gHwParamsAppFactoryDataExtension_d, New APIs:
    * Nv_WriteAppFactoryData(), Nv_GetAppFactoryData()
  - See HWParameter.h
- [Platform]
  - Implement PLATFORM_GetIeee802_15_4Addr() API in fwk_platform_ot.c - New gPlatformUseUniqueDeviceIdFor15_4Addr_d compile Macro
  - Wakeup NBU domain when reading RADIO_CTRL UID_LSB register in PLATFORM_GenerateNewBDAddr()
- [Reset]
  - New reset Implementations using Deep power down mode or LVD:
    * new files fwk_platform_reset.[ch]
    * new APIs: PLATFORM_ForceDeepPowerDownReset(), PLATFORM_ForceLvdReset() + reset on ext pins
    * new compile flags: gAppForceDeepPowerDownResetOnResetPinDet_d and gAppForceLvdResetOnResetPinDet_d to reset on external pins
- [FSCI]
  - fix when gFsciRxAck_c enabled
  - integrate new reset APIs

6.1.4: RW610/RW612 RFP1

- [Low Power]
  - Added support of low power for OpenThread stack.
  - Added PWR_AllowDeviceToSleep/PWR_DisallowDeviceToSleep/PWR_IsDeviceAllowedToSleep APIs.
- [platform]
  - Added PLATFORM_GetMaxTimeStamp API.
  - Fixed high impact Coverity.
- [FreeRTOS]
  - Created a new utilities module for FreeRTOS: fwk_freertos_utils.c/h.
  - Implemented a tick compensation mechanism to be used in FreeRTOS idle hook, likely around flash operations. This mechanism aims to estimate the number of ticks missed by FreeRTOS in case the interrupts are masked for a long time.

6.1.4: KW45/K32W1 MR2

- [Low power]
  - Powerdown mode tested and enabled on Low Power Reference Design applications
  - XTAL32K removal functionality using FRO32K, supported from NBU firmwares - limitation: Application domain supports Deep Sleep only (not power down)

  - NBU low power improvement: low power entry sequence improvement and system clock reduction to 16Mhz during WFI
  - Wake up time from cold boot, reset, power switch greatly improved. Device starts on FRO32K, switch to XTAL32K when ready if gBoardUseFro32k_d not set
  - Bug fixes:
    * Move PWR LowPower callback to PLATFORM layers
    * Fix wrong compensation of SysTicks
    * Reinit system clocks when exiting power down mode: BOARD_ExitPowerDownCb(), restore 96MHz clock is set before going to low power
    * Call Timermanager lowpower entry exit callbacks from PLATFORM_EnterLowPower()
    * Update PLATFORM_ShutdownRadio() function to force NBU for Deep power down mode
  - K32W1:
    * Support lowpower mode for 15.4 stacks
- [NVM]
  - New Compilation MACRO gNvDualImageSupport to support multiple firmware image with different register dataset
  - Change default configuration gNvStorageIncluded_d to 1, gNvFragmentation_Enabled_d to 1, gUnmirroredFeatureSet_d to TRUE
  - Some MISRA issues for this new configuration.
  - Remove deprecated functionality gNvUseFlexNVM_d
- [SecLib]
  - New NXP Ultrafast ecp256 security library:
    * New optimized API for ecdh DhKey/ecp256 key pair computation: Ecdh_ComputeDhKeyUltraFast(), ECP256_GenerateKeyPairUltraFast().
    * New macro gSecLibUseDspExtension_d.
    * Improved software version of Seclib with Ultrafast library for ECP256_LePointValid()
  - Bug fixes:
    * Share same mutex between Seclib and RNG to prevent concurrent access to S200
    * Optimized S200 re-initialization, restore ecdh key pair after power down
    * Fixed race condition when power down low power entry is aborted
    * Endianness function updates and clean up
- [OTA]
  - OTASupport improvements:
    * New API OTA_GetImgState(), OTA_UpdateImgState()
    * OTASupport and fwk_platform_extflash API updates for external flash: OTA_SelectExternalStoragePartition(), PLATFORM_IsExternalFlashSectorBlank(), PLATFORM_IsExternalFlashPageBlank(), PLATFORM_OtaGetOtaPartitionConfig()
    * Updated OtaExternalFlash.c, 2 new APIs in fwk_platform_extflash.c

    - Removed unused FLASH_op_type and FLASH_TransactionOpNode_t definitions from public API
    - Removed unused InternalFlash_EraseBlock() from OtaInternalFlash.c
- [NBU firmware]
  - Mechanism to set frequency constraint to controller from the host PLATFORM_SetNbuConstraintFrequency()
  - NbuInfo has one more digit in versionBuildNo field
- [Board]
  - Support Extflash low power mode, add BOARD_UninitExternalFlash(), PLATFORM_UninitExternalFlash(), PLATFORM_ReinitExternalFlash()
  - Support XTAL32K removal functionatity, use FRO32K instead by setting gBoardUseFro32k_d to 1 in board.h file
  - Support localization boards KW45B41Z-LOC Rev C
  - Low power improvement: New BOARD_InitPins() and BOARD_InitPinButtonBootConfig() called from hardware_init.c
  - Removed KW45_A0_SUPPORT support (dcdc)
  - Bug fixes:
    - Fixed glitches on the serial manager RX when exiting from power down
    - Fixed ADC not deinitialized in clock gated modes in BOARD_EnterLowPowerCb()
    - Fixed UART output flush when going to low power: BOARD_UninitAppConsole()
- [platform]
  - PLATFORM_InitBle(), PLATFORM_SendHci() can now block with timeout if NBU does not answer. Application can register callback function to be notified when it occurs: PLATFORM_RegisterBleErrorCallback()
  - Added API to set and get 32Khz XTAL capacitance values: PLATFORM_GetOscCap32KValue() and PLATFORM_SetOscCap32KValue()
  - Added new Service FWK call gFwkSrvNbuMemFullIndication_c to get NBU mem full indication, register with PLATFORM_RegisterNbuMemErrorCallback()
  - Added support negative value in platform intercore service
- [linker script]
  - Realigned gcc linker script with IAR linker script.
  - Added possibility to redefine cstack_start position
  - Added Possibility to change gNvmSectors in gcc linker script
  - Added dedicated reserved Section in shared memory for LL debugging
- [FreeRTOSConfig.h]
  - Removed unused MACRO configFRTOS_MEMORY_SCHEME and configTOTAL_HEAP_SIZE
- [HW Param]
  - Added xtalCap32K field to store XTAL32K triming value
- [fwk_hal_macros.h]
  - Added MACRO for KB, MB and set, clear bits in bit fields
- [Debug]

  - Added MACROs for performance measurement using DWT: DBG_PERF_MEAS

6.1.3 KW45 MR1 QP1

- [Initialization] Delay the switch to XTAL32K source clock until the BLE host stack is initialized
- [lowpower] NBU wakeup from lowpower: configuration can now be programmed with BOARD_NBU_WAKEUP_DELAY_LPO_CYCLE, BOARD_RADIO_DOMAIN_WAKE_UP_DELAY in board.h file
- [NBU firmware] Major fix for NBU system clock accuracy
- [clock_config]
  - Update SRAM margin and flash config when switching system frequency
  - Trim FIRC in HSRUN case
- [XTAL 32K trim] XTAL 32K configuration can be tuned in board.h file with BOARD_32MHZ_XTAL_TRIM_DEFAULT, BOARD_32KHZ_XTAL_CLOAD_DEFAULT, BOARD_32KHZ_XTAL_COARSE_ADJ_DEFAULT
- [MAC address] Add OUI field in PLATFORM_GenerateNewBDAddr() when using Unique Device Id

6.1.2: RW610/RW612 PRC1

- [Low Power]
  - Updates after SDK Power Manager files renaming.
  - Moved PWR LowPower callback to PLATFORM layers.
  - Bug fixes:
    * Fixed wrong compensation of SysTicks during tickless idle.
    * Reinit RTC bus clock after exit from PM3 (power down).
- [OTA]
  - Initial support for OTA using the external flash.
- [platform]
  - Implemented platform specific time stamp APIs over OSTIMER.
  - Implemented platform specific APIs for OTA and external flash support.
  - Removed PLATFORM_GetLowpowerMode API.
  - Added support of CPU2 wake up over Spinel for OpenThread stack.
  - Bug fixes:
    * Fixed issues related to handling CPU2 power state.
- [board]
  - Updated flash_config to support 64MB range.
- [linker script]
  - Fixed wrong assert.

6.1.1: KW45/K32W1 MR1

- [platform] Use new FLib_MemSet32Aligned() to write in ECC RAM bank to force ECC calculation in the MEM_ReinitRamBank() function
- [FunctionLib] Implement new API to set a word aligned
- [platform] Set coarse amplifier gain of the oscilattor 32k to 3
- [platform] Switch back to RNG for MAC Adress generation
- [SecLib] Get rid of the lowpower constraint of deep sleep in ECDH API
- [DCDC] Set DCDC output voltage to 1.35V in case LDO core is set to 1.1V to ensure a drop of 250mV between them
- [NVM] NvIdle() is now returning the number of operations that has been executed
- [documentation] Add markdown of each framework module by default on all package
- [LowPower] Add a delay advised by hardware team on exit of lowpower for SPC
- [SecLib] Rework of SecLib_mbedTLS ECDH functions
- [OTA] Make OTA_IsTransactionPending() public API
- [FunctionLib] Change prototype of FLib_MemCpyWord(), pDst is now a void* to permit more flexibility
- [NVM] Add an API to know if there is a pending operation in the queue
- [FSCI] Fix wrong error case handling in FSCI_Monitor()

6.1.0: KW45/K32W1 RFP

- [LowPower] Do not call PLATFORM_StopWakeUpTimer() in PWR_EnterLowPower() if PLATFORM_StartWakeUpTimer() was not previously called
- [boards] Add the possibility to wakeup on UART 0 even if it is not the default UART
- [boards] Add support for Hardware flow control for UART0, Enable with gBoardUseUart0HwFlowControl, Pin mux update with two additional API for RTS, CTS pins
- [Sensors] Improve ADC wakeup time from deep sleep state: use save and restore API for ADC context before/after deep sleep state.
- [linker script] update SMU2 shared memory region layout with NBU: increase sqram_btblebuf_size to support 24 connections. Shared memory region moved to the end
- [SecLib] SecLib_DeriveBluetoothSKD() API update to support if EdgeLock key shall be regenerated

6.0.11: KW45/K32W1 PRC3.1

FSCI: Framework Serial Communication Interface

Overview The Framework Serial Communication Interface (FSCI) is both a software module and a protocol that allows monitoring and extensive testing of the protocol layers. It also allows separation of the protocol stack between two protocol layers in a two processing entities setup, the host processor (typically running the upper layers of a protocol stack) and the Black Box application (typically containing the lower layers of the stack, serving as a modem). The Test Tool software is an example of a host processor, which can interact with FSCI Black Boxes at various

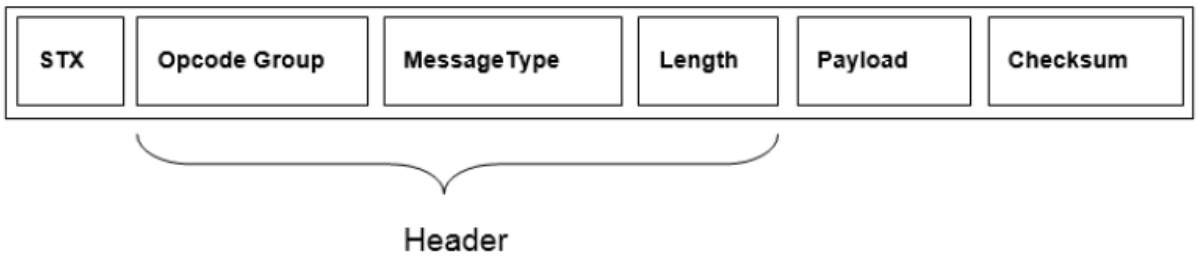
layers. In this setup, the user can run numerous commands to test the Black Box application services and interfaces.

The FSCI enables common service features for each device enables monitoring of specific interfaces and API calls. Additionally, the FSCI injects or calls specific events and commands into the interfaces between layers.

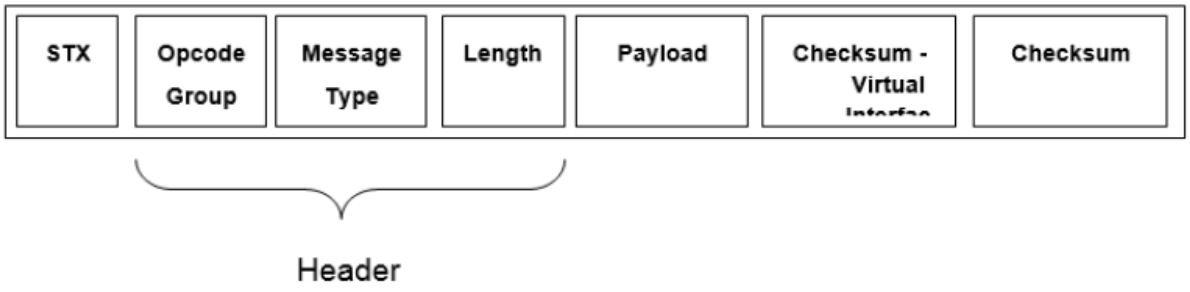
An entity which needs to be interfaced to the FSCI module can use the API to register opcodes to specific interfaces. After doing so, any packet coming from that interface with the same opcode triggers a callback execution. Two or more entities cannot register the same opcode on the same interface, but they can do so on different interfaces. For example, two MAC instances can register the same opcodes, one over UARTA, and the other over UARTB. This way, Test Tool can communicate with each MAC layer over two UART interfaces.

The FSCI module executes either in the context of the Serial Manager task or owns its dedicated task if the compilation Macro *gFsciUseDedicatedTask_c* is set to 1.

FSCI packet structure The FSCI module sends and receives messages as shown in the figure below. This structure is not specific to a serial interface and is designed to offer the best communication reliability. The Black Box device expects messages in little-endian format. It also responds with messages in little-endian format.



Below is an illustration of the FSCI packet structure when a virtual interface is used instead :



Field name	Length (bytes)	Description
STX	1	Used for synchronization over the serial interface. The value is always 0x02.
Opcode Group	1	Distinguishes between different Service Access Primitives (for example MLME or MCPS).
Message Type	1	Specifies the exact message opcode that is contained in the packet.
Length	1 or 2	The length of the packet payload, excluding the header and FCS. The length field content must be provided in little-endian format.
Payload	variable	Payload of the actual message.
Checksum	1	Checksum field used to check the data integrity of the packet.
Checksum2	0 or 1	The second CRC field appears only for virtual interfaces.

NOTE : When virtual interfaces are used, the first checksum is decremented with the ID of the interface. The second checksum is used for error detection.

constant definition The following Macro configurs the FSCI module

```
#define gFsciIncluded_c 0 /* Enable/Disable FSCI module */
#define gFsciUseDedicatedTask_c 1 /* Enable Fsci task to avoid recursivity in Fsci module (Misra␣
↪compliant) */
#define gFsciMaxOpGroups_c 8
#define gFsciMaxInterfaces_c 1
#define gFsciMaxVirtualInterfaces_c 0
#define gFsciMaxPayloadLen_c 245 /* bytes */
#define gFsciTimestampSize_c 0 /* bytes */
#define gFsciLenHas2Bytes_c 0 /* boolean */
#define gFsciUseEscapeSeq_c 0 /* boolean */
#define gFsciUseFmtLog_c 0 /* boolean */
#define gFsciUseFileDataLog_c 0 /* boolean */
#define gFsciLoggingInterface_c 1 /* [0..gFsciMaxInterfaces_c) */
#define gFsciHostMacSupport_c 0 /* Host support at MAC layer */
```

The following provides the OpGroups values reserved by MAC, application, and FSCI.

FSCI Host FSCI Host is a functionality that allows separation at a certain stack layer between two entities, usually two boards running separate layers of a stack.

Support is provided for functionality at the MAC layer, for example, MAC/PHY layers of a stack are running as a Black Box on a board, and MAC higher layers are running on another. The higher layers send and receive serial commands to and from the MAC Black Box using the FSCI set of operation codes and groups.

The protocol of communication between the two is the same. The current level of support is provided for:

- FSCI_MsgResetCPUReqFunc – sends a CPU reset request to black box
- FSCI_MsgWriteExtendedAdrReqFunc – configures MAC extended address to the Black Box
- FSCI_MsgReadExtendedAdrReqFunc – N/A

The approach on the Host interfacing a Black Box using synchronous primitives is by default the polling of the FSCI_receivePacket function, until the response is received from the Black Box. The calling task polls whenever the task is being scheduled. This is required because a stack synchronous primitive requires that the response of that request is available in the context of the caller right after the SAP call has been executed.

The other option, available for RTOS environments, is using an event mechanism. The calling task blocks waiting for the event that is sent from the Serial Manager task when the response is available from the Black Box. This option is disabled by default. The disadvantage of this option is that the primitive cannot be received from another Black Box through a serial interface because the blocked task is the Serial Manager task, which reaches a deadlock as cannot be released again.

FSCI ACK ACK transmission is enabled through the gFsciTxAck_c macro definition. Each FSCI valid packet received triggers an FSCI ACK packet transmission on the same FSCI interface that the packet was received on. The serial write call is performed synchronously to send the ACK packet before any other FSCI packet. Only then the registered handler is called to process the received packet. The ACK is represented by the gFSCI_CnfOpcodeGroup_c and mFsciMsgAck_c Opcode. An additional byte is left empty in the payload so that it can be used optionally as a packet identifier to correlate packets and ACKs. ACK reception is the other component that is enabled through gFsciRxAck_c. The behavior is such that every FSCI packet sent through a serial

interface triggers an FSCI ACK packet reception on the same interface after the packet is sent. If an ACK packet is received, the transmission is considered successful. Otherwise, the packet is resent a number of times. The ACK wait period is configurable through mFsciRxAckTimeoutMs_c and the number of transmission retries through mFsciTxRetryCnt_c. The ACK mechanism described above can also be coupled with a FSCI packet reception timeout enabled through gFsciRxTimeout_c and configurable through mFsciRxRestartTimeoutMs_c. Whenever there are no more bytes to be read from a serial interface, a timeout is configured at the predefined value if no other bytes are received. If new bytes are received, the timer is stopped and eventually canceled at successful reception. However, if, for any reason, the timeout is triggered, the FSCI module considers that the current packet is invalid, drops it, and searches for a new start marker.

FSCI usage example Detailed data types and APIs are described in ConnFWK API documentation.

Initialization

```
/* Configure the number of interfaces and virtual interfaces used */
#define gFsciMaxInterfaces_c 4
#define gFsciMaxVirtualInterfaces_c 2
....
/* Define the interfaces used */
static const gFsciSerialConfig_t myFsciSerials[] = {
    /* Baudrate, interface type, channel No, virtual interface */ {gUARTBaudRate115200_c, gSerialMgrUart_
↪c, 1, 0}, {gUARTBaudRate115200_c, gSerialMgrUart_c, 1, 1}, {0 , gSerialMgrIICSlave_c, 1, 0}, {0 ,␣
↪gSerialMgrUSB_c, 0, 0},
};
....
/* Call init function to open all interfaces */
FSCI_Init( (void*)mFsciSerials );
```

Registering operation groups

```
myOpGroup = 0x12; // Operation Group used
myParam = NULL; // pointer to a parameter to be passed to the handler function (myHandlerFunc)
myInterface = 1; // index of entry from myFsciSerials
...
FSCI_RegisterOpGroup( myOpGroup, gFsciMonitorMode_c, myHandlerFunc, myParam, myInterface );
```

Implementing handler function

```
void fsciMcpsReqHandler(void *pData, void* param, uint32_t interfaceId)
{
    clientPacket_t *pClientPacket = ((clientPacket_t*)pData);
    fsciLen_t myNewLen;
    switch( pClientPacket->structured.header.opCode )
    {
        case 0x01:
        {
            /* Reuse packet received over the serial interface The OpCode remains the same. The length of the␣
↪response must be <= that the length of the received packet */
            pClientPacket->structured.header.opGroup = myResponseOpGroup;/* Process packet */
            ...
            pClientPacket->structured.header. len = myNewLen;
            FSCI_transmitFormatedPacket(pClientPacket, interfaceId);
            return;
        }
        case 0x02:
        {
```

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```
        /* Alocate a new message for the response. The received packet is Freed */
        clientPacket_t *pResponsePkt = MEM_BufferAlloc( sizeof(clientPacketHdr_t) + myPayloadSize_d␣
↪+ sizeof(uint8_t) // CRC);
        if(pResponsePkt)
        {
            /* Process received data and fill the response packet */ ...
            pResponsePkt->structured.header. len = myPayloadSize_d;
            FSCI_transmitFormatedPacket(pClientPacket, interfaceId);
        }
        break;
    }
    default:
        MEM_BufferFree( pData );
        FSCI_Error( gFsciUnknownOpcode_c, interfaceId );
        return;
  }
  /* Free message received over the serial interface */
  MEM_BufferFree( pData );
}
```

Helper Functions Library

Overview This framework provides a collection of features commonly used in embedded software centered on memory manipulation.

HWParameter: Hardware parameter

Production Data Storage Hardware parameters provide production data storage

Overview Different platforms/boards need board/network node-specific settings to function according to the design. (Examples of such settings are IEEE® addresses and radio calibration values specific to the node.) For this purpose, the last flash sector is reserved and contains hardware-specific parameters for production data storage. These parameters pertain to the network node as a distinct entity. For example, a silicon mounted on a PCB in a specific configuration, rather than to just the silicon itself. This sector is reserved by the linker file, through the PROD_DATA section and it should be read/written only through the API described below.

> Note : This sector is not erased/written at code download time and it is not updated via over-the-air firmware update procedures to preserve the respective node-specific data, regardless of the firmware running on it.

Constant Definitions Name :

```
extern uint32_t PROD_DATA_BASE_ADDR[];
```

Description :

This symbol is defined in the linker script. It specifies the start address of the PROD_DATA section.

Name :

```
static const uint8_t mProdDataIdentifier[10] = {"PROD_DATA:"};
```

Description :

The value of this constant is copied as identification word (header) at the beginning of the PROD_DATA area and verified by the dedicated read function.

Note: the length of mProdDataIdentifier imposes the definition of PROD_DATA_ID_STRING_SZ as 10. The legacy HW parameters structure provides headroom for future usage. There are currently 63 bytes available.

Data type definitions Name :

```
typedef PACKED_STRUCT HwParameters_tag
{
    uint8_t identificationWord[PROD_DATA_ID_STRING_SZ]; /* internal usage only: valid data present */
    /*@{*/
    uint8_t bluetooth_address[BLE_MAC_ADDR_SZ];      /*!< Bluetooth address */
    uint8_t ieee_802_15_4_address[IEEE_802_15_4_SZ]; /*!< IEEE 802.15.4 MAC address - K32W1 only
↪*/
    uint8_t xtalTrim;                                /*!< XTAL 32MHz Trim value */
    uint8_t xtalCap32K;                               /*!< XTAL 32kHz capacitance value */
    /* For forward compatibility additional fields may be added here
       Existing data in flash will not be compatible after modifying the hardwareParameters_t typedef.
       In this case the size of the padding has to be adjusted.
    */
    uint8_t reserved[1];
    /* first byte of padding : actual size if 63 for legacy HwParameters but
      complement to 128 bytes in the new structure */
}
hardwareParameters_t;
```

Description:

Defines the structure of the hardware-dependent information.

> Note : Some members of this structure may be ignored on a specific board/silicon configuration. Also, new members may be added for implementation-specific purposes and the backward compatibility must be maintained.

The CRC calculation starts from the reserved field of the hardwareParameters_t and ends before the hardwareParamsCrc field. Additional members to this structure may be added using the following method :

Add new fields before the reserved field. This method does not cause a CRC fail, but you must keep in mind to subtract the total size of the new fields from the size of the reserved field. For example, if a field of uint8_t size is added using this method, the size of the reserved field shall be changed to 63.

Co-locating application factory data in HW Parameters flash sector. The sector containing the Hardware parameter structure may be located in the internal flash, usually at its last sector. The actual Hardware parameter structure has a size of 128 bytes - including padding reserved for future use. Since there is plenty of room available in a flash sector (4kB or 8kB), co-locating Application Factory Data in the same structure prevents from reserving another flash sector for these data. The application designer may adopt this solution by defining gHwParamsAppFactoryDataExtension_d as 1. A total of 2kB is alloted to this purpose.

If this option was chosen, whenever any of the Hardware parameter fields is modified, its CRC16 will change so the sector will need erasing. The gHwParamsAppFactoryDataPreserveOnHwParamUpdate_d compilation option deals with restoring the contents of the App Factory Data. Nonetheless this requires a temporary allocation a 2kB buffer to preserve the previous content and restore then on completion of the Hw Parameter update.

Special reserved area at start of IFR1 in range [0x02002000..0x02002600[On development boards a 1536 byte area is reserved and the actual Hardware parameter area begins at offset 0x600. Preserving this area on a HW parameter update also requires a temporary 1.5kB dynamic allocation (in addition to the App Factory 2kB allocation), to be able to restore on completion of update operation.

HW Parameters Production Data placement options The placement of production data (PROD_DATA) can be selected based on the definition of gHwParamsProdDataPlacement_c (see fwk_config.h). The productions data seldom need update for final products, once calibration data, MAC addresses or others have been programmed. Two cases exist, plus a transition mode :

1) gHwParamsProdDataMainFlashMode_c (0) :
   - PROD_DATA are located at top of Main Flash. Hardware parameters section is placed in the last sector of internal flash [0xfe000..0x100000[.
   - The linker script must reserve this area explicitly so as to prevent placement of NVM or text sections at that location by setting gUseProdInfoMainFlash_d.
2) gHwParamsProdDataMainFlash2IfrMode_c(1) : - PROD_DATA are located in IFR1, but MainFlash version still exists during interim period. - If the contents of the PROD_DATA section in MainFlash is valid (not blank and correct CRC) but the IFR PROD_DATA is still blank, copy the contents of MainFlash PROD_DATA to IFR location. - When done PROD_DATA in IFR are used. Once the transition is done, an application using (2: gHwParamsProdDataPlacementIfrMode_c) may be programmed.
3) gHwParamsProdDataIfrMode_c (2) :
   - PROD_DATA section dwells in the IFR1 sector [0x02002000..0x02004000[
   - in development phase the area comprised between [0x02002000..0x02002600[must be reserved for internal purposes.
   - This allows to free up the top sector of Main Flash by linking with gUseProdInfoMainFlash_d unset.

LowPower

Low Power reference user guide This Readme file describes the connectivity software architecture and provides the general low power enablement user guide.

1- Connectivity Low Power SW architecture The connectivity low power software architecture is composed of various components. These are described from the lower layer to the application layer:

1. The SDK power manager in component/power_manager. This component provides the basic low power framework. It is not specific to the connectivity but generic across devices. it covers:
   - gather the low power constraints for upper layer and take the decision on the best suitable low power state the device is allowed to go to fullfill the constraints.
   - call the low power entry and exit function callbacks
   - call the appropriate SW routines to switch the device into the suitable low power state
2. Connectivity Low power module in the connectivity framework. This module is composed of:

- The low power service called PWR inside framework/LowPower (this folder), This module is generic to all connectivity devices.
- The platform lowpower: fwk_platform_lowpower.[ch] located in framework\platform\<platform_name>. These files are a collection of low power routines functions for the PWR module and upper layer. These are specific to the device.

  Both PWR and platform lowpower files are detailed in section below.

3. Low power Application modules, it consists of 3 parts:
   - Application initialization file app_services_init.c where the application initializes the low power framework, see next section 'Demo example for typical usage of low power framework'
   - Application Idle task from application to call the main low power entry function PWR_EnterLowPower() to switch the device into lowpower. This function is application specific, one example is given in the section 1.3.3
   - Low power board files : board_lp.[ch] located in board/lowpower. These files implement the low power entry and exit functions related to the application and board. Customers shall modify these files for their own needs. Example code is given for the connectivity applications.

     User guide is provided in section 1.3 below.

   Note : Linker script may also be impacted for power down mode support in order to provide an RAM area for ROM warm boot (depends on the platform) and application warmboot stack

The Low power central and master reference design applications provide an example of Low power implementation for BLE. Customer can also refer to the associated document 'low power connectivity reference design user guide'.

1.1 - SDK power manager This module provides the main low power functionalities such as:

- Decide the best low-power mode dependent on the constraints set by upper layers by using PWR_SetLowPowerModeConstraints() API function.
- Handle the sequences to enter and exit low-power mode.
- Enable and configure wake up sources, call the application callbacks on low power entry/exit sequences.

The SDK power manager provides the capability for application and all components to receive low power constraints to the power. The Application does not set the low-power mode the device shall go into. When going to low power, the SDK power manager selects the best low-power mode that fits all the constraints.

As an example, if the low power constraint set from Application is Power Down mode, and no other constraint is set, the SDK power manager selects Power down mode, the next time the device enters low power. However, if a new constraint is set by another component, such as the SecLib module that operates Hardware encryption, the SecLib module would select WFI as additional low power constraint. Also, the SDK power manager selects this last low-power mode until the constraint is released by the SecLib module. It then reselects Power Down mode for further low power entry modes.

1.2 - PWR Low power module The PWR module in the connectivity framework provides additional services for the connectivity stacks and applications on top of the SDK power manager.

It also provides a simple API for Connectivity Stack and Connectivity applications.

However, more advanced features such as configuring the wake-up sources are only accessible from the SDK Power Manager API.

In addition to the SDK Power Manager, the PWR module uses the software resources from lower level drivers but is independent of the platform used.

1.2.1 - Functional description Initialization of the PWR module should be done through PWR_Init() function. This is mainly to initialize the SDK power manager and the platform for low power. It also registers PWR low power entry/exit callback PWR_LowpowerCb() to the SDK power manager. This function will be called back when entering and exiting low power to perform mandatory save/restore operations for connectivity stacks. The application can perform extra optional save/restore operations in the board_lp file where it can register to the SDK Power Manager its own callback. This is usually used to handle optional peripherals such as serial interfaces, GPIOs, and so on.The main entry function is PWR_EnterLowPower(). It should be called from Idle task when no SW activity is required. The maximum duration for lowpower is given as argument timeoutUs in useconds. This function will check the next Hardware event in the connectivity stack, typically the next Radio activity. A wakeup timer is programmed if the timeoutUs value is shorter than the next radio event timing. Passing a timeout of 0us will be interpreted as no timeout on the application side.

On device wakeup from low power state, the function will return the time duration the device has been in low power state.

Two APi are provided to set and release low power state constraints : PWR_SetLowPowerModeConstraint() and PWR_ReleaseLowPowerModeConstraint(). These are helper functions. User can use directly the SDK power manager if needed.

The PWR module also provides some API to be set as callbacks into other components to prevent from going to low power state. It can be used in following examples :

1. If a DMA is running, the module in charge of the DMA would need to set a constraint to avoid the system from going to a low power state when the RAM and system bus are no longer available.
2. If transfer is going on a peripheral, the drivers shall set a constraint to forbid low power mode.
3. If encryption is on going through an Hardware accelerator, the HW accelerator and the required ressources (clocks, etc), shall be kept active also by setting a constraints.

1.2.2 - Tickless mode support This module also provides some routines functions PWR_SysticksPreProcess() and PWR_SysticksPostProcess() from PWR_systicks.c in order to support the tickless mode when using FreeRTOS. The tickless mode is the capability to suspend the periodic system ticks from FreeRTOS and keep timebase tracking using another low power counter. In this implementation, the Timer Manager and time_stamp component are used for this purpose.

Idle task shall call these functions PWR_SysticksPreProcess() and PWR_SysticksPostProcess() before and after the call to the main low power entry function PWR_EnterLowPower().

Refer to framework/LowPower/PWR_systicks.c file or section 2.1 below for more information.

1.3 - Low power platform submodule Low power platform module file fwk_platform_lowpower.c provides the necessary helper functions to support low power device initialization, device entry, and exit routines. These are platform and device specific. Typically, the PWR module uses the low power platform submodule for all low power specific routines.

The low power platform submodule is documented in the Connectivity Framework Reference Manual document and in the Connectivity Framework API document.

1.4 - Low power board files Low power board files board_lp.[ch] are both application and board specific. Users should update this file to add new functions to include new used peripherals that require low power support. In the current SDK package, only Serial Manager over UART and button (IO toggle wake up source) are supported and demonstrated in the Bluetooth LE demo application.

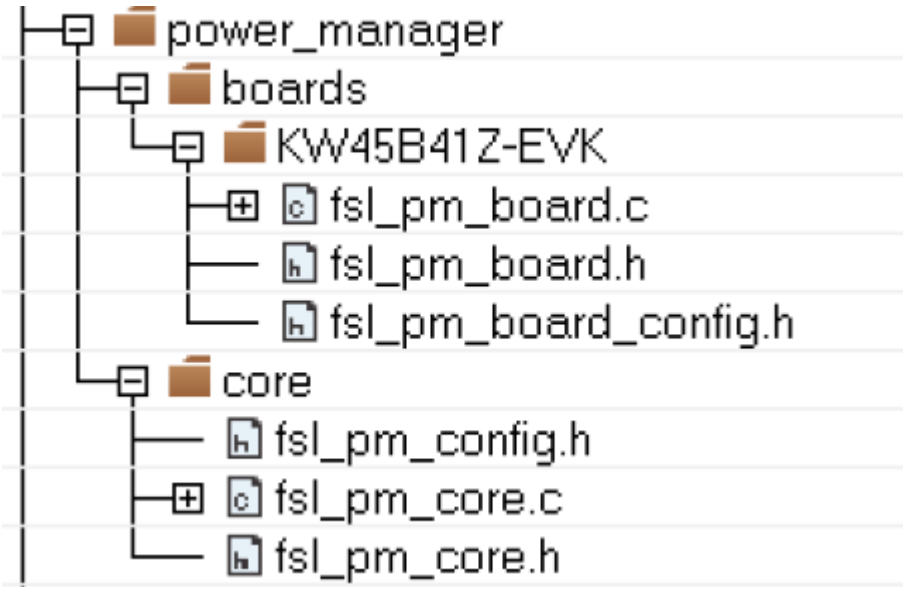
Other peripherals that require specific action on low power entry and restore on low power exit should be added to low power board files. For more details, refer to section Low power board file update

2 - Low power Application user guide This section provides a user guide to enable Low power on a connectivity application, It gives example of typical implementation for the initialization, Idle task function and low power entry/exit functions.

2.1 - Application Project updates It is recommended to reuse the low-power peripheral/central reference design application projects as a start. This ensures that everything is in place for the low-power optimization feature. Then, application files may be added to one of the two projects.

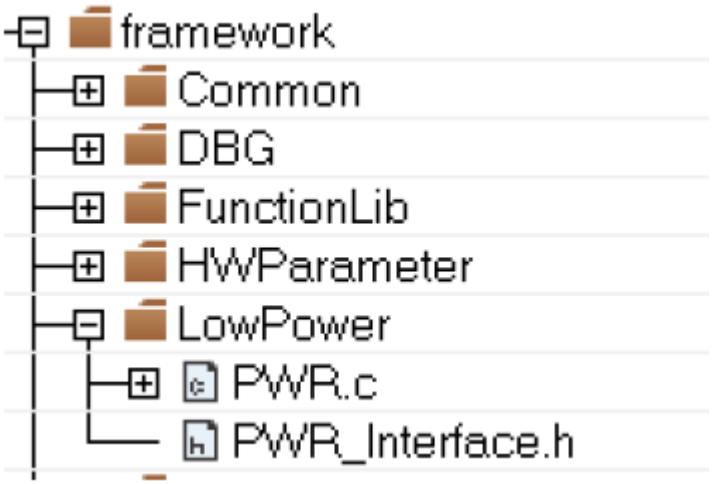
However, users can start directly from the application project and implement low power in it, by performing the steps described in the following sections.

2.1.1 - SDK Power Manager Most of the Low power functionality is implemented in the SDK Power Manager. The files to add into the project SDK power_manager module are listed in the figure below:



You need to use the files located in the folder that match your device.

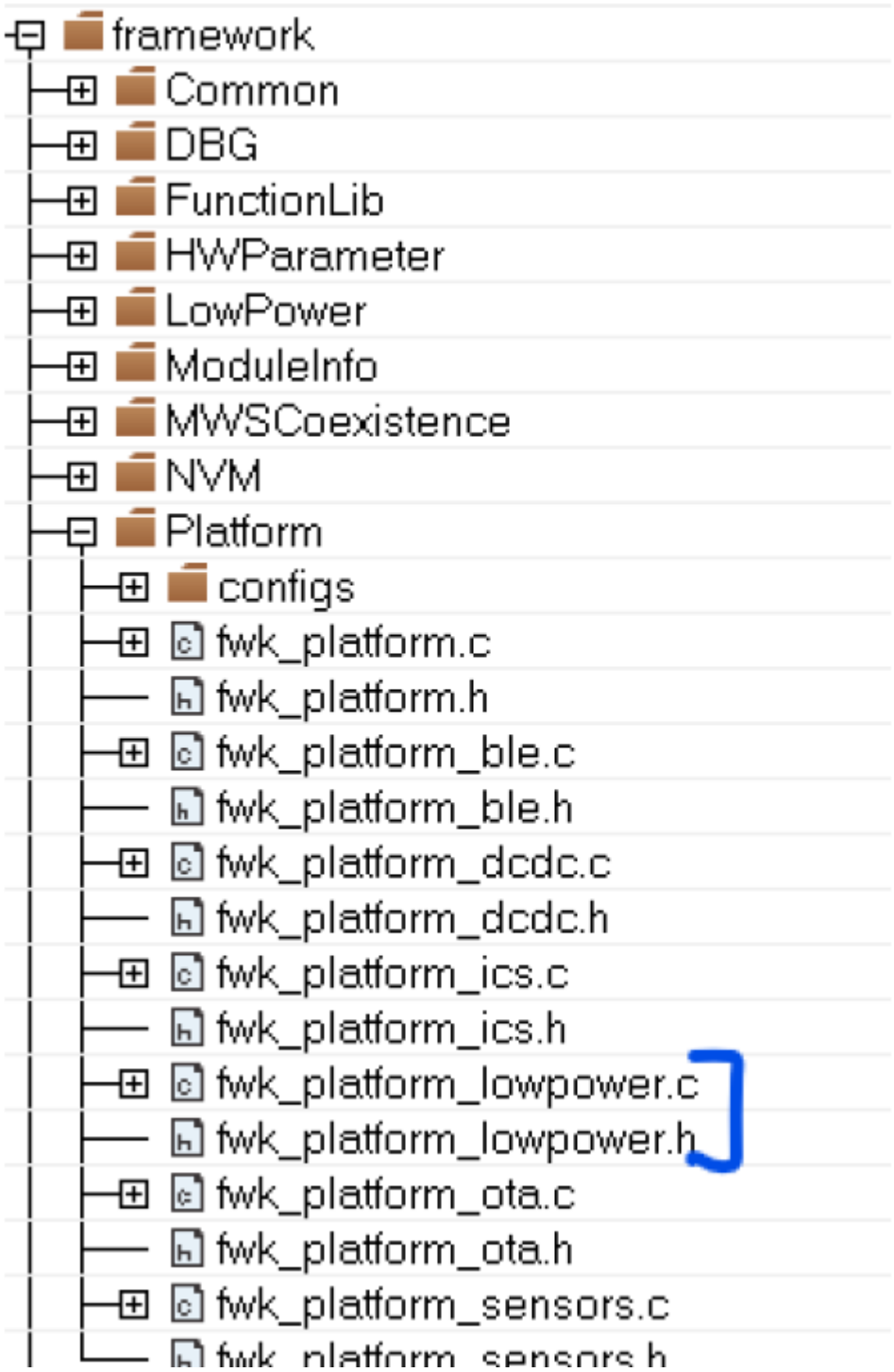
2.1.2 - PWR connectivity framework module PWR.c PWR_Interface.h shall be added to your application projects :



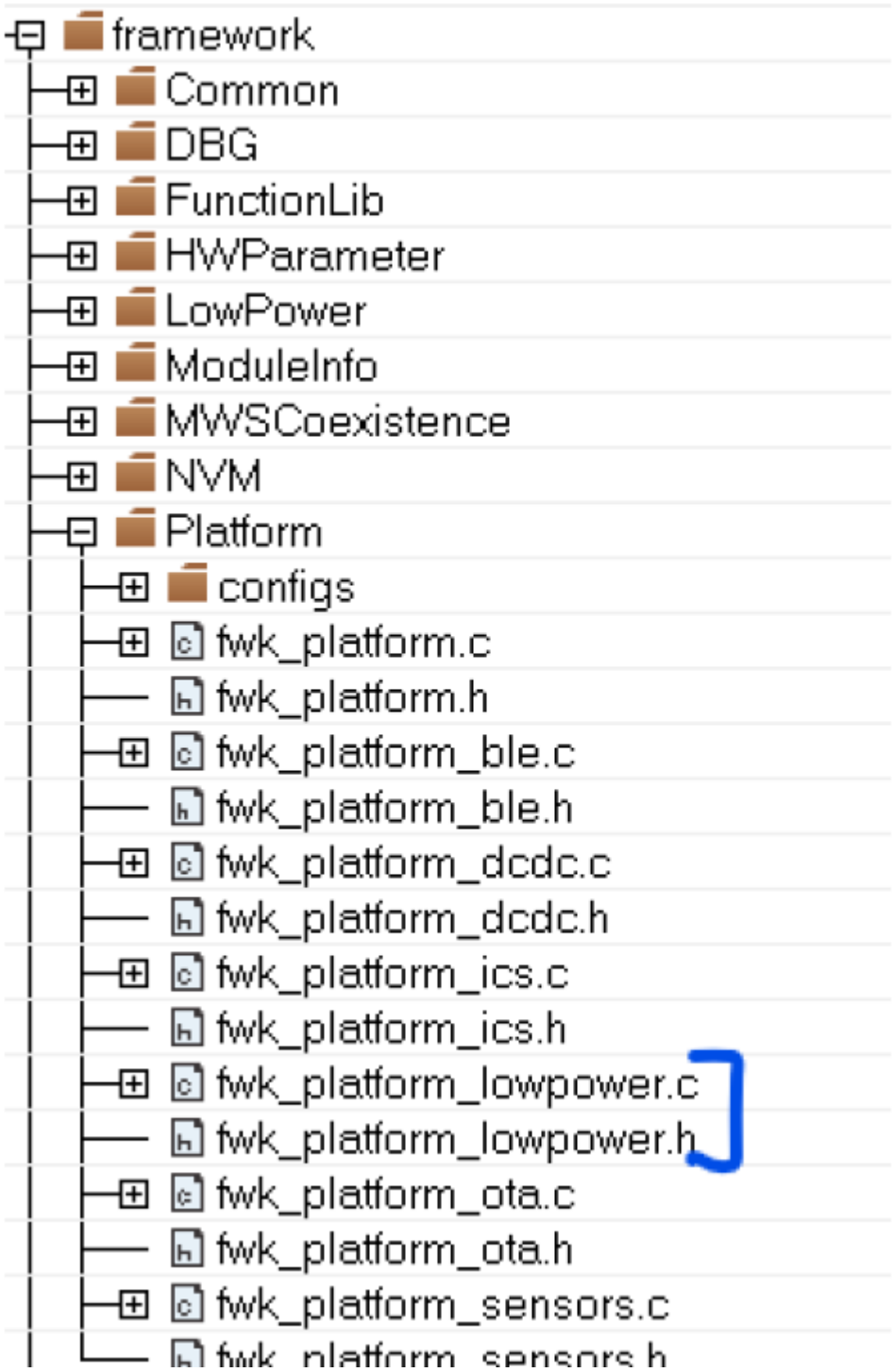
Optionally, in order to support Systick less mode, PWR_systicks.c or PWR_systicks_bm.c could also be added.

The include path to add is: middleware/wireless/framework/LowPower

2.1.3 -Low power platform submodule Low power platform files can be found in the 'Platform' module in the connectivity framework:



2.1.4 - Low power board files These files are located in the same folder that the other board files board.[ch]. Hence, it is not required to add any new include path at compiler command line.



2.1.5 - Application RTOS Idle hook and tickeless hook functions See section 2.4.3 Idle task implementation example

2.2 - Low power and wake up sources Initialization Low power initialization and configuration are performed in APP_ServiceInitLowpower()function. This is called from APP_InitServices() function called from the main() function so all is already set up when calling the main application entry point, typically BluetoothLEHost_AppInit() function in the Bluetooth LE demo applications.

The default Low Power mode configured in APP_InitServices() is Deep Sleep mode. In Bluetooth

LE, (or any other stack technology), Deep Sleep mode fits for all use cases. For instance, for Bluetooth LE states: Advertising, Connected, Scanning states. This mode already performs a very good level of power saving and likely, this is not required to optimize more if the device is powered from external supply.

APP_ServiceInitLowpower() function performs the following initialization and configuration:

- Initialize the Connectivity framework Low power module PWR_Init(), this function initialized the SDK power manager.
- Configure the wakeup sources such as serial manager wake up source for UART, or button for IO wake up configuration. These are typical wakeup sources used in the connectivity application. Developer may want to add additional wake up sources here specific for the application.

  Note : The low power timer wakeup source and wakeup from Radio domain are directly enabled from the Connectivity framework Low power module PWR as it is mandatory for the connectivity stack. If your application supports other peripherals (such as i2c, spi, and others) that require wake sources from low power, developer should add additional wake up sources setting in this function APP_ServiceInitLowpower(). The complete list of wakeup sources are available from the SDK power manager component, see file fsl_pm_board.h in component/boards/<device_name>/.
- Initialize and register the Low power board file used to register and implement low power entry and exit callback function used for peripheral. This is done by calling the BOARD_LowPowerInit() function.
- Register low power Enter and exit critical function to driver component to enable / disable low power when the Hardware is active. Example is given for serial manager that needs to disable low power when the TX ring buffer contains data so the device does not enter low power until the buffer is empty.

Finally, APP_ServiceInitLowpower() function configures the Deep Sleep mode as the default low power constraint for the application. It is recommended to keep this level of low power constraint during all the connectivity stack initialization.

Example of low power framework initialization can be found in app_services_init.c file. Below is some code example for initializing the low power framework and wake up sources:

```
static void APP_ServiceInitLowpower(void)
{
    PWR_ReturnStatus_t status = PWR_Success;

    /* It is required to initialize PWR module so the application
     * can call PWR API during its init (wake up sources...) */
    PWR_Init();

    /* Initialize board_lp module, likely to register the enter/exit
     * low power callback to Power Manager */
    BOARD_LowPowerInit();

    /* Set Deep Sleep constraint by default (works for All application)
     *   Application will be allowed to release the Deep Sleep constraint
     *   and set a deepest lowpower mode constraint such as Power down if it needs
     *   more optimization */
    status = PWR_SetLowPowerModeConstraint(PWR_DeepSleep);
    assert(status == PWR_Success);

#if (defined(gAppButtonCnt_c) && (gAppButtonCnt_c > 0))

    /* Init and enable button0 as wake up source
     * BOARD_WAKEUP_SOURCE_BUTTON0 can be customized based on board configuration
```

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```
    * On EVK we use the SW2 mapped to GPIOD */
   PM_InitWakeupSource(&button0WakeUpSource, BOARD_WAKEUP_SOURCE_BUTTON0, NULL,␣
↪true);
#endif

#if (gAppButtonCnt_c > 1)
   /* Init and enable button1 as wake up source
    * BOARD_WAKEUP_SOURCE_BUTTON1 can be customized based on board configuration
    * On EVK we use the SW3 mapped to PTC6 */
   PM_InitWakeupSource(&button1WakeUpSource, BOARD_WAKEUP_SOURCE_BUTTON1, NULL,␣
↪true);
#endif

#if (defined(gAppUseSerialManager_c) && (gAppUseSerialManager_c > 0))

#if defined(gAppLpuart0WakeUpSourceEnable_d) && (gAppLpuart0WakeUpSourceEnable_d > 0)
   /* To be able to wake up from LPUART0, we need to keep the FRO6M running
    * also, we need to keep the WAKE domain is SLEEP.
    * We can't put the WAKE domain in DEEP SLEEP because the LPUART0 is not mapped
    * to the WUU as wake up source */
   (void)PM_SetConstraints(PM_LP_STATE_NO_CONSTRAINT, APP_LPUART0_WAKEUP_
↪CONSTRAINTS);
#endif

   /* Register PWR functions into SerialManager module in order to disable device lowpower
      during SerialManager processing. Typically, allow only WFI instruction when
      uart data are processed by serail manager  */
   SerialManager_SetLowpowerCriticalCb(&gSerMgr_LowpowerCriticalCBs);
#endif

#if defined(gAppUseSensors_d) && (gAppUseSensors_d > 0)
   Sensors_SetLowpowerCriticalCb(&app_LowpowerSensorsCriticalCBs);
#endif

   (void)status;
}
```

2.3 - low power entry/exit sequences : board files updates Board Files that handles low-power are board_lp.[ch] files.

Low power board files implement the low-power callbacks of the peripherals to be notified when entering or exiting Low Power mode. This module also registers these low-power callbacks to the SDK Power Manager component to get the notifications when the device is about to enter low-power or exit Low Power mode. The Low-power callbacks are registered from BOARD_LowPowerInit() function. This function is called from app_services_init.c file after PWR module initialization.

The low power callback functions can be categorized in two groups:

- Entry Low power call back functions: These are usually used to prepare the peripherals to enter low-power. For example, they can be used for flushing FIFOs, switching off some clocks, and reconfiguring pin mux to avoid leakage on pins. In case of Power Down mode, these functions could be used to save the Hardware peripheral context.
- Exit Low power call back functions: These are typically used to restore the peripherals to functionality. Therefore, they perform the reverse of what is done by the entry call-back functions: restoring the pin mux, re-enabling the clock, in case of Power Down mode, restoring the Hardware peripheral context, and so on.

Note that distinction can be done between clock gating mode (Deep Sleep mode), and power gated mode (Power down mode) when entering and exiting Low Power mode. The

BOARD_EnterLowPowerCb() and BOARD_ExitLowPowerCb() functions provide the code to call the various peripheral entry and exit functions to go and exit Deep Sleep mode: serial manager, button, debug console, and others.

However, the processing to save and restore the Hardware peripheral is implemented in different functions BOARD_EnterPowerDownCb() and BOARD_ExitPowerDownCb(). These two functions should be called when exiting power gated modes of the power domain. These two should implement specific code for such case (likely the complete reinitialization of each peripheral). In order to know the Low Power mode that the wake up domain, or main domain has been entered, the low-power platform API PLATFORM_GetLowpowerMode() can be called.

> **Note :** BOARD_ExitPowerDownCb() is called before BOARD_ExitLowPowerCb() as it is generally required to restore the Hardware peripheral contexts before reconfiguring the pin mux to avoid any signal glitches on the pads

Also, It is important to know whether the location of the Hardware peripheral is in the main domain or wake up domain. The two power domains can go into different power modes with the limitation that the wakeup domain cannot go to a deepest Low Power mode than the main domain. Depending on the constraint set on SDK power manager, the wake up domain could remain in active while the main domain can go to deep sleep or power down modes. In this case, the peripherals in the wake up domain does not required to be restored, as explained in the section Power Down. Likely, only pin mux reconfiguration is required in this case.

example Low power entry and exit functions shall be registered to the SDK power manager so these functions will be called when the device will enter and exit low power mode. This is done by BOARD_LowPowerInit() typically called from application source code in app_services_init.c file

```
static pm_notify_element_t boardLpNotifyGroup = {
    .notifyCallback = BOARD_LowpowerCb,
    .data           = NULL,
};

void BOARD_LowPowerInit(void)
{
    status_t status;

    status = PM_RegisterNotify(kPM_NotifyGroup2, &boardLpNotifyGroup);
    assert(status == kStatus_Success);
    (void)status;
}
```

BOARD_LowpowerCb() callback function will handle both the entry and exit sequences. An argument is passed to the function to indicate the lowpower state the device enter/exit. Typical implementation is given below. Customer shall make sure to differentiate low power entry and exit, and the various low power states.

Typically, nothing is expected to be done if low power state is WFI or Sleep mode. These modes are some light low power states and the system can be woken up by interrupt trigger.

In Deep sleep mode, the clock tree and source clocks are off, the system needs to be woken up from an event from the WUU module.

In Power down mode, some peripherals are likely to be powered off, context save and restore may need to be done in these functions.

```
static status_t BOARD_LowpowerCb(pm_event_type_t eventType, uint8_t powerState, void *data)
{
    status_t ret = kStatus_Success;
    if (powerState < PLATFORM_DEEP_SLEEP_STATE)
    {
        /* Nothing to do when entering WFI or Sleep low power state
           NVIC fully functionnal to trigger upcoming interrupts */
```

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```
    }
    else
    {
        if (eventType == kPM_EventEnteringSleep)
        {
            BOARD_EnterLowPowerCb();

            if (powerState >= PLATFORM_POWER_DOWN_STATE)
            {
                /* Power gated low power modes often require extra specific
                 * entry/exit low power procedures, those should be implemented
                 * in the following BOARD API */
                BOARD_EnterPowerDownCb();
            }
        }
        else
        {
            /* Check if Main power domain domain really went to Power down,
             *   powerState variable is just an indication, Lowpower mode could have been skipped by an␣
↪immediate wakeup
             */
            PLATFORM_PowerDomainState_t main_pd_state = PLATFORM_NO_LOWPOWER;
            PLATFORM_status_t           status;

            status = PLATFORM_GetLowpowerMode(PLATFORM_MainDomain, &main_pd_state);
            assert(status == PLATFORM_Successful);
            (void)status;

            if (main_pd_state == PLATFORM_POWER_DOWN_MODE)
            {
                /* Process wake up from power down mode on Main domain
                 *  Note that Wake up domain has not been in power down mode */
                BOARD_ExitPowerDownCb();
            }

            BOARD_ExitLowPowerCb();
        }
    }
    return ret;
}
```

2.4 - Low power constraint updates and optimization Except for the board file update as seen in previous section, the application does not need any other changes for low-power support in Deep Sleep mode. It shall work as if no low-power is supported. However, If more aggressive power saving is required, this constraint can be changed in your application in order to further reduce the power consumption in Low Power mode.

2.4.1 - Changing the Default Application low power constraint after firmware initialization The Low power reference design applications (central or peripheral) provides demonstration on how to change the Application low power constraint. In the Application main entry point BluetoothLEHost_AppInit(), Deep Sleep mode is configured by default from APP_ServiceInitLowpower() function.

> **Note :** It is recommended to keep Deep Sleep mode as default during all the stack initialization phase until BluetoothLEHost_Initialized() and BleApp_StartInit() functions are called. In case of Bonded device with privacy, it is recommended to wait for gControllerPrivacyStateChanged_c event to be called.

BleApp_LowpowerInit() function provides an example of code on how to release the default Deep sleep low-power constraint and set a new constraint such as Power down mode for the application. This deeper low-power mode is used when no Bluetooth LE activity is on going, and if no other higher Low-power constraint is set by another components or layer. For instance, if some serial transmission is on going by the serial manager, or if the SecLib module has on going activity on the HW crypto accelerator, the low-power mode could less deep.

```
static void BleApp_LowpowerInit(void)
{
#if defined(gAppLowpowerEnabled_d) && (gAppLowpowerEnabled_d>0)
    PWR_ReturnStatus_t status;

    /*
     * Optionally, Allow now Deepest lowpower mode constraint given by gAPP_
↪LowPowerConstraintInNoBleActivity_c
     *    rather than DeepSleep mode.
     * Deep Sleep mode constraint has been set in APP_InitServices(), this is fine
     *    to keep this constraint for typical lowpower application but we want the
     *    lowpower reference design application to be more agressive in term of power saving.

     *   To apply a lower lowpower mode than Deep Sleep mode, we need to
     *    - 1) First, release the Deep sleep mode constraint previously set  by default in app_services_init()
     *    - 2) Apply new lowpower constraint when No BLE activity
     *   In the various BLE states (advertising, scanning, connected mode), a new Lowpower
     *    mode constraint will be applied depending of Application Compilation macro set in app_preinclude.
↪h :
     *    gAppPowerDownInAdvertising, gAppPowerDownInConnected, gAppPowerDownInScanning
     */

    /*  1) Release the Deep sleep mode constraint previously set  by default in app_services_init() */
    status = PWR_ReleaseLowPowerModeConstraint(PWR_DeepSleep);
    assert(status == PWR_Success);
    (void)status;

    /*  2) Apply new Lowpower mode constraint gAppLowPowerConstraintInNoBleActivity_c *
     *      The BleAppStart() call above has already set up the new lowpower constraint
     *       when Advertising request has been sent to controller        */
    BleApp_SetLowPowerModeConstraint(gAppLowPowerConstraintInNoBleActivity_c);
#endif
}
```

2.4.2 - Changing the Application lowest low power constraint during application execution

In the various application use cases, (in the various Bluetooth LE activity states, advertising, connected, scanning), some lower low-power constraint can be set, as Power down for advertising, Deep Sleep for connected, or Scanning. Customer can change the level of Low Power mode in the various use case mainly depending of the time duration the device is supposed to remain in low-power. The longer the time that the device remains in low power, the higher the benefit for a deeper Low Power mode such as Power down mode. However, please note that the wake up from power down mode takes significantly more time than deep sleep as ROM code is re executed and the hardware logic needs to be restored. Sections Deep Sleep and Power Down provide some guidance on when to use Deep Sleep mode or Power Down modes respectively.

In the low power reference design applications, four application compilations macros are defined to adjust the low-power mode into advertising, scanning, connected, or no Bluetooth LE activity. Other use cases can be added as desired. For instance, If application needs to run a DMA transfer, or if application needs to wakeup regularly to process data from external device, it may be useful to set WFI constraint (in case of DMA transfer), or Deep Sleep constraint (in case of regular wake up to process external data), rather than power down or a even lower low-power mode.

The 4 application compilation macros can be found in app_preinclude.h file of the project. See

app_preinclude.h for low power reference design peripheral application :

```
/*! Lowpower Constraint setting for various BLE states (Advertising, Scanning, connected mode)
   The value shall map with the type defintion PWR_LowpowerMode_t in PWR_Interface.h
     0 : no LowPower, WFI only
     1 : Reserved
     2 : Deep Sleep
     3 : Power Down
     4 : Deep Power Down
   Note that if a Ble State is configured to Power Down mode, please make sure
     gLowpowerPowerDownEnable_d variable is set to 1 in Linker Script
   The PowerDown mode will allow lowest power consumption but the wakeup time is longer
     and the first 16K in SRAM is reserved to ROM code (this section will be corrupted on
     each power down wakeup so only temporary data could be stored there.)
         Power down feature not supported. */

#define gAppLowPowerConstraintInAdvertising_c          3
/* Scanning not supported on peripheral */
//#define gAppLowPowerConstraintInScanning_c            2
#define gAppLowPowerConstraintInConnected_c           2
#define gAppLowPowerConstraintInNoBleActivity_c       4
```

In lowpower_central.c lowpower_preripheral.c files, the application sets and releases the low power constraint from BleApp_SetLowPowerModeConstraint() and BleApp_ReleaseLowPowerModeConstraint() functions. These functions are called with the macro value passed as argument.

> **Important Note :** Setting the application low power constraint shall be done on new Bluetooth LE state request so the new constraint is applied immediately, while the application low-power mode constraint shall be released when the Bluetooth LE state is exited. For example, setting the new low power constraint for Advertising shall be done when the application requests advertising to start. Releasing the low power constraint shall be done in the advertising stop callback (advertising has been stopped).

After releasing the low power constraint, the previous low power constraint, (likely the one that has been set during firmware initialization in APP_ServiceInitLowpower() function, or the updated low power constraint in BleApp_StartInit() function) applies again.

2.4.3 - Idle task implementation example

2.4.3.1 Tickless mode support and Low power entry function Idle task configuration from FreeRTOS shall be enabled by configUSE_TICKLESS_IDLE in FreeRTOSConfig.h. This will have the effect to have vPortSuppressTicksAndSleep() called from Idle task created by FreeRTOS. Here is a typical implementation of this function:

```
void vPortSuppressTicksAndSleep(TickType_t xExpectedIdleTime)
{

    bool abortIdle = false;
    uint64_t actualIdleTimeUs, expectedIdleTimeUs;

    /* The OSA_InterruptDisable() API will prevent us to wakeup so we use
     * OSA_DisableIRQGlobal() */
    OSA_DisableIRQGlobal();

    /* Disable and prepare systicks for low power */
    abortIdle = PWR_SysticksPreProcess((uint32_t)xExpectedIdleTime, &expectedIdleTimeUs);

    if (abortIdle == false)
    {
```

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```
        /* Enter low power with a maximal timeout */
        actualIdleTimeUs = PWR_EnterLowPower(expectedIdleTimeUs);

        /* Re enable systicks and compensate systick timebase */
        PWR_SysticksPostProcess(expectedIdleTimeUs, actualIdleTimeUs);
    }

    /* Exit from critical section */
    OSA_EnableIRQGlobal();
}
```

2.4.3.2 Connectivity background tasks and Idle hook function example Some process needs to be run in background before going into low power. This is the case for writing in NVM, or firmware update OTA to be writen in Flash. If so, configUSE_IDLE_HOOK shall be enabled in FreeRTOSCOnfig.h so vApplicationIdleHook() will be called prior to vPortSuppressTicksAndSleep(). Typical implementation of vApplicationIdleHook() function can be found here :

```
void vApplicationIdleHook(void)
{
    /* call some background tasks required by connectivity */
#if ((gAppUseNvm_d) || \
    (defined gAppOtaASyncFlashTransactions_c && (gAppOtaASyncFlashTransactions_c > 0)))

    if (PLATFORM_CheckNextBleConnectivityActivity() == true)
    {
        BluetoothLEHost_ProcessIdleTask();
    }
#endif
}
```

PLATFORM_CheckNextBleConnectivityActivity() function implemented in low power platform file fwk_platform_lowpower.c typically checks the next connectivity event and returns true if there's enough time to perform time consuming tasks such as flash erase/write operations (can be defined by the compile macro depending on the platform).

2. Low power features

2.1 - FreeRTOS systicks Low power module in framework supports the systick generation for FreeRTOS. Systicks in FreeRTOS are most of the time not required in the Bluetooth LE demos applications because the framework already supports timers by the timer manager component, so the application can use the timers from this module. The systicks in FreeRTOS are useful for all internal timer service provided by FreeRTOS (through OSA) like OSA_TimeDelay(), OSA_TimeGetMsec(), OSA_EventWait(). When systicks are enabled, an interrupt (systick interrupt) is triggered and executed on a periodic basis. In order to save power, periodic systick interrupts are undesirable and thus disabled when going to low-power mode. This feature is called low power FreeRTOS tickless mode. When entering the low power state, the system ticks shall be disabled and switch to a low power timer. On wake-up, the module retrieves the time passed in low power and compensate the ticks count accordingly. This feature does not apply on bare metal scheduler.

On FreeRTOS, the vPortSuppressTicksAndSleep() function implemented in the app_low_power.c file will be called when going to idle. FreeRTOS will give to this function the xExpectedIdleTime, time in tick periods before a task is due to be moved into the Ready state. This function will manage the systicks (disable/enable) through PWR_SysticksPreProcess() and PWR_SysticksPostProcess() calls. Then, when calling PWR_EnterLowPower(), a time out duration in micro seconds will be given and the function will set a timer before entering low power.

In addition, this function will return the low power period duration, used to compensate the ticks count.

In our example low power reference design peripheral application, an OSA_EventWait() has been added to demonstrate the tickless mode feature. You can adjust the timeout with the gAppTaskWaitTimeout_ms_c flag in the app_preinclude.h file, its value in our demo is 8000ms. So 8 seconds after stopping any activity we will wake up from low power. If the flag is not defined in the application its value will be osaWaitForever_c and there will be no OS wake up.

2.2 - Selective RAM bank retention To optimize the consumption in low power, the linker script specific function PLATFORM_GetDefaultRamBanksRetained() is implemented. This function obtains the RAM banks that need to be retained when the device goes in low power, in order to set them with PLATFORM_SetRamBanksRetained() function. The RAM banks that are not needed are set in power off state, when the device goes in low power mode.

The function PLATFORM_GetDefaultRamBanksRetained() is linker script specific. Hence, it cannot be adapted for a different application. If these functions are called from board_lp.c, it is possible to give to PLATFORM_SetRamBanksRetained() a different bank_mask adapted to your specific application.

In deep power down, this feature does not have any impact because in this power mode, all RAM banks are already powered off.

3 - Low power modes overview PWR module API provides the capability to set low power mode constraints from various components or from the application. These constraints are provided to the SDK power manager. Upper layer (all Application code, connectivity stacks, etc.) can call directly the SDK Power Manger if it requires more advanced tuning. The PWR API can be found in PWR_Interface.h.

> **Note :** 'Upper layer' signifies all layers, applications, components, or modules that are above the connectivity framework in the Software architecture.
>
> **Note :** Each power domain has its own Low Power mode capability. The Low Power modes described below are for the main domain and it is supposed that the wake up domain goes to the same Low Power mode. This is not always true as the wake up domain that contains some wake up peripheral can go a lower Low Power mode state than the main domain so the peripherals in the wake up domain can remain operational when the main domain is in Low Power mode (deep sleep or power down modes). In this case, the context of the Hardware peripheral located in the wake up domain does not need to be saved and restored as for the peripherals located in the main domain

3.1 Wait for Interrupt (WFI) Definition

In the Wait for Interrupt (WFI) state, the CPU core is powered on, but is in an idle mode with the clock turned OFF.

Wake up time and typical use case

The wakeup time from this Low Power mode is insignificant because the Fast clock from FRO is still running.

This Low Power mode is mainly used when there is an hardware activity while the Software runs the Idle task. This allows the code execution to be temporarily suspende, thus reducing a bit the power consumption of the device by switching off the processor clock. When an interrupt fires, the processor clock is instantaneously restored to process the Interrupt Service Routine (ISR).

Usage

In order to prevent the software from programming the device to go to a lower Low Power mode (such as Deep Sleep, Power Down mode or Deep Power Down mode), the component responsible for the hardware drivers shall call PWR_SetLowPowerModeConstraint(PWR_WFI) function. When the Hardware activity is completed, the component shall release the constraint by calling PWR_ReleaseLowPowerModeConstraint(PWR_WFI).

Alternatively, the component can call PWR_LowPowerEnterCritical() and then PWR_LowPowerExitCritical() functions.

For fine tuning of the Low Power mode allowing more power saving, the component can call directly the SDK power manager API with PM_SetConstraints() function using the appropriate Low Power mode and low power constraint. However, this is reserved for more advanced user that knows the device very well. It is not recommended to do so.

The PWR module has no external dependencies, so the low-power entry and exit callback functions must be defined by the user for each peripheral that has specific low power constraints It is consequently convenient to register to the component the low power callbacks structure that is used for entering and exit low power critical sections. In Bluetooth LE, you can take the example in the app_conn.c file as shown here :

```
#if defined(gAppLowpowerEnabled_d) && (gAppLowpowerEnabled_d>0)
static const Seclib_LowpowerCriticalCBs_t app_LowpowerCriticalCBs =
{
  .SeclibEnterLowpowerCriticalFunc = &PWR_LowPowerEnterCritical,
  .SeclibExitLowpowerCriticalFunc  = &PWR_LowPowerExitCritical,
};
#endif

void BluetoothLEHost_Init(..)
{
  ...
      /* Cryptographic hardware initialization */
      SecLib_Init();
#if defined(gAppLowpowerEnabled_d) && (gAppLowpowerEnabled_d>0)
      /* Register PWR functions into SecLib module in order to disable device lowpower
         during Seclib processing. Typically, allow only WFI instruction when
         commands (key generation, encryption) are processed by Seclib  */
      SecLib_SetLowpowerCriticalCb(&app_LowpowerCriticalCBs);
#endif
  ...
}
```

Limitations

No limitation when using the WFI mode.

3.2 Sleep mode Sleep mode is similar to WFI low power mode but with some additional clock gating. The Sleep mode is device specific, please consult the Hardware reference manuel of the device for more information.

3.2 Deep Sleep mode Definition

In Deep Sleep mode, the fast clock is turned off, and the CPU along with the main power domain are placed into a retention state, with the voltage being scaled down to support state retention only. Because no high frequency clock is running, the voltage applied on the power domain can be reduced to reduce leakage on the hardware logic. This reduces the overall power consumption in the Deep Sleep mode. When waking up from Deep sleep mode, the core voltage is increased back to nominal voltage and the fast clock (FRO) is turned back on, the peripheral in this domain can be reused as normal.

To same more additional power, Some unused RAM banks can be powered off. this prevents from having current leakage and consequently, allow to reduce even more the power consumption in Deep SLeep mode. This is achieved by calling PLATFORM_SetRamBanksRetained() from low power entry function from board_lp.c file.

Usage

All firmware is able to implement Deep Sleep mode transparently to the application thanks to the PWR module, low power platform submodule and low power board file. This is described in the section Low-power implementation.

When entering this mode, it is recommended to turn the output pins into input mode, or high impedance to reduce leakage on the pads. This is typically done in pin_mux.c file, called from board.c file and executed from the low power callback in board_lp.c file. As an example, the TX line of the UART peripheral can be turned to disabled so it prevents the current from being drawn by the pad in Low Power mode.

Wake up time and typical use case

The wake up time is very fast, it takes mostly the time for the Fast FRO to start up again (couple of hundreds of microseconds) so this mode is a very good balance between power consumption in low-power mode and wake up latency and shall be used extensively in most of the use cases of the application.

Limitations

In Deep Sleep mode, the clock is disabled to the CPU and the main peripheral domain, so peripheral activity (for example, an on-going DMA transfer) is not possible in Deep Sleep mode.

3.3 Power Down mode **Definition**

In Power Down mode, both the clock, and power are shut off to the CPU and the main peripheral domain. SRAM is retained, but register values are lost. The SDK power manager handles the restore of the processor registers and dependencies such as interrupt controller and similar ones transparently from the application.

Usage

The application, with the help of the low power board files, saves and restores the peripherals that were located in the power domain during the entry and exit of the power down mode. This is done from low power board_lp files in the entry/exit low power callbacks. Example is given for the serial manager and debug console in *board_lp.c* file in function *BOARD_ExitPowerDownCb()*.

If the device contains a dedicated wake up power domain where some wake up peripherals are located, if this wake up domain is not turned into power down mode but only Deep sleep mode or active mode, this peripheral does not need for a save and restore on low power entry/exit. For instance, on KW45, This is basically achieved when enabling the wakeup source of the peripheral *PWR_EnableWakeUpSource()* from *APP_ServiceInitLowpower()* function. Alternatively, this can be directly achieved by setting the constraint to the SDK power manager by calling *PM_SetConstraints()*, (use APP_LPUART0_WAKEUP_CONSTRAINTS for wakeup from UART constraint).

On exit from low power, The low power state of power domain can be retrieved by Platform API PLATFORM_GetLowpowerMode(). This API shall be called from low power exit callback function only.

As for Deep Sleep mode, software shall configure the output pins into input or high impedance during the Low Power mode to avoid leakage on the pads.

Wake up time and typical use case

The wake up time is significantly longer than wake up time from Deep Sleep (from several hundreds of micro-seconds to a couple of milliseconds depending on the platform). On some platform, it can takes longer, for instance, if ROM code is implemented and perform authentication checks for security and hardware logic in power domain needs to be restored (case for KW45).

However, After ROM code execution, the SDK power manager resumes the Idle task execution from where it left before entering low-power mode. Hence, the wakeup time from this mode is still significantly lower that the initialization time from a power on reset or any other reset.

Depending on the wakeup time of the platform and the low power time duration, This mode is recommended when no Software activity is expected to happen for the next several seconds. In Bluetooth LE, this mode is preferred in advertising or without Bluetooth LE activity. However, in scanning or connected mode, Regular wakes up happens regularly for instance to retrieve HCI message responses from the Link layer, the Deep Sleep mode is rather recommended.

Limitations

In addition to the Deep Sleep limitation (no Hardware processing on going when going to Power down mode) and the significant increase of the wake time, the Power Down mode requires the ROM code to execute and this last uses significant amount of memory in SRAM.

Typically, The first SRAM bank (16 KBytes) is used by the ROM code during execution so the Application firmware can use this section of SRAM for storing bss, rw data, or stacks. Only temporary data could be stored here and this location is overwritten on every Power Down exit sequence.

In order to avoid placing firmware data section (bss, rw, etc.) in the first SRAM bank, the linker script variable *gLowpowerPowerDownEnable_d* should be set to 1. Setting the linker script variable to avoid placing firmware data section in the first SRAM bank, The effect of setting this flag is to prevent the firmware from using the first 16 KB in SRAM.

> *Note* : This setting is ONLY required if the application implements Power Down mode.
> If Application uses other low-power mode, this is not required.

3.4 Deep Power-down mode **Definition**

In Deep Power Down mode, the SRAM is not retained. This power mode is the lowest disponible, it is exited through reset sequence.

Usage

In addition to the Power Down limitation, the Deep Power Down mode shut down all memory in SRAM. Because it is exited through reset sequence the wake time is also longer.

Wake up time and typical use case

As this low-power mode is exited through the reset sequence, the wake up time is longer than any other mode. In Bluetooth LE, this mode is possible in no Bluetooth LE activity, and is preferred if we know that there will be no Bluetooth LE activity before a several amount of time.

Limitations

All memory in SRAM will be shut down in deep power down, the main limitation in going in this low-power mode is that the context will not be saved.

ModuleInfo

Overview The ModuleInfo is a small Connectivity Framework module that provides a mechanism that allows stack components to register information about themselves.

The information comprises :

- Component or module name (for example: Bootloader, IEEE 802.15.4 MAC, and Bluetooth LE Host) and associated version string
- Component or module ID
- Version number
- Build number

The information can be retrieved using shell commands or FSCI commands.

Detailed data types and APIs used in ConnFWK_APIs_documentation.pdf.

NVM: Non-volatile memory module

Overview In a standard Harvard-architecture-based MCU, the flash memory is used to store the program code and program constant data. Modern processors have a built-in flash memory controller that can be used under user program execution to store non-volatile data. The flash memories have individually erasable segments (sectors) and each segment has a limited number of erase cycles. If the same segments are used to store various kinds of data all the time, those segments quickly become unreliable. Therefore, a wear-leveling mechanism is necessary to prolong the service life of the memory. The NVM module in the connectivity framework provides a file system with a wear-leveling mechanism, described in the subsequent sections. The *NvIdle()* function handles the program and erase memory operations. Before resetting the MCU, *NvShutdown()* must be called to ensure that all save operations have been processed.

NVM boundaries and linker script requirement Most of the MCUs have only a standard flash memory that the non-volatile (NV) storage system uses. The amount of memory that the NV system uses for permanent storage and its boundaries are defined in the linker configuration file though the following linker symbols :

- NV_STORAGE_START_ADDRESS
- NV_STORAGE_END_ADDRESS
- NV_STORAGE_MAX_SECTORS
- NV_STORAGE_SECTOR_SIZE

The reserved memory consists of two virtual pages. The virtual pages are equally sized and each page is using one or more physical flash sectors. Therefore, the smallest configuration is using two physical sectors, one sector per virtual page.

NVM Table The Flash Management and Non-Volatile Storage Module holds a pointer to a RAM table. The upper layers of this table register information about data that the storage system should save and restore. An example of NVM table entry list is given below.

pData	ElemCount	ElemSize	EntryId	EntryType
0x1FFF9000	3	8	0xF1F4	MirroredInRam
0x1FFF7640	5	4	0xA2A6	NotMirroredInRam
0x1FFF1502	6	1	0x4212	NotMirroredInRam AutoRestore
0x1FFFF200	2	6	0x118F	MirroredInRam

NVM Table entry As show above, A NVM table entry contains a generic pointer to a contiguous RAM data structure, the number of elements the structure contains, the size of a single element, a table entry ID, and an entry type.

A RAM table entry has the following structure:

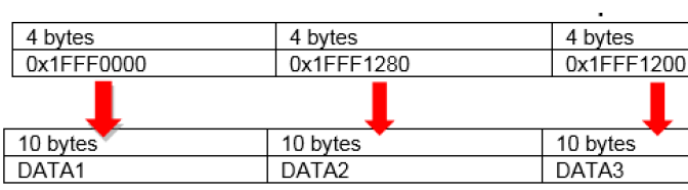
- pData (4 bytes) is a pointer to the RAM memory location where the dataset elements are stored.

- elemCnt (2 bytes) represents how many elements the dataset has.
- elemSz (2 bytes) is the size of a single element.
- entryID is a 16-bit unique ID of the dataset.
- dataEntryType is a 16-bit value representing the type of entry (mirrored/unmirrored/unmirrored auto restore).

For mirrored datasets, pData must point directly to the RAM data. For unmirrored datasets, it must be a double pointer to a vector of pointers. Each pointer in this table points to a RAM/FLASH area. Mirrored datasets require the data to be permanently kept in RAM, while unmirrored datasets have dataset entries either in flash or in RAM. If the unmirrored entries must be restored at the initialization, NotMirroredInRamAutoRestore should be used. The entryID gUnmirroredFeatureSet_d should be set to 1 for enabling unmirrored entries in the application. The last entry in the RAM table must have the entryID set to gNvEndOfTableId_c.

pData	0x1FFF8000
elemCnt	4
elemSz	10
entryID	1
dataEntryType	gNVM_NotM gNVM_NotM

The figure below provides an example of table entry :



When the data pointed to by the table entry pointer (pData) has changed (entirely or just a single element), the upper layers call the appropriate API function that requests the storage system to save the modified data. All the save operations (except for the synchronous save and atomic save) and the page erase and page copy operations are performed on system idle task. The application must create a task that calls NvIdle in an infinite loop. It should be created with OSA_PRIORITY_IDLE. However, the application may choose another priority. The save operations are done in one virtual page, which is the active page. After a save operation is performed on an unmirrored dataset, pData points to a flash location and the RAM pointer is freed. As a result, the effective data should always be allocated using the memory management module.

Active page The active page contains information about the records and the records. The storage system can save individual elements of a table entry or the entire table entry. Unmirrored datasets can only have individual saves. On mirrored datasets, the save/restore functions must receive the pointer to RAM data. For example, if the application must save the third element in the above vector, it should send 0x1FFF8000 + 2 * elemSz. For unmirrored datasets, the application must send the pointer that points to the area where the data is located. For example, if the application must save the third element in the above vector, it should send 0x1FFF8000 + 2 * sizeof(void*).

The page validity is guaranteed by the page counter. The page counter is a 32-bit value and is written at the beginning and at the end of the active page. The values need to be equal to consider the page a valid one. The value of the page counter is incremented after each page copy operation. A page erase operation is performed when the system is formatted. It is also performed when the page is full and a new record cannot be written into that page. Before being erased, the full page is first copied (only the most recent saves) and erased afterward.

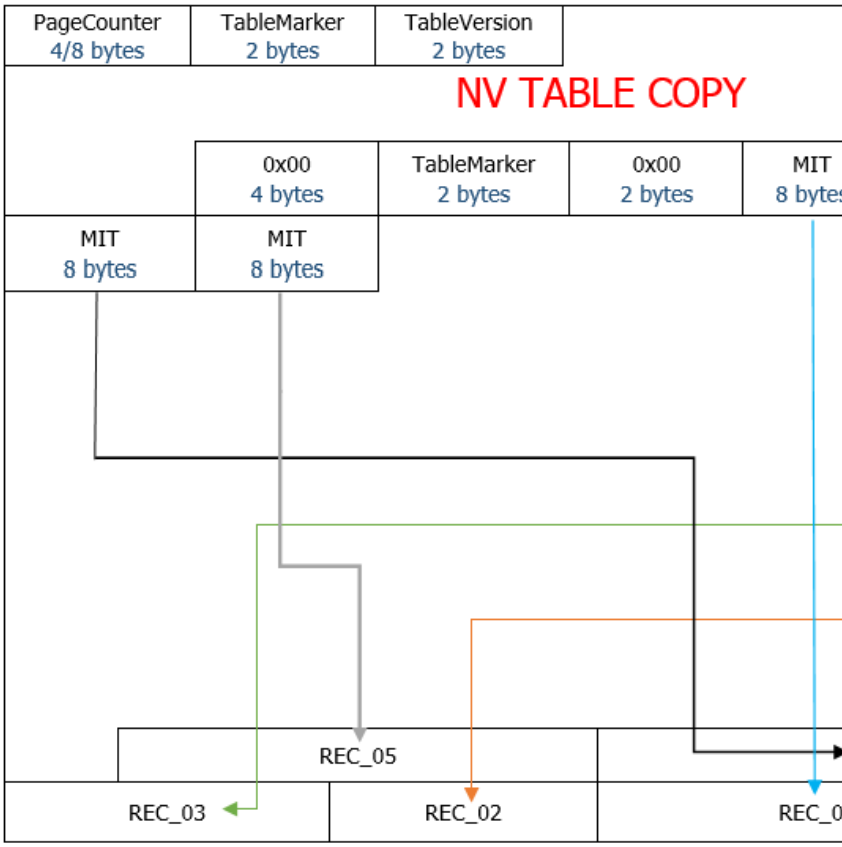
The validity of the Meta Information Tag (MIT), and, therefore, of a record, is guaranteed by the MIT start and stop validation bytes. These two bytes must be equal to consider the record

referred by the MIT valid. Furthermore, the value of these bytes indicates the type of the record, whether it is a single element or an entire table entry. The nonvolatile storage system allows dynamic changes of the table within the RAM memory, as follows:

- Remove table entry
- Register table entry

A new table entry can be successfully registered if there is at least one entry previously removed or if the NV table contains uninitialized table entries, declared explicitly to register new table entries at run time. A new table entry can also replace an existing one if the register table entry is called with an overwrite set to true. This functionality is disabled by default and must be enabled by the application by setting gNvUseExtendedFeatureSet_d to 1.

The layout of an active page is shown below:



As shown above, the table stored in the RAM memory is copied into the flash active page, just after the table version. The “table start” and “table end” are marked by the table markers. The data pointers from RAM are not copied. A flash copy of a RAM table entry has the following structure:

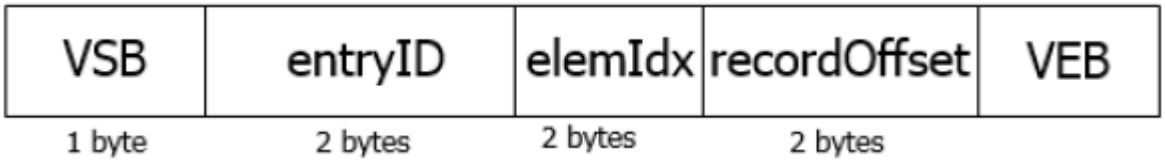
Where:

- entryID is the ID of the table entry
- entryType represents the type of the entry (mirrored/unmirrored/unmirrored auto restore)
- elemCnt is the elements count of that entry
- elemSz is the size of a single element

This copy of the RAM table in flash is used to determine whether the RAM table has changed. The table marker has a value of 0x4254 (“TB” if read as ASCII codes) and marks the beginning

and end of the NV table copy.

After the end of the RAM table copy, the Meta Information Tags (MITs) follow. Each MIT is used to store information related to one record. An MIT has the following structure:

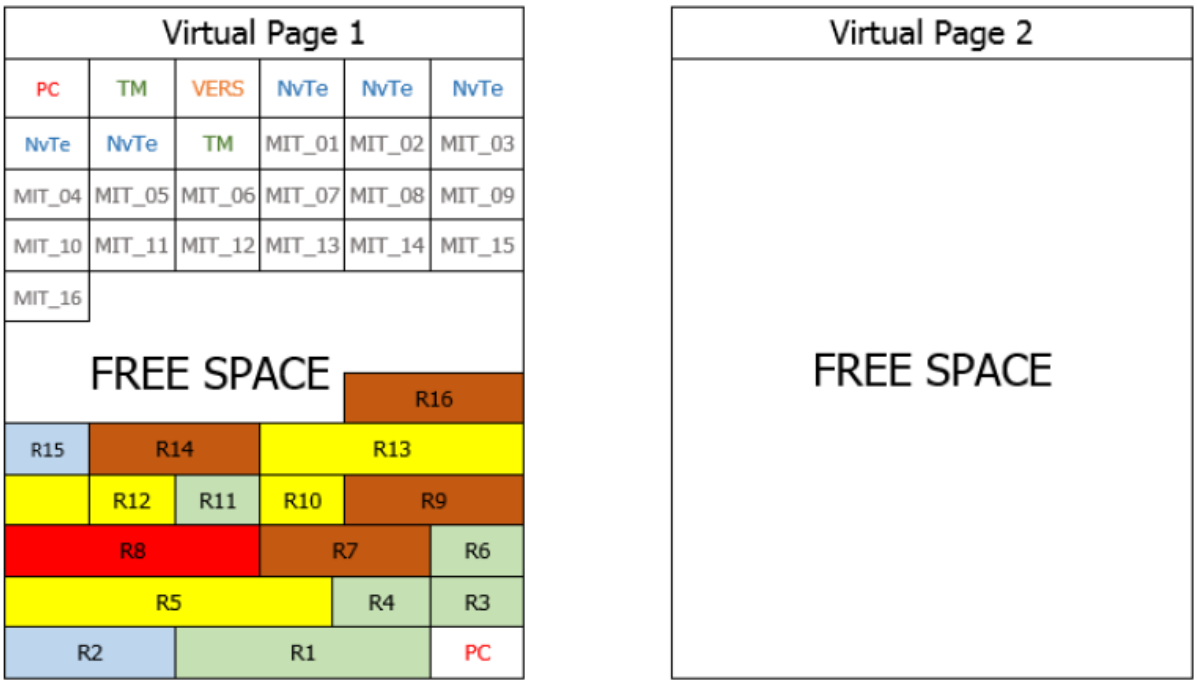


Where:

- VSB is the validation start byte.
- entryID is the ID of the NV table entry.
- elemIdx is the element index.
- recordOffset is the offset of the record related to the start address of the virtual page.
- VEB is the validation end byte.

A valid MIT has a VSB equal to a VEB. If the MIT refers to a single-element record type, VSB=VEB=0xAA. If the MIT refers to a full table entry record type (all elements from a table entry), VSB=VEB=0x55. Because the records are written to the flash page, the available page space decreases. As a result, the page becomes full and a new record does not have enough free space to be copied into that page.

In the example given below, the virtual page 1 is considered to be full if a new save request is pending and the page free space is not sufficient to copy the new record and the additional MIT. In this case, the latest saved datasets (table entries) are copied to virtual page 2.

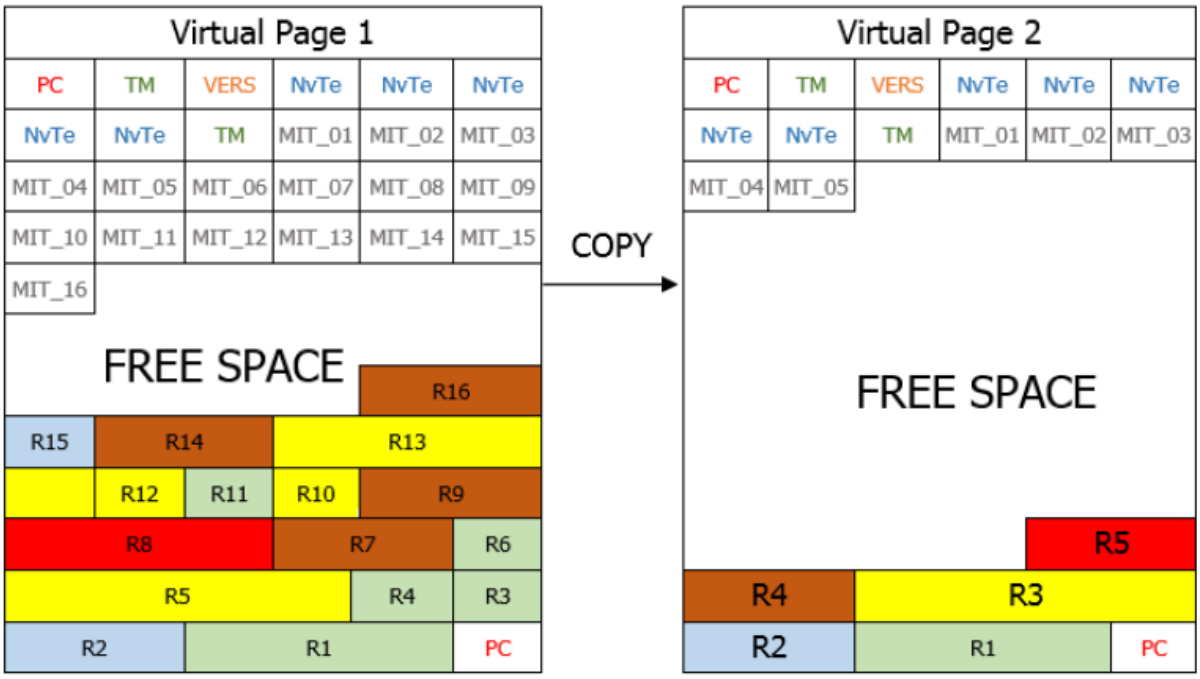


In this example, there are five datasets (one color for each dataset) with both 'full' and 'single' record types.

- R1 is a 'full' record type (contains all the NV table entry elements), whereas R3, R4, R6 and R11 are 'single' record types.
- R2 – full record type; R15 – single record type
- R5, R13 – full record type; R10, R12 – single record type

- R8 – full record type
- R7, R9, R14, R16 – full record type

As shown above, the R3, R4, R6, and R11 are 'single' record types, while R1 is a 'full' record type of the same dataset. When copied to virtual page 2, a defragmentation process takes place. As a result, the record copied to virtual page 2 has as much elements as R1, but individual elements are taken from R3, R4, R6, and R11. After the copy process completes, the virtual page 2 has five 'full' record types, one for each dataset. |This is illustrated below:



Finally, the virtual page 2 is validated by writing the PC value and a request to erase virtual page 1 is performed. The page is erased on an idle task, sector by sector where only one sector is erased at a time when idle task is executed.

If there is any difference between the RAM and flash tables, the application must call RecoverNvEntry for each entry that is different from its RAM copy to recover the entry data (ID, Type, ElemSz, ElemCnt) from flash before calling NvInit. The application must allocate the pData and change the RAM entry. It can choose to ignore the flash entry if the entry is not desired. If any entry from RAM differs from its flash equivalent at initialization, a page copy is triggered that ignores the entries that are different. In other words, data stored in those entries is lost.

The application can check if the RAM table was updated. In other words, if the MCU program was changed and the RAM table was updated, using the function GetFlashTableVersion and compare the result with the constant gNvFlashTableVersion_c. If the versions are different, NvInit detects the update and automatically upgrades the flash table. The upgrade process triggers a page copy that moves the flash data from the active page to the other one. It keeps the entries that were not modified intact and it moves the entries that had their elements count changed as follows:

- If the RAM element count is smaller than the flash element count, the upgrade only copies as many elements as are in RAM.
- If the RAM element count is larger than the flash element count, the upgrade copies all data from flash and fills the remaining space with data from RAM. If the entry size is changed, the entry is not copied. Any entryIds that are present in flash and not present in RAM are also not copied. This functionality is not supported if gNvUseExtendedFeatureSet_d is not set to 1.

ECC Fault detection The KW45/K32W1 internal flash is organized in 16 byte phrases and 8kB sectors (minimal erase unit). Its flash controller is synthesized so that it generates ECC information and an ECC generator / checker. During the programming of internal flash, errors may accidentally happen and cause ECC errors as a flash phrase is being written. These may happen due to multiple reasons:

- programmatic errors such as overwriting an already programmed phrase (transitioning bits from 0b to 1b). These are evitable by performing a blank check verification over phrase to be programmed, at the expense of processing power.
- occurrence of power drop or glitches during a programming operation.
- excessive wear of flash sector. The flash controller is capable of correcting one single ECC error but raises a bud fault whenever reading a phrase containing more than one ECC fault. Once an ECC error has 'infected' a flash phrase, the fault will remain and raise again at each read operation over the same phrase including blank check and prefetch. It can only be rid of by erasing the whole flash sector that contained the faulty phrase. In order to recover from situations where an ECC fault has occurred a gNvSalvageFromEccFault_d option has been added, which forces gNvVerifyReadBackAfterProgram_d to be defined to TRUE. If defined, the gNvVerifyReadBackAfterProgram_d option of the NVM module, causes the program to read back the programmed area after every flash programming operation. The verification is performed in safe mode if gNvSalvageFromEccFault_d is also defined. This is so as to detect ECC faults as early as possible as they appear, indeed when verifying a programming operation, one cannot be certain of the absence of ECC fault and avoid the bus fault. The safe API is thence used to perform the read back operation is performed using this safe API, so that we can tread in the flash and detect potential errors. The defects are detected on the fly whereas in the absence of safe read back, the error would cause a fault, potentially much later. During normal operation, assuming that no chip reset was provoked, this will consist in a single ECC fault either in the last record data or its meta information. Detecting such a fault calls for an immediate page copy to the other virtual page, so that the currently active page gets erased and the error gets cleared. Should the ECC fault occurs in the middle of a page copy operation, the switch of active page is postponed so that the fault page can be erased again and the copy can be restarted.

If the system underwent a power drop during a flash programming operation, sufficient to provoke a reset, at the ensuing reboot, ECC fault(s) may be present in the NVM area at the location that was being written. The detection is performed by an NVM sweeping mechanism, using the safe read API. That marks the faulty virtual page so that all subsequent reads within this virtual page are done with the safe API. If this case arises, a copy of the valid contents of the faulty page is attempted to the other virtual page. At NVM initialization, faults should be detected, either at the top of the meta data or at the bottom of the record area within the previous active page. This should guarantee that only the latest record write operation may be impaired. When the page copy has taken place, the faulty page is erased and the execution may resume. During NvCopyPage, when 'garbage collecting' occurs or whenever the current virtual active page needs to be transferred to the other virtual page, ECC errors are intercepted so that the operation can be attempted again in case of error. In case of NVM contents clobbering by programming errors, the salvage operation does its best to rescue as many records as possible but data will inevitably be lost.

An additional option -namely *gInterceptEccBusFaults_d* - was introduced in order to catch and correct ECC faults at Bus Fault handler level. Indeed, should an ECC bus fault fire, in spite of the precautions taken with NVM's gNvSalvageFromEccFault_d, we verify if the fault belongs to the NV storage. If so, a drastic policy can be adopted consisting in an erasure of the faulty sector. The corresponding Bus Fault handling is not part of the NVM, but dwells in the framework platform specific sources. Alternative handling could be implemented by the customer.

Save policy: Execution of program and erase operations on a flash an MCU core fetches code from cause perturbations of the core activity or requires to place critical code in RAM so that real-time ISR can still be served. The penalty of a sector erase is much higher than a simple program operation. The NVM is designed so as to limit the erase operations at 'garbage collecting' time,

so that flash wear is limited and no time is wasted. Several write policies are implemented to cope with the application constraints, one synchronous mode API and several posted write APIs. Among the posted write policies, the gNvmSaveOnIdleTimerPolicy_d compilation option selects a mode where flash write operations occur at time interval within the Idle task. Another option exists to 'randomize' the time interval with some jitter.

1) NvSyncSave performs a write synchronously with the disadvantage of stalling processor activity until comp
2) NvSaveOnCount posts a pending write operation and postpones the actual flash operation until number of record updates has reached a maximum. The actual write happens during Idle Task execution.see NvSetCountsBetweenSaves related API.
3) NvSaveOnInterval: posts a pending write operation and postpones the actual flash operation until the predefined number of ticks has elapsed. Optional mode - Active if (gNvmSaveOnIdleTimerPolicy_d & gNvmUseSaveOnTimerOn_c). see NvSetMinimumTicksBetweenSaves related API. Note that gNvmUseSaveIntervalJitter_c policy is a sub-option of gNvmSaveOnIdleTimerPolicy_d used to randomize slightly the time at which the write operation will happen.

Constant macro definition

- *gNvStorageIncluded_d* : If set to TRUE, it enables the whole functionality of the nonvolatile storage system. By default, it is set to FALSE (no code or data is generated for this module).
- *gNvUseFlexNVM_d* : If set to TRUE, it enables the FlexNVM functionality of the nonvolatile storage system. By default, it is set to FALSE. If FlexNVM is used, the standard nonvolatile storage system is disabled.
- *gNvFragmentation_Enabled_d* : Macro used to enable/disable the fragmented saves/restores (a particular element from a table entry can be saved or restored). It is set to FALSE by default.
- *gNvUseExtendedFeatureSet_d* : Macro used to enable/disable the extended feature set of the module:
  - Remove existing NV table entries
  - Register new NV table entries
  - Table upgrade

  It is set to FALSE by default.
- *gUnmirroredFeatureSet_d* : Macro used to enable unmirrored datasets. It is set to 0 by default.
- *gNvTableEntriesCountMax_c* : This constant defines the maximum count of the table entries (datasets) that the application is going to use. It is set to 32 by default.
- *gNvRecordsCopiedBufferSize_c* : This constant defines the size of the buffer used by the page copy function, when the copy operation performs defragmentation. The chosen value must be bigger than the maximum number of elements stored in any of the table entries. It is set by default to 64.
- *gNvCacheBufferSize_c* : This constant defines the size of the cache buffer used by the page copy function, when the copy operation does not perform defragmentation. The chosen value must be a multiple of 8. It is set by default to 64.
- *gNvMinimumTicksBetweenSaves_c* : This constant defines the minimum timer ticks between dataset saves (in seconds). It is set to 4 by default.
- *gNvCountsBetweenSaves_c* : This constant defines the number of calls to 'NvSaveOnCount' between dataset saves. It is set to 256 by default.

- *gNvInvalidDataEntry_c* : Macro used to mark a table entry as invalid in the NV table. The default value is 0xFFFFU.
- *gNvFormatRetryCount_c* : Macro used to define the maximum retries count value for the format operation. It is set to 3 by default.
- *gNvPendingSavesQueueSize_c* : Macro used to define the size of the pending saves queue. It is set to 32 by default.
- *gFifoOverwriteEnabled_c* : Macro used to enable overwriting older entries in the pending saves queue (if it is full). If it is FALSE and the queue is full, the module tries to process the oldest save in the queue to free a position. It is set to FALSE by default.
- *gNvMinimumFreeBytesCountStart_c* : Macro used to define the minimum free space at initialization. If the free space is smaller than this value, a page copy is triggered. It is set by default to 128.
- *gNvEndOfTableId_c* : Macro used to define the ID of the end-of-table entry. It is set to 0xFFFEU by default. No valid entry should use this ID.
- *gNvTableMarker_c* : Macro used to define the table marker value. The table marker is used to indicate the start and the end of the flash copy of the NV table. It is set to 0x4254U by default.
- *gNvFlashTableVersion_c* : Macro used to define the flash table version. It is used to determine if the NVM table was updated. It is set to 1 by default. The application should modify this every time the NVM table is updated and the data from NVM is still required.
- *gNvTableKeptInRam_d* : Set gNvTableKeptInRam_d to FALSE, if the NVM table is stored in FLASH memory (default). If the NVM table is stored in RAM memory, set the macro to TRUE.
- *gNvVerifyReadBackAfterProgram_d* : set by default force verification of NVM programming operations. Is forced implicitly when gNvSalvageFromEccFault_d is defined.
- *gNvSalvageFromEccFault_d* : use safe flash API to read from flash, and provide corrective action when ECC fault is met.

OtaSupport: Over-the-Air Programming Support

Overview This module includes APIs for the over-the-air image upgrade process. A Server device receives an image over the serial interface from a PC or other device thorough FSCI commands. If the Server has an image storage, the image is saved locally. If not, the image is requested chunk by chunk: With image storage

- OTA_RegisterToFsci()
- OTA_InitExternalMemory()
- OTA_WriteExternalMemory()
- ...
- OTA_WriteExternalMemory()

Without image storage:

- OTA_RegisterToFsci()
- OTA_QueryImageReq()
- OTA_ImageChunkReq()
- ...
- OTA_ImageChunkReq()

A Client device processes the received image by computing the CRC and filter unused data and stores the received image into a non-volatile storage. After the entire image has been transferred and verified, the Client device informs the Bootloader application that a new image is available, and that the MCU must be reset to start the upgrade process. See the following command sequence:

- OTA_StartImage()
- OTA_PushImageChunk() and OTA_CrcCompute ()
- ...
- OTA_PushImageChunk() and OTA_CrcCompute ()
- OTA_CommitImage()
- OTA_SetNewImageFlag()
- ResetMCU()

SecLib_RNG: Security library and random number generator

Random number generator

Overview The RNG module is part of the framework used for random number generation. It uses hardware RNG peripherals as entropy sources (TRNG, Secure Subsystem, ...) to provide a true random number generator interface. A Pseudo-Random number generator (PRNG) implementation is available. The PRNG may depend of SecLib services (thus requiring a common mutex) to perform HMAC-SHA256, SHA256, AES-CTR, or alternateively a Lehmer Linear Congruential generator. A prerequisite for the PRNG to function with desired randomness is to be seeded using a proper source of entropy. If no hardware acceleration is present, the RNG may fallback to lesser quality ad-hoc source e.g if present SIM_UID registers, the UIDL is used as the initial seed for the random number generator.

Initialization The RNG module requires an initialization via a call to RNG_Init. The RNG initialization involves a call to RNG_SetSeed.

In the case of a dual core system consisting of a Host core and an NBU core, the Secure Subsystem is owned by the Host core. The Host core then has a direct access to its TRNG embedded in its secure subssystem. On the NBU code side, a request is emitted via RPMSG to the Host to provide a seed. On receipt of this request, the Host sets a 'reseed needed' flag (from the ISR context) If the core running the RNG service owns the TRNG entropy hardware (if any), it can get the seed directly form this hardware synchronously. In the case of an NBU that does not control the devices entropy source, that is owned by the Host, it request a seed from the Host processor via RPMSG exchange. On receipt of this request the Host sets a flag notifying of this request from the RPMSG ISR context. From the Idle thread, this flag is polled via the RNG_IsReseedNeeded API. If set the seed is regenerated and forwarded to the NBU via RPMSG.

RNG_ReInit API is to be used at wake up time in the context of LowPower. RNG_DeInit is used for unit tests and coverage purposes but has no useful role in a real application.

Seed handling RNG_SetSeed: RNG_SetExternalSeed may be used to inject application entropy to RNG context seed using a supplied array of bytes. RNG_IsReseedNeeded used from task in Host core to check whether seed must be sent to NBU core.

RNG_GetTrueRandomNumber is the API used to generate a Random 32 bit number from a HW source of entropy. It is essential if only to seed the pseudo random number generator.

RNG_GetPseudoRandomData is used to generate arrays of random bytes.

Security Library

Overview The framework provides support for cryptography in the security module. It supports both software and hardware encryption. Depending on the device, the hardware encryption uses either the S200, MMCAU, LTC, or CAU3 module instruction set or dedicated AES and SHA hardware blocks.

Software implementation is provided in a library format.

Support for security algorithms

	SW Seclib : SecLib.c	EdgeLock SecLib_sss.c	Seclib_e	Mbedtls SecLib_mbec	nccl (part of SecLib.c)	Usage example
AES_128	SecLib_aes.c	x		x		
AES_128_ECB		x		x		
AES_128_CBC	x	x		x		
AES_128_CTR encryption	x	x				
AES_128_OFB Encryption	x					
AES_128_CMAC	x	x		x		BLE connection, ieee 15.4
AES_128_EAX	x					
AES_128_CCM	x	x		x		BLE, ieee 15.4
SHA1	SecLib_sha.c	x		x		
SHA256	x	x		x		
HMAC_SHA256	x	x		x		PRNG, Digest for Matter
ECDH_P256 shared secret generation	x (by 15 incremental steps) -> SecLib_ecdh.c	x with MACRO SecLibECDHUseSSS	x	x	x	BLE pairing,
EC_P256 key pair generation	x	x	x	x	x	
EC_P256 public key generation from private key			x	x	x	Matter (ECDSA)
ECDSA_P256 hash and msg signature generation / verification		only if owner of the key pair		x	x	Matter
SPAKE2+ P256 arithmetics				x	x	Matter

BLE advanced secure mode

New elements in existing structures: computeDhKeyParam_t::keepInternalBlob - boolean telling if the shared blob is kept in this structure(in .outpoint) after ECDH_P256_ComputeDhKey() or ECDH_P256_ComputeDhKeySeg() call.

New arguments in existing functions: ECDH_P256_ComputeDhKey keepBlobDhKey - boolean telling ECDH_P256_ComputeDhKey() or ECDH_P256_ComputeDhKeySeg() to keep the shared object after computation for later use (it is required by the SecLib_GenerateBluetoothF5KeysSecure).

New macros: gSecLibSssUseEncryptedKeys_d - Enable or disable S200 blobs SecLib support. 0 - the Bluetooth Keys are available in plaintext, 1 - the Bluetooth Keys are not available in plaintext, but in secured blobs. Default is disabled.

New functions:

LE Secure connections pairing:

void ECDH_P256_FreeDhKeyDataSecure This is a function used to free the shared object stored in computeDhKeyParam_t. When user calls ECDH_P256_ComputeDhKeySeg() with keepBlobDhKey set to 1, it should also call **ECDH_P256_FreeDhKeyDataSecure** .

SecLib_GenerateBluetoothF5Keys This function is extracted from the Bluetooth LE Host Stack implementation. This corresponds to the legacy implementation without key blobs.

SecLib_GenerateBluetoothF5KeysSecure Similar to **SecLib_GenerateBluetoothF5Keys** this function is modified to work with key blobs, the reason is to not use SSS inside the Bluetooth LE Host Stack.

SecLib_DeriveBluetoothSKD This is a helper function used by the Bluetooth LE Host Stack in the pairing procedure, when receiving the vendor HCI command specifying that the ESK needs to be provided to LL.

ELKE_BLE_SM_F5_DeriveKeys This is a private function, helper for **SecLib_GenerateBluetoothF5KeysSecure**. It was provided by the STEC team.

Privacy:

SecLib_ObfuscateKeySecure This is a function used by the Bluetooth LE Host Stack to obfuscate the IRK before setting it to Bluetooth LE Controller or before saving it to NVM

SecLib_DeobfuscateKeySecure This is a function used by the Bluetooth LE Host Stack to extract the plaintext IRK key from the saved NVM blob.

SecLib_VerifyBluetoothAh This function is extracted from the legacy Bluetooth LE Host Stack implementation using plaintext keys.

SecLib_VerifyBluetoothAhSecure Similar to **SecLib_VerifyBluetoothAh** with modification to work with S200 key blob.

SecLib_GenerateSymmetricKey This is a function used by the application to generate the local IRK and local CSRK.

SecLib_GenerateBluetoothEIRKBlobSecure This is a function used by the application to generate the EIRK needed by Bluetooth LE Controller from the IRK blob.

A2B feature

ECDH_P256_ComputeA2BKey This function is used to compute the EdgeLock to EdgeLock key. pInPeerPublicKey points to the peer public key, pOutE2EKey is the pointer to where the E2E key object will be stored, this will be freed by the application when it is no longer required by calling ECDH_P256_FreeE2EKeyData().

ECDH_P256_FreeE2EKeyData This function is used to free the key object given as a parameter. It is used by the application to free the E2E key when is no longer needed.

SecLib_ExportA2BBlobSecure This function is used to import an ELKE blob or plain text symmetric key in s200 and export an E2E key blob. The input type is identified by the keyType parameter.

SecLib_ImportA2BBlobSecure This function is used to import an E2E key blob in s200 and export an ELKE blob or plain text symmetric key. The output type is identified by the keyType parameter.

LE Secure connections Pairing flow and SecLib usage:

1. Each device needs to generate locally the public+private keypair. This is done using **ECDH_P256_GenerateKeys**.
2. Devices exchange their public keys.
3. Upon receiving the peer device's public key, local device is computing DH key using **ECDH_P256_ComputeDhKey**.
4. Each device sends DHKeyCheck packet
5. Upon receiving DhKeyCheck each device computes LTK blob using **SecLib_GenerateBluetoothF5Keys**
6. After computing the each device sends HCI_LeStartEnc (on initiator), HCI_Le_Provide_Long_Term_Key (on responder)
7. Bluetooth LE Controller sends back SKD report custom event
8. Bluetooth LE Host Stack computes ESKD based on LTK blob using **SecLib_DeriveBluetoothSKD** and sends it to Bluetooth LE Controller
9. Bluetooth LE Controller encrypts the link

IRK flow and SecLib usage:

1. At startup, when gInitializationComplete_c event is received:
   - the local IRK is generated using **SecLib_GenerateSymmetricKey**
   - the local EIRK is generated using **SecLib_GenerateBluetoothEIRKBlobSecure**
   - local CSRK is generated using **SecLib_GenerateSymmetricKey**
2. During legacy pairing when receiving bonding keys, IRK is obfuscated using **SecLib_ObfuscateKeySecure** and stored
3. When app wants to set the OOB keys using Gap_SaveKeys the IRK is obfuscated using **SecLib_ObfuscateKeySecure**
4. When application calls API Gap_VerifyPrivateResolvableAddress IRK is obfuscated using **SecLib_ObfuscateKeySecure** and verified using **SecLib_VerifyBluetoothAhSecure**
5. When a new connection is received in Host with RPA address not resolved by the Bluetooth LE Controller, the Host tries to resolve it by obfuscating it using **SecLib_ObfuscateKeySecure** and verifying it using **SecLib_VerifyBluetoothAhSecure**
6. When adding a peer in Bluetooth LE Controller resolving list, the peer's IRK is obfuscated using **SecLib_ObfuscateKeySecure** before setting it using **HCI_Le_Add_Device_To_Resolving_List**.
7. When an IRK plaintext is requested by the application using Gap_LoadKeys it is obtained using **SecLib_DeobfuscateKeySecure**
8. When legacy pairing completes and LTK needs to be send in the pairing complete event (gConnEvtPairingComplete_c) the **SecLib_DeobfuscateKey** is used to extract the plaintext.

A2B flow and SecLib usage:

1. At startup, when gInitializationComplete_c event is received, the application will call **ECDH_P256_GenerateKeys** to generate the public/private key pair required for the E2E key derivation and send the public key to the peer device.
2. When the public key is received from the peer device, the application will call **ECDH_P256_ComputeA2BKeySecure** to generate the EdgeLock to EdgeLock key.
3. The application will obtain an E2E IRK blob by calling **SecLib_ExportA2BBlobSecure** with key type gSecElkeBlob_c. The obtained blob is sent to the peer anchor. The peer anchor will call **SecLib_ImportA2BBlob** with keyType gSecElkeBlob_c and save the resulting ELKE blob in NVM, for Digital Key both anchors must have the same IRK.
4. After pairing, in order to send the LTK and IRK contained in the bonding data securely, the application will call **SecLib_ExportA2BBlobSecure** with keyType gSecLtkElkeBlob_c for the LTK, and **SecLib_ExportA2BBlobSecure** with keyType gSecPlainText_c for the IRK. The E2E blobs obtained are sent along with the rest of the bonding data to the peer anchor device.
5. After the bonding data is trasfered the E2E key is no longer needed and **ECDH_P256_FreeE2EKeyData** is called with the key object obtained at step 2 when **ECDH_P256_ComputeA2BKeySecure** was called.

Sensors

Overview The Sensors module provides an API to communicate with the ADC. Two values can be obtained by this module :

- Temperature value

- Battery level

The temperature is given in tenths of degrees Celsius and the battery in percentage.

This module is multi-caller, the ADC is protected by a mutex on the resource and by prevententing lowpower (only WFI) during its processing. Platform specific code can be find in fwk_platform_sensors.c/h.

Constant macro definitions Name :

```
#define VALUE_NOT_AVAILABLE_8 0xFFu
#define VALUE_NOT_AVAILABLE_32 0xFFFFFFFFu
```

Description :

Defines the error value that can be compared to the value obtain on the ADC.

SFC : Smart Frequency Calibration

Overview The Smart Frequency Calibration module provides operations and calibration for the FRO32K source clock. This module is split between main core and Radio core:

- fwk_rf_sfc.[ch]: RF_SFC module on Radio core that provides Main FRO32K measurement/calibration and state machine in synchornization with Radio domain activities. See details below.
- fwk_sfc.h: SFC module on host core that provides type definition for usage with fwk_platform_ics.[ch] with PLATFORM_FwkSrvSetRfSfcConfig() API and fwk_platform_ble.c for received callback from the NBU core

Host SFC Module

Algorithm parametrization This module provides ability to configure the RF_SFC module by sending message to Radio core through fwk_platform_ics.c PLATFORM_FwkSrvSetRfSfcConfig():

- Filter size
- Maximum ppm threshold
- Maximum calibration interval
- Number of sample in filter to swicth from convergence to monitor mode

Ppm target The ppm target is the deviation from the target clock accepted by the algorithm. When the deviation is larger than the ppm target. The algorithm will update the trimming value and reset the filter. The ppm target cannot be more aggressive RF_SFC_MAXIMAL_PPM_TARGET in order to avoid having to update trimming value at each measurement.

Filter size Filter size must be included between RF_SFC_MINIMAL_FILTER_SIZE and RF_SFC_MAXIMAL_FILTER_SIZE. See *Filtering and Frequency estimation* section for more details on the parameter.

Maximum calibration interval In monitor mode, new measurement are triggered by low-power entry/exit. If the NBU core has a lot of radio activity it could never enter lowpower. The maximum calibration interval is here to ensure a measurement is done regularly. When executing idle the SFC module checks when the last measurement has been done, if it has been too long, it reset the filter and forces a new measurement

Trig sample number The trig sample number is the number of samples needed by the algorithm in its filter to switch from convergence to monitor mode. Having more than one sample in convergence mode allows to confirm the trimming value that we have set.

SFC debug information On the other way, the RF_SFC from Radio core sends back notifications to SFC module on main core using RX callback PLATFORM_RegisterFroNotificationCallback() from fwk_platform_ics.h and such information:

- last measured frequency
- average ppm from 32768Khz frequency
- last ppm measured from 32768Khz frequency
- FRO trimming value

RF_SFC module The RF_SFC module provides the functionality to calibrate the FRO32K source clock during Initialization and radio activity.

The RF_SFC is mostly used on XTAL32K less solution when no 32Khz crystal is soldered on the board. It allows to calibrate the FRO32K source clock to the desired frequency to keep Radio time base within the allowed tolerance given by the connectivity standards. However, even on a XTAL32K solution, the RF_SFC is also used during Initialization until the XTAL32K is up and running in the system. The system firstly runs on the FRO32K clock source then switch to the XTAL32K clock source when it is ready with enough accuracy. This allows to save significant boot time as the FRO32K start up (including calibration) is much faster compared to XTAL32K .

This module will handle:

- FRO32K clock frequency measurement against 32Mhz crystal. It schedules appropriately the start of the measurement and gets the result when completed,
- Filter and estimate the 32Khz frequency value and error by averaging from the last measurements,
- FRO32K calibration in order to update the trimming value to reduce the frequency error on the clock.

The targeted frequency offset shall be within 200ppm. The RF_SFC will handle two modes of operation:

- Convergence mode: when frequency estimation is above 200pm,
- Monitor mode: when frequency estimation is below 200pm.

The RF_SFC module works in active and all low power modes on NBU domain, or on host application domain except power down mode. Power down mode on host application domain is not supported with the FRO32K configuration as clock source.

Feature enablement Enabling the FRO32K is done by calling the PLATFORM_InitFro32K() function during application initialization in hardware_init.c file, in BOARD_InitHardware() function. If FRO32K is not enabled, Oscillator XTAL32K shall be called instead by calling PLATFORM_InitOsc32K() function. The call to PLATFORM_InitFro32K() from BOARD_InitHardware() can be done by setting the Compilation flag gBoardUseFro32k_d to 1 in hardware_init.c or any header files included from this file.

```
#define gBoardUseFro32k_d       1
```

Detailed description

Frequency measurements When NBU low power is enabled, the frequency measurements are triggered on Low power wake-up by HW signal. The SFC process called from Idle task will check regularly the completion of the frequency measurement. When the measurement is done, it goes to filtering and frequency estimation process. The frequency measurement duration depends on monitor mode or convergence mode: In convergence mode, the frequency measurement duration is 0.5ms while it is 2ms in monitor mode. In monitor mode, the duration value remains less than the minimal radio activity duration so it does not impact the low power consumption in monitoring mode.

Filtering and Frequency estimation The FRO32KHz frequency measurement values are noisy because of thermal noise on the FRO32K itself. Also, the frequency measurement can introduce some error. In monitoring mode, it is required to filter the measurements by applying an exponential filter. new_estimation = (new_measurement + ((1 « n) -1) * last_estimation) » n

Default value for n is 7 (meaning 128 samples in the averaging window).

Frequency calibration When the frequency estimation gets higher than the targeted 200ppm target, the RF_SFC updates the trimming value for one positive or negative increment. For this purpose, it requires to:

- wake up the host application domain and keep the domain active,
- update the trim register of the FRO32K , this register is used to trim the capacitance value of the FRO32K,
- re-allow the host application domain to enter low power.

A slight power impact is expected during a calibration update due to host domain wake-up.

Operational modes When the low power mode is enabled on NBU power domain, RF SFC handles two modes of operation: convergence and monitor modes. However, when low power is disabled on NBU power domain, only convergence mode is supported.

Convergence mode Convergence mode is used when the estimated FRO32K frequency is above 200ppm or when the filter has been reset. Typically this occurs :

- During Power ON reset or other reset when NBU is switched OFF
- When temperature varies and FRO32K frequency deviates outside 200ppm threshold target
- When no calibration has been done during some time as we discard old values that could influence the algorithm

The convergence mode process typically starts with a FRO32K trim register update, performs a frequency measurement and the FRO32K trim register is updated until the measured frequency gets below 200ppm. These operations are repeated in a loop until the estimated frequency value gets below 200ppm. When below 200ppm during multiple measurements, the RC SFC switches to Monitoring mode. The convergence mode is only a transition mode to monitoring mode. In convergence mode, the NBU power domain does not go to low power. The convergence mode time duration depends on the initial frequency error of the FR032K. Default frequency measurement duration is 0.5ms so 20 measurements (given as example only) will require less than 10 ms to converge.

Monitoring mode Monitoring mode is used when the estimated FRO32K frequency is below 200ppm. In this mode, the measurement is triggered on NBU domain wake up from low power mode using an internal hardware signal. The exponential filter is applied to compute the frequency estimation. If the frequency estimation value is still within 200ppm, the NBU power domain is allowed to go to low power. If the estimated value gets above the 200ppm threshold, the RF SFC switch back to convergence mode. The trim register is updated by one increment (positive or negative) and because the frequency has been adjusted and changed, the estimated filtered frequency is reset to discard all previous measurements. Going back to convergence mode typically happens during a temperature gradient. If the temperature is constant, it is not expected to have the estimated value to go beyond 200ppm so no calibration should be required.

Initialization and configuration During initialization, the RF SFC module will block the Radio Software until monitoring mode is reached. This is to prevent the radio from running with an inaccurate time base due to an important 32k clock frequency error.

Initialization and configuration is done by the NBU core. The configuration parameters can set up:

- The 200ppm target threshold. This value shall be 200ppm or higher.
- The filtering number n (see section above), It shall be between 0 and 8. Default is 7 which is similar to an averaging filter of 128 samples. A higher value will be more robust against noise. A lower value will track temperature variation more faster.

In order to prevent the host application domain from going into power down mode (power down mode not supported with FRO32K as clock source), the fwkSrvLowPowerConstraintCallbacks functions structure is registered to the Framework service on host application core from fwk_platform_lowpower.c file, PLATFORM_LowPowerInit() function. The NBU code applies a low power Deep Sleep constraint to the application core. This constraint is released when the NBU firmware has no activity to do and re-applied when a new activity starts.

Lowpower impact

Power impact during active mode: In monitoring mode (this should be 99.9% of the time if temperature does not vary), the FRO32KHz frequency measurements are performed during a Radio activity so it does not increase the active current as the sources clocks are already active. Also, it does not increase the active time as the measurement takes less time than an advertising event or connection event so no impact on power consumption.

The main power impact will be in convergence mode. In this case, measurements/calibrations are done in loop until the monitoring mode is reached (frequency error less than 200ppm). This could happen:

- During power ON reset,
- When temperature varies: The frequency will deviate from 32768Hz and FRO32K trimming register correction will need to be updated for that,
- When no measurement has been done during some time as we cannot predict if the FRO has drifted, so we discard older values and start convergence mode.

When FRO32K frequency needs to be adjusted, the NBU core will wake-up the main power domain and will update the FRO32K trimming register.

Power impact during low power mode: The power consumption in low power mode will increase slightly due to running FRO32K compared to XTAL32K. The power consumption of FRO32K typically consumes 350nA while it is only 100nA with XTAL32K. Refer to the product datasheet for the exact numbers.

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

Overview The purpose of this document is to describes the FreeRTOS kernel repo integration into the NXP MCUXpresso Software Development Kit: mcuxsdk. MCUXpresso SDK provides a comprehensive development solutions designed to optimize, ease, and help accelerate embedded system development of applications based on MCUs from NXP. This project involves the FreeRTOS kernel repo fork with:

- cmake and Kconfig support to allow the configuration and build in MCUXpresso SDK ecosystem
- FreeRTOS OS additions, such as FreeRTOS driver wrappers, RTOS ready FatFs file system, and the implementation of FreeRTOS tickless mode

The history of changes in FreeRTOS kernel repo for MCUXpresso SDK are summarized in *CHANGELOG_mcuxsdk.md* file.

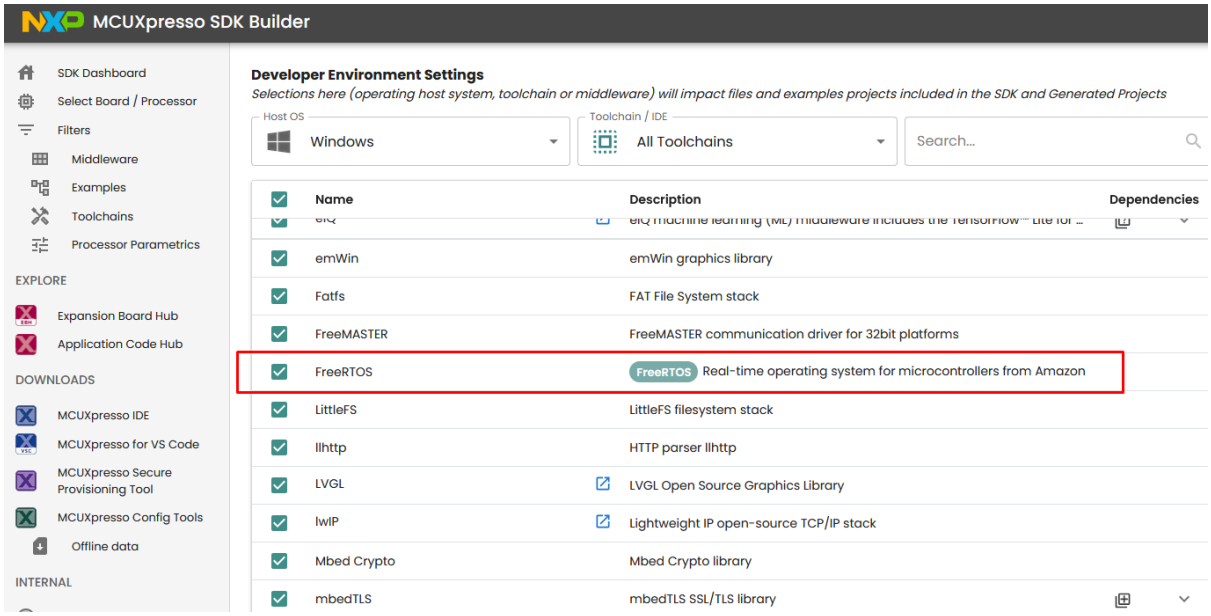
The MCUXpresso SDK framework also contains a set of FreeRTOS examples which show basic FreeRTOS OS features. This makes it easy to start a new FreeRTOS project or begin experimenting with FreeRTOS OS. Selected drivers and middleware are RTOS ready with related FreeRTOS adaptation layer.

FreeRTOS example applications The FreeRTOS examples are written to demonstrate basic FreeRTOS features and the interaction between peripheral drivers and the RTOS.

List of examples The list of freertos_examples, their description and availability for individual supported MCUXpresso SDK development boards can be obtained here: https://mcuxpresso.nxp.com/mcuxsdk/latest/html/examples/freertos_examples/index.html

Location of examples The FreeRTOS examples are located in mcuxsdk-examples repository, see the freertos_examples folder.

Once using MCUXpresso SDK zip packages created via the MCUXpresso SDK Builder the FreeRTOS kernel library and associated freertos_examples are added into final zip package once FreeRTOS components is selected on the Developer Environment Settings page:



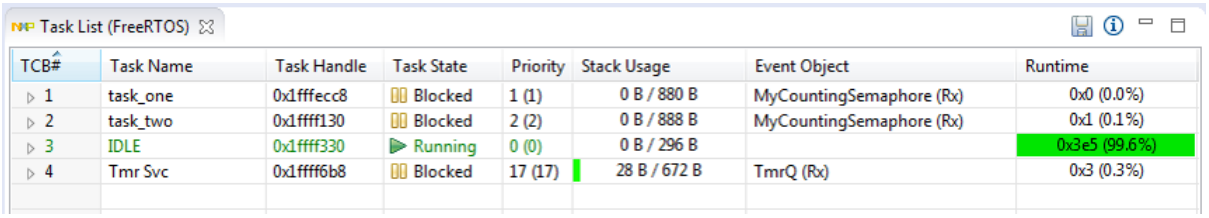
The FreeRTOS examples in MCUXpresso SDK zip packages are located in <MCUXpressoSDK_install_dir>/boards/<board_name>/freertos_examples/ subfolders.

Building a FreeRTOS example application For information how to use the cmake and Kconfig based build and configuration system and how to build freertos_examples visit: MCUXpresso SDK documentation for Build And Configuration MCUXpresso SDK Getting Start Guide

Tip: To list all FreeRTOS example projects and targets that can be built via the west build command, use this west list_project command in mcuxsdk workspace:

```
west list_project -p examples/freertos_examples
```

FreeRTOS aware debugger plugin NXP provides FreeRTOS task aware debugger for GDB. The plugin is compatible with Eclipse-based (MCUXpressoIDE) and is available after the installation.



FreeRTOS kernel for MCUXpresso SDK ChangeLog

Changelog FreeRTOS kernel for MCUXpresso 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.

[Unreleased]

Added

- Kconfig added CONFIG_FREERTOS_USE_CUSTOM_CONFIG_FRAGMENT config to optionally include custom FreeRTOSConfig fragment
  include file FreeRTOSConfig_frag.h. File must be provided by application.
- Added missing Kconfig option for configUSE_PICOLIBC_TLS.
- Add correct header files to build when configUSE_NEWLIB_REENTRANT and configUSE_PICOLIBC_TLS is selected in config.

[11.1.0_rev0]

- update amazon freertos version

[11.0.1_rev0]

- update amazon freertos version

[10.5.1_rev0]

- update amazon freertos version

[10.4.3_rev1]

- Apply CM33 security fix from 10.4.3-LTS-Patch-2. See rtos\freertos\freertos_kernel\History.txt
- Apply CM33 security fix from 10.4.3-LTS-Patch-1. See rtos\freertos\freertos_kernel\History.txt

[10.4.3_rev0]

- update amazon freertos version.

[10.4.3_rev0]

- update amazon freertos version.

[9.0.0_rev3]

- New features:
  - Tickless idle mode support for Cortex-A7. Add fsl_tickless_epit.c and fsl_tickless_generic.h in portable/IAR/ARM_CA9 folder.
  - Enabled float context saving in IAR for Cortex-A7. Added configUSE_TASK_FPU_SUPPORT macros. Modified port.c and portmacro.h in portable/IAR/ARM_CA9 folder.
- Other changes:
  - Transformed ARM_CM core specific tickless low power support into generic form under freertos/Source/portable/low_power_tickless/.

[9.0.0_rev2]

- New features:
  - Enabled MCUXpresso thread aware debugging. Add freertos_tasks_c_additions.h and configINCLUDE_FREERTOS_TASK_C_ADDITIONS_H and configFREERTOS_MEMORY_SCHEME macros.

[9.0.0_rev1]

- New features:
  - Enabled -flto optimization in GCC by adding **attribute**((used)) for vTaskSwitchContext.
  - Enabled KDS Task Aware Debugger. Apply FreeRTOS patch to enable configRECORD_STACK_HIGH_ADDRESS macro. Modified files are task.c and FreeRTOS.h.

[9.0.0_rev0]

- New features:
  - Example freertos_sem_static.
  - Static allocation support RTOS driver wrappers.
- Other changes:
  - Tickless idle rework. Support for different timers is in separated files (fsl_tickless_systick.c, fsl_tickless_lptmr.c).
  - Removed configuration option configSYSTICK_USE_LOW_POWER_TIMER. Low power timer is now selected by linking of apropriate file fsl_tickless_lptmr.c.
  - Removed configOVERRIDE_DEFAULT_TICK_CONFIGURATION in RVDS port. Use of **attribute**((weak)) is the preferred solution. Not same as _weak!

[8.2.3]

- New features:
  - Tickless idle mode support.
  - Added template application for Kinetis Expert (KEx) tool (template_application).
- Other changes:
  - Folder structure reduction. Keep only Kinetis related parts.

FreeRTOS kernel Readme

MCUXpresso SDK: FreeRTOS kernel This repository is a fork of FreeRTOS kernel (https://github.com/FreeRTOS/FreeRTOS-Kernel)(11.1.0). Modifications have been made to adapt to NXP MCUXpresso SDK. CMakeLists.txt and Kconfig added to enable FreeRTOS kernel repo sources build in MCUXpresso SDK. It is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository mcuxsdk-manifests(https://github.com/nxp-mcuxpresso/mcuxsdk-manifests) for the complete delivery of MCUXpresso SDK.

For more information about the FreeRTOS kernel repo adoption see README_mcuxsdk.md: FreeRTOS kernel for MCUXpresso SDK Readme document.

Getting started This repository contains FreeRTOS kernel source/header files and kernel ports only. This repository is referenced as a submodule in FreeRTOS/FreeRTOS repository, which contains pre-configured demo application projects under FreeRTOS/Demo directory.

The easiest way to use FreeRTOS is to start with one of the pre-configured demo application projects. That way you will have the correct FreeRTOS source files included, and the correct include paths configured. Once a demo application is building and executing you can remove the demo application files, and start to add in your own application source files. See the FreeRTOS Kernel Quick Start Guide for detailed instructions and other useful links.

Additionally, for FreeRTOS kernel feature information refer to the Developer Documentation, and API Reference.

Also for contributing and creating a Pull Request please refer to *the instructions here*.

Getting help If you have any questions or need assistance troubleshooting your FreeRTOS project, we have an active community that can help on the FreeRTOS Community Support Forum.

To consume FreeRTOS-Kernel

Consume with CMake If using CMake, it is recommended to use this repository using FetchContent. Add the following into your project's main or a subdirectory's CMakeLists.txt:

- Define the source and version/tag you want to use:

```
FetchContent_Declare( freertos_kernel
  GIT_REPOSITORY https://github.com/FreeRTOS/FreeRTOS-Kernel.git
  GIT_TAG        main #Note: Best practice to use specific git-hash or tagged version
)
```

In case you prefer to add it as a git submodule, do:

```
git submodule add https://github.com/FreeRTOS/FreeRTOS-Kernel.git <path of the submodule>
git submodule update --init
```

- Add a freertos_config library (typically an INTERFACE library) The following assumes the directory structure:
  - include/FreeRTOSConfig.h

```
add_library(freertos_config INTERFACE)

target_include_directories(freertos_config SYSTEM
INTERFACE
    include
)

target_compile_definitions(freertos_config
  INTERFACE
    projCOVERAGE_TEST=0
)
```

In case you installed FreeRTOS-Kernel as a submodule, you will have to add it as a subdirectory:

```
add_subdirectory(${FREERTOS_PATH})
```

- Configure the FreeRTOS-Kernel and make it available
  - this particular example supports a native and cross-compiled build option.

```
set( FREERTOS_HEAP "4" CACHE STRING "" FORCE)
# Select the native compile PORT
set( FREERTOS_PORT "GCC_POSIX" CACHE STRING "" FORCE)
# Select the cross-compile PORT
if (CMAKE_CROSSCOMPILING)
  set(FREERTOS_PORT "GCC_ARM_CA9" CACHE STRING "" FORCE)
endif()

FetchContent_MakeAvailable(freertos_kernel)
```

- In case of cross compilation, you should also add the following to freertos_config:

```
target_compile_definitions(freertos_config INTERFACE ${definitions})
target_compile_options(freertos_config INTERFACE ${options})
```

Consuming stand-alone - Cloning this repository To clone using HTTPS:

```
git clone https://github.com/FreeRTOS/FreeRTOS-Kernel.git
```

Using SSH:

```
git clone git@github.com:FreeRTOS/FreeRTOS-Kernel.git
```

Repository structure

- The root of this repository contains the three files that are common to every port - list.c, queue.c and tasks.c. The kernel is contained within these three files. croutine.c implements the optional co-routine functionality - which is normally only used on very memory limited systems.
- The ./portable directory contains the files that are specific to a particular microcontroller and/or compiler. See the readme file in the ./portable directory for more information.
- The ./include directory contains the real time kernel header files.
- The ./template_configuration directory contains a sample FreeRTOSConfig.h to help jumpstart a new project. See the *FreeRTOSConfig.h* file for instructions.

Code Formatting FreeRTOS files are formatted using the "uncrustify" tool. The configuration file used by uncrustify can be found in the FreeRTOS/CI-CD-GitHub-Actions's uncrustify.cfg file.

Line Endings File checked into the FreeRTOS-Kernel repository use unix-style LF line endings for the best compatibility with git.

For optimal compatibility with Microsoft Windows tools, it is best to enable the git autocrlf feature. You can enable this setting for the current repository using the following command:

```
git config core.autocrlf true
```

Git History Optimizations Some commits in this repository perform large refactors which touch many lines and lead to unwanted behavior when using the git blame command. You can configure git to ignore the list of large refactor commits in this repository with the following command:

```
git config blame.ignoreRevsFile .git-blame-ignore-revs
```

Spelling and Formatting We recommend using Visual Studio Code, commonly referred to as VSCode, when working on the FreeRTOS-Kernel. The FreeRTOS-Kernel also uses cSpell as part of its spelling check. The config file for which can be found at *cspell.config.yaml* There is additionally a cSpell plugin for VSCode that can be used as well. .cSpellWords.txt contains words that are not traditionally found in an English dictionary. It is used by the spellchecker to verify the various jargon, variable names, and other odd words used in the FreeRTOS code base are correct. If your pull request fails to pass the spelling and you believe this is a mistake, then add the word to .cSpellWords.txt. When adding a word please then sort the list, which can be done by running the bash command: `sort -u .cSpellWords.txt -o .cSpellWords.txt` Note that only the FreeRTOS-Kernel Source Files, *include*, *portable/MemMang*, and *portable/Common* files are checked for proper spelling, and formatting at this time.

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

MCUXpresso SDK: backoffAlgorithm Library This repository is a fork of backoffAlgorithm library (https://github.com/FreeRTOS/backoffalgorithm)(1.3.0). Modifications have been made to adapt to NXP MCUXpresso SDK. CMakeLists.txt and Kconfig added to enable backoffAlgorithm repo sources build in MCUXpresso SDK. It is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository mcuxsdk-manifests(https://github.com/nxp-mcuxpresso/mcuxsdk-manifests) for the complete delivery of MCUXpresso SDK.

backoffAlgorithm Library This repository contains the backoffAlgorithm library, a utility library to calculate backoff period using an exponential backoff with jitter algorithm for retrying network operations (like failed network connection with server). This library uses the "Full Jitter" strategy for the exponential backoff with jitter algorithm. More information about the algorithm can be seen in the Exponential Backoff and Jitter AWS blog.

The backoffAlgorithm library is distributed under the *MIT Open Source License*.

Exponential backoff with jitter is typically used when retrying a failed network connection or operation request with the server. An exponential backoff with jitter helps to mitigate failed network operations with servers, that are caused due to network congestion or high request load on the server, by spreading out retry requests across multiple devices attempting network operations. Besides, in an environment with poor connectivity, a client can get disconnected at any time. A backoff strategy helps the client to conserve battery by not repeatedly attempting reconnections when they are unlikely to succeed.

See memory requirements for this library *here*.

backoffAlgorithm v1.3.0 source code is part of the FreeRTOS 202210.00 LTS release.

backoffAlgorithm v1.0.0 source code is part of the FreeRTOS 202012.00 LTS release.

Reference example The example below shows how to use the backoffAlgorithm library on a POSIX platform to retry a DNS resolution query for amazon.com.

```
#include "backoff_algorithm.h"
#include <stdlib.h>
#include <string.h>
#include <netdb.h>
#include <unistd.h>
#include <time.h>

/* The maximum number of retries for the example code. */
#define RETRY_MAX_ATTEMPTS            ( 5U )

/* The maximum back-off delay (in milliseconds) for between retries in the example. */
#define RETRY_MAX_BACKOFF_DELAY_MS    ( 5000U )

/* The base back-off delay (in milliseconds) for retry configuration in the example. */
#define RETRY_BACKOFF_BASE_MS         ( 500U )

int main()
{
    /* Variables used in this example. */
    BackoffAlgorithmStatus_t retryStatus = BackoffAlgorithmSuccess;
    BackoffAlgorithmContext_t retryParams;
    char serverAddress[] = "amazon.com";
    uint16_t nextRetryBackoff = 0;

    int32_t dnsStatus = -1;
    struct addrinfo hints;
    struct addrinfo ** pListHead = NULL;
    struct timespec tp;

    /* Add hints to retrieve only TCP sockets in getaddrinfo. */
    ( void ) memset( &hints, 0, sizeof( hints ) );

    /* Address family of either IPv4 or IPv6. */
    hints.ai_family = AF_UNSPEC;
    /* TCP Socket. */
    hints.ai_socktype = ( int32_t ) SOCK_STREAM;
    hints.ai_protocol = IPPROTO_TCP;

    /* Initialize reconnect attempts and interval. */
    BackoffAlgorithm_InitializeParams( &retryParams,
                                       RETRY_BACKOFF_BASE_MS,
                                       RETRY_MAX_BACKOFF_DELAY_MS,
                                       RETRY_MAX_ATTEMPTS );


    /* Seed the pseudo random number generator used in this example (with call to
     * rand() function provided by ISO C standard library) for use in backoff period
     * calculation when retrying failed DNS resolution. */

    /* Get current time to seed pseudo random number generator. */
    ( void ) clock_gettime( CLOCK_REALTIME, &tp );
    /* Seed pseudo random number generator with seconds. */
    srand( tp.tv_sec );

    do
    {
        /* Perform a DNS lookup on the given host name. */
        dnsStatus = getaddrinfo( serverAddress, NULL, &hints, pListHead );
```

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```
        /* Retry if DNS resolution query failed. */
        if( dnsStatus != 0 )
        {
            /* Generate a random number and get back-off value (in milliseconds) for the next retry.
             * Note: It is recommended to use a random number generator that is seeded with
             * device-specific entropy source so that backoff calculation across devices is different
             * and possibility of network collision between devices attempting retries can be avoided.
             *
             * For the simplicity of this code example, the pseudo random number generator, rand()
             * function is used. */
            retryStatus = BackoffAlgorithm_GetNextBackoff( &retryParams, rand(), &nextRetryBackoff );

            /* Wait for the calculated backoff period before the next retry attempt of querying DNS.
             * As usleep() takes nanoseconds as the parameter, we multiply the backoff period by 1000. */
            ( void ) usleep( nextRetryBackoff * 1000U );
        }
    } while( ( dnsStatus != 0 ) && ( retryStatus != BackoffAlgorithmRetriesExhausted ) );

    return dnsStatus;
}
```

Building the library A compiler that supports **C90 or later** such as *gcc* is required to build the library.

Additionally, the library uses a header file introduced in ISO C99, stdint.h. For compilers that do not provide this header file, the *source/include* directory contains *stdint.readme*, which can be renamed to stdint.h to build the backoffAlgorithm library.

For instance, if the example above is copied to a file named example.c, *gcc* can be used like so:

```
gcc -I source/include example.c source/backoff_algorithm.c -o example
./example
```

gcc can also produce an output file to be linked:

```
gcc -I source/include -c source/backoff_algorithm.c
```

Building unit tests

Checkout Unity Submodule By default, the submodules in this repository are configured with update=none in *.gitmodules*, to avoid increasing clone time and disk space usage of other repositories (like amazon-freertos that submodules this repository).

To build unit tests, the submodule dependency of Unity is required. Use the following command to clone the submodule:

```
git submodule update --checkout --init --recursive test/unit-test/Unity
```

Platform Prerequisites

- For running unit tests
  - C89 or later compiler like gcc
  - CMake 3.13.0 or later
- For running the coverage target, gcov is additionally required.

Steps to build Unit Tests

1. Go to the root directory of this repository. (Make sure that the **Unity** submodule is cloned as described *above*.)
2. Create build directory: `mkdir build && cd build`
3. Run *cmake* while inside build directory: `cmake -S ../test`
4. Run this command to build the library and unit tests: `make all`
5. The generated test executables will be present in `build/bin/tests` folder.
6. Run `ctest` to execute all tests and view the test run summary.

Contributing See *CONTRIBUTING.md* for information on contributing.

4.1.4 corehttp

C language HTTP client library designed for embedded platforms.

MCUXpresso SDK: coreHTTP Client Library

This repository is a fork of coreHTTP Client library (https://github.com/FreeRTOS/corehttp)(3.0.0). Modifications have been made to adapt to NXP MCUXpresso SDK. CMakeLists.txt and Kconfig added to enable coreHTTP Client repo sources build in MCUXpresso SDK. It is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository mcuxsdk-manifests(https://github.com/nxp-mcuxpresso/mcuxsdk-manifests) for the complete delivery of MCUXpresso SDK.

coreHTTP Client Library

This repository contains a C language HTTP client library designed for embedded platforms. It has no dependencies on any additional libraries other than the standard C library, llhttp, and a customer-implemented transport interface. This library is distributed under the *MIT Open Source License*.

This library has gone through code quality checks including verification that no function has a GNU Complexity score over 8. This library has also undergone both static code analysis from Coverity static analysis, and validation of memory safety and data structure invariance through the CBMC automated reasoning tool.

See memory requirements for this library *here*.

coreHTTP v3.0.0 source code is part of the FreeRTOS 202210.00 LTS release.

coreHTTP v2.0.0 source code is part of the FreeRTOS 202012.00 LTS release.

coreHTTP Config File The HTTP client library exposes configuration macros that are required for building the library. A list of all the configurations and their default values are defined in *core_http_config_defaults.h*. To provide custom values for the configuration macros, a custom config file named `core_http_config.h` can be provided by the user application to the library.

By default, a `core_http_config.h` custom config is required to build the library. To disable this requirement and build the library with default configuration values, provide `HTTP_DO_NOT_USE_CUSTOM_CONFIG` as a compile time preprocessor macro.

The HTTP client library can be built by either:

- Defining a core_http_config.h file in the application, and adding it to the include directories for the library build. **OR**
- Defining the HTTP_DO_NOT_USE_CUSTOM_CONFIG preprocessor macro for the library build.

Building the Library The *httpFilePaths.cmake* file contains the information of all source files and header include paths required to build the HTTP client library.

As mentioned in the *previous section*, either a custom config file (i.e. core_http_config.h) OR HTTP_DO_NOT_USE_CUSTOM_CONFIG macro needs to be provided to build the HTTP client library.

For a CMake example of building the HTTP library with the httpFilePaths.cmake file, refer to the coverity_analysis library target in *test/CMakeLists.txt* file.

Building Unit Tests

Platform Prerequisites

- For running unit tests, the following are required:
  - **C90 compiler** like gcc
  - **CMake 3.13.0 or later**
  - **Ruby 2.0.0 or later** is required for this repository's CMock test framework.
- For running the coverage target, the following are required:
  - **gcov**
  - **lcov**

Steps to build Unit Tests

1. Go to the root directory of this repository.
2. Run the *cmake* command: cmake -S test -B build -DBUILD_CLONE_SUBMODULES=ON
3. Run this command to build the library and unit tests: make -C build all
4. The generated test executables will be present in build/bin/tests folder.
5. Run cd build && ctest to execute all tests and view the test run summary.

CBMC To learn more about CBMC and proofs specifically, review the training material here.

The test/cbmc/proofs directory contains CBMC proofs.

In order to run these proofs you will need to install CBMC and other tools by following the instructions here.

Reference examples The AWS IoT Device SDK for Embedded C repository contains demos of using the HTTP client library here on a POSIX platform. These can be used as reference examples for the library API.

Documentation

Existing Documentation For pre-generated documentation, please see the documentation linked in the locations below:

Location
AWS IoT Device SDK for Embedded C FreeRTOS.org

Note that the latest included version of coreHTTP may differ across repositories.

Generating Documentation The Doxygen references were created using Doxygen version 1.9.2. To generate the Doxygen pages, please run the following command from the root of this repository:

```
doxygen docs/doxygen/config.doxyfile
```

Contributing See *CONTRIBUTING.md* for information on contributing.

4.1.5 corejson

JSON parser.

Readme

MCUXpresso SDK: coreJSON Library This repository is a fork of coreJSON library (https://github.com/FreeRTOS/corejson)(3.2.0). Modifications have been made to adapt to NXP MCUXpresso SDK. CMakeLists.txt and Kconfig added to enable coreJSON repo sources build in MCUXpresso SDK. It is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository mcuxsdk-manifests(https://github.com/nxp-mcuxpresso/mcuxsdk-manifests) for the complete delivery of MCUXpresso SDK.

coreJSON Library This repository contains the coreJSON library, a parser that strictly enforces the ECMA-404 JSON standard and is suitable for low memory footprint embedded devices. The coreJSON library is distributed under the *MIT Open Source License*.

This library has gone through code quality checks including verification that no function has a GNU Complexity score over 8, and checks against deviations from mandatory rules in the MISRA coding standard. Deviations from the MISRA C:2012 guidelines are documented under *MISRA Deviations*. This library has also undergone both static code analysis from Coverity static analysis, and validation of memory safety through the CBMC automated reasoning tool.

See memory requirements for this library *here*.

coreJSON v3.2.0 source code is part of the FreeRTOS 202210.00 LTS release.

coreJSON v3.0.0 source code is part of the FreeRTOS 202012.00 LTS release.

Reference example

```
#include <stdio.h>
#include "core_json.h"

int main()
{
    // Variables used in this example.
    JSONStatus_t result;
    char buffer[] = "{\"foo\":\"abc\",\"bar\":{\"foo\":\"xyz\"}}";
    size_t bufferLength = sizeof( buffer ) - 1;
    char queryKey[] = "bar.foo";
    size_t queryKeyLength = sizeof( queryKey ) - 1;
    char * value;
    size_t valueLength;

    // Calling JSON_Validate() is not necessary if the document is guaranteed to be valid.
    result = JSON_Validate( buffer, bufferLength );

    if( result == JSONSuccess )
    {
        result = JSON_Search( buffer, bufferLength, queryKey, queryKeyLength,
                              &value, &valueLength );
    }

    if( result == JSONSuccess )
    {
        // The pointer "value" will point to a location in the "buffer".
        char save = value[ valueLength ];
        // After saving the character, set it to a null byte for printing.
        value[ valueLength ] = '\0';
        // "Found: bar.foo -> xyz" will be printed.
        printf( "Found: %s -> %s\n", queryKey, value );
        // Restore the original character.
        value[ valueLength ] = save;
    }

    return 0;
}
```

A search may descend through nested objects when the queryKey contains matching key strings joined by a separator, .. In the example above, bar has the value {"foo":"xyz"}. Therefore, a search for query key bar.foo would output xyz.

Building coreJSON A compiler that supports **C90 or later** such as *gcc* is required to build the library.

Additionally, the library uses 2 header files introduced in ISO C99, stdbool.h and stdint.h. For compilers that do not provide this header file, the *source/include* directory contains *stdbool.readme* and *stdint.readme*, which can be renamed to stdbool.h and stdint.h respectively.

For instance, if the example above is copied to a file named example.c, *gcc* can be used like so:

```
gcc -I source/include example.c source/core_json.c -o example
./example
```

gcc can also produce an output file to be linked:

```
gcc -I source/include -c source/core_json.c
```

Documentation

Existing documentation For pre-generated documentation, please see the documentation linked in the locations below:

Location
AWS IoT Device SDK for Embedded C FreeRTOS.org

Note that the latest included version of the coreJSON library may differ across repositories.

Generating documentation The Doxygen references were created using Doxygen version 1.9.2. To generate the Doxygen pages, please run the following command from the root of this repository:

```
doxygen docs/doxygen/config.doxyfile
```

Building unit tests

Checkout Unity Submodule By default, the submodules in this repository are configured with `update=none` in *.gitmodules*, to avoid increasing clone time and disk space usage of other repositories (like amazon-freertos that submodules this repository).

To build unit tests, the submodule dependency of Unity is required. Use the following command to clone the submodule:

```
git submodule update --checkout --init --recursive test/unit-test/Unity
```

Platform Prerequisites

- For running unit tests
  - C90 compiler like gcc
  - CMake 3.13.0 or later
  - Ruby 2.0.0 or later is additionally required for the Unity test framework (that we use).
- For running the coverage target, gcov is additionally required.

Steps to build Unit Tests

1. Go to the root directory of this repository. (Make sure that the **Unity** submodule is cloned as described *above*.)
2. Create build directory: `mkdir build && cd build`
3. Run *cmake* while inside build directory: `cmake -S ../test`
4. Run this command to build the library and unit tests: `make all`
5. The generated test executables will be present in `build/bin/tests` folder.
6. Run `ctest` to execute all tests and view the test run summary.

CBMC To learn more about CBMC and proofs specifically, review the training material here.

The test/cbmc/proofs directory contains CBMC proofs.

In order to run these proofs you will need to install CBMC and other tools by following the instructions here.

Contributing See *CONTRIBUTING.md* for information on contributing.

4.1.6 coremqtt

MQTT publish/subscribe messaging library.

MCUXpresso SDK: coreMQTT Library

This repository is a fork of coreMQTT library (https://github.com/FreeRTOS/coremqtt)(2.1.1). Modifications have been made to adapt to NXP MCUXpresso SDK. CMakeLists.txt and Kconfig added to enable coreMQTT repo sources build in MCUXpresso SDK. It is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository mcuxsdk-manifests(https://github.com/nxp-mcuxpresso/mcuxsdk-manifests) for the complete delivery of MCUXpresso SDK.

coreMQTT Client Library

This repository contains the coreMQTT library that has been optimized for a low memory footprint. The coreMQTT library is compliant with the MQTT 3.1.1 standard. It has no dependencies on any additional libraries other than the standard C library, a customer-implemented network transport interface, and *optionally* a user-implemented platform time function. This library is distributed under the *MIT Open Source License*.

This library has gone through code quality checks including verification that no function has a GNU Complexity score over 8, and checks against deviations from mandatory rules in the MISRA coding standard. Deviations from the MISRA C:2012 guidelines are documented under *MISRA Deviations*. This library has also undergone both static code analysis from Coverity static analysis, and validation of memory safety through the CBMC automated reasoning tool.

See memory requirements for this library *here*.

coreMQTT v2.1.1 source code is part of the FreeRTOS 202210.01 LTS release.

MQTT Config File The MQTT client library exposes build configuration macros that are required for building the library. A list of all the configurations and their default values are defined in *core_mqtt_config_defaults.h*. To provide custom values for the configuration macros, a custom config file named core_mqtt_config.h can be provided by the application to the library.

By default, a core_mqtt_config.h custom config is required to build the library. To disable this requirement and build the library with default configuration values, provide MQTT_DO_NOT_USE_CUSTOM_CONFIG as a compile time preprocessor macro.

Thus, the MQTT library can be built by either:

- Defining a core_mqtt_config.h file in the application, and adding it to the include directories list of the library
  OR
- Defining the MQTT_DO_NOT_USE_CUSTOM_CONFIG preprocessor macro for the library build.

Sending metrics to AWS IoT When establishing a connection with AWS IoT, users can optionally report the Operating System, Hardware Platform and MQTT client version information of their device to AWS. This information can help AWS IoT provide faster issue resolution and technical support. If users want to report this information, they can send a specially formatted string (see below) in the username field of the MQTT CONNECT packet.

Format

The format of the username string with metrics is:

```
<Actual_Username>?SDK=<OS_Name>&Version=<OS_Version>&Platform=<Hardware_Platform>&
↪MQTTLib=<MQTT_Library_name>@<MQTT_Library_version>
```

Where

- <Actual_Username> is the actual username used for authentication, if username and password are used for authentication. When username and password based authentication is not used, this is an empty value.
- <OS_Name> is the Operating System the application is running on (e.g. FreeRTOS)
- <OS_Version> is the version number of the Operating System (e.g. V10.4.3)
- <Hardware_Platform> is the Hardware Platform the application is running on (e.g. WinSim)
- <MQTT_Library_name> is the MQTT Client library being used (e.g. coreMQTT)
- <MQTT_Library_version> is the version of the MQTT Client library being used (e.g. 1.0.2)

Example

- Actual_Username = “iotuser”, OS_Name = FreeRTOS, OS_Version = V10.4.3, Hardware_Platform_Name = WinSim, MQTT_Library_Name = coremqtt, MQTT_Library_version = 2.1.1. If username is not used, then “iotuser” can be removed.

```
/* Username string:
 * iotuser?SDK=FreeRTOS&Version=v10.4.3&Platform=WinSim&MQTTLib=coremqtt@2.1.1
 */

#define OS_NAME                    ”FreeRTOS”
#define OS_VERSION                 ”V10.4.3”
#define HARDWARE_PLATFORM_NAME     ”WinSim”
#define MQTT_LIB                   ”coremqtt@2.1.1”

#define USERNAME_STRING            ”iotuser?SDK=” OS_NAME ”&Version=” OS_VERSION ”&
↪Platform=” HARDWARE_PLATFORM_NAME ”&MQTTLib=” MQTT_LIB
#define USERNAME_STRING_LENGTH     ( ( uint16_t ) ( sizeof( USERNAME_STRING ) - 1 ) )

MQTTConnectInfo_t connectInfo;
connectInfo.pUserName = USERNAME_STRING;
connectInfo.userNameLength = USERNAME_STRING_LENGTH;
mqttStatus = MQTT_Connect( pMqttContext, &connectInfo, NULL, CONNACK_RECV_TIMEOUT_MS,␣
↪pSessionPresent );
```

Upgrading to v2.0.0 and above With coreMQTT versions >=v2.0.0, there are breaking changes. Please refer to the *coreMQTT version >=v2.0.0 Migration Guide*.

Building the Library The *mqttFilePaths.cmake* file contains the information of all source files and the header include path required to build the MQTT library.

Additionally, the MQTT library requires two header files that are not part of the ISO C90 standard library, stdbool.h and stdint.h. For compilers that do not provide these header files, the

source/include directory contains the files *stdbool.readme* and *stdint.readme*, which can be renamed to stdbool.h and stdint.h, respectively, to provide the type definitions required by MQTT.

As mentioned in the previous section, either a custom config file (i.e. core_mqtt_config.h) OR MQTT_DO_NOT_USE_CUSTOM_CONFIG macro needs to be provided to build the MQTT library.

For a CMake example of building the MQTT library with the mqttFilePaths.cmake file, refer to the coverity_analysis library target in *test/CMakeLists.txt* file.

Building Unit Tests

Checkout CMock Submodule By default, the submodules in this repository are configured with update=none in *.gitmodules* to avoid increasing clone time and disk space usage of other repositories (like amazon-freertos that submodules this repository).

To build unit tests, the submodule dependency of CMock is required. Use the following command to clone the submodule:

```
git submodule update --checkout --init --recursive test/unit-test/CMock
```

Platform Prerequisites

- Docker

or the following:

- For running unit tests
  - **C90 compiler** like gcc
  - **CMake 3.13.0 or later**
  - **Ruby 2.0.0 or later** is additionally required for the CMock test framework (that we use).
- For running the coverage target, **gcov** and **lcov** are additionally required.

Steps to build Unit Tests

1. If using docker, launch the container:
   1. docker build -t coremqtt .
   2. docker run -it -v "$PWD":/workspaces/coreMQTT -w /workspaces/coreMQTT coremqtt
2. Go to the root directory of this repository. (Make sure that the **CMock** submodule is cloned as described *above*)
3. Run the *cmake* command: cmake -S test -B build
4. Run this command to build the library and unit tests: make -C build all
5. The generated test executables will be present in build/bin/tests folder.
6. Run cd build && ctest to execute all tests and view the test run summary.

CBMC To learn more about CBMC and proofs specifically, review the training material here.

The test/cbmc/proofs directory contains CBMC proofs.

In order to run these proofs you will need to install CBMC and other tools by following the instructions here.

Reference examples Please refer to the demos of the MQTT client library in the following locations for reference examples on POSIX and FreeRTOS platforms:

Platform	Location	Transport Interface Implementation
POSIX	AWS IoT Device SDK for Embedded C	POSIX sockets for TCP/IP and OpenSSL for TLS stack
FreeRTOS	FreeRTOS/FreeRTOS	FreeRTOS+TCP for TCP/IP and mbedTLS for TLS stack
FreeRTOS	FreeRTOS AWS Reference Integrations	Based on Secure Sockets Abstraction

Documentation

Existing Documentation For pre-generated documentation, please see the documentation linked in the locations below:

Location
AWS IoT Device SDK for Embedded C FreeRTOS.org

Note that the latest included version of coreMQTT may differ across repositories.

Generating Documentation The Doxygen references were created using Doxygen version 1.9.2. To generate the Doxygen pages, please run the following command from the root of this repository:

```
doxygen docs/doxygen/config.doxyfile
```

Contributing See *CONTRIBUTING.md* for information on contributing.

4.1.7 coremqtt-agent

The coreMQTT Agent library is a high level API that adds thread safety to the coreMQTT library.

Readme

MCUXpresso SDK: coreMQTT Agent Library This repository is a fork of coreMQTT Agent library (https://github.com/FreeRTOS/coremqtt-agent)(1.2.0). Modifications have been made to adapt to NXP MCUXpresso SDK. CMakeLists.txt and Kconfig added to enable coreMQTT Agent repo sources build in MCUXpresso SDK. It is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository mcuxsdk-manifests(https://github.com/nxp-mcuxpresso/mcuxsdk-manifests) for the complete delivery of MCUXpresso SDK.

coreMQTT Agent Library The coreMQTT Agent library is a high level API that adds thread safety to the coreMQTT library. The library provides thread safe equivalents to the coreMQTT's APIs, greatly simplifying its use in multi-threaded environments. The coreMQTT Agent library manages the MQTT connection by serializing the access to the coreMQTT library and reducing implementation overhead (e.g., removing the need for the application to repeatedly call to MQTT_ProcessLoop). This allows your multi-threaded applications to share the same MQTT connection, and enables you to design an embedded application without having to worry about coreMQTT thread safety.

This library has gone through code quality checks including verification that no function has a GNU Complexity score over 8, and checks against deviations from mandatory rules in the MISRA coding standard. Deviations from the MISRA C:2012 guidelines are documented under *MISRA Deviations*. This library has also undergone both static code analysis from Coverity static analysis, and validation of memory safety through the CBMC automated reasoning tool.

See memory requirements for this library *here*.

Cloning this repository This repo uses Git Submodules to bring in dependent components.

To clone using HTTPS:

```
git clone https://github.com/FreeRTOS/coreMQTT-Agent.git --recurse-submodules
```

Using SSH:

```
git clone git@github.com:FreeRTOS/coreMQTT-Agent.git --recurse-submodules
```

If you have downloaded the repo without using the --recurse-submodules argument, you need to run:

```
git submodule update --init --recursive
```

coreMQTT Agent Library Configurations The MQTT Agent library uses the same core_mqtt_config.h configuration file as coreMQTT, with the addition of configuration constants listed at the top of *core_mqtt_agent.h* and *core_mqtt_agent_command_functions.h*. Documentation for these configurations can be found here.

To provide values for these configuration values, they must be either:

- Defined in core_mqtt_config.h used by coreMQTT **OR**
- Passed as compile time preprocessor macros

Porting the coreMQTT Agent Library In order to use the MQTT Agent library on a platform, you need to supply thread safe functions for the agent's *messaging interface*.

Messaging Interface Each of the following functions must be thread safe.

Function Pointer	Description
MQTTAgentMessageSend_t	A function that sends commands (as MQTTAgentCommand_t * pointers) to be received by MQTTAgent_CommandLoop. This can be implemented by pushing to a thread safe queue.
MQTTAgentMessageRecv_t	A function used by MQTTAgent_CommandLoop to receive MQTTAgentCommand_t * pointers that were sent by API functions. This can be implemented by receiving from a thread safe queue.
MQTTAgentCommandGet_t	A function that returns a pointer to an allocated MQTTAgentCommand_t structure, which is used to hold information and arguments for a command to be executed in MQTTAgent_CommandLoop(). If using dynamic memory, this can be implemented using malloc().
MQTTAgentCommandRelease_t	A function called to indicate that a command structure that had been allocated with the MQTTAgentCommandGet_t function pointer will no longer be used by the agent, so it may be freed or marked as not in use. If using dynamic memory, this can be implemented with free().

Reference implementations for the interface functions can be found in the *reference examples* below.

Additional Considerations

Static Memory If only static allocation is used, then the MQTTAgentCommandGet_t and MQTTAgentCommandRelease_t could instead be implemented with a pool of MQTTAgentCommand_t structures, with a queue or semaphore used to control access and provide thread safety. The below *reference examples* use static memory with a command pool.

Subscription Management The MQTT Agent does not track subscriptions for MQTT topics. The receipt of any incoming PUBLISH packet will result in the invocation of a single MQTTAgentIncomingPublishCallback_t callback, which is passed to MQTTAgent_Init() for initialization. If it is desired for different handlers to be invoked for different incoming topics, then the publish callback will have to manage subscriptions and fan out messages. A platform independent subscription manager example is implemented in the *reference examples* below.

Building the Library You can build the MQTT Agent source files that are in the *source* directory, and add *source/include* to your compiler's include path. Additionally, the MQTT Agent library requires the coreMQTT library, whose files follow the same source/ and source/include pattern as the agent library; its build instructions can be found here.

If using CMake, the *mqttAgentFilePaths.cmake* file contains the above information of the source files and the header include path from this repository. The same information is found for coreMQTT from mqttFilePaths.cmake in the *coreMQTT submodule*.

For a CMake example of building the MQTT Agent library with the mqttAgentFilePaths.cmake file, refer to the coverity_analysis library target in *test/CMakeLists.txt* file.

Building Unit Tests

Checkout CMock Submodule To build unit tests, the submodule dependency of CMock is required. Use the following command to clone the submodule:

```
git submodule update --checkout --init --recursive test/unit-test/CMock
```

Unit Test Platform Prerequisites

- For running unit tests
  - **C90 compiler** like gcc
  - **CMake 3.13.0 or later**
  - **Ruby 2.0.0 or later** is additionally required for the CMock test framework (that we use).
- For running the coverage target, **gcov** and **lcov** are additionally required.

Steps to build Unit Tests

1. Go to the root directory of this repository. (Make sure that the **CMock** submodule is cloned as described *above*)
2. Run the *cmake* command: `cmake -S test -B build`
3. Run this command to build the library and unit tests: `make -C build all`
4. The generated test executables will be present in `build/bin/tests` folder.
5. Run `cd build && ctest` to execute all tests and view the test run summary.

CBMC To learn more about CBMC and proofs specifically, review the training material here.

The `test/cbmc/proofs` directory contains CBMC proofs.

In order to run these proofs you will need to install CBMC and other tools by following the instructions here.

Reference examples Please refer to the demos of the MQTT Agent library in the following locations for reference examples on FreeRTOS platforms:

Location
coreMQTT Agent Demos FreeRTOS/FreeRTOS

Documentation The MQTT Agent API documentation can be found here.

Generating documentation The Doxygen references were created using Doxygen version 1.9.2. To generate the Doxygen pages yourself, please run the following command from the root of this repository:

```
doxygen docs/doxygen/config.doxyfile
```

Getting help You can use your Github login to get support from both the FreeRTOS community and directly from the primary FreeRTOS developers on our active support forum. You can find a list of frequently asked questions here.

Contributing See *CONTRIBUTING.md* for information on contributing.

License This library is licensed under the MIT License. See the *LICENSE* file.

4.1.8 corepkcs11

PKCS #11 key management library.

Readme

MCUXpresso SDK: corePKCS11 Library This repository is a fork of PKCS #11 key management library (https://github.com/FreeRTOS/corePKCS11/tree/v3.5.0)(v3.5.0). Modifications have been made to adapt to NXP MCUXpresso SDK. CMakeLists.txt and Kconfig added to enable corepkcs11 repo sources build in MCUXpresso SDK. It is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository mcuxsdk-manifests(https://github.com/nxp-mcuxpresso/mcuxsdk-manifests) for the complete delivery of MCUXpresso SDK.

corePKCS11 Library PKCS #11 is a standardized and widely used API for manipulating common cryptographic objects. It is important because the functions it specifies allow application software to use, create, modify, and delete cryptographic objects, without ever exposing those objects to the application's memory. For example, FreeRTOS AWS reference integrations use a small subset of the PKCS #11 API to, among other things, access the secret (private) key necessary to create a network connection that is authenticated and secured by the Transport Layer Security (TLS) protocol – without the application ever 'seeing' the key.

The Cryptoki or PKCS #11 standard defines a platform-independent API to manage and use cryptographic tokens. The name, "PKCS #11", is used interchangeably to refer to the API itself and the standard which defines it.

This repository contains a software based mock implementation of the PKCS #11 interface (API) that uses the cryptographic functionality provided by Mbed TLS. Using a software mock enables rapid development and flexibility, but it is expected that the mock be replaced by an implementation specific to your chosen secure key storage in production devices.

Only a subset of the PKCS #11 standard is implemented, with a focus on operations involving asymmetric keys, random number generation, and hashing.

The targeted use cases include certificate and key management for TLS authentication and code-sign signature verification, on small embedded devices.

corePKCS11 is implemented on PKCS #11 v2.4.0, the full PKCS #11 standard can be found on the oasis website.

This library has gone through code quality checks including verification that no function has a GNU Complexity score over 8, and checks against deviations from mandatory rules in the MISRA coding standard. Deviations from the MISRA C:2012 guidelines are documented under *MISRA Deviations*. This library has also undergone both static code analysis from Coverity static analysis and validation of memory safety through the CBMC automated reasoning tool.

See memory requirements for this library *here*.

corePKCS11 v3.5.0 source code is part of the FreeRTOS 202210.00 LTS release.

corePKCS11 v3.0.0 source code is part of the FreeRTOS 202012.00 LTS release.

Purpose Generally vendors for secure cryptoprocessors such as Trusted Platform Module (TPM), Hardware Security Module (HSM), Secure Element, or any other type of secure hardware enclave, distribute a PKCS #11 implementation with the hardware. The purpose of the corePKCS11 software only mock library is therefore to provide a non hardware specific PKCS #11 implementation that allows for rapid prototyping and development before switching to a cryptoprocessor specific PKCS #11 implementation in production devices.

Since the PKCS #11 interface is defined as part of the PKCS #11 specification replacing this library with another implementation should require little porting effort, as the interface will not change. The system tests distributed in this repository can be leveraged to verify the behavior of a different implementation is similar to corePKCS11.

corePKCS11 Configuration The corePKCS11 library exposes preprocessor macros which must be defined prior to building the library. A list of all the configurations and their default values are defined in the doxygen documentation for this library.

Build Prerequisites

Library Usage For building the library the following are required:

- **A C99 compiler**
- **mbedcrypto** library from mbedtls version 2.x or 3.x.
- **pkcs11 API header(s)** available from OASIS or OpenSC

Optionally, variables from the pkcsFilePaths.cmake file may be referenced if your project uses cmake.

Integration and Unit Tests In order to run the integration and unit test suites the following are dependencies are necessary:

- **C Compiler**
- **CMake 3.13.0 or later**
- **Ruby 2.0.0 or later** required by CMock.
- **Python 3** required for configuring mbedtls.
- **git** required for fetching dependencies.
- **GNU Make** or **Ninja**

The *mbedtls*, *CMock*, and *Unity* libraries are downloaded and built automatically using the cmake FetchContent feature.

Coverage Measurement and Instrumentation The following software is required to run the coverage target:

- Linux, MacOS, or another POSIX-like environment.
- A recent version of **GCC** or **Clang** with support for gcov-like coverage instrumentation.
- **gcov** binary corresponding to your chosen compiler
- **lcov** from the Linux Test Project
- **perl** needed to run the lcov utility.

Coverage builds are validated on recent versions of Ubuntu Linux.

Running the Integration and Unit Tests

1. Navigate to the root directory of this repository in your shell.
2. Run **cmake** to construct a build tree: `cmake -S test -B build`
   - You may specify your preferred build tool by appending `-G'Unix Makefiles'` or `-GNinja` to the command above.
   - You may append `-DUNIT_TESTS=0` or `-DSYSTEM_TESTS=0` to disable Unit Tests or Integration Tests respectively.
3. Build the test binaries: `cmake --build ./build --target all`
4. Run `ctest --test-dir ./build` or `cmake --build ./build --target test` to run the tests without capturing coverage.
5. Run `cmake --build ./build --target coverage` to run the tests and capture coverage data.

CBMC To learn more about CBMC and proofs specifically, review the training material here.

The `test/cbmc/proofs` directory contains CBMC proofs.

In order to run these proofs you will need to install CBMC and other tools by following the instructions here.

Reference examples The FreeRTOS-Labs repository contains demos using the PKCS #11 library here using FreeRTOS on the Windows simulator platform. These can be used as reference examples for the library API.

Porting Guide Documentation for porting corePKCS11 to a new platform can be found on the AWS docs web page.

corePKCS11 is not meant to be ported to projects that have a TPM, HSM, or other hardware for offloading crypto-processing. This library is specifically meant to be used for development and prototyping.

Related Example Implementations These projects implement the PKCS #11 interface on real hardware and have similar behavior to corePKCS11. It is preferred to use these, over corePKCS11, as they allow for offloading Cryptography to separate hardware.

- ARM's Platform Security Architecture.
- Microchip's cryptoauthlib.
- Infineon's Optiga Trust X.

Documentation

Existing Documentation For pre-generated documentation, please see the documentation linked in the locations below:

Location
AWS IoT Device SDK for Embedded C
FreeRTOS.org

Note that the latest included version of corePKCS11 may differ across repositories.

Generating Documentation The Doxygen references were created using Doxygen version 1.9.2. To generate the Doxygen pages, please run the following command from the root of this repository:

```
doxygen docs/doxygen/config.doxyfile
```

Security See *CONTRIBUTING* for more information.

License This library is licensed under the MIT-0 License. See the LICENSE file.

4.1.9 freertos-plus-tcp

Open source RTOS FreeRTOS Plus TCP.

Readme

MCUXpresso SDK: FreeRTOS-Plus-TCP Library This repository is a fork of FreeRTOS-Plus-TCP library (https://github.com/FreeRTOS/freertos-plus-tcp)(4.0.0). Modifications have been made to adapt to NXP MCUXpresso SDK. CMakeLists.txt and Kconfig added to enable FreeRTOS-Plus-TCP repo sources build in MCUXpresso SDK. It is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository mcuxsdk-manifests(https://github.com/nxp-mcuxpresso/mcuxsdk-manifests) for the complete delivery of MCUXpresso SDK.

Introduction This branch contains unified IPv4 and IPv6 functionalities. Refer to the Getting started Guide (found here) for more details.

FreeRTOS-Plus-TCP Library FreeRTOS-Plus-TCP is a lightweight TCP/IP stack for FreeRTOS. It provides a familiar Berkeley sockets interface, making it as simple to use and learn as possible. FreeRTOS-Plus-TCP's features and RAM footprint are fully scalable, making FreeRTOS-Plus-TCP equally applicable to smaller lower throughput microcontrollers as well as larger higher throughput microprocessors.

This library has undergone static code analysis and checks for compliance with the MISRA coding standard. Any deviations from the MISRA C:2012 guidelines are documented under MISRA Deviations. The library is validated for memory safety and data structure invariance through the CBMC automated reasoning tool for the functions that parse data originating from the network. The library is also protocol tested using Maxwell protocol tester for both IPv4 and IPv6.

Getting started The easiest way to use the 4.0.0 version of FreeRTOS-Plus-TCP is to refer the Getting started Guide (found here) Another way is to start with the pre-configured demo application project (found in this directory). That way you will have the correct FreeRTOS source files included, and the correct include paths configured. Once a demo application is building and executing you can remove the demo application files, and start to add in your own application source files. See the FreeRTOS Kernel Quick Start Guide for detailed instructions and other useful links.

Additionally, for FreeRTOS-Plus-TCP source code organization refer to the Documentation, and API Reference.

Getting help If you have any questions or need assistance troubleshooting your FreeRTOS project, we have an active community that can help on the FreeRTOS Community Support Forum. Please also refer to FAQ for frequently asked questions.

Also see the Submitting a bugs/feature request section of CONTRIBUTING.md for more details.

Note: All the remaining sections are generic and applies to all the versions from V3.0.0 onwards.

Upgrading to V3.0.0 and V3.1.0 In version 3.0.0 or 3.1.0, the folder structure of FreeRTOS-Plus-TCP has changed and the files have been broken down into smaller logically separated modules. This change makes the code more modular and conducive to unit-tests. FreeRTOS-Plus-TCP V3.0.0 improves the robustness, security, and modularity of the library. Version 3.0.0 adds comprehensive unit test coverage for all lines and branches of code and has undergone protocol testing, and penetration testing by AWS Security to reduce the exposure to security vulnerabilities. Additionally, the source files have been moved to a source directory. This change requires modification of any existing project(s) to include the modified source files and directories. There are examples on how to use the new files and directory structure. For an example based on the Xilinx Zynq-7000, use the code in this branch and follow these instructions to build and run the demo.

FreeRTOS-Plus-TCP V3.1.0 source code(.c .h) is part of the FreeRTOS 202210.00 LTS release.

Generating pre V3.0.0 folder structure for backward compatibility: If you wish to continue using a version earlier than V3.0.0 i.e. continue to use your existing source code organization, a script is provided to generate the folder structure similar to this.

Note: After running the script, while the .c files will have same names as the pre V3.0.0 source, the files in the include directory will have different names and the number of files will differ as well. This should, however, not pose any problems to most projects as projects generally include all files in a given directory.

Running the script to generate pre V3.0.0 folder structure: For running the script, you will need Python version > 3.7. You can download/install it from here.

Once python is downloaded and installed, you can verify the version from your terminal/command window by typing python --version.

To run the script, you should switch to the FreeRTOS-Plus-TCP directory that was created using the *Cloning this repository* step above. And then run python <Path/to/the/script>/GenerateOriginalFiles.py.

To consume FreeRTOS+TCP

Consume with CMake If using CMake, it is recommended to use this repository using FetchContent. Add the following into your project's main or a subdirectory's CMakeLists.txt:

- Define the source and version/tag you want to use:

```
FetchContent_Declare( freertos_plus_tcp
  GIT_REPOSITORY https://github.com/FreeRTOS/FreeRTOS-Plus-TCP.git
  GIT_TAG        master #Note: Best practice to use specific git-hash or tagged version
  GIT_SUBMODULES "" # Don't grab any submodules since not latest
)
```

- Configure the FreeRTOS-Kernel and make it available
  - this particular example supports a native and cross-compiled build option.

```
set( FREERTOS_PLUS_FAT_DEV_SUPPORT OFF CACHE BOOL "" FORCE)
# Select the native compile PORT
set( FREERTOS_PLUS_FAT_PORT "POSIX" CACHE STRING "" FORCE)
# Select the cross-compile PORT
if (CMAKE_CROSSCOMPILING)
  # Eg. Zynq 2019_3 version of port
  set(FREERTOS_PLUS_FAT_PORT "ZYNQ_2019_3" CACHE STRING "" FORCE)
endif()

FetchContent_MakeAvailable(freertos_plus_tcp)
```

Consuming stand-alone This repository uses Git Submodules to bring in dependent components.

Note: If you download the ZIP file provided by GitHub UI, you will not get the contents of the submodules. (The ZIP file is also not a valid Git repository)

To clone using HTTPS:

```
git clone https://github.com/FreeRTOS/FreeRTOS-Plus-TCP.git ./FreeRTOS-Plus-TCP
cd ./FreeRTOS-Plus-TCP
git submodule update --checkout --init --recursive tools/CMock test/FreeRTOS-Kernel
```

Using SSH:

```
git clone git@github.com:FreeRTOS/FreeRTOS-Plus-TCP.git ./FreeRTOS-Plus-TCP
cd ./FreeRTOS-Plus-TCP
git submodule update --checkout --init --recursive tools/CMock test/FreeRTOS-Kernel
```

Porting The porting guide is available on this page.

Repository structure This repository contains the FreeRTOS-Plus-TCP repository and a number of supplementary libraries for testing/PR Checks. Below is the breakdown of what each directory contains:

- tools
  - This directory contains the tools and related files (CMock/uncrustify) required to run tests/checks on the TCP source code.
- tests
  - This directory contains all the tests (unit tests and CBMC) and the dependencies (FreeRTOS-Kernel/Litani-port) the tests require.
- source/portable
  - This directory contains the portable files required to compile the FreeRTOS-Plus-TCP source code for different hardware/compilers.
- source/include
  - The include directory has all the 'core' header files of FreeRTOS-Plus-TCP source.
- source
  - This directory contains all the [.c] source files.

Note At this time it is recommended to use BufferAllocation_2.c in which case it is essential to use the heap_4.c memory allocation scheme. See memory management.

Kernel sources The FreeRTOS Kernel Source is in FreeRTOS/FreeRTOS-Kernel repository, and it is consumed by testing/PR checks as a submodule in this repository.

The version of the FreeRTOS Kernel Source in use could be accessed at ./test/FreeRTOS-Kernel directory.

CBMC The test/cbmc/proofs directory contains CBMC proofs.

To learn more about CBMC and proofs specifically, review the training material here.

In order to run these proofs you will need to install CBMC and other tools by following the instructions here.