USER'S GUIDE

Apollo5 Family OEM Provisioning Tools

Ultra-Low Power Apollo SoC Family

A-SOCAP5-UGGA03EN v1.0

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Revision History

Revision	Date	Description
1.0	May 2025	Initial Release.

Reference Documents

Document ID	Description
A-SOCAP5-UGGA04EN	Apollo5 Security User's Guide
A-SOCAP5-UGGA02EN	Apollo5 Family Secure Update User's Guide
A-SOCAP5-UGGA01EN	Apollo5 Family MRAM Recovery User's Guide

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1

Introduction

This document provides an overview of the OEM provisioning process, initial configuration, and run time updates for the Apollo5 Family SoC and the details of the tools required to accomplish these tasks. References to Apollo5 refers all members of the Apollo5 Family, unless explicitly stated otherwise.

> **NOTE:** Unless specifically noted, all the tools mentioned below are included in the AmbiqSuite SDK release under directory **/tools/apollo510_scripts**. As other Apollo5xx devices are released they will have their own dedicated **/tools/apollo5xx_scripts** directory.

1.1 System Requirements

The provisioning tools and associated scripts are cross platform and can run on any platform that supports:

- OpenSSL – 3.0 or higher
- Python – 3.8.10 or later
  - pyserial 3.5 (required for **uart_wired_update.py** and **uart_recovery_host.py** scripts)
  - cryptography 44.0.0 (required for encrypted or signed image formats)

The following python libraries are needed only when running the remote signing server example:

- Flask - (verify that urllib3 is >2.0, required by Open SSL)

1.2 Terminology

This section defines some of the terminologies used in this document.

Table 1-1: Terminology

Abbreviation	Definition
ICV	Integrated Circuit Vendor
DM LCS	Device Manufacturer Life Cycle State
OEM	Original Equipment Manufacturer
RoT	Root of Trust
RMA	Returned Merchandise Authorization

SECTION

2

Keys

The Apollo5 Security infrastructure relies on asymmetric and symmetric keys for a variety of purposes, ranging from creating a Root of Trust, to using asymmetric keys for authentication, and symmetric keys for various encryption needs.

> **NOTE:** The pathnames for scripts and config files in this chapter are listed as if the working directory is currently set to the SDK directory **/tools/apollo510_scripts**.

- **Signing Keys**

  The Apollo5 uses Asymmetric PKA for establishing authenticity of loaded images as well as update images.

  A Secureboot enabled part requires a certificate chain for successful boot. The chain itself contains three certificates, each with a Public Key, with the root certificate binding to the INFOC-OTP Root of Trust. Images/certificates are signed using the corresponding Private Keys. Key assets are maintained as Password encrypted .pem files.

  > **NOTE:** In cases where the OEM lacks direct access to private keys (e.g., when using a signing server), the AmbiqSuite SDK provides a plugin interface that allows the OEM to provide a plugin specific to their development environment that enables communication with a remote signing server for certificate signing.

- **Encryption Keys**

  The Apollo5 uses Symmetric AES-CTR encryption for code confidentiality. Symmetric key based AES-CMAC can also be used to add authentication and encryption to provisioning information during manufacturing as well.

OEMs can program their desired AES keys into INFOC-OTP during the OEM provisioning process. Specifically, OEMs program the Apollo5 two hardware keys Kcp, a Kce, and a bank of additional AES keys (known as the keybank) in the INFOC-OTP.

- **Key Generation**

  While the OEM may have their own process to generate the key assets (e.g., HSM), AmbiqSuite SDK provides simple utilities that can be used to generate them as well.

2.1 Key Gen Utility

The Key Gen Utility is used to generate all the keys required for OEM provisioning at device manufacturing. The following python utility can be used to generate the keys.

```
./oem_tools_pkg/am_oem_key_gen_util/am_oem_key_gen_util.py
```

2.1.1 Input Parameters

The inputs to the Key Gen Utility are provided through a configuration file specified as a command-line parameter. The inputs configured in the configuration file are described in the example config file itself at the following location:

```
./oem_tools_pkg/am_oem_key_gen_util/oemKeyGenConfig.cfg
```

2.1.2 Key Gen Command

The following command runs the Key Gen script:

```
./oem_tools_pkg/am_oem_key_gen_util/$
python am_oem_key_gen_util.py ./oemKeyGenConfig.cfg
```

Upon successful execution, the Key Gen Utility creates two folders containing all the required symmetric and asymmetric keys for INFOC-OTP provisioning. It also generates the asymmetric keys for the OEM certificate chain and debug/RMA certificates.

```
./oem_tools_pkg/am_oem_key_gen_util/oemAesKeys
./oem_tools_pkg/am_oem_key_gen_util/oemRsaKeys
```

The keybank keys are generated separately.

2.2 Signing Server Plugin Support

Ambiq provides tools for generating certificates with customizable signing via plugins, including examples for local and remote signing (with HSM example). Plugins follow a standardized interface for signing operations, allowing users to implement security features tailored to their needs while remaining compatible with future Ambiqsuite SDK updates.

Key Features:

1. **Plugin Framework:**
    a. Located in **cert_gen_utils/plugin/signature_interface.py**.
    b. Default plugin (**LocalInterface**) supports local signing; configurable for remote signing (e.g., via **HTTPInterface**).
    c. Plugins must implement **sign(keyIdx: str, data: bytes**) and can include custom configuration files.
2. **Configuration Files:**
    a. Includes essential fields like auth-key, signature-plugin-path, and signature-plugin-cfg.
    b. Example entries provided for quick integration.
3. **Simulated HSM Example:**
    a. Provided in **cert_gen_utils/plugin_reference/sign_server.py**.
    b. Enables remote signing via Flask-based server.
    c. Configurable through the **am_remote_keys_plugin.cfg** file.
    d. Supports signing and verification operations using RSA encryption.

This framework streamlines secure certificate generation and simplifies plugin customization for advanced use cases. For more information regarding plugin implementation, please review the README found in:

./oem_tools_pkg/cert_utils/cert_gen_utils/plugin_references/README.txt

SECTION

3

OEM Provisioning

OEM provisioning is the process of creating digital security assets in a form that is suitable for the customer's production flow. The Apollo5 provides two different flows for generating the OEM's Security Assets that are needed to move the device from DM-LCS to Secure-LCS. The first creates a plain (unencrypted) data blob, and the alternate encrypts the OEM assets using the ICV Key Request/Response from Ambiq that allows the encryption of the Security assets so that the OEMs keys and ROT cannot be compromised. This may be needed if the provisioning tools are being handled by untrusted individuals, for example when the products are being manufactured and provisioned by a third party in a factory where the provisioning assets may be handled by non-trusted individuals.

Figure 3-1 shows the general flow for the plain (unencrypted) OEM security asset generation for the Apollo5 Family.

Figure 3-1: OEM Plain (Unencrypted) Provisioning Data Blob Generation

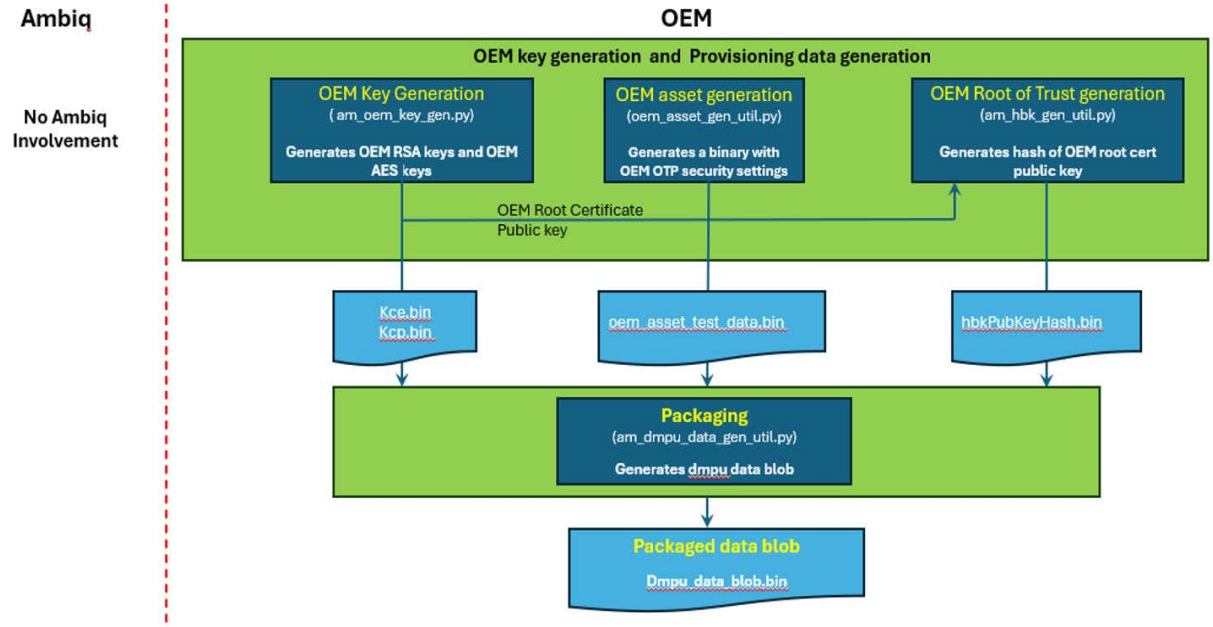
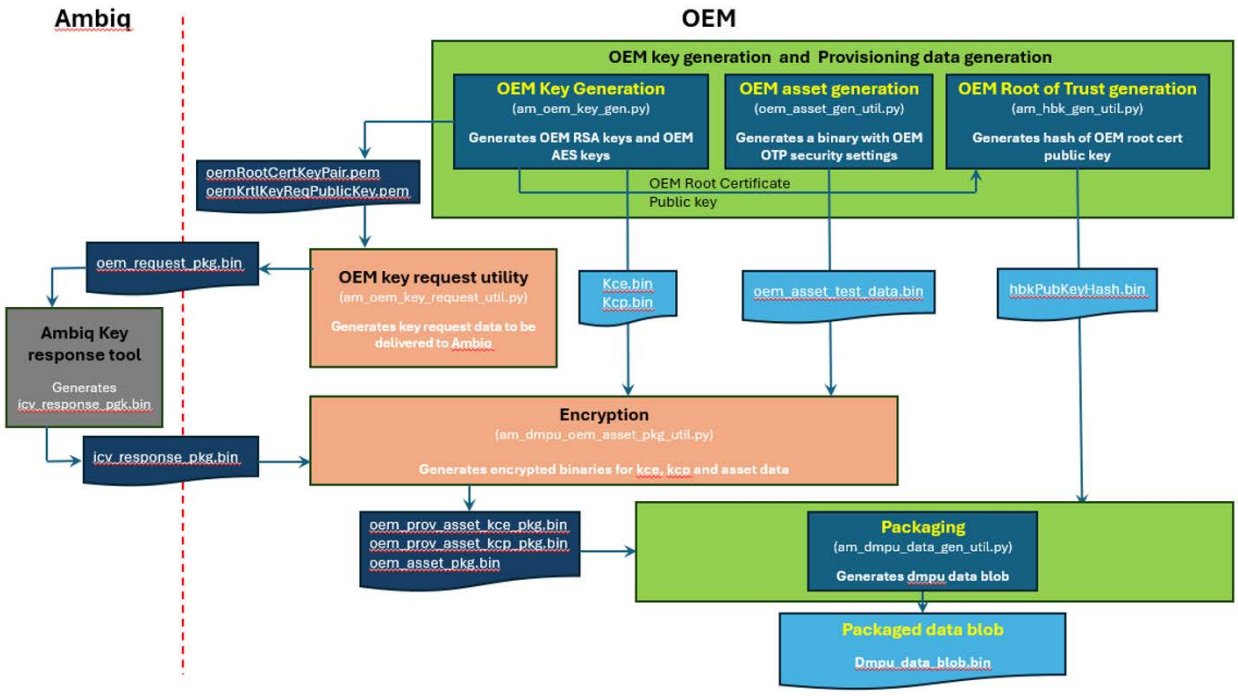


Figure 3-2 shows the flow for the generation of the Encrypted OEM security asset generation.

Figure 3-2: OEM Encrypted Provisioning Data Blob Generation



Ambiq provides the tools for each of these steps in the **/tools/Apollo510_scripts/ oem_tools_pkg** directory. The following sections in this chapter will assume this as the base directory for pathnames for the utilities described.

3.1 OEM Key Generation

The Key Gen Utility is used to generate the asymmetric keys required for OEM provisioning at the device manufacturing.

The following python utility is used to generate the keys:

```
./oem_tools_pkg/am_oem_key_gen_util/am_oem_keys_gen_util.py
```

3.1.1 Input Parameters

The inputs to the Key Gen Utility are provided in a configuration file passed as a command-line parameter. The inputs specified in the configuration file are described in the example config file located at:

```
./oem_tools_pkg/am_oem_key_gen_util/oemKeyGenConfig.cfg
```

3.1.2 Command

The following command runs the Key Gen script:

```
python am_oem_keys_gen_util.py ./oemKeyGenConfig.cfg
```

After a successful execution, the Key Gen Utility creates the following two folders containing all the required symmetric and asymmetric keys for INFOC-OTP provisioning. It also generates the asymmetric keys for OEM certificate chain and debug/RMA certificates.

```
./oem_tools_pkg/am_oem_key_gen_util/oemAesKeys
./oem_tools_pkg/am_oem_key_gen_util/oemRsaKeys
```

The keybank keys are generated separately by the OEM and input during the OEM asset generation in the next section.

3.2 OEM Asset Gen Util

The OEM Asset Gen Utility generates an OEM Security binary file used to initialize OEM INFOC-OTP security settings. These settings are specified in the file named **oem_asset_gen.cfg** which is an input to the **oem_asset_gen_util.py** script.

The tool creates a binary data file that is an input to the OEM Provisioning Data Gen Utility discussed in the *Section 3.6 OEM Provisioning Data Gen Util on page 20*.

3.2.1 Input Parameters

The OEM's INFOC-OTP security setting can be modified in the configuration file:

```
./oem_tools_pkg/oem_asset_prov_utils/oem_asset_package/am_config/
oem_asset_gen.cfg
```

The SDK contains example files for creating either "secure" (Authentication and encryption required on any update files) and "non-secure" (Authentication and encryption not required) OEM Security binary file. These **.cfg** files are contained in the same **/am_config** directory.

- **oem_asset_gen_nonsec.cfg** - config that does not require update files to be encrypted or authenticated. (non-secure)
- **oem_asset_gen_sec.cfg** - config that requires update files to be both encrypted or authenticated. (secure)

3.2.2 Command

The following command is used to run the **oem_asset_gen_util.py** to generate the encrypted OEM assets blob:

Run from: `./oem_tools_pkg/oem_asset_prov_utils/oem_asset_package/`

```
python oem_asset_gen_util.py  ./am_config/oem_asset_gen.cfg
```

The output of the tool generates the file **oem_asset_test_data.bin** in the same directory it was run from.

3.3 HBK Gen Utility

The HBK Gen Utility generates the hash of the Root-of-Trust's public key for the OEM that is programmed as HBK1 in INFOC-OTP.

```
./oem_tools_pkg/cert_utils/am_hbk_gen/am_hbk_gen_util.py
```

3.3.1 Input Parameters

The parameters to the HBK Gen Util are command-line parameters as shown below.

```
python am_hbk_gen_util.py -key <path to the OEM Root Public key> -
endian <B | L> -hash_format <SHA256 | SHA256_TRUNC >
```

3.3.2 Command

The command below will generate the truncated hash of the OEM's Root Certificate Public key.

Run from: `./oem_tools_pkg/cert_utils/am_hbk_gen`

```
python  am_hbk_gen_util.py  -key  ../../am_oem_key_gen_util/
oemRSAKeys/ oemRootCertPublicKey.pem  -endian L  -hash_format
SHA256_TRUNC
```

The output files will be generated at the following output folder:

```
./oem_tools_pkg/cert_utils/am_hbk_gen/hbk_gen_util_outPut
```

3.4 OEM Key Request Utility

> **NOTE:** This step is only needed when generating an encrypted OEM security data image. For plain (unencrypted) data this step can be skipped.

The OEM Key Request Utility is used to generate the derived Krtl-key-request-certificate to be processed at Ambiq's secure lab. The output of this utility is sent to Ambiq which contains the key request public key. This is used by Ambiq's response utility to encrypt the derived **Krtl** key which is then used for encrypting the OEM assets. The script to generate the Key request is:

```
./oem_tools_pkg/oem_asset_prov_utils/oem_key_request/
am_oem_key_request_util.py
```

3.4.1 Input Parameters

The inputs to the OEM Key Request Utility are provided through the configuration file as a command line parameter. The details of the config file parameters are described in the example config file itself.

```
./oem_tools_pkg/oem_asset_prov_utils/oem_key_request/am_config/
am_dmpu_oem_key_request.cfg
```

3.4.2 Command(s)

The following command will generate the key request binary data:

Run from: `./oem_tools_pkg/oem_asset_prov_utils/oem_key_request`

```
python  am_oem_key_request_util.py  ./am_config/ am_dmpu_oem_key_request.cfg
```

The output file containing the key request data is generated as follows:

```
./oem_tools_pkg/oem_asset_prov_utils/oem_key_request/oem_request_pkg.bin
```

The file is sent to Ambiq that will process it and will return the file **icv_response_pkg.bin.**

3.5 OEM Asset Packaging Utility

NOTE: This step is only needed when generating an encrypted OEM security data image. For plain (unencrypted) data this step can be skipped.

The OEM Asset Packaging Utility **am_dmpu_oem_asset_pkg_util.py** script is used to encrypt the OEM assets before sending it to the device manufacturing to provision the encrypted assets securely. It can be found in the directory:

./oem_tools_pkg/oem_asset_prov_utils/oem_asset_package

This utility encrypts three plain text assets separately (Kcp, Kce, and the OEM Security binary file, generated earlier) and generates three encrypted assets blobs. The plain text OEM security binary file and **icv_response_pkg.bin** received from Ambiq are placed at the following location as described in the example config file:

./oem_tools_pkg/oem_asset_prov_utils/oem_asset_package/inputData/

3.5.1 Input Parameters

In directory: **./oem_tools_pkg/oem_asset_prov_utils/oem_asset_package/am_config**

Files: **oem_asset_enc.cfg**
am_asset_oem_ce.cfg
am_asset_oem_cp.cfg

3.5.2 Command(s)

The following command(s) are used to generate the encrypted OEM assets:

Run from: **./oem_tools_pkg/oem_asset_prov_utils/oem_asset_package**

```
python am_dmpu_oem_asset_pkg_util.py  ./am_config/oem_asset_enc.cfg
python am_dmpu_oem_asset_pkg_util.py  ./am_config/am_asset_oem_ce.cfg
python am_dmpu_oem_asset_pkg_util.py  ./am_config/am_asset_oem_cp.cfg
```

The output files containing the encrypted assets are will be place in the same directory as follows:

oem_asset_pkg.bin
oem_prov_asset_kce_pkg.bin
oem_prov_asset_kcp_pkg.bin

3.6 OEM Provisioning Data Gen Util

The OEM Provisioning Data Gen Utility generates the final OEM provisioning data blob which is unpackaged by the OPT tool on the device before provisioning the data. The data image may be optionally encrypted using the previous steps discussed above (the ICV Key Request/Response and the OEM Asset Packaging).

The tool mainly joins the three OEM assets generated by OEM Key Generation, and the OEM Asset Generation, (and then optionally encrypted by the OEM Asset Packaging Utility). It also adds default DCU, initial software version and more to the final blob which is provided through the config file.

The utility is available at the following path:

```
./oem_tools_pkg/oem_asset_prov_utils/oem_asset_package/
am_dmpu_prov_data_gen_util.py
```

3.6.1 Input Parameters

The following config file is used to configure the generation of the OEM provisioning blob:

In directory: `./oem_tools_pkg/oem_asset_prov_utils/oem_asset_package/am_config`

File: **am_dmpu_data_gen.cfg**

3.6.2 Command

The following command is used to generate the encrypted OEM assets blob:

Run from: `./oem_tools_pkg/oem_asset_prov_utils/oem_asset_package`

```
python   am_dmpu_prov_data_gen_util.py  ./am_config/am_dmpu_data_gen.cfg
```

The output of the tool generates:

```
. /dmpu_prov_data_blob.bin
```

The SDK provides several example config files for generating various types of data blobs that can be substituted for **am_dmpu_data_gen.cfg**.

- **am_dmpu_data_gen_plain_nonsec.cfg** – This generates a unencrypted OPT data blob (when steps 3.4 and 3.5 were skipped), and secureboot is disabled (the image at MAINPOINTER will be run without being authenticated).
- **am_dmpu_data_gen_nonsec.cfg** – This generates an encrypted OPT data blob (when the ICV Key request/response was used). This config also has secure boot disabled, when the device transitions to secure.

- **am_dmpu_data_gen_sec.cfg** – This generates an encrypted OPT data blob with Secureboot enabled. With secureboot is enabled, the user application will run only when authenticated with **oem_cert_chain**.

3.7 OEM Provisioning Tool (OPT)

The OPT is an Ambiq signed tool which is downloaded and executed on the chip in the OEM's manufacturing facility processing the OEM provisioning data and writing the INFOC-OPT fields with the selected data and options.

The OPT tool is available at the following location:

```
./oem_tools_pkg/oem_prov_tool/opt_image_pkg.bin
```

The tool is downloaded into SRAM at address 0x20030000, and the OEM assets (encrypted or plain), generated in the previous section, are loaded into SRAM at address 0x20037000. After downloading these 2 blobs, the device is then reset. During the subsequent reboot, the OEM assets get provisioned if both the blobs are authenticated successfully. After a successful OEM provisioning, the device will reset, and the Apollo5 will have been transitioned to secure LCS.

> **NOTE:** If the provisioning fails for some reason, the device will remain in DM LCS.

3.7.1 Combined OPT Binary

Optionally, both the OPT blobs (**opt_image_pkg.bin** and **dmpu_prov_data_blob.bin**) can be combined into one OPT blob that can be downloaded to 0x20030000.

The following command is used to generate the combined OPT blob:

Run from `./oem_tools_pkg/oem_asset_prov_utils/oem_asset_package/`

```
python am_opt_combined_gen_util.py ./am_config/ am_opt_combined_gen.cfg
```

The output of the tool generates as follows:

```
./oem_tools_pkg/oem_asset_prov_utils/oem_asset_package/
opt_image_combined.bin
```

SECTION

4

Customer Infospace Provisioning (INFO0)

Customer infospace, also known as INFO0, controls a variety of customer-specific features of the MCU. The following sections provide information on how to provision INFO0 for a particular application.

The scripts for the following examples are also located in **/tools/apoll05b_scripts** directory in the AmbiqSuite SDK.

4.1 INFO0 - MRAM and OTP

The Apollo5 device has two "INFO0" spaces, one that is based on MRAM (rewritable) and one that is OTP (one time programmable). Only one of which is active at any one time, providing INFO0 configuration data to the device. Either can be written at any time. Which one is active is determined by the selector register **INFOC_SHDW_TRIM_INFO0_SEL** at (0x400C23FC). See the register documentation for this register and its use.

INFO0-OTP is 256 bytes in size and INFO0-MRAM is 2048 bytes (2K) in size. The first ~160bytes have a defined use (that is the same for both Info0-MRAM and Info0-OPT), with the remaining space in each available to the customer for their use.

The **create_info0.py** script described below always outputs 256b .bin file which can be used to program either the full INFO0-OTP or the first 256 bytes of INFO0-MRAM. The customer would modify the script for their specific use if locations beyond the first 256 bytes are to be used.

4.2 Info0 Generation

The script create_info0.py is used to create a binary file that is then used to program/update INFO0 (either MRAM or OTP). The user specifies INFO0 parameters either via command-line options, or in a config file, or a combination of the two, with command-line arguments taking precedence. A full list of options can be found in Appendix A. A reduced list of options (minus the MRAM recovery specific options) can be accessed by using the --help flag, the full list can be displayed with the -hx (help extended) flag:

```
python create_info0.py --help
```

While the arguments are listed as optional from the script's execution perspective, various options are required depending on the desired use of the Apollo5 device.

```
$ python3 create_info0.py --help
usage: create_info0.py [-h][-hx] [--info0Cfg] [--valid {0,1,2}]
                       [--version VERSION] [--main MAINPTR]
                       [--cchain CERTCHAINPTR][--wTO WIREDTIMEOUT]
                       [--u0 U0] [--u1 U1] [--u2 U2] [--u3 U3] [--u4 U4]
                       [--u5 U5] [--sdcert SDCERT] [--rma RMAOVERRIDE]
                       [--sresv SRESV] [--loglevel {0,1,2,3,4,5}] output

Generate Apollo5 Info0 Blob
positional arguments:
  output                  Output filename (without the extension)
optional arguments:
  -h, --help              show this help message and exit
  --hx                    show extended help message and exit
  --info0Cfg              Relative path to INFO0 configuration file.
  --valid {0,1,2}         INFO0 Valid 0 = Uninitialized, 1 = Valid, 2 = Invalid
                          (Default = 1)?
  --version VERSION       version (Default = 0)
  --main MAINPTR          Main Firmware location (Default = 0x410000)
  --cchain CERTCHAINPTR   Certificate Chain location (Default = 0x00000000)
  --wTO WIREDTIMEOUT      Wired interface timeout in millisec (default = 2000)
  --u0 U0                 UART Config 0 (default = 0x00000000)
  --u1 U1                 UART Config 1 (default = 0x00000000)
  --u2 U2                 UART Config 2 (default = 0x00000000)
  --u3 U3                 UART Config 3 (default = 0x00000000)
  --u4 U4                 UART Config 4 (default = 0x00000000)
  --u5 U5                 UART Config 5 (default = 0x00000000)
  --sdcert SDCERT         Secure Debug Cert Address (default = 0x7ff400)
  --rma RMAOVERRIDE       RMA Override Config 2 = Enabled, 5 = Disabled
                          (default = 0x2)
--sresv SRESV             SRAM Reservation (Default 0x0)
--loglevel {0,1,2,3,4,5}
                          Set Log Level (0: None), (1: Error), (2: INFO),
                          (4: Verbose), (5: Debug) [Default = Info]
```

Example Usage:

To create INFO0 image with Wired UART set on pins 53 (Tx) and 55 (Rx) with baud 115200 (0x1C200), and the timeout of 5 Sec. running the Main image (if nonsecure boot) at 0x410000,

and the SD Cert location set to 0x7ff400. If configured for secureboot, the OEM cert chain is located at 0x4C0000.

```
python ./create_info0.py --valid 1 --u0 0x1C200c0 --u1 0x00003537 --u2 0x4
--u3 0x4 --u4 0x0 --u5 0x0 --main 0x410000 --version 1 --wTO 5000 --sdcert
0x7FF400 --cchain 0x4c0000 info0
```

This will generate a info0.bin, which can then be used to program to INFO0 in the Apollo5 device (either INFO0-MRAM or INFO0-OTP).

4.3 Info0 Programming

The generated info0.bin can be programmed directly using the a debugger (using the supplied Jlink script), programmatically using HAL functions, or via the Wired Update process supported by the SBL.

AmbiqSuite SDK provides two sample scripts, **jlink-prog-info0.txt** and **jlink-prog-info0-otp.txt** for the direct programming of Info0 (MRAM and OTP respectively) using a Jlink debugger.

This script can be processed by the JLINK command line utility with an invocation following the following format (for Windows):

```
JLink.exe -CommanderScript jlink-prog-info0.txt   (for Info0-MRAM)
```

or

```
JLink.exe -CommanderScript jlink-prog-info0-otp.txt   (for Info0-OTP)
```

Alternatively, INFO0 can be programmed using the SBL assisted update flow, by generating an Info0 update image (see *Section 7.3.3 Info0 Update Images on page 41*) and then using one of the supported methods to download the update image and initiate an update (see *Section 8 Downloading Images and Initiating Updates on page 43*).

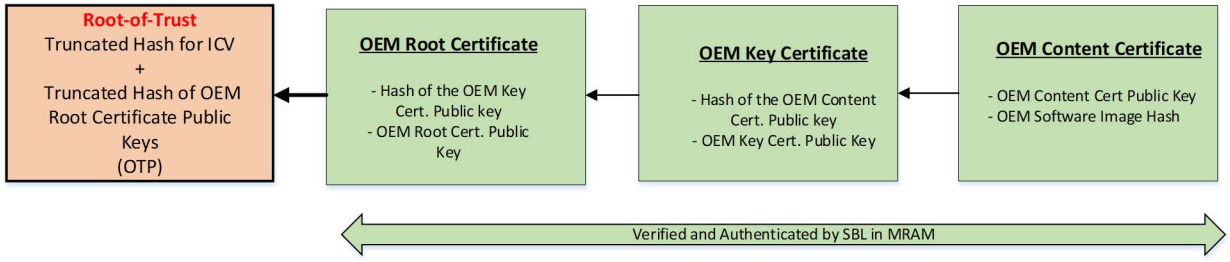
SECTION

5

OEM Image Certificate Generation

Provisioning of the Apollo5 Family in the DM LCS to support Secureboot depends upon a "chain" of public key certificates as shown in Figure 5-1. This method provides flexibility and additional security in case the content changes or a certificate in the chain is compromised.

Figure 5-1: OEM Certificate Generation



5.1 Prerequisite

The OEM certificate chain generation process assumes that OEM RSA keys have already been generated using the KeyGen Utility during the provisioning data generation process. The OEM Certificate chain should use these same OEM RSA keys.

While processing the Certificate Chain authentication on the device, it is also assumed that the device is already provisioned with the Root of Trust (HBK1 in the INFOC-OTP), as the OEM Root Certificate is authenticated using the RoT. When in DM LCS, before the ROT is programmed, the OEM Root Certificate authentication is bypassed, and accepted as valid, but the remaining certs continue to be validated.

5.2 Note on the Tool Output Files

Many of the steps below will generate both ***.txt** files that are appropriate to cut and paste into source code files for testing. However, the tools also generate ***.bin** files that provide the assets for later steps to produce a provisioning blob.

5.3 OEM Root Certificate Gen

The OEM Root Certificate is used to validate the Public key provided by the OEM. It also authenticates the Public key embedded in the OEM key certificate, which is next in the chain.

```
./oem_tools_pkg/cert_utils/cert_gen_utils/am_cert_key_util.py
```

5.3.1 Input Parameters

The inputs to the OEM Root Certificate Gen is provided through the configuration file as a command-line parameter. The details of the configuration file parameters are described in the following file with example configuration values.

```
./oem_tools_pkg/cert_utils/cert_gen_utils/am_config/
am_oem_root_cert_hbk1.cfg
```

5.3.2 Command

The following command generates the OEM Root Certificate:

```
./oem_tools_pkg/cert_utils/cert_gen_utils/$
python am_cert_key_util.py ./am_config/am_oem_root_cert_hbk1.cfg
```

The output files containing the OEM Root Certificate are generated in binary and text formats:

```
./oem_tools_pkg/cert_utils/cert_gen_utils/am_cert_key_util_output/
oem_root_cert_hbk1.bin
./oem_tools_pkg/cert_utils/cert_gen_utils/am_cert_key_util_output/
oem_root_cert_hbk1_Cert.txt
```

5.4 OEM Key Certificate Gen

The OEM Key Certificate Utility generates the OEM Key Certificate to validate the Public key in the Content Certificate which is next in the OEM Certificate Chain:

```
./oem_tools_pkg/cert_utils/cert_gen_utils/am_cert_key_util.py
```

5.4.1 Input Parameters

The input to the OEM Key Certificate Gen is provided through the configuration file as a command-line parameter. The details of the configuration file parameters are described in the following file with example configuration values.

```
./oem_tools_pkg/cert_utils/cert_gen_utils/am_config/
am_oem_key_cert.cfg
```

5.4.2 Command

The following command generates the OEM Key Certificate:

```
./oem_tools_pkg/cert_utils/cert_gen_utils/$
python am_cert_key_util.py ./am_config/am_oem_key_cert.cfg
```

The output file containing the OEM Key Certificate is generated in binary and text formats:

```
./oem_tools_pkg/cert_utils/cert_gen_utils/am_cert_key_util_output/
oem_key_cert.bin
```

```
./oem_tools_pkg/cert_utils/cert_gen_utils/am_cert_key_util_output/
oem_key_cert_Cert.txt
```

5.5 OEM Content Certificate Gen

The OEM Content Certificate is used to authenticate OEM software image(s) on the device. It contains a list of software images, along with the start addresses and their sizes.

```
./oem_tools_pkg/cert_utils/cert_gen_utils/am_cert_content_util.py
```

5.5.1 Input Parameters

The inputs to the OEM Content Certificate Gen Tool is provided through the configuration file as a command-line parameter. The details of the configuration file parameters are described in the following with example configuration values.

> **NOTE:** Ambiq SBL requires the software image(s) are stored in MRAM unencrypted and are executed directly from the stored location itself. Choose the corresponding configuration as described in the config file and set the **images_table.tbl** accordingly, as mentioned below. Check with Ambiq before using other options.

```
./oem_tools_pkg/cert_utils/cert_gen_utils/am_config/
am_oem_cnt_cert.cfg
```

The list of software images is listed in a text file that is used by the config file as mentioned above. The example list file is placed at the following location:

```
./oem_tools_pkg/cert_utils/cert_gen_utils/inputData/images_table.tbl
```

The format of the image table are as follows:

- **ImageName** - Path to the image file.
- **RAMloadAdd** - Since the image is executed from the MRAM itself, as configured in config file, this must be set to image start address in MRAM.
- **flashStoreAdd** – Must be set to 0xFFFFFFFF.
- **Maxsize** - Must be set to a value equal to, or greater than the image size.
- **Enc-Scheme** - 0 = plain text, 1 = encrypted.
  Note: The encrypted option is not supported and must not be selected.
- **WriteProtect** - When set to 0x1, Ambiq Bootloader will write protect the image (in 16K increments) as part of secure boot. Set it to 0, if no write protection is needed.
- **CopyProtect** - When set to 0x1, Ambiq Bootloader will copy protect the image (in 16K increments) as part of secure boot. Set it to 0, if no copy protection is needed. Note that, if enabled, the executable image must be built with no literals in the code area (e.g., execute only), as it will otherwise fail because of read operations within the image.
- **ExtendedFormat** - Not Supported. Must be set to 0.

5.5.2 Command

The following command will be used to generate the content certificate:

```
./oem_tools_pkg/cert_utils/cert_gen_utils/$
python am_cert_content_util.py ./am_config/am_oem_cnt_cert.cfg
```

The output files containing the Content Cert assets are generated as follows:

```
./oem_tools_pkg/cert_utils/cert_gen_utils/
am_cert_content_util_output/content_cert.bin
./oem_tools_pkg/cert_utils/cert_gen_utils/
am_cert_content_util_output/content_cert_Cert.txt
```

SECTION

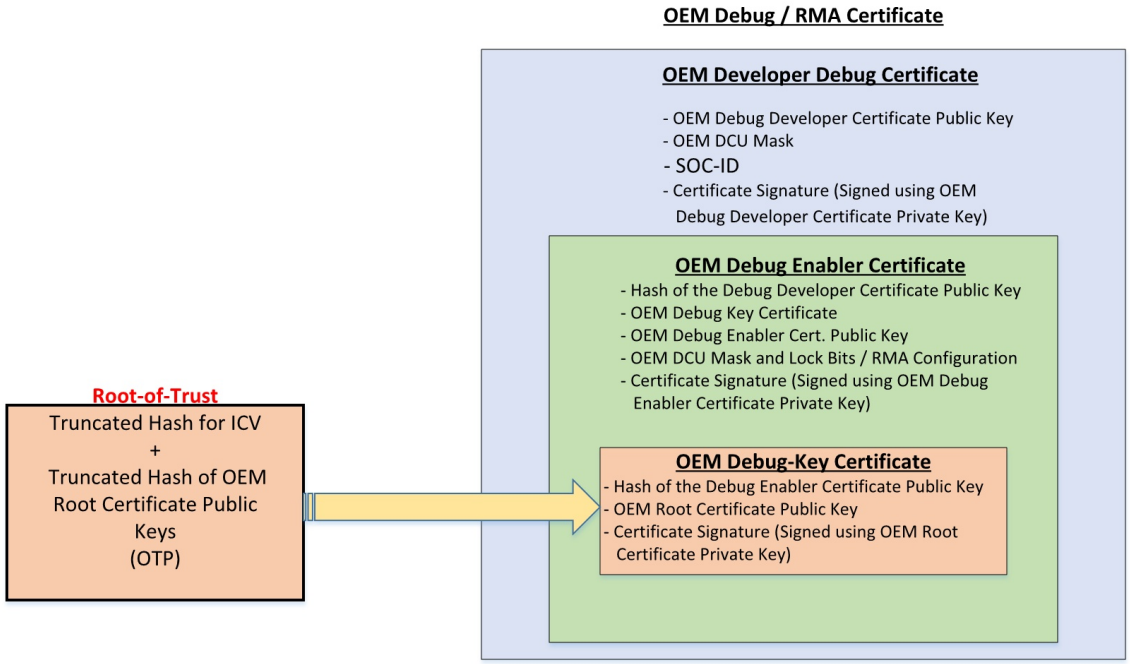
6

OEM Debug Certificate Generation

The debug certificate(s) is used to enable the debugging or changing the device to RMA LCS for device analysis. The Debug certificates can be processed in either DM and Secure LCS.

The debug certificate consists of three certificates: Debug-key certificate, Debug Enabler certificate, and Debug Developer certificate as shown in Figure 6-1. All these certificates need to be generated in sequence. The debug-key certificate is added to the debug enabler certificate using the Debug enabler certificate gen config file. Similarly, the debug enabler certificate is added to the debug developer certificate using the debug developer certificate gen config file. Finally, the debug developer certificate is downloaded onto the device as a single entity to be processed by the SBR as three combined certificates.

Figure 6-1: OEM Debug Certificates



6.1 OEM Debug-Key Certificate Gen

The OEM Debug-Key Certificate is used to validate the Public key provided by the OEM. It also authenticates the Public key embedded in the OEM Enabler Certificate, which is next in the debug certificate chain.

In directory: **`./oem_tools_pkg/cert_utils/cert_gen_utils/`**

Script: **am_cert_key_util.py**

6.1.1 Input Parameters

The inputs to the OEM Debug-Key Certificate Gen are provided through the configuration file as a command-line parameter. The details of the configuration file parameters are described in the example configuration file.

In directory: **`./oem_tools_pkg/cert_utils/cert_gen_utils/am_config`**

File: **am_oem_dbg_key_cert.cfg**

6.1.2 Command

The following command generates the OEM Debug-Key Certificate:

Run in directory: **`./oem_tools_pkg/cert_utils/cert_gen_utils/`**

```
python amcert_key_util.py ./am_config/am_oem_dbg_key_cert.cfg
```

The output file containing the ICV Debug-Key Certificate is generated in binary and text formats as follows:

In directory **`./oem_tools_pkg/cert_utils/cert_gen_utils/am_cert_key_util_output`**

Files: **debug_oem_key_cert.bin**
debug_oem_key_cert_Cert.txt

6.2 OEM Debug Enabler Certificate Gen

The OEM Debug Enabler Certificate utility is used to generate the debug enabler certificate which contains the OEM DCU debug masks, and lock masks, or RMA information (in case of RMA certificate for OEM). It also authenticates the Public key embedded in the OEM debug developer certificate, which is next in the debug certificate chain.

In directory: **`./oem_tools_pkg/cert_utils/cert_gen_utils/`**

Script: **am_cert_dbg_enabler_util.py**

6.2.1 Input Parameters

The inputs to the OEM Debug Enabler Certificate Gen is provided through the configuration file as a command-line parameter. The details of the configuration file parameters are described in the example configuration file.

In directory: **`./oem_tools_pkg/cert_utils/cert_gen_utils/am_config`**

File: **am_oem_dbg_enabler_cert.cfg**

6.2.2 Command

The following command generates the OEM Debug Enabler Certificate:

Run in directory: **`./oem_tools_pkg/cert_utils/cert_gen_utils/`**

```
python am_cert_dbg_enabler_util.py ./am_config/
am_oem_dbg_enabler_cert.cfg
```

The output file containing the OEM Debug Enabler Certificate is generated only in binary format:

In directory: **`./oem_tools_pkg/cert_utils/cert_gen_utils/am_debug_cert_output`**

File: **oem_dbg_cert_enabler_pkg.bin**

6.3 OEM Debug Developer Certificate Gen

The OEM Debug Developer Certificate is used to generate the final debug certificate which contains OEM debug-key Certificate, OEM Debug Enabler Certificate, and SOC-ID (Chip specific Identification).

In directory: **`./oem_tools_pkg /cert_utils/cert_gen_utils/`**

Script: **am_cert_dbg_developer_util.py**

6.3.1 Input Parameters

The inputs to the OEM Debug Developer Certificate Gen is provided through the configuration file as a command-line parameter. The details of the configuration file parameters are described in the example configuration file:

In directory: **`./oem_tools_pkg /cert_utils/cert_gen_utils/am_config`**

File: **am_oem_dbg_developer_cert.cfg**

6.3.2 Command

The following command generates the OEM Developer Certificate:

Run in directory: **`./oem_tools_pkg/cert_utils/cert_gen_utils`**

```
python am_cert_dbg_developer_util.py ./am_config/
am_oem_dbg_developer_cert.cfg
```

The output files containing the OEM Debug Developer Certificate are generated in binary and text ('c' Header file) formats as follows:

In directory: **`./oem_tools_pkg/cert_utils/cert_gen_utils/am_debug_cert_output`**

Files: **oem_dbg_cert_developer_pkg.bin**
oemDeveloperCert.h

SECTION

7

Image Generation for Apollo5 SBL

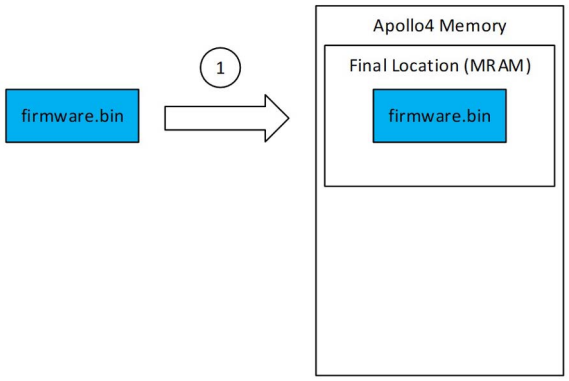
The Apollo5's boot ROM and SBL (secure boot loader) are capable of performing a wide variety of update functions, each of which requires a binary image with a specific format, which in turn is loaded using a specific protocol. This section provides an overview of the various types of binaries supported by the SBL, as well as some information about the scripts used to generate them.

7.1 Overview of Image Types

7.1.1 Firmware

Raw application binaries are the most basic image format for the Apollo5. This is simply a compiled application in the standard Arm binary format, and can be loaded directly into MRAM using any SWD programming tool (including the JLINK device on the Apollo5 evaluation kits). All later firmware images will be derived from this basic image.

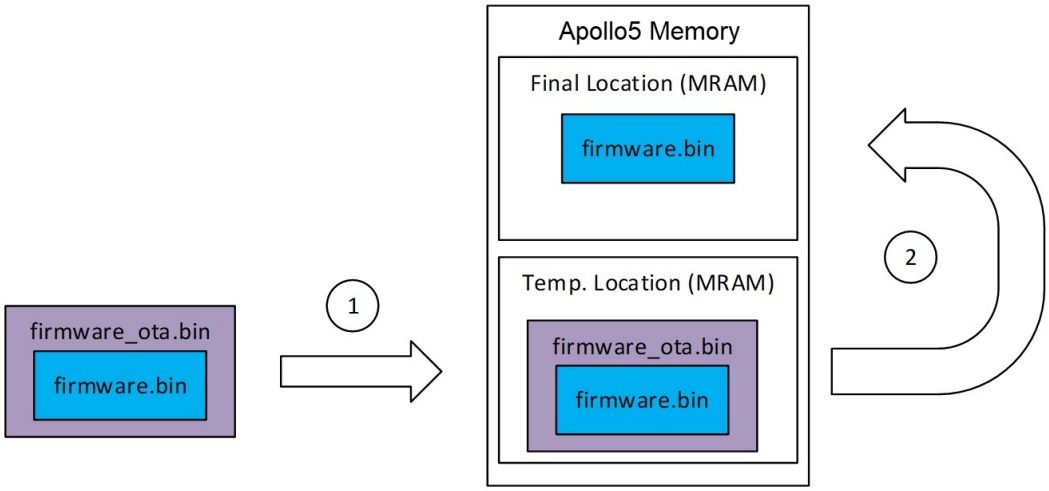
Figure 7-1: Firmware



7.1.2 Firmware OTA

Firmware OTA images are created by adding metadata to raw binaries using the **create_cust_image_blob.py** script (described in detail later in this document). OTA images are first loaded into a temporary location in MRAM using SWD programming tools (step 1) or through other application specific means for field upgrade (e.g., Firmware upgrade over BLE), and then the SBL will validate and load the inner application binary to its final destination (step 2). OTA images provide the user with the option to encrypt and/or sign application binaries. The most common use case for an OTA image is for a firmware upgrade. An existing user application can receive a binary (optionally encrypted or signed) from an external source, program that binary to a location, and then instruct the SBL to finish the firmware upgrade following a reset, potentially replacing the original user application.

Figure 7-2: Firmware OTA



To make this two step process easier during development, AmbiqSuite includes a set of JLink scripts demonstrating how to load the OTA image to an appropriate temporary location over SWD and then trigger the SBL to perform the second step of the upgrade. See the **tools/apollo510_scripts** directory in AmbiqSuite to find these scripts. The scripts also serve as a reference for the process an application would need to follow when performing over-the-air upgrades when using alternative means to download the OTA image.

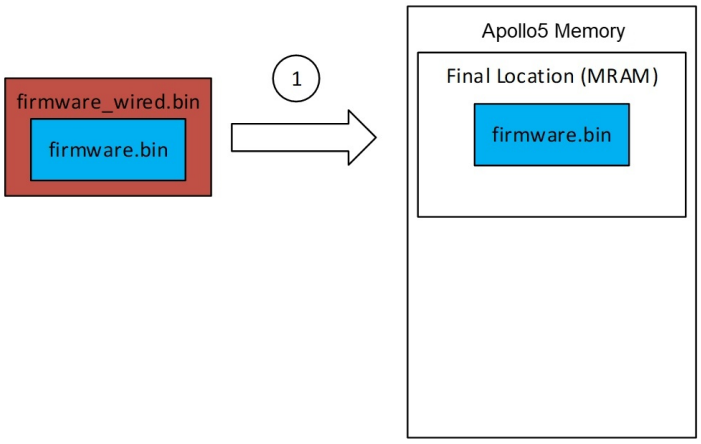
The same OTA process is reused for non-firmware upgrades like INFO0, trim patches, key revocations, etc., as well.

7.1.3 Wired Download

The SBL provides Wired Download functionality, where the raw images are preformatted for the SBL to understand and process them.

Similar to OTA images, wired download images are also created by adding metadata to raw binaries with the **create_cust_image_blob.py** script. Wired download metadata can be used to wrap any image type, and it will change how the image may be downloaded and stored/processed on the device. The wired download image format is understood both by the SBL and by the PC-side utility **uart_wired_update.py**. Using this utility and a wired download image, a user can effectively program the Apollo5 MRAM using a UART instead of an SWD connection. This is helpful in situations where an SWD connection is unavailable, including situations where an open SWD port might be a security risk. Depending on device configuration, the wired download could provide a secure (encrypted and authenticated) channel for device programming/updates. The wired download is fully managed by the SBL, so this procedure can be used on an otherwise unprogrammed the Apollo5 device. The SBL will read the wired download data directly over the UART interface, potentially decrypting it or authenticate using an RSA signature, and program the data to its final location in MRAM. No temporary MRAM is required for this process.

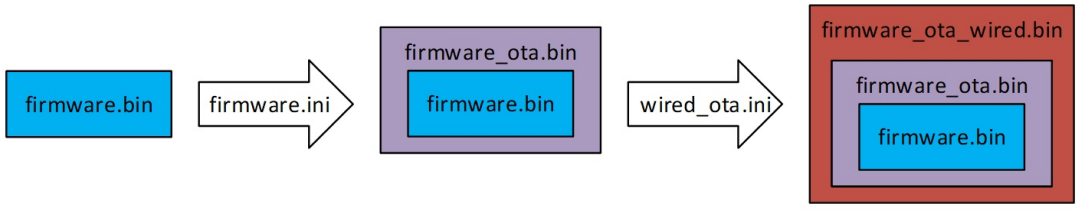
Figure 7-3: Wired Download



7.1.4 Wired OTA

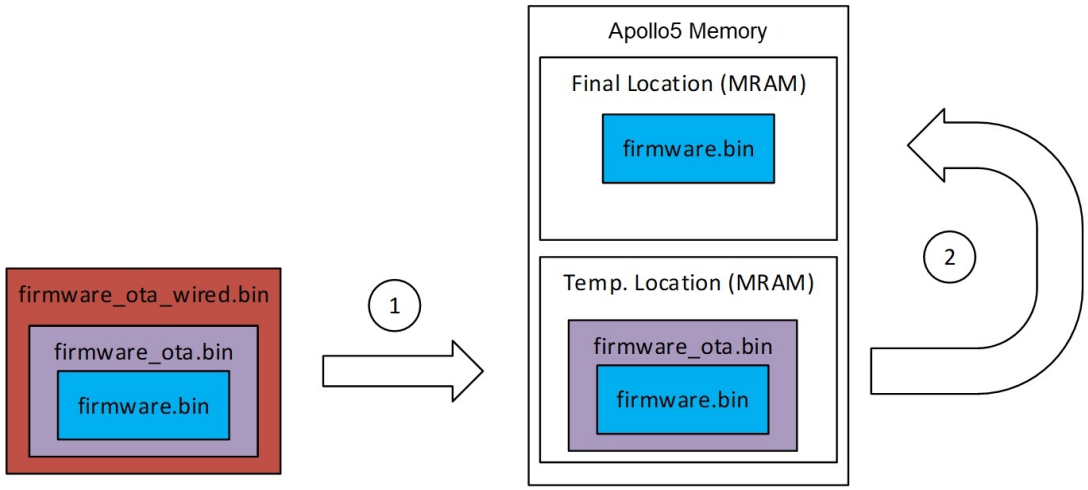
The OTA and Wired Download formats from the previous sections can be used simultaneously in a single image. In this case, the user will first process the raw binary to create an OTA image, and then process the OTA image to create a Wired OTA image. This format combines the advantages of both formats to create an image that can be loaded entirely over UART, but which can also be loaded to a temporary location to avoid corrupting the current known good image until the update is fully decrypted and authenticated.

Figure 7-4: Wired OTA



The update process with a Wired OTA image is similar to the standard OTA process, but the image download step is performed over UART instead of SWD. In step one, the UART boot host will send the Wired OTA image to the SBL, which will program its contents (the OTA image) to a temporary location in MRAM. Afterwards, the Apollo5 will reboot and perform step 2, where it processes the OTA image and programs the device firmware to its final location.

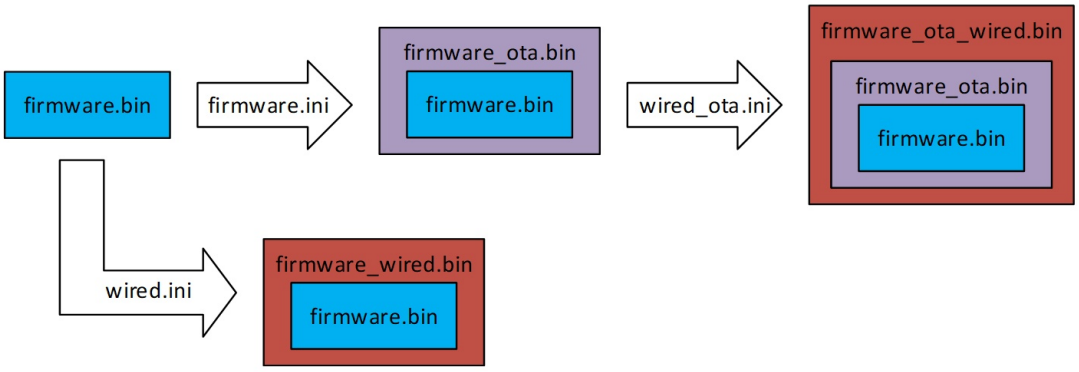
Figure 7-5: Wired OTA - Step 2



7.1.5 Summary

The diagram below further summarizes the relationship between raw binaries, OTA images, Wired Download images, and Wired OTA images. While the examples used in the previous sections all assumed we were working with an application binary, there are other image types that can be used in place of the OTA image type shown here.

Figure 7-6: Relationship Summary



The following sections discuss these additional image types and also explains in detail how the supporting scripts work.

7.2 Image Generation Scripts

The Apollo5's SBL (secure boot loader) can perform a wide variety of functions, each requires a binary image with a specific format, which is then loaded into the device over one of the support interfaces. The **create_cust_image_blob.py** script described in this section can generates these image formats, including the following:

- Secure and non-secure Firmware OTA
- Wired Download
- Certificate Chain Update
- Key Revocation
- INFO0 Update
- OEM Application Recovery

7.2.1 Basic Script Usage

Most image formats for the Apollo5 are handled by **create_cust_image_blob.py**. This script can be controlled either with command line parameters, by config file, or with a combination of the two, where the command-line arguments always take precedence.

The full list of options can be found by calling the script using the **--help** command line option. The options required will vary depending on the image type being created. The following sections describe the supported image types along with the relevant options for each one.

For more examples of how to use **create_cust_image_blob.py**, see the **tools/apollo510_scripts/examples** directory of AmbiqSuite SDK.

7.2.2 Example Configuration File

Below is an example showing the configuration files used for **create_cust_image_blob.py** alongside the equivalent command-line commands.

Configuration file "firmware.ini":

```
#*******************************************************************************
#
# Configuration file for create_cust_image_blob.py
#
# Run "create_cust_image_blob.py --help" for more information about the
options
# below.
#
# All numerical values below may be expressed in either decimal or
hexadecimal
# "0x" notation.
#
# To re-generate this file using all default values, run
# "create_cust_image_blob.py --create-config"
#
#*******************************************************************************
[Settings]
chip = apollo510
app_file = hello_world.bin
# Location where the image should be installed
load_address = 0x410000
enc_algo = 0x0
# specify enc_algo as 1 to do AES encryption
auth_algo = 0x0
# auth_key relevant only if auth_algo is 1
# auth_key indicates which PK is used for signature
auth_key = 0x2
kek_index = 0x80
image_type = firmware
certificate = None
output = hello_world_ota.bin
key_table = keys.ini
```

This configuration creates **hello_world_ota.bin** (a non-secure firmware OTA image) from **hello_world.bin** (a compiled Apollo5 binary), with no encryption, authentication, or content certificate. To execute this configuration, one would execute the following command from the same directory as the file.

```
$ python ./create_cust_image_blob.py -c firmware.ini
```

Equivalently, this configuration can also be expressed on the command line as follows.

```
$ python3 ./create_cust_image_blob.py --chip apollo510 --bin
hello_world.bin --load-address 0x410000 --enc-algo 0 --kek-index 0x80
--auth_algo 0 --auth-key 0x2 --image-type firmware
```

7.2.3 Universal Security Options

The Apollo5 SBL supports AES encryption and RSA authentication for a wide variety of update types. Correspondingly, the **create_cust_image_blob.py** script includes features to encrypt and/or sign binaries in the correct format to be decrypted and validated by the SBL. Each of the security options below can be applied to any image type. Additional options for specific image types will be covered in later sections.

- **auth_algo**: The authentication method to use. (0 = none, 1 = RSA (RSA PSS 2072 after Hash SHA 256))
- **auth_key**: The key index of the authentication key. The index represents the actual asymmetric key used for signing. It corresponds to public key contained in one of the preinstalled certificates on the device (0 = root cert, 1 = key cert, 2 = content cert).
- **enc_algo**: The encryption algorithm to use for securing the transfer (0 = none, 1 = AES-128 CTR mode)
- **kek_index**: The index for the key encryption key to be used. The index represents the key encryption key used to decrypt the encrypted key bundled in the image. Index 0 and 1 represent hardware keys (Kcp or Kce respectively) programmed during provisioning. Key indices 0x80 onwards represent INFOC-OTP key-bank keys, with each index representing a 128b AES key.
- **key_table**: Path to a configuration file describing the encryption keys used with the Apollo5.
  Note: This can be set to **None** if no encryption or authentication is needed.

The **key_table** file contains pointers to various Private Key assets used to sign the image blobs, as well as the symmetric keys used for encryption.

The asymmetric key material should correspond to the certificates provisioned on the chips, and are referenced using password encrypted **.pem** files.

The symmetric key material should match with the INFOC-OTP keys programmed in the chips, and are referenced using pointers to binary key and key bank files. Typically, these keys will be used as Key Encryption Keys (KEK) for an OTA image.

To use a particular key, you will need to supply the **keys.ini** file as shown below, as well as a KEK index for encryption and Auth Keys index for signing.

```
# Key file
[Root Key]
index = 0x0
format = pem
filename = oem_tools_pkg/am_oem_key_gen_util/oemRSAKeys/
oemRootCertKeyPair.pem
passfile = oem_tools_pkg/am_oem_key_gen_util/oemRSAKeys/
pwdOemRootCertKey_Rsa.txt
```

```
[Key Cert Key]
index = 0x1
format = pem

filename = oem_tools_pkg/am_oem_key_gen_util/oemRSAKeys/
oemKeyCertKeyPair.pem
passfile = oem_tools_pkg/am_oem_key_gen_util/oemRSAKeys/
pwdOemKeyCertKey_Rsa.txt

[Content Cert Key]
index = 0x2
format = pem
filename = oem_tools_pkg/am_oem_key_gen_util/oemRSAKeys/
oemContentCertKeyPair.pem
passfile = oem_tools_pkg/am_oem_key_gen_util/oemRSAKeys/
pwdOemContentCertKey_Rsa.txt

[Symmetric Keys]
kcp = ../../oem_tools_pkg/am_oem_key_gen_util/oemAESKeys/kcp.bin
kce = ../../oem_tools_pkg/am_oem_key_gen_util/oemAESKeys/kce.bin
kb0 = oem_tools_pkg/oem_asset_prov_utils/inputData/keyBank0.bin
kb1 = oem_tools_pkg/oem_asset_prov_utils/inputData/keyBank1.bin
kb2 = oem_tools_pkg/oem_asset_prov_utils/inputData/keyBank2.bin
kb3 = oem_tools_pkg/oem_asset_prov_utils/inputData/keyBank3.bin
```

7.3 Generating Specific Image Types

7.3.1 Firmware OTA Images

Firmware OTA images contain firmware and metadata to be used by the boot-loader to update the firmware on the device. Firmware images can also be created with built-in encryption and authentication using the "secure-firmware" image type. The following options are relevant for both firmware and secure-firmware images:

- **app_file**: File to be used as the application binary
- **certificate**: For secure images, the binary file corresponding to the content certificate to be installed alongside the application binary.
- **image_type**: set to "firmware" for non-secure images, or "secure-firmware" for secure images.
- **load_address**: Address where the application should be written in the MRAM.

7.3.2 Wired Download Images

Wired download images can contain any data blob and instructions for programming to a specific location. The bootloader will read the image and program the blob to the specified location. Wired images can be created with or without built-in encryption using the "wired" image type. Once the wired image is created, the **uart_wired_update.py** script can be used to execute the wired download instructions and load the blob into the Apollo5 memory. Wired download images support the following options:

- **app_file**: Binary file to write to internal memory
- **image_type**: set to "wired"
- **load_address**: Address where the binary data should be written in the MRAM.
- **ota**: Set this bit to alert the SBL that this wired download contains a firmware OTA.
- **wired_chunk_size**: Largest number of bytes the Apollo5 should download in a single pass. See wired OTA description in *Section 9.1 Upgrading Multiple Images in One Step on page 47*.

7.3.3 Info0 Update Images

This image type can be used to update the INFO0 data area in the Apollo5 device. INFO0 is used to contain non-volatile Apollo5 device settings. For more information, see the **create_info0.py** script documentation in *Section 4.2 Info0 Generation on page 23*. INFO0 could be updated as a whole, or partially.

- **app_file**: Binary file to write to info0 space
- **image_type**: set to "info0"
- **offset**: The word offset within info0 where this update binary should be written.
- **load_address**: Address where the binary data should be written in the MRAM.
- **ota**: Set this bit to alert the SBL that this wired download contains a firmware OTA.
- **prog_dest**: The destination to be programmed INFO0-OTP, MRAM, Both or the currently active one.

7.3.4 OEM Certificate Chain Update

OEM Chain Update images are used to make updates to the certificate chain used by the Apollo5 SBL. The root certificate, key certificate, and content certificate all get changed using this process. This option is primarily used to increment the certificate version to ensure images cannot be rolled back to older certificates.

- **image_type**: set to "oem_chain"
- **certificate**: Filename for the content certificate to be installed.
- **root_cert**: Filename for the root certificate to be installed.
- **key_cert**: Filename for the key certificate to be installed.

7.3.5 Key Revocation Images

The Apollo5 "keybank" keys (as discussed in *Section 1 Keys on page 11*) are programmed into INFOC-OTP and can be used for encryption both in the boot process and in the main application. The purpose of the "key revocation" image type is to provide a way to revoke access to specific keybank keys in case they have been compromised.

In addition to the universal options, the key revocation image type supports only the following option:

- **app_bin**: Filename for the key update binary to be used for key revocation.

The "key update binary" itself is a 64-bit bitmask (little endian), where each bit corresponds to a single 128-bit AES key in the keybank. Setting a bit revokes the key with the same number (for example, setting bit 0 revokes keybank AES key 0).

SECTION

8

Downloading Images and Initiating Updates

As described in the previous chapter, the Apollo5 SBL is capable of receiving and validating firmware updates through multiple methods. This chapter focuses on the available methods for transferring data from a boot host (often a PC) to the Apollo5 SBL. The currently supported data transfer methods are as follows:

- SWD Debugger (such as JLink)
- Wired Update
- Over the Air (with the help of a user application)

AmbiqSuite contains examples for each of these transfer methods, and any of them may be used to deliver firmware updates in customer applications. The following sections describe the available examples in further detail.

8.1 SWD Download Using JLINK

The most straightforward firmware download method is over SWD with a hardware debugger (like JLINK). Using the debugger, a user may write directly to main MRAM. Depending on the type of image being downloaded, the SBL will then perform the image validation and OTA processing immediately following the next reset operation.

AmbiqSuite includes JLINK scripts that demonstrate how the JLINK can be used to program a specific memory location in the Apollo5, and initiate an update through SBL.

These scripts include:

- **General Update**

  jlink-ota.txt: An example of a debugger-driven OTA download. This can be used with any update image except for SBL update.

This script can be run by the JLINK command line utility the following command (for Windows):

```
JLink.exe   -CommanderScript   jlink-ota.txt
```

- **SBL Update**

  Jlink-ota-bootrom.txt: Installs a replacement Secure Bootloader (SBL) done through the bootrom in the Apollo5 device, similar to the regular OTA, but uses the jlink script jlink-ota-bootrom.txt to perform a SBL-OTA update.

  This script can be run by the JLINK command line utility the following command (for Windows):

```
JLink.exe -CommanderScript jlink-ota-bootrom.txt
```

  In both cases the Jlink script should be edited to supply the pathname of the file to be loaded and processed.

8.2 Wired Update

Wired updates are a way to send data to the SBL without using a debugger connection. The SBL contains a UART or SPI based boot client that can receive firmware updates from a host application. The UART boot host program is called **uart_wired_update.py**, and is discussed further in the next chapter.

8.3 Over the Air Updates

The SBL can also be used to support over the air updates enabled by user firmware. In this case, the user firmware will communicate with a boot host and download an OTA image (described in the image formats section earlier). Once the download is completed, the user application can program the update blob information by programming the OTA infrastructure (see *Apollo5 Family Secure Update User's Guide*), and initiate a device reset. The SBL takes over on the next reboot and validates the downloaded image, and performs a firmware upgrade

The AmbiqSuite SDK provides an example of an OTA firmware update over BLE through the "AMOTA" app for the Apollo5. This example implements a specific transfer protocol with a counterpart host implemented as a Phone App (Ambiq_BLE App).

The **ota_binary_converter.py** script in **/tools/Apollo5_amota/scripts** can be used to generate an OTA blob compatible with AMOTA. Most of the optional parameters are not relevant for the Apollo5.

Example usage:

```
python   ota_binary_converter.py   --appbin main_ota.bin   -o main_
ota_amota
```

Thereafter, the normal procedure to upgrade the image using AMOTA and Ambiq_BLE App on the phone can be used to upgrade the firmware on the device.

SECTION

9

UART Wired Update

For UART based wired update to work, the device needs to be provisioned to allow UART wired update through INFOC-OTP and INFO0 settings (see *Apollo5 Family Security User's Guide*). SBL will then go into update mode in one of the two cases:

- Encountering Boot error (e.g., invalid main image)
- GPIO Override (configured through INFOC-OTP)

The host needs to be connected to the UART's pins as configured in Info0's UART configurations, and the host initiates the communication within a short time window, which is also configured in Info0.

The script **uart_wired_update.py** is designed to emulate the host side functions when using the UART as the wired interface. It can be used during development to test the UART wired update features, and to program the Apollo5 device while the debugger is disabled. Usage information for **uart_wired_update.py** appears below:

```
$ python uart_wired_update.py --help

\ambiqsuite\tools\apollo510_scripts>python uart_wired_update.py -h

usage: uart_wired_update.py [-h] [-b BAUD] [--raw RAW] [-f BINFILE] [-o OTADESC]
                            [-r {0,1,2}] [-a {0,1,-1}] port

UART Wired Update Host for Apollo5

positional arguments:

  port         Serial COMx Port

optional arguments:

  -h, --help   show this help message and exit
  -b BAUD      Baud Rate (default is 115200)
  --raw RAW    Binary file for raw message
  -f BINFILE   Binary file to program into the target device
  -o OTADESC   OTA Descriptor Page address (hex) - (Default is 0xFE000) - enter
               0xFFFFFFFF to instruct SBL to skip OTA
  -r {0,1,2}   Should it send reset command after image download? (0 = no reset,
               1 = POI, 2 = POR) (default is 1)
  -a {0,1,-1}  Should it send abort command? (0 = abort, 1 = abort and quit, -1 = no
               abort) (default is -1)
```

Example usage: Downloading an application using the wired download protocol.

```
python  uart_wired_update.py   -b 115200 COM3   -o 0xFFFFFFFF   -r 0   -f
application_wired.bin
```

Example usage: Downloading an OTA image of an application binary using the wired protocol.

```
python   uart_wired_update.py   -b 115200 COM3   -r 0   -f
application_wired_ota.bin
```

9.1 Upgrading Multiple Images in One Step

SBL supports upgrading multiple images in a single upgrade cycle using multiple entries in the OTA Descriptor.

UART Wired Update scripts can be used to achieve the same. The script is run multiple times, once for each image. The key here is that OTA Descriptor is to be set only in the first invocation, and reset is to be issued only for the last one.

The example below shows upgrading isolated data segments and a main image (all considered nonsecure main images generated as in *Section 6.1.1 Input Parameters on page 30*) together using **uart_wired_update.py**:

First image (also programs the OTA Descriptor, and does not reset the device):

```
python uart_wired_update.py  -b 115200 COM<X>  -f
img1_nonsecure_wire.bin  --r 0
```

Second image (does not program the OTA Descriptor or reset the device):

```
python uart_wired_update.py -b 115200 COM<X> -f
img2_nonsecure_wire.bin --r 0       -o 0xFFFFFFFF
```

Third image (does not program the OTA Descriptor but resets the device to initiate the processing of all three downloaded images):

```
python  uart_wired_update.py  -b 115200 COM<X>  -f
img3_nonsecure_wire.bin --r 1           -o 0xFFFFFFFF
```

9.2 Upgrading Large Binary (Using --wired-chunk-size feature)

SBL uses DTCM memory for local reassembly and processing of wired update messages to ensure only validated images are written to MRAM. The SBL reserves a fixed amount of memory for its own operation, reducing the total amount of DTCM available for wired updates. User applications may also require some portions of DTCM to remain intact, further limiting the available space for updates. To allow for wired downloads greater than the size of the available DTCM, the wired download

procedure can be made to download a large image in smaller chunks using the **--wire-chunk-size** option.

To split a wired download into sections, you can specify the **--wire-chunk-size** option in the wired download configuration file specifying the maximum number of bytes available in the Apollo5 MCU (the maximum block size). The **create_cust_image_blob.py** script will then automatically split the OTA image into a series of Wired Download images wrapped into a single binary. You can then download this binary to the Apollo5 device using the **uart_wired_update.py** script as normal. The script will detect that the wired update image is composed of multiple pieces and performs the download accordingly.

SECTION

10

Wired Download Procedure

The standard use of wired download images is to allow a binary image to be programmed to a device using a method other than direct programming using the Serial Wire Debug (SWD). This can be useful when the SWD interface is either disabled or physically inaccessible. The basic procedure for downloading a binary to the Apollo5 memory using the wired download option is as follows:

1. Use **create_cust_image_blob.py** to wrap the binary (shown here as "application.bin") into a wired download image. Here, the configuration input file "wired.ini" contains information about where the application binary should be downloaded.

   ```
   python   create_cust_image_blob.py   -c wired.ini    --app_file
   application.bin  --output application_wired.bin
   ```

2. Use the resulting **application_wired.bin** file is then transferred using the **uart_wired_update.py** script to load the application into the Apollo5 memory. This will place a copy of **application.bin** directly into the Apollo5 memory at the address specified in wired.ini configuration file.

10.1 Using Wired Download for OTA

A common use of the "wired download" format is to program a firmware OTA image into a temporary location in the Apollo5 memory, and then have the SBL validate it and move it to its final location. Some reasons you might favor this approach over the previous approach include:

- You are using a secure device, and you need to install a matching content certificate alongside your application binary. (OTA files allow the inclusion of content certificates)
- You want the binary data to be encrypted during the download portion.

- You want the binary data to be authenticated by the SBL before being installed. For most wired download OTA operations, you can use the following procedure:

1. Use **create_cust_image_blob.py** to wrap an application binary into an OTA blob. Here, **firmware.ini** contains the relevant settings for generating the OTA image, and command line options are used to set the input and output binary names.

```
python create_cust_image_blob.py  -c firmware.ini  --app_file
application.bin           --output application_ota.bin
```

2. Use **create_cust_image_blob.py** a second time to wrap the OTA image into a wired download image. Here, the wired.ini file would need to set the "ota" option so the SBL can properly process the data.

```
python  create_cust_image_blob.py  -c wired.ini  --app_file
application_ota.bin       --output application_ota_wired.bin
```

3. Use the **uart_wired_update.py** script to load **application_ota_wired.bin** into the Apollo5 memory and begin the firmware update process.

Ambiq SBL performs all the validations of the image in the DTCM memory before programming to MRAM. This inherently means that the max size for the image that can be downloaded in one go is limited to the available memory to SBL. If you need to download a particularly large image, you can use the **--wired_chunk_size** argument to split the download into multiple pieces. In this case, the bootloader will perform a series of "wired download" operations, each individually verified until the OTA image is fully constructed in the Apollo5 MRAM.

SECTION

11

Appendix A: create_info0.py options

The **create_info0.py** script is driven by command line arguments and/or config file (.ini) file keyword options. There is an extensive list of options. The table below lists all the options that can be supplied to the **create_info0.py** script.

The **.ini** keywords are used in the config file to specify the various options are based register/field names defined the Info0 Register documents (minus the **INFO0**, or **INFO0_OTP** prefix). Details of each field and its use can be found in the register documentation.

Fields with a * are subfields of the previous full 32-bit word field that precedes the * grouping. The options can be specified either as the single full 32-bit word value or using the individual sub fields of the word. The **.ini** file is processed in sequential order and the last processed value for a field/subfield will take precedence (if there is an overlap or duplication). Command line options specified will take precedence over the same options specified in the config file.

Table 11-1: create_info0.py Options

Cmd Line Args		.ini keyword (config files)	Values (32-bit unless specified)[1]
--valid		VALID	1 = Valid (default) (valid sig w/data) 2 = Invalid (invalid sig, data all 0s)
--version		SECURITY_VERSION_VERSION	
--main		MAINPTR_ADDRESS	Default = 0x00410000
--cchain		CERTCHAINPTR_ADDRESS	
--wTO		WIRED_TIMEOUT_TIMEOUT	Default = 2000 (millisecond)
--u0		SECURITY_WIRED_IFC_CFG0	
--u1		SECURITY_WIRED_IFC_CFG1	
--u2		SECURITY_WIRED_IFC_CFG2	
--u3		SECURITY_WIRED_IFC_CFG3	
--u4		SECURITY_WIRED_IFC_CFG4	
--u5		SECURITY_WIRED_IFC_CFG5	
--sdcert		SBR_SDCERT	Default = 0x007FF400
--rma		SECURITY_RMAOVERRIDE_OVERRIDE	2=enabled, 5=disabled (default = 2)
--sresv		SECURITY_SRAM_RESV_SRAM_RESV	
--rcvyCtl		MRAM_RCVY_CTRL	
--rcvyEN	*	MRAM_RCVY_CTRL_MRAM_RCVY_EN	
--progGPIO	*	MRAM_RCVY_CTRL_GPIO_RCVY_INPROGRESS	

Table 11-1: create_info0.py Options *(Continued)*

Cmd Line Args		.ini keyword (config files)	Values (32-bit unless specified)[1]
--emmcPart	*	MRAM_RCVY_CTRL_EMMC_PARTITION	
--wdtEn	*	MRAM_RCVY_CTRL_WD_EN	
--rcvyPol	*	MRAM_RCVY_CTRL_GPIO_CTRL_POL	
--rcvyPin	*	MRAM_RCVY_CTRL_GPIO_CTRL_PIN	
--rcvyRbt	*	MRAM_RCVY_CTRL_APP_RCVY_REBOOT	
--rcvyTyp	*	MRAM_RCVY_CTRL_NV_RCVY_TYPE	
--rcvyModNum	*	MRAM_RCVY_CTRL_NV_MODULE_NUM	
--rcvyWire	*	MRAM_RCVY_CTRL_WIRED_RCVY_EN	
--rcvyAppEN	*	MRAM_RCVY_CTRL_APP_RCVY_EN	
--meta		NV_METADATA_OFFSET_META_OFFSET	
--pwrRstCfg		NV_PWR_RESET_CFG	
--jedecRst	*	NV_PWR_RESET_CFG_JEDEC_RESET	
--pwrRstPol	*	NV_PWR_RESET_CFG_RESET_POL	
--pwrPol	*	NV_PWR_RESET_CFG_PWR_POL	
--pwrDlyUnt	*	NV_PWR_RESET_CFG_PWR_DLY_UNITS	
--pwrDly	*	NV_PWR_RESET_CFG_RESET_DLY	
--nvPin		NV_PIN_NUMS	
--nvCEPin	*	NV_PIN_NUMS_CE_PIN	
--nvRstPin	*	NV_PIN_NUMS_RESET_PIN	
--nvPwrPin	*	NV_PIN_NUMS_PWR_PIN	
--cmdPinCfg		NV_CE_CMD_PINCFG_CE_CMD_PINCGF	
--clkPinCfg	*	NV_CLK_PINCFG_CLK_PINCGF	
--dataPinCfg	*	NV_DATA_PINCFG_DATA_PINCFG	
--dqsPinCfg	*	NV_DQS_PINCFG_DQS_PINCGF	
--nv0		NV_CONFIG0_CONFIG0	
--nv1		NV_CONFIG0_CONFIG1	
--nv2		NV_CONFIG0_CONFIG2	
--nv3		NV_CONFIG0_CONFIG3	
--nvOpt		NV_OPTIONS	
--emmcWidth	*	NV_OPTIONS_EMMC_BUS_WIDTH	
--emmcVolt	*	NV_OPTIONS_EMMC_VOLTAGE	
--mspiPadSet	*	NV_OPTIONS_MSPI_PADSET1	
--mspiD4Clk	*	NV_OPTIONS_MSPI_D4CLK	
--mspiRdClkSel	*	NV_OPTIONS_MSPI_READ_CLKSEL	
--mspiWidth	*	NV_OPTIONS_MSPI_WIDTHS	
--mspiPreClkSel	*	NV_OPTIONS_MSPI_PRECMD_CLKSEL	
--mspiPreCtl	*	NV_OPTIONS_MSPI_PRECMD_CLKSEL	
--mspiRdCmd	*	NV_OPTIONS_MSPI_READCMD	
--preCMDs		NV_MSPI_PRECMDS	
--preCMD1	*	NV_MSPI_PRECMDS_PCMD0	
--preCMD2	*	NV_MSPI_PRECMDS_PCMD1	
--preCMD3	*	NV_MSPI_PRECMDS_PCMD2	
--preCMD4	*	NV_MSPI_PRECMDS_PCMD3	
--retryWD		MRAM_RCV_RETRIES_TIMES	
--maxRetry	*	MRAM_RCV_RETRIES_TIMES_MAX_RETRIES	
--minRetryTm	*	MRAM_RCV_RETRIES_TIMES_MIN_RETRY_TIME	
--maxRetryTm	*	MRAM_RCV_RETRIES_TIMES_MAX_RETRY_TIME	
--info0Cfg		INFO0CFG	File/pathname to Info0 Config file
--loglevel		LOG_LEVEL	0-5

[1] All fields default to 0x0 unless specified.

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