



User Guide

Alif Security Toolkit

V1.97.0

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Introduction

The Alif Security Toolkit (SETOOLS) contains several tools (written in Python3) required to program and provision an Alif Semiconductor SoC device.

Provisioning means being able to add images to the internal NVM storage (MRAM) as well as adding Security assets such as Keys to the One Time Programmable memory (OTP).

ALIF images, known as System TOC (STOC), for the device are already provisioned into the MRAM, a user cannot change these, but can update to a new STOC version supplied by Alif. User images such as Application programs (binaries written for A32 or M55 cores) need to be packaged and written to the MRAM. The packages are called an Application Table of Contents (ATOC).

There are also pre-built binary images for the ALIF Table of Contents (STOC) Package. The STOC contains the latest binary version of SERAM. The STOC also contains debug stubs which will execute on the Application cores to allow connection from the Debugger. These stubs are only loaded to Application CPUs that are not configured to run.

NOTE: These tools are designed to work with the following environment:

- Windows PC Executables (Windows 10/11)
- LINUX Executables (Ubuntu 18.4/20.4/22.4)
- MacOS Executables (tested with OS Sonoma 14.1).
- Ensemble DevKit Gen 2

The Alif [Ensemble DevKit User Guide \(Gen 2\)](#) includes instructions on how to connect the SE-UART output of the CPU to the host computer. This guide will then refer to the [Alif Security Toolkit Quick Start Guide](#) which contains instructions for installation of these tools.

This release version is **`app-release-exec-windows(linux)(macos)-SE_FW_1.0.93_DEV.zip`**

1. Python Executables

The Security tools are executable images, previously these python scripts were delivered as source code. These executables do not require python or any pre-requisite libraries to be installed.

Example:

```
$ ./maintenance
[INFO] COM8 open Serial port success
[INFO] baud rate 55000

Available options:

1 - Device Control
2 - Device Information
3 - MRAM
4 - Utilities
5 - Setting capabilities
6 - ROM

Select an option (Enter to exit): |
```

Previously you were required to run

```
$ python3 <tool-name>.py
```

Now you just run

```
$ <tool-name>
```

```
$ ./<tool-name>
```

NOTE: Screenshots in this document and other application notes or user guides might show the previous format but apply to this version or later releases if you enter just <tool-name> instead of “python3 <tool-name>.py”.

2. Quick User Guide

Please ensure you have followed the Installation Guide in the Alif Security Toolkit Quick Start Guide before proceeding.

The recommended <release-location> installation directories are:

Windows:	C:\app-release-exec
Linux:	/home/\$USER/app-release-exec-linux
MAC OS:	/Users/\$USER/app-release-exec-macos

Updating to the latest ALIF release

```
$ cd <release-location>
$ updateSystemPackage
```

```
$ ./updateSystemPackage
Burning: System Package in MRAM
Selected Device:
Part# E7 (AE722F80F55D5AS) - 5.5 MRAM / 13.5 SRAM - Rev: B2
- MRAM Base Address: 0x80580000

[INFO] baud rate 55000
[INFO] dynamic baud rate change Enabled
COM ports detected = 2
-> COM8
-> COM9
Enter port name:COM8
[INFO] COM8 open Serial port success
Bootloader stage: SERAM
Device Revision: B2
Maintenance Mode = Enabled
Authenticate Image: True
Signature File: alif\SP-AE722F80F55D5AS-rev-b2.bin.sign
Auth Token: 0x3c2e2c15
Verify Image
alif\SP-AE722F80F55D5AS-rev-b2.bin[#####]100%: 275280/275280 bytes
6.17 seconds
Authenticate Image: True
Signature File: alif\offset-58-rev-b2.bin.sign
Auth Token: 0x516c5343
Verify Image
alif\offset-58-rev-b2.bin [#####]100%: 16/16 bytes
0.00 seconds
```

Adding / Changing an application image

To change or update an image to add to MRAM do the following:

```
$ cd <release-location>
$ edit build/config/app-cfg.json and add new binaries images

$ app-gen-toc

(Or use below command to use a different configuration)

$ app-gen-toc -f build/config/app-myfile.json

$ app-write-mram
```

The app-gen-toc tool performs the packaging of your binary ready for writing to the MRAM.

The app-write-mram.py tool performs the writing of the application package to the MRAM. After this is completed, it will reset your target platform and the contents of the MRAM will be executed.

3. TOC Packages

The device will arrive already provisioned. This means that the SES is already programmed into the MRAM.

System Table of Contents (STOC)

On initial power up you will see the following SE-UART output:

```
COM8 - Tera Term VT
File Edit Setup Control Window Help

$SEROM v1.97.11 0x0000B300

$SES B0 v1.97.0 Jun 20 2024 16:25:17
[SES] No ATOC
[SES] STOC Part# match ok
[SES] System partition address 0x80580000
[SES] STOC DEVICE ok
[SES] STOC ok
[SES] M55-HE booted from address 0x58000000
[SES] LCS=0
[SES] FC=Rgn
0:2 7:1 8:1 9:1 13:0 13:1 13:2

+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Name | CPU | Store Addr | Obj Addr | Dest Addr | Boot Addr | Size | Version | Flags | Time (ns) |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| DEVICE | CM0+ | 0x805C1EC0 | 0x805C14C0 | ----- | ----- | 340 | 0.5.0 | u U | 14.62 |
| * SERAM0 | CM0+ | ----- | 0x000000C0 | ----- | ----- | 88908 | 1.97.0 | ----- | 0.00 |
| SERAM1 | CM0+ | ----- | 0x000200C0 | ----- | ----- | 88908 | 1.97.0 | ----- | 0.00 |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+

Legend: <u><C>ompressed, <L>oaded, <U>erified, <s>kipped verification, <B>ooted, <E>ncrypted, <D>eferred

[SES] SE frequency is 100.03 MHz
[SES] os Kernel V10.4.2 <Tickless>
[SES] Main Task - looping forever...
!
```


SE-UART Output Fields

The output from the SE-UART shows what SES has processed during the boot sequence of the device.

SEROM

Shows the version of the SEROM software and the SoC revision register contents.

Banner

Shows the version of the SES software.

LCS (Life Cycle State)

Shows the LCS state of the device.

[SES] Output

Shows the state of processing the STOC and ATOC images found in MRAM.

Device configuration

```
[SES] ATOC MISC ok
[SES] System partition address 0x80580000
[SES] STOC DEVICE ok
[SES] ATOC DEVICE ok
```

Other images processing –

```
[SES] STOC ok
[SES] ATOC ok
```

[SES] Table

Shows the details of all TOC objects processed from MRAM.

Name	ASCII string name from the JSON file.
- DEVICE	Shows a DEVICE Config object.
- SERAM0/1	Shows the two Banks of SES software. An '*' denotes which Bank was booted from.
- HE_DBG	Shows the default Debug stub executed if not ATOC is present.
CPU	Which CPU is being targeted.
Store Address	Where in MRAM is this object stored.
Obj Address	TOC address
Dest Addr	Where in RAM is this object being copied to.
Boot Addr	What address is being used to Boot from.
Size	Size of the binary object
Version	Version ID specified in the JSON file.
Flags	
C	Image is Compressed
u	Image is Uncompressed

L	Image is LOADED to a RAM location
V	Image is VERIFIED
s	Image is SKIPPED
B	Image has been BOOTED
D	Image is DEFERRED, Booting will happen later
Time	Time in microseconds from the start of TOC processing until completion, this could include booting.

SES Boot Error messages

SES can report the following Boot loader messages:

BL_STATUS_OK	0x00
BL_ERROR_APP_INVALID_TOC_ADDRESS	0x01
BL_ERROR_APP_INVALID_TOC_OFFSET	0x02
BL_ERROR_UNALIGNED_ADDRESS	0x03
BL_ERROR_INVALID_TOC_ADDRESS_RANGE	0x04
BL_ERROR_INVALID_TOC_FLAGS	0x05
BL_ERROR_INVALID_IMAGE_DATA	0x06
BL_ERROR_CERTIFICATE_NO_VERIFY_IN_MEMORY	0x07
BL_ERROR_CERTIFICATE_NO_VERIFY_IN_FLASH	0x08
BL_ERROR_CERTIFICATE_INVALID_LOAD_ADDRESS	0x09
BL_ERROR_CERTIFICATE_INVALID_CHAIN	0x0A
BL_ERROR_CERTIFICATE_STORAGE_ADDRESS_INVALID	0x0B
BL_ERROR_DEVICE_ADDRESS_INVALID	0x0C
BL_ERROR_UNCOMPRESS_FAILED	0x0D
BL_ERROR_SIGNATURE_VERIFY_FAILED	0x0E
BL_ERROR_APP_ACCESSING_PROTECTED_AREA	0x0F
BL_ERROR_ICV_ACCESSING_PROTECTED_AREA	0x10
BL_ERROR_FAILED_TOC_CRC32	0x11
BL_ERROR_INVALID_TOC	0x12
BL_ERROR_EXCEED_MAXIMUM_TOC_ENTRIES	0x13
BL_ERROR_NOT_IMAGE_NOT_DEVICE_CFG	0x14
BL_ERROR_INVALID_TOC_ENTRY_ID	0x15
BL_ERROR_INVALID_TOC_CPU_ID	0x16
BL_ERROR_ENTRY_NOT_SIGNED	0x17
BL_ERROR_LOAD_TO_MRAM_NOT_ALLOWED	0x18
BL_ERROR_NO_FREE_SLOTS	0x19
BL_ERROR_INVALID_M55_BOOT_ADDRESS	0x1A
BL_TOC_OBJECT_NOT_FOUND	0x1B
BL_TOC_OBJECT_FOR_CPU_NOT_FOUND	0x1C
BL_TOC_IMAGE_NOT_BOOTABLE	0x1D
BL_TOC_IMAGE_NOT_FOUND	0x1E

Firewall Error messages

Exceptions raised by Corstone Firewall Components are reported on the SES output screen.

Firewall exception from FC13, caused by Master ID 0x11 at address 0x80580000, transaction properties 0x00020000

Meaning:

FC <number> Firewall component which generated the exception.

Master ID The Corstone Master ID that issued the transaction causing the exception. It can be an APP CPU, but can also be another Corstone master like a DMA controller, USB host, etc.

Address The address targeted by the transaction.

Transaction properties the value of the Corstone register FE_TP. The bits in it indicate the transaction properties read/write, data/instruction, unprivileged/privileged, and secure/non-secure.

Error messages – no ATOC in MRAM

If there is no ATOC in MRAM, the following error messages are displayed -

```
[SES] MRAM error bypass is Enabled  
[SES] No ATOC  
[SES] System partition address 0x80580000  
[SES] STOC DEVICE ok  
[SES] STOC ok  
[SES] M55-HE booted from address 0x58000000
```

Any other errors during the boot process will be reported.

Application Table of Contents (ATOC)

The Application TOC package contains a Factory image.

Our releases consist of:

- M55_HE_TCM LED Blinky program.

This code is stored in MRAM and copied to a RAM location (The TCM for the M55_HE_CPU and booted.

To try the Blinky program

```
$ cd <release-location>
```

```
$ app-write-image
```

To rebuild this ATOC package

```
$ cd <release-location>
```

```
$ app-gen-toc -f build/config/app-cfg.json
```

```
$ app-write-image
```

ATOC Placed Images

ATOC packages allow for the absolute placement of user images in MRAM. See “mramAddress” option in the app-gen-toc configuration file.

Users must ensure that these images conform to the MRAM alignment rules and always be 16-byte aligned.

Images that are managed by the ATOC tool i.e., not placed at an absolute address are guaranteed to be aligned correctly.

NTOC Images

NTOC (No TOC) images are Execute in place (XIP) images stored at the base address of MRAM.

The M55_HE is the *only* CPU that executes these images.

These images are not generated by the Security Toolkit i.e., they are not ATOC images as such they have restrictions such as they cannot be signed.

SES uses the following algorithm to process these objects:

```
IF ATOC is present
    Process ATOC and Boot
ELSE
    IF MTOC is present
        Process MTOC and Boot
    ELSE
        IF (0x80000000 and 0x80000004 has valid $SP and $PC)
            ReleaseM55_HE
        ELSE
            Load STOC Debug stub (if present)
```

SES reads the first two 32-bits of MRAM:

- Word1 = \$SP (Stack Pointer)
- Word2 = \$PC (Program Counter)

Then uses the following logic:

- Is the Program counter in the valid Application address range of MRAM?
- Is the Stack Pointer in a valid RAM memory range?

If these above criteria are not met, then the image will not be released (booted).

NOTE: MTOC support was dropped in CMSIS release V0.9.1.

Change Sets

Change Sets are used to allow for Static initialization of registers at Boot up time.

This is known as Static device configuration. Change Set data is processed and executed as part of the TOC processing. A User could use this for peripheral / register / memory initialization without the necessity to write any code. Pin muxing, Firewall, Clock, Event, and Interrupt masking can be programmed using this method.

Change Sets can be added to the STOC packages (by ALIF only) and to the Application TOC packages by Users.

What is a Change Set?

A Change Set is a group of 32-bit values representing an Address, a Mask, and a Value. With these three elements, any memory or register address can be modified using Change Sets.

Adding a Change Set

If we take the application configuration file app-cfg.json

```
{
  "BLINK-HE": {
    "binary": "m55_blink_he.bin",
    "version" : "1.0.0",
    "cpu_id": "M55_HE",
    "loadAddress": "0x60000000",
    "flags": ["load", "boot"]
  },
  "DEVICE": {
    "binary": "device-config.json",
    "version" : "0.5.00"
  },
}
```

Here we have added a DEVICE configuration section.
The device-config.json file is as follows:

```
{
  "clocks": {
    "ChangeSets" : [
      {
        "address" : "0x08000018",
        "mask" : "0xFFFFFFFF",
        "value" : "0xdeadbeef"
      }
    ]
  }
}
```

For this example, we are adding a Change Set to a location in Global memory SRAM_1 (0x08000018).

When SES boots it will process the DEVICE Configuration section in MRAM

```
[SES] LCS=0
[SES] System TOC address 0x80580000
[DEU] Change Set
+-----+-----+-----+
| Address | Mask | Value |
+-----+-----+-----+
| 0x08000004 | 0xFFFFFFFF | 0xDEADBEEF |
| 0x0800000C | 0x0000FFFF | 0xDEADBEEF |
| 0x08000010 | 0xFFFFFFFF | 0x0000C0DE |
| 0x08000008 | 0xFFFFFFFF | 0x0000CAFE |
+-----+-----+-----+
[DEU] Wounding Data: 0x00C03FFB
[SES] System partition processed <0x00000000> BL_STATUS_OK
[DEU] Change Set
+-----+-----+-----+
| Address | Mask | Value |
+-----+-----+-----+
| 0x08000018 | 0xFFFF0000 | 0xDEADBEEF |
+-----+-----+-----+
[SES] Application partition processed <0x00000000> BL_STATUS_OK
```

In this example, there are some DEVICE configurations for the ALIF System TOC then the Application TOC is processed we see the Change Set being applied.

Example – Setting the Ethernet external Clock

The Ethernet external clock can be enabled using the following Change Set configuration.

```
"ChangeSets" : [
{
  "address" : "0x71007408",
  "mask" : "0x00000001",
  "value" : "0x00000001"
}
]
```

After SERAM processes the above Change Set, the Ethernet external clock will be enabled.

Error handling with a Change Set

There are some checks done within SES for addresses added through Changesets. These include:

- Checking the address is not within the ALIF MRAM area.

Invalid address in STOC partition

In the example below an attempt is made to write to the STOC MRAM area

```
[SES] LCS=0
[SES] System partition address 0x80580000
[DEU] Change Set
+-----+-----+-----+
| Address | Mask | Value |
+-----+-----+-----+
| 0x08000018 | 0xFFFFFFFF | 0xDEADBEEF |
| 0x805C14E0 | 0xFFFFFFFF | 0x0000CAFE |
[ERROR] address 805c14e0 is in STOC partition
+-----+-----+-----+
[DEU] Wounding Data: 0x00C03FFB
[SES] System partition processed <0x00000000> BL_STATUS_OK
[SES] Application partition processed <0x00000000> BL_STATUS_OK
```

4. ISP (In System Programming)

ISP is a mechanism for connecting to the Secure Enclave using the Secure Enclave UART (SE-UART) and performing various operations with the device.

Please ensure the prerequisite python packages are installed before starting. See the installation instructions in the Alif Security Toolkit Quick Start Guide.

SE-UART Connection

UART Settings

Baud Rate	55000 (default)
Data	8 bits
Parity	None
Stop Bits	1 bit
Flow control	None

Dynamic Baud Rate Change

Tools updating MRAM (updateSystemPackage, app-write-mram) will increase the baud rate from the default value to 921600 baud. Once the operation is completed the Baud rate is set back to the default value.

Use the '-s' option to override this dynamic change facility.

SES supports MRAM updates at the standard HF RC/XO frequencies, with baud rate bumping. I.e., no need to specify '-s'. If the device is running at a non-standard frequency, via the 1/X or 1/Z dividers - the MRAM updates should be done via the '-s' switch.

Baud Rate Override

The ISP method uses a default baud rate. For REV_A1 devices this is 100000.

You can override the default baud rate by doing either:

- Edit the local configuration file isp_config_data.cfg and change baudrate.
- Use the -b option e.g. -b 55000

All ISP tools have this option.

UART Errors – PermissionError

```
$ ./app-write-mram
Writing MRAM with parameters:
Device Part# E7 (AE722F80F55D5AS) - 5.5 MRAM / 13.5 SRAM - Rev: B2
- Available MRAM: 5767168 bytes
[INFO] Burning: ../build/AppTocPackage.bin 0x8057c4e0
[INFO] baud rate 55000
[INFO] dynamic baud rate change Enabled
[ERROR] openSerial could not open port 'COM8': PermissionError(13, 'Access is denied.', None, 5)
[ERROR] isp openSerial failed for COM8
```

There is only one SE-UART on the device. If you are using ISP, please ensure you have no other Tera term or putty sessions using the same SE-UART. The following shows the output if the SE-UART is already being used by another program:

This indicates that the UART is already being used (e.g., a Tera-Term session is still running).

UART Errors – Disconnected

This error occurs when a Disconnect event occurs such as Powering off the FDTI UART whilst in an ISP operation.

```
Available options:
1 - Hard maintenance mode
2 - Soft maintenance mode
3 - Device reset

Select an option (Enter to return): 1

[ERROR] /dev/ttyUSB0 readSerial reporting disconnected
```

In this example, we are in Hard Maintenance mode waiting for input from the Target board. The UART power is turned off and we will see the following error message printed that there has been a disconnection event.

UART Errors – FileNotFoundError

```
$ ./maintenance
[ERROR] openSerial could not open port 'COM8': FileNotFoundError(2, 'The system cannot find the file specified.', None, 2)
[ERROR] isp openSerial failed for COM8
```

This error usually indicates that your target system is not powered.

ISP Discovery

This command discovers the available Serial communication ports. The first time you execute an SETOOLS script you will be prompted for the required serial port.

When the ports are presented, just enter the port name and press [ENTER]. Just pressing [ENTER] will pick the last item in the list.

This port data is saved in a local configuration file (isp_config_data.cfg).

The next time an SETOOLS command is invoked if this configuration file is present, it will use the parameters from this file.

To override this option simply use the -d option:

```
$ ./app-write-mram -d
Writing MRAM with parameters:
Device Part# E7 (AE722F80F55D5AS) - 5.5 MRAM / 13.5 SRAM - Rev: B2
- Available MRAM: 5767168 bytes
[INFO] Burning: ../build/AppTocPackage.bin 0x8057c4e0
[INFO] baud rate 55000
[INFO] dynamic baud rate change Enabled
COM ports detected = 2
-> COM8
-> COM9
Enter port name:|
```

This will force a re-discovery of the Serial ports.

All the MRAM ISP tools have the discovery option which will prompt you for the serial port.

ISP when in Low power mode

When an application has put the device into STOP power mode, ISP will not be operational (the device is Powered off).

5. Tool Flow

The tools allow a user to provision the device.

This includes programming MRAM with application binaries for A32 and M55 embedded processors available for user applications.

- a. Use `tools-config` to review and modify current tool options.
- b. Generate RoT with `app-gen-rot.py` only once (or anytime new keys are required) – **Not required** as this release packet already contains a sample RoT and corresponding keys and certificates, but it can be used if user wants to re-generate the RoT.
- c. Edit `build/config/app-cfg.json` file (or a json file with other name) with images to include in the desired **AppTocPackage.bin** image and copy the binaries into the `build/` directory. Run `app-gen-toc.py` to generate the package.
- d. Power on the board and connect the Serial interface for the following steps.
 - d.1 (Optional) Use `updateSystemPackage.py` to update latest Alif Secure Enclave firmware.
 - d.2 Use `app-write-mram.py` to upload the `AppTocPackage.bin` image into the MRAM.
 - d.2.1 (Optional) Reset the board to reboot the chip to verify that the SERAM image loads and boots properly.

Debug Stubs

To enable connection with the debugger such as ARM-DS, the target core needs to be running.

This is achieved by running debug stubs on the cores. If the M55_HE Application core does not have an application loaded for it, the system will insert a debug stub for it.

For the other APP cores, the user must instantiate debug stubs by entering them in an ATOC configuration file.

You can create an ATOC image with 3 SRAM debug stubs for the 3 CPU cores by running

```
app-gen-toc -f build/config/app-cpu-stubs.json
```

Then erase the application part of MRAM by running

```
app-write-mram -e app
```

And then write the image with 3 debug stubs to MRAM by running

```
app-write-mram
```

Details of these programs are described below.

The following is the SE-UART output on boot when the Application MRAM is not programmed.

Name	CPU	Store Addr	Obj Addr	Dest Addr	Boot Addr	Size	Version	Flags	Time (ms)
SERAM0	CM0+	-----	0x00000120	-----	-----	54976	1.0.0	u s	0.00
SERAM1	CM0+	-----	0x00020B20	-----	-----	54976	1.0.0	u s	0.00
DEVICE	CM0+	0x805C1F20	0x805C1520	-----	-----	760	0.5.5	u U	10.41
A32_DBG	A32_0	0x805C2C20	0x805C2220	0x02000000	0x02000000	644	1.0.0	uLVB	9.69
HP_DBG	M55-HP	0x805C38B0	0x805C2EB0	0x50000000	0x50000000	2256	1.0.0	uLVB	9.95
HE_DBG	M55-HE	0x805C4B80	0x805C4180	0x60000000	0x60000000	2256	9.9.9	uLVB	9.97

Legend: <u><C>ompressed, <L>oaded, <U>erified, <s>kipped verification, ooted, <E>ncrypted, <D>eferred

The debug stubs, denoted by the _DBG names, are loaded by SES for each relevant Application core.

MRAM Burners

Two tools used to write MRAM

- updateSystemPackage
- app-write-mram

One will update the System TOC (STOC) and the other will update the Users Application MRAM area.

When using a generated TOC package this will be guaranteed to correctly aligned and padded for writing to MRAM.

In the case of User supplied images the burning tool will warn of any alignment issues such as not being aligned on 16-byte boundaries. The user will need to correct the issue(s) and re-run the burning tool.

6. Running the Tools

tools-config

From the command prompt.

```
$ ./tools-config
SETOOLS OPTIONS CONFIGURATION

*****
Current configuration
- DEVICE Family: Ensemble - Part#: E7 (AE722F80F55D5AE) - 5.5 MRAM / 13.5 SRAM - Rev: B0
- MRAM BURNER
  Interface: isp
  JTAG Adapter: J-Link
*****

Available options:
1 - Part#
2 - Revision
3 - Interface
4 - JTAG Adapter
5 - Exit (default)

Please enter the number of your option: |
$ tools-config
```

This script will show the current tool options and allow for their modification.

Press the menu number to show available options.

```
$ ./tools-config
SETOOLS OPTIONS CONFIGURATION

*****
Current configuration
- DEVICE Family: Ensemble - Part#: E7 (AE722F80F55D5AE) - 5.5 MRAM / 13.5 SRAM - Rev: B0
- MRAM BURNER
  Interface: isp
  JTAG Adapter: J-Link
*****

Available options:
1 - Part#
2 - Revision
3 - Interface
4 - JTAG Adapter
5 - Exit (default)

Please enter the number of your option: 1

Available options:
1 - Ensemble (default)

Please enter the number of your option: 1

Available options:
1 - E7 (AE722F80F55D5AE) - 5.5 MRAM / 13.5 SRAM (default)
2 - E5 (AE512F80F55D5AE) - 5.5 MRAM / 13.5 SRAM
3 - E3 (AE302F80F55D5AE) - 5.5 MRAM / 13.5 SRAM
4 - E3 (AE302F80C1557UE) - 1.5 MRAM / 5.75 SRAM
5 - E3 (AE302F40C1537UE) - 1.5 MRAM / 3.75 SRAM
6 - E1 (AE101F4071542UE) - 1.5 MRAM / 4.25 SRAM
7 - E1 (AE101F1061517UE) - 1.5 MRAM / 1.75 SRAM

Please enter the number of your option: |
```

Choose the desired option pressing the option number (or press Enter key to choose the default one, shown in parentheses).

Once the tool options are configured, the rest of the tools will take these options automatically.

(Note: every time a new Part Number or device Revision is changed, it's recommended to re-generate the APP TOC Package using the app-toc.py tool).

Tools-config command line mode:

Besides the interactive mode explained above (with menus and selections), the tool also allows the user to select the Part# (option 1 in the menu) and Revision (option 2) using the following command line options:

- -p PART# (use double quotes). Examples:
 - -p "E7 (AE722F80F55D5AE) - 5.5 MRAM / 13.5 SRAM"
 - -p "E1 (AE101F4071542UE) - 1.5 MRAM / 4.25 SRAM"
 - -p "e7 (AE722F80F55D5AE) - 5.5 mRAM / 13.5 srAM"
- -r REVISION. Examples:
 - -r B0
 - -r B2

app-gen-rot

From the command prompt.

```
$ app-gen-rot (-h for help)
```

The Security Tools already have a development key embedded.

You will need to use the -o, --overwrite flag to create a new one.

The tool will prompt the user to enter a password to encrypt the generated keys before saving them in the disk. The password will be saved as 'oem_keys_pass.pwd' and it will be needed for each operation that requires reading the encrypted keys.

```
$ ./app-gen-rot -o
utils/key/hbk1_hash.txt
utils/key/hbk1_zeros.txt
utils/key/kce.txt
utils/key/OEMRoT.pem
utils/key/OEMRoTPublic.pem
utils/key/OEMSBContent.pem
utils/key/OEMSBContentPublic.pem
utils/key/OEMSBKey.pem
utils/key/OEMSBKeyPublic.pem
utils/key/oem_keys_pass.pwd
cert/OEMSBKey1.crt
cert/OEMSBKey2.crt
cert/SBApp-device-config.bin.crt
cert/SBm55_blink_he.bin.crt
cert/SBm55_he_power_test.bin.crt
cert/SBm55_hp_power_test.bin.crt
Please enter a new password for the keys to generate:silly
Generating APP RoT keys (to be used in Key 1 Certificate)
2023-06-28 15:53:37,367 - RSA Key Generator Utility started (Logging to build/logs/key_gen_log.log)
2023-06-28 15:53:37,724 - Private key written to: utils/key/OEMRoT.pem
2023-06-28 15:53:37,726 - Public key written to: utils/key/OEMRoTPublic.pem
2023-06-28 15:53:37,726 - Script completed successfully
Generating APP SB Key keys (to be used in Key 2 Certificate)
2023-06-28 15:53:37,727 - RSA Key Generator Utility started (Logging to build/logs/key_gen_log.log)
2023-06-28 15:53:38,200 - Private key written to: utils/key/OEMSBKey.pem
2023-06-28 15:53:38,212 - Public key written to: utils/key/OEMSBKeyPublic.pem
2023-06-28 15:53:38,213 - Script completed successfully
Generating APP SB Content keys (to be used in Content Certificates)
2023-06-28 15:53:38,214 - RSA Key Generator Utility started (Logging to build/logs/key_gen_log.log)
2023-06-28 15:53:38,446 - Private key written to: utils/key/OEMSBContent.pem
2023-06-28 15:53:38,449 - Public key written to: utils/key/OEMSBContentPublic.pem
2023-06-28 15:53:38,449 - Script completed successfully
Generating APP Hbk1
2023-06-28 15:53:38,451 - Hbk1 Generator Utility started (Logging to build/logs/gen_hbk_log.log)
2023-06-28 15:53:38,451 - Step 1: Calculating hash
2023-06-28 15:53:38,452 - Step 2: Calculate num of zero bits over the hash
2023-06-28 15:53:38,454 - Script completed successfully
Generating APP SB Key 1 Certificate
2023-06-28 15:53:38,467 - Key Certificate Generation Utility started (Logging to build/logs/OEMSBKey1.log)
2023-06-28 15:53:38,468 - Parsing config file: utils/cfg/OEMSBKey1.cfg
2023-06-28 15:53:38,471 - Parsed items:
[('cert-keypair', 'utils/key/OEMRoT.pem'), ('cert-keypair-pwd', 'utils/key/oem_keys_pass.pwd'), ('hbk-id', '1'), ('nvcounter-val', '0'), ('next-cert-pubkey', 'utils/key/OEMSBKeyPublic.pem'), ('cert-pkg', 'cert/OEMSBKey1.crt')]
2023-06-28 15:53:38,472 - Raw content of config file:
# This configuration file is for the offline key certificate tool cert_key_util.py (Key Certificate Generation Tool - KCGT).
```

```

2023-06-28 15:53:38,472 - Raw content of config file:
# This configuration file is for the offline key certificate tool cert_key_util.py (Key Certificate Generation Tool - KCGT).
#
# The available parameters in this configuration file are the following
# @@@ [KEY-CFG] : Mandatory header.
# The internal non-configurable header.
# @@@ cert-keypair : Mandatory parameter.
# The file holding the RSA keypair for signing this certificate, in PEM format.
# @@@ cert-keypair-pwd : Optional. If omitted the tool prompts for direct input.
# The passphrase file for the keypair file, in .txt format.
# @@@ hbk-id : Mandatory parameter. The tool is agnostic to the certificate usage, this parameter cannot be omitted.
# The ID of the Hbk field in OTP memory that the public key of this certificate is verified against:
# - 0: 128-bit Hbk0.
# - 1: 128-bit Hbk1.
# - 2: 256-bit Hbk.
# The ROM code uses this field only if this certificate is the first certificate in:
# - A two-level SB certificate chain.
# - A three-level SB certificate chain.
# - A three-level Secure Debug chain.
# @@@ nvcounter-val : Mandatory parameter.
# The NV counter value:
# - 0..64: the ICV counter.
# - 0..96: the OEM counter.
# - 0..160: the full counter, if OEM and ICV are a single entity.
# The passphrase file for the keypair file, in .txt format.
# @@@ next-cert-pubkey : Mandatory parameter.
# The file holding the RSA public key for signing the next certificate in the chain, in PEM format.
# @@@ cert-pkg : Mandatory parameter.
# The key certificate package output file.
[KEY-CFG]
cert-keypair = utils/key/OEMRoT.pem
cert-keypair-pwd = utils/key/oem_keys_pass.pwd
hbk-id = 1
nvcounter-val = 0
next-cert-pubkey = utils/key/OEMSBKeyPublic.pem
cert-pkg = cert/OEMSBKey1.crt

2023-06-28 15:53:38,474 - **** Creating Key certificate ****
2023-06-28 15:53:38,482 - Write the certificate to file
2023-06-28 15:53:38,484 - **** Certificate file creation has been completed successfully ****
Generating APP SB Key 2 Certificate
2023-06-28 15:53:38,485 - Key Certificate Generation Utility started (Logging to build/logs/OEMSBKey2.log)
2023-06-28 15:53:38,486 - Parsing config file: utils/cfg/OEMSBKey2.cfg
2023-06-28 15:53:38,493 - Parsed items:
[('cert-keypair', 'utils/key/OEMSBKey.pem'), ('cert-keypair-pwd', 'utils/key/oem_keys_pass.pwd'), ('hbk-id', '1'), ('nvcounter-val', '0'), ('next-cert-pubkey', 'utils/ke
y/OEMSBContentPublic.pem'), ('cert-pkg', 'cert/OEMSBKey2.crt')]
2023-06-28 15:53:38,494 - Raw content of config file:
# This configuration file is for the offline key certificate tool cert_key_util.py (Key Certificate Generation Tool - KCGT).
#
# The available parameters in this configuration file are the following

```

```

2023-06-28 15:53:38,474 - **** Creating Key certificate ****
2023-06-28 15:53:38,482 - Write the certificate to file
2023-06-28 15:53:38,484 - **** Certificate file creation has been completed successfully ****
Generating APP SB Key 2 Certificate
2023-06-28 15:53:38,485 - Key Certificate Generation Utility started (Logging to build/logs/OEMSBKey2.log)
2023-06-28 15:53:38,486 - Parsing config file: utils/cfg/OEMSBKey2.cfg
2023-06-28 15:53:38,493 - Parsed items:
[('cert-keypair', 'utils/key/OEMSBKey.pem'), ('cert-keypair-pwd', 'utils/key/oem_keys_pass.pwd'), ('hbk-id', '1'), ('nvcounter-val', '0'), ('next-cert-pubkey', 'utils/ke
y/OEMSBContentPublic.pem'), ('cert-pkg', 'cert/OEMSBKey2.crt')]
2023-06-28 15:53:38,494 - Raw content of config file:
# This configuration file is for the offline key certificate tool cert_key_util.py (Key Certificate Generation Tool - KCGT).
#
# The available parameters in this configuration file are the following
# @@@ [KEY-CFG] : Mandatory header.
# The internal non-configurable header.
# @@@ cert-keypair : Mandatory parameter.
# The file holding the RSA keypair for signing this certificate, in PEM format.
# @@@ cert-keypair-pwd : Optional. If omitted the tool prompts for direct input.
# The passphrase file for the keypair file, in .txt format.
# @@@ hbk-id : Mandatory parameter. The tool is agnostic to the certificate usage, this parameter cannot be omitted.
# The ID of the Hbk field in OTP memory that the public key of this certificate is verified against:
# - 0: 128-bit Hbk0.
# - 1: 128-bit Hbk1.
# - 2: 256-bit Hbk.
# The ROM code uses this field only if this certificate is the first certificate in:
# - A two-level SB certificate chain.
# - A three-level SB certificate chain.
# - A three-level Secure Debug chain.
# @@@ nvcounter-val : Mandatory parameter.
# The NV counter value:
# - 0..64: the ICV counter.
# - 0..96: the OEM counter.
# - 0..160: the full counter, if OEM and ICV are a single entity.
# The passphrase file for the keypair file, in .txt format.
# @@@ next-cert-pubkey : Mandatory parameter.
# The file holding the RSA public key for signing the next certificate in the chain, in PEM format.
# @@@ cert-pkg : Mandatory parameter.
# The key certificate package output file.
[KEY-CFG]
cert-keypair = utils/key/OEMSBKey.pem
cert-keypair-pwd = utils/key/oem_keys_pass.pwd
hbk-id = 1
nvcounter-val = 0
next-cert-pubkey = utils/key/OEMSBContentPublic.pem
cert-pkg = cert/OEMSBKey2.crt

2023-06-28 15:53:38,497 - **** Creating Key certificate ****
2023-06-28 15:53:38,505 - Write the certificate to file
2023-06-28 15:53:38,506 - **** Certificate file creation has been completed successfully ****
Check logs in build/logs/ directory
Done!

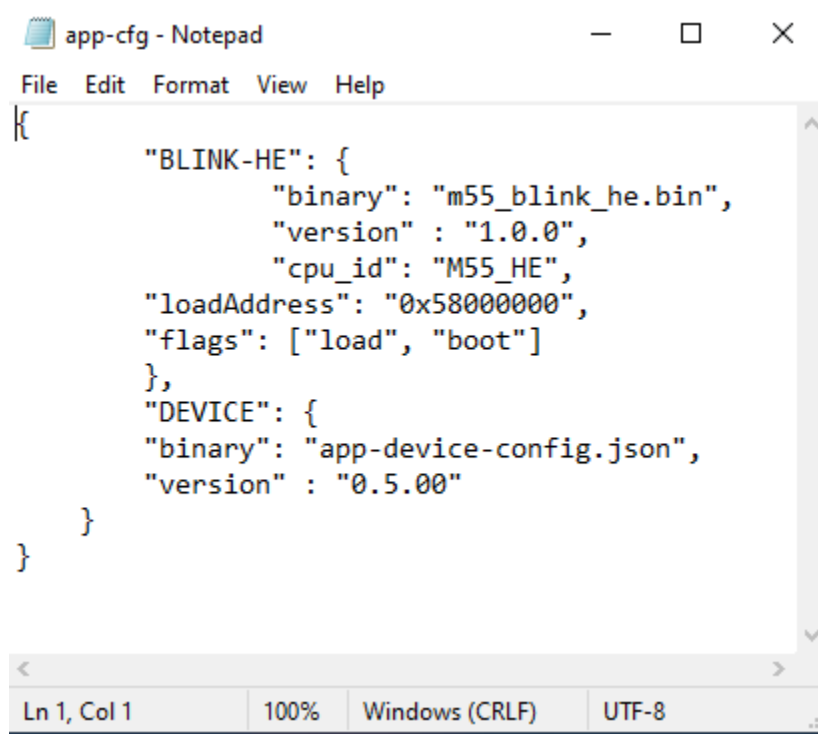
```

Once finished, keys will be generated in *utils/key/*, certificates are generated in *cert/*, and logs in *build/logs/* folder.

app-gen-toc

To generate the APP TOC Package, the `build/config/app-cfg.json` file must be configured. Alternatively, a configuration file can be created with a different name and the tool's `-f` option can cause that alternate file to be used as input to the program.

Here is an example configuration file:



```
{
  "BLINK-HE": {
    "binary": "m55_blink_he.bin",
    "version" : "1.0.0",
    "cpu_id": "M55_HE",
    "loadAddress": "0x58000000",
    "flags": ["load", "boot"]
  },
  "DEVICE": {
    "binary": "app-device-config.json",
    "version" : "0.5.00"
  }
}
```

This configuration file is in JSON format and must specify each of the binary images the user wants to include in the APP TOC Package. [SERAM will process the images in the specified order \(from top to bottom\).](#)

A JSON file may contain multiple objects, where each object is represented by a set of name-value pairs.

In the configuration file, each image must be specified as an object in the following way;

```
"IMAGE_IDENTIFIER": {  
    "attribute_1": "value_1",  
    "attribute_2": "value_2",  
    .....  
    "attribute_n": "value_n"  
}
```

Multiple images will be declared by multiple objects, separated by comma. For example;

```
{  
    "IMAGE_1": {  
  
    },  
    "IMAGE_2": {  
  
    },  
    .....  
    "IMAGE_N": {  
  
    }  
}
```

The "IMAGE_IDENTIFIER" is an 8-character length (MAX) description intended to give a short description to the image. The tool will truncate or extend this field's length as appropriate. This name **should be unique** per configuration file.

Inside each image object, different attributes can be used to define the parameters of the binary image. The following attributes are valid:

binary: [MANDATORY] - this attribute declares the name of the binary to be included in the APP TOC Package. It is assumed the binary exists in the build/images/ folder.

version: [OPTIONAL] – this attribute declares the version of the image, and it should follow the 'X.Y.Z' format. Example; '1.0.0'

loadAddress: [MANDATORY if LOAD flag is set] – this attribute specifies the loading address in (RAM) memory where the code will be executed from. Global Memory Addresses (in hexadecimal format) should be used for this attribute.

mramAddress: [OPTIONAL] – this attribute specifies the MRAM address location where the user wishes the image to reside, and addresses (in hexadecimal format) starting from 0x8000-0100 (for REV_Ax) can be used. This option is to support the "Fixed Address Image" or "absolute placement" use case, where the user needs to position the binary in a specific address in MRAM, so other running code can locate this image in the specified location (Linux use case). If this attribute is used with the BOOT flag, XIP (execution in place) is supported. If this flag is not set, then the image will reside at this address, with no further implication. If this attribute is NOT specified, the tool will define the MRAM position to allocate the binary in memory.

flags: [OPTIONAL] – the following flags can be used – example [“load”, “boot”]:

- LOAD – The image will be loaded into the specified memory address
- BOOT – The specified CPU_ID will be started to execute the image
- ENCRYPT – The image will be encrypted
- COMPRESS – The image will be compressed
- DEFERRED – The image will be skipped at boot time (i.e., no boot or load) and wait for a service request at runtime

cpu_id: [OPTIONAL] – this attribute indicates the CPU to start once the binary is ready to be executed. Valid values are:

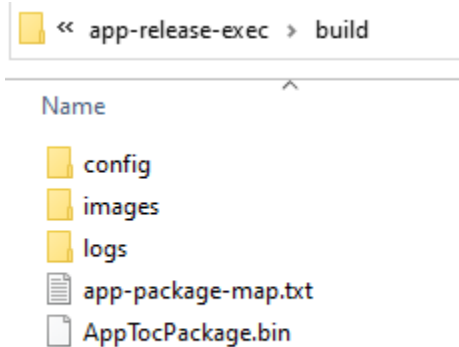
[A32_0, A32_1, A32_2, A32_3, M55_HP, M55_HE]

Note: Only one CPU_ID should be specified.

signed: [OPTIONAL] – this attribute is a binary value (true/false) specifying if the image is signed (“signed”: true) or unsigned (“signed”: false). In a typical case for Secure Boot, all images should be signed, so there is no need to specify this attribute. Only if the user wishes to specify an unsigned image, this attribute should be set as false.

disabled: [OPTIONAL] – this attribute allows a temporary disable of an image in the configuration file for testing purposes, so there is no need to delete the object for that image. Specifying “disabled”: true, the tool will ignore the entry. Either deleting the attribute, or setting it as false, the tool will include back the image in the final APP Package.

The JSON configuration file, along with all the binaries declared in it, should be allocated in the build/ folder (build/config/ and build/images respectively);



Once the *app-cfg.json* file is configured as desired, we need to be sure that all declared images do exist in the *build/images/* folder.

After running the *app-gen-toc.py* tool, the **APP TOC Package** (AppTocPackage.bin) will be generated in the *build/* folder.

The *build/logs/* folder contains a log for the Generation (OEMSBContent.log file)

Once the configuration is done, and all declared images exist in *build/images/* folder, continue with the APP TOC Package generation step.

From the command prompt.

```
$ app-gen-toc (-h for help)
```

```
$ ./app-gen-toc
Generating APP Package with:
Device Part# E7 (AE722F80F55D5LS) - 5.5 MRAM / 13.5 SRAM - Rev: B2
- System MRAM Base Address: 0x80580000
- APP MRAM Base Address: 0x80000000
- APP MRAM Size: 5767168
- Configuration file: build/config/app-cfg.json
- Output file: build/AppTocPackage.bin

Generating Device Configuration for: app-device-config.json
Calculating APP area...
Creating Content Certificates...
2024-01-26 13:46:31,300 - Content Certificate Generation Utility started (Logging to ../build/logs/ICVSBContent.log)
2024-01-26 13:46:31,561 - Content Certificate Generation Utility started (Logging to ../build/logs/ICVSBContent.log)
Creating APP TOC Package...
Adding ATOC...
APP TOC Package size: 15104 bytes
Creating Signature...
Binary File: ../build/AppTocPackage.bin
2024-01-26 13:46:31,809 - Content Certificate Generation Utility started (Logging to ../build/logs/ICVSBContent.log)
Content Certificate File: build/AppTocPackage.bin.crt
Signature File: build/AppTocPackage.bin.sign
Done!
```

Once the tool finishes, a map file named *app-package-map.txt* will be created in build/ folder to provide a reference of the memory map and images/certificates packaged in the APP TOC Package created by the tool. This memory map file will have the following structure.

```
oem-package-map.txt - Notepad
File Edit Format View Help
*** User managed MRAM locations***
0xa000100      0x280    640    signed    a32_stub_0.bin

*** OEM Package Start Address***

- Certificates for User managed images
0xa057d670     0x690    1680    Key1/Key2 Certificates
0xa057dd00     0x370     880    SBa32_stub_0.bin.crt

- Certificates & images for Tool managed images
0xa057e070     0x370     880    SBm55_stub_hp.bin.crt
0xa057e3e0     0x8d0    2256    m55_stub_hp.bin
0xa057ecb0     0x690    1680    Key1/Key2 Certificates
0xa057f340     0x370     880    SBm55_stub_he.bin.crt
0xa057f6b0     0x8d0    2256    m55_stub_he.bin

- OEM TOC (Table of Content)
0xa057ff80     0x10     16    OEM TOC Header
0xa057ff90     0x20     32    OEM TOC entry for A32_0    obj_a
0xa057ffb0     0x20     32    OEM TOC entry for M55_HP    obj_a
0xa057ffd0     0x20     32    OEM TOC entry for M55_HE    obj_a
0xa057fff0     0x10     16    OEM TOC Tail

OEM Package Summary:
- OEM Package total size: 10640 bytes
- OEM Package Start Address: 0xa057d670
- OEM TOC size: 128 bytes
- OEM TOC Start Address: 0xa057ff80
- OEM CRC32: 0xe25282ff

*** END of OEM Package ***
```

Additionally, a script file will be created in bin/ folder to automate the burn of this package into MRAM, using the app-write-mram.py tool. See next section for details.

Valid LoadAddress Regions

The valid address ranges supported are as follows:

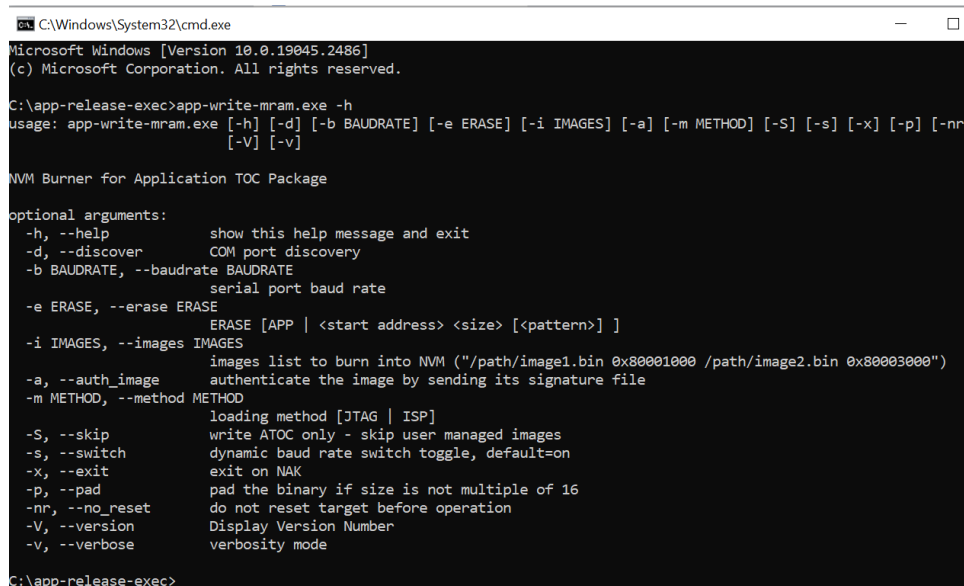
Start Address	End Address	Name
0x0200-0000	0x0240-0000	SRAM1_BASE
0x0800-0000	0x0828-0000	SRAM0_BASE
0x5000-0000	0x5004-0000	M55_HP_ITCM_BASE
0x5080-0000	0x5090-0000	M55_HP_DTCM_BASE
0x5800-0000	0x5804-0000	M55_HE_ITCM_BASE
0x5880-0000	0x5884-0000	M55_HE_DTCM_BASE
0x6200-0000	0x6210-0000	MODEM_ITCM_BASE
0x6210-0000	0x6220-0000	MODEM_DTCM_BASE
0x6310-0000	0x6330-0000	DSP_DTCM_BASE
0x6000-0000	0x6004-0000	GNSS_ITCM_BASE
0x8000-0000	0x8060-0000	MRAM_BASE

app-write-mram

- This utility uses ISP (In System Programming) via the SE-UART connection or JTAG supporting SEGGER J-Link adapter, to update the MRAM.

From the Windows Command prompt.

```
$ app-write-mram (-h for help)
```



```
C:\Windows\System32\cmd.exe
Microsoft Windows [Version 10.0.19045.2486]
(c) Microsoft Corporation. All rights reserved.

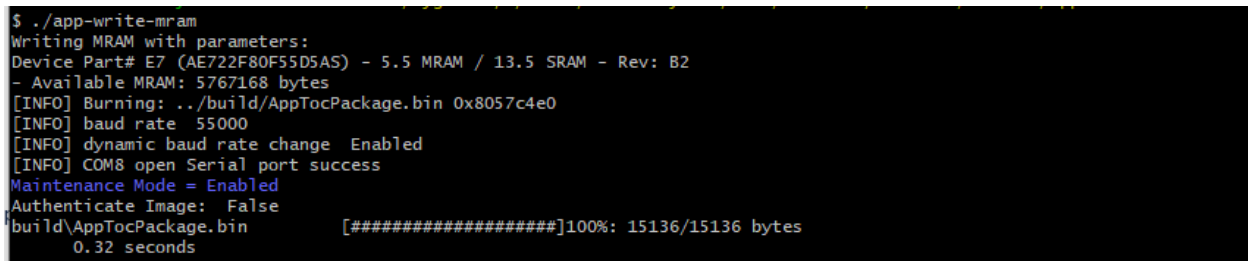
C:\app-release-exec>app-write-mram.exe -h
usage: app-write-mram.exe [-h] [-d] [-b BAUDRATE] [-e ERASE] [-i IMAGES] [-a] [-m METHOD] [-S] [-s] [-x] [-p] [-nr]
                        [-V] [-v]

NVM Burner for Application TOC Package

optional arguments:
  -h, --help            show this help message and exit
  -d, --discover         COM port discovery
  -b BAUDRATE, --baudrate BAUDRATE
                        serial port baud rate
  -e ERASE, --erase ERASE
                        ERASE [APP | <start address> <size> [<pattern>] ]
  -i IMAGES, --images IMAGES
                        images list to burn into NVM ("/path/image1.bin 0x80001000 /path/image2.bin 0x80003000")
  -a, --auth_image       authenticate the image by sending its signature file
  -m METHOD, --method METHOD
                        loading method [JTAG | ISP]
  -S, --skip             write ATOC only - skip user managed images
  -s, --switch           dynamic baud rate switch toggle, default=on
  -x, --exit             exit on NAK
  -p, --pad             pad the binary if size is not multiple of 16
  -nr, --no_reset        do not reset target before operation
  -V, --version          Display Version Number
  -v, --verbose          verbosity mode

C:\app-release-exec>
```

Before running this utility, be sure the CPU board is powered on and the SEUART is connected to the PC. Open Windows Command prompt and change directory to the release directory. Call the script as the example shows.



```
$ ./app-write-mram
Writing MRAM with parameters:
Device Part# E7 (AE722F80F55D5AS) - 5.5 MRAM / 13.5 SRAM - Rev: B2
- Available MRAM: 5767168 bytes
[INFO] Burning: ../build/AppTocPackage.bin 0x8057c4e0
[INFO] baud rate 55000
[INFO] dynamic baud rate change Enabled
[INFO] COM8 open Serial port success
Maintenance Mode = Enabled
Authenticate Image: False
../build/AppTocPackage.bin [#####]100%: 15136/15136 bytes
0.32 seconds
```

The first time this command is executed it will prompt the user for the Serial Communications port name. This information is stored in a local file and will be read again when this command is executed.

You can override this using the -d (discovery) option and you will be prompted again for the port name.

There is a verbose mode (-v) which will print all the communications between the host and the target. During this mode, the progress bar is suppressed.

If the ATOC image was signed (using the script sign_image.py), the option '-a' (Authenticate Image) can be specified, which instructs app-write-mram.py to send the signature.

```
$ app-write-mram -a
```

Maintenance Mode Internals

When updating MRAM (using app-write-mram or updateSystemPackage) SES is placed into a forced Maintenance mode. This means all cores are stopped achieved by resetting the device and then entering maintenance mode. This ensures no cores are operating when the MRAM update is performed.

Once the update is completed, the whole device is reset (this is done via an ISP command).

Maintenance Mode reporting

This tool will also report the Maintenance state of the Target system. See the section on the Maintenance tool for more details.

```
$ ./app-write-mram
Writing MRAM with parameters:
Device Part# E7 (AE722F80F55D5AS) - 5.5 MRAM / 13.5 SRAM - Rev: B2
- Available MRAM: 5767168 bytes
[INFO] Burning: ../build/AppTocPackage.bin 0x8057c4e0
[INFO] baud rate 55000
[INFO] dynamic baud rate change Enabled
[INFO] COM8 open Serial port success
Maintenance Mode = Enabled
Authenticate Image: False
build\AppTocPackage.bin [#####]100%: 15136/15136 bytes
0.32 seconds
```

In the above, the maintenance mode is *Enabled*.

Erase option

Erase option will allow, via ISP, the contents of the Application MRAM to be erased. Erasing means that the MRAM location is written with zeros. The writing is verified. See later description on how to add your own pattern.

Erasing all the application MRAM

```
$ app-write-mram -e app
```

```
$ ./app-write-mram -e app
Writing MRAM with parameters:
Device Part# E7 (AE722F80F55D5AS) - 5.5 MRAM / 13.5 SRAM - Rev: B2
- Available MRAM: 5767168 bytes
[INFO] Erasing: erase 0x80000000 0x580000
[INFO] baud rate 55000
[INFO] dynamic baud rate change Enabled
[INFO] COM8 open Serial port success
[INFO] erase 0x80000000 5767168 (5,767,168)
```

Depending on the size of the Application MRAM this can take a few seconds to complete, do not panic, the tool will exit when the operation completes, or an error is detected.

NOTE: The pattern written is always zeros and cannot be changed.

Erasing a specific address of application MRAM

The user can specify a specific address and length to erase.

Erasing a specific address of application MRAM

The user can specify a specific address and length to erase.

```
$ ./app-write-mram -e "0x80000000 0x10"
Writing MRAM with parameters:
Device Part# E7 (AE722F80F55D5AS) - 5.5 MRAM / 13.5 SRAM - Rev: B2
- Available MRAM: 5767168 bytes
[INFO] Erasing: erase 0x80000000 0x10
[INFO] baud rate 55000
[INFO] dynamic baud rate change Enabled
[INFO] COM8 open Serial port success
[INFO] erase 0x80000000 16 (16)
```

This will erase from the start of MRAM for 16 Bytes, it will be erased with zeros.

Erasing a specific address of application MRAM with a pattern

The user can specify a specific address and length to erase along with a pattern to be written.

```
$ ./app-write-mram -e "0x80000000 0x10 0xa5a5a5a5"
Writing MRAM with parameters:
Device Part# E7 (AE722F80F55D5AS) - 5.5 MRAM / 13.5 SRAM - Rev: B2
- Available MRAM: 5767168 bytes
[INFO] Erasing: erase 0x80000000 0x10 0xa5a5a5a5
[INFO] baud rate 55000
[INFO] dynamic baud rate change Enabled
[INFO] COM8 open Serial port success
[INFO] erase 0x80000000 16 (16)
```

In this example, the pattern 0xa5a5a5a5 will be written to the <address> for <length> bytes.

Erasing a specific address of MRAM that is illegal.

If the user specifies a region of MRAM that is not allowed to be accessed

```
$ ./app-write-mram -e "0x80580000 0x10"
Writing MRAM with parameters:
Device Part# E7 (AE722F80F55D5AS) - 5.5 MRAM / 13.5 SRAM - Rev: B2
- Available MRAM: 5767168 bytes
[INFO] Erasing: erase 0x80580000 0x10
[INFO] baud rate 55000
[INFO] dynamic baud rate change Enabled
[INFO] COM8 open Serial port success
[INFO] erase 0x80580000 16 (16)
[ERROR] illegal address 0x80580010 (0x80580000 + 0x10)
```

In this example, an error is flagged that the address is illegal.

Padding binaries (-p option)

The MRAM controller requires write operations with data size in multiple of 16 bytes.

The tools take care of this requirement by always producing images that satisfy this constraint.

In case the user specifies binaries to be placed in specific MRAM addresses (using the “mramAddress” attribute in the **app-gen-toc** configuration file), these binaries should also satisfy the MRAM controller requirement (i.e., the size should be multiple of 16 bytes). When running the **app-write-mram** tool, if a user binary does not satisfy this constraint, the tool will throw an error message and abort the process.

The user should invoke the tool using the **-p** (or **--pad**) option to force the tool to pad the binaries. Be aware that using this option, the user provided binary will be modified (padded) and no backup will be created.

JTAG Method (-m)

JTAG is supported as a method of burning Application MRAM. The JTAG supported is SEGGER J-LINK

```
$ app-write-mram -m jtag
```

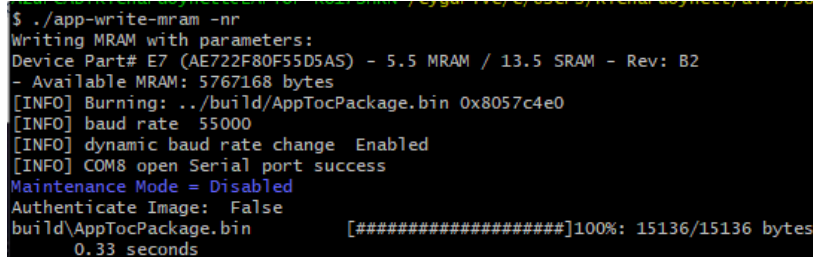
This method can be set as a default by using tools-config.

It should be noted that after the write has occurred a [RESET] is signaled to the Target. With the J-LINK this reset does not appear to have any effect and a manual press of [RESET] is required.

No Reset option (-nr)

The Reset option causes the command to reset the target and put it in 'Maintenance mode', in which no CPU cores are running (the TOCs are not processed). This is useful in cases where it is not desirable to have them running while writing to MRAM. To overwrite this mode (default), use -nr option (no reset)

```
$ app-write-mram -nr
```



```
$ ./app-write-mram -nr
Writing MRAM with parameters:
Device Part# E7 (AE722F80F55D5A5) - 5.5 MRAM / 13.5 SRAM - Rev: B2
- Available MRAM: 5767168 bytes
[INFO] Burning: ../build/AppTocPackage.bin 0x8057c4e0
[INFO] baud rate 55000
[INFO] dynamic baud rate change Enabled
[INFO] COM8 open Serial port success
Maintenance Mode = Disabled
Authenticate Image: False
build\AppTocPackage.bin [#####]100%: 15136/15136 bytes
0.33 seconds
```

Note: By default, the reset is enabled, the override is '-nr'

Images option (-i)

The -i option was implemented to provide a facility to download individual files at specific addresses. Note, this is not needed to download the *AppTocPackage.bin* file as the tool takes care of this.

Initially JTAG was used (via ARM-DS with ULink Pro) to burn images to MRAM. This uses semi-hosting to download the files. Since the MRAM burner runs from the *app-release/bin* directory, the **file should be specified relative to this path**. Subsequently, both ISP and J-Link support for MRAM burning were developed but still assume this filename approach for compatibility.

As an example, a binary file stored in *app-release/build/images/m55_blink.bin*, should be specified with its *relative path* from the *app-release/bin* directory.

```
$ app-write-mram -i "../build/config/images/m55_blink.bin 0x80001000"
```

Note also that double quotes must be provided.

SKIP Images option (-S)

The -S option will write only the ATOC to MRAM. Any managed images to be written will be ignored.

SWITCH option (-s)

The -s option will toggle the dynamic baud rate change when performing bulk transfer operations. By default, dynamic baud rate change is ENABLED.

No reset option (-nr)

The -nr option will not reset the Target being doing the Application MRAM write.

ATOC Policy

~~SES V81 onwards a policy was implemented that if there is no ATOC, SES will default to using the HFRC clock source, it will *not enable the PLL* and switch to it.~~

The HFRC is not very precise, and it is possible that on some boards it runs at a quite different frequency from its nominal 76.8MHz, this may result in seeing ISP errors (such as Checksum).

The policy was changed and starting with V83 – the policy when there is no ATOC is to assume that the external crystals HFXO and LFXO are present, and to switch the device to using them, including starting the PLL and switching to it.

updateSystemPackage

Before running this utility, be sure the CPU board is powered on and the SEUART is connected to the PC. Open Windows Command prompt and change directory to the release directory. Call the script as the example shows.

```
$ updateSystemPackage
```

```
C:\Projects\QA\DEV\app-release-exec>updateSystemPackage.exe
Burning: System Package in MRAM
Selected Device:
Part# E7 (AE722F80F55D5LS) - 5.5 MRAM / 13.5 SRAM - Rev: B2

Connecting to the target device...
[INFO] baud rate 55000
[INFO] dynamic baud rate change Enabled
[INFO] COM10 open Serial port success
Bootloader stage: SERAM
Detected Device:
Part# AE302F80F55D5LE - Rev: B2
- MRAM Base Address: 0x80580000
Connected target is not the default Part#
Do you want to set this part as default? (y/n): y
Maintenance Mode - Enabled
Authenticate Image: True
Signature File: alif\SP-AE302F80F55D5LE-rev-b2-dev.bin.sign
Auth Token: 0x239021b
Verify Image
alif\SP-AE302F80F55D5LE-rev-b2-dev.bin[#####]100%: 275280/275280 bytes
7.06 seconds
Authenticate Image: True
Signature File: alif\offset-58-rev-b2-dev.bin.sign
Auth Token: 0x4238a5e5
Verify Image
alif\offset-58-rev-b2-dev.bin [#####]100%: 16/16 bytes
0.00 seconds
C:\Projects\QA\DEV\app-release-exec>
```

ALIF images are signed. SES will check that image is signed (based on the LCS state of the device) and only allow signed images.

The tool will Probe the target device to ensure it matches the device chosen through tools-config. In the above screen shot, we see:

```
Bootloader stage: SERAM
```

This shows that SERAM is running, the alternative is that SEROM is running and in this case, this is the wrong tool to be using.

Device Revision: B0

This shows the target device that is attached. The tool will exit if there is a mismatch.

No Reset option (-nr)

The Reset option causes the command to reset the target and put it in 'Maintenance mode', in which no CPU cores are running (the TOCs are not processed). This is useful in cases where it is not desirable to have them running while writing to MRAM. To overwrite this mode (default), use -nr option (no reset)

```
$ updateSystemPackage -nr
```

No Authentication (-na) option

If the device is in DM (Device Manufacturer) or SE (Secure Enable) lifecycle state, images written to the System partition of MRAM must be signed by Alif. The APP release package already contains signatures for the STOC images. The script updateSystemPackage.py runs by default in 'Authenticated Mode', i.e., it sends the image signatures to the device for verification. The option 'no-authentication' can be used to override that behavior and run in 'non authenticated mode' instead. This is allowed in CM LCS, but not allowed in DM and SE LCSs.

```
$ updateSystemPackage -na
```

maintenance

Maintenance mode allows for the recovery of MRAM executable images and interaction with SES.

Running the Tool

```
$ maintenance (-h for help)
```

```
$ ./maintenance -h
usage: maintenance.exe [-h] [-b BAUDRATE] [-d] [-opt OPTION] [-V] [-v]

FUSION Maintenance Tool

optional arguments:
  -h, --help            show this help message and exit
  -b BAUDRATE, --baudrate BAUDRATE
                        serial port baud rate
  -d, --discover        COM port discovery
  -opt OPTION, --option OPTION
                        call option [sesbanner]
  -V, --version         Display Version Number
  -v, --verbose         verbosity mode
```

The command presents several options including maintenance mode.

Select an option number from the menu.

To exit the tool just press [ENTER] at the option selection.

Command line options

```
$ maintenance -opt <option>
```

Option

sesbanner Returns the SES Banner string.

This allows a command to be executed by the Maintenance tool without navigating the menu options.

```
$ ./maintenance -opt sesbanner
[INFO] COM8 open Serial port success
[INFO] baud rate 55000
SES B0 EVALUATION_BOARD v0.76.0 Jun 27 2023 16:01:26
```

Maintenance Menu Grouping

The maintenance menus are grouped into categories.

Action	Menu Groups							
	Device Control	Device Info	MRAM	Utilities	Set	ROM	SEROM	SES
Hard maintenance mode	•							•
Soft maintenance mode	•							•
Device Reset	•							•
Device enquiry		•					•	•
Get revision info		•					•	•
Get TOC info		•						•
Get SES banner		•						•
Get CPU boot info		•						•
Get OTP Data		•					•	•
Get MRAM data		•					•	•
Get log data		•						•
Get SEROM trace data		•					•	
Get SERAM trace data		•						•
Get Power data		•						•
Get Clock data		•						•
Get SERAM metrics				•				•
Terminal mode				•			•	•
Get ECC Key				•				•
Get Firewall configuration				•				•
Erase application MRAM			•					•
Fast erase application MRAM			•					•
Fast erase application NTOC			•					
Get MRAM info			•					•

Recovery							•	
Enable LOGGING					•			•
Disable LOGGING					•			•
Enable PRINTING					•			•
Disable PRINTING					•			•

NOTE: Some ISP commands are common between SEROM and SES.

Device Control

Top level group menu

```
Select an option (Enter to exit): 1
Available options:
1 - Hard maintenance mode
2 - Soft maintenance mode
3 - Device reset
Select an option (Enter to return): |
```

Hard maintenance Mode

Hard maintenance mode will wait until the user has pressed RESET on the target board.

Once RESET has been pressed the tool will drop back to the Available options menu. NOTE: This mode skips the TOC processing section of SES, if you use the get TOC info option it will return no data as no TOCs have been loaded.

To exit the tool, just press [ENTER]

Soft maintenance Mode

Soft maintenance mode is like Hard maintenance mode, but no [RESET] button needs to be pressed on the target board.

Device Reset

Issues a Reset ISP command to the board.

Device Information

Top level group menu

```
Available options:

1 - Get TOC info
2 - Get SES Banner
3 - Get CPU boot info
4 - Device enquiry
5 - Get revision info
6 - Get OTP data
7 - Get MRAM data
8 - Get log data
9 - Get SEROM trace data
10 - Get SERAM trace data
11 - Get power data
12 - Get clock data
```

Get Table of contents information

This will return the TOC contents in MRAM along with the boot status of the Application CPUs.

```
Select an option (Enter to return): 1

+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Name | CPU | Store Addr | Obj Addr | Dest Addr | Boot Addr | Size | Version | Flags | Time (ms)|
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| DEVICE | CM0+ | 0x805c1ee0 | 0x805C14E0 | ----- | ----- | 404 | 0.5.0 | u V | 14.58 |
| SERAM0 | CM0+ | ----- | 0x000000E0 | ----- | ----- | 78208 | 1.0.0 | ----- | 0.00 |
| SERAM1 | CM0+ | ----- | 0x00020AE0 | ----- | ----- | 78208 | 1.0.0 | ----- | 0.00 |
| HE_DBG | M55-HE | 0x805c2a80 | 0x805C2080 | 0x58000000 | 0x58000000 | 2256 | 1.0.0 | uLVB | 14.73 |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+

Available options:
```

Legend Reference

Name	Name of entry from JSON file.
CPU	Which CPU is this TOC referencing.
Store Address	MRAM location
Object address	MRAM TOC address
Destination address	Copy address for object (if relevant).
Boot Address	Boot address
Size	Size of TOC entry
Version	Version id from JSON file
Flags	Directives for the TOC object
	u Uncompressed image
	C Compressed Image
	L Image is loaded from MRAM
	V Image is verified
	s Image is Skipped
	B Image has been Booted

- E Image is Encrypted
- D Image is Deferred, will be Loaded / Booted at a later time.

When you are in hard maintenance mode, the TOC table contents will look very different. The main reason is that Hard Maintenance skips the TOC processing stage entirely except for some DEVICE CONFIG objects. No Application CPU cores are booted or loaded with images whilst in this mode.

Get SES Banner

```
Select an option (Enter to return): 2
SES B0 v1.0.94 Apr 18 2024 23:11:57
```

This returns the version string for the SES image

NOTE: The Banner output is only 80 characters.

Get CPU boot information

```
Select an option (Enter to return): 3
+-----+-----+-----+
| CPU   |Booted| Boot Addr |
+-----+-----+-----+
| A32_0 |      | ----- |
| A32_1 |      | ----- |
| M55-HP|      | ----- |
| M55-HE| YES  | 0x58000000|
+-----+-----+-----+
```

This returns the status of the CPU cores.

This is an example in which CPUs are currently booted.

Device Enquiry

Returns if connected to SEROM or SES. Any errors are reported otherwise 0x0 (Success) is returned.

Device Enquiry - SES

```
Select an option (Enter to return): 4
SERAM Error = 0x0 Extended Error = 0x0 Maintenance Mode = Disabled
Available options:
```

It will also tell you if you are in Maintenance mode, in above case it is DISABLED

```
Select an option (Enter to return): 4
SERAM Error = 0x0 Extended Error = 0x0 Maintenance Mode = Enabled
Available options:
```

In the above case it is ENABLED

Device Enquiry – SEROM

When connected to SEROM:

```
Available options:
1 - Get TOC info
2 - Get SES Banner
3 - Get CPU boot info
4 - Device enquiry
5 - Get revision info
6 - Get OTP data
7 - Get MRAM data
8 - Get Log data
9 - Get SEROM trace data
10 - Get SERAM trace data
11 - Get power data
12 - Get clock data

Select an option (Enter to return): 4
SEROM Error = 0x12 (SEROM_ATOC_HEADER_STRING_INVALID) Extended Error = 0x0 Maintenance Mode = <None>
```

NOTE: If you are connected to SEROM then this means your MRAM is not provisioned with an SES image. Maintenance mode is not applicable in this scenario.

Get Revision Information

Device Information

Item	Meaning
Version	SOC id register
ALIF_PN	ALIF Part Number
HBK0	SHA-128 of ALIF RoT Public key
HBK1	SHA-128 of Customer RoT Public key
HBK_FW	
Wounding	Shows DISABLED Wounding bits
DCU	Debug Lock bits
MfgData	ALIF Manufacturing data
SerialN	ALIF Device Serial Number
LCS	Life Cycle State CM, DM, SE, RMA

Revision B0

Returns device specific information such as the SOC ID, Part#.

```
Select an option (Enter to return): 5
Version      = 0xB000
ALIF_PN      = AE302F80F55D5LE
HBK0         = 0x3b4df3e19a5862b4540710284ba679c8
HBK1         = 0x0
HBK_FW       = 0x0
Wounding     = 0x19
  DFT        Disable
  A32_0      Disable
  A32_1      Disable
DCU          = 0x0
MfgData      = 0x0
SerialN      = 0x0
LCS          = 0x1 (DM)
```

Available options:

```
Select an option (Enter to return): 5
Version      = 0xB000
ALIF_PN      = 0x0
HBK0         = 0x0
HBK1         = 0x0
HBK_FW       = 0x0
Wounding     = 0x0
DCU          = 0x0
MfgData      = 0x10459026897
  + x-loc    151
  + y-loc    104
  + Wafer ID 2
  + lot ID   UASY04001
SerialN      = 0x0
LCS          = 0x0 (CM)
```

Get OTP data

Returns OTP data based on a provided OTP word offset

```
Select an option (Enter to return): 6
Enter word addr(hex): 51
0x0051 0x0

Available options:
```

In this example, we are extracting the ALIF Manufacturing data location (Word offset 0x51)

Not all OTP locations are visible, in this case you will see:

```
Select an option (Enter to return): 6
Enter word addr(hex): 0
RX<-- length= 4 command= COMMAND_NAK          checksum= 0x10 error= ISP_ERROR_ILLEGAL_ADDRESS
[ERROR] 0x0000 ISP_ERROR_ILLEGAL_ADDRESS

Available options:
```

An error message is reported that you have supplied an ILLEGAL address offset.

Allowable OTP offsets

Offset	Contents
0x10 – 0x18	ICV Flags
0x21 – 0x2B	OEM Flags
0x34 – 0x7C	Everything else

Get MRAM data

Returns four words of MRAM data based on a provided MRAM word offset. The display shows the word offset entered followed by four words of data.

```
Select an option (Enter to return): 7
Enter hex word offset: 0
0x0 0x0 0x0 0x0 0x0
```

Get log data

Returns the last SE-UART data sent:

```
.....
| Name | CPU | Store Addr | Obj Addr | Dest Addr | Boot Addr | Size | Version | Flags | Time (ms)|
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| DEVICE | CM0+ | 0x805C1EE0 | 0x805C14E0 | ----- | ----- | 672 | 0.5.0 | u V | 0.00 |
| SERAM0 | CM0+ | ----- | 0x000000E0 | ----- | ----- | 89024 | 1.0.0 | ----- | 0.00 |
| SERAM1 | CM0+ | ----- | 0x00020AE0 | ----- | ----- | 89024 | 1.0.0 | ----- | 0.00 |
| HE_DBG | M55-HE | 0x805C2B80 | 0x805C2180 | 0x60000000 | 0x60000000 | 2256 | 1.0.0 | uLVB | 0.00 |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
Legend: (u)(C)ompressed, (L)oaded, (V)erified, (s)kipped verification, (B)ooted, (E)ncrypted, (D)eferred

[SES] os Kernel V10.4.2
[SES] Main Task - looping forever...
```

Get trace data

Trace data are Markers left in SEROM memory space as SEROM and SES are executed. There are separate buffers used for SEROM and SES.

NOTE: If you are in RECOVERY Mode (SEROM only mode) you can only see the SEROM Trace data.

SEROM Trace Data

```
Select an option (Enter to return): 9
*** SERAM Trace Buffer decode ***
*** Trace Header ***
[00000256] 1a1a23
[00000260] eeeeeeee
Trace total = 26
*****
```

Address	Seq#	LR	Trace Marker	Marker Data
[00000000]	1	0x022F	Begin Reset_Handler	
[00000004]	2	0x023B	Turn On System Power	0x0000003F
[0000000c]	3	0x2D31	SE Firewall configuration	
[00000010]	4	0x2D3F	HOST Firewall configuration	
[00000014]	5	0x4B5D	Firewall controller ready	
[00000018]	6	0x024D	Firewall initialized	
[0000001c]	7	0x0257	Begin CGU clock configuration	
[00000020]	8	0x0265	CGU clock configuration complete	
[00000024]	9	0x0E55	SOC reset was triggered	0x00000002
[0000002c]	10	0x0E61	SOC reset was triggered	0x00000000
[00000034]	11	0x0EED	SOC reset was triggered	
[00000038]	12	0x4D05	Begin Main	
[0000003c]	13	0x2CA5	Begin CC312 initializations	
[00000040]	14	0x2CD9	LCS = 0 -> CM	
[00000044]	15	0x0A95	Find STOC in MRAM	
[00000048]	16	0x0C73	Bank A is newer	
[0000004c]	17	0x1131	Locate certificate chain	
[00000050]	18	0x1183	Verify certificate chain	
[00000054]	19	0x1081	Begin certificate chain verification	0x00000003
[0000005c]	20	0x1093	Verify each certificate	0x901CC8E0
[00000064]	21	0x1093	Verify each certificate	0x901CCC28
[0000006c]	22	0x1093	Verify each certificate	0x901CCF70
[00000074]	23	0x10FB	End certificate chain verification	
[00000078]	24	0x4B41	Load MSP Address	0x3001FE00
[00000080]	25	0x4B23	Load JUMP Address	0x30006CC5
[00000088]	26	0x0E2D	Jump to SERAM	

SERAM Trace Data

```
Select an option (Enter to return): 10
*** SERAM Trace Buffer decode ***
*** Trace Header ***
[00000504] 1e1e39
[00000508] eeeeeeee
trace_total = 30
*****
```

Address	Seq#	LR	Trace Marker	Marker Data
[00000004]	1	0x4323	Firewall Static BEGIN	T: 610
[0000000c]	2	0x43D5	Firewall Static END	T: 15740
[00000010]	3	0x43DF	Firewall initialized	
[00000014]	4	0x0B59	Begin DCU configuration	0xFFFFFFFF
[0000001c]	5	0x0B89	Finish DCU configuration	0xFFFFFFFF
[00000028]	6	0x5537	Maintenance Detection BEGIN	T: 89365
[00000030]	7	0x5571	Maintenance Detection END	T: 90651
[00000034]	8	0xC1B9	Cold boot	
[00000038]	9	0x2761	Begin installing analog trim values	
[0000003c]	10	0x2779	Trim OTP word 0x55	0x00000000
[00000044]	11	0x2793	No trim values specified	0x00000000
[00000050]	12	0xC45B	CC Lib BEGIN	T: 547276
[00000058]	13	0xC487	CC Lib END	T: 548414
[00000060]	14	0xC1F5	ATOC MISC BEGIN	T: 549524
[00000068]	15	0xC205	ATOC MISC END	T: 2039238
[00000070]	16	0xC22F	STOC DEVICE BEGIN	T: 2045424
[00000078]	17	0xC23F	STOC DEVICE END	T: 3958841
[00000080]	18	0xC749	PLL BEGIN	T: 3965555
[00000088]	19	0xC77F	PLL END	T: 4333495
[00000090]	20	0xC4C5	M55 HE TCM Init BEGIN	T: 4417538
[00000098]	21	0xC4E5	M55 HE TCM Init END	T:10710288
[000000a0]	22	0xC2C7	STOC Process BEGIN	T:12171556
[000000a8]	23	0xC2FF	ATOC Process BEGIN	T:12202666
[000000b0]	24	0x35FB	M55_HE released	T:13728081
[000000b8]	25	0xC339	TOC Process END	T:13733518
[000000c0]	26	0xC397	TOC Print BEGIN	T:13735376
[000000c8]	27	0xC3D7	TOC Print END	T:37374906
[000000d0]	28	0xC4F1	BANK Maintenance BEGIN	T:37982495
[000000d8]	29	0xC503	BANK Maintenance END	T:38543876
[000000e0]	30	0xC7BD	SERAM boot complete	T:38544876

Get Power data

This option returns the Power state of the SoC:

```
Select an option (Enter to return): 11
es0_ppu_status      0x00000000      OFF
es1_ppu_status      0x00000008      ON
se_ppu_status        0x00000008      ON
fw_ppu_status        0x00000007      FUNC_RET
systop_ppu_status    0x00000008      ON
dbgtop_ppu_status    0x00000008      ON
clustop_ppu_status    0x00000000      OFF
a32_0_ppu_status     0x00000000      OFF
a32_1_ppu_status     0x00000000      OFF
modem_ppu_status     0x00000000      OFF
modem_aon_status     0x00000000      OFF
sse700_aon_status    0x00000001      ON
```

Get Clock data

This option returns the Clock and PLL state of the SoC:

```
12 - Get clock data

Select an option (Enter to return): 12
Clock Status
  HFXTAL STARTED
  PLL LOCKED
  SE CLOCK: PLL
CLK freq A32 800Mhz
CLK freq ES0 400Mhz
CLK freq ES1 160Mhz
SE frequency 100.03MHz

Registers:
HOSTCPUCLK_CTRL : 0x00000004
HOSTCPUCLK_DIV0 : 0x001F0000
HOSTCPUCLK_DIV1 : 0x001F0000
ACLK_CTRL       : 0x00000202
ACLK_DIV0       : 0x00000000
OSC_CTRL        : 0x00110011
PLL_LOCK_CTRL   : 0x00000001
PLL_CLK_SEL     : 0x00110111
ESCLK_SEL       : 0x00000033
CLK_ENA         : 0x11033111
SYSTOP_CLK_DIV  : 0x00000102
MISC_REG1       : 0x000002A4
XO_REG1         : 0x11D08439
  xtal_cap:8 gm_pfet:16 gm_nfet:16
PD4_CLK_SEL     : 0x00000000
PD4_CLK_PLL     : 0x00000000
MISC_CTRL       : 0x00001001
DCDC_REG1       : 0x614DE693
DCDC_REG2       : 0x8F014441
VBAT_ANA_REG1   : 0x06479E80
  osc_rc_32k_freq_cont:0 xtal32k_en:1 xtal32k_gm_cont:15 xtal32k_cap_cont:8 bor_en:1 bor_hyst:1 bor_thresh:0
VBAT_ANA_REG2   : 0x00C06B6
  pmubg_vref_cont:11 osc_76Mrc_cont_bit0:1 osc_76M_div_cont_fast:0 osc_76Mrc_cont:16 osc_76M_div_cont_slow:1
```

MRAM

Top level menu group

```
Select an option (Enter to exit): 3

Available options:

1 - Erase Application Mram
2 - Fast Erase Application Mram
3 - Fast Erase App. Mram (include NTOC)
4 - Get MRAM info

Select an option (Enter to return):
```

NOTE: If you are in Recovery (ROM) mode, these commands will not operate as SEROM does not support these MRAM erase commands.

Erase Application MRAM

```
Available options:

1 - Get TOC info
2 - Get SES Banner
3 - Get CPU boot info
4 - Device enquiry
5 - Get revision info

Select an option (Enter to return): 1
```

Name	CPU	Store Addr	Obj Addr	Dest Addr	Boot Addr	Size	Version	Flags	Time (ms)
DEVICE	CM0+	0x805C1EE0	0x805C14E0	-----	-----	672	0.5.0	u V	9.38
SERAM0	CM0+	-----	0x000000E0	-----	-----	66752	1.0.0	-----	0.00
SERAM1	CM0+	-----	0x00020AE0	-----	-----	66752	1.0.0	-----	0.00
HE_DBG	M55-HE	-----	0x805C2180	-----	-----	2256	1.0.0	uLs	0.00
BLINK-HE	M55-HE	0x8057EC90	0x8057E290	0x60000000	0x60000000	4912	1.0.0	uLVB	9.46

Legend: (u)(C)ompressed, (L)oaded, (V)erified, (s)kipped verification, (B)ooted, (E)ncrypted, (D)eferred

This option will erase the Application MRAM. It is the equivalent of using the '-e app' option of app-write-mram.

In this example, we see that we have one Application (BLINK-HE) running from Application MRAM.

We will now erase this. Choose the Erase Application MRAM. This will instruct SES to erase the Application MRAM. The size of the MRAM to erase is known as you selected the device type using the tools-config.

```
Available options:

1 - Erase Application Mram
2 - Fast Erase Application Mram
3 - Get MRAM info

Select an option (Enter to return): 1
[INFO] erasing 0x80000000 5,767,168 bytes
[INFO] Full Erase done

Available options:

1 - Erase Application Mram
2 - Fast Erase Application Mram
3 - Get MRAM info

Select an option (Enter to return):
```

If we inspect the TOC information, we can see that the BLINK-HE application has been removed from MRAM.

```
Available options:
1 - Get TOC info
2 - Get SES Banner
3 - Get CPU boot info
4 - Device enquiry
5 - Get revision info

Select an option (Enter to return): 1
```

Name	CPU	Store Addr	Obj Addr	Dest Addr	Boot Addr	Size	Version	Flags	Time (ms)
DEVICE	CM0+	0x805C1EE0	0x805C14E0	-----	-----	672	0.5.0	u V	9.39
SERAM0	CM0+	-----	0x000000E0	-----	-----	66752	1.0.0	-----	0.00
SERAM1	CM0+	-----	0x00020AE0	-----	-----	66752	1.0.0	-----	0.00
HE_DBG	M55-HE	0x805C2B80	0x805C2180	0x60000000	0x60000000	2256	1.0.0	uLVB	0.00

Legend: (u)(C)ompressed, (L)oaded, (V)erified, (s)kipped verification, (B)ooted, (E)ncrypted, (D)eferred

Fast Erase Application MRAM

This option will invalidate the Application TOC without erasing the Application MRAM. While the effect will be the same as the Erase Application MRAM option, this option does not *clear* the Application MRAM area.

Fast Erase Application MRAM (including NTOC)

This option will invalidate the Application TOC and erase the first 16 bytes of Application MRAM.

NTOC is the method by which the M55_HE from MRAM address 0x80000000.

This option is needed when the user wants to invalidate a binary previously burnt in MRAM address 0x80000000.

Get MRAM info (MRAM Walker)

This walks the entire MRAM memory looking for Table of Contents objects:

```
Available options:
1 - Erase Application Mram
2 - Fast Erase Application Mram
3 - Get MRAM info

Select an option (Enter to return): 3
ATOC 0x8057ffc0
+ header      OEMTOC01
+ header_size 16
+ # toc entries 1
+ entry_size  32
+ version     0x1
STOC 0x80580000
+ header      ALIFTOC1
+ header_size 48
+ # toc entries 4
+ entry_size  32
+ version     0x1
ATOC 0x8058eca0
ATOC 0x805af6a0
```

In this example (For REV_A), two System TOC objects were found.

The first is the initial boot object, note that the # of toc entries = 0.

Utilities

Top level menu group

```
Select an option (Enter to exit): 4
Available options:
1 - Terminal mode
2 - Get SERAM metrics
3 - Get ECC key
4 - Get Firewall configuration
Select an option (Enter to return):
```

Terminal Mode

This option echoes the SE-UART output.

```
Select an option (Enter to return): 1
[TERMINAL] Ctrl-C to exit
|

SEROM v0.47.68 0x0000B200

SES B0 v1.0.90 Feb  8 2024 00:38:18
[SES] ATOC MISC ok
[SES] System partition address 0x80580000
[SES] STOC DEVICE ok
[SES] ATOC DEVICE ok
[SES] STOC ok
[SES] ATOC ok
[SES] LCS=1
[SES] FC:Rgn
0:2 1:5 1:6 1:7 1:8 3:1 3:2 3:3 3:4 3:5 3:6
3:7
3:8 3:9 3:10 3:11 3:12 3:13 3:14 3:15 3:16 3:17 3:18 3:19 3:20 3:24 3:25 3:26 3:27 3:28 3:29 3:32 3:33 3:39
4:0 4:1 5:0 5:1

+-----+
| Name | CPU | Store Addr | Obj Addr | Dest Addr | Boot Addr | Size | Version | Flags | Time (ms)|
+-----+
| DEVICE | CM0+ | 0x8057CE20 | 0x8057C420 | ----- | ----- | 376 | 0.5.0 | u V | 14.50 |
| DEVICE | CM0+ | 0x805C1EE0 | 0x805C14E0 | ----- | ----- | 344 | 0.5.0 | u V | 14.65 |
| * SERAM0 | CM0+ | ----- | 0x000000E0 | ----- | ----- | 97240 | 1.0.0 | ----- | 0.00 |
| SERAM1 | CM0+ | ----- | 0x00020AE0 | ----- | ----- | 97240 | 1.0.0 | ----- | 0.00 |
| HE_DBG | M55-HE | ----- | 0x805C2040 | ----- | ----- | 2256 | 1.0.0 | uLs | 0.00 |
| BLINK-HE | M55-HE | 0x8057D9A0 | 0x8057CFA0 | 0x58000000 | 0x58000000 | 9708 | 1.0.0 | uLVB | 15.71 |
+-----+
Legend: (u)(C)ompressed, (L)oaded, (V)erified, (s)kipped verification, (B)ooted, (E)ncrypted, (D)eferred

[SES] SE frequency is 100.02 MHz
[SES] os Kernel V10.4.2 (Tickless)
[SES] Main Task - looping forever...
```

In this example, [RESET] was pressed on the board and we see the complete boot up information echoed.

To exit this mode press CTRL-C and it will drop back to the maintenance menu.

SES Metrics

```
Available options:

1 - Terminal mode
2 - Get SERAM metrics

Select an option (Enter to return): 2

+-----+
| TaskName | Size | Used |
+-----+
| SERAM_main_task | 1024 | 300 |
| SERAM_uart_task | 3072 | 720 |
+-----+
SES uptime 0:00:04:20
```

Returns (for now) stack information details used by SES as well as the uptime since SES booted. The uptime format is Days:Hours:Minutes:Seconds

Get address/Set address

These diagnostic commands are not supported.

Get ECC key

This option returns the public ECC key of the device. If the ECC key is not provisioned yet, all 0's is returned.

```
Available options:
1 - Terminal mode
2 - Get SERAM metrics
3 - Get ECC key
4 - Get Firewall configuration

Select an option (Enter to return): 3
ECC key (HEX): 26E6434B17CE4227585BE3068A05322196005A5349E2D1A7A9D9AE8185DDE76DC5C20DB614A64227AB218D514E76F248EEFD4B46C4AF87602C123A0BFF56E5AF
```

Get Firewall configuration

This option returns the current Firewall configuration status, i.e., what regions have been configured in which Firewall Components ('FC: x').

```
FC: 3 region: 2
FC: 3 region: 3
FC: 3 region: 4
FC: 3 region: 5
FC: 3 region: 6
FC: 3 region: 7
FC: 3 region: 8
FC: 3 region: 9
FC: 3 region: 10
FC: 3 region: 11
FC: 3 region: 12
FC: 3 region: 13
FC: 3 region: 14
FC: 3 region: 15
FC: 3 region: 16
FC: 3 region: 17
FC: 3 region: 18
FC: 3 region: 19
FC: 3 region: 20
FC: 3 region: 24
FC: 3 region: 25
FC: 3 region: 26
FC: 3 region: 27
FC: 3 region: 28
FC: 3 region: 29
FC: 3 region: 32
FC: 3 region: 33
FC: 3 region: 39
FC: 4 region: 0
FC: 4 region: 1
FC: 5 region: 0
FC: 5 region: 1
```

Setting capabilities

Top level menu group

```
Available options:
1 - Enable LOGGING
2 - Disable LOGGING
3 - Enable PRINTING
4 - Disable PRINTING
```

Enable / Disable LOGGING

Controls whether the SES messages are added to the log buffer. The log buffer can be read using the 'Device Information' option.

Enable / Disable PRINTING

Toggle PRINTING – controls whether the SERAM messages are printed directly to the SE UART or put in a buffer from where they are periodically printed out.

ROM

Devices support a limited subset of ISP commands built into the ROM.

If the NVM contains no viable SES image to load, SEROM will enter an ISP mode to allow recovery.

Recovery mode will take an SES image and write it to the NVM using a specific ISP protocol supported by SEROM, it is not the same as used for wiring the Application MRAM.

Top level menu group

```
Available options:
1 - Recovery

Select an option (Enter to return):

Available options:
1 - Device Control
2 - Device Information
3 - MRAM
4 - Utilities
5 - Setting capabilities
6 - ROM

Select an option (Enter to exit):
```

Recovery Session

```
Available options:
1 - Recovery

Select an option (Enter to return): 1
Bootloader stage: SEROM
Device Revision: B0
[INFO] System TOC Recovery with parameters:
- Device Part# E7 (AE722F80F55D5AE) - 5.5 MRAM / 13.5 SRAM - Rev: B0
- MRAM Base Address: 0x80580000
alif\SystemPackage-rev-b0.bin [#####]100%: 275280/275280 bytes
[INFO] recovery time 275.0056 seconds
alif\offset-rev-b0.bin [#####]100%: 16/16 bytes
[INFO] recovery time 0.0114 seconds
[INFO] Target reset

Available options:
```

The device is in recovery mode and has loaded the SES image via SEROM into MRAM.

Target not in recovery mode

```
Available options:
1 - Device Control
2 - Device Information
3 - MRAM
4 - Utilities
5 - Setting capabilities
6 - ROM

Select an option (Enter to exit): 6
Available options:
1 - Recovery

Select an option (Enter to return): 1
Bootloader stage: SERAM
[ERROR] Device not in Recovery mode, use systemUpdatePackage Tool
```

This message is shown if the target device is not in recovery mode probably because it is running SES already.

Target device mismatch

```
Available options:
1 - Device Control
2 - Device Information
3 - MRAM
4 - Utilities
5 - Setting capabilities
6 - ROM

Select an option (Enter to exit): 6
Available options:
1 - Recovery

Select an option (Enter to return): 1
[ERROR] Target device B0 mismatch with configured device A1

Available options:
1 - Recovery

Select an option (Enter to return):
```

This message shows that the target Device is different from the one selected by tools-config for this session.

Recovery UART Speed

When in RECOVERY mode the device is running ISP from the ROM which runs at RC frequency, so you will notice it is slower than when SES is performing MRAM updates.

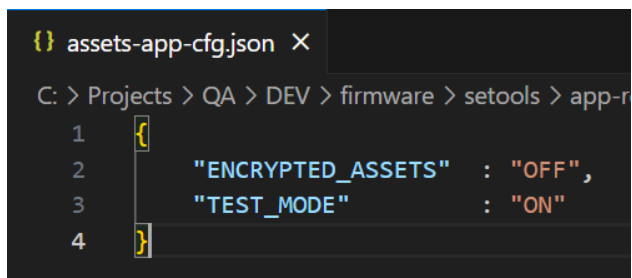
- There is no PLL support inside the ROM code so the baud rate cannot be increased like it is when SES is doing updates (Using app-mram-write, updateSystemPackage).
- ISP protocol used in the ROM is MRAM line based i.e. 128bits at a time with no buffering.

app-assets-gen

The app-assets-gen tool generates the “assets package” required to provision the device with the app-provision tool (see next section).

This file is loaded by the app-provision tool and contains assets and options for the provisioning. Provisioning means keys and other values to be programmed (OTP) into the device.

The options can be configured with a JSON file. Default configuration file is `build\config\assets-app-cfg.json`



```
{
  "ENCRYPTED_ASSETS" : "OFF",
  "TEST_MODE" : "ON"
}
```

Options description:

- **ENCRYPTED_ASSETS:**
 - Defines if the assets are encrypted or not. Unencrypted assets should only be used in trusted environments.
 - NOTE: Encrypted assets are not supported yet.
- **TEST_MODE:**
 - This option DOES NOT burn the OTP area, so the program can run multiple times without advancing the LCS to SE.
 - This is provided to test the process without affecting the device.

Once the desired configuration is done, the assets package can be generated using the tool:

```
$ app-assets-gen (-h for help)
```

```
C:\SET00LS>app-assets-gen.exe
Generating APP assets with:
- Device Part# E7 (AE722F80F55D5LS) - 5.5 MRAM / 13.5 SRAM - Rev: B2
- Configuration file: build/config/assets-app-cfg.json
- Output file: build/assets-app-cfg.bin

Creating Assets Package...
Checking Assets Package...
Package integrity Ok!
AssetID: APPASSET
Asset Version: 1

Provisioning Options:
ENCRYPTED_ASSETS      OFF
TEST_MODE            ON

Done!
```

The command generates the assets package and checks the generated binary to extract the Options selected (it reads back the options from the binary, not from the json file).

Also, using the `-c` flag, the tool will skip the assets package generation and it just checks the options used to generate it.

\$ app-assets-gen -c

```
C:\SET00LS>app-assets-gen.exe -c
Generating APP assets with:
- Device Part# E7 (AE722F80F55D5LS) - 5.5 MRAM / 13.5 SRAM - Rev: B2
- Output file: build/assets-app-cfg.bin

Checking Assets Package...
Package integrity Ok!
AssetID: APPASSET
Asset Version: 1

Provisioning Options:
ENCRYPTED_ASSETS      OFF
TEST_MODE            ON

Done!
```

Using the `-f` option, we can specify an input file (.json format if assets package is being generated, or .bin file if only checking the options used to generate the binary).

Example:

```
$ app-assets-gen -f build\config\assets-cfg.json
$ app-assets-gen -c -f build\assets-cfg.bin
```

The output file is always created in the build\ folder and the name will be the same as the configuration file.

app-provision

The app-provision tool will inject user assets (keys and secrets) into the device and move the device from DM (Device Manufacturing) to SE (Secure Enable) LCS (Life-Cycle State).

The SE LCS is used for devices from the manufacturing line and “in the field”. It permits the execution of security functions but blocks all debugging and testing capabilities.

Using Secure Boot is mandatory in this SE LCS.

```
$ app-provision (-h for help)
```

```
C:\SETTOOLS>app-provision.exe
APP Provision with parameters:
Device Part# E7 (AE722F80F55D5LS) - 5.5 MRAM / 13.5 SRAM - Rev: B2
Assets file: build/assets-app-cfg.bin

[INFO] COM12 open Serial port success
[INFO] Running APP Provisioning code...
←[94m APP Provision ran in TEST MODE!
←[0m
[INFO] Done
```

The default assets file is build\assets-app-cfg.bin. Use the -a option to specify other assets file.

To perform a real provision, configure TEST_MODE OFF in the assets configuration file, and re-build the assets using the app-assets-gen tool;

```
C:\SETTOOLS>app-assets-gen.exe
Generating APP assets with:
- Device Part# E7 (AE722F80F55D5LS) - 5.5 MRAM / 13.5 SRAM - Rev: B2
- Configuration file: build/config/assets-app-cfg.json
- Output file: build/assets-app-cfg.bin

Creating Assets Package...
Checking Assets Package...
Package integrity Ok!
AssetID: APPASSET
Asset Version: 1

Provisioning Options:
ENCRYPTED_ASSETS      OFF
TEST_MODE            OFF

Done!
```

Running the app-provision tool with this new assets binary, it will provision the device;

```
C:\SETTOOLS>app-provision.exe
APP Provision with parameters:
Device Part# E7 (AE722F80F55D5LS) - 5.5 MRAM / 13.5 SRAM - Rev: B2
Assets file: build/assets-app-cfg.bin

[INFO] COM12 open Serial port success
[INFO] Running APP Provisioning code...
←[94m APP Provision Return Code: 0x0
←[0m
[INFO] Done
```

Once this script finishes, the device will advance from DM to SE (Secure Enable) LCS, after reset.

```
C:\Windows\System32\cmd.exe - maintenance.exe
Select an option (Enter to return): 1
[TERMINAL] Ctrl-C to exit

SEROM v0.47.68 0x0000B200

[SES] Cold boot path
*** Host Firewall configured

[SES] MRAM error bypass is Enabled

SES B0 EVALUATION_BOARD v1.0.87 Dec 8 2023 23:59:45
[SES] Device ID = 0x0000B200
[SES] PLL code version 0.0.4
[SES] LCS=5
[SES] System partition address 0x80580000
[DEV] Wounding Data: 0x00C0FFFB
[SES] System device configuration processed (0x00000000) BL_STATUS_OK
[SES] Application device configuration processed (0x00000001) BL_ERROR_APP_INVALID_TOC_ADDRESS
[SES] System partition processed (0x00000000) BL_STATUS_OK
[SES] Application partition processed (0x00000001) BL_ERROR_APP_INVALID_TOC_ADDRESS
```

app-secure-debug (--rma)

A device in SE LCS (Secure State) blocks all debugging and testing capabilities. The Secure Debug tool gives the user a mechanism to:

- Open the debug port in case a debugging session is needed, in a device in SE LCS. Using a secure debug certificate, the user can debug an application.
- Transition a device to RMA LCS (end of product cycle), before sending the device to Alif for failure analysis or further inspection.

To generate a secure debug certificate, run:

```
$ app-secure-debug (-h for help)
```

```
C:\Windows\System32\cmd.exe

C:\Projects\QA\DEV\app-release>python3 app-secure-debug.py
Secure Debug with parameters:
Device Part# E7 (AE722F80F55D5LS) - 5.5 MRAM / 13.5 SRAM - Rev: B2
[INFO] COM12 open Serial port success
[INFO] Alif secure debug
Creating Signature...
Binary File: ../build/alif_secure_debug.bin
2024-03-04 11:43:55,787 - Content Certificate Generation Utility started (Logging to ../build/logs/SBContent.log)
Content Certificate File: build/alif_secure_debug.bin.crt
Signature File: build/alif_secure_debug.bin.sign
Verify Certificate
Signature File: build/alif_secure_debug.bin.sign

C:\Projects\QA\DEV\app-release>
```

At this point, a jtag adapter can connect to an application core and a debug session can be done. Since the certificate is only valid for each debug session, after reset of power-cycle, a new certificate should be generated.

To move the device to RMA LCS, run:

```
$ app-secure-debug --rma
```

```
C:\Windows\System32\cmd.exe

C:\Projects\QA\DEV\app-release>python3 app-secure-debug.py --rma
Secure Debug with parameters:
Device Part# E7 (AE722F80F55D5LS) - 5.5 MRAM / 13.5 SRAM - Rev: B2
[INFO] COM12 open Serial port success
[INFO] Alif secure debug
Creating Signature...
Binary File: ../build/alif_secure_debug.bin
2024-03-04 11:48:57,040 - Content Certificate Generation Utility started (Logging to ../build/logs/SBContent.log)
Content Certificate File: build/alif_secure_debug.bin.crt
Signature File: build/alif_secure_debug.bin.sign
Verify Certificate
Signature File: build/alif_secure_debug.bin.sign

C:\Projects\QA\DEV\app-release>
```

After this command, the device is in RMA LCS.

Tool Exit codes

The tools will return the following runtime execution Error codes.

- 0 Indicates success.
- 1 Indicates a failure.

NACK Error Handling

The ISP protocol uses an Acknowledge (ACK) / Not Acknowledge (NACK) protocol scheme. If NACK is seen this is followed by an Error code.

If a NACK packet is seen it will always be printed and the tool will EXIT.

```
$ python3 updateSystemPackage.py -m isp -x
Burning: System Package in MRAM
Device Part# AE722F80957D2CH - Rev: A0
- MRAM Base Address: 0xa0580000

alif\header.bin          [#####]100%: 48/48 bytes
alif\SystemPackage.bin   [#####]100%: 281280/281152 bytes
RX<-- length= 4 command= COMMAND_NAK      checksum= 0x6 error= ISP_BAD_DEST_ADDRESS
```

TIMEOUT Error Handling

An ISP session requires an initial ISP START command sent to the Target to put it into ISP mode. If this command fails, then the ISP session will not occur, and an Error is reported that the Target did not respond

```
Available options:

1 - maintenance mode
2 - device reset
3 - device enquiry
4 - get revision info
5 - get TOC info

Select an option: 4
[ERROR] Target did not respond
```

This Error will exit the program.

Possible causes for this Error:

- Incorrect baud rate setting
- Target is not powered or is in a low power state such as STOP mode.

7. CONDUCTOR Tool Flow

The ALIF CONDUCTOR tool is a web-based application that allows a user to configure a Device. Please refer to the CONDUCTOR documentation for more details. This section will focus on the CONDUCTOR material generated for STATIC configuration and how to get this configuration data built using SETOOLS.

CONDUCTOR can be used to generate configurations for

- Static Pin Mux
- Static Clocks
- Static Application space Firewall

The output of the CONDUCTOR tool is a JSON file that can be included into an application as a DEVICE Config object. This object is executed by SES on boot up of the device, so by the time the Application CPUs are booted settings for PinMux, Clock and Firewall are already set.

This method is known as STATIC configuration. As the configuration is stored in Application MRAM space (as part of the ATOC) it will remain there until deleted or overwritten.

Configuration Options

There are three main methods of configuring the device for PinMux, Clock and Firewall:

- STATIC
- DYNAMIC
- Wild-West

STATIC configuration

Configuration data is part of the ATOC (DEVICE Configuration object) and will be installed on each boot of the device before the Application cores are booted.

DYNAMIC configuration

Configuration is done using SERVICE library calls from an application core once booted. This means the initializations are done at run-time or dynamically. These settings can also be changed by subsequent SERVICE library calls.

Wild-West configuration

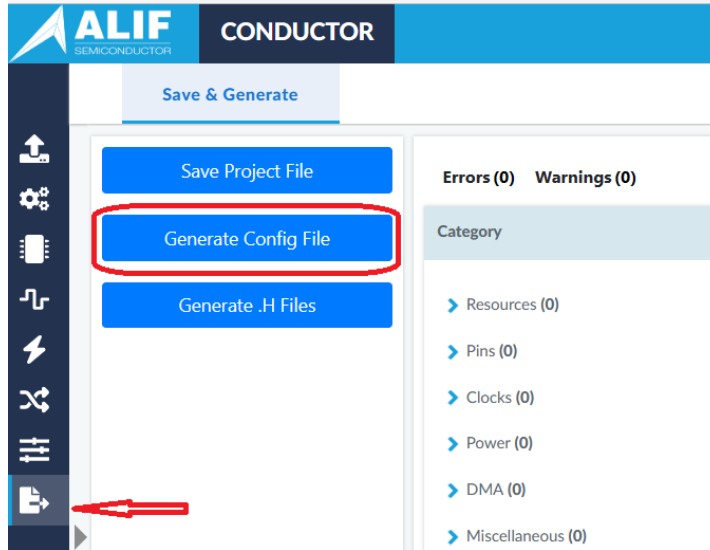
In this mode the application core will be setting the registers directly. There is no protection against multiple CPUs over writing each other's settings.

Using the CONDUCTOR Tool with SETOOLS

The Conductor tool generates two types of output – Device Configuration and C header files. SERAM uses the Device Configuration output. It is a JSON file that needs to be copied to the APP release folder (under build\config) and then referenced by the DEVICE entry in the ATOC config file.

Steps –

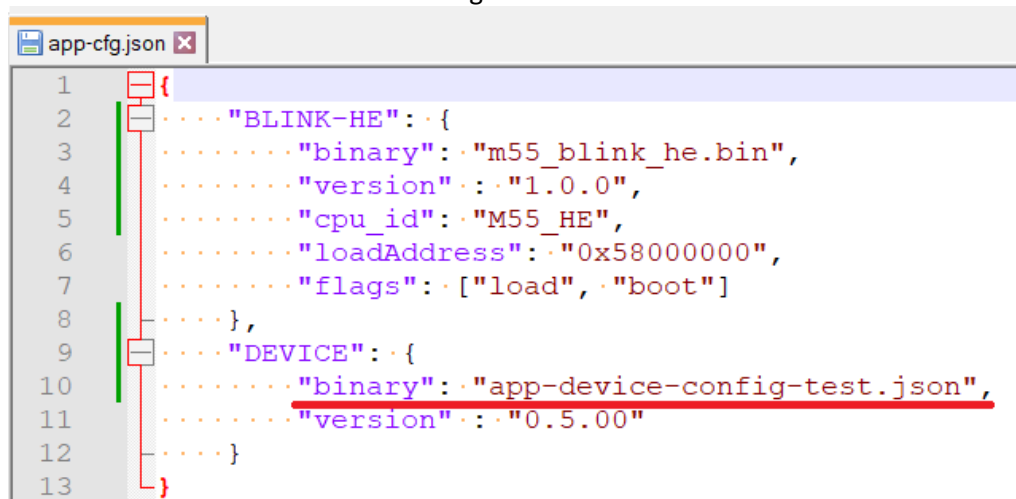
1. Generate a Device Configuration File from the Conductor tool -



The default output file name is something like
'Config__AE722F80F55D5AS_20230705_0910.json'.

You can rename the file at this point or do that later.

2. Copy the file to the <APP release folder>\build\config.
The Conductor tool saves the generated file in the browser's default Downloads folder, so copy it from there to your APP release.
3. Optionally, rename the file, e.g., to 'app-device-config-test.json'.
4. Reference the file from the ATOC config file –



8. Document History

Version	Date	Change Log
0.84.0	October 2023	Web release for Security Toolkit v0.84.0 tools
0.85.0	November 2023	Initial support for MAC OS in SETOOLS
0.87.0	December 2023	Adding assets-gen and app-provision tool details