



MCUXpresso SDK Documentation

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Table of contents

1	EVK-MIMX8MP	3
1.1	Overview	3
1.2	Getting Started with MCUXpresso SDK Package	3
1.2.1	Getting Started with Package	3
1.3	Getting Started with MCUXpresso SDK GitHub	19
1.3.1	Getting Started with MCUXpresso SDK Repository	19
1.4	Release Notes	43
1.4.1	MCUXpresso SDK Release Notes	43
1.5	ChangeLog	46
1.5.1	MCUXpresso SDK Changelog	46
1.6	Driver API Reference Manual	107
1.7	Middleware Documentation	107
1.7.1	Multicore	107
1.7.2	FreeMASTER	107
1.7.3	FreeRTOS	107
2	MIMX8ML8	109
2.1	AIPSTZ: AHB to IP Bridge	109
2.2	ASRC: Asynchronous sample rate converter	111
2.3	ASRC Driver	111
2.4	ASRC SDMA Driver	125
2.5	Audiomix	129
2.6	CACHE: ARMV7-M7 CACHE Memory Controller	135
2.7	Clock	138
2.8	EDMA: Enhanced Direct Memory Access (eDMA) Controller Driver	176
2.9	ECSPI: Enhanced Configurable Serial Peripheral Interface Driver	195
2.10	ECSPI Driver	195
2.11	ECSPI SDMA Driver	209
2.12	ENET: Ethernet MAC Driver	212
2.13	EQOS-TSN: Ethernet QoS with TSN Driver	242
2.14	Enet_qos_qos	242
2.15	FlexCAN: Flex Controller Area Network Driver	283
2.16	FlexCAN Driver	283
2.17	GPC: General Power Controller Driver	324
2.18	GPIO: General-Purpose Input/Output Driver	328
2.19	GPT: General Purpose Timer	333
2.20	I2C: Inter-Integrated Circuit Driver	340
2.21	I2C Driver	340
2.22	Iomuxc_driver	352
2.23	Common Driver	378
2.24	MU: Messaging Unit	390
2.25	PDM: Microphone Interface	399
2.26	PDM Driver	399
2.27	PDM EDMA Driver	411
2.28	PDM SDMA Driver	415
2.29	PWM: Pulse Width Modulation Driver	417

2.30	RDC: Resource Domain Controller	423
2.31	RDC_SEMA42: Hardware Semaphores Driver	429
2.32	SAI: Serial Audio Interface	431
2.33	SAI Driver	431
2.34	SAI EDMA Driver	458
2.35	SAI SDMA Driver	464
2.36	SDMA: Smart Direct Memory Access (SDMA) Controller Driver	468
2.37	SEMA4: Hardware Semaphores Driver	486
2.38	TMU: Thermal Management Unit Driver	489
2.39	UART: Universal Asynchronous Receiver/Transmitter Driver	494
2.40	UART Driver	494
2.41	UART FreeRTOS Driver	509
2.42	UART SDMA Driver	509
2.43	USDHC: Ultra Secured Digital Host Controller Driver	511
2.44	WDOG: Watchdog Timer Driver	541
3	Middleware	547
3.1	Motor Control	547
3.1.1	FreeMASTER	547
3.2	MultiCore	584
3.2.1	Multicore SDK	584
4	RTOS	683
4.1	FreeRTOS	683
4.1.1	FreeRTOS kernel	683
4.1.2	FreeRTOS drivers	683
4.1.3	backoffalgorithm	683
4.1.4	corehttp	683
4.1.5	corejson	683
4.1.6	coremqtt	684
4.1.7	corepkcs11	684
4.1.8	freertos-plus-tcp	684

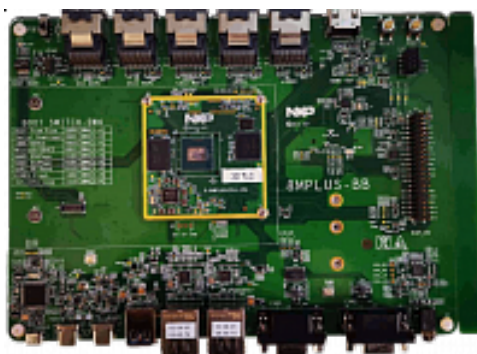
This documentation contains information specific to the evkmimx8mp board.

Chapter 1

EVK-MIMX8MP

1.1 Overview

The i.MX 8M Plus family of boards provides a powerful and flexible development system for NXP's Cortex-M7 MCUs.



MCU device and part on board is shown below:

- Device: MIMX8ML8
- PartNumber: MIMX8ML8DVNLZ

1.2 Getting Started with MCUXpresso SDK Package

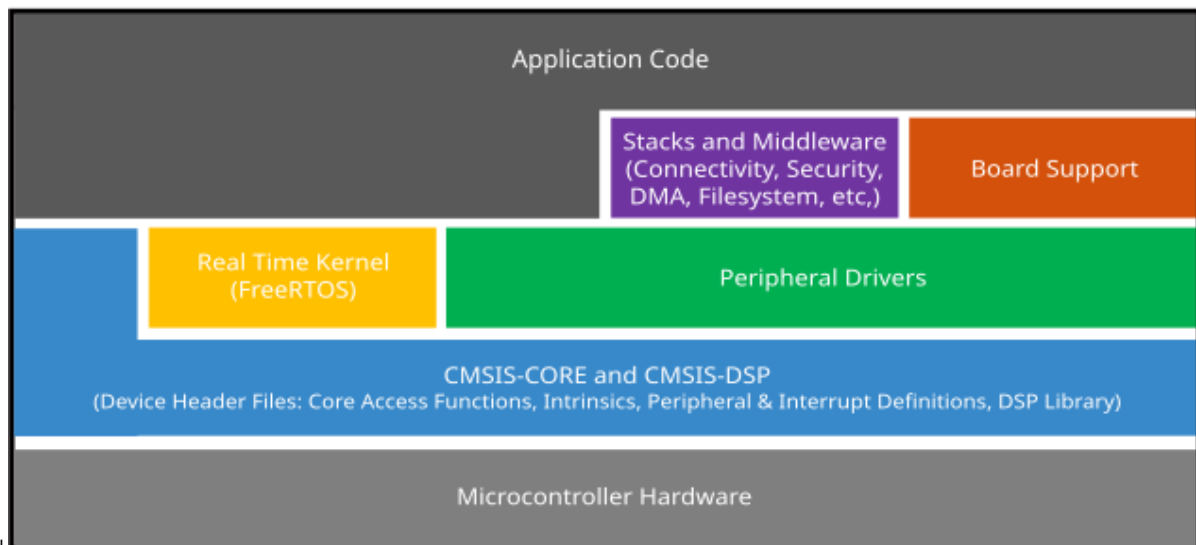
1.2.1 Getting Started with Package

Overview

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

For supported toolchain versions, see *MCUXpresso SDK Release Notes for EVK-MIMX8MP* (document MCUXSDKIMX8MPRN).

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



MCUXpresso SDK board support folders

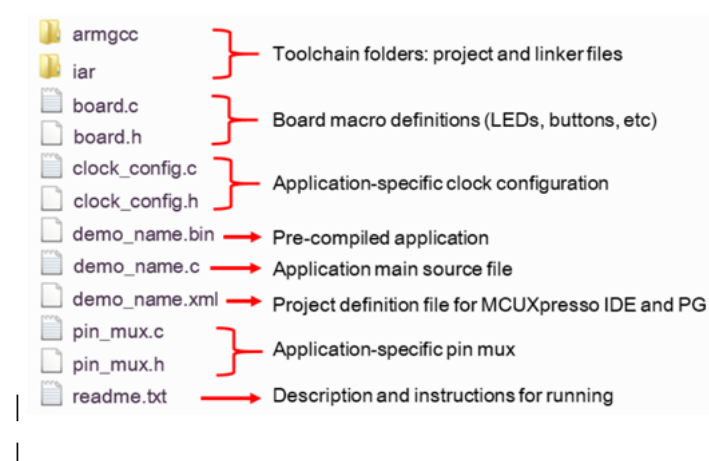
MCUXpresso SDK board support provides example applications for NXP development and evaluation boards for Arm Cortex-M cores. Board support packages are found inside of the top level boards folder, and each supported board has its own folder (MCUXpresso SDK package can support multiple boards). Within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

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

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

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

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



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

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

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

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

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

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

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

Toolchain introduction

The MCUXpresso SDK release for i.MX 8M Plus includes the build system to be used with some toolchains. In this chapter, the toolchain support is presented and detailed.

Compiler/Debugger The MCUXpresso SDK i.MX 8M Plus release supports building and debugging with the toolchains listed in Table 1.

The user can choose the appropriate one for development.

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

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

www.segger.com

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

www.segger.com

|

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

Note:

- To support i.MX 8M Plus, the patch for IAR and Segger J-Link should be installed. The patch named [iar_segger_support_patch_imx8mp.zip](#) can be used with MCUXpresso SDK. See the [readme.txt](#) in the patch for additional information about patch installation.
- For the security reason, only after the U-Boot is boot up, the JTAG can be allowed to connect to M core.

Parent topic: [Toolchain introduction](#)

Run a demo application using IAR

This section describes the steps required to build, run, and debug example applications provided in the MCUXpresso SDK. The `hello_world` demo application targeted for the i.MX 8MP EVK hardware platform is used as an example, although these steps can be applied to any example application in the MCUXpresso SDK.

Build an example application Before using IAR, get the IAR and Segger J-Link patch, `iar_segger_support_patch_imx8p.zip`. Install the i.MX8MP support patch following the guides in `readme.txt` located in the archive.

Do the following steps to build the `hello_world` example application.

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

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

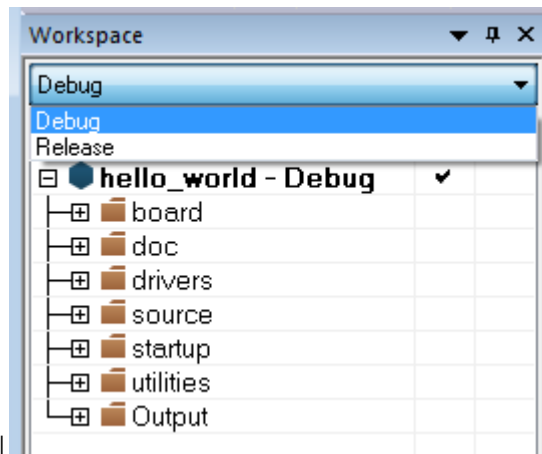
Using the i.MX 8MP EVK hardware platform as an example, the `hello_world` workspace is located in:

```
<install_dir>/boards/evkmimx8mp/demo_apps/hello_world/iar/hello_world.eww
```

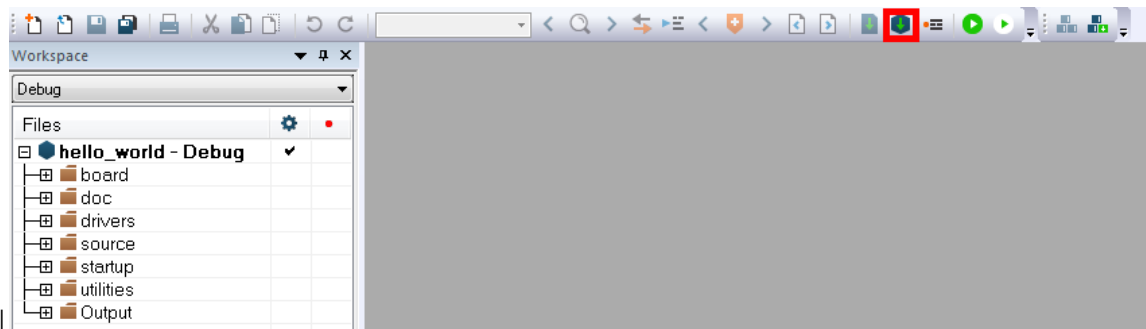
Other example applications may have additional folders in their path.

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

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



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

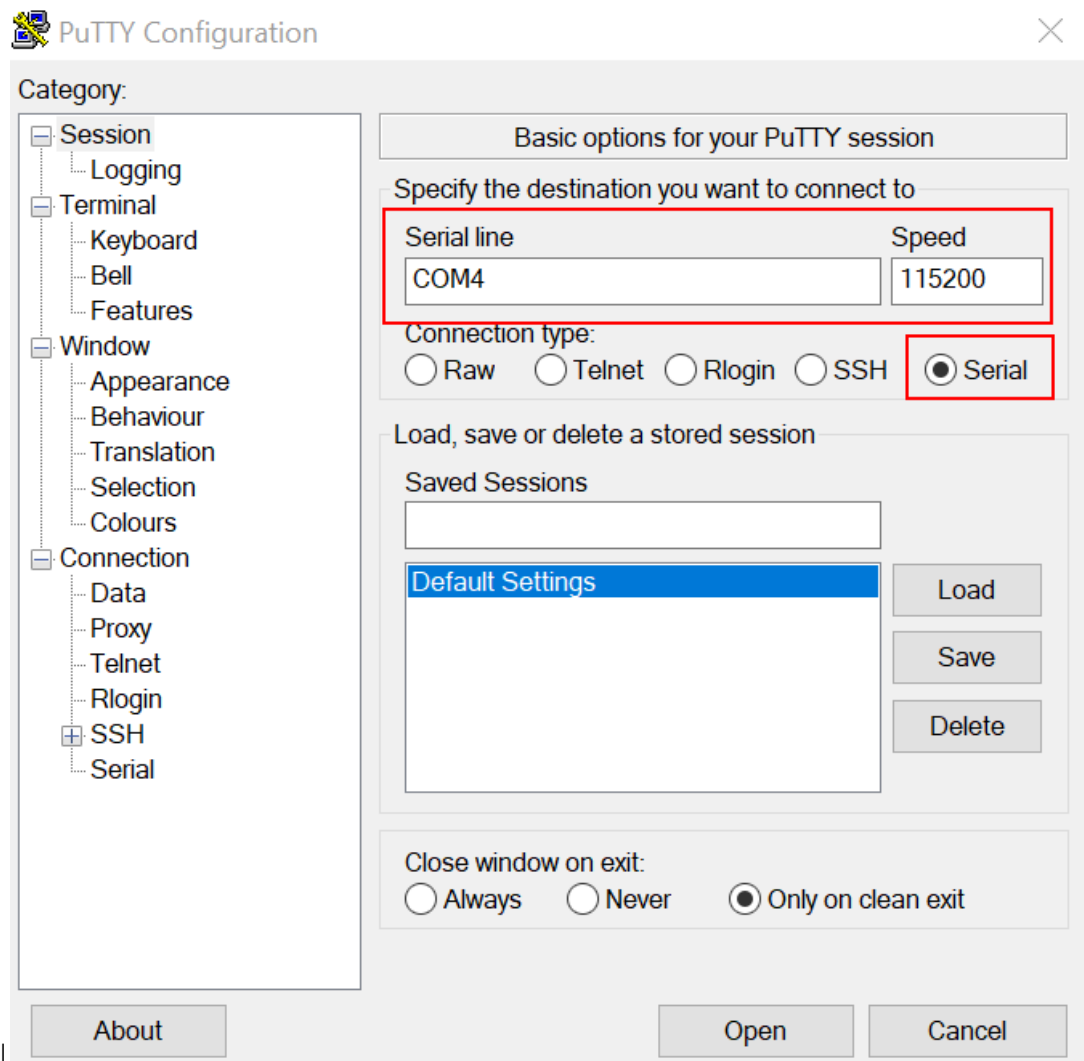


4. The build completes without errors.

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

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

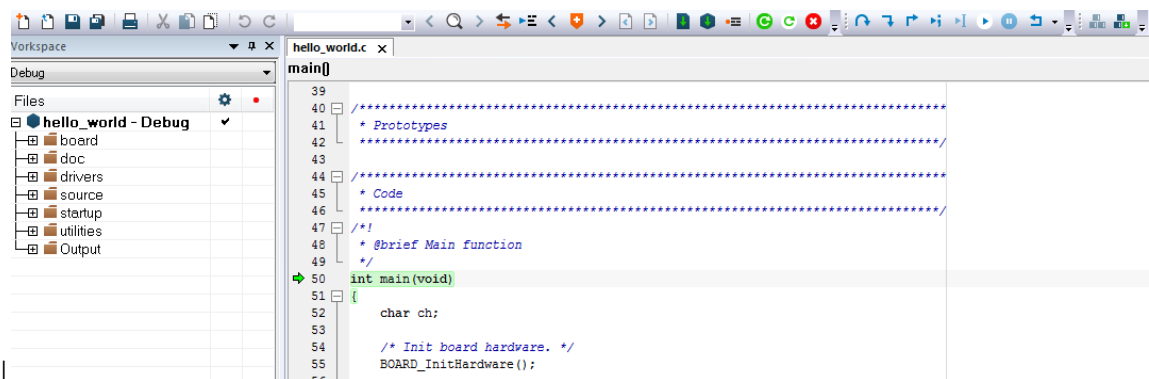
1. This board supports the J-Link PLUS debug probe. Before using it, install SEGGER J-Link software, which can be downloaded from <http://www.segger.com/downloads/jlink/>.
2. Connect the development platform to your PC via USB cable between the USB-UART MICRO USB connector and the PC USB connector, then connect 12 V power supply and J-Link Plus to the device.
3. Open the terminal application on the PC, such as PuTTY or TeraTerm, and connect to the debug COM port (to determine the COM port number, see [How to determine COM port](#)). Configure the terminal with these settings:
 1. 115200 baud rate
 2. No parity
 3. 8 data bits
 4. 1 stop bit



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



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



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



7. The `hello_world` application now runs and a banner appears on the terminal. If this does not occur, check your terminal settings and connections.



****Note:**** For downloading the DDR target application, insert one TF card with U-Boot code. This is [required both on IAR and GCC](#).

****Note:**** For converting the DDR target elf to bin, run the following commands (take git bash console as [example](#)).

1. For the elf file built by Arm GCC:

```
$ <ARMGCC PATH>/bin/arm-none-eabi-objcopy.exe -Obinary --remove-section=.stacktop_and_pc
<hello_world_<mcore type>.elf> <hello_world_<mcore type>.bin>
```

2. For the elf/out file built by IAR:

```
$ <ARMGCC PATH>/bin/arm-none-eabi-objcopy.exe --remove-section=.stacktop_and_pc hello_world_
<mcore type>.elf hello_world_<mcore type>_stripped.elf
$IAR PATH>/arm/bin/ielftool.exe --bin hello_world_<mcore type>_stripped.elf hello_world_<mcore_
type>.bin
```

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

Run a demo using ARMGCC / VSCODE

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

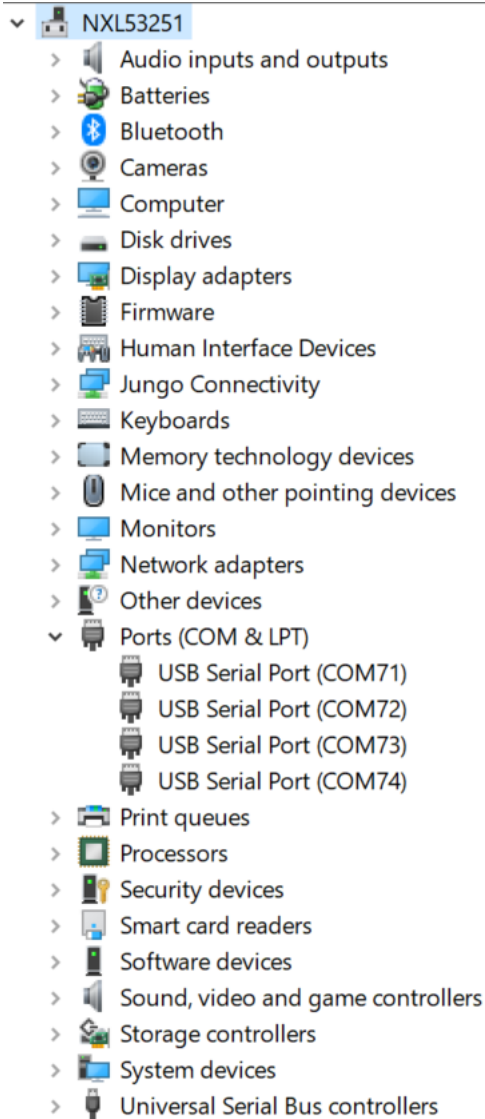
Refer to the [running a demo using MCUXpresso VSC](#) section for detailed instructions on setting up and configuring your project in Visual Studio Code.

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

Running an application by U-Boot

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

1. Connect the **DEBUG UART** slot on the board to your PC through the USB cable. The Windows OS installs the USB driver automatically, and the Ubuntu OS finds the serial devices as well.
2. On Windows OS, open the device manager, find **USB serial Port** in **Ports (COM & LPT)**. Assume that the ports are COM71 - COM74. COM73 is for the debug message from the Cortex-A53 and COM74 is for the Cortex-M7. The port number is allocated randomly, so opening both is beneficial for development. On Ubuntu OS, find the TTY device with name `/dev/ttyUSB*` to determine your debug port. Similar to Windows OS, opening both is beneficial for development.



3. Build the application (for example, `hello_world`) to get the bin file (`hello_world.bin`).
4. Prepare an SD card with the prebuilt U-Boot image and copy bin file (`hello_world.bin`) into the SD card. Then, insert the SD card to the target board. Make sure to use the default boot SD slot and check the dipswitch configuration.
5. Open your preferred serial terminals for the serial devices, setting the speed to 115200 bps, 8 data bits, 1 stop bit (115200, 8N1), no parity, then power on the board.
6. Power on the board and hit any key to stop autoboot in the terminals, then enter to U-Boot command line mode. You can then write the image and run it from TCM, DRAM and QSPI/XIP with the following commands:

1. If the `hello_world.bin` is made from the debug/release target, which means the binary file will run at TCM, use the following commands to boot:
 - `fatload mmc 1:1 0x48000000 hello_world.bin;cp.b 0x48000000 0x7e0000 20000;`
 - `bootaux 0x7e0000`
2. If the `hello_world.bin` is made from the `ddr_debug/ddr_release` target, which means the binary file runs at DRAM, use the following commands:
 - `fatload mmc 1:1 0x80000000 hello_world.bin`
 - `dcache flush`
 - `bootaux 0x80000000`
3. If the `hello_world.bin` is made from the `flash_debug/flash_release` target, which means the binary file runs at QSPI/XIP, use the following commands:
 - `sf probe`
 - `sf read 0x80000000 0 4`
 - `fatload mmc 1:1 0x48000000 flash.bin`
 - `dcache flush`
 - `sf erase 0 0x100000`
 - `sf write 0x48000000 0 0x100000`
 - `bootaux 0x80000000` **Note:** If the Linux OS kernel runs together with M7, make sure the correct dtb file is used. This dtb file reserves resources used by M7 and avoids the Linux kernel from configuring them. Use the following command in U-Boot before running the kernel:

```
setenv fdtfile 'imx8mp-evk-rpmsg.dtb'
```

Note: For the SCH RevB4 board, use `imx8mp-evk-revb4-rpmsg.dtb` for multicore examples.

Note: For Linux release version L5.15.71-2.2.0 and later, the `run prepare_mcore` command must run before the `bootaux` command.

```

COM73 - PuTTY

U-Boot SPL 2019.04-5.4.3-1.1.0+g8beac7ef22 (Feb 06 2020 - 10:33:05 +0000)
power_pca9450b_init
DDRINFO: start DRAM init
DDRINFO:ddrphy calibration done
DDRINFO: ddrmix config done
Normal Boot
Trying to boot from ROMAPI
image offset 0x8000, pagesize 0x200, ivt offset 0x0

U-Boot 2019.04-5.4.3-1.1.0+g8beac7ef22 (Feb 06 2020 - 10:33:05 +0000)

CPU:   Freescale i.MX8MP rev1.0 2300 MHz (running at 1200 MHz)
CPU:   Commercial temperature grade (0C to 95C) at 43C
Reset cause: POR
Model: NXP i.MX8MPlus LPDDR4 EVK board
DRAM:  6 GiB
TCPC:   Vendor ID [0x1fc9], Product ID [0x5110], Addr [I2C2 0x50]
SNK.Power3.0 on CC1
PDO 0: type 0, 5000 mV, 3000 mA [E]
PDO 1: type 0, 9000 mV, 3000 mA []
PDO 2: type 0, 15000 mV, 3000 mA []
PDO 3: type 0, 20000 mV, 2250 mA []
Requesting PDO 3: 20000 mV, 2250 mA
Source accept request
PD source ready!
tcpc_pd_receive_message: Polling ALERT register, TCPC_ALERT_RX_STATUS bit failed, ret = -62
Power supply on USB2
TCPC:   Vendor ID [0x1fc9], Product ID [0x5110], Addr [I2C1 0x50]
MMC:    FSL_SDHC: 1, FSL_SDHC: 2
Loading Environment from MMC... Run CMD11 1.8V switch
OK
No panel detected: default to MIPI2HDMI
adv7535_init: Can't find device id=0x3d, on bus 1
Display: MIPI2HDMI (1920x1080)
Video: 1920x1080x24
In:     serial
Out:    serial
Err:    serial

BuildInfo:
- ATF a7b31cf
- U-Boot 2019.04-5.4.3-1.1.0+g8beac7ef22

Run CMD11 1.8V switch
switch to partitions #0, OK
mmc1 is current device
flash target is MMC:1
Run CMD11 1.8V switch
Net:
Error: ethernet@30be0000 address not set.

Error: ethernet@30be0000 address not set.

Error: ethernet@30bf0000 address not set.
eth-1: ethernet@30be0000
Error: ethernet@30bf0000 address not set.
, eth-1: ethernet@30bf0000
Fastboot: Normal
Normal Boot
Hit any key to stop autoboot: 0
u-boot=> fatload mmc 1:1 0x48000000 hello_world.bin;cp.b 0x48000000 0x7e0000 20000;
16812 bytes read in 20 ms (820.3 KiB/s)
u-boot=> bootaux 0x7e0000
## Starting auxiliary core at 0x007E0000 ...
u-boot=>

```

|

|

- |
7. Open another terminal application on the PC, such as PuTTY and connect to the debug COM port (to determine the COM port number, see [How to determine COM port](#)). Configure the terminal with these settings:

- 115200
 - No parity
 - 8 data bits
 - 1 stop bit
8. The `hello_world` application is now running and a banner is displayed on the terminal. If this is not true, check your terminal settings and connections.



Run a flash target demo by UUU

This section describes the steps to use the UUU to build and run example applications provided in the MCUXpresso SDK. The `hello_world` demo application targeted for the i.MX 8M Plus EVK hardware platform is used as an example, although these steps can be applied to any example application in the MCUXpresso SDK.

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

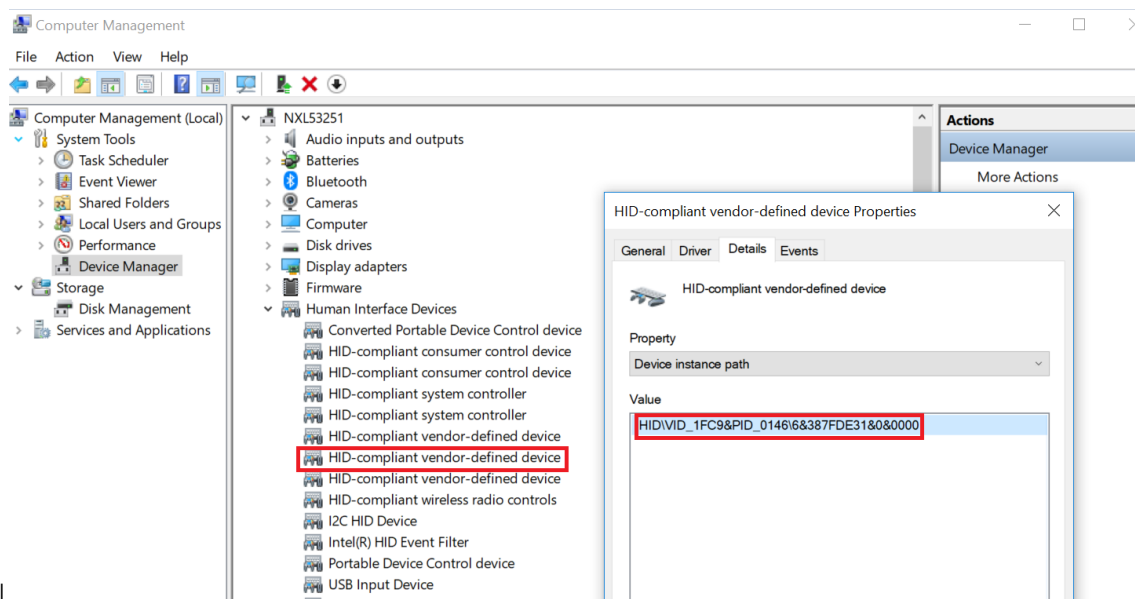
Download the MfgTool The Universal Upgrade Utility (UUU) is an upgraded version of MfgTool. It is a command line tool that aims at installing the bootloader to various storage including SD, QSPI, and so on, for i.MX series devices with ease.

The tool can be downloaded from [github](#). Use version 1.3.134 or higher for full support for the M7 image. Download `uuu.exe` for Windows OS, or download UUU for Linux. Configure the path so that the executable can later be called anywhere in the command line.

Parent topic:Set up environment

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

1. Set the board boot mode to Download Mode [SW0001[1-4]].
2. Connect the development platform to your PC via USB cable between the SERIAL port and the PC USB connector. The SERIAL port is J301 on the base board.
3. The PC recognizes the i.MX 8M Plus device as (VID:PID)=(1FC9:0146).



Parent topic: Set up environment

Parent topic: [Run a flash target demo by UUU](#)

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

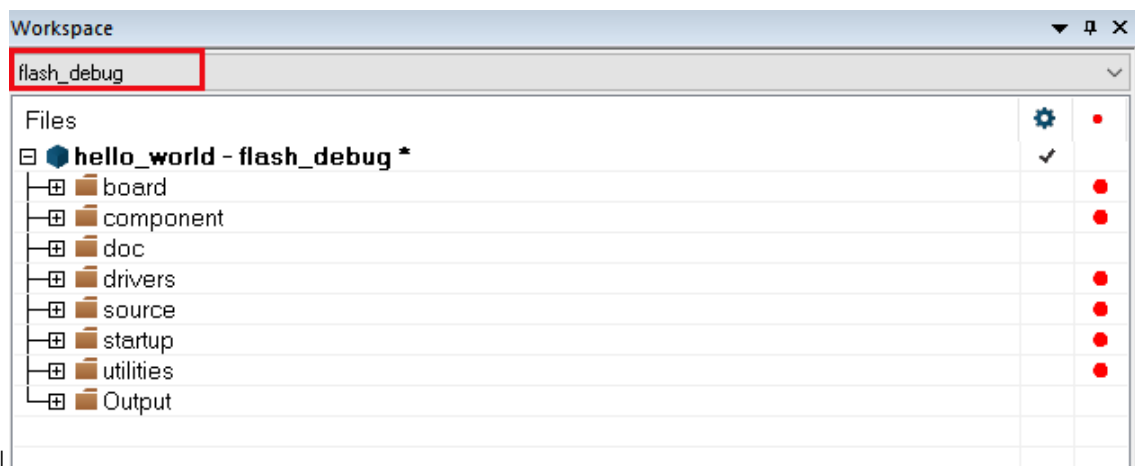
1. If not already done, open the desired demo application workspace. Most example application workspace files can be located using the following path:

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

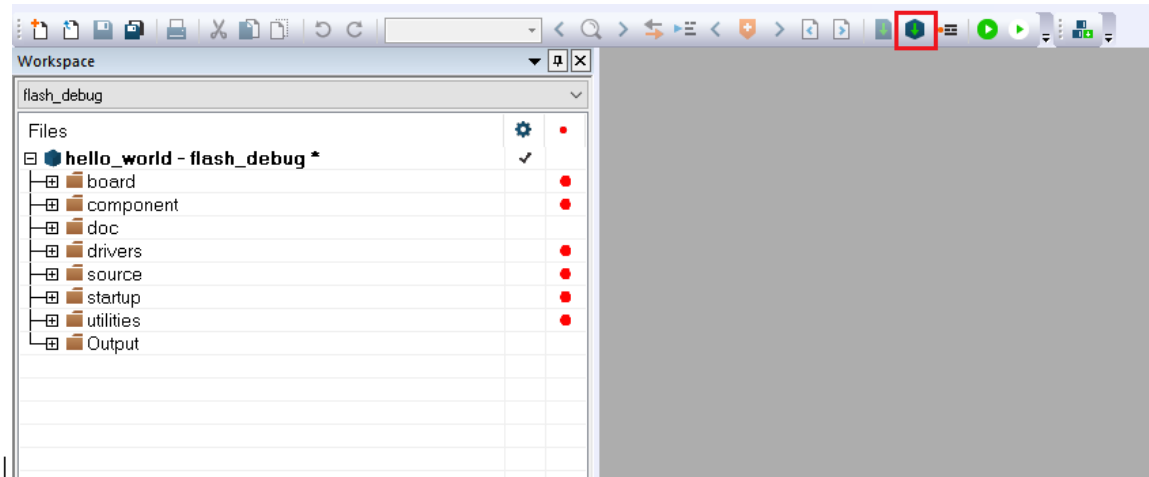
Using the i.MX 8M Plus EVK board as an example, the workspace is located in:

```
<install_dir>/boards/evkmimx8mp/demo_apps/hello_world/iar/hello_world.eww
```

2. Select the desired build target from the drop-down. For this example, select **hello_world – flash_debug**.



3. To build the demo application, click **Make**, highlighted in red in the following figure.

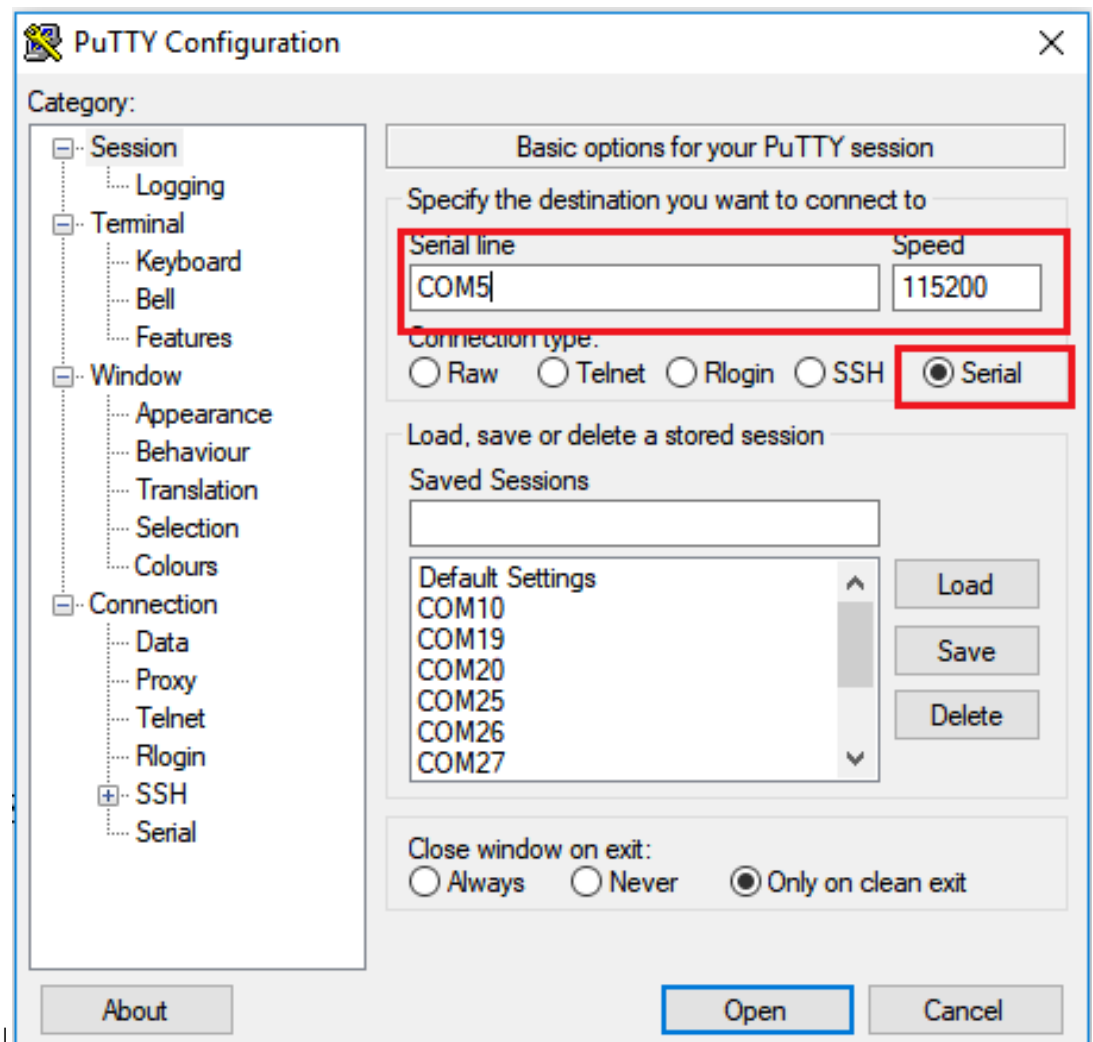


4. The build completes without errors.
5. Copy it to the UUU tool directory.

Parent topic: [Run a flash target demo by UUU](#)

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

1. Connect the development platform to your PC via USB cable between the J23 USB DEBUG connector and the PC. It provides console output while using UUU.
2. Connect the J6 USB Type-C connector and the PC. It provides the data path for UUU.
3. Open the terminal application on the PC, such as PuTTY or TeraTerm, and connect to the debug COM port (to determine the COM port number, see [How to determine COM port](#)). Configure the terminal with these settings:
 1. 115200 baud rate
 2. No parity
 3. 8 data bits



4. 1 stop bit |

4. Get the fspi version U-Boot image named **imx-boot-imx8mpevk-fspi.bin-flash_evk_flexspi** from the linux release package.
5. In the command line, execute uuu to get script for qspi: `uuu -bshow qspi > qspi_auto.sh`.

Then edit `qspi_auto.sh`, replace this line:

FB: ucmd if qspihdr dump \${fastboot_buffer}; then setenv qspihdr_exist yes; else setenv qspihdr_exist no; fi;

with the below line:

```
FB: ucmd setenv fastboot_buffer ${loadaddr}
FB: download -f _image

FB: ucmd if test ! -n "$fastboot_bytes"; then setenv fastboot_bytes $filesize; else true; fi

# Check Image if include flexspi header
#FB: ucmd if qspihdr dump ${fastboot_buffer}; then setenv qspihdr_exist yes; else setenv qspihdr_exist no; fi;
FB: ucmd setenv qspihdr_exist no

FB: t 60000; ucmd if test $(qspihdr_exist) = yes; then qspihdr init $(fastboot_buffer) $(fastboot_bytes) safe; else
true; fi;

#If uboot can't support qspihdr command, use uboot image to write qspi image, which require image include qspi flash
header
FB: ucmd if test $(qspihdr_exist) = no; then sf probe; else true; fi;
FB: t 40000; ucmd if test $(qspihdr_exist) = no; then sf erase 0 $(fastboot_bytes); else true; fi;
FB: t 20000; ucmd if test $(qspihdr_exist) = no; then sf write $(fastboot_buffer) 0 $(fastboot_bytes); else true; fi;
;
FB: done
-> $ uuu uuu qspi_auto.sh
uuu (Universal Update Utility) for nxp imx chips -- libuuu.1.5.141-18.g764f0fe

Success 1 Failure 0

2:181 9/ 9 [Done] ] FB: done
```

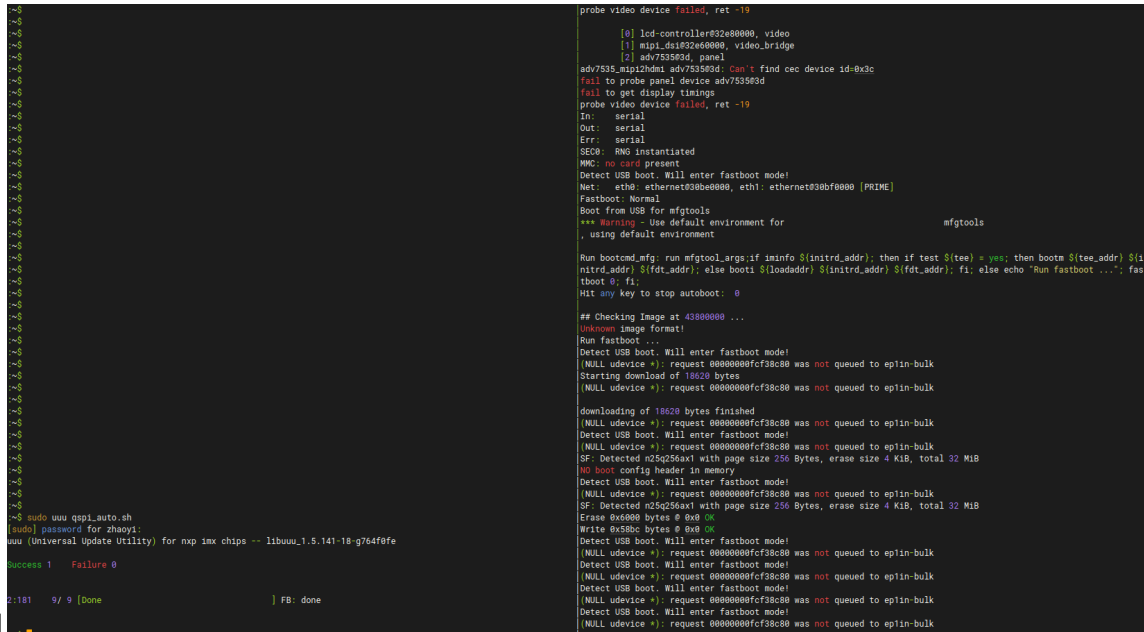
FB: ucmd setenv qspihdr_exist no |

6. rename file `imx-boot-imx8mpevk-fspi.bin-flash_evk_flexspi` with `_flexspi.bin`,
rename `hello_world.bin` with `_image`

7. In the command line, execute `uuu` with the `qspi_auto.sh`:

```
uuu qspi_auto.sh
```

The UUU puts the platform into fast boot mode and automatically flashes the target bin to QSPI. The command line and fast boot console is as shown (run_an_example_application.md#COMMANDLINEFASTBOOT).



```

probe video device failed, ret -19
[0] lcd-controller@32e0000, video
[1] mipi-dsi@32e0000, video-bridge
[2] adv7535@3d, panel
adv7535_mipi2hdmi adv7535@3d: can't find cec device id=0x3c
fail to probe panel device adv7535@3d
fail to get display timings
probe video device failed, ret -19
In: serial
Out: serial
Err: serial
SEC0: RWG instantiated
MMC: no card present
Detect USB boot. Will enter fastboot mode!
Net: eth0: ethernet@30b0000, eth1: ethernet@30b0000 (PRIME)
Fastboot: Normal
Boot from USB for mfgtools
*** Warning - Use default environment for mfgtools
, using default environment

Run bootcmd_mfg: run mfgtool_args; if isinfo ${initrd_addr}; then if test ${tee} = yes; then bootm ${tee_addr} ${i
nitrd_addr} ${fdt_addr}; else bootl ${loadaddr} ${initrd_addr} ${fdt_addr}; fi; else echo "Run fastboot ..."; fas
tboot 0; fi;
Hit any key to stop autoboot: 0

## Checking Image at 43800000 ...
Unknown Image format!
Run fastboot ...
Detect USB boot. Will enter fastboot mode!
(NULL device *): request 00000000fc38c80 was not queued to epl-in-bulk
Starting download of 18620 bytes
(NULL device *): request 00000000fc38c80 was not queued to epl-in-bulk

downloading of 18620 bytes finished
(NULL device *): request 00000000fc38c80 was not queued to epl-in-bulk
Detect USB boot. Will enter fastboot mode!
(NULL device *): request 00000000fc38c80 was not queued to epl-in-bulk
SF: Detected n25q256x1 with page size 256 Bytes, erase size 4 KiB, total 32 MiB
No boot: config header in memory
Detect USB boot. Will enter fastboot mode!
(NULL device *): request 00000000fc38c80 was not queued to epl-in-bulk
SF: Detected n25q256x1 with page size 256 Bytes, erase size 4 KiB, total 32 MiB
Erase 0x0000 bytes 0 x0 OK
Write 0x0000 bytes 0 x0 OK
Detect USB boot. Will enter fastboot mode!
(NULL device *): request 00000000fc38c80 was not queued to epl-in-bulk
Detect USB boot. Will enter fastboot mode!
(NULL device *): request 00000000fc38c80 was not queued to epl-in-bulk
Detect USB boot. Will enter fastboot mode!
(NULL device *): request 00000000fc38c80 was not queued to epl-in-bulk
Detect USB boot. Will enter fastboot mode!
(NULL device *): request 00000000fc38c80 was not queued to epl-in-bulk

```

8. Then, power off the board and change the boot mode to eMMC/SDHC3 [SW0010[1-4]], and power on the board again.
9. Use following command in U-Boot to kickoff m7:

```

sf probe
sf read ${loadaddr} 0 4
bootaux 0x8000000

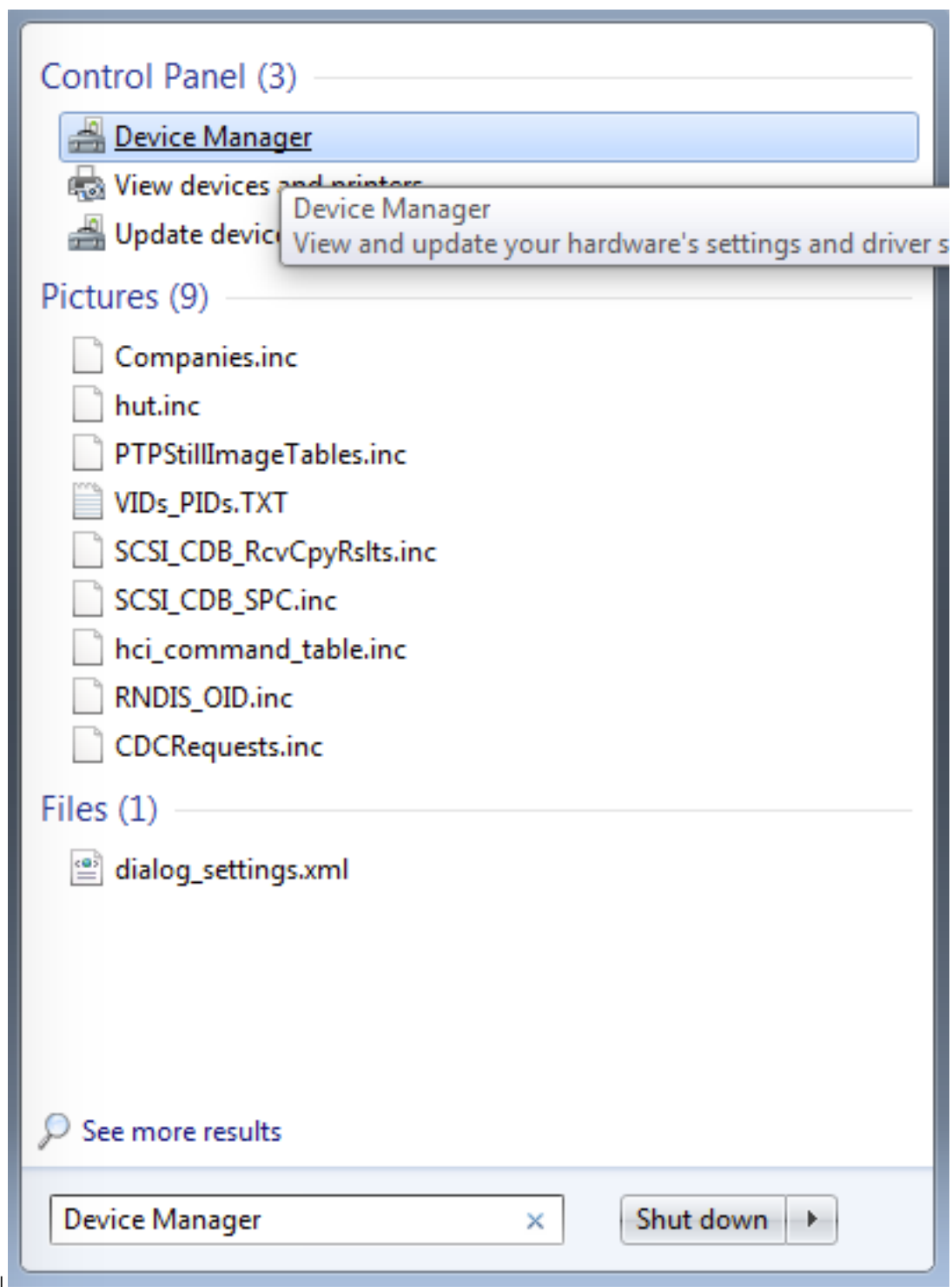
```

Parent topic: [Run a flash target demo by UUU](#)

How to determine COM port

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

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



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

1. **USB-UART interface**



1.3 Getting Started with MCUXpresso SDK GitHub

1.3.1 Getting Started with MCUXpresso SDK Repository

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

Overview

The GitHub Repository SDK approach offers:

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

Benefits of the Multi-Repository Approach

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

Setup and Configuration

Follow these steps to prepare your development environment:

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

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

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

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

Essential Tools

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

Installation:

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

Setup:

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

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

Installation:

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

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

Installation:

```
pip install -U west
```

Minimum version: 1.2.0 or newer

Build System Tools

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

Recommended version: 3.30.0 or newer

Installation:

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

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

Minimum version: 1.12.1 or newer

Installation:

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

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

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

Installation: Follow the Ruby environment setup guide

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

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

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

Windows:

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

Linux/macOS:

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

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

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

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

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

Python/pip issues:

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

Slow downloads:

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

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

Prerequisites Verify the requirements:

System Requirements:

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

Verification Commands:

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

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

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

Get the latest SDK from main branch:

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

Get SDK at specific revision:

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

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

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

```
cd mcuxpresso-sdk
```

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

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

```
west update
```

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

Best for:

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

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

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

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

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

Best for:

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

Examples:

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

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

Step 3: Verify Installation

Confirm successful setup:

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

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

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

Board-Specific Setup

Update only repositories required for a specific board:

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

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

Device-Specific Setup

Update only repositories required for a specific device family:

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

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

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

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

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

Benefits of Targeted Setup Reduced Download Size

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

Optimized Workspace

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

Flexible Development

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

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

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

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

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

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

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

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

Workspace Management

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

For Complete SDK Workspace:

```
# Update manifest repository
cd manifests
git pull

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

For Targeted Workspace:

```
# Update manifest repository
cd manifests
git pull

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

Workspace Status Check workspace synchronization status:

```
# Show status of all repositories
west status

# Show detailed information about repositories
west list
```

Troubleshooting Network Issues:

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

Permission Issues:

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

Disk Space:

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

Repository Management Issues:

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

Next Steps With your workspace initialized:

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

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

Explore SDK Structure and Content

Learn about the organization of the SDK and its components:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Top-Level Organization

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

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

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

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

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

Common Example Files

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

Board-Specific Files

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

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


```

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

```

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

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

Documentation Structure SDK documentation is distributed across multiple locations:

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

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

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

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

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

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

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

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

Development Workflows

Get started with building and running projects:

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

Prerequisites

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

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

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

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

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

Basic Build Process

Simple Build Build the hello_world example with default settings:

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

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

Specifying Configuration

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

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

Alternative Toolchains

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

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

Multicore Applications For multicore devices, specify the core ID:

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

For multicore projects using sysbuild:

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

Flash an Application Flash the built application to your board:

```
west flash -r linkserver
```

Debug Start a debug session:

```
west debug -r linkserver
```

Common Build Options

Clean Build Force a complete rebuild:

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

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

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

Device Variants For boards supporting multiple device variants:

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

Project Configuration

CMake Configuration Only Run configuration without building:

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

Interactive Configuration Launch the configuration GUI:

```
west build -t guiconfig
```

Troubleshooting

Build Failures Use pristine builds to resolve dependency issues:

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

Getting Help View the help information for west build:

```
west build -h
```

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

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

Next Steps

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

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

Prerequisites

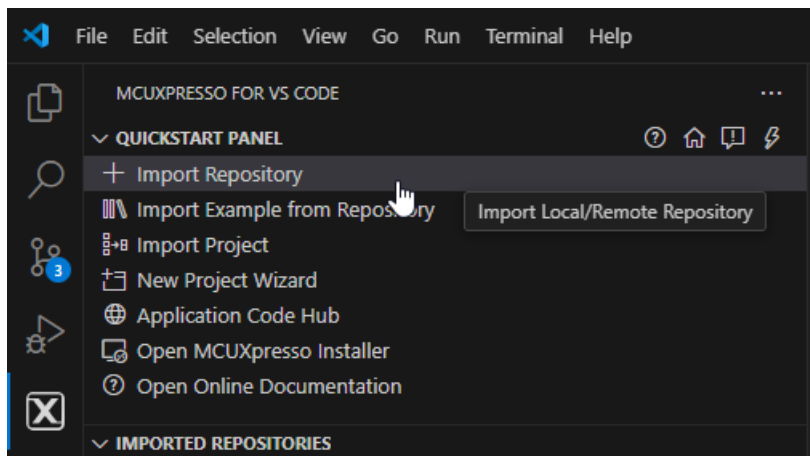
- SDK workspace initialized (GitHub Repository SDK or Repository-Layout SDK Package)
- Development tools installed per [Installation Guide](#)
- Visual Studio Code installed
- MCUXpresso for VS Code extension installed

Extension Installation

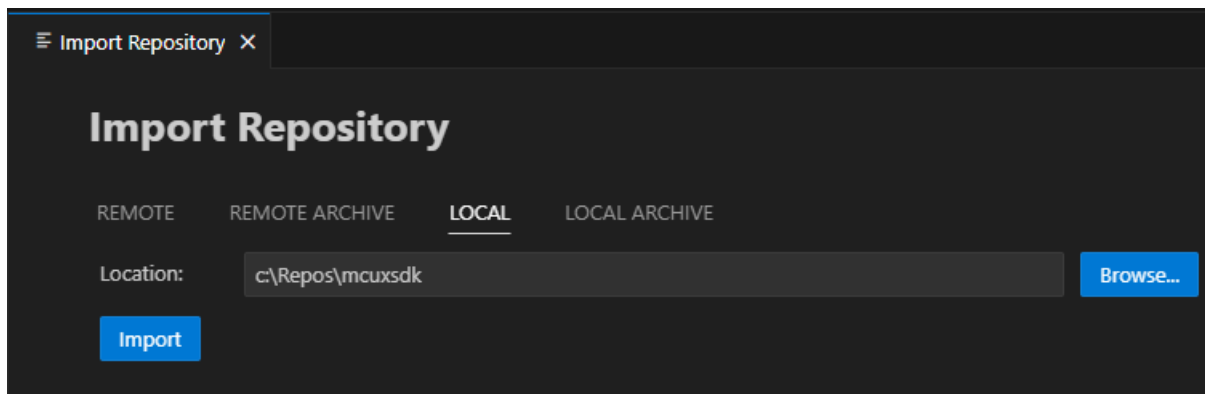
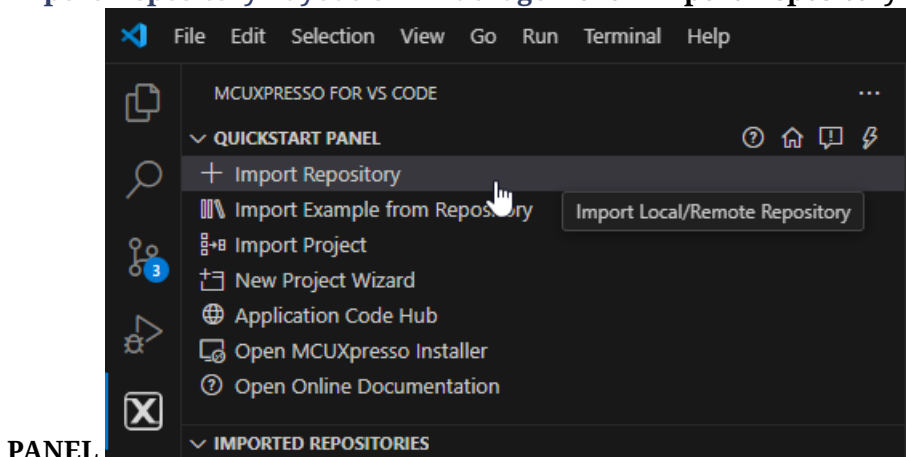
Install MCUXpresso for VS Code The MCUXpresso for VS Code extension provides integrated development capabilities for MCUXpresso SDK projects. Refer to the [MCUXpresso for VS Code Wiki](#) for detailed installation and setup instructions.

SDK Import and Setup

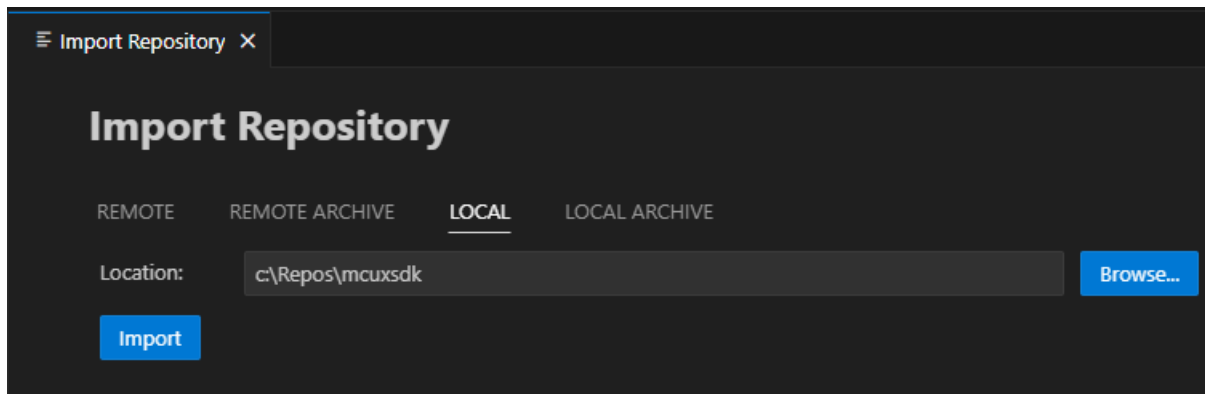
Import Methods The SDK can be imported in several ways. The MCUXpresso for VS Code extension supports both GitHub Repository SDK and Repository-Layout SDK Package distributions.

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

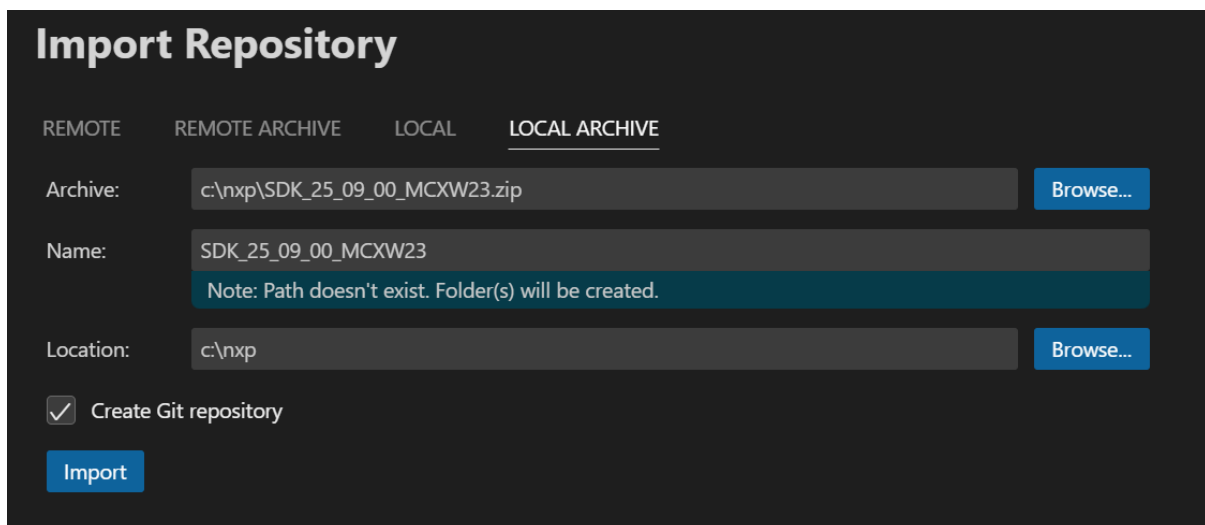
Note: You can import the SDK in several ways. Refer to [MCUXpresso for VS Code Wiki](#) for details. Select **Local** if you've already obtained the SDK according to [setting up the repo](#). Select your location and click **Import**.

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

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



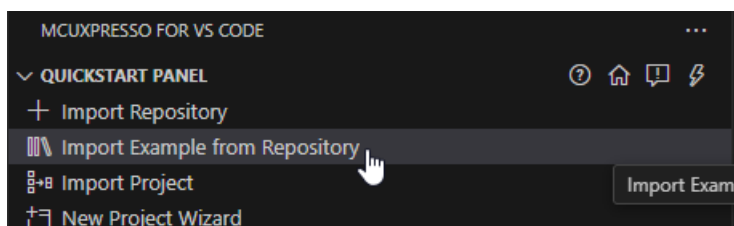
Else if the SDK is ZIP archive, select **Local Archive**, browse to the downloaded SDK ZIP file, fill the link of expect location, then click **Import**.



Building Example Applications

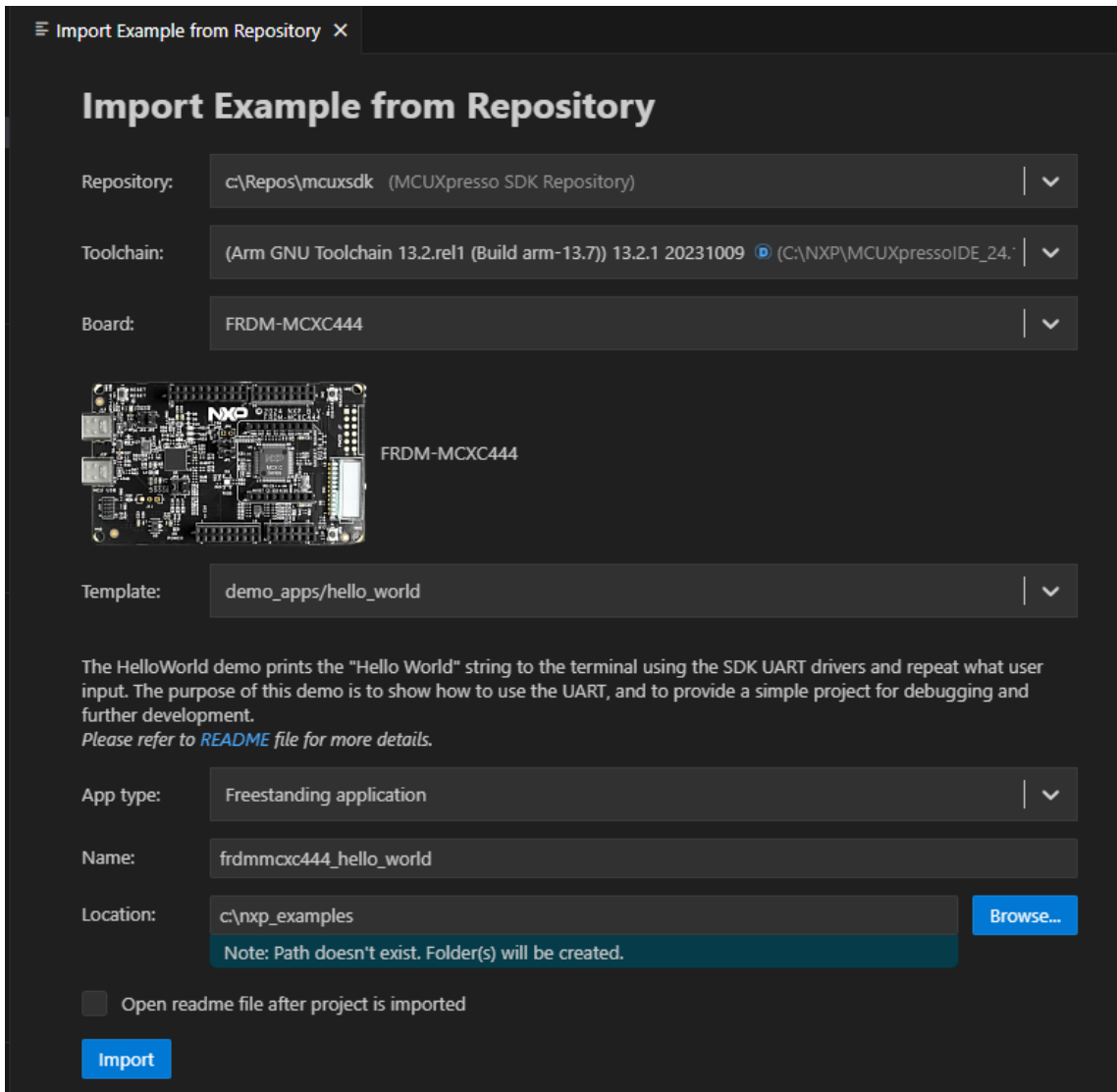
Import Example Project

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



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

3. Click **Import**



Import Example from Repository X

Import Example from Repository

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

Toolchain: (Arm GNU Toolchain 13.2.rel1 (Build arm-13.7)) 13.2.1 20231009 | v

Board: FRDM-MCXC444 | v



FRDM-MCXC444

Template: demo_apps/hello_world | v

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

App type: Freestanding application | v

Name: frdmmcxc444_hello_world

Location: c:\nxp_examples | Browse...

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

☐ Open readme file after project is imported

Import

Application Types Repository Applications:

- Located inside the MCUXpresso SDK
- Integrated with SDK workspace

Freestanding Applications:

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

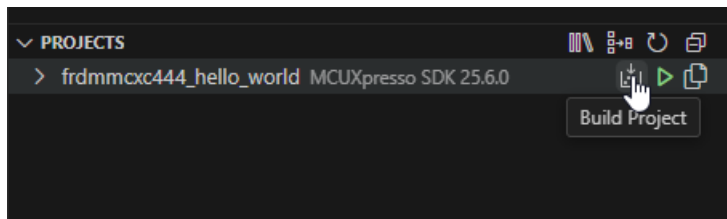
Trust Confirmation VS Code will prompt you to confirm if the imported files are trusted. Click **Yes** to proceed.

Building Projects

Build Process

1. Navigate to **PROJECTS** view

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

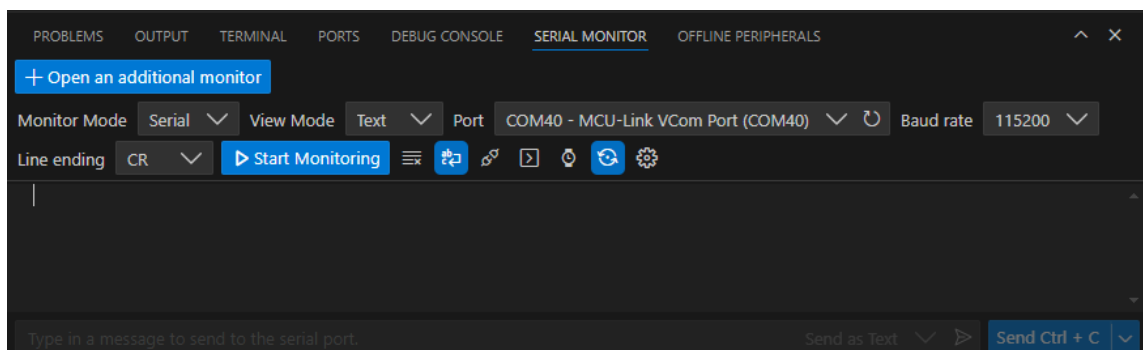


The integrated terminal will display build output at the bottom of the VS Code window.

Running and Debugging

Serial Monitor Setup

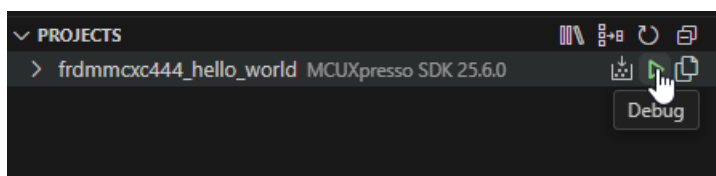
1. Open **Serial Monitor** from VS Code's integrated terminal



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

Debug Session

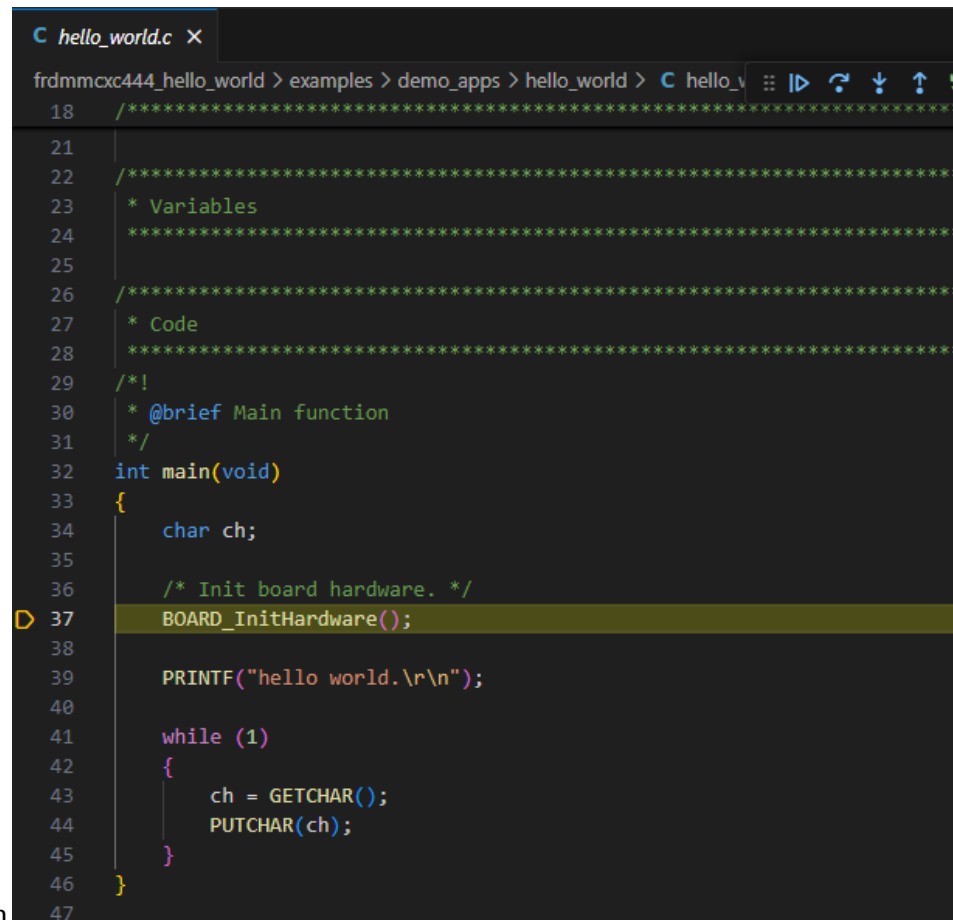
1. Navigate to **PROJECTS** view
2. Click the play button to initiate a debug session



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

Debug Controls Use the debug controls to manage execution:

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



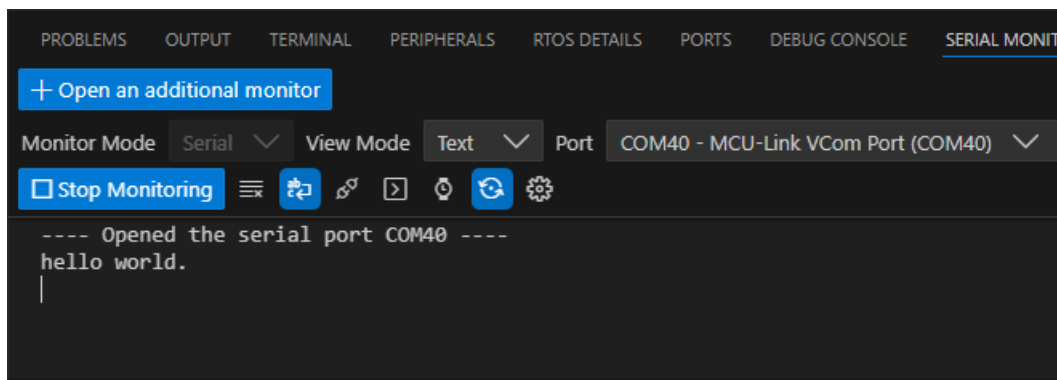
```

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

```

- **Stop:** Terminate debug session

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



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

Project Configuration

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

- Example applications
- Board configurations

- Middleware components
- Build system integration

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

Troubleshooting

Import Issues SDK not detected:

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

Project import failures:

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

Build Problems Build failures:

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

Debug Issues Debug session fails:

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

Serial monitor problems:

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

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

Advanced Features

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

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

Next Steps

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

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

Prerequisites

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

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

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

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

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

Basic Build Commands

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

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

Specifying Build Configuration

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

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

Multicore Applications For multicore devices, specify the core ID:

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

For multicore projects using sysbuild:

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

Shield Support For boards with shields:

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

Advanced Build Options

Clean Builds Force a complete rebuild:

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

Dry Run See what commands would be executed:

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

Device Variants For boards supporting multiple device variants:

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

Project Configuration

CMake Configuration Only Run configuration without building:

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

Interactive Configuration Launch the configuration GUI:

```
west build -t guiconfig
```

Flashing and Debugging

Flash Application Flash the built application to your board:

```
west flash -r linkserver
```

Debug Session Start a debugging session:

```
west debug -r linkserver
```

IDE Project Generation Generate IDE project files for traditional IDEs:

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

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

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

Troubleshooting

Build Failures Use pristine builds to resolve dependency issues:

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

Toolchain Issues Verify environment variables are set correctly:

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

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

Getting Help Display help information:

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

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

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

Best Practices

Project Organization

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

Build Efficiency

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

Development Workflow

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

Next Steps

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

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

Prerequisites

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

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

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

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

Manual Workflow Use the following steps:

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

```
west cfg_project_info -b lpcpresso55s69 ...mcuxsdk/examples/demo_apps/hello_world/ -Dcore_
↪ id=cm33_core0
```

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

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

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

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

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

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

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

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

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

1.4 Release Notes

1.4.1 MCUXpresso SDK Release Notes

Overview

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

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

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

MCUXpresso SDK

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

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

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

Development tools

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

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

Supported development systems

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

De- velop- ment boards	MCU devices
EVK-MIMX8MP	MIMX8ML3CVNKZ, MIMX8ML3DVNLZ, MIMX8ML4CVNKZ, MIMX8ML4DVNLZ, MIMX8ML5CVNKZ, MIMX8ML5DVNLZ, MIMX8ML6CVNKZ, MIMX8ML6DVNLZ, MIMX8ML8CVNKZ, MIMX8ML8DVNLZ , MIMX8ML2CVNKZ, MIMX8ML2DVNLZ

MCUXpresso SDK release package

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

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

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

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

RTOS

FreeRTOS Real-time operating system for microcontrollers from Amazon

Middleware

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

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

TinyCBOR Concise Binary Object Representation (CBOR) Library

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

Multicore Multicore Software Development Kit

llhttp HTTP parser llhttp

FreeMASTER FreeMASTER communication driver for 32-bit platforms.

Release contents

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

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

Known issues

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

Cannot add SDK components into FreeRTOS projects

It is not possible to add any SDK components into FreeRTOS project using the MCUXpresso IDE New Project wizard.

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
-

AIPSTZ**[2.0.1]**

- Bug Fixes
 - MISRA C-2012 issue fixed: rule 10.3, 10.4, and 14.4.

[2.0.0]

- Initial version.
-

eASRC**[2.0.7]**

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

[2.0.6]

- Improvements
 - Updated use of definitions in the function `ASRC_SetSlotConfig` and `ASRC_EnableContextSlot`.

[2.0.5]

- Improvements
 - Fixed the typo and multichannel configuration issues in asrc driver.
 - Updated the asrc firmware table for better THD performance.

[2.0.4]

- Improvements
 - Corrected the data width support by IEC60958,
 - Updated the default stage1 result to float to avoid convert result distortion.

[2.0.3]

- Bug Fixes
 - Corrected the btis shift index used in function `ASRC_TransferBlocking`.
 - Ensured the resampler and prefilter are not in bypass mode when the conversion require the function.

[2.0.2]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 10.1, 10.3, 10.4, 14.3, 14.4, 16.3, 16.1, 16.8, 17.7.

[2.0.1]

- Bug Fixes
 - Fixed the context id hard code issue in the function ASRC_TransferInCreateHandleSDMA/ASRC_TransferOutCreateHandleSDMA.
- Improvements
 - Added support for the data size bigger than 64K in sdma driver.

[2.0.0]

- Initial version.
-

ASRC_SDMA

[2.0.4]

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

[2.0.3]

- Refer asrc driver change log 2.0.0 to 2.0.3
-

CACHE ARMv7-M7

[2.0.5]

- Bug Fixes
 - Fixed cache operations to handle zero size and overflow in invalidate/clean functions

[2.0.4]

- Bug Fixes
 - Fixed doxygen issue.

[2.0.3]

- Improvements
 - Deleted redundancy code about calculating cache clean/invalidate size and address aligns.

[2.0.2]

- Bug Fixes
 - Fixed violation of MISRA C-2012 Rule 10.1, 10.3 and 10.4.

[2.0.1]

- Bug Fixes
 - Fixed cache size issue in L2CACHE_GetDefaultConfig API.

[2.0.0]

- Initial version.
-

COMMON**[2.6.3]**

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

[2.6.2]

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

[2.6.1]

- Improvements
 - Support Cortex M23.

[2.6.0]

- Bug Fixes
 - Fix CERT-C violations.

[2.5.0]

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

[2.4.3]

- Improvements
 - Enable 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 `stdint.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.
-

ECSPI**[2.3.3]**

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

[2.3.2]

- Improvements
 - Changed ECSPI_DUMMYDATA to 0x00.

[2.3.1]

- Bug Fixes
 - Fixed ECSPI_GetInstance potential issue that return wrong instance number.

[2.3.0]

- Bug Fixes
 - Fixed burst length issue,the burst length range shall range from 1-4096 bits, so the width shall be uint8_t rather than uint16_t.

[2.2.0]

- Bug Fixes
 - Removed the useless channel configuration of waveform, since the waveform can not be configured when not using the exchange bit(ECSPIx_CONREG[XCH]) for the transfer.
 - Fixed violations of MISRA C-2012 rules: 10.1, 11.9, 8.4.

[2.1.1]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rules: 10.1, 10.3, 10.4, 11.9, 14.4, 15.7, 17.7.

[2.1.0]

- Improvements
 - Added timeout mechanism when waiting certain states in transfer driver.

[2.0.2]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rules: 10.1, 10.3, 10.4

[2.0.1]

- Bug Fixes
 - Memset local variable SDMA transfer configuration structure to make sure unused members in structure are cleared.
 - Fixed sign-compare warning in ECSPI_SendTransfer.

[2.0.0]

- Initial version.
-

EDMA (DMA3)

[2.5.3]

- Bug Fixes
 - Fixed coverity issues with CERT INT30-C, CERT INT31-C compliance.
 - Fixed violations of MISRA C-2012 rule 10.4, 8.5.

[2.5.2]

- Bug Fixes
 - Fixed the EDMA header index retrieval error caused by done bit calculation mistake issue.

[2.5.1]

- Bug Fixes
 - enables the auto stop request feature in API EDMA_ResetChannel

[2.5.0]

- Improvements
 - Add API EDMA_GetTransferSize for EDMA_PrepareTransferConfig to reduce HIS CCM value.

[2.4.0]

- Improvements
 - Added peripheral to peripheral support in DMA3 driver.
- Bug Fixes
 - Fixed the ERQ bit reading error issue.

[2.3.2]

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

[2.3.1]

- Bug Fixes
 - Added clear TCD_CITER_ELINKNO and TCD_BITER_ELINKNO registers in EDMA_AbortTransfer to make sure the TCD registers in a correct state for next calling of EDMA_SubmitTransfer.

[2.3.0]

- Improvements
 - Added feature FSL_FEATURE_EDMA_HAS_NO_SBR_ATTR_BIT to separate DMA without ATTR bitfield.

[2.2.7]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 10.8, 5.6.

[2.2.6]

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

[2.2.5]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 10.1, 10.4.

[2.2.4]

- Bug Fixes
 - Fix the issue that EDMA_AbortTransfer not reset edma handle(tcdUsed, tail, header) and fix EDMA_InstallTCDMemory(handle->header = 1)

[2.2.3]

- Improvements
 - Added feature FSL_FEATURE_EDMA_MODULE_CHANNEL_IRQ_ENTRY_SUPPORT_PARAMETER to support driver IRQ handler with parameters.
 - Added feature FSL_FEATURE_EDMA_HAS_COMMON_CLOCK_GATE to improve clock gate control in dma driver.

[2.2.2]

- Bug Fixes
 - Fixed the issue of EDMA_SubmitTransfer return busy when calling EDMA_EnableChannelInterrupts before submit transfer.
 - Fixed violations of MISRA C-2012 rule 10.4, 10.1, 9.2, 10.4, 10.6, 14.4, 10.7, 14.3, 11.6.

[2.2.1]

- Improvements
 - Removed channel MUX reset from `EDMA_ResetChannel`, since channel mux should be constant while channel is alive.

[2.2.0]

- Improvements
 - Added new API `EDMA_SetChannelMux` to support channel mux feature.
 - Added new API `EDMA_PrepareTransferConfig` to expose parameters source offset and destination offset.
 - Exposed `EDMA_InstallTCD` function to application.
 - Added source/destination address alignment check.

[2.1.1]

- Improvements
 - Added 8bytes transfer width feature support in driver.

[2.1.0]

- Bug Fixes
 - Added const type for parameter configuration in `EDMA_SubmitTransfer` and `EDMA_HandleTransferConfig` API.
 - Added configurations for `srcAddr` and `destAddr` in `EDMA_PrepareTransfer` API.

[2.0.2]

- Improvements
 - Updated eDMA driver to support `MP_CR` bit `GMRC`.
 - Updated eDMA instance name for i.MX 8QM.
 - Used instance number as factor to calculate channel number for different instance instead of hard code.

[2.0.1]

- New Features
 - Added control macro to enable/disable the `CLOCK` code in current driver.
 - Added `s_EDMAEnabledChannel` to record enabled channel to merge all the channel IRQ handler into driver IRQ handler.
 - Added feature macro for bits `EMI` and `EBW` in `MP_CSR`.
- Improvements
 - Removed all the separated channel IRQ handler in DMA driver.

[2.0.0]

- Initial version.
-

ENET**[2.11.0]**

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

[2.10.1]

- Bug Fixes
 - Fixed WAKEUP interrupt not being handled.

[2.10.0]

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

[2.9.3]

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

[2.9.2]

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

[2.9.1]

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

[2.9.0]

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

[2.8.0]

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

[2.7.1]

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

[2.7.0]

- Improvements
 - Deleted deprecated zero copy Tx/Rx functions and set callback function which can be configured in ENET_Init.
 - Moved the Rx zero copy buffer allocation to Rx BD initialization function to reduce unnecessary looping code.
- Bug Fixes
 - Fixed the issue that predefined Rx buffers which should not be used when enabling Rx zero copy are still be handled by cache operation, it causes hardfault on some platforms.
 - Fixed the issue that zero-copy Rx function doesn't check Rx length of 0 in the BD with EMPTY bit is 0, it may occur in the corner case reported by customer. Not sure how it turns out, consider it as an ENET IP issue and drop this abnormal BD.

[2.6.3]

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

[2.6.2]

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

[2.6.1]

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

[2.6.0]

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

[2.5.4]

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

[2.5.3]

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

[2.5.2]

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

[2.5.1]

- Bug Fixes
 - Fixed document typo.

[2.5.0]

- Bug Fixes
 - Fixed the SendFrame/SendFrameZeroCopy functions issue with scattered buffers.
 - Updated the formula of MDC calculation.
 - Used a feature macro to distinguish the old IP design from the new design, because old IP design always reads a value zero from ATCR->CAPTURE bit. For old IP, driver calculates and wait the necessary delay cycles after setting ATCR->CAPTURE then gets the timestamp value.
- New Features
 - Added new zero copy Tx/Rx function.

- New zero copy Tx function combines scattered and contiguous Tx buffer in one API, it also supports more Tx features which buffer descriptor supports but previous Tx function doesn't support.
- New zero copy Rx function use dynamic buffer mechanism and simpler interface.
- Improvements
 - Corrected the interrupt handler for PTP timestamp IRQ and PTP1588 event IRQ since platform difference.
 - Added missing IRQ handlers for PTP1588 events on some platforms.
 - Corrected the max Tx frame length verification, it will not depend on a fixed macro. The ENET_FRAME_MAX_FRAMELEN is only an default value for driver, application can configure it. Driver calculates the limitation with the max frame length in register which may takes extended 4 or 8 bytes VLAN tag if VLAN/SVLAN enables.
 - Deleted deprecated Clause 45 read/write legacy APIs.

[2.4.3]

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

[2.4.2]

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

[2.4.1]

- Bug Fixes
 - Fixed the PTP time capture issue.

[2.4.0]

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

[2.3.4]

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

[2.3.3]

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

[2.3.2]

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

[2.3.1]

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

[2.3.0]

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

[2.2.6]

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

[2.2.5]

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

[2.2.4]

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

[2.2.3]

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

[2.2.2]

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

[2.2.1]

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

[2.1.1]

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

[2.0.1]

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

[2.0.0]

- Initial version.
-

ENET_QOS

[2.7.2]

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

[2.7.1]

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

[2.7.0]

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

[2.6.5]

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

[2.6.4]

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

[2.6.3]

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

[2.6.2]

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

[2.6.1]

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

[2.6.0]

- New features
 - Added hardware checksum acceleration support.

[2.5.3]

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

[2.5.2]

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

[2.5.1]

- Improvements
 - Supported RMII mode.

[2.5.0]

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

[2.4.1]

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

[2.4.0]

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

[2.3.0]

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

[2.2.2]

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

[2.2.1]

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

[2.2.0]

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

[2.1.1]

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

[2.1.0]

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

[2.0.0]

- Initial version.
-

FLEXCAN

[2.14.5]

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

[2.14.4]

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

[2.14.3]

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

[2.14.2]

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

[2.14.1]

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

[2.14.0]

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

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

[2.13.1]

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

[2.13.0]

- Improvements
 - Support payload endianness selection feature.

[2.12.0]

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

[2.11.8]

- Improvements
 - Synchronize flexcan driver update on s32z platform.

[2.11.7]

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

[2.11.6]

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

[2.11.5]

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

[2.11.4]

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

[2.11.3]

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

[2.11.2]

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

[2.11.1]

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

[2.11.0]

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

[2.10.1]

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

[2.10.0]

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

[2.9.2]

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

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

[2.9.1]

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

[2.9.0]

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

[2.8.7]

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

[2.8.6]

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

[2.8.5]

- Improvements
 - Make driver aarch64 compatible.

[2.8.4]

- Bug Fixes
 - Fixed FlexCan_Errata_6032 to disable all interrupts.

[2.8.3]

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

[2.8.2]

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

[2.8.1]

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

[2.8.0]

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

[2.7.1]

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

[2.7.0]

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

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

[2.6.2]

- Improvements
 - Add CANFD frame data length enumeration.

[2.6.1]

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

[2.6.0]

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

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

[2.5.2]

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

[2.5.1]

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

[2.5.0]

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

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

[2.4.0]

- Bug Fixes
 - MISRA C-2012 issue check.

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

[2.3.2]

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

[2.3.1]

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

[2.3.0]

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

[2.2.3]

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

[2.2.2]

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

[2.2.1]

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

[2.2.0]

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

[2.1.0]

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

[2.0.0]

- Initial version.
-

GPC**[2.2.0]**

- Improvements
 - Optimized the exited APIs to support extended IRQs and slots.
- Bug Fixes
 - Fixed the violations of MISRA C-2012 rules.

[2.1.0]

- Improvements
 - Unified the register or bit fields' name which contains specific cortex M core information.
- Bug Fixes
 - Fixed Coverity Out-of-bounds issue.

[2.0.1]

- Improvements
 - Added parameters to enable/disable the WFI and DSM mask.

[2.0.0]

- Initial version.
-

GPIO

[2.0.7]

- Bug Fixes
 - Fixed coverity MSG issues with CERT INT30-C compliance.

[2.0.6]

- Bug Fixes
 - Fixed compile warning: ‘GPIO_GetInstance’ defined but not used when macro FSL_SDK_DISABLE_DRIVER_CLOCK_CONTROL is defined.

[2.0.5]

- Bug Fixes
 - Fixed MISRA C-2012 issue: rule-17.7.

[2.0.4]

- Improvements
 - Updated the GPIO_PinWrite to use atomic operation if possible.
- Bug Fixes
 - Fixed GPIO_PortToggle bug with platforms don’t have register DR_TOGGLE.

[2.0.3]

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

[2.0.2]

- Bug Fixes
 - Fixed the bug of enabling wrong GPIO clock gate in initial API. Since some GPIO instances may not have a clock gate enabled, it checks the clock gate number and makes sure the clock gate is valid.

[2.0.1]

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

[2.0.0]

- Initial version.
-

GPT**[2.0.6]**

- Bug Fixes
 - Fix CERT INT30-C issues.

[2.0.5]

- Improvements
 - Support workaround for ERR003777. This workaround helps switching the clock sources.

[2.0.4]

- Bug Fixes
 - Fixed compiler warning when built with `FSL_SDK_DISABLE_DRIVER_CLOCK_CONTROL` flag enabled.

[2.0.3]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 5.3 by customizing function parameter.

[2.0.2]

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

[2.0.1]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 10.1, 10.3, 10.4, 10.6, 10.8, 17.7.

[2.0.0]

- Initial version.
-

I2C

[2.0.7]

- Bug Fixes
 - Fixed MISRA issues.
 - * Fixed rules 8.4, 8.5.

[2.0.6]

- Bug Fixes
 - Fixed the bug that, in I2C_MasterStop after the stop command is issued, the IBB flag should be cleared rather than set.
 - Fixed the bug that to clear kI2C_ArbitrationLostFlag and kI2C_IntPendingFlag, their bits should be written '0' rather than '1'.

[2.0.5]

- Bug Fixes
 - Fixed Coverity issue of unchecked return value in I2C_RTOS_Transfer.
 - Fixed MISRA issues.
 - * Fixed rules 10.1, 10.3, 10.4, 11.9, 14.4, 15.7, 16.4, 17.7.
- Improvements
 - Updated the I2C_WAIT_TIMEOUT macro to unified name I2C_RETRY_TIMES.

[2.0.4]

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

[2.0.3]

- Improvements
 - Improved code readability, added new static API I2C_WaitForStatusReady for the status flag wait, and changed to call I2C_WaitForStatusReady instead of polling flags with reading register.

[2.0.2]

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

[2.0.1]

- Bug Fixes
 - Added a proper handle for transfer config flag kI2C_TransferNoStartFlag to support transmit with kI2C_TransferNoStartFlag flag. Only supports write only or write+read with no start flag; does not support read only with no start flag.

[2.0.0]

- Initial version.
-

MU**[2.3.1]**

- Bug Fixes
 - Fixed FSL_FEATURE_MU_HAS_RESET_DEASSERT_INT macro use.

[2.3.0]

- New Features
 - Added MU_BUSY_POLL_COUNT parameter to prevent infinite polling loops in MU operations.
 - Added timeout mechanism to all polling loops in MU driver code.
 - Added new function MU_ReceiveMsgTimeout() to include timeout mechanism.
- Improvements
 - Updated function signatures to return status codes for better error handling:
 - * Changed MU_ResetBothSides to return status_t instead of void
 - * Updated MU_SendMsg to return status_t for timeout indication
 - * Updated MU_ReceiveMsg to use MU_TIMEOUT_VALUE (0xFFFFFFFF) as a special return value to indicate timeout
 - Enhanced documentation across all functions to clarify timeout behavior and return values.

[2.2.0]

- New Features
 - Added API MU_GetRxStatusFlags.

[2.1.3]

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

[2.1.2]

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

[2.1.1]

- Bug Fixes
 - Fixed general interrupt comment typo.

[2.1.0]

- Improvements
 - Added new enum `mu_msg_reg_index_t`.

[2.0.7]

- Bug Fixes
 - Fixed `MU_GetInterruptsPending` bug that can not get general interrupt status.

[2.0.6]

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

[2.0.5]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 14.4, 15.5.

[2.0.4]

- Improvements
 - Improved for the platforms which don't support reset assert interrupt and get the other core power mode.

[2.0.3]

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

[2.0.2]

- Improvements
 - Added support for MIMX8MQx.

[2.0.1]

- Improvements
 - Added support for MCIMX7Ux_M4.

[2.0.0]

- Initial version.
-

PDM**[2.9.3]**

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

[2.9.2]

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

[2.9.1]

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

[2.9.0]

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

[2.8.1]

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

[2.8.0]

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

[2.7.4]

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

[2.7.3]

- Improvements
- Added feature `FSL_FEATURE_PDM_HAS_NO_VADEF` to remove the support of VADEF bit-field in `VADO_STAT` register.

[2.7.2]

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

[2.7.1]

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

[2.7.0]

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

[2.6.0]

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

[2.5.0]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 8.4, 16.5, 10.4, 10.3, 10.1, 11.9, 17.7, 10.6, 14.4, 11.8, 11.6.

[2.4.1]

- Bug Fixes
 - Fixed MDK 66-D warning in pdm driver.

[2.4.0]

- Improvements
 - Added api `PDM_TransferSetChannelConfig/PDM_ReadFifo` to support read different width data.
 - Added feature `FSL_FEATURE_PDM_HAS_RANGE_CTRL` and api `PDM_ClearRangeStatus/PDM_GetRangeStatus` for range register.
- Bug Fixes

- Fixed violation of MISRA C-2012 Rule 14.4, 10.3, 10.4.

[2.3.0]

- Improvements
 - Enabled envelope/energy voice detect mode by adding apis PDM_SetHwvadInEnvelopeBasedMode/PDM_SetHwvadInEnergyBasedMode.
 - Added feature FSL_FEATURE_PDM_CHANNEL_NUM for different SOC.

[2.2.1]

- Bug Fixes
 - Fixed violation of MISRA C-2012 Rule 10.1, 10.3, 10.4, 10.6, 10.7, 11.3, 11.8, 14.4, 17.7, 18.4.
 - Added medium quality mode support in function PDM_SetSampleRateConfig.

[2.2.0]

- Improvements
 - Added api PDM_SetSampleRateConfig to improve user experience and marked api PDM_SetSampleRate as deprecated.

[2.1.1]

- Improvements
- Used new SDMA API SDMA_SetDoneConfig instead of SDMA_EnableSwDone for PDM SDMA driver.

[2.1.0]

- Improvements
 - Added software buffer queue for transactional API.

[2.0.1]

- Improvements
 - Improved HWVAD feature.

[2.0.0]

- Initial version.
-

PDM_EDMA

[2.6.5]

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

[2.6.4]

- Improvements
 - Add handling for runtime change of number of linked transfers

[2.6.3]

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

[2.6.2]

- Improvements
 - Add macro `MCUX_SDK_PDM_EDMA_PDM_ENABLE_INTERNAL` to let the user decide whether to enable it when calling `PDM_TransferReceiveEDMA`.

[2.6.1]

- Bug Fixes
 - Fixed violation of MISRA C-2012 Rule 10.3, 10.4.

[2.6.0]

- Improvements
 - Updated api `PDM_TransferReceiveEDMA` to support channel block interleave transfer.
 - Added new api `PDM_TransferSetMultiChannelInterleaveType` to support channel interleave type configurations.

[2.5.0]

- Refer PDM driver change log 2.1.0 to 2.5.0
-

PDM_SDMA

[2.7.1]

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

[2.7.0]

- Improvements
 - Added new api `PDM_TransferTerminateReceiveSDMA` to reset all PDM SDMA internal state machine.

[2.6.0]

- Bug Fixes
 - Fixed burst length overflow issue when using multi fifo.
 - Added alignment check between transfer size and the fifo width.

[2.5.0]

- Refer PDM driver change log 2.1.0 to 2.3.1
-

PWM**[2.0.1]**

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

[2.0.0]

- Initial version.
-

RDC**[2.2.0]**

- New Features
 - Added APIs to get memory region or peripheral access policy for specific domain.

[2.1.1]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 10.6.

[2.1.0]

- Improvements
 - Enhanced to support memory region larger than 32-bit address.

[2.0.2]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 10.3, 10.4, 11.3, 11.8, 17.7.

[2.0.1]

- Bug Fixes:
 - Added __DSB after new configuration is set to ensure the new configuration takes effect.

[2.0.0]

- Initial version.
-

RDC_SEMA42

[2.0.5]

- Bug Fixes
 - Fixed CERT INT30-C issues.

[2.0.4]

- Improvements
 - Changed to implement RDC_SEMAPHORE_Lock base on RDC_SEMAPHORE_TryLock.

[2.0.3]

- Improvements:
 - Supported the RDC_SEMAPHORE_Type structure whose gate registers are defined as an array.

[2.0.2]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 10.3, 10.4, 10.8, 14.3, 14.4, 18.1.

[2.0.1]

- Improvements:
 - Added support for the platforms that don't have dedicated RDC_SEMA42 clock gate.

[2.0.0]

- Initial version.
-

SAI

[2.4.10]

- Improvements
 - Allow enabling/disabling implicit channel configuration.
 - Allow NULL FIFO watermark.
- Bug Fixes
 - Fix compilation warnings when asserts are disabled

[2.4.9]

- Added Errata ERR051421 workaround.

[2.4.8]

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

[2.4.7]

- Added conditional support for bit clock swap feature
- Added common IRQ handler entry SAI_DriverIRQHandler.

[2.4.6]

- Bug Fixes
 - Fixed the IAR build warning.

[2.4.5]

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

[2.4.4]

- Bug Fixes
 - Fixed enumeration sai_fifo_combine_t - add RX configuration.

[2.4.3]

- Bug Fixes
 - Fixed enumeration sai_fifo_combine_t value configuration issue.

[2.4.2]

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

[2.4.1]

- Bug Fixes
 - Fixed bitWidth incorrectly assigned issue.

[2.4.0]

- Improvements
 - Removed deprecated APIs.

[2.3.8]

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

[2.3.7]

- Improvements
 - Change feature “FSL_FEATURE_SAI_FIFO_COUNT” to “FSL_FEATURE_SAI_HAS_FIFO”.
 - Added feature “FSL_FEATURE_SAI_FIFO_COUNTn(x)” to align SAI fifo count function with IP in function

[2.3.6]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 5.6.

[2.3.5]

- Improvements
 - Make driver to be aarch64 compatible.

[2.3.4]

- Bug Fixes
 - Corrected the fifo combine feature macro used in driver.

[2.3.3]

- Bug Fixes
 - Added bit clock polarity configuration when sai act as slave.
 - Fixed out of bound access coverity issue.
 - Fixed violations of MISRA C-2012 rule 10.3, 10.4.

[2.3.2]

- Bug Fixes
 - Corrected the frame sync configuration when sai act as slave.

[2.3.1]

- Bug Fixes
 - Corrected the peripheral name in function SAI0_DriverIRQHandler.
 - Fixed violations of MISRA C-2012 rule 17.7.

[2.3.0]

- Bug Fixes
 - Fixed the build error caused by the SOC has no fifo feature.

[2.2.3]

- Bug Fixes
 - Corrected the peripheral name in function SAI0_DriverIRQHandler.

[2.2.2]

- Bug Fixes
 - Fixed the issue of MISRA 2004 rule 9.3.
 - Fixed sign-compare warning.
 - Fixed the PA082 build warning.
 - Fixed sign-compare warning.
 - Fixed violations of MISRA C-2012 rule 10.3,17.7,10.4,8.4,10.7,10.8,14.4,17.7,11.6,10.1,10.6,8.4,14.3,16.4,18.2
 - Allow to reset Rx or Tx FIFO pointers only when Rx or Tx is disabled.
- Improvements
 - Added 24bit raw audio data width support in sai sdma driver.
 - Disabled the interrupt/DMA request in the SAI_Init to avoid generates unexpected sai FIFO requests.

[2.2.1]

- Improvements
 - Added mclk post divider support in function SAI_SetMasterClockDivider.
 - Removed useless configuration code in SAI_RxSetSerialDataConfig.
- Bug Fixes
 - Fixed the SAI SDMA driver build issue caused by the wrong structure member name used in the function SAI_TransferRxSetConfigSDMA/SAI_TransferTxSetConfigSDMA.
 - Fixed BAD BIT SHIFT OPERATION issue caused by the FSL_FEATURE_SAI_CHANNEL_COUNTn.
 - Applied ERR05144: not set FCONT = 1 when TMR > 0, otherwise the TX may not work.

[2.2.0]

- Improvements
 - Added new APIs for parameters collection and simplified user interfaces:
 - * SAI_Init
 - * SAI_SetMasterClockConfig
 - * SAI_TxSetBitClockRate
 - * SAI_TxSetSerialDataConfig
 - * SAI_TxSetFrameSyncConfig
 - * SAI_TxSetFifoConfig
 - * SAI_TxSetBitclockConfig
 - * SAI_TxSetConfig
 - * SAI_TxSetTransferConfig

- * SAI_RxSetBitClockRate
- * SAI_RxSetSerialDataConfig
- * SAI_RxSetFrameSyncConfig
- * SAI_RxSetFifoConfig
- * SAI_RxSetBitclockConfig
- * SAI_RXSetConfig
- * SAI_RxSetTransferConfig
- * SAI_GetClassicI2SConfig
- * SAI_GetLeftJustifiedConfig
- * SAI_GetRightJustifiedConfig
- * SAI_GetTDMConfig

[2.1.9]

- Improvements
 - Improved SAI driver comment for clock polarity.
 - Added enumeration for SAI for sample inputs on different edges.
 - Changed FSL_FEATURE_SAI_CHANNEL_COUNT to FSL_FEATURE_SAI_CHANNEL_COUNTn(base) for the difference between the different SAI instances.
- Added new APIs:
 - SAI_TxSetBitClockDirection
 - SAI_RxSetBitClockDirection
 - SAI_RxSetFrameSyncDirection
 - SAI_TxSetFrameSyncDirection

[2.1.8]

- Improvements
 - Added feature macro test for the sync mode2 and mode 3.
 - Added feature macro test for masterClockHz in sai_transfer_format_t.

[2.1.7]

- Improvements
 - Added feature macro test for the mclkSource member in sai_config_t.
 - Changed “FSL_FEATURE_SAI5_SAI6_SHARE_IRQ” to “FSL_FEATURE_SAI_SAI5_SAI6_SHARE_IRQ”.
 - Added #ifndef #endif check for SAI_XFER_QUEUE_SIZE to allow redefinition.
- Bug Fixes
 - Fixed build error caused by feature macro test for mclkSource.

[2.1.6]

- Improvements
 - Added feature macro test for mclkSourceClockHz check.
 - Added bit clock source name for general devices.
- Bug Fixes
 - Fixed incorrect channel numbers setting while calling RX/TX set format together.

[2.1.5]

- Bug Fixes
 - Corrected SAI3 driver IRQ handler name.
 - Added I2S4/5/6 IRQ handler.
 - Added base in handler structure to support different instances sharing one IRQ number.
- New Features
 - Updated SAI driver for MCR bit MICS.
 - Added 192 KHZ/384 KHZ in the sample rate enumeration.
 - Added multi FIFO interrupt/SDMA transfer support for TX/RX.
 - Added an API to read/write multi FIFO data in a blocking method.
 - Added bclk bypass support when bclk is same with mclk.

[2.1.4]

- New Features
 - Added an API to enable/disable auto FIFO error recovery in platforms that support this feature.
 - Added an API to set data packing feature in platforms which support this feature.

[2.1.3]

- New Features
 - Added feature to make I2S frame sync length configurable according to bitWidth.

[2.1.2]

- Bug Fixes
 - Added 24-bit support for SAI eDMA transfer. All data shall be 32 bits for send/receive, as eDMA cannot directly handle 3-Byte transfer.

[2.1.1]

- Improvements
 - Reduced code size while not using transactional API.

[2.1.0]

- Improvements
 - API name changes:
 - * SAI_GetSendRemainingBytes -> SAI_GetSentCount.
 - * SAI_GetReceiveRemainingBytes -> SAI_GetReceivedCount.
 - * All names of transactional APIs were added with “Transfer” prefix.
 - * All transactional APIs use base and handle as input parameter.
 - * Unified the parameter names.
- Bug Fixes
 - Fixed WLC bug while reading TCSR/RCSR registers.
 - Fixed MOE enable flow issue. Moved MOE enable after MICS settings in SAI_TxInit/SAI_RxInit.

[2.0.0]

- Initial version.
-

SAI_EDMA

[2.7.3]

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

[2.7.2]

- Improvements
 - Add macros `MCUX_SDK_SAI_EDMA_TX_ENABLE_INTERNAL` and `MCUX_SDK_SAI_EDMA_RX_ENABLE_INTERNAL` to let the user decide whether to enable SAI when calling `SAI_TransferSendEDMA/SAI_TransferReceiveEDMA`.

[2.7.1]

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

[2.7.0]

- Improvements
 - Updated api `SAI_TransferReceiveEDMA` to support voice channel block interleave transfer.
 - Updated api `SAI_TransferSendEDMA` to support voice channel block interleave transfer.
 - Added new api `SAI_TransferSetInterleaveType` to support channel interleave type configurations.

[2.6.0]

- Improvements
 - Removed deprecated APIs.

[2.5.1]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 20.7.

[2.5.0]

- Improvements
 - Added new api SAI_TransferSendLoopEDMA/SAI_TransferReceiveLoopEDMA to support loop transfer.
 - Added multi sai channel transfer support.

[2.4.0]

- Improvements
 - Added new api SAI_TransferGetValidTransferSlotsEDMA which can be used to get valid transfer slot count in the sai edma transfer queue.
 - Deprecated the api SAI_TransferRxSetFormatEDMA and SAI_TransferTxSetFormatEDMA.
- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 10.3,10.4.

[2.3.2]

- Refer SAI driver change log 2.1.0 to 2.3.2
-

SAI_SDMA**[2.6.0]**

- Improvements
 - Removed deprecated API (SAI_TransferTxSetFormatSDMA,SAI_TransferRxSetFormatSDMA) and replaced them with new API (SAI_TransferRxSetConfigSDMA,SAI_TransferTxSetConfigSDMA)

[2.5.3]

- Bug Fixes
 - Fixed the internal state of bd pool can not be reset in SAI_TransferTerminateSendSDMA.

[2.5.2]

- Improvements
 - Change feature “FSL_FEATURE_SAI_FIFO_COUNT” to “FSL_FEATURE_SAI_HAS_FIFO”.
 - Added feature “FSL_FEATURE_SAI_FIFO_COUNTn(x)” to align SAI fifo count function with IP in function

[2.5.1]

- Bug Fixes
 - Fixed the incorrect internal queue state after abort the transfer in callback.

[2.5.0]

- Bug Fixes
 - Fixed the incorrect driver queue state after calling abort function.
- Improvements
 - Added new api SAI_TransferTerminateSendSDMA/SAI_TransferTerminateReceiveSDMA.

[2.4.1]

- Bug Fixes
 - Fixed the handler array s_sdmaPrivateHandle overflow issue.

[2.4.0]

- Bug Fixes
 - Fixed burst length overflow issue when using multi fifo.
 - Added alignment check between transfer size and the fifo width.
 - Fixed violations of MISRA C-2012 rule 10.6.

[2.3.1]

- Refer SAI driver change log 2.1.0 to 2.3.1
-

SDMA

[2.4.3]

- Bug Fixes
 - Fixed coverity issues with CERT INT30-C, CERT INT31-C compliance.

[2.4.2]

- Bug Fixes
 - Add global variable s_ramScriptLoaded to fix compatibility issues.

[2.4.1]

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

[2.4.0]

- Improvements
 - Added load ram script automatically according to the peripheral type.
 - Updated sdma ram script to version I.MX7D_4_6.
 - Added api SDMA_GetRamScriptVersion to support to SDMA ram script version.
- Bug Fixes
 - Removed the SDMA_StartChannelEvents from SDMA_StartTransfer as sdma scheduler will handle it automatically

[2.3.6]

- Bug Fixes
 - Cleared the SDMAARM_CONFIG_CSM initial value before write value 0 using OR.

[2.3.5]

- Bug Fixes
 - Added transfer size validation to avoid overflow.

[2.3.4]

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

[2.3.3]

- Improvements
 - Improved sdma driver comments and parameters validation.

[2.3.2]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 10.6.

[2.3.1]

- Improvements
 - Removed clear all channel interrupt status in SDMA_HandleIRQ to avoid the possibility of losing interrupt.

[2.3.0]

- Improvements
 - Added peripheral-to-peripheral support in SDMA driver.
 - Added 24bit data width support in sdma driver.
- Bug Fixes
 - Fixed Coverity issue: left shift may overflow issue.
 - Fixed MISRA2004 issue: the operand of underlying type ‘unsigned char’ or ‘unsigned short’ caused the result cast to the underlying type.
 - Fixed violations of MISRA C-2012 rule 10.3, 11.9, 10.4, 17.7, 20.7, 14.4, 11.6, 12.2, 16.4.

[2.2.1]

- Bug Fixes
 - Fixed MISRA 2004 issue in sdma driver.

[2.2.0]

- Improvements
 - Added fsl_sdma_script.h to define the sdma script address and firmware.
 - Updated the format of generic register R7 to align with newest firmware.

[2.1.1]

- Improvements
 - Added SDMA_SetDoneConfig to support hardware/software done configuration.
 - Marked SDMC_EnableSwDone as deprecated.
- Bug Fixes
 - Fixed logical dead code issue in function SDMA_SetDoneConfig.

[2.1.0]

- Improvements
 - Added SDMA_SetMultiFifoConfig API to support multi fifo feature.
 - Added SDMA_EnableSwDone API to support software done feature.
 - Added SDMA_LoadScript API to support load script to SDMA program memory.
 - Added SDMA_DumpScript API to support dump script from SDMA program memory.
 - Added SDMA3 IRQ handler.

[2.0.0]

- Initial version.
-

SEMA4

[2.2.2]

- Improvements
 - Updated SEMA4_TryLock function to avoid unsigned integer operations wrap issue.

[2.2.1]

- Bug Fixes
 - Fixed violations of the CERT INT31-C, MISRA C-2012 rules 10.3, 10.4.

[2.2.0]

- New Features
 - Added SEMA4_BUSY_POLL_COUNT parameter to prevent infinite polling loops in SEMA4 operations.
 - Added timeout mechanism to all polling loops in SEMA4 driver code.
- Improvements
 - Updated SEMA4_Lock function to return status_t instead of void for better error handling.
 - Enhanced documentation to clarify timeout behavior and return values.

[2.1.0]

- Improvements
 - Changed mask parameter type in SEMA4_EnableGateNotifyInterrupt() and SEMA4_DisableGateNotifyInterrupt() functions to avoid casting from unsigned long to unsigned short in the code when modifying the 16bits CPINE register.

[2.0.3]

- Improvements
 - Changed to implement SEMA4_Lock base on SEMA4_TryLock.

[2.0.2]

- Improvements:
 - Supported the SEMA4_Type structure whose gate registers are defined as an array.

[2.0.1]

- Bug Fixes
 - Fixed violations of the MISRA C-2012 rules 10.3, 10.4, 15.5, 18.1, 18.4.

[2.0.0]

- Initial version.

TMU

[2.0.0]

- Initial version.
 - This module was first developed on i.MX 8MP to support multi-site temperature monitor.
-

UART

[2.3.2]

- Improvements
 - Make driver aarch64 compatible

[2.3.1]

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

[2.3.0]

- Bug Fixes
 - Fixed DMA transfer blocking issue by enabling tx idle interrupt after DMA transmission finishes.

[2.2.1]

- Bug Fixes
 - Fixed MISRA 2012 rule 10.4 violation.

[2.2.0]

- New Features
 - Modified `uart_config_t`, `UART_Init` and `UART_GetDefaultConfig` APIs so that the RTS and CTS used for hardware flow control can be enabled during module initialization.
 - Added API `UART_SetRxRTSWatermark` so that the water mark level of RTS deassertion can be configured.

[2.1.1]

- Bug Fixes
 - Fixed MISRA 8.5 violation.

[2.1.0]

- Improvements
 - Added timeout mechanism when waiting for certain states in transfer driver.

[2.0.2]

- Improvements
 - Added check for transmission complete in UART_WriteBlocking, UART_TransferHandleIRQ and UART_SendSDMACallback to ensure all the data would be sent out to bus.
 - Modified UART_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
 - Fixed MISRA issues.
 - * Fixed rules 10.1, 10.3, 10.4, 10.6, 10.7, 10.8, 11.9, 14.4.

[2.0.1]

- Bug Fixes
 - Memset local variable SDMA transfer configuration structure to make sure unused members in structure are cleared.

[2.0.0]

- Initial version.
-

UART_SDMA**[2.3.0]**

- Refer UART driver change log 2.0.0 to 2.1.1, 2.3.0.
-

USDHC**[2.8.8]**

- Bug Fixes
 - Fixed build issue with armgcc O3.

[2.8.7]

- Bug Fixes
 - Disabled CMD error check for standard tuning per RM.

[2.8.6]

- Bug Fixes
 - Invalidate cache after blocking read.

[2.8.5]

- Improvements
 - Enable the driver to be AARCH64 compatible.

[2.8.4]

- Improvements
 - Add feature macro FSL_FEATURE_USDHC_HAS_NO_VS18.

[2.8.3]

- Improvements
 - Improved api USDHC_EnableAutoTuningForCmdAndData to adapt to new bit field name for USDHC_VEND_SPEC2 register.

[2.8.2]

- Improvements
 - Added feature macro FSL_FEATURE_USDHC_HAS_NO_VOLTAGE_SELECT.

[2.8.1]

- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 11.9.

[2.8.0]

- Improvements
 - Fixed the mmc boot transfer failed issue which is caused by the Dma complete interrupt not enabled.
 - Marked api USDHC_AdjustDelayForManualTuning as deprecated and added new api USDHC_SetTuingDelay/USDHC_GetTuningDelayStatus.
 - Improved the manual tuning flow accroding to specification.
 - Added memory address conversion to support buffers which could only be accessed using alias address by non-core masters.
 - Fixed violations of MISRA C-2012 rule 10.4.

[2.7.0]

- Improvements
 - Added api `USDHC_TransferScatterGatherADMANonBlocking` to support scatter gather transfer.
 - Added feature `FSL_FEATURE_USDHC_REGISTER_HOST_CTRL_CAP_HAS_NO_RETUNING_TIME_COUNTER` for re-tuning time counter field in `HOST_CTRL_CAP` register.
- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 11.9, 10.1, 10.3, 10.4, 8.4.

[2.6.0]

- Improvements
 - Added api `USDHC_SetStandardTuningCounter` to support adjust tuning counter of Standard tuning.

[2.5.1]

- Improvements
 - Used different status code for command and data interrupt callback.
 - Added cache line invalidate for receive buffer in driver IRQ handler to fix CM7 speculative access issue.

[2.5.0]

- Improvements
 - Added new api `USDHC_SetStrobeDllOverride` for HS400 strobe dll override mode delay taps configurations.
 - Corrected the STROBE DLL configurations sequence.

[2.4.0]

- Improvements
 - Added feature macro for read/write burst length.
 - * Disabled redundant interrupt per different transfer request.
 - * Disabled interrupt and reset command/data pointer in handle when transfer completes.
- Bug Fixes
 - Fixed violations of MISRA C-2012 rule 11.9, 15.7, 4.7, 16.4, 10.1, 10.3, 10.4, 11.3, 14.4, 10.6, 17.7, 16.1, 16.3.
 - Fixed PA082 build warning.
 - Fixed logically dead code Coverity issue.

[2.3.0]

- Improvements
 - Added USDHC_SetDataConfig API to support manual tuning.
 - Removed the limitaion that source clock must be bigger than the target in function USDHC_SetSdClock by using source clock frequency as target directly.
 - Added peripheral reset in USDHC_Init function.
 - Added tuning reset support in function USDHC_Reset function.

[2.2.8]

- Bug Fixes
 - Fixed out-of bounds write in function USDHC_ReceiveCommandResponse.

[2.2.7]

- Improvements
 - Added API USDHC_GetEnabledInterruptStatusFlags and used in USDHC_TransferHandleIRQ.
 - Removed useless member interruptFlags in usdhc_handle_t.

[2.2.6]

- Improvements
 - Added address align check for ADMA descriptor table address.
 - Changed USDHC_ADMA1_DESCRIPTOR_MAX_LENGTH_PER_ENTRY to (65536-4096) to make sure the data address is 4KB align for a transfer which need more than one ADMA1 descriptor.

[2.2.5]

- Bug Fixes
 - Fixed MDK 66-D warning.

[2.2.4]

- Bug Fixes
 - Fixed issue that real clock frequency wss mismatched with target clock frequency, which was caused by an incorrect prescaler calculation.
- New Features
 - Added control macro to enable/disable the CLOCK code in current driver.

[2.2.3]

- Bug Fixes
 - Fixed issue where AMDA did not disable with DMAEN clear.
- Improvements
 - Improved set clock function to check the output frequency range.

- Dynamic set SDCLKFS during DDR enable or disable.

[2.2.2]

- Improvements
 - Improved read transfer cache maintain operation, combined clean, and invalidated them into one function.

[2.2.1]

- Bug Fixes
 - Disabled the invalidate cache operation for tuning.

[2.2.0]

- Improvements
 - Improved USDHC to support MMC boot feature.

[2.1.3]

- Bug Fixes
 - Fixed MISRA issue.

[2.1.2]

- Bug Fixes
 - Fixed Coverity issue.
 - Added base address and userData parameter for all callback functions.

[2.1.1]

- Improvements
 - Added cache maintain operation.
 - Added timeout status check for the DATA transfer which ignore error.
 - Added feature macro for SDR50/SDR104 mode.
 - Removed useless IRQ handler from different platforms.

[2.1.0]

- Improvements
 - Integrated tuning into transfer function.
 - Added strobe DLL feature.
 - Added enableAutoCommand23 in data structure.
 - Removed enable card clock function because the controller would handle the clock on/off.

[2.0.0]

- Initial version.
-

WDOG

[2.2.0]

- Bug Fixes
 - Fixed the wrong behavior of `workMode.enableWait`, `workMode.enableStop`, `workMode.enableDebug` in configuration structure `wdog_config_t`. When set the items to true, WDOG will continue working in those modes.

[2.1.1]

- Bug Fixes
 - MISRA C-2012 issue fixed: rule 10.1, 10.3, 10.4, 10.6, 10.7 and 11.9.
 - Fixed the issue of the inseparable process interrupted by other interrupt source.
 - * `WDOG_Init`
 - * `WDOG_Refresh`

[2.1.0]

- New Features
 - Added new API “`WDOG_TriggerSystemSoftwareReset()`” to allow users to reset the system by software.
 - Added new API “`WDOG_TriggerSoftwareSignal()`” to allow users to trigger a `WDOG_B` signal by software.
 - Removed the parameter “`softwareAssertion`” and “`softwareResetSignal`” out of the `wdog_config_t` structure.
 - Added new parameter “`enableTimeOutAssert`” to the `wdog_config_t` structure. With this parameter enabled, when the WDOG timeout occurs, a `WDOG_B` signal will be asserted. This signal can be routed to external pin of the chip. Note that `WDOG_B` signal remains asserted until a power-on reset (POR) occurs.

[2.0.1]

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

[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.

[*MIMX8ML8*](#)

1.7 Middleware Documentation

Find links to detailed middleware documentation for key components. While not all onboard middleware is covered, this serves as a useful reference for configuration and development.

1.7.1 Multicore

[*Multicore SDK*](#)

1.7.2 FreeMASTER

[*freemaster*](#)

1.7.3 FreeRTOS

[*FreeRTOS*](#)

Chapter 2

MIMX8ML8

2.1 AIPSTZ: AHB to IP Bridge

```
void AIPSTZ_SetMasterPrivilegeLevel(AIPSTZ_Type *base, aipstz_master_t master, uint32_t  
                                     privilegeConfig)
```

Configure the privilege level for master.

Parameters

- base – AIPSTZ peripheral base pointer
- master – Masters for AIPSTZ.
- privilegeConfig – Configuration is ORed from aipstz_master_privilege_level_t.

```
void AIPSTZ_SetPeripheralAccessControl(AIPSTZ_Type *base, aipstz_peripheral_t peripheral,  
                                       uint32_t accessControl)
```

Configure the access for peripheral.

Parameters

- base – AIPSTZ peripheral base pointer
- peripheral – Peripheral for AIPSTZ.
- accessControl – Configuration is ORed from aipstz_peripheral_access_control_t.

FSL_AIPSTZ_DRIVER_VERSION

Version 2.0.1

```
enum _aipstz_master_privilege_level
```

List of AIPSTZ privilege configuration.

Values:

```
enumerator kAIPSTZ_MasterBufferedWriteEnable
```

Write accesses from this master are allowed to be buffered.

```
enumerator kAIPSTZ_MasterTrustedForReadEnable
```

This master is trusted for read accesses.

```
enumerator kAIPSTZ_MasterTrustedForWriteEnable
```

This master is trusted for write accesses.

enumerator kAIPSTZ_MasterForceUserModeEnable

Accesses from this master are forced to user-mode.

enum __aipstz_master

List of AIPSTZ masters. Organized by width for the 8-15 bits and shift for lower 8 bits.

Values:

enumerator kAIPSTZ_Master0

enumerator kAIPSTZ_Master1

enumerator kAIPSTZ_Master2

enumerator kAIPSTZ_Master3

enumerator kAIPSTZ_Master5

enum __aipstz_peripheral_access_control

List of AIPSTZ peripheral access control configuration.

Values:

enumerator kAIPSTZ_PeripheralAllowUntrustedMaster

enumerator kAIPSTZ_PeripheralWriteProtected

enumerator kAIPSTZ_PeripheralRequireSupervisor

enumerator kAIPSTZ_PeripheralAllowBufferedWrite

enum __aipstz_peripheral

List of AIPSTZ peripherals. Organized by register offset for higher 32 bits, width for the 8-15 bits and shift for lower 8 bits.

Values:

enumerator kAIPSTZ_Peripheral0

enumerator kAIPSTZ_Peripheral1

enumerator kAIPSTZ_Peripheral2

enumerator kAIPSTZ_Peripheral3

enumerator kAIPSTZ_Peripheral4

enumerator kAIPSTZ_Peripheral5

enumerator kAIPSTZ_Peripheral6

enumerator kAIPSTZ_Peripheral7

enumerator kAIPSTZ_Peripheral8

enumerator kAIPSTZ_Peripheral9

enumerator kAIPSTZ_Peripheral10

enumerator kAIPSTZ_Peripheral11

enumerator kAIPSTZ_Peripheral12

enumerator kAIPSTZ_Peripheral13

enumerator kAIPSTZ_Peripheral14

enumerator kAIPSTZ_Peripheral15
enumerator kAIPSTZ_Peripheral16
enumerator kAIPSTZ_Peripheral17
enumerator kAIPSTZ_Peripheral18
enumerator kAIPSTZ_Peripheral19
enumerator kAIPSTZ_Peripheral20
enumerator kAIPSTZ_Peripheral21
enumerator kAIPSTZ_Peripheral22
enumerator kAIPSTZ_Peripheral23
enumerator kAIPSTZ_Peripheral24
enumerator kAIPSTZ_Peripheral25
enumerator kAIPSTZ_Peripheral26
enumerator kAIPSTZ_Peripheral27
enumerator kAIPSTZ_Peripheral28
enumerator kAIPSTZ_Peripheral29
enumerator kAIPSTZ_Peripheral30
enumerator kAIPSTZ_Peripheral31
enumerator kAIPSTZ_Peripheral32
enumerator kAIPSTZ_Peripheral33

typedef enum *_aipstz_master_privilege_level* aipstz_master_privilege_level_t

List of AIPSTZ privilege configuration.

typedef enum *_aipstz_master* aipstz_master_t

List of AIPSTZ masters. Organized by width for the 8-15 bits and shift for lower 8 bits.

typedef enum *_aipstz_peripheral_access_control* aipstz_peripheral_access_control_t

List of AIPSTZ peripheral access control configuration.

typedef enum *_aipstz_peripheral* aipstz_peripheral_t

List of AIPSTZ peripherals. Organized by register offset for higher 32 bits, width for the 8-15 bits and shift for lower 8 bits.

2.2 ASRC: Asynchronous sample rate converter

2.3 ASRC Driver

uint32_t ASRC_GetInstance(ASRC_Type *base)

Get instance number of the ASRC peripheral.

Parameters

- base – ASRC base pointer.

void ASRC_Init(ASRC_Type *base)

brief Initializes the asrc peripheral.

This API gates the asrc clock. The asrc module can't operate unless ASRC_Init is called to enable the clock.

param base asrc base pointer.

void ASRC_Deinit(ASRC_Type *base)

De-initializes the ASRC peripheral.

This API gates the ASRC clock and disable ASRC module. The ASRC module can't operate unless ASRC_Init

Parameters

- base – ASRC base pointer.

void ASRC_GetContextDefaultConfig(*asrc_context_config_t* *config, uint32_t channels, uint32_t inSampleRate, uint32_t outSampleRate)

ASRC get context default configuration.

Parameters

- config – ASRC context configuration pointer.
- channels – input audio data channel numbers.
- inSampleRate – input sample rate.
- outSampleRate – output sample rate.

status_t ASRC_SetContextConfig(ASRC_Type *base, *asrc_context_t* context, *asrc_context_config_t* *config)

ASRC configure context.

Parameters

- base – ASRC base pointer.
- context – index of asrc context, reference *asrc_context_t*.
- config – ASRC context configuration pointer.

Return values

kStatus_InvalidArgument – invalid parameters. kStatus_ASRCConfigureFailed context configure failed. kStatus_Success context configure success.

status_t ASRC_SetContextOutputConfig(ASRC_Type *base, *asrc_context_t* context, *asrc_context_output_config_t* *config)

ASRC configure context output.

Parameters

- base – ASRC base pointer.
- context – index of asrc context, reference *asrc_context_t*.
- config – ASRC context output configuration pointer.

status_t ASRC_SetContextInputConfig(ASRC_Type *base, *asrc_context_t* context, *asrc_context_input_config_t* *config)

ASRC configure context input.

Parameters

- base – ASRC base pointer.
- context – index of asrc context, reference *asrc_context_t*.

- config – ASRC context input configuration pointer.

```
static inline void ASRC_EnableContextRun(ASRC_Type *base, asrc_context_t context, bool
                                         enable)
```

ASRC context enable run. All control fields associated with a context must be stable prior to setting context run enable.

Parameters

- base – ASRC base pointer.
- context – ASRC context index.
- enable – true is enable, inform the datapath begin processing sample data for the context. false is disable, data processing will halt immediately.

```
static inline void ASRC_EnableContextRunStop(ASRC_Type *base, asrc_context_t context, bool
                                              enable)
```

ASRC context enable run stop. This function used to flush the ASRC pipeline and completely end processing for a context.

Parameters

- base – ASRC base pointer.
- context – ASRC context index.
- enable – true is enable, false is disable.

```
static inline void ASRC_EnableContextInDMA(ASRC_Type *base, asrc_context_t context, bool
                                           enable)
```

ASRC context input DMA request enable.

Parameters

- base – ASRC base pointer.
- context – ASRC context index.
- enable – true is enable, false is disable.

```
static inline void ASRC_EnableContextOutDMA(ASRC_Type *base, asrc_context_t context, bool
                                             enable)
```

ASRC context output DMA request enable.

Parameters

- base – ASRC base pointer.
- context – ASRC context index.
- enable – true is enable, false is disable.

```
static inline void ASRC_EnablePreFilterBypass(ASRC_Type *base, asrc_context_t context, bool
                                              bypass)
```

ASRC prefilter bypass mode This function enable or disable the ASRC prefilter bypass mode.

Parameters

- base – ASRC peripheral base address.
- context – context processor number.
- bypass – true is bypass, false is normal mode.

```
static inline void ASRC_EnableResamplerBypass(ASRC_Type *base, asrc_context_t context, bool
                                              bypass)
```

ASRC resampler bypass mode This function enable or disable the ASRC resampler bypass mode.

Parameters

- base – ASRC peripheral base address.
- context – context processor number.
- bypass – true is bypass, false is normal mode.

```
static inline void ASRC_SetContextChannelNumber(ASRC_Type *base, asrc_context_t context,
                                              uint32_t channels)
```

ASRC set context channel number. Note: The maximum channel number in one context can not exceed 32.

Parameters

- base – ASRC peripheral base address.
- context – context number.
- channels – channel number, should <= 32.

```
uint32_t ASRC_GetContextOutSampleSize(uint32_t inSampleRate, uint32_t inSamplesSize,
                                      uint32_t inWidth, uint32_t outSampleRate, uint32_t
                                      outWidth)
```

ASRC get output sample count.

Parameters

- inSampleRate – output sample rate.
- inSamplesSize – input sample rate.
- inWidth – input samples buffer size, the size of buffer should be converted to align with 4 byte .
- outSampleRate – input sample width.
- outWidth – Output width.

Return values

output – samples size.

```
static inline void ASRC_EnableInterrupt(ASRC_Type *base, uint32_t mask)
```

ASRC interrupt enable This function enable the ASRC interrupt with the provided mask.

Parameters

- base – ASRC peripheral base address.
- mask – The interrupts to enable. Logical OR of _asrc_interrupt_mask.

```
static inline void ASRC_DisableInterrupt(ASRC_Type *base, uint32_t mask)
```

ASRC interrupt disable This function disable the ASRC interrupt with the provided mask.

Parameters

- base – ASRC peripheral base address.
- mask – The interrupts to disable. Logical OR of _asrc_interrupt_mask.

```
static inline uint32_t ASRC_GetInterruptStatus(ASRC_Type *base)
```

Gets the ASRC interrupt status flag state.

Parameters

- base – ASRC base pointer

Returns

ASRC Tx status flag value. Use the Status Mask to get the status value needed.

static inline void ASRC_ClearInterruptStatus(ASRC_Type *base, uint32_t status)
clear the ASRC interrupt status flag state.

Parameters

- base – ASRC base pointer
- status – status flag to be cleared.

static inline uint32_t ASRC_GetFifoStatus(ASRC_Type *base, *asrc_context_t* context)
Gets the ASRC fifo status flag.

Parameters

- base – ASRC base pointer
- context – context id

static inline void ASRC_WriteContextFifo(ASRC_Type *base, *asrc_context_t* context, uint32_t data)
write the ASRC context fifo.

Parameters

- base – ASRC base pointer.
- context – context id.
- data – data to write.

static inline uint32_t ASRC_ReadContextFifo(ASRC_Type *base, *asrc_context_t* context)
read the ASRC context fifo.

Parameters

- base – ASRC base pointer.
- context – context id.

Return values

read – data.

static inline uint32_t ASRC_GetWriteContextFifoAddr(ASRC_Type *base, *asrc_context_t* context)
Get ASRC write fifo address.

Parameters

- base – ASRC base pointer.
- context – context id.

Return values

write – fifo address.

static inline uint32_t ASRC_GetReadContextFifoAddr(ASRC_Type *base, *asrc_context_t* context)
Get the ASRC read context fifo address.

Parameters

- base – ASRC base pointer.
- context – context id.

Return values

read – fifo address.

uint32_t ASRC_ReadFIFORemainedSample(ASRC_Type *base, *asrc_context_t* context, uint32_t *outAddr, uint32_t outWidth, uint32_t sampleCount)

Get the ASRC read fifo remained samples. Since the DMA request will be triggered only when the sample group in read fifo is bigger then the watermark, so when the data size cannot be divisible by the (watermark + 1), then part of sample will left in read fifo, application should call this api to get the left samples.

Parameters

- base – ASRC base pointer.
- context – context id.
- outAddr – address to receive remained sample in read fifo.
- outWidth – output data width.
- sampleCount – specify the read sample count.

Return values

sample – counts actual read from output fifo.

status_t ASRC__TransferBlocking(ASRC_Type *base, *asrc_context_t* context, *asrc_transfer_t* *xfer)

ASRC blocking convert audio sample rate. This function depends on the configuration of input and output, so it should be called after the ASRC_SetContextConfig. The data format it supports: 1.16bit 16bit per sample in input buffer, input buffer size should be calculate as: samples 2U output buffer size can be calculated by call function ASRC_GetContextOutSampleSize, the parameter outWidth should be 2. 2.20bit 24bit per sample in input buffer, input buffer size should be calculate as: samples 3U output buffer size can be calculated by call function ASRC_GetContextOutSampleSize, the outWidth should be 3. 3.24bit 24bit per sample in input buffer, input buffer size should be calculate as: samples * 3U output buffer size can be calculated by call function ASRC_GetContextOutSampleSize, the outWidth should be 3. 4.32bit 32bit per sample in input buffer, input buffer size should be calculate as: samples * 4U output buffer size can be calculated by call function ASRC_GetContextOutSampleSize, the outWidth should be 4.

Parameters

- base – ASRC base pointer.
- context – context id.
- xfer – .xfer configuration.

Return values

kStatus__Success. –

FSL_ASRC_DRIVER_VERSION

Version 2.0.7

ASRC return status, *_asrc_status*.

Values:

enumerator kStatus__ASRCIdle

ASRC is idle.

enumerator kStatus__ASRCBusy

ASRC is busy.

enumerator kStatus__ASRCInvalidArgument

ASRC invalid argument.

enumerator kStatus__ASRCConfigureFailed

ASRC configure failed

enumerator kStatus_ASRCConvertError
ASRC convert error failed

enumerator kStatus_ASRCNotSupport
ASRC not support

enumerator kStatus_ASRCQueueFull
ASRC queue full

enumerator kStatus_ASRCQueueIdle
ASRC queue idle

enumerator kStatus_ASRCLoadFirmwareFailed
ASRC load firmware failed

enumerator kStatus_ASRCResamplerConfigureFailed
ASRC resampler configured failed

enumerator kStatus_ASRCPrefilterConfigureFailed
ASRC prefilter configured failed

enum _asrc_context
asrc context id

Values:

enumerator kASRC_Context0
Context 0 value

enumerator kASRC_Context1
Context 1 value

enumerator kASRC_Context2
Context 2 value

enumerator kASRC_Context3
Context 3 value

The ASRC interrupt enable flag, `_asrc_interrupt_mask`.

Values:

enumerator kASRC_Context0InputFifoOverflow
context 0 input fifo overflow

enumerator kASRC_Context1InputFifoOverflow
context 1 input fifo overflow

enumerator kASRC_Context2InputFifoOverflow
context 2 input fifo overflow

enumerator kASRC_Context3InputFifoOverflow
context 3 input fifo overflow

enumerator kASRC_Context0OutFifoReadEmpty
context 0 out fifo read empty

enumerator kASRC_Context1OutFifoReadEmpty
context 1 out fifo read empty

enumerator kASRC_Context2OutFifoReadEmpty
context 2 out fifo read empty

enumerator kASRC_Context3OutFifoReadEmpty
context 3 out fifo read empty

enumerator kASRC_Context0RunStopDone
context 0 run stop done interrupt

enumerator kASRC_Context1RunStopDone
context 1 run stop done interrupt

enumerator kASRC_Context2RunStopDone
context 2 run stop done interrupt

enumerator kASRC_Context3RunStopDone
context 3 run stop done interrupt

enumerator kASRC_ContextAllInterruptStatus
all the context interrupt status

ASRC fifo status, _asrc_fifo_status.

Values:

enumerator kASRC_FifoStatusInputFifoWatermarkFlag
input water mark flag raised

enumerator kASRC_FifoStatusOutputFifoWatermarkFlag
output water mark flag raised

enum _asrc_data_endianness
arsc data endianness

Values:

enumerator kASRC_DataEndianLittle
context data little endian

enumerator kASRC_DataEndianBig
context data big endian

enum _asrc_data_width
data width

Values:

enumerator kASRC_DataWidth32Bit
data width 32bit

enumerator kASRC_DataWidth24Bit
data width 24bit

enumerator kASRC_DataWidth20Bit
data width 20bit

enumerator kASRC_DataWidth16Bit
data width 16bit

enum _asrc_data_type
data type

Values:

enumerator kASRC_DataTypeInteger
data type int

enumerator kASRC_DataTypeFloat
data type float, single precision floating point format

enum _asrc_data_sign
sign extension

Values:

enumerator kASRC_DataSigned
input data is signed

enumerator kASRC_DataUnsigned
input data is unsinged

enum _asrc_sampleBuffer_init_mode
asrc prefilter and resampler sample buffer init mode

Values:

enumerator kASRC_SampleBufferNoPreFillOnInit
do not pre-fill

enumerator kASRC_SampleBufferFillFirstSampleOnInit
replicate the first sample to fill the right half of the sample buffer

enumerator kASRC_SampleBufferFillZeroOnInit
zero fill the right half og the sample buffer

enum _asrc_sampleBuffer_stop_mode
asrc prefilter and resampler sample buffer stop mode

Values:

enumerator kASRC_SampleBufferFillLastSampleOnStop
replicate the last sample to fill the left half of the sample buffer

enumerator kASRC_SampleBufferFillZeroOnStop
zero fill the left half of the sample buffer

enum _asrc_prefilter_stage1_result
ASRC prefilter stage1 result format.

Values:

enumerator kASRC_PrefilterStage1ResultInt
prefilter stage1 results are stored in 32 bit int format

enumerator kASRC_PrefilterStage1ResultFloat
prefilter stage1 results are stored in 32 bit float format

enum _asrc_resampler_taps
ASRC resampler taps.

Values:

enumerator kASRC_ResamplerTaps_32
resampler taps 32

enumerator kASRC_ResamplerTaps_64
resampler taps 64

enumerator kASRC_ResamplerTaps_128
resampler taps 128

ASRC support sample rate, `_asrc_sample_rate`.

Values:

enumerator `kASRC_SampleRate_8000`
8K sample rate

enumerator `kASRC_SampleRate_11025`
11025 sample rate

enumerator `kASRC_SampleRate_12000`
12K sample rate

enumerator `kASRC_SampleRate_16000`
16K sample rate

enumerator `kASRC_SampleRate_22050`
22.05K sample rate

enumerator `kASRC_SampleRate_24000`
24K sample rate

enumerator `kASRC_SampleRate_32000`
32K sample rate

enumerator `kASRC_SampleRate_44100`
44.1K sample rate

enumerator `kASRC_SampleRate_48000`
48K sample rate

enumerator `kASRC_SampleRate_64000`
64K sample rate

enumerator `kASRC_SampleRate_88200`
88.2K sample rate

enumerator `kASRC_SampleRate_96000`
96K sample rate

enumerator `kASRC_SampleRate_128000`
128K sample rate

enumerator `kASRC_SampleRate_176400`
176K sample rate

enumerator `kASRC_SampleRate_192000`
256K sample rate

enumerator `kASRC_SampleRate_256000`
256K sample rate

enumerator `kASRC_SampleRate_352800`
352.8K sample rate

enumerator `kASRC_SampleRate_384000`
384K sample rate

enumerator `kASRC_SampleRate_768000`
768K sample rate

```
typedef enum _asrc_context asrc_context_t
    asrc context id

typedef enum _asrc_data_endianness asrc_data_endianness_t
    asrc data endianness

typedef enum _asrc_data_width asrc_data_width_t
    data width

typedef enum _asrc_data_type asrc_data_type_t
    data type

typedef enum _asrc_data_sign asrc_data_sign_t
    sign extension

typedef enum _asrc_sampleBuffer_init_mode asrc_sampleBuffer_init_mode_t
    asrc prefilter and resampler sample buffer init mode

typedef enum _asrc_sampleBuffer_stop_mode asrc_sampleBuffer_stop_mode_t
    asrc prefilter and resampler sample buffer stop mode

typedef enum _asrc_prefilter_stage1_result asrc_prefilter_stage1_result_t
    ASRC prefilter stage1 result format.

typedef enum _asrc_resampler_taps asrc_resampler_taps_t
    ASRC resampler taps.

typedef struct _asrc_data_format asrc_data_format_t
    asrc context data format

typedef struct _asrc_access_ctrl asrc_access_ctrl_t
    asrc context access control The ASRC provides interleaving support in hardware to ensure
    that a variety of sample source can be internally combined to conform with this format. The
    interleave pattern is controlled using 3 register fields: GROUP_LENGTH, ACCESS_LENGTH,
    ITERATIONIS. This is intended to support hardware configurations which distribute a single
    context across samples from multiple audio sources. Take an example as below: access-
    GroupLen = 6, the sample group length is 6 samples accessIterations = 2, the 2 sequential
    ACCESS_LENGTH read from single source accessLen = 2, the 2 samples fetch from one
    source.

typedef struct _asrc_context_input_config asrc_context_input_config_t
    asrc context input configuration

typedef struct _asrc_context_output_config asrc_context_output_config_t
    asrc context output configuration

typedef struct _asrc_context_prefilter_config asrc_context_prefilter_config_t
    asrc context prefilter configuration

typedef struct _asrc_context_resampler_config asrc_context_resampler_config_t
    asrc context resampler configuration

typedef struct _asrc_context_config asrc_context_config_t
    asrc context configuration

typedef struct _asrc_transfer asrc_transfer_t
    ASRC transfer.

FSL_ASRC_INPUT_FIFO_DEPTH
    ASRC fifo depth.

FSL_ASRC_OUTPUT_FIFO_DEPTH
```

ASRC_SUPPORT_MAXIMUM_CONTEXT_PROCESSOR_NUMBER

ASRC support maximum channel number of context.

struct _asrc_data_format

#include <fsl_asrc.h> asrc context data format

Public Members

uint8_t dataPosition

context input data sample position

asrc_data_endianness_t dataEndianness

context input data endianness

asrc_data_width_t dataWidth

context input data width

asrc_data_type_t dataType

context input data type

asrc_data_sign_t dataSign

context input data signed or unsigned

struct _asrc_access_ctrl

#include <fsl_asrc.h> asrc context access control The ASRC provides interleaving support in hardware to ensure that a variety of sample source can be internally combined to conform with this format. The interleave pattern is controlled using 3 register fields: GROUP_LENGTH, ACCESS_LENGTH, ITERATIONIS. This is intended to support hardware configurations which distribute a single context across samples from multiple audio sources. Take an example as below: accessGroupLen = 6, the sample group length is 6 samples accessIterations = 2, the 2 sequential ACCESS_LENGTH read from single source accessLen = 2, the 2 samples fetch from one source.

Public Members

uint8_t accessIterations

number of sequential fetches per source

uint8_t accessGroupLen

number of channels in a context

uint8_t accessLen

number of channels per source1

struct _asrc_context_input_config

#include <fsl_asrc.h> asrc context input configuration

Public Members

uint32_t sampleRate

input audio data sample rate

uint8_t watermark

input water mark per samples

asrc_access_ctrl_t accessCtrl

input access control

asrc_data_format_t dataFormat
input data format

struct *_asrc_context_output_config*
#include <fsl_asrc.h> asrc context output configuration

Public Members

uint32_t sampleRate
output audio data sample rate

uint8_t watermark
output water mark per samples

asrc_access_ctrl_t accessCtrl
output access control

asrc_data_format_t dataFormat
output data format

bool enableDither
output path contains a TPDF dither function. The dither function support all fixed output modes(16, 20, 24, 32bits) dither is not supported in 32bit floating point output mode

bool enableIEC60958
output IEC60958 bit field insertion enable

struct *_asrc_context_prefilter_config*
#include <fsl_asrc.h> asrc context prefilter configuration

Public Members

asrc_sampleBuffer_init_mode_t initMode
prefilter initial mode

asrc_sampleBuffer_stop_mode_t stopMode
prefilter stop mode

asrc_prefilter_stage1_result_t stage1Result
stage1 data store format

uint32_t filterSt1Taps
prefilter stage1 taps

uint32_t filterSt2Taps
prefilter stage2 taps

uint32_t filterSt1Exp
prefilter stage1 expansion factor

const uint32_t *filterCoeffAddress
prefilter coeff address

struct *_asrc_context_resampler_config*
#include <fsl_asrc.h> asrc context resampler configuration

Public Members

asrc_sampleBuffer_init_mode_t initMode
initial mode

asrc_sampleBuffer_stop_mode_t stopMode
resampler stop mode

asrc_resampler_taps_t tap
resampler taps

uint32_t filterPhases
interpolation phases

uint64_t filterCenterTap
interpolation center tap

const uint32_t *filterCoeffAddress
interpolation coeff address

struct _asrc_context_config
#include <fsl_asrc.h> asrc context configuration

Public Members

uint8_t contextChannelNums
context channel numbers

asrc_context_input_config_t contextInput
context input configuration

asrc_context_output_config_t contextOutput
context output configuration

asrc_context_prefilter_config_t contextPrefilter
context pre filter configuration

asrc_context_resampler_config_t contextResampler
context resampler configuration

struct _asrc_transfer
#include <fsl_asrc.h> ASRC transfer.

Public Members

uint32_t *inDataAddr
address of audio data to be converted

uint32_t inDataSize
size of the audio data

uint32_t *outDataAddr
address of audio data that is been converted

uint32_t outDataSize
size of the audio data

2.4 ASRC SDMA Driver

```
void ASRC__TransferInCreateHandleSDMA(ASRC_Type *base, asrc_sdma_handle_t *handle,
                                     asrc_sdma_callback_t callback, sdma_handle_t
                                     *dmaHandle, uint32_t eventSource, asrc_context_t
                                     context, const asrc_p2p_sdma_config_t *periphConfig,
                                     void *userData)
```

Initializes the ASRC input SDMA handle.

This function initializes the ASRC input DMA handle, which can be used for other ASRC transactional APIs. Usually, for a specified ASRC context, call this API once to get the initialized handle.

Parameters

- base – ASRC base pointer.
- handle – ASRC SDMA handle pointer.
- base – ASRC peripheral base address.
- callback – Pointer to user callback function.
- dmaHandle – SDMA handle pointer, this handle shall be static allocated by users.
- eventSource – ASRC input sdma event source.
- context – ASRC context number.
- periphConfig – peripheral configurations, used for case.
- userData – User parameter passed to the callback function.

```
void ASRC__TransferOutCreateHandleSDMA(ASRC_Type *base, asrc_sdma_handle_t *handle,
                                       asrc_sdma_callback_t callback, sdma_handle_t
                                       *dmaHandle, uint32_t eventSource, asrc_context_t
                                       context, const asrc_p2p_sdma_config_t
                                       *periphConfig, void *userData)
```

Initializes the ASRC output SDMA handle.

This function initializes the ASRC out DMA handle, which can be used for other ASRC transactional APIs. Usually, for a specified ASRC context, call this API once to get the initialized handle.

Parameters

- base – ASRC base pointer.
- handle – ASRC SDMA handle pointer.
- callback – ASRC outcallback.
- dmaHandle – SDMA handle pointer, this handle shall be static allocated by users.
- eventSource – ASRC output event source.
- context – ASRC context number.
- periphConfig – peripheral configurations, used for case.
- userData – User parameter passed to the callback function.

```
status_t ASRC__TransferSetContextConfigSDMA(ASRC_Type *base, asrc_sdma_handle_t *handle,
                                             asrc_context_config_t *asrcConfig)
```

Configures the ASRC context.

Parameters

- base – ASRC base pointer.
- handle – ASRC SDMA handle pointer.
- asrcConfig – asrc context configurations.

status_t ASRC_TransferSDMA(*ASRC_Type* *base, *asrc_sdma_handle_t* *handle, *asrc_transfer_t* *xfer)

Performs a non-blocking ASRC transfer using DMA.

Parameters

- base – ASRC base pointer.
- handle – ASRC SDMA handle pointer.
- xfer – ASRC xfer configurations pointer.

Return values

- kStatus_Success – Start a ASRC SDMA send successfully.
- kStatus_InvalidArgument – The input argument is invalid.
- kStatus_TxBusy – ASRC is busy sending data.

void ASRC_TransferAbortInSDMA(*ASRC_Type* *base, *asrc_sdma_handle_t* *handle)

Aborts a ASRC in transfer using SDMA.

Parameters

- base – ASRC base pointer.
- handle – ASRC SDMA handle pointer.

void ASRC_TransferAbortOutSDMA(*ASRC_Type* *base, *asrc_sdma_handle_t* *handle)

brief Aborts a ASRC out transfer using SDMA.

param base ASRC base pointer. param handle ASRC SDMA handle pointer.

FSL_ASRC_SDMA_DRIVER_VERSION

Version 2.0.4

typedef struct *_asrc_sdma_handle* *asrc_sdma_handle_t*

ASRC sdma handle prototype.

typedef void (**asrc_sdma_callback_t*)(*ASRC_Type* *base, *asrc_sdma_handle_t* *handle, *status_t* status, void *userData)

ASRC SDMA transfer callback function for finish and error.

typedef void (**asrc_start_peripheral_t*)(bool start)

ASRC trigger peripheral function pointer.

typedef struct *_asrc_p2p_sdma_config* *asrc_p2p_sdma_config_t*

destination peripheral configuration

typedef struct *_asrc_sdma_in_handle* *asrc_sdma_in_handle_t*

ASRC sdma in handle.

typedef struct *_asrc_sdma_out_handle* *asrc_sdma_out_handle_t*

ASRC sdma out handle.

ASRC_XFER_IN_QUEUE_SIZE

ASRC xfer queue size.

ASRC_XFER_OUT_QUEUE_SIZE

struct *_asrc_p2p_sdma_config*

#include <fsl_asrc_sdma.h> destination peripheral configuration

Public Members

uint32_t eventSource
peripheral event source

uint8_t watermark
peripheral watermark

uint8_t channel
peripheral channel number

uint8_t fifoWidth
peripheral fifo width

bool enableContinuous
true is the amount of samples to be transferred is unknown and script will keep on transferring as long as both events are detected and script must be stopped by application, false is The amount of samples to be transferred is equal to the count field of mode word

asrc_start_peripheral_t startPeripheral
trigger peripheral start

struct _asrc_sdma_in_handle
#include <fsl_asrc_sdma.h> ASRC sdma in handle.

Public Members

sdma_handle_t *sdmaHandle
DMA handler for ASRC

uint32_t eventSource
ASRC event source number

asrc_sdma_callback_t callback
Callback for users while transfer finish or error occurs

void *userData
User callback parameter

sdma_buffer_descriptor_t bdPool[4U]
BD pool for SDMA transfer.

uint8_t asrcInWatermark
The transfer data count in a DMA request

uint8_t bytesPerSample
Bytes in a sample

uint32_t *asrcQueue[4U]
Transfer queue storing queued transfer.

size_t sdmaTransferSize[4U]
Data bytes need to transfer

volatile uint8_t queueUser
Index for user to queue transfer.

volatile uint8_t queueDriver
Index for driver to get the transfer data and size

```
const asrc_p2p_sdma_config_t *peripheralConfig
    peripheral configuration
uint32_t state
    Internal state for ASRC SDMA transfer
struct _asrc_sdma_out_handle
    #include <fsl_asrc_sdma.h> ASRC sdma out handle.
```

Public Members

```
sdma_handle_t *sdmaHandle
    DMA handler for ASRC
void *userData
    User callback parameter
uint32_t state
    Internal state for ASRC SDMA transfer
uint8_t bytesPerSample
    Bytes in a sample
uint32_t eventSource
    ASRC event source number
asrc_sdma_callback_t callback
    Callback for users while transfer finish or error occurs
uint8_t asrcOutWatermark
    The transfer data count in a DMA request
sdma_buffer_descriptor_t bdPool[(4U * 2U)]
    BD pool for SDMA transfer.
uint32_t *asrcQueue[(4U * 2U)]
    Transfer queue storing queued transfer.
size_t sdmaTransferSize[(4U * 2U)]
    Data bytes need to transfer
volatile uint8_t queueUser
    Index for user to queue transfer.
volatile uint8_t queueDriver
    Index for driver to get the transfer data and size
const asrc_p2p_sdma_config_t *peripheralConfig
    peripheral configuration
uint32_t nonAlignSize
    non align size
void *nonAlignAddr
    non align address
struct _asrc_sdma_handle
    #include <fsl_asrc_sdma.h> ASRC DMA transfer handle, users should not touch the content
    of the handle.
```

Public Members

asrc_sdma_in_handle_t inDMAHandle

input dma handle

asrc_sdma_out_handle_t outDMAHandle

output dma handle

asrc_context_t context

ASRC context number

uint8_t dataChannels

ASRC process data channel number

2.5 Audiomix

enum _audiomix_attch_clk

audio mix attch clk id

Values:

enumerator kAUDIOMIX_Attach_SAI1_MCLK2_To_SAI1_ROOT

attach SAI1 MCLK2 to SAI1 root

enumerator kAUDIOMIX_Attach_SAI1_MCLK2_To_SAI2_ROOT

attach SAI1 MCLK2 to SAI2 root

enumerator kAUDIOMIX_Attach_SAI1_MCLK2_To_SAI3_ROOT

attach SAI1 MCLK2 to SAI3 root

enumerator kAUDIOMIX_Attach_SAI1_MCLK2_To_SAI5_ROOT

attach SAI1 MCLK2 to SAI5 root

enumerator kAUDIOMIX_Attach_SAI1_MCLK2_To_SAI6_ROOT

attach SAI1 MCLK2 to SAI6 root

enumerator kAUDIOMIX_Attach_SAI1_MCLK2_To_SAI7_ROOT

attach SAI1 MCLK2 to SAI7 root

enumerator kAUDIOMIX_Attach_SAI1_MCLK2_To_SAI1_MCLK

attach SAI1 MCLK2 to SAI1 MCLK

enumerator kAUDIOMIX_Attach_SAI1_MCLK2_To_SAI2_MCLK

attach SAI1 MCLK2 to SAI2 MCLK

enumerator kAUDIOMIX_Attach_SAI1_MCLK2_To_SAI3_MCLK

attach SAI1 MCLK2 to SAI3 MCLK

enumerator kAUDIOMIX_Attach_SAI1_MCLK2_To_SAI5_MCLK

attach SAI1 MCLK2 to SAI5 MCLK

enumerator kAUDIOMIX_Attach_SAI1_MCLK2_To_SAI6_MCLK

attach SAI1 MCLK2 to SAI6 MCLK

enumerator kAUDIOMIX_Attach_SAI1_MCLK2_To_SAI7_MCLK

attach SAI1 MCLK2 to SAI7 MCLK

enumerator kAUDIOMIX_Attach_SAI1_MCLK1_To_SAI1_ROOT

attach SAI1 MCLK1 to SAI1 root

```
enumerator kAUDIOMIX_Attach_SAI1_MCLK1_To_SAI1_MCLK
attach SAI1 MCLK1 to SAI1 MCLK
enumerator kAUDIOMIX_Attach_SAI2_MCLK2_To_SAI1_ROOT
attach SAI2 MCLK2 to SAI1 root
enumerator kAUDIOMIX_Attach_SAI2_MCLK2_To_SAI2_ROOT
attach SAI2 MCLK2 to SAI2 root
enumerator kAUDIOMIX_Attach_SAI2_MCLK2_To_SAI3_ROOT
attach SAI2 MCLK2 to SAI3 root
enumerator kAUDIOMIX_Attach_SAI2_MCLK2_To_SAI5_ROOT
attach SAI2 MCLK2 to SAI5 root
enumerator kAUDIOMIX_Attach_SAI2_MCLK2_To_SAI6_ROOT
attach SAI2 MCLK2 to SAI6 root
enumerator kAUDIOMIX_Attach_SAI2_MCLK2_To_SAI7_ROOT
attach SAI2 MCLK2 to SAI7 root
enumerator kAUDIOMIX_Attach_SAI2_MCLK2_To_SAI1_MCLK
attach SAI2 MCLK2 to SAI1 MCLK
enumerator kAUDIOMIX_Attach_SAI2_MCLK2_To_SAI2_MCLK
attach SAI2 MCLK2 to SAI2 MCLK
enumerator kAUDIOMIX_Attach_SAI2_MCLK2_To_SAI3_MCLK
attach SAI2 MCLK2 to SAI3 MCLK
enumerator kAUDIOMIX_Attach_SAI2_MCLK2_To_SAI5_MCLK
attach SAI2 MCLK2 to SAI5 MCLK
enumerator kAUDIOMIX_Attach_SAI2_MCLK2_To_SAI6_MCLK
attach SAI2 MCLK2 to SAI6 MCLK
enumerator kAUDIOMIX_Attach_SAI2_MCLK2_To_SAI7_MCLK
attach SAI2 MCLK2 to SAI7 MCLK
enumerator kAUDIOMIX_Attach_SAI2_MCLK2_To_SPDIF_ExtCLK
attach SAI2 MCLK2 to SPDIF EXTCLK
enumerator kAUDIOMIX_Attach_SAI2_MCLK1_To_SAI2_ROOT
attach SAI2 MCLK1 to SAI2 root
enumerator kAUDIOMIX_Attach_SAI2_MCLK1_To_SAI2_MCLK
attach SAI2 MCLK1 to SAI2 MCLK
enumerator kAUDIOMIX_Attach_SAI3_MCLK2_To_SAI1_ROOT
attach SAI3 MCLK2 to SAI1 root
enumerator kAUDIOMIX_Attach_SAI3_MCLK2_To_SAI2_ROOT
attach SAI3 MCLK2 to SAI2 root
enumerator kAUDIOMIX_Attach_SAI3_MCLK2_To_SAI3_ROOT
attach SAI3 MCLK2 to SAI3 root
enumerator kAUDIOMIX_Attach_SAI3_MCLK2_To_SAI5_ROOT
attach SAI3 MCLK2 to SAI5 root
enumerator kAUDIOMIX_Attach_SAI3_MCLK2_To_SAI6_ROOT
attach SAI3 MCLK2 to SAI6 root
```

enumerator kAUDIOMIX_Attach_SAI3_MCLK2_To_SAI7_ROOT
attach SAI3 MCLK2 to SAI7 root

enumerator kAUDIOMIX_Attach_SAI3_MCLK2_To_SAI1_MCLK
attach SAI3 MCLK2 to SAI1 MCLK

enumerator kAUDIOMIX_Attach_SAI3_MCLK2_To_SAI2_MCLK
attach SAI3 MCLK2 to SAI2 MCLK

enumerator kAUDIOMIX_Attach_SAI3_MCLK2_To_SAI3_MCLK
attach SAI3 MCLK2 to SAI3 MCLK

enumerator kAUDIOMIX_Attach_SAI3_MCLK2_To_SAI5_MCLK
attach SAI3 MCLK2 to SAI5 MCLK

enumerator kAUDIOMIX_Attach_SAI3_MCLK2_To_SAI6_MCLK
attach SAI3 MCLK2 to SAI6 MCLK

enumerator kAUDIOMIX_Attach_SAI3_MCLK2_To_SAI7_MCLK
attach SAI3 MCLK2 to SAI7 MCLK

enumerator kAUDIOMIX_Attach_SAI3_MCLK2_To_SPDIF_ExtCLK
attach SAI3 MCLK2 to SPDIF EXTCLK

enumerator kAUDIOMIX_Attach_SAI3_MCLK1_To_SAI3_ROOT
attach SAI3 MCLK1 to SAI3 root

enumerator kAUDIOMIX_Attach_SAI3_MCLK1_To_SAI3_MCLK
attach SAI3 MCLK1 to SAI3 MCLK

enumerator kAUDIOMIX_Attach_SAI5_MCLK2_To_SAI1_ROOT
attach SAI5 MCLK2 to SAI1 root

enumerator kAUDIOMIX_Attach_SAI5_MCLK2_To_SAI2_ROOT
attach SAI5 MCLK2 to SAI2 root

enumerator kAUDIOMIX_Attach_SAI5_MCLK2_To_SAI3_ROOT
attach SAI5 MCLK2 to SAI3 root

enumerator kAUDIOMIX_Attach_SAI5_MCLK2_To_SAI5_ROOT
attach SAI5 MCLK2 to SAI5 root

enumerator kAUDIOMIX_Attach_SAI5_MCLK2_To_SAI6_ROOT
attach SAI5 MCLK2 to SAI6 root

enumerator kAUDIOMIX_Attach_SAI5_MCLK2_To_SAI7_ROOT
attach SAI5 MCLK2 to SAI7 root

enumerator kAUDIOMIX_Attach_SAI5_MCLK2_To_SAI1_MCLK
attach SAI5 MCLK2 to SAI1 MCLK

enumerator kAUDIOMIX_Attach_SAI5_MCLK2_To_SAI2_MCLK
attach SAI5 MCLK2 to SAI2 MCLK

enumerator kAUDIOMIX_Attach_SAI5_MCLK2_To_SAI3_MCLK
attach SAI5 MCLK2 to SAI3 MCLK

enumerator kAUDIOMIX_Attach_SAI5_MCLK2_To_SAI5_MCLK
attach SAI5 MCLK2 to SAI5 MCLK

enumerator kAUDIOMIX_Attach_SAI5_MCLK2_To_SAI6_MCLK
attach SAI5 MCLK2 to SAI6 MCLK

```
enumerator kAUDIOMIX_Attach_SAI5_MCLK2_To_SAI7_MCLK
    attach SAI5 MCLK2 to SAI7 MCLK
enumerator kAUDIOMIX_Attach_SAI5_MCLK2_To_SPDIF_ExtCLK
    attach SAI5 MCLK2 to SPDIF EXTCLK
enumerator kAUDIOMIX_Attach_SAI5_MCLK1_To_SAI5_ROOT
    attach SAI5 MCLK1 to SAI5 root
enumerator kAUDIOMIX_Attach_SAI5_MCLK1_To_SAI5_MCLK
    attach SAI5 MCLK1 to SAI5 MCLK
enumerator kAUDIOMIX_Attach_SAI6_MCLK2_To_SAI1_ROOT
    attach SAI6 MCLK2 to SAI1 root
enumerator kAUDIOMIX_Attach_SAI6_MCLK2_To_SAI2_ROOT
    attach SAI6 MCLK2 to SAI2 root
enumerator kAUDIOMIX_Attach_SAI6_MCLK2_To_SAI3_ROOT
    attach SAI6 MCLK2 to SAI3 root
enumerator kAUDIOMIX_Attach_SAI6_MCLK2_To_SAI5_ROOT
    attach SAI6 MCLK2 to SAI5 root
enumerator kAUDIOMIX_Attach_SAI6_MCLK2_To_SAI6_ROOT
    attach SAI6 MCLK2 to SAI6 root
enumerator kAUDIOMIX_Attach_SAI6_MCLK2_To_SAI7_ROOT
    attach SAI6 MCLK2 to SAI7 root
enumerator kAUDIOMIX_Attach_SAI6_MCLK2_To_SAI1_MCLK
    attach SAI6 MCLK2 to SAI1 MCLK
enumerator kAUDIOMIX_Attach_SAI6_MCLK2_To_SAI2_MCLK
    attach SAI6 MCLK2 to SAI2 MCLK
enumerator kAUDIOMIX_Attach_SAI6_MCLK2_To_SAI3_MCLK
    attach SAI6 MCLK2 to SAI3 MCLK
enumerator kAUDIOMIX_Attach_SAI6_MCLK2_To_SAI5_MCLK
    attach SAI6 MCLK2 to SAI5 MCLK
enumerator kAUDIOMIX_Attach_SAI6_MCLK2_To_SAI6_MCLK
    attach SAI6 MCLK2 to SAI6 MCLK
enumerator kAUDIOMIX_Attach_SAI6_MCLK2_To_SAI7_MCLK
    attach SAI6 MCLK2 to SAI7 MCLK
enumerator kAUDIOMIX_Attach_SAI6_MCLK2_To_SPDIF_ExtCLK
    attach SAI6 MCLK2 to SPDIF EXTCLK
enumerator kAUDIOMIX_Attach_SAI6_MCLK1_To_SAI6_ROOT
    attach SAI6 MCLK2 to SAI6 root
enumerator kAUDIOMIX_Attach_SAI6_MCLK1_To_SAI6_MCLK
    attach SAI6 MCLK2 to SAI6 MCLK
enumerator kAUDIOMIX_Attach_SAI7_MCLK2_To_SAI1_ROOT
    attach SAI7 MCLK2 to SAI1 root
enumerator kAUDIOMIX_Attach_SAI7_MCLK2_To_SAI2_ROOT
    attach SAI7 MCLK2 to SAI2 root
```



```

enumerator kAUDIOMIX_Attach_SAI7_MCLK2_To_SAI3_ROOT
    attach SAI7 MCLK2 to SAI3 root
enumerator kAUDIOMIX_Attach_SAI7_MCLK2_To_SAI5_ROOT
    attach SAI7 MCLK2 to SAI5 root
enumerator kAUDIOMIX_Attach_SAI7_MCLK2_To_SAI6_ROOT
    attach SAI7 MCLK2 to SAI6 root
enumerator kAUDIOMIX_Attach_SAI7_MCLK2_To_SAI7_ROOT
    attach SAI7 MCLK2 to SAI7 root
enumerator kAUDIOMIX_Attach_SAI7_MCLK2_To_SAI1_MCLK
    attach SAI7 MCLK2 to SAI1 MCLK
enumerator kAUDIOMIX_Attach_SAI7_MCLK2_To_SAI2_MCLK
    attach SAI7 MCLK2 to SAI2 MCLK
enumerator kAUDIOMIX_Attach_SAI7_MCLK2_To_SAI3_MCLK
    attach SAI7 MCLK2 to SAI3 MCLK
enumerator kAUDIOMIX_Attach_SAI7_MCLK2_To_SAI5_MCLK
    attach SAI7 MCLK2 to SAI5 MCLK
enumerator kAUDIOMIX_Attach_SAI7_MCLK2_To_SAI6_MCLK
    attach SAI7 MCLK2 to SAI6 MCLK
enumerator kAUDIOMIX_Attach_SAI7_MCLK2_To_SAI7_MCLK
    attach SAI7 MCLK2 to SAI7 MCLK
enumerator kAUDIOMIX_Attach_SAI7_MCLK2_To_SPDIF_ExtCLK
    attach SAI7 MCLK2 to SPDIF_ExtCLK
enumerator kAUDIOMIX_Attach_SAI7_MCLK1_To_SAI7_ROOT
    attach SAI7 MCLK1 to SAI7 root
enumerator kAUDIOMIX_Attach_SAI7_MCLK1_To_SAI7_MCLK
    attach SAI7 MCLK1 to SAI7 MCLK
enumerator kAUDIOMIX_Attach_PDM_Root_to_CCM_PDM
    attach PDM ROOT to CCM PDM clock
enumerator kAUDIOMIX_Attach_PDM_Root_to_SAI_PLL_DVI2
    attach PDM ROOT to sai pll div2
enumerator kAUDIOMIX_Attach_PDM_Root_to_SAI1_MCLK
    attach PDM ROOT to SAI1 mclk
enum _audiomix_power_ctrl
    audio mix power control
    Values:
    enumerator kAUDIOMIX_PowerCtrlEDMA
        edma power control
    enumerator kAUDIOMIX_PowerCtrlSDMA2
        SDMA2 power control
    enumerator kAUDIOMIX_PowerCtrlSDMA3
        SDMA3 power control

```

enumerator kAUDIOMIX_PowerCtrlPDM
PDM power control

enumerator kAUDIOMIX_PowerCtrlSAI1
SAI1 power control

enumerator kAUDIOMIX_PowerCtrlSAI2
SAI2 power control

enumerator kAUDIOMIX_PowerCtrlSAI3
SAI3 power control

enumerator kAUDIOMIX_PowerCtrlSAI5
SAI5 power control

enumerator kAUDIOMIX_PowerCtrlSAI6
SAI6 power control

enumerator kAUDIOMIX_PowerCtrlSAI7
SAI7 power control

typedef enum *audiomix_attch_clk* audiomix_attch_clk_t
audio mix attch clk id

FSL_AUDIOMIX_DRIVER_VERSION
AUDIOMIX driver version 2.0.1.

AUDIOMIX_ATTACH_ID(offset, mask, value)
AUDIOMIX attach id combination.

GET_AUDIOMIX_ATTACH_ID_OFFSET(id)

GET_AUDIOMIX_ATTACH_ID_MASK(id)

GET_AUDIOMIX_ATTACH_ID_value(id)

void AUDIOMIX_AttachClk(AUDIOMIX_Type *base, *audiomix_attch_clk_t* id)
audiomix attach clock.

Parameters

- base – audiomix base address.
- id – attach clock id.

static inline uint32_t AUDIOMIX_GetIPStopAck(AUDIOMIX_Type *base, uint32_t ip)
audiomix low power ack bit status.

Parameters

- base – audiomix base address.
- ip – reference *_audiomix_power_ctrl*, can be a value or combine value in *_audiomix_power_ctrl*

static inline void AUDIOMIX_SetIPStop(AUDIOMIX_Type *base, uint32_t ip)
audiomix low power stop mode

Parameters

- base – audiomix base address.
- ip – reference *_audiomix_power_ctrl*, can be a value or combine value in *_audiomix_power_ctrl*

```
static inline void AUDIOMIX_SetEARCReset(AUDIOMIX_Type *base, bool enable)
    audiomix earc reset
```

Parameters

- base – audiomix base address.
- enable – true is reset, false is release.

```
static inline void AUDIOMIX_SetEARCPHYReset(AUDIOMIX_Type *base, bool enable)
    audiomix earc PHY reset
```

Parameters

- base – audiomix base address.
- enable – true is reset, false is release.

```
void AUDIOMIX_InitAudioPll(AUDIOMIX_Type *base, const ccm_analog_frac_pll_config_t
    *config)
```

Initializes the SAI PLL. note This function can't detect whether the AUDIO PLL has been enabled and used by some IPs.

Parameters

- base – audiomix base address.
- config – Pointer to the configuration structure(see ref ccm_analog_frac_pll_config_t enumeration).

```
void AUDIOMIX_DeinitAudioPll1(AUDIOMIX_Type *base)
```

brief De-initialize the SAI PLL.

```
uint32_t AUDIOMIX_GetAudioPllFreq(AUDIOMIX_Type *base)
```

Get the sai PLL output freq.

Return values

sai – pll output freq.

2.6 CACHE: ARMV7-M7 CACHE Memory Controller

```
static inline void L1CACHE_EnableICache(void)
```

Enables cortex-m7 L1 instruction cache.

```
static inline void L1CACHE_DisableICache(void)
```

Disables cortex-m7 L1 instruction cache.

```
static inline void L1CACHE_InvalidateICache(void)
```

Invalidate cortex-m7 L1 instruction cache.

```
void L1CACHE_InvalidateICacheByRange(uint32_t address, uint32_t size_byte)
```

Invalidate cortex-m7 L1 instruction cache by range.

Note: The start address and size_byte should be 32-byte(FSL_FEATURE_L1ICACHE_LINESIZE_BYTE) aligned. The startAddr here will be forced to align to L1 I-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 start address of the memory to be invalidated.
- size_byte – The memory size.

static inline void L1CACHE_EnableDCache(void)

Enables cortex-m7 L1 data cache.

static inline void L1CACHE_DisableDCache(void)

Disables cortex-m7 L1 data cache.

static inline void L1CACHE_InvalidateDCache(void)

Invalidates cortex-m7 L1 data cache.

static inline void L1CACHE_CleanDCache(void)

Cleans cortex-m7 L1 data cache.

static inline void L1CACHE_CleanInvalidateDCache(void)

Cleans and Invalidates cortex-m7 L1 data cache.

static inline void L1CACHE_InvalidateDCacheByRange(uint32_t address, uint32_t size_byte)

Invalidates cortex-m7 L1 data cache by range.

Note: The start address and size_byte should be 32-byte(FSL_FEATURE_L1DCACHE_LINESIZE_BYTE) aligned. The startAddr here will be forced to align to L1 D-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 start address of the memory to be invalidated.
- size_byte – The memory size.

static inline void L1CACHE_CleanDCacheByRange(uint32_t address, uint32_t size_byte)

Cleans cortex-m7 L1 data cache by range.

Note: The start address and size_byte should be 32-byte(FSL_FEATURE_L1DCACHE_LINESIZE_BYTE) aligned. The startAddr here will be forced to align to L1 D-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 start address of the memory to be cleaned.
- size_byte – The memory size.

static inline void L1CACHE_CleanInvalidateDCacheByRange(uint32_t address, uint32_t
size_byte)

Cleans and Invalidates cortex-m7 L1 data cache by range.

Note: The start address and size_byte should be 32-byte(FSL_FEATURE_L1DCACHE_LINESIZE_BYTE) aligned. The startAddr here will be forced to align to L1 D-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 start address of the memory to be clean and invalidated.
- size_byte – The memory size.

void ICACHE_InvalidateByRange(uint32_t address, uint32_t size_byte)

Invalidates all instruction caches by range.

Both cortex-m7 L1 cache line and L2 PL310 cache line length is 32-byte.

Note: address and size should be aligned to cache line size 32-Byte due to the cache operation unit is one cache line. 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.

void DCACHE_InvalidateByRange(uint32_t address, uint32_t size_byte)

Invalidates all data caches by range.

Both cortex-m7 L1 cache line and L2 PL310 cache line length is 32-byte.

Note: address and size should be aligned to cache line size 32-Byte due to the cache operation unit is one cache line. 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.

void DCACHE_CleanByRange(uint32_t address, uint32_t size_byte)

Cleans all data caches by range.

Both cortex-m7 L1 cache line and L2 PL310 cache line length is 32-byte.

Note: address and size should be aligned to cache line size 32-Byte due to the cache operation unit is one cache line. 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.

void DCACHE_CleanInvalidateByRange(uint32_t address, uint32_t size_byte)

Cleans and Invalidates all data caches by range.

Both cortex-m7 L1 cache line and L2 PL310 cache line length is 32-byte.

Note: address and size should be aligned to cache line size 32-Byte due to the cache operation unit is one cache line. 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.

FSL_CACHE_DRIVER_VERSION
cache driver version 2.0.4.

2.7 Clock

enum _clock_name

Clock name used to get clock frequency.

Values:

enumerator kCLOCK_CoreM7Clk
ARM M7 Core clock

enumerator kCLOCK_AxiClk
Main AXI bus clock.

enumerator kCLOCK_AhbClk
AHB bus clock.

enumerator kCLOCK_IpgClk
IPG bus clock.

enumerator kCLOCK_PerClk
Peripheral Clock.

enumerator kCLOCK_EnetIpgClk
ENET IPG Clock.

enumerator kCLOCK_Osc24MClk
OSC 24M clock.

enumerator kCLOCK_ArmPllClk
Arm PLL clock.

enumerator kCLOCK_DramPllClk
Dram PLL clock.

enumerator kCLOCK_VpuPllClk
Vpu PLL clock.

enumerator kCLOCK_SysPll1Clk
Sys PLL1 clock.

enumerator kCLOCK_SysPll1Div2Clk
Sys PLL1 clock divided by 2.

enumerator kCLOCK_SysPll1Div3Clk
Sys PLL1 clock divided by 3.

enumerator kCLOCK_SysPll1Div4Clk
Sys PLL1 clock divided by 4.

enumerator kCLOCK_SysPll1Div5Clk
Sys PLL1 clock divided by 5.

enumerator kCLOCK_SysPll1Div6Clk
Sys PLL1 clock divided by 6.

enumerator kCLOCK_SysPll1Div8Clk
Sys PLL1 clock divided by 8.

enumerator kCLOCK_SysPll1Div10Clk
Sys PLL1 clock divided by 10.

enumerator kCLOCK_SysPll1Div20Clk
Sys PLL1 clock divided by 20.

enumerator kCLOCK_SysPll2Clk
Sys PLL2 clock.

enumerator kCLOCK_SysPll2Div2Clk
Sys PLL2 clock divided by 2.

enumerator kCLOCK_SysPll2Div3Clk
Sys PLL2 clock divided by 3.

enumerator kCLOCK_SysPll2Div4Clk
Sys PLL2 clock divided by 4.

enumerator kCLOCK_SysPll2Div5Clk
Sys PLL2 clock divided by 5.

enumerator kCLOCK_SysPll2Div6Clk
Sys PLL2 clock divided by 6.

enumerator kCLOCK_SysPll2Div8Clk
Sys PLL2 clock divided by 8.

enumerator kCLOCK_SysPll2Div10Clk
Sys PLL2 clock divided by 10.

enumerator kCLOCK_SysPll2Div20Clk
Sys PLL2 clock divided by 20.

enumerator kCLOCK_SysPll3Clk
Sys PLL3 clock.

enumerator kCLOCK_AudioPll1Clk
Audio PLL1 clock.

enumerator kCLOCK_AudioPll2Clk
Audio PLL2 clock.

enumerator kCLOCK_VideoPll1Clk
Video PLL1 clock.

enumerator kCLOCK_ExtClk1
External clock1.

enumerator kCLOCK_ExtClk2
External clock2.

enumerator kCLOCK_ExtClk3

External clock3.

enumerator kCLOCK_ExtClk4

External clock4.

enumerator kCLOCK_NoneName

None Clock Name.

enum _clock_ip_name

CCM CCGR gate control.

Values:

enumerator kCLOCK_IpInvalid

enumerator kCLOCK_Debug

DEBUG Clock Gate.

enumerator kCLOCK_Dram

DRAM Clock Gate.

enumerator kCLOCK_Ecspi1

ECSPI1 Clock Gate.

enumerator kCLOCK_Ecspi2

ECSPI2 Clock Gate.

enumerator kCLOCK_Ecspi3

ECSPI3 Clock Gate.

enumerator kCLOCK_Enet1

ENET1 Clock Gate.

enumerator kCLOCK_Gpio1

GPIO1 Clock Gate.

enumerator kCLOCK_Gpio2

GPIO2 Clock Gate.

enumerator kCLOCK_Gpio3

GPIO3 Clock Gate.

enumerator kCLOCK_Gpio4

GPIO4 Clock Gate.

enumerator kCLOCK_Gpio5

GPIO5 Clock Gate.

enumerator kCLOCK_Gpt1

GPT1 Clock Gate.

enumerator kCLOCK_Gpt2

GPT2 Clock Gate.

enumerator kCLOCK_Gpt3

GPT3 Clock Gate.

enumerator kCLOCK_Gpt4

GPT4 Clock Gate.

enumerator kCLOCK_Gpt5

GPT5 Clock Gate.

enumerator kCLOCK_Gpt6
GPT6 Clock Gate.

enumerator kCLOCK_I2c1
I2C1 Clock Gate.

enumerator kCLOCK_I2c2
I2C2 Clock Gate.

enumerator kCLOCK_I2c3
I2C3 Clock Gate.

enumerator kCLOCK_I2c4
I2C4 Clock Gate.

enumerator kCLOCK_I2c5
I2C5 Clock Gate.

enumerator kCLOCK_I2c6
I2C6 Clock Gate.

enumerator kCLOCK_Can1
FlexCAN1 Clock Gate.

enumerator kCLOCK_Can2
FlexCAN2 Clock Gate.

enumerator kCLOCK_Enet_Qos
ENET QOS Clock Gate.

enumerator kCLOCK_Iomux
IOMUX Clock Gate.

enumerator kCLOCK_Ipmux1
IPMUX1 Clock Gate.

enumerator kCLOCK_Ipmux2
IPMUX2 Clock Gate.

enumerator kCLOCK_Ipmux3
IPMUX3 Clock Gate.

enumerator kCLOCK_Mu
MU Clock Gate.

enumerator kCLOCK_Ocram
OCRAM Clock Gate.

enumerator kCLOCK_OcramS
OCRAM S Clock Gate.

enumerator kCLOCK_Pwm1
PWM1 Clock Gate.

enumerator kCLOCK_Pwm2
PWM2 Clock Gate.

enumerator kCLOCK_Pwm3
PWM3 Clock Gate.

enumerator kCLOCK_Pwm4
PWM4 Clock Gate.

enumerator kCLOCK_Qspi
QSPI Clock Gate.

enumerator kCLOCK_Nand
NAND Clock Gate.

enumerator kCLOCK_Rdc
RDC Clock Gate.

enumerator kCLOCK_Sdma1
SDMA1 Clock Gate.

enumerator kCLOCK_Sec_Debug
SEC_DEBUG Clock Gate.

enumerator kCLOCK_Sema42_1
RDC SEMA42 Clock Gate.

enumerator kCLOCK_Sema42_2
RDC SEMA42 Clock Gate.

enumerator kCLOCK_Sim_enet
SIM_ENET Clock Gate.

enumerator kCLOCK_Sim_m
SIM_M Clock Gate.

enumerator kCLOCK_Sim_main
SIM_MAIN Clock Gate.

enumerator kCLOCK_Sim_s
SIM_S Clock Gate.

enumerator kCLOCK_Sim_wakeup
SIM_WAKEUP Clock Gate.

enumerator kCLOCK_Gpu2D
GPU2D Clock Gate.

enumerator kCLOCK_Gpu3D
GPU3D Clock Gate.

enumerator kCLOCK_Uart1
UART1 Clock Gate.

enumerator kCLOCK_Uart2
UART2 Clock Gate.

enumerator kCLOCK_Uart3
UART3 Clock Gate.

enumerator kCLOCK_Uart4
UART4 Clock Gate.

enumerator kCLOCK_Usdhc1
USDHC1 Clock Gate.

enumerator kCLOCK_Usdhc2
USDHC2 Clock Gate.

enumerator kCLOCK_Wdog1
WDOG1 Clock Gate.

enumerator kCLOCK_Wdog2
WDOG2 Clock Gate.

enumerator kCLOCK_Wdog3
WDOG3 Clock Gate.

enumerator kCLOCK_Vpu_G1
VPU_G1 Clock Gate.

enumerator kCLOCK_Gpu
GPU Clock Gate.

enumerator kCLOCK_Vpu_Vc8ke
VPU_VC8KE Clock Gate.

enumerator kCLOCK_Vpu_G2
VPU_G2 Clock Gate.

enumerator kCLOCK_Npu
NPU Clock Gate.

enumerator kCLOCK_Hsio
HSIO Clock Gate.

enumerator kCLOCK_Media
MEDIA Clock Gate.

enumerator kCLOCK_Usdhc3
USDHC3 Clock Gate.

enumerator kCLOCK_Hdmi
HDMI Clock Gate.

enumerator kCLOCK_TempSensor
TempSensor Clock Gate.

enumerator kCLOCK_Audio
AUDIO Clock Gate.

enumerator kCLOCK_Earc
EARC clock gate

enumerator kCLOCK_AudioDspDebug
AUDIO DSP DEBUG clock gate

enumerator kCLOCK_AudioDsp
audio dsp clock gate

enumerator kCLOCK_Spba2
SPBA2 clock gate

enumerator kCLOCK_Sdma3
SDMA3 clock gate

enumerator kCLOCK_Sdma2
SDMA2 clock gate

enumerator kCLOCK_Pdm
PDM clock gate

enumerator kCLOCK_Asrc
ASRC clock gate

enumerator kCLOCK_Sai7_Mclk3
SAI7 MCLK3 clock gate

enumerator kCLOCK_Sai7_Mclk2
SAI7 MCLK2 clock gate

enumerator kCLOCK_Sai7_Mclk1
SAI7 MCLK1 clock gate

enumerator kCLOCK_Sai7
SAI7 clock gate

enumerator kCLOCK_Sai6_Mclk3
SAI6 MCLK3 clock gate

enumerator kCLOCK_Sai6_Mclk2
SAI6 MCLK2 clock gate

enumerator kCLOCK_Sai6_Mclk1
SAI6 MCLK1 clock gate

enumerator kCLOCK_Sai6
SAI6 clock gate

enumerator kCLOCK_Sai5_Mclk3
SAI5 MCLK3 clock gate

enumerator kCLOCK_Sai5_Mclk2
sai5 MCLK2 clock gate

enumerator kCLOCK_Sai5_Mclk1
SAI5 MCLK1 clock gate

enumerator kCLOCK_Sai5
SAI5 clock gate

enumerator kCLOCK_Sai3_Mclk3
SAI3 MCLK3 clock gate

enumerator kCLOCK_Sai3_Mclk2
SAI3 MCLK2 clock gate

enumerator kCLOCK_Sai3_Mclk1
SAI3 MCLK1 clock gate

enumerator kCLOCK_Sai3
SAI3 clock gate

enumerator kCLOCK_Sai2_Mclk3
SAI2 MCLK3 clock gate

enumerator kCLOCK_Sai2_Mclk2
SAI2 MCLK2 clock gate

enumerator kCLOCK_Sai2_Mclk1
SAI2 MCLK1 clock gate

enumerator kCLOCK_Sai2
SAI2 clock gate

enumerator kCLOCK_Sai1_Mclk3
SAI1 MCLK3 clock gate

enumerator kCLOCK_Sai1_Mclk2
SAI1 MCLK2 clock gate

enumerator kCLOCK_Sai1_Mclk1
SAI1 MCLK1 clock gate

enumerator kCLOCK_Sai1
SAI1 clock gate

enumerator kCLOCK_EarcPhy
EARC PHY clock gate

enumerator kCLOCK_Mu3
MU3 clock gate

enumerator kCLOCK_Mu2
MU2 clock gate

enumerator kCLOCK_Pll
PLL clock gate

enumerator kCLOCK_Edma
EDMA clock gate

enumerator kCLOCK_Aud2htx
AUD2HTX clock gate

enumerator kCLOCK_Ocram_A
OCRAM A clock gate

enum _clock_root_control
ccm root name used to get clock frequency.

Values:

enumerator kCLOCK_RootM7
ARM Cortex-M7 Clock control name.

enumerator kCLOCK_RootHsioAxi
HSIO AXI Clock control name.

enumerator kCLOCK_RootMainAxi
MAIN AXI Clock control name.

enumerator kCLOCK_RootEnetAxi
ENET AXI Clock control name.

enumerator kCLOCK_RootNandUsdhcBus
NAND USDHC BUS Clock control name.

enumerator kCLOCK_RootVpuBus
VPU BUS Clock control name.

enumerator kCLOCK_RootMediaAxi
MEDIA AXI Clock control name.

enumerator kCLOCK_RootMediaApb
MEDIA APB Clock control name.

enumerator kCLOCK_RootHdmiApb
HDMI APB Clock control name.

enumerator kCLOCK_RootNoc
NOC Clock control name.

enumerator kCLOCK_RootAhb
AHB Clock control name.

enumerator kCLOCK_RootIpg
IPG Clock control name.

enumerator kCLOCK_RootAudioAhb
Audio AHB Clock control name.

enumerator kCLOCK_RootAudioIpg
Audio IPG Clock control name.

enumerator kCLOCK_RootDramAlt
DRAM ALT Clock control name.

enumerator kCLOCK_RootFlexCan1
FLEXCAN1 Clock control name.

enumerator kCLOCK_RootFlexCan2
FLEXCAN2 Clock control name.

enumerator kCLOCK_RootSai1
SAI1 Clock control name.

enumerator kCLOCK_RootSai2
SAI2 Clock control name.

enumerator kCLOCK_RootSai3
SAI3 Clock control name.

enumerator kCLOCK_RootSai5
SAI5 Clock control name.

enumerator kCLOCK_RootSai6
SAI6 Clock control name.

enumerator kCLOCK_RootSai7
SAI7 Clock control name.

enumerator kCLOCK_RootEnetQos
ENET QOS Clock control name.

enumerator kCLOCK_RootEnetQosTimer
ENET QOS TIMER Clock control name.

enumerator kCLOCK_RootEnetRef
ENET Clock control name.

enumerator kCLOCK_RootEnetTimer
ENET TIMER Clock control name.

enumerator kCLOCK_RootEnetPhy
ENET PHY Clock control name.

enumerator kCLOCK_RootNand
NAND Clock control name.

enumerator kCLOCK_RootQspi
QSPI Clock control name.

enumerator kCLOCK_RootUsdhc1
USDHC1 Clock control name.

enumerator kCLOCK_RootUsdhc2
USDHC2 Clock control name.

enumerator kCLOCK_RootUsdhc3
USDHC3 Clock control name.

enumerator kCLOCK_RootI2c1
I2C1 Clock control name.

enumerator kCLOCK_RootI2c2
I2C2 Clock control name.

enumerator kCLOCK_RootI2c3
I2C3 Clock control name.

enumerator kCLOCK_RootI2c4
I2C4 Clock control name.

enumerator kCLOCK_RootI2c5
I2C5 Clock control name.

enumerator kCLOCK_RootI2c6
I2C6 Clock control name.

enumerator kCLOCK_RootUart1
UART1 Clock control name.

enumerator kCLOCK_RootUart2
UART2 Clock control name.

enumerator kCLOCK_RootUart3
UART3 Clock control name.

enumerator kCLOCK_RootUart4
UART4 Clock control name.

enumerator kCLOCK_RootGic
GIC Clock control name.

enumerator kCLOCK_RootEcspi1
ECSPI1 Clock control name.

enumerator kCLOCK_RootEcspi2
ECSPI2 Clock control name.

enumerator kCLOCK_RootEcspi3
ECSPI3 Clock control name.

enumerator kCLOCK_RootPwm1
PWM1 Clock control name.

enumerator kCLOCK_RootPwm2
PWM2 Clock control name.

enumerator kCLOCK_RootPwm3
PWM3 Clock control name.

enumerator kCLOCK_RootPwm4
PWM4 Clock control name.

enumerator kCLOCK_RootGpt1

GPT1 Clock control name.

enumerator kCLOCK_RootGpt2

GPT2 Clock control name.

enumerator kCLOCK_RootGpt3

GPT3 Clock control name.

enumerator kCLOCK_RootGpt4

GPT4 Clock control name.

enumerator kCLOCK_RootGpt5

GPT5 Clock control name.

enumerator kCLOCK_RootGpt6

GPT6 Clock control name.

enumerator kCLOCK_RootWdog

WDOG Clock control name.

enumerator kCLOCK_RootPdm

PDM Clock control name.

enum _clock_root

ccm clock root used to get clock frequency.

Values:

enumerator kCLOCK_M7ClkRoot

ARM Cortex-M7 Clock control name.

enumerator kCLOCK_HsioAxiClkRoot

HSIO AXI Clock control name.

enumerator kCLOCK_MainAxiClkRoot

MAIN AXI Clock control name.

enumerator kCLOCK_EnetAxiClkRoot

ENET AXI Clock control name.

enumerator kCLOCK_NandUsdhcBusClkRoot

NAND USDHC BUS Clock control name.

enumerator kCLOCK_VpuBusClkRoot

VPU BUS Clock control name.

enumerator kCLOCK_MediaAxiClkRoot

MEDIA AXI Clock control name.

enumerator kCLOCK_MediaApbClkRoot

MEDIA APB Clock control name.

enumerator kCLOCK_HdmiApbClkRoot

HDMI APB Clock control name.

enumerator kCLOCK_NocClkRoot

NOC Clock control name.

enumerator kCLOCK_AhbClkRoot

AHB Clock control name.

enumerator kCLOCK_IpgClkRoot
IPG Clock control name.

enumerator kCLOCK_AudioAhbClkRoot
Audio AHB Clock control name.

enumerator kCLOCK_AudioIpgClkRoot
Audio IPG Clock control name.

enumerator kCLOCK_DramAltClkRoot
DRAM ALT Clock control name.

enumerator kCLOCK_FlexCan1ClkRoot
FLEXCAN1 Clock control name.

enumerator kCLOCK_FlexCan2ClkRoot
FLEXCAN2 Clock control name.

enumerator kCLOCK_Sai1ClkRoot
SAI1 Clock control name.

enumerator kCLOCK_Sai2ClkRoot
SAI2 Clock control name.

enumerator kCLOCK_Sai3ClkRoot
SAI3 Clock control name.

enumerator kCLOCK_Sai5ClkRoot
SAI5 Clock control name.

enumerator kCLOCK_Sai6ClkRoot
SAI6 Clock control name.

enumerator kCLOCK_Sai7ClkRoot
SAI7 Clock control name.

enumerator kCLOCK_EnetQosClkRoot
ENET QOS Clock control name.

enumerator kCLOCK_EnetQosTimerClkRoot
ENET QOS TIMER Clock control name.

enumerator kCLOCK_EnetRefClkRoot
ENET Clock control name.

enumerator kCLOCK_EnetTimerClkRoot
ENET TIMER Clock control name.

enumerator kCLOCK_EnetPhyClkRoot
ENET PHY Clock control name.

enumerator kCLOCK_NandClkRoot
NAND Clock control name.

enumerator kCLOCK_QspiClkRoot
QSPI Clock control name.

enumerator kCLOCK_Usdhc1ClkRoot
USDHC1 Clock control name.

enumerator kCLOCK_Usdhc2ClkRoot
USDHC2 Clock control name.

enumerator kCLOCK_Usdhc3ClkRoot
USDHC3 Clock control name.

enumerator kCLOCK_I2c1ClkRoot
I2C1 Clock control name.

enumerator kCLOCK_I2c2ClkRoot
I2C2 Clock control name.

enumerator kCLOCK_I2c3ClkRoot
I2C3 Clock control name.

enumerator kCLOCK_I2c4ClkRoot
I2C4 Clock control name.

enumerator kCLOCK_I2c5ClkRoot
I2C5 Clock control name.

enumerator kCLOCK_I2c6ClkRoot
I2C6 Clock control name.

enumerator kCLOCK_Uart1ClkRoot
UART1 Clock control name.

enumerator kCLOCK_Uart2ClkRoot
UART2 Clock control name.

enumerator kCLOCK_Uart3ClkRoot
UART3 Clock control name.

enumerator kCLOCK_Uart4ClkRoot
UART4 Clock control name.

enumerator kCLOCK_GicClkRoot
GIC Clock control name.

enumerator kCLOCK_Ecspi1ClkRoot
ECSPI1 Clock control name.

enumerator kCLOCK_Ecspi2ClkRoot
ECSPI2 Clock control name.

enumerator kCLOCK_Ecspi3ClkRoot
ECSPI3 Clock control name.

enumerator kCLOCK_Pwm1ClkRoot
PWM1 Clock control name.

enumerator kCLOCK_Pwm2ClkRoot
PWM2 Clock control name.

enumerator kCLOCK_Pwm3ClkRoot
PWM3 Clock control name.

enumerator kCLOCK_Pwm4ClkRoot
PWM4 Clock control name.

enumerator kCLOCK_Gpt1ClkRoot
GPT1 Clock control name.

enumerator kCLOCK_Gpt2ClkRoot
GPT2 Clock control name.

enumerator kCLOCK_Gpt3ClkRoot
GPT3 Clock control name.

enumerator kCLOCK_Gpt4ClkRoot
GPT4 Clock control name.

enumerator kCLOCK_Gpt5ClkRoot
GPT5 Clock control name.

enumerator kCLOCK_Gpt6ClkRoot
GPT6 Clock control name.

enumerator kCLOCK_WdogClkRoot
WDOG Clock control name.

enumerator kCLOCK_PdmClkRoot
PDM Clock control name.

enum _clock_rootmux_m7_clk_sel
Root clock select enumeration for ARM Cortex-M7 core.

Values:

enumerator kCLOCK_M7RootmuxOsc24M
ARM Cortex-M7 Clock from OSC 24M.

enumerator kCLOCK_M7RootmuxSysPll2Div5
ARM Cortex-M7 Clock from SYSTEM PLL2 divided by 5.

enumerator kCLOCK_M7RootmuxSysPll2Div4
ARM Cortex-M7 Clock from SYSTEM PLL2 divided by 4.

enumerator kCLOCK_M7RootmuxSysVpuPll
ARM Cortex-M7 Clock from VPU PLL.

enumerator kCLOCK_M7RootmuxSysPll1
ARM Cortex-M7 Clock from SYSTEM PLL1.

enumerator kCLOCK_M7RootmuxAudioPll1
ARM Cortex-M7 Clock from AUDIO PLL1.

enumerator kCLOCK_M7RootmuxVideoPll1
ARM Cortex-M7 Clock from VIDEO PLL1.

enumerator kCLOCK_M7RootmuxSysPll3
ARM Cortex-M7 Clock from SYSTEM PLL3.

enum _clock_rootmux_axi_clk_sel
Root clock select enumeration for MAIN AXI bus.

Values:

enumerator kCLOCK_AxiRootmuxOsc24M
ARM MAIN AXI Clock from OSC 24M.

enumerator kCLOCK_AxiRootmuxSysPll2Div3
ARM MAIN AXI Clock from SYSTEM PLL2 divided by 3.

enumerator kCLOCK_AxiRootmuxSysPll1
ARM MAIN AXI Clock from SYSTEM PLL1.

enumerator kCLOCK_AxiRootmuxSysPll2Div4
ARM MAIN AXI Clock from SYSTEM PLL2 divided by 4.

enumerator kCLOCK_AxiRootmuxSysPll2
ARM MAIN AXI Clock from SYSTEM PLL2.

enumerator kCLOCK_AxiRootmuxAudioPll1
ARM MAIN AXI Clock from AUDIO PLL1.

enumerator kCLOCK_AxiRootmuxVideoPll1
ARM MAIN AXI Clock from VIDEO PLL1.

enumerator kCLOCK_AxiRootmuxSysPll1Div8
ARM MAIN AXI Clock from SYSTEM PLL1 divided by 8.

enum _clock_rootmux_ahb_clk_sel
Root clock select enumeration for AHB bus.

Values:

enumerator kCLOCK_AhbRootmuxOsc24M
ARM AHB Clock from OSC 24M.

enumerator kCLOCK_AhbRootmuxSysPll1Div6
ARM AHB Clock from SYSTEM PLL1 divided by 6.

enumerator kCLOCK_AhbRootmuxSysPll1
ARM AHB Clock from SYSTEM PLL1.

enumerator kCLOCK_AhbRootmuxSysPll1Div2
ARM AHB Clock from SYSTEM PLL1 divided by 2.

enumerator kCLOCK_AhbRootmuxSysPll2Div8
ARM AHB Clock from SYSTEM PLL2 divided by 8.

enumerator kCLOCK_AhbRootmuxSysPll3
ARM AHB Clock from SYSTEM PLL3.

enumerator kCLOCK_AhbRootmuxAudioPll1
ARM AHB Clock from AUDIO PLL1.

enumerator kCLOCK_AhbRootmuxVideoPll1
ARM AHB Clock from VIDEO PLL1.

enum _clock_rootmux_audio_ahb_clk_sel
Root clock select enumeration for Audio AHB bus.

Values:

enumerator kCLOCK_AudioAhbRootmuxOsc24M
ARM Audio AHB Clock from OSC 24M.

enumerator kCLOCK_AudioAhbRootmuxSysPll2Div2
ARM Audio AHB Clock from SYSTEM PLL2 divided by 2.

enumerator kCLOCK_AudioAhbRootmuxSysPll1
ARM Audio AHB Clock from SYSTEM PLL1.

enumerator kCLOCK_AudioAhbRootmuxSysPll2
ARM Audio AHB Clock from SYSTEM PLL2.

enumerator kCLOCK_AudioAhbRootmuxSysPll2Div6
ARM Audio AHB Clock from SYSTEM PLL2 divided by 6.

enumerator kCLOCK_AudioAhbRootmuxSysPll3
ARM Audio AHB Clock from SYSTEM PLL3.

enumerator kCLOCK_AudioAhbRootmuxAudioPll1
ARM Audio AHB Clock from AUDIO PLL1.

enumerator kCLOCK_AudioAhbRootmuxVideoPll1
ARM Audio AHB Clock from VIDEO PLL1.

enum _clock_rootmux_qspi_clk_sel
Root clock select enumeration for QSPI peripheral.

Values:

enumerator kCLOCK_QspiRootmuxOsc24M
ARM QSPI Clock from OSC 24M.

enumerator kCLOCK_QspiRootmuxSysPll1Div2
ARM QSPI Clock from SYSTEM PLL1 divided by 2.

enumerator kCLOCK_QspiRootmuxSysPll2Div3
ARM QSPI Clock from SYSTEM PLL2 divided by 3.

enumerator kCLOCK_QspiRootmuxSysPll2Div2
ARM QSPI Clock from SYSTEM PLL2 divided by 2.

enumerator kCLOCK_QspiRootmuxAudioPll2
ARM QSPI Clock from AUDIO PLL2.

enumerator kCLOCK_QspiRootmuxSysPll1Div3
ARM QSPI Clock from SYSTEM PLL1 divided by 3

enumerator kCLOCK_QspiRootmuxSysPll3
ARM QSPI Clock from SYSTEM PLL3.

enumerator kCLOCK_QspiRootmuxSysPll1Div8
ARM QSPI Clock from SYSTEM PLL1 divided by 8.

enum _clock_rootmux_ecspi_clk_sel
Root clock select enumeration for ECSPI peripheral.

Values:

enumerator kCLOCK_EcspiRootmuxOsc24M
ECSPI Clock from OSC 24M.

enumerator kCLOCK_EcspiRootmuxSysPll2Div5
ECSPI Clock from SYSTEM PLL2 divided by 5.

enumerator kCLOCK_EcspiRootmuxSysPll1Div20
ECSPI Clock from SYSTEM PLL1 divided by 20.

enumerator kCLOCK_EcspiRootmuxSysPll1Div5
ECSPI Clock from SYSTEM PLL1 divided by 5.

enumerator kCLOCK_EcspiRootmuxSysPll1
ECSPI Clock from SYSTEM PLL1.

enumerator kCLOCK_EcspiRootmuxSysPll3
ECSPI Clock from SYSTEM PLL3.

enumerator kCLOCK_EcspiRootmuxSysPll2Div4
ECSPI Clock from SYSTEM PLL2 divided by 4.

enumerator kCLOCK_EcspiRootmuxAudioPll2
ECSPI Clock from AUDIO PLL2.

enum _clock_rootmux_enet_axi_clk_sel

Root clock select enumeration for ENET AXI bus.

Values:

enumerator kCLOCK__EnetAxiRootmuxOsc24M

ENET AXI Clock from OSC 24M.

enumerator kCLOCK__EnetAxiRootmuxSysPll1Div3

ENET AXI Clock from SYSTEM PLL1 divided by 3.

enumerator kCLOCK__EnetAxiRootmuxSysPll1

ENET AXI Clock from SYSTEM PLL1.

enumerator kCLOCK__EnetAxiRootmuxSysPll2Div4

ENET AXI Clock from SYSTEM PLL2 divided by 4.

enumerator kCLOCK__EnetAxiRootmuxSysPll2Div5

ENET AXI Clock from SYSTEM PLL2 divided by 5.

enumerator kCLOCK__EnetAxiRootmuxAudioPll1

ENET AXI Clock from AUDIO PLL1.

enumerator kCLOCK__EnetAxiRootmuxVideoPll1

ENET AXI Clock from VIDEO PLL1.

enumerator kCLOCK__EnetAxiRootmuxSysPll3

ENET AXI Clock from SYSTEM PLL3.

enum _clock_rootmux_enet_qos_clk_sel

Root clock select enumeration for ENET QOS Clcok.

Values:

enumerator kCLOCK__EnetQosRootmuxOsc24M

ENET QOS Clock from OSC 24M.

enumerator kCLOCK__EnetQosRootmuxSysPll2Div8

ENET QOS Clock from SYSTEM PLL2 divided by 8.

enumerator kCLOCK__EnetQosRootmuxSysPll2Div20

ENET QOS Clock from SYSTEM PLL2 divided by 20.

enumerator kCLOCK__EnetQosRootmuxSysPll2Div10

ENET QOS Clock from SYSTEM PLL2 divided by 10.

enumerator kCLOCK__EnetQosRootmuxSysPll1Div5

ENET QOS Clock from SYSTEM PLL1 divided by 5.

enumerator kCLOCK__EnetQosRootmuxAudioPll1

ENET QOS Clock from AUDIO PLL1.

enumerator kCLOCK__EnetQosRootmuxVideoPll1

ENET QOS Clock from VIDEO PLL1.

enumerator kCLOCK__EnetQosRootmuxExtClk4

ENET QOS Clock from External Clock 4.

enum _clock_rootmux_enet_ref_clk_sel

Root clock select enumeration for ENET REF Clcok.

Values:

enumerator kCLOCK__EnetRefRootmuxOsc24M

ENET REF Clock from OSC 24M.

enumerator kCLOCK__EnetRefRootmuxSysPll2Div8

ENET REF Clock from SYSTEM PLL2 divided by 8.

enumerator kCLOCK__EnetRefRootmuxSysPll2Div20

ENET REF Clock from SYSTEM PLL2 divided by 20.

enumerator kCLOCK__EnetRefRootmuxSysPll2Div10

ENET REF Clock from SYSTEM PLL2 divided by 10.

enumerator kCLOCK__EnetRefRootmuxSysPll1Div5

ENET REF Clock from SYSTEM PLL1 divided by 5.

enumerator kCLOCK__EnetRefRootmuxAudioPll1

ENET REF Clock from AUDIO PLL1.

enumerator kCLOCK__EnetRefRootmuxVideoPll1

ENET REF Clock from VIDEO PLL1.

enumerator kCLOCK__EnetRefRootmuxExtClk4

ENET REF Clock from External Clock 4.

enum _clock_rootmux_enet_qos_timer_clk_sel

Root clock select enumeration for ENET QOS TIMER Clcok.

Values:

enumerator kCLOCK__EnetQosTimerRootmuxOsc24M

ENET QOS TIMER Clock from OSC 24M.

enumerator kCLOCK__EnetQosTimerRootmuxSysPll2Div10

ENET QOS TIMER Clock from SYSTEM PLL2 divided by 10.

enumerator kCLOCK__EnetQosTimerRootmuxAudioPll1

ENET QOS TIMER Clock from AUDIO PLL1.

enumerator kCLOCK__EnetQosTimerRootmuxExtClk1

ENET QOS TIMER Clock from External Clock 1.

enumerator kCLOCK__EnetQosTimerRootmuxExtClk2

ENET QOS TIMER Clock External Clock 2.

enumerator kCLOCK__EnetQosTimerRootmuxExtClk3

ENET QOS TIMER Clock from External Clock 3.

enumerator kCLOCK__EnetQosTimerRootmuxExtClk4

ENET QOS TIMER Clock from External Clock 4.

enumerator kCLOCK__EnetQosTimerRootmuxVideoPll1

ENET QOS TIMER Clock from VIDEO PLL1.

enum _clock_rootmux_enet_timer_clk_sel

Root clock select enumeration for ENET TIMER Clcok.

Values:

enumerator kCLOCK__EnetTimerRootmuxOsc24M

ENET TIMER Clock from OSC 24M.

enumerator kCLOCK__EnetTimerRootmuxSysPll2Div10

ENET TIMER Clock from SYSTEM PLL2 divided by 10.

enumerator kCLOCK__EnetTimerRootmuxAudioPll1
ENET TIMER Clock from AUDIO PLL1.

enumerator kCLOCK__EnetTimerRootmuxExtClk1
ENET TIMER Clock from External Clock 1.

enumerator kCLOCK__EnetTimerRootmuxExtClk2
ENET TIMER Clock External Clock 2.

enumerator kCLOCK__EnetTimerRootmuxExtClk3
ENET TIMER Clock from External Clock 3.

enumerator kCLOCK__EnetTimerRootmuxExtClk4
ENET TIMER Clock from External Clock 4.

enumerator kCLOCK__EnetTimerRootmuxVideoPll1
ENET TIMER Clock from VIDEO PLL1.

enum _clock_rootmux_enet_phy_clk_sel
Root clock select enumeration for ENET PHY Clcok.

Values:

enumerator kCLOCK__EnetPhyRootmuxOsc24M
ENET PHY Clock from OSC 24M.

enumerator kCLOCK__EnetPhyRootmuxSysPll2Div20
ENET PHY Clock from SYSTEM PLL2 divided by 20.

enumerator kCLOCK__EnetPhyRootmuxSysPll2Div8
ENET PHY Clock from SYSTEM PLL2 divided by 8.

enumerator kCLOCK__EnetPhyRootmuxSysPll2Div5
ENET PHY Clock from SYSTEM PLL2 divided by 5.

enumerator kCLOCK__EnetPhyRootmuxSysPll2Div2
ENET PHY Clock from SYSTEM PLL2 divided by 2.

enumerator kCLOCK__EnetPhyRootmuxAudioPll1
ENET PHY Clock from AUDIO PLL1.

enumerator kCLOCK__EnetPhyRootmuxVideoPll1
ENET PHY Clock from VIDEO PLL1.

enumerator kCLOCK__EnetPhyRootmuxAudioPll2
ENET PHY Clock from AUDIO PLL2.

enum _clock_rootmux_flexcan_clk_sel
Root clock select enumeration for FLEXCAN peripheral.

Values:

enumerator kCLOCK__FlexCanRootmuxOsc24M
FLEXCAN Clock from OSC 24M.

enumerator kCLOCK__FlexCanRootmuxSysPll2Div5
FLEXCAN Clock from SYSTEM PLL2 divided by 5.

enumerator kCLOCK__FlexCanRootmuxSysPll1Div20
FLEXCAN Clock from SYSTEM PLL1 divided by 20.

enumerator kCLOCK__FlexCanRootmuxSysPll1Div5
FLEXCAN Clock from SYSTEM PLL1 divided by 5.

enumerator kCLOCK_FlexCanRootmuxSysPll1
FLEXCAN Clock from SYSTEM PLL1.

enumerator kCLOCK_FlexCanRootmuxSysPll3
FLEXCAN Clock from SYSTEM PLL3.

enumerator kCLOCK_FlexCanRootmuxSysPll2Div4
FLEXCAN Clock from SYSTEM PLL2 divided by 4.

enumerator kCLOCK_FlexCanRootmuxAudioPll2
FLEXCAN Clock from AUDIO PLL2.

enum _clock_rootmux_i2c_clk_sel
Root clock select enumeration for I2C peripheral.

Values:

enumerator kCLOCK_I2cRootmuxOsc24M
I2C Clock from OSC 24M.

enumerator kCLOCK_I2cRootmuxSysPll1Div5
I2C Clock from SYSTEM PLL1 divided by 5.

enumerator kCLOCK_I2cRootmuxSysPll2Div20
I2C Clock from SYSTEM PLL2 divided by 20.

enumerator kCLOCK_I2cRootmuxSysPll3
I2C Clock from SYSTEM PLL3 .

enumerator kCLOCK_I2cRootmuxAudioPll1
I2C Clock from AUDIO PLL1.

enumerator kCLOCK_I2cRootmuxVideoPll1
I2C Clock from VIDEO PLL1.

enumerator kCLOCK_I2cRootmuxAudioPll2
I2C Clock from AUDIO PLL2.

enumerator kCLOCK_I2cRootmuxSysPll1Div6
I2C Clock from SYSTEM PLL1 divided by 6.

enum _clock_rootmux_uart_clk_sel
Root clock select enumeration for UART peripheral.

Values:

enumerator kCLOCK_UartRootmuxOsc24M
UART Clock from OSC 24M.

enumerator kCLOCK_UartRootmuxSysPll1Div10
UART Clock from SYSTEM PLL1 divided by 10.

enumerator kCLOCK_UartRootmuxSysPll2Div5
UART Clock from SYSTEM PLL2 divided by 5.

enumerator kCLOCK_UartRootmuxSysPll2Div10
UART Clock from SYSTEM PLL2 divided by 10.

enumerator kCLOCK_UartRootmuxSysPll3
UART Clock from SYSTEM PLL3.

enumerator kCLOCK_UartRootmuxExtClk2
UART Clock from External Clock 2.

enumerator kCLOCK_UartRootmuxExtClk34
UART Clock from External Clock 3, External Clock 4.

enumerator kCLOCK_UartRootmuxAudioPll2
UART Clock from Audio PLL2.

enum _clock_rootmux_gpt
Root clock select enumeration for GPT peripheral.

Values:

enumerator kCLOCK_GptRootmuxOsc24M
GPT Clock from OSC 24M.

enumerator kCLOCK_GptRootmuxSystemPll2Div10
GPT Clock from SYSTEM PLL2 divided by 10.

enumerator kCLOCK_GptRootmuxSysPll1Div2
GPT Clock from SYSTEM PLL1 divided by 2.

enumerator kCLOCK_GptRootmuxSysPll1Div20
GPT Clock from SYSTEM PLL1 divided by 20.

enumerator kCLOCK_GptRootmuxVideoPll1
GPT Clock from VIDEO PLL1.

enumerator kCLOCK_GptRootmuxSystemPll1Div10
GPT Clock from SYSTEM PLL1 divided by 10.

enumerator kCLOCK_GptRootmuxAudioPll1
GPT Clock from AUDIO PLL1.

enumerator kCLOCK_GptRootmuxExtClk123
GPT Clock from External Clock1, External Clock2, External Clock3.

enum _clock_rootmux_wdog_clk_sel
Root clock select enumeration for WDOG peripheral.

Values:

enumerator kCLOCK_WdogRootmuxOsc24M
WDOG Clock from OSC 24M.

enumerator kCLOCK_WdogRootmuxSysPll1Div6
WDOG Clock from SYSTEM PLL1 divided by 6.

enumerator kCLOCK_WdogRootmuxSysPll1Div5
WDOG Clock from SYSTEM PLL1 divided by 5.

enumerator kCLOCK_WdogRootmuxVpuPll
WDOG Clock from VPU DLL.

enumerator kCLOCK_WdogRootmuxSystemPll2Div8
WDOG Clock from SYSTEM PLL2 divided by 8.

enumerator kCLOCK_WdogRootmuxSystemPll3
WDOG Clock from SYSTEM PLL3.

enumerator kCLOCK_WdogRootmuxSystemPll1Div10
WDOG Clock from SYSTEM PLL1 divided by 10.

enumerator kCLOCK_WdogRootmuxSystemPll2Div6
WDOG Clock from SYSTEM PLL2 divided by 6.

enum _clock_rootmux_pwm_clk_sel

Root clock select enumeration for PWM peripheral.

Values:

enumerator kCLOCK_PwmRootmuxOsc24M

PWM Clock from OSC 24M.

enumerator kCLOCK_PwmRootmuxSysPll2Div10

PWM Clock from SYSTEM PLL2 divided by 10.

enumerator kCLOCK_PwmRootmuxSysPll1Div5

PWM Clock from SYSTEM PLL1 divided by 5.

enumerator kCLOCK_PwmRootmuxSysPll1Div20

PWM Clock from SYSTEM PLL1 divided by 20.

enumerator kCLOCK_PwmRootmuxSystemPll3

PWM Clock from SYSTEM PLL3.

enumerator kCLOCK_PwmRootmuxExtClk12

PWM Clock from External Clock1, External Clock2.

enumerator kCLOCK_PwmRootmuxSystemPll1Div10

PWM Clock from SYSTEM PLL1 divided by 10.

enumerator kCLOCK_PwmRootmuxVideoPll1

PWM Clock from VIDEO PLL1.

enum _clock_rootmux_sai_clk_sel

Root clock select enumeration for SAI peripheral.

Values:

enumerator kCLOCK_SaiRootmuxOsc24M

SAI Clock from OSC 24M.

enumerator kCLOCK_SaiRootmuxAudioPll1

SAI Clock from AUDIO PLL1.

enumerator kCLOCK_SaiRootmuxAudioPll2

SAI Clock from AUDIO PLL2.

enumerator kCLOCK_SaiRootmuxVideoPll1

SAI Clock from VIDEO PLL1.

enumerator kCLOCK_SaiRootmuxSysPll1Div6

SAI Clock from SYSTEM PLL1 divided by 6.

enumerator kCLOCK_SaiRootmuxOsc26m

SAI Clock from OSC HDMI 26M.

enumerator kCLOCK_SaiRootmuxExtClk1

SAI Clock from External Clock1, External Clock2, External Clock3.

enumerator kCLOCK_SaiRootmuxExtClk2

SAI Clock from External Clock2, External Clock3, External Clock4.

enum _clock_rootmux_pdm_clk_sel

Root clock select enumeration for PDM peripheral.

Values:

enumerator kCLOCK_PdmRootmuxOsc24M

PDM Clock from OSC 24M.

enumerator kCLOCK_PdmRootmuxSysPll2Div10

PDM Clock from SYSTEM PLL2 divided by 10.

enumerator kCLOCK_PdmRootmuxAudioPll1

PDM Clock from AUDIO PLL1.

enumerator kCLOCK_PdmRootmuxSysPll1

PDM Clock from SYSTEM PLL1.

enumerator kCLOCK_PdmRootmuxSysPll2

PDM Clock from SYSTEM PLL2.

enumerator kCLOCK_PdmRootmuxSysPll3

PDM Clock from SYSTEM PLL3.

enumerator kCLOCK_PdmRootmuxExtClk3

PDM Clock from External Clock3.

enumerator kCLOCK_PdmRootmuxAudioPll2

PDM Clock from AUDIO PLL2.

enum _clock_rootmux_noc_clk_sel

Root clock select enumeration for NOC CLK.

Values:

enumerator kCLOCK_NocRootmuxOsc24M

NOC Clock from OSC 24M.

enumerator kCLOCK_NocRootmuxSysPll1

NOC Clock from SYSTEM PLL1.

enumerator kCLOCK_NocRootmuxSysPll3

NOC Clock from SYSTEM PLL3.

enumerator kCLOCK_NocRootmuxSysPll2

NOC Clock from SYSTEM PLL2.

enumerator kCLOCK_NocRootmuxSysPll2Div2

NOC Clock from SYSTEM PLL2 divided by 2.

enumerator kCLOCK_NocRootmuxAudioPll1

NOC Clock from AUDIO PLL1.

enumerator kCLOCK_NocRootmuxVideoPll1

NOC Clock from VIDEO PLL1.

enumerator kCLOCK_NocRootmuxAudioPll2

NOC Clock from AUDIO PLL2.

enum _clock_pll_gate

CCM PLL gate control.

Values:

enumerator kCLOCK_ArmPllGate

ARM PLL Gate.

enumerator kCLOCK_GpuPllGate

GPU PLL Gate.

enumerator kCLOCK_VpuPllGate
VPU PLL Gate.

enumerator kCLOCK_DramPllGate
DRAM PLL1 Gate.

enumerator kCLOCK_SysPll1Gate
SYSTEM PLL1 Gate.

enumerator kCLOCK_SysPll1Div2Gate
SYSTEM PLL1 Div2 Gate.

enumerator kCLOCK_SysPll1Div3Gate
SYSTEM PLL1 Div3 Gate.

enumerator kCLOCK_SysPll1Div4Gate
SYSTEM PLL1 Div4 Gate.

enumerator kCLOCK_SysPll1Div5Gate
SYSTEM PLL1 Div5 Gate.

enumerator kCLOCK_SysPll1Div6Gate
SYSTEM PLL1 Div6 Gate.

enumerator kCLOCK_SysPll1Div8Gate
SYSTEM PLL1 Div8 Gate.

enumerator kCLOCK_SysPll1Div10Gate
SYSTEM PLL1 Div10 Gate.

enumerator kCLOCK_SysPll1Div20Gate
SYSTEM PLL1 Div20 Gate.

enumerator kCLOCK_SysPll2Gate
SYSTEM PLL2 Gate.

enumerator kCLOCK_SysPll2Div2Gate
SYSTEM PLL2 Div2 Gate.

enumerator kCLOCK_SysPll2Div3Gate
SYSTEM PLL2 Div3 Gate.

enumerator kCLOCK_SysPll2Div4Gate
SYSTEM PLL2 Div4 Gate.

enumerator kCLOCK_SysPll2Div5Gate
SYSTEM PLL2 Div5 Gate.

enumerator kCLOCK_SysPll2Div6Gate
SYSTEM PLL2 Div6 Gate.

enumerator kCLOCK_SysPll2Div8Gate
SYSTEM PLL2 Div8 Gate.

enumerator kCLOCK_SysPll2Div10Gate
SYSTEM PLL2 Div10 Gate.

enumerator kCLOCK_SysPll2Div20Gate
SYSTEM PLL2 Div20 Gate.

enumerator kCLOCK_SysPll3Gate
SYSTEM PLL3 Gate.

enumerator kCLOCK_AudioPll1Gate
AUDIO PLL1 Gate.

enumerator kCLOCK_AudioPll2Gate
AUDIO PLL2 Gate.

enumerator kCLOCK_VideoPll1Gate
VIDEO PLL1 Gate.

enumerator kCLOCK_VideoPll2Gate
VIDEO PLL2 Gate.

enum _clock_gate_value
CCM gate control value.

Values:

enumerator kCLOCK_ClockNotNeeded
Clock always disabled.

enumerator kCLOCK_ClockNeededRun
Clock enabled when CPU is running.

enumerator kCLOCK_ClockNeededRunWait
Clock enabled when CPU is running or in WAIT mode.

enumerator kCLOCK_ClockNeededAll
Clock always enabled.

enum _clock_pll_bypass_ctrl
PLL control names for PLL bypass.

These constants define the PLL control names for PLL bypass.

- 0:15: REG offset to CCM_ANALOG_BASE in bytes.
- 16:20: bypass bit shift.

Values:

enumerator kCLOCK_AudioPll1BypassCtrl
CCM Audio PLL1 bypass Control.

enumerator kCLOCK_AudioPll2BypassCtrl
CCM Audio PLL2 bypass Control.

enumerator kCLOCK_VideoPll1BypassCtrl
CCM Video Pll1 bypass Control.

enumerator kCLOCK_DramPllInternalPll1BypassCtrl
CCM DRAM PLL bypass Control.

enumerator kCLOCK_ArmPllPwrBypassCtrl
CCM Arm PLL bypass Control.

enumerator kCLOCK_SysPll1InternalPll1BypassCtrl
CCM System PLL1 bypass Control.

enumerator kCLOCK_SysPll2InternalPll1BypassCtrl
CCM System PLL2 bypass Control.

enumerator kCLOCK_SysPll3InternalPll1BypassCtrl
CCM System PLL3 bypass Control.

enum _ccm_analog_pll_clke

PLL clock names for clock enable/disable settings.

These constants define the PLL clock names for PLL clock enable/disable operations.

- 0:15: REG offset to CCM_ANALOG_BASE in bytes.
- 16:20: Clock enable bit shift.

Values:

enumerator kCLOCK__AudioPll1Clke

Audio pll1 clke

enumerator kCLOCK__AudioPll2Clke

Audio pll2 clke

enumerator kCLOCK__VideoPll1Clke

Video pll1 clke

enumerator kCLOCK__DramPllClke

Dram pll clke

enumerator kCLOCK__ArmPllClke

Arm pll clke

enumerator kCLOCK__SystemPll1Clke

System pll1 clke

enumerator kCLOCK__SystemPll1Div2Clke

System pll1 Div2 clke

enumerator kCLOCK__SystemPll1Div3Clke

System pll1 Div3 clke

enumerator kCLOCK__SystemPll1Div4Clke

System pll1 Div4 clke

enumerator kCLOCK__SystemPll1Div5Clke

System pll1 Div5 clke

enumerator kCLOCK__SystemPll1Div6Clke

System pll1 Div6 clke

enumerator kCLOCK__SystemPll1Div8Clke

System pll1 Div8 clke

enumerator kCLOCK__SystemPll1Div10Clke

System pll1 Div10 clke

enumerator kCLOCK__SystemPll1Div20Clke

System pll1 Div20 clke

enumerator kCLOCK__SystemPll2Clke

System pll2 clke

enumerator kCLOCK__SystemPll2Div2Clke

System pll2 Div2 clke

enumerator kCLOCK__SystemPll2Div3Clke

System pll2 Div3 clke

enumerator kCLOCK__SystemPll2Div4Clke

System pll2 Div4 clke

enumerator kCLOCK_SystemPll2Div5Clke
System pll2 Div5 clke

enumerator kCLOCK_SystemPll2Div6Clke
System pll2 Div6 clke

enumerator kCLOCK_SystemPll2Div8Clke
System pll2 Div8 clke

enumerator kCLOCK_SystemPll2Div10Clke
System pll2 Div10 clke

enumerator kCLOCK_SystemPll2Div20Clke
System pll2 Div20 clke

enumerator kCLOCK_SystemPll3Clke
System pll3 clke

enum _clock_pll_ctrl

ANALOG Power down override control.

Values:

enumerator kCLOCK_AudioPll1Ctrl

enumerator kCLOCK_AudioPll2Ctrl

enumerator kCLOCK_VideoPll1Ctrl

enumerator kCLOCK_DramPllCtrl

enumerator kCLOCK_VpuPllCtrl

enumerator kCLOCK_ArmPllCtrl

enumerator kCLOCK_SystemPll1Ctrl

enumerator kCLOCK_SystemPll2Ctrl

enumerator kCLOCK_SystemPll3Ctrl

PLL reference clock select.

Values:

enumerator kANALOG_PllRefOsc24M
reference OSC 24M

enumerator kANALOG_PllPadClk
reference PAD CLK

typedef enum _clock_name clock_name_t

Clock name used to get clock frequency.

typedef enum _clock_ip_name clock_ip_name_t

CCM CCGR gate control.

typedef enum _clock_root_control clock_root_control_t

ccm root name used to get clock frequency.

typedef enum _clock_root clock_root_t

ccm clock root used to get clock frequency.

`typedef enum _clock_rootmux_m7_clk_sel clock_rootmux_m7_clk_sel_t`
Root clock select enumeration for ARM Cortex-M7 core.

`typedef enum _clock_rootmux_axi_clk_sel clock_rootmux_axi_clk_sel_t`
Root clock select enumeration for MAIN AXI bus.

`typedef enum _clock_rootmux_ahb_clk_sel clock_rootmux_ahb_clk_sel_t`
Root clock select enumeration for AHB bus.

`typedef enum _clock_rootmux_audio_ahb_clk_sel clock_rootmux_audio_ahb_clk_sel_t`
Root clock select enumeration for Audio AHB bus.

`typedef enum _clock_rootmux_qspi_clk_sel clock_rootmux_qspi_clk_sel_t`
Root clock select enumeration for QSPI peripheral.

`typedef enum _clock_rootmux_ecspi_clk_sel clock_rootmux_ecspi_clk_sel_t`
Root clock select enumeration for ECSPI peripheral.

`typedef enum _clock_rootmux_enet_axi_clk_sel clock_rootmux_enet_axi_clk_sel_t`
Root clock select enumeration for ENET AXI bus.

`typedef enum _clock_rootmux_enet_qos_clk_sel clock_rootmux_enet_qos_clk_sel_t`
Root clock select enumeration for ENET QOS Clcok.

`typedef enum _clock_rootmux_enet_ref_clk_sel clock_rootmux_enet_ref_clk_sel_t`
Root clock select enumeration for ENET REF Clcok.

`typedef enum _clock_rootmux_enet_qos_timer_clk_sel clock_rootmux_enet_qos_timer_clk_sel_t`
Root clock select enumeration for ENET QOS TIMER Clcok.

`typedef enum _clock_rootmux_enet_timer_clk_sel clock_rootmux_enet_timer_clk_sel_t`
Root clock select enumeration for ENET TIMER Clcok.

`typedef enum _clock_rootmux_enet_phy_clk_sel clock_rootmux_enet_phy_clk_sel_t`
Root clock select enumeration for ENET PHY Clcok.

`typedef enum _clock_rootmux_flexcan_clk_sel clock_rootmux_flexcan_clk_sel_t`
Root clock select enumeration for FLEXCAN peripheral.

`typedef enum _clock_rootmux_i2c_clk_sel clock_rootmux_i2c_clk_sel_t`
Root clock select enumeration for I2C peripheral.

`typedef enum _clock_rootmux_uart_clk_sel clock_rootmux_uart_clk_sel_t`
Root clock select enumeration for UART peripheral.

`typedef enum _clock_rootmux_gpt clock_rootmux_gpt_t`
Root clock select enumeration for GPT peripheral.

`typedef enum _clock_rootmux_wdog_clk_sel clock_rootmux_wdog_clk_sel_t`
Root clock select enumeration for WDOG peripheral.

`typedef enum _clock_rootmux_pwm_clk_sel clock_rootmux_Pwm_clk_sel_t`
Root clock select enumeration for PWM peripheral.

`typedef enum _clock_rootmux_sai_clk_sel clock_rootmux_sai_clk_sel_t`
Root clock select enumeration for SAI peripheral.

`typedef enum _clock_rootmux_pdm_clk_sel clock_rootmux_pdm_clk_sel_t`
Root clock select enumeration for PDM peripheral.

`typedef enum _clock_rootmux_noc_clk_sel clock_rootmux_noc_clk_sel_t`
Root clock select enumeration for NOC CLK.

typedef enum *_clock_pll_gate* clock_pll_gate_t

CCM PLL gate control.

typedef enum *_clock_gate_value* clock_gate_value_t

CCM gate control value.

typedef enum *_clock_pll_bypass_ctrl* clock_pll_bypass_ctrl_t

PLL control names for PLL bypass.

These constants define the PLL control names for PLL bypass.

- 0:15: REG offset to CCM_ANALOG_BASE in bytes.
- 16:20: bypass bit shift.

typedef enum *_ccm_analog_pll_clke* clock_pll_clke_t

PLL clock names for clock enable/disable settings.

These constants define the PLL clock names for PLL clock enable/disable operations.

- 0:15: REG offset to CCM_ANALOG_BASE in bytes.
- 16:20: Clock enable bit shift.

typedef enum *_clock_pll_ctrl* clock_pll_ctrl_t

ANALOG Power down override control.

typedef struct *_ccm_analog_frac_pll_config* ccm_analog_frac_pll_config_t

Fractional-N PLL configuration. Note: all the dividers in this configuration structure are the actually divider, software will map it to register value.

typedef struct *_ccm_analog_integer_pll_config* ccm_analog_integer_pll_config_t

Integer PLL configuration. Note: all the dividers in this configuration structure are the actually divider, software will map it to register value.

FSL_CLOCK_DRIVER_VERSION

CLOCK driver version 2.2.0.

SDK_DEVICE_MAXIMUM_CPU_CLOCK_FREQUENCY

OSC24M_CLK_FREQ

XTAL 24M clock frequency.

CLKPAD_FREQ

pad clock frequency.

ECSPI_CLOCKS

Clock ip name array for ECSPI.

EDMA_CLOCKS

Clock ip name array for EDMA.

ENET_CLOCKS

Clock ip name array for ENET.

ENETQOS_CLOCKS

Clock ip name array for ENET_QOS.

FLEXCAN_CLOCKS

Clock ip name array for FLEXCAN.

GPIO_CLOCKS

Clock ip name array for GPIO.

GPT_CLOCKS

Clock ip name array for GPT.

I2C_CLOCKS

Clock ip name array for I2C.

IOMUX_CLOCKS

Clock ip name array for IOMUX.

IPMUX_CLOCKS

Clock ip name array for IPMUX.

PWM_CLOCKS

Clock ip name array for PWM.

RDC_CLOCKS

Clock ip name array for RDC.

SAI_CLOCKS

Clock ip name array for SAI.

RDC_SEMA42_CLOCKS

Clock ip name array for RDC SEMA42.

UART_CLOCKS

Clock ip name array for UART.

USDHC_CLOCKS

Clock ip name array for USDHC.

WDOG_CLOCKS

Clock ip name array for WDOG.

TMU_CLOCKS

Clock ip name array for TEMPSENSOR.

SDMA_CLOCKS

Clock ip name array for SDMA.

MU_CLOCKS

Clock ip name array for MU.

QSPI_CLOCKS

Clock ip name array for QSPI.

PDM_CLOCKS

Clock ip name array for PDM.

ASRC_CLOCKS

Clock ip name array for ASRC.

CCM_BIT_FIELD_EXTRACTION(val, mask, shift)

CCM reg macros to extract corresponding registers bit field.

CCM_REG_OFF(root, off)

CCM reg macros to map corresponding registers.

CCM_REG(root)

CCM_REG_SET(root)

CCM_REG_CLR(root)

AUDIO_PLL1_GEN_CTRL_OFFSET

CCM Analog registers offset.

AUDIO_PLL2_GEN_CTRL_OFFSET

VIDEO_PLL1_GEN_CTRL_OFFSET

GPU_PLL_GEN_CTRL_OFFSET

VPU_PLL_GEN_CTRL_OFFSET

ARM_PLL_GEN_CTRL_OFFSET

SYS_PLL1_GEN_CTRL_OFFSET

SYS_PLL2_GEN_CTRL_OFFSET

SYS_PLL3_GEN_CTRL_OFFSET

DRAM_PLL_GEN_CTRL_OFFSET

CCM_ANALOG_TUPLE(reg, shift)

CCM ANALOG tuple macros to map corresponding registers and bit fields.

CCM_ANALOG_TUPLE_SHIFT(tuple)

CCM_ANALOG_TUPLE_REG_OFF(base, tuple, off)

CCM_ANALOG_TUPLE_REG(base, tuple)

CLOCK_GATE_IN_AUDIOMIX

CCM CCGR and root tuple.

CLOCK_GATE_IN_CCM

CLOCK_GATE_TYPE(tuple)

CCM_TUPLE(ccgr, root)

CCM_TUPLE_CCGR(tuple)

CCM_TUPLE_ROOT(tuple)

AUDIOMIX_TUPLE(offset, gate, root)

audio mix CCGR

AUDIOMIX_TUPLE_OFFSET(tuple)

AUDIOMIX_TUPLE_GATE(tuple)

AUDIOMIX_TUPLE_ROOT(tuple)

CLOCK_ROOT_SOURCE

clock root source

CLOCK_ROOT_CONTROL_TUPLE

kCLOCK_CoreSysClk

For compatible with other platforms without CCM.

CLOCK_GetCoreSysClkFreq

For compatible with other platforms without CCM.

static inline void CLOCK_SetRootMux(*clock_root_control_t* rootClk, uint32_t mux)

Set clock root mux. User maybe need to set more than one mux ROOT according to the clock tree description in the reference manual.

Parameters

- rootClk – Root clock control (see *clock_root_control_t* enumeration).
- mux – Root mux value (see *_ccm_rootmux_xxx* enumeration).

static inline uint32_t CLOCK_GetRootMux(*clock_root_control_t* rootClk)

Get clock root mux. In order to get the clock source of root, user maybe need to get more than one ROOT's mux value to obtain the final clock source of root.

Parameters

- rootClk – Root clock control (see *clock_root_control_t* enumeration).

Returns

Root mux value (see *_ccm_rootmux_xxx* enumeration).

static inline void CLOCK_EnableRoot(*clock_root_control_t* rootClk)

Enable clock root.

Parameters

- rootClk – Root clock control (see *clock_root_control_t* enumeration)

static inline void CLOCK_DisableRoot(*clock_root_control_t* rootClk)

Disable clock root.

Parameters

- rootClk – Root control (see *clock_root_control_t* enumeration)

static inline bool CLOCK_IsRootEnabled(*clock_root_control_t* rootClk)

Check whether clock root is enabled.

Parameters

- rootClk – Root control (see *clock_root_control_t* enumeration)

Returns

CCM root enabled or not.

- true: Clock root is enabled.
- false: Clock root is disabled.

void CLOCK_UpdateRoot(*clock_root_control_t* ccmRootClk, uint32_t mux, uint32_t pre, uint32_t post)

Update clock root in one step, for dynamical clock switching Note: The PRE and POST dividers in this function are the actually divider, software will map it to register value.

Parameters

- ccmRootClk – Root control (see *clock_root_control_t* enumeration)
- mux – mux value (see *_ccm_rootmux_xxx* enumeration)
- pre – Pre divider value (0-7, divider=n+1)
- post – Post divider value (0-63, divider=n+1)

void CLOCK_SetRootDivider(*clock_root_control_t* ccmRootClk, uint32_t pre, uint32_t post)

Set root clock divider Note: The PRE and POST dividers in this function are the actually divider, software will map it to register value.

Parameters

- `ccmRootClk` – Root control (see `clock_root_control_t` enumeration)
- `pre` – Pre divider value (1-8)
- `post` – Post divider value (1-64)

static inline uint32_t CLOCK__GetRootPreDivider(*clock_root_control_t* rootClk)

Get clock root PRE_PODF. In order to get the clock source of root, user maybe need to get more than one ROOT's mux value to obtain the final clock source of root.

Parameters

- `rootClk` – Root clock name (see `clock_root_control_t` enumeration).

Returns

Root Pre divider value.

static inline uint32_t CLOCK__GetRootPostDivider(*clock_root_control_t* rootClk)

Get clock root POST_PODF. In order to get the clock source of root, user maybe need to get more than one ROOT's mux value to obtain the final clock source of root.

Parameters

- `rootClk` – Root clock name (see `clock_root_control_t` enumeration).

Returns

Root Post divider value.

static inline void CLOCK__ControlGate(uintptr_t ccmGate, *clock_gate_value_t* control)

Set PLL or CCGR gate control.

Parameters

- `ccmGate` – Gate control (see `clock_pll_gate_t` and `clock_ip_name_t` enumeration)
- `control` – Gate control value (see `clock_gate_value_t`)

void CLOCK__EnableClock(*clock_ip_name_t* ccmGate)

Enable CCGR clock gate and root clock gate for each module User should set specific gate for each module according to the description of the table of system clocks, gating and override in CCM chapter of reference manual. Take care of that one module may need to set more than one clock gate.

Parameters

- `ccmGate` – Gate control for each module (see `clock_ip_name_t` enumeration).

void CLOCK__DisableClock(*clock_ip_name_t* ccmGate)

Disable CCGR clock gate for the each module User should set specific gate for each module according to the description of the table of system clocks, gating and override in CCM chapter of reference manual. Take care of that one module may need to set more than one clock gate.

Parameters

- `ccmGate` – Gate control for each module (see `clock_ip_name_t` enumeration).

static inline void CLOCK__PowerUpPll(CCM_ANALOG_Type *base, *clock_pll_ctrl_t* pllControl)

Power up PLL.

Parameters

- `base` – CCM_ANALOG base pointer.
- `pllControl` – PLL control name (see `clock_pll_ctrl_t` enumeration)

static inline void CLOCK_PowerDownPll(CCM_ANALOG_Type *base, *clock_pll_ctrl_t* pllControl)
Power down PLL.

Parameters

- base – CCM_ANALOG base pointer.
- pllControl – PLL control name (see *clock_pll_ctrl_t* enumeration)

static inline void CLOCK_SetPllBypass(CCM_ANALOG_Type *base, *clock_pll_bypass_ctrl_t* pllControl, bool bypass)

PLL bypass setting.

Parameters

- base – CCM_ANALOG base pointer.
- pllControl – PLL control name (see *clock_pll_bypass_ctrl_t* enumeration)
- bypass – Bypass the PLL.
 - true: Bypass the PLL.
 - false: Do not bypass the PLL.

static inline bool CLOCK_IsPllBypassed(CCM_ANALOG_Type *base, *clock_pll_bypass_ctrl_t* pllControl)

Check if PLL is bypassed.

Parameters

- base – CCM_ANALOG base pointer.
- pllControl – PLL control name (see *clock_pll_bypass_ctrl_t* enumeration)

Returns

PLL bypass status.

- true: The PLL is bypassed.
- false: The PLL is not bypassed.

static inline bool CLOCK_IsPllLocked(CCM_ANALOG_Type *base, *clock_pll_ctrl_t* pllControl)

Check if PLL clock is locked.

Parameters

- base – CCM_ANALOG base pointer.
- pllControl – PLL control name (see *clock_pll_ctrl_t* enumeration)

Returns

PLL lock status.

- true: The PLL clock is locked.
- false: The PLL clock is not locked.

static inline void CLOCK_EnableAnalogClock(CCM_ANALOG_Type *base, *clock_pll_clke_t* pllClock)

Enable PLL clock.

Parameters

- base – CCM_ANALOG base pointer.
- pllClock – PLL clock name (see *clock_pll_clke_t* enumeration)

```
static inline void CLOCK_DisableAnalogClock(CCM_ANALOG_Type *base, clock_pll_clke_t  
                                           pllClock)
```

Disable PLL clock.

Parameters

- base – CCM_ANALOG base pointer.
- pllClock – PLL clock name (see clock_pll_clke_t enumeration)

```
static inline void CLOCK_OverridePllClke(CCM_ANALOG_Type *base, clock_pll_clke_t ovClock,  
                                          bool override)
```

Override PLL clock output enable.

Parameters

- base – CCM_ANALOG base pointer.
- ovClock – PLL clock name (see clock_pll_clke_t enumeration)
- override – Override the PLL.
 - true: Override the PLL clke, CCM will handle it.
 - false: Do not override the PLL clke.

```
static inline void CLOCK_OverridePllPd(CCM_ANALOG_Type *base, clock_pll_ctrl_t pdClock,  
                                       bool override)
```

Override PLL power down.

Parameters

- base – CCM_ANALOG base pointer.
- pdClock – PLL clock name (see clock_pll_ctrl_t enumeration)
- override – Override the PLL.
 - true: Override the PLL clke, CCM will handle it.
 - false: Do not override the PLL clke.

```
void CLOCK_InitArmPll(const ccm_analog_integer_pll_config_t *config)
```

Initializes the ANALOG ARM PLL.

Note: This function can't detect whether the Arm PLL has been enabled and used by some IPs.

Parameters

- config – Pointer to the configuration structure(see ccm_analog_integer_pll_config_t enumeration).

```
void CLOCK_DeinitArmPll(void)
```

De-initialize the ARM PLL.

```
void CLOCK_InitSysPll1(const ccm_analog_integer_pll_config_t *config)
```

Initializes the ANALOG SYS PLL1.

Note: This function can't detect whether the SYS PLL has been enabled and used by some IPs.

Parameters

- `config` – Pointer to the configuration structure(see `ccm_analog_integer_pll_config_t` enumeration).

`void CLOCK_DeinitSysPll1(void)`

De-initialize the System PLL1.

`void CLOCK_InitSysPll2(const ccm_analog_integer_pll_config_t *config)`

Initializes the ANALOG SYS PLL2.

Note: This function can't detect whether the SYS PLL has been enabled and used by some IPs.

Parameters

- `config` – Pointer to the configuration structure(see `ccm_analog_integer_pll_config_t` enumeration).

`void CLOCK_DeinitSysPll2(void)`

De-initialize the System PLL2.

`void CLOCK_InitSysPll3(const ccm_analog_integer_pll_config_t *config)`

Initializes the ANALOG SYS PLL3.

Note: This function can't detect whether the SYS PLL has been enabled and used by some IPs.

Parameters

- `config` – Pointer to the configuration structure(see `ccm_analog_integer_pll_config_t` enumeration).

`void CLOCK_DeinitSysPll3(void)`

De-initialize the System PLL3.

`void CLOCK_InitAudioPll1(const ccm_analog_frac_pll_config_t *config)`

Initializes the ANALOG AUDIO PLL1.

Note: This function can't detect whether the AUDIO PLL has been enabled and used by some IPs.

Parameters

- `config` – Pointer to the configuration structure(see `ccm_analog_frac_pll_config_t` enumeration).

`void CLOCK_DeinitAudioPll1(void)`

De-initialize the Audio PLL1.

`void CLOCK_InitAudioPll2(const ccm_analog_frac_pll_config_t *config)`

Initializes the ANALOG AUDIO PLL2.

Note: This function can't detect whether the AUDIO PLL has been enabled and used by some IPs.

Parameters

- `config` – Pointer to the configuration structure(see `ccm_analog_frac_pll_config_t` enumeration).

`void CLOCK_DeinitAudioPll2(void)`

De-initialize the Audio PLL2.

`void CLOCK_InitVideoPll1(const ccm_analog_frac_pll_config_t *config)`

Initializes the ANALOG VIDEO PLL1.

Parameters

- `config` – Pointer to the configuration structure(see `ccm_analog_frac_pll_config_t` enumeration).

`void CLOCK_DeinitVideoPll1(void)`

De-initialize the Video PLL1.

`void CLOCK_InitIntegerPll(CCM_ANALOG_Type *base, const ccm_analog_integer_pll_config_t *config, clock_pll_ctrl_t type)`

Initializes the ANALOG Integer PLL.

Parameters

- `base` – CCM ANALOG base address
- `config` – Pointer to the configuration structure(see `ccm_analog_integer_pll_config_t` enumeration).
- `type` – integer pll type

`uint32_t CLOCK_GetIntegerPllFreq(CCM_ANALOG_Type *base, clock_pll_ctrl_t type, uint32_t refClkFreq, bool pll1Bypass)`

Get the ANALOG Integer PLL clock frequency.

Parameters

- `base` – CCM ANALOG base address.
- `type` – integer pll type
- `refClkFreq` – Reference clock frequency.
- `pll1Bypass` – pll1 bypass flag

Returns

Clock frequency

`void CLOCK_InitFracPll(CCM_ANALOG_Type *base, const ccm_analog_frac_pll_config_t *config, clock_pll_ctrl_t type)`

Initializes the ANALOG Fractional PLL.

Parameters

- `base` – CCM ANALOG base address.
- `config` – Pointer to the configuration structure(see `ccm_analog_frac_pll_config_t` enumeration).
- `type` – fractional pll type.

`uint32_t CLOCK_GetFracPllFreq(CCM_ANALOG_Type *base, clock_pll_ctrl_t type, uint32_t refClkFreq)`

Gets the ANALOG Fractional PLL clock frequency.

Parameters

- `base` – CCM_ANALOG base pointer.
- `type` – fractional pll type.

- refClkFreq – Reference clock frequency.

Returns

Clock frequency

uint32_t CLOCK_GetPllFreq(*clock_pll_ctrl_t* pll)

Gets PLL clock frequency.

Parameters

- pll – fractional pll type.

Returns

Clock frequency

uint32_t CLOCK_GetPllRefClkFreq(*clock_pll_ctrl_t* ctrl)

Gets PLL reference clock frequency.

Parameters

- ctrl – fractional pll type.

Returns

Clock frequency

uint32_t CLOCK_GetFreq(*clock_name_t* clockName)

Gets the clock frequency for a specific clock name.

This function checks the current clock configurations and then calculates the clock frequency for a specific clock name defined in *clock_name_t*.

Parameters

- clockName – Clock names defined in *clock_name_t*

Returns

Clock frequency value in hertz

uint32_t CLOCK_GetClockRootFreq(*clock_root_t* clockRoot)

Gets the frequency of selected clock root.

Parameters

- clockRoot – The clock root used to get the frequency, please refer to *clock_root_t*.

Returns

The frequency of selected clock root.

uint32_t CLOCK_GetCoreM7Freq(void)

Get the CCM Cortex M7 core frequency.

Returns

Clock frequency; If the clock is invalid, returns 0.

uint32_t CLOCK_GetAxiFreq(void)

Get the CCM Axi bus frequency.

Returns

Clock frequency; If the clock is invalid, returns 0.

uint32_t CLOCK_GetAhbFreq(void)

Get the CCM Ahb bus frequency.

Returns

Clock frequency; If the clock is invalid, returns 0.

uint32_t CLOCK_GetEnetAxiFreq(void)

brief Get the CCM Enet AXI bus frequency.

return Clock frequency; If the clock is invalid, returns 0.

uint8_t refSel

pll reference clock sel

uint32_t mainDiv

Value of the 10-bit programmable main-divider, range must be 64~1023

uint32_t dsm

Value of 16-bit DSM

uint8_t preDiv

Value of the 6-bit programmable pre-divider, range must be 1~63

uint8_t postDiv

Value of the 3-bit programmable Scaler, range must be 0~6

uint8_t refSel

pll reference clock sel

uint32_t mainDiv

Value of the 10-bit programmable main-divider, range must be 64~1023

uint8_t preDiv

Value of the 6-bit programmable pre-divider, range must be 1~63

uint8_t postDiv

Value of the 3-bit programmable Scaler, range must be 0~6

struct _ccm_analog_frac_pll_config

#include <fsl_clock.h> Fractional-N PLL configuration. Note: all the dividers in this configuration structure are the actually divider, software will map it to register value.

struct _ccm_analog_integer_pll_config

#include <fsl_clock.h> Integer PLL configuration. Note: all the dividers in this configuration structure are the actually divider, software will map it to register value.

2.8 EDMA: Enhanced Direct Memory Access (eDMA) Controller Driver

void EDMA_Init(DMA_Type *base, const *edma_config_t* *config)

Initializes the eDMA peripheral.

This function ungates the eDMA clock and configures the eDMA peripheral according to the configuration structure.

Note: This function enables the minor loop map feature.

Parameters

- base – eDMA peripheral base address.
- config – A pointer to the configuration structure, see “*edma_config_t*”.

`void EDMA_Deinit(DMA_Type *base)`

Deinitializes the eDMA peripheral.

This function gates the eDMA clock.

Parameters

- `base` – eDMA peripheral base address.

`void EDMA_InstallTCD(DMA_Type *base, uint32_t channel, edma_tcd_t *tcd)`

Push content of TCD structure into hardware TCD register.

Parameters

- `base` – EDMA peripheral base address.
- `channel` – EDMA channel number.
- `tcd` – Point to TCD structure.

`void EDMA_GetDefaultConfig(edma_config_t *config)`

Gets the eDMA default configuration structure.

This function sets the configuration structure to default values. The default configuration is set to the following values:

```
config.enableMasterIdReplication = true;
config.enableHaltOnError = true;
config.enableRoundRobinArbitration = false;
config.enableDebugMode = false;
config.enableBufferedWrites = false;
```

Parameters

- `config` – A pointer to the eDMA configuration structure.

`static inline void EDMA_EnableAllChannelLink(DMA_Type *base, bool enable)`

Enables/disables all channel linking.

This function enables/disables all channel linking in the management page. For specific channel linking enablement & configuration, please refer to `EDMA_SetChannelLink` and `EDMA_TcdSetChannelLink` APIs.

For example, to disable all channel linking in the DMA0 management page:

```
EDMA_EnableAllChannelLink(DMA0, false);
```

Parameters

- `base` – eDMA peripheral base address.
- `enable` – Switcher of the channel linking feature for all channels. “true” means to enable. “false” means not.

`void EDMA_ResetChannel(DMA_Type *base, uint32_t channel)`

Sets all TCD registers to default values.

This function sets TCD registers for this channel to default values.

Note: This function must not be called while the channel transfer is ongoing or it causes unpredictable results.

Note: This function enables the auto stop request feature.

Parameters

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

```
void EDMA_SetTransferConfig(DMA_Type *base, uint32_t channel, const edma_transfer_config_t *config, edma_tcd_t *nextTcd)
```

Configures the eDMA transfer attribute.

This function configures the transfer attribute, including source address, destination address, transfer size, address offset, and so on. It also configures the scatter gather feature if the user supplies the TCD address. Example:

```
edma_transfer_config_t config;
edma_tcd_t tcd;
config.srcAddr = ..;
config.destAddr = ..;
...
EDMA_SetTransferConfig(DMA0, channel, &config, &stcd);
```

Note: If nextTcd is not NULL, it means scatter gather feature is enabled and DREQ bit is cleared in the previous transfer configuration, which is set in the eDMA_ResetChannel.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.
- config – Pointer to eDMA transfer configuration structure.
- nextTcd – Point to TCD structure. It can be NULL if users do not want to enable scatter/gather feature.

```
void EDMA_SetMinorOffsetConfig(DMA_Type *base, uint32_t channel, const edma_minor_offset_config_t *config)
```

Configures the eDMA minor offset feature.

The minor offset means that the signed-extended value is added to the source address or destination address after each minor loop.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.
- config – A pointer to the minor offset configuration structure.

```
static inline void EDMA_SetChannelArbitrationGroup(DMA_Type *base, uint32_t channel, uint32_t group)
```

Configures the eDMA channel arbitration group.

This function configures the channel arbitration group. The arbitration group priorities are evaluated by numeric value from highest group number to lowest.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number
- group – Fixed-priority arbitration group number for the channel.

```
static inline void EDMA_SetChannelPreemptionConfig(DMA_Type *base, uint32_t channel, const
                                                    edma_channel_Preemption_config_t
                                                    *config)
```

Configures the eDMA channel preemption feature.

This function configures the channel preemption attribute and the priority of the channel.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number
- config – A pointer to the channel preemption configuration structure.

```
static inline uint32_t EDMA_GetChannelSystemBusInformation(DMA_Type *base, uint32_t
                                                         channel)
```

Gets the eDMA channel identification and attribute information on the system bus interface.

Parameters

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

Returns

The mask of the channel system bus information. Users need to use the `_edma_channel_sys_bus_info` type to decode the return variables.

```
void EDMA_SetChannelLink(DMA_Type *base, uint32_t channel, edma_channel_link_type_t
                        type, uint32_t linkedChannel)
```

Sets the channel link for the eDMA transfer.

This function configures either the minor link or the major link mode. The minor link means that the channel link is triggered every time CITER decreases by 1. The major link means that the channel link is triggered when the CITER is exhausted.

Note: Users should ensure that DONE flag is cleared before calling this interface, or the configuration is invalid.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.
- type – A channel link type, which can be one of the following:
 - kEDMA_LinkNone
 - kEDMA_MinorLink
 - kEDMA_MajorLink
- linkedChannel – The linked channel number.

```
void EDMA_SetBandWidth(DMA_Type *base, uint32_t channel, edma_bandwidth_t bandWidth)
```

Sets the bandwidth for the eDMA transfer.

Because the eDMA processes the minor loop, it continuously generates read/write sequences until the minor count is exhausted. The bandwidth forces the eDMA to stall after the completion of each read/write access to control the bus request bandwidth seen by the crossbar switch.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.
- bandWidth – A bandwidth setting, which can be one of the following:
 - kEDMABandwidthStallNone
 - kEDMABandwidthStall4Cycle
 - kEDMABandwidthStall8Cycle

```
void EDMA_SetModulo(DMA_Type *base, uint32_t channel, edma_modulo_t srcModulo,  
                   edma_modulo_t destModulo)
```

Sets the source modulo and the destination modulo for the eDMA transfer.

This function defines a specific address range specified to be the value after (SADDR + SOFF)/(DADDR + DOFF) calculation is performed or the original register value. It provides the ability to implement a circular data queue easily.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.
- srcModulo – A source modulo value.
- destModulo – A destination modulo value.

```
static inline void EDMA_EnableAsyncRequest(DMA_Type *base, uint32_t channel, bool enable)
```

Enables an async request for the eDMA transfer.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.
- enable – The command to enable (true) or disable (false).

```
static inline void EDMA_EnableAutoStopRequest(DMA_Type *base, uint32_t channel, bool  
                                              enable)
```

Enables an auto stop request for the eDMA transfer.

If enabling the auto stop request, the eDMA hardware automatically disables the hardware channel request.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.
- enable – The command to enable (true) or disable (false).

```
void EDMA_EnableChannelInterrupts(DMA_Type *base, uint32_t channel, uint32_t mask)
```

Enables the interrupt source for the eDMA transfer.

Parameters

- base – eDMA peripheral base address.
- channel – eDMA channel number.
- mask – The mask of interrupt source to be set. Users need to use the defined `edma_interrupt_enable_t` type.

`void EDMA_DisableChannelInterrupts(DMA_Type *base, uint32_t channel, uint32_t mask)`
 Disables the interrupt source for the eDMA transfer.

Parameters

- `base` – eDMA peripheral base address.
- `channel` – eDMA channel number.
- `mask` – The mask of the interrupt source to be set. Use the defined `edma_interrupt_enable_t` type.

`static inline void EDMA_SetChannelMux(DMA_Type *base, uint32_t channel, uint32_t mux)`
 Set channel mux source.

Note: When the peripheral is no longer needed, the mux configuration for that channel should be written to 0, thus releasing the resource.

Parameters

- `base` – eDMA peripheral base address.
- `channel` – eDMA channel number.
- `mux` – the mux source value is SOC specific, please reference the SOC for detail.

`void EDMA_TcdReset(edma_tcd_t *tcd)`
 Sets all fields to default values for the TCD structure.

This function sets all fields for this TCD structure to default value.

Note: This function enables the auto stop request feature.

Parameters

- `tcd` – Pointer to the TCD structure.

`void EDMA_TcdSetTransferConfig(edma_tcd_t *tcd, const edma_transfer_config_t *config, edma_tcd_t *nextTcd)`

Configures the eDMA TCD transfer attribute.

The TCD is a transfer control descriptor. The content of the TCD is the same as the hardware TCD registers. The STCD is used in the scatter-gather mode. This function configures the TCD transfer attribute, including source address, destination address, transfer size, address offset, and so on. It also configures the scatter gather feature if the user supplies the next TCD address. Example:

```
edma_transfer_config_t config = {
...
}
edma_tcd_t tcd __aligned(32);
edma_tcd_t nextTcd __aligned(32);
EDMA_TcdSetTransferConfig(&tcd, &config, &nextTcd);
```

Note: TCD address should be 32 bytes aligned or it causes an eDMA error.

Note: If the `nextTcd` is not NULL, the scatter gather feature is enabled and DREQ bit is cleared in the previous transfer configuration, which is set in the `EDMA_TcdReset`.

Parameters

- `tcd` – Pointer to the TCD structure.
- `config` – Pointer to eDMA transfer configuration structure.
- `nextTcd` – Pointer to the next TCD structure. It can be NULL if users do not want to enable scatter/gather feature.

```
void EDMA__TcdSetMinorOffsetConfig(edma_tcd_t *tcd, const edma_minor_offset_config_t *config)
```

Configures the eDMA TCD minor offset feature.

A minor offset is a signed-extended value added to the source address or a destination address after each minor loop.

Parameters

- `tcd` – A point to the TCD structure.
- `config` – A pointer to the minor offset configuration structure.

```
void EDMA__TcdSetChannelLink(edma_tcd_t *tcd, edma_channel_link_type_t type, uint32_t linkedChannel)
```

Sets the channel link for the eDMA TCD.

This function configures either a minor link or a major link. The minor link means the channel link is triggered every time CITER decreases by 1. The major link means that the channel link is triggered when the CITER is exhausted.

Note: Users should ensure that DONE flag is cleared before calling this interface, or the configuration is invalid.

Parameters

- `tcd` – Point to the TCD structure.
- `type` – Channel link type, it can be one of:
 - `kEDMA_LinkNone`
 - `kEDMA_MinorLink`
 - `kEDMA_MajorLink`
- `linkedChannel` – The linked channel number.

```
static inline void EDMA__TcdSetBandWidth(edma_tcd_t *tcd, edma_bandwidth_t bandWidth)
```

Sets the bandwidth for the eDMA TCD.

Because the eDMA processes the minor loop, it continuously generates read/write sequences until the minor count is exhausted. The bandwidth forces the eDMA to stall after the completion of each read/write access to control the bus request bandwidth seen by the crossbar switch.

Parameters

- `tcd` – A pointer to the TCD structure.
- `bandWidth` – A bandwidth setting, which can be one of the following:
 - `kEDMABandwidthStallNone`
 - `kEDMABandwidthStall4Cycle`
 - `kEDMABandwidthStall8Cycle`

```
void EDMA__TcdSetModulo(edma_tcd_t *tcd, edma_modulo_t srcModulo, edma_modulo_t
                        destModulo)
```

Sets the source modulo and the destination modulo for the eDMA TCD.

This function defines a specific address range specified to be the value after (SADDR + SOFF)/(DADDR + DOFF) calculation is performed or the original register value. It provides the ability to implement a circular data queue easily.

Parameters

- tcd – A pointer to the TCD structure.
- srcModulo – A source modulo value.
- destModulo – A destination modulo value.

```
static inline void EDMA__TcdEnableAutoStopRequest(edma_tcd_t *tcd, bool enable)
```

Sets the auto stop request for the eDMA TCD.

If enabling the auto stop request, the eDMA hardware automatically disables the hardware channel request.

Parameters

- tcd – A pointer to the TCD structure.
- enable – The command to enable (true) or disable (false).

```
void EDMA__TcdEnableInterrupts(edma_tcd_t *tcd, uint32_t mask)
```

Enables the interrupt source for the eDMA TCD.

Parameters

- tcd – Point to the TCD structure.
- mask – The mask of interrupt source to be set. Users need to use the defined `edma_interrupt_enable_t` type.

```
void EDMA__TcdDisableInterrupts(edma_tcd_t *tcd, uint32_t mask)
```

Disables the interrupt source for the eDMA TCD.

Parameters

- tcd – Point to the TCD structure.
- mask – The mask of interrupt source to be set. Users need to use the defined `edma_interrupt_enable_t` type.

```
static inline void EDMA__EnableChannelRequest(DMA_Type *base, uint32_t channel)
```

Enables the eDMA hardware channel request.

This function enables the hardware channel request.

Parameters

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

```
static inline void EDMA__DisableChannelRequest(DMA_Type *base, uint32_t channel)
```

Disables the eDMA hardware channel request.

This function disables the hardware channel request.

Parameters

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

```
static inline void EDMA_TriggerChannelStart(DMA_Type *base, uint32_t channel)
```

Starts the eDMA transfer by using the software trigger.

This function starts a minor loop transfer.

Parameters

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

```
uint32_t EDMA_GetRemainingMajorLoopCount(DMA_Type *base, uint32_t channel)
```

Gets the Remaining major loop count from the eDMA current channel TCD.

This function checks the TCD (Task Control Descriptor) status for a specified eDMA channel and returns the number of major loop count that has not finished.

Note: 1. This function can only be used to get unfinished major loop count of transfer without the next TCD, or it might be inaccuracy.

- a. The unfinished/remaining transfer bytes cannot be obtained directly from registers while the channel is running. Because to calculate the remaining bytes, the initial NBYTES configured in DMA_TCDn_NBYTES_MLNO register is needed while the eDMA IP does not support getting it while a channel is active. In another word, the NBYTES value reading is always the actual (decrementing) NBYTES value the dma_engine is working with while a channel is running. Consequently, to get the remaining transfer bytes, a software-saved initial value of NBYTES (for example copied before enabling the channel) is needed. The formula to calculate it is shown below: $\text{RemainingBytes} = \text{RemainingMajorLoopCount} * \text{NBYTES}(\text{initially configured})$
-

Parameters

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

Returns

Major loop count which has not been transferred yet for the current TCD.

```
static inline uint32_t EDMA_GetErrorStatusFlags(DMA_Type *base)
```

Gets the eDMA channel error status flags.

Parameters

- base – eDMA peripheral base address.

Returns

The mask of error status flags. Users need to use the `_edma_error_status_flags` type to decode the return variables.

```
uint32_t EDMA_GetChannelStatusFlags(DMA_Type *base, uint32_t channel)
```

Gets the eDMA channel status flags.

Parameters

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

Returns

The mask of channel status flags. Users need to use the `_edma_channel_status_flags` type to decode the return variables.

`void EDMA__ClearChannelStatusFlags(DMA_Type *base, uint32_t channel, uint32_t mask)`

Clears the eDMA channel status flags.

Parameters

- `base` – eDMA peripheral base address.
- `channel` – eDMA channel number.
- `mask` – The mask of channel status to be cleared. Users need to use the defined `_edma_channel_status_flags` type.

`void EDMA__CreateHandle(edma_handle_t *handle, DMA_Type *base, uint32_t channel)`

Creates the eDMA handle.

This function is called if using the transactional API for eDMA. This function initializes the internal state of the eDMA handle.

Parameters

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

`void EDMA__InstallTCDMemory(edma_handle_t *handle, edma_tcd_t *tcdPool, uint32_t tcdSize)`

Installs the TCDs memory pool into the eDMA handle.

This function is called after the `EDMA__CreateHandle` to use scatter/gather feature.

Parameters

- `handle` – eDMA handle pointer.
- `tcdPool` – A memory pool to store TCDs. It must be 32 bytes aligned.
- `tcdSize` – The number of TCD slots.

`void EDMA__SetCallback(edma_handle_t *handle, edma_callback callback, void *userData)`

Installs a callback function for the eDMA transfer.

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

Parameters

- `handle` – eDMA handle pointer.
- `callback` – eDMA callback function pointer.
- `userData` – A parameter for the callback function.

`void EDMA__PrepareTransferConfig(edma_transfer_config_t *config, void *srcAddr, uint32_t srcWidth, int16_t srcOffset, void *destAddr, uint32_t destWidth, int16_t destOffset, uint32_t bytesEachRequest, uint32_t transferBytes)`

Prepares the eDMA transfer structure configurations.

This function prepares the transfer configuration structure according to the user input.

Note: The data address and the data width must be consistent. For example, if the SRC is 4 bytes, the source address must be 4 bytes aligned, or it results in source address error (SAE).

Parameters

- `config` – The user configuration structure of type `edma_transfer_config_t`.
- `srcAddr` – eDMA transfer source address.
- `srcWidth` – eDMA transfer source address width(bytes).
- `srcOffset` – eDMA transfer source address offset
- `destAddr` – eDMA transfer destination address.
- `destWidth` – eDMA transfer destination address width(bytes).
- `destOffset` – eDMA transfer destination address offset
- `bytesEachRequest` – eDMA transfer bytes per channel request.
- `transferBytes` – eDMA transfer bytes to be transferred.

```
void EDMA__PrepareTransfer(edma_transfer_config_t *config, void *srcAddr, uint32_t srcWidth,  
                           void *destAddr, uint32_t destWidth, uint32_t bytesEachRequest,  
                           uint32_t transferBytes, edma_transfer_type_t transferType)
```

Prepares the eDMA transfer structure.

This function prepares the transfer configuration structure according to the user input.

Note: The data address and the data width must be consistent. For example, if the SRC is 4 bytes, the source address must be 4 bytes aligned, or it results in source address error (SAE).

Parameters

- `config` – The user configuration structure of type `edma_transfer_config_t`.
- `srcAddr` – eDMA transfer source address.
- `srcWidth` – eDMA transfer source address width(bytes).
- `destAddr` – eDMA transfer destination address.
- `destWidth` – eDMA transfer destination address width(bytes).
- `bytesEachRequest` – eDMA transfer bytes per channel request.
- `transferBytes` – eDMA transfer bytes to be transferred.
- `transferType` – eDMA transfer type.

```
status_t EDMA__SubmitTransfer(edma_handle_t *handle, const edma_transfer_config_t *config)
```

Submits the eDMA transfer request.

This function submits the eDMA transfer request according to the transfer configuration structure. If submitting 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` – eDMA handle pointer.
- `config` – Pointer to eDMA transfer configuration structure.

Return values

- `kStatus_EDMA_Success` – It means submit transfer request succeed.
- `kStatus_EDMA_QueueFull` – It means TCD queue is full. Submit transfer request is not allowed.
- `kStatus_EDMA_Busy` – It means the given channel is busy, need to submit request later.

`void EDMA_StartTransfer(edma_handle_t *handle)`

eDMA starts transfer.

This function enables the channel request. Users can call this function after submitting the transfer request or before submitting the transfer request.

Parameters

- handle – eDMA handle pointer.

`void EDMA_StopTransfer(edma_handle_t *handle)`

eDMA stops transfer.

This function disables the channel request to pause the transfer. Users can call `EDMA_StartTransfer()` again to resume the transfer.

Parameters

- handle – eDMA handle pointer.

`void EDMA_AbortTransfer(edma_handle_t *handle)`

eDMA aborts transfer.

This function disables the channel request and clear transfer status bits. Users can submit another transfer after calling this API.

Parameters

- handle – DMA handle pointer.

`static inline uint32_t EDMA_GetUnusedTCDNumber(edma_handle_t *handle)`

Get unused TCD slot number.

This function gets current tcd index which is run. If the TCD pool pointer is NULL, it will return 0.

Parameters

- handle – DMA handle pointer.

Returns

The unused tcd slot number.

`static inline uint32_t EDMA_GetNextTCDAddress(edma_handle_t *handle)`

Get the next tcd address.

This function gets the next tcd address. If this is last TCD, return 0.

Parameters

- handle – DMA handle pointer.

Returns

The next TCD address.

`static inline edma_transfer_size_t EDMA_GetTransferSize(uint32_t width)`

Get the transfer size.

This function gets the transfer size.

Parameters

- width – transfer width(bytes).

Returns

The transfer size.

void EDMA_HandleIRQ(*edma_handle_t* *handle)

eDMA IRQ handler for the current major loop transfer completion.

This function clears the channel major interrupt flag and calls the callback function if it is not NULL.

Parameters

- handle – eDMA handle pointer.

FSL_EDMA_DRIVER_VERSION

eDMA driver version

Version 2.5.3.

enum _edma_transfer_size

eDMA transfer configuration

Values:

enumerator kEDMA_TransferSize1Bytes

Source/Destination data transfer size is 1 byte every time

enumerator kEDMA_TransferSize2Bytes

Source/Destination data transfer size is 2 bytes every time

enumerator kEDMA_TransferSize4Bytes

Source/Destination data transfer size is 4 bytes every time

enumerator kEDMA_TransferSize8Bytes

Source/Destination data transfer size is 8 bytes every time

enumerator kEDMA_TransferSize16Bytes

Source/Destination data transfer size is 16 bytes every time

enumerator kEDMA_TransferSize32Bytes

Source/Destination data transfer size is 32 bytes every time

enumerator kEDMA_TransferSize64Bytes

Source/Destination data transfer size is 64 bytes every time

enum _edma_modulo

eDMA modulo configuration

Values:

enumerator kEDMA_ModuloDisable

Disable modulo

enumerator kEDMA_Modulo2bytes

Circular buffer size is 2 bytes.

enumerator kEDMA_Modulo4bytes

Circular buffer size is 4 bytes.

enumerator kEDMA_Modulo8bytes

Circular buffer size is 8 bytes.

enumerator kEDMA_Modulo16bytes

Circular buffer size is 16 bytes.

enumerator kEDMA_Modulo32bytes

Circular buffer size is 32 bytes.

enumerator kEDMA_Modulo64bytes

Circular buffer size is 64 bytes.

enumerator kEDMA_Modulo128bytes

Circular buffer size is 128 bytes.

enumerator kEDMA_Modulo256bytes

Circular buffer size is 256 bytes.

enumerator kEDMA_Modulo512bytes

Circular buffer size is 512 bytes.

enumerator kEDMA_Modulo1Kbytes

Circular buffer size is 1 K bytes.

enumerator kEDMA_Modulo2Kbytes

Circular buffer size is 2 K bytes.

enumerator kEDMA_Modulo4Kbytes

Circular buffer size is 4 K bytes.

enumerator kEDMA_Modulo8Kbytes

Circular buffer size is 8 K bytes.

enumerator kEDMA_Modulo16Kbytes

Circular buffer size is 16 K bytes.

enumerator kEDMA_Modulo32Kbytes

Circular buffer size is 32 K bytes.

enumerator kEDMA_Modulo64Kbytes

Circular buffer size is 64 K bytes.

enumerator kEDMA_Modulo128Kbytes

Circular buffer size is 128 K bytes.

enumerator kEDMA_Modulo256Kbytes

Circular buffer size is 256 K bytes.

enumerator kEDMA_Modulo512Kbytes

Circular buffer size is 512 K bytes.

enumerator kEDMA_Modulo1Mbytes

Circular buffer size is 1 M bytes.

enumerator kEDMA_Modulo2Mbytes

Circular buffer size is 2 M bytes.

enumerator kEDMA_Modulo4Mbytes

Circular buffer size is 4 M bytes.

enumerator kEDMA_Modulo8Mbytes

Circular buffer size is 8 M bytes.

enumerator kEDMA_Modulo16Mbytes

Circular buffer size is 16 M bytes.

enumerator kEDMA_Modulo32Mbytes

Circular buffer size is 32 M bytes.

enumerator kEDMA_Modulo64Mbytes

Circular buffer size is 64 M bytes.

enumerator kEDMA_Modulo128Mbytes

Circular buffer size is 128 M bytes.

enumerator kEDMA_Modulo256Mbytes

Circular buffer size is 256 M bytes.

enumerator kEDMA_Modulo512Mbytes

Circular buffer size is 512 M bytes.

enumerator kEDMA_Modulo1Gbytes

Circular buffer size is 1 G bytes.

enumerator kEDMA_Modulo2Gbytes

Circular buffer size is 2 G bytes.

enum _edma_bandwidth

Bandwidth control.

Values:

enumerator kEDMA_BandwidthStallNone

No eDMA engine stalls.

enumerator kEDMA_BandwidthStall4Cycle

eDMA engine stalls for 4 cycles after each read/write.

enumerator kEDMA_BandwidthStall8Cycle

eDMA engine stalls for 8 cycles after each read/write.

enum _edma_channel_link_type

Channel link type.

Values:

enumerator kEDMA_LinkNone

No channel link

enumerator kEDMA_MinorLink

Channel link after each minor loop

enumerator kEDMA_MajorLink

Channel link while major loop count exhausted

eDMA channel status flags, _edma_channel_status_flags

Values:

enumerator kEDMA_DoneFlag

DONE flag, set while transfer finished, CITER value exhausted

enumerator kEDMA_ErrorFlag

eDMA error flag, an error occurred in a transfer

enumerator kEDMA_InterruptFlag

eDMA interrupt flag, set while an interrupt occurred of this channel

eDMA channel error status flags, _edma_error_status_flags

Values:

enumerator kEDMA_DestinationBusErrorFlag

Bus error on destination address

enumerator kEDMA_SourceBusErrorFlag

Bus error on the source address

enumerator kEDMA_ScatterGatherErrorFlag

Error on the Scatter/Gather address, not 32byte aligned.

enumerator kEDMA_NbytesErrorFlag

NBYTES/CITER configuration error

enumerator kEDMA_DestinationOffsetErrorFlag

Destination offset not aligned with destination size

enumerator kEDMA_DestinationAddressErrorFlag

Destination address not aligned with destination size

enumerator kEDMA_SourceOffsetErrorFlag

Source offset not aligned with source size

enumerator kEDMA_SourceAddressErrorFlag

Source address not aligned with source size

enumerator kEDMA_TransferCanceledFlag

Transfer cancelled

enumerator kEDMA_ErrorChannelFlag

Error channel number of the cancelled channel number

enumerator kEDMA_ValidFlag

No error occurred, this bit is 0. Otherwise, it is 1.

eDMA channel system bus information, _edma_channel_sys_bus_info

Values:

enumerator kEDMA_PrivilegedAccessLevel

Privileged Access Level for DMA transfers. 0b - User protection level; 1b - Privileged protection level.

enumerator kEDMA_MasterId

DMA's master ID when channel is active and master ID replication is enabled.

enum _edma_interrupt_enable

eDMA interrupt source

Values:

enumerator kEDMA_ErrorInterruptEnable

Enable interrupt while channel error occurs.

enumerator kEDMA_MajorInterruptEnable

Enable interrupt while major count exhausted.

enumerator kEDMA_HalfInterruptEnable

Enable interrupt while major count to half value.

enum _edma_transfer_type

eDMA transfer type

Values:

enumerator kEDMA_MemoryToMemory

Transfer from memory to memory

enumerator kEDMA_PeripheralToMemory

Transfer from peripheral to memory

enumerator kEDMA_MemoryToPeripheral

Transfer from memory to peripheral

enumerator kEDMA_PeripheralToPeripheral

Transfer from Peripheral to peripheral

eDMA transfer status, `_edma_transfer_status`

Values:

enumerator kStatus_EDMA_QueueFull

TCD queue is full.

enumerator kStatus_EDMA_Busy

Channel is busy and can't handle the transfer request.

typedef enum *_edma_transfer_size* `edma_transfer_size_t`

eDMA transfer configuration

typedef enum *_edma_modulo* `edma_modulo_t`

eDMA modulo configuration

typedef enum *_edma_bandwidth* `edma_bandwidth_t`

Bandwidth control.

typedef enum *_edma_channel_link_type* `edma_channel_link_type_t`

Channel link type.

typedef enum *_edma_interrupt_enable* `edma_interrupt_enable_t`

eDMA interrupt source

typedef enum *_edma_transfer_type* `edma_transfer_type_t`

eDMA transfer type

typedef struct *_edma_config* `edma_config_t`

eDMA global configuration structure.

typedef struct *_edma_transfer_config* `edma_transfer_config_t`

eDMA transfer configuration

This structure configures the source/destination transfer attribute.

typedef struct *_edma_channel_Preemption_config* `edma_channel_Preemption_config_t`

eDMA channel priority configuration

typedef struct *_edma_minor_offset_config* `edma_minor_offset_config_t`

eDMA minor offset configuration

typedef struct *_edma_tcd* `edma_tcd_t`

eDMA TCD.

This structure is same as TCD register which is described in reference manual, and is used to configure the scatter/gather feature as a next hardware TCD.

typedef void (*`edma_callback`)(struct *_edma_handle* *`handle`, void *`userData`, bool `transferDone`, uint32_t `tcDs`)

Define callback function for eDMA.

typedef uint32_t (*`edma_memorymap_callback`)(uint32_t `addr`)

Memory map function callback for DMA.

```
typedef struct _edma_handle edma_handle_t
    eDMA transfer handle structure

struct _edma_config
    #include <fsl_edma.h> eDMA global configuration structure.
```

Public Members

```
bool enableMasterIdReplication
    Enable (true) master ID replication. If Master ID replication is disabled, the privileged
    protection level (supervisor mode) for DMA transfers is used.

bool enableHaltOnError
    Enable (true) transfer halt on error. Any error causes the HALT bit to set. Subsequently,
    all service requests are ignored until the HALT bit is cleared.

bool enableRoundRobinArbitration
    Enable (true) round robin channel arbitration method or fixed priority arbitration is
    used for channel selection

bool enableDebugMode
    Enable(true) eDMA debug mode. When in debug mode, the eDMA stalls the start of a
    new channel. Executing channels are allowed to complete.

struct _edma_transfer_config
    #include <fsl_edma.h> eDMA transfer configuration
    This structure configures the source/destination transfer attribute.
```

Public Members

```
uint32_t srcAddr
    Source data address.

uint32_t destAddr
    Destination data address.

edma_transfer_size_t srcTransferSize
    Source data transfer size.

edma_transfer_size_t destTransferSize
    Destination data transfer size.

int16_t srcOffset
    Sign-extended offset applied to the current source address to form the next-state value
    as each source read is completed.

int16_t destOffset
    Sign-extended offset applied to the current destination address to form the next-state
    value as each destination write is completed.

uint32_t minorLoopBytes
    Bytes to transfer in a minor loop

uint32_t majorLoopCounts
    Major loop iteration count.

struct _edma_channel_Preemption_config
    #include <fsl_edma.h> eDMA channel priority configuration
```

Public Members

bool enableChannelPreemption

If true: a channel can be suspended by other channel with higher priority

bool enablePreemptAbility

If true: a channel can suspend other channel with low priority

uint8_t channelPriority

Channel priority

struct _edma_minor_offset_config

#include <fsl_edma.h> eDMA minor offset configuration

Public Members

bool enableSrcMinorOffset

Enable(true) or Disable(false) source minor loop offset.

bool enableDestMinorOffset

Enable(true) or Disable(false) destination minor loop offset.

uint32_t minorOffset

Offset for a minor loop mapping.

struct _edma_tcd

#include <fsl_edma.h> eDMA TCD.

This structure is same as TCD register which is described in reference manual, and is used to configure the scatter/gather feature as a next hardware TCD.

Public Members

__IO uint32_t SADDR

SADDR register, used to save source address

__IO uint16_t SOFF

SOFF register, save offset bytes every transfer

__IO uint16_t ATTR

ATTR register, source/destination transfer size and modulo

__IO uint32_t NBYTES

Nbytes register, minor loop length in bytes

__IO uint32_t SLAST

SLAST register

__IO uint32_t DADDR

DADDR register, used for destination address

__IO uint16_t DOFF

DOFF register, used for destination offset

__IO uint16_t CITER

CITER register, current minor loop numbers, for unfinished minor loop.

__IO uint32_t DLAST_SGA

DLASTSGA register, next stdc address used in scatter-gather mode

`__IO uint16_t CSR`
CSR register, for TCD control status

`__IO uint16_t BITER`
BITER register, begin minor loop count.

`struct _edma_handle`
#include <fsl_edma.h> eDMA transfer handle structure

Public Members

`edma_callback` callback
Callback function for major count exhausted.

`void *userData`
Callback function parameter.

`DMA_Type *base`
eDMA peripheral base address.

`edma_tcd_t *tcdPool`
Pointer to memory stored TCDs.

`uint8_t channel`
eDMA channel number.

`volatile int8_t header`
The first TCD index.

`volatile int8_t tail`
The last TCD index.

`volatile int8_t tcdUsed`
The number of used TCD slots.

`volatile int8_t tcdSize`
The total number of TCD slots in the queue.

`uint8_t flags`
The status of the current channel.

`edma_memorymap_callback` memoryCallback
Callback function for memory map convert in complex system

2.9 ECSPI: Enhanced Configurable Serial Peripheral Interface Driver

2.10 ECSPI Driver

`void ECSPI_MasterGetDefaultConfig(ecspi_master_config_t *config)`
Sets the ECSPI configuration structure to default values.

The purpose of this API is to get the configuration structure initialized for use in `ECSPI_MasterInit()`. User may use the initialized structure unchanged in `ECSPI_MasterInit`, or modify some fields of the structure before calling `ECSPI_MasterInit`. After calling this API, the master is ready to transfer. Example:

```
ecspi_master_config_t config;  
ECSPI_MasterGetDefaultConfig(&config);
```

Parameters

- config – pointer to config structure

```
void ECSPI_MasterInit(ECSPI_Type *base, const ecspi_master_config_t *config, uint32_t  
srcClock_Hz)
```

Initializes the ECSPI with configuration.

The configuration structure can be filled by user from scratch, or be set with default values by `ECSPI_MasterGetDefaultConfig()`. After calling this API, the slave is ready to transfer. Example

```
ecspi_master_config_t config = {  
.baudRate_Bps = 400000,  
...  
};  
ECSPI_MasterInit(ECSPI0, &config);
```

Parameters

- base – ECSPI base pointer
- config – pointer to master configuration structure
- srcClock_Hz – Source clock frequency.

```
void ECSPI_SlaveGetDefaultConfig(ecspi_slave_config_t *config)
```

Sets the ECSPI configuration structure to default values.

The purpose of this API is to get the configuration structure initialized for use in `ECSPI_SlaveInit()`. User may use the initialized structure unchanged in `ECSPI_SlaveInit()`, or modify some fields of the structure before calling `ECSPI_SlaveInit()`. After calling this API, the master is ready to transfer. Example:

```
ecspi_slave_config_t config;  
ECSPI_SlaveGetDefaultConfig(&config);
```

Parameters

- config – pointer to config structure

```
void ECSPI_SlaveInit(ECSPI_Type *base, const ecspi_slave_config_t *config)
```

Initializes the ECSPI with configuration.

The configuration structure can be filled by user from scratch, or be set with default values by `ECSPI_SlaveGetDefaultConfig()`. After calling this API, the slave is ready to transfer. Example

```
ecspi_slave_config_t config = {  
.baudRate_Bps = 400000,  
...  
};  
ECSPI_SlaveInit(ECSPI1, &config);
```

Parameters

- base – ECSPI base pointer
- config – pointer to master configuration structure

`void ECSPI_Deinit(ECSPI_Type *base)`

De-initializes the ECSPI.

Calling this API resets the ECSPI module, gates the ECSPI clock. The ECSPI module can't work unless calling the ECSPI_MasterInit/ECSPI_SlaveInit to initialize module.

Parameters

- base – ECSPI base pointer

`static inline void ECSPI_Enable(ECSPI_Type *base, bool enable)`

Enables or disables the ECSPI.

Parameters

- base – ECSPI base pointer
- enable – pass true to enable module, false to disable module

`static inline uint32_t ECSPI_GetStatusFlags(ECSPI_Type *base)`

Gets the status flag.

Parameters

- base – ECSPI base pointer

Returns

ECSPI Status, use status flag to AND `_ecspi_flags` could get the related status.

`static inline void ECSPI_ClearStatusFlags(ECSPI_Type *base, uint32_t mask)`

Clear the status flag.

Parameters

- base – ECSPI base pointer
- mask – ECSPI Status, use status flag to AND `_ecspi_flags` could get the related status.

`static inline void ECSPI_EnableInterrupts(ECSPI_Type *base, uint32_t mask)`

Enables the interrupt for the ECSPI.

Parameters

- base – ECSPI base pointer
- mask – ECSPI interrupt source. The parameter can be any combination of the following values:
 - `kECSPI_TxfifoEmptyInterruptEnable`
 - `kECSPI_TxFifoDataRequestInterruptEnable`
 - `kECSPI_TxFifoFullInterruptEnable`
 - `kECSPI_RxFifoReadyInterruptEnable`
 - `kECSPI_RxFifoDataRequestInterruptEnable`
 - `kECSPI_RxFifoFullInterruptEnable`
 - `kECSPI_RxFifoOverflowInterruptEnable`
 - `kECSPI_TransferCompleteInterruptEnable`
 - `kECSPI_AllInterruptEnable`

`static inline void ECSPI_DisableInterrupts(ECSPI_Type *base, uint32_t mask)`

Disables the interrupt for the ECSPI.

Parameters

- base – ECSPI base pointer
- mask – ECSPI interrupt source. The parameter can be any combination of the following values:
 - kECSPI_TxfifoEmptyInterruptEnable
 - kECSPI_TxFifoDataRequestInterruptEnable
 - kECSPI_TxFifoFullInterruptEnable
 - kECSPI_RxFifoReadyInterruptEnable
 - kECSPI_RxFifoDataRequestInterruptEnable
 - kECSPI_RxFifoFullInterruptEnable
 - kECSPI_RxFifoOverflowInterruptEnable
 - kECSPI_TransferCompleteInterruptEnable
 - kECSPI_AllInterruptEnable

static inline void ECSPI_SoftwareReset(ECSPI_Type *base)
Software reset.

Parameters

- base – ECSPI base pointer

static inline bool ECSPI_IsMaster(ECSPI_Type *base, *ecspi_channel_source_t* channel)
Mode check.

Parameters

- base – ECSPI base pointer
- channel – ECSPI channel source

Returns

mode of channel

static inline void ECSPI_EnableDMA(ECSPI_Type *base, uint32_t mask, bool enable)
Enables the DMA source for ECSPI.

Parameters

- base – ECSPI base pointer
- mask – ECSPI DMA source. The parameter can be any of the following values:
 - kECSPI_TxDmaEnable
 - kECSPI_RxDmaEnable
 - kECSPI_DmaAllEnable
- enable – True means enable DMA, false means disable DMA

static inline uint8_t ECSPI_GetTxFifoCount(ECSPI_Type *base)
Get the Tx FIFO data count.

Parameters

- base – ECSPI base pointer.

Returns

the number of words in Tx FIFO buffer.

```
static inline uint8_t ECSPI_GetRxFifoCount(ECSPI_Type *base)
```

Get the Rx FIFO data count.

Parameters

- base – ECSPI base pointer.

Returns

the number of words in Rx FIFO buffer.

```
static inline void ECSPI_SetChannelSelect(ECSPI_Type *base, ecspi_channel_source_t channel)
```

Set channel select for transfer.

Parameters

- base – ECSPI base pointer
- channel – Channel source.

```
void ECSPI_SetChannelConfig(ECSPI_Type *base, ecspi_channel_source_t channel, const  
                           ecspi_channel_config_t *config)
```

Set channel select configuration for transfer.

The purpose of this API is to set the channel will be use to transfer. User may use this API after instance has been initialized or before transfer start. The configuration structure *ecspi_channel_config* can be filled by user from scratch. After calling this API, user can select this channel as transfer channel.

Parameters

- base – ECSPI base pointer
- channel – Channel source.
- config – Configuration struct of channel

```
void ECSPI_SetBaudRate(ECSPI_Type *base, uint32_t baudRate_Bps, uint32_t srcClock_Hz)
```

Sets the baud rate for ECSPI transfer. This is only used in master.

Parameters

- base – ECSPI base pointer
- baudRate_Bps – baud rate needed in Hz.
- srcClock_Hz – ECSPI source clock frequency in Hz.

```
status_t ECSPI_WriteBlocking(ECSPI_Type *base, const uint32_t *buffer, size_t size)
```

Sends a buffer of data bytes using a blocking method.

Note: This function blocks via polling until all bytes have been sent.

Parameters

- base – ECSPI base pointer
- buffer – The data bytes to send
- size – The number of data bytes to send

Return values

- kStatus_Success – Successfully start a transfer.
- kStatus_ECSPI_Timeout – The transfer timed out and was aborted.

```
static inline void ECSPI_WriteData(ECSPI_Type *base, uint32_t data)
```

Writes a data into the ECSPI data register.

Parameters

- base – ECSPI base pointer
- data – Data needs to be write.

```
static inline uint32_t ECSPI_ReadData(ECSPI_Type *base)
```

Gets a data from the ECSPI data register.

Parameters

- base – ECSPI base pointer

Returns

Data in the register.

```
void ECSPI_MasterTransferCreateHandle(ECSPI_Type *base, ecspi_master_handle_t *handle,  
                                     ecspi_master_callback_t callback, void *userData)
```

Initializes the ECSPI master handle.

This function initializes the ECSPI master handle which can be used for other ECSPI master transactional APIs. Usually, for a specified ECSPI instance, call this API once to get the initialized handle.

Parameters

- base – ECSPI peripheral base address.
- handle – ECSPI handle pointer.
- callback – Callback function.
- userData – User data.

```
status_t ECSPI_MasterTransferBlocking(ECSPI_Type *base, ecspi_transfer_t *xfer)
```

Transfers a block of data using a polling method.

Parameters

- base – SPI base pointer
- xfer – pointer to *spi_xfer_config_t* structure

Return values

- kStatus_Success – Successfully start a transfer.
- kStatus_InvalidArgument – Input argument is invalid.
- kStatus_ECSPI_Timeout – The transfer timed out and was aborted.

```
status_t ECSPI_MasterTransferNonBlocking(ECSPI_Type *base, ecspi_master_handle_t *handle,  
                                         ecspi_transfer_t *xfer)
```

Performs a non-blocking ECSPI interrupt transfer.

Note: The API immediately returns after transfer initialization is finished.

Note: If ECSPI transfer data frame size is 16 bits, the transfer size cannot be an odd number.

Parameters

- base – ECSPI peripheral base address.

- `handle` – pointer to `ecspi_master_handle_t` structure which stores the transfer state
- `xfer` – pointer to `ecspi_transfer_t` structure

Return values

- `kStatus_Success` – Successfully start a transfer.
- `kStatus_InvalidArgument` – Input argument is invalid.
- `kStatus_ECSPi_Busy` – ECSPi is not idle, is running another transfer.

`status_t` ECSPi_MasterTransferGetCount(`ECSPi_Type` *`base`, `ecspi_master_handle_t` *`handle`, `size_t` *`count`)

Gets the bytes of the ECSPi interrupt transferred.

Parameters

- `base` – ECSPi peripheral base address.
- `handle` – Pointer to ECSPi transfer handle, this should be a static variable.
- `count` – Transferred bytes of ECSPi master.

Return values

- `kStatus_ECSPi_Success` – Succeed get the transfer count.
- `kStatus_NoTransferInProgress` – There is not a non-blocking transaction currently in progress.

`void` ECSPi_MasterTransferAbort(`ECSPi_Type` *`base`, `ecspi_master_handle_t` *`handle`)

Aborts an ECSPi transfer using interrupt.

Parameters

- `base` – ECSPi peripheral base address.
- `handle` – Pointer to ECSPi transfer handle, this should be a static variable.

`void` ECSPi_MasterTransferHandleIRQ(`ECSPi_Type` *`base`, `ecspi_master_handle_t` *`handle`)

Interrupts the handler for the ECSPi.

Parameters

- `base` – ECSPi peripheral base address.
- `handle` – pointer to `ecspi_master_handle_t` structure which stores the transfer state.

`void` ECSPi_SlaveTransferCreateHandle(`ECSPi_Type` *`base`, `ecspi_slave_handle_t` *`handle`, `ecspi_slave_callback_t` `callback`, `void` *`userData`)

Initializes the ECSPi slave handle.

This function initializes the ECSPi slave handle which can be used for other ECSPi slave transactional APIs. Usually, for a specified ECSPi instance, call this API once to get the initialized handle.

Parameters

- `base` – ECSPi peripheral base address.
- `handle` – ECSPi handle pointer.
- `callback` – Callback function.
- `userData` – User data.

```
static inline status_t ECSPI_SlaveTransferNonBlocking(ECSPI_Type *base, ecspi_slave_handle_t
                                                    *handle, ecspi_transfer_t *xfer)
```

Performs a non-blocking ECSPI slave interrupt transfer.

Note: The API returns immediately after the transfer initialization is finished.

Parameters

- base – ECSPI peripheral base address.
- handle – pointer to *ecspi_master_handle_t* structure which stores the transfer state
- xfer – pointer to *ecspi_transfer_t* structure

Return values

- *kStatus_Success* – Successfully start a transfer.
- *kStatus_InvalidArgument* – Input argument is invalid.
- *kStatus_ECSPI_Busy* – ECSPI is not idle, is running another transfer.

```
static inline status_t ECSPI_SlaveTransferGetCount(ECSPI_Type *base, ecspi_slave_handle_t
                                                    *handle, size_t *count)
```

Gets the bytes of the ECSPI interrupt transferred.

Parameters

- base – ECSPI peripheral base address.
- handle – Pointer to ECSPI transfer handle, this should be a static variable.
- count – Transferred bytes of ECSPI slave.

Return values

- *kStatus_ECSPI_Success* – Succeed get the transfer count.
- *kStatus_NoTransferInProgress* – There is not a non-blocking transaction currently in progress.

```
static inline void ECSPI_SlaveTransferAbort(ECSPI_Type *base, ecspi_slave_handle_t *handle)
```

Aborts an ECSPI slave transfer using interrupt.

Parameters

- base – ECSPI peripheral base address.
- handle – Pointer to ECSPI transfer handle, this should be a static variable.

```
void ECSPI_SlaveTransferHandleIRQ(ECSPI_Type *base, ecspi_slave_handle_t *handle)
```

Interrupts a handler for the ECSPI slave.

Parameters

- base – ECSPI peripheral base address.
- handle – pointer to *ecspi_slave_handle_t* structure which stores the transfer state

```
FSL_ECSPI_DRIVER_VERSION
```

ECSPI driver version.

Return status for the ECSPI driver.

Values:

enumerator kStatus_ECSPI_Busy

ECSPI bus is busy

enumerator kStatus_ECSPI_Idle

ECSPI is idle

enumerator kStatus_ECSPI_Error

ECSPI error

enumerator kStatus_ECSPI_HardwareOverflow

ECSPI hardware overflow

enumerator kStatus_ECSPI_Timeout

ECSPI timeout polling status flags.

enum _ecspi_clock_polarity

ECSPI clock polarity configuration.

Values:

enumerator kECSPI_PolarityActiveHigh

Active-high ECSPI polarity high (idles low).

enumerator kECSPI_PolarityActiveLow

Active-low ECSPI polarity low (idles high).

enum _ecspi_clock_phase

ECSPI clock phase configuration.

Values:

enumerator kECSPI_ClockPhaseFirstEdge

First edge on SPCK occurs at the middle of the first cycle of a data transfer.

enumerator kECSPI_ClockPhaseSecondEdge

First edge on SPCK occurs at the start of the first cycle of a data transfer.

ECSPI interrupt sources.

Values:

enumerator kECSPI_TxifoEmptyInterruptEnable

Transmit FIFO buffer empty interrupt

enumerator kECSPI_TxFifoDataRequestInterruptEnable

Transmit FIFO data request interrupt

enumerator kECSPI_TxFifoFullInterruptEnable

Transmit FIFO full interrupt

enumerator kECSPI_RxFifoReadyInterruptEnable

Receiver FIFO ready interrupt

enumerator kECSPI_RxFifoDataRequestInterruptEnable

Receiver FIFO data request interrupt

enumerator kECSPI_RxFifoFullInterruptEnable

Receiver FIFO full interrupt

enumerator kECSPI_RxFifoOverflowInterruptEnable

Receiver FIFO buffer overflow interrupt

enumerator kECSPI_TransferCompleteInterruptEnable
Transfer complete interrupt

enumerator kECSPI_AllInterruptEnable
All interrupt

ECSPI status flags.

Values:

enumerator kECSPI_TxfifoEmptyFlag
Transmit FIFO buffer empty flag

enumerator kECSPI_TxFifoDataRequestFlag
Transmit FIFO data request flag

enumerator kECSPI_TxFifoFullFlag
Transmit FIFO full flag

enumerator kECSPI_RxFifoReadyFlag
Receiver FIFO ready flag

enumerator kECSPI_RxFifoDataRequestFlag
Receiver FIFO data request flag

enumerator kECSPI_RxFifoFullFlag
Receiver FIFO full flag

enumerator kECSPI_RxFifoOverflowFlag
Receiver FIFO buffer overflow flag

enumerator kECSPI_TransferCompleteFlag
Transfer complete flag

ECSPI DMA enable.

Values:

enumerator kECSPI_TxDmaEnable
Tx DMA request source

enumerator kECSPI_RxDmaEnable
Rx DMA request source

enumerator kECSPI_DmaAllEnable
All DMA request source

enum _ecspi_data_ready

ECSPI SPI_RDY signal configuration.

Values:

enumerator kECSPI_DataReadyIgnore
SPI_RDY signal is ignored

enumerator kECSPI_DataReadyFallingEdge
SPI_RDY signal will be triggered by the falling edge

enumerator kECSPI_DataReadyLowLevel
SPI_RDY signal will be triggered by a low level

enum _ecspi_channel_source

ECSPI channel select source.

Values:

enumerator kECSPI_Channel0

Channel 0 is selected

enumerator kECSPI_Channel1

Channel 1 is selected

enumerator kECSPI_Channel2

Channel 2 is selected

enumerator kECSPI_Channel3

Channel 3 is selected

enum _ecspi_master_slave_mode

ECSPI master or slave mode configuration.

Values:

enumerator kECSPI_Slave

ECSPI peripheral operates in slave mode.

enumerator kECSPI_Master

ECSPI peripheral operates in master mode.

enum _ecspi_data_line_inactive_state_t

ECSPI data line inactive state configuration.

Values:

enumerator kECSPI_DataLineInactiveStateHigh

The data line inactive state stays high.

enumerator kECSPI_DataLineInactiveStateLow

The data line inactive state stays low.

enum _ecspi_clock_inactive_state_t

ECSPI clock inactive state configuration.

Values:

enumerator kECSPI_ClockInactiveStateLow

The SCLK inactive state stays low.

enumerator kECSPI_ClockInactiveStateHigh

The SCLK inactive state stays high.

enum _ecspi_chip_select_active_state_t

ECSPI active state configuration.

Values:

enumerator kECSPI_ChipSelectActiveStateLow

The SS signal line active stays low.

enumerator kECSPI_ChipSelectActiveStateHigh

The SS signal line active stays high.

enum _ecspi_sample_period_clock_source

ECSPI sample period clock configuration.

Values:

enumerator `kECSPI_spiClock`

The sample period clock source is SCLK.

enumerator `kECSPI_lowFreqClock`

The sample period clock source is low_frequency reference clock(32.768 kHz).

typedef enum `_ecspi_clock_polarity` `ecspi_clock_polarity_t`

ECSPI clock polarity configuration.

typedef enum `_ecspi_clock_phase` `ecspi_clock_phase_t`

ECSPI clock phase configuration.

typedef enum `_ecspi_data_ready` `ecspi_Data_ready_t`

ECSPI SPI_RDY signal configuration.

typedef enum `_ecspi_channel_source` `ecspi_channel_source_t`

ECSPI channel select source.

typedef enum `_ecspi_master_slave_mode` `ecspi_master_slave_mode_t`

ECSPI master or slave mode configuration.

typedef enum `_ecspi_data_line_inactive_state_t` `ecspi_data_line_inactive_state_t`

ECSPI data line inactive state configuration.

typedef enum `_ecspi_clock_inactive_state_t` `ecspi_clock_inactive_state_t`

ECSPI clock inactive state configuration.

typedef enum `_ecspi_chip_select_active_state_t` `ecspi_chip_select_active_state_t`

ECSPI active state configuration.

typedef enum `_ecspi_sample_period_clock_source` `ecspi_sample_period_clock_source_t`

ECSPI sample period clock configuration.

typedef struct `_ecspi_channel_config` `ecspi_channel_config_t`

ECSPI user channel configure structure.

typedef struct `_ecspi_master_config` `ecspi_master_config_t`

ECSPI master configure structure.

typedef struct `_ecspi_slave_config` `ecspi_slave_config_t`

ECSPI slave configure structure.

typedef struct `_ecspi_transfer` `ecspi_transfer_t`

ECSPI transfer structure.

typedef struct `_ecspi_master_handle` `ecspi_master_handle_t`

typedef `ecspi_master_handle_t` `ecspi_slave_handle_t`

Slave handle is the same with master handle

typedef void (*`ecspi_master_callback_t`)(`ECSPI_Type` *`base`, `ecspi_master_handle_t` *`handle`, `status_t` `status`, void *`userData`)

ECSPI master callback for finished transmit.

typedef void (*`ecspi_slave_callback_t`)(`ECSPI_Type` *`base`, `ecspi_slave_handle_t` *`handle`, `status_t` `status`, void *`userData`)

ECSPI slave callback for finished transmit.

uint32_t `ECSPI_GetInstance`(`ECSPI_Type` *`base`)

Get the instance for ECSPI module.

Parameters

- `base` – ECSPI base address

ECSPI_DUMMYDATA

ECSPI dummy transfer data, the data is sent while txBuff is NULL.

SPI_RETRY_TIMES

Retry times for waiting flag.

struct __ecspi_channel_config

#include <fsl_ecspi.h> ECSPI user channel configure structure.

Public Members

ecspi_master_slave_mode_t channelMode

Channel mode

ecspi_clock_inactive_state_t clockInactiveState

Clock line (SCLK) inactive state

ecspi_data_line_inactive_state_t dataLineInactiveState

Data line (MOSI&MISO) inactive state

ecspi_chip_select_active_state_t chipSlectActiveState

Chip select(SS) line active state

ecspi_clock_polarity_t polarity

Clock polarity

ecspi_clock_phase_t phase

Clock phase

struct __ecspi_master_config

#include <fsl_ecspi.h> ECSPI master configure structure.

Public Members

ecspi_channel_source_t channel

Channel number

ecspi_channel_config_t channelConfig

Channel configuration

ecspi_sample_period_clock_source_t samplePeriodClock

Sample period clock source

uint16_t burstLength

Burst length. The length shall be less than 4096 bits

uint8_t chipSelectDelay

SS delay time

uint16_t samplePeriod

Sample period

uint8_t txFifoThreshold

TX Threshold

uint8_t rxFifoThreshold

RX Threshold

uint32_t baudRate_Bps

ECSPI baud rate for master mode

bool enableLoopback

Enable the ECSPI loopback test.

struct __ecspi_slave_config

#include <fsl_ecspi.h> ECSPI slave configure structure.

Public Members

uint16_t burstLength

Burst length. The length shall be less than 4096 bits

uint8_t txFifoThreshold

TX Threshold

uint8_t rxFifoThreshold

RX Threshold

ecspi_channel_config_t channelConfig

Channel configuration

struct __ecspi_transfer

#include <fsl_ecspi.h> ECSPI transfer structure.

Public Members

const uint32_t *txData

Send buffer

uint32_t *rxData

Receive buffer

size_t dataSize

Transfer bytes

ecspi_channel_source_t channel

ECSPI channel select

struct __ecspi_master_handle

#include <fsl_ecspi.h> ECSPI master handle structure.

Public Members

ecspi_channel_source_t channel

Channel number

const uint32_t *volatile txData

Transfer buffer

uint32_t *volatile rxData

Receive buffer

volatile size_t txRemainingBytes

Send data remaining in bytes

volatile size_t rxRemainingBytes

Receive data remaining in bytes

volatile uint32_t state

ECSPI internal state

`size_t` transferSize
Bytes to be transferred
`ecspi_master_callback_t` callback
ECSPI callback
`void *userData`
Callback parameter

2.11 ECSPI SDMA Driver

```
void ECSPIMasterTransferCreateHandleSDMA(ECSPI_Type *base, ecspi_sdma_handle_t *handle,
                                         ecspi_sdma_callback_t callback, void *userData,
                                         sdma_handle_t *txHandle, sdma_handle_t
                                         *rxHandle, uint32_t eventSourceTx, uint32_t
                                         eventSourceRx, uint32_t TxChannel, uint32_t
                                         RxChannel)
```

Initialize the ECSPI master SDMA handle.

This function initializes the ECSPI master SDMA handle which can be used for other SPI master transactional APIs. Usually, for a specified ECSPI instance, user need only call this API once to get the initialized handle.

Parameters

- `base` – ECSPI peripheral base address.
- `handle` – ECSPI handle pointer.
- `callback` – User callback function called at the end of a transfer.
- `userData` – User data for callback.
- `txHandle` – SDMA handle pointer for ECSPI Tx, the handle shall be static allocated by users.
- `rxHandle` – SDMA handle pointer for ECSPI Rx, the handle shall be static allocated by users.
- `eventSourceTx` – event source for ECSPI send, which can be found in SDMA mapping.
- `eventSourceRx` – event source for ECSPI receive, which can be found in SDMA mapping.
- `TxChannel` – SDMA channel for ECSPI send.
- `RxChannel` – SDMA channel for ECSPI receive.

```
void ECSPISlaveTransferCreateHandleSDMA(ECSPI_Type *base, ecspi_sdma_handle_t *handle,
                                         ecspi_sdma_callback_t callback, void *userData,
                                         sdma_handle_t *txHandle, sdma_handle_t
                                         *rxHandle, uint32_t eventSourceTx, uint32_t
                                         eventSourceRx, uint32_t TxChannel, uint32_t
                                         RxChannel)
```

Initialize the ECSPI Slave SDMA handle.

This function initializes the ECSPI Slave SDMA handle which can be used for other SPI Slave transactional APIs. Usually, for a specified ECSPI instance, user need only call this API once to get the initialized handle.

Parameters

- `base` – ECSPI peripheral base address.

- `handle` – ECSPI handle pointer.
- `callback` – User callback function called at the end of a transfer.
- `userData` – User data for callback.
- `txHandle` – SDMA handle pointer for ECSPI Tx, the handle shall be static allocated by users.
- `rxHandle` – SDMA handle pointer for ECSPI Rx, the handle shall be static allocated by users.
- `eventSourceTx` – event source for ECSPI send, which can be found in SDMA mapping.
- `eventSourceRx` – event source for ECSPI receive, which can be found in SDMA mapping.
- `TxChannel` – SDMA channel for ECSPI send.
- `RxChannel` – SDMA channel for ECSPI receive.

status_t ECSPI_MasterTransferSDMA(ECSPI_Type *base, *ecspi_sdma_handle_t* *handle, *ecspi_transfer_t* *xfer)

Perform a non-blocking ECSPI master transfer using SDMA.

Note: This interface returned immediately after transfer initiates.

Parameters

- `base` – ECSPI peripheral base address.
- `handle` – ECSPI SDMA handle pointer.
- `xfer` – Pointer to sdma transfer structure.

Return values

- `kStatus_Success` – Successfully start a transfer.
- `kStatus_InvalidArgument` – Input argument is invalid.
- `kStatus_ECSPI_Busy` – ECSPI is not idle, is running another transfer.

status_t ECSPI_SlaveTransferSDMA(ECSPI_Type *base, *ecspi_sdma_handle_t* *handle, *ecspi_transfer_t* *xfer)

Perform a non-blocking ECSPI slave transfer using SDMA.

Note: This interface returned immediately after transfer initiates.

Parameters

- `base` – ECSPI peripheral base address.
- `handle` – ECSPI SDMA handle pointer.
- `xfer` – Pointer to sdma transfer structure.

Return values

- `kStatus_Success` – Successfully start a transfer.
- `kStatus_InvalidArgument` – Input argument is invalid.
- `kStatus_ECSPI_Busy` – ECSPI is not idle, is running another transfer.

`void ECSPI_MasterTransferAbortSDMA(ECSPI_Type *base, ecspi_sdma_handle_t *handle)`
Abort a ECSPI master transfer using SDMA.

Parameters

- `base` – ECSPI peripheral base address.
- `handle` – ECSPI SDMA handle pointer.

`void ECSPI_SlaveTransferAbortSDMA(ECSPI_Type *base, ecspi_sdma_handle_t *handle)`
Abort a ECSPI slave transfer using SDMA.

Parameters

- `base` – ECSPI peripheral base address.
- `handle` – ECSPI SDMA handle pointer.

`FSL_ECSPI_FREERTOS_DRIVER_VERSION`

ECSPI FreeRTOS driver version.

`typedef struct ecspi_sdma_handle ecspi_sdma_handle_t`

`typedef void (*ecspi_sdma_callback_t)(ECSPI_Type *base, ecspi_sdma_handle_t *handle, status_t status, void *userData)`

ECSPI SDMA callback called at the end of transfer.

`struct ecspi_sdma_handle`

`#include <fsl_ecspi_sdma.h>` ECSPI SDMA transfer handle, users should not touch the content of the handle.

Public Members

`bool txInProgress`

Send transfer finished

`bool rxInProgress`

Receive transfer finished

`sdma_handle_t *txSdmaHandle`

DMA handler for ECSPI send

`sdma_handle_t *rxSdmaHandle`

DMA handler for ECSPI receive

`ecspi_sdma_callback_t callback`

Callback for ECSPI SDMA transfer

`void *userData`

User Data for ECSPI SDMA callback

`uint32_t state`

Internal state of ECSPI SDMA transfer

`uint32_t ChannelTx`

Channel for send handle

`uint32_t ChannelRx`

Channel for receive handler

2.12 ENET: Ethernet MAC Driver

void ENET_GetDefaultConfig(*enet_config_t* *config)

Gets the ENET default configuration structure.

The purpose of this API is to get the default ENET MAC controller configure structure for ENET_Init(). User may use the initialized structure unchanged in ENET_Init(), or modify some fields of the structure before calling ENET_Init(). Example:

```
enet_config_t config;
ENET_GetDefaultConfig(&config);
```

Parameters

- config – The ENET mac controller configuration structure pointer.

status_t ENET_Up(ENET_Type *base, *enet_handle_t* *handle, const *enet_config_t* *config, const *enet_buffer_config_t* *bufferConfig, uint8_t *macAddr, uint32_t srcClock_Hz)

Initializes the ENET module.

This function initializes the module with the ENET configuration.

Note: ENET has two buffer descriptors legacy buffer descriptors and enhanced IEEE 1588 buffer descriptors. The legacy descriptor is used by default. To use the IEEE 1588 feature, use the enhanced IEEE 1588 buffer descriptor by defining “ENET_ENHANCEDBUFFERDESCRIPTOR_MODE” and calling ENET_Ptp1588Configure() to configure the 1588 feature and related buffers after calling ENET_Up().

Parameters

- base – ENET peripheral base address.
- handle – ENET handler pointer.
- config – ENET mac configuration structure pointer. The “enet_config_t” type mac configuration return from ENET_GetDefaultConfig can be used directly. It is also possible to verify the Mac configuration using other methods.
- bufferConfig – ENET buffer configuration structure pointer. The buffer configuration should be prepared for ENET Initialization. It is the start address of “ringNum” enet_buffer_config structures. To support added multi-ring features in some soc and compatible with the previous enet driver version. For single ring supported, this bufferConfig is a buffer configure structure pointer; for multi-ring supported and used case, this bufferConfig pointer should be a buffer configure structure array pointer.
- macAddr – ENET mac address of Ethernet device. This MAC address should be provided.
- srcClock_Hz – The internal module clock source for MII clock.

Return values

- kStatus_Success – Succeed to initialize the ethernet driver.
- kStatus_ENET_InitMemoryFail – Init fails since buffer memory is not enough.

status_t ENET_Init(ENET_Type *base, *enet_handle_t* *handle, const *enet_config_t* *config, const *enet_buffer_config_t* *bufferConfig, uint8_t *macAddr, uint32_t srcClock_Hz)

Initializes the ENET module.

This function ungates the module clock and initializes it with the ENET configuration.

Note: ENET has two buffer descriptors legacy buffer descriptors and enhanced IEEE 1588 buffer descriptors. The legacy descriptor is used by default. To use the IEEE 1588 feature, use the enhanced IEEE 1588 buffer descriptor by defining “ENET_ENHANCEDBUFFERDESCRIPTOR_MODE” and calling ENET_Ptp1588Configure() to configure the 1588 feature and related buffers after calling ENET_Init().

Parameters

- base – ENET peripheral base address.
- handle – ENET handler pointer.
- config – ENET mac configuration structure pointer. The “enet_config_t” type mac configuration return from ENET_GetDefaultConfig can be used directly. It is also possible to verify the Mac configuration using other methods.
- bufferConfig – ENET buffer configuration structure pointer. The buffer configuration should be prepared for ENET Initialization. It is the start address of “ringNum” enet_buffer_config structures. To support added multi-ring features in some soc and compatible with the previous enet driver version. For single ring supported, this bufferConfig is a buffer configure structure pointer, for multi-ring supported and used case, this bufferConfig pointer should be a buffer configure structure array pointer.
- macAddr – ENET mac address of Ethernet device. This MAC address should be provided.
- srcClock_Hz – The internal module clock source for MII clock.

Return values

- kStatus_Success – Succeed to initialize the ethernet driver.
- kStatus_ENET_InitMemoryFail – Init fails since buffer memory is not enough.

void ENET_Down(ENET_Type *base)

Stops the ENET module.

This function disables the ENET module.

Parameters

- base – ENET peripheral base address.

void ENET_Deinit(ENET_Type *base)

Deinitializes the ENET module.

This function gates the module clock, clears ENET interrupts, and disables the ENET module.

Parameters

- base – ENET peripheral base address.

static inline void ENET_Reset(ENET_Type *base)

Resets the ENET module.

This function restores the ENET module to reset state. Note that this function sets all registers to reset state. As a result, the ENET module can't work after calling this function.

Parameters

- base – ENET peripheral base address.

void ENET_SetMII(ENET_Type *base, *enet_mii_speed_t* speed, *enet_mii_duplex_t* duplex)

Sets the ENET MII speed and duplex.

This API is provided to dynamically change the speed and duplex for MAC.

Parameters

- base – ENET peripheral base address.
- speed – The speed of the RMII mode.
- duplex – The duplex of the RMII mode.

void ENET_SetSMI(ENET_Type *base, uint32_t srcClock_Hz, bool isPreambleDisabled)

Sets the ENET SMI(serial management interface)- MII management interface.

Parameters

- base – ENET peripheral base address.
- srcClock_Hz – This is the ENET module clock frequency. See clock distribution.
- isPreambleDisabled – The preamble disable flag.
 - true Enables the preamble.
 - false Disables the preamble.

static inline bool ENET_GetSMI(ENET_Type *base)

Gets the ENET SMI- MII management interface configuration.

This API is used to get the SMI configuration to check whether the MII management interface has been set.

Parameters

- base – ENET peripheral base address.

Returns

The SMI setup status true or false.

static inline uint32_t ENET_ReadSMIData(ENET_Type *base)

Reads data from the PHY register through an SMI interface.

Parameters

- base – ENET peripheral base address.

Returns

The data read from PHY

static inline void ENET_StartSMIWrite(ENET_Type *base, uint8_t phyAddr, uint8_t regAddr, *enet_mii_write_t* operation, uint16_t data)

Sends the MDIO IEEE802.3 Clause 22 format write command.

After calling this function, need to check whether the transmission is over then do next MDIO operation. For ease of use, encapsulated ENET_MDIOWrite() can be called. For customized requirements, implement with combining separated APIs.

Parameters

- base – ENET peripheral base address.
- phyAddr – The PHY address. Range from 0 ~ 31.
- regAddr – The PHY register address. Range from 0 ~ 31.

- operation – The write operation.
- data – The data written to PHY.

```
static inline void ENET_StartSMIRRead(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_MDIOWrite()/ENET_MDIOWriteReg()/ENET_MDIOWriteReg() can be called. For customized requirements, implement with combining separated APIs.

Parameters

- base – ENET peripheral base address.
- portAddr – The MDIO port address(PHY address).
- devAddr – The device address.
- regAddr – The PHY register address.

```
static inline void ENET_StartExtC45SMIWriteData(ENET_Type *base, uint8_t portAddr, uint8_t devAddr, uint16_t data)
```

Sends the MDIO IEEE802.3 Clause 45 format write data command.

After calling this function, need to check whether the transmission is over then do next MDIO operation. For ease of use, encapsulated ENET_MDIOC45Write() can be called. For customized requirements, implement with combining separated APIs.

Parameters

- base – ENET peripheral base address.
- portAddr – The MDIO port address(PHY address).
- devAddr – The device address.
- data – The data written to PHY.

```
static inline void ENET_StartExtC45SMIReadData(ENET_Type *base, uint8_t portAddr, uint8_t devAddr)
```

Sends the MDIO IEEE802.3 Clause 45 format read data command.

After calling this function, need to check whether the transmission is over then do next MDIO operation. For ease of use, encapsulated ENET_MDIOC45Read() can be called. For customized requirements, implement with combining separated APIs.

Parameters

- base – ENET peripheral base address.
- portAddr – The MDIO port address(PHY address).
- devAddr – The device address.

```
status_t ENET_MDIOC45Write(ENET_Type *base, uint8_t portAddr, uint8_t devAddr, uint16_t regAddr, uint16_t data)
```

MDIO write with IEEE802.3 Clause 45 format.

Parameters

- base – ENET peripheral base address.
- portAddr – The MDIO port address(PHY address).
- devAddr – The device address.
- regAddr – The PHY register address.
- data – The data written to PHY.

Returns

kStatus_Success MDIO access succeeds.

Returns

kStatus_Timeout MDIO access timeout.

```
status_t ENET_MDIOC45Read(ENET_Type *base, uint8_t portAddr, uint8_t devAddr, uint16_t regAddr, uint16_t *pData)
```

MDIO read with IEEE802.3 Clause 45 format.

Parameters

- base – ENET peripheral base address.
- portAddr – The MDIO port address(PHY address).
- devAddr – The device address.
- regAddr – The PHY register address.
- pData – The data read from PHY.

Returns

kStatus_Success MDIO access succeeds.

Returns

kStatus_Timeout MDIO access timeout.

```
static inline void ENET_SetRGMIIClockDelay(ENET_Type *base, bool txEnabled, bool rxEnabled)
```

Control the usage of the delayed tx/rx RGMII clock.

Parameters

- base – ENET peripheral base address.
- txEnabled – Enable or disable to generate the delayed version of RGMII_TXC.
- rxEnabled – Enable or disable to use the delayed version of RGMII_RXC.

```
void ENET_SetMacAddr(ENET_Type *base, uint8_t *macAddr)
```

Sets the ENET module Mac address.

Parameters

- base – ENET peripheral base address.
- macAddr – The six-byte Mac address pointer. The pointer is allocated by application and input into the API.

```
void ENET_GetMacAddr(ENET_Type *base, uint8_t *macAddr)
```

Gets the ENET module Mac address.

Parameters

- base – ENET peripheral base address.
- macAddr – The six-byte Mac address pointer. The pointer is allocated by application and input into the API.

```
void ENET_AddMulticastGroup(ENET_Type *base, uint8_t *address)
```

Adds the ENET device to a multicast group.

Parameters

- base – ENET peripheral base address.
- address – The six-byte multicast group address which is provided by application.

```
void ENET_LeaveMulticastGroup(ENET_Type *base, uint8_t *address)
```

Moves the ENET device from a multicast group.

Parameters

- base – ENET peripheral base address.
- address – The six-byte multicast group address which is provided by application.

```
static inline void ENET_ActiveRead(ENET_Type *base)
```

Activates frame reception for multiple rings.

This function is to active the enet read process.

Note: This must be called after the MAC configuration and state are ready. It must be called after the ENET_Init(). This should be called when the frame reception is required.

Parameters

- base – ENET peripheral base address.

```
static inline void ENET_EnableSleepMode(ENET_Type *base, bool enable)
```

Enables/disables the MAC to enter sleep mode. This function is used to set the MAC enter sleep mode. When entering sleep mode, the magic frame wakeup interrupt should be enabled to wake up MAC from the sleep mode and reset it to normal mode.

Parameters

- base – ENET peripheral base address.
- enable – True enable sleep mode, false disable sleep mode.

```
static inline void ENET_GetAccelFunction(ENET_Type *base, uint32_t *txAccelOption, uint32_t *rxAccelOption)
```

Gets ENET transmit and receive accelerator functions from MAC controller.

Parameters

- base – ENET peripheral base address.
- txAccelOption – The transmit accelerator option. The “enet_tx_accelerator_t” is recommended to be used to as the mask to get the exact the accelerator option.
- rxAccelOption – The receive accelerator option. The “enet_rx_accelerator_t” is recommended to be used to as the mask to get the exact the accelerator option.

```
static inline void ENET_EnableInterrupts(ENET_Type *base, uint32_t mask)
```

Enables the ENET interrupt.

This function enables the ENET interrupt according to the provided mask. The mask is a logical OR of enumeration members. See enet_interrupt_enable_t. For example, to enable the TX frame interrupt and RX frame interrupt, do the following.

```
ENET_EnableInterrupts(ENET, kENET_TxFrameInterrupt | kENET_RxFrameInterrupt);
```

Parameters

- base – ENET peripheral base address.
- mask – ENET interrupts to enable. This is a logical OR of the enumeration enet_interrupt_enable_t.

```
static inline void ENET_DisableInterrupts(ENET_Type *base, uint32_t mask)
```

Disables the ENET interrupt.

This function disables the ENET interrupts according to the provided mask. The mask is a logical OR of enumeration members. See enet_interrupt_enable_t. For example, to disable the TX frame interrupt and RX frame interrupt, do the following.

```
ENET_DisableInterrupts(ENET, kENET_TxFrameInterrupt | kENET_RxFrameInterrupt);
```

Parameters

- base – ENET peripheral base address.
- mask – ENET interrupts to disable. This is a logical OR of the enumeration `enet_interrupt_enable_t`.

```
static inline uint32_t ENET_GetInterruptStatus(ENET_Type *base)
```

Gets the ENET interrupt status flag.

Parameters

- base – ENET peripheral base address.

Returns

The event status of the interrupt source. This is the logical OR of members of the enumeration `enet_interrupt_enable_t`.

```
static inline void ENET_ClearInterruptStatus(ENET_Type *base, uint32_t mask)
```

Clears the ENET interrupt events status flag.

This function clears enabled ENET interrupts according to the provided mask. The mask is a logical OR of enumeration members. See the `enet_interrupt_enable_t`. For example, to clear the TX frame interrupt and RX frame interrupt, do the following.

```
ENET_ClearInterruptStatus(ENET, kENET_TxFrameInterrupt | kENET_RxFrameInterrupt);
```

Parameters

- base – ENET peripheral base address.
- mask – ENET interrupt source to be cleared. This is the logical OR of members of the enumeration `enet_interrupt_enable_t`.

```
void ENET_SetRxISRHandler(ENET_Type *base, enet_isr_t ISRHandler)
```

Set the second level Rx IRQ handler.

Parameters

- base – ENET peripheral base address.
- ISRHandler – The handler to install.

```
void ENET_SetTxISRHandler(ENET_Type *base, enet_isr_t ISRHandler)
```

Set the second level Tx IRQ handler.

Parameters

- base – ENET peripheral base address.
- ISRHandler – The handler to install.

```
void ENET_SetErrISRHandler(ENET_Type *base, enet_isr_t ISRHandler)
```

Set the second level Err IRQ handler.

Parameters

- base – ENET peripheral base address.
- ISRHandler – The handler to install.

```
void ENET_GetRxErrBeforeReadFrame(enet_handle_t *handle, enet_data_error_stats_t *eErrorStatic, uint8_t ringId)
```

Gets the error statistics of a received frame for ENET specified ring.

This API must be called after the `ENET_GetRxFrameSize` and before the `ENET_ReadFrame()`. If the `ENET_GetRxFrameSize` returns `kStatus_ENET_RxFrameError`, the `ENET_GetRxErrBeforeReadFrame` can be used to get the exact error statistics. This is an example.

```
status = ENET_GetRxFrameSize(&g_handle, &length, 0);
if (status == kStatus_ENET_RxFrameError)
{
    Comments: Get the error information of the received frame.
    ENET_GetRxErrBeforeReadFrame(&g_handle, &eErrStatic, 0);
    Comments: update the receive buffer.
    ENET_ReadFrame(EXAMPLE_ENET, &g_handle, NULL, 0);
}
```

Parameters

- handle – The ENET handler structure pointer. This is the same handler pointer used in the ENET_Init.
- eErrorStatic – The error statistics structure pointer.
- ringId – The ring index, range from 0 ~ (FSL_FEATURE_ENET_INSTANCE_QUEUEEn(x) - 1).

void ENET_EnableStatistics(ENET_Type *base, bool enable)

Enables/disables collection of transfer statistics.

Note that this function does not reset any of the already collected data, use the function ENET_ResetStatistics to clear the transfer statistics if needed.

Parameters

- base – ENET peripheral base address.
- enable – True enable statistics collection, false disable statistics collection.

void ENET_GetStatistics(ENET_Type *base, *enet_transfer_stats_t* *statistics)

Gets transfer statistics.

Copies the actual value of hardware counters into the provided structure. Calling this function does not reset the counters in hardware.

Parameters

- base – ENET peripheral base address.
- statistics – The statistics structure pointer.

void ENET_ResetStatistics(ENET_Type *base)

Resets transfer statistics.

Sets the value of hardware transfer counters to zero.

Parameters

- base – ENET peripheral base address.

status_t ENET_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 isEnabled, uint8_t ringId)

Enable or disable tx descriptors reclaim mechanism.

Note: This function must be called when no pending send frame action. Set enable if you want to reclaim context or timestamp in interrupt.

Parameters

- `handle` – The ENET handler pointer. This is the same handler pointer used in the ENET_Init.
- `isEnabled` – Enable or disable flag.
- `ringId` – The ring index or ring number.

Return values

- `kStatus_Success` – Succeed to enable/disable Tx reclaim.
- `kStatus_Fail` – Fail to enable/disable Tx reclaim.

`void ENET_ReclaimTxDescriptor(ENET_Type *base, enet_handle_t *handle, uint8_t ringId)`

Reclaim tx descriptors. This function is used to update the tx descriptor status and store the tx timestamp when the 1588 feature is enabled. This is called by the transmit interrupt IRQ handler after the complete of a frame transmission.

Parameters

- base – ENET peripheral base address.
- handle – The ENET handler pointer. This is the same handler pointer used in the ENET_Init.
- ringId – The ring index or ring number.

`status_t ENET_GetRxFrame(ENET_Type *base, enet_handle_t *handle, enet_rx_frame_struct_t *rxFrame, uint8_t ringId)`

Receives one frame in specified BD ring with zero copy.

This function uses the user-defined allocation and free callbacks. Every time application gets one frame through this function, driver stores the buffer address(es) in `enet_buffer_struct_t` and allocate new buffer(s) for the BD(s). If there's no memory buffer in the pool, this function drops current one frame to keep the Rx frame in BD ring is as fresh as possible.

Note: Application must provide a memory pool including at least BD number + n buffers in order for this function to work properly, because each BD must always take one buffer while driver is running, then other extra n buffer(s) can be taken by application. Here n is the `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 finishes.
- kStatus_ENET_TxFrameOverLen – The Tx frame length is over max ethernet frame length.

void ENET_TransmitIRQHandler(ENET_Type *base, *enet_handle_t* *handle)

The transmit IRQ handler.

Parameters

- base – ENET peripheral base address.
- handle – The ENET handler pointer.

void ENET_ReceiveIRQHandler(ENET_Type *base, *enet_handle_t* *handle)

The receive IRQ handler.

Parameters

- base – ENET peripheral base address.
- handle – The ENET handler pointer.

void ENET_ErrorIRQHandler(ENET_Type *base, *enet_handle_t* *handle)

Some special IRQ handler including the error, mii, wakeup irq handler.

Parameters

- base – ENET peripheral base address.
- handle – The ENET handler pointer.

void ENET_Ptp1588IRQHandler(ENET_Type *base)

the common IRQ handler for the 1588 irq handler.

This is used for the 1588 timer interrupt.

Parameters

- base – ENET peripheral base address.

void ENET_CommonFrame0IRQHandler(ENET_Type *base)

the common IRQ handler for the tx/rx/error etc irq handler.

This is used for the combined tx/rx/error interrupt for single/mutli-ring (frame 0).

Parameters

- base – ENET peripheral base address.

FSL_ENET_DRIVER_VERSION

Defines the driver version.

ENET_BUFFDESCRIPTOR_RX_EMPTY_MASK

Empty bit mask.

ENET_BUFFDESCRIPTOR_RX_SOFTOWNER1_MASK

Software owner one mask.

ENET_BUFFDESCRIPTOR_RX_WRAP_MASK

Next buffer descriptor is the start address.

ENET_BUFFDESCRIPTOR_RX_SOFTOWNER2_Mask

Software owner two mask.

ENET_BUFFDESCRIPTOR_RX_LAST_MASK

Last BD of the frame mask.

ENET_BUFFDESCRIPTOR_RX_MISS_MASK

Received because of the promiscuous mode.

ENET_BUFFDESCRIPTOR_RX_BROADCAST_MASK

Broadcast packet mask.

ENET_BUFFDESCRIPTOR_RX_MULTICAST_MASK

Multicast packet mask.

ENET_BUFFDESCRIPTOR_RX_LENVIOLATE_MASK

Length violation mask.

ENET_BUFFDESCRIPTOR_RX_NOOCTET_MASK

Non-octet aligned frame mask.

ENET_BUFFDESCRIPTOR_RX_CRC_MASK

CRC error mask.

ENET_BUFFDESCRIPTOR_RX_OVERRUN_MASK

FIFO overrun mask.

ENET_BUFFDESCRIPTOR_RX_TRUNC_MASK

Frame is truncated mask.

ENET_BUFFDESCRIPTOR_TX_READY_MASK

Ready bit mask.

ENET_BUFFDESCRIPTOR_TX_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 mac-SpecialConfig 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 rxFifo-FullThreshold 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 mac-SpecialConfig 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 rxFifo-FullThreshold and txFifoWatermark in the enet_config_t.

typedef enum *_enet_interrupt_enable* enet_interrupt_enable_t

List of interrupts supported by the peripheral. This enumeration uses one-bit encoding to allow a logical OR of multiple members. Members usually map to interrupt enable bits in one or more peripheral registers.

typedef enum *_enet_event* enet_event_t

Defines the common interrupt event for callback use.

typedef enum *_enet_idle_slope* enet_idle_slope_t

Defines certain idle slope for bandwidth fraction.

typedef enum *_enet_tx_accelerator* enet_tx_accelerator_t

Defines the transmit accelerator configuration.

Note that the hardware does not insert ICMPv6 protocol checksums as mentioned in errata ERR052152.

typedef enum *_enet_rx_accelerator* enet_rx_accelerator_t

Defines the receive accelerator configuration.

Note that the hardware does not validate ICMPv6 protocol checksums as mentioned in errata ERR052152.

typedef struct *_enet_rx_bd_struct* enet_rx_bd_struct_t

Defines the receive buffer descriptor structure for the little endian system.

typedef struct *_enet_tx_bd_struct* enet_tx_bd_struct_t

Defines the enhanced transmit buffer descriptor structure for the little endian system.

typedef struct *_enet_data_error_stats* enet_data_error_stats_t

Defines the ENET data error statistics structure.

typedef struct *_enet_rx_frame_error* enet_rx_frame_error_t

Defines the Rx frame error structure.

typedef struct *_enet_transfer_stats* enet_transfer_stats_t

Defines the ENET transfer statistics structure.

typedef struct *enet_frame_info* enet_frame_info_t

Defines the frame info structure.

typedef struct *_enet_tx_dirty_ring* enet_tx_dirty_ring_t

Defines the ENET transmit dirty addresses ring/queue structure.

typedef void (*enet_rx_alloc_callback_t)(ENET_Type *base, void *userData, uint8_t ringId)

Defines the ENET Rx memory buffer alloc function pointer.

typedef void (*enet_rx_free_callback_t)(ENET_Type *base, void *buffer, void *userData, uint8_t ringId)

Defines the ENET Rx memory buffer free function pointer.

```
typedef struct _enet_buffer_config enet_buffer_config_t
```

Defines the receive buffer descriptor configuration structure.

Note that for the internal DMA requirements, the buffers have a corresponding alignment requirements.

- a. The aligned receive and transmit buffer size must be evenly divisible by ENET_BUFF_ALIGNMENT. when the data buffers are in cacheable region when cache is enabled, all those size should be aligned to the maximum value of "ENET_BUFF_ALIGNMENT" and the cache line size.
- b. The aligned transmit and receive buffer descriptor start address must be at least 64 bit aligned. However, it's recommended to be evenly divisible by ENET_BUFF_ALIGNMENT. buffer descriptors should be put in non-cacheable region when cache is enabled.
- c. The aligned transmit and receive data buffer start address must be evenly divisible by ENET_BUFF_ALIGNMENT. Receive buffers should be continuous with the total size equal to "rxBdNumber * rxBuffSizeAlign". Transmit buffers should be continuous with the total size equal to "txBdNumber * txBuffSizeAlign". when the data buffers are in cacheable region when cache is enabled, all those size should be aligned to the maximum value of "ENET_BUFF_ALIGNMENT" and the cache line size.

```
typedef struct _enet_intcoalesce_config enet_intcoalesce_config_t
```

Defines the interrupt coalescing configure structure.

```
typedef struct _enet_avb_config enet_avb_config_t
```

Defines the ENET AVB Configure structure.

This is used for to configure the extended ring 1 and ring 2.

- a. The classification match format is $(CMP3 \ll 12) \mid (CMP2 \ll 8) \mid (CMP1 \ll 4) \mid CMP0$. composed of four 3-bit compared VLAN priority field cmp0~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 is smaller than the txWatermark, the frame is still transmitted. The rule is the same for rxFifoFullThreshold in the receive direction.

- d. When “kENET_ControlFlowControlEnable” is set in the macSpecialConfig, ensure that the pauseDuration, rxFifoEmptyThreshold, and rxFifoStatEmptyThreshold are set for flow control enabled case.
- e. When “kENET_ControlStoreAndFwdDisabled” is set in the macSpecialConfig, ensure that the rxFifoFullThreshold and txFifoWatermark are set for store and forward disable.
- f. The rxAccelerConfig and txAccelerConfig default setting with 0 - accelerator are disabled. The “enet_tx_accelerator_t” and “enet_rx_accelerator_t” are recommended to be used to enable the transmit and receive accelerator. After the accelerators are enabled, the store and forward feature should be enabled. As a result, kENET_ControlStoreAndFwdDisabled should not be set.
- g. The intCoalesceCfg can be used in the rx or tx enabled cases to decrease the CPU loading.

`typedef struct _enet_tx_bd_ring enet_tx_bd_ring_t`

Defines the ENET transmit buffer descriptor ring/queue structure.

`typedef struct _enet_rx_bd_ring enet_rx_bd_ring_t`

Defines the ENET receive buffer descriptor ring/queue structure.

`typedef struct _enet_buffer_struct enet_buffer_struct_t`

`typedef struct _enet_rx_frame_attribute_struct enet_rx_frame_attribute_t`

`typedef struct _enet_rx_frame_struct enet_rx_frame_struct_t`

`typedef struct _enet_tx_frame_struct enet_tx_frame_struct_t`

`typedef void (*enet_isr_t)(ENET_Type *base, enet_handle_t *handle)`

Define interrupt IRQ handler.

`const clock_ip_name_t s_enetClock[]`

Pointers to enet clocks for each instance.

`const clock_ip_name_t s_enetExtraClock[]`

`uint32_t ENET_GetInstance(ENET_Type *base)`

Get the ENET instance from peripheral base address.

Parameters

- base – ENET peripheral base address.

Returns

ENET instance.

`ENET_BUFFDESCRIPTOR_RX_ERR_MASK`

Defines the receive error status flag mask.

`struct _enet_rx_bd_struct`

`#include <fsl_enet.h>` Defines the receive buffer descriptor structure for the little endian system.

Public Members

`uint16_t length`

Buffer descriptor data length.

uint16_t control

Buffer descriptor control and status.

uint32_t buffer

Data buffer pointer.

struct __enet_tx_bd_struct

#include <fsl_enet.h> Defines the enhanced transmit buffer descriptor structure for the little endian system.

Public Members

uint16_t length

Buffer descriptor data length.

uint16_t control

Buffer descriptor control and status.

uint32_t buffer

Data buffer pointer.

struct __enet_data_error_stats

#include <fsl_enet.h> Defines the ENET data error statistics structure.

Public Members

uint32_t statsRxLenGreaterErr

Receive length greater than RCR[MAX_FL].

uint32_t statsRxAlignErr

Receive non-octet alignment/

uint32_t statsRxFcsErr

Receive CRC error.

uint32_t statsRxOverRunErr

Receive over run.

uint32_t statsRxTruncateErr

Receive truncate.

struct __enet_rx_frame_error

#include <fsl_enet.h> Defines the Rx frame error structure.

Public Members

bool statsRxTruncateErr

Receive truncate.

bool statsRxOverRunErr

Receive over run.

bool statsRxFcsErr

Receive CRC error.

bool statsRxAlignErr

Receive non-octet alignment.

bool statsRxLenGreaterErr
Receive length greater than RCR[MAX_FL].

struct __enet__transfer_stats
#include <fsl_enet.h> Defines the ENET transfer statistics structure.

Public Members

uint32_t statsRxFrameCount
Rx frame number.

uint32_t statsRxFrameOk
Good Rx frame number.

uint32_t statsRxCrcErr
Rx frame number with CRC error.

uint32_t statsRxAlignErr
Rx frame number with alignment error.

uint32_t statsRxDropInvalidSFD
Dropped frame number due to invalid SFD.

uint32_t statsRxFifoOverflowErr
Rx FIFO overflow count.

uint32_t statsTxFrameCount
Tx frame number.

uint32_t statsTxFrameOk
Good Tx frame number.

uint32_t statsTxCrcAlignErr
The transmit frame is error.

uint32_t statsTxFifoUnderRunErr
Tx FIFO underrun count.

struct enet__frame__info
#include <fsl_enet.h> Defines the frame info structure.

Public Members

void *context
User specified data

struct __enet__tx__dirty__ring
#include <fsl_enet.h> Defines the ENET transmit dirty addresses ring/queue structure.

Public Members

enet_frame_info_t *txDirtyBase
Dirty buffer descriptor base address pointer.

uint16_t txGenIdx
tx generate index.

uint16_t txConsumeIdx
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.

- 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.
- 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.
- The aligned transmit and receive data buffer start address must be evenly divisible by `ENET_BUFF_ALIGNMENT`. Receive buffers should be continuous with the total size equal to “`rxBdNumber * rxBuffSizeAlign`”. Transmit buffers should be continuous with the total size equal to “`txBdNumber * txBuffSizeAlign`”. when the data buffers are in cacheable region when cache is enabled, all those size should be aligned to the maximum value of “`ENET_BUFF_ALIGNMENT`” and the cache line size.

Public Members

uint16_t rxBdNumber
Receive buffer descriptor number.

uint16_t txBdNumber
Transmit buffer descriptor number.

uint16_t rxBuffSizeAlign
Aligned receive data buffer size.

uint16_t txBuffSizeAlign
Aligned transmit data buffer size.

volatile `enet_rx_bd_struct_t` *rxBdStartAddrAlign
Aligned receive buffer descriptor start address: should be non-cacheable.

volatile `enet_tx_bd_struct_t` *txBdStartAddrAlign
Aligned transmit buffer descriptor start address: should be non-cacheable.

uint8_t *rxBufferAlign
Receive data buffer start address.

uint8_t *txBufferAlign
Transmit data buffer start address.

bool rxMaintainEnable
Receive buffer cache maintain.

bool txMaintainEnable
Transmit buffer cache maintain.

enet_frame_info_t *txFrameInfo

Transmit frame information start address.

struct __enet_intcoalesce_config

#include <fsl_enet.h> Defines the interrupt coalescing configure structure.

Public Members

uint8_t txCoalesceFrameCount[1]

Transmit interrupt coalescing frame count threshold.

uint16_t txCoalesceTimeCount[1]

Transmit interrupt coalescing timer count threshold.

uint8_t rxCoalesceFrameCount[1]

Receive interrupt coalescing frame count threshold.

uint16_t rxCoalesceTimeCount[1]

Receive interrupt coalescing timer count threshold.

struct __enet_avb_config

#include <fsl_enet.h> Defines the ENET AVB Configure structure.

This is used for to configure the extended ring 1 and ring 2.

- a. The classification match format is $(CMP3 \ll 12) \mid (CMP2 \ll 8) \mid (CMP1 \ll 4) \mid CMP0$. composed of four 3-bit compared VLAN priority field cmp0~cmp3, cm0 ~ cmp3 are used in parallel.

If CMP1,2,3 are not unused, please set them to the same value as CMP0.

- a. The idleSlope is used to calculate the Band Width fraction, $BW \text{ fraction} = 1 / (1 + 512/idleSlope)$. 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_FULLL 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 decrease the CPU loading.

Public Members

uint32_t macSpecialConfig

Mac special configuration. A logical OR of “enet_special_control_flag_t”.

uint32_t interrupt

Mac interrupt source. A logical OR of “enet_interrupt_enable_t”.

uint16_t rxMaxFrameLen

Receive maximum frame length.

enet_mii_mode_t miiMode

MII mode.

enet_mii_speed_t miiSpeed

MII Speed.

enet_mii_duplex_t miiDuplex

MII duplex.

uint8_t rxAccelerConfig

Receive accelerator, A logical OR of “enet_rx_accelerator_t”.

uint8_t txAccelerConfig

Transmit accelerator, A logical OR of “enet_rx_accelerator_t”.

uint16_t pauseDuration

For flow control enabled case: Pause duration.

uint8_t rxFifoEmptyThreshold

For flow control enabled case: when RX FIFO level reaches this value, it makes MAC generate XOFF pause frame.

uint8_t rxFifoStatEmptyThreshold

For flow control enabled case: number of frames in the receive FIFO, independent of size, that can be accept. If the limit is reached, reception continues and a pause frame is triggered.

uint8_t rxFifoFullThreshold

For store and forward disable case, the data required in RX FIFO to notify the MAC receive ready status.

uint8_t txFifoWatermark

For store and forward disable case, the data required in TX FIFO before a frame transmit start.

enet_intcoalesce_config_t *intCoalesceCfg

If the interrupt coalesce 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 txConsumeIdx

Transmit consume index.

volatile uint16_t txDescUsed

Transmit descriptor used number.

uint16_t txRingLen

Transmit ring length.

struct __enet_rx_bd_ring

#include <fsl_enet.h> Defines the ENET receive buffer descriptor ring/queue structure.

Public Members

volatile enet_rx_bd_struct_t *rxBdBase

Buffer descriptor base address pointer.

uint16_t rxGenIdx

The current available receive buffer descriptor pointer.

uint16_t rxRingLen

Receive ring length.

struct __enet_handle

#include <fsl_enet.h> Defines the ENET handler structure.

Public Members

enet_rx_bd_ring_t rxBdRing[1]
Receive buffer descriptor.

enet_tx_bd_ring_t txBdRing[1]
Transmit buffer descriptor.

uint16_t rxBuffSizeAlign[1]
Receive buffer size alignment.

uint16_t txBuffSizeAlign[1]
Transmit buffer size alignment.

bool rxMaintainEnable[1]
Receive buffer cache maintain.

bool txMaintainEnable[1]
Transmit buffer cache maintain.

uint8_t ringNum
Number of used rings.

enet_callback_t callback
Callback function.

void *userData
Callback function parameter.

enet_tx_dirty_ring_t txDirtyRing[1]
Ring to store tx frame information.

bool txReclaimEnable[1]
Tx reclaim enable flag.

enet_rx_alloc_callback_t rxBuffAlloc
Callback function to alloc memory for zero copy Rx.

enet_rx_free_callback_t rxBuffFree
Callback function to free memory for zero copy Rx.

uint8_t multicastCount[64]
Multicast collisions counter

uint32_t enetClock
The clock of enet peripheral, to caculate core cycles for PTP timestamp.

uint32_t tsDelayCount
The count of core cycles for PTP timestamp capture delay.

struct __enet_buffer_struct
#include <fsl_enet.h>

Public Members

void *buffer
The buffer store the whole or partial frame.

uint16_t length
The byte length of this buffer.

struct __enet_rx_frame_attribute_struct
#include <fsl_enet.h>

Public Members

bool promiscuous

This frame is received because of promiscuous mode.

```
struct __enet_rx_frame_struct  
#include <fsl_enet.h>
```

Public Members

enet_buffer_struct_t *rxBuffArray
Rx frame buffer structure.

uint16_t totLen
Rx frame total length.

enet_rx_frame_attribute_t rxAttribute
Rx frame attribute structure.

enet_rx_frame_error_t rxFrameError
Rx frame error.

```
struct __enet_tx_frame_struct  
#include <fsl_enet.h>
```

Public Members

enet_buffer_struct_t *txBuffArray
Tx frame buffer structure.

uint32_t txBuffNum
Buffer number of this Tx frame.

void *context
Driver reclaims and gives it in Tx over callback, usually store network packet header.

2.13 EQOS-TSN: Ethernet QoS with TSN Driver

2.14 Enet_qos_qos

void ENET_QOS_GetDefaultConfig(*enet_qos_config_t* *config)
Gets the ENET default configuration structure.

The purpose of this API is to get the default ENET configure structure for ENET_QOS_Init(). User may use the initialized structure unchanged in ENET_QOS_Init(), or modify some fields of the structure before calling ENET_QOS_Init(). Example:

```
enet_qos_config_t config;  
ENET_QOS_GetDefaultConfig(&config);
```

Parameters

- config – The ENET mac controller configuration structure pointer.

```
status_t ENET_QOS_Up(ENET_QOS_Type *base, const enet_qos_config_t *config, uint8_t
                    *macAddr, uint8_t macCount, uint32_t refclkSrc_Hz)
```

Initializes the ENET module.

This function initializes it with the ENET basic configuration.

Parameters

- base – ENET peripheral base address.
- config – ENET mac configuration structure pointer. The “enet_qos_config_t” type mac configuration return from ENET_QOS_GetDefaultConfig can be used directly. It is also possible to verify the Mac configuration using other methods.
- macAddr – Pointer to ENET mac address array of Ethernet device. This MAC address should be provided.
- macCount – Count of macAddr in the ENET mac address array
- refclkSrc_Hz – ENET input reference clock.

```
status_t ENET_QOS_Init(ENET_QOS_Type *base, const enet_qos_config_t *config, uint8_t
                      *macAddr, uint8_t macCount, uint32_t refclkSrc_Hz)
```

Initializes the ENET module.

This function ungates the module clock and initializes it with the ENET basic configuration.

Parameters

- base – ENET peripheral base address.
- config – ENET mac configuration structure pointer. The “enet_qos_config_t” type mac configuration return from ENET_QOS_GetDefaultConfig can be used directly. It is also possible to verify the Mac configuration using other methods.
- macAddr – Pointer to ENET mac address array of Ethernet device. This MAC address should be provided.
- macCount – Count of macAddr in the ENET mac address array
- refclkSrc_Hz – ENET input reference clock.

```
void ENET_QOS_Down(ENET_QOS_Type *base)
```

Stops the ENET module.

This function disables the ENET module.

Parameters

- base – ENET peripheral base address.

```
void ENET_QOS_Deinit(ENET_QOS_Type *base)
```

Deinitializes the ENET module.

This function gates the module clock and disables the ENET module.

Parameters

- base – ENET peripheral base address.

```
uint32_t ENET_QOS_GetInstance(ENET_QOS_Type *base)
```

Get the ENET instance from peripheral base address.

Parameters

- base – ENET peripheral base address.

Returns

ENET instance.

status_t ENET_QOS_DescriptorInit(ENET_QOS_Type *base, *enet_qos_config_t* *config,
enet_qos_buffer_config_t *bufferConfig)

Initialize for all ENET descriptors.

Note: This function is do all tx/rx descriptors initialization. Because this API read all interrupt registers first and then set the interrupt flag for all descriptors, if the interrupt register is set. so the descriptor initialization should be called after ENET_QOS_Init(), ENET_QOS_EnableInterrupts() and ENET_QOS_CreateHandle()(if transactional APIs are used).

Parameters

- base – ENET peripheral base address.
- config – The configuration for ENET.
- bufferConfig – All buffers configuration.

status_t ENET_QOS_RxBufferAllocAll(ENET_QOS_Type *base, *enet_qos_handle_t* *handle)

Allocates Rx buffers for all BDs. It's used for zero copy Rx. In zero copy Rx case, Rx buffers are dynamic. This function will populate initial buffers in all BDs for receiving. Then ENET_QOS_GetRxFrame() is used to get Rx frame with zero copy, it will allocate new buffer to replace the buffer in BD taken by application application should free those buffers after they're used.

Note: This function should be called after ENET_QOS_CreateHandler() and buffer allocating callback function should be ready.

Parameters

- base – ENET_QOS peripheral base address.
- handle – The ENET_QOS handler structure. This is the same handler pointer used in the ENET_QOS_Init.

void ENET_QOS_RxBufferFreeAll(ENET_QOS_Type *base, *enet_qos_handle_t* *handle)

Frees Rx buffers in all BDs. It's used for zero copy Rx. In zero copy Rx case, Rx buffers are dynamic. This function will free left buffers in all BDs.

Parameters

- base – ENET_QOS peripheral base address.
- handle – The ENET_QOS handler structure. This is the same handler pointer used in the ENET_QOS_Init.

void ENET_QOS_StartRxTx(ENET_QOS_Type *base, uint8_t txRingNum, uint8_t rxRingNum)

Starts the ENET rx/tx. This function enable the tx/rx and starts the rx/tx DMA. This shall be set after ENET initialization and before starting to receive the data.

Note: This must be called after all the ENET initialization. And should be called when the ENET receive/transmit is required.

Parameters

- base – ENET peripheral base address.

- rxRingNum – The number of the used rx rings. It shall not be larger than the ENET_QOS_RING_NUM_MAX(2). If the ringNum is set with 1, the ring 0 will be used.
- txRingNum – The number of the used tx rings. It shall not be larger than the ENET_QOS_RING_NUM_MAX(2). If the ringNum is set with 1, the ring 0 will be used.

```
status_t ENET_QOS_SetMII(ENET_QOS_Type *base, enet_qos_mii_speed_t speed,
                        enet_qos_mii_duplex_t duplex)
```

Sets the ENET MII speed and duplex.

This API is provided to dynamically change the speed and duplex for MAC.

Parameters

- base – ENET peripheral base address.
- speed – The speed of the RMII mode.
- duplex – The duplex of the RMII mode.

Returns

kStatus_Success The ENET MII speed and duplex has been set successfully.

Returns

kStatus_InvalidArgument Could not set the desired ENET MII speed and duplex combination.

```
void ENET_QOS_SetSMI(ENET_QOS_Type *base, uint32_t csrClock_Hz)
```

Sets the ENET SMI(serial management interface)- MII management interface.

Parameters

- base – ENET peripheral base address.
- csrClock_Hz – CSR clock frequency in HZ

```
static inline bool ENET_QOS_IsSMIBusy(ENET_QOS_Type *base)
```

Checks if the SMI is busy.

Parameters

- base – ENET peripheral base address.

Returns

The status of MII Busy status.

```
static inline uint16_t ENET_QOS_ReadSMIData(ENET_QOS_Type *base)
```

Reads data from the PHY register through SMI interface.

Parameters

- base – ENET peripheral base address.

Returns

The data read from PHY

```
void ENET_QOS_StartSMIWrite(ENET_QOS_Type *base, uint8_t phyAddr, uint8_t regAddr,
                           uint16_t data)
```

Sends the MDIO IEEE802.3 Clause 22 format write command. After send command, user needs to check whether the transmission is over with ENET_QOS_IsSMIBusy().

Parameters

- base – ENET peripheral base address.
- phyAddr – The PHY address.
- regAddr – The PHY register address.

- data – The data written to PHY.

`void ENET_QOS_StartSMIRRead(ENET_QOS_Type *base, uint8_t phyAddr, uint8_t regAddr)`

Sends the MDIO IEEE802.3 Clause 22 format read command. After send command, user needs to check whether the transmission is over with `ENET_QOS_IsSMIBusy()`.

Parameters

- base – ENET peripheral base address.
- phyAddr – The PHY address.
- regAddr – The PHY register address.

`void ENET_QOS_StartExtC45SMIWrite(ENET_QOS_Type *base, uint8_t portAddr, uint8_t devAddr, uint16_t regAddr, uint16_t data)`

Sends the MDIO IEEE802.3 Clause 45 format write command. After send command, user needs to check whether the transmission is over with `ENET_QOS_IsSMIBusy()`.

Parameters

- base – ENET peripheral base address.
- portAddr – The MDIO port address(PHY address).
- devAddr – The device address.
- regAddr – The PHY register address.
- data – The data written to PHY.

`void ENET_QOS_StartExtC45SMIRRead(ENET_QOS_Type *base, uint8_t portAddr, uint8_t devAddr, uint16_t regAddr)`

Sends the MDIO IEEE802.3 Clause 45 format read command. After send command, user needs to check whether the transmission is over with `ENET_QOS_IsSMIBusy()`.

Parameters

- base – ENET peripheral base address.
- portAddr – The MDIO port address(PHY address).
- devAddr – The device address.
- regAddr – The PHY register address.

`status_t ENET_QOS_MDIOWrite(ENET_QOS_Type *base, uint8_t phyAddr, uint8_t regAddr, uint16_t data)`

MDIO write with IEEE802.3 MDIO Clause 22 format.

Parameters

- base – ENET peripheral base address.
- phyAddr – The PHY address.
- regAddr – The PHY register.
- data – The data written to PHY.

Returns

`kStatus_Success` MDIO access succeeds.

Returns

`kStatus_Timeout` MDIO access timeout.

`status_t ENET_QOS_MDIORRead(ENET_QOS_Type *base, uint8_t phyAddr, uint8_t regAddr, uint16_t *pData)`

MDIO read with IEEE802.3 MDIO Clause 22 format.

Parameters

- base – ENET peripheral base address.
- phyAddr – The PHY address.
- regAddr – The PHY register.
- pData – The data read from PHY.

Returns

kStatus_Success MDIO access succeeds.

Returns

kStatus_Timeout MDIO access timeout.

status_t ENET_QOS_MDIO_C45_Write(ENET_QOS_Type *base, uint8_t portAddr, uint8_t devAddr, uint16_t regAddr, uint16_t data)

MDIO write with IEEE802.3 Clause 45 format.

Parameters

- base – ENET peripheral base address.
- portAddr – The MDIO port address(PHY address).
- devAddr – The device address.
- regAddr – The PHY register address.
- data – The data written to PHY.

Returns

kStatus_Success MDIO access succeeds.

Returns

kStatus_Timeout MDIO access timeout.

status_t ENET_QOS_MDIO_C45_Read(ENET_QOS_Type *base, uint8_t portAddr, uint8_t devAddr, uint16_t regAddr, uint16_t *pData)

MDIO read with IEEE802.3 Clause 45 format.

Parameters

- base – ENET peripheral base address.
- portAddr – The MDIO port address(PHY address).
- devAddr – The device address.
- regAddr – The PHY register address.
- pData – The data read from PHY.

Returns

kStatus_Success MDIO access succeeds.

Returns

kStatus_Timeout MDIO access timeout.

static inline void ENET_QOS_SetMacAddr(ENET_QOS_Type *base, uint8_t *macAddr, uint8_t index)

Sets the ENET module Mac address.

Parameters

- base – ENET peripheral base address.
- macAddr – The six-byte Mac address pointer. The pointer is allocated by application and input into the API.
- index – Configure macAddr to MAC_ADDRESS[index] register.

```
void ENET_QOS_GetMacAddr(ENET_QOS_Type *base, uint8_t *macAddr, uint8_t index)
```

Gets the ENET module Mac address.

Parameters

- base – ENET peripheral base address.
- macAddr – The six-byte Mac address pointer. The pointer is allocated by application and input into the API.
- index – Get macAddr from MAC_ADDRESS[index] register.

```
void ENET_QOS_AddMulticastGroup(ENET_QOS_Type *base, uint8_t *address)
```

Adds the ENET_QOS device to a multicast group.

Parameters

- base – ENET_QOS peripheral base address.
- address – The six-byte multicast group address which is provided by application.

```
void ENET_QOS_LeaveMulticastGroup(ENET_QOS_Type *base, uint8_t *address)
```

Moves the ENET_QOS device from a multicast group.

Parameters

- base – ENET_QOS peripheral base address.
- address – The six-byte multicast group address which is provided by application.

```
static inline void ENET_QOS_AcceptAllMulticast(ENET_QOS_Type *base)
```

Enable ENET device to accept all multicast frames.

Parameters

- base – ENET peripheral base address.

```
static inline void ENET_QOS_RejectAllMulticast(ENET_QOS_Type *base)
```

ENET device reject to accept all multicast frames.

Parameters

- base – ENET peripheral base address.

```
void ENET_QOS_EnterPowerDown(ENET_QOS_Type *base, uint32_t *wakeFilter)
```

Set the MAC to enter into power down mode. the remote power wake up frame and magic frame can wake up the ENET from the power down mode.

Parameters

- base – ENET peripheral base address.
- wakeFilter – The wakeFilter provided to configure the wake up frame filter. Set the wakeFilter to NULL is not required. But if you have the filter requirement, please make sure the wakeFilter pointer shall be eight continuous 32-bits configuration.

```
static inline void ENET_QOS_ExitPowerDown(ENET_QOS_Type *base)
```

Set the MAC to exit power down mode. Exit from the power down mode and recover to normal work mode.

Parameters

- base – ENET peripheral base address.

status_t ENET_QOS_EnableRxParser(ENET_QOS_Type *base, bool enable)

Enable/Disable Rx parser, please notice that for enable/disable Rx Parser, should better disable Receive first.

Parameters

- base – ENET_QOS peripheral base address.
- enable – Enable/Disable Rx parser function

Return values

- kStatus_Success – Configure rx parser success.
- kStatus_ENET_QOS_Timeout – Poll status flag timeout.

void ENET_QOS_EnableInterrupts(ENET_QOS_Type *base, uint32_t mask)

Enables the ENET DMA and MAC interrupts.

This function enables the ENET interrupt according to the provided mask. The mask is a logical OR of `enet_qos_dma_interrupt_enable_t` and `enet_qos_mac_interrupt_enable_t`. For example, to enable the dma and mac interrupt, do the following.

```
ENET_QOS_EnableInterrupts(ENET, kENET_QOS_DmaRx | kENET_QOS_DmaTx | kENET_QOS_MacPmt);
```

Parameters

- base – ENET peripheral base address.
- mask – ENET interrupts to enable. This is a logical OR of both enumeration :: `enet_qos_dma_interrupt_enable_t` and `enet_qos_mac_interrupt_enable_t`.

void ENET_QOS_DisableInterrupts(ENET_QOS_Type *base, uint32_t mask)

Disables the ENET DMA and MAC interrupts.

This function disables the ENET interrupt according to the provided mask. The mask is a logical OR of `enet_qos_dma_interrupt_enable_t` and `enet_qos_mac_interrupt_enable_t`. For example, to disable the dma and mac interrupt, do the following.

```
ENET_QOS_DisableInterrupts(ENET, kENET_QOS_DmaRx | kENET_QOS_DmaTx | kENET_QOS_MacPmt);
```

Parameters

- base – ENET peripheral base address.
- mask – ENET interrupts to disables. This is a logical OR of both enumeration :: `enet_qos_dma_interrupt_enable_t` and `enet_qos_mac_interrupt_enable_t`.

static inline uint32_t ENET_QOS_GetDmaInterruptStatus(ENET_QOS_Type *base, uint8_t channel)

Gets the ENET DMA interrupt status flag.

Parameters

- base – ENET peripheral base address.
- channel – The DMA Channel. Shall not be larger than `ENET_QOS_RING_NUM_MAX`.

Returns

The event status of the interrupt source. This is the logical OR of members of the enumeration :: `enet_qos_dma_interrupt_enable_t`.

```
static inline void ENET_QOS_ClearDmaInterruptStatus(ENET_QOS_Type *base, uint8_t channel,
                                                    uint32_t mask)
```

Clear the ENET DMA interrupt status flag.

Parameters

- base – ENET peripheral base address.
- channel – The DMA Channel. Shall not be larger than ENET_QOS_RING_NUM_MAX.
- mask – The interrupt status to be cleared. This is the logical OR of members of the enumeration :: enet_qos_dma_interrupt_enable_t.

```
static inline uint32_t ENET_QOS_GetMacInterruptStatus(ENET_QOS_Type *base)
```

Gets the ENET MAC interrupt status flag.

Parameters

- base – ENET peripheral base address.

Returns

The event status of the interrupt source. Use the enum in enet_qos_mac_interrupt_enable_t and right shift ENET_QOS_MACINT_ENUM_OFFSET to mask the returned value to get the exact interrupt status.

```
void ENET_QOS_ClearMacInterruptStatus(ENET_QOS_Type *base, uint32_t mask)
```

Clears the ENET mac interrupt events status flag.

This function clears enabled ENET interrupts according to the provided mask. The mask is a logical OR of enumeration members. See the enet_qos_mac_interrupt_enable_t. For example, to clear the TX frame interrupt and RX frame interrupt, do the following.

```
ENET_QOS_ClearMacInterruptStatus(ENET, kENET_QOS_MacPmt);
```

Parameters

- base – ENET peripheral base address.
- mask – ENET interrupt source to be cleared. This is the logical OR of members of the enumeration :: enet_qos_mac_interrupt_enable_t.

```
static inline bool ENET_QOS_IsTxDescriptorDmaOwn(enet_qos_tx_bd_struct_t *txDesc)
```

Get the tx descriptor DMA Own flag.

Parameters

- txDesc – The given tx descriptor.

Return values

True – the dma own tx descriptor, false application own tx descriptor.

```
void ENET_QOS_SetupTxDescriptor(enet_qos_tx_bd_struct_t *txDesc, void *buffer1, uint32_t
                                bytes1, void *buffer2, uint32_t bytes2, uint32_t framelen,
                                bool intEnable, bool tsEnable, enet_qos_desc_flag flag,
                                uint8_t slotNum)
```

Setup a given tx descriptor. This function is a low level functional API to setup or prepare a given tx descriptor.

Note: This must be called after all the ENET initialization. And should be called when the ENET receive/transmit is required. Transmit buffers are ‘zero-copy’ buffers, so the buffer must remain in memory until the packet has been fully transmitted. The buffers should be free or requeued in the transmit interrupt irq handler.

Parameters

- txDesc – The given tx descriptor.
- buffer1 – The first buffer address in the descriptor.
- bytes1 – The bytes in the first buffer.
- buffer2 – The second buffer address in the descriptor.
- bytes2 – The bytes in the second buffer.
- framelen – The length of the frame to be transmitted.
- intEnable – Interrupt enable flag.
- tsEnable – The timestamp enable.
- flag – The flag of this tx descriptor, `enet_qos_desc_flag`.
- slotNum – The slot num used for AV only.

```
static inline void ENET_QOS_UpdateTxDescriptorTail(ENET_QOS_Type *base, uint8_t channel,  
                                                  uint32_t txDescTailAddrAlign)
```

Update the tx descriptor tail pointer. This function is a low level functional API to update the tx descriptor tail. This is called after you setup a new tx descriptor to update the tail pointer to make the new descriptor accessible by DMA.

Parameters

- base – ENET peripheral base address.
- channel – The tx DMA channel.
- txDescTailAddrAlign – The new tx tail pointer address.

```
static inline void ENET_QOS_UpdateRxDescriptorTail(ENET_QOS_Type *base, uint8_t channel,  
                                                  uint32_t rxDescTailAddrAlign)
```

Update the rx descriptor tail pointer. This function is a low level functional API to update the rx descriptor tail. This is called after you setup a new rx descriptor to update the tail pointer to make the new descriptor accessible by DMA and to anounce the rx poll command for DMA.

Parameters

- base – ENET peripheral base address.
- channel – The rx DMA channel.
- rxDescTailAddrAlign – The new rx tail pointer address.

```
static inline uint32_t ENET_QOS_GetRxDescriptor(enet_qos_rx_bd_struct_t *rxDesc)
```

Gets the context in the ENET rx descriptor. This function is a low level functional API to get the status flag from a given rx descriptor.

Note: This must be called after all the ENET initialization. And should be called when the ENET receive/transmit is required.

Parameters

- rxDesc – The given rx descriptor.

Return values

The – RDES3 regions for write-back format rx buffer descriptor.

```
void ENET_QOS_UpdateRxDescriptor(enet_qos_rx_bd_struct_t *rxDesc, void *buffer1, void  
                                *buffer2, bool intEnable, bool doubleBuffEnable)
```

Updates the buffers and the own status for a given rx descriptor. This function is a low level functional API to Updates the buffers and the own status for a given rx descriptor.

Note: This must be called after all the ENET initialization. And should be called when the ENET receive/transmit is required.

Parameters

- rxDesc – The given rx descriptor.
- buffer1 – The first buffer address in the descriptor.
- buffer2 – The second buffer address in the descriptor.
- intEnable – Interrupt enable flag.
- doubleBuffEnable – The double buffer enable flag.

```
status_t ENET_QOS_ConfigureRxParser(ENET_QOS_Type *base, enet_qos_rxp_config_t  
                                    *rxpConfig, uint16_t entryCount)
```

Configure flexible rx parser.

This function is used to configure the flexible rx parser table.

Parameters

- base – ENET peripheral base address..
- rxpConfig – The rx parser configuration pointer.
- entryCount – The rx parser entry count.

Return values

- kStatus_Success – Configure rx parser success.
- kStatus_ENET_QOS_Timeout – Poll status flag timeout.

```
status_t ENET_QOS_ReadRxParser(ENET_QOS_Type *base, enet_qos_rxp_config_t *rxpConfig,  
                               uint16_t entryIndex)
```

Read flexible rx parser configuration at specified index.

This function is used to read flexible rx parser configuration at specified index.

Parameters

- base – ENET peripheral base address..
- rxpConfig – The rx parser configuration pointer.
- entryIndex – The rx parser entry index to read, start from 0.

Return values

- kStatus_Success – Configure rx parser success.
- kStatus_ENET_QOS_Timeout – Poll status flag timeout.

```
status_t ENET_QOS_EstProgramGcl(ENET_QOS_Type *base, enet_qos_est_gcl_t *gcl, uint32_t  
                                ptpClk_Hz)
```

Program Gate Control List.

This function is used to program the Enhanced Scheduled Transmisson. (IEEE802.1Qbv)

Parameters

- base – ENET peripheral base address..

- `gcl` – Pointer to the Gate Control List structure.
- `ptpClk_Hz` – frequency of the PTP clock.

`status_t` ENET_QOS_EstReadGcl(ENET_QOS_Type *base, *enet_qos_est_gcl_t* *gcl, uint32_t listLen, bool hwList)

Read Gate Control List.

This function is used to read the Enhanced Scheduled Transmisson list. (IEEE802.1Qbv)

Parameters

- `base` – ENET peripheral base address..
- `gcl` – Pointer to the Gate Control List structure.
- `listLen` – length of the provided opList array in `gcl` structure.
- `hwList` – Boolean if True read HW list, false read SW list.

static inline void ENET_QOS_FpeEnable(ENET_QOS_Type *base)

Enable Frame Preemption.

This function is used to enable frame preemption. (IEEE802.1Qbu)

Parameters

- `base` – ENET peripheral base address..

static inline void ENET_QOS_FpeDisable(ENET_QOS_Type *base)

Disable Frame Preemption.

This function is used to disable frame preemption. (IEEE802.1Qbu)

Parameters

- `base` – ENET peripheral base address..

static inline void ENET_QOS_FpeConfigPreemptable(ENET_QOS_Type *base, uint8_t queueMask)

Configure preemptable transmit queues.

This function is used to configure the preemptable queues. (IEEE802.1Qbu)

Parameters

- `base` – ENET peripheral base address..
- `queueMask` – bitmask representing queues to set in preemptable mode. The N-th bit represents the queue N.

void ENET_QOS_AVBConfigure(ENET_QOS_Type *base, const *enet_qos_cbs_config_t* *config, uint8_t queueIndex)

Sets the ENET AVB feature.

ENET_QOS AVB feature configuration, set transmit bandwidth. This API is called when the AVB feature is required.

Parameters

- `base` – ENET_QOS peripheral base address.
- `config` – The ENET_QOS AVB feature configuration structure.
- `queueIndex` – ENET_QOS queue index.

void ENET_QOS_GetStatistics(ENET_QOS_Type *base, *enet_qos_transfer_stats_t* *statistics)

Gets statistical data in transfer.

Parameters

- base – ENET_QOS peripheral base address.
- statistics – The statistics structure pointer.

```
void ENET_QOS_CreateHandler(ENET_QOS_Type *base, enet_qos_handle_t *handle,  
                           enet_qos_config_t *config, enet_qos_buffer_config_t  
                           *bufferConfig, enet_qos_callback_t callback, void *userData)
```

Create ENET Handler.

This is a transactional API and it's provided to store all data which are needed during the whole transactional process. This API should not be used when you use functional APIs to do data tx/rx. This is function will store many data/flag for transactional use, so all configure API such as ENET_QOS_Init(), ENET_QOS_DescriptorInit(), ENET_QOS_EnableInterrupts() etc.

Note: as our transactional transmit API use the zero-copy transmit buffer. so there are two thing we emphasize here:

- a. tx buffer free/requeue for application should be done in the tx interrupt handler. Please set callback: kENET_QOS_TxIntEvent with tx buffer free/requeue process APIs.
 - b. the tx interrupt is forced to open.
-

Parameters

- base – ENET peripheral base address.
- handle – ENET handler.
- config – ENET configuration.
- bufferConfig – ENET buffer configuration.
- callback – The callback function.
- userData – The application data.

```
status_t ENET_QOS_GetRxFramSize(ENET_QOS_Type *base, enet_qos_handle_t *handle,  
                                uint32_t *length, uint8_t channel)
```

Gets the size of the read frame. This function gets a received frame size from the ENET buffer descriptors.

Note: The FCS of the frame is automatically removed by MAC and the size is the length without the FCS. After calling ENET_QOS_GetRxFramSize, ENET_QOS_ReadFrame() should be called to update the receive buffers If the result is not "kStatus_ENET_QOS_RxFramEmpty".

Parameters

- base – ENET peripheral base address.
- handle – The ENET handler structure. This is the same handler pointer used in the ENET_QOS_Init.
- length – The length of the valid frame received.
- channel – The DMAC channel for the rx.

Return values

- kStatus_ENET_QOS_RxFramEmpty – No frame received. Should not call ENET_QOS_ReadFrame to read frame.

- `kStatus_ENET_QOS_RxFrameError` – Data error happens. `ENET_QOS_ReadFrame` should be called with NULL data and NULL length to update the receive buffers.
- `kStatus_Success` – Receive a frame Successfully then the `ENET_QOS_ReadFrame` should be called with the right data buffer and the captured data length input.

```
status_t ENET_QOS_ReadFrame(ENET_QOS_Type *base, enet_qos_handle_t *handle, uint8_t
                           *data, uint32_t length, uint8_t channel, enet_qos_ptp_time_t
                           *ts)
```

Reads a frame from the ENET device. This function reads a frame from the ENET DMA descriptors. The `ENET_QOS_GetRxFrameSize` should be used to get the size of the prepared data buffer. For example use rx dma channel 0:

```
uint32_t length;
enet_qos_handle_t g_handle;
status_t = ENET_QOS_GetRxFrameSize(&g_handle, &length, 0);
if (length != 0)
{
    uint8_t *data = memory allocate interface;
    if (!data)
    {
        ENET_QOS_ReadFrame(ENET, &g_handle, NULL, 0, 0);
    }
    else
    {
        status_t = ENET_QOS_ReadFrame(ENET, &g_handle, data, length, 0);
    }
}
else if (status_t == kStatus_ENET_QOS_RxFrameError)
{
    ENET_QOS_ReadFrame(ENET, &g_handle, NULL, 0, 0);
}
```

Parameters

- `base` – ENET peripheral base address.
- `handle` – The ENET handler structure. This is the same handler pointer used in the `ENET_QOS_Init`.
- `data` – The data buffer provided by user to store the frame which memory size should be at least “length”.
- `length` – The size of the data buffer which is still the length of the received frame.
- `channel` – The rx DMA channel. shall not be larger than 2.
- `ts` – Pointer to the structure `enet_qos_ptp_time_t` to save frame timestamp.

Returns

The execute status, successful or failure.

```
status_t ENET_QOS_SendFrame(ENET_QOS_Type *base, enet_qos_handle_t *handle, uint8_t
                           *data, uint32_t length, uint8_t channel, bool isNeedTs, void
                           *context, enet_qos_tx_offload_t txOffloadOps)
```

Transmits an ENET frame.

Note: The CRC is automatically appended to the data. Input the data to send without the

CRC.

Parameters

- `base` – ENET peripheral base address.
- `handle` – The ENET handler pointer. This is the same handler pointer used in the `ENET_QOS_Init`.
- `data` – The data buffer provided by user to be send.
- `length` – The length of the data to be send.
- `channel` – Channel to send the frame, same with queue index.
- `isNeedTs` – True to enable timestamp save for the frame
- `context` – pointer to user context to be kept in the tx dirty frame information.
- `txOffloadOps` – The Tx frame checksum offload option.

Return values

- `kStatus_Success` – Send frame succeed.
- `kStatus_ENET_QOS_TxFrameBusy` – Transmit buffer descriptor is busy under transmission. The transmit busy happens when the data send rate is over the MAC capacity. The waiting mechanism is recommended to be added after each call return with `kStatus_ENET_QOS_TxFrameBusy`.

`void ENET_QOS_ReclaimTxDescriptor(ENET_QOS_Type *base, enet_qos_handle_t *handle, uint8_t channel)`

Reclaim tx descriptors. This function is used to update the tx descriptor status and store the tx timestamp when the 1588 feature is enabled. This is called by the transmit interrupt IRQ handler after the complete of a frame transmission.

Parameters

- `base` – ENET peripheral base address.
- `handle` – The ENET handler pointer. This is the same handler pointer used in the `ENET_QOS_Init`.
- `channel` – The tx DMA channel.

`void ENET_QOS_CommonIRQHandler(ENET_QOS_Type *base, enet_qos_handle_t *handle)`

The ENET IRQ handler.

Parameters

- `base` – ENET peripheral base address.
- `handle` – The ENET handler pointer.

`void ENET_QOS_SetISRHandler(ENET_QOS_Type *base, enet_qos_isr_t ISRHandler)`

Set the second level IRQ handler, allow user to overwrite the default second level weak IRQ handler.

Parameters

- `base` – ENET peripheral base address.
- `ISRHandler` – The handler to install.

`status_t ENET_QOS_Ptp1588CorrectTimerInCoarse(ENET_QOS_Type *base, enet_qos_systime_op operation, uint32_t second, uint32_t nanosecond)`

Correct the ENET PTP 1588 timer in coarse method.

Parameters

- base – ENET peripheral base address.
- operation – The system time operation, refer to “enet_qos_systime_op”
- second – The correction second.
- nanosecond – The correction nanosecond.

status_t ENET_QOS_Ptp1588CorrectTimerInFine(ENET_QOS_Type *base, uint32_t addend)
Correct the ENET PTP 1588 timer in fine method.

Note: Should take refer to the chapter “System time correction” and see the description for the “fine correction method”.

Parameters

- base – ENET peripheral base address.
- addend – The addend value to be set in the fine method

static inline uint32_t ENET_QOS_Ptp1588GetAddend(ENET_QOS_Type *base)
Get the ENET Time stamp current addend value.

Parameters

- base – ENET peripheral base address.

Returns

The addend value.

void ENET_QOS_Ptp1588GetTimerNoIRQDisable(ENET_QOS_Type *base, uint64_t *second,
uint32_t *nanosecond)

Gets the current ENET time from the PTP 1588 timer without IRQ disable.

Parameters

- base – ENET peripheral base address.
- second – The PTP 1588 system timer second.
- nanosecond – The PTP 1588 system timer nanosecond. For the unit of the nanosecond is 1ns. so the nanosecond is the real nanosecond.

static inline *status_t* ENET_Ptp1588PpsControl(ENET_QOS_Type *base,
enet_qos_ptp_pps_instance_t instance,
enet_qos_ptp_pps_trgt_mode_t trgtMode,
enet_qos_ptp_pps_cmd_t cmd)

Sets the ENET PTP 1588 PPS control. All channels operate in flexible PPS output mode.

Parameters

- base – ENET peripheral base address.
- instance – The ENET QOS PTP PPS instance.
- trgtMode – The target time register mode.
- cmd – The target flexible PPS output control command.

status_t ENET_QOS_Ptp1588PpsSetTrgtTime(ENET_QOS_Type *base,
enet_qos_ptp_pps_instance_t instance, uint32_t
seconds, uint32_t nanoseconds)

Sets the ENET QOS PTP 1588 PPS target time registers.

Parameters

- base – ENET QOS peripheral base address.
- instance – The ENET QOS PTP PPS instance.
- seconds – The target seconds.
- nanoseconds – The target nanoseconds.

```
static inline void ENET_QOS_Ptp1588PpsSetWidth(ENET_QOS_Type *base,  
                                                enet_qos_ptp_pps_instance_t instance,  
                                                uint32_t width)
```

Sets the ENET QOS PTP 1588 PPS output signal interval.

Parameters

- base – ENET QOS peripheral base address.
- instance – The ENET QOS PTP PPS instance.
- width – Signal Width. It is stored in terms of number of units of sub-second increment value. The width value must be lesser than interval value.

```
static inline void ENET_QOS_Ptp1588PpsSetInterval(ENET_QOS_Type *base,  
                                                  enet_qos_ptp_pps_instance_t instance,  
                                                  uint32_t interval)
```

Sets the ENET QOS PTP 1588 PPS output signal width.

Parameters

- base – ENET QOS peripheral base address.
- instance – The ENET QOS PTP PPS instance.
- interval – Signal Interval. It is stored in terms of number of units of sub-second increment value.

```
void ENET_QOS_Ptp1588GetTimer(ENET_QOS_Type *base, uint64_t *second, uint32_t  
                             *nanosecond)
```

Gets the current ENET time from the PTP 1588 timer.

Parameters

- base – ENET peripheral base address.
- second – The PTP 1588 system timer second.
- nanosecond – The PTP 1588 system timer nanosecond. For the unit of the nanosecond is 1ns.so the nanosecond is the real nanosecond.

```
void ENET_QOS_GetTxFrame(enet_qos_handle_t *handle, enet_qos_frame_info_t *txFrame,  
                        uint8_t channel)
```

Gets the time stamp of the transmit frame.

This function is used for PTP stack to get the timestamp captured by the ENET driver.

Parameters

- handle – The ENET handler pointer.This is the same state pointer used in ENET_QOS_Init.
- txFrame – Input parameter, pointer to enet_qos_frame_info_t for saving read out frame information.
- channel – Channel for searching the tx frame.

```
status_t ENET_QOS_GetRxFramE(ENET_QOS_Type *base, enet_qos_handle_t *handle,  
                             enet_qos_rx_frame_struct_t *rxFrame, uint8_t channel)
```

Receives one frame in specified BD ring with zero copy.

This function will use the user-defined allocate and free callback. Every time application gets one frame through this function, driver will allocate new buffers for the BDs whose buffers have been taken by application.

Note: This function will drop current frame and update related BDs as available for DMA if new buffers allocating fails. Application must provide a memory pool including at least BD number + 1 buffers(+2 if enable double buffer) to make this function work normally. If user calls this function in Rx interrupt handler, be careful that this function makes Rx BD ready with allocating new buffer(normal) or updating current BD(out of memory). If there's always new Rx frame input, Rx interrupt will be triggered forever. Application need to disable Rx interrupt according to specific design in this case.

Parameters

- base – ENET peripheral base address.
- handle – The ENET handler pointer. This is the same handler pointer used in the ENET_Init.
- rxFrame – The received frame information structure provided by user.
- channel – Channel for searching the rx frame.

Return values

- kStatus_Success – Succeed to get one frame and allocate new memory for Rx buffer.
- kStatus_ENET_QOS_RxFrameEmpty – There's no Rx frame in the BD.
- kStatus_ENET_QOS_RxFrameError – There's issue in this receiving.
- kStatus_ENET_QOS_RxFrameDrop – There's no new buffer memory for BD, drop this frame.

FSL_ENET_QOS_DRIVER_VERSION

Defines the driver version.

ENET_QOS_RXDESCRIP_RD_BUFF1VALID_MASK

Defines for read format.

Buffer1 address valid.

ENET_QOS_RXDESCRIP_RD_BUFF2VALID_MASK

Buffer2 address valid.

ENET_QOS_RXDESCRIP_RD_IOC_MASK

Interrupt enable on complete.

ENET_QOS_RXDESCRIP_RD_OWN_MASK

Own bit.

ENET_QOS_RXDESCRIP_WR_ERR_MASK

Defines for write back format.

ENET_QOS_RXDESCRIP_WR_PYLOAD_MASK

ENET_QOS_RXDESCRIP_WR_PTPMSGTYPE_MASK

ENET_QOS_RXDESCRIP_WR_PTPTYPE_MASK

ENET_QOS_RXDESCRIP_WR_PTPVERSION_MASK
ENET_QOS_RXDESCRIP_WR_PTPTSA_MASK
ENET_QOS_RXDESCRIP_WR_PACKETLEN_MASK
ENET_QOS_RXDESCRIP_WR_ERRSUM_MASK
ENET_QOS_RXDESCRIP_WR_TYPE_MASK
ENET_QOS_RXDESCRIP_WR_DE_MASK
ENET_QOS_RXDESCRIP_WR_RE_MASK
ENET_QOS_RXDESCRIP_WR_OE_MASK
ENET_QOS_RXDESCRIP_WR_RWT_MASK
ENET_QOS_RXDESCRIP_WR_GP_MASK
ENET_QOS_RXDESCRIP_WR_CRC_MASK
ENET_QOS_RXDESCRIP_WR_RS0V_MASK
ENET_QOS_RXDESCRIP_WR_RS1V_MASK
ENET_QOS_RXDESCRIP_WR_RS2V_MASK
ENET_QOS_RXDESCRIP_WR_LD_MASK
ENET_QOS_RXDESCRIP_WR_FD_MASK
ENET_QOS_RXDESCRIP_WR_CTXT_MASK
ENET_QOS_RXDESCRIP_WR_OWN_MASK
ENET_QOS_RXDESCRIP_WR_SA_FAILURE_MASK
ENET_QOS_RXDESCRIP_WR_DA_FAILURE_MASK
ENET_QOS_TXDESCRIP_RD_BL1_MASK
 Defines for read format.
ENET_QOS_TXDESCRIP_RD_BL2_MASK
ENET_QOS_TXDESCRIP_RD_BL1(n)
ENET_QOS_TXDESCRIP_RD_BL2(n)
ENET_QOS_TXDESCRIP_RD_TTSE_MASK
ENET_QOS_TXDESCRIP_RD_IOC_MASK
ENET_QOS_TXDESCRIP_RD_FL_MASK
ENET_QOS_TXDESCRIP_RD_FL(n)
ENET_QOS_TXDESCRIP_RD_CIC(n)
ENET_QOS_TXDESCRIP_RD_TSE_MASK
ENET_QOS_TXDESCRIP_RD_SLOT(n)
ENET_QOS_TXDESCRIP_RD_SAIC(n)

ENET_QOS_TXDESCRIP_RD_CPC(n)

ENET_QOS_TXDESCRIP_RD_LDFD(n)

ENET_QOS_TXDESCRIP_RD_LD_MASK

ENET_QOS_TXDESCRIP_RD_FD_MASK

ENET_QOS_TXDESCRIP_RD_CTXT_MASK

ENET_QOS_TXDESCRIP_RD_OWN_MASK

ENET_QOS_TXDESCRIP_WB_TTSS_MASK

Defines for write back format.

ENET_QOS_ABNORM_INT_MASK

ENET_QOS_NORM_INT_MASK

ENET_QOS_RING_NUM_MAX

The Maximum number of tx/rx descriptor rings.

ENET_QOS_FRAME_MAX_FRAMELEN

Default maximum Ethernet frame size.

ENET_QOS_FCS_LEN

Ethernet FCS length.

ENET_QOS_ADDR_ALIGNMENT

Recommended Ethernet buffer alignment.

ENET_QOS_BUFF_ALIGNMENT

Receive buffer alignment shall be 4bytes-aligned.

ENET_QOS_MTL_RXFIFOSIZE

The rx fifo size.

ENET_QOS_MTL_TXFIFOSIZE

The tx fifo size.

ENET_QOS_MACINT_ENUM_OFFSET

The offset for mac interrupt in enum type.

ENET_QOS_RXP_ENTRY_COUNT

RXP table entry count, implied by FRPES in MAC_HW_FEATURE3

ENET_QOS_RXP_BUFFER_SIZE

RXP Buffer size, implied by FRPBS in MAC_HW_FEATURE3

ENET_QOS_EST_WID

Width of the time interval in Gate Control List

ENET_QOS_EST_DEP

Maximum depth of Gate Control List

Defines the status return codes for transaction.

Values:

enumerator kStatus_ENET_QOS_InitMemoryFail

Init fails since buffer memory is not enough.

enumerator kStatus_ENET_QOS_RxFrameError

A frame received but data error happen.

enumerator kStatus_ENET_QOS_RxFrameFail

Failed to receive a frame.

enumerator kStatus_ENET_QOS_RxFrameEmpty

No frame arrive.

enumerator kStatus_ENET_QOS_RxFrameDrop

Rx frame is dropped since no buffer memory.

enumerator kStatus_ENET_QOS_TxFrameBusy

Transmit descriptors are under process.

enumerator kStatus_ENET_QOS_TxFrameFail

Transmit frame fail.

enumerator kStatus_ENET_QOS_TxFrameOverLen

Transmit oversize.

enumerator kStatus_ENET_QOS_Est_SwListBusy

SW Gcl List not yet processed by HW.

enumerator kStatus_ENET_QOS_Est_SwListWriteAbort

SW Gcl List write aborted .

enumerator kStatus_ENET_QOS_Est_InvalidParameter

Invalid parameter in Gcl List .

enumerator kStatus_ENET_QOS_Est_BtrError

Base Time Error when loading list.

enumerator kStatus_ENET_QOS_TrgtBusy

Target time register busy.

enumerator kStatus_ENET_QOS_Timeout

Target time register busy.

enumerator kStatus_ENET_QOS_PpsBusy

Pps command busy.

enum _enet_qos_mii_mode

Defines the MII/RGMII mode for data interface between the MAC and the PHY.

Values:

enumerator kENET_QOS_MiiMode

MII mode for data interface.

enumerator kENET_QOS_RgmiiMode

RGMII mode for data interface.

enumerator kENET_QOS_RmiiMode

RMII mode for data interface.

enum _enet_qos_mii_speed

Defines the 10/100/1000 Mbps speed for the MII data interface.

Values:

enumerator kENET_QOS_MiiSpeed10M

Speed 10 Mbps.

enumerator kENET_QOS_MiiSpeed100M
Speed 100 Mbps.

enumerator kENET_QOS_MiiSpeed1000M
Speed 1000 Mbps.

enumerator kENET_QOS_MiiSpeed2500M
Speed 2500 Mbps.

enum _enet_qos_mii_duplex

Defines the half or full duplex for the MII data interface.

Values:

enumerator kENET_QOS_MiiHalfDuplex
Half duplex mode.

enumerator kENET_QOS_MiiFullDuplex
Full duplex mode.

enum _enet_qos_mii_normal_opcode

Define the MII opcode for normal MDIO_CLAUSES_22 Frame.

Values:

enumerator kENET_QOS_MiiWriteFrame
Write frame operation for a valid MII management frame.

enumerator kENET_QOS_MiiReadFrame
Read frame operation for a valid MII management frame.

enum _enet_qos_dma_burstlen

Define the DMA maximum transmit burst length.

Values:

enumerator kENET_QOS_BurstLen1
DMA burst length 1.

enumerator kENET_QOS_BurstLen2
DMA burst length 2.

enumerator kENET_QOS_BurstLen4
DMA burst length 4.

enumerator kENET_QOS_BurstLen8
DMA burst length 8.

enumerator kENET_QOS_BurstLen16
DMA burst length 16.

enumerator kENET_QOS_BurstLen32
DMA burst length 32.

enumerator kENET_QOS_BurstLen64
DMA burst length 64. eight times enabled.

enumerator kENET_QOS_BurstLen128
DMA burst length 128. eight times enabled.

enumerator kENET_QOS_BurstLen256
DMA burst length 256. eight times enabled.

enum _enet_qos_desc_flag

Define the flag for the descriptor.

Values:

enumerator kENET_QOS_MiddleFlag

It's a middle descriptor of the frame.

enumerator kENET_QOS_LastFlagOnly

It's the last descriptor of the frame.

enumerator kENET_QOS_FirstFlagOnly

It's the first descriptor of the frame.

enumerator kENET_QOS_FirstLastFlag

It's the first and last descriptor of the frame.

enum _enet_qos_systime_op

Define the system time adjust operation control.

Values:

enumerator kENET_QOS_SystimeAdd

System time add to.

enumerator kENET_QOS_SystimeSubtract

System time subtract.

enum _enet_qos_ts_rollover_type

Define the system time rollover control.

Values:

enumerator kENET_QOS_BinaryRollover

System time binary rollover.

enumerator kENET_QOS_DigitalRollover

System time digital rollover.

enum _enet_qos_special_config

Defines some special configuration for ENET.

These control flags are provided for special user requirements. Normally, there is no need to set these control flags for ENET initialization. But if you have some special requirements, set the flags to specialControl in the enet_qos_config_t.

Note: “kENET_QOS_StoreAndForward” is recommended to be set.

Values:

enumerator kENET_QOS_DescDoubleBuffer

The double buffer is used in the tx/rx descriptor.

enumerator kENET_QOS_StoreAndForward

The rx/tx store and forward enable.

enumerator kENET_QOS_PromiscuousEnable

The promiscuous enabled.

enumerator kENET_QOS_FlowControlEnable

The flow control enabled.

enumerator kENET_QOS_BroadCastRxDisable

The broadcast disabled.

enumerator kENET_QOS_MulticastAllEnable

All multicast are passed.

enumerator kENET_QOS_8023AS2KPacket

8023as support for 2K packets.

enumerator kENET_QOS_HashMulticastEnable

The multicast packets are filtered through hash table.

enumerator kENET_QOS_RxChecksumOffloadEnable

The Rx checksum offload enabled.

enum _enet_qos_dma_interrupt_enable

List of DMA interrupts supported by the ENET interrupt. This enumeration uses one-bot encoding to allow a logical OR of multiple members.

Values:

enumerator kENET_QOS_DmaTx

Tx interrupt.

enumerator kENET_QOS_DmaTxStop

Tx stop interrupt.

enumerator kENET_QOS_DmaTxBuffUnavail

Tx buffer unavailable.

enumerator kENET_QOS_DmaRx

Rx interrupt.

enumerator kENET_QOS_DmaRxBuffUnavail

Rx buffer unavailable.

enumerator kENET_QOS_DmaRxStop

Rx stop.

enumerator kENET_QOS_DmaRxWatchdogTimeout

Rx watchdog timeout.

enumerator kENET_QOS_DmaEarlyTx

Early transmit.

enumerator kENET_QOS_DmaEarlyRx

Early receive.

enumerator kENET_QOS_DmaBusErr

Fatal bus error.

enum _enet_qos_mac_interrupt_enable

List of mac interrupts supported by the ENET interrupt. This enumeration uses one-bot encoding to allow a logical OR of multiple members.

Values:

enumerator kENET_QOS_MacTimestamp

enum _enet_qos_event

Defines the common interrupt event for callback use.

Values:

enumerator kENET_QOS_RxIntEvent

Receive interrupt event.

enumerator kENET_QOS_TxIntEvent

Transmit interrupt event.

enumerator kENET_QOS_WakeUpIntEvent

Wake up interrupt event.

enumerator kENET_QOS_TimeStampIntEvent

Time stamp interrupt event.

enum _enet_qos_queue_mode

Define the MTL mode for multiple queues/rings.

Values:

enumerator kENET_QOS_AVB_Mode

Enable queue in AVB mode.

enumerator kENET_QOS_DCB_Mode

Enable queue in DCB mode.

enum _enet_qos_mtl_multiqueue_txsche

Define the MTL tx scheduling algorithm for multiple queues/rings.

Values:

enumerator kENET_QOS_txWeightRR

Tx weight round-robin.

enumerator kENET_QOS_txWeightFQ

Tx weight fair queuing.

enumerator kENET_QOS_txDefictWeightRR

Tx deficit weighted round-robin.

enumerator kENET_QOS_txStrPrio

Tx strict priority.

enum _enet_qos_mtl_multiqueue_rxsche

Define the MTL rx scheduling algorithm for multiple queues/rings.

Values:

enumerator kENET_QOS_rxStrPrio

Rx strict priority, Queue 0 has the lowest priority.

enumerator kENET_QOS_rxWeightStrPrio

Weighted Strict Priority.

enum _enet_qos_mtl_rxqueuemap

Define the MTL rx queue and DMA channel mapping.

Values:

enumerator kENET_QOS_StaticDirctMap

The received fame in rx Qn(n = 0,1) directly map to dma channel n.

enumerator kENET_QOS_DynamicMap

The received frame in rx Qn(n = 0,1) map to the dma channel m(m = 0,1) related with the same Mac.

enum _enet_qos_rx_queue_route

Defines the package type for receive queue routing.

Values:

enumerator kENET_QOS_PacketNoQ

enumerator kENET_QOS_PacketAVCPQ

enumerator kENET_QOS_PacketPTPQ

enumerator kENET_QOS_PacketUPQ

enumerator kENET_QOS_PacketMCBCQ

enum _enet_qos_ptp_event_type

Defines the ENET PTP message related constant.

Values:

enumerator kENET_QOS_PtpEventMsgType

PTP event message type.

enumerator kENET_QOS_PtpSrcPortIdLen

PTP message sequence id length.

enumerator kENET_QOS_PtpEventPort

PTP event port number.

enumerator kENET_QOS_PtpGnrlPort

PTP general port number.

enum _enet_qos_ptp_pps_instance

Defines the PPS instance numbers.

Values:

enumerator kENET_QOS_PtpPpsInstance0

PPS instance 0.

enumerator kENET_QOS_PtpPpsInstance1

PPS instance 1.

enumerator kENET_QOS_PtpPpsInstance2

PPS instance 2.

enumerator kENET_QOS_PtpPpsInstance3

PPS instance 3.

enum _enet_qos_ptp_pps_trgt_mode

Defines the Target Time register mode.

Values:

enumerator kENET_QOS_PtpPpsTrgtModeOnlyInt

Only interrupts.

enumerator kENET_QOS_PtpPpsTrgtModeIntSt

Both interrupt and output signal.

enumerator kENET_QOS_PtpPpsTrgtModeOnlySt

Only output signal.

enum _enet_qos_ptp_pps_cmd

Defines commands for ppscmd register.

Values:

enumerator kENET_QOS_PtpPpsCmdNC
No Command.

enumerator kENET_QOS_PtpPpsCmdSSP
Start Single Pulse.

enumerator kENET_QOS_PtpPpsCmdSPT
Start Pulse Train.

enumerator kENET_QOS_PtpPpsCmdCS
Cancel Start.

enumerator kENET_QOS_PtpPpsCmdSPTAT
Stop Pulse Train At Time.

enumerator kENET_QOS_PtpPpsCmdSPTI
Stop Pulse Train Immediately.

enumerator kENET_QOS_PtpPpsCmdCSPT
Cancel Stop Pulse Train.

enum _enet_qos_ets_list_length

Defines the enumeration of ETS list length.

Values:

enumerator kENET_QOS_Ets_List_64
List length of 64

enumerator kENET_QOS_Ets_List_128
List length of 128

enumerator kENET_QOS_Ets_List_256
List length of 256

enumerator kENET_QOS_Ets_List_512
List length of 512

enumerator kENET_QOS_Ets_List_1024
List length of 1024

enum _enet_qos_ets_gccr_addr

Defines the enumeration of ETS gate control address.

Values:

enumerator kENET_QOS_Ets_btr_low
BTR Low

enumerator kENET_QOS_Ets_btr_high
BTR High

enumerator kENET_QOS_Ets_ctr_low
CTR Low

enumerator kENET_QOS_Ets_ctr_high
CTR High

enumerator kENET_QOS_Ets_ter
TER

enumerator kENET_QOS_Ets_llr
LLR

enum _enet_qos_rxp_dma_chn

Defines the enumeration of DMA channel used for rx parser entry.

Values:

enumerator kENET_QOS_Rxp_DMACHn0
DMA Channel 0 used for RXP entry match

enumerator kENET_QOS_Rxp_DMACHn1
DMA Channel 1 used for RXP entry match

enumerator kENET_QOS_Rxp_DMACHn2
DMA Channel 2 used for RXP entry match

enumerator kENET_QOS_Rxp_DMACHn3
DMA Channel 3 used for RXP entry match

enumerator kENET_QOS_Rxp_DMACHn4
DMA Channel 4 used for RXP entry match

enum _enet_qos_tx_offload

Define the Tx checksum offload options.

Values:

enumerator kENET_QOS_TxOffloadDisable
Disable Tx checksum offload.

enumerator kENET_QOS_TxOffloadIPHeader
Enable IP header checksum calculation and insertion.

enumerator kENET_QOS_TxOffloadIPHeaderPlusPayload
Enable IP header and payload checksum calculation and insertion.

enumerator kENET_QOS_TxOffloadAll
Enable IP header, payload and pseudo header checksum calculation and insertion.

typedef enum _enet_qos_mii_mode enet_qos_mii_mode_t

Defines the MII/RGMII mode for data interface between the MAC and the PHY.

typedef enum _enet_qos_mii_speed enet_qos_mii_speed_t

Defines the 10/100/1000 Mbps speed for the MII data interface.

typedef enum _enet_qos_mii_duplex enet_qos_mii_duplex_t

Defines the half or full duplex for the MII data interface.

typedef enum _enet_qos_mii_normal_opcode enet_qos_mii_normal_opcode

Define the MII opcode for normal MDIO_CLAUSES_22 Frame.

typedef enum _enet_qos_dma_burstlen enet_qos_dma_burstlen

Define the DMA maximum transmit burst length.

typedef enum _enet_qos_desc_flag enet_qos_desc_flag

Define the flag for the descriptor.

typedef enum _enet_qos_systime_op enet_qos_systime_op

Define the system time adjust operation control.

typedef enum *_enet_qos_ts_rollover_type* enet_qos_ts_rollover_type

Define the system time rollover control.

typedef enum *_enet_qos_special_config* enet_qos_special_config_t

Defines some special configuration for ENET.

These control flags are provided for special user requirements. Normally, there is no need to set this control flags for ENET initialization. But if you have some special requirements, set the flags to specialControl in the enet_qos_config_t.

Note: “kENET_QOS_StoreAndForward” is recommended to be set.

typedef enum *_enet_qos_dma_interrupt_enable* enet_qos_dma_interrupt_enable_t

List of DMA interrupts supported by the ENET interrupt. This enumeration uses one-hot encoding to allow a logical OR of multiple members.

typedef enum *_enet_qos_mac_interrupt_enable* enet_qos_mac_interrupt_enable_t

List of mac interrupts supported by the ENET interrupt. This enumeration uses one-hot encoding to allow a logical OR of multiple members.

typedef enum *_enet_qos_event* enet_qos_event_t

Defines the common interrupt event for callback use.

typedef enum *_enet_qos_queue_mode* enet_qos_queue_mode_t

Define the MTL mode for multiple queues/rings.

typedef enum *_enet_qos_mtl_multiqueue_txsche* enet_qos_mtl_multiqueue_txsche

Define the MTL tx scheduling algorithm for multiple queues/rings.

typedef enum *_enet_qos_mtl_multiqueue_rxsche* enet_qos_mtl_multiqueue_rxsche

Define the MTL rx scheduling algorithm for multiple queues/rings.

typedef enum *_enet_qos_mtl_rxqueueuemap* enet_qos_mtl_rxqueueuemap_t

Define the MTL rx queue and DMA channel mapping.

typedef enum *_enet_qos_rx_queue_route* enet_qos_rx_queue_route_t

Defines the package type for receive queue routing.

typedef enum *_enet_qos_ptp_event_type* enet_qos_ptp_event_type_t

Defines the ENET PTP message related constant.

typedef enum *_enet_qos_ptp_pps_instance* enet_qos_ptp_pps_instance_t

Defines the PPS instance numbers.

typedef enum *_enet_qos_ptp_pps_trgt_mode* enet_qos_ptp_pps_trgt_mode_t

Defines the Target Time register mode.

typedef enum *_enet_qos_ptp_pps_cmd* enet_qos_ptp_pps_cmd_t

Defines commands for ppscmd register.

typedef enum *_enet_qos_ets_list_length* enet_qos_ets_list_length_t

Defines the enumeration of ETS list length.

typedef enum *_enet_qos_ets_gccr_addr* enet_qos_ets_gccr_addr_t

Defines the enumeration of ETS gate control address.

typedef enum *_enet_qos_rxp_dma_chn* enet_qos_rxp_dma_chn_t

Defines the enumeration of DMA channel used for rx parser entry.

typedef enum *_enet_qos_tx_offload* enet_qos_tx_offload_t

Define the Tx checksum offload options.

```
typedef struct _enet_qos_rx_bd_struct enet_qos_rx_bd_struct_t
```

Defines the receive descriptor structure has the read-format and write-back format structure. They both has the same size with different region definition. so we define the read-format region as the receive descriptor structure Use the read-format region mask bits in the descriptor initialization Use the write-back format region mask bits in the receive data process.

```
typedef struct _enet_qos_tx_bd_struct enet_qos_tx_bd_struct_t
```

Defines the transmit descriptor structure has the read-format and write-back format structure. They both has the same size with different region definition. so we define the read-format region as the transmit descriptor structure Use the read-format region mask bits in the descriptor initialization Use the write-back format region mask bits in the transmit data process.

```
typedef struct _enet_qos_tx_bd_config_struct enet_qos_tx_bd_config_struct_t
```

Defines the Tx BD configuration structure.

```
typedef struct _enet_qos_ptp_time enet_qos_ptp_time_t
```

Defines the ENET PTP time stamp structure.

```
typedef struct enet_qos_frame_info enet_qos_frame_info_t
```

Defines the frame info structure.

```
typedef struct _enet_qos_tx_dirty_ring enet_qos_tx_dirty_ring_t
```

Defines the ENET transmit dirty addresses ring/queue structure.

```
typedef struct _enet_qos_ptp_config enet_qos_ptp_config_t
```

Defines the ENET PTP configuration structure.

```
typedef struct _enet_qos_est_gate_op enet_qos_est_gate_op_t
```

Defines the EST gate operation structure.

```
typedef struct _enet_qos_est_gcl enet_qos_est_gcl_t
```

Defines the EST gate control list structure.

```
typedef struct _enet_qos_rxp_config enet_qos_rxp_config_t
```

Defines the ENET_QOS Rx parser configuration structure.

```
typedef struct _enet_qos_buffer_config enet_qos_buffer_config_t
```

Defines the buffer descriptor configure structure.

Note:

- a. The receive and transmit descriptor start address pointer and tail pointer must be word-aligned.
 - b. The recommended minimum tx/rx ring length is 4.
 - c. The tx/rx descriptor tail address shall be the address pointer to the address just after the end of the last last descriptor. because only the descriptors between the start address and the tail address will be used by DMA.
 - d. The descriptor address is the start address of all used contiguous memory. for example, the rxDescStartAddrAlign is the start address of rxRingLen contiguous descriptor memories for rx descriptor ring 0.
 - e. The “*rxBufferstartAddr” is the first element of rxRingLen (2*rxRingLen for double buffers) rx buffers. It means the *rxBufferStartAddr is the rx buffer for the first descriptor the *rxBufferStartAddr + 1 is the rx buffer for the second descriptor or the rx buffer for the second buffer in the first descriptor. so please make sure the rxBufferStartAddr is the address of a rxRingLen or 2*rxRingLen array.
-

```
typedef struct _enet_qos_cbs_config enet_qos_cbs_config_t
```

Defines the CBS configuration for queue.

```
typedef struct _enet_qos_tx_queue_config enet_qos_queue_tx_config_t
```

Defines the queue configuration structure.

```
typedef struct _enet_qos_rx_queue_config enet_qos_queue_rx_config_t
```

Defines the queue configuration structure.

```
typedef struct _enet_qos_multiqueue_config enet_qos_multiqueue_config_t
```

Defines the configuration when multi-queue is used.

```
typedef void (*enet_qos_rx_alloc_callback_t)(ENET_QOS_Type *base, void *userData, uint8_t channel)
```

Defines the Rx memory buffer alloc function pointer.

```
typedef void (*enet_qos_rx_free_callback_t)(ENET_QOS_Type *base, void *buffer, void *userData, uint8_t channel)
```

Defines the Rx memory buffer free function pointer.

```
typedef struct _enet_qos_config enet_qos_config_t
```

Defines the basic configuration structure for the ENET device.

Note: Default the signal queue is used so the “*multiqueueCfg” is set default with NULL. Set the pointer with a valid configuration pointer if the multiple queues are required. If multiple queue is enabled, please make sure the buffer configuration for all are prepared also.

```
typedef struct _enet_qos_handle enet_qos_handle_t
```

```
typedef void (*enet_qos_callback_t)(ENET_QOS_Type *base, enet_qos_handle_t *handle, enet_qos_event_t event, uint8_t channel, void *userData)
```

ENET callback function.

```
typedef struct _enet_qos_tx_bd_ring enet_qos_tx_bd_ring_t
```

Defines the ENET transmit buffer descriptor ring/queue structure.

```
typedef struct _enet_qos_rx_bd_ring enet_qos_rx_bd_ring_t
```

Defines the ENET receive buffer descriptor ring/queue structure.

```
typedef struct _enet_qos_state enet_qos_state_t
```

Defines the ENET state structure.

Note: The structure contains saved state for the instance. It could be stored in *enet_qos_handle_t*, but that's used only with the transactional API.

```
typedef struct _enet_qos_buffer_struct enet_qos_buffer_struct_t
```

Defines the frame buffer structure.

```
typedef struct _enet_qos_rx_frame_error enet_qos_rx_frame_error_t
```

Defines the Rx frame error structure.

```
typedef struct _enet_qos_rx_frame_attribute_struct enet_qos_rx_frame_attribute_t
```

```
typedef struct _enet_qos_rx_frame_struct enet_qos_rx_frame_struct_t
```

Defines the Rx frame data structure.

```
typedef struct _enet_qos_transfer_stats enet_qos_transfer_stats_t
```

Defines the ENET QOS transfer statistics structure.

```
typedef void (*enet_qos_isr_t)(ENET_QOS_Type *base, enet_qos_handle_t *handle)
```

```
const clock_ip_name_t s_enetqosClock[]
```

Pointers to enet clocks for each instance.

```
void ENET_QOS_SetSYSControl(enet_qos_mii_mode_t miiMode)
```

Set ENET system configuration.

Note: User needs to provide the implementation because the implementation is SoC specific. This function set the phy selection and enable clock. It should be called before any other ethernet operation.

Parameters

- miiMode – The MII/RGMII/RMII mode for interface between the phy and Ethernet.

```
void ENET_QOS_EnableClock(bool enable)
```

Enable/Disable ENET qos clock.

Note: User needs to provide the implementation because the implementation is SoC specific. This function should be called before config RMII mode.

```
struct _enet_qos_rx_bd_struct
```

#include <fsl_enet_qos.h> Defines the receive descriptor structure has the read-format and write-back format structure. They both has the same size with different region definition. so we define the read-format region as the receive descriptor structure Use the read-format region mask bits in the descriptor initialization Use the write-back format region mask bits in the receive data process.

Public Members

```
__IO uint32_t buff1Addr
```

Buffer 1 address

```
__IO uint32_t reserved
```

Reserved

```
__IO uint32_t buff2Addr
```

Buffer 2 or next descriptor address

```
__IO uint32_t control
```

Buffer 1/2 byte counts and control

```
struct _enet_qos_tx_bd_struct
```

#include <fsl_enet_qos.h> Defines the transmit descriptor structure has the read-format and write-back format structure. They both has the same size with different region definition. so we define the read-format region as the transmit descriptor structure Use the read-format region mask bits in the descriptor initialization Use the write-back format region mask bits in the transmit data process.

Public Members

```
__IO uint32_t buff1Addr
```

Buffer 1 address

__IO uint32_t buff2Addr
 Buffer 2 address

__IO uint32_t buffLen
 Buffer 1/2 byte counts

__IO uint32_t controlStat
 TDDES control and status word

struct __enet_qos_tx_bd_config_struct
 #include <fsl_enet_qos.h> Defines the Tx BD configuration structure.

Public Members

void *buffer1
 The first buffer address in the descriptor.

uint32_t bytes1
 The bytes in the fist buffer.

void *buffer2
 The second buffer address in the descriptor.

uint32_t bytes2
 The bytes in the second buffer.

uint32_t framelen
 The length of the frame to be transmitted.

bool intEnable
 Interrupt enable flag.

bool tsEnable
 The timestamp enable.

enet_qos_tx_offload_t txOffloadOps
 The Tx checksum offload option.

enet_qos_desc_flag flag
 The flag of this tx desciriptor, see “enet_qos_desc_flag”.

struct __enet_qos_ptp_time
 #include <fsl_enet_qos.h> Defines the ENET PTP time stamp structure.

Public Members

uint64_t second
 Second.

uint32_t nanosecond
 Nanosecond.

struct enet_qos_frame_info
 #include <fsl_enet_qos.h> Defines the frame info structure.

Public Members

`void *context`

User specified data, could be buffer address for free

`bool isTsAvail`

Flag indicates timestamp available status

`enet_qos_ptp_time_t timeStamp`

Timestamp of frame

`struct __enet_qos_tx_dirty_ring`

#include <fsl_enet_qos.h> Defines the ENET transmit dirty addresses ring/queue structure.

Public Members

`enet_qos_frame_info_t *txDirtyBase`

Dirty buffer descriptor base address pointer.

`uint16_t txGenIdx`

tx generate index.

`uint16_t txConsumIdx`

tx consume index.

`uint16_t txRingLen`

tx ring length.

`bool isFull`

tx ring is full flag, add this parameter to avoid waste one element.

`struct __enet_qos_ptp_config`

#include <fsl_enet_qos.h> Defines the ENET PTP configuration structure.

Public Members

`bool fineUpdateEnable`

Use the fine update.

`uint32_t defaultAddend`

Default addend value when fine update is enable, could be $2^{32} / (\text{refClk\_Hz} / \text{ENET\_QOS\_MICRSECS\_ONESECOND} / \text{ENET\_QOS\_SYSTIME\_REQUIRED\_CLK\_MHZ})$.

`bool ptp1588V2Enable`

The desired system time frequency. Must be lower than reference clock. (Only used with fine correction method). ptp 1588 version 2 is used.

`enet_qos_ts_rollover_type tsRollover`

1588 time nanosecond rollover.

`struct __enet_qos_est_gate_op`

#include <fsl_enet_qos.h> Defines the EST gate operation structure.

`struct __enet_qos_est_gcl`

#include <fsl_enet_qos.h> Defines the EST gate control list structure.

Public Members

bool enable

Enable or disable EST

uint64_t cycleTime

Base Time 32 bits seconds 32 bits nanoseconds

uint32_t extTime

Cycle Time 32 bits seconds 32 bits nanoseconds

uint32_t numEntries

Time Extension 32 bits seconds 32 bits nanoseconds

enet_qos_est_gate_op_t *opList

Number of entries

struct __enet_qos_rxp_config

#include <fsl_enet_qos.h> Defines the ENET_QOS Rx parser configuration structure.

Public Members

uint32_t matchEnable

4-byte match data used for comparing with incoming packet

uint8_t acceptFrame

When matchEnable is set to 1, the matchData is used for comparing

uint8_t rejectFrame

When acceptFrame = 1 and data is matched, the frame will be sent to DMA channel

uint8_t inverseMatch

When rejectFrame = 1 and data is matched, the frame will be dropped

uint8_t nextControl

Inverse match

uint8_t reserved

Next instruction indexing control

uint8_t frameOffset

Reserved control fields

uint8_t okIndex

Frame offset in the packet data to be compared for match, in terms of 4 bytes.

uint8_t dmaChannel

Memory Index to be used next.

uint32_t reserved2

The DMA channel enet_qos_rxp_dma_chn_t used for receiving the frame when frame match and acceptFrame = 1

struct __enet_qos_buffer_config

#include <fsl_enet_qos.h> Defines the buffer descriptor configure structure.

Note:

- The receive and transmit descriptor start address pointer and tail pointer must be word-aligned.
- The recommended minimum tx/rx ring length is 4.

- c. The tx/rx descriptor tail address shall be the address pointer to the address just after the end of the last last descriptor. because only the descriptors between the start address and the tail address will be used by DMA.
 - d. The descriptor address is the start address of all used contiguous memory. for example, the rxDescStartAddrAlign is the start address of rxRingLen contiguous descriptor memories for rx descriptor ring 0.
 - e. The “*rxBufferstartAddr” is the first element of rxRingLen (2*rxRingLen for double buffers) rx buffers. It means the *rxBufferStartAddr is the rx buffer for the first descriptor the *rxBufferStartAddr + 1 is the rx buffer for the second descriptor or the rx buffer for the second buffer in the first descriptor. so please make sure the rxBufferStartAddr is the address of a rxRingLen or 2*rxRingLen array.
-

Public Members

uint8_t rxRingLen

The length of receive buffer descriptor ring.

uint8_t txRingLen

The length of transmit buffer descriptor ring.

enet_qos_tx_bd_struct_t *txDescStartAddrAlign

Aligned transmit descriptor start address.

enet_qos_tx_bd_struct_t *txDescTailAddrAlign

Aligned transmit descriptor tail address.

enet_qos_frame_info_t *txDirtyStartAddr

Start address of the dirty tx frame information.

enet_qos_rx_bd_struct_t *rxDescStartAddrAlign

Aligned receive descriptor start address.

enet_qos_rx_bd_struct_t *rxDescTailAddrAlign

Aligned receive descriptor tail address.

uint32_t *rxBufferStartAddr

Start address of the rx buffers.

uint32_t rxBuffSizeAlign

Aligned receive data buffer size.

bool rxBuffNeedMaintain

Whether receive data buffer need cache maintain.

struct __enet_qos_cbs_config

#include <fsl_enet_qos.h> Defines the CBS configuration for queue.

Public Members

uint16_t sendSlope

Send slope configuration.

uint16_t idleSlope

Idle slope configuration.

uint32_t highCredit

High credit.

uint32_t lowCredit

Low credit.

struct enet_qos_tx_queue_config

#include <fsl_enet_qos.h> Defines the queue configuration structure.

Public Members

enet_qos_queue_mode_t mode

tx queue mode configuration.

uint32_t weight

Refer to the MTL TxQ Quantum Weight register.

uint32_t priority

Refer to Transmit Queue Priority Mapping register.

enet_qos_cbs_config_t *cbsConfig

CBS configuration if queue use AVB mode.

struct enet_qos_rx_queue_config

#include <fsl_enet_qos.h> Defines the queue configuration structure.

Public Members

enet_qos_queue_mode_t mode

rx queue mode configuration.

uint8_t mapChannel

tx queue map dma channel.

uint32_t priority

Rx queue priority.

enet_qos_rx_queue_route_t packetRoute

Receive packet routing.

struct enet_qos_multiqueue_config

#include <fsl_enet_qos.h> Defines the configuration when multi-queue is used.

Public Members

enet_qos_dma_burstlen burstLen

Burst len for the multi-queue.

uint8_t txQueueUse

Used Tx queue count.

enet_qos_mtl_multiqueue_txsche mtltxSche

Transmit schedule for multi-queue.

enet_qos_queue_tx_config_t txQueueConfig[ENET_QOS_DMA_CH_COUNT]

Tx Queue configuration.

uint8_t rxQueueUse

Used Rx queue count.

enet_qos_mtl_multiqueue_rxsche mtlrxSche

Receive schedule for multi-queue.

enet_qos_queue_rx_config_t rxQueueConfig[ENET_QOS_DMA_CH_COUNT]

Rx Queue configuration.

struct *_enet_qos_config*

#include <fsl_enet_qos.h> Defines the basic configuration structure for the ENET device.

Note: Default the signal queue is used so the “*multiqueueCfg” is set default with NULL. Set the pointer with a valid configuration pointer if the multiple queues are required. If multiple queue is enabled, please make sure the buffer configuration for all are prepared also.

Public Members

uint16_t specialControl

The logic or of *enet_qos_special_config_t*

enet_qos_multiqueue_config_t *multiqueueCfg

Use multi-queue.

enet_qos_mii_mode_t miiMode

MII mode.

enet_qos_mii_speed_t miiSpeed

MII Speed.

enet_qos_mii_duplex_t miiDuplex

MII duplex.

uint16_t pauseDuration

Used in the tx flow control frame, only valid when *kENET_QOS_FlowControlEnable* is set.

enet_qos_ptp_config_t *ptpConfig

PTP 1588 feature configuration

uint32_t csrClock_Hz

CSR clock frequency in HZ.

enet_qos_rx_alloc_callback_t rxBuffAlloc

Callback to alloc memory, must be provided for zero-copy Rx.

enet_qos_rx_free_callback_t rxBuffFree

Callback to free memory, must be provided for zero-copy Rx.

struct *_enet_qos_tx_bd_ring*

#include <fsl_enet_qos.h> Defines the ENET transmit buffer descriptor ring/queue structure.

Public Members

enet_qos_tx_bd_struct_t *txBdBase

Buffer descriptor base address pointer.

uint16_t txGenIdx

tx generate index.

uint16_t txConsumIdx

tx consume index.

volatile uint16_t txDescUsed
tx descriptor used number.

uint16_t txRingLen
tx ring length.

struct __enet_qos_rx_bd_ring
#include <fsl_enet_qos.h> Defines the ENET receive buffer descriptor ring/queue structure.

Public Members

enet_qos_rx_bd_struct_t *rxBdBase
Buffer descriptor base address pointer.

uint16_t rxGenIdx
The current available receive buffer descriptor pointer.

uint16_t rxRingLen
Receive ring length.

uint32_t rxBuffSizeAlign
Receive buffer size.

struct __enet_qos_handle
#include <fsl_enet_qos.h> Defines the ENET handler structure.

Public Members

uint8_t txQueueUse
Used tx queue count.

uint8_t rxQueueUse
Used rx queue count.

bool doubleBuffEnable
The double buffer is used in the descriptor.

bool rxintEnable
Rx interrupt enabled.

bool rxMaintainEnable[ENET_QOS_DMA_CH_COUNT]
Rx buffer cache maintain enabled.

enet_qos_rx_bd_ring_t rxBdRing[ENET_QOS_DMA_CH_COUNT]
Receive buffer descriptor.

enet_qos_tx_bd_ring_t txBdRing[ENET_QOS_DMA_CH_COUNT]
Transmit buffer descriptor.

enet_qos_tx_dirty_ring_t txDirtyRing[ENET_QOS_DMA_CH_COUNT]
Transmit dirty buffers addresses.

uint32_t *rxBufferStartAddr[ENET_QOS_DMA_CH_COUNT]
Rx buffer start address for reInitialize.

enet_qos_callback_t callback
Callback function.

void *userData
Callback function parameter.

uint8_t multicastCount[64]

Multicast collisions counter

enet_qos_rx_alloc_callback_t rxBuffAlloc

Callback to alloc memory, must be provided for zero-copy Rx.

enet_qos_rx_free_callback_t rxBuffFree

Callback to free memory, must be provided for zero-copy Rx.

struct _enet_qos_state

#include <fsl_enet_qos.h> Defines the ENET state structure.

Note: The structure contains saved state for the instance. It could be stored in enet_qos_handle_t, but that's used only with the transactional API.

Public Members

enet_qos_mii_mode_t miiMode

MII mode.

struct _enet_qos_buffer_struct

#include <fsl_enet_qos.h> Defines the frame buffer structure.

Public Members

void *buffer

The buffer store the whole or partial frame.

uint16_t length

The byte length of this buffer.

struct _enet_qos_rx_frame_error

#include <fsl_enet_qos.h> Defines the Rx frame error structure.

Public Members

bool rxDstAddrFilterErr

Destination Address Filter Fail.

bool rxSrcAddrFilterErr

SA Address Filter Fail.

bool rxDribbleErr

Dribble error.

bool rxReceiveErr

Receive error.

bool rxOverflowErr

Receive over flow.

bool rxWatchDogErr

Watch dog timeout.

bool rxGaintPacketErr

Receive gaint packet.

bool rxCrcErr

Receive CRC error.

struct __enet_qos_rx_frame_attribute_struct
#include <fsl_enet_qos.h>

Public Members

bool isTsAvail

Rx frame timestamp is available or not.

enet_qos_ptp_time_t timestamp

The nanosecond part timestamp of this Rx frame.

struct __enet_qos_rx_frame_struct
#include <fsl_enet_qos.h> Defines the Rx frame data structure.

Public Members

enet_qos_buffer_struct_t *rxBuffArray

Rx frame buffer structure.

uint16_t totLen

Rx frame total length.

enet_qos_rx_frame_attribute_t rxAttribute

Rx frame attribute structure.

enet_qos_rx_frame_error_t rxFrameError

Rx frame error.

struct __enet_qos_transfer_stats
#include <fsl_enet_qos.h> Defines the ENET QOS transfer statistics structure.

Public Members

uint32_t statsRxFrameCount

Rx frame number.

uint32_t statsRxCrcErr

Rx frame number with CRC error.

uint32_t statsRxAlignErr

Rx frame number with alignment error.

uint32_t statsRxLengthErr

Rx frame length field doesn't equal to packet size.

uint32_t statsRxFifoOverflowErr

Rx FIFO overflow count.

uint32_t statsTxFrameCount

Tx frame number.

uint32_t statsTxFifoUnderRunErr

Tx FIFO underrun count.

2.15 FlexCAN: Flex Controller Area Network Driver

2.16 FlexCAN Driver

`bool FLEXCAN_IsInstanceHasFDMode(CAN_Type *base)`

Determine whether the FlexCAN instance support CAN FD mode at run time.

Note: Use this API only if different soc parts share the SOC part name macro define. Otherwise, a different SOC part name can be used to determine at compile time whether the FlexCAN instance supports CAN FD mode or not. If need use this API to determine if CAN FD mode is supported, the FLEXCAN_Init function needs to be executed first, and then call this API and use the return to value determines whether to supports CAN FD mode, if return true, continue calling FLEXCAN_FDInit to enable CAN FD mode.

Parameters

- `base` – FlexCAN peripheral base address.

Returns

return TRUE if instance support CAN FD mode, FALSE if instance only support classic CAN (2.0) mode.

`uint32_t FLEXCAN_GetFDMailboxOffset(CAN_Type *base, uint8_t mbIdx)`

Get Mailbox offset number by dword.

This function gets the offset number of the specified mailbox. Mailbox is not consecutive between memory regions when payload is not 8 bytes so need to calculate the specified mailbox address. For example, in the first memory region, MB[0].CS address is 0x4002_4080. For 32 bytes payload frame, the second mailbox is $((1/12)*512 + 1\%12*40)/4 = 10$, meaning 10 dword after the 0x4002_4080, which is actually the address of mailbox MB[1].CS.

Parameters

- `base` – FlexCAN peripheral base address.
- `mbIdx` – Mailbox index.

Returns

Mailbox address offset in word.

`status_t FLEXCAN_EnterFreezeMode(CAN_Type *base)`

Enter FlexCAN Freeze Mode.

This function makes the FlexCAN work under Freeze Mode.

Parameters

- `base` – FlexCAN peripheral base address.

Returns

`kStatus_Success` Enter Freeze Mode successful `kStatus_Timeout` Timeout when wait for Freeze Mode Acknowledge

`status_t FLEXCAN_ExitFreezeMode(CAN_Type *base)`

Exit FlexCAN Freeze Mode.

This function makes the FlexCAN leave Freeze Mode.

Parameters

- `base` – FlexCAN peripheral base address.

Returns

kStatus_Success Enter Freeze Mode successful kStatus_Timeout Timeout when wait for Freeze Mode Acknowledge

uint32_t FLEXCAN_GetInstance(CAN_Type *base)

Get the FlexCAN instance from peripheral base address.

Parameters

- base – FlexCAN peripheral base address.

Returns

FlexCAN instance.

bool FLEXCAN_CalculateImprovedTimingValues(CAN_Type *base, uint32_t bitRate, uint32_t sourceClock_Hz, flexcan_timing_config_t *pTimingConfig)

Calculates the improved timing values by specific bit Rates for classical CAN.

This function use to calculates the Classical CAN timing values according to the given bit rate. The Calculated timing values will be set in CTRL1/CBT/ENCBT register. The calculation is based on the recommendation of the CiA 301 v4.2.0 and previous version document.

Parameters

- base – FlexCAN peripheral base address.
- bitRate – The classical CAN speed in bps defined by user, should be less than or equal to 1Mbps.
- sourceClock_Hz – The Source clock frequency in Hz.
- pTimingConfig – Pointer to the FlexCAN timing configuration structure.

Returns

TRUE if timing configuration found, FALSE if failed to find configuration.

void FLEXCAN_Init(CAN_Type *base, const flexcan_config_t *pConfig, uint32_t sourceClock_Hz)

Initializes a FlexCAN instance.

This function initializes the FlexCAN module with user-defined settings. This example shows how to set up the flexcan_config_t parameters and how to call the FLEXCAN_Init function by passing in these parameters.

```
flexcan_config_t flexcanConfig;
flexcanConfig.clkSrc      = kFLEXCAN_ClkSrc0;
flexcanConfig.bitRate     = 1000000U;
flexcanConfig.maxMbNum    = 16;
flexcanConfig.enableLoopBack = false;
flexcanConfig.enableSelfWakeup = false;
flexcanConfig.enableIndividMask = false;
flexcanConfig.enableDoze    = false;
flexcanConfig.disableSelfReception = false;
flexcanConfig.enableListenOnlyMode = false;
flexcanConfig.timingConfig = timingConfig;
FLEXCAN_Init(CAN0, &flexcanConfig, 4000000UL);
```

Parameters

- base – FlexCAN peripheral base address.
- pConfig – Pointer to the user-defined configuration structure.
- sourceClock_Hz – FlexCAN Protocol Engine clock source frequency in Hz.


```
bool FLEXCAN_FDCalculateImprovedTimingValues(CAN_Type *base, uint32_t bitRate, uint32_t
                                             bitRateFD, uint32_t sourceClock_Hz,
                                             flexcan_timing_config_t *pTimingConfig)
```

Calculates the improved timing values by specific bit rates for CANFD.

This function use to calculates the CANFD timing values according to the given nominal phase bit rate and data phase bit rate. The Calculated timing values will be set in CBT/ENCBT and FDCBT/EDCBT registers. The calculation is based on the recommendation of the CiA 1301 v1.0.0 document.

Parameters

- base – FlexCAN peripheral base address.
- bitRate – The CANFD bus control speed in bps defined by user.
- bitRateFD – The CAN FD data phase speed in bps defined by user. Equal to bitRate means disable bit rate switching.
- sourceClock_Hz – The Source clock frequency in Hz.
- pTimingConfig – Pointer to the FlexCAN timing configuration structure.

Returns

TRUE if timing configuration found, FALSE if failed to find configuration

```
void FLEXCAN_FDInit(CAN_Type *base, const flexcan_config_t *pConfig, uint32_t
                    sourceClock_Hz, flexcan_mb_size_t dataSize, bool brs)
```

Initializes a FlexCAN instance.

This function initializes the FlexCAN module with user-defined settings. This example shows how to set up the flexcan_config_t parameters and how to call the FLEXCAN_FDInit function by passing in these parameters.

```
flexcan_config_t flexcanConfig;
flexcanConfig.clkSrc      = kFLEXCAN_ClkSrc0;
flexcanConfig.bitRate     = 1000000U;
flexcanConfig.bitRateFD   = 2000000U;
flexcanConfig.maxMbNum    = 16;
flexcanConfig.enableLoopBack = false;
flexcanConfig.enableSelfWakeup = false;
flexcanConfig.enableIndividMask = false;
flexcanConfig.disableSelfReception = false;
flexcanConfig.enableListenOnlyMode = false;
flexcanConfig.enableDoze    = false;
flexcanConfig.timingConfig  = timingConfig;
FLEXCAN_FDInit(CAN0, &flexcanConfig, 8000000UL, kFLEXCAN_16BperMB, true);
```

Parameters

- base – FlexCAN peripheral base address.
- pConfig – Pointer to the user-defined configuration structure.
- sourceClock_Hz – FlexCAN Protocol Engine clock source frequency in Hz.
- dataSize – FlexCAN Message Buffer payload size. The actual transmitted or received CAN FD frame data size needs to be less than or equal to this value.
- brs – True if bit rate switch is enabled in FD mode.

```
void FLEXCAN_Deinit(CAN_Type *base)
```

De-initializes a FlexCAN instance.

This function disables the FlexCAN module clock and sets all register values to the reset value.

Parameters

- base – FlexCAN peripheral base address.

void FLEXCAN_GetDefaultConfig(*flexcan_config_t* *pConfig)

Gets the default configuration structure.

This function initializes the FlexCAN configuration structure to default values. The default values are as follows. flexcanConfig->clkSrc = kFLEXCAN_ClkSrc0; flexcanConfig->bitRate = 1000000U; flexcanConfig->bitRateFD = 2000000U; flexcanConfig->maxMbNum = 16; flexcanConfig->enableLoopBack = false; flexcanConfig->enableSelfWakeup = false; flexcanConfig->enableIndividMask = false; flexcanConfig->disableSelfReception = false; flexcanConfig->enableListenOnlyMode = false; flexcanConfig->enableDoze = false; flexcanConfig->enablePretendedeNetworking = false; flexcanConfig->enableMemoryErrorControl = true; flexcanConfig->enableNonCorrectableErrorEnterFreeze = true; flexcanConfig->enableTransceiverDelayMeasure = true; flexcanConfig->enableRemoteRequestFrameStored = true; flexcanConfig->payloadEndianness = kFLEXCAN_bigEndian; flexcanConfig.timingConfig = timingConfig;

Parameters

- pConfig – Pointer to the FlexCAN configuration structure.

void FLEXCAN_SetTimingConfig(CAN_Type *base, const *flexcan_timing_config_t* *pConfig)

Sets the FlexCAN classical CAN protocol timing characteristic.

This function gives user settings to classical CAN or CAN FD nominal phase timing characteristic. The function is for an experienced user. For less experienced users, call the FLEXCAN_SetBitRate() instead.

Note: Calling FLEXCAN_SetTimingConfig() overrides the bit rate set in FLEXCAN_Init() or FLEXCAN_SetBitRate().

Parameters

- base – FlexCAN peripheral base address.
- pConfig – Pointer to the timing configuration structure.

status_t FLEXCAN_SetBitRate(CAN_Type *base, uint32_t sourceClock_Hz, uint32_t bitRate_Bps)

Set bit rate of FlexCAN classical CAN frame or CAN FD frame nominal phase.

This function set the bit rate of classical CAN frame or CAN FD frame nominal phase base on FLEXCAN_CalculateImprovedTimingValues() API calculated timing values.

Note: Calling FLEXCAN_SetBitRate() overrides the bit rate set in FLEXCAN_Init().

Parameters

- base – FlexCAN peripheral base address.
- sourceClock_Hz – Source Clock in Hz.
- bitRate_Bps – Bit rate in Bps.

Returns

kStatus_Success - Set CAN baud rate (only Nominal phase) successfully.

`void FLEXCAN_SetFDTimingConfig(CAN_Type *base, const flexcan_timing_config_t *pConfig)`
Sets the FlexCAN CANFD data phase timing characteristic.

This function gives user settings to CANFD data phase timing characteristic. The function is for an experienced user. For less experienced users, call the `FLEXCAN_SetFDBitRate()` to set both Nominal/Data bit Rate instead.

Note: Calling `FLEXCAN_SetFDTimingConfig()` overrides the data phase bit rate set in `FLEXCAN_FDInit()`/`FLEXCAN_SetFDBitRate()`.

Parameters

- `base` – FlexCAN peripheral base address.
- `pConfig` – Pointer to the timing configuration structure.

`status_t FLEXCAN_SetFDBitRate(CAN_Type *base, uint32_t sourceClock_Hz, uint32_t bitRateN_Bps, uint32_t bitRateD_Bps)`

Set bit rate of FlexCAN FD frame.

This function set the baud rate of FLEXCAN FD base on `FLEXCAN_FDCalculateImprovedTimingValues()` API calculated timing values.

Parameters

- `base` – FlexCAN peripheral base address.
- `sourceClock_Hz` – Source Clock in Hz.
- `bitRateN_Bps` – Nominal bit Rate in Bps.
- `bitRateD_Bps` – Data bit Rate in Bps.

Returns

`kStatus_Success` - Set CAN FD bit rate (include Nominal and Data phase) successfully.

`void FLEXCAN_SetRxMbGlobalMask(CAN_Type *base, uint32_t mask)`

Sets the FlexCAN receive message buffer global mask.

This function sets the global mask for the FlexCAN message buffer in a matching process. The configuration is only effective when the Rx individual mask is disabled in the `FLEXCAN_Init()`.

Parameters

- `base` – FlexCAN peripheral base address.
- `mask` – Rx Message Buffer Global Mask value.

`void FLEXCAN_SetRxFifoGlobalMask(CAN_Type *base, uint32_t mask)`

Sets the FlexCAN receive FIFO global mask.

This function sets the global mask for FlexCAN FIFO in a matching process.

Parameters

- `base` – FlexCAN peripheral base address.
- `mask` – Rx Fifo Global Mask value.

`void FLEXCAN_SetRxIndividualMask(CAN_Type *base, uint8_t maskIdx, uint32_t mask)`

Sets the FlexCAN receive individual mask.

This function sets the individual mask for the FlexCAN matching process. The configuration is only effective when the Rx individual mask is enabled in the `FLEXCAN_Init()`. If the Rx FIFO is disabled, the individual mask is applied to the corresponding Message Buffer. If the

Rx FIFO is enabled, the individual mask for Rx FIFO occupied Message Buffer is applied to the Rx Filter with the same index. Note that only the first 32 individual masks can be used as the Rx FIFO filter mask.

Parameters

- base – FlexCAN peripheral base address.
- maskIdx – The Index of individual Mask.
- mask – Rx Individual Mask value.

void FLEXCAN_SetTxMbConfig(CAN_Type *base, uint8_t mbIdx, bool enable)

Configures a FlexCAN transmit message buffer.

This function aborts the previous transmission, cleans the Message Buffer, and configures it as a Transmit Message Buffer.

Parameters

- base – FlexCAN peripheral base address.
- mbIdx – The Message Buffer index.
- enable – Enable/disable Tx Message Buffer.
 - true: Enable Tx Message Buffer.
 - false: Disable Tx Message Buffer.

void FLEXCAN_SetRxMbConfig(CAN_Type *base, uint8_t mbIdx, const flexcan_rx_mb_config_t *pRxMbConfig, bool enable)

Configures a FlexCAN Receive Message Buffer.

This function cleans a FlexCAN build-in Message Buffer and configures it as a Receive Message Buffer. User should invoke this API when CTRL2[RRS]=1. When CTRL2[RRS]=1, frame's ID is compared to the IDs of the receive mailboxes with the CODE field configured as kFLEXCAN_RxMbEmpty, kFLEXCAN_RxMbFull or kFLEXCAN_RxMbOverrun. Message buffer will store the remote frame in the same fashion of a data frame. No automatic remote response frame will be generated. User need to setup another message buffer to respond remote request.

Parameters

- base – FlexCAN peripheral base address.
- mbIdx – The Message Buffer index.
- pRxMbConfig – Pointer to the FlexCAN Message Buffer configuration structure.
- enable – Enable/disable Rx Message Buffer.
 - true: Enable Rx Message Buffer.
 - false: Disable Rx Message Buffer.

static inline void FLEXCAN_SetMbID(CAN_Type *base, uint8_t mbIdx, uint32_t id)

Configures a FlexCAN Message Buffer identifier.

Parameters

- base – FlexCAN peripheral base address.
- mbIdx – The Message Buffer index.
- id – CAN Message Buffer Identifier, should use FLEXCAN_ID_EXT() or FLEXCAN_ID_STD() macro.

```
void FLEXCAN_SetFDTxMbConfig(CAN_Type *base, uint8_t mbIdx, bool enable)
```

Configures a FlexCAN transmit message buffer.

This function aborts the previous transmission, cleans the Message Buffer, and configures it as a Transmit Message Buffer.

Parameters

- base – FlexCAN peripheral base address.
- mbIdx – The Message Buffer index.
- enable – Enable/disable Tx Message Buffer.
 - true: Enable Tx Message Buffer.
 - false: Disable Tx Message Buffer.

```
void FLEXCAN_SetFDRxMbConfig(CAN_Type *base, uint8_t mbIdx, const  
                             flexcan_rx_mb_config_t *pRxMbConfig, bool enable)
```

Configures a FlexCAN Receive Message Buffer.

This function cleans a FlexCAN build-in Message Buffer and configures it as a Receive Message Buffer.

Parameters

- base – FlexCAN peripheral base address.
- mbIdx – The Message Buffer index.
- pRxMbConfig – Pointer to the FlexCAN Message Buffer configuration structure.
- enable – Enable/disable Rx Message Buffer.
 - true: Enable Rx Message Buffer.
 - false: Disable Rx Message Buffer.

```
static inline void FLEXCAN_SetFDMbID(CAN_Type *base, uint8_t mbIdx, uint32_t id)
```

Configures a FlexCAN Message Buffer identifier.

Parameters

- base – FlexCAN peripheral base address.
- mbIdx – The Message Buffer index.
- id – CAN Message Buffer Identifier, should use FLEXCAN_ID_EXT() or FLEXCAN_ID_STD() macro.

```
void FLEXCAN_SetRemoteResponseMbConfig(CAN_Type *base, uint8_t mbIdx, const  
                                       flexcan_frame_t *pFrame)
```

Configures a FlexCAN Remote Response Message Buffer.

User should invoke this API when CTRL2[RRS]=0. When CTRL2[RRS]=0, frame's ID is compared to the IDs of the receive mailboxes with the CODE field configured as kFLEXCAN_RxMbRanswer. If there is a matching ID, then this mailbox content will be transmitted as response. The received remote request frame is not stored in receive buffer. It is only used to trigger a transmission of a frame in response.

Parameters

- base – FlexCAN peripheral base address.
- mbIdx – The Message Buffer index.
- pFrame – Pointer to CAN message frame structure for response.

```
void FLEXCAN_SetRxFifoConfig(CAN_Type *base, const flexcan_rx_fifo_config_t *pRxFifoConfig,
                             bool enable)
```

Configures the FlexCAN Legacy Rx FIFO.

This function configures the FlexCAN Rx FIFO with given configuration.

Note: Legacy Rx FIFO only can receive classic CAN message.

Parameters

- base – FlexCAN peripheral base address.
- pRxFifoConfig – Pointer to the FlexCAN Legacy Rx FIFO configuration structure. Can be NULL when enable parameter is false.
- enable – Enable/disable Legacy Rx FIFO.
 - true: Enable Legacy Rx FIFO.
 - false: Disable Legacy Rx FIFO.

```
void FLEXCAN_SetPNConfig(CAN_Type *base, const flexcan_pn_config_t *pConfig)
```

Configures the FlexCAN Pretended Networking mode.

This function configures the FlexCAN Pretended Networking mode with given configuration.

Parameters

- base – FlexCAN peripheral base address.
- pConfig – Pointer to the FlexCAN Rx FIFO configuration structure.

```
static inline uint64_t FLEXCAN_GetStatusFlags(CAN_Type *base)
```

Gets the FlexCAN module interrupt flags.

This function gets all FlexCAN status flags. The flags are returned as the logical OR value of the enumerators `_flexcan_flags`. To check the specific status, compare the return value with enumerators in `_flexcan_flags`.

Parameters

- base – FlexCAN peripheral base address.

Returns

FlexCAN status flags which are ORed by the enumerators in the `_flexcan_flags`.

```
static inline void FLEXCAN_ClearStatusFlags(CAN_Type *base, uint64_t mask)
```

Clears status flags with the provided mask.

This function clears the FlexCAN status flags with a provided mask. An automatically cleared flag can't be cleared by this function.

Parameters

- base – FlexCAN peripheral base address.
- mask – The status flags to be cleared, it is logical OR value of `_flexcan_flags`.

```
static inline void FLEXCAN_GetBusErrCount(CAN_Type *base, uint8_t *txErrBuf, uint8_t
                                           *rxErrBuf)
```

Gets the FlexCAN Bus Error Counter value.

This function gets the FlexCAN Bus Error Counter value for both Tx and Rx direction. These values may be needed in the upper layer error handling.

Parameters

- base – FlexCAN peripheral base address.
- txErrBuf – Buffer to store Tx Error Counter value.
- rxErrBuf – Buffer to store Rx Error Counter value.

static inline uint64_t FLEXCAN_GetMbStatusFlags(CAN_Type *base, uint64_t mask)

Gets the FlexCAN low 64 Message Buffer interrupt flags.

This function gets the interrupt flags of a given Message Buffers.

Parameters

- base – FlexCAN peripheral base address.
- mask – The ORed FlexCAN Message Buffer mask.

Returns

The status of given Message Buffers.

static inline uint64_t FLEXCAN_GetHigh64MbStatusFlags(CAN_Type *base, uint64_t mask)

Gets the FlexCAN High 64 Message Buffer interrupt flags.

Valid only if the number of available MBs exceeds 64.

Parameters

- base – FlexCAN peripheral base address.
- mask – The ORed FlexCAN Message Buffer mask.

Returns

The status of given Message Buffers.

static inline void FLEXCAN_ClearMbStatusFlags(CAN_Type *base, uint64_t mask)

Clears the FlexCAN low 64 Message Buffer interrupt flags.

This function clears the interrupt flags of a given Message Buffers.

Parameters

- base – FlexCAN peripheral base address.
- mask – The ORed FlexCAN Message Buffer mask.

static inline void FLEXCAN_ClearHigh64MbStatusFlags(CAN_Type *base, uint64_t mask)

Clears the FlexCAN High 64 Message Buffer interrupt flags.

Valid only if the number of available MBs exceeds 64.

Parameters

- base – FlexCAN peripheral base address.
- mask – The ORed FlexCAN Message Buffer mask.

void FLEXCAN_GetMemoryErrorReportStatus(CAN_Type *base,
flexcan_memory_error_report_status_t
*errorStatus)

Gets the FlexCAN Memory Error Report registers status.

This function gets the FlexCAN Memory Error Report registers status.

Parameters

- base – FlexCAN peripheral base address.
- errorStatus – Pointer to FlexCAN Memory Error Report registers status structure.

static inline uint8_t FLEXCAN_GetPNMatchCount(CAN_Type *base)

Gets the FlexCAN Number of Matches when in Pretended Networking.

This function gets the number of times a given message has matched the predefined filtering criteria for ID and/or PL before a wakeup event.

Parameters

- base – FlexCAN peripheral base address.

Returns

The number of received wake up messages.

static inline void FLEXCAN_EnableInterrupts(CAN_Type *base, uint64_t mask)

Enables FlexCAN interrupts according to the provided mask.

This function enables the FlexCAN interrupts according to the provided mask. The mask is a logical OR of enumeration members, see `_flexcan_interrupt_enable`.

Parameters

- base – FlexCAN peripheral base address.
- mask – The interrupts to enable. Logical OR of `_flexcan_interrupt_enable`.

static inline void FLEXCAN_DisableInterrupts(CAN_Type *base, uint64_t mask)

Disables FlexCAN interrupts according to the provided mask.

This function disables the FlexCAN interrupts according to the provided mask. The mask is a logical OR of enumeration members, see `_flexcan_interrupt_enable`.

Parameters

- base – FlexCAN peripheral base address.
- mask – The interrupts to disable. Logical OR of `_flexcan_interrupt_enable`.

static inline void FLEXCAN_EnableMbInterrupts(CAN_Type *base, uint64_t mask)

Enables FlexCAN low 64 Message Buffer interrupts.

This function enables the interrupts of given Message Buffers.

Parameters

- base – FlexCAN peripheral base address.
- mask – The ORed FlexCAN Message Buffer mask.

static inline void FLEXCAN_EnableHigh64MbInterrupts(CAN_Type *base, uint64_t mask)

Enables FlexCAN high 64 Message Buffer interrupts.

Valid only if the number of available MBs exceeds 64.

Parameters

- base – FlexCAN peripheral base address.
- mask – The ORed FlexCAN Message Buffer mask.

static inline void FLEXCAN_DisableMbInterrupts(CAN_Type *base, uint64_t mask)

Disables FlexCAN low 64 Message Buffer interrupts.

This function disables the interrupts of given Message Buffers.

Parameters

- base – FlexCAN peripheral base address.
- mask – The ORed FlexCAN Message Buffer mask.


```
static inline void FLEXCAN_DisableHigh64MbInterrupts(CAN_Type *base, uint64_t mask)
```

Disables FlexCAN high 64 Message Buffer interrupts.

Valid only if the number of available MBs exceeds 64.

Parameters

- base – FlexCAN peripheral base address.
- mask – The ORed FlexCAN Message Buffer mask.

```
void FLEXCAN_EnableRxFifoDMA(CAN_Type *base, bool enable)
```

Enables or disables the FlexCAN Rx FIFO DMA request.

This function enables or disables the DMA feature of FlexCAN build-in Rx FIFO.

Parameters

- base – FlexCAN peripheral base address.
- enable – true to enable, false to disable.

```
static inline uintptr_t FLEXCAN_GetRxFifoHeadAddr(CAN_Type *base)
```

Gets the Rx FIFO Head address.

This function returns the FlexCAN Rx FIFO Head address, which is mainly used for the DMA/eDMA use case.

Parameters

- base – FlexCAN peripheral base address.

Returns

FlexCAN Rx FIFO Head address.

```
static inline status_t FLEXCAN_Enable(CAN_Type *base, bool enable)
```

Enables or disables the FlexCAN module operation.

This function enables or disables the FlexCAN module.

Parameters

- base – FlexCAN base pointer.
- enable – true to enable, false to disable.

Returns

kStatus_Success Enable FlexCAN module successful
kStatus_Timeout Timeout when wait for Low-Power Mode Acknowledge

```
status_t FLEXCAN_WriteTxMb(CAN_Type *base, uint8_t mbIdx, const flexcan_frame_t *pTxFrame)
```

Writes a FlexCAN Message to the Transmit Message Buffer.

This function writes a CAN Message to the specified Transmit Message Buffer and changes the Message Buffer state to start CAN Message transmit. After that the function returns immediately.

Parameters

- base – FlexCAN peripheral base address.
- mbIdx – The FlexCAN Message Buffer index.
- pTxFrame – Pointer to CAN message frame to be sent.

Return values

- kStatus_Success – - Write Tx Message Buffer Successfully.
- kStatus_Fail – - Tx Message Buffer is currently in use.

status_t FLEXCAN_ReadRxMb(CAN_Type *base, uint8_t mbIdx, *flexcan_frame_t* *pRxFrame)

Reads a FlexCAN Message from Receive Message Buffer.

This function reads a CAN message from a specified Receive Message Buffer. The function fills a receive CAN message frame structure with just received data and activates the Message Buffer again. The function returns immediately.

Parameters

- base – FlexCAN peripheral base address.
- mbIdx – The FlexCAN Message Buffer index.
- pRxFrame – Pointer to CAN message frame structure for reception.

Return values

- kStatus_Success – Rx Message Buffer is full and has been read successfully.
- kStatus_FLEXCAN_RxOverflow – Rx Message Buffer is already overflowed and has been read successfully.
- kStatus_Fail – Rx Message Buffer is empty.

status_t FLEXCAN_WriteFDTxMb(CAN_Type *base, uint8_t mbIdx, const *flexcan_fd_frame_t* *pTxFrame)

Writes a FlexCAN FD Message to the Transmit Message Buffer.

This function writes a CAN FD Message to the specified Transmit Message Buffer and changes the Message Buffer state to start CAN FD Message transmit. After that the function returns immediately.

Parameters

- base – FlexCAN peripheral base address.
- mbIdx – The FlexCAN FD Message Buffer index.
- pTxFrame – Pointer to CAN FD message frame to be sent.

Return values

- kStatus_Success – Write Tx Message Buffer Successfully.
- kStatus_Fail – Tx Message Buffer is currently in use.

status_t FLEXCAN_ReadFDRxMb(CAN_Type *base, uint8_t mbIdx, *flexcan_fd_frame_t* *pRxFrame)

Reads a FlexCAN FD Message from Receive Message Buffer.

This function reads a CAN FD message from a specified Receive Message Buffer. The function fills a receive CAN FD message frame structure with just received data and activates the Message Buffer again. The function returns immediately.

Parameters

- base – FlexCAN peripheral base address.
- mbIdx – The FlexCAN FD Message Buffer index.
- pRxFrame – Pointer to CAN FD message frame structure for reception.

Return values

- kStatus_Success – Rx Message Buffer is full and has been read successfully.
- kStatus_FLEXCAN_RxOverflow – Rx Message Buffer is already overflowed and has been read successfully.
- kStatus_Fail – Rx Message Buffer is empty.

status_t FLEXCAN_ReadRxFifo(CAN_Type *base, *flexcan_frame_t* *pRxFrame)

Reads a FlexCAN Message from Legacy Rx FIFO.

This function reads a CAN message from the FlexCAN Legacy Rx FIFO.

Parameters

- base – FlexCAN peripheral base address.
- pRxFrame – Pointer to CAN message frame structure for reception.

Return values

- kStatus_Success – Read Message from Rx FIFO successfully.
- kStatus_Fail – Rx FIFO is not enabled.

status_t FLEXCAN_ReadPNWakeUpMB(CAN_Type *base, uint8_t mbIdx, *flexcan_frame_t* *pRxFrame)

Reads a FlexCAN Message from Wake Up MB.

This function reads a CAN message from the FlexCAN Wake up Message Buffers. There are four Wake up Message Buffers (WMBs) used to store incoming messages in Pretended Networking mode. The WMB index indicates the arrival order. The last message is stored in WMB3.

Parameters

- base – FlexCAN peripheral base address.
- pRxFrame – Pointer to CAN message frame structure for reception.
- mbIdx – The FlexCAN Wake up Message Buffer index. Range in 0x0 ~ 0x3.

Return values

- kStatus_Success – Read Message from Wake up Message Buffer successfully.
- kStatus_Fail – Wake up Message Buffer has no valid content.

status_t FLEXCAN_TransferFDSendBlocking(CAN_Type *base, uint8_t mbIdx, *flexcan_fd_frame_t* *pTxFrame)

Performs a polling send transaction on the CAN bus.

Note: A transfer handle does not need to be created before calling this API.

Parameters

- base – FlexCAN peripheral base pointer.
- mbIdx – The FlexCAN FD Message Buffer index.
- pTxFrame – Pointer to CAN FD message frame to be sent.

Return values

- kStatus_Success – Write Tx Message Buffer Successfully.
- kStatus_Fail – Tx Message Buffer is currently in use.
- kStatus_Timeout – Failed to send frames within specific time.

status_t FLEXCAN_TransferFDReceiveBlocking(CAN_Type *base, uint8_t mbIdx, *flexcan_fd_frame_t* *pRxFrame)

Performs a polling receive transaction on the CAN bus.

Note: A transfer handle does not need to be created before calling this API.

Parameters

- base – FlexCAN peripheral base pointer.
- mbIdx – The FlexCAN FD Message Buffer index.
- pRxFrame – Pointer to CAN FD message frame structure for reception.

Return values

- kStatus_Success – Rx Message Buffer is full and has been read successfully.
- kStatus_FLEXCAN_RxOverflow – Rx Message Buffer is already overflowed and has been read successfully.
- kStatus_Fail – Rx Message Buffer is empty.
- kStatus_Timeout – Failed to receive frames within specific time.

status_t FLEXCAN_TransferFDSendNonBlocking(CAN_Type *base, *flexcan_handle_t* *handle, *flexcan_mb_transfer_t* *pMbXfer)

Sends a message using IRQ.

This function sends a message using IRQ. This is a non-blocking function, which returns right away. When messages have been sent out, the send callback function is called.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.
- pMbXfer – FlexCAN FD Message Buffer transfer structure. See the *flexcan_mb_transfer_t*.

Return values

- kStatus_Success – Start Tx Message Buffer sending process successfully.
- kStatus_Fail – Write Tx Message Buffer failed.
- kStatus_FLEXCAN_TxBusy – Tx Message Buffer is in use.

status_t FLEXCAN_TransferFDReceiveNonBlocking(CAN_Type *base, *flexcan_handle_t* *handle, *flexcan_mb_transfer_t* *pMbXfer)

Receives a message using IRQ.

This function receives a message using IRQ. This is non-blocking function, which returns right away. When the message has been received, the receive callback function is called.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.
- pMbXfer – FlexCAN FD Message Buffer transfer structure. See the *flexcan_mb_transfer_t*.

Return values

- kStatus_Success – Start Rx Message Buffer receiving process successfully.
- kStatus_FLEXCAN_RxBusy – Rx Message Buffer is in use.

```
void FLEXCAN_TransferFDBortSend(CAN_Type *base, flexcan_handle_t *handle, uint8_t mbIdx)
```

Aborts the interrupt driven message send process.

This function aborts the interrupt driven message send process.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.
- mbIdx – The FlexCAN FD Message Buffer index.

```
void FLEXCAN_TransferFDBortReceive(CAN_Type *base, flexcan_handle_t *handle, uint8_t mbIdx)
```

Aborts the interrupt driven message receive process.

This function aborts the interrupt driven message receive process.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.
- mbIdx – The FlexCAN FD Message Buffer index.

```
status_t FLEXCAN_TransferSendBlocking(CAN_Type *base, uint8_t mbIdx, flexcan_frame_t *pTxFrame)
```

Performs a polling send transaction on the CAN bus.

Note: A transfer handle does not need to be created before calling this API.

Parameters

- base – FlexCAN peripheral base pointer.
- mbIdx – The FlexCAN Message Buffer index.
- pTxFrame – Pointer to CAN message frame to be sent.

Return values

- kStatus_Success – - Write Tx Message Buffer Successfully.
- kStatus_Fail – - Tx Message Buffer is currently in use.
- kStatus_Timeout – - Failed to send frames within specific time.

```
status_t FLEXCAN_TransferReceiveBlocking(CAN_Type *base, uint8_t mbIdx, flexcan_frame_t *pRxFrame)
```

Performs a polling receive transaction on the CAN bus.

Note: A transfer handle does not need to be created before calling this API.

Parameters

- base – FlexCAN peripheral base pointer.
- mbIdx – The FlexCAN Message Buffer index.
- pRxFrame – Pointer to CAN message frame structure for reception.

Return values

- `kStatus_Success` -- Rx Message Buffer is full and has been read successfully.
- `kStatus_FLEXCAN_RxOverflow` -- Rx Message Buffer is already overflowed and has been read successfully.
- `kStatus_Fail` -- Rx Message Buffer is empty.
- `kStatus_Timeout` -- Failed to receive frames within specific time.

`status_t` FLEXCAN_TransferReceiveFifoBlocking(CAN_Type *base, *flexcan_frame_t* *pRxFrame)
Performs a polling receive transaction from Legacy Rx FIFO on the CAN bus.

Note: A transfer handle does not need to be created before calling this API.

Parameters

- `base` – FlexCAN peripheral base pointer.
- `pRxFrame` – Pointer to CAN message frame structure for reception.

Return values

- `kStatus_Success` -- Read Message from Rx FIFO successfully.
- `kStatus_Fail` -- Rx FIFO is not enabled.
- `kStatus_Timeout` -- Failed to receive frames within specific time.

`void` FLEXCAN_TransferCreateHandle(CAN_Type *base, *flexcan_handle_t* *handle, *flexcan_transfer_callback_t* callback, void *userData)

Initializes the FlexCAN handle.

This function initializes the FlexCAN handle, which can be used for other FlexCAN transactional APIs. Usually, for a specified FlexCAN instance, call this API once to get the initialized handle.

Parameters

- `base` – FlexCAN peripheral base address.
- `handle` – FlexCAN handle pointer.
- `callback` – The callback function.
- `userData` – The parameter of the callback function.

`status_t` FLEXCAN_TransferSendNonBlocking(CAN_Type *base, *flexcan_handle_t* *handle, *flexcan_mb_transfer_t* *pMbXfer)

Sends a message using IRQ.

This function sends a message using IRQ. This is a non-blocking function, which returns right away. When messages have been sent out, the send callback function is called.

Parameters

- `base` – FlexCAN peripheral base address.
- `handle` – FlexCAN handle pointer.
- `pMbXfer` – FlexCAN Message Buffer transfer structure. See the `flexcan_mb_transfer_t`.

Return values

- `kStatus_Success` – Start Tx Message Buffer sending process successfully.
- `kStatus_Fail` – Write Tx Message Buffer failed.
- `kStatus_FLEXCAN_TxBusy` – Tx Message Buffer is in use.

status_t FLEXCAN_TransferReceiveNonBlocking(*CAN_Type* *base, *flexcan_handle_t* *handle, *flexcan_mb_transfer_t* *pMbXfer)

Receives a message using IRQ.

This function receives a message using IRQ. This is non-blocking function, which returns right away. When the message has been received, the receive callback function is called.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.
- pMbXfer – FlexCAN Message Buffer transfer structure. See the *flexcan_mb_transfer_t*.

Return values

- *kStatus_Success* – Start Rx Message Buffer receiving process successfully.
- *kStatus_FLEXCAN_RxBusy* – Rx Message Buffer is in use.

status_t FLEXCAN_TransferReceiveFifoNonBlocking(*CAN_Type* *base, *flexcan_handle_t* *handle, *flexcan_fifo_transfer_t* *pFifoXfer)

Receives a message from Rx FIFO using IRQ.

This function receives a message using IRQ. This is a non-blocking function, which returns right away. When all messages have been received, the receive callback function is called.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.
- pFifoXfer – FlexCAN Rx FIFO transfer structure. See the *flexcan_fifo_transfer_t*.

Return values

- *kStatus_Success* – Start Rx FIFO receiving process successfully.
- *kStatus_FLEXCAN_RxFifoBusy* – Rx FIFO is currently in use.

status_t FLEXCAN_TransferGetReceiveFifoCount(*CAN_Type* *base, *flexcan_handle_t* *handle, *size_t* *count)

Gets the Legacy Rx Fifo transfer status during an interrupt non-blocking receive.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.
- count – Number of CAN messages receive so far by the non-blocking transaction.

Return values

- *kStatus_InvalidArgument* – count is Invalid.
- *kStatus_Success* – Successfully return the count.

uint32_t FLEXCAN_GetTimeStamp(*flexcan_handle_t* *handle, *uint8_t* mbIdx)

Gets the detail index of Mailbox's Timestamp by handle.

Then function can only be used when calling non-blocking Data transfer (TX/RX) API, After TX/RX data transfer done (User can get the status by handler's callback function), we can get the detail index of Mailbox's timestamp by handle, Detail non-blocking data transfer API (TX/RX) contain. -FLEXCAN_TransferSendNonBlocking

-FLEXCAN_TransferFDSendNonBlocking -FLEXCAN_TransferReceiveNonBlocking -
FLEXCAN_TransferFDReceiveNonBlocking -FLEXCAN_TransferReceiveFifoNonBlocking

Parameters

- handle – FlexCAN handle pointer.
- mbIdx – The FlexCAN Message Buffer index.

Return values

the – index of mailbox 's timestamp stored in the handle.

static inline uint32_t FLEXCAN_GetHighResolutionTimeStamp(CAN_Type *base, uint8_t mbIdx)

void FLEXCAN_TransferAbortSend(CAN_Type *base, *flexcan_handle_t* *handle, uint8_t mbIdx)

Aborts the interrupt driven message send process.

This function aborts the interrupt driven message send process.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.
- mbIdx – The FlexCAN Message Buffer index.

void FLEXCAN_TransferAbortReceive(CAN_Type *base, *flexcan_handle_t* *handle, uint8_t
mbIdx)

Aborts the interrupt driven message receive process.

This function aborts the interrupt driven message receive process.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.
- mbIdx – The FlexCAN Message Buffer index.

void FLEXCAN_TransferAbortReceiveFifo(CAN_Type *base, *flexcan_handle_t* *handle)

Aborts the interrupt driven message receive from Rx FIFO process.

This function aborts the interrupt driven message receive from Rx FIFO process.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.

void FLEXCAN_TransferHandleIRQ(CAN_Type *base, *flexcan_handle_t* *handle)

FlexCAN IRQ handle function.

This function handles the FlexCAN Error, the Message Buffer, and the Rx FIFO IRQ request.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.

void FLEXCAN_MbHandleIRQ(CAN_Type *base, *flexcan_handle_t* *handle, uint32_t startMbIdx,
uint32_t endMbIdx)

FlexCAN Message Buffer IRQ handle function.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.

- startMbIdx – First Message Buffer to handle.
- endMbIdx – Last Message Buffer to handle.

void FLEXCAN_BusoffErrorHandleIRQ(CAN_Type *base, flexcan_handle_t *handle)

FlexCAN Bus Off, Error and Warning IRQ handle function.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.

void FLEXCAN_PNWakeUpHandleIRQ(CAN_Type *base, flexcan_handle_t *handle)

FlexCAN Pretended Networking Wake-up IRQ handle function.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.

void FLEXCAN_MemoryErrorHandleIRQ(CAN_Type *base, flexcan_handle_t *handle)

FlexCAN Memory Error IRQ handle function.

Parameters

- base – FlexCAN peripheral base address.
- handle – FlexCAN handle pointer.

FSL_FLEXCAN_DRIVER_VERSION

FlexCAN driver version.

FlexCAN transfer status.

Values:

enumerator kStatus_FLEXCAN_TxBusy

Tx Message Buffer is Busy.

enumerator kStatus_FLEXCAN_TxIdle

Tx Message Buffer is Idle.

enumerator kStatus_FLEXCAN_TxSwitchToRx

Remote Message is send out and Message buffer changed to Receive one.

enumerator kStatus_FLEXCAN_RxBusy

Rx Message Buffer is Busy.

enumerator kStatus_FLEXCAN_RxIdle

Rx Message Buffer is Idle.

enumerator kStatus_FLEXCAN_RxOverflow

Rx Message Buffer is Overflowed.

enumerator kStatus_FLEXCAN_RxFifoBusy

Rx Message FIFO is Busy.

enumerator kStatus_FLEXCAN_RxFifoIdle

Rx Message FIFO is Idle.

enumerator kStatus_FLEXCAN_RxFifoOverflow

Rx Message FIFO is overflowed.

enumerator kStatus_FLEXCAN_RxFifoWarning

Rx Message FIFO is almost overflowed.

enumerator kStatus_FLEXCAN_RxFifoDisabled

Rx Message FIFO is disabled during reading.

enumerator kStatus_FLEXCAN_ErrorStatus

FlexCAN Module Error and Status.

enumerator kStatus_FLEXCAN_WakeUp

FlexCAN is waken up from STOP mode.

enumerator kStatus_FLEXCAN_UnHandled

UnHandled Interrupt asserted.

enumerator kStatus_FLEXCAN_RxRemote

Rx Remote Message Received in Mail box.

enumerator kStatus_FLEXCAN_MemoryError

FlexCAN Memory Error.

enum _flexcan_frame_format

FlexCAN frame format.

Values:

enumerator kFLEXCAN_FrameFormatStandard

Standard frame format attribute.

enumerator kFLEXCAN_FrameFormatExtend

Extend frame format attribute.

enum _flexcan_frame_type

FlexCAN frame type.

Values:

enumerator kFLEXCAN_FrameTypeData

Data frame type attribute.

enumerator kFLEXCAN_FrameTypeRemote

Remote frame type attribute.

enum _flexcan_clock_source

FlexCAN clock source.

Deprecated:

Do not use the kFLEXCAN_ClkSrcOs. It has been superceded kFLEXCAN_ClkSrc0

Do not use the kFLEXCAN_ClkSrcPeri. It has been superceded kFLEXCAN_ClkSrc1

Values:

enumerator kFLEXCAN_ClkSrcOsc

FlexCAN Protocol Engine clock from Oscillator.

enumerator kFLEXCAN_ClkSrcPeri

FlexCAN Protocol Engine clock from Peripheral Clock.

enumerator kFLEXCAN_ClkSrc0

FlexCAN Protocol Engine clock selected by user as SRC == 0.

enumerator kFLEXCAN_ClkSrc1

FlexCAN Protocol Engine clock selected by user as SRC == 1.

enum _flexcan_wake_up_source

FlexCAN wake up source.

Values:

enumerator kFLEXCAN_WakeupSrcUnfiltered

FlexCAN uses unfiltered Rx input to detect edge.

enumerator kFLEXCAN_WakeupSrcFiltered

FlexCAN uses filtered Rx input to detect edge.

enum _flexcan_endianness

FlexCAN payload endianness.

Values:

enumerator kFLEXCAN_bigEndian

Transmit frame with MSB first, receive frame with big-endian format.

enumerator kFLEXCAN_littleEndian

Transmit frame with LSB first, receive frame with little-endian format.

enum _flexcan_MB_timestamp_base

FlexCAN timebase used for capturing 16-bit TIME_STAMP field of message buffer.

Values:

enumerator kFLEXCAN_CANTimer

FlexCAN free-running timer.

enumerator kFLEXCAN_Lower16bitsHRTimer

Lower 16 bits of high-resolution on-chip timer.

enumerator kFLEXCAN_Upper16bitsHRTimer

Upper 16 bits of high-resolution on-chip timer.

enum _flexcan_capture_point

FlexCAN capture point of 32-bit high resolution timebase during a CAN frame.

Values:

enumerator kFLEXCAN_CANFrameID2ndBit

Second bit of identifier field of any frame is on the CAN bus. HR_TIME_STAMPn register will not capture 32-bit counter value.

enumerator kFLEXCAN_CANFrameEnd

End of the CAN frame.

enumerator kFLEXCAN_CANFrameStart

Start of the CAN frame.

enumerator kFLEXCAN_CANFDFrameRes

Start of frame for classical CAN frames; res bit for CAN FD frames.

enum _flexcan_rx_fifo_filter_type

FlexCAN Rx Fifo Filter type.

Values:

enumerator kFLEXCAN_RxFifoFilterTypeA

One full ID (standard and extended) per ID Filter element.

enumerator kFLEXCAN_RxFifoFilterTypeB

Two full standard IDs or two partial 14-bit ID slices per ID Filter Table element.

enumerator kFLEXCAN_RxFifoFilterTypeC

Four partial 8-bit Standard or extended ID slices per ID Filter Table element.

enumerator kFLEXCAN_RxFifoFilterTypeD

All frames rejected.

enum _flexcan_mb_size

FlexCAN Message Buffer Payload size.

Values:

enumerator kFLEXCAN_8BperMB

Selects 8 bytes per Message Buffer.

enumerator kFLEXCAN_16BperMB

Selects 16 bytes per Message Buffer.

enumerator kFLEXCAN_32BperMB

Selects 32 bytes per Message Buffer.

enumerator kFLEXCAN_64BperMB

Selects 64 bytes per Message Buffer.

enum _flexcan_fd_frame_length

FlexCAN CAN FD frame supporting data length (available DLC values).

For Tx, when the Data size corresponding to DLC value stored in the MB selected for transmission is larger than the MB Payload size, FlexCAN adds the necessary number of bytes with constant 0xCC pattern to complete the expected DLC. For Rx, when the Data size corresponding to DLC value received from the CAN bus is larger than the MB Payload size, the high order bytes that do not fit the Payload size will lose.

Values:

enumerator kFLEXCAN_0BperFrame

Frame contains 0 valid data bytes.

enumerator kFLEXCAN_1BperFrame

Frame contains 1 valid data bytes.

enumerator kFLEXCAN_2BperFrame

Frame contains 2 valid data bytes.

enumerator kFLEXCAN_3BperFrame

Frame contains 3 valid data bytes.

enumerator kFLEXCAN_4BperFrame

Frame contains 4 valid data bytes.

enumerator kFLEXCAN_5BperFrame

Frame contains 5 valid data bytes.

enumerator kFLEXCAN_6BperFrame

Frame contains 6 valid data bytes.

enumerator kFLEXCAN_7BperFrame

Frame contains 7 valid data bytes.

enumerator kFLEXCAN_8BperFrame

Frame contains 8 valid data bytes.

enumerator kFLEXCAN_12BperFrame
Frame contains 12 valid data bytes.

enumerator kFLEXCAN_16BperFrame
Frame contains 16 valid data bytes.

enumerator kFLEXCAN_20BperFrame
Frame contains 20 valid data bytes.

enumerator kFLEXCAN_24BperFrame
Frame contains 24 valid data bytes.

enumerator kFLEXCAN_32BperFrame
Frame contains 32 valid data bytes.

enumerator kFLEXCAN_48BperFrame
Frame contains 48 valid data bytes.

enumerator kFLEXCAN_64BperFrame
Frame contains 64 valid data bytes.

enum _flexcan_rx_fifo_priority
FlexCAN Enhanced/Legacy Rx FIFO priority.

The matching process starts from the Rx MB(or Enhanced/Legacy Rx FIFO) with higher priority. If no MB(or Enhanced/Legacy Rx FIFO filter) is satisfied, the matching process goes on with the Enhanced/Legacy Rx FIFO(or Rx MB) with lower priority.

Values:

enumerator kFLEXCAN_RxFifoPrioLow
Matching process start from Rx Message Buffer first.

enumerator kFLEXCAN_RxFifoPrioHigh
Matching process start from Enhanced/Legacy Rx FIFO first.

enum _flexcan_interrupt_enable
FlexCAN interrupt enable enumerations.

This provides constants for the FlexCAN interrupt enable enumerations for use in the FlexCAN functions.

Note: FlexCAN Message Buffers and Legacy Rx FIFO interrupts not included in.

Values:

enumerator kFLEXCAN_BusOffInterruptEnable
Bus Off interrupt, use bit 15.

enumerator kFLEXCAN_ErrorInterruptEnable
CAN Error interrupt, use bit 14.

enumerator kFLEXCAN_TxWarningInterruptEnable
Tx Warning interrupt, use bit 11.

enumerator kFLEXCAN_RxWarningInterruptEnable
Rx Warning interrupt, use bit 10.

enumerator kFLEXCAN_FDErrorInterruptEnable
CAN FD Error interrupt, use bit 31.

enumerator kFLEXCAN_PNMatchWakeUpInterruptEnable

PN Match Wake Up interrupt, use high word bit 17.

enumerator kFLEXCAN_PNTimeoutWakeUpInterruptEnable

PN Timeout Wake Up interrupt, use high word bit 16.

enumerator kFLEXCAN_HostAccessNCErrInterruptEnable

Host Access With Non-Correctable Errors interrupt, use high word bit 0.

enumerator kFLEXCAN_FlexCanAccessNCErrInterruptEnable

FlexCAN Access With Non-Correctable Errors interrupt, use high word bit 2.

enumerator kFLEXCAN_HostOrFlexCanCErrInterruptEnable

Host or FlexCAN Access With Correctable Errors interrupt, use high word bit 3.

enum _flexcan_flags

FlexCAN status flags.

This provides constants for the FlexCAN status flags for use in the FlexCAN functions.

Note: The CPU read action clears the bits corresponding to the FLEXCAN_ErrorFlag macro, therefore user need to read status flags and distinguish which error is occur using _flexcan_error_flags enumerations.

Values:

enumerator kFLEXCAN_ErrorOverrunFlag

Error Overrun Status.

enumerator kFLEXCAN_FDErrorIntFlag

CAN FD Error Interrupt Flag.

enumerator kFLEXCAN_BusoffDoneIntFlag

Bus Off process completed Interrupt Flag.

enumerator kFLEXCAN_SynchFlag

CAN Synchronization Status.

enumerator kFLEXCAN_TxWarningIntFlag

Tx Warning Interrupt Flag.

enumerator kFLEXCAN_RxWarningIntFlag

Rx Warning Interrupt Flag.

enumerator kFLEXCAN_IdleFlag

FlexCAN In IDLE Status.

enumerator kFLEXCAN_FaultConfinementFlag

FlexCAN Fault Confinement State.

enumerator kFLEXCAN_TransmittingFlag

FlexCAN In Transmission Status.

enumerator kFLEXCAN_ReceivingFlag

FlexCAN In Reception Status.

enumerator kFLEXCAN_BusOffIntFlag

Bus Off Interrupt Flag.

enumerator kFLEXCAN_ErrorIntFlag

CAN Error Interrupt Flag.

enumerator kFLEXCAN_ErrorFlag

enumerator kFLEXCAN_PNMatchIntFlag

PN Matching Event Interrupt Flag.

enumerator kFLEXCAN_PNTimeoutIntFlag

PN Timeout Event Interrupt Flag.

enumerator kFLEXCAN_HostAccessNonCorrectableErrorIntFlag

Host Access With Non-Correctable Error Interrupt Flag.

enumerator kFLEXCAN_FlexCanAccessNonCorrectableErrorIntFlag

FlexCAN Access With Non-Correctable Error Interrupt Flag.

enumerator kFLEXCAN_CorrectableErrorIntFlag

Correctable Error Interrupt Flag.

enumerator kFLEXCAN_HostAccessNonCorrectableErrorOverrunFlag

Host Access With Non-Correctable Error Interrupt Overrun Flag.

enumerator kFLEXCAN_FlexCanAccessNonCorrectableErrorOverrunFlag

FlexCAN Access With Non-Correctable Error Interrupt Overrun Flag.

enumerator kFLEXCAN_CorrectableErrorOverrunFlag

Correctable Error Interrupt Overrun Flag.

enumerator kFLEXCAN_AllMemoryErrorIntFlag

All Memory Error Interrupt Flags.

enumerator kFLEXCAN_AllMemoryErrorFlag

All Memory Error Flags.

enum _flexcan_error_flags

FlexCAN error status flags.

The FlexCAN Error Status enumerations is used to report current error of the FlexCAN bus. This enumerations should be used with KFLEXCAN_ErrorFlag in _flexcan_flags enumerations to determine which error is generated.

Values:

enumerator kFLEXCAN_FDStuffingError

Stuffing Error.

enumerator kFLEXCAN_FDFormError

Form Error.

enumerator kFLEXCAN_FDCrcError

Cyclic Redundancy Check Error.

enumerator kFLEXCAN_FDBit0Error

Unable to send dominant bit.

enumerator kFLEXCAN_FDBit1Error

Unable to send recessive bit.

enumerator kFLEXCAN_TxErrorWarningFlag

Tx Error Warning Status.

enumerator kFLEXCAN_RxErrorWarningFlag

Rx Error Warning Status.

enumerator kFLEXCAN_StuffingError

Stuffing Error.

enumerator kFLEXCAN_FormError

Form Error.

enumerator kFLEXCAN_CrcError

Cyclic Redundancy Check Error.

enumerator kFLEXCAN_AckError

Received no ACK on transmission.

enumerator kFLEXCAN_Bit0Error

Unable to send dominant bit.

enumerator kFLEXCAN_Bit1Error

Unable to send recessive bit.

FlexCAN Legacy Rx FIFO status flags.

The FlexCAN Legacy Rx FIFO Status enumerations are used to determine the status of the Rx FIFO. Because Rx FIFO occupy the MB0 ~ MB7 (Rx Fifo filter also occupies more Message Buffer space), Rx FIFO status flags are mapped to the corresponding Message Buffer status flags.

Values:

enumerator kFLEXCAN_RxFifoOverflowFlag

Rx FIFO overflow flag.

enumerator kFLEXCAN_RxFifoWarningFlag

Rx FIFO almost full flag.

enumerator kFLEXCAN_RxFifoFrameAvlFlag

Frames available in Rx FIFO flag.

enum _flexcan_memory_error_type

FlexCAN Memory Error Type.

Values:

enumerator kFLEXCAN_CorrectableError

The memory error is correctable which means on bit error.

enumerator kFLEXCAN_NonCorrectableError

The memory error is non-correctable which means two bit errors.

enum _flexcan_memory_access_type

FlexCAN Memory Access Type.

Values:

enumerator kFLEXCAN_MoveOutFlexCanAccess

The memory error was detected during move-out FlexCAN access.

enumerator kFLEXCAN_MoveInAccess

The memory error was detected during move-in FlexCAN access.

enumerator kFLEXCAN_TxArbitrationAccess

The memory error was detected during Tx Arbitration FlexCAN access.

enumerator kFLEXCAN_RxMatchingAccess

The memory error was detected during Rx Matching FlexCAN access.

enumerator kFLEXCAN_MoveOutHostAccess

The memory error was detected during Rx Matching Host (CPU) access.

enum _flexcan_byte_error_syndrome

FlexCAN Memory Error Byte Syndrome.

Values:

enumerator kFLEXCAN_NoError

No bit error in this byte.

enumerator kFLEXCAN_ParityBits0Error

Parity bit 0 error in this byte.

enumerator kFLEXCAN_ParityBits1Error

Parity bit 1 error in this byte.

enumerator kFLEXCAN_ParityBits2Error

Parity bit 2 error in this byte.

enumerator kFLEXCAN_ParityBits3Error

Parity bit 3 error in this byte.

enumerator kFLEXCAN_ParityBits4Error

Parity bit 4 error in this byte.

enumerator kFLEXCAN_DataBits0Error

Data bit 0 error in this byte.

enumerator kFLEXCAN_DataBits1Error

Data bit 1 error in this byte.

enumerator kFLEXCAN_DataBits2Error

Data bit 2 error in this byte.

enumerator kFLEXCAN_DataBits3Error

Data bit 3 error in this byte.

enumerator kFLEXCAN_DataBits4Error

Data bit 4 error in this byte.

enumerator kFLEXCAN_DataBits5Error

Data bit 5 error in this byte.

enumerator kFLEXCAN_DataBits6Error

Data bit 6 error in this byte.

enumerator kFLEXCAN_DataBits7Error

Data bit 7 error in this byte.

enumerator kFLEXCAN_AllZeroError

All-zeros non-correctable error in this byte.

enumerator kFLEXCAN_AllOneError

All-ones non-correctable error in this byte.

enumerator kFLEXCAN_NonCorrectableErrors

Non-correctable error in this byte.

enum _flexcan_pn_match_source

FlexCAN Pretended Networking match source selection.

Values:

enumerator kFLEXCAN_PNMatSrcID

Message match with ID filtering.

enumerator kFLEXCAN_PNMatSrcIDAndData

Message match with ID filtering and payload filtering.

enum _flexcan_pn_match_mode

FlexCAN Pretended Networking mode match type.

Values:

enumerator kFLEXCAN_PNMatModeEqual

Match upon ID/Payload contents against an exact target value.

enumerator kFLEXCAN_PNMatModeGreater

Match upon an ID/Payload value greater than or equal to a specified target value.

enumerator kFLEXCAN_PNMatModeSmaller

Match upon an ID/Payload value smaller than or equal to a specified target value.

enumerator kFLEXCAN_PNMatModeRange

Match upon an ID/Payload value inside a range, greater than or equal to a specified lower limit, and smaller than or equal to a specified upper limit

typedef enum _flexcan_frame_format flexcan_frame_format_t

FlexCAN frame format.

typedef enum _flexcan_frame_type flexcan_frame_type_t

FlexCAN frame type.

typedef enum _flexcan_clock_source flexcan_clock_source_t

FlexCAN clock source.

Deprecated:

Do not use the kFLEXCAN_ClkSrcOs. It has been superseded kFLEXCAN_ClkSrc0

Do not use the kFLEXCAN_ClkSrcPeri. It has been superseded kFLEXCAN_ClkSrc1

typedef enum _flexcan_wake_up_source flexcan_wake_up_source_t

FlexCAN wake up source.

typedef enum _flexcan_endianness flexcan_endianness_t

FlexCAN payload endianness.

typedef enum _flexcan_MB_timestamp_base flexcan_MB_timestamp_base_t

FlexCAN timebase used for capturing 16-bit TIME_STAMP field of message buffer.

typedef enum _flexcan_capture_point flexcan_capture_point_t

FlexCAN capture point of 32-bit high resolution timebase during a CAN frame.

typedef enum _flexcan_rx_fifo_filter_type flexcan_rx_fifo_filter_type_t

FlexCAN Rx Fifo Filter type.

typedef enum _flexcan_mb_size flexcan_mb_size_t

FlexCAN Message Buffer Payload size.

typedef enum _flexcan_rx_fifo_priority flexcan_rx_fifo_priority_t

FlexCAN Enhanced/Legacy Rx FIFO priority.

The matching process starts from the Rx MB(or Enhanced/Legacy Rx FIFO) with higher priority. If no MB(or Enhanced/Legacy Rx FIFO filter) is satisfied, the matching process goes on with the Enhanced/Legacy Rx FIFO(or Rx MB) with lower priority.

typedef enum _flexcan_memory_error_type flexcan_memory_error_type_t

FlexCAN Memory Error Type.

typedef enum *_flexcan_memory_access_type* flexcan_memory_access_type_t

FlexCAN Memory Access Type.

typedef enum *_flexcan_byte_error_syndrome* flexcan_byte_error_syndrome_t

FlexCAN Memory Error Byte Syndrome.

typedef struct *_flexcan_memory_error_report_status* flexcan_memory_error_report_status_t

FlexCAN memory error register status structure.

This structure contains the memory access properties that caused a memory error access. It is used as the parameter of FLEXCAN_GetMemoryErrorReportStatus() function. And user can use FLEXCAN_GetMemoryErrorReportStatus to get the status of the last memory error access.

typedef struct *_flexcan_frame* flexcan_frame_t

FlexCAN message frame structure.

typedef struct *_flexcan_fd_frame* flexcan_fd_frame_t

CAN FD message frame structure.

The CAN FD message supporting up to sixty four bytes can be used for a data frame, depending on the length selected for the message buffers. The length should be a enumeration member, see *_flexcan_fd_frame_length*.

typedef struct *_flexcan_timing_config* flexcan_timing_config_t

FlexCAN protocol timing characteristic configuration structure.

typedef struct *_flexcan_config* flexcan_config_t

FlexCAN module configuration structure.

Deprecated:

Do not use the baudRate. It has been superceded bitRate

Do not use the baudRateFD. It has been superceded bitRateFD

typedef struct *_flexcan_rx_mb_config* flexcan_rx_mb_config_t

FlexCAN Receive Message Buffer configuration structure.

This structure is used as the parameter of FLEXCAN_SetRxMbConfig() function. The FLEXCAN_SetRxMbConfig() function is used to configure FlexCAN Receive Message Buffer. The function abort previous receiving process, clean the Message Buffer and activate the Rx Message Buffer using given Message Buffer setting.

typedef enum *_flexcan_pn_match_source* flexcan_pn_match_source_t

FlexCAN Pretended Networking match source selection.

typedef enum *_flexcan_pn_match_mode* flexcan_pn_match_mode_t

FlexCAN Pretended Networking mode match type.

typedef struct *_flexcan_pn_config* flexcan_pn_config_t

FlexCAN Pretended Networking configuration structure.

This structure is used as the parameter of FLEXCAN_SetPNConfig() function. The FLEXCAN_SetPNConfig() function is used to configure FlexCAN Networking work mode.

typedef struct *_flexcan_rx_fifo_config* flexcan_rx_fifo_config_t

FlexCAN Legacy Rx FIFO configuration structure.

typedef struct *_flexcan_mb_transfer* flexcan_mb_transfer_t

FlexCAN Message Buffer transfer.

`typedef struct flexcan_fifo_transfer flexcan_fifo_transfer_t`

FlexCAN Rx FIFO transfer.

`typedef struct flexcan_handle flexcan_handle_t`

FlexCAN handle structure definition.

`typedef void (*flexcan_transfer_callback_t)(CAN_Type *base, flexcan_handle_t *handle, status_t status, uint64_t result, void *userData)`

`FLEXCAN_WAIT_TIMEOUT`

`FLEXCAN_POLLING_TIMEOUT`

Max loops to wait for polling transfer.

`FLEXCAN_MODULE_TIMEOUT`

Max loops to wait for FlexCAN register access complete.

`DLC_LENGTH_DECODE(dlc)`

FlexCAN frame length helper macro.

`FLEXCAN_ID_STD(id)`

FlexCAN Frame ID helper macro.

Standard Frame ID helper macro.

`FLEXCAN_ID_EXT(id)`

Extend Frame ID helper macro.

`FLEXCAN_RX_MB_STD_MASK(id, rtr, ide)`

FlexCAN Rx Message Buffer Mask helper macro.

Standard Rx Message Buffer Mask helper macro.

`FLEXCAN_RX_MB_EXT_MASK(id, rtr, ide)`

Extend Rx Message Buffer Mask helper macro.

`FLEXCAN_RX_FIFO_STD_MASK_TYPE_A(id, rtr, ide)`

FlexCAN Legacy Rx FIFO Mask helper macro.

Standard Rx FIFO Mask helper macro Type A helper macro.

`FLEXCAN_RX_FIFO_STD_MASK_TYPE_B_HIGH(id, rtr, ide)`

Standard Rx FIFO Mask helper macro Type B upper part helper macro.

`FLEXCAN_RX_FIFO_STD_MASK_TYPE_B_LOW(id, rtr, ide)`

Standard Rx FIFO Mask helper macro Type B lower part helper macro.

`FLEXCAN_RX_FIFO_STD_MASK_TYPE_C_HIGH(id)`

Standard Rx FIFO Mask helper macro Type C upper part helper macro.

`FLEXCAN_RX_FIFO_STD_MASK_TYPE_C_MID_HIGH(id)`

Standard Rx FIFO Mask helper macro Type C mid-upper part helper macro.

`FLEXCAN_RX_FIFO_STD_MASK_TYPE_C_MID_LOW(id)`

Standard Rx FIFO Mask helper macro Type C mid-lower part helper macro.

`FLEXCAN_RX_FIFO_STD_MASK_TYPE_C_LOW(id)`

Standard Rx FIFO Mask helper macro Type C lower part helper macro.

`FLEXCAN_RX_FIFO_EXT_MASK_TYPE_A(id, rtr, ide)`

Extend Rx FIFO Mask helper macro Type A helper macro.

`FLEXCAN_RX_FIFO_EXT_MASK_TYPE_B_HIGH(id, rtr, ide)`

Extend Rx FIFO Mask helper macro Type B upper part helper macro.

FLEXCAN_RX_FIFO_EXT_MASK_TYPE_B_LOW(id, rtr, ide)

Extend Rx FIFO Mask helper macro Type B lower part helper macro.

FLEXCAN_RX_FIFO_EXT_MASK_TYPE_C_HIGH(id)

Extend Rx FIFO Mask helper macro Type C upper part helper macro.

FLEXCAN_RX_FIFO_EXT_MASK_TYPE_C_MID_HIGH(id)

Extend Rx FIFO Mask helper macro Type C mid-upper part helper macro.

FLEXCAN_RX_FIFO_EXT_MASK_TYPE_C_MID_LOW(id)

Extend Rx FIFO Mask helper macro Type C mid-lower part helper macro.

FLEXCAN_RX_FIFO_EXT_MASK_TYPE_C_LOW(id)

Extend Rx FIFO Mask helper macro Type C lower part helper macro.

FLEXCAN_RX_FIFO_STD_FILTER_TYPE_A(id, rtr, ide)

FlexCAN Rx FIFO Filter helper macro.

Standard Rx FIFO Filter helper macro Type A helper macro.

FLEXCAN_RX_FIFO_STD_FILTER_TYPE_B_HIGH(id, rtr, ide)

Standard Rx FIFO Filter helper macro Type B upper part helper macro.

FLEXCAN_RX_FIFO_STD_FILTER_TYPE_B_LOW(id, rtr, ide)

Standard Rx FIFO Filter helper macro Type B lower part helper macro.

FLEXCAN_RX_FIFO_STD_FILTER_TYPE_C_HIGH(id)

Standard Rx FIFO Filter helper macro Type C upper part helper macro.

FLEXCAN_RX_FIFO_STD_FILTER_TYPE_C_MID_HIGH(id)

Standard Rx FIFO Filter helper macro Type C mid-upper part helper macro.

FLEXCAN_RX_FIFO_STD_FILTER_TYPE_C_MID_LOW(id)

Standard Rx FIFO Filter helper macro Type C mid-lower part helper macro.

FLEXCAN_RX_FIFO_STD_FILTER_TYPE_C_LOW(id)

Standard Rx FIFO Filter helper macro Type C lower part helper macro.

FLEXCAN_RX_FIFO_EXT_FILTER_TYPE_A(id, rtr, ide)

Extend Rx FIFO Filter helper macro Type A helper macro.

FLEXCAN_RX_FIFO_EXT_FILTER_TYPE_B_HIGH(id, rtr, ide)

Extend Rx FIFO Filter helper macro Type B upper part helper macro.

FLEXCAN_RX_FIFO_EXT_FILTER_TYPE_B_LOW(id, rtr, ide)

Extend Rx FIFO Filter helper macro Type B lower part helper macro.

FLEXCAN_RX_FIFO_EXT_FILTER_TYPE_C_HIGH(id)

Extend Rx FIFO Filter helper macro Type C upper part helper macro.

FLEXCAN_RX_FIFO_EXT_FILTER_TYPE_C_MID_HIGH(id)

Extend Rx FIFO Filter helper macro Type C mid-upper part helper macro.

FLEXCAN_RX_FIFO_EXT_FILTER_TYPE_C_MID_LOW(id)

Extend Rx FIFO Filter helper macro Type C mid-lower part helper macro.

FLEXCAN_RX_FIFO_EXT_FILTER_TYPE_C_LOW(id)

Extend Rx FIFO Filter helper macro Type C lower part helper macro.

FLEXCAN_PN_STD_MASK(id, rtr)

FlexCAN Pretended Networking ID Mask helper macro.

Standard Rx Message Buffer Mask helper macro.

FLEXCAN_PN_EXT_MASK(id, rtr)

Extend Rx Message Buffer Mask helper macro.

FLEXCAN_PN_INT_MASK(x)

FlexCAN interrupt/status flag helper macro.

FLEXCAN_PN_INT_UNMASK(x)

FLEXCAN_PN_STATUS_MASK(x)

FLEXCAN_PN_STATUS_UNMASK(x)

FLEXCAN_MECR_INT_MASK(x)

FLEXCAN_MECR_INT_UNMASK(x)

FLEXCAN_MECR_STATUS_MASK(x)

FLEXCAN_MECR_STATUS_UNMASK(x)

FLEXCAN_ERROR_AND_STATUS_INT_FLAG

FLEXCAN_PNWAKE_UP_FLAG

FLEXCAN_WAKE_UP_FLAG

FLEXCAN_MEMORY_ERROR_INT_FLAG

FLEXCAN_ENHANCED_RX_FIFO_INT_FLAG

FlexCAN Enhanced Rx FIFO base address helper macro.

FLEXCAN_CALLBACK(x)

FlexCAN transfer callback function.

The FlexCAN transfer callback returns a value from the underlying layer. If the status equals to `kStatus_FLEXCAN_ErrorStatus`, the result parameter is the Content of FlexCAN status register which can be used to get the working status(or error status) of FlexCAN module. If the status equals to other FlexCAN Message Buffer transfer status, the result is the index of Message Buffer that generate transfer event. If the status equals to other FlexCAN Message Buffer transfer status, the result is meaningless and should be Ignored.

struct flexcan_memory_error_report_status

#include <fsl_flexcan.h> FlexCAN memory error register status structure.

This structure contains the memory access properties that caused a memory error access. It is used as the parameter of `FLEXCAN_GetMemoryErrorReportStatus()` function. And user can use `FLEXCAN_GetMemoryErrorReportStatus` to get the status of the last memory error access.

Public Members

flexcan_memory_error_type_t errorType

The type of memory error that giving rise to the report.

flexcan_memory_access_type_t accessType

The type of memory access that giving rise to the memory error.

uint16_t accessAddress

The address where memory error detected.

uint32_t errorData

The raw data word read from memory with error.

struct `_flexcan_frame`

`#include <fsl_flexcan.h>` FlexCAN message frame structure.

struct `_flexcan_fd_frame`

`#include <fsl_flexcan.h>` CAN FD message frame structure.

The CAN FD message supporting up to sixty four bytes can be used for a data frame, depending on the length selected for the message buffers. The length should be a enumeration member, see `_flexcan_fd_frame_length`.

Public Members

uint32_t `hrtimestamp`

Note: HR timestamp offset is changed dynamically according to data length code (DLC). External 32-bit on-chip timer high-resolution timestamp.

struct `_flexcan_timing_config`

`#include <fsl_flexcan.h>` FlexCAN protocol timing characteristic configuration structure.

Public Members

uint32_t `preDivider`

Classic CAN or CAN FD nominal phase bit rate prescaler.

uint32_t `rJumpwidth`

Classic CAN or CAN FD nominal phase Re-sync Jump Width.

uint32_t `phaseSeg1`

Classic CAN or CAN FD nominal phase Segment 1.

uint32_t `phaseSeg2`

Classic CAN or CAN FD nominal phase Segment 2.

uint32_t `propSeg`

Classic CAN or CAN FD nominal phase Propagation Segment.

uint32_t `fpreDivider`

CAN FD data phase bit rate prescaler.

uint32_t `frJumpwidth`

CAN FD data phase Re-sync Jump Width.

uint32_t `fphaseSeg1`

CAN FD data phase Phase Segment 1.

uint32_t `fphaseSeg2`

CAN FD data phase Phase Segment 2.

uint32_t `fpropSeg`

CAN FD data phase Propagation Segment.

struct `_flexcan_config`

`#include <fsl_flexcan.h>` FlexCAN module configuration structure.

Deprecated:

Do not use the `baudRate`. It has been superceded `bitRate`

Do not use the `baudRateFD`. It has been superceded `bitRateFD`

Public Members

flexcan_clock_source_t clkSrc

Clock source for FlexCAN Protocol Engine.

flexcan_wake_up_source_t wakeupSrc

Wake up source selection.

uint8_t maxMbNum

The maximum number of Message Buffers used by user.

bool enableLoopBack

Enable or Disable Loop Back Self Test Mode.

bool enableTimerSync

Enable or Disable Timer Synchronization.

bool enableIndividMask

Enable or Disable Rx Individual Mask and Queue feature.

bool disableSelfReception

Enable or Disable Self Reflection.

bool enableListenOnlyMode

Enable or Disable Listen Only Mode.

bool enableDoze

Enable or Disable Doze Mode.

bool enablePretendedeNetworking

Enable or Disable the Pretended Networking mode.

bool enableMemoryErrorControl

Enable or Disable the memory errors detection and correction mechanism.

bool enableNonCorrectableErrorEnterFreeze

Enable or Disable Non-Correctable Errors In FlexCAN Access Put Device In Freeze Mode.

bool enableTransceiverDelayMeasure

Enable or Disable the transceiver delay measurement, when it is enabled, then the secondary sample point position is determined by the sum of the transceiver delay measurement plus the enhanced TDC offset.

bool enableRemoteRequestFrameStored

true: Store Remote Request Frame in the same fashion of data frame. false: Generate an automatic Remote Response Frame.

flexcan_endianness_t payloadEndianness

Selects the byte order for the payload of transmit and receive frames, see *flexcan_endianness_t*.

bool enableExternalTimeTick

true: External time tick clocks the free-running timer. false: FlexCAN bit clock clocks the free-running timer.

flexcan_MB_timestamp_base_t captureTimeBase

Timebase of message buffer 16-bit TIME_STAMP field.

flexcan_capture_point_t capturePoint

Point in time when 32-bit timebase is captured during CAN frame.

struct `_flexcan_rx_mb_config`

#include <fsl_flexcan.h> FlexCAN Receive Message Buffer configuration structure.

This structure is used as the parameter of `FLEXCAN_SetRxMbConfig()` function. The `FLEXCAN_SetRxMbConfig()` function is used to configure FlexCAN Receive Message Buffer. The function abort previous receiving process, clean the Message Buffer and activate the Rx Message Buffer using given Message Buffer setting.

Public Members

uint32_t id

CAN Message Buffer Frame Identifier, should be set using `FLEXCAN_ID_EXT()` or `FLEXCAN_ID_STD()` macro.

flexcan_frame_format_t format

CAN Frame Identifier format(Standard of Extend).

flexcan_frame_type_t type

CAN Frame Type(Data or Remote for classical CAN only).

struct `_flexcan_pn_config`

#include <fsl_flexcan.h> FlexCAN Pretended Networking configuration structure.

This structure is used as the parameter of `FLEXCAN_SetPNConfig()` function. The `FLEXCAN_SetPNConfig()` function is used to configure FlexCAN Networking work mode.

Public Members

bool enableTimeout

Enable or Disable timeout event trigger wakeup.

uint16_t timeoutValue

The timeout value that generates a wakeup event, the counter timer is incremented based on 64 times the CAN Bit Time unit.

bool enableMatch

Enable or Disable match event trigger wakeup.

flexcan_pn_match_source_t matchSrc

Selects the match source (ID and/or data match) to trigger wakeup.

uint8_t matchNum

The number of times a given message must match the predefined ID and/or data before generating a wakeup event, range in 0x1 ~ 0xFF.

flexcan_pn_match_mode_t idMatchMode

The ID match type.

flexcan_pn_match_mode_t dataMatchMode

The data match type.

uint32_t idLower

The ID target values 1 which used either for ID match “equal to”, “smaller than”, “greater than” comparisons, or as the lower limit value in ID match “range detection”.

uint32_t idUpper

The ID target values 2 which used only as the upper limit value in ID match “range detection” or used to store the ID mask in “equal to”.

uint8_t lengthLower

The lower limit for length of data bytes which used only in data match “range detection”. Range in 0x0 ~ 0x8.

uint8_t lengthUpper

The upper limit for length of data bytes which used only in data match “range detection”. Range in 0x0 ~ 0x8.

struct _flexcan_rx_fifo_config

#include <fsl_flexcan.h> FlexCAN Legacy Rx FIFO configuration structure.

Public Members

uint32_t *idFilterTable

Pointer to the FlexCAN Legacy Rx FIFO identifier filter table.

uint8_t idFilterNum

The FlexCAN Legacy Rx FIFO Filter elements quantity.

flexcan_rx_fifo_filter_type_t idFilterType

The FlexCAN Legacy Rx FIFO Filter type.

flexcan_rx_fifo_priority_t priority

The FlexCAN Legacy Rx FIFO receive priority.

struct _flexcan_mb_transfer

#include <fsl_flexcan.h> FlexCAN Message Buffer transfer.

Public Members

flexcan_frame_t *frame

The buffer of CAN Message to be transfer.

uint8_t mbIdx

The index of Message buffer used to transfer Message.

struct _flexcan_fifo_transfer

#include <fsl_flexcan.h> FlexCAN Rx FIFO transfer.

Public Members

flexcan_frame_t *frame

The buffer of CAN Message to be received from Legacy Rx FIFO.

size_t frameNum

Number of CAN Message need to be received from Legacy or Enhanced Rx FIFO.

struct _flexcan_handle

#include <fsl_flexcan.h> FlexCAN handle structure.

Public Members

flexcan_transfer_callback_t callback

Callback function.

`void *userData`

FlexCAN callback function parameter.

`flexcan_frame_t *volatile mbFrameBuf[CAN_WORD1_COUNT]`

The buffer for received CAN data from Message Buffers.

`flexcan_fd_frame_t *volatile mbFDFrameBuf[CAN_WORD1_COUNT]`

The buffer for received CAN FD data from Message Buffers.

`flexcan_frame_t *volatile rxFifoFrameBuf`

The buffer for received CAN data from Legacy Rx FIFO.

`size_t rxFifoFrameNum`

The number of CAN messages remaining to be received from Legacy or Enhanced Rx FIFO.

`size_t rxFifoTransferTotalNum`

Total CAN Message number need to be received from Legacy or Enhanced Rx FIFO.

`volatile uint8_t mbState[CAN_WORD1_COUNT]`

Message Buffer transfer state.

`volatile uint8_t rxFifoState`

Rx FIFO transfer state.

`volatile uint32_t timestamp[CAN_WORD1_COUNT]`

Mailbox transfer timestamp.

`struct byteStatus`

Public Members

`bool byteIsRead`

The byte *n* (0~3) was read or not. The type of error and which bit in byte (*n*) is affected by the error.

`struct __unnamed20__`

Public Members

`uint32_t timestamp`

FlexCAN internal Free-Running Counter Time Stamp.

`uint32_t length`

CAN frame data length in bytes (Range: 0~8).

`uint32_t type`

CAN Frame Type(DATA or REMOTE).

`uint32_t format`

CAN Frame Identifier(STD or EXT format).

`uint32_t __pad0__`

Reserved.

`uint32_t idhit`

CAN Rx FIFO filter hit id(This value is only used in Rx FIFO receive mode).

`struct __unnamed22__`

Public Members

uint32_t id

CAN Frame Identifier, should be set using FLEXCAN_ID_EXT() or FLEXCAN_ID_STD() macro.

uint32_t __pad0__

Reserved.

union __unnamed24__

Public Members

struct __flexcan__frame

struct __flexcan__frame

struct __unnamed26__

Public Members

uint32_t dataWord0

CAN Frame payload word0.

uint32_t dataWord1

CAN Frame payload word1.

struct __unnamed28__

Public Members

uint8_t dataByte3

CAN Frame payload byte3.

uint8_t dataByte2

CAN Frame payload byte2.

uint8_t dataByte1

CAN Frame payload byte1.

uint8_t dataByte0

CAN Frame payload byte0.

uint8_t dataByte7

CAN Frame payload byte7.

uint8_t dataByte6

CAN Frame payload byte6.

uint8_t dataByte5

CAN Frame payload byte5.

uint8_t dataByte4

CAN Frame payload byte4.

struct __unnamed30__

Public Members

uint32_t timestamp

FlexCAN internal Free-Running Counter Time Stamp.

uint32_t length

CAN FD frame data length code (DLC), range see `_flexcan_fd_frame_length`, When the length ≤ 8 , it equal to the data length, otherwise the number of valid frame data is not equal to the length value. user can use `DLC_LENGTH_DECODE(length)` macro to get the number of valid data bytes.

uint32_t type

CAN Frame Type(DATA only).

uint32_t format

CAN Frame Identifier(STD or EXT format).

uint32_t srr

Substitute Remote request.

uint32_t esi

Error State Indicator.

uint32_t brs

Bit Rate Switch.

uint32_t edl

Extended Data Length.

struct __unnamed32__

Public Members

uint32_t id

CAN Frame Identifier, should be set using `FLEXCAN_ID_EXT()` or `FLEXCAN_ID_STD()` macro.

uint32_t __pad0__

Reserved.

union __unnamed34__

Public Members

struct _flexcan_fd_frame

struct _flexcan_fd_frame

struct __unnamed36__

Public Members

uint32_t dataWord[16]

CAN FD Frame payload, 16 double word maximum.

struct __unnamed38__

Public Members

uint8_t dataByte3
CAN Frame payload byte3.

uint8_t dataByte2
CAN Frame payload byte2.

uint8_t dataByte1
CAN Frame payload byte1.

uint8_t dataByte0
CAN Frame payload byte0.

uint8_t dataByte7
CAN Frame payload byte7.

uint8_t dataByte6
CAN Frame payload byte6.

uint8_t dataByte5
CAN Frame payload byte5.

uint8_t dataByte4
CAN Frame payload byte4.

union __unnamed40__

Public Members

struct __flexcan__config

struct __flexcan__config

struct __unnamed42__

Public Members

uint32_t baudRate
FlexCAN bit rate in bps, for classical CAN or CANFD nominal phase.

uint32_t baudRateFD
FlexCAN FD bit rate in bps, for CANFD data phase.

struct __unnamed44__

Public Members

uint32_t bitRate
FlexCAN bit rate in bps, for classical CAN or CANFD nominal phase.

uint32_t bitRateFD
FlexCAN FD bit rate in bps, for CANFD data phase.

union __unnamed46__

Public Members

struct __flexcan_pn_config

< The data target values 1 which used either for data match “equal to”, “smaller than”, “greater than” comparisons, or as the lower limit value in data match “range detection”.

struct __flexcan_pn_config

struct ____unnamed50____

< The data target values 1 which used either for data match “equal to”, “smaller than”, “greater than” comparisons, or as the lower limit value in data match “range detection”.

Public Members

uint32_t lowerWord0

CAN Frame payload word0.

uint32_t lowerWord1

CAN Frame payload word1.

struct ____unnamed52____

Public Members

uint8_t lowerByte3

CAN Frame payload byte3.

uint8_t lowerByte2

CAN Frame payload byte2.

uint8_t lowerByte1

CAN Frame payload byte1.

uint8_t lowerByte0

CAN Frame payload byte0.

uint8_t lowerByte7

CAN Frame payload byte7.

uint8_t lowerByte6

CAN Frame payload byte6.

uint8_t lowerByte5

CAN Frame payload byte5.

uint8_t lowerByte4

CAN Frame payload byte4.

union ____unnamed48____

Public Members

struct __flexcan_pn_config

< The data target values 2 which used only as the upper limit value in data match “range detection” or used to store the data mask in “equal to”.

struct __flexcan_pn_config

struct ____unnamed54____

< The data target values 2 which used only as the upper limit value in data match “range detection” or used to store the data mask in “equal to”.

Public Members

uint32_t upperWord0

CAN Frame payload word0.

uint32_t upperWord1

CAN Frame payload word1.

struct ____unnamed56____

Public Members

uint8_t upperByte3

CAN Frame payload byte3.

uint8_t upperByte2

CAN Frame payload byte2.

uint8_t upperByte1

CAN Frame payload byte1.

uint8_t upperByte0

CAN Frame payload byte0.

uint8_t upperByte7

CAN Frame payload byte7.

uint8_t upperByte6

CAN Frame payload byte6.

uint8_t upperByte5

CAN Frame payload byte5.

uint8_t upperByte4

CAN Frame payload byte4.

2.17 GPC: General Power Controller Driver

FSL_GPC_DRIVER_VERSION

GPC driver version 2.2.0.

enum _gpc_lpm_mode

GPC LPM mode definition.

Values:

enumerator kGPC_RunMode
run mode

enumerator kGPC_WaitMode
wait mode

enumerator kGPC_StopMode
stop mode

enum _gpc_pgc_ack_sel

PGC ack signal selection

Values:

enumerator kGPC_DummyPGCPowerUpAck
dummy power up ack signal

enumerator kGPC_VirtualPGCPowerUpAck
virtual pgc power up ack signal

enumerator kGPC_DummyPGCPowerDownAck
dummy power down ack signal

enumerator kGPC_VirtualPGCPowerDownAck
virtual pgc power down ack signal

enumerator kGPC_NocPGCPowerUpAck
NOC power up ack signal

enumerator kGPC_NocPGCPowerDownAck
NOC power

enum _gpc_standby_count

Standby counter which GPC will wait between PMIC_STBY_REQ negation and assertion of PMIC_READY

Values:

enumerator kGPC_StandbyCounter4CkilClk
4 ckil clocks

enumerator kGPC_StandbyCounter8CkilClk
8 ckil clocks

enumerator kGPC_StandbyCounter16CkilClk
16 ckil clocks

enumerator kGPC_StandbyCounter32CkilClk
32 ckil clocks

enumerator kGPC_StandbyCounter64CkilClk
64 ckil clocks

enumerator kGPC_StandbyCounter128CkilClk
128 ckil clocks

enumerator kGPC_StandbyCounter256CkilClk
256 ckil clocks

enumerator kGPC_StandbyCounter512CkilClk
512 ckil clocks

typedef struct *_gpc_lpm_config* gpc_lpm_config_t
configuration for enter DSM mode

typedef struct *_gpc_dsm_config* gpc_dsm_config_t

static inline void GPC_AllowIRQs(GPC_Type *base)
Allow all the IRQ/Events within the charge of GPC.

Parameters

- base – GPC peripheral base address.

static inline void GPC_DisallowIRQs(GPC_Type *base)
Disallow all the IRQ/Events within the charge of GPC.

Parameters

- base – GPC peripheral base address.

static inline uint32_t GPC_GetLpmMode(GPC_Type *base)
Get current LPM mode.

Parameters

- base – GPC peripheral base address.

Return values

lpm – mode, reference *_gpc_lpm_mode*

void GPC_EnableIRQ(GPC_Type *base, uint32_t irqId)
Enable the IRQ.

Parameters

- base – GPC peripheral base address.
- irqId – ID number of IRQ to be enabled, available range is 0-127,reference SOC headerfile *IRQn_Type*.

void GPC_DisableIRQ(GPC_Type *base, uint32_t irqId)
Disable the IRQ.

Parameters

- base – GPC peripheral base address.
- irqId – ID number of IRQ to be disabled, available range is 0-127,reference SOC headerfile *IRQn_Type*.

bool GPC_GetIRQStatusFlag(GPC_Type *base, uint32_t irqId)
Get the IRQ/Event flag.

Parameters

- base – GPC peripheral base address.
- irqId – ID number of IRQ to be enabled, available range is 0-127,reference SOC headerfile *IRQn_Type*.

Returns

Indicated IRQ/Event is asserted or not.

static inline void GPC_DsmTriggerMask(GPC_Type *base, bool enable)
Mask the DSM trigger.

Parameters

- base – GPC peripheral base address.
- enable – true to enable mask, false to disable mask.

static inline void GPC_WFIMask(GPC_Type *base, bool enable)

Mask the WFI.

Parameters

- base – GPC peripheral base address.
- enable – true to enable mask, false to disable mask.

static inline void GPC_SelectPGCAckSignal(GPC_Type *base, uint32_t mask)

Select the PGC ACK signal.

Parameters

- base – GPC peripheral base address.
- mask – reference `_gpc_pgc_ack_sel`.

static inline void GPC_PowerDownRequestMask(GPC_Type *base, bool enable)

Power down request to virtual PGC mask or not.

Parameters

- base – GPC peripheral base address.
- enable – true to mask, false to not mask.

static inline void GPC_PGCMapping(GPC_Type *base, uint32_t mask)

PGC CPU Mapping.

Parameters

- base – GPC peripheral base address.
- mask – mask value reference PGC CPU mapping definition.

static inline void GPC_TimeSlotConfigureForPUS(GPC_Type *base, uint8_t slotIndex, uint32_t value)

Time slot configure.

Parameters

- base – GPC peripheral base address.
- slotIndex – time slot index.
- value – value to be configured

void GPC_EnterWaitMode(GPC_Type *base, *gpc_lpm_config_t* *config)

Enter WAIT mode.

Parameters

- base – GPC peripheral base address.
- config – lpm mode configurations.

void GPC_EnterStopMode(GPC_Type *base, *gpc_lpm_config_t* *config)

Enter STOP mode.

Parameters

- base – GPC peripheral base address.
- config – lpm mode configurations.

```
void GPC_Init(GPC_Type *base, uint32_t powerUpSlot, uint32_t powerDownSlot)
```

GPC init function.

Parameters

- base – GPC peripheral base address.
- powerUpSlot – power up slot number.
- powerDownSlot – power down slot number.

```
GPC_PCG_TIME_SLOT_TOTAL_NUMBER
```

Total number of the timeslot.

```
struct __gpc_lpm_config
```

```
#include <fsl_gpc.h>
```

Public Members

```
bool enFastWakeUp
```

enable fast wake up from lpm mode

```
bool enCpuClk
```

enable CPU clock when LPM enter

```
bool enVirtualPGCPowerup
```

enable virtual PGC power up with LPM enter

```
bool enVirtualPGCPowerdown
```

enable virtual PGC power down with LPM enter

```
bool enWfiMask
```

enable WFI Mask

```
bool enDsmMask
```

enable DSM Mask

```
struct __gpc_dsm_config
```

```
#include <fsl_gpc.h>
```

Public Members

```
bool disableRamLpctl
```

Memory can be defined to go to retention mode or not

```
bool enPMICStandBy
```

PMIC can be defined to be stand-by mode or not

```
uint8_t pmicStandByCounter
```

PMIC standby counter, reference `_gpc_standby_count`

```
uint8_t regBypassCounter
```

if PMIC standby is request, regulator bypass should be enable, and the counter can be defined

2.18 GPIO: General-Purpose Input/Output Driver

`void GPIO_PinInit(GPIO_Type *base, uint32_t pin, const gpio_pin_config_t *Config)`

Initializes the GPIO peripheral according to the specified parameters in the `initConfig`.

Parameters

- `base` – GPIO base pointer.
- `pin` – Specifies the pin number
- `Config` – pointer to a `gpio_pin_config_t` structure that contains the configuration information.

`void GPIO_PinWrite(GPIO_Type *base, uint32_t pin, uint8_t output)`

Sets the output level of the individual GPIO pin to logic 1 or 0.

Parameters

- `base` – GPIO base pointer.
- `pin` – GPIO port pin number.
- `output` – GPIO pin output logic level.
 - 0: corresponding pin output low-logic level.
 - 1: corresponding pin output high-logic level.

`static inline void GPIO_WritePinOutput(GPIO_Type *base, uint32_t pin, uint8_t output)`

Sets the output level of the individual GPIO pin to logic 1 or 0.

Deprecated:

Do not use this function. It has been superseded by `GPIO_PinWrite`.

`static inline void GPIO_PortSet(GPIO_Type *base, uint32_t mask)`

Sets the output level of the multiple GPIO pins to the logic 1.

Parameters

- `base` – GPIO peripheral base pointer (GPIO1, GPIO2, GPIO3, and so on.)
- `mask` – GPIO pin number macro

`static inline void GPIO_SetPinsOutput(GPIO_Type *base, uint32_t mask)`

Sets the output level of the multiple GPIO pins to the logic 1.

Deprecated:

Do not use this function. It has been superseded by `GPIO_PortSet`.

`static inline void GPIO_PortClear(GPIO_Type *base, uint32_t mask)`

Sets the output level of the multiple GPIO pins to the logic 0.

Parameters

- `base` – GPIO peripheral base pointer (GPIO1, GPIO2, GPIO3, and so on.)
- `mask` – GPIO pin number macro

`static inline void GPIO_ClearPinsOutput(GPIO_Type *base, uint32_t mask)`

Sets the output level of the multiple GPIO pins to the logic 0.

Deprecated:

Do not use this function. It has been superseded by `GPIO_PortClear`.

```
static inline void GPIO_PortToggle(GPIO_Type *base, uint32_t mask)
```

Reverses the current output logic of the multiple GPIO pins.

Parameters

- base – GPIO peripheral base pointer (GPIO1, GPIO2, GPIO3, and so on.)
- mask – GPIO pin number macro

```
static inline uint32_t GPIO_PinRead(GPIO_Type *base, uint32_t pin)
```

Reads the current input value of the GPIO port.

Parameters

- base – GPIO base pointer.
- pin – GPIO port pin number.

Return values

GPIO – port input value.

```
static inline uint32_t GPIO_ReadPinInput(GPIO_Type *base, uint32_t pin)
```

Reads the current input value of the GPIO port.

Deprecated:

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

```
static inline uint8_t GPIO_PinReadPadStatus(GPIO_Type *base, uint32_t pin)
```

Reads the current GPIO pin pad status.

Parameters

- base – GPIO base pointer.
- pin – GPIO port pin number.

Return values

GPIO – pin pad status value.

```
static inline uint8_t GPIO_ReadPadStatus(GPIO_Type *base, uint32_t pin)
```

Reads the current GPIO pin pad status.

Deprecated:

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

```
void GPIO_PinSetInterruptConfig(GPIO_Type *base, uint32_t pin, gpio_interrupt_mode_t  
                                pinInterruptMode)
```

Sets the current pin interrupt mode.

Parameters

- base – GPIO base pointer.
- pin – GPIO port pin number.
- pinInterruptMode – pointer to a gpio_interrupt_mode_t structure that contains the interrupt mode information.

```
static inline void GPIO_SetPinInterruptConfig(GPIO_Type *base, uint32_t pin,  
                                              gpio_interrupt_mode_t pinInterruptMode)
```

Sets the current pin interrupt mode.

Deprecated:

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

```
static inline void GPIO_PortEnableInterrupts(GPIO_Type *base, uint32_t mask)
```

Enables the specific pin interrupt.

Parameters

- base – GPIO base pointer.
- mask – GPIO pin number macro.

```
static inline void GPIO_EnableInterrupts(GPIO_Type *base, uint32_t mask)
```

Enables the specific pin interrupt.

Parameters

- base – GPIO base pointer.
- mask – GPIO pin number macro.

```
static inline void GPIO_PortDisableInterrupts(GPIO_Type *base, uint32_t mask)
```

Disables the specific pin interrupt.

Parameters

- base – GPIO base pointer.
- mask – GPIO pin number macro.

```
static inline void GPIO_DisableInterrupts(GPIO_Type *base, uint32_t mask)
```

Disables the specific pin interrupt.

Deprecated:

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

```
static inline uint32_t GPIO_PortGetInterruptFlags(GPIO_Type *base)
```

Reads individual pin interrupt status.

Parameters

- base – GPIO base pointer.

Return values

current – pin interrupt status flag.

```
static inline uint32_t GPIO_GetPinsInterruptFlags(GPIO_Type *base)
```

Reads individual pin interrupt status.

Parameters

- base – GPIO base pointer.

Return values

current – pin interrupt status flag.

```
static inline void GPIO_PortClearInterruptFlags(GPIO_Type *base, uint32_t mask)
```

Clears pin interrupt flag. Status flags are cleared by writing a 1 to the corresponding bit position.

Parameters

- base – GPIO base pointer.
- mask – GPIO pin number macro.

static inline void GPIO_ClearPinsInterruptFlags(GPIO_Type *base, uint32_t mask)

Clears pin interrupt flag. Status flags are cleared by writing a 1 to the corresponding bit position.

Parameters

- base – GPIO base pointer.
- mask – GPIO pin number macro.

FSL_GPIO_DRIVER_VERSION

GPIO driver version.

enum _gpio_pin_direction

GPIO direction definition.

Values:

enumerator kGPIO_DigitalInput

Set current pin as digital input.

enumerator kGPIO_DigitalOutput

Set current pin as digital output.

enum _gpio_interrupt_mode

GPIO interrupt mode definition.

Values:

enumerator kGPIO_NoIntmode

Set current pin general IO functionality.

enumerator kGPIO_IntLowLevel

Set current pin interrupt is low-level sensitive.

enumerator kGPIO_IntHighLevel

Set current pin interrupt is high-level sensitive.

enumerator kGPIO_IntRisingEdge

Set current pin interrupt is rising-edge sensitive.

enumerator kGPIO_IntFallingEdge

Set current pin interrupt is falling-edge sensitive.

enumerator kGPIO_IntRisingOrFallingEdge

Enable the edge select bit to override the ICR register's configuration.

typedef enum _gpio_pin_direction gpio_pin_direction_t

GPIO direction definition.

typedef enum _gpio_interrupt_mode gpio_interrupt_mode_t

GPIO interrupt mode definition.

typedef struct _gpio_pin_config gpio_pin_config_t

GPIO Init structure definition.

struct _gpio_pin_config

#include <fsl_gpio.h> GPIO Init structure definition.

Public Members

gpio_pin_direction_t direction

Specifies the pin direction.

uint8_t outputLogic

Set a default output logic, which has no use in input

gpio_interrupt_mode_t interruptMode

Specifies the pin interrupt mode, a value of gpio_interrupt_mode_t.

2.19 GPT: General Purpose Timer

void GPT_Init(GPT_Type *base, const gpt_config_t *initConfig)

Initialize GPT to reset state and initialize running mode.

Parameters

- base – GPT peripheral base address.
- initConfig – GPT mode setting configuration.

void GPT_Deinit(GPT_Type *base)

Disables the module and gates the GPT clock.

Parameters

- base – GPT peripheral base address.

void GPT_GetDefaultConfig(gpt_config_t *config)

Fills in the GPT configuration structure with default settings.

The default values are:

```
config->clockSource = kGPT_ClockSource_Periph;
config->divider = 1U;
config->enableRunInStop = true;
config->enableRunInWait = true;
config->enableRunInDoze = false;
config->enableRunInDbg = false;
config->enableFreeRun = false;
config->enableMode = true;
```

Parameters

- config – Pointer to the user configuration structure.

static inline void GPT_SoftwareReset(GPT_Type *base)

Software reset of GPT module.

Parameters

- base – GPT peripheral base address.

static inline void GPT_SetClockSource(GPT_Type *base, gpt_clock_source_t gptClkSource)

Set clock source of GPT.

Parameters

- base – GPT peripheral base address.
- gptClkSource – Clock source (see gpt_clock_source_t typedef enumeration).

static inline gpt_clock_source_t GPT_GetClockSource(GPT_Type *base)

Get clock source of GPT.

Parameters

- base – GPT peripheral base address.

Returns

clock source (see `gpt_clock_source_t` typedef enumeration).

static inline void `GPT_SetClockDivider(GPT_Type *base, uint32_t divider)`

Set pre scaler of GPT.

Parameters

- `base` – GPT peripheral base address.
- `divider` – Divider of GPT (1-4096).

static inline uint32_t `GPT_GetClockDivider(GPT_Type *base)`

Get clock divider in GPT module.

Parameters

- `base` – GPT peripheral base address.

Returns

clock divider in GPT module (1-4096).

static inline void `GPT_SetOscClockDivider(GPT_Type *base, uint32_t divider)`

OSC 24M pre-scaler before selected by clock source.

Parameters

- `base` – GPT peripheral base address.
- `divider` – OSC Divider(1-16).

static inline uint32_t `GPT_GetOscClockDivider(GPT_Type *base)`

Get OSC 24M clock divider in GPT module.

Parameters

- `base` – GPT peripheral base address.

Returns

OSC clock divider in GPT module (1-16).

static inline void `GPT_StartTimer(GPT_Type *base)`

Start GPT timer.

Parameters

- `base` – GPT peripheral base address.

static inline void `GPT_StopTimer(GPT_Type *base)`

Stop GPT timer.

Parameters

- `base` – GPT peripheral base address.

static inline uint32_t `GPT_GetCurrentTimerCount(GPT_Type *base)`

Reads the current GPT counting value.

Parameters

- `base` – GPT peripheral base address.

Returns

Current GPT counter value.

static inline void `GPT_SetInputOperationMode(GPT_Type *base, gpt_input_capture_channel_t channel, gpt_input_operation_mode_t mode)`

Set GPT operation mode of input capture channel.

Parameters

- `base` – GPT peripheral base address.
- `channel` – GPT capture channel (see `gpt_input_capture_channel_t` typedef enumeration).
- `mode` – GPT input capture operation mode (see `gpt_input_operation_mode_t` typedef enumeration).

```
static inline gpt_input_operation_mode_t GPT_GetInputOperationMode(GPT_Type *base,
                                                                    gpt_input_capture_channel_t
                                                                    channel)
```

Get GPT operation mode of input capture channel.

Parameters

- `base` – GPT peripheral base address.
- `channel` – GPT capture channel (see `gpt_input_capture_channel_t` typedef enumeration).

Returns

GPT input capture operation mode (see `gpt_input_operation_mode_t` typedef enumeration).

```
static inline uint32_t GPT_GetInputCaptureValue(GPT_Type *base, gpt_input_capture_channel_t
                                                channel)
```

Get GPT input capture value of certain channel.

Parameters

- `base` – GPT peripheral base address.
- `channel` – GPT capture channel (see `gpt_input_capture_channel_t` typedef enumeration).

Returns

GPT input capture value.

```
static inline void GPT_SetOutputOperationMode(GPT_Type *base,
                                              gpt_output_compare_channel_t channel,
                                              gpt_output_operation_mode_t mode)
```

Set GPT operation mode of output compare channel.

Parameters

- `base` – GPT peripheral base address.
- `channel` – GPT output compare channel (see `gpt_output_compare_channel_t` typedef enumeration).
- `mode` – GPT output operation mode (see `gpt_output_operation_mode_t` typedef enumeration).

```
static inline gpt_output_operation_mode_t GPT_GetOutputOperationMode(GPT_Type *base,
                                                                    gpt_output_compare_channel_t
                                                                    channel)
```

Get GPT operation mode of output compare channel.

Parameters

- `base` – GPT peripheral base address.
- `channel` – GPT output compare channel (see `gpt_output_compare_channel_t` typedef enumeration).

Returns

GPT output operation mode (see `gpt_output_operation_mode_t` typedef enumeration).

```
static inline void GPT_SetOutputCompareValue(GPT_Type *base, gpt_output_compare_channel_t
                                             channel, uint32_t value)
```

Set GPT output compare value of output compare channel.

Parameters

- base – GPT peripheral base address.
- channel – GPT output compare channel (see *gpt_output_compare_channel_t* typedef enumeration).
- value – GPT output compare value.

```
static inline uint32_t GPT_GetOutputCompareValue(GPT_Type *base,
                                                  gpt_output_compare_channel_t channel)
```

Get GPT output compare value of output compare channel.

Parameters

- base – GPT peripheral base address.
- channel – GPT output compare channel (see *gpt_output_compare_channel_t* typedef enumeration).

Returns

GPT output compare value.

```
static inline void GPT_ForceOutput(GPT_Type *base, gpt_output_compare_channel_t channel)
```

Force GPT output action on output compare channel, ignoring comparator.

Parameters

- base – GPT peripheral base address.
- channel – GPT output compare channel (see *gpt_output_compare_channel_t* typedef enumeration).

```
static inline void GPT_EnableInterrupts(GPT_Type *base, uint32_t mask)
```

Enables the selected GPT interrupts.

Parameters

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

```
static inline void GPT_DisableInterrupts(GPT_Type *base, uint32_t mask)
```

Disables the selected GPT interrupts.

Parameters

- base – GPT peripheral base address
- mask – The interrupts to disable. This is a logical OR of members of the enumeration *gpt_interrupt_enable_t*

```
static inline uint32_t GPT_GetEnabledInterrupts(GPT_Type *base)
```

Gets the enabled GPT interrupts.

Parameters

- base – GPT peripheral base address

Returns

The enabled interrupts. This is the logical OR of members of the enumeration *gpt_interrupt_enable_t*

static inline uint32_t GPT_GetStatusFlags(GPT_Type *base, *gpt_status_flag_t* flags)

Get GPT status flags.

Parameters

- base – GPT peripheral base address.
- flags – GPT status flag mask (see *gpt_status_flag_t* for bit definition).

Returns

GPT status, each bit represents one status flag.

static inline void GPT_ClearStatusFlags(GPT_Type *base, *gpt_status_flag_t* flags)

Clears the GPT status flags.

Parameters

- base – GPT peripheral base address.
- flags – GPT status flag mask (see *gpt_status_flag_t* for bit definition).

FSL_GPT_DRIVER_VERSION

enum *_gpt_clock_source*

List of clock sources.

Note: Actual number of clock sources is SoC dependent

Values:

enumerator kGPT_ClockSource_Off

GPT Clock Source Off.

enumerator kGPT_ClockSource_Periph

GPT Clock Source from Peripheral Clock.

enumerator kGPT_ClockSource_HighFreq

GPT Clock Source from High Frequency Reference Clock.

enumerator kGPT_ClockSource_Ext

GPT Clock Source from external pin.

enumerator kGPT_ClockSource_LowFreq

GPT Clock Source from Low Frequency Reference Clock.

enumerator kGPT_ClockSource_Osc

GPT Clock Source from Crystal oscillator.

enum *_gpt_input_capture_channel*

List of input capture channel number.

Values:

enumerator kGPT_InputCapture_Channel1

GPT Input Capture Channel1.

enumerator kGPT_InputCapture_Channel2

GPT Input Capture Channel2.

enum *_gpt_input_operation_mode*

List of input capture operation mode.

Values:

enumerator kGPT_InputOperation_Disabled
Don't capture.

enumerator kGPT_InputOperation_RiseEdge
Capture on rising edge of input pin.

enumerator kGPT_InputOperation_FallEdge
Capture on falling edge of input pin.

enumerator kGPT_InputOperation_BothEdge
Capture on both edges of input pin.

enum _gpt_output_compare_channel
List of output compare channel number.

Values:

enumerator kGPT_OutputCompare_Channel1
Output Compare Channel1.

enumerator kGPT_OutputCompare_Channel2
Output Compare Channel2.

enumerator kGPT_OutputCompare_Channel3
Output Compare Channel3.

enum _gpt_output_operation_mode
List of output compare operation mode.

Values:

enumerator kGPT_OutputOperation_Disconnected
Don't change output pin.

enumerator kGPT_OutputOperation_Toggle
Toggle output pin.

enumerator kGPT_OutputOperation_Clear
Set output pin low.

enumerator kGPT_OutputOperation_Set
Set output pin high.

enumerator kGPT_OutputOperation_Activelow
Generate a active low pulse on output pin.

enum _gpt_interrupt_enable
List of GPT interrupts.

Values:

enumerator kGPT_OutputCompare1InterruptEnable
Output Compare Channel1 interrupt enable

enumerator kGPT_OutputCompare2InterruptEnable
Output Compare Channel2 interrupt enable

enumerator kGPT_OutputCompare3InterruptEnable
Output Compare Channel3 interrupt enable

enumerator kGPT_InputCapture1InterruptEnable
Input Capture Channel1 interrupt enable

```

enumerator kGPT_InputCapture2InterruptEnable
    Input Capture Channel1 interrupt enable
enumerator kGPT_RollOverFlagInterruptEnable
    Counter rolled over interrupt enable
enum __gpt_status_flag
    Status flag.
    Values:
enumerator kGPT_OutputCompare1Flag
    Output compare channel 1 event.
enumerator kGPT_OutputCompare2Flag
    Output compare channel 2 event.
enumerator kGPT_OutputCompare3Flag
    Output compare channel 3 event.
enumerator kGPT_InputCapture1Flag
    Input Capture channel 1 event.
enumerator kGPT_InputCapture2Flag
    Input Capture channel 2 event.
enumerator kGPT_RollOverFlag
    Counter reaches maximum value and rolled over to 0 event.
typedef enum __gpt_clock_source gpt_clock_source_t
    List of clock sources.

```

Note: Actual number of clock sources is SoC dependent

```

typedef enum __gpt_input_capture_channel gpt_input_capture_channel_t
    List of input capture channel number.
typedef enum __gpt_input_operation_mode gpt_input_operation_mode_t
    List of input capture operation mode.
typedef enum __gpt_output_compare_channel gpt_output_compare_channel_t
    List of output compare channel number.
typedef enum __gpt_output_operation_mode gpt_output_operation_mode_t
    List of output compare operation mode.
typedef enum __gpt_interrupt_enable gpt_interrupt_enable_t
    List of GPT interrupts.
typedef enum __gpt_status_flag gpt_status_flag_t
    Status flag.
typedef struct __gpt_init_config gpt_config_t
    Structure to configure the running mode.
struct __gpt_init_config
    #include <fsl_gpt.h> Structure to configure the running mode.

```

Public Members

gpt_clock_source_t clockSource
clock source for GPT module.

uint32_t divider
clock divider (prescaler+1) from clock source to counter.

bool enableFreeRun
true: FreeRun mode, false: Restart mode.

bool enableRunInWait
GPT enabled in wait mode.

bool enableRunInStop
GPT enabled in stop mode.

bool enableRunInDoze
GPT enabled in doze mode.

bool enableRunInDbg
GPT enabled in debug mode.

bool enableMode
true: counter reset to 0 when enabled; false: counter retain its value when enabled.

2.20 I2C: Inter-Integrated Circuit Driver

2.21 I2C Driver

void I2C_MasterInit(I2C_Type *base, const *i2c_master_config_t* *masterConfig, uint32_t srcClock_Hz)

Initializes the I2C peripheral. Call this API to ungate the I2C clock and configure the I2C with master configuration.

Note: This API should be called at the beginning of the application. Otherwise, any operation to the I2C module can cause a hard fault because the clock is not enabled. The configuration structure can be custom filled or it can be set with default values by using the I2C_MasterGetDefaultConfig(). After calling this API, the master is ready to transfer. This is an example.

```
i2c_master_config_t config = {  
    .enableMaster = true,  
    .baudRate_Bps = 100000  
};  
I2C_MasterInit(I2C0, &config, 12000000U);
```

Parameters

- base – I2C base pointer
- masterConfig – A pointer to the master configuration structure
- srcClock_Hz – I2C peripheral clock frequency in Hz


```
void I2C_MasterDeinit(I2C_Type *base)
```

De-initializes the I2C master peripheral. Call this API to gate the I2C clock. The I2C master module can't work unless the I2C_MasterInit is called.

Parameters

- base – I2C base pointer

```
void I2C_MasterGetDefaultConfig(i2c_master_config_t *masterConfig)
```

Sets the I2C master configuration structure to default values.

The purpose of this API is to get the configuration structure initialized for use in the I2C_MasterInit(). Use the initialized structure unchanged in the I2C_MasterInit() or modify the structure before calling the I2C_MasterInit(). This is an example.

```
i2c_master_config_t config;
I2C_MasterGetDefaultConfig(&config);
```

Parameters

- masterConfig – A pointer to the master configuration structure.

```
void I2C_SlaveInit(I2C_Type *base, const i2c_slave_config_t *slaveConfig)
```

Initializes the I2C peripheral. Call this API to ungate the I2C clock and initialize the I2C with the slave configuration.

Note: This API should be called at the beginning of the application. Otherwise, any operation to the I2C module can cause a hard fault because the clock is not enabled. The configuration structure can partly be set with default values by I2C_SlaveGetDefaultConfig() or it can be custom filled by the user. This is an example.

```
i2c_slave_config_t config = {
    .enableSlave = true,
    .slaveAddress = 0x1DU,
};
I2C_SlaveInit(I2C0, &config);
```

Parameters

- base – I2C base pointer
- slaveConfig – A pointer to the slave configuration structure

```
void I2C_SlaveDeinit(I2C_Type *base)
```

De-initializes the I2C slave peripheral. Calling this API gates the I2C clock. The I2C slave module can't work unless the I2C_SlaveInit is called to enable the clock.

Parameters

- base – I2C base pointer

```
void I2C_SlaveGetDefaultConfig(i2c_slave_config_t *slaveConfig)
```

Sets the I2C slave configuration structure to default values.

The purpose of this API is to get the configuration structure initialized for use in the I2C_SlaveInit(). Modify fields of the structure before calling the I2C_SlaveInit(). This is an example.

```
i2c_slave_config_t config;
I2C_SlaveGetDefaultConfig(&config);
```

Parameters

- slaveConfig – A pointer to the slave configuration structure.

static inline void I2C__Enable(I2C_Type *base, bool enable)

Enables or disables the I2C peripheral operation.

Parameters

- base – I2C base pointer
- enable – Pass true to enable and false to disable the module.

static inline uint32_t I2C__MasterGetStatusFlags(I2C_Type *base)

Gets the I2C status flags.

Parameters

- base – I2C base pointer

Returns

status flag, use status flag to AND _i2c_flags to get the related status.

static inline void I2C__MasterClearStatusFlags(I2C_Type *base, uint32_t statusMask)

Clears the I2C status flag state.

The following status register flags can be cleared kI2C_ArbitrationLostFlag and kI2C_IntPendingFlag.

Parameters

- base – I2C base pointer
- statusMask – The status flag mask, defined in type i2c_status_flag_t. The parameter can be any combination of the following values:
 - kI2C_ArbitrationLostFlag
 - kI2C_IntPendingFlag

static inline uint32_t I2C__SlaveGetStatusFlags(I2C_Type *base)

Gets the I2C status flags.

Parameters

- base – I2C base pointer

Returns

status flag, use status flag to AND _i2c_flags to get the related status.

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 kI2C_ArbitrationLostFlag and kI2C_IntPendingFlag

Parameters

- base – I2C base pointer
- statusMask – The status flag mask, defined in type i2c_status_flag_t. The parameter can be any combination of the following values:
 - kI2C_IntPendingFlag

void I2C__EnableInterrupts(I2C_Type *base, uint32_t mask)

Enables I2C interrupt requests.

Parameters

- base – I2C base pointer

- **mask** – interrupt source The parameter can be combination of the following source if defined:
 - `kI2C_GlobalInterruptEnable`
 - `kI2C_StopDetectInterruptEnable/kI2C_StartDetectInterruptEnable`
 - `kI2C_SdaTimeoutInterruptEnable`

`void I2C_DisableInterrupts(I2C_Type *base, uint32_t mask)`

Disables I2C interrupt requests.

Parameters

- **base** – I2C base pointer
- **mask** – interrupt source The parameter can be combination of the following source if defined:
 - `kI2C_GlobalInterruptEnable`
 - `kI2C_StopDetectInterruptEnable/kI2C_StartDetectInterruptEnable`
 - `kI2C_SdaTimeoutInterruptEnable`

`void I2C_MasterSetBaudRate(I2C_Type *base, uint32_t baudRate_Bps, uint32_t srcClock_Hz)`

Sets the I2C master transfer baud rate.

Parameters

- **base** – I2C base pointer
- **baudRate_Bps** – the baud rate value in bps
- **srcClock_Hz** – Source clock

`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.

`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 uint8_t *txBuff, size_t txSize, uint32_t flags)

Performs a polling send transaction on the I2C bus.

Parameters

- base – The I2C peripheral base pointer.
- 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 decide whether need to send a stop, use kI2C_TransferDefaultFlag to issue a stop and kI2C_TransferNoStop to not send a stop.

Return values

- kStatus_Success – Successfully complete the data transmission.
- kStatus_I2C_ArbitrationLost – Transfer error, arbitration lost.
- kStatus_I2C_Nak – Transfer error, receive NAK during transfer.

status_t I2C_MasterReadBlocking(I2C_Type *base, uint8_t *rxBuff, size_t rxSize, uint32_t flags)

Performs a polling receive transaction on the I2C bus.

Note: The I2C_MasterReadBlocking function stops the bus before reading the final byte. Without stopping the bus prior for the final read, the bus issues another read, resulting in garbage data being read into the data register.

Parameters

- base – I2C peripheral base pointer.
- rxBuff – The pointer to the data to store the received data.
- rxSize – The length in bytes of the data to be received.
- flags – Transfer control flag to decide whether need to send a stop, use kI2C_TransferDefaultFlag to issue a stop and kI2C_TransferNoStop to not send a stop.

Return values

- kStatus_Success – Successfully complete the data transmission.
- kStatus_I2C_Timeout – Send stop signal failed, timeout.

status_t I2C_SlaveWriteBlocking(I2C_Type *base, const uint8_t *txBuff, size_t txSize)

Performs a polling send transaction on the I2C bus.

Parameters

- base – The I2C peripheral base pointer.
- txBuff – The pointer to the data to be transferred.
- txSize – The length in bytes of the data to be transferred.

Return values

- `kStatus_Success` – Successfully complete the data transmission.
- `kStatus_I2C_ArbitrationLost` – Transfer error, arbitration lost.
- `kStatus_I2C_Nak` – Transfer error, receive NAK during transfer.

status_t I2C_SlaveReadBlocking(I2C_Type *base, uint8_t *rxBuff, size_t rxSize)

Performs a polling receive transaction on the I2C bus.

Parameters

- `base` – I2C peripheral base pointer.
- `rxBuff` – The pointer to the data to store the received data.
- `rxSize` – The length in bytes of the data to be received.

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.
- `kStatus_I2C_Nak` – Transfer error, receive NAK during transfer.

void I2C_MasterTransferCreateHandle(I2C_Type *base, *i2c_master_handle_t* *handle,
i2c_master_transfer_callback_t callback, *void* *userData)

Initializes the I2C handle which is used in transactional functions.

Parameters

- `base` – I2C base pointer.
- `handle` – pointer to *i2c_master_handle_t* structure to store the transfer state.
- `callback` – pointer to user callback function.
- `userData` – user parameter passed to the callback function.

status_t I2C_MasterTransferNonBlocking(I2C_Type *base, *i2c_master_handle_t* *handle,
i2c_master_transfer_t *xfer)

Performs a master interrupt non-blocking transfer on the I2C bus.

Note: Calling the API returns immediately after transfer initiates. The user needs to call `I2C_MasterGetTransferCount` to poll the transfer status to check whether the transfer is finished. If the return status is not `kStatus_I2C_Busy`, the transfer is finished.

Parameters

- `base` – I2C base pointer.
- `handle` – pointer to `i2c_master_handle_t` structure which stores the transfer state.
- `xfer` – pointer to `i2c_master_transfer_t` structure.

Return values

- `kStatus_Success` – Successfully start the data transmission.
- `kStatus_I2C_Busy` – Previous transmission still not finished.
- `kStatus_I2C_Timeout` – Transfer error, wait signal timeout.

`status_t I2C_MasterTransferGetCount(I2C_Type *base, i2c_master_handle_t *handle, size_t *count)`

Gets the master transfer status during a interrupt non-blocking transfer.

Parameters

- `base` – I2C base pointer.
- `handle` – pointer to `i2c_master_handle_t` structure which stores the transfer state.
- `count` – Number of bytes transferred so far by the non-blocking transaction.

Return values

- `kStatus_InvalidArgument` – `count` is Invalid.
- `kStatus_Success` – Successfully return the count.

`status_t I2C_MasterTransferAbort(I2C_Type *base, i2c_master_handle_t *handle)`

Aborts an interrupt non-blocking transfer early.

Note: This API can be called at any time when an interrupt non-blocking transfer initiates to abort the transfer early.

Parameters

- `base` – I2C base pointer.
- `handle` – pointer to `i2c_master_handle_t` structure which stores the transfer state

Return values

- `kStatus_I2C_Timeout` – Timeout during polling flag.
- `kStatus_Success` – Successfully abort the transfer.

`void I2C_MasterTransferHandleIRQ(I2C_Type *base, void *i2cHandle)`

Master interrupt handler.

Parameters

- `base` – I2C base pointer.
- `i2cHandle` – pointer to `i2c_master_handle_t` structure.

`void I2C_SlaveTransferCreateHandle(I2C_Type *base, i2c_slave_handle_t *handle, i2c_slave_transfer_callback_t callback, void *userData)`

Initializes the I2C handle which is used in transactional functions.

Parameters

- `base` – I2C base pointer.
- `handle` – pointer to `i2c_slave_handle_t` structure to store the transfer state.
- `callback` – pointer to user callback function.
- `userData` – user parameter passed to the callback function.

`status_t I2C_SlaveTransferNonBlocking(I2C_Type *base, i2c_slave_handle_t *handle, uint32_t eventMask)`

Starts accepting slave transfers.

Call this API after calling the `I2C_SlaveInit()` and `I2C_SlaveTransferCreateHandle()` to start processing transactions driven by an I2C master. The slave monitors the I2C bus and passes events to the callback that was passed into the call to `I2C_SlaveTransferCreateHandle()`. The callback is always invoked from the interrupt context.

The set of events received by the callback is customizable. To do so, set the `eventMask` parameter to the OR'd combination of `i2c_slave_transfer_event_t` enumerators for the events you wish to receive. The `kI2C_SlaveTransmitEvent` and `kLPI2C_SlaveReceiveEvent` events are always enabled and do not need to be included in the mask. Alternatively, 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.

`void I2C_SlaveTransferAbort(I2C_Type *base, i2c_slave_handle_t *handle)`

Aborts the slave transfer.

Note: This API can be called at any time to stop slave for handling the bus events.

Parameters

- `base` – I2C base pointer.
- `handle` – pointer to `i2c_slave_handle_t` structure which stores the transfer state.

`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, void *i2cHandle)

Slave interrupt handler.

Parameters

- base – I2C base pointer.
- i2cHandle – pointer to i2c_slave_handle_t structure which stores the transfer state

FSL_I2C_DRIVER_VERSION

I2C driver version.

I2C status return codes.

Values:

enumerator kStatus_I2C_Busy

I2C is busy with current transfer.

enumerator kStatus_I2C_Idle

Bus is Idle.

enumerator kStatus_I2C_Nak

NAK received during transfer.

enumerator kStatus_I2C_ArbitrationLost

Arbitration lost during transfer.

enumerator kStatus_I2C_Timeout

Timeout polling status flags.

enumerator kStatus_I2C_Addr_Nak

NAK received during the address probe.

enum _i2c_flags

I2C peripheral flags.

The following status register flags can be cleared:

- kI2C_ArbitrationLostFlag
- kI2C_IntPendingFlag

Note: These enumerations are meant to be OR'd together to form a bit mask.

Values:

enumerator kI2C_ReceiveNakFlag

I2C receive NAK flag.

enumerator kI2C_IntPendingFlag

I2C interrupt pending flag.

enumerator kI2C_TransferDirectionFlag

I2C transfer direction flag.

enumerator kI2C_ArbitrationLostFlag

I2C arbitration lost flag.

enumerator kI2C_BusBusyFlag

I2C bus busy flag.

enumerator kI2C_AddressMatchFlag

I2C address match flag.

enumerator kI2C_TransferCompleteFlag

I2C transfer complete flag.

enum _i2c_interrupt_enable

I2C feature interrupt source.

Values:

enumerator kI2C_GlobalInterruptEnable

I2C global interrupt.

enum _i2c_direction

The direction of master and slave transfers.

Values:

enumerator kI2C_Write

Master transmits to the slave.

enumerator kI2C_Read

Master receives from the slave.

enum _i2c_master_transfer_flags

I2C transfer control flag.

Values:

enumerator kI2C_TransferDefaultFlag

A transfer starts with a start signal, stops with a stop signal.

enumerator kI2C_TransferNoStartFlag

A transfer starts without a start signal, only support write only or write+read with no start flag, do not support read only with no start flag.

enumerator kI2C_TransferRepeatedStartFlag

A transfer starts with a repeated start signal.

enumerator kI2C_TransferNoStopFlag

A transfer ends without a stop signal.

enum _i2c_slave_transfer_event

Set of events sent to the callback for nonblocking 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() 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`

A callback is requested to provide data to transmit (slave-transmitter role).

enumerator `kI2C_SlaveReceiveEvent`

A callback is requested to provide a buffer in which to place received data (slave-receiver role).

enumerator `kI2C_SlaveTransmitAckEvent`

A callback needs to either transmit an ACK or NACK.

enumerator `kI2C_SlaveCompletionEvent`

A stop was detected or finished transfer, completing the transfer.

enumerator `kI2C_SlaveAllEvents`

A bit mask of all available events.

typedef enum `_i2c_direction` `i2c_direction_t`

The direction of master and slave transfers.

typedef struct `_i2c_master_config` `i2c_master_config_t`

I2C master user configuration.

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` `status`, void *`userData`)

I2C master transfer callback typedef.

typedef struct `_i2c_master_transfer` `i2c_master_transfer_t`

I2C master transfer structure.

typedef enum `_i2c_slave_transfer_event` `i2c_slave_transfer_event_t`

Set of events sent to the callback for nonblocking 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()` 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_config` `i2c_slave_config_t`

I2C slave user configuration.

typedef struct `_i2c_slave_transfer` `i2c_slave_transfer_t`

I2C slave transfer structure.

typedef void (*`i2c_slave_transfer_callback_t`)(`I2C_Type` *`base`, `i2c_slave_transfer_t` *`xfer`, void *`userData`)

I2C slave transfer callback typedef.

`I2C_RETRY_TIMES`

Retry times for waiting flag.

struct `_i2c_master_config`

`#include <fsl_i2c.h>` I2C master user configuration.

Public Members

bool enableMaster

Enables the I2C peripheral at initialization time.

uint32_t baudRate_Bps

Baud rate configuration of I2C peripheral.

struct _i2c_master_transfer

#include <fsl_i2c.h> I2C master transfer structure.

Public Members

uint32_t flags

A transfer flag which controls the transfer.

uint8_t slaveAddress

7-bit slave address.

i2c_direction_t direction

A transfer direction, read or write.

uint32_t subaddress

A sub address. Transferred MSB first.

uint8_t subaddressSize

A size of the command buffer.

uint8_t *volatile data

A transfer buffer.

volatile size_t dataSize

A transfer size.

struct _i2c_master_handle

#include <fsl_i2c.h> I2C master handle structure.

Public Members

i2c_master_transfer_t transfer

I2C master transfer copy.

size_t transferSize

Total bytes to be transferred.

uint8_t state

A transfer state maintained during transfer.

i2c_master_transfer_callback_t completionCallback

A callback function called when the transfer is finished.

void *userData

A callback parameter passed to the callback function.

struct _i2c_slave_config

#include <fsl_i2c.h> I2C slave user configuration.

Public Members

`bool enableSlave`
Enables the I2C peripheral at initialization time.

`uint16_t slaveAddress`
A slave address configuration.

`struct __i2c_slave_transfer`
#include <fsl_i2c.h> I2C slave transfer structure.

Public Members

`i2c_slave_transfer_event_t event`
A reason that the callback is invoked.

`uint8_t *volatile data`
A transfer buffer.

`volatile size_t dataSize`
A transfer size.

`status_t completionStatus`
Success or error code describing how the transfer completed. Only applies for `kI2C_SlaveCompletionEvent`.

`size_t transferredCount`
A number of bytes actually transferred since the start or since the last repeated start.

`struct __i2c_slave_handle`
#include <fsl_i2c.h> I2C slave handle structure.

Public Members

`volatile uint8_t state`
A transfer state maintained during transfer.

`i2c_slave_transfer_t transfer`
I2C slave transfer copy.

`uint32_t eventMask`
A mask of enabled events.

`i2c_slave_transfer_callback_t callback`
A callback function called at the transfer event.

`void *userData`
A callback parameter passed to the callback.

2.22 Iomuxc_driver

```
static inline void IOMUXC_SetPinMux(uintptr_t muxRegister, uint32_t muxMode, uintptr_t
                                     inputRegister, uint32_t inputDaisy, uintptr_t
                                     configRegister, uint32_t inputOnfield)
```

Sets the IOMUXC pin mux mode.

This is an example to set the I2C4_SDA as the pwm1_OUT:

```
IOMUXC_SetPinMux(IOMUXC_I2C4_SDA_PWM1_OUT, 0);
```

Note: The first five parameters can be filled with the pin function ID macros.

Parameters

- muxRegister – The pin mux register_
- muxMode – The pin mux mode_
- inputRegister – The select input register_
- inputDaisy – The input daisy_
- configRegister – The config register_
- inputOnfield – The pad->module input inversion_

```
static inline void IOMUXC_SetPinConfig(uintptr_t muxRegister, uint32_t muxMode, uintptr_t
                                     inputRegister, uint32_t inputDaisy, uintptr_t
                                     configRegister, uint32_t configValue)
```

Sets the IOMUXC pin configuration.

This is an example to set pin configuration for IOMUXC_I2C4_SDA_PWM1_OUT:

```
IOMUXC_SetPinConfig(IOMUXC_I2C4_SDA_PWM1_OUT, IOMUXC_SW_PAD_CTL_PAD_
↳ ODE_MASK | IOMUXC0_SW_PAD_CTL_PAD_DSE(2U))
```

Note: The previous five parameters can be filled with the pin function ID macros.

Parameters

- muxRegister – The pin mux register_
- muxMode – The pin mux mode_
- inputRegister – The select input register_
- inputDaisy – The input daisy_
- configRegister – The config register_
- configValue – The pin config value_

FSL_IOMUXC_DRIVER_VERSION

IOMUXC driver version 2.0.4.

IOMUXC_BOOT_MODE0_SRC_BOOT_MODE0

IOMUXC_BOOT_MODE1_SRC_BOOT_MODE1

IOMUXC_BOOT_MODE2_SRC_BOOT_MODE2

IOMUXC_BOOT_MODE3_SRC_BOOT_MODE3

IOMUXC_JTAG_MOD_JTAG_MODE

IOMUXC_JTAG_TDI_JTAG_TDI

IOMUXC_JTAG_TMS_JTAG_TMS

IOMUXC_JTAG_TCK_JTAG_TCK
IOMUXC_JTAG_TDO_JTAG_TDO
IOMUXC_RTC_XTALI_SNVS_RTC
IOMUXC_PMIC_STBY_REQ_CCM_PMIC_STBY_REQ
IOMUXC_PMIC_ON_REQ_SNVS_PMIC_ON_REQ
IOMUXC_ONOFF_SNVS_ONOFF
IOMUXC_POR_B_SNVS_POR_B
IOMUXC_GPIO1_IO00_GPIO1_IO00
IOMUXC_GPIO1_IO00_CCM_ENET_PHY_REF_CLK_ROOT
IOMUXC_GPIO1_IO00_ISP_FL_TRIG_0
IOMUXC_GPIO1_IO00_ANAMIX_REF_CLK_32K
IOMUXC_GPIO1_IO00_CCM_EXT_CLK1
IOMUXC_GPIO1_IO01_GPIO1_IO01
IOMUXC_GPIO1_IO01_PWM1_OUT
IOMUXC_GPIO1_IO01_ISP_SHUTTER_TRIG_0
IOMUXC_GPIO1_IO01_ANAMIX_REF_CLK_24M
IOMUXC_GPIO1_IO01_CCM_EXT_CLK2
IOMUXC_GPIO1_IO02_GPIO1_IO02
IOMUXC_GPIO1_IO02_WDOG1_WDOG_B
IOMUXC_GPIO1_IO02_ISP_FLASH_TRIG_0
IOMUXC_GPIO1_IO02_WDOG1_WDOG_ANY
IOMUXC_GPIO1_IO02_SJC_DE_B
IOMUXC_GPIO1_IO03_GPIO1_IO03
IOMUXC_GPIO1_IO03_USDHC1_VSELECT
IOMUXC_GPIO1_IO03_ISP_PRELIGHT_TRIG_0
IOMUXC_GPIO1_IO03_SDMA1_EXT_EVENT0
IOMUXC_GPIO1_IO04_GPIO1_IO04
IOMUXC_GPIO1_IO04_USDHC2_VSELECT
IOMUXC_GPIO1_IO04_ISP_SHUTTER_OPEN_0
IOMUXC_GPIO1_IO04_SDMA1_EXT_EVENT1
IOMUXC_GPIO1_IO05_GPIO1_IO05
IOMUXC_GPIO1_IO05_M7_NMI
IOMUXC_GPIO1_IO05_ISP_FL_TRIG_1

IOMUXC_GPIO1_IO05_CCM_PMIC_READY
IOMUXC_GPIO1_IO06_GPIO1_IO06
IOMUXC_GPIO1_IO06_ENET_QOS_MDC
IOMUXC_GPIO1_IO06_ISP_SHUTTER_TRIG_1
IOMUXC_GPIO1_IO06_USDHC1_CD_B
IOMUXC_GPIO1_IO06_CCM_EXT_CLK3
IOMUXC_GPIO1_IO07_GPIO1_IO07
IOMUXC_GPIO1_IO07_ENET_QOS_MDIO
IOMUXC_GPIO1_IO07_ISP_FLASH_TRIG_1
IOMUXC_GPIO1_IO07_USDHC1_WP
IOMUXC_GPIO1_IO07_CCM_EXT_CLK4
IOMUXC_GPIO1_IO08_GPIO1_IO08
IOMUXC_GPIO1_IO08_ENET_QOS_1588_EVENT0_IN
IOMUXC_GPIO1_IO08_PWM1_OUT
IOMUXC_GPIO1_IO08_ISP_PRELIGHT_TRIG_1
IOMUXC_GPIO1_IO08_ENET_QOS_1588_EVENT0_AUX_IN
IOMUXC_GPIO1_IO08_USDHC2_RESET_B
IOMUXC_GPIO1_IO09_GPIO1_IO09
IOMUXC_GPIO1_IO09_ENET_QOS_1588_EVENT0_OUT
IOMUXC_GPIO1_IO09_PWM2_OUT
IOMUXC_GPIO1_IO09_ISP_SHUTTER_OPEN_1
IOMUXC_GPIO1_IO09_USDHC3_RESET_B
IOMUXC_GPIO1_IO09_SDMA2_EXT_EVENT0
IOMUXC_GPIO1_IO10_GPIO1_IO10
IOMUXC_GPIO1_IO10_USB1_ID
IOMUXC_GPIO1_IO10_PWM3_OUT
IOMUXC_GPIO1_IO11_GPIO1_IO11
IOMUXC_GPIO1_IO11_USB2_ID
IOMUXC_GPIO1_IO11_PWM2_OUT
IOMUXC_GPIO1_IO11_USDHC3_VSELECT
IOMUXC_GPIO1_IO11_CCM_PMIC_READY
IOMUXC_GPIO1_IO12_GPIO1_IO12
IOMUXC_GPIO1_IO12_USB1_PWR

IOMUXC_GPIO1_IO12_SDMA2_EXT_EVENT1
IOMUXC_GPIO1_IO13_GPIO1_IO13
IOMUXC_GPIO1_IO13_USB1_OC
IOMUXC_GPIO1_IO13_PWM2_OUT
IOMUXC_GPIO1_IO14_GPIO1_IO14
IOMUXC_GPIO1_IO14_USB2_PWR
IOMUXC_GPIO1_IO14_USDHC3_CD_B
IOMUXC_GPIO1_IO14_PWM3_OUT
IOMUXC_GPIO1_IO14_CCM_CLKO1
IOMUXC_GPIO1_IO15_GPIO1_IO15
IOMUXC_GPIO1_IO15_USB2_OC
IOMUXC_GPIO1_IO15_USDHC3_WP
IOMUXC_GPIO1_IO15_PWM4_OUT
IOMUXC_GPIO1_IO15_CCM_CLKO2
IOMUXC_ENET_MDC_ENET_QOS_MDC
IOMUXC_ENET_MDC_AUDIOMIX_SAI6_TX_DATA0
IOMUXC_ENET_MDC_GPIO1_IO16
IOMUXC_ENET_MDC_USDHC3_STROBE
IOMUXC_ENET_MDIO_ENET_QOS_MDIO
IOMUXC_ENET_MDIO_AUDIOMIX_SAI6_TX_SYNC
IOMUXC_ENET_MDIO_AUDIOMIX_PDM_BIT_STREAM3
IOMUXC_ENET_MDIO_GPIO1_IO17
IOMUXC_ENET_MDIO_USDHC3_DATA5
IOMUXC_ENET_TD3_ENET_QOS_RGMII_TD3
IOMUXC_ENET_TD3_AUDIOMIX_SAI6_TX_BCLK
IOMUXC_ENET_TD3_AUDIOMIX_PDM_BIT_STREAM2
IOMUXC_ENET_TD3_GPIO1_IO18
IOMUXC_ENET_TD3_USDHC3_DATA6
IOMUXC_ENET_TD2_ENET_QOS_RGMII_TD2
IOMUXC_ENET_TD2_CCM_ENET_QOS_CLOCK_GENERATE_REF_CLK
IOMUXC_ENET_TD2_AUDIOMIX_SAI6_RX_DATA0
IOMUXC_ENET_TD2_AUDIOMIX_PDM_BIT_STREAM1
IOMUXC_ENET_TD2_GPIO1_IO19

IOMUXC_ENET_TD2_USDHC3_DATA7
IOMUXC_ENET_TD1_ENET_QOS_RGMII_TD1
IOMUXC_ENET_TD1_AUDIOMIX_SAI6_RX_SYNC
IOMUXC_ENET_TD1_AUDIOMIX_PDM_BIT_STREAM0
IOMUXC_ENET_TD1_GPIO1_IO20
IOMUXC_ENET_TD1_USDHC3_CD_B
IOMUXC_ENET_TD0_ENET_QOS_RGMII_TD0
IOMUXC_ENET_TD0_AUDIOMIX_SAI6_RX_BCLK
IOMUXC_ENET_TD0_AUDIOMIX_PDM_CLK
IOMUXC_ENET_TD0_GPIO1_IO21
IOMUXC_ENET_TD0_USDHC3_WP
IOMUXC_ENET_TX_CTL_ENET_QOS_RGMII_TX_CTL
IOMUXC_ENET_TX_CTL_AUDIOMIX_SAI6_MCLK
IOMUXC_ENET_TX_CTL_AUDIOMIX_SPDIF1_OUT
IOMUXC_ENET_TX_CTL_GPIO1_IO22
IOMUXC_ENET_TX_CTL_USDHC3_DATA0
IOMUXC_ENET_TXC_CCM_ENET_QOS_CLOCK_GENERATE_TX_CLK
IOMUXC_ENET_TXC_ENET_QOS_TX_ER
IOMUXC_ENET_TXC_AUDIOMIX_SAI7_TX_DATA0
IOMUXC_ENET_TXC_GPIO1_IO23
IOMUXC_ENET_TXC_USDHC3_DATA1
IOMUXC_ENET_RX_CTL_ENET_QOS_RGMII_RX_CTL
IOMUXC_ENET_RX_CTL_AUDIOMIX_SAI7_TX_SYNC
IOMUXC_ENET_RX_CTL_AUDIOMIX_PDM_BIT_STREAM3
IOMUXC_ENET_RX_CTL_GPIO1_IO24
IOMUXC_ENET_RX_CTL_USDHC3_DATA2
IOMUXC_ENET_RXC_CCM_ENET_QOS_CLOCK_GENERATE_RX_CLK
IOMUXC_ENET_RXC_ENET_QOS_RX_ER
IOMUXC_ENET_RXC_AUDIOMIX_SAI7_TX_BCLK
IOMUXC_ENET_RXC_AUDIOMIX_PDM_BIT_STREAM2
IOMUXC_ENET_RXC_GPIO1_IO25
IOMUXC_ENET_RXC_USDHC3_DATA3
IOMUXC_ENET_RD0_ENET_QOS_RGMII_RD0

IOMUXC_ENET_RD0_AUDIOMIX_SAI7_RX_DATA0
IOMUXC_ENET_RD0_AUDIOMIX_PDM_BIT_STREAM1
IOMUXC_ENET_RD0_GPIO1_IO26
IOMUXC_ENET_RD0_USDHC3_DATA4
IOMUXC_ENET_RD1_ENET_QOS_RGMII_RD1
IOMUXC_ENET_RD1_AUDIOMIX_SAI7_RX_SYNC
IOMUXC_ENET_RD1_AUDIOMIX_PDM_BIT_STREAM0
IOMUXC_ENET_RD1_GPIO1_IO27
IOMUXC_ENET_RD1_USDHC3_RESET_B
IOMUXC_ENET_RD2_ENET_QOS_RGMII_RD2
IOMUXC_ENET_RD2_AUDIOMIX_SAI7_RX_BCLK
IOMUXC_ENET_RD2_AUDIOMIX_PDM_CLK
IOMUXC_ENET_RD2_GPIO1_IO28
IOMUXC_ENET_RD2_USDHC3_CLK
IOMUXC_ENET_RD3_ENET_QOS_RGMII_RD3
IOMUXC_ENET_RD3_AUDIOMIX_SAI7_MCLK
IOMUXC_ENET_RD3_AUDIOMIX_SPDIF1_IN
IOMUXC_ENET_RD3_GPIO1_IO29
IOMUXC_ENET_RD3_USDHC3_CMD
IOMUXC_SD1_CLK_USDHC1_CLK
IOMUXC_SD1_CLK_ENET1_MDC
IOMUXC_SD1_CLK_I2C5_SCL
IOMUXC_SD1_CLK_UART1_TX
IOMUXC_SD1_CLK_UART1_RX
IOMUXC_SD1_CLK_GPIO2_IO00
IOMUXC_SD1_CMD_USDHC1_CMD
IOMUXC_SD1_CMD_ENET1_MDIO
IOMUXC_SD1_CMD_I2C5_SDA
IOMUXC_SD1_CMD_UART1_RX
IOMUXC_SD1_CMD_UART1_TX
IOMUXC_SD1_CMD_GPIO2_IO01
IOMUXC_SD1_DATA0_USDHC1_DATA0
IOMUXC_SD1_DATA0_ENET1_RGMII_TD1

IOMUXC_SD1_DATA0_I2C6_SCL
IOMUXC_SD1_DATA0_UART1_RTS_B
IOMUXC_SD1_DATA0_UART1_CTS_B
IOMUXC_SD1_DATA0_GPIO2_IO02
IOMUXC_SD1_DATA1_USDHC1_DATA1
IOMUXC_SD1_DATA1_ENET1_RGMII_TD0
IOMUXC_SD1_DATA1_I2C6_SDA
IOMUXC_SD1_DATA1_UART1_CTS_B
IOMUXC_SD1_DATA1_UART1_RTS_B
IOMUXC_SD1_DATA1_GPIO2_IO03
IOMUXC_SD1_DATA2_USDHC1_DATA2
IOMUXC_SD1_DATA2_ENET1_RGMII_RD0
IOMUXC_SD1_DATA2_I2C4_SCL
IOMUXC_SD1_DATA2_UART2_TX
IOMUXC_SD1_DATA2_UART2_RX
IOMUXC_SD1_DATA2_GPIO2_IO04
IOMUXC_SD1_DATA3_USDHC1_DATA3
IOMUXC_SD1_DATA3_ENET1_RGMII_RD1
IOMUXC_SD1_DATA3_I2C4_SDA
IOMUXC_SD1_DATA3_UART2_RX
IOMUXC_SD1_DATA3_UART2_TX
IOMUXC_SD1_DATA3_GPIO2_IO05
IOMUXC_SD1_DATA4_USDHC1_DATA4
IOMUXC_SD1_DATA4_ENET1_RGMII_TX_CTL
IOMUXC_SD1_DATA4_I2C1_SCL
IOMUXC_SD1_DATA4_UART2_RTS_B
IOMUXC_SD1_DATA4_UART2_CTS_B
IOMUXC_SD1_DATA4_GPIO2_IO06
IOMUXC_SD1_DATA5_USDHC1_DATA5
IOMUXC_SD1_DATA5_ENET1_TX_ER
IOMUXC_SD1_DATA5_I2C1_SDA
IOMUXC_SD1_DATA5_UART2_CTS_B
IOMUXC_SD1_DATA5_UART2_RTS_B

IOMUXC_SD1_DATA5_GPIO2_IO07
IOMUXC_SD1_DATA6_USDHC1_DATA6
IOMUXC_SD1_DATA6_ENET1_RGMII_RX_CTL
IOMUXC_SD1_DATA6_I2C2_SCL
IOMUXC_SD1_DATA6_UART3_TX
IOMUXC_SD1_DATA6_UART3_RX
IOMUXC_SD1_DATA6_GPIO2_IO08
IOMUXC_SD1_DATA7_USDHC1_DATA7
IOMUXC_SD1_DATA7_ENET1_RX_ER
IOMUXC_SD1_DATA7_I2C2_SDA
IOMUXC_SD1_DATA7_UART3_RX
IOMUXC_SD1_DATA7_UART3_TX
IOMUXC_SD1_DATA7_GPIO2_IO09
IOMUXC_SD1_RESET_B_USDHC1_RESET_B
IOMUXC_SD1_RESET_B_ENET1_TX_CLK
IOMUXC_SD1_RESET_B_I2C3_SCL
IOMUXC_SD1_RESET_B_UART3_RTS_B
IOMUXC_SD1_RESET_B_UART3_CTS_B
IOMUXC_SD1_RESET_B_GPIO2_IO10
IOMUXC_SD1_STROBE_USDHC1_STROBE
IOMUXC_SD1_STROBE_I2C3_SDA
IOMUXC_SD1_STROBE_UART3_CTS_B
IOMUXC_SD1_STROBE_UART3_RTS_B
IOMUXC_SD1_STROBE_GPIO2_IO11
IOMUXC_SD2_CD_B_USDHC2_CD_B
IOMUXC_SD2_CD_B_GPIO2_IO12
IOMUXC_SD2_CLK_USDHC2_CLK
IOMUXC_SD2_CLK_ECSPi2_SCLK
IOMUXC_SD2_CLK_UART4_RX
IOMUXC_SD2_CLK_UART4_TX
IOMUXC_SD2_CLK_GPIO2_IO13
IOMUXC_SD2_CMD_USDHC2_CMD
IOMUXC_SD2_CMD_ECSPi2_MOSI

IOMUXC_SD2_CMD_UART4_TX
IOMUXC_SD2_CMD_UART4_RX
IOMUXC_SD2_CMD_AUDIOMIX_PDM_CLK
IOMUXC_SD2_CMD_GPIO2_IO14
IOMUXC_SD2_DATA0_USDHC2_DATA0
IOMUXC_SD2_DATA0_I2C4_SDA
IOMUXC_SD2_DATA0_UART2_RX
IOMUXC_SD2_DATA0_UART2_TX
IOMUXC_SD2_DATA0_AUDIOMIX_PDM_BIT_STREAM0
IOMUXC_SD2_DATA0_GPIO2_IO15
IOMUXC_SD2_DATA1_USDHC2_DATA1
IOMUXC_SD2_DATA1_I2C4_SCL
IOMUXC_SD2_DATA1_UART2_TX
IOMUXC_SD2_DATA1_UART2_RX
IOMUXC_SD2_DATA1_AUDIOMIX_PDM_BIT_STREAM1
IOMUXC_SD2_DATA1_GPIO2_IO16
IOMUXC_SD2_DATA2_USDHC2_DATA2
IOMUXC_SD2_DATA2_ECSPi2_SS0
IOMUXC_SD2_DATA2_AUDIOMIX_SPDIF1_OUT
IOMUXC_SD2_DATA2_AUDIOMIX_PDM_BIT_STREAM2
IOMUXC_SD2_DATA2_GPIO2_IO17
IOMUXC_SD2_DATA3_USDHC2_DATA3
IOMUXC_SD2_DATA3_ECSPi2_MISO
IOMUXC_SD2_DATA3_AUDIOMIX_SPDIF1_IN
IOMUXC_SD2_DATA3_AUDIOMIX_PDM_BIT_STREAM3
IOMUXC_SD2_DATA3_GPIO2_IO18
IOMUXC_SD2_RESET_B_USDHC2_RESET_B
IOMUXC_SD2_RESET_B_GPIO2_IO19
IOMUXC_SD2_WP_USDHC2_WP
IOMUXC_SD2_WP_GPIO2_IO20
IOMUXC_SD2_WP_CORESIGHT_EVENTI
IOMUXC_NAND_ALE_NAND_ALE
IOMUXC_NAND_ALE_FLEXPi_A_SCLK

IOMUXC_NAND_ALE_AUDIOMIX_SAI3_TX_BCLK
IOMUXC_NAND_ALE_ISP_FL_TRIG_0
IOMUXC_NAND_ALE_UART3_RX
IOMUXC_NAND_ALE_UART3_TX
IOMUXC_NAND_ALE_GPIO3_IO00
IOMUXC_NAND_ALE_CORESIGHT_TRACE_CLK
IOMUXC_NAND_CE0_B_NAND_CE0_B
IOMUXC_NAND_CE0_B_FLEXSPI_A_SS0_B
IOMUXC_NAND_CE0_B_AUDIOMIX_SAI3_TX_DATA0
IOMUXC_NAND_CE0_B_ISP_SHUTTER_TRIG_0
IOMUXC_NAND_CE0_B_UART3_TX
IOMUXC_NAND_CE0_B_UART3_RX
IOMUXC_NAND_CE0_B_GPIO3_IO01
IOMUXC_NAND_CE0_B_CORESIGHT_TRACE_CTL
IOMUXC_NAND_CE1_B_NAND_CE1_B
IOMUXC_NAND_CE1_B_FLEXSPI_A_SS1_B
IOMUXC_NAND_CE1_B_USDHC3_STROBE
IOMUXC_NAND_CE1_B_I2C4_SCL
IOMUXC_NAND_CE1_B_GPIO3_IO02
IOMUXC_NAND_CE1_B_CORESIGHT_TRACE00
IOMUXC_NAND_CE2_B_NAND_CE2_B
IOMUXC_NAND_CE2_B_FLEXSPI_B_SS0_B
IOMUXC_NAND_CE2_B_USDHC3_DATA5
IOMUXC_NAND_CE2_B_I2C4_SDA
IOMUXC_NAND_CE2_B_GPIO3_IO03
IOMUXC_NAND_CE2_B_CORESIGHT_TRACE01
IOMUXC_NAND_CE3_B_NAND_CE3_B
IOMUXC_NAND_CE3_B_FLEXSPI_B_SS1_B
IOMUXC_NAND_CE3_B_USDHC3_DATA6
IOMUXC_NAND_CE3_B_I2C3_SDA
IOMUXC_NAND_CE3_B_GPIO3_IO04
IOMUXC_NAND_CE3_B_CORESIGHT_TRACE02
IOMUXC_NAND_CLE_NAND_CLE

IOMUXC_NAND_CLE_FLEXSPI_B_SCLK
IOMUXC_NAND_CLE_USDHC3_DATA7
IOMUXC_NAND_CLE_UART4_RX
IOMUXC_NAND_CLE_UART4_TX
IOMUXC_NAND_CLE_GPIO3_IO05
IOMUXC_NAND_CLE_CORESIGHT_TRACE03
IOMUXC_NAND_DATA00_NAND_DATA00
IOMUXC_NAND_DATA00_FLEXSPI_A_DATA0
IOMUXC_NAND_DATA00_AUDIOMIX_SAI3_RX_DATA0
IOMUXC_NAND_DATA00_ISP_FLASH_TRIG_0
IOMUXC_NAND_DATA00_UART4_RX
IOMUXC_NAND_DATA00_UART4_TX
IOMUXC_NAND_DATA00_GPIO3_IO06
IOMUXC_NAND_DATA00_CORESIGHT_TRACE04
IOMUXC_NAND_DATA01_NAND_DATA01
IOMUXC_NAND_DATA01_FLEXSPI_A_DATA1
IOMUXC_NAND_DATA01_AUDIOMIX_SAI3_TX_SYNC
IOMUXC_NAND_DATA01_ISP_PRELIGHT_TRIG_0
IOMUXC_NAND_DATA01_UART4_TX
IOMUXC_NAND_DATA01_UART4_RX
IOMUXC_NAND_DATA01_GPIO3_IO07
IOMUXC_NAND_DATA01_CORESIGHT_TRACE05
IOMUXC_NAND_DATA02_NAND_DATA02
IOMUXC_NAND_DATA02_FLEXSPI_A_DATA2
IOMUXC_NAND_DATA02_USDHC3_CD_B
IOMUXC_NAND_DATA02_UART4_CTS_B
IOMUXC_NAND_DATA02_UART4_RTS_B
IOMUXC_NAND_DATA02_I2C4_SDA
IOMUXC_NAND_DATA02_GPIO3_IO08
IOMUXC_NAND_DATA02_CORESIGHT_TRACE06
IOMUXC_NAND_DATA03_NAND_DATA03
IOMUXC_NAND_DATA03_FLEXSPI_A_DATA3
IOMUXC_NAND_DATA03_USDHC3_WP

IOMUXC_NAND_DATA03_UART4_RTS_B
IOMUXC_NAND_DATA03_UART4_CTS_B
IOMUXC_NAND_DATA03_ISP_FL_TRIG_1
IOMUXC_NAND_DATA03_GPIO3_IO09
IOMUXC_NAND_DATA03_CORESIGHT_TRACE07
IOMUXC_NAND_DATA04_NAND_DATA04
IOMUXC_NAND_DATA04_FLEXSPI_B_DATA0
IOMUXC_NAND_DATA04_USDHC3_DATA0
IOMUXC_NAND_DATA04_FLEXSPI_A_DATA4
IOMUXC_NAND_DATA04_ISP_SHUTTER_TRIG_1
IOMUXC_NAND_DATA04_GPIO3_IO10
IOMUXC_NAND_DATA04_CORESIGHT_TRACE08
IOMUXC_NAND_DATA05_NAND_DATA05
IOMUXC_NAND_DATA05_FLEXSPI_B_DATA1
IOMUXC_NAND_DATA05_USDHC3_DATA1
IOMUXC_NAND_DATA05_FLEXSPI_A_DATA5
IOMUXC_NAND_DATA05_ISP_FLASH_TRIG_1
IOMUXC_NAND_DATA05_GPIO3_IO11
IOMUXC_NAND_DATA05_CORESIGHT_TRACE09
IOMUXC_NAND_DATA06_NAND_DATA06
IOMUXC_NAND_DATA06_FLEXSPI_B_DATA2
IOMUXC_NAND_DATA06_USDHC3_DATA2
IOMUXC_NAND_DATA06_FLEXSPI_A_DATA6
IOMUXC_NAND_DATA06_ISP_PRELIGHT_TRIG_1
IOMUXC_NAND_DATA06_GPIO3_IO12
IOMUXC_NAND_DATA06_CORESIGHT_TRACE10
IOMUXC_NAND_DATA07_NAND_DATA07
IOMUXC_NAND_DATA07_FLEXSPI_B_DATA3
IOMUXC_NAND_DATA07_USDHC3_DATA3
IOMUXC_NAND_DATA07_FLEXSPI_A_DATA7
IOMUXC_NAND_DATA07_ISP_SHUTTER_OPEN_1
IOMUXC_NAND_DATA07_GPIO3_IO13
IOMUXC_NAND_DATA07_CORESIGHT_TRACE11

IOMUXC_NAND_DQS_NAND_DQS
IOMUXC_NAND_DQS_FLEXSPI_A_DQS
IOMUXC_NAND_DQS_AUDIOMIX_SAI3_MCLK
IOMUXC_NAND_DQS_ISP_SHUTTER_OPEN_0
IOMUXC_NAND_DQS_I2C3_SCL
IOMUXC_NAND_DQS_GPIO3_IO14
IOMUXC_NAND_DQS_CORESIGHT_TRACE12
IOMUXC_NAND_RE_B_NAND_RE_B
IOMUXC_NAND_RE_B_FLEXSPI_B_DQS
IOMUXC_NAND_RE_B_USDHC3_DATA4
IOMUXC_NAND_RE_B_UART4_TX
IOMUXC_NAND_RE_B_UART4_RX
IOMUXC_NAND_RE_B_GPIO3_IO15
IOMUXC_NAND_RE_B_CORESIGHT_TRACE13
IOMUXC_NAND_READY_B_NAND_READY_B
IOMUXC_NAND_READY_B_USDHC3_RESET_B
IOMUXC_NAND_READY_B_I2C3_SCL
IOMUXC_NAND_READY_B_GPIO3_IO16
IOMUXC_NAND_READY_B_CORESIGHT_TRACE14
IOMUXC_NAND_WE_B_NAND_WE_B
IOMUXC_NAND_WE_B_USDHC3_CLK
IOMUXC_NAND_WE_B_I2C3_SDA
IOMUXC_NAND_WE_B_GPIO3_IO17
IOMUXC_NAND_WE_B_CORESIGHT_TRACE15
IOMUXC_NAND_WP_B_NAND_WP_B
IOMUXC_NAND_WP_B_USDHC3_CMD
IOMUXC_NAND_WP_B_I2C4_SCL
IOMUXC_NAND_WP_B_GPIO3_IO18
IOMUXC_NAND_WP_B_CORESIGHT_EVENTO
IOMUXC_SAI5_RXFS_AUDIOMIX_SAI5_RX_SYNC
IOMUXC_SAI5_RXFS_AUDIOMIX_SAI1_TX_DATA0
IOMUXC_SAI5_RXFS_PWM4_OUT
IOMUXC_SAI5_RXFS_I2C6_SCL

IOMUXC_SAI5_RXFS_GPIO3_IO19
IOMUXC_SAI5_RXC_AUDIOMIX_SAI5_RX_BCLK
IOMUXC_SAI5_RXC_AUDIOMIX_SAI1_TX_DATA1
IOMUXC_SAI5_RXC_PWM3_OUT
IOMUXC_SAI5_RXC_I2C6_SDA
IOMUXC_SAI5_RXC_AUDIOMIX_PDM_CLK
IOMUXC_SAI5_RXC_GPIO3_IO20
IOMUXC_SAI5_RXD0_AUDIOMIX_SAI5_RX_DATA0
IOMUXC_SAI5_RXD0_AUDIOMIX_SAI1_TX_DATA2
IOMUXC_SAI5_RXD0_PWM2_OUT
IOMUXC_SAI5_RXD0_I2C5_SCL
IOMUXC_SAI5_RXD0_AUDIOMIX_PDM_BIT_STREAM0
IOMUXC_SAI5_RXD0_GPIO3_IO21
IOMUXC_SAI5_RXD1_AUDIOMIX_SAI5_RX_DATA1
IOMUXC_SAI5_RXD1_AUDIOMIX_SAI1_TX_DATA3
IOMUXC_SAI5_RXD1_AUDIOMIX_SAI1_TX_SYNC
IOMUXC_SAI5_RXD1_AUDIOMIX_SAI5_TX_SYNC
IOMUXC_SAI5_RXD1_AUDIOMIX_PDM_BIT_STREAM1
IOMUXC_SAI5_RXD1_GPIO3_IO22
IOMUXC_SAI5_RXD1_CAN1_TX
IOMUXC_SAI5_RXD2_AUDIOMIX_SAI5_RX_DATA2
IOMUXC_SAI5_RXD2_AUDIOMIX_SAI1_TX_DATA4
IOMUXC_SAI5_RXD2_AUDIOMIX_SAI1_TX_SYNC
IOMUXC_SAI5_RXD2_AUDIOMIX_SAI5_TX_BCLK
IOMUXC_SAI5_RXD2_AUDIOMIX_PDM_BIT_STREAM2
IOMUXC_SAI5_RXD2_GPIO3_IO23
IOMUXC_SAI5_RXD2_CAN1_RX
IOMUXC_SAI5_RXD3_AUDIOMIX_SAI5_RX_DATA3
IOMUXC_SAI5_RXD3_AUDIOMIX_SAI1_TX_DATA5
IOMUXC_SAI5_RXD3_AUDIOMIX_SAI1_TX_SYNC
IOMUXC_SAI5_RXD3_AUDIOMIX_SAI5_TX_DATA0
IOMUXC_SAI5_RXD3_AUDIOMIX_PDM_BIT_STREAM3
IOMUXC_SAI5_RXD3_GPIO3_IO24

IOMUXC_SAI5_RXD3_CAN2_TX
IOMUXC_SAI5_MCLK_AUDIOMIX_SAI5_MCLK
IOMUXC_SAI5_MCLK_AUDIOMIX_SAI1_TX_BCLK
IOMUXC_SAI5_MCLK_PWM1_OUT
IOMUXC_SAI5_MCLK_I2C5_SDA
IOMUXC_SAI5_MCLK_GPIO3_IO25
IOMUXC_SAI5_MCLK_CAN2_RX
IOMUXC_SAI1_RXFS_AUDIOMIX_SAI1_RX_SYNC
IOMUXC_SAI1_RXFS_ENET1_1588_EVENT0_IN
IOMUXC_SAI1_RXFS_GPIO4_IO00
IOMUXC_SAI1_RXC_AUDIOMIX_SAI1_RX_BCLK
IOMUXC_SAI1_RXC_AUDIOMIX_PDM_CLK
IOMUXC_SAI1_RXC_ENET1_1588_EVENT0_OUT
IOMUXC_SAI1_RXC_GPIO4_IO01
IOMUXC_SAI1_RXD0_AUDIOMIX_SAI1_RX_DATA0
IOMUXC_SAI1_RXD0_AUDIOMIX_SAI1_TX_DATA1
IOMUXC_SAI1_RXD0_AUDIOMIX_PDM_BIT_STREAM0
IOMUXC_SAI1_RXD0_ENET1_1588_EVENT1_IN
IOMUXC_SAI1_RXD0_GPIO4_IO02
IOMUXC_SAI1_RXD1_AUDIOMIX_SAI1_RX_DATA1
IOMUXC_SAI1_RXD1_AUDIOMIX_PDM_BIT_STREAM1
IOMUXC_SAI1_RXD1_ENET1_1588_EVENT1_OUT
IOMUXC_SAI1_RXD1_GPIO4_IO03
IOMUXC_SAI1_RXD2_AUDIOMIX_SAI1_RX_DATA2
IOMUXC_SAI1_RXD2_AUDIOMIX_PDM_BIT_STREAM2
IOMUXC_SAI1_RXD2_ENET1_MDC
IOMUXC_SAI1_RXD2_GPIO4_IO04
IOMUXC_SAI1_RXD3_AUDIOMIX_SAI1_RX_DATA3
IOMUXC_SAI1_RXD3_AUDIOMIX_PDM_BIT_STREAM3
IOMUXC_SAI1_RXD3_ENET1_MDIO
IOMUXC_SAI1_RXD3_GPIO4_IO05
IOMUXC_SAI1_RXD4_AUDIOMIX_SAI1_RX_DATA4
IOMUXC_SAI1_RXD4_AUDIOMIX_SAI6_TX_BCLK

IOMUXC_SAI1_RXD4_AUDIOMIX_SAI6_RX_BCLK
IOMUXC_SAI1_RXD4_ENET1_RGMII_RD0
IOMUXC_SAI1_RXD4_GPIO4_IO06
IOMUXC_SAI1_RXD5_AUDIOMIX_SAI1_RX_DATA5
IOMUXC_SAI1_RXD5_AUDIOMIX_SAI6_TX_DATA0
IOMUXC_SAI1_RXD5_AUDIOMIX_SAI6_RX_DATA0
IOMUXC_SAI1_RXD5_AUDIOMIX_SAI1_RX_SYNC
IOMUXC_SAI1_RXD5_ENET1_RGMII_RD1
IOMUXC_SAI1_RXD5_GPIO4_IO07
IOMUXC_SAI1_RXD6_AUDIOMIX_SAI1_RX_DATA6
IOMUXC_SAI1_RXD6_AUDIOMIX_SAI6_TX_SYNC
IOMUXC_SAI1_RXD6_AUDIOMIX_SAI6_RX_SYNC
IOMUXC_SAI1_RXD6_ENET1_RGMII_RD2
IOMUXC_SAI1_RXD6_GPIO4_IO08
IOMUXC_SAI1_RXD7_AUDIOMIX_SAI1_RX_DATA7
IOMUXC_SAI1_RXD7_AUDIOMIX_SAI6_MCLK
IOMUXC_SAI1_RXD7_AUDIOMIX_SAI1_TX_SYNC
IOMUXC_SAI1_RXD7_AUDIOMIX_SAI1_TX_DATA4
IOMUXC_SAI1_RXD7_ENET1_RGMII_RD3
IOMUXC_SAI1_RXD7_GPIO4_IO09
IOMUXC_SAI1_TXFS_AUDIOMIX_SAI1_TX_SYNC
IOMUXC_SAI1_TXFS_ENET1_RGMII_RX_CTL
IOMUXC_SAI1_TXFS_GPIO4_IO10
IOMUXC_SAI1_TXC_AUDIOMIX_SAI1_TX_BCLK
IOMUXC_SAI1_TXC_ENET1_RGMII_RXC
IOMUXC_SAI1_TXC_GPIO4_IO11
IOMUXC_SAI1_TXD0_AUDIOMIX_SAI1_TX_DATA0
IOMUXC_SAI1_TXD0_ENET1_RGMII_TD0
IOMUXC_SAI1_TXD0_GPIO4_IO12
IOMUXC_SAI1_TXD1_AUDIOMIX_SAI1_TX_DATA1
IOMUXC_SAI1_TXD1_ENET1_RGMII_TD1
IOMUXC_SAI1_TXD1_GPIO4_IO13
IOMUXC_SAI1_TXD2_AUDIOMIX_SAI1_TX_DATA2

IOMUXC_SAI1_TXD2_ENET1_RGMII_TD2
IOMUXC_SAI1_TXD2_GPIO4_IO14
IOMUXC_SAI1_TXD3_AUDIOMIX_SAI1_TX_DATA3
IOMUXC_SAI1_TXD3_ENET1_RGMII_TD3
IOMUXC_SAI1_TXD3_GPIO4_IO15
IOMUXC_SAI1_TXD4_AUDIOMIX_SAI1_TX_DATA4
IOMUXC_SAI1_TXD4_AUDIOMIX_SAI6_RX_BCLK
IOMUXC_SAI1_TXD4_AUDIOMIX_SAI6_TX_BCLK
IOMUXC_SAI1_TXD4_ENET1_RGMII_TX_CTL
IOMUXC_SAI1_TXD4_GPIO4_IO16
IOMUXC_SAI1_TXD5_AUDIOMIX_SAI1_TX_DATA5
IOMUXC_SAI1_TXD5_AUDIOMIX_SAI6_RX_DATA0
IOMUXC_SAI1_TXD5_AUDIOMIX_SAI6_TX_DATA0
IOMUXC_SAI1_TXD5_ENET1_RGMII_TXC
IOMUXC_SAI1_TXD5_GPIO4_IO17
IOMUXC_SAI1_TXD6_AUDIOMIX_SAI1_TX_DATA6
IOMUXC_SAI1_TXD6_AUDIOMIX_SAI6_RX_SYNC
IOMUXC_SAI1_TXD6_AUDIOMIX_SAI6_TX_SYNC
IOMUXC_SAI1_TXD6_ENET1_RX_ER
IOMUXC_SAI1_TXD6_GPIO4_IO18
IOMUXC_SAI1_TXD7_AUDIOMIX_SAI1_TX_DATA7
IOMUXC_SAI1_TXD7_AUDIOMIX_SAI6_MCLK
IOMUXC_SAI1_TXD7_AUDIOMIX_PDM_CLK
IOMUXC_SAI1_TXD7_ENET1_TX_ER
IOMUXC_SAI1_TXD7_GPIO4_IO19
IOMUXC_SAI1_MCLK_AUDIOMIX_SAI1_MCLK
IOMUXC_SAI1_MCLK_AUDIOMIX_SAI1_TX_BCLK
IOMUXC_SAI1_MCLK_ENET1_TX_CLK
IOMUXC_SAI1_MCLK_GPIO4_IO20
IOMUXC_SAI2_RXFS_AUDIOMIX_SAI2_RX_SYNC
IOMUXC_SAI2_RXFS_AUDIOMIX_SAI5_TX_SYNC
IOMUXC_SAI2_RXFS_AUDIOMIX_SAI5_TX_DATA1
IOMUXC_SAI2_RXFS_AUDIOMIX_SAI2_RX_DATA1

IOMUXC_SAI2_RXFS_UART1_TX
IOMUXC_SAI2_RXFS_UART1_RX
IOMUXC_SAI2_RXFS_GPIO4_IO21
IOMUXC_SAI2_RXFS_AUDIOMIX_PDM_BIT_STREAM2
IOMUXC_SAI2_RXC_AUDIOMIX_SAI2_RX_BCLK
IOMUXC_SAI2_RXC_AUDIOMIX_SAI5_TX_BCLK
IOMUXC_SAI2_RXC_CAN1_TX
IOMUXC_SAI2_RXC_UART1_RX
IOMUXC_SAI2_RXC_UART1_TX
IOMUXC_SAI2_RXC_GPIO4_IO22
IOMUXC_SAI2_RXC_AUDIOMIX_PDM_BIT_STREAM1
IOMUXC_SAI2_RXD0_AUDIOMIX_SAI2_RX_DATA0
IOMUXC_SAI2_RXD0_AUDIOMIX_SAI5_TX_DATA0
IOMUXC_SAI2_RXD0_ENET_QOS_1588_EVENT2_OUT
IOMUXC_SAI2_RXD0_AUDIOMIX_SAI2_TX_DATA1
IOMUXC_SAI2_RXD0_UART1_RTS_B
IOMUXC_SAI2_RXD0_UART1_CTS_B
IOMUXC_SAI2_RXD0_GPIO4_IO23
IOMUXC_SAI2_RXD0_AUDIOMIX_PDM_BIT_STREAM3
IOMUXC_SAI2_TXFS_AUDIOMIX_SAI2_TX_SYNC
IOMUXC_SAI2_TXFS_AUDIOMIX_SAI5_TX_DATA1
IOMUXC_SAI2_TXFS_ENET_QOS_1588_EVENT3_OUT
IOMUXC_SAI2_TXFS_AUDIOMIX_SAI2_TX_DATA1
IOMUXC_SAI2_TXFS_UART1_CTS_B
IOMUXC_SAI2_TXFS_UART1_RTS_B
IOMUXC_SAI2_TXFS_GPIO4_IO24
IOMUXC_SAI2_TXFS_AUDIOMIX_PDM_BIT_STREAM2
IOMUXC_SAI2_TXC_AUDIOMIX_SAI2_TX_BCLK
IOMUXC_SAI2_TXC_AUDIOMIX_SAI5_TX_DATA2
IOMUXC_SAI2_TXC_CAN1_RX
IOMUXC_SAI2_TXC_GPIO4_IO25
IOMUXC_SAI2_TXC_AUDIOMIX_PDM_BIT_STREAM1
IOMUXC_SAI2_TXD0_AUDIOMIX_SAI2_TX_DATA0

IOMUXC_SAI2_TXD0_AUDIOMIX_SAI5_TX_DATA3
IOMUXC_SAI2_TXD0_ENET_QOS_1588_EVENT2_IN
IOMUXC_SAI2_TXD0_CAN2_TX
IOMUXC_SAI2_TXD0_ENET_QOS_1588_EVENT2_AUX_IN
IOMUXC_SAI2_TXD0_GPIO4_IO26
IOMUXC_SAI2_MCLK_AUDIOMIX_SAI2_MCLK
IOMUXC_SAI2_MCLK_AUDIOMIX_SAI5_MCLK
IOMUXC_SAI2_MCLK_ENET_QOS_1588_EVENT3_IN
IOMUXC_SAI2_MCLK_CAN2_RX
IOMUXC_SAI2_MCLK_ENET_QOS_1588_EVENT3_AUX_IN
IOMUXC_SAI2_MCLK_GPIO4_IO27
IOMUXC_SAI2_MCLK_AUDIOMIX_SAI3_MCLK
IOMUXC_SAI3_RXFS_AUDIOMIX_SAI3_RX_SYNC
IOMUXC_SAI3_RXFS_AUDIOMIX_SAI2_RX_DATA1
IOMUXC_SAI3_RXFS_AUDIOMIX_SAI5_RX_SYNC
IOMUXC_SAI3_RXFS_AUDIOMIX_SAI3_RX_DATA1
IOMUXC_SAI3_RXFS_AUDIOMIX_SPDIF1_IN
IOMUXC_SAI3_RXFS_GPIO4_IO28
IOMUXC_SAI3_RXFS_AUDIOMIX_PDM_BIT_STREAM0
IOMUXC_SAI3_RXC_AUDIOMIX_SAI3_RX_BCLK
IOMUXC_SAI3_RXC_AUDIOMIX_SAI2_RX_DATA2
IOMUXC_SAI3_RXC_AUDIOMIX_SAI5_RX_BCLK
IOMUXC_SAI3_RXC_GPT1_CLK
IOMUXC_SAI3_RXC_UART2_CTS_B
IOMUXC_SAI3_RXC_UART2_RTS_B
IOMUXC_SAI3_RXC_GPIO4_IO29
IOMUXC_SAI3_RXC_AUDIOMIX_PDM_CLK
IOMUXC_SAI3_RXD_AUDIOMIX_SAI3_RX_DATA0
IOMUXC_SAI3_RXD_AUDIOMIX_SAI2_RX_DATA3
IOMUXC_SAI3_RXD_AUDIOMIX_SAI5_RX_DATA0
IOMUXC_SAI3_RXD_UART2_RTS_B
IOMUXC_SAI3_RXD_UART2_CTS_B
IOMUXC_SAI3_RXD_GPIO4_IO30

IOMUXC_SAI3_RXD_AUDIOMIX_PDM_BIT_STREAM1
IOMUXC_SAI3_TXFS_AUDIOMIX_SAI3_TX_SYNC
IOMUXC_SAI3_TXFS_AUDIOMIX_SAI2_TX_DATA1
IOMUXC_SAI3_TXFS_AUDIOMIX_SAI5_RX_DATA1
IOMUXC_SAI3_TXFS_AUDIOMIX_SAI3_TX_DATA1
IOMUXC_SAI3_TXFS_UART2_RX
IOMUXC_SAI3_TXFS_UART2_TX
IOMUXC_SAI3_TXFS_GPIO4_IO31
IOMUXC_SAI3_TXFS_AUDIOMIX_PDM_BIT_STREAM3
IOMUXC_SAI3_TXC_AUDIOMIX_SAI3_TX_BCLK
IOMUXC_SAI3_TXC_AUDIOMIX_SAI2_TX_DATA2
IOMUXC_SAI3_TXC_AUDIOMIX_SAI5_RX_DATA2
IOMUXC_SAI3_TXC_GPT1_CAPTURE1
IOMUXC_SAI3_TXC_UART2_TX
IOMUXC_SAI3_TXC_UART2_RX
IOMUXC_SAI3_TXC_GPIO5_IO00
IOMUXC_SAI3_TXC_AUDIOMIX_PDM_BIT_STREAM2
IOMUXC_SAI3_TXD_AUDIOMIX_SAI3_TX_DATA0
IOMUXC_SAI3_TXD_AUDIOMIX_SAI2_TX_DATA3
IOMUXC_SAI3_TXD_AUDIOMIX_SAI5_RX_DATA3
IOMUXC_SAI3_TXD_GPT1_CAPTURE2
IOMUXC_SAI3_TXD_AUDIOMIX_SPDIF1_EXT_CLK
IOMUXC_SAI3_TXD_GPIO5_IO01
IOMUXC_SAI3_MCLK_AUDIOMIX_SAI3_MCLK
IOMUXC_SAI3_MCLK_PWM4_OUT
IOMUXC_SAI3_MCLK_AUDIOMIX_SAI5_MCLK
IOMUXC_SAI3_MCLK_AUDIOMIX_SPDIF1_OUT
IOMUXC_SAI3_MCLK_GPIO5_IO02
IOMUXC_SAI3_MCLK_AUDIOMIX_SPDIF1_IN
IOMUXC_SPDIF_TX_AUDIOMIX_SPDIF1_OUT
IOMUXC_SPDIF_TX_PWM3_OUT
IOMUXC_SPDIF_TX_I2C5_SCL
IOMUXC_SPDIF_TX_GPT1_COMPARE1

IOMUXC_SPDIF_TX_CAN1_TX
IOMUXC_SPDIF_TX_GPIO5_IO03
IOMUXC_SPDIF_RX_AUDIOMIX_SPDIF1_IN
IOMUXC_SPDIF_RX_PWM2_OUT
IOMUXC_SPDIF_RX_I2C5_SDA
IOMUXC_SPDIF_RX_GPT1_COMPARE2
IOMUXC_SPDIF_RX_CAN1_RX
IOMUXC_SPDIF_RX_GPIO5_IO04
IOMUXC_SPDIF_EXT_CLK_AUDIOMIX_SPDIF1_EXT_CLK
IOMUXC_SPDIF_EXT_CLK_PWM1_OUT
IOMUXC_SPDIF_EXT_CLK_GPT1_COMPARE3
IOMUXC_SPDIF_EXT_CLK_GPIO5_IO05
IOMUXC_ECSP11_SCLK_ECSP11_SCLK
IOMUXC_ECSP11_SCLK_UART3_RX
IOMUXC_ECSP11_SCLK_UART3_TX
IOMUXC_ECSP11_SCLK_I2C1_SCL
IOMUXC_ECSP11_SCLK_AUDIOMIX_SAI7_RX_SYNC
IOMUXC_ECSP11_SCLK_GPIO5_IO06
IOMUXC_ECSP11_MOSI_ECSP11_MOSI
IOMUXC_ECSP11_MOSI_UART3_TX
IOMUXC_ECSP11_MOSI_UART3_RX
IOMUXC_ECSP11_MOSI_I2C1_SDA
IOMUXC_ECSP11_MOSI_AUDIOMIX_SAI7_RX_BCLK
IOMUXC_ECSP11_MOSI_GPIO5_IO07
IOMUXC_ECSP11_MISO_ECSP11_MISO
IOMUXC_ECSP11_MISO_UART3_CTS_B
IOMUXC_ECSP11_MISO_UART3_RTS_B
IOMUXC_ECSP11_MISO_I2C2_SCL
IOMUXC_ECSP11_MISO_AUDIOMIX_SAI7_RX_DATA0
IOMUXC_ECSP11_MISO_GPIO5_IO08
IOMUXC_ECSP11_SS0_ECSP11_SS0
IOMUXC_ECSP11_SS0_UART3_RTS_B
IOMUXC_ECSP11_SS0_UART3_CTS_B

IOMUXC_ECSP1_SS0_I2C2_SDA
IOMUXC_ECSP1_SS0_AUDIOMIX_SAI7_TX_SYNC
IOMUXC_ECSP1_SS0_GPIO5_IO09
IOMUXC_ECSP2_SCLK_ECSP2_SCLK
IOMUXC_ECSP2_SCLK_UART4_RX
IOMUXC_ECSP2_SCLK_UART4_TX
IOMUXC_ECSP2_SCLK_I2C3_SCL
IOMUXC_ECSP2_SCLK_AUDIOMIX_SAI7_TX_BCLK
IOMUXC_ECSP2_SCLK_GPIO5_IO10
IOMUXC_ECSP2_MOSI_ECSP2_MOSI
IOMUXC_ECSP2_MOSI_UART4_TX
IOMUXC_ECSP2_MOSI_UART4_RX
IOMUXC_ECSP2_MOSI_I2C3_SDA
IOMUXC_ECSP2_MOSI_AUDIOMIX_SAI7_TX_DATA0
IOMUXC_ECSP2_MOSI_GPIO5_IO11
IOMUXC_ECSP2_MISO_ECSP2_MISO
IOMUXC_ECSP2_MISO_UART4_CTS_B
IOMUXC_ECSP2_MISO_UART4_RTS_B
IOMUXC_ECSP2_MISO_I2C4_SCL
IOMUXC_ECSP2_MISO_AUDIOMIX_SAI7_MCLK
IOMUXC_ECSP2_MISO_CCM_CLKO1
IOMUXC_ECSP2_MISO_GPIO5_IO12
IOMUXC_ECSP2_SS0_ECSP2_SS0
IOMUXC_ECSP2_SS0_UART4_RTS_B
IOMUXC_ECSP2_SS0_UART4_CTS_B
IOMUXC_ECSP2_SS0_I2C4_SDA
IOMUXC_ECSP2_SS0_CCM_CLKO2
IOMUXC_ECSP2_SS0_GPIO5_IO13
IOMUXC_I2C1_SCL_I2C1_SCL
IOMUXC_I2C1_SCL_ENET_QOS_MDC
IOMUXC_I2C1_SCL_ECSP1_SCLK
IOMUXC_I2C1_SCL_GPIO5_IO14
IOMUXC_I2C1_SDA_I2C1_SDA

IOMUXC_I2C1_SDA_ENET_QOS_MDIO
IOMUXC_I2C1_SDA_ECSP11_MOSI
IOMUXC_I2C1_SDA_GPIO5_IO15
IOMUXC_I2C2_SCL_I2C2_SCL
IOMUXC_I2C2_SCL_ENET_QOS_1588_EVENT1_IN
IOMUXC_I2C2_SCL_USDHC3_CD_B
IOMUXC_I2C2_SCL_ECSP11_MISO
IOMUXC_I2C2_SCL_ENET_QOS_1588_EVENT1_AUX_IN
IOMUXC_I2C2_SCL_GPIO5_IO16
IOMUXC_I2C2_SDA_I2C2_SDA
IOMUXC_I2C2_SDA_ENET_QOS_1588_EVENT1_OUT
IOMUXC_I2C2_SDA_USDHC3_WP
IOMUXC_I2C2_SDA_ECSP11_SS0
IOMUXC_I2C2_SDA_GPIO5_IO17
IOMUXC_I2C3_SCL_I2C3_SCL
IOMUXC_I2C3_SCL_PWM4_OUT
IOMUXC_I2C3_SCL_GPT2_CLK
IOMUXC_I2C3_SCL_ECSP12_SCLK
IOMUXC_I2C3_SCL_GPIO5_IO18
IOMUXC_I2C3_SDA_I2C3_SDA
IOMUXC_I2C3_SDA_PWM3_OUT
IOMUXC_I2C3_SDA_GPT3_CLK
IOMUXC_I2C3_SDA_ECSP12_MOSI
IOMUXC_I2C3_SDA_GPIO5_IO19
IOMUXC_I2C4_SCL_I2C4_SCL
IOMUXC_I2C4_SCL_PWM2_OUT
IOMUXC_I2C4_SCL_PCIE_CLKREQ_B
IOMUXC_I2C4_SCL_ECSP12_MISO
IOMUXC_I2C4_SCL_GPIO5_IO20
IOMUXC_I2C4_SDA_I2C4_SDA
IOMUXC_I2C4_SDA_PWM1_OUT
IOMUXC_I2C4_SDA_ECSP12_SS0
IOMUXC_I2C4_SDA_GPIO5_IO21

IOMUXC_UART1_RXD_UART1_RX
IOMUXC_UART1_RXD_UART1_TX
IOMUXC_UART1_RXD_ECSPi3_SCLK
IOMUXC_UART1_RXD_GPIO5_IO22
IOMUXC_UART1_TXD_UART1_TX
IOMUXC_UART1_TXD_UART1_RX
IOMUXC_UART1_TXD_ECSPi3_MOSI
IOMUXC_UART1_TXD_GPIO5_IO23
IOMUXC_UART2_RXD_UART2_RX
IOMUXC_UART2_RXD_UART2_TX
IOMUXC_UART2_RXD_ECSPi3_MISO
IOMUXC_UART2_RXD_GPT1_COMPARE3
IOMUXC_UART2_RXD_GPIO5_IO24
IOMUXC_UART2_TXD_UART2_TX
IOMUXC_UART2_TXD_UART2_RX
IOMUXC_UART2_TXD_ECSPi3_SS0
IOMUXC_UART2_TXD_GPT1_COMPARE2
IOMUXC_UART2_TXD_GPIO5_IO25
IOMUXC_UART3_RXD_UART3_RX
IOMUXC_UART3_RXD_UART3_TX
IOMUXC_UART3_RXD_UART1_CTS_B
IOMUXC_UART3_RXD_UART1_RTS_B
IOMUXC_UART3_RXD_USDHC3_RESET_B
IOMUXC_UART3_RXD_GPT1_CAPTURE2
IOMUXC_UART3_RXD_CAN2_TX
IOMUXC_UART3_RXD_GPIO5_IO26
IOMUXC_UART3_TXD_UART3_TX
IOMUXC_UART3_TXD_UART3_RX
IOMUXC_UART3_TXD_UART1_RTS_B
IOMUXC_UART3_TXD_UART1_CTS_B
IOMUXC_UART3_TXD_USDHC3_VSELECT
IOMUXC_UART3_TXD_GPT1_CLK
IOMUXC_UART3_TXD_CAN2_RX

IOMUXC_UART3_TXD_GPIO5_IO27
IOMUXC_UART4_RXD_UART4_RX
IOMUXC_UART4_RXD_UART4_TX
IOMUXC_UART4_RXD_UART2_CTS_B
IOMUXC_UART4_RXD_UART2_RTS_B
IOMUXC_UART4_RXD_PCIE_CLKREQ_B
IOMUXC_UART4_RXD_GPT1_COMPARE1
IOMUXC_UART4_RXD_I2C6_SCL
IOMUXC_UART4_RXD_GPIO5_IO28
IOMUXC_UART4_TXD_UART4_TX
IOMUXC_UART4_TXD_UART4_RX
IOMUXC_UART4_TXD_UART2_RTS_B
IOMUXC_UART4_TXD_UART2_CTS_B
IOMUXC_UART4_TXD_GPT1_CAPTURE1
IOMUXC_UART4_TXD_I2C6_SDA
IOMUXC_UART4_TXD_GPIO5_IO29
IOMUXC_HDMI_DDC_SCL_HDMIMIX_HDMI_SCL
IOMUXC_HDMI_DDC_SCL_I2C5_SCL
IOMUXC_HDMI_DDC_SCL_CAN1_TX
IOMUXC_HDMI_DDC_SCL_GPIO3_IO26
IOMUXC_HDMI_DDC_SCL_EARC_TEST_OUT0
IOMUXC_HDMI_DDC_SDA_HDMIMIX_HDMI_SDA
IOMUXC_HDMI_DDC_SDA_I2C5_SDA
IOMUXC_HDMI_DDC_SDA_CAN1_RX
IOMUXC_HDMI_DDC_SDA_GPIO3_IO27
IOMUXC_HDMI_DDC_SDA_EARC_TEST_OUT1
IOMUXC_HDMI_CEC_HDMIMIX_HDMI_CEC
IOMUXC_HDMI_CEC_I2C6_SCL
IOMUXC_HDMI_CEC_CAN2_TX
IOMUXC_HDMI_CEC_GPIO3_IO28
IOMUXC_HDMI_HPD_HDMIMIX_HDMI_HPD
IOMUXC_HDMI_HPD_AUDIOMIX_HDMI_HPD_O
IOMUXC_HDMI_HPD_I2C6_SDA

IOMUXC_HDMI_HPD_CAN2_RX
 IOMUXC_HDMI_HPD_GPIO3_IO29
 FSL_COMPONENT_ID

2.23 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 USB CDC.

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_UART
 Debug console based on LPC_UART.

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 specified by *bits* to the variable at address *address*.

SDK_ATOMIC_LOCAL_CLEAR(addr, bits)

Clear the bits specified by *bits* to the variable at address *address*.

SDK_ATOMIC_LOCAL_TOGGLE(addr, bits)

Toggle the bits specified 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 specified by *clearBits* and set the bits specified by *setBits*.

SDK_ATOMIC_LOCAL_COMPARE_AND_SET(addr, expected, newValue)

For the variable at address *address*, check whether the value equal to *expected*. If value same as *expected* then update *newValue* to address and return **true** , else return **false** .

SDK_ATOMIC_LOCAL_TEST_AND_SET(addr, newValue)

For the variable at address *address*, set as *newValue* value and return old value.

USEC_TO_COUNT(us, clockFreqInHz)

Macro to convert a microsecond period to raw count value

COUNT_TO_USEC(count, clockFreqInHz)

Macro to convert a raw count value to microsecond

MSEC_TO_COUNT(ms, clockFreqInHz)

Macro to convert a millisecond period to raw count value

COUNT_TO_MSEC(count, clockFreqInHz)

Macro to convert a raw count value to millisecond

SDK_ISR_EXIT_BARRIER

SDK_ALIGN(var, alignbytes)

Macro to define a variable with alignbytes alignment

SDK_L1DCACHE_ALIGN(var)

Macro to define a variable with L1 d-cache line size alignment

SDK_SIZEALIGN(var, alignbytes)

Macro to define a variable with L2 cache line size alignment

Macro to change a value to a given size aligned value (rounded up)

SDK_SIZEALIGN_UP(var, alignbytes)

Macro to change a value to a given size aligned value (rounded up), the wrapper of SDK_SIZEALIGN

SDK_SIZEALIGN_DOWN(var, alignbytes)

Macro to change a value to a given size aligned value (rounded down)

SDK_IS_ALIGNED(var, alignbytes)

Macro to check if a value is aligned to a given size

AT_NONCACHEABLE_SECTION(var)

Define a variable *var*, and place it in non-cacheable section.

AT_NONCACHEABLE_SECTION_ALIGN(*var*, *alignbytes*)

Define a variable *var*, and place it in non-cacheable section, the start address of the variable is aligned to *alignbytes*.

AT_NONCACHEABLE_SECTION_INIT(*var*)

Define a variable *var* with initial value, and place it in non-cacheable section.

AT_NONCACHEABLE_SECTION_ALIGN_INIT(*var*, *alignbytes*)

Define a variable *var* with initial value, and place it in non-cacheable section, the start address of the variable is aligned to *alignbytes*.

MCUX_CS

AT_CACHE_LINE_SECTION(*var*)

Define a variable *var*, which is cache line size aligned and be placed in CacheLineData section.

AT_CACHE_LINE_SECTION_INIT(*var*)

Define a variable *var* with initial value, which is cache line size aligned and be placed in CacheLineData.init section.

CACHE_LINE_DATA

AT_QUICKACCESS_SECTION_CODE(*func*)

Place function in a section which can be accessed quickly by core.

AT_QUICKACCESS_SECTION_DATA(*var*)

Place data in a section which can be accessed quickly by core.

AT_QUICKACCESS_SECTION_DATA_ALIGN(*var*, *alignbytes*)

Place data in a section which can be accessed quickly by core, and the variable address is set to align with *alignbytes*.

MCUX_RAMFUNC

Function attribute to place function in RAM. For example, to place function *my_func* in ram, use like:

```
MCUX_RAMFUNC my_func
```

RAMFUNCTION_SECTION_CODE(*func*)

Place function in ram.

enum *_status_groups*

Status group numbers.

Values:

enumerator *kStatusGroup_Generic*

Group number for generic status codes.

enumerator *kStatusGroup_FLASH*

Group number for FLASH status codes.

enumerator *kStatusGroup_LPSPI*

Group number for LPSPI status codes.

enumerator *kStatusGroup_FLEXIO_SPI*

Group number for FLEXIO SPI status codes.

enumerator *kStatusGroup_DSPI*

Group number for DSPI status codes.

enumerator kStatusGroup_FLEXIO_UART
Group number for FLEXIO UART status codes.

enumerator kStatusGroup_FLEXIO_I2C
Group number for FLEXIO I2C status codes.

enumerator kStatusGroup_LPI2C
Group number for LPI2C status codes.

enumerator kStatusGroup_UART
Group number for UART status codes.

enumerator kStatusGroup_I2C
Group number for 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_MIPIDSI
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.

enumerator kStatusGroup_LPC_QSPI

Group number for LPC QSPI status codes.

Generic status return codes.

Values:

enumerator kStatus_Success

Generic status for Success.

enumerator kStatus_Fail

Generic status for Fail.

enumerator kStatus_ReadOnly

Generic status for read only failure.

enumerator kStatus_OutOfRange

Generic status for out of range access.

enumerator kStatus_InvalidArgument

Generic status for invalid argument check.

enumerator kStatus_Timeout

Generic status for timeout.

enumerator kStatus_NoTransferInProgress

Generic status for no transfer in progress.

enumerator kStatus_Busy

Generic status for module is busy.

enumerator kStatus_NoData

Generic status for no data is found for the operation.

typedef int32_t status_t

Type used for all status and error return values.

void *SDK_Malloc(size_t size, size_t alignbytes)

Allocate memory with given alignment and aligned size.

This is provided to support the dynamically allocated memory used in cache-able region.

Parameters

- size – The length required to malloc.
- alignbytes – The alignment size.

Return values

The – allocated memory.

void SDK_Free(void *ptr)

Free memory.

Parameters

- ptr – The memory to be release.

void SDK_DelayAtLeastUs(uint32_t delayTime_us, uint32_t coreClock_Hz)

Delay at least for some time. Please note that, this API uses while loop for delay, different run-time environments make the time not precise, if precise delay count was needed, please implement a new delay function with hardware timer.

Parameters

- delayTime_us – Delay time in unit of microsecond.
- coreClock_Hz – Core clock frequency with Hz.

static inline *status_t* EnableIRQ(IRQn_Type interrupt)

Enable specific interrupt.

Enable LEVEL1 interrupt. For some devices, there might be multiple interrupt levels. For example, there are NVIC and intmux. Here the interrupts connected to NVIC are the LEVEL1 interrupts, because they are routed to the core directly. The interrupts connected to intmux are the LEVEL2 interrupts, they are routed to NVIC first then routed to core.

This function only enables the LEVEL1 interrupts. The number of LEVEL1 interrupts is indicated by the feature macro FSL_FEATURE_NUMBER_OF_LEVEL1_INT_VECTORS.

Parameters

- interrupt – The IRQ number.

Return values

- kStatus_Success – Interrupt enabled successfully
- kStatus_Fail – Failed to enable the interrupt

static inline *status_t* DisableIRQ(IRQn_Type interrupt)

Disable specific interrupt.

Disable LEVEL1 interrupt. For some devices, there might be multiple interrupt levels. For example, there are NVIC and intmux. Here the interrupts connected to NVIC are the LEVEL1 interrupts, because they are routed to the core directly. The interrupts connected to intmux are the LEVEL2 interrupts, they are routed to NVIC first then routed to core.

This function only disables the LEVEL1 interrupts. The number of LEVEL1 interrupts is indicated by the feature macro FSL_FEATURE_NUMBER_OF_LEVEL1_INT_VECTORS.

Parameters

- interrupt – The IRQ number.

Return values

- kStatus_Success – Interrupt disabled successfully
- kStatus_Fail – Failed to disable the interrupt

static inline *status_t* EnableIRQWithPriority(IRQn_Type interrupt, uint8_t priNum)

Enable the IRQ, and also set the interrupt priority.

Only handle LEVEL1 interrupt. For some devices, there might be multiple interrupt levels. For example, there are NVIC and intmux. Here the interrupts connected to NVIC are the LEVEL1 interrupts, because they are routed to the core directly. The interrupts connected to intmux are the LEVEL2 interrupts, they are routed to NVIC first then routed to core.

This function only handles the LEVEL1 interrupts. The number of LEVEL1 interrupts is indicated by the feature macro FSL_FEATURE_NUMBER_OF_LEVEL1_INT_VECTORS.

Parameters

- interrupt – The IRQ to Enable.

- priNum – Priority number set to interrupt controller register.

Return values

- kStatus_Success – Interrupt priority set successfully
- kStatus_Fail – Failed to set the interrupt priority.

static inline *status_t* IRQ_SetPriority(IRQn_Type interrupt, uint8_t priNum)

Set the IRQ priority.

Only handle LEVEL1 interrupt. For some devices, there might be multiple interrupt levels. For example, there are NVIC and intmux. Here the interrupts connected to NVIC are the LEVEL1 interrupts, because they are routed to the core directly. The interrupts connected to intmux are the LEVEL2 interrupts, they are routed to NVIC first then routed to core.

This function only handles the LEVEL1 interrupts. The number of LEVEL1 interrupts is indicated by the feature macro FSL_FEATURE_NUMBER_OF_LEVEL1_INT_VECTORS.

Parameters

- interrupt – The IRQ to set.
- priNum – Priority number set to interrupt controller register.

Return values

- kStatus_Success – Interrupt priority set successfully
- kStatus_Fail – Failed to set the interrupt priority.

static inline *status_t* IRQ_ClearPendingIRQ(IRQn_Type interrupt)

Clear the pending IRQ flag.

Only handle LEVEL1 interrupt. For some devices, there might be multiple interrupt levels. For example, there are NVIC and intmux. Here the interrupts connected to NVIC are the LEVEL1 interrupts, because they are routed to the core directly. The interrupts connected to intmux are the LEVEL2 interrupts, they are routed to NVIC first then routed to core.

This function only handles the LEVEL1 interrupts. The number of LEVEL1 interrupts is indicated by the feature macro FSL_FEATURE_NUMBER_OF_LEVEL1_INT_VECTORS.

Parameters

- interrupt – The flag which IRQ to clear.

Return values

- kStatus_Success – Interrupt priority set successfully
- kStatus_Fail – Failed to set the interrupt priority.

static inline uint32_t DisableGlobalIRQ(void)

Disable the global IRQ.

Disable the global interrupt and return the current primask register. User is required to provided the primask register for the EnableGlobalIRQ().

Returns

Current primask value.

static inline void EnableGlobalIRQ(uint32_t primask)

Enable the global IRQ.

Set the primask register with the provided primask value but not just enable the primask. The idea is for the convenience of integration of RTOS. some RTOS get its own management mechanism of primask. User is required to use the EnableGlobalIRQ() and DisableGlobalIRQ() in pair.

Parameters

- `primask` – value of primask register to be restored. The primask value is supposed to be provided by the `DisableGlobalIRQ()`.

```
static inline bool __SDK_AtomicLocalCompareAndSet(uint32_t *addr, uint32_t expected, uint32_t
                                                    newValue)
```

```
static inline uint32_t __SDK_AtomicTestAndSet(uint32_t *addr, uint32_t newValue)
```

`FSL_DRIVER_TRANSFER_DOUBLE_WEAK_IRQ`

Macro to use the default weak IRQ handler in drivers.

`MAKE_STATUS(group, code)`

Construct a status code value from a group and code number.

`MAKE_VERSION(major, minor, bugfix)`

Construct the version number for drivers.

The driver version is a 32-bit number, for both 32-bit platforms(such as Cortex M) and 16-bit platforms(such as DSC).

Unused	Major Version	Minor Version	Bug Fix	
31	25 24	17 16	9 8	0

`ARRAY_SIZE(x)`

Computes the number of elements in an array.

`UINT64_H(X)`

Macro to get upper 32 bits of a 64-bit value

`UINT64_L(X)`

Macro to get lower 32 bits of a 64-bit value

`SUPPRESS_FALL_THROUGH_WARNING()`

For switch case code block, if case section ends without “break;” statement, there will be fallthrough warning with compiler flag `-Wextra` or `-Wimplicit-fallthrough=n` when using `armgcc`. To suppress this warning, “`SUPPRESS_FALL_THROUGH_WARNING()`,” need to be added at the end of each case section which misses “break;”statement.

`MSDK_REG_SECURE_ADDR(x)`

Convert the register address to the one used in secure mode.

`MSDK_REG_NONSECURE_ADDR(x)`

Convert the register address to the one used in non-secure mode.

`MSDK_HAS_DWT_CYCCNT`

The chip supports DWT CYCCNT or not.

`MSDK_INVALID_IRQ_HANDLER`

Invalid IRQ handler address.

2.24 MU: Messaging Unit

```
void MU_Init(MU_Type *base)
```

Initializes the MU module.

This function enables the MU clock only.

Parameters

- `base` – MU peripheral base address.

`void MU_Deinit(MU_Type *base)`

De-initializes the MU module.

This function disables the MU clock only.

Parameters

- `base` – MU peripheral base address.

`static inline void MU_SendMsgNonBlocking(MU_Type *base, uint32_t regIndex, uint32_t msg)`

Writes a message to the TX register.

This function writes a message to the specific TX register. It does not check whether the TX register is empty or not. The upper layer should make sure the TX register is empty before calling this function. This function can be used in ISR for better performance.

```
while (!(kMU_Tx0EmptyFlag & MU_GetStatusFlags(base))) { } Wait for TX0 register empty.
MU_SendMsgNonBlocking(base, kMU_MsgReg0, MSG_VAL); Write message to the TX0 register.
```

Parameters

- `base` – MU peripheral base address.
- `regIndex` – TX register index, see `mu_msg_reg_index_t`.
- `msg` – Message to send.

`status_t MU_SendMsg(MU_Type *base, uint32_t regIndex, uint32_t msg)`

Blocks to send a message.

This function waits until the TX register is empty and sends the message. If `MU_BUSY_POLL_COUNT` is defined and non-zero, the function will timeout after the specified number of polling iterations and returns `kStatus_Timeout`.

Parameters

- `base` – MU peripheral base address.
- `regIndex` – MU message register, see `mu_msg_reg_index_t`.
- `msg` – Message to send.

Return values

- `kStatus_Success` – Message sent successfully.
- `kStatus_Timeout` – Timeout occurred while waiting for TX register to be empty.

Returns

`status_t`

`static inline uint32_t MU_ReceiveMsgNonBlocking(MU_Type *base, uint32_t regIndex)`

Reads a message from the RX register.

This function reads a message from the specific RX register. It does not check whether the RX register is full or not. The upper layer should make sure the RX register is full before calling this function. This function can be used in ISR for better performance.

```
uint32_t msg;
while (!(kMU_Rx0FullFlag & MU_GetStatusFlags(base)))
{
} Wait for the RX0 register full.

msg = MU_ReceiveMsgNonBlocking(base, kMU_MsgReg0); Read message from RX0 register.
```

Parameters

- base – MU peripheral base address.
- regIndex – RX register index, see `mu_msg_reg_index_t`.

Returns

The received message.

`status_t MU_ReceiveMsgTimeout(MU_Type *base, uint32_t regIndex, uint32_t *readValue)`

Blocks to receive a message with timeout protection.

This function waits until the RX register is full and receives the message. If `MU_BUSY_POLL_COUNT` is defined and non-zero, the function will timeout after the specified number of polling iterations and return `kStatus_Timeout`.

This function provides the same blocking behavior as `MU_ReceiveMsg()` but with additional timeout protection to prevent system hangs if the other core becomes unresponsive or if hardware issues occur.

Note: Both `MU_ReceiveMsg()` and `MU_ReceiveMsgTimeout()` are blocking functions. The difference is that this function includes timeout protection while `MU_ReceiveMsg()` waits indefinitely.

Parameters

- base – MU peripheral base address.
- regIndex – RX register index, see `mu_msg_reg_index_t`.
- readValue – Pointer to store the received message.

Return values

- `kStatus_Success` – Message received successfully.
- `kStatus_InvalidArgument` – Invalid `readValue` pointer.
- `kStatus_Timeout` – Timeout occurred while waiting for RX register to be full.

Returns

`status_t`

`uint32_t MU_ReceiveMsg(MU_Type *base, uint32_t regIndex)`

Blocks to receive a message (infinite wait, no timeout protection).

This function waits until the RX register is full and receives the message. This function will wait indefinitely until a message is received.

Note: Both `MU_ReceiveMsg()` and `MU_ReceiveMsgTimeout()` are blocking functions. The difference is that `MU_ReceiveMsgTimeout()` includes timeout protection while this function waits indefinitely.

Warning: This function does not include timeout protection and may cause system hangs if the other core becomes unresponsive. For applications requiring timeout protection, use `MU_ReceiveMsgTimeout()` instead.

Parameters

- base – MU peripheral base address.
- regIndex – RX register index, see `mu_msg_reg_index_t`.

Returns

The received message.

static inline void MU_SetFlagsNonBlocking(MU_Type *base, uint32_t flags)

Sets the 3-bit MU flags reflect on the other MU side.

This function sets the 3-bit MU flags directly. Every time the 3-bit MU flags are changed, the status flag kMU_FlagsUpdatingFlag asserts indicating the 3-bit MU flags are updating to the other side. After the 3-bit MU flags are updated, the status flag kMU_FlagsUpdatingFlag is cleared by hardware. During the flags updating period, the flags cannot be changed. The upper layer should make sure the status flag kMU_FlagsUpdatingFlag is cleared before calling this function.

```
while (kMU_FlagsUpdatingFlag & MU_GetStatusFlags(base))
{
    } Wait for previous MU flags updating.

MU_SetFlagsNonBlocking(base, 0U); Set the mU flags.
```

Parameters

- base – MU peripheral base address.
- flags – The 3-bit MU flags to set.

status_t MU_SetFlags(MU_Type *base, uint32_t flags)

Blocks setting the 3-bit MU flags reflect on the other MU side.

This function blocks setting the 3-bit MU flags. Every time the 3-bit MU flags are changed, the status flag kMU_FlagsUpdatingFlag asserts indicating the 3-bit MU flags are updating to the other side. After the 3-bit MU flags are updated, the status flag kMU_FlagsUpdatingFlag is cleared by hardware. During the flags updating period, the flags cannot be changed. This function waits for the MU status flag kMU_FlagsUpdatingFlag cleared and sets the 3-bit MU flags.

If MU_BUSY_POLL_COUNT is defined and non-zero, the function will timeout after the specified number of polling iterations and return kStatus_Timeout.

Parameters

- base – MU peripheral base address.
- flags – The 3-bit MU flags to set.

Return values

- kStatus_Success – Flags were set successfully.
- kStatus_Timeout – Timeout occurred while waiting for flags to update.

Returns

status_t

static inline uint32_t MU_GetFlags(MU_Type *base)

Gets the current value of the 3-bit MU flags set by the other side.

This function gets the current 3-bit MU flags on the current side.

Parameters

- base – MU peripheral base address.

Returns

flags Current value of the 3-bit flags.

static inline uint32_t MU_GetStatusFlags(MU_Type *base)

Gets the MU status flags.

This function returns the bit mask of the MU status flags. See `_mu_status_flags`.

```
uint32_t flags;
flags = MU_GetStatusFlags(base); Get all status flags.
if (kMU_Tx0EmptyFlag & flags)
{
    The TX0 register is empty. Message can be sent.
    MU_SendMsgNonBlocking(base, kMU_MsgReg0, MSG0_VAL);
}
if (kMU_Tx1EmptyFlag & flags)
{
    The TX1 register is empty. Message can be sent.
    MU_SendMsgNonBlocking(base, kMU_MsgReg1, MSG1_VAL);
}
```

Parameters

- base – MU peripheral base address.

Returns

Bit mask of the MU status flags, see `_mu_status_flags`.

static inline uint32_t MU_GetRxStatusFlags(MU_Type *base)

Return the RX status flags.

This function return the RX status flags. Note: RFn bits of SR[27-24](mu status register) are mapped in reverse numerical order: RF0 -> SR[27] RF1 -> SR[26] RF2 -> SR[25] RF3 -> SR[24]

```
status_reg = MU_GetRxStatusFlags(base);
```

Parameters

- base – MU peripheral base address.

Returns

MU RX status

static inline uint32_t MU_GetInterruptsPending(MU_Type *base)

Gets the MU IRQ pending status of enabled interrupts.

This function returns the bit mask of the pending MU IRQs of enabled interrupts. Only these flags are checked. kMU_Tx0EmptyFlag kMU_Tx1EmptyFlag kMU_Tx2EmptyFlag kMU_Tx3EmptyFlag kMU_Rx0FullFlag kMU_Rx1FullFlag kMU_Rx2FullFlag kMU_Rx3FullFlag kMU_GenInt0Flag kMU_GenInt1Flag kMU_GenInt2Flag kMU_GenInt3Flag

Parameters

- base – MU peripheral base address.

Returns

Bit mask of the MU IRQs pending.

static inline void MU_ClearStatusFlags(MU_Type *base, uint32_t mask)

Clears the specific MU status flags.

This function clears the specific MU status flags. The flags to clear should be passed in as bit mask. See `_mu_status_flags`.

```
Clear general interrupt 0 and general interrupt 1 pending flags.
MU_ClearStatusFlags(base, kMU_GenInt0Flag | kMU_GenInt1Flag);
```

Parameters

- base – MU peripheral base address.
- mask – Bit mask of the MU status flags. See `_mu_status_flags`. The following flags are cleared by hardware, this function could not clear them.
 - `kMU_Tx0EmptyFlag`
 - `kMU_Tx1EmptyFlag`
 - `kMU_Tx2EmptyFlag`
 - `kMU_Tx3EmptyFlag`
 - `kMU_Rx0FullFlag`
 - `kMU_Rx1FullFlag`
 - `kMU_Rx2FullFlag`
 - `kMU_Rx3FullFlag`
 - `kMU_EventPendingFlag`
 - `kMU_FlagsUpdatingFlag`
 - `kMU_OtherSideInResetFlag`

`static inline void MU_EnableInterrupts(MU_Type *base, uint32_t mask)`

Enables the specific MU interrupts.

This function enables the specific MU interrupts. The interrupts to enable should be passed in as bit mask. See `_mu_interrupt_enable`.

Enable general interrupt 0 and TX0 empty interrupt.
`MU_EnableInterrupts(base, kMU_GenInt0InterruptEnable | kMU_Tx0EmptyInterruptEnable);`

Parameters

- base – MU peripheral base address.
- mask – Bit mask of the MU interrupts. See `_mu_interrupt_enable`.

`static inline void MU_DisableInterrupts(MU_Type *base, uint32_t mask)`

Disables the specific MU interrupts.

This function disables the specific MU interrupts. The interrupts to disable should be passed in as bit mask. See `_mu_interrupt_enable`.

Disable general interrupt 0 and TX0 empty interrupt.
`MU_DisableInterrupts(base, kMU_GenInt0InterruptEnable | kMU_Tx0EmptyInterruptEnable);`

Parameters

- base – MU peripheral base address.
- mask – Bit mask of the MU interrupts. See `_mu_interrupt_enable`.

`status_t MU_TriggerInterrupts(MU_Type *base, uint32_t mask)`

Triggers interrupts to the other core.

This function triggers the specific interrupts to the other core. The interrupts to trigger are passed in as bit mask. See `_mu_interrupt_trigger`. The MU should not trigger an interrupt to the other core when the previous interrupt has not been processed by the other core. This function checks whether the previous interrupts have been processed. If not, it returns an error.

```
if (kStatus_Success != MU_TriggerInterrupts(base, kMU_GenInt0InterruptTrigger | kMU_
↪ GenInt2InterruptTrigger))
{
    Previous general purpose interrupt 0 or general purpose interrupt 2
    has not been processed by the other core.
}
```

Parameters

- base – MU peripheral base address.
- mask – Bit mask of the interrupts to trigger. See `_mu_interrupt_trigger`.

Return values

- kStatus_Success – Interrupts have been triggered successfully.
- kStatus_Fail – Previous interrupts have not been accepted.

static inline void MU_MaskHardwareReset(MU_Type *base, bool mask)

Mask hardware reset by the other core.

The other core could call `MU_HardwareResetOtherCore()` to reset current core. To mask the reset, call this function and pass in true.

Parameters

- base – MU peripheral base address.
- mask – Pass true to mask the hardware reset, pass false to unmask it.

FSL_MU_DRIVER_VERSION

MU driver version.

enum _mu_status_flags

MU status flags.

Values:

enumerator kMU_Tx0EmptyFlag

TX0 empty.

enumerator kMU_Tx1EmptyFlag

TX1 empty.

enumerator kMU_Tx2EmptyFlag

TX2 empty.

enumerator kMU_Tx3EmptyFlag

TX3 empty.

enumerator kMU_Rx0FullFlag

RX0 full.

enumerator kMU_Rx1FullFlag

RX1 full.

enumerator kMU_Rx2FullFlag

RX2 full.

enumerator kMU_Rx3FullFlag

RX3 full.

enumerator kMU_GenInt0Flag

General purpose interrupt 0 pending.

enumerator kMU__GenInt1Flag
General purpose interrupt 1 pending.

enumerator kMU__GenInt2Flag
General purpose interrupt 2 pending.

enumerator kMU__GenInt3Flag
General purpose interrupt 3 pending.

enumerator kMU__EventPendingFlag
MU event pending.

enumerator kMU__FlagsUpdatingFlag
MU flags update is on-going.

enumerator kMU__ResetAssertInterruptFlag
The other core reset assert interrupt pending.

enumerator kMU__ResetDeassertInterruptFlag
The other core reset de-assert interrupt pending.

enumerator kMU__OtherSideInResetFlag
The other side is in reset.

enumerator kMU__MuResetInterruptFlag
The other side initializes MU reset.

enumerator kMU__HardwareResetInterruptFlag
Current side has been hardware reset by the other side.

enum __mu_interrupt_enable
MU interrupt source to enable.

Values:

enumerator kMU__Tx0EmptyInterruptEnable
TX0 empty.

enumerator kMU__Tx1EmptyInterruptEnable
TX1 empty.

enumerator kMU__Tx2EmptyInterruptEnable
TX2 empty.

enumerator kMU__Tx3EmptyInterruptEnable
TX3 empty.

enumerator kMU__Rx0FullInterruptEnable
RX0 full.

enumerator kMU__Rx1FullInterruptEnable
RX1 full.

enumerator kMU__Rx2FullInterruptEnable
RX2 full.

enumerator kMU__Rx3FullInterruptEnable
RX3 full.

enumerator kMU__GenInt0InterruptEnable
General purpose interrupt 0.

enumerator kMU__GenInt1InterruptEnable

General purpose interrupt 1.

enumerator kMU__GenInt2InterruptEnable

General purpose interrupt 2.

enumerator kMU__GenInt3InterruptEnable

General purpose interrupt 3.

enumerator kMU__ResetAssertInterruptEnable

The other core reset assert interrupt.

enumerator kMU__ResetDeassertInterruptEnable

The other core reset de-assert interrupt.

enumerator kMU__MuResetInterruptEnable

The other side initializes MU reset. The interrupt is ORed with the general purpose interrupt 3. The general purpose interrupt 3 is issued when the other side set the MU reset and this interrupt is enabled.

enumerator kMU__HardwareResetInterruptEnable

Current side has been hardware reset by the other side.

enum __mu_interrupt_trigger

MU interrupt that could be triggered to the other core.

Values:

enumerator kMU__GenInt0InterruptTrigger

General purpose interrupt 0.

enumerator kMU__GenInt1InterruptTrigger

General purpose interrupt 1.

enumerator kMU__GenInt2InterruptTrigger

General purpose interrupt 2.

enumerator kMU__GenInt3InterruptTrigger

General purpose interrupt 3.

enum __mu_msg_reg_index

MU message register.

Values:

enumerator kMU__MsgReg0

enumerator kMU__MsgReg1

enumerator kMU__MsgReg2

enumerator kMU__MsgReg3

typedef enum __mu_msg_reg_index mu_msg_reg_index_t

MU message register.

MU_CR_NMI_MASK

MU_BUSY_POLL_COUNT

Maximum polling iterations for MU waiting loops.

This parameter defines the maximum number of iterations for any polling loop in the MU code before timing out and returning an error.

It applies to all waiting loops in MU driver, such as waiting for TX register to be empty or waiting for RX register to be full.

This is a count of loop iterations, not a time-based value.

If defined as 0, polling loops will continue indefinitely until their exit condition is met, which could potentially cause the system to hang if a core becomes unresponsive.

MU_GET_CORE_FLAG(flags)

MU_GET_STAT_FLAG(flags)

MU_GET_TX_FLAG(flags)

MU_GET_RX_FLAG(flags)

MU_GET_GI_FLAG(flags)

2.25 PDM: Microphone Interface

2.26 PDM Driver

void PDM_Init(PDM_Type *base, const *pdm_config_t* *config)

Initializes the PDM peripheral.

Ungates the PDM clock, resets the module, and configures PDM with a configuration structure. The configuration structure can be custom filled or set with default values by PDM_GetDefaultConfig().

Note: This API should be called at the beginning of the application to use the PDM driver. Otherwise, accessing the PDM module can cause a hard fault because the clock is not enabled.

Parameters

- base – PDM base pointer
- config – PDM configuration structure.

void PDM_Deinit(PDM_Type *base)

De-initializes the PDM peripheral.

This API gates the PDM clock. The PDM module can't operate unless PDM_Init is called to enable the clock.

Parameters

- base – PDM base pointer

static inline void PDM_Reset(PDM_Type *base)

Resets the PDM module.

Parameters

- base – PDM base pointer

static inline void PDM_Enable(PDM_Type *base, bool enable)

Enables/disables PDM interface.

Parameters

- base – PDM base pointer
- enable – True means PDM interface is enabled, false means PDM interface is disabled.

static inline void PDM_EnableDebugMode(PDM_Type *base, bool enable)

Enables/disables debug mode for PDM. The PDM interface cannot enter debug mode once in Disable/Low Leakage or Low Power mode.

Parameters

- base – PDM base pointer
- enable – True means PDM interface enter debug mode, false means PDM interface in normal mode.

static inline void PDM_EnableInDebugMode(PDM_Type *base, bool enable)

Enables/disables PDM interface in debug mode.

Parameters

- base – PDM base pointer
- enable – True means PDM interface is enabled debug mode, false means PDM interface is disabled after after completing the current frame in debug mode.

static inline void PDM_EnterLowLeakageMode(PDM_Type *base, bool enable)

Enables/disables PDM interface disable/Low Leakage mode.

Parameters

- base – PDM base pointer
- enable – True means PDM interface is in disable/low leakage mode, False means PDM interface is in normal mode.

static inline void PDM_EnableChannel(PDM_Type *base, uint8_t channel, bool enable)

Enables/disables the PDM channel.

Parameters

- base – PDM base pointer
- channel – PDM channel number need to enable or disable.
- enable – True means enable PDM channel, false means disable.

void PDM_SetChannelConfig(PDM_Type *base, uint32_t channel, const *pdm_channel_config_t* *config)

PDM one channel configurations.

Parameters

- base – PDM base pointer
- config – PDM channel configurations.
- channel – channel number. after completing the current frame in debug mode.

status_t PDM_SetSampleRateConfig(PDM_Type *base, uint32_t sourceClock_HZ, uint32_t sampleRate_HZ)

PDM set sample rate.

Note: This function is depend on the configuration of the PDM and PDM channel, so the correct call sequence is

```
PDM_Init(base, pdmConfig)
PDM_SetChannelConfig(base, channel, &channelConfig)
PDM_SetSampleRateConfig(base, source, sampleRate)
```

Parameters

- base – PDM base pointer
- sourceClock_HZ – PDM source clock frequency.
- sampleRate_HZ – PDM sample rate.

```
status_t PDM_SetSampleRate(PDM_Type *base, uint32_t enableChannelMask,
                           pdm_df_quality_mode_t qualityMode, uint8_t osr, uint32_t clkDiv)
```

PDM set sample rate.

Deprecated:

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

Parameters

- base – PDM base pointer
- enableChannelMask – PDM channel enable mask.
- qualityMode – quality mode.
- osr – cic oversample rate
- clkDiv – clock divider

```
uint32_t PDM_GetInstance(PDM_Type *base)
```

Get the instance number for PDM.

Parameters

- base – PDM base pointer.

```
static inline uint32_t PDM_GetStatus(PDM_Type *base)
```

Gets the PDM internal status flag. Use the Status Mask in `_pdm_internal_status` to get the status value needed.

Parameters

- base – PDM base pointer

Returns

PDM status flag value.

```
static inline uint32_t PDM_GetFifoStatus(PDM_Type *base)
```

Gets the PDM FIFO status flag. Use the Status Mask in `_pdm_fifo_status` to get the status value needed.

Parameters

- base – PDM base pointer

Returns

FIFO status.

```
static inline uint32_t PDM_GetRangeStatus(PDM_Type *base)
```

Gets the PDM Range status flag. Use the Status Mask in `_pdm_range_status` to get the status value needed.

Parameters

- base – PDM base pointer

Returns

output status.

static inline void PDM_ClearStatus(PDM_Type *base, uint32_t mask)

Clears the PDM Tx status.

Parameters

- base – PDM base pointer
- mask – State mask. It can be a combination of the status between kPDM_StatusFrequencyLow and kPDM_StatusCh7FifoDataAvaliable.

static inline void PDM_ClearFIFOStatus(PDM_Type *base, uint32_t mask)

Clears the PDM Tx status.

Parameters

- base – PDM base pointer
- mask – State mask. It can be a combination of the status in _pdm_fifo_status.

static inline void PDM_ClearRangeStatus(PDM_Type *base, uint32_t mask)

Clears the PDM range status.

Parameters

- base – PDM base pointer
- mask – State mask. It can be a combination of the status in _pdm_range_status.

void PDM_EnableInterrupts(PDM_Type *base, uint32_t mask)

Enables the PDM interrupt requests.

Parameters

- base – PDM base pointer
- mask – interrupt source The parameter can be a combination of the following sources if defined.
 - kPDM_ErrorInterruptEnable
 - kPDM_FIFOInterruptEnable

static inline void PDM_DisableInterrupts(PDM_Type *base, uint32_t mask)

Disables the PDM interrupt requests.

Parameters

- base – PDM base pointer
- mask – interrupt source The parameter can be a combination of the following sources if defined.
 - kPDM_ErrorInterruptEnable
 - kPDM_FIFOInterruptEnable

static inline void PDM_EnableDMA(PDM_Type *base, bool enable)

Enables/disables the PDM DMA requests.

Parameters

- base – PDM base pointer
- enable – True means enable DMA, false means disable DMA.

```
static inline uint32_t PDM_GetDataRegisterAddress(PDM_Type *base, uint32_t channel)
```

Gets the PDM data register address.

This API is used to provide a transfer address for the PDM DMA transfer configuration.

Parameters

- base – PDM base pointer.
- channel – Which data channel used.

Returns

data register address.

```
void PDM_ReadFifo(PDM_Type *base, uint32_t startChannel, uint32_t channelNums, void  
                 *buffer, size_t size, uint32_t dataWidth)
```

PDM read fifo.

Note: : This function support 16 bit only for IP version that only supports 16bit.

Parameters

- base – PDM base pointer.
- startChannel – start channel number.
- channelNums – total enabled channelnums.
- buffer – received buffer address.
- size – number of samples to read.
- dataWidth – sample width.

```
void PDM_SetChannelGain(PDM_Type *base, uint32_t channel, pdm_df_output_gain_t gain)
```

Set the PDM channel gain.

Please note for different quality mode, the valid gain value is different, reference RM for detail.

Parameters

- base – PDM base pointer.
- channel – PDM channel index.
- gain – channel gain, the register gain value range is 0 - 15.

```
void PDM_TransferCreateHandle(PDM_Type *base, pdm_handle_t *handle,  
                             pdm_transfer_callback_t callback, void *userData)
```

Initializes the PDM handle.

This function initializes the handle for the PDM transactional APIs. Call this function once to get the handle initialized.

Parameters

- base – PDM base pointer.
- handle – PDM handle pointer.
- callback – Pointer to the user callback function.
- userData – User parameter passed to the callback function.

status_t PDM_TransferSetChannelConfig(PDM_Type *base, *pdm_handle_t* *handle, uint32_t channel, const *pdm_channel_config_t* *config, uint32_t format)

PDM set channel transfer config.

Parameters

- base – PDM base pointer.
- handle – PDM handle pointer.
- channel – PDM channel.
- config – channel config.
- format – data format, support data width configurations, *_pdm_data_width*.

Return values

kStatus_PDM_ChannelConfig_Failed – or *kStatus_Success*.

status_t PDM_TransferReceiveNonBlocking(PDM_Type *base, *pdm_handle_t* *handle, *pdm_transfer_t* *xfer)

Performs an interrupt non-blocking receive transfer on PDM.

Note: This API returns immediately after the transfer initiates. Call the *PDM_RxGetTransferStatusIRQ* to poll the transfer status and check whether the transfer is finished. If the return status is not *kStatus_PDM_Busy*, the transfer is finished.

Parameters

- base – PDM base pointer
- handle – Pointer to the *pdm_handle_t* structure which stores the transfer state.
- xfer – Pointer to the *pdm_transfer_t* structure.

Return values

- *kStatus_Success* – Successfully started the data receive.
- *kStatus_PDM_Busy* – Previous receive still not finished.

void PDM_TransferAbortReceive(PDM_Type *base, *pdm_handle_t* *handle)

Aborts the current IRQ receive.

Note: This API can be called when an interrupt non-blocking transfer initiates to abort the transfer early.

Parameters

- base – PDM base pointer
- handle – Pointer to the *pdm_handle_t* structure which stores the transfer state.

void PDM_TransferHandleIRQ(PDM_Type *base, *pdm_handle_t* *handle)

Tx interrupt handler.

Parameters

- base – PDM base pointer.
- handle – Pointer to the *pdm_handle_t* structure.

FSL_PDM_DRIVER_VERSION

Version 2.9.3

PDM return status.

Values:

enumerator kStatus_PDM_Busy

PDM is busy.

enumerator kStatus_PDM_CLK_LOW

PDM clock frequency low

enumerator kStatus_PDM_FIFO_ERROR

PDM FIFO underrun or overflow

enumerator kStatus_PDM_QueueFull

PDM FIFO underrun or overflow

enumerator kStatus_PDM_Idle

PDM is idle

enumerator kStatus_PDM_Output_ERROR

PDM is output error

enumerator kStatus_PDM_ChannelConfig_Failed

PDM channel config failed

enum _pdm_interrupt_enable

The PDM interrupt enable flag.

Values:

enumerator kPDM_ErrorInterruptEnable

PDM channel error interrupt enable.

enumerator kPDM_FIFOInterruptEnable

PDM channel FIFO interrupt

enum _pdm_internal_status

The PDM status.

Values:

enumerator kPDM_StatusDfBusyFlag

Decimation filter is busy processing data

enumerator kPDM_StatusFrequencyLow

Mic app clock frequency not high enough

enumerator kPDM_StatusCh0FifoDataAvaliable

channel 0 fifo data reached watermark level

enumerator kPDM_StatusCh1FifoDataAvaliable

channel 1 fifo data reached watermark level

enumerator kPDM_StatusCh2FifoDataAvaliable

channel 2 fifo data reached watermark level

enumerator kPDM_StatusCh3FifoDataAvaliable

channel 3 fifo data reached watermark level

enum `_pdm_channel_enable_mask`

PDM channel enable mask.

Values:

enumerator `kPDM_EnableChannel0`

channel 0 enable mask

enumerator `kPDM_EnableChannel1`

channel 1 enable mask

enumerator `kPDM_EnableChannel2`

channel 2 enable mask

enumerator `kPDM_EnableChannel3`

channel 3 enable mask

enumerator `kPDM_EnableChannelAll`

enum `_pdm_fifo_status`

The PDM fifo status.

Values:

enumerator `kPDM_FifoStatusUnderflowCh0`

channel0 fifo status underflow

enumerator `kPDM_FifoStatusUnderflowCh1`

channel1 fifo status underflow

enumerator `kPDM_FifoStatusUnderflowCh2`

channel2 fifo status underflow

enumerator `kPDM_FifoStatusUnderflowCh3`

channel3 fifo status underflow

enumerator `kPDM_FifoStatusOverflowCh0`

channel0 fifo status overflow

enumerator `kPDM_FifoStatusOverflowCh1`

channel1 fifo status overflow

enumerator `kPDM_FifoStatusOverflowCh2`

channel2 fifo status overflow

enumerator `kPDM_FifoStatusOverflowCh3`

channel3 fifo status overflow

enum `_pdm_range_status`

The PDM output status.

Values:

enumerator `kPDM_RangeStatusUnderFlowCh0`

channel0 range status underflow

enumerator `kPDM_RangeStatusUnderFlowCh1`

channel1 range status underflow

enumerator `kPDM_RangeStatusUnderFlowCh2`

channel2 range status underflow

enumerator `kPDM_RangeStatusUnderFlowCh3`

channel3 range status underflow

enumerator kPDM_RangeStatusOverflowCh0
channel0 range status overflow

enumerator kPDM_RangeStatusOverflowCh1
channel1 range status overflow

enumerator kPDM_RangeStatusOverflowCh2
channel2 range status overflow

enumerator kPDM_RangeStatusOverflowCh3
channel3 range status overflow

enum __pdm_dc_removal

PDM DC removal configurations.

Values:

enumerator kPDM_DcRemovalCutOff20Hz
DC removal cut off 20HZ

enumerator kPDM_DcRemovalCutOff13Hz
DC removal cut off 13.3HZ

enumerator kPDM_DcRemovalCutOff40Hz
DC removal cut off 40HZ

enumerator kPDM_DcRemovalBypass
DC removal bypass

enum __pdm_df_quality_mode

PDM decimation filter quality mode.

Values:

enumerator kPDM_QualityModeMedium
quality mode medium

enumerator kPDM_QualityModeHigh
quality mode high

enumerator kPDM_QualityModeLow
quality mode low

enumerator kPDM_QualityModeVeryLow0
quality mode very low0

enumerator kPDM_QualityModeVeryLow1
quality mode very low1

enumerator kPDM_QualityModeVeryLow2
quality mode very low2

enum __pdm_quality_mode_k_factor

PDM quality mode K factor.

Values:

enumerator kPDM_QualityModeHighKFactor
high quality mode K factor = 1 / 2

enumerator kPDM_QualityModeMediumKFactor
medium/very low0 quality mode K factor = 2 / 2

enumerator kPDM_QualityModeLowKFactor

low/very low1 quality mode K factor = 4 / 2

enumerator kPDM_QualityModeVeryLow2KFactor

very low2 quality mode K factor = 8 / 2

enum __pdm_df_output_gain

PDM decimation filter output gain.

Values:

enumerator kPDM_DfOutputGain0

Decimation filter output gain 0

enumerator kPDM_DfOutputGain1

Decimation filter output gain 1

enumerator kPDM_DfOutputGain2

Decimation filter output gain 2

enumerator kPDM_DfOutputGain3

Decimation filter output gain 3

enumerator kPDM_DfOutputGain4

Decimation filter output gain 4

enumerator kPDM_DfOutputGain5

Decimation filter output gain 5

enumerator kPDM_DfOutputGain6

Decimation filter output gain 6

enumerator kPDM_DfOutputGain7

Decimation filter output gain 7

enumerator kPDM_DfOutputGain8

Decimation filter output gain 8

enumerator kPDM_DfOutputGain9

Decimation filter output gain 9

enumerator kPDM_DfOutputGain10

Decimation filter output gain 10

enumerator kPDM_DfOutputGain11

Decimation filter output gain 11

enumerator kPDM_DfOutputGain12

Decimation filter output gain 12

enumerator kPDM_DfOutputGain13

Decimation filter output gain 13

enumerator kPDM_DfOutputGain14

Decimation filter output gain 14

enumerator kPDM_DfOutputGain15

Decimation filter output gain 15

enum __pdm_data_width

PDM data width.

Values:

```
enumerator kPDM_DataWidth24
    PDM data width 24bit
enumerator kPDM_DataWidth32
    PDM data width 32bit
typedef enum _pdm_dc_removal pdm_dc_removal_t
    PDM DC removal configurations.
typedef enum _pdm_df_quality_mode pdm_df_quality_mode_t
    PDM decimation filter quality mode.
typedef enum _pdm_df_output_gain pdm_df_output_gain_t
    PDM decimation filter output gain.
typedef struct _pdm_channel_config pdm_channel_config_t
    PDM channel configurations.
typedef struct _pdm_config pdm_config_t
    PDM user configuration structure.
typedef struct _pdm_transfer pdm_transfer_t
    PDM SDMA transfer structure.
typedef struct _pdm_handle pdm_handle_t
    PDM handle.
typedef void (*pdm_transfer_callback_t)(PDM_Type *base, pdm_handle_t *handle, status_t
status, void *userData)
    PDM transfer callback prototype.
PDM_XFER_QUEUE_SIZE
    PDM XFER QUEUE SIZE.
struct _pdm_channel_config
    #include <fsl_pdm.h> PDM channel configurations.
```

Public Members

```
pdm_dc_removal_t outputCutOffFreq
    PDM output DC removal cut off frequency
pdm_df_output_gain_t gain
    Decimation Filter Output Gain
struct _pdm_config
    #include <fsl_pdm.h> PDM user configuration structure.
```

Public Members

```
bool enableDoze
    This module will enter disable/low leakage mode if DOZEN is active with ipg_doze is
    asserted
bool enableFilterBypass
    Switchable bypass path for the decimation filter
uint8_t fifoWatermark
    Watermark value for FIFO
```

pdm_df_quality_mode_t qualityMode

Quality mode

uint8_t cicOverSampleRate

CIC filter over sampling rate

struct *__pdm_transfer*

#include <fsl_pdm.h> PDM SDMA transfer structure.

Public Members

volatile *uint8_t* *data

Data start address to transfer.

volatile *size_t* dataSize

Total Transfer bytes size.

struct *__pdm_handle*

#include <fsl_pdm.h> PDM handle structure.

Public Members

uint32_t state

Transfer status

pdm_transfer_callback_t callback

Callback function called at transfer event

void *userData

Callback parameter passed to callback function

pdm_transfer_t pdmQueue[(4U)]

Transfer queue storing queued transfer

size_t transferSize[(4U)]

Data bytes need to transfer

volatile *uint8_t* queueUser

Index for user to queue transfer

volatile *uint8_t* queueDriver

Index for driver to get the transfer data and size

uint32_t format

data format

uint8_t watermark

Watermark value

uint8_t startChannel

end channel

uint8_t channelNums

Enabled channel number

2.27 PDM EDMA Driver

```
void PDM_TransferInstallEDMATCDMemory(pdm_edma_handle_t *handle, void *tcdAddr, size_t
                                     tcdNum)
```

Install EDMA descriptor memory.

Parameters

- handle – Pointer to EDMA channel transfer handle.
- tcdAddr – EDMA head descriptor address.
- tcdNum – EDMA link descriptor address.

```
void PDM_TransferCreateHandleEDMA(PDM_Type *base, pdm_edma_handle_t *handle,
                                  pdm_edma_callback_t callback, void *userData,
                                  edma_handle_t *dmaHandle)
```

Initializes the PDM Rx eDMA handle.

This function initializes the PDM slave DMA handle, which can be used for other PDM master transactional APIs. Usually, for a specified PDM instance, call this API once to get the initialized handle.

Parameters

- base – PDM base pointer.
- handle – PDM eDMA handle pointer.
- callback – Pointer to user callback function.
- userData – User parameter passed to the callback function.
- dmaHandle – eDMA handle pointer, this handle shall be static allocated by users.

```
void PDM_TransferSetMultiChannelInterleaveType(pdm_edma_handle_t *handle,
                                                pdm_edma_multi_channel_interleave_t
                                                multiChannelInterleaveType)
```

Initializes the multi PDM channel interleave type.

This function initializes the PDM DMA handle member `interleaveType`, it shall be called only when application would like to use type `kPDM_EDMAMultiChannelInterleavePerChannelBlock`, since the default `interleaveType` is `kPDM_EDMAMultiChannelInterleavePerChannelSample` always

Parameters

- handle – PDM eDMA handle pointer.
- multiChannelInterleaveType – Multi channel interleave type.

```
void PDM_TransferSetChannelConfigEDMA(PDM_Type *base, pdm_edma_handle_t *handle,
                                       uint32_t channel, const pdm_channel_config_t
                                       *config)
```

Configures the PDM channel.

Parameters

- base – PDM base pointer.
- handle – PDM eDMA handle pointer.
- channel – channel index.
- config – pdm channel configurations.

```
status_t PDM_TransferReceiveEDMA(PDM_Type *base, pdm_edma_handle_t *handle,  
                                pdm_edma_transfer_t *xfer)
```

Performs a non-blocking PDM receive using eDMA.

Mcaro MCUX_SDK_PDM_EDMA_PDM_ENABLE_INTERNAL can control whether PDM is enabled internally or externally.

- a. Scatter gather case: This function support dynamic scatter gather and static scatter gather, a. for the dynamic scatter gather case: Application should call PDM_TransferReceiveEDMA function continuously to make sure new receive request is submit before the previous one finish. b. for the static scatter gather case: Application should use the link transfer feature and make sure a loop link transfer is provided, such as:

```
pdm_edma_transfer_t pdmXfer[2] =  
{  
    {  
        .data = s_buffer,  
        .dataSize = BUFFER_SIZE,  
        .linkTransfer = &pdmXfer[1],  
    },  
  
    {  
        .data = &s_buffer[BUFFER_SIZE],  
        .dataSize = BUFFER_SIZE,  
        .linkTransfer = &pdmXfer[0]  
    },  
};
```

- b. Multi channel case: This function support receive multi pdm channel data, for example, if two channel is requested,

```
PDM_TransferSetChannelConfigEDMA(DEMO_PDM, &s_pdmRxHandle_0, DEMO_PDM_  
↪ENABLE_CHANNEL_0, &channelConfig);  
PDM_TransferSetChannelConfigEDMA(DEMO_PDM, &s_pdmRxHandle_0, DEMO_PDM_  
↪ENABLE_CHANNEL_1, &channelConfig);  
PDM_TransferReceiveEDMA(DEMO_PDM, &s_pdmRxHandle_0, pdmXfer);
```

The output data will be formatted as below if handle->interleaveType =

Note: This interface returns immediately after the transfer initiates. Call the PDM_GetReceiveRemainingBytes to poll the transfer status and check whether the PDM transfer is finished.

```
void PDM_TransferTerminateReceiveEDMA(PDM_Type *base, pdm_edma_handle_t *handle)
```

Terminate all PDM receive.

This function will clear all transfer slots buffered in the pdm queue. If users only want to abort the current transfer slot, please call PDM_TransferAbortReceiveEDMA.

Parameters

- base – PDM base pointer.
- handle – PDM eDMA handle pointer.

```
void PDM_TransferAbortReceiveEDMA(PDM_Type *base, pdm_edma_handle_t *handle)
```

Aborts a PDM receive using eDMA.

This function only aborts the current transfer slots, the other transfer slots' information still kept in the handler. If users want to terminate all transfer slots, just call PDM_TransferTerminateReceiveEDMA.

Parameters

- base – PDM base pointer
- handle – PDM eDMA handle pointer.

status_t PDM_TransferGetReceiveCountEDMA(PDM_Type *base, *pdm_edma_handle_t* *handle, size_t *count)

Gets byte count received by PDM.

Parameters

- base – PDM base pointer
- handle – PDM eDMA handle pointer.
- count – Bytes count received by PDM.

Return values

- kStatus_Success – Succeed get the transfer count.
- kStatus_NoTransferInProgress – There is no non-blocking transaction in progress.

FSL_PDM_EDMA_DRIVER_VERSION

Version 2.6.5

enum __pdm_edma_multi_channel_interleave

pdm multi channel interleave type

Values:

enumerator kPDM_EDMA_MultiChannelInterleavePerChannelSample

enumerator kPDM_EDMA_MultiChannelInterleavePerChannelBlock

typedef struct *pdm_edma_handle* pdm_edma_handle_t

PDM edma handler.

typedef enum *pdm_edma_multi_channel_interleave* pdm_edma_multi_channel_interleave_t

pdm multi channel interleave type

typedef struct *pdm_edma_transfer* pdm_edma_transfer_t

PDM edma transfer.

typedef void (*pdm_edma_callback_t)(PDM_Type *base, *pdm_edma_handle_t* *handle, *status_t* status, void *userData)

PDM eDMA transfer callback function for finish and error.

MCUX_SDK_PDM_EDMA_PDM_ENABLE_INTERNAL

the PDM enable position When calling PDM_TransferReceiveEDMA

struct __pdm_edma_transfer

#include <fsl_pdm_edma.h> PDM edma transfer.

Public Members

volatile uint8_t *data

Data start address to transfer.

volatile size_t dataSize

Total Transfer bytes size.

struct *_pdm_edma_transfer* *linkTransfer

linked transfer configurations

struct *_pdm_edma_handle*

#include <fsl_pdm_edma.h> PDM DMA transfer handle, users should not touch the content of the handle.

Public Members

edma_handle_t *dmaHandle

DMA handler for PDM send

uint8_t count

The transfer data count in a DMA request

uint32_t receivedBytes

total transfer count

uint32_t state

Internal state for PDM eDMA transfer

pdm_edma_callback_t callback

Callback for users while transfer finish or error occurs

bool isLoopTransfer

loop transfer

void *userData

User callback parameter

edma_tcd_t *tcd

TCD pool for eDMA transfer.

uint32_t tcdNum

TCD number

uint32_t tcdUser

Index for user to queue transfer.

uint32_t tcdDriver

Index for driver to get the transfer data and size

volatile uint32_t tcdUsedNum

Index for user to queue transfer.

pdm_edma_multi_channel_interleave_t interleaveType

multi channel transfer interleave type

uint8_t endChannel

The last enabled channel

uint8_t channelNums

total channel numbers

2.28 PDM SDMA Driver

```
void PDM_TransferCreateHandleSDMA(PDM_Type *base, pdm_sdma_handle_t *handle,
                                  pdm_sdma_callback_t callback, void *userData,
                                  sdma_handle_t *dmaHandle, uint32_t eventSource)
```

Initializes the PDM eDMA handle.

This function initializes the PDM DMA handle, which can be used for other PDM master transactional APIs. Usually, for a specified PDM instance, call this API once to get the initialized handle.

Parameters

- base – PDM base pointer.
- handle – PDM eDMA handle pointer.
- callback – Pointer to user callback function.
- userData – User parameter passed to the callback function.
- dmaHandle – eDMA handle pointer, this handle shall be static allocated by users.
- eventSource – PDM event source number.

```
status_t PDM_TransferReceiveSDMA(PDM_Type *base, pdm_sdma_handle_t *handle,
                                  pdm_transfer_t *xfer)
```

Performs a non-blocking PDM receive using eDMA.

Note: This interface returns immediately after the transfer initiates. Call the `PDM_GetReceiveRemainingBytes` to poll the transfer status and check whether the PDM transfer is finished.

Parameters

- base – PDM base pointer
- handle – PDM eDMA handle pointer.
- xfer – Pointer to DMA transfer structure.

Return values

- `kStatus_Success` – Start a PDM eDMA receive successfully.
- `kStatus_InvalidArgument` – The input argument is invalid.
- `kStatus_RxBusy` – PDM is busy receiving data.

```
void PDM_TransferAbortReceiveSDMA(PDM_Type *base, pdm_sdma_handle_t *handle)
```

Aborts a PDM receive using eDMA.

Parameters

- base – PDM base pointer
- handle – PDM eDMA handle pointer.

```
void PDM_SetChannelConfigSDMA(PDM_Type *base, pdm_sdma_handle_t *handle, uint32_t
                              channel, const pdm_channel_config_t *config)
```

PDM channel configurations.

Parameters

- base – PDM base pointer.

- handle – PDM eDMA handle pointer.
- channel – channel number.
- config – channel configurations.

void PDM_TransferTerminateReceiveSDMA(PDM_Type *base, *pdm_sdma_handle_t* *handle)
Terminate all the PDM sdma receive transfer.

Parameters

- base – PDM base pointer.
- handle – PDM SDMA handle pointer.

FSL_PDM_SDMA_DRIVER_VERSION

Version 2.7.1

typedef struct *_pdm_sdma_handle* *pdm_sdma_handle_t*

typedef void (**pdm_sdma_callback_t*)(PDM_Type *base, *pdm_sdma_handle_t* *handle, *status_t* status, void *userData)

PDM eDMA transfer callback function for finish and error.

struct *_pdm_sdma_handle*

#include <fsl_pdm_sdma.h> PDM DMA transfer handle, users should not touch the content of the handle.

Public Members

sdma_handle_t *dmaHandle

DMA handler for PDM send

uint8_t nbytes

eDMA minor byte transfer count initially configured.

uint8_t fifoWidth

fifo width

uint8_t endChannel

The last enabled channel

uint8_t channelNums

total channel numbers

uint32_t count

The transfer data count in a DMA request

uint32_t state

Internal state for PDM eDMA transfer

uint32_t eventSource

PDM event source number

pdm_sdma_callback_t callback

Callback for users while transfer finish or error occurs

void *userData

User callback parameter

sdma_buffer_descriptor_t bdPool[(4U)]

BD pool for SDMA transfer.

`pdm_transfer_t` pdmQueue[(4U)]
Transfer queue storing queued transfer.

`size_t` transferSize[(4U)]
Data bytes need to transfer

`volatile uint8_t` queueUser
Index for user to queue transfer.

`volatile uint8_t` queueDriver
Index for driver to get the transfer data and size

2.29 PWM: Pulse Width Modulation Driver

`status_t` PWM_Init(PWM_Type *base, const *pwm_config_t* *config)
Ungates the PWM clock and configures the peripheral for basic operation.

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

Parameters

- base – PWM peripheral base address
- config – Pointer to user's PWM config structure.

Returns

kStatus_Success means success; else failed.

`void` PWM_Deinit(PWM_Type *base)
Gate the PWM submodule clock.

Parameters

- base – PWM peripheral base address

`void` PWM_GetDefaultConfig(*pwm_config_t* *config)
Fill in the PWM config struct with the default settings.

The default values are:

```
config->enableStopMode = false;
config->enableDozeMode = false;
config->enableWaitMode = false;
config->enableDozeMode = false;
config->clockSource = kPWM_LowFrequencyClock;
config->prescale = 0U;
config->outputConfig = kPWM_SetAtRolloverAndClearAtcomparison;
config->fifoWater = kPWM_FIFOWaterMark_2;
config->sampleRepeat = kPWM_EachSampleOnce;
config->byteSwap = kPWM_ByteNoSwap;
config->halfWordSwap = kPWM_HalfWordNoSwap;
```

Parameters

- config – Pointer to user's PWM config structure.

`static inline void` PWM_StartTimer(PWM_Type *base)
Starts the PWM counter when the PWM is enabled.

When the PWM is enabled, it begins a new period, the output pin is set to start a new period while the prescaler and counter are released and counting begins.

Parameters

- base – PWM peripheral base address

static inline void PWM_StopTimer(PWM_Type *base)

Stops the PWM counter when the pwm is disabled.

Parameters

- base – PWM peripheral base address

static inline void PWM_EnableInterrupts(PWM_Type *base, uint32_t mask)

Enables the selected PWM interrupts.

Parameters

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

static inline void PWM_DisableInterrupts(PWM_Type *base, uint32_t mask)

Disables the selected PWM interrupts.

Parameters

- base – PWM peripheral base address
- mask – The interrupts to disable. This is a logical OR of members of the enumeration pwm_interrupt_enable_t

static inline uint32_t PWM_GetEnabledInterrupts(PWM_Type *base)

Gets the enabled PWM interrupts.

Parameters

- base – PWM peripheral base address

Returns

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

static inline uint32_t PWM_GetStatusFlags(PWM_Type *base)

Gets the PWM status flags.

Parameters

- base – PWM peripheral base address

Returns

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

static inline void PWM_clearStatusFlags(PWM_Type *base, uint32_t mask)

Clears the PWM status flags.

Parameters

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

static inline uint32_t PWM_GetFIFOAvailable(PWM_Type *base)

Gets the PWM FIFO available.

Parameters

- base – PWM peripheral base address

Returns

The status flags. This is the logical OR of members of the enumeration `pwm_fifo_available_t`

static inline void PWM_SetSampleValue(PWM_Type *base, uint32_t value)

Sets the PWM sample value.

Parameters

- `base` – PWM peripheral base address
- `value` – The sample value. This is the input to the 4x16 FIFO. The value in this register denotes the value of the sample being currently used.

static inline uint32_t PWM_GetSampleValue(PWM_Type *base)

Gets the PWM sample value.

Parameters

- `base` – PWM peripheral base address

Returns

The sample value. It can be read only when the PWM is enable.

FSL_PWM_DRIVER_VERSION

enum _pwm_clock_source

PWM clock source select.

Values:

enumerator kPWM_PeripheralClock

The Peripheral clock is used as the clock

enumerator kPWM_HighFrequencyClock

High-frequency reference clock is used as the clock

enumerator kPWM_LowFrequencyClock

Low-frequency reference clock(32KHz) is used as the clock

enum _pwm_fifo_water_mark

PWM FIFO water mark select. Sets the data level at which the FIFO empty flag will be set.

Values:

enumerator kPWM_FIFOWaterMark_1

FIFO empty flag is set when there are more than or equal to 1 empty slots

enumerator kPWM_FIFOWaterMark_2

FIFO empty flag is set when there are more than or equal to 2 empty slots

enumerator kPWM_FIFOWaterMark_3

FIFO empty flag is set when there are more than or equal to 3 empty slots

enumerator kPWM_FIFOWaterMark_4

FIFO empty flag is set when there are more than or equal to 4 empty slots

enum _pwm_byte_data_swap

PWM byte data swap select. It determines the byte ordering of the 16-bit data when it goes into the FIFO from the sample register.

Values:

enumerator kPWM_ByteNoSwap

byte ordering remains the same

enumerator kPWM_ByteSwap
byte ordering is reversed

enum __pwm_half_word_data_swap
PWM half-word data swap select.

Values:

enumerator kPWM_HalfWordNoSwap
Half word swapping does not take place

enumerator kPWM_HalfWordSwap
Half word from write data bus are swapped

enum __pwm_output_configuration
PWM Output Configuration.

Values:

enumerator kPWM_SetAtRolloverAndClearAtcomparison
Output pin is set at rollover and cleared at comparison

enumerator kPWM_ClearAtRolloverAndSetAtcomparison
Output pin is cleared at rollover and set at comparison

enumerator kPWM_NoConfigure
PWM output is disconnected

enum __pwm_sample_repeat
PWM FIFO sample repeat It determines the number of times each sample from the FIFO is to be used.

Values:

enumerator kPWM_EachSampleOnce
Use each sample once

enumerator kPWM_EachSampletwice
Use each sample twice

enumerator kPWM_EachSampleFourTimes
Use each sample four times

enumerator kPWM_EachSampleEightTimes
Use each sample eight times

enum __pwm_interrupt_enable
List of PWM interrupt options.

Values:

enumerator kPWM_FIFOEmptyInterruptEnable
This bit controls the generation of the FIFO Empty interrupt.

enumerator kPWM_RolloverInterruptEnable
This bit controls the generation of the Rollover interrupt.

enumerator kPWM_CompareInterruptEnable
This bit controls the generation of the Compare interrupt

enum __pwm_status_flags
List of PWM status flags.

Values:

enumerator kPWM_FIFOEmptyFlag

This bit indicates the FIFO data level in comparison to the water level set by FWM field in the control register.

enumerator kPWM_RolloverFlag

This bit shows that a roll-over event has occurred.

enumerator kPWM_CompareFlag

This bit shows that a compare event has occurred.

enumerator kPWM_FIFOWriteErrorFlag

This bit shows that an attempt has been made to write FIFO when it is full.

enum __pwm_fifo_available

List of PWM FIFO available.

Values:

enumerator kPWM_NoDataInFIFOFlag

No data available

enumerator kPWM_OneWordInFIFOFlag

1 word of data in FIFO

enumerator kPWM_TwoWordsInFIFOFlag

2 word of data in FIFO

enumerator kPWM_ThreeWordsInFIFOFlag

3 word of data in FIFO

enumerator kPWM_FourWordsInFIFOFlag

4 word of data in FIFO

typedef enum _pwm_clock_source pwm_clock_source_t

PWM clock source select.

typedef enum _pwm_fifo_water_mark pwm_fifo_water_mark_t

PWM FIFO water mark select. Sets the data level at which the FIFO empty flag will be set.

typedef enum _pwm_byte_data_swap pwm_byte_data_swap_t

PWM byte data swap select. It determines the byte ordering of the 16-bit data when it goes into the FIFO from the sample register.

typedef enum _pwm_half_word_data_swap pwm_half_word_data_swap_t

PWM half-word data swap select.

typedef enum _pwm_output_configuration pwm_output_configuration_t

PWM Output Configuration.

typedef enum _pwm_sample_repeat pwm_sample_repeat_t

PWM FIFO sample repeat It determines the number of times each sample from the FIFO is to be used.

typedef enum _pwm_interrupt_enable pwm_interrupt_enable_t

List of PWM interrupt options.

typedef enum _pwm_status_flags pwm_status_flags_t

List of PWM status flags.

typedef enum _pwm_fifo_available_pwm_pwm_fifo_available_t

List of PWM FIFO available.

typedef struct _pwm_config pwm_config_t

```
static inline void PWM_SoftwareReset(PWM_Type *base)
```

Software reset.

PWM is reset when this bit is set to 1. It is a self clearing bit. Setting this bit resets all the registers to their reset values except for the STOPEN, DOZEN, WAITEN, and DBGEN bits in this control register.

Parameters

- base – PWM peripheral base address

```
static inline void PWM_SetPeriodValue(PWM_Type *base, uint32_t value)
```

Sets the PWM period value.

Parameters

- base – PWM peripheral base address
- value – The period value. The PWM period register (PWM_PWMPR) determines the period of the PWM output signal. Writing 0xFFFF to this register will achieve the same result as writing 0xFFFE. $PWMO\ (Hz) = PCLK(Hz) / (period + 2)$

```
static inline uint32_t PWM_GetPeriodValue(PWM_Type *base)
```

Gets the PWM period value.

Parameters

- base – PWM peripheral base address

Returns

The period value. The PWM period register (PWM_PWMPR) determines the period of the PWM output signal.

```
static inline uint32_t PWM_GetCounterValue(PWM_Type *base)
```

Gets the PWM counter value.

Parameters

- base – PWM peripheral base address

Returns

The counter value. The current count value.

```
struct __pwm_config
```

```
#include <fsl_pwm.h>
```

Public Members

```
bool enableStopMode
```

True: PWM continues to run in stop mode; False: PWM is paused in stop mode.

```
bool enableDozeMode
```

True: PWM continues to run in doze mode; False: PWM is paused in doze mode.

```
bool enableWaitMode
```

True: PWM continues to run in wait mode; False: PWM is paused in wait mode.

```
bool enableDebugMode
```

True: PWM continues to run in debug mode; False: PWM is paused in debug mode.

```
uint16_t prescale
```

Pre-scaler to divide down the clock The prescaler value is not more than 0xFFFF. Divide by (value + 1)

pwm_clock_source_t clockSource

Clock source for the counter

pwm_output_configuration_t outputConfig

Set the mode of the PWM output on the output pin.

pwm_fifo_water_mark_t fifoWater

Set the data level for FIFO.

pwm_sample_repeat_t sampleRepeat

The number of times each sample from the FIFO is to be used.

pwm_byte_data_swap_t byteSwap

It determines the byte ordering of the 16-bit data when it goes into the FIFO from the sample register.

pwm_half_word_data_swap_t halfWordSwap

It determines which half word data from the 32-bit IP Bus interface is written into the lower 16 bits of the sample register.

2.30 RDC: Resource Domain Controller

enum _rdc_interrupts

RDC interrupts.

Values:

enumerator kRDC_RestoreCompleteInterrupt

Interrupt generated when the RDC has completed restoring state to a recently re-powered memory regions.

enum _rdc_flags

RDC status.

Values:

enumerator kRDC_PowerDownDomainOn

Power down domain is ON.

enum _rdc_access_policy

Access permission policy.

Values:

enumerator kRDC_NoAccess

Could not read or write.

enumerator kRDC_WriteOnly

Write only.

enumerator kRDC_ReadOnly

Read only.

enumerator kRDC_ReadWrite

Read and write.

typedef struct *_rdc_hardware_config* rdc_hardware_config_t

RDC hardware configuration.

typedef struct *_rdc_domain_assignment* rdc_domain_assignment_t

Master domain assignment.

```
typedef struct _rdc_periph_access_config rdc_periph_access_config_t
```

Peripheral domain access permission configuration.

```
typedef struct _rdc_mem_access_config rdc_mem_access_config_t
```

Memory region domain access control configuration.

Note that when setting the `rdc_mem_access_config_t::baseAddress` and `rdc_mem_access_config_t::endAddress`, should be aligned to the region resolution, see `rdc_mem_t` definitions.

```
typedef struct _rdc_mem_status rdc_mem_status_t
```

Memory region access violation status.

```
void RDC_Init(RDC_Type *base)
```

Initializes the RDC module.

This function enables the RDC clock.

Parameters

- `base` – RDC peripheral base address.

```
void RDC_Deinit(RDC_Type *base)
```

De-initializes the RDC module.

This function disables the RDC clock.

Parameters

- `base` – RDC peripheral base address.

```
void RDC_GetHardwareConfig(RDC_Type *base, rdc_hardware_config_t *config)
```

Gets the RDC hardware configuration.

This function gets the RDC hardware configurations, including number of bus masters, number of domains, number of memory regions and number of peripherals.

Parameters

- `base` – RDC peripheral base address.
- `config` – Pointer to the structure to get the configuration.

```
static inline void RDC_EnableInterrupts(RDC_Type *base, uint32_t mask)
```

Enable interrupts.

Parameters

- `base` – RDC peripheral base address.
- `mask` – Interrupts to enable, it is OR'ed value of `enum _rdc_interrupts`.

```
static inline void RDC_DisableInterrupts(RDC_Type *base, uint32_t mask)
```

Disable interrupts.

Parameters

- `base` – RDC peripheral base address.
- `mask` – Interrupts to disable, it is OR'ed value of `enum _rdc_interrupts`.

```
static inline uint32_t RDC_GetInterruptStatus(RDC_Type *base)
```

Get the interrupt pending status.

Parameters

- `base` – RDC peripheral base address.

Returns

Interrupts pending status, it is OR'ed value of `enum _rdc_interrupts`.

```
static inline void RDC_ClearInterruptStatus(RDC_Type *base, uint32_t mask)
```

Clear interrupt pending status.

Parameters

- base – RDC peripheral base address.
- mask – Status to clear, it is OR'ed value of enum `_rdc_interrupts`.

```
static inline uint32_t RDC_GetStatus(RDC_Type *base)
```

Get RDC status.

Parameters

- base – RDC peripheral base address.

Returns

mask RDC status, it is OR'ed value of enum `_rdc_flags`.

```
static inline void RDC_ClearStatus(RDC_Type *base, uint32_t mask)
```

Clear RDC status.

Parameters

- base – RDC peripheral base address.
- mask – RDC status to clear, it is OR'ed value of enum `_rdc_flags`.

```
void RDC_SetMasterDomainAssignment(RDC_Type *base, rdc_master_t master, const  
rdc_domain_assignment_t *domainAssignment)
```

Set master domain assignment.

Parameters

- base – RDC peripheral base address.
- master – Which master to set.
- domainAssignment – Pointer to the assignment.

```
void RDC_GetDefaultMasterDomainAssignment(rdc_domain_assignment_t *domainAssignment)
```

Get default master domain assignment.

The default configuration is:

```
assignment->domainId = 0U;  
assignment->lock = 0U;
```

Parameters

- domainAssignment – Pointer to the assignment.

```
static inline void RDC_LockMasterDomainAssignment(RDC_Type *base, rdc_master_t master)
```

Lock master domain assignment.

Once locked, it could not be unlocked until next reset.

Parameters

- base – RDC peripheral base address.
- master – Which master to lock.

```
void RDC_SetPeriphAccessConfig(RDC_Type *base, const rdc_periph_access_config_t *config)
```

Set peripheral access policy.

Parameters

- base – RDC peripheral base address.

- config – Pointer to the policy configuration.

void RDC_GetDefaultPeriphAccessConfig(*rdc_periph_access_config_t* *config)

Get default peripheral access policy.

The default configuration is:

```
config->lock = false;
config->enableSema = false;
config->policy = RDC_ACCESS_POLICY(0, kRDC_ReadWrite) |
                RDC_ACCESS_POLICY(1, kRDC_ReadWrite) |
                RDC_ACCESS_POLICY(2, kRDC_ReadWrite) |
                RDC_ACCESS_POLICY(3, kRDC_ReadWrite);
```

Parameters

- config – Pointer to the policy configuration.

static inline void RDC_LockPeriphAccessConfig(RDC_Type *base, rdc_periph_t periph)

Lock peripheral access policy configuration.

Once locked, it could not be unlocked until reset.

Parameters

- base – RDC peripheral base address.
- periph – Which peripheral to lock.

static inline uint8_t RDC_GetPeriphAccessPolicy(RDC_Type *base, rdc_periph_t periph, uint8_t domainId)

Get the peripheral access policy for specific domain.

Parameters

- base – RDC peripheral base address.
- periph – Which peripheral to get.
- domainId – Get policy for which domain.

Returns

Access policy, see `_rdc_access_policy`.

void RDC_SetMemAccessConfig(RDC_Type *base, const *rdc_mem_access_config_t* *config)

Set memory region access policy.

Note that when setting the baseAddress and endAddress in config, should be aligned to the region resolution, see `rdc_mem_t` definitions.

Parameters

- base – RDC peripheral base address.
- config – Pointer to the policy configuration.

void RDC_GetDefaultMemAccessConfig(*rdc_mem_access_config_t* *config)

Get default memory region access policy.

The default configuration is:

```
config->lock = false;
config->baseAddress = 0;
config->endAddress = 0;
config->policy = RDC_ACCESS_POLICY(0, kRDC_ReadWrite) |
                RDC_ACCESS_POLICY(1, kRDC_ReadWrite) |
                RDC_ACCESS_POLICY(2, kRDC_ReadWrite) |
                RDC_ACCESS_POLICY(3, kRDC_ReadWrite);
```

Parameters

- config – Pointer to the policy configuration.

static inline void RDC_LockMemAccessConfig(RDC_Type *base, rdc_mem_t mem)

Lock memory access policy configuration.

Once locked, it could not be unlocked until reset. After locked, you can only call RDC_SetMemAccessValid to enable the configuration, but can not disable it or change other settings.

Parameters

- base – RDC peripheral base address.
- mem – Which memory region to lock.

static inline void RDC_SetMemAccessValid(RDC_Type *base, rdc_mem_t mem, bool valid)

Enable or disable memory access policy configuration.

Parameters

- base – RDC peripheral base address.
- mem – Which memory region to operate.
- valid – Pass in true to valid, false to invalid.

void RDC_GetMemViolationStatus(RDC_Type *base, rdc_mem_t mem, *rdc_mem_status_t* *status)

Get the memory region violation status.

The first access violation is captured. Subsequent violations are ignored until the status register is cleared. Contents are cleared upon reading the register. Clearing of contents occurs only when the status is read by the memory region's associated domain ID(s).

Parameters

- base – RDC peripheral base address.
- mem – Which memory region to get.
- status – The returned status.

static inline void RDC_ClearMemViolationFlag(RDC_Type *base, rdc_mem_t mem)

Clear the memory region violation flag.

Parameters

- base – RDC peripheral base address.
- mem – Which memory region to clear.

static inline uint8_t RDC_GetMemAccessPolicy(RDC_Type *base, rdc_mem_t mem, uint8_t domainId)

Get the memory region access policy for specific domain.

Parameters

- base – RDC peripheral base address.
- mem – Which memory region to get.
- domainId – Get policy for which domain.

Returns

Access policy, see `_rdc_access_policy`.

static inline uint8_t RDC_GetCurrentMasterDomainId(RDC_Type *base)

Gets the domain ID of the current bus master.

This function returns the domain ID of the current bus master.

Parameters

- base – RDC peripheral base address.

Returns

Domain ID of current bus master.

FSL_RDC_DRIVER_VERSION

RDC_ACCESS_POLICY(domainID, policy)

struct _rdc_hardware_config
#include <fsl_rdc.h> RDC hardware configuration.

Public Members

uint32_t domainNumber
Number of domains.

uint32_t masterNumber
Number of bus masters.

uint32_t periphNumber
Number of peripherals.

uint32_t memNumber
Number of memory regions.

struct _rdc_domain_assignment
#include <fsl_rdc.h> Master domain assignment.

Public Members

uint32_t domainId
Domain ID.

uint32_t __pad0__
Reserved.

uint32_t lock
Lock the domain assignment.

struct _rdc_periph_access_config
#include <fsl_rdc.h> Peripheral domain access permission configuration.

Public Members

rdc_periph_t periph
Peripheral name.

bool lock
Lock the permission until reset.

bool enableSema
Enable semaphore or not, when enabled, master should call RDC_SEMA42_Lock to lock the semaphore gate accordingly before access the peripheral.

uint16_t policy
Access policy.

struct _rdc_mem_access_config

#include <fsl_rdc.h> Memory region domain access control configuration.

Note that when setting the `rdc_mem_access_config_t::baseAddress` and `rdc_mem_access_config_t::endAddress`, should be aligned to the region resolution, see `rdc_mem_t` definitions.

Public Members

`rdc_mem_t mem`

Memory region descriptor name.

`bool lock`

Lock the configuration.

`uint64_t baseAddress`

Start address of the memory region.

`uint64_t endAddress`

End address of the memory region.

`uint16_t policy`

Access policy.

struct _rdc_mem_status

#include <fsl_rdc.h> Memory region access violation status.

Public Members

`bool hasViolation`

Violating happens or not.

`uint8_t domainID`

Violating Domain ID.

`uint64_t address`

Violating Address.

2.31 RDC_SEMA42: Hardware Semaphores Driver

`FSL_RDC_SEMA42_DRIVER_VERSION`

RDC_SEMA42 driver version.

`void RDC_SEMA42_Init(RDC_SEMAPHORE_Type *base)`

Initializes the RDC_SEMA42 module.

This function initializes the RDC_SEMA42 module. It only enables the clock but does not reset the gates because the module might be used by other processors at the same time. To reset the gates, call either `RDC_SEMA42_ResetGate` or `RDC_SEMA42_ResetAllGates` function.

Parameters

- `base` – RDC_SEMA42 peripheral base address.

`void RDC_SEMA42_Deinit(RDC_SEMAPHORE_Type *base)`

De-initializes the RDC_SEMA42 module.

This function de-initializes the RDC_SEMA42 module. It only disables the clock.

Parameters

- base – RDC_SEMA42 peripheral base address.

status_t RDC_SEMA42_TryLock(RDC_SEMAPHORE_Type *base, uint8_t gateNum, uint8_t masterIndex, uint8_t domainId)

Tries to lock the RDC_SEMA42 gate.

This function tries to lock the specific RDC_SEMA42 gate. If the gate has been locked by another processor, this function returns an error code.

Parameters

- base – RDC_SEMA42 peripheral base address.
- gateNum – Gate number to lock.
- masterIndex – Current processor master index.
- domainId – Current processor domain ID.

Return values

- kStatus_Success – Lock the sema42 gate successfully.
- kStatus_Failed – Sema42 gate has been locked by another processor.

void RDC_SEMA42_Lock(RDC_SEMAPHORE_Type *base, uint8_t gateNum, uint8_t masterIndex, uint8_t domainId)

Locks the RDC_SEMA42 gate.

This function locks the specific RDC_SEMA42 gate. If the gate has been locked by other processors, this function waits until it is unlocked and then lock it.

Parameters

- base – RDC_SEMA42 peripheral base address.
- gateNum – Gate number to lock.
- masterIndex – Current processor master index.
- domainId – Current processor domain ID.

static inline void RDC_SEMA42_Unlock(RDC_SEMAPHORE_Type *base, uint8_t gateNum)

Unlocks the RDC_SEMA42 gate.

This function unlocks the specific RDC_SEMA42 gate. It only writes unlock value to the RDC_SEMA42 gate register. However, it does not check whether the RDC_SEMA42 gate is locked by the current processor or not. As a result, if the RDC_SEMA42 gate is not locked by the current processor, this function has no effect.

Parameters

- base – RDC_SEMA42 peripheral base address.
- gateNum – Gate number to unlock.

static inline int32_t RDC_SEMA42_GetLockMasterIndex(RDC_SEMAPHORE_Type *base, uint8_t gateNum)

Gets which master has currently locked the gate.

Parameters

- base – RDC_SEMA42 peripheral base address.
- gateNum – Gate number.

Returns

Return -1 if the gate is not locked by any master, otherwise return the master index.

`int32_t RDC_SEMA42_GetLockDomainID(RDC_SEMAPHORE_Type *base, uint8_t gateNum)`
 Gets which domain has currently locked the gate.

Parameters

- `base` – RDC_SEMA42 peripheral base address.
- `gateNum` – Gate number.

Returns

Return -1 if the gate is not locked by any domain, otherwise return the domain ID.

`status_t RDC_SEMA42_ResetGate(RDC_SEMAPHORE_Type *base, uint8_t gateNum)`

Resets the RDC_SEMA42 gate to an unlocked status.

This function resets a RDC_SEMA42 gate to an unlocked status.

Parameters

- `base` – RDC_SEMA42 peripheral base address.
- `gateNum` – Gate number.

Return values

- `kStatus_Success` – RDC_SEMA42 gate is reset successfully.
- `kStatus_Failed` – Some other reset process is ongoing.

`static inline status_t RDC_SEMA42_ResetAllGates(RDC_SEMAPHORE_Type *base)`

Resets all RDC_SEMA42 gates to an unlocked status.

This function resets all RDC_SEMA42 gate to an unlocked status.

Parameters

- `base` – RDC_SEMA42 peripheral base address.

Return values

- `kStatus_Success` – RDC_SEMA42 is reset successfully.
- `kStatus_RDC_SEMA42_Reseting` – Some other reset process is ongoing.

`RDC_SEMA42_GATE_NUM_RESET_ALL`

The number to reset all RDC_SEMA42 gates.

`RDC_SEMA42_GATEn(base, n)`

RDC_SEMA42 gate n register address.

`RDC_SEMA42_GATE_COUNT`

RDC_SEMA42 gate count.

`RDC_SEMAPHORE_GATE_GTFSM_MASK`

2.32 SAI: Serial Audio Interface

2.33 SAI Driver

`void SAI_Init(I2S_Type *base)`

Initializes the SAI peripheral.

This API gates the SAI clock. The SAI module can't operate unless `SAI_Init` is called to enable the clock.

Parameters

- base – SAI base pointer.

void SAI_Deinit(I2S_Type *base)

De-initializes the SAI peripheral.

This API gates the SAI clock. The SAI module can't operate unless SAI_TxInit or SAI_RxInit is called to enable the clock.

Parameters

- base – SAI base pointer.

void SAI_TxReset(I2S_Type *base)

Resets the SAI Tx.

This function enables the software reset and FIFO reset of SAI Tx. After reset, clear the reset bit.

Parameters

- base – SAI base pointer

void SAI_RxReset(I2S_Type *base)

Resets the SAI Rx.

This function enables the software reset and FIFO reset of SAI Rx. After reset, clear the reset bit.

Parameters

- base – SAI base pointer

void SAI_TxEnable(I2S_Type *base, bool enable)

Enables/disables the SAI Tx.

Parameters

- base – SAI base pointer.
- enable – True means enable SAI Tx, false means disable.

void SAI_RxEnable(I2S_Type *base, bool enable)

Enables/disables the SAI Rx.

Parameters

- base – SAI base pointer.
- enable – True means enable SAI Rx, false means disable.

static inline void SAI_TxSetBitClockDirection(I2S_Type *base, sai_master_slave_t masterSlave)

Set Rx bit clock direction.

Select bit clock direction, master or slave.

Parameters

- base – SAI base pointer.
- masterSlave – reference sai_master_slave_t.

static inline void SAI_RxSetBitClockDirection(I2S_Type *base, sai_master_slave_t masterSlave)

Set Rx bit clock direction.

Select bit clock direction, master or slave.

Parameters

- base – SAI base pointer.

- masterSlave – reference sai_master_slave_t.

```
static inline void SAI_RxSetFrameSyncDirection(I2S_Type *base, sai_master_slave_t
                                              masterSlave)
```

Set Rx frame sync direction.

Select frame sync direction, master or slave.

Parameters

- base – SAI base pointer.
- masterSlave – reference sai_master_slave_t.

```
static inline void SAI_TxSetFrameSyncDirection(I2S_Type *base, sai_master_slave_t masterSlave)
```

Set Tx frame sync direction.

Select frame sync direction, master or slave.

Parameters

- base – SAI base pointer.
- masterSlave – reference sai_master_slave_t.

```
void SAI_TxSetBitClockRate(I2S_Type *base, uint32_t sourceClockHz, uint32_t sampleRate,
                           uint32_t bitWidth, uint32_t channelNumbers)
```

Transmitter bit clock rate configurations.

Parameters

- base – SAI base pointer.
- sourceClockHz – Bit clock source frequency.
- sampleRate – Audio data sample rate.
- bitWidth – Audio data bitWidth.
- channelNumbers – Audio channel numbers.

```
void SAI_RxSetBitClockRate(I2S_Type *base, uint32_t sourceClockHz, uint32_t sampleRate,
                           uint32_t bitWidth, uint32_t channelNumbers)
```

Receiver bit clock rate configurations.

Parameters

- base – SAI base pointer.
- sourceClockHz – Bit clock source frequency.
- sampleRate – Audio data sample rate.
- bitWidth – Audio data bitWidth.
- channelNumbers – Audio channel numbers.

```
void SAI_TxSetBitclockConfig(I2S_Type *base, sai_master_slave_t masterSlave, sai_bit_clock_t
                             *config)
```

Transmitter Bit clock configurations.

Parameters

- base – SAI base pointer.
- masterSlave – master or slave.
- config – bit clock other configurations, can be NULL in slave mode.

```
void SAI_RxSetBitclockConfig(I2S_Type *base, sai_master_slave_t masterSlave, sai_bit_clock_t *config)
```

Receiver Bit clock configurations.

Parameters

- base – SAI base pointer.
- masterSlave – master or slave.
- config – bit clock other configurations, can be NULL in slave mode.

```
void SAI_SetMasterClockConfig(I2S_Type *base, sai_master_clock_t *config)
```

Master clock configurations.

Parameters

- base – SAI base pointer.
- config – master clock configurations.

```
void SAI_TxSetFifoConfig(I2S_Type *base, sai_fifo_t *config)
```

SAI transmitter fifo configurations.

Parameters

- base – SAI base pointer.
- config – fifo configurations.

```
void SAI_RxSetFifoConfig(I2S_Type *base, sai_fifo_t *config)
```

SAI receiver fifo configurations.

Parameters

- base – SAI base pointer.
- config – fifo configurations.

```
void SAI_TxSetFrameSyncConfig(I2S_Type *base, sai_master_slave_t masterSlave, sai_frame_sync_t *config)
```

SAI transmitter Frame sync configurations.

Parameters

- base – SAI base pointer.
- masterSlave – master or slave.
- config – frame sync configurations, can be NULL in slave mode.

```
void SAI_RxSetFrameSyncConfig(I2S_Type *base, sai_master_slave_t masterSlave, sai_frame_sync_t *config)
```

SAI receiver Frame sync configurations.

Parameters

- base – SAI base pointer.
- masterSlave – master or slave.
- config – frame sync configurations, can be NULL in slave mode.

```
void SAI_TxSetSerialDataConfig(I2S_Type *base, sai_serial_data_t *config)
```

SAI transmitter Serial data configurations.

Parameters

- base – SAI base pointer.
- config – serial data configurations.

void SAI_RxSetSerialDataConfig(I2S_Type *base, *sai_serial_data_t* *config)
SAI receiver Serial data configurations.

Parameters

- base – SAI base pointer.
- config – serial data configurations.

void SAI_TxSetConfig(I2S_Type *base, *sai_transceiver_t* *config)
SAI transmitter configurations.

Parameters

- base – SAI base pointer.
- config – transmitter configurations.

void SAI_RxSetConfig(I2S_Type *base, *sai_transceiver_t* *config)
SAI receiver configurations.

Parameters

- base – SAI base pointer.
- config – receiver configurations.

void SAI_GetClassicI2SConfig(*sai_transceiver_t* *config, *sai_word_width_t* bitWidth,
sai_mono_stereo_t mode, uint32_t saiChannelMask)

Get classic I2S mode configurations.

Parameters

- config – transceiver configurations.
- bitWidth – audio data bitWidth.
- mode – audio data channel.
- saiChannelMask – mask value of the channel to be enable.

void SAI_GetLeftJustifiedConfig(*sai_transceiver_t* *config, *sai_word_width_t* bitWidth,
sai_mono_stereo_t mode, uint32_t saiChannelMask)

Get left justified mode configurations.

Parameters

- config – transceiver configurations.
- bitWidth – audio data bitWidth.
- mode – audio data channel.
- saiChannelMask – mask value of the channel to be enable.

void SAI_GetRightJustifiedConfig(*sai_transceiver_t* *config, *sai_word_width_t* bitWidth,
sai_mono_stereo_t mode, uint32_t saiChannelMask)

Get right justified mode configurations.

Parameters

- config – transceiver configurations.
- bitWidth – audio data bitWidth.
- mode – audio data channel.
- saiChannelMask – mask value of the channel to be enable.

```
void SAI_GetTDMConfig(sai_transceiver_t *config, sai_frame_sync_len_t frameSyncWidth,  
                    sai_word_width_t bitWidth, uint32_t dataWordNum, uint32_t  
                    saiChannelMask)
```

Get TDM mode configurations.

Parameters

- config – transceiver configurations.
- frameSyncWidth – length of frame sync.
- bitWidth – audio data word width.
- dataWordNum – word number in one frame.
- saiChannelMask – mask value of the channel to be enable.

```
void SAI_GetDSPConfig(sai_transceiver_t *config, sai_frame_sync_len_t frameSyncWidth,  
                    sai_word_width_t bitWidth, sai_mono_stereo_t mode, uint32_t  
                    saiChannelMask)
```

Get DSP mode configurations.

DSP/PCM MODE B configuration flow for TX. RX is similiar but uses SAI_RxSetConfig instead of SAI_TxSetConfig:

```
SAI_GetDSPConfig(config, kSAI_FrameSyncLenOneBitClk, bitWidth, kSAI_Stereo, channelMask)  
SAI_TxSetConfig(base, config)
```

Note: DSP mode is also called PCM mode which support MODE A and MODE B, DSP/PCM MODE A configuration flow. RX is similiar but uses SAI_RxSetConfig instead of SAI_TxSetConfig:

```
SAI_GetDSPConfig(config, kSAI_FrameSyncLenOneBitClk, bitWidth, kSAI_Stereo, channelMask)  
config->frameSync.frameSyncEarly = true;  
SAI_TxSetConfig(base, config)
```

Parameters

- config – transceiver configurations.
- frameSyncWidth – length of frame sync.
- bitWidth – audio data bitWidth.
- mode – audio data channel.
- saiChannelMask – mask value of the channel to enable.

```
static inline uint32_t SAI_TxGetStatusFlag(I2S_Type *base)
```

Gets the SAI Tx status flag state.

Parameters

- base – SAI base pointer

Returns

SAI Tx status flag value. Use the Status Mask to get the status value needed.

```
static inline void SAI_TxClearStatusFlags(I2S_Type *base, uint32_t mask)
```

Clears the SAI Tx status flag state.

Parameters

- base – SAI base pointer

- mask – State mask. It can be a combination of the following source if defined:
 - kSAI_WordStartFlag
 - kSAI_SyncErrorFlag
 - kSAI_FIFOErrorFlag

static inline uint32_t SAI_RxGetStatusFlag(I2S_Type *base)

Gets the SAI Tx status flag state.

Parameters

- base – SAI base pointer

Returns

SAI Rx status flag value. Use the Status Mask to get the status value needed.

static inline void SAI_RxClearStatusFlags(I2S_Type *base, uint32_t mask)

Clears the SAI Rx status flag state.

Parameters

- base – SAI base pointer
- mask – State mask. It can be a combination of the following sources if defined.
 - kSAI_WordStartFlag
 - kSAI_SyncErrorFlag
 - kSAI_FIFOErrorFlag

void SAI_TxSoftwareReset(I2S_Type *base, sai_reset_type_t resetType)

Do software reset or FIFO reset .

FIFO reset means clear all the data in the FIFO, and make the FIFO pointer both to 0. Software reset means clear the Tx internal logic, including the bit clock, frame count etc. But software reset will not clear any configuration registers like TCR1~TCR5. This function will also clear all the error flags such as FIFO error, sync error etc.

Parameters

- base – SAI base pointer
- resetType – Reset type, FIFO reset or software reset

void SAI_RxSoftwareReset(I2S_Type *base, sai_reset_type_t resetType)

Do software reset or FIFO reset .

FIFO reset means clear all the data in the FIFO, and make the FIFO pointer both to 0. Software reset means clear the Rx internal logic, including the bit clock, frame count etc. But software reset will not clear any configuration registers like RCR1~RCR5. This function will also clear all the error flags such as FIFO error, sync error etc.

Parameters

- base – SAI base pointer
- resetType – Reset type, FIFO reset or software reset

void SAI_TxSetChannelFIFOMask(I2S_Type *base, uint8_t mask)

Set the Tx channel FIFO enable mask.

Parameters

- base – SAI base pointer

- mask – Channel enable mask, 0 means all channel FIFO disabled, 1 means channel 0 enabled, 3 means both channel 0 and channel 1 enabled.

void SAI_RxSetChannelFIFOMask(I2S_Type *base, uint8_t mask)

Set the Rx channel FIFO enable mask.

Parameters

- base – SAI base pointer
- mask – Channel enable mask, 0 means all channel FIFO disabled, 1 means channel 0 enabled, 3 means both channel 0 and channel 1 enabled.

void SAI_TxSetDataOrder(I2S_Type *base, sai_data_order_t order)

Set the Tx data order.

Parameters

- base – SAI base pointer
- order – Data order MSB or LSB

void SAI_RxSetDataOrder(I2S_Type *base, sai_data_order_t order)

Set the Rx data order.

Parameters

- base – SAI base pointer
- order – Data order MSB or LSB

void SAI_TxSetBitClockPolarity(I2S_Type *base, sai_clock_polarity_t polarity)

Set the Tx data order.

Parameters

- base – SAI base pointer
- polarity –

void SAI_RxSetBitClockPolarity(I2S_Type *base, sai_clock_polarity_t polarity)

Set the Rx data order.

Parameters

- base – SAI base pointer
- polarity –

void SAI_TxSetFrameSyncPolarity(I2S_Type *base, sai_clock_polarity_t polarity)

Set the Tx data order.

Parameters

- base – SAI base pointer
- polarity –

void SAI_RxSetFrameSyncPolarity(I2S_Type *base, sai_clock_polarity_t polarity)

Set the Rx data order.

Parameters

- base – SAI base pointer
- polarity –

`void SAI_TxSetFIFOPacking(I2S_Type *base, sai_fifo_packing_t pack)`
Set Tx FIFO packing feature.

Parameters

- `base` – SAI base pointer.
- `pack` – FIFO pack type. It is element of `sai_fifo_packing_t`.

`void SAI_RxSetFIFOPacking(I2S_Type *base, sai_fifo_packing_t pack)`
Set Rx FIFO packing feature.

Parameters

- `base` – SAI base pointer.
- `pack` – FIFO pack type. It is element of `sai_fifo_packing_t`.

`static inline void SAI_TxSetFIFOErrorContinue(I2S_Type *base, bool isEnabled)`
Set Tx FIFO error continue.

FIFO error continue mode means SAI will keep running while FIFO error occurred. If this feature not enabled, SAI will hang and users need to clear FEF flag in TCSR register.

Parameters

- `base` – SAI base pointer.
- `isEnabled` – Is FIFO error continue enabled, true means enable, false means disable.

`static inline void SAI_RxSetFIFOErrorContinue(I2S_Type *base, bool isEnabled)`
Set Rx FIFO error continue.

FIFO error continue mode means SAI will keep running while FIFO error occurred. If this feature not enabled, SAI will hang and users need to clear FEF flag in RCSR register.

Parameters

- `base` – SAI base pointer.
- `isEnabled` – Is FIFO error continue enabled, true means enable, false means disable.

`static inline void SAI_TxEnableInterrupts(I2S_Type *base, uint32_t mask)`
Enables the SAI Tx interrupt requests.

Parameters

- `base` – SAI base pointer
- `mask` – interrupt source The parameter can be a combination of the following sources if defined.
 - `kSAI_WordStartInterruptEnable`
 - `kSAI_SyncErrorInterruptEnable`
 - `kSAI_FIFOWarningInterruptEnable`
 - `kSAI_FIFORequestInterruptEnable`
 - `kSAI_FIFOErrorInterruptEnable`

`static inline void SAI_RxEnableInterrupts(I2S_Type *base, uint32_t mask)`
Enables the SAI Rx interrupt requests.

Parameters

- `base` – SAI base pointer

- **mask** – interrupt source The parameter can be a combination of the following sources if defined.
 - kSAI_WordStartInterruptEnable
 - kSAI_SyncErrorInterruptEnable
 - kSAI_FIFOWarningInterruptEnable
 - kSAI_FIFORequestInterruptEnable
 - kSAI_FIFOErrorInterruptEnable

static inline void SAI_TxDisableInterrupts(I2S_Type *base, uint32_t mask)

Disables the SAI Tx interrupt requests.

Parameters

- **base** – SAI base pointer
- **mask** – interrupt source The parameter can be a combination of the following sources if defined.
 - kSAI_WordStartInterruptEnable
 - kSAI_SyncErrorInterruptEnable
 - kSAI_FIFOWarningInterruptEnable
 - kSAI_FIFORequestInterruptEnable
 - kSAI_FIFOErrorInterruptEnable

static inline void SAI_RxDisableInterrupts(I2S_Type *base, uint32_t mask)

Disables the SAI Rx interrupt requests.

Parameters

- **base** – SAI base pointer
- **mask** – interrupt source The parameter can be a combination of the following sources if defined.
 - kSAI_WordStartInterruptEnable
 - kSAI_SyncErrorInterruptEnable
 - kSAI_FIFOWarningInterruptEnable
 - kSAI_FIFORequestInterruptEnable
 - kSAI_FIFOErrorInterruptEnable

static inline void SAI_TxEnableDMA(I2S_Type *base, uint32_t mask, bool enable)

Enables/disables the SAI Tx DMA requests.

Parameters

- **base** – SAI base pointer
- **mask** – DMA source The parameter can be combination of the following sources if defined.
 - kSAI_FIFOWarningDMAEnable
 - kSAI_FIFORequestDMAEnable
- **enable** – True means enable DMA, false means disable DMA.

static inline void SAI_RxEnableDMA(I2S_Type *base, uint32_t mask, bool enable)
Enables/disables the SAI Rx DMA requests.

Parameters

- base – SAI base pointer
- mask – DMA source The parameter can be a combination of the following sources if defined.
 - kSAI_FIFOWarningDMAEnable
 - kSAI_FIFORequestDMAEnable
- enable – True means enable DMA, false means disable DMA.

static inline uintptr_t SAI_TxGetDataRegisterAddress(I2S_Type *base, uint32_t channel)
Gets the SAI Tx data register address.

This API is used to provide a transfer address for the SAI DMA transfer configuration.

Parameters

- base – SAI base pointer.
- channel – Which data channel used.

Returns

data register address.

static inline uintptr_t SAI_RxGetDataRegisterAddress(I2S_Type *base, uint32_t channel)
Gets the SAI Rx data register address.

This API is used to provide a transfer address for the SAI DMA transfer configuration.

Parameters

- base – SAI base pointer.
- channel – Which data channel used.

Returns

data register address.

void SAI_WriteBlocking(I2S_Type *base, uint32_t channel, uint32_t bitWidth, uint8_t *buffer,
uint32_t size)

Sends data using a blocking method.

Note: This function blocks by polling until data is ready to be sent.

Parameters

- base – SAI base pointer.
- channel – Data channel used.
- bitWidth – How many bits in an audio word; usually 8/16/24/32 bits.
- buffer – Pointer to the data to be written.
- size – Bytes to be written.

void SAI_WriteMultiChannelBlocking(I2S_Type *base, uint32_t channel, uint32_t channelMask,
uint32_t bitWidth, uint8_t *buffer, uint32_t size)

Sends data to multi channel using a blocking method.

Note: This function blocks by polling until data is ready to be sent.

Parameters

- base – SAI base pointer.
- channel – Data channel used.
- channelMask – channel mask.
- bitWidth – How many bits in an audio word; usually 8/16/24/32 bits.
- buffer – Pointer to the data to be written.
- size – Bytes to be written.

```
static inline void SAI_WriteData(I2S_Type *base, uint32_t channel, uint32_t data)
```

Writes data into SAI FIFO.

Parameters

- base – SAI base pointer.
- channel – Data channel used.
- data – Data needs to be written.

```
void SAI_ReadBlocking(I2S_Type *base, uint32_t channel, uint32_t bitWidth, uint8_t *buffer,  
                     uint32_t size)
```

Receives data using a blocking method.

Note: This function blocks by polling until data is ready to be sent.

Parameters

- base – SAI base pointer.
- channel – Data channel used.
- bitWidth – How many bits in an audio word; usually 8/16/24/32 bits.
- buffer – Pointer to the data to be read.
- size – Bytes to be read.

```
void SAI_ReadMultiChannelBlocking(I2S_Type *base, uint32_t channel, uint32_t channelMask,  
                                 uint32_t bitWidth, uint8_t *buffer, uint32_t size)
```

Receives multi channel data using a blocking method.

Note: This function blocks by polling until data is ready to be sent.

Parameters

- base – SAI base pointer.
- channel – Data channel used.
- channelMask – channel mask.
- bitWidth – How many bits in an audio word; usually 8/16/24/32 bits.
- buffer – Pointer to the data to be read.
- size – Bytes to be read.

```
static inline uint32_t SAI_ReadData(I2S_Type *base, uint32_t channel)
```

Reads data from the SAI FIFO.

Parameters

- base – SAI base pointer.
- channel – Data channel used.

Returns

Data in SAI FIFO.

```
void SAI_TransferTxCreateHandle(I2S_Type *base, sai_handle_t *handle, sai_transfer_callback_t  
callback, void *userData)
```

Initializes the SAI Tx handle.

This function initializes the Tx handle for the SAI Tx transactional APIs. Call this function once to get the handle initialized.

Parameters

- base – SAI base pointer
- handle – SAI handle pointer.
- callback – Pointer to the user callback function.
- userData – User parameter passed to the callback function

```
void SAI_TransferRxCreateHandle(I2S_Type *base, sai_handle_t *handle, sai_transfer_callback_t  
callback, void *userData)
```

Initializes the SAI Rx handle.

This function initializes the Rx handle for the SAI Rx transactional APIs. Call this function once to get the handle initialized.

Parameters

- base – SAI base pointer.
- handle – SAI handle pointer.
- callback – Pointer to the user callback function.
- userData – User parameter passed to the callback function.

```
void SAI_TransferTxSetConfig(I2S_Type *base, sai_handle_t *handle, sai_transceiver_t *config)
```

SAI transmitter transfer configurations.

This function initializes the Tx, include bit clock, frame sync, master clock, serial data and fifo configurations.

Parameters

- base – SAI base pointer.
- handle – SAI handle pointer.
- config – transmitter configurations.

```
void SAI_TransferRxSetConfig(I2S_Type *base, sai_handle_t *handle, sai_transceiver_t *config)
```

SAI receiver transfer configurations.

This function initializes the Rx, include bit clock, frame sync, master clock, serial data and fifo configurations.

Parameters

- base – SAI base pointer.
- handle – SAI handle pointer.

- config – receiver configurations.

status_t SAI_TransferSendNonBlocking(I2S_Type *base, *sai_handle_t* *handle, *sai_transfer_t* *xfer)

Performs an interrupt non-blocking send transfer on SAI.

Note: This API returns immediately after the transfer initiates. Call the SAI_TxGetTransferStatusIRQ to poll the transfer status and check whether the transfer is finished. If the return status is not kStatus_SAI_Busy, the transfer is finished.

Parameters

- base – SAI base pointer.
- handle – Pointer to the *sai_handle_t* structure which stores the transfer state.
- xfer – Pointer to the *sai_transfer_t* structure.

Return values

- kStatus_Success – Successfully started the data receive.
- kStatus_SAI_TxBusy – Previous receive still not finished.
- kStatus_InvalidArgument – The input parameter is invalid.

status_t SAI_TransferReceiveNonBlocking(I2S_Type *base, *sai_handle_t* *handle, *sai_transfer_t* *xfer)

Performs an interrupt non-blocking receive transfer on SAI.

Note: This API returns immediately after the transfer initiates. Call the SAI_RxGetTransferStatusIRQ to poll the transfer status and check whether the transfer is finished. If the return status is not kStatus_SAI_Busy, the transfer is finished.

Parameters

- base – SAI base pointer
- handle – Pointer to the *sai_handle_t* structure which stores the transfer state.
- xfer – Pointer to the *sai_transfer_t* structure.

Return values

- kStatus_Success – Successfully started the data receive.
- kStatus_SAI_RxBusy – Previous receive still not finished.
- kStatus_InvalidArgument – The input parameter is invalid.

status_t SAI_TransferGetSendCount(I2S_Type *base, *sai_handle_t* *handle, *size_t* *count)

Gets a set byte count.

Parameters

- base – SAI base pointer.
- handle – Pointer to the *sai_handle_t* structure which stores the transfer state.
- count – Bytes count sent.

Return values

- `kStatus_Success` – Succeed get the transfer count.
- `kStatus_NoTransferInProgress` – There is not a non-blocking transaction currently in progress.

`status_t SAI_TransferGetReceiveCount(I2S_Type *base, sai_handle_t *handle, size_t *count)`

Gets a received byte count.

Parameters

- `base` – SAI base pointer.
- `handle` – Pointer to the `sai_handle_t` structure which stores the transfer state.
- `count` – Bytes count received.

Return values

- `kStatus_Success` – Succeed get the transfer count.
- `kStatus_NoTransferInProgress` – There is not a non-blocking transaction currently in progress.

`void SAI_TransferAbortSend(I2S_Type *base, sai_handle_t *handle)`

Aborts the current send.

Note: This API can be called any time when an interrupt non-blocking transfer initiates to abort the transfer early.

Parameters

- `base` – SAI base pointer.
- `handle` – Pointer to the `sai_handle_t` structure which stores the transfer state.

`void SAI_TransferAbortReceive(I2S_Type *base, sai_handle_t *handle)`

Aborts the current IRQ receive.

Note: This API can be called when an interrupt non-blocking transfer initiates to abort the transfer early.

Parameters

- `base` – SAI base pointer
- `handle` – Pointer to the `sai_handle_t` structure which stores the transfer state.

`void SAI_TransferTerminateSend(I2S_Type *base, sai_handle_t *handle)`

Terminate all SAI send.

This function will clear all transfer slots buffered in the sai queue. If users only want to abort the current transfer slot, please call `SAI_TransferAbortSend`.

Parameters

- `base` – SAI base pointer.
- `handle` – SAI eDMA handle pointer.

void SAI_TransferTerminateReceive(I2S_Type *base, sai_handle_t *handle)

Terminate all SAI receive.

This function will clear all transfer slots buffered in the sai queue. If users only want to abort the current transfer slot, please call SAI_TransferAbortReceive.

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.

void SAI_TransferTxHandleIRQ(I2S_Type *base, sai_handle_t *handle)

Tx interrupt handler.

Parameters

- base – SAI base pointer.
- handle – Pointer to the sai_handle_t structure.

void SAI_TransferRxHandleIRQ(I2S_Type *base, sai_handle_t *handle)

Tx interrupt handler.

Parameters

- base – SAI base pointer.
- handle – Pointer to the sai_handle_t structure.

void SAI_DriverIRQHandler(uint32_t instance)

SAI driver IRQ handler common entry.

This function provides the common IRQ request entry for SAI.

Parameters

- instance – SAI instance.

FSL_SAI_DRIVER_VERSION

Version 2.4.10

_sai_status_t, SAI return status.

Values:

enumerator kStatus_SAI_TxBusy
SAI Tx is busy.

enumerator kStatus_SAI_RxBusy
SAI Rx is busy.

enumerator kStatus_SAI_TxError
SAI Tx FIFO error.

enumerator kStatus_SAI_RxError
SAI Rx FIFO error.

enumerator kStatus_SAI_QueueFull
SAI transfer queue is full.

enumerator kStatus_SAI_TxIdle
SAI Tx is idle

enumerator kStatus_SAI_RxIdle
SAI Rx is idle

_sai_channel_mask, sai channel mask value, actual channel numbers is depend soc specific
Values:

enumerator kSAI_Channel0Mask
channel 0 mask value

enumerator kSAI_Channel1Mask
channel 1 mask value

enumerator kSAI_Channel2Mask
channel 2 mask value

enumerator kSAI_Channel3Mask
channel 3 mask value

enumerator kSAI_Channel4Mask
channel 4 mask value

enumerator kSAI_Channel5Mask
channel 5 mask value

enumerator kSAI_Channel6Mask
channel 6 mask value

enumerator kSAI_Channel7Mask
channel 7 mask value

enum _sai_protocol

Define the SAI bus type.

Values:

enumerator kSAI_BusLeftJustified
Uses left justified format.

enumerator kSAI_BusRightJustified
Uses right justified format.

enumerator kSAI_BusI2S
Uses I2S format.

enumerator kSAI_BusPCMA
Uses I2S PCM A format.

enumerator kSAI_BusPCMB
Uses I2S PCM B format.

enum _sai_master_slave

Master or slave mode.

Values:

enumerator kSAI_Master
Master mode include bclk and frame sync

enumerator kSAI_Slave
Slave mode include bclk and frame sync

enumerator kSAI_Bclk_Master_FrameSync_Slave
bclk in master mode, frame sync in slave mode

enumerator kSAI_Bclk_Slave_FrameSync_Master
bclk in slave mode, frame sync in master mode

enum _sai_mono_stereo
Mono or stereo audio format.

Values:

enumerator kSAI_Stereo
Stereo sound.

enumerator kSAI_MonoRight
Only Right channel have sound.

enumerator kSAI_MonoLeft
Only left channel have sound.

enum _sai_data_order
SAI data order, MSB or LSB.

Values:

enumerator kSAI_DataLSB
LSB bit transferred first

enumerator kSAI_DataMSB
MSB bit transferred first

enum _sai_clock_polarity
SAI clock polarity, active high or low.

Values:

enumerator kSAI_PolarityActiveHigh
Drive outputs on rising edge

enumerator kSAI_PolarityActiveLow
Drive outputs on falling edge

enumerator kSAI_SampleOnFallingEdge
Sample inputs on falling edge

enumerator kSAI_SampleOnRisingEdge
Sample inputs on rising edge

enum _sai_sync_mode
Synchronous or asynchronous mode.

Values:

enumerator kSAI_ModeAsync
Asynchronous mode

enumerator kSAI_ModeSync
Synchronous mode (with receiver or transmit)

enumerator kSAI_ModeSyncWithOtherTx
Synchronous with another SAI transmit

enumerator kSAI_ModeSyncWithOtherRx
Synchronous with another SAI receiver

enum _sai_bclk_source

Bit clock source.

Values:

enumerator kSAI_BclkSourceBusclk

Bit clock using bus clock

enumerator kSAI_BclkSourceMclkOption1

Bit clock MCLK option 1

enumerator kSAI_BclkSourceMclkOption2

Bit clock MCLK option2

enumerator kSAI_BclkSourceMclkOption3

Bit clock MCLK option3

enumerator kSAI_BclkSourceMclkDiv

Bit clock using master clock divider

enumerator kSAI_BclkSourceOtherSai0

Bit clock from other SAI device

enumerator kSAI_BclkSourceOtherSai1

Bit clock from other SAI device

_sai_interrupt_enable_t, The SAI interrupt enable flag

Values:

enumerator kSAI_WordStartInterruptEnable

Word start flag, means the first word in a frame detected

enumerator kSAI_SyncErrorInterruptEnable

Sync error flag, means the sync error is detected

enumerator kSAI_FIFOWarningInterruptEnable

FIFO warning flag, means the FIFO is empty

enumerator kSAI_FIFOErrorInterruptEnable

FIFO error flag

enumerator kSAI_FIFORequestInterruptEnable

FIFO request, means reached watermark

_sai_dma_enable_t, The DMA request sources

Values:

enumerator kSAI_FIFOWarningDMAEnable

FIFO warning caused by the DMA request

enumerator kSAI_FIFORequestDMAEnable

FIFO request caused by the DMA request

_sai_flags, The SAI status flag

Values:

enumerator kSAI_WordStartFlag

Word start flag, means the first word in a frame detected

enumerator kSAI_SyncErrorFlag

Sync error flag, means the sync error is detected

enumerator kSAI_FIFOErrorFlag

FIFO error flag

enumerator kSAI_FIFORequestFlag

FIFO request flag.

enumerator kSAI_FIFOWarningFlag

FIFO warning flag

enum _sai_reset_type

The reset type.

Values:

enumerator kSAI_ResetTypeSoftware

Software reset, reset the logic state

enumerator kSAI_ResetTypeFIFO

FIFO reset, reset the FIFO read and write pointer

enumerator kSAI_ResetAll

All reset.

enum _sai_fifo_packing

The SAI packing mode The mode includes 8 bit and 16 bit packing.

Values:

enumerator kSAI_FifoPackingDisabled

Packing disabled

enumerator kSAI_FifoPacking8bit

8 bit packing enabled

enumerator kSAI_FifoPacking16bit

16bit packing enabled

enum _sai_sample_rate

Audio sample rate.

Values:

enumerator kSAI_SampleRate8KHz

Sample rate 8000 Hz

enumerator kSAI_SampleRate11025Hz

Sample rate 11025 Hz

enumerator kSAI_SampleRate12KHz

Sample rate 12000 Hz

enumerator kSAI_SampleRate16KHz

Sample rate 16000 Hz

enumerator kSAI_SampleRate22050Hz

Sample rate 22050 Hz

enumerator kSAI_SampleRate24KHz

Sample rate 24000 Hz

enumerator kSAI_SampleRate32KHz
Sample rate 32000 Hz

enumerator kSAI_SampleRate44100Hz
Sample rate 44100 Hz

enumerator kSAI_SampleRate48KHz
Sample rate 48000 Hz

enumerator kSAI_SampleRate96KHz
Sample rate 96000 Hz

enumerator kSAI_SampleRate192KHz
Sample rate 192000 Hz

enumerator kSAI_SampleRate384KHz
Sample rate 384000 Hz

enum _sai_word_width
Audio word width.

Values:

enumerator kSAI_WordWidth8bits
Audio data width 8 bits

enumerator kSAI_WordWidth16bits
Audio data width 16 bits

enumerator kSAI_WordWidth24bits
Audio data width 24 bits

enumerator kSAI_WordWidth32bits
Audio data width 32 bits

enum _sai_data_pin_state
sai data pin state definition

Values:

enumerator kSAI_DataPinStateTriState
transmit data pins are tri-stated when slots are masked or channels are disabled

enumerator kSAI_DataPinStateOutputZero
transmit data pins are never tri-stated and will output zero when slots are masked or channel disabled

enum _sai_fifo_combine
sai fifo combine mode definition

Values:

enumerator kSAI_FifoCombineDisabled
sai TX/RX fifo combine mode disabled

enumerator kSAI_FifoCombineModeEnabledOnRead
sai TX fifo combine mode enabled on FIFO reads

enumerator kSAI_FifoCombineModeEnabledOnWrite
sai TX fifo combine mode enabled on FIFO write

enumerator kSAI_RxFifoCombineModeEnabledOnWrite
sai RX fifo combine mode enabled on FIFO write

```
enumerator kSAI_RXFifoCombineModeEnabledOnRead
    sai RX fifo combine mode enabled on FIFO reads
enumerator kSAI_FifoCombineModeEnabledOnReadWrite
    sai TX/RX fifo combined mode enabled on FIFO read/writes
enum __sai_transceiver_type
    sai transceiver type
    Values:
    enumerator kSAI_Transmitter
        sai transmitter
    enumerator kSAI_Receiver
        sai receiver
enum __sai_frame_sync_len
    sai frame sync len
    Values:
    enumerator kSAI_FrameSyncLenOneBitClk
        1 bit clock frame sync len for DSP mode
    enumerator kSAI_FrameSyncLenPerWordWidth
        Frame sync length decided by word width
typedef enum __sai_protocol sai_protocol_t
    Define the SAI bus type.
typedef enum __sai_master_slave sai_master_slave_t
    Master or slave mode.
typedef enum __sai_mono_stereo sai_mono_stereo_t
    Mono or stereo audio format.
typedef enum __sai_data_order sai_data_order_t
    SAI data order, MSB or LSB.
typedef enum __sai_clock_polarity sai_clock_polarity_t
    SAI clock polarity, active high or low.
typedef enum __sai_sync_mode sai_sync_mode_t
    Synchronous or asynchronous mode.
typedef enum __sai_bclk_source sai_bclk_source_t
    Bit clock source.
typedef enum __sai_reset_type sai_reset_type_t
    The reset type.
typedef enum __sai_fifo_packing sai_fifo_packing_t
    The SAI packing mode The mode includes 8 bit and 16 bit packing.
typedef struct __sai_config sai_config_t
    SAI user configuration structure.
typedef enum __sai_sample_rate sai_sample_rate_t
    Audio sample rate.
typedef enum __sai_word_width sai_word_width_t
    Audio word width.
```



```
typedef enum _sai_data_pin_state sai_data_pin_state_t
    sai data pin state definition

typedef enum _sai_fifo_combine sai_fifo_combine_t
    sai fifo combine mode definition

typedef enum _sai_transceiver_type sai_transceiver_type_t
    sai transceiver type

typedef enum _sai_frame_sync_len sai_frame_sync_len_t
    sai frame sync len

typedef struct _sai_transfer_format sai_transfer_format_t
    sai transfer format

typedef struct _sai_master_clock sai_master_clock_t
    master clock configurations

typedef struct _sai_fifo sai_fifo_t
    sai fifo configurations

typedef struct _sai_bit_clock sai_bit_clock_t
    sai bit clock configurations

typedef struct _sai_frame_sync sai_frame_sync_t
    sai frame sync configurations

typedef struct _sai_serial_data sai_serial_data_t
    sai serial data configurations

typedef struct _sai_transceiver sai_transceiver_t
    sai transceiver configurations

typedef struct _sai_transfer sai_transfer_t
    SAI transfer structure.

typedef struct _sai_handle sai_handle_t

typedef void (*sai_transfer_callback_t)(I2S_Type *base, sai_handle_t *handle, status_t status,
void *userData)
    SAI transfer callback prototype.
```

MCUX_SDK_SAI_ALLOW_NULL_FIFO_WATERMARK

Used to control whether SAI_RxSetFifoConfig()/SAI_TxSetFifoConfig() allows a NULL FIFO watermark.

If this macro is set to 0 then SAI_RxSetFifoConfig()/SAI_TxSetFifoConfig() will set the watermark to half of the FIFO's depth if passed a NULL watermark.

MCUX_SDK_SAI_DISABLE_IMPLICIT_CHAN_CONFIG

Disable implicit channel data configuration within SAI_TxSetConfig()/SAI_RxSetConfig().

Use this macro to control whether SAI_RxSetConfig()/SAI_TxSetConfig() will attempt to implicitly configure the channel data. By channel data we mean the startChannel, channelMask, endChannel, and channelNums fields from the sai_transciever_t structure. By default, SAI_TxSetConfig()/SAI_RxSetConfig() will attempt to compute these fields, which may not be desired in cases where the user wants to set them before the call to said functions.

SAI_XFER_QUEUE_SIZE

SAI transfer queue size, user can refine it according to use case.

FSL_SAI_HAS_FIFO_EXTEND_FEATURE

sai fifo feature

```
struct __sai_config
    #include <fsl_sai.h> SAI user configuration structure.
```

Public Members

```
sai_protocol_t protocol
    Audio bus protocol in SAI

sai_sync_mode_t syncMode
    SAI sync mode, control Tx/Rx clock sync

bool mclkOutputEnable
    Master clock output enable, true means master clock divider enabled

sai_bclk_source_t bclkSource
    Bit Clock source

sai_master_slave_t masterSlave
    Master or slave
```

```
struct __sai_transfer_format
    #include <fsl_sai.h> sai transfer format
```

Public Members

```
uint32_t sampleRate_Hz
    Sample rate of audio data

uint32_t bitWidth
    Data length of audio data, usually 8/16/24/32 bits

sai_mono_stereo_t stereo
    Mono or stereo

uint32_t masterClockHz
    Master clock frequency in Hz

uint8_t watermark
    Watermark value

uint8_t channel
    Transfer start channel

uint8_t channelMask
    enabled channel mask value, reference __sai_channel_mask

uint8_t endChannel
    end channel number

uint8_t channelNums
    Total enabled channel numbers

sai_protocol_t protocol
    Which audio protocol used

bool isFrameSyncCompact
    True means Frame sync length is configurable according to bitWidth, false means
    frame sync length is 64 times of bit clock.
```

```
struct __sai_master_clock
    #include <fsl_sai.h> master clock configurations
```

Public Members

bool mclkOutputEnable
master clock output enable

uint32_t mclkHz
target mclk frequency

uint32_t mclkSourceClkHz
mclk source frequency

struct __sai_fifo
#include <fsl_sai.h> sai fifo configurations

Public Members

bool fifoContinueOnError
fifo continues when error occur

sai_fifo_combine_t fifoCombine
fifo combine mode

sai_fifo_packing_t fifoPacking
fifo packing mode

uint8_t fifoWatermark
fifo watermark

struct __sai_bit_clock
#include <fsl_sai.h> sai bit clock configurations

Public Members

bool bclkSrcSwap
bit clock source swap

bool bclkInputDelay
bit clock actually used by the transmitter is delayed by the pad output delay, this has effect of decreasing the data input setup time, but increasing the data output valid time
.

sai_clock_polarity_t bclkPolarity
bit clock polarity

sai_bclk_source_t bclkSource
bit Clock source

struct __sai_frame_sync
#include <fsl_sai.h> sai frame sync configurations

Public Members

uint8_t frameSyncWidth
frame sync width in number of bit clocks

bool frameSyncEarly
TRUE is frame sync assert one bit before the first bit of frame FALSE is frame sync assert with the first bit of the frame

`bool frameSyncGenerateOnDemand`
internal frame sync is generated when FIFO waring flag is clear

`sai_clock_polarity_t frameSyncPolarity`
frame sync polarity

`struct __sai_serial_data`
`#include <fsl_sai.h>` sai serial data configurations

Public Members

`sai_data_pin_state_t dataMode`
sai data pin state when slots masked or channel disabled

`sai_data_order_t dataOrder`
configure whether the LSB or MSB is transmitted first

`uint8_t dataWord0Length`
configure the number of bits in the first word in each frame

`uint8_t dataWordNLength`
configure the number of bits in the each word in each frame, except the first word

`uint8_t dataWordLength`
used to record the data length for dma transfer

`uint8_t dataFirstBitShifted`
Configure the bit index for the first bit transmitted for each word in the frame

`uint8_t dataWordNum`
configure the number of words in each frame

`uint32_t dataMaskedWord`
configure whether the transmit word is masked

`struct __sai_transceiver`
`#include <fsl_sai.h>` sai transceiver configurations

Public Members

`sai_serial_data_t serialData`
serial data configurations

`sai_frame_sync_t frameSync`
ws configurations

`sai_bit_clock_t bitClock`
bit clock configurations

`sai_fifo_t fifo`
fifo configurations

`sai_master_slave_t masterSlave`
transceiver is master or slave

`sai_sync_mode_t syncMode`
transceiver sync mode

`uint8_t startChannel`
Transfer start channel

uint8_t channelMask
enabled channel mask value, reference `_sai_channel_mask`

uint8_t endChannel
end channel number

uint8_t channelNums
Total enabled channel numbers

struct `_sai_transfer`
#include <fsl_sai.h> SAI transfer structure.

Public Members

uint8_t *data
Data start address to transfer.

size_t dataSize
Transfer size.

struct `_sai_handle`
#include <fsl_sai.h> SAI handle structure.

Public Members

I2S_Type *base
base address

uint32_t state
Transfer status

sai_transfer_callback_t callback
Callback function called at transfer event

void *userData
Callback parameter passed to callback function

uint8_t bitWidth
Bit width for transfer, 8/16/24/32 bits

uint8_t channel
Transfer start channel

uint8_t channelMask
enabled channel mask value, refernece `_sai_channel_mask`

uint8_t endChannel
end channel number

uint8_t channelNums
Total enabled channel numbers

sai_transfer_t saiQueue[(4U)]
Transfer queue storing queued transfer

size_t transferSize[(4U)]
Data bytes need to transfer

volatile uint8_t queueUser
Index for user to queue transfer

volatile uint8_t queueDriver
Index for driver to get the transfer data and size

uint8_t watermark
Watermark value

2.34 SAI EDMA Driver

```
void SAI_TransferTxCreateHandleEDMA(I2S_Type *base, sai_edma_handle_t *handle,  
                                   sai_edma_callback_t callback, void *userData,  
                                   edma_handle_t *txDmaHandle)
```

Initializes the SAI eDMA handle.

This function initializes the SAI master DMA handle, which can be used for other SAI master transactional APIs. Usually, for a specified SAI instance, call this API once to get the initialized handle.

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.
- callback – Pointer to user callback function.
- userData – User parameter passed to the callback function.
- txDmaHandle – eDMA handle pointer, this handle shall be static allocated by users.

```
void SAI_TransferRxCreateHandleEDMA(I2S_Type *base, sai_edma_handle_t *handle,  
                                   sai_edma_callback_t callback, void *userData,  
                                   edma_handle_t *rxDmaHandle)
```

Initializes the SAI Rx eDMA handle.

This function initializes the SAI slave DMA handle, which can be used for other SAI master transactional APIs. Usually, for a specified SAI instance, call this API once to get the initialized handle.

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.
- callback – Pointer to user callback function.
- userData – User parameter passed to the callback function.
- rxDmaHandle – eDMA handle pointer, this handle shall be static allocated by users.

```
void SAI_TransferSetInterleaveType(sai_edma_handle_t *handle, sai_edma_interleave_t  
                                  interleaveType)
```

Initializes the SAI interleave type.

This function initializes the SAI DMA handle member interleaveType, it shall be called only when application would like to use type kSAI_EDMAInterleavePerChannelBlock, since the default interleaveType is kSAI_EDMAInterleavePerChannelSample always

Parameters

- handle – SAI eDMA handle pointer.
- interleaveType – Multi channel interleave type.

```
void SAI_TransferTxSetConfigEDMA(I2S_Type *base, sai_edma_handle_t *handle,
                                sai_transceiver_t *saiConfig)
```

Configures the SAI Tx.

Note: SAI eDMA supports data transfer in a multiple SAI channels if the FIFO Combine feature is supported. To activate the multi-channel transfer enable SAI channels by filling the channelMask of sai_transceiver_t with the corresponding values of _sai_channel_mask enum, enable the FIFO Combine mode by assigning kSAI_FifoCombineModeEnabledOnWrite to the fifoCombine member of sai_fifo_combine_t which is a member of sai_transceiver_t. This is an example of multi-channel data transfer configuration step.

```
sai_transceiver_t config;
SAI_GetClassicI2SConfig(&config, kSAI_WordWidth16bits, kSAI_Stereo, kSAI_Channel0Mask|kSAI_
↪Channel1Mask);
config.fifo.fifoCombine = kSAI_FifoCombineModeEnabledOnWrite;
SAI_TransferTxSetConfigEDMA(I2S0, &edmaHandle, &config);
```

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.
- saiConfig – sai configurations.

```
void SAI_TransferRxSetConfigEDMA(I2S_Type *base, sai_edma_handle_t *handle,
                                sai_transceiver_t *saiConfig)
```

Configures the SAI Rx.

Note: SAI eDMA supports data transfer in a multiple SAI channels if the FIFO Combine feature is supported. To activate the multi-channel transfer enable SAI channels by filling the channelMask of sai_transceiver_t with the corresponding values of _sai_channel_mask enum, enable the FIFO Combine mode by assigning kSAI_FifoCombineModeEnabledOnRead to the fifoCombine member of sai_fifo_combine_t which is a member of sai_transceiver_t. This is an example of multi-channel data transfer configuration step.

```
sai_transceiver_t config;
SAI_GetClassicI2SConfig(&config, kSAI_WordWidth16bits, kSAI_Stereo, kSAI_Channel0Mask|kSAI_
↪Channel1Mask);
config.fifo.fifoCombine = kSAI_FifoCombineModeEnabledOnRead;
SAI_TransferRxSetConfigEDMA(I2S0, &edmaHandle, &config);
```

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.
- saiConfig – sai configurations.

```
status_t SAI_TransferSendEDMA(I2S_Type *base, sai_edma_handle_t *handle, sai_transfer_t
                                *xfer)
```

Performs a non-blocking SAI transfer using DMA.

This function support multi channel transfer,

- a. for the sai IP support fifo combine mode, application should enable the fifo combine mode, no limitation on channel numbers
- b. for the sai IP not support fifo combine mode, sai edma provide another solution which using EDMA modulo feature, but support 2 or 4 channels only.

Note: This interface returns immediately after the transfer initiates. Call `SAI_GetTransferStatus` to poll the transfer status and check whether the SAI transfer is finished.

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.
- xfer – Pointer to the DMA transfer structure.

Return values

- `kStatus_Success` – Start a SAI eDMA send successfully.
- `kStatus_InvalidArgument` – The input argument is invalid.
- `kStatus_TxBusy` – SAI is busy sending data.

status_t SAI_TransferReceiveEDMA(I2S_Type *base, sai_edma_handle_t *handle, sai_transfer_t *xfer)

Performs a non-blocking SAI receive using eDMA.

This function support multi channel transfer,

- a. for the sai IP support fifo combine mode, application should enable the fifo combine mode, no limitation on channel numbers
- b. for the sai IP not support fifo combine mode, sai edma provide another solution which using EDMA modulo feature, but support 2 or 4 channels only.

Note: This interface returns immediately after the transfer initiates. Call the `SAI_GetReceiveRemainingBytes` to poll the transfer status and check whether the SAI transfer is finished.

Parameters

- base – SAI base pointer
- handle – SAI eDMA handle pointer.
- xfer – Pointer to DMA transfer structure.

Return values

- `kStatus_Success` – Start a SAI eDMA receive successfully.
- `kStatus_InvalidArgument` – The input argument is invalid.
- `kStatus_RxBusy` – SAI is busy receiving data.

status_t SAI_TransferSendLoopEDMA(I2S_Type *base, sai_edma_handle_t *handle, sai_transfer_t *xfer, uint32_t loopTransferCount)

Performs a non-blocking SAI loop transfer using eDMA.

Once the loop transfer start, application can use function `SAI_TransferAbortSendEDMA` to stop the loop transfer.

Note: This function support loop transfer only,such as A->B->...->A, application must be aware of that the more counts of the loop transfer, then more tcd memory required, as the function use the tcd pool in `sai_edma_handle_t`, so application could redefine the `SAI_XFER_QUEUE_SIZE` to determine the proper TCD pool size. This function support one sai channel only.

Parameters

- `base` – SAI base pointer.
- `handle` – SAI eDMA handle pointer.
- `xfer` – Pointer to the DMA transfer structure, should be a array with elements counts ≥ 1 (`loopTransferCount`).
- `loopTransferCount` – the counts of `xfer` array.

Return values

- `kStatus_Success` – Start a SAI eDMA send successfully.
- `kStatus_InvalidArgument` – The input argument is invalid.

`status_t` `SAI_TransferReceiveLoopEDMA(I2S_Type *base, sai_edma_handle_t *handle, sai_transfer_t *xfer, uint32_t loopTransferCount)`

Performs a non-blocking SAI loop transfer using eDMA.

Once the loop transfer start, application can use function `SAI_TransferAbortReceiveEDMA` to stop the loop transfer.

Note: This function support loop transfer only,such as A->B->...->A, application must be aware of that the more counts of the loop transfer, then more tcd memory required, as the function use the tcd pool in `sai_edma_handle_t`, so application could redefine the `SAI_XFER_QUEUE_SIZE` to determine the proper TCD pool size. This function support one sai channel only.

Parameters

- `base` – SAI base pointer.
- `handle` – SAI eDMA handle pointer.
- `xfer` – Pointer to the DMA transfer structure, should be a array with elements counts ≥ 1 (`loopTransferCount`).
- `loopTransferCount` – the counts of `xfer` array.

Return values

- `kStatus_Success` – Start a SAI eDMA receive successfully.
- `kStatus_InvalidArgument` – The input argument is invalid.

`void` `SAI_TransferTerminateSendEDMA(I2S_Type *base, sai_edma_handle_t *handle)`

Terminate all SAI send.

This function will clear all transfer slots buffered in the sai queue. If users only want to abort the current transfer slot, please call `SAI_TransferAbortSendEDMA`.

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.

`void SAI_TransferTerminateReceiveEDMA(I2S_Type *base, sai_edma_handle_t *handle)`

Terminate all SAI receive.

This function will clear all transfer slots buffered in the sai queue. If users only want to abort the current transfer slot, please call `SAI_TransferAbortReceiveEDMA`.

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.

`void SAI_TransferAbortSendEDMA(I2S_Type *base, sai_edma_handle_t *handle)`

Aborts a SAI transfer using eDMA.

This function only aborts the current transfer slots, the other transfer slots' information still kept in the handler. If users want to terminate all transfer slots, just call `SAI_TransferTerminateSendEDMA`.

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.

`void SAI_TransferAbortReceiveEDMA(I2S_Type *base, sai_edma_handle_t *handle)`

Aborts a SAI receive using eDMA.

This function only aborts the current transfer slots, the other transfer slots' information still kept in the handler. If users want to terminate all transfer slots, just call `SAI_TransferTerminateReceiveEDMA`.

Parameters

- base – SAI base pointer
- handle – SAI eDMA handle pointer.

`status_t SAI_TransferGetSendCountEDMA(I2S_Type *base, sai_edma_handle_t *handle, size_t *count)`

Gets byte count sent by SAI.

Parameters

- base – SAI base pointer.
- handle – SAI eDMA handle pointer.
- count – Bytes count sent by SAI.

Return values

- `kStatus_Success` – Succeed get the transfer count.
- `kStatus_NoTransferInProgress` – There is no non-blocking transaction in progress.

`status_t SAI_TransferGetReceiveCountEDMA(I2S_Type *base, sai_edma_handle_t *handle, size_t *count)`

Gets byte count received by SAI.

Parameters

- base – SAI base pointer
- handle – SAI eDMA handle pointer.

- `count` – Bytes count received by SAI.

Return values

- `kStatus_Success` – Succeed get the transfer count.
- `kStatus_NoTransferInProgress` – There is no non-blocking transaction in progress.

`uint32_t SAI_TransferGetValidTransferSlotsEDMA(I2S_Type *base, sai_edma_handle_t *handle)`

Gets valid transfer slot.

This function can be used to query the valid transfer request slot that the application can submit. It should be called in the critical section, that means the application could call it in the corresponding callback function or disable IRQ before calling it in the application, otherwise, the returned value may not correct.

Parameters

- `base` – SAI base pointer
- `handle` – SAI eDMA handle pointer.

Return values

`valid` – slot count that application submit.

`FSL_SAI_EDMA_DRIVER_VERSION`

Version 2.7.3

`enum _sai_edma_interleave`

sai interleave type

Values:

enumerator `kSAI_EDMAInterleavePerChannelSample`

enumerator `kSAI_EDMAInterleavePerChannelBlock`

`typedef struct sai_edma_handle sai_edma_handle_t`

`typedef void (*sai_edma_callback_t)(I2S_Type *base, sai_edma_handle_t *handle, status_t status, void *userData)`

SAI eDMA transfer callback function for finish and error.

`typedef enum _sai_edma_interleave sai_edma_interleave_t`

sai interleave type

`MCUX_SDK_SAI_EDMA_RX_ENABLE_INTERNAL`

the SAI enable position When calling `SAI_TransferReceiveEDMA`

`MCUX_SDK_SAI_EDMA_TX_ENABLE_INTERNAL`

the SAI enable position When calling `SAI_TransferSendEDMA`

`struct sai_edma_handle`

`#include <fsl_sai_edma.h>` SAI DMA transfer handle, users should not touch the content of the handle.

Public Members

`edma_handle_t *dmaHandle`

DMA handler for SAI send

`uint8_t nbytes`

eDMA minor byte transfer count initially configured.

`uint8_t bytesPerFrame`
Bytes in a frame

`uint8_t channelMask`
Enabled channel mask value, reference `_sai_channel_mask`

`uint8_t channelNums`
total enabled channel nums

`uint8_t channel`
Which data channel

`uint8_t count`
The transfer data count in a DMA request

`uint32_t state`
Internal state for SAI eDMA transfer

`sai_edma_callback_t callback`
Callback for users while transfer finish or error occurs

`void *userData`
User callback parameter

`uint8_t tcd[((4U) + 1U) * sizeof(edma_tcd_t)]`
TCD pool for eDMA transfer.

`sai_transfer_t saiQueue[(4U)]`
Transfer queue storing queued transfer.

`size_t transferSize[(4U)]`
Data bytes need to transfer

`sai_edma_interleave_t interleaveType`
Transfer interleave type

`volatile uint8_t queueUser`
Index for user to queue transfer.

`volatile uint8_t queueDriver`
Index for driver to get the transfer data and size

2.35 SAI SDMA Driver

```
void SAI_TransferTxCreateHandleSDMA(I2S_Type *base, sai_sdma_handle_t *handle,  
                                   sai_sdma_callback_t callback, void *userData,  
                                   sdma_handle_t *dmaHandle, uint32_t eventSource)
```

Initializes the SAI SDMA handle.

This function initializes the SAI master DMA handle, which can be used for other SAI master transactional APIs. Usually, for a specified SAI instance, call this API once to get the initialized handle.

Parameters

- `base` – SAI base pointer.
- `handle` – SAI SDMA handle pointer.
- `base` – SAI peripheral base address.
- `callback` – Pointer to user callback function.

- `userData` – User parameter passed to the callback function.
- `dmaHandle` – SDMA handle pointer, this handle shall be static allocated by users.
- `eventSource` – SAI event source number.

```
void SAI_TransferRxCreateHandleSDMA(I2S_Type *base, sai_sdma_handle_t *handle,  
                                   sai_sdma_callback_t callback, void *userData,  
                                   sdma_handle_t *dmaHandle, uint32_t eventSource)
```

Initializes the SAI Rx SDMA handle.

This function initializes the SAI slave DMA handle, which can be used for other SAI master transactional APIs. Usually, for a specified SAI instance, call this API once to get the initialized handle.

Parameters

- `base` – SAI base pointer.
- `handle` – SAI SDMA handle pointer.
- `base` – SAI peripheral base address.
- `callback` – Pointer to user callback function.
- `userData` – User parameter passed to the callback function.
- `dmaHandle` – SDMA handle pointer, this handle shall be static allocated by users.
- `eventSource` – SAI event source number.

```
status_t SAI_TransferSendSDMA(I2S_Type *base, sai_sdma_handle_t *handle, sai_transfer_t  
                             *xfer)
```

Performs a non-blocking SAI transfer using DMA.

Note: This interface returns immediately after the transfer initiates. Call `SAI_GetTransferStatus` to poll the transfer status and check whether the SAI transfer is finished.

Parameters

- `base` – SAI base pointer.
- `handle` – SAI SDMA handle pointer.
- `xfer` – Pointer to the DMA transfer structure.

Return values

- `kStatus_Success` – Start a SAI SDMA send successfully.
- `kStatus_InvalidArgument` – The input argument is invalid.
- `kStatus_TxBusy` – SAI is busy sending data.

```
status_t SAI_TransferReceiveSDMA(I2S_Type *base, sai_sdma_handle_t *handle, sai_transfer_t  
                                *xfer)
```

Performs a non-blocking SAI receive using SDMA.

Note: This interface returns immediately after the transfer initiates. Call the `SAI_GetReceiveRemainingBytes` to poll the transfer status and check whether the SAI transfer is finished.

Parameters

- base – SAI base pointer
- handle – SAI SDMA handle pointer.
- xfer – Pointer to DMA transfer structure.

Return values

- kStatus_Success – Start a SAI SDMA receive successfully.
- kStatus_InvalidArgument – The input argument is invalid.
- kStatus_RxBusy – SAI is busy receiving data.

```
void SAI_TransferAbortSendSDMA(I2S_Type *base, sai_sdma_handle_t *handle)
```

Aborts a SAI transfer using SDMA.

Parameters

- base – SAI base pointer.
- handle – SAI SDMA handle pointer.

```
void SAI_TransferAbortReceiveSDMA(I2S_Type *base, sai_sdma_handle_t *handle)
```

Aborts a SAI receive using SDMA.

Parameters

- base – SAI base pointer
- handle – SAI SDMA handle pointer.

```
void SAI_TransferTerminateReceiveSDMA(I2S_Type *base, sai_sdma_handle_t *handle)
```

Terminate all the SAI sdma receive transfer.

Parameters

- base – SAI base pointer.
- handle – SAI SDMA handle pointer.

```
void SAI_TransferTerminateSendSDMA(I2S_Type *base, sai_sdma_handle_t *handle)
```

Terminate all the SAI sdma send transfer.

Parameters

- base – SAI base pointer.
- handle – SAI SDMA handle pointer.

```
void SAI_TransferRxSetConfigSDMA(I2S_Type *base, sai_sdma_handle_t *handle,  
                                sai_transceiver_t *saiConfig)
```

brief Configures the SAI RX.

param base SAI base pointer. param handle SAI SDMA handle pointer. param saiConig sai configurations.

```
void SAI_TransferTxSetConfigSDMA(I2S_Type *base, sai_sdma_handle_t *handle,  
                                sai_transceiver_t *saiConfig)
```

brief Configures the SAI Tx.

param base SAI base pointer. param handle SAI SDMA handle pointer. param saiConig sai configurations.

FSL_SAI_SDMA_DRIVER_VERSION

Version 2.6.0

```
typedef struct _sai_sdma_handle sai_sdma_handle_t
```

```
typedef void (*sai_sdma_callback_t)(I2S_Type *base, sai_sdma_handle_t *handle, status_t status, void *userData)
```

SAI SDMA transfer callback function for finish and error.

```
struct _sai_sdma_handle
```

#include <fsl_sai_sdma.h> SAI DMA transfer handle, users should not touch the content of the handle.

Public Members

sdma_handle_t *dmaHandle

DMA handler for SAI send

uint8_t bytesPerFrame

Bytes in a frame

uint8_t channel

start data channel

uint8_t channelNums

total transfer channel numbers, used for multifo

uint8_t channelMask

enabled channel mask value, refernece *_sai_channel_mask*

uint8_t fifoOffset

fifo address offset between multifo

uint32_t count

The transfer data count in a DMA request

uint32_t state

Internal state for SAI SDMA transfer

uint32_t eventSource

SAI event source number

sai_sdma_callback_t callback

Callback for users while transfer finish or error occurs

void *userData

User callback parameter

sdma_buffer_descriptor_t bdPool[(4U)]

BD pool for SDMA transfer.

sai_transfer_t saiQueue[(4U)]

Transfer queue storing queued transfer.

size_t transferSize[(4U)]

Data bytes need to transfer

volatile uint8_t queueUser

Index for user to queue transfer.

volatile uint8_t queueDriver

Index for driver to get the transfer data and size

2.36 SDMA: Smart Direct Memory Access (SDMA) Controller Driver

`void SDMA_Init(SDMAARM_Type *base, const sdma_config_t *config)`

Initializes the SDMA peripheral.

This function ungates the SDMA clock and configures the SDMA peripheral according to the configuration structure.

Note: This function enables the minor loop map feature.

Parameters

- `base` – SDMA peripheral base address.
- `config` – A pointer to the configuration structure, see “*sdma_config_t*”.

`void SDMA_Deinit(SDMAARM_Type *base)`

Deinitializes the SDMA peripheral.

This function gates the SDMA clock.

Parameters

- `base` – SDMA peripheral base address.

`void SDMA_GetDefaultConfig(sdma_config_t *config)`

Gets the SDMA default configuration structure.

This function sets the configuration structure to default values. The default configuration is set to the following values.

```
config.enableRealTimeDebugPin = false;
config.isSoftwareResetClearLock = true;
config.ratio = kSDMA_HalfARMClockFreq;
```

Parameters

- `config` – A pointer to the SDMA configuration structure.

`void SDMA_ResetModule(SDMAARM_Type *base)`

Sets all SDMA core register to reset status.

If only reset ARM core, SDMA register cannot return to reset value, shall call this function to reset all SDMA register to reset value. But the internal status cannot be reset.

Parameters

- `base` – SDMA peripheral base address.

`static inline void SDMA_EnableChannelErrorInterrupts(SDMAARM_Type *base, uint32_t channel)`

Enables the interrupt source for the SDMA error.

Enable this will trigger an interrupt while SDMA occurs error while executing scripts.

Parameters

- `base` – SDMA peripheral base address.
- `channel` – SDMA channel number.


```
static inline void SDMA_DisableChannelErrorInterrupts(SDMAARM_Type *base, uint32_t
                                                    channel)
```

Disables the interrupt source for the SDMA error.

Parameters

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

```
void SDMA_ConfigBufferDescriptor(sdma_buffer_descriptor_t *bd, uint32_t srcAddr, uint32_t
                                destAddr, sdma_transfer_size_t busWidth, size_t bufferSize,
                                bool isLast, bool enableInterrupt, bool isWrap,
                                sdma_transfer_type_t type)
```

Sets buffer descriptor contents.

This function sets the descriptor contents such as source, dest address and status bits.

Parameters

- bd – Pointer to the buffer descriptor structure.
- srcAddr – Source address for the buffer descriptor.
- destAddr – Destination address for the buffer descriptor.
- busWidth – The transfer width, it only can be a member of *sdma_transfer_size_t*.
- bufferSize – Buffer size for this descriptor, this number shall less than 0xFFFF. If need to transfer a big size, shall divide into several buffer descriptors.
- isLast – Is the buffer descriptor the last one for the channel to transfer. If only one descriptor used for the channel, this bit shall set to TRUE.
- enableInterrupt – If trigger an interrupt while this buffer descriptor transfer finished.
- isWrap – Is the buffer descriptor need to be wrapped. While this bit set to true, it will automatically wrap to the first buffer descrtiptor to do transfer.
- type – Transfer type, memory to memory, peripheral to memory or memory to peripheral.

```
static inline void SDMA_SetChannelPriority(SDMAARM_Type *base, uint32_t channel, uint8_t
                                           priority)
```

Set SDMA channel priority.

This function sets the channel priority. The default value is 0 for all channels, priority 0 will prevents channel from starting, so the priority must be set before start a channel.

Parameters

- base – SDMA peripheral base address.
- channel – SDMA channel number.
- priority – SDMA channel priority.

```
static inline void SDMA_SetSourceChannel(SDMAARM_Type *base, uint32_t source, uint32_t
                                         channelMask)
```

Set SDMA request source mapping channel.

This function sets which channel will be triggered by the dma request source.

Parameters

- base – SDMA peripheral base address.

- `source` – SDMA dma request source number.
- `channelMask` – SDMA channel mask. 1 means channel 0, 2 means channel 1, 4 means channel 3. SDMA supports an event trigger multi-channel. A channel can also be triggered by several source events.

`static inline void SDMA_StartChannelSoftware(SDMAARM_Type *base, uint32_t channel)`

Start a SDMA channel by software trigger.

This function start a channel.

Parameters

- `base` – SDMA peripheral base address.
- `channel` – SDMA channel number.

`static inline void SDMA_StartChannelEvents(SDMAARM_Type *base, uint32_t channel)`

Start a SDMA channel by hardware events.

This function start a channel.

Parameters

- `base` – SDMA peripheral base address.
- `channel` – SDMA channel number.

`static inline void SDMA_StopChannel(SDMAARM_Type *base, uint32_t channel)`

Stop a SDMA channel.

This function stops a channel.

Parameters

- `base` – SDMA peripheral base address.
- `channel` – SDMA channel number.

`void SDMA_SetContextSwitchMode(SDMAARM_Type *base, sdma_context_switch_mode_t mode)`

Set the SDMA context switch mode.

Parameters

- `base` – SDMA peripheral base address.
- `mode` – SDMA context switch mode.

`static inline uint32_t SDMA_GetChannelInterruptStatus(SDMAARM_Type *base)`

Gets the SDMA interrupt status of all channels.

Parameters

- `base` – SDMA peripheral base address.

Returns

The interrupt status for all channels. Check the relevant bits for specific channel.

`static inline void SDMA_ClearChannelInterruptStatus(SDMAARM_Type *base, uint32_t mask)`

Clear the SDMA channel interrupt status of specific channels.

Parameters

- `base` – SDMA peripheral base address.
- `mask` – The interrupt status need to be cleared.

```
static inline uint32_t SDMA_GetChannelStopStatus(SDMAARM_Type *base)
```

Gets the SDMA stop status of all channels.

Parameters

- base – SDMA peripheral base address.

Returns

The stop status for all channels. Check the relevant bits for specific channel.

```
static inline void SDMA_ClearChannelStopStatus(SDMAARM_Type *base, uint32_t mask)
```

Clear the SDMA channel stop status of specific channels.

Parameters

- base – SDMA peripheral base address.
- mask – The stop status need to be cleared.

```
static inline uint32_t SDMA_GetChannelPendStatus(SDMAARM_Type *base)
```

Gets the SDMA channel pending status of all channels.

Parameters

- base – SDMA peripheral base address.

Returns

The pending status for all channels. Check the relevant bits for specific channel.

```
static inline void SDMA_ClearChannelPendStatus(SDMAARM_Type *base, uint32_t mask)
```

Clear the SDMA channel pending status of specific channels.

Parameters

- base – SDMA peripheral base address.
- mask – The pending status need to be cleared.

```
static inline uint32_t SDMA_GetErrorStatus(SDMAARM_Type *base)
```

Gets the SDMA channel error status.

SDMA channel error flag is asserted while an incoming DMA request was detected and it triggers a channel that is already pending or being serviced. This probably means there is an overflow of data for that channel.

Parameters

- base – SDMA peripheral base address.

Returns

The error status for all channels. Check the relevant bits for specific channel.

```
bool SDMA_GetRequestSourceStatus(SDMAARM_Type *base, uint32_t source)
```

Gets the SDMA request source pending status.

Parameters

- base – SDMA peripheral base address.
- source – DMA request source number.

Returns

True means the request source is pending, otherwise not pending.

```
void SDMA_CreateHandle(sdma_handle_t *handle, SDMAARM_Type *base, uint32_t channel,  
                      sdma_context_data_t *context)
```

Creates the SDMA handle.

This function is called if using the transactional API for SDMA. This function initializes the internal state of the SDMA handle.

Parameters

- `handle` – SDMA handle pointer. The SDMA handle stores callback function and parameters.
- `base` – SDMA peripheral base address.
- `channel` – SDMA channel number.
- `context` – Context structure for the channel to download into SDMA. Users shall make sure the context located in a non-cacheable memory, or it will cause SDMA run fail. Users shall not touch the context contents, it only be filled by SDMA driver in `SDMA_SubmitTransfer` function.

```
void SDMA__InstallBDMemory(sdma_handle_t *handle, sdma_buffer_descriptor_t *BDPool,  
                           uint32_t BDCount)
```

Installs the BDs memory pool into the SDMA handle.

This function is called after the `SDMA_CreateHandle` to use multi-buffer feature.

Parameters

- `handle` – SDMA handle pointer.
- `BDPool` – A memory pool to store BDs. It must be located in non-cacheable address.
- `BDCount` – The number of BD slots.

```
void SDMA__SetCallback(sdma_handle_t *handle, sdma_callback callback, void *userData)
```

Installs a callback function for the SDMA transfer.

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

Parameters

- `handle` – SDMA handle pointer.
- `callback` – SDMA callback function pointer.
- `userData` – A parameter for the callback function.

```
void SDMA__SetMultiFifoConfig(sdma_transfer_config_t *config, uint32_t fifoNums, uint32_t  
                             fifoOffset)
```

multi fifo configurations.

This api is used to support multi fifo for SDMA, if user want to get multi fifo data, then this api should be called before submit transfer.

Parameters

- `config` – transfer configurations.
- `fifoNums` – fifo numbers that multi fifo operation perform, support up to 15 fifo numbers.
- `fifoOffset` – `fifoOffset = fifo address offset / sizeof(uint32_t) - 1`.

```
void SDMA__EnableSwDone(SDMAARM_Type *base, sdma_transfer_config_t *config, uint8_t sel,  
                        sdma_peripheral_t type)
```

enable sdma sw done feature.

Deprecated:

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

Parameters

- base – SDMA base.
- config – transfer configurations.
- sel – sw done selector.
- type – peripheral type is used to determine the corresponding peripheral sw done selector bit.

```
void SDMA__SetDoneConfig(SDMAARM_Type *base, sdma_transfer_config_t *config,  
                        sdma_peripheral_t type, sdma_done_src_t doneSrc)
```

sdma channel done configurations.

Parameters

- base – SDMA base.
- config – transfer configurations.
- type – peripheral type.
- doneSrc – reference sdma_done_src_t.

```
void SDMA__LoadScript(SDMAARM_Type *base, uint32_t destAddr, void *srcAddr, size_t  
                    bufferSizeBytes)
```

load script to sdma program memory.

Parameters

- base – SDMA base.
- destAddr – dest script address, should be SDMA program memory address.
- srcAddr – source address of target script.
- bufferSizeBytes – bytes size of script.

```
void SDMA__DumpScript(SDMAARM_Type *base, uint32_t srcAddr, void *destAddr, size_t  
                    bufferSizeBytes)
```

dump script from sdma program memory.

Parameters

- base – SDMA base.
- srcAddr – should be SDMA program memory address.
- destAddr – address to store scripts.
- bufferSizeBytes – bytes size of script.

```
static inline const char *SDMA__GetRamScriptVersion(SDMAARM_Type *base)
```

Get RAM script version.

Parameters

- base – SDMA base.

Returns

The script version of RAM.

```
void SDMA__PrepareTransfer(sdma_transfer_config_t *config, uint32_t srcAddr, uint32_t  
                        destAddr, uint32_t srcWidth, uint32_t destWidth, uint32_t  
                        bytesEachRequest, uint32_t transferSize, uint32_t eventSource,  
                        sdma_peripheral_t peripheral, sdma_transfer_type_t type)
```

Prepares the SDMA transfer structure.

This function prepares the transfer configuration structure according to the user input.

Note: The data address and the data width must be consistent. For example, if the SRC is 4 bytes, the source address must be 4 bytes aligned, or it results in source address error.

Parameters

- `config` – The user configuration structure of type `sdma_transfer_t`.
- `srcAddr` – SDMA transfer source address.
- `destAddr` – SDMA transfer destination address.
- `srcWidth` – SDMA transfer source address width(bytes).
- `destWidth` – SDMA transfer destination address width(bytes).
- `bytesEachRequest` – SDMA transfer bytes per channel request.
- `transferSize` – SDMA transfer bytes to be transferred.
- `eventSource` – Event source number for the transfer, if use software trigger, just write 0.
- `peripheral` – Peripheral type, used to decide if need to use some special scripts.
- `type` – SDMA transfer type. Used to decide the correct SDMA script address in SDMA ROM.

```
void SDMA__PrepareP2PTransfer(sdma_transfer_config_t *config, uint32_t srcAddr, uint32_t  
                             destAddr, uint32_t srcWidth, uint32_t destWidth, uint32_t  
                             bytesEachRequest, uint32_t transferSize, uint32_t eventSource,  
                             uint32_t eventSource1, sdma_peripheral_t peripheral,  
                             sdma_p2p_config_t *p2p)
```

Prepares the SDMA P2P transfer structure.

This function prepares the transfer configuration structure according to the user input.

Note: The data address and the data width must be consistent. For example, if the SRC is 4 bytes, the source address must be 4 bytes aligned, or it results in source address error.

Parameters

- `config` – The user configuration structure of type `sdma_transfer_t`.
- `srcAddr` – SDMA transfer source address.
- `destAddr` – SDMA transfer destination address.
- `srcWidth` – SDMA transfer source address width(bytes).
- `destWidth` – SDMA transfer destination address width(bytes).
- `bytesEachRequest` – SDMA transfer bytes per channel request.
- `transferSize` – SDMA transfer bytes to be transferred.
- `eventSource` – Event source number for the transfer.
- `eventSource1` – Event source1 number for the transfer.

- peripheral – Peripheral type, used to decide if need to use some special scripts.
- p2p – sdma p2p configuration pointer.

void SDMA_SubmitTransfer(*sdma_handle_t* *handle, const *sdma_transfer_config_t* *config)

Submits the SDMA transfer request.

This function submits the SDMA transfer request according to the transfer configuration structure.

Parameters

- handle – SDMA handle pointer.
- config – Pointer to SDMA transfer configuration structure.

void SDMA_StartTransfer(*sdma_handle_t* *handle)

SDMA starts transfer.

This function enables the channel request. Users can call this function after submitting the transfer request or before submitting the transfer request.

Parameters

- handle – SDMA handle pointer.

void SDMA_StopTransfer(*sdma_handle_t* *handle)

SDMA stops transfer.

This function disables the channel request to pause the transfer. Users can call SDMA_StartTransfer() again to resume the transfer.

Parameters

- handle – SDMA handle pointer.

void SDMA_AbortTransfer(*sdma_handle_t* *handle)

SDMA aborts transfer.

This function disables the channel request and clear transfer status bits. Users can submit another transfer after calling this API.

Parameters

- handle – DMA handle pointer.

uint32_t SDMA_GetTransferredBytes(*sdma_handle_t* *handle)

Get transferred bytes while not using BD pools.

This function returns the buffer descriptor count value if not using buffer descriptor. While do a simple transfer, which only uses one descriptor, the SDMA driver inside handle the buffer descriptor. In uart receive case, it can tell users how many data already received, also it can tells users how many data transfferd while error occurred. Notice, the count would not change while transfer is on-going using default SDMA script.

Parameters

- handle – DMA handle pointer.

Returns

Transferred bytes.

bool SDMA_IsPeripheralInSPBA(uint32_t addr)

Judge if address located in SPBA.

Parameters

- addr – Address which need to judge.

Return values

True – means located in SPBA, false means not.

void SDMA_HandleIRQ(*sdma_handle_t* *handle)

SDMA IRQ handler for complete a buffer descriptor transfer.

This function clears the interrupt flags and also handle the CCB for the channel.

Parameters

- handle – SDMA handle pointer.

FSL_SDMA_DRIVER_VERSION

SDMA driver version.

Version 2.4.3.

enum *_sdma_transfer_size*

SDMA transfer configuration.

Values:

enumerator kSDMA_TransferSize1Bytes

Source/Destination data transfer size is 1 byte every time

enumerator kSDMA_TransferSize2Bytes

Source/Destination data transfer size is 2 bytes every time

enumerator kSDMA_TransferSize3Bytes

Source/Destination data transfer size is 3 bytes every time

enumerator kSDMA_TransferSize4Bytes

Source/Destination data transfer size is 4 bytes every time

enum *_sdma_bd_status*

SDMA buffer descriptor status.

Values:

enumerator kSDMA_BDStatusDone

BD ownership, 0 means ARM core owns the BD, while 1 means SDMA owns BD.

enumerator kSDMA_BDStatusWrap

While this BD is last one, the next BD will be the first one

enumerator kSDMA_BDStatusContinuous

Buffer is allowed to transfer/receive to/from multiple buffers

enumerator kSDMA_BDStatusInterrupt

While this BD finished, send an interrupt.

enumerator kSDMA_BDStatusError

Error occurred on buffer descriptor command.

enumerator kSDMA_BDStatusLast

This BD is the last BD in this array. It means the transfer ended after this buffer

enumerator kSDMA_BDStatusExtend

Buffer descriptor extend status for SDMA scripts

enum *_sdma_bd_command*

SDMA buffer descriptor command.

Values:

enumerator kSDMA_BDCommandSETDM

Load SDMA data memory from ARM core memory buffer.

enumerator kSDMA_BDCommandGETDM

Copy SDMA data memory to ARM core memory buffer.

enumerator kSDMA_BDCommandSETPM

Load SDMA program memory from ARM core memory buffer.

enumerator kSDMA_BDCommandGETPM

Copy SDMA program memory to ARM core memory buffer.

enumerator kSDMA_BDCommandSETCTX

Load context for one channel into SDMA RAM from ARM platform memory buffer.

enumerator kSDMA_BDCommandGETCTX

Copy context for one channel from SDMA RAM to ARM platform memory buffer.

enum _sdma_context_switch_mode

SDMA context switch mode.

Values:

enumerator kSDMA_ContextSwitchModeStatic

SDMA context switch mode static

enumerator kSDMA_ContextSwitchModeDynamicLowPower

SDMA context switch mode dynamic with low power

enumerator kSDMA_ContextSwitchModeDynamicWithNoLoop

SDMA context switch mode dynamic with no loop

enumerator kSDMA_ContextSwitchModeDynamic

SDMA context switch mode dynamic

enum _sdma_clock_ratio

SDMA core clock frequency ratio to the ARM DMA interface.

Values:

enumerator kSDMA_HalfARMClockFreq

SDMA core clock frequency half of ARM platform

enumerator kSDMA_ARMClockFreq

SDMA core clock frequency equals to ARM platform

enum _sdma_transfer_type

SDMA transfer type.

Values:

enumerator kSDMA_MemoryToMemory

Transfer from memory to memory

enumerator kSDMA_PeripheralToMemory

Transfer from peripheral to memory

enumerator kSDMA_MemoryToPeripheral

Transfer from memory to peripheral

enumerator kSDMA_PeripheralToPeripheral

Transfer from peripheral to peripheral

enum sdma_peripheral

Peripheral type use SDMA.

Values:

enumerator kSDMA_PeripheralTypeMemory

Peripheral DDR memory

enumerator kSDMA_PeripheralTypeUART

UART use SDMA

enumerator kSDMA_PeripheralTypeUART_SP

UART instance in SPBA use SDMA

enumerator kSDMA_PeripheralTypeSPDIF

SPDIF use SDMA

enumerator kSDMA_PeripheralNormal

Normal peripheral use SDMA

enumerator kSDMA_PeripheralNormal_SP

Normal peripheral in SPBA use SDMA

enumerator kSDMA_PeripheralMultiFifoPDM

multi fifo PDM

enumerator kSDMA_PeripheralMultiFifoSaiRX

multi fifo sai rx use SDMA

enumerator kSDMA_PeripheralMultiFifoSaiTX

multi fifo sai tx use SDMA

enumerator kSDMA_PeripheralASRCM2P

asrc m2p

enumerator kSDMA_PeripheralASRCP2M

asrc p2m

enumerator kSDMA_PeripheralASRCP2P

asrc p2p

_sdma_transfer_status SDMA transfer status

Values:

enumerator kStatus_SDMA_ERROR

SDMA context error.

enumerator kStatus_SDMA_Busy

Channel is busy and can't handle the transfer request.

_sdma_multi_fifo_mask SDMA multi fifo mask

Values:

enumerator kSDMA_MultiFifoWatermarkLevelMask

multi fifo watermark level mask

enumerator kSDMA_MultiFifoNumsMask

multi fifo nums mask

enumerator kSDMA_MultiFifoOffsetMask
multi fifo offset mask

enumerator kSDMA_MultiFifoSwDoneMask
multi fifo sw done mask

enumerator kSDMA_MultiFifoSwDoneSelectorMask
multi fifo sw done selector mask

_sdma_multi_fifo_shift SDMA multi fifo shift

Values:

enumerator kSDMA_MultiFifoWatermarkLevelShift
multi fifo watermark level shift

enumerator kSDMA_MultiFifoNumsShift
multi fifo nums shift

enumerator kSDMA_MultiFifoOffsetShift
multi fifo offset shift

enumerator kSDMA_MultiFifoSwDoneShift
multi fifo sw done shift

enumerator kSDMA_MultiFifoSwDoneSelectorShift
multi fifo sw done selector shift

_sdma_done_channel SDMA done channel

Values:

enumerator kSDMA_DoneChannel0
SDMA done channel 0

enumerator kSDMA_DoneChannel1
SDMA done channel 1

enumerator kSDMA_DoneChannel2
SDMA done channel 2

enumerator kSDMA_DoneChannel3
SDMA done channel 3

enumerator kSDMA_DoneChannel4
SDMA done channel 4

enumerator kSDMA_DoneChannel5
SDMA done channel 5

enumerator kSDMA_DoneChannel6
SDMA done channel 6

enumerator kSDMA_DoneChannel7
SDMA done channel 7

enum _sdma_done_src
SDMA done source.

Values:

enumerator kSDMA_DoneSrcSW
software done

enumerator kSDMA_DoneSrcHwEvent0U
HW event 0 is used for DONE event

enumerator kSDMA_DoneSrcHwEvent1U
HW event 1 is used for DONE event

enumerator kSDMA_DoneSrcHwEvent2U
HW event 2 is used for DONE event

enumerator kSDMA_DoneSrcHwEvent3U
HW event 3 is used for DONE event

enumerator kSDMA_DoneSrcHwEvent4U
HW event 4 is used for DONE event

enumerator kSDMA_DoneSrcHwEvent5U
HW event 5 is used for DONE event

enumerator kSDMA_DoneSrcHwEvent6U
HW event 6 is used for DONE event

enumerator kSDMA_DoneSrcHwEvent7U
HW event 7 is used for DONE event

enumerator kSDMA_DoneSrcHwEvent8U
HW event 8 is used for DONE event

enumerator kSDMA_DoneSrcHwEvent9U
HW event 9 is used for DONE event

enumerator kSDMA_DoneSrcHwEvent10U
HW event 10 is used for DONE event

enumerator kSDMA_DoneSrcHwEvent11U
HW event 11 is used for DONE event

enumerator kSDMA_DoneSrcHwEvent12U
HW event 12 is used for DONE event

enumerator kSDMA_DoneSrcHwEvent13U
HW event 13 is used for DONE event

enumerator kSDMA_DoneSrcHwEvent14U
HW event 14 is used for DONE event

enumerator kSDMA_DoneSrcHwEvent15U
HW event 15 is used for DONE event

enumerator kSDMA_DoneSrcHwEvent16U
HW event 16 is used for DONE event

enumerator kSDMA_DoneSrcHwEvent17U
HW event 17 is used for DONE event

enumerator kSDMA_DoneSrcHwEvent18U
HW event 18 is used for DONE event

enumerator kSDMA_DoneSrcHwEvent19U
HW event 19 is used for DONE event

enumerator `kSDMA_DoneSrcHwEvent20U`

HW event 20 is used for DONE event

enumerator `kSDMA_DoneSrcHwEvent21U`

HW event 21 is used for DONE event

enumerator `kSDMA_DoneSrcHwEvent22U`

HW event 22 is used for DONE event

enumerator `kSDMA_DoneSrcHwEvent23U`

HW event 23 is used for DONE event

enumerator `kSDMA_DoneSrcHwEvent24U`

HW event 24 is used for DONE event

enumerator `kSDMA_DoneSrcHwEvent25U`

HW event 25 is used for DONE event

enumerator `kSDMA_DoneSrcHwEvent26U`

HW event 26 is used for DONE event

enumerator `kSDMA_DoneSrcHwEvent27U`

HW event 27 is used for DONE event

enumerator `kSDMA_DoneSrcHwEvent28U`

HW event 28 is used for DONE event

enumerator `kSDMA_DoneSrcHwEvent29U`

HW event 29 is used for DONE event

enumerator `kSDMA_DoneSrcHwEvent30U`

HW event 30 is used for DONE event

enumerator `kSDMA_DoneSrcHwEvent31U`

HW event 31 is used for DONE event

typedef enum *_sdma_transfer_size* `sdma_transfer_size_t`

SDMA transfer configuration.

typedef enum *_sdma_bd_status* `sdma_bd_status_t`

SDMA buffer descriptor status.

typedef enum *_sdma_bd_command* `sdma_bd_command_t`

SDMA buffer descriptor command.

typedef enum *_sdma_context_switch_mode* `sdma_context_switch_mode_t`

SDMA context switch mode.

typedef enum *_sdma_clock_ratio* `sdma_clock_ratio_t`

SDMA core clock frequency ratio to the ARM DMA interface.

typedef enum *_sdma_transfer_type* `sdma_transfer_type_t`

SDMA transfer type.

typedef enum *sdma_peripheral* `sdma_peripheral_t`

Peripheral type use SDMA.

typedef enum *_sdma_done_src* `sdma_done_src_t`

SDMA done source.

typedef struct *_sdma_config* `sdma_config_t`

SDMA global configuration structure.

```
typedef struct _sdma_multi_fifo_config sdma_multi_fifo_config_t
```

SDMA multi fifo configurations.

```
typedef struct _sdma_sw_done_config sdma_sw_done_config_t
```

SDMA sw done configurations.

```
typedef struct _sdma_p2p_config sdma_p2p_config_t
```

SDMA peripheral to peripheral R7 config.

```
typedef struct _sdma_transfer_config sdma_transfer_config_t
```

SDMA transfer configuration.

This structure configures the source/destination transfer attribute.

```
typedef struct _sdma_buffer_descriptor sdma_buffer_descriptor_t
```

SDMA buffer descriptor structure.

This structure is a buffer descriptor, this structure describes the buffer start address and other options

```
typedef struct _sdma_channel_control sdma_channel_control_t
```

SDMA channel control descriptor structure.

```
typedef struct _sdma_context_data sdma_context_data_t
```

SDMA context structure for each channel. This structure can be load into SDMA core, with this structure, SDMA scripts can start work.

```
typedef void (*sdma_callback)(struct _sdma_handle *handle, void *userData, bool transferDone, uint32_t bdIndex)
```

Define callback function for SDMA.

```
typedef struct _sdma_handle sdma_handle_t
```

SDMA transfer handle structure.

SDMA_DRIVER_LOAD_RAM_SCRIPT

```
struct _sdma_config
```

#include <fsl_sdma.h> SDMA global configuration structure.

Public Members

bool enableRealTimeDebugPin

If enable real-time debug pin, default is closed to reduce power consumption.

bool isSoftwareResetClearLock

If software reset clears the LOCK bit which prevent writing SDMA scripts into SDMA.

sdma_clock_ratio_t ratio

SDMA core clock ratio to ARM platform DMA interface

```
struct _sdma_multi_fifo_config
```

#include <fsl_sdma.h> SDMA multi fifo configurations.

Public Members

uint8_t fifoNums

fifo numbers

uint8_t fifoOffset

offset between multi fifo data register address

```
struct __sdma_sw_done_config
    #include <fsl_sdma.h> SDMA sw done configurations.
```

Public Members

bool enableSwDone
 true is enable sw done, false is disable

uint8_t swDoneSel
 sw done channel number per peripheral type

```
struct __sdma_p2p_config
    #include <fsl_sdma.h> SDMA peripheral to peripheral R7 config.
```

Public Members

uint8_t sourceWatermark
 lower watermark value

uint8_t destWatermark
 higher water makr value

bool continuousTransfer
 0: the amount of samples to be transferred is equal to the cont field of mode word 1: the amount of samples to be transferred is unknown and script will keep on transferring as long as both events are detected and script must be stopped by application.

```
struct __sdma_transfer_config
    #include <fsl_sdma.h> SDMA transfer configuration.

    This structure configures the source/destination transfer attribute.
```

Public Members

uint32_t srcAddr
 Source address of the transfer

uint32_t destAddr
 Destination address of the transfer

sdma_transfer_size_t srcTransferSize
 Source data transfer size.

sdma_transfer_size_t destTransferSize
 Destination data transfer size.

uint32_t bytesPerRequest
 Bytes to transfer in a minor loop

uint32_t transferSzie
 Bytes to transfer for this descriptor

uint32_t scriptAddr
 SDMA script address located in SDMA ROM.

uint32_t eventSource
 Event source number for the channel. 0 means no event, use software trigger

uint32_t eventSource1
event source 1

bool isEventIgnore
True means software trigger, false means hardware trigger

bool isSoftTriggerIgnore
If ignore the HE bit, 1 means use hardware events trigger, 0 means software trigger

sdma_transfer_type_t type
Transfer type, transfer type used to decide the SDMA script.

sdma_multi_fifo_config_t multiFifo
multi fifo configurations

sdma_sw_done_config_t swDone
sw done selector

uint32_t watermarkLevel
watermark level

uint32_t eventMask0
event mask 0

uint32_t eventMask1
event mask 1

struct *_sdma_buffer_descriptor*

#include <fsl_sdma.h> SDMA buffer descriptor structure.

This structure is a buffer descriptor, this structure describes the buffer start address and other options

Public Members

uint32_t count
Bytes of the buffer length for this buffer descriptor.

uint32_t status
E,R,I,C,W,D status bits stored here

uint32_t command
command mostly used for channel 0

uint32_t bufferAddr
Buffer start address for this descriptor.

uint32_t extendBufferAddr
External buffer start address, this is an optional for a transfer.

struct *_sdma_channel_control*

#include <fsl_sdma.h> SDMA channel control descriptor structure.

Public Members

uint32_t currentBDAAddr
Address of current buffer descriptor processed

uint32_t baseBDAAddr
The start address of the buffer descriptor array

uint32_t channelDesc
Optional for transfer

uint32_t status
Channel status

struct _sdma_context_data
#include <fsl_sdma.h> SDMA context structure for each channel. This structure can be load into SDMA core, with this structure, SDMA scripts can start work.

Public Members

uint32_t GeneralReg[8]
8 general registers used for SDMA RISC core

struct _sdma_handle
#include <fsl_sdma.h> SDMA transfer handle structure.

Public Members

sdma_callback callback
Callback function for major count exhausted.

void *userData
Callback function parameter.

SDMAARM_Type *base
SDMA peripheral base address.

sdma_buffer_descriptor_t *BDPool
Pointer to memory stored BD arrays.

uint32_t bdCount
How many buffer descriptor

uint32_t bdIndex
How many buffer descriptor

uint32_t eventSource
Event source count for the channel

uint32_t eventSource1
Event source 1 count for the channel

sdma_context_data_t *context
Channel context to execute in SDMA

uint8_t channel
SDMA channel number.

uint8_t priority
SDMA channel priority

uint8_t flags
The status of the current channel.

2.37 SEMA4: Hardware Semaphores Driver

FSL_SEMA4_DRIVER_VERSION

SEMA4 driver version.

void SEMA4_Init(SEMA4_Type *base)

Initializes the SEMA4 module.

This function initializes the SEMA4 module. It only enables the clock but does not reset the gates because the module might be used by other processors at the same time. To reset the gates, call either SEMA4_ResetGate or SEMA4_ResetAllGates function.

Parameters

- base – SEMA4 peripheral base address.

void SEMA4_Deinit(SEMA4_Type *base)

De-initializes the SEMA4 module.

This function de-initializes the SEMA4 module. It only disables the clock.

Parameters

- base – SEMA4 peripheral base address.

status_t SEMA4_TryLock(SEMA4_Type *base, uint8_t gateNum, uint8_t procNum)

Tries to lock the SEMA4 gate.

This function tries to lock the specific SEMA4 gate. If the gate has been locked by another processor, this function returns an error code.

Parameters

- base – SEMA4 peripheral base address.
- gateNum – Gate number to lock.
- procNum – Current processor number.

Return values

- kStatus_Success – Lock the sema4 gate successfully.
- kStatus_Fail – Sema4 gate has been locked by another processor.

status_t SEMA4_Lock(SEMA4_Type *base, uint8_t gateNum, uint8_t procNum)

Locks the SEMA4 gate.

This function locks the specific SEMA4 gate. If the gate has been locked by other processors, this function waits until it is unlocked and then lock it.

If SEMA4_BUSY_POLL_COUNT is defined and non-zero, the function will timeout after the specified number of polling iterations and return kStatus_Timeout.

Parameters

- base – SEMA4 peripheral base address.
- gateNum – Gate number to lock.
- procNum – Current processor number.

Return values

- kStatus_Success – The gate was successfully locked.
- kStatus_Timeout – Timeout occurred while waiting for the gate to be unlocked.

Returns

status_t

static inline void SEMA4_Unlock(SEMA4_Type *base, uint8_t gateNum)

Unlocks the SEMA4 gate.

This function unlocks the specific SEMA4 gate. It only writes unlock value to the SEMA4 gate register. However, it does not check whether the SEMA4 gate is locked by the current processor or not. As a result, if the SEMA4 gate is not locked by the current processor, this function has no effect.

Parameters

- base – SEMA4 peripheral base address.
- gateNum – Gate number to unlock.

static inline int32_t SEMA4_GetLockProc(SEMA4_Type *base, uint8_t gateNum)

Gets the status of the SEMA4 gate.

This function checks the lock status of a specific SEMA4 gate.

Parameters

- base – SEMA4 peripheral base address.
- gateNum – Gate number.

Returns

Return -1 if the gate is unlocked, otherwise return the processor number which has locked the gate.

status_t SEMA4_ResetGate(SEMA4_Type *base, uint8_t gateNum)

Resets the SEMA4 gate to an unlocked status.

This function resets a SEMA4 gate to an unlocked status.

Parameters

- base – SEMA4 peripheral base address.
- gateNum – Gate number.

Return values

- kStatus_Success – SEMA4 gate is reset successfully.
- kStatus_Fail – Some other reset process is ongoing.

static inline status_t SEMA4_ResetAllGates(SEMA4_Type *base)

Resets all SEMA4 gates to an unlocked status.

This function resets all SEMA4 gate to an unlocked status.

Parameters

- base – SEMA4 peripheral base address.

Return values

- kStatus_Success – SEMA4 is reset successfully.
- kStatus_Fail – Some other reset process is ongoing.

static inline void SEMA4_EnableGateNotifyInterrupt(SEMA4_Type *base, uint8_t procNum,
uint16_t mask)

Enable the gate notification interrupt.

Gate notification provides such feature, when core tried to lock the gate and failed, it could get notification when the gate is idle.

Parameters

- base – SEMA4 peripheral base address.
- procNum – Current processor number.
- mask – OR'ed value of the gate index, for example: (1«0) | (1«1) means gate 0 and gate 1.

```
static inline void SEMA4_DisableGateNotifyInterrupt(SEMA4_Type *base, uint8_t procNum,  
                                                    uint16_t mask)
```

Disable the gate notification interrupt.

Gate notification provides such feature, when core tried to lock the gate and failed, it could get notification when the gate is idle.

Parameters

- base – SEMA4 peripheral base address.
- procNum – Current processor number.
- mask – OR'ed value of the gate index, for example: (1«0) | (1«1) means gate 0 and gate 1.

```
static inline uint32_t SEMA4_GetGateNotifyStatus(SEMA4_Type *base, uint8_t procNum)
```

Get the gate notification flags.

Gate notification provides such feature, when core tried to lock the gate and failed, it could get notification when the gate is idle. The status flags are cleared automatically when the gate is locked by current core or locked again before the other core.

Parameters

- base – SEMA4 peripheral base address.
- procNum – Current processor number.

Returns

OR'ed value of the gate index, for example: (1«0) | (1«1) means gate 0 and gate 1 flags are pending.

```
status_t SEMA4_ResetGateNotify(SEMA4_Type *base, uint8_t gateNum)
```

Resets the SEMA4 gate IRQ notification.

This function resets a SEMA4 gate IRQ notification.

Parameters

- base – SEMA4 peripheral base address.
- gateNum – Gate number.

Return values

- kStatus_Success – Reset successfully.
- kStatus_Fail – Some other reset process is ongoing.

```
static inline status_t SEMA4_ResetAllGateNotify(SEMA4_Type *base)
```

Resets all SEMA4 gates IRQ notification.

This function resets all SEMA4 gate IRQ notifications.

Parameters

- base – SEMA4 peripheral base address.

Return values

- kStatus_Success – Reset successfully.

- `kStatus_Fail` – Some other reset process is ongoing.

`SEMA4_GATE_NUM_RESET_ALL`

The number to reset all SEMA4 gates.

`SEMA4_GATEn(base, n)`

SEMA4 gate `n` register address.

`SEMA4_BUSY_POLL_COUNT`

Maximum polling iterations for SEMA4 waiting loops.

This parameter defines the maximum number of iterations for any polling loop in the SEMA4 driver code before timing out and returning an error.

It applies to all waiting loops in SEMA4 driver, such as waiting for a gate to be unlocked, waiting for a reset to complete, or waiting for a resource to become available.

This is a count of loop iterations, not a time-based value.

If defined as 0, polling loops will continue indefinitely until their exit condition is met, which could potentially cause the system to hang if hardware doesn't respond or if a resource is never released.

2.38 TMU: Thermal Management Unit Driver

TMU interrupt enable, `_tmu_interrupt_enable`.

Values:

enumerator `kTMU_ImmediateTemperature0InterruptEnable`

Immediate temperature threshold exceeded interrupt enable of probe0.

enumerator `kTMU_AverageTemperature0InterruptEnable`

Average temperature threshold exceeded interrupt enable of probe0.

enumerator `kTMU_AverageTemperature0CriticalInterruptEnable`

Average temperature critical threshold exceeded interrupt enable of probe0.

enumerator `kTMU_ImmediateTemperature1Interrupt1Enable`

Immediate temperature threshold exceeded interrupt enable of probe1.

enumerator `kTMU_AverageTemperature1Interrupt1Enable`

Average temperature threshold exceeded interrupt enable of probe1.

enumerator `kTMU_AverageTemperature1CriticalInterrupt1Enable`

Average temperature critical threshold exceeded interrupt enable of probe1.

TMU interrupt enable, `_tmu_interrupt_status_flags`.

Values:

enumerator `kTMU_ImmediateTemperature0InterruptStatusFlags`

Immediate temperature threshold exceeded interrupt status of probe0.

enumerator `kTMU_AverageTemperature0InterruptStatusFlags`

Average temperature threshold exceeded interrupt status of probe0.

enumerator `kTMU_AverageTemperature0CriticalInterruptStatusFlags`

Average temperature critical threshold exceeded interrupt status of probe0.

enumerator kTMU_ImmediateTemperature1Interrupt1StausFlags

Immediate temperature threshold exceeded interrupt status of probe1.

enumerator kTMU_AverageTemperature1Interrupt1StausFlags

Average temperature threshold exceeded interrupt status of probe1.

enumerator kTMU_AverageTemperature1CriticalInterrupt1StausFlags

Average temperature critical threshold exceeded interrupt status of probe1.

enum _tmu_probe_select

Probe selection.

Values:

enumerator kTMU_ProbeSelectMainProbe

Select the main probe only.

enumerator kTMU_ProbeSelectRemoteProbe

Select the remote probe(near A53) only.

enumerator kTMU_ProbeSelectBothProbes

Select both 2 probes.

enum _tmu_average_low_pass_filter

Average low pass filter setting.

Values:

enumerator kTMU_AverageLowPassFilter1_0

Average low pass filter = 1.

enumerator kTMU_AverageLowPassFilter0_5

Average low pass filter = 0.5.

enumerator kTMU_AverageLowPassFilter0_25

Average low pass filter = 0.25.

enumerator kTMU_AverageLowPassFilter0_125

Average low pass filter = 0.125.

typedef struct _tmu_threshold_config tmu_threshold_config_t

configuration for TMU threshold.

typedef enum _tmu_probe_select tmu_probe_select_t

Probe selection.

typedef enum _tmu_average_low_pass_filter tmu_average_low_pass_filter_t

Average low pass filter setting.

typedef struct _tmu_config tmu_config_t

Configuration for TMU module.

void TMU_Init(TMU_Type *base, const *tmu_config_t* *config)

Enable the access to TMU registers and Initialize TMU module.

Parameters

- base – TMU peripheral base address.
- config – Pointer to configuration structure. Refer to “tmu_config_t” structure.

void TMU_Deinit(TMU_Type *base)

De-initialize TMU module and Disable the access to DCDC registers.

Parameters

- base – TMU peripheral base address.

void TMU_Enable(TMU_Type *base, bool enable)

Enable/disable TMU module.

Parameters

- base – TMU peripheral base address.
- enable – enable or disable TMU.

void TMU_GetDefaultConfig(*tmu_config_t* *config)

Gets the default configuration for TMU.

This function initializes the user configuration structure to default value. The default value are:

Example:

```
config.averageLPF           = kTMU_AverageLowPassFilter0_5;
config.probeSelect          = kTMU_ProbeSelectMainProbe;
config.thresholdConfig.immediateThresholdEnable = false;
config.thresholdConfig.immediateThresholdValue  = DEMO_TMU_IMMEDIATE_THRESOLD;
config.thresholdConfig.AverageThresholdEnable   = true;
config.thresholdConfig.averageThresholdValue    = DEMO_TMU_AVERAGE_THRESOLD;
config.thresholdConfig.AverageCriticalThresholdEnable = false;
config.thresholdConfig.averageCriticalThresholdValue = DEMO_TMU_AVERAGE_CRITICAL_
↪ THRESOLD;
```

Parameters

- config – Pointer to TMU configuration structure.

static inline void TMU_EnableInterrupts(TMU_Type *base, uint32_t mask)

Enable the TMU interrupts.

Parameters

- base – TMU peripheral base address.
- mask – The interrupt mask. Refer to “_tmu_interrupt_enable” enumeration.

static inline void TMU_DisableInterrupts(TMU_Type *base, uint32_t mask)

Disable the TMU interrupts.

Parameters

- base – TMU peripheral base address.
- mask – The interrupt mask. Refer to “_tmu_interrupt_enable” enumeration.

static inline uint32_t TMU_GetInterruptStatusFlags(TMU_Type *base)

Get interrupt status flags.

Parameters

- base – TMU peripheral base address.

Return values

The – current interrupt status.

```
static inline void TMU_ClearInterruptStatusFlags(TMU_Type *base, uint32_t mask)
```

Clear interrupt status flags.

Parameters

- base – TMU peripheral base address.
- mask – The mask of interrupt status flags. Refer to “_tmu_interrupt_status_flags” enumeration.

```
status_t TMU_GetImmediateTemperature(TMU_Type *base, tmu_probe_select_t probe, int8_t *temperature)
```

Get the last immediate temperature at site.

Parameters

- base – TMU peripheral base address.
- probe – probe selection, if select both 2 probes, return main probe temperature by default. Refer to “tmu_probe_select_t” structure.
- temperature – Last immediate temperature reading at site when V=1. besides, Bit-8 is sign bit: 1 means negative and 0 means positive.

Return values

get – immediate temperature status.

```
status_t TMU_GetAverageTemperature(TMU_Type *base, tmu_probe_select_t probe, int8_t *temperature)
```

Get the last average temperature at site.

Parameters

- base – TMU peripheral base address.
- probe – probe selection, if select both 2 probes, return main probe temperature by default. Refer to “tmu_probe_select_t” structure.
- temperature – Last average temperature reading at site; besides, Bit-8 is sign bit: 1 means negative and 0 means positive.

Return values

get – average temperature status.

```
void TMU_UpdateHighTemperatureThreshold(TMU_Type *base, tmu_probe_select_t probe, const tmu_threshold_config_t *thresholdConfig)
```

Update the high temperature threshold value.

Parameters

- base – TMU peripheral base address.
- probe – probe selection, if select both 2 probes, set main probe path by default. Refer to “tmu_probe_select_t” structure.
- thresholdConfig – threshold configuration. Refer to “tmu_threshold_config_t” structure.

FSL_TMU_DRIVER_VERSION

TMU driver version.

Version 2.0.0.

```
struct _tmu_threshold_config
```

#include <fsl_tmu.h> configuration for TMU threshold.

Public Members

`bool immediateThresholdEnable`

Enable high temperature immediate threshold.

`bool AverageThresholdEnable`

Enable high temperature average threshold.

`bool AverageCriticalThresholdEnable`

Enable high temperature average critical threshold.

`uint8_t immediateThresholdValueOfMainProbe`

Range:-40~125. Valid when corresponding threshold is enabled. High temperature immediate threshold value of main probe. Besides, bit-8 is sign bit: 1 means negative and 0 means positive.

`uint8_t averageThresholdValueOfMainProbe`

Range:-40~125. Valid when corresponding threshold is enabled. High temperature average threshold value of main probe. Besides, bit-8 is sign bit: 1 means negative and 0 means positive.

`uint8_t averageCriticalThresholdValueOfMainProbe`

Range:-40~125. Valid when corresponding threshold is enabled. High temperature average critical threshold value of main probe. Besides, bit-8 is sign bit: 1 means negative and 0 means positive.

`uint8_t immediateThresholdValueOfRemoteProbe`

Range:-40~125. Valid when corresponding threshold is enabled. High temperature immediate threshold value of remote probe. Besides, bit-8 is sign bit: 1 means negative and 0 means positive.

`uint8_t averageThresholdValueOfRemoteProbe`

Range:-40~125. Valid when corresponding threshold is enabled. High temperature average threshold value of remote probe. Besides, bit-8 is sign bit: 1 means negative and 0 means positive.

`uint8_t averageCriticalThresholdValueOfRemoteProbe`

Range:-40~125. Valid when corresponding threshold is enabled. High temperature average critical threshold value of remote probe. Besides, bit-8 is sign bit: 1 means negative and 0 means positive.

`struct __tmu_config`

#include <fsl_tmu.h> Configuration for TMU module.

Public Members

`tmu_probe_select_t probeSelect`

The temperature monitor probe select.

`tmu_average_low_pass_filter_t averageLPF`

The average temperature is calculated as: $ALPF \times \text{Current\_Temp} + (1 - ALPF) \times \text{Average\_Temp}$. For proper operation, this field should only change when monitoring is disabled.

`tmu_threshold_config_t thresholdConfig`

The high temperature threshold configuration.

2.39 UART: Universal Asynchronous Receiver/Transmitter Driver

2.40 UART Driver

static inline void UART__SoftwareReset(UART_Type *base)

Resets the UART using software.

This function resets the transmit and receive state machines, all FIFOs and register USR1, USR2, UBIR, UBMCR, UBRC, URXD, UTXD and UTS[6-3]

Parameters

- base – UART peripheral base address.

status_t UART__Init(UART_Type *base, const uart_config_t *config, uint32_t srcClock_Hz)

Initializes an UART instance with the user configuration structure and the peripheral clock.

This function configures the UART module with user-defined settings. Call the UART_GetDefaultConfig() function to configure the configuration structure and get the default configuration. The example below shows how to use this API to configure the UART.

```
uart_config_t uartConfig;
uartConfig.baudRate_Bps = 115200U;
uartConfig.parityMode = kUART_ParityDisabled;
uartConfig.dataBitsCount = kUART_EightDataBits;
uartConfig.stopBitCount = kUART_OneStopBit;
uartConfig.txFifoWatermark = 2;
uartConfig.rxFifoWatermark = 1;
uartConfig.enableAutoBaudrate = false;
uartConfig.enableTx = true;
uartConfig.enableRx = true;
UART__Init(UART1, &uartConfig, 24000000U);
```

Parameters

- base – UART peripheral base address.
- config – Pointer to a user-defined configuration structure.
- srcClock_Hz – UART clock source frequency in HZ.

Return values

kStatus_Success – UART initialize succeed

void UART__Deinit(UART_Type *base)

Deinitializes a UART instance.

This function waits for transmit to complete, disables TX and RX, and disables the UART clock.

Parameters

- base – UART peripheral base address.

void UART__GetDefaultConfig(uart_config_t *config)

Gets the default configuration structure.

1

This function initializes the UART configuration structure to a default value. The default values are: uartConfig->baudRate_Bps = 115200U; uartConfig->parityMode =

```
kUART_ParityDisabled; uartConfig->dataBitsCount = kUART_EightDataBits; uartConfig->stopBitCount = kUART_OneStopBit; uartConfig->txFifoWatermark = 2; uartConfig->rxFifoWatermark = 1; uartConfig->enableAutoBaudrate = false; uartConfig->enableTx = false; uartConfig->enableRx = false;
```

Parameters

- config – Pointer to a configuration structure.

```
status_t UART_SetBaudRate(UART_Type *base, uint32_t baudRate_Bps, uint32_t srcClock_Hz)
```

Sets the UART instance baud rate.

This function configures the UART module baud rate. This function is used to update the UART module baud rate after the UART module is initialized by the UART_Init.

```
UART_SetBaudRate(UART1, 115200U, 20000000U);
```

Parameters

- base – UART peripheral base address.
- baudRate_Bps – UART baudrate to be set.
- srcClock_Hz – UART clock source frequency in Hz.

Return values

- kStatus_UART_BaudrateNotSupport – Baudrate is not support in the current clock source.
- kStatus_Success – Set baudrate succeeded.

```
static inline void UART_Enable(UART_Type *base)
```

This function is used to Enable the UART Module.

Parameters

- base – UART base pointer.

```
static inline void UART_SetIdleCondition(UART_Type *base, uart_idle_condition_t condition)
```

This function is used to configure the IDLE line condition.

Parameters

- base – UART base pointer.
- condition – IDLE line detect condition of the enumerators in `uart_idle_condition_t`.

```
static inline void UART_Disable(UART_Type *base)
```

This function is used to Disable the UART Module.

Parameters

- base – UART base pointer.

```
bool UART_GetStatusFlag(UART_Type *base, uint32_t flag)
```

This function is used to get the current status of specific UART status flag(including interrupt flag). The available status flag can be select from `uart_status_flag_t` enumeration.

Parameters

- base – UART base pointer.
- flag – Status flag to check.

Return values

current – state of corresponding status flag.

`void UART_ClearStatusFlag(UART_Type *base, uint32_t flag)`

This function is used to clear the current status of specific UART status flag. The available status flag can be select from `uart_status_flag_t` enumeration.

Parameters

- `base` – UART base pointer.
- `flag` – Status flag to clear.

`void UART_EnableInterrupts(UART_Type *base, uint32_t mask)`

Enables UART interrupts according to the provided mask.

This function enables the UART interrupts according to the provided mask. The mask is a logical OR of enumeration members. See `_uart_interrupt_enable`. For example, to enable TX empty interrupt and RX data ready interrupt, do the following.

```
UART_EnableInterrupts(UART1, kUART_TxEmptyEnable | kUART_RxDataReadyEnable);
```

Parameters

- `base` – UART peripheral base address.
- `mask` – The interrupts to enable. Logical OR of `_uart_interrupt_enable`.

`void UART_DisableInterrupts(UART_Type *base, uint32_t mask)`

Disables the UART interrupts according to the provided mask.

This function disables the UART interrupts according to the provided mask. The mask is a logical OR of enumeration members. See `_uart_interrupt_enable`. For example, to disable TX empty interrupt and RX data ready interrupt do the following.

```
UART_EnableInterrupts(UART1, kUART_TxEmptyEnable | kUART_RxDataReadyEnable);
```

Parameters

- `base` – UART peripheral base address.
- `mask` – The interrupts to disable. Logical OR of `_uart_interrupt_enable`.

`uint32_t UART_GetEnabledInterrupts(UART_Type *base)`

Gets enabled UART interrupts.

This function gets the enabled UART interrupts. The enabled interrupts are returned as the logical OR value of the enumerators `_uart_interrupt_enable`. To check a specific interrupt enable status, compare the return value with enumerators in `_uart_interrupt_enable`. For example, to check whether the TX empty interrupt is enabled:

```
uint32_t enabledInterrupts = UART_GetEnabledInterrupts(UART1);  
  
if (kUART_TxEmptyEnable & enabledInterrupts)  
{  
    ...  
}
```

Parameters

- `base` – UART peripheral base address.

Returns

UART interrupt flags which are logical OR of the enumerators in `_uart_interrupt_enable`.

```
static inline void UART_EnableTx(UART_Type *base, bool enable)
```

Enables or disables the UART transmitter.

This function enables or disables the UART transmitter.

Parameters

- base – UART peripheral base address.
- enable – True to enable, false to disable.

```
static inline void UART_EnableRx(UART_Type *base, bool enable)
```

Enables or disables the UART receiver.

This function enables or disables the UART receiver.

Parameters

- base – UART peripheral base address.
- enable – True to enable, false to disable.

```
static inline void UART_WriteByte(UART_Type *base, uint8_t data)
```

Writes to the transmitter register.

This function is used to write data to transmitter register. The upper layer must ensure that the TX register is empty or that the TX FIFO has room before calling this function.

Parameters

- base – UART peripheral base address.
- data – Data write to the TX register.

```
static inline uint8_t UART_ReadByte(UART_Type *base)
```

Reads the receiver register.

This function is used to read data from receiver register. The upper layer must ensure that the receiver register is full or that the RX FIFO has data before calling this function.

Parameters

- base – UART peripheral base address.

Returns

Data read from data register.

```
status_t UART_WriteBlocking(UART_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 – UART peripheral base address.
- data – Start address of the data to write.
- length – Size of the data to write.

Return values

- kStatus_UART_Timeout – Transmission timed out and was aborted.
- kStatus_Success – Successfully wrote all data.

```
status_t UART_ReadBlocking(UART_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 reads data from the TX register.

Parameters

- base – UART peripheral base address.
- data – Start address of the buffer to store the received data.
- length – Size of the buffer.

Return values

- kStatus_UART_RxHardwareOverrun – Receiver overrun occurred while receiving data.
- kStatus_UART_NoiseError – A noise error occurred while receiving data.
- kStatus_UART_FramingError – A framing error occurred while receiving data.
- kStatus_UART_ParityError – A parity error occurred while receiving data.
- kStatus_UART_Timeout – Transmission timed out and was aborted.
- kStatus_Success – Successfully received all data.

```
void UART_TransferCreateHandle(UART_Type *base, uart_handle_t *handle,  
                             uart_transfer_callback_t callback, void *userData)
```

Initializes the UART handle.

This function initializes the UART handle which can be used for other UART transactional APIs. Usually, for a specified UART instance, call this API once to get the initialized handle.

Parameters

- base – UART peripheral base address.
- handle – UART handle pointer.
- callback – The callback function.
- userData – The parameter of the callback function.

```
void UART_TransferStartRingBuffer(UART_Type *base, uart_handle_t *handle, uint8_t  
                                *ringBuffer, size_t ringBufferSize)
```

Sets up the RX ring buffer.

This function sets up the RX ring buffer to a specific UART handle.

When the RX ring buffer is used, data received are stored into the ring buffer even when the user doesn't call the UART_TransferReceiveNonBlocking() API. If data is already 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, only 31 bytes are used for saving data.

Parameters

- base – UART peripheral base address.
- handle – UART 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 UART_TransferStopRingBuffer(UART_Type *base, uart_handle_t *handle)`

Aborts the background transfer and uninstalls the ring buffer.

This function aborts the background transfer and uninstalls the ring buffer.

Parameters

- *base* – UART peripheral base address.
- *handle* – UART handle pointer.

`size_t UART_TransferGetRxRingBufferLength(uart_handle_t *handle)`

Get the length of received data in RX ring buffer.

Parameters

- *handle* – UART handle pointer.

Returns

Length of received data in RX ring buffer.

`status_t UART_TransferSendNonBlocking(UART_Type *base, uart_handle_t *handle,
 uart_transfer_t *xfer)`

Transmits a buffer of data using the interrupt method.

This function sends data using an interrupt method. This is a non-blocking function, which returns directly without waiting for all data to be written to the TX register. When all data is written to the TX register in the ISR, the UART driver calls the callback function and passes the `kStatus_UART_TxIdle` as status parameter.

Note: The `kStatus_UART_TxIdle` is passed to the upper layer when all data is written to the TX register. However, it does not ensure that all data is sent out. Before disabling the TX, check the `kUART_TransmissionCompleteFlag` to ensure that the TX is finished.

Parameters

- *base* – UART peripheral base address.
- *handle* – UART handle pointer.
- *xfer* – UART transfer structure. See `uart_transfer_t`.

Return values

- `kStatus_Success` – Successfully start the data transmission.
- `kStatus_UART_TxBusy` – Previous transmission still not finished; data not all written to TX register yet.
- `kStatus_InvalidArgument` – Invalid argument.

`void UART_TransferAbortSend(UART_Type *base, uart_handle_t *handle)`

Aborts the interrupt-driven data transmit.

This function aborts the interrupt-driven data sending. The user can get the `remainBytes` to find out how many bytes are not sent out.

Parameters

- *base* – UART peripheral base address.
- *handle* – UART handle pointer.

```
status_t UART_TransferGetSendCount(UART_Type *base, uart_handle_t *handle, uint32_t *count)
```

Gets the number of bytes written to the UART TX register.

This function gets the number of bytes written to the UART TX register by using the interrupt method.

Parameters

- base – UART peripheral base address.
- handle – UART handle pointer.
- count – Send bytes count.

Return values

- kStatus_NoTransferInProgress – No send in progress.
- kStatus_InvalidArgument – The parameter is invalid.
- kStatus_Success – Get successfully through the parameter count;

```
status_t UART_TransferReceiveNonBlocking(UART_Type *base, uart_handle_t *handle, uart_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 UART driver. When the new data arrives, the receive request is serviced first. When all data is received, the UART driver notifies the upper layer through a callback function and passes the status parameter `kStatus_UART_RxIdle`. For example, 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 UART 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 – UART peripheral base address.
- handle – UART handle pointer.
- xfer – UART transfer structure, see `uart_transfer_t`.
- receivedBytes – Bytes received from the ring buffer directly.

Return values

- kStatus_Success – Successfully queue the transfer into transmit queue.
- kStatus_UART_RxBusy – Previous receive request is not finished.
- kStatus_InvalidArgument – Invalid argument.

```
void UART_TransferAbortReceive(UART_Type *base, uart_handle_t *handle)
```

Aborts the interrupt-driven data receiving.

This function aborts the interrupt-driven data receiving. The user can get the `remainBytes` to know how many bytes are not received yet.

Parameters

- base – UART peripheral base address.
- handle – UART handle pointer.


```
status_t UART_TransferGetReceiveCount(UART_Type *base, uart_handle_t *handle, uint32_t *count)
```

Gets the number of bytes that have been received.

This function gets the number of bytes that have been received.

Parameters

- base – UART peripheral base address.
- handle – UART 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 UART_TransferHandleIRQ(UART_Type *base, void *irqHandle)
```

UART IRQ handle function.

This function handles the UART transmit and receive IRQ request.

Parameters

- base – UART peripheral base address.
- irqHandle – UART handle pointer.

```
static inline void UART_EnableTxDMA(UART_Type *base, bool enable)
```

Enables or disables the UART transmitter DMA request.

This function enables or disables the transmit request when the transmitter has one or more slots available in the TxFIFO. The fill level in the TxFIFO that generates the DMA request is controlled by the TXTL bits.

Parameters

- base – UART peripheral base address.
- enable – True to enable, false to disable.

```
static inline void UART_EnableRxDMA(UART_Type *base, bool enable)
```

Enables or disables the UART receiver DMA request.

This function enables or disables the receive request when the receiver has data in the Rx FIFO. The fill level in the Rx FIFO at which a DMA request is generated is controlled by the RXTL bits.

Parameters

- base – UART peripheral base address.
- enable – True to enable, false to disable.

```
static inline void UART_SetTxFifoWatermark(UART_Type *base, uint8_t watermark)
```

This function is used to set the watermark of UART Tx FIFO. A maskable interrupt is generated whenever the data level in the TxFIFO falls below the Tx FIFO watermark.

Parameters

- base – UART base pointer.
- watermark – The Tx FIFO watermark.

static inline void UART_SetRxRTSWatermark(UART_Type *base, uint8_t watermark)

This function is used to set the watermark of UART RTS deassertion.

The RTS signal deasserts whenever the data count in RxFIFO reaches the Rx RTS watermark.

Parameters

- base – UART base pointer.
- watermark – The Rx RTS watermark.

static inline void UART_SetRxFifoWatermark(UART_Type *base, uint8_t watermark)

This function is used to set the watermark of UART Rx FIFO. A maskable interrupt is generated whenever the data level in the Rx FIFO reaches the Rx FIFO watermark.

Parameters

- base – UART base pointer.
- watermark – The Rx FIFO watermark.

static inline void UART_EnableAutoBaudRate(UART_Type *base, bool enable)

This function is used to set the enable condition of Automatic Baud Rate Detection feature.

Parameters

- base – UART base pointer.
- enable – Enable/Disable Automatic Baud Rate Detection feature.
 - true: Enable Automatic Baud Rate Detection feature.
 - false: Disable Automatic Baud Rate Detection feature.

static inline bool UART_IsAutoBaudRateComplete(UART_Type *base)

This function is used to read if the automatic baud rate detection has finished.

Parameters

- base – UART base pointer.

Returns

- true: Automatic baud rate detection has finished.
- false: Automatic baud rate detection has not finished.

FSL_UART_DRIVER_VERSION

UART driver version.

Error codes for the UART driver.

Values:

enumerator kStatus_UART_TxBusy

Transmitter is busy.

enumerator kStatus_UART_RxBusy

Receiver is busy.

enumerator kStatus_UART_TxIdle

UART transmitter is idle.

enumerator kStatus_UART_RxIdle

UART receiver is idle.

enumerator kStatus_UART_TxWatermarkTooLarge

TX FIFO watermark too large

enumerator kStatus_UART_RxWatermarkTooLarge
RX FIFO watermark too large

enumerator kStatus_UART_FlagCannotClearManually
UART flag can't be manually cleared.

enumerator kStatus_UART_Error
Error happens on UART.

enumerator kStatus_UART_RxRingBufferOverrun
UART RX software ring buffer overrun.

enumerator kStatus_UART_RxHardwareOverrun
UART RX receiver overrun.

enumerator kStatus_UART_NoiseError
UART noise error.

enumerator kStatus_UART_FramingError
UART framing error.

enumerator kStatus_UART_ParityError
UART parity error.

enumerator kStatus_UART_BaudrateNotSupport
Baudrate is not support in current clock source

enumerator kStatus_UART_BreakDetect
Receiver detect BREAK signal

enumerator kStatus_UART_Timeout
UART times out.

enum _uart_data_bits
UART data bits count.

Values:

enumerator kUART_SevenDataBits
Seven data bit

enumerator kUART_EightDataBits
Eight data bit

enum _uart_parity_mode
UART parity mode.

Values:

enumerator kUART_ParityDisabled
Parity disabled

enumerator kUART_ParityEven
Even error check is selected

enumerator kUART_ParityOdd
Odd error check is selected

enum _uart_stop_bit_count
UART stop bit count.

Values:

enumerator kUART_OneStopBit

One stop bit

enumerator kUART_TwoStopBit

Two stop bits

enum __uart_idle_condition

UART idle condition detect.

Values:

enumerator kUART_IdleFor4Frames

Idle for more than 4 frames

enumerator kUART_IdleFor8Frames

Idle for more than 8 frames

enumerator kUART_IdleFor16Frames

Idle for more than 16 frames

enumerator kUART_IdleFor32Frames

Idle for more than 32 frames

enum __uart_interrupt_enable

This structure contains the settings for all of the UART interrupt configurations.

Values:

enumerator kUART_AutoBaudEnable

enumerator kUART_TxReadyEnable

enumerator kUART_IdleEnable

enumerator kUART_RxReadyEnable

enumerator kUART_TxEmptyEnable

enumerator kUART_RtsDeltaEnable

enumerator kUART_EscapeEnable

enumerator kUART_RtsEnable

enumerator kUART_AgingTimerEnable

enumerator kUART_DtrEnable

enumerator kUART_ParityErrorEnable

enumerator kUART_FrameErrorEnable

enumerator kUART_DcdEnable

enumerator kUART_RiEnable

enumerator kUART_RxDsEnable

enumerator kUART_tAirWakeEnable

enumerator kUART_AwakeEnable

enumerator kUART_DtrDeltaEnable

enumerator kUART_AutoBaudCntEnable

enumerator kUART_IrEnable
enumerator kUART_WakeEnable
enumerator kUART_TxCompleteEnable
enumerator kUART_BreakDetectEnable
enumerator kUART_RxOverrunEnable
enumerator kUART_RxDataReadyEnable
enumerator kUART_RxDmaIdleEnable
enumerator kUART_AllInterruptsEnable

UART status flags.

This provides constants for the UART status flags for use in the UART functions.

Values:

enumerator kUART_RxCharReadyFlag
 Rx Character Ready Flag.
enumerator kUART_RxErrorFlag
 Rx Error Detect Flag.
enumerator kUART_RxOverrunErrorFlag
 Rx Overrun Flag.
enumerator kUART_RxFrameErrorFlag
 Rx Frame Error Flag.
enumerator kUART_RxBreakDetectFlag
 Rx Break Detect Flag.
enumerator kUART_RxParityErrorFlag
 Rx Parity Error Flag.
enumerator kUART_ParityErrorFlag
 Parity Error Interrupt Flag.
enumerator kUART_RtsStatusFlag
 RTS_B Pin Status Flag.
enumerator kUART_TxReadyFlag
 Transmitter Ready Interrupt/DMA Flag.
enumerator kUART_RtsDeltaFlag
 RTS Delta Flag.
enumerator kUART_EscapeFlag
 Escape Sequence Interrupt Flag.
enumerator kUART_FrameErrorFlag
 Frame Error Interrupt Flag.
enumerator kUART_RxReadyFlag
 Receiver Ready Interrupt/DMA Flag.
enumerator kUART_AgingTimerFlag
 Aging Timer Interrupt Flag.

enumerator kUART_DtrDeltaFlag
DTR Delta Flag.

enumerator kUART_RxDsFlag
Receiver IDLE Interrupt Flag.

enumerator kUART_tAirWakeFlag
Asynchronous IR WAKE Interrupt Flag.

enumerator kUART_AwakeFlag
Asynchronous WAKE Interrupt Flag.

enumerator kUART_Rs485SlaveAddrMatchFlag
RS-485 Slave Address Detected Interrupt Flag.

enumerator kUART_AutoBaudFlag
Automatic Baud Rate Detect Complete Flag.

enumerator kUART_TxEmptyFlag
Transmit Buffer FIFO Empty.

enumerator kUART_DtrFlag
DTR edge triggered interrupt flag.

enumerator kUART_IdleFlag
Idle Condition Flag.

enumerator kUART_AutoBaudCntStopFlag
Auto-baud Counter Stopped Flag.

enumerator kUART_RiDeltaFlag
Ring Indicator Delta Flag.

enumerator kUART_RiFlag
Ring Indicator Input Flag.

enumerator kUART_IrFlag
Serial Infrared Interrupt Flag.

enumerator kUART_WakeFlag
Wake Flag.

enumerator kUART_DcdDeltaFlag
Data Carrier Detect Delta Flag.

enumerator kUART_DcdFlag
Data Carrier Detect Input Flag.

enumerator kUART_RtsFlag
RTS Edge Triggered Interrupt Flag.

enumerator kUART_TxCompleteFlag
Transmitter Complete Flag.

enumerator kUART_BreakDetectFlag
BREAK Condition Detected Flag.

enumerator kUART_RxOverrunFlag
Overrun Error Flag.

enumerator kUART_RxDataReadyFlag
Receive Data Ready Flag.

```
typedef enum _uart_data_bits uart_data_bits_t
    UART data bits count.

typedef enum _uart_parity_mode uart_parity_mode_t
    UART parity mode.

typedef enum _uart_stop_bit_count uart_stop_bit_count_t
    UART stop bit count.

typedef enum _uart_idle_condition uart_idle_condition_t
    UART idle condition detect.

typedef struct _uart_config uart_config_t
    UART configuration structure.

typedef struct _uart_transfer uart_transfer_t
    UART transfer structure.

typedef struct _uart_handle uart_handle_t
    Forward declaration of the handle typedef.

typedef void (*uart_transfer_callback_t)(UART_Type *base, uart_handle_t *handle, status_t
status, void *userData)
    UART transfer callback function.

typedef void (*uart_isr_t)(UART_Type *base, void *handle)

const IRQn_Type s_uartIRQ[]

uart_isr_t s_uartIsr

void *s_uartHandle[]
    Pointers to uart handles for each instance.

uint32_t UART_GetInstance(UART_Type *base)
    Get the UART instance from peripheral base address.
```

Parameters

- base – UART peripheral base address.

Returns

UART instance.

```
UART_RETRY_TIMES
```

Retry times for waiting flag.

```
struct _uart_config
    #include <fsl_uart.h> UART configuration structure.
```

Public Members

```
uint32_t baudRate_Bps
```

UART baud rate.

```
uart_parity_mode_t parityMode
```

Parity error check mode of this module.

```
uart_data_bits_t dataBitsCount
```

Data bits count, eight (default), seven

```
uart_stop_bit_count_t stopBitCount
```

Number of stop bits in one frame.

uint8_t txFifoWatermark

TX FIFO watermark

uint8_t rxFifoWatermark

RX FIFO watermark

uint8_t rxRTSWatermark

RX RTS watermark, RX FIFO data count being larger than this triggers RTS deassertion

bool enableAutoBaudRate

Enable automatic baud rate detection

bool enableTx

Enable TX

bool enableRx

Enable RX

bool enableRxRTS

RX RTS enable

bool enableTxCTS

TX CTS enable

struct __uart__transfer

#include <fsl_uart.h> UART transfer structure.

Public Members

size_t dataSize

The byte count to be transfer.

struct __uart__handle

#include <fsl_uart.h> UART handle structure.

Public Members

const uint8_t *volatile txData

Address of remaining data to send.

volatile size_t txDataSize

Size of the remaining data to send.

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.
uart_transfer_callback_t callback
    Callback function.
void *userData
    UART callback function parameter.
volatile uint8_t txState
    TX transfer state.
volatile uint8_t rxState
    RX transfer state
union __unnamed61__
```

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.
```

2.41 UART FreeRTOS Driver

2.42 UART SDMA Driver

```
void UART_TransferCreateHandleSDMA(UART_Type *base, uart_sdma_handle_t *handle,
    uart_sdma_transfer_callback_t callback, void
    *userData, sdma_handle_t *txSdmaHandle,
    sdma_handle_t *rxSdmaHandle, uint32_t
    eventSourceTx, uint32_t eventSourceRx)
```

Initializes the UART handle which is used in transactional functions.

Parameters

- base – UART peripheral base address.
- handle – Pointer to the `uart_sdma_handle_t` structure.
- callback – UART callback, NULL means no callback.
- userData – User callback function data.
- rxSdmaHandle – User-requested DMA handle for RX DMA transfer.
- txSdmaHandle – User-requested DMA handle for TX DMA transfer.
- eventSourceTx – Eventsource for TX DMA transfer.
- eventSourceRx – Eventsource for RX DMA transfer.

```
status_t UART_SendSDMA(UART_Type *base, uart_sdma_handle_t *handle, uart_transfer_t *xfer)
```

Sends data using sDMA.

This function sends data using sDMA. This is a non-blocking function, which returns right away. When all data is sent, the send callback function is called.

Parameters

- base – UART peripheral base address.
- handle – UART handle pointer.
- xfer – UART sDMA transfer structure. See `uart_transfer_t`.

Return values

- `kStatus_Success` – if succeeded; otherwise failed.
- `kStatus_UART_TxBusy` – Previous transfer ongoing.
- `kStatus_InvalidArgument` – Invalid argument.

```
status_t UART_ReceiveSDMA(UART_Type *base, uart_sdma_handle_t *handle, uart_transfer_t *xfer)
```

Receives data using sDMA.

This function receives data using sDMA. This is a non-blocking function, which returns right away. When all data is received, the receive callback function is called.

Parameters

- base – UART peripheral base address.
- handle – Pointer to the `uart_sdma_handle_t` structure.
- xfer – UART sDMA transfer structure. See `uart_transfer_t`.

Return values

- `kStatus_Success` – if succeeded; otherwise failed.
- `kStatus_UART_RxBusy` – Previous transfer ongoing.
- `kStatus_InvalidArgument` – Invalid argument.

```
void UART_TransferAbortSendSDMA(UART_Type *base, uart_sdma_handle_t *handle)
```

Aborts the sent data using sDMA.

This function aborts sent data using sDMA.

Parameters

- base – UART peripheral base address.
- handle – Pointer to the `uart_sdma_handle_t` structure.

```
void UART_TransferAbortReceiveSDMA(UART_Type *base, uart_sdma_handle_t *handle)
```

Aborts the receive data using sDMA.

This function aborts receive data using sDMA.

Parameters

- base – UART peripheral base address.
- handle – Pointer to the `uart_sdma_handle_t` structure.

```
void UART_TransferSdmaHandleIRQ(UART_Type *base, void *uartSdmaHandle)
```

UART IRQ handle function.

This function handles the UART transmit complete IRQ request and invoke user callback.

Parameters

- base – UART peripheral base address.
- uartSdmaHandle – UART handle pointer.

FSL_UART_SDMA_DRIVER_VERSION

UART SDMA driver version.

```
typedef struct _uart_sdma_handle uart_sdma_handle_t
```

```
typedef void (*uart_sdma_transfer_callback_t)(UART_Type *base, uart_sdma_handle_t *handle,
status_t status, void *userData)
```

UART transfer callback function.

```
struct _uart_sdma_handle
```

```
#include <fsl_uart_sdma.h> UART sDMA handle.
```

Public Members

uart_sdma_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.

sdma_handle_t *txSdmaHandle

The sDMA TX channel used.

sdma_handle_t *rxSdmaHandle

The sDMA RX channel used.

volatile uint8_t txState

TX transfer state.

volatile uint8_t rxState

RX transfer state

2.43 USDHC: Ultra Secured Digital Host Controller Driver

```
void USDHC_Init(USDHC_Type *base, const usdhc_config_t *config)
```

USDHC module initialization function.

Configures the USDHC according to the user configuration.

Example:

```
usdhc_config_t config;
config.cardDetectDat3 = false;
config.endianMode = kUSDHC_EndianModeLittle;
config.dmaMode = kUSDHC_DmaModeAdma2;
config.readWatermarkLevel = 128U;
config.writeWatermarkLevel = 128U;
USDHC_Init(USDHC, &config);
```

Parameters

- base – USDHC peripheral base address.
- config – USDHC configuration information.

Return values

kStatus_Success – Operate successfully.

void USDHC_Deinit(USDHC_Type *base)

Deinitializes the USDHC.

Parameters

- base – USDHC peripheral base address.

bool USDHC_Reset(USDHC_Type *base, uint32_t mask, uint32_t timeout)

Resets the USDHC.

Parameters

- base – USDHC peripheral base address.
- mask – The reset type mask(_usdhc_reset).
- timeout – Timeout for reset.

Return values

- true – Reset successfully.
- false – Reset failed.

status_t USDHC_SetAdmaTableConfig(USDHC_Type *base, usdhc_adma_config_t *dmaConfig, usdhc_data_t *dataConfig, uint32_t flags)

Sets the DMA descriptor table configuration. A high level DMA descriptor configuration function.

Parameters

- base – USDHC peripheral base address.
- dmaConfig – ADMA configuration
- dataConfig – Data descriptor
- flags – ADAM descriptor flag, used to indicate to create multiple or single descriptor, please refer to enum _usdhc_adma_flag.

Return values

- kStatus_OutOfRange – ADMA descriptor table length isn't enough to describe data.
- kStatus_Success – Operate successfully.

status_t USDHC_SetInternalDmaConfig(USDHC_Type *base, usdhc_adma_config_t *dmaConfig, const uint32_t *dataAddr, bool enAutoCmd23)

Internal DMA configuration. This function is used to config the USDHC DMA related registers.

Parameters

- base – USDHC peripheral base address.
- dmaConfig – ADMA configuration.
- dataAddr – Transfer data address, a simple DMA parameter, if ADMA is used, leave it to NULL.
- enAutoCmd23 – Flag to indicate Auto CMD23 is enable or not, a simple DMA parameter, if ADMA is used, leave it to false.

Return values

- `kStatus_OutOfRange` – ADMA descriptor table length isn't enough to describe data.
- `kStatus_Success` – Operate successfully.

`status_t` `USDHC_SetADMA2Descriptor(uint32_t *admaTable, uint32_t admaTableWords, const uint32_t *dataBufferAddr, uint32_t dataBytes, uint32_t flags)`

Sets the ADMA2 descriptor table configuration.

Parameters

- `admaTable` – ADMA table address.
- `admaTableWords` – ADMA table length.
- `dataBufferAddr` – Data buffer address.
- `dataBytes` – Data Data length.
- `flags` – ADAM descriptor flag, used to indicate to create multiple or single descriptor, please refer to `enum _usdhc_adma_flag`.

Return values

- `kStatus_OutOfRange` – ADMA descriptor table length isn't enough to describe data.
- `kStatus_Success` – Operate successfully.

`status_t` `USDHC_SetADMA1Descriptor(uint32_t *admaTable, uint32_t admaTableWords, const uint32_t *dataBufferAddr, uint32_t dataBytes, uint32_t flags)`

Sets the ADMA1 descriptor table configuration.

Parameters

- `admaTable` – ADMA table address.
- `admaTableWords` – ADMA table length.
- `dataBufferAddr` – Data buffer address.
- `dataBytes` – Data length.
- `flags` – ADAM descriptor flag, used to indicate to create multiple or single descriptor, please refer to `enum _usdhc_adma_flag`.

Return values

- `kStatus_OutOfRange` – ADMA descriptor table length isn't enough to describe data.
- `kStatus_Success` – Operate successfully.

`static inline void` `USDHC_EnableInternalDMA(USDHC_Type *base, bool enable)`

Enables internal DMA.

Parameters

- `base` – USDHC peripheral base address.
- `enable` – enable or disable flag

`static inline void` `USDHC_EnableInterruptStatus(USDHC_Type *base, uint32_t mask)`

Enables the interrupt status.

Parameters

- base – USDHC peripheral base address.
- mask – Interrupt status flags mask(_usdhc_interrupt_status_flag).

static inline void USDHC_DisableInterruptStatus(USDHC_Type *base, uint32_t mask)
Disables the interrupt status.

Parameters

- base – USDHC peripheral base address.
- mask – The interrupt status flags mask(_usdhc_interrupt_status_flag).

static inline void USDHC_EnableInterruptSignal(USDHC_Type *base, uint32_t mask)
Enables the interrupt signal corresponding to the interrupt status flag.

Parameters

- base – USDHC peripheral base address.
- mask – The interrupt status flags mask(_usdhc_interrupt_status_flag).

static inline void USDHC_DisableInterruptSignal(USDHC_Type *base, uint32_t mask)
Disables the interrupt signal corresponding to the interrupt status flag.

Parameters

- base – USDHC peripheral base address.
- mask – The interrupt status flags mask(_usdhc_interrupt_status_flag).

static inline uint32_t USDHC_GetEnabledInterruptStatusFlags(USDHC_Type *base)
Gets the enabled interrupt status.

Parameters

- base – USDHC peripheral base address.

Returns

Current interrupt status flags mask(_usdhc_interrupt_status_flag).

static inline uint32_t USDHC_GetInterruptStatusFlags(USDHC_Type *base)
Gets the current interrupt status.

Parameters

- base – USDHC peripheral base address.

Returns

Current interrupt status flags mask(_usdhc_interrupt_status_flag).

static inline void USDHC_ClearInterruptStatusFlags(USDHC_Type *base, uint32_t mask)
Clears a specified interrupt status. write 1 clears.

Parameters

- base – USDHC peripheral base address.
- mask – The interrupt status flags mask(_usdhc_interrupt_status_flag).

static inline uint32_t USDHC_GetAutoCommand12ErrorStatusFlags(USDHC_Type *base)
Gets the status of auto command 12 error.

Parameters

- base – USDHC peripheral base address.

Returns

Auto command 12 error status flags mask(_usdhc_auto_command12_error_status_flag).

```
static inline uint32_t USDHC_GetAdmaErrorStatusFlags(USDHC_Type *base)
```

Gets the status of the ADMA error.

Parameters

- base – USDHC peripheral base address.

Returns

ADMA error status flags mask(_usdhc_adma_error_status_flag).

```
static inline uint32_t USDHC_GetPresentStatusFlags(USDHC_Type *base)
```

Gets a present status.

This function gets the present USDHC's status except for an interrupt status and an error status.

Parameters

- base – USDHC peripheral base address.

Returns

Present USDHC's status flags mask(_usdhc_present_status_flag).

```
void USDHC_GetCapability(USDHC_Type *base, usdhc_capability_t *capability)
```

Gets the capability information.

Parameters

- base – USDHC peripheral base address.
- capability – Structure to save capability information.

```
static inline void USDHC_ForceClockOn(USDHC_Type *base, bool enable)
```

Forces the card clock on.

Parameters

- base – USDHC peripheral base address.
- enable – enable/disable flag

```
uint32_t USDHC_SetSdClock(USDHC_Type *base, uint32_t srcClock_Hz, uint32_t busClock_Hz)
```

Sets the SD bus clock frequency.

Parameters

- base – USDHC peripheral base address.
- srcClock_Hz – USDHC source clock frequency united in Hz.
- busClock_Hz – SD bus clock frequency united in Hz.

Returns

The nearest frequency of busClock_Hz configured for SD bus.

```
bool USDHC_SetCardActive(USDHC_Type *base, uint32_t timeout)
```

Sends 80 clocks to the card to set it to the active state.

This function must be called each time the card is inserted to ensure that the card can receive the command correctly.

Parameters

- base – USDHC peripheral base address.
- timeout – Timeout to initialize card.

Return values

- true – Set card active successfully.
- false – Set card active failed.

static inline void USDHC_AssertHardwareReset(USDHC_Type *base, bool high)

Triggers a hardware reset.

Parameters

- base – USDHC peripheral base address.
- high – 1 or 0 level

static inline void USDHC_SetDataBusWidth(USDHC_Type *base, *usdhc_data_bus_width_t* width)

Sets the data transfer width.

Parameters

- base – USDHC peripheral base address.
- width – Data transfer width.

static inline void USDHC_WriteData(USDHC_Type *base, uint32_t data)

Fills the data port.

This function is used to implement the data transfer by Data Port instead of DMA.

Parameters

- base – USDHC peripheral base address.
- data – The data about to be sent.

static inline uint32_t USDHC_ReadData(USDHC_Type *base)

Retrieves the data from the data port.

This function is used to implement the data transfer by Data Port instead of DMA.

Parameters

- base – USDHC peripheral base address.

Returns

The data has been read.

void USDHC_SendCommand(USDHC_Type *base, *usdhc_command_t* *command)

Sends command function.

Parameters

- base – USDHC peripheral base address.
- command – configuration

static inline void USDHC_EnableWakeupEvent(USDHC_Type *base, uint32_t mask, bool enable)

Enables or disables a wakeup event in low-power mode.

Parameters

- base – USDHC peripheral base address.
- mask – Wakeup events mask(*_usdhc_wakeup_event*).
- enable – True to enable, false to disable.

static inline void USDHC_CardDetectByData3(USDHC_Type *base, bool enable)

Detects card insert status.

Parameters

- base – USDHC peripheral base address.
- enable – enable/disable flag

static inline bool USDHC_DetectCardInsert(USDHC_Type *base)

Detects card insert status.

Parameters

- base – USDHC peripheral base address.

static inline void USDHC_EnableSdioControl(USDHC_Type *base, uint32_t mask, bool enable)

Enables or disables the SDIO card control.

Parameters

- base – USDHC peripheral base address.
- mask – SDIO card control flags mask(`_usdhc_sdio_control_flag`).
- enable – True to enable, false to disable.

static inline void USDHC_SetContinueRequest(USDHC_Type *base)

Restarts a transaction which has stopped at the block GAP for the SDIO card.

Parameters

- base – USDHC peripheral base address.

static inline void USDHC_RequestStopAtBlockGap(USDHC_Type *base, bool enable)

Request stop at block gap function.

Parameters

- base – USDHC peripheral base address.
- enable – True to stop at block gap, false to normal transfer.

void USDHC_SetMmcBootConfig(USDHC_Type *base, const *usdhc_boot_config_t* *config)

Configures the MMC boot feature.

Example:

```
usdhc_boot_config_t config;
config.ackTimeoutCount = 4;
config.bootMode = kUSDHC_BootModeNormal;
config.blockCount = 5;
config.enableBootAck = true;
config.enableBoot = true;
config.enableAutoStopAtBlockGap = true;
USDHC_SetMmcBootConfig(USDHC, &config);
```

Parameters

- base – USDHC peripheral base address.
- config – The MMC boot configuration information.

static inline void USDHC_EnableMmcBoot(USDHC_Type *base, bool enable)

Enables or disables the mmc boot mode.

Parameters

- base – USDHC peripheral base address.
- enable – True to enable, false to disable.

static inline void USDHC_SetForceEvent(USDHC_Type *base, uint32_t mask)

Forces generating events according to the given mask.

Parameters

- base – USDHC peripheral base address.

- mask – The force events bit position (`_usdhc_force_event`).

static inline bool USDHC_RequestTuningForSDR50(USDHC_Type *base)

Checks the SDR50 mode request tuning bit. When this bit set, application shall perform tuning for SDR50 mode.

Parameters

- base – USDHC peripheral base address.

static inline bool USDHC_RequestReTuning(USDHC_Type *base)

Checks the request re-tuning bit. When this bit is set, user should do manual tuning or standard tuning function.

Parameters

- base – USDHC peripheral base address.

static inline void USDHC_EnableAutoTuning(USDHC_Type *base, bool enable)

The SDR104 mode auto tuning enable and disable. This function should be called after tuning function execute pass, auto tuning will handle by hardware.

Parameters

- base – USDHC peripheral base address.
- enable – enable/disable flag

void USDHC_EnableAutoTuningForCmdAndData(USDHC_Type *base)

The auto tuning enable for CMD/DATA line.

Parameters

- base – USDHC peripheral base address.

void USDHC_EnableManualTuning(USDHC_Type *base, bool enable)

Manual tuning trigger or abort. User should handle the tuning cmd and find the boundary of the delay then calculate a average value which will be configured to the **CLK_TUNE_CTRL_STATUS**. This function should be called before function `USDHC_AdjustDelayForManualTuning`.

Parameters

- base – USDHC peripheral base address.
- enable – tuning enable flag

static inline uint32_t USDHC_GetTuningDelayStatus(USDHC_Type *base)

Get the tuning delay cell setting.

Parameters

- base – USDHC peripheral base address.

Return values

CLK – Tuning Control and Status register value.

status_t USDHC_SetTuningDelay(USDHC_Type *base, uint32_t preDelay, uint32_t outDelay, uint32_t postDelay)

The tuning delay cell setting.

Parameters

- base – USDHC peripheral base address.
- preDelay – Set the number of delay cells on the feedback clock between the feedback clock and `CLK_PRE`.

- outDelay – Set the number of delay cells on the feedback clock between CLK_PRE and CLK_OUT.
- postDelay – Set the number of delay cells on the feedback clock between CLK_OUT and CLK_POST.

Return values

- kStatus_Fail – config the delay setting fail
- kStatus_Success – config the delay setting success

status_t USDHC_AdjustDelayForManualTuning(USDHC_Type *base, uint32_t delay)

Adjusts delay for mannual tuning.

Deprecated:

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

Parameters

- base – USDHC peripheral base address.
- delay – setting configuration

Return values

- kStatus_Fail – config the delay setting fail
- kStatus_Success – config the delay setting success

static inline void USDHC_SetStandardTuningCounter(USDHC_Type *base, uint8_t counter)

set tuning counter tuning.

Parameters

- base – USDHC peripheral base address.
- counter – tuning counter

Return values

- kStatus_Fail – config the delay setting fail
- kStatus_Success – config the delay setting success

void USDHC_EnableStandardTuning(USDHC_Type *base, uint32_t tuningStartTap, uint32_t step, bool enable)

The enable standard tuning function. The standard tuning window and tuning counter using the default config tuning cmd is sent by the software, user need to check whether the tuning result can be used for SDR50, SDR104, and HS200 mode tuning.

Parameters

- base – USDHC peripheral base address.
- tuningStartTap – start tap
- step – tuning step
- enable – enable/disable flag

static inline uint32_t USDHC_GetExecuteStdTuningStatus(USDHC_Type *base)

Gets execute STD tuning status.

Parameters

- base – USDHC peripheral base address.

static inline uint32_t USDHC_CheckStdTuningResult(USDHC_Type *base)

Checks STD tuning result.

Parameters

- base – USDHC peripheral base address.

static inline uint32_t USDHC_CheckTuningError(USDHC_Type *base)

Checks tuning error.

Parameters

- base – USDHC peripheral base address.

void USDHC_EnableDDRMMode(USDHC_Type *base, bool enable, uint32_t nibblePos)

The enable/disable DDR mode.

Parameters

- base – USDHC peripheral base address.
- enable – enable/disable flag
- nibblePos – nibble position

static inline void USDHC_EnableHS400Mode(USDHC_Type *base, bool enable)

The enable/disable HS400 mode.

Parameters

- base – USDHC peripheral base address.
- enable – enable/disable flag

static inline void USDHC_ResetStrobeDLL(USDHC_Type *base)

Resets the strobe DLL.

Parameters

- base – USDHC peripheral base address.

static inline void USDHC_EnableStrobeDLL(USDHC_Type *base, bool enable)

Enables/disables the strobe DLL.

Parameters

- base – USDHC peripheral base address.
- enable – enable/disable flag

void USDHC_ConfigStrobeDLL(USDHC_Type *base, uint32_t delayTarget, uint32_t updateInterval)

Configs the strobe DLL delay target and update interval.

Parameters

- base – USDHC peripheral base address.
- delayTarget – delay target
- updateInterval – update interval

static inline void USDHC_SetStrobeDllOverride(USDHC_Type *base, uint32_t delayTaps)

Enables manual override for slave delay chain using **STROBE_SLV_OVERRIDE_VAL**.

Parameters

- base – USDHC peripheral base address.
- delayTaps – Valid delay taps range from 1 - 128 taps. A value of 0 selects tap 1, and a value of 0x7F selects tap 128.

```
static inline uint32_t USDHC_GetStrobeDLLStatus(USDHC_Type *base)
```

Gets the strobe DLL status.

Parameters

- base – USDHC peripheral base address.

```
void USDHC_SetDataConfig(USDHC_Type *base, usdhc_transfer_direction_t dataDirection,  
                        uint32_t blockCount, uint32_t blockSize)
```

USDHC data configuration.

Parameters

- base – USDHC peripheral base address.
- dataDirection – Data direction, tx or rx.
- blockCount – Data block count.
- blockSize – Data block size.

```
void USDHC_TransferCreateHandle(USDHC_Type *base, usdhc_handle_t *handle, const  
                               usdhc_transfer_callback_t *callback, void *userData)
```

Creates the USDHC handle.

Parameters

- base – USDHC peripheral base address.
- handle – USDHC handle pointer.
- callback – Structure pointer to contain all callback functions.
- userData – Callback function parameter.

```
status_t USDHC_TransferNonBlocking(USDHC_Type *base, usdhc_handle_t *handle,  
                                   usdhc_adma_config_t *dmaConfig, usdhc_transfer_t  
                                   *transfer)
```

Transfers the command/data using an interrupt and an asynchronous method.

This function sends a command and data and returns immediately. It doesn't wait for the transfer to complete or to encounter an error. The application must not call this API in multiple threads at the same time. Because of that this API doesn't support the re-entry mechanism.

Note: Call API `USDHC_TransferCreateHandle` when calling this API.

Parameters

- base – USDHC peripheral base address.
- handle – USDHC handle.
- dmaConfig – ADMA configuration.
- transfer – Transfer content.

Return values

- `kStatus_InvalidArgument` – Argument is invalid.
- `kStatus_USDHC_BusyTransferring` – Busy transferring.
- `kStatus_USDHC_PrepareAdmaDescriptorFailed` – Prepare ADMA descriptor failed.
- `kStatus_Success` – Operate successfully.

```
status_t USDHC_TransferBlocking(USDHC_Type *base, usdhc_adma_config_t *dmaConfig,  
                               usdhc_transfer_t *transfer)
```

Transfers the command/data using a blocking method.

This function waits until the command response/data is received or the USDHC encounters an error by polling the status flag.

The application must not call this API in multiple threads at the same time. Because this API doesn't support the re-entry mechanism.

Note: There is no need to call API USDHC_TransferCreateHandle when calling this API.

Parameters

- base – USDHC peripheral base address.
- dmaConfig – adma configuration
- transfer – Transfer content.

Return values

- kStatus_InvalidArgument – Argument is invalid.
- kStatus_USDHC_PrepareAdmaDescriptorFailed – Prepare ADMA descriptor failed.
- kStatus_USDHC_SendCommandFailed – Send command failed.
- kStatus_USDHC_TransferDataFailed – Transfer data failed.
- kStatus_Success – Operate successfully.

```
void USDHC_TransferHandleIRQ(USDHC_Type *base, usdhc_handle_t *handle)
```

IRQ handler for the USDHC.

This function deals with the IRQs on the given host controller.

Parameters

- base – USDHC peripheral base address.
- handle – USDHC handle.

```
FSL_USDHC_DRIVER_VERSION
```

Driver version 2.8.8.

Enum_usdhc_status. USDHC status.

Values:

```
enumerator kStatus_USDHC_BusyTransferring
```

Transfer is on-going.

```
enumerator kStatus_USDHC_PrepareAdmaDescriptorFailed
```

Set DMA descriptor failed.

```
enumerator kStatus_USDHC_SendCommandFailed
```

Send command failed.

```
enumerator kStatus_USDHC_TransferDataFailed
```

Transfer data failed.

enumerator kStatus_USDHC_DMADataAddrNotAlign
Data address not aligned.

enumerator kStatus_USDHC_ReTuningRequest
Re-tuning request.

enumerator kStatus_USDHC_TuningError
Tuning error.

enumerator kStatus_USDHC_NotSupport
Not support.

enumerator kStatus_USDHC_TransferDataComplete
Transfer data complete.

enumerator kStatus_USDHC_SendCommandSuccess
Transfer command complete.

enumerator kStatus_USDHC_TransferDMAComplete
Transfer DMA complete.

Enum _usdhc_capability_flag. Host controller capabilities flag mask. .

Values:

enumerator kUSDHC_SupportAdmaFlag
Support ADMA.

enumerator kUSDHC_SupportHighSpeedFlag
Support high-speed.

enumerator kUSDHC_SupportDmaFlag
Support DMA.

enumerator kUSDHC_SupportSuspendResumeFlag
Support suspend/resume.

enumerator kUSDHC_SupportV330Flag
Support voltage 3.3V.

enumerator kUSDHC_SupportV300Flag
Support voltage 3.0V.

enumerator kUSDHC_Support4BitFlag
Flag in HTCAPBLT_MBL's position, supporting 4-bit mode.

enumerator kUSDHC_Support8BitFlag
Flag in HTCAPBLT_MBL's position, supporting 8-bit mode.

enumerator kUSDHC_SupportDDR50Flag
SD version 3.0 new feature, supporting DDR50 mode.

enumerator kUSDHC_SupportSDR104Flag
Support SDR104 mode.

enumerator kUSDHC_SupportSDR50Flag
Support SDR50 mode.

Enum _usdhc_wakeup_event. Wakeup event mask. .

Values:

enumerator kUSDHC_WakeupEventOnCardInt

Wakeup on card interrupt.

enumerator kUSDHC_WakeupEventOnCardInsert

Wakeup on card insertion.

enumerator kUSDHC_WakeupEventOnCardRemove

Wakeup on card removal.

enumerator kUSDHC_WakeupEventsAll

All wakeup events

Enum _usdhc_reset. Reset type mask. .

Values:

enumerator kUSDHC_ResetAll

Reset all except card detection.

enumerator kUSDHC_ResetCommand

Reset command line.

enumerator kUSDHC_ResetData

Reset data line.

enumerator kUSDHC_ResetTuning

Reset tuning circuit.

enumerator kUSDHC_ResetsAll

All reset types

Enum _usdhc_transfer_flag. Transfer flag mask.

Values:

enumerator kUSDHC_EnableDmaFlag

Enable DMA.

enumerator kUSDHC_CommandTypeSuspendFlag

Suspend command.

enumerator kUSDHC_CommandTypeResumeFlag

Resume command.

enumerator kUSDHC_CommandTypeAbortFlag

Abort command.

enumerator kUSDHC_EnableBlockCountFlag

Enable block count.

enumerator kUSDHC_EnableAutoCommand12Flag

Enable auto CMD12.

enumerator kUSDHC_DataReadFlag

Enable data read.

enumerator kUSDHC_MultipleBlockFlag

Multiple block data read/write.

enumerator kUSDHC_EnableAutoCommand23Flag

Enable auto CMD23.

enumerator kUSDHC_ResponseLength136Flag
136-bit response length.

enumerator kUSDHC_ResponseLength48Flag
48-bit response length.

enumerator kUSDHC_ResponseLength48BusyFlag
48-bit response length with busy status.

enumerator kUSDHC_EnableCrcCheckFlag
Enable CRC check.

enumerator kUSDHC_EnableIndexCheckFlag
Enable index check.

enumerator kUSDHC_DataPresentFlag
Data present flag.

Enum _usdhc_present_status_flag. Present status flag mask. .

Values:

enumerator kUSDHC_CommandInhibitFlag
Command inhibit.

enumerator kUSDHC_DataInhibitFlag
Data inhibit.

enumerator kUSDHC_DataLineActiveFlag
Data line active.

enumerator kUSDHC_SdClockStableFlag
SD bus clock stable.

enumerator kUSDHC_WriteTransferActiveFlag
Write transfer active.

enumerator kUSDHC_ReadTransferActiveFlag
Read transfer active.

enumerator kUSDHC_BufferWriteEnableFlag
Buffer write enable.

enumerator kUSDHC_BufferReadEnableFlag
Buffer read enable.

enumerator kUSDHC_ReTuningRequestFlag
Re-tuning request flag, only used for SDR104 mode.

enumerator kUSDHC_DelaySettingFinishedFlag
Delay setting finished flag.

enumerator kUSDHC_CardInsertedFlag
Card inserted.

enumerator kUSDHC_CommandLineLevelFlag
Command line signal level.

enumerator kUSDHC_Data0LineLevelFlag
Data0 line signal level.

enumerator kUSDHC_Data1LineLevelFlag
Data1 line signal level.

enumerator kUSDHC_Data2LineLevelFlag
Data2 line signal level.

enumerator kUSDHC_Data3LineLevelFlag
Data3 line signal level.

enumerator kUSDHC_Data4LineLevelFlag
Data4 line signal level.

enumerator kUSDHC_Data5LineLevelFlag
Data5 line signal level.

enumerator kUSDHC_Data6LineLevelFlag
Data6 line signal level.

enumerator kUSDHC_Data7LineLevelFlag
Data7 line signal level.

Enum _usdhc_interrupt_status_flag. Interrupt status flag mask. .

Values:

enumerator kUSDHC_CommandCompleteFlag
Command complete.

enumerator kUSDHC_DataCompleteFlag
Data complete.

enumerator kUSDHC_BlockGapEventFlag
Block gap event.

enumerator kUSDHC_DmaCompleteFlag
DMA interrupt.

enumerator kUSDHC_BufferWriteReadyFlag
Buffer write ready.

enumerator kUSDHC_BufferReadReadyFlag
Buffer read ready.

enumerator kUSDHC_CardInsertionFlag
Card inserted.

enumerator kUSDHC_CardRemovalFlag
Card removed.

enumerator kUSDHC_CardInterruptFlag
Card interrupt.

enumerator kUSDHC_ReTuningEventFlag
Re-Tuning event, only for SD3.0 SDR104 mode.

enumerator kUSDHC_TuningPassFlag
SDR104 mode tuning pass flag.

enumerator kUSDHC_TuningErrorFlag
SDR104 tuning error flag.

enumerator kUSDHC_CommandTimeoutFlag
Command timeout error.

enumerator kUSDHC_CommandCrcErrorFlag
Command CRC error.

enumerator kUSDHC_CommandEndBitErrorFlag
Command end bit error.

enumerator kUSDHC_CommandIndexErrorFlag
Command index error.

enumerator kUSDHC_DataTimeoutFlag
Data timeout error.

enumerator kUSDHC_DataCrcErrorFlag
Data CRC error.

enumerator kUSDHC_DataEndBitErrorFlag
Data end bit error.

enumerator kUSDHC_AutoCommand12ErrorFlag
Auto CMD12 error.

enumerator kUSDHC_DmaErrorFlag
DMA error.

enumerator kUSDHC_CommandErrorFlag
Command error

enumerator kUSDHC_DataErrorFlag
Data error

enumerator kUSDHC_ErrorFlag
All error

enumerator kUSDHC_DataFlag
Data interrupts

enumerator kUSDHC_DataDMAFlag
Data interrupts

enumerator kUSDHC_CommandFlag
Command interrupts

enumerator kUSDHC_CardDetectFlag
Card detection interrupts

enumerator kUSDHC_SDR104TuningFlag
SDR104 tuning flag.

enumerator kUSDHC_AllInterruptFlags
All flags mask

Enum _usdhc_auto_command12_error_status_flag. Auto CMD12 error status flag mask. .

Values:

enumerator kUSDHC_AutoCommand12NotExecutedFlag
Not executed error.

enumerator kUSDHC__AutoCommand12TimeoutFlag
Timeout error.

enumerator kUSDHC__AutoCommand12EndBitErrorFlag
End bit error.

enumerator kUSDHC__AutoCommand12CrcErrorFlag
CRC error.

enumerator kUSDHC__AutoCommand12IndexErrorFlag
Index error.

enumerator kUSDHC__AutoCommand12NotIssuedFlag
Not issued error.

Enum _usdhc_standard_tuning. Standard tuning flag.

Values:

enumerator kUSDHC__ExecuteTuning
Used to start tuning procedure.

enumerator kUSDHC__TuningSampleClockSel
When **std_tuning_en** bit is set, this bit is used to select sampling clock.

Enum _usdhc_adma_error_status_flag. ADMA error status flag mask. .

Values:

enumerator kUSDHC__AdmaLenghMismatchFlag
Length mismatch error.

enumerator kUSDHC__AdmaDescriptorErrorFlag
Descriptor error.

Enum _usdhc_adma_error_state. ADMA error state.

This state is the detail state when ADMA error has occurred.

Values:

enumerator kUSDHC__AdmaErrorStateStopDma
Stop DMA, previous location set in the ADMA system address is errored address.

enumerator kUSDHC__AdmaErrorStateFetchDescriptor
Fetch descriptor, current location set in the ADMA system address is errored address.

enumerator kUSDHC__AdmaErrorStateChangeAddress
Change address, no DMA error has occurred.

enumerator kUSDHC__AdmaErrorStateTransferData
Transfer data, previous location set in the ADMA system address is errored address.

enumerator kUSDHC__AdmaErrorStateInvalidLength
Invalid length in ADMA descriptor.

enumerator kUSDHC__AdmaErrorStateInvalidDescriptor
Invalid descriptor fetched by ADMA.

enumerator kUSDHC__AdmaErrorState
ADMA error state

Enum `_usdhc_force_event`. Force event bit position. .

Values:

enumerator `kUSDHC_ForceEventAutoCommand12NotExecuted`
Auto CMD12 not executed error.

enumerator `kUSDHC_ForceEventAutoCommand12Timeout`
Auto CMD12 timeout error.

enumerator `kUSDHC_ForceEventAutoCommand12CrcError`
Auto CMD12 CRC error.

enumerator `kUSDHC_ForceEventEndBitError`
Auto CMD12 end bit error.

enumerator `kUSDHC_ForceEventAutoCommand12IndexError`
Auto CMD12 index error.

enumerator `kUSDHC_ForceEventAutoCommand12NotIssued`
Auto CMD12 not issued error.

enumerator `kUSDHC_ForceEventCommandTimeout`
Command timeout error.

enumerator `kUSDHC_ForceEventCommandCrcError`
Command CRC error.

enumerator `kUSDHC_ForceEventCommandEndBitError`
Command end bit error.

enumerator `kUSDHC_ForceEventCommandIndexError`
Command index error.

enumerator `kUSDHC_ForceEventDataTimeout`
Data timeout error.

enumerator `kUSDHC_ForceEventDataCrcError`
Data CRC error.

enumerator `kUSDHC_ForceEventDataEndBitError`
Data end bit error.

enumerator `kUSDHC_ForceEventAutoCommand12Error`
Auto CMD12 error.

enumerator `kUSDHC_ForceEventCardInt`
Card interrupt.

enumerator `kUSDHC_ForceEventDmaError`
Dma error.

enumerator `kUSDHC_ForceEventTuningError`
Tuning error.

enumerator `kUSDHC_ForceEventsAll`
All force event flags mask.

enum `_usdhc_transfer_direction`
Data transfer direction.

Values:

enumerator kUSDHC_TransferDirectionReceive
USDHC transfer direction receive.

enumerator kUSDHC_TransferDirectionSend
USDHC transfer direction send.

enum __usdhc_data_bus_width
Data transfer width.

Values:

enumerator kUSDHC_DataBusWidth1Bit
1-bit mode

enumerator kUSDHC_DataBusWidth4Bit
4-bit mode

enumerator kUSDHC_DataBusWidth8Bit
8-bit mode

enum __usdhc_endian_mode
Endian mode.

Values:

enumerator kUSDHC_EndianModeBig
Big endian mode.

enumerator kUSDHC_EndianModeHalfWordBig
Half word big endian mode.

enumerator kUSDHC_EndianModeLittle
Little endian mode.

enum __usdhc_dma_mode
DMA mode.

Values:

enumerator kUSDHC_DmaModeSimple
External DMA.

enumerator kUSDHC_DmaModeAdma1
ADMA1 is selected.

enumerator kUSDHC_DmaModeAdma2
ADMA2 is selected.

enumerator kUSDHC_ExternalDMA
External DMA mode selected.

Enum __usdhc_sdio_control_flag. SDIO control flag mask. .

Values:

enumerator kUSDHC_StopAtBlockGapFlag
Stop at block gap.

enumerator kUSDHC_ReadWaitControlFlag
Read wait control.

enumerator kUSDHC_InterruptAtBlockGapFlag
Interrupt at block gap.

enumerator kUSDHC_ReadDoneNo8CLK
Read done without 8 clk for block gap.

enumerator kUSDHC_ExactBlockNumberReadFlag
Exact block number read.

enum __usdhc_boot_mode
MMC card boot mode.

Values:

enumerator kUSDHC_BootModeNormal
Normal boot

enumerator kUSDHC_BootModeAlternative
Alternative boot

enum __usdhc_card_command_type
The command type.

Values:

enumerator kCARD_CommandTypeNormal
Normal command

enumerator kCARD_CommandTypeSuspend
Suspend command

enumerator kCARD_CommandTypeResume
Resume command

enumerator kCARD_CommandTypeAbort
Abort command

enumerator kCARD_CommandTypeEmpty
Empty command

enum __usdhc_card_response_type
The command response type.

Defines the command response type from card to host controller.

Values:

enumerator kCARD_ResponseTypeNone
Response type: none

enumerator kCARD_ResponseTypeR1
Response type: R1

enumerator kCARD_ResponseTypeR1b
Response type: R1b

enumerator kCARD_ResponseTypeR2
Response type: R2

enumerator kCARD_ResponseTypeR3
Response type: R3

enumerator kCARD_ResponseTypeR4
Response type: R4

enumerator kCARD_ResponseTypeR5
Response type: R5

enumerator kCARD_ResponseTypeR5b

Response type: R5b

enumerator kCARD_ResponseTypeR6

Response type: R6

enumerator kCARD_ResponseTypeR7

Response type: R7

Enum _usdhc_adma1_descriptor_flag. The mask for the control/status field in ADMA1 descriptor.

Values:

enumerator kUSDHC_Adma1DescriptorValidFlag

Valid flag.

enumerator kUSDHC_Adma1DescriptorEndFlag

End flag.

enumerator kUSDHC_Adma1DescriptorInterruptFlag

Interrupt flag.

enumerator kUSDHC_Adma1DescriptorActivity1Flag

Activity 1 flag.

enumerator kUSDHC_Adma1DescriptorActivity2Flag

Activity 2 flag.

enumerator kUSDHC_Adma1DescriptorTypeNop

No operation.

enumerator kUSDHC_Adma1DescriptorTypeTransfer

Transfer data.

enumerator kUSDHC_Adma1DescriptorTypeLink

Link descriptor.

enumerator kUSDHC_Adma1DescriptorTypeSetLength

Set data length.

Enum _usdhc_adma2_descriptor_flag. ADMA1 descriptor control and status mask.

Values:

enumerator kUSDHC_Adma2DescriptorValidFlag

Valid flag.

enumerator kUSDHC_Adma2DescriptorEndFlag

End flag.

enumerator kUSDHC_Adma2DescriptorInterruptFlag

Interrupt flag.

enumerator kUSDHC_Adma2DescriptorActivity1Flag

Activity 1 mask.

enumerator kUSDHC_Adma2DescriptorActivity2Flag

Activity 2 mask.

enumerator kUSDHC_Adma2DescriptorTypeNop

No operation.

enumerator kUSDHC__Adma2DescriptorTypeReserved
Reserved.

enumerator kUSDHC__Adma2DescriptorTypeTransfer
Transfer type.

enumerator kUSDHC__Adma2DescriptorTypeLink
Link type.

Enum _usdhc_adma_flag. ADMA descriptor configuration flag. .

Values:

enumerator kUSDHC__AdmaDescriptorSingleFlag
Try to finish the transfer in a single ADMA descriptor. If transfer size is bigger than one ADMA descriptor's ability, new another descriptor for data transfer.

enumerator kUSDHC__AdmaDescriptorMultipleFlag
Create multiple ADMA descriptors within the ADMA table, this is used for mmc boot mode specifically, which need to modify the ADMA descriptor on the fly, so the flag should be used combining with stop at block gap feature.

enum _usdhc_burst_len
DMA transfer burst len config.

Values:

enumerator kUSDHC__EnBurstLenForINCR
Enable burst len for INCR.

enumerator kUSDHC__EnBurstLenForINCR4816
Enable burst len for INCR4/INCR8/INCR16.

enumerator kUSDHC__EnBurstLenForINCR4816WRAP
Enable burst len for INCR4/8/16 WRAP.

Enum _usdhc_transfer_data_type. Tansfer data type definition.

Values:

enumerator kUSDHC__TransferDataNormal
Transfer normal read/write data.

enumerator kUSDHC__TransferDataTuning
Transfer tuning data.

enumerator kUSDHC__TransferDataBoot
Transfer boot data.

enumerator kUSDHC__TransferDataBootcontinous
Transfer boot data continuously.

typedef enum _usdhc_transfer_direction usdhc_transfer_direction_t
Data transfer direction.

typedef enum _usdhc_data_bus_width usdhc_data_bus_width_t
Data transfer width.

typedef enum _usdhc_endian_mode usdhc_endian_mode_t
Endian mode.

typedef enum *_usdhc_dma_mode* usdhc_dma_mode_t
DMA mode.

typedef enum *_usdhc_boot_mode* usdhc_boot_mode_t
MMC card boot mode.

typedef enum *_usdhc_card_command_type* usdhc_card_command_type_t
The command type.

typedef enum *_usdhc_card_response_type* usdhc_card_response_type_t
The command response type.
Defines the command response type from card to host controller.

typedef enum *_usdhc_burst_len* usdhc_burst_len_t
DMA transfer burst len config.

typedef uint32_t usdhc_adma1_descriptor_t
Defines the ADMA1 descriptor structure.

typedef struct *_usdhc_adma2_descriptor* usdhc_adma2_descriptor_t
Defines the ADMA2 descriptor structure.

typedef struct *_usdhc_capability* usdhc_capability_t
USDHC capability information.
Defines a structure to save the capability information of USDHC.

typedef struct *_usdhc_boot_config* usdhc_boot_config_t
Data structure to configure the MMC boot feature.

typedef struct *_usdhc_config* usdhc_config_t
Data structure to initialize the USDHC.

typedef struct *_usdhc_command* usdhc_command_t
Card command descriptor.
Defines card command-related attribute.

typedef struct *_usdhc_adma_config* usdhc_adma_config_t
ADMA configuration.

typedef struct *_usdhc_scatter_gather_data_list* usdhc_scatter_gather_data_list_t
Card scatter gather data list.
Allow application register uncontinuous data buffer for data transfer.

typedef struct *_usdhc_scatter_gather_data* usdhc_scatter_gather_data_t
Card scatter gather data descriptor.
Defines a structure to contain data-related attribute. The 'enableIgnoreError' is used when upper card driver wants to ignore the error event to read/write all the data and not to stop read/write immediately when an error event happens. For example, bus testing procedure for MMC card.

typedef struct *_usdhc_scatter_gather_transfer* usdhc_scatter_gather_transfer_t
usdhc scatter gather transfer.

typedef struct *_usdhc_data* usdhc_data_t
Card data descriptor.
Defines a structure to contain data-related attribute. The 'enableIgnoreError' is used when upper card driver wants to ignore the error event to read/write all the data and not to stop read/write immediately when an error event happens. For example, bus testing procedure for MMC card.

```
typedef struct _usdhc_transfer usdhc_transfer_t
```

Transfer state.

```
typedef struct _usdhc_handle usdhc_handle_t
```

USDHC handle typedef.

```
typedef struct _usdhc_transfer_callback usdhc_transfer_callback_t
```

USDHC callback functions.

```
typedef status_t (*usdhc_transfer_function_t)(USDHC_Type *base, usdhc_transfer_t *content)
```

USDHC transfer function.

```
typedef struct _usdhc_host usdhc_host_t
```

USDHC host descriptor.

```
USDHC_MAX_BLOCK_COUNT
```

Maximum block count can be set one time.

```
FSL_USDHC_ENABLE_SCATTER_GATHER_TRANSFER
```

USDHC scatter gather feature control macro.

```
USDHC_ADMA1_ADDRESS_ALIGN
```

The alignment size for ADDRESS filed in ADMA1's descriptor.

```
USDHC_ADMA1_LENGTH_ALIGN
```

The alignment size for LENGTH field in ADMA1's descriptor.

```
USDHC_ADMA2_ADDRESS_ALIGN
```

The alignment size for ADDRESS field in ADMA2's descriptor.

```
USDHC_ADMA2_LENGTH_ALIGN
```

The alignment size for LENGTH filed in ADMA2's descriptor.

```
USDHC_ADMA1_DESCRIPTOR_ADDRESS_SHIFT
```

The bit shift for ADDRESS filed in ADMA1's descriptor.

Address/page field	Reserved	Attribute					
31 12	11 6	05	04	03	02	01	00
address or data length	000000	Act2	Act1	0	Int	End	Valid

Act2	Act1	Comment	31-28	27-12
0	0	No op	Don't care	
0	1	Set data length	0000	Data Length
1	0	Transfer data	Data address	
1	1	Link descriptor	Descriptor address	

```
USDHC_ADMA1_DESCRIPTOR_ADDRESS_MASK
```

The bit mask for ADDRESS field in ADMA1's descriptor.

```
USDHC_ADMA1_DESCRIPTOR_LENGTH_SHIFT
```

The bit shift for LENGTH filed in ADMA1's descriptor.

```
USDHC_ADMA1_DESCRIPTOR_LENGTH_MASK
```

The mask for LENGTH field in ADMA1's descriptor.

USDHC_ADMA1_DESCRIPTOR_MAX_LENGTH_PER_ENTRY

The maximum value of LENGTH filed in ADMA1's descriptor. Since the max transfer size ADMA1 support is 65535 which is indivisible by 4096, so to make sure a large data load transfer (>64KB) continuously (require the data address be always align with 4096), software will set the maximum data length for ADMA1 to (64 - 4)KB.

USDHC_ADMA2_DESCRIPTOR_LENGTH_SHIFT

The bit shift for LENGTH field in ADMA2's descriptor.

Address field	Length	Reserved	Attribute						
63 32	31 16	15 06	05	04	03	02	01	00	
32-bit address	16-bit length	0000000000	Act2	Act1	0	Int	End	Valid	

Act2	Act1	Comment	Operation
0	0	No op	Don't care
0	1	Reserved	Read this line and go to next one
1	0	Transfer data	Transfer data with address and length set in this descriptor line
1	1	Link descriptor	Link to another descriptor

USDHC_ADMA2_DESCRIPTOR_LENGTH_MASK

The bit mask for LENGTH field in ADMA2's descriptor.

USDHC_ADMA2_DESCRIPTOR_MAX_LENGTH_PER_ENTRY

The maximum value of LENGTH field in ADMA2's descriptor.

struct __usdhc_adma2_descriptor

#include <fsl_usdhc.h> Defines the ADMA2 descriptor structure.

Public Members

uint32_t attribute

The control and status field.

uint32_t address

The address field.

struct __usdhc_capability

#include <fsl_usdhc.h> USDHC capability information.

Defines a structure to save the capability information of USDHC.

Public Members

uint32_t sdVersion

Support SD card/sdio version.

uint32_t mmcVersion

Support EMMC card version.

uint32_t maxBlockLength

Maximum block length united as byte.

uint32_t maxBlockCount

Maximum block count can be set one time.

uint32_t flags

Capability flags to indicate the support information(_usdhc_capability_flag).

struct __usdhc_boot_config

#include <fsl_usdhc.h> Data structure to configure the MMC boot feature.

Public Members

uint32_t ackTimeoutCount

Timeout value for the boot ACK. The available range is 0 ~ 15.

usdhc_boot_mode_t bootMode

Boot mode selection.

uint32_t blockCount

Stop at block gap value of automatic mode. Available range is 0 ~ 65535.

size_t blockSize

Block size.

bool enableBootAck

Enable or disable boot ACK.

bool enableAutoStopAtBlockGap

Enable or disable auto stop at block gap function in boot period.

struct __usdhc_config

#include <fsl_usdhc.h> Data structure to initialize the USDHC.

Public Members

uint32_t dataTimeout

Data timeout value.

usdhc_endian_mode_t endianMode

Endian mode.

uint8_t readWatermarkLevel

Watermark level for DMA read operation. Available range is 1 ~ 128.

uint8_t writeWatermarkLevel

Watermark level for DMA write operation. Available range is 1 ~ 128.

struct __usdhc_command

#include <fsl_usdhc.h> Card command descriptor.

Defines card command-related attribute.

Public Members

uint32_t index

Command index.

uint32_t argument

Command argument.

usdhc_card_command_type_t type

Command type.

usdhc_card_response_type_t responseType

Command response type.

uint32_t response[4U]

Response for this command.

uint32_t responseErrorFlags

Response error flag, which need to check the command reponse.

uint32_t flags

Cmd flags.

struct __usdhc_adma_config

#include <fsl_usdhc.h> ADMA configuration.

Public Members

usdhc_dma_mode_t dmaMode

DMA mode.

uint32_t *admaTable

ADMA table address, can't be null if transfer way is ADMA1/ADMA2.

uint32_t admaTableWords

ADMA table length united as words, can't be 0 if transfer way is ADMA1/ADMA2.

struct __usdhc_scatter_gather_data_list

#include <fsl_usdhc.h> Card scatter gather data list.

Allow application register uncontinuous data buffer for data transfer.

struct __usdhc_scatter_gather_data

#include <fsl_usdhc.h> Card scatter gather data descriptor.

Defines a structure to contain data-related attribute. The 'enableIgnoreError' is used when upper card driver wants to ignore the error event to read/write all the data and not to stop read/write immediately when an error event happens. For example, bus testing procedure for MMC card.

Public Members

bool enableAutoCommand12

Enable auto CMD12.

bool enableAutoCommand23

Enable auto CMD23.

bool enableIgnoreError

Enable to ignore error event to read/write all the data.

usdhc_transfer_direction_t dataDirection

data direction

uint8_t dataType

this is used to distinguish the normal/tuning/boot data.

size_t blockSize

Block size.

usdhc_scatter_gather_data_list_t sgData

scatter gather data

struct __usdhc_scatter_gather_transfer

#include <fsl_usdhc.h> usdhc scatter gather transfer.

Public Members

usdhc_scatter_gather_data_t *data

Data to transfer.

usdhc_command_t *command

Command to send.

struct __usdhc_data

#include <fsl_usdhc.h> Card data descriptor.

Defines a structure to contain data-related attribute. The 'enableIgnoreError' is used when upper card driver wants to ignore the error event to read/write all the data and not to stop read/write immediately when an error event happens. For example, bus testing procedure for MMC card.

Public Members

bool enableAutoCommand12

Enable auto CMD12.

bool enableAutoCommand23

Enable auto CMD23.

bool enableIgnoreError

Enable to ignore error event to read/write all the data.

uint8_t dataType

this is used to distinguish the normal/tuning/boot data.

size_t blockSize

Block size.

uint32_t blockCount

Block count.

uint32_t *rxData

Buffer to save data read.

const uint32_t *txData

Data buffer to write.

struct __usdhc_transfer

#include <fsl_usdhc.h> Transfer state.

Public Members

usdhc_data_t *data

Data to transfer.

usdhc_command_t *command
Command to send.

struct __usdhc_transfer_callback
#include <fsl_usdhc.h> USDHC callback functions.

Public Members

void (*CardInserted)(USDHC_Type *base, void *userData)
Card inserted occurs when DAT3/CD pin is for card detect

void (*CardRemoved)(USDHC_Type *base, void *userData)
Card removed occurs

void (*SdioInterrupt)(USDHC_Type *base, void *userData)
SDIO card interrupt occurs

void (*BlockGap)(USDHC_Type *base, void *userData)
stopped at block gap event

void (*TransferComplete)(USDHC_Type *base, *usdhc_handle_t* *handle, *status_t* status, void *userData)
Transfer complete callback.

void (*ReTuning)(USDHC_Type *base, void *userData)
Handle the re-tuning.

struct __usdhc_handle
#include <fsl_usdhc.h> USDHC handle.
Defines the structure to save the USDHC state information and callback function.

Note: All the fields except interruptFlags and transferredWords must be allocated by the user.

Public Members

usdhc_data_t *volatile data
Transfer parameter. Data to transfer.

usdhc_command_t *volatile command
Transfer parameter. Command to send.

volatile uint32_t transferredWords
Transfer status. Words transferred by DATAPORT way.

usdhc_transfer_callback_t callback
Callback function.

void *userData
Parameter for transfer complete callback.

struct __usdhc_host
#include <fsl_usdhc.h> USDHC host descriptor.

Public Members

USDHC_Type *base

USDHC peripheral base address.

uint32_t sourceClock_Hz

USDHC source clock frequency united in Hz.

usdhc_config_t config

USDHC configuration.

usdhc_capability_t capability

USDHC capability information.

usdhc_transfer_function_t transfer

USDHC transfer function.

2.44 WDOG: Watchdog Timer Driver

void WDOG_GetDefaultConfig(*wdog_config_t* *config)

Initializes the WDOG configuration structure.

This function initializes the WDOG configuration structure to default values. The default values are as follows.

```
wdogConfig->enableWdog = true;
wdogConfig->workMode.enableWait = true;
wdogConfig->workMode.enableStop = true;
wdogConfig->workMode.enableDebug = true;
wdogConfig->enableInterrupt = false;
wdogConfig->enablePowerdown = false;
wdogConfig->resetExtension = false;
wdogConfig->timeoutValue = 0xFFU;
wdogConfig->interruptTimeValue = 0x04u;
```

See also:

wdog_config_t

Parameters

- config – Pointer to the WDOG configuration structure.

void WDOG_Init(WDOG_Type *base, const *wdog_config_t* *config)

Initializes the WDOG.

This function initializes the WDOG. When called, the WDOG runs according to the configuration.

This is an example.

```
wdog_config_t config;
WDOG_GetDefaultConfig(&config);
config.timeoutValue = 0xFFU;
config->interruptTimeValue = 0x04u;
WDOG_Init(wdog_base,&config);
```

Parameters

- base – WDOG peripheral base address

- config – The configuration of WDOG

`void WDOG_Deinit(WDOG_Type *base)`

Shuts down the WDOG.

This function shuts down the WDOG. Watchdog Enable bit is a write one once only bit. It is not possible to clear this bit by a software write, once the bit is set. This bit(WDE) can be set/reset only in debug mode(exception).

`static inline void WDOG_Enable(WDOG_Type *base)`

Enables the WDOG module.

This function writes a value into the WDOG_WCR register to enable the WDOG. This is a write one once only bit. It is not possible to clear this bit by a software write, once the bit is set. only debug mode exception.

Parameters

- base – WDOG peripheral base address

`static inline void WDOG_Disable(WDOG_Type *base)`

Disables the WDOG module.

This function writes a value into the WDOG_WCR register to disable the WDOG. This is a write one once only bit. It is not possible to clear this bit by a software write,once the bit is set. only debug mode exception

Parameters

- base – WDOG peripheral base address

`static inline void WDOG_TriggerSystemSoftwareReset(WDOG_Type *base)`

Trigger the system software reset.

This function will write to the WCR[SRS] bit to trigger a software system reset. This bit will automatically resets to “1” after it has been asserted to “0”. Note: Calling this API will reset the system right now, please using it with more attention.

Parameters

- base – WDOG peripheral base address

`static inline void WDOG_TriggerSoftwareSignal(WDOG_Type *base)`

Trigger an output assertion.

This function will write to the WCR[WDA] bit to trigger WDOG_B signal assertion. The WDOG_B signal can be routed to external pin of the chip, the output pin will turn to as-assertion along with WDOG_B signal. Note: The WDOG_B signal will remain assert until a power on reset occurred, so, please take more attention while calling it.

Parameters

- base – WDOG peripheral base address

`static inline void WDOG_EnableInterrupts(WDOG_Type *base, uint16_t mask)`

Enables the WDOG interrupt.

This bit is a write once only bit. Once the software does a write access to this bit, it will get locked and cannot be reprogrammed until the next system reset assertion

Parameters

- base – WDOG peripheral base address
- mask – The interrupts to enable The parameter can be combination of the following source if defined.
 - kWDOG_InterruptEnable

```
uint16_t WDOG_GetStatusFlags(WDOG_Type *base)
```

Gets the WDOG all reset status flags.

This function gets all reset status flags.

```
uint16_t status;
status = WDOG_GetStatusFlags (wdog_base);
```

See also:

`_wdog_status_flags`

- true: a related status flag has been set.
- false: a related status flag is not set.

Parameters

- base – WDOG peripheral base address

Returns

State of the status flag: asserted (true) or not-asserted (false).

```
void WDOG_ClearInterruptStatus(WDOG_Type *base, uint16_t mask)
```

Clears the WDOG flag.

This function clears the WDOG status flag.

This is an example for clearing the interrupt flag.

```
WDOG_ClearStatusFlags(wdog_base, KWDOG_InterruptFlag);
```

Parameters

- base – WDOG peripheral base address
- mask – The status flags to clear. The parameter could be any combination of the following values. `KWDOG_TimeoutFlag`

```
static inline void WDOG_SetTimeoutValue(WDOG_Type *base, uint16_t timeoutCount)
```

Sets the WDOG timeout value.

This function sets the timeout value. This function writes a value into WCR registers. The time-out value can be written at any point of time but it is loaded to the counter at the time when WDOG is enabled or after the service routine has been performed.

Parameters

- base – WDOG peripheral base address
- timeoutCount – WDOG timeout value; count of WDOG clock tick.

```
static inline void WDOG_SetInterruptTimeoutValue(WDOG_Type *base, uint16_t timeoutCount)
```

Sets the WDOG interrupt count timeout value.

This function sets the interrupt count timeout value. This function writes a value into WIC registers which are write-once. This field is write once only. Once the software does a write access to this field, it will get locked and cannot be reprogrammed until the next system reset assertion.

Parameters

- base – WDOG peripheral base address
- timeoutCount – WDOG timeout value; count of WDOG clock tick.

static inline void WDOG_DisablePowerDownEnable(WDOG_Type *base)

Disable the WDOG power down enable bit.

This function disable the WDOG power down enable(PDE). This function writes a value into WMCR registers which are write-once. This field is write once only. Once software sets this bit it cannot be reset until the next system reset.

Parameters

- base – WDOG peripheral base address

void WDOG_Refresh(WDOG_Type *base)

Refreshes the WDOG timer.

This function feeds the WDOG. This function should be called before the WDOG timer is in timeout. Otherwise, a reset is asserted.

Parameters

- base – WDOG peripheral base address

FSL_WDOG_DRIVER_VERSION

Defines WDOG driver version.

WDOG_REFRESH_KEY

enum __wdog_interrupt_enable

WDOG interrupt configuration structure, default settings all disabled.

This structure contains the settings for all of the WDOG interrupt configurations.

Values:

enumerator kWDOG_InterruptEnable

WDOG timeout generates an interrupt before reset

enum __wdog_status_flags

WDOG status flags.

This structure contains the WDOG status flags for use in the WDOG functions.

Values:

enumerator kWDOG_RunningFlag

Running flag, set when WDOG is enabled

enumerator kWDOG_PowerOnResetFlag

Power On flag, set when reset is the result of a powerOnReset

enumerator kWDOG_TimeoutResetFlag

Timeout flag, set when reset is the result of a timeout

enumerator kWDOG_SoftwareResetFlag

Software flag, set when reset is the result of a software

enumerator kWDOG_InterruptFlag

interrupt flag, whether interrupt has occurred or not

typedef struct __wdog_work_mode wdog_work_mode_t

Defines WDOG work mode.

typedef struct __wdog_config wdog_config_t

Describes WDOG configuration structure.

struct __wdog_work_mode

#include <fsl_wdog.h> Defines WDOG work mode.

Public Members

`bool enableWait`
If set to true, WDOG continues in wait mode

`bool enableStop`
If set to true, WDOG continues in stop mode

`bool enableDebug`
If set to true, WDOG continues in debug mode

`struct __wdog_config`
#include <fsl_wdog.h> Describes WDOG configuration structure.

Public Members

`bool enableWdog`
Enables or disables WDOG

`wdog_work_mode_t workMode`
Configures WDOG work mode in debug stop and wait mode

`bool enableInterrupt`
Enables or disables WDOG interrupt

`uint16_t timeoutValue`
Timeout value

`uint16_t interruptTimeValue`
Interrupt count timeout value

`bool softwareResetExtension`
software reset extension

`bool enablePowerDown`
power down enable bit

`bool enableTimeOutAssert`
Enable WDOG_B timeout assertion.

Chapter 3

Middleware

3.1 Motor Control

3.1.1 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_pd_bdm** uses JTAG or BDM debugging interface to access the target RAM directly while the CPU is running. Note that such approach can be used with any MCU application, even without any special driver code. The computer reads from and writes into the RAM directly without CPU intervention. The Packet-Driven BDM (PD-BDM) communication uses the same memory access to exchange command and response frames. With PD-BDM, the FreeMASTER tool is able to go beyond basic memory read/write operations and accesses also advanced features like Recorder, TSA, or Pipes. The typical transmission speed is around 10 kbps. A PD-BDM communication plug-in must be used in FreeMASTER and configured properly for the selected debugging interface. Note that this communication cannot be used while a debugging interface is used by a debugger session.
- **fmstr_any** is a special example application which demonstrates how the NXP MCUXpresso Config Tools can be used to configure pins, clocks, peripherals, interrupts, and even the FreeMASTER “middleware” driver features in a graphical and user friendly way. The user can switch between the Serial, CAN, and other ways of communication and generate the required initialization code automatically.

Zephyr sample applications Zephyr sample applications demonstrate Kconfig and Device Tree configuration which configure the FreeMASTER middleware module for a selected communication option (Serial, CAN, Network or RTT).

Refer to *readme.md* files in each sample directory for description of configuration options required to implement FreeMASTER connectivity.

Description

This section shows how to add the FreeMASTER Communication Driver into application and how to configure the connection to the FreeMASTER visualization tool.

Features The FreeMASTER driver implements the FreeMASTER protocol V4 and provides the following features which may be accessed using the FreeMASTER visualization tool:

- Read/write access to any memory location on the target.
- Optional password protection of the read, read/write, and read/write/flash access levels.

- Atomic bit manipulation on the target memory (bit-wise write access).
- Optimal size-aligned access to memory which is also suitable to access the peripheral register space.
- Oscilloscope access—real-time access to target variables. The sample rate may be limited by the communication speed.
- Recorder— access to the fast transient recorder running on the board as a part of the FreeMASTER driver. The sample rate is only limited by the MCU CPU speed. The length of the data recorded depends on the amount of available memory.
- Multiple instances of Oscilloscopes and Recorders without the limitation of maximum number of variables.
- Application commands—high-level message delivery from the PC to the application.
- TSA tables—describing the data types, variables, files, or hyperlinks exported by the target application. The TSA newly supports also non-memory mapped resources like external EEPROM or SD Card files.
- Pipes—enabling the buffered stream-oriented data exchange for a general-purpose terminal-like communication, diagnostic data streaming, or other data exchange.

The FreeMASTER driver features:

- Full FreeMASTER protocol V4 implementation with a new V4 style of CRC used.
- Layered approach supporting Serial, CAN, Network, PD-BDM, and other transports.
- Layered low-level Serial transport driver architecture enabling to select UART, LPUART, USART, and other physical implementations of serial interfaces, including USB-CDC.
- Layered low-level CAN transport driver architecture enabling to select FlexCAN, msCAN, MCAN, and other physical implementations of the CAN interface.
- Layered low-level Networking transport enabling to select TCP, UDP or J-Link RTT communication.
- TSA support to write-protect memory regions or individual variables and to deny the access to the unsafe memory.
- The pipe callback handlers are invoked whenever new data is available for reading from the pipe.
- Two Serial Single-Wire modes of operation are enabled. The “external” mode has the RX and TX shorted on-board. The “true” single-wire mode interconnects internally when the MCU or UART modules support it.

The following sections briefly describe all FreeMASTER features implemented by the driver. See the PC-based FreeMASTER User Manual for more details on how to use the features to monitor, tune, or control an embedded application.

Board Detection The FreeMASTER protocol V4 defines the standard set of configuration values which the host PC tool reads to identify the target and to access other target resources properly. The configuration includes the following parameters:

- Version of the driver and the version of the protocol implemented.
- MTU as the Maximum size of the Transmission Unit (for example; communication buffer size).
- Application name, description, and version strings.
- Application build date and time as a string.
- Target processor byte ordering (little/big endian).
- Protection level that requires password authentication.

- Number of the Recorder and Oscilloscope instances.
- RAM Base Address for optimized memory access commands.

Memory Read This basic feature enables the host PC to read any data memory location by specifying the address and size of the required memory area. The device response frame must be shorter than the MTU to fit into the outgoing communication buffer. To read a device memory of any size, the host uses the information retrieved during the Board Detection and splits the large-block request to multiple partial requests.

The driver uses size-aligned operations to read the target memory (for example; uses proper read-word instruction when an address is aligned to 4 bytes).

Memory Write Similarly to the Memory Read operation, the Memory Write feature enables to write to any RAM memory location on the target device. A single write command frame must be shorter than the MTU to fit into the target communication buffer. Larger requests must be split into smaller ones.

The driver uses size-aligned operations to write to the target memory (for example; uses proper write-word instruction when an address is aligned to 4 bytes).

Masked Memory Write To implement the write access to a single bit or a group of bits of target variables, the Masked Memory Write feature is available in the FreeMASTER protocol and it is supported by the driver using the Read-Modify-Write approach.

Be careful when writing to bit fields of volatile variables that are also modified in an application interrupt. The interrupt may be serviced in the middle of a read-modify-write operation and it may cause data corruption.

Oscilloscope The protocol and driver enables any number of variables to be read at once with a single request from the host. This feature is called Oscilloscope and the FreeMASTER tool uses it to display a real-time graph of variable values.

The driver can be configured to support any number of Oscilloscope instances and enable simultaneously running graphs to be displayed on the host computer screen.

Recorder The protocol enables the host to select target variables whose values are then periodically recorded into a dedicated on-board memory buffer. After such data sampling stops (either on a host request or by evaluating a threshold-crossing condition), the data buffer is downloaded to the host and displayed as a graph. The data sampling rate is not limited by the speed of the communication line, so it enables displaying the variable transitions in a very high resolution.

The driver can be configured to support multiple Recorder instances and enable multiple recorder graphs to be displayed on the host screen. Having multiple recorders also enables setting the recording point differently for each instance. For example; one instance may be recording data in a general timer interrupt while another instance may record at a specific control algorithm time in the PWM interrupt.

TSA With the TSA feature, data types and variables can be described directly in the application source code. Such information is later provided to the FreeMASTER tool which may use it instead of reading symbol data from the application ELF executable file.

The information is encoded as so-called TSA tables which become direct part of the application code. The TSA tables contain descriptors of variables that shall be visible to the host tool. The descriptors can describe the memory areas by specifying the address and size of the memory

block or more conveniently using the C variable names directly. Different set of TSA descriptors can be used to encode information about the structure types, unions, enumerations, or arrays.

The driver also supports special types of TSA table entries to describe user resources like external EEPROM and SD Card files, memory-mapped files, virtual directories, web URL hyperlinks, and constant enumerations.

TSA Safety When the TSA is enabled in the application, the TSA Safety can be enabled and validate the memory accesses directly by the embedded-side driver. When the TSA Safety is turned on, any memory request received from the host is validated and accepted only if it belongs to a TSA-described object. The TSA entries can be declared as Read-Write or Read-Only so that the driver can actively deny the write access to the Read-Only objects.

Application commands The Application Commands are high-level messages that can be delivered from the PC Host to the embedded application for further processing. The embedded application can either poll the status, or be called back when a new Application Command arrives to be processed. After the embedded application acknowledges that the command is handled, the host receives the Result Code and reads the other return data from memory. Both the Application Commands and the Result Codes are specific to a given application and it is user's responsibility to define them. The FreeMASTER protocol and the FreeMASTER driver only implement the delivery channel and a set of API calls to enable the Application Command processing in general.

Pipes The Pipes enable buffered and stream-oriented data exchange between the PC Host and the target application. Any pipe can be written to and read from at both ends (either on the PC or the MCU). The data transmission is acknowledged using the special FreeMASTER protocol commands. It is guaranteed that the data bytes are delivered from the writer to the reader in a proper order and without losses.

Serial single-wire operation The MCU Serial Communication Driver natively supports normal dual-wire operation. Because the protocol is half-duplex only, the driver can also operate in two single-wire modes:

- “External” single-wire operation where the Receiver and Transmitter pins are shorted on the board. This mode is supported by default in the MCU driver because the Receiver and Transmitter units are enabled or disabled whenever needed. It is also easy to extend this operation for the RS485 communication.
- “True” single-wire mode which uses only a single pin and the direction switching is made by the UART module. This mode of operation must be enabled by defining the FMSTR_SERIAL_SINGLEWIRE configuration option.

Multi-session support With networking interface it is possible for multiple clients to access the target MCU simultaneously. Reading and writing of target memory is processed atomically so there is no risk of data corruption. The state-full resources such as Recorders or Oscilloscopes are locked to a client session upon first use and access is denied to other clients until lock is released..

Zephyr-specific

Dedicated communication task FreeMASTER communication may run isolated in a dedicated task. The task automates the FMSTR_Init and FMSTR_Poll calls together with periodic activities enabling the FreeMASTER UI to fetch information about tasks and CPU utilization. The task can be started automatically or manually, and it must be assigned a priority to be able to react on interrupts and other communication events. Refer to Zephyr FreeMASTER sample applications which all use this communication task.

Zephyr shell and logging over FreeMASTER pipe FreeMASTER implements a shell backend which may use FreeMASTER pipe as a I/O terminal and logging output. Refer to Zephyr FreeMASTER sample applications which all use this feature.

Automatic TSA tables TSA tables can be declared as “automatic” in Zephyr which make them automatically registered in the table list. This may be very useful when there are many TSA tables or when the tables are defined in different (often unrelated) libraries linked together. In this case user does not need to build a list of all tables manually.

Driver files The driver source files can be found in a top-level src folder, further divided into the sub-folders:

- **src/platforms** platform-specific folder—one folder exists for each supported processor platform (for example; 32-bit Little Endian platform). Each such folder contains a platform header file with data types and a code which implements the potentially platform-specific operations, such as aligned memory access.
- **src/common** folder—contains the common driver source files shared by the driver for all supported platforms. All the .c files must be added to the project, compiled, and linked together with the application.
 - *freemaster.h* - master driver header file, which declares the common data types, macros, and prototypes of the FreeMASTER driver API functions.
 - *freemaster_cfg.h.example* - this file can serve as an example of the FreeMASTER driver configuration file. Save this file into a project source code folder and rename it to *freemaster_cfg.h*. The FreeMASTER driver code includes this file to get the project-specific configuration options and to optimize the compilation of the driver.
 - *freemaster_defcfg.h* - defines the default values for each FreeMASTER configuration option if the option is not set in the *freemaster_cfg.h* file.
 - *freemaster_protocol.h* - defines the FreeMASTER protocol constants used internally by the driver.
 - *freemaster_protocol.c* - implements the FreeMASTER protocol decoder and handles the basic Get Configuration Value, Memory Read, and Memory Write commands.
 - *freemaster_rec.c* - handles the Recorder-specific commands and implements the Recorder sampling and triggering routines. When the Recorder is disabled by the FreeMASTER driver configuration file, this file only compiles to empty API functions.
 - *freemaster_scope.c* - handles the Oscilloscope-specific commands. If the Oscilloscope is disabled by the FreeMASTER driver configuration file, this file compiles as void.
 - *freemaster_pipes.c* - implements the Pipes functionality when the Pipes feature is enabled.
 - *freemaster_appcmd.c* - handles the communication commands used to deliver and execute the Application Commands within the context of the embedded application. When the Application Commands are disabled by the FreeMASTER driver configuration file, this file only compiles to empty API functions.

- *freemaster_tsa.c* - handles the commands specific to the TSA feature. This feature enables the FreeMASTER host tool to obtain the TSA memory descriptors declared in the embedded application. If the TSA is disabled by the FreeMASTER driver configuration file, this file compiles as void.
- *freemaster_tsa.h* - contains the declaration of the macros used to define the TSA memory descriptors. This file is indirectly included into the user application code (via *freemaster.h*).
- *freemaster_sha.c* - implements the SHA-1 hash code used in the password authentication algorithm.
- *freemaster_private.h* - contains the declarations of functions and data types used internally in the driver. It also contains the C pre-processor statements to perform the compile-time verification of the user configuration provided in the *freemaster_cfg.h* file.
- *freemaster_serial.c* - implements the serial protocol logic including the CRC, FIFO queuing, and other communication-related operations. This code calls the functions of the low-level communication driver indirectly via a character-oriented API exported by the specific low-level driver.
- *freemaster_serial.h* - defines the low-level character-oriented Serial API.
- *freemaster_can.c* - implements the CAN protocol logic including the CAN message preparation, signalling using the first data byte in the CAN frame, and other communication-related operations. This code calls the functions of the low-level communication driver indirectly via a message-oriented API exported by the specific low-level driver.
- *freemaster_can.h* - defines the low-level message-oriented CAN API.
- *freemaster_net.c* - implements the Network protocol transport logic including multiple session management code.
- *freemaster_net.h* - definitions related to the Network transport.
- *freemaster_pdbdm.c* - implements the packet-driven BDM communication buffer and other communication-related operations.
- *freemaster_utils.c* - aligned memory copy routines, circular buffer management and other utility functions
- *freemaster_utils.h* - definitions related to utility code.
- **src/drivers/[sdk]/serial** - contains the code related to the serial communication implemented using one of the supported SDK frameworks.
 - *freemaster_serial_XXX.c* and *.h* - implement low-level access to the communication peripheral registers. Different files exist for the UART, LPUART, USART, and other kinds of Serial communication modules.
- **src/drivers/[sdk]/can** - contains the code related to the serial communication implemented using one of the supported SDK frameworks.
 - *freemaster_XXX.c* and *.h* - implement low-level access to the communication peripheral registers. Different files exist for the FlexCAN, msCAN, MCAN, and other kinds of CAN communication modules.
- **src/drivers/[sdk]/network** - contains low-level code adapting the FreeMASTER Network transport to an underlying TCP/IP or RTT stack.
 - *freemaster_net_lwip_tcp.c* and *_udp.c* - default networking implementation of TCP and UDP transports using lwIP stack.
 - *freemaster_net_segger_rtt.c* - implementation of network transport using Segger J-Link RTT interface

Driver configuration The driver is configured using a single header file (*freemaster_cfg.h*). Create this file and save it together with other project source files before compiling the driver code. All FreeMASTER driver source files include the *freemaster_cfg.h* file and use the macros defined here for the conditional and parameterized compilation. The C compiler must locate the configuration file when compiling the driver files. Typically, it can be achieved by putting this file into a folder where the other project-specific included files are stored.

As a starting point to create the configuration file, get the *freemaster_cfg.h.example* file, rename it to *freemaster_cfg.h*, and save it into the project area.

Note: It is NOT recommended to leave the *freemaster_cfg.h* file in the FreeMASTER driver source code folder. The configuration file must be placed at a project-specific location, so that it does not affect the other applications that use the same driver.

Configurable items This section describes the configuration options which can be defined in *freemaster_cfg.h*.

Interrupt modes

```
#define FMSTR_LONG_INTR    [0|1]
#define FMSTR_SHORT_INTR   [0|1]
#define FMSTR_POLL_DRIVEN [0|1]
```

Value Type boolean (0 or 1)

Description Exactly one of the three macros must be defined to non-zero. The others must be defined to zero or left undefined. The non-zero-defined constant selects the interrupt mode of the driver. See [Driver interrupt modes](#).

- FMSTR_LONG_INTR — long interrupt mode
- FMSTR_SHORT_INTR — short interrupt mode
- FMSTR_POLL_DRIVEN — poll-driven mode

Note: Some options may not be supported by all communication interfaces. For example, the FMSTR_SHORT_INTR option is not supported by the USB_CDC interface.

Protocol transport

```
#define FMSTR_TRANSPORT [identifier]
```

Value Type Driver identifiers are structure instance names defined in FreeMASTER source code. Specify one of existing instances to make use of the protocol transport.

Description Use one of the pre-defined constants, as implemented by the FreeMASTER code. The current driver supports the following transports:

- FMSTR_SERIAL - serial communication protocol
- FMSTR_CAN - using CAN communication
- FMSTR_PDBDM - using packet-driven BDM communication
- FMSTR_NET - network communication using TCP or UDP protocol

Serial transport This section describes configuration parameters used when serial transport is used:

```
#define FMSTR_TRANSPORT FMSTR_SERIAL
```

FMSTR_SERIAL_DRV Select what low-level driver interface will be used when implementing the Serial communication.

```
#define FMSTR_SERIAL_DRV [identifier]
```

Value Type Driver identifiers are structure instance names defined in FreeMASTER drivers code. Specify one of existing serial driver instances.

Description When using MCUXpresso SDK, use one of the following constants (see */drivers/mcuxsdk/serial* implementation):

- **FMSTR_SERIAL_MCUX_UART** - UART driver
- **FMSTR_SERIAL_MCUX_LPUART** - LPUART driver
- **FMSTR_SERIAL_MCUX_USART** - USART driver
- **FMSTR_SERIAL_MCUX_MINIUSART** - miniUSART driver
- **FMSTR_SERIAL_MCUX_QSCI** - DSC QSCI driver
- **FMSTR_SERIAL_MCUX_USB** - USB/CDC class driver (also see code in the */support/mcuxsdk_usb* folder)
- **FMSTR_SERIAL_56F800E_EONCE** - DSC JTAG EOnCE driver

Other SDKs or BSPs may define custom low-level driver interface structure which may be used as **FMSTR_SERIAL_DRV**. For example:

- **FMSTR_SERIAL_DREG_UART** - demonstrates the low-level interface implemented without the MCUXpresso SDK and using direct access to peripheral registers.

FMSTR_SERIAL_BASE

```
#define FMSTR_SERIAL_BASE [address|symbol]
```

Value Type Optional address value (numeric or symbolic)

Description Specify the base address of the UART, LPUART, USART, or other serial peripheral module to be used for the communication. This value is not defined by default. User application should call `FMSTR_SetSerialBaseAddress()` to select the peripheral module.

FMSTR_COMM_BUFFER_SIZE

```
#define FMSTR_COMM_BUFFER_SIZE [number]
```

Value Type 0 or a value in range 32...255

Description Specify the size of the communication buffer to be allocated by the driver. Default value, which suits all driver features, is used when this option is defined as 0.

FMSTR_COMM_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_QUEUE_SIZE*) and the character time is the time needed to transmit or receive a single byte over the SCI line.

Completely Poll-driven

```
#define FMSTR_POLL_DRIVEN 1
```

In this mode, both the communication and the FreeMASTER protocol decoding are done in the *FMSTR_Poll* routine. No interrupts are needed and the *FMSTR_SerialIsr*, *FMSTR_CanIsr*, and similar handlers compile to an empty code.

When using this mode, ensure that the *FMSTR_Poll* function is called by the application at least once per the serial “character time” which is the time needed to transmit or receive a single character.

In the latter two modes (*FMSTR_SHORT_INTR* and *FMSTR_POLL_DRIVEN*), the protocol handling takes place in the *FMSTR_Poll* routine. An application interrupt can occur in the middle of the

Read Memory or Write Memory commands' execution and corrupt the variable being accessed by the FreeMASTER driver. In these two modes, some issues or glitches may occur when using FreeMASTER to visualize or monitor volatile variables modified in interrupt servicing code.

The same issue may appear even in the full interrupt mode (FMSTR_LONG_INTR), if volatile variables are modified in the interrupt code with a priority higher than the priority of the communication interrupt.

Data types Simple portability was one of the main requirements when writing the FreeMASTER driver. This is why the driver code uses the privately-declared data types and the vast majority of the platform-dependent code is separated in the platform-dependent source files. The data types used in the driver API are all defined in the platform-specific header file.

To prevent name conflicts with the symbols used in the application, all data types, macros, and functions have the FMSTR_ prefix. The only global variables used in the driver are the transport and low-level API structures exported from the driver-implementation layer to upper layers. Other than that, all private variables are declared as static and named using the fmstr_ prefix.

Communication interface initialization The FreeMASTER driver does not perform neither the initialization nor the configuration of the peripheral module that it uses to communicate. It is the application startup code responsibility to configure the communication module before the FreeMASTER driver is initialized by the FMSTR_Init call.

When the Serial communication module is used as the FreeMASTER communication interface, configure the UART receive and transmit pins, the serial communication baud rate, parity (no-parity), the character length (eight bits), and the number of stop bits (one) before initializing the FreeMASTER driver. For either the long or the short interrupt modes of the driver (see [Driver interrupt modes](#)), configure the interrupt controller and register an application-specific interrupt handler for all interrupt sources related to the selected serial peripheral module. Call the FMSTR_SerialIsr function from the application handler.

When a CAN module is used as the FreeMASTER communication interface, configure the CAN receive and transmit pins and the CAN module bit rate before initializing the FreeMASTER driver. For either the long or the short interrupt modes of the driver (see [Driver interrupt modes](#)), configure the interrupt controller and register an application-specific interrupt handler for all interrupt sources related to the selected CAN peripheral module. Call the FMSTR_CanIsr function from the application handler.

Note: It is not necessary to enable or unmask the serial nor the CAN interrupts before initializing the FreeMASTER driver. The driver enables or disables the interrupts and communication lines, as required during runtime.

FreeMASTER Recorder calls When using the FreeMASTER Recorder in the application (FMSTR_USE_RECORDER > 0), call the FMSTR_RecorderCreate function early after FMSTR_Init to set up each recorder instance to be used in the application. Then call the FMSTR_Recorder function periodically in the code where the data recording should occur. A typical place to call the Recorder routine is at the timer or PWM interrupts, but it can be anywhere else. The example applications provided together with the driver code call the FMSTR_Recorder in the main application loop.

In applications where FMSTR_Recorder is called periodically with a constant period, specify the period in the Recorder configuration structure before calling FMSTR_RecorderCreate. This setting enables the PC Host FreeMASTER tool to display the X-axis of the Recorder graph properly scaled for the time domain.

Driver usage Start using or evaluating FreeMASTER by opening some of the example applications available in the driver setup package.

Follow these steps to enable the basic FreeMASTER connectivity in the application:

- Make sure that all *.c files of the FreeMASTER driver from the `src/common/platforms/[your_platform]` folder are a part of the project. See [Driver files](#) for more details.
- Configure the FreeMASTER driver by creating or editing the `freemaster_cfg.h` file and by saving it into the application project directory. See [Driver configuration](#) for more details.
- Include the `freemaster.h` file into any application source file that makes the FreeMASTER API calls.
- Initialize the Serial or CAN modules. Set the baud rate, parity, and other parameters of the communication. Do not enable the communication interrupts in the interrupt mask registers.
- For the FMSTR_LONG_INTR and FMSTR_SHORT_INTR modes, install the application-specific interrupt routine and call the FMSTR_SerialIsr or FMSTR_CanIsr functions from this handler.
- Call the FMSTR_Init function early on in the application initialization code.
- Call the FMSTR_RecorderCreate functions for each Recorder instance to enable the Recorder feature.
- In the main application loop, call the FMSTR_Poll API function periodically when the application is idle.
- For the FMSTR_SHORT_INTR and FMSTR_LONG_INTR modes, enable the interrupts globally so that the interrupts can be handled by the CPU.

Communication troubleshooting The most common problem that causes communication issues is a wrong baud rate setting or a wrong pin multiplexer setting of the target MCU. When a communication between the PC Host running FreeMASTER and the target MCU cannot be established, try enabling the FMSTR_DEBUG_TX option in the `freemaster_cfg.h` file and call the FMSTR_Poll function periodically in the main application task loop.

With this feature enabled, the FreeMASTER driver periodically transmits a test frame through the Serial or CAN lines. Use a logic analyzer or an oscilloscope to monitor the signals at the communication pins of the CPU device to examine whether the bit rate and signal polarity are configured properly.

Driver API

This section describes the driver Application Programmers' Interface (API) needed to initialize and use the FreeMASTER serial communication driver.

Control API There are three key functions to initialize and use the driver.

FMSTR_Init

Prototype

```
FMSTR_BOOL FMSTR_Init(void);
```

- Declaration: `freemaster.h`
- Implementation: `freemaster_protocol.c`

Description This function initializes the internal variables of the FreeMASTER driver and enables the communication interface. This function does not change the configuration of the selected communication module. The hardware module must be initialized before the *FMSTR_Init* function is called.

A call to this function must occur before calling any other FreeMASTER driver API functions.

FMSTR_Poll

Prototype

```
void FMSTR_Poll(void);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_protocol.c*

Description In the poll-driven or short interrupt modes, this function handles the protocol decoding and execution (see *Driver interrupt modes*). In the poll-driven mode, this function also handles the communication interface with the PC. Typically, the *FMSTR_Poll* function is called during the “idle” time in the main application task loop.

To prevent the receive data overflow (loss) on a serial interface, make sure that the *FMSTR_Poll* function is called at least once per the time calculated as:

$$N * Tchar$$

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-language symbol.

```
FMSTR_TSA_TABLE_BEGIN(table_id)
```

After this opening macro, the TSA descriptors are placed using these macros:

```
/* Adding variable descriptors */
FMSTR_TSA_RW_VAR(name, type) /* read/write variable entry */
FMSTR_TSA_RO_VAR(name, type) /* read-only variable entry */

/* Description of complex data types */
FMSTR_TSA_STRUCT(struct_name) /* structure or union type entry */
FMSTR_TSA_MEMBER(struct_name, member_name, type) /* structure member entry */

/* Memory blocks */
FMSTR_TSA_RW_MEM(name, type, address, size) /* read/write memory block */
FMSTR_TSA_RO_MEM(name, type, address, size) /* read-only memory block */
```

The table is closed using the FMSTR_TSA_TABLE_END macro:

```
FMSTR_TSA_TABLE_END()
```

TSA descriptor parameters The TSA descriptor macros accept these parameters:

- *name* — variable name. The variable must be defined before the TSA descriptor references it.
- *type* — variable or member type. Only one of the pre-defined type constants may be used (see below).
- *struct_name* — structure type name. The type must be defined (typedef) before the TSA descriptor references it.

- *member_name* — structure member name.

Note: The structure member descriptors (FMSTR_TSA_MEMBER) must immediately follow the parent structure descriptor (FMSTR_TSA_STRUCT) in the table.

Note: To write-protect the variables in the FreeMASTER driver (FMSTR_TSA_RO_VAR), enable the TSA-Safety feature in the configuration file.

TSA variable types The table lists *type* identifiers which can be used in TSA descriptors:

Constant	Description
FMSTR_TSA_UINTn	Unsigned integer type of size <i>n</i> bits (n=8,16,32,64)
FMSTR_TSA_SINTn	Signed integer type of size <i>n</i> bits (n=8,16,32,64)
FMSTR_TSA_FRACn	Fractional number of size <i>n</i> bits (n=16,32,64).
FMSTR_TSA_FRAC_Q(<i>m,n</i>)	Signed fractional number in general Q form (m+n+1 total bits)
FMSTR_TSA_FRAC_UQ(<i>m,n</i>)	Unsigned fractional number in general UQ form (m+n total bits)
FMSTR_TSA_FLOAT	4-byte standard IEEE floating-point type
FMSTR_TSA_DOUBLE	8-byte standard IEEE floating-point type
FMSTR_TSA_POINTER	Generic pointer type defined (platform-specific 16 or 32 bit)
FM-STR_TSA_USERTYPE(<i>name</i>)	Structure or union type declared with FMSTR_TSA_STRUCT record

TSA table list There shall be exactly one TSA Table List in the application. The list contains one entry for each TSA table defined anywhere in the application.

The TSA Table List begins with the FMSTR_TSA_TABLE_LIST_BEGIN macro and continues with the TSA table entries for each table.

```
FMSTR_TSA_TABLE_LIST_BEGIN()
```

```
FMSTR_TSA_TABLE(table_id)
FMSTR_TSA_TABLE(table_id2)
FMSTR_TSA_TABLE(table_id3)
...
```

The list is closed with the FMSTR_TSA_TABLE_LIST_END macro:

```
FMSTR_TSA_TABLE_LIST_END()
```

TSA Active Content entries FreeMASTER v2.0 and higher supports TSA Active Content, enabling the TSA tables to describe the memory-mapped files, virtual directories, and URL hyperlinks. FreeMASTER can access such objects similarly to accessing the files and folders on the local hard drive.

With this set of TSA entries, the FreeMASTER pages can be embedded directly into the target MCU flash and accessed by FreeMASTER directly over the communication line. The HTML-coded pages rendered inside the FreeMASTER window can access the TSA Active Content resources using a special URL referencing the *fmrstr:* 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 */
```

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```

/* The readme.txt file will be accessible at the fmstr://text_files/readme.txt URL */
FMSTR_TSA_MEMFILE("readme.txt", readme_txt, sizeof(readme_txt)) /* memory-mapped file */

/* Files can also be specified with a full path so the DIRECTORY entry does not apply */
FMSTR_TSA_MEMFILE("/index.htm", index, sizeof(index)) /* memory-mapped file */
FMSTR_TSA_MEMFILE("/prj/demo.pmp", demo_pmp, sizeof(demo_pmp)) /* memory-mapped file */

/* Hyperlinks can point to a local MEMFILE object or to the Internet */
FMSTR_TSA_HREF("Board's Built-in Welcome Page", "/index.htm")
FMSTR_TSA_HREF("FreeMASTER Home Page", "http://www.nxp.com/freemaster")

/* Project file links simplify opening the projects from any URLs */
FMSTR_TSA_PROJECT("Demonstration Project (embedded)", "/prj/demo.pmp")
FMSTR_TSA_PROJECT("Full Project (online)", "http://mycompany.com/prj/demo.pmp")

FMSTR_TSA_TABLE_END()

```

TSA API

FMSTR_SetUpTsaBuff

Prototype

```
FMSTR_BOOL FMSTR_SetUpTsaBuff(FMSTR_ADDR buffAddr, FMSTR_SIZE buffSize);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_tsa.c*

Arguments

- *buffAddr* [in] - address of the memory buffer for the dynamic TSA table
- *buffSize* [in] - size of the memory buffer which determines the maximum number of TSA entries to be added in the runtime

Description This function must be used to assign the RAM memory buffer to the TSA subsystem when FMSTR_USE_TSA_DYNAMIC is enabled. The memory buffer is then used to store the TSA entries added dynamically to the runtime TSA table using the FMSTR_TsaAddVar function call. The runtime TSA table is processed by the FreeMASTER PC Host tool along with all static tables as soon as the communication port is open.

The size of the memory buffer determines the number of TSA entries that can be added dynamically. Depending on the MCU platform, one TSA entry takes either 8 or 16 bytes.

FMSTR_TsaAddVar

Prototype

```
FMSTR_BOOL FMSTR_TsaAddVar(FMSTR_TSATBL_STRPTR tsaName, FMSTR_TSATBL_STRPTR
↪ tsaType,
    FMSTR_TSATBL_VOIDPTR varAddr, FMSTR_SIZE32 varSize,
    FMSTR_SIZE flags);
```

- Declaration: *freemaster.h*

- Implementation: *freemaster_tsa.c*

Arguments

- *tsaName* [in] - name of the object
- *tsaType* [in] - name of the object type
- *varAddr* [in] - address of the object
- *varSize* [in] - size of the object
- *flags* [in] - access flags; a combination of these values:
 - *FMSTR_TSA_INFO_RO_VAR* — read-only memory-mapped object (typically a variable)
 - *FMSTR_TSA_INFO_RW_VAR* — read/write memory-mapped object
 - *FMSTR_TSA_INFO_NON_VAR* — other entry, describing structure types, structure members, enumerations, and other types

Description This function can be called only when the dynamic TSA table is enabled by the *FMSTR_USE_TSA_DYNAMIC* configuration option and when the *FMSTR_SetUpTsaBuff* function call is made to assign the dynamic TSA table memory. This function adds an entry into the dynamic TSA table. It can be used to register a read-only or read/write memory object or describe an item of the user-defined type.

See [TSA table definition](#) for more details about the TSA table entries.

Application Commands API

FMSTR_GetAppCmd

Prototype

```
FMSTR_APPCMD_CODE FMSTR_GetAppCmd(void);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_appcmd.c*

Description This function can be used to detect if there is an Application Command waiting to be processed by the application. If no command is pending, this function returns the *FMSTR_APPCMDRESULT_NOCMD* constant. Otherwise, this function returns the code of the Application Command that must be processed. Use the *FMSTR_AppCmdAck* call to acknowledge the Application Command after it is processed and to return the appropriate result code to the host.

The *FMSTR_GetAppCmd* function does not report the commands for which a callback handler function exists. If the *FMSTR_GetAppCmd* function is called when a callback-registered command is pending (and before it is actually processed by the callback function), this function returns *FMSTR_APPCMDRESULT_NOCMD*.

FMSTR_GetAppCmdData

Prototype

```
FMSTR_APPCMD_PDATA FMSTR_GetAppCmdData(FMSTR_SIZE* dataLen);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_appcmd.c*

Arguments

- *dataLen* [out] - pointer to the variable that receives the length of the data available in the buffer. It can be NULL when this information is not needed.

Description This function can be used to retrieve the Application Command data when the application determines that an Application Command is pending (see [FMSTR_GetAppCmd](#)).

There is just a single buffer to hold the Application Command data (the buffer length is FMSTR_APPCMD_BUFF_SIZE bytes). If the data are to be used in the application after the command is processed by the FMSTR_AppCmdAck call, copy the data out to a private buffer.

FMSTR_AppCmdAck

Prototype

```
void FMSTR_AppCmdAck(FMSTR_APPCMD_RESULT resultCode);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_appcmd.c*

Arguments

- *resultCode* [in] - the result code which is to be returned to FreeMASTER

Description This function is used when the Application Command processing finishes in the application. The resultCode passed to this function is returned back to the host and the driver is re-initialized to expect the next Application Command.

After this function is called and before the next Application Command arrives, the return value of the FMSTR_GetAppCmd function is FMSTR_APPCMDRESULT_NOCMD.

FMSTR_AppCmdSetResponseData

Prototype

```
void FMSTR_AppCmdSetResponseData(FMSTR_ADDR resultDataAddr, FMSTR_SIZE resultDataLen);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_appcmd.c*

Arguments

- *resultDataAddr* [in] - pointer to the data buffer that is to be copied to the Application Command data buffer
- *resultDataLen* [in] - length of the data to be copied. It must not exceed the FMSTR_APPCMD_BUFF_SIZE value.

Description This function can be used before the Application Command processing finishes, when there are data to be returned back to the PC.

The response data buffer is copied into the Application Command data buffer, from where it is accessed when the host requires it. Do not use FMSTR_GetAppCmdData and the data buffer after FMSTR_AppCmdSetResponseData is called.

Note: The current version of FreeMASTER does not support the Application Command response data.

FMSTR_RegisterAppCmdCall

Prototype

```
FMSTR_BOOL FMSTR_RegisterAppCmdCall(FMSTR_APPCMD_CODE appCmdCode, FMSTR_
↪PAPPCMDFUNC callbackFunc);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_appcmd.c*

Arguments

- *appCmdCode* [in] - the Application Command code for which the callback is to be registered
- *callbackFunc* [in] - pointer to the callback function that is to be registered. Use NULL to unregister a callback registered previously with this Application Command.

Return value This function returns a non-zero value when the callback function was successfully registered or unregistered. It can return zero when trying to register a callback function for more than FMSTR_MAX_APPCMD_CALLS different Application Commands.

Description This function can be used to register the given function as a callback handler for the Application Command. The Application Command is identified using single-byte code. The callback function is invoked automatically by the FreeMASTER driver when the protocol decoder obtains a request to get the application command result code.

The prototype of the callback function is

```
FMSTR_APPCMD_RESULT HandlerFunction(FMSTR_APPCMD_CODE nAppcmd,
FMSTR_APPCMD_PDATA pData, FMSTR_SIZE nDataLen);
```

Where:

- *nAppcmd* -Application Command code
- *pData* —points to the Application Command data received (if any)
- *nDataLen* —information about the Application Command data length

The return value of the callback function is used as the Application Command Result Code and returned to FreeMASTER.

Note: The FMSTR_MAX_APPCMD_CALLS configuration macro defines how many different Application Commands may be handled by a callback function. When FMSTR_MAX_APPCMD_CALLS is undefined or defined as zero, the FMSTR_RegisterAppCmdCall function always fails.

Pipes API

FMSTR_PipeOpen

Prototype

```
FMSTR_HPIPE FMSTR_PipeOpen(FMSTR_PIPE_PORT pipePort, FMSTR_PPIPEFUNC pipeCallback,
    FMSTR_ADDR pipeRxBuff, FMSTR_PIPE_SIZE pipeRxSize,
    FMSTR_ADDR pipeTxBuff, FMSTR_PIPE_SIZE pipeTxSize,
    FMSTR_U8 type, const FMSTR_CHAR *name);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_pipes.c*

Arguments

- *pipePort* [in] - port number that identifies the pipe for the client
- *pipeCallback* [in] - pointer to the callback function that is called whenever a pipe data status changes
- *pipeRxBuff* [in] - address of the receive memory buffer
- *pipeRxSize* [in] - size of the receive memory buffer
- *pipeTxBuff* [in] - address of the transmit memory buffer
- *pipeTxSize* [in] - size of the transmit memory buffer
- *type* [in] - a combination of FMSTR_PIPE_MODE_XXX and FMSTR_PIPE_SIZE_XXX constants describing primary pipe data format and usage. This type helps FreeMASTER decide how to access the pipe by default. Optional, use 0 when undetermined.
- *name* [in] - user name of the pipe port. This name is visible to the FreeMASTER user when creating the graphical pipe interface.

Description This function initializes a new pipe and makes it ready to accept or send the data to the PC Host client. The receive memory buffer is used to store the received data before they are read out by the FMSTR_PipeRead call. When this buffer gets full, the PC Host client denies the data transmission into this pipe until there is enough free space again. The transmit memory buffer is used to store the data transmitted by the application to the PC Host client using the FMSTR_PipeWrite call. The transmit buffer can get full when the PC Host is disconnected or when it is slow in receiving and reading out the pipe data.

The function returns the pipe handle which must be stored and used in the subsequent calls to manage the pipe object.

The callback function (if specified) is called whenever new data are received through the pipe and available for reading. This callback is also called when the data waiting in the transmit buffer are successfully pushed to the PC Host and the transmit buffer free space increases. The prototype of the callback function provided by the user application must be as follows. The *PipeHandler* name is only a placeholder and must be defined by the application.

```
void PipeHandler(FMSTR_HPIPE pipeHandle);
```

FMSTR_PipeClose

Prototype

```
void FMSTR_PipeClose(FMSTR_HPIPE pipeHandle);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_pipes.c*

Arguments

- *pipeHandle* [in] - pipe handle returned from the FMSTR_PipeOpen function call

Description This function de-initializes the pipe object. No data can be received or sent on the pipe after this call.

FMSTR_PipeWrite

Prototype

```
FMSTR_PIPE_SIZE FMSTR_PipeWrite(FMSTR_HPIPE pipeHandle, FMSTR_ADDR pipeData,  
    FMSTR_PIPE_SIZE pipeDataLen, FMSTR_PIPE_SIZE writeGranularity);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_pipes.c*

Arguments

- *pipeHandle* [in] - pipe handle returned from the FMSTR_PipeOpen function call
- *pipeData* [in] - address of the data to be written
- *pipeDataLen* [in] - length of the data to be written
- *writeGranularity* [in] - size of the minimum unit of data which is to be written

Description This function puts the user-specified data into the pipe's transmit memory buffer and schedules it for transmission. This function returns the number of bytes that were successfully written into the buffer. This number may be smaller than the number of the requested bytes if there is not enough free space in the transmit buffer.

The *writeGranularity* argument can be used to split the data into smaller chunks, each of the size given by the *writeGranularity* value. The FMSTR_PipeWrite function writes as many data chunks as possible into the transmit buffer and does not attempt to write an incomplete chunk. This feature can prove to be useful to avoid the intermediate caching when writing an array of integer values or other multi-byte data items. When making the *nGranularity* value equal to the *nLength* value, all data are considered as one chunk which is either written successfully as a whole or not at all. The *nGranularity* value of 0 or 1 disables the data-chunk approach.

FMSTR_PipeRead

Prototype

```
FMSTR_PIPE_SIZE FMSTR_PipeRead(FMSTR_HPIPE pipeHandle, FMSTR_ADDR pipeData,
    FMSTR_PIPE_SIZE pipeDataLen, FMSTR_PIPE_SIZE readGranularity);
```

- Declaration: *freemaster.h*
- Implementation: *freemaster_pipes.c*

Arguments

- *pipeHandle* [in] - pipe handle returned from the FMSTR_PipeOpen function call
- *pipeData* [in] - address of the data buffer to be filled with the received data
- *pipeDataLen* [in] - length of the data to be read
- *readGranularity* [in] - size of the minimum unit of data which is to be read

Description This function copies the data received from the pipe from its receive buffer to the user buffer for further processing. The function returns the number of bytes that were successfully copied to the buffer. This number may be smaller than the number of the requested bytes if there is not enough data bytes available in the receive buffer.

The readGranularity argument can be used to copy the data in larger chunks in the same way as described in the FMSTR_PipeWrite function.

API data types This section describes the data types used in the FreeMASTER driver. The information provided here can be useful when modifying or porting the FreeMASTER Communication Driver to new NXP platforms.

Note: The licensing conditions prohibit use of FreeMASTER and the FreeMASTER Communication Driver with non-NXP MPU or MCU products.

Public common types The table below describes the public data types used in the FreeMASTER driver API calls. The data types are declared in the *freemaster.h* header file.

Type name	Description
<i>FM-STR_ADDR</i> For example, this type is defined as long integer on the 56F8xxx platform where the 24-bit addresses must be supported, but the C-pointer may be only 16 bits wide in some compiler configurations.	Data type used to hold the memory address. On most platforms, this is normally a C-pointer, but it may also be a pure integer type.
<i>FM-STR_SIZE</i> It is required that this type is unsigned and at least 16 bits wide integer.	Data type used to hold the memory block size.
<i>FM-STR_BOOL</i> This type is used only in zero/non-zero conditions in the driver code.	Data type used as a general boolean type.
<i>FM-STR_APPCM</i> Generally, this is an unsigned 8-bit value.	Data type used to hold the Application Command code.
<i>FM-STR_APPCM</i> Generally, this is an unsigned 8-bit value.	Data type used to create the Application Command data buffer.
<i>FM-STR_APPCM</i> Generally, this is an unsigned 8-bit value.	Data type used to hold the Application Command result code.

Public TSA types The table describes the TSA-specific public data types. These types are declared in the *freemaster_tsa.h* header file, which is included in the user application indirectly by the *freemaster.h* file.

<i>FM-STR_TSA_TII</i>	Data type used to hold a descriptor index in the TSA table or a table index in the list of TSA tables. By default, this is defined as <i>FM-STR_SIZE</i> .
<i>FM-STR_TSA_TS</i>	Data type used to hold a memory block size, as used in the TSA descriptors. By default, this is defined as <i>FM-STR_SIZE</i> .

Public Pipes types The table describes the data types used by the FreeMASTER Pipes API:

<i>FM-STR_HPIPE</i>	Pipe handle that identifies the open-pipe object. Generally, this is a pointer to a void type.
<i>FM-STR_PIPE_PC</i>	Integer type required to hold at least 7 bits of data. Generally, this is an unsigned 8-bit or 16-bit type.
<i>FM-STR_PIPE_SI</i>	Integer type required to hold at least 16 bits of data. This is used to store the data buffer sizes.
<i>FM-STR_PPIPEF</i>	Pointer to the pipe handler function. See FM-STR_PipeOpen for more details.

Internal types The table describes the data types used internally by the FreeMASTER driver. The data types are declared in the platform-specific header file and they are not available in the application code.

<i>FMSTR_U8</i>	The smallest memory entity.
On the vast majority of platforms, this is an unsigned 8-bit integer.	
On the 56F8xx DSP platform, this is defined as an unsigned 16-bit integer.	
<i>FMSTR_U16</i>	Unsigned 16-bit integer.
<i>FMSTR_U32</i>	Unsigned 32-bit integer.
<i>FMSTR_S8</i>	Signed 8-bit integer.
<i>FMSTR_S16</i>	Signed 16-bit integer.
<i>FMSTR_S32</i>	Signed 32-bit integer.
<i>FMSTR_FLOAT</i>	4-byte standard IEEE floating-point type.
<i>FMSTR_FLAGS</i>	Data type forming a union with a structure of flag bit-fields.
<i>FMSTR_SIZE8</i>	Data type holding a general size value, at least 8 bits wide.
<i>FMSTR_INDEX</i>	General for-loop index. Must be signed, at least 16 bits wide.
<i>FMSTR_BCHR</i>	A single character in the communication buffer.
Typically, this is an 8-bit unsigned integer, except for the DSP platforms where it is a 16-bit integer.	
<i>FMSTR_BPTR</i>	A pointer to the communication buffer (an array of <i>FMSTR_BCHR</i>).

Document references

Links

- This document online: <https://mcuxpresso.nxp.com/mcuxsdk/latest/html/middleware/freemaster/doc/index.html>

- FreeMASTER tool home: www.nxp.com/freemaster
- FreeMASTER community area: community.nxp.com/community/freemaster
- FreeMASTER GitHub code repo: <https://github.com/nxp-mcuxpresso/mcux-freemaster>
- MCUXpresso SDK home: www.nxp.com/mcuxpresso
- MCUXpresso SDK builder: mcuxpresso.nxp.com/en

Documents

- *FreeMASTER Usage Serial Driver Implementation* (document [AN4752](#))
- *Integrating FreeMASTER Time Debugging Tool With CodeWarrior For Microcontrollers v10.X Project* (document [AN4771](#))
- *Flash Driver Library For MC56F847xx And MC56F827xx DSC Family* (document [AN4860](#))

Revision history This Table summarizes the changes done to this document since the initial release.

Revision	Date	Description
1.0	03/2006	Limited initial release
2.0	09/2007	Updated for FreeMASTER version. New Freescale document template used.
2.1	12/2007	Added description of the new Fast Recorder feature and its API.
2.2	04/2010	Added support for MPC56xx platform, Added new API for use CAN interface.
2.3	04/2011	Added support for Kxx Kinetis platform and MQX operating system.
2.4	06/2011	Serial driver update, adds support for USB CDC interface.
2.5	08/2011	Added Packet Driven BDM interface.
2.7	12/2013	Added FLEXCAN32 interface, byte access and isr callback configuration option.
2.8	06/2014	Removed obsolete license text, see the software package content for up-to-date license.
2.9	03/2015	Update for driver version 1.8.2 and 1.9: FreeMASTER Pipes, TSA Active Content, LIN Transport Layer support, DEBUG-TX communication troubleshooting, Kinetis SDK support.
3.0	08/2016	Update for driver version 2.0: Added support for MPC56xx, MPC57xx, KEAxx and S32Kxx platforms. New NXP document template as well as new license agreement used. added MCAN interface. Folders structure at the installation destination was rearranged.
4.0	04/2019	Update for driver released as part of FreeMASTER v3.0 and MCUXpresso SDK 2.6. Updated to match new V4 serial communication protocol and new configuration options. This version of the document removes substantial portion of outdated information related to S08, S12, ColdFire, Power and other legacy platforms.
4.1	04/2020	Minor update for FreeMASTER driver included in MCUXpresso SDK 2.8.
4.2	09/2020	Added example applications description and information about the MCUXpresso Config Tools. Fixed the pipe-related API description.
4.3	10/2024	Added description of Network and Segger J-Link RTT interface configuration. Accompanying the MCUXpresso SDK version 24.12.00.
4.4	04/2025	Added Zephyr-specific information. Accompanying the MCUXpresso SDK version 25.06.00.

3.2 MultiCore

3.2.1 Multicore SDK

Multicore Software Development Kit (MCSDK) is a Software Development Kit that provides comprehensive software support for NXP dual/multicore devices. The MCSDK is combined with the MCUXpresso SDK to make the software framework for easy development of multicore applications.

Multicore SDK (MCSDK) Release Notes

Overview These are the release notes for the NXP Multicore Software Development Kit (MCSDK) version 25.12.00.

This software package contains components for efficient work with multicore devices as well as for the multiprocessor communication.

What is new

- eRPC [CHANGELOG](#)
- RPPMsg-Lite [CHANGELOG](#)
- MCMgr [CHANGELOG](#)
- Supported evaluation boards (multicore examples):
 - LPCXpresso55S69
 - FRDM-K32L3A6
 - MIMXRT1170-EVKB
 - MIMXRT1160-EVK
 - MIMXRT1180-EVK
 - MCX-N5XX-EVK
 - MCX-N9XX-EVK
 - FRDM-MCXN947
 - MIMXRT700-EVK
 - KW47-EVK
 - KW47-LOC
 - FRDM-MCXW72
 - MCX-W72-EVK
 - FRDM-IMXRT1186
- Supported evaluation boards (multiprocessor examples):
 - LPCXpresso55S36
 - FRDM-K22F
 - FRDM-K32L2B
 - MIMXRT685-EVK
 - MIMXRT1170-EVKB
 - MIMXRT1180
 - FRDM-MCXN236
 - FRDM-MCXC242
 - FRDM-MCXC444
 - MCX-N9XX-EVK
 - FRDM-MCXN947
 - MIMXRT700-EVK
 - FRDM-IMXRT1186

Development tools The Multicore SDK (MCSDK) was compiled and tested with development tools referred in: [Development tools](#)

Release contents This table describes the release contents. Not all MCUXpresso SDK packages contain the whole set of these components.

Deliverable	Location
Multicore SDK location	<MCUXpressoSDK_install_dir>/middleware/multicore/
Documentation	<MCSDK_dir>/mcuxsdk-doc/
Embedded Remote Procedure Call component	<MCSDK_dir>/erpc/
Multicore Manager component	<MCSDK_dir>/mcmgr/
RPMsg-Lite	<MCSDK_dir>/rpmsg_lite/
Multicore demo applications	<MCUXpressoSDK_install_dir>/examples/multicore_examples/
Multiprocessor demo applications	<MCUXpressoSDK_install_dir>/examples/multiprocessor_examples/

Multicore SDK release overview Together, the Multicore SDK (MCSDK) and the MCUXpresso SDK (SDK) form a framework for the development of software for NXP multicore devices. The MCSDK release consists of the following elementary software components for multicore:

- Embedded Remote Procedure Call (eRPC)
- Multicore Manager (MCMGR) - included just in SDK for multicore devices
- Remote Processor Messaging - Lite (RPMsg-Lite) - included just in SDK for multicore devices

The MCSDK is also accompanied with documentation and several multicore and multiprocessor demo applications.

Demo applications The multicore demo applications demonstrate the usage of the MCSDK software components on supported multicore development boards.

The following multicore demo applications are located together with other MCUXpresso SDK examples in the <MCUXpressoSDK_install_dir>/examples/multicore_examples subdirectories.

- erpc_matrix_multiply_mu
- erpc_matrix_multiply_mu_rtos
- erpc_matrix_multiply_rpmsg
- erpc_matrix_multiply_rpmsg_rtos
- erpc_two_way_rpc_rpmsg_rtos
- freertos_message_buffers
- hello_world
- multicore_manager
- rpmsg_lite_pingpong
- rpmsg_lite_pingpong_rtos
- rpmsg_lite_pingpong_dsp
- rpmsg_lite_pingpong_tzm

The eRPC multicore component can be leveraged for inter-processor communication and remote procedure calls between SoCs / development boards.

The following multiprocessor demo applications are located together with other MCUXpresso SDK examples in

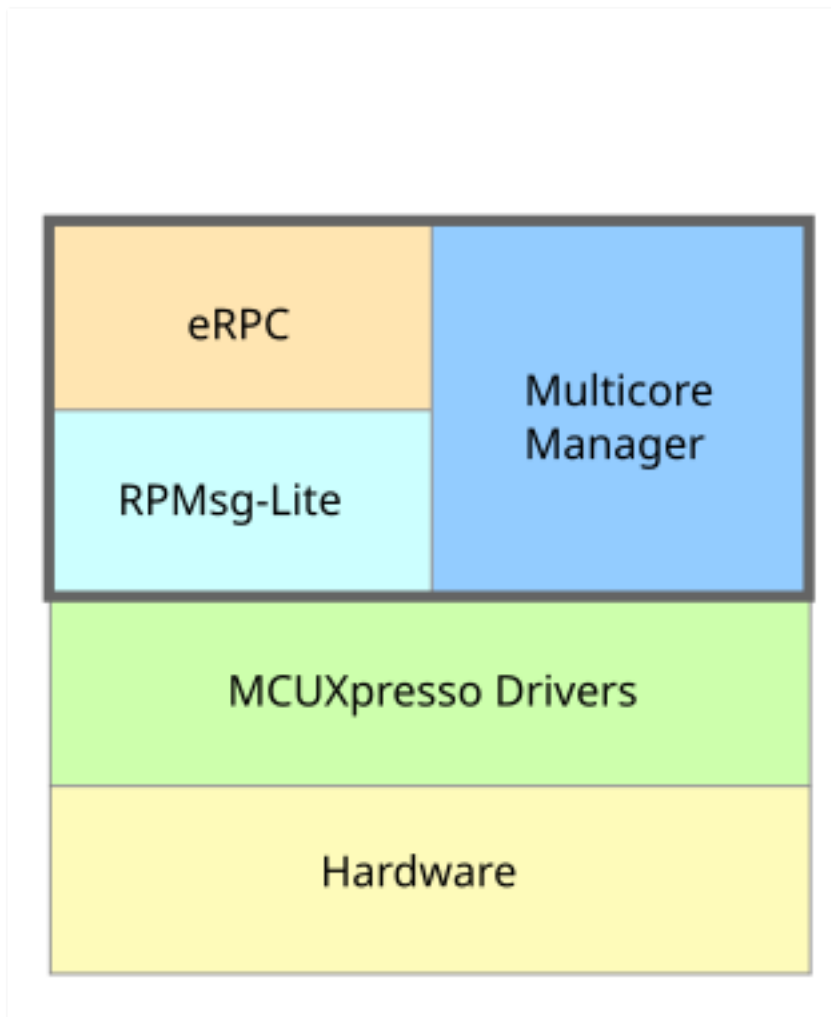
the <MCUXpressoSDK_install_dir>/examples/multiprocessor_examples subdirectories.

- erpc_client_matrix_multiply_spi
- erpc_server_matrix_multiply_spi
- erpc_client_matrix_multiply_uart
- erpc_server_matrix_multiply_uart
- erpc_server_dac_adc
- erpc_remote_control

Getting Started with Multicore SDK (MCSDK)

Overview Multicore Software Development Kit (MCSDK) is a Software Development Kit that provides comprehensive software support for NXP dual/multicore devices. The MCSDK is combined with the MCUXpresso SDK to make the software framework for easy development of multicore applications.

The following figure highlights the layers and main software components of the MCSDK.

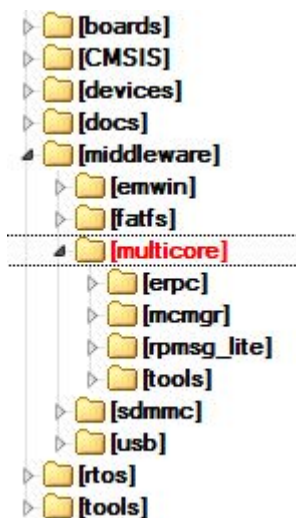


All the MCSDK-related files are located in `<MCUXpressoSDK_install_dir>/middleware/multicore` folder.

For supported toolchain versions, see the *Multicore SDK v25.12.00 Release Notes* (document MCS-DKRN). For the latest version of this and other MCSDK documents, visit www.nxp.com.

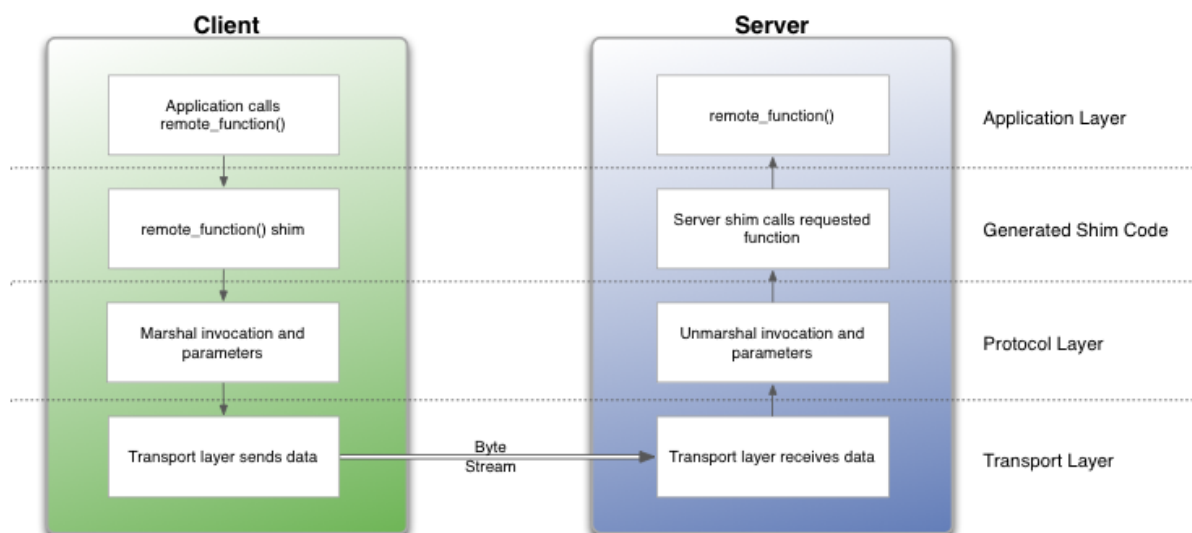
Multicore SDK (MCSDK) components The MCSDK consists of the following software components:

- **Embedded Remote Procedure Call (eRPC):** This component is a combination of a library and code generator tool that implements a transparent function call interface to remote services (running on a different core).
- **Multicore Manager (MCMGR):** This library maintains information about all cores and starts up secondary/auxiliary cores.
- **Remote Processor Messaging - Lite (RPMsg-Lite):** Inter-Processor Communication library.



Embedded Remote Procedure Call (eRPC) The Embedded Remote Procedure Call (eRPC) is the RPC system created by NXP. The RPC is a mechanism used to invoke a software routine on a remote system via a simple local function call.

When a remote function is called by the client, the function's parameters and an identifier for the called routine are marshaled (or serialized) into a stream of bytes. This byte stream is transported to the server through a communications channel (IPC, TPC/IP, UART, and so on). The server unmarshals the parameters, determines which function was invoked, and calls it. If the function returns a value, it is marshaled and sent back to the client.



RPC implementations typically use a combination of a tool (erpcgen) and IDL (interface definition language) file to generate source code to handle the details of marshaling a function's parameters and building the data stream.

Main eRPC features:

- Scalable from BareMetal to Linux OS - configurable memory and threading policies.
- Focus on embedded systems - intrinsic support for C, modular, and lightweight implementation.
- Abstracted transport interface - RPMsg is the primary transport for multicore, UART, or SPI-based solutions can be used for multichip.

The eRPC library is located in the `<MCUXpressoSDK_install_dir>/middleware/multicore/erpc` folder. For detailed information about the eRPC, see the documentation available in the `<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/doc` folder.

Multicore Manager (MCMGR) The Multicore Manager (MCMGR) software library provides a number of services for multicore systems.

The main MCMGR features:

- Maintains information about all cores in system.
- Secondary/auxiliary cores startup and shutdown.
- Remote core monitoring and event handling.

The MCMGR library is located in the `<MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr` folder. For detailed information about the MCMGR library, see the documentation available in the `<MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr/doc` folder.

Remote Processor Messaging Lite (RPMsg-Lite) RPMsg-Lite is a lightweight implementation of the RPMsg protocol. The RPMsg protocol defines a standardized binary interface used to communicate between multiple cores in a heterogeneous multicore system. Compared to the legacy OpenAMP implementation, RPMsg-Lite offers a code size reduction, API simplification, and improved modularity.

The main RPMsg protocol features:

- Shared memory interprocessor communication.
- Virtio-based messaging bus.
- Application-defined messages sent between endpoints.

- Portable to different environments/platforms.
- Available in upstream Linux OS.

The RPMsg-Lite library is located in the `<MCUXpressoSDK_install_dir>/middleware/multicore/rpmsg-lite` folder. For detailed information about the RPMsg-Lite, see the RPMsg-Lite User's Guide located in the `<MCUXpressoSDK_install_dir>/middleware/multicore/rpmsg_lite/doc` folder.

MCSDK demo applications Multicore and multiprocessor example applications are stored together with other MCUXpresso SDK examples, in the dedicated multicore subfolder.

Location		Folder
Multicore projects	example	<code><MCUXpressoSDK_install_dir>/examples/multicore_examples/<application_name>/</code>
Multiprocessor projects	example	<code><MCUXpressoSDK_install_dir>/examples/multiprocessor_examples/<application_name>/</code>

See the *Getting Started with MCUXpresso SDK* (document MCUXSDKGSUG) and *Getting Started with MCUXpresso SDK for XXX Derivatives* documents for more information about the MCUXpresso SDK example folder structure and the location of individual files that form the example application projects. These documents also contain information about building, running, and debugging multicore demo applications in individual supported IDEs. Each example application also contains a readme file that describes the operation of the example and required setup steps.

Inter-Processor Communication (IPC) levels The MCSDK provides several mechanisms for Inter-Processor Communication (IPC). Particular ways and levels of IPC are described in this chapter.

IPC using low-level drivers

The NXP multicore SoCs are equipped with peripheral modules dedicated for data exchange between individual cores. They deal with the Mailbox peripheral for LPC parts and the Messaging Unit (MU) peripheral for Kinetis and i.MX parts. The common attribute of both modules is the ability to provide a means of IPC, allowing multiple CPUs to share resources and communicate with each other in a simple manner.

The most lightweight method of IPC uses the MCUXpresso SDK low-level drivers for these peripherals. Using the Mailbox/MU driver API functions, it is possible to pass a value from core to core via the dedicated registers (could be a scalar or a pointer to shared memory) and also to trigger inter-core interrupts for notifications.

For details about individual driver API functions, see the MCUXpresso SDK API Reference Manual of the specific multicore device. The MCUXpresso SDK is accompanied with the RPMsg-Lite documentation that shows how to use this API in multicore applications.

Messaging mechanism

On top of Mailbox/MU drivers, a messaging system can be implemented, allowing messages to send between multiple endpoints created on each of the CPUs. The RPMsg-Lite library of the MCSDK provides this ability and serves as the preferred MCUXpresso SDK messaging library. It implements ring buffers in shared memory for messages exchange without the need of a locking mechanism.

The RPMsg-Lite provides the abstraction layer and can be easily ported to different multicore platforms and environments (Operating Systems). The advantages of such a messaging system are ease of use (there is no need to study behavior of the used underlying hardware) and smooth application code portability between platforms due to unified messaging API.

However, this costs several kB of code and data memory. The MCUXpresso SDK is accompanied by the RPMsg-Lite documentation and several multicore examples. You can also obtain the latest RPMsg-Lite code from the GitHub account github.com/nxp-mcuxpresso/rpmsg-lite.

Remote procedure calls

To facilitate the IPC even more and to allow the remote functions invocation, the remote procedure call mechanism can be implemented. The eRPC of the MCSDK serves for these purposes and allows the ability to invoke a software routine on a remote system via a simple local function call. Utilizing different transport layers, it is possible to communicate between individual cores of multicore SoCs (via RPMsg-Lite) or between separate processors (via SPI, UART, or TCP/IP). The eRPC is mostly applicable to the MPU parts with enough of memory resources like i.MX parts.

The eRPC library allows you to export existing C functions without having to change their prototypes (in most cases). It is accompanied by the code generator tool that generates the shim code for serialization and invocation based on the IDL file with definitions of data types and remote interfaces (API).

If the communicating peer is running as a Linux OS user-space application, the generated code can be either in C/C++ or Python.

Using the eRPC simplifies the access to services implemented on individual cores. This way, the following types of applications running on dedicated cores can be easily interfaced:

- Communication stacks (USB, Thread, Bluetooth Low Energy, Zigbee)
- Sensor aggregation/fusion applications
- Encryption algorithms
- Virtual peripherals

The eRPC is publicly available from the following GitHub account: github.com/EmbeddedRPC/erpc. Also, the MCUXpresso SDK is accompanied by the eRPC code and several multicore and multiprocessor eRPC examples.

The mentioned IPC levels demonstrate the scalability of the Multicore SDK library. Based on application needs, different IPC techniques can be used. It depends on the complexity, required speed, memory resources, system design, and so on. The MCSDK brings users the possibility for quick and easy development of multicore and multiprocessor applications.

Changelog Multicore SDK

All notable changes to this project will be documented in this file.

The format is based on [Keep a Changelog](#), and this project adheres to [Semantic Versioning](#).

[25.12.00]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.14.0
 - eRPC generator (erpcgen) v1.14.0
 - Multicore Manager (MCMgr) v5.0.2
 - RPMsg-Lite v5.3.0

[25.09.00]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.14.0

- eRPC generator (erpcgen) v1.14.0
- Multicore Manager (MCMgr) v5.0.1
- RPSMsg-Lite v5.2.1

[25.06.00]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.14.0
 - eRPC generator (erpcgen) v1.14.0
 - Multicore Manager (MCMgr) v5.0.0
 - RPSMsg-Lite v5.2.0

[25.03.00]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.13.0
 - eRPC generator (erpcgen) v1.13.0
 - Multicore Manager (MCMgr) v4.1.7
 - RPSMsg-Lite v5.1.4

[24.12.00]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.13.0
 - eRPC generator (erpcgen) v1.13.0
 - Multicore Manager (MCMgr) v4.1.6
 - RPSMsg-Lite v5.1.3

[2.16.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.13.0
 - eRPC generator (erpcgen) v1.13.0
 - Multicore Manager (MCMgr) v4.1.5
 - RPSMsg-Lite v5.1.2

[2.15.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.12.0
 - eRPC generator (erpcgen) v1.12.0
 - Multicore Manager (MCMgr) v4.1.5
 - RPSMsg-Lite v5.1.1

[2.14.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.11.0
 - eRPC generator (erpcgen) v1.11.0
 - Multicore Manager (MCMgr) v4.1.4
 - RPSMsg-Lite v5.1.0

[2.13.0_imxrt1180a0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.10.0
 - eRPC generator (erpcgen) v1.10.0
 - Multicore Manager (MCMgr) v4.1.3
 - RPSMsg-Lite v5.0.0

[2.13.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.10.0
 - eRPC generator (erpcgen) v1.10.0
 - Multicore Manager (MCMgr) v4.1.3
 - RPSMsg-Lite v5.0.0

[2.12.0_imx93]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.9.1
 - eRPC generator (erpcgen) v1.9.1
 - Multicore Manager (MCMgr) v4.1.2
 - RPSMsg-Lite v4.0.1

[2.12.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.9.1
 - eRPC generator (erpcgen) v1.9.1
 - Multicore Manager (MCMgr) v4.1.2
 - RPSMsg-Lite v4.0.0

[2.11.1]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.9.0
 - eRPC generator (erpcgen) v1.9.0
 - Multicore Manager (MCMgr) v4.1.1
 - RPSMsg-Lite v3.2.1

[2.11.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.9.0
 - eRPC generator (erpcgen) v1.9.0
 - Multicore Manager (MCMgr) v4.1.1
 - RPSMsg-Lite v3.2.0

[2.10.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.8.1
 - eRPC generator (erpcgen) v1.8.1
 - Multicore Manager (MCMgr) v4.1.1
 - RPSMsg-Lite v3.1.2

[2.9.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.8.0
 - eRPC generator (erpcgen) v1.8.0
 - Multicore Manager (MCMgr) v4.1.1
 - RPSMsg-Lite v3.1.1

[2.8.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.7.4
 - eRPC generator (erpcgen) v1.7.4
 - Multicore Manager (MCMgr) v4.1.0
 - RPSMsg-Lite v3.1.0

[2.7.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.7.3
 - eRPC generator (erpcgen) v1.7.3
 - Multicore Manager (MCMgr) v4.1.0
 - RPSMsg-Lite v3.0.0

[2.6.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.7.2
 - eRPC generator (erpcgen) v1.7.2
 - Multicore Manager (MCMgr) v4.0.3
 - RPSMsg-Lite v2.2.0

[2.5.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.7.1
 - eRPC generator (erpcgen) v1.7.1
 - Multicore Manager (MCMgr) v4.0.2
 - RPSMsg-Lite v2.0.2

[2.4.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.7.0
 - eRPC generator (erpcgen) v1.7.0
 - Multicore Manager (MCMgr) v4.0.1
 - RPSMsg-Lite v2.0.1

[2.3.1]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.6.0
 - eRPC generator (erpcgen) v1.6.0
 - Multicore Manager (MCMgr) v4.0.0
 - RPSMsg-Lite v1.2.0

[2.3.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.5.0
 - eRPC generator (erpcgen) v1.5.0
 - Multicore Manager (MCMgr) v3.0.0
 - RPMMsg-Lite v1.2.0

[2.2.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.4.0
 - eRPC generator (erpcgen) v1.4.0
 - Multicore Manager (MCMgr) v2.0.1
 - RPMMsg-Lite v1.1.0

[2.1.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.3.0
 - eRPC generator (erpcgen) v1.3.0

[2.0.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.2.0
 - eRPC generator (erpcgen) v1.2.0
 - Multicore Manager (MCMgr) v2.0.0
 - RPMMsg-Lite v1.0.0

[1.1.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.1.0
 - Multicore Manager (MCMgr) v1.1.0
 - Open-AMP / RPMMsg based on SHA1 ID 44b5f3c0a6458f3cf80 rev01

[1.0.0]

- Multicore SDK component versions:
 - embedded Remote Procedure Call (eRPC) v1.0.0
 - Multicore Manager (MCMgr) v1.0.0
 - Open-AMP / RPMMsg based on SHA1 ID 44b5f3c0a6458f3cf80 rev00

Multicore SDK Components

RPMSG-Lite

MCUXpresso SDK : mcuxsdk-middleware-rpmsg-lite

Overview This repository is for MCUXpresso SDK RPMSG-Lite middleware delivery and it contains RPMSG-Lite component officially provided in NXP MCUXpresso SDK. This repository is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository [mcuxsdk](#) for the complete delivery of MCUXpresso SDK to be able to build and run RPMSG-Lite examples that are based on mcux-sdk-middleware-rpmsg-lite component.

Documentation Overall details can be reviewed here: [MCUXpresso SDK Online Documentation](#)

Visit [RPMSG-Lite - Documentation](#) to review details on the contents in this sub-repo.

For Further API documentation, please look at [doxygen documentation](#)

Setup Instructions on how to install the MCUXpresso SDK provided from GitHub via west manifest [Getting Started with SDK - Detailed Installation Instructions](#)

Contribution We welcome and encourage the community to submit patches directly to the rpmsg-lite project placed on github. Contributing can be managed via pull-requests. Before a pull-request is created the code should be tested and properly formatted.

RPMSG-Lite This documentation describes the RPMsg-Lite component, which is a lightweight implementation of the Remote Processor Messaging (RPMsg) protocol. The RPMsg protocol defines a standardized binary interface used to communicate between multiple cores in a heterogeneous multicore system.

Compared to the RPMsg implementation of the Open Asymmetric Multi Processing (OpenAMP) framework (<https://github.com/OpenAMP/open-amp>), the RPMsg-Lite offers a code size reduction, API simplification, and improved modularity. On smaller Cortex-M0+ based systems, it is recommended to use RPMsg-Lite.

The RPMsg-Lite is an open-source component developed by NXP Semiconductors and released under the BSD-compatible license.

For overview please read RPMSG-Lite VirtIO Overview.

For RPMSG-Lite Design Considerations please read RPMSG-Lite Design Considerations.

Motivation to create RPMsg-Lite There are multiple reasons why RPMsg-Lite was developed. One reason is the need for the small footprint of the RPMsg protocol-compatible communication component, another reason is the simplification of extensive API of OpenAMP RPMsg implementation.

RPMsg protocol was not documented, and its only definition was given by the Linux Kernel and legacy OpenAMP implementations. This has changed with [1] which is a standardization protocol allowing multiple different implementations to coexist and still be mutually compatible.

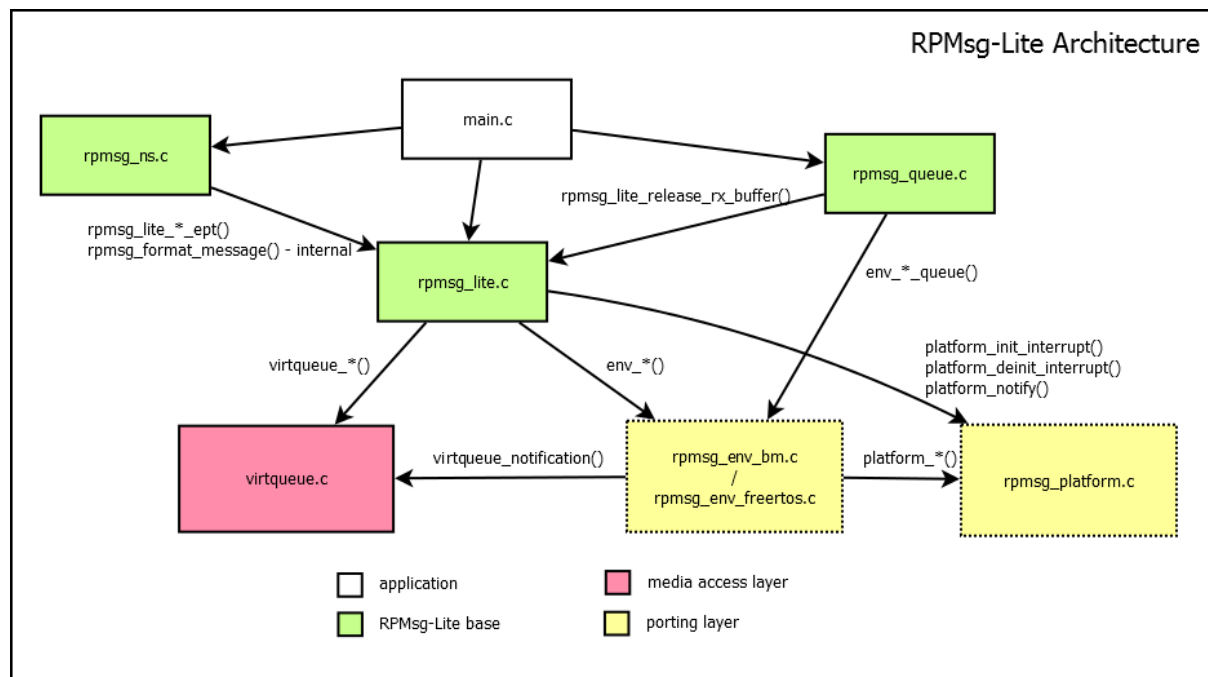
Small MCU-based systems often do not implement dynamic memory allocation. The creation of static API in RPMsg-Lite enables another reduction of resource usage. Not only does the dynamic allocation adds another 5 KB of code size, but also communication is slower and less deterministic, which is a property introduced by dynamic memory. The following table shows some rough comparison data between the OpenAMP RPMsg implementation and new RPMsg-Lite implementation:

Component / Configuration	Flash [B]	RAM [B]
OpenAMP RPMsg / Release (reference)	5547	456 + dynamic
RPMsg-Lite / Dynamic API, Release	3462	56 + dynamic
Relative Difference [%]	~62.4%	~12.3%
RPMsg-Lite / Static API (no malloc), Release	2926	352
Relative Difference [%]	~52.7%	~77.2%

Implementation The implementation of RPMsg-Lite can be divided into three sub-components, from which two are optional. The core component is situated in `rpmsg_lite.c`. Two optional components are used to implement a blocking receive API (in `rpmsg_queue.c`) and dynamic “named” endpoint creation and deletion announcement service (in `rpmsg_ns.c`).

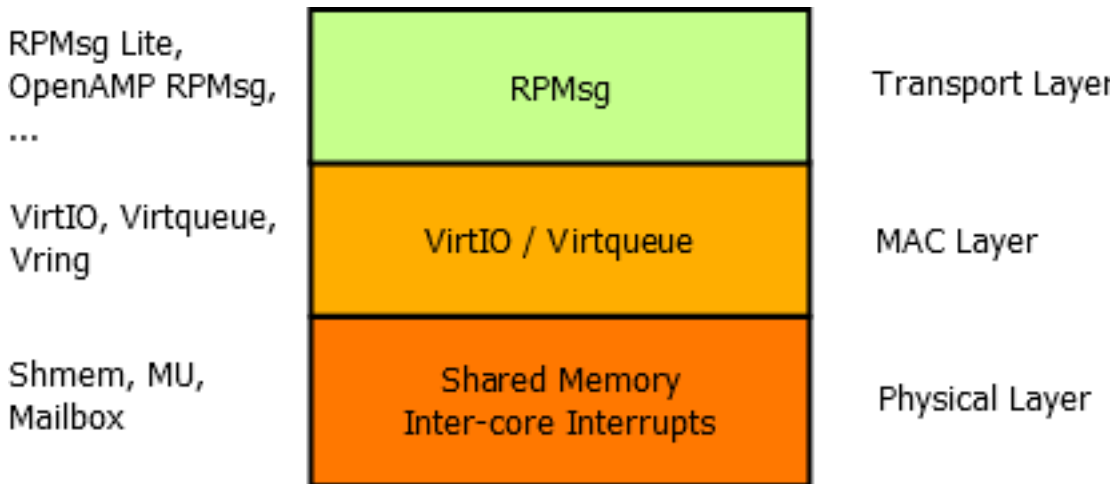
The actual “media access” layer is implemented in `virtqueue.c`, which is one of the few files shared with the OpenAMP implementation. This layer mainly defines the shared memory model, and internally defines used components such as `vring` or `virtqueue`.

The porting layer is split into two sub-layers: the environment layer and the platform layer. The first sublayer is to be implemented separately for each environment. (The bare metal environment already exists and is implemented in `rpmsg_env_bm.c`, and the FreeRTOS environment is implemented in `rpmsg_env_freertos.c` etc.) Only the source file, which matches the used environment, is included in the target application project. The second sublayer is implemented in `rpmsg_platform.c` and defines low-level functions for interrupt enabling, disabling, and triggering mainly. The situation is described in the following figure:



RPMsg-Lite core sub-component This subcomponent implements a blocking send API and callback-based receive API. The RPMsg protocol is part of the transport layer. This is realized by using so-called endpoints. Each endpoint can be assigned a different receive callback function.

However, it is important to notice that the callback is executed in an interrupt environment in current design. Therefore, certain actions like memory allocation are discouraged to execute in the callback. The following figure shows the role of RPMsg in an ISO/OSI-like layered model:



Queue sub-component (optional) This subcomponent is optional and requires implementation of the `env_*_queue()` functions in the environment porting layer. It uses a blocking receive API, which is common in RTOS-environments. It supports both copy and nocopy blocking receive functions.

Name Service sub-component (optional) This subcomponent is a minimum implementation of the name service which is present in the Linux Kernel implementation of RPMsg. It allows the communicating node both to send announcements about “named” endpoint (in other words, channel) creation or deletion and to receive these announcement taking any user-defined action in an application callback. The endpoint address used to receive name service announcements is arbitrarily fixed to be 53 (0x35).

Usage The application should put the `/rpmmsg_lite/lib/include` directory to the include path and in the application, include either the `rpmmsg_lite.h` header file, or optionally also include the `rpmmsg_queue.h` and/or `rpmmsg_ns.h` files. Both porting sublayers should be provided for you by NXP, but if you plan to use your own RTOS, all you need to do is to implement your own environment layer (in other words, `rpmmsg_env_myrtos.c`) and to include it in the project build.

The initialization of the stack is done by calling the `rpmmsg_lite_master_init()` on the master side and the `rpmmsg_lite_remote_init()` on the remote side. This initialization function must be called prior to any RPMsg-Lite API call. After the init, it is wise to create a communication endpoint, otherwise communication is not possible. This can be done by calling the `rpmmsg_lite_create_ept()` function. It optionally accepts a last argument, where an internal context of the endpoint is created, just in case the `RL_USE_STATIC_API` option is set to 1. If not, the stack internally calls `env_alloc()` to allocate dynamic memory for it. In case a callback-based receiving is to be used, an ISR-callback is registered to each new endpoint with user-defined callback data pointer. If a blocking receive is desired (in case of RTOS environment), the `rpmmsg_queue_create()` function must be called before calling `rpmmsg_lite_create_ept()`. The queue handle is passed to the endpoint creation function as a callback data argument and the callback function is set to `rpmmsg_queue_rx_cb()`. Then, it is possible to use `rpmmsg_queue_receive()` function to listen on a queue object for incoming messages. The `rpmmsg_lite_send()` function is used to send messages to the other side.

The RPMsg-Lite also implements no-copy mechanisms for both sending and receiving operations. These methods require specifics that have to be considered when used in an application.

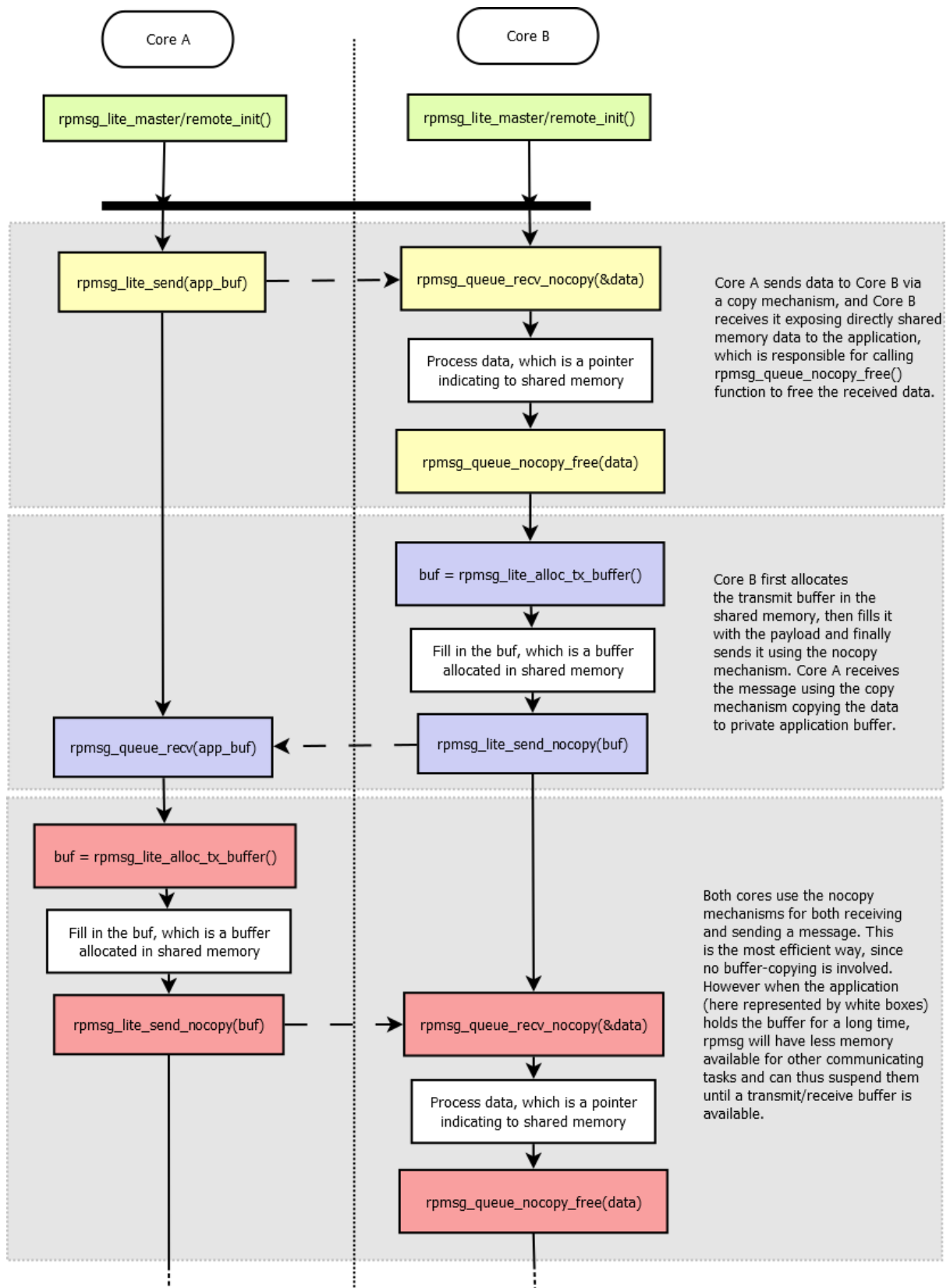
no-copy-send mechanism: This mechanism allows sending messages without the cost for copying data from the application buffer to the RPMsg/virtio buffer in the shared memory. The sequence of no-copy sending steps to be performed is as follows:

- Call the `rpmmsg_lite_alloc_tx_buffer()` function to get the virtio buffer and provide the buffer pointer to the application.
- Fill the data to be sent into the pre-allocated virtio buffer. Ensure that the filled data does not exceed the buffer size (provided as the `rpmmsg_lite_alloc_tx_buffer()` size output parameter).
- Call the `rpmmsg_lite_send_nocopy()` function to send the message to the destination endpoint. Consider the cache functionality and the virtio buffer alignment. See the `rpmmsg_lite_send_nocopy()` function description below.

no-copy-receive mechanism: This mechanism allows reading messages without the cost for copying data from the virtio buffer in the shared memory to the application buffer. The sequence of no-copy receiving steps to be performed is as follows:

- Call the `rpmmsg_queue_rcv_nocopy()` function to get the virtio buffer pointer to the received data.
- Read received data directly from the shared memory.
- Call the `rpmmsg_queue_nocopy_free()` function to release the virtio buffer and to make it available for the next data transfer.

The user is responsible for destroying any RPMsg-Lite objects he has created in case of deinitialization. In order to do this, the function `rpmmsg_queue_destroy()` is used to destroy a queue, `rpmmsg_lite_destroy_ept()` is used to destroy an endpoint and finally, `rpmmsg_lite_deinit()` is used to deinitialize the RPMsg-Lite intercore communication stack. Deinitialize all endpoints using a queue before deinitializing the queue. Otherwise, you are actively invalidating the used queue handle, which is not allowed. RPMsg-Lite does not check this internally, since its main aim is to be lightweight.



Examples RPSMsg Lite multicore examples are part of NXP MCUXpressoSDK packages. Visit <https://mcuxpresso.nxp.com> to configure, build and download these packages. To get the board list with multicore support (RPSMsg Lite included) use filtering based on Middleware and search for 'multicore' string. Once the selected package with the multicore middleware is downloaded,

see

`<MCUXpressoSDK_install_dir>/boards/<board_name>/multicore_examples` for RPMsg_Lite multicore examples with 'rpmmsg_lite_' name prefix.

Another way of getting NXP MCUXpressoSDK RPMsg_Lite multicore examples is using the [mcuxsdk-manifests](#) Github repo. Follow the description how to use the West tool to clone and update the mcuxsdk-manifests repo in [readme section](#). Once done the armgcc rpmmsg_lite examples can be found in

`mcuxsdk/examples/_<board_name>/multicore_examples`

You can use the evkmimxrt1170 as the board_name for instance. Similar to MCUXpressoSDK packages the RPMsg_Lite examples use the 'rpmmsg_lite_' name prefix.

Notes

Environment layers implementation Several environment layers are provided in `lib/rpmmsg_lite/porting/environment` folder. Not all of them are fully tested however. Here is the list of environment layers that passed testing:

- `rpmmsg_env_bm.c`
- `rpmmsg_env_freertos.c`
- `rpmmsg_env_xos.c`
- `rpmmsg_env_threadx.c`

The rest of environment layers has been created and used in some experimental projects, it has been running well at the time of creation but due to the lack of unit testing there is no guarantee it is still fully functional.

Shared memory configuration It is important to correctly initialize/configure the shared memory for data exchange in the application. The shared memory must be accessible from both the master and the remote core and it needs to be configured as Non-Cacheable memory. Dedicated shared memory section in linker file is also a good practise, it is recommended to use linker files from MCUXpressoSDK packages for NXP devices based applications. It needs to be ensured no other application part/component is unintentionally accessing this part of memory.

Configuration options The RPMsg-Lite can be configured at the compile time. The default configuration is defined in the `rpmmsg_default_config.h` header file. This configuration can be customized by the user by including `rpmmsg_config.h` file with custom settings. The following table summarizes all possible RPMsg-Lite configuration options.

Config- uration option	De- fault value	Usage
RL_MS_PE (1)		Delay in milliseconds used in non-blocking API functions for polling.
RL_BUFFE (496)		Size of the buffer payload, it must be more than 1 byte, and has to be word align (including rpmsg header size 16 bytes), if not it will be aligned up
RL_BUFFE (2)		Number of the buffers, it must be power of two (2, 4, ...)
RL_API_H (1)		Zero-copy API functions enabled/disabled.
RL_USE_S' (0)		Static API functions (no dynamic allocation) enabled/disabled.
RL_USE_D (0)		Memory cache management of shared memory. Use in case of data cache is enabled for shared memory.
RL_CLEAF (0)		Clearing used buffers before returning back to the pool of free buffers enabled/disabled.
RL_USE_M (0)		When enabled IPC interrupts are managed by the Multicore Manager (IPC interrupts router), when disabled RPMsg-Lite manages IPC interrupts by itself.
RL_USE_E (0)		When enabled the environment layer uses its own context. Required for some environments (QNX). The default value is 0 (no context, saves some RAM).
RL_DEBU (0)		When enabled buffer pointers passed to <code>rpmsg_lite_send_nocopy()</code> and <code>rpmsg_lite_release_rx_buffer()</code> functions (enabled by <code>RL_API_HAS_ZEROCOPY</code> config) are checked to avoid passing invalid buffer pointer. The default value is 0 (disabled). Do not use in RPMsg-Lite to Linux configuration.
RL_ALLOV (0)		When enabled the opposite side is notified each time received buffers are consumed and put into the queue of available buffers. Enable this option in RPMsg-Lite to Linux configuration to allow unblocking of the Linux blocking send. The default value is 0 (RPMsg-Lite to RPMsg-Lite communication).
RL_ALLOV (0)		It allows to define custom shared memory configuration and replacing the shared memory related global settings from <code>rpmsg_config.h</code> . This is useful when multiple instances are running in parallel but different shared memory arrangement (vring size & alignment, buffers size & count) is required. The default value is 0 (all RPMsg_Lite instances use the same shared memory arrangement as defined by common config macros).
RL_ASSER	see rpmsg	Assert implementation.

How to format rpmsg-lite code To format code, use the application developed by Google, named *clang-format*. This tool is part of the [llvm](#) project. Currently, the clang-format 10.0.0 version is used for rpmsg-lite. The set of style settings used for clang-format is defined in the `.clang-format` file, placed in a root of the rpmsg-lite directory where Python script `run_clang_format.py` can be executed. This script executes the application named *clang-format.exe*. You need to have the path of this application in the OS's environment path, or you need to change the script.

References

[1] M. Novak, M. Cingel, **Lockless Shared Memory Based Multicore Communication Protocol**
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Changelog RPMSG-Lite All notable changes to this project will be documented in this file. The format is based on [Keep a Changelog](#), and this project adheres to [Semantic Versioning](#).

[v5.3.0]

Added

- RT700 porting layer added support to send rpmsg messages between CM33_0 <-> Hifi1 and CM33_1 <-> Hifi4 cores.
- Add new platform macro `RL_PLATFORM_MAX_ISR_COUNT` this will set number of IRQ count per platform. This macro is then used in environment layers to set `isr_table` size where irq handles are registered. It size should match the bit length of `VQ_ID` so all combinations can fit into table.
- Unit tests updated to improve code coverage, new unit tests added covering static allocations in rtos environment layers.

Fixed

- `virtio.h` removed `typedef uint8_t boolean` and in its place use standard C99 `bool` type to avoid potential type conflicts.
- `env_acquire_sync_lock()` and `env_release_sync_lock()` synchronization primitives removed
- Kconfig consolidation, when `RL_ALLOW_CUSTOM_SHMEM_CONFIG` enabled the `platform_get_custom_shmem_config()` function needs to be implemented in platform layer to provide custom shared memory configuration for RPMsg-Lite instance.

v5.2.1

Added

- Doc added RPMSG-Lite VirtIO Overview
- Doc added RPMSG-Lite Design Considerations
- Added `frdmimxrt1186` unit testing

Changed

- Remove limitation that `RL_BUFFER_SIZE` needs to be power of 2. It just has to be more than 16 bytes, e.g. 16 bytes of rpmsg header and payload size at least 1 byte and word aligned, if not it will be aligned up.

Fixed

- Fixed CERT-C INT31-C violation in `platform_notify` function in `rpmsg_platform.c` for `imxrt700_m33`, `imxrt700_hifi4`, `imxrt700_hifi1` platforms

v5.2.0

Added

- Add MCXL20 porting layer and unit testing
- New utility macro `RL_CALCULATE_BUFFER_COUNT_DOWN_SAFE` to safely determine maximum buffer count within shared memory while preventing integer underflow.
- RT700 platform add support for MCMGR in DSPs

Changed

- Change `rpmsg_platform.c` to support new MCMGR API
- Improved input validation in initialization functions to properly handle insufficient memory size conditions.
- Refactored repeated buffer count calculation pattern for better code maintainability.
- To make sure that remote has already registered IRQ there is required App level IPC mechanism to notify master about it

Fixed

- Fixed `env_wait_for_link_up` function to handle timeout in link state checks for baremetal and qnx environment, `RL_BLOCK` mode can be used to wait indefinitely.
- Fixed CERT-C INT31-C violation by adding compile-time check to ensure `RL_PLATFORM_HIGHEST_LINK_ID` remains within safe range for 16-bit casting in virtqueue ID creation.
- Fixed CERT-C INT30-C violations by adding protection against unsigned integer underflow in shared memory calculations, specifically in `shmem_length - (uint32_t)RL_VRING_OVERHEAD` and `shmem_length - 2U * shmem_config.vring_size` expressions.
- Fixed CERT INT31-C violation in `platform_interrupt_disable()` and similar functions by replacing unsafe cast from `uint32_t` to `int32_t` with a return of 0 constant.
- Fixed unsigned integer underflow in `rpmsg_lite_alloc_tx_buffer()` where subtracting header size from buffer size could wrap around if buffer was too small, potentially leading to incorrect buffer sizing.
- Fixed CERT-C INT31-C violation in `rpmsg_lite.c` where `size` parameter was cast from `uint32_t` to `uint16_t` without proper validation.
 - Applied consistent masking approach to both `size` and `flags` parameters: `(uint16_t)(value & 0xFFFFU)`.
 - This fix prevents potential data loss when `size` values exceed 65535.
- Fixed CERT INT31-C violation in `env_memset` functions by explicitly converting `int32_t` values to unsigned char using bit masking. This prevents potential data loss or misinterpretation when passing values outside the unsigned char range (0-255) to the standard `memset()` function.
- Fixed CERT-C INT31-C violations in RPMsg-Lite environment porting: Added validation checks for signed-to-unsigned integer conversions to prevent data loss and misinterpretation.
 - `rpmsg_env_freertos.c`: Added validation before converting `int32_t` to `UBaseType_t`.
 - `rpmsg_env_qnx.c`: Fixed format string and added validation before assigning to `mqstat` fields.
 - `rpmsg_env_threadx.c`: Added validation to prevent integer overflow and negative values.
 - `rpmsg_env_xos.c`: Added range checking before casting to `uint16_t`.
 - `rpmsg_env_zephyr.c`: Added validation before passing values to `k_msgq_init`.
- Fixed a CERT INT31-C compliance issue in `env_get_current_queue_size()` function where an unsigned queue count was cast to a signed `int32_t` without proper validation, which could lead to lost or misinterpreted data if queue size exceeded `INT32_MAX`.
- Fixed CERT INT31-C violation in `rpmsg_platform.c` where `memcmp()` return value (signed int) was compared with unsigned constant without proper type handling.

- Fixed CERT INT31-C violation in `rpmsg_platform.c` where casting from `uint32_t` to `uint16_t` could potentially result in data loss. Changed length variable type from `uint16_t` to `uint32_t` to properly handle memory address differences without truncation.
- Fixed potential integer overflow in `env_sleep_msec()` function in ThreadX environment implementation by rearranging calculation order in the sleep duration formula.
- Fixed CERT-C INT31-C violation in RPMsg-Lite where bitwise NOT operations on integer constants were performed in signed integer context before being cast to unsigned. This could potentially lead to misinterpreted data on `imx943` platform.
- Added `RL_MAX_BUFFER_COUNT` (32768U) and `RL_MAX_VRING_ALIGN` (65536U) limit to ensure alignment values cannot contribute to integer overflow
- Fixed CERT INT31-C violation in `vring_need_event()`, added cast to `uint16_t` for each operand.

v5.1.4 - 27-Mar-2025

Added

- Add KW43B43 porting layer

Changed

- Doxygen bump to version 1.9.6

v5.1.3 - 13-Jan-2025

Added

- Memory cache management of shared memory. Enable with `#define RL_USE_DCACHE (1)` in `rpmsg_config.h` in case of data cache is used.
- Cmake/Kconfig support added.
- Porting layers for `imx95`, `imxrt700`, `mcmxw71x`, `mcmxw72x`, `kw47b42` added.

v5.1.2 - 08-Jul-2024

Changed

- Zephyr-related changes.
- Minor Misra corrections.

v5.1.1 - 19-Jan-2024

Added

- Test suite provided.
- Zephyr support added.

Changed

- Minor changes in platform and env. layers, minor test code updates.

v5.1.0 - 02-Aug-2023**Added**

- RPMMsg-Lite: Added aarch64 support.

Changed

- RPMMsg-Lite: Increased the queue size to (2 * RL_BUFFER_COUNT) to cover zero copy cases.
- Code formatting using LLVM16.

Fixed

- Resolved issues in ThreadX env. layer implementation.

v5.0.0 - 19-Jan-2023**Added**

- Timeout parameter added to `rpmmsg_lite_wait_for_link_up` API function.

Changed

- Improved debug check buffers implementation - instead of checking the pointer fits into shared memory check the presence in the VirtIO ring descriptors list.
- VRING_SIZE is set based on number of used buffers now (as calculated in `vring_init`) - updated for all platforms that are not communicating to Linux rpmmsg counterpart.

Fixed

- Fixed wrong RL_VRING_OVERHEAD macro comment in platform.h files
- Misra corrections.

v4.0.0 - 20-Jun-2022**Added**

- Added support for custom shared memory arrangement per the RPMMsg_Lite instance.
- Introduced new `rpmmsg_lite_wait_for_link_up()` API function - this allows to avoid using busy loops in rtos environments, GitHub PR [#21](#).

Changed

- Adjusted `rpmmsg_lite_is_link_up()` to return RL_TRUE/RL_FALSE.

v3.2.0 - 17-Jan-2022

Added

- Added support for i.MX8 MP multicore platform.

Changed

- Improved static allocations - allow OS-specific objects being allocated statically, GitHub PR [#14](#).
- Aligned rpmsg_env_xos.c and some platform layers to latest static allocation support.

Fixed

- Minor Misra and typo corrections, GitHub PR [#19](#), [#20](#).

v3.1.2 - 16-Jul-2021

Added

- Addressed MISRA 21.6 rule violation in rpmsg_env.h (use SDK's PRINTF in MCUXpressoSDK examples, otherwise stdio printf is used).
- Added environment layers for XOS.
- Added support for i.MX RT500, i.MX RT1160 and i.MX RT1170 multicore platforms.

Fixed

- Fixed incorrect description of the rpmsg_lite_get_endpoint_from_addr function.

Changed

- Updated RL_BUFFER_COUNT documentation (issue [#10](#)).
- Updated imxrt600_hifi4 platform layer.

v3.1.1 - 15-Jan-2021

Added

- Introduced RL_ALLOW_CONSUMED_BUFFERS_NOTIFICATION config option to allow opposite side notification sending each time received buffers are consumed and put into the queue of available buffers.
- Added environment layers for Threadx.
- Added support for i.MX8QM multicore platform.

Changed

- Several MISRA C-2012 violations addressed.

v3.1.0 - 22-Jul-2020

Added

- Added support for several new multicore platforms.

Fixed

- MISRA C-2012 violations fixed (7.4).
- Fixed missing lock in `rpmsg_lite_rx_callback()` for QNX env.
- Correction of `rpmsg_lite_instance` structure members description.
- Address -Waddress-of-packed-member warnings in GCC9.

Changed

- Clang update to v10.0.0, code re-formatted.

v3.0.0 - 20-Dec-2019**Added**

- Added support for several new multicore platforms.

Fixed

- MISRA C-2012 violations fixed, incl. data types consolidation.
- Code formatted.

v2.2.0 - 20-Mar-2019**Added**

- Added configuration macro `RL_DEBUG_CHECK_BUFFERS`.
- Several MISRA violations fixed.
- Added environment layers for QNX and Zephyr.
- Allow environment context required for some environment (controlled by the `RL_USE_ENVIRONMENT_CONTEXT` configuration macro).
- Data types consolidation.

v1.1.0 - 28-Apr-2017**Added**

- Supporting i.MX6SX and i.MX7D MPU platforms.
- Supporting LPC5411x MCU platform.
- Baremetal and FreeRTOS support.
- Support of copy and zero-copy transfer.
- Support of static API (without dynamic allocations).

Multicore Manager

MCUXpresso SDK : mcuxsdk-middleware-mcmgr (Multicore Manager)

Overview This repository is for MCUXpresso SDK Multicore Manager middleware delivery and it contains Multicore Manager component officially provided in NXP MCUXpresso SDK. This repository is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository [mcuxsdk](#) for the complete delivery of MCUXpresso SDK to be able to build and run Multicore Manager examples that are based on mcux-sdk-middleware-mcmgr component.

Documentation Overall details can be reviewed here: [MCUXpresso SDK Online Documentation](#)

Visit [Multicore Manager - Documentation](#) to review details on the contents in this sub-repo.

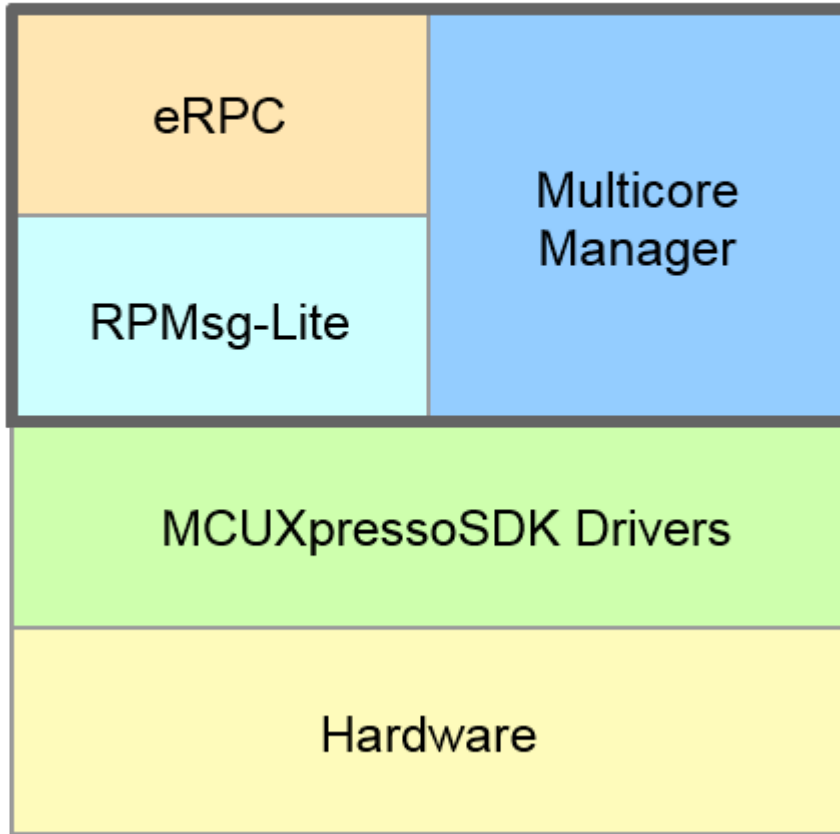
For Further API documentation, please look at [doxygen documentation](#)

Setup Instructions on how to install the MCUXpresso SDK provided from GitHub via west manifest [Getting Started with SDK - Detailed Installation Instructions](#)

Contribution We welcome and encourage the community to submit patches directly to the mcmgr project placed on github. Contributing can be managed via pull-requests. Before a pull-request is created the code should be tested and properly formatted.

Multicore Manager (MCMGR) The Multicore Manager (MCMGR) software library provides a number of services for multicore systems. This library is distributed as a part of the Multicore SDK (MCSDK). Together, the MCSDK and the MCUXpresso SDK (SDK) form a framework for development of software for NXP multicore devices.

The MCMGR component is located in the `<MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr` directory.



The Multicore Manager provides the following major functions:

- Maintains information about all cores in system.
- Secondary/auxiliary core(s) startup and shutdown.
- Remote core monitoring and event handling.

Usage of the MCMGR software component The main use case of MCMGR is the secondary/auxiliary core start. This functionality is performed by the public API function.

Example of MCMGR usage to start secondary core:

```
#include "mcmgr.h"

void main()
{
    /* Initialize MCMGR - low level multicore management library.
       Call this function as close to the reset entry as possible,
       (into the startup sequence) to allow CoreUp event triggering. */
    MCMGR_EarlyInit();

    /* Initialize MCMGR, install generic event handlers */
    MCMGR_Init();
}
```

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```

/* Boot secondary core application from the CORE1_BOOT_ADDRESS, pass "1" as startup data,
↳ starting synchronously. */
MCMGR_StartCore(kMCMGR_Core1, CORE1_BOOT_ADDRESS, 1, kMCMGR_Start_Synchronous);
.
.
.
/* Stop secondary core execution. */
MCMGR_StopCore(kMCMGR_Core1);
}

```

Some platforms allow stopping and re-starting the secondary core application again, using the MCMGR_StopCore / MCMGR_StartCore API calls. It is necessary to ensure the initially loaded image is not corrupted before re-starting, especially if it deals with the RAM target. Cache coherence has to be considered/ensured as well.

It could also happen that the secondary core application stops running correctly and the primary core application does not know about that situation. Therefore, it is beneficial to implement a mechanism for core health monitoring. The *test_heartbeat* unit test can serve as an example how to ensure that: secondary core could periodically send heartbeat signals to the primary core using MCMGR_TriggerEvent() API to indicate that it is alive and functioning properly.

Another important MCMGR feature is the ability for remote core monitoring and handling of events such as reset, exception, and application events. Application-specific callback functions for events are registered by the MCMGR_RegisterEvent() API. Triggering these events is done using the MCMGR_TriggerEvent() API. mcmgr_event_type_t enums all possible event types.

An example of MCMGR usage for remote core monitoring and event handling. Code for the primary side:

```

#include "mcmgr.h"

#define APP_RPMSG_READY_EVENT_DATA (1)
#define APP_NUMBER_OF_CORES (2)
#define APP_SECONDARY_CORE kMCMGR_Core1

/* Callback function registered via the MCMGR_RegisterEvent() and triggered by MCMGR_TriggerEvent()
↳ called on the secondary core side */
void RPSMsgRemoteReadyEventHandler(mcmgr_core_t coreNum, uint16_t eventData, void *context)
{
    uint16_t *data = &((uint16_t *)context)[coreNum];

    *data = eventData;
}

void main()
{
    uint16_t RPSMsgRemoteReadyEventData[NUMBER_OF_CORES] = {0};

    /* Initialize MCMGR - low level multicore management library.
       Call this function as close to the reset entry as possible,
       (into the startup sequence) to allow CoreUp event triggering. */
    MCMGR_EarlyInit();

    /* Initialize MCMGR, install generic event handlers */
    MCMGR_Init();

    /* Register the application event before starting the secondary core */
    MCMGR_RegisterEvent(kMCMGR_RemoteApplicationEvent, RPSMsgRemoteReadyEventHandler, (void
↳ *)RPSMsgRemoteReadyEventData);

```

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```

/* Boot secondary core application from the CORE1_BOOT_ADDRESS, pass rpmsg_lite_base address
↳as startup data, starting synchronously. */
MCMGR_StartCore(APP_SECONDARY_CORE, CORE1_BOOT_ADDRESS, (uint32_t)rpmsg_lite_
↳base, kMCMGR_Start_Synchronous);

/* Wait until the secondary core application signals the rpmsg remote has been initialized and is ready to
↳communicate. */
while(APP_RPMSG_READY_EVENT_DATA != RPSMsgRemoteReadyEventData[APP_SECONDARY_
↳CORE]) {};
.
.
.
}

```

Code for the secondary side:

```

#include "mcmgr.h"

#define APP_RPMSG_READY_EVENT_DATA (1)

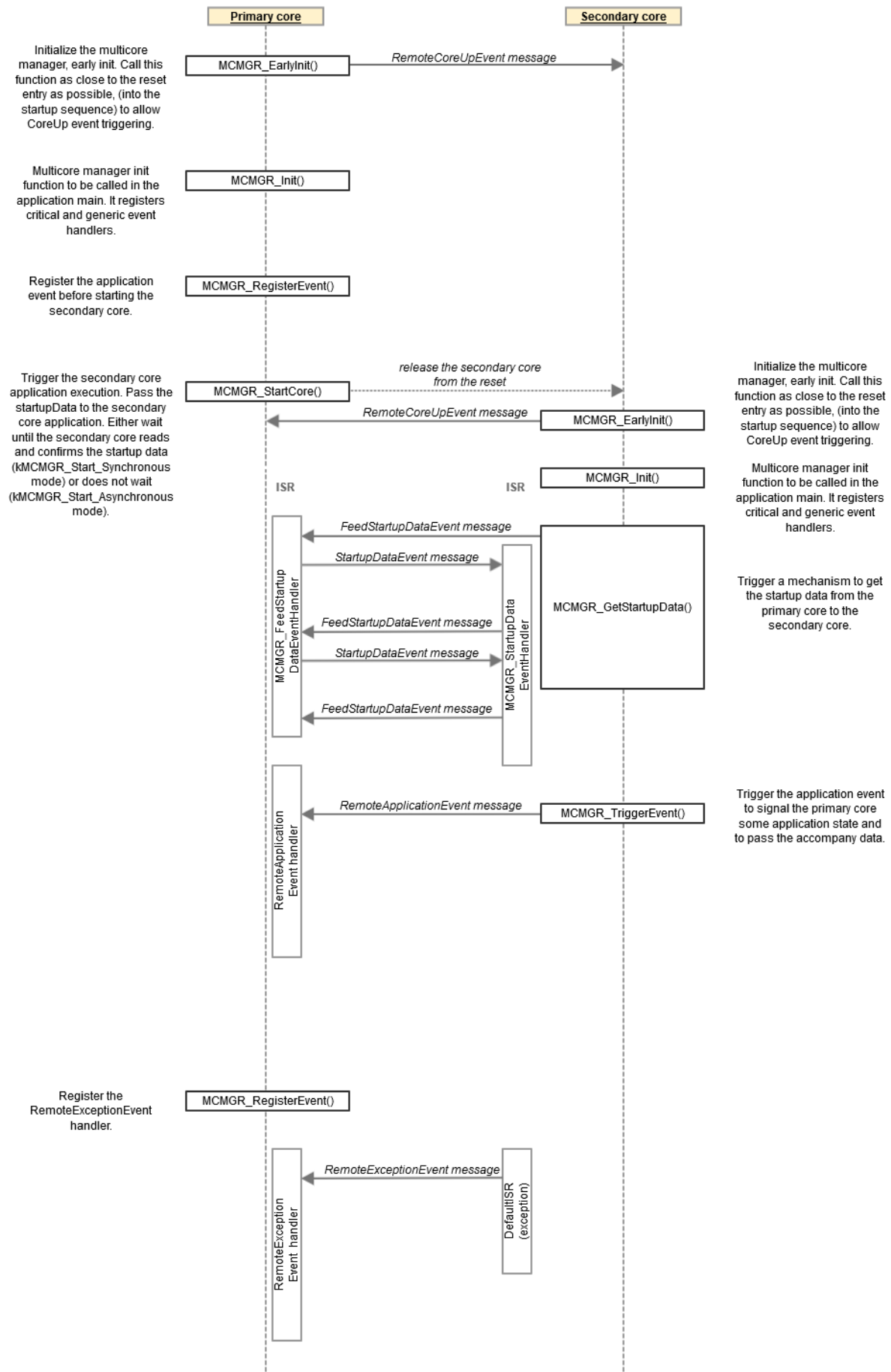
void main()
{
    /* Initialize MCMGR - low level multicore management library.
       Call this function as close to the reset entry as possible,
       (into the startup sequence) to allow CoreUp event triggering. */
    MCMGR_EarlyInit();

    /* Initialize MCMGR, install generic event handlers */
    MCMGR_Init();
    .
    .
    .

    /* Signal the to other core that we are ready by triggering the event and passing the APP_RPMSG_
    ↳READY_EVENT_DATA */
    MCMGR_TriggerEvent(kMCMGR_Core0, kMCMGR_RemoteApplicationEvent, APP_RPMSG_
    ↳READY_EVENT_DATA);
    .
    .
    .
}

```

MCMGR Data Exchange Diagram The following picture shows how the handshakes are supposed to work between the two cores in the MCMGR software.



Changelog Multicore Manager All notable changes to this project will be documented in this file.

The format is based on [Keep a Changelog](#), and this project adheres to [Semantic Versioning](#).

[v5.0.2]

Added

- Added gcov options and configs to support mcmgr code coverage
- Added new test_weak_mu_isr testcase for devices with MU peripheral
- Added new test_heartbeat testcase showing heartbeat mechanism between primary and secondary cores using the MCMGR

v5.0.1

Added

- Added frdmimxrt1186 unit testing

Changed

- [KW43] Rename core#1 reset control register

Fixed

- Added CX flag into CMakeLists.txt to allow c++ build compatibility.
- Fix path to mcmgr headers directory in doxyfile

v5.0.0

Added

- Added MCMGR_BUSY_POLL_COUNT macro to prevent infinite polling loops in MCMGR operations.
- Implemented timeout mechanism for all polling loops in MCMGR code.
- Added support to handle more then two cores. Breaking API change by adding parameter coreNum specifying core number in functions bellow.
 - MCMGR_GetStartupData(uint32_t *startupData, mcmgr_core_t coreNum)
 - MCMGR_TriggerEvent(mcmgr_event_type_t type, uint16_t eventData, mcmgr_core_t coreNum)
 - MCMGR_TriggerEventForce(mcmgr_event_type_t type, uint16_t eventData, mcmgr_core_t coreNum)
 - typedef void (*mcmgr_event_callback_t)(uint16_t data, void *context, mcmgr_core_t coreNum);

When registering the event with function `MCMGR_RegisterEvent()` user now needs to provide `callbackData` pointer to array of elements per every core in system (see README.md for example). In case of systems with only two cores the `coreNum` in callback can be ignored as events can arrive only from one core. Please see Porting guide for more details: Porting-GuideTo_v5.md

- Updated all porting files to support new MCMGR API.
- Added new platform specific include file `mcmgr_platform.h`. It will contain common platform specific macros that can be then used in `mcmgr` and application. e.g. platform core count `MCMGR_CORECOUNT` 4.
- Move all header files to new `inc` directory.
- Added new platform-specific include files `inc/platform/<platform_name>/mcmgr_platform.h`.

Added

- Add MCXL20 porting layer and unit testing

v4.1.7

Fixed

- `mcmgr_stop_core_internal()` function now returns `kStatus_MCMGR_NotImplemented` status code instead of `kStatus_MCMGR_Success` when device does not support stop of secondary core. Ports affected: kw32w1, kw45b41, kw45b42, mcxw716, mcxw727.

[v4.1.6]

Added

- Multicore Manager moved to standalone repository.
- Add porting layers for imxrt700, mcmxw727, kw47b42.
- New `MCMGR_ProcessDeferredRxIsr()` API added.

[v4.1.5]

Added

- Add notification into `MCMGR_EarlyInit` and `mcmgr_early_init_internal` functions to avoid using uninitialized data in their implementations.

[v4.1.4]

Fixed

- Avoid calling tx isr callbacks when respective Messaging Unit Transmit Interrupt Enable flag is not set in the CR/TCR register.
- Messaging Unit RX and status registers are cleared after the initialization.

[v4.1.3]**Added**

- Add porting layers for imxrt1180.

Fixed

- mu_isr() updated to avoid calling tx isr callbacks when respective Transmit Interrupt Enable flag is not set in the CR/TCR register.
- mcmgr_mu_internal.c code adaptation to new supported SoCs.

[v4.1.2]**Fixed**

- Update mcmgr_stop_core_internal() implementations to set core state to kMCMGR_ResetCoreState.

[v4.1.0]**Fixed**

- Code adjustments to address MISRA C-2012 Rules

[v4.0.3]**Fixed**

- Documentation updated to describe handshaking in a graphic form.
- Minor code adjustments based on static analysis tool findings

[v4.0.2]**Fixed**

- Align porting layers to the updated MCUXpressoSDK feature files.

[v4.0.1]**Fixed**

- Code formatting, removed unused code

[v4.0.0]

Added

- Add new MCMGR_TriggerEventForce() API.

[v3.0.0]

Removed

- Removed MCMGR_LoadApp(), MCMGR_MapAddress() and MCMGR_SignalReady()

Modified

- Modified MCMGR_GetStartupData()

Added

- Added MCMGR_EarlyInit(), MCMGR_RegisterEvent() and MCMGR_TriggerEvent()
- Added the ability for remote core monitoring and event handling

[v2.0.1]

Fixed

- Updated to be Misra compliant.

[v2.0.0]

Added

- Support for lpcxpresso54114 board.

[v1.1.0]

Fixed

- Ported to KSDK 2.0.0.

[v1.0.0]

Added

- Initial release.

eRPC

MCUXpresso SDK : mcuxsdk-middleware-erpc

Overview This repository is for MCUXpresso SDK eRPC middleware delivery and it contains eRPC component officially provided in NXP MCUXpresso SDK. This repository is part of the MCUXpresso SDK overall delivery which is composed of several sub-repositories/projects. Navigate to the top/parent repository [mcuxsdk](#) for the complete delivery of MCUXpresso SDK to be able to build and run eRPC examples that are based on mcux-sdk-middleware-erpc component.

Documentation Overall details can be reviewed here: [MCUXpresso SDK Online Documentation](#)

Visit [eRPC - Documentation](#) to review details on the contents in this sub-repo.

Setup Instructions on how to install the MCUXpresso SDK provided from GitHub via west manifest [Getting Started with SDK - Detailed Installation Instructions](#)

Contribution We welcome and encourage the community to submit patches directly to the eRPC project placed on github. Contributing can be managed via pull-requests. Before a pull-request is created the code should be tested and properly formatted.

eRPC

- [MCUXpresso SDK : mcuxsdk-middleware-erpc](#)

- [Overview](#)
- [Documentation](#)
- [Setup](#)
- [Contribution](#)

- [eRPC](#)

- [About](#)
- [Releases](#)
 - * [Edge releases](#)
- [Documentation](#)
- [Examples](#)
- [References](#)
- [Directories](#)
- [Building and installing](#)
 - * [Requirements](#)
 - [Windows](#)
 - [Mac OS X](#)
 - * [Building](#)
 - [CMake and KConfig](#)
 - [Make](#)

* *Installing for Python*

- *Known issues and limitations*
- *Code providing*

About

eRPC (Embedded RPC) is an open source Remote Procedure Call (RPC) system for multichip embedded systems and heterogeneous multicore SoCs.

Unlike other modern RPC systems, such as the excellent [Apache Thrift](#), eRPC distinguishes itself by being designed for tightly coupled systems, using plain C for remote functions, and having a small code size (<5kB). It is not intended for high performance distributed systems over a network.

eRPC does not force upon you any particular API style. It allows you to export existing C functions, without having to change their prototypes. (There are limits, of course.) And although the internal infrastructure is written in C++, most users will be able to use only the simple C setup APIs shown in the examples below.

A code generator tool called `erpcgen` is included. It accepts input IDL files, having an `.erpc` extension, that have definitions of your data types and remote interfaces, and generates the shim code that handles serialization and invocation. `erpcgen` can generate either C/C++ or Python code.

Example `.erpc` file:

```
// Define a data type.
enum LEDName { kRed, kGreen, kBlue }

// An interface is a logical grouping of functions.
interface IO {
    // Simple function declaration with an empty reply.
    set_led(LEDName whichLed, bool onOrOff) -> void
}
```

Client side usage:

```
void example_client(void) {
    erpc_transport_t transport;
    erpc_mbf_t message_buffer_factory;
    erpc_client_t client_manager;

    /* Init eRPC client infrastructure */
    transport = erpc_transport_cmsis_uart_init(Driver_USART0);
    message_buffer_factory = erpc_mbf_dynamic_init();
    client_manager = erpc_client_init(transport, message_buffer_factory);

    /* init eRPC client IO service */
    initIO_client(client_manager);

    // Now we can call the remote function to turn on the green LED.
    set_led(kGreen, true);

    /* deinit objects */
    deinitIO_client();
    erpc_client_deinit(client_manager);
    erpc_mbf_dynamic_deinit(message_buffer_factory);
}
```

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```

    erpc_transport_tcp_deinit(transport);
}

void example_client(void) {
    erpc_transport_t transport;
    erpc_mbf_t message_buffer_factory;
    erpc_client_t client_manager;

    /* Init eRPC client infrastructure */
    transport = erpc_transport_cmsis_uart_init(Driver_USART0);
    message_buffer_factory = erpc_mbf_dynamic_init();
    client_manager = erpc_client_init(transport, message_buffer_factory);

    /* scope for client service */
    {
        /* init eRPC client IO service */
        IO_client client(client_manager);

        // Now we can call the remote function to turn on the green LED.
        client.set_led(kGreen, true);
    }

    /* deinit objects */
    erpc_client_deinit(client_manager);
    erpc_mbf_dynamic_deinit(message_buffer_factory);
    erpc_transport_tcp_deinit(transport);
}

```

Server side usage:

```

// Implement the remote function.
void set_led(LEDName whichLed, bool onOrOff) {
    // implementation goes here
}

void example_server(void) {
    erpc_transport_t transport;
    erpc_mbf_t message_buffer_factory;
    erpc_server_t server;
    erpc_service_t service = create_IO_service();

    /* Init eRPC server infrastructure */
    transport = erpc_transport_cmsis_uart_init(Driver_USART0);
    message_buffer_factory = erpc_mbf_dynamic_init();
    server = erpc_server_init(transport, message_buffer_factory);

    /* add custom service implementation to the server */
    erpc_add_service_to_server(server, service);

    // Run the server.
    erpc_server_run();

    /* deinit objects */
    destroy_IO_service(service);
    erpc_server_deinit(server);
    erpc_mbf_dynamic_deinit(message_buffer_factory);
    erpc_transport_tcp_deinit(transport);
}

```

```

// Implement the remote function.
class IO : public IO_interface

```

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```
{
    /* eRPC call definition */
    void set_led(LEDName whichLed, bool onOrOff) override {
        // implementation goes here
    }
}

void example_server(void) {
    erpc_transport_t transport;
    erpc_mbf_t message_buffer_factory;
    erpc_server_t server;
    IO IOImpl;
    IO_service io(&IOImpl);

    /* Init eRPC server infrastructure */
    transport = erpc_transport_cmsis_uart_init(Driver_USART0);
    message_buffer_factory = erpc_mbf_dynamic_init();
    server = erpc_server_init(transport, message_buffer_factory);

    /* add custom service implementation to the server */
    erpc_add_service_to_server(server, &io);

    /* poll for requests */
    erpc_status_t err = server.run();

    /* deinit objects */
    erpc_server_deinit(server);
    erpc_mbf_dynamic_deinit(message_buffer_factory);
    erpc_transport_tcp_deinit(transport);
}
```

A number of transports are supported, and new transport classes are easy to write.

Supported transports can be found in *erpc/erpc_c/transport* folder. E.g:

- CMSIS UART
- NXP Kinetis SPI and DSPI
- POSIX and Windows serial port
- TCP/IP (mostly for testing)
- [NXP RPMsg-Lite / RPMsg TTY](#)
- SPIdev Linux
- USB CDC
- NXP Messaging Unit

eRPC is available with an unrestrictive BSD 3-clause license. See the [LICENSE file](#) for the full license text.

Releases [eRPC releases](#)

Edge releases Edge releases can be found on [eRPC CircleCI](#) webpage. Choose build of interest, then platform target and choose ARTIFACTS tab. Here you can find binary application from chosen build.

Documentation Documentation is in the wiki section.

eRPC Infrastructure documentation

Examples Example IDL is available in the *examples/* folder.

Plenty of eRPC multicore and multiprocessor examples can be also found in NXP MCUXpressoSDK packages. Visit <https://mcuxpresso.nxp.com> to configure, build and download these packages.

To get the board list with multicore support (eRPC included) use filtering based on Middleware and search for 'multicore' string. Once the selected package with the multicore middleware is downloaded, see

<MCUXpressoSDK_install_dir>/boards/<board_name>/multicore_examples for eRPC multicore examples (RPMsg_Lite or Messaging Unit transports used) or

<MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples for eRPC multiprocessor examples (UART or SPI transports used).

eRPC examples use the 'erpc_' name prefix.

Another way of getting NXP MCUXpressoSDK eRPC multicore and multiprocessor examples is using the [mcux-sdk](#) Github repo. Follow the description how to use the West tool to clone and update the mcuxsdk repo in [readme Overview section](#). Once done the armgcc eRPC examples can be found in

mcuxsdk/examples/<board_name>/multicore_examples or in

mcuxsdk/examples/<board_name>/multiprocessor_examples folders.

You can use the evkmimxrt1170 as the board_name for instance. Similar to MCUXpressoSDK packages the eRPC examples use the 'erpc_' name prefix.

References This section provides links to interesting erpc-based projects, articles, blogs or guides:

- [erpc \(EmbeddedRPC\) getting started notes](#)
- [ERPC Linux Local Environment Construction and Use](#)
- [The New Wio Terminal eRPC Firmware](#)

Directories *doc* - Documentation.

doxygen - Configuration and support files for running Doxygen over the eRPC C++ infrastructure and erpcgen code.

erpc_c - Holds C/C++ infrastructure for eRPC. This is the code you will include in your application.

erpc_python - Holds Python version of the eRPC infrastructure.

erpcgen - Holds source code for erpcgen and makefiles or project files to build erpcgen on Windows, Linux, and OS X.

erpcsniffer - Holds source code for erpcsniffer application.

examples - Several example IDL files.

mk - Contains common makefiles for building eRPC components.

test - Client/server tests. These tests verify the entire communications path from client to server and back.

utilities - Holds utilities which bring additional benefit to eRPC apps developers.

Building and installing These build instructions apply to host PCs and embedded Linux. For bare metal or RTOS embedded environments, you should copy the *erpc_c* directory into your application sources.

CMake and KConfig build:

It builds a static library of the eRPC C/C++ infrastructure, the `erpcgen` executable, and optionally the unit tests and examples.

CMake is compatible with gcc and clang. On Windows local MingGW downloaded by *script* can be used.

Make build:

It builds a static library of the eRPC C/C++ infrastructure, the `erpcgen` executable, and optionally the unit tests.

The makefiles are compatible with gcc or clang on Linux, OS X, and Cygwin. A Windows build of erpcgen using Visual Studio is also available in the *erpcgen/VisualStudio_v14* directory. There is also an Xcode project file in the *erpcgen* directory, which can be used to build erpcgen for OS X.

Requirements eRPC now support building **erpcgen**, **erpc_lib**, **tests** and **C examples** using CMake.

Requirements when using CMake:

- **CMake** (minimal version 3.20.0)
- Generator - **Make**, **Ninja**, ...
- **C/C++ compiler** - **GCC**, **CLANG**, ...
- **Binson** - <https://www.gnu.org/software/bison/>
- **Flex** - <https://github.com/westes/flex/>

Requirements when using Make:

- **Make**
- **C/C++ compiler - GCC, CLANG, ...**
- **Binson** - <https://www.gnu.org/software/bison/>
- **Flex** - <https://github.com/westes/flex/>

Windows Related steps to build **erpcgen** using **Visual Studio** are described in `erpcgen/VisualStudio_v14/readme_erpcgen.txt`.

To install MinGW, Bison, Flex locally on Windows:

```
./install_dependencies.ps1
* ^^^
#### Linux
^^^ bash
./install_dependencies.sh
```

Mandatory for case, when build for different architecture is needed

- gcc-multilib, g++-multilib

Mac OS X

```
./install_dependencies.sh
```

Building

CMake and KConfig eRPC use CMake and KConfig to configure and build eRPC related targets. KConfig can be edited by *prj.conf* or *menuconfig* when building.

Generate project, config and build. In *erpc/* execute:

```
cmake -B ./build # in erpc/build generate cmake project
cmake --build ./build --target menuconfig # Build menuconfig and configure erpcgen, erpc_lib, tests and
↳examples
cmake --build ./build # Build all selected target from prj.conf/menuconfig
```

****CMake will use the system's default compilers and generator**

If you want to use Windows and locally installed MinGW, use *CMake preset* :

```
cmake --preset mingw64 # Generate project in ./build using mingw64's make and compilers
cmake --build ./build --target menuconfig # Build menuconfig and configure erpcgen, erpc_lib, tests and
↳examples
cmake --build ./build # Build all selected target from prj.conf/menuconfig
```

Make To build the library and erpcgen, run from the repo root directory:

```
make
```

To install the library, erpcgen, and include files, run:

```
make install
```

You may need to `sudo` the `make install`.

By default this will install into `/usr/local`. If you want to install elsewhere, set the `PREFIX` environment variable. Example for installing into `/opt`:

```
make install PREFIX=/opt
```

List of top level Makefile targets:

- `erpc`: build the `liberpc.a` static library
- `erpcgen`: build the `erpcgen` tool
- `erpcsniffer`: build the sniffer tool
- `test`: build the unit tests under the *test* directory
- `all`: build all of the above
- `install`: install `liberpc.a`, `erpcgen`, and include files

eRPC code is validated with respect to the C++ 11 standard.

Installing for Python To install the Python infrastructure for eRPC see instructions in the *erpc python readme*.

Known issues and limitations

- Static allocations controlled by the `ERPC_ALLOCATION_POLICY` config macro are not fully supported yet, i.e. not all erpc objects can be allocated statically now. It deals with the ongoing process and the full static allocations support will be added in the future.

Code providing Repository on Github contains two main branches: **main** and **develop**. Code is developed on **develop** branch. Release version is created via merging **develop** branch into **main** branch.

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eRPC Getting Started

Overview This *Getting Started User Guide* shows software developers how to use Remote Procedure Calls (RPC) in embedded multicore microcontrollers (eRPC).

The eRPC documentation is located in the `<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/doc` folder.

Create an eRPC application This section describes a generic way to create a client/server eRPC application:

1. **Design the eRPC application:** Decide which data types are sent between applications, and define functions that send/receive this data.
2. **Create the IDL file:** The IDL file contains information about data types and functions used in an eRPC application, and is written in the IDL language.
3. **Use the eRPC generator tool:** This tool takes an IDL file and generates the shim code for the client and the server-side applications.
4. **Create an eRPC application:**
 1. Create two projects, where one project is for the client side (primary core) and the other project is for the server side (secondary core).
 2. Add generated files for the client application to the client project, and add generated files for the server application to the server project.
 3. Add infrastructure files.
 4. Add user code for client and server applications.
 5. Set the client and server project options.
5. **Run the eRPC application:** Run both the server and the client applications. Make sure that the server has been run before the client request was sent.

A specific example follows in the next section.

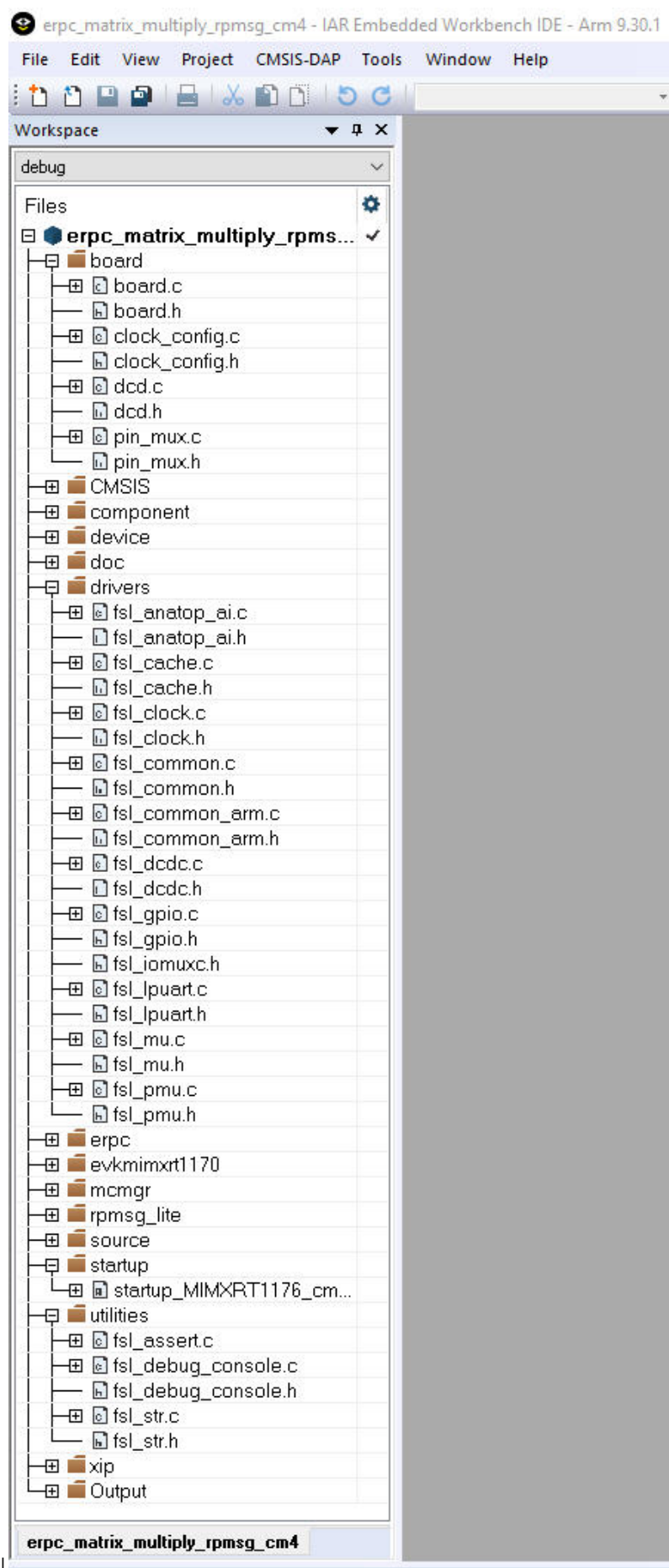
Multicore server application The “Matrix multiply” eRPC server project is located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg/cm4/iar`

The project files for the eRPC server have the `_cm4` suffix.

Server project basic source files The startup files, board-related settings, peripheral drivers, and utilities belong to the basic project source files and form the skeleton of all MCUXpresso SDK applications. These source files are located in:

- `<MCUXpressoSDK_install_dir>/devices/<device>`
- `<MCUXpressoSDK_install_dir>/boards/<board_name>/multicore_examples/<example_name>/`



|

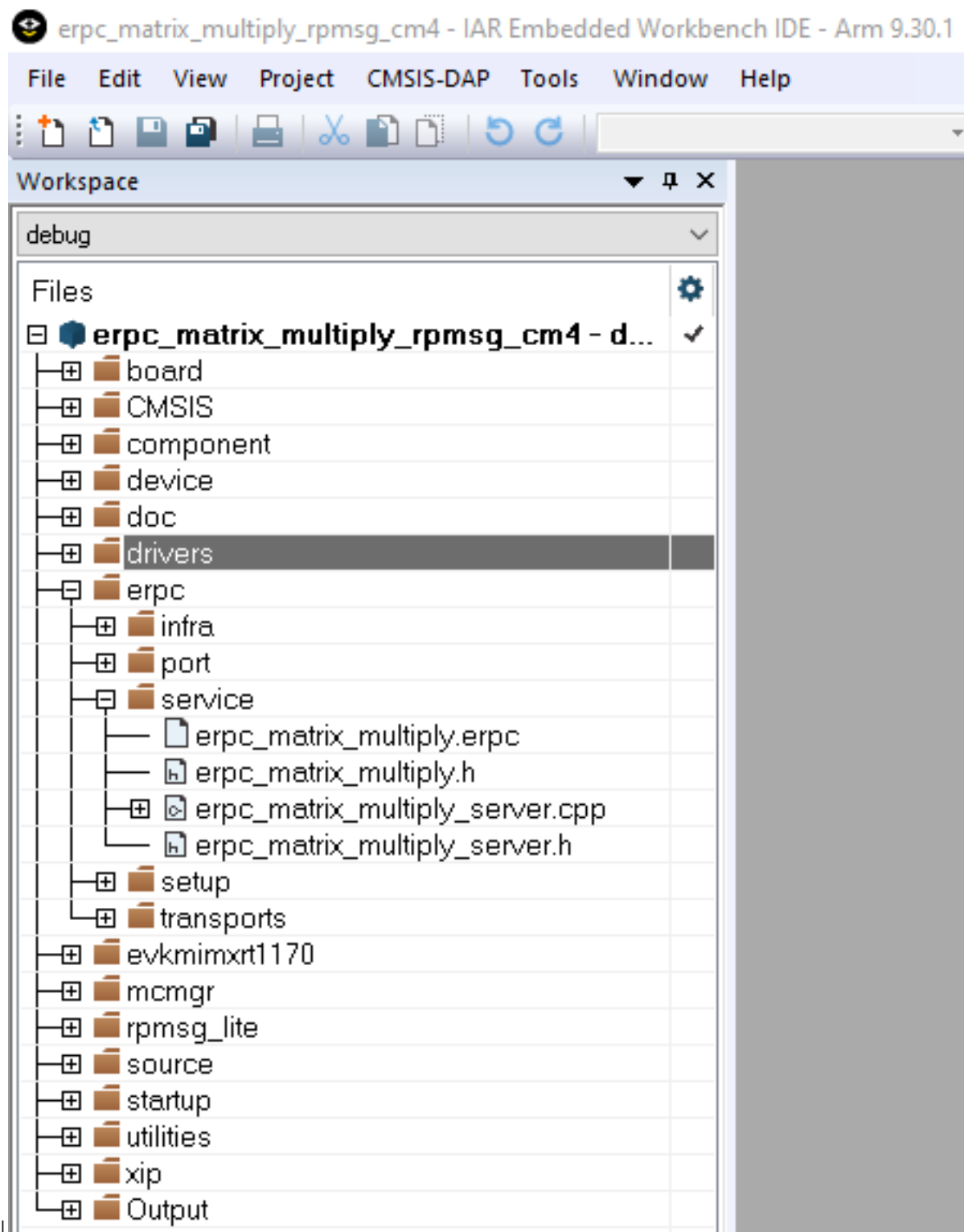
Parent topic:Multicore server application

Server related generated files The server-related generated files are:

- erpc__matric__multiply.h
- erpc__matrix__multiply__server.h
- erpc__matrix__multiply__server.cpp

The server-related generated files contain the shim code for functions and data types declared in the IDL file. These files also contain functions for the identification of client requested functions, data deserialization, calling requested function's implementations, and data serialization and return, if requested by the client. These shim code files can be found in the following folder:

<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/s



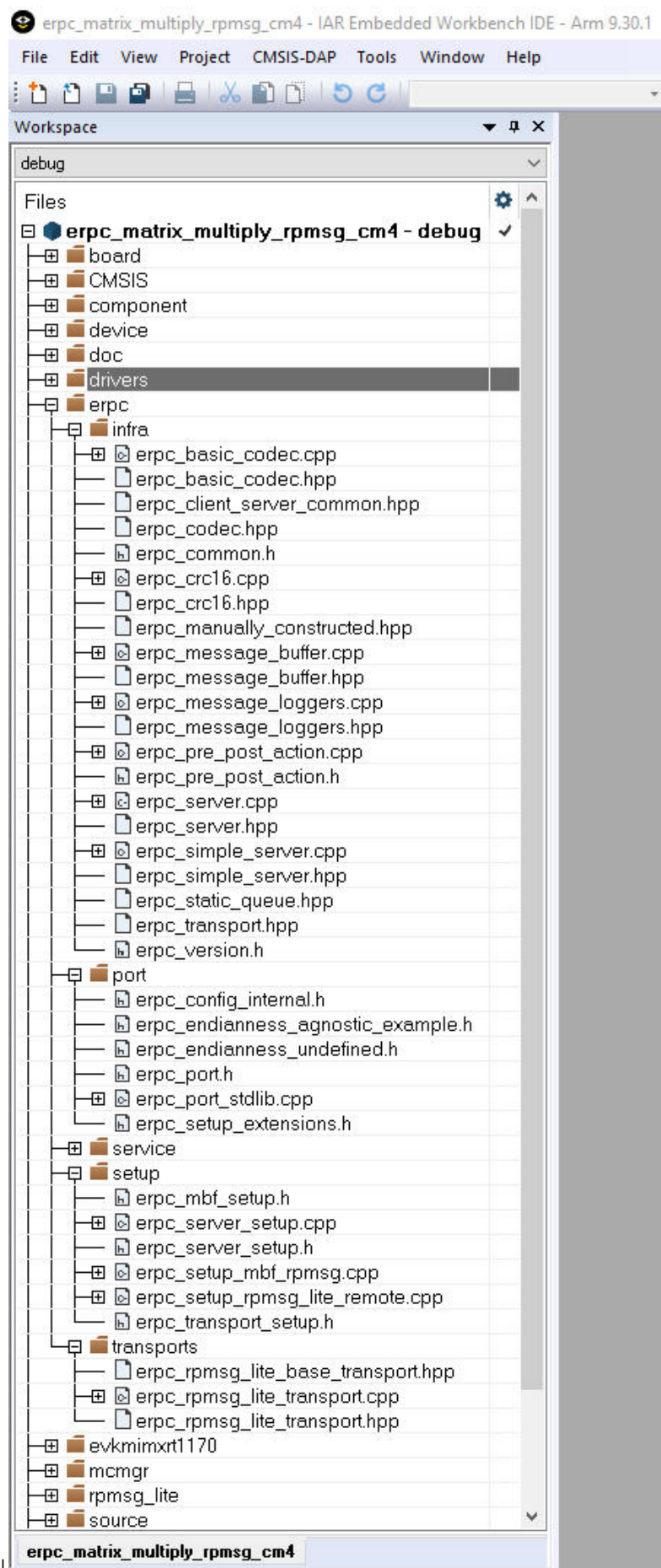
Parent topic: Multicore server application

Server infrastructure files The eRPC infrastructure files are located in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/erpc_c`

The **erpc_c** folder contains files for creating eRPC client and server applications in the C/C++ language. These files are distributed into subfolders.

- The **infra** subfolder contains C++ infrastructure code used to build server and client applications.
 - Four files, `erpc_server.hpp`, `erpc_server.cpp`, `erpc_simple_server.hpp`, and `erpc_simple_server.cpp`, are used for running the eRPC server on the server-side applications. The simple server is currently the only implementation of the server, and its role is to catch client requests, identify and call requested functions, and send data back when requested.
 - Three files (`erpc_codec.hpp`, `erpc_basic_codec.hpp`, and `erpc_basic_codec.cpp`) are used for codecs. Currently, the basic codec is the initial and only implementation of the codecs.
 - The `erpc_common.hpp` file is used for common eRPC definitions, typedefs, and enums.
 - The `erpc_manually_constructed.hpp` file is used for allocating static storage for the used objects.
 - Message buffer files are used for storing serialized data: `erpc_message_buffer.h` and `erpc_message_buffer.cpp`.
 - The `erpc_transport.h` file defines the abstract interface for transport layer.
- The **port** subfolder contains the eRPC porting layer to adapt to different environments.
 - `erpc_port.h` file contains definition of `erpc_malloc()` and `erpc_free()` functions.
 - `erpc_port_stdlib.cpp` file ensures adaptation to `stdlib`.
 - `erpc_config_internal.h` internal erpc configuration file.
- The **setup** subfolder contains a set of plain C APIs that wrap the C++ infrastructure, providing client and server init and deinit routines that greatly simplify eRPC usage in C-based projects. No knowledge of C++ is required to use these APIs.
 - The `erpc_server_setup.h` and `erpc_server_setup.cpp` files need to be added into the “Matrix multiply” example project to demonstrate the use of C-wrapped functions in this example.
 - The `erpc_transport_setup.h` and `erpc_setup_rpmsg_lite_remote.cpp` files need to be added into the project in order to allow the C-wrapped function for transport layer setup.
 - The `erpc_mbf_setup.h` and `erpc_setup_mbf_rpmsg.cpp` files need to be added into the project in order to allow message buffer factory usage.
- The **transports** subfolder contains transport classes for the different methods of communication supported by eRPC. Some transports are applicable only to host PCs, while others are applicable only to embedded or multicore systems. Most transports have corresponding client and server setup functions in the setup folder.
 - RPMsg-Lite is used as the transport layer for the communication between cores, `erpc_rpmsg_lite_base_transport.hpp`, `erpc_rpmsg_lite_transport.hpp`, and `erpc_rpmsg_lite_transport.cpp` files need to be added into the server project.



|

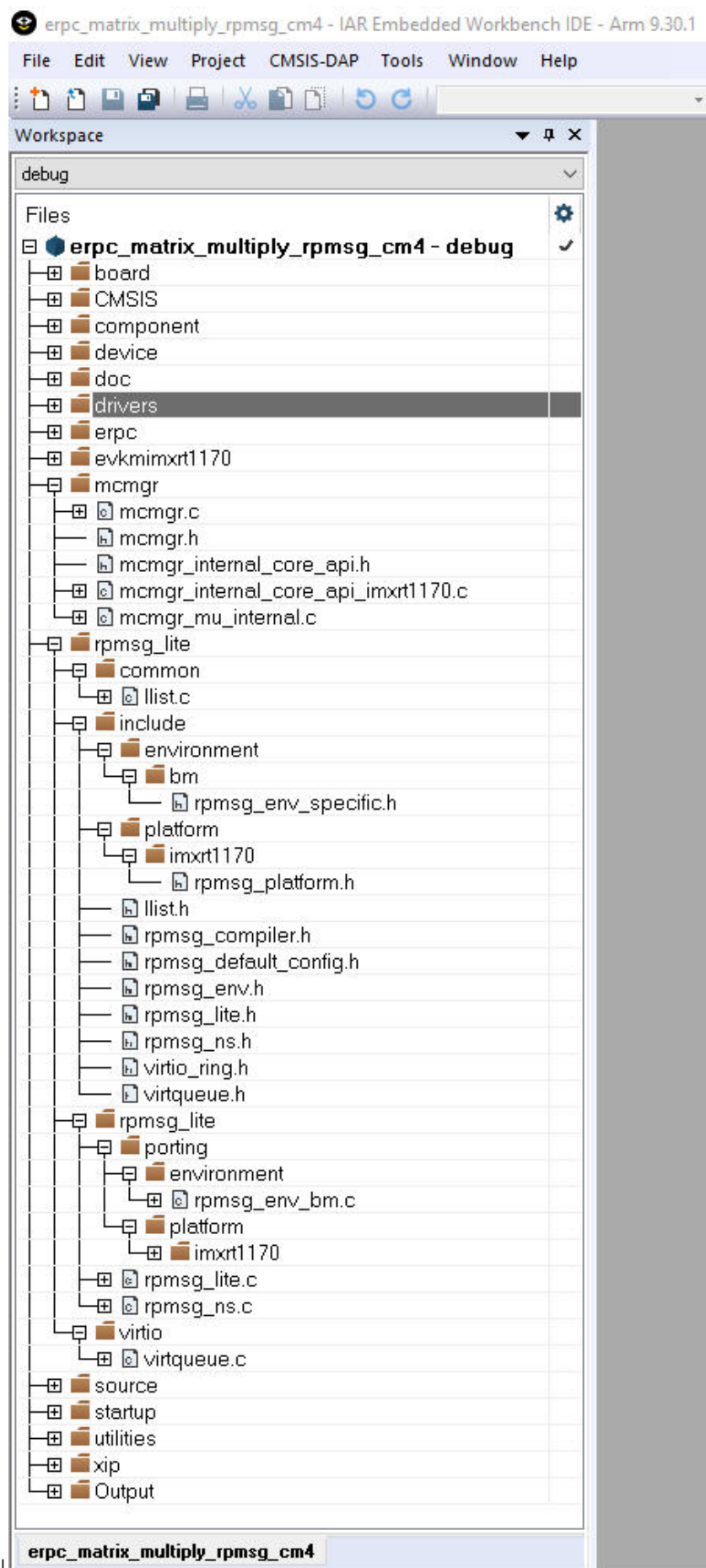
Parent topic: Multicore server application

Server multicore infrastructure files Because of the RPMsg-Lite (transport layer), it is also necessary to include RPMsg-Lite related files, which are in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/rpmsg_lite/`

The multicore example applications also use the Multicore Manager software library to control the secondary core startup and shutdown. These source files are located in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr/`



Parent topic: Multicore server application

Server user code The server's user code is stored in the `main_core1.c` file, located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg/cm4`

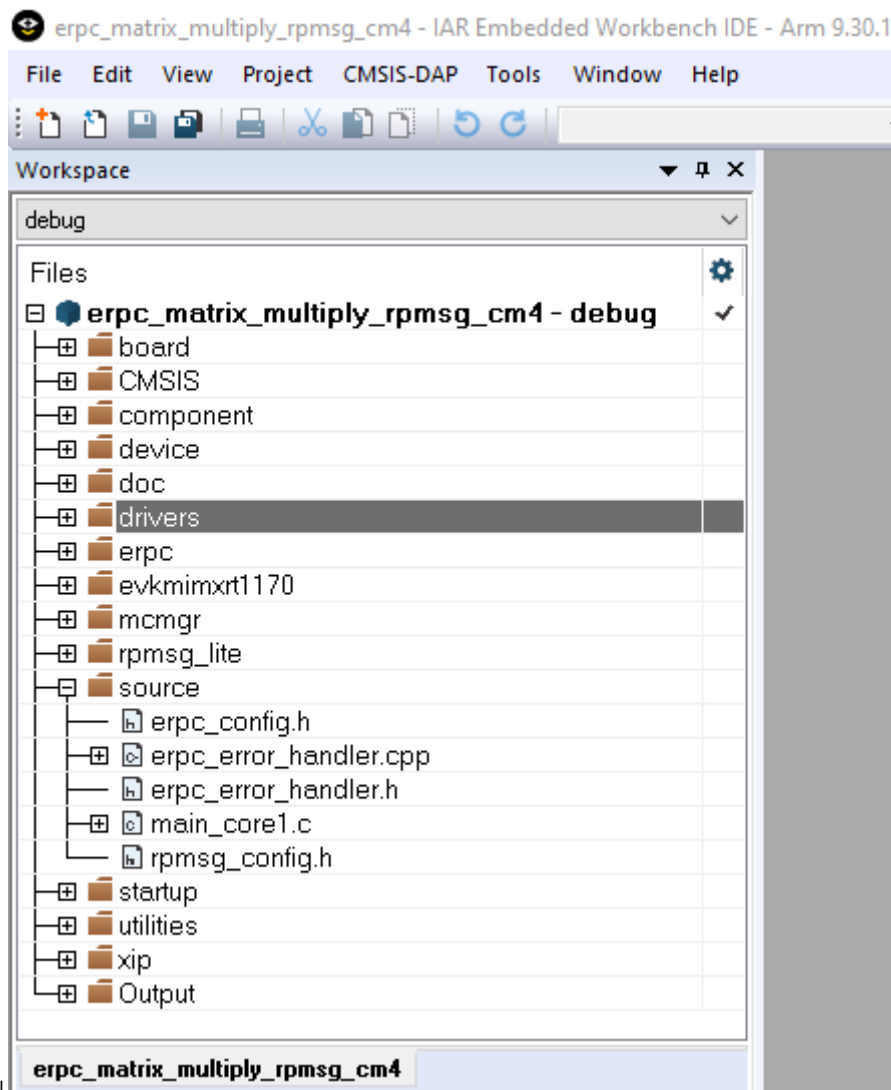
The `main_core1.c` file contains two functions:

- The **main()** function contains the code for the target board and eRPC server initialization. After the initialization, the matrix multiply service is added and the eRPC server waits for client's requests in the while loop.
- The **erpcMatrixMultiply()** function is the user implementation of the eRPC function defined in the IDL file.
- There is the possibility to write the application-specific eRPC error handler. The eRPC error handler of the matrix multiply application is implemented in the `erpc_error_handler.h` and `erpc_error_handler.cpp` files.

The eRPC-relevant code is captured in the following code snippet:

```
/* erpcMatrixMultiply function user implementation */
void erpcMatrixMultiply(const Matrix *matrix1, const Matrix *matrix2, Matrix *result_matrix)
{
    ...
}
int main()
{
    ...
    /* RPSMsg-Lite transport layer initialization */
    erpc_transport_t transport;
    transport = erpc_transport_rpmsg_lite_remote_init(src, dst, (void*)startupData,
    ERPC_TRANSPORT_RPMSG_LITE_LINK_ID, SignalReady, NULL);
    ...
    /* MessageBufferFactory initialization */
    erpc_mbf_t message_buffer_factory;
    message_buffer_factory = erpc_mbf_rpmsg_init(transport);
    ...
    /* eRPC server side initialization */
    erpc_server_t server;
    server = erpc_server_init(transport, message_buffer_factory);
    ...
    /* Adding the service to the server */
    erpc_service_t service = create_MatrixMultiplyService_service();
    erpc_add_service_to_server(server, service);
    ...
    while (1)
    {
        /* Process eRPC requests */
        erpc_status_t status = erpc_server_poll(server);
        /* handle error status */
        if (status != kErpcStatus_Success)
        {
            /* print error description */
            erpc_error_handler(status, 0);
            ...
        }
        ...
    }
}
```

Except for the application main file, there are configuration files for the RPMsg-Lite (rpmsg_config.h) and eRPC (erpc_config.h), located in the `<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg` folder.



Parent topic:Multicore server application

Parent topic:[Create an eRPC application](#)

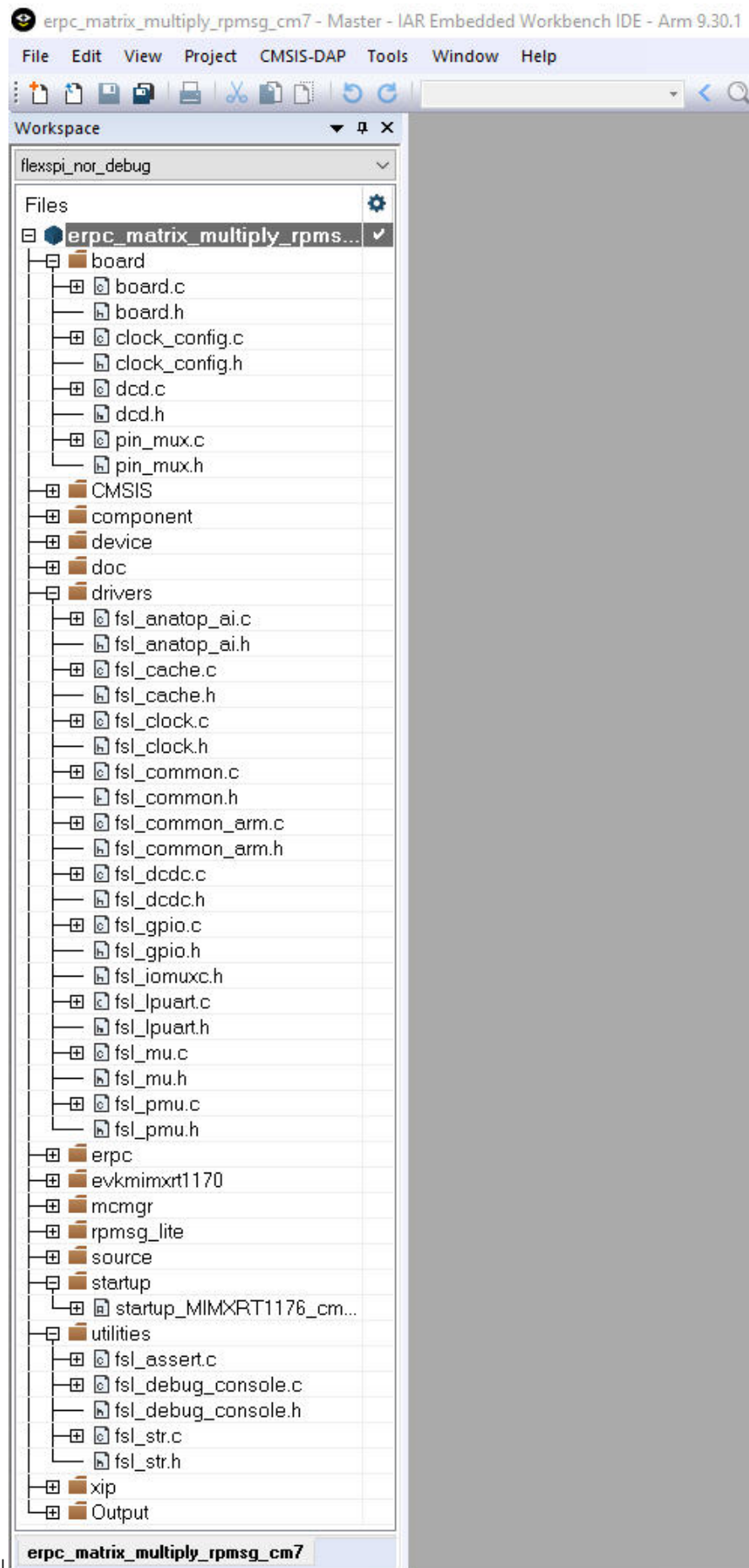
Multicore client application The “Matrix multiply” eRPC client project is located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg/cm7/iar`

Project files for the eRPC client have the `_cm7` suffix.

Client project basic source files The startup files, board-related settings, peripheral drivers, and utilities belong to the basic project source files and form the skeleton of all MCUXpresso SDK applications. These source files are located in the following folders:

- `<MCUXpressoSDK_install_dir>/devices/<device>`
- `<MCUXpressoSDK_install_dir>/boards/<board_name>/multicore_examples/<example_name>/`



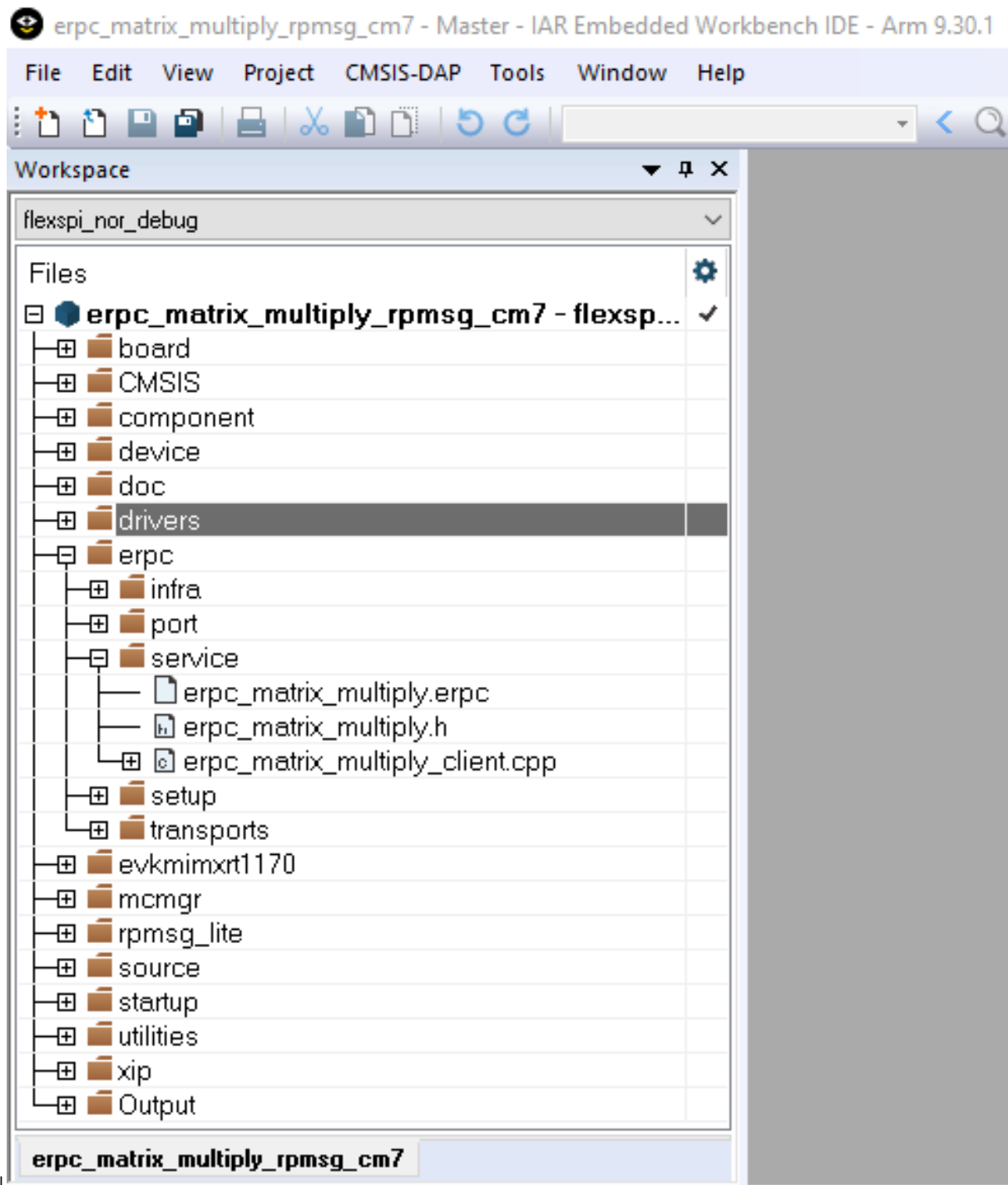
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Parent topic:Multicore client application

Client-related generated files The client-related generated files are:

- erpc__matric__multiply.h
- erpc__matrix__multiply__client.cpp

These files contain the shim code for the functions and data types declared in the IDL file. These functions also call methods for codec initialization, data serialization, performing eRPC requests, and de-serializing outputs into expected data structures (if return values are expected). These shim code files can be found in the `<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/service/` folder.



Parent topic:Multicore client application

Client infrastructure files The eRPC infrastructure files are located in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/erpc_c`

The **erpc_c** folder contains files for creating eRPC client and server applications in the C/C++ language. These files are distributed into subfolders.

- The **infra** subfolder contains C++ infrastructure code used to build server and client applications.

- Two files, `erpc_client_manager.h` and `erpc_client_manager.cpp`, are used for managing the client-side application. The main purpose of the client files is to create, perform, and release eRPC requests.
- Three files (`erpc_codec.hpp`, `erpc_basic_codec.hpp`, and `erpc_basic_codec.cpp`) are used for codecs. Currently, the basic codec is the initial and only implementation of the codecs.
- `erpc_common.h` file is used for common eRPC definitions, typedefs, and enums.
- `erpc_manually_constructed.hpp` file is used for allocating static storage for the used objects.
- Message buffer files are used for storing serialized data: `erpc_message_buffer.hpp` and `erpc_message_buffer.cpp`.
- `erpc_transport.hpp` file defines the abstract interface for transport layer.

The **port** subfolder contains the eRPC porting layer to adapt to different environments.

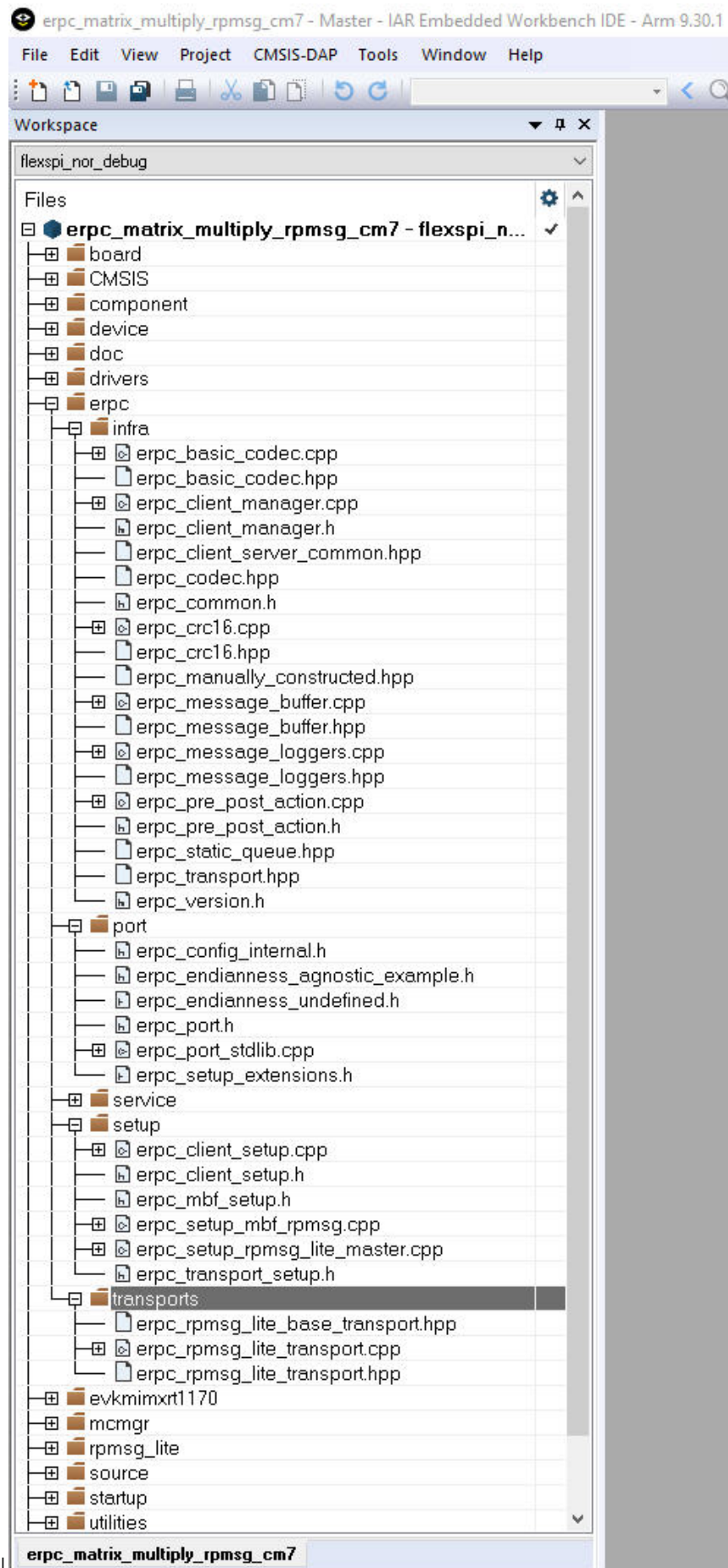
- `erpc_port.h` file contains definition of `erpc_malloc()` and `erpc_free()` functions.
- `erpc_port_stdlib.cpp` file ensures adaptation to `stdlib`.
- `erpc_config_internal.h` internal eRPC configuration file.

The **setup** subfolder contains a set of plain C APIs that wrap the C++ infrastructure, providing client and server init and deinit routines that greatly simplify eRPC usage in C-based projects. No knowledge of C++ is required to use these APIs.

- `erpc_client_setup.h` and `erpc_client_setup.cpp` files needs to be added into the “Matrix multiply” example project to demonstrate the use of C-wrapped functions in this example.
- `erpc_transport_setup.h` and `erpc_setup_rpmsg_lite_master.cpp` files needs to be added into the project in order to allow C-wrapped function for transport layer setup.
- `erpc_mbf_setup.h` and `erpc_setup_mbf_rpmsg.cpp` files needs to be added into the project in order to allow message buffer factory usage.

The **transports** subfolder contains transport classes for the different methods of communication supported by eRPC. Some transports are applicable only to host PCs, while others are applicable only to embedded or multicore systems. Most transports have corresponding client and server setup functions, in the setup folder.

- RPMsg-Lite is used as the transport layer for the communication between cores, `erpc_rpmsg_lite_base_transport.hpp`, `erpc_rpmsg_lite_transport.hpp`, and `erpc_rpmsg_lite_transport.cpp` files needs to be added into the client project.



|

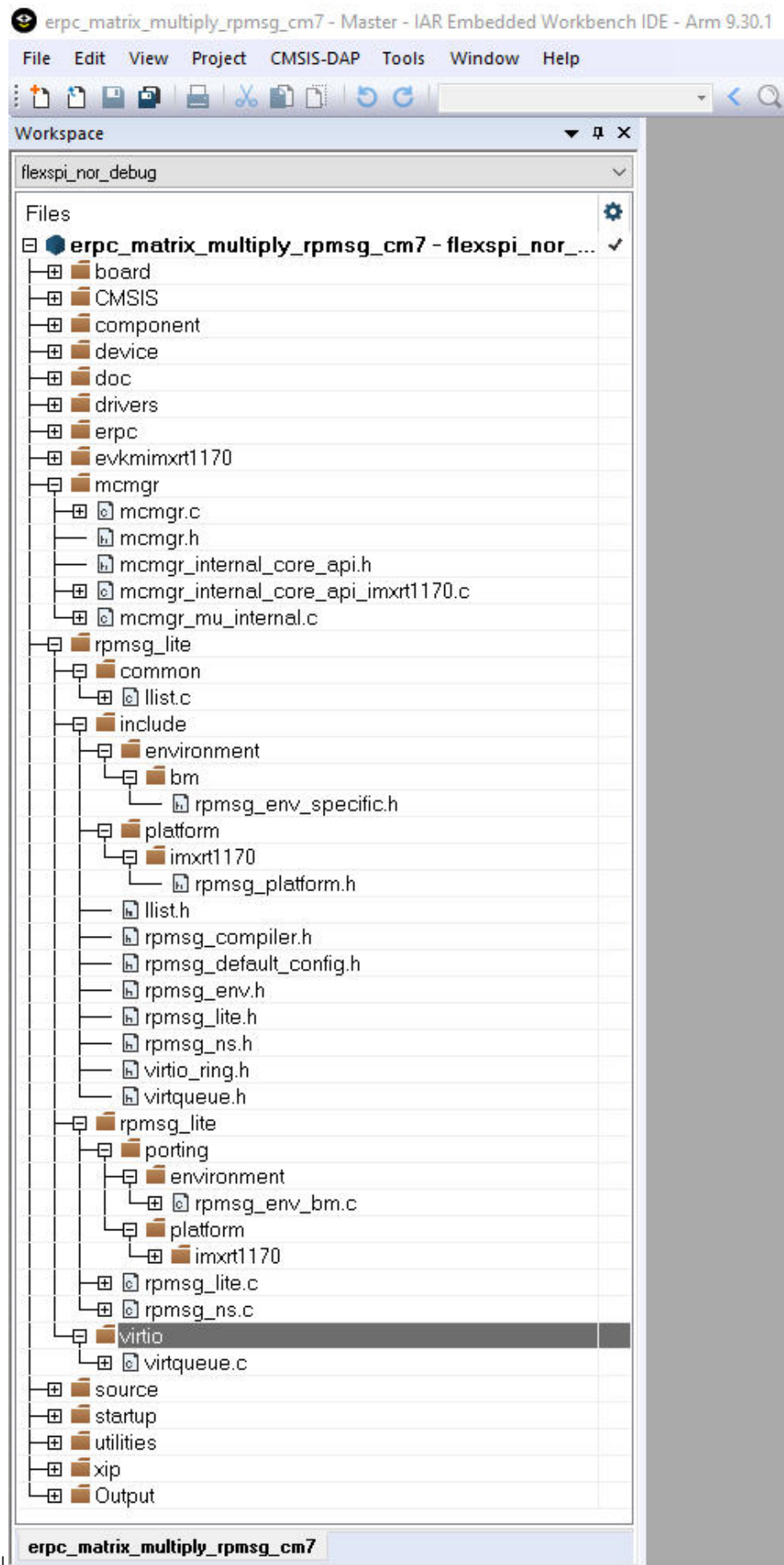
Parent topic:Multicore client application

Client multicore infrastructure files Because of the RPMsg-Lite (transport layer), it is also necessary to include RPMsg-Lite related files, which are in the following folder:

<MCUXpressoSDK_install_dir>/middleware/multicore/rpmsg_lite/

The multicore example applications also use the Multicore Manager software library to control the secondary core startup and shutdown. These source files are located in the following folder:

<MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr/



|
Parent topic:Multicore client application

Client user code The client's user code is stored in the main_core0.c file, located in the following folder:

<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_example/erpc_matrix_multiply_rpmsg/cm7

The main_core0.c file contains the code for target board and eRPC initialization.

- After initialization, the secondary core is released from reset.
- When the secondary core is ready, the primary core initializes two matrix variables.
- The erpcMatrixMultiply eRPC function is called to issue the eRPC request and get the result.

It is possible to write the application-specific eRPC error handler. The eRPC error handler of the matrix multiply application is implemented in erpc_error_handler.h and erpc_error_handler.cpp files.

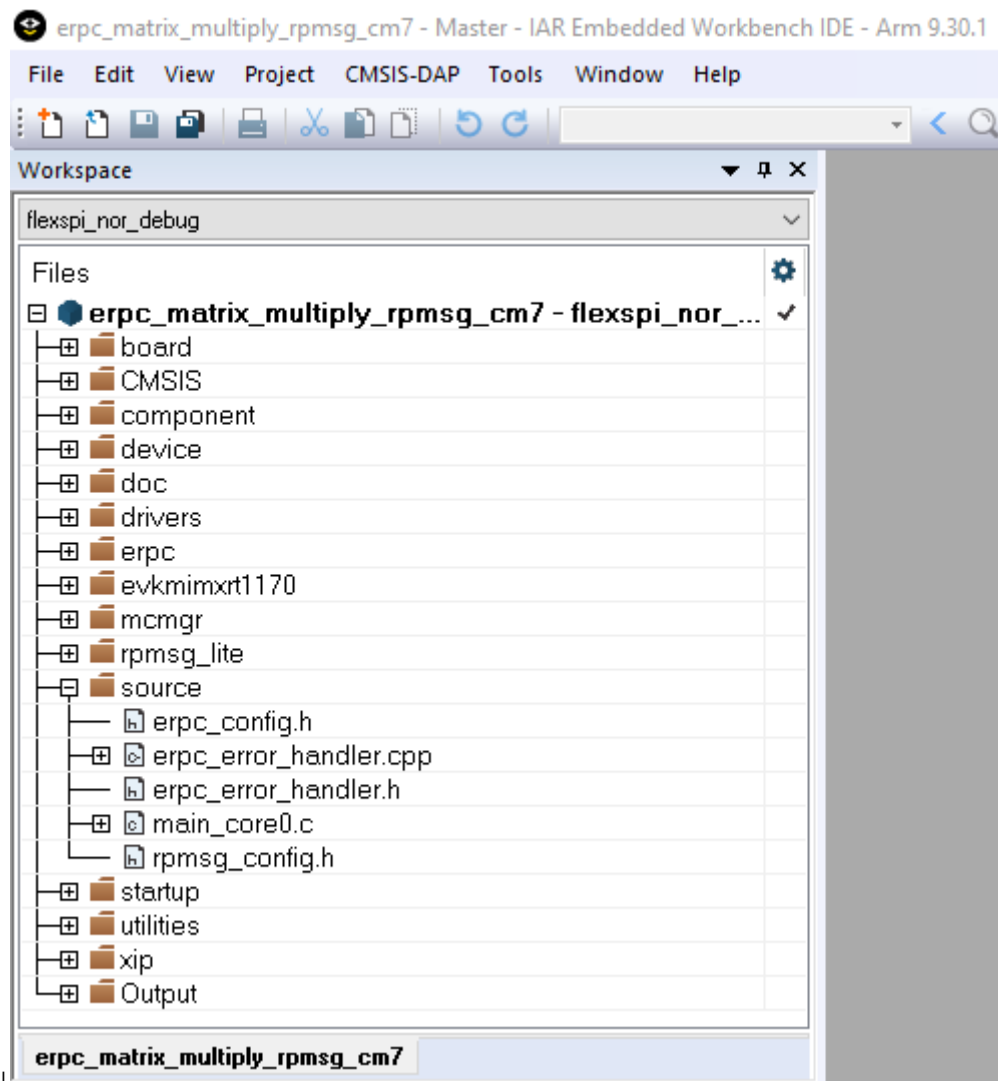
The matrix multiplication can be issued repeatedly, when pressing a software board button.

The eRPC-relevant code is captured in the following code snippet:

```
...
extern bool g_erpc_error_occurred;
...
/* Declare matrix arrays */
Matrix matrix1 = {0}, matrix2 = {0}, result_matrix = {0};
...
/* RPSMsg-Lite transport layer initialization */
erpc_transport_t transport;
transport = erpc_transport_rpmsg_lite_master_init(src, dst,
ERPC_TRANSPORT_RPMSG_LITE_LINK_ID);
...
/* MessageBufferFactory initialization */
erpc_mbf_t message_buffer_factory;
message_buffer_factory = erpc_mbf_rpmsg_init(transport);
...
/* eRPC client side initialization */
erpc_client_t client;
client = erpc_client_init(transport, message_buffer_factory);
...
/* Set default error handler */
erpc_client_set_error_handler(client, erpc_error_handler);
...
while (1)
{
    /* Invoke the erpcMatrixMultiply function */
    erpcMatrixMultiply(matrix1, matrix2, result_matrix);
    ...
    /* Check if some error occurred in eRPC */
    if (g_erpc_error_occurred)
    {
        /* Exit program loop */
        break;
    }
    ...
}
```

Except for the application main file, there are configuration files for the RPSMsg-Lite (rpmsg_config.h) and eRPC (erpc_config.h), located in the following folder:

<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg



Parent topic:Multicore client application

Parent topic:[Create an eRPC application](#)

Multiprocessor server application The “Matrix multiply” eRPC server project for multiprocessor applications is located in the `<MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_server_matrix_multiply_<transport_layer>` folder.

Most of the multiprocessor application setup is the same as for the multicore application. The multiprocessor server application requires server-related generated files (server shim code), server infrastructure files, and the server user code. There is no need for server multicore infrastructure files (MCMGR and RPMsg-Lite). The RPMsg-Lite transport layer is replaced either by SPI or UART transports. The following table shows the required transport-related files per each transport type.

SPI	<eRPC base directory>/erpc_c/setup/erpc_setup_(d)spi_slave.cpp
	<eRPC base directory>/erpc_c/transports/erpc_(d)spi_slave_transport.hpp
	<eRPC base directory>/erpc_c/transports/erpc_(d)spi_slave_transport.cpp
UART	<eRPC base directory>/erpc_c/setup/erpc_setup_uart_cmsis.cpp

<eRPC base directory>/erpc_c/transport/erpc_uart_cmsis_transport.hpp

<eRPC base directory>/erpc_c/transport/erpc_uart_cmsis_transport.cpp

|

Server user code The server's user code is stored in the main_server.c file, located in the <MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_server_matrix_multiply_<transport_layer>/ folder.

The eRPC-relevant code with UART as a transport is captured in the following code snippet:

```
/* erpcMatrixMultiply function user implementation */
void erpcMatrixMultiply(Matrix matrix1, Matrix matrix2, Matrix result_matrix)
{
    ...
}
int main()
{
    ...
    /* UART transport layer initialization, ERPC_DEMO_UART is the structure of CMSIS UART driver.
    ↪operations */
    erpc_transport_t transport;
    transport = erpc_transport_cmsis_uart_init((void *)&ERPC_DEMO_UART);
    ...
    /* MessageBufferFactory initialization */
    erpc_mbf_t message_buffer_factory;
    message_buffer_factory = erpc_mbf_dynamic_init();
    ...
    /* eRPC server side initialization */
    erpc_server_t server;
    server = erpc_server_init(transport, message_buffer_factory);
    ...
    /* Adding the service to the server */
    erpc_service_t service = create_MatrixMultiplyService_service();
    erpc_add_service_to_server(server, service);
    ...
    while (1)
    {
        /* Process eRPC requests */
        erpc_status_t status = erpc_server_poll(server)
        /* handle error status */
        if (status != kErpcStatus_Success)
        {
            /* print error description */
            erpc_error_handler(status, 0);
            ...
        }
        ...
    }
}
```

Parent topic:Multiprocessor server application

Multiprocessor client application The “Matrix multiply” eRPC client project for multiprocessor applications is located in the <MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_client_matrix_multiply_<transport_layer>/iar/ folder.

Most of the multiprocessor application setup is the same as for the multicore application. The multiprocessor server application requires client-related generated files (server shim code),

client infrastructure files, and the client user code. There is no need for client multicore infrastructure files (MCMGR and RPSMsg-Lite). The RPSMsg-Lite transport layer is replaced either by SPI or UART transports. The following table shows the required transport-related files per each transport type.

SPI	<eRPC base directory>/erpc_c/setup/erpc_setup_(d)spi_master.cpp
	<eRPC base directory>/erpc_c/transports/ erpc_(d)spi_master_transport.hpp
	<eRPC base directory>/erpc_c/transports/ erpc_(d)spi_master_transport.cpp
UART	<eRPC base directory>/erpc_c/setup/erpc_setup_uart_cmsis.cpp
	<eRPC base directory>/erpc_c/transports/erpc_uart_cmsis_transport.hpp
	<eRPC base directory>/erpc_c/transports/erpc_uart_cmsis_transport.cpp

Client user code The client's user code is stored in the `main_client.c` file, located in the `<MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_client_matrix_multiply_<transport_layer>/` folder.

The eRPC-relevant code with UART as a transport is captured in the following code snippet:

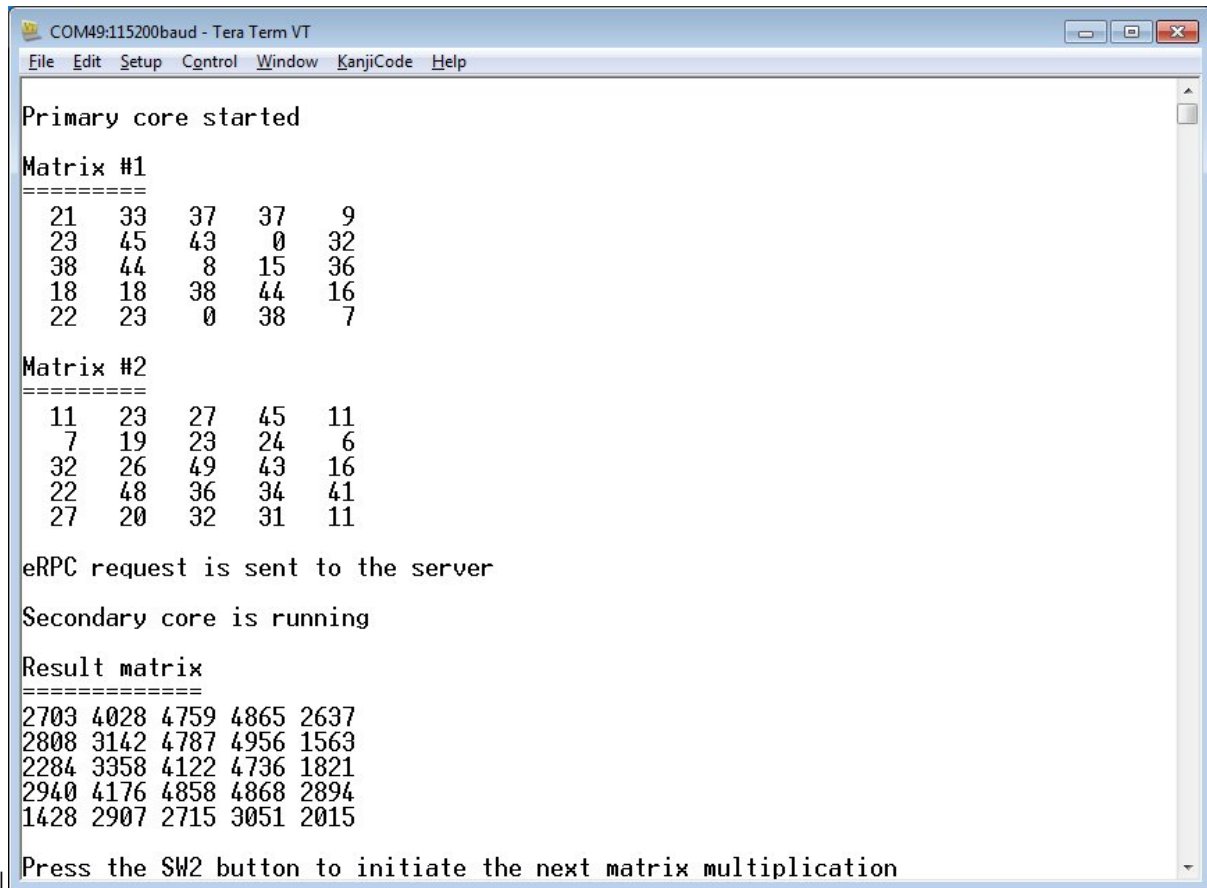
```
...
extern bool g_erpc_error_occurred;
...
/* Declare matrix arrays */
Matrix matrix1 = {0}, matrix2 = {0}, result_matrix = {0};
...
/* UART transport layer initialization, ERPC_DEMO_UART is the structure of CMSIS UART driver
↳operations */
erpc_transport_t transport;
transport = erpc_transport_cmsis_uart_init((void *)&ERPC_DEMO_UART);
...
/* MessageBufferFactory initialization */
erpc_mbf_t message_buffer_factory;
message_buffer_factory = erpc_mbf_dynamic_init();
...
/* eRPC client side initialization */
erpc_client_t client;
client = erpc_client_init(transport,message_buffer_factory);
...
/* Set default error handler */
erpc_client_set_error_handler(client, erpc_error_handler);
...
while (1)
{
    /* Invoke the erpcMatrixMultiply function */
    erpcMatrixMultiply(matrix1, matrix2, result_matrix);
    ...
    /* Check if some error occurred in eRPC */
    if (g_erpc_error_occurred)
    {
        /* Exit program loop */
        break;
    }
    ...
}
```

Parent topic:Multiprocessor client application

Parent topic:Multiprocessor server application

Parent topic:[Create an eRPC application](#)

Running the eRPC application Follow the instructions in *Getting Started with MCUXpresso SDK* (document MCUXSDKGSUG) (located in the <MCUXpressoSDK_install_dir>/docs folder), to load both the primary and the secondary core images into the on-chip memory, and then effectively debug the dual-core application. After the application is running, the serial console should look like:



```

COM49:115200baud - Tera Term VT
File Edit Setup Control Window KanjiCode Help

Primary core started

Matrix #1
=====
 21  33  37  37   9
 23  45  43   0  32
 38  44   8  15  36
 18  18  38  44  16
 22  23   0  38   7

Matrix #2
=====
 11  23  27  45  11
  7  19  23  24   6
 32  26  49  43  16
 22  48  36  34  41
 27  20  32  31  11

eRPC request is sent to the server

Secondary core is running

Result matrix
=====
2703 4028 4759 4865 2637
2808 3142 4787 4956 1563
2284 3358 4122 4736 1821
2940 4176 4858 4868 2894
1428 2907 2715 3051 2015

Press the SW2 button to initiate the next matrix multiplication

```

For multiprocessor applications that are running between PC and the target evaluation board or between two boards, follow the instructions in the accompanied example readme files that provide details about the proper board setup and the PC side setup (Python).

Parent topic:[Create an eRPC application](#)

Parent topic:[eRPC example](#)

eRPC example This section shows how to create an example eRPC application called “Matrix multiply”, which implements one eRPC function (matrix multiply) with two function parameters (two matrices). The client-side application calls this eRPC function, and the server side performs the multiplication of received matrices. The server side then returns the result.

For example, use the NXP MIMXRT1170-EVK board as the target dual-core platform, and the IAR Embedded Workbench for ARM (EWARM) as the target IDE for developing the eRPC example.

- The primary core (CM7) runs the eRPC client.
- The secondary core (CM4) runs the eRPC server.
- RPMsg-Lite (Remote Processor Messaging Lite) is used as the eRPC transport layer.

The “Matrix multiply” application can be also run in the multi-processor setup. In other words, the eRPC client running on one SoC communicates with the eRPC server that runs on another SoC, utilizing different transport channels. It is possible to run the board-to-PC example (PC as the eRPC server and a board as the eRPC client, and vice versa) and also the board-to-board example. These multiprocessor examples are prepared for selected boards only.

| Multicore application source and project files | `<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore/`
 | Multiprocessor application source and project files | `<MCUXpressoSDK_install_dir>/boards/<board_name>/multi`
`<MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_server_matrix_multiply_<tr`
 | | eRPC source files | `<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/` | | RPLite
 source files | `<MCUXpressoSDK_install_dir>/middleware/multicore/rplite/`

Designing the eRPC application The matrix multiply application is based on calling single eRPC function that takes 2 two-dimensional arrays as input and returns matrix multiplication results as another 2 two-dimensional array. The IDL file syntax supports arrays with the dimension length set by the number only (in the current eRPC implementation). Because of this, a variable is declared in the IDL dedicated to store information about matrix dimension length, and to allow easy maintenance of the user and server code.

For a simple use of the two-dimensional array, the alias name (new type definition) for this data type has is declared in the IDL. Declaring this alias name ensures that the same data type can be used across the client and server applications.

Parent topic: [eRPC example](#)

Creating the IDL file The created IDL file is located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/`

The created IDL file contains the following code:

```
program erpc_matrix_multiply
/*! This const defines the matrix size. The value has to be the same as the
Matrix array dimension. Do not forget to re-generate the erpc code once the
matrix size is changed in the erpc file */
const int32 matrix_size = 5;
/*! This is the matrix array type. The dimension has to be the same as the
matrix size const. Do not forget to re-generate the erpc code once the
matrix size is changed in the erpc file */
type Matrix = int32[matrix_size][matrix_size];
interface MatrixMultiplyService {
erpcMatrixMultiply(in Matrix matrix1, in Matrix matrix2, out Matrix result_matrix) ->
void
}
```

Details:

- The IDL file starts with the program name (*erpc_matrix_multiply*), and this program name is used in the naming of all generated outputs.
- The declaration and definition of the constant variable named *matrix_size* follows next. The *matrix_size* variable is used for passing information about the length of matrix dimensions to the client/server user code.
- The alias name for the two-dimensional array type (*Matrix*) is declared.
- The interface group *MatrixMultiplyService* is located at the end of the IDL file. This interface group contains only one function declaration *erpcMatrixMultiply*.
- As shown above, the function’s declaration contains three parameters of *Matrix* type: *matrix1* and *matrix2* are input parameters, while *result_matrix* is the output parameter. Additionally, the returned data type is declared as void.

When writing the IDL file, the following order of items is recommended:

1. Program name at the top of the IDL file.
2. New data types and constants declarations.
3. Declarations of interfaces and functions at the end of the IDL file.

Parent topic: [eRPC example](#)

Using the eRPC generator tool | Windows OS | `<MCUXpressoSDK_install_dir>/middleware/multicore/tools/erpcgen/Linux_x64`
| Linux OS | `<MCUXpressoSDK_install_dir>/middleware/multicore/tools/erpcgen/Linux_x86`
`<MCUXpressoSDK_install_dir>/middleware/multicore/tools/erpcgen/Linux_x86`
| | Mac OS | `<MCUXpressoSDK_install_dir>/middleware/multicore/tools/erpcgen/Mac`

The files for the “Matrix multiply” example are pre-generated and already a part of the application projects. The following section describes how they have been created.

- The easiest way to create the shim code is to copy the erpcgen application to the same folder where the IDL file (*.erpc) is located; then run the following command:

```
erpcgen <IDL_file>.erpc
```

- In the “Matrix multiply” example, the command should look like:

```
erpcgen erpc_matrix_multiply.erpc
```

Additionally, another method to create the shim code is to execute the eRPC application using input commands:

- “-?”/”—help” – Shows supported commands.
- “-o <filePath>”/”—output<filePath>” – Sets the output directory.

For example,

```
<path_to_erpcgen>/erpcgen -o <path_to_output>  
<path_to_IDL>/<IDL_file_name>.erpc
```

For the “Matrix multiply” example, when the command is executed from the default erpcgen location, it looks like:

```
erpcgen -o  
../../../../../boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/service  
../../../../../boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/service/erpc_matrix_mu
```

In both cases, the following four files are generated into the `<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/service` folder:

- erpc_matrix_multiply.h
- erpc_matrix_multiply_client.cpp
- erpc_matrix_multiply_server.h
- erpc_matrix_multiply_server.cpp

For multiprocessor examples, the eRPC file and pre-generated files can be found in the `<MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_common/erpc_matrix_multiply/service` folder.

For Linux OS users:

- Do not forget to set the permissions for the eRPC generator application.
- Run the application as `./erpcgen...` instead of as `erpcgen ....`

Parent topic: [eRPC example](#)

Create an eRPC application This section describes a generic way to create a client/server eRPC application:

1. **Design the eRPC application:** Decide which data types are sent between applications, and define functions that send/receive this data.
2. **Create the IDL file:** The IDL file contains information about data types and functions used in an eRPC application, and is written in the IDL language.
3. **Use the eRPC generator tool:** This tool takes an IDL file and generates the shim code for the client and the server-side applications.
4. **Create an eRPC application:**
 1. Create two projects, where one project is for the client side (primary core) and the other project is for the server side (secondary core).
 2. Add generated files for the client application to the client project, and add generated files for the server application to the server project.
 3. Add infrastructure files.
 4. Add user code for client and server applications.
 5. Set the client and server project options.
5. **Run the eRPC application:** Run both the server and the client applications. Make sure that the server has been run before the client request was sent.

A specific example follows in the next section.

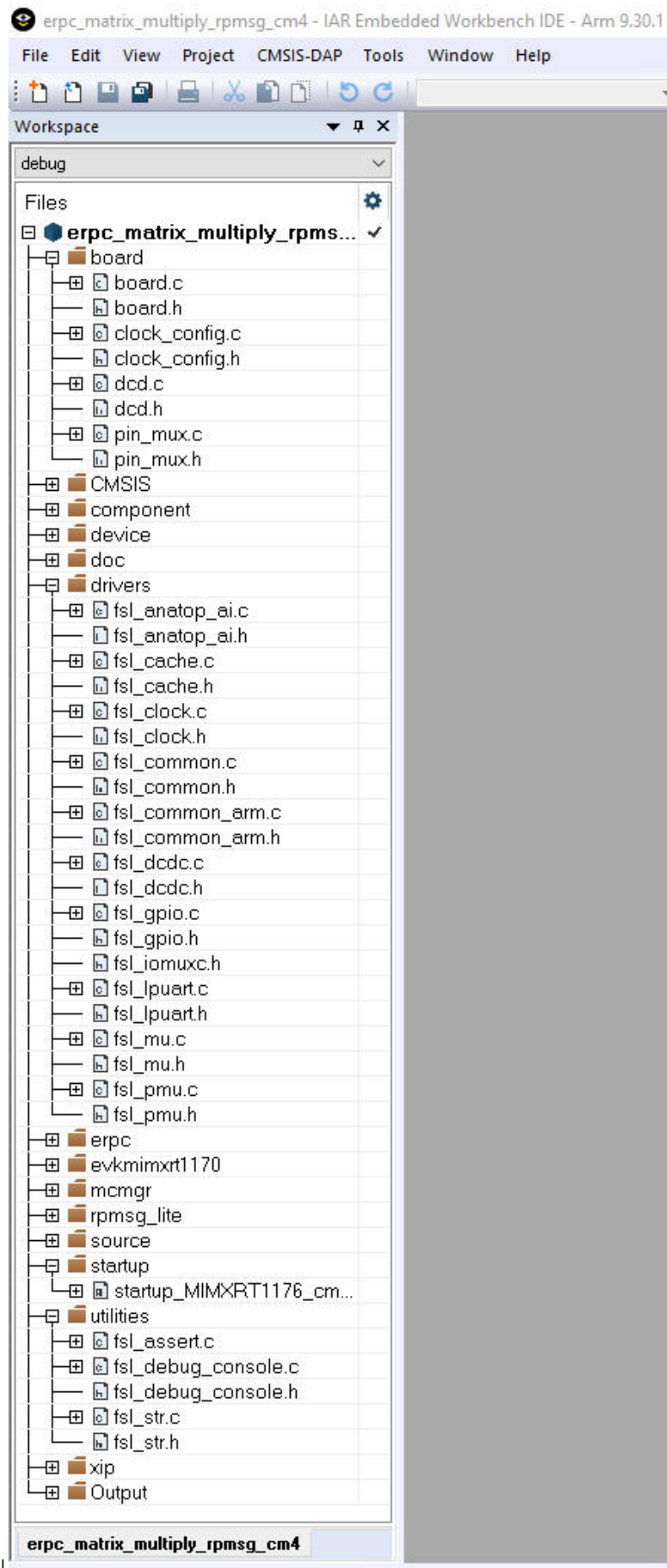
Multicore server application The “Matrix multiply” eRPC server project is located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmmsg/cm4/iar`

The project files for the eRPC server have the `_cm4` suffix.

Server project basic source files The startup files, board-related settings, peripheral drivers, and utilities belong to the basic project source files and form the skeleton of all MCUXpresso SDK applications. These source files are located in:

- `<MCUXpressoSDK_install_dir>/devices/<device>`
- `<MCUXpressoSDK_install_dir>/boards/<board_name>/multicore_examples/<example_name>/`



|

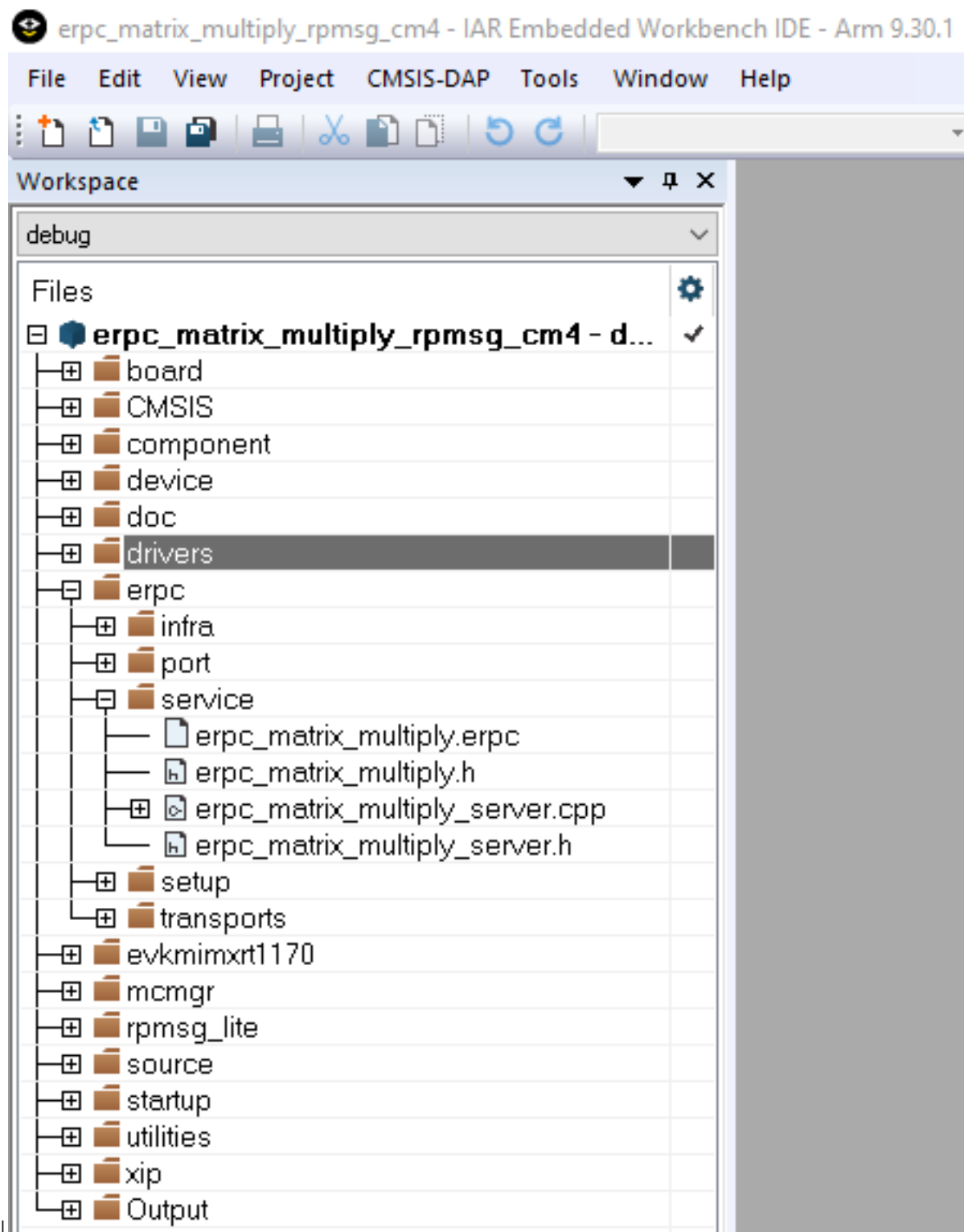
Parent topic:Multicore server application

Server related generated files The server-related generated files are:

- erpc__matric__multiply.h
- erpc__matrix__multiply__server.h
- erpc__matrix__multiply__server.cpp

The server-related generated files contain the shim code for functions and data types declared in the IDL file. These files also contain functions for the identification of client requested functions, data deserialization, calling requested function's implementations, and data serialization and return, if requested by the client. These shim code files can be found in the following folder:

<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/



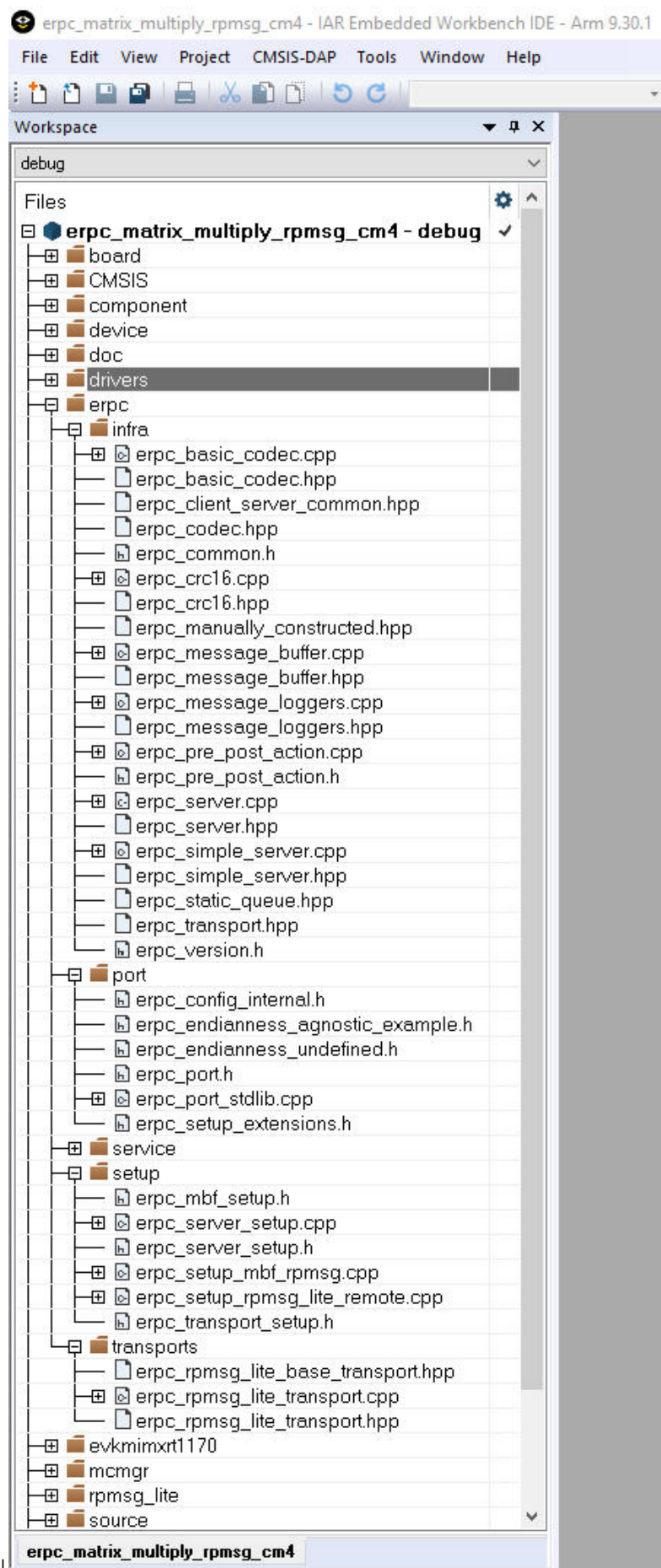
Parent topic:Multicore server application

Server infrastructure files The eRPC infrastructure files are located in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/erpc_c`

The **erpc_c** folder contains files for creating eRPC client and server applications in the C/C++ language. These files are distributed into subfolders.

- The **infra** subfolder contains C++ infrastructure code used to build server and client applications.
 - Four files, `erpc_server.hpp`, `erpc_server.cpp`, `erpc_simple_server.hpp`, and `erpc_simple_server.cpp`, are used for running the eRPC server on the server-side applications. The simple server is currently the only implementation of the server, and its role is to catch client requests, identify and call requested functions, and send data back when requested.
 - Three files (`erpc_codec.hpp`, `erpc_basic_codec.hpp`, and `erpc_basic_codec.cpp`) are used for codecs. Currently, the basic codec is the initial and only implementation of the codecs.
 - The `erpc_common.hpp` file is used for common eRPC definitions, typedefs, and enums.
 - The `erpc_manually_constructed.hpp` file is used for allocating static storage for the used objects.
 - Message buffer files are used for storing serialized data: `erpc_message_buffer.h` and `erpc_message_buffer.cpp`.
 - The `erpc_transport.h` file defines the abstract interface for transport layer.
- The **port** subfolder contains the eRPC porting layer to adapt to different environments.
 - `erpc_port.h` file contains definition of `erpc_malloc()` and `erpc_free()` functions.
 - `erpc_port_stdlib.cpp` file ensures adaptation to `stdlib`.
 - `erpc_config_internal.h` internal erpc configuration file.
- The **setup** subfolder contains a set of plain C APIs that wrap the C++ infrastructure, providing client and server init and deinit routines that greatly simplify eRPC usage in C-based projects. No knowledge of C++ is required to use these APIs.
 - The `erpc_server_setup.h` and `erpc_server_setup.cpp` files need to be added into the “Matrix multiply” example project to demonstrate the use of C-wrapped functions in this example.
 - The `erpc_transport_setup.h` and `erpc_setup_rpmsg_lite_remote.cpp` files need to be added into the project in order to allow the C-wrapped function for transport layer setup.
 - The `erpc_mbf_setup.h` and `erpc_setup_mbf_rpmsg.cpp` files need to be added into the project in order to allow message buffer factory usage.
- The **transports** subfolder contains transport classes for the different methods of communication supported by eRPC. Some transports are applicable only to host PCs, while others are applicable only to embedded or multicore systems. Most transports have corresponding client and server setup functions in the setup folder.
 - RPMsg-Lite is used as the transport layer for the communication between cores, `erpc_rpmsg_lite_base_transport.hpp`, `erpc_rpmsg_lite_transport.hpp`, and `erpc_rpmsg_lite_transport.cpp` files need to be added into the server project.



|

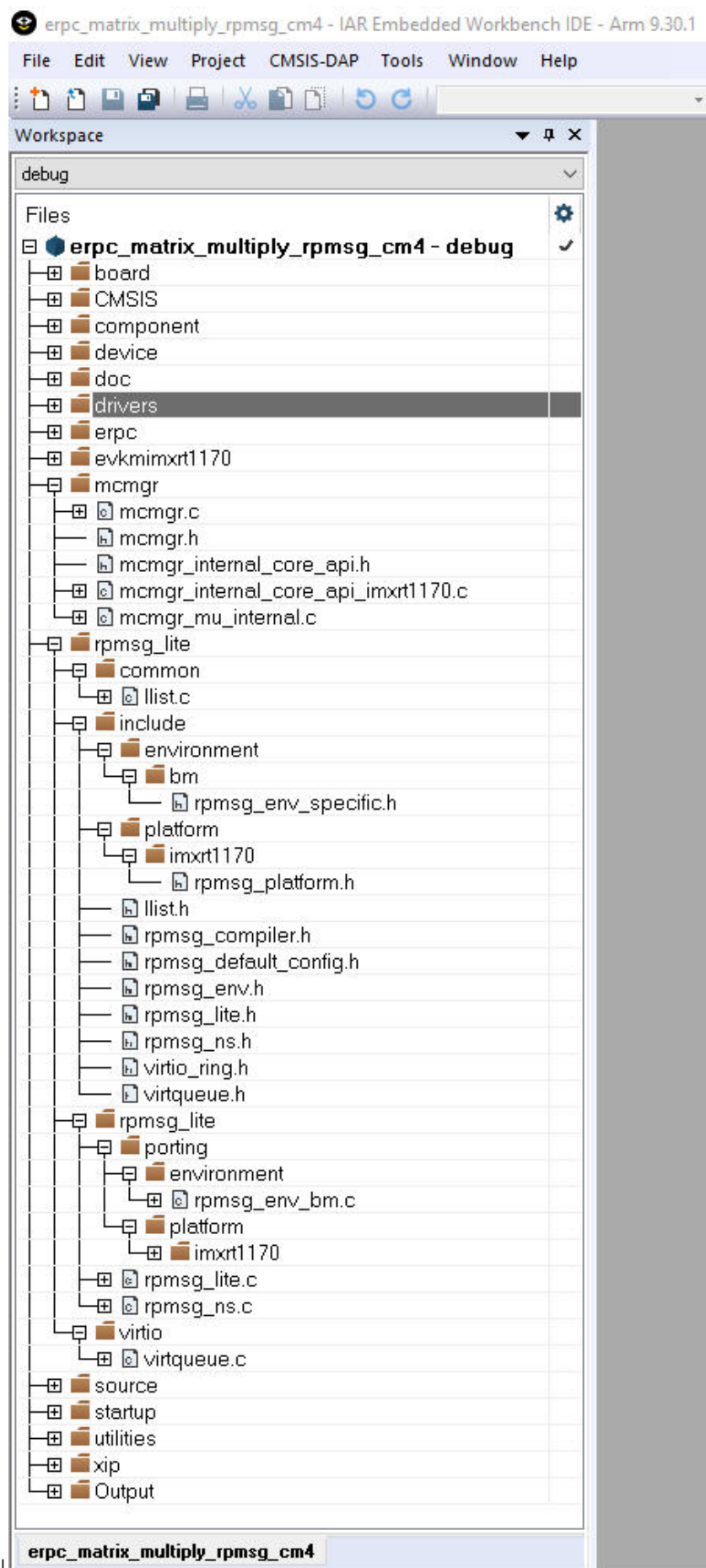
Parent topic: Multicore server application

Server multicore infrastructure files Because of the RPSMsg-Lite (transport layer), it is also necessary to include RPSMsg-Lite related files, which are in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/rpsmsg_lite/`

The multicore example applications also use the Multicore Manager software library to control the secondary core startup and shutdown. These source files are located in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr/`



Parent topic: Multicore server application

Server user code The server's user code is stored in the `main_core1.c` file, located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg/cm4`

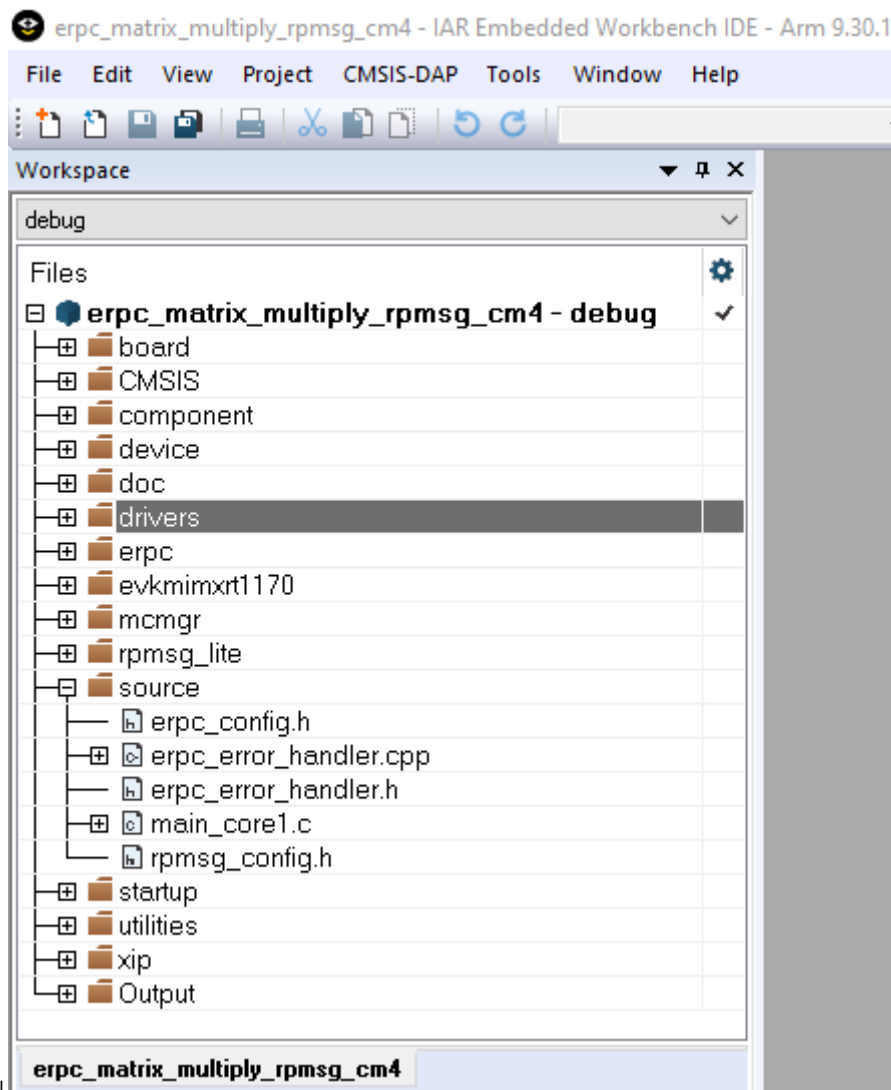
The `main_core1.c` file contains two functions:

- The **main()** function contains the code for the target board and eRPC server initialization. After the initialization, the matrix multiply service is added and the eRPC server waits for client's requests in the while loop.
- The **erpcMatrixMultiply()** function is the user implementation of the eRPC function defined in the IDL file.
- There is the possibility to write the application-specific eRPC error handler. The eRPC error handler of the matrix multiply application is implemented in the `erpc_error_handler.h` and `erpc_error_handler.cpp` files.

The eRPC-relevant code is captured in the following code snippet:

```
/* erpcMatrixMultiply function user implementation */
void erpcMatrixMultiply(const Matrix *matrix1, const Matrix *matrix2, Matrix *result_matrix)
{
    ...
}
int main()
{
    ...
    /* RPSMsg-Lite transport layer initialization */
    erpc_transport_t transport;
    transport = erpc_transport_rpmsg_lite_remote_init(src, dst, (void*)startupData,
    ERPC_TRANSPORT_RPMSG_LITE_LINK_ID, SignalReady, NULL);
    ...
    /* MessageBufferFactory initialization */
    erpc_mbf_t message_buffer_factory;
    message_buffer_factory = erpc_mbf_rpmsg_init(transport);
    ...
    /* eRPC server side initialization */
    erpc_server_t server;
    server = erpc_server_init(transport, message_buffer_factory);
    ...
    /* Adding the service to the server */
    erpc_service_t service = create_MatrixMultiplyService_service();
    erpc_add_service_to_server(server, service);
    ...
    while (1)
    {
        /* Process eRPC requests */
        erpc_status_t status = erpc_server_poll(server);
        /* handle error status */
        if (status != kErpcStatus_Success)
        {
            /* print error description */
            erpc_error_handler(status, 0);
            ...
        }
        ...
    }
}
```

Except for the application main file, there are configuration files for the RPMsg-Lite (rpmsg_config.h) and eRPC (erpc_config.h), located in the `<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg` folder.



Parent topic:Multicore server application

Parent topic:[Create an eRPC application](#)

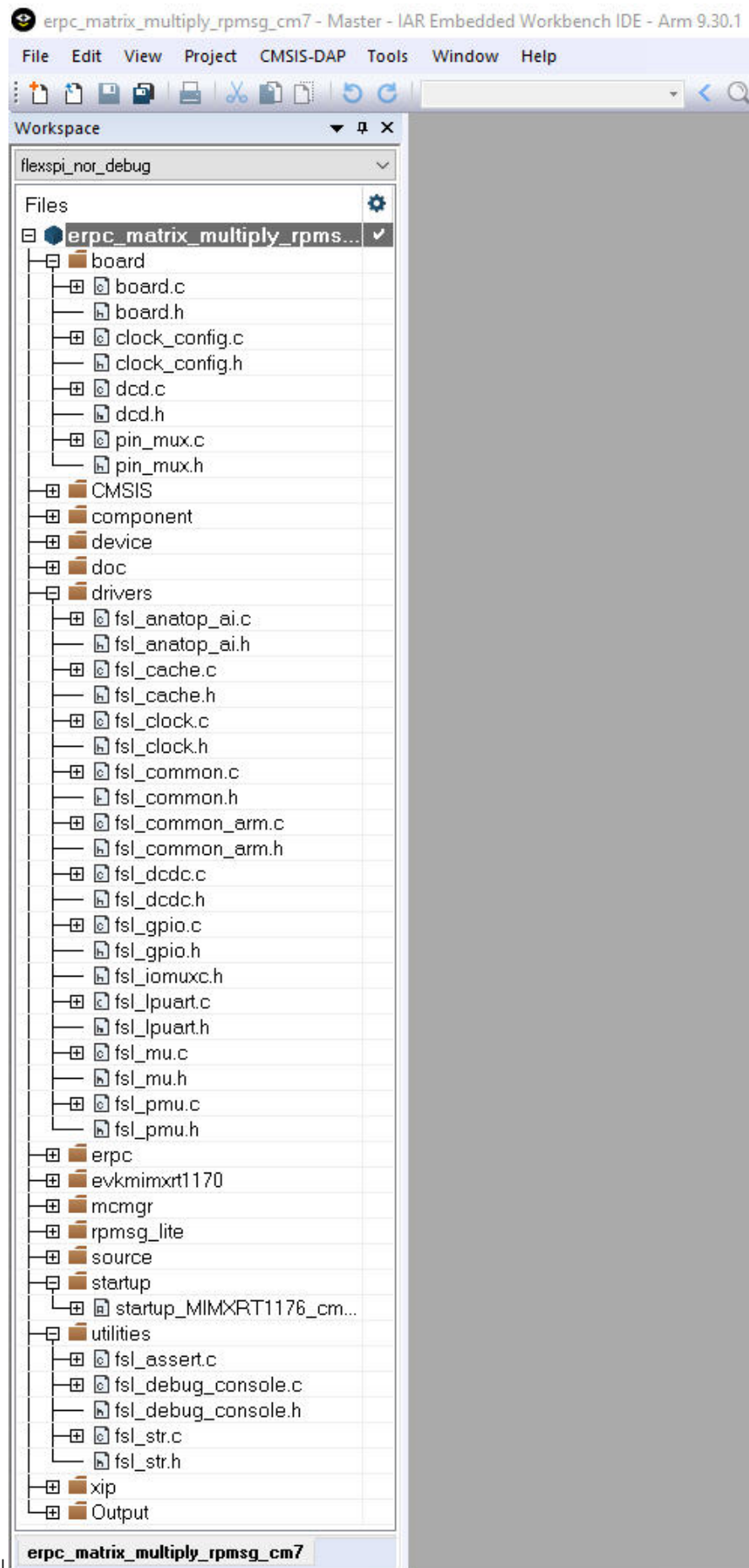
Multicore client application The “Matrix multiply” eRPC client project is located in the following folder:

`<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg/cm7/iar`

Project files for the eRPC client have the `_cm7` suffix.

Client project basic source files The startup files, board-related settings, peripheral drivers, and utilities belong to the basic project source files and form the skeleton of all MCUXpresso SDK applications. These source files are located in the following folders:

- `<MCUXpressoSDK_install_dir>/devices/<device>`
- `<MCUXpressoSDK_install_dir>/boards/<board_name>/multicore_examples/<example_name>/`

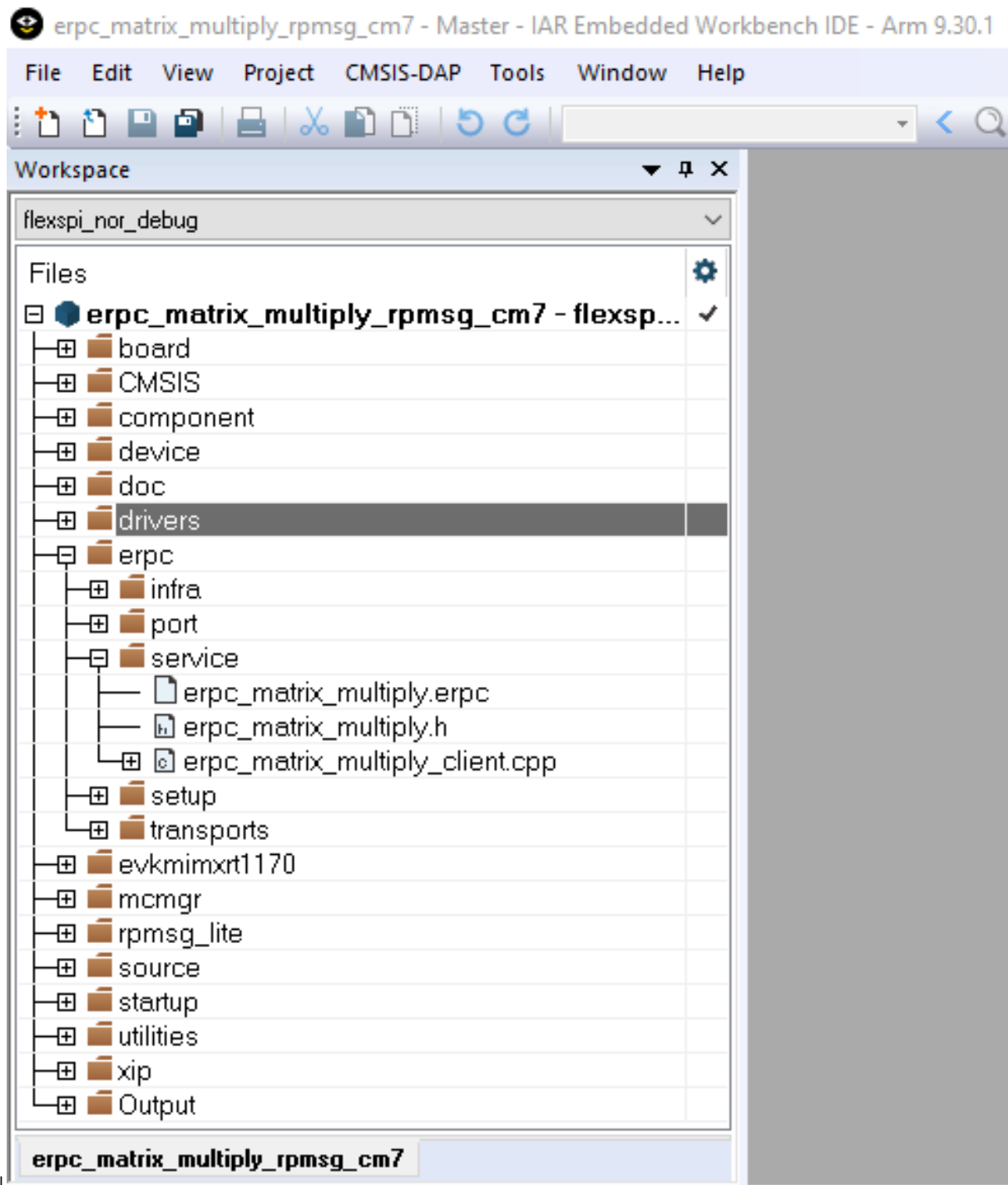


|

Parent topic: Multicore client application**Client-related generated files** The client-related generated files are:

- erpc__matric__multiply.h
- erpc__matrix__multiply__client.cpp

These files contain the shim code for the functions and data types declared in the IDL file. These functions also call methods for codec initialization, data serialization, performing eRPC requests, and de-serializing outputs into expected data structures (if return values are expected). These shim code files can be found in the `<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_common/erpc_matrix_multiply/service/` folder.



Parent topic: Multicore client application

Client infrastructure files The eRPC infrastructure files are located in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/erpc/erpc_c`

The **erpc_c** folder contains files for creating eRPC client and server applications in the C/C++ language. These files are distributed into subfolders.

- The **infra** subfolder contains C++ infrastructure code used to build server and client applications.

- Two files, `erpc_client_manager.h` and `erpc_client_manager.cpp`, are used for managing the client-side application. The main purpose of the client files is to create, perform, and release eRPC requests.
- Three files (`erpc_codec.hpp`, `erpc_basic_codec.hpp`, and `erpc_basic_codec.cpp`) are used for codecs. Currently, the basic codec is the initial and only implementation of the codecs.
- `erpc_common.h` file is used for common eRPC definitions, typedefs, and enums.
- `erpc_manually_constructed.hpp` file is used for allocating static storage for the used objects.
- Message buffer files are used for storing serialized data: `erpc_message_buffer.hpp` and `erpc_message_buffer.cpp`.
- `erpc_transport.hpp` file defines the abstract interface for transport layer.

The **port** subfolder contains the eRPC porting layer to adapt to different environments.

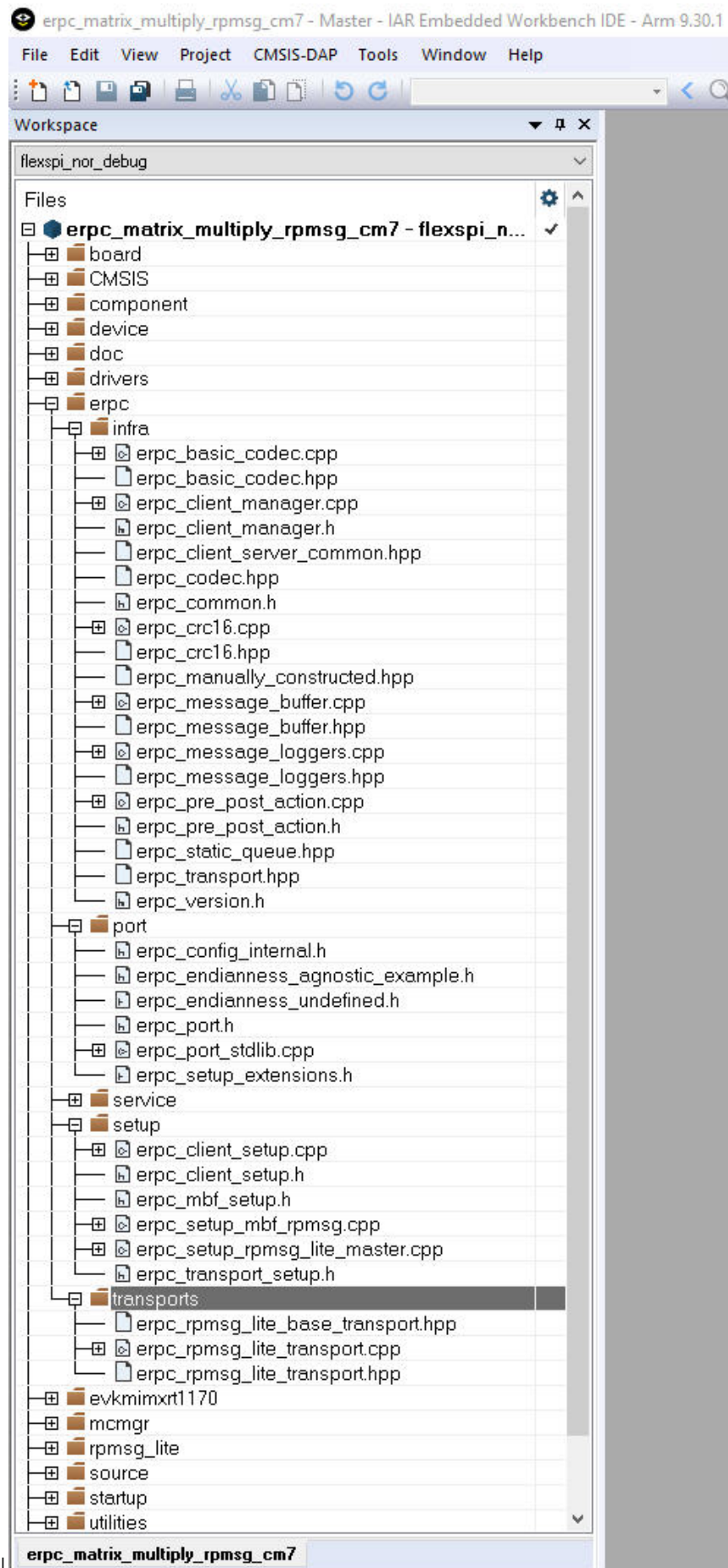
- `erpc_port.h` file contains definition of `erpc_malloc()` and `erpc_free()` functions.
- `erpc_port_stdlib.cpp` file ensures adaptation to `stdlib`.
- `erpc_config_internal.h` internal eRPC configuration file.

The **setup** subfolder contains a set of plain C APIs that wrap the C++ infrastructure, providing client and server init and deinit routines that greatly simplify eRPC usage in C-based projects. No knowledge of C++ is required to use these APIs.

- `erpc_client_setup.h` and `erpc_client_setup.cpp` files needs to be added into the “Matrix multiply” example project to demonstrate the use of C-wrapped functions in this example.
- `erpc_transport_setup.h` and `erpc_setup_rpmsg_lite_master.cpp` files needs to be added into the project in order to allow C-wrapped function for transport layer setup.
- `erpc_mbf_setup.h` and `erpc_setup_mbf_rpmsg.cpp` files needs to be added into the project in order to allow message buffer factory usage.

The **transports** subfolder contains transport classes for the different methods of communication supported by eRPC. Some transports are applicable only to host PCs, while others are applicable only to embedded or multicore systems. Most transports have corresponding client and server setup functions, in the setup folder.

- RPMsg-Lite is used as the transport layer for the communication between cores, `erpc_rpmsg_lite_base_transport.hpp`, `erpc_rpmsg_lite_transport.hpp`, and `erpc_rpmsg_lite_transport.cpp` files needs to be added into the client project.



|

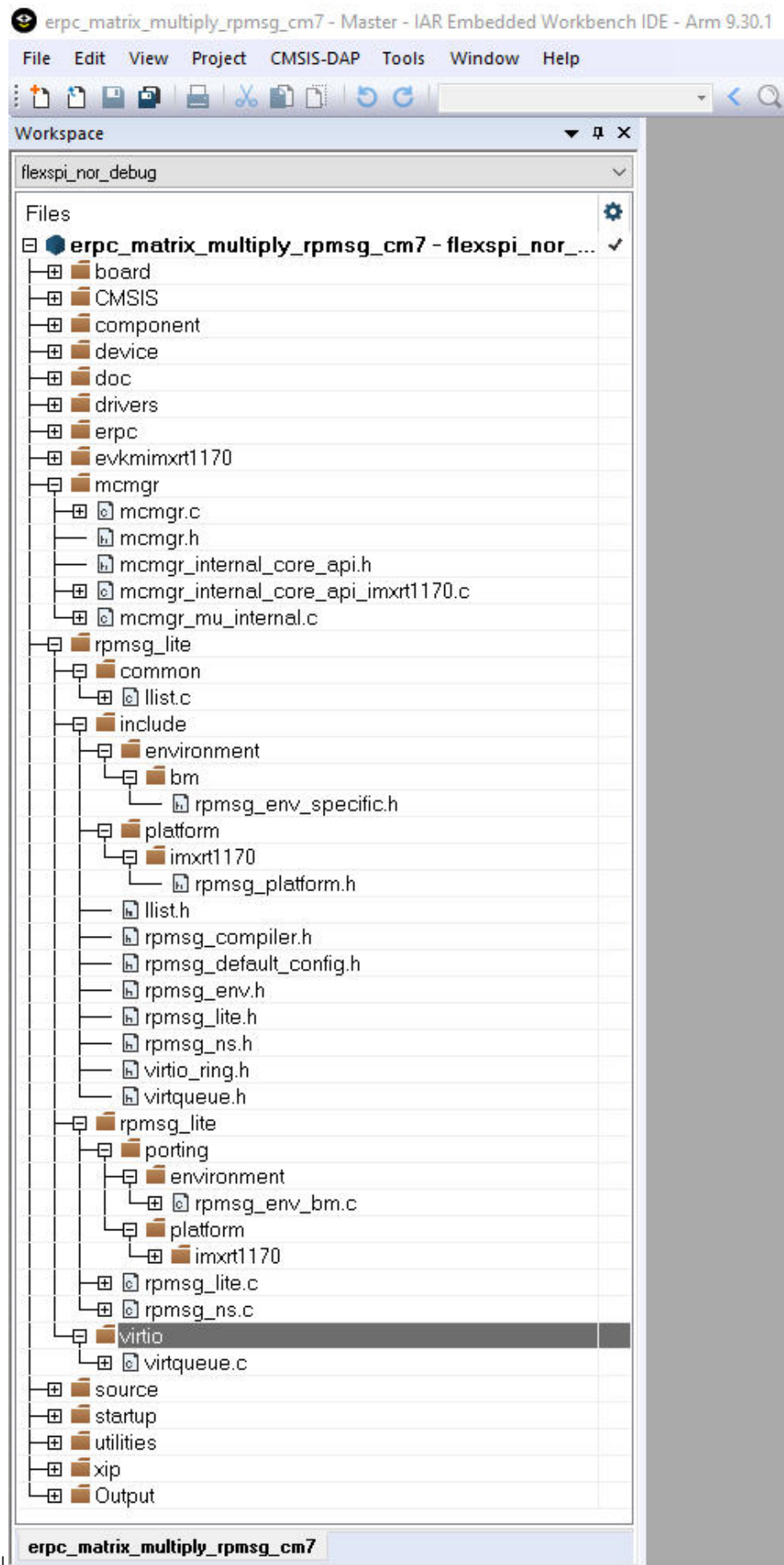
Parent topic: Multicore client application

Client multicore infrastructure files Because of the RPMsg-Lite (transport layer), it is also necessary to include RPMsg-Lite related files, which are in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/rpmsg_lite/`

The multicore example applications also use the Multicore Manager software library to control the secondary core startup and shutdown. These source files are located in the following folder:

`<MCUXpressoSDK_install_dir>/middleware/multicore/mcmgr/`



|

Parent topic:Multicore client application

Client user code The client's user code is stored in the main_core0.c file, located in the following folder:

<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_example/erpc_matrix_multiply_rpmsg/cm7

The main_core0.c file contains the code for target board and eRPC initialization.

- After initialization, the secondary core is released from reset.
- When the secondary core is ready, the primary core initializes two matrix variables.
- The erpcMatrixMultiply eRPC function is called to issue the eRPC request and get the result.

It is possible to write the application-specific eRPC error handler. The eRPC error handler of the matrix multiply application is implemented in erpc_error_handler.h and erpc_error_handler.cpp files.

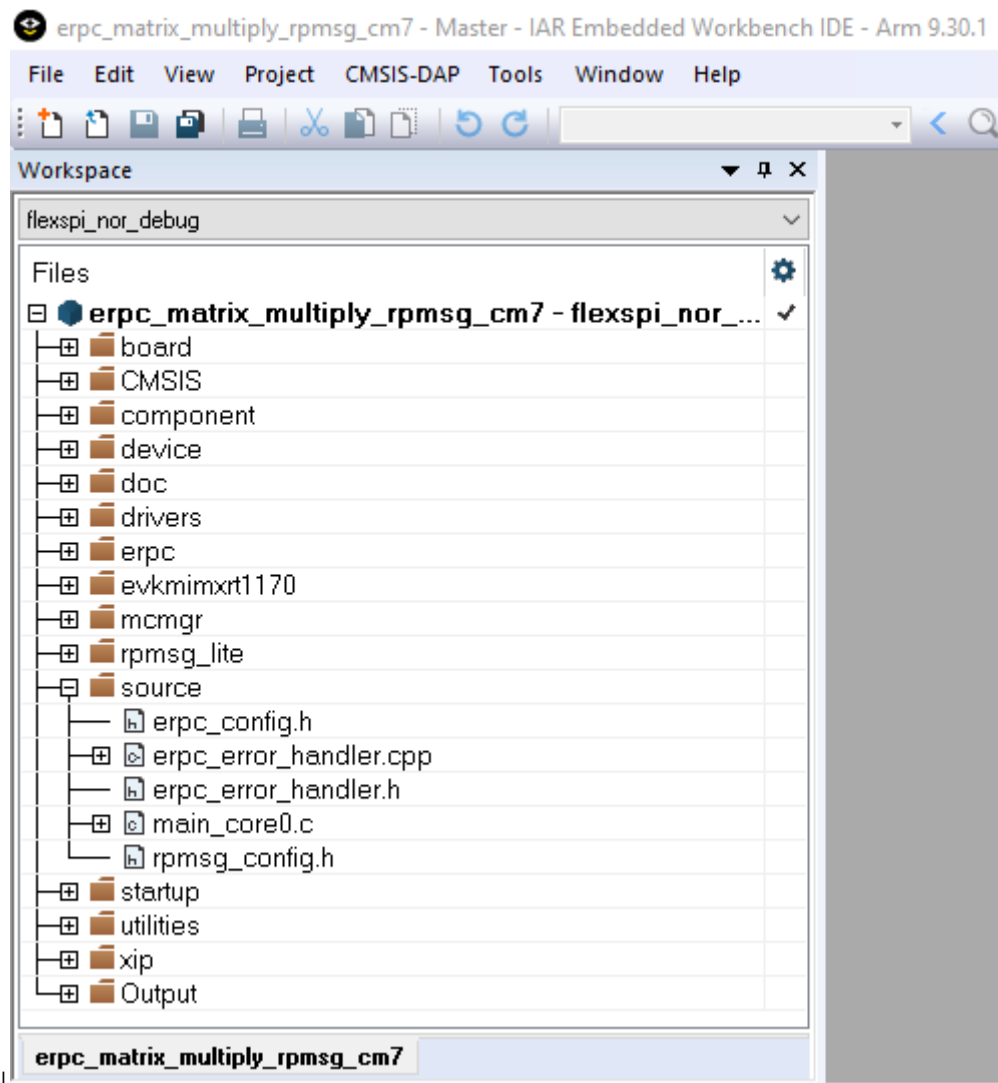
The matrix multiplication can be issued repeatedly, when pressing a software board button.

The eRPC-relevant code is captured in the following code snippet:

```
...
extern bool g_erpc_error_occurred;
...
/* Declare matrix arrays */
Matrix matrix1 = {0}, matrix2 = {0}, result_matrix = {0};
...
/* RPSMsg-Lite transport layer initialization */
erpc_transport_t transport;
transport = erpc_transport_rpmsg_lite_master_init(src, dst,
ERPC_TRANSPORT_RPMSG_LITE_LINK_ID);
...
/* MessageBufferFactory initialization */
erpc_mbf_t message_buffer_factory;
message_buffer_factory = erpc_mbf_rpmsg_init(transport);
...
/* eRPC client side initialization */
erpc_client_t client;
client = erpc_client_init(transport, message_buffer_factory);
...
/* Set default error handler */
erpc_client_set_error_handler(client, erpc_error_handler);
...
while (1)
{
    /* Invoke the erpcMatrixMultiply function */
    erpcMatrixMultiply(matrix1, matrix2, result_matrix);
    ...
    /* Check if some error occurred in eRPC */
    if (g_erpc_error_occurred)
    {
        /* Exit program loop */
        break;
    }
    ...
}
```

Except for the application main file, there are configuration files for the RPSMsg-Lite (rpmsg_config.h) and eRPC (erpc_config.h), located in the following folder:

<MCUXpressoSDK_install_dir>/boards/evkmimxrt1170/multicore_examples/erpc_matrix_multiply_rpmsg



Parent topic: Multicore client application

Parent topic: [Create an eRPC application](#)

Multiprocessor server application The “Matrix multiply” eRPC server project for multiprocessor applications is located in the `<MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_server_matrix_multiply_<transport_layer>` folder.

Most of the multiprocessor application setup is the same as for the multicore application. The multiprocessor server application requires server-related generated files (server shim code), server infrastructure files, and the server user code. There is no need for server multicore infrastructure files (MCMGR and RPMsg-Lite). The RPMsg-Lite transport layer is replaced either by SPI or UART transports. The following table shows the required transport-related files per each transport type.

SPI	<eRPC base directory>/erpc_c/setup/erpc_setup_(d)spi_slave.cpp
	<eRPC base directory>/erpc_c/transports/erpc_(d)spi_slave_transport.hpp
	<eRPC base directory>/erpc_c/transports/erpc_(d)spi_slave_transport.cpp
UART	<eRPC base directory>/erpc_c/setup/erpc_setup_uart_cmsis.cpp

<eRPC base directory>/erpc_c/transport/erpc_uart_cmsis_transport.hpp

<eRPC base directory>/erpc_c/transport/erpc_uart_cmsis_transport.cpp

|

Server user code The server's user code is stored in the main_server.c file, located in the <MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_server_matrix_multiply_<transport_layer>/ folder.

The eRPC-relevant code with UART as a transport is captured in the following code snippet:

```
/* erpcMatrixMultiply function user implementation */
void erpcMatrixMultiply(Matrix matrix1, Matrix matrix2, Matrix result_matrix)
{
    ...
}
int main()
{
    ...
    /* UART transport layer initialization, ERPC_DEMO_UART is the structure of CMSIS UART driver.
    ↪operations */
    erpc_transport_t transport;
    transport = erpc_transport_cmsis_uart_init((void *)&ERPC_DEMO_UART);
    ...
    /* MessageBufferFactory initialization */
    erpc_mbf_t message_buffer_factory;
    message_buffer_factory = erpc_mbf_dynamic_init();
    ...
    /* eRPC server side initialization */
    erpc_server_t server;
    server = erpc_server_init(transport, message_buffer_factory);
    ...
    /* Adding the service to the server */
    erpc_service_t service = create_MatrixMultiplyService_service();
    erpc_add_service_to_server(server, service);
    ...
    while (1)
    {
        /* Process eRPC requests */
        erpc_status_t status = erpc_server_poll(server)
        /* handle error status */
        if (status != kErpcStatus_Success)
        {
            /* print error description */
            erpc_error_handler(status, 0);
            ...
        }
        ...
    }
}
```

Parent topic:Multiprocessor server application

Multiprocessor client application The “Matrix multiply” eRPC client project for multiprocessor applications is located in the <MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_client_matrix_multiply_<transport_layer>/iar/ folder.

Most of the multiprocessor application setup is the same as for the multicore application. The multiprocessor server application requires client-related generated files (server shim code),

client infrastructure files, and the client user code. There is no need for client multicore infrastructure files (MCMGR and RPSMsg-Lite). The RPSMsg-Lite transport layer is replaced either by SPI or UART transports. The following table shows the required transport-related files per each transport type.

SPI	<eRPC base directory>/erpc_c/setup/erpc_setup_(d)spi_master.cpp
	<eRPC base directory>/erpc_c/transports/ erpc_(d)spi_master_transport.hpp
	<eRPC base directory>/erpc_c/transports/ erpc_(d)spi_master_transport.cpp
UART	<eRPC base directory>/erpc_c/setup/erpc_setup_uart_cmsis.cpp
	<eRPC base directory>/erpc_c/transports/erpc_uart_cmsis_transport.hpp
	<eRPC base directory>/erpc_c/transports/erpc_uart_cmsis_transport.cpp

Client user code The client's user code is stored in the `main_client.c` file, located in the `<MCUXpressoSDK_install_dir>/boards/<board_name>/multiprocessor_examples/erpc_client_matrix_multiply_<transport_layer>/` folder.

The eRPC-relevant code with UART as a transport is captured in the following code snippet:

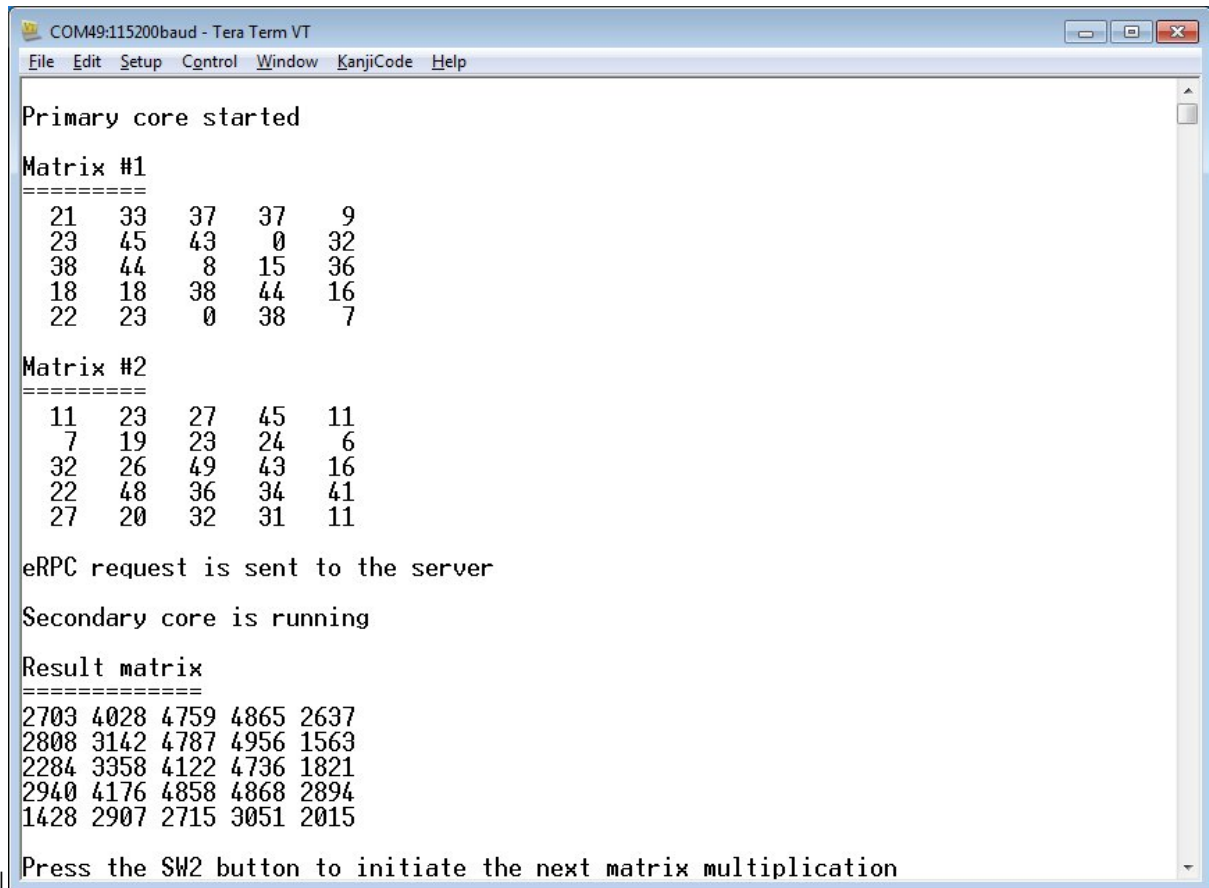
```
...
extern bool g_erpc_error_occurred;
...
/* Declare matrix arrays */
Matrix matrix1 = {0}, matrix2 = {0}, result_matrix = {0};
...
/* UART transport layer initialization, ERPC_DEMO_UART is the structure of CMSIS UART driver
↳operations */
erpc_transport_t transport;
transport = erpc_transport_cmsis_uart_init((void *)&ERPC_DEMO_UART);
...
/* MessageBufferFactory initialization */
erpc_mbf_t message_buffer_factory;
message_buffer_factory = erpc_mbf_dynamic_init();
...
/* eRPC client side initialization */
erpc_client_t client;
client = erpc_client_init(transport,message_buffer_factory);
...
/* Set default error handler */
erpc_client_set_error_handler(client, erpc_error_handler);
...
while (1)
{
    /* Invoke the erpcMatrixMultiply function */
    erpcMatrixMultiply(matrix1, matrix2, result_matrix);
    ...
    /* Check if some error occurred in eRPC */
    if (g_erpc_error_occurred)
    {
        /* Exit program loop */
        break;
    }
    ...
}
```

Parent topic:Multiprocessor client application

Parent topic:Multiprocessor server application

Parent topic:[Create an eRPC application](#)

Running the eRPC application Follow the instructions in *Getting Started with MCUXpresso SDK* (document MCUXSDKGSUG) (located in the <MCUXpressoSDK_install_dir>/docs folder), to load both the primary and the secondary core images into the on-chip memory, and then effectively debug the dual-core application. After the application is running, the serial console should look like:



```

COM49:115200baud - Tera Term VT
File Edit Setup Control Window KanjiCode Help

Primary core started

Matrix #1
=====
 21  33  37  37   9
 23  45  43   0  32
 38  44   8  15  36
 18  18  38  44  16
 22  23   0  38   7

Matrix #2
=====
 11  23  27  45  11
  7  19  23  24   6
 32  26  49  43  16
 22  48  36  34  41
 27  20  32  31  11

eRPC request is sent to the server

Secondary core is running

Result matrix
=====
2703 4028 4759 4865 2637
2808 3142 4787 4956 1563
2284 3358 4122 4736 1821
2940 4176 4858 4868 2894
1428 2907 2715 3051 2015

Press the SW2 button to initiate the next matrix multiplication

```

For multiprocessor applications that are running between PC and the target evaluation board or between two boards, follow the instructions in the accompanied example readme files that provide details about the proper board setup and the PC side setup (Python).

Parent topic:[Create an eRPC application](#)

Parent topic:[eRPC example](#)

Other uses for an eRPC implementation The eRPC implementation is generic, and its use is not limited to just embedded applications. When creating an eRPC application outside the embedded world, the same principles apply. For example, this manual can be used to create an eRPC application for a PC running the Linux operating system. Based on the used type of transport medium, existing transport layers can be used, or new transport layers can be implemented.

For more information and erpc updates see the github.com/EmbeddedRPC.

Note about the source code in the document Example code shown in this document has the following copyright and BSD-3-Clause license:

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Changelog eRPC All notable changes to this project will be documented in this file.

The format is based on [Keep a Changelog](#), and this project adheres to [Semantic Versioning](#).

Unreleased

Added

Fixed

- Python code of the eRPC infrastructure was updated to match the proper python code style, add type annotations and improve readability.

1.14.0

Added

- Added Cmake/Kconfig support.
- Made java code jdk11 compliant, GitHub PR #432.
- Added imxrt1186 support into mu transport layer.
- erpcgen: Added assert for listType before usage, GitHub PR #406.

Fixed

- eRPC: Sources reformatted.
- erpc: Fixed typo in semaphore get (mutex -> semaphore), and write it can fail in case of timeout, GitHub PR #446.
- erpc: Free the arbitrated client token from client manager, GitHub PR #444.

- erpc: Fixed Makefile, install the erpc_simple_server header, GitHub PR #447.
- erpc_python: Fixed possible AttributeError and OSError on calling TCPTransport.close(), GitHub PR #438.
- Examples and tests consolidated.

1.13.0

Added

- erpc: Add BSD-3 license to endianness agnostic files, GitHub PR #417.
- eRPC: Add new Zephyr-related transports (zephyr_uart, zephyr_mbox).
- eRPC: Add new Zephyr-related examples.

Fixed

- eRPC,erpcgen: Fixing/improving markdown files, GitHub PR #395.
- eRPC: Fix Python client TCPTransports not being able to close, GitHub PR #390.
- eRPC,erpcgen: Align switch brackets, GitHub PR #396.
- erpc: Fix zephyr uart transport, GitHub PR #410.
- erpc: UART ZEPHYR Transport stop to work after a few transactions when using USB-CDC resolved, GitHub PR #420.

Removed

- eRPC,erpcgen: Remove cstbool library, GitHub PR #403.

1.12.0

Added

- eRPC: Add dynamic/static option for transport init, GitHub PR #361.
- eRPC,erpcgen: Winsock2 support, GitHub PR #365.
- eRPC,erpcgen: Feature/support multiple clients, GitHub PR #271.
- eRPC,erpcgen: Feature/buffer head - Framed transport header data stored in Message-Buffer, GitHub PR #378.
- eRPC,erpcgen: Add experimental Java support.

Fixed

- eRPC: Fix receive error value for spidev, GitHub PR #363.
- eRPC: UartTransport::init adaptation to changed driver.
- eRPC: Fix typo in assert, GitHub PR #371.
- eRPC,erpcgen: Move enums to enum classes, GitHub PR #379.
- eRPC: Fixed rpmsg tty transport to work with serial transport, GitHub PR #373.

1.11.0

Fixed

- eRPC: Makefiles update, GitHub PR #301.
- eRPC: Resolving warnings in Python, GitHub PR #325.
- eRPC: Python3.8 is not ready for usage of typing.Any type, GitHub PR #325.
- eRPC: Improved codec function to use reference instead of address, GitHub PR #324.
- eRPC: Fix NULL check for pending client creation, GitHub PR #341.
- eRPC: Replace sprintf with snprintf, GitHub PR #343.
- eRPC: Use MU_SendMsg blocking call in MU transport.
- eRPC: New LPSPI and LPI2C transport layers.
- eRPC: Freeing static objects, GitHub PR #353.
- eRPC: Fixed casting in deinit functions, GitHub PR #354.
- eRPC: Align LIBUSB_SIO.GetNumPorts API use with libusb_sio python module v. 2.1.11.
- erpcgen: Renamed temp variable to more generic one, GitHub PR #321.
- erpcgen: Add check that string read is not more than max length, GitHub PR #328.
- erpcgen: Move to g++ in pytest, GitHub PR #335.
- erpcgen: Use build=release for make, GitHub PR #334.
- erpcgen: Removed boost dependency, GitHub PR #346.
- erpcgen: Mingw support, GitHub PR #344.
- erpcgen: VS build update, GitHub PR #347.
- erpcgen: Modified name for common types macro scope, GitHub PR #337.
- erpcgen: Fixed memcpy for template, GitHub PR #352.
- eRPC,erpcgen: Change default build target to release + adding artefacts, GitHub PR #334.
- eRPC,erpcgen: Remove redundant includes, GitHub PR #338.
- eRPC,erpcgen: Many minor code improvements, GitHub PR #323.

1.10.0

Fixed

- eRPC: MU transport layer switched to blocking MU_SendMsg() API use.

1.10.0

Added

- eRPC: Add TCP_NODELAY option to python, GitHub PR #298.

Fixed

- eRPC: MUPort adaptation to new supported SoCs.
- eRPC: Simplifying CI with installing dependencies using shell script, GitHub PR #267.
- eRPC: Using event for waiting for sock connection in TCP python server, formatting python code, C specific includes, GitHub PR #269.
- eRPC: Endianness agnostic update, GitHub PR #276.
- eRPC: Assertion added for functions which are returning status on freeing memory, GitHub PR #277.
- eRPC: Fixed closing arbitrator server in unit tests, GitHub PR #293.
- eRPC: Makefile updated to reflect the correct header names, GitHub PR #295.
- eRPC: Compare value length to used length() in reading data from message buffer, GitHub PR #297.
- eRPC: Replace EXPECT_TRUE with EXPECT_EQ in unit tests, GitHub PR #318.
- eRPC: Adapt rpmsg_lite based transports to changed rpmsg_lite_wait_for_link_up() API parameters.
- eRPC, erpcgen: Better distinguish which file can and cannot be linked by C linker, GitHub PR #266.
- eRPC, erpcgen: Stop checking if pointer is NULL before sending it to the erpc_free function, GitHub PR #275.
- eRPC, erpcgen: Changed api to count with more interfaces, GitHub PR #304.
- erpcgen: Check before reading from heap the buffer boundaries, GitHub PR #287.
- erpcgen: Several fixes for tests and CI, GitHub PR #289.
- erpcgen: Refactoring erpcgen code, GitHub PR #302.
- erpcgen: Fixed assigning const value to enum, GitHub PR #309.
- erpcgen: Enable runTesttest_enumErrorCode_allDirection, serialize enums as int32 instead of uint32.

1.9.1

Fixed

- eRPC: Construct the USB CDC transport, rather than a client, GitHub PR #220.
- eRPC: Fix premature import of package, causing failure when attempting installation of Python library in a clean environment, GitHub PR #38, #226.
- eRPC: Improve python detection in make, GitHub PR #225.
- eRPC: Fix several warnings with deprecated call in pytest, GitHub PR #227.
- eRPC: Fix freeing union members when only default need be freed, GitHub PR #228.
- eRPC: Fix making test under Linux, GitHub PR #229.
- eRPC: Assert costumizing, GitHub PR #148.
- eRPC: Fix corrupt clientList bug in TransportArbitrator, GitHub PR #199.
- eRPC: Fix build issue when invoking g++ with -Wno-error=free-nonheap-object, GitHub PR #233.
- eRPC: Fix inout cases, GitHub PR #237.

- eRPC: Remove ERPC_PRE_POST_ACTION dependency on return type, GitHub PR #238.
- eRPC: Adding NULL to ptr when codec function failed, fixing memcpy when fail is present during deserialization, GitHub PR #253.
- eRPC: MessageBuffer usage improvement, GitHub PR #258.
- eRPC: Get rid of serial and enum34 dependency (enum34 is in python3 since 3.4 (from 2014)), GitHub PR #247.
- eRPC: Several MISRA violations addressed.
- eRPC: Fix timeout for Freertos semaphore, GitHub PR #251.
- eRPC: Use of rpmsg_lite_wait_for_link_up() in rpmsg_lite based transports, GitHub PR #223.
- eRPC: Fix codec nullptr dereferencing, GitHub PR #264.
- erpcgen: Fix two syntax errors in erpcgen Python output related to non-encapsulated unions, improved test for union, GitHub PR #206, #224.
- erpcgen: Fix serialization of list/binary types, GitHub PR #240.
- erpcgen: Fix empty list parsing, GitHub PR #72.
- erpcgen: Fix templates for malloc errors, GitHub PR #110.
- erpcgen: Get rid of encapsulated union declarations in global scale, improve enum usage in unions, GitHub PR #249, #250.
- erpcgen: Fix compile error:UniqueIdChecker.cpp:156:104:'sort' was not declared, GitHub PR #265.

1.9.0

Added

- eRPC: Allow used LIBUSBSIO device index being specified from the Python command line argument.

Fixed

- eRPC: Improving template usage, GitHub PR #153.
- eRPC: run_clang_format.py cleanup, GitHub PR #177.
- eRPC: Build TCP transport setup code into liberpc, GitHub PR #179.
- eRPC: Fix multiple definitions of g_client error, GitHub PR #180.
- eRPC: Fix memset past end of buffer in erpc_setup_mbf_static.cpp, GitHub PR #184.
- eRPC: Fix deprecated error with newer pytest version, GitHub PR #203.
- eRPC, erpcgen: Static allocation support and usage of rpmsg static FreeRTOSs related API, GitHub PR #168, #169.
- erpcgen: Remove redundant module imports in erpcgen, GitHub PR #196.

1.8.1

Added

- eRPC: New i2c_slave_transport transport introduced.

Fixed

- eRPC: Fix misra erpc c, GitHub PR #158.
- eRPC: Allow conditional compilation of message_loggers and pre_post_action.
- eRPC: (D)SPI slave transports updated to avoid busy loops in rtos environments.
- erpcgen: Re-implement EnumMember::hasValue(), GitHub PR #159.
- erpcgen: Fixing several misra issues in shim code, erpcgen and unit tests updated, GitHub PR #156.
- erpcgen: Fix bison file, GitHub PR #156.

1.8.0

Added

- eRPC: Support win32 thread, GitHub PR #108.
- eRPC: Add mbed support for malloc() and free(), GitHub PR #92.
- eRPC: Introduced pre and post callbacks for eRPC call, GitHub PR #131.
- eRPC: Introduced new USB CDC transport.
- eRPC: Introduced new Linux spidev-based transport.
- eRPC: Added formatting extension for VSC, GitHub PR #134.
- erpcgen: Introduce ustring type for unsigned char and force cast to char*, GitHub PR #125.

Fixed

- eRPC: Update makefile.
- eRPC: Fixed warnings and error with using MessageLoggers, GitHub PR #127.
- eRPC: Extend error msg for python server service handle function, GitHub PR #132.
- eRPC: Update CMSIS UART transport layer to avoid busy loops in rtos environments, introduce semaphores.
- eRPC: SPI transport update to allow usage without handshaking GPIO.
- eRPC: Native _WIN32 erpc serial transport and threading.
- eRPC: Arbitrator deadlock fix, TCP transport updated, TCP setup functions introduced, GitHub PR #121.
- eRPC: Update of matrix_multiply.py example: Add -serial and -baud argument, GitHub PR #137.
- eRPC: Update of .clang-format, GitHub PR #140.
- eRPC: Update of erpc_framed_transport.cpp: return error if received message has zero length, GitHub PR #141.
- eRPC, erpcgen: Fixed error messages produced by -Wall -Wextra -Wshadow -pedantic-errors compiler flags, GitHub PR #136, #139.
- eRPC, erpcgen: Core re-formatted using Clang version 10.
- erpcgen: Enable deallocation in server shim code when callback/function pointer used as out parameter in IDL.
- erpcgen: Removed '\$' character from generated symbol name in '_\$union' suffix, GitHub PR #103.

- erpcgen: Resolved mismatch between C++ and Python for callback index type, GitHub PR #111.
- erpcgen: Python generator improvements, GitHub PR #100, #118.
- erpcgen: Fixed error messages produced by -Wall -Wextra -Wshadow -pedantic-errors compiler flags, GitHub PR #136.

1.7.4

Added

- eRPC: Support MU transport unit testing.
- eRPC: Adding mbed os support.

Fixed

- eRPC: Unit test code updated to handle service add and remove operations.
- eRPC: Several MISRA issues in rpmsg-based transports addressed.
- eRPC: Fixed Linux/TCP acceptance tests in release target.
- eRPC: Minor documentation updates, code formatting.
- erpcgen: Whitespace removed from C common header template.

1.7.3

Fixed

- eRPC: Improved the test_callbacks logic to be more understandable and to allow requested callback execution on the server side.
- eRPC: TransportArbitrator::prepareClientReceive modified to avoid incorrect return value type.
- eRPC: The ClientManager and the ArbitratedClientManager updated to avoid performing client requests when the previous serialization phase fails.
- erpcgen: Generate the shim code for destroy of statically allocated services.

1.7.2

Added

- eRPC: Add missing doxygen comments for transports.

Fixed

- eRPC: Improved support of const types.
- eRPC: Fixed Mac build.
- eRPC: Fixed serializing python list.
- eRPC: Documentation update.

1.7.1

Fixed

- eRPC: Fixed semaphore in static message buffer factory.
- erpcgen: Fixed MU received error flag.
- erpcgen: Fixed tcp transport.

1.7.0

Added

- eRPC: List names are based on their types. Names are more deterministic.
- eRPC: Service objects are as a default created as global static objects.
- eRPC: Added missing doxygen comments.
- eRPC: Added support for 64bit numbers.
- eRPC: Added support of program language specific annotations.

Fixed

- eRPC: Improved code size of generated code.
- eRPC: Generating crc value is optional.
- eRPC: Fixed CMSIS Uart driver. Removed dependency on KSDK.
- eRPC: Forbid users use reserved words.
- eRPC: Removed outByref for function parameters.
- eRPC: Optimized code style of callback functions.

1.6.0

Added

- eRPC: Added @nullable support for scalar types.

Fixed

- eRPC: Improved code size of generated code.
- eRPC: Improved eRPC nested calls.
- eRPC: Improved eRPC list length variable serialization.

1.5.0

Added

- eRPC: Added support for unions type non-wrapped by structure.
- eRPC: Added callbacks support.
- eRPC: Added support @external annotation for functions.
- eRPC: Added support @name annotation.
- eRPC: Added Messaging Unit transport layer.
- eRPC: Added RPMSG Lite RTOS TTY transport layer.
- eRPC: Added version verification and IDL version verification between eRPC code and eRPC generated shim code.
- eRPC: Added support of shared memory pointer.
- eRPC: Added annotation to forbid generating const keyword for function parameters.
- eRPC: Added python matrix multiply example.
- eRPC: Added nested call support.
- eRPC: Added struct member “byref” option support.
- eRPC: Added support of forward declarations of structures
- eRPC: Added Python RPMsg Multiendpoint kernel module support
- eRPC: Added eRPC sniffer tool

1.4.0**Added**

- eRPC: New RPMsg-Lite Zero Copy (RPMsgZC) transport layer.

Fixed

- eRPC: win_flex_bison.zip for windows updated.
- eRPC: Use one codec (instead of inCodec outCodec).

[1.3.0]**Added**

- eRPC: New annotation types introduced (@length, @max_length, ...).
- eRPC: Support for running both erpc client and erpc server on one side.
- eRPC: New transport layers for (LP)UART, (D)SPI.
- eRPC: Error handling support.

[1.2.0]**Added**

- eRPC source directory organization changed.
- Many eRPC improvements.

[1.1.0]

Added

- Multicore SDK 1.1.0 ported to KSDK 2.0.0.

[1.0.0]

Added

- Initial Release

Chapter 4

RTOS

4.1 FreeRTOS

4.1.1 FreeRTOS kernel

Open source RTOS kernel for small devices.

[FreeRTOS kernel for MCUXpresso SDK Readme](#)

[FreeRTOS kernel for MCUXpresso SDK ChangeLog](#)

[FreeRTOS kernel Readme](#)

4.1.2 FreeRTOS drivers

This is set of NXP provided FreeRTOS reentrant bus drivers.

4.1.3 backoffalgorithm

Algorithm for calculating exponential backoff with jitter for network retry attempts.

[Readme](#)

4.1.4 corehttp

C language HTTP client library designed for embedded platforms.

4.1.5 corejson

JSON parser.

Readme

4.1.6 coremqtt

MQTT publish/subscribe messaging library.

4.1.7 corepkcs11

PKCS #11 key management library.

Readme

4.1.8 freertos-plus-tcp

Open source RTOS FreeRTOS Plus TCP.

Readme