# FUSION B0

# SE Host Services API and User Guide

# V 0.0.39

# August 2023

# Table of Contents

## Contents

# TODO

- OSPI needs example code to show setting of EXTERNAL / INTERNAL Keys usage.
- Power example needs updating with latest tests and aiPM APIs
- SERVICES APIS to add
  - Dynamic
    - Interrupt muxing
    - Event routing
  - Image loading
  - Deferred boot
  - PSA

# Introduction

The Fusion product series is a scalable SoC solution for IoT Edge Computing platforms.

SERVICES provide a method for the Application CPUs (M55_HE, HP, A32) to communicate with the Secure Enclave. This secure communication path is achieved using the MHU (Message Handling Unit) hardware block.

The SERVICES library consists of C code that interfaces with an MHU driver to facilitate this communication.

Services fall into the following categories:

- Maintenance Services
- Crypto Services
- Update Services
- Secure Debug Service
- Application Services

The library source code is provided along with a test harness showing the invocation of each SERVICE library call.

The example (test harness) can be used as a framework to copy for integrating SERVICES into your application code. You should only need to include the SERVICE header files and link with the pre-built SERVICE libraries provided.

The examples can be built for all Application cores in XIP and Non-XIP mode. ATOC configuration files are also provided. The examples are stand-alone but can be built using the ALIF Ensemble CMSIS delivery.

ARM Clang and ARM GNU CC are both supported. **Note:** that the pre-built libraries are compiled using ARM Clang. Just run `make realclean` and rebuild everything.

The pre-built libraries were intended to quicken the process of integrating SERVICES into an application. For real development it is recommended to add the SERVICES to your build process

# Version History

| Version | Type | Change | |
|---|---|---|---|
| V0.0.39 | | CMSISV0.9.4 | |
| V0.0.38 | | CMSISV0.9.3 | |
| V0.0.37 | | CMSISV0.9.2<br>aiPM Clock changes (Header) | |
| V0.0.36 | | CMSISV0.9.1<br>Global to Local: address translation removal. Use CMSIS | SE-1961<br>SE-1947 |
| V0.0.35 | | aiPM SERVICE RUN<br>SERVICES build switch to CMake | SE-1923<br>SE-1924 |
| V0.0.34 | Feature | aiPM SERVICE introduction<br>CMSIS V0.9.0 updates | SE-1887<br>SE-1886 |
| V0.0.33 | | | |
| V0.0.31 | | | |
| V0.0.30 | BUG | [JIRA] (SE-1796) [SE-Services] Issue in PinMux and padcontrol error code | SE-1796 |
| V0.0.29 | Clean API | Consistent Error code handling in SERVICES transport layer<br>SRAM0,1, MRAM Power enable | SE-1731<br>SE-1696 |
| V0.0.28 | API | Rename standby API<br>Corstone clocks configuration as services | SE-1447<br>SE-1684 |
| V0.0.27 | BUG | Fix warnings in service release | SE-1709 |
| V0.0.26 | Feature | PLL Service API exposure<br>Service for global standby mode added<br>APIs for Finer grain Retention control<br>clean up Makefiles<br>CMSIS 0.5.2 updates | SE-1660<br>SE-1609<br>SE-1608<br>SE-1658<br>SE-1676 |
| V0.0.25 | Feature | CMake M55_power added | SE-1645 |
| V0.0.24 | | REV_B0 release including Power example | SE-1612 |
| V0.0.23 | Feature | API<br>Support for RTSS 0.5.0 CMSIS release | SE-1585 |
| V0.0.22 | Feature | Error codes are transport related only<br>LocalToGlobal address translation changes<br>Split actual message sending from SERVICES_send_msg() | |
| V0.0.21 | Feature | Adding SPARK build flag | |
| V0.0.20 | Feature | Update license headers | SE-1512 |
| | | RISC-V reset SERVICE | SE-1511 |
| V0.0.19 | Feature | Adding CMake build option, README.md file added | |
| V0.0.18 | BUG Fixes | See limitations | |
| V0.0.17 | BUG Fixes | See limitations | |

| | | | |
|---|---|---|---|
| V0.0.16 | <> | | |
| V0.0.15 | BUG Fixes | See limitations | |
| V0.0.14 | Example | Test harness updated | |
| V0.0.13 | Startup | Updated m55 startup code | |
| V0.0.12 | API | Added SERVICES_system_read_otp | |
| V0.0.11 | API | Added SERVICES_system_get_toc_data | |
| V0.0.10 | API | standardized variables for send/resp | |
| V0.0.9 | API | SERVICES_uart_write added size parameter | |
| | | New Error code SERVICES_REQ_BAD_PRINT_LENGTH | |
| | | New Error code SERVICES_REQ_NULL_PARAMETER | |

# Limitations

Current releases support

- A32 (Not until REV_B2 devices)
- M55-HE, M55-LE Application CPUs
- Bare metal systems
- LINUX

## Known limitations:

### SE-UART Spamming

When using CONTINUOS modes via the SE-UART print SERVICE the amount of print traffic can be very heavy and make the system unresponsive. We recommend you use a local UART (UART 2 or 4) dedicated to the M55_HE or M55_HP.

The SERVICES print capability using the SE-UART was added as a convenience to save having to set up external UARTs.

## Known release issues:

0.0.39

- A32 builds do not work.
- XIP with CMSISV0.9.4 does not work. Default / use CMSIS V0.9.3

0.0.38

- <>

0.0.37

- BASIC3 EXAMPLE – reports of Hard faults seen on Wake up. -> FIXED

0.0.36

- <>

0.0.35

- [JIRA] (SE-1960) [SERVICES] XIP arm clang examples are no longer running -> NEW

0.0.34

- [JIRA] (SE-1909) [SERVICES] makefile under MS-DOS -> RESOLVED.
- [JIRA] (SE-1891) [SERVICES] Issue with the cmsis_version name is SE-Services pack -> RESOLVED.
- [JIRA] (SE-1910) [SERVICES] Remove Makefile traces -> RESOLVED.
- [JIRA] (SE-1896) [Services] Issue with Cmake build process -> RESOLVED.
- [JIRA] (SE-1886) [SERVICES] Updates for CMSIS V0.9.0 -> NEW
- [JIRA] (SE-1900) [SERVICES] SERVICES_system_get_otp_data() needs implementing

0.0.33

- [JIRA] (SE-1913) [SE-Services] Issue in cpu boot sequence -> RESOLVED.
- [JIRA] (SE-1910) [SERVICES] Remove Makefile traces – makefile debug enabled.
- [JIRA] (SE-1909) [SERVICES] makefile under MS-DOS – use of DEL command
- [JIRA] (SE-1878) [Services] M55_HE XIP=off showing an Error during boot -> RESOLVED

- [JIRA] (SE-1900) [SERVICES] SERVICES_system_get_otp_data() needs implementing -> NEW
- [JIRA] (SE-1896) [Services] Issue with Cmake build process -> NEW.
- [JIRA] (SE-1878) [Services] M55_HE XIP=off showing an Error during boot -> NEW

0.0.32

- [JIRA] (SE-1813) [Services] Warnings during the compilation of services images using cmake and ARM-GCC
- [JIRA] (SE-1843) Calling SERVICES_system_set_services_debug with debug_enable false breaks subsystem off
- [JIRA] (SE-1853) Incomplete examples for SERVICES_xxx
- [JIRA] (SE-1851) Invalid example code in SERVICES documentation
- [JIRA] (SE-1822) [SERVICES] M55_HP showing Error on boot.
- [JIRA] (SE-1815) LPTimer or LPGPIO does not work as a stop mode wake up sources.

0.0.31

- [JIRA] (SE-1822) [SERVICES] M55_HP showing Error on boot -> RESOLVED.
- [JIRA] (SE-1844) [SERVICES] Add disable service for memory power control - Currently RESOLVED by removing SERVICES_power_memory_req() as a test.
- [JIRA] (SE-1847) Calling SERVICES_pll_initialize breaks subsystem off test.
- [JIRA] (SE-1843) Calling SERVICES_system_set_services_debug with debug_enable false breaks subsystem off
- [JIRA] (SE-1813) [Services] Warnings during the compilation of services images using cmake and ARM-GCC -> RESOLVED.

0.0.30

- [JIRA] (SE-1822) [SERVICES] M55_HP showing Error on boot.
- [JIRA] (SE-1813) [Services] Warnings during the compilation of services images using cmake and ARM-GCC
- [JIRA] (SE-1649) [SERVICES] hardfault when writing to RTC_A register.
- [JIRA] (SE-1582) [SERVICES][REV_B0] Services examples do not run from MRAM or TCM

0.0.29

- [JIRA] (SE-1782) [SERVICES] Need to change the address of HP in the JSON file of "services-he-hp-a32-xip"
- [JIRA] (SE-1731) [SERVICES] Consistent Error handling -> RESOLVED

0.0.28

- <>

0.0.27

- [JIRA] (SE-1709) [SERVICES] Fix warnings in service release -> RESOLVED

0.0.26

- [JIRA] (SE-1676) [SERVICES] CMSIS 0.5.2 updates -> RESOLVED
- [JIRA] (PSBT-150) RTSS 0.5.0 compiler warning -> RESOLVED (With CMSIS V0.5.2)
- [JIRA] (PSBT-149) Spelling mistakes -> RESOLVED
- [JIRA] (SE-1658) [SERVICES] clean up Makefiles -> RESOLVED
- [JIRA] (SE-1631) [SERVICES] build all (GNU) fails with A32 build -> RESOLVED. Now skips the A32 build rather than Fail.
- JIRA] (SE-1509) [SERVICES] GNU C Compilations lack XIP examples -> RESOLVED

0.0.25

- GCC sample ld files added for XIP
- [JIRA] (SE-1680) [SERVICES] makefile.gnu all install - HP image is missing
- [JIRA] (SE-1628) [SERVICES] Standby mode SRAM0 SRAM1 retention -> RESOLVED
- [JIRA] (SE-1674) [SERVICES] Overlap regions for HE-HP example -> RESOLVED
- [JIRA] (SE-1497) [SERVICES] TEST Services initialize polling -> RESOLVED
- [JIRA] (SE-1644) [SERVICES] Unsupported build matrix options should error not fail -> RESOLVED
- [JIRA] (SE-1645) [SERVICES] power example GCC build -> RESOLVED
- [JIRA] (PSBT-150) RTSS 0.5.0 compiler warning

0.0.24

- [JIRA] (SE-1674) [SERVICES] Overlap regions for HE-HP example
- Make option (cmsis override) – HELP banner shows 'make cmsis CMSIS=x.y.z', syntax is make cmsis=x.y.z
- [JIRA] (SE-1652) [SETOOLS] APP release builder uses wrong cfg for REV_B0 – app-cpu.cfg has wrong address 0x60000000 instead of 0x58000000. This is a bug in the release builder copying the REV_A1 JSON file instead of REV_B0 to the release.
- [JIRA] (PSBT-150) RTSS 0.5.0 compiler warning – during the build there is a –noreturn warning printed.
- [JIRA] (SE-1649) [SERVICES] hardfault when writing to RTC_A register – temporarily commented out (example still runs) until this is fixed.
- [JIRA] (SE-1631) [SERVICES] build all (GNU) fails with A32 build – use Make clean and rebuild.
- [JIRA] (SE-1612) [SERVICES] Not able to see the cpu id information for M55_HP -> RESOLVED

0.0.23

- [JIRA] (SE-1612) [SERVICES] Not able to see the cpu id information for M55_HP
- [JIRA] (PSBT-150) RTSS 0.5.0 compiler warning – You will see a compiler warning for the Reset_Handler regarding NoRETURN.
- [JIRA] (PSBT-151) L6242E: Cannot link object services_host_handler.o as its attributes are incompatible with the image attributes.
- [JIRA] (PSBT-149) Spelling mistakes
- JIRA] (SE-1447) [SERVICES] Spelling errors (In the LD files from APPS) -> RESOLVED

0.0.22

- [JIRA] (SE-1582) [SERVICES][REV_B0] Services examples do not run from MRAM
- [JIRA] (SE-1576) [SERVICES] Services UART print is always enabled
- [JIRA] (SE-1553) [SERVICES] make all for GNU still using ARM-Clang

0.0.21

- <>

0.0.20

- JIRA] (SE-1502) [SERVICES] Extra bracket character in services_lib_api.h causing build failure with C++ -> RESOLVED

0.0.19

- CMake - builds *only* for M55_HE TCM load (SE-1509)
- [JIRA] (SE-1526) [SERVICES] A32 XIP example fails -> NEW

0.0.18

- [JIRA] (SE-1496) [SERVICES] GCC Compilation warning [-Wunused-variable] -> RESOLVED
- [JIRA] (SE-1487) [SERVICES] A32 example missing json file -> RESOLVED

- [JIRA] (SE-1442) [SERVICES] unused function in MHU driver -> RESOLVED
- [JIRA] (SE-1427) [SERVICES] A32 example crashes when run from MRAM

0.0.17

- [JIRA] (SE-1487) [SERVICES] A32 example missing json file -> NEW
- [JIRA] (SE-1465) [SERVICES] debug output is enabled -> RESOLVED
- [JIRA] (SE-1471) [SERVICES] DOS based make issue -> RESOLVED
- [JIRA] (SE-1443) [SERVICES] newlib link warnings -> RESOLVED

0.0.16

- A32 example is not part of the GNU C compilation.
- [JIRA] (SE-1439) [SERVICES] Compiler warnings with GCC -> RESOLVED
- [JIRA] (SE-1442) [SERVICES] unused function in MHU driver -> RESOLVED

0.0.15

- A32 example is not part of the GNU C compilation. This was not done as there were issues with A32 example fixed in this sprint.
- [JIRA] (SE-1443) [SERVICES] newlib link warnings - with GNU C warnings are seen with SERVICES library link
- [JIRA] (SE-1442) [SERVICES] unused function in MHU driver – warning seen with GNU about unused function
- [JIRA] (SE-1349) [SERVICES] A32 example output incorrect

0.0.14

- [JIRA](SE-1423) TTY Output - <unknown> is passed for CPU type in Library revision output

0.0.13

- A32 crash seen when booting from MRAM

0.0.12

- <>

0.0.11

- OTP read is “not implemented”, awaiting SES change for OTP API reads.

0.0.10

- <>

0.0.9

- UART prints via Services are maximum size of 256 bytes.
- Pin and Pad control messages can be seen as part of the SE-UART output even if the SERVICE debug is DISABLED. This is a bug and will be fixed.

0.0.8

- RTSS / CMSIS require edits to be made to the SERVICES example to work under ARM-DS (MiniTOC). Integration of a unified MHU driver is still not completed for CMSIS.

0.0.7

- RTSS / CMSIS builds do not support REV_B0 devices. It will build, but execution fails.

0.0.6

- RTSS / CMSIS build causes compiler error with redefinition of M55_HE preprocessor flag.

V46

- <>

V42

- <>

V41

- Other running applications can interfere with operation of the Services. The MHU interrupts can stop. Suggest that other Applications, such as the Blinky, are removed and replaced with a debug stub
- Stepping over the init() function in the M55 Examples actually enters the function, if this happens just jump out of this function

In V42 it is no longer needed to put a debug stub on an M55 core before running the Services example on it. An Arm DS debugger script was added that initializes certain M55 registers, and combined with a change in the code, puts the M55 in a known state that doesn't cause issues. The details are in the section 'Running the M55 HE Host Example'.

## SE Host SERVICES Versions with SERAM Pairings

| Version | SERAM | Notes |
|---|---|---|
| 0.039 | V81 | |
| 0.038 | V80 | |
| 0.037 | V79 | |
| 0.036 | V78 | |
| 0.035 | V77 | |
| 0.034 | V76 | |
| 0.033 | V75 | |
| 0.032 | V74 | |
| 0.029 | V71 | REV_B0 PLL, Clock updates |
| 0.028 | V69 | |
| 0.027 | V68 | |
| 0.026 | | |
| 0.025 | V67 | |
| 0.024 | V66 | |
| 0.023 | V65 | |
| 0.022 | V64 | |
| 0.021 | V63 | SPARK flag build |
| 0.020 | V62 | Add FUSION_EXTERNAL_SYS0 |
| 0.0.16 | V58 | OTP addition |
| 0.0.11 | V51 | Get all TOC data |
| 0.0.10 | V50 | EWiC configuration call |
| 0.0.9 | V49 | |
| 0.0.8 | V47 | Header file change |
| 0.0.7 | V47 | Mbed TLS accelerators |
| 0.0.6 | V46 | API for enable / disable SES debug status |
| 0.0.5 | V46 | API changes for Error code |
| 0.0.4 | | Boot reset addition |
| 0.0.3 | | RPC Parameter changes |
| 0.0.2 | | First refactoring |
| 0.0.1 | | First implementation |

## Supported SE Host Services summary

| Service Group | Ax | B0 | | Notes |
|---|---|---|---|---|
| **Maintenance** | | | | |
| | ● | ● | SERVICES_heartbeat | Health status |
| | ● | ● | SERVICES_heartbeat_async | |
| | | | | |
| **System Management** | | | | |
| | ● | ● | SERVICES_system_get_toc_data | |
| | ● | ● | SERVICES_system_get_toc_number | |
| | ● | ● | SERVICES_system_get_toc_via_name | |
| | ● | ● | SERVICES_system_get_toc_version | N/I |
| | ● | ● | SERVICES_system_get_toc_via_cpuid | |
| | ● | ● | SERVICES_system_get_device_part_number | |
| | ● | ● | SERVICES_system_get_device_data | |
| | ● | ● | SERVICES_system_set_services_debug | Debug toggle |
| | ● | ● | SERVICES_system_get_otp_data | N/I |
| | ● | ● | SERVICES_system_read_otp | |
| | ● | ● | SERVICES_get_se_revision | |
| | | | | |
| **Application / Pin mux management** | | | | |
| | ● | ● | SERVICES_pinmux | |
| | ● | ● | SERVICES_padcontrol | |
| | ● | ● | SERVICES_uart_write | |
| | | ● | SERVICES_application_ospi_write_key | |
| | ● | ● | SERVICES_SRAM_retention_config | |
| | | | | |
| **Power** | | | | |
| | | ● | SERVICES_power_stop_mode_request | |
| | | ● | SERVICES_power_ewic_config | |
| | | ● | SERVICES_power_wakeup_config | |
| | | ● | SERVICES_power_mem_retention_config | |
| | | ● | SERVICES_power_m55_he_vtor_save | |
| | | ● | SERVICES_power_m55_hp_vtor_save | |
| | | ● | SERVICES_power_memory_req | |
| | | ● | SERVICES_global_standby_mode | |
| | | ● | SERVICES_get_run_cfg | aiPM |
| | | ● | SERVICES_set_run_cfg | aiPM |
| | | ● | SERVICES_get_off_cfg | aiPM |
| | | ● | SERVICES_set_off_cfg | aiPM |
| | | | | |

| | | | | |
|---|---|---|---|---|
| **Security /Crypto** | | | | |
| | ● | ● | SERVICES_cryptocell_get_lcs | |
| | ● | ● | SERVICES_cryptocell_get_rnd | TRNG |
| | ● | ● | SERVICES_cryptocell_mbedtls_aes_init | |
| | ● | ● | SERVICES_cryptocell_mbedtls_aes_set_key | |
| | ● | ● | SERVICES_cryptocell_mbedtls_aes_crypt | |
| | ● | ● | SERVICES_cryptocell_mbedtls_sha_starts | |
| | ● | ● | SERVICES_cryptocell_mbedtls_sha_process | |
| | ● | ● | SERVICES_cryptocell_mbedtls_sha_update | |
| | ● | ● | SERVICES_cryptocell_mbedtls_sha_finish | |
| | ● | ● | SERVICES_cryptocell_mbedtls_ccm_gcm_set_key | |
| | ● | ● | SERVICES_cryptocell_mbedtls_ccm_gcm_crypt | |
| | ● | ● | SERVICES_cryptocell_mbedtls_ccm_gcm_chachapoly_crypt | |
| | ● | ● | SERVICES_cryptocell_mbedtls_ccm_gcm_poly1305_crypt | |
| | ● | ● | SERVICES_cryptocell_mbedtls_cmac_init_setkey | |
| | ● | ● | SERVICES_cryptocell_mbedtls_cmac_update | |
| | ● | ● | SERVICES_cryptocell_mbedtls_cmac_finish | |
| | ● | ● | SERVICES_cryptocell_mbedtls_cmac_reset | |
| | | | | |
| **Boot** | | | | |
| | ● | ● | SERVICES_boot_process_toc_entry | |
| | ● | ● | SERVICES_boot_cpu | |
| | ● | ● | SERVICES_set_vtor | |
| | ● | ● | SERVICES_boot_reset_cpu | |
| | ● | ● | SERVICES_boot_release_cpu | |
| | ● | ● | SERVICES_boot_reset_soc | |
| | | | | |
| **Clock** | | | | |
| | | ● | SERVICES_clocks_select_osc_source | |
| | | ● | SERVICES_clocks_select_pll_source | |
| | | ● | SERVICES_clocks_enable_clock | |
| | | ● | SERVICES_clocks_set_ES0_frequency | |
| | | ● | SERVICES_clocks_set_ES1_frequency | |
| | | ● | SERVICES_clocks_select_a32_source | |
| | | ● | SERVICES_clocks_select_aclk_source | |
| | | ● | SERVICES_clocks_set_divider | |
| | | | | |

N/I - Not implemented means the SERVICE exists but is not fully completed in SES.

## SE Host Services Delivery Components

A release package from ALIF consists of the following components:

- Source code SERVICES library
  - Public header files
- Makefile(s) for ARM Clang and ARM GNU C builds
- Example ports for Bare metal and Linux
  - Example SERVICE library initializations.
- Example use cases for M55_HE, M55_HP, A32 and M55_HE+M55_HP
  - Example runs a test program calling all available SERVICES API.
  - Output is sent via the SE-UART to save having to install extra UART debug ports.
- Example use cases for Low Power

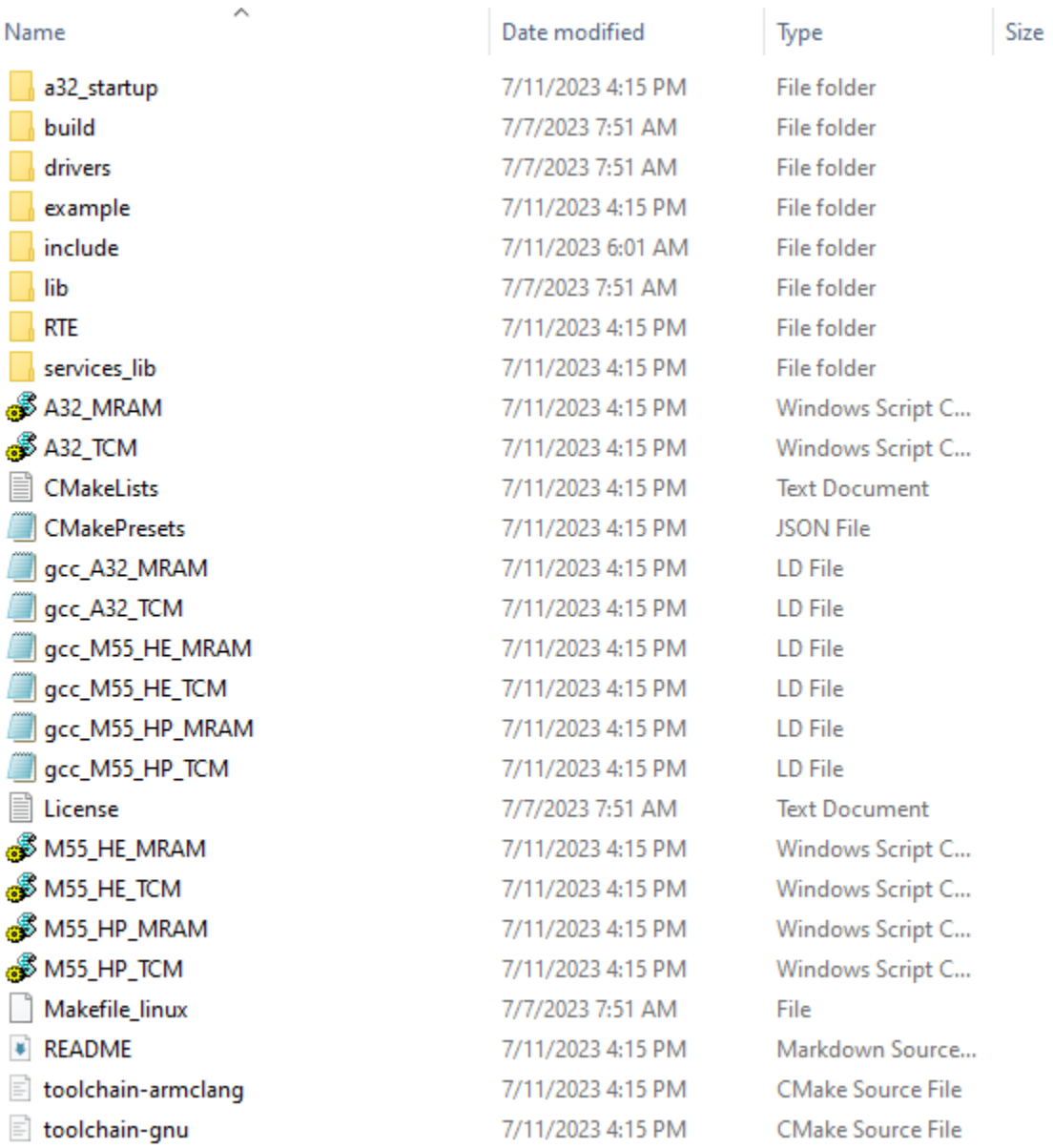
## Pre-requisites

The following components are required to be installed before using / building SE SERVICES:

- ALIF Ensemble RTSS Release >= Version 0.5.0
  - CMSIS Packs for Ensemble devices
  - Following the installation instructions for this package
- GNU Make V4.4
- Cmake V3.22.2
- Security Toolkit (SETOOLS)
  - Not required for building, but for generating the ATOC packages for the Target

# Building SE Services – Windows / LINUX

Unpack the se-host-services-release-SE_FW_0.<version#>.000_DEV.zip



| Name | Date modified | Type | Size |
|---|---|---|---|
| a32_startup | 7/11/2023 4:15 PM | File folder | |
| build | 7/7/2023 7:51 AM | File folder | |
| drivers | 7/7/2023 7:51 AM | File folder | |
| example | 7/11/2023 4:15 PM | File folder | |
| include | 7/11/2023 6:01 AM | File folder | |
| lib | 7/7/2023 7:51 AM | File folder | |
| RTE | 7/11/2023 4:15 PM | File folder | |
| services_lib | 7/11/2023 4:15 PM | File folder | |
| A32_MRAM | 7/11/2023 4:15 PM | Windows Script C... | |
| A32_TCM | 7/11/2023 4:15 PM | Windows Script C... | |
| CMakeLists | 7/11/2023 4:15 PM | Text Document | |
| CMakePresets | 7/11/2023 4:15 PM | JSON File | |
| gcc_A32_MRAM | 7/11/2023 4:15 PM | LD File | |
| gcc_A32_TCM | 7/11/2023 4:15 PM | LD File | |
| gcc_M55_HE_MRAM | 7/11/2023 4:15 PM | LD File | |
| gcc_M55_HE_TCM | 7/11/2023 4:15 PM | LD File | |
| gcc_M55_HP_MRAM | 7/11/2023 4:15 PM | LD File | |
| gcc_M55_HP_TCM | 7/11/2023 4:15 PM | LD File | |
| License | 7/7/2023 7:51 AM | Text Document | |
| M55_HE_MRAM | 7/11/2023 4:15 PM | Windows Script C... | |
| M55_HE_TCM | 7/11/2023 4:15 PM | Windows Script C... | |
| M55_HP_MRAM | 7/11/2023 4:15 PM | Windows Script C... | |
| M55_HP_TCM | 7/11/2023 4:15 PM | Windows Script C... | |
| Makefile_linux | 7/7/2023 7:51 AM | File | |
| README | 7/11/2023 4:15 PM | Markdown Source... | |
| toolchain-armclang | 7/11/2023 4:15 PM | CMake Source File | |
| toolchain-gnu | 7/11/2023 4:15 PM | CMake Source File | |

The release archive consists of the following target components.

| Name | Purpose | Notes |
|---|---|---|
| a32_startup | A32 startup code | |
| Build | | |
| include | Services header files | |
| lib | | |
| services_lib | Host source code for Services | |
| Example | SERVICES test harnesses | |
| README.md | instructions | |

CMAKE is used.

## Building with ARM GNU C

```
$ cd se-host-service-release
$ mkdir build_he_gcc_tcm
$ cd build_he_he_gcc_tcm
$ cmake .. -G "Unix Makefiles" -DENSEMBLE_CORE=M55_HE -
DCMAKE_TOOLCHAIN_FILE=toolchain-gnu.cmake
$ make install

$ cd se-host-service-release
$ mkdir build_he_power_gcc_tcm
$ cd build_he_power_gcc_tcm
$ cmake .. -G "Unix Makefiles" -DENSEMBLE_CORE=M55_HE -
DCMAKE_TOOLCHAIN_FILE=toolchain-gnu.cmake -DPOWER=ON
$ make install
```

The SERVICE library is built as part of these builds.

## Building with ARM CLANG

```
$ cd se-host-services-release
$ mkdir build_he_power_clang_tcm
$ cd build_he_power_clang_tcm
$ cmake .. -G "Unix Makefiles" -DENSEMBLE_CORE=M55_HE -DPOWER=ON
DCMAKE_TOOLCHAIN_FILE=toolchain-armclang.cmake
$ make install -j 8
```

```
$ cd se-host-services-release
$ mkdir build_he_clang_tcm
$ cd build_he_clang_tcm
$ cmake .. -G "Unix Makefiles" -DENSEMBLE_CORE=M55_HE -
DCMAKE_TOOLCHAIN_FILE=toolchain-armclang.cmake
$ make install -j 8
```

NOTE: Parallel make (using -j <job#>) is available

## SERVICES Library Dependencies

The SERVICES library and support file for starting SERVICES has a few dependencies.

- CMSIS Package installation location
- CMSIS Package source and include locations.
- Compiler flags

### CMSIS Package

CMSIS dependency is mainly for header files for the targeted Application CPU e.g., “M55_HE.h”

The SERVICE example uses the CMSIS startup sequences for booting the Application cores.

CMSIS packages consist of an ARM and ALIF component. The ARM components is specific for the various types of cores. The ALIF components contain specific ALIF Device and Board components.

### CMSIS RTSS V0.9.x Release

There is no backwards compatibility with previous RTSS releases.

- The interrupt handler names for Secure Enclave communication over MHU have changed again.
- Makefile updates for different include and source directory paths.

## JSON Configurations

The examples can be built for the following Application cores:

- M55_HE
- M55_HP
- A32

Sample ATOC JSON files are provided for:

- Code running from MRAM (XIP).
- Code running from TCM memory.
- M55_HE
- M55_HP
- M55_HE + M55_HP

| JSON File | TCM | MRAM |
|---|---|---|
| services_a32 | ✓ | |
| services_a32-xip | | ✓ |
| services_he | ✓ | |
| services_he_hp | ✓ | |
| services_he_hp_a32 | ✓ | |
| services_he_hp_a32_xip | | ✓ |
| services_he_hp_xip | ✓ | |
| services_he_xip | | ✓ |
| services_hp | ✓ | |
| services_hp_xip | | ✓ |

# Power Example

The Power examples demonstrate how to use SERVICES to achieve low power states.

The SERVICES are used to configure the device and enable STOP mode.

## Power Example features

| Features | RUN mode | OFF mode |
|---|---|---|
| Memory Retention | Supported | Supported only in STOP |
| Wake up | Supported | Supported only in STOP |
| EWIC | Supported | Supported only in STOP |
| Power domain | Supported | Supported only in STOP |
| VDD ioflex 3V3 | Supported | Supported only in STOP |
| VTOR | Supported | Supported only in STOP |
| DCDC | TBD | TBD |
| Clocks | TBD | TBD |

| Feature | M55-HP | M55-HE | Support | Comments |
|---|---|---|---|---|
| Stop mode | Vote | Vote | Supported | Both CPUs must vote<br>NOTE: If a CPU goes OFF, its vote is counted. If it wakes up (before STOP mode), its vote is not revoked - TBD |
| Stop mode | Vote | No vote | TBD | Not booted/not running/wounded cases not checked - TBD |
| Stop mode | No vote | Vote | TBD | Not booted/not running/wounded cases not checked - TBD |
| Stop mode | No vote | No vote | No STOP mode | |
| Wake up from STOP TCM | TBD | Supported<br>(m55 retainted only) | | M55-HE TCM must be retained |
| Wake up from STOP XIP | TBD | Supported<br>(SERAM not retained only) | | Fast boot only |
| Wake up from STOP SERAM (retained) | | | Supported | SEROM skips SERAM image verification |
| Wake up from STOP SERAM (not retained) | | | Supported | Fast boot<br>- M55-HE released from reset by SEROM.<br>- TCM must be reainted<br>- XIP not supported |
| Subsystem OFF settings | TBD | TBD | Only STOP | When a subsystem powers off, the OFF settings are not currently applied.<br>OFF setting are applied only in STOP mode |

## Power Example Use Cases

Please refer to the README.md file in the SERVICES release for details of the Example use cases e.g., how to build and run.

### BASIC1/2

- Keeps device ON after wake-up from STOP mode.
- M55_HE is booted on wake-up.

### BASIC3

- Continually cycles from STOP->WAKE.

### BASIC4

- Example
  - Make a Set RUN Config call, to change the clock settings to something different from the default.
  - Measure the CPU speed, to verify that the above call was executed successfully.
  - Make a Set OFF Config call.
  - Make the PM calls to go OFF. It seems now that is Alif CMSIS functionality.
- Can be configured (built) for continuous or limited run (10) mode.
- **NOTE**: There is an issue when measuring the CPU speeds of both M55s at the same time. It seems it is caused by the shared usage of RTC_A, which is also used for wakeup logic.

### BASIC5

- FASTBOOT with SE not retained.

### BASIC6

- Global standby example in TCM.

### BASIC7

- IDLE mode example in TCM

### BASIC8 to BASIC13 – Clock configuration examples

Each of these examples perform a single aiPM call to set the RUN clock configuration of the device.

- BASIC8 – run the device off the PLL at full CPU frequencies.
- BASIC9 – run the device off the PLL at reduced M55 CPUs frequencies.
- BASIC10 – run the device off the HFXO at full HFXO frequency.
- BASIC11 – run the device off the HFXO at scaled down HFXO frequency.
- BASIC12 – run the device off the HFRC at full HFRC frequency.
- BASIC13 – run the device off the HFRC at scaled down HFRC frequency.

### BASIC14 – GET request examples

- Shows use of the get_off and get_run APIs.

### BASIC15 – Clock Source Cycling

- Cycles the device between PLL, HFXO and HFRC clock sources.
- Can be continuous or limited to 10 cycles.

### BASIC16 – M55s run in TCM not retained.

- SES loads M55 code from MRAM to it's TCM. M55-HE is not retained.
- M55 does a set_run() request
- M55 does a set_off() request
- SES puts the device in STOP mode when both m55s go OFF
- RTC_A expiry causes wake up
- PLL not enabled on wake up
    - Run at RC clock speed 76 MHz
- SES wakes up
    - Starts PLL
        - Run at 100 Mhz
    - Initializes m55-he TCM memory
- SES boots both m55-he and m55-hp from ATOC
    - As both CPUs are booted, you will see the chip cycle.

## SES Power Policies

- Both M55 cores *must* be running to go into STOP mode.
    - Requires **two** votes to power down the chip.
    - In future, other conditions with be considered, e.g., wounding, not booted etc.
- Logic added to process ATOC and boot M55_HE and M55_HP in case the M55_HE TCM was not retained.
- SES will apply retention settings as soon as a service request is received because they cannot be applied after a subsystem goes OFF.

## Power Example Running – Notes / Limitations

### ISP not responding.

- [ERROR] Target not responding causes:
    - If you have the device in a Power OFF state be aware that commands sent from the SETOOLS maintenance command will return [ERROR] Target not responding as the device is turned off. ISP is not running / listening on the target when the Power is off.
- Cannot use UpdateSystemPackage
    - If you have programmed the device to disable the PLL then using Bulk MRAM transfer commands such as UpdateSystemPackage or app-write-mram will probably fail. The reason is that these commands automatically raise the baud rate for ISP which assumes the PLL is enabled. To use these commands

```
$ updatesystempackage -s
$ app-write-mram -s
```

The -s option suppresses the baud rate increase.

To gain control of the device again you will need to enter Hard Maintenance mode.

## Power Examples Limitations

- Wakeup timers that expire before you enter STOP mode.
    - You will not enter stop mode.
- The booting of specific CPU core as per requested wake up event is not yet supported.
    - On any configured wake up event the m55-he is booted if its TCM is retained or ATOC is processed, and bootable images are booted (potentially both m55-he and m55-hp if the ATOC has bootable images for both)

The wake up from STOP mode has *many* scenarios e.g., XIP, retained, not all these scenarios are implemented yet.

## SES Clock Policies

- SES COLD Boot
    - SES checks for presence of Application DCT objects specifying Clock directions.
    - If no DCT object is present, SES will set the LF Clock Source to the LFXO (Default)

## SERVICES test harness example

A test harness example is provided showing calls to all the SERVICES APIs.

See `example\common\services_test.c`.

There are numerous build options available. Not all tests can be run at once as they either do not return or they reboot the system.

### Examples customization options.

Output of the results from the example test can be via the ARM-DS Console or the SE-UART.

In `services_test.c` there are the following defines

```
#define TEST_PRINT_ENABLE           1   /* Enable printing from Test harness */
#define PRINT_VIA_CONSOLE           0   /* Print via Debugger console        */
#define PRINT_VIA_SE_UART           1   /* Print via SE UART terminal        */
```

| Flag | Meaning |
|---|---|
| TEST_PRINT_ENABLE | Turn on output from the test |
| PRINT_VIA_CONSOLE | Print messages to arm-ds (printf()) |
| PRINT_VIA_SE_UART | Print messages to the SE-UART |

You can enable both Console and SE-UART.

If you want to run the test from MRAM the PRINT_VIA_CONSOLE must be disabled.

## Changing CMSIS Packs

The SERVICES examples use ALIF CMSIS mainly for:

- M55_HE and HP startup sequences.
- MHU interrupt vectors and numbers
- Global Standy APIs for Low Power example

The SERVICES examples build defaults to the latest ALIF CMSIS Packs.

Changing CMSIS versions is as follows:

```
$ cmake .. -G "Unix Makefiles" -DENSEMBLE_CORE=M55_HE -
DCMAKE_TOOLCHAIN_FILE=toolchain-armclang.cmake -Dalifcmsis=”0.9.2”
```

# Building and running the Examples

## Building the M55 HE Example - run from TCM.

There are two json files supplied in the Services release:

- services-he.json
  - Single Core
- services-he-hp.json
  - Dual Core

Follow the instructions to build the M55_HE or HP example.

```
$ cd <host-release directory>
$ mkdir build_he
$ cd build_he
$ cmake .. -G "Unix Makefiles" -DENSEMBLE_CORE=M55_HE -
DCMAKE_TOOLCHAIN_FILE=toolchain-armclang.cmake
$ make install
```

To boot M55_HE application CPUs you need these steps:

```
$ cd <release directory>/app-release-exec
$ ./app-gen-toc -f build/config/service-he.json
$ ./app-write-mram
```

## Building the M55 HE Example - run from MRAM.

There are two json files supplied in the Services release:

- services-he-xip.json
  - Single Core
- services-he-hp-xip.json
  - Dual Core

Follow the instructions to build the M55_HE or HP example.

```
$ cd <host-release directory>
$ mkdir build_he_mram
$ cd build_he_mram
$ cmake .. -G "Unix Makefiles" -DENSEMBLE_CORE=M55_HE -
DCMAKE_TOOLCHAIN_FILE=toolchain-armclang.cmake -DXIP=1
$ make install
```

To boot M55_HE application CPU you need these steps:

```
$ cd <release directory>/app-release-exec
$ ./app-gen-toc -f build/config/service-he-xip.json
$ ./app-write-mram
```

## Building the A32 Example

<TBD>

## Building the A32 XIP Example

<TBD>

## Building and running the M55_HE Power Example (ARM Clang)

```
$ cd se-host-service-release
$ mkdir build_he_power
$ cd build_he_power
$ cmake .. -G "Unix Makefiles" -DENSEMBLE_CORE=M55_HE -
DCMAKE_TOOLCHAIN_FILE=toolchain-armclang.cmake -DPOWER=ON
$ make install

$ cd ../app-release-exec
$ ./app-gen-toc -f build/config/service-he.json
$ ./app-write-mram
```

## Building and running the M55_HE Power Example (ARM GNUC)

```
$ cd se-host-service-release
$ mkdir build_he_power
$ cd build_he_power
$ cmake .. -G "Unix Makefiles" -DENSEMBLE_CORE=M55_HE -
DCMAKE_TOOLCHAIN_FILE=toolchain-gnu.cmake -DPOWER=ON
$ make install

$ cd ../app-release-exec
$ ./app-gen-toc -f build/config/service-he.json
$ ./app-write-mram
```

## Building and running the M55_HP Power Example (ARM Clang)

```
$ cd se-host-service-release
$ mkdir build_hp_power
$ cd build_hp_power
$ cmake .. -G "Unix Makefiles" -DENSEMBLE_CORE=M55_HP -
DCMAKE_TOOLCHAIN_FILE=toolchain-armclang.cmake -DPOWER=ON
$ make install

$ cd ../app-release-exec
$ ./app-gen-toc -f build/config/service-hp.json
$ ./app-write-mram
```

## Building and running the M55_HP Power Example (ARM GNUC)

```
$ cd se-host-service-release
$ mkdir build_hp_power
$ cd build_hp_power
$ cmake .. -G "Unix Makefiles" -DENSEMBLE_CORE=M55_HP -
DCMAKE_TOOLCHAIN_FILE=toolchain-gnu.cmake -DPOWER=ON
$ make install
```

```
$ cd ../app-release-exec
$ ./app-gen-toc -f build/config/service-hp.json
$ ./app-write-mram
```

## Building SE Host Services – LINUX

Unpack the se-host-services-release-SE_FW_0.<version#>.000_DEV.zip

There is a separate makefile file for building the Services library for Linux - 'Makefile_linux', so that file should be used instead of the default 'Makefile' –

```
$ make -f Makefile_linux lib
```

By default, things are set up to use the native GCC compiler in Cygwin.

To use the Alif Yocto cross compiler toolchain and generate binaries for the Alif Linux distribution, a couple of changes are needed.

- comment out the compiler definitions (like 'CC = gcc') in Makefile_linux. The Yocto toolchain provides its own definitions.
- modify the file services_lib\services_host_handler_linux.c and replace '#if 0' with '#if 1', to include the Linux kernel header file for the MHU driver.

## Installing examples

The examples come with supplied JSON files for A32, M55_HE and M55_HP processors including variants for MRAM (XIP) and TCM running.

There is an option to install these examples into your Application Release to enable building an ATOC for putting into MRAM. To build the ATOC you need the JSON file and the binary image for Application. These files are copied from the se-host-services-release into your application release.

```
$ cd se-host-services-release
```

Note the use of the `INSTALL_DIR` to specify where your application release lives.

When you unpack your application release you will get a directory structure as follows:

```
app-release-exec-windows-SE-FW_0.<version>
      + app-release-exec
            + build
                  + config
                  + images
```

The JSON files will be copied to the config directory and the binaries will be copied to images. This is where the ATOC generation tools will look.

A sample sequence would be as follows:

```
$ cd se-host-services-release
$ mkdir build_he
$ cd build_he
$ cmake .. -G "Unix Makefiles" -DENSEMBLE_CORE=M55_HE -
DCMAKE_TOOLCHAIN_FILE=toolchain-armclang.cmake
$ make install -j 8
```

## Installing examples to a different location

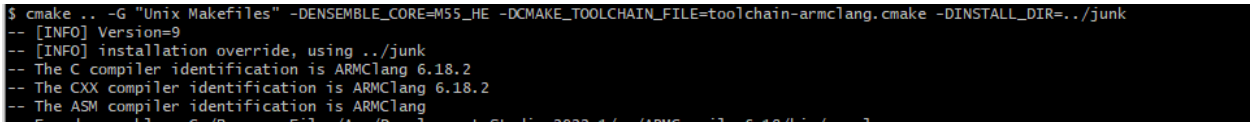
An example of using the INSTALL_DIR is as follows:

```
-DINSTALL_DIR=<some path>
```

If you do not specify the `INSTALL_DIR` then the default is `app-release-exec`

Use the following to override the default:

```
$ cd se-host-services-release
$ mkdir build_he
$ cd build_he
$ cmake .. -G "Unix Makefiles" -DENSEMBLE_CORE=M55_HE -
DCMAKE_TOOLCHAIN_FILE=toolchain-armclang.cmake -DINSTALL_DIR=<some
location>
$ make install -j 8
```

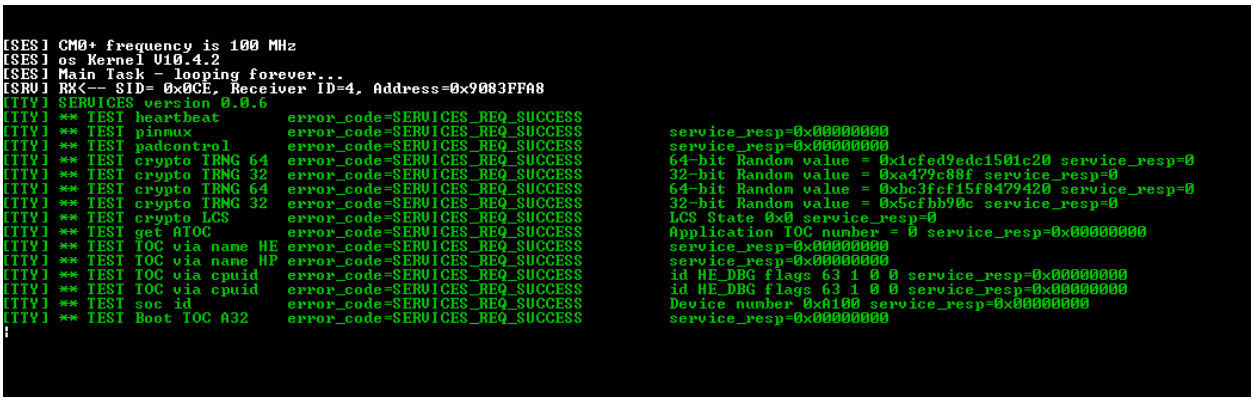



A message shows that installation override is enabled.

## Running with SERVICES Debug disabled

The test harness has a call to SERVICES_system_set_services_debug() which can disable or enable the debug traffic from SES for the SERVICE traffic.

With the SERVICES debug set to false:

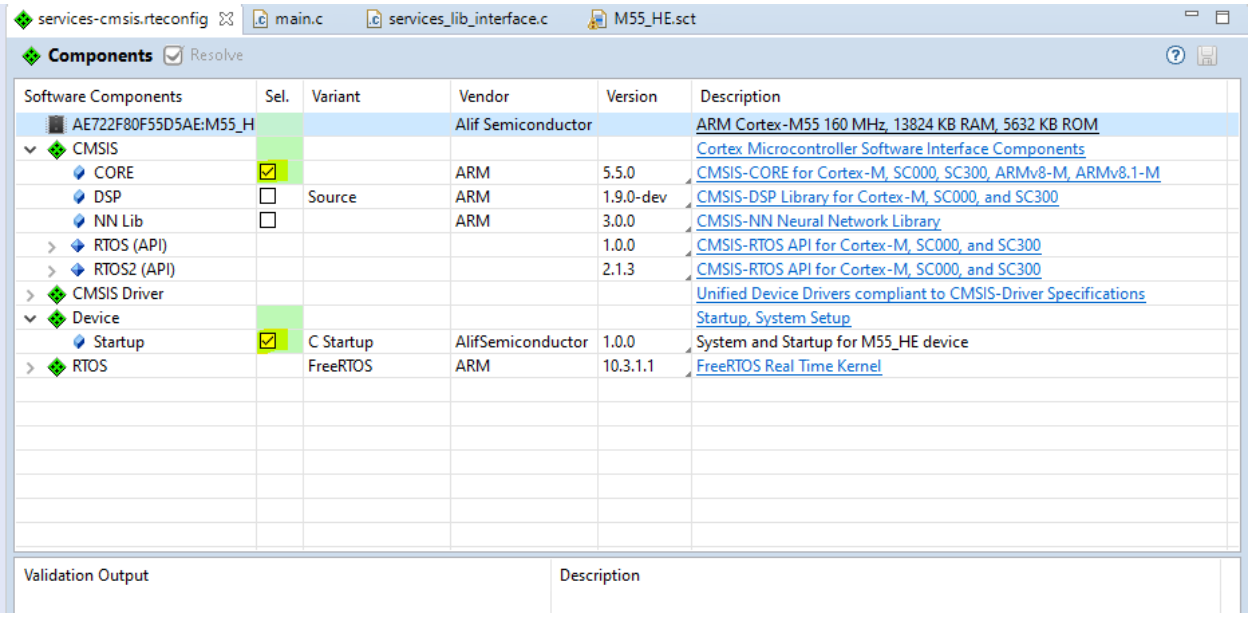



The SERVICE call to set the debug output off can be seen (the default is enabled in SES). After that, there is no SERVICE debug traffic from SES.

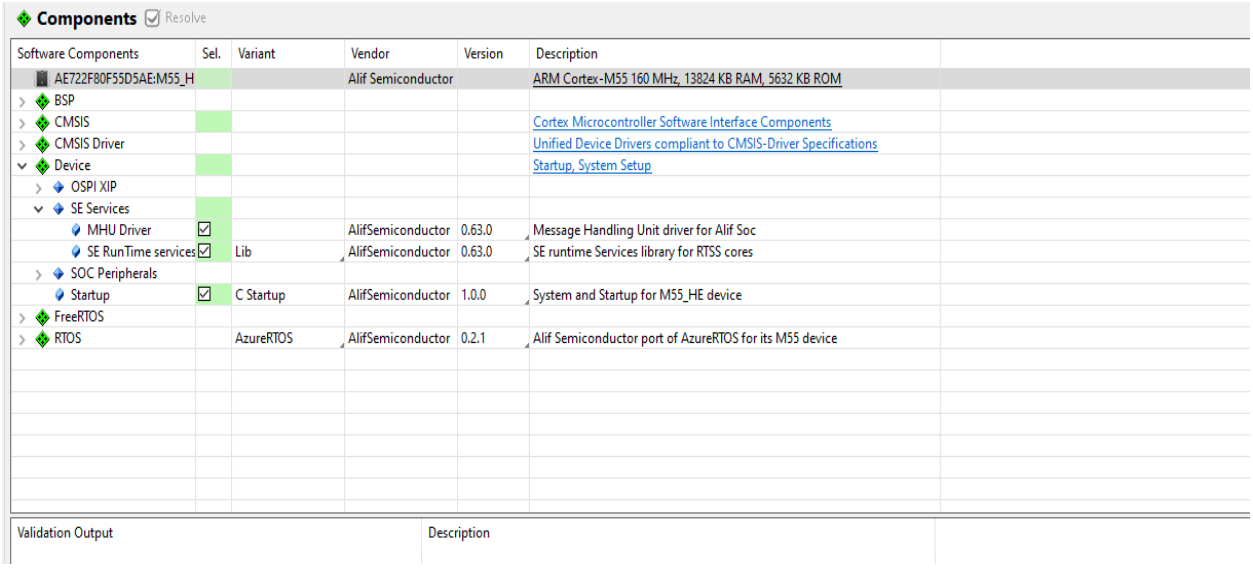
## Building the M55 Host Example under ARM-DS

Before starting, ensure you have the ALIFSemiconductor CMSIS Pack installed (See AP002 Getting Started with Bare Metal & Azure RTOS)

- Create a new Project -> C Project -> CMSIS C/C++ Project
- Select Device -> Alif Semiconductor -> Ensemble -> E7 -> AE722F80F55D5AE (or the other one) -> AE722F80F55AE:M55_HE
- In the Project Components window,
    - Check the following highlighted boxes,
    - Then File -> Save



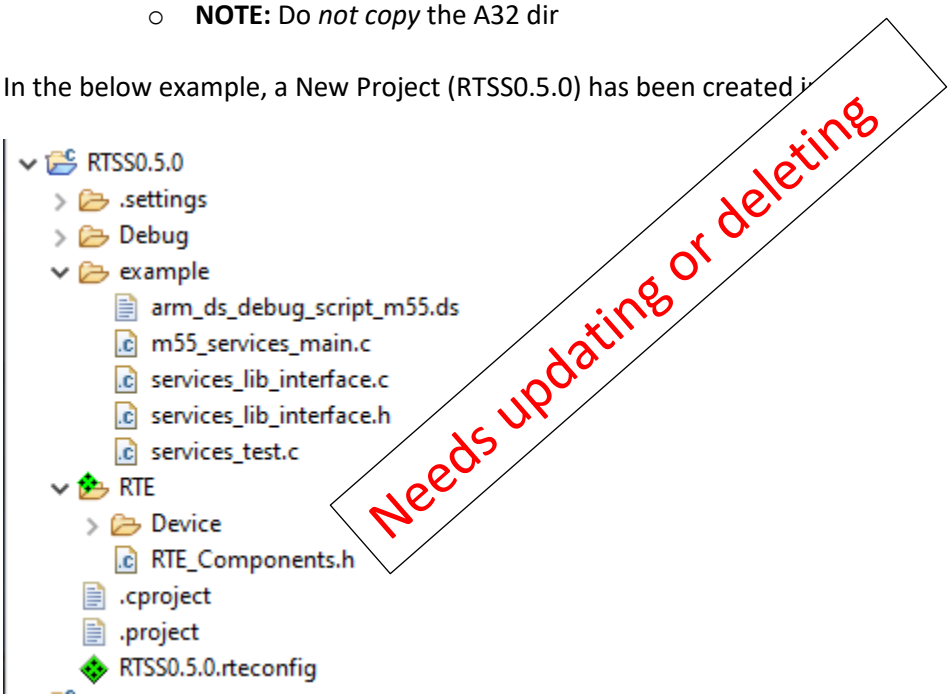

Select the SE Services




## Creating a SERVICES based project in ARM-DS

- Copy the source files from your unpacked services release into your project or from the CMSIS Pack (RTSS V0.5.0 or above)
- Copy the following directories / files from the SE Services release over to the ARM-DS project.
  - `./example/m55_he`
  - `./example/common`
  - **NOTE:** Do *not copy* the A32 dir

In the below example, a New Project (RTSS0.5.0) has been created i




You can copy the services library and MHU driver source as well.

The example source has been included as this contains the main() entry point.

## Adding ALIF SERVICES to your Application code

Calling SERVICES from your Application requires the following:

- Include the header file `/service-release/include/services_lib_api.h` into your code.
- Link with
  - `/service-release/lib/libservices_m55_lib.a (or _a32_)`
  - `/service-release/lib/libmhu_m55_lib.a (or _a32_)`
- Link with pre-compiled libraries in the CMSIS release
- Copy or create your own service_lib_interface.c file and add it to your build.
  - Change any interrupt sources as required.
  - Implement wait function for your environment.
  - Implement print function for your environment.

## SE Host Services Library API

The Host Service API is built on a transport protocol layer. This is to facilitate changing the underlying protocol without affecting the rest of the library.

The services library package consists of the following:

| Component | Description |
|---|---|
| `libservices_m55_lib.a` | Host Services M55 Library |
| `libservices_a32_lib.a` | Host Services A32 Library |
| `libmhu_m55_lib.a` | Host Services M55 MHU Library (Baremetal) |
| `libmhu_a32_lib.a` | Host Services A32 MHU Library (Baremetal) |
| | |
| `services_lib_api.h` | APIs to access the services library |
| `services_lib_interface.c` | To be completed by the user. Compiled with the host CPU application program |

There is a porting / abstraction interface component which the user must update depending upon their operating system choice and driver interface to the Message Handling hardware (MHU).

ALIF supply completed interfaces (currently) for

- Bare metal
- ~~FreeRTOS~~
- ~~ThreadX~~
- Linux

The Host services library provides APIs to facilitate service requests from a host CPU to the SE. it must be set up and initialized before dispatching a Host service request to the SE. It needs access to the MHU driver functions to facilitate MHU communication.

The Host services library also requires other generic functions:

| | |
|---|---|
| `SERVICES_wait_ms(uint32_t wait_time_ms)` | Delay function |
| `SERVICES_send_mhu_message_to_se(uint32_t message)` | Interface to the MHU driver |

This layer is intended for any Operating System abstraction.

## Host Services Library Interface API Porting Layer

This needs to be updated by the user depending upon the operating system being used (or base metal) and the interface to the Message handling hardware. The requirements of the operating system are very light.

The file `services_lib_interface.c` is the porting interface which needs to be filled in by the user.

### SERVICES_wait_ms

```
// Delay function
int wait_ms(uint32_t wait_time_ms)
```

### SERVICES_send_mhu_message_to_se

```
// MHU send message to SE on MHU0 channel0
int send_mhu_message_to_se(uint32_t message)
```

The above functions must be configured in `services_init_params` structure and pass to the service library initialization function below.

## Host Services Library API Layer

A Service call from an application processor looks like any other C function call, it can take parameters and return results via pass by reference parameters.

The Host Services library is responsible for taking the application Service call and communicating this to the Secure Enclave using the MHU.

### SERVICES_initialize

The SERVICES library needs to be initialized before use. There are several parameters that are needed by the SERVICES library such as which MHU is being used, packet buffers etc.

Please refer to the SE Host Services API section for more details.

```
// Service library initialization
void SERVICES_initialize(services_lib_t * init_params)

SERVICES_initialize(services_lib_t * init_params);

// Service synchronization
int SERVICES_synchronize_with_se(uint32_t services_handle)

number_of_retries = SERVICES_synchronize_with_se(services_handle);
```

The M55-HE and M55-HP are started before SERAM is ready to process service calls. This function sends heartbeat requests until one of them succeeds. It returns the number of retries. The maximum number of retries is 100.

### SERVICES_send_request

```
// Service request call
uint32_t SERVICES_send_request(uint32_t services_handle,
                               uint16_t service_id,
                               void * service_data,
                               SERVICES_sender_callback callback);

Error_code = SERVICES_send_request(handle, SERVICE_HEARTBEAT_ID,
&service_data, 0);
```

The service request dispatches the service request to the SE. If the callback parameter is NULL, the function waits for the SE to send a response back and then returns an error code. This is analogous to a remote procedure call. If a callback is provided, the call returns immediately after sending the request. The service's transport layer calls the provided back when the service response arrives.
It needs access to the host CPUs MHU driver functions to send, receive and ACK messages over the MHU.

### SERVICES_send_msg_acked_callback

```
// MHU message ACK callback function
void SERVICES_send_msg_acked_callback(void)
```

The above callback function must be passed to the MHU driver during initialization. It is called by the driver when an MHU message is ACKed by the SE. Channel clear interrupt CH_INT_ST is set when SE has received the MHU message and SE clears the channel status CH_ST bits by setting CH_CLR. This is assumed to be an ACK from SE that it has received an MHU message sent by the host CPU.

### SERVICES_rx_msg_callback

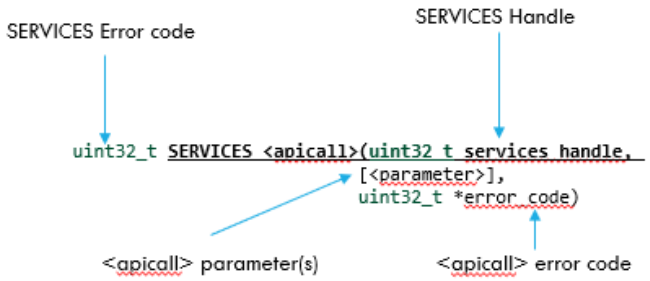
```
// MHU message received callback function
void SERVICES_rx_msg_callback(uint32_t message);
```

The above callback function must be passed to the MHU driver during initialization. It is called by the driver when an MHU message is received from the SE as a response to a service request earlier to the SE

```
// Pinmux service
int PINMUX_config(Port_t port_num, Pin_t pin_num, Pinfunction_t
function);
```

# SE Host SERVICES Library - Anatomy of a SERVICE Call

A SERVICES API call takes the following format:




- SERVICES API are regular function calls taking the format SERVICES_<module>
- Returns Services error code.
  - This relates to the SERVICES transport layer.
- Other return values are passed in the function prototype.
  - These parameters can be IN and OUT and can be variable sized.
  - Results from the SERVICE call are returned via these variables.
  - The error_code return relates to the error returned from the actual SERVICE call.

## SE Host Service Library Internal implementation

Each SERVICE defines a unique parameter block structure.

- See `example_service_t` in the diagram below.
- This always contains the Header and a return response error code,
- There may be passed parameters from the Caller.
- There may be return parameters to the Caller.

For each SERVICE call processed in SERAM the parameter block is dereferenced

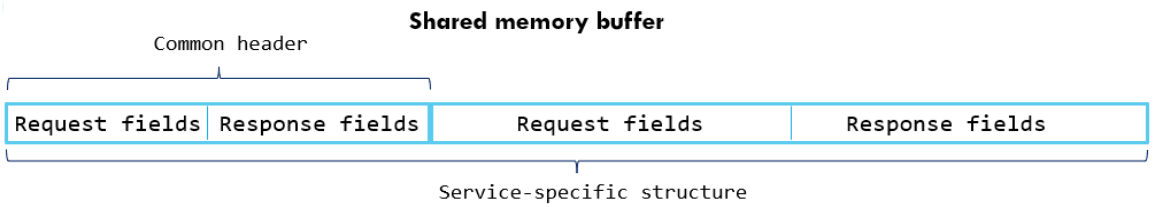
- Sent parameters can be passed to the calling function.
- The Error code from the called function will be sent back as part of the parameter block.

```c
typedef struct
{
  service_header_t header;
  volatile uint32_t send_<param>;      /*!< Send   parameter */
  volatile uint32_t resp_<param>;      /*!< Return parameter */
  volatile uint32_t resp_error_code;   /*!< Call error code  */
} example_service_t;

void SERVICES_example_call(services_req_t *service)
{
  example_service_t *p_svc =
    (example_service_t *)service->pkt_buffer_address; /* services request */
  uint32_t error_code;
  uint32_t local_result;

  error_code = function_call(p_svc->send_<param>, &local_result);

  p_svc->resp_<param>    = local_result;
  p_svc->resp_error_code = error_code;

  SERVICES_send_response_code(service, SERVICES_REQ_SUCCESS);
}
```

There is no copying of data between the Host Application CPU and the Secure enclave.

## SE Host Service Library Transport Protocol details

The transport protocol is as follows:




**Common header format**

| Service ID: req |
|---|
| Flags: req |
| Error Code: resp |
| Padding |

```c
typedef struct
{
  uint16_t send_sid;
  uint16_t send_flags;
  uint16_t resp_error_code; // transport
layer error code
  uint16_t none_padding;
} service_header_t;
```

**Service-specific structure example**

```c
typedef struct
{
  service_header_t header;
  uint8_t send_port_num;
  uint8_t send_pin_num;
  uint8_t send_config_data;
  uint8_t resp_error_code; // service-specific
error code
} pinmux_svc_t;
```

## SE Host Service Library Transport Error Codes

The following are the valid return and Error codes for the services library.

| Error Code | Value | Meaning |
|---|---|---|
| SERVICES_REQ_SUCCESS | 0x00 | |
| SERVICES_REQ_NOT_ACKNOWLEDGE | 0xFF | |
| SERVICES_REQ_TIMEOUT | 0xFD | |
| SERVICES_REQ_UNKNOWN_COMMAND | 0xFC | |

This error relates to any operation on the transport layer of the SERVICES library. Most SERVICES library APIs have a second error code which is the error code return from the called function.

## SE Host Services Library Error Handling

There are two levels of Error with a SERVICES API call,

- SERVICES Transport layer error code
- Function call error code

# SE Host Services API

The services provided by the SE via the MHU are as follows.

## Miscellaneous

### SERVICES_Initialize

**Syntax:**

uint32_t SERVICES_initialize(services_lib_t * init_params)

**Description:**

Initialize the services library.

A user needs to supply the following platform specific data and functions for the following operations.

- Global address of the CPU's local data memory 0x0 for A32, start of DTCMs for the M55 cores.
- Packet buffer
  - Defined in Application memory space.
  - Used by the SERVICES library.
- Send MHU message function – provided by the MHU driver.
- wait (delay) function – platform and OS specific.
- print function – platform and OS specific.

The examples source contains service_lib_interface.c which shows how to set up the SERVICES library. This is not part of the SERVICES Library code as it is expected to be customized by a User for their application, which is why this is included as source code in the examples.

**Parameters:**

| | |
|---|---|
| init_params | Initialization parameters |

**Returns:**

**Restrictions:**

None

**Example:**

```
#include "services_lib_api.h" /* services_lib_t lives here */

static uint8_t
  s_packet_buffer[SERVICES_MAX_PACKET_BUFFER_SIZE] __attribute__ ((aligned (4)));

int SERVICES_print(const char * fmt, ...)
{
  /* To be filled in by the user */
```

```
  return 0;
}

int32_t SERVICES_wait_ms(uint32_t wait_time_ms)
{
  /* To be filled in by the user */

  return 0;
}

int main (void)
{
  uint32_t ErrorCode = SERVICES_OK;

  services_lib_t  services_init_params =
  {
    .global_offset         = DTCM_GLOBAL_ADDRESS - M55_DTCM_LOCAL_OFFSET,
    .packet_buffer_address = (uint32_t)s_packet_buffer,
    .fn_send_mhu_message   = send_message,
    .fn_wait_ms            = &SERVICES_wait_ms,
    .wait_timeout          = timeout,
    .fn_print_msg          = &SERVICES_print,
  };

  ErrorCode = SERVICES_initialize(&services_init_params);

  if (ErrorCode != SERVICES_REQ_SUCCESS)
  {
    return ErrorCode;
  }
}
```

### SERVICES_version

**Syntax:**

const char *SERVICES_version(void)

**Description:**

Returns the version of the Host library.

**Parameters:**
None

**Returns:**

Version string

**Restrictions:**
None

**Example:**

```
#include <services_lib_api.h>

int main (void)
{
  uint32_t ErrorCode = SERVICES_OK;

  printf("SERVICES version %s\n", SERVICES_version());
}
```

## SERVICES_register_channel

**Syntax:**

uint32_t SERVICES_register_channel(uint32_t mhu_id, uint32_t channel_number);

**Description:**

Returns a handle for a specific MHU and channel, to be used in subsequent service calls.

**Parameters:**

| | |
|---|---|
| mhu_id | MHU ID |
| channel_number | Channel number (within the MHU) |

**Returns:**

Service channel handle

**Restrictions:**
The MHU ID and channel number must be valid.

The maximum number of MHU Channels is 124.

**Example:**

```
#include <services_lib_api.h>

#define NUM_MHU                2

#define MHU_M55_SE_MHU0        0
#define MHU_M55_SE_MHU1        1

int main (void)
{
  mhu_initialize();
  SERVICES_Setup(s_mhu_driver_out.send_message, MAXIMUM_TIMEOUT);

  uint32_t services_handle = SERVICES_register_channel(MHU_M55_SE_MHU0, 0);

  printf("SERVICES handle %d\n", services_handle);
}
```

### SERVICES_prepare_packet_buffer

**Syntax:**

uintptr_t SERVICES_prepare_packet_buffer(uint32_t size)

**Description:**

Prepares a packet buffer.

Used by the SERVICES library to allocate a packet buffer from the global Packet buffer memory.

**Parameters:**

| | |
|---|---|
| Size | Packet buffer size |

**Returns:**

Pointer to packet buffer.

**Restrictions:**

**Example:**

### SERVICES_local_to_global_addr

**Syntax:**

uintptr_t uint32_t SERVICES_local_to_global_addr(uint32_t local_addr)

**Description:**

Address translation – local to global

Used internally by the SERVICES library.

**Parameters:**

| | |
|---|---|
| local_addr | address to translate |

**Returns:**

Pointer to packet buffer.

**Restrictions:**

**Example:**

### SERVICES_global_to_local_addr

**Syntax:**

uintptr_t uint32_t SERVICES_global_to_local_addr(uint32_t global_addr)

**Description:**

Address translation – global to local

Used internally by the SERVICES library.

**Parameters:**

| | |
|---|---|
| global_addr | address to translate |

**Returns:**

Pointer to packet buffer.

**Restrictions:**

**Example:**

## Maintenance Services

The maintenance services provide a mechanism to maintain a reliable connection between the sender and receiver and/or request general information from the receiver. The following maintenance services are supported by SE.

### SERVICES_heartbeat

**Syntax:**

uint32_t SERVICES_heartbeat (uint32_t services_handle)

**Description:**

Heartbeat request.

This service is analogous to “ping”.

It is a message sent by the sender to tell the receiver that it is alive. It can also be sent by SE to check if another core is alive and responding. When this message is ACKed by the receiver, the sender knows that the receiver is alive. This message does not warrant a response from the receiver other than ACK.

**Parameters:**

services_handle

**Returns:**

**Restrictions:**
None

**Example:**

```
int main (void)
{
  uint32_t ErrorCode = SERVICES_OK;

  mhu_initialize();
  SERVICES_Setup(s_mhu_driver_out.send_message, MAXIMUM_TIMEOUT);

  //SERVICES_wait_ms(0x1000000);

  uint32_t services_handle = SERVICES_register_channel(MHU_M55_SE_MHU0, 0);

  ErrorCode = SERVICES_heartbeat(services_handle);
  if (ErrorCode != SERVICES_REQ_SUCCESS)
  {
    return ErrorCode;
  }
```

```
  return ErrorCode;
}
```

## SERVICES_synchronize_with_se

**Syntax:**

int SERVICES_synchronize_with_se(uint32_t services_handle)

**Description:**

Wait for the SE to become available.

This function is built on top of SERVICES_heartbeat.

**Parameters:**

services_handle

**Returns:**

**Restrictions:**
None

**Example:**

```
int main (void)
{
  int retry_count;

  /* keep sending heartbeat services requests until one succeeds */
  retry_count = SERVICES_synchronize_with_se(services_handle);

}
```

## System Management

### SERVICES_system_set_services_debug

**Syntax:**

```
uint32_t SERVICES_system_set_services_debug (uint32_t services_handle,
                                             bool debug_enable,
                                             uint32_t *error_code)
```

**Description:**

Enable / Disable Service debug traffic from SES.

**Parameters:**

| | |
|---|---|
| service_handle | Service Handle |
| debug_enable | Toggle debug output. |
| error_code | Service Error Code |

**Returns:**

**Restrictions:**
None

**Example:**

```
int main (void)
{
  uint32_t service_error_code;

  SERVICES_system_set_services_debug(services_handle,
                                     false,/* False = NO debug output */
                                     &service_error_code);
  if (service_error_code != SERVICES_REQ_SUCCESS)
  {
     /* Deal with error */
  }
}
```

## SERVICES_system_read_otp

**Syntax:**

```
uint32_t SERVICES_system_read_otp     (uint32_t services_handle,
                                       uint32_t otp_offset,
                                       uint32_t *otp_value_word,
                                       uint32_t *error_code)
```

**Description:**

Read an OTP offset.

**Parameters:**

| | |
|---|---|
| service_handle | Service Handle |
| otp_offset | OTP Byte offset to read. |
| otp_value_word | OTP value at otp_offset |
| error_code | Service Error Code |

**Returns:**
SERVICES_REQ_INVALID_OTP_OFFSET

**Restrictions:**

**Example:**

```
int main (void)
{
  uint32_t ErrorCode = SERVICES_REQ_SUCCESS
  uint32_t service_error_code;
  uint32_t otp_value;

  ErrorCode = SERVICES_system_read_otp(services_handle,
                                       0x51, /* Offset */
                                       &otp_value,
                                       &service_error_code);
  if (ErrorCode != SERVICES_REQ_SUCCESS)
  {
    return ErrorCode;
  }
}
```

## SERVICES_system_get_otp_data

**Syntax:**
```
uint32_t SERVICES_system_get_otp_data (uint32_t services_handle,
                                       SERVICES_otp_data_t *otp_info,
                                       uint32_t * error_code)
```

**Description:**

Returns details of OTP data

**Parameters:**

| | |
|---|---|
| service_handle | Service Handle |
| otp_info | Details of OTP contents |
| error_code | Service Error Code |

**Returns:**
SERVICES_REQ_COMMAND_NOT_IMPLEMENTED (for now)

**Restrictions:**
OTP format is still under definition. This function returns SERVICES_REQ_COMMAND_NOT_IMPLEMENTED (for now). This function will be deprecated eventually.

**Example:**
```
int main (void)
{
  uint32_t ErrorCode = SERVICES_OK;
  uint32_t service_error_code;
  SERVICES_otp_data_t otp_info;

  ErrorCode = SERVICES_system_get_otp_data(services_handle,
                                           &otp_info,
                                           &service_error_code);
  if (ErrorCode != SERVICES_REQ_SUCCESS)
  {
    return ErrorCode;
  }
}
```

## SERVICES_system_get_toc_data

**Syntax:**

```
uint32_t SERVICES_system_get_toc_data (uint32_t services_handle,
                                       SERVICES_toc_data_t *toc_info,
                                       uint32_t * error_code)
```

**Description:**

Returns details of TOC objects in MRAM.

```
typedef struct
{
  uint8_t   image_identifier[8];      /**< TOC name    */
  uint32_t  version;                  /**< TOC Version */
  uint32_t  cpu;                      /**< TOC Cpu ID  */
  uint32_t  store_address;
  uint32_t  load_address;             /**< TOC load    */
  uint32_t  boot_address;
  uint32_t  image_size;
  uint32_t  flags;
} SERVICES_toc_info_t;

/**
 * @struct SERVICES_toc_data_t
 */
typedef struct
{
  uint32_t number_of_toc_entries;
  SERVICES_toc_info_t toc_entry[SERVICES_NUMBER_OF_TOC_ENTRIES];

} SERVICES_toc_data_t;
```

The number of TOC entries found is returned followed by the TOC entry details.

**Parameters:**

| | |
|---|---|
| service_handle | Service Handle |
| toc_info | Details for all TOCs found |
| error_code | Service Error Code |

**Returns:**

**Restrictions:**

None

**Example:**

```
int main (void)
{
  uint32_t ErrorCode = SERVICES_OK;
  uint32_t service_error_code;
SERVICES_toc_data_t toc_info;

  ErrorCode = SERVICES_system_get_toc_data(services_handle,
                                           &toc_info,
                                           &service_error_code);
  if (ErrorCode != SERVICES_REQ_SUCCESS)
  {
    return ErrorCode;
  }
}
```

### SERVICES_system_get_toc_number

**Syntax:**

```
uint32_t SERVICES_system_get_toc_number(uint32_t services_handle,
                                        uint32_t *toc_number,
                                        uint32_t * error_code)
```

**Description:**

Returns the number of Table of contents in MRAM

**Parameters:**

| | |
|---|---|
| service_handle | Service Handle |
| toc_number | Number of TOCs |
| error_code | Service Error Code |

**Returns:**

**Restrictions:**
None

**Example:**

```
int main (void)
{
  uint32_t ErrorCode = SERVICES_OK;
  uint32_t number_of_tocs;
  uint32_t service_error_code;

  ErrorCode = SERVICES_system_get_toc_number(services_handle,
                                             &number_of_tocs,
                                             &service_error_code);
  if (ErrorCode != SERVICES_REQ_SUCCESS)
  {
    return ErrorCode;
  }
}
```

### SERVICES_system_get_toc_via_name

**Syntax:**

```
uint32_t SERVICES_system_get_toc_via_name(uint32_t services_handle,
                                          const uint8_t *cpu_name,
                                          uint32_t * error_code);
```

**Description:**

Returns the ??

**Parameters:**

| | |
|---|---|
| service_handle | Service Handle |
| cpu_name | name of Application |
| error_code | Service Error Code |

**Returns:**

**Restrictions:**
None

**Example:**

```
int main (void)
{
  uint32_t ErrorCode = SERVICES_OK;
  uint32_t service_error_code;

  ErrorCode = SERVICES_system_get_toc_via_name(services_handle,
                                               (uint8_t *)"M55-HP",
                                               &service_error_code);
  if (ErrorCode != SERVICES_REQ_SUCCESS)
  {
    return ErrorCode;
  }
}
```

## SERVICES_system_get_toc_via_cpuid

**Syntax:**

```
uint32_t SERVICES_system_get_toc_via_cpuid(uint32_t services_handle,
                                           SERVICE_cpuid_t cpuid,
                                           SERVICES_toc_data_t *toc_info,
                                           uint32_t * error_code);
```

**Description:**

Returns the TOC information for a given CPU.

Valid CPUs are

```
typedef enum
{
  FUSION_A32_0    = 0,
  FUSION_A32_1    = 1,
  FUSION_M55_HP   = 2,
  FUSION_M55_HE   = 3

} SERVICE_cpuid_t;
```

If there is more than one TOC entry per CPUID this will be reflected in the toc_info structure returned from the SERVICE call.

**Parameters:**

| | |
|---|---|
| service_handle | Service Handle |
| cpuid | Which Application CPU |
| toc_info | ATOC information |
| error_code | Service Error Code |

**Returns:**

**Restrictions:**

**Example:**

```
int main (void)
{
  uint32_t ErrorCode = SERVICES_OK;
  SERVICES_toc_data_t toc_info;
  Uint32_t service_error_code;

 error_code = SERVICES_system_get_toc_via_cpuid(services_handle,
                                                FUSION_M55_HE,
```

```
                                                &toc_info,
                                                &service_error_code);
  if (ErrorCode != SERVICES_REQ_SUCCESS)
  {
    return ErrorCode;
  }

  /* Process each TOC entry found */
  for (int each_toc = 0; each_toc < toc_info.number_of_toc_entries; each_toc++)
  {
    SERVICES_toc_info_t *toc_entry_p;

    toc_entry_p = (SERVICES_toc_info_t *)&toc_info.toc_entry[each_toc];

    /* do something with the TOC information */
}
```

## SERVICES_system_get_device_part_number

**Syntax:**

```
uint32_t SERVICES_system_get_device_part_number(uint32_t services_handle,
                                                uint32_t *device_part_number,
                                                uint32_t * error_code)
```

**Description:**

Returns the SoC device identifier.

**Parameters:**

| | |
|---|---|
| service_handle | Service Handle |
| device_part_number | Device id (Soc ID) |
| error_code | Service Error Code |

**Returns:**

device_part_number as integer e.g., 0x0000B200

**Restrictions:**
None

**Example:**

```
int main (void)
{
  uint32_t ErrorCode = SERVICES_OK;
  uint32_t device_id;
  uint32_t service_error_code;

  ErrorCode = SERVICES_system_get_device_part_number(services_handle,
                                                     &device_part_number,
                                                     &service_error_code);
  if (ErrorCode != SERVICES_REQ_SUCCESS)
  {
    return ErrorCode;
  }
}
```

## SERVICES_system_get_device_data

**Syntax:**

```
uint32_t SERVICES_system_get_device_data(uint32_t services_handle,
                                         SERVICES_version_data_t *device_info,
                                         uint32_t * error_code)
```

**Description:**

Retrieves the Device information.

The return is SERVICES_version_data_t as follows:

```
typedef struct
{
  uint32_t revision_id;   /* SoC revision           */
  uint8_t ALIF_PN[16];    /* SoC part number        */
  uint8_t HBK0   [16];    /* ALIF Key               */
  uint8_t HBK1   [16];    /* ALIF Key               */
  uint8_t HBK_FW [20];    /* ALIF Firmware version  */
  uint8_t config [4];     /* Wounding data          */
  uint8_t DCU    [16];    /* DCU settings           */
  uint8_t MfgData[32];    /* Manufacturing data     */
  uint8_t SerialN[8];     /* SoC Serial number      */
  uint8_t LCS;            /* SoC lifecycle state    */
} SERVICES_version_data_t;
```

**Parameters:**

| | |
|---|---|
| service_handle | Service Handle |
| device_info | Device info |
| error_code | Service Error Code |

**Returns:**

**Restrictions:**
None

**Example:**

```
int main (void)
{
  uint32_t ErrorCode = SERVICES_OK;
  uint32_t device_id;
  SERVICES_version_data_t device_data;
  uint32_t service_error_code;
```

```
  ErrorCode = SERVICES_system_get_device_info(services_handle,
                                              &device_data,
                                              &service_error_code);
  if (ErrorCode != SERVICES_REQ_SUCCESS)
  {
    return ErrorCode;
  }
}
```

## SERVICES_get_se_revision

**Syntax:**

```
uint32_t SERVICES_get_se_revision(uint32_t services_handle,
                                  uint8_t *revision_data,
                                  uint32_t *error_code)
```

**Description:**

Retrieve the SES Banner string.

**Parameters:**

| | |
|---|---|
| service_handle | Service Handle |
| revision_data | banner string return |
| error_code | Service Error Code |

**Returns:**

String containing the banner data. Maximum size is 80 characters.

**Restrictions:**
None

**Example:**

```
int main (void)
{
  uint32_t error_code = SERVICES_REQ_SUCCESS;
  uint32_t service_error_code;
  uint8_t se_revision[80];

  error_code = SERVICES_get_se_revision(services_handle,
                                        (uint8_t*)&se_revision[0],
                                        &services_error_code);

  if (error_code != SERVICES_REQ_SUCCESS)
  {
      /* deal with error */
  }
}
```

## Application Services

Application services provide mechanisms to configure certain functions. The SE can be requested to make these configuration changes.

### SERVICES_uart_write

**Syntax:**

uint32_t SERVICES_uart_write(uint32_t services_handle, size_t size, const uint8_t *uart_data)

**Description:**

SE-UART write. The buffer provided is printed via the Secure enclave UART (SE-UART) port.

**Parameters:**

| | |
|---|---|
| services_handle | Service handle |
| size | Number of bytes to write |
| uart_data | Buffer containing print data |

**None**

**Returns:**

**Restrictions:**
None

**Example:**

```
int main (void)
{
  uint32_t ErrorCode = SERVICES_OK;
  uint8_t buffer[256];

  ... <format print buffer>

  ErrorCode = SERVICES_uart_write(services_handle,
                                  sizeof(buffer),
                                  (uint8_t *)buffer);
  if (ErrorCode != SERVICES_REQ_SUCCESS)
  {
    return ErrorCode;
  }
}
```

## SERVICES_pinmux

Refer document se-mhu-pinmux-pad_configuration

**Syntax:**

uint32_t SERVICES_pinmux(uint32_t services_handle, uint8_t port_number,

uint8_t pin_number, uint8_t configuration_value,

uint32_t * error_core)

**Description:**

Pinmux request

**Parameters:**

services_handle

| | |
|---|---|
| port_number | Port Number |
| pin_number | Pin Number |
| configuration_value | ? |
| error_code | Service Error Code |

**Returns:**

**Restrictions:**
None

**Example:**

```
int main (void)
{
  uint32_t ErrorCode = SERVICES_OK;
  uint32_t service_error_code;

  ErrorCode = SERVICES_pinmux(services_handle, 1, 14, 0, &service_error_code);
  if (ErrorCode != SERVICES_REQ_SUCCESS)
  {
    return ErrorCode;
  }
}
```

## SERVICES_padcontrol

NOTE: Refer to document se-mhu-pinmux-pad_configuration

**Syntax:**

uint32_t SERVICES_padcontrol(uint32_t services_handle, uint8_t port_number,
uint8_t pin_number, uint8_t configuration_value,
uint32_t * error_core)

**Description:**

Pad control request.

**Parameters:**

services_handle

| | |
|---|---|
| port_number | Port Number |
| pin_number | Pin Number |
| configuration_value | ? |
| error_code | Service Error Code |

**Returns:**

**Restrictions:**
None

**Example:**

```
int main (void)
{
  uint32_t ErrorCode = SERVICES_OK;
  uint32_t service_error_code;

  ErrorCode = SERVICES_padcontrol(services_handle, 1, 14, 0, &service_error_code);
  if (ErrorCode != SERVICES_REQ_SUCCESS)
  {
    return ErrorCode;
  }
}
```

## SERVICES_application_ospi_write_key

**Syntax:**

uint32_t SERVICES_application_ospi_write_key(uint32_t services_handle, uint32_t command, uint8_t *key, uint32_t * error_code)

**Description:**

Write an AES decryption key to the OSPI registers. The command field indicates whether to use an externally provided key or a key stored in the OTP, and which OSPI to apply it to – OSPI0 or OSPI1.

```
#define OSPI_WRITE_OTP_KEY_OSPI0              0
#define OSPI_WRITE_OTP_KEY_OSPI1              1
#define OSPI_WRITE_EXTERNAL_KEY_OSPI0         2
#define OSPI_WRITE_EXTERNAL_KEY_OSPI1         3
```

**Parameters:**

| | |
|---|---|
| services_handle | Service handle |
| command | Indicates OSPI0/OSPI1 and external/OTP key |
| key | Buffer containing print data |
| error_code | Service error code |

**Returns:**

**Restrictions:**
None

**Example:**

## SERVICES_SRAM_retention_config

**Syntax:**

uint32_t SERVICES_SRAM_retention_config(uint32_t services_handle,

uint32_t sram_mem_retention,

uint32_t *service_error_code);

**Description:**
Configure retention for global SRAM0 or SRAM1

**Parameters:**

| | |
|---|---|
| services_handle | Service handle |
| sram_mem_retention | Which SRAM |
| service_error_code | Return error code |

```
#define POWER_MEM_RETENTION_SRAM0 0x30

#define POWER_MEM_RETENTION_SRAM1 0x31
```

**Returns:**
ErrorCode - SERVICES_REQ_SUCCESS, SERVICES_REQ_CANNOT_EXECUTE_SERVICE

Service_error_code  ERROR_POWER_SRAM_RETENTION_INVALID Incorrect SRAM bank specified.

**Restrictions:**
REV_A1 does not configure any retention.

**Example:**

```
int main (void)
{
  uint32_t error_code = SERVICES_REQ_SUCCESS;

  uint32_t service_error_code;

  error_code = SERVICES_SRAM_retention_config(services_handle,

                                              POWER_MEM_RETENTION_SRAM0,

                                              &service_error_code);

  if (error_code != SERVICES_REQ_SUCCESS)
  {
```

```
    return error_code;
  }
}
```

## Clock Management

Set or Get System Clock settings

## Interrupt muxing

<Action: Add more details>

## Event routing

<Action: Add more details>

## Power Services

### SERVICES_power_stop_mode_request

**Syntax:**

uint32_t SERVICES_power_stop_mode_request(uint32_t services_handle)

**Description:**

Request the Secure Enclave to enter stop mode.

**Parameters:**

services_handle

**Returns:**
ErrorCode - SERVICES_REQ_SUCCESS, SERVICES_REQ_CANNOT_EXECUTE_SERVICE

**Restrictions:**

**Example:**

```
int main (void)
{
  uint32_t ErrorCode = SERVICES_OK;

  error_code = SERVICES_power_stop_mode_request(services_handle);
  if (ErrorCode != SERVICES_REQ_SUCCESS)
  {
    return ErrorCode;
  }
}
```

### SERVICES_power_ewic_config

**Syntax:**

uint32_t SERVICES_power_ewic_config(uint32_t services_handle,

uint32_t ewic_source);

**Description:**

Configure the EWIC

**Parameters:**

services_handle

ewic_source EWIC source

**Returns:**

ErrorCode - SERVICES_REQ_SUCCESS, SERVICES_REQ_CANNOT_EXECUTE_SERVICE

**Restrictions:**

**Example:**

```
int main (void)
{
  uint32_t error_code = SERVICES_REQ_SUCCESS;
  uint32_t ewic_config;

  ewic_config &= (1 << 6);
  error_code = SERVICES_power_ewic_config(services_handle,
                                          ewic_config);

  if (error_code != SERVICES_REQ_SUCCESS)
  {
    return error_code;
  }
}
```

## SERVICES_power_wakeup_config

**Syntax:**

uint32_t SERVICES_power_wakeup_config(uint32_t services_handle,

uint32_t vbat_wakeup_source,

services_power_profile_t power_profile)

**Description:**

Configure the wake up source

**Parameters:**

services_handle

vbat_wakeup_source Wake up source

```
typedef enum
{
  VBAT_WAKEUP_MDM           = 0x1,          // bit0
  VBAT_WAKEUP_RTC_SE        = 0x10,         // bit4
  VBAT_WAKEUP_RTC_A         = 0x20,         // bit5
  VBAT_WAKEUP_LPCMP         = 0x40,         // bit6
  VBAT_WAKEUP_BROWN_OUT     = 0x80,         // bit7
  VBAT_WAKEUP_LPTIMER       = 0XF00,        // bit11:8
  VBAT_WAKEUP_LPGPIO        = 0XFF0000,     // bit23:16
} SERVICES_wakeup_cfg_t;
```

power_profile Power profile

```
typedef enum
{
  LOWEST_POWER_PROFILE = 0,      /**< LOWEST_POWER_PROFILE */
  HIGH_PERFORMANCE_POWER_PROFILE,/**< HIGH_PERFORMANCE_POWER_PROFILE */
  USER_SPECIFIED_PROFILE,        /**< USER_SPECIFIED_PROFILE */
  DEFAULT_POWER_PROFILE,         /**< DEFAULT_POWER_PROFILE */
  NUMBER_OF_POWER_PROFILES       /**< NUMBER_OF_POWER_PROFILES */
} services_power_profile_t;
```

**Returns:**

ErrorCode - SERVICES_REQ_SUCCESS, SERVICES_REQ_CANNOT_EXECUTE_SERVICE

**Restrictions:**

**Example:**

```
int main (void)
{
  uint32_t error_code = SERVICES_REQ_SUCCESS;

  error_code = SERVICES_power_wakeup_config(services_handle,
                                            VBAT_WAKEUP_RTC_SE
                                            | VBAT_WAKEUP_RTC_A,
                                            LOWEST_POWER_PROFILE);

  if (error_code != SERVICES_REQ_SUCCESS)
  {
    return error_code;
  }
}
```

## SERVICES_power_mem_retention_config

**Syntax:**

uint32_t

SERVICES_power_mem_retention_config(uint32_t services_handle,

uint32_t mem_retention,

services_power_profile_t power_profile)

**Description:**

Configure memory retention.

**Parameters:**

services_handle

mem_retention Memory to be retained.

```
// Memory retention bit encoding for mem_retention_enable
#define POWER_MEM_RET_FIREWALL_RAM              0x01UL
#define POWER_MEM_RET_SE_SRAM                   0x02UL
#define POWER_MEM_RET_BACKUP_RAM_4KB            0x04UL
// M55-HE TCM RET1: ITCM 0-128kb; DTCM 0-128kb
#define POWER_MEM_RET_ES1_TCM_RET1              0x08UL
// M55-HE TCM RET1: ITCM 128-256kb; DTCM 128-256kb
#define POWER_MEM_RET_ES1_TCM_RET2              0x10UL
// XTENSA TCM RET1: ITCM 128-512kb
#define POWER_MEM_RET_XTENSA_TCM_RET1           0x20UL
// XTENSA TCM RET1: ITCM 64-128kb
#define POWER_MEM_RET_XTENSA_TCM_RET2           0x40UL
// XTENSA TCM RET1: ITCM 0-64kb
#define POWER_MEM_RET_XTENSA_TCM_RET3           0x80UL
// M55-M TCM RET1: ITCM 1MB; DTCM 384kb
#define POWER_MEM_RET_M55_M_TCM_RET1            0x100UL
#define POWER_MEM_RET_MODEM_BACKUP_RAM_16KB     0x200UL
```

power_profile Power profile

```
typedef enum
{
  LOWEST_POWER_PROFILE = 0,       /**< LOWEST_POWER_PROFILE */
  HIGH_PERFORMANCE_POWER_PROFILE,/**< HIGH_PERFORMANCE_POWER_PROFILE */
  USER_SPECIFIED_PROFILE,         /**< USER_SPECIFIED_PROFILE */
  DEFAULT_POWER_PROFILE,          /**< DEFAULT_POWER_PROFILE */
  NUMBER_OF_POWER_PROFILES        /**< NUMBER_OF_POWER_PROFILES */
} services_power_profile_t;
```

**Returns:**
ErrorCode - SERVICES_REQ_SUCCESS, SERVICES_REQ_CANNOT_EXECUTE_SERVICE

**Restrictions:**

**Example:**
```
int main (void)
{
  uint32_t error_code = SERVICES_REQ_SUCCESS;

  error_code = SERVICES_power_mem_retention_config(services_handle,
                                                   POWER_MEM_RETENTION_SE_RAM,
                                                   LOWEST_POWER_PROFILE);

  if (error_code != SERVICES_REQ_SUCCESS)
  {
    return error_code;
  }
}
```

## SERVICES_power_m55_he_vtor_save

**Syntax:**

SERVICES_power_m55_he_vtor_save(uint32_t services_handle,

uint32_t ns_vtor_addr,

uint32_t se_vtor_addr,

services_power_profile_t power_profile)

**Description:**

m55-he VTOR value save for wake up

**Parameters:**

services_handle

| | |
|---|---|
| ns_vtor_addr | Non-secure VTOR address |
| se_vtor_addr | Secure VTOR address |
| power_profile | Power profile |

```
typedef enum
{
  LOWEST_POWER_PROFILE = 0,       /**< LOWEST_POWER_PROFILE */
  HIGH_PERFORMANCE_POWER_PROFILE,/**< HIGH_PERFORMANCE_POWER_PROFILE */
  USER_SPECIFIED_PROFILE,         /**< USER_SPECIFIED_PROFILE */
  DEFAULT_POWER_PROFILE,          /**< DEFAULT_POWER_PROFILE */
  NUMBER_OF_POWER_PROFILES        /**< NUMBER_OF_POWER_PROFILES */
} services_power_profile_t;
```

**Returns:**

ErrorCode - SERVICES_REQ_SUCCESS, SERVICES_REQ_CANNOT_EXECUTE_SERVICE

**Restrictions:**

**Example:**

```
int main (void)
{
  uint32_t error_code = SERVICES_REQ_SUCCESS;

    error_code = SERVICES_power_m55_he_vtor_save(services_handle,
                                                 0x0,
```

```
                                                0x0,
                                                LOWEST_POWER_PROFILE);

  if (error_code != SERVICES_REQ_SUCCESS)
  {
    return error_code;
  }
}
```

## SERVICES_power_m55_hp_vtor_save

**Syntax:**

SERVICES_power_m55_hp_vtor_save(uint32_t services_handle,

uint32_t ns_vtor_addr,

uint32_t se_vtor_addr,

services_power_profile_t power_profile)

**Description:**

m55-hp VTOR value save for wake up

**Parameters:**

services_handle

| | |
|---|---|
| ns_vtor_addr | Non-secure VTOR address |
| se_vtor_addr | Secure VTOR address |
| power_profile | Power profile |

```
typedef enum
{
  LOWEST_POWER_PROFILE = 0,       /**< LOWEST_POWER_PROFILE */
  HIGH_PERFORMANCE_POWER_PROFILE,/**< HIGH_PERFORMANCE_POWER_PROFILE */
  USER_SPECIFIED_PROFILE,         /**< USER_SPECIFIED_PROFILE */
  DEFAULT_POWER_PROFILE,          /**< DEFAULT_POWER_PROFILE */
  NUMBER_OF_POWER_PROFILES        /**< NUMBER_OF_POWER_PROFILES */
} services_power_profile_t;
```

**Returns:**

ErrorCode - SERVICES_REQ_SUCCESS, SERVICES_REQ_CANNOT_EXECUTE_SERVICE

**Restrictions:**

**Example:**

```
int main (void)
{
  uint32_t error_code = SERVICES_REQ_SUCCESS;

    error_code = SERVICES_power_m55_hp_vtor_save(services_handle,
                                                 0x0,
```

```
                                                0x0,
                                                LOWEST_POWER_PROFILE);

  if (error_code != SERVICES_REQ_SUCCESS)
  {
    return error_code;
  }
}
```

## SERVICES_corestone_standby_mode

**Syntax:**

SERVICES_corestone_standby_mode (uint32_t services_handle,

host_cpu_clus_pwr_req_t host_cpu_clus_pwr_req,

bsys_pwr_req_t bsys_pwr_req,

uint32_t *error_code)

**Description:**

Function to configure corestone standby mode

**Parameters:**

services_handle

| | |
|---|---|
| host_cpu_clus_pwr_req | Host CPU cluster power state request configuration |
| bsys_pwr_req | Base system power request configuration |
| power_profile | Power profile |

**Returns:**
ErrorCode - `SERVICES_REQ_SUCCESS, SERVICES_REQ_CANNOT_EXECUTE_SERVICE`

**Restrictions:**

**Example:**

```
int main (void)
{
  uint32_t error_code = SERVICES_REQ_SUCCESS;
    host_cpu_clus_pwr_req_t host_cpu_clus_pwr_req;
    bsys_pwr_req_t bsys_pwr_req;

    host_cpu_clus_pwr_req.word = 0;
    host_cpu_clus_pwr_req.bits.mem_ret_req = 0;
    host_cpu_clus_pwr_req.bits.pwr_req = 1;

    bsys_pwr_req.word = 0;
    bsys_pwr_req.bits.systop_pwr_req = 1;
    bsys_pwr_req.bits.dbgtop_pwr_req = 0;
    bsys_pwr_req.bits.refclk_req = 1;
    bsys_pwr_req.bits.wakeup_en = 0;
```

```
    error_code = SERVICES_corestone_standby_mode(services_handle,
                                                 host_cpu_clus_pwr_req,
                                                 bsys_pwr_req,
                                                 &service_error_code);

  if (error_code != SERVICES_REQ_SUCCESS)
  {
    return error_code;
  }
}
```

### SERVICES_power_memory_req

**Syntax:**

uint32_t SERVICES_power_memory_req(uint32_t services_handle,

uint32_t memory_request,

uint32_t *error_code)

**Description:**

Function to disable power to SERAM0, SERAM1 or MRAM

The following are Memory requests:

```
POWER_MEM_SRAM_0_ENABLE
POWER_MEM_SRAM_1_ENABLE
POWER_MEM_SRAM_0_ISOLATION_ENABLE
POWER_MEM_SRAM_1_ISOLATION_ENABLE
POWER_MEM_MRAM_ENABLE
```

**NOTE**: This is subject to change

**Parameters:**

services_handle

memory_request, Which Memory to deal with

**Returns:**
ErrorCode - SERVICES_REQ_SUCCESS, SERVICES_REQ_CANNOT_EXECUTE_SERVICE

**Restrictions:**
MRAM may not be able to be disabled directly (To be checked on real device).

**Example:**

```
int main (void)
{
  error_code = SERVICES_power_memory_req(services_handle,
                                         (POWER_MEM_SRAM_0_ENABLE |
                                          POWER_MEM_SRAM_1_ISOLATION_ENABLE),
                                         &return_error_code);


  if (error_code != SERVICES_REQ_SUCCESS)
  {
    return error_code;
```

```
  }
}
```

### SERVICES_get_run_cfg

**Syntax:**

uint32_t SERVICES_get_run_cfg(uint32_t services_handle,

run_profile_t *pp,

uint32_t *error_code);

**Description:**

Retrieve the current RUN mode status.

**Parameters:**

services_handle

| | |
|---|---|
| pp | Run mode parameter block. |
| error_code | Return error code |

**Returns:**
ErrorCode - SERVICES_REQ_SUCCESS, SERVICES_REQ_CANNOT_EXECUTE_SERVICE

**Restrictions:**

**Example:**

```
int main (void)
{
  uint32_t error_code = SERVICES_REQ_SUCCESS;
  run_profile_t runp;

  error_code = SERVICES_get_run_cfg(services_handle, &runp,
                                    &service_error_code);

  if (error_code != SERVICES_REQ_SUCCESS)
  {
    return error_code;
  }
}
```

### SERVICES_set_run_cfg

**Syntax:**

uint32_t SERVICES_set_run_cfg(uint32_t services_handle,

run_profile_t *pp,

uint32_t *error_code);

**Description:**

Set the RUN mode parameters.

**Parameters:**

services_handle

| | |
|---|---|
| pp | Run mode parameters. |
| error_code | Return error code |

**Returns:**
ErrorCode - SERVICES_REQ_SUCCESS, SERVICES_REQ_CANNOT_EXECUTE_SERVICE

**Restrictions:**

**Example:**

```
int main (void)
{
  uint32_t error_code = SERVICES_REQ_SUCCESS;
  run_profile_t runp;

  error_code = SERVICES_set_run_cfg(services_handle, &runp,
                                    &service_error_code);


  if (error_code != SERVICES_REQ_SUCCESS)
  {
    return error_code;
  }
}
```

### SERVICES_get_off_cfg

**Syntax:**

uint32_t SERVICES_get_off_cfg(uint32_t services_handle,

off_profile_t *wp,

uint32_t *error_code);

**Description:**

Retrieved the current OFF mode parameters.

**Parameters:**

services_handle

| | |
|---|---|
| wp | Off mode parameter block |
| error_code | Return error code |

**Returns:**
ErrorCode - SERVICES_REQ_SUCCESS, SERVICES_REQ_CANNOT_EXECUTE_SERVICE

**Restrictions:**

**Example:**

```
int main (void)
{
  uint32_t error_code = SERVICES_REQ_SUCCESS;
                                          ewic_config);
  off_profile_t off_mode;

  error_code = SERVICES_set_off_cfg(services_handle,
                                    &off_mode,
                                    &service_error_code);


  if (error_code != SERVICES_REQ_SUCCESS)
  {
    return error_code;
  }
}
```

## SERVICES_set_off_cfg

**Syntax:**

uint32_t SERVICES_set_off_cfg(uint32_t services_handle,

off_profile_t *wp,

uint32_t *error_code);

**Description:**

Set the OFF-mode parameters.

**Parameters:**

services_handle

| | |
|---|---|
| wp | off mode parameter block |
| error_code | Return error |

**Returns:**
ErrorCode - SERVICES_REQ_SUCCESS, SERVICES_REQ_CANNOT_EXECUTE_SERVICE

**Restrictions:**

**Example:**

```
int main (void)
{
  uint32_t error_code = SERVICES_REQ_SUCCESS;
  off_profile_t off_mode;

  error_code = SERVICES_get_off_cfg(services_handle,
                                    &runp,
                                    &service_error_code);

  if (error_code != SERVICES_REQ_SUCCESS)
  {
    return error_code;
  }
}
```

## Reset Services

Set or Get system reset.
<ACTION: Define policy>

## Boot Services

Most Services in this group have a ‘cpu_id’ parameter. The supported CPU ids are -

*FUSION_A32_0*
*FUSION_A32_1*
*FUSION_M55_HP*
*FUSION_M55_HE*
*FUSION_EXTERNAL_SYS0*

### SERVICES_boot_process_toc_entry

**Syntax:**

uint32_t SERVICES_boot_process_toc_entry(uint32_t services_handle, const uint8_t * entry_id, uint32_t * error_code)

**Description:**

Request to process a TOC entry. Depending on the information in the TOC entry, this could result in the booting of a CPU core.

This is a higher-level function compared to the other Boot services, and is a convenient way to boot a CPU core.

**Parameters:**

services_handle
entry_id ID of the TOC entry to process.
The ‘entry_id’ field is 8 bytes in size, matching the corresponding TOC entry field ‘image_identifier’.
error_code Service Error Code

**Returns:**

**Restrictions:**
None

## SERVICES_boot_cpu

**Syntax:**

uint32_t SERVICES_boot_cpu(uint32_t services_handle, uint32_t cpu_id, uint32_t address, uint32_t * error_code)

**Description:**

Request to boot a CPU core. This service does not perform image loading, verification, etc., it just boots the core, specifying the boot address.

It is recommended to use this service only for booting the A32 cores but not for the M55 cores.

For the M55 cores, there are cases in which this service does not work. The currently known case is the M55-HP core in FUSION REV_Bx devices, where resetting the core also invalidates its TCM content. For that reason, it is recommended that the M55 cores are booted using one of the following methods –

- SERVICES_boot_process_toc_entry().
- SERVICES_set_vtor(), SERVICES_reset_cpu(), and SERVICES_release_cpu(), described in the next sections.

**Parameters:**

| | |
|---|---|
| services_handle | |
| cpu_id | ID of the CPU to boot |
| address | Boot address for the CPU |
| error_code | Service Error Code |

**Returns:**

```
SERVICES_REQ_SUCCESS
SERVICES_REQ_NOT_ACKNOWLEDGE
SERVICES_REQ_ACKNOWLEDGE
SERVICES_REQ_TIMEOUT
SERVICES_RESP_UNKNOWN_COMMAND
SERVICES_REQ_BAD_PACKET_SIZE
SERVICES_REQ_CANNOT_EXECUTE_SERVICE
SERVICES_REQ_BAD_PAYLOAD
SERVICES_REQ_BAD_PAYLOAD_LENGTH
SERVICES_REQ_PAYLOAD_OK
SERVICES_REQ_PIN_LOCKED
```

**Restrictions:**

None

## SERVICES_boot_set_vtor

**Syntax:**

uint32_t SERVICES_boot_set_vtor(uint32_t services_handle, uint32_t cpu_id, uint32_t address, uint32_t * error_code)

**Description:**

Request to initialize the VTOR value for a M55 CPU core.

Note that the address value is stored in a Global register, not in the CPU's internal VTOR register. To transfer the address to the internal VTOR, call SERVICES_reset_cpu() after this call.

**Parameters:**

| | |
|---|---|
| services_handle | |
| cpu_id | ID of the CPU to boot |
| address | The address to be stored in the VTOR |
| error_code | Service Error Code |

**Returns:**

**Restrictions:**
FUSION_EXTERNAL_SYS0 is not a valid operation on FUSION Ensemble or Crescendo devices.

## SERVICES_boot_reset_cpu

**Syntax:**

uint32_t SERVICES_boot_reset_cpu(uint32_t services_handle, uint32_t cpu_id, uint32_t * error_code)

**Description:**

Request to reset a CPU core, which effectively stops the core. For M55 cores, it also transfers the VTOR value from the Global VTOR register to the CPU's internal VTOR.

**Parameters:**

| | |
|---|---|
| services_handle | |
| cpu_id | ID of the CPU to boot |
| error_code | Service Error Code |

**Returns:**

**Restrictions:**
None

### SERVICES_boot_release_cpu

**Syntax:**

uint32_t SERVICES_boot_release_cpu(uint32_t services_handle, uint32_t cpu_id, uint32_t * error_code)

**Description:**

Request to release a CPU core. This service does not perform image loading, verification, etc., and does not reset the CPU or specify the boot address, it just releases the core.

If the CPU is not running, this function can be called to release it.

If the CPU is running, SERVICES_boot_reset_cpu() must be called before this function to stop the core.

Notes on releasing M55 cores –

- in some cases, resetting the core also invalidates its TCM. A known case is the M55-HP core in FUSION REV_Bx devices. Because of that, after calling SERVICES_boot_reset_cpu() to stop the core, the image in the TCM must be reloaded, before calling SERVICES_boot_release_cpu() to start the core.
- If the VTOR value of the core needs to be changed, that too requires calling SERVICES_boot_reset_cpu(), to transfer the new address value to the core's internal VTOR. So, the call order of services in this case is – 1. SERVICES_boot_set_vtor(), 2. SERVICES_boot_reset_cpu(), 3. load the image in the TCM, 3. SERVICES_boot_release_cpu().

**Parameters:**

| | |
|---|---|
| services_handle | |
| cpu_id | ID of the CPU to boot |
| error_code | Service Error Code |

**Returns:**

**Restrictions:**

FUSION_EXTERNAL_SYS0 is not a valid operation on FUSION Ensemble or Crescendo devices.

### SERVICES_boot_reset_soc

**Syntax:**

uint32_t SERVICES_boot_reset_soc(uint32_t services_handle)

**Description:**

Request to reset the entire SoC.

**Parameters:**

services_handle

**Returns:**

**Restrictions:**
None

## Image loading

Image loading, release, run.
<Action: Add more details>

### Deferred boot

Request to boot another CPU.
<Action: Add more details>

## Crypto Services

The SE provides several crypto services to other cores as detailed below.

### SERVICES_cryptocell_get_rnd

**Syntax:**

uint32_t SERVICES_cryptocell_get_rnd(uint32_t services_handle, uint16_t rnd_length, void * rnd_value, uint32_t * error_code)

**Description:**

Request random number

The service SERVICES_cryptocell_get_rnd returns a random vector generated by the cryptocell-rt library using the MBedTLS API call mbedtls_ctr_drbg_random().

The desired length of the vector to generate is passed as an input parameter. Currently, the maximum supported vector length is 128 bytes.

**Parameters:**

services_handle

| | |
|---|---|
| rnd_length | Length of random number vector |
| rnd_value | returned Random number |
| error_code | Service Error Code |

**None**

**Returns:**

**Restrictions:**
None

**Example:**

```
int main (void)
{
  uint32_t ErrorCode = SERVICES_OK;
  uint64_t rnd_value;
  uint32_t service_error_code;

  ErrorCode = SERVICES_cryptocell_get_rnd(services_handle,
              sizeof(uint64_t),/* random number/vector length in bytes*/
              &rnd_value,
```

```
            &service_error_code);
  if (ErrorCode != SERVICES_REQ_SUCCESS)
  {
    return ErrorCode;
  }
}
```

## SERVICES_cryptocell_get_lcs

**Syntax:**

uint32_t SERVICES_cryptocell_get_lcs(uint32_t services_handle, uint32_t *lcs_state, uint32_t * error_code)

**Description:**
The service SERVICES_cryptocell_get_lcs returns the current Life Cycle State.

**Parameters:**

services_handle

lcs_state Life cycle state

error_code Service Error Code

**Returns:**

**Restrictions:**
None

**Example:**

```
int main (void)
{
  uint32_t ErrorCode = SERVICES_OK;
  uint32_t lcs_state;
  uint32_t service_error_code

  ErrorCode = SERVICES_cryptocell_get_lcs(services_handle, &lcs_state,
&service_error_code);
  if (ErrorCode != SERVICES_REQ_SUCCESS)
  {
    return ErrorCode;
  }
}
```

## MbedTLS Services

These services expose the hardware accelerated functionality provided by the Arm CryptoCell-RT library in SES.

Arm has chosen to use MbedTLS as the public API to that functionality. For that reason, the exposed Services correspond to MbedTLS public APIs.

IMPORTANT: **These Services are not intended to be used directly by applications**. Instead, they should be used by a client-side MbedTLS library implementation in which hardware acceleration is done by calling the Services.

To simplify the Services APIs and to avoid introducing MbedTLS types into them, all parameters of the MbedTLS functions are passed as uint32_t. The client-side MbedTLS implementation must convert them to the appropriate types. Also, to reduce the number of Service APIs, some of them cover multiple MbedtTLS API functions.

Please refer to the MbedTLS documentation for more information on these APIs, usage and parameters.

### *SERVICES_cryptocell_mbedtls_hardware_poll*

**Syntax:**
uint32_t SERVICES_cryptocell_mbedtls_hardware_poll(uint32_t services_handle,
uint32_t * error_code,
uint32_t data,
uint32_t output,
uint32_t len,
uint32_t olen)

**Description:**
Service API replacement for mbedtls_hardware_poll()

### *SERVICES_cryptocell_mbedtls_aes_init*

**Syntax:**
uint32_t SERVICES_cryptocell_mbedtls_aes_init(uint32_t services_handle,
uint32_t * error_code,
uint32_t ctx)

**Description:**
Service API replacement for mbedtls_aes_init()

### *SERVICES_cryptocell_mbedtls_aes_set_key*

**Syntax:**
uint32_t SERVICES_cryptocell_mbedtls_aes_set_key(uint32_t services_handle,
uint32_t * error_code,
uint32_t ctx,
uint32_t key,
uint32_t keybits,
uint32_t dir)

**Description:**
Service API replacement for mbedtls_aes_set_key_enc() and mbedtls_aes_set_key_dec()

### *SERVICES_cryptocell_mbedtls_aes_crypt*

**Syntax:**

```
uint32_t SERVICES_cryptocell_mbedtls_aes_crypt(uint32_t services_handle,
                                               uint32_t * error_code,
                                               uint32_t ctx,
                                               uint32_t crypt_type,
                                               uint32_t mode,
                                               uint32_t length,
                                               uint32_t iv,
                                               uint32_t input,
                                               uint32_t output)
```

**Description:**

Service API replacement for the mbedtls_aes_crypt_XXX functions

### *SERVICES_cryptocell_mbedtls_sha_starts*

**Syntax:**

```
uint32_t SERVICES_cryptocell_mbedtls_sha_starts(uint32_t services_handle,
                                                uint32_t * error_code,
                                                uint32_t ctx,
                                                uint32_t sha_type)
```

**Description:**

Service API replacement for mbedtls_sha_starts()

### *SERVICES_cryptocell_mbedtls_sha_process*

**Syntax:**
uint32_t SERVICES_cryptocell_mbedtls_sha_process(uint32_t services_handle,
uint32_t * error_code,
uint32_t ctx,
uint32_t sha_type,
uint32_t data)

**Description:**
Service API replacement for mbedtls_sha_process()

### *SERVICES_cryptocell_mbedtls_sha_update*

**Syntax:**
uint32_t SERVICES_cryptocell_mbedtls_sha_update(uint32_t services_handle,
uint32_t * error_code,
uint32_t ctx,
uint32_t sha_type,
uint32_t data,
uint32_t data_length)

**Description:**
Service API replacement for mbedtls_sha_update()

*SERVICES_cryptocell_mbedtls_sha_finish*

**Syntax:**
uint32_t SERVICES_cryptocell_mbedtls_sha_finish(uint32_t services_handle,
uint32_t * error_code,
uint32_t ctx,
uint32_t sha_type,
uint32_t data)

**Description:**
Service API replacement for mbedtls_sha_finish()

### *SERVICES_cryptocell_mbedtls_ccm_gcm_set_key*

**Syntax:**

```
uint32_t SERVICES_cryptocell_mbedtls_ccm_gcm_set_key(uint32_t services_handle,
   uint32_t * error_code,
   uint32_t context_addr,
   uint32_t key_type,
   uint32_t cipher,
   uint32_t key_addr,
   uint32_t key_bits)
```

**Description:**

Service API replacement for mbedtls_ccm_set_key() and mbedtls_gcm_set_key()

*SERVICES_cryptocell_mbedtls_ccm_gcm_crypt*

**Syntax:**

```
uint32_t SERVICES_cryptocell_mbedtls_ccm_gcm_crypt(uint32_t services_handle,
   uint32_t * error_code,
   uint32_t context_addr,
   uint32_t crypt_type,
   uint32_t length,
   uint32_t iv_addr,
   uint32_t iv_length,
   uint32_t add_addr,
   uint32_t add_length,
   uint32_t input_addr,
   uint32_t output_addr,
   uint32_t tag_addr,
   uint32_t tag_length)
```

**Description:**

Service API replacement for the mbedtls CCM and GCM crypto functions

*SERVICES_cryptocell_mbedtls_chacha20_crypt*

**Syntax:**

```
uint32_t SERVICES_cryptocell_mbedtls_chacha20_crypt(uint32_t services_handle,
   uint32_t * error_code,
   uint32_t key_addr,
   uint32_t nonce_addr,
   uint32_t counter,
   uint32_t data_len,
   uint32_t input_addr,
   uint32_t output_addr)
```

**Description:**

Service API replacement for mbedtl_chacha20_crypt()

*SERVICES_cryptocell_mbedtls_chachapoly_crypt*

**Syntax:**

```
uint32_t SERVICES_cryptocell_mbedtls_chachapoly_crypt(uint32_t services_handle,
   uint32_t * error_code,
   uint32_t context_addr,
   uint32_t crypt_type,
   uint32_t length,
   uint32_t nonce_addr,
   uint32_t aad_addr,
   uint32_t aad_len,
   uint32_t tag_addr,
   uint32_t input_addr,
   uint32_t output_addr)
```

**Description:**

Service API replacement for the mbedtl chachapoly crypto functions

### *SERVICES_cryptocell_mbedtls_poly1305_crypt*

**Syntax:**

```
uint32_t SERVICES_cryptocell_mbedtls_poly1305_crypt(uint32_t services_handle,
   uint32_t * error_code,
   uint32_t key_addr,
   uint32_t input_addr,
   uint32_t ilen,
   uint32_t mac_addr)
```

**Description:**

Service API replacement for mbedtl_poly1305_mac()

### *SERVICES_cryptocell_mbedtls_cmac_init_setkey*

**Syntax:**
uint32_t SERVICES_cryptocell_mbedtls_cmac_init_setkey(uint32_t services_handle,
  uint32_t * error_code,
  uint32_t context_addr,
  uint32_t key_addr,
  uint32_t key_bits)

**Description:**
Service API replacement for mbedtls_cmac_init_setkey()

### *SERVICES_cryptocell_mbedtls_cmac_update*

**Syntax:**
uint32_t SERVICES_cryptocell_mbedtls_cmac_update(uint32_t services_handle,
  uint32_t * error_code,
  uint32_t context_addr,
  uint32_t input_addr,
  uint32_t input_length)

**Description:**
Service API replacement for mbedtls_cmac_update()

### *SERVICES_cryptocell_mbedtls_cmac_finish*

**Syntax:**
uint32_t SERVICES_cryptocell_mbedtls_cmac_finish(uint32_t services_handle,
  uint32_t * error_code,
  uint32_t context_addr,
  uint32_t output_addr)

**Description:**
Service API replacement for mbedtls_cmac_finish()

### *SERVICES_cryptocell_mbedtls_cmac_reset*

**Syntax:**
uint32_t SERVICES_cryptocell_mbedtls_cmac_reset(uint32_t services_handle,
  uint32_t * error_code,
  uint32_t context_addr)

**Description:**
Service API replacement for mbedtls_cmac_finish()

## Clocks Services

Services to control the Clock, PLL and XTAL (High-frequency external oscillator) settings.

### SERVICES_clocks_select_osc_source

**Syntax:**

uint32_t SERVICES_clocks_select_osc_source (uint32_t services_handle, oscillator_source_t source, oscillator_target_t target, uint32_t * error_code)

**Description:**

Selects between RC or XTAL clock source for various modules (HF or LF). The selected clock is referred to as the 'OSC' clock.

**Parameters:**

| | |
|---|---|
| services_handle | |
| source | RC or XTAL (either HF or LF, depending on the target) |
| target | SYS clocks, PERIPH clocks, S32K clock |
| error code | Service error code |

**Returns:**

Transport layer error code

## SERVICES_clocks_select_pll_source

**Syntax:**

uint32_t SERVICES_clocks_select_pll_source(uint32_t services_handle, pll_source_t source, pll_target_t target, uint32_t * error_code)

**Description:**

Select OSC or PLL as the source clock for various modules.

**Parameters:**

| | |
|---|---|
| services_handle | |
| source | OSC or PLL |
| target | SYSREFCLK, SYSCLK, ES0, ES1 |
| error code | Service error code |

**Returns:**

Transport layer error code

### SERVICES_clocks_enable_clock

**Syntax:**

uint32_t SERVICES_clocks_enable_clock(uint32_t services_handle, clock_enable_t clock, bool enable, uint32_t * error_code)

**Description:**

Enable or disable a clock.

**Parameters:**

| | |
|---|---|
| services_handle | |
| clock | Clock to enable or disable |
| enable | Enable/disable flag |
| error code | Service error code |

**Returns:**

Transport layer error code

## SERVICES_clocks_set_ES0_frequency

**Syntax:**

uint32_t SERVICES_clocks_set_ES0_frequency(uint32_t services_handle, clock_frequency_t frequency, uint32_t * error_code)

**Description:**

Set the frequency of External System 0 (M55-HP).

**Parameters:**

| | |
|---|---|
| services_handle | |
| frequency | Frequency to set |
| error code | Service error code |

**Returns:**

Transport layer error code

## SERVICES_clocks_set_ES1_frequency

**Syntax:**

uint32_t SERVICES_clocks_set_ES1_frequency(uint32_t services_handle, clock_frequency_t frequency, uint32_t * error_code)

**Description:**

Set the frequency of External System 1 (M55-HE).

**Parameters:**
services_handle
frequency Frequency to set
error code Service error code

**Returns:**
Transport layer error code

## SERVICES_clocks_select_a32_source

**Syntax:**

uint32_t SERVICES_clocks_select_a32_source (uint32_t services_handle, a32_source_t source, uint32_t * error_code)

**Description:**

Selects the clock source for the A32 CPU cores.

**Parameters:**

| | |
|---|---|
| services_handle | |
| source | Clock source – CPUPLL, SYSPLL, REFCLK, Clock gate |
| error code | Service error code |

**Returns:**

Transport layer error code

### SERVICES_clocks_select_aclk_source

**Syntax:**

uint32_t SERVICES_clocks_select_aclk_source (uint32_t services_handle, aclk_source_t source, uint32_t * error_code)

**Description:**

Selects the clock source for the AXI bus.

**Parameters:**

| | |
|---|---|
| services_handle | |
| source | Clock source – SYSPLL, REFCLK, Clock gate |
| error code | Service error code |

**Returns:**

Transport layer error code

## SERVICES_clocks_set_divider

**Syntax:**

uint32_t SERVICES_clocks_set_divider (uint32_t services_handle, clock_divider_t divider, uint32_t value, uint32_t * error_code)

**Description:**

Selects the value of a clock divider.

**Parameters:**

| | |
|---|---|
| services_handle | |
| divider | Which divider to set – CPUPLL, SYSPLL, ACLK (Corstone), HCLK, PCLK (Alif) |
| value | Divider value. 0x0 to 0x1F for Corstone dividers, 0x0 to 0x2 for Alif divider |
| error code | Service error code |

**Returns:**

Transport layer error code

## SERVICES_pll_xtal_start

**Syntax:**

uint32_t SERVICES_pll_xtal_start(uint32_t services_handle, bool faststart, bool boost, uint32_t delay_count, uint32_t * error_code)

**Description:**

Start the external HF crystal.

**Parameters:**

| | |
|---|---|
| services_handle | |
| faststart | Enable 'fast start' mode |
| boost | Enable 'boost' mode |
| delay_count | Timeout to wait for crystal startup |
| error code | Service error code |

**Returns:**

Transport layer error code

## SERVICES_pll_xtal_stop

**Syntax:**

uint32_t SERVICES_pll_xtal_stop(uint32_t services_handle, uint32_t * error_code)

**Description:**

Stop the external HF crystal.

**Parameters:**
services_handle
error code Service error code

**Returns:**
Transport layer error code

### SERVICES_pll_xtal_is_started

**Syntax:**

uint32_t SERVICES_pll_xtal_is_started(uint32_t services_handle, bool * is_started, uint32_t * error_code)

**Description:**

Check if the external HF Crystal is started.

**Parameters:**

| | |
|---|---|
| services_handle | |
| is_started | External HF Crystal started status |
| error code | Service error code |

**Returns:**

Transport layer error code

## SERVICES_pll_clkpll_start

**Syntax:**

uint32_t SERVICES_pll_clkpll_start(uint32_t services_handle, bool faststart, uint32_t delay_count, uint32_t * error_code)

**Description:**

Start the PLL.

**Parameters:**

| | |
|---|---|
| services_handle | |
| faststart | Enable 'fast start' mode |
| delay_count | Timeout to wait for PLL lock |
| error code | Service error code |

**Returns:**

Transport layer error code

### SERVICES_pll_clkpll_stop

**Syntax:**

uint32_t SERVICES_pll_clkpll_stop(uint32_t services_handle, uint32_t * error_code)

**Description:**

Stop the PLL.

**Parameters:**
services_handle
error code Service error code

**Returns:**
Transport layer error code

## SERVICES_pll_clkpll_is_locked

**Syntax:**

uint32_t SERVICES_pll_clkpll_is_locked(uint32_t services_handle, bool * is_locked, uint32_t * error_code)

**Description:**

Check if the PLL is started and locked.

**Parameters:**
services_handle
is_locked PLL locked status
error code Service error code

**Returns:**
Transport layer error code

## SERVICES_pll_initialize

**Syntax:**

uint32_t SERVICES_pll_initialize(uint32_t services_handle, uint32_t * error_code)

**Description:**

Initialize the device to enable XTAL and PLL and switch all clocks to PLL.

**Parameters:**
services_handle
error code Service error code

**Returns:**
Transport layer error code

## SERVICES_pll_deinit

**Syntax:**

uint32_t SERVICES_pll_deinit(uint32_t services_handle, uint32_t * error_code)

**Description:**

De-initialize the device – switch all clocks to TC and disable XTAL and PLL.

**Parameters:**

services_handle
error code Service error code

**Returns:**
Transport layer error code

## Lifecycle control

<Action: TBD>

## Update Services

<Action: Add more details>

# Document History

| Version | Date | Author | Change Log |
|---|---|---|---|
| 0.1 | Jan 2022 | R. ONYETT | Initial concept and realization |
| 0.2 | Feb 2022 | R. ONYETT | Screenshot updates |
| 0.3 | Feb 2022 | R. ONYETT | Updated API docs, ARM-DS use |
| V43-03 | Feb 2022 | R. ONYETT | Added release version suffix |
| V44-03 | Mar 2022 | R. ONYETT | Added SERVICES_uart_write |
| V45.03 | Mar 2022 | R. ONYETT | Describe example builds and json files |
| V46 005 | Apr 2022 | R. ONYETT | API updates. Changed version |
| V0.0.6 | Apr 2022 | R. ONYETT | Added debug toggle API |
| V0.0.9 | May 2022 | R. ONYETT | UART write extra parameter |
| V0.0.10 | May 2022 | G. Stoykov | Add MbedTLS symmetric crypto services |
| | | | |
| V0.0.13 | July 2022 | S. KENKARE | Example restructure. A32 changes. |
| V0.0.20 | Nov 2022 | R. ONYETT | Formatting |