

RSL15 Firmware Reference

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CHAPTER 1

Introduction

1.1 PURPOSE

IMPORTANT: onsemi acknowledges that this document might contain the inappropriate terms “white list”, “master” and “slave”. We have a plan to work with other companies to identify an industry wide solution that can eradicate non-inclusive terminology but maintains the technical relationship of the original wording. Once new terminologies are agreed upon, future products will contain new terminology.

This group of topics describes the firmware included in the RSL15 System-on-Chip. It includes descriptions, function listings, and usage examples to help you understand the firmware and its parts.

The firmware described in this reference provides developers with a convenient software layer on which to build their applications. It is also responsible for system-level tasks such as booting the system and implementing portions of the security layer. The firmware consists of include files, macros, libraries, ROM code, and executables.

1.2 INTENDED AUDIENCE

This group of topics is intended for use by developers who are designing and implementing applications for the RSL15 System-on-Chip. Both novice and experienced developers can benefit. The descriptions and code examples can help novice users to learn the system, while experienced developers can go straight to the reference chapters that describe the available functions, macros, libraries and executables.

These topics assume that the reader has a basic understanding of:

- The architecture of the RSL15 chip
- The C programming language
- The fundamentals of the Arm[®] Thumb[®]-2 assembly language
- The integrated development environment and toolchains that form the development tools for the RSL15 SoC

1.3 CONVENTIONS

`monospace font`

Assembly code, macros, functions, defines and addresses.

italics

File and path names, or any portion of them.

<angle brackets>

Optional parameters and placeholders for specific information. To use an optional parameter or replace a placeholder, specify the information within the brackets; do not include the brackets themselves.

*

Wild card placeholder; typically used to indicate a place where two or more numeric constants could be used.

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Note, Important, Caution, Warning

Information requiring special notice is presented in several attention-grabbing formats depending on the consequences of ignoring the information:

NOTE: Significant supplemental information, hints, or tips.

IMPORTANT: Information that is more significant than a Note; intended to help you avoid frustration.

CAUTION: Information that can prevent you from damaging equipment or software.

WARNING: Information that can prevent harm to humans.

1.4 FURTHER READING

The following documents are installed with the RSL15 system, in the default location `C:/Users/<your_user_name>/AppData/Local/Arm/Packs/ONSemiconductor/RSL15/<version_number>/documentation`. These manuals are available only in PDF format:

- *Arm TrustZone CryptoCell-312 Software Developers Manual*
- multiple CEVA manuals in the `/ceva` folder

For even more information, consult these publicly-available documents:

- *Armv8M Architecture Reference Manual* (PDF download available from <https://developer.arm.com/documentation/ddi0553/latest>).
- *Arm Cortex-M33 Processor Technical Reference Manual*, revision r1p0, from <https://developer.arm.com/documentation/100230/0100>
- *Bluetooth Core Specification version 5.2*, available from <https://www.bluetooth.com/specifications/adopted-specifications>
- TrustZone documentation available from the Arm website at <https://developer.arm.com/ip-products/security-ip/trustzone/trustzone-for-cortex-m>
- Other ArmCortex-M33 publications, available from the Arm website at <https://developer.arm.com/ip-products/processors/cortex-m/cortex-m33>

For information about the Evaluation and Development Board, see the [RSL15 Evaluation and Development Board Manual](#) and the [RSL15 web page](#) on the [onsemi](#) website.

CHAPTER 2

Firmware Overview

RSL15 is supported by a set of firmware components that provide:

- A thin layer of support between the hardware and the developer. This firmware allows developers to focus on application development, reducing the number of details they need to know about the underlying RSL15 hardware.
- A support layer for common complex run time operations frequently included in user applications
- Security and lifetime provisioning elements, which help support the security elements needed throughout a device's lifecycle
- Wireless protocol support functionality for Bluetooth[®] Low Energy applications
- Manufacturing and debug support elements

2.1 INTRODUCTION

The system firmware provides hardware definitions and a hardware abstraction layer for common operations. These definitions and abstraction layer are easier to use and understand than low-level C or assembly code. The firmware components supporting common run time, debug, and manufacturing elements simplify incorporation of the device into a system throughout the development cycle. In addition, the security and wireless protocol firmware elements provide more advanced functionality, which can form the basis for applications developed to take advantage of the hardware that the RSL15 SoC provides.

When multiple programmers are involved in development, using the firmware leads to increased consistency, which in turn leads to increased overall robustness and correctness of code.

In some cases, depending on the particulars of the application, the firmware implementation might not be optimal; however, even in these situations, the firmware serves as an example and an advanced starting point for custom-developed functions and macros.

All firmware components execute on the Arm Cortex[®]-M33 processor, and all of these components are CMSIS-compatible.

2.1.1 Compliance Exceptions

The firmware provided for the Arm Cortex-M33 processor is generally compliant with the MISRA-C rules, as required by the CMSIS standard. The RSL15 firmware exceptions in compliance are the same compliance exceptions that are part of the CMSIS-Core standard.

The RSL15 firmware and CMSIS-Core violate the following MISRA-C rules:

- Required Rule 8.5, object/function definition in header file. Violated because function definitions in header files are used to allow inlining of functions.
- Required Rule 18.4, declaration of union type or object of union type: {...}. Violated because unions are used for effective representation of core registers.
- Advisory Rule 19.7, function-like macro defined. Violated because function-like macros are used to allow for more efficient code.

2.2 SUPPORTED DATA TYPES

The "RSL15 Supported Data Types" table (Table 1) shows the data types and their sizes as supported by the RSL15 firmware.

RSL15 Firmware Reference

Table 1. RSL15 Supported Data Types

Data Type	Number of Bytes
double ¹	8
float	4
int	4
long int	4
uint8_t	1
uint16_t	2
uint32_t	4
uint64_t	8

NOTE: All `uint_t` types are included under the `stdint.h` library.

2.3 FIRMWARE COMPONENTS

The firmware files consist of include files (denoted with `.h` extensions) and library binaries (denoted with `.a` extensions). Some libraries are also provided in source code format. Descriptions of the firmware components, and detailed API references, are provided in the remainder of this group of topics.

Applications that use the libraries provided must:

1. Include the associated firmware include file.
2. Link against any dependencies of the desired library.
3. Link against a version of the desired library.

The Arm CryptoCell™-312 libraries are available in Release configuration.

The event kernel support firmware and the Bluetooth Low Energy protocol stack are available as a library.

2.4 FIRMWARE NAMING CONVENTIONS

For clarity and ease of use, many firmware components follow several naming conventions for library functions and macros. These conventions are compatible with the CMSIS naming requirements.

- Macros (defined using a `#define` statement) use all capitals in the macro name. These macro names include an all-capital prefix indicating the library or other firmware element they are supporting (e.g., `SYS_`). If the macro supports a specific target component, this prefix is followed by the name of the component it supports. The rest of the macro name indicates the intended functionality of the macro.
- Inline and standard firmware functions use camel-case function names (e.g., `CalcPhaseCnt`). All functions use a prefix to indicate which library provides the function (e.g., `Sys_`). The remainder of a function's name indicates the block it affects and the function's intended functionality.

Table 2 lists the prefixes for each of the firmware libraries that use prefixes.

RSL15 Firmware Reference

Table 2. Library Function Naming Convention

Library	Macro Prefix	Function Prefix
Hardware Abstraction Layer, System Library	SYS_	sys_
Flash Support Library	FLASH_	Flash_
Event Kernel	KE_	kernel_, ke_

Elements that follow other naming conventions include the following:

- The CMSIS library and drivers follow the CMSIS standard, which provides standard names for all CMSIS macros and functions.
- The Arm CryptoCell-312 libraries largely use an API defined by Arm for the Arm TrustZone[®] CryptoCell-312 IP.
- The Bluetooth Library uses naming and terminology from the Bluetooth Core Specification; for more information on the naming conventions for the Bluetooth Library, see the CEVA[®] documentation provided with your RSL15 install.
- The swmTrace library is a logging library that is paired with the Real-Time Transfer (RTT) viewer that is part of the onsemi IDE and uses the RTT interface defined by SEGGER[®].

2.5 FIRMWARE RESOURCE USAGE

The firmware uses the Arm Cortex-M33 processor system stack. It expects that the Arm Cortex-M33 processor's stack pointer points to a valid stack that grows downward (i.e., decreasing memory addresses).

Other system memory used by the system are listed in the "Reserved Resources (Continued)" table (Table 3).

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Table 3. Reserved Resources

Reservation	Addresses	Notes
NVR0 to NVR3	0x00080000 to 0x000803FF	CryptoCell-312 support records and tables
NVR6	0x00080600 to 0x000806FF	<p>System custom trim records. Firmware and sample applications use these records if available when the <code>Sys_Trim_LoadCustom()</code> function is called, selecting defaults for trim settings if they are not available.</p> <p>Optional contents include:</p> <ul style="list-style-type: none"> • 0x80600 : 4-byte signature consisting of four ASCII encoded capital letters or numbers <ul style="list-style-type: none"> • SIP*, TRR* signatures are reserved for use by onsemi. • 0x80604 : 4-byte ICH_TRIM <ul style="list-style-type: none"> • To be stored to ACS_VCC_CTRL_ICH_TRIM in the ACS_VCC_CTRL register (valid range is 0x00000000 to 0x0000000F). • 0x80608 : 4-byte XTAL_TRIM <ul style="list-style-type: none"> • To be stored to RF_REG2E_XTAL_TRIM_XTAL_TRIM in the RF_REG2E register (valid range is 0x00000000 to 0x000000FF). • 0x806F0: 4-byte Unix-style test timestamp • 0x806FC : CRC32 calculated over 0x80600 to 0x806FB <p>Trims are considered available if all of the following are true:</p> <ul style="list-style-type: none"> • The signature is valid • The calculated CRC is correct • The provided trim is within the valid range.
NVR7	0x00080700 to 0x000807FF	Trim records; accessible using the <code>TRIM_Type</code> structure from <code>rs115_map.h</code>
MNVR	0x00080800 to 0x000808FF	Manufacturing and manufacturing trim records; cannot be modified outside of manufacturing.
FLASH_RSVD	0x00158000 to 0x00158BFF	Arm CryptoCell-312 DEU transfer space

RSL15 Firmware Reference

Table 3. Reserved Resources (Continued)

Reservation	Addresses	Notes
FLASH_BOND_RSVD	0x00158C00 to 0x001593FF	Recommended location for Bluetooth Low Energy bond information
SystemCoreClock	0x20000000 to 0x20000003	Reserved for mandatory global variable required by CMSIS.
ROM Status	0x20000004 to 0x20000013	Program ROM status variables
ROM Reserved (Flash Library)	0x20000014 to 0x20000017	Reserved for ROM-linked flash library

Other system components (DMA channels, LSAD inputs, etc.) that are used by the firmware are noted in the documentation for the specific component.

Some RSL15 product variants might have additional custom trim values stored in the NVR6 region. Sample codes in the SDK include the `SYS_TRIM_LOAD_CUSTOM()` macro function, which reads and applies those values.

In detail, the `SYS_TRIM_LOAD_CUSTOM()` function reads the custom value of the DC-DC inductor charge current trim and the custom value of the XTAL 48 MHz oscillator trim, and loads them into corresponding registers (the `ICH_TRIM` field of the `ACS_VCC_CTRL` register, the `RF_REG2E_XTAL_TRIM_XTAL_TRIM_INIT` field of the `RF_REG2E` register, and the `RF_REG2E_XTAL_TRIM_XTAL_TRIM` field of the same register) if all of the following conditions are met:

- A custom flash value identifier, `CUST` or `SIP1`, is found.
- CRC value is verified correctly.
- Valid trim values are found.

When the custom flash value identifier is not found, no custom flash value has been programmed. As a result, the `SYS_TRIM_LOAD_CUSTOM()` function returns without reading or loading any trim values as mentioned above. In other words, in this case, default trim values will be used.

NOTE: Only call the `SYS_TRIM_LOAD_CUSTOM()` function after the RF block is powered. If it is called before the RF block is powered, and the device has been programmed with valid contents in its NVR6, a hardfault results, and the device gets reset.

2.6 VERSIONS

Version symbols are provided for each major firmware component. The version symbols can be used directly or indirectly to verify the version of the components being used to build an application. There are three types of version symbols available:

Define

A preprocessor define or set of defines containing the version information.

Symbolic

A compiled symbol contained within a binary library

Global Variable

A global variable in memory containing the symbol

RSL15 Firmware Reference

As an example, the available version information for the flash library firmware component is listed in the "Example Firmware Versions - Flash Library" table (Table 4).

Table 4. Example Firmware Versions - Flash Library

Type	Version Symbol	Description
Define	FLASH_FW_VER_MAJOR	Major component of the library version; updated for non-backward compatible changes
Define	FLASH_FW_VER_MINOR	Minor component of the library version; updated for backward compatible changes, reset if major version is incremented
Define	FLASH_FW_VER_REVISION	Revision for the library version; incremented for minor changes or bug-fixes that do not affect library use
Define	FLASH_FW_VER	Combined library version (16 bits): <ul style="list-style-type: none"> • 15:12 major version • 11:8 minor version • 7:0 revision
Global Variable	FlashLib_Version	Constant variable assigned to hold the combined library version definition

¹Unlike the `float` type, the `double` type is not directly supported by the hardware. The use of the `double` type is supported through a software implementation that is computationally taxing on the system. For the best performance, avoid using doubles whenever possible.

CHAPTER 3

Hardware Definitions

Hardware definition files are integral to the system firmware. The hardware definitions apply a layer of data structures and address mappings to the underlying hardware, so that every control register, bit field in the system, memory, and interrupt vector is easily accessible from C and assembly code. This set of header files provides a system definition for the RSL15 SoC, including:

- Register and bit descriptions for registers accessible to the processor
- Memory maps for all of the memories and memory-mapped elements that are accessible to the processor
- Interrupt vector table descriptions for the processor
- Macros that support the Arm Cortex-M33 processor's basic core functionality

The format and configuration of all of these support files conform to CMSIS compatibility requirements wherever possible. As required by CMSIS, the hardware definitions are included by the top-level CMSIS include file (*rs115.h*) alongside the other CMSIS requirements. For more information about CMSIS, and this top-level include file, see "Introduction" on page 73.

If an application includes the top-level header file, and defines `RSL15_CID` to match the chip identifier of the relevant RSL15 device, then all of the support macros and HAL functions that are available to support that processor development on the chip are made accessible to that application.

NOTE: All devices that share a chip identifier are guaranteed to be compatible with the same firmware.

3.1 REGISTER AND REGISTER BIT-FIELD DEFINITIONS

Using the hardware definition files allows you to refer to system components by C structures, assembly code, and preprocessor symbols instead of by addresses and bit fields. This greatly improves the readability, reliability and maintainability of your application code. The use of hardware definitions in an application also means that some hardware changes, such as changes to addresses or bit field values, are transparent to your application code.

Hardware register descriptions for the Arm Cortex-M33 processor's private peripherals are provided by the CMSIS package from Arm. Hardware register descriptions for all other components, and bit settings that are appropriate for use with the hardware register descriptions for the private peripherals, are available in the following files:

- *rs115_hw.h*: This generic include file selects the desired underlying header file appropriate to your hardware by using the `RSL15_CID` definition.
- *rs115_hw_cid*.h*: This include file is the header file that is appropriate for all devices that are compatible with the defined `RSL15_CID` (i.e., devices sharing the same chip version and major revision).
- *rs115_hw_flat_cid*.h*: An unstructured version of the *rs115_hw_cid*.h* header file, which includes all of the same definitions but no structure typedefs (useful for application elements written in assembly).

NOTE: For applications that are intended to operate in non-secure application modes, the *rs115_hw_cid*_ns.h* headers are used, as long as `NON_SECURE` is defined by the preprocessor.

Hardware descriptions in the register include files provide definitions supporting the SoC components using the defines and C objects listed in the "Hardware Register Components" table (Table 5).

RSL15 Firmware Reference

Table 5. Hardware Register Components

Item	Example	Description
Component Register Structure	GPIO_Type	Provides a list of all registers that support a specified component, and the read/write types for those registers
Component Register Instance	GPIO	Links the component register structure to the underlying hardware or sets of hardware
Bit-Field Positions	GPIO_CFG_DRIVE_Pos	Defines the base position for any bit-field within a register
Bit-Field Mask	GPIO_CFG_DRIVE_Mask	Defines a bit mask for any bit-field of more than one bit within a register
Register Structure	GPIO_CFG_Type	Provides a list of all sub-registers and alias structures <ul style="list-style-type: none"> Sub-registers are defined byte (8-bit) or short (16-bit) access interfaces to part of a register that includes all elements belonging to the same configuration area. Aliases are Arm Cortex-M33 processor bitband aliases that provide bit access to individual single-bit bit-fields where the underlying hardware supports this single-bit access.
Register Instance	GPIO_CFG	Links the register structure to the underlying hardware or sets of hardware for sub-registers
Bit-Setting	GPIO_MODE_GPIO_IN_0	Defines providing human-readable equivalents to settings that can be applied to a register bit-field to obtain the desired behavior
Bit-Field Sub-Register Positions	GPIO_CFG_IO_MODE_BYTE_Pos	Defines the base position for any bit-field within a register's sub-register
Bit-Field Sub-Register Mask	GPIO_CFG_IO_MODE_BYTE_Mask	Defines a bit mask for any bit-field of more than one bit within a register's sub-register
Sub-Register Bit-Setting	GPIO_MODE_GPIO_IN_0_BYTE	Defines providing human-readable equivalents to settings that can be applied to a register's sub-register bit-field to obtain the desired behavior

3.2 MEMORY MAP DEFINITION

The *rs115_map.h* header file contains the specific memory map definitions that provide the locations of the following structures within the memory maps of the processor:

- Instruction and data bus memory structures
- System bus memory structures
- Peripheral bus memory-mapped control registers (including the base of control register groups for each system component)
- Private peripheral bus internal memory-mapped control registers
- System variables
- Calibration trim records

For more information on the memory map and memory mapped elements accessible to the Arm Cortex-M33 processor, see the *RSL15 Hardware Reference*.

RSL15 Firmware Reference

3.3 INTERRUPT VECTOR DEFINITION

Interrupt vectors provide you with access to interrupts that facilitate orderly processing operations, for optimal application processing speed and minimal delays. Interrupt vector definitions are provided for the Arm Cortex-M33 processor in the *rs115_vectors.h* header file.

Interrupt handling functionality in the Arm Cortex-M33 processor is provided by a nested vector interrupt controller (NVIC) implemented with the processor. The NVIC handles predefined interrupts internal to the core including a non-maskable interrupt (NMI), and interrupts external to the processor, that are linked to interfaces and peripherals. The NVIC is supported by standard firmware as part of the CMSIS library (as described in [Chapter 5 "CMSIS Library" on page 73](#)), and by the Hardware Abstraction Layer library (described in [Chapter 4 "Hardware Abstraction Layer" on page 72](#)), which offers additional supporting functions. These definitions have the form `<interrupt_name>_IRQn`.

For more information and a complete list of interrupt vectors, along with enumeration defines and values, see the Arm Cortex-M33 Processor chapter of the *RSL15 Hardware Reference*.

CHAPTER 4

Hardware Abstraction Layer

The Hardware Abstraction Layer (HAL) library provides a set of multiple register access functions for the majority of the system components included in the RSL15 SoC. These functions, and the included function headers, can easily be used to configure the hardware blocks through safe register accesses with no need to refer to register tables and corresponding settings in the RSL15.

The HAL library is distributed in source-code form in the RSL15 SDK. All the library functions are blocking and interruptible. The library does not use any interrupts or DMA channels.

4.1 USAGE

To use the HAL library functions, the HAL library must be included via the project's **.rteconfig* file, under **Libraries**. Additionally, the *rs15.h* header file must be included in the application source.

The HAL functions follow `Sys_<hardware block>_<function>` name syntax, with:

- **<hardware block>** indicating the system component being configured or acted upon
 - In some cases, the hardware block is prefixed by a standard operation such as `Set_` or `Get_`
- **<function>** describing the functionality implemented by the HAL firmware

Simple wrapper macros, with the same names but capitalized, are also provided for many functions. These macros do not require a user application to provide a pointer to the block being configured or operated upon, as the macros default to the first instance available. For example, `SYS_I2C_CONFIG` is a macro that calls the `Sys_I2C_Config` function with `I2C0` for the pointer parameter.

For the complete HAL library API, refer to [Chapter 16 "Hardware Abstraction Layer Reference"](#) on page 160.

CHAPTER 5

CMSIS Library

The Arm Cortex-M33 processor is supported by a standards-compliant CMSIS library and extensions to the CMSIS requirements.

5.1 INTRODUCTION

The Arm Cortex-M33 processor is supported by a standards-compliant CMSIS library and extensions to the CMSIS requirements. The CMSIS library performs the following functions:

- Provides access to the generic functions provided by the standard Arm CMSIS implementation
 - The functions are included in the CMSIS header files, and reference documentation is provided by the standard Arm CMSIS documentation (http://arm-software.github.io/CMSIS_5/Core/html/modules.html).
- Implements the CMSIS-required device-specific functions with an appropriate implementation for RSL15
- Adds extensions to the generic and required CMSIS functions to provide additional common support functions, including:
 - Weak definitions for all interrupt handlers for the Arm Cortex-M33 processor and associated NVIC
 - A C start-up routine for ensuring that applications reach main in a safe state
 - Dynamic memory allocation (through an implementation of `sbrk`)
 - Hardware-safe functions for updating the system clock source and operating frequency

The weakly defined interrupt handlers included in the CMSIS library provide empty implementation for the interrupt vectors, each of which simply returns from the interrupt. These interrupt handlers have the form `<interrupt_name>_IRQHandler()`. If a user application defines a function with this same name, the user application's definition of the interrupt handler replaces the default (empty) handlers.

The CMSIS library is supported by the top-level include file for RSL15, `rs115.h`, which includes all CMSIS, [Hardware Definitions](#), and [Hardware Abstraction Layer](#) elements. To use the CMSIS library, include `rs115.h` and link against the `libcmsis.a` library archive.

For the complete API, refer to [Chapter 15 "CMSIS Reference"](#) on page 139.

CHAPTER 6

CMSIS Drivers

The CMSIS drivers are generic device-independent APIs for peripherals, including I²C, SPI, and UART. These drivers are created to allow easy setup and use of peripherals and interfaces by handling most of the manual configuration work in the back-end. The drivers can be used in the sample applications by including the appropriate interface header files and the CMSIS drivers library.

6.1 INTRODUCTION

This topic presents the description of all the available CMSIS drivers and the instructions on how to use the configuration file (*RTE_Device.h*). The specifications and headers for all of the functions used in these CMSIS drivers have been provided by Arm, and the corresponding documentation can be found on the Arm Keil website, on this page: <http://www.keil.com/pack/doc/CMSIS/Driver/html/index.html>.

This topic assumes that the user is familiar with importing projects into the IDE, and also with the location of the sample applications. For more information about these topics, see the *RSL15 Getting Started Guide*.

A list of interfaces with CMSIS driver support is shown in the "Interfaces for Which a CMSIS Driver is Available" table (Table 6).

Table 6. Interfaces for Which a CMSIS Driver is Available

CMSIS Driver	Interfaces Supported	Sample Application
DMA	DMA channels 0 to 3	dma
I2C	I2C0, I2C1	i2c_cmsis
SPI	SPI0, SPI1	spi_cmsis
USART	USART0	uart_cmsis

The drivers used for CMSIS pack sample applications are shown in the "Types of Drivers" table (Table 7):

Table 7. Types of Drivers

CMSIS Driver
SPI, I2C, USART

6.2 USING THE CMSIS DRIVERS

CMSIS drivers provide generic peripheral interfaces for middleware and application code. To use the CMSIS driver library, the drivers must be included in the application. Instructions for using the CMSIS drivers are shown in the following sections.

6.2.1 Adding a CMSIS Driver

To add a CMSIS driver to an application, perform the following steps:

1. Open the `<sample_name>.rtconfig` file from the project folder and select the CMSIS driver(s) that is/are required for the application. CMSIS drivers, including UART, SPI and I2C, are found under **CMSIS Drivers** in the application's `.rtconfig` file.
2. After enabling required drivers, save the `<sample_name>.rtconfig` file.

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See the "Adding the UART CMSIS Driver to the uart_cmsis Sample Application" figure (Figure 1) as an example of how to add the USART CMSIS driver to the *uart_cmsis* sample application. As seen in the figure, the USART driver for RSL15 is checked, and is therefore included in the sample application.

Software Components	Sel.	Variant	Vendor	Version	Description
RSL15	<input checked="" type="checkbox"/>		ON Semiconductor		ARM Cortex-M33 48 MHz, 64 KB RAM, 20 KB ROM
> CMSIS	<input checked="" type="checkbox"/>				Cortex Microcontroller Software Interface Components Unified Device Drivers compliant to CMSIS-Driver Specifications
> CMSIS Driver	<input checked="" type="checkbox"/>				
> CAN (API)	<input type="checkbox"/>			1.2.0	CAN Driver API for Cortex-M
> Ethernet (API)	<input type="checkbox"/>			2.1.0	Ethernet MAC and PHY Driver API for Cortex-M
> Ethernet MAC (API)	<input type="checkbox"/>			2.1.0	Ethernet MAC Driver API for Cortex-M
> Ethernet PHY (API)	<input type="checkbox"/>			2.1.0	Ethernet PHY Driver API for Cortex-M
> Flash (API)	<input type="checkbox"/>			2.2.0	Flash Driver API for Cortex-M
> I2C (API)	<input type="checkbox"/>			2.3.0	I2C Driver API for Cortex-M
> Custom	<input type="checkbox"/>		ARM	2.3.0	Access to #include Driver_I2C.h file and code template for custom implem
> I2C	<input type="checkbox"/>	source	ON Semiconductor	1.0.1-80	I2C Driver for RSL15
> MCI (API)	<input type="checkbox"/>			2.3.0	MCI Driver API for Cortex-M
> NAND (API)	<input type="checkbox"/>			2.3.0	NAND Flash Driver API for Cortex-M
> SAI (API)	<input type="checkbox"/>			1.1.0	SAI Driver API for Cortex-M
> SPI (API)	<input type="checkbox"/>			2.2.0	SPI Driver API for Cortex-M
> Custom	<input type="checkbox"/>		ARM	2.2.0	Access to #include Driver_SPI.h file and code template for custom implem
> SPI	<input type="checkbox"/>	source	ON Semiconductor	1.0.1-80	SPI Driver for RSL15
> USART (API)	<input checked="" type="checkbox"/>			2.3.0	USART Driver API for Cortex-M
> Custom	<input type="checkbox"/>		ARM	2.3.0	Access to #include Driver_USART.h file and code template for custom impl
> USART	<input checked="" type="checkbox"/>	source	ON Semiconductor	1.0.1-80	USART Driver for RSL15
> USB Device (API)	<input type="checkbox"/>			2.2.0	USB Device Driver API for Cortex-M
> USB Host (API)	<input type="checkbox"/>			2.2.0	USB Host Driver API for Cortex-M
> WiFi (API)	<input type="checkbox"/>			1.0.0-beta	WiFi driver
> Device	<input checked="" type="checkbox"/>				Startup, System Setup

Figure 1. Adding the UART CMSIS Driver to the uart_cmsis Sample Application

6.2.2 Configuring CMSIS Drivers with RTE_Device.h

CMSIS drivers require I/O pin assignments and optional setup for DMA when being configured for use in a sample application. Both I/O pin assignments and DMA setup are configured in *RTE_Device.h*. In any sample application, the path to find the *RTE_Device.h* file is as follows: *RTE > Device > RSL15 > RTE_Device.h*. To view and configure *RTE_Device.h* in an easily readable GUI, right click on *RTE_Device.h* in the Project Explorer view and select **Open With > CMSIS Configuration Wizard**. The Wizard window opens, as shown in the "Viewing and Configuring RTE_Device.h with the CMSIS Configuration Wizard" figure (Figure 2).

RSL15 Firmware Reference

Option	Value
▼ DMA Configuration	<input checked="" type="checkbox"/>
> DMA 0 enabled	<input checked="" type="checkbox"/>
> DMA 1 enabled	<input checked="" type="checkbox"/>
> DMA 2 enabled	<input type="checkbox"/>
> DMA 3 enabled	<input type="checkbox"/>
> RF Output Power Configuration	<input type="checkbox"/>
▼ USART0 (Universal synchronous asynchronous receiver transmitter)	<input checked="" type="checkbox"/>
▼ USART auto configuration	<input checked="" type="checkbox"/>
Baudrate	115200
▼ USART GPIO configuration	
USART0_RX GPIO	5
USART0_TX GPIO	6
▼ USART0 DMA control	<input checked="" type="checkbox"/>
USART0 rx dma channel selection	0
USART0 tx dma channel selection	1
> I2C0 (Inter-integrated Circuit Interface 0)	<input type="checkbox"/>
> I2C1 (Inter-integrated Circuit Interface 1)	<input type="checkbox"/>
> SPI0 (Serial Peripheral Interface 0) [Driver_SPI0]	<input type="checkbox"/>
> SPI1 (Serial Peripheral Interface 1) [Driver_SPI1]	<input type="checkbox"/>
▼ GPIO Configuration	<input checked="" type="checkbox"/>
> GPIO 0 configure	<input checked="" type="checkbox"/>
> GPIO 1 configure	<input type="checkbox"/>

Figure 2. Viewing and Configuring RTE_Device.h with the CMSIS Configuration Wizard

NOTE: This file (*RTE_Device.h*) is best viewed using the CMSIS Configuration Wizard.

As seen in the "Viewing and Configuring RTE_Device.h with the CMSIS Configuration Wizard" figure (Figure 2), optional setup for DMA control is available in the sample application's *RTE_Device.h* file via the CMSIS Configuration Wizard. In this file, under **DMA Configuration**, the DMA channels can be configured.

DMA channel configuration can be enabled by checking the box for a channel, and disabled by unchecking it.. In the "Viewing and Configuring RTE_Device.h with the CMSIS Configuration Wizard" figure (Figure 2), the **DMA 0 enabled** and **DMA 1 enabled** boxes are checked, meaning that DMA channels 0 and 1 have their configurations enabled and are ready to be used for data transfers.

The CMSIS Configuration Wizard view of the *RTE_Device.h* file also shows options under **USART0 DMA Control** that allow channel selection for the USART0 RX DMA channel and USART0 TX DMA channel. In the "Viewing and Configuring RTE_Device.h with the CMSIS Configuration Wizard" figure (Figure 2) the RX DMA channel for the USART0 interface is configured to use DMA channel 0, while the TX DMA channel uses DMA channel 1.

CHAPTER 7

Program ROM

The RSL15 Program ROM is responsible for ensuring that an RSL15 device correctly performs a controlled boot sequence allowing application code to execute. The Program ROM does this while taking into account the possible life cycle states of the device, the active power modes, and any required security functionality.

In addition to bringing the system up, the program ROM also ensures that the default state of a device is consistent after a cold boot sequence.

Finally, the ROM provides access to commonly-used functionality that can be called from application code, allowing these functions to be eliminated from the application footprint.

7.1 OVERVIEW

7.1.1 Versions

There are three version numbers reported by the RSL15 ROM. Each version number is defined as a 32-bit value containing major, minor and revision numbers in the form `major.minor.revision`. These items are stored at predefined locations in the ROM program memory, as shown in the "ROM Versions" table (Table 8).

Table 8. ROM Versions

Address	Version Type	Version
0x00000010	Program ROM	1.5.00
0x00000014	Secure Boot ROM Library (Arm)	1.0.00
0x00000018	Flash Library	3.0.00

7.2 ROM INITIALIZATION SEQUENCE

The ROM is split into two main parts:

1. The low level initialization and setup, which is written in assembler: this part is responsible for ensuring that the power supplies are set up, and that memory instances are enabled for default power-up conditions.
2. The higher level functionality implemented in C dealing with the various peripherals, life cycle states and security features: these are defined in more detail in [Section 7.5 "Security Subsystem"](#) on page 85.

The ROM initialization sequence is shown graphically in the "ROM Initialization Sequence Flowchart" figure (Figure 3). The flowchart describes the various paths through the boot sequence, taking into account the possible life cycle states and power modes.

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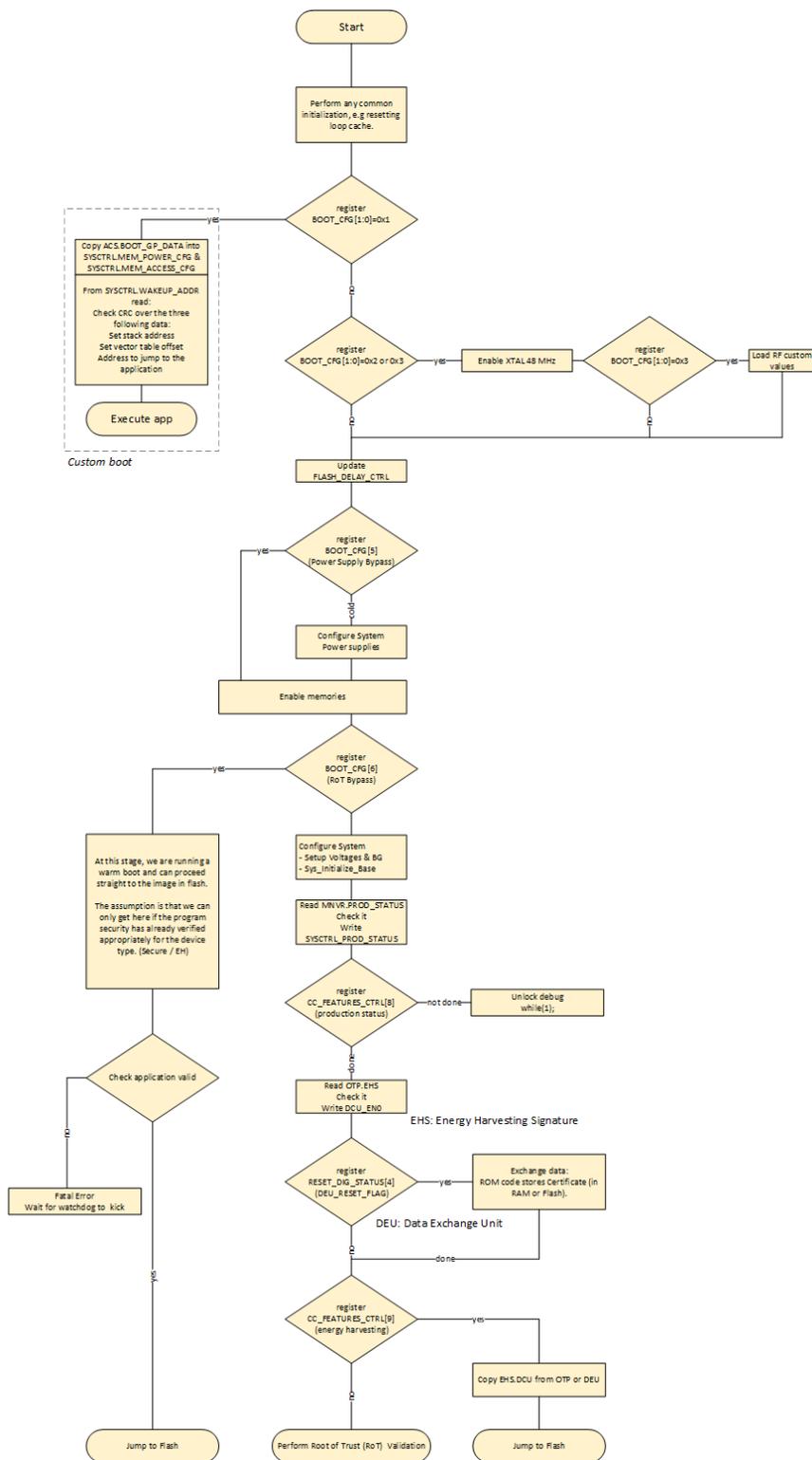


Figure 3. ROM Initialization Sequence Flowchart

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The "Boot Options" table (Table 9) shows the available boot options.

Table 9. Boot Options

ACS_BOOT_CFG	CC312AO	Results
BOOT_ROT_BYPASS_ENABLE	Enable	Pass but with cold boot
BOOT_ROT_BYPASS_DISABLE	Enable	Pass but with cold boot
BOOT_ROT_BYPASS_DISABLE	Disable	Fail with CCAO_REBOOT_RESET_FLAG_SET in ACS_RESET_STATUS
BOOT_ROT_BYPASS_ENABLE	Disable	Fail with watchdog reset in boot ROM

7.2.1 ROM Basic Initialization

The basic system initialization function is called once the power supplies and memories have been set to known default states. At this stage the RAM is enabled and the C stack is available for use.

The primary sequence of this initialization is as follows:

- Set up the NVIC to allow only NMI and Hard Fault exceptions.
- Disable the MPU, bus, and usage faults, forcing them to be always promoted to hard faults.
- Disable all of the external interrupts and clear all pending status indicators.
- Assign the NMI to a constant low source.
- Stop any running flash or flash copier operations.
- Reset the GPIOs.
- Enable all JTAG pins.
- Disable Pad Retention Mode.
- Configure the watchdog timer for a maximum timeout, and refresh.
- Disable DMA.
- Configure Non Secure code zone.
- Disable the SAU and set the ALLNS to zero so that everything is secure.
- Configure the non-secure accesses to RAM and peripherals as disabled.
- Make sure that the flash is not busy before setting up the RC.
- Configure the RC for 12 MHz.
- Select the RC oscillator as the system clock.
- Set up the various clock pre-scalars.
- Disable RF access.
- Disable the baseband interface.
- Enable all memories.
- Ensure that the Arm CryptoCell-312 (CC312) is enabled and ready to run.
- Set the system core clock variable and flash delays, indicating that the device is configured to use the 12 MHz RC oscillator.

7.2.2 ROM Status Variables & Status Codes

As part of its execution, the ROM sets several status variables indicating its execution status. These variables are stored near the base of RAM, starting at 0x20000004:

ROM Status

Variable indicating the status of the ROM execution, residing at 0x20000004.

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ROM Context

Variable indicating the state of the device in which the ROM is executing. For example, this state could be energy harvesting mode or one of the secure life cycle modes. Resides at 0x20000008.

Application Status

Variable that is free to be used by the application. Resides at 0x2000000C.

Application Context

Variable that is free to be used by the application. Resides at 0x20000010.

The two tables below contain the possible values of ROM status ("ROM Status Values" table (Table 10)) and ROM context (the "ROM Context Values (Continued)" table (Table 11)).

Table 10. ROM Status Values

Status or Context Name	Description	Value
RS_PRODUCTION_BOOT	Indicates that the ROM is in production boot mode	0xBB000001
RS_FATAL_ERROR	Indicates a fatal boot error	0x0000FE00
RS_SE_BOOT	Indicates secure boot status values	0x5EC00000
RS_SE_BOOT_BAD_CONFIG	Indicates a bad configuration has been detected during a secure boot	0x5EC0FE01 (RS_SE_BOOT RS_FATAL_ERROR 0x00000001)
RS_COLD_BOOT	Indicates a cold boot state	0xCB000000
RS_COLD_BOOT_FAILED	Indicates a cold boot failure.	0xCB00FE00 (RS_COLD_BOOT RS_FATAL_ERROR)

Table 11. ROM Context Values

Status or Context name	Description	Value
RS_EH_BOOT	Energy harvesting mode boot	0xEE000000
RS_EH_NO_KEY	Energy harvesting mode, no key provided	0xEE000001 (RS_EH_BOOT + 1)
RS_EH_INV_KEY	Energy harvesting mode, the key provided is invalid	0xEE000002 (RS_EH_BOOT + 2)
RS_EH_HAS_KEY_NO_CERT	Energy harvesting mode, the key is provided but there is no valid certificate.	0xEE000003 (RS_EH_BOOT + 3)
RS_EH_HAS_KEY_HAS_CERT	Energy harvesting mode, the key is provided and there is a valid certificate.	0xEE000004 (RS_EH_BOOT + 4)
RS_EH_NO_DCU	Energy harvesting mode, the DCU setting is missing.	0xEE000005 (RS_EH_BOOT + 5)
RS_EH_INV_DCU	Energy harvesting mode, the DCU setting is invalid.	0xEE000006 (RS_EH_BOOT + 6)
RS_EH_HAS_DCU	Energy harvesting mode, the DCU setting is valid	0xEE000007 (RS_EH_BOOT + 7)

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Table 11. ROM Context Values (Continued)

Status or Context name	Description	Value
RS_CONTEXT	Indicates a context variable.	0x00008000
RS_CONTEXT_RMA_FAIL	Indicates a RMA state failure	0x00008100 (RS_CONTEXT + 0x100)
RS_CONTEXT_ROT_FAIL	Indicates a Root-Of-Trust failure	0x00008200 (RS_CONTEXT + 0x200)
RS_CONTEXT_ALL_BITS	Masking allowing modification of all context bits.	0xFFFFFFFF
RS_CONTEXT_LCS_BITS	Mask allowing modification of Life-cycle state bits.	0x000000FF
RS_CONTEXT_CTX_BITS	Mask allowing modification of Life-cycle state bits.	0x0000FF00

7.3 APPLICATION VALIDATION AND BOOT

The RSL15 program ROM contains a set of functions that are used to validate and boot applications, following the completion of the security processes.

The ROM considers an application valid if it starts with its vector table, and no errors that would prevent boot are detected. Possible errors, and the error codes reported for these errors, are described in the "[Application Validation \(Continued\)](#)" table (Table 12).

Table 12. Application Validation

Error	Error Code	Description
None	0x0	No error detected
Bad Alignment	0x1	The Arm Cortex-M33 processor requires that the application's vector table is aligned to a 512-byte boundary in memory, for a device with the number of external interrupts that are included in the RSL15 SoC. The location of the specified application is not at a valid location in memory.
Bad Stack Pointer	0x2	The initial stack pointer must point to a valid memory location on the system bus. This requires that the specified stack pointer is 32-bit aligned, and that the next address stack data will be placed at is in DRAM or BB_DRAM.

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Table 12. Application Validation (Continued)

Error	Error Code	Description
Bad Reset Vector	0x3	<p>The program ROM checks that the reset handler is located immediately after the vector table (or after a CRC located after the vector table). This check is performed indirectly by confirming that the reset vector points to a location that:</p> <ul style="list-style-type: none"> Provides space for at least the minimum number of entries in the vector table (a minimum valid vector table contains 4 entries: the stack pointer, reset vector, NMI handler, and hard fault handler) Provides space for no more than the stack pointer, the 88 potential vectors, and a CRC (maximum of 90 words between the base of the application and the reset vector's location)
Failed to Start the Application	0x6	Indicates that the application has failed to boot or has returned with no identifiable cause.
Bad CRC	0x7	<p>A CRC-CCITT value can be placed between the vector table and the reset handler. The boot validation step validates if a CRC calculated over the vector table matches the value written at this location.</p> <p>NOTE: This error code is considered to be a non-fatal error, since the inclusion of a CRC is optional. The first entry on the application's stack after boot will indicate whether no-error has occurred (0x0) or if a bad CRC has been discovered (0x7).</p>

If the ROM determines that an application should be booted, the ROM:

1. Sets the VTOR bit-field in the Arm Cortex-M33 processor's SCB register to point to the application's vector table
2. Loads the initial stack pointer value from the application's vector table to the Arm Cortex-M33 processor's SP register
3. Pushes the application's status code to the `SYSCTRL_SYSCLK_CNT` register (valid error codes for a booted application are None and Bad CRC, as described in the "[Application Validation \(Continued\)](#)" table (Table 12))
4. Branches to the beginning of the reset handler, as indicated by the reset vector in the application's vector table

7.4 VECTOR TABLES

The ROM provides some access to built-in common functionality via the use of a ROM Jump Table. The features provided in this jump table are defined in the "[Jump Table Functions \(Continued\)](#)" table (Table 13), together with a brief description of the use of each. Access to these functions is provided through `rom_vect.h` (typically included through the top-level `rs115.h` include file) and `flash_rom.h` (used in place of `flash.h`).

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Table 13. Jump Table Functions

Offset	Feature	Description
0x00	__Sys_Initialize_Base void __Sys_Initialize_Base(void);	Base device initialization
0x04	__Sys_Delay void __Sys_Delay(unsigned int cycles);	Delay a number of cycles
0x08	__ProgramROM_ValidateApp uint32_t __ProgramROM_ValidateApp(uint32_t* app_addr);	Validate an application
0x0C	__ProgramROM_StartApp uint32_t __ProgramROM_StartApp(uint32_t* app_addr);	Validate an application, and if valid, start execution of that application
0x10	Flash_Initialize FlashStatus_t Flash_Initialize(unsigned no, FlashClockFrequency_t freq);	Initialize a flash bank
0x14	Flash_WriteWord FlashStatus_t Flash_WriteWord(bool enb_endurance);	Write 32-bit word to flash
0x18	Flash_ReadWord FlashStatus_t Flash_ReadWord(uint32_t addr, uint32_t *word);	Read 32-bit word from flash
0x1C	Flash_WriteDouble FlashStatus_t Flash_WriteDouble(uint32_t addr, const uint32_t *word, bool enb_endurance);	Write two 32-bit words to flash
0x20	Flash_ReadDouble FlashStatus_t Flash_ReadDouble(uint32_t addr, uint32_t *word);	Read two 32-bit words from flash

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Table 13. Jump Table Functions (Continued)

Offset	Feature	Description
0x24	Flash_WriteBuffer FlashStatus_t Flash_WriteBuffer(uint32_t addr, uint32_t word_length, const uint32_t *words, bool enb_endurance);	Write an array of 32-bit words
0x28	Flash_ReadBuffer FlashStatus_t Flash_ReadBuffer(uint32_t flash_address, uint32_t dram_address, unsigned word_length);	Read an array of 32-bit words
0x2C	Flash_EraseFlashBank FlashStatus_t Flash_EraseFlashBank(uint32_t no);	Erase a specific flash bank
0x30	Flash_EraseChip FlashStatus_t Flash_EraseChip(void);	Erase all flash
0x34	Flash_EraseSector FlashStatus_t Flash_EraseSector(uint32_t addr, bool enb_endurance);	Erase Flash Sector
0x38	Flash_BlankCheck FlashStatus_t Flash_BlankCheck(uint32_t addr, unsigned word_length);	Verify area of flash is empty
0x3C	__ProgramROM_Read_MNVR void __ProgramROM_Read_MNVR(uint32_t addr, uint32_t *word, uint8_t *readECC);	Read data from MNVR

RSL15 Firmware Reference

7.5 SECURITY SUBSYSTEM

RSL15 includes security IP provided by Arm, specifically the Arm CryptoCell-312 (CC312) security processor. In addition, the Arm Cortex-M33 processor itself includes support for TrustZone.

The ROM ensures that the hardware Root-of-Trust (RoT) is verified when running as a secure device. This ensures that no untrusted code can be executed by the ROM.

RSL15 also supports deployment as a non-secure device, allowing much lower power utilization. This mode is provided primarily for energy harvesting applications. However, this is not limited by design; any application can be executed in the lower security model if required.

IMPORTANT: For detailed information about the device states, the secure Root of Trust (RoT), and tools provided to support the security subsystem, see the *RSL15 Security User's Guide*.

7.5.1 Secure Boot Process

There are a limited number of steps involved when evaluating the secure Root of Trust (RoT) in the secure state:

- Verify the peripheral ID.
- Get the current life cycle state.
- Secure debug authentication:
 - If debug certificates are available, they must be validated.
 - If valid, debug facilities need to be enabled.
- Image verification phase:
 - Verify the certificate chain.
 - Handle key certificates.
 - Handle content certificates and content.
 - Lock resources.
- In the case of an error occurring during this flow, abort the boot sequence in a secure state.
- If validation completes and the image is authenticated, execute the validated image.

7.6 ROM LIFE CYCLE STATES (LCS) & OPERATIONAL MODES

The standard Arm CryptoCell-312 secure life cycle model allows for four life cycle states:

- CM - Chip Manufacture
- DM - Device Manufacture
- SE - Secure

The transitions between these states are strictly defined by the life cycle model, and we have maintained this in our system.

In addition to the standard Arm lifecycle states, we have added an additional production state before CM which reflects the possibility of a device coming from manufacture with an unconfigured OTP. In this case, the ROM does not allow application code to be run, but it does allow the device to be configured to enter CM state.

In parallel to the secure life cycle model, we also provide for a non-secure model in which the device is defined to be in Energy-Harvesting (EH) state. In this case, the Root of Trust security features are turned off and security is provided using a security mechanism dependent on valid applications unlocking the device.

RSL15 Firmware Reference

A device in Production state can be configured to be in EH state. If this is not explicitly configured, then the device is treated as a secure device.

- A completely unconfigured device is defined to be in Production state.
 - In this state, the device can be configured as either a secure device or a non-secure device.
 - In this state, no executable code is run on power-up.
 - In manufacturing, we expect all devices to be set as non-secure devices.
- A non-secure device has a signature indicating its state in OTP.
 - In order to transition from the non-secure state to a secure state, this signature needs to be removed.
 - As the signature resides in OTP, it cannot be re-instated once it has been deleted. This provides a one-way transition from non-secure to secure state.
- Once a device is set to secure, there is no mechanism to bring it back to non-secure.

IMPORTANT: If a device is in the Production state, it is possible to go directly to a secure state without transitioning through the non-secure state. In this case, care must be taken to clear the non-secure signature locations, as otherwise it can be possible to revert the device to non-secure. See the *RSL15 Security User's Guide* for more information on device transitions.

7.7 DATA EXCHANGE UNIT (DEU) SUPPORT

In order to enable the debug ports and any other features controlled by the Debug Control Unit, certificates must be provided to the device. These can reside in RAM for one time only use, or can reside in flash to allow the port enablement to survive a cold reboot.

The provision of these certificates is handled through the DEU. All interfacing with the DEU is performed via the ROM code. Application code has no access to this device.

The ROM supports the following features when communicating with the DEU:

- **LOAD** - Allows a certificate to be loaded to a device and stored in RAM
- **ERASE** - Erases any certificates which are currently stored in flash
- **WRITE** - Writes the current set of certificates from RAM to flash
- **SOCID** - Requests the SOC ID from the device
- **CONNECT** - Connects to a device via the DEU port
- **COMPLETE** - Completes the connection to the device

7.8 RESERVED FLASH SECTORS

On RSL15, the application configuration and debug certificates are held in data flash in consecutive sectors. (Data flash in RSL15 has a sector size of 256 bytes.)

- One sector for the application configuration
- One sector for the EH_STATE debug certificate
- Ten sectors for the ROT_STATE debug certificates

Therefore, a total of 3 KB are reserved for use by the different security mechanisms.

The layout of this is shown in the "Reserved Space for Security Mechanisms" figure (Figure 4).

RSL15 Firmware Reference

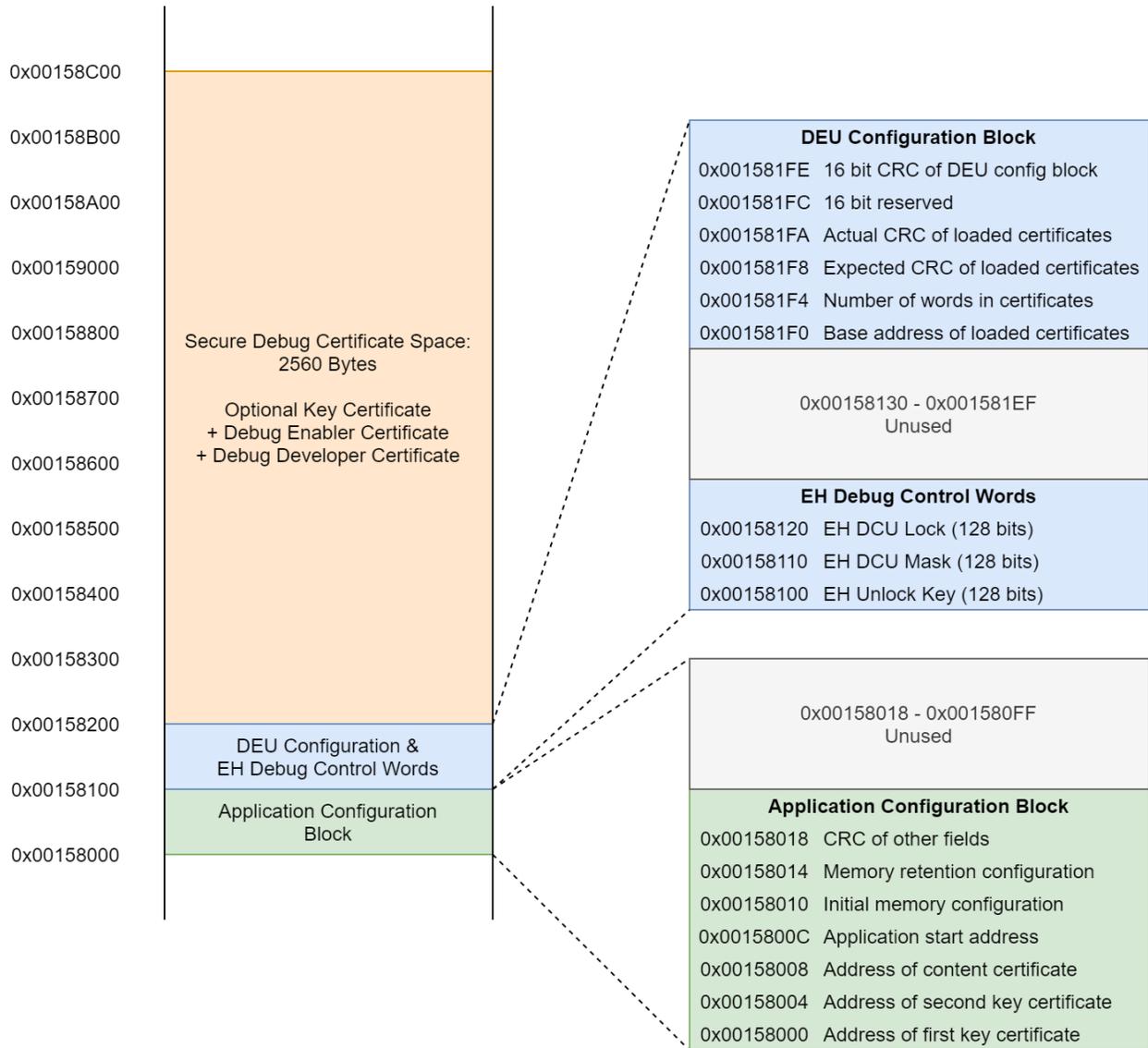


Figure 4. Reserved Space for Security Mechanisms

If you are not using the secure Root of Trust, then it is generally considered safe to repurpose the 10 sectors allocated to the debug certificates. The other two sectors need to be left reserved.

CHAPTER 8

Flash Library

The flash library provides support for erasing and programming parts of the built in flash memory. This library provides an API that abstracts the details needed properly handle the flash.

8.1 LIBRARY FORMS

The flash library is available in two forms:

1. As a static library, accessed by including the *flash.h* header file and linking against the *libflashlib.a* library object
2. As a **Program ROM** component, accessed as memory mapped elements using the *flash_rom.h* header file

For the complete flash library API, refer to [Chapter 1 "Flash Library Reference"](#) on page 1.

IMPORTANT: A copy of the flash library has been built into the ROM, as described in [Section 7.4 “Vector Tables”](#) on page 82, for use in applications. All functions provided by the flash library must be executed from RAM or ROM, as executing them from flash can result in hidden, flash-access-related failures.

8.2 FLASH LIBRARY USAGE

The flash library can be used to program and erase the built-in flash, with the following considerations:

- A minimum SYSCLK frequency of 1 MHz, sourced from a clock source with an error below $\pm 10\%$, is required for safe operation of the flash library. The SYSCLK must be sourced from the RFCLK (48 MHz XTAL) to meet its accuracy requirement.
- The MNVR section of flash, outside of the user-defined redundancy sector pointers, cannot be written using the flash library.
- The endurance of flash is limited by the total time flash cells are subjected to program and erase currents. As a result, a number of flash operations provide options around the endurance of the flash cells:
 - Flash writes can use a one stage normal write or a two stage endurance write. For use cases where an area of flash is written many times, a two stage write is recommended.
 - Use of mass erase can speed up flash operations, as it is the quickest way to erase the whole flash array - but use of mass erase subjects the whole array to an erase current for significantly longer than seen with any sector erase operation.
 - Flash sector erases can use a endurance erase that attempts to erase the flash sector up to four times, using a short erase pulse to maximize the number of program/erase cycles that a flash sector can be subjected to. For use cases that require maximum retention time, the normal flash sector erase needs to be used.

For more information about the built-in flash memory, see the *RSL15 Hardware Reference*.

CHAPTER 9

Security and Life Cycle Provisioning Elements

Information about the security and lifetime provisioning elements for RSL15 is primarily found in the *RSL15 Security User's Guide*.

9.1 OVERVIEW

The Security and Life Cycle Provisioning process can be managed using RSLSec, which is a software utility available for RSL15. Its command line interface enables users to perform the transitions and access other security features through parameters, as described in the *RSL15 Security User's Guide*. This utility works to leverage the underlying security system for RSL15, including the ROM and security IP.

9.2 THIRD PARTY DOCUMENTATION

The Arm TrustZone CryptoCell-312 Software Developers Manual (SW Revision r0p0) is provided with the RSL15 SDK, in PDF form in the *Arm_documentation* folder.

Additional third-party information can be found on the <https://developer.arm.com/ip-products/security-ip/trustzone/trustzone-for-cortex-m> webpage.

CHAPTER 10

Arm CryptoCell-312 Security IP

The RSL15 system includes the Arm CryptoCell-312 IP, which is used to maintain security of the device, allow secure operation of the application firmware, and permit related user applications to access security features.

IMPORTANT: The CC312 functions, when using hardware accelerators, use a WFI instruction while waiting for the hardware accelerator to complete its processing. Therefore, these functions must not be called in the context of any interrupt routines that have a priority higher than, or equal to, the CC312 interrupt.

IMPORTANT: The CC312 functions are not reentrant. These functions cannot be called again until their execution has been completed.

A significant part of the Arm CryptoCell-312's operation is based on the use of the Mbed TLS libraries.

10.1 ARM CRYPTOCELL-312 MBED TLS

RSL15 provides a standardized interface to the cryptographic features on the device using a customized version of Mbed TLS, which has been tuned to make efficient use of the cryptographic acceleration hardware provided by the Arm CryptoCell-312.

At present, the Mbed TLS variant supported by RSL15 is version 2.16.2. Some features of this have been replaced by alternative versions to make the best use of the underlying hardware. The interface has been maintained so that standard Mbed TLS applications can work as expected.

For further information on developing cryptographic applications with RSL15, refer to the *Arm CryptoCell-312 Runtime Software Developers Manual*, Issue 01, revision r1p3.

CHAPTER 11

Event Kernel

NOTE: Some of the material in this topic has been adapted with permission from CEVA documentation. This chapter is intended to complement the CEVA API documentation included with your RSL15 install.

The RSL15 event kernel is a small and efficient event and message handling system that can be used as a Real Time Operating System (RTOS) or as a process executed under an RTOS, offering the following features:

- Exchange of messages
- Message saving
- Timer functionality
- The kernel also provides an event functionality used to defer actions

The purpose of the event kernel is to provide messages (such as the ones in [Section 11.2 “Messages” on page 91](#)) and timed tasks to keep RF traffic on schedule and aligned with the specification requirements.

11.1 OVERVIEW

11.1.1 Include Files

The "Kernel File List" table ([Table 14](#)) shows a list of the kernel include files, with descriptions.

Table 14. Kernel File List

File	Description
<i>ke.h</i>	Contains the kernel environment definition
<i>ke_event.h</i>	Contains the event handling primitives
<i>ke_mem.h</i>	Contains the implementation of the heap management module
<i>ke_msg.h</i>	This file contains the scheduler primitives called to create or delete a task. It also contains the scheduler itself
<i>ke_task.h</i>	Contains the implementation of the kernel task management
<i>ke_timer.h</i>	Contains the scheduler primitives called to create or delete a timer task. It also contains the timer scheduler itself

11.1.2 Kernel Environment

The kernel environment structure contains the queues used for event, timer and message management, including:

- A queue of sent messages that have not yet been delivered to the receiver
- A queue of messages delivered to the receiver, but not yet consumed
- A queue for timer events

11.2 MESSAGES

11.2.1 Overview

Message queues provide a mechanism to transmit one or more messages to a task. (Queue names and purposes are defined in [Section 11.1.2 “Kernel Environment” on page 91](#).)

Transmission of messages is performed in three steps:

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- Sender task allocates a message structure
- Message parameters are filled
- Message structure is pushed in the kernel

A message is identified by a unique ID composed of the task type and an increasing number. A message has a list of parameters that is defined in a structure (see [Section 11.2.2 “Message Format”](#) on page 92).

11.2.2 Message Format

The structure of the message contains:

- `id`: Message identifier
- `dest_id`: Destination kernel identifier
- `src_id`: Source kernel identifier
- `param_len`: Parameter embedded structure length
- `param`: Parameter embedded structure. Must be word-aligned.

The source and destination tasks describe which task the message is coming from/to. As a task can implement multiple instances, these source and destination task identifiers are constructed with both the task index and the task type, as shown in the "Destination or source task identifier construction" figure (Figure 5).

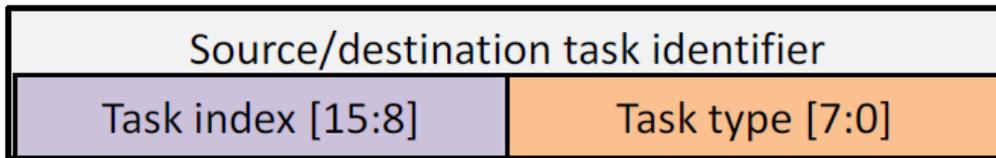


Figure 5. Destination or source task identifier construction

11.2.3 Parameter Management

During message allocation, the size of the parameter is passed and memory is allocated in the kernel heap. To store this data, the pointer on the parameters is returned. The scheduler frees this memory after the transition completion.

11.2.4 Message Queue Primitives

11.2.4.1 Message Allocation

```
ke_msg_alloc
```

Prototype:

```
void *ke_msg_alloc(ke_msg_id_t const id, ke_task_id_t const dest_id,
                  ke_task_id_t const src_id, uint16_t const param_str)
```

Parameters:**Table 15. Message Allocation Parameters**

Type	Parameters	Description
ke_msg_id_t	id	Message Identifier
ke_task_id_t	dest_id	Destination Task Identifier
ke_task_id_t	src_id	Source Task Identifier
uint16_t	param_len	Size of the message parameters to be allocated

Return:

Pointer to the parameter member of the `ke_msg`. If the parameter structure is empty, the pointer points to the end of the message and must not be used (except to retrieve the message pointer or to send the message).

Description:

This primitive allocates memory for a message that has to be sent. The memory is allocated dynamically on the heap, and the length of the variable parameter structure must be provided in order to allocate the correct size.

11.2.4.2 Message Allocation Macro (Static Structure)

```
KE_MSG_ALLOC
```

Prototype:

```
KE_MSG_ALLOC(id, dest_id,
             src_id, param_str)
```

Parameters:**Table 16. Message Allocation Macro Parameters for Static Structures**

Type	Parameters	Description
ke_msg_id_t	id	Message Identifier
ke_task_id_t	dest_id	Destination Task Identifier
ke_task_id_t	src_id	Source Task Identifier
void const *	param_str	Structure tag for the message data

Return:

Pointer to the allocated structure cast to the correct type.

Description:

This macro calls `ke_msg_alloc()` and cast the returned pointer to the appropriate structure. Can only be used if a parameter structure exists for this message (otherwise, use `ke_msg_send_basic()`).

11.2.4.3 Message Allocation Macro (Variable Structure)

```
KE_MSG_ALLOC_DYN
```

Prototype:

```
KE_MSG_ALLOC_DYN(id, dest_id,
                 src_id, param_str, length)
```

Parameters:

Table 17. Message Dynamic Allocation Parameters

Type	Parameters	Description
ke_msg_id_t	id	Message Identifier
ke_task_id_t	dest_id	Destination Task Identifier
ke_task_id_t	src_id	Source Task Identifier
void const *	param_str	Structure tag for the message data
uint16_t	length	Length of the variable portion of the data structure

Return:

Pointer to the allocated structure of variable length, cast to the correct type.

Description:

This macro calls `ke_msg_alloc()` and cast the returned pointer to the appropriate structure. Can only be used if a parameter structure exists for this message (otherwise, use `ke_msg_send_basic()`).

NOTE: This function can only be used if the variable data array is located at the end of the structure to be allocated.

11.2.4.4 Message Free

```
ke_msg_free
```

Prototype:

```
void ke_msg_free(struct ke_msg const *param)
```

Parameters:

Table 18. Message Free Parameters

Type	Parameters	Description
struct ke_msg const *	param	Pointer to the message to be freed

Return:

None

Description:

Free allocated message.

11.2.4.5 Message Free Macro

```
KE_MSG_FREE
```

Prototype:

```
KE_MSG_FREE(param_ptr)
```

Parameters:**Table 19. Message Free Parameters**

Type	Parameters	Description
void const *	param_ptr	Structure tag for the message data

Return:

None

Description:

This macro calls `ke_msg_free()` to free a previously allocated message.

11.2.4.6 Message Send

```
ke_msg_send
```

Prototype:

```
void ke_msg_send(void const *param_ptr)
```

Parameters:**Table 20. Message Send Parameters**

Type	Parameters	Description
void const *	param_ptr	Pointer to the parameter member of the message that is to be sent

Return:

None

Description:

Send a message previously allocated with any `ke_msg_alloc()`-like functions. The kernel takes care of freeing the message memory. Once the function has been called, it is not possible to access the message's data any more as the kernel might have copied the message and freed the original memory.

11.2.4.7 Message Send Basic

```
ke_msg_send_basic
```

Prototype:

```
void ke_msg_send_basic(ke_msg_id_t const id, ke_task_id_t const dest_id, ke_task_id_t const src_id)
```

Parameters:**Table 21. Message Send Basic Parameters**

Type	Parameters	Description
ke_msg_id_t	id	Message Identifier
ke_task_id_t	dest_id	Destination Task Identifier
ke_task_id_t	src_id	Source Task Identifier

Return:

None

Description:

Send a message that has a zero length parameter member. No allocation is required as this is performed internally.

11.2.4.8 Message Forward

```
ke_msg_forward
```

Prototype:

```
void ke_msg_forward(void const *param_ptr, ke_task_id_t const dest_id, ke_task_id_t const src_id)
```

Parameters:**Table 22. Message Forward Parameters**

Type	Parameters	Description
void const *	param_ptr	Pointer to the parameter member of the message that is to be sent
ke_task_id_t	dest_id	Destination Task Identifier
ke_task_id_t	src_id	Source Task Identifier

Return:

None

Description:

Forward a message to another task by changing its destination and source task IDs.

11.3 SCHEDULER**11.3.1 Overview**

The scheduler is called in the main loop of the user application using the `BLE_Kernel_Process()` function.

IMPORTANT: For maximum stability, ensure that the user application calls `BLE_Kernel_Process()` at least once during each Bluetooth connection interval. For more information, see [Section 13.2 “Baseband and Kernel Functions”](#) on page 120.

In the user application’s main loop, the kernel checks if the event field is non-null, and executes the event handlers for which the corresponding event bit is set.

11.3.2 Requirements**11.3.2.1 Scheduling Algorithm**

The "Scheduling Algorithm" figure (Figure 6) shows how the scheduler handles messages. The message handler pops messages from the message queue, passes them to the pre-defined message handler, and then handles either releasing or saving those messages based on the responses from those handlers.

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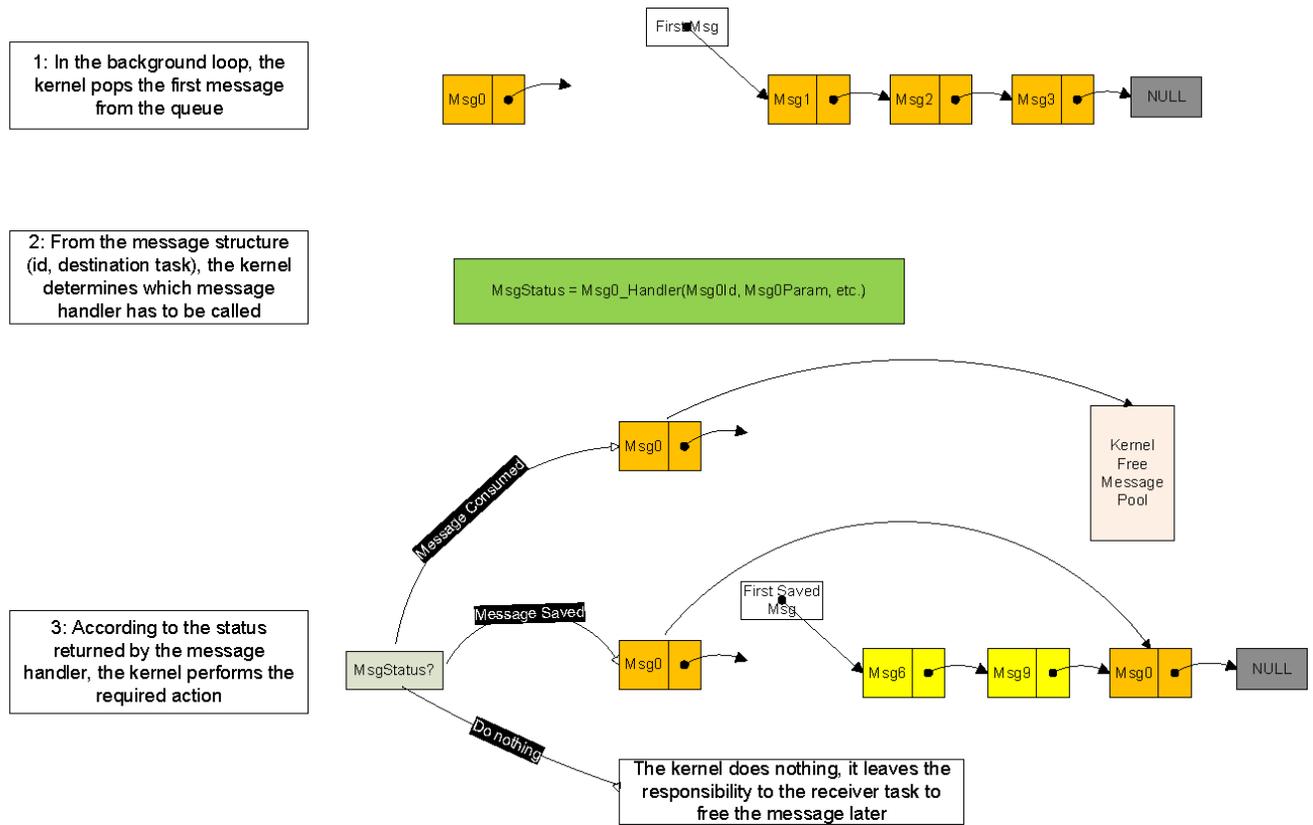


Figure 6. Scheduling Algorithm

11.3.2.2 Save Service

The Save service can save a message (i.e., store it in memory without it being consumed). If the task state changes after a message is received, the scheduler tries to handle the saved message before scheduling any other signals.

11.4 TASKS

A kernel task is defined by:

- Its task type (i.e., a constant value defined by the kernel, unique for each task)
- Its task descriptor, which is a structure as shown in the "Task Descriptor Construction" figure (Figure 7) containing all the information about the task:
 - The messages handlers table
 - The states table
 - The number of instances of the task
 - The number of messages it can handle

The kernel keeps a pointer to each task descriptor, which is used to handle the scheduling of the messages transmitted from one task to another.

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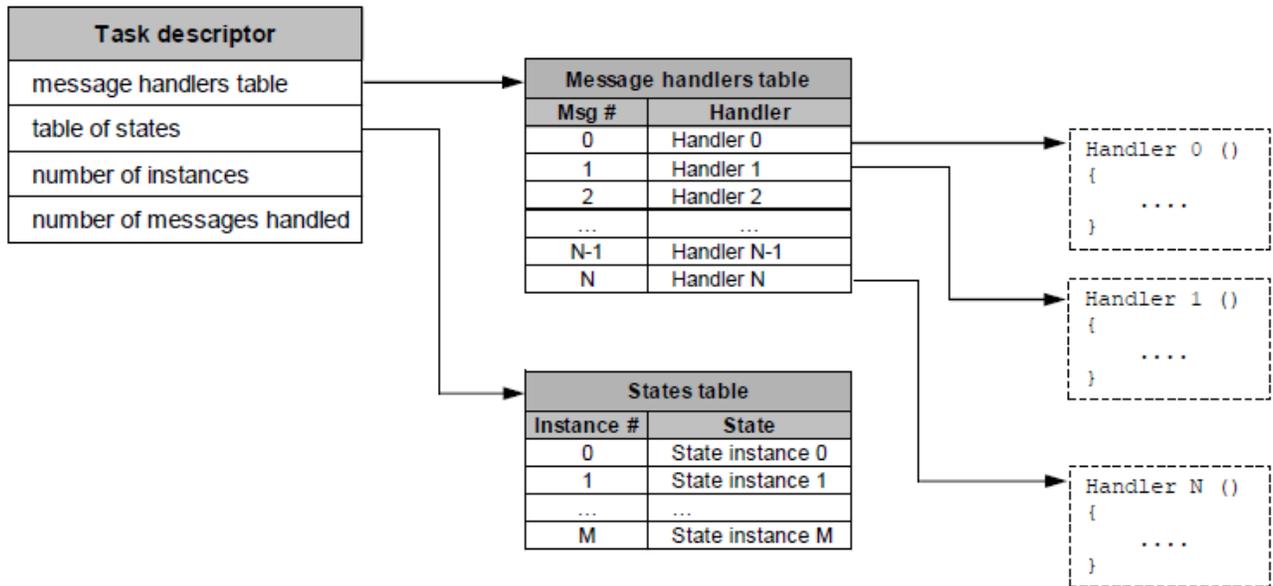


Figure 7. Task Descriptor Construction

11.5 KERNEL TIMER

11.5.1 Overview

The RW Kernel provides:

- A time reference (absolute time counter)
- Timer services to start and stop the timer

Timers are implemented by means of a reserved queue of delayed messages. Timer messages do not have parameters.

IMPORTANT: Kernel timer functions (`ke_timer_*`) must not be used in an interrupt context. Do not call them within any interrupt service routines. The kernel timer is not interrupt-safe.

11.5.2 Time Definition

Time is defined as duration; the minimum step is a multiple of 1 ms.

11.5.3 Timer Object

The structure of the timer message contains:

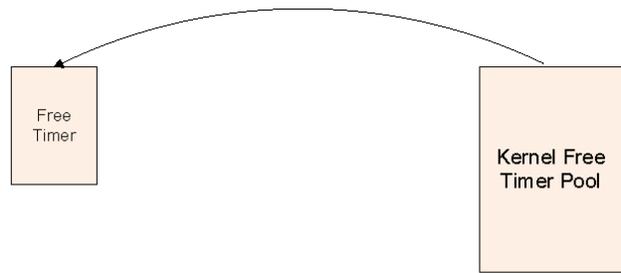
- `*next`: Pointer on the next timer
- `id`: Message identifier
- `task`: Destination task identifier
- `time`: Duration

11.5.4 Timer Setting

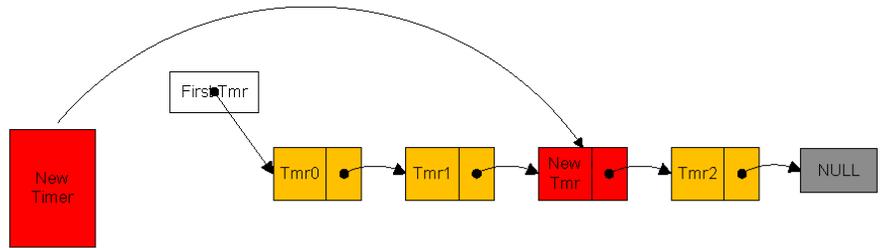
The "Timer Setting Flow" figure (Figure 8) shows the flow for setting up timer messages.

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1: When a task requests to program a timer in the future, the kernel allocates one timer structure from the free pool. The kernel then fills the new timer with the parameters passed by the task (time, timer_id, task_id)



2: The kernel pushes the new timer at the right place into the ordered timer list



3: If the new timer is the first of the list, then the kernel programs the HW gross target time to match the target time of the new timer

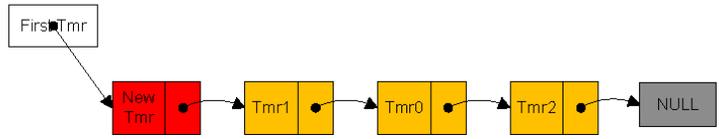


Figure 8. Timer Setting Flow

11.5.5 Time Primitives

11.5.5.1 Timer Set

Set a timer.

Prototype:

```
void ke_timer_set(ke_msg_id_t const timer_id, ke_task_id_t const task, uint32_t const delay);
```

Parameters:

Table 23. Timer Set Parameters

Type	Parameters	Description
ke_msg_id_t	timer_id	Timer identifier
ke_task_id_t	task_id	Task identifier
uint32_t	delay	Timer duration (multiple of 1ms; maximum is 41,943,039 ms)

Return:

None

Description:

The function first cancels the timer if it exists; then it creates a new one.

When the timer expires, a message is sent to the task provided as argument, with the timer id as message id.

11.5.5.2 Timer Clear

Remove a registered timer.

Prototype:

```
void ke_timer_clear(ke_msg_id_t const timer_id, ke_task_id_t const task);
```

Parameters:**Table 24. Timer Clear Parameters**

Type	Parameters	Description
ke_msg_id_t	timer_id	Timer identifier
ke_task_id_t	task_id	Task identifier

Return:

None

Description:

This function searches for the timer element identified by its timer and task identifiers. If found, it is stopped and freed; otherwise an error message is returned.

11.5.5.3 Timer Activity

Check if a requested timer is active.

Prototype:

```
bool ke_timer_active(ke_msg_id_t const timer_id, ke_task_id_t const task);
```

Parameters:**Table 25. Timer Activity Parameters**

Type	Parameters	Description
ke_msg_id_t	timer_id	Timer identifier
ke_task_id_t	task_id	Task identifier

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Return:

TRUE if the timer identified by Timer ID is active for the Task ID; FALSE otherwise

Description:

This function pops the first timer from the timer queue and notifies the appropriate task by sending a kernel message. If the timer is periodic, it is set again; if it is one-shot, the timer is freed. The function also checks the next timers, and processes them if they have expired or are about to expire. The "Timer Expiry Flow" figure (Figure 9) shows the process flow for handling expired timers.

11.5.5.4 Timer Adjust

Adjust all kernel timers by specified adjustment delay.

Prototype:

```
void ke_timer_adjust_all(uint32_t delay);
```

Parameters:**Table 26. Timer Adjust Parameters**

Type	Parameters	Description
uint16_t	delay	Adjustment delay is a multiple of 1 ms

Return:

None

Description:

This function updates all timers to align to a new SYSCLK after a system clock adjustment.

11.5.5.5 Timer Expiry

The "Timer Expiry Flow" figure (Figure 9) shows the flow of timer messages when the timer expires.

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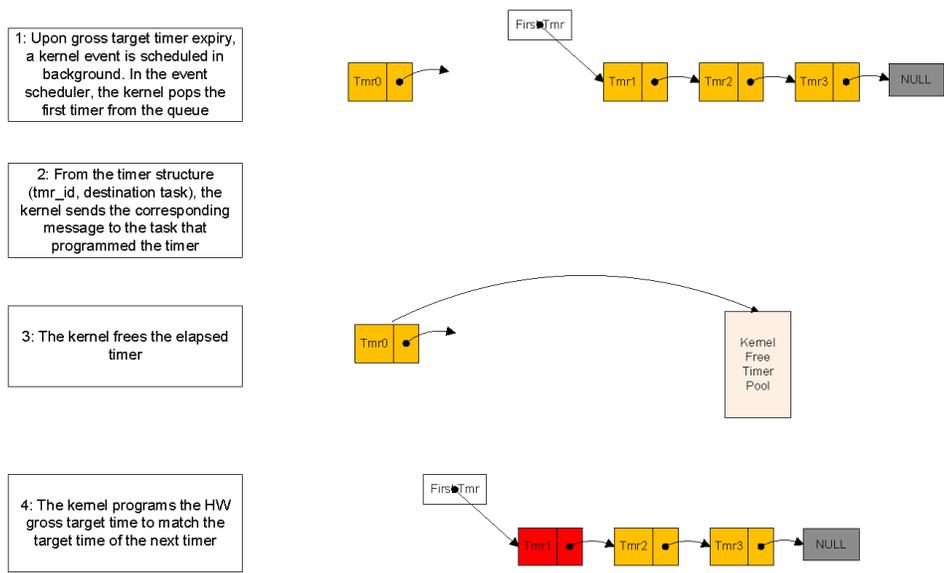


Figure 9. Timer Expiry Flow

11.6 USEFUL MACROS

- Builds the task identifier from the type and the index of that task:

```
#define KE_BUILD_ID(type, index) ( (ke_task_id_t) (((index) << 8) | (type)) )
```

- Retrieves task type from task id:

```
#define KE_TYPE_GET(ke_task_id) ((ke_task_id) & 0xFF)
```

- Retrieves task index number from task id:

```
#define KE_IDX_GET(ke_task_id) (((ke_task_id) >> 8) & 0xFF)
```

CHAPTER 12

Bluetooth Stack

NOTE: Some of the material in this topic has been adapted with permission from CEVA documentation. This chapter is intended to complement the CEVA API documentation included with your RSL15 install. Consult this documentation when API function information cannot be found in the CEVA documentation.

This topic explains how the Bluetooth stack, including the HCI (host/controller interface), GATT (generic attribute profile), and GAP (generic access profile), is implemented for RSL15. This chapter also provides a description of the Bluetooth profile libraries that are provided with the RSL15 system to support standard use cases.

12.1 INTRODUCTION

12.1.1 Include and Object Files

The Bluetooth stack is accessed through the *ble.h* header file. This header is supported by a set of include files located in the *include\ble* folder of the installation.

The stack is extended by a number of GATT-based profiles and services. The headers for these profiles are located in the *include\ble\profiles* folder, and a list of the available supporting objects is provided in the "Bluetooth GATT-Based Profile and Service Object Files" table (Table 27).

Table 27. Bluetooth GATT-Based Profile and Service Object Files

Profile Name	Profile	Profile Library Name	Profile Description
Battery Service	BAS	libbasc libbass	The Battery Service exposes the state of a battery within a device, or it reads the battery state of a peer device.
Device Information Service	DIS	libdisc libdiss	This service exposes manufacturer and/or vendor information about their own device or discovers peer device information.
Glucose Service	GLS	libglps	This service exposes glucose and other data from a personal glucose sensor for use in consumer healthcare applications.

All of the individual profile libraries use the Bluetooth Low Energy stack through the profile's specified interfaces. These interfaces are documented in the interface specifications. Because the Bluetooth Low Energy stack itself requires a reciprocal link in order to find all of the profile components, the stack library has been built with an object factory that instantiates calls to each of the profiles. If a profile is used by an application, the Bluetooth stack needs to use the specified profile library.

12.1.2 Bluetooth Stack

The RSL15 device supports a Bluetooth stack through a combination of hardware and firmware resources. The hardware components of the Bluetooth stack are described in the *RSL15 Hardware Reference*. The firmware components of the Bluetooth stack are accessible through a Bluetooth library and associated header files.

The Bluetooth stack is optionally accessible through HCI over UART or through the host (GAP, GATT, L2CAP) and profile APIs.

The "Bluetooth Stack and Kernel Object Files" table (Table 28) describes the Bluetooth stacks provided with RSL15 and their associated object files.

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Table 28. Bluetooth Stack and Kernel Object Files

Stack Type	Library Name	Description
Standard stack	<i>Vib\ble_core\Release</i> <i>Vib\ble_profiles\Release</i>	These libraries provide the complete standard stack and support for all RSL15 Bluetooth features.
HCI stack	<i>Vib\ble_core\Release_HCI</i> <i>Vib\ble_profiles\Release_HCI</i>	These libraries can be used with an HCI interface over UART.

12.1.3 Stack Support Functions

The Bluetooth stack library includes a set of support functions that augment the stack firmware, as described in [Chapter 13 "Bluetooth and Kernel Library" on page 118](#). All other stack APIs are described in their reference documentation, with support for specific Bluetooth layers described in the following documents:

GAP

RW-BLE-GAP-IS.pdf

GATT

RW-BLE-GATT-IS.pdf

L2CAP

RW-BLE-L2C-IS.pdf

Profiles

RW-BLE-PRF--IS.pdf*

12.1.4 Managing Bluetooth Low Energy Stack RAM Usage

The Bluetooth Low Energy stack is provided as a compiled library and cannot be modified by the user. However, some of the stack variables are defined at the application level, and the user has some control over the size of these variables. This is a guide to optimizing stack RAM memory usage by adjusting the application level variable defines as dependent upon the application use case.

The application level variables are defined to support the maximum number of connections and activities, which is 10 and 11 respectively, as described in the CEVA documentation provided with RSL15. If the application use case does not require the maximum number of connections and activities, application level variable sizes can be reduced to save memory.

NOTE: It is not recommended to adjust application level variable sizes in the HCI stack, as this can adversely affect Bluetooth certification.

The simplest method and recommended starting point to reduce stack memory usage is to reduce the value of `APP_MAX_NB_CON`. This scales most of the other application level variables as well, resulting in a reduction of memory usage. This is usually sufficient for most users. If you are an advanced user requiring further optimization, read on.

The memory allocated by the stack is divided into different parts. The first part comprises the required environment and global variables that are independent of the number of connections or activities. This part cannot be changed by developers.

The second part is heap memory, which the kernel takes as a global variable (*.bss* section), and later the kernel and the Bluetooth Low Energy stack use it as the heap memory for their procedures. It is divided into four parts:

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- Environment variables
- Message heap memory
- Data base memory
- Non-retention memory

By default, all parameters are set to address the maximum number of connections and activities, which are 10 and 11 respectively. If definition `APP_HEAP_SIZE_DEFINED` is defined in the `app.h` file of any Bluetooth Low Energy application, then the heap sizes can be customized in the `ble_protocol_support.c` file (where they are defined and allocated). The following code example shows how the required memory sizes can be calculated (defined in `ble_protocol_support.c`).

```

/// Memory allocated for environment variables
uint32_t rwip_heap_env[RWIP_CALC_HEAP_LEN(APP_RWIP_HEAP_ENV_SIZE)];
/// Memory allocated for Attribute database
uint32_t rwip_heap_db[RWIP_CALC_HEAP_LEN(APP_RWIP_HEAP_DB_SIZE)];
/// Memory allocated for kernel messages
uint32_t rwip_heap_msg[RWIP_CALC_HEAP_LEN(APP_RWIP_HEAP_MSG_SIZE)];
/// Non Retention memory block
uint32_t rwip_heap_non_ret[RWIP_CALC_HEAP_LEN(APP_RWIP_HEAP_NON_RET_SIZE)];

```

We assume:

`APP_MAX_NB_ACTIVITY` and `APP_MAX_NB_CON` are defined in the application, based on the application's use case. Please note that `PP_BLE_CONNECTION_MAX` needs to be at least one value bigger than `APP_MAX_NB_CON`.

```

APP_RWIP_HEAP_ENV_SIZE =
(600 + (APP_MAX_NB_ACTIVITY) * 230
 + APP_MAX_NB_CON * ((sizeof(struct gapc_env_tag)
 + KE_HEAP_MEM_RESERVED)
 + (sizeof(struct gattc_env_tag) + KE_HEAP_MEM_RESERVED)
 + (sizeof(struct l2cc_env_tag) + KE_HEAP_MEM_RESERVED)
 + ((APP_MAX_NB_ACTIVITY) * (sizeof(struct gapm_actv_scan_tag)
 + KE_HEAP_MEM_RESERVED))

```

`APP_RWIP_HEAP_DB_SIZE`: This depends on how much data base memory (GATT services) is added. The default value is 3072 bytes, but developers can choose a smaller value based on their use case (see [Section 13.3 “Managing Bluetooth Low Energy Stack RAM Usage”](#) on page 124 for more information).

```

APP_RWIP_HEAP_MSG_SIZE =
(1650 + 2 * ((16 + (APP_MAX_NB_ACTIVITY - 1) * 56)
 + (58 + (APP_MAX_NB_ACTIVITY - 1) * 26)
 + ((APP_MAX_NB_ACTIVITY) * 66)
 + ((APP_MAX_NB_ACTIVITY) * 100)
 + ((APP_MAX_NB_ACTIVITY) * 12)))
+ (((BLEHL_HEAP_MSG_SIZE_PER_CON * APP_MAX_NB_CON) > BLEHL_HEAP_DATA_THP_SIZE)
 ?
 (BLEHL_HEAP_MSG_SIZE_PER_CON * APP_MAX_NB_CON) : BLEHL_HEAP_DATA_THP_SIZE)

```

`APP_RWIP_HEAP_NON_RET_SIZE`: By default, this is set to 656 bytes. It is used for security algorithm calculations. This part of memory does not need to be in retention mode when the use case calls for keeping the

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Bluetooth Low Energy link active and going to sleep with VDDM in retention. If enough memory is allocated — for example, in the database — the kernel can allocate this part of memory from another heap. Developers need to make sure that this default amount of memory is available, in non-ret heap or in another heap.

In this way, users can set their own APP_MAX_NB_CON and APP_MAX_NB_ACTIVITY values, and decrease the memory size allocated by default settings.

12.2 HCI

The role of the HCI is to provide a uniform interface method of accessing a Bluetooth Low Energy controller’s capabilities from the host. The HCI layer is part of the Bluetooth Low Energy protocol stack, as shown in the "Bluetooth Low Energy Protocol Stack" figure (Figure 10).

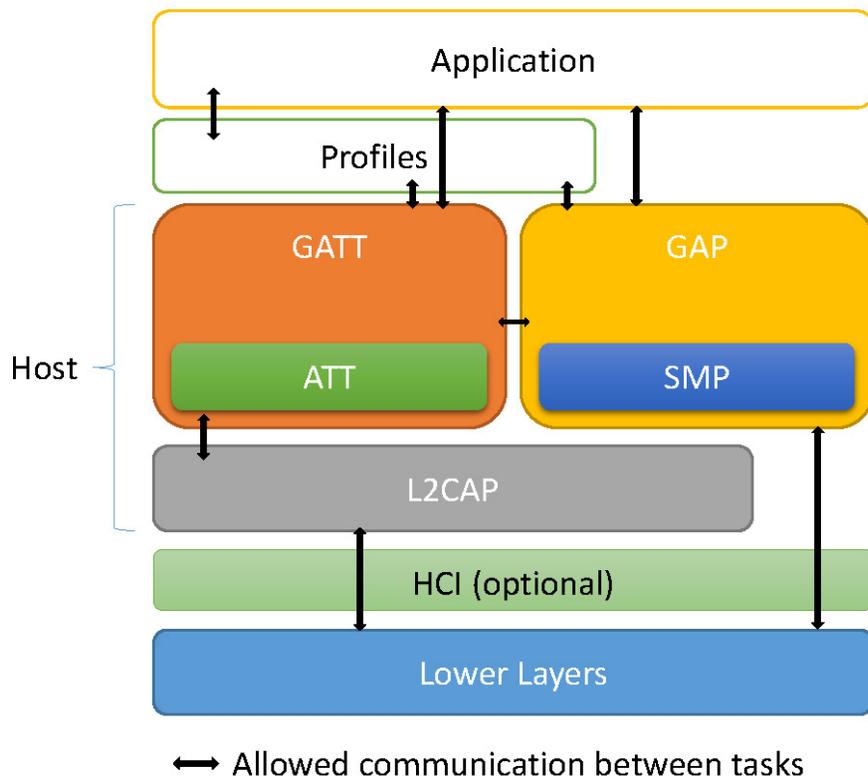


Figure 10. Bluetooth Low Energy Protocol Stack

The Bluetooth stack optionally provides an HCI layer, which provides direct access to the stack at an interface between the host and controller layers. The role of the HCI is to convey the information from one layer to the other by following the rules defined in the HCI portion of the Bluetooth standard. As shown in the sample code, the RSL15 HCI layer implementation can be used to interface with a transport layer that manages the reception and transmission of messages over a UART physical interface.

As shown in the "HCI" figure (12.2), the two main configurations are supported by the HCI software.

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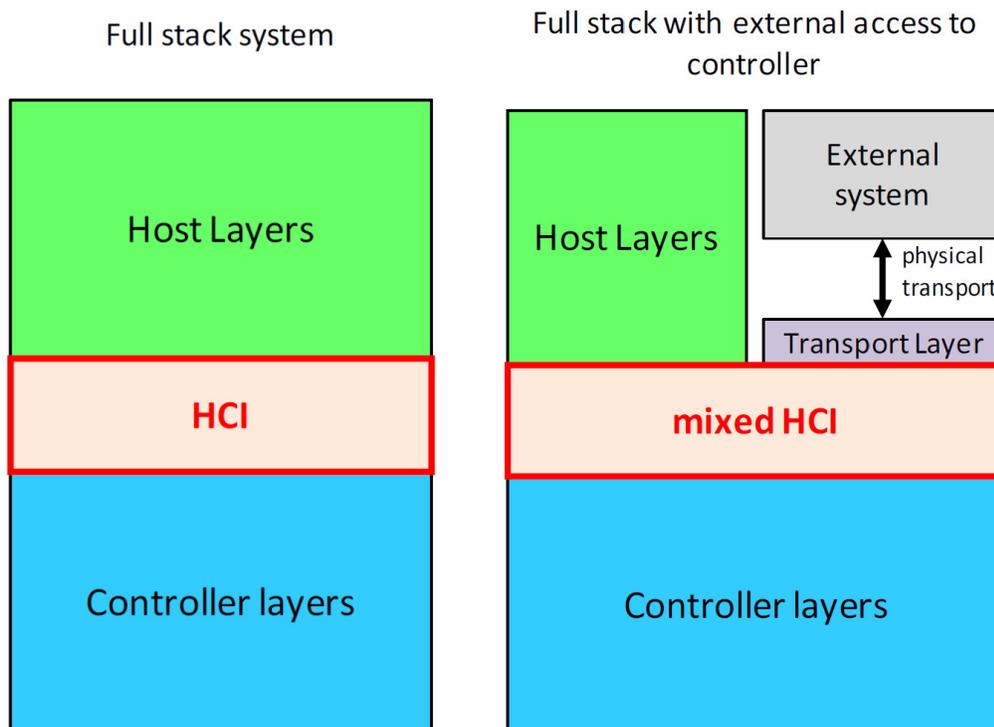


Figure 11. HCI Working Modes

RSL15 has both a full stack system, and compatibility providing an external system with access to the Bluetooth Controller.

12.2.1 HCI Software Architecture

The HCI software is an interface communication block (depicted in the "HCI Software Interfaces" figure (Figure 12)) that can be used for three main purposes:

1. Communication between internal controller and external host
 - In this case, RSL15 can be used only as a controller and can communicate to an external host for verification and certification purposes or as a standalone Bluetooth Low Energy controller device (for example, connecting to a PC where an open host stack is running). It is demonstrated using the *hci* sample application from the RSL15 SDK.
2. Communication between internal controller and internal host
 - In this case, a fully embedded host and application is used. HCI cannot be used with an external UART interface.
3. Communication between internal host and external application
 - In this case, an external application communicates to the RSL15 host over UART. This interface is not based on the HCI standard (because there is no such use case or standard defined in the Bluetooth core specification). However, an external application can use the same *hci* sample application and use the same kernel messaging and format specified in GAP, GATT, L2CAP, and profile API documentation.

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The only difference is that the first byte of any message sent or received over UART needs to be 0x05 (AHI_KE_MSG_TYPE definition of the RSL15 Bluetooth Low Energy stack).

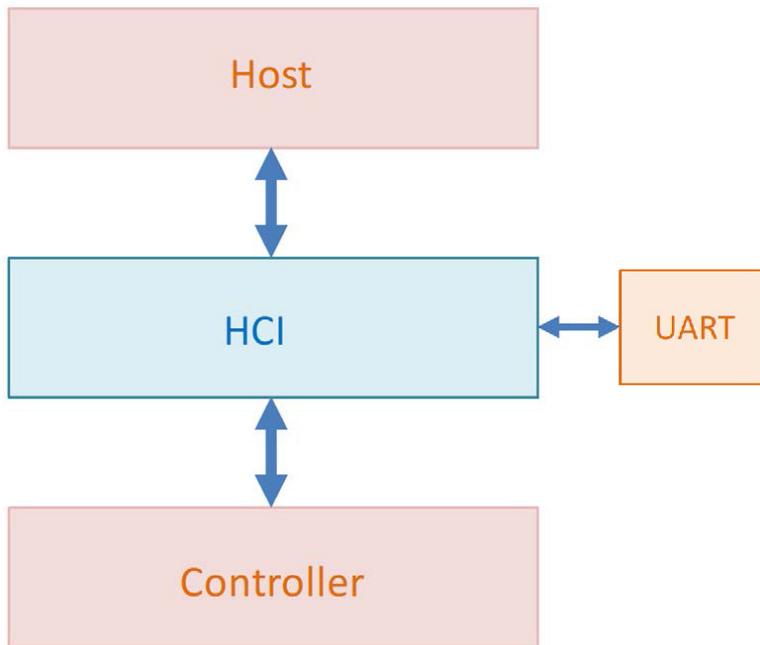


Figure 12. HCI Software Interfaces

12.3 GATT

The GATT is the gateway used by the Attribute Protocol to discover, read, write and obtain indications of the attributes present in the server attribute, and to configure the broadcasting of attributes. The GATT lies above the Attribute Protocol and communicates with the Generic Access Profile (GAP), higher layer profiles, and applications. The architecture of the GATT is shown in 12.3.

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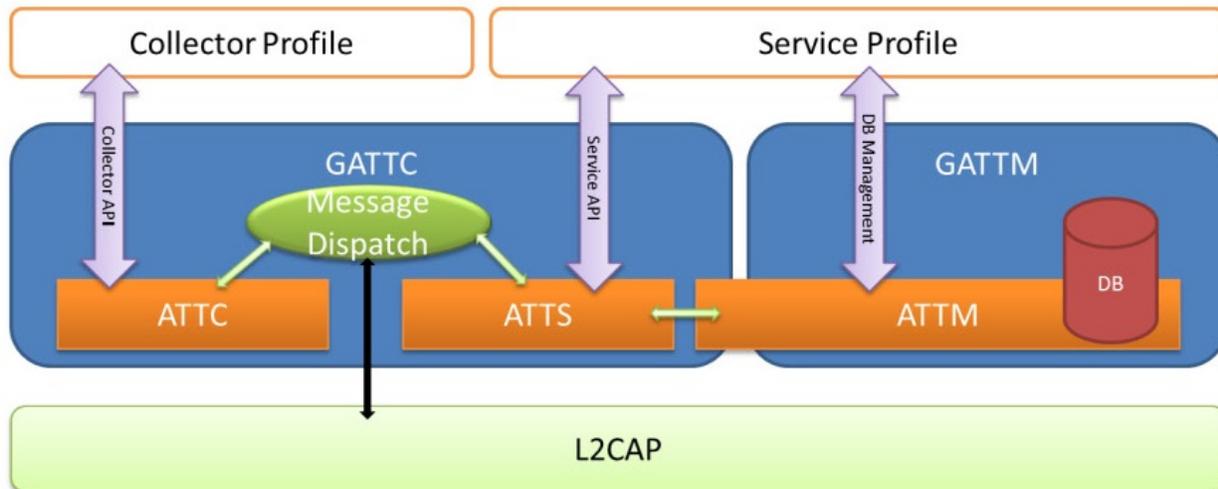


Figure 13. GATT Architecture

For more information about the GATT, and the Bluetooth Stack implementation of GATT, see the *Bluetooth Core Specification* (Volume 3, part G) and the provided CEVA *GATT Interface Specification API* document (*RW-BLE-GATT-IS.pdf*).

12.4 GAP

The Generic Access Profile (GAP) describes the generic procedures related to discovery of Bluetooth devices and link management aspects of connecting to Bluetooth devices. It also defines procedures related to use of different Bluetooth security modes.

The GAP module deals with four features:

1. Management of non-connected activities
2. Management of connected activities
3. Handling of Bluetooth Low Energy security, including pairing, bonding, encryption, and privacy.
4. Handling of life cycle of upper layer profiles

IMPORTANT: The Bluetooth standard for Bluetooth Low Energy provides several pairing schemes that can be used. Use of legacy pairing is not recommended due to known security concerns. We recommend that applications use secure connections for pairing, as per the *Bluetooth® Security and Privacy Best Practices Guide*, due to secure connection's improved overall security including substantially better MITM protection.

For more information about the GAP, and the Bluetooth Stack implementation of GAP, see the *Bluetooth Core Specification* (Volume 3, part C), the *Bluetooth® Security and Privacy Best Practices Guide*, and the provided CEVA *GAP Interface Specification API* document (*RW-BLE-GAP-IS.pdf*).

12.4.1 Non-Connected Procedures

This section describes the support provided to an application that uses non-connected procedures.

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Management of these non-connected procedures is based on creation of activities representing the different available procedures. Four kind of activities can be created:

- Advertising activity
- Scanning activity
- Initiating activity
- Periodic Synchronization activity

12.4.1.1 Activity Overview

GAP API provides a set of command messages allowing to:

- Create an activity (`GAPM_ACTIVITY_CREATE_CMD`)
- Start a created activity (`GAPM_ACTIVITY_START_CMD`)
- Stop a started activity (`GAPM_ACTIVITY_STOP_CMD`)
- Delete a created activity (`GAPM_ACTIVITY_DELETE_CMD`)

A descriptions of these commands can be found in the *CEVA Gap Interface Specification*.

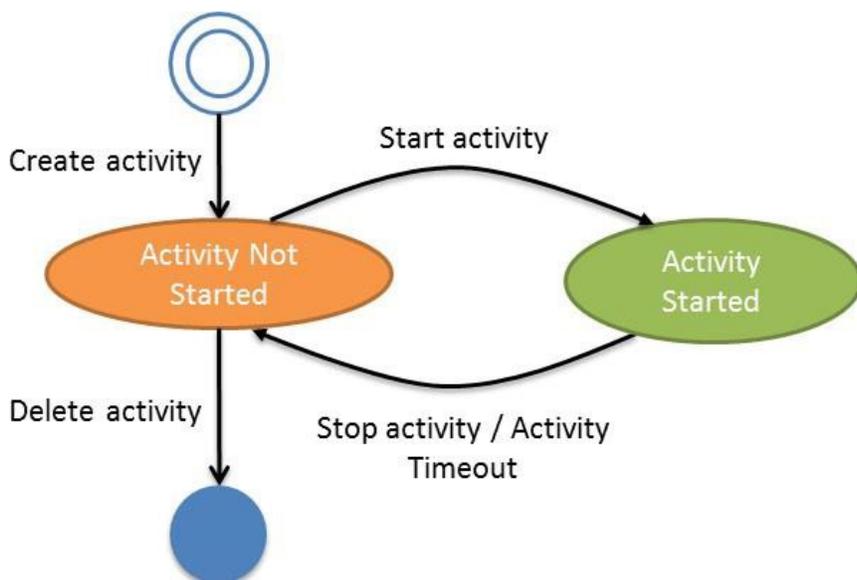


Figure 14. Activity Life Cycle

Figure 14 shows an overview of the life cycle of an activity.

- Before being usable, an activity must first be created.
- The activity must then be started.
- The activity can be considered finished after one of several events has occurred:
 - Request is received from application
 - Timeout
 - End of requested operation (after connection, synchronization,...)
- An activity can either be started again, if the application needs to perform the same procedure, or it can be deleted so that the allocated structure can be reused by another activity.

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NOTE: It is not possible to directly update an activity’s parameters. Instead, the application must create another activity with different parameters.

The number of activities that can be created in parallel depends on how many activities are supported by the upper layers. However, a few rules exist about the activities that can be started in parallel:

- It is possible to create and start several advertising activities in parallel.
- It is not possible to start two scanning or two initiating activities in parallel, due to HCI commands not allowing management of such operations, because management of such operations is not supported by HCI commands. However, it is possible to create two such activities in parallel.
- It is possible to start one scanning and one initiating activity in parallel with each other.

12.4.1.2 Advertising Activity

An advertising activity can be run on a device that is configured as a broadcaster device.

An advertising activity is defined by its discoverable and connectable modes, as described in [Table 29](#).

Table 29. Advertising Activity Modes

Discoverable Mode	Connectable Mode
<p>Non-discoverable mode:</p> <p>Procedure that can be limited in time. A device in this mode cannot be found by a general or limited discovery procedure.</p> <p>Filtering policy or targeted address can be used in this procedure.</p> <p>In AD_TYPE flag of advertising data, LE general and LE limited discoverable flag are set to zero.</p>	<p>Non-connectable mode:</p> <p>A device in this mode cannot be connected by a central device.</p>
<p>General discoverable mode:</p> <p>Procedure without duration limit. A device in this mode can be found by a general discovery procedure.</p> <p>Whitelist shall not be involved in this mode.</p> <p>In AD_TYPE flag of advertising data, LE general is set to 1 and LE limited discoverable flag is set to zero.</p>	<p>Undirected-connectable mode:</p> <p>A device in this mode can accept connection from any device or from device present in the whitelist.</p>
<p>Limited discoverable mode:</p> <p>Procedure with a limited duration. A device in this mode can be found either by a general or limited discovery procedure.</p> <p>Whitelist is not involved in this mode.</p> <p>In AD_TYPE flag of advertising data, LE general is set to zero and LE limited discoverable flag is set to 1.</p>	<p>Directed-connectable mode:</p> <p>A device in this mode can accept connection only by the targeted address.</p>

In this table, the Periodic Advertising Synchronizability mode and Broadcast mode are missing.

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- Periodic Advertising Synchronizability mode is neither a connectable mode nor a discoverable mode. A device in this mode sends synchronization information about periodic advertising.
- Broadcast mode is a non-connectable and non-discoverable mode.

Creation of advertising activity is possible using the `GAPM_ACTIVITY_CREATE_CMD` message, which allows creation of three different types of advertising:

- Legacy advertising activity
- Extended advertising activity
- Periodic advertising activity

NOTE: The discoverability modes such as non-discoverable mode, general discoverable mode and limited discoverable mode are considered as a property of the advertising mode.

12.4.1.2.1 Advertising Properties

The advertising properties are used to describe the content of advertising packets or behavior of the advertising activity. This section provides a small description for each of the configurable properties.

Directed

This property means that a specific device is targeted by the advertiser; the targeted device address is present in the advertising packet. For legacy advertising this applies only in connectable mode, but this is not the case for extended advertising.

High Duty Cycle

This property applies only in legacy direct advertising. The controller advertises the direct connectable packet for 1.28 s, with an advertising interval ≤ 3.75 ms.

Scannable

Advertising activity opens an RX window to receive a scan request packet, and sends in reply a scan response packet.

Connectable

Advertising activity opens an RX window to receive a connect request packet. This property is mandatory to start a connection as slave.

Anonymous

This applies only in extended advertising that is neither connectable nor scannable. The device address is not present at all in the advertised packet, but the packet can contain a targeted address.

TX Power

This applies only in extended advertising, and means that transmit power is present in an advertising packet.

Scan Request Notification

When a scan request packet is received over the air, a scan report is triggered to inform the application about observer device present over the air.

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Filter Policy

This indicates if the whitelist is involved, or not to accept scan requests or connect requests. This property applies only for non-discoverable mode advertising.

12.4.1.2.2 Legacy Advertising Activity

The create legacy advertising activity operation allows an application to start legacy advertising on primary advertising channels (37, 38, and 39) at 1 Mb/s. Table 30 shows properties available for each kind of advertising mode supported for legacy advertising.

Table 30. Advertising Properties for Legacy Advertising (Primary Channel Only)

Modes/Properties 0: Must be Disabled 1: Must be Active X: Can be Either Active or Disabled	Disc Mode	High Duty Cycle	Directed	Scannable	Connectable	TX Packet Type
Non-connectable	Non-disc (Broadcaster mode)	0	0	X	0	
	Limited	0	0	X	0	
	General	0	0	X	0	
Undirected connectable	Non-disc	0	0	1	1	ADV_IND
	Limited	0	0	1	1	
	General	0	0	1	1	
Directed connectable	Non-disc	X	1	0	1	ADV_DIRECT_IND

12.4.1.2.3 Extended Advertising Activity

The create extended advertising activity operation allows an application to start extended advertising on secondary advertising channels (0 to 36) using 1 Mb/s, 2 Mb/s, or LE Coded PHY. Table 31 shows properties available for each kind of advertising mode supported for extended advertising.

NOTE: Advertising extension does not support to have both connectable and scannable modes (scannable means that advertiser replies to AUX_SCAN_REQ). So it is possible to set the scan response data only for non-connected modes if the scan property is set.

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Table 31. Advertising Properties for Extended Advertising (Secondary Channel Usage)

Modes/Properties 0: Must be Disabled 1: Must be Active X: Can be Either Active or Disabled	Disc Mode	Anonymous	Directed	Scannable	Connectable
Non-connectable	General	0	0	X	0
	Limited	0	0	X	0
	Non-disc (Broadcaster Mode)	0	X	X	0
	Non-disc (Broadcaster Mode)	1	X	0	0
Undirected connectable	Non-disc	0	0	0	1
	General	0	0	0	1
	Limited	0	0	0	1
Directed connectable	Non-disc	0	1	0	1

12.4.1.2.4 Periodic Advertising Activity

The create periodic advertising activity operation allows an application to start a periodic advertising on secondary advertising channels (0 to 36) using 1 Mb/s, 2 Mb/s or LE Coded PHY. In order for a scanner to get information about position of the periodic advertising, a non-connectable and non-scannable extended advertising activity is started.

With this activity it is possible to set advertising data (limited to one fragment) and periodic advertising data.

Table 32 shows properties available for periodic advertising.

Table 32. Advertising Properties for Periodic Advertising (Secondary Channel Usage)

Modes/Properties 0: Must be Disabled 1: Must be Active X: Can be Either Active or Disabled	Disc Mode	Anonymous	Directed	Scannable	Connectable
Periodic Advertising Synchronizability	General	0	0	0	0
	Limited	0	0	0	0
	Non-disc	0	X	0	0

12.4.1.3 Scanning Activity

The purpose of the scanning activity is the reception of advertising packets. The Observer or Central role is mandatory for the creation of a scanning activity. Scanning activities are managed by the GAPM SCAN module.

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Six scanning modes are available:

Observer Mode

A passive or an active scan procedure with non-limited duration. In this mode, the application is notified about any received advertising data, whatever its type.

Selective Observer Mode

A passive or active scan procedure with non-limited duration using whitelist filtering.

General Discovery

A passive or an active scan procedure with a limited duration. In this mode, a device is able to discover advertiser devices broadcasting data in limited or general discoverable mode. Do not use the whitelist.

Limited Discovery

Passive or an active scan procedure with a limited duration. In this mode, a device is able to discover advertiser devices broadcasting data in limited discoverable mode. Do not use the whitelist.

General Connectable Discovery

Discover all connectable devices.

Selective Connectable Discovery

Discover connectable devices using whitelist filtering.

NOTE: Due to the content of HCI LE Extended Set Scan Param/Enable commands, a scanning activity cannot be started in parallel with another scanning activity.

Scan can be performed on LE 1M PHY or LE Coded PHY, or on both PHYs in parallel.

12.4.1.4 Initiating Activity

The purpose of initiating activity is the establishment of a Bluetooth Low Energy connection as master. This implies that support of the Central role is mandatory for creation of an initiating activity. Initiating activities are managed by GAPM INIT module.

Three connection modes are available:

Direct Connection Establishment

This procedure initiates a connection with a specific device.

Automatic Connection Establishment

This procedure makes use of the whitelist to establish a connection with known devices. The application needs to set the whitelist before starting this activity. As soon as connection with one of the whitelisted devices is established, the activity autonomously restarts the connection establishment procedure for the next device, until all desired connections have been established.

Name Discovery

As soon as connection is established, this procedure performs a read of the device name characteristic (GATT UUID 0x2A00) and then disconnects. The device name is sent to the application by using the GAPM_PEER_NAME_IND message.

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NOTE: Based on the content of the HCI LE Extended Creation Connection command, only one initiating activity can be started at a given time.

12.4.1.5 Periodic Synchronization Activity

The periodic synchronization activity is used to perform a periodic advertising synchronization establishment procedure. Periodic synchronization activity is managed by the `GAPM_PER_SYNC` module. Observer mode needs to be supported for creation of a periodic synchronization activity.

To establish a synchronization, there are two possible options: waiting information from an existing link using a periodic advertising sync transfer from a peer device, or establishing synchronization without a connection. When not using a connection, it is mandatory to start a scan activity in parallel. This scan activity can be started before or after the periodic synchronization activity.

In the case of a periodic sync transfer, activity must be started with the connection index before expecting sync information from a peer device.

Once the activity has been created, it can be started using the `GAPM_ACTIVITY_START_CMD` message to synchronize with either one specific device (general type) or any of the devices present in the periodic advertising list (selective type).

NOTE: It is not allowed for two periodic synchronization activities to be waiting for synchronization at a same time.

CHAPTER 13

Bluetooth and Kernel Library

This topic describes:

- The custom application programming interface (API) for the event kernel and Bluetooth stack library
- The Bluetooth abstraction API that provides a simplified access to the Bluetooth stack library
- Using the event kernel and Bluetooth stack in an application

13.1 USE OF THE EVENT KERNEL AND BLUETOOTH STACK

Applications using the event kernel and Bluetooth Stack make use of both the custom API, described in Section 13.2 “Baseband and Kernel Functions”, and standard event kernel and Bluetooth Stack APIs, as described in the provided CEVA/RivieraWaves documentation.

IMPORTANT: To ensure Bluetooth connection stability, the Event Kernel and Bluetooth stack require that their interrupts be handled in a timely manner. For maximum Bluetooth stability, their interrupts must remain enabled throughout a connection interval and must be configured as the highest priority interrupts in the system to avoid preemption. For more information, see Section 13.2 “Baseband and Kernel Functions” on page 120.

To assist in understanding the event kernel and Bluetooth stack, the following sections outline the customary usage of these components within the context of a typical application use case.

13.1.1 The Kernel Scheduler

The kernel scheduler is responsible for constantly checking messages communicated by different tasks. Applications might use as few as one task, although more complex applications typically include several tasks. Additionally, applications can contain multiple instances of the same task.

Different application tasks control different Bluetooth Low Energy functionalities. An application sometimes needs to communicate with different tasks, such as GAPM, GAPC, GATTM, GATTC, and different standard and custom profiles (services). The kernel scheduler is responsible for handling these messages.

When the application needs to send a message, it allocates memory in the kernel buffer, fills in the message with any parameter that it wants to send, and then fills in the source address and destination address as the message identifier. The application calls a function from the kernel asking to send this message to the destination. The kernel scheduler checks that buffer. If it is filled, the scheduler sends the message to the destination task by automatically calling a pre-defined message handler. The kernel scheduler also handles all timers used by the stack, services, or application. When a timer expires, the kernel scheduler automatically calls a function or message handler allocated to the timer’s identifier.

13.1.2 Message Handlers

Coordinating with the event scheduler, the message handlers manage any request or command associated with a scheduled event.

For example, any message, request or command sent from the application to the GAPM has an associated `GAPM_COMPLETE` event. This event message is sent from the stack to the application. Based on its message identifier, this message is called automatically by the kernel.

NOTE: We recommend that users read the CEVA documentation for GATT and GAP before attempting to add their own message handler for a specific API or message.

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To add a message handler, you first need to add `DEFINE_MESSAGE_HANDLER` in the corresponding `.h` file, and define a function in the corresponding file, which can be `ble_standard.h`, `application.h`, or `standard_profile.h`.

To add a message handler, users must:

1. Add a task message ID for the handler to the message enumeration used by the application.
2. Add a callback function and function prototype that executes when an event with the task message ID added in step 1 occurs.
3. Register the task message ID and callback function using:

```
MsgHandler_Add(ke_msg_id_t const msg_id, MsgHandlerCallback_t callback);
```

13.1.3 Core Bluetooth Profiles

Core Bluetooth profiles provide the standard communications structures needed to communicate between devices and to organize Bluetooth data. These core profiles are listed here:

- The Generic Access Profile (GAP) contains standard compliant implementations of the broadcasting and connecting mechanisms by which a Bluetooth Low Energy device can communicate with the outside world. The GAP implementation is divided into GAPM (GAP Manager) and GAPC (GAP Controller) services, and is described in the GAP Interface Specification.
- The Generic Attribute Profile (GATT) contains rules for how attributes (data) are formatted, packaged, and sent between Bluetooth Low Energy devices once they have a dedicated connection. The GATT implementation is divided into GATTM (GATT Manager) and GATTC (GATT Controller) services, and is described in CEVA's GATT Interface Specification.

13.1.4 Standard Profiles and Services

Standard services are pre-defined data structures and methods, which Bluetooth Low Energy devices can use to communicate Bluetooth-specific data between devices in a standardized way. Standard profiles define how a group of one or more services interact and are used.

The attributes of standard services are already recognized by the Bluetooth Low Energy stack, so you do not need to list the attributes when adding standard services to an application. Each standard service has a 16-bit UUID (unique numeric identifier).

13.1.5 Custom Profiles and Services

Custom services, like standard services, are data structures, and the methods which Bluetooth Low Energy devices can use to communicate with, and work with, your Bluetooth Low Energy applications to add functionality. Unlike standard services, custom services are not pre-defined. Users control what custom services do, creating them to meet the needs of their own applications. For custom services, a list all of the attributes needed for the service must be provided to the stack, because the stack cannot automatically tell which attributes to add. Each custom service needs a 128-bit UUID.

Custom profiles can be defined that use both standard and custom services in similar ways to standard profiles.

13.1.6 Event Kernel and Bluetooth Low Energy Library Initialization and Execution

When using the event kernel and Bluetooth stack in a user application, the application must:

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- Initialize the event kernel and Bluetooth stack using the `BLE_Initialize()` function, described in Section 13.2 “Baseband and Kernel Functions”.
- Periodically execute the kernel scheduler using the `BLE_Kernel_Process()` function, described in Section 11.3 “Scheduler”.
 - For proper operation, this function must be called in the application’s main loop prior to placing the core into a state waiting for an interrupt.
 - If using low power modes, the `BLE_Baseband_Sleep()` function needs to be called after running the event scheduler before going to sleep. Only transition the device to Sleep Mode or Standby Mode if this function returns `RWIP_DEEP_SLEEP`.

NOTE: While connected to a remote device, the application must allow Bluetooth- and RF-related interrupts to be handled regularly, by not disabling and blocking interrupts for multiple Bluetooth connection periods.

13.2 BASEBAND AND KERNEL FUNCTIONS

To maximize the Bluetooth Low Energy connection stability, the stack must be provided sufficient processing time. We recommended that you:

1. Set the stack interrupts to the highest priority to prevent preemption or ISR processing delays.
2. Minimize the continuous time when interrupts are disabled
3. Have the application call `BLE_Kernel_Process()` at least once per Bluetooth connection interval.

Use of the event kernel and baseband are primarily supported by the functions described in the "Event Kernel Support Functions" table (Table 33). These functions initialize and execute these components, while supporting transitions between different power modes. Function prototypes for these functions are included through *ble.h*, and these prototypes are defined in *ble/rwip.h*.

Table 33. Event Kernel Support Functions

Function	Description
<code>BLE_Initialize</code>	Initialize the event kernel and Bluetooth baseband for use within an application.
<code>BLE_Baseband_Sleep</code>	Place the Bluetooth baseband to sleep if the current Bluetooth Low Energy stack and the event kernel state indicate it is safe.
<code>BLE_Kernel_Process</code>	Execute any pending events that have been scheduled with the event kernel.
<code>BLE_Baseband_Is_Awake</code>	Check if the Bluetooth baseband is awake.

13.2.1 BLE_Initialize

Prototype:

```
void BLE_Initialize(uint8_t * param_ptr)
```

Parameters:

Table 34. BLE_Initialize Parameters

Type	Parameters	Description
<code>uint8_t *</code>	<code>param_ptr</code>	Reserved for future use (input/output parameter)

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Return:

None

Description:

Initializes the Bluetooth Low Energy stack and the event kernel for use within an application.

Example

```
/* Initialize the kernel and Bluetooth stack */
uint8_t param;
BLE_Initialize(&param);
```

13.2.2 BLE_Baseband_Sleep

Prototype:

```
uint8_t BLE_Baseband_Sleep(struct ble_sleep_api_param_tag *param_ptr)
```

Parameters:

Table 35. BLE_Baseband_Sleep Parameters

Type	Parameters	Description
struct ble_sleep_api_param_tag *	param_ptr	param_ptr->app_sleep_request = Application sleep request; set to 1 if the Bluetooth baseband is intended to go to sleep when possible, 0 if the system is meant to stay awake param_ptr->max_sleep_duration = Requested maximum sleep duration in multiples of 312.5 μs (when this value is set to 0xFFFFFFFF, the maximum sleep duration is 36 hours and 16 minutes) param_ptr->min_sleep_duration = Requested minimum sleep duration in μs param_ptr->calculated_sleep_duration = Return value, in low power baseband clock cycles, providing the calculated sleep duration

NOTE: Minimum sleep duration that BLE_Baseband_Sleep() sets is the maximum value of min_sleep_duration and the BB_ENBPRESET_TWOSC bit field from the BB_ENBPRESET register.

Return:

Allowed sleep state.

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- `RWIP_DEEP_SLEEP` if the baseband controller has been put to sleep, the baseband timer is set, and the core can switch to Sleep Mode (after saving the baseband and RF registers) or Standby Mode.
- `RWIP_CPU_SLEEP` if the core can be put to sleep, but the system is not meant to enter Sleep Mode or Standby Mode.
- `RWIP_ACTIVE` otherwise.

Description:

A user application calls this function to put the system into Sleep Mode. This function performs the following operations:

1. Checks the event kernel and Bluetooth Low Energy stack to decide whether it is the right time for the system to go into Sleep Mode
2. Programs and starts the low-power BB timer (if requested)
3. Puts the BB and RF hardware into Sleep Mode (if requested)
4. Returns the calculated sleep duration and sleep decision to the application

The application uses input parameter `param_ptr->app_sleep_request` to indicate whether it requests this function to put the BB and RF hardware into Sleep Mode when possible (0x0: not requesting; 0x1: requesting). In detail:

When the application calls this function with `param_ptr->app_sleep_request` set to 0x0:

- If Sleep Mode is possible, this function writes the expected baseband sleep duration (in low-power clock cycles) in the `param_ptr->calculated_sleep_duration` field, and returns `RWIP_DEEP_SLEEP`.

NOTE: In this case, `BLE_Baseband_Sleep()` does not put the BB and RF hardware into Sleep Mode even if it is possible, because this has not been requested.

- If Sleep Mode is not possible, this function returns `RWIP_CPU_SLEEP` or `RWIP_ACTIVE`.

When the application calls this function with `param_ptr->app_sleep_request` set to 0x1:

- If Sleep Mode is possible, this function writes the expected baseband sleep duration (in low-power clock cycles) in the `param_ptr->calculated_sleep_duration` field, programs and starts the low-power BB timer, puts the BB and RF hardware into Sleep Mode, and finally returns `RWIP_DEEP_SLEEP`.
- If Sleep Mode is not possible, this function returns `RWIP_CPU_SLEEP` or `RWIP_ACTIVE`.

In other words, the application calls `BLE_Baseband_Sleep()` with `param_ptr->app_sleep_request` set to 0x0 when it simply wants to check if Sleep Mode is possible and to get the expected baseband sleep duration. If Sleep Mode is possible, the application then might want to check the expected baseband sleep duration and other application-specific contexts to decide if it wants to enter Sleep Mode or not. If the application decides to enter Sleep Mode, it needs to call `BLE_Baseband_Sleep()` again with `param_ptr->app_sleep_request` set to 0x1.

Example:

```
/* Attempt to place the device to sleep */
struct ble_sleep_api_param_tag param;
param.app_sleep_request = 1;
param.max_sleep_duration = MAX_SLEEP_DURATION;
param.min_sleep_duration = MIN_SLEEP_DURATION;
```

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```

switch (BLE_Baseband_Sleep (&param))
{
    case RWIP_DEEP_SLEEP:
    {
        /* Save the baseband and RF registers, then go to sleep */
        BB_Sleep (POWER_MODE);
        break;
    }
    case RWIP_CPU_SLEEP:
    {
        /* Wait for interrupt */
        __WFI ();
        break;
    }
    case RWIP_ACTIVE:
    default:
    {
    }
}
}

```

13.2.3 BLE_Kernel_Process**Prototype:**

```
void BLE_Kernel_Process (void)
```

Parameters:

None

Return:

None

Description:

Execute any pending events that have been scheduled with the event kernel.

Example:

```

/* Main application loop:
 * - Run the kernel scheduler
 * - Refresh the watchdog and wait for an interrupt before continuing */
while (1)
{
    BLE_Kernel_Process ();

    /* Refresh the watchdog timer */
    SYS_WATCHDOG_REFRESH ();

    /* Wait for an event before executing the scheduler again */
    __WFI ();
}

```

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13.2.4 BLE_Baseband_Is_Awake**Prototype:**

```
bool BLE_Baseband_Is_Awake(void)
```

Parameters:

None

Return:

True if the Bluetooth baseband is awake, false otherwise.

Description:

Check if the Bluetooth baseband is awake.

Example:

```
/* Check if the Bluetooth baseband is still awake */
if (BLE_Baseband_Is_Awake())
{
    BLE_Baseband_Sleep(&param);
}
```

13.3 MANAGING BLUETOOTH LOW ENERGY STACK RAM USAGE

The Bluetooth Low Energy stack is provided as a compiled library and cannot be modified by the user. However, some of the stack variables are defined at the application level, and the user has some control over the size of these variables. This is a guide to optimizing stack RAM memory usage by adjusting the application level variable defines as dependent upon the application use case.

The application level variables are defined to support the maximum number of connections and activities, which is 10 and 11 respectively. (See the CEVA documentation provided with your RSL15 download, in the default location *C:\Users\<user_name>\ON_Semiconductor\PACK\ONSemiconductor\RSL15\<version>\documentation\ceva.*) If the application use case does not require the maximum number of connections and activities, application level variable sizes can be reduced to save memory.

NOTE: It is not recommended to adjust application level variable sizes in the HCI stack, as this can adversely affect Bluetooth certification.

The simplest method and recommended starting point to reduce stack memory usage is to reduce the value of `APP_MAX_NB_CON`. This scales most of the other application level variables as well, resulting in a reduction of memory usage. This is usually sufficient for most users. If you are an advanced user requiring further optimization, read on.

The memory allocated by the stack is divided into different parts. The first part comprises the required environment and global variables that are independent of the number of connections or activities. This part cannot be changed by developers.

The second part is heap memory, which the kernel takes as a global variable (*.bss* section), and later the kernel and the Bluetooth Low Energy stack use it as the heap memory for their procedures. It is divided into four parts:

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- Environment variables
- Message heap memory
- Data base memory
- Non-retention memory

By default, all parameters are set to address the maximum number of connections and activities, which are 10 and 11 respectively. If definition `APP_HEAP_SIZE_DEFINED` is defined in the `app.h` file of any Bluetooth Low Energy application, then the heap sizes can be customized in the `ble_protocol_support.c` file (where they are defined and allocated). The following code example shows how the required memory sizes can be calculated (defined in `ble_protocol_support.c`).

```

/// Memory allocated for environment variables
uint32_t rwip_heap_env[RWIP_CALC_HEAP_LEN(APP_RWIP_HEAP_ENV_SIZE)];
/// Memory allocated for Attribute database
uint32_t rwip_heap_db[RWIP_CALC_HEAP_LEN(APP_RWIP_HEAP_DB_SIZE)];
/// Memory allocated for kernel messages
uint32_t rwip_heap_msg[RWIP_CALC_HEAP_LEN(APP_RWIP_HEAP_MSG_SIZE)];
/// Non Retention memory block
uint32_t rwip_heap_non_ret[RWIP_CALC_HEAP_LEN(APP_RWIP_HEAP_NON_RET_SIZE)];

```

We assume:

`APP_MAX_NB_ACTIVITY` and `APP_MAX_NB_CON` are defined in the application, based on the application's use case. Please note that `PP_BLE_CONNECTION_MAX` needs to be at least one value bigger than `APP_MAX_NB_CON`.

```

APP_RWIP_HEAP_ENV_SIZE =
(600 + (APP_MAX_NB_ACTIVITY) * 230)
+ APP_MAX_NB_CON * ((sizeof(struct gapc_env_tag)
+ KE_HEAP_MEM_RESERVED)
+ (sizeof(struct gattc_env_tag) + KE_HEAP_MEM_RESERVED)
+ (sizeof(struct l2cc_env_tag) + KE_HEAP_MEM_RESERVED))
+ ((APP_MAX_NB_ACTIVITY) * (sizeof(struct gapm_actv_scan_tag)
+ KE_HEAP_MEM_RESERVED))

```

`APP_RWIP_HEAP_DB_SIZE`: This depends on how much data base memory (GATT services) is added. The default value is 3072 bytes, but developers can choose a smaller value based on their use case. This stack memory heap (section) is used for several purposes:

- GAP and GATT database: total size 158 B
- Database of Bluetooth Low Energy Profiles. Considering that only BAS and DIS are available, the required sizes are as follows, providing an application requests adding them:
 - DISC: 694 B
 - DISS: 154 B
 - BASC: 392B
 - BASS: 70 B

NOTE: BASC and BSS can be one instance or two instances. Depending how many an application adds, the used memory size increases by two if two instances are configured.

- Database for custom services. Each service needs 22 B for service itself. For each attribute it needs a maximum of 22 B in addition, depending on attribute types. We recommend that you consider the maximum value.
- L2CAP credit-based connection-oriented channels environment (LECB): this needs 36 B per channel.

```

APP_RWIP_HEAP_MSG_SIZE =

```

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```
(1650 + 2 * ((16 + (APP_MAX_NB_ACTIVITY - 1) * 56)
+ (58 + (APP_MAX_NB_ACTIVITY - 1) * 26)
+ ((APP_MAX_NB_ACTIVITY) * 66)
+ ((APP_MAX_NB_ACTIVITY) * 100)
+ ((APP_MAX_NB_ACTIVITY) * 12)))
+ (((BLEHL_HEAP_MSG_SIZE_PER_CON * APP_MAX_NB_CON) > BLEHL_HEAP_DATA_THP_SIZE)
?
(BLEHL_HEAP_MSG_SIZE_PER_CON * APP_MAX_NB_CON) : BLEHL_HEAP_DATA_THP_SIZE)
```

APP_RWIP_HEAP_NON_RET_SIZE: By default, this is set to 656 bytes. It is used for security algorithm calculations. This part of memory does not need to be in retention mode when the use case calls for keeping the Bluetooth Low Energy link active and going to sleep with VDDM in retention. If enough memory is allocated — for example, in the database — the kernel can allocate this part of memory from another heap. Developers need to make sure that this default amount of memory is available, in non-ret heap or in another heap.

In this way, users can set their own APP_MAX_NB_CON and APP_MAX_NB_ACTIVITY values, and decrease the memory size allocated by default settings.

13.4 BLUETOOTH LOW ENERGY LINK LAYER METRICS

A user application can enable or disable the tracking of metrics for Bluetooth Low Energy links. This is accomplished by calling the following function, with the en input parameter set to 0x1 or 0x0, respectively:

```
uint8_t BLE_Link_Metrics(uint8_t en, uint8_t actidx, struct ble_link_metrics
*metricsPtr)
```

We recommend using this function to enable the link metrics tracking when a Bluetooth Low Energy link is established (i.e., when GAPC_CONNECTION_REQ_IND is received), and disable the tracking at Bluetooth Low Energy disconnection (i.e., when GAPC_DISCONNECT_IND is received).

Example code for the BLE_Link_Metrics() function:

```
struct ble_link_metrics bleLinkMetrics[APP_MAX_NB_CON];
...
/* At receiving GAPC_CONNECTION_REQ_IND */
memset(&bleLinkMetrics[conidx], 0, sizeof(struct ble_link_metrics));
ble_metrics_ret_val = BLE_Link_Metrics(1, p->conhdl, &bleLinkMetrics[conidx]);
...
/* At receiving GAPC_DISCONNECT_IND */
ble_metrics_ret_val = BLE_Link_Metrics(0, gap_env.connection[conidx].conhdl,
&bleLinkMetrics[conidx]);
...
```

This example shows data structure ble_link_metrics used to track the metrics for a Bluetooth Low Energy link:

```
struct ble_link_metrics
{
    uint8_t enable;
    uint32_t noerr_pkt_non_empty_cnt;
```

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```

uint32_t noerr_pkt_empty_cnt;
uint32_t sync_err_cnt;
uint32_t rxtime_err_cnt;
uint32_t len_err_cnt;
uint32_t crc_err_cnt;
uint32_t mic_err_cnt;
uint32_t llid_err_cnt;
uint32_t sn_err_cnt;
uint32_t nsen_err_cnt;
uint32_t rxcte_err_cnt;
};
    
```

The "ble_link_metrics Field Names and their Meanings" table (Table 36) shows the meaning of each field in the ble_link_metrics data structure:

Table 36. ble_link_metrics Field Names and their Meanings

Field Name	Contents
enable	Enable (0x1) or disable (0x0) the tracking of link metrics
noerr_pkt_non_empty_cnt	The number of received non-empty packets without any errors
noerr_pkt_empty_cnt	The number of received empty packets without any errors
sync_err_cnt	The number of received packets with Sync Word not correct or not detected
rxtime_err_cnt	The number of received packets with RX time greater than a threshold configured by the stack till the last CRC bit
len_err_cnt	The number of received packets with lengths greater than the maximum value allowed by the event configured by the stack
crc_err_cnt	The number of received packets with incorrect CRC
mic_err_cnt	The number of received packets with incorrect MIC
llid_err_cnt	The number of received packets with invalid LLID
sn_err_cnt	The number of received packets with incorrect sequence number (SN)
nsen_err_cnt	The number of received packets with incorrect next expected sequence number (NESN)
rxcte_err_cnt	The number of received packets with incomplete reception of CTE field to indicate an abort of the reception during the CTE field

When a packet is received at the link layer of the Bluetooth Low Energy stack, if the tracking of the associated link is enabled (whether the received packet is erroneous or not), the counters in ble_link_metrics data structure associated with the link are updated using the logic below:

```

if(rxstatus & EM_BLE_SYNC_ERR_BIT)
{
    sync_err_cnt++;
}
else if(rxstatus & EM_BLE_RXTIME_ERR_BIT)
{
    
```

```

    rxtime_err_cnt++;
}
else if(rxstatus & EM_BLE_LEN_ERR_BIT)
{
    len_err_cnt++;
}
else if(rxstatus & EM_BLE_CRC_ERR_BIT)
{
    crc_err_cnt++;
}
else if(rxstatus & EM_BLE_MIC_ERR_BIT)
{
    mic_err_cnt++;
}
else if(rxstatus & EM_BLE_LLID_ERR_BIT)
{
    llid_err_cnt++;
}
else if(rxstatus & EM_BLE_SN_ERR_BIT)
{
    sn_err_cnt++;
}
else if(rxstatus & EM_BLE_NESN_ERR_BIT)
{
    nsen_err_cnt++;
}
else if(rxstatus & EM_BLE_RXCTEERR_BIT)
{
    rxcte_err_cnt++;
}
else
{
    if(rxLength == 0)
    {
        noerr_pkt_empty_cnt++;
    }
    else
    {
        noerr_pkt_non_empty_cnt++;
    }
}
}

```

13.4.1 BLE_Link_Metrics

```

uint8_t BLE_Link_Metrics(uint8_t en, uint8_t actidx, struct ble_link_metrics
*metricsPtr)

```

Location: lld_con.c: 3643

This function enables or disables the tracking of Bluetooth Low Energy link metrics.

Returns:

Return value from this function indicates if the requested action (enable or disable) has been performed successfully.

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Parameters:

Direction	Name	Description
in	en	0x1 to enable the tracking of link metrics, 0x0 to disable it
in	actidx	Activity identifier of Bluetooth Low Energy link
in	metricsPtr	Pointer to the <code>ble_link_metrics</code> data structure, which maintains link metric counters
out	Return value	Returns status and indicates if requested action (enable/disable) has been performed successfully <ul style="list-style-type: none"> • 0x0 if requested action has been performed successfully • 0x1 if activity identifier of Bluetooth Low Energy link is invalid • 0x2 if the pointer to <code>ble_link_metrics</code> data structure is NULL

13.5 BLUETOOTH STACK SUPPORTING API FUNCTIONS

13.5.1 Device_BLE_Param_Get

Prototype:

```
uint8_t Device_BLE_Param_Get(uint8_t param_id, uint8_t *lengthPtr, uint8_t *buf)
```

This is a callback function that is called by the Bluetooth stack whenever the associated data is required. If the application returns `PARAM_OK`, it means that requested parameter is provided by the application; if it returns `PARAM_FAIL`, it means the stack can use the default settings/parameters.

In this function there is a switch/case, described below:

- `PARAM_ID_BD_ADDRESS`: the global public address of the device
- `PARAM_ID_LPCLK_DRIFT`: the clock accuracy in ppm for the low power clock. There are three clock sources: XTAL32, RC OSC 32, and clock input from a GPIO[0- 3]. By default it is 500 ppm, but the application can provide another value based on the clock accuracy used. For the central role it is not expected to be bigger than 500.
- `PARAM_ID_ACTCLK_DRIFT`: the clock accuracy of XTAL 48 MHz in ppm that depends on the XTAL component used in PCB. If it is not provided by application maximum, 50 ppm will be used.
- `PARAM_ID_OSC_WAKEUP_TIME`: the time that, after wakeup from a low power mode, XTAL48 and other blocks of need time to power up and be ready. The value is in μ s.
- `PARAM_ID_CH_ASS_EN`: can be used in a central role to indicate if the channel assessment mechanism needs to be executed by the stack or not. It has True and False values.
- `PARAM_ID_LPCLK_NO_XTAL32K`: determines if a XTAL 32768 Hz is used as the low power clock source or another option of clock source/value is used. If 32768 Hz with maximum 500 ppm is not used, then the actual clock value can be provided by calling `LPCLK_PeriodValue_Set(LPCLK_PERIOD_VALUE)`; refer to sample application code.
- `PARAM_ID_LE_PRIVATE_KEY_P256` and `PARAM_ID_LE_PUBLIC_KEY_P256`: if ECC public and private keys are provided by the application, this can be used for debugging purposes or for use cases where an application

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needs to generate the keys by itself (using the Arm CryptoCell-312 hardware accelerator or any other way) rather than having them generated by the Bluetooth stack.

- `PARAM_ID_LE_DBG_FIXED_P256_KEY`: values are True or False, indicating if the stack should use forced keys provided by application or not.
- `PARAM_ID_CH_ASSESS_PARAMS`: when a channel assessment algorithm is enabled by the application, the related parameters can be provided through this case that need to follow `struct channel_map_assess_tag`.
- `PARAM_ID_DTM_ANT_ID_TO_PTRN_PARAMS`: for antenna-switching use cases, the antennal pattern table can be provided through this case.
- `PARAM_ID_CUSTOMIZED_HEAP_SIZE`: if an application needs to control and define the memory size used by the Bluetooth stack (stack heap), the four heap sizes values can be provided; otherwise the stack will use default sizes. (Refer to "Introduction" on page 104 for details).
- `PARAM_ID_DFT_SLAVE_MD`: When a peripheral device sends a packet, it sets the MD bit to make sure that an acknowledge can be received from the central peer device in the same connection event. It has true and false values. By default, it is set to true, which means that the MD bit is set.
- `PARAM_ID_ACTIVITY_MOVE_CONFIG`: When there is more than one Bluetooth Low Energy connection, events anchor points might overlap and a peripheral device can send a connection parameter update request to peer central devices asking for an anchor point move. By default, it is enabled (true). It can be disabled if the application sets it to false.
- `PARAM_ID_LE_CODED_PHY_500`: In the RSL15 *peripheral_server* sample project, setting `ADV_EXTENSION=1` causes the application to use `GAPM_PHY_TYPE_LE_CODED` for advertising at a default rate of 250 Kbps. But if 500 Kbps is required instead, then this case is used.

13.5.2 platform_reset

Prototype:

```
void platform_reset(uint32_t error)
```

This function is called whenever the stack memory is full, so that the application can be notified of the situation and handle it accordingly.

13.5.3 srand_func

Prototype:

```
void srand_func(uint32_t seed)
```

This provides a seed value for the `rand()` function used in the stack.

13.5.4 rand_func

Prototype:

```
int rand_func(void)
```

Instead of the C `rand` function, the application can provide its own implementation or use the TRNG accelerator from the Arm CryptoCell-312.

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13.5.5 Device_RF_RSSI_Convert**Prototype:**

```
int8_t Device_RF_RSSI_Convert(uint8_t rssi_reg)
```

This function can be used by application to convert or read the RF RSSI register to an actual dBm value. A general function is provided, but RSSI needs calibration for use cases that need an more accurate RSSI.

13.5.6 Device_RF_TxPwr_Get_dBm**Prototype:**

```
int8_t Device_RF_TxPwr_Get_dBm(uint8_t txpwr_idx)
```

This callback function is called whenever the stack needs to convert the RF0_REG1A_PA_PWR_PA_PWR_BYTE field of register RF0_REG1A to a dBm value.

13.5.7 Device_RF_TxPwr_Get_Idx**Prototype:**

```
uint8_t Device_RF_TxPwr_Get_Idx(int8_t txpwr_dbm)
```

This callback function is used whenever the stack is converting output power in dBm to a value used to set the RF0_REG1A_PA_PWR_PA_PWR_BYTE field of register RF0_REG1A.

13.5.8 BLE_Set_RxStatusCallback**Prototype:**

```
void App_RxStatus_Callback(uint8_t *actidx, uint16_t *status, uint8_t *rssi, uint8_t *chnl, uint16_t *length)
```

Parameters:

- *actidx
- *status
- *rssi
- *chnl
- *length

Return:

The returned RSSI is a raw RSSI register read value and needs to be converted to dBm.

Description:

This API can register an application callback function, so that whenever a packet is received, the Bluetooth Low Energy stack calls that callback function and returns the listed parameters as arguments of that function.

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Examples:

```

/* registering a callback function any time in application after Bluetooth Low Energy
initialization */

BLE_Set_RxStatusCallBack(App_RxStatus_Callback);

/*callback function:*/

void App_RxStatus_Callback(uint8_t *actidx, uint16_t *status, uint8_t *rssi, uint8_t
*chnl, uint16_t *length)
{
    int8_t calculated_rssi = ((0.328 * (*rssi)) - 108);

    if(*status == 0)
    {
        swmTrace_printf("\n\r actidx = %d, status = %d, rssi = %d, chnl= %d, length =
%d", *actidx, *status, calculated_rssi, *chnl, *length);    }
    }

/* When this functionality is required another API needs to be called before BLE_
Initialize() is called, as shown below: */

BLE_Set_RFOffSeqMode(1);
uint8_t param_ptr;

BLE_Initialize(&param_ptr);

```

This information is only valid if the status of the received packet is zero (no error). The callback function does not consume a great deal of processing time, as it is called in the Bluetooth Low Energy RX ISR.

A rough estimation formula can be used as shown below, but in general the RSSI needs to be calibrated to take into account sample-to-sample variation, and channel variation that depends on PCB, XTAL48 trimming, and antenna/matching circuit design. Changes in temperature can also cause variation.

13.5.9 Device_RF_SetMaxPwrIdx**Prototype:**

```
uint8_t Device_RF_SetMaxPwrIdx(void)
```

This API/callback function is called by the Bluetooth Low Energy stack to set a maximum power index, which is later used for non-advertisement activities powered by TX output.

The return value is based on the format that function `Device_RF_TxPwr_Get_Idx(desired dBm value)` returns.

Setting `adv_param.max_tx_pwr` to any value between -127 and 126 causes the stack to call `Device_RF_TxPwr_Get_Idx()`, and the return index to this function determines the actual ADV TX power.

However, for connections, scan response, and initiating activities, the stack uses the value that is provided in advance by the application during the stack initialization when `Device_RF_SetMaxPwrIdx()` is called.

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Thus, applications can control ADV TX powers through `adv_param.max_tx_pwr`, and output power levels for connections are controlled by `Device_RF_SetMaxPwrIdx()`.

13.5.10 BLE_Set_ScanConIndStatusCallBack

Prototype:

```
BLE_Set_ScanConIndStatusCallBack(App_ScanConIndStatus_Callback);
```

Parameters:

none

Return:

The returned RSSI is a raw RSSI register read value and needs to be converted to dBm.

Description:

Through this function, it is possible to register an application callback function to access the channel number and RSSI for any successfully received scan request and connection indication. It requires that `BLE_Set_RFOffSeqMode(1)` be called in advance.

Example:

```
BLE_Set_ScanConIndStatusCallBack(App_ScanConIndStatus_Callback);

void App_ScanConIndStatus_Callback(uint8_t *type, uint8_t *rssi, uint8_t *chnl)
{
    int8_t calculated_rssi = ((0.328 * (*rssi)) - 108);
    if(*type == BLE_SCAN_REQ)
    {
        swmTrace_printf("\n\r SCAN_REQ, rssi = %d, chnl= %d", calculated_rssi,
*chnl);
    }
    else if(*type == BLE_CONNECT_IND)
    {
        swmTrace_printf("\n\r CONNECT_IND, rssi = %d, chnl= %d", calculated_rssi,
*chnl);
    }
}
```

13.5.11 Hci_Vs_Cmd_App_Func

Prototype:

```
uint8_t Hci_Vs_Cmd_App_Func(uint8_t cmd_code,
uint8_t length, uint8_t *data_buf,
uint8_t *result_length, uint8_t *result_data)
```

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Parameters:

- cmd_code
- length
- *data_buf
- *result_length
- *result_data

Return:

Status.

Description:

When running an hci application that uses the HCI variant of the Bluetooth Low Energy stack to support HCI commands over UART, `HCI_DBG_VS_APP_CMD_OPCODE` needs to be implemented in the application. This allows users to develop any desired vendor-specific command. The format of the message is handled by the stack, and the application needs to have a function implemented such that it can interpret the command code, input parameters length, and data, and sends a response with the status, length and data. Some of the command codes are used by RF tools, so users can add unused command codes.

Example:

```
uint8_t Hci_Vs_Cmd_App_Func(uint8_t cmd_code,
uint8_t length, uint8_t *data_buf,
uint8_t *result_length, uint8_t *result_data)
{
uint8_t status = CO_ERROR_NO_ERROR;
*result_length = 0;
uint16_t freq_Mhz;
int8_t pwr_dBm, txOrRx; /* 0: Tx, 1:Tx */

switch(cmd_code)
{ case HCI_VS_RF_CW_ENABLE_CMD_CODE: txOrRx = data_buf[0]; freq_Mhz = (data_buf[1] +
(data_buf[2] << 8)); //TODO break;
case HCI_VS_RF_CW_DISABLE_CMD_CODE: //TODO break; case HCI_VS_RF_OUTPUT_PWR_CMD_CODE:
pwr_dBm =
(int8_t)data_buf[0]; //TODO To be replace with HAL RF set output power function break;
default: status =
CO_ERROR_INVALID_HCI_PARAM; break; }

return(status);
}
```

The above commands are implemented and can be found in the *hci* sample code.

13.5.12 BLE_Set_MaxRFConnectionPwr**Prototype:**

```
void BLE_Set_MaxRFConnectionPwr(void)
```

Parameters:

None

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Return:

None

Description:

This API can be used by an application to set the maximum RF transmission output power for Bluetooth Low Energy connections. It must be invoked before a connection is established (RF transmission power cannot be changed during a connection and therefore calling this API during a connection does not change the power). This API calls `Device_RF_SetMaxPwrIdx()`, where it uses the `rf_tx_power_dbm` field of the `ble_dev_params` data structure; therefore, this `rf_tx_power_dbm` field must be set to the desired output power (dBm value) in advance by the application before a new connection is made.

NOTE: Setting the VDDPA Enable or Disable configuration is the application's responsibility. The effect that the `RF0_REG1A_PA_PWR_PA_PWR_BYTE` field of the `RF0_REG1A` register has on output power is this API's responsibility.

Example:

```
/* Before a new Bluetooth Low Energy connection is established */

/* Set RF TX power to -5 dBm */
ble_dev_params.rf_tx_power_dbm = -5;
BLE_Set_MaxRFConnectionPwr();
```

13.5.13 uint32_t ke_get_max_mem_usage**Prototype:**

```
uint32_t ke_get_max_mem_usage(void)
```

Parameters:

None

Return:

Maximum memory used by the Bluetooth stack in the application

Description:

The maximum memory that the Bluetooth stack has used in the application at any time can be returned using this API.

Example:

```
/* Get the Maximum memory used by the Bluetooth stack in the application */
uint32_t max_mem_usage_stack = ke_get_max_mem_usage();
```

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13.5.14 uint16_t ke_get_mem_usage

Prototype:

```
uint32_t ke_get_max_mem_usage(void)
```

Parameters:

type : Kernel memory heap type which can be set using one of the following arguments

- KE_MEM_ENV: Memory allocated for environment variables
- KE_MEM_ATT_DB: Memory allocated for Attribute database
- KE_MEM_KE_MSG: Memory allocated for kernel messages
- KE_MEM_NON_RETENTION: Non-retention memory block

Return:

The amount of memory allocated for the specified Bluetooth stack heap type at the time of calling this API

Description:

The amount of memory that is allocated for the Bluetooth stack heap type of environment variables, attribute database, kernel messages, or non-retention memory block can be returned using this API.

Example:

```
/* Memory heap allocated for environment variables */
uint32_t mem_env = ke_get_mem_usage(KE_MEM_ENV);
/* Memory heap allocated for Attribute database */
uint32_t mem_env = ke_get_mem_usage(KE_MEM_ATT_DB);
/* Memory heap allocated for kernel messages*/
uint32_t mem_env = ke_get_mem_usage(KE_MEM_KE_MSG);
/* Memory heap allocated for non-retention memory block */
uint32_t mem_env = ke_get_mem_usage(KE_MEM_NON_RETENTION);
```

13.6 BLUETOOTH LOW ENERGY ABSTRACTION

The Bluetooth Low Energy abstraction is a wrapper for the Bluetooth APIs provided by CEVA for the RSL15 device. This provides a simplified API to access the Bluetooth components, which can be included through the *ble_abstraction.h* header. Component wrappers include:

Generic Access Profile (GAP)

This profile defines the generic procedures related to discovery of Bluetooth devices (idle mode procedures), link management aspects of connecting to Bluetooth devices (connection mode procedures), and management of security procedures.

As defined in *ble_gap.h* / *ble_gap.c*, this portion of the Bluetooth abstraction API extends the GAP support described in *RW-BLE-GAP-IS.pdf*.

Generic Attribute Profile (GATT)

This profile provides a service framework using the Bluetooth attribute protocol for discovering services, and for reading and writing characteristic values on a peer device.

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As defined in *ble_gatt.h / ble_gatt.c*, this portion of the Bluetooth abstraction API extends the GATT support described in *RW-BLE-GATT-IS.pdf*.

Protocol Support

As defined in *ble_protocol_support.h / ble_protocol_support.c*, this portion of the Bluetooth abstraction API provides access to support components that are used with the Bluetooth stack. This includes:

- The Bluetooth address
- The RF front-end transmit power configuration and received signal strength indication (RSSI)
- Bluetooth parameters
- Random number generation

Bondlist

Support for managing bonding information used by the Bluetooth GAP interface. This includes storage and access to the device addresses and privacy-related identity resolving keys (IRKs) for any devices bonded to this RSL15 device.

This support is defined in *bondlist.h / bondlist.c*, and is used with the Bluetooth GAP support.

Message Handler

This block extends the event kernel message handling, described in [Section 11.2 “Messages” on page 91](#). The Bluetooth abstraction API for this support is defined in *msg_handler.h / msg_handler.c*.

The Bluetooth Low Energy abstraction is configured by adding the `ble_abstraction` to an application using the *RTE_Device.h* file, as described in [Section 1.1 “Configuring The Driver Run-time Environment” on page 1](#).

CHAPTER 14

swmTrace Library

The swmTrace library is a complement to the RTT Viewer plugin described in the Diagnostic Strategies chapter of the *RSL15 Developer's Guide*. The swmTrace library is a logging utility, intended to provide debugging capabilities through an application running on the Arm Cortex-M33 core. When using the swmTrace library's functions with the RTT viewer, the logging information shown by the RTT Viewer is color-coded, based on the level of logging used and the particular function calls to the swmTrace library.

14.1 INTRODUCTION

Although this library's expected primary use case is with the SEGGER RTT technology through the SDK's RTT Viewer, you can also use the library with UART simply by linking to a different library variant. There are four library variants that can be selected between without changing the underlying code:

- RTT variants include both blocking and non-blocking debug.
- UART variants include support for DMA and user defined pins for UART, TX and RX, where both variants are non-blocking.

NOTE: The TX circular buffer used for UART printing has a 512-character limit. If more characters are queued up before the buffer is flushed, the characters exceeding the buffer limit are dropped.

14.2 ONSEMI IDE SETUP

In the onsemi IDE, the swmTrace Library requires that you set at least one of the following configurations in **Properties > C/C++ Build > Settings > Cross ARM C Linker > Miscellaneous**:

- Check the **newlib-nano** checkbox to enable newlib-nano.
- Check the **Do not use syscalls** checkbox.
- In the text-box labelled **Other linker flags**, enter `-specs=rdimon.specs`

We strongly recommend that you set up the first configuration enabling newlib-nano, regardless of whether you set the other two. newlib-nano is enabled by default in all RSL15 sample projects. Enabling newlib-nano in the onsemi IDE also minimizes the flash and RAM requirements of applications.

14.3 USAGE

Various levels of logging are available. See *swmTrace_api.h* for full details, but examples include `SWM_LOG_LEVEL_VERBOSE` and `SWM_LOG_TEST_PASS`. All levels of logging use the `SWM_LOG_` prefix.

Sample applications are available specifically to illustrate the usage of the swmTrace library. See *swmTrace_logger* under the sample application folder. Other sample applications also make use of the swmTrace library.

CHAPTER 15

CMSIS Reference

Hardware register abstraction layer for the SOC.

15.1 SUMMARY

Variables

- [RSL15_Sys_Version](#) : RSL15 firmware version (variable)
- [Heap_Begin](#) : Start location for the heap.
- [Heap_Limit](#) : Top limit for the heap.
- [stack_limit](#) : Bottom limit for the stack.
- [stack](#) : Start location for the stack.
- [data_init](#) : Pointer to the data to used to initialize volatile memory.
- [data_start](#) : Start address of the initialized data area in volatile memory.
- [data_end](#) : End address of the initialized data area in volatile memory.
- [bss_start](#) : Start address of the cleared data area in volatile memory.
- [bss_end](#) : End address of the cleared data area in volatile memory.
- [preinit_array_start](#) : Weakly defined function list pointer for pre-initialization functions.
- [preinit_array_end](#) : Weakly defined pointer to the end of the pre-initialization function list.
- [init_array_start](#) : Weakly defined function list pointer for initialization functions.
- [init_array_end](#) : Weakly defined pointer to the end of the initialization function list.
- [flash_layout](#) : Flash layout for the RSL15 device.
- [SystemCoreClock](#) : Contains the current SYS_CLK frequency, in Hz.

Data Structures

- [flash_region](#) : Structure used to define flash regions.

Macros

- [RSL15_SYS_VER_MAJOR](#) : RSL15 header file major version.
- [RSL15_SYS_VER_MINOR](#) : RSL15 header file minor version.
- [RSL15_SYS_VER_REVISION](#) : RSL15 header file revision version.
- [RSL15_SYS_VER](#) : RSL15 firmware version.
- [ARMv8MML_REV](#) : Arm v8 architecture revision.
- [CM33_REV](#) : Core revision r0p4.
- [FPU_PRESENT](#) : FPU present.
- [DSP_PRESENT](#) : DSP extension present.
- [SAUREGION_PRESENT](#) : SAU regions present.
- [MPU_PRESENT](#) : MPU present.
- [VTOR_PRESENT](#) : VTOR present.
- [NVIC_PRIO_BITS](#) : 3 bits used for interrupt priority levels
- [Vendor_SysTickConfig](#) : Standard SysTick configuration is used.
- [I2C_REF_VALID](#) : Validation of I2C register block pointer reference for assert statements.

RSL15 Firmware Reference

- [LIN_REF_VALID](#) : Validation of LIN register block pointer reference for assert statements.
- [PCM_REF_VALID](#) : Validation of PCM register block pointer reference for assert statements.
- [PWM_REF_VALID](#) : Validation of PWM register block pointer reference for assert statements.
- [SPI_REF_VALID](#) : Validation of SPI register block pointer reference for assert statements.
- [UART_REF_VALID](#) : Validation of UART register block pointer reference for assert statements.
- [TIMER_REF_VALID](#) : Validation of TIMER register block pointer reference for assert statements.
- [DMA_REF_VALID](#) : Validation of DMA register block pointer reference for assert statements.
- [FLASH_REF_VALID](#) : Validation of FLASH register block pointer reference for assert statements.
- [GPIO_PAD_COUNT](#) : GPIO peripheral definitions.
- [GPIO_GROUP_LOW_PAD_RANGE](#) : Number of GPIO pads in the lowest group (all)
- [GPIO_EVENT_CHANNEL_COUNT](#) : Number of available GPIO interrupts.
- [GPIO0](#) : GPIO pads definitions
- [GPIO1](#) : GPIO 1.
- [GPIO2](#) : GPIO 2.
- [GPIO3](#) : GPIO 3.
- [GPIO4](#) : GPIO 4.
- [GPIO5](#) : GPIO 5.
- [GPIO6](#) : GPIO 6.
- [GPIO7](#) : GPIO 7.
- [GPIO8](#) : GPIO 8.
- [GPIO9](#) : GPIO 9.
- [GPIO10](#) : GPIO 10.
- [GPIO11](#) : GPIO 11.
- [GPIO12](#) : GPIO 12.
- [GPIO13](#) : GPIO 13.
- [GPIO14](#) : GPIO 14.
- [GPIO15](#) : GPIO 15.
- [SYS_DUMMY_READ](#) : Register that always reads back as 0x00000000.
- [SYS_DUMMY_WRITE](#) : Register to which writes are ineffective.
- [ERRNO_NO_ERROR](#) : No error.
- [ERRNO_GENERAL_FAILURE](#) : General error.
- [DEFAULT_FREQ](#) : High speed main RC oscillator default frequency set by boot ROM application Default value is 3 MHz uncalibrated.
- [STANDBYCLK_DEFAULT_FREQ](#) : Low speed standby RC oscillator default frequency.
- [RFCLK_BASE_FREQ](#) : Frequency of the 48 MHz crystal used for the RF front-end.
- [EXTCLK_MAX_FREQ](#) : Maximum frequency supported by using an external clock.
- [SWCLK_MAX_FREQ](#) : Maximum frequency supported by the SWJ-DP interface.
- [RCOSC_MAX_FREQ](#) : Maximum frequency supported by the internal RC oscillator.

Functions

- [_start](#) : Initialize the application data and start execution with main.
- [_sbrk](#) : Increment (or decrement) the top of the heap.
- [SystemInit](#) : Initializes the system by clearing and disabling interrupts, updating the SystemCoreClock variable and updating flash timing registers based on the read SYS_CLK.
- [SystemCoreClockUpdate](#) : Reads system registers to determine the current system clock frequency, update the SystemCoreClock variable and update the flash timing registers accordingly.

15.2 CMSIS REFERENCE VARIABLE DOCUMENTATION

15.2.1 RSL15_Sys_Version

```
const short RSL15_Sys_Version
```

Location: rsl15.h:58

RSL15 firmware version (variable)

15.2.2 __Heap_Begin__

```
uint8_t __Heap_Begin__
```

Location: rsl15_start.h:42

Start location for the heap.

15.2.3 __Heap_Limit__

```
uint8_t __Heap_Limit__
```

Location: rsl15_start.h:43

Top limit for the heap.

15.2.4 __stack_limit

```
uint32_t __stack_limit
```

Location: rsl15_start.h:48

Bottom limit for the stack.

15.2.5 __stack

```
uint32_t __stack
```

Location: rsl15_start.h:49

Start location for the stack.

15.2.6 `__data_init__`

```
uint32_t __data_init__
```

Location: `rsl15_start.h:54`

Pointer to the data to used to initialize volatile memory.

15.2.7 `__data_start__`

```
uint32_t __data_start__
```

Location: `rsl15_start.h:55`

Start address of the initialized data area in volatile memory.

15.2.8 `__data_end__`

```
uint32_t __data_end__
```

Location: `rsl15_start.h:56`

End address of the initialized data area in volatile memory.

15.2.9 `__bss_start__`

```
uint32_t __bss_start__
```

Location: `rsl15_start.h:58`

Start address of the cleared data area in volatile memory.

15.2.10 `__bss_end__`

```
uint32_t __bss_end__
```

Location: rsl15_start.h:59

End address of the cleared data area in volatile memory.

15.2.11 `__preinit_array_start__`

```
void(* __preinit_array_start__[]) (void)
```

Location: rsl15_start.h:65

Weakly defined function list pointer for pre-initialization functions.

15.2.12 `__preinit_array_end__`

```
void(* __preinit_array_end__[]) (void)
```

Location: rsl15_start.h:68

Weakly defined pointer to the end of the pre-initialization function list.

15.2.13 `__init_array_start__`

```
void(* __init_array_start__[]) (void)
```

Location: rsl15_start.h:71

Weakly defined function list pointer for initialization functions.

15.2.14 `__init_array_end__`

```
void(* __init_array_end__[]) (void)
```

Location: rsl15_start.h:74

Weakly defined pointer to the end of the initialization function list.

15.2.15 flash_layout

```
const struct flash_region flash_layout[] =
{
    {
        .start = FLASH0_CODE_BASE,
        .end = FLASH0_CODE_TOP,
        .flash = FLASH,
        .IRQn = FLASH0_COPY_IRQn,
    },
    {
        .start = FLASH0_DATA_BASE,
        .end = FLASH0_DATA_TOP,
        .flash = FLASH,
        .IRQn = FLASH0_COPY_IRQn,
    },
}
```

Location: rsl15_start.h:104

Flash layout for the RSL15 device.

15.2.16 SystemCoreClock

```
uint32_t SystemCoreClock
```

Location: system_rsl15.h:74

Contains the current SYS_CLK frequency, in Hz.

15.3 CMSIS REFERENCE DATA STRUCTURES TYPE DOCUMENTATION

15.3.1 flash_region

Location: rsl15_start.h:110

Structure used to define flash regions.

Data Fields

RSL15 Firmware Reference

Type	Name	Description
uint32_t	<i>start</i>	First address in the flash region.
uint32_t	<i>end</i>	Last address in the flash region.
FLASH_Type *	<i>flash</i>	Flash interface for this region.
uint32_t	<i>IRQn</i>	Interrupt supporting this flash region.

15.4 CMSIS REFERENCE MACRO DEFINITION DOCUMENTATION

15.4.1 RSL15_SYS_VER_MAJOR

```
#define RSL15_SYS_VER_MAJOR 0x01
```

RSL15 header file major version.

Location: rsl15.h:44

15.4.2 RSL15_SYS_VER_MINOR

```
#define RSL15_SYS_VER_MINOR 0x00
```

RSL15 header file minor version.

Location: rsl15.h:47

15.4.3 RSL15_SYS_VER_REVISION

```
#define RSL15_SYS_VER_REVISION 0x01
```

RSL15 header file revision version.

Location: rsl15.h:50

15.4.4 RSL15_SYS_VER

```
#define RSL15_SYS_VER ((RSL15\_SYS\_VER\_MAJOR << 12) | \
                      (RSL15\_SYS\_VER\_MINOR << 8) | \
                      (RSL15\_SYS\_VER\_REVISION))
```

RSL15 Firmware Reference

RSL15 firmware version.

Location: rsl15.h:53

15.4.5 __ARMv8MML_REV

```
#define __ARMv8MML_REV 0x0000U
```

Arm v8 architecture revision.

Location: rsl15.h:100

15.4.6 __CM33_REV

```
#define __CM33_REV 0x0000U
```

Core revision r0p4.

Location: rsl15.h:101

15.4.7 __FPU_PRESENT

```
#define __FPU_PRESENT 1U
```

FPU present.

Location: rsl15.h:102

15.4.8 __DSP_PRESENT

```
#define __DSP_PRESENT 1U
```

DSP extension present.

Location: rsl15.h:103

15.4.9 __SAUREGION_PRESENT

```
#define __SAUREGION_PRESENT 1U
```

SAU regions present.

Location: rsl15.h:104

15.4.10 __MPU_PRESENT

```
#define __MPU_PRESENT 1U
```

MPU present.

Location: rsl15.h:105

15.4.11 __VTOR_PRESENT

```
#define __VTOR_PRESENT 1U
```

VTOR present.

Location: rsl15.h:106

15.4.12 __NVIC_PRIO_BITS

```
#define __NVIC_PRIO_BITS 3U
```

3 bits used for interrupt priority levels

Location: rsl15.h:107

15.4.13 __Vendor_SysTickConfig

```
#define __Vendor_SysTickConfig 0U
```

Standard SysTick configuration is used.

Location: rsl15.h:108

RSL15 Firmware Reference

15.4.14 I2C_REF_VALID

```
#define I2C_REF_VALID (((uint32_t)(ref) == (uint32_t)I2C) | \  
                      ((uint32_t)(ref) == (uint32_t)I2C0) | \  
                      ((uint32_t)(ref) == (uint32_t)I2C1))
```

Validation of I2C register block pointer reference for assert statements.

Location: rsl15.h:165

15.4.15 LIN_REF_VALID

```
#define LIN_REF_VALID (((uint32_t)(ref) == (uint32_t)LIN) | \  
                      ((uint32_t)(ref) == (uint32_t)LIN0))
```

Validation of LIN register block pointer reference for assert statements.

Location: rsl15.h:170

15.4.16 PCM_REF_VALID

```
#define PCM_REF_VALID (((uint32_t)(ref) == (uint32_t)PCM) | \  
                      ((uint32_t)(ref) == (uint32_t)PCM0))
```

Validation of PCM register block pointer reference for assert statements.

Location: rsl15.h:174

15.4.17 PWM_REF_VALID

```
#define PWM_REF_VALID (((uint32_t)(ref) == (uint32_t)PWM) | \  
                      ((uint32_t)(ref) == (uint32_t)PWM0))
```

Validation of PWM register block pointer reference for assert statements.

Location: rsl15.h:178

RSL15 Firmware Reference

15.4.18 SPI_REF_VALID

```
#define SPI_REF_VALID (((uint32_t)(ref) == (uint32_t)SPI) | \
                      ((uint32_t)(ref) == (uint32_t)SPI0) | \
                      ((uint32_t)(ref) == (uint32_t)SPI1))
```

Validation of SPI register block pointer reference for assert statements.

Location: rsl15.h:182

15.4.19 UART_REF_VALID

```
#define UART_REF_VALID (((uint32_t)(ref) == (uint32_t)UART) | \
                       ((uint32_t)(ref) == (uint32_t)UART0))
```

Validation of UART register block pointer reference for assert statements.

Location: rsl15.h:187

15.4.20 TIMER_REF_VALID

```
#define TIMER_REF_VALID (((uint32_t)(ref) == (uint32_t)TIMER) | \
                        ((uint32_t)(ref) == (uint32_t)TIMER0) | \
                        ((uint32_t)(ref) == (uint32_t)TIMER1) | \
                        ((uint32_t)(ref) == (uint32_t)TIMER2) | \
                        ((uint32_t)(ref) == (uint32_t)TIMER3))
```

Validation of TIMER register block pointer reference for assert statements.

Location: rsl15.h:191

15.4.21 DMA_REF_VALID

```
#define DMA_REF_VALID (((uint32_t)(ref) == (uint32_t)DMA) | \
                      ((uint32_t)(ref) == (uint32_t)DMA0) | \
                      ((uint32_t)(ref) == (uint32_t)DMA1) | \
                      ((uint32_t)(ref) == (uint32_t)DMA2) | \
                      ((uint32_t)(ref) == (uint32_t)DMA3))
```

Validation of DMA register block pointer reference for assert statements.

Location: rsl15.h:198

15.4.22 FLASH_REF_VALID

```
#define FLASH_REF_VALID (((uint32_t)(ref) == (uint32_t)FLASH) | \  
                        ((uint32_t)(ref) == (uint32_t)FLASH0))
```

Validation of FLASH register block pointer reference for assert statements.

Location: rsl15.h:205

15.4.23 GPIO_PAD_COUNT

```
#define GPIO_PAD_COUNT 16
```

GPIO peripheral definitions.

Maximum number of GPIO pads

Location: rsl15.h:218

15.4.24 GPIO_GROUP_LOW_PAD_RANGE

```
#define GPIO_GROUP_LOW_PAD_RANGE 16
```

Number of GPIO pads in the lowest group (all)

Location: rsl15.h:219

15.4.25 GPIO_EVENT_CHANNEL_COUNT

```
#define GPIO_EVENT_CHANNEL_COUNT 4
```

Number of available GPIO interrupts.

Location: rsl15.h:220

15.4.26 GPIO0

```
#define GPIO0 0
```

GPIO pads definitions

GPIO 0

Location: rsl15.h:223

15.4.27 GPIO1

```
#define GPIO1 1
```

GPIO 1.

Location: rsl15.h:224

15.4.28 GPIO2

```
#define GPIO2 2
```

GPIO 2.

Location: rsl15.h:225

15.4.29 GPIO3

```
#define GPIO3 3
```

GPIO 3.

Location: rsl15.h:226

15.4.30 GPIO4

```
#define GPIO4 4
```

GPIO 4.

Location: rsl15.h:227

15.4.31 GPIO5

```
#define GPIO5 5
```

GPIO 5.

Location: rsl15.h:228

15.4.32 GPIO6

```
#define GPIO6 6
```

GPIO 6.

Location: rsl15.h:229

15.4.33 GPIO7

```
#define GPIO7 7
```

GPIO 7.

Location: rsl15.h:230

15.4.34 GPIO8

```
#define GPIO8 8
```

GPIO 8.

Location: rsl15.h:231

15.4.35 GPIO9

```
#define GPIO9 9
```

GPIO 9.

Location: rsl15.h:232

15.4.36 GPIO10

```
#define GPIO10 10
```

GPIO 10.

Location: rsl15.h:233

15.4.37 GPIO11

```
#define GPIO11 11
```

GPIO 11.

Location: rsl15.h:234

15.4.38 GPIO12

```
#define GPIO12 12
```

GPIO 12.

Location: rsl15.h:235

15.4.39 GPIO13

```
#define GPIO13 13
```

GPIO 13.

Location: rsl15.h:236

15.4.40 GPIO14

```
#define GPIO14 14
```

GPIO 14.

Location: rsl15.h:237

15.4.41 GPIO15

```
#define GPIO15 15
```

GPIO 15.

Location: rsl15.h:238

15.4.42 SYS_DUMMY_READ

```
#define SYS_DUMMY_READ SYSCTRL->PROD_STATUS
```

Register that always reads back as 0x00000000.

Location: rsl15.h:251

15.4.43 SYS_DUMMY_WRITE

```
#define SYS_DUMMY_WRITE SYSCTRL->CC_DCU_EN0
```

Register to which writes are ineffective.

Location: rsl15.h:254

15.4.44 ERRNO_NO_ERROR

```
#define ERRNO_NO_ERROR 0x0000
```

No error.

Location: rsl15.h:312

15.4.45 ERRNO_GENERAL_FAILURE

```
#define ERRNO_GENERAL_FAILURE 0x0001
```

General error.

Location: rsl15.h:315

15.4.46 DEFAULT_FREQ

```
#define DEFAULT_FREQ 5000000
```

High speed main RC oscillator default frequency set by boot ROM application Default value is 3 MHz uncalibrated.

Assuming a worse case of 5 MHz

Location: system_rsl15.h:56

15.4.47 STANDBYCLK_DEFAULT_FREQ

```
#define STANDBYCLK_DEFAULT_FREQ 32768
```

Low speed standby RC oscillator default frequency.

Location: system_rsl15.h:59

15.4.48 RFCLK_BASE_FREQ

```
#define RFCLK_BASE_FREQ 48000000
```

Frequency of the 48 MHz crystal used for the RF front-end.

Location: system_rsl15.h:62

RSL15 Firmware Reference**15.4.49 EXTCLK_MAX_FREQ**

```
#define EXTCLK_MAX_FREQ 48000000
```

Maximum frequency supported by using an external clock.

Location: system_rsl15.h:65

15.4.50 SWCLK_MAX_FREQ

```
#define SWCLK_MAX_FREQ 48000000
```

Maximum frequency supported by the SWJ-DP interface.

Location: system_rsl15.h:68

15.4.51 RCOSC_MAX_FREQ

```
#define RCOSC_MAX_FREQ 12000000
```

Maximum frequency supported by the internal RC oscillator.

Location: system_rsl15.h:71

15.5 CMSIS REFERENCE FUNCTION DOCUMENTATION**15.5.1 _start**

```
void _start()
```

Initialize the application data and start execution with main.

Should be called from the reset vector.

Location: rsl15_start.h:91

Return

None

Assumptions

The symbols **data_init**, **data_start**, **data_end**, **bss_start**, **bss_end**, and **stack_limit** are defined when the application is linked.

Assumptions

The symbol **flash_layout** exists, and is an array of structures containing the start, end, and FLASH_Type* of all the banks of flash, in ascending memory address order, that the data region could be present in.

Example Code for _start

```
// Initialize static application data
_start();
```

15.5.2 _sbrk

```
int8_t * _sbrk(int increment)
```

Increment (or decrement) the top of the heap.

Location: rsl15_start.h:104

Parameters

Direction	Name	Description
in	<i>increment</i>	Increment to be applied to the top of the heap

Return

RSL15 Firmware Reference

The prior value of the heap top (points to the base of the newly allocated data if the heap was incremented); returns -1 if the function was unable to allocate the requested memory

Assumptions

The symbols **Heap_Begin**, **Heap_Limit** are defined when the application is linked.

Example Code for `_sbrk`

```
// Initialize the heap with no increment
_sbrk(0);
```

15.5.3 SystemInit

```
void SystemInit()
```

Initializes the system by clearing and disabling interrupts, updating the SystemCoreClock variable and updating flash timing registers based on the read SYS_CLK.

Location: system_rsl15.h:48

Example Code for SystemInit

```
// Setup the system core clock variable
SystemInit();
```

15.5.4 SystemCoreClockUpdate

```
void SystemCoreClockUpdate()
```

Reads system registers to determine the current system clock frequency, update the SystemCoreClock variable and update the flash timing registers accordingly.

Location: system_rsl15.h:82

Example Code for SystemCoreClockUpdate

```
// Update the declared system clock (SYSCLK) frequency  
// used by the Arm Cortex-M3 firmware  
SystemCoreClockUpdate();
```

CHAPTER 16

Hardware Abstraction Layer Reference

Simple hardware abstraction layer library reference.

16.1 SUMMARY

16.2 ACTIVITY COUNTER

Activity counter hardware abstraction layer.

16.2.1 Summary

Functions

- [Sys_ACNT_Start](#) : Start activity counter.
- [Sys_ACNT_Stop](#) : Stop activity counter.
- [Sys_ACNT_Clear](#) : Clear activity counter values.

16.2.2 Activity Counter Function Documentation

16.2.2.1 Sys_ACNT_Start

```
void Sys_ACNT_Start()
```

Start activity counter.

Location: acnt.h:42

Example Code for Sys_ACNT_Start

```
// Start the activity counter  
Sys\_ACNT\_Start();
```

16.2.2.2 Sys_ACNT_Stop

```
void Sys_ACNT_Stop()
```

Stop activity counter.

Location: acnt.h:52

Example Code for Sys_ACNT_Stop

```
// Stop the activity counter  
Sys\_ACNT\_Stop\(\);
```

16.2.2.3 Sys_ACNT_Clear

```
void Sys_ACNT_Clear()
```

Clear activity counter values.

Location: acnt.h:62

Example Code for Sys_ACNT_Clear

```
// Clear the current counter value in the activity counters.  
Sys\_ACNT\_Clear\(\);
```

16.3 ANALOG CONTROL SYSTEM

Analog Control System hardware abstraction layer.

16.3.1 Summary

Functions

- [Sys_ACS_WriteRegister](#) : Safely write an ACS register, without corrupting the RTC counts.

16.3.2 Analog Control System Function Documentation

RSL15 Firmware Reference

16.3.2.1 Sys_ACS_WriteRegister

```
void Sys_ACS_WriteRegister(volatile uint32_t * p_register, uint32_t value)
```

Safely write an ACS register, without corrupting the RTC counts.

Location: acs.h:45

Parameters

Direction	Name	Description
in	<i>p_register</i>	Address of the register to write.
in	<i>value</i>	Value to be written to the register.

Example Code for Sys_ACS_WriteRegister

```
// Disable the buck converter
Sys_ACS_WriteRegister(&ACS->VCC_CTRL,
    ((ACS->VCC_CTRL & ~VCC_BUCK) | VCC_LDO));
```

16.4 ASYNCHRONOUS CLOCK COUNTER

Asynchronous Clock Counter (ASCC) hardware abstraction layer.

16.4.1 Summary**Functions**

- [Sys_ASCC_GPIOConfig](#) : Configure the sync pulse and asynchronous clock sources.
- [Sys_ASCC_Config](#) : Configure the asynchronous clock counter and set initial phase and period count values.
- [Sys_ASCC_StartCounters](#) : Reset the counter, and start the phase and period counter mechanisms.

16.4.2 Asynchronous Clock Counter Function Documentation**16.4.2.1 Sys_ASCC_GPIOConfig**

```
void Sys_ASCC_GPIOConfig(uint32_t cfg, uint32_t sync, uint32_t async)
```

RSL15 Firmware Reference

Configure the sync pulse and asynchronous clock sources.

Location: ascc.h:48

Parameters

Direction	Name	Description
in	<i>cfg</i>	GPIO pin configuration for the ASCC pads
in	<i>sync</i>	GPIO pad input for the synchronization pulse
in	<i>async</i>	GPIO pad input for the asynchronous clock source

Example Code for Sys_ASCC_GPIOConfig

```
// Configure GPIO pads to connect to the asynchronous clock counter
Sys_ASCC_GPIOConfig(GPIO_MODE_INPUT | GPIO_WEAK_PULL_UP, GPIO0, GPIO1);
```

16.4.2.2 Sys_ASCC_Config

```
void Sys_ASCC_Config(ASCC_Type * ascc, uint32_t cfg, uint32_t phasecnt, uint32_t
periodcnt)
```

Configure the asynchronous clock counter and set initial phase and period count values.

Location: ascc.h:69

Parameters

Direction	Name	Description
in	<i>ascc</i>	Pointer to the asynchronous clock counter instance
in	<i>cfg</i>	The number of clock periods the period counter measures; use ASCC_PERIODS_*
in	<i>phasecnt</i>	The clock phase counter initial value
in	<i>periodcnt</i>	The clock period counter initial value

Example Code for Sys_ASCC_Config

```
// Configure the ASCC to measure 16 periods
// Set the initial count of the phase and period counts to 0
Sys_ASCC_Config(ASCC, ASCC_PERIODS_16, 0, 0);
```

16.4.2.3 Sys_ASCC_StartCounters

```
void Sys_ASCC_StartCounters(ASCC_Type * ascc)
```

Reset the counter, and start the phase and period counter mechanisms.

Location: ascc.h:83

Parameters

Direction	Name	Description
in	<i>ascc</i>	Pointer to the asynchronous clock counter instance

Example Code for Sys_ASCC_StartCounters

```
// Reset the ASCC counters and start counting again
Sys_ASCC_StartCounters(ASCC);
```

16.5 BASEBAND INTERFACE

Baseband interface hardware abstraction layer.

16.5.1 Summary**Macros**

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- [BLE_NONE](#) : No Bluetooth Low Energy event.
- [BLE_RISING_EDGE](#) : Bluetooth Low Energy rising edge event.
- [BLE_FALLING_EDGE](#) : Bluetooth Low Energy falling edge event.
- [BLE_TRANSITION](#) : Bluetooth Low Energy transition event.

Functions

- [Sys_BBIF_CoexIntConfig](#) : Configure the coexistence interrupts to monitor for Bluetooth and other RF activity.

16.5.2 Baseband Interface Macro Definition Documentation**16.5.2.1 BLE_NONE**

```
#define BLE_NONE 0x0U
```

No Bluetooth Low Energy event.

Location: bbif.h:38

16.5.2.2 BLE_RISING_EDGE

```
#define BLE_RISING_EDGE 0x1U
```

Bluetooth Low Energy rising edge event.

Location: bbif.h:41

16.5.2.3 BLE_FALLING_EDGE

```
#define BLE_FALLING_EDGE 0x2U
```

Bluetooth Low Energy falling edge event.

Location: bbif.h:44

16.5.2.4 BLE_TRANSITION

```
#define BLE_TRANSITION 0x3U
```

Bluetooth Low Energy transition event.

Location: bbif.h:47

16.5.3 Baseband Interface Function Documentation

16.5.3.1 Sys_BBIF_CoexIntConfig

```
void Sys_BBIF_CoexIntConfig(uint32_t edge, uint32_t types, uint32_t cf_ant_delay, uint32_t cf_powerup)
```

Configure the coexistence interrupts to monitor for Bluetooth and other RF activity.

Location: bbif.h:66

Parameters

Direction	Name	Description
in	<i>edge</i>	The edge used for all coexistence interrupts; use BLE_ [NONE RISING_EDGE FALLING_EDGE TRANSITION]
in	<i>types</i>	The types of coexistence interrupts that are relevant; use BLE_RX_BUSY, BLE_TX_BUSY, BLE_IN_PROCESS, and/or EVENT_IN_PROCESS
in	<i>cf_ant_delay</i>	Correction factor to be applied to account for antenna delays; used to advance the coexistence interrupts by the specified number of uS.
in	<i>cf_powerup</i>	Correction factor to be applied to account for power-up delays on TX, RX; used to advance the coexistence interrupts by the specified number of uS.

Example Code for Sys_BBIF_CoexIntConfig

```
// Enable co-existence interrupts on BLE rising edge events and while
// receiving on the BLE communication
Sys_BBIF_CoexIntConfig(BLE_RISING_EDGE, BLE_RX_BUSY, 0, 0);
```

16.6 CLOCK CONFIGURATION

Clock configuration hardware abstraction layer.

16.6.1 Summary

Variables

- [SystemCoreClock](#) : CMSIS required system core clock variable.

Functions

- [Sys_Clocks_XTALClk_Wait](#) : Waits for the XTAL clock to start with a timeout using system clock counter.
- [Sys_Clocks_RCSystemClkConfig](#) : Configure the RC oscillator and system clock.
- [Sys_Clocks_SystemClkConfig](#) : Configure the system clock.
- [Sys_Clocks_XTALClkConfig](#) : Configure the 48 MHz XTAL Oscillator.
- [Sys_Clocks_DividerConfig](#) : Configure the clock divisors for a standard configuration:

16.6.2 Clock Configuration Variable Documentation

16.6.2.1 SystemCoreClock

```
uint32_t SystemCoreClock
```

Location: clock.h:46

CMSIS required system core clock variable.

16.6.3 Clock Configuration Function Documentation

16.6.3.1 Sys_Clocks_XTALClk_Wait

```
void Sys_Clocks_XTALClk_Wait()
```

Waits for the XTAL clock to start with a timeout using system clock counter.

Location: clock.h:49

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16.6.3.2 Sys_Clocks_RCSystemClkConfig

```
void Sys_Clocks_RCSystemClkConfig(uint32_t cfg, uint32_t rc_cfg)
```

Configure the RC oscillator and system clock.

Location: clock.h:114

Parameters

Direction	Name	Description
in	<i>cfg</i>	Configuration of the system clock source and prescale value; use SYSCLK_CLKSRC_[RCCLK STANDBYCLK RFCLK JTCK], and JTCK_PRESCALE_*
in	<i>rc_cfg</i>	Configuration for the RC oscillator

Example Code for Sys_Clocks_RCSystemClkConfig

```
// Enable RC oscillators, set 12 MHz multiplier for start RC oscillator
// Set nominal trim settings for RC oscillators
Sys_Clocks_RCSystemClkConfig(SYSCLK_CLKSRC_RCCLK, RC_OSC_12MHZ |
    RC_OSC_ENABLE |
    RC32_OSC_NOM |
    RC_OSC_NOM);
```

16.6.3.3 Sys_Clocks_SystemClkConfig

```
void Sys_Clocks_SystemClkConfig(uint32_t cfg)
```

Configure the system clock.

Location: clock.h:138

Parameters

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Direction	Name	Description
in	<i>cfg</i>	Configuration of the system clock source and prescale value; use SYSCLK_CLKSRC_[RCCLK STANDBYCLK RFCLK JTCK], and JTCK_PRESCALE_*

Assumptions

The flash delay configuration is correct for the previously selected system clock source and frequency; if also changing the RC oscillator frequency, use [Sys_Clocks_RCSystemClkConfig\(\)](#)

Example Code for Sys_Clocks_SystemClkConfig

```
// Set SYSCLK source to the RF clock.
Sys_Clocks_SystemClkConfig_Example(SYSCLK_CLKSRC_RFCLK)
```

16.6.3.4 Sys_Clocks_XTALClkConfig

```
void Sys_Clocks_XTALClkConfig(uint32_t xtal_prescaler)
```

Configure the 48 MHz XTAL Oscillator.

Location: clock.h:151

Parameters

Direction	Name	Description
in	<i>xtal_prescaler</i>	Configuration of the 48MHz XTAL Oscillator as clock and its prescale value; use CK_DIV_1_6_PRESCALE_[NO_CLOCK_BYTE 1_BYTE 2_BYTE 3_BYTE 4_BYTE 5_BYTE 6_BYTE],

Example Code for Sys_Clocks_XTALClkConfig

```
// Configure the RFCLK to 8 MHz, using the 48 MHz external crystal.
Sys_Clocks_XTALClkConfig(CK_DIV_1_6_PRESCALE_6)
```

16.6.3.5 Sys_Clocks_DividerConfig

```
void Sys_Clocks_DividerConfig(uint32_t uartclk_freq, uint32_t sensorclk_freq, uint32_t
userclk_freq)
```

Configure the clock divisors for a standard configuration:

Location: clock.h:231

Parameters

Direction	Name	Description
in	<i>uartclk_freq</i>	Target frequency for the UART clock
in	<i>sensorclk_freq</i>	Target frequency for the sensor clock
in	<i>userclk_freq</i>	Target frequency for user clock; if the target frequency exceeds the system clock frequency and the RF clock is available, USERCLK will be sourced from RF clock.

- SLOWCLK (1 MHz)
- BBCLK (8 MHz)
- DCCLK (4 MHz)
- CPCLK (166 kHz)
- UARTCLK as per *uartclk_freq*
- SENSOR_CLK as per *sensorclk_freq*
- USERCLK as per *userclk_freq*

If an exact configuration cannot be found for the desired frequency, the clock divisor will be set to ensure the divided clock does not exceed the specified target frequency.

Assumptions

The system clock has previously been configured.

Example Code for Sys_Clocks_DividerConfig

```
// Set UARTCLK to 115200 Hz
// Set SENSORCLK to 1000 Hz
// Set USERCLK to 1000000 Hz
// Set other clocks to typical values:
// SLOWCLK set to 1 MHz
// BBCLK set to 8 MHz
// DCCLK set to 4 MHz
// CPCLK set to 125 kHz
Sys_Clocks_DividerConfig(115200, 1000, 1000000)
```

16.7 ARM CORTEX-M PROCESSOR

Arm Cortex-M processor support hardware abstraction layer.

16.7.1 Summary**Macros**

- [SYS_WAIT_FOR_EVENT](#) : Wait for an event.
- [SYS_WAIT_FOR_INTERRUPT](#) : Wait for an interrupt.

16.7.2 Arm Cortex-M Processor Macro Definition Documentation**16.7.2.1 SYS_WAIT_FOR_EVENT**

```
#define SYS_WAIT_FOR_EVENT __ASM("wfe")
```

Wait for an event.

Location: cortex.h:44

Example Code for SYS_WAIT_FOR_EVENT

```
// Stop executing code, put core into low power state, waiting for an event.
SYS_WAIT_FOR_EVENT;
```

16.7.2.2 SYS_WAIT_FOR_INTERRUPT

```
#define SYS_WAIT_FOR_INTERRUPT __ASM("wfi")
```

Wait for an interrupt.

Location: cortex.h:50

Example Code for SYS_WAIT_FOR_INTERRUPT

```
// Stop executing code, put core into low power state, waiting for an
// interrupt.
SYS_WAIT_FOR_INTERRUPT;
```

16.8 CYCLIC REDUNDANCY CHECK

Cyclic Redundancy Check (CRC) hardware abstraction layer.

16.8.1 Summary**Macros**

- [SYS_CRC_CONFIG](#) : Macro wrapper for [Sys_Set_CRC_Config\(\)](#) Configure the CRC generator type, endianness of the input data, and standard vs non-standard CRC behavior.
- [SYS_CRC_32INITVALUE](#) : Macro wrapper for [Sys_CRC_32InitValue\(\)](#) Initialize CRC for CRC-32.
- [SYS_CRC_CCITTINITVALUE](#) : Macro wrapper for [Sys_CRC_CCITTInitValue\(\)](#) Initialize CRC for CRC-CCITT.
- [SYS_CRC_GETCURRENTVALUE](#) : Macro wrapper for [Sys_CRC_GetCurrentValue\(\)](#) Initialize CRC for CRC-CCITT.
- [SYS_CRC_GETFINALVALUE](#) : Macro wrapper for [Sys_CRC_GetFinalValue\(\)](#) Initialize final CRC value.
- [SYS_CRC_ADD](#) : Macro wrapper for [Sys_CRC_Add\(\)](#) Add data to the current CRC calculation, based on size.

Functions

- [Sys_Set_CRC_Config](#) : Configure the CRC generator type, endianness of the input data, and standard vs non-standard CRC behavior.
- [Sys_CRC_32InitValue](#) : Initialize CRC for CRC-32.
- [Sys_CRC_CCITTInitValue](#) : Initialize CRC for CRC-CCITT.
- [Sys_CRC_GetCurrentValue](#) : Retrieve current value from CRC.

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- [Sys_CRC_GetFinalValue](#) : Initialize final CRC value.
- [Sys_CRC_Add](#) : Add data to the current CRC calculation, based on size.

16.8.2 Cyclic Redundancy Check Macro Definition Documentation

16.8.2.1 SYS_CRC_CONFIG

```
#define SYS_CRC_CONFIG Sys\_Set\_CRC\_Config(CRC, (config))
```

Macro wrapper for [Sys_Set_CRC_Config\(\)](#) Configure the CRC generator type, endianness of the input data, and standard vs non-standard CRC behavior.

Location: crc.h:164

Parameters

Direction	Name	Description
in	<i>config</i>	CRC generator configuration; use CRC_[CCITT 32], CRC_[BIG LITTLE]_ENDIAN, CRC_BIT_ORDER_[STANDARD NON_STANDARD], CRC_FINAL_REVERSE_[STANDARD NON_STANDARD], and CRC_FINAL_XOR_[STANDARD NON_STANDARD]

Assumptions

Note that D_CRC supports only CRC_CCITT mode, hence no configuration is applied for this instance.

Example Code for SYS_CRC_CONFIG

```
// Configure the default CRC block to CRC-32 (IEEE 802.3) algorithm,
// using little endian and non-standard (opposite) bit order
SYS\_CRC\_CONFIG(CRC_32 | CRC_LITTLE_ENDIAN |
    CRC_BIT_ORDER_NON_STANDARD);
```

16.8.2.2 SYS_CRC_32INITVALUE

```
#define SYS_CRC_32INITVALUE Sys\_CRC\_32InitValue(CRC)
```

Macro wrapper for [Sys_CRC_32InitValue\(\)](#) Initialize CRC for CRC-32.

Location: crc.h:173

Assumptions

Note that D_CRC supports only CRC_CCITT mode, hence no configuration is applied for this instance.

Example Code for SYS_CRC_32INITVALUE

```
//Initialize the default CRC block for CRC-32  
SYS\_CRC\_32INITVALUE();
```

16.8.2.3 SYS_CRC_CCITTINITVALUE

```
#define SYS_CRC_CCITTINITVALUE Sys\_CRC\_CCITTInitValue(CRC)
```

Macro wrapper for [Sys_CRC_CCITTInitValue\(\)](#) Initialize CRC for CRC-CCITT.

Location: crc.h:181

Assumptions

CRC is configured to work in CRC-CCITT mode.

Example Code for SYS_CRC_CCITTINITVALUE

```
//Initialize the default CRC block for CRC-CCITT  
SYS\_CRC\_CCITTINITVALUE();
```

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16.8.2.4 SYS_CRC_GETCURRENTVALUE

```
#define SYS_CRC_GETCURRENTVALUE Sys\_CRC\_GetCurrentValue(CRC)
```

Macro wrapper for [Sys_CRC_GetCurrentValue\(\)](#) Initialize CRC for CRC-CCITT.

Location: crc.h:188

Example Code for SYS_CRC_GETCURRENTVALUE

```
// Retrieve current value from the default CRC block  
SYS\_CRC\_GETCURRENTVALUE ();
```

16.8.2.5 SYS_CRC_GETFINALVALUE

```
#define SYS_CRC_GETFINALVALUE Sys\_CRC\_GetFinalValue(CRC)
```

Macro wrapper for [Sys_CRC_GetFinalValue\(\)](#) Initialize final CRC value.

Location: crc.h:200

Return

CRC final value.

Assumptions

D_I2C only supports CRC-CCITT mode. Use `Sys_CRC_GetCurrentValue` instead. Returns initial value of CRC if `D_CRC` is passed or any other unknown instance.

Example Code for SYS_CRC_GETFINALVALUE

```
// Retrieve final value from the default CRC block
SYS_CRC_GETFINALVALUE();
```

16.8.2.6 SYS_CRC_ADD

```
#define SYS_CRC_ADD Sys_CRC_Add(CRC, (data), (size))
```

Macro wrapper for [Sys_CRC_Add\(\)](#) Add data to the current CRC calculation, based on size.

Location: crc.h:209

Parameters

Direction	Name	Description
in	<i>data</i>	Data to add
in	<i>size</i>	Size of data to add, 1, 8, 16, 24, 32 are valid.

Example Code for SYS_CRC_ADD

```
// Add 8 bits of data to the default CRC block
SYS_CRC_ADD(0xF1, 8);
```

16.8.3 Cyclic Redundancy Check Function Documentation**16.8.3.1 Sys_Set_CRC_Config**

```
void Sys_Set_CRC_Config(CRC_Type * crc, uint32_t config)
```

Configure the CRC generator type, endianness of the input data, and standard vs non-standard CRC behavior.

Location: crc.h:52

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Parameters

Direction	Name	Description
in	<i>crc</i>	Pointer to the CRC instance
in	<i>config</i>	CRC generator configuration; use CRC_[CCITT 32], CRC_[BIG LITTLE]_ENDIAN, CRC_BIT_ORDER_[STANDARD NON_STANDARD], CRC_FINAL_REVERSE_[STANDARD NON_STANDARD], and CRC_FINAL_XOR_[STANDARD NON_STANDARD]

Assumptions

Note that D_CRC supports only CRC_CCITT mode, hence no configuration is applied for this instance.

Example Code for Sys_Set_CRC_Config

```
// Configure CRC block to CRC-32 (IEEE 802.3) algorithm,
// using little endian and non-standard (opposite) bit order
Sys_Set_CRC_Config(CRC, CRC_32 | CRC_LITTLE_ENDIAN |
CRC_BIT_ORDER_NON_STANDARD);
```

16.8.3.2 Sys_CRC_32InitValue

```
void Sys_CRC_32InitValue(CRC_Type * crc)
```

Initialize CRC for CRC-32.

Location: crc.h:68

Parameters

Direction	Name	Description
in	<i>crc</i>	Pointer to the CRC instance

Assumptions

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Note that D_CRC supports only CRC_CCITT mode, hence no configuration is applied for this instance.

Example Code for Sys_CRC_32InitValue

```
// Initialize the CRC block for CRC-32
Sys_CRC_32InitValue(CRC);
```

16.8.3.3 Sys_CRC_CCITTInitValue

```
void Sys_CRC_CCITTInitValue(CRC_Type * crc)
```

Initialize CRC for CRC-CCITT.

Location: crc.h:83

Parameters

Direction	Name	Description
in	<i>crc</i>	Pointer to the CRC instance

Assumptions

CRC is configured to work in CRC-CCITT mode.

Example Code for Sys_CRC_CCITTInitValue

```
// Initialize the CRC block for CRC-CCITT
Sys_CRC_CCITTInitValue(CRC);
```

16.8.3.4 Sys_CRC_GetCurrentValue

```
uint32_t Sys_CRC_GetCurrentValue(const CRC_Type * crc)
```

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Retrieve current value from CRC.

Location: crc.h:95

Parameters

Direction	Name	Description
in	<i>crc</i>	Pointer to the CRC instance

Return

Current CRC value.

Example Code for Sys_CRC_GetCurrentValue

```
// Retrieve current value from the CRC block
value = Sys\_CRC\_GetCurrentValue(CRC);
```

16.8.3.5 Sys_CRC_GetFinalValue

```
uint32_t Sys_CRC_GetFinalValue(const CRC_Type * crc)
```

Initialize final CRC value.

Location: crc.h:111

Parameters

Direction	Name	Description
in	<i>crc</i>	Pointer to the CRC instance

Return

CRC final value.

Assumptions

D_CRC only supports CRC-CCITT mode. Use Sys_CRC_GetCurrentValue instead. Returns initial value of CRC if D_CRC is passed or any other unknown instance.

Example Code for Sys_CRC_GetFinalValue

```
// Retrieve final value from the CRC block
Sys_CRC_GetFinalValue(CRC);
```

16.8.3.6 Sys_CRC_Add

```
void Sys_CRC_Add(CRC_Type * crc, uint32_t data, uint32_t size)
```

Add data to the current CRC calculation, based on size.

Location: crc.h:138

Parameters

Direction	Name	Description
in	<i>crc</i>	Pointer to the CRC instance
in	<i>data</i>	Data to add
in	<i>size</i>	Size of data to add, 1, 8, 16, 24, 32 are valid.

Example Code for Sys_CRC_Add

```
// Add 8 bits of data to the current CRC block
Sys_CRC_Add(CRC, 0xF1, 8);
```

16.9 DIRECT MEMORY ACCESS

Direct Memory Access (DMA) hardware abstraction layer.

16.9.1 Summary**Macros**

- [SYS_DMA_CHANNELCONFIG](#) : Macro wrapper for [Sys_DMA_ChannelConfig\(\)](#) Configure the DMA channels for a data transfer.
- [SYS_DMA_MODE_ENABLE](#) : Macro wrapper for [Sys_DMA_Mode_Enable\(\)](#) Configure the DMA channels for a data transfer.

Functions

- [Sys_DMA_ChannelConfig](#) : Configure the DMA channels for a data transfer.
- [Sys_DMA_Mode_Enable](#) : Configure the DMA channels for a data transfer.
- [Sys_DMA_Get_Status](#) : Get the status register of the DMA instance.
- [Sys_DMA_Clear_Status](#) : Writes to the CNT_INT_CLEAR, COMPLETE_INT_CLEAR, or SRC_BUFFER_FILL_LVL_WR.
- [Sys_DMA_Set_Ctrl](#) : Sets the DMA_CTRL of the DMA instance.

16.9.2 Direct Memory Access Macro Definition Documentation**16.9.2.1 SYS_DMA_CHANNELCONFIG**

```
#define SYS_DMA_CHANNELCONFIG Sys\_DMA\_ChannelConfig(DMA, cfg, \
                                                    transferlength, counterInt,
srcAddr, \
                                                    destAddr)
```

Macro wrapper for [Sys_DMA_ChannelConfig\(\)](#) Configure the DMA channels for a data transfer.

Location: dma.h:176

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Parameters

Direction	Name	Description
in	<i>cfg</i>	Configuration of the DMA transfer behavior; use DMA_[LITTLE BIG]_ENDIAN, [DEST SRC]_TRANS_LENGTH_SEL, DMA_PRIORITY_[0 1 2 3], DMA_SRC_* DMA_DEST_* WORD_SIZE_*, DMA_SRC_ADDR_*, DMA_DEST_ADDR_*, DMA_SRC_ADDR_LSB_TOGGLE_[DISABLE ENABLE], DMA_CNT_INT_[DISABLE ENABLE], DMA_COMPLETE_INT_[DISABLE ENABLE]
in	<i>transferlength</i>	Configuration of the DMA transfer length
in	<i>counterInt</i>	Configuration of when the counter interrupt will occur during the transfer
in	<i>srcAddr</i>	Base source address for the DMA transfer
in	<i>destAddr</i>	Base destination address for the DMA transfer

Example Code for SYS_DMA_CHANNELCONFIG

```

4 // Configure the default DMA channels for data transfer using a transfer length of
// and interrupting at the beginning of the transfer
SYS_DMA_CHANNELCONFIG(DMA_BIG_ENDIAN | DEST_TRANS_LENGTH_SEL |
DMA_PRIORITY 1 | DMA_CNT_INT_ENABLE, 4, 0,
(uint32_t)0x2001ffc8, (uint32_t)0x2001ffb8);

```

16.9.2.2 SYS_DMA_MODE_ENABLE

```
#define SYS_DMA_MODE_ENABLE Sys DMA Mode Enable(DMA, (mode))
```

Macro wrapper for [Sys DMA Mode Enable\(\)](#) Configure the DMA channels for a data transfer.

Location: dma.h:191

Parameters

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Direction	Name	Description
in	<i>mode</i>	Enable mode of operation of the DMA Channel; use DMA_[DISABLE ENABLE DMA_ENABLE_WRAP DMA_ENABLE_WRAP_RESTART DMA_TRIGGER DMA_TRIGGER_WRAP DMA_TRIGGER_WRAP_RESTART]

Example Code for SYS_DMA_MODE_ENABLE

```
// Enable the default DMA block
SYS_DMA_MODE_ENABLE(DMA_ENABLE);
```

16.9.3 Direct Memory Access Function Documentation**16.9.3.1 Sys_DMA_ChannelConfig**

```
void Sys_DMA_ChannelConfig(DMA_Type * dma, uint32_t cfg, uint32_t transferLength, uint32_t counterInt, uint32_t srcAddr, uint32_t destAddr)
```

Configure the DMA channels for a data transfer.

Location: dma.h:62

Parameters

Direction	Name	Description
in	<i>dma</i>	Pointer to the DMA instance
in	<i>cfg</i>	Configuration of the DMA transfer behavior; use DMA_[LITTLE BIG]_ENDIAN, [DEST SRC]_TRANS_LENGTH_SEL, DMA_PRIORITY_[0 1 2 3], DMA_SRC_* DMA_DEST_* WORD_SIZE_*, DMA_SRC_ADDR_*, DMA_DEST_ADDR_*, DMA_SRC_ADDR_LSB_TOGGLE_[DISABLE ENABLE], DMA_CNT_INT_[DISABLE ENABLE], DMA_COMPLETE_INT_[DISABLE ENABLE]
in	<i>transferLength</i>	Configuration of the DMA transfer length

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Direction	Name	Description
in	<i>counterInt</i>	Configuration of when the counter interrupt will occur during the transfer
in	<i>srcAddr</i>	Base source address for the DMA transfer
in	<i>destAddr</i>	Base destination address for the DMA transfer

Example Code for Sys_DMA_ChannelConfig

```
// Configure the DMA1 channels for data transfer using a transfer length of 4
// and interrupting at the beginning of the transfer
uint32_t srcAddr = (uint32_t)0x2001ffc8;
uint32_t destAddr = (uint32_t)0x2001ffb8;
Sys_DMA_ChannelConfig(DMA1, DMA_BIG_ENDIAN | DEST_TRANS_LENGTH_SEL |
DMA_PRIORITY_1 | DMA_CNT_INT_ENABLE, 4, 0,
srcAddr, destAddr);
```

16.9.3.2 Sys_DMA_Mode_Enable

```
void Sys_DMA_Mode_Enable(DMA_Type * dma, uint32_t mode)
```

Configure the DMA channels for a data transfer.

Location: dma.h:107

Parameters

Direction	Name	Description
in	<i>dma</i>	Pointer to the DMA instance
in	<i>mode</i>	Enable mode of operation of the DMA Channel; use DMA_[DISABLE ENABLE DMA_ENABLE_WRAP DMA_ENABLE_WRAP_RESTART DMA_TRIGGER DMA_TRIGGER_WRAP DMA_TRIGGER_WRAP_RESTART]

Example Code for Sys_DMA_Mode_Enable

```
// Enable DMA1
Sys_DMA_Mode_Enable(DMA1, DMA_ENABLE);
```

16.9.3.3 Sys_DMA_Get_Status

```
uint32_t Sys_DMA_Get_Status(DMA_Type * dma)
```

Get the status register of the DMA instance.

Location: dma.h:120

Parameters

Direction	Name	Description
in	<i>dma</i>	Pointer to the DMA instance

Return

The DMA_STATUS of the DMA instance.

Example Code for Sys_DMA_Get_Status

```
// Get the current status of DMA channel 1
result = Sys_DMA_Get_Status(DMA1);
```

16.9.3.4 Sys_DMA_Clear_Status

```
void Sys_DMA_Clear_Status(DMA_Type * dma, uint32_t ctrl)
```

Writes to the CNT_INT_CLEAR, COMPLETE_INT_CLEAR, or SRC_BUFFER_FILL_LVL_WR.

Location: dma.h:133

Parameters

Direction	Name	Description
in	<i>dma</i>	Pointer to the DMA instance
in	<i>ctrl</i>	Data to be written to the DMA_SATUS register

Example Code for Sys_DMA_Clear_Status

```
// Clear the status register of DMA channel 1
result = Sys\_DMA\_Clear\_Status(DMA1, DMA_COMPLETE_INT_CLEAR | DMA_CNT_INT_CLEAR);
```

16.9.3.5 Sys_DMA_Set_Ctrl

```
void Sys_DMA_Set_Ctrl(DMA_Type * dma, uint32_t ctrl)
```

Sets the DMA_CTRL of the DMA instance.

Location: dma.h:145

Parameters

Direction	Name	Description
in	<i>dma</i>	Pointer to the DMA instance
in	<i>ctrl</i>	Data to be written to the DMA_CTRL register

Example Code for Sys_DMA_Set_Ctrl

```
// Enables DMA channel 1 which will disable the DMA when the transfer is completed.
result = Sys\_DMA\_Set\_Ctrl(DMA1, DMA_ENABLE);
```

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16.10 FLASH COPIER

Flash copier hardware abstraction layer.

16.10.1 Summary

Functions

- [Sys Flash Copy](#) : Copy data from the flash memory to a RAM memory instance.
- [Sys Flash Compare](#) : Compare data in the flash to a pre-specified value.
- [Sys Flash CalculateCRC](#) : Calculate CRC of words in flash using flash copier.

16.10.2 Flash Copier Function Documentation

16.10.2.1 Sys_Flash_Copy

```
void Sys_Flash_Copy(FLASH_Type * flash, uint32_t src_addr, uint32_t dest_addr, uint32_t length, uint32_t cpy_dest)
```

Copy data from the flash memory to a RAM memory instance.

Location: flash_copier.h:55

Parameters

Direction	Name	Description
in	<i>flash</i>	Pointer to the flash instance
in	<i>src_addr</i>	Source address in flash to copy data from
in	<i>dest_addr</i>	Destination address in RAM to copy data to
in	<i>length</i>	Number of words to copy
in	<i>cpy_dest</i>	Destination copier is CRC or memories; use COPY_TO_[CRC MEM], and COPY_TO_[32 40]_BIT

Assumptions

src_addr points to an address in flash memory dest_addr points to an address in RAM memory The flash copy does not need to be complete before returning If CRC is selected as the destination, dest_addr is ignored and 32-bit copy mode is selected automatically.

Example Code for Sys_Flash_Copy

```
// Copy a block of 256 bytes from flash to RAM.
uint32_t srcAddr = (uint32_t)0x001D8000;
uint32_t destAddr = (uint32_t)0x2000E000;
Sys_Flash_Copy(FLASH, srcAddr, destAddr, 0x100, COPY_TO_MEM | COPY_TO_32BIT);
```

16.10.2.2 Sys_Flash_Compare

```
uint32_t Sys_Flash_Compare(FLASH_Type * flash, uint32_t cfg, uint32_t addr, uint32_t
length, uint32_t value, uint32_t value_ecc)
```

Compare data in the flash to a pre-specified value.

Location: flash_copier.h:76

Parameters

Direction	Name	Description
in	<i>flash</i>	Pointer to the flash instance
in	<i>cfg</i>	Flash comparator configuration; use COMP_MODE_[CONSTANT CHBK]_BYTE, COMP_ADDR_[DOWN UP]_BYTE, and COMP_ADDR_STEP_*_BYTE
in	<i>addr</i>	Base address of the area to verify
in	<i>length</i>	Number of words to verify
in	<i>value</i>	Value that the words read from flash will be compared against
in	<i>value_ecc</i>	Value that the error-correction coding bits from the extended words read from flash will be compared against

Return

0 if comparison succeeded, 1 if the comparison failed.

Assumptions

addr points to an address in flash memory

Example Code for Sys_Flash_Compare

```
// Verify that 256 bytes in flash are all 0xFFFFFFFF.
uint32_t srcAddr = (uint32_t)0x001D8000;
Sys_Flash_Compare(FLASH, COMP_MODE_CONSTANT_BYTE |
                  COMP_ADDR_UP_BYTE |
                  COMP_ADDR_STEP_1_BYTE,
                  srcAddr, 0x100, 0xFFFFFFFF, 0);
```

16.10.2.3 Sys_Flash_CalculateCRC

```
uint32_t Sys_Flash_CalculateCRC(FLASH_Type * flash, uint32_t addr, uint32_t length,
uint32_t * crc)
```

Calculate CRC of words in flash using flash copier.

Location: flash_copier.h:91

Parameters

Direction	Name	Description
in	<i>flash</i>	Flash instance being used
in	<i>addr</i>	Address belonging to the flash instance
in	<i>length</i>	Total number of words used in CRC calculation
out	<i>crc</i>	CRC value calculated using CRC peripheral

Return

0 if calculation has succeeded, 1 if the calculation has failed.

NOTE: Flash copier and CRC register are modified

RSL15 Firmware Reference

Example Code for Sys_Flash_CalculateCRC

```
// Perform CRC of the 256 bytes in flash at srcAddr.
uint32_t srcAddr = (uint32_t)0x001D8000;
Sys_Flash_CalculateCRC(FLASH, COMP_MODE_CONSTANT_BYTE |
                       COMP_ADDR_UP_BYTE |
                       COMP_ADDR_STEP_1_BYTE,
                       srcAddr, 0x100, 0xFFFFFFFF, 0);
```

16.11 GENERAL-PURPOSE I/O INTERFACE

General-Purpose I/O (GPIO) Interface hardware abstraction layer.

16.11.1 Summary**Macros**

- [GPIO_LEVEL1_DRIVE](#) : 1st level GPIO drive strength
- [GPIO_LEVEL2_DRIVE](#) : 2nd level GPIO drive strength
- [GPIO_LEVEL3_DRIVE](#) : 3rd level GPIO drive strength
- [GPIO_LEVEL4_DRIVE](#) : 4th level GPIO drive strength
- [SYS_GPIO_CONFIG](#) : Configure the specified digital I/O.

Functions

- [Sys_GPIO_NMIConfig](#) : Configure a source for NMI input selection.
- [Sys_GPIO_IntConfig](#) : Configure a GPIO interrupt source.
- [Sys_GPIO_CM33JTAGConfig](#) : Configure Arm Cortex-M3 SWJ-DP.
- [Sys_GPIO_Set_High](#) : Set the specified GPIO output value to high.
- [Sys_GPIO_Set_Low](#) : Set the specified GPIO output value to low.
- [Sys_GPIO_Toggle](#) : Toggle the current value of the specified GPIO output.
- [Sys_GPIO_Read](#) : Read the specified GPIO value.
- [Sys_GPIO_Write](#) : Write the specified GPIO value.
- [Sys_GPIO_Set_SingleDirection](#) : Set the input/output direction for a particular GPIO.
- [Sys_GPIO_Set_Direction](#) : Set the input/output direction for any GPIOs configured as GPIOs.

16.11.2 General-Purpose I/O Interface Macro Definition Documentation**16.11.2.1 GPIO_LEVEL1_DRIVE**

```
#define GPIO_LEVEL1_DRIVE GPIO_2X_DRIVE
```

1st level GPIO drive strength

Location: gpio.h:45

16.11.2.2 GPIO_LEVEL2_DRIVE

```
#define GPIO_LEVEL2_DRIVE GPIO_3X_DRIVE
```

2nd level GPIO drive strength

Location: gpio.h:48

16.11.2.3 GPIO_LEVEL3_DRIVE

```
#define GPIO_LEVEL3_DRIVE GPIO_5X_DRIVE
```

3rd level GPIO drive strength

Location: gpio.h:51

16.11.2.4 GPIO_LEVEL4_DRIVE

```
#define GPIO_LEVEL4_DRIVE GPIO_6X_DRIVE
```

4th level GPIO drive strength

Location: gpio.h:54

16.11.2.5 SYS_GPIO_CONFIG

```
#define SYS_GPIO_CONFIG SYS\_ASSERT(pad < GPIO\_PAD\_COUNT); \  
GPIO->CFG[(pad)] = (config)
```

Configure the specified digital I/O.

Location: gpio.h:69

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>pad</i>	Digital I/O pad to configure; use a constant
in	<i>config</i>	I/O configuration; use GPIO_*X_DRIVE, GPIO_LPF_[ENABLE DISABLE], GPIO_*_PULL, and GPIO_MODE_*

Example Code for SYS_GPIO_CONFIG

```
// Enable GPIO 5 as GPIO input using no pull-up resistor
SYS_GPIO_CONFIG(GPIO5, GPIO_MODE_GPIO_IN | GPIO_NO_PULL);
```

16.11.3 General-Purpose I/O Interface Function Documentation**16.11.3.1 Sys_GPIO_NMIConfig**

```
void Sys_GPIO_NMIConfig(uint32_t config, uint32_t source, uint32_t polarity)
```

Configure a source for NMI input selection.

Location: gpio.h:80

Parameters

Direction	Name	Description
in	<i>config</i>	GPIO pin configuration if NMI is pad
in	<i>source</i>	NMI source; use NMI_SRC_*
in	<i>polarity</i>	NMI polarity; use NMI_ACTIVE_[LOW HIGH]

Example Code for Sys_GPIO_NMIConfig

```
// Configure NMI input using GPIO 13 as active-low source without low-pass filter
Sys_GPIO_NMIConfig(GPIO_LPF_ENABLE, NMI_SRC_GPIO_13, NMI_ACTIVE_LOW);
```

RSL15 Firmware Reference

16.11.3.2 Sys_GPIO_IntConfig

```
void Sys_GPIO_IntConfig(uint32_t index, uint32_t config, uint32_t dbnc_clk, uint32_t dbnc_cnt)
```

Configure a GPIO interrupt source.

Location: gpio.h:105

Parameters

Direction	Name	Description
in	<i>index</i>	GPIO interrupt source to configure; use a constant
in	<i>config</i>	GPIO interrupt configuration; use GPIO__INT_DEBOUNCE_[DISABLE ENABLE], GPIO_INT_SRC_*, and GPIO_INT_EVENT_[NONE HIGH_LEVEL LOW_LEVEL RISING_EDGE FALLING_EDGE TRANSITION]
in	<i>dbnc_clk</i>	Interrupt button debounce filter clock; use GPIO_DEBOUNCE_SLOWCLK_DIV[32 1024]
in	<i>dbnc_cnt</i>	Interrupt button debounce filter count

Example Code for Sys_GPIO_IntConfig

```
// configure GPIO interrupt channel 7 to use GPIO 11 as interrupt source, with
// 1 debounce filter count.
Sys_GPIO_IntConfig(7, (GPIO_INT_DEBOUNCE_ENABLE | GPIO_INT_SRC_GPIO_11),
GPIO_DEBOUNCE_SLOWCLK_DIV1024, 1);
```

16.11.3.3 Sys_GPIO_CM33JTAGConfig

```
void Sys_GPIO_CM33JTAGConfig(uint32_t config, uint8_t mode)
```

Configure Arm Cortex-M3 SWJ-DP.

Location: gpio.h:130

RSL15 Firmware Reference

Parameters

Direction	Name	Description
in	<i>config</i>	JTAG pad configuration; use JTMS_[NO_PULL WEAK_PULL_UP WEAK_PULL_DOWN STRONG_PULL_UP], JTMS_[2X 3X 5X 6X]_DRIVE, JTCK_[NO_PULL WEAK_PULL_UP WEAK_PULL_DOWN STRONG_PULL_UP], JTMS_LPF_[DISABLED ENABLED], and JTCK_LPF_[DISABLED ENABLED]
in	<i>mode</i>	Enable one of the two JTAG modes or SW mode; use 0 for SW mode, 1 for JTAG with reset enabled, and 2 for JTAG with reset disabled

Example Code for Sys_GPIO_CM33JTAGConfig

```
// Enable Arm Cortex-M3 SWJ-DP port and JTAG
Sys_GPIO_CM33JTAGConfig(true, true);
```

16.11.3.4 Sys_GPIO_Set_High

```
void Sys_GPIO_Set_High(uint32_t pad)
```

Set the specified GPIO output value to high.

Location: gpio.h:160

Parameters

Direction	Name	Description
in	<i>pad</i>	GPIO pad to set high

Example Code for Sys_GPIO_Set_High

```
// Set GPIO2 high
Sys_GPIO_Set_High(GPIO2);
```

16.11.3.5 Sys_GPIO_Set_Low

```
void Sys_GPIO_Set_Low(uint32_t pad)
```

Set the specified GPIO output value to low.

Location: gpio.h:171

Parameters

Direction	Name	Description
in	<i>pad</i>	GPIO pad to set low

Example Code for Sys_GPIO_Set_Low

```
// Set GPIO2 low
Sys_GPIO_Set_Low(GPIO2);
```

16.11.3.6 Sys_GPIO_Toggle

```
void Sys_GPIO_Toggle(uint32_t pad)
```

Toggle the current value of the specified GPIO output.

Location: gpio.h:182

Parameters

Direction	Name	Description
in	<i>pad</i>	GPIO pad to toggle

Example Code for Sys_GPIO_Toggle

```
// Toggle the state of the GPIO2 pin
Sys_GPIO_Toggle(GPIO2);
```

16.11.3.7 Sys_GPIO_Read

```
uint32_t Sys_GPIO_Read(uint32_t pad)
```

Read the specified GPIO value.

Location: gpio.h:194

Parameters

Direction	Name	Description
in	<i>pad</i>	GPIO pad to set low

Return

uint32_t pin value; 0 or 1

Example Code for Sys_GPIO_Read

```
// Read the current value of the GPIO2 pin
Sys_GPIO_Read(GPIO2);
```

16.11.3.8 Sys_GPIO_Write

```
void Sys_GPIO_Write(uint32_t pad, bool value)
```

RSL15 Firmware Reference

Write the specified GPIO value.

Location: gpio.h:206

Parameters

Direction	Name	Description
in	<i>pad</i>	GPIO pad to write value
in	<i>value</i>	1 or 0 written to GPIO

Example Code for Sys_GPIO_Write

```
// Write a 1 to GPIO2
Sys_GPIO_Write(GPIO2, 1);
```

16.11.3.9 Sys_GPIO_Set_SingleDirection

```
void Sys_GPIO_Set_SingleDirection(uint32_t pad, uint32_t dir)
```

Set the input/output direction for a particular GPIO.

Location: gpio.h:221

Parameters

Direction	Name	Description
in	<i>pad</i>	GPIO pad to write value
in	<i>dir</i>	Input/output configuration settings for any GPIOs from 0 to 15 that are configured as GPIO pads; use GPIO*_DIR_IN, and GPIO*_DIR_OUT

RSL15 Firmware Reference

Example Code for Sys_GPIO_Set_SingleDirection

```
// Set the direction of the GPIO2 pin
Sys_GPIO_Set_SingleDirection(GPIO2, GPIO2_DIR_OUT);
```

16.11.3.10 Sys_GPIO_Set_Direction

```
void Sys_GPIO_Set_Direction(uint32_t dir)
```

Set the input/output direction for any GPIOs configured as GPIOs.

Location: gpio.h:244

Parameters

Direction	Name	Description
in	<i>dir</i>	Input/output configuration settings for any GPIOs from 0 to 15 that are configured as GPIO pads; use GPIO*_DIR_IN, and GPIO*_DIR_OUT

Example Code for Sys_GPIO_Set_Direction

```
// Set GPIO2 as an output
Sys_GPIO_Set_Direction(GPIO2_DIR_OUT);
```

16.12 I2C

Inter-Integrated Circuit (I2C) hardware abstraction layer.

16.12.1 Summary**Macros**

- [I2C_CONFIG_MASK](#) : Mask for the I2C_CFG register.
- [I2C_PADS_NUM](#) : Number of pads used for the I2C interface, for a single instance.

RSL15 Firmware Reference

- [SYS_I2C_GPIOCONFIG](#) : Macro wrapper for [Sys_I2C_GPIOConfig\(\)](#) Configure two GPIOs for the specified I2C interface.
- [SYS_I2C_CONFIG](#) : Macro wrapper for [Sys_I2C_Config\(\)](#) Apply I2C Master mode related configuration.
- [SYS_I2C_STARTREAD](#) : Macro wrapper for [Sys_I2C_StartRead\(\)](#) Send slave address on the bus with a read request.
- [SYS_I2C_STARTWRITE](#) : Macro wrapper for [Sys_I2C_StartWrite\(\)](#) Send slave address on the bus with a write request.
- [SYS_I2C_ACK](#) : Macro wrapper for [Sys_I2C_ACK\(\)](#) Issue an ACK on the I2C interface.
- [SYS_I2C_NACK](#) : Macro wrapper for [Sys_I2C_NACK\(\)](#) Issue a NACK on the I2C interface.
- [SYS_I2C_LASTDATA](#) : Macro wrapper for [Sys_I2C_LastData\(\)](#) Indicate that the current data is the last byte.
- [SYS_I2C_RESET](#) : Macro wrapper for [Sys_I2C_Reset\(\)](#) Reset the I2C interface.
- [SYS_I2C_NACKANDSTOP](#) : Macro wrapper for [Sys_I2C_NackAndStop\(\)](#) Issue a NACK followed by a Stop condition on I2C bus.

Functions

- [Sys_I2C_GPIOConfig](#) : Configure two GPIOs for the specified I2C interface.
- [Sys_I2C_Config](#) : Apply I2C Master mode related configuration.
- [Sys_I2C_StartRead](#) : Send slave address on the bus with a read request.
- [Sys_I2C_StartWrite](#) : Send slave address on the bus with a write request.
- [Sys_I2C_ACK](#) : Issue an ACK on the I2C interface.
- [Sys_I2C_NACK](#) : Issue a NACK on the I2C interface.
- [Sys_I2C_LastData](#) : Indicate that the current data is the last byte.
- [Sys_I2C_Reset](#) : Reset the I2C interface.
- [Sys_I2C_NackAndStop](#) : Issue a NACK followed by a Stop condition on I2C bus.

16.12.2 I2C Macro Definition Documentation

16.12.2.1 I2C_CONFIG_MASK

```
#define I2C_CONFIG_MASK (((uint32_t)1U << I2C_CFG_CONNECT_IN_STANDBY_Pos) | \
  ((uint32_t)1U << I2C_CFG_TX_DMA_ENABLE_Pos) | \
  ((uint32_t)1U << I2C_CFG_RX_DMA_ENABLE_Pos) | \
  ((uint32_t)1U << I2C_CFG_TX_INT_ENABLE_Pos) | \
  ((uint32_t)1U << I2C_CFG_RX_INT_ENABLE_Pos) | \
  ((uint32_t)1U << I2C_CFG_BUS_ERROR_INT_ENABLE_Pos) | \
  (1U << I2C_CFG_OVERRUN_INT_ENABLE_Pos) | \
  (1U << I2C_CFG_STOP_INT_ENABLE_Pos) | \
  (1U << I2C_CFG_AUTO_ACK_ENABLE_Pos) | \
  I2C_CFG_SLAVE_PRESCALE_Mask | \
  I2C_CFG_MASTER_PRESCALE_Mask | \
  I2C_CFG_SLAVE_ADDRESS_Mask | \
  (1U << I2C_CFG_SLAVE_Pos))
```

Mask for the I2C_CFG register.

RSL15 Firmware Reference

Location: i2c.h:41

16.12.2.2 I2C_PADS_NUM

```
#define I2C_PADS_NUM 2U
```

Number of pads used for the I2C interface, for a single instance.

Location: i2c.h:57

16.12.2.3 SYS_I2C_GPIOCONFIG

```
#define SYS_I2C_GPIOCONFIG Sys I2C GPIOConfig(I2C, (config), (scl), (sda))
```

Macro wrapper for [Sys I2C GPIOConfig\(\)](#) Configure two GPIOs for the specified I2C interface.

Location: i2c.h:206

Parameters

Direction	Name	Description
in	<i>config</i>	GPIO pin configuration for the I2C pads
in	<i>scl</i>	GPIO to use as the I2C transmit pad; use an integer
in	<i>sda</i>	GPIO to use as the I2C receive pad; use an integer

Example Code for SYS_I2C_GPIOCONFIG

```
// Configure GPIO3 and GPIO4 as SCL and SDA, enable 1 kOhm pull-up resistors,
// and disable low-pass filter for default I2C interface
SYS\_I2C\_GPIOCONFIG((GPIO_LPF_DISABLE | GPIO_1K_PULL_UP),
GPIO3, GPIO4);
```

16.12.2.4 SYS_I2C_CONFIG

```
#define SYS_I2C_CONFIG Sys I2C Config(I2C, (config))
```

RSL15 Firmware Reference

Macro wrapper for [Sys I2C Config\(\)](#) Apply I2C Master mode related configuration.

Location: i2c.h:229

Parameters

Direction	Name	Description
in	<i>config</i>	I2C configurations for master mode; use I2C_[CONNECT DISCONNECT]_IN_STANDBY, I2C_TX_DMA_[ENABLE DISABLE] I2C_RX_DMA_[ENABLE DISABLE] I2C_TX_INT_[ENABLE DISABLE] I2C_RX_INT_[ENABLE DISABLE] I2C_BUS_ERROR_INT_[ENABLE DISABLE] I2C_OVERRUN_INT_[ENABLE DISABLE] I2C_STOP_INT_[ENABLE DISABLE] I2C_AUTO_ACK_[ENABLE DISABLE] I2C_MASTER_PRESCALE_*, I2C_SLAVE_PRESCALE_*, a slave address constant shifted to I2C_CTRL0_SLAVE_ADDRESS_Pos, I2C_SLAVE_[ENABLE DISABLE]

Example Code for SYS_I2C_CONFIG

```
// Apply I2C Master mode related configuration for default I2C interface
// Set up prescaler, auto acknowledge, interrupt, and slave enable
SYS\_I2C\_CONFIG((I2C_SLAVE_PRESCALE_4 |
    I2C_AUTO_ACK_ENABLE |
    I2C_RX_INT_ENABLE |
    I2C_TX_INT_ENABLE |
    I2C_STOP_INT_ENABLE |
    I2C_OVERRUN_INT_ENABLE |
    I2C_BUS_ERROR_INT_ENABLE |
    I2C_SLAVE_ENABLE |
    (64 << I2C_CFG_SLAVE_ADDRESS_Pos)));
```

16.12.2.5 SYS_I2C_STARTREAD

```
#define SYS_I2C_STARTREAD Sys I2C StartRead(I2C, (addr))
```

Macro wrapper for [Sys I2C StartRead\(\)](#) Send slave address on the bus with a read request.

Location: i2c.h:237

RSL15 Firmware Reference

Parameters

Direction	Name	Description
in	<i>addr</i>	I2C address to use for write transaction

Example Code for SYS_I2C_STARTREAD

```
// Send slave address 64 on the default I2C bus with a read request
SYS_I2C_STARTREAD(64);
```

16.12.2.6 SYS_I2C_STARTWRITE

```
#define SYS_I2C_STARTWRITE Sys_I2C_StartWrite(I2C, (addr))
```

Macro wrapper for [Sys_I2C_StartWrite\(\)](#) Send slave address on the bus with a write request.

Location: i2c.h:245

Parameters

Direction	Name	Description
in	<i>addr</i>	I2C address to use for write transaction

Example Code for SYS_I2C_STARTWRITE

```
// Send slave address 64 on the default I2C bus with a write request
SYS_I2C_STARTWRITE(64);
```

16.12.2.7 SYS_I2C_ACK

```
#define SYS_I2C_ACK Sys_I2C_ACK(I2C)
```

Macro wrapper for [Sys_I2C_ACK\(\)](#) Issue an ACK on the I2C interface.

Location: i2c.h:252

Example Code for SYS_I2C_ACK

```
// Issue a ACK on the default I2C interface  
SYS\_I2C\_ACK\(\) ;
```

16.12.2.8 SYS_I2C_NACK

```
#define SYS_I2C_NACK Sys\_I2C\_NACK(I2C)
```

Macro wrapper for [Sys_I2C_NACK\(\)](#) Issue a NACK on the I2C interface.

Location: i2c.h:259

Example Code for SYS_I2C_NACK

```
// Issue a NACK on the default I2C interface  
SYS\_I2C\_NACK\(\) ;
```

16.12.2.9 SYS_I2C_LASTDATA

```
#define SYS_I2C_LASTDATA Sys\_I2C\_LastData(I2C)
```

Macro wrapper for [Sys_I2C_LastData\(\)](#) Indicate that the current data is the last byte.

Location: i2c.h:266

Example Code for SYS_I2C_LASTDATA

```
//Indicate that the current data is the last byte  
SYS\_I2C\_LASTDATA();
```

16.12.2.10 SYS_I2C_RESET

```
#define SYS_I2C_RESET Sys\_I2C\_Reset(I2C)
```

Macro wrapper for [Sys_I2C_Reset\(\)](#) Reset the I2C interface.

Location: i2c.h:273

Example Code for SYS_I2C_RESET

```
// Reset the default I2C interface  
SYS\_I2C\_RESET();
```

16.12.2.11 SYS_I2C_NACKANDSTOP

```
#define SYS_I2C_NACKANDSTOP Sys\_I2C\_NackAndStop(I2C)
```

Macro wrapper for [Sys_I2C_NackAndStop\(\)](#) Issue a NACK followed by a Stop condition on I2C bus.

Location: i2c.h:280

Example Code for SYS_I2C_NACKANDSTOP

```
// Issue a NACK followed by a Stop condition on default I2C bus  
SYS\_I2C\_NACKANDSTOP();
```

16.12.3 I2C Function Documentation

RSL15 Firmware Reference

16.12.3.1 Sys_I2C_GPIOConfig

```
void Sys_I2C_GPIOConfig(const I2C_Type * i2c, uint32_t config, uint32_t scl, uint32_t sda)
```

Configure two GPIOs for the specified I2C interface.

Location: i2c.h:68

Parameters

Direction	Name	Description
in	<i>i2c</i>	Pointer to the I2C instance
in	<i>config</i>	GPIO pin configuration for the I2C pads
in	<i>scl</i>	GPIO to use as the I2C transmit pad; use an integer
in	<i>sda</i>	GPIO to use as the I2C receive pad; use an integer

Example Code for Sys_I2C_GPIOConfig

```
// Configure GPIO3 and GPIO4 as SCL and SDA, enable 1 kOhm pull-up resistors,
// and disable low-pass filter for I2C interface
Sys_I2C_GPIOConfig(I2C, (GPIO_LPF_DISABLE | GPIO_1K_PULL_UP),
                   GPIO3, GPIO4);
```

16.12.3.2 Sys_I2C_Config

```
void Sys_I2C_Config(I2C_Type * i2c, uint32_t config)
```

Apply I2C Master mode related configuration.

Location: i2c.h:110

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>i2c</i>	Pointer to the I2C instance
in	<i>config</i>	I2C configurations for master mode; use I2C_[CONNECT DISCONNECT]_IN_STANDBY, I2C_TX_DMA_[ENABLE DISABLE] I2C_RX_DMA_[ENABLE DISABLE] I2C_TX_INT_[ENABLE DISABLE] I2C_RX_INT_[ENABLE DISABLE] I2C_BUS_ERROR_INT_[ENABLE DISABLE] I2C_OVERRUN_INT_[ENABLE DISABLE] I2C_STOP_INT_[ENABLE DISABLE] I2C_AUTO_ACK_[ENABLE DISABLE] I2C_MASTER_PRESCALE_*, I2C_SLAVE_PRESCALE_*, a slave address constant shifted to I2C_CTRL0_SLAVE_ADDRESS_Pos, I2C_SLAVE_[ENABLE DISABLE]

Example Code for Sys_I2C_Config

```
// Apply I2C Master mode related configuration for I2C interface
// Set up prescaler, auto acknowledge, interrupt, and slave enable
Sys_I2C_Config(I2C, (I2C_SLAVE_PRESCALE_4 |
    I2C_AUTO_ACK_ENABLE |
    I2C_RX_INT_ENABLE |
    I2C_TX_INT_ENABLE |
    I2C_STOP_INT_ENABLE |
    I2C_OVERRUN_INT_ENABLE |
    I2C_BUS_ERROR_INT_ENABLE |
    I2C_SLAVE_ENABLE |
    (64 << I2C_CFG_SLAVE_ADDRESS_Pos)));
```

16.12.3.3 Sys_I2C_StartRead

```
void Sys_I2C_StartRead(I2C_Type * i2c, uint32_t addr)
```

Send slave address on the bus with a read request.

Location: i2c.h:122

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>i2c</i>	Pointer to the I2C instance
in	<i>addr</i>	I2C address to use for write transaction

Example Code for Sys_I2C_StartRead

```
// Send slave address 64 on the I2C bus with a read request
Sys_I2C_StartRead(I2C, 64);
```

16.12.3.4 Sys_I2C_StartWrite

```
void Sys_I2C_StartWrite(I2C_Type * i2c, uint32_t addr)
```

Send slave address on the bus with a write request.

Location: i2c.h:136

Parameters

Direction	Name	Description
in	<i>i2c</i>	I2C instance number
in	<i>addr</i>	I2C address to use for write transaction

Example Code for Sys_I2C_StartWrite

```
// Send slave address 64 on the I2C bus with a write request
Sys_I2C_StartWrite(I2C, 64);
```

16.12.3.5 Sys_I2C_ACK

```
void Sys_I2C_ACK(I2C_Type * i2c)
```

Issue a ACK on the I2C interface.

Location: i2c.h:148

Parameters

Direction	Name	Description
in	<i>i2c</i>	Pointer to the I2C instance

Example Code for Sys_I2C_ACK

```
// Issue a ACK on the I2C interface
Sys_I2C_ACK(I2C);
```

16.12.3.6 Sys_I2C_NACK

```
void Sys_I2C_NACK(I2C_Type * i2c)
```

Issue a NACK on the I2C interface.

Location: i2c.h:159

Parameters

Direction	Name	Description
in	<i>i2c</i>	Pointer to the I2C instance

Example Code for Sys_I2C_NACK

```
// Issue a NACK on the I2C interface
Sys_I2C_NACK(I2C);
```

16.12.3.7 Sys_I2C_LastData

```
void Sys_I2C_LastData(I2C_Type * i2c)
```

Indicate that the current data is the last byte.

Location: i2c.h:170

Parameters

Direction	Name	Description
in	<i>i2c</i>	Pointer to the I2C instance

Example Code for Sys_I2C_LastData

```
//Indicate that the current data is the last byte
Sys\_I2C\_LastData(I2C);
```

16.12.3.8 Sys_I2C_Reset

```
void Sys_I2C_Reset(I2C_Type * i2c)
```

Reset the I2C interface.

Location: i2c.h:181

Parameters

Direction	Name	Description
in	<i>i2c</i>	Pointer to the I2C instance

Example Code for Sys_I2C_Reset

```
// Reset the I2C interface
Sys_I2C_Reset(I2C);
```

16.12.3.9 Sys_I2C_NackAndStop

```
void Sys_I2C_NackAndStop(I2C_Type * i2c)
```

Issue a NACK followed by a Stop condition on I2C bus.

Location: i2c.h:192

Parameters

Direction	Name	Description
in	<i>i2c</i>	Pointer to the I2C instance

Example Code for Sys_I2C_NackAndStop

```
// Issue a NACK followed by a Stop condition on I2C bus
Sys_I2C_NackAndStop(I2C);
```

16.13 LIN

LIN hardware abstraction layer.

16.13.1 Summary**Functions**

- [Sys_LIN_GPIOConfig](#) : Configure two GPIOs for the specified LIN interface.
- [Sys_LIN_Enable](#) : Enable/Wake the connected transceiver, enable LIN.
- [Sys_LIN_Disable](#) : Disable the connected transceiver, disable LIN.
- [Sys_LIN_ClearErrors](#) : Clear all error flags.

16.13.2 LIN Function Documentation

16.13.2.1 Sys_LIN_GPIOConfig

```
void Sys_LIN_GPIOConfig(const LIN_Type * lin, uint32_t config, uint32_t tx, uint32_t rx)
```

Configure two GPIOs for the specified LIN interface.

Location: lin.h:50

Parameters

Direction	Name	Description
in	<i>lin</i>	Pointer to the LIN instance
in	<i>config</i>	GPIO pin configuration for the LIN pads
in	<i>tx</i>	GPIO to use as the LIN transmit pad; use an integer
in	<i>rx</i>	GPIO to use as the LIN receive pad; use an integer

Example Code for Sys_LIN_GPIOConfig

```
// Configure GPIO2 and GPIO3 for the LIN interface
Sys_LIN_GPIOConfig(LIN, GPIO_6X_DRIVE | GPIO_LPF_DISABLE | GPIO_STRONG_PULL_UP,
 2, 3)
```

16.13.2.2 Sys_LIN_Enable

```
void Sys_LIN_Enable(LIN_Type * lin)
```

Enable/Wake the connected transceiver, enable LIN.

Location: lin.h:77

Parameters

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Direction	Name	Description
in	<i>lin</i>	Pointer to the LIN instance

Assumptions

None

Example Code for Sys_LIN_Enable

```
// Disable the LIN interface
Sys_LIN_Enable(LIN)
```

16.13.2.3 Sys_LIN_Disable

```
void Sys_LIN_Disable(LIN_Type * lin)
```

Disable the connected transceiver, disable LIN.

Location: lin.h:91

Parameters

Direction	Name	Description
in	<i>lin</i>	Pointer to the LIN instance

Example Code for Sys_LIN_Disable

```
// Disable the LIN interface
Sys_LIN_Disable(LIN)
```

RSL15 Firmware Reference

16.13.2.4 Sys_LIN_ClearErrors

```
void Sys_LIN_ClearErrors(LIN_Type * lin)
```

Clear all error flags.

Location: lin.h:104

Parameters

Direction	Name	Description
in	<i>lin</i>	Pointer to the LIN instance

Example Code for Sys_LIN_ClearErrors

```
// Clear any errors generated by the LIN interface
Sys_LIN_ClearErrors(LIN)
```

16.14 LSAD

LSAD hardware abstraction layer.

16.14.1 Summary**Typedefs**

- [lsad_io_t](#)
- [lsad_in_t](#)
- [lsad_channel_t](#)
- [lsad_prescale_t](#)
- [lsad_mode_t](#)

Data Structures

- [F_LSAD_TRIM](#): LSAD structure for offset/gain conversion function.

Enumerations

- [lsad_io](#)
- [lsad_pol](#)
- [lsad_channel](#)
- [lsad_prescale](#)
- [lsad_mode](#)

Macros

- [LSAD_BIT_RES](#) : Converts a raw ADC value to a voltage, calculated as follows $\text{voltage} = \text{adc_val} * (2 \text{ V} * 1000 \text{ [mV]}/1 \text{ V} / 2^{14} \text{ steps.})$
- [RES_15BIT](#)
- [RES_16BIT](#)
- [V_REF_DIFF_MV](#)
- [RESOLUTION_DIV](#)
- [ADC_VAL_MV](#)
- [LSAD_OFFSET_ERROR_CONV_QUOTIENT](#)
- [LSAD_GAIN_ERROR_CONV_QUOTIENT](#)
- [ERROR_LSAD_INPUT_CFG](#)
- [PRE_SEL_SIZE](#)
- [LSAD_CFG_ARR_LENGTH](#)
- [LSAD_CFG_ARR_WIDTH](#)
- [GPIO_IDX](#)
- [IO_CFG_IDX](#)
- [MASK_IDX](#)
- [POS_SEL_IDX](#)
- [NEG_SEL_IDX](#)
- [NO_CFG](#)
- [LSAD_SPECIAL_CFG_ARR_LENGTH](#)
- [LSAD_SPECIAL_CFG_ARR_WIDTH](#)
- [LSAD_OCCUPIED_INPUT_ARR_WIDTH](#)
- [USER_CFG_IDX](#)
- [POS_SEL_SPEC_IDX](#)
- [NEG_SEL_SPEC_IDX](#)
- [SEL_IDX_SHIFT_DEF](#)
- [LSAD_CH_NUM](#)
- [LSAD_INPUTS_NUM](#)
- [OCCUPIED](#)
- [NOT_OCCUPIED](#)
- [EVEN_GPIO_NUM](#)
- [ODD_GPIO_NUM](#)
- [OCC_STATE_IDX](#)
- [EVENODD_IDX](#)
- [INPUT_MASK_IDX](#)
- [NEG_INPUTSEL_START](#)
- [POS_INPUTSEL_START](#)

RSL15 Firmware Reference

Functions

- [Sys LSAD Gain Offset](#) : Convert a gain and offset value from NVR in integer format to float format.
- [Sys LSAD TempSensor Gain Offset](#) : Convert a gain and offset value from NVR in integer format to float format for the temperature sensor.
- [Sys LSAD TrimsInit](#) : Loads ATE trim values specific to the LSAD.
- [Sys LSAD ModeConfig](#) : Configure the LSAD to use either normal or continuous mode.
- [Sys LSAD AlarmConfig](#) : Configure the LSAD monitor alarm.
- [Sys LSAD InterruptEnable](#) : Sets LSAD interrupt to occur on conversion of the selected channel.
- [Sys LSAD Start](#) : Start LSAD measurements at the frequency determined by the specified prescale.
- [Sys LSAD Stop](#) : Stop LSAD measurements.
- [Sys LSAD InputConfig](#) : Configure LSAD channel inputs.
- [Sys LSAD Special InputConfig](#) : Read special LSAD configuration from the LSAD_SpecialCfg array.
- [Sys LSAD PreSelectWrite](#) : Set LSAD->PRE_SEL_INPUT and return configuration which is written to LSAD->INPUT_SEL[channel].
- [Sys LSAD GPIO InputConfig](#) : This function reads GPIO configuration from LSAD_GPIOCfg array.
- [Sys LSAD GetRawData](#) : Obtain the latest data from the DATA_TRIM_CH register.
- [Sys LSAD ConvertToMVUntrimmed](#) : Convert data from DATA_TRIM_CH to millivolts using calibrated trim data.
- [Sys LSAD ConvertToMVTrimmed](#) : Convert data from DATA_TRIM_CH to millivolts without using calibrated trim data.
- [Sys LSAD NewSampleClear](#) : Clears the ready bit from the MONITOR_STATUS register to acknowledge the most recent LSAD sample and indicate that the next sample will not cause an overrun.

16.14.2 LSAD Typedef Documentation

16.14.2.1 lsad_io_t

```
typedef enum lsad_io lsad_io_t
```

Location: lsad.h:163

16.14.2.2 lsad_in_t

```
typedef enum lsad_pol lsad_in_t
```

Location: lsad.h:169

16.14.2.3 lsad_channel_t

```
typedef enum lsad_channel lsad_channel_t
```

Location: lsad.h:181

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16.14.2.4 lsad_prescale_t

```
typedef enum lsad_prescale lsad_prescale_t
```

Location: lsad.h:200

16.14.2.5 lsad_mode_t

```
typedef enum lsad_mode lsad_mode_t
```

Location: lsad.h:206

16.14.3 LSAD Data Structures Type Documentation**16.14.3.1 F_LSAD_TRIM**

Location: lsad.h:117

LSAD structure for offset/gain conversion function.

Data Fields

Type	Name	Description
float	<i>lf_offset</i>	Low frequency LSAD offset.
float	<i>hf_offset</i>	High frequency LSAD offset.
float	<i>lf_gain</i>	Low frequency LSAD gain.
float	<i>hf_gain</i>	High frequency LSAD gain.

16.14.4 LSAD Enumeration Type Documentation**16.14.4.1 lsad_io**

Location: lsad.h:133

Members

- LSAD_GPIO0_CFG = 0U
- LSAD_GPIO1_CFG = 1U
- LSAD_GPIO2_CFG = 2U
- LSAD_GPIO3_CFG = 3U
- LSAD_GPIO4_CFG = 4U
- LSAD_GPIO5_CFG = 5U
- LSAD_GPIO6_CFG = 6U
- LSAD_GPIO7_CFG = 7U
- LSAD_GPIO8_CFG = 8U
- LSAD_GPIO9_CFG = 9U
- LSAD_GPIO10_CFG = 10U
- LSAD_GPIO11_CFG = 11U
- LSAD_GPIO12_CFG = 12U
- LSAD_GPIO13_CFG = 13U
- LSAD_GPIO14_CFG = 14U
- LSAD_GPIO15_CFG = 15U
- LSAD_GROUND_CFG = 17U
- LSAD_AOUT_CFG = 18U
- LSAD_TEMP_CFG = 19U
- LSAD_VBAT_CFG = 20U
- LSAD_NOT_USED_CFG = LSAD_VBAT_CFG

16.14.4.2 lsad_pol

Location: lsad.h:165

Members

- NEG_IN
- POS_IN

16.14.4.3 lsad_channel

Location: lsad.h:171

Members

- LSAD_INPUT_CH0 = 0
- LSAD_INPUT_CH1 = 1
- LSAD_INPUT_CH2 = 2
- LSAD_INPUT_CH3 = 3
- LSAD_INPUT_CH4 = 4
- LSAD_INPUT_CH5 = 5
- LSAD_INPUT_CH6 = 6
- LSAD_INPUT_CH7 = 7

16.14.4.4 lsad_prescale

Location: lsad.h:183

Members

- LSAD_PS_200 = LSAD_PRESCALE_200
- LSAD_PS_400 = LSAD_PRESCALE_400
- LSAD_PS_640 = LSAD_PRESCALE_640
- LSAD_PS_800 = LSAD_PRESCALE_800
- LSAD_PS_1600 = LSAD_PRESCALE_1600

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- LSAD_PS_3200 = LSAD_PRESCALE_3200
- LSAD_PS_6400 = LSAD_PRESCALE_6400
- LSAD_PS_20H = LSAD_PRESCALE_20H
- LSAD_PS_40H = LSAD_PRESCALE_40H
- LSAD_PS_80H = LSAD_PRESCALE_80H
- LSAD_PS_128H = LSAD_PRESCALE_128H
- LSAD_PS_160H = LSAD_PRESCALE_160H
- LSAD_PS_320H = LSAD_PRESCALE_320H
- LSAD_PS_640H = LSAD_PRESCALE_640H
- LSAD_PS_1280H = LSAD_PRESCALE_1280H

16.14.4.5 lsad_mode

Location: lsad.h:202

Members

- LSAD_MODE_NORMAL = LSAD_NORMAL
- LSAD_MODE_CONTINUOUS = LSAD_CONTINUOUS

16.14.5 LSAD Macro Definition Documentation

16.14.5.1 LSAD_BIT_RES

```
#define LSAD_BIT_RES (14U)
```

Converts a raw ADC value to a voltage, calculated as follows $\text{voltage} = \text{adc_val} * (2 \text{ V} * 1000 \text{ [mV]}/1 \text{ V} / 2^{14} \text{ steps.})$

Location: lsad.h:54

Return

The voltage output in mV

Assumptions

Low frequency mode for the ADC is used, meaning that the resolution of the ADC is 14-bits. CONVERT provides voltage level as a milliVolt value based on the input ADC value.

16.14.5.2 RES_15BIT

```
#define RES_15BIT (32768.0f)
```

Location: lsad.h:56

16.14.5.3 RES_16BIT

```
#define RES_16BIT (65536.0f)
```

Location: lsad.h:58

16.14.5.4 V_REF_DIFF_MV

```
#define V_REF_DIFF_MV (1000)
```

Location: lsad.h:60

16.14.5.5 RESOLUTION_DIV

```
#define RESOLUTION_DIV ((x) >> (LSAD\_BIT\_RES - 1))
```

Location: lsad.h:64

16.14.5.6 ADC_VAL_MV

```
#define ADC_VAL_MV ((int32_t)RESOLUTION_DIV((x) * V_REF_DIFF_MV))
```

Location: lsad.h:68

16.14.5.7 LSAD_OFFSET_ERROR_CONV_QUOTIENT

```
#define LSAD_OFFSET_ERROR_CONV_QUOTIENT (RES_15BIT)
```

Location: lsad.h:72

16.14.5.8 LSAD_GAIN_ERROR_CONV_QUOTIENT

```
#define LSAD_GAIN_ERROR_CONV_QUOTIENT (RES_16BIT)
```

Location: lsad.h:74

16.14.5.9 ERROR_LSAD_INPUT_CFG

```
#define ERROR_LSAD_INPUT_CFG (0x80)
```

Location: lsad.h:77

16.14.5.10 PRE_SEL_SIZE

```
#define PRE_SEL_SIZE (4)
```

Location: lsad.h:79

16.14.5.11 LSAD_CFG_ARR_LENGTH

```
#define LSAD_CFG_ARR_LENGTH (32U)
```

Location: lsad.h:82

16.14.5.12 LSAD_CFG_ARR_WIDTH

```
#define LSAD_CFG_ARR_WIDTH (5U)
```

Location: lsad.h:83

16.14.5.13 GPIO_IDX

```
#define GPIO_IDX (0U)
```

Location: lsad.h:84

16.14.5.14 IO_CFG_IDX

```
#define IO_CFG_IDX (1U)
```

Location: lsad.h:85

16.14.5.15 MASK_IDX

```
#define MASK_IDX (2U)
```

Location: lsad.h:86

16.14.5.16 POS_SEL_IDX

```
#define POS_SEL_IDX (3U)
```

Location: lsad.h:87

16.14.5.17 NEG_SEL_IDX

```
#define NEG_SEL_IDX (4U)
```

Location: lsad.h:88

16.14.5.18 NO_CFG

```
#define NO_CFG (0xFF)
```

Location: lsad.h:89

16.14.5.19 LSAD_SPECIAL_CFG_ARR_LENGTH

```
#define LSAD_SPECIAL_CFG_ARR_LENGTH (4U)
```

Location: lsad.h:91

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16.14.5.20 LSAD_SPECIAL_CFG_ARR_WIDTH

```
#define LSAD_SPECIAL_CFG_ARR_WIDTH (3U)
```

Location: lsad.h:92

16.14.5.21 LSAD_OCCUPIED_INPUT_ARR_WIDTH

```
#define LSAD_OCCUPIED_INPUT_ARR_WIDTH (3U)
```

Location: lsad.h:93

16.14.5.22 USER_CFG_IDX

```
#define USER_CFG_IDX (0U)
```

Location: lsad.h:94

16.14.5.23 POS_SEL_SPEC_IDX

```
#define POS_SEL_SPEC_IDX (1U)
```

Location: lsad.h:95

16.14.5.24 NEG_SEL_SPEC_IDX

```
#define NEG_SEL_SPEC_IDX (2U)
```

Location: lsad.h:96

16.14.5.25 SEL_IDX_SHIFT_DEF

```
#define SEL_IDX_SHIFT_DEF (15U)
```

Location: lsad.h:98

16.14.5.26 LSAD_CH_NUM

```
#define LSAD_CH_NUM (8U)
```

Location: lsad.h:100

16.14.5.27 LSAD_INPUTS_NUM

```
#define LSAD_INPUTS_NUM (4U)
```

Location: lsad.h:102

16.14.5.28 OCCUPIED

```
#define OCCUPIED (1U)
```

Location: lsad.h:104

16.14.5.29 NOT_OCCUPIED

```
#define NOT_OCCUPIED (0U)
```

Location: lsad.h:105

16.14.5.30 EVEN_GPIO_NUM

```
#define EVEN_GPIO_NUM (0U)
```

Location: lsad.h:107

16.14.5.31 ODD_GPIO_NUM

```
#define ODD_GPIO_NUM (1U)
```

Location: lsad.h:108

16.14.5.32 OCC_STATE_IDX

```
#define OCC_STATE_IDX (2U)
```

Location: lsad.h:109

16.14.5.33 EVENODD_IDX

```
#define EVENODD_IDX (1U)
```

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Location: lsad.h:110

16.14.5.34 INPUT_MASK_IDX

```
#define INPUT_MASK_IDX 0U
```

Location: lsad.h:111

16.14.5.35 NEG_INPUTSEL_START

```
#define NEG_INPUTSEL_START (1U)
```

Location: lsad.h:113

16.14.5.36 POS_INPUTSEL_START

```
#define POS_INPUTSEL_START (0U)
```

Location: lsad.h:114

16.14.6 LSAD Function Documentation

16.14.6.1 Sys_LSAD_Gain_Offset

```
void Sys_LSAD_Gain_Offset(const volatile struct LSAD_TRIM * i_gain_offset, struct F\_LSAD\_TRIM * f_gain_offset)
```

Convert a gain and offset value from NVR in integer format to float format.

Location: lsad.h:220

Parameters

Direction	Name	Description
in	<i>i_gain_offset</i>	Gain and offset error from NVR, raw integer form
out	<i>f_gain_offset</i>	Gain and offset error converted to floating point.

RSL15 Firmware Reference

Example Code for Sys_LSAD_Gain_Offset

```
// Convert gain and offset values in integer format to floating point values
// used in compensation for LSAD measurements. Low frequency and high frequency
// values are converted.
F_LSAD_TRIM f_gain_offset[1];
Sys_LSAD_Gain_Offset(&(trim_region->temp_sensor), &(f_gain_offset[0]));
```

16.14.6.2 Sys_LSAD_TempSensor_Gain_Offset

```
void Sys_LSAD_TempSensor_Gain_Offset(const volatile struct TEMP_SENSOR_TRIM * i_gain_
offset, struct F_LSAD_TRIM * f_gain_offset)
```

Convert a gain and offset value from NVR in integer format to float format for the temperature sensor.

Location: lsad.h:242

Parameters

Direction	Name	Description
in	<i>i_gain_offset</i>	Gain and offset error from NVR, raw integer form
out	<i>f_gain_offset</i>	Gain and offset error converted to floating point.

Example Code for Sys_LSAD_TempSensor_Gain_Offset

```
// Convert gain and offset values in integer format to floating point values
// used in compensation of measurements for the temperature sensor. Only low
// frequency values are converted.
F_LSAD_TRIM f_gain_offset[1];
Sys_LSAD_TempSensor_Gain_Offset(&(trim_region->temp_sensor), &(f_gain_offset[0]));
```

16.14.6.3 Sys_LSAD_TrimsInit

```
void Sys_LSAD_TrimsInit()
```

Loads ATE trim values specific to the LSAD.

Location: lsad.h:257

Example Code for Sys_LSAD_TrimsInit

```
// Initialize the LSAD with calibrated trim values.
Sys_LSAD_TrimsInit();
```

16.14.6.4 Sys_LSAD_ModeConfig

```
void Sys_LSAD_ModeConfig(lsad_mode_t mode)
```

Configure the LSAD to use either normal or continuous mode.

Location: lsad.h:264

Parameters

Direction	Name	Description
in	<i>mode</i>	Either normal (sample all channels) or continuous (sample one channel)

Example Code for Sys_LSAD_ModeConfig

```
// Configure the LSAD to normal mode, where the LSAD converts channels.
Sys_LSAD_ModeConfig(LSAD_MODE_NORMAL);
```

16.14.6.5 Sys_LSAD_AlarmConfig

```
void Sys_LSAD_AlarmConfig(lsad_channel_t channel, uint8_t threshold, uint8_t count)
```

Configure the LSAD monitor alarm.

RSL15 Firmware Reference

Location: lsad.h:274

Parameters

Direction	Name	Description
in	<i>channel</i>	The LSAD channel on which to enable the alarm
in	<i>threshold</i>	The value below which the alarm should be triggered. The values 0-255 are linearly mapped to 0-2 V with a step size of 7.8 mV.
in	<i>count</i>	The number of readings below the threshold needed to trigger the alarm

Example Code for Sys_LSAD_AlarmConfig

```
// Configure the LSAD to trigger the monitor alarm when the voltage on channel 0
// drops below the value encoded in ALARM_THRESHOLD for ALARM_
COUNT number of samples.
Sys_LSAD_AlarmConfig(LSAD_INPUT_CH0, ALARM_THRESHOLD, ALARM_COUNT);
```

16.14.6.6 Sys_LSAD_InterruptEnable

```
void Sys_LSAD_InterruptEnable(lsad_channel_t IRQ_channel)
```

Sets LSAD interrupt to occur on conversion of the selected channel.

Location: lsad.h:282

Parameters

Direction	Name	Description
in	<i>IRQ_channel</i>	The channel after which to interrupt. In continuous mode, this is the only channel sampled.

RSL15 Firmware Reference

Example Code for Sys_LSAD_InterruptEnable

```
// Enable LSAD interrupt, set to trigger after sampling channel LSAD_IRQ_
CHANNEL by default.
// It can be configured to a different channel in app.h of the LSAD sample.
Sys\_LSAD\_InterruptEnable(LSAD_IRQ_CHANNEL);
```

16.14.6.7 Sys_LSAD_Start

```
void Sys_LSAD_Start(lsad_prescale_t prescale)
```

Start LSAD measurements at the frequency determined by the specified prescale.

Location: lsad.h:289

Parameters

Direction	Name	Description
in	<i>prescale</i>	The prescale setting used to derive the LSAD sampling frequency

Example Code for Sys_LSAD_Start

```
// Start LSAD measurements with the frequency determined by prescale value.
Sys\_LSAD\_Start(LSAD_PRESCALE);
```

16.14.6.8 Sys_LSAD_Stop

```
void Sys_LSAD_Stop()
```

Stop LSAD measurements.

Location: lsad.h:295

Example Code for Sys_LSAD_Stop

```
// Stop LSAD measurements
Sys_LSAD_Stop();
```

16.14.6.9 Sys_LSAD_InputConfig

```
uint32_t Sys_LSAD_InputConfig(lsad_channel_t channel, lsad_io_t pos_io, lsad_io_t neg_io)
```

Configure LSAD channel inputs.

Location: lsad.h:306

Parameters

Direction	Name	Description
in	<i>channel</i>	The LSAD channel to configure
in	<i>pos_io</i>	The signal to connect to the positive input of the channel
in	<i>neg_io</i>	The signal to connect to the negative input of the channel

Return

Resulting input selection register

Example Code for Sys_LSAD_InputConfig

```
// Use LSAD channel 0.
// Set LSAD positive source to GPIO13.
// Set LSAD negative source to Ground.
Sys_LSAD_InputConfig(LSAD_INPUT_CH0, LSAD_GPIO13_CFG, LSAD_GROUND_CFG);
```

16.14.6.10 Sys_LSAD_Special_InputConfig

```
uint8_t Sys_LSAD_Special_InputConfig(lsad_io_t gpio)
```

Read special LSAD configuration from the LSAD_SpecialCfg array.

Location: lsad.h:314

Parameters

Direction	Name	Description
in	<i>gpio</i>	The signal to compare with special LSAD input values

Return

The corresponding LSAD configuration

Example Code for Sys_LSAD_Special_InputConfig

```
// Get the positive input configurations of the LSAD.
lsad_io_t pos_io = LSAD_GPIO13_CFG;
uint8_t pos_lsad_cfg;
pos_lsad_cfg = Sys\_LSAD\_Special\_InputConfig(pos_io);
```

16.14.6.11 Sys_LSAD_PreSelectWrite

```
uint32_t Sys_LSAD_PreSelectWrite(uint8_t cfg, lsad_io_t gpio, lsad_in_t input_type)
```

Set LSAD->PRE_SEL_INPUT and return configuration which is written to LSAD->INPUT_SEL[channel].

Location: lsad.h:326

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>cfg</i>	The LSAD configuration returned from Sys_LSAD_InputConfig()
in	<i>gpio</i>	The signal to be configured as an LSAD input
in	<i>input_type</i>	Specifies if the signal should be connected to the positive or negative input

Return

The configuration data for the input selection register

Example Code for Sys_LSAD_PreSelectWrite

```
// Set the LSAD pre-selection register to positive input and return the
// configuration that should be written to LSAD->INPUT_SEL[channel].
uint32_t pos_sel;
pos_sel = Sys\_LSAD\_PreSelectWrite(pos_lsad_cfg, pos_io, POS_IN);
```

16.14.6.12 Sys_LSAD_GPIO_InputConfig

```
uint8_t Sys_LSAD_GPIO_InputConfig(lsad_io_t gpio)
```

This function reads GPIO configuration from LSAD_GPIOCfg array.

Location: lsad.h:335

Parameters

Direction	Name	Description
in	<i>gpio</i>	The signal to compare with gpio numbers

Return

lsad_conf

Example Code for Sys_LSAD_GPIO_InputConfig

```
// Get the GPIO configuration of the specified GPIO (13).
lsad_io_t gpio = LSAD_GPIO13_CFG;
cfg = Sys\_LSAD\_GPIO\_InputConfig(gpio);
```

16.14.6.13 Sys_LSAD_GetRawData

```
uint32_t Sys_LSAD_GetRawData(lsad_channel_t channel)
```

Obtain the latest data from the DATA_TRIM_CH register.

Location: lsad.h:344

Parameters

Direction	Name	Description
in	<i>channel</i>	The LSAD channel from which to obtain data

Return

The obtained data

Example Code for Sys_LSAD_GetRawData

```
// Sum the incoming LSAD data to be averaged later.
static int32_t raw_LSAD_sum[NUM_LSAD_CHANNELS_USED] = {0};
for(uint8_t chn = 0; chn < NUM_LSAD_CHANNELS_USED; chn++)
{
    raw_LSAD_sum[chn] += Sys\_LSAD\_GetRawData((lsad_channel_t)chn);
}
```

16.14.6.14 Sys_LSAD_ConvertToMVUntrimmed

```
uint32_t Sys_LSAD_ConvertToMVUntrimmed(uint32_t raw_data)
```

Convert data from DATA_TRIM_CH to millivolts using calibrated trim data.

Location: lsad.h:353

Parameters

Direction	Name	Description
in	<i>raw_data</i>	The value obtained from DATA_TRIM_CH

Return

The converted data

Example Code for Sys_LSAD_ConvertToMVUntrimmed

```
// Process the averaged data without calibrated trim values.
int32_t lsad_mv_raw = Sys\_LSAD\_ConvertToMVUntrimmed(raw_LSAD_avg);
```

16.14.6.15 Sys_LSAD_ConvertToMVTrimmed

```
int32_t Sys_LSAD_ConvertToMVTrimmed(uint32_t raw_data)
```

Convert data from DATA_TRIM_CH to millivolts without using calibrated trim data.

Location: lsad.h:362

Parameters

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Direction	Name	Description
in	<i>raw_data</i>	The value obtained from DATA_TRIM_CH

Return

The converted data

Example Code for Sys_LSAD_ConvertToMVTrimmed

```
// Process the averaged data with calibrated trim values.
int32_t lsad_mv_calib = Sys\_LSAD\_ConvertToMVTrimmed(raw_LSAD_avg);
```

16.14.6.16 Sys_LSAD_NewSampleClear

```
void Sys_LSAD_NewSampleClear()
```

Clears the ready bit from the MONITOR_STATUS register to acknowledge the most recent LSAD sample and indicate that the next sample will not cause an overrun.

Location: lsad.h:370

Example Code for Sys_LSAD_NewSampleClear

```
// Clear LSAD ready bit, indicating LSAD data has been processed so
// the next conversion completion will not cause an overrun.
Sys\_LSAD\_NewSampleClear();
```

16.15 NESTED VECTORED INTERRUPT CONTROLLER

Nested Vectored Interrupt Controller (NVIC) hardware abstraction layer.

16.15.1 Summary

Functions

- [Sys_NVIC_DisableAllInt](#) : Disable all external interrupts.
- [Sys_NVIC_ClearAllPendingInt](#) : Clear the pending status for all external interrupts.

16.15.2 Nested Vectored Interrupt Controller Function Documentation**16.15.2.1 Sys_NVIC_DisableAllInt**

```
__STATIC_INLINE void Sys_NVIC_DisableAllInt()
```

Disable all external interrupts.

Location: nvic.h:42

Example Code for Sys_NVIC_DisableAllInt

```
// Disable all external interrupts  
Sys\_NVIC\_DisableAllInt();
```

16.15.2.2 Sys_NVIC_ClearAllPendingInt

```
__STATIC_INLINE void Sys_NVIC_ClearAllPendingInt()
```

Clear the pending status for all external interrupts.

Location: nvic.h:53

Example Code for Sys_NVIC_ClearAllPendingInt

```
// Clear all pending external interrupts  
Sys\_NVIC\_ClearAllPendingInt();
```

16.16 POWER SUPPLY

Power supply hardware abstraction layer.

16.16.1 Summary**Macros**

- [ACS_VCC_CTRL_REGULATOR_Mask](#)

Functions

- [Sys_Power_SetVCCRegulator](#) : Select VCC power regulator (Buck or LD)
- [Sys_Power_RFEnable](#) : RF Power Switch and Isolation.
- [Sys_Power_CC312_Enable](#) : CryptoCell312 Power Enable.
- [Sys_Power_CC312_Disable](#) : CryptoCell312 Power Disable.
- [Sys_Power_CC312AO_Enable](#) : CryptoCell312AO Power Switch and Isolation.
- [Sys_Power_CC312AO_Disable](#) : CryptoCell312AO Power Switch and Isolation.
- [Sys_Power_FPU_Enable](#) : Enable the FPU.
- [Sys_Power_FPU_Disable](#) : Disable the FPU.

16.16.2 Power Supply Macro Definition Documentation**16.16.2.1 ACS_VCC_CTRL_REGULATOR_Mask**

```
#define ACS_VCC_CTRL_REGULATOR_Mask ((uint32_t) (0x1U << ACS_VCC_CTRL_BUCK_ENABLE_Pos))
```

Location: power.h:41

16.16.3 Power Supply Function Documentation**16.16.3.1 Sys_Power_SetVCCRegulator**

```
void Sys_Power_SetVCCRegulator()
```

Select VCC power regulator (Buck or LD)

Location: power.h:47

Example Code for Sys_Power_SetVCCRegulator**16.16.3.2 Sys_Power_RFEnable**

```
void Sys_Power_RFEnable()
```

RF Power Switch and Isolation.

Location: power.h:77

Example Code for Sys_Power_RFEnable

```
// Enable RF power switches, remove RF Isolation  
Sys\_Power\_RFEnable\(\);
```

16.16.3.3 Sys_Power_CC312_Enable

```
void Sys_Power_CC312_Enable()
```

CryptoCell312 Power Enable.

Location: power.h:99

Example Code for Sys_Power_CC312_Enable

```
// Enable the CryptoCell block and remove its power isolation.  
Sys\_Power\_CC312\_Enable\(\);
```

16.16.3.4 Sys_Power_CC312_Disable

```
void Sys_Power_CC312_Disable()
```

CryptoCell312 Power Disable.

Location: power.h:123

Example Code for Sys_Power_CC312_Disable

```
// Disable and isolate power for the CryptoCell block.  
Sys\_Power\_CC312\_Disable();
```

16.16.3.5 Sys_Power_CC312AO_Enable

```
void Sys_Power_CC312AO_Enable()
```

CryptoCell312AO Power Switch and Isolation.

Location: power.h:140

Example Code for Sys_Power_CC312AO_Enable

```
// Enable the CryptoCell block and remove its power isolation, and power  
// on the Always On (AO) component for the CryptoCell block.  
Sys\_Power\_CC312AO\_Enable();
```

16.16.3.6 Sys_Power_CC312AO_Disable

```
void Sys_Power_CC312AO_Disable()
```

CryptoCell312AO Power Switch and Isolation.

Location: power.h:165

Example Code for Sys_Power_CC312AO_Disable

```
// Disable and isolate power for the CryptoCell block, and power off the  
// Always On (AO) component for the CryptoCell block.  
Sys\_Power\_CC312AO\_Disable\(\);
```

16.16.3.7 Sys_Power_FPU_Enable

```
void Sys_Power_FPU_Enable()
```

Enable the FPU.

Location: power.h:188

Example Code for Sys_Power_FPU_Enable

```
// Enables the FPU and removes its isolation.  
Sys\_Power\_FPU\_Enable\(\);
```

16.16.3.8 Sys_Power_FPU_Disable

```
uint32_t Sys_Power_FPU_Disable()
```

Disable the FPU.

Location: power.h:223

Return

FPU_Q_ACCEPTED if the FPU power down was successful. FPU_Q_DENIED if the FPU power down failed or if the FPU is already off.

Example Code for Sys_Power_FPU_Disable

```
// Disables and isolates the FPU.
result = Sys_Power_FPU_Disable();
```

16.17 HAL POWER MODES**16.17.1 Summary****Typedefs**

- [AppResumeAddress t](#) : Function pointer for the application return address.
- [AppPeripheralFunc t](#) : Function pointer for the peripheral reconfiguration addresses.

Variables

- [app_lowpower_mode_cfg](#) : Default low-power system configuration.

Data Structures

- [RetentionRegCfg t](#) : Sleep Mode retention regulator configuration.
- [StandbyTrimCfg t](#) : Standby Mode retention regulator configuration.
- [ClockCfg t](#) : Run Mode clock configuration.
- [LowPowerModeCfg t](#) : Power Mode configuration.

Enumerations

- [PowerMode t](#) : Power Mode options available for the system.
- [RetentionType t](#) : Retention options available for Sleep Mode.

Macros

- [POWER_MODES_BLE_NOT_PRESENT](#) : Options to set if the application makes use of Bluetooth.
- [POWER_MODES_BLE_PRESENT](#)
- [VDDT_RETENTION_DISABLE](#) : VDDT baseband retention regulator options.
- [VDDT_RETENTION_ENABLE](#)
- [VDDC_RETENTION_DISABLE](#) : VDDC core digital retention regulator options.
- [VDDC_RETENTION_ENABLE](#)
- [VDDM_RETENTION_TRIM_PRESET](#) : Sleep retention regulator configuration presets.
- [VDDT_RETENTION_ENABLE_PRESET](#)
- [VDDC_RETENTION_TRIM_PRESET](#)
- [VDDACS_RETENTION_TRIM_PRESET](#)

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- [WAKEUP_CTRL_FLAGS_TO_CLEAR_BITS](#) : Convert wakeup flags to clear bits.
- [WAKEUP_ALL_FLAGS_CLEAR](#) : Clear all of the sticky wakeup flags.
- [WAKEUP_GPIO0_FLAG_CLEAR](#) : Clear sticky wakeup flags.
- [WAKEUP_GPIO1_FLAG_CLEAR](#)
- [WAKEUP_GPIO2_FLAG_CLEAR](#)
- [WAKEUP_GPIO3_FLAG_CLEAR](#)
- [WAKEUP_BB_TIMER_FLAG_CLEAR](#)
- [WAKEUP_RTC_ALARM_FLAG_CLEAR](#)
- [WAKEUP_RTC_CLOCK_FLAG_CLEAR](#)
- [WAKEUP_RTC_OVERFLOW_FLAG_CLEAR](#)
- [WAKEUP_DCDC_OVERLOAD_FLAG_CLEAR](#)
- [WAKEUP_ACOMP_FLAG_CLEAR](#)
- [WAKEUP_FIFO_FULL_FLAG_CLEAR](#)
- [WAKEUP_THRESHOLD_FULL_FLAG_CLEAR](#)

Functions

- [Sys PowerModes SetWakeupConfig](#) : Set up the wakeup configuration.
- [Sys PowerModes EnableWakeupSources](#) : Enable one or more wakeup sources.
- [Sys PowerModes DisableWakeupSources](#) : Disable one or more wakeup sources.
- [Sys PowerModes EnterPowerMode](#) : Enter a low-power mode based on the provided configuration.
- [Sys PowerModes WakeupWithReset](#) : Wakeup from flash after a sleep reset.
- [Sys PowerModes IdleUntilBBWake](#) : Place the system into Idle Mode until the baseband is awake.

16.17.2 HAL Power Modes Typedef Documentation

16.17.2.1 AppResumeAddress_t

```
typedef void(* AppResumeAddress_t
```

Location: power_modes.h:231

Function pointer for the application return address.

A pointer used in the [LowPowerModeCfg_t](#) configuration structure to store the address of an application-level function that the system will resume from once the wakeup process has completed.

NOTE: This address is only applicable when using Sleep Mode with memory retention selected.

16.17.2.2 AppPeripheralFunc_t

```
typedef void(* AppPeripheralFunc_t
```

RSL15 Firmware Reference

Location: power_modes.h:242

Function pointer for the peripheral reconfiguration addresses.

A pointer used in the configuration structure ([LowPowerModeCfg_t](#)) to store the address of an application-level save function and restore function that are called when entering and exiting a low-power mode, respectively. The user must define and assign the functions to reconfigure any required peripherals (e.g. GPIO, LSAD, interrupts, etc.).

16.17.3 HAL Power Modes Variable Documentation

16.17.3.1 app_lowpower_mode_cfg

`LowPowerModeCfg_t app_lowpower_mode_cfg`

Location: power_modes.h:381

Default low-power system configuration.

An instance of the low-power configuration structure containing default low-power and wakeup settings that can be used by the application.

NOTE: Before using this configuration, function pointers should be provided to ensure peripherals are properly saved/restored and the application is resumed. The defaults provided here may not work with all Power Mode and Retention Type combinations. Values should be modified as needed.

16.17.4 HAL Power Modes Data Structures Type Documentation

16.17.4.1 RetentionRegCfg_t

Location: power_modes.h:251

Sleep Mode retention regulator configuration.

A structure that is used within the [LowPowerModeCfg_t](#) configuration structure to set the power retention regulator settings (i.e trimming values) desired for the application when using Sleep Mode.

RSL15 Firmware Reference

Data Fields

Type	Name	Description
uint8_t	<i>vddm_ret_trim</i>	VDDM retention trimming value; use VDDM_RETENTION_TRIM_[MINIMUM TYPICAL MAXIMUM].
uint8_t	<i>vddt_ret</i>	VDDT baseband timer regulator retention; use VDDT_RETENTION_[ENABLE DISABLE].
uint8_t	<i>vddacs_ret_trim</i>	VDDACS retention trimming value; use VDDACS_RETENTION_TRIM_[MINIMUM TYPICAL MAXIMUM].
uint8_t	<i>vddc_ret_trim</i>	VDDC retention trimming value; use VDDC_RETENTION_TRIM_[MINIMUM TYPICAL MAXIMUM].
uint8_t	<i>vddc_ret_en</i>	VDDC core digital regulator retention; use VDDC_RETENTION_[ENABLE DISABLE].

16.17.4.2 StandbyTrimCfg_t

Location: power_modes.h:272

Standby Mode retention regulator configuration.

A structure that is used within the [LowPowerModeCfg_t](#) configuration structure to set the regulator settings (i.e. trimming values) desired for the application when using Standby Mode.

Data Fields

Type	Name	Description
uint8_t	<i>vddc_standby_trim</i>	VDDC standby trimming value; use 0x00 to 0x3F.
uint8_t	<i>vddm_standby_trim</i>	VDDM standby trimming value; use 0x00 to 0x3F.

16.17.4.3 ClockCfg_t

Location: power_modes.h:283

Run Mode clock configuration.

RSL15 Firmware Reference

A structure that is used to set the clock frequencies for the system to use while in Run Mode.

Data Fields

Type	Name	Description
uint32_t	<i>systemclk_freq</i>	System clock frequency value.
uint32_t	<i>uartclk_freq</i>	UART clock frequency derived from system clock.
uint32_t	<i>sensorclk_freq</i>	Sensor clock frequency value.
uint32_t	<i>userclk_freq</i>	User clock frequency.

16.17.4.4 LowPowerModeCfg_t

Location: power_modes.h:324

Power Mode configuration.

A structure that is used to set the desired configuration for entering and exiting a low-power mode. Includes the following: => Wakeup sources as set in the ACS_WAKEUP_CFG register. => Boot configuration as set in the ACS_BOOT_CFG register. BOOT_CUSTOM should only be used in Sleep Mode with memory retention. => The Bluetooth present flag that indicates if the application is using the Bluetooth Low-Energy stack. => The DMA channel to use when entering/exiting a low-power mode. Only used if Sleep or Standby Mode is used with the Bluetooth present flag is set. => Power Mode that the system should enter when called upon. See PowerMode_t for details on available modes. => Retention type that should be used if entering Sleep Mode. => Clock configuration used to reconfigure the clocks after wake up. => Power retention regulator configuration used to update the ACS_VDDRET_CTRL register trim values. Only used in Sleep Mode. => Configuration used to update the standby voltage trim in the ACS_VDDM_CTRL and ACS_VDDC_CTRL registers. Only used in Standby Mode. => Pointers to user-defined functions that are used to save and restore the configuration for the peripherals (e.g. GPIO, LSAD, GPIO interrupts) used by the application. => A pointer to a user-defined function that the system will resume execution after waking up. Only used in Sleep Mode with memory retention.

Data Fields

RSL15 Firmware Reference

Type	Name	Description
uint32_t	<i>wakeup_cfg</i>	Use any combination of WAKEUP_DELAY_[1 2 4 ... 128], WAKEUP_DCDC_OVERLOAD_[ENABLE DISABLE], WAKEUP_GPIO*_[RISING FALLING], WAKEUP_GPIO*_[ENABLE DISABLE], WAKEUP_FIFO_[ENABLE DISABLE], WAKEUP_RTC_OVERFLOW_[ENABLE DISABLE]
uint32_t	<i>boot_cfg</i>	Use BOOT_CUSTOM, BOOT_FLASH_XTAL_DISABLE, BOOT_FLASH_XTAL_DEFAULT_TRIM, BOOT_FLASH_XTAL_CUSTOM_TRIM.
bool	<i>ble_present_flag</i>	Indicate if Bluetooth stack is present.
uint8_t	<i>dma_channel_rf</i>	Use a value from 0 to 3.
PowerMode_t	<i>power_mode</i>	Use RUN_MODE, IDLE_MODE, STANDBY_MODE, SLEEP_MODE.
RetentionType_t	<i>retention_type</i>	Use NO_RETENTION, MEMORY_RETENTION, CORE_RETENTION.
ClockCfg_t	<i>clock_cfg</i>	Clock configuration.
RetentionRegCfg_t	<i>vddret_ctrl</i>	Sleep retention regulator configuration.
StandbyTrimCfg_t	<i>standby_trim</i>	Standby trim configuration.
AppPeripheralFunc_t	<i>p_save_peripherals</i>	Pointer to save configuration function.
AppPeripheralFunc_t	<i>p_restore_peripherals</i>	Pointer to reconfiguration function.
AppResumeAddress_t	<i>p_app_resume</i>	Function pointer to resume address.

16.17.5 HAL Power Modes Enumeration Type Documentation

16.17.5.1 PowerMode_t

Location: power_modes.h:201

Power Mode options available for the system.

This set of options is used to select which level of Power Mode the system should use when entering a low-power state. If RUN_MODE is selected, the system will avoid entering a low-power state. If IDLE_MODE is selected, the system will enter the ARM wait-for-interrupt (__WFI) state. If STANDBY_MODE or SLEEP_MODE is selected the system will attempt to enter the respective state.

Members

- RUN_MODE
- IDLE_MODE
- STANDBY_MODE
- SLEEP_MODE

16.17.5.2 RetentionType_t

Location: power_modes.h:215

Retention options available for Sleep Mode.

This set of options is used to select which type of retention (core, memory, or no retention) is desired for the application when entering Sleep Mode.

Members

- NO_RETENTION

Sleep with no retention.

- MEMORY_RETENTION

Sleep with memory retention only.

- CORE_RETENTION

Sleep with Core retention.

16.17.6 HAL Power Modes Macro Definition Documentation

16.17.6.1 POWER_MODES_BLE_NOT_PRESENT

```
#define POWER_MODES_BLE_NOT_PRESENT (false)
```

Options to set if the application makes use of Bluetooth.

These constants can be used to set the `ble_present` field of the configuration structure (

Location: `power_modes.h:60`

[LowPowerModeCfg_t](#)). By selecting `POWER_MODES_BLE_PRESENT`, certain RF and baseband registers will be saved before entering a low-power mode and restored after waking up. By selecting `POWER_MODES_BLE_NOT_PRESENT`, the RF and baseband registers will not be saved and restored.

16.17.6.2 POWER_MODES_BLE_PRESENT

```
#define POWER_MODES_BLE_PRESENT (true)
```

Location: `power_modes.h:61`

16.17.6.3 VDDT_RETENTION_DISABLE

```
#define VDDT_RETENTION_DISABLE (0x0U)
```

VDDT baseband retention regulator options.

These preset values can be used to set if the VDDT retention (`ACS_VDDRET_CTRL->VDDTRET_ENABLE`) should be enabled or disabled by setting the `vddret_ctrl.vddt_ret` field of the configuration structure (

Location: `power_modes.h:71`

[LowPowerModeCfg_t](#)) accordingly. When enabled, the baseband timer retention supply is powered.

16.17.6.4 VDDT_RETENTION_ENABLE

```
#define VDDT_RETENTION_ENABLE (0x1U)
```

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Location: power_modes.h:72

16.17.6.5 VDDC_RETENTION_DISABLE

```
#define VDDC_RETENTION_DISABLE (0x0U)
```

VDDC core digital retention regulator options.

These preset values can be used to set if the VDDC retention (ACS_VDDRET_CTRL->VDDCRET_ENABLE) should be enabled or disabled by setting the vddret_ctrl.vddc_ret_en field of the configuration structure (

Location: power_modes.h:85

[LowPowerModeCfg_t](#)) accordingly. When enabled, the core digital retention supply is powered. By default, this setting is enabled for Sleep Mode with Core Retention, and disabled for Sleep Mode with Memory Retention or No Retention.

16.17.6.6 VDDC_RETENTION_ENABLE

```
#define VDDC_RETENTION_ENABLE (0x1U)
```

Location: power_modes.h:86

16.17.6.7 VDDM_RETENTION_TRIM_PRESET

```
#define VDDM_RETENTION_TRIM_PRESET (0x01)
```

Sleep retention regulator configuration presets.

These preset values are used by the vddret_ctrl field of the

Location: power_modes.h:113

[LowPowerModeCfg_t](#) structure to configure the following retention regulators:

- VDDM retention regulator trim (ACS_VDDRET_CTRL->VDDMRET_VTRIM)
- VDDT baseband retention regulator enable (ACS_VDDRET_CTRL->VDDTRET_ENABLE)

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- VDDC retention regulator trim (ACS_VDDRET_CTRL->VDDCRET_VTRIM)
- VDDACS retention regulator trim (ACS_VDDRET_CTRL->VDDACS_VTRIM)

The preset values are selected based on the chosen product variant (automotive or industrial). The automotive variant requires greater preset values to support operation across its extended temperature range.

NOTE: If the baseband is not utilized in the application (e.g. Bluetooth is not used and the kernel timer is not used), the VDDT baseband retention regulator can be disabled to reduce power consumption by setting VDDT_RETENTION_ENABLE_PRESET to VDDT_RETENTION_DISABLE.

16.17.6.8 VDDT_RETENTION_ENABLE_PRESET

```
#define VDDT_RETENTION_ENABLE_PRESET VDDT_RETENTION_ENABLE
```

Location: power_modes.h:114

16.17.6.9 VDDC_RETENTION_TRIM_PRESET

```
#define VDDC_RETENTION_TRIM_PRESET (0x01)
```

Location: power_modes.h:115

16.17.6.10 VDDACS_RETENTION_TRIM_PRESET

```
#define VDDACS_RETENTION_TRIM_PRESET (0x03)
```

Location: power_modes.h:116

16.17.6.11 WAKEUP_CTRL_FLAGS_TO_CLEAR_BITS

```
#define WAKEUP_CTRL_FLAGS_TO_CLEAR_BITS ( ((x) >> 16) & 0x1F) \
| ((x) >> 21) & 0x0F) \
| ((x) >> 25) & 0x07) )
```

Convert wakeup flags to clear bits.

Converts the sticky flags of the ACS_WAKEUP_CTRL register into their respective clear bits for the register.

Location: power_modes.h:132

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	x	(uint32_t) The ACS_WAKEUP_CTRL wakeup flags to be converted.

Return

(uint32_t) The ACS_WAKEUP_CTRL clear flag bits.

16.17.6.12 WAKEUP_ALL_FLAGS_CLEAR

```
#define WAKEUP_ALL_FLAGS_CLEAR Sys ACS WriteRegister( \
                                &ACS->WAKEUP_CTRL, \
                                (uint32_t) (0xFFFF))
```

Clear all of the sticky wakeup flags.

A macro function to clear the sticky wakeup flags, for all of the wakeup event types, in the wakeup control register.

Location: power_modes.h:141

16.17.6.13 WAKEUP_GPIO0_FLAG_CLEAR

```
#define WAKEUP_GPIO0_FLAG_CLEAR Sys ACS WriteRegister( \
                                &ACS->WAKEUP_CTRL, \
                                WAKEUP_GPIO0_EVENT_CLEAR)
```

Clear sticky wakeup flags.

A set of macro functions for clearing specific sticky wakeup event flags in the wakeup control register.

Location: power_modes.h:150

16.17.6.14 WAKEUP_GPIO1_FLAG_CLEAR

```
#define WAKEUP_GPIO1_FLAG_CLEAR Sys ACS WriteRegister( \
                                &ACS->WAKEUP_CTRL, \
                                WAKEUP_GPIO1_EVENT_CLEAR)
```

RSL15 Firmware Reference

Location: power_modes.h:153

16.17.6.15 WAKEUP_GPIO2_FLAG_CLEAR

```
#define WAKEUP_GPIO2_FLAG_CLEAR Sys ACS WriteRegister( \
    &ACS->WAKEUP_CTRL, \
    WAKEUP_GPIO2_EVENT_CLEAR)
```

Location: power_modes.h:156

16.17.6.16 WAKEUP_GPIO3_FLAG_CLEAR

```
#define WAKEUP_GPIO3_FLAG_CLEAR Sys ACS WriteRegister( \
    &ACS->WAKEUP_CTRL, \
    WAKEUP_GPIO3_EVENT_CLEAR)
```

Location: power_modes.h:159

16.17.6.17 WAKEUP_BB_TIMER_FLAG_CLEAR

```
#define WAKEUP_BB_TIMER_FLAG_CLEAR Sys ACS WriteRegister( \
    &ACS->WAKEUP_CTRL, \
    WAKEUP_BB_TIMER_CLEAR)
```

Location: power_modes.h:162

16.17.6.18 WAKEUP_RTC_ALARM_FLAG_CLEAR

```
#define WAKEUP_RTC_ALARM_FLAG_CLEAR Sys ACS WriteRegister( \
    &ACS->WAKEUP_CTRL, \
    WAKEUP_RTC_ALARM_EVENT_CLEAR)
```

Location: power_modes.h:165

16.17.6.19 WAKEUP_RTC_CLOCK_FLAG_CLEAR

```
#define WAKEUP_RTC_CLOCK_FLAG_CLEAR Sys ACS WriteRegister( \
    &ACS->WAKEUP_CTRL, \
    WAKEUP_RTC_CLOCK_EVENT_CLEAR)
```

Location: power_modes.h:168

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16.17.6.20 WAKEUP_RTC_OVERFLOW_FLAG_CLEAR

```
#define WAKEUP_RTC_OVERFLOW_FLAG_CLEAR Sys ACS WriteRegister( \
    &ACS->WAKEUP_CTRL, \
    WAKEUP_RTC_OVERFLOW_EVENT_CLEAR)
```

Location: power_modes.h:171

16.17.6.21 WAKEUP_DCDC_OVERLOAD_FLAG_CLEAR

```
#define WAKEUP_DCDC_OVERLOAD_FLAG_CLEAR Sys ACS WriteRegister( \
    &ACS->WAKEUP_CTRL, \
    WAKEUP_DCDC_OVERLOAD_EVENT_CLEAR)
```

Location: power_modes.h:174

16.17.6.22 WAKEUP_ACOMP_FLAG_CLEAR

```
#define WAKEUP_ACOMP_FLAG_CLEAR Sys ACS WriteRegister( \
    &ACS->WAKEUP_CTRL, \
    WAKEUP_ACOMP_EVENT_CLEAR)
```

Location: power_modes.h:177

16.17.6.23 WAKEUP_FIFO_FULL_FLAG_CLEAR

```
#define WAKEUP_FIFO_FULL_FLAG_CLEAR Sys ACS WriteRegister( \
    &ACS->WAKEUP_CTRL, \
    WAKEUP_FIFO_FULL_EVENT_CLEAR)
```

Location: power_modes.h:180

16.17.6.24 WAKEUP_THRESHOLD_FULL_FLAG_CLEAR

```
#define WAKEUP_THRESHOLD_FULL_FLAG_CLEAR Sys ACS WriteRegister( \
    &ACS->WAKEUP_CTRL, \
    THRESHOLD_FULL_EVENT_CLEAR)
```

Location: power_modes.h:183

16.17.7 HAL Power Modes Function Documentation

RSL15 Firmware Reference

16.17.7.1 Sys_PowerModes_SetWakeupConfig

```
void Sys_PowerModes_SetWakeupConfig(uint32_t wakeup_cfg)
```

Set up the wakeup configuration.

Initializes the ACS_WAKEUP_CFG register with the specified wakeup sources. Clears any wakeup event flags triggered during the initialization.

Location: power_modes.h:398

Parameters

Direction	Name	Description
in	<i>wakeup_cfg</i>	(uint32_t) The wakeup configuration contained in the LowPowerModeCfg_t instance.

NOTE: This function will modify the ACS_WAKEUP_CFG register.

Example Code for Sys_PowerModes_SetWakeupConfig

```
// Using the default configuration, update wakeup sources
app_lowpower_mode_cfg.wakeup_cfg = WAKEUP_DELAY_2
                                | WAKEUP_GPIO0_ENABLE
                                | WAKEUP_GPIO0_FALLING
                                | WAKEUP_GPIO1_ENABLE
                                | WAKEUP_GPIO1_FALLING
                                | WAKEUP_DCDC_OVERLOAD_DISABLE
                                | WAKEUP_FIFO_ENABLE;
// Initialize wakeup configuration before entering sleep
Sys_PowerModes_SetWakeupConfig(app_lowpower_mode_cfg.wakeup_cfg);
```

16.17.7.2 Sys_PowerModes_EnableWakeupSources

```
void Sys_PowerModes_EnableWakeupSources(uint32_t wakeup_src, uint32_t * p_wakeup_cfg)
```

Enable one or more wakeup sources.

RSL15 Firmware Reference

Adds the provided wakeup source to the provided wakeup configuration and then enables the wakeup source in the ACS_WAKEUP_CFG register. The provided wakeup source can be several sources OR'd together to enable multiple at a time.

Location: power_modes.h:420

Parameters

Direction	Name	Description
in	<i>wakeup_src</i>	(uint32_t) The wakeup sources to enable. Use the defined constants WAKEUP_DCDC_OVERLOAD_ENABLE, WAKEUP_GPIO*_FALLING, WAKEUP_GPIO*_ENABLE, WAKEUP_RTC_OVERFLOW_ENABLE, WAKEUP_FIFO_ENABLE.
in	<i>p_wakeup_cfg</i>	(uint32_t*) A pointer to the wakeup configuration in the LowPowerModeCfg_t instance.

NOTE: This function will only modify the corresponding source enable bits. The wakeup event flags are not cleared in the process.

Example Code for Sys_PowerModes_EnableWakeupSources

```
// Power Mode wakeup configuration enable
Sys_PowerModes_EnableWakeupSources((WAKEUP_FIFO_ENABLE | WAKEUP_GPIO1_
ENABLE), &app_lowpower_mode_cfg->wakeup_cfg);
```

16.17.7.3 Sys_PowerModes_DisableWakeupSources

```
void Sys_PowerModes_DisableWakeupSources(uint32_t wakeup_src, uint32_t * p_wakeup_cfg)
```

Disable one or more wakeup sources.

Removes the provided wakeup source from the provided wakeup configuration and then disables the wakeup source in the ACS_WAKEUP_CFG register. The provided wakeup source can be several sources OR'd together to disable multiple at a time.

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Location: power_modes.h:442

Parameters

Direction	Name	Description
	<i>wakeup_src</i>	
in	<i>p_wakeup_cfg</i>	(uint32_t*) A pointer to the wakeup configuration in the LowPowerModeCfg_t instance.

NOTE: This function will only modify the corresponding source enable bits. The wakeup event flags are not cleared in the process.

Example Code for Sys_PowerModes_DisableWakeupSources

```
// Power Mode wakeup configuration disable
Sys_PowerModes_DisableWakeupSources(WAKEUP_FIFO_ENABLE | WAKEUP_GPIO1_
ENABLE), &app_lowpower_mode_cfg->wakeup_cfg);
```

16.17.7.4 Sys_PowerModes_EnterPowerMode

```
void Sys_PowerModes_EnterPowerMode(LowPowerModeCfg_t * p_power_mode_cfg)
```

Enter a low-power mode based on the provided configuration.

Powers down the system according to the selected Power Mode and retention type. The system reawakens when a configured wakeup event occurs.

Location: power_modes.h:457

Parameters

Direction	Name	Description
in	<i>p_power_mode_cfg</i>	(LowPowerModeCfg_t *) A pointer to the LowPowerModeCfg_t instance.

RSL15 Firmware Reference

NOTE: This function will enter a low-power mode if there are no wakeup events or NVIC interrupts pending, otherwise it will continue to RUN mode and service pending events and interrupts. This function will modify the ACS_BOOT_CFG register.

Example Code for Sys_PowerModes_EnterPowerMode

```
// Define variables to store GPIO register states during sleep
static uint32_t gpio_cfg[GPIO_PAD_COUNT] = {0};
static uint32_t gpio_output = 0;
static uint32_t gpio_jtag_sw_pad_cfg = 0;
// Define a function to save the GPIO register states
static void App_GPIOSaveStates(void)
{
    for (uint8_t i = 0; i < GPIO_PAD_COUNT; i++)
    {
        gpio_cfg[i] = GPIO->CFG[i];
    }
    gpio_output = GPIO->OUTPUT_DATA;
    gpio_jtag_sw_pad_cfg = GPIO->JTAG_SW_PAD_CFG;
}
// Define a function to restore the GPIO register states
static void App_GPIORestoreStates(void)
{
    for (uint8_t i = 0; i < GPIO_PAD_COUNT; i++)
    {
        GPIO->CFG[i] = gpio_cfg[i];
    }
    GPIO->OUTPUT_DATA = gpio_output;
    GPIO->JTAG_SW_PAD_CFG = gpio_jtag_sw_pad_cfg;
}
// Use the default low-power configuration and provide a resume address
app_lowpower_mode_cfg.p_app_resume = App_MainLoop;
// Add the peripheral (GPIO) save & restore functions to the config
app_lowpower_mode_cfg.p_save_peripherals = App_GPIOSaveStates;
app_lowpower_mode_cfg.p_restore_peripherals = App_GPIORestoreStates;
// Power Mode enter sleep with memory retention
Sys_PowerModes_EnterPowerMode(&app_lowpower_mode_cfg);
```

16.17.7.5 Sys_PowerModes_WakeupWithReset

```
void Sys_PowerModes_WakeupWithReset(LowPowerModeCfg_t * p_power_mode_cfg)
```

Wakeup from flash after a sleep reset.

Wakes up the system from flash after the system has awoken from a reset caused by Sleep Mode without retention.

RSL15 Firmware Reference

Location: power_modes.h:468

Parameters

Direction	Name	Description
in	<i>p_power_mode_cfg</i>	(LowPowerModeCfg_t *) A pointer to the LowPowerModeCfg_t instance.

NOTE: This function initializes the system after a wakeup with reset.

Example Code for Sys_PowerModes_WakeupWithReset

```
// Initialize the system after a wakeup where the system was reset
(no retention).
Sys\_PowerModes\_WakeupWithReset(&app_lowpower_mode_cfg);
```

16.17.7.6 Sys_PowerModes_IdleUntilBBAwake

```
void Sys_PowerModes_IdleUntilBBAwake()
```

Place the system into Idle Mode until the baseband is awake.

Performs an atomic check to see if the baseband is awake and if not places the system into Idle Mode until the baseband related interrupt becomes pending.

Location: power_modes.h:476

16.18 PULSE-WIDTH MODULATION

Pulse-Width Modulation (PWM) hardware abstraction layer.

16.18.1 Summary

Macros

RSL15 Firmware Reference

- [PWM_CHANNELS](#) : The total number of PWM channels.
- [HIGH_FRACTIONAL](#) : High fractional.

Functions

- [Sys_PWM_GPIOConfig](#) : Configure a GPIO pad for the PWM interface.
- [Sys_PWM_Config](#) : Set length of PWM period and number of high cycles within a PWM period.
- [Sys_PWM_Enable](#) : Enable a set of PWM channels.
- [Sys_PWM_Disable](#) : Disable the PWM[4:0] channel Disabling the PWM channel will set the counter and prescaler to zero.
- [Sys_PWM_Reset_Channel](#) : Reset the PWM[4:0] channel Disable the PWM[4:0] channel, reset the PWM_CFG [4:0] and PWM_OFFSET[4:1] registers and the related counter.

16.18.2 Pulse-Width Modulation Macro Definition Documentation**16.18.2.1 PWM_CHANNELS**

```
#define PWM_CHANNELS 5
```

The total number of PWM channels.

Location: pwm.h:42

16.18.2.2 HIGH_FRACTIONAL

```
#define HIGH_FRACTIONAL 0x100
```

High fractional.

Location: pwm.h:45

16.18.3 Pulse-Width Modulation Function Documentation**16.18.3.1 Sys_PWM_GPIOConfig**

```
void Sys_PWM_GPIOConfig(uint8_t gpio, uint8_t channel, uint32_t cfg, uint8_t inverted)
```

Configure a GPIO pad for the PWM interface.

RSL15 Firmware Reference

Location: pwm.h:60

Parameters

Direction	Name	Description
in	<i>gpio</i>	Pad to configure as the output for the specified PWM channel
in	<i>channel</i>	PWM channel
in	<i>cfg</i>	Configuration of the GPIO pad
in	<i>inverted</i>	Output PWM interface signal inverted

Example Code for Sys_PWM_GPIOConfig

```
// Enable PWM channel 0 on GPIO5. Use a non-inverted waveform
Sys_PWM_GPIOConfig(PWM0_GPIO5, PWM_CH0,
    GPIO_6X_DRIVE | GPIO_LPF_DISABLE | GPIO_STRONG_PULL_UP,
    PWM_NON_INVERTED);
```

16.18.3.2 Sys_PWM_Config

```
void Sys_PWM_Config(uint8_t channel, uint32_t period, float duty_cycle, uint32_t offset)
```

Set length of PWM period and number of high cycles within a PWM period.

Location: pwm.h:85

Parameters

Direction	Name	Description
in	<i>channel</i>	PWM channel
in	<i>period</i>	Length of a PWM period
in	<i>duty_cycle</i>	Duty cycle value (expressed in percentage)
in	<i>offset</i>	Cycles between the rising edge of the specified PWM channel and the rising edge of PWM channel 0

Example Code for Sys_PWM_Config

```
// Configure PWM channel 0 to a period of 2, with 50% duty cycle an no offset
Sys_PWM_Config(PWM_CH0, 2, 50, 0);
```

16.18.3.3 Sys_PWM_Enable

```
void Sys_PWM_Enable(uint32_t enable)
```

Enable a set of PWM channels.

Location: pwm.h:113

Parameters

Direction	Name	Description
in	<i>enable</i>	PWM channel

Example Code for Sys_PWM_Enable

```
// Enable output of PWM channel 0
Sys_PWM_Enable(PWM0_ENABLE);
```

16.18.3.4 Sys_PWM_Disable

```
void Sys_PWM_Disable(uint32_t disable)
```

Disable the PWM[4:0] channel Disabling the PWM channel will set the counter and prescaler to zero.

Location: pwm.h:125

Parameters

Direction	Name	Description
in	<i>disable</i>	PWM channel

Example Code for Sys_PWM_Disable

```
// Disable output of PWM channel 0, clear the counter and prescaler
Sys_PWM_Disable(PWM0_ENABLE);
```

16.18.3.5 Sys_PWM_Reset_Channel

```
void Sys_PWM_Reset_Channel(uint32_t reset)
```

Reset the PWM[4:0] channel Disable the PWM[4:0] channel, reset the PWM_CFG[4:0] and PWM_OFFSET[4:1] registers and the related counter.

Location: pwm.h:137

Parameters

Direction	Name	Description
in	<i>reset</i>	PWM channel

Example Code for Sys_PWM_Reset_Channel

```
// Reset PWM channel 0
Sys_PWM_Reset_Channel(PWM0_RESET);
```

16.19 RFFE RADIO FREQUENCY FRONT END

RSL15 Firmware Reference

Radio Frequency Front End (RFFE) hardware abstraction layer.

16.19.1 Summary

Macros

- [STABILIZATION_DELAY](#) : External include files.
- [MEASUREMENT_DELAY](#) : Corresponds to sample rate of the LSAD as configured (625 Hz)
- [V_TO_MV](#) : Factor for converting back and forth from mV to V.
- [V_TO_MV_F](#) : Float iteration of factor for converting back and forth from mV to V.
- [DEF_CHANNEL](#) : Default LSAD channel used to measure voltage rails.
- [MAX_LSAD_CHANNEL](#) : Maximum number of LSAD channels in the design.
- [VDDPA_EN](#) : VDDPA enable selection.
- [VDDPA_DIS](#) : VDDPA disable selection.
- [VCC_VDDRF_MARGIN](#) : We strongly recommended having VCC at least 50mV higher than VDDRF.
- [TRIM_MARGIN](#) : Trim margin.
- [MV_PER_DBM_VDDPA](#) : Estimated voltage increase per 1dBm increased TX power.
- [MV_PER_DBM_VDDRF](#) : Estimated voltage increase per 1dBm increased TX power.
- [STEPS_PER_DBM_VDDRF](#) : Estimated trim steps per 1dBm increased TX power.
- [STEPS_PER_DBM_VDDPA](#) : Estimated trim steps per 1dBm increased TX power.
- [RF_MAX_POWER](#) : Maximum RF output power possible.
- [RF_MAX_POWER_NO_VDDPA](#) : Maximum RF output power possible without using VDDPA.
- [RF_NO_VDDPA_TYPICAL_POWER](#) : Typical RF output power when VDDPA is not used, with default trims.
- [RF_DEFAULT_POWER](#) : RF output power used by default.
- [RF_MIN_POWER](#) : Minimum possible RF output power.
- [PA_PWR_BYTE_0DBM](#) : RF Output Power code for 0dBm.
- [PA_ENABLE_BIAS_SETTING](#) : Power amplifier bias enable.
- [PA_DISABLE_BIAS_SETTING](#) : Power amplifier bias disable.
- [SW_CTRL_DELAY_3_BYTE](#) : Switch control delay.
- [RAMPUP_DELAY_3_BYTE](#) : Ramp-up delay.
- [DISABLE_DELAY_3_BYTE](#) : Disable delay.
- [ERRNO_TX_POWER_MARKER](#) : Error marker for RFFE errors.
- [ERRNO_NO_TRIMS](#) : No trims found when attempting to adjust voltage rails.
- [ERRNO_RFFE_MISSINGSETTING_ERROR](#) : Setting does not exist.
- [ERRNO_RFFE_INVALIDSETTING_ERROR](#) : Setting is not possible.
- [ERRNO_RFFE_VCC_INSUFFICIENT](#) : VCC is too low to increase VDDRF sufficiently to support the requested RF output power.
- [WARNING_RFFE_VLOW_POWER_STATE](#) : Warning that the device is in a very low RF output power state.
- [WARNING_RFFE_PA_ENABLED_STATE](#) : Warning that the device has the power amplifier enabled.
- [CONVERT](#) : Converts an ADC code to a voltage, calculated as follows $\text{voltage} = \text{adc_code} * (2 \text{ V} * 1000 \text{ [mV]}/1 \text{ V} / 2^{14} \text{ steps})$.
- [SWAP](#) : Swap the values in variables a and b.
- [SYS_RFFE_SETTXPOWER](#) : Set the TX Power according to the desired target value with an accuracy of +/-1 dBm for +6 dBm to -17 dBm.

Functions

RSL15 Firmware Reference

- [Sys RFFE GetTXPower](#) : Retrieve the current setting for RF output power by using the values retrieved from the appropriate registers.
- [Sys RFFE SetTXPower](#) : Set the TX Power according to the desired target value with an accuracy of +/-1 dBm for +6 dBm to -17 dBm.

16.19.2 RFFE Radio Frequency Front End Macro Definition Documentation**16.19.2.1 STABILIZATION_DELAY**

```
#define STABILIZATION_DELAY (SystemCoreClock * 3 / 625)
```

External include files.

Three times the length of time corresponding to the minimum sample rate, which is deemed sufficient to allow the LSAD to stabilize

Location: rffe.h:46

16.19.2.2 MEASUREMENT_DELAY

```
#define MEASUREMENT_DELAY (SystemCoreClock / 625)
```

Corresponds to sample rate of the LSAD as configured (625 Hz)

Location: rffe.h:49

16.19.2.3 V_TO_MV

```
#define V_TO_MV 1000
```

Factor for converting back and forth from mV to V.

Location: rffe.h:52

16.19.2.4 V_TO_MV_F

```
#define V_TO_MV_F 1000.0f
```

Float iteration of factor for converting back and forth from mV to V.

Location: rffe.h:55

16.19.2.5 DEF_CHANNEL

```
#define DEF_CHANNEL 6
```

Default LSAD channel used to measure voltage rails.

Location: rffe.h:58

16.19.2.6 MAX_LSAD_CHANNEL

```
#define MAX_LSAD_CHANNEL 7
```

Maximum number of LSAD channels in the design.

Location: rffe.h:61

16.19.2.7 VDDPA_EN

```
#define VDDPA_EN 1
```

VDDPA enable selection.

Location: rffe.h:64

16.19.2.8 VDDPA_DIS

```
#define VDDPA_DIS 0
```

VDDPA disable selection.

Location: rffe.h:67

16.19.2.9 VCC_VDDRF_MARGIN

```
#define VCC_VDDRF_MARGIN 50
```

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We strongly recommended having VCC at least 50mV higher than VDDRF.

Location: rffe.h:70

16.19.2.10 TRIM_MARGIN

```
#define TRIM_MARGIN 10 /*mv*/
```

Trim margin.

The granularity of trims for VDDRF allow for a certain error above or below the set value

Location: rffe.h:74

16.19.2.11 MV_PER_DBM_VDDPA

```
#define MV_PER_DBM_VDDPA 100
```

Estimated voltage increase per 1dBm increased TX power.

Location: rffe.h:77

16.19.2.12 MV_PER_DBM_VDDRF

```
#define MV_PER_DBM_VDDRF 75
```

Estimated voltage increase per 1dBm increased TX power.

Location: rffe.h:80

16.19.2.13 STEPS_PER_DBM_VDDRF

```
#define STEPS_PER_DBM_VDDRF 6
```

Estimated trim steps per 1dBm increased TX power.

Location: rffe.h:83

16.19.2.14 STEPS_PER_DBM_VDDPA

```
#define STEPS_PER_DBM_VDDPA 10
```

Estimated trim steps per 1dBm increased TX power.

Location: rffe.h:86

16.19.2.15 RF_MAX_POWER

```
#define RF_MAX_POWER 6
```

Maximum RF output power possible.

Location: rffe.h:89

16.19.2.16 RF_MAX_POWER_NO_VDDPA

```
#define RF_MAX_POWER_NO_VDDPA 2
```

Maximum RF output power possible without using VDDPA.

Location: rffe.h:92

16.19.2.17 RF_NO_VDDPA_TYPICAL_POWER

```
#define RF_NO_VDDPA_TYPICAL_POWER 0
```

Typical RF output power when VDDPA is not used, with default trims.

Location: rffe.h:95

16.19.2.18 RF_DEFAULT_POWER

```
#define RF_DEFAULT_POWER 0
```

RF output power used by default.

Location: rffe.h:98

16.19.2.19 RF_MIN_POWER

```
#define RF_MIN_POWER -17
```

Minimum possible RF output power.

Location: rffe.h:101

16.19.2.20 PA_PWR_BYTE_0DBM

```
#define PA_PWR_BYTE_0DBM 0x0C
```

RF Output Power code for 0dBm.

Location: rffe.h:104

16.19.2.21 PA_ENABLE_BIAS_SETTING

```
#define PA_ENABLE_BIAS_SETTING 0xF3
```

Power amplifier bias enable.

Location: rffe.h:107

16.19.2.22 PA_DISABLE_BIAS_SETTING

```
#define PA_DISABLE_BIAS_SETTING 0x73
```

Power amplifier bias disable.

Location: rffe.h:110

16.19.2.23 SW_CTRL_DELAY_3_BYTE

```
#define SW_CTRL_DELAY_3_BYTE ((uint8_t)0x2U)
```

Switch control delay.

Location: rffe.h:114

16.19.2.24 RAMPUP_DELAY_3_BYTE

```
#define RAMPUP_DELAY_3_BYTE ((uint8_t)0x2U)
```

Ramp-up delay.

Location: rffe.h:117

16.19.2.25 DISABLE_DELAY_3_BYTE

```
#define DISABLE_DELAY_3_BYTE ((uint8_t)0x2U)
```

Disable delay.

Location: rffe.h:120

16.19.2.26 ERRNO_TX_POWER_MARKER

```
#define ERRNO_TX_POWER_MARKER 0x30
```

Error marker for RFFE errors.

Location: rffe.h:124

16.19.2.27 ERRNO_NO_TRIMS

```
#define ERRNO_NO_TRIMS (0x01 | ERRNO\_TX\_POWER\_MARKER)
```

No trims found when attempting to adjust voltage rails.

Location: rffe.h:127

16.19.2.28 ERRNO_RFFE_MISSINGSETTING_ERROR

```
#define ERRNO_RFFE_MISSINGSETTING_ERROR (0x02 | ERRNO\_TX\_POWER\_MARKER)
```

Setting does not exist.

Location: rffe.h:130

16.19.2.29 ERRNO_RFFE_INVALIDSETTING_ERROR

```
#define ERRNO_RFFE_INVALIDSETTING_ERROR (0x03 | ERRNO\_TX\_POWER\_MARKER)
```

Setting is not possible.

Location: rffe.h:133

16.19.2.30 ERRNO_RFFE_VCC_INSUFFICIENT

```
#define ERRNO_RFFE_VCC_INSUFFICIENT (0x04 | ERRNO\_TX\_POWER\_MARKER)
```

VCC is too low to increase VDDRF sufficiently to support the requested RF output power.

Location: rffe.h:136

16.19.2.31 WARNING_RFFE_VLOW_POWER_STATE

```
#define WARNING_RFFE_VLOW_POWER_STATE (0x05 | ERRNO\_TX\_POWER\_MARKER)
```

Warning that the device is in a very low RF output power state.

Location: rffe.h:140

16.19.2.32 WARNING_RFFE_PA_ENABLED_STATE

```
#define WARNING_RFFE_PA_ENABLED_STATE (0x06 | ERRNO\_TX\_POWER\_MARKER)
```

Warning that the device has the power amplifier enabled.

Location: rffe.h:143

16.19.2.33 CONVERT

```
#define CONVERT ((uint32_t)((x * 1000) >> 13))
```

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Converts an ADC code to a voltage, calculated as follows $\text{voltage} = \text{adc_code} * (2 \text{ V} * 1000 \text{ [mV]}/1 \text{ V} / 2^{14} \text{ steps})$.

Location: rffe.h:154

Parameters

Direction	Name	Description
in	<i>x</i>	the ADC code input

Return

The voltage output in mV

Assumptions

Low frequency mode for the ADC is used, meaning that the resolution of the ADC is 14-bits. CONVERT provides voltage level as a milliVolt value based on the input ADC code.

16.19.2.34 SWAP

```
#define SWAP ((t) = (a), (a) = (b), (b) = (t))
```

Swap the values in variables a and b.

Location: rffe.h:164

Parameters

Direction	Name	Description
in	<i>a</i>	holds the value that must go to b
in	<i>b</i>	holds the value that must go to a
in	<i>t</i>	a temporary buffer for the swap

Return

b holds the value previously in a

16.19.2.35 SYS_RFFE_SETTXPOWER

```
#define SYS_RFFE_SETTXPOWER Sys\_RFFE\_SetTXPower(target, DEF\_CHANNEL, VDDPA\_DIS)
```

Set the TX Power according to the desired target value with an accuracy of +/-1 dBm for +6 dBm to -17 dBm.

This function sets VDDRF, VDDPA, and PA_PWR (RF_REG1A) when applicable. Note: This function provides RF TX power configurations that match the requested levels, without considering the potential for increased power consumption due to the use of VDDPA.

Location: rffe.h:208

Parameters

Direction	Name	Description
in	<i>target</i>	Target transmission power in the range from -17 to +6 dBm in 1 dBm increments.

Return

Return value error value, if any

Example Code for SYS_RFFE_SETTXPOWER

```
// Reads the current register settings and measures VDDRF, if required, to
// determine the current TX power setting.
result = SYS\_RFFE\_SETTXPOWER(0);
```

16.19.3 RFFE Radio Frequency Front End Function Documentation

16.19.3.1 Sys_RFFE_GetTXPower

```
int8_t Sys_RFFE_GetTXPower(uint32_t lsad_channel)
```

Retrieve the current setting for RF output power by using the values retrieved from the appropriate registers.

Location: rffe.h:173

Parameters

Direction	Name	Description
in	<i>lsad_channel</i>	The LSAD channel used for measuring VDDRF

Return

The currently set TX output power. Returns -100 in error state.

Example Code for Sys_RFFE_GetTXPower

```
// Use LSAD channel 0 to measure VDDRF if necessary to determine the currently
// set TX output power.
result = Sys\_RFFE\_GetTXPower(0);
```

16.19.3.2 Sys_RFFE_SetTXPower

```
uint32_t Sys_RFFE_SetTXPower(int8_t target, uint8_t lsad_channel, bool pa_en)
```

Set the TX Power according to the desired target value with an accuracy of +/-1 dBm for +6 dBm to -17 dBm.

This function sets VDDRF, VDDPA, and PA_PWR (RF_REG1A) when applicable. Note: This function provides RF TX power configurations that match the requested levels, without considering the potential for increased power

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consumption due to the use of VDDPA.

Location: rffe.h:193

Parameters

Direction	Name	Description
in	<i>target</i>	Target transmission power in the range from -17 to +6 dBm in 1 dBm increments.
in	<i>lsad_channel</i>	LSAD channel to use to measure rails, if necessary.
in	<i>pa_en</i>	If 1, the power amplifier will be enabled, otherwise, it will be disabled. The power amplifier will be enabled regardless if 'target' is greater than 2.

Return

Return value error value, if any

Example Code for Sys_RFFE_SetTXPower

```
// Set the TX power for the device to 6 dBm, uses LSAD channel 0 to measure
// (unused in the case of 6 dBm), and enables VDDPA.
result = Sys_RFFE_SetTXPower(6, 0, VDDPA_EN);
```

16.20 REAL-TIME CLOCK

Real-time clock hardware abstraction layer.

16.20.1 Summary

Functions

RSL15 Firmware Reference

- [Sys_RTC_Config](#) : Configure RTC block.
- [Sys_RTC_Count_Threshold](#) : Configure RTC Counter Threshold.
- [Sys_RTC_Value_Seconds](#) : Read the current value of the RTC timer in seconds.
- [Sys_RTC_Value](#) : Read the current value of the RTC timer.

16.20.2 Real-Time Clock Function Documentation

16.20.2.1 Sys_RTC_Config

```
void Sys_RTC_Config(uint32_t rtc_cfg, uint32_t rtc_ctrl)
```

Configure RTC block.

Location: rtc.h:49

Parameters

Direction	Name	Description
in	<i>rtc_cfg</i>	Select the RTC clock event and clock source; use RTC_CLOCK_*, and RTC_CLK_SRC_*
in	<i>rtc_ctrl</i>	RTC control register; use RTC_FORCE_CLOCK, RTC_[DISABLE ENABLE]_CLOCK_EVENT, RTC_[DISABLE ENABLE]_ALARM_EVENT, RTC_RESET, and RTC_[DISABLE ENABLE]

Example Code for Sys_RTC_Config

```
// Enable clock and alarm events and enable the RTC
// Configure the RTC clock to trigger once a second
// Use external 32kHz crystal as the clock
Sys\_RTC\_Config(RTC_CLK_SRC_XTAL32K | RTC_CLOCK_1S,
                RTC_ENABLE_CLOCK_EVENT | RTC_ENABLE_ALARM_EVENT | RTC_ENABLE);
```

16.20.2.2 Sys_RTC_Count_Threshold

```
void Sys_RTC_Count_Threshold(uint32_t threshold)
```

Configure RTC Counter Threshold.

RSL15 Firmware Reference

Location: rtc.h:63

Parameters

Direction	Name	Description
in	<i>threshold</i>	Compare value for the RTC counter; use RTC_COUNT_THRES_*

Example Code for Sys_RTC_Count_Threshold

```
// Set the RTC counter threshold to 32767 (1 second, assuming an RTC clock
// frequency of 32768 Hz)
result = Sys\_RTC\_Count\_Threshold(32767);
```

16.20.2.3 Sys_RTC_Value_Seconds

```
uint32_t Sys_RTC_Value_Seconds()
```

Read the current value of the RTC timer in seconds.

Location: rtc.h:73

Return

RTC timer current value in seconds

Example Code for Sys_RTC_Value_Seconds

```
// Return the current value of the RTC counter, converted to seconds
result = Sys\_RTC\_Value\_Seconds();
```

16.20.2.4 Sys_RTC_Value

```
uint32_t Sys_RTC_Value()
```

Read the current value of the RTC timer.

Location: rtc.h:83

Return

RTC timer counter current value

Example Code for Sys_RTC_Value

```
// Return the current value of the RTC counter  
result = Sys\_RTC\_Value\(\);
```

16.21 SAR_ADC

SAR_ADC hardware abstraction layer.

16.21.1 Summary

Macros

- [VDDSAR_FREQ_THRESHOLD](#)
- [MAX_SENSOR_CLK_HIGH](#)
- [MAX_SENSOR_CLK_LOW](#)

Functions

- [Sys_Calibrate_SARADC](#) : Calibrate the SAR ADC, generating gain and offset values.

16.21.2 SAR_ADC Macro Definition Documentation

RSL15 Firmware Reference

16.21.2.1 VDDSAR_FREQ_THRESHOLD

```
#define VDDSAR_FREQ_THRESHOLD (2500)
```

Location: sar_adc.h:44

16.21.2.2 MAX_SENSOR_CLK_HIGH

```
#define MAX_SENSOR_CLK_HIGH (16000000UL)
```

Location: sar_adc.h:48

16.21.2.3 MAX_SENSOR_CLK_LOW

```
#define MAX_SENSOR_CLK_LOW (2000000UL)
```

Location: sar_adc.h:52

16.21.3 SAR_ADC Function Documentation**16.21.3.1 Sys_Calibrate_SARADC**

```
void Sys_Calibrate_SARADC(uint32_t vddsar_mv, uint32_t supply_src, uint32_t * offset,  
float * gain)
```

Calibrate the SAR ADC, generating gain and offset values.

The gain and offset values are stored in the SAR ADC but are returned here as well.

Location: sar_adc.h:72

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>vddsar_mv</i>	Set the SAR supply voltage. 2.5 to 3.3 V sets SENSOR_CLK between 8 and 16 MHz. Less than 2.5 V sets SENSOR_CLK to 2 MHz.
in	<i>supply_src</i>	Select the SAR supply source: use SAR_SUPPLY_BY_VBAT, SAR_SUPPLY_BY_GPIO9
out	<i>offset</i>	Gets the offset stored in SAR_ADC
out	<i>gain</i>	Gets the calibrated gain correction

Assumptions

The SAR ADC is configured to use VBAT for the calibration.

Example Code for Sys_Calibrate_SARADC

```
// Calibrate the SAR ADC with SAR positive input having signal between VSSA
// and 3000mV.
// Set gain_correction to the calibrated gain correction
// Set sar_adc_offset to the offset stored in SAR-ADC (i.e. 8192 levels)
float gain_correction = 0;
uint32_t sar_adc_offset = 0;
Sys_Calibrate_SARADC(SAR_ADC_VBAT_SUPPLY_MV, SAR_SUPPLY_BY_VBAT, &sar_adc_
offset, &gain_correction);
```

16.22 SIMPLE ASSERTIONS

Simple Assertion (SASSERT) hardware abstraction layer.

16.22.1 Summary**Macros**

- [SYS_ASSERT](#) : Assertion handler; default behavior is no operation.

16.22.2 Simple Assertions Macro Definition Documentation

RSL15 Firmware Reference

16.22.2.1 SYS_ASSERT

```
#define SYS_ASSERT False
```

Assertion handler; default behavior is no operation.

Location: sassert.h:47

16.23 ULTRA-LOW POWER DATA ACQUISITION SUBSYSTEM

Ultra-low power data acquisition (sensor) subsystem hardware abstraction layer.

16.23.1 Summary**Functions**

- [Sys_Sensor_SARConfig](#) : Configure the SAR-ADC interface.
- [Sys_Sensor_PulseCountConfig](#) : Configure sensor pulse count state.
- [Sys_Sensor_StorageConfig](#) : Configure data storage settings.
- [Sys_Sensor_DelayConfig](#) : Configure sensor delay clocks and length.
- [Sys_Sensor_Enable](#) : Enable the sensor.
- [Sys_Sensor_Disable](#) : Disable the sensor.
- [Sys_Sensor_TimerReset](#) : The sensor timer counter, the sensor timer enable and the ADC counter are reset.
- [Sys_Sensor_CurrentState](#) : Read the current status and delay state of the sensor interface.
- [Sys_Sensor_CurrentCountValue](#) : Read the current value of the sensor's main counter.

16.23.2 Ultra-Low Power Data Acquisition Subsystem Function Documentation**16.23.2.1 Sys_Sensor_SARConfig**

```
void Sys_Sensor_SARConfig(uint32_t sar_cfg, uint32_t sar_ctrl, uint32_t clk_cfg)
```

Configure the SAR-ADC interface.

Location: sensor.h:52

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>sar_cfg</i>	SAR-ADC configuration; use SAR_PRE_SEL_GPIO_*, SAR_IN_*_SRC_*, SAR_DATA_OUT_RX_DMA_[ENABLED DISABLED], SAR_DATA_OUT_UPDATE_[AUTO ENABLE], SAR_SUPPLY_[AUTO ENABLE], and SAR_SUPPLY_BY_[VBAT VDDA]
in	<i>sar_ctrl</i>	SAR-ADC control configuration; use SAR_SEL_*, SAR_NSAMPLING_CYCLE_*, SAR_[CONV_12BIT CONV_14BIT CAL_WEIGHT AUTO_ZERO], SAR_[START_SINGLE START_CONTINUOUS STOP_CONTINUOUS]
in	<i>clk_cfg</i>	select interface clock source; use SENSOR_CLK_[STANDBY SYSCLK_DIV]_BYTE

Example Code for Sys_Sensor_SARConfig

```

// Configure the SAR to measure on GPIO0 and GPIO1.
// - Define positive input and negative input signal as supply voltage/2
// - Do not use DMA
// - Data buffer updated on finished conversion
// - SAR supply is only on when used
// - SAR supply is VBAT
// - Gated 2's complement offset compensated output (gated means output is
//   zero until valid data becomes available)
// - Data sampling lasts 1 cycle
// - Create 12 bit samples
// - Stop continuous conversions
// - Use standby clock as the sensor clock source
Sys_Sensor_SARConfig(SAR_PRE_SEL_GPIO_1 |
                    SAR_PRE_SEL_GPIO_0 |
                    SAR_IN_P_SRC_SAR_SUPPLY_DIV2 |
                    SAR_IN_N_SRC_SAR_SUPPLY_DIV2 |
                    SAR_DATA_OUT_RX_DMA_DISABLED |
                    SAR_DATA_OUT_UPDATE_AUTO |
                    SAR_SUPPLY_AUTO |
                    SAR_SUPPLY_BY_VBAT,
                    SAR_SEL_GATED_SIGNED_COMPENSATED |
                    SAR_NSAMPLING_CYCLE_1 |
                    SAR_CONV_12BIT |
                    SAR_STOP_CONTINUOUS,
                    SENSOR_CLK_STANDBY_BYTE);

```

16.23.2.2 Sys_Sensor_PulseCountConfig

```
void Sys_Sensor_PulseCountConfig(uint32_t pc_cfg, uint32_t clk_cfg)
```

Configure sensor pulse count state.

Location: sensor.h:73

Parameters

Direction	Name	Description
in	<i>pc_cfg</i>	Pulse-counter configuration; use COUNT_INT_*, PC_SRC_*, PC_COUNT_ON_[HIGH_LEVEL RISING_EDGE]
in	<i>clk_cfg</i>	select interface clock source; use SENSOR_CLK_[STANDBY SYSCLK_DIV]_BYTE

Example Code for Sys_Sensor_PulseCountConfig

```
// - Set pulse count source to constant high
// - Set total count state to be 4 periods of sensor clock
// - Select standby clock as sensor clock source
Sys_Sensor_PulseCountConfig(PC_SRC_CONST_HIGH | COUNT_INT_4, SENSOR_CLK_STANDBY_BYTE)
```

16.23.2.3 Sys_Sensor_StorageConfig

```
void Sys_Sensor_StorageConfig(uint32_t sum_en, uint32_t nbr_samples, uint32_t threshold_min, uint32_t threshold_max, uint32_t store_en, uint32_t fifo_size, uint32_t fifo_cfg)
```

Configure data storage settings.

Location: sensor.h:107

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>sum_en</i>	Enable summation mode; use SENSOR_SUMMATION_[ENABLED DISABLED]
in	<i>nbr_samples</i>	Number of samples to store before wakeup in sensor detect mode or for impedance measurement; use SENSOR_NBR_SAMPLES_*
in	<i>threshold_min</i>	Sensor data level threshold (min) for wakeup; use SENSOR_THRESHOLD_MIN_*, SENSOR_THRESHOLD_MIN_[DISABLED ENABLED]
in	<i>threshold_max</i>	Sensor data level threshold (max) for wakeup; use SENSOR_THRESHOLD_MAX_*, SENSOR_THRESHOLD_MAX_[DISABLED ENABLED]
in	<i>store_en</i>	Enable storing samples in FIFO
in	<i>fifo_size</i>	Number of samples to store in FIFO before wakeup of core.
in	<i>fifo_cfg</i>	Enable FIFO interrupts and/or DMA triggers; use FIFO_RX_DMA_[ENABLED DISABLED], and FIFO_RX_INT_[ENABLED DISABLED]

Example Code for Sys_Sensor_StorageConfig

```
// - Disable summing of sequential samples
// - Number of data samples to generate before wakeup generated
// - Enable sensor threshold and set it to a value of 1
// - Enable storing of sensor data samples in the sensor FIFO
// - Set sensor FIFO size to 1 sample
// - Disable interrupts and dma transfer of data from FIFO
Sys_Sensor_StorageConfig(SENSOR_SUMMATION_DISABLED, SENSOR_NBR_SAMPLES_1,
    SENSOR_THRESHOLD_MIN_ENABLED | SENSOR_THRESHOLD_MIN_1,
    SENSOR_THRESHOLD_MAX_ENABLED | SENSOR_THRESHOLD_MAX_1,
    SENSOR_FIFO_STORE_ENABLED, SENSOR_FIFO_SIZE1,
    FIFO_RX_DMA_DISABLED | FIFO_RX_INT_ENABLED);
```

16.23.2.4 Sys_Sensor_DelayConfig

```
void Sys_Sensor_DelayConfig(uint32_t dly_cfg)
```

Configure sensor delay clocks and length.

Use sub-register defines.

RSL15 Firmware Reference

Location: sensor.h:129

Parameters

Direction	Name	Description
in	<i>dly_cfg</i>	select interface clock source; use DLY_*_SHORT, DLY_DIV_[ENABLED DISABLED]_SHORT, and DLY_[USED NOT_USED]_SHORT

NOTE: Clock can be configured for 32 kHz (0) or 1 kHz (1-default)

Example Code for Sys_Sensor_DelayConfig

```
// - Enable delay state
// - Delay state runs at sensor clock divided by 32
// - Delay state is 256 sensor clock/32 periods
Sys_Sensor_DelayConfig(DLY_USED | DLY_DIV_ENABLED | DLY_256)
```

16.23.2.5 Sys_Sensor_Enable

```
void Sys_Sensor_Enable()
```

Enable the sensor.

In secure mode, also enable power to the sensor.

Location: sensor.h:139

Example Code for Sys_Sensor_Enable

```
// Enable the ULP power data acquisition (sensor) subsystem
Sys_Sensor_Enable()
```

16.23.2.6 Sys_Sensor_Disable

```
void Sys_Sensor_Disable()
```

Disable the sensor.

In secure mode, also disable power to the sensor.

Location: sensor.h:157

Example Code for Sys_Sensor_Disable

```
// Disable the ULP power data acquisition (sensor) subsystem  
Sys\_Sensor\_Disable()
```

16.23.2.7 Sys_Sensor_TimerReset

```
void Sys_Sensor_TimerReset()
```

The sensor timer counter, the sensor timer enable and the ADC counter are reset.

Location: sensor.h:176

Example Code for Sys_Sensor_TimerReset

```
// The sensor timer counter, the sensor timer enable and the ADC counter are reset  
Sys\_Sensor\_TimerReset()
```

16.23.2.8 Sys_Sensor_CurrentState

```
uint8_t Sys_Sensor_CurrentState()
```

Read the current status and delay state of the sensor interface.

Location: sensor.h:188

Return

current state of the sensor interface.

Example Code for Sys_Sensor_CurrentState

```
// Read the current state of the sensor interface  
Sys\_Sensor\_CurrentState\(\)
```

16.23.2.9 Sys_Sensor_CurrentCountValue

```
uint32_t Sys_Sensor_CurrentCountValue()
```

Read the current value of the sensor's main counter.

Location: sensor.h:200

Return

current value of the main counter.

Example Code for Sys_Sensor_CurrentCountValue

```
// Read the current value of the main sensor counter  
Sys\_Sensor\_CurrentCountValue\(\)
```

RSL15 Firmware Reference

16.24 SPI

Serial Peripheral Interface (SPI) hardware abstraction layer.

16.24.1 Summary

Macros

- [SPI_CONFIG_MASK](#) : Mask for the SPI_CFG register.
- [SPI_PADS_NUM](#) : Number of pads used for the SPI interface, for a single instance.
- [IS_GPIO_REAL](#) : Verify if the GPIO number corresponds to an actual pin, as opposed to a constant high/low value.
- [SYS_SPI_CONFIG](#) : Configure the specified SPI interface's operation and controller information.
- [SYS_SPI_TRANSFERCONFIG](#) : Configure the SPI transfer information for the specified SPI instance.
- [SYS_SPI_READ](#) : Generate clock and CS to read data from SPI interface.
- [SYS_SPI_WRITE](#) : Generate clock and CS to write data to SPI interface.
- [SYS_SPI_GPIOCONFIG](#) : Configure four GPIOs for the SPI0 interface.
- [SYS_DSPI_GPIOCONFIG](#) : Configure four GPIOs for the SPI0 interface for DSPI.
- [SYS_QSPI_GPIOCONFIG](#) : Configure six GPIOs for the SPI0 interface for QSPI cfg GPIO pin configuration for the SPI pads clk GPIO to use as the QSPI clock pad cs GPIO to use as the QSPI chip select pad io0 GPIO to use as the QSPI io0 io1 GPIO to use as the QSPI io1 io2 GPIO to use as the QSPI io2 io3 GPIO to use as the QSPI io3.

Functions

- [Sys SPI Config](#) : Configure the specified SPI interface's operation and controller information.
- [Sys SPI TransferConfig](#) : Configure the SPI transfer information for the specified SPI instance.
- [Sys SPI Read](#) : Generate clock and CS to read data from SPI interface.
- [Sys SPI Write](#) : Generate clock and CS to write data to SPI interface.
- [Sys SPI GPIOConfig](#) : Configure four GPIOs for the specified SPI interface.
- [Sys DSPI GPIOConfig](#) : Configure four GPIOs for the specified SPI interface.
- [Sys QSPI GPIOConfig](#) : Configure six GPIOs for the specified SPI interface.

16.24.2 SPI Macro Definition Documentation

16.24.2.1 SPI_CONFIG_MASK

```
#define SPI_CONFIG_MASK ((1 << SPI_CFG_TX_DMA_ENABLE_Pos) | \
    (1 << SPI_CFG_RX_DMA_ENABLE_Pos) | \
    (1 << SPI_CFG_TX_END_INT_ENABLE_Pos) | \
    (1 << SPI_CFG_TX_START_INT_ENABLE_Pos) | \
    (1 << SPI_CFG_RX_INT_ENABLE_Pos) | \
    (1 << SPI_CFG_CS_RISE_INT_ENABLE_Pos) | \
    (1 << SPI_CFG_OVERRUN_INT_ENABLE_Pos) | \
    (1 << SPI_CFG_UNDERRUN_INT_ENABLE_Pos) | \
    (1 << SPI_CFG_MODE_Pos) | \
```

RSL15 Firmware Reference

```

SPI_CFG_MODE_Mask           | \
(1 << SPI_CFG_WORD_SIZE_Pos) | \
SPI_CFG_WORD_SIZE_Mask     | \
(1 << SPI_CFG_PRESCALE_Pos)  | \
SPI_CFG_PRESCALE_Mask      | \
(1 << SPI_CFG_CLK_POLARITY_Pos) | \
(1 << SPI_CFG_SLAVE_Pos)

```

Mask for the SPI_CFG register.

Location: spi.h:61

16.24.2.2 SPI_PADS_NUM

```
#define SPI_PADS_NUM 6
```

Number of pads used for the SPI interface, for a single instance.

Location: spi.h:81

16.24.2.3 IS_GPIO_REAL

```
#define IS_GPIO_REAL (gpio_number < GPIO\_PAD\_COUNT)
```

Verify if the GPIO number corresponds to an actual pin, as opposed to a constant high/low value.

Location: spi.h:88

16.24.2.4 SYS_SPI_CONFIG

```
#define SYS_SPI_CONFIG Sys SPI Config(SPI, (config))
```

Configure the specified SPI interface's operation and controller information.

Location: spi.h:341

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>config</i>	Interface operation configuration; use SPI_SELECT_[MASTER SLAVE], SPI_CLK_POLARITY_[NORMAL INVERSE], SPI_PRESCALE_*, SPI_WORD_SIZE_*, SPI_MODE_[SPI DSPI QSPI] SPI_UNDERRUN_INT_[ENABLE DISABLE], SPI_OVERRUN_INT_[ENABLE DISABLE], SPI_CS_RISE_INT_[ENABLE DISABLE], SPI_RX_INT_[ENABLE DISABLE] SPI_TX_INT_[ENABLE DISABLE] SPI_RX_DMA_[ENABLE DISABLE] SPI_TX_DMA_[ENABLE DISABLE]

Example Code for SYS_SPI_CONFIG

```
// Configure the default SPI interface's operation and controller information:
// - Master mode
// - Use 8-bit words
// - Select interrupts enabled
// - Prescale the SPI interface clock by 32
SYS_SPI_CONFIG((SPI_MODE_QSPI | SPI_WORD_SIZE_8 | SPI_TX_START_INT_ENABLE |
                SPI_RX_INT_ENABLE | SPI_OVERRUN_INT_ENABLE |
                SPI_PRESCALE_32 | SPI_UNDERRUN_INT_ENABLE));
```

16.24.2.5 SYS_SPI_TRANSFERCONFIG

```
#define SYS_SPI_TRANSFERCONFIG Sys SPI TransferConfig(SPI, (config))
```

Configure the SPI transfer information for the specified SPI instance.

Location: spi.h:359

Parameters

Direction	Name	Description
in	<i>config</i>	Interface transfer configuration; use SPI_ENABLE, SPI_DISABLE, SPI_RESET, SPI_START, SPI_MODE_READ_WRITE, SPI_MODE_READ, SPI_MODE_WRITE, SPI_MODE_NOP, SPI_CS_0, SPI_CS_1,

Example Code for SYS_SPI_TRANSFERCONFIG

```
// Enable and configure default SPI interface to read operation mode
SYS_SPI_TRANSFERCONFIG(SPI_ENABLE | SPI_MODE_READ);
```

16.24.2.6 SYS_SPI_READ

```
#define SYS_SPI_READ Sys\_SPI\_Read(SPI)
```

Generate clock and CS to read data from SPI interface.

Location: spi.h:369

Return

Data read from the SPI interface

Assumptions

SPI is configured as master mode and transfer operation mode is SPI_MODE_READ_WRITE(full duplex) or (SPI_MODE_READ) half duplex

Example Code for SYS_SPI_READ

```
// Generate clock and CS to read data from the default SPI interface
SYS\_SPI\_READ();
```

16.24.2.7 SYS_SPI_WRITE

```
#define SYS_SPI_WRITE Sys\_SPI\_Write(SPI, (data))
```

Generate clock and CS to write data to SPI interface.

Location: spi.h:379

RSL15 Firmware Reference

Parameters

Direction	Name	Description
in	<i>data</i>	Data to be sent over SPI

Assumptions

SPI is configured as master mode and transfer operation mode is SPI_MODE_READ_WRITE(full duplex) or (SPI_MODE_WRITE) half duplex

Example Code for SYS_SPI_WRITE

```
// Generate clock and CS to write data to the default SPI interface
SYS_SPI_WRITE(0xFF);
```

16.24.2.8 SYS_SPI_GPIOCONFIG

```
#define SYS_SPI_GPIOCONFIG Sys\_SPI\_GPIOConfig(SPI, (slave), (cfg), (clk), (cs), (seri), (sero))
```

Configure four GPIOs for the SPI0 interface.

Location: spi.h:392

Parameters

Direction	Name	Description
in	<i>slave</i>	SPI master/slave configuration; use SPI*_SELECT_[MASTER SLAVE]
in	<i>cfg</i>	GPIO pin configuration for the SPI pads
in	<i>clk</i>	GPIO to use as the SPI clock pad
in	<i>cs</i>	GPIO to use as the SPI chip select pad
in	<i>seri</i>	GPIO to use as the SPI serial input pad
in	<i>sero</i>	GPIO to use as the SPI serial output pad

Example Code for SYS_SPI_GPIOCONFIG

```
// Configure GPIOs 0, 1, 2, and 3 for the default SPI interface with
// low-pass filter disabled, 8X drive-strength, and 1 kOhm pull-up resistors
SYS_SPI_GPIOCONFIG(GPIO0, (GPIO_LPF_DISABLE | GPIO_8X_DRIVE |
GPIO_1K_PULL_UP), GPIO0, GPIO1, GPIO2, GPIO3);
```

16.24.2.9 SYS_DSPI_GPIOCONFIG

```
#define SYS_DSPI_GPIOCONFIG Sys_DSPI_GPIOConfig(SPI, (cfg), (clk), (cs), (io0), (io1))
```

Configure four GPIOs for the SPI0 interface for DSPI.

Location: spi.h:404

Parameters

Direction	Name	Description
in	<i>cfg</i>	GPIO pin configuration for the SPI pads
in	<i>clk</i>	GPIO to use as the DSPI clock pad
in	<i>cs</i>	GPIO to use as the DSPI chip select pad
in	<i>io0</i>	GPIO to use as the DSPI io0
in	<i>io1</i>	GPIO to use as the DSPI io1

Example Code for SYS_DSPI_GPIOCONFIG

```
// Configure GPIOs 0, 1, 2, and 3 for the default DSPI interface with
// low-pass filter disabled, 8X drive-strength, and 1 kOhm pull-up resistors
SYS_DSPI_GPIOCONFIG((GPIO_LPF_DISABLE | GPIO_8X_DRIVE |
GPIO_1K_PULL_UP), GPIO0, GPIO1, GPIO2, GPIO3);
```

RSL15 Firmware Reference

16.24.2.10 SYS_QSPI_GPIOCONFIG

```
#define SYS_QSPI_GPIOCONFIG Sys\_QSPI\_GPIOConfig(SPI, (cfg), (clk), (cs), (io0), (io1), \
    (io2), (io3))
```

Configure six GPIOs for the SPI0 interface for QSPI cfg GPIO pin configuration for the SPI pads clk GPIO to use as the QSPI clock pad cs GPIO to use as the QSPI chip select pad io0 GPIO to use as the QSPI io0 io1 GPIO to use as the QSPI io1 io2 GPIO to use as the QSPI io2 io3 GPIO to use as the QSPI io3.

Location: spi.h:418

Example Code for SYS_QSPI_GPIOCONFIG

```
// Configure GPIOs 0, 1, 2, 3, 4, and 5 for the default QSPI interface with
// low-pass filter disabled, 8X drive-strength, and 1 kOhm pull-up resistors
SYS\_QSPI\_GPIOCONFIG((GPIO_LPF_DISABLE | GPIO_8X_DRIVE | GPIO_1K_PULL_UP),
    GPIO0, GPIO1, GPIO2, GPIO3, GPIO4, GPIO5);
```

16.24.3 SPI Function Documentation**16.24.3.1 Sys_SPI_Config**

```
void Sys_SPI_Config(SPI_Type * spi, uint32_t config)
```

Configure the specified SPI interface's operation and controller information.

Location: spi.h:109

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>spi</i>	Pointer to the SPI instance
in	<i>config</i>	Interface operation configuration; use SPI_SELECT_[MASTER SLAVE], SPI_CLK_POLARITY_[NORMAL INVERSE], SPI_PRESCALE_*, SPI_WORD_SIZE_*, SPI_MODE_[SPI DSPI QSPI] SPI_UNDERRUN_INT_[ENABLE DISABLE], SPI_OVERRUN_INT_[ENABLE DISABLE], SPI_CS_RISE_INT_[ENABLE DISABLE], SPI_RX_INT_[ENABLE DISABLE] SPI_TX_INT_[ENABLE DISABLE] SPI_RX_DMA_[ENABLE DISABLE] SPI_TX_DMA_[ENABLE DISABLE]

Example Code for Sys_SPI_Config

```

// Configure the SPI interface's operation and controller information:
// - Master mode
// - Use 8-bit words
// - Select interrupts enabled
// - Prescale the SPI interface clock by 32
Sys_SPI_Config(SPI, SPI_SELECT_MASTER | SPI_WORD_SIZE_8 | SPI_TX_START_INT_ENABLE |
               SPI_RX_INT_ENABLE | SPI_OVERRUN_INT_ENABLE |
               SPI_PRESCALE_32 | SPI_UNDERRUN_INT_ENABLE);
    
```

16.24.3.2 Sys_SPI_TransferConfig

```
void Sys_SPI_TransferConfig(SPI_Type * spi, uint32_t config)
```

Configure the SPI transfer information for the specified SPI instance.

Location: spi.h:132

Parameters

Direction	Name	Description
in	<i>spi</i>	Pointer to the SPI instance
in	<i>config</i>	Interface transfer configuration; use SPI_ENABLE, SPI_DISABLE, SPI_RESET, SPI_START, SPI_MODE_READ_WRITE, SPI_MODE_READ, SPI_MODE_WRITE, SPI_MODE_NOP, SPI_CS_0, SPI_CS_1,

Example Code for Sys_SPI_TransferConfig

```
// Enable and configure the SPI interface to read operation mode
Sys_SPI_TransferConfig(SPI, SPI_ENABLE | SPI_MODE_READ);
```

16.24.3.3 Sys_SPI_Read

```
uint32_t Sys_SPI_Read(const SPI_Type * spi)
```

Generate clock and CS to read data from SPI interface.

Location: spi.h:147

Parameters

Direction	Name	Description
in	<i>spi</i>	Pointer to the SPI instance

Return

data Data read from the SPI interface

Assumptions

SPI is configured as master mode and transfer operation mode is SPI_MODE_READ_WRITE(full duplex) or (SPI_MODE_READ) half duplex

Example Code for Sys_SPI_Read

```
// Generate clock and CS to read data from SPI interface
Sys_SPI_Read(SPI);
```

16.24.3.4 Sys_SPI_Write

```
void Sys_SPI_Write(SPI_Type * spi, uint32_t data)
```

Generate clock and CS to write data to SPI interface.

Location: spi.h:162

Parameters

Direction	Name	Description
in	<i>spi</i>	Pointer to the SPI instance
in	<i>data</i>	Data to be sent over SPI

Assumptions

SPI is configured as master mode and transfer operation mode is SPI_MODE_READ_WRITE(full duplex) or (SPI_MODE_WRITE) half duplex

Example Code for Sys_SPI_Write

```
// Generate clock and CS to write data to SPI interface
Sys_SPI_Write(SPI, 0xFF);
```

16.24.3.5 Sys_SPI_GPIOConfig

```
void Sys_SPI_GPIOConfig(const SPI_Type * spi, uint32_t slave, uint32_t cfg, uint32_t clk,
uint32_t cs, uint32_t seri, uint32_t sero)
```

Configure four GPIOs for the specified SPI interface.

Location: spi.h:181

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>spi</i>	Pointer to the SPI instance
in	<i>slave</i>	SPI master/slave configuration; use SPI*_SELECT_[MASTER SLAVE]
in	<i>cfg</i>	GPIO pin configuration for the SPI pads
in	<i>clk</i>	GPIO to use as the SPI clock pad
in	<i>cs</i>	GPIO to use as the SPI chip select pad
in	<i>seri</i>	GPIO to use as the SPI serial input pad
in	<i>sero</i>	GPIO to use as the SPI serial output pad

Example Code for Sys_SPI_GPIOConfig

```
// Configure GPIOs 0, 1, 2, and 3 for the SPI0 interface with
// low-pass filter disabled, 8X drive-strength, and 1 kOhm pull-up resistors
Sys_SPI_GPIOConfig(SPI, GPIO0, (GPIO_LPF_DISABLE | GPIO_8X_DRIVE |
GPIO_1K_PULL_UP), GPIO0, GPIO1, GPIO2, GPIO3);
```

16.24.3.6 Sys_DSPI_GPIOConfig

```
void Sys_DSPI_GPIOConfig(const SPI_Type * spi, uint32_t cfg, uint32_t clk, uint32_t cs,
uint32_t io0, uint32_t io1)
```

Configure four GPIOs for the specified SPI interface.

Location: spi.h:265

Parameters

Direction	Name	Description
in	<i>spi</i>	Pointer to the SPI instance
in	<i>cfg</i>	GPIO pin configuration for the SPI pads
in	<i>clk</i>	GPIO to use as the DSPI clock pad

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Direction	Name	Description
in	<i>cs</i>	GPIO to use as the DSPI chip select pad
in	<i>io0</i>	GPIO to use as the DSPI io0
in	<i>io1</i>	GPIO to use as the DSPI io1

Example Code for Sys_DSPI_GPIOConfig

```
// Configure GPIOs 0, 1, 2, and 3 for the DSPI0 interface with
// low-pass filter disabled, 8X drive-strength, and 1 kOhm pull-up resistors
Sys_DSPI_GPIOConfig(SPI, (GPIO_LPF_DISABLE | GPIO_8X_DRIVE |
GPIO_1K_PULL_UP), GPIO0, GPIO1, GPIO2, GPIO3);
```

16.24.3.7 Sys_QSPI_GPIOConfig

```
void Sys_QSPI_GPIOConfig(const SPI_Type * spi, uint32_t cfg, uint32_t clk, uint32_t cs,
uint32_t io0, uint32_t io1, uint32_t io2, uint32_t io3)
```

Configure six GPIOs for the specified SPI interface.

Location: spi.h:297

Parameters

Direction	Name	Description
in	<i>spi</i>	Pointer to the SPI instance
in	<i>cfg</i>	GPIO pin configuration for the SPI pads
in	<i>clk</i>	GPIO to use as the QSPI clock pad
in	<i>cs</i>	GPIO to use as the QSPI chip select pad
in	<i>io0</i>	GPIO to use as the QSPI io0
in	<i>io1</i>	GPIO to use as the QSPI io1
in	<i>io2</i>	GPIO to use as the QSPI io2
in	<i>io3</i>	GPIO to use as the QSPI io3

Example Code for Sys_QSPI_GPIOConfig

```
// Configure GPIOs 0, 1, 2, 3, 4, and 5 for the QSPI0 interface with
// low-pass filter disabled, 8X drive-strength, and 1 kOhm pull-up resistors
Sys\_QSPI\_GPIOConfig(SPI, (GPIO_LPF_DISABLE | GPIO_8X_DRIVE | GPIO_1K_PULL_UP),
                     GPIO0, GPIO1, GPIO2, GPIO3, GPIO4, GPIO5);
```

16.25 GENERAL-PURPOSE TIMER

General-purpose timer hardware abstraction layer.

16.25.1 Summary**Macros**

- [SYS_TIMER_CONFIG](#) : Configures the default timer instance.
- [SYS_TIMER_START](#) : Starts the default timer instance.
- [SYS_TIMER_STOP](#) : Stops the default timer instance.

Functions

- [Sys_Timer_Config](#) : Configure timer instance.
- [Sys_Timer_Start](#) : Start or restart timer instance.
- [Sys_Timer_Stop](#) : Stop the timer instance.

16.25.2 General-Purpose Timer Macro Definition Documentation**16.25.2.1 SYS_TIMER_CONFIG**

```
#define SYS_TIMER_CONFIG Sys\_Timer\_Config(TIMER, (cfg0), \
                                           (cfg1), (timeout))
```

Configures the default timer instance.

Location: timer.h:83

16.25.2.2 SYS_TIMER_START

```
#define SYS_TIMER_START Sys\_Timer\_Start(TIMER)
```

Starts the default timer instance.

Location: timer.h:87

16.25.2.3 SYS_TIMER_STOP

```
#define SYS_TIMER_STOP Sys Timer Stop(TIMER)
```

Stops the default timer instance.

Location: timer.h:90

16.25.3 General-Purpose Timer Function Documentation

16.25.3.1 Sys_Timer_Config

```
void Sys_Timer_Config(TIMER_Type * timer, uint32_t cfg0, uint32_t cfg1, uint32_t timeout)
```

Configure timer instance.

Location: timer.h:51

Parameters

Direction	Name	Description
in	<i>timer</i>	Pointer to the timer instance
in	<i>cfg0</i>	Timer configuration 0; use TIMER_PRESCALE_*,
in	<i>cfg1</i>	Timer configuration 1; use TIMER_MULTI_COUNT_* [TIMER_SHOT_MODE TIMER_FREE_RUN]
in	<i>timeout</i>	number of timer clock cycles before a timeout would occur

Example Code for Sys_Timer_Config

```
// Configure TIMER2 instance:
// - Divide the input clock frequency by 2
// - Stop on 2nd Time-out occurrence and issue an interrupt
// - Select the GPIO interrupt defined in GPIO_INT_CFG3
// - GPIO interrupt single capture mode
// - Free-run mode
// - Long timeout
Sys_Timer_Config(TIMER2, TIMER_PRESCALE_2,
                 TIMER_MULTI_COUNT_2 |
                 TIMER_SRC_GPIO_INT3 |
                 TIMER_GPIO_INT_SINGLE |
                 TIMER_FREE_RUN, 0xFFFF);
```

16.25.3.2 Sys_Timer_Start

```
void Sys_Timer_Start(TIMER_Type * timer)
```

Start or restart timer instance.

Location: timer.h:65

Parameters

Direction	Name	Description
in	<i>timer</i>	Pointer to the timer instance

Example Code for Sys_Timer_Start

```
// Start or restart TIMER instance
Sys_Timer_Start(TIMER);
```

16.25.3.3 Sys_Timer_Stop

```
void Sys_Timer_Stop(TIMER_Type * timer)
```

Stop the timer instance.

Location: timer.h:76

Parameters

Direction	Name	Description
in	<i>timer</i>	Pointer to the timer instance

Example Code for Sys_Timer_Stop

```
// Stop the TIMER3 instance
Sys_Timer_Stop(TIMER3);
```

16.26 TIME OF FLIGHT

Time of Flight (TOF) hardware abstraction layer.

16.26.1 Summary**Functions**

- [Sys_TOF_Config](#) : Configure TOF module.
- [Sys_TOF_Start](#) : Start the time of flight module.
- [Sys_TOF_Stop](#) : Stop the time of flight module.

16.26.2 Time of Flight Function Documentation**16.26.2.1 Sys_TOF_Config**

```
void Sys_TOF_Config(uint32_t cfg)
```

Configure TOF module.

Location: tof.h:53

Parameters

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Direction	Name	Description
in	<i>cfg</i>	Time of flight configuration; use [TOF_ERROR_INT_ENABLE TOF_ERROR_INT_DISABLE], [TOF_OVERRUN_INT_ENABLE TOF_OVERRUN_INT_DISABLE], [TOF_AVG_DATA_INT_ENABLE TOF_AVG_DATA_INT_DISABLE], [TOF_DATA_INT_ENABLE TOF_DATA_INT_DISABLE], [TOF_AVG_DATA_DMA_ENABLE TOF_AVG_DATA_DMA_DISABLE], [TOF_DATA_DMA_ENABLE TOF_DATA_DMA_DISABLE], [TOF_AVG_DATA_*, TOF_STOP_SRC_*, TOF_START_SRC_*, TOF_CLK_PRESCALE_*

Example Code for Sys_TOF_Config

```
// Configure time-of-flight module:
// - Enable the error, overrun and average data complete interrupts
// - Average data interrupt is triggered after 16 samples
Sys_TOF_Config(TOF_ERROR_INT_ENABLE |
               TOF_OVERRUN_INT_ENABLE |
               TOF_AVG_DATA_INT_ENABLE |
               TOF_DATA_INT_ENABLE |
               TOF_AVG_DATA_16);
```

16.26.2.2 Sys_TOF_Start

```
void Sys_TOF_Start()
```

Start the time of flight module.

Location: tof.h:63

Example Code for Sys_TOF_Start

```
// Start the time-of-flight counter.
Sys_TOF_Start();
```

16.26.2.3 Sys_TOF_Stop

```
void Sys_TOF_Stop()
```

Stop the time of flight module.

Location: tof.h:73

Example Code for Sys_TOF_Stop

```
// Stop the time-of-flight counter.  
Sys\_TOF\_Stop\(\);
```

16.27 TRIMMING SUPPORT

Power, clock, and sensor component trimming hardware abstraction layer.

16.27.1 Summary

Variables

- [trim_args1](#) : Trim targets for items needing one trim.
- [trim_args2](#) : Trim targets for items needing two trims.

Enumerations

- [TrimTarget t](#) : Default trim targets present in NVR7.
- [TrimName t](#) : Voltage rail and oscillator names.

Macros

- [NULL_POINTER](#) : NULL pointer.
- [MIN_32_BIT](#) : Minimum 32-bit value.
- [MAX_32_BIT](#) : Maximum 32-bit value.
- [MIN_18_BIT](#) : Minimum 18-bit value.
- [MAX_18_BIT](#) : Maximum 18-bit value.
- [MIN_16_BIT](#) : Minimum 16-bit value.
- [MAX_16_BIT](#) : Maximum 16-bit value.

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- [MIN 8 BIT](#) : Minimum 8-bit value.
- [MAX 8 BIT](#) : Maximum 8-bit value.
- [MAX 4 BIT](#) : Maximum 4-bit value.
- [ERROR NO ERROR](#)
- [ERROR NULL](#) : Null pointer error.
- [ERROR NO TRIM FOUND](#) : Target trim value not found.
- [ERROR INVALID TRIM](#) : Trims in region specified are not valid.
- [ERROR INVALID CRC](#) : Trim region CRC has failed.
- [ERROR BG INVALID](#) : Bandgap target value is invalid.
- [ERROR BG V INVALID](#) : Bandgap voltage trim is invalid.
- [ERROR BG I INVALID](#) : Bandgap current trim is invalid.
- [ERROR DCDC INVALID](#) : DCDC trim is invalid.
- [ERROR VDDC INVALID](#) : VDDC trim is invalid.
- [ERROR VDDC STBY INVALID](#) : VDDC standby trim is invalid.
- [ERROR VDDM INVALID](#) : VDDM trim is invalid.
- [ERROR VDDM STBY INVALID](#) : VDDM standby trim is invalid.
- [ERROR VDDRF INVALID](#) : VDDRF trim is invalid.
- [ERROR VDDPA INVALID](#) : VDDPA trim is invalid.
- [ERROR VDDPA MIN INVALID](#) : VDDPA minimum trim is invalid.
- [ERROR VDDIF INVALID](#) : VDDIF trim is invalid.
- [ERROR VDDFLASH INVALID](#) : VDDFLASH trim is invalid.
- [ERROR RCOSC INVALID](#) : RC start oscillator trim is invalid.
- [ERROR RCOSC32 INVALID](#) : RC standby oscillator trim is invalid.
- [ERROR LSAD INVALID](#) : LSAD gain or offset is invalid.
- [ERROR TEMPERATURE INVALID](#) : Temperature sensor gain or offset is invalid.
- [ERROR THERMISTOR INVALID](#) : Thermistor gain or offset is invalid.
- [ERROR MEASURED INVALID](#) : Measured reference temperature is invalid.
- [ERROR TRIM CUSTOM SIGNATURE INVALID](#) : Custom signature check is invalid.
- [ERROR TRIM CUSTOM ICH INVALID](#) : Custom ICH trim value is invalid.
- [ERROR TRIM CUSTOM XTAL INVALID](#) : Custom Xtal trim value is invalid.
- [TR REG TRIM MASK](#) : Temperature record 18-bit trim value mask.
- [TRIM 8 BIT TRIM MASK](#) : 8-bit trim value mask
- [TRIM 16 BIT TRIM MASK](#) : 16-bit trim value mask
- [TRIM NVR7 2 BIT RC FSEL MASK](#)
- [TRIM NVR7 VCC DCDC Pos](#)
- [LSAD HF](#) : LSAD high frequency compensation values.
- [LSAD LF](#) : LSAD low frequency compensation values.
- [LSAD OFFSET](#) : LSAD offset compensation address offset.
- [LSAD OFFSET MASK](#) : LSAD offset compensation mask.
- [LSAD GAIN](#) : LSAD gain compensation address offset.
- [LSAD GAIN MASK](#) : LSAD gain compensation mask.
- [TRIM](#) : Default trim instance, pointing to NVR7.
- [TRIM SUPPLEMENTAL](#) : Supplemental trim instance, pointing to NVR4.
- [TRIM CUSTOM SIP1 SIGNATURE](#) : SiP Signature for NVR6 custom trim calibration.
- [TRIM CUSTOM CUST SIGNATURE](#) : Custom Signature for NVR6 custom trim calibration.
- [ICH TRIM DEFAULT](#)
- [SYS TRIM LOAD DEFAULT](#) : Load default trim values from NVR7.
- [SYS TRIM LOAD SUPPLEMENTAL](#) : Load supplemental trim values from NVR4.
- [SYS TRIM LOAD CUSTOM](#) : Load custom trim values from NVR6.

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Functions

- [Sys Trim LoadTrims](#) : Load trim values from the specified memory location.
- [Sys Trim LoadSingleTrim](#) : Load a trim value for a specific voltage regulator or oscillator.
- [Sys Trim VerifyTrims](#) : Verify if the trims memory is populated correctly.
- [Sys Trim CheckCRC](#) : Check if the CRC for the indicated region is valid.
- [Sys Trim GetTrim](#) : Get the trim value requested, check if it is valid.
- [Sys Trim LoadBandgap](#) : Load target trim value, if present.
- [Sys Trim LoadDCDC](#) : Load target trim value for current mode (LDO or BUCK).
- [Sys Trim LoadVDDC](#) : Load target trim value, if present.
- [Sys Trim LoadVDDM](#) : Load target trim value, if present.
- [Sys Trim LoadVDDPA](#) : Load target trim value, if present.
- [Sys Trim LoadVDDRF](#) : Load target trim value, if present.
- [Sys Trim LoadCustom](#) : Load custom trim values from NVR6.
- [Sys Trim LoadVDDFLASH](#) : Load target trim value, if present.
- [Sys Trim LoadRCOSC](#) : Load target trim value, if present.
- [Sys Trim LoadRCOSC32](#) : Load target trim value, if present.
- [Sys Trim LoadThermistor](#) : Load target trim value, if present.
- [Sys Trim GetLSADTrim](#) : Load LSAD gain and offset value from specified address. Verifies valid values first.

16.27.2 Trimming Support Variable Documentation

16.27.2.1 trim_args1

```
uint32_t trim_args1[TRIM_NUM_FUNCTIONS_1_ARG]
```

Location: trim.h:280

Trim targets for items needing one trim.

16.27.2.2 trim_args2

```
uint32_t trim_args2[TRIM_NUM_FUNCTIONS_2_ARGS][2]
```

Location: trim.h:281

Trim targets for items needing two trims.

16.27.3 Trimming Support Enumeration Type Documentation

16.27.3.1 TrimTarget_t

Location: trim.h:169

Default trim targets present in NVR7.

Members

- TARGET_BANDGAP_V = 75

750mV

- TARGET_BANDGAP_I = 100

1000nA

- TARGET_DCDC_1200 = 120

1.2V

- TARGET_DCDC_1120 = 112

1.12V

- TARGET_DCDC_1350 = 135

1.35V

- TARGET_DCDC_1100 = 110

1.10V

- TARGET_VDDC_1150 = 115

1.15V

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- TARGET_VDDC_1000 = 100

1.00V

- TARGET_VDDC_1080 = 108

1.08V

- TARGET_VDDC_920 = 92

0.92V

- TARGET_VDDC_1050 = 105

1.05V

- TARGET_VDDC_STANDBY = 80

0.80V

- TARGET_VDDM_1150 = 115

1.15V

- TARGET_VDDM_1080 = 108

1.08V

- TARGET_VDDM_1100 = 110

1.05V

- TARGET_VDDM_STANDBY = 80

0.80V

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- TARGET_VDDRF_1100 = 110

1.10V

- TARGET_VDDRF_1070 = 107

1.07V

- TARGET_VDDRF_1200 = 120

1.20V

- TARGET_VDDPA_1300 = 130

1.30V

- TARGET_VDDPA_1260 = 126

1.26V

- TARGET_VDDPA_1600 = 160

1.60V

- TARGET_VDDPA_MIN_1100 = 110

1.10V

- TARGET_VDDIF_1800 = 180

1.80V

- TARGET_FLASH_1600 = 160

1.60V

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- TARGET_RC3 = 3000

3MHz

- TARGET_RC12 = 12000

12MHz

- TARGET_RC24 = 24000

24MHz

- TARGET_RC48 = 48000

48MHz

- TARGET_RC32K = 32768

32kHz

- TARGET_THERMISTOR_10 = 10

10uA

- TARGET_THERMISTOR_5 = 5

5.0uA

16.27.3.2 TrimName_t

Location: trim.h:208

Voltage rail and oscillator names.

Members

- TRIM_BANDGAP
- TRIM_DCDC

Select loading bandgap trim values.

- TRIM_VDDC

Select loading DCDC trim values.

- TRIM_VDDM

Select loading VDDC trim values.

- TRIM_VDDRF

Select loading VDDM trim values.

- TRIM_VDDPA

Select loading VDDRF trim values.

- TRIM_VDDIF

Select loading VDDPA trim values.

- TRIM_FLASH

Select loading VDDIF trim values.

- TRIM_RCOSC

Select loading VDDFLASH trim values.

- TRIM_RCOSC32

Select loading RC oscillator trim values.

16.27.4 Trimming Support Macro Definition Documentation

16.27.4.1 NULL_POINTER

```
#define NULL_POINTER 0
```

NULL pointer.

Location: trim.h:54

16.27.4.2 MIN_32_BIT

```
#define MIN_32_BIT 0x00000000UL
```

Minimum 32-bit value.

Location: trim.h:58

16.27.4.3 MAX_32_BIT

```
#define MAX_32_BIT 0xFFFFFFFFUL
```

Maximum 32-bit value.

Location: trim.h:61

16.27.4.4 MIN_18_BIT

```
#define MIN_18_BIT 0x000000U
```

Minimum 18-bit value.

Location: trim.h:64

16.27.4.5 MAX_18_BIT

```
#define MAX_18_BIT 0x3FFFFU
```

Maximum 18-bit value.

Location: trim.h:67

16.27.4.6 MIN_16_BIT

```
#define MIN_16_BIT 0x0000U
```

Minimum 16-bit value.

Location: trim.h:70

16.27.4.7 MAX_16_BIT

```
#define MAX_16_BIT 0xFFFFU
```

Maximum 16-bit value.

Location: trim.h:73

16.27.4.8 MIN_8_BIT

```
#define MIN_8_BIT 0x00U
```

Minimum 8-bit value.

Location: trim.h:76

16.27.4.9 MAX_8_BIT

```
#define MAX_8_BIT 0xFFU
```

Maximum 8-bit value.

Location: trim.h:79

16.27.4.10 MAX_4_BIT

```
#define MAX_4_BIT 0xFU
```

Maximum 4-bit value.

Location: trim.h:82

16.27.4.11 ERROR_NO_ERROR

```
#define ERROR_NO_ERROR 0
```

Location: trim.h:86

errors

16.27.4.12 ERROR_NULL

```
#define ERROR_NULL (1 << 1)
```

Null pointer error.

Location: trim.h:89

16.27.4.13 ERROR_NO_TRIM_FOUND

```
#define ERROR_NO_TRIM_FOUND (1 << 3)
```

Target trim value not found.

Location: trim.h:92

16.27.4.14 ERROR_INVALID_TRIM

```
#define ERROR_INVALID_TRIM (1 << 4)
```

Trims in region specified are not valid.

Location: trim.h:95

16.27.4.15 ERROR_INVALID_CRC

```
#define ERROR_INVALID_CRC (1 << 5)
```

Trim region CRC has failed.

Location: trim.h:98

16.27.4.16 ERROR_BG_INVALID

```
#define ERROR_BG_INVALID (1 << 6)
```

Bandgap target value is invalid.

Location: trim.h:101

16.27.4.17 ERROR_BG_V_INVALID

```
#define ERROR_BG_V_INVALID (1 << 7)
```

Bandgap voltage trim is invalid.

Location: trim.h:104

16.27.4.18 ERROR_BG_I_INVALID

```
#define ERROR_BG_I_INVALID (1 << 8)
```

Bandgap current trim is invalid.

Location: trim.h:107

16.27.4.19 ERROR_DCDC_INVALID

```
#define ERROR_DCDC_INVALID (1 << 9)
```

DCDC trim is invalid.

Location: trim.h:110

16.27.4.20 ERROR_VDDC_INVALID

```
#define ERROR_VDDC_INVALID (1 << 10)
```

VDDC trim is invalid.

Location: trim.h:113

16.27.4.21 ERROR_VDDC_STBY_INVALID

```
#define ERROR_VDDC_STBY_INVALID (1 << 11)
```

VDDC standby trim is invalid.

Location: trim.h:116

16.27.4.22 ERROR_VDDM_INVALID

```
#define ERROR_VDDM_INVALID (1 << 12)
```

VDDM trim is invalid.

Location: trim.h:119

16.27.4.23 ERROR_VDDM_STBY_INVALID

```
#define ERROR_VDDM_STBY_INVALID (1 << 13)
```

VDDM standby trim is invalid.

Location: trim.h:122

16.27.4.24 ERROR_VDDRF_INVALID

```
#define ERROR_VDDRF_INVALID (1 << 14)
```

VDDRF trim is invalid.

Location: trim.h:125

16.27.4.25 ERROR_VDDPA_INVALID

```
#define ERROR_VDDPA_INVALID (1 << 15)
```

VDDPA trim is invalid.

Location: trim.h:128

16.27.4.26 ERROR_VDDPA_MIN_INVALID

```
#define ERROR_VDDPA_MIN_INVALID (1 << 16)
```

VDDPA minimum trim is invalid.

Location: trim.h:131

16.27.4.27 ERROR_VDDIF_INVALID

```
#define ERROR_VDDIF_INVALID (1 << 17)
```

VDDIF trim is invalid.

Location: trim.h:134

16.27.4.28 ERROR_VDDFLASH_INVALID

```
#define ERROR_VDDFLASH_INVALID (1 << 18)
```

VDDFLASH trim is invalid.

Location: trim.h:137

16.27.4.29 ERROR_RCOSC_INVALID

```
#define ERROR_RCOSC_INVALID (1 << 19)
```

RC start oscillator trim is invalid.

Location: trim.h:140

16.27.4.30 ERROR_RCOSC32_INVALID

```
#define ERROR_RCOSC32_INVALID (1 << 20)
```

RC standby oscillator trim is invalid.

Location: trim.h:143

16.27.4.31 ERROR_LSAD_INVALID

```
#define ERROR_LSAD_INVALID (1 << 21)
```

LSAD gain or offset is invalid.

Location: trim.h:146

16.27.4.32 ERROR_TEMPERATURE_INVALID

```
#define ERROR_TEMPERATURE_INVALID (1 << 22)
```

Temperature sensor gain or offset is invalid.

Location: trim.h:149

16.27.4.33 ERROR_THERMISTOR_INVALID

```
#define ERROR_THERMISTOR_INVALID (1 << 23)
```

Thermistor gain or offset is invalid.

Location: trim.h:152

16.27.4.34 ERROR_MEASURED_INVALID

```
#define ERROR_MEASURED_INVALID (1 << 25)
```

Measured reference temperature is invalid.

Location: trim.h:155

16.27.4.35 ERROR_TRIM_CUSTOM_SIGNATURE_INVALID

```
#define ERROR_TRIM_CUSTOM_SIGNATURE_INVALID (1 << 26)
```

Custom signature check is invalid.

Location: trim.h:158

16.27.4.36 ERROR_TRIM_CUSTOM_ICH_INVALID

```
#define ERROR_TRIM_CUSTOM_ICH_INVALID (1 << 27)
```

Custom ICH trim value is invalid.

Location: trim.h:161

16.27.4.37 ERROR_TRIM_CUSTOM_XTAL_INVALID

```
#define ERROR_TRIM_CUSTOM_XTAL_INVALID (1 << 28)
```

Custom Xtal trim value is invalid.

Location: trim.h:164

16.27.4.38 TR_REG_TRIM_MASK

```
#define TR_REG_TRIM_MASK 0x3FU
```

Temperature record 18-bit trim value mask.

Location: trim.h:224

16.27.4.39 TRIM_8_BIT_TRIM_MASK

```
#define TRIM_8_BIT_TRIM_MASK 0xFFU
```

8-bit trim value mask

Location: trim.h:227

16.27.4.40 TRIM_16_BIT_TRIM_MASK

```
#define TRIM_16_BIT_TRIM_MASK 0xFFFFU
```

16-bit trim value mask

Location: trim.h:230

16.27.4.41 TRIM_NVR7_2_BIT_RC_FSEL_MASK

```
#define TRIM_NVR7_2_BIT_RC_FSEL_MASK (0x3U << 7)
```

Location: trim.h:233

16.27.4.42 TRIM_NVR7_VCC_DCDC_Pos

```
#define TRIM_NVR7_VCC_DCDC_Pos 8
```

Location: trim.h:236

16.27.4.43 LSAD_HF

```
#define LSAD_HF 0
```

LSAD high frequency compensation values.

Location: trim.h:240

16.27.4.44 LSAD_LF

```
#define LSAD_LF 1
```

LSAD low frequency compensation values.

Location: trim.h:243

16.27.4.45 LSAD_OFFSET

```
#define LSAD_OFFSET 0x00U
```

LSAD offset compensation address offset.

Location: trim.h:246

16.27.4.46 LSAD_OFFSET_MASK

```
#define LSAD_OFFSET_MASK 0xFFU
```

LSAD offset compensation mask.

Location: trim.h:249

16.27.4.47 LSAD_GAIN

```
#define LSAD_GAIN 0x04U
```

LSAD gain compensation address offset.

Location: trim.h:252

16.27.4.48 LSAD_GAIN_MASK

```
#define LSAD_GAIN_MASK 0x3FFU
```

LSAD gain compensation mask.

Location: trim.h:255

16.27.4.49 TRIM

```
#define TRIM (TRIM_Type *)TRIM_BASE_DEFAULT
```

Default trim instance, pointing to NVR7.

Location: trim.h:265

16.27.4.50 TRIM_SUPPLEMENTAL

```
#define TRIM_SUPPLEMENTAL (TRIM_Type *)FLASH0_NVR4_BASE
```

Supplemental trim instance, pointing to NVR4.

Location: trim.h:268

16.27.4.51 TRIM_CUSTOM_SIP1_SIGNATURE

```
#define TRIM_CUSTOM_SIP1_SIGNATURE 0x53495031
```

SiP Signature for NVR6 custom trim calibration.

Location: trim.h:271

16.27.4.52 TRIM_CUSTOM_CUST_SIGNATURE

```
#define TRIM_CUSTOM_CUST_SIGNATURE 0x43555354
```

Custom Signature for NVR6 custom trim calibration.

Location: trim.h:274

16.27.4.53 ICH_TRIM_DEFAULT

```
#define ICH_TRIM_DEFAULT (0x5U)
```

Location: trim.h:277

RSL15 Firmware Reference

16.27.4.54 SYS_TRIM_LOAD_DEFAULT

```
#define SYS_TRIM_LOAD_DEFAULT Sys Trim LoadTrims(TRIM, trim args1, trim args2)
```

Load default trim values from NVR7.

Location: trim.h:520

Return

A code indicating whether an error has occurred. Error codes: [errors](#)

Example Code for SYS_TRIM_LOAD_DEFAULT

```
// Load all valid default trim values from MNVR/NVR7 for
// power rails and oscillators
result = SYS\_TRIM\_LOAD\_DEFAULT();
```

16.27.4.55 SYS_TRIM_LOAD_SUPPLEMENTAL

```
#define SYS_TRIM_LOAD_SUPPLEMENTAL Sys Trim LoadTrims(TRIM_SUPPLEMENTAL, x, y)
```

Load supplemental trim values from NVR4.

Location: trim.h:536

Parameters

Direction	Name	Description
in	<i>x</i>	uint32_t[6] containing targets in this order: DCDC, VDDRF, VDDIF, VDDFLASH, RC 3MHz, RC 32kHz
in	<i>y</i>	uint32_t[4][2] containing targets in this order: Bandgap voltage Bandgap current VDDC voltage VDDC standby voltage VDDM voltage VDDM standby voltage VDDPA voltage VDDPA minimum voltage

Return

A code indicating whether an error has occurred. Error codes: [errors](#)

NOTE: For detail on input parameters, see trim_arg1 & 2 in trim.c

Example Code for SYS_TRIM_LOAD_SUPPLEMENTAL

```
// Load the requested supplemental trim values
result = SYS\_TRIM\_LOAD\_DEFAULT\(\);
```

16.27.4.56 SYS_TRIM_LOAD_CUSTOM

```
#define SYS_TRIM_LOAD_CUSTOM Sys Trim LoadCustom\(\)
```

Load custom trim values from NVR6.

Location: trim.h:544

Return

A code indicating whether an error has occurred. Error codes: [errors](#)

Example Code for SYS_TRIM_LOAD_CUSTOM

```
// Load all valid custom trim values from NVR6
result = SYS\_TRIM\_LOAD\_CUSTOM\(\)
```

16.27.5 Trimming Support Function Documentation

RSL15 Firmware Reference

16.27.5.1 Sys_Trim_LoadTrims

```
uint32_t Sys_Trim_LoadTrims(TRIM_Type * trim_region, uint32_t targets_1, uint32_t targets_2)
```

Load trim values from the specified memory location.

Location: trim.h:301

Parameters

Direction	Name	Description
in	<i>trim_region</i>	Pointer to section of memory containing trim values, typically base of NVR7.
in	<i>targets_1</i>	uint32_t[6] containing targets in this order: DCDC, VDDRF, VDDIF, VDDFLASH, RC 3MHz, RC 32kHz
in	<i>targets_2</i>	uint32_t[4][2] containing targets in this order: Bandgap voltage Bandgap current VDDC voltage VDDC standby voltage VDDM voltage VDDM standby voltage VDDPA voltage VDDPA minimum voltage

Return

A code indicating whether an error has occurred. Error codes: [errors](#)

NOTE: Does not work with LSAD gain/offset. Use [lsadload Sys Trim GetLSADTrim\(\)](#) instead.

NOTE: For detail on input parameters, see trim_args1 & 2 in trim.c

Example Code for Sys_Trim_LoadTrims

```
// Load all valid default trim values from NVR7 for
// power rails and oscillators
result = Sys Trim LoadTrims(trim_region);
```

RSL15 Firmware Reference

16.27.5.2 Sys_Trim_LoadSingleTrim

```
uint32_t Sys_Trim_LoadSingleTrim(uint32_t target_name, uint32_t target_value1, uint32_t
target_value2)
```

Load a trim value for a specific voltage regulator or oscillator.

This function attempts to load calibration values from customer trim settings in NVR4, then load manufacturing calibration values from NVR7 if customer calibration values are not found.

Location: trim.h:319

Parameters

Direction	Name	Description
in	<i>target_name</i>	Voltage regulator or oscillator to load trim values for.
in	<i>target_value1</i>	Main trim target value
in	<i>target_value2</i>	Secondary trim target value used on some regulators.

Return

A code indicating whether an error has occurred. Error codes: [errors](#)

NOTE: Does not work with LSAD gain/offset. Use [lsadload Sys_Trim_GetLSADTrim\(\)](#) instead.

Example Code for Sys_Trim_LoadSingleTrim

```
// Load all valid default trim values from NVR7 for
// power rails and oscillators
result = Sys\_Trim\_LoadTrims(trim_region);
```

16.27.5.3 Sys_Trim_VerifyTrims

```
uint32_t Sys_Trim_VerifyTrims(TRIM_Type * trim_region)
```

RSL15 Firmware Reference

Verify if the trims memory is populated correctly.

Location: trim.h:331

Parameters

Direction	Name	Description
in	<i>trim_region</i>	Pointer to section of memory containing trim values, typically base of NVR7.

Return

A code indicating whether an error has occurred. Error codes: [errors](#)

Example Code for Sys_Trim_VerifyTrims

```
// Verify that the input region contains validly programmed values.
result = Sys\_Trim\_VerifyTrims(trim_region);
```

16.27.5.4 Sys_Trim_CheckCRC

```
uint32_t Sys_Trim_CheckCRC(TRIM_Type * trim_region)
```

Check if the CRC for the indicated region is valid.

Location: trim.h:341

Parameters

Direction	Name	Description
in	<i>trim_region</i>	Pointer to section of memory containing trim values, typically base of NVR7.

Return

A code indicating whether an error has occurred. Error codes: [errors](#)

Example Code for Sys_Trim_CheckCRC

```
// Performs a CRC on the data in the region storing the trim settings.
result = Sys\_Trim\_CheckCRC(trim_region);
```

16.27.5.5 Sys_Trim_GetTrim

```
uint32_t Sys_Trim_GetTrim(uint32_t * addr, uint16_t trim_target, uint32_t record_length,
uint16_t * trim_val)
```

Get the trim value requested, check if it is valid.

Location: trim.h:353

Parameters

Direction	Name	Description
in	<i>addr</i>	Pointer to address of base of trim record.
in	<i>trim_target</i>	Target voltage/current/clock
in	<i>record_length</i>	Number of records for that trim value.
out	<i>trim_val</i>	Pointer to return retrieved trim value.

Return

A code indicating whether an error has occurred. Error codes: [errors](#)

RSL15 Firmware Reference

Example Code for Sys_Trim_GetTrim

```
// Retrieves a trim setting from the indicated region, if that target exists.
result = Sys\_Trim\_GetTrim(trim_region, TARGET\_RC12, 4, &trim_voltage);
```

16.27.5.6 Sys_Trim_LoadBandgap

```
uint32_t Sys_Trim_LoadBandgap(TRIM_Type * trim_values, uint32_t target_v, uint32_t
target_i)
```

Load target trim value, if present.

Location: trim.h:368

Parameters

Direction	Name	Description
in	<i>trim_values</i>	Pointer to section of memory containing trim values, typically base of NVR7.
in	<i>target_v</i>	The target voltage trim setting.
in	<i>target_i</i>	The target current trim setting.

Return

A code indicating whether an error has occurred. Error codes: [errors](#)

Example Code for Sys_Trim_LoadBandgap

```
// Loads the bandgap trim settings from NVR7.
result = Sys\_Trim\_LoadBandgap(trim_region, TARGET\_BANDGAP\_V, TARGET\_BANDGAP\_I);
```

16.27.5.7 Sys_Trim_LoadDCDC

```
uint32_t Sys_Trim_LoadDCDC(TRIM_Type * trim_values, uint32_t target)
```

RSL15 Firmware Reference

Load target trim value for current mode (LDO or BUCK).

Location: trim.h:381

Parameters

Direction	Name	Description
in	<i>trim_values</i>	Pointer to section of memory containing trim values, typically base of NVR7.
in	<i>target</i>	The target voltage trim setting.

Return

A code indicating whether an error has occurred. Error codes: [errors](#)

Example Code for Sys_Trim_LoadDCDC

```
// Loads the DC-DC converter trim settings from NVR7 for 1.2 V.
result = Sys_Trim_LoadDCDC(trim_region, TARGET_DCDC_1200);
```

16.27.5.8 Sys_Trim_LoadVDDC

```
uint32_t Sys_Trim_LoadVDDC(TRIM_Type * trim_values, uint32_t target, uint32_t target_
standby)
```

Load target trim value, if present.

Location: trim.h:393

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>trim_values</i>	Pointer to section of memory containing trim values, typically base of NVR7.
in	<i>target</i>	The target voltage trim setting.
in	<i>target_standby</i>	The target standby voltage trim setting.

Return

A code indicating whether an error has occurred. Error codes: [errors](#)

Example Code for Sys_Trim_LoadVDDC

```
// Loads the VDDC regulator trim settings from NVR7 for 1.15 V.
result = Sys Trim LoadVDDC(trim_region, TARGET VDDC 1150, TARGET VDDC STANDBY);
```

16.27.5.9 Sys_Trim_LoadVDDM

```
uint32_t Sys_Trim_LoadVDDM(TRIM_Type * trim_values, uint32_t target, uint32_t target_
standby)
```

Load target trim value, if present.

Location: trim.h:406

Parameters

Direction	Name	Description
in	<i>trim_values</i>	Pointer to section of memory containing trim values, typically base of NVR7.
in	<i>target</i>	The target voltage trim setting.
in	<i>target_standby</i>	The target standby voltage trim setting.

Return

A code indicating whether an error has occurred. Error codes: [errors](#)

Example Code for Sys_Trim_LoadVDDM

```
// Loads the VDDM regulator trim settings from NVR7 for 1.15 V.
result = Sys_Trim_LoadVDDM(trim_region, TARGET_VDDM_1150, TARGET_VDDM_STANDBY);
```

16.27.5.10 Sys_Trim_LoadVDDPA

```
uint32_t Sys_Trim_LoadVDDPA(TRIM_Type * trim_values, uint32_t target)
```

Load target trim value, if present.

Location: trim.h:418

Parameters

Direction	Name	Description
in	<i>trim_values</i>	Pointer to section of memory containing trim values, typically base of NVR7.
in	<i>target</i>	The target voltage trim setting.

Return

A code indicating whether an error has occurred. Error codes: [errors](#)

RSL15 Firmware Reference

Example Code for Sys_Trim_LoadVDDPA

```
// Loads the VDDPA regulator trim settings from NVR7 for 1.6 V.
result = Sys_Trim_LoadVDDPA(trim_region, TARGET_VDDPA_1600, TARGET_VDDPA_MIN_1100);
```

16.27.5.11 Sys_Trim_LoadVDDRF

```
uint32_t Sys_Trim_LoadVDDRF(TRIM_Type * trim_values, uint32_t target)
```

Load target trim value, if present.

Location: trim.h:429

Parameters

Direction	Name	Description
in	<i>trim_values</i>	Pointer to section of memory containing trim values, typically base of NVR7.
in	<i>target</i>	The target voltage trim setting.

Return

A code indicating whether an error has occurred. Error codes: [errors](#)

Example Code for Sys_Trim_LoadVDDRF

```
// Loads the VDDRF regulator trim settings from NVR7 for 1.1 V.
result = Sys_Trim_LoadVDDRF(trim_region, TARGET_VDDRF_1100);
```

16.27.5.12 Sys_Trim_LoadCustom

```
uint32_t Sys_Trim_LoadCustom()
```

Load custom trim values from NVR6.

Location: trim.h:437

Return

A code indicating whether an error has occurred. Error codes: [errors](#)

Example Code for Sys_Trim_LoadCustom

```
// Load all valid custom trim values from NVR6
result = SYS\_TRIM\_LOAD\_CUSTOM()
```

16.27.5.13 Sys_Trim_LoadVDDFLASH

```
uint32_t Sys_Trim_LoadVDDFLASH(TRIM_Type * trim_values, uint32_t target)
```

Load target trim value, if present.

Location: trim.h:465

Parameters

Direction	Name	Description
in	<i>trim_values</i>	Pointer to section of memory containing trim values, typically base of NVR7.
in	<i>target</i>	The voltage trim setting desired.

Return

A code indicating whether an error has occurred. Error codes: [errors](#)

RSL15 Firmware Reference

Example Code for Sys_Trim_LoadVDDFLASH

```
// Loads the VDDFLASH regulator trim settings from NVR7 for 1.6 V.
result = Sys_Trim_LoadVDDFLASH(trim_region, TARGET_VDDFLASH_1600);
```

16.27.5.14 Sys_Trim_LoadRCOSC

```
uint32_t Sys_Trim_LoadRCOSC(TRIM_Type * trim_values, uint32_t target)
```

Load target trim value, if present.

Location: trim.h:476

Parameters

Direction	Name	Description
in	<i>trim_values</i>	Pointer to section of memory containing trim values, typically base of NVR7.
in	<i>target</i>	The target clock trim setting.

Return

A code indicating whether an error has occurred. Error codes: [errors](#)

Example Code for Sys_Trim_LoadRCOSC

```
// Loads the RC Start oscillator trim settings from NVR7 for 12 MHz.
result = Sys_Trim_LoadRCOSC(trim_region, TARGET_RC12);
```

16.27.5.15 Sys_Trim_LoadRCOSC32

```
uint32_t Sys_Trim_LoadRCOSC32(TRIM_Type * trim_values, uint32_t target)
```

Load target trim value, if present.

RSL15 Firmware Reference

Location: trim.h:487

Parameters

Direction	Name	Description
in	<i>trim_values</i>	Pointer to section of memory containing trim values, typically base of NVR7.
in	<i>target</i>	The target clock trim setting.

Return

A code indicating whether an error has occurred. Error codes: [errors](#)

Example Code for Sys_Trim_LoadRCOSC32

```
// Loads the RC 32768Hz oscillator trim settings from NVR7 for 32768 Hz.
result = Sys_Trim_LoadRCOSC32(trim_region, TARGET_RC32K);
```

16.27.5.16 Sys_Trim_LoadThermistor

```
uint32_t Sys_Trim_LoadThermistor(TRIM_Type * trim_values, uint16_t target)
```

Load target trim value, if present.

Location: trim.h:498

Parameters

Direction	Name	Description
in	<i>trim_values</i>	Pointer to section of memory containing trim values, typically base of NVR7.
in	<i>target</i>	The target thermistor trim setting.

Return

A code indicating whether an error has occurred. Error codes: [errors](#)

Example Code for Sys_Trim_LoadThermistor

```
// Loads the trim settings for the thermistor current source.
result = Sys\_Trim\_LoadThermistor(trim_region, TARGET\_THERMISTOR\_10);
```

16.27.5.17 Sys_Trim_GetLSADTrim

```
uint32_t Sys_Trim_GetLSADTrim(uint32_t * addr, uint32_t * gain, uint32_t * offset)
```

Load LSAD gain and offset value from specified address. Verifies valid values first.

Location: trim.h:512

Parameters

Direction	Name	Description
in	<i>addr</i>	Pointer to memory containing offset in the first word, and gain in the second word.
out	<i>gain</i>	Pointer to return gain value.
out	<i>offset</i>	Pointer to return offset value.

Return

A code indicating whether an error has occurred. Error codes: [errors](#)

lsadload

NOTE: Assumes format of LSAD gain and offset storage.

Example Code for Sys_Trim_GetLSADTrim

```
// Loads gain and offset values for the LSAD module from NVR7.
result = Sys\_Trim\_GetLSADTrim(trim_region, &gain, &offset);
```

16.28 UART

Universal Asynchronous Receiver/Transmitter (UART) hardware abstraction layer.

16.28.1 Summary**Macros**

- [UART_PADS_NUM](#) : The number of input GPIO pad configurations for a UART interface (1 per instance)
- [SYS_UART_GPIOCONFIG](#) : Macro wrapper for [Sys_UART_GPIOConfig\(\)](#).
- [SYS_UART_CONFIG](#) : Macro wrapper for [Sys_UART_Config\(\)](#).

Functions

- [Sys_UART_GPIOConfig](#) : Configure two GPIOs for the specified UART interface.
- [Sys_UART_Config](#) : Configure and enable a UART interface.

16.28.2 UART Macro Definition Documentation**16.28.2.1 UART_PADS_NUM**

```
#define UART_PADS_NUM 1
```

The number of input GPIO pad configurations for a UART interface (1 per instance)

Location: uart.h:41

16.28.2.2 SYS_UART_GPIOCONFIG

```
#define SYS_UART_GPIOCONFIG Sys\_UART\_GPIOConfig(UART, (cfg), (pad_tx), (pad_rx))
```

Macro wrapper for [Sys_UART_GPIOConfig\(\)](#).

RSL15 Firmware Reference

Configure two GPIOs for the specified UART interface.

Location: uart.h:91

Parameters

Direction	Name	Description
in	<i>cfg</i>	GPIO pin configuration for the UART pads
in	<i>pad_tx</i>	GPIO to use as the UART transmit pad
in	<i>pad_rx</i>	GPIO to use as the UART receive pad

Example Code for SYS_UART_GPIOCONFIG

```
// Configure GPIOs 5 and 6 for the default UART interface with
// low-pass filter disabled, 8X drive-strength, and 1 kOhm pull-up resistors
SYS_UART_GPIOCONFIG((GPIO_LPF_DISABLE | GPIO_1K_PULL_UP |
                    GPIO_6X_DRIVE), GPIO5, GPIO6);
```

16.28.2.3 SYS_UART_CONFIG

```
#define SYS_UART_CONFIG Sys UART Config(UART, (uart_clk_hz), (baud), (config))
```

Macro wrapper for [Sys UART Config\(\)](#).

Configure and enable a UART interface.

Location: uart.h:107

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>uart_clk_hz</i>	UART clock speed in hertz
in	<i>baud</i>	Baud rate to which UART* is configured
in	<i>config</i>	DMA and interrupt mode enable; use UART_TX_DMA_[ENABLE DISABLE] UART_RX_DMA_[ENABLE DISABLE] UART_TX_INT_[ENABLE DISABLE] UART_RX_INT_[ENABLE DISABLE] UART_OVERRUN_INT_[ENABLE DISABLE]

Example Code for SYS_UART_CONFIG

```
// Enable and Configure the default UART:
// - 8 MHz clock speed
// - 9600 Hz baud rate
// - A TX DMA request is generated when new data is
//   requested by the UART interface
// - An RX DMA request is generated when new data is
//   received by the UART interface
// - Interrupts enabled
SYS_UART_CONFIG(8000000, 9600, (UART_TX_DMA_ENABLE |
    UART_RX_DMA_ENABLE | UART_TX_START_INT_ENABLE |
    UART_RX_INT_ENABLE | UART_OVERRUN_INT_ENABLE));
```

16.28.3 UART Function Documentation**16.28.3.1 Sys_UART_GPIOConfig**

```
void Sys_UART_GPIOConfig(const UART_Type * uart, uint32_t cfg, uint32_t pad_tx, uint32_t
pad_rx)
```

Configure two GPIOs for the specified UART interface.

Location: uart.h:52

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>uart</i>	Pointer to the UART instance
in	<i>cfg</i>	GPIO pin configuration for the UART pads
in	<i>pad_tx</i>	GPIO to use as the UART transmit pad
in	<i>pad_rx</i>	GPIO to use as the UART receive pad

Example Code for Sys_UART_GPIOConfig

```
// Configure GPIOs 5 and 6 for the UART interface with
// low-pass filter disabled, 8X drive-strength, and 1 kOhm pull-up resistors
Sys_UART_GPIOConfig(UART, (GPIO_LPF_DISABLE | GPIO_1K_PULL_UP |
GPIO_8X_DRIVE), GPIO5, GPIO6);
```

16.28.3.2 Sys_UART_Config

```
void Sys_UART_Config(UART_Type * uart, uint32_t uart_clk_hz, uint32_t baud, uint32_t
config)
```

Configure and enable a UART interface.

Location: uart.h:80

Parameters

Direction	Name	Description
in	<i>uart</i>	Pointer to the UART instance
in	<i>uart_clk_hz</i>	UART clock speed in hertz
in	<i>baud</i>	Baud rate to which UART* is configured
in	<i>config</i>	DMA and interrupt mode enable; use UART_TX_DMA_[ENABLE DISABLE] UART_RX_DMA_[ENABLE DISABLE] UART_TX_INT_[ENABLE DISABLE] UART_RX_INT_[ENABLE DISABLE] UART_OVERRUN_INT_[ENABLE DISABLE]

RSL15 Firmware Reference

Example Code for Sys_UART_Config

```
// Enable and Configure a UART:  
// - 8 MHz clock speed  
// - 9600 Hz baud rate  
// - A TX DMA request is generated when new data is  
//   requested by the UART interface  
// - An RX DMA request is generated when new data is  
//   received by the UART interface  
// - Interrupts enabled  
Sys\_UART\_Config(UART, 8000000, 9600, (UART_TX_DMA_ENABLE |  
    UART_RX_DMA_ENABLE | UART_TX_START_INT_ENABLE |  
    UART_RX_INT_ENABLE | UART_OVERRUN_INT_ENABLE));
```

16.29 WATCHDOG

Watchdog timer hardware abstraction layer.

16.29.1 Summary**Macros**

- [SYS_WATCHDOG_REFRESH](#) : Refresh the chip and software watchdog timers.

16.29.2 Watchdog Macro Definition Documentation**16.29.2.1 SYS_WATCHDOG_REFRESH**

```
#define SYS_WATCHDOG_REFRESH WATCHDOG->CTRL = WATCHDOG_REFRESH
```

Refresh the chip and software watchdog timers.

Location: watchdog.h:40

CHAPTER 17

Flash Library Reference

Flash Library Reference.

17.1 SUMMARY

Variables

- [FlashLib Version](#) : Firmware revision code variable.

Macros

- [FLASH_FW_VER_MAJOR](#) : Flash library major version number.
- [FLASH_FW_VER_MINOR](#) : Flash library minor version number.
- [FLASH_FW_VER_REVISION](#) : Flash library revision version number.
- [FLASH_FW_VER](#) : Flash library version number, concatenation of all version numbers.
- [FLASH0](#) : Define FLASH0 as the first flash instance, if this is not defined in the headers.
- [FLASH_INSTANCE_NUM](#) : Total number of flash instances.
- [FLASH_0_DESCR_NUM](#) : Total number of descriptor types in flash 0 (both RSL15 variants).
- [RSL15_284_FLASH_SET](#) : Define the set of memories enabled for the RSL15-284 configuration.

Functions

- [Flash Initialize](#) : Initialize clock and access to flash.
- [Flash WriteWord](#) : Write a word to a flash address.
- [Flash WriteBuffer](#) : Write contents of a static memory buffer to flash.
- [Flash WriteDouble](#) : Write a 38-bit word to flash.
- [Flash ReadWord](#) : Read a 32-bit word from flash.
- [Flash ReadBuffer](#) : Read contents of flash into a static memory buffer.
- [Flash ReadDouble](#) : Read a 38-bit word from flash.
- [Flash EraseFlashBank](#) : Erase a single flash bank.
- [Flash EraseChip](#) : Erase all data and code flash.
- [Flash EraseSector](#) : Erase a sector flash.
- [Flash BlankCheck](#) : Check if flash region is blank.

17.2 DETAILED DESCRIPTION

This reference chapter presents a detailed description of all the functions in the flash programming and erase support library. This reference includes calling parameters, returned values, and assumptions.

Warning: All functions provided by the flash library should be executed from RAM or ROM, as executing them from flash can result in hidden, flash-access-related failures.

17.3 FLASH LIBRARY REFERENCE VARIABLE DOCUMENTATION

17.3.1 FlashLib_Version

```
const short FlashLib_Version
```

Location: flash.h:59

Firmware revision code variable.

Access to this variable is available through the ROM tables.

17.4 FLASH LIBRARY REFERENCE MACRO DEFINITION DOCUMENTATION

17.4.1 FLASH_FW_VER_MAJOR

```
#define FLASH_FW_VER_MAJOR 0x03
```

Flash library major version number.

Location: flash.h:44

17.4.2 FLASH_FW_VER_MINOR

```
#define FLASH_FW_VER_MINOR 0x00
```

Flash library minor version number.

Location: flash.h:47

17.4.3 FLASH_FW_VER_REVISION

```
#define FLASH_FW_VER_REVISION 0x02
```

Flash library revision version number.

Location: flash.h:50

17.4.4 FLASH_FW_VER

```
#define FLASH_FW_VER ((FLASH_FW_VER_MAJOR << 12) | \  
                    (FLASH_FW_VER_MINOR << 8) | \  
                    FLASH_FW_VER_REVISION)
```

Flash library version number, concatenation of all version numbers.

Location: flash.h:53

17.4.5 FLASH0

```
#define FLASH0 ((FLASH_Type *)FLASH_BASE)
```

Define FLASH0 as the first flash instance, if this is not defined in the headers.

Location: flash.h:63

17.4.6 FLASH_INSTANCE_NUM

```
#define FLASH_INSTANCE_NUM 0x1U
```

Total number of flash instances.

Location: flash_rsl15.h:30

17.4.7 FLASH_0_DESCR_NUM

```
#define FLASH_0_DESCR_NUM 0x3U
```

Total number of descriptor types in flash 0 (both RSL15 variants).

Location: flash_rsl15.h:33

17.4.8 RSL15_284_FLASH_SET

```
#define RSL15_284_FLASH_SET 0x17
```

RSL15 Firmware Reference

Define the set of memories enabled for the RSL15-284 configuration.

Location: flash_rsl15.h:36

17.5 FLASH LIBRARY REFERENCE FUNCTION DOCUMENTATION

17.5.1 Flash_Initialize

```
FlashStatus_t Flash_Initialize(unsigned int num, FlashClockFrequency_t freq)
```

Initialize clock and access to flash.

This function powers-up and enables access to a flash region. It also applies the correct delay settings based on the specified flash clock frequency (freq).

Location: flash.h:85

Parameters

Direction	Name	Description
in	<i>num</i>	Flash instance to be initialized
in	<i>freq</i>	Flash clock frequency in Hertz, only defined frequencies supported

Return

Flash API status code

See: FlashClockFrequency_t

See: FlashStatus_t

RSL15 Firmware Reference

NOTE: System clock frequency should not be changed while the flash is being erased or programmed. An accurate system clock frequency of 1 MHz or higher is required for proper flash operation. If using the RC oscillator, care must be taken as the trimmed frequency for this oscillator has a high temperature dependency.

17.5.2 Flash_WriteWord

```
FlashStatus_t Flash_WriteWord(uint32_t addr, uint32_t word, bool enb_endurance)
```

Write a word to a flash address.

This function writes a single word to flash.

Location: flash.h:105

Parameters

Direction	Name	Description
in	<i>addr</i>	Address of the word to be written.
in	<i>word</i>	Data to be written to flash.
in	<i>enb_endurance</i>	Set to 0 for default flash endurance; Set to 1 to enable two-stage programming for higher endurance of the data programmed.

Return

Flash API status code

See: FlashStatus_t

NOTE: *addr* must be word aligned.
Contents of flash must be erased prior to performing a write.
Interrupts are not disabled; operation is undefined if the calling application modifies the values of flash registers before returning from this function call.

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17.5.3 Flash_WriteBuffer

```
FlashStatus_t Flash_WriteBuffer(uint32_t addr, uint32_t word_length, const uint32_t *
words, bool enb_endurance)
```

Write contents of a static memory buffer to flash.

This function writes the contents of a static memory buffer to flash. A read-back verification is performed after write to ensure the write has been successful.

Location: flash.h:137

Parameters

Direction	Name	Description
in	<i>addr</i>	Address of first word location in flash.
in	<i>word_length</i>	Total number of words to be written to flash.
in	<i>words</i>	A 32-bit C pointer to the memory location of the buffer to be written to flash.
in	<i>enb_endurance</i>	Set to 0 for default flash endurance; Set to 1 to enable two-stage programming for higher endurance of data programmed.

Return

Flash API status code

See: FlashStatus_t

NOTE: *addr* must be word aligned.

Contents of flash must be erased prior to performing a write.

Interrupts are disabled during critical sections, to ensure proper flash operation.

Applications must ensure that the function completes and that the return value is FLASH_ERR_NONE to consider the two-stage programming to be complete.

Source address of data being read and destination address being written, can not be part the same

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flash instance.

CRC peripheral registers are modified during execution, and restored before returning. The CRC must not be used by the application while writing the buffer to flash.

17.5.4 Flash_WriteDouble

```
FlashStatus_t Flash_WriteDouble(uint32_t addr, const uint32_t * word, bool enb_endurance)
```

Write a 38-bit word to flash.

This function temporarily disables automatic flash ECC generation, allowing the user to write 38-bits to a single word address in flash.

Location: flash.h:164

Parameters

Direction	Name	Description
in	<i>addr</i>	Address of the word to be written in flash.
in	<i>word</i>	32-bit C pointer to the word and ECC data to be written to flash: <ul style="list-style-type: none"> word[0] contains the data to be written to flash word[1] [5:0] contains the 6-bit data to be written as the ECC value.
in	<i>enb_endurance</i>	Set to 0 for default flash endurance; Set to 1 to enable two-stage programming for higher endurance of data programmed.

Return

Flash API status code

A read-back verification is performed after write to ensure the write has been successful.

See: FlashStatus_t

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NOTE: addr must be word aligned.

Interrupts are not disabled; operation is undefined if the calling application modifies the values of flash registers before returning from this function call.

17.5.5 Flash_ReadWord

```
FlashStatus_t Flash_ReadWord(uint32_t addr, uint32_t * word)
```

Read a 32-bit word from flash.

This function reads a 32-bit word from flash. If ECC is enabled (default), hardware will log/generate interrupt on ECC errors.

Location: flash.h:181

Parameters

Direction	Name	Description
in	<i>addr</i>	Address in flash to be read.
out	<i>word</i>	32-bit C pointer to the word read from flash.

Return

Flash API status code

See: FlashStatus_t

NOTE: addr must be word aligned.

Interrupts are not disabled; operation is undefined if the calling application modifies the values of flash registers before returning from this function call.

17.5.6 Flash_ReadBuffer

```
FlashStatus_t Flash_ReadBuffer(uint32_t flash_addr, uint32_t dram_addr, unsigned int word_length)
```

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Read contents of flash into a static memory buffer.

This function uses the flash copier to read contents of flash into a memory buffer.

Location: flash.h:202

Parameters

Direction	Name	Description
in	<i>flash_addr</i>	Address of first word location in flash.
in	<i>dram_addr</i>	Address of first word location in static memory.
in	<i>word_length</i>	Total number of words to be read from flash.

Return

Flash API status code

See: `FlashStatus_t`

NOTE: `flash_addr` and `dram_addr` must be word aligned.

Interrupts are not disabled; operation is undefined if the calling application modifies the values of flash registers before returning from this function call.

This function fails if the DMA or CryptoCell continuously blocks memory accesses by the flash copier by accessing memory on every cycle.

17.5.7 Flash_ReadDouble

```
FlashStatus_t Flash_ReadDouble(uint32_t addr, uint32_t * word)
```

Read a 38-bit word from flash.

This function temporarily disables automatic flash ECC generation, allowing the user to read all 38 bits from a single word address in flash.

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Location: flash.h:227

Parameters

Direction	Name	Description
in	<i>addr</i>	Address of the word to be read from flash.
out	<i>word</i>	32-bit C pointer to the word and ECC data read from flash: <ul style="list-style-type: none"> word[0] contains the data to word read from flash. word[1] [5:0] contains the 6-bit data ECC value read.

Return

Flash API status code

NOTE: ECC checks are not performed on the 32-bit data word or 6-bit ECC value.

See: FlashStatus_t

NOTE: *addr* must be word aligned.

Interrupts are not disabled; operation is undefined if the calling application modifies the values of flash registers before returning from this function call.

17.5.8 Flash_EraseFlashBank

```
FlashStatus_t Flash_EraseFlashBank(uint32_t num)
```

Erase a single flash bank.

This function erases all code and data regions of a flash instance.

Location: flash.h:245

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Parameters

Direction	Name	Description
in	<i>num</i>	Flash instance not to be erased.

Return

Flash API status code

See: FlashStatus_t

NOTE: A blank check is not performed to ensure that the flash has been successfully erased. Flash_BBlankCheck can be used by an application to verify if the erase has been successful. NVR regions are not erased. Interrupts are not disabled; operation is undefined if the calling application modifies the values of flash registers before returning from this function call.

17.5.9 Flash_EraseChip

```
FlashStatus_t Flash_EraseChip()
```

Erase all data and code flash.

This function erases all code and data regions of all flash instances.

Location: flash.h:262

Return

Flash API status code

See: FlashStatus_t

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NOTE: A blank check is not performed to ensure that the flash has been successfully erased. Flash_BBlankCheck can be used by an application to verify if the erase has been successful. NVR regions are not erased. Interrupts are not disabled; operation is undefined if the calling application modifies the values of flash registers before returning from this function call.

17.5.10 Flash_EraseSector

```
FlashStatus_t Flash_EraseSector(uint32_t addr, bool enb_endurance)
```

Erase a sector flash.

This function erases a flash sector (512 words for code, 64 words for data).

Location: flash.h:278

Parameters

Direction	Name	Description
in	<i>addr</i>	An address within the flash sector to be erased.
in	<i>enb_endurance</i>	Set to 0 for default flash endurance; Set to 1 to enable two-stage erase iteration for higher endurance of flash.

Return

Flash API status code. See FlashStatus_t

NOTE: Interrupts are not disabled; operation is undefined if the calling application modifies the values of flash registers before returning from this function call.

17.5.11 Flash_BlankCheck

```
FlashStatus_t Flash_BlankCheck(uint32_t addr, unsigned int word_length)
```

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Check if flash region is blank.

This function uses the flash copier in comparator mode to verify if the flash contents are empty (i.e containing the erase value 0xFFFFFFFF).

Location: flash.h:294

Parameters

Direction	Name	Description
in	<i>addr</i>	Address of the first word in flash to be verified.
in	<i>word_length</i>	Total number of words to be verified.

Return

Flash API status code FlashStatus_t

NOTE: Interrupts are not disabled; operation is undefined if the calling application modifies the values of flash registers before returning from this function call.
addr must be word aligned.

CHAPTER 18

CMSIS Drivers Reference

CMSIS Drivers Reference.

18.1 SUMMARY

Typedefs

- [ARM_DRIVER_VERSION](#) : Driver Version.
- [ARM_POWER_STATE](#) : General power states.

Data Structures

- [ARM_DRIVER_VERSION](#) : Driver Version.

Enumerations

- [ARM_POWER_STATE](#) : General power states.

Macros

- [ARM_DRIVER_VERSION_MAJOR_MINOR](#) : Driver API Version.
- [ARM_DRIVER_OK](#) : General return codes
- [ARM_DRIVER_ERROR](#) : Unspecified error.
- [ARM_DRIVER_ERROR_BUSY](#) : Driver is busy.
- [ARM_DRIVER_ERROR_TIMEOUT](#) : Timeout occurred.
- [ARM_DRIVER_ERROR_UNSUPPORTED](#) : Operation not supported.
- [ARM_DRIVER_ERROR_PARAMETER](#) : Parameter error.
- [ARM_DRIVER_ERROR_SPECIFIC](#) : Start of driver specific errors.

18.2 CMSIS DRIVERS REFERENCE TYPEDEF DOCUMENTATION

18.2.1 ARM_DRIVER_VERSION

```
typedef struct ARM\_DRIVER\_VERSION ARM_DRIVER_VERSION
```

Location: Driver_Common.h:62

Driver Version.

18.2.2 ARM_POWER_STATE

```
typedef enum ARM\_POWER\_STATE ARM_POWER_STATE
```

Location: Driver_Common.h:80

General power states.

18.3 CMSIS DRIVERS REFERENCE DATA STRUCTURES TYPE DOCUMENTATION**18.3.1 _ARM_DRIVER_VERSION**

Location: Driver_Common.h:59

Driver Version.

Data Fields

Type	Name	Description
uint16_t	<i>api</i>	API version.
uint16_t	<i>drv</i>	Driver version.

18.4 CMSIS DRIVERS REFERENCE ENUMERATION TYPE DOCUMENTATION**18.4.1 _ARM_POWER_STATE**

Location: Driver_Common.h:76

General power states.

Members

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- ARM_POWER_OFF

Power off: No operation possible.

- ARM_POWER_LOW

Low Power mode: Retain state, detect and signal wake-up events.

- ARM_POWER_FULL

Power on: Full operation at maximum performance.

18.5 CMSIS DRIVERS REFERENCE MACRO DEFINITION DOCUMENTATION

18.5.1 ARM_DRIVER_VERSION_MAJOR_MINOR

```
#define ARM_DRIVER_VERSION_MAJOR_MINOR (((major) << 8) | (minor))
```

Driver API Version.

Location: Driver_Common.h:54

18.5.2 ARM_DRIVER_OK

```
#define ARM_DRIVER_OK 0
```

General return codes

Operation succeeded

Location: Driver_Common.h:65

18.5.3 ARM_DRIVER_ERROR

```
#define ARM_DRIVER_ERROR -1
```

Unspecified error.

Location: Driver_Common.h:66

18.5.4 ARM_DRIVER_ERROR_BUSY

```
#define ARM_DRIVER_ERROR_BUSY -2
```

Driver is busy.

Location: Driver_Common.h:67

18.5.5 ARM_DRIVER_ERROR_TIMEOUT

```
#define ARM_DRIVER_ERROR_TIMEOUT -3
```

Timeout occurred.

Location: Driver_Common.h:68

18.5.6 ARM_DRIVER_ERROR_UNSUPPORTED

```
#define ARM_DRIVER_ERROR_UNSUPPORTED -4
```

Operation not supported.

Location: Driver_Common.h:69

18.5.7 ARM_DRIVER_ERROR_PARAMETER

```
#define ARM_DRIVER_ERROR_PARAMETER -5
```

Parameter error.

Location: Driver_Common.h:70

18.5.8 ARM_DRIVER_ERROR_SPECIFIC

```
#define ARM_DRIVER_ERROR_SPECIFIC -6
```

Start of driver specific errors.

Location: Driver_Common.h:71

18.6 CMSIS DMA DRIVER

CMSIS DMA Driver Reference.

18.6.1 Summary

Typedefs

- [DMA_SEL t](#) : Selects the DMA channel.
- [DMA_TRG t](#) : Selects the DMA src/dst target interface.
- [DMA_SRC_STEP t](#) : Selects the step size increment to the DMA channel source address.
- [DMA_DST_STEP t](#) : Selects the step size increment to the DMA channel destination address.
- [DMA_SRC_DST_TRANS_LENGTH_SEL t](#) : Selects whether the transfer length counter depends on either the source word counts or the destination word count.
- [DMA_DATA_MODE t](#) : Selects how often data is transferred.
- [DMA_BYTE_ORDER t](#) : Selects the order of the data bytes.
- [DMA_WORD_SIZE t](#) : Selects the src/dst data word size.
- [DMA_CH_PRI t](#) : Selects priority of DMA channels.
- [ADC_EVENT_SRC t](#) : Selects DMA interrupt channel source.
- [DMA_SignalEvent t](#) : Pointer to [DMA_SignalEvent](#) : Signal Timer event.
- [DMA_CFG t](#) : DMA channel configuration.
- [DMA_ADDR_CFG t](#) : DMA src/dst address configuration.
- [DMA_PRI_CFG t](#) : DMA interrupt priority configuration.
- [DMA_STATUS t](#) : DMA status.
- [DRIVER_DMA t](#) : Access structure of the DMA Driver.

Data Structures

- [DMA_CFG t](#) : DMA channel configuration.
- [DMA_ADDR_CFG t](#) : DMA src/dst address configuration.
- [DMA_PRI_CFG t](#) : DMA interrupt priority configuration.
- [DMA_STATUS t](#) : DMA status.
- [DRIVER_DMA t](#) : Access structure of the DMA Driver.

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Enumerations

- [DMA_SEL_t](#) : Selects the DMA channel.
- [DMA_TRG_t](#) : Selects the DMA src/dst target interface.
- [DMA_SRC_STEP_t](#) : Selects the step size increment to the DMA channel source address.
- [DMA_DST_STEP_t](#) : Selects the step size increment to the DMA channel destination address.
- [DMA_SRC_DST_TRANS_LENGTH_SEL_t](#) : Selects whether the transfer length counter depends on either the source word counts or the destination word count.
- [DMA_DATA_MODE_t](#) : Selects how often data is transferred.
- [DMA_BYTE_ORDER_t](#) : Selects the order of the data bytes.
- [DMA_WORD_SIZE_t](#) : Selects the src/dst data word size.
- [DMA_CH_PRI_t](#) : Selects priority of DMA channels.
- [ADC_EVENT_SRC_t](#) : Selects DMA interrupt channel source.

Macros

- [ARM_DMA_API_VERSION](#) : DMA API version.
- [DMA_ERROR_UNCONFIGURED](#) : DMA channel has not been configured yet.

Functions

- [DMA_GetVersion](#) : Get driver version.
- [DMA_Initialize](#) : Initialize DMA driver with default configuration.
- [DMA_Configure](#) : Configure particular DMA channel.
- [DMA_ConfigureWord](#) : Configure particular DMA channel.
- [DMA_ConfigureAddr](#) : Configure DMA channel source and destination addresses.
- [DMA_SetInterruptPriority](#) : Configure the DMA interrupt priority.
- [DMA_CreateConfigWord](#) : Create DMA channel configuration word.
- [DMA_SetConfigWord](#) : Quickly updates the DMA channel configuration.
- [DMA_Stop](#) : Stops the DMA transfer.
- [DMA_GetCounterValue](#) : Returns the current counter value of DMA channel.
- [DMA_GetStatus](#) : Returns the DMA channel status.
- [DMA_SignalEvent](#) : Signal DMA events.

18.6.2 CMSIS DMA Driver Typedef Documentation**18.6.2.1 DMA_SEL_t**

```
typedef enum DMA\_SEL\_t DMA_SEL_t
```

Location: Driver_DMA.h:49

Selects the DMA channel.

18.6.2.2 DMA_TRG_t

```
typedef enum DMA\_TRG\_t DMA_TRG_t
```

Location: Driver_DMA.h:63

Selects the DMA src/dst target interface.

18.6.2.3 DMA_SRC_STEP_t

```
typedef enum DMA\_SRC\_STEP\_t DMA_SRC_STEP_t
```

Location: Driver_DMA.h:85

Selects the step size increment to the DMA channel source address.

18.6.2.4 DMA_DST_STEP_t

```
typedef enum DMA\_DST\_STEP\_t DMA_DST_STEP_t
```

Location: Driver_DMA.h:107

Selects the step size increment to the DMA channel destination address.

18.6.2.5 DMA_SRC_DST_TRANS LENGHT_SEL_t

```
typedef enum DMA\_SRC\_DST\_TRANS LENGHT\_SEL\_t DMA_SRC_DST_TRANS LENGHT_SEL_t
```

Location: Driver_DMA.h:116

Selects whether the transfer length counter depends on either the source word counts or the destination word count.

18.6.2.6 DMA_DATA_MODE_t

```
typedef enum DMA\_DATA\_MODE\_t DMA_DATA_MODE_t
```

Location: Driver_DMA.h:124

Selects how often data is transferred.

18.6.2.7 DMA_BYTE_ORDER_t

```
typedef enum DMA\_BYTE\_ORDER\_t DMA_BYTE_ORDER_t
```

Location: Driver_DMA.h:132

Selects the order of the data bytes.

18.6.2.8 DMA_WORD_SIZE_t

```
typedef enum DMA\_WORD\_SIZE\_t DMA_WORD_SIZE_t
```

Location: Driver_DMA.h:161

Selects the src/dst data word size.

18.6.2.9 DMA_CH_PRI_t

```
typedef enum DMA\_CH\_PRI\_t DMA_CH_PRI_t
```

Location: Driver_DMA.h:171

Selects priority of DMA channels.

18.6.2.10 ADC_EVENT_SRC_t

```
typedef enum ADC\_EVENT\_SRC\_t ADC_EVENT_SRC_t
```

Location: Driver_DMA.h:181

Selects DMA interrupt channel source.

18.6.2.11 DMA_SignalEvent_t

```
typedef void(* DMA_SignalEvent_t
```

Location: Driver_DMA.h:263

Pointer to [DMA_SignalEvent](#) : Signal Timer event.

18.6.2.12 DMA_CFG_t

```
typedef struct DMA\_CFG\_t DMA_CFG_t
```

Location: Driver_DMA.h:277

DMA channel configuration.

18.6.2.13 DMA_ADDR_CFG_t

```
typedef struct DMA\_ADDR\_CFG\_t DMA_ADDR_CFG_t
```

Location: Driver_DMA.h:288

DMA src/dst address configuration.

18.6.2.14 DMA_PRI_CFG_t

```
typedef struct DMA\_PRI\_CFG\_t DMA_PRI_CFG_t
```

Location: Driver_DMA.h:299

DMA interrupt priority configuration.

18.6.2.15 DMA_STATUS_t

```
typedef struct DMA\_STATUS\_t DMA_STATUS_t
```

Location: Driver_DMA.h:311

DMA status.

18.6.2.16 DRIVER_DMA_t

```
typedef struct DRIVER\_DMA\_t DRIVER_DMA_t
```

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Location: Driver_DMA.h:331

Access structure of the DMA Driver.

18.6.3 CMSIS DMA Driver Data Structures Type Documentation

18.6.3.1 _DMA_CFG_t

Location: Driver_DMA.h:268

DMA channel configuration.

Data Fields

Type	Name	Description
DMA_TRG_t	<i>src_sel</i>	DMA source target.
DMA_SRC_STEP_t	<i>src_step</i>	Source step mode.
DMA_WORD_SIZE_t	<i>word_size</i>	Source word size.
DMA_TRG_t	<i>dst_sel</i>	DMA destination target.
DMA_DST_STEP_t	<i>dst_step</i>	Destination step mode.
DMA_CH_PRI_t	<i>ch_priority</i>	Channel priority.
uint32_t	<i>__pad0__</i>	Reserved.

18.6.3.2 _DMA_ADDR_CFG_t

Location: Driver_DMA.h:282

DMA src/dst address configuration.

Data Fields

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Type	Name	Description
const void *	<i>src_addr</i>	Source address.
const void *	<i>dst_addr</i>	Destination address.
uint32_t	<i>counter_len</i>	Value which when reached triggers the counter event.
uint32_t	<i>transfer_len</i>	DMA transfer length.

18.6.3.3 _DMA_PRI_CFG_t

Location: Driver_DMA.h:293

DMA interrupt priority configuration.

Data Fields

Type	Name	Description
uint32_t	<i>preempt_pri</i>	Preempt priority.
uint32_t	<i>__pad0__</i>	Reserved.
uint32_t	<i>subgrp_pri</i>	Subgroup priority.
uint32_t	<i>__pad1__</i>	Reserved.

18.6.3.4 _DMA_STATUS_t

Location: Driver_DMA.h:304

DMA status.

Data Fields

Type	Name	Description
uint32_t	<i>active</i>	Transfer was started.
uint32_t	<i>completed</i>	Transfer was completed.

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uint32_t	<i>counter_reached</i>	Counter value was reached.
uint32_t	<i>buffer_fill_lvl</i>	Error occurred.
uint32_t	<i>__pad0__</i>	Reserved.

18.6.3.5 _DRIVER_DMA_t

Location: Driver_DMA.h:316

Access structure of the DMA Driver.

Data Fields

Type	Name	Description
ARM_DRIVER_VERSION (*)	<i>GetVersion</i> (void)	Pointer to DMA_GetVersion : Get driver version.
int32_t (*)	<i>Initialize</i> (DMA_SignalEvent_t cb_event)	Pointer to DMA_Initialize : Initialize DMA driver.
int32_t (*)	<i>Configure</i> (DMA_SEL_t sel, const DMA_CFG_t *cfg, DMA_SignalEvent_t cb)	Pointer to DMA_Configure : Configure DMA channel.
int32_t (*)	<i>ConfigureWord</i> (DMA_SEL_t sel, uint32_t cfg, DMA_SignalEvent_t cb)	Pointer to DMA_ConfigureWord : Configure DMA channel.
int32_t (*)	<i>ConfigureAddr</i> (DMA_SEL_t sel, const DMA_ADDR_CFG_t *pri)	Pointer to DMA_ConfigureAddr : Configure DMA interrupt priority.
int32_t (*)	<i>SetInterruptPriority</i> (DMA_SEL_t sel, const DMA_PRI_CFG_t *pri)	Pointer to DMA_SetInterruptPriority : Configure DMA interrupt priority.
uint32_t (*)	<i>CreateConfigWord</i> (const DMA_CFG_t *cfg)	Pointer to DMA_CreateConfigWord : Create DMA channel configuration word.
void (*)	<i>SetConfigWord</i> (DMA_SEL_t sel, uint32_t cfg)	Pointer to DMA_SetConfigWord : Quickly update DMA channel configuration word.

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int32_t(*)	<i>Start</i> (DMA_SEL_t sel, uint32_t trigger, uint32_t trigger_source)	Pointer to DMA_Start : Start DMA transfer.
int32_t(*)	<i>Stop</i> (DMA_SEL_t sel)	Pointer to DMA_Stop : Stop DMA transfer.
uint32_t(*)	<i>GetCounterValue</i> (DMA_SEL_t sel)	Pointer to DMA_GetCounterValue : Get the current channel transfer counter.
DMA_STATUS_t (*)	<i>GetStatus</i> (DMA_SEL_t sel)	Pointer to DMA_GetStatus : Returns DMA channel status.

18.6.4 CMSIS DMA Driver Enumeration Type Documentation

18.6.4.1 _DMA_SEL_t

Location: Driver_DMA.h:44

Selects the DMA channel.

Members

- DMA_CH_0 = 0

DMA channel 0.

- DMA_CH_1 = 1

DMA channel 1.

- DMA_CH_2 = 2

DMA channel 2.

- DMA_CH_3 = 3

DMA channel 3.

18.6.4.2 _DMA_TRG_t

Location: Driver_DMA.h:54

Selects the DMA src/dst target interface.

Members

- DMA_TRG_MEM = 0
- DMA_TRG_SPI0 = 1

Source / destination target = SPI0.

- DMA_TRG_SPI1 = 2

Source / destination target = SPI1.

- DMA_TRG_I2C0 = 3

Source / destination target = I2C0.

- DMA_TRG_I2C1 = 4

Source / destination target = I2C1.

- DMA_TRG_UART = 5

Source / destination target = UART.

- DMA_TRG_PCM = 6

Source / destination target = PCM.

- `DMA_TRG_TOF = 7`

Source / destination target = TOF.

18.6.4.3 `_DMA_SRC_STEP_t`

Location: `Driver_DMA.h:68`

Selects the step size increment to the DMA channel source address.

Members

- `DMA_CFG0_SRC_ADDR_STATIC = 0x00`

Do not increment the source address used by DMA channel.

- `DMA_CFG0_SRC_ADDR_INCR_1 = 0x01`

Set the step size of DMA channel source address to 1.

- `DMA_CFG0_SRC_ADDR_INCR_2 = 0x02`

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Set the step size of DMA channel source address to 2.

- `DMA_CFG0_SRC_ADDR_INCR_3 = 0x03`

Set the step size of DMA channel source address to 3.

- `DMA_CFG0_SRC_ADDR_INCR_4 = 0x04`

Set the step size of DMA channel source address to 4.

- `DMA_CFG0_SRC_ADDR_INCR_5 = 0x05`

Set the step size of DMA channel source address to 5.

- `DMA_CFG0_SRC_ADDR_INCR_6 = 0x06`

Set the step size of DMA channel source address to 6.

- `DMA_CFG0_SRC_ADDR_INCR_7 = 0x07`

Set the step size of DMA channel source address to 7.

- `DMA_CFG0_SRC_ADDR_DECR_8 = 0x08`

Set the step size of DMA channel source address to negative 8.

- `DMA_CFG0_SRC_ADDR_DECR_7 = 0x09`

Set the step size of DMA channel source address to negative 7.

- `DMA_CFG0_SRC_ADDR_DECR_6 = 0x0A`

Set the step size of DMA channel source address to negative 6.

- `DMA_CFG0_SRC_ADDR_DECR_5 = 0x0B`

Set the step size of DMA channel source address to negative 5.

- `DMA_CFG0_SRC_ADDR_DECR_4 = 0x0C`

Set the step size of DMA channel source address to negative 4.

- `DMA_CFG0_SRC_ADDR_DECR_3 = 0x0D`

Set the step size of DMA channel source address to negative 3.

- `DMA_CFG0_SRC_ADDR_DECR_2 = 0x0E`

Set the step size of DMA channel source address to negative 2.

- `DMA_CFG0_SRC_ADDR_DECR_1 = 0x0F`

Set the step size of DMA channel source address to negative 1.

18.6.4.4 _DMA_DST_STEP_t

Location: Driver_DMA.h:90

Selects the step size increment to the DMA channel destination address.

Members

- `DMA_CFG0_DEST_ADDR_STATIC = 0x00`

Do not increment the destination address used by DMA channel.

- `DMA_CFG0_DEST_ADDR_INCR_1 = 0x01`

Set the step size of DMA channel destination address to 1.

- `DMA_CFG0_DEST_ADDR_INCR_2 = 0x02`

Set the step size of DMA channel destination address to 2.

- `DMA_CFG0_DEST_ADDR_INCR_3 = 0x03`

Set the step size of DMA channel destination address to 3.

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- `DMA_CFG0_DEST_ADDR_INCR_4 = 0x04`

Set the step size of DMA channel destination address to 4.

- `DMA_CFG0_DEST_ADDR_INCR_5 = 0x05`

Set the step size of DMA channel destination address to 5.

- `DMA_CFG0_DEST_ADDR_INCR_6 = 0x06`

Set the step size of DMA channel destination address to 6.

- `DMA_CFG0_DEST_ADDR_INCR_7 = 0x07`

Set the step size of DMA channel destination address to 7.

- `DMA_CFG0_DEST_ADDR_DECR_8 = 0x08`

Set the step size of DMA channel destination address to negative 8.

- `DMA_CFG0_DEST_ADDR_DECR_7 = 0x09`

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Set the step size of DMA channel destination address to negative 7.

- `DMA_CFG0_DEST_ADDR_DECR_6 = 0x0A`

Set the step size of DMA channel destination address to negative 6.

- `DMA_CFG0_DEST_ADDR_DECR_5 = 0x0B`

Set the step size of DMA channel destination address to negative 5.

- `DMA_CFG0_DEST_ADDR_DECR_4 = 0x0C`

Set the step size of DMA channel destination address to negative 4.

- `DMA_CFG0_DEST_ADDR_DECR_3 = 0x0D`

Set the step size of DMA channel destination address to negative 3.

- `DMA_CFG0_DEST_ADDR_DECR_2 = 0x0E`

Set the step size of DMA channel destination address to negative 2.

- `DMA_CFG0_DEST_ADDR_DECR_1 = 0x0F`

Set the step size of DMA channel destination address to negative 1.

18.6.4.5 `_DMA_SRC_DST_TRANS LENGHT_SEL_t`

Location: `Driver_DMA.h:112`

Selects whether the transfer length counter depends on either the source word counts or the destination word count.

Members

- `DMA_CFG0_DEST_TRANS_LENGTH_SEL = 0x00`

Transfer length counter depends on the destination word count.

- `DMA_CFG0_SRC_TRANS_LENGTH_SEL = 0x01`

Transfer length counter depends on the size word count.

18.6.4.6 `_DMA_DATA_MODE_t`

Location: `Driver_DMA.h:121`

Selects how often data is transferred.

Members

- `DMA_REPEAT = 0x0U`

Data to be transfered repeatedly.

- `DMA_SINGLE = 0x1U`

Single data transfer.

18.6.4.7 _DMA_BYTE_ORDER_t

Location: Driver_DMA.h:129

Selects the order of the data bytes.

Members

- `DMA_ENDIANNES_LITTLE = 0x0U`

Little endian to be used.

- `DMA_ENDIANNES_BIG = 0x1U`

Big endian to be used.

18.6.4.8 _DMA_WORD_SIZE_t

Location: Driver_DMA.h:137

Selects the src/dst data word size.

Members

- `DMA_CFG0_DEST_WORD_SIZE_32BITS_TO_32BITS = 0x00`

Source data uses 32-bit word and destination data uses 32-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_32BITS_TO_4BITS = 0x01`

Source data uses 32-bit word and destination data uses 4-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_32BITS_TO_8BITS = 0x02`

Source data uses 32-bit word and destination data uses 8-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_32BITS_TO_16BITS = 0x04`

Source data uses 32-bit word and destination data uses 16-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_4BITS_TO_32BITS = 0x08`

Source data uses 4-bit word and destination data uses 32-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_4BITS_TO_4BITS = 0x09`

Source data uses 4-bit word and destination data uses 4-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_4BITS_TO_8BITS = 0x0A`

Source data uses 4-bit word and destination data uses 8-bit word.

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- `DMA_CFG0_DEST_WORD_SIZE_4BITS_TO_16BITS = 0x0C`

Source data uses 4-bit word and destination data uses 16-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_4BITS_TO_24BITS = 0x0E`

Source data uses 4-bit word and destination data uses 24-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_8BITS_TO_32BITS = 0x10`

Source data uses 8-bit word and destination data uses 32-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_8BITS_TO_4BITS = 0x11`

Source data uses 8-bit word and destination data uses 4-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_8BITS_TO_8BITS = 0x12`

Source data uses 8-bit word and destination data uses 8-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_8BITS_TO_16BITS = 0x14`

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Source data uses 8-bit word and destination data uses 16-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_8BITS_TO_24BITS = 0x16`

Source data uses 8-bit word and destination data uses 24-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_16BITS_TO_32BITS = 0x20`

Source data uses 16-bit word and destination data uses 32-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_16BITS_TO_4BITS = 0x21`

Source data uses 16-bit word and destination data uses 4-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_16BITS_TO_8BITS = 0x22`

Source data uses 16-bit word and destination data uses 8-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_16BITS_TO_16BITS = 0x24`

Source data uses 16-bit word and destination data uses 16-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_16BITS_TO_24BITS = 0x26`

Source data uses 16-bit word and destination data uses 24-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_24BITS_TO_4BITS = 0x31`

Source data uses 24-bit word and destination data uses 4-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_24BITS_TO_8BITS = 0x32`

Source data uses 24-bit word and destination data uses 8-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_24BITS_TO_16BITS = 0x34`

Source data uses 24-bit word and destination data uses 16-bit word.

- `DMA_CFG0_DEST_WORD_SIZE_24BITS_TO_24BITS = 0x36`

Source data uses 24-bit word and destination data uses 24-bit word.

18.6.4.9 `_DMA_CH_PRI_t`

Location: `Driver_DMA.h:166`

Selects priority of DMA channels.

Members

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- `DMA_CH_PRI_0 = 0x0U`

Channel priority = 0.

- `DMA_CH_PRI_1 = 0x1U`

Channel priority = 1.

- `DMA_CH_PRI_2 = 0x2U`

Channel priority = 2.

- `DMA_CH_PRI_3 = 0x3U`

Channel priority = 3.

18.6.4.10 `_ADC_EVENT_SRC_t`

Location: `Driver_DMA.h:176`

Selects DMA interrupt channel source.

Members

- `DMA_DMA0_EVENT = 1 << DMA_CH_0`

DMA channel 0 event.

- `DMA_DMA1_EVENT = 1 << DMA_CH_1`

DMA channel 1 event.

- `DMA_DMA2_EVENT = 1 << DMA_CH_2`

DMA channel 2 event.

- `DMA_DMA3_EVENT = 1 << DMA_CH_3`

DMA channel 3 event.

18.6.5 CMSIS DMA Driver Macro Definition Documentation

18.6.5.1 ARM_DMA_API_VERSION

```
#define ARM_DMA_API_VERSION ARM\_DRIVER\_VERSION MAJOR MINOR(1,0)
```

DMA API version.

Location: Driver_DMA.h:37

18.6.5.2 DMA_ERROR_UNCONFIGURED

```
#define DMA_ERROR_UNCONFIGURED (ARM\_DRIVER\_ERROR\_SPECIFIC - 1)
```

DMA channel has not been configured yet.

Location: Driver_DMA.h:184

18.6.6 CMSIS DMA Driver Function Documentation

18.6.6.1 DMA_GetVersion

```
ARM\_DRIVER\_VERSION DMA_GetVersion()
```

Get driver version.

Location: Driver_DMA.c:21

Return[ARM DRIVER VERSION](#)**18.6.6.2 DMA_Initialize**

```
int32_t DMA_Initialize()
```

Initialize DMA driver with default configuration.

Location: Driver_DMA.c:22

Return[execution status](#)**18.6.6.3 DMA_Configure**

```
int32_t DMA_Configure(DMA\_SEL\_t sel, const DMA\_CFG\_t * cfg, DMA\_SignalEvent\_t cb)
```

Configure particular DMA channel.

Location: Driver_DMA.c:23

Parameters

Direction	Name	Description
in	<i>sel</i>	DMA channel to be configured (DMA_SEL_t)
in	<i>cfg</i>	Pointer to DMA_CFG_t
in	<i>cb</i>	Pointer to DMA_SignalEvent_t

Return[execution status](#)

18.6.6.4 DMA_ConfigureWord

```
int32_t DMA_ConfigureWord(DMA\_SEL\_t sel, uint32_t cfg, DMA\_SignalEvent\_t cb)
```

Configure particular DMA channel.

Location: Driver_DMA.c:24

Parameters

Direction	Name	Description
in	<i>sel</i>	DMA channel to be configured (DMA_SEL_t)
in	<i>cfg</i>	Configuration word
in	<i>cb</i>	Pointer to DMA_SignalEvent_t

Return

[execution status](#)

18.6.6.5 DMA_ConfigureAddr

```
int32_t DMA_ConfigureAddr(DMA\_SEL\_t sel, const DMA\_ADDR\_CFG\_t * cfg)
```

Configure DMA channel source and destination addresses.

Location: Driver_DMA.c:25

Parameters

Direction	Name	Description
in	<i>sel</i>	DMA to be configured (DMA_SEL_t)
in	<i>cfg</i>	Pointer to DMA_ADDR_CFG_t

Return[execution status](#)**18.6.6.6 DMA_SetInterruptPriority**

```
int32_t DMA_SetInterruptPriority(DMA\_SEL\_t sel, const DMA\_PRI\_CFG\_t * cfg)
```

Configure the DMA interrupt priority.

Location: Driver_DMA.c:26

Parameters

Direction	Name	Description
in	<i>sel</i>	DMA channel to be configured (DMA_SEL_t)
in	<i>cfg</i>	Pointer to DMA_PRI_CFG_t

Return[execution status](#)**18.6.6.7 DMA_CreateConfigWord**

```
uint32_t DMA_CreateConfigWord(const DMA\_CFG\_t * cfg)
```

Create DMA channel configuration word.

Location: Driver_DMA.c:27

Parameters

Direction	Name	Description
in	<i>cfg</i>	Pointer to DMA_CFG_t

Return

configuration word

18.6.6.8 DMA_SetConfigWord

```
int32_t DMA_SetConfigWord(DMA\_SEL\_t sel, uint32_t cfg)
```

Quickly updates the DMA channel configuration.

Location: Driver_DMA.c:28

Parameters

Direction	Name	Description
in	<i>sel</i>	DMA channel to be configured (DMA_SEL_t)
in	<i>cfg</i>	configuration word

Return

none

18.6.6.9 DMA_Stop

```
int32_t DMA_Stop(DMA\_SEL\_t sel)
```

Stops the DMA transfer.

Location: Driver_DMA.c:30

Parameters

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Direction	Name	Description
in	<i>sel</i>	DMA channel number to be used (DMA_SEL_t)

Return

[execution status](#)

18.6.6.10 DMA_GetCounterValue

```
uint32_t DMA_GetCounterValue(DMA\_SEL\_t sel)
```

Returns the current counter value of DMA channel.

Location: Driver_DMA.c:31

Parameters

Direction	Name	Description
in	<i>sel</i>	DMA channel value to be read (DMA_SEL_t)

Return

DMA channel counter value

18.6.6.11 DMA_GetStatus

```
DMA\_STATUS\_t DMA_GetStatus(DMA\_SEL\_t sel)
```

Returns the DMA channel status.

Clears the status register on read.

Location: Driver_DMA.c:32

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Parameters

Direction	Name	Description
in	<i>sel</i>	DMA channel value to be read (DMA_SEL_t)

Return

DMA channel status ([DMA_STATUS_t](#))

18.6.6.12 DMA_SignalEvent

```
void DMA_SignalEvent(uint32_t event)
```

Signal DMA events.

Location: Driver_DMA.c:34

Parameters

Direction	Name	Description
in	<i>event</i>	Notification mask (_ADC_EVENT_SRC_t)

Return

None

18.7 CMSIS GPIO DRIVER

CMSIS GPIO Driver Reference.

18.7.1 Summary**Typedefs**

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- [GPIO_SEL_t](#) : GPIO Control Codes: GPIO Selection.
- [GPIO_DIR_t](#) : GPIO Control Codes: GPIO direction.
- [GPIO_INT_SEL_t](#) : GPIO Control Codes: GPIO INT Selection.
- [GPIO_DRIVE_t](#) : GPIO Control Codes: Drive strength.
- [GPIO_LPF_t](#) : GPIO Control Codes: Low pass filter.
- [GPIO_PULL_t](#) : GPIO Control Codes: Pull control.
- [GPIO_OUTPUT_LEVEL_t](#) : GPIO Control Codes: Output Level.
- [GPIO_MODE_t](#) : GPIO Control Codes: IO Mode.
- [GPIO_FUNC_REGISTERS_t](#) : GPIO Control Codes: GPIO alternative function registers.
- [GPIO_EN_DIS_t](#) : GPIO Control Codes: Enable / Disable values.
- [GPIO_EVENT_t](#) : GPIO Control Codes: Interrupts events.
- [GPIO_DBC_CLK_t](#) : GPIO Control Codes: Debounce clock source.
- [GPIO_DRIVE_STRENGTHS_t](#) : GPIO Control Codes: Pads strength.
- [GPIO_SignalEvent_t](#) : Pointer to [GPIO_SignalEvent](#) : Signal GPIO Event.
- [GPIO_DBF_CFG_t](#) : Debounce filter configuration.
- [GPIO_PRI_CFG_t](#) : GPIO interrupt priority configuration.
- [GPIO_CFG_t](#) : GPIO Driver configuration.
- [GPIO_PAD_CFG_t](#) : GPIO PAD configuration.
- [GPIO_INT_CFG_t](#) : GPIO INT configuration.
- [GPIO_EXTCLK_CFG_t](#) : External clock pad configuration.
- [GPIO_JTAG_SW_CFG_t](#) : JTAG configuration.
- [DRIVER_GPIO_t](#) : Access structure of the GPIO Driver.

Data Structures

- [GPIO_DBF_CFG_t](#) : Debounce filter configuration.
- [GPIO_PRI_CFG_t](#) : GPIO interrupt priority configuration.
- [GPIO_CFG_t](#) : GPIO Driver configuration.
- [GPIO_PAD_CFG_t](#) : GPIO PAD configuration.
- [GPIO_INT_CFG_t](#) : GPIO INT configuration.
- [GPIO_EXTCLK_CFG_t](#) : External clock pad configuration.
- [GPIO_JTAG_SW_CFG_t](#) : JTAG configuration.
- [DRIVER_GPIO_t](#) : Access structure of the GPIO Driver.

Enumerations

- [GPIO_SEL_t](#) : GPIO Control Codes: GPIO Selection.
- [GPIO_DIR_t](#) : GPIO Control Codes: GPIO direction.
- [GPIO_INT_SEL_t](#) : GPIO Control Codes: GPIO INT Selection.
- [GPIO_DRIVE_t](#) : GPIO Control Codes: Drive strength.
- [GPIO_LPF_t](#) : GPIO Control Codes: Low pass filter.
- [GPIO_PULL_t](#) : GPIO Control Codes: Pull control.
- [GPIO_OUTPUT_LEVEL_t](#) : GPIO Control Codes: Output Level.
- [GPIO_MODE_t](#) : GPIO Control Codes: IO Mode.
- [GPIO_FUNC_REGISTERS_t](#) : GPIO Control Codes: GPIO alternative function registers.
- [GPIO_EN_DIS_t](#) : GPIO Control Codes: Enable / Disable values.
- [GPIO_EVENT_t](#) : GPIO Control Codes: Interrupts events.

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- [GPIO_DBC_CLK_t](#) : GPIO Control Codes: Debounce clock source.
- [GPIO_DRIVE_STRENGTHS_t](#) : GPIO Control Codes: Pads strength.

Macros

- [ARM_GPIO_API_VERSION](#) : GPIO API version.
- [GPIO_EVENT_0_IRQ](#) : GPIO Event.
- [GPIO_EVENT_1_IRQ](#) : GPIO1 interrupt event value.
- [GPIO_EVENT_2_IRQ](#) : GPIO2 interrupt event value.
- [GPIO_EVENT_3_IRQ](#) : GPIO3 interrupt event value.

Functions

- [GPIO_GetVersion](#) : Get driver version.
- [GPIO_Initialize](#) : Initialize the GPIO driver.
- [GPIO_Configure](#) : Configure common GPIO settings.
- [GPIO_ConfigurePad](#) : Configure the GPIO pad.
- [GPIO_ConfigureInterrupt](#) : Configure the GPIO interrupt.
- [GPIO_SetInterruptPriority](#) : Configure GPIO interrupt priority.
- [GPIO_ConfigureJTAG](#) : Configure the GPIO JTAG mode.
- [GPIO_SetHigh](#) : Set particular GPIO pad.
- [GPIO_ToggleValue](#) : Toggle particular GPIO pad.
- [GPIO_SetLow](#) : Reset particular GPIO pad.
- [GPIO_ReadValue](#) : Returns the selected GPIO pad value.
- [GPIO_ResetAltFuncRegister](#) : Reset the particular alternative function register.
- [GPIO_SignalEvent](#) : Signal GPIO events.

18.7.2 CMSIS GPIO Driver Typedef Documentation**18.7.2.1 GPIO_SEL_t**

```
typedef enum GPIO\_SEL\_t GPIO_SEL_t
```

Location: Driver_GPIO.h:59

GPIO Control Codes: GPIO Selection.

18.7.2.2 GPIO_DIR_t

```
typedef enum GPIO\_DIR\_t GPIO_DIR_t
```

Location: Driver_GPIO.h:80

GPIO Control Codes: GPIO direction.

18.7.2.3 GPIO_INT_SEL_t

```
typedef enum GPIO\_INT\_SEL\_t GPIO_INT_SEL_t
```

Location: Driver_GPIO.h:88

GPIO Control Codes: GPIO INT Selection.

18.7.2.4 GPIO_DRIVE_t

```
typedef enum GPIO\_DRIVE\_t GPIO_DRIVE_t
```

Location: Driver_GPIO.h:96

GPIO Control Codes: Drive strength.

18.7.2.5 GPIO_LPF_t

```
typedef enum GPIO\_LPF\_t GPIO_LPF_t
```

Location: Driver_GPIO.h:102

GPIO Control Codes: Low pass filter.

18.7.2.6 GPIO_PULL_t

```
typedef enum GPIO\_PULL\_t GPIO_PULL_t
```

Location: Driver_GPIO.h:110

GPIO Control Codes: Pull control.

18.7.2.7 GPIO_OUTPUT_LEVEL_t

```
typedef enum GPIO\_OUTPUT\_LEVEL\_t GPIO_OUTPUT_LEVEL_t
```

Location: Driver_GPIO.h:116

GPIO Control Codes: Output Level.

18.7.2.8 GPIO_MODE_t

```
typedef enum GPIO\_MODE\_t GPIO_MODE_t
```

Location: Driver_GPIO.h:260

GPIO Control Codes: IO Mode.

18.7.2.9 GPIO_FUNC_REGISTERS_t

```
typedef enum GPIO\_FUNC\_REGISTERS\_t GPIO_FUNC_REGISTERS_t
```

Location: Driver_GPIO.h:278

GPIO Control Codes: GPIO alternative function registers.

18.7.2.10 GPIO_EN_DIS_t

```
typedef enum GPIO\_EN\_DIS\_t GPIO_EN_DIS_t
```

Location: Driver_GPIO.h:284

GPIO Control Codes: Enable / Disable values.

18.7.2.11 GPIO_EVENT_t

```
typedef enum GPIO\_EVENT\_t GPIO_EVENT_t
```

Location: Driver_GPIO.h:295

GPIO Control Codes: Interrupts events.

18.7.2.12 GPIO_DBC_CLK_t

```
typedef enum GPIO\_DBC\_CLK\_t GPIO_DBC_CLK_t
```

Location: Driver_GPIO.h:301

GPIO Control Codes: Debounce clock source.

18.7.2.13 GPIO_DRIVE_STRENGTHS_t

```
typedef enum GPIO\_DRIVE\_STRENGTHS\_t GPIO_DRIVE_STRENGTHS_t
```

Location: Driver_GPIO.h:307

GPIO Control Codes: Pads strength.

18.7.2.14 GPIO_SignalEvent_t

```
typedef void(* GPIO_SignalEvent_t
```

Location: Driver_GPIO.h:392

Pointer to [GPIO_SignalEvent](#) : Signal GPIO Event.

18.7.2.15 GPIO_DBF_CFG_t

```
typedef struct GPIO\_DBF\_CFG\_t GPIO_DBF_CFG_t
```

Location: Driver_GPIO.h:402

Debounce filter configuration.

18.7.2.16 GPIO_PRI_CFG_t

```
typedef struct GPIO\_PRI\_CFG\_t GPIO_PRI_CFG_t
```

Location: Driver_GPIO.h:413

GPIO interrupt priority configuration.

18.7.2.17 GPIO_CFG_t

```
typedef struct GPIO\_CFG\_t GPIO_CFG_t
```

Location: Driver_GPIO.h:423

GPIO Driver configuration.

18.7.2.18 GPIO_PAD_CFG_t

```
typedef struct GPIO\_PAD\_CFG\_t GPIO_PAD_CFG_t
```

Location: Driver_GPIO.h:436

GPIO PAD configuration.

18.7.2.19 GPIO_INT_CFG_t

```
typedef struct GPIO\_INT\_CFG\_t GPIO_INT_CFG_t
```

Location: Driver_GPIO.h:448

GPIO INT configuration.

18.7.2.20 GPIO_EXTCLK_CFG_t

```
typedef struct GPIO\_EXTCLK\_CFG\_t GPIO_EXTCLK_CFG_t
```

Location: Driver_GPIO.h:458

External clock pad configuration.

18.7.2.21 GPIO_JTAG_SW_CFG_t

```
typedef struct GPIO\_JTAG\_SW\_CFG\_t GPIO_JTAG_SW_CFG_t
```

Location: Driver_GPIO.h:473

JTAG configuration.

18.7.2.22 DRIVER_GPIO_t

```
typedef struct DRIVER\_GPIO\_t DRIVER_GPIO_t
```

Location: Driver_GPIO.h:492

Access structure of the GPIO Driver.

18.7.3 CMSIS GPIO Driver Data Structures Type Documentation**18.7.3.1 _GPIO_DBF_CFG_t**

Location: Driver_GPIO.h:397

Debounce filter configuration.

Data Fields

Type	Name	Description
uint8_t	<i>count</i>	Debounce filter count value
GPIO_DBC_CLK_t	<i>clk_source</i>	Debounce filter clock source.
uint8_t	<i>__pad0__</i>	Reserved

18.7.3.2 _GPIO_PRI_CFG_t

Location: Driver_GPIO.h:407

GPIO interrupt priority configuration.

Data Fields

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Type	Name	Description
uint32_t	<i>preempt_pri</i>	Preempt priority
uint32_t	<i>__pad0__</i>	Reserved
uint32_t	<i>subgrp_pri</i>	Subgroup priority.
uint32_t	<i>__pad1__</i>	Reserved

18.7.3.3 _GPIO_CFG_t

Location: Driver_GPIO.h:418

GPIO Driver configuration.

Data Fields

Type	Name	Description
GPIO_DRIVE_STRENGTHS_t	<i>drive_strengths</i>	Drive strengths configuration.
uint8_t	<i>__pad0__</i>	Reserved
GPIO_DBF_CFG_t	<i>debounce_cfg</i>	Debounce filter configuration.

18.7.3.4 _GPIO_PAD_CFG_t

Location: Driver_GPIO.h:428

GPIO PAD configuration.

Data Fields

Type	Name	Description
GPIO_PULL_t	<i>pull_mode</i>	Pull control.
GPIO_DRIVE_t	<i>drive_mode</i>	Drive mode.
GPIO_LPF_t	<i>lpf_en</i>	Low pass filter enable.

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GPIO_MODE_t	<i>io_mode</i>	IO mode.
GPIO_OUTPUT_LEVEL_t	<i>output_level</i>	Output level.
uint8_t	<i>__pad0__</i>	Reserved.

18.7.3.5 _GPIO_INT_CFG_t

Location: Driver_GPIO.h:441

GPIO INT configuration.

Data Fields

Type	Name	Description
GPIO_SEL_t	<i>src_sel</i>	Interrupt source selection.
GPIO_EVENT_t	<i>event</i>	Event selection
GPIO_EN_DIS_t	<i>debounce_en</i>	Debounce filter enable
GPIO_EN_DIS_t	<i>interrup_en</i>	Interrupt enable flag
uint8_t	<i>__pad0__</i>	Reserved

18.7.3.6 _GPIO_EXTCLK_CFG_t

Location: Driver_GPIO.h:453

External clock pad configuration.

Data Fields

Type	Name	Description
GPIO_PULL_t	<i>pull_mode</i>	Pull control
GPIO_LPF_t	<i>lpf_en</i>	Low pass filter enable.
uint8_t	<i>__pad0__</i>	Reserved

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18.7.3.7 _GPIO_JTAG_SW_CFG_t

Location: Driver_GPIO.h:463

JTAG configuration.

Data Fields

Type	Name	Description
GPIO_LPF_t	<i>swclk_jtck_lpf_en</i>	SWCLK/JTCK low pass filter enable
GPIO_LPF_t	<i>swdio_jtms_lpf_en</i>	SWDIO/JTMS low pass filter enable
GPIO_EN_DIS_t	<i>jtag_data_en</i>	JTAG data available on GPIO[2:3]
GPIO_EN_DIS_t	<i>jtag_trst_en</i>	JTAG trst available on GPIO4
GPIO_PULL_t	<i>swclk_jtck_pull</i>	SWCLK/JTCK pull mode
GPIO_PULL_t	<i>swdio_jtms_pull</i>	SWDIO/JTMS pull mode
GPIO_DRIVE_t	<i>swdio_jtms_drive</i>	SWDIO/JTMS drive mode
uint8_t	<i>__pad0__</i>	Reserved

18.7.3.8 _DRIVER_GPIO_t

Location: Driver_GPIO.h:478

Access structure of the GPIO Driver.

Data Fields

Type	Name	Description
ARM_DRIVER_VERSION (*)	<i>GetVersion)(void)</i>	Pointer to GPIO_GetVersion : Get driver version.
int32_t (*)	<i>Initialize)(GPIO_SignalEvent_t cb)</i>	Pointer to GPIO_Initialize : Initialize the GPIO driver.
int32_t (*)	<i>Configure)(const GPIO_</i>	Pointer to GPIO_Configure : Configure common GPIO

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	<i>CFG_t *cfg)</i>	settings.
<i>int32_t (*</i>	<i>ConfigurePad)(GPIO_SEL_t sel, const GPIO_PAD_CFG_t *cfg)</i>	Pointer to GPIO_ConfigurePad : Configure the GPIO pad.
<i>int32_t (*</i>	<i>ConfigureInterrupt)(GPIO_INT_SEL_t sel, const GPIO_INT_CFG_t *cfg)</i>	Pointer to GPIO_ConfigureInterrupt : Configure the GPIO interrupt.
<i>int32_t (*</i>	<i>SetInterruptPriority)(GPIO_INT_SEL_t sel, const GPIO_PRI_CFG_t *pri)</i>	Pointer to GPIO_SetInterruptPriority : Configure GPIO interrupt priority.
<i>int32_t (*</i>	<i>ConfigureJTAGSW)(const GPIO_JTAG_SW_CFG_t *cfg)</i>	Pointer to GPIO_ConfigureJTAG : Configure the GPIO JTAG mode.
<i>void (*</i>	<i>SetDir)(GPIO_SEL_t sel, GPIO_DIR_t dir)</i>	Pointer to GPIO_SetDir : Set particular GPIO pad direction.
<i>void (*</i>	<i>SetHigh)(GPIO_SEL_t sel)</i>	Pointer to GPIO_SetHigh : Set particular GPIO pad.
<i>void (*</i>	<i>ToggleValue)(GPIO_SEL_t sel)</i>	Pointer to GPIO_ToggleValue : Toggle particular GPIO pad.
<i>void (*</i>	<i>SetLow)(GPIO_SEL_t sel)</i>	Pointer to GPIO_SetLow : Reset particular GPIO pad.
<i>uint32_t (*</i>	<i>ReadValue)(GPIO_SEL_t sel)</i>	Pointer to GPIO_ReadValue : Return the selected GPIO value.
<i>int32_t (*</i>	<i>ResetAltFuncRegister)(GPIO_FUNC_REGISTERS_t sel)</i>	Pointer to GPIO_ResetAltFuncRegister : Reset GPIO alternative function register.

18.7.4 CMSIS GPIO Driver Enumeration Type Documentation

18.7.4.1 _GPIO_SEL_t

Location: Driver_GPIO.h:42

GPIO Control Codes: GPIO Selection.

Members

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- GPIO_0 = 0x0

GPIO pad 0

- GPIO_1 = 0x1

GPIO pad 1

- GPIO_2 = 0x2

GPIO pad 2

- GPIO_3 = 0x3

GPIO pad 3

- GPIO_4 = 0x4

GPIO pad 4

- GPIO_5 = 0x5

GPIO pad 5

- GPIO_6 = 0x6

GPIO pad 6

- GPIO_7 = 0x7

GPIO pad 7

- GPIO_8 = 0x8

GPIO pad 8

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- GPIO_9 = 0x9

GPIO pad 9

- GPIO_10 = 0xA

GPIO pad 10.

- GPIO_11 = 0xB

GPIO pad 11.

- GPIO_12 = 0xC

GPIO pad 12.

- GPIO_13 = 0xD

GPIO pad 13.

- GPIO_14 = 0xE

GPIO pad 14.

- GPIO_15 = 0xF

GPIO pad 15.

18.7.4.2 _GPIO_DIR_t

Location: Driver_GPIO.h:62

GPIO Control Codes: GPIO direction.

Members

- GPIO_DIR_IN = 0x0

GPIO direction input

- GPIO_DIR_OUT_0 = 0x1

GPIO direction output 0

- GPIO_DIR_OUT_1 = 0x2

GPIO direction output 1

- GPIO_DIR_OUT_2 = 0x4

GPIO direction output 2

- GPIO_DIR_OUT_3 = 0x8

GPIO direction output 3

- GPIO_DIR_OUT_4 = 0x10

GPIO direction output 4

- GPIO_DIR_OUT_5 = 0x20

GPIO direction output 5

- GPIO_DIR_OUT_6 = 0x40

GPIO direction output 6

- GPIO_DIR_OUT_7 = 0x80

GPIO direction output 7

- GPIO_DIR_OUT_8 = 0x100

GPIO direction output 8

- GPIO_DIR_OUT_9 = 0x200

GPIO direction output 9

- GPIO_DIR_OUT_10 = 0x400

GPIO direction output 10

- GPIO_DIR_OUT_11 = 0x800

GPIO direction output 11

- GPIO_DIR_OUT_12 = 0x1000

GPIO direction output 12

- GPIO_DIR_OUT_13 = 0x2000

GPIO direction output 13

- GPIO_DIR_OUT_14 = 0x4000

GPIO direction output 14

- GPIO_DIR_OUT_15 = 0x8000

GPIO direction output 15

18.7.4.3 _GPIO_INT_SEL_t

Location: Driver_GPIO.h:83

GPIO Control Codes: GPIO INT Selection.

Members

- GPIO_INT_0 = 0x0

GPIO interrupt 0.

- GPIO_INT_1 = 0x1

GPIO interrupt 1.

- GPIO_INT_2 = 0x2

GPIO interrupt 2.

- GPIO_INT_3 = 0x3

GPIO interrupt 3.

18.7.4.4 _GPIO_DRIVE_t

Location: Driver_GPIO.h:91

GPIO Control Codes: Drive strength.

Members

- GPIO_2X = 0x0

2x drive strength

- GPIO_3X = 0x1

3x drive strength

- GPIO_5X = 0x2

5x drive strength

- GPIO_6X = 0x3

6x drive strength

18.7.4.5 _GPIO_LPF_t

Location: Driver_GPIO.h:99

GPIO Control Codes: Low pass filter.

Members

- GPIO_LPF_DISABLED = 0x0

Low pass filter disabled.

- GPIO_LPF_ENABLED = 0x1

Low pass filter enabled

18.7.4.6 _GPIO_PULL_t

Location: Driver_GPIO.h:105

GPIO Control Codes: Pull control.

Members

- GPIO_PC_NO_PULL = 0x0

No pull selected

- GPIO_PC_WEAK_PULL_UP = 0x1

Weak pull-up selected

- GPIO_PC_WEAK_PULL_DOWN = 0x2

Weak pull-down selected.

- GPIO_PC_STRONG_PULL_UP = 0x3

Strong pull-up selected.

18.7.4.7 _GPIO_OUTPUT_LEVEL_t

Location: Driver_GPIO.h:113

GPIO Control Codes: Output Level.

Members

- GPIO_OUTPUT_LEVEL_LOW = 0x0

Initial output level set to LOW.

- GPIO_OUTPUT_LEVEL_HIGH = 0x1

Initial output level set to HIGH.

18.7.4.8 _GPIO_MODE_t

Location: Driver_GPIO.h:119

GPIO Control Codes: IO Mode.

Members

- MODE_GPIO_DISABLE = 0x000
- MODE_GPIO_INPUT = 0x001
- MODE_GPIO_GPIO_IN = 0x002
- MODE_GPIO_GPIO_OUT = 0x003
- MODE_GPIO_SLOWCLK = 0x004
- MODE_GPIO_SYSCLK = 0x005
- MODE_GPIO_USRCLK = 0x006
- MODE_GPIO_RCCLK = 0x007
- MODE_GPIO_SWCLK_DIV = 0x008
- MODE_GPIO_EXTCLK_DIV = 0x009
- MODE_GPIO_RFCLK = 0x00A
- MODE_GPIO_STANDBYCLK = 0x00B
- MODE_GPIO_SENSORCLK = 0x00C

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- MODE_GPIO_SPI0_IO0 = 0x00D
- MODE_GPIO_SPI0_IO1 = 0x00E
- MODE_GPIO_SPI0_IO2 = 0x00F
- MODE_GPIO_SPI0_IO3 = 0x010
- MODE_GPIO_SPI0_CS = 0x011
- MODE_GPIO_SPI0_CLK = 0x012
- MODE_GPIO_SPI1_IO0 = 0x013
- MODE_GPIO_SPI1_IO1 = 0x014
- MODE_GPIO_SPI1_IO2 = 0x015
- MODE_GPIO_SPI1_IO3 = 0x016
- MODE_GPIO_SPI1_CS = 0x017
- MODE_GPIO_SPI1_CLK = 0x018
- MODE_GPIO_UART0_TX = 0x019
- MODE_GPIO_I2C0_SCL = 0x01A
- MODE_GPIO_I2C0_SDA = 0x01B
- MODE_GPIO_I2C1_SCL = 0x01C
- MODE_GPIO_I2C1_SDA = 0x01D
- MODE_GPIO_PCM0_SERO = 0x01E
- MODE_GPIO_PCM0_FRAME = 0x01F
- MODE_GPIO_PWM0 = 0x020
- MODE_GPIO_PWM1 = 0x021
- MODE_GPIO_PWM2 = 0x022
- MODE_GPIO_PWM3 = 0x023
- MODE_GPIO_PWM4 = 0x024
- MODE_GPIO_PWM0_INV = 0x025
- MODE_GPIO_PWM1_INV = 0x026
- MODE_GPIO_PWM2_INV = 0x027
- MODE_GPIO_PWM3_INV = 0x028
- MODE_GPIO_PWM4_INV = 0x029
- MODE_GPIO_LIN0_TX = 0x02A

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- MODE_GPIO_BB_TX_DATA = 0x02B
- MODE_GPIO_BB_TX_DATA_VALID = 0x02C
- MODE_GPIO_BB_SPI_CSN = 0x02D
- MODE_GPIO_BB_SPI_CLK = 0x02E
- MODE_GPIO_BB_SPI_MOSI = 0x02F
- MODE_GPIO_BB_DBG_0 = 0x030
- MODE_GPIO_BB_DBG_1 = 0x031
- MODE_GPIO_BB_DBG_2 = 0x032
- MODE_GPIO_BB_DBG_3 = 0x033
- MODE_GPIO_BB_DBG_4 = 0x034
- MODE_GPIO_BB_DBG_5 = 0x035
- MODE_GPIO_BB_DBG_6 = 0x036
- MODE_GPIO_BB_DBG_7 = 0x037
- MODE_GPIO_BB_BLE_SYNC = 0x038
- MODE_GPIO_BB_BLE_IN_PROCESS = 0x039
- MODE_GPIO_BB_BLE_TX = 0x03A
- MODE_GPIO_BB_BLE_RX = 0x03B
- MODE_GPIO_BB_BLE_PTI_0 = 0x03C
- MODE_GPIO_BB_BLE_PTI_1 = 0x03D
- MODE_GPIO_BB_BLE_PTI_2 = 0x03E
- MODE_GPIO_BB_BLE_PTI_3 = 0x03F
- MODE_GPIO_BB_ANT_SW_EN = 0x040
- MODE_GPIO_BB_ANT_SW_0 = 0x041
- MODE_GPIO_BB_ANT_SW_1 = 0x042
- MODE_GPIO_BB_ANT_SW_2 = 0x043
- MODE_GPIO_BB_ANT_SW_3 = 0x044
- MODE_GPIO_BB_ANT_SW_4 = 0x045
- MODE_GPIO_BB_ANT_SW_5 = 0x046
- MODE_GPIO_BB_ANT_SW_6 = 0x047
- MODE_GPIO_BB_CTE_MODE = 0x048

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- MODE_GPIO_BB_CTE_SAMPLE_P = 0x049
- MODE_GPIO_RF_SPI_MISO = 0x04A
- MODE_GPIO_RF_GPIO0 = 0x04B
- MODE_GPIO_RF_GPIO1 = 0x04C
- MODE_GPIO_RF_GPIO2 = 0x04D
- MODE_GPIO_RF_GPIO3 = 0x04E
- MODE_GPIO_RF_GPIO4 = 0x04F
- MODE_GPIO_RF_GPIO5 = 0x050
- MODE_GPIO_RF_GPIO6 = 0x051
- MODE_GPIO_RF_GPIO7 = 0x052
- MODE_GPIO_RF_GPIO8 = 0x053
- MODE_GPIO_RF_GPIO9 = 0x054
- MODE_GPIO_RF_IQ_DATA_P = 0x055
- MODE_GPIO_RF_I_DATA_0 = 0x056
- MODE_GPIO_RF_I_DATA_1 = 0x057
- MODE_GPIO_RF_I_DATA_2 = 0x058
- MODE_GPIO_RF_I_DATA_3 = 0x059
- MODE_GPIO_RF_I_DATA_4 = 0x05A
- MODE_GPIO_RF_I_DATA_5 = 0x05B
- MODE_GPIO_RF_I_DATA_6 = 0x05C
- MODE_GPIO_RF_I_DATA_7 = 0x05D
- MODE_GPIO_RF_Q_DATA_0 = 0x05E
- MODE_GPIO_RF_Q_DATA_1 = 0x05F
- MODE_GPIO_RF_Q_DATA_2 = 0x060
- MODE_GPIO_RF_Q_DATA_3 = 0x061
- MODE_GPIO_RF_Q_DATA_4 = 0x062
- MODE_GPIO_RF_Q_DATA_5 = 0x063
- MODE_GPIO_RF_Q_DATA_6 = 0x064
- MODE_GPIO_RF_Q_DATA_7 = 0x065
- MODE_GPIO_RF_ANT_SW_0 = 0x066

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- MODE_GPIO_RF_ANT_SW_1 = 0x067
- MODE_GPIO_RF_ANT_SW_2 = 0x068
- MODE_GPIO_RF_ANT_SW_3 = 0x069
- MODE_GPIO_TOF_START = 0x06A
- MODE_GPIO_TOF_STOP = 0x06B
- MODE_GPIO_PCM_SERI_IN = 0x100
- MODE_GPIO_PCM_FRAME_IN = 0x101
- MODE_GPIO_PCM_FRAME_OUT = 0x102
- MODE_GPIO_PCM_CLK_IN = 0x103
- MODE_GPIO_SPI0_CS_IN = 0x200
- MODE_GPIO_SPI0_CLK_IN = 0x201
- MODE_GPIO_SPI1_CS_IN = 0x202
- MODE_GPIO_SPI1_CLK_IN = 0x203
- MODE_GPIO_UART_RX_IN = 0x300
- MODE_GPIO_I2C0_SCL_IN = 0x400
- MODE_GPIO_I2C0_SDA_IN = 0x401
- MODE_GPIO_I2C1_SCL_IN = 0x402
- MODE_GPIO_I2C1_SDA_IN = 0x403
- MODE_GPIO_NMI_IN = 0x500
- MODE_GPIO_BB_RX_CLK_IN = 0x600
- MODE_GPIO_BB_RX_DATA_IN = 0x601
- MODE_GPIO_BB_SYNC_P_IN = 0x602
- MODE_GPIO_BB_SPI_MISO_IN = 0x603
- MODE_GPIO_RF_SPI_MOSI_IN = 0x700
- MODE_GPIO_RF_SPI_CSN_IN = 0x701
- MODE_GPIO_RF_SPI_CLK_IN = 0x702
- MODE_GPIO_RF_GPIO0_IN = 0x800
- MODE_GPIO_RF_GPIO1_IN = 0x801
- MODE_GPIO_RF_GPIO2_IN = 0x802
- MODE_GPIO_RF_GPIO3_IN = 0x803

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- `MODE_GPIO_RF_GPIO4_IN = 0x804`
- `MODE_GPIO_RF_GPIO5_IN = 0x805`
- `MODE_GPIO_RF_GPIO6_IN = 0x806`
- `MODE_GPIO_RF_GPIO7_IN = 0x807`
- `MODE_GPIO_RF_GPIO8_IN = 0x808`
- `MODE_GPIO_RF_GPIO9_IN = 0x809`
- `MODE_GPIO_ADC_IN = 0x80A`

18.7.4.9 `_GPIO_FUNC_REGISTERS_t`

Location: `Driver_GPIO.h:263`

GPIO Control Codes: GPIO alternative function registers.

Members

- `GPIO_FUNC_REG_SPI0 = 0x00`

SPI 0 register

- `GPIO_FUNC_REG_SPI1 = 0x01`

SPI 1 register

- `GPIO_FUNC_REG_UART0 = 0x03`

UART register

- `GPIO_FUNC_REG_I2C0 = 0x04`

I2C 0 register

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- `GPIO_FUNC_REG_I2C1 = 0x05`

I2C 1 register

- `GPIO_FUNC_REG_PCM0 = 0x06`

PCM register

- `GPIO_FUNC_REG_NMI = 0x07`

NMI register

- `GPIO_FUNC_REG_BB_RX = 0x08`

BB RX register

- `GPIO_FUNC_REG_BB_SPI = 0x09`

BB SPI register

- `GPIO_FUNC_REG_RF_SPI = 0x0A`

RF SPI register

- `GPIO_FUNC_REG_RF_GPIO03 = 0x0B`

RF GPIO03 register

- `GPIO_FUNC_REG_RF_GPIO47 = 0x0C`

RF GPIO47 register

- `GPIO_FUNC_REG_RF_GPIO89 = 0x0D`

RF GPIO89 register

- `GPIO_FUNC_REG_JTAG_SW_PAD = 0x0E`

JTAG SW pad register.

18.7.4.10 `_GPIO_EN_DIS_t`

Location: `Driver_GPIO.h:281`

GPIO Control Codes: Enable / Disable values.

Members

- `GPIO_DISABLE = 0`

GPIO disable value.

- `GPIO_ENABLE = 1`

GPIO enable value

18.7.4.11 `_GPIO_EVENT_t`

Location: `Driver_GPIO.h:288`

GPIO Control Codes: Interrupts events.

Members

- `GPIO_IN_EVENT_NONE = 0`

Interrupt event none

- `GPIO_IN_EVENT_HIGH_LEVEL = 1`

Interrupt event high level

- `GPIO_IN_EVENT_LOW_LEVEL = 2`

Interrupt event low level

- `GPIO_IN_EVENT_RISING_EDGE = 3`

Interrupt event rising edge

- `GPIO_IN_EVENT_FALLING_EDGE = 4`

Interrupt event falling edge.

- `GPIO_IN_EVENT_TRANSITION = 5`

Interrupt event transition**18.7.4.12 _GPIO_DBC_CLK_t**

Location: `Driver_GPIO.h:298`

GPIO Control Codes: Debounce clock source.

Members

- `GPIO_DBC_CLK_SLOWCLK_DIV32 = 0`

Debounce clock source = slow clock / 32

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- `GPIO_DBC_CLK_SLOWCLK_DIV1024 = 1`

Debounce clock source = slow clock / 1024.

18.7.4.13 `_GPIO_DRIVE_STRENGTHS_t`

Location: `Driver_GPIO.h:304`

GPIO Control Codes: Pads strength.

Members

- `GPIO_LOW_DRIVE = 0`

Regular drive strengths

- `GPIO_HIGH_DRIVE = 1`

Drive strengths increased by ~50%.

18.7.5 CMSIS GPIO Driver Macro Definition Documentation

18.7.5.1 `ARM_GPIO_API_VERSION`

```
#define ARM_GPIO_API_VERSION ARM\_DRIVER\_VERSION\_MAJOR\_MINOR(1,0)
```

GPIO API version.

Location: `Driver_GPIO.h:37`

18.7.5.2 GPIO_EVENT_0_IRQ

```
#define GPIO_EVENT_0_IRQ (1UL << 0)
```

GPIO Event.

GPIO0 interrupt event value

Location: Driver_GPIO.h:310

18.7.5.3 GPIO_EVENT_1_IRQ

```
#define GPIO_EVENT_1_IRQ (1UL << 1)
```

GPIO1 interrupt event value.

Location: Driver_GPIO.h:311

18.7.5.4 GPIO_EVENT_2_IRQ

```
#define GPIO_EVENT_2_IRQ (1UL << 2)
```

GPIO2 interrupt event value.

Location: Driver_GPIO.h:312

18.7.5.5 GPIO_EVENT_3_IRQ

```
#define GPIO_EVENT_3_IRQ (1UL << 3)
```

GPIO3 interrupt event value.

Location: Driver_GPIO.h:313

18.7.6 CMSIS GPIO Driver Function Documentation

18.7.6.1 GPIO_GetVersion

[ARM DRIVER VERSION](#) GPIO_GetVersion()

Get driver version.

Location: Driver_GPIO.c:21

Return

[ARM DRIVER VERSION](#)

18.7.6.2 GPIO_Initialize

int32_t GPIO_Initialize([GPIO SignalEvent t](#) cb)

Initialize the GPIO driver.

Location: Driver_GPIO.c:22

Parameters

Direction	Name	Description
in	<i>cb</i>	Pointer to GPIO SignalEvent

Return

[execution status](#)

18.7.6.3 GPIO_Configure

int32_t GPIO_Configure(const [GPIO_CFG t](#) * cfg)

Configure common GPIO settings.

Location: Driver_GPIO.c:23

Parameters

Direction	Name	Description
in	<i>cfg</i>	Pointer to GPIO_CFG_t

Return

[execution status](#)

18.7.6.4 GPIO_ConfigurePad

```
int32_t GPIO_ConfigurePad(GPIO\_SEL\_t sel, const GPIO\_PAD\_CFG\_t * cfg)
```

Configure the GPIO pad.

Location: Driver_GPIO.c:24

Parameters

Direction	Name	Description
in	<i>sel</i>	Pad selection GPIO_SEL_t
in	<i>cfg</i>	Pointer to GPIO_PAD_CFG_t

Return

[execution status](#)

18.7.6.5 GPIO_ConfigureInterrupt

```
int32_t GPIO_ConfigureInterrupt(GPIO\_INT\_SEL\_t sel, const GPIO\_INT\_CFG\_t * cfg)
```

Configure the GPIO interrupt.

Location: Driver_GPIO.c:25

Parameters

Direction	Name	Description
in	<i>sel</i>	Interrupt selection GPIO_INT_SEL_t
in	<i>cfg</i>	Pointer to GPIO_INT_CFG_t

Return

[execution status](#)

18.7.6.6 GPIO_SetInterruptPriority

```
int32_t GPIO_SetInterruptPriority(GPIO\_INT\_SEL\_t sel, const GPIO\_PRI\_CFG\_t * cfg)
```

Configure GPIO interrupt priority.

Location: Driver_GPIO.c:26

Parameters

Direction	Name	Description
in	<i>sel</i>	Interrupt selection GPIO_INT_SEL_t
in	<i>cfg</i>	Pointer to GPIO_PRI_CFG_t

Return

[execution status](#)

18.7.6.7 GPIO_ConfigureJTAG

```
int32_t GPIO_ConfigureJTAG(const GPIO\_JTAG\_SW\_CFG\_t * cfg)
```

Configure the GPIO JTAG mode.

Location: Driver_GPIO.c:27

Parameters

Direction	Name	Description
in	<i>cfg</i>	Pointer to GPIO_JTAG_SW_CFG_t

Return

[execution status](#)

18.7.6.8 GPIO_SetHigh

```
void GPIO_SetHigh(GPIO\_SEL\_t sel)
```

Set particular GPIO pad.

Location: Driver_GPIO.c:29

Parameters

Direction	Name	Description
in	<i>sel</i>	Pad selection GPIO_SEL_t

Return

None

18.7.6.9 GPIO_ToggleValue

```
void GPIO_ToggleValue(GPIO\_SEL\_t sel)
```

Toggle particular GPIO pad.

Location: Driver_GPIO.c:30

Parameters

Direction	Name	Description
in	<i>sel</i>	Pad selection GPIO_SEL_t

Return

None

18.7.6.10 GPIO_SetLow

```
void GPIO_SetLow(GPIO\_SEL\_t sel)
```

Reset particular GPIO pad.

Location: Driver_GPIO.c:31

Parameters

Direction	Name	Description
in	<i>sel</i>	Pad selection GPIO_SEL_t

Return

None

18.7.6.11 GPIO_ReadValue

```
uint32_t GPIO_ReadValue(GPIO\_SEL\_t sel)
```

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Returns the selected GPIO pad value.

Location: Driver_GPIO.c:32

Parameters

Direction	Name	Description
in	<i>sel</i>	Pad selection GPIO_SEL_t

Return

GPIO pad value

18.7.6.12 GPIO_ResetAltFuncRegister

```
int32_t GPIO_ResetAltFuncRegister(GPIO\_FUNC\_REGISTERS\_t reg)
```

Reset the particular alternative function register.

Location: Driver_GPIO.c:33

Parameters

Direction	Name	Description
in	<i>reg</i>	Register selection GPIO_FUNC_REGISTERS_t

Return

[execution status](#)

18.7.6.13 GPIO_SignalEvent

```
void GPIO_SignalEvent(uint32_t event)
```

Signal GPIO events.

Location: Driver_GPIO.c:35

Parameters

Direction	Name	Description
in	<i>event</i>	notification mask

Return

None

18.8 CMSIS I2C DRIVER

CMSIS I²C Driver Reference.

18.8.1 Summary

Typedefs

- [ARM I2C STATUS](#) : I2C Status.
- [ARM I2C SignalEvent t](#) : Pointer to [ARM I2C SignalEvent](#) : Signal I2C Event.
- [ARM I2C CAPABILITIES](#) : I2C Driver Capabilities.
- [ARM DRIVER I2C](#) : Access structure of the I2C Driver.

Data Structures

- [ARM I2C STATUS](#) : I2C Status.
- [ARM I2C CAPABILITIES](#) : I2C Driver Capabilities.
- [ARM DRIVER I2C](#) : Access structure of the I2C Driver.

Macros

- [ARM I2C API VERSION](#) : I2C API version.
- [ARM I2C OWN ADDRESS](#) : Set Own Slave Address; arg = address.
- [ARM I2C BUS SPEED](#) : Set Bus Speed; arg = speed.

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- [ARM I2C BUS CLEAR](#) : Execute Bus clear: send nine clock pulses.
- [ARM I2C ABORT TRANSFER](#) : Abort Master/Slave Transmit/Receive.
- [ARM I2C BUS SPEED STANDARD](#) : Standard Speed (100kHz)
- [ARM I2C BUS SPEED FAST](#) : Fast Speed (400kHz)
- [ARM I2C BUS SPEED FAST PLUS](#) : Fast+ Speed (1MHz)
- [ARM I2C BUS SPEED HIGH](#) : High Speed (3.4MHz)
- [ARM I2C ADDRESS 10BIT](#) : 10-bit address flag
- [ARM I2C ADDRESS GC](#) : General Call flag.
- [ARM I2C EVENT TRANSFER DONE](#) : I2C Event
- [ARM I2C EVENT TRANSFER INCOMPLETE](#) : Master/Slave Transmit/Receive incomplete transfer.
- [ARM I2C EVENT SLAVE TRANSMIT](#) : Slave Transmit operation requested.
- [ARM I2C EVENT SLAVE RECEIVE](#) : Slave Receive operation requested.
- [ARM I2C EVENT ADDRESS NACK](#) : Address not acknowledged from Slave.
- [ARM I2C EVENT GENERAL CALL](#) : General Call indication.
- [ARM I2C EVENT ARBITRATION LOST](#) : Master lost arbitration.
- [ARM I2C EVENT BUS ERROR](#) : Bus error detected (START/STOP at illegal position)
- [ARM I2C EVENT BUS CLEAR](#) : Bus clear finished.

Functions

- [ARM I2C GetVersion](#) : Get driver version.
- [ARM I2C GetCapabilities](#) : Get driver capabilities.
- [ARM I2C Initialize](#) : Initialize I2C Interface.
- [ARM I2C Uninitialize](#) : De-initialize I2C Interface.
- [ARM I2C PowerControl](#) : Control I2C Interface Power.
- [ARM I2C MasterTransmit](#) : Start transmitting data as I2C Master.
- [ARM I2C MasterReceive](#) : Start receiving data as I2C Master.
- [ARM I2C SlaveTransmit](#) : Start transmitting data as I2C Slave.
- [ARM I2C SlaveReceive](#) : Start receiving data as I2C Slave.
- [ARM I2C GetDataCount](#) : Get transferred data count.
- [ARM I2C Control](#) : Control I2C Interface.
- [ARM I2C GetStatus](#) : Get I2C status.
- [ARM I2C SignalEvent](#) : Signal I2C Events.

18.8.2 CMSIS I2C Driver Typedef Documentation

18.8.2.1 ARM_I2C_STATUS

```
typedef struct ARM\_I2C\_STATUS ARM_I2C_STATUS
```

Location: Driver_I2C.h:112

I2C Status.

18.8.2.2 ARM_I2C_SignalEvent_t

```
typedef void(* ARM_I2C_SignalEvent_t
```

Location: Driver_I2C.h:198

Pointer to [ARM I2C SignalEvent](#) : Signal I2C Event.

18.8.2.3 ARM_I2C_CAPABILITIES

```
typedef struct ARM I2C CAPABILITIES ARM_I2C_CAPABILITIES
```

Location: Driver_I2C.h:207

I2C Driver Capabilities.

18.8.2.4 ARM_DRIVER_I2C

```
typedef struct ARM DRIVER I2C ARM_DRIVER_I2C
```

Location: Driver_I2C.h:226

Access structure of the I2C Driver.

18.8.3 CMSIS I2C Driver Data Structures Type Documentation

18.8.3.1 _ARM_I2C_STATUS

Location: Driver_I2C.h:104

I2C Status.

Data Fields

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Type	Name	Description
uint32_t	<i>busy</i>	Busy flag.
uint32_t	<i>mode</i>	Mode: 0=Slave, 1=Master.
uint32_t	<i>direction</i>	Direction: 0=Transmitter, 1=Receiver.
uint32_t	<i>general_call</i>	General Call indication (cleared on start of next Slave operation)
uint32_t	<i>arbitration_lost</i>	Master lost arbitration (cleared on start of next Master operation)
uint32_t	<i>bus_error</i>	Bus error detected (cleared on start of next Master/Slave operation)
uint32_t	<i>reserved</i>	(Reserved for future use)

18.8.3.2 _ARM_I2C_CAPABILITIES

Location: Driver_I2C.h:204

I2C Driver Capabilities.

Data Fields

Type	Name	Description
uint32_t	<i>address_10_bit</i>	Supports 10-bit addressing.
uint32_t	<i>reserved</i>	Reserved (must be zero)

18.8.3.3 _ARM_DRIVER_I2C

Location: Driver_I2C.h:213

Access structure of the I2C Driver.

Data Fields

RSL15 Firmware Reference

Type	Name	Description
ARM_DRIVER_VERSION (*)	<i>GetVersion</i> (void)	Pointer to ARM_I2C_GetVersion : Get driver version.
ARM_I2C_CAPABILITIES (*)	<i>GetCapabilities</i> (void)	Pointer to ARM_I2C_GetCapabilities : Get driver capabilities.
int32_t (*)	<i>Initialize</i> (ARM_I2C_SignalEvent_t cb_event)	Pointer to ARM_I2C_Initialize : Initialize I2C Interface.
int32_t (*)	<i>Uninitialize</i> (void)	Pointer to ARM_I2C_Uninitialize : De-initialize I2C Interface.
int32_t (*)	<i>PowerControl</i> (ARM_POWER_STATE state)	Pointer to ARM_I2C_PowerControl : Control I2C Interface Power.
int32_t (*)	<i>MasterTransmit</i> (uint32_t addr, const uint8_t *data, uint32_t num, bool xfer_pending)	Pointer to ARM_I2C_MasterTransmit : Start transmitting data as I2C Master.
int32_t (*)	<i>MasterReceive</i> (uint32_t addr, uint8_t *data, uint32_t num, bool xfer_pending)	Pointer to ARM_I2C_MasterReceive : Start receiving data as I2C Master.
int32_t (*)	<i>SlaveTransmit</i> (const uint8_t *data, uint32_t num)	Pointer to ARM_I2C_SlaveTransmit : Start transmitting data as I2C Slave.
int32_t (*)	<i>SlaveReceive</i> (uint8_t *data, uint32_t num)	Pointer to ARM_I2C_SlaveReceive : Start receiving data as I2C Slave.
int32_t (*)	<i>GetDataCount</i> (void)	Pointer to ARM_I2C_GetDataCount : Get transferred data count.
int32_t (*)	<i>Control</i> (uint32_t control, uint32_t arg)	Pointer to ARM_I2C_Control : Control I2C Interface.
ARM_I2C_STATUS (*)	<i>GetStatus</i> (void)	Pointer to ARM_I2C_GetStatus : Get I2C status.

18.8.4 CMSIS I2C Driver Macro Definition Documentation

18.8.4.1 ARM_I2C_API_VERSION

```
#define ARM_I2C_API_VERSION ARM\_DRIVER\_VERSION\_MAJOR\_MINOR(2,3)
```

I2C API version.

Location: Driver_I2C.h:78

18.8.4.2 ARM_I2C_OWN_ADDRESS

```
#define ARM_I2C_OWN_ADDRESS (0x01)
```

Set Own Slave Address; arg = address.

Location: Driver_I2C.h:83

18.8.4.3 ARM_I2C_BUS_SPEED

```
#define ARM_I2C_BUS_SPEED (0x02)
```

Set Bus Speed; arg = speed.

Location: Driver_I2C.h:84

18.8.4.4 ARM_I2C_BUS_CLEAR

```
#define ARM_I2C_BUS_CLEAR (0x03)
```

Execute Bus clear: send nine clock pulses.

Location: Driver_I2C.h:85

18.8.4.5 ARM_I2C_ABORT_TRANSFER

```
#define ARM_I2C_ABORT_TRANSFER (0x04)
```

Abort Master/Slave Transmit/Receive.

Location: Driver_I2C.h:86

18.8.4.6 ARM_I2C_BUS_SPEED_STANDARD

```
#define ARM_I2C_BUS_SPEED_STANDARD (0x01)
```

Standard Speed (100kHz)

Location: Driver_I2C.h:89

18.8.4.7 ARM_I2C_BUS_SPEED_FAST

```
#define ARM_I2C_BUS_SPEED_FAST (0x02)
```

Fast Speed (400kHz)

Location: Driver_I2C.h:90

18.8.4.8 ARM_I2C_BUS_SPEED_FAST_PLUS

```
#define ARM_I2C_BUS_SPEED_FAST_PLUS (0x03)
```

Fast+ Speed (1MHz)

Location: Driver_I2C.h:91

18.8.4.9 ARM_I2C_BUS_SPEED_HIGH

```
#define ARM_I2C_BUS_SPEED_HIGH (0x04)
```

High Speed (3.4MHz)

Location: Driver_I2C.h:92

18.8.4.10 ARM_I2C_ADDRESS_10BIT

```
#define ARM_I2C_ADDRESS_10BIT (0x0400)
```

10-bit address flag

Location: Driver_I2C.h:97

18.8.4.11 ARM_I2C_ADDRESS_GC

```
#define ARM_I2C_ADDRESS_GC (0x8000)
```

General Call flag.

Location: Driver_I2C.h:98

18.8.4.12 ARM_I2C_EVENT_TRANSFER_DONE

```
#define ARM_I2C_EVENT_TRANSFER_DONE (1UL << 0)
```

I2C Event

Master/Slave Transmit/Receive finished

Location: Driver_I2C.h:116

18.8.4.13 ARM_I2C_EVENT_TRANSFER_INCOMPLETE

```
#define ARM_I2C_EVENT_TRANSFER_INCOMPLETE (1UL << 1)
```

Master/Slave Transmit/Receive incomplete transfer.

Location: Driver_I2C.h:117

18.8.4.14 ARM_I2C_EVENT_SLAVE_TRANSMIT

```
#define ARM_I2C_EVENT_SLAVE_TRANSMIT (1UL << 2)
```

Slave Transmit operation requested.

Location: Driver_I2C.h:118

18.8.4.15 ARM_I2C_EVENT_SLAVE_RECEIVE

```
#define ARM_I2C_EVENT_SLAVE_RECEIVE (1UL << 3)
```

Slave Receive operation requested.

Location: Driver_I2C.h:119

18.8.4.16 ARM_I2C_EVENT_ADDRESS_NACK

```
#define ARM_I2C_EVENT_ADDRESS_NACK (1UL << 4)
```

Address not acknowledged from Slave.

Location: Driver_I2C.h:120

18.8.4.17 ARM_I2C_EVENT_GENERAL_CALL

```
#define ARM_I2C_EVENT_GENERAL_CALL (1UL << 5)
```

General Call indication.

Location: Driver_I2C.h:121

18.8.4.18 ARM_I2C_EVENT_ARBITRATION_LOST

```
#define ARM_I2C_EVENT_ARBITRATION_LOST (1UL << 6)
```

Master lost arbitration.

Location: Driver_I2C.h:122

18.8.4.19 ARM_I2C_EVENT_BUS_ERROR

```
#define ARM_I2C_EVENT_BUS_ERROR (1UL << 7)
```

Bus error detected (START/STOP at illegal position)

Location: Driver_I2C.h:123

18.8.4.20 ARM_I2C_EVENT_BUS_CLEAR

```
#define ARM_I2C_EVENT_BUS_CLEAR (1UL << 8)
```

Bus clear finished.

Location: Driver_I2C.h:124

18.8.5 CMSIS I2C Driver Function Documentation

18.8.5.1 ARM_I2C_GetVersion

[ARM_DRIVER_VERSION](#) ARM_I2C_GetVersion()

Get driver version.

Location: Driver_I2C.c:38

Return

[ARM_DRIVER_VERSION](#)

18.8.5.2 ARM_I2C_GetCapabilities

[ARM_I2C_CAPABILITIES](#) ARM_I2C_GetCapabilities()

Get driver capabilities.

Location: Driver_I2C.c:43

Return

[ARM_I2C_CAPABILITIES](#)

18.8.5.3 ARM_I2C_Initialize

int32_t ARM_I2C_Initialize([ARM_I2C_SignalEvent_t](#) cb_event)

Initialize I2C Interface.

Location: Driver_I2C.c:48

Parameters

Direction	Name	Description
in	<i>cb_event</i>	Pointer to ARM_I2C_SignalEvent

Return

[execution status](#)

18.8.5.4 ARM_I2C_Uninitialize

```
int32_t ARM_I2C_Uninitialize()
```

De-initialize I2C Interface.

Location: Driver_I2C.c:52

Return

[execution status](#)

18.8.5.5 ARM_I2C_PowerControl

```
int32_t ARM_I2C_PowerControl(ARM\_POWER\_STATE state)
```

Control I2C Interface Power.

Location: Driver_I2C.c:56

Parameters

Direction	Name	Description
in	<i>state</i>	Power state

Return[execution status](#)**18.8.5.6 ARM_I2C_MasterTransmit**

```
int32_t ARM_I2C_MasterTransmit(uint32_t addr, const uint8_t * data, uint32_t num, bool
xfer_pending)
```

Start transmitting data as I2C Master.

Location: Driver_I2C.c:72

Parameters

Direction	Name	Description
in	<i>addr</i>	Slave address (7-bit or 10-bit)
in	<i>data</i>	Pointer to buffer with data to transmit to I2C Slave
in	<i>num</i>	Number of data bytes to transmit
in	<i>xfer_pending</i>	Transfer operation is pending - Stop condition will not be generated

Return[execution status](#)**18.8.5.7 ARM_I2C_MasterReceive**

```
int32_t ARM_I2C_MasterReceive(uint32_t addr, uint8_t * data, uint32_t num, bool xfer_
pending)
```

Start receiving data as I2C Master.

Location: Driver_I2C.c:76

RSL15 Firmware Reference

Parameters

Direction	Name	Description
in	<i>addr</i>	Slave address (7-bit or 10-bit)
out	<i>data</i>	Pointer to buffer for data to receive from I2C Slave
in	<i>num</i>	Number of data bytes to receive
in	<i>xfer_pending</i>	Transfer operation is pending - Stop condition will not be generated

Return

[execution status](#)

18.8.5.8 ARM_I2C_SlaveTransmit

```
int32_t ARM_I2C_SlaveTransmit(const uint8_t * data, uint32_t num)
```

Start transmitting data as I2C Slave.

Location: Driver_I2C.c:80

Parameters

Direction	Name	Description
in	<i>data</i>	Pointer to buffer with data to transmit to I2C Master
in	<i>num</i>	Number of data bytes to transmit

Return

[execution status](#)

18.8.5.9 ARM_I2C_SlaveReceive

```
int32_t ARM_I2C_SlaveReceive(uint8_t * data, uint32_t num)
```

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Start receiving data as I2C Slave.

Location: Driver_I2C.c:84

Parameters

Direction	Name	Description
out	<i>data</i>	Pointer to buffer for data to receive from I2C Master
in	<i>num</i>	Number of data bytes to receive

Return

[execution status](#)

18.8.5.10 ARM_I2C_GetDataCount

```
int32_t ARM_I2C_GetDataCount()
```

Get transferred data count.

Location: Driver_I2C.c:88

Return

number of data bytes transferred; -1 when Slave is not addressed by Master

18.8.5.11 ARM_I2C_Control

```
int32_t ARM_I2C_Control(uint32_t control, uint32_t arg)
```

Control I2C Interface.

Location: Driver_I2C.c:92

RSL15 Firmware Reference

Parameters

Direction	Name	Description
in	<i>control</i>	Operation
in	<i>arg</i>	Argument of operation (optional)

Return

[execution status](#)

18.8.5.12 ARM_I2C_GetStatus

[ARM_I2C_STATUS](#) ARM_I2C_GetStatus()

Get I2C status.

Location: Driver_I2C.c:124

Return

I2C status [ARM_I2C_STATUS](#)

18.8.5.13 ARM_I2C_SignalEvent

void ARM_I2C_SignalEvent(uint32_t event)

Signal I2C Events.

Location: Driver_I2C.c:128

Parameters

Direction	Name	Description
in	<i>event</i>	I2C_events notification mask

18.9 CMSIS PWM DRIVER

CMSIS PWM Driver Reference.

18.9.1 Summary

Typedefs

- [PWM_SEL_t](#) : PWM Control Codes: PWM Selection.
- [PWM_CFG_t](#) : PWM Driver configuration.
- [DRIVER_PWM_t](#) : Access structure of the PWM Driver.

Data Structures

- [PWM_CFG_t](#) : PWM Driver configuration.
- [DRIVER_PWM_t](#) : Access structure of the PWM Driver.

Enumerations

- [PWM_SEL_t](#) : PWM Control Codes: PWM Selection.

Macros

- [ARM_PWM_API_VERSION](#) : PWM API version
- [PWM_ERROR_UNCONFIGURED](#) : Driver has not been configured yet.

Functions

- [PWM_GetVersion](#) : Get driver version.
- [PWM_Initialize](#) : Initialize PWM driver with default configuration.
- [PWM_Configure](#) : Configure PWM common setting.
- [PWM_SelectClock](#) : Select the PWM clock source.
- [PWM_Reset](#) : Reset the PWM.
- [PWM_SetDithering](#) : Set the PWM dithering.
- [PWM_SetPeriod](#) : Set the PWM period.
- [PWM_SetDutyCycle](#) : Set the PWM duty cycle (expressed in percentage)
- [PWM_SetHighPeriod](#) : Set the PWM duty cycle (expressed in cycles).
- [PWM_SetOffset](#) : Set the offset between PWM.
- [PWM_Start](#) : Start the PWM.
- [PWM_Stop](#) : Stop the PWM.

18.9.2 CMSIS PWM Driver Typedef Documentation

18.9.2.1 PWM_SEL_t

```
typedef enum PWM\_SEL\_t PWM_SEL_t
```

Location: Driver_PWM.h:48

PWM Control Codes: PWM Selection.

18.9.2.2 PWM_CFG_t

```
typedef struct PWM\_CFG\_t PWM_CFG_t
```

Location: Driver_PWM.h:131

PWM Driver configuration.

18.9.2.3 DRIVER_PWM_t

```
typedef struct DRIVER\_PWM\_t DRIVER_PWM_t
```

Location: Driver_PWM.h:149

Access structure of the PWM Driver.

18.9.3 CMSIS PWM Driver Data Structures Type Documentation

18.9.3.1 _PWM_CFG_t

Location: Driver_PWM.h:125

PWM Driver configuration.

Data Fields

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Type	Name	Description
uint32_t	<i>period</i>	Period value
uint32_t	<i>high_cycle</i>	High cycle value.
uint32_t	<i>dithering</i>	Dithering value
uint32_t	<i>offset</i>	Offset value

18.9.3.2 _DRIVER_PWM_t

Location: Driver_PWM.h:136

Access structure of the PWM Driver.

Data Fields

Type	Name	Description
ARM_DRIVER_VERSION (*)	<i>GetVersion</i> (void)	Pointer to PWM_GetVersion : Get driver version.
int32_t (*)	<i>Initialize</i> (void)	Pointer to PWM_Initialize : Initialize PWM driver.
int32_t (*)	<i>Configure</i> (PWM_SEL_t sel, const PWM_CFG_t *pwm_cfg)	Pointer to PWM_Configure : Configure PWM common setting.
int32_t (*)	<i>SelectClock</i> (uint8_t clock_src, uint8_t slowclk_prescale)	Pointer to PWM_SelectClock : Configure PWM clock source.
int32_t (*)	<i>Reset</i> (PWM_SEL_t sel)	Pointer to PWM_Reset : Reset PWM
int32_t (*)	<i>SetDithering</i> (PWM_SEL_t sel, uint8_t dithering)	Pointer to PWM_SetDithering : Add dithering to PWM channel.
int32_t (*)	<i>SetPeriod</i> (PWM_SEL_t sel, uint16_t period)	Pointer to PWM_SetPeriod : Set the period.
int32_t (*)	<i>SetDutyCycle</i> (PWM_SEL_t sel, uint8_t duty_cycle)	Pointer to PWM_SetDutyCycle : Set the duty cycle (percentage).

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<code>int32_t (*</code>	<code>SetHighPeriod)(PWM_SEL_t sel, uint16_t high_period)</code>	Pointer to PWM_SetHighPeriod : Set the high cycle period.
<code>int32_t (*</code>	<code>SetOffset)(PWM_SEL_t sel, uint16_t offset)</code>	Pointer to PWM_SetOffset : Set offset between PWM.
<code>int32_t (*</code>	<code>Start)(PWM_SEL_t sel)</code>	Pointer to PWM_Start : Start the PWM.
<code>int32_t (*</code>	<code>Stop)(PWM_SEL_t sel)</code>	Pointer to PWM_Stop : Stop the PWM.

18.9.4 CMSIS PWM Driver Enumeration Type Documentation

18.9.4.1 _PWM_SEL_t

Location: Driver_PWM.h:42

PWM Control Codes: PWM Selection.

Members

- `PWM_0 = 0`

PWM module 0.

- `PWM_1 = 1`

PWM module 1.

- `PWM_2 = 2`

PWM module 2.

- `PWM_3 = 3`

PWM module 3.

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- PWM_4 = 4

PWM module 4.

18.9.5 CMSIS PWM Driver Macro Definition Documentation

18.9.5.1 ARM_PWM_API_VERSION

```
#define ARM_PWM_API_VERSION ARM\_DRIVER\_VERSION MAJOR MINOR(1,0)
```

PWM API version

Location: Driver_PWM.h:37

18.9.5.2 PWM_ERROR_UNCONFIGURED

```
#define PWM_ERROR_UNCONFIGURED (ARM\_DRIVER\_ERROR\_SPECIFIC - 1)
```

Driver has not been configured yet.

Location: Driver_PWM.h:51

18.9.6 CMSIS PWM Driver Function Documentation

18.9.6.1 PWM_GetVersion

```
ARM\_DRIVER\_VERSION PWM_GetVersion()
```

Get driver version.

Location: Driver_PWM.c:21

Return

[ARM DRIVER VERSION](#)**18.9.6.2 PWM_Initialize**

```
int32_t PWM_Initialize()
```

Initialize PWM driver with default configuration.

Location: Driver_PWM.c:22

Return

[execution status](#)

18.9.6.3 PWM_Configure

```
int32_t PWM_Configure(PWM\_SEL\_t sel, const PWM\_CFG\_t * pwm_cfg)
```

Configure PWM common setting.

Location: Driver_PWM.c:23

Parameters

Direction	Name	Description
in	<i>sel</i>	PWM to be configured PWM_SEL_t
in	<i>pwm_cfg</i>	Pointer to PWM_CFG_t

Return

[execution status](#)

18.9.6.4 PWM_SelectClock

```
int32_t PWM_SelectClock(uint8_t clock_src, uint8_t slowclk_prescale)
```

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Select the PWM clock source.

Location: Driver_PWM.c:24

Parameters

Direction	Name	Description
in	<i>clock_src</i>	Clock source for the PWM block
in	<i>slowclk_prescale</i>	Prescale to divide SYSCLK into SLOWCLK

Return

[execution status](#)

18.9.6.5 PWM_Reset

```
int32_t PWM_Reset(PWM\_SEL\_t sel)
```

Reset the PWM.

Location: Driver_PWM.c:25

Parameters

Direction	Name	Description
in	<i>sel</i>	PWM to be reset PWM_SEL_t

Return

[execution status](#)

RSL15 Firmware Reference

18.9.6.6 PWM_SetDithering

```
int32_t PWM_SetDithering(PWM\_SEL\_t sel, uint8_t dithering)
```

Set the PWM dithering.

Location: Driver_PWM.c:26

Parameters

Direction	Name	Description
in	<i>sel</i>	PWM to be configured PWM_SEL_t
in	<i>dithering</i>	PWM dithering value

Return

[execution status](#)

18.9.6.7 PWM_SetPeriod

```
int32_t PWM_SetPeriod(PWM\_SEL\_t sel, uint16_t period)
```

Set the PWM period.

Location: Driver_PWM.c:27

Parameters

Direction	Name	Description
in	<i>sel</i>	PWM to be configured PWM_SEL_t
in	<i>period</i>	Period value

Return

[execution status](#)

18.9.6.8 PWM_SetDutyCycle

```
int32_t PWM_SetDutyCycle(PWM\_SEL\_t sel, uint8_t duty_cycle)
```

Set the PWM duty cycle (expressed in percentage)

Location: Driver_PWM.c:28

Parameters

Direction	Name	Description
in	<i>sel</i>	PWM to be configured PWM_SEL_t
in	<i>duty_cycle</i>	Duty cycle value (expressed in percentage)

Return

[execution status](#)

18.9.6.9 PWM_SetHighPeriod

```
int32_t PWM_SetHighPeriod(PWM\_SEL\_t sel, uint16_t high_period)
```

Set the PWM duty cycle (expressed in cycles).

Location: Driver_PWM.c:29

Parameters

Direction	Name	Description
in	<i>sel</i>	PWM to be configured PWM_SEL_t
in	<i>high_period</i>	Duty cycle value (expressed in cycles)

Return[execution status](#)**18.9.6.10 PWM_SetOffset**

```
int32_t PWM_SetOffset(PWM\_SEL\_t sel, uint16_t offset)
```

Set the offset between PWM.

Location: Driver_PWM.c:30

Parameters

Direction	Name	Description
in	<i>sel</i>	PWM to be configured PWM_SEL_t
in	<i>offset</i>	Offset between PWM

Return[execution status](#)**18.9.6.11 PWM_Start**

```
int32_t PWM_Start(PWM\_SEL\_t sel)
```

Start the PWM.

Location: Driver_PWM.c:31

Parameters

Direction	Name	Description
in	<i>sel</i>	PWM to be started PWM_SEL_t

Return[execution status](#)**18.9.6.12 PWM_Stop**int32_t PWM_Stop([PWM_SEL_t](#) sel)

Stop the PWM.

Location: Driver_PWM.c:32

Parameters

Direction	Name	Description
in	<i>sel</i>	PWM to be stopped PWM_SEL_t

Return[execution status](#)**18.10 CMSIS SPI DRIVER**

CMSIS SPI Driver Reference.

18.10.1 Summary**Typedefs**

- [ARM_SPI_STATUS](#) : SPI Status .
- [ARM_SPI_SignalEvent_t](#) : Pointer to [ARM_SPI_SignalEvent](#) : Signal SPI Event.
- [ARM_SPI_CAPABILITIES](#) : SPI Driver Capabilities.
- [ARM_DRIVER_SPI](#) : Access structure of the SPI Driver.

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Data Structures

- [ARM_SPI_STATUS](#) : SPI Status .
- [ARM_SPI_CAPABILITIES](#) : SPI Driver Capabilities.
- [ARM_DRIVER_SPI](#) : Access structure of the SPI Driver.

Macros

- [ARM_SPI_API_VERSION](#) : SPI API version.
- [ARM_SPI_CONTROL_Pos](#) : Position of the 0th bit of the SPI Control field in the ARM_SPI structure.
- [ARM_SPI_CONTROL_Msk](#) : Positioning of SPI Control field in the ARM_SPI structure.
- [ARM_SPI_MODE_INACTIVE](#) : SPI Inactive.
- [ARM_SPI_MODE_MASTER](#) : SPI Master (Output on MOSI, Input on MISO); arg = Bus Speed in bps.
- [ARM_SPI_MODE_SLAVE](#) : SPI Slave (Output on MISO, Input on MOSI).
- [ARM_SPI_MODE_MASTER_SIMPLEX](#) : SPI Master (Output/Input on MOSI); arg = Bus Speed in bps.
- [ARM_SPI_MODE_SLAVE_SIMPLEX](#) : SPI Slave (Output/Input on MISO).
- [ARM_SPI_FRAME_FORMAT_Pos](#) : Position of the 0th bit of the Frame format field in the ARM_SPI structure.
- [ARM_SPI_FRAME_FORMAT_Msk](#) : Positioning of Frame format field in the ARM_SPI structure.
- [ARM_SPI_CPOLO_CPHA0](#) : Clock Polarity 0, Clock Phase 0 (default).
- [ARM_SPI_CPOLO_CPHA1](#) : Clock Polarity 0, Clock Phase 1.
- [ARM_SPI_CPOL1_CPHA0](#) : Clock Polarity 1, Clock Phase 0.
- [ARM_SPI_CPOL1_CPHA1](#) : Clock Polarity 1, Clock Phase 1.
- [ARM_SPI_TI_SSI](#) : Texas Instruments Frame Format.
- [ARM_SPI_MICROWIRE](#) : National Microwire Frame Format.
- [ARM_SPI_DATA_BITS_Pos](#) : Position of the 0th bit of the Data bits field in the ARM_SPI structure.
- [ARM_SPI_DATA_BITS_Msk](#) : Positioning of the Data bits field in the ARM_SPI structure.
- [ARM_SPI_DATA_BITS](#) : Number of Data bits.
- [ARM_SPI_BIT_ORDER_Pos](#) : Position of the 0th bit of the Bit order field in the ARM_SPI structure.
- [ARM_SPI_BIT_ORDER_Msk](#) : Positioning of the Bit order field in the ARM_SPI structure.
- [ARM_SPI_MSB_LSB](#) : SPI Bit order from MSB to LSB (default).
- [ARM_SPI_LSB_MSB](#) : SPI Bit order from LSB to MSB.
- [ARM_SPI_SS_MASTER_MODE_Pos](#) : Position of the 0th bit of the Slave Select Master Mode field in the ARM_SPI structure.
- [ARM_SPI_SS_MASTER_MODE_Msk](#) : Positioning of the Slave Select Master Mode field in the ARM_SPI structure.
- [ARM_SPI_SS_MASTER_UNUSED](#) : SPI Slave Select when Master: Not used (default).
- [ARM_SPI_SS_MASTER_SW](#) : SPI Slave Select when Master: Software controlled.
- [ARM_SPI_SS_MASTER_HW_OUTPUT](#) : SPI Slave Select when Master: Hardware controlled Output.
- [ARM_SPI_SS_MASTER_HW_INPUT](#) : SPI Slave Select when Master: Hardware monitored Input.
- [ARM_SPI_SS_SLAVE_MODE_Pos](#) : Position of the 0th bit of the Slave Select Slave Mode field in the ARM_SPI structure.
- [ARM_SPI_SS_SLAVE_MODE_Msk](#) : Positioning of the Slave Select Slave mode field in the ARM_SPI structure.
- [ARM_SPI_SS_SLAVE_HW](#) : SPI Slave Select when Slave: Hardware monitored (default).
- [ARM_SPI_SS_SLAVE_SW](#) : SPI Slave Select when Slave: Software controlled.
- [ARM_SPI_SET_BUS_SPEED](#) : Set Bus Speed in bps; arg = value.
- [ARM_SPI_GET_BUS_SPEED](#) : Get Bus Speed in bps.

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- [ARM SPI SET DEFAULT TX VALUE](#) : Set default Transmit value; arg = value.
- [ARM SPI CONTROL SS](#) : Control Slave Select; arg: 0=inactive, 1=active.
- [ARM SPI ABORT TRANSFER](#) : Abort current data transfer.
- [ARM SPI SS INACTIVE](#) : SPI Slave Select Signal Inactive.
- [ARM SPI SS ACTIVE](#) : SPI Slave Select Signal Active.
- [ARM SPI ERROR MODE](#) : Specified Mode not supported.
- [ARM SPI ERROR FRAME FORMAT](#) : Specified Frame Format not supported.
- [ARM SPI ERROR DATA BITS](#) : Specified number of Data bits not supported.
- [ARM SPI ERROR BIT ORDER](#) : Specified Bit order not supported.
- [ARM SPI ERROR SS MODE](#) : Specified Slave Select Mode not supported.
- [ARM SPI EVENT TRANSFER COMPLETE](#) : SPI Event
- [ARM SPI EVENT DATA LOST](#) : Data lost: Receive overflow / Transmit underflow.
- [ARM SPI EVENT MODE FAULT](#) : Master Mode Fault (SS deactivated when Master).

Functions

- [ARM SPI GetVersion](#) : Get driver version.
- [ARM SPI GetCapabilities](#) : Get driver capabilities.
- [ARM SPI Initialize](#) : Initialize SPI Interface.
- [ARM SPI Uninitialize](#) : De-initialize SPI Interface.
- [ARM SPI PowerControl](#) : Control SPI Interface Power.
- [ARM SPI Send](#) : Start sending data to SPI transmitter.
- [ARM SPI Receive](#) : Start receiving data from SPI receiver.
- [ARM SPI Transfer](#) : Start sending/receiving data to/from SPI transmitter/receiver.
- [ARM SPI GetDataCount](#) : Get transferred data count.
- [ARM SPI Control](#) : Control SPI Interface.
- [ARM SPI GetStatus](#) : Get SPI status.
- [ARM SPI SignalEvent](#) : Signal SPI Events.

18.10.2 CMSIS SPI Driver Typedef Documentation

18.10.2.1 ARM_SPI_STATUS

```
typedef struct ARM\_SPI\_STATUS ARM_SPI_STATUS
```

Location: Driver_SPI.h:148

SPI Status .

18.10.2.2 ARM_SPI_SignalEvent_t

```
typedef void(* ARM_SPI_SignalEvent_t
```

Location: Driver_SPI.h:222

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Pointer to [ARM_SPI_SignalEvent](#) : Signal SPI Event.

18.10.2.3 ARM_SPI_CAPABILITIES

```
typedef struct ARM\_SPI\_CAPABILITIES ARM_SPI_CAPABILITIES
```

Location: Driver_SPI.h:234

SPI Driver Capabilities.

18.10.2.4 ARM_DRIVER_SPI

```
typedef struct ARM\_DRIVER\_SPI ARM_DRIVER_SPI
```

Location: Driver_SPI.h:253

Access structure of the SPI Driver.

18.10.3 CMSIS SPI Driver Data Structures Type Documentation

18.10.3.1 _ARM_SPI_STATUS

Location: Driver_SPI.h:143

SPI Status .

Data Fields

Type	Name	Description
uint32_t	<i>busy</i>	Transmitter/Receiver busy flag.
uint32_t	<i>data_lost</i>	Data lost: Receive overflow / Transmit underflow (cleared on start of transfer operation).
uint32_t	<i>mode_fault</i>	Mode fault detected; optional (cleared on start of transfer operation).
uint32_t	<i>reserved</i>	(Reserved for future use)

18.10.3.2 _ARM_SPI_CAPABILITIES

Location: Driver_SPI.h:228

SPI Driver Capabilities.

Data Fields

Type	Name	Description
uint32_t	<i>simplex</i>	supports Simplex Mode (Master and Slave).
uint32_t	<i>ti_ssi</i>	supports TI Synchronous Serial Interface.
uint32_t	<i>microwire</i>	supports Microwire Interface.
uint32_t	<i>event_mode_fault</i>	Signal Mode Fault event: ARM_SPI_EVENT_MODE_FAULT .
uint32_t	<i>reserved</i>	Reserved (must be zero).

18.10.3.3 _ARM_DRIVER_SPI

Location: Driver_SPI.h:239

Access structure of the SPI Driver.

Data Fields

Type	Name	Description
ARM_DRIVER_VERSION (*)	<i>GetVersion)(void)</i>	Pointer to ARM_SPI_GetVersion : Get driver version.
ARM_SPI_CAPABILITIES (*)	<i>GetCapabilities)(void)</i>	Pointer to ARM_SPI_GetCapabilities : Get driver capabilities.
int32_t (*)	<i>Initialize)(ARM_SPI_SignalEvent_t cb_event)</i>	Pointer to ARM_SPI_Initialize : Initialize SPI Interface.
int32_t (*)	<i>Uninitialize)(void)</i>	Pointer to ARM_SPI_Uninitialize : De-initialize SPI

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		Interface.
int32_t(*)	<i>PowerControl</i>)(ARM_POWER_STATE state)	Pointer to ARM_SPI_PowerControl : Control SPI Interface Power.
int32_t(*)	<i>Send</i>)(const void *data, uint32_t num)	Pointer to ARM_SPI_Send : Start sending data to SPI Interface.
int32_t(*)	<i>Receive</i>)(void *data, uint32_t num)	Pointer to ARM_SPI_Receive : Start receiving data from SPI Interface.
int32_t(*)	<i>Transfer</i>)(const void *data_out, void *data_in, uint32_t num)	Pointer to ARM_SPI_Transfer : Start sending/receiving data to/from SPI.
uint32_t(*)	<i>GetDataCount</i>)(void)	Pointer to ARM_SPI_GetDataCount : Get transferred data count.
int32_t(*)	<i>Control</i>)(uint32_t control, uint32_t arg)	Pointer to ARM_SPI_Control : Control SPI Interface.
ARM_SPI_STATUS (*)	<i>GetStatus</i>)(void)	Pointer to ARM_SPI_GetStatus : Get SPI status.

18.10.4 CMSIS SPI Driver Macro Definition Documentation

18.10.4.1 ARM_SPI_API_VERSION

```
#define ARM_SPI_API_VERSION ARM\_DRIVER\_VERSION MAJOR MINOR (2,2)
```

SPI API version.

Location: Driver_SPI.h:69

18.10.4.2 ARM_SPI_CONTROL_Pos

```
#define ARM_SPI_CONTROL_Pos 0
```

Position of the 0th bit of the SPI Control field in the ARM_SPI structure.

Location: Driver_SPI.h:74

18.10.4.3 ARM_SPI_CONTROL_Msk

```
#define ARM_SPI_CONTROL_Msk (0xFFUL << ARM\_SPI\_CONTROL\_Pos)
```

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Positioning of SPI Control field in the ARM_SPI structure.

Location: Driver_SPI.h:75

18.10.4.4 ARM_SPI_MODE_INACTIVE

```
#define ARM_SPI_MODE_INACTIVE (0x00UL << ARM\_SPI\_CONTROL\_Pos)
```

SPI Inactive.

Location: Driver_SPI.h:78

18.10.4.5 ARM_SPI_MODE_MASTER

```
#define ARM_SPI_MODE_MASTER (0x01UL << ARM\_SPI\_CONTROL\_Pos)
```

SPI Master (Output on MOSI, Input on MISO); arg = Bus Speed in bps.

Location: Driver_SPI.h:79

18.10.4.6 ARM_SPI_MODE_SLAVE

```
#define ARM_SPI_MODE_SLAVE (0x02UL << ARM\_SPI\_CONTROL\_Pos)
```

SPI Slave (Output on MISO, Input on MOSI).

Location: Driver_SPI.h:80

18.10.4.7 ARM_SPI_MODE_MASTER_SIMPLEX

```
#define ARM_SPI_MODE_MASTER_SIMPLEX (0x03UL << ARM\_SPI\_CONTROL\_Pos)
```

SPI Master (Output/Input on MOSI); arg = Bus Speed in bps.

Location: Driver_SPI.h:81

18.10.4.8 ARM_SPI_MODE_SLAVE_SIMPLEX

```
#define ARM_SPI_MODE_SLAVE_SIMPLEX (0x04UL << ARM\_SPI\_CONTROL\_Pos)
```

SPI Slave (Output/Input on MISO).

Location: Driver_SPI.h:82

18.10.4.9 ARM_SPI_FRAME_FORMAT_Pos

```
#define ARM_SPI_FRAME_FORMAT_Pos 8
```

Position of the 0th bit of the Frame format field in the ARM_SPI structure.

Location: Driver_SPI.h:85

18.10.4.10 ARM_SPI_FRAME_FORMAT_Msk

```
#define ARM_SPI_FRAME_FORMAT_Msk (7UL << ARM\_SPI\_FRAME\_FORMAT\_Pos)
```

Positioning of Frame format field in the ARM_SPI structure.

Location: Driver_SPI.h:86

18.10.4.11 ARM_SPI_CPOL0_CPHA0

```
#define ARM_SPI_CPOL0_CPHA0 (0UL << ARM\_SPI\_FRAME\_FORMAT\_Pos)
```

Clock Polarity 0, Clock Phase 0 (default).

Location: Driver_SPI.h:87

18.10.4.12 ARM_SPI_CPOL0_CPHA1

```
#define ARM_SPI_CPOL0_CPHA1 (1UL << ARM\_SPI\_FRAME\_FORMAT\_Pos)
```

Clock Polarity 0, Clock Phase 1.

Location: Driver_SPI.h:88

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18.10.4.13 ARM_SPI_CPOL1_CPHA0

```
#define ARM_SPI_CPOL1_CPHA0 (2UL << ARM\_SPI\_FRAME\_FORMAT\_Pos)
```

Clock Polarity 1, Clock Phase 0.

Location: Driver_SPI.h:89

18.10.4.14 ARM_SPI_CPOL1_CPHA1

```
#define ARM_SPI_CPOL1_CPHA1 (3UL << ARM\_SPI\_FRAME\_FORMAT\_Pos)
```

Clock Polarity 1, Clock Phase 1.

Location: Driver_SPI.h:90

18.10.4.15 ARM_SPI_TI_SSI

```
#define ARM_SPI_TI_SSI (4UL << ARM\_SPI\_FRAME\_FORMAT\_Pos)
```

Texas Instruments Frame Format.

Location: Driver_SPI.h:91

18.10.4.16 ARM_SPI_MICROWIRE

```
#define ARM_SPI_MICROWIRE (5UL << ARM\_SPI\_FRAME\_FORMAT\_Pos)
```

National Microwire Frame Format.

Location: Driver_SPI.h:92

18.10.4.17 ARM_SPI_DATA_BITS_Pos

```
#define ARM_SPI_DATA_BITS_Pos 12
```

Position of the 0th bit of the Data bits field in the ARM_SPI structure.

Location: Driver_SPI.h:95

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18.10.4.18 ARM_SPI_DATA_BITS_Msk

```
#define ARM_SPI_DATA_BITS_Msk (0x3FUL << ARM\_SPI\_DATA\_BITS\_Pos)
```

Positioning of the Data bits field in the ARM_SPI structure.

Location: Driver_SPI.h:96

18.10.4.19 ARM_SPI_DATA_BITS

```
#define ARM_SPI_DATA_BITS ((n) & 0x3F) << ARM\_SPI\_DATA\_BITS\_Pos)
```

Number of Data bits.

Location: Driver_SPI.h:97

18.10.4.20 ARM_SPI_BIT_ORDER_Pos

```
#define ARM_SPI_BIT_ORDER_Pos 18
```

Position of the 0th bit of the Bit order field in the ARM_SPI structure.

Location: Driver_SPI.h:100

18.10.4.21 ARM_SPI_BIT_ORDER_Msk

```
#define ARM_SPI_BIT_ORDER_Msk (1UL << ARM\_SPI\_BIT\_ORDER\_Pos)
```

Positioning of the Bit order field in the ARM_SPI structure.

Location: Driver_SPI.h:101

18.10.4.22 ARM_SPI_MSB_LSB

```
#define ARM_SPI_MSB_LSB (0UL << ARM\_SPI\_BIT\_ORDER\_Pos)
```

SPI Bit order from MSB to LSB (default).

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Location: Driver_SPI.h:102

18.10.4.23 ARM_SPI_LSB_MSB

```
#define ARM_SPI_LSB_MSB (1UL << ARM\_SPI\_BIT\_ORDER\_Pos)
```

SPI Bit order from LSB to MSB.

Location: Driver_SPI.h:103

18.10.4.24 ARM_SPI_SS_MASTER_MODE_Pos

```
#define ARM_SPI_SS_MASTER_MODE_Pos 19
```

Position of the 0th bit of the Slave Select Master Mode field in the ARM_SPI structure.

Location: Driver_SPI.h:106

18.10.4.25 ARM_SPI_SS_MASTER_MODE_Msk

```
#define ARM_SPI_SS_MASTER_MODE_Msk (3UL << ARM\_SPI\_SS\_MASTER\_MODE\_Pos)
```

Positioning of the Slave Select Master Mode field in the ARM_SPI structure.

Location: Driver_SPI.h:107

18.10.4.26 ARM_SPI_SS_MASTER_UNUSED

```
#define ARM_SPI_SS_MASTER_UNUSED (0UL << ARM\_SPI\_SS\_MASTER\_MODE\_Pos)
```

SPI Slave Select when Master: Not used (default).

Location: Driver_SPI.h:108

18.10.4.27 ARM_SPI_SS_MASTER_SW

```
#define ARM_SPI_SS_MASTER_SW (1UL << ARM\_SPI\_SS\_MASTER\_MODE\_Pos)
```

SPI Slave Select when Master: Software controlled.

Location: Driver_SPI.h:109

18.10.4.28 ARM_SPI_SS_MASTER_HW_OUTPUT

```
#define ARM_SPI_SS_MASTER_HW_OUTPUT (2UL << ARM\_SPI\_SS\_MASTER\_MODE\_Pos)
```

SPI Slave Select when Master: Hardware controlled Output.

Location: Driver_SPI.h:110

18.10.4.29 ARM_SPI_SS_MASTER_HW_INPUT

```
#define ARM_SPI_SS_MASTER_HW_INPUT (3UL << ARM\_SPI\_SS\_MASTER\_MODE\_Pos)
```

SPI Slave Select when Master: Hardware monitored Input.

Location: Driver_SPI.h:111

18.10.4.30 ARM_SPI_SS_SLAVE_MODE_Pos

```
#define ARM_SPI_SS_SLAVE_MODE_Pos 21
```

Position of the 0th bit of the Slave Select Slave Mode field in the ARM_SPI structure.

Location: Driver_SPI.h:112

18.10.4.31 ARM_SPI_SS_SLAVE_MODE_Msk

```
#define ARM_SPI_SS_SLAVE_MODE_Msk (1UL << ARM\_SPI\_SS\_SLAVE\_MODE\_Pos)
```

Positioning of the Slave Select Slave mode field in the ARM_SPI structure.

Location: Driver_SPI.h:113

18.10.4.32 ARM_SPI_SS_SLAVE_HW

```
#define ARM_SPI_SS_SLAVE_HW (0UL << ARM\_SPI\_SS\_SLAVE\_MODE\_Pos)
```

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SPI Slave Select when Slave: Hardware monitored (default).

Location: Driver_SPI.h:114

18.10.4.33 ARM_SPI_SS_SLAVE_SW

```
#define ARM_SPI_SS_SLAVE_SW (1UL << ARM\_SPI\_SS\_SLAVE\_MODE\_Pos)
```

SPI Slave Select when Slave: Software controlled.

Location: Driver_SPI.h:115

18.10.4.34 ARM_SPI_SET_BUS_SPEED

```
#define ARM_SPI_SET_BUS_SPEED (0x10UL << ARM\_SPI\_CONTROL\_Pos)
```

Set Bus Speed in bps; arg = value.

Location: Driver_SPI.h:119

18.10.4.35 ARM_SPI_GET_BUS_SPEED

```
#define ARM_SPI_GET_BUS_SPEED (0x11UL << ARM\_SPI\_CONTROL\_Pos)
```

Get Bus Speed in bps.

Location: Driver_SPI.h:120

18.10.4.36 ARM_SPI_SET_DEFAULT_TX_VALUE

```
#define ARM_SPI_SET_DEFAULT_TX_VALUE (0x12UL << ARM\_SPI\_CONTROL\_Pos)
```

Set default Transmit value; arg = value.

Location: Driver_SPI.h:121

18.10.4.37 ARM_SPI_CONTROL_SS

```
#define ARM_SPI_CONTROL_SS (0x13UL << ARM\_SPI\_CONTROL\_Pos)
```

Control Slave Select; arg: 0=inactive, 1=active.

Location: Driver_SPI.h:122

18.10.4.38 ARM_SPI_ABORT_TRANSFER

```
#define ARM_SPI_ABORT_TRANSFER (0x14UL << ARM\_SPI\_CONTROL\_Pos)
```

Abort current data transfer.

Location: Driver_SPI.h:123

18.10.4.39 ARM_SPI_SS_INACTIVE

```
#define ARM_SPI_SS_INACTIVE 0
```

SPI Slave Select Signal Inactive.

Location: Driver_SPI.h:127

18.10.4.40 ARM_SPI_SS_ACTIVE

```
#define ARM_SPI_SS_ACTIVE 1
```

SPI Slave Select Signal Active.

Location: Driver_SPI.h:128

18.10.4.41 ARM_SPI_ERROR_MODE

```
#define ARM_SPI_ERROR_MODE (ARM\_DRIVER\_ERROR\_SPECIFIC - 1)
```

Specified Mode not supported.

Location: Driver_SPI.h:132

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18.10.4.42 ARM_SPI_ERROR_FRAME_FORMAT

```
#define ARM_SPI_ERROR_FRAME_FORMAT (ARM DRIVER ERROR SPECIFIC - 2)
```

Specified Frame Format not supported.

Location: Driver_SPI.h:133

18.10.4.43 ARM_SPI_ERROR_DATA_BITS

```
#define ARM_SPI_ERROR_DATA_BITS (ARM DRIVER ERROR SPECIFIC - 3)
```

Specified number of Data bits not supported.

Location: Driver_SPI.h:134

18.10.4.44 ARM_SPI_ERROR_BIT_ORDER

```
#define ARM_SPI_ERROR_BIT_ORDER (ARM DRIVER ERROR SPECIFIC - 4)
```

Specified Bit order not supported.

Location: Driver_SPI.h:135

18.10.4.45 ARM_SPI_ERROR_SS_MODE

```
#define ARM_SPI_ERROR_SS_MODE (ARM DRIVER ERROR SPECIFIC - 5)
```

Specified Slave Select Mode not supported.

Location: Driver_SPI.h:136

18.10.4.46 ARM_SPI_EVENT_TRANSFER_COMPLETE

```
#define ARM_SPI_EVENT_TRANSFER_COMPLETE (1UL << 0)
```

SPI Event

Data Transfer completed.

Location: Driver_SPI.h:152

18.10.4.47 ARM_SPI_EVENT_DATA_LOST

```
#define ARM_SPI_EVENT_DATA_LOST (1UL << 1)
```

Data lost: Receive overflow / Transmit underflow.

Location: Driver_SPI.h:153

18.10.4.48 ARM_SPI_EVENT_MODE_FAULT

```
#define ARM_SPI_EVENT_MODE_FAULT (1UL << 2)
```

Master Mode Fault (SS deactivated when Master).

Location: Driver_SPI.h:154

18.10.5 CMSIS SPI Driver Function Documentation

18.10.5.1 ARM_SPI_GetVersion

```
ARM\_DRIVER\_VERSION ARM_SPI_GetVersion()
```

Get driver version.

Location: Driver_SPI.c:42

Return

[ARM_DRIVER_VERSION](#)

18.10.5.2 ARM_SPI_GetCapabilities

```
ARM\_SPI\_CAPABILITIES ARM_SPI_GetCapabilities()
```

Get driver capabilities.

Location: Driver_SPI.c:47

Return

[ARM SPI CAPABILITIES](#)

18.10.5.3 ARM_SPI_Initialize

```
int32_t ARM_SPI_Initialize(ARM\_SPI\_SignalEvent\_t cb_event)
```

Initialize SPI Interface.

Location: Driver_SPI.c:52

Parameters

Direction	Name	Description
in	<i>cb_event</i>	Pointer to ARM_SPI_SignalEvent

Return

[execution status](#)

18.10.5.4 ARM_SPI_Uninitialize

```
int32_t ARM_SPI_Uninitialize()
```

De-initialize SPI Interface.

Location: Driver_SPI.c:56

Return[execution status](#)**18.10.5.5 ARM_SPI_PowerControl**`int32_t ARM_SPI_PowerControl(ARM_POWER_STATE state)`

Control SPI Interface Power.

Location: Driver_SPI.c:60

Parameters

Direction	Name	Description
in	<i>state</i>	Power state

Return[execution status](#)**18.10.5.6 ARM_SPI_Send**`int32_t ARM_SPI_Send(const void * data, uint32_t num)`

Start sending data to SPI transmitter.

Location: Driver_SPI.c:76

Parameters

Direction	Name	Description
in	<i>data</i>	Pointer to buffer with data to send to SPI transmitter
in	<i>num</i>	Number of data items to send

Return[execution status](#)**18.10.5.7 ARM_SPI_Receive**

```
int32_t ARM_SPI_Receive(void * data, uint32_t num)
```

Start receiving data from SPI receiver.

Location: Driver_SPI.c:80

Parameters

Direction	Name	Description
out	<i>data</i>	Pointer to buffer for data to receive from SPI receiver
in	<i>num</i>	Number of data items to receive

Return[execution status](#)**18.10.5.8 ARM_SPI_Transfer**

```
int32_t ARM_SPI_Transfer(const void * data_out, void * data_in, uint32_t num)
```

Start sending/receiving data to/from SPI transmitter/receiver.

Location: Driver_SPI.c:84

Parameters

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Direction	Name	Description
in	<i>data_out</i>	Pointer to buffer with data to send to SPI transmitter
out	<i>data_in</i>	Pointer to buffer for data to receive from SPI receiver
in	<i>num</i>	Number of data items to transfer

Return

[execution status](#)

18.10.5.9 ARM_SPI_GetDataCount

```
uint32_t ARM_SPI_GetDataCount()
```

Get transferred data count.

Location: Driver_SPI.c:88

Return

number of data items transferred

18.10.5.10 ARM_SPI_Control

```
int32_t ARM_SPI_Control(uint32_t control, uint32_t arg)
```

Control SPI Interface.

Location: Driver_SPI.c:92

Parameters

Direction	Name	Description
in	<i>control</i>	Operation
in	<i>arg</i>	Argument of operation (optional)

Return

common [execution status](#) and driver specific [spi execution status](#)

18.10.5.11 ARM_SPI_GetStatus

[ARM_SPI_STATUS](#) ARM_SPI_GetStatus()

Get SPI status.

Location: Driver_SPI.c:125

Return

SPI status [ARM_SPI_STATUS](#)

18.10.5.12 ARM_SPI_SignalEvent

void ARM_SPI_SignalEvent(uint32_t event)

Signal SPI Events.

Location: Driver_SPI.c:129

Parameters

Direction	Name	Description
in	<i>event</i>	SPI_events notification mask

Return

none

18.11 CMSIS TIMER DRIVER

CMSIS Timer Driver Reference.

18.11.1 Summary

Typedefs

- [TIMER_SEL_t](#) : Timer selection.
- [TIMER_MODE_t](#) : Timer mode selection.
- [TIMER_CLKSRC_t](#) : Timer clock source selection.
- [TIMER_PRESCALE_t](#) : Timer prescale values selection.
- [TIMER_MULTI_COUNT_t](#) : Timer multi-count values selection.
- [TIMER_GPIO_STATUS_t](#) : Timer GPIO status.
- [TIMER_GPIO_INT_MODE_t](#) : Timer GPIO capture mode.
- [TIMER_GPIO_t](#) : Timer GPIO interrupt selection.
- [TIMER_SYSTICK_CLKSRC_t](#) : Timer SysTick Clock sources.
- [ADC_EVENT_t](#) : Timer interrupt events selection.
- [TIMER_SignalEvent_t](#) : Pointer to [TIMER_SignalEvent](#) : Signal Timer event.
- [TIMER_t](#) : Timer Driver configuration.
- [SYSTICK_t](#) : SysTick Driver configuration.
- [TIMER_CFG_t](#) : Common TIMER driver configuration.
- [TIMER_PRI_CFG_t](#) : Timer interrupt priority configuration.
- [DRIVER_TIMER_t](#) : Access structure of the TIMER Driver.

Data Structures

- [TIMER_t](#) : Timer Driver configuration.
- [SYSTICK_t](#) : SysTick Driver configuration.
- [TIMER_PRI_CFG_t](#) : Timer interrupt priority configuration.
- [DRIVER_TIMER_t](#) : Access structure of the TIMER Driver.

Enumerations

- [TIMER_SEL_t](#) : Timer selection.
- [TIMER_MODE_t](#) : Timer mode selection.
- [TIMER_CLKSRC_t](#) : Timer clock source selection.
- [TIMER_PRESCALE_t](#) : Timer prescale values selection.
- [TIMER_MULTI_COUNT_t](#) : Timer multi-count values selection.
- [TIMER_GPIO_STATUS_t](#) : Timer GPIO status.
- [TIMER_GPIO_INT_MODE_t](#) : Timer GPIO capture mode.
- [TIMER_GPIO_t](#) : Timer GPIO interrupt selection.
- [TIMER_SYSTICK_CLKSRC_t](#) : Timer SysTick Clock sources.
- [ADC_EVENT_t](#) : Timer interrupt events selection.

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Macros

- [ARM_TIMER_API_VERSION](#) : Timer API version.
- [TIMER_ERROR_UNCONFIGURED](#) : Driver has not been configured yet.

Functions

- [TIMER_GetVersion](#) : Get driver version.
- [TIMER_Initialize](#) : Initialize Timer driver with default configuration.
- [TIMER_Configure](#) : Configure particular Timer.
- [TIMER_SetInterruptPriority](#) : Configure the Timer interrupt priority.
- [TIMER_Start](#) : Starts the Timer.
- [TIMER_Stop](#) : Stops the Timer.
- [TIMER_SetValue](#) : Sets the timeout / reload value of the selected Timer.
- [TIMER_GetValue](#) : Returns the current value of Timer.
- [TIMER_GetValueCapture](#) : Returns the current value of Timer.
- [TIMER_GetSysTickState](#) : Returns 1 if SysTick has already reached 0.
- [TIMER_SignalEvent](#) : Signal Timer events.
- [TIMER_SetGPIOInterrupt](#) : Set GPIO interrupt capture status.

18.11.2 CMSIS Timer Driver Typedef Documentation**18.11.2.1 TIMER_SEL_t**

```
typedef enum TIMER\_SEL\_t TIMER_SEL_t
```

Location: Driver_TIMER.h:49

Timer selection.

18.11.2.2 TIMER_MODE_t

```
typedef enum TIMER\_MODE\_t TIMER_MODE_t
```

Location: Driver_TIMER.h:57

Timer mode selection.

18.11.2.3 TIMER_CLKSRC_t

```
typedef enum TIMER\_CLKSRC\_t TIMER_CLKSRC_t
```

Location: Driver_TIMER.h:65

Timer clock source selection.

18.11.2.4 TIMER_PRESCALE_t

```
typedef enum TIMER\_PRESCALE\_t TIMER_PRESCALE_t
```

Location: Driver_TIMER.h:79

Timer prescale values selection.

18.11.2.5 TIMER_MULTI_COUNT_t

```
typedef enum TIMER\_MULTI\_COUNT\_t TIMER_MULTI_COUNT_t
```

Location: Driver_TIMER.h:93

Timer multi-count values selection.

18.11.2.6 TIMER_GPIO_STATUS_t

```
typedef enum TIMER\_GPIO\_STATUS\_t TIMER_GPIO_STATUS_t
```

Location: Driver_TIMER.h:101

Timer GPIO status.

18.11.2.7 TIMER_GPIO_INT_MODE_t

```
typedef enum TIMER\_GPIO\_INT\_MODE\_t TIMER_GPIO_INT_MODE_t
```

Location: Driver_TIMER.h:109

Timer GPIO capture mode.

18.11.2.8 TIMER_GPIO_t

```
typedef enum TIMER\_GPIO\_t TIMER_GPIO_t
```

Location: Driver_TIMER.h:119

Timer GPIO interrupt selection.

18.11.2.9 TIMER_SYSTICK_CLKSRC_t

```
typedef enum TIMER\_SYSTICK\_CLKSRC\_t TIMER_SYSTICK_CLKSRC_t
```

Location: Driver_TIMER.h:127

Timer SysTick Clock sources.

18.11.2.10 ADC_EVENT_t

```
typedef enum ADC\_EVENT\_t ADC_EVENT_t
```

Location: Driver_TIMER.h:138

Timer interrupt events selection.

18.11.2.11 TIMER_SignalEvent_t

```
typedef void(* TIMER\_SignalEvent\_t)
```

Location: Driver_TIMER.h:207

Pointer to [TIMER_SignalEvent](#) : Signal Timer event.

18.11.2.12 TIMER_t

```
typedef struct TIMER\_t TIMER_t
```

Location: Driver_TIMER.h:223

Timer Driver configuration.

18.11.2.13 SYSTICK_t

```
typedef struct \_SYSTICK\_t SYSTICK_t
```

Location: Driver_TIMER.h:233

SysTick Driver configuration.

18.11.2.14 TIMER_CFG_t

```
typedef union \_TIMER\_CFG\_t TIMER_CFG_t
```

Location: Driver_TIMER.h:242

Common TIMER driver configuration.

18.11.2.15 TIMER_PRI_CFG_t

```
typedef struct \_TIMER\_PRI\_CFG\_t TIMER_PRI_CFG_t
```

Location: Driver_TIMER.h:253

Timer interrupt priority configuration.

18.11.2.16 DRIVER_TIMER_t

```
typedef struct \_DRIVER\_TIMER\_t DRIVER_TIMER_t
```

Location: Driver_TIMER.h:270

Access structure of the TIMER Driver.

18.11.3 CMSIS Timer Driver Data Structures Type Documentation

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18.11.3.1 **_TIMER_t**

Location: Driver_TIMER.h:212

Timer Driver configuration.

Data Fields

Type	Name	Description
TIMER_MODE_t	<i>mode</i>	Timer mode to be used.
TIMER_CLKSRC_t	<i>clk_src</i>	Clock source to be used.
TIMER_GPIO_INT_MODE_t	<i>gpio_mode</i>	GPIO capture mode to be used.
uint32_t	<i>__pad0__</i>	Reserved.
TIMER_PRESCALE_t	<i>prescale_val</i>	Timer prescale value.
TIMER_MULTI_COUNT_t	<i>multi_cnt</i>	Multi count value.
uint32_t	<i>__pad1__</i>	Reserved.
TIMER_GPIO_t	<i>gpio_int</i>	GPIO value.
uint32_t	<i>timeout_val</i>	Timer timeout value.

18.11.3.2 **_SYSTICK_t**

Location: Driver_TIMER.h:228

SysTick Driver configuration.

Data Fields

Type	Name	Description
TIMER_SYSTICK_CLKSRC_t	<i>clk_src</i>	Clock source to be used.
uint32_t	<i>__pad0__</i>	Reserved.
uint32_t	<i>reload_val</i>	SysTick value.

18.11.3.3 _TIMER_PRI_CFG_t

Location: Driver_TIMER.h:247

Timer interrupt priority configuration.

Data Fields

Type	Name	Description
uint32_t	<i>preempt_pri</i>	Preempt priority.
uint32_t	<i>__pad0__</i>	Reserved.
uint32_t	<i>subgrp_pri</i>	Subgroup priority.
uint32_t	<i>__pad1__</i>	Reserved.

18.11.3.4 _DRIVER_TIMER_t

Location: Driver_TIMER.h:258

Access structure of the TIMER Driver.

Data Fields

Type	Name	Description
ARM_DRIVER_VERSION (*)	<i>GetVersion</i> (void)	Pointer to TIMER_GetVersion : Get driver version.
int32_t (*)	<i>Initialize</i> (TIMER_SignalEvent_t cb)	Pointer to TIMER_Initialize : Initialize Timer driver.
int32_t (*)	<i>Configure</i> (TIMER_SEL_t sel, const TIMER_CFG_t *cfg)	Pointer to TIMER_Configure : Configure driver.
int32_t (*)	<i>SetInterruptPriority</i> (TIMER_SEL_t sel, const TIMER_PRI_	Pointer to TIMER_SetInterruptPriority : Configure Timer interrupt priority.

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	<i>CFG_t *pri</i>)	
<i>int32_t (*</i>	<i>Start)(TIMER_SEL_t sel)</i>	Pointer to TIMER_Start : Start particular Timer.
<i>int32_t (*</i>	<i>Stop)(TIMER_SEL_t sel)</i>	Pointer to TIMER_Stop : Stop particular Timer.
<i>int32_t (*</i>	<i>SetValue)(TIMER_SEL_t sel, uint32_t value)</i>	Pointer to TIMER_SetValue : Set the particular Timer value.
<i>int32_t (*</i>	<i>SetGPIOInterrupt)(TIMER_SEL_t sel)</i>	Pointer to TIMER_SetGPIOInterrupt : Set GPIO interrupt capture status.
<i>uint32_t (*</i>	<i>GetValue)(TIMER_SEL_t sel)</i>	Pointer to TIMER_GetValue : Get the particular Timer value.
<i>uint32_t (*</i>	<i>GetValueCapture)(TIMER_SEL_t sel)</i>	Pointer to TIMER_GetValueCapture : Get the Timer GPIO Interrupt Captured Value.
<i>uint32_t (*</i>	<i>GetSysTickState)(void)</i>	Pointer to TIMER_GetSysTickState : Returns 1 if SysTick has already reached 0.

18.11.4 CMSIS Timer Driver Enumeration Type Documentation

18.11.4.1 _TIMER_SEL_t

Location: Driver_TIMER.h:43

Timer selection.

Members

- `TIMER_0 = 0`

Timer module 0.

- `TIMER_1 = 1`

Timer module 1.

- `TIMER_2 = 2`

Timer module 2.

- `TIMER_3 = 3`

Timer module 3.

- `TIMER_SYSTICK = 4`

Timer module SysTick.

18.11.4.2 `_TIMER_MODE_t`

Location: `Driver_TIMER.h:54`

Timer mode selection.

Members

- `TIMER_MODE_SHOT = 0x0U`

Timer mode = TIMER_SHOT_MODE_BITBAND.

- TIMER_MODE_FREE_RUN = 0x1U

Timer mode = TIMER_FREE_RUN_BITBAND.

18.11.4.3 _TIMER_CLKSRC_t

Location: Driver_TIMER.h:62

Timer clock source selection.

Members

- TIMER_SLOWCLOCK_DIV32 = 0x0U

Timer src = SLOWCLOCK DIV32.

- TIMER_SLOWCLOCK_DIV2 = 0x1U

Timer src = SLOWCLOCK DIV2.

18.11.4.4 _TIMER_PRESCALE_t

Location: Driver_TIMER.h:70

Timer prescale values selection.

Members

- `TIMER_PRESCALE_VAL_1 = 0x0U`

Timer prescale = 1.

- `TIMER_PRESCALE_VAL_2 = 0x1U`

Timer prescale = 2.

- `TIMER_PRESCALE_VAL_4 = 0x2U`

Timer prescale = 4.

- `TIMER_PRESCALE_VAL_8 = 0x3U`

Timer prescale = 8.

- `TIMER_PRESCALE_VAL_16 = 0x4U`

Timer prescale = 16.

- `TIMER_PRESCALE_VAL_32 = 0x5U`

Timer prescale = 32.

- `TIMER_PRESCALE_VAL_64 = 0x6U`

Timer prescale = 64.

- `TIMER_PRESCALE_VAL_128 = 0x7U`

Timer prescale = 128.

18.11.4.5 `_TIMER_MULTI_COUNT_t`

Location: `Driver_TIMER.h:84`

Timer multi-count values selection.

Members

- `TIMER_MULTI_COUNT_VAL_1 = 0x0U`

Timer multiCount = 1.

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- `TIMER_MULTI_COUNT_VAL_2 = 0x1U`

Timer multiCount = 2.

- `TIMER_MULTI_COUNT_VAL_3 = 0x2U`

Timer multiCount = 3.

- `TIMER_MULTI_COUNT_VAL_4 = 0x3U`

Timer multiCount = 4.

- `TIMER_MULTI_COUNT_VAL_5 = 0x4U`

Timer multiCount = 5.

- `TIMER_MULTI_COUNT_VAL_6 = 0x5U`

Timer multiCount = 6.

- `TIMER_MULTI_COUNT_VAL_7 = 0x6U`

Timer multiCount = 7.

- `TIMER_MULTI_COUNT_VAL_8 = 0x7U`

Timer multiCount = 8.

18.11.4.6 `_TIMER_GPIO_STATUS_t`

Location: `Driver_TIMER.h:98`

Timer GPIO status.

Members

- `TIMER_GPIO_INT_DISABLE_STATUS = 0x0U`

Timer GPIO status = disable.

- `TIMER_GPIO_INT_ENABLE_STATUS = 0x1U`

Timer GPIO status = enable.

18.11.4.7 `_TIMER_GPIO_INT_MODE_t`

Location: `Driver_TIMER.h:106`

Timer GPIO capture mode.

Members

- `TIMER_GPIO_SINGLE_MODE = 0x0U`

Timer capture mode = single.

- `TIMER_GPIO_CONTINUOUS_MODE = 0x1U`

Timer capture mode = continuous.

18.11.4.8 _TIMER_GPIO_t

Location: Driver_TIMER.h:114

Timer GPIO interrupt selection.

Members

- `TIMER_GPIO_0 = 0x0U`

Timer GPIO interrupt 0.

- `TIMER_GPIO_1 = 0x1U`

Timer GPIO interrupt 1.

- `TIMER_GPIO_2 = 0x2U`

Timer GPIO interrupt 2.

- `TIMER_GPIO_3 = 0x3U`

Timer GPIO interrupt 3.

18.11.4.9 _TIMER_SYSTICK_CLKSRC_t

Location: Driver_TIMER.h:124

Timer SysTick Clock sources.

Members

- SYSTICK_CLKSOURCE_EXTREFCLK = 0x0U

SysTick Timer CLK src = external ref.

- SYSTICK_CLKSOURCE_CORECLK = 0x1U

SysTick Timer CLK src = core CLK.

18.11.4.10 _ADC_EVENT_t

Location: Driver_TIMER.h:132

Timer interrupt events selection.

Members

- TIMER_TIMER0_EVENT = 1 << TIMER_0

Timer0 event.

- TIMER_TIMER1_EVENT = 1 << TIMER_1

Timer1 event.

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- `TIMER_TIMER2_EVENT = 1 << TIMER_2`

Timer2 event.

- `TIMER_TIMER3_EVENT = 1 << TIMER_3`

Timer3 event.

- `TIMER_SYSTICK_EVENT = 1 << TIMER_SYSTICK`

SysTick event.

18.11.5 CMSIS Timer Driver Macro Definition Documentation

18.11.5.1 ARM_TIMER_API_VERSION

```
#define ARM_TIMER_API_VERSION ARM\_DRIVER\_VERSION MAJOR MINOR(1,0)
```

Timer API version.

Location: Driver_TIMER.h:36

18.11.5.2 TIMER_ERROR_UNCONFIGURED

```
#define TIMER_ERROR_UNCONFIGURED (ARM\_DRIVER\_ERROR SPECIFIC - 1)
```

Driver has not been configured yet.

Location: Driver_TIMER.h:141

18.11.6 CMSIS Timer Driver Function Documentation

18.11.6.1 TIMER_GetVersion

[ARM_DRIVER_VERSION](#) TIMER_GetVersion()

Get driver version.

Location: Driver_Timer.c:21

Return

[ARM_DRIVER_VERSION](#)

18.11.6.2 TIMER_Initialize

int32_t TIMER_Initialize([TIMER_SignalEvent](#) t cb)

Initialize Timer driver with default configuration.

Location: Driver_Timer.c:22

Parameters

Direction	Name	Description
in	<i>cb</i>	Pointer to TIMER_SignalEvent

Return

[execution status](#)

18.11.6.3 TIMER_Configure

int32_t TIMER_Configure([TIMER_SEL](#) t sel, const [TIMER_CFG](#) t * cfg)

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Configure particular Timer.

Location: Driver_Timer.c:23

Parameters

Direction	Name	Description
in	<i>sel</i>	Timer to be configured (TIMER_SEL_t)
in	<i>cfg</i>	Pointer to TIMER_CFG_t

Return

[execution status](#)

18.11.6.4 TIMER_SetInterruptPriority

```
int32_t TIMER_SetInterruptPriority(TIMER\_SEL\_t sel, const TIMER\_PRI\_CFG\_t * cfg)
```

Configure the Timer interrupt priority.

Location: Driver_Timer.c:24

Parameters

Direction	Name	Description
in	<i>sel</i>	Timer to be configured (TIMER_SEL_t)
in	<i>cfg</i>	Pointer to TIMER_PRI_CFG_t

Return

[execution status](#)

18.11.6.5 TIMER_Start

```
int32_t TIMER_Start(TIMER\_SEL t sel)
```

Starts the Timer.

Location: Driver_Timer.c:25

Parameters

Direction	Name	Description
in	<i>sel</i>	Timer number to be started (TIMER_SEL t)

Return

[execution status](#)

18.11.6.6 TIMER_Stop

```
int32_t TIMER_Stop(TIMER\_SEL t sel)
```

Stops the Timer.

Location: Driver_Timer.c:26

Parameters

Direction	Name	Description
in	<i>sel</i>	Timer number to be stopped (TIMER_SEL t)

Return

[execution status](#)

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18.11.6.7 TIMER_SetValue

```
int32_t TIMER_SetValue(TIMER\_SEL t sel, uint32_t val)
```

Sets the timeout / reload value of the selected Timer.

Location: Driver_Timer.c:27

Parameters

Direction	Name	Description
in	<i>sel</i>	Timer value to be read (TIMER_SEL t)
in	<i>val</i>	Timer value to be set

Return

[execution status](#) of error status

18.11.6.8 TIMER_GetValue

```
uint32_t TIMER_GetValue(TIMER\_SEL t sel)
```

Returns the current value of Timer.

Location: Driver_Timer.c:29

Parameters

Direction	Name	Description
in	<i>sel</i>	Timer value to be read (TIMER_SEL t)

Return

Timer value or 0 if Timer was not enabled

18.11.6.9 TIMER_GetValueCapture

```
uint32_t TIMER_GetValueCapture(TIMER\_SEL t sel)
```

Returns the current value of Timer.

Location: Driver_Timer.c:30

Parameters

Direction	Name	Description
in	<i>sel</i>	Timer value to be read (TIMER_SEL t)

Return

Timer capture value or 0 if Timer was not enabled

18.11.6.10 TIMER_GetSysTickState

```
uint32_t TIMER_GetSysTickState()
```

Returns 1 if SysTick has already reached 0.

Location: Driver_Timer.c:31

Return

SysTick status or 0 if SysTick was not enabled

18.11.6.11 TIMER_SignalEvent

```
void TIMER_SignalEvent(uint32_t event)
```

Signal Timer events.

Location: Driver_Timer.c:33

Parameters

Direction	Name	Description
in	<i>event</i>	Notification mask

Return

none

18.11.6.12 TIMER_SetGPIOInterrupt

```
int32_t TIMER_SetGPIOInterrupt(TIMER\_SEL\_t sel)
```

Set GPIO interrupt capture status.

Location: Driver_Timer.c:28

Parameters

Direction	Name	Description
in	<i>sel</i>	Timer value to be read (TIMER_SEL_t)

Return

[execution status](#)

18.12 CMSIS USART DRIVER

CMSIS USART Driver Reference.

18.12.1 Summary

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Typedefs

- [ARM_USART_STATUS](#) : USART Status.
- [ARM_USART_MODEM_CONTROL](#) : USART Modem Control.
- [ARM_USART_MODEM_STATUS](#) : USART Modem Status.
- [ARM_USART_SignalEvent_t](#) : Pointer to [ARM_USART_SignalEvent](#) : Signal USART Event.
- [ARM_USART_CAPABILITIES](#) : USART Device Driver Capabilities.
- [ARM_DRIVER_USART](#) : Access structure of the USART Driver.

Data Structures

- [ARM_USART_STATUS](#) : USART Status.
- [ARM_USART_MODEM_STATUS](#) : USART Modem Status.
- [ARM_USART_CAPABILITIES](#) : USART Device Driver Capabilities.
- [ARM_DRIVER_USART](#) : Access structure of the USART Driver.

Enumerations

- [ARM_USART_MODEM_CONTROL](#) : USART Modem Control.

Macros

- [ARM_USART_API_VERSION](#) : API version.
- [ARM_USART_CONTROL_Pos](#) : Position of the 0th bit of the USART control field in the ARM_USART structure.
- [ARM_USART_CONTROL_Msk](#) : Positioning of USART control field in the ARM_USART structure.
- [ARM_USART_MODE_ASYNCHRONOUS](#) : UART (Asynchronous); arg = Baudrate.
- [ARM_USART_MODE_SYNCHRONOUS_MASTER](#) : Synchronous Master (generates clock signal); arg = Baudrate.
- [ARM_USART_MODE_SYNCHRONOUS_SLAVE](#) : Synchronous Slave (external clock signal).
- [ARM_USART_MODE_SINGLE_WIRE](#) : UART Single-wire (half-duplex); arg = Baudrate.
- [ARM_USART_MODE_IRDA](#) : UART IrDA; arg = Baudrate.
- [ARM_USART_MODE_SMART_CARD](#) : UART Smart Card; arg = Baudrate.
- [ARM_USART_DATA_BITS_Pos](#) : Position of the 0th bit of the Data bits field in the ARM_USART structure.
- [ARM_USART_DATA_BITS_Msk](#) : Positioning of the Data bits field in the ARM_USART structure.
- [ARM_USART_DATA_BITS_5](#) : 5 data bits.
- [ARM_USART_DATA_BITS_6](#) : 6 data bits.
- [ARM_USART_DATA_BITS_7](#) : 7 data bits.
- [ARM_USART_DATA_BITS_8](#) : 8 data bits (default).
- [ARM_USART_DATA_BITS_9](#) : 9 data bits.
- [ARM_USART_PARITY_Pos](#) : Position of the 0th bit of the Mode parameters Parity field in the ARM_USART structure.
- [ARM_USART_PARITY_Msk](#) : Positioning of the Mode parameters Parity field in the ARM_USART structure.
- [ARM_USART_PARITY_NONE](#) : No parity (default).
- [ARM_USART_PARITY_EVEN](#) : Even parity.
- [ARM_USART_PARITY_ODD](#) : Odd parity.

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- [ARM USART STOP BITS Pos](#) : Position of the 0th bit of the Mode parameters Stop bits field in the ARM_USART structure.
- [ARM USART STOP BITS Msk](#) : Positioning of the Mode parameters Stop bits field in the ARM_USART structure.
- [ARM USART STOP BITS 1](#) : 1 stop bit (default).
- [ARM USART STOP BITS 2](#) : 2 stop bits.
- [ARM USART STOP BITS 1 5](#) : 1.5 stop bits.
- [ARM USART STOP BITS 0 5](#) : 0.5 stop bits.
- [ARM USART FLOW CONTROL Pos](#) : Position of the 0th bit of the Mode parameters Flow control field in the ARM_USART structure.
- [ARM USART FLOW CONTROL Msk](#) : Positioning of the Mode parameters Flow control field in the ARM_USART structure.
- [ARM USART FLOW CONTROL NONE](#) : No flow control (default).
- [ARM USART FLOW CONTROL RTS](#) : RTS flow control.
- [ARM USART FLOW CONTROL CTS](#) : CTS flow control.
- [ARM USART FLOW CONTROL RTS CTS](#) : RTS/CTS flow control.
- [ARM USART CPOL Pos](#) : Position of the 0th bit of the Mode parameters Clock polarity field in the ARM_USART structure.
- [ARM USART CPOL Msk](#) : Positioning of the Mode parameters Clock polarity field in the ARM_USART structure.
- [ARM USART CPOL0](#) : CPOL = 0 (default).
- [ARM USART CPOL1](#) : CPOL = 1.
- [ARM USART CPHA Pos](#) : Position of the 0th bit of the Mode parameters Clock phase field in the ARM_USART structure.
- [ARM USART CPHA Msk](#) : Positioning of the Mode parameters Clock phase field in the ARM_USART structure.
- [ARM USART CPHA0](#) : CPHA = 0 (default).
- [ARM USART CPHA1](#) : CPHA = 1.
- [ARM USART SET DEFAULT TX VALUE](#) : Set default transmit value (synchronous receive only); arg = value.
- [ARM USART SET IRDA PULSE](#) : Set IrDA Pulse in ns; arg: 0=3/16 of bit period.
- [ARM USART SET SMART CARD GUARD TIME](#) : Set smart card guard time; arg = number of bit periods.
- [ARM USART SET SMART CARD CLOCK](#) : Set smart card clock in Hz; arg: 0=Clock not generated.
- [ARM USART CONTROL SMART CARD NACK](#) : Smart card NACK generation; arg: 0=disabled, 1=enabled.
- [ARM USART CONTROL TX](#) : Transmitter; arg: 0=disabled, 1=enabled.
- [ARM USART CONTROL RX](#) : Receiver; arg: 0=disabled, 1=enabled.
- [ARM USART CONTROL BREAK](#) : Continuous break transmission; arg: 0=disabled, 1=enabled.
- [ARM USART ABORT SEND](#) : Abort [ARM USART Send](#).
- [ARM USART ABORT RECEIVE](#) : Abort [ARM USART Receive](#).
- [ARM USART ABORT TRANSFER](#) : Abort [ARM USART Transfer](#).
- [ARM USART ERROR MODE](#) : Specified mode not supported.
- [ARM USART ERROR BAUDRATE](#) : Specified baudrate not supported.
- [ARM USART ERROR DATA BITS](#) : Specified number of data bits not supported.
- [ARM USART ERROR PARITY](#) : Specified parity not supported.
- [ARM USART ERROR STOP BITS](#) : Specified number of stop bits not supported.
- [ARM USART ERROR FLOW CONTROL](#) : Specified flow control not supported.

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- [ARM USART ERROR CPOL](#) : Specified clock polarity not supported.
- [ARM USART ERROR CPHA](#) : Specified clock phase not supported.
- [ARM USART EVENT SEND COMPLETE](#) : USART Event
- [ARM USART EVENT RECEIVE COMPLETE](#) : Receive completed.
- [ARM USART EVENT TRANSFER COMPLETE](#) : Transfer completed.
- [ARM USART EVENT TX COMPLETE](#) : Transmit completed (optional).
- [ARM USART EVENT TX UNDERFLOW](#) : Transmit data not available (synchronous slave).
- [ARM USART EVENT RX OVERFLOW](#) : Receive data overflow.
- [ARM USART EVENT RX TIMEOUT](#) : Receive character timeout (optional).
- [ARM USART EVENT RX BREAK](#) : Break detected on receive.
- [ARM USART EVENT RX FRAMING ERROR](#) : Framing error detected on receive.
- [ARM USART EVENT RX PARITY ERROR](#) : Parity error detected on receive.
- [ARM USART EVENT CTS](#) : CTS state changed (optional).
- [ARM USART EVENT DSR](#) : DSR state changed (optional).
- [ARM USART EVENT DCD](#) : DCD state changed (optional).
- [ARM USART EVENT RI](#) : RI state changed (optional).

Functions

- [ARM USART GetVersion](#) : Get driver version.
- [ARM USART GetCapabilities](#) : Get driver capabilities.
- [ARM USART Initialize](#) : Initialize USART Interface.
- [ARM USART Uninitialize](#) : De-initialize USART Interface.
- [ARM USART PowerControl](#) : Control USART Interface Power.
- [ARM USART Send](#) : Start sending data to USART transmitter.
- [ARM USART Receive](#) : Start receiving data from USART receiver.
- [ARM USART Transfer](#) : Start sending/receiving data to/from USART transmitter/receiver.
- [ARM USART GetTxCount](#) : Get transmitted data count.
- [ARM USART GetRxCount](#) : Get received data count.
- [ARM USART Control](#) : Control USART Interface.
- [ARM USART GetStatus](#) : Get USART status.
- [ARM USART SetModemControl](#) : Set USART Modem Control line state.
- [ARM USART GetModemStatus](#) : Get USART Modem Status lines state.
- [ARM USART SignalEvent](#) : Signal USART Events.

18.12.2 CMSIS USART Driver Typedef Documentation

18.12.2.1 ARM_USART_STATUS

```
typedef struct ARM\_USART\_STATUS ARM_USART_STATUS
```

Location: Driver_USART.h:176

USART Status.

18.12.2.2 ARM_USART_MODEM_CONTROL

```
typedef enum ARM\_USART\_MODEM\_CONTROL ARM_USART_MODEM_CONTROL
```

Location: Driver_USART.h:186

USART Modem Control.

18.12.2.3 ARM_USART_MODEM_STATUS

```
typedef struct ARM\_USART\_MODEM\_STATUS ARM_USART_MODEM_STATUS
```

Location: Driver_USART.h:197

USART Modem Status.

18.12.2.4 ARM_USART_SignalEvent_t

```
typedef void(* ARM_USART_SignalEvent_t
```

Location: Driver_USART.h:295

Pointer to [ARM_USART_SignalEvent](#) : Signal USART Event.

18.12.2.5 ARM_USART_CAPABILITIES

```
typedef struct ARM\_USART\_CAPABILITIES ARM_USART_CAPABILITIES
```

Location: Driver_USART.h:324

USART Device Driver Capabilities.

18.12.2.6 ARM_DRIVER_USART

```
typedef struct ARM\_DRIVER\_USART ARM_DRIVER_USART
```

Location: Driver_USART.h:347

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Access structure of the USART Driver.

18.12.3 CMSIS USART Driver Data Structures Type Documentation

18.12.3.1 _ARM_USART_STATUS

Location: Driver_USART.h:167

USART Status.

Data Fields

Type	Name	Description
uint32_t	<i>tx_busy</i>	Transmitter busy flag.
uint32_t	<i>rx_busy</i>	Receiver busy flag.
uint32_t	<i>tx_underflow</i>	Transmit data underflow detected (cleared on start of next send operation).
uint32_t	<i>rx_overflow</i>	Receive data overflow detected (cleared on start of next receive operation).
uint32_t	<i>rx_break</i>	Break detected on receive (cleared on start of next receive operation).
uint32_t	<i>rx_framing_error</i>	Framing error detected on receive (cleared on start of next receive operation).
uint32_t	<i>rx_parity_error</i>	Parity error detected on receive (cleared on start of next receive operation).
uint32_t	<i>reserved</i>	(Reserved for future use)

18.12.3.2 _ARM_USART_MODEM_STATUS

Location: Driver_USART.h:191

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USART Modem Status.

Data Fields

Type	Name	Description
uint32_t	<i>cts</i>	CTS state: 1=Active, 0=Inactive.
uint32_t	<i>dsr</i>	DSR state: 1=Active, 0=Inactive.
uint32_t	<i>dcd</i>	DCD state: 1=Active, 0=Inactive.
uint32_t	<i>ri</i>	RI state: 1=Active, 0=Inactive.
uint32_t	<i>reserved</i>	(Reserved for future use)

18.12.3.3 _ARM_USART_CAPABILITIES

Location: Driver_USART.h:301

USART Device Driver Capabilities.

Data Fields

Type	Name	Description
uint32_t	<i>asynchronous</i>	supports UART (asynchronous) mode.
uint32_t	<i>synchronous_master</i>	supports synchronous master mode.
uint32_t	<i>synchronous_slave</i>	supports synchronous slave mode.
uint32_t	<i>single_wire</i>	supports UART single-wire mode.
uint32_t	<i>irda</i>	supports UART IrDA mode.
uint32_t	<i>smart_card</i>	supports UART smart card mode.
uint32_t	<i>smart_card_clock</i>	Smart card clock generator available.
uint32_t	<i>flow_control_rts</i>	RTS flow control available.
uint32_t	<i>flow_control_cts</i>	CTS flow control available.
uint32_t	<i>event_tx_complete</i>	Transmit completed event: ARM_USART_EVENT_TX_COMPLETE .
uint32_t	<i>event_rx_timeout</i>	Signal receive character timeout event: ARM_USART_EVENT_RX_TIMEOUT .

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uint32_t	<i>rts</i>	RTS Line: 0=not available, 1=available.
uint32_t	<i>cts</i>	CTS Line: 0=not available, 1=available.
uint32_t	<i>dtr</i>	DTR Line: 0=not available, 1=available.
uint32_t	<i>dsr</i>	DSR Line: 0=not available, 1=available.
uint32_t	<i>dcd</i>	DCD Line: 0=not available, 1=available.
uint32_t	<i>ri</i>	RI Line: 0=not available, 1=available.
uint32_t	<i>event_cts</i>	Signal CTS change event: ARM_USART_EVENT_CTS .
uint32_t	<i>event_dsr</i>	Signal DSR change event: ARM_USART_EVENT_DSR .
uint32_t	<i>event_dcd</i>	Signal DCD change event: ARM_USART_EVENT_DCD .
uint32_t	<i>event_ri</i>	Signal RI change event: ARM_USART_EVENT_RI .
uint32_t	<i>reserved</i>	Reserved (must be zero).

18.12.3.4 **_ARM_DRIVER_USART**

Location: Driver_USART.h:330

Access structure of the USART Driver.

Data Fields

Type	Name	Description
ARM_DRIVER_VERSION (*)	<i>GetVersion)(void)</i>	Pointer to ARM_USART_GetVersion : Get driver version.
ARM_USART_CAPABILITIES (*)	<i>GetCapabilities)(void)</i>	Pointer to ARM_USART_GetCapabilities : Get driver capabilities.
int32_t (*)	<i>Initialize)(ARM_USART_SignalEvent_t cb_event)</i>	Pointer to ARM_USART_Initialize : Initialize USART Interface.
int32_t (*)	<i>Uninitialize)(void)</i>	Pointer to ARM_USART_Uninitialize : De-initialize USART Interface.
int32_t (*)	<i>PowerControl)(ARM_POWER_STATE state)</i>	Pointer to ARM_USART_PowerControl : Control USART Interface Power.
int32_t (*)	<i>Send)(const void *data, uint32_t num)</i>	Pointer to ARM_USART_Send : Start sending data to USART transmitter.

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<code>int32_t (*)</code>	<i>Receive</i> (<code>void *data, uint32_t num</code>)	Pointer to ARM_USART_Receive : Start receiving data from USART receiver.
<code>int32_t (*)</code>	<i>Transfer</i> (<code>const void *data_out, void *data_in, uint32_t num</code>)	Pointer to ARM_USART_Transfer : Start sending/receiving data to/from USART.
<code>uint32_t (*)</code>	<i>GetTxCount</i> (<code>void</code>)	Pointer to ARM_USART_GetTxCount : Get transmitted data count.
<code>uint32_t (*)</code>	<i>GetRxCount</i> (<code>void</code>)	Pointer to ARM_USART_GetRxCount : Get received data count.
<code>int32_t (*)</code>	<i>Control</i> (<code>uint32_t control, uint32_t arg</code>)	Pointer to ARM_USART_Control : Control USART Interface.
ARM_USART_STATUS (*)	<i>GetStatus</i> (<code>void</code>)	Pointer to ARM_USART_GetStatus : Get USART status.
<code>int32_t (*)</code>	<i>SetModemControl</i> (<code>ARM_USART_MODEM_CONTROL control</code>)	Pointer to ARM_USART_SetModemControl : Set USART modem control line state.
ARM_USART_MODEM_STATUS (*)	<i>GetModemStatus</i> (<code>void</code>)	Pointer to ARM_USART_GetModemStatus : Get USART modem status lines state.

18.12.4 CMSIS USART Driver Enumeration Type Documentation

18.12.4.1 _ARM_USART_MODEM_CONTROL

Location: Driver_USART.h:181

USART Modem Control.

Members

- `ARM_USART_RTS_CLEAR`

Deactivate RTS.

- `ARM_USART_RTS_SET`

Activate RTS.

- ARM_USART_DTR_CLEAR

Deactivate DTR.

- ARM_USART_DTR_SET

Activate DTR.

18.12.5 CMSIS USART Driver Macro Definition Documentation

18.12.5.1 ARM_USART_API_VERSION

```
#define ARM_USART_API_VERSION ARM\_DRIVER\_VERSION MAJOR MINOR (2, 3)
```

API version.

Location: Driver_USART.h:78

18.12.5.2 ARM_USART_CONTROL_Pos

```
#define ARM_USART_CONTROL_Pos 0
```

Position of the 0th bit of the USART control field in the ARM_USART structure.

Location: Driver_USART.h:81

18.12.5.3 ARM_USART_CONTROL_Msk

```
#define ARM_USART_CONTROL_Msk (0xFFUL << ARM\_USART\_CONTROL\_Pos)
```

Positioning of USART control field in the ARM_USART structure.

Location: Driver_USART.h:82

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18.12.5.4 ARM_USART_MODE_ASYNCHRONOUS

```
#define ARM_USART_MODE_ASYNCHRONOUS (0x01UL << ARM\_USART\_CONTROL\_Pos)
```

UART (Asynchronous); arg = Baudrate.

Location: Driver_USART.h:85

18.12.5.5 ARM_USART_MODE_SYNCHRONOUS_MASTER

```
#define ARM_USART_MODE_SYNCHRONOUS_MASTER (0x02UL << ARM\_USART\_CONTROL\_Pos)
```

Synchronous Master (generates clock signal); arg = Baudrate.

Location: Driver_USART.h:86

18.12.5.6 ARM_USART_MODE_SYNCHRONOUS_SLAVE

```
#define ARM_USART_MODE_SYNCHRONOUS_SLAVE (0x03UL << ARM\_USART\_CONTROL\_Pos)
```

Synchronous Slave (external clock signal).

Location: Driver_USART.h:87

18.12.5.7 ARM_USART_MODE_SINGLE_WIRE

```
#define ARM_USART_MODE_SINGLE_WIRE (0x04UL << ARM\_USART\_CONTROL\_Pos)
```

UART Single-wire (half-duplex); arg = Baudrate.

Location: Driver_USART.h:88

18.12.5.8 ARM_USART_MODE_IRDA

```
#define ARM_USART_MODE_IRDA (0x05UL << ARM\_USART\_CONTROL\_Pos)
```

UART IrDA; arg = Baudrate.

Location: Driver_USART.h:89

18.12.5.9 ARM_USART_MODE_SMART_CARD

```
#define ARM_USART_MODE_SMART_CARD (0x06UL << ARM\_USART\_CONTROL\_Pos)
```

UART Smart Card; arg = Baudrate.

Location: Driver_USART.h:90

18.12.5.10 ARM_USART_DATA_BITS_Pos

```
#define ARM_USART_DATA_BITS_Pos 8
```

Position of the 0th bit of the Data bits field in the ARM_USART structure.

Location: Driver_USART.h:93

18.12.5.11 ARM_USART_DATA_BITS_Msk

```
#define ARM_USART_DATA_BITS_Msk (7UL << ARM\_USART\_DATA\_BITS\_Pos)
```

Positioning of the Data bits field in the ARM_USART structure.

Location: Driver_USART.h:94

18.12.5.12 ARM_USART_DATA_BITS_5

```
#define ARM_USART_DATA_BITS_5 (5UL << ARM\_USART\_DATA\_BITS\_Pos)
```

5 data bits.

Location: Driver_USART.h:95

18.12.5.13 ARM_USART_DATA_BITS_6

```
#define ARM_USART_DATA_BITS_6 (6UL << ARM\_USART\_DATA\_BITS\_Pos)
```

6 data bits.

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Location: Driver_USART.h:96

18.12.5.14 ARM_USART_DATA_BITS_7

```
#define ARM_USART_DATA_BITS_7 (7UL << ARM\_USART\_DATA\_BITS\_Pos)
```

7 data bits.

Location: Driver_USART.h:97

18.12.5.15 ARM_USART_DATA_BITS_8

```
#define ARM_USART_DATA_BITS_8 (0UL << ARM\_USART\_DATA\_BITS\_Pos)
```

8 data bits (default).

Location: Driver_USART.h:98

18.12.5.16 ARM_USART_DATA_BITS_9

```
#define ARM_USART_DATA_BITS_9 (1UL << ARM\_USART\_DATA\_BITS\_Pos)
```

9 data bits.

Location: Driver_USART.h:99

18.12.5.17 ARM_USART_PARITY_Pos

```
#define ARM_USART_PARITY_Pos 12
```

Position of the 0th bit of the Mode parameters Parity field in the ARM_USART structure.

Location: Driver_USART.h:102

18.12.5.18 ARM_USART_PARITY_Msk

```
#define ARM_USART_PARITY_Msk (3UL << ARM\_USART\_PARITY\_Pos)
```

Positioning of the Mode parameters Parity field in the ARM_USART structure.

Location: Driver_USART.h:103

18.12.5.19 ARM_USART_PARITY_NONE

```
#define ARM_USART_PARITY_NONE (0UL << ARM\_USART\_PARITY\_Pos)
```

No parity (default).

Location: Driver_USART.h:104

18.12.5.20 ARM_USART_PARITY_EVEN

```
#define ARM_USART_PARITY_EVEN (1UL << ARM\_USART\_PARITY\_Pos)
```

Even parity.

Location: Driver_USART.h:105

18.12.5.21 ARM_USART_PARITY_ODD

```
#define ARM_USART_PARITY_ODD (2UL << ARM\_USART\_PARITY\_Pos)
```

Odd parity.

Location: Driver_USART.h:106

18.12.5.22 ARM_USART_STOP_BITS_Pos

```
#define ARM_USART_STOP_BITS_Pos 14
```

Position of the 0th bit of the Mode parameters Stop bits field in the ARM_USART structure.

Location: Driver_USART.h:109

18.12.5.23 ARM_USART_STOP_BITS_Msk

```
#define ARM_USART_STOP_BITS_Msk (3UL << ARM\_USART\_STOP\_BITS\_Pos)
```

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Positioning of the Mode parameters Stop bits field in the ARM_USART structure.

Location: Driver_USART.h:110

18.12.5.24 ARM_USART_STOP_BITS_1

```
#define ARM_USART_STOP_BITS_1 (0UL << ARM\_USART\_STOP\_BITS\_Pos)
```

1 stop bit (default).

Location: Driver_USART.h:111

18.12.5.25 ARM_USART_STOP_BITS_2

```
#define ARM_USART_STOP_BITS_2 (1UL << ARM\_USART\_STOP\_BITS\_Pos)
```

2 stop bits.

Location: Driver_USART.h:112

18.12.5.26 ARM_USART_STOP_BITS_1_5

```
#define ARM_USART_STOP_BITS_1_5 (2UL << ARM\_USART\_STOP\_BITS\_Pos)
```

1.5 stop bits.

Location: Driver_USART.h:113

18.12.5.27 ARM_USART_STOP_BITS_0_5

```
#define ARM_USART_STOP_BITS_0_5 (3UL << ARM\_USART\_STOP\_BITS\_Pos)
```

0.5 stop bits.

Location: Driver_USART.h:114

18.12.5.28 ARM_USART_FLOW_CONTROL_Pos

```
#define ARM_USART_FLOW_CONTROL_Pos 16
```

Position of the 0th bit of the Mode parameters Flow control field in the ARM_USART structure.

Location: Driver_USART.h:117

18.12.5.29 ARM_USART_FLOW_CONTROL_Msk

```
#define ARM_USART_FLOW_CONTROL_Msk (3UL << ARM\_USART\_FLOW\_CONTROL\_Pos)
```

Positioning of the Mode parameters Flow control field in the ARM_USART structure.

Location: Driver_USART.h:118

18.12.5.30 ARM_USART_FLOW_CONTROL_NONE

```
#define ARM_USART_FLOW_CONTROL_NONE (0UL << ARM\_USART\_FLOW\_CONTROL\_Pos)
```

No flow control (default).

Location: Driver_USART.h:119

18.12.5.31 ARM_USART_FLOW_CONTROL_RTS

```
#define ARM_USART_FLOW_CONTROL_RTS (1UL << ARM\_USART\_FLOW\_CONTROL\_Pos)
```

RTS flow control.

Location: Driver_USART.h:120

18.12.5.32 ARM_USART_FLOW_CONTROL_CTS

```
#define ARM_USART_FLOW_CONTROL_CTS (2UL << ARM\_USART\_FLOW\_CONTROL\_Pos)
```

CTS flow control.

Location: Driver_USART.h:121

18.12.5.33 ARM_USART_FLOW_CONTROL_RTS_CTS

```
#define ARM_USART_FLOW_CONTROL_RTS_CTS (3UL << ARM\_USART\_FLOW\_CONTROL\_Pos)
```

RTS/CTS flow control.

Location: Driver_USART.h:122

18.12.5.34 ARM_USART_CPOL_Pos

```
#define ARM_USART_CPOL_Pos 18
```

Position of the 0th bit of the Mode parameters Clock polarity field in the ARM_USART structure.

Location: Driver_USART.h:125

18.12.5.35 ARM_USART_CPOL_Msk

```
#define ARM_USART_CPOL_Msk (1UL << ARM\_USART\_CPOL\_Pos)
```

Positioning of the Mode parameters Clock polarity field in the ARM_USART structure.

Location: Driver_USART.h:126

18.12.5.36 ARM_USART_CPOL0

```
#define ARM_USART_CPOL0 (0UL << ARM\_USART\_CPOL\_Pos)
```

CPOL = 0 (default).

Location: Driver_USART.h:127

18.12.5.37 ARM_USART_CPOL1

```
#define ARM_USART_CPOL1 (1UL << ARM\_USART\_CPOL\_Pos)
```

CPOL = 1.

Location: Driver_USART.h:128

18.12.5.38 ARM_USART_CPHA_Pos

```
#define ARM_USART_CPHA_Pos 19
```

Position of the 0th bit of the Mode parameters Clock phase field in the ARM_USART structure.

Location: Driver_USART.h:131

18.12.5.39 ARM_USART_CPHA_Msk

```
#define ARM_USART_CPHA_Msk (1UL << ARM\_USART\_CPHA\_Pos)
```

Positioning of the Mode parameters Clock phase field in the ARM_USART structure.

Location: Driver_USART.h:132

18.12.5.40 ARM_USART_CPHA0

```
#define ARM_USART_CPHA0 (0UL << ARM\_USART\_CPHA\_Pos)
```

CPHA = 0 (default).

Location: Driver_USART.h:133

18.12.5.41 ARM_USART_CPHA1

```
#define ARM_USART_CPHA1 (1UL << ARM\_USART\_CPHA\_Pos)
```

CPHA = 1.

Location: Driver_USART.h:134

18.12.5.42 ARM_USART_SET_DEFAULT_TX_VALUE

```
#define ARM_USART_SET_DEFAULT_TX_VALUE (0x10UL << ARM\_USART\_CONTROL\_Pos)
```

Set default transmit value (synchronous receive only); arg = value.

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Location: Driver_USART.h:138

18.12.5.43 ARM_USART_SET_IRDA_PULSE

```
#define ARM_USART_SET_IRDA_PULSE (0x11UL << ARM USART CONTROL Pos)
```

Set IrDA Pulse in ns; arg: 0=3/16 of bit period.

Location: Driver_USART.h:139

18.12.5.44 ARM_USART_SET_SMART_CARD_GUARD_TIME

```
#define ARM_USART_SET_SMART_CARD_GUARD_TIME (0x12UL << ARM USART CONTROL Pos)
```

Set smart card guard time; arg = number of bit periods.

Location: Driver_USART.h:140

18.12.5.45 ARM_USART_SET_SMART_CARD_CLOCK

```
#define ARM_USART_SET_SMART_CARD_CLOCK (0x13UL << ARM USART CONTROL Pos)
```

Set smart card clock in Hz; arg: 0=Clock not generated.

Location: Driver_USART.h:141

18.12.5.46 ARM_USART_CONTROL_SMART_CARD_NACK

```
#define ARM_USART_CONTROL_SMART_CARD_NACK (0x14UL << ARM USART CONTROL Pos)
```

Smart card NACK generation; arg: 0=disabled, 1=enabled.

Location: Driver_USART.h:142

18.12.5.47 ARM_USART_CONTROL_TX

```
#define ARM_USART_CONTROL_TX (0x15UL << ARM USART CONTROL Pos)
```

Transmitter; arg: 0=disabled, 1=enabled.

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Location: Driver_USART.h:143

18.12.5.48 ARM_USART_CONTROL_RX

```
#define ARM_USART_CONTROL_RX (0x16UL << ARM\_USART\_CONTROL\_Pos)
```

Receiver; arg: 0=disabled, 1=enabled.

Location: Driver_USART.h:144

18.12.5.49 ARM_USART_CONTROL_BREAK

```
#define ARM_USART_CONTROL_BREAK (0x17UL << ARM\_USART\_CONTROL\_Pos)
```

Continuous break transmission; arg: 0=disabled, 1=enabled.

Location: Driver_USART.h:145

18.12.5.50 ARM_USART_ABORT_SEND

```
#define ARM_USART_ABORT_SEND (0x18UL << ARM\_USART\_CONTROL\_Pos)
```

Abort [ARM_USART_Send](#).

Location: Driver_USART.h:146

18.12.5.51 ARM_USART_ABORT_RECEIVE

```
#define ARM_USART_ABORT_RECEIVE (0x19UL << ARM\_USART\_CONTROL\_Pos)
```

Abort [ARM_USART_Receive](#).

Location: Driver_USART.h:147

18.12.5.52 ARM_USART_ABORT_TRANSFER

```
#define ARM_USART_ABORT_TRANSFER (0x1AUL << ARM\_USART\_CONTROL\_Pos)
```

Abort [ARM USART Transfer](#).

Location: Driver_USART.h:148

18.12.5.53 ARM_USART_ERROR_MODE

```
#define ARM_USART_ERROR_MODE (ARM DRIVER ERROR SPECIFIC - 1)
```

Specified mode not supported.

Location: Driver_USART.h:153

18.12.5.54 ARM_USART_ERROR_BAUDRATE

```
#define ARM_USART_ERROR_BAUDRATE (ARM DRIVER ERROR SPECIFIC - 2)
```

Specified baudrate not supported.

Location: Driver_USART.h:154

18.12.5.55 ARM_USART_ERROR_DATA_BITS

```
#define ARM_USART_ERROR_DATA_BITS (ARM DRIVER ERROR SPECIFIC - 3)
```

Specified number of data bits not supported.

Location: Driver_USART.h:155

18.12.5.56 ARM_USART_ERROR_PARITY

```
#define ARM_USART_ERROR_PARITY (ARM DRIVER ERROR SPECIFIC - 4)
```

Specified parity not supported.

Location: Driver_USART.h:156

18.12.5.57 ARM_USART_ERROR_STOP_BITS

```
#define ARM_USART_ERROR_STOP_BITS (ARM DRIVER ERROR SPECIFIC - 5)
```

Specified number of stop bits not supported.

Location: Driver_USART.h:157

18.12.5.58 ARM_USART_ERROR_FLOW_CONTROL

```
#define ARM_USART_ERROR_FLOW_CONTROL (ARM DRIVER ERROR SPECIFIC - 6)
```

Specified flow control not supported.

Location: Driver_USART.h:158

18.12.5.59 ARM_USART_ERROR_CPOL

```
#define ARM_USART_ERROR_CPOL (ARM DRIVER ERROR SPECIFIC - 7)
```

Specified clock polarity not supported.

Location: Driver_USART.h:159

18.12.5.60 ARM_USART_ERROR_CPHA

```
#define ARM_USART_ERROR_CPHA (ARM DRIVER ERROR SPECIFIC - 8)
```

Specified clock phase not supported.

Location: Driver_USART.h:160

18.12.5.61 ARM_USART_EVENT_SEND_COMPLETE

```
#define ARM_USART_EVENT_SEND_COMPLETE (1UL << 0)
```

USART Event

Send completed; however USART may still transmit data.

Location: Driver_USART.h:201

18.12.5.62 ARM_USART_EVENT_RECEIVE_COMPLETE

```
#define ARM_USART_EVENT_RECEIVE_COMPLETE (1UL << 1)
```

Receive completed.

Location: Driver_USART.h:202

18.12.5.63 ARM_USART_EVENT_TRANSFER_COMPLETE

```
#define ARM_USART_EVENT_TRANSFER_COMPLETE (1UL << 2)
```

Transfer completed.

Location: Driver_USART.h:203

18.12.5.64 ARM_USART_EVENT_TX_COMPLETE

```
#define ARM_USART_EVENT_TX_COMPLETE (1UL << 3)
```

Transmit completed (optional).

Location: Driver_USART.h:204

18.12.5.65 ARM_USART_EVENT_TX_UNDERFLOW

```
#define ARM_USART_EVENT_TX_UNDERFLOW (1UL << 4)
```

Transmit data not available (synchronous slave).

Location: Driver_USART.h:205

18.12.5.66 ARM_USART_EVENT_RX_OVERFLOW

```
#define ARM_USART_EVENT_RX_OVERFLOW (1UL << 5)
```

Receive data overflow.

Location: Driver_USART.h:206

18.12.5.67 ARM_USART_EVENT_RX_TIMEOUT

```
#define ARM_USART_EVENT_RX_TIMEOUT (1UL << 6)
```

Receive character timeout (optional).

Location: Driver_USART.h:207

18.12.5.68 ARM_USART_EVENT_RX_BREAK

```
#define ARM_USART_EVENT_RX_BREAK (1UL << 7)
```

Break detected on receive.

Location: Driver_USART.h:208

18.12.5.69 ARM_USART_EVENT_RX_FRAMING_ERROR

```
#define ARM_USART_EVENT_RX_FRAMING_ERROR (1UL << 8)
```

Framing error detected on receive.

Location: Driver_USART.h:209

18.12.5.70 ARM_USART_EVENT_RX_PARITY_ERROR

```
#define ARM_USART_EVENT_RX_PARITY_ERROR (1UL << 9)
```

Parity error detected on receive.

Location: Driver_USART.h:210

18.12.5.71 ARM_USART_EVENT_CTS

```
#define ARM_USART_EVENT_CTS (1UL << 10)
```

CTS state changed (optional).

Location: Driver_USART.h:211

18.12.5.72 ARM_USART_EVENT_DSR

```
#define ARM_USART_EVENT_DSR (1UL << 11)
```

DSR state changed (optional).

Location: Driver_USART.h:212

18.12.5.73 ARM_USART_EVENT_DCD

```
#define ARM_USART_EVENT_DCD (1UL << 12)
```

DCD state changed (optional).

Location: Driver_USART.h:213

18.12.5.74 ARM_USART_EVENT_RI

```
#define ARM_USART_EVENT_RI (1UL << 13)
```

RI state changed (optional).

Location: Driver_USART.h:214

18.12.6 CMSIS USART Driver Function Documentation

18.12.6.1 ARM_USART_GetVersion

```
ARM\_DRIVER\_VERSION ARM_USART_GetVersion()
```

Get driver version.

Location: Driver_USART.c:59

Return[ARM DRIVER VERSION](#)**18.12.6.2 ARM_USART_GetCapabilities**[ARM USART CAPABILITIES](#) ARM_USART_GetCapabilities()

Get driver capabilities.

Location: Driver_USART.c:64

Return[ARM USART CAPABILITIES](#)**18.12.6.3 ARM_USART_Initialize**int32_t ARM_USART_Initialize([ARM USART SignalEvent t](#) cb_event)

Initialize USART Interface.

Location: Driver_USART.c:69

Parameters

Direction	Name	Description
in	<i>cb_event</i>	Pointer to ARM USART SignalEvent

Return[execution status](#)

18.12.6.4 ARM_USART_Uninitialize

```
int32_t ARM_USART_Uninitialize()
```

De-initialize USART Interface.

Location: Driver_USART.c:73

Return

[execution status](#)

18.12.6.5 ARM_USART_PowerControl

```
int32_t ARM_USART_PowerControl(ARM\_POWER\_STATE state)
```

Control USART Interface Power.

Location: Driver_USART.c:77

Parameters

Direction	Name	Description
in	<i>state</i>	Power state

Return

[execution status](#)

18.12.6.6 ARM_USART_Send

```
int32_t ARM_USART_Send(const void * data, uint32_t num)
```

Start sending data to USART transmitter.

Location: Driver_USART.c:93

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Parameters

Direction	Name	Description
in	<i>data</i>	Pointer to buffer with data to send to USART transmitter
in	<i>num</i>	Number of data items to send

Return

[execution status](#)

18.12.6.7 ARM_USART_Receive

```
int32_t ARM_USART_Receive(void * data, uint32_t num)
```

Start receiving data from USART receiver.

Location: Driver_USART.c:97

Parameters

Direction	Name	Description
out	<i>data</i>	Pointer to buffer for data to receive from USART receiver
in	<i>num</i>	Number of data items to receive

Return

[execution status](#)

18.12.6.8 ARM_USART_Transfer

```
int32_t ARM_USART_Transfer(const void * data_out, void * data_in, uint32_t num)
```

Start sending/receiving data to/from USART transmitter/receiver.

Location: Driver_USART.c:101

Parameters

Direction	Name	Description
in	<i>data_out</i>	Pointer to buffer with data to send to USART transmitter
out	<i>data_in</i>	Pointer to buffer for data to receive from USART receiver
in	<i>num</i>	Number of data items to transfer

Return

[execution status](#)

18.12.6.9 ARM_USART_GetTxCount

```
uint32_t ARM_USART_GetTxCount ()
```

Get transmitted data count.

Location: Driver_USART.c:105

Return

number of data items transmitted

18.12.6.10 ARM_USART_GetRxCount

```
uint32_t ARM_USART_GetRxCount ()
```

Get received data count.

Location: Driver_USART.c:109

Return

number of data items received

18.12.6.11 ARM_USART_Control

```
int32_t ARM_USART_Control(uint32_t control, uint32_t arg)
```

Control USART Interface.

Location: Driver_USART.c:113

Parameters

Direction	Name	Description
in	<i>control</i>	Operation
in	<i>arg</i>	Argument of operation (optional)

Return

common [execution status](#) and driver specific [usart execution status](#)

18.12.6.12 ARM_USART_GetStatus

```
ARM USART STATUS ARM_USART_GetStatus()
```

Get USART status.

Location: Driver_USART.c:117

Return

USART status [ARM USART STATUS](#)

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18.12.6.13 ARM_USART_SetModemControl

```
int32_t ARM_USART_SetModemControl(ARM\_USART\_MODEM\_CONTROL control)
```

Set USART Modem Control line state.

Location: Driver_USART.c:121

Parameters

Direction	Name	Description
in	<i>control</i>	ARM_USART_MODEM_CONTROL

Return

[execution status](#)

18.12.6.14 ARM_USART_GetModemStatus

```
ARM\_USART\_MODEM\_STATUS ARM_USART_GetModemStatus()
```

Get USART Modem Status lines state.

Location: Driver_USART.c:125

Return

modem status [ARM_USART_MODEM_STATUS](#)

18.12.6.15 ARM_USART_SignalEvent

```
void ARM_USART_SignalEvent(uint32_t event)
```

Signal USART Events.

Location: Driver_USART.c:129

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Parameters

Direction	Name	Description
in	<i>event</i>	USART_events notification mask

Return

none

CHAPTER 19

swmTrace Reference

The swmTrace library functions and macros provide a logging utility that helps you to debug an application running on the Arm Cortex-M33 core.

19.1 SUMMARY

Macros

- [swmLogVerbose](#) : Shortcut macro for verbose logging.
- [swmLogInfo](#) : Shortcut macro for informational logging.
- [swmLogWarn](#) : Shortcut macro for warnings.
- [swmLogError](#) : Shortcut macro for errors.
- [swmLogFatal](#) : Shortcut macro for fatal errors.
- [swmLogTestPass](#) : Shortcut macro for test PASS indicators.
- [swmLogTestFail](#) : Shortcut macro for test FAIL indicators.

Functions

- [swmTrace_init](#) : Trace initialization function.
- [swmTrace_txInProgress](#) : Provides indication if transmission is in progress.
- [swmTrace_printf](#) : This provides a printf-like implementation for all possible trace mechanisms.
- [swmTrace_vprintf](#) : This provides a vprintf-like implementation for all possible trace mechanisms.
- [swmTrace_getch](#) : A method to allow characters to be passed from the logging target to the traced application.
- [swmLog](#) : A general logging method that allows us to output only trace messages if a particular log level has been selected.

19.2 SWMTRACE REFERENCE MACRO DEFINITION DOCUMENTATION

19.2.1 swmLogVerbose

```
#define swmLogVerbose swmLog(SWM_LOG_LEVEL_VERBOSE, __VA_ARGS__)
```

Shortcut macro for verbose logging.

Location: swmTrace_api.h:125

19.2.2 swmLogInfo

```
#define swmLogInfo swmLog(SWM_LOG_LEVEL_INFO, __VA_ARGS__)
```

Shortcut macro for informational logging.

Location: swmTrace_api.h:130

19.2.3 swmLogWarn

```
#define swmLogWarn swmLog(SWM_LOG_LEVEL_WARNING, __VA_ARGS__)
```

Shortcut macro for warnings.

Location: swmTrace_api.h:135

19.2.4 swmLogError

```
#define swmLogError swmLog(SWM_LOG_LEVEL_ERROR, __VA_ARGS__)
```

Shortcut macro for errors.

Location: swmTrace_api.h:140

19.2.5 swmLogFatal

```
#define swmLogFatal swmLog(SWM_LOG_LEVEL_FATAL, __VA_ARGS__)
```

Shortcut macro for fatal errors.

Location: swmTrace_api.h:145

19.2.6 swmLogTestPass

```
#define swmLogTestPass swmLog(SWM_LOG_TEST_PASS, __VA_ARGS__)
```

Shortcut macro for test PASS indicators.

Location: swmTrace_api.h:150

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19.2.7 swmLogTestFail

```
#define swmLogTestFail swmLog(SWM_LOG_TEST_FAIL, __VA_ARGS__)
```

Shortcut macro for test FAIL indicators.

Location: swmTrace_api.h:155

19.3 SWMTRACE REFERENCE FUNCTION DOCUMENTATION**19.3.1 swmTrace_init**

```
void swmTrace_init(const uint32_t * configuration, uint32_t size)
```

Trace initialization function.

This method allows the tracing functions to be initialized in a general way, allowing different trace options to be supplied, depending on the type of trace library selected.

Location: swmTrace_api.h:79

Parameters

Direction	Name	Description
in	<i>configuration</i>	Consists of an array of 32-bit words that define the selected initialization options.
in	<i>size</i>	Indicates the number of options provided.

NOTE: The list of options can be set up as a superset of all the possible options, and only the ones required for a given trace library are used. The possible options are defined in the swmTrace_options.h file.

19.3.2 swmTrace_txInProgress

```
bool swmTrace_txInProgress()
```

Provides indication if transmission is in progress.

Location: swmTrace_api.h:85

Return

True if a string is being transmitted; false otherwise.

19.3.3 swmTrace_printf

```
void swmTrace_printf(const char * sFormat, ... )
```

This provides a printf-like implementation for all possible trace mechanisms.

Location: swmTrace_api.h:93

Parameters

Direction	Name	Description
in	<i>sFormat</i>	Defines the format of the string to print. This is followed by a variable number of arguments.

19.3.4 swmTrace_vprintf

```
void swmTrace_vprintf(const char * sFormat, va_list * pParamList)
```

This provides a vprintf-like implementation for all possible trace mechanisms.

Location: swmTrace_api.h:102

Parameters

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Direction	Name	Description
in	<i>sFormat</i>	Defines the format of the string to print.
in	<i>pParamList</i>	Defines a pointer to a <i>va_list</i> object in a form similar to <i>vprintf</i> .

19.3.5 swmTrace_getch

```
bool swmTrace_getch(char * ch)
```

A method to allow characters to be passed from the logging target to the traced application.

Location: *swmTrace_api.h*:111

Parameters

Direction	Name	Description
in	<i>ch</i>	A pointer to a character object which holds the returned character.

Return

True if a valid character has been returned; false otherwise.

19.3.6 swmLog

```
void swmLog(uint32_t level, const char * sFormat, ... )
```

A general logging method that allows us to output only trace messages if a particular log level has been selected.

Location: *swmTrace_api.h*:120

Parameters

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Direction	Name	Description
in	<i>level</i>	The level of this log message. Only messages which have a level equal to or higher than the currently selected level are output.
in	<i>sFormat</i>	The format of the output string, as per printf.

CHAPTER 20

Bluetooth Low Energy Stack Abstraction

Bluetooth Low Energy Stack Abstraction Reference.

20.1 SUMMARY

Typedefs

- [MsgHandlerCallback t](#) : BLE abstraction message handler function type.

Variables

- [ble_dev_params](#) : Structure to save BLE device parameters provided by the application.

Data Structures

- [GAPM_ActivityStatus t](#) : GAPM activity status.
- [GAP_Env t](#) : GAP environment.
- [att_db_desc](#) : Custom service attribute database description.
- [cust_svc_desc](#) : Custom service descriptor.
- [GATT_Env t](#) : GATT environment.
- [low_power_clock](#) : Application defined low power clocks and sources.
- [ble_device_parameter](#) : Application defined BLE device parameters used by BLE stack.
- [BASC_Env t](#) : Battery service client environment.
- [BASS_Env t](#) : Battery service server environment.
- [DISS_DeviceInfoField t](#) : Global DISS specific info structure.
- [DISS_DeviceInfo t](#) : Global DISS info compilation structure.
- [DISS_Env t](#) : DISS state structure.

Enumerations

- [gapm_activity_state](#) : GAPM activity state.
- [gapm_state](#) : GAPM state.
- [cfm_msg_instr_enum](#) : Instructions to send or withhold confirmation message.
- [basc_app_msg_id](#) : BASC application task messages.
- [bass_app_msg_id](#) : BASS application task messages.

Macros

- [GAPM_CFG_ADDR_PUBLIC](#) : GAPM privacy configuration identity address public.
- [GAPM_CFG_ADDR_PRIVATE](#) : GAPM privacy configuration identity address private.
- [GAPM_CFG_HOST_PRIVACY](#) : GAPM privacy configuration set to host privacy.

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- [GAPM_CFG_CONTROLLER_PRIVACY](#) : GAPM privacy configuration set to controller privacy.
- [GAPM_DEFAULT_ROLE](#) : GAPM default device configuration (used in GAPM_SET_DEV_CONFIG_CMD)
- [GAPM_DEFAULT_RENEW_DUR](#) : Default duration for regenerating device address when privacy is enabled (in seconds)
- [GAPM_DEFAULT_GAP_START_HDL](#) : Default start handle for GAP service (dynamically allocated)
- [GAPM_DEFAULT_GATT_START_HDL](#) : Default start handle for GATT service (dynamically allocated)
- [GAPM_DEFAULT_ATT_CFG](#) : Default attribute database configuration.
- [GAPM_DEFAULT_TX_OCT_MAX](#) : Default value for the controller's maximum transmitted number of payload octets to be used.
- [GAPM_DEFAULT_TX_TIME_MAX](#) : Suggested value for the controller's maximum packet transmission time to be used.
- [GAPM_DEFAULT_MTU_MAX](#) : Default maximum MTU acceptable for device (L2CAP)
- [GAPM_DEFAULT_MPS_MAX](#) : Default maximum MPS (L2CAP)
- [GAPM_DEFAULT_MAX_NB_LECB](#) : Default maximum number of LE Credit based connection that can be established (L2CAP)
- [GAPM_DEFAULT_AUDIO_CFG](#) : Default LE Audio Mode Configuration.
- [GAP_ROLE_MASTER](#) : GAP master.
- [GAP_ROLE_SLAVE](#) : GAP slave.
- [GAPM_DEFAULT_ADV_DATA](#) : Default advertisement data (length, data)
- [GAPM_DEFAULT_ADV_DATA_LEN](#) : Default length of advertisement data.
- [GAPM_DEFAULT_SCANRSP_DATA](#) : Default scan response data.
- [GAPM_DEFAULT_SCANRSP_DATA_LEN](#) : Default length of scan response data.
- [GAPM_DEFAULT_SCAN_INTERVAL](#) : GAPM default StartConnectionCmd configuration (GAPM_START_CONNECTION_CMD)
- [GAPM_DEFAULT_SCAN_WINDOW](#) : Scan window to 50% of the interval.
- [GAPM_DEFAULT_CON_INTV_MIN](#) : Default connection interval and slave latency.
- [GAPM_DEFAULT_CON_INTV_MAX](#) : 25 ms (units of 1.25ms)
- [GAPM_DEFAULT_CON_LATENCY](#) : Slave latency: number of events that can be missed while maintaining a connection.
- [GAPM_DEFAULT_SUPERV_TO](#) : Default supervisory timeout.
- [GAPM_DEFAULT_CE_LEN_MIN](#) : Recommended minimum duration of connection events 40 ms.
- [GAPM_DEFAULT_CE_LEN_MAX](#) : Recommended maximum duration of connection events 40 ms.
- [GAPM_DEFAULT_ADV_INTV_MIN](#) : Advertising minimum and maximum interval.
- [GAPM_DEFAULT_ADV_INTV_MAX](#) : 40ms (64*0.625ms)
- [GAPM_DEFAULT_ADV_CHMAP](#) : Advertising channel map - 37, 38, 39.
- [GATTC_DEFAULT_START_HDL](#) : Default GATTC handles.
- [GATTC_DEFAULT_END_HDL](#) : GATTC default end handle.
- [CS_SERVICE_UUID_16](#) : Macros to declare a (custom) service with 16, 32 and 128 bit UUID srvidx Service index uuid Service UUID.
- [CS_SERVICE_UUID_32](#) : Custom service with 32 bit UUID.
- [CS_SERVICE_UUID_128](#) : Custom service with 128 bit UUID.
- [CS_ATT_SERVICE_128](#) : Standard declaration/description UUIDs in 16-byte format.
- [CS_ATT_CHARACTERISTIC_128](#) : Custom service characteristic.
- [CS_ATT_CLIENT_CHAR_CFG_128](#) : Custom service attribute for client characteristic configuration.
- [CS_ATT_CHAR_USER_DESC_128](#) : Custom service attribute characteristic user description.
- [CS_CHAR_UUID_16](#) : Macros to define characteristics with 16, 32 and 128 bit UUID attidx_char: Characteristic attribute index attidx_val: Value attribute index uuid UUID perm Permissions (see gattm_att_

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desc) length Maximum length value (in bytes) data Pointer to the data structure in the application callback Function to transfer the data between the application and the GATTM.

- [CS CHAR UUID 32](#) : Custom service characteristic with 32 bit UUID.
- [CS CHAR UUID 128](#) : Custom service characteristic with 128 bit UUID.
- [CS CHAR CCC](#) : Macro to add to the characteristic a CCC attridx CCC attribute index data Pointer to the 2-byte CCC data value in the application callback Function to transfer the CCC data between the application and the GATTM.
- [CS CHAR USER_DESC](#) : Macro to add to the characteristic a user description attridx Description attribute index length Description length (in bytes) data Pointer to the description string (constant) callback Function to transfer the description string to the GATTM.
- [MIN](#) : Macro to Find Minimum.
- [HCI VS RF CW ENABLE CMD CODE](#) : Vendor specific to enable CW (RX or TX)
- [HCI VS RF CW DISABLE CMD CODE](#) : Vendor specific to enable CW (RX or TX)
- [HCI VS RF OUTPUT PWR CMD CODE](#) : Vendor specific to set desired output power.

Functions

- [GAP Initialize](#) : Initialize GAP environment.
- [GAP GetEnv](#) : Get GAP environment.
- [GAP GetProfileAddedTaskId](#) : Get GAP environment added profiles task identifiers.
- [GAP IsAddrPrivateResolvable](#) : Check address if its private resolvable.
- [GAP AddAdvData](#) : Add GAP advertise data.
- [GAPM ResetCmd](#) : Perform GAPM reset with specified GAPM operation.
- [GAPM SoftwareReset](#) : Perform GAPM software reset.
- [GAPM PlatformReset](#) : Perform GAPM platform reset.
- [GAPM SetDevConfigCmd](#) : Prepare and send set the device configuration.
- [GAPM GetDeviceConfig](#) : get Device configuration
- [GAPM ProfileTaskAddCmd](#) : Prepare and Send GAPM_PROFILE_TASK_ADD_CMD to the Bluetooth stack.
- [GAPM GetProfileAddedCount](#) : Get number of profiles added by the Bluetooth stack.
- [GAPM LepsmRegisterCmd](#) : Prepare and send GAPM_LEPSM_REGISTER_CMD to the Bluetooth stack.
- [GAPM GenRandAddrCmd](#) : Prepare and send GAPM_GEN_RAND_ADDR_CMD to the Bluetooth stack.
- [GAPM ResolvAddrCmd](#) : Prepare and send GAPM_RESOLV_ADDR_CMD to the Bluetooth stack.
- [GAPM ActivityCreateAdvCmd](#) : Prepare and send GAPM_ACTIVITY_CREATE_CMD to create an advertising activity.
- [GAPM ActivityCreateScanCmd](#) : Prepare and send GAPM_ACTIVITY_CREATE_CMD to create scan activity.
- [GAPM ActivityCreateInitCmd](#) : Prepare and send GAPM_ACTIVITY_CREATE_CMD to create an initiating activity.
- [GAPM ActivityCreatePeriodSyncCmd](#) : Prepare and send GAPM_ACTIVITY_CREATE_CMD to create a periodic sync activity.
- [GAPM AdvActivityStart](#) : Prepare and send GAPM_ACTIVITY_START_CMD to start an advertising activity.
- [GAPM InitActivityStart](#) : Prepare and send GAPM_ACTIVITY_START_CMD to start an initiating activity.
- [GAPM ScanActivityStart](#) : Prepare and send GAPM_ACTIVITY_START_CMD to start a scanning activity.
- [GAPM PerSyncActivityStart](#) : Prepare and send GAPM_ACTIVITY_START_CMD to start a periodic sync activity.
- [GAPM ActivityStartCmd](#) : Prepare and send GAPM_ACTIVITY_START_CMD to start an activity.
- [GAPM ActivityStop](#) : Prepare and send GAPM_ACTIVITY_STOP_CMD to stop a specified activity.
- [GAPM ActivityStopAll](#) : Prepare and send GAPM_ACTIVITY_STOP_CMD to stop all existing activities.

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- [GAPM DeleteActivity](#) : Prepare and send GAPM_ACTIVITY_DELETE_CMD to delete a specified activity.
- [GAPM DeleteAllActivities](#) : Prepare and send GAPM_ACTIVITY_DELETE_CMD to delete all the activities.
- [GAPM ActivityStopCmd](#) : Prepare and send GAPM_ACTIVITY_STOP_CMD to stop a specified activity.
- [GAPM DeleteActivityCmd](#) : Prepare and send GAPM_ACTIVITY_DELETE_CMD to delete activity/activities.
- [GAPM SetAdvDataCmd](#) : Prepare and send GAPM_SET_ADV_DATA_CMD to set an advertising data or scan response data or periodic advertising data.
- [GAPM MsgHandler](#) : Message handler for GAPM events.
- [GAPC ParamUpdateCmd](#) : Prepare and send GAPC_PARAM_UPDATE_CMD to perform an update on parameters.
- [GAPC ParamUpdateCfm](#) : Prepare and send GAPC_PARAM_UPDATE_CFM to accept or reject connection parameters.
- [GAPC ConnectionCfm](#) : Prepare and send GAPC_CONNECTION_CFM in a response to connection request.
- [GAPC DisconnectCmd](#) : Prepare and send GAPC_DISCONNECT_CMD to disconnect link.
- [GAPC IsConnectionActive](#) : Check if the specified connection is active.
- [GAPC DisconnectAll](#) : Prepare and send GAPC_DISCONNECT_CMD to disconnect all the links.
- [GAPC ConnectionCount](#) : Get the number of active connection count.
- [GAPC MasterConnectionCount](#) : Get the master connection count.
- [GAPC SlaveConnectionCount](#) : Get the slave connection count.
- [GAPC GetConnectionInfo](#) : Get the connection information of a specified connection ID.
- [GAPC GetDevInfoCfm Name](#) : Prepare and send GAPC_GET_DEV_INFO_CFM to send the device name.
- [GAPC GetDevInfoCfm Appearance](#) : Prepare and send GAPC_GET_DEV_INFO_CFM to send the device appearance.
- [GAPC GetDevInfoCfm SlvPrefParams](#) : Prepare and send GAPC_GET_DEV_INFO_CFM to send device slave preferred parameters.
- [GAPC GetDevInfoCfm](#) : Prepare and send GAPC_GET_DEV_INFO_CFM to send requested information.
- [GAPC SetDevInfoCfm](#) : Prepare and send GAPC_SET_DEV_INFO_CFM to confirm if the requested device information was written.
- [GAPC BondCfm](#) : GAPC bond and encryption operations.
- [GAPC EncryptCmd](#) : Prepare and send GAPC_ENCRYPT_CMD to request encrypting the connection link.
- [GAPC EncryptCfm](#) : Prepare and send GAPC_ENCRYPT_CFM to confirm an encryption request.
- [GAPC IsBonded](#) : Check if the connection is bonded.
- [GAPC GetBondInfo](#) : Get bond information for the connection.
- [GAPC BondCmd](#) : Prepare and send GAPC_BOND_CMD to initiate a bond procedure.
- [GAPC AddRecordToBondList](#) : Add record to bond list.
- [GAPC MsgHandler](#) : GAPC message handler.
- [GAPM ListSetWICmd](#) : Prepare and send GAPM_LIST_SET_CMD to set the white list content.
- [GAPM ListSetRalCmd](#) : Prepare and send GAPM_LIST_SET_CMD to set the resolving list content.
- [GAPM IsIRKValid](#) : Check if IRK is valid.
- [WhiteList ResolvableList Update](#) : Update the white list and the resolve List.
- [GAPM GetWhitelistNumDev](#) : Get number of devices in whitelist.
- [GAPM SetWhitelistNumDev](#) : Set the number of devices in whitelist.
- [GAPC SetPhyCmd](#) : GAPC PHY management operations.
- [GAPC CteTxCfgCmd](#) : GAPC constant Tone extension operations.
- [GAPC CteRxCfgCmd](#) : Prepare and send GAPC_CTE_RX_CFG_CMD to configure CTE RX.
- [GAPC CteReqCtrlCmd](#) : Prepare and send GAPC_CTE_REQ_CTRL_CMD to control CTE requests.
- [GAPC CteRspCtrlCmd](#) : Prepare and send GAPC_CTE_RSP_CTRL_CMD to control CTE reception.
- [GAPC GetInfoCmd](#) : GAPC local and peer device information operations.
- [GAPM PerAdvCteTxCmd](#) : Prepare and send GAPM_PER_ADV_CTE_TX_CTL_CMD to control CTE transmission in a periodic advertising activity.

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- [GAPM_PerAdvReportCtrlCmd](#) : Prepare and send GAPM_PER_ADV_REPORT_CTRL_CMD to control reception of periodic advertising report in a periodic advertising sync activity.
- [GAPM_PerSyncIQSamplingCtrlCmd](#) : Prepare and send GAPM_PER_SYNC_IQ_SAMPLING_CTRL_CMD to control capturing IQ samples from the constant tone extension of periodic advertising packets.
- [GATT_Initialize](#) : GATT initialization.
- [GATT_GetEnv](#) : Get GATT environment.
- [GATT_SetEnvData](#) : Set GATT environment data.
- [GATT_GetMaxCustomServiceNumber](#) : Get the maximum number of custom services in GATT.
- [GATTM_GetServiceAddedCount](#) : Get GATT added services count.
- [GATTM_ResetServiceAttributeDatabaseID](#) : Resets GATT services attribute database ID.
- [GATTM_AddAttributeDatabase](#) : Add service and attributes to the Bluetooth stack.
- [GATTM_GetHandle](#) : Get the handle for an attribute.
- [GATTM_MsgHandler](#) : Handle GATTM messages.
- [GATTC_Initialize](#) : GATTC initialization.
- [GATTC_DiscByUUIDSvc](#) : GATTC services discovery by UUID.
- [GATTC_DiscAllSvc](#) : GATTC all services discovery.
- [GATTC_DiscAllChar](#) : GATTC all characteristics discovery.
- [GATTC_SendEvtCmd](#) : GATTC send event.
- [GATTC_SendEvtCfm](#) : GATTC send event confirmation.
- [GATTC_MtuExchange](#) : Prepare and send GATTC_EXC_MTU_CMD to start MTU exchange procedure.
- [GATTC_ReadReqInd](#) : GATTC handle read request indication.
- [GATTC_WriteReqInd](#) : GATTC handle write request indication.
- [GATTC_AttnfoReqInd](#) : GATTC request attribute information.
- [GATTC_MsgHandler](#) : Handle GATTM messages.
- [Device_BLE_Public_Address_Read](#) : Read the Bluetooth public address to ble_public_addr.
- [Device_BLE_Param_Get](#) : Read BLE device parameters.
- [rand_func](#) : Generate a pseudo-random number.
- [set_app_rand_func](#) : Sets random number generator function to be used by the BLE stack when calling [rand_func\(\)](#)
- [srand_func](#) : Seeds pseudo-random number generator used by function rand()
- [set_app_rand_seed_val](#) : Sets seed value to be used by the BLE stack when calling [srand_func\(\)](#)
- [default_rf_rssi_func](#) : Default RF to RSSI conversion function to be used by the BLE stack when calling Device_RF_RSSI_Convert().
- [set_app_rf_rssi_func](#) : Sets RF to RSSI conversion function to be used by the BLE stack when calling Device_RF_RSSI_Convert()
- [MsgHandler_GetTaskAppDesc](#) : Provide an application task descriptor with default handler set to the MsgHandler_Notify function.
- [MsgHandler_Add](#) : Add/subscribe a message handler callback function.
- [MsgHandler_Notify](#) : Notify the callback functions associated with the msg_id.
- [BASC_Initialize](#) : Initialize BASC environment.
- [BASC_EnableReq](#) : Enable the client role of the BAS.
- [BASC_ReadInfoReq](#) : Prepare and send BASC_READ_INFO_REQ to read value from peer.
- [BASC_BattLevelNtfCfgReq](#) : Send a request to change notification configuration.
- [BASC_RequestBattLevelOnTimeout](#) : Send a request for periodic battery level update.
- [BASC_GetLastBatteryLevel](#) : Read the most recent battery level.
- [BASC_GetEnv](#) : Get the BASC environment.
- [BASC_MsgHandler](#) : Handle the BASC events.
- [BASS_Initialize](#) : Initialize BASS environment.
- [BASS_NotifyOnTimeout](#) : BASS configure periodic notification.

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- [BASS NotifyOnBattLevelChange](#) : BASS notify peers on battery level change.
- [BASS ProfileTaskAddCmd](#) : Add a battery profile in kernel.
- [BASS EnableReq](#) : Enable the server role in BAS.
- [BASS BattLevelUpdReq](#) : Prepare and send BASS_BATT_LEVEL_UPD_REQ for battery level notification.
- [BASS GetEnv](#) : Get the BASS environment.
- [BASS IsAdded](#) : Check if the BASS is added successfully.
- [BASS MsgHandler](#) : Handle BASS messages.
- [DISS Initialize](#) : Initialize the device information server service environment and configure message handlers.
- [DISS ProfileTaskAddCmd](#) : Send a request to add the device information service in kernel and database.
- [DISS EnvGet](#) : Return a reference to the internal DISS environment structure.
- [DISS IsAdded](#) : Return a boolean indication if the DISS server has been successfully added to the services database.
- [DISS MsgHandler](#) : Handle all the events related to the device information service server.
- [DISS DeviceInfoValueReqInd](#) : Handle the indication when the peer device requests a value.

20.2 DETAILED DESCRIPTION

This reference chapter presents a detailed description of all the support provided for the Bluetooth Low Energy Stack Abstraction. This reference includes calling parameters, returned values, and assumptions.

20.3 BLUETOOTH LOW ENERGY STACK ABSTRACTION TYPEDEF DOCUMENTATION

20.3.1 MsgHandlerCallback_t

```
typedef void(* MsgHandlerCallback_t
```

Location: msg_handler.h:33

BLE abstraction message handler function type.

20.4 BLUETOOTH LOW ENERGY STACK ABSTRACTION VARIABLE DOCUMENTATION

20.4.1 ble_dev_params

```
struct ble_device_parameter ble_dev_params
```

Location: ble_protocol_support.h:1

Structure to save BLE device parameters provided by the application.

20.5 BLUETOOTH LOW ENERGY STACK ABSTRACTION DATA STRUCTURES TYPE DOCUMENTATION

20.5.1 GAPM_ActivityStatus_t

Location: ble_gap.h:137

GAPM activity status.

Data Fields

Type	Name	Description
uint8_t	<i>actv_idx</i>	Activity identifier.
enum gapm_actv_type	<i>type</i>	GAPM activity type.
enum gapm_activity_state	<i>state</i>	GAPM activity state.
bool	<i>advDataSet</i>	True if advertisement data is set.
bool	<i>scanRspDataSet</i>	True if scan response data is set.

20.5.2 GAP_Env_t

Location: ble_gap.h:149

GAP environment.

Data Fields

Type	Name	Description
enum gapm_state	<i>gapmState</i>	State of GAPM.
uint16_t	<i>profileAddedCount</i>	of standard BLE profile added
struct gapm_set_dev_config_cmd	<i>deviceConfig</i>	Device configuration for GAPM_SET_DEV_CONFIG.

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struct gapc_connection_req_ind	<i>connection[APP_MAX_NB_CON]</i>	GAPC_CONNECTION_REQ_IND information of connections.
BondInfo_t	<i>bondInfo[APP_MAX_NB_CON]</i>	Bond information of connections.
GAPM ActivityStatus_t *	<i>actv[APP_MAX_NB_ACTIVITY]</i>	GAPM activity status of activities.
uint16_t	<i>profileAddedTaskId [APP_MAX_NB_PROFILES]</i>	Task IDs for added profiles.

20.5.3 att_db_desc

Location: ble_gatt.h:151

Custom service attribute database description.

Data Fields

Type	Name	Description
uint16_t	<i>att_idx</i>	Convert into uint8_t.
struct gattm_att_desc	<i>att</i>	GATTM Attribute description structure.
bool	<i>is_service</i>	True if it is service.
uint16_t	<i>length</i>	Total number of characteristics to add.
void *	<i>data</i>	Pointer to data.
uint8_t (*)	<i>callback)(uint8_t conidx, uint16_t attidx, uint16_t handle, uint8_t *toData, const uint8_t *fromData, uint16_t lenData, uint16_t operation, uint8_t hl_status, uint8_t *cfm_msg_instr)</i>	Pointer to callback function.

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20.5.4 `cust_svc_desc`

Location: `ble_gatt.h:170`

Custom service descriptor.

Data Fields

Type	Name	Description
<code>uint16_t</code>	<code>cust_svc_start_hdl</code>	Start handle array of custom services in the stack's attribute database.
<code>const struct att_db_desc *</code>	<code>cust_svc_att_db</code>	Custom services attribute database.
<code>uint16_t</code>	<code>cust_svc_att_db_len</code>	Custom service attribute database length.

20.5.5 `GATT_Env_t`

Location: `ble_gatt.h:181`

GATT environment.

Data Fields

Type	Name	Description
<code>uint16_t</code>	<code>addedSvcCount</code>	Counter of successfully added custom service/s in stack.
<code>uint16_t *</code>	<code>discSvcCount</code>	Counter of discovered service/s per connection id.
<code>cust_svc_desc *</code>	<code>cust_svc_db</code>	Custom service database array.
<code>uint16_t</code>	<code>max_cust_svc</code>	Maximum number of custom services.
<code>const struct att_db_desc *</code>	<code>att_db</code>	Attribute database specific to related custom service.
<code>uint16_t</code>	<code>att_db_len</code>	Length of attribute database specific to related custom service.

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20.5.6 low_power_clock

Location: ble_protocol_support.h:46

Application defined low power clocks and sources.

Data Fields

Type	Name	Description
uint8_t	<i>low_pwr_clk_xtal32</i>	Value of LPCLK_SRC_XTAL32 from application.
uint8_t	<i>low_pwr_clk_rc32</i>	Value of LPCLK_SRC_RC32 from application.
uint8_t	<i>low_pwr_standby_clk_src</i>	Value of LPCLK_STANDBYCLK_SRC from application.

20.5.7 ble_device_parameter

Location: ble_protocol_support.h:56

Application defined BLE device parameters used by BLE stack.

Data Fields

Type	Name	Description
uint32_t	<i>low_pwr_clk_accuracy</i>	Low power clock accuracy in ppm.
uint32_t	<i>twosc</i>	TWOSC us.
uint32_t	<i>rf_tx_power_dbm</i>	The default TX power in dbm.
struct low power clock	<i>low_pwr_clk</i>	Low power clock selection.

20.5.8 BASC_Env_t

Location: ble_basc.h:36

RSL15 Firmware Reference

Battery service client environment.

Data Fields

Type	Name	Description
struct gapm_profile_added_ind	<i>profile_added_ind</i>	Profile service handle.
uint32_t	<i>battLevelReqTimeout</i>	Timeout for periodic battery level request.
uint8_t	<i>bas_nb[APP_MAX_NB_CON]</i>	Number of battery instances [1,BASC_NB_BAS_INSTANCES_MAX].
bool	<i>enabled[APP_MAX_NB_CON]</i>	The flag that indicates that service has been enabled.
uint8_t	<i>batt_lv[APP_MAX_NB_CON][BASC_NB_BAS_INSTANCES_MAX]</i>	Battery level characteristic value.
uint8_t	<i>ntf_cfg[APP_MAX_NB_CON][BASC_NB_BAS_INSTANCES_MAX]</i>	Notification configuration.
uint8_t	<i>req_ntf_cfg[APP_MAX_NB_CON][BASC_NB_BAS_INSTANCES_MAX]</i>	Control notification is required or not.
struct prf_char_pres_fmt	<i>char_pres_format [APP_MAX_NB_CON][BASC_NB_BAS_INSTANCES_MAX]</i>	Battery level characteristic presentation format descriptor value structure
struct bas_content	<i>bas[APP_MAX_NB_CON][BASC_NB_BAS_INSTANCES_MAX]</i>	Battery service content structure.

20.5.9 BASS_Env_t

Location: ble_bass.h:37

RSL15 Firmware Reference

Battery service server environment.

Data Fields

Type	Name	Description
uint8_t	<i>bas_nb</i>	Number of battery instances [1,BASS_NB_BAS_INSTANCES_MAX].
uint8_t	<i>batt_ntf_cfg[APP_MAX_NB_CON]</i>	The current value of CCCD of battery value that has been set by the client device.
bool	<i>enabled[APP_MAX_NB_CON]</i>	The flag that indicates that service has been enabled.
uint32_t	<i>battLevelNotificationTimeout</i>	Timeout value for sending batter level notification.
bool	<i>battLevelNotificationTimerEnqueued</i>	Flag that tells whether the timer for battery level notification is enabled or not.
uint32_t	<i>battLevelMonitoringTimeout</i>	Timeout value for battery level monitoring.
bool	<i>battLevelMonitoringTimerEnqueued</i>	Flag that tells whether the timer for monitoring battery level is enabled or not.
uint8_t	<i>lastBattLevel[BASS_NB_BAS_INSTANCES_MAX]</i>	Most recent value of battery level.
uint8_t (*)	<i>readBattLevelCallback)(uint8_t bas_nb)</i>	Pointer to an application function that returns the battery level.
struct gapm_profile_added_ind	<i>profile_added_ind</i>	Profile service handle.

20.5.10 DISS_DeviceInfoField_t

Location: ble_diss.h:37

Global DISS specific info structure.

Data Fields

Type	Name	Description
uint8_t	<i>len</i>	Length of data.
uint8_t *	<i>data</i>	Pointer to data.

RSL15 Firmware Reference

20.5.11 DISS_DeviceInfo_t

Location: ble_diss.h:46

Global DISS info compilation structure.

Data Fields

Type	Name	Description
struct DISS_DeviceInfoField_t	<i>MANUFACTURER_NAME</i>	Manufacturer name characteristic.
struct DISS_DeviceInfoField_t	<i>MODEL_NB_STR</i>	Model number string characteristic.
struct DISS_DeviceInfoField_t	<i>SERIAL_NB_STR</i>	Serial number string characteristic.
struct DISS_DeviceInfoField_t	<i>FIRM_REV_STR</i>	Firmware revision string characteristic.
struct DISS_DeviceInfoField_t	<i>SYSTEM_ID</i>	System ID characteristic.
struct DISS_DeviceInfoField_t	<i>HARD_REV_STR</i>	Hardware revision string characteristic.
struct DISS_DeviceInfoField_t	<i>SW_REV_STR</i>	Software revision string characteristic.
struct DISS_DeviceInfoField_t	<i>IEEE</i>	IEEE 11073-20601 regulatory certification data characteristic.
struct DISS_DeviceInfoField_t	<i>PNP</i>	PnP ID characteristic.

20.5.12 DISS_Env_t

Location: ble_diss.h:63

DISS state structure.

Data Fields

Type	Name	Description
uint16_t	<i>features</i>	DISS features that will be enabled. See <code>diss_task.h</code> for reference
bool	<i>serviceAdded</i>	The flag that indicates that service has been added.
const struct DISS_DeviceInfo t *	<i>deviceInfo</i>	DISS device information compilation structure arm.

20.6 BLUETOOTH LOW ENERGY STACK ABSTRACTION ENUMERATION TYPE DOCUMENTATION**20.6.1 gapm_activity_state**

Location: `ble_gap.h`:115

GAPM activity state.

Members

- `ACTIVITY_STATE_NOT_CREATED = 0`

GAPM Activity state value when activity state not created.

- `ACTIVITY_STATE_CREATING`

GAPM Activity state value when start creating activity.

- `ACTIVITY_STATE_NOT_STARTED`

GAPM Activity state value when not started.

- `ACTIVITY_STATE_STARTING`

GAPM Activity state value when activity state is starting.

- `ACTIVITY_STATE_STARTED`

GAPM Activity state value when activity state is started.

20.6.2 `gapm_state`

Location: `ble_gap.h:127`

GAPM state.

Members

- `GAPM_STATE_INITIAL = 0`

Initial state, before a `GAPM_RESET` is performed.

- `GAPM_STATE_RESET`

After `GAPM_RESET`, before the device is configured.

- `GAPM_STATE_READY`

After the device is configured with `GAPM_SetDeviceConfig`.

20.6.3 `cfm_msg_instr_enum`

Location: `ble_gatt.h:142`

RSL15 Firmware Reference

Instructions to send or withhold confirmation message.

Members

- `CFM_MSG_INSTR_TO_SEND = 0x00`
- `CFM_MSG_INSTR_NOT_TO_SEND`

20.6.4 basc_app_msg_id

Location: `ble_basc.h:70`

BASC application task messages.

Members

- `BASC_BATT_LEVEL_REQ_TIMEOUT = TASK_FIRST_MSG(TASK_ID_BASC) + 50`

BASC battery level request timeout id.

20.6.5 bass_app_msg_id

Location: `ble_bass.h:64`

BASS application task messages.

Members

- `BASS_BATT_LEVEL_NTF_TIMEOUT = TASK_FIRST_MSG(TASK_ID_BASS) + 50`

BASS battery level notification timeout ID.

RSL15 Firmware Reference

- BASS_BATT_MONITORING_TIMEOUT

BASS battery level monitor timeout ID.

- BASS_BATT_LEVEL_CHANGED

BASS battery level change ID.

20.7 BLUETOOTH LOW ENERGY STACK ABSTRACTION MACRO DEFINITION DOCUMENTATION

20.7.1 GAPM_CFG_ADDR_PUBLIC

```
#define GAPM_CFG_ADDR_PUBLIC (0 << GAPM_PRIV_CFG_PRIV_ADDR_POS)
```

GAPM privacy configuration identity address public.

Location: ble_gap.h:36

20.7.2 GAPM_CFG_ADDR_PRIVATE

```
#define GAPM_CFG_ADDR_PRIVATE (1 << GAPM_PRIV_CFG_PRIV_ADDR_POS)
```

GAPM privacy configuration identity address private.

Location: ble_gap.h:39

20.7.3 GAPM_CFG_HOST_PRIVACY

```
#define GAPM_CFG_HOST_PRIVACY (0 << GAPM_PRIV_CFG_PRIV_EN_POS)
```

GAPM privacy configuration set to host privacy.

Location: ble_gap.h:42

RSL15 Firmware Reference

20.7.4 GAPM_CFG_CONTROLLER_PRIVACY

```
#define GAPM_CFG_CONTROLLER_PRIVACY (1 << GAPM_PRIV_CFG_PRIV_EN_POS)
```

GAPM privacy configuration set to controller privacy.

Location: ble_gap.h:45

20.7.5 GAPM_DEFAULT_ROLE

```
#define GAPM_DEFAULT_ROLE GAP_ROLE_ALL
```

GAPM default device configuration (used in GAPM_SET_DEV_CONFIG_CMD)

Default device role is both peripheral and central

Location: ble_gap.h:52

20.7.6 GAPM_DEFAULT_RENEW_DUR

```
#define GAPM_DEFAULT_RENEW_DUR 60
```

Default duration for regenerating device address when privacy is enabled (in seconds)

Location: ble_gap.h:55

20.7.7 GAPM_DEFAULT_GAP_START_HDL

```
#define GAPM_DEFAULT_GAP_START_HDL 0
```

Default start handle for GAP service (dynamically allocated)

Location: ble_gap.h:57

20.7.8 GAPM_DEFAULT_GATT_START_HDL

```
#define GAPM_DEFAULT_GATT_START_HDL 0
```

RSL15 Firmware Reference

Default start handle for GATT service (dynamically allocated)

Location: ble_gap.h:59

20.7.9 GAPM_DEFAULT_ATT_CFG

```
#define GAPM_DEFAULT_ATT_CFG 0
```

Default attribute database configuration.

Location: ble_gap.h:60

20.7.10 GAPM_DEFAULT_TX_OCT_MAX

```
#define GAPM_DEFAULT_TX_OCT_MAX 0xfb
```

Default value for the controller's maximum transmitted number of payload octets to be used.

Location: ble_gap.h:63

20.7.11 GAPM_DEFAULT_TX_TIME_MAX

```
#define GAPM_DEFAULT_TX_TIME_MAX (14 * 8 \
+ \
GAPM\_DEFAULT\_TX\_OCT\_MAX \
* 8)
```

Suggested value for the controller's maximum packet transmission time to be used.

Location: ble_gap.h:66

20.7.12 GAPM_DEFAULT_MTU_MAX

```
#define GAPM_DEFAULT_MTU_MAX 0x200
```

Default maximum MTU acceptable for device (L2CAP)

Location: ble_gap.h:71

20.7.13 GAPM_DEFAULT_MPS_MAX

```
#define GAPM_DEFAULT_MPS_MAX 0x200
```

Default maximum MPS (L2CAP)

Location: ble_gap.h:72

20.7.14 GAPM_DEFAULT_MAX_NB_LECB

```
#define GAPM_DEFAULT_MAX_NB_LECB 0
```

Default maximum number of LE Credit based connection that can be established (L2CAP)

Location: ble_gap.h:75

20.7.15 GAPM_DEFAULT_AUDIO_CFG

```
#define GAPM_DEFAULT_AUDIO_CFG 0
```

Default LE Audio Mode Configuration.

Location: ble_gap.h:76

20.7.16 GAP_ROLE_MASTER

```
#define GAP_ROLE_MASTER 0
```

GAP master.

Location: ble_gap.h:77

20.7.17 GAP_ROLE_SLAVE

```
#define GAP_ROLE_SLAVE 1
```

GAP slave.

Location: ble_gap.h:78

RSL15 Firmware Reference

20.7.18 GAPM_DEFAULT_ADV_DATA

```
#define GAPM_DEFAULT_ADV_DATA { 7, GAP_AD_TYPE_COMPLETE_NAME, \
                                'O', 'N', ' ', 'B', 'L', 'E', \
                                3, GAP_AD_TYPE_MANU_SPECIFIC_DATA, \
                                0x62, 0x3 }
```

Default advertisement data (length, data)

Location: ble_gap.h:80

20.7.19 GAPM_DEFAULT_ADV_DATA_LEN

```
#define GAPM_DEFAULT_ADV_DATA_LEN 12
```

Default length of advertisement data.

Location: ble_gap.h:84

20.7.20 GAPM_DEFAULT_SCANRSP_DATA

```
#define GAPM_DEFAULT_SCANRSP_DATA GAPM\_DEFAULT\_ADV\_DATA
```

Default scan response data.

Location: ble_gap.h:85

20.7.21 GAPM_DEFAULT_SCANRSP_DATA_LEN

```
#define GAPM_DEFAULT_SCANRSP_DATA_LEN GAPM\_DEFAULT\_ADV\_DATA\_LEN
```

Default length of scan response data.

Location: ble_gap.h:86

20.7.22 GAPM_DEFAULT_SCAN_INTERVAL

```
#define GAPM_DEFAULT_SCAN_INTERVAL 100
```

GAPM default StartConnectionCmd configuration (GAPM_START_CONNECTION_CMD)

Default scan interval 62.5ms

Location: ble_gap.h:89

20.7.23 GAPM_DEFAULT_SCAN_WINDOW

```
#define GAPM_DEFAULT_SCAN_WINDOW 50
```

Scan window to 50% of the interval.

Location: ble_gap.h:90

20.7.24 GAPM_DEFAULT_CON_INTV_MIN

```
#define GAPM_DEFAULT_CON_INTV_MIN 20
```

Default connection interval and slave latency.

25 ms (units of 1.25ms)

Location: ble_gap.h:93

20.7.25 GAPM_DEFAULT_CON_INTV_MAX

```
#define GAPM_DEFAULT_CON_INTV_MAX 20
```

25 ms (units of 1.25ms)

Location: ble_gap.h:94

20.7.26 GAPM_DEFAULT_CON_LATENCY

```
#define GAPM_DEFAULT_CON_LATENCY 0
```

RSL15 Firmware Reference

Slave latency: number of events that can be missed while maintaining a connection.

Location: ble_gap.h:96

20.7.27 GAPM_DEFAULT_SUPERV_TO

```
#define GAPM_DEFAULT_SUPERV_TO 300
```

Default supervisory timeout.

3 seconds

Location: ble_gap.h:99

20.7.28 GAPM_DEFAULT_CE_LEN_MIN

```
#define GAPM_DEFAULT_CE_LEN_MIN 2 * GAPM\_DEFAULT\_CON\_INTV\_MIN
```

Recommended minimum duration of connection events 40 ms.

Location: ble_gap.h:101

20.7.29 GAPM_DEFAULT_CE_LEN_MAX

```
#define GAPM_DEFAULT_CE_LEN_MAX 2 * GAPM\_DEFAULT\_CON\_INTV\_MAX
```

Recommended maximum duration of connection events 40 ms.

Location: ble_gap.h:103

20.7.30 GAPM_DEFAULT_ADV_INTV_MIN

```
#define GAPM_DEFAULT_ADV_INTV_MIN 64
```

Advertising minimum and maximum interval.

40ms (64*0.625ms)

Location: ble_gap.h:106

20.7.31 GAPM_DEFAULT_ADV_INTV_MAX

```
#define GAPM_DEFAULT_ADV_INTV_MAX 64
```

40ms (64*0.625ms)

Location: ble_gap.h:107

20.7.32 GAPM_DEFAULT_ADV_CHMAP

```
#define GAPM_DEFAULT_ADV_CHMAP 0x07
```

Advertising channel map - 37, 38, 39.

Location: ble_gap.h:110

20.7.33 GATTC_DEFAULT_START_HDL

```
#define GATTC_DEFAULT_START_HDL 0x0001
```

Default GATTC handles.

GATTC default start handle

Location: ble_gatt.h:35

20.7.34 GATTC_DEFAULT_END_HDL

```
#define GATTC_DEFAULT_END_HDL 0xFFFF
```

GATTC default end handle.

Location: ble_gatt.h:36

RSL15 Firmware Reference

20.7.35 CS_SERVICE_UUID_16

```
#define CS_SERVICE_UUID_16 { srvidx, { uuid, PERM(SVC_UUID_LEN, UUID_16), 0, 0 }, true,
0, NULL, NULL }
```

Macros to declare a (custom) service with 16, 32 and 128 bit UUID srvidx Service index uuid Service UUID.

Custom service with 16 bit UUID

Location: ble_gatt.h:42

20.7.36 CS_SERVICE_UUID_32

```
#define CS_SERVICE_UUID_32 { srvidx, { uuid, PERM(SVC_UUID_LEN, UUID_32), 0, 0 }, true,
0, NULL, NULL }
```

Custom service with 32 bit UUID.

Location: ble_gatt.h:45

20.7.37 CS_SERVICE_UUID_128

```
#define CS_SERVICE_UUID_128 { srvidx, { uuid, PERM(SVC_UUID_LEN, UUID_128), 0, 0 }, true,
0, NULL, NULL }
```

Custom service with 128 bit UUID.

Location: ble_gatt.h:48

20.7.38 CS_ATT_SERVICE_128

```
#define CS_ATT_SERVICE_128 { 0x00, 0x28, 0x00, 0x00, 0x00, 0x00, 0x00, \
                                0x00, 0x00, 0x00, 0x00, 0x00, 0x00, \
                                0x00, 0x00, 0x00 }
```

Standard declaration/description UUIDs in 16-byte format.

Custom service attribute

RSL15 Firmware Reference

Location: ble_gatt.h:52

20.7.39 CS_ATT_CHARACTERISTIC_128

```
#define CS_ATT_CHARACTERISTIC_128 { 0x03, 0x28, 0x00, 0x00, 0x00, 0x00, 0x00, \
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, \
    0x00, 0x00, 0x00 }
```

Custom service characteristic.

Location: ble_gatt.h:55

20.7.40 CS_ATT_CLIENT_CHAR_CFG_128

```
#define CS_ATT_CLIENT_CHAR_CFG_128 { 0x02, 0x29, 0x00, 0x00, 0x00, 0x00, 0x00, \
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, \
    0x00, 0x00, 0x00 }
```

Custom service attribute for client characteristic configuration.

Location: ble_gatt.h:59

20.7.41 CS_ATT_CHAR_USER_DESC_128

```
#define CS_ATT_CHAR_USER_DESC_128 { 0x01, 0x29, 0x00, 0x00, 0x00, 0x00, 0x00, \
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, \
    0x00, 0x00, 0x00 }
```

Custom service attribute characteristic user description.

Location: ble_gatt.h:63

20.7.42 CS_CHAR_UUID_16

```
#define CS_CHAR_UUID_16 { attidx_char, { CS\_ATT\_CHARACTERISTIC\_128, PERM(RD, ENABLE), 0, \
0 }, false, 0, NULL, NULL }, \
    { attidx_val, { uuid, perm, length, PERM(RI, ENABLE) | PERM(UUID_LEN, UUID_16) }, \
false, length, data, callback }
```

Macros to define characteristics with 16, 32 and 128 bit UUID attidx_char: Characteristic attribute index attidx_val:
Value attribute index uuid UUID perm Permissions (see gattm_att_desc) length Maximum length value (in bytes) data

RSL15 Firmware Reference

Pointer to the data structure in the application callback Function to transfer the data between the application and the GATTM.

Custom service characteristic with 16 bit UUID

Location: ble_gatt.h:83

20.7.43 CS_CHAR_UUID_32

```
#define CS_CHAR_UUID_32 { attidx_char, { CS\_ATT\_CHARACTERISTIC\_128, PERM(RD, ENABLE), 0,
0 }, false, 0, NULL, NULL }, \
    { attidx_val, { uuid, perm, length, PERM(RI, ENABLE) | PERM(UUID_LEN, UUID_32) },
false, length, data, callback }
```

Custom service characteristic with 32 bit UUID.

Location: ble_gatt.h:95

20.7.44 CS_CHAR_UUID_128

```
#define CS_CHAR_UUID_128 { attidx_char, { CS\_ATT\_CHARACTERISTIC\_128, PERM(RD, ENABLE), 0,
0 }, false, 0, NULL, NULL }, \
    { attidx_val, { uuid, perm, length, PERM(RI, ENABLE) | PERM(UUID_LEN, UUID_128) },
false, length, data, callback }
```

Custom service characteristic with 128 bit UUID.

Location: ble_gatt.h:106

20.7.45 CS_CHAR_CCC

```
#define CS_CHAR_CCC { attidx, { CS\_ATT\_CLIENT\_CHAR\_CFG\_128, PERM(RD, ENABLE) | PERM
(WRITE_REQ, ENABLE), 0, PERM(RI, ENABLE) }, false, 2, \
    data, \
    callback }
```

Macro to add to the characteristic a CCC attidx CCC attribute index data Pointer to the 2-byte CCC data value in the application callback Function to transfer the CCC data between the application and the GATTM.

Location: ble_gatt.h:114

RSL15 Firmware Reference

20.7.46 CS_CHAR_USER_DESC

```
#define CS_CHAR_USER_DESC { attidx, { CS\_ATT\_CHAR\_USER\_DESC\_128, PERM(RD, ENABLE),  
length, PERM(RI, ENABLE) }, false, length, data, callback }
```

Macro to add to the characteristic a user description attidx Description attribute index length Description length (in bytes) data Pointer to the description string (constant) callback Function to transfer the description string to the GATTM.

Location: ble_gatt.h:124

20.7.47 MIN

```
#define MIN ((a) < (b)) ? (a) : (b)
```

Macro to Find Minimum.

Location: ble_gatt.h:128

20.7.48 HCI_VS_RF_CW_ENABLE_CMD_CODE

```
#define HCI_VS_RF_CW_ENABLE_CMD_CODE 0x01
```

Vendor specific to enable CW (RX or TX)

Location: ble_protocol_support.h:33

20.7.49 HCI_VS_RF_CW_DISABLE_CMD_CODE

```
#define HCI_VS_RF_CW_DISABLE_CMD_CODE 0x02
```

Vendor specific to enable CW (RX or TX)

Location: ble_protocol_support.h:36

20.7.50 HCI_VS_RF_OUTPUT_PWR_CMD_CODE

```
#define HCI_VS_RF_OUTPUT_PWR_CMD_CODE 0x03
```

Vendor specific to set desired output power.

Location: ble_protocol_support.h:39

20.8 BLUETOOTH LOW ENERGY STACK ABSTRACTION FUNCTION DOCUMENTATION

20.8.1 GAP_Initialize

```
void GAP_Initialize()
```

Initialize GAP environment.

Initialize GAP environment after each GAPM reset.

Location: ble_gap.h:167

20.8.2 GAP_GetEnv

```
const GAP\_Env\_t * GAP_GetEnv()
```

Get GAP environment.

Initialize GAP environment after each GAPM reset.

Location: ble_gap.h:176

Return

Pointer to GAP environment structure

20.8.3 GAP_GetProfileAddedTaskId

```
uint16_t * GAP_GetProfileAddedTaskId()
```

RSL15 Firmware Reference

Get GAP environment added profiles task identifiers.

Location: ble_gap.h:183

Return

Pointer to an array of added profiles task identifiers

20.8.4 GAP_IsAddrPrivateResolvable

```
bool GAP_IsAddrPrivateResolvable(const uint8_t * addr, uint8_t addrType)
```

Check address if its private resolvable.

Location: ble_gap.h:192

Parameters

Direction	Name	Description
in	<i>addr</i>	Pointer to address
in	<i>addrType</i>	Type of address

Return

True if address is private resolvable false otherwise

20.8.5 GAP_AddAdvData

```
bool GAP_AddAdvData(bool isExtendedAdv, uint8_t newDataLen, enum gap_ad_type newDataFlag,
const uint8_t * newData, uint8_t * resultAdvData, uint8_t * resultAdvDataLen)
```

Add GAP advertise data.

Add BLE advertisement data and scan response data to buffer

RSL15 Firmware Reference

Location: ble_gap.h:207

Parameters

Direction	Name	Description
in	<i>isExtendedAdv</i>	If extended advertising is required
in	<i>newDataLen</i>	Advertisement data length to add
in	<i>newDataFlag</i>	Type of advertisement data
in	<i>newData</i>	Pointer to new advertisement data to add
in	<i>resultAdvData</i>	Pointer to resultant advertisement data buffer
in	<i>resultAdvDataLen</i>	Length of resultant advertisement data

Return

True if new advertisement data is added false otherwise

20.8.6 GAPM_ResetCmd

```
void GAPM_ResetCmd(enum gapm_operation operation)
```

Perform GAPM reset with specified GAPM operation.

Location: ble_gap.h:216

Parameters

Direction	Name	Description
in	<i>operation</i>	GAPM operation code

20.8.7 GAPM_SoftwareReset

```
void GAPM_SoftwareReset()
```

RSL15 Firmware Reference

Perform GAPM software reset.

Do software reset using GAPM_RESET operation.

Location: ble_gap.h:223

20.8.8 GAPM_PlatformReset

```
void GAPM_PlatformReset()
```

Perform GAPM platform reset.

Do platform reset using GAPM_PLF_RESET operation.

Location: ble_gap.h:230

20.8.9 GAPM_SetDevConfigCmd

```
void GAPM_SetDevConfigCmd(const struct gapm_set_dev_config_cmd * deviceConfig)
```

Prepare and send set the device configuration.

Set the device configuration such as device role, manage device address type, privacy configuration, GAP/GATT service start, configure data length extension, set specific write permissions in GAP database, enable or not audio features.

Location: ble_gap.h:244

Parameters

Direction	Name	Description
in	<i>deviceConfig</i>	Pointer to constant GAPM set device configuration command

NOTE: : This command is allowed only when no link is established

20.8.10 GAPM_GetDeviceConfig

```
const struct gapm_set_dev_config_cmd * GAPM_GetDeviceConfig()
```

get Device configuration

Get the device configuration such as device role, manage device address type, privacy configuration, GAP/GATT service start, configure data length extension, set specific write permissions in GAP database, enable or not audio features.

Location: ble_gap.h:256

Return

Pointer to constant constant GAPM set device configuration command

20.8.11 GAPM_ProfileTaskAddCmd

```
void GAPM_ProfileTaskAddCmd(uint8_t sec_lvl, uint16_t prf_task_id, uint16_t app_task,  
uint16_t start_hdl, uint8_t * param, uint32_t paramSize)
```

Prepare and Send GAPM_PROFILE_TASK_ADD_CMD to the Bluetooth stack.

Prepare and send GAPM_PROFILE_TASK_ADD_CMD to the Bluetooth stack to allocate a task for a specific profile (service or client).

Location: ble_gap.h:271

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>sec_lvl</i>	Security level
in	<i>prf_task_id</i>	Profile task identifier of profile to add
in	<i>app_task</i>	Application task number
in	<i>start_hdl</i>	Service start handle (0 for dynamically allocated in attribute database)
in	<i>param</i>	Pointer to parameter value to initialize profile
in	<i>paramSize</i>	Size of parameter

20.8.12 GAPM_GetProfileAddedCount

```
uint16_t GAPM_GetProfileAddedCount()
```

Get number of profiles added by the Bluetooth stack.

Get the GAP environment variable that keeps track of number of added GAPM profiles.

Location: ble_gap.h:281

Return

Number of GAPM profile added successfully

20.8.13 GAPM_LepsmRegisterCmd

```
void GAPM_LepsmRegisterCmd(uint16_t le_psm, uint16_t app_task, uint8_t sec_lvl)
```

Prepare and send GAPM_LEPSM_REGISTER_CMD to the Bluetooth stack.

Prepare and send GAPM_LEPSM_REGISTER_CMD to register an LE protocol/Service multiplexer ID in the device allowing a peer device to create LE credit based connection on it.

Location: ble_gap.h:293

RSL15 Firmware Reference

Parameters

Direction	Name	Description
in	<i>le_psm</i>	LE protocol/service multiplexer
in	<i>app_task</i>	Application task number
in	<i>sec_lvl</i>	Security level

20.8.14 GAPM_GenRandAddrCmd

```
void GAPM_GenRandAddrCmd(enum random_addr_type rnd_type)
```

Prepare and send GAPM_GEN_RANDOM_ADDR_CMD to the Bluetooth stack.

Prepare and send GAPM_LEPSM_REGISTER_CMD to generate a random device address without starting any air operation.

Location: ble_gap.h:303

Parameters

Direction	Name	Description
in	<i>rnd_type</i>	Random address type

20.8.15 GAPM_ResolveAddrCmd

```
void GAPM_ResolveAddrCmd(uint8_t conidx, const uint8_t * peerAddr)
```

Prepare and send GAPM_RESOLVE_ADDR_CMD to the Bluetooth stack.

Prepare and send GAPM_RESOLVE_ADDR_CMD to resolve a random address using array of IRK exchanged and bonded with device during pairing operation.

Location: ble_gap.h:314

RSL15 Firmware Reference

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier
in	<i>peerAddr</i>	Resolvable random address to solve

20.8.16 GAPM_ActivityCreateAdvCmd

```
bool GAPM_ActivityCreateAdvCmd(GAPM\_ActivityStatus\_t * actv_status, enum gapm_own_addr
own_addr_type, const struct gapm_adv_create_param * adv_param)
```

Prepare and send GAPM_ACTIVITY_CREATE_CMD to create an advertising activity.

Prepare and send GAPM_ACTIVITY_CREATE_CMD with operation GAPM_CREATE_ADV_ACTIVITY to create an advertising activity.

Location: ble_gap.h:327

Parameters

Direction	Name	Description
in	<i>actv_status</i>	Pointer to GAPM activity status
in	<i>own_addr_type</i>	Bluetooth device's own address type
in	<i>adv_param</i>	Pointer to constant advertising parameters structure

Return

False if no activity slot found, true otherwise

20.8.17 GAPM_ActivityCreateScanCmd

```
bool GAPM_ActivityCreateScanCmd(GAPM\_ActivityStatus\_t * actv_status, enum gapm_own_addr
own_addr_type)
```

RSL15 Firmware Reference

Prepare and send GAPM_ACTIVITY_CREATE_CMD to create scan activity.

Prepare and send GAPM_ACTIVITY_CREATE_CMD with operation GAPM_CREATE_SCAN_ACTIVITY to create scan activity.

Location: ble_gap.h:341

Parameters

Direction	Name	Description
in	<i>actv_status</i>	Pointer to GAPM activity status
in	<i>own_addr_type</i>	Bluetooth device's own address type

Return

False if no activity slot found, true otherwise

20.8.18 GAPM_ActivityCreateInitCmd

```
bool GAPM_ActivityCreateInitCmd(GAPM\_ActivityStatus\_t * actv_status, enum gapm_own_addr_
own_addr_type)
```

Prepare and send GAPM_ACTIVITY_CREATE_CMD to create an initiating activity.

Prepare and send GAPM_ACTIVITY_CREATE_CMD with operation GAPM_CREATE_INIT_ACTIVITY to create an initiating activity.

Location: ble_gap.h:354

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>actv_status</i>	Pointer to GAPM activity status
in	<i>own_addr_type</i>	Bluetooth device's own address type

Return

False if no activity slot found, true otherwise

20.8.19 GAPM_ActivityCreatePeriodSyncCmd

```
bool GAPM_ActivityCreatePeriodSyncCmd(GAPM\_ActivityStatus\_t * actv_status, enum gapm_own_addr own_addr_type)
```

Prepare and send GAPM_ACTIVITY_CREATE_CMD to create a periodic sync activity.

Prepare and send GAPM_ACTIVITY_CREATE_CMD with operation GAPM_CREATE_PERIOD_SYNC_ACTIVITY to create a periodic synchronization activity.

Location: ble_gap.h:367

Parameters

Direction	Name	Description
in	<i>actv_status</i>	Pointer to GAPM activity status
in	<i>own_addr_type</i>	Bluetooth device's own address type

Return

False if no activity slot found, true otherwise

20.8.20 GAPM_AdvActivityStart

```
bool GAPM_AdvActivityStart(uint8_t actv_idx, uint16_t duration, uint8_t max_adv_evt)
```

RSL15 Firmware Reference

Prepare and send GAPM_ACTIVITY_START_CMD to start an advertising activity.

Prepare and send GAPM_ACTIVITY_START_CMD to request the host to start a previously created advertising activity.

Location: ble_gap.h:383

Parameters

Direction	Name	Description
in	<i>actv_idx</i>	Activity identifier
in	<i>duration</i>	Advertising duration (in unit of 10ms). 0 means that advertising continues until the host disables it.
in	<i>max_adv_evt</i>	Maximum number of extended advertising events the controller shall attempt to send prior to terminating the extended advertising

Return

False if no activity slot found, true otherwise

20.8.21 GAPM_InitActivityStart

```
bool GAPM_InitActivityStart(uint8_t actv_idx, struct gapm_init_param * initParam)
```

Prepare and send GAPM_ACTIVITY_START_CMD to start an initiating activity.

Prepare and send GAPM_ACTIVITY_START_CMD to request the host to start previously created initiating activity.

Location: ble_gap.h:395

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>actv_idx</i>	Activity identifier
in	<i>initParam</i>	Pointer to initiating parameters structure

Return

False if no activity slot found, true otherwise

20.8.22 GAPM_ScanActivityStart

```
bool GAPM_ScanActivityStart(uint8_t actv_idx, struct gapm_scan_param * scanParam)
```

Prepare and send GAPM_ACTIVITY_START_CMD to start a scanning activity.

Prepare and send GAPM_ACTIVITY_START_CMD to request the host to start previously created scanning activity.

Location: ble_gap.h:407

Parameters

Direction	Name	Description
in	<i>actv_idx</i>	Activity identifier
in	<i>scanParam</i>	Pointer to scan parameters structure

Return

False if no activity slot found, true otherwise

20.8.23 GAPM_PerSyncActivityStart

```
bool GAPM_PerSyncActivityStart(uint8_t actv_idx, struct gapm_per_sync_param * per_sync_param)
```

RSL15 Firmware Reference

Prepare and send GAPM_ACTIVITY_START_CMD to start a periodic sync activity.

Prepare and send GAPM_ACTIVITY_START_CMD to request the host to start previously created periodic synchronization activity.

Location: ble_gap.h:419

Parameters

Direction	Name	Description
in	<i>actv_idx</i>	Activity identifier
in	<i>per_sync_param</i>	Pointer to periodic sync parameters structure

Return

False if no activity slot found, true otherwise

20.8.24 GAPM_ActivityStartCmd

```
bool GAPM_ActivityStartCmd(uint8_t actv_idx, union gapm_u_param * u_param)
```

Prepare and send GAPM_ACTIVITY_START_CMD to start an activity.

Prepare and send GAPM_ACTIVITY_START_CMD to request the host to start previously created activity.

Location: ble_gap.h:431

Parameters

Direction	Name	Description
in	<i>actv_idx</i>	Activity identifier
in	<i>u_param</i>	Pointer to union to containing activity parameters

Return

False if no activity slot found, true otherwise

20.8.25 GAPM_ActivityStop

```
bool GAPM_ActivityStop(uint8_t actv_idx)
```

Prepare and send GAPM_ACTIVITY_STOP_CMD to stop a specified activity.

Prepare and send GAPM_ACTIVITY_STOP_CMD with operation GAPM_STOP_ACTIVITY request the host to stop a specified activity.

Location: ble_gap.h:442

Parameters

Direction	Name	Description
in	<i>actv_idx</i>	Activity identifier

Return

False if activity does not exist, true otherwise

20.8.26 GAPM_ActivityStopAll

```
bool GAPM_ActivityStopAll()
```

Prepare and send GAPM_ACTIVITY_STOP_CMD to stop all existing activities.

Prepare and send GAPM_ACTIVITY_STOP_CMD with operation GAPM_STOP_ALL_ACTIVITIES request the host to stop all existing activities.

Location: ble_gap.h:452

Return

False if activity does not exist, true otherwise

20.8.27 GAPM_DeleteActivity

```
bool GAPM_DeleteActivity(uint8_t actv_idx)
```

Prepare and send GAPM_ACTIVITY_DELETE_CMD to delete a specified activity.

Prepare and send GAPM_ACTIVITY_DELETE_CMD with operation GAPM_DELETE_ACTIVITY to request the host to delete an existing specified activity.

Location: ble_gap.h:463

Parameters

Direction	Name	Description
in	<i>actv_idx</i>	Activity identifier (used only if operation is GAPM_DELETE_ACTIVITY)

Return

False if activity does not exist, true otherwise

20.8.28 GAPM_DeleteAllActivities

```
bool GAPM_DeleteAllActivities()
```

Prepare and send GAPM_ACTIVITY_DELETE_CMD to delete all the activities.

RSL15 Firmware Reference

Prepare and send GAPM_ACTIVITY_DELETE_CMD with operation GAPM_DELETE_ALL_ACTIVITIES to request the host to delete all existing activities.

Location: ble_gap.h:473

Return

False if activity does not exist, true otherwise

20.8.29 GAPM_ActivityStopCmd

```
bool GAPM_ActivityStopCmd(uint8_t operation, uint8_t actv_idx)
```

Prepare and send GAPM_ACTIVITY_STOP_CMD to stop a specified activity.

Prepare and send GAPM_ACTIVITY_STOP_CMD with operation GAPM_STOP_ACTIVITY request the host to stop a specified activity.

Location: ble_gap.h:485

Parameters

Direction	Name	Description
in	<i>operation</i>	GAPM operation code [GAPM_STOP_ACTIVITY or GAPM_STOP_ALL_ACTIVITIES]
in	<i>actv_idx</i>	Activity identifier (used only if operation is GAPM_STOP_ACTIVITY)

Return

False if activity does not exist, true otherwise

RSL15 Firmware Reference

20.8.30 GAPM_DeleteActivityCmd

```
bool GAPM_DeleteActivityCmd(uint8_t operation, uint8_t actv_idx)
```

Prepare and send GAPM_ACTIVITY_DELETE_CMD to delete activity/activities.

Prepare and send GAPM_ACTIVITY_DELETE_CMD to request the host to delete either an activity or all currently existing activities.

Location: ble_gap.h:497

Parameters

Direction	Name	Description
in	<i>operation</i>	GAPM operation code [GAPM_DELETE_ACTIVITY or GAPM_DELETE_ALL_ACTIVITIES]
in	<i>actv_idx</i>	Activity identifier (used only if operation is GAPM_DELETE_ACTIVITY)

Return

False if activity does not exist, true otherwise

20.8.31 GAPM_SetAdvDataCmd

```
bool GAPM_SetAdvDataCmd(uint8_t operation, uint8_t actv_idx, uint8_t length, uint8_t * data)
```

Prepare and send GAPM_SET_ADV_DATA_CMD to set an advertising data or scan response data or periodic advertising data.

Prepare and send GAPM_SET_ADV_DATA_CMD to either set an advertising data or the scan response data or the periodic advertising data for a given advertising activity identified by activity ID.

Location: ble_gap.h:514

RSL15 Firmware Reference

Parameters

Direction	Name	Description
in	<i>operation</i>	GAPM operation code (GAPM_SET_ADV_DATA or GAPM_SET_SCAN_RSP_DATA or GAPM_SET_PERIOD_ADV_DATA)
in	<i>actv_idx</i>	Activity identifier
in	<i>length</i>	Length of data
in	<i>data</i>	Pointer to data

Return

False if activity slot not found, true otherwise

20.8.32 GAPM_MsgHandler

```
void GAPM_MsgHandler(ke_msg_id_t const msg_id, void const * param, ke_task_id_t const
dest_id, ke_task_id_t const src_id)
```

Message handler for GAPM events.

This function receives GAPM events from the Bluetooth stack and perform actions accordingly. It initialize GAP and GATT at reset and also manages GAPM states and the GAP environment.

Location: ble_gap.h:527

Parameters

Direction	Name	Description
in	<i>msg_id</i>	Kernel message identifier
in	<i>param</i>	Pointer to constant parameter
in	<i>dest_id</i>	Constant destination kernel identifier
in	<i>src_id</i>	Constant source kernel identifier

RSL15 Firmware Reference

20.8.33 GAPC_ParamUpdateCmd

```
void GAPC_ParamUpdateCmd(uint8_t conidx, uint16_t intv_min, uint16_t intv_max, uint16_t latency, uint16_t time_out, uint16_t ce_len_min, uint16_t ce_len_max)
```

Prepare and send GAPC_PARAM_UPDATE_CMD to perform an update on parameters.

Prepare and send GAPC_PARAM_UPDATE_CMD to perform an update of connection parameters.

Location: ble_gap.h:543

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier
in	<i>intv_min</i>	Minimum of connection interval (value = intv_max * 1.25 ms)
in	<i>intv_max</i>	Maximum of connection interval (value = intv_max * 1.25 ms)
in	<i>latency</i>	connection latency
in	<i>time_out</i>	Link supervision timeout (value = time_out * 10 ms)
in	<i>ce_len_min</i>	Minimum CE length (value = ce_len_min * 0.625 ms)
in	<i>ce_len_max</i>	Maximum CE length (value = ce_len_min * 0.625 ms)

20.8.34 GAPC_ParamUpdateCfm

```
void GAPC_ParamUpdateCfm(uint8_t conidx, bool accept, uint16_t ce_len_min, uint16_t ce_len_max)
```

Prepare and send GAPC_PARAM_UPDATE_CFM to accept or reject connection parameters.

Prepare and send GAPC_PARAM_UPDATE_CFM to accept or reject connection parameters proposed by the peer device.

Location: ble_gap.h:557

RSL15 Firmware Reference

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier
in	<i>accept</i>	Accept(0x01) or reject(0x00) slave connection parameters
in	<i>ce_len_min</i>	Minimum CE length (value = <i>ce_len_min</i> * 0.625 ms)
in	<i>ce_len_max</i>	Maximum CE length (value = <i>ce_len_min</i> * 0.625 ms)

20.8.35 GAPC_ConnectionCfm

```
void GAPC_ConnectionCfm(uint8_t conidx, struct gapc_connection_cfm * param)
```

Prepare and send GAPC_CONNECTION_CFM in a response to connection request.

Prepare and send GAPC_CONNECTION_CFM in a response to connection request from the peer to enable local attribute tasks and security manager for the connection.

Location: ble_gap.h:569

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier
in	<i>param</i>	Pointer to GAPC connection confirmation structure

20.8.36 GAPC_DisconnectCmd

```
void GAPC_DisconnectCmd(uint8_t conidx, uint8_t reason)
```

Prepare and send GAPC_DISCONNECT_CMD to disconnect link.

Prepare and send GAPC_DISCONNECT_CMD to request a disconnection of the link.

RSL15 Firmware Reference

Location: ble_gap.h:580

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier
in	<i>reason</i>	Reason for disconnection

20.8.37 GAPC_IsConnectionActive

```
bool GAPC_IsConnectionActive(uint8_t conidx)
```

Check if the specified connection is active.

Check if specified connection ID is active or not.

Location: ble_gap.h:591

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier

Return

True if given connection id have valid GAP connection handle, false otherwise

20.8.38 GAPC_DisconnectAll

```
void GAPC_DisconnectAll(uint8_t reason)
```

Prepare and send GAPC_DISCONNECT_CMD to disconnect all the links.

Prepare and send GAPC_DISCONNECT_CMD to request disconnection for each active connections.

Location: ble_gap.h:601

Parameters

Direction	Name	Description
in	<i>reason</i>	Reason for disconnection

20.8.39 GAPC_ConnectionCount

```
uint8_t GAPC_ConnectionCount()
```

Get the number of active connection count.

Location: ble_gap.h:608

Return

Number of active connection count

20.8.40 GAPC_MasterConnectionCount

```
uint8_t GAPC_MasterConnectionCount()
```

Get the master connection count.

Location: ble_gap.h:615

Return

Number of master connection count

20.8.41 GAPC_SlaveConnectionCount

```
uint8_t GAPC_SlaveConnectionCount()
```

Get the slave connection count.

Location: ble_gap.h:622

Return

Number of slave connection count

20.8.42 GAPC_GetConnectionInfo

```
const struct gapc_connection_req_ind * GAPC_GetConnectionInfo(uint8_t conidx)
```

Get the connection information of a specified connection ID.

Get GAPC connection information of a specified connection ID.

Location: ble_gap.h:632

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier

Return

Pointer to constant structure gapc_connection_req_ind

20.8.43 GAPC_GetDevInfoCfm_Name

```
void GAPC_GetDevInfoCfm_Name(uint8_t conidx, const char * devName)
```

RSL15 Firmware Reference

Prepare and send GAPC_GET_DEV_INFO_CFM to send the device name.

Prepare and send GAPC_GET_DEV_INFO_CFM to send the device name information to the peer device.

Location: ble_gap.h:643

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier
in	<i>devName</i>	Pointer to device name

20.8.44 GAPC_GetDevInfoCfm_Appearance

```
void GAPC_GetDevInfoCfm_Appearance(uint8_t conidx, uint16_t appearance)
```

Prepare and send GAPC_GET_DEV_INFO_CFM to send the device appearance.

Prepare and send GAPC_GET_DEV_INFO_CFM to send the device appearance icon to the peer device.

Location: ble_gap.h:654

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier
in	<i>appearance</i>	Appearance icon

20.8.45 GAPC_GetDevInfoCfm_SlvPrefParams

```
void GAPC_GetDevInfoCfm_SlvPrefParams(uint8_t conidx, uint16_t con_intv_min, uint16_t con_intv_max, uint16_t slave_latency, uint16_t conn_timeout)
```

Prepare and send GAPC_GET_DEV_INFO_CFM to send device slave preferred parameters.

RSL15 Firmware Reference

Prepare and send GAPC_GET_DEV_INFO_CFM to to send device slave preferred parameters to peer device.

Location: ble_gap.h:668

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier
in	<i>con_intv_min</i>	Minimum connection interval (value = con_intv_min * 1.25 ms)
in	<i>con_intv_max</i>	Maximum connection interval (value = con_intv_max * 1.25 ms)
in	<i>slave_latency</i>	Slave latency
in	<i>conn_timeout</i>	Connection supervision timeout (value = conn_timeout * 10 ms)

20.8.46 GAPC_GetDevInfoCfm

```
void GAPC_GetDevInfoCfm(uint8_t conidx, uint8_t req, const union gapc_dev_info_val * dat)
```

Prepare and send GAPC_GET_DEV_INFO_CFM to send requested information.

Prepare and send GAPC_GET_DEV_INFO_CFM to send requested information to the peer device.

Location: ble_gap.h:682

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier
in	<i>req</i>	Requested information
in	<i>dat</i>	Pointer to constant union GAPC device information value

RSL15 Firmware Reference

20.8.47 GAPC_SetDevInfoCfm

```
bool GAPC_SetDevInfoCfm(uint8_t conidx, uint8_t req, bool accept)
```

Prepare and send GAPC_SET_DEV_INFO_CFM to confirm if the requested device information was written.

Prepare and send GAPC_SET_DEV_INFO_CFM to provide confirmation to the Bluetooth stack if the requested device information was written.

Location: ble_gap.h:697

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier
in	<i>req</i>	Requested information (GAPC_DEV_NAME or GAPC_DEV_APPEARANCE)
in	<i>accept</i>	True if the write request has been approved, false otherwise

Return

False if req is not GAPC_DEV_NAME or GAPC_DEV_APPEARANCE, true otherwise

20.8.48 GAPC_BondCfm

```
void GAPC_BondCfm(uint8_t conidx, enum gapc_bond request, bool accept, const union gapc_bond_cfm_data * data)
```

GAPC bond and encryption operations.

Prepare and send GAPC_BOND_CFM to send confirmation to a bond request Prepare and send GAPC_BOND_CFM to provide confirmation of the receipt of a GAPC_BOND_REQ_IND message.

Location: ble_gap.h:714

RSL15 Firmware Reference

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier
in	<i>request</i>	Bond request type
in	<i>accept</i>	Accept(0x01) or reject(0x00) request
in	<i>data</i>	Pointer to constant GAPC bond confirmation data union

20.8.49 GAPC_EncryptCmd

```
void GAPC_EncryptCmd(uint8_t conidx, uint16_t ediv, const uint8_t * randnb, const uint8_t * ltk, uint8_t key_size)
```

Prepare and send GAPC_ENCRYPT_CMD to request encrypting the connection link.

Prepare and send GAPC_ENCRYPT_CMD as the master to request initiation of the link encryption procedure.

Location: ble_gap.h:729

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier
in	<i>ediv</i>	Encryption diversifier
in	<i>randnb</i>	Pointer to constant random number
in	<i>ltk</i>	Pointer to constant long term key
in	<i>key_size</i>	Size of LTK key

20.8.50 GAPC_EncryptCfm

```
void GAPC_EncryptCfm(uint8_t conidx, bool found, const uint8_t * ltk, uint8_t key_size)
```

Prepare and send GAPC_ENCRYPT_CFM to confirm an encryption request.

RSL15 Firmware Reference

Prepare and send GAPC_ENCRYPT_CFM to provide confirmation of the receipt of a GAPC_ENCRYPY_REQ_IND message.

Location: ble_gap.h:743

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier
in	<i>found</i>	Nonzero if LTK is found for peer device, zero otherwise
in	<i>ltk</i>	Pointer to constant long term key
in	<i>key_size</i>	Size of LTK key

20.8.51 GAPC_IsBonded

```
bool GAPC_IsBonded(uint8_t conidx)
```

Check if the connection is bonded.

Check if the specified connection ID is active and if it has a valid bond state.

Location: ble_gap.h:753

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier

Return

True if connection is active and it has valid bond state, false otherwise

20.8.52 GAPC_GetBondInfo

```
const BondInfo\_t * GAPC_GetBondInfo(uint8_t conidx)
```

Get bond information for the connection.

Get bond information for a specified connection ID.

Location: ble_gap.h:764

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier

Return

Pointer to constant bond information structure if connection is active and its bonded, NULL otherwise

20.8.53 GAPC_BondCmd

```
void GAPC_BondCmd(uint8_t conidx, const struct gapc_pairing * pairing)
```

Prepare and send GAPC_BOND_CMD to initiate a bond procedure.

Prepare and send GAPC_BOND_CMD to the master of the link in order to initiate the bond procedure.

Location: ble_gap.h:775

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier
in	<i>pairing</i>	Pointer to constant structure pairing information

20.8.54 GAPC_AddRecordToBondList

```
uint16_t GAPC_AddRecordToBondList(uint8_t conidx)
```

Add record to bond list.

Add device with a specified connection ID to bond list.

Location: ble_gap.h:785

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier

Return

Non-zero if successful, zero otherwise

20.8.55 GAPC_MsgHandler

```
void GAPC_MsgHandler(ke_msg_id_t const msg_id, void const * param, ke_task_id_t const
dest_id, ke_task_id_t const src_id)
```

GAPC message handler.

Receives GAPC events from the Bluetooth stack and perform actions accordingly.

Location: ble_gap.h:797

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>msg_id</i>	Kernel message identifier
in	<i>param</i>	Pointer to constant parameter
in	<i>dest_id</i>	Constant destination kernel identifier
in	<i>src_id</i>	Constant source kernel identifier

20.8.56 GAPM_ListSetWlCmd

```
void GAPM_ListSetWlCmd(uint8_t operation, uint8_t nb, struct gap_bdaddr * devices_wl)
```

Prepare and send GAPM_LIST_SET_CMD to set the white list content.

Prepare and send GAPM_LIST_SET_CMD to set the content of the white list.

Location: ble_gap.h:810

Parameters

Direction	Name	Description
in	<i>operation</i>	GAPM operation code to set the content of white list
in	<i>nb</i>	Number of entries to be added in the list
in	<i>devices_wl</i>	Pointer to structure containing list of addresses to be added in the white list

20.8.57 GAPM_ListSetRalCmd

```
void GAPM_ListSetRalCmd(uint8_t operation, uint8_t nb, struct gap_ral_dev_info * rl_devinfo)
```

Prepare and send GAPM_LIST_SET_CMD to set the resolving list content.

Prepare and send GAPM_LIST_SET_CMD to set the content of the resolving list.

Location: ble_gap.h:823

RSL15 Firmware Reference

Parameters

Direction	Name	Description
in	<i>operation</i>	GAPM operation code to set the content of white list
in	<i>nb</i>	Number of entries to be added in the list
in	<i>rl_devinfo</i>	Pointer to structure containing list of addresses to be added in the resolving list

20.8.58 GAPM_IsIRKValid

```
bool GAPM_IsIRKValid(const BondInfo\_t * bond_info)
```

Check if IRK is valid.

Function checks if a valid IRK has been previously exchanged or not.

Location: ble_gap.h:834

Parameters

Direction	Name	Description
in	<i>bond_info</i>	Pointer to constant bond information

Return

True if *irk_exchanged* in the specified *bond_info* is nonzero, false otherwise

20.8.59 WhiteList_ResolvableList_Update

```
bool WhiteList_ResolvableList_Update()
```

Update the white list and the resolve List.

Copies the addresses of the devices in the bond list and updates them in the Bluetooth stack's white list and the resolvable list (if applicable).

Location: ble_gap.h:842

20.8.60 GAPM_GetWhitelistNumDev

```
uint16_t GAPM_GetWhitelistNumDev()
```

Get number of devices in whitelist.

Get the variable that keeps track of number of devices added to whitelist.

Location: ble_gap.h:851

Return

Number of devices in whitelist

20.8.61 GAPM_SetWhitelistNumDev

```
void GAPM_SetWhitelistNumDev()
```

Set the number of devices in whitelist.

Set the GAPM variable that keeps track of number of devices added to whitelist to value.

Location: ble_gap.h:860

Return

None

RSL15 Firmware Reference

20.8.62 GAPC_SetPhyCmd

```
void GAPC_SetPhyCmd(uint8_t conidx, uint8_t rx_rate, uint8_t tx_rate, uint8_t
preferredRate)
```

GAPC PHY management operations.

Prepare and send GAPC_SET_PHY_CMD to set the preferred PHY Prepare and send GAPC_SET_PHY_CMD to set the preferred PHY for current active link.

Location: ble_gap.h:877

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier
in	<i>rx_rate</i>	Preferred LE PHYs for reception
in	<i>tx_rate</i>	Preferred LE PHYs for transmission
in	<i>preferredRate</i>	Preferred coding scheme for LE coded

20.8.63 GAPC_CteTxCfgCmd

```
void GAPC_CteTxCfgCmd(uint8_t conidx, uint8_t cte_type, uint8_t ant_pattern_len, uint8_t
* ant_id)
```

GAPC constant Tone extension operations.

Prepare and send GAPC_CTE_TX_CFG_CMD to configure CTE TX Prepare and send GAPC_CTE_TX_CFG_CMD to configure constant tone extension transmission.

Location: ble_gap.h:895

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>conidx</i>	Connection identifier
in	<i>cte_type</i>	CTE types
in	<i>ant_pattern_len</i>	Length of switching pattern
in	<i>ant_id</i>	Pointer to antenna IDs

20.8.64 GAPC_CteRxCfgCmd

```
void GAPC_CteRxCfgCmd(uint8_t conidx, uint8_t slot_dur, uint8_t ant_pattern_len, uint8_t
* ant_id, bool sample_en)
```

Prepare and send GAPC_CTE_RX_CFG_CMD to configure CTE RX.

Prepare and send GAPC_CTE_RX_CFG_CMD to configure constant tone extension reception.

Location: ble_gap.h:910

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier
in	<i>slot_dur</i>	Slot durations (1: 1us, 2: 2us)
in	<i>ant_pattern_len</i>	Length of switching pattern
in	<i>ant_id</i>	Pointer to antenna IDs
in	<i>sample_en</i>	Enable or disable sampling

20.8.65 GAPC_CteReqCtrlCmd

```
void GAPC_CteReqCtrlCmd(uint8_t conidx, uint8_t cte_type, uint8_t cte_len, uint8_t cte_
interval, bool enable)
```

Prepare and send GAPC_CTE_REQ_CTRL_CMD to control CTE requests.

Prepare and send GAPC_CTE_REQ_CTRL_CMD to control constant tone extension requests.

RSL15 Firmware Reference

Location: ble_gap.h:925

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier
in	<i>cte_type</i>	CTE types
in	<i>cte_len</i>	Request CTE length (in 8us unit)
in	<i>cte_interval</i>	CTE request interval (in no of connection events)
in	<i>enable</i>	Enable or disable TX/RX CTE

20.8.66 GAPC_CteRspCtrlCmd

```
void GAPC_CteRspCtrlCmd(uint8_t conidx, bool enable)
```

Prepare and send GAPC_CTE_RSP_CTRL_CMD to control CTE reception.

Prepare and send GAPC_CTE_RSP_CTRL_CMD to control constant tone extension reception.

Location: ble_gap.h:937

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier
in	<i>enable</i>	Enable or disable TX/RX CTE

20.8.67 GAPC_GetInfoCmd

```
void GAPC_GetInfoCmd(uint8_t conidx, uint8_t operation)
```

GAPC local and peer device information operations.

RSL15 Firmware Reference

Prepare and send GAPC_GET_INFO_CMD to get the peer information Prepare and send GAPC_GET_INFO_CMD to get information about the peer device or about the current active link.

Location: ble_gap.h:952

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection identifier
in	<i>operation</i>	GAPC requested operation

20.8.68 GAPM_PerAdvCteTxCmd

```
bool GAPM_PerAdvCteTxCmd(uint8_t actv_idx, bool enable)
```

Prepare and send GAPM_PER_ADV_CTE_TX_CTL_CMD to control CTE transmission in a periodic advertising activity.

Location: ble_gap.h:962

Parameters

Direction	Name	Description
in	<i>actv_idx</i>	Activity identifier
in	<i>enable</i>	Enable or disable CTE transmission

Return

False if activity slot is equal to max number of activity, true otherwise

20.8.69 GAPM_PerAdvReportCtrlCmd

```
bool GAPM_PerAdvReportCtrlCmd(uint8_t actv_idx, bool enable)
```

RSL15 Firmware Reference

Prepare and send GAPM_PER_ADV_REPORT_CTRL_CMD to control reception of periodic advertising report in a periodic advertising sync activity.

Location: ble_gap.h:972

Parameters

Direction	Name	Description
in	<i>actv_idx</i>	Activity identifier
in	<i>enable</i>	Enable or disable reception of periodic advertising report

Return

False if activity slot is equal to max number of activity, true otherwise

20.8.70 GAPM_PerSyncIQSamplingCtrlCmd

```
bool GAPM_PerSyncIQSamplingCtrlCmd(uint8_t actv_idx, uint8_t slot_dur, uint8_t max_sample_cte, uint8_t ant_pattern_len, uint8_t * ant_id, bool enable)
```

Prepare and send GAPM_PER_SYNC_IQ_SAMPLING_CTRL_CMD to control capturing IQ samples from the constant tone extension of periodic advertising packets.

Location: ble_gap.h:987

Parameters

Direction	Name	Description
in	<i>actv_idx</i>	Activity identifier
in	<i>slot_dur</i>	Slot durations (1: 1us 2: 2us)
in	<i>max_sample_cte</i>	Maximum sampled CTEs
in	<i>ant_pattern_len</i>	Length of switching pattern
in	<i>ant_id</i>	Pointer to antenna IDs
in	<i>enable</i>	Enable IQ sampling

Return

False if activity slot is equal to max number of activity, true otherwise

20.8.71 GATT_Initialize

```
void GATT_Initialize()
```

GATT initialization.

Initialize the GATT environment.

Location: ble_gatt.h:198

20.8.72 GATT_GetEnv

```
const GATT\_Env\_t * GATT_GetEnv()
```

Get GATT environment.

Function gets a reference to the internal GATT environment structure.

Location: ble_gatt.h:207

Return

A constant pointer to [GATT_Env_t](#)

20.8.73 GATT_SetEnvData

```
void GATT_SetEnvData(uint16_t * disc_svc_count, cust\_svc\_desc * custom_service_db, uint8_t max_cust_svc_num)
```

RSL15 Firmware Reference

Set GATT environment data.

Set the GATT environment discovery service counter (array), custom service database and maximum number of custom services.

Location: ble_gatt.h:219

Parameters

Direction	Name	Description
in	<i>disc_svc_count</i>	Pointer to discovered services count
in	<i>custom_service_db</i>	Pointer to custom service database
in	<i>max_cust_svc_num</i>	Maximum number of custom services

20.8.74 GATT_GetMaxCustomServiceNumber

```
uint16_t GATT_GetMaxCustomServiceNumber()
```

Get the maximum number of custom services in GATT.

Function gets the maximum number of custom services in GATT environment.

Location: ble_gatt.h:229

Return

max_cust_svc_num maximum number of custom services

20.8.75 GATTM_GetServiceAddedCount

```
uint16_t GATTM_GetServiceAddedCount()
```

Get GATT added services count.

RSL15 Firmware Reference

Function gets number of GATT services that have been added.

Location: ble_gatt.h:238

Return

the number of GATT services that have been added

20.8.76 GATTM_ResetServiceAttributeDatabaseID

```
void GATTM_ResetServiceAttributeDatabaseID()
```

Resets GATT services attribute database ID.

Function resets GATT services attribute database ID. This should be called before re-adding the attribute databases via

Location: ble_gatt.h:247

[GATTM_AddAttributeDatabase\(\)](#) without complete system reset.

20.8.77 GATTM_AddAttributeDatabase

```
void GATTM_AddAttributeDatabase(const struct att\_db\_desc * att_db, uint16_t att_db_len)
```

Add service and attributes to the Bluetooth stack.

Prepare and send GATTM_ADD_SVC_REQ to add services/characteristics into the Bluetooth stack database.

Location: ble_gatt.h:259

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>att_db</i>	Pointer to constant custom service attribute database
in	<i>att_db_len</i>	Number of elements in the <i>att_db</i> array

NOTE: Triggers a GATTM_ADD_SVC_RSP for every service added.

20.8.78 GATTM_GetHandle

```
uint16_t GATTM_GetHandle(uint8_t cs_svc_number, uint16_t attidx)
```

Get the handle for an attribute.

Returns the stack database handle for a certain attribute index.

Location: ble_gatt.h:274

Parameters

Direction	Name	Description
in	<i>cs_svc_number</i>	Custom service number related to attribute
in	<i>attidx</i>	Attribute index

Return

Handle value, in case of success or 0, in case the *attidx* or the start handle is invalid

NOTE: The user has used GATT_AddAttributeDatabase() to construct the database and the stack has already finished adding services to the database.

20.8.79 GATTM_MsgHandler

```
void GATTM_MsgHandler(ke_msg_id_t const msg_id, void const * param, ke_task_id_t const dest_id, ke_task_id_t const src_id)
```

Handle GATTM messages.

Message handler for the GATT manager

Location: ble_gatt.h:286

Parameters

Direction	Name	Description
in	<i>msg_id</i>	Kernel message identifier
in	<i>param</i>	Pointer to constant message parameter (unused)
in	<i>dest_id</i>	Destination task identifier
in	<i>src_id</i>	Source task identifier

20.8.80 GATTC_Initialize

```
void GATTC_Initialize()
```

GATTC initialization.

Initialize GATTC

Location: ble_gatt.h:294

20.8.81 GATTC_DiscByUUIDSvc

```
void GATTC_DiscByUUIDSvc(uint8_t conidx, uint8_t uuid, uint8_t uuid_len, uint16_t start_hdl, uint16_t end_hdl)
```

GATTC services discovery by UUID.

Start a discovery by UUID(GATTC_DISC_BY_UUID_SVC) in a specified handle range.

RSL15 Firmware Reference

Location: ble_gatt.h:308

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection index
	<i>uuid</i>	
in	<i>uuid_len</i>	UUID length (ATT_UUID_16_LEN or ATT_UUID_32_LEN or ATT_UUID_128_LEN)
in	<i>start_hdl</i>	Start handle of a discovery range
in	<i>end_hdl</i>	End handle of a discovery range

20.8.82 GATTC_DiscAllSvc

```
void GATTC_DiscAllSvc(uint8_t conidx, uint16_t start_hdl, uint16_t end_hdl)
```

GATTC all services discovery.

Start a discovery for all services in a specified handle range.

Location: ble_gatt.h:320

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection index
in	<i>start_hdl</i>	Start handle of discovery range
in	<i>end_hdl</i>	End handle of discovery range

20.8.83 GATTC_DiscAllChar

```
void GATTC_DiscAllChar(uint8_t conidx, uint16_t start_hdl, uint16_t end_hdl)
```

GATTC all characteristics discovery.

RSL15 Firmware Reference

Start a characteristic discovery for all characteristics in a specified handle range.

Location: ble_gatt.h:332

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection index
in	<i>start_hdl</i>	Start handle of discovery range
in	<i>end_hdl</i>	End handle of discovery range

20.8.84 GATTC_SendEvtCmd

```
void GATTC_SendEvtCmd(uint8_t conidx, uint8_t operation, uint16_t seq_num, uint16_t handle, uint16_t length, uint8_t * value)
```

GATTC send event.

Send GATTC characteristic notification or indication event.

Location: ble_gatt.h:346

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection index
in	<i>operation</i>	GATTC_NOTIFY or GATTC_INDICATE
in	<i>seq_num</i>	Operation sequence number
in	<i>handle</i>	Characteristic handle
in	<i>length</i>	Attribute length
in	<i>value</i>	Pointer to attribute data value

RSL15 Firmware Reference

20.8.85 GATTC_SendEvtCfm

```
void GATTC_SendEvtCfm(uint8_t conidx, uint16_t handle)
```

GATTC send event confirmation.

Send a GATTC indication event confirmation.

Location: ble_gatt.h:357

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection index
in	<i>handle</i>	Characteristic handle

20.8.86 GATTC_MtuExchange

```
void GATTC_MtuExchange(uint8_t conidx)
```

Prepare and send GATTC_EXC_MTU_CMD to start MTU exchange procedure.

Prepare and send GATTC_EXC_MTU_CMD to start MTU exchange procedure.

Location: ble_gatt.h:366

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection index

20.8.87 GATTC_ReadReqInd

```
void GATTC_ReadReqInd(ke_msg_id_t const msg_id, struct gattc_read_req_ind const * param,  
ke_task_id_t const dest_id, ke_task_id_t const src_id)
```

RSL15 Firmware Reference

GATTC handle read request indication.

Handle a received read request indication from GATT controller.

Location: ble_gatt.h:380

Parameters

Direction	Name	Description
in	<i>msg_id</i>	Kernel message identifier
in	<i>param</i>	Pointer to constant message parameters (in format of structure gattc_read_req_ind)
in	<i>dest_id</i>	Destination task identifier
in	<i>src_id</i>	Source task identifier

NOTE: Indicate if the message was consumed, compare with KE_MSG_CONSUMED

20.8.88 GATTC_WriteReqInd

```
void GATTC_WriteReqInd(ke_msg_id_t const msg_id, struct gattc_write_req_ind const *
param, ke_task_id_t const dest_id, ke_task_id_t const src_id)
```

GATTC handle write request indication.

Handle a received write request indication from GATT controller.

Location: ble_gatt.h:396

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>msg_id</i>	Kernel message identifier
in	<i>param</i>	Pointer to constant message parameters (in format of structure <code>gattc_write_req_ind</code>)
in	<i>dest_id</i>	Destination task identifier
in	<i>src_id</i>	Source task identifier

NOTE: Indicate if the message was consumed, compare with `KE_MSG_CONSUMED`

20.8.89 GATTC_AttrInfoReqInd

```
void GATTC_AttrInfoReqInd(ke_msg_id_t const msg_id, struct gattc_read_req_ind const *
param, ke_task_id_t const dest_id, ke_task_id_t const src_id)
```

GATTC request attribute information.

Request an attribute info indication to be passed to the upper layers of the Bluetooth stack. Could also be triggered during prepare write to check if attribute modification is authorized by profile/application or not and to get current attribute length.

Location: `ble_gatt.h:415`

Parameters

Direction	Name	Description
in	<i>msg_id</i>	Kernel message identifier
in	<i>param</i>	Pointer to constant message parameters (in format of structure <code>gattc_read_req_ind</code>)
in	<i>dest_id</i>	Destination task identifier
in	<i>src_id</i>	Source task identifier

NOTE: Indicate if the message was consumed, compare with `KE_MSG_CONSUMED`

RSL15 Firmware Reference

20.8.90 GATTC_MsgHandler

```
void GATTC_MsgHandler(ke_msg_id_t const msg_id, void const * param, ke_task_id_t const
dest_id, ke_task_id_t const src_id)
```

Handle GATTM messages.

Message handler for GATT manager messages received from kernel

Location: ble_gatt.h:430

Parameters

Direction	Name	Description
in	<i>msg_id</i>	Kernel message identifier
in	<i>param</i>	Pointer to constant message parameter (unused)
in	<i>dest_id</i>	Destination task identifier
in	<i>src_id</i>	Source task identifier

NOTE: Indicate if the message was consumed, compare with KE_MSG_CONSUMED

20.8.91 Device_BLE_Public_Address_Read

```
void Device_BLE_Public_Address_Read(uint32_t ble_addr_location)
```

Read the Bluetooth public address to ble_public_addr.

Read the Bluetooth public address from a given location and save it to ble_public_addr (array).

Location: ble_protocol_support.h:77

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>ble_addr_location</i>	Location to read value from

20.8.92 Device_BLE_Param_Get

```
uint8_t Device_BLE_Param_Get(uint8_t param_id, uint8_t * lengthPtr, uint8_t * buf)
```

Read BLE device parameters.

Read bluetooth low energy parameters, security keys, and channel assessment parameters that are provided by the application or NVR3.

Location: ble_protocol_support.h:90

Parameters

Direction	Name	Description
in	<i>param_id</i>	Parameter identifier
in	<i>lengthPtr</i>	Pointer to the length of parameter
in	<i>buf</i>	Pointer to returned value

Return

Indicate if the requested parameter is provided by application

20.8.93 rand_func

```
int rand_func()
```

Generate a pseudo-random number.

Location: ble_protocol_support.h:97

Return

A pseudo-random number

20.8.94 set_app_rand_func

```
void set_app_rand_func(int(*) (void) func)
```

Sets random number generator function to be used by the BLE stack when calling [rand_func\(\)](#)

Location: ble_protocol_support.h:105

Parameters

Direction	Name	Description
in	<i>func</i>	Function containing random number generator

20.8.95 srand_func

```
void srand_func(uint32_t seed)
```

Seeds pseudo-random number generator used by function rand()

Location: ble_protocol_support.h:112

Parameters

Direction	Name	Description
in	<i>seed</i>	Seed value

20.8.96 set_app_rand_seed_val

```
void set_app_rand_seed_val(uint32_t seed)
```

Sets seed value to be used by the BLE stack when calling [srand_func\(\)](#)

RSL15 Firmware Reference

Location: ble_protocol_support.h:119

Parameters

Direction	Name	Description
in	<i>seed</i>	Seed value

20.8.97 default_rf_rssi_func

```
int8_t default_rf_rssi_func(uint8_t rssi_reg)
```

Default RF to RSSI conversion function to be used by the BLE stack when calling Device_RF_RSSI_Convert().

This is in the event that APP_BLE_RSSI_CONVERSION_DEFINED is set to 1, but the user has not called

Location: ble_protocol_support.h:129

Parameters

Direction	Name	Description
in	<i>rssi_reg</i>	RF data value

[set_app_rf_rssi_func\(\)](#).

20.8.98 set_app_rf_rssi_func

```
void set_app_rf_rssi_func(int8_t(*) (uint8_t) func)
```

Sets RF to RSSI conversion function to be used by the BLE stack when calling Device_RF_RSSI_Convert()

Location: ble_protocol_support.h:137

Parameters

RSL15 Firmware Reference

Direction	Name	Description
in	<i>func</i>	Function containing RF to RSSI calculations

20.8.99 MsgHandler_GetTaskAppDesc

```
const struct ke_task_desc * MsgHandler_GetTaskAppDesc()
```

Provide an application task descriptor with default handler set to the MsgHandler_Notify function.

Location: msg_handler.h:42

Return

A TASK_APP descriptor to be used in the ke_create_task function

20.8.100 MsgHandler_Add

```
bool MsgHandler_Add(ke_msg_id_t const msg_id, MsgHandlerCallback\_t callback)
```

Add/subscribe a message handler callback function.

If the msg_id argument is a message identifier (such as GAPM_CMP_EVT), the callback function is called only when the specific event is triggered

Location: msg_handler.h:58

Parameters

Direction	Name	Description
in	<i>msg_id</i>	A message identifier (such as GAPM_CMP_EVT) or a task identifier (such as TASK_ID_GAPM)
in	<i>callback</i>	A pointer to the callback function that should be called when an event matching msg_id happens

Return

True if it was able to add/register the handler, false otherwise

If the `msg_id` argument is a task identifier (such as `TASK_ID_GAPM`), the callback function is for for any event triggered from that task

20.8.101 MsgHandler_Notify

```
int MsgHandler_Notify(ke_msg_id_t const msg_id, void const * param, ke_task_id_t const
dest_id, ke_task_id_t const src_id)
```

Notify the callback functions associated with the `msg_id`.

This function searches the list of handlers added using `MsgHandler_Add` and notify each one with matching `msg_id`.

Location: `msg_handler.h:80`

Parameters

Direction	Name	Description
in	<i>msg_id</i>	A message identifier (such as <code>GAPM_CMP_EVT</code>) or a task identifier (such as <code>TASK_ID_GAPM</code>)
in	<i>param</i>	Message parameter
in	<i>dest_id</i>	Destination task identifier
in	<i>src_id</i>	Source task identifier

Return

`KE_MSG_CONSUMED` back to the kernel

It also makes sure to call the BLE abstraction message handlers prior to any application message handler

RSL15 Firmware Reference

NOTE: This function was designed to be used as the default handler of the kernel and shall NOT be called directly by the application. To notify an event, the application should instead enqueue a message in the kernel, in order to avoid chaining the context of function calls and causing a stack overflow

20.8.102 BASC_Initialize

```
void BASC_Initialize()
```

Initialize BASC environment.

Initialize battery service client environment and configure message handlers.

Location: ble_basc.h:81

20.8.103 BASC_EnableReq

```
void BASC_EnableReq(uint8_t conidx)
```

Enable the client role of the BAS.

Prepare and send BASC_ENABLE_REQ to enable the client role of the battery service.

Location: ble_basc.h:92

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection index

NOTE: *conidx* is valid (between 0 and GAP_MAX_CONNECTIONS-1)

20.8.104 BASC_ReadInfoReq

```
void BASC_ReadInfoReq(uint8_t conidx, uint8_t bas_nb, uint8_t info)
```

RSL15 Firmware Reference

Prepare and send `BASC_READ_INFO_REQ` to read value from peer.

Prepare and send `BASC_READ_INFO_REQ` to read the value of characteristic or descriptor in the peer device database.

Location: `ble_basc.h:104`

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection index
in	<i>bas_nb</i>	Battery instance number
in	<i>info</i>	Peer battery info type

20.8.105 `BASC_BattLevelNtfCfgReq`

```
void BASC_BattLevelNtfCfgReq(uint8_t conidx, uint8_t bas_nb, uint8_t ntf_cfg)
```

Send a request to change notification configuration.

Prepare and send `BASC_BATT_LEVEL_NTF_CFG_REQ` to request to change battery level notification configuration in the peer device.

Location: `ble_basc.h:116`

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection index
in	<i>bas_nb</i>	Battery instance number
in	<i>ntf_cfg</i>	The value of notification configuration

RSL15 Firmware Reference

20.8.106 BASC_RequestBattLevelOnTimeout

```
void BASC_RequestBattLevelOnTimeout(uint32_t timeout_ms)
```

Send a request for periodic battery level update.

Configure a kernel timer to periodically send battery level requests.

Location: ble_basc.h:126

Parameters

Direction	Name	Description
in	<i>timeout_ms</i>	Delay between requests in units of 10ms. If timeout == 0, disable periodic requests.

20.8.107 BASC_GetLastBatteryLevel

```
uint8_t BASC_GetLastBatteryLevel(uint8_t conidx, uint8_t bas_nb)
```

Read the most recent battery level.

Read the most recent value of battery level from the BASC environment.

Location: ble_basc.h:137

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection index
in	<i>bas_nb</i>	Battery instance number

Return

Value of battery level

20.8.108 **BASC_GetEnv**

```
const BASC\_Env\_t * BASC_GetEnv()
```

Get the BASC environment.

Return a reference to the internal BASC environment structure.

Location: ble_basc.h:146

Return

Constant pointer to [BASC_Env_t](#)

20.8.109 **BASC_MsgHandler**

```
void BASC_MsgHandler(ke_msg_id_t const msg_id, void const * param, ke_task_id_t const dest_id, ke_task_id_t const src_id)
```

Handle the BASC events.

Handle all the events related to battery service client.

Location: ble_basc.h:158

Parameters

Direction	Name	Description
in	<i>msg_id</i>	Kernel message identifier
in	<i>param</i>	Pointer to constant message parameter
in	<i>dest_id</i>	Destination task identifier
in	<i>src_id</i>	Source task identifier

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20.8.110 BASS_Initialize

```
void BASS_Initialize(uint8_t bas_nb, uint8_t(*) (uint8_t bas_nb) readBattLevelCallback)
```

Initialize BASS environment.

Initialize a battery service server environment and configure message handlers.

Location: ble_bass.h:82

Parameters

Direction	Name	Description
in	<i>bas_nb</i>	Number of battery instances [1,2].
in	<i>readBattLevelCallback</i>	Pointer to user application callback function that returns the battery value.

20.8.111 BASS_NotifyOnTimeout

```
void BASS_NotifyOnTimeout(uint32_t timeout)
```

BASS configure periodic notification.

Configure a battery service to send periodic notifications.

Location: ble_bass.h:93

Parameters

Direction	Name	Description
in	<i>timeout</i>	Timeout period in units of 10ms. disabled if timeout == 0

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20.8.112 BASS_NotifyOnBattLevelChange

```
void BASS_NotifyOnBattLevelChange(uint32_t timeout)
```

BASS notify peers on battery level change.

Configure battery service to periodically monitor the battery level according to the timeout. The battery level is queried read through the callback function passed as argument to

Location: ble_bass.h:107

Parameters

Direction	Name	Description
in	<i>timeout</i>	Timeout period in units of 10ms. disabled if timeout == 0

[BASS_Initialize\(\)](#). Connected peers are only notified if the battery level changes. It triggers a BASS_BATT_LEVEL_CHANGED event, which the user application may subscribe to.

20.8.113 BASS_ProfileTaskAddCmd

```
void BASS_ProfileTaskAddCmd()
```

Add a battery profile in kernel.

Send request to add a battery profile in kernel and database.

Location: ble_bass.h:114

20.8.114 BASS_EnableReq

```
void BASS_EnableReq(uint8_t conidx)
```

Enable the server role in BAS.

Prepare and send BASS_ENABLE_REQ to enable the server role of the battery service.

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Location: ble_bass.h:124

Parameters

Direction	Name	Description
in	<i>conidx</i>	Connection index

20.8.115 BASS_BattLevelUpdReq

```
void BASS_BattLevelUpdReq(uint8_t batt_lvl, uint8_t bas_nb)
```

Prepare and send BASS_BATT_LEVEL_UPD_REQ for battery level notification.

Prepare and send BASS_BATT_LEVEL_UPD_REQ to update the battery level characteristic value for the BAS instance. This value will be stored in the database so that it can be read by the peer device.

Location: ble_bass.h:137

Parameters

Direction	Name	Description
in	<i>batt_lvl</i>	Battery level [0, 100]
in	<i>bas_nb</i>	Battery server instance number

20.8.116 BASS_GetEnv

```
const BASS\_Env\_t * BASS_GetEnv()
```

Get the BASS environment.

Return a reference to the internal BASS environment structure.

Location: ble_bass.h:146

Return

Constant pointer to [BASS_Env_t](#)

20.8.117 BASS_IsAdded

```
bool BASS_IsAdded()
```

Check if the BASS is added successfully.

Returns a boolean indication if the BAS server has been successfully added to the services database.

Location: ble_bass.h:156

Return

True if the service has been successfully added, false otherwise

20.8.118 BASS_MsgHandler

```
void BASS_MsgHandler(ke_msg_id_t const msg_id, void const * param, ke_task_id_t const  
dest_id, ke_task_id_t const src_id)
```

Handle BASS messages.

Handle all events related to the battery service server

Location: ble_bass.h:168

Parameters

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Direction	Name	Description
in	<i>msg_id</i>	Kernel message identifier
in	<i>param</i>	Pointer to constant message parameters
in	<i>dest_id</i>	Destination task identifier
in	<i>src_id</i>	Source task identifier

20.8.119 DISS_Initialize

```
int DISS_Initialize(uint16_t features, const struct DISS\_DeviceInfo\_t * deviceInfo)
```

Initialize the device information server service environment and configure message handlers.

Location: ble_diss.h:81

Parameters

Direction	Name	Description
in	<i>features</i>	The enabled features for the device information service. Values define as enum <code>diss_features</code> in <code>diss_task.h</code> .
in	<i>deviceInfo</i>	Constant pointer to DISS_DeviceInfo_t

Return

0 if the initialization was successful, < 0 otherwise

20.8.120 DISS_ProfileTaskAddCmd

```
void DISS_ProfileTaskAddCmd()
```

Send a request to add the device information service in kernel and database.

Location: ble_diss.h:87

20.8.121 DISS_EnvGet

```
const DISS\_Env\_t * DISS_EnvGet ()
```

Return a reference to the internal DISS environment structure.

Location: ble_diss.h:94

Return

A constant pointer to [DISS_Env_t](#)

20.8.122 DISS_IsAdded

```
bool DISS_IsAdded ()
```

Return a boolean indication if the DISS server has been successfully added to the services database.

Location: ble_diss.h:102

Return

True if the service is added successful, false otherwise

20.8.123 DISS_MsgHandler

```
void DISS_MsgHandler(ke_msg_id_t const msg_id, void const * param, ke_task_id_t const  
dest_id, ke_task_id_t const src_id)
```

Handle all the events related to the device information service server.

Location: ble_diss.h:112

Parameters

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Direction	Name	Description
in	<i>msg_id</i>	Kernel message identifier
in	<i>param</i>	Message parameter
in	<i>dest_id</i>	Destination task identifier
in	<i>src_id</i>	Source task identifier

20.8.124 DISS_DeviceInfoValueReqInd

```
void DISS_DeviceInfoValueReqInd(ke_msg_id_t const msgid, void const * param, ke_task_id_t const dest_id, ke_task_id_t const src_id)
```

Handle the indication when the peer device requests a value.

Location: ble_diss.h:123

Parameters

Direction	Name	Description
in	<i>msgid</i>	Kernel message identifier
in	<i>param</i>	Message parameters in format of struct <code>diss_value_req_ind</code>
in	<i>dest_id</i>	Destination task identifier
in	<i>src_id</i>	Source task identifier

CHAPTER 21

BLE_ABSTRACTION

21.1 SUMMARY

Data Structures

- [BondInfo_t](#) : Bond Information.

Macros

- [BOND_INFO_BASE](#) : Start address and size of the memory region where bond list is stored:
- [BOND_INFO_SIZE](#) : Each Bond takes up 72 Bytes of the FLASH.
- [STATIC_ASSERT](#)
- [BONDLIST_MAX_SIZE](#)
- [BOND_INFO_FLASH_SECTORS_COUNT](#)
- [BOND_INFO_STATE_INVALID](#) : Invalid bond info state.
- [BOND_INFO_STATE_EMPTY](#) : Empty bond info state.
- [BOND_INFO_STATE_VALID](#) : Macro for valid bond info state.

Functions

- [STATIC_ASSERT](#)
- [BondList_Size](#) : Bondlist functions.
- [BondList_GetIRKs](#) : Get the IRKs from bond lists.
- [BondList_FindByIRK](#) : Search for the bond information matching specified IRK in flash.
- [BondList_FindByAddr](#) : Search for the bonding information for a peer device in flash matching specified address and address type.
- [BondList_FlashDefrag](#) : Squeeze bond information together to make space for a new entry.
- [BondList_Add](#) : Add bond information to the bond list.
- [BondList_Remove](#) : Remove a bond list entry matching the specified index.
- [BondList_RemoveAll](#) : Erase bond list sectors containing bond list information in flash.

21.2 BLE_ABSTRACTION DATA STRUCTURES TYPE DOCUMENTATION

21.2.1 BondInfo_t

Location: bondlist.h:39

Bond Information.

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Data Fields

Type	Name	Description
uint16_t	<i>state</i>	State of bond.
uint8_t	<i>pairing_lvl</i>	Pairing level.
uint8_t	<i>csr_k_exchanged</i>	Non-zero if CSRK has been exchanged.
uint8_t	<i>ltk[16]</i>	Long term key.
uint16_t	<i>ediv</i>	Encryption diversifier.
uint8_t	<i>reserved1[2]</i>	Reserved.
uint8_t	<i>addr[6]</i>	Peer address.
uint8_t	<i>addr_type</i>	Address type.
uint8_t	<i>irk_exchanged</i>	Non-zero if IRK has been exchanged.
uint8_t	<i>csr_k[16]</i>	Connection resolving signature key.
uint8_t	<i>irk[16]</i>	Identity resolving key.
uint8_t	<i>rand[8]</i>	Random number.

21.3 BLE_ABSTRACTION MACRO DEFINITION DOCUMENTATION

21.3.1 BOND_INFO_BASE

```
#define BOND_INFO_BASE FLASH_BOND_INFO_BASE
```

Start address and size of the memory region where bond list is stored:

Location: bondlist.h:67

- BOND_INFO_BASE: 3KB from base of data flash array (the first 3KB of data flash array is reserved to ROM use)
- BOND_INFO_FLASH_SECTORS_COUNT: Defaulted to 8 sectors (2KB) Notes: if needed, user application can re-define BOND_INFO_BASE and BOND_INFO_FLASH_SECTORS_COUNT. Any increase to the number of sectors will also need to be updated in the linker script. Start of address for bond info

21.3.2 BOND_INFO_SIZE

```
#define BOND_INFO_SIZE (72)
```

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Each Bond takes up 72 Bytes of the FLASH.

Location: bondlist.h:74

21.3.3 STATIC_ASSERT

```
#define STATIC_ASSERT typedef char static_assertion_failed_##MSG[(COND) ? 1 : -1]
```

Location: bondlist.h:76

21.3.4 BONDLIST_MAX_SIZE

```
#define BONDLIST_MAX_SIZE (28)
```

Location: bondlist.h:85

21.3.5 BOND_INFO_FLASH_SECTORS_COUNT

```
#define BOND_INFO_FLASH_SECTORS_COUNT ((BONDLIST_MAX_SIZE * BOND\_INFO\_SIZE) >> 8)
```

Location: bondlist.h:93

21.3.6 BOND_INFO_STATE_INVALID

```
#define BOND_INFO_STATE_INVALID 0x00
```

Invalid bond info state.

Location: bondlist.h:98

21.3.7 BOND_INFO_STATE_EMPTY

```
#define BOND_INFO_STATE_EMPTY 0xFFFF
```

Empty bond info state.

Location: bondlist.h:101

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21.3.8 BOND_INFO_STATE_VALID

```
#define BOND_INFO_STATE_VALID ((state != BOND\_INFO\_STATE\_INVALID) && \  
                             (state != BOND\_INFO\_STATE\_EMPTY) && \  
                             (state <= BONDLIST_MAX_SIZE))
```

Macro for valid bond info state.

Location: bondlist.h:104

21.4 BLE_ABSTRACTION FUNCTION DOCUMENTATION**21.4.1 STATIC_ASSERT**

```
STATIC_ASSERT()
```

Location: bondlist.h:81

21.4.2 BondList_Size

```
uint8_t BondList_Size()
```

Bondlist functions.

Get the number of entries in the bond list stored to flash

Location: bondlist.h:117

Return

Number of entries in the the bond list with a valid bond state

21.4.3 BondList_GetIRKs

```
uint8_t BondList_GetIRKs(struct gap_sec_key * irks)
```

Get the IRKs from bond lists.

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Get the IRKs from bond lists having valid bond state

Location: bondlist.h:127

Parameters

Direction	Name	Description
in	<i>irks</i>	Pointer to gap_sec_key structure

Return

Number of IRKs found

21.4.4 BondList_FindByIRK

```
const BondInfo\_t * BondList_FindByIRK(const uint8_t * irk)
```

Search for the bond information matching specified IRK in flash.

Location: bondlist.h:136

Parameters

Direction	Name	Description
in	<i>irk</i>	Matching IRK to search for

Return

If found an entry in flash, return its address as a pointer to a const [BondInfo_t](#) element NULL otherwise

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21.4.5 BondList_FindByAddr

```
const BondInfo\_t * BondList_FindByAddr(const uint8_t * addr, uint8_t addrType)
```

Search for the bonding information for a peer device in flash matching specified address and address type.

Location: bondlist.h:147

Parameters

Direction	Name	Description
in	<i>addr</i>	Address of the peer device to search
in	<i>addrType</i>	Address type of the peer device to search

Return

If found an entry in flash, return its address as a pointer to a const [BondInfo_t](#) element NULL otherwise

21.4.6 BondList_FlashDefrag

```
bool BondList_FlashDefrag()
```

Squeeze bond information together to make space for a new entry.

Location: bondlist.h:154

Return

True if successful, false otherwise

21.4.7 BondList_Add

```
uint16_t BondList_Add(BondInfo\_t * bond_info)
```

Add bond information to the bond list.

Location: bondlist.h:163

Parameters

Direction	Name	Description
in	<i>bond_info</i>	Pointer to bond information

Return

Non-zero if bond information is added to bond list successfully, false otherwise

21.4.8 BondList_Remove

```
bool BondList_Remove(uint16_t bondStateIndex)
```

Remove a bond list entry matching the specified index.

Location: bondlist.h:171

Parameters

Direction	Name	Description
in	<i>bondStateIndex</i>	Index of bond list to remove

Return

True if successful, false otherwise

21.4.9 BondList_RemoveAll

```
bool BondList_RemoveAll()
```

Erase bond list sectors containing bond list information in flash.

Location: bondlist.h:179

Return

If found an error erasing any sector, return false true otherwise

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