

EG06xK&Ex120K&EM060K Series

Secure Boot Application Note

LTE-A Module Series

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About the Document

Revision History

Version	Date	Author	Description
-	2022-05-09	Shaun DUAN	Creation of the document
1.0	2022-05-26	Shaun DUAN	First official release
1.1	2023-12-07	Shaun DUAN/ Jayde TONG	<ol style="list-style-type: none">1. Added the applicable modules EG060K Series, EG120K Series, EM060K Series and EM120K-GL.2. Updated the content of certificate chain (Chapter 2.3).3. Added AT+QSECBOOT="roothash" (Chapter 3.3).4. Updated development considerations (Chapter 4).

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1 Introduction

Quectel LTE-A EG06xK, Ex120K and EM060K series modules support Secure Boot function. This document describes how to use AT commands to enable the Secure Boot function on EG06xK, Ex120K and EM060K series modules, including an overview of Secure Boot, detailed explanations of AT commands, and precautions.

1.1. Applicable Modules

Table 1: Applicable Modules

Module Family	Module
EG06xK	EG060K Series
	EG065K Series
Ex120K	EM120K-GL
	EG120K Series
-	EM060K Series

2 Secure Boot Overview

2.1. Definition

Secure Boot is defined as a boot sequence based on the trust platform. In order to ensure that only software that passes verification is executed, Secure Boot adds signature verification during the startup process.

At each stage of the Secure Boot process, signature verification is performed to prevent any software without valid signature or maliciously modified software from running on the module. A root trusted entity is needed during the boot process. The Primary Boot Loader (PBL), embedded in the module as a firmware, is unmodifiable, and therefore can serve as the root trusted entity.

2.2. Secure Boot Enabling

Secure Boot can only be enabled with the fuse on the hardware and cannot be disabled after being enabled.

The Secure Boot process comprises multiple stages, and the image in each stage performs a specific function. After the Secure Boot is enabled, the image to be executed in each stage needs to be verified by the previously verified image. If the verification fails, the entire boot process stops, and the module cannot boot up.

As the root of trust (RoT), the PBL is the firmware embedded in chips and cannot be modified. Therefore, it is considered as the most trusted entity in the booting process, and authenticates the image to be executed in the next boot stage. The SBL is usually verified in the second boot stage. After it is successfully authenticated by the PBL, it can be executed and used to authenticate the image in the next stage. Since the SBL has been trusted, it can be used to authenticate the image in the next stage.

2.3. Certificate Chain

Secure Boot adopts 2048-bit RSA algorithm and SHA-256 digest algorithm for signing the certificates and images.

The certificate chain of the module adopts three-level certificates: Self-signed root certificate, Attestation CA certificate and Attestation certificate.

2.4. Image Signing

The standard format of images is ELF. During Secure Boot, the images to be executed in each boot stage must be signed first. A binary file in the standard ELF format includes several segments indicating different types of information separately, wherein the hash table segment stores signature related information. The hash table segment also includes the hash values of each segment and the information about certificate trust chain.

The images that must be signed in the Secure Boot process for the module are as follows:

- *sbl1.mbn*
- *appsboot.mbn*
- *prog_nand_firehose_9x55.mbn*
- *rpm.mbn*
- *tz.mbn*
- *devcfg.mbn*
- *qdsp6sw.mbn*
- *mba.mbn*
- *mcfg_sw.mbn*
- *mcfg_hw.mbn*

2.5. QFPROM Configuration

The modules include one-time programmable fuses. The initial states of all fuses are 0 (Secure Boot disabled). Once a writing operation is performed on the fuse (or the fuse is blown), the state of the fuse permanently becomes 1 (Secure Boot enabled). The state cannot be changed after the fuse is blown, which means that the Secure Boot enabling is an irreversible operation. To start Secure Boot, the program tool QFPROM is required.

QFPROM is used to store, in NVROM, configurations related to chip authentication and can implement the secure environment required by Secure Boot. Configure QFPROM and then blow the fuse, to complete all security functions such as output of Debug port, JTAG, secure file system, and software version rollback prevention.

3 Secure Boot Related AT Commands

3.1. AT Command Syntax

3.1.1. Definitions

- **<CR>** Carriage return character.
- **<LF>** Line feed character.
- **<...>** Parameter name. Angle brackets do not appear on the command line.
- **[...]** Optional parameter of a command or an optional part of TA information response. Square brackets do not appear on the command line. When an optional parameter is not given in a command, the new value equals its previous value or the default settings, unless otherwise specified.

Underline Default setting of a parameter.

3.1.2. AT Command Syntax

All command lines must start with **AT** or **at** and end with **<CR>**. Information responses and result codes always start and end with a carriage return character and a line feed character: **<CR><LF><response><CR><LF>**. In tables presenting commands and responses throughout this document, only the commands and responses are presented, and **<CR>** and **<LF>** are deliberately omitted.

Table 2: Types of AT Commands

Command Type	Syntax	Description
Test Command	AT+<cmd>=?	Test the existence of the corresponding command and return information about the type, value, or range of its parameter.
Read Command	AT+<cmd>?	Check the current parameter value of the corresponding command.
Write Command	AT+<cmd>=<p1>[,<p2>[,<p3>[...]]]	Set user-definable parameter value.
Execution Command	AT+<cmd>	Return a specific information parameter or perform a specific action.

3.2. Declaration of AT Command Examples

The AT command examples in this document are provided to help you learn about the use of the AT commands introduced herein. The examples, however, should not be taken as Quectel's recommendations or suggestions about how to design a program flow or what status to set the module into. Sometimes multiple examples may be provided for one AT command. However, this does not mean that there is a correlation among these examples, or that they should be executed in a given sequence.

3.3. AT Commands Description

3.3.1. AT+QSECBOOT Enable or Query Secure Boot

AT+QSECBOOT Enable or Query Secure Boot	
Test Command AT+QSECBOOT=?	Response +QSECBOOT: "status", (list of supported <enable>s) +QSECBOOT: "serialnum", <serial_number> +QSECBOOT: "roothash", <root_hash> +QSECBOOT: "progsec", (list of supported <enable>s) OK If there is any error: ERROR
Maximum Response Time	300 ms
Characteristic	/

3.3.1.1. AT+QSECBOOT="status" Query Enabling Status of Secure Boot

This command queries enabling status of Secure Boot.

AT+QSECBOOT="status" Query Enabling Status of Secure Boot	
Write Command AT+QSECBOOT="status"	Response +QSECBOOT: "status", <enable> OK If there is any error:

	ERROR
Maximum Response Time	300 ms
Characteristic	/

Parameter

<enable>	Integer type. Enabling status of Secure Boot.
1	Enabled
0	Disabled

3.3.1.2. AT+QSECBOOT="serialnum" Query Unique Serial Number of Module

This command queries the unique serial number of the module.

AT+QSECBOOT="serialnum" Query Unique Serial Number of Module	
Write Command AT+QSECBOOT="serialnum"	Response +QSECBOOT: "serialnum",<serial_number> OK If there is any error: ERROR
Maximum Response Time	300 ms
Characteristic	/

Parameter

<serial_number>	String type. Serial number of the module in hexadecimal format without double quotes.
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3.3.1.3. AT+QSECBOOT="roothash" Query the Hash Value of the Root Certificate

This command queries the hash value of the root certificate after Secure Boot is enabled in the module.

AT+QSECBOOT="roothash" Query the Hash Value of the Root Certificate	
Write Command AT+QSECBOOT="roothash"	Response +QSECBOOT: "roothash",<root_hash>

	OK If there is any error: ERROR
Maximum Response Time	300 ms
Characteristic	/

Parameter

<root_hash>	String type. Hash value of the root certificate in hexadecimal format without double quotes.
--------------------------	--

NOTE

The hash value of the root certificate is 0 when Secure Boot is not enabled.

3.3.1.4. AT+QSECBOOT="progsec" Enable Secure Boot

This command enables Secure Boot.

AT+QSECBOOT="progsec" Enable Secure Boot	
Write Command AT+QSECBOOT="progsec"[,<enable>]	Response If the optional parameter is omitted, query the current setting: +QSECBOOT: "progsec",<enable> OK If the optional parameter is specified, enable Secure Boot: OK If there is any error: ERROR
Maximum Response Time	300 ms
Characteristic	This command takes effect after the module is rebooted. The configuration is saved automatically.

Parameter

<enable>	Integer type. Whether Secure Boot is enabled.
1	Enabled
<u>0</u>	Disabled (Only valid in the query result)

4 Development Considerations

1. Secure Boot can only be enabled with the hardware fuse and cannot be disabled after being enabled.
2. It is recommended to use **AT+QSECBOOT="progsec",1** to enable the Secure Boot, which is not enabled by default. This command downloads the image file in the sec partition and automatically activates the Secure Boot after rebooting the module.
3. After the Secure Boot is enabled, it is not supported to use the firehose to downgrade the firmware to a version that does not support the Secure Boot.
4. After the Secure Boot is enabled, it is not supported to downgrade the firmware to a version that does not support the Secure Boot through FOTA, otherwise the module cannot be started normally.
5. The PCIe Fuse mode also downloads the image file in the sec partition, which conflicts with the enabling of Secure Boot. If the Secure Boot is enabled first, the PCIe Fuse mode cannot be enabled. Therefore, you need to enable PCIe Fuse mode first and then enable the Secure Boot.
6. Secure Boot must be enabled at the factory stage. It is forbidden to enable the Secure Boot after the firmware version is upgraded to a version that supports the Secure Boot. Otherwise, some functions may be abnormal and cannot be recovered. Before the Secure Boot is enabled, it is strongly recommended that do not perform any configuration on the module, such as the SIMLOCK configuration.

5 Appendix Terms and Abbreviations

Table 3: Terms and Abbreviations

Abbreviation	Description
CA	Certificate Authority
ELF	Executable and Linkable Format
FOTA	Firmware Over-The-Air
MBN	Multi Boot Image Format
PBL	Primary Boot Loader
PCIe	Peripheral Component Interconnect Express
QFPROM	Qualcomm Fuse Programmable Read Only Memory
ROM	Read Only Memory
RPM	RPM Package Manager (originally Red Hat Package Manager)
RoT	Root of Trust
SBL	Secondary Boot Loader
SHA	Secure Hash Algorithm