Renesas RA Family

# Renesas Boot Firmware for RA8M1 MCU Group

## Introduction

This application note describes the communication protocol, command set, and usage of the boot firmware provided with Renesas RA8M1 MCU Group.

## Target Device

RA8M1 MCU Group

## Contents

## 1. Terminology

### 1.1 Boot Firmware

Boot firmware is the program included in the microcontroller to rewrite the flash memory.

### 1.2 Flash Memory

The following areas are collectively called flash memory:

- Code Flash: The ROM area where program code is written (FLP/FLI)
- Data Flash: The ROM area where data is written (EEP)

The Code Flash area used by the user is called the "User area," the Data Flash area used by the user is called the "Data area," and the area to store configuration data is called the "Config area". The boot firmware rewrites and reads the User area, Data area, and Config area according to the commands given by the user.

Also, in this document, the flash memory area that can be rewritten by boot firmware may be generically referred to as "memory".

Figure 1 shows an example of flash memory structure. Memory structure differs from device to device.
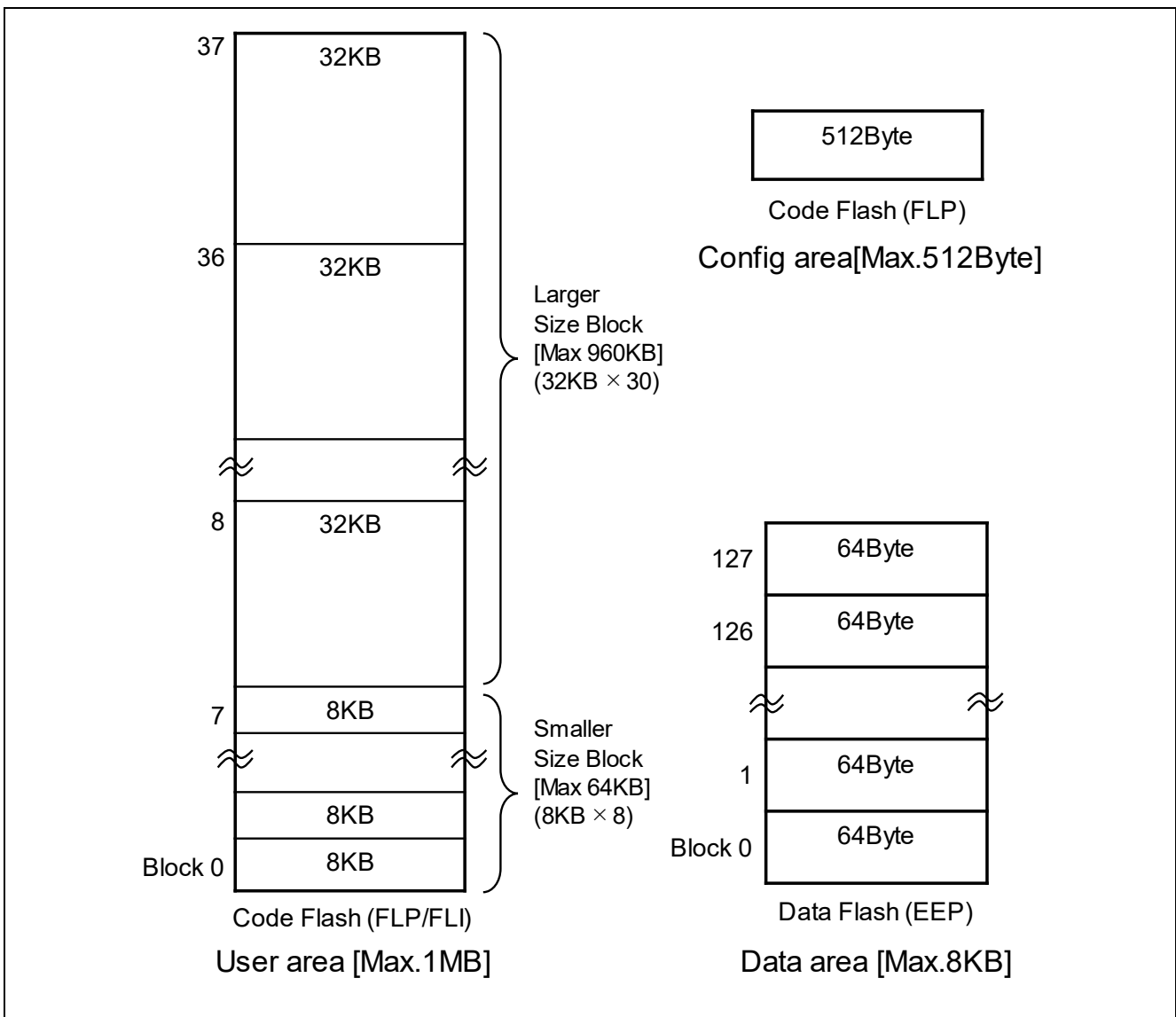


**Figure 1. Flash Memory Structure Example**

## 1.3  Device Lifecycle Management (DLM)

The Renesas Advanced (RA) Family MCUs adopt the device lifecycle concept and maintain the lifecycle state inside the device.

The boot firmware controls the executable commands and the range of operations that can be performed with each command in each lifecycle state. In addition, the boot firmware has a user-executable command as the only way to transition lifecycle states.
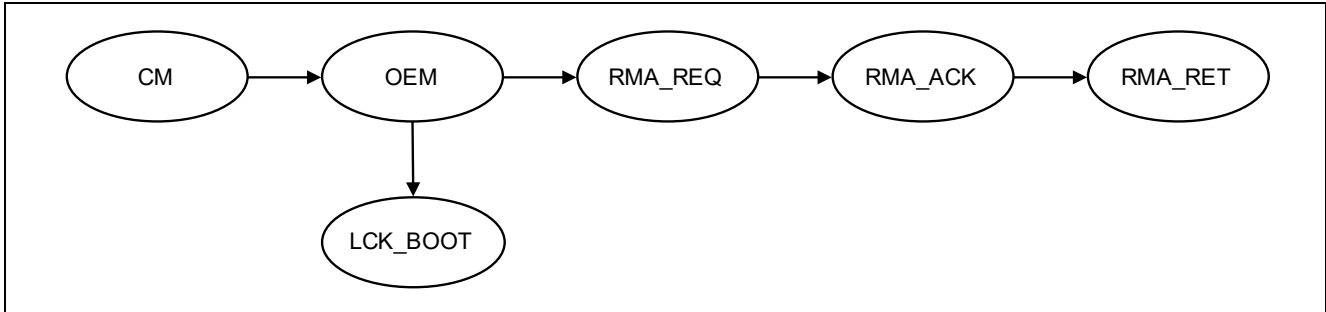


Figure 2.    Device Lifecycle States

Table 1.    DLM States

| DLM State Name | Description |
|---|---|
| CM | Chip Manufacturing |
| OEM | Original Equipment Manufacturer |
| LCK_BOOT | LoCKed BOOT interface |
| RMA_REQ | Return Material Authorization REQuest |
| RMA_ACK | Return Material Authorization ACKnowledged |
| RMA_RET | Return Material Authorization RETurn |

## 1.4  Authentication Level (AL)

In the RA8 MCU Series, the executable commands and the range of operations that can be performed with each command are determined by not only the DLM state but also the Authentication level. There are three Authentication levels: AL2, AL1, and AL0. The executable operation range is the widest at AL2 and the narrowest at AL0.

Changing the Authentication level is possible only when the DLM state is OEM, so that the executable operation range at OEM is more subdivided. On the other hand, changing the Authentication level when the DLM state is not OEM is not possible because the DLM state and Authentication level are uniquely associated with DLM states other than OEM. To change the Authentication level at OEM, change the Protection level, then reset the device, or use dedicated boot firmware commands. Level change by the boot firmware command is a temporary change, and the Authentication level returns to the level before the change when resetting the device.
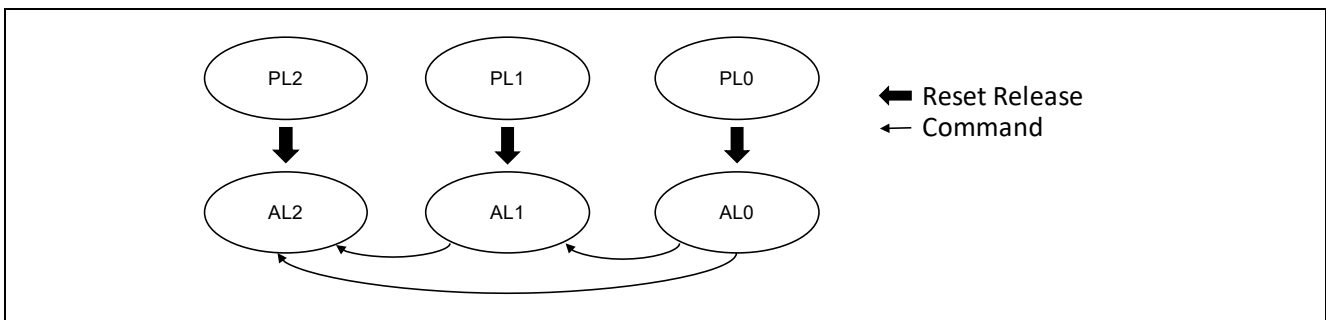


Figure 3.    Authentication Level Transitions

**Table 2.    Authentication Level States**

| AL State Name | Description |
|---|---|
| AL2 | Authentication Level 2 |
| AL1 | Authentication Level 1 |
| AL0 | Authentication Level 0 |

## 1.5   Protection Level (PL)

Protection level is the initial Authentication level: the Authentication level when the device boots is determined by the Protection level. Like Authentication level, it is not possible to change the Protection level when the DLM state is not OEM. To change the Protection level at OEM, use dedicated boot firmware commands.
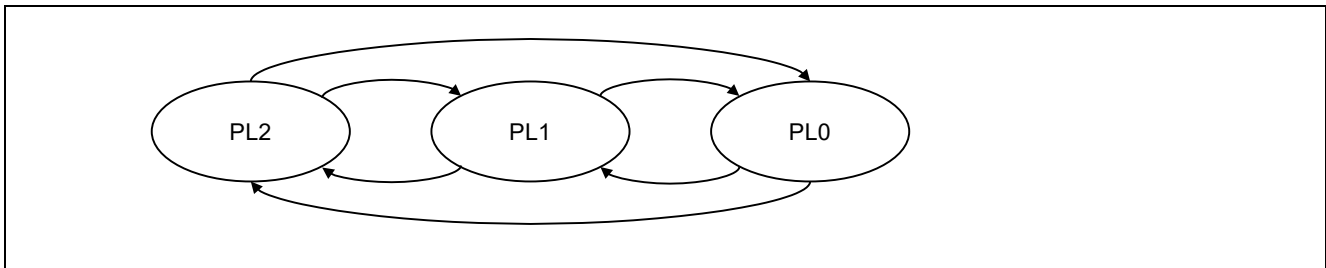


**Figure 4.    Protection Level Transitions**

**Table 3.    Protection Level States**

| PL State Name | Description |
|---|---|
| PL2 | Protection Level 2 |
| PL1 | Protection Level 1 |
| PL0 | Protection Level 0 |

## 1.6   Secure / Non-secure

Renesas Advanced (RA) Family MCUs have the attributes of Secure and Non-secure. In particular, the memory area is divided into two exclusive areas: a Secure area and a Non-secure area. The CPU core has two security states: a Secure state and a Non-secure state. The security state of the CPU changes depending on the Secure attribute of the memory where the execution code exists. When the CPU core processes the execution code in the Secure area, it is in the Secure state, and when it processes the execution code in the Non-secure area, it is in the Non-secure state.

The boot firmware specifies a Secure area and a non-secure area for the User area and Data area by a command from the user. The allocation setting of the secure area and non-secure area is referred to as "boundary" in this document. The boundary can be set using the **Boundary** setting command of boot firmware.

## 1.7   Block Protection

Block protection refers to a function that prohibits erasing/writing the specified range of flash memory. The specified range is done in blocks, and there are two types of protection listed in Table 4.

**Table 4.    Block Protection Types**

| Types of protection | Description |
|---|---|
| Block protection (BPS) | Protection that can temporarily enable erasing/writing by register setting of the flash sequencer. |
| Permanent block protection (PBPS) | Protection that permanently disables releasing the Block protection setting. |

## 1.8 Lock Bit

Lock bit refers to a function that prohibits erasing/writing the specified range of flash memory. There are the following differences from Block protection:

- The specified range is not in block units.
- Protection cannot be temporarily disabled by register settings.

## 1.9 Image

"Image" means data written to flash memory or MRAM using boot firmware.

While "write data" refers to each data to be written, "image" refers to a set of write data to be written to a device or an area.
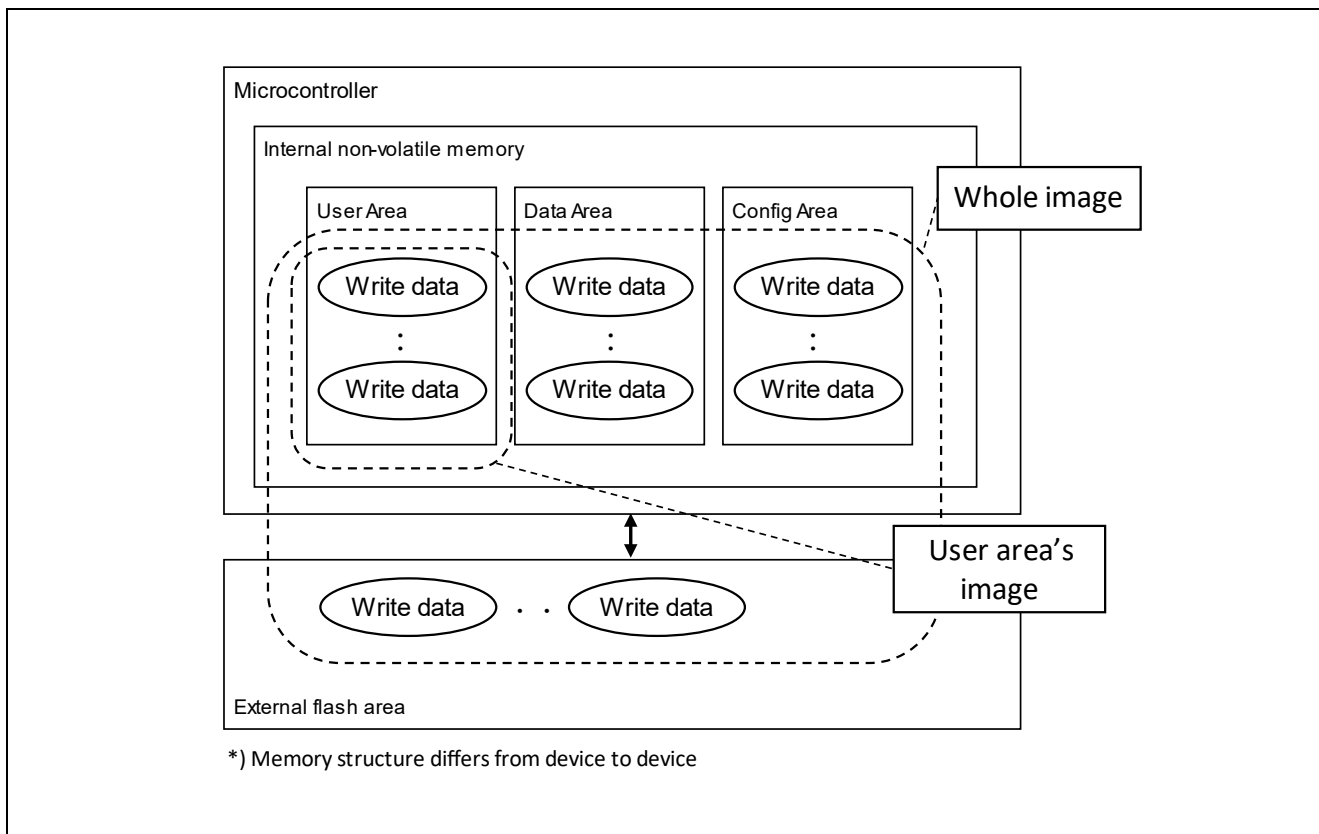


**Figure 5.  Memory Image Concept**

## 2. System Architecture

Boot firmware has a serial programming interface to send and receive memory control commands between the microcontroller and the host in the serial programming mode. Boot firmware is embedded into the device.

## 2.1 RA8M1 MCU Group

This chapter describes the system architecture of RA8M1 MCU Group regarding the flash memory control.

**Table 5.  Operating Environment**

| CPU core | Arm Cortex-M85 |
|---|---|
| Max CPU operating frequency | 480 MHz (Boot firmware operating frequency: 200 MHz) |
| Main-OSC | 8, 10, 12, 15, 16, 20, 24, 32, 48 MHz<br>• If neither is set, operates with HOCO.<br>• However, if a Main-OSC whose frequency is around plus-minus 3% or less of the frequency above is set, there is a possibility that the frequency is misjudged and therefore USB communication fails. To avoid this, it is recommended to choose one of the following options when using USB communication: |

| | |
|---|---|
| | — Use a Main-OSC whose frequency is the very value listed above.<br>— Do not use a Main-OSC and use a Sub-OSC with a frequency that is supported by the device's specifications. |
| Operating voltage | VCC = 1.68–3.6 V<br>When using USB communication: VCC = 3.0–3.6 V |
| Operating mode | Boot mode |
| Flash memory | <table><tr><td>Code Flash</td><td>User area</td><td>Max. 2016 KB [2MAT]</td></tr><tr><td></td><td>User boot area</td><td>None</td></tr><tr><td>Data Flash</td><td>Data area</td><td>Max. 12 KB</td></tr><tr><td></td><td>Extended data area</td><td>None</td></tr></table> |
| RAM | SRAM: 1 MB (used by the Boot firmware: within 256 KB) |
| Communication method | • [2-wire UART communication]<br>— (Initial/Min) 9600 bps<br>— (Max) 6 Mbps<br>• [USB communication]<br>— 12 Mbps<br>— When performing USB communication with HOCO, Sub-OSC must be oscillating stably.<br>— USB communication operation is only guaranteed for use with Windows 10 as the host OS. Use with other host OS systems is not guaranteed.<br>• [JTAG/SWD communication]<br>— 25 MHz |
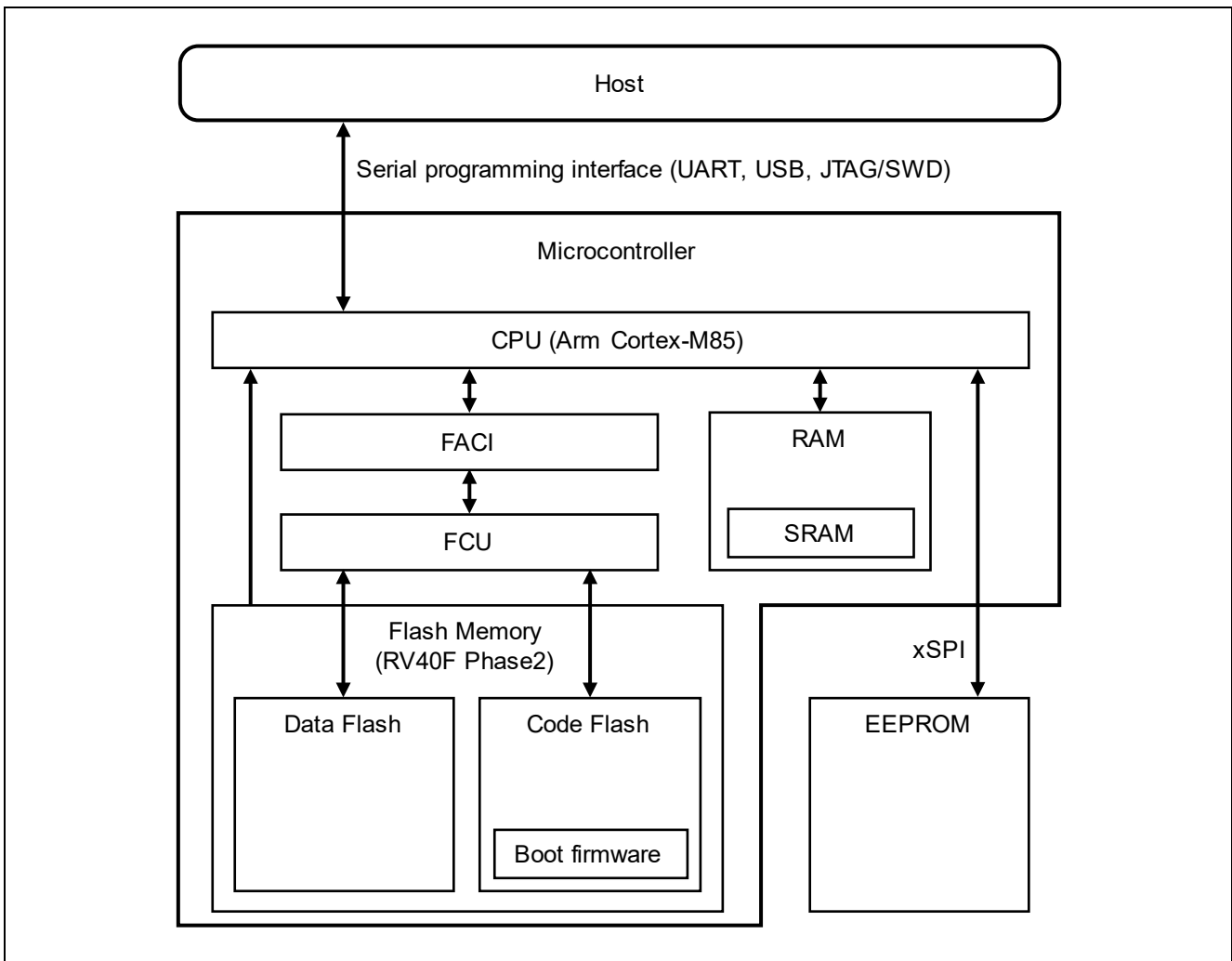
**Figure 6.    Block Diagram**

## 3.    Communication Methods

Boot firmware has interfaces for the following communication methods:

- 2-wire UART communication
- Universal Serial Bus (USB) communication
- JTAG/SWD communication

## 3.1    2-wire UART communication

Boot firmware supports the 2-wire UART communication as shown in Figure 7.
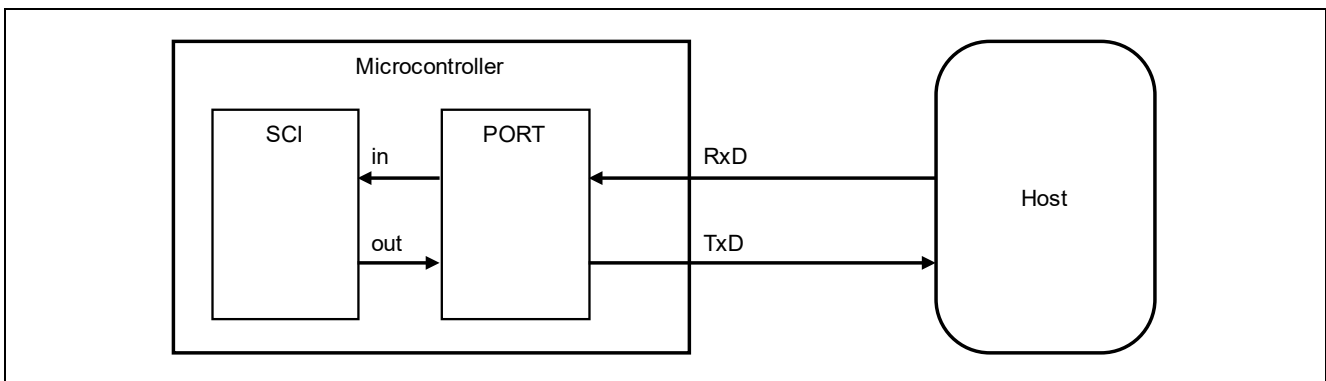


**Figure 7.    2-Wire UART Communication**

**Table 6. UART Settings**

| Interface | RSCI-3 ch9 |
|---|---|
| **RxD** | P208, input mode |
| **TxD** | P209, output mode |
| **Transfer rate** | 9600 bps (minimum, until the baudrate setting command) |
| | 6 Mbps (maximum) |
| **Data length** | 8 bits (LSB first) |
| **Parity bit** | None |
| **Stop bit** | 1 bit |

Communication is performed at 9600 bps until the baudrate setting command. After the baudrate setting command is completed, communication is performed at the desired transfer rate. The maximum transfer rate that can be communicated with the device is returned by "RMB" of the signature request command.

**Note:** If the communication cable is disconnected during communication, subsequent operations are not guaranteed.

## 3.2 Universal Serial Bus (USB) Communication

Boot firmware supports USB communication as shown in Figure 8.
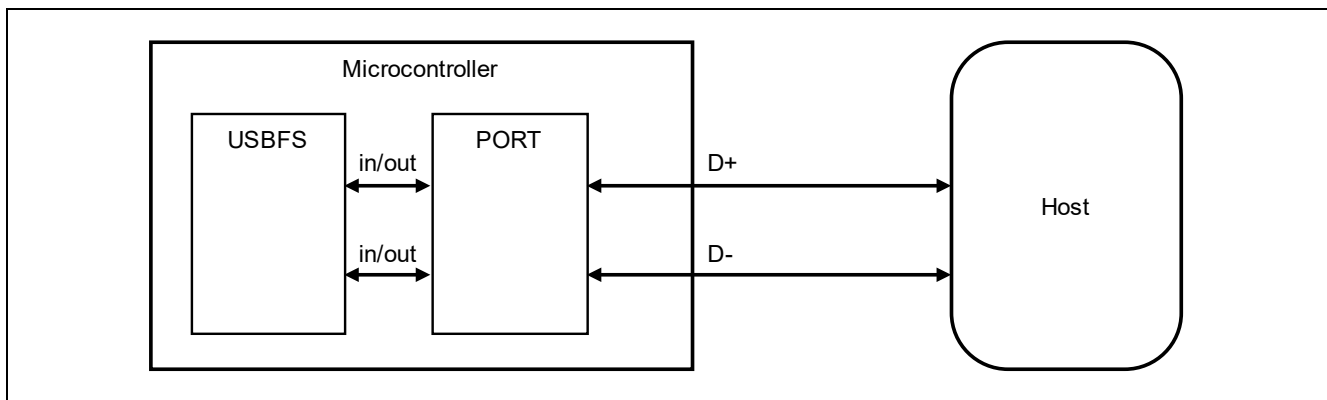


**Figure 8. USB Communication**

**Table 7. USB Settings**

| Interface | USBFS |
|---|---|
| **VBUS** | P407, input mode |
| **D+** | Input-output mode |
| **D-** | Input-output mode |
| **Transfer rate** | 12 Mbps (USB2.0 Full-Speed) |
| **Device class** | Communication device class (CDC) |
| | • SubClass: Abstract Control Model (ACM) |
| | • Protocol: Common AT commands |
| **Vendor ID** | 045Bh (Renesas) |
| **Product ID** | 0261h |
| **Transfer mode** | Control (in/out) |
| | Bulk (in, out) |
| | Interrupt (in) |
| **Endpoint** | EP0: Default control pipe, control transfers (in/out) |
| | EP1: TxD pipe, bulk transfers (in) 64 bytes |
| | EP2: RxD pipe, bulk transfers (out) 64 bytes |
| | EP6: Control pipe, interrupt transfers (in) |

Notes:

- If the USB cable is disconnected during communication, subsequent operations are not guaranteed.
- When performing USB communication, the host is notified as self-power mode.
- USB boot does not guarantee operation with bus power.

## 3.3   JTAG/SWD Communication

Boot firmware supports JTAG/SWD communication. JTAG/SWD communication is enabled by setting a magic code in the JBMDR register during terminal reset.
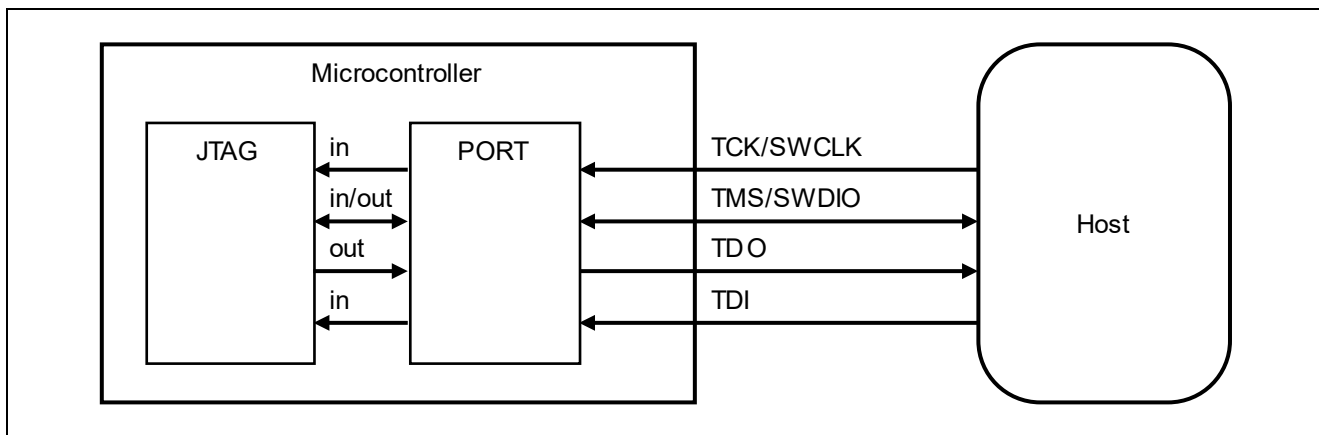


**Figure 9.    JTAG/SWD Communication**

**Table 8.    JTAG/SWD Settings**

| [JTAG] TCK | P211, input mode |
|---|---|
| [JTAG] TMS | P210, input mode |
| [JTAG] TDO | P209, output mode |
| [JTAG] TDI | P208, input mode |
| [SWD] SWCLK | P211, input mode |
| [SWD] SWDIO | P210, input-output mode |
| Transfer rate | 25 MHz (maximum) |
| Data length | 32 bits |
| Magic code | A5h |

### 3.3.1   Endianness of Transmission and Reception Data

Store the data transmitted from the host in the JBRDR register in 4-byte words in order from the lower byte.

The data transmitted from the microcontroller is stored in the JBTDR register in 4-byte words in order from the lower byte.

**Example: 1-byte data transmission from the host to the microcontroller**

Sending data: 55h

| JBRDR[31:24] | JBRDR[23:16] | JBRDR[15:8] | JBRDR[7:0] |
|---|---|---|---|
| Don't care | Don't care | Don't care | 55h |

**Example: 7-byte data transmission from the microcontroller to the host**

Sending data: 00h, 01h, 02h, 03h

| JBTDR[31:24] | JBTDR[23:16] | JBTDR[15:8] | JBTDR[7:0] |
|---|---|---|---|
| 03h | 02h | 01h | 00h |

Sending data: 04h, 05h, 06h

| JBTDR[31:24] | JBTDR[23:16] | JBTDR[15:8] | JBTDR[7:0] |
|---|---|---|---|
| Don't care | 06h | 05h | 04h |

### 3.3.2 Communication Handshake

The host and microcontroller perform a handshake using the JBSTR register in JTAG/SWD communication.

The host must check that JBSTR.RDF=0 before writing data to JBRDR, and JBSTR.TDE=0 before reading data from JBTDR.

However, this handshake can be omitted when transmitting and receiving 5th byte or after in a packet. Specifically, the host can write JBRDR and read JBTDR without checking JBSTR.

5th-byte or after in a packet means the following bytes specifically for command and data packets:

| | |
|---|---|
| **Command packet** | Command information − ETX |
| **Data packet** | Data − ETX |

# 4.  General Procedure

Boot firmware transits phases in the following order after the reset release:

1. Initialization phase
2. Communication setting phase
3. Command acceptable phase

The above sequence cannot be altered.

## 4.1  Sequence Diagram (Generic Sequence)
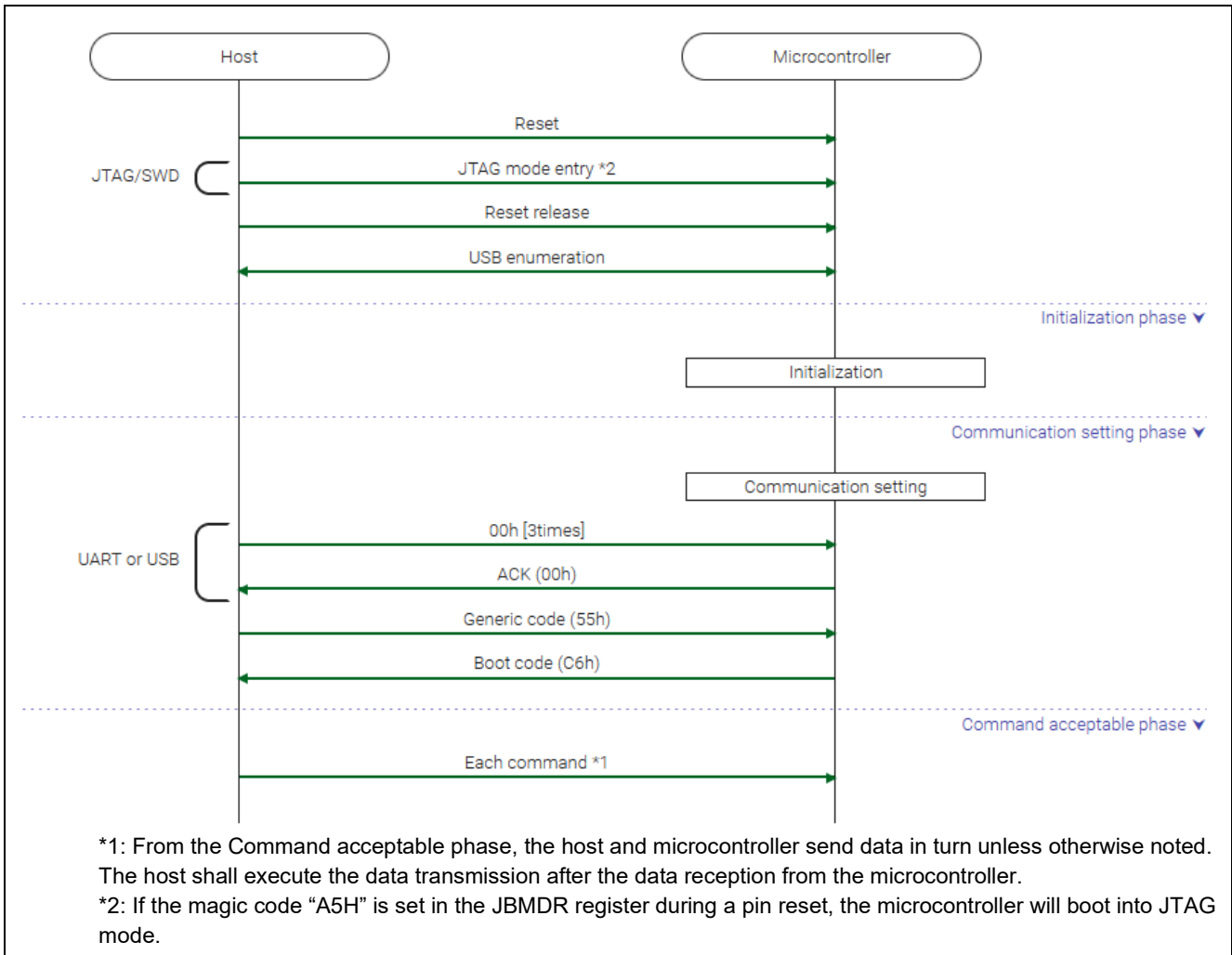


**Figure 10.  Sequence Diagram (Generic Sequence)**

## 4.2  State Transition Diagram (Generic State Transition)



*1: Boot firmware adopts IP (SCI or USBFS) that received 00h consecutively three times earlier as the communication method.
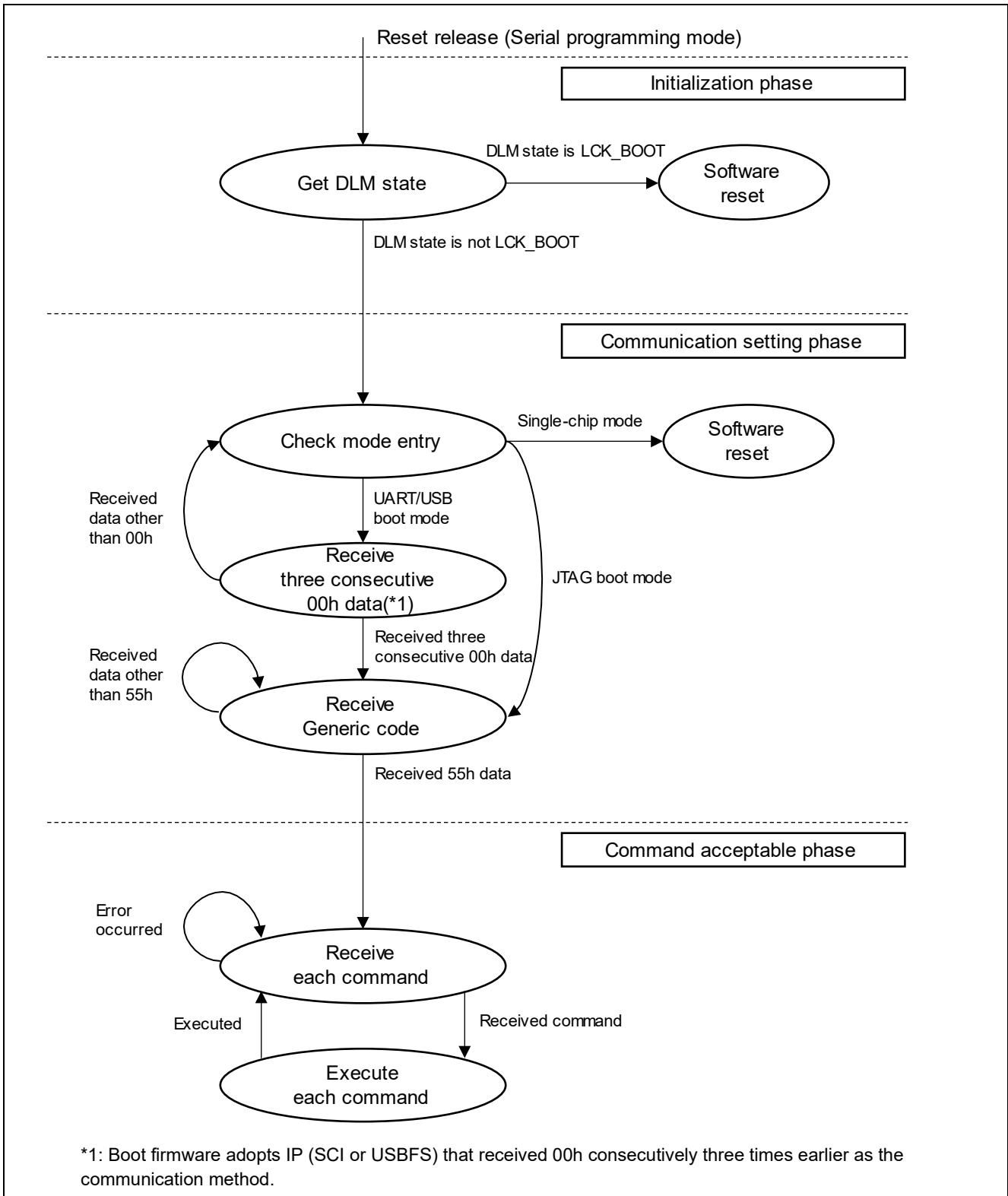
**Figure 11.  State Transition Diagram (Generic State Transition)**

## 4.3 Initialization Phase

Boot firmware initializes hardware modules in this phase. After that, boot firmware transits to the "Communication setting phase".

### 4.3.1 Processing Procedure

Boot firmware initializes after reset release.

Boot firmware initializes hardware modules, then transits to the "Communication setting phase".

## 4.4 Communication Setting Phase

The boot firmware establishes communication with the host in this phase. Check the connection of each communication method under the conditions shown in Table 9. After receiving the generic code using the established communication method, the boot firmware transitions to the "Command acceptable phase".

**Table 9.   Communication Method Determination**

| Condition | Communication method |
|---|---|
| Data "00h" was continuously received 3 times by 2-wire UART communication. | 2-wire UART communication |
| Data "00h" was continuously received 3 times by USB communication. | USB communication |
| DBGSTR.CDBGPWRUPREQ=1 is set during terminal reset.<br>Magic code "A5h" was set in the JBMDR register during terminal reset.<br>MD pin level is high. | JTAG/SWD communication |

### 4.4.1 Processing Procedure

Boot firmware performs communication settings:

- When all the following conditions are met, the boot firmware performs a software reset:
  — MD=1
  — JBMDR≠A5h
  — First 8 bytes of User area≠all-F
- When all the following conditions are met, JTAG/SWD communication is determined to be selected.
  * When JTAG/SWD communication is selected, boot firmware waits for the generic code without waiting for 00h.
  — MD=1
  — JBMDR=A5h
- When JTAG/SWD communication is not selected, boot firmware waits for 00h to be received.
  If 00h is received continuously for 3 bytes in either 2-wire UART communication or USB communication, "ACK" is transmitted. (Data is received until the communication mode is determined)
  The time from when reset is released until 00h can be received is shown in AC Characteristics.
- After that, when the generic code is received, boot firmware sends a "Boot code".
  If a code other than the generic code is received, the boot firmware waits to receive the generic code again.
  The time from when reset is released until the generic code can be received is shown in AC Characteristics.
- The boot firmware transitions to the "Command acceptable phase" when the transmission of "Boot code" is completed.

## 4.4.2 Settings of the 2-wire UART Communication

When the device operating mode is serial programming mode, the boot firmware initializes SCI and waits for reception. By receiving 00h three times consecutively, it is determined that asynchronous 2-wire communication is selected as the communication method. Before receiving 3 bytes, if data other than 00h is received or some data is received from USB, the count value is reset.
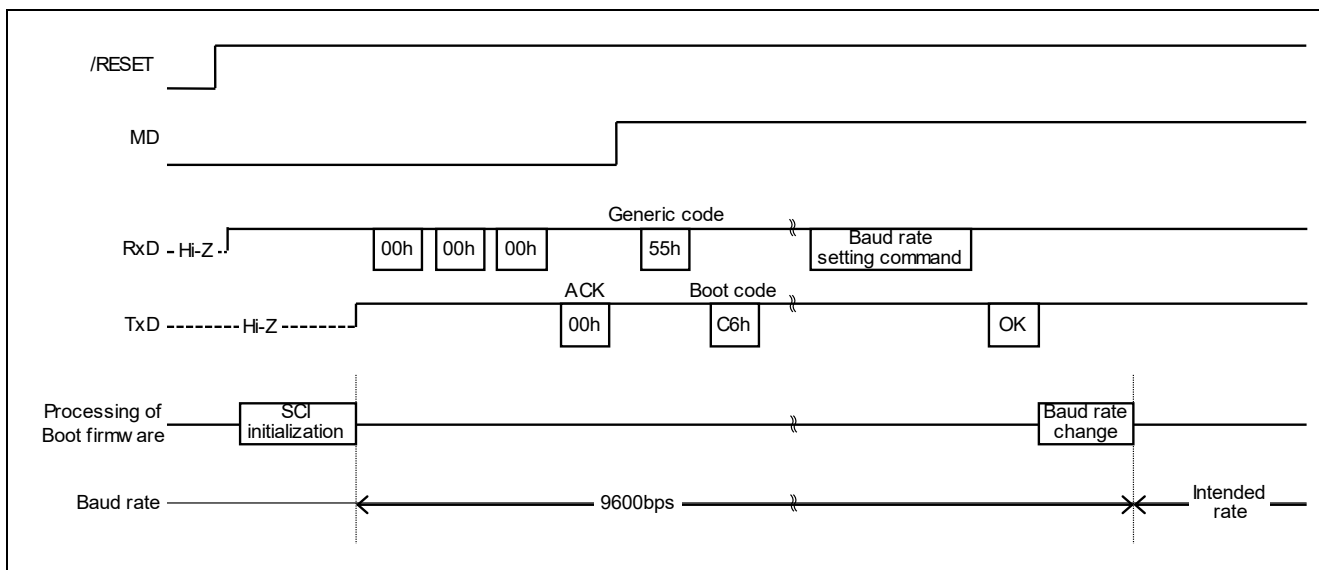


**Figure 12. 2-wire UART Communication Setting**

Boot firmware version lower than 3.0 outputs High from TxD after SCI initialization.

Boot firmware version after or equal to 3.0 enables pull-up of TxD after SCI initialization, and outputs High from TxD after 3-byte 00h reception. After SCI initialization, the boot firmware outputs High from TxD.

By performing the following procedure, communication establishment is completed, and the process moves to the "Command acceptable phase":

1. Receive 3 bytes of 00h data (9600bps) from the host.
   (Perform 00h data transmission until ACK is received in step 2.)
2. Send 00h data (ACK) from boot firmware.
3. Receive 55h data (Generic code) from the host.
4. Send C6h data (Boot code) from boot firmware.

If ACK is not returned even after sending 00h data, check the communication environment and try again from reset release.

### 4.4.3   Settings of the USB Communication

When the device's operating mode is serial programming mode, the boot firmware configures the USB into an enumerable state. Set the data communication start by USB Configured status detection. By receiving 00h three times consecutively, it is determined that USB communication is selected as the communication method. Before receiving 3 bytes, if data other than 00h is received or some data is received from UART, the count value is reset.
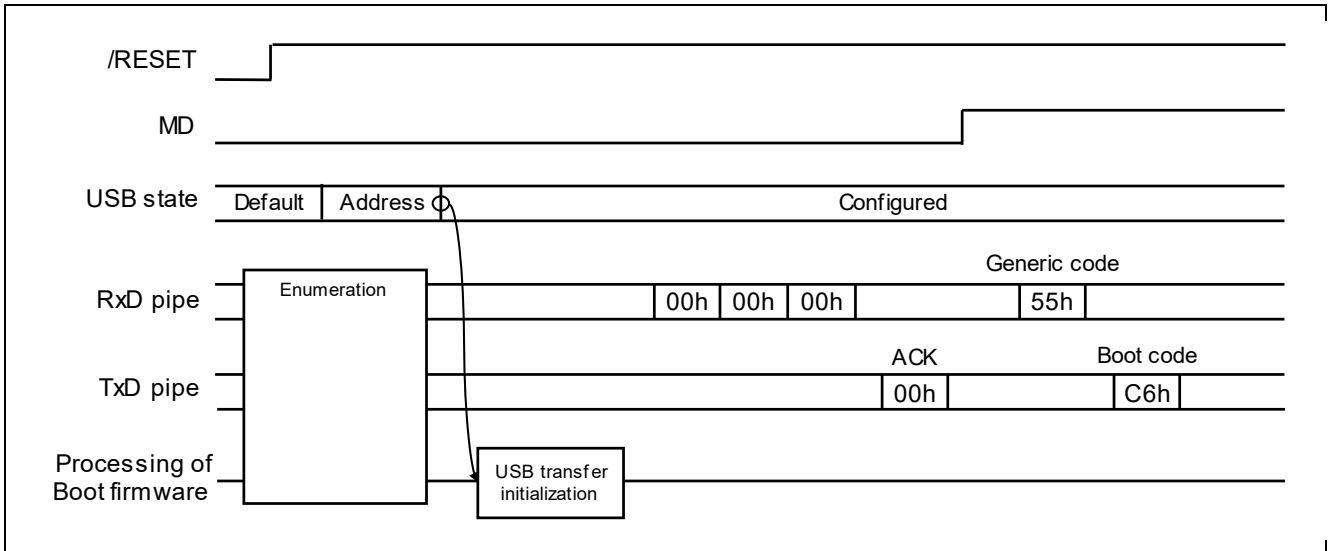


**Figure 13.  USB Communication Setting**

By performing the following procedure, communication establishment is completed, and the process moves to the "Command acceptable phase":

1. When the boot firmware detects the USB Configured state, the USB communication start setting is performed.
2. Receive 3 bytes of 00h data from the host.
   (Perform 00h data transmission until ACK is received in step 3.)
3. Send 00h data (ACK) from boot firmware.
4. Receive 55h data (Generic code) from the host.
5. Send C6h data (Boot code) from boot firmware.

If ACK is not returned even after sending 00h data, check the communication environment and try again from the reset release.

### 4.4.4    Settings of the JTAG/SWD communication

When the boot firmware detects MD=1 and JBMDR=A5h, the boot firmware establishes communication with JTAG/SWD communication.
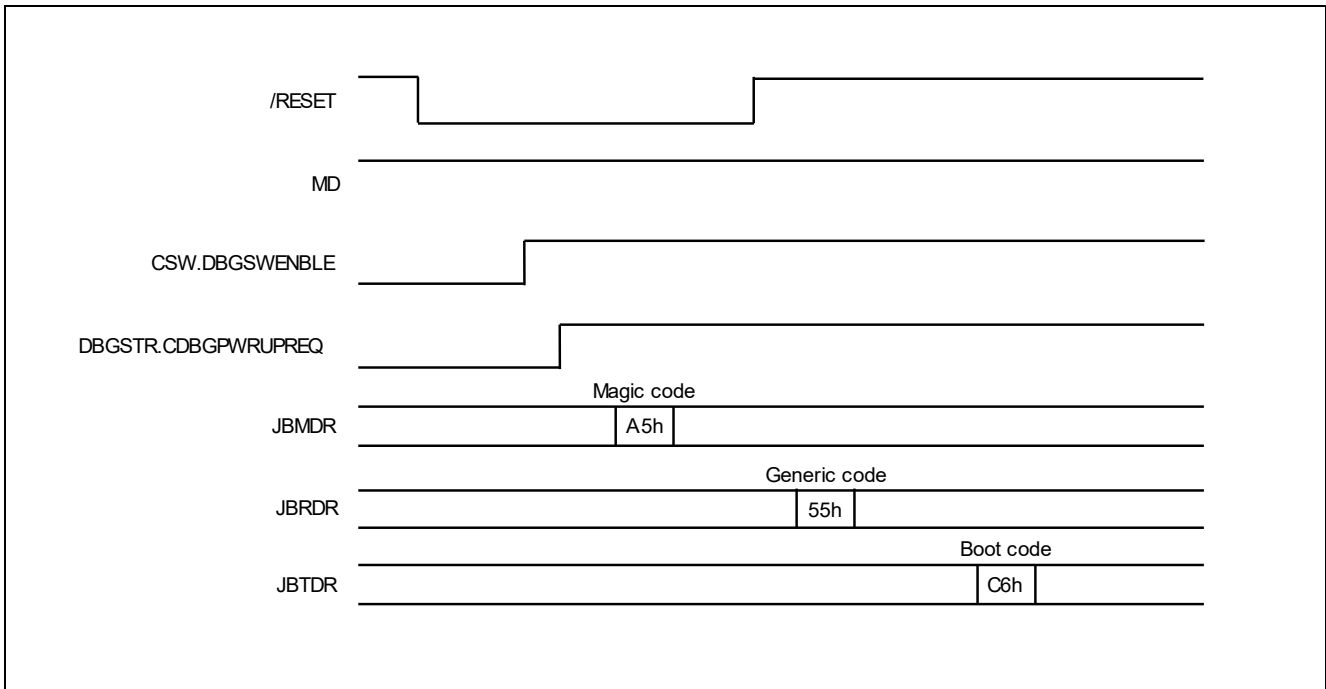


**Figure 14.  JTAG/SWD Communication Setting**

By performing the following procedure, communication establishment is completed, and the process moves to the "Command acceptable phase":

1.  Assert the terminal reset.
2.  Set CSW.DBGSWENBLE to 1.
3.  Set DBGSTR.CDBGPWRUPREQ to 1.
4.  Wait until DBGSTR.CDBGPWRUPACK becomes 1.
5.  Set JBMDR to A5h.
6.  Release the terminal reset.
7.  If MD=1 after following the above procedure, the boot firmware sets the JTAG/SWD communication start setting.
8.  Receive 55h data (Generic code) from the host.
9.  Send C6h data (Boot code) from the boot firmware.

Follow the steps below to disconnect JTAG/SWD communication with boot firmware:

1.  Assert the terminal reset.
2.  Set JBMDR to 00h.
3.  Set DBGSTR.CDBGPWRUPREQ to 0.
4.  Wait until DBGSTR.CDBGPWRUPACK becomes 0.
5.  Set CSW.DBGSWENBLE to 0.

## 4.5    Command Acceptable Phase

Boot firmware accepts the commands in this phase.

### 4.5.1    Processing Procedure

When the boot firmware receives a command packet, it performs packet analysis:

*   The boot firmware recognizes the start of the command packet by receiving SOH.
*   If the boot firmware receives something other than SOH, it waits until SOH is received.
*   If ETX is not added to the received command packet, the boot firmware sends a "Packet error".

- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the CMD in the received command packet is an undefined code, the boot firmware sends an "Unsupported command error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.

When the processing above is successfully completed, the boot firmware executes command processing.

When a command is normally finished, boot firmware stays on the "Command acceptable phase".

# 5. Packet Format

Use the following packet types:

- Command packet
- Data packet

## 5.1.1 Elements in the Packet

- CMD: Command code
- RES: Response code
- STS: Status code
- ST2: Status details
- ADR: Failure address
- DLM: Device Lifecycle Management state code

## 5.1.2 Command Packet

The host sends a command packet to the microcontroller in the following format.

**Table 10. Command Packet Format**

| Symbol | Size | Value | Description |
|---|---|---|---|
| SOH | 1 byte | 01h | Start of command packet. |
| LNH | 1 byte | - | Packet length (length of "CMD + Command information") [High]. |
| LNL | 1 byte | - | Packet length (length of "CMD + Command information") [Low]. |
| CMD | 1 byte | - | Command code. |
| Command information | 0−255 bytes | - | Command information. Examples:<br>• For Write command: Start/End address<br>• For Baudrate setting command: UART baudrate |
| SUM | 1 byte | - | Sum data of "LNH + LNL + CMD + Command information" (expressed as two's complement).<br>For example: LNH + LNL + CMD + Command information(1) + Command information(2) + ... + Command information(n) + SUM = 00h. |
| ETX | 1 byte | 03h | End of packet. |

Note: If the host sends data that exceeds 261 bytes, subsequent operations are not guaranteed.

### 5.1.3 Data Packet

Host and boot firmware send data to each other in the following format.

**Table 11. Data Packet Format**

| Symbol | Size | Value | Description |
|--------|------|-------|-------------|
| SOD | 1 byte | 81h | Start of data packet. |
| LNH | 1 byte | - | Packet length (length of "RES + Data") [High] (*1). |
| LNL | 1 byte | - | Packet length (length of "RES + Data") [Low] (*1). |
| RES | 1 byte | - | Response code. |
| Data | (*3) | - | Transmit data. Examples:<br>• For Write data transmission: Write data.<br>• For Status transmission: Status code (STS), Status details (ST2) and Failure address (ADR). |
| SUM | 1 byte | - | Sum data of "LNH + LNL + RES + Data" (expressed as two's complement)<br>For example: LNH + LNL + RES + Data(1) + Data(2) + ... + Data(n) + SUM = 00h. |
| ETX | 1 byte | 03h | End of packet. |

Notes:

*1: If the host sends a packet whose length is 0 byte or over 1025 bytes, the microcontroller returns a packet with an indefinite RES value.

*2: If the host sends data that exceeds 1030 bytes, subsequent operations are not guaranteed.

*3: The size is 1–1024 bytes. As an exception, the maximum is 1040 bytes only for the Encrypted data write command.

### 5.1.4 CMD: Command Code

**Table 12. Command Codes**

| Value | Name | Description |
|-------|------|-------------|
| 71h | DLM state transit command | Authentication-free DLM transition. |
| 2Ch | DLM state request command | Get the current DLM state. |
| 72h | Protection level transit command | Protection level transition. |
| 73h | Protection level request command | Get the Protection level. |
| 75h | Authentication level request command | Get the Authentication level. |
| 30h | Authentication command | Authentication-required DLM and AL transition. |
| 28h | Key setting command | Insert the key. |
| 2Ah | User key setting command | Insert the user custom key. |
| 29h | Key verify command | Verify the key. |
| 2Bh | User key verify command | Verify the user's custom key. |
| 50h | Initialize command | Initialize all the memory areas. |
| 4Eh | Boundary setting command | Set the boundary. |
| 4Fh | Boundary request command | Get the boundary setting. |
| 51h | Parameter setting command | Set the parameter. |
| 52h | Parameter request command | Get the parameter setting. |
| 4Ah | Lock bit setting command | Set the Lock bit. |
| 4Bh | Lock bit request command | Get the Lock bit setting. |
| 4Ch | ARC configuration setting command | Set the Anti-Rollback Counter configuration. |
| 4Dh | ARC configuration request command | Get the Anti-Rollback Counter configuration. |
| 00h | Inquiry command | Return ACK. |
| 3Ah | Signature request command | Get the signature information. |
| 3Bh | Area information request command | Get the area information. |
| 34h | Baudrate setting command | Set baudrate (only UART). |
| 12h | Erase command | Erase data on the target area. |

| Value | Name | Description |
|-------|------|-------------|
| 13h | Write command | Write data to target area. |
| 15h | Read command | Read data from target area |
| 18h | CRC command | Cyclic Redundancy Check of target area. |
| 2Eh | OEM root public key setting command | Insert the encrypted hash of root public key. |
| 26h | Code certificate update command | Update the code certificate. |
| 27h | Code certificate check command | Check the code certificate. |
| 36h | External flash memory setting command | Set the external flash memory. |
| 1Ah | Encrypted data write command | Write encrypted data to target area. |

### 5.1.5  RES: Response Code
**Table 13.  Response Codes**

| Value | Name | Description |
|-------|------|-------------|
| 00h | CMD | OK (ongoing normally) | - |
| 80h | CMD | ERR (occurrence of an error) | - |

### 5.1.6  STS: Status Code
**Table 14.  Status Codes**

| Value | Name | Description | Notes |
|-------|------|-------------|-------|
| 00h | Communication is normal [OK] | - | |
| C0h | Unsupported command error | Received an unsupported command. | (*1) |
| C1h | Packet error | Abnormality of packet format. | (*1) |
| C2h | Checksum error | Abnormality of packet's checksum value. | (*1) |
| D0h | Parameter error | Abnormality of packet parameter. | (*1) |
| D2h | Invalid address error | Invalid address in the current boundary settings. | (*1) |
| D3h | Certificate storage error | Certificate storage area is invalid. | (*1) |
| D5h | Command acceptance error | A command cannot execute in its current state. | (*1) |
| D6h | DLM state unmatched error | Device reset is not asserted after DLM state is changed. | (*1) |
| D7h | Hardware error | Abnormality of memory value. | (*1) |
| DAh | Protection error | Accessing protected areas or performing prohibited actions. | (*1) |
| DBh | Trusted system error | Abnormality from the Trusted system. | (*1) |
| DCh | Boot loader version error | Abnormality of OEM boot loader version. | (*1) |
| E4h | Secure error | Access to an area which is inaccessible with current privilege. | (*1) |
| E5h | Flash access error | Abnormality from the Flash sequencer or the external flash memory access driver. | (*1), (*2), (*3) |
| E8h | Verify error | Verification of the written data fails. | (*1) |
| E7h | Flash initialization error | Flash memory initialization is abnormal. | (*1) |

Notes:
*1: When this error occurs, the response code (RES) will be ERR.
*2: The boot firmware also returns the Status details (ST2) and the Failure address (ADR) as additional error information when there is abnormality from the Flash sequencer.
*3: This error occurs when the flash sequencer enters the "command lock" state after the execution of a flash sequencer command.

### 5.1.7  ST2: Status Details

**Table 15.  Status Details**

| Value | Name | Description |
|---|---|---|
| FSTATR[31:0] | Flash status | When a Flash access error occurs, boot firmware returns the value of the FSTATR register. When not, boot firmware returns FFFFFFFFh. Boot firmware clears the FSTATR register after the status sending, so even when error(s) occur, the host can retry the next command without reset release. |
| AAAA0000h–AAAAFFFFh | Trusted system status | When a Trusted system error occurs, boot firmware returns the detailed information shown below:<br>• AAAA0100h: An invalid magic number is set.<br>• AAAA0101h: Unsupported version is set.<br>• AAAA0102h: Out of range TLV Length is set.<br>• AAAA0103h: Missing required TLV field.<br>• AAAA0104h: The length exceeding the end of the manifest is specified in Length of the TLV field.<br>• AAAA0105h: An invalid image length is set.<br>• AAAA0106h: There is a wrong combination of signature algorithms.<br>• AAAA0200h: Cryptographic processing failure.<br>• AAAA0201h: Verification failed.<br>• AAAA0300h: CRC value mismatch<br>• AAAA0202h: Unsupported algorithm.<br>• AAAA0204h: Parameter error. |

### 5.1.8  ADR: Failure Address

**Table 16.  Failure Address**

| Value | Name | Description |
|---|---|---|
| 00000000h–FFFFFFFFh | Failure address | When a Flash access error occurs, boot firmware returns the value of the start address of the flash sequencer command. When not, boot firmware returns FFFFFFFFh. |

### 5.1.9  DLM: Device Lifecycle Management State Code

**Table 17.  DLM State Codes**

| Value | Name | Description |
|---|---|---|
| 01h | CM | Chip Manufacturing |
| 04h | OEM | Original Equipment Manufacturer |
| 06h | LCK_BOOT | LoCKed BOOT interface |
| 07h | RMA_REQ | Return Material Authorization REQuest |
| 08h | RMA_ACK | Return Material Authorization ACKnowledged |
| 09h | RMA_RET | Return Material Authorization RETurn |

## 6.  Command List

**Table 18.  Command List**

| Name | Communication Method | DLM State | | | | Prerequisite Command |
|---|---|---|---|---|---|---|
| | | CM | OEM | LCK_BOOT | RMA_REQ | |
| DLM State Transit Command | 2-wire UART, USB, JTAG/SWD | ◎ | ◎ | (*1) | | - |
| DLM State Request Command | 2-wire UART, USB, JTAG/SWD | ◎ | ◎ | (*1) | ◎ | - |

| Name | Communication Method | DLM State | | | | Prerequisite Command |
|---|---|---|---|---|---|---|
| | | CM | OEM | LCK_BOOT | RMA_REQ | |
| Protection Level Transit Command | 2-wire UART, USB, JTAG/SWD | | ◎ | (*1) | | - |
| Protection Level Request Command | 2-wire UART, USB, JTAG/SWD | ◎ | ◎ | (*1) | ◎ | - |
| Authentication Level Request Command | 2-wire UART, USB, JTAG/SWD | ◎ | ◎ | (*1) | ◎ | - |
| Authentication Command | 2-wire UART, USB, JTAG/SWD | ◎ | ◎ | (*1) | ◎ | - |
| Key Setting Command | 2-wire UART, USB, JTAG/SWD | | ◎ | (*1) | | - |
| User Key Setting Command | 2-wire UART, USB, JTAG/SWD | | ◎ | (*1) | | - |
| Key Verify Command | 2-wire UART, USB, JTAG/SWD | ◎ | ◎ | (*1) | ◎ | - |
| User Key Verify Command | 2-wire UART, USB, JTAG/SWD | ◎ | ◎ | (*1) | ◎ | - |
| Initialize Command | 2-wire UART, USB, JTAG/SWD | | ◎ | (*1) | | - |
| Boundary Setting Command | 2-wire UART, USB, JTAG/SWD | | ◎ | (*1) | | - |
| Boundary Request Command | 2-wire UART, USB, JTAG/SWD | ◎ | ◎ | (*1) | ◎ | - |
| Parameter Setting Command | 2-wire UART, USB, JTAG/SWD | | ◎ | (*1) | | - |
| Parameter Request Command | 2-wire UART, USB, JTAG/SWD | ◎ | ◎ | (*1) | ◎ | - |
| Lock Bit Setting Command | 2-wire UART, USB, JTAG/SWD | | ◎ | (*1) | | - |
| Lock Bit Request Command | 2-wire UART, USB, JTAG/SWD | | ◎ | (*1) | | - |
| ARC Configuration Setting Command | 2-wire UART, USB, JTAG/SWD | | ◎ | (*1) | | - |
| ARC Configuration Request Command | 2-wire UART, USB, JTAG/SWD | | ◎ | (*1) | | - |
| Inquiry Command | 2-wire UART, USB, JTAG/SWD | ◎ | ◎ | (*1) | ◎ | - |
| Signature Request Command | 2-wire UART, USB, JTAG/SWD | ◎ | ◎ | (*1) | ◎ | - |
| Area Information Request Command | 2-wire UART, USB, JTAG/SWD | ◎ | ◎ | (*1) | ◎ | - |
| Baudrate Setting Command | 2-wire UART, USB, JTAG/SWD | ◎ | ◎ | (*1) | ◎ | - |
| Erase Command | 2-wire UART, USB, JTAG/SWD | | ◎ | (*1) | | - |
| Write Command | 2-wire UART, USB, JTAG/SWD | | ◎ | (*1) | | - |
| Read Command | 2-wire UART, USB, JTAG/SWD | | ◎ | (*1) | | - |
| CRC Command | 2-wire UART, USB, JTAG/SWD | ◎ | ◎ | (*1) | ◎ | - |

| Name | Communication Method | DLM State | | | | Prerequisite Command |
| --- | --- | --- | --- | --- | --- | --- |
| | | CM | OEM | LCK_BOOT | RMA_REQ | |
| OEM Root Public Key Setting Command | 2-wire UART, USB, JTAG/SWD | | ◎ | (*1) | | - |
| Code Certificate Update Command | 2-wire UART, USB, JTAG/SWD | | ◎ | (*1) | | - |
| Code Certificate Check Command | 2-wire UART, USB, JTAG/SWD | ◎ | ◎ | (*1) | ◎ | - |
| External Flash Memory Setting Command | 2-wire UART, USB, JTAG/SWD | | ◎ | (*1) | | - |
| Encrypted Data Write Command | 2-wire UART, USB, JTAG/SWD | | ◎ | (*1) | | - |

Notes:

◎ : Command is available in the state. (If an unavailable command is sent, boot firmware returns "Command acceptance error".)

*1: LCK_BOOT state never transits to Command acceptable phase because boot firmware executes software reset in the Initialization phase.

## 6.1 Device Lifecycle Management

The following DLM state transitions can be caused by each command:
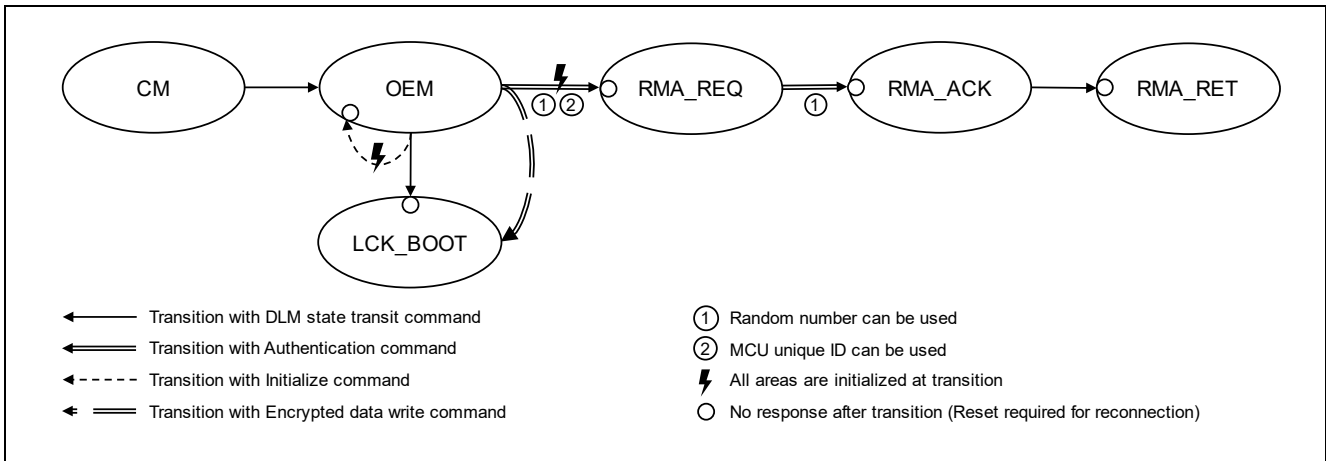


**Figure 15. DLM State Transitions**

## 6.2 DLM State Transit Command

This command transitions the DLM state without authentication.

Boot firmware will enter an infinite loop when the DLM state transitions to LCK_BOOT or RMA_RET.

This command requires adherence to conditions described in Command List.
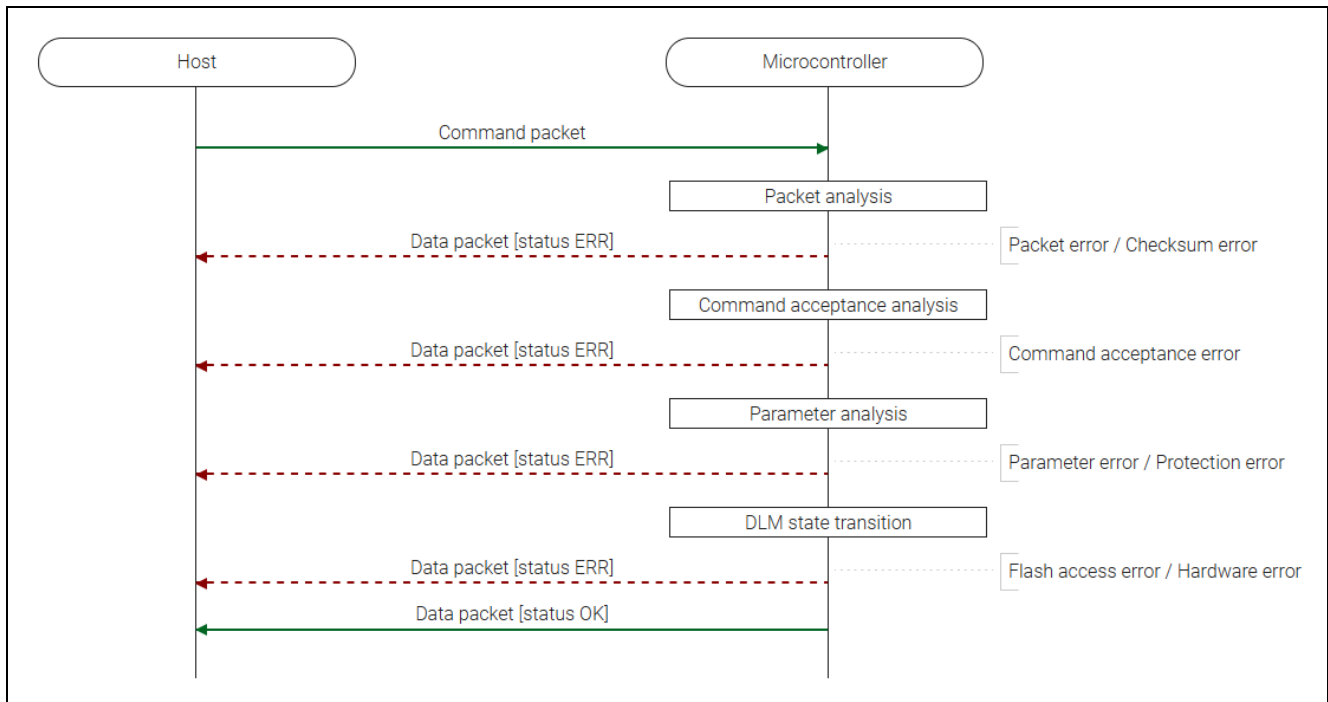


**Figure 16.  DLM State Transit Command Sequence Diagram**

### 6.2.1 Packets
### 6.2.1.1 Command Packet

| SOH | (1 byte) | 01h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 03h |
| CMD | (1 byte) | 71h (DLM state transit command) |
| SDLM | (1 byte) | Source DLM state code:<br>• 01h: CM<br>• 04h: OEM<br>• 08h: RMA_ACK |
| DDLM | (1 byte) | Destination DLM state code:<br>• 04h: OEM<br>• 06h: LCK_BOOT<br>• 09h: RMA_RET |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.2.1.2　Data Packet [Status OK]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 71h (OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | 8Dh |
| ETX | (1 byte) | 03h |

### 6.2.1.3　Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | F1h (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

## 6.2.2　Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If this command cannot be executed in the current DLM state, the boot firmware sends a "Command acceptance error".
- If device reset is not asserted after the Encrypted data write command execution, the boot firmware sends a "Command acceptance error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware analyzes the command parameters:

- When SDLM is different from the current DLM state, boot firmware returns "Parameter error".
- When DDLM is a DLM state that cannot be entered from the current DLM state without authentication, boot firmware returns "Parameter error".
- If LCK_BOOT is specified for DDLM while the transition to LCK_BOOT is disabled, boot firmware returns "Protection error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  \* Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware transitions to the DLM state.

- If an error occurs during DLM state transitioning, boot firmware returns "Flash access error" and waits for the next command.
  \* Check the DLM state after the Flash access error has occurred with the DLM state request command.
- If the DLM state after the transition is an invalid value, the boot firmware sends a "Hardware error" and becomes unresponsive.
  Also, if the DLM state after transition is LCK_BOOT or RMA_RET, the boot firmware will send "OK" and will not respond.
- When DLM state transit successful completion, "OK" is returned and the boot firmware waits for the next command.

### 6.2.3  Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Executing this command is unavailable in the current DLM state. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Source DLM state code is different from the current DLM state. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Destination DLM state code is not a transitionable DLM state. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| LCK_BOOT was specified for the Destination DLM state code with the transition to LCK_BOOT disabled. | Protection error | FFFFFFFFh | FFFFFFFFh |
| FACI detected an error after the command execution in not disclosed area. | Flash access error | Flash status | FFFFFFFFh |
| DLM state is abnormal. | Hardware error | FFFFFFFFh | FFFFFFFFh |
| Protection level is abnormal. | Hardware error | FFFFFFFFh | FFFFFFFFh |
| Successful completion. | OK | FFFFFFFFh | FFFFFFFFh |

### 6.2.4 DLM State Transition

Figure 17 shows the DLM states that can be transited by the DLM State Transit command.
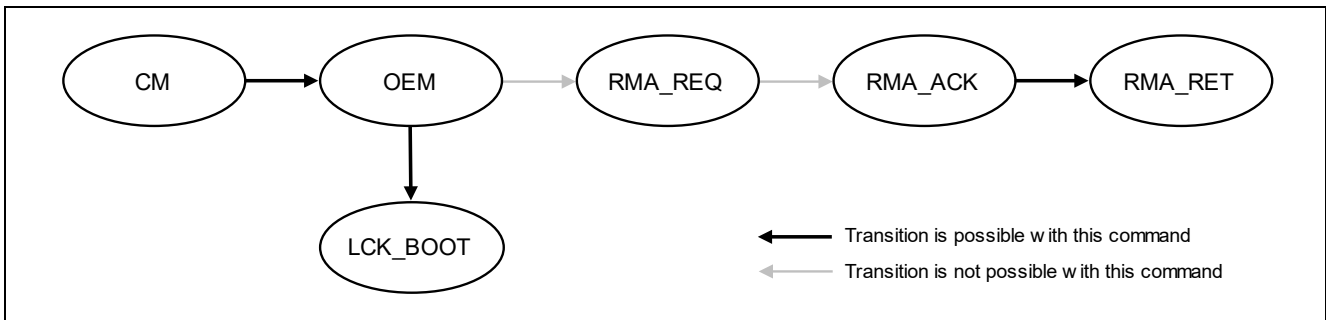


**Figure 17. Valid State Transitions for DLM State Transit Command**

| Source DLM | Destination DLM | Requirements for Transition |
|---|---|---|
| CM | OEM | - |
| OEM | LCK_BOOT | Transition to LCK_BOOT (Parameter ID: 02h) is enabled. |
| RMA_ACK | RMA_RET | - |

## 6.3 DLM State Request Command

This command is used to get the current DLM state.

This command requires adherence to conditions described in Command List.

### 6.3.1 Sequence Diagram
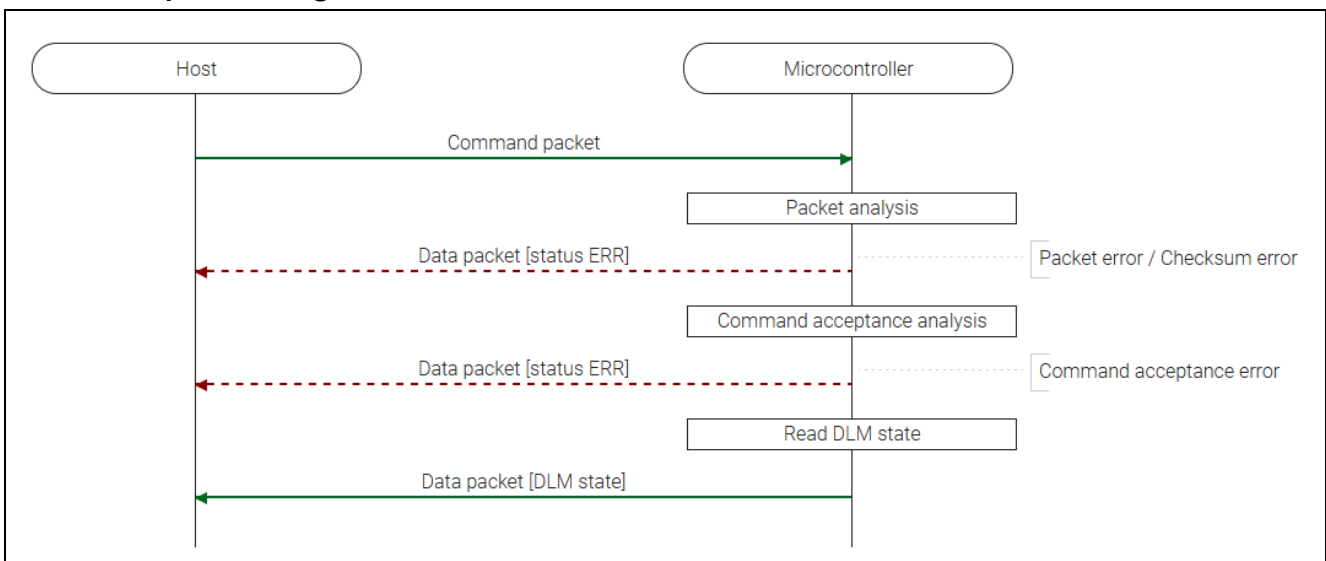


**Figure 18. DLM State Request Command Sequence Diagram**

### 6.3.2 Packets

#### 6.3.2.1 Command Packet

| SOH | (1 byte) | 01h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 01h |
| CMD | (1 byte) | 2Ch (DLM state request command) |
| SUM | (1 byte) | D3h |
| ETX | (1 byte) | 03h |

### 6.3.2.2  Data Packet [DLM State]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 02h |
| RES | (1 byte) | 2Ch (OK) |
| DLM | (1 byte) | DLM state code |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.3.2.3  Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | ACh (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.3.3    Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
- If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If the device reset is not asserted after the Encrypted data write command is executed, the boot firmware sends a "Command acceptance error".
- When the above error occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware returns the current DLM state:

- Send DLM state and return to command wait state.
  * Memory contents do not change before command reception.

### 6.3.4   Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |

## 6.4   Protection Level Transit Command

This command transitions to the Protection level.

This command requires adherence to conditions described in Command List.

### 6.4.1   Sequence Diagram



**Figure 19.   Protection Level Transit Command Sequence Diagram**

### 6.4.2 Packets

#### 6.4.2.1 Command Packet

| SOH | (1 byte) | 01h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 03h |
| CMD | (1 byte) | 72h (Protection level transit command) |
| SPL | (1 byte) | Source PL code:<br>• 02h: Protection level 2<br>• 03h: Protection level 1<br>• 04h: Protection level 0 |
| DPL | (1 byte) | Destination PL code:<br>• 02h: Protection level 2<br>• 03h: Protection level 1<br>• 04h: Protection level 0 |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

#### 6.4.2.2 Data Packet [Status OK]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 72h (OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | 8Ch |
| ETX | (1 byte) | 03h |

#### 6.4.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | F2h (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.4.2.4   Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
- If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If this command cannot be executed in the current DLM state, the boot firmware sends a "Command acceptance error".
- If the device reset is not asserted after the Encrypted data write command is executed, the boot firmware sends a "Command acceptance error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware analyzes the command parameters:

- When SPL is different from the current Protection level, boot firmware returns "Parameter error".
- When DPL is a Protection level that cannot be transited to from the current Protection level, boot firmware returns "Parameter error".
- If transit to the specified DPL in the current Authentication level is not allowed, boot firmware returns a "Protection error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware will transition to the Protection level:

- If an error occurs during the transition Protection level, boot firmware returns "Flash access error" and waits for the next command.
  * Check the Protection level after the Flash access error has occurred with the Protection level request command.
- If the Protection level after the transition is an invalid value, the boot firmware sends a "Hardware error" and becomes unresponsive.
- When Protection level transit successfully completes, "OK" is returned and the boot firmware waits for the next command.

### 6.4.3   Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Executing this command is unavailable in the current DLM state. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Source PL code is different from the current Protection level. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Destination PL code is not transitionable Protection level. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Does not meet the Authentication level required for transition to the specified destination PL code. | Protection error | FFFFFFFFh | FFFFFFFFh |
| FACI detected an error after the command execution in not disclosed area. | Flash access error | Flash status | FFFFFFFFh |
| Protection level is abnormal. | Hardware error | FFFFFFFFh | FFFFFFFFh |
| Successful completion. | OK | FFFFFFFFh | FFFFFFFFh |

### 6.4.4   Protection Level Transition

Figure 20 shows the Protection level that can be transit by this command.
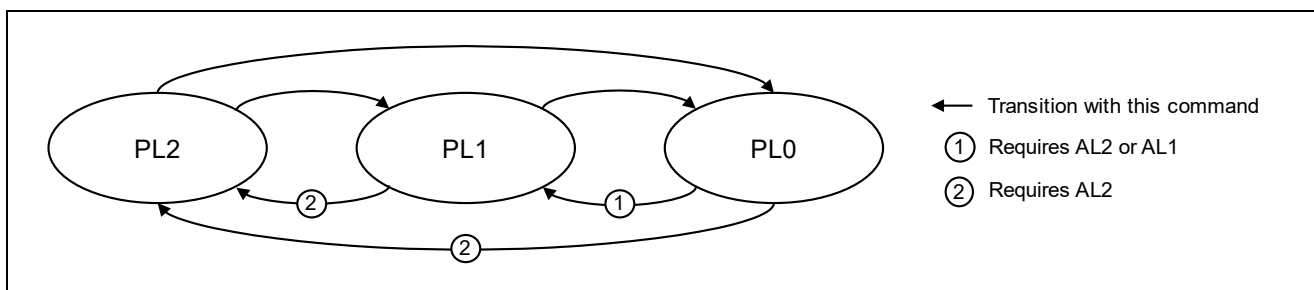


**Figure 20.   Valid Protection Level Transitions**

| Source PL | Destination PL | Current Authentication level | | |
|---|---|---|---|---|
| | | AL2 | AL1 | AL0 |
| PL0 | PL1 | OK | OK | Protection error |
| | PL2 | | Protection error | |
| PL1 | PL0 | | OK | N/A (Impossible combination) |
| | PL2 | | Protection error | |
| PL2 | PL0 | | N/A (Impossible combination) | |
| | PL1 | | | |

## 6.5 Protection Level Request Command

This command is used to get the current Protection level.

This command requires adherence to conditions described in Command List.
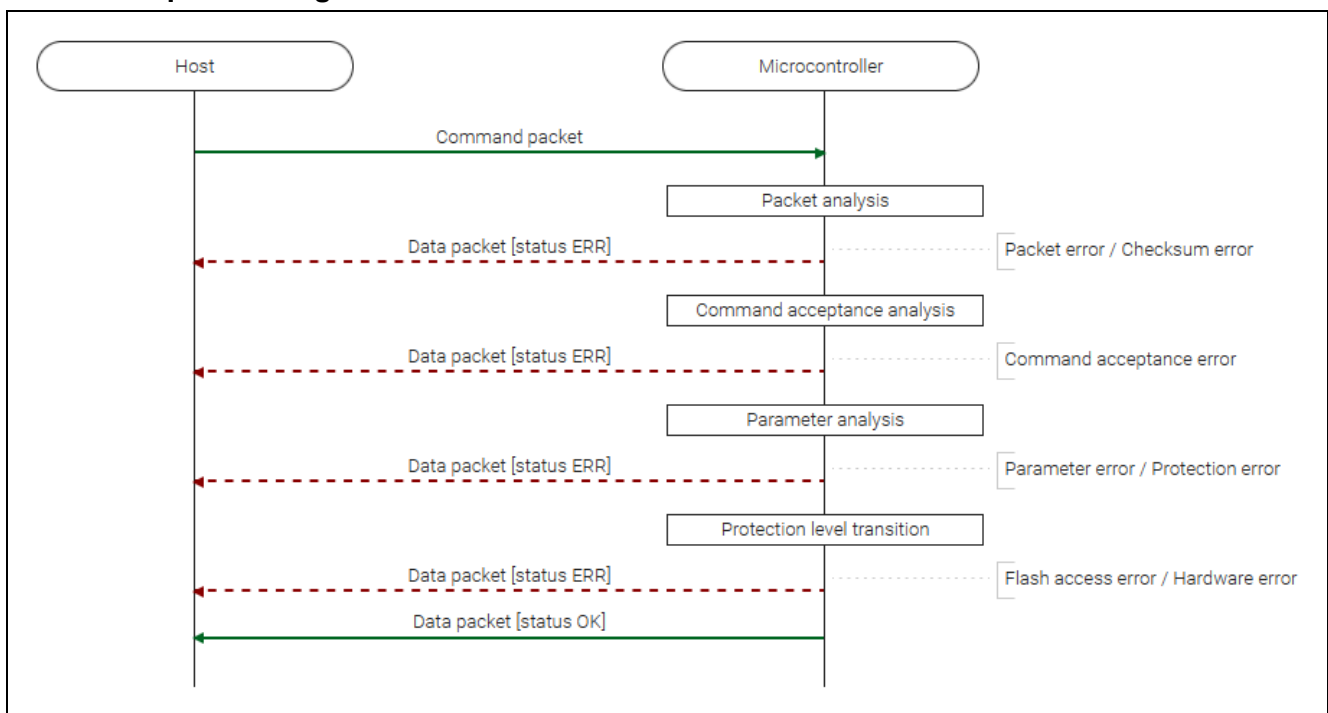
### 6.5.1 Sequence Diagram
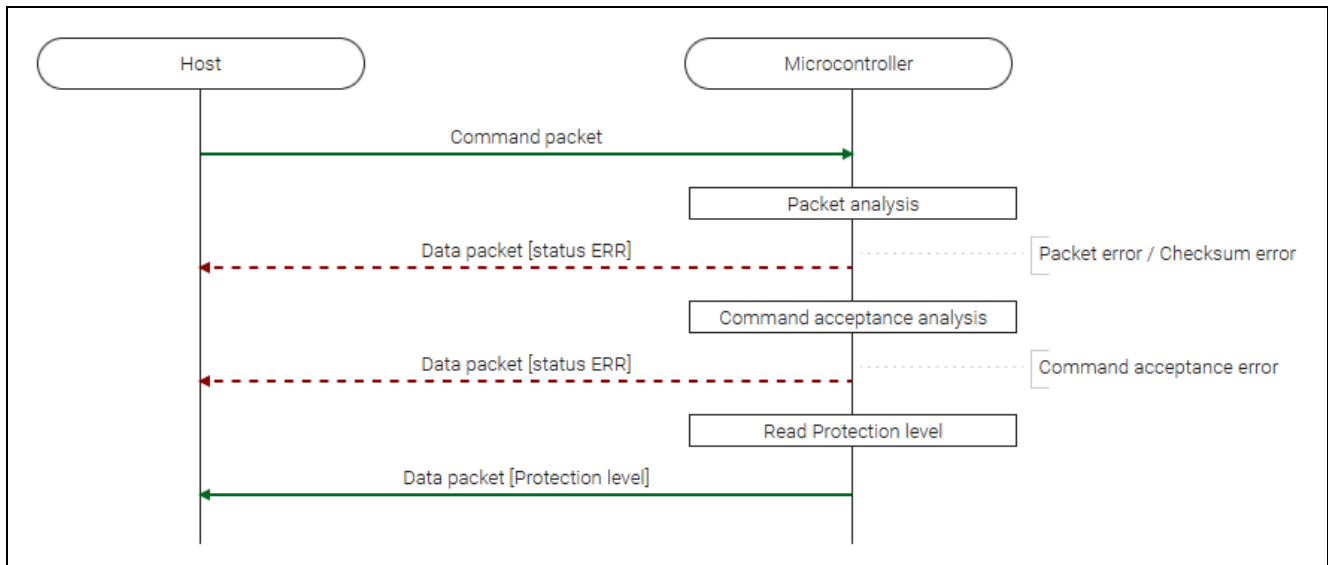


**Figure 21.  Protection Level Request Sequence Diagram**

### 6.5.2 Packets
### 6.5.2.1 Command Packet

| SOH | (1 byte) | 01h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 01h |
| CMD | (1 byte) | 73h (Protection level request command) |
| SUM | (1 byte) | 8Ch |
| ETX | (1 byte) | 03h |

### 6.5.2.2 Data Packet [Protection Level]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 02h |
| RES | (1 byte) | 73h (OK) |
| CPL | (1 byte) | Current PL code<br>• 02h: Protection level 2<br>• 03h: Protection level 1<br>• 04h: Protection level 0 |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.5.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | F3h (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.5.3 Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If the device reset is not asserted after the Encrypted data write command is executed, the boot firmware sends a "Command acceptance error".
- When the above error occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware returns the Protection level:

- Send Protection level and return to command wait state.
  * Memory contents do not change before command reception.

### 6.5.4 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|-----------|-----|-----|-----|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |

## 6.6 Authentication Level Request Command

This command is used to get the current Authentication level.

This command requires adherence to conditions described in Command List.

### 6.6.1 Sequence Diagram
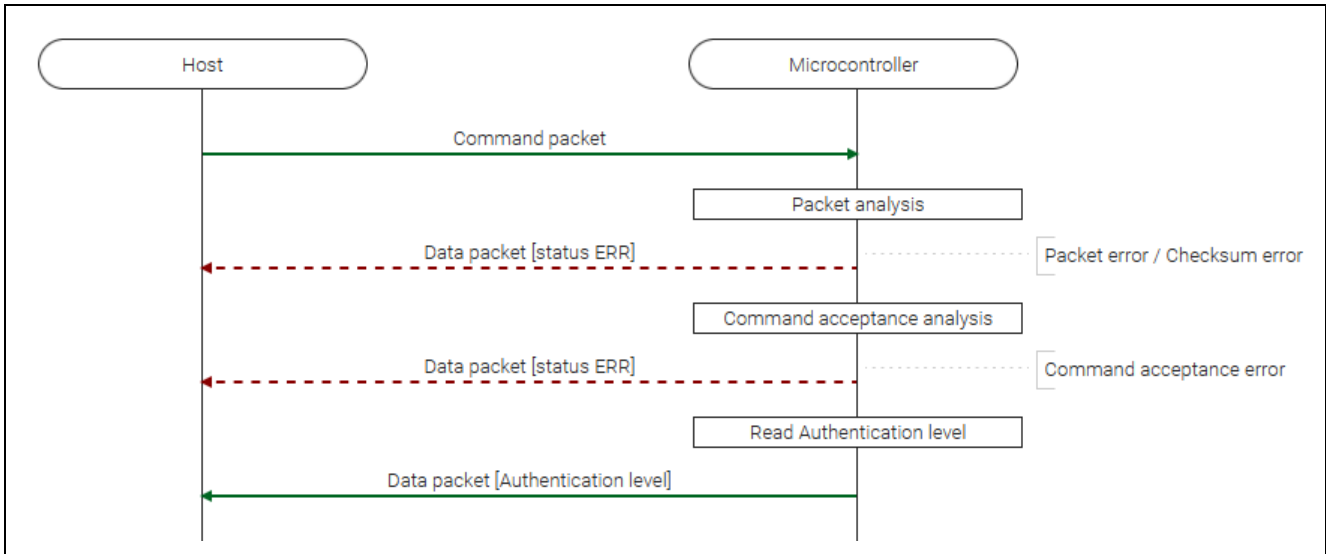


**Figure 22. Authentication Level Request Command Sequence Diagram**

### 6.6.2 Packets

### 6.6.2.1 Command Packet

| SOH | (1 byte) | 01h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 01h |
| CMD | (1 byte) | 75h (Authentication level request command) |
| SUM | (1 byte) | 8Ah |
| ETX | (1 byte) | 03h |

### 6.6.2.2 Data Packet [Authentication Level]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 02h |
| RES | (1 byte) | 75h (OK) |
| CAL | (1 byte) | Current AL code<br>• 02h: Authentication level 2<br>• 03h: Authentication level 1<br>• 04h: Authentication level 0 |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.6.2.3　Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | F5h (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.6.3　Processing procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If the device reset is not asserted after the Encrypted data write command is executed, the boot firmware sends a "Command acceptance error".
- When the above error occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware returns the Authentication level:

- Send Authentication level and return to the command wait state.
  * Memory contents do not change before command reception.

### 6.6.4　Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |

## 6.7   Authentication Command

This command authenticates using a key and transitions the DLM state or the Authentication level.

Authentication is executed by the challenge and response method or Unique ID.

Boot firmware erases the flash memory when the DLM state transits to RMA_REQ. Erase processing at this time is not affected by the block protection settings (BPS, BPS_SEC).

This command requires adherence to conditions described in Command List.

### 6.7.1   Sequence Diagram
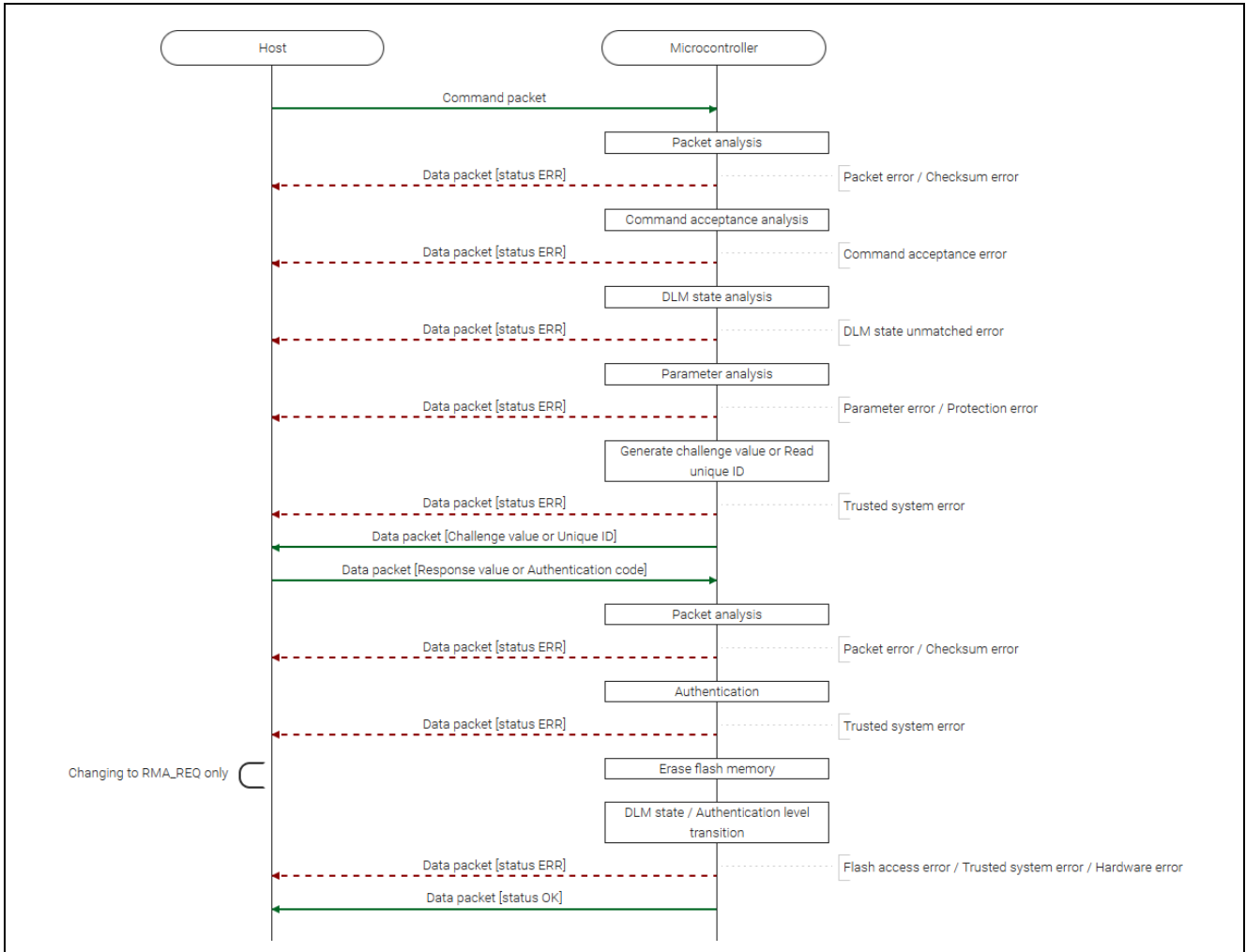


**Figure 23.   Authentication Command Sequence Diagram**

### 6.7.2 Packets
### 6.7.2.1 Command Packet

| SOH | (1 byte) | 01h |
|------|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 04h |
| CMD | (1 byte) | 30h (Authentication command) |
| SDLM | (1 byte) | Source DLM/AL code.<br>For DLM transitions:<br>• 04h: OEM<br>• 07h: RMA_REQ<br>For AL transitions:<br>• 03h: AL1<br>• 04h: AL0 |
| DDLM | (1 byte) | Destination DLM/AL code.<br>For DLM transitions:<br>• 07h: RMA_REQ<br>• 08h: RMA_ACK<br>For AL transitions:<br>• 02h: AL2<br>• 03h: AL1 |
| CHCT | (1 byte) | Authentication type:<br>• 00h: Random number (Can be used in all transit cases.)<br>• 01h: MCU unique ID (Can be used only in transit to RMA_REQ.) |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.7.2.2 Data Packet [Challenge Value or Unique ID]

| SOD | (1 byte) | 81h |
|------|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 11h |
| RES | (1 byte) | 30h (OK) |
| CHCD | (16 bytes) | Challenge value or Unique ID<br>For example: 01234567_89AB ... 2233_44556677h -> 01h, 23h, 45h, ... , 55h, 66h, 77h |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.7.2.3 Data Packet [Response Value or Authentication Code]

| SOD | (1 byte) | 81h |
|------|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 21h |
| RES | (1 byte) | 30h (OK) |
| MAC | (32 bytes) | Response value or Authentication code<br>For example: 01234567_89AB ... 2233_44556677h -> 01h, 23h, 45h, ... , 55h, 66h, 77h<br>For details of the Response value, refer to the Response Value Calculation. |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

#### 6.7.2.4 Data Packet [Status OK]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 30h (OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | CEh |
| ETX | (1 byte) | 03h |

#### 6.7.2.5 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | B0h (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.7.3 Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If this command cannot be executed in the current DLM state, the boot firmware sends a "Command acceptance error".
- If the device reset is not asserted after the Encrypted data write command is executed, the boot firmware sends a "Command acceptance error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, the boot firmware performs DLM state analysis:

- If the currently active DLM state does not match the stored DLM state, the boot firmware sends a "DLM state unmatched error".
- When the above error occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware analyzes the command parameters:

- When SDLM is different from the current DLM state or Authentication level, boot firmware returns a "Parameter error".
- When SDLM and DDLM are not a transitionable combination, boot firmware returns a "Parameter error".
- When any of the following conditions are met, boot firmware returns "Protection error":
  — Authentication with AL2_KEY is disabled and DDLM is RMA_REQ.
  — Authentication with AL2_KEY is disabled and DDLM is AL2.
  — Authentication with AL1_KEY is disabled and DDLM is AL1.
- When CHCT is not a challenge type that can be used to transition the DLM state, boot firmware returns a "Parameter error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware sends data packet [Challenge value or Unique ID]:

- If the Challenge value / Unique ID is successfully generated, the boot firmware sends the value.
- If the Trusted system becomes abnormal after the Challenge value / Unique ID generation, the boot firmware returns nothing and does not respond.
  * Memory contents do not change before command reception.
- If the Challenge value / Unique ID generation fails, the boot firmware sends a "Trusted system error" and returns to the command wait state.
  * Memory contents do not change before command reception.

Boot firmware receives and analyzes a data packet [Response value or Authentication code] after the processing above:

- Boot firmware detects the beginning of a data packet by receiving SOD.
  When boot firmware receives other data than SOD, it discards the data and waits for the next data until SOD is sent.
- When the received data packet does not have ETX, "Packet error" is returned.
- When SUM in the received data packet is different from the value calculated by boot firmware, a "Checksum error" is returned.
- When LNH and LNL in the received data packet do not comply with the packet format, "Packet error" is returned.
- When RES in the received data packet is different from defined values, "Packet error" is returned.
- When LNH and LNL in the received data packet do not comply with the specifications of this command, "Packet error" is returned.
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware authenticates with received Response value or Authentication code:

- If the Trusted system becomes abnormal after authentication, the boot firmware returns nothing and does not respond.
  * Memory contents do not change before command reception.
- When authentication fails, "Trusted system error" is returned and the boot firmware waits for the next command.
  * Memory contents do not change before command reception.

When authentication is successfully completed and the DLM state transits to RMA_REQ, boot firmware erases the memory.

Note:   This command erases the memory even if initialization is disabled. (Refer to the Parameter request command.)

- If an error occurs during erasure in the Block, protect the setting, the boot firmware sends a "Flash access error" and returns to the command wait state.
  Also, if the Trusted system becomes abnormal after initialization of the Trusted system, the boot firmware returns nothing and does not respond.
  * The value of the Block protect setting is undefined.
- If an error occurs during erasure in the User area, the boot firmware sends a "Flash access error" and returns to the command wait state.
  Also, if the Trusted system becomes abnormal after initialization of the Trusted system, the boot firmware returns nothing and does not respond.
  * The value of the area after ADR (Failure address) of the User area is undefined.
- If an error occurs during erasure in the Data area, the boot firmware sends a "Flash access error" and returns to the command wait state.
  Also, if the Trusted system becomes abnormal after initialization of the Trusted system, the boot firmware returns nothing and does not respond.
  * The value of the Data area is undefined.
- If an error occurs during erasure in the Config area, the boot firmware sends a "Flash access error" and returns to the command wait state.
  Also, if the Trusted system becomes abnormal after initialization of the Trusted system, the boot firmware returns nothing and does not respond.
  * The value of the Config area is undefined.
- If an error occurs during erasure in the EEP Config area, the boot firmware sends a "Flash access error" and returns to the command wait state.
  Also, if the Trusted system becomes abnormal after initialization of the Trusted system, the boot firmware returns nothing and does not respond.
  * The value of the EEP Config area is undefined.
- If an error occurs during boundary setting and Key index (Wrapped key) erasure in the User area, the boot firmware sends a "Flash access error" and returns to the command wait state.
  Also, if the Trusted system becomes abnormal after initialization of the Trusted system, the boot firmware returns nothing and does not respond.

When the Authentication is successfully completed (in case of transition to RMA_REQ, erase of memory is also successful), boot firmware executes the transition:

- If the Trusted system becomes abnormal during the transition, the boot firmware returns nothing and does not respond.
  * Check the DLM state after the error has occurred with the DLM state request command.
- If an error occurs during the transition, boot firmware returns "Flash access error" or "Trusted system error" and waits for the next command.
  * Check the DLM state after the error has occurred with the DLM state request command.
- If the DLM state after the transition is an invalid value, the boot firmware sends a "Hardware error" and becomes unresponsive.
- If the above error does not occur, the boot firmware sends "OK" and becomes unresponsive (DLM transition) or waits for the next command (Authentication level transition).
  * When the DLM state transitions to RMA_REQ, each area of the memory is in the following state:
  — User area is erased except below:
  — Blocks for which "0" is set for permanent block protection setting (PBPS, PBPS_SEC).
    * Not affected by block protection settings (BPS, BPS_SEC).
  — All Data areas are erased.
  — The Config area is written the value when shipped except the following:
    - Permanent block protection setting (PBPS, PBPS_SEC).
    - Block protection setting (BPS, BPS_SEC) for blocks on which "0" is set for permanent block protection setting (PBPS, PBPS_SEC).

- Secure Attribute setting for block protection (BPS_SEL).
- FSPR and BTFLG when FSPR = 0.
— The EEP config area is written the value when shipped except the following:
  - Data for which the Lock bit is set.
    *) EEP Config area is erased in 16-byte units. Therefore, this non-erased area is also a 16-byte unit for a 4-byte protected area.

### 6.7.4   Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Executing this command is unavailable in the current DLM state. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| The currently active DLM state does not match the stored DLM state. | DLM state unmatched error | FFFFFFFFh | FFFFFFFFh |
| SDLM is different from the current DLM state or AL. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| SDLM and DDLM are not a transitionable combination. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| AL2 or RMA_REQ specified for DDLM with AL2_KEY disabled. | Protection error | FFFFFFFFh | FFFFFFFFh |
| AL1 specified for DDLM with AL1_KEY disabled. | Protection error | FFFFFFFFh | FFFFFFFFh |
| Authentication type is different from the value specified by this command. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Challenge value / Unique ID generation failed. | Trusted system error | FFFFFFFFh | FFFFFFFFh |
| The response code of the received data packet is different from the value specified by this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Authentication failed. | Trusted system error | FFFFFFFFh | FFFFFFFFh |
| FACI detected an error after the command execution in disclosed area. | Flash access error | Flash status | Failure address |
| FACI detected an error after the command execution in not disclosed area. | Flash access error | Flash status | FFFFFFFFh |
| DLM state is abnormal. | Hardware error | FFFFFFFFh | FFFFFFFFh |
| Protection level is abnormal. | Hardware error | FFFFFFFFh | FFFFFFFFh |
| Successful completion. | OK | FFFFFFFFh | FFFFFFFFh |

### 6.7.5  Authentication Level Transition

Figure 24 shows the Authentication level that can be transit by this command.

(Authentication level transition is possible only when the DLM state is "OEM".)
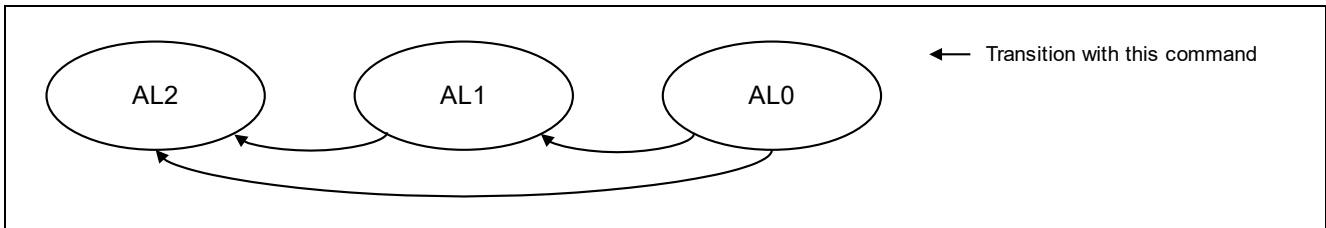


**Figure 24.  Valid Authentication Level Transitions**

| Source AL | Destination AL | Required key | Requirements for Transition |
|---|---|---|---|
| AL0 | AL1 | AL1_KEY | Authentication using AL1_KEY (Parameter ID: 04h) is enabled. |
| | AL2 | AL2_KEY | Authentication using AL2_KEY (Parameter ID: 03h) is enabled. |
| AL1 | AL2 | | |

### 6.7.6  Response Value Calculation

Response = AES-128 CMAC (Key, 128-bit challenge)

*Fill "1" to lower 16 bytes of MAC on the Data Packet because the calculated Response is 16 bytes.

## 6.8  Key Setting Command

This command sets the authentication key to the device. The authentication key must be specified in the DLM state that be able to set the key.

This command requires adherence to conditions described in Command List.

### 6.8.1  Sequence Diagram



**Figure 25.  Key Setting Command Sequence Diagram**

### 6.8.2   Packets
#### 6.8.2.1   Command Packet

| SOH | (1 byte) | 01h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 02h |
| CMD | (1 byte) | 28h (Key setting command) |
| KYTY | (1 byte) | Key type:<br>• 01h: AL2_KEY<br>• 02h: AL1_KEY<br>• 03h: RMA_KEY |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

#### 6.8.2.2   Data Packet [Key Data]

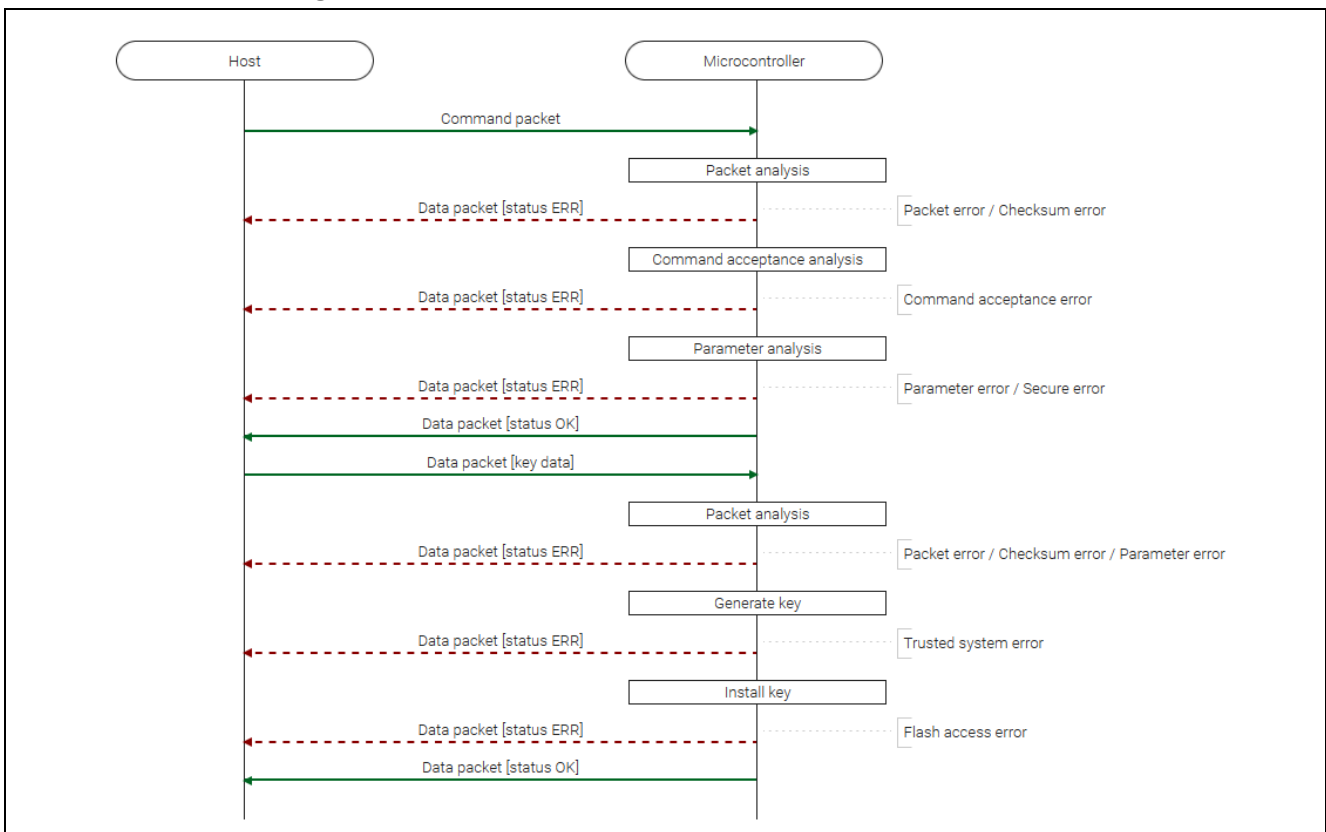| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 55h |
| RES | (1 byte) | 28h (OK) |
| SKR | (4 bytes) | Shared key ring number.<br>For example: 01234567h -> 01h, 23h, 45h, 67h |
| ESKY | (32 bytes) | Wrapped install key (W-UFPK).<br>For example: 01234567_89AB ... 2233_44556677h -> 01h, 23h, 45h, ... , 55h, 66h, 77h |
| IVEC | (16 bytes) | Initialization Vector.<br>For example: 01234567_89AB ... 2233_44556677h -> 01h, 23h, 45h, ... , 55h, 66h, 77h |
| EOKY | (32 bytes) | Install data (Encrypted key \| MAC).<br>Encrypted key (bytes 0–15) + MAC (bytes 16-31)<br>For example: If install data is as follows, the host should send EOKY in the order shown in the lower table.<br>Install data: |

Encrypted key

| 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 |
|---|---|---|---|---|---|---|---|
| 08 | 09 | 0A | 0B | 0C | 0D | 0E | 0F |

MAC

| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|
| 18 | 19 | 1A | 1B | 1C | 1D | 1E | 1F |

Order of sending EOKY:

| 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th |
|---|---|---|---|---|---|---|---|
| 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 |
| **9th** | **10th** | **11th** | **12th** | **13th** | **14th** | **15th** | **16th** |
| 08 | 09 | 0A | 0B | 0C | 0D | 0E | 0F |
| **17th** | **18th** | **19th** | **20th** | **21st** | **22nd** | **23rd** | **24th** |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| **25th** | **26th** | **27th** | **28th** | **29th** | **30th** | **31st** | **32nd** |
| 18 | 19 | 1A | 1B | 1C | 1D | 1E | 1F |

| SUM | (1 byte) | Sum data |
|---|---|---|
| ETX | (1 byte) | 03h |

### 6.8.2.3　Data Packet [Status OK]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 28h (OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | D6h |
| ETX | (1 byte) | 03h |

### 6.8.2.4　Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | A8h (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.8.3　Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If this command cannot be executed in the current DLM state, the boot firmware sends a "Command acceptance error".
- If the device reset is not asserted after the Encrypted data write command is executed, the boot firmware sends a "Command acceptance error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes the parameter analysis:

- When KYTY is an unspecified value, boot firmware returns "Parameter error" and waits for the next command.
  * Memory contents do not change before command reception.
- When KYTY cannot be set in the current Authentication level, boot firmware returns "Secure error" and waits for the next command.
  * Memory contents do not change before command reception.
- If the above error does not occur, the boot firmware sends "OK".

When the processing above is successfully completed, boot firmware receives and analyzes the data packet:

- Boot firmware detects the beginning of a data packet by receiving SOD.
  When boot firmware receives other data than SOD, it discards the data and waits for the next data until SOD is sent.
- When the received data packet does not have ETX, "Packet error" is returned.
- When SUM in the received data packet is different from the value calculated by boot firmware, a "Checksum error" is returned.
- When LNH and LNL in the received data packet do not comply with the packet format, "Packet error" is returned.
- When RES in the received data packet is different from defined values, "Packet error" is returned.
- When the number of received data exceeds the value specified in the command in the received data packet, "Parameter error" is returned.
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware generates the Key index (Wrapped key):

- If the Trusted system becomes abnormal after creating a key index (Wrapped key), the boot firmware returns nothing and does not respond.
  * Memory contents do not change before command reception.
- If the generation of the Key index (Wrapped key) fails, the boot firmware sends a "Trusted system error" and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware writes the Key index to memory:

- If an error occurs while writing the Key index (Wrapped key), the boot firmware sends a "Flash access error" and returns to the command wait state.
  * Use the Key verify command to check the status of the Key index (Wrapped key) after a Flash access error occurs.
- When the authentication key setting is successfully completed, boot firmware returns "OK" and waits for the next command.

### 6.8.4 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Executing this command is unavailable in the current DLM state. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| The specified Key type is an unspecified value. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The specified Key type cannot be inserted at the current Authentication level. | Secure error | FFFFFFFFh | FFFFFFFFh |
| The response code of the received data packet is different from the value specified by this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| The total length of received data of data packets exceeds the value specified in the command. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Authentication key generate failed. | Trusted system error | FFFFFFFFh | FFFFFFFFh |
| FACI detected an error after the command execution in not disclosed area. | Flash access error | Flash status | FFFFFFFFh |
| Successful completion. | OK | FFFFFFFFh | FFFFFFFFh |

### 6.8.5 Key type that can be set in each Authentication Level

Table 19 shows the Key types that can be set in each Authentication level.

**Table 19. Key Types for Each Authentication Level**

| Authentication level | Key type |
|---|---|
| AL2 | AL2_KEY<br>AL1_KEY<br>RMA_KEY |
| AL1 | AL1_KEY |

## 6.9 User Key Setting Command

This command generates a Key index (Wrapped key) using the Wrapped install key (W-UFPK) and Install data (Encrypted key | MAC) received from the host and saves it in the specified area. Write processing at this time is not affected by the block protection settings (BPS, BPS_SEC).

The storage area must be erased in advance.

This command requires adherence to conditions described in Command List.

### 6.9.1　Sequence Diagram
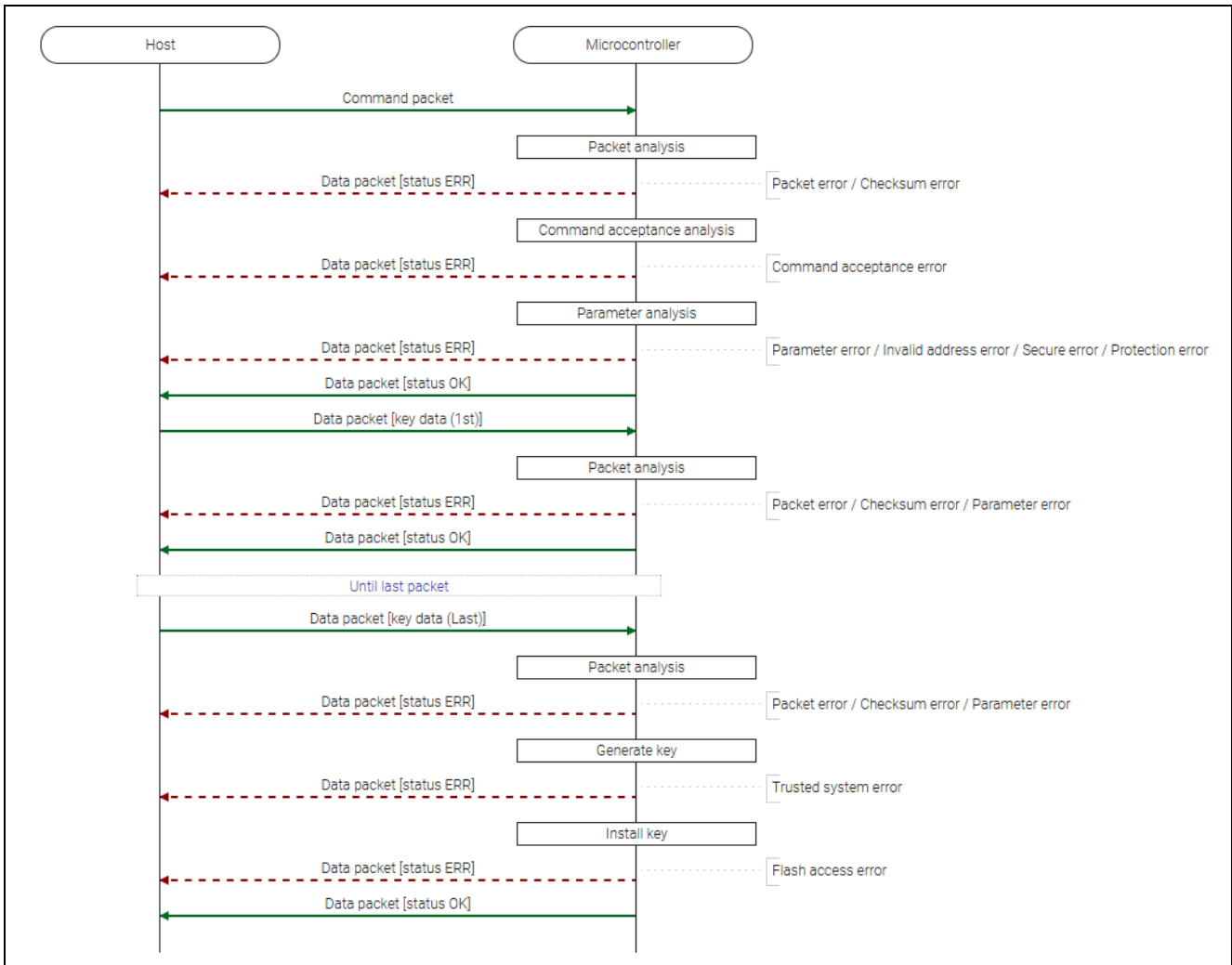


**Figure 26.　User Key Setting Command Sequence Diagram**

### 6.9.2　Packets
### 6.9.2.1　Command Packet

| SOH | (1 byte) | 01h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 06h |
| CMD | (1 byte) | 2Ah (User key setting command) |
| KADR | (4 bytes) | Key setting address.<br>For example: 00004000h -> 00h, 00h, 40h, 00h |
| ENTY | (1 byte) | User key type.<br>Refer to User key list. |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.9.2.2　Data Packet [Key Data (1st)]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | N + 53 (Higher 1 byte) |
| LNL | (1 byte) | N + 53 (Lower 1 byte) |
| RES | (1 byte) | 2Ah (OK) |
| SKR | (4 bytes) | Shared key ring number.<br>For example: 01234567h -> 01h, 23h, 45h, 67h |
| ESKY | (32 bytes) | Wrapped install key (W-UFPK).<br>For example: 01234567_89AB ... 2233_44556677h -> 01h, 23h, 45h, ... , 55h, 66h, 77h |
| IVEC | (16 bytes) | Initialization vector.<br>For example: 01234567_89AB ... 2233_44556677h -> 01h, 23h, 45h, ... , 55h, 66h, 77h |
| ENKY | (N bytes) | Install data (Encrypted key \| MAC) .<br>For example: If the key type is ECC P-192 Private Key, the host should send ENKY in the order shown in the lower table.<br>Install data: |

Encrypted Key

| 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 |
|---|---|---|---|---|---|---|---|
| 08 | 09 | 0A | 0B | 0C | 0D | 0E | 0F |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 18 | 19 | 1A | 1B | 1C | 1D | 1E | 1F |

MAC

| 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|---|
| 28 | 29 | 2A | 2B | 2C | 2D | 2E | 2F |

Order of sending ENKY:

| 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th |
|---|---|---|---|---|---|---|---|
| 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 |
| **9th** | **10th** | **11th** | **12th** | **13th** | **14th** | **15th** | **16th** |
| 08 | 09 | 0A | 0B | 0C | 0D | 0E | 0F |
| **17th** | **18th** | **19th** | **20th** | **21st** | **22nd** | **23rd** | **24th** |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| **25th** | **26th** | **27th** | **28th** | **29th** | **30th** | **31st** | **32nd** |
| 18 | 19 | 1A | 1B | 1C | 1D | 1E | 1F |
| **33rd** | **34th** | **35th** | **36th** | **37th** | **38th** | **39th** | **40th** |
| 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| **41st** | **42nd** | **43rd** | **44th** | **45th** | **46th** | **47th** | **48th** |
| 28 | 29 | 2A | 2B | 2C | 2D | 2E | 2F |

| SUM | (1 byte) | Sum data |
|---|---|---|
| ETX | (1 byte) | 03h |

N = 1–972

*) Do not send SKR, ESKY, IVEC, and ENKY separately with multiple packets, except RSA-4096 Private key.

For RSA-4096 Private key, send first 972 bytes of the Install data with the first packet and send the remaining 68 bytes with the second packet.

### 6.9.2.3   Data Packet [Key Data (2nd~Last)]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | N + 1 (Higher 1 byte) |
| LNL | (1 byte) | N + 1 (Lower 1 byte) |
| RES | (1 byte) | 2Ah (OK) |
| ENKY | (N bytes) | Install data (Encrypted key \| MAC).<br>*Order of sending: Low -> ... -> High |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

N = 1~1024

### 6.9.2.4   Data Packet [Status OK]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 2Ah (OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | D4h |
| ETX | (1 byte) | 03h |

### 6.9.2.5   Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | AAh (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.9.3   Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If this command cannot be executed in the current DLM state, the boot firmware sends a "Command acceptance error".
- When the above error occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware analyzes the command parameters:

- If ENTY is not specified as the Key type, the boot firmware will send a "Parameter error".
- If the area for Key index size from KADR is not included in the User area or Data area specified in the area information, the boot firmware sends a "Parameter error".
- If the area from KADR to Key index size is across different KOAs, the boot firmware sends a "Parameter error".
- If the WAU for the specified area is 0, the boot firmware sends a "Parameter error".
- If KADR is not specified in the area's WAU, the boot firmware sends a "Parameter error".
- If the specified range contains addresses that are inaccessible with the current boundary settings, the boot firmware sends an "Invalid address error".
- If the current Authentication level is AL1 and the specified range includes a secure area, the boot firmware sends a "Secure error".
- If the current Authentication level is AL0, the boot firmware sends a "Secure error".
- If the area for the key index size from KADR contains a permanently protected block, the boot firmware sends a "Protection error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.
- If the above errors do not occur, the boot firmware sends "OK".

When the processing above is successfully completed, boot firmware receives and analyzes the data packet:

- Boot firmware detects the beginning of a data packet by receiving SOD.
- When boot firmware receives other data than SOD, it discards the data and waits for the next data until SOD is sent.
- When the received data packet does not have ETX, "Packet error" is returned.
- When SUM in the received data packet is different from the value calculated by boot firmware, a "Checksum error" is returned.
- When LNH and LNL in the received data packet do not comply with the packet format, "Packet error" is returned.
- When RES in the received data packet is different from defined values, "Packet error" is returned.
- When the number of accumulated ENKY data exceeds the Install data size indicated by ENTY in the received data packet, the boot firmware sends a "Parameter error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.
- If the key data has not been received, the boot firmware receives the next data packet.

When all key data has been received, the boot firmware generates a key index (Wrapped key):

- If the Trusted system becomes abnormal after creating a key index (Wrapped key), the boot firmware returns nothing and does not respond.
  * Memory contents do not change before command reception.
- If the generation of the Key index (Wrapped key) fails, the boot firmware sends a "Trusted system error" and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware writes Key index to the dedicated area:

- If an error occurs while writing Key index (Wrapped key), the boot firmware sends a "Flash access error" and returns to the command wait state.
  * WAU size from failure address (ADR) of memory area are undefined.
- If the key index (Wrapped key) is successfully saved to the device, the boot firmware sends "OK" and returns to the command wait state.

### 6.9.4 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Executing this command is unavailable in the current DLM state. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| User key type is not specified as the Key type. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The area from the Key setting address to the key index size does not fit in the range of the User area and Data area specified by area information. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The area from the Key setting address to the Key index size spans different Kinds of areas. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The key storage area WAU is 0. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Key setting address is not specified in the WAU for the area. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The area from the Key setting address to the Key index size contains addresses that are inaccessible with the current boundary settings. | Invalid address error | FFFFFFFFh | FFFFFFFFh |
| The current Authentication level is AL1, and the Key setting address contains a Secure region. | Secure error | FFFFFFFFh | FFFFFFFFh |
| The current Authentication level is AL0. | Secure error | FFFFFFFFh | FFFFFFFFh |
| There is a block with permanent block protection in the area from the Key setting address to the Key index size. | Protection error | FFFFFFFFh | FFFFFFFFh |
| The response code of the received data packet is different from the value specified by this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| In the received data packet, the cumulative number of Install data exceeds the Install data size of the key specified by User key type. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Key index (Wrapped Key) generation failed. | Trusted system error | FFFFFFFFh | FFFFFFFFh |
| FACI detected an error after the command execution. | Flash access error | Flash status | Failure address |
| Successful completion. | OK | FFFFFFFFh | FFFFFFFFh |

#### 6.9.4.1  User Key List

The list of user keys specified by this command is shown in Table 20.

**Table 20.  User Key List**

| Key type | Installation key | Install data size (bytes) | Key index size (bytes) |
|----------|------------------|---------------------------|------------------------|
| 05h | AES-128 | 32 | 36 |
| 06h | AES-192 | 48 | 52 |
| 07h | AES-256 | 48 | 52 |
| 08h | AES-128 XTS | 48 | 52 |
| 09h | AES-256 XTS | 80 | 84 |
| 0Ah | RSA-1024 Public key | 160 | 164 |
| 0Bh | RSA-1024 Private key | 272 | 276 |
| 0Ch | RSA-2048 Public key | 288 | 292 |
| 0Dh | RSA-2048 Private key | 528 | 532 |
| 0Eh | RSA-3072 Public key | 416 | 420 |
| 0Fh | RSA-3072 Private key | 784 | 788 |
| 10h | RSA-4096 Public key | 544 | 548 |
| 11h | RSA-4096 Private key | 1040 | 1044 |
| 12h | ECC P192 Public key | 80 | 84 |
| 13h | ECC P192 Private key | 48 | 52 |
| 14h | ECC P224 Public key | 80 | 84 |
| 15h | ECC P224 Private key | 48 | 52 |
| 16h | ECC P256 Public key | 80 | 84 |
| 17h | ECC P256 Private key | 48 | 52 |
| 18h | ECC P384 Public key | 112 | 116 |
| 19h | ECC P384 Private key | 64 | 68 |
| 1Ah | HMAC-SHA224 | 48 | 52 |
| 1Bh | HMAC-SHA256 | 48 | 52 |
| 1Ch | ECC P256r1 Public Key | 80 | 84 |
| 1Dh | ECC P256r1 Private Key | 48 | 52 |
| 1Eh | ECC P384r1 Public Key | 112 | 116 |
| 1Fh | ECC P384r1 Private Key | 64 | 68 |
| 20h | ECC P512r1 Public Key | 144 | 148 |
| 21h | ECC P512r1 Private Key | 80 | 84 |
| 22h | ECC secp256k1 Public Key | 80 | 84 |
| 23h | ECC secp256k1 Private Key | 48 | 52 |
| 24h | ECC P521 Public Key | 176 | 180 |
| 25h | ECC P521 Private Key | 96 | 100 |
| 26h | Ed25519 Public Key | 48 | 52 |
| 27h | Ed25519 Private Key | 48 | 52 |
| 28h | HMAC-SHA384 | 64 | 68 |
| 29h | HMAC-SHA512 | 80 | 84 |
| 2Ah | HMAC-SHA512-224 | 80 | 84 |
| 2Bh | HMAC-SHA512-256 | 80 | 84 |
| FEh | RSA-2048 Public Key for TLS | 288 | 292 |
| FFh | Key update key | 48 | 52 |

## 6.10 Key Verify Command

This command verifies the authentication key that setting to device.

This command requires adherence to conditions described in Command List.

### 6.10.1 Sequence Diagram
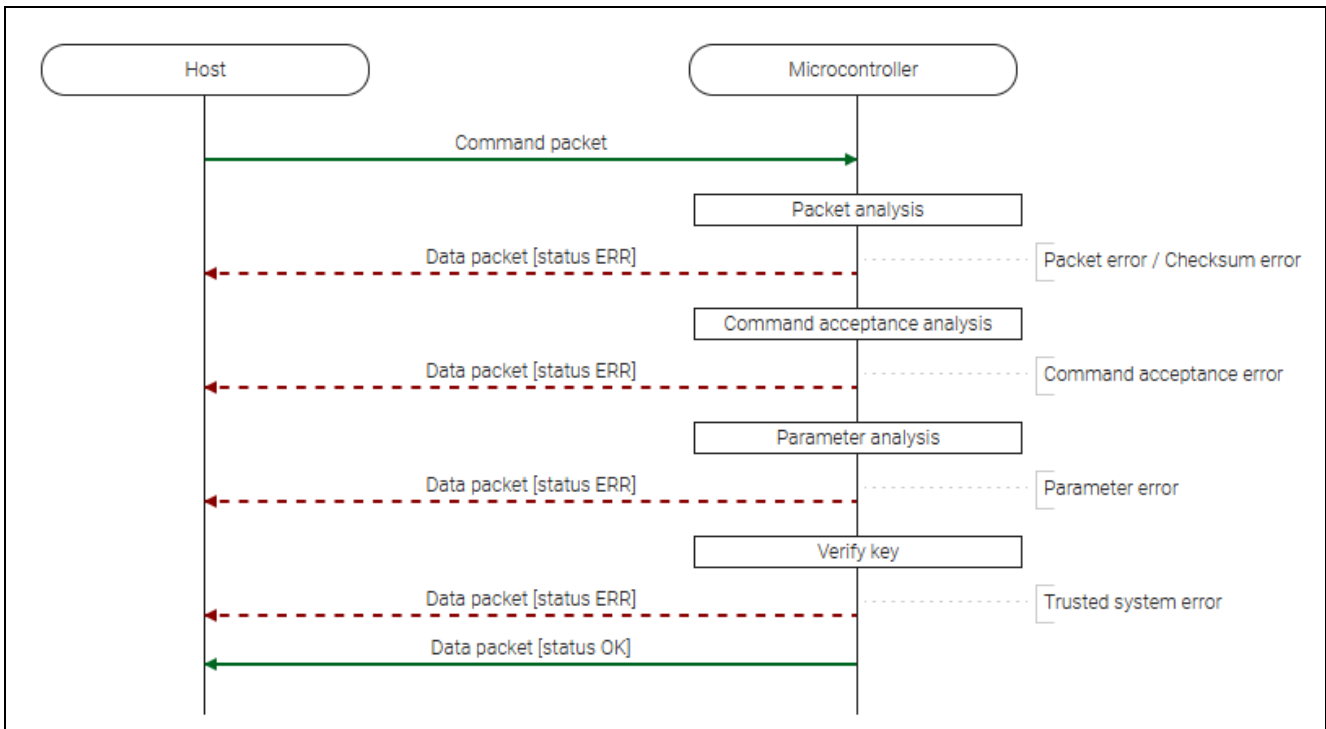


**Figure 27. Key Verify Command Sequence Diagram**

### 6.10.2 Packets
### 6.10.2.1 Command Packet

| SOH | (1 byte) | 01h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 02h |
| CMD | (1 byte) | 29h (Key verify command) |
| KYTY | (1 byte) | Key type:<br>• 01h: AL2_KEY<br>• 02h: AL1_KEY<br>• 03h: RMA_KEY |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.10.2.2 Data Packet [Status OK]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 29h (OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | D5h |
| ETX | (1 byte) | 03h |

### 6.10.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | A9h (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.10.2.4 Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If the device reset is not asserted after the Encrypted data write command is executed, the boot firmware sends a "Command acceptance error".
- When the above error occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes the parameter analysis:

- If KYTY is an unsupported key type, the boot firmware sends a "Parameter error" and returns to the command wait state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware verifies the Key index (Wrapped key).

- If verification of the key index (Wrapped key) fails, the boot firmware sends a "Trusted system error" and returns to the command wait state.
  If the Trusted system becomes abnormal during verification of the key index (Wrapped key), the boot firmware returns nothing and does not respond.
  * Memory contents do not change before command reception.
- If the verification of the key index (Wrapped key) is completed successfully, the boot firmware sends "OK" and returns to the command wait state.
  * Memory contents do not change before command reception.

### 6.10.3 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Key type is not supported key type. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Verify the authentication key failed. | Trusted system error | FFFFFFFFh | FFFFFFFFh |
| Successful completion. | OK | FFFFFFFFh | FFFFFFFFh |

## 6.11 User Key Verify Command

This command verifies the authentication key that setting to device.

This command requires adherence to conditions described in Command List.

### 6.11.1 Sequence Diagram
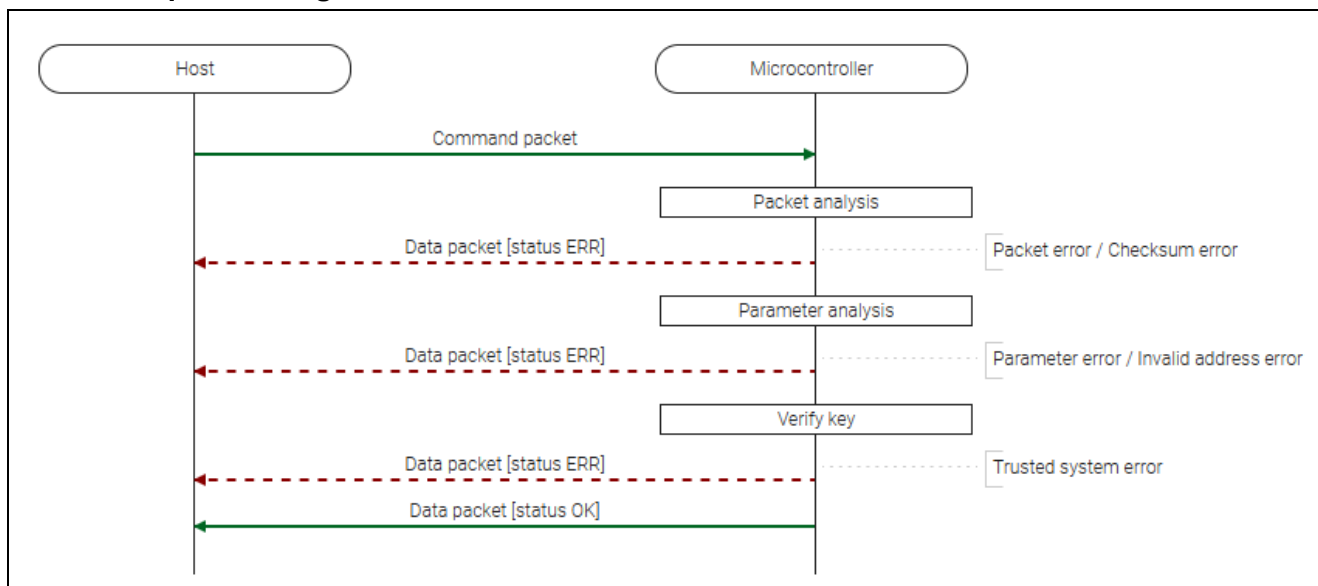


**Figure 28. User Key Verify Command Sequence Diagram**

## 6.11.2 Packets
### 6.11.2.1 Command Packet

| SOH | (1 byte) | 01h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 06h |
| CMD | (1 byte) | 2Bh (User key verify command) |
| KADR | (4 bytes) | Key address. For example: 00004000h -> 00h, 00h, 40h, 00h |
| ENTY | (1 byte) | User key type. Supports the same key type as User key setting command. |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.11.2.2 Data Packet [Status OK]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 2Bh (OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | D6h |
| ETX | (1 byte) | 03h |

### 6.11.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | ABh (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

## 6.11.3 Processing Procedure
Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes the parameter analysis:

- If ENTY is not specified as the Key type, the boot firmware will send a "Parameter error".
- If the area for Key index size from KADR is not included in the User area or Data area specified in the area information, the boot firmware sends a "Parameter error".
- If the area from KADR to Key index size is across different KOAs, the boot firmware sends a "Parameter error".
- If the WAU for the specified area is 0, the boot firmware sends a "Parameter error".
- If KADR is not specified in the WAU of the area, the boot firmware sends a "Parameter error".
- If the specified range contains addresses that are inaccessible with the current boundary settings, the boot firmware sends an "Invalid address error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware verifies the authentication key:

- When there is a mismatch in the authentication key stored in the device, boot firmware returns "Trusted system error".
  If the Trusted system becomes abnormal during key verification, the boot firmware returns nothing and does not respond.
  * Memory contents do not change before command reception.
- If the above error does not occur, the boot firmware sends "OK".
  * Memory contents do not change before command reception.

## 6.11.4 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| User key type is not specified as the Key type. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The area from the Key address to the Key index size does not fit in the range of User area and Data area specified by area information. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The area from the Key address to the Key index size spans different Kinds of areas. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The key storage area WAU is 0. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Key address is not specified in the WAU for the area. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The area from the Key address to the Key index size contains addresses that are inaccessible with the current boundary settings. | Invalid address error | FFFFFFFFh | FFFFFFFFh |
| Key index verification failed. | Trusted system error | FFFFFFFFh | FFFFFFFFh |
| Successful completion. | OK | FFFFFFFFh | FFFFFFFFh |

## 6.12 Initialize Command

This command initializes the following areas and transits the Protection level state to PL2:

- User area
- Data area
- Config area
- EEP config area
- Boundary setting
- Key index (Wrapped key)

Initialization used here means that erasure for erasable areas and writing initial values for non-erasable areas. Initialization processing at this time is not affected by the block protection settings (BPS, BPS_SEC).

This command requires adherence to conditions described in Command List.

### 6.12.1 Sequence Diagram
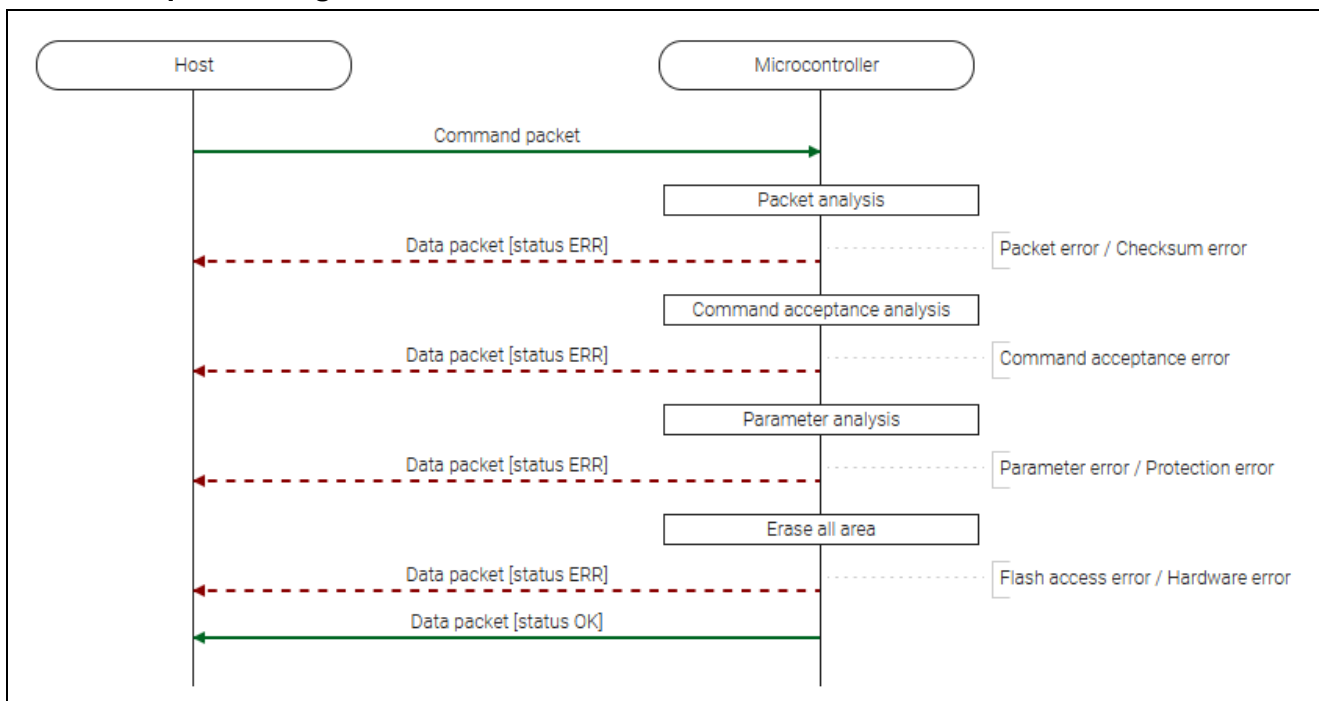


**Figure 29.  Initialize Command Sequence Diagram**

### 6.12.2 Packets
### 6.12.2.1 Command Packet

| SOH | (1 byte) | 01h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 03h |
| CMD | (1 byte) | 50h (Initialize command) |
| SDLM | (1 byte) | Source DLM state code:<br>• 04h: OEM |
| DDLM | (1 byte) | Destination DLM state code:<br>• 04h: OEM |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.12.2.2 Data Packet [Status OK]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 50h (OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | AEh |
| ETX | (1 byte) | 03h |

### 6.12.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | D0h (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

## 6.12.3 Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If this command cannot be executed in the current DLM state, the boot firmware sends a "Command acceptance error".
- If the device reset is not asserted after the Encrypted data write command is executed, the boot firmware sends a "Command acceptance error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, the boot firmware analyzes the command parameters:

- When SDLM does not match with the current DLM state, "Parameter error" is returned.
- When DDLM is not OEM, "Parameter error" is returned.
- When initialization is disabled, "Protection error" is returned.
- When authentication with AL2_KEY is disabled, "Protection error" is returned.
- When Permanent protected block exists (There is a bit that is "0" in PBPS[139:0] and PBPS_SEC[139:0]), "Protection error" is returned.
- When the FSPR bit is 0, the "Protection error" is returned.
- When there is an EEP config area locked by the lock bit, a "Protection error" is returned.
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes memory initialization:

- If an error occurs while initializing the Block, protect the setting, the boot firmware sends a "Flash access error" and returns to the command wait state.
  * The value of the Block protect setting is undefined.
- If an error occurs while initializing the User area, the boot firmware sends a "Flash access error" and returns to the command wait state.
  * The value of the area after ADR (Failure address) of the User area is undefined.
- If an error occurs while initializing the Data area, the boot firmware sends a "Flash access error" and returns to the command wait state.
  * The value of the Data area is undefined.
- If an error occurs while initializing the Config area, the boot firmware sends a "Flash access error" and returns to the command wait state.
  * The value of the Config area is undefined.
- If an error occurs while initializing the EEP Config area, the boot firmware sends a "Flash access error" and returns to the command wait state.
  * The value of the EEP Config area is undefined.
- If an error occurs while initializing boundary setting and Key index (Wrapped key), the boot firmware sends a "Flash access error" and returns to the command wait state.
- If an error occurs during the transition Protection level, boot firmware returns "Flash access error" and waits for the next command.
  * Check the Protection level after the Flash access error has occurred with the Protection level request command.
- If the Protection level is an invalid value, the boot firmware sends a "Hardware error" and becomes unresponsive.
- If initialization is completed normally, the boot firmware sends "OK" and does not respond.
  * The memory is in the following state and the Protection level is PL2:
    - User area: Erased.
    - Data area: Erased.
    - Config area: Value when shipped, except for that reserved area is not changed before command execution.
    - EEP Config area: Value when shipped, except for that reserved area is not changed before command execution.

## 6.12.4 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Executing this command is unavailable in the current DLM state. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Source DLM state code is different from the current DLM state. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Destination DLM state code is not OEM. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Initialization is disabled. | Protection error | FFFFFFFFh | FFFFFFFFh |
| AL2_KEY is disable. | Protection error | FFFFFFFFh | FFFFFFFFh |
| There is a permanently protected block. | Protection error | FFFFFFFFh | FFFFFFFFh |
| The FSPR bit is set. (FSPR = 0) | Protection error | FFFFFFFFh | FFFFFFFFh |
| There is an EEP config area locked by the Lock bit. | Protection error | FFFFFFFFh | FFFFFFFFh |
| FACI detected an error after the command execution in the disclosed area. | Flash access error | Flash status | Failure address |
| FACI detected an error after the command execution in not disclosed area. | Flash access error | Flash status | FFFFFFFFh |
| Protection level is abnormal. | Hardware error | FFFFFFFFh | FFFFFFFFh |
| Successful completion. | OK | FFFFFFFFh | FFFFFFFFh |

## 6.12.5 Precautions

- The following parameters are not initialized by this command. For details on each parameter, refer to the Parameter setting command.
  — Disable of authentication using AL1_KEY
  — Disable transition to LCK_BOOT
- The following areas are not initialized by this command.
  — Anti-rollback counter area
  — Lock bit for Anti-rollback counter area(*)
  — External flash area

In addition, the Lock bit for the Anti-rollback counter is outside the scope of Protection error.

In other words, boot firmware does not return a Protection error but executes initialization even when the Lock bit for the Anti-rollback counter is set.

*)There may be other uninitialized bits in the area where the Lock bit for the Anti-rollback counter area is located.

Refer to the user's manual of the device for details.

### 6.12.6 Protection Level Transition

The transition of the Protection level by this command is shown below.
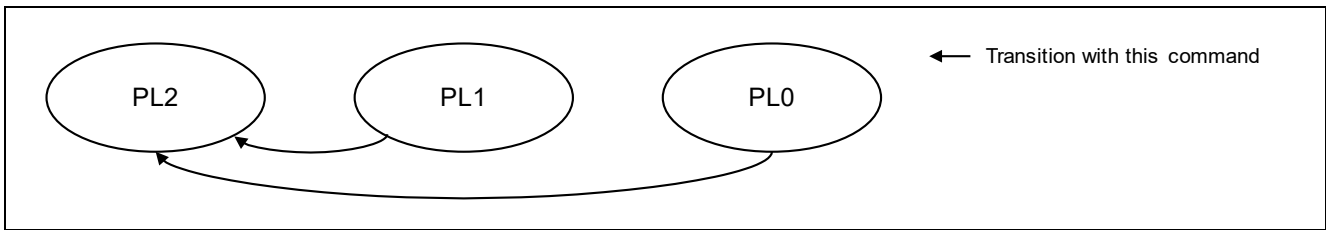


**Figure 30.　Protection Level Transitions**

## 6.13 Boundary Setting Command

This command receives the boundary setting and stores it in the device.

The accessible addresses of the following areas change depending on the boundary settings:

- User area
- Data area

This command requires adherence to conditions described in Command List.

### 6.13.1 Sequence Diagram
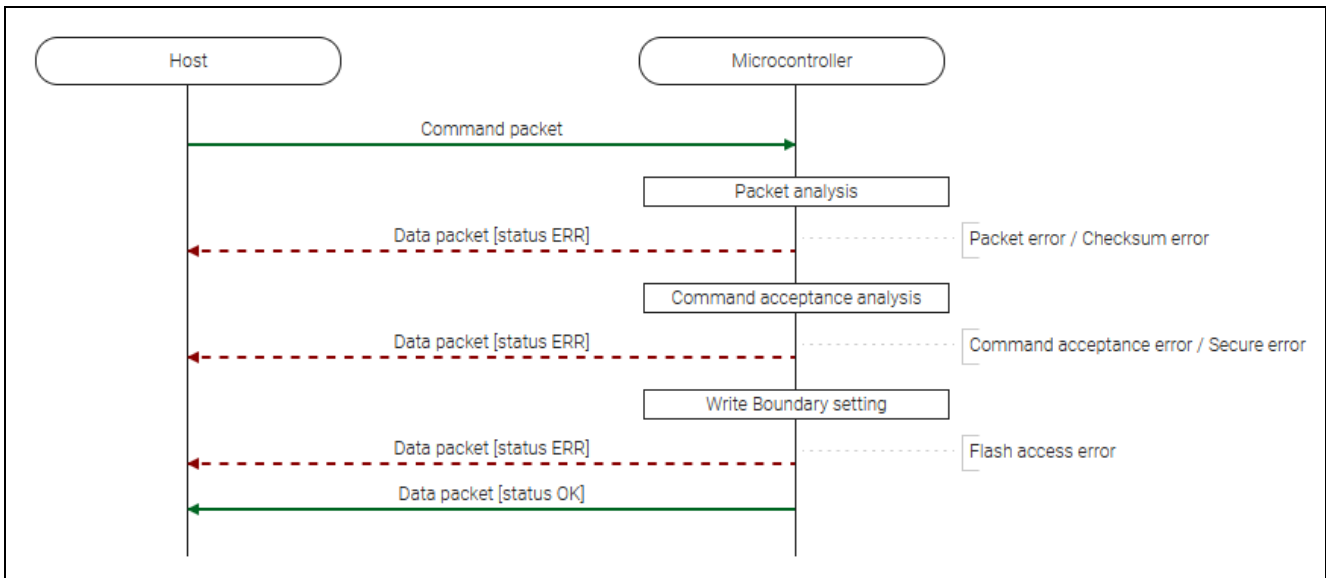


**Figure 31.　Boundary Setting Command Sequence Diagram**

### 6.13.2  Packets
### 6.13.2.1 Command Packet

| SOH | (1 byte) | 01h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Bh |
| CMD | (1 byte) | 4Eh (Boundary setting command) |
| RSV | (2 bytes) | 0000h (unused code) |
| CFS | (2 bytes) | Size of Code Flash Secure region [KB].<br>For example: 0100h -> 01h, 00h (256 KB)<br>* 32 KB align |
| DFS | (2 bytes) | Size of Data Flash Secure region [KB].<br>For example: 0004h -> 00h, 04h (4 KB) |
| RSV | (2 bytes) | 0000h (unused code) |
| RSV | (2 bytes) | 0000h (unused code) |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

* If CFS does not comply with alignment, boot firmware rounds down them.

### 6.13.2.2 Data Packet [Status OK]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 4Eh (OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.13.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | CEh (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.13.3 Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.

* Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If this command cannot be executed in the current DLM state, the boot firmware sends a "Command acceptance error".
- If the device reset is not asserted after the Encrypted data write command is executed, the boot firmware sends a "Command acceptance error".
- If the current Authentication level is AL1 or AL0, the boot firmware sends a "Secure error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware writes the boundary setting:

- If an error occurs while writing, the boot firmware sends a "Flash access error" and returns to the command wait state.
- When the write processing is normally finished, boot firmware returns "OK" and waits for the next command.

### 6.13.4 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Executing this command is unavailable in the current DLM state. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Authentication level is AL1 or AL0. | Secure error | FFFFFFFFh | FFFFFFFFh |
| FACI detected an error after the command execution in not disclosed area. | Flash access error | Flash status | FFFFFFFFh |
| Successful completion. | OK | FFFFFFFFh | FFFFFFFFh |

### 6.13.5 Example of Use

The relationship between boundary settings and secure regions are shown below.

Example: CFS=0200h, DFS=0004h
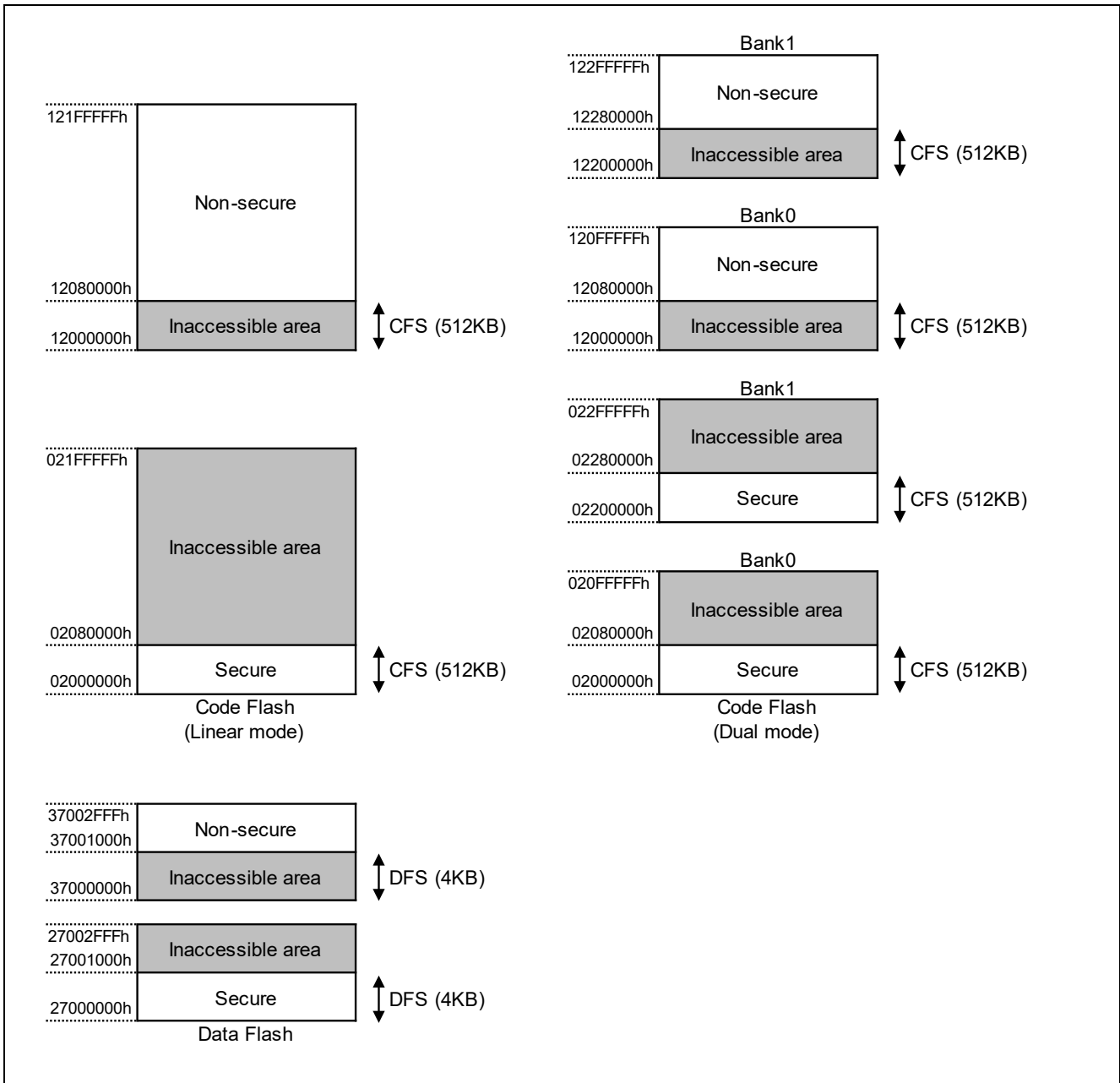


**Figure 32. Boundary Setting Example**

## 6.14 Boundary Request Command

This command sends the boundary setting value to the host. (Returns the value currently stored in the device.)

This command requires adherence to conditions described in Command List.

### 6.14.1 Sequence Diagram
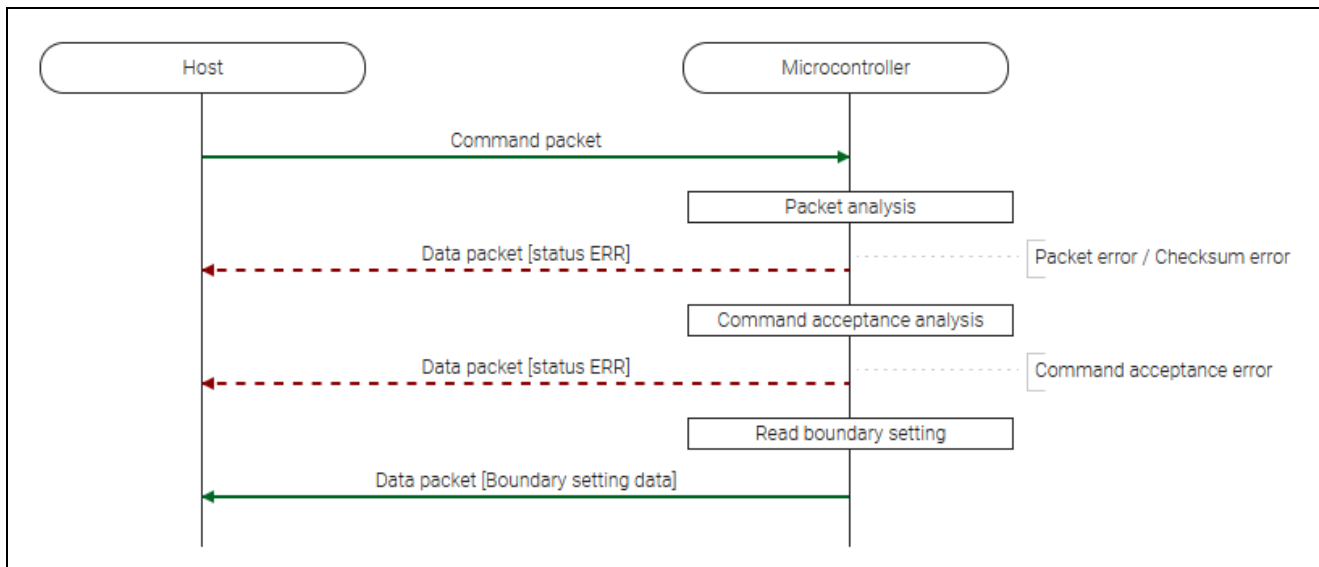


**Figure 33.  Boundary Request Command Sequence Diagram**

### 6.14.2 Packets
### 6.14.2.1 Command Packet

| SOH | (1 byte) | 01h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 01h |
| CMD | (1 byte) | 4Fh (Boundary request command) |
| SUM | (1 byte) | B0h |
| ETX | (1 byte) | 03h |

### 6.14.2.2 Data packet [Boundary Setting Data]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Bh |
| RES | (1 byte) | 4Fh (OK) |
| RSV | (2 bytes) | 0000h (unused code) |
| CFS | (2 bytes) | Size of Code Flash Secure region [KB]<br>For example: 0100h -> 01h, 00h (256 KB) |
| DFS | (2 bytes) | Size of Data Flash Secure region [KB]<br>For example: 0004h -> 00h, 04h (4 KB) |
| RSV | (2 bytes) | 0000h (unused code) |
| RSV | (2 bytes) | 0000h (unused code) |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.14.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | CFh (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.14.3 Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If the device reset is not asserted after the Encrypted data write command is executed, the boot firmware sends a "Command acceptance error".
- When the above error occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware returns the boundary setting.

- Boot firmware sends "Boundary information" and waits for next command.
  * Memory contents do not change before command reception.

### 6.14.4 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|-----------|-----|-----|-----|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |

## 6.15 Parameter Setting Command

This command stores the received parameter in the device.

This command require adherence to conditions described in Command List.

### 6.15.1 Sequence Diagram



**Figure 34.  Parameter Setting Command Sequence Diagram**

### 6.15.2 Packets
### 6.15.2.1 Command Packet

| | | | | | | |
|---|---|---|---|---|---|---|
| SOH | (1 byte) | 01h | | | | |
| LNH | (1 byte) | 00h | | | | |
| LNL | (1 byte) | 03h | | | | |
| CMD | (1 byte) | 51h (Parameter setting command) | | | | |
| PMID | (1 byte) | Parameter ID Specifiable parameter: | | | | |
| | | **PMID** | **Parameter description** | **Specifiable at** | **Specifiable after Encrypted data write command** | |
| | | 01h | Disable initialization | AL2/AL1/AL0 | Specifiable | |
| | | 02h | Disable LCK_BOOT | AL2/AL1 | Specifiable | |
| | | 03h | Disable AL2_key | AL2 | Specifiable | |
| | | 04h | Disable AL1_key | AL2/AL1 | Non-specifiable | |
| PRMT | (1 byte) | Parameter data:<br>• [PMID=01h]<br>— 00h: Disable initialization<br>• [PMID=02h]<br>— 00h: Disable transition to LCK_BOOT<br>• [PMID=03h]<br>— 00h: Disable of authentication using AL2_KEY (*1)<br>• [PMID=04h]<br>— 00h: Disable of authentication using AL1_KEY | | | | |
| SUM | (1 byte) | Sum data | | | | |
| ETX | (1 byte) | 03h | | | | |

*1: When disabled, initialization and transition to RMA_REQ are also impossible.

### 6.15.2.2 Data Packet [Status OK]

| SOD | (1 byte) | 81h |
| --- | --- | --- |
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 51h (OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.15.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
| --- | --- | --- |
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | D1h (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

## 6.15.3 Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If this command cannot be executed in the current DLM state, the boot firmware sends a "Command acceptance error".
- When the above error occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware analyzes the command parameters:

- When designated PMID is unsupported, "Parameter error" is returned.
- When designated PMID is cannot be set in the current Authentication level, "Secure error" is returned.
- If both the following conditions are met, the boot firmware sends a "Command acceptance error":
  — Device reset is not asserted after Encrypted data write command execution.
  — Parameter ID that is non-specifiable after Encrypted data write command is specified.
- If PRMT is not the specified value, the boot firmware sends a "Parameter error" and returns to the command wait state.
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware writes parameter setting.

- If an error occurs while writing, the boot firmware sends a "Flash access error" and returns to the command wait state.
- When the write processing is normally finished, boot firmware returns "OK" and waits for the next command.

### 6.15.4 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Executing this command is unavailable in the current DLM state. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| The specified Parameter ID is an unsupported value. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The specified Parameter ID cannot be set at the current Authentication level. | Secure error | FFFFFFFFh | FFFFFFFFh |
| Both the following conditions are met:<br>• Device reset is not asserted after Encrypted data write command execution.<br>• Parameter ID that is non-specifiable after Encrypted data write command is specified. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Parameter data is not the specified value. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| FACI detected an error after the command execution in not disclosed area. | Flash access error | Flash status | FFFFFFFFh |
| Successful completion. | OK | FFFFFFFFh | FFFFFFFFh |

### 6.15.5 Parameter Details

The following shows the parameter data (PRMT) details.

[Disable setting for the function]

- PRMT[2:0]: 000b
- PRMT[7:3]: Any value can be specified (ignored when writing).

* PRMT[2:0] accepts only 000b. If the specified parameter has been already set, the boot firmware does not write but returns OK.

* Once disabled, the function cannot be enabled again.

## 6.16 Parameter Request Command

This command reads the specified parameter from the device and sends it to the host. (Returns the value currently stored in the device.)

This command require adherence to conditions described in Command List.

### 6.16.1 Sequence Diagram



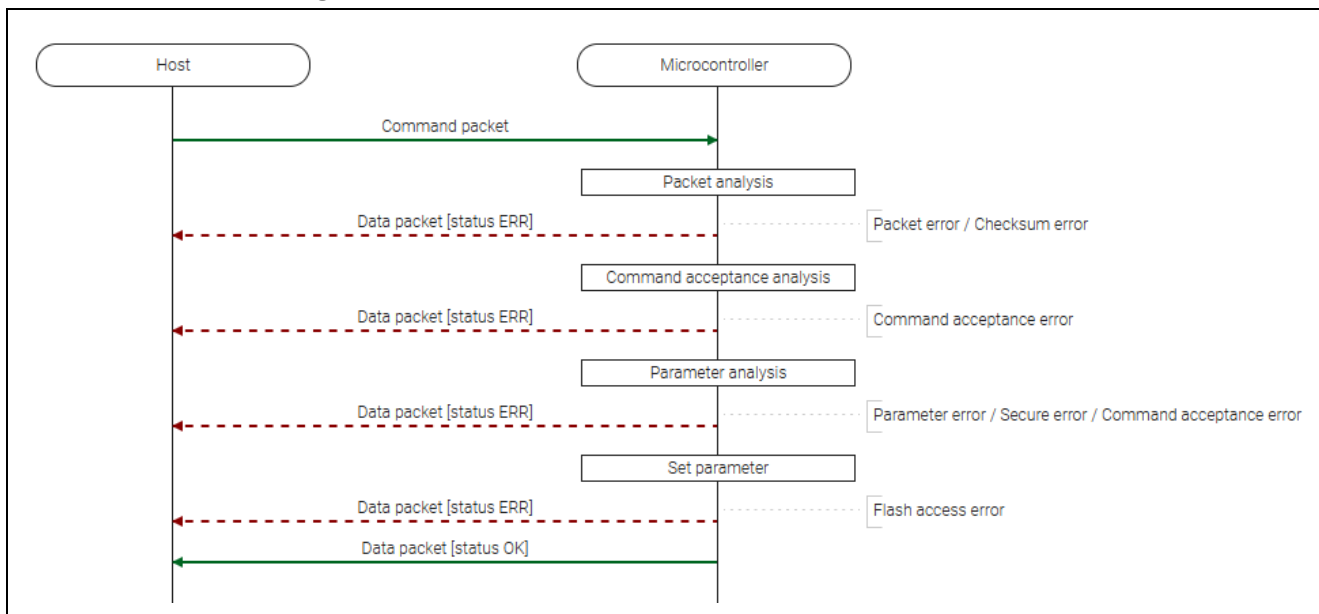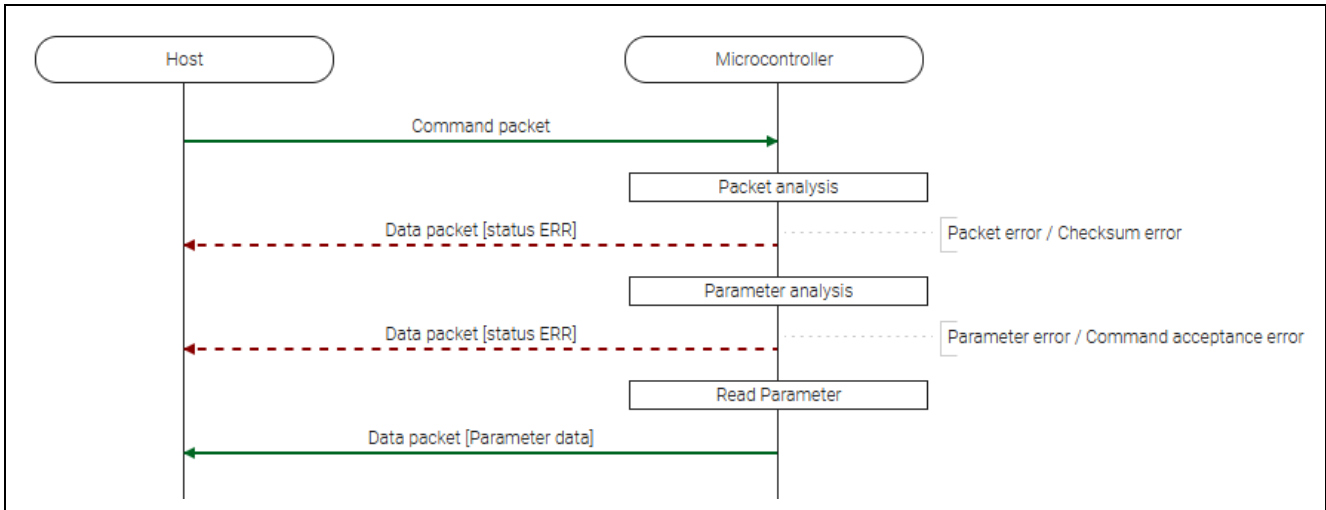**Figure 35.  Parameter Request Command Sequence Diagram**

### 6.16.2 Packets
### 6.16.2.1 Command Packet

| SOH | (1 byte) | 01h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 02h |
| CMD | (1 byte) | 52h (Parameter request command) |
| PMID | (1 byte) | Parameter ID<br>Specifiable parameter:<br><br>| PMID | Parameter description | Specifiable after Encrypted data write command |<br>|---|---|---|<br>| 01h | Disable initialization | Specifiable |<br>| 02h | Disable LCK_BOOT | Specifiable |<br>| 03h | Disable AL2_key | Specifiable |<br>| 04h | Disable AL1_key | Non-specifiable | |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.16.2.2 Data Packet [Parameter Data]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 02h |
| RES | (1 byte) | 52h (OK) |
| PRMT | (1 byte) | Parameter data:<br>• [PMID=01h]<br>— 00h: Initialization is disabled.<br>— 07h: Initialization is enabled.<br>• [PMID=02h]<br>— 00h: Transition to LCK_BOOT is disabled.<br>— 07h: Transition to LCK_BOOT is enabled.<br>• [PMID=03h]<br>— 00h: Authentication using AL2_KEY is disabled (*1).<br>— 07h: Authentication using AL2_KEY is enabled.<br>• [PMID=04h]<br>— 00h: Authentication using AL1_KEY is disabled.<br>— 07h: Authentication using AL1_KEY is enabled. |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

*1: When disabled, initialization and transition to RMA_REQ are also impossible.

### 6.16.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | D2h (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.16.3 Processing Procedure

Boot firmware receives and analyzes a command packet:

• The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
• If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
• If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
• If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
• If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
• When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware analyzes the command parameters:

- When designated PMID is unsupported, "Parameter error" is returned.
- If both the following conditions are met, the boot firmware sends a "Command acceptance error":
  — Device reset is not asserted after Encrypted data write command execution.
  — Parameter ID that is non-specifiable after Encrypted data write command is specified.
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.

\* Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware returns the parameter setting:

- Boot firmware send parameter and waits for next command.
  \* Memory contents do not change before command reception.

### 6.16.4 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| The specified Parameter ID is an unsupported value. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Both the following conditions are met:<br>- Device reset is not asserted after Encrypted data write command execution.<br>- Parameter ID that is non-specifiable after Encrypted data write command is specified. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |

### 6.16.5 Parameter Details

The following shows the parameter data (PRMT) details.

[The function is disabled]

- PRMT[2:0]: 000b
- PRMT[7:3]: Always returns 0

[The function is enabled]

- PRMT[2:0]: 111b
- PRMT[7:3]: Always returns 0

## 6.17 Lock Bit Setting Command

This command sets the received Lock bit data to the Lock bit area of EEP Config area.

This command require adherence to conditions described in Command List.

### 6.17.1 Sequence Diagram
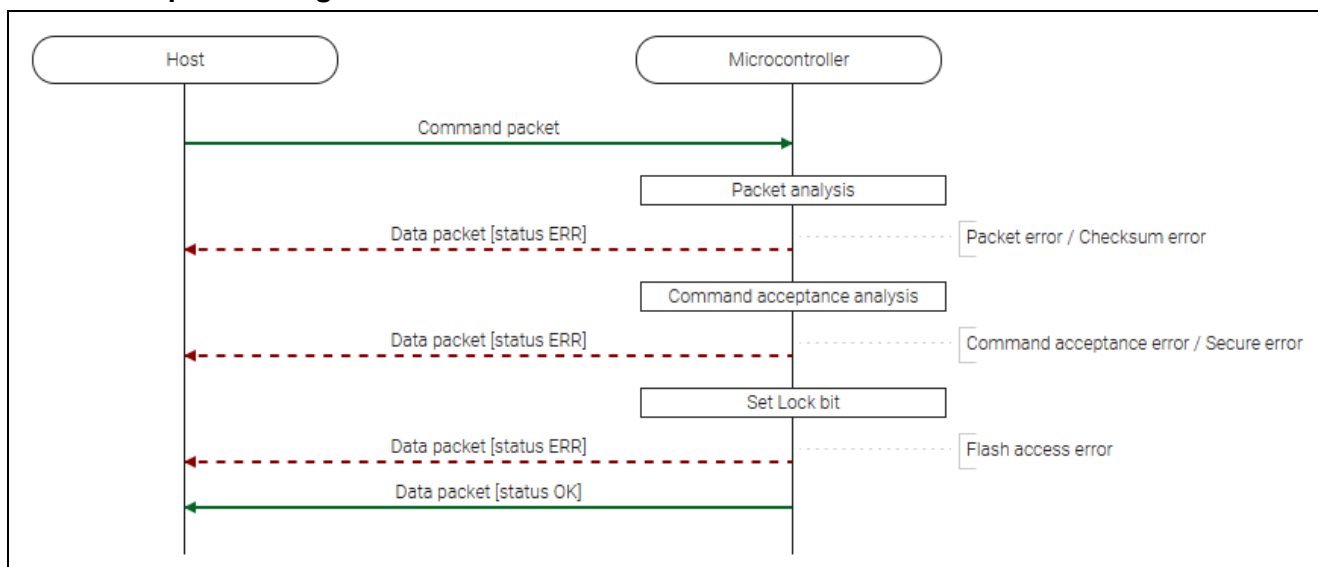


**Figure 36.  Lock Bit Setting Command Sequence Diagram**

### 6.17.2 Packets
### 6.17.2.1 Command Packet

| SOH | (1 byte) | 01h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 13h |
| CMD | (1 byte) | 4Ah (Lock bit setting command) |
| LCK | (18 bytes) | Lock bit data.<br>[Meaning of the set value]:<br>• 1b: Lock bit protection is not valid<br>• 0b: Lock bit protection is valid<br>[Data sending order]:<br>First received data is written to lower address of Lock bit area. For example: When the received LCK is 00h, 01h ... 10h, 11h, the data are written as follows:<br>• 00h is written to 27030380h (*1)<br>• 01h is written to 27030381h (*1)<br>•   :<br>• 10h is written to 27030390h (*1)<br>• 11h is written to 27030391h[5:0] (*1, 2)<br><br>*1) Note that these are RA8M1 MCU group addresses and may vary by device.<br>Refer to the device's user's manual for details.<br>*2) Bit[7:6] is not changed because this command does not set Lock bit for Hash of OEM root public key also as described in the following Precautions. |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.17.2.2 Data Packet [Status OK]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 4Ah(OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.17.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | CAh (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

## 6.17.3 Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If this command cannot be executed in the current DLM state, the boot firmware sends a "Command acceptance error".
- If current Authentication level is AL1 or AL0, the boot firmware sends a "Secure error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware writes Lock bit:

- If an error occurs while writing Lock bit, the boot firmware sends a "Flash access error" and returns to the command wait state.
  * Memory status is Lock bit area is indefinite.
- If the Lock bit is successfully saved to the device, the boot firmware returns "OK" and returns to the command wait state.
  * The Lock bit is set to the memory.

### 6.17.4 Status Information from the Microcontroller
(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Executing this command is unavailable in the current DLM state. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Current Authentication level is AL1 or AL0. | Secure error | FFFFFFFFh | FFFFFFFFh |
| FACI detected an error after the command execution. | Flash access error | Flash status | Failure address |
| Successful completion. | OK | FFFFFFFFh | FFFFFFFFh |

### 6.17.5 Precautions
1. This command does not set Lock bit for Hash of OEM root public key.
   Lock bit data for Hash of OEM root public key in the received LCK is ignored.
   Use OEM root public key setting command to set Lock bit for Hash of OEM root public key.
2. It is not possible to set 1b to the Lock bit that has already been set to 0b.
   Boot firmware does not return Protection error nor Flash access error but returns OK in this case.
   Note that the set value of Lock bit is not changed though boot firmware returns OK.

## 6.18 Lock Bit Request Command

This command reads the setting data in Lock bit of EEP Config area and sends them to the host.

This command require adherence to conditions described in Command List.

### 6.18.1 Sequence Diagram
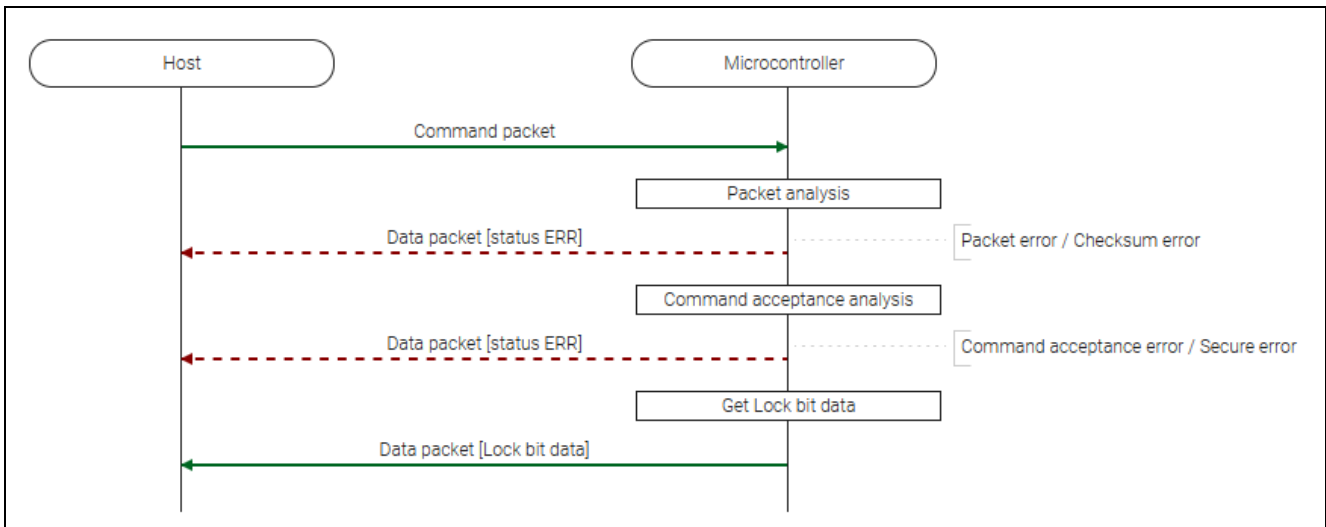


**Figure 37. Lock Bit Request Command Sequence Diagram**

### 6.18.2 Packets
### 6.18.2.1 Command Packet

| SOH | (1 byte) | 01h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 01h |
| CMD | (1 byte) | 4Bh (Lock bit request command) |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.18.2.2 Data Packet [Lock Bit Data]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 13h |
| RES | (1 byte) | 4Bh (OK) |
| LCK | (18 bytes) | Lock bit data.<br>[Meaning of the set value]:<br>• 1b: Lock bit protection is not valid.<br>• 0b: Lock bit protection is valid.<br><br>[Data sending order]:<br>Data written in lower address of Lock bit area is sent first. For example: 00h, 01h ... 10h, D1h(*2) are sent when the data in Lock bit area are as follows:<br>• 27030380h: 00h(*1)<br>• 27030381h: 01h(*1)<br>• :<br>• 27030390h: 10h(*1)<br>• 27030391h[5:0]: 11h(*1)<br><br>*1) Note that these are RA8M1 MCU group addresses and may vary by device. Refer to the device's user's manual for details.<br>*2) Bit[7:6] of this data are always 11b because this command does not send Lock bit for Hash of OEM root public key also as described in the following Precautions. |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.18.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | CBh (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.18.3 Processing Procedure

Boot firmware receives and analyzes a command packet:

• The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
• If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
• If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
• If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
• If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
• When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If this command cannot be executed in the current DLM state, the boot firmware sends a "Command acceptance error".
- If current Authentication level is AL1 or AL0, the boot firmware sends a "Secure error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware returns Lock bit:

- Boot firmware send "Lock bit information" and waits for next command.
  * Memory contents do not change before command reception.

### 6.18.4 Status Information from the Microcontroller
(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Executing this command is unavailable in the current DLM state. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Current Authentication level is AL1 or AL0. | Secure error | FFFFFFFFh | FFFFFFFFh |

### 6.18.5 Precautions
(1) This command does not send Lock bit for Hash of OEM root public key. Lock bit data for Hash of OEM root public key in the sent LCK is always all-1.

## 6.19 ARC Configuration Setting Command

This command sets the received Anti-Rollback Counter configuration data to the device.

This command require adherence to conditions described in Command List.

### 6.19.1 Sequence Diagram
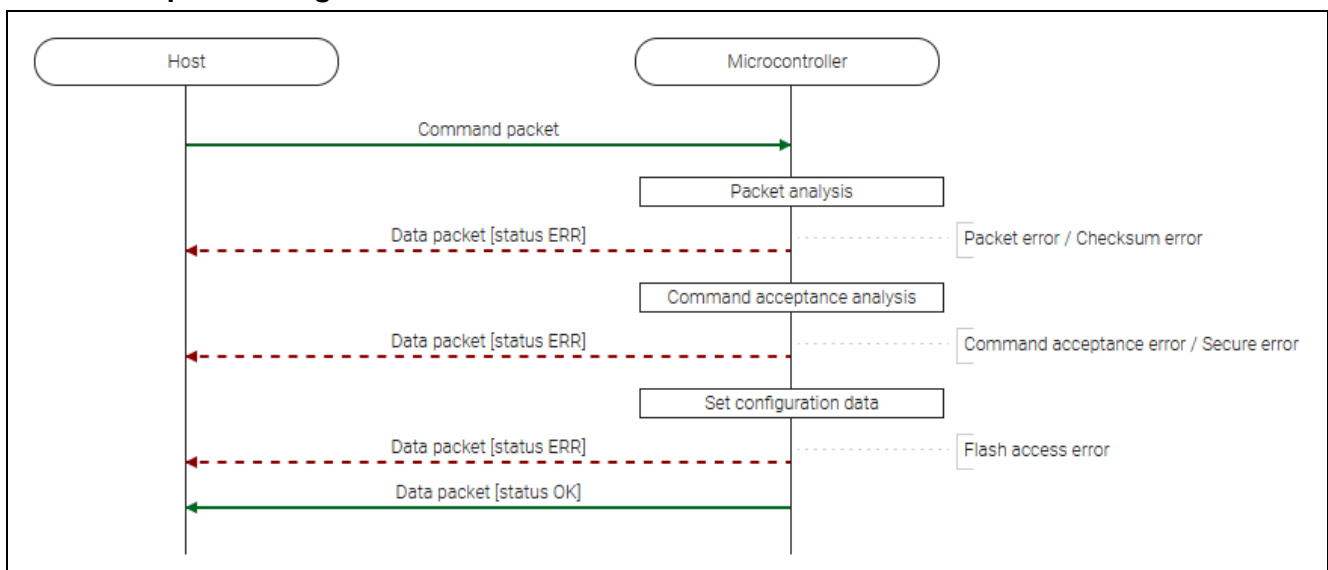


**Figure 38.  ARC Configuration Setting Command Sequence Diagram**

### 6.19.2  Packets
### 6.19.2.1 Command Packet

| SOH | (1 byte) | 01h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 05h |
| CMD | (1 byte) | 4Ch (ARC configuration setting command) |
| ARC | (4 bytes) | Anti-Rollback Configuration data. First received data is written to lower address of ARC configuration area. |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.19.2.2 Data Packet [Status OK]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 4Ch (OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.19.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | CCh (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.19.3  Processing Procedure
Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If this command cannot be executed in the current DLM state, the boot firmware sends a "Command acceptance error".
- If the current Authentication level is AL1 or AL0, the boot firmware sends a "Secure error" and returns to the command waiting state.
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware writes Anti-Rollback Counter setting:

- If an error occurs while writing, the boot firmware sends a "Flash access error" and returns to the command wait state.
- When the write processing is normally finished, boot firmware returns "OK" and waits for the next command.

### 6.19.4 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Executing this command is unavailable in the current DLM state. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Current Authentication level is AL1 or AL0. | Secure error | FFFFFFFFh | FFFFFFFFh |
| FACI detected an error after the command execution. | Flash access error | Flash status | Failure address |
| Successful completion. | OK | FFFFFFFFh | FFFFFFFFh |

### 6.19.5 Mapping of Anti-Rollback Counter Configuration Data

Refer to user's manual of the device for the mapping of Anti-Rollback counter configuration data.

Table 21 shows the mapping of RA8M1 MCU Group as an example.

**Table 21. Example Mapping of RA8M1 MCU Group**

| Address | Bit | Data |
|---|---|---|
| 2703_03C0h | 7:6 | (reserved) |
| | 5 | ARCBL_LK |
| | 4:1 | ARCNS_LK[3:0] |
| | 0 | ARCS_LK |
| 2703_03C1h | 7:0 | (reserved) |
| 2703_03C2h | 7:2 | (reserved) |
| | 1:0 | CNF_ARCNS[1:0] |
| 2703_03C3h | 7:0 | (reserved) |

## 6.20 ARC Configuration Request Command

This command reads Anti-Rollback Counter configuration data and sends them to the host.

This command require adherence to conditions described in Command List.

### 6.20.1 Sequence Diagram
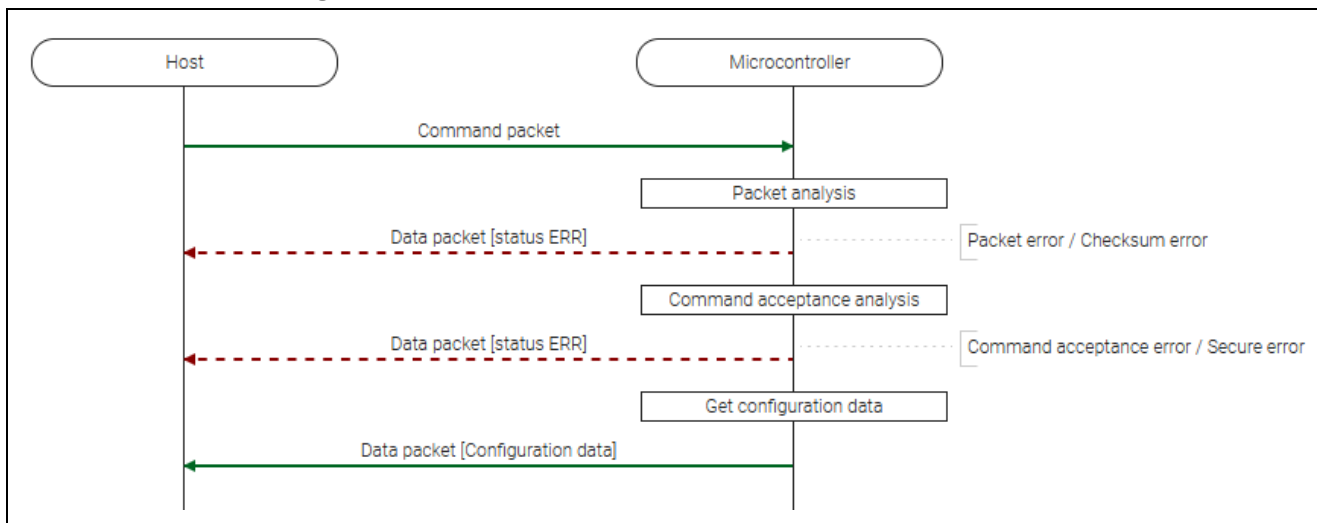


**Figure 39.   ARC Configuration Request Command Sequence Diagram**

### 6.20.2 Packets
### 6.20.2.1 Command Packet

| SOH | (1 byte) | 01h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 01h |
| CMD | (1 byte) | 4Dh (ARC configuration request command) |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.20.2.2 Data Packet [Configuration Data]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 05h |
| RES | (1 byte) | 4Dh (OK) |
| ARC | (4 bytes) | Anti-Rollback Configuration data. Data written in lower address of ARC configuration area is sent first. |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.20.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | CDh (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.20.3 Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If this command cannot be executed in the current DLM state, the boot firmware sends a "Command acceptance error".
- If the current Authentication level is AL1 or AL0, the boot firmware sends a "Secure error" and returns to the command waiting state.
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory contents do not change before command reception.

When the processing above is successfully completed, boot firmware returns Anti-Rollback Counter setting:

- Boot firmware send "Anti-Rollback Counter information" and waits for next command.
  * Memory contents do not change before command reception.

### 6.20.4 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Executing this command is unavailable in the current DLM state. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Current Authentication level is AL1 or AL0. | Secure error | FFFFFFFFh | FFFFFFFFh |

## 6.21 Inquiry Command

This command is used to check if boot firmware is "Command acceptable phase" or not.

This command require adherence to conditions described in Command List.

### 6.21.1 Sequence Diagram
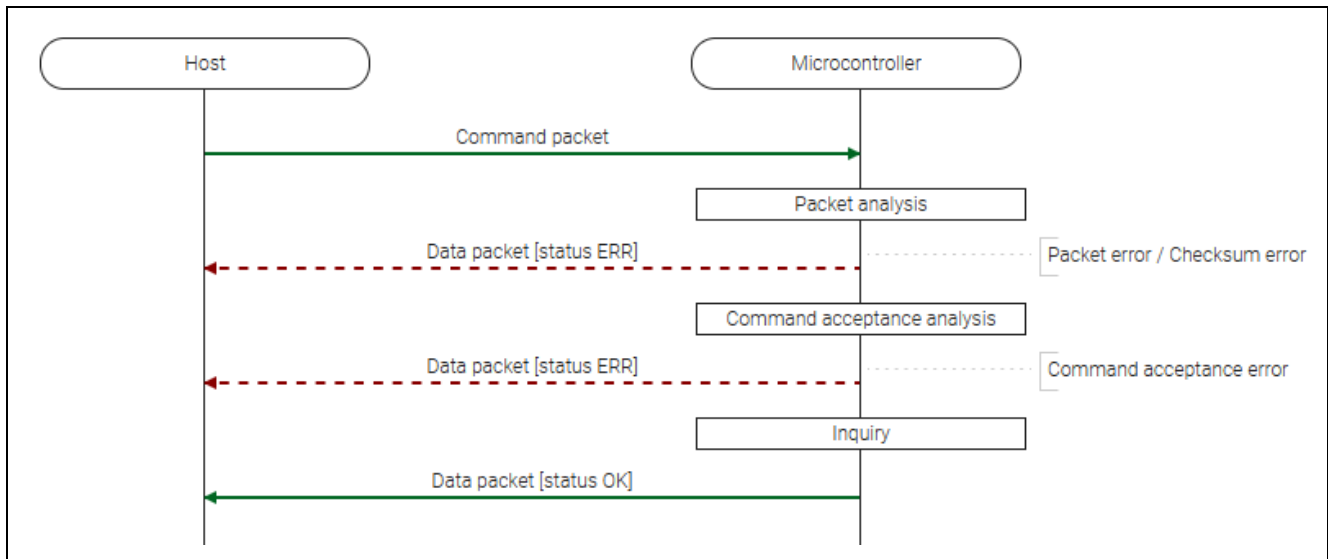


**Figure 40.  Inquiry Command Sequence Diagram**

### 6.21.2 Packets
### 6.21.2.1 Command Packet

| SOH | (1 byte) | 01h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 01h |
| CMD | (1 byte) | 00h (Inquiry command) |
| SUM | (1 byte) | FFh |
| ETX | (1 byte) | 03h |

### 6.21.2.2 Data Packet [Status OK]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 00h (OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | FEh |
| ETX | (1 byte) | 03h |

## 6.21.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 80h (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.21.3  Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If device reset is not asserted after the Encrypted data write command execution, the boot firmware sends a "Command acceptance error".
- When the above error occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, boot firmware executes the inquiry processing:

- The boot firmware sends "OK".
  * Memory status does not change before command reception.

### 6.21.4  Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| The process has ended normally. | OK | FFFFFFFFh | FFFFFFFFh |

## 6.22 Signature Request Command

This command sends the information of the device signature to the host.

This command require adherence to conditions described in Command List.

### 6.22.1 Sequence Diagram
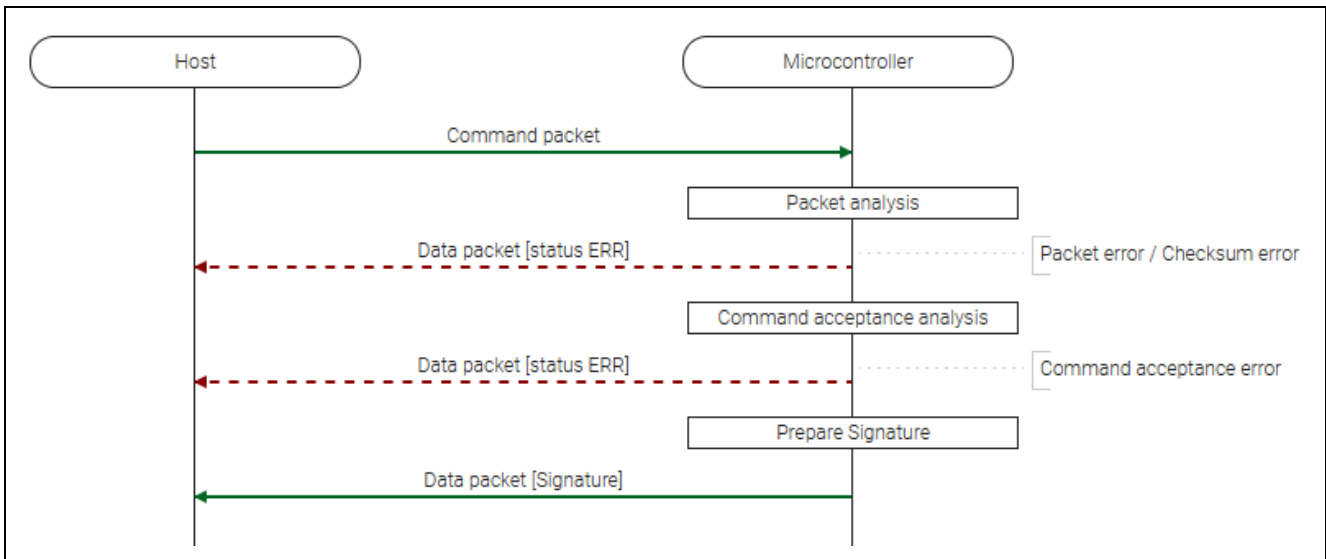


**Figure 41.  Signature Request Command Sequence Diagram**

### 6.22.2 Packets
### 6.22.2.1 Command Packet

| SOH | (1 byte) | 01h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 01h |
| CMD | (1 byte) | 3Ah (Signature request command) |
| SUM | (1 byte) | C5h |
| ETX | (1 byte) | 03h |

## 6.22.2.2 Data Packet [Signature]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 2Ah |
| RES | (1 byte) | 3Ah (OK) |
| RMB | (4 bytes) | Recommended maximum UART baudrate of the device [bps].<br>*Order of sending: High -> ... -> Low<br>For example: 6 Mbps (6000000bps) -> 00h, 5Bh, 8Dh, 80h |
| NOA | (1 byte) | Number of accessible areas<br>For example, if the device has 4 areas -> 04h |
| TYP | (1 byte) | Type code (features and functions of the device):<br>03h: RA8M1 MCU Group and others |
| BFV | (3 byte) | Boot firmware version<br>Order of sending: Major version -> minor version -> build<br>For example, v2.4.1.6 -> 02h, 04h, 10h |
| DID | (16 bytes) | Device ID<br>16-byte ID code (unique ID) for identifying the particular MCU |
| PTN | (16 bytes) | Product type name.<br>Character strings (20h for the space)<br>Order of sending example: R7FA6M3AH<br>->52h, 37h, 46h, 41h, 36h, 4dh, 33h, 41h, 48h, 20h, 20h, 20h, 20h, 20h, 20h, 20h |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

## 6.22.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | BAh (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

## 6.22.3 Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If device reset is not asserted after the Encrypted data write command execution, the boot firmware sends a "Command acceptance error".
- When the above error occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, boot firmware returns the signature.

- Send a signature and return to command waiting.
  * Memory status does not change before command reception.

### 6.22.4 Status Information from the Microcontroller
(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |

## 6.23 Area Information Request Command

This command sends the information of the designated area to the host. The alignment of the target address of command shall follow this area information.

This command require adherence to conditions described in Command List.
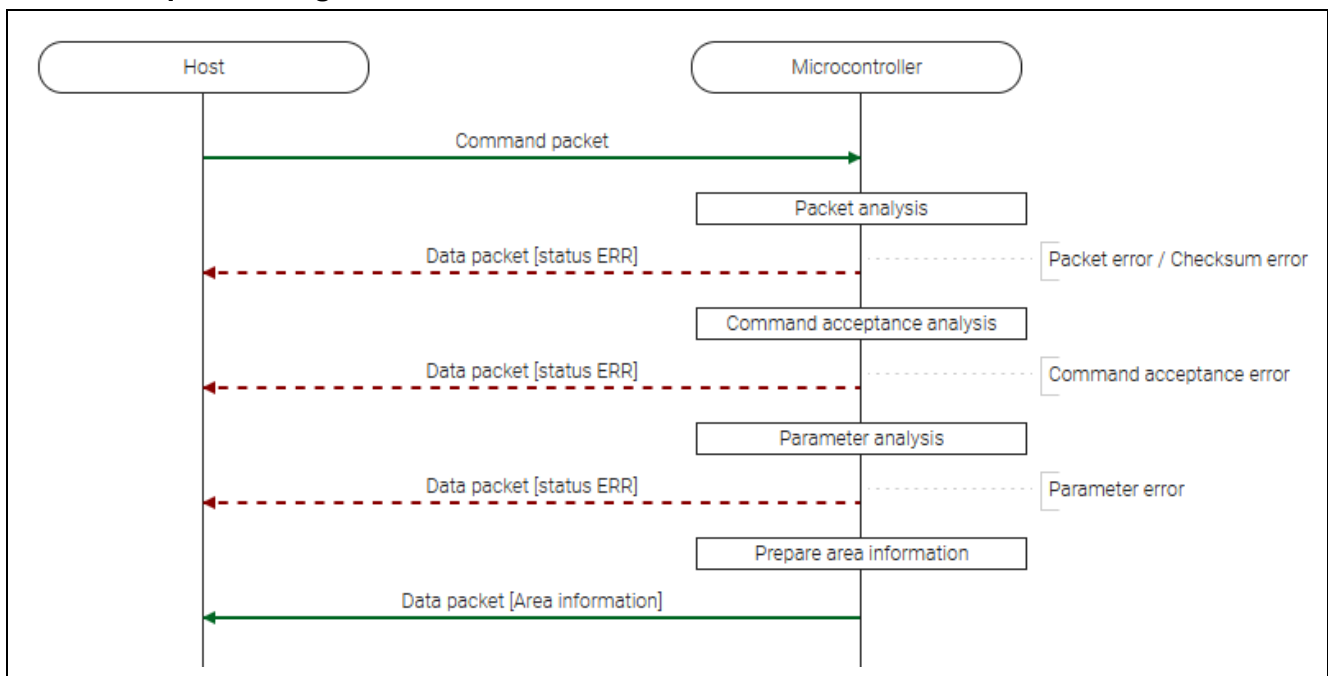
### 6.23.1 Sequence Diagram



**Figure 42.  Area Information Request Command Sequence Diagram**

### 6.23.2 Packets
### 6.23.2.1 Command Packet

| SOH | (1 byte) | 01h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 02h |
| CMD | (1 byte) | 3Bh (Area information request command) |
| NUM | (1 byte) | Area number [0–NOA-1] |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.23.2.2 Data Packet [Area Information]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 1Ah |
| RES | (1 byte) | 3Bh (OK) |
| KOA | (1 byte) | Kind of the area:<br>• 0Nh: User area N (*2)<br>• 1Nh: Data area N (*2)<br>• 2Nh: Config area N (*2)<br>• 3Nh: EEP config area N (*2)<br>• 4Nh: External flash area N (*2) |
| SAD | (4 bytes) | Start address.<br>Order of sending: High -> ... -> Low<br>For example: 00010000h -> 00h, 01h, 00h, 00h |
| EAD | (4 bytes) | End address<br>*Order of sending: High -> ... -> Low<br>For example: 001FFFFFh -> 00h, 1Fh, FFh, FFh |
| EAU | (4 bytes) | Erase access unit (alignment) [byte] (*1)<br> Order of sending: High -> ... -> Low<br>For example: 32KB (32768byte) -> 00h, 00h, 80h, 00h<br>Target command: Erase command. |
| WAU | (4 bytes) | Write access unit (alignment) [byte] (*1)<br>Order of sending: High -> ... -> Low<br>For example: 128byte -> 00h, 00h, 00h, 80h<br>Target command: Write command, User key setting command, User key verify command, Code certificate update command, Encrypted data write command. |
| RAU | (4 bytes) | Read access unit (alignment) [byte] (*1)<br>Order of sending: High -> ... -> Low<br>For example: 1byte -> 00h, 00h, 00h, 01h<br>Target command: Read command. |
| CAU | (4 bytes) | CRC access unit (alignment) [byte] (*1)<br>Order of sending: High -> ... -> Low<br>For example: 4byte -> 00h, 00h, 00h, 04h<br>Target command: CRC command |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

*1: If each access unit is 00000000h, target command is not available for the area.
*2: N = 0–F

### 6.23.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | BBh (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.23.3  Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If device reset is not asserted after the Encrypted data write command execution, the boot firmware sends a "Command acceptance error".
- When the above error occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, the boot firmware analyzes the command parameters:

- If the specified NUM is "NOA" returned by "Signature request command" or more, send "Parameter error" and return to command waiting status.
  * Memory status does not change before command reception.
- When the above error occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, the area information will be returned:

- Send area information of specified NUM and return to command waiting status.
  * Memory status does not change before command reception.

### 6.23.4  Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| If Area number in the received packet is a non-existent area number. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |

### 6.23.5 Example of Area Information

Example: RA8M1 (Linear mode)

| NUM | Area | KOA | SAD | EAD | EAU | WAU | RAU | CAU |
|---|---|---|---|---|---|---|---|---|
| 0 | User area 0(S) (*3) | 00h | 02000000h | 0200FFFFh | 8KB | 128B | 1B | 32KB |
| 1 | User area 0(L) (*3) | 00h | 02010000h | 021F7FFFh (*5) | 32KB | 128B | 1B | 32KB |
| 2 | Config area 0 | 20h | 0300A100h | 0300A17Fh | 0 (*1) | 16B | 1B | 128B |
| 3 | Config area 1 | 21h | 0300A200h | 0300A2FFh | 0 (*1) | 16B | 1B | 128B |
| 4 | User area 1(S) (*3) | 01h | 12000000h | 1200FFFFh | 8KB | 128B | 1B | 32KB |
| 5 | User area 1(L) (*3) | 01h | 12010000h | 121F7FFFh (*5) | 32KB | 128B | 1B | 32KB |
| 6 | Config area 2 | 22h | 1300A180h | 1300A1FFh | 0 (*1) | 16B | 1B | 128B |
| 7 | Data area 0 (*3) | 10h | 27000000h | 27002FFFh | 64B | 4B | 1B | 1KB |
| 8 | EEP Config area 0 | 30h | 27030050h | 2703035Fh(*6) | 0 (*1) | 16B | 1B | 16B |
| 9 | Data area 1 (*3) | 11h | 37000000h | 37002FFFh | 64B | 4B | 1B | 1KB |
| 10 | External flash area 0 (*2,*4) | 40h | 60000000h | 9FFFFFFFh | 1B | 1B | 1B | 1KB |

*1: When Access unit is 0, it indicates that the corresponding operation is not supported.
*2: Execute "External flash memory setting command" before accessing this area. Access to addresses to which no external flash memory is allocated is not guaranteed.
*3: The accessible address changes depending on the boundary settings.
*4: RA8M1 WS1 boot firmware does not send external flash area's information but sends Parameter error when specifying this NUM since it does not support external flash area programming.
*5: These addresses are not xxxx7FFFh but xxxxFFFFh for RA8M1 WS1 because User area's sizes are different between WS1 and others for 2MB product.
*6: This EAD is not 2703035Fh but 270303FFh for RA8M1 WS1 since the following commands which are used to program 27030360h - 3FFh are added for WS2 boot firmware:
　　　- Lock bit setting command
　　　- Lock bit request command
　　　- ARC configuration setting command
　　　- ARC configuration request command

Example: RA8M1 (Dual mode)

| NUM | Area | KOA | SAD | EAD | EAU | WAU | RAU | CAU |
|---|---|---|---|---|---|---|---|---|
| 0 | User area 0(S) (*3) | 00h | 02000000h | 0200FFFFh | 8KB | 128B | 1B | 32KB |
| 1 | User area 0(L) (*3) | 00h | 02010000h | 020F7FFFh (*5) | 32KB | 128B | 1B | 32KB |
| 2 | User area 1(S) (*3) | 01h | 02200000h | 0220FFFFh | 8KB | 128B | 1B | 32KB |
| 3 | User area 1(L) (*3) | 01h | 02210000h | 022F7FFFh (*5) | 32KB | 128B | 1B | 32KB |
| 4 | Config area 0 | 20h | 0300A100h | 0300A17Fh | 0 (*1) | 16B | 1B | 128B |
| 5 | Config area 1 | 21h | 0300A200h | 0300A2FFh | 0 (*1) | 16B | 1B | 128B |
| 6 | User area 2(S) (*3) | 02h | 12000000h | 1200FFFFh | 8KB | 128B | 1B | 32KB |
| 7 | User area 2(L) (*3) | 02h | 12010000h | 120F7FFFh (*5) | 32KB | 128B | 1B | 32KB |
| 8 | User area 3(S) (*3) | 03h | 12200000h | 1220FFFFh | 8KB | 128B | 1B | 32KB |
| 9 | User area 3(L) (*3) | 03h | 12210000h | 122F7FFFh (*5) | 32KB | 128B | 1B | 32KB |
| 10 | Config area 2 | 22h | 1300A180h | 1300A1FFh | 0 (*1) | 16B | 1B | 128B |
| 11 | Data area 0 (*3) | 10h | 27000000h | 27002FFFh | 64B | 4B | 1B | 1KB |
| 12 | EEP Config area 0 | 30h | 27030050h | 2703035Fh(*6) | 0 (*1) | 16B | 1B | 16B |
| 13 | Data area 1 (*3) | 11h | 37000000h | 37002FFFh | 64B | 4B | 1B | 1KB |
| 14 | External flash area 0 (*2,*4) | 40h | 60000000h | 9FFFFFFFh | 1B | 1B | 1B | 1KB |

*1: When Access unit is 0, it indicates that the corresponding operation is not supported.

*2: Execute "External flash memory setting command" before accessing this area. Access to addresses to which no external flash memory is allocated is not guaranteed.

*3: The accessible address changes depending on the boundary settings.

*4: RA8M1 WS1 boot firmware does not send external flash area's information but sends Parameter error when specifying this NUM since it does not support external flash area programming.

*5: These addresses are not xxxx7FFFh but xxxxFFFFh for RA8M1 WS1 because User area's sizes are different between WS1 and others for 2MB product.

*6: This EAD is not 2703035Fh but 270303FFh for RA8M1 WS1 since the following commands which are used to program 27030360h - 3FFh are added for WS2 boot firmware.
- Lock bit setting command
- Lock bit request command
- ARC configuration setting command
- ARC configuration request command

## 6.24 Baudrate Setting Command

This command receives baudrate data and change the UART baudrate of the device. If an error occurs, the baudrate is not changed. This command does not change the communication speed except for UART communication.

This command require adherence to conditions described in Command List.
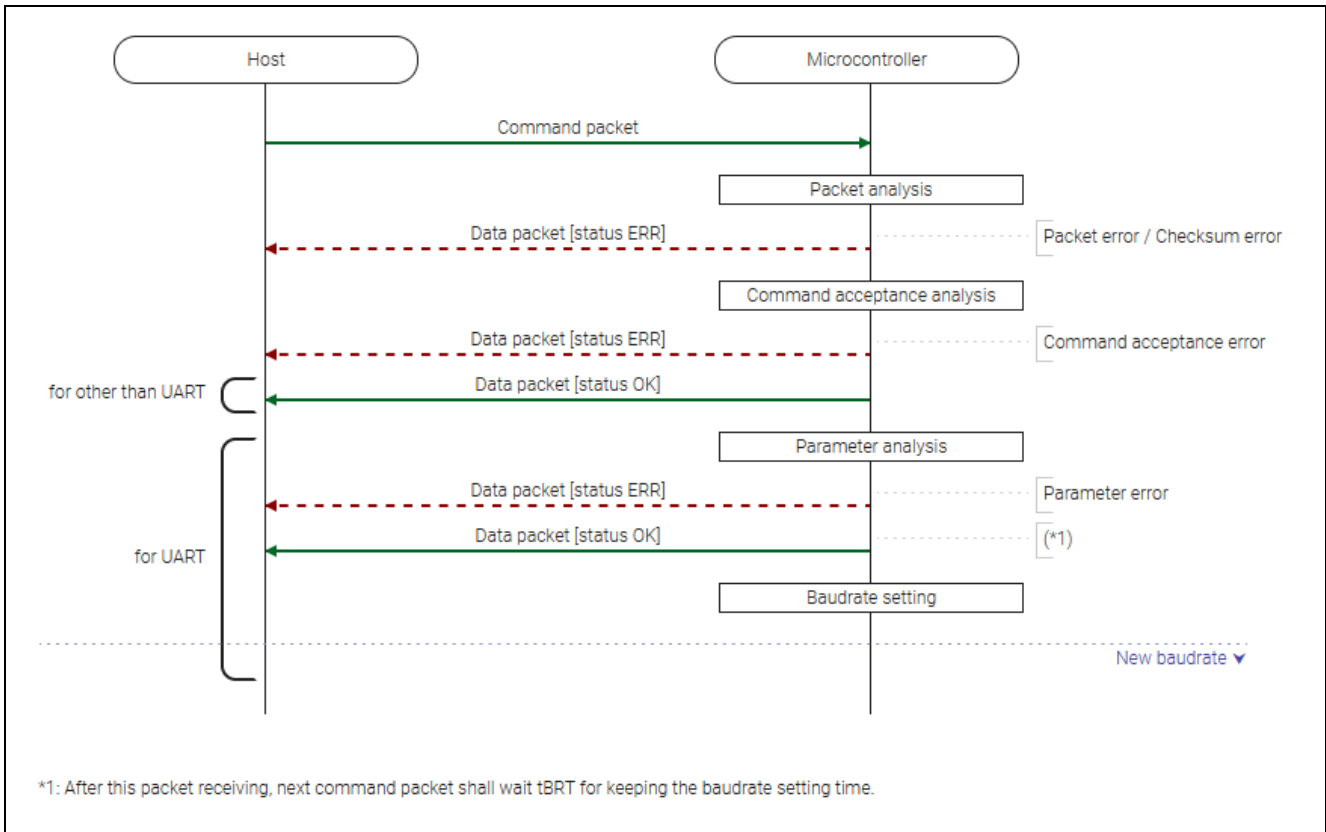
### 6.24.1 Sequence Diagram



**Figure 43.  Baudrate Setting Command Sequence Diagram**

### 6.24.2 Packets
### 6.24.2.1 Command Packet

| SOH | (1 byte) | 01h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 05h |
| CMD | (1 byte) | 34h (Baudrate setting command) |
| BRT | (4 bytes) | UART baudrate [bps]<br>You can set one of the following values.<br>Order of sending BRT: |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

| Baudrate | 1st | 2nd | 3rd | 4th |
|---|---|---|---|---|
| 9600bps | 00 | 00 | 25 | 80 |
| 115200bps | 00 | 01 | C2 | 00 |
| 500Kbps | 00 | 07 | A1 | 20 |
| 1.0Mbps | 00 | 0F | 42 | 40 |
| 1.5Mbps | 00 | 16 | E3 | 60 |
| 2.0Mbps | 00 | 1E | 84 | 80 |
| 4.0Mbps | 00 | 3D | 09 | 00 |
| 6.0Mbps | 00 | 5B | 8D | 80 |

### 6.24.2.2 Data Packet [Status OK]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 34h (OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | CAh |
| ETX | (1 byte) | 03h |

### 6.24.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | B4h (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.24.3 Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If device reset is not asserted after the Encrypted data write command execution, the boot firmware sends a "Command acceptance error".
- When the above error occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the communication mode is not asynchronous 2-wire communication, a response will be returned when the processing above ends normally:

- If the communication mode is not asynchronous 2-wire communication, send "OK" and return to the command waiting state.
  * Memory status does not change before command reception.

In asynchronous 2-wire communication, parameter analysis is performed when the processing above is completed successfully:

- Sends "Parameter error" if the specified BRT (Baudrate) is greater than the RMB in the Signature request command.
- Sends "Parameter error" if the specified BRT (Baudrate) is not a supported baudrate value.
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

In asynchronous 2-wire communication, when the processing above is completed normally, the baud rate is set:

- After sending "OK", set the baudrate and return to the command waiting state.
  * Memory status does not change before command reception.
  * After the boot firmware returned OK (started the baudrate setting), wait 1 ms before sending next command.

### 6.24.4 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Received UART baudrate is greater than RMB. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Different from the baudrate value supported by the received UART baudrate. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Communication mode is different from UART. | OK | FFFFFFFFh | FFFFFFFFh |
| Started the baudrate setting. | OK | FFFFFFFFh | FFFFFFFFh |

**Table 22. Baudrate Setting Values**

| Intended Baudrate | ABCS | CKS[1:0] | BRR[7:0] | MDDR[7:0] | Accuracy |
|---|---|---|---|---|---|
| 9600bps | 0 | 00b | FFh | C9h | -0.2% |
| 115200bps | 0 | 00b | 1Ah | FEh | -0.3% |
| 500Kbps | 0 | 00b | 05h | F5h | -0.3% |
| 1.0Mbps | 0 | 00b | 02h | F5h | -0.3% |
| 1.5Mbps | 0 | 00b | 01h | F5h | -0.3% |
| 2.0Mbps | 0 | 00b | 00h | A3h | -0.5% |
| 4.0Mbps | 1 | 00b | 00h | A3h | -0.5% |
| 6.0Mbps | 1 | 00b | 00h | F5h | -0.3% |
| Other | unavailable | unavailable | unavailable | unavailable | - |

## 6.25 Erase Command

This command erases data in the specified area of the flash memory. The alignment of the target addresses shall follow the area information returned by the Area information request command. Erasures are executed in order from the start address to the end address by the erase access unit.

Erase processing at this time is not affected by the block protection settings (BPS, BPS_SEC).

This command require adherence to conditions described in Command List.

### 6.25.1 Sequence Diagram
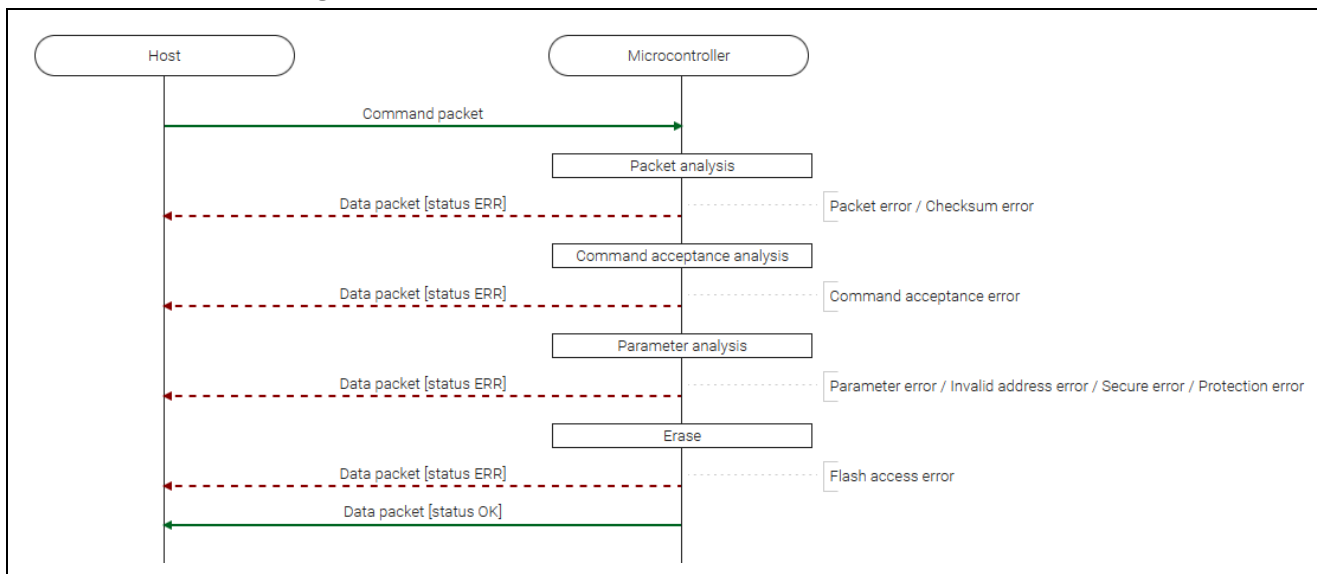


**Figure 44. Erase Command Sequence Diagram**

### 6.25.2 Packets
### 6.25.2.1 Command Packet

| SOH | (1 byte) | 01h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 09h |
| CMD | (1 byte) | 12h (Erase command) |
| SAD | (4 bytes) | Start address. For example: 00004000h -> 00h, 00h, 40h, 00h |
| EAD | (4 bytes) | End address. For example: 003FFFFFh -> 00h, 3Fh, FFh, FFh |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.25.2.2 Data Packet [Status OK]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 12h (OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

## 6.25.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
| --- | --- | --- |
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 92h (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

## 6.25.3 Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If this command cannot be executed in the current DLM state, the boot firmware sends a "Command acceptance error".
- If device reset is not asserted after the Encrypted data write command execution, the boot firmware sends a "Command acceptance error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, the boot firmware analyzes the command parameters:

- If the SAD is greater than EAD, the boot firmware sends a "Parameter error".
- If the SAD or EAD is outside the range specified in the area information, the boot firmware sends a "Parameter error".
- If SAD and EAD belong to different KOA, boot firmware sends a "Parameter error".
- If the EAU for the specified area is 0, the boot firmware sends a "Parameter error".
- If SAD and EAD are not specified in the EAU of the area, the boot firmware sends a "Parameter error".
- If the area specified with SAD and EAD includes address that is inaccessible with current boundary setting, the boot firmware sends a "Invalid address error".
- If the current Authentication level is AL1 and the specified range includes a secure area, the boot firmware sends a "Secure error".
- If the current Authentication level is AL0, the boot firmware sends a "Secure error".
- When designated erasure range includes a permanent protected block, "Protection error" is returned.
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When no error occurs, boot firmware executes the erase processing:

- If an error occurs during erasure, the boot firmware sends a "Flash access error" and returns to the command wait state.
  * The value of the area after ADR (Failure address) of the memory is undefined.
- If an error is returned from external flash memory access driver, the boot firmware sends a "Flash access error" and returns to the command wait state.
- When the erase processing is normally finished, boot firmware returns "OK" and waits for the next command.
  * Specified area on memory are erased state.

### 6.25.4 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Executing this command is unavailable in the current DLM state. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Start address is bigger than End address. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Start address or End address is outside the scope of user area specified in area information. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Start address and End address belongs to different Kinds of area. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The access unit "EAU" of the specified area is 0. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Start address or End address doesn't comply with EAU of the area. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The area from Start address to End address contains addresses that are inaccessible with the current boundary settings. | Invalid address error | FFFFFFFFh | FFFFFFFFh |
| Current Authentication level is AL1, and designated erasure range includes Secure region. | Secure error | FFFFFFFFh | FFFFFFFFh |
| Current Authentication level is AL0. | Secure error | FFFFFFFFh | FFFFFFFFh |
| Designated erasing range includes permanent protected blocks. | Protection error | FFFFFFFFh | FFFFFFFFh |
| FACI detected an error after the command execution. | Flash access error | Flash status | Failure address |
| An error occurred in the external flash memory access driver. | Flash access error | FFFFFFFFh | FFFFFFFFh |
| Successful completion. | OK | FFFFFFFFh | FFFFFFFFh |

### 6.25.5 Precautions

(1) When accessing the external flash area, the driver function for access is called, so send the driver code with the "External flash memory setting command" in advance. In this command, "EraseChip driver" is called when the entire area of External flash area 0 is specified. Otherwise, the "EraseSector driver" will be called every time a sector is erased.

Also, access to addresses to which external flash memory is not allocated is not guaranteed.

## 6.26 Write Command

This command receives data from host and writes those data to the specified area. The alignment of the target address shall follow the area information returned by the Area information request command. Writings are executed in order from the start address to the end address by the write access unit.

Write processing at this time is not affected by the block protection settings (BPS, BPS_SEC).

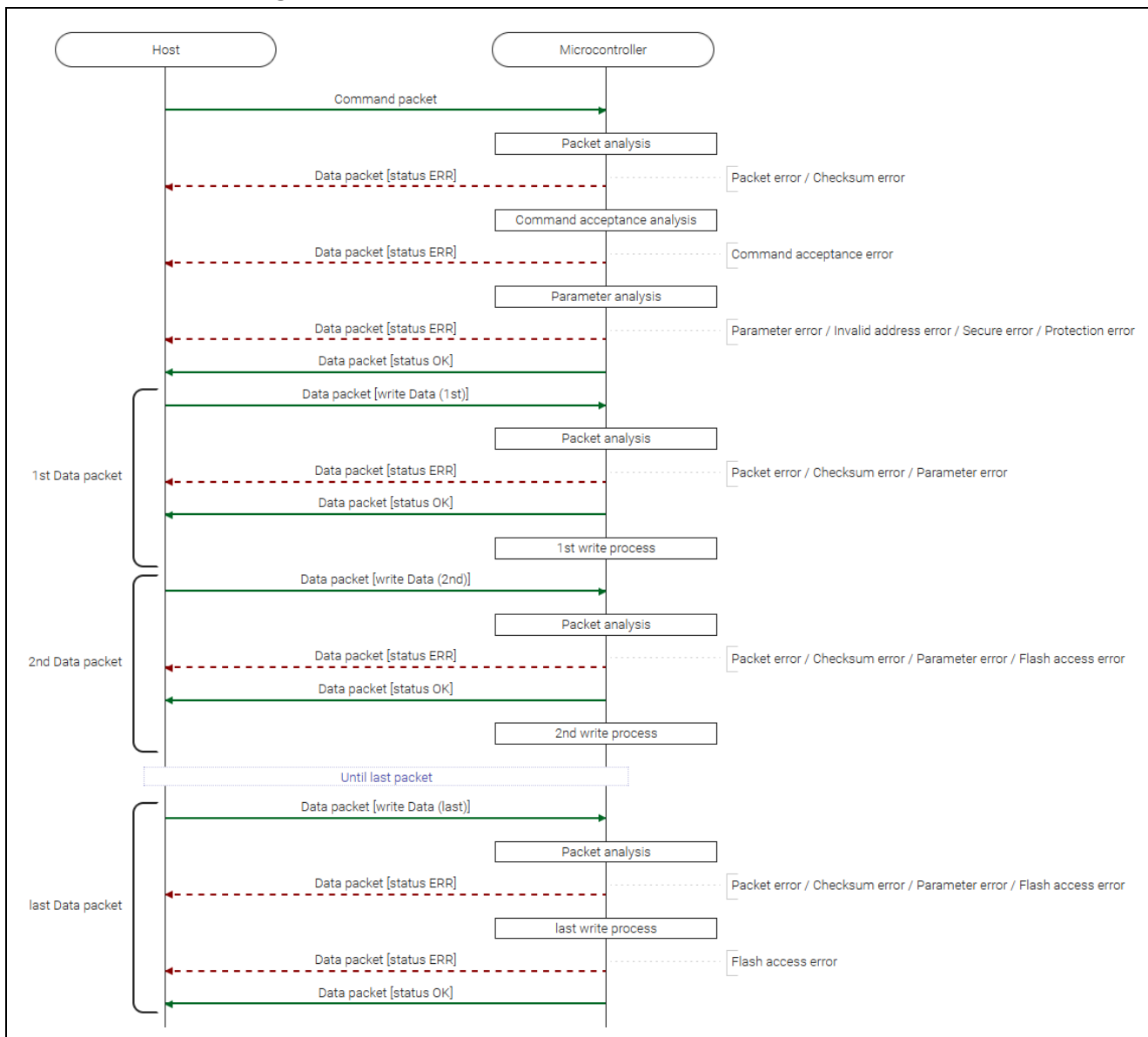This command require adherence to conditions described in Command List.

### 6.26.1 Sequence Diagram



**Figure 45.  Write Command Sequence Diagram**

### 6.26.2 Packets
### 6.26.2.1 Command Packet

| SOH | (1 byte) | 01h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 09h |
| CMD | (1 byte) | 13h (Write command) |
| SAD | (4 bytes) | Start address. |
| | | For example: 00004000h -> 00h, 00h, 40h, 00h |
| EAD | (4 bytes) | End address. |
| | | For example: 003FFFFFh -> 00h, 3Fh, FFh, FFh |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.26.2.2 Data Packet [Write Data]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | N + 1 (Higher 1 byte) |
| LNL | (1 byte) | N + 1 (Lower 1 byte) |
| RES | (1 byte) | 13h (OK) |
| DAT | (N bytes) | Write data |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

N = 1–1024
  *) N must be multiple of 4 when writing to external flash area.

### 6.26.2.3 Data Packet [Status OK]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 13h (OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.26.2.4 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 93h (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.26.3 Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If this command cannot be executed in the current DLM state, the boot firmware sends a "Command acceptance error".
- If device reset is not asserted after the Encrypted data write command execution, the boot firmware sends a "Command acceptance error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, the boot firmware analyzes the command parameters:

- If the SAD is greater than EAD, the boot firmware sends a "Parameter error".
- If the SAD or EAD is outside the range specified in the area information, the boot firmware sends a "Parameter error".
- If SAD and EAD belong to different KOA, boot firmware will send a "Parameter error".
- If the WAU for the specified area is 0, the boot firmware sends a "Parameter error".
- If SAD and EAD are not specified in the WAU of the area, the boot firmware sends a "Parameter error".
- If the area specified with SAD and EAD includes address that is inaccessible with current boundary setting, the boot firmware sends a "Invalid address error".
- If the current Authentication level is AL1 and the specified range includes a secure area, the boot firmware sends a "Secure error".
- If the current Authentication level is AL0, the boot firmware sends a "Secure error".
- When designated writing range includes PBPS block, "Protection error" is returned.
- When designated writing range includes area that the lock bit is set, "Protection error" is returned.
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.
- If the above error does not occur, the boot firmware sends "OK".

When the processing above is successfully completed, boot firmware receives and analyzes a data packet:

- The boot firmware recognizes the start of the data packet by receiving SOD.
  If the boot firmware receives something other than SOD, it will wait until it receives SOD.
- If ETX is not added to the received data packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received data packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- When RES in the received data packet is different from defined values by each command, "Packet error" is returned.
- When total length of the received data of data packets exceeds the size of specified area, "Parameter error" is returned.
- If size of the write data is not specified in the WAU of the area, the boot firmware sends a "Parameter error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the received data packet is not the last write data, boot firmware returns "OK" and executes the write processing:

- Boot firmware returns "OK" and executes the write processing.
- When the write processing is abnormally finished, boot firmware receives the next data packet, returns "Flash access error" and waits for the next command.
  * WAU size from failure address (ADR) of memory area are undefined.
- If an error is returned from external flash memory access driver, the boot firmware sends a "Flash access error" and returns to the command wait state.
- When the write processing is normally finished, boot firmware receives the next data packet.

When the received data packet is the last write data, boot firmware executes the write processing and returns status:

- Boot firmware executes the write processing.
- If an error occurs while writing, the boot firmware sends a "Flash access error" and returns to the command wait state.
  * WAU size from failure address (ADR) of memory area are undefined.
- If an error is returned from external flash memory access driver, the boot firmware sends a "Flash access error" and returns to the command wait state.
- When the write processing is normally finished, boot firmware returns "OK" and waits for the next command.
  * Sent data are written to the specified area on memory.

### 6.26.4 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Executing this command is unavailable in the current DLM state. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Start address is bigger than End address. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Start address or End address is outside the scope of accessible area specified in area information. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Start address and End address belong to different Kinds of area. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The access unit "WAU" of the specified area is 0. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Start address or End address does not comply with WAU of the area. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The area from Start address to End address contains addresses that are inaccessible with the current boundary settings. | Invalid address error | FFFFFFFFh | FFFFFFFFh |
| Current Authentication level is AL1, and designated writing range includes Secure region. | Secure error | FFFFFFFFh | FFFFFFFFh |
| Current Authentication level is AL0. | Secure error | FFFFFFFFh | FFFFFFFFh |
| Designated writing range includes permanent protected blocks. | Protection error | FFFFFFFFh | FFFFFFFFh |
| Designated writing range includes an area where the Lock bit is set. | Protection error | FFFFFFFFh | FFFFFFFFh |
| The response code of the received data packet is different from the value specified by this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| The total length of received data of data packets exceeds the specified end address. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The data size of the data packet does not comply with writing unit of the area. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| FACI detected an error after the command execution. | Flash access error | Flash status | Failure address |
| An error occurred in the external flash memory access driver. | Flash access error | FFFFFFFFh | FFFFFFFFh |
| Successful completion. | OK | FFFFFFFFh | FFFFFFFFh |

### 6.26.5 Precautions

(1) If permanent block protection in the Config area is set, the protected area cannot be rewritten. Therefore, rewrite the protected area before setting the permanent block protection.

(2) If Lock bit in the EEP config area is set, the protected area cannot be rewritten. Therefore, rewrite the protected area before setting the Lock bit.

(3) When accessing the external flash area, the driver function for access is called, so send the driver code with the "External flash memory setting command" in advance. This command calls the "Program Data driver".

Also, access to addresses to which external flash memory is not allocated is not guaranteed.

## 6.27 Read Command

This command reads data from a specified area and sends those data to host. The alignment of the target addresses shall follow the area information returned by the Area information request command. Readings are executed in order from the start address to the end address by the read access unit.

This command require adherence to conditions described in Command List.

### 6.27.1 Sequence Diagram
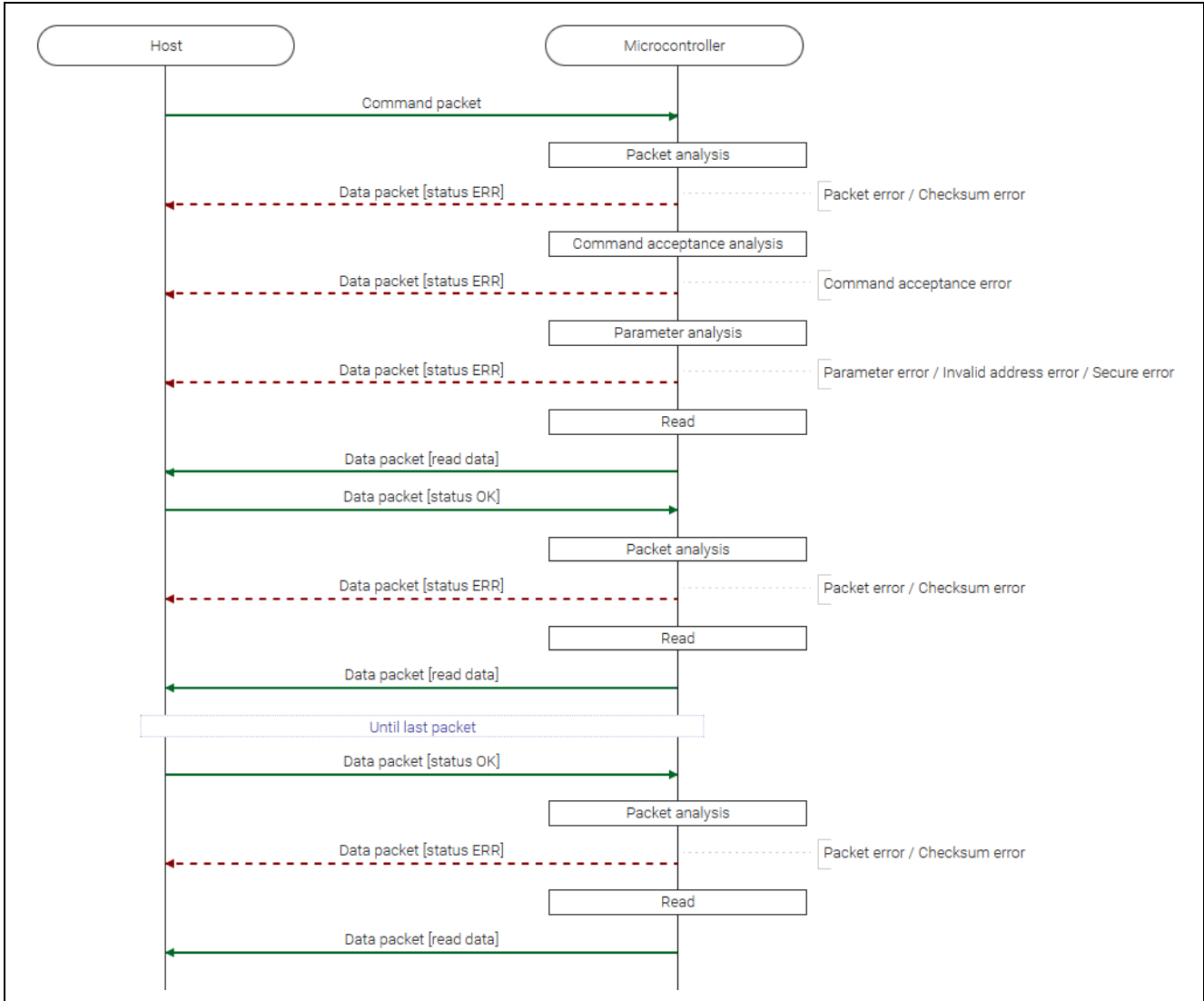


**Figure 46. Read Command Sequence Diagram**

### 6.27.2 Packets
### 6.27.2.1 Command Packet

| SOH | (1 byte) | 01h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 09h |
| CMD | (1 byte) | 15h (Read command) |
| SAD | (4 bytes) | Start address. For example: 00004000h -> 00h, 00h, 40h, 00h |
| EAD | (4 bytes) | End address. For example: 003FFFFFh -> 00h, 3Fh, FFh, FFh |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.27.2.2 Data Packet [Status OK]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 15h (OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.27.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 95h (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.27.2.4 Data Packet [Read Data]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | N + 1 (Higher 1byte) |
| LNL | (1 byte) | N + 1 (Lower 1byte) |
| RES | (1 byte) | 15h (OK) |
| DAT | (N bytes) | Read data |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

N = 1–1024

### 6.27.3 Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If this command cannot be executed in the current DLM state, the boot firmware sends a "Command acceptance error".
- If device reset is not asserted after the Encrypted data write command execution, the boot firmware sends a "Command acceptance error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, the boot firmware analyzes the command parameters:

- If the SAD is greater than EAD, the boot firmware sends a "Parameter error".
- If the SAD or EAD is outside the range specified in the area information, the boot firmware sends a "Parameter error".
- If SAD and EAD belong to different KOA, boot firmware will send a "Parameter error".
- If the RAU for the specified area is 0, the boot firmware sends a "Parameter error".
- If the area specified with SAD and EAD includes an address that is inaccessible with the current boundary setting, the boot firmware sends an "Invalid address error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, the boot firmware performs a secure analysis:

- If the current Authentication level is AL1 and the specified range includes a secure area, the boot firmware sends a "Secure error".
- If the current Authentication level is AL0, the boot firmware sends a "Secure error".

When no error occurs, boot firmware executes the read processing:

- Boot firmware returns the data stored in the internal buffer (packet-length: Max.1024bytes).
- When all the data have been sent, boot firmware waits for the next command.
  * Memory status does not change before command reception.

If data transmission for the specified size is not completed, the boot firmware receives the data packet and performs packet analysis:

- Boot firmware detects the beginning of a data packet by receiving SOD.
  When boot firmware receives other data than SOD, it discards the data and waits for the next data until SOD is sent.
- When the received data packet does not have ETX, "Packet error" is returned.
- When SUM in the received data packet is different from the value calculated by boot firmware, a "Checksum error" is returned.
- When LNH and LNL in the received data packet do not comply with the packet format, "Packet error" is returned.
- When RES in the received data packet is different from defined values, "Packet error" is returned.
- When LNH and LNL in the received data packet do not comply format with this command, "Packet error" is returned.
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.
- If the above errors do not occur, the boot firmware continues to read and send data.

### 6.27.3.1 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Executing this command is unavailable in the current DLM state. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Start address is bigger than End address. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Start address or End address is outside the scope of accessible area specified in area information. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Start address and End address belong to different Kinds of area. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The access unit "RAU" of the specified area is 0. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Start address or End address does not comply with RAU of the area. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The area from Start address to End address contains addresses that are inaccessible with the current boundary settings. | Invalid address error | FFFFFFFFh | FFFFFFFFh |
| Current Authentication level is AL1, designated reading range is User area, Data area, or EEP config area, and includes Secure region. | Secure error | FFFFFFFFh | FFFFFFFFh |
| Current Authentication level is AL0. | Secure error | FFFFFFFFh | FFFFFFFFh |
| The response code of the received data packet is different from the value specified by this command. | Packet error | FFFFFFFFh | FFFFFFFFh |

### 6.27.4 Precautions

(1) To access the external flash area, you need to execute the "External flash memory setting command" in advance. Also, access to addresses that are not assigned external flash memory is not guaranteed.

## 6.28 CRC Command

This command calculates CRC data from a specified area and sends it to host. The alignment of the target addresses shall follow the area information returned by the Area information request command. Calculations are executed in order from the start address to the end address by the CRC access unit.

This command requires adherence to conditions described in Command List.

Boot firmware uses the following CRC method:

| Name | CRC-32-IEEE-802.3 |
|---|---|
| Default value | FFFFFFFFh |
| Shift direction | Left shift |
| Polynomial representations | (MSB first) 04C11DB7h |

### 6.28.1 Sequence Diagram
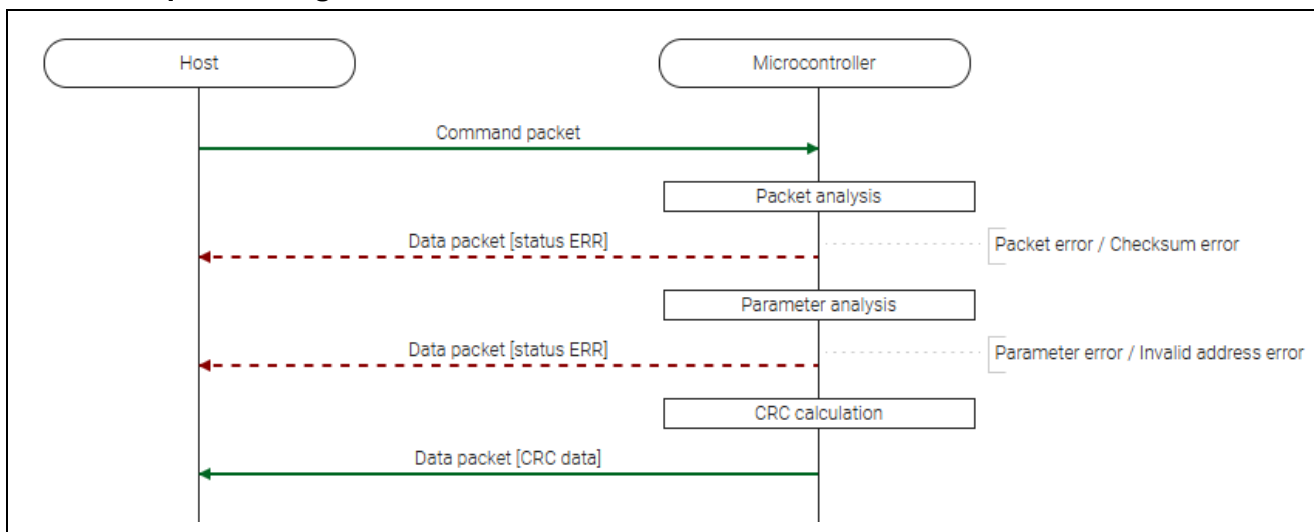


**Figure 47.　CRC Command Sequence Diagram**

### 6.28.2 Packets
### 6.28.2.1 Command Packet

| SOH | (1 byte) | 01h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 09h |
| CMD | (1 byte) | 18h (CRC command) |
| SAD | (4 bytes) | Start address |
| EAD | (4 bytes) | End address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.28.2.2 Data packet [CRC data]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 05h |
| RES | (1 byte) | 18h (OK) |
| CRC | (4 bytes) | CRC data (result of calculation). For example: 01234567h -> 01h, 23h, 45h, 67h |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

## 6.28.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 98h (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

## 6.28.3  Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, the boot firmware analyzes the command parameters:

- If the SAD is greater than EAD, the boot firmware sends a "Parameter error".
- If the SAD or EAD is outside the range specified in the area information, the boot firmware sends a "Parameter error".
- If SAD and EAD belong to different KOA, boot firmware will send a "Parameter error".
- If the CAU for the specified area is 0, the boot firmware sends a "Parameter error".
- If SAD and EAD are not specified in the CAU of the area, the boot firmware sends a "Parameter error".
- If the area specified with SAD and EAD includes an address that is inaccessible with the current boundary setting, the boot firmware sends an "Invalid address error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, boot firmware executes the CRC calculation:

- After the CRC calculation, boot firmware returns "CRC data" and waits for the next command.
  * Memory status does not change before command reception.

### 6.28.4 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Start address is bigger than End address. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Start address or End address is outside the scope of accessible area specified in area information. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Start address and End address belong to different Kinds of area. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The access unit "CAU" of the specified area is 0. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Start address or End address does not comply with CAU of the area. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The area from Start address to End address contains addresses that are inaccessible with the current boundary settings. | Invalid address error | FFFFFFFFh | FFFFFFFFh |

### 6.28.5 Precautions

(1) Since erased Data area's value is undefined, calculated CRC data would be incorrect if range of calculating CRC data includes erased Data area.

(2) To access the external flash area, you need to execute the "External flash memory setting command" in advance. Also, access to addresses that are not assigned external flash memory is not guaranteed.

## 6.29 OEM Root Public Key Setting Command

This command sets the OEM root public key encrypted hash value (OEM_ROOT_PK) to device.

This command require adherence to conditions described in Command List.

### 6.29.1 Sequence Diagram
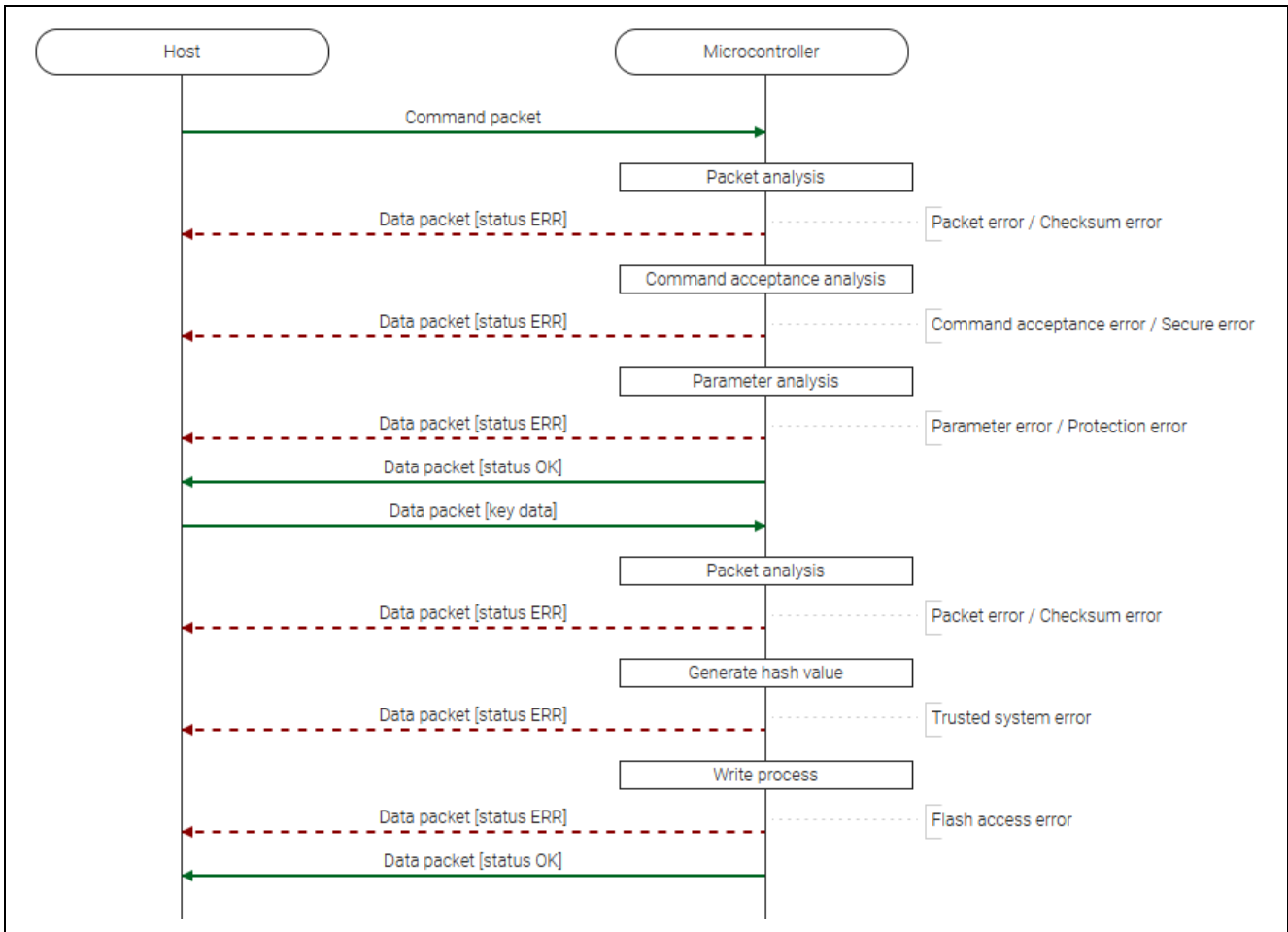


**Figure 48. OEM Root Public Key Setting Command Sequence Diagram**

### 6.29.2 Packets
### 6.29.2.1 Command Packet

| SOH | (1 byte) | 01h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 03h |
| CMD | (1 byte) | 2Eh (OEM root public key setting command) |
| KID | (1 byte) | Public-key ID:<br>• 00h: Public-key 0 |
| PLK | (1 byte) | Permanent lock:<br>• 00h: Set permanent lock of the OEM root public key hash<br>• FFh: Do not set permanent lock of the OEM root public key hash |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

## 6.29.2.2 Data packet [key data]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 85h |
| RES | (1 byte) | 2Eh (OK) |
| SKR | (4 bytes) | Shared key ring number.<br>For example: 01234567h -> 01h, 23h, 45h, 67h |
| ESKY | (32 bytes) | Wrapped install key (W-UFPK).<br>For example: 01234567_89AB ... 2233_44556677h -> 01h, 23h, 45h, ... , 55h, 66h, 77h |
| IVEC | (16 bytes) | Initialization Vector.<br>For example: 01234567_89AB ... 2233_44556677h -> 01h, 23h, 45h, ... , 55h, 66h, 77h |

| RPK | (80byte) | OEM root public key (OEM_ROOT_PK | MAC). Encrypted key (bytes 0-63) + MAC (bytes 64-79) For example: If install data is as follows, the host should send RPK in order shown in the lower table. Install data: |
|-----|----------|---|
| | | |
| | | SUM |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

Install data:

| Encrypted key | | | | | | | |
|----|----|----|----|----|----|----|----|
| 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 |
| 08 | 09 | 0A | 0B | 0C | 0D | 0E | 0F |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 18 | 19 | 1A | 1B | 1C | 1D | 1E | 1F |
| 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | 29 | 2A | 2B | 2C | 2D | 2E | 2F |
| 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| 38 | 39 | 3A | 3B | 3C | 3D | 3E | 3F |
| **MAC** | | | | | | | |
| 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 |
| 48 | 49 | 4A | 4B | 4C | 4D | 4E | 4F |

Order of sending RPK:

| 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th |
|------|------|------|------|------|------|------|------|
| 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 |
| **9th** | **10th** | **11th** | **12th** | **13th** | **14th** | **15th** | **16th** |
| 08 | 09 | 0A | 0B | 0C | 0D | 0E | 0F |
| **17th** | **18th** | **19th** | **20th** | **21st** | **22nd** | **23rd** | **24th** |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| **25th** | **26th** | **27th** | **28th** | **29th** | **30th** | **31st** | **32nd** |
| 18 | 19 | 1A | 1B | 1C | 1D | 1E | 1F |
| **33rd** | **34th** | **35th** | **36th** | **37th** | **38th** | **39th** | **40th** |
| 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| **41st** | **42nd** | **43rd** | **44th** | **45th** | **46th** | **47th** | **48th** |
| 28 | 29 | 2A | 2B | 2C | 2D | 2E | 2F |
| **49th** | **50th** | **51st** | **52nd** | **53rd** | **54th** | **55th** | **56th** |
| 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| **57th** | **58th** | **59th** | **60th** | **61st** | **62nd** | **63rd** | **64th** |
| 38 | 39 | 3A | 3B | 3C | 3D | 3E | 3F |
| **65th** | **66th** | **67th** | **68th** | **69th** | **70th** | **71st** | **72nd** |
| 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 |
| **73rd** | **74th** | **75th** | **76th** | **77th** | **78th** | **79th** | **80th** |
| 48 | 49 | 4A | 4B | 4C | 4D | 4E | 4F |

### 6.29.2.3 Data Packet [Status OK]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 2Eh (OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.29.2.4 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | AEh (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

## 6.29.3 Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If this command cannot be executed in the current DLM state, the boot firmware sends a "Command acceptance error".
- If the device reset is not asserted after the Encrypted data write command is executed, the boot firmware sends a "Command acceptance error".
- If the current Authentication level is AL1 or AL0, the boot firmware sends a "Secure error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, the boot firmware analyzes the command parameters:

- If KID is not specified as the Key type, the boot firmware will send a "Parameter error".
- If PLK is not specified as a value, the boot firmware will send a "Parameter error".
- If the permanent lock is set for the hash value of the public-key ID, the boot firmware sends a "Protection error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  \* Memory status does not change before command reception.
- If the above error does not occur, the boot firmware sends "OK".

When the processing above is successfully completed, boot firmware receives and analyzes the data packet:

- Boot firmware detects the beginning of a data packet by receiving SOD.
  When boot firmware receives other data than SOD, it discards the data and waits for the next data until SOD is sent.
- When the received data packet does not have ETX, "Packet error" is returned.
- When SUM in the received data packet is different from the value calculated by boot firmware, a "Checksum error" is returned.
- When LNH and LNL in the received data packet do not comply with the packet format, "Packet error" is returned.
- When RES in the received data packet is different from defined values, "Packet error" is returned.
- When the number of received data exceeds the value specified by the command in the received data packet, the boot firmware sends a "Parameter error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  \* Memory status does not change before command reception.

When all key data has been received, the boot firmware generates a hash value:

- If the Trusted system becomes abnormal after generating the hash value of OEM_ROOT_PK, the boot firmware returns nothing and does not respond.
  \* Memory status does not change before command reception.
- If the hash value of OEM_ROOT_PK fails to be generated, the boot firmware sends a "Trusted system error" and returns to the command waiting state.
  \* Memory status does not change before command reception.

Boot firmware writes a hash value of OEM_ROOT_PK after hash value generation:

- If an error occurs while writing the hash value of OEM_ROOT_PK, the boot firmware sends a "Flash access error" and returns to the command wait state.
  \* Memory status is the hash value of OEM_ROOT_PK, or its permanent lock area is indefinite.
- If the hash value of OEM_ROOT_PK is successfully saved to the device, the boot firmware sends "OK" and returns to the command wait state.
  \* The hash value of OEM_ROOT_PK is written to the memory.
  When PLK=00h, the permanent lock is also set.

### 6.29.4 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Executing this command is unavailable in the current DLM state. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Authentication level is AL1 or AL0. | Secure error | FFFFFFFFh | FFFFFFFFh |
| The specified Public-key ID is an unsupported value. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The specified Permanent lock is an unsupported value. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Permanent lock is set for the Hash value of the specified Public-key ID. | Protection error | FFFFFFFFh | FFFFFFFFh |
| The response code of the received data packet is different from the value specified by this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| The total length of received data of data packets exceeds the value specified in the command. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Hash value generation failed. | Trusted system error | FFFFFFFFh | FFFFFFFFh |
| FACI detected an error after the command execution in not disclosed area. | Flash access error | Flash status | FFFFFFFFh |
| Successful completion. | OK | FFFFFFFFh | FFFFFFFFh |

## 6.30 Code Certificate Update Command

This command executes the following functions depending on the specified MAC type by the Command packet

- [MAC type: HMAC-SHA256]
    — Check the integrity of the following items:
        - "Hash of OEM root public key" and "Key certificate"
        - "Key certificate" and "Code certificate"
        - "Code certificate" and "OEM boot loader"
    — Write the "Code certificate" and "MAC value of Code certificate and OEM boot loader" to the area indicated by the Code certificate start address.
    — Update the version of the OEM boot loader to the value indicated by the Code certificate.
- [MAC type: None]
    — Calculate the CRC value of the OEM boot loader and compare it with the CRC value included in Code certificate.
    — Write the "Code certificate" to the area indicated by the Code certificate start address.

This command requires adherence to conditions described in Command List.

### 6.30.1 Sequence Diagram
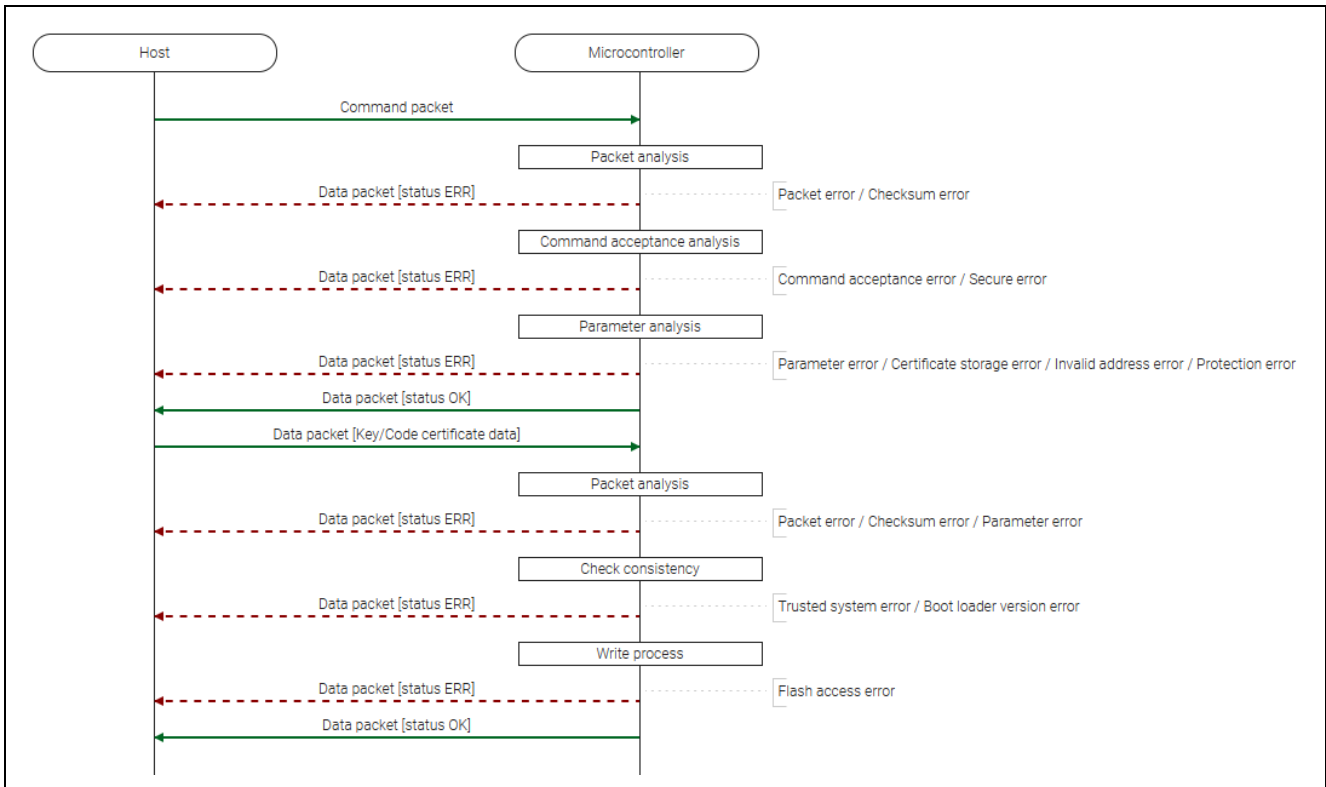


**Figure 49. Code Certificate Update Command Sequence Diagram**

### 6.30.2 Packets
### 6.30.2.1 Command Packet

| SOH | (1 byte) | 01h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 06h |
| CMD | (1 byte) | 26h (Code certificate update command) |
| MAC | (1 byte) | MAC type: <br> • 02h: HMAC-SHA256 <br> • FFh: None (CRC check) |
| KCS | (2 bytes) | Key certificate size (maximum 208 bytes). <br> For example: 208 bytes -> 00h, D0h |
| CCS | (2 bytes) | Code certificate size (maximum 216 bytes)/ <br> For example: 216 bytes -> 00h, D8h |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.30.2.2 Data Packet [Key/Code Certificate Data]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | N + M + 1 (Higher 1 byte) |
| LNL | (1 byte) | N + M + 1 (Lower 1 byte) |
| RES | (1 byte) | 26h (OK) |
| KCD | (N bytes) | Key certificate data |
| CCD | (M bytes) | Code certificate data |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

N = KCS, M = CCS

### 6.30.2.3 Data Packet [Status OK]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 26h (OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.30.2.4 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | A6h (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

## 6.30.3 Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If this command cannot be executed in the current DLM state, the boot firmware sends a "Command acceptance error".
- If the current Authentication level is AL1 or AL0, the boot firmware sends a "Secure error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, boot firmware analyzes the command parameters:

- When any of the following conditions are met, boot firmware returns "Parameter error".
  — MAC is not specified as MAC type.
  — KCS is larger than the specified max size (208 bytes).
  — CCS is larger than the specified max size (216 bytes).
- If the area for writing "Code certificate" when the MAC type is "None" or "Code certificate" and "MAC value of Code certificate and OEM boot loader" when the type is other than "None" extends outside the range of User area or Data area, the boot firmware sends a "Certificate storage error".
- If the area for writing "Code certificate" when the MAC type is "None" or "Code certificate" and "MAC value of Code certificate and OEM boot loader" when the type is other than "None" is across different KOAs, the boot firmware sends a "Certificate storage error".
- If the WAU of the area for writing "Code certificate" when the MAC type is "None" or "Code certificate" and "MAC value of Code certificate and OEM boot loader" when the type is other than "None" is 0, the boot firmware sends a "Certificate storage error".
- If the area for writing "Code certificate" when the MAC type is "None" or "Code certificate" and "MAC value of Code certificate and OEM boot loader" when the type is other than "None" is not specified in the WAU for the addresses, the boot firmware sends a "Certificate storage error".
- If the area for writing "Code certificate" when the MAC type is "None" or "Code certificate" and "MAC value of Code certificate and OEM boot loader" when the type is other than "None" includes an address that is inaccessible with current boundary setting, the boot firmware sends an "Invalid address error".
- If the area for writing "Code certificate" when the MAC type is "None" or "Code certificate" and "MAC value of Code certificate and OEM boot loader" when the type is other than "None" contains a permanent protected block, the boot firmware sends a "Protection error".
- If the lock bit of the Anti-Rollback Counter for OEM_BL is set when the MAC type is other than "None", the boot firmware sends a "Protection error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.
- If the above errors do not occur, the boot firmware sends "OK".

When the processing above is successfully completed, boot firmware receives and analyzes the data packet:

- Boot firmware detects the beginning of a data packet by receiving SOD.
  When boot firmware receives other data than SOD, it discards the data and waits for the next data until SOD is sent.
- When the received data packet does not have ETX, "Packet error" is returned.
- When SUM in the received data packet is different from the value calculated by boot firmware, a "Checksum error" is returned.
- When LNH and LNL in the received data packet do not comply with the packet format, "Packet error" is returned.
- When RES in the received data packet is different from defined values, "Packet error" is returned.
- When the size of the received KCD and CCD exceeds the size specified by KCS and CCS in the command packet, the boot firmware sends a "Parameter error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, boot firmware verifies the consistency:

- If the OEM boot loader version indicated by the Code certificate is in any of the cases below when the MAC type is other than "None," the boot firmware sends a "Boot loader version error" and returns to the command waiting state:
  — If the OEM boot loader version indicated by the Code certificate is greater than the maximum value of the OEM boot loader version defined by device specifications.
  — If the OEM boot loader version indicated by the Code certificate is less than or equal to the OEM boot loader version that is already written.
  * Memory status does not change before command reception.
- If the Trusted system becomes abnormal after verification of consistency, the boot firmware returns nothing and does not respond.
  * Memory status does not change before command reception.
- If the verification of consistency fails, the boot firmware sends a "Trusted system error" and returns to the command waiting state.
  * Memory status does not change before command reception.

When the verification of consistency succeeds, the boot firmware writes "Code certificate" when the MAC type is "None" or "Code certificate" and "MAC value of Code certificate and OEM boot loader" when the type is other than "None" to the Code certificate start address:

- If an error occurs while writing "Code certificate" or "MAC value of Code certificate and OEM boot loader", the boot firmware sends a "Flash access error" and returns to the command wait state.
  * WAU size from failure address (ADR) of memory area is undefined.
- When the writing on the Code certificate is normally finished, and the MAC type is None (FFh), boot firmware returns "OK" and waits for the next command.
  * Code certificate is written to memory.

When successful writing and MAC type is other than "None," the boot firmware updates the OEM boot loader version:

- If an error occurs while updating the OEM boot loader version, the boot firmware sends a "Flash access error" and returns to the command wait state.
  * Anti-RollBack Counter for OEM_BL of memory area are undefined.
- When the OEM boot loader version is successfully updated, the boot firmware sends "OK" and returns to the command wait state.
  * Code certificate and MAC value are written, and the OEM boot loader version is updated.

### 6.30.4 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Executing this command is unavailable in the current DLM state. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Authentication level is AL1 or AL0. | Secure error | FFFFFFFFh | FFFFFFFFh |
| The specified MAC type is an unsupported value. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Key certificate size exceeds the specified value. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Code certificate size exceeds the specified value. | Parameter error | FFFFFFFFh | FFFFFFFFh |

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The area for writing "Code certificate" and "MAC value of Code certificate and OEM boot loader(*1)" extends outside the range of User area or Data area. | Certificate storage error | FFFFFFFFh | FFFFFFFFh |
| The area for writing "Code certificate" and "MAC value of Code certificate and OEM boot loader(*1)" spans different Kinds of area. | Certificate storage error | FFFFFFFFh | FFFFFFFFh |
| The area for writing "Code certificate" and "MAC value of Code certificate and OEM boot loader(*1)" WAU is 0. | Certificate storage error | FFFFFFFFh | FFFFFFFFh |
| The area for writing "Code certificate" and "MAC value of Code certificate and OEM boot loader(*1)" is not specified in the WAU for the addresses. | Certificate storage error | FFFFFFFFh | FFFFFFFFh |
| The area for writing "Code certificate" and "MAC value of Code certificate and OEM boot loader(*1)" contains addresses that are inaccessible with the current boundary settings. | Invalid address error | FFFFFFFFh | FFFFFFFFh |
| The area for writing "Code certificate" and "MAC value of Code certificate and OEM boot loader(*1)" includes a permanent protected block. | Protection error | FFFFFFFFh | FFFFFFFFh |
| Anti-Rollback Counter for OEM_BL Lock bit is set.(*1) | Protection error | FFFFFFFFh | FFFFFFFFh |
| The response code of the received data packet is different from the value specified by this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| The number of received KCD and CCD data in the received data packet is different from the KCS and CCS specified in the command packet. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| OEM boot loader version indicated by Code certificate is greater than the maximum value of OEM boot loader version defined by device specifications.(*1) | Boot loader version error | FFFFFFFFh | FFFFFFFFh |
| OEM boot loader version indicated by Code certificate is less than or equal to the OEM boot loader version that is already written.(*1) | Boot loader version error | FFFFFFFFh | FFFFFFFFh |
| Verification of consistency failed. | Trusted system error | Trusted system status | FFFFFFFFh |
| FACI detected an error after the command execution. | Flash access error | Flash status | Failure address |
| FACI detected an error after the command execution when updating the OEM boot loader version.(*1) | Flash access error | Flash status | FFFFFFFFh |
| Successful completion. | OK | FFFFFFFFh | FFFFFFFFh |

*1) Only when MAC type = HMAC-SHA256

### 6.30.5 Precautions

(1) Use this command after writing "OEM boot loader" to the User area and "Code certificate start address" to the EEP config area with the Write command or Encrypted data write command in advance.

(2) Use this command after saving the "OEM root public key encrypted Hash value" in the device in advance with the OEM root public key setting command.

(3) Verification fails if data of received Key certificate or Code certificate does not conform to device specifications. Refer to the user's manual of the device for certificates' specifications.

(4) Key certificate is not necessary when MAC type = None. Specify KCS = 0 and do not send any data as Key certificate data in this case.

## 6.31 Code Certificate Check Command

This command executes the following functions depending on the specified MAC type by the Command packet

- [MAC type: HMAC-SHA256]
  — Check the consistency of "Code certificate" and "the MAC value of Code certificate and OEM boot loader" which are stored in the device.
  — Read and return the version of the OEM boot loader, which is stored in the device.
- [MAC type: None]
  — Calculate the CRC value of the OEM boot loader and compare it with the CRC value included in Code certificate which are stored in the device.

This command requires adherence to conditions described in Command List.
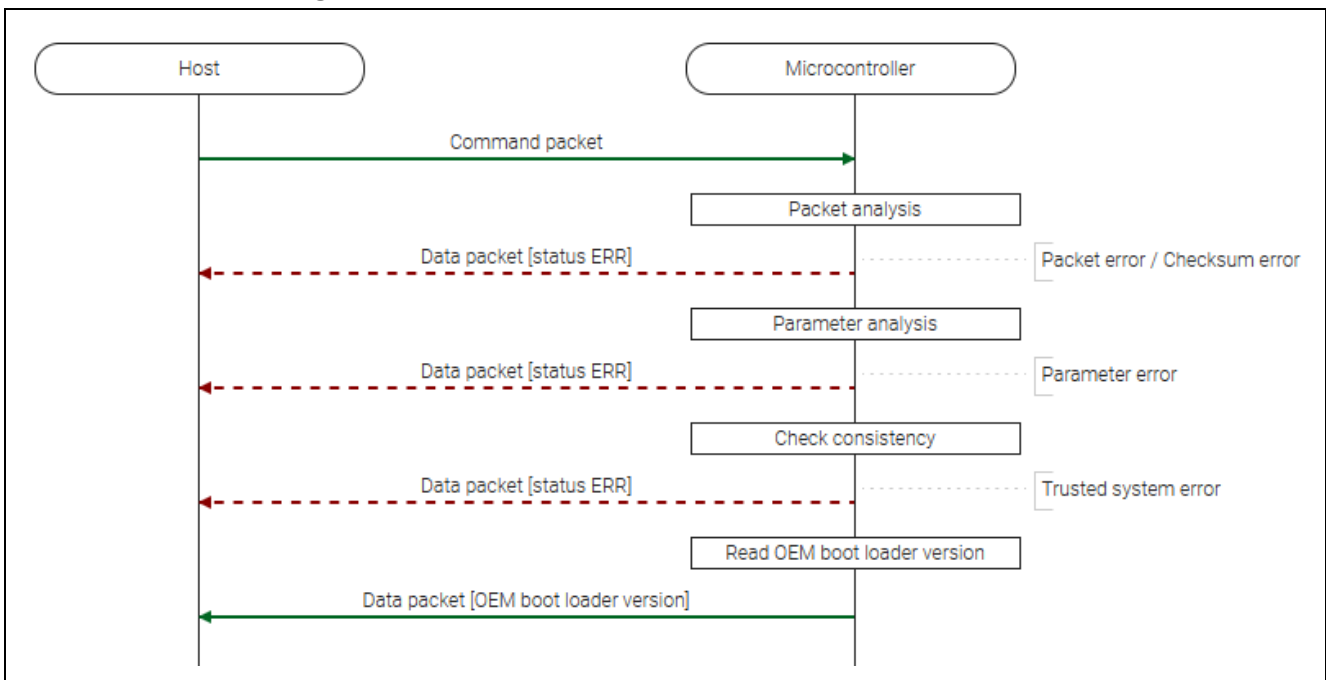
### 6.31.1 Sequence Diagram



**Figure 50.  Code Certificate Check Command Sequence Diagram**

## 6.31.2  Packets

### 6.31.2.1 Command Packet

| SOH | (1 byte) | 01h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 06h |
| CMD | (1 byte) | 27h (Code certificate check command) |
| MAC | (1 byte) | MAC type:<br>• 02h: HMAC-SHA256<br>• FFh: None (CRC check) |
| KCS | (2 bytes) | Key certificate size (maximum 208 bytes).<br>For example: 208 bytes -> 00h, D0h<br>Specify fixed size 208 bytes since KCS is unused in this product. |
| CCS | (2 bytes) | Code certificate size (maximum 216 bytes).<br>For example: 216 bytes -> 00h, D8h |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.31.2.2 Data Packet [OEM Boot Loader Version]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 05h |
| RES | (1 byte) | 27h (OK) |
| BLV | (4 bytes) | OEM boot loader version (unused when MAC type = None).<br>For example: Version = 10 -> 00h, 00h, 00h, 0Ah<br>When MAC type = None, this field is not used and is always FFFFFFFFh. |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.31.2.3 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | A7h (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.31.3 Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, the boot firmware analyzes the command parameters:

- When any of the following conditions are met, boot firmware returns "Parameter error".
  — MAC is not specified MAC type.
  — KCS exceeds the specified maximum size (208 bytes).
  — CCS exceeds the specified maximum size (216 bytes).
- When the above error occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, the boot firmware checks the consistency:

- If the consistency check fails, the boot firmware sends a "Trusted system error" and returns to the command wait state.
  * Memory status does not change before command reception.

When the verification of consistency is successful, the boot firmware returns the version of the OEM boot loader:

- When MAC type is "None", OEM boot loader version is returned all-F.
- When the verification of consistency is completed successfully, the boot firmware sends "version of OEM boot loader" and returns to the command wait state.
  * Memory status does not change before command reception.

### 6.31.4 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| The specified MAC type is an unsupported value. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Key certificate size exceeds the specified value. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Code certificate size exceeds the specified value. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| Consistency check failed. | Trusted system error | Trusted system status | FFFFFFFFh |

## 6.32 External Flash Memory Setting Command

This command configures initial settings for external flash area access, receives external flash memory access driver codes from the host, and stores them in RAM.

This command must be executed before executing other commands specifying an external flash area.

This command requires adherence to conditions described in Command List.
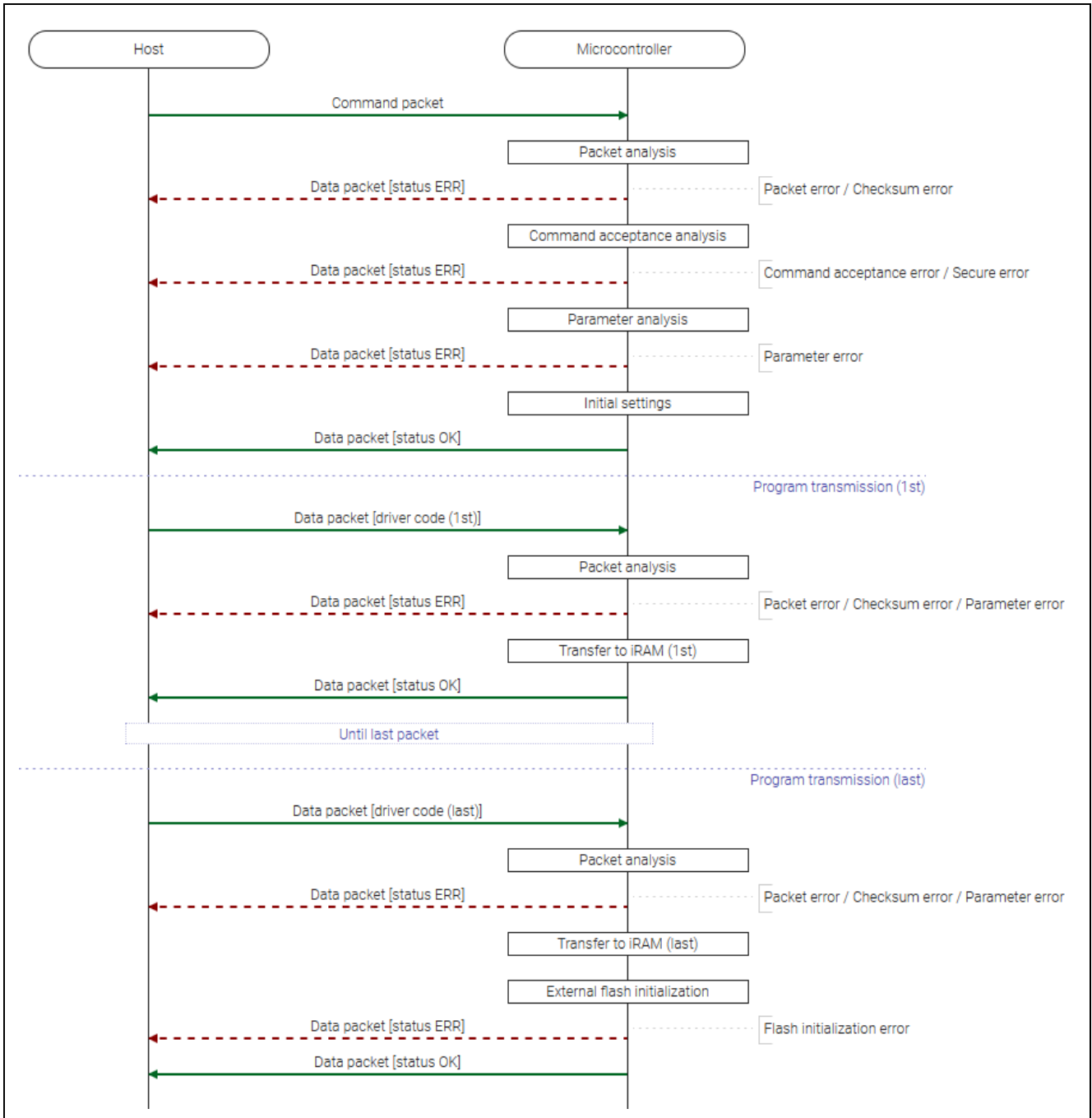
### 6.32.1 Sequence Diagram



**Figure 51.  External Flash Memory Setting Command Sequence Diagram**

### 6.32.2 Packets
### 6.32.2.1 Command Packet

| SOH | (1 byte) | 01h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 07h |
| CMD | (1 byte) | 36h (External flash memory setting command) |
| OCK | (1 byte) | OCTACLK frequency:<br>• 00h: 66.66MHz<br>• 01h: 100MHz<br>• 02h: 133.33MHz<br>• 03h: 200MHz |
| VCC | (1 byte) | VCC2 voltage:<br>• 00h: Lower than 2.7V<br>• 01h: Higher than or equal to 2.7V |
| LOP | (4 bytes) | Data length of external flash memory access driver [bytes].<br>For example: 2048 bytes -> 0000_0800h -> 00h, 00h, 08h, 00h |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.32.2.2 Data Packet [Driver Code]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | N + 1 (Higher 1 byte) |
| LNL | (1 byte) | N + 1 (Lower 1 byte) |
| RES | (1 byte) | 36h (OK) |
| DAT | (N bytes) | External flash memory access driver |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

N = 4–1024 (must be multiple of 4)

### 6.32.2.3 Data Packet [Status OK]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 36h (OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | C8h |
| ETX | (1 byte) | 03h |

### 6.32.2.4 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | B6h (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.32.3 Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If this command cannot be executed in the current DLM state, the boot firmware sends a "Command acceptance error".
- If device reset is not asserted after the Encrypted data write command execution, the boot firmware sends a "Command acceptance error".
- If the current Authentication level is AL0, the boot firmware sends a "Secure error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, boot firmware analyzes the command parameters:

- If OCK is an unspecified value, the boot firmware will send a "Parameter error".
- If VCC is an unspecified value, the boot firmware will send a "Parameter error".
- If LOP exceeds 37000h byte, the boot firmware will send a "Parameter error".
- If LOP is 0 bytes, the boot firmware will send a "Parameter error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the processing above is successfully completed, the boot firmware initializes hardware modules for accessing external flash memory:

- The boot firmware initializes hardware modules and sends "OK".

When the processing above is successfully completed, boot firmware receives and analyzes the data packet:

- Boot firmware detects the beginning of a data packet by receiving SOD.
  When boot firmware receives other data than SOD, it discards the data and waits for the next data until SOD is sent.
- When the received data packet does not have ETX, "Packet error" is returned.
- When SUM in the received data packet is different from the value calculated by boot firmware, a "Checksum error" is returned.
- When LNH and LNL in the received data packet do not comply with the packet format, "Packet error" is returned.
- When RES in the received data packet is different from defined values, "Packet error" is returned.
- When the total size of the received driver code exceeds the specified LOP, the boot firmware sends a "Parameter error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.
  * Memory status does not change before command reception.

When the received data packet is not the last driver code, the boot firmware sends "OK" after writing the driver code to RAM:

- The boot firmware sends "OK" after writing driver code to RAM.
- The boot firmware receives the next data packet after sending "OK".

When the received data packet is the last driver code, the boot firmware writes the driver code to RAM:

- The boot firmware writes driver code to RAM.

After driver code reception, the boot firmware initializes hardware resources required to access external flash memory:

- The boot firmware calls the Initialize driver to initialize hardware resources required to access external flash memory.
- If the Initialize driver returns FFFFFFFFh, the boot firmware sends a "Flash initialization error" and waits for the next command.
- When the Initialize driver returns 00000000h, the boot firmware sends "OK" and waits for the next command.

### 6.32.4 Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Executing this command is unavailable in the current DLM state. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| The current Authentication level is AL0. | Secure error | FFFFFFFFh | FFFFFFFFh |
| The specified OCTACLK frequency is an unspecified value. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The specified VCC2 voltage is an unspecified value. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| LOP exceeds 37000h bytes. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| LOP is 0 bytes. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| The response code of the received data packet is different from the value specified by this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| The total length of received data of data packets exceeds the specified LOP. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| An error occurred while initializing the external flash memory. | Flash initialization error | FFFFFFFFh | FFFFFFFFh |
| Successful completion. | OK | FFFFFFFFh | FFFFFFFFh |

### 6.32.5 External Flash Memory Access Driver

The specifications of the external flash memory access driver are described below.

Mapping of the driver area:

| Offset address from SRAM0 base | Allocated data | Explanation |
|---|---|---|
| +08000h - 0803Fh | Initialize driver entry point | Wrap functions to the driver body. |
| +08040h - 0807Fh | EraseSector driver entry point | |
| +08080h - 080BFh | EraseChip driver entry point | |
| +080C0h - 080FFh | ProgramData driver entry point | |
| +08100h - 3EFFFh | Driver code body + Stack area | Body of the drivers and the stack. Stack pointer is initialized to this area's end address + 1 (= SRAM0 base + 3F000h). |
| +3F000h - 3FFFFh | Data buffer area | Data buffer used for write data of ProgramData driver. Boot firmware stores the write data to this area and pass the pointer to this area by ProgramData driver's argument. This area is not intended for that the drivers write. |

Arguments and return value shall be passed in accordance with "ABI for the Arm 32-bit Architecture":

| Value | General register |
| --- | --- |
| Return value | r0 |
| Argument 1 | r0 |
| Argument 2 | r1 |
| Argument 3 | r2 |

[Initialize driver]

| API specification |
| --- |
| Syntax: |
|     int32_t R_Flash_Initialize ( uint32_t rfu ) |
| Arguments: |
|     [in] rfu: Unused (reserved for future use) |
| Return value: |
|     00000000h: Operation succeeded |
|     FFFFFFFFh: Error occurred |
| **Function explanation** |
| Initialize the external flash memory interface. |
| This driver is called when external flash memory setting command is executed. |
| It is recommended that this driver executes the following functions: |
| • Initialize Octal SPI Peripheral registers. |
| • Initialize Ports setting used for Octal SPI. |
| • Initialize variables that the drivers use. |
| • Return initialization result by the return value. |

[EraseSector driver]

| API specification |
| --- |
| Syntax: |
|     int32_t R_Flash_EraseSector ( uint32_t addr ) |
| Arguments: |
|     [in] addr: Sector address |
| Return value: |
|     Other than FFFFFFFFh: Erased size [byte] |
|     FFFFFFFFh: Error occurred |
| **Function explanation** |
| Erase flash memory sector. |
| This driver is called when Erase command is executed to external flash area. |
| It is recommended that this driver executes the following functions: |
| • Erase a sector specified by "addr". |
| • Return the erased size by the return value, or return FFFFFFFFh when erasure fails. |
| Boot firmware repeats calling this driver until "addr" reaches the specified EAD as in the example below: |
| 1. Erase command is executed (SAD=0x80000000, EAD=0x8000FFFF). |
| 2. Boot firmware calls EraseSector driver (addr=0x80000000). |
| 3. EraseSector driver returns 0x00008000. |
| 4. Boot firmware calls EraseSector driver (addr=0x80008000). |
| 5. EraseSector driver returns 0x00008000. |
| 6. Boot firmware finishes Erase command since addr exceeds the EAD. |

[EraseChip driver]

| API specification |
| --- |
| Syntax:<br>    int32_t R_Flash_EraseChip ( void )<br>Return value:<br>    00000000h: Operation succeeded<br>    FFFFFFFFh: Error occurred |
| **Function explanation** |
| Erase complete flash.<br>This driver is called when Erase command is executed to whole external flash area (for example: 0x60000000–0x9FFFFFFF for RA8M1 MCU Group).<br>It is recommended that this driver executes the following functions:<br>• Erase whole flash memory<br>• Return the erasure result<br>This driver is optional for faster full chip erase. Full erase is achievable also by using EraseSector driver.<br>However, if the connected external flash memory's size is the same as whole external flash area's size, to execute full erase, this driver must be implemented or the Erase command must be executed twice (separately) to avoid calling this driver. |

[ProgramData driver]

| API specification |
| --- |
| Syntax:<br>    int32_t R_Flash_ProgramData ( uint32_t addr, const void *data, uint32_t cnt )<br>Arguments:<br>    [in] addr: Data address.<br>    [in] data: Pointer to a buffer containing the data to be programmed to Flash.<br>    [in] cnt: Number of data items to program.<br>Return value:<br>    Other than FFFFFFFFh: Programmed size [byte]<br>    FFFFFFFFh: Error occurred |
| **Function explanation** |
| Program data to flash memory.<br>This driver is called when the Write or Encrypted data write command is executed to the external flash area.<br>It is recommended that this driver executes the following functions:<br>• Program the data passed by "data". Program destination address is "addr" and program length is "cnt".<br>• Return the programmed size by the return value, or return FFFFFFFFh when program fails.<br>Boot firmware repeats calling this driver until "addr" reaches the specified EAD as in the example below:<br>1. Write command is executed (SAD=0x80000000, EAD=0x800007FF).<br>2. 1st data is sent (data length is 1024 bytes).<br>3. Boot firmware calls ProgramData driver (addr=0x80000000, cnt=1024).<br>4. ProgramData driver returns 1024.<br>5. 2nd data is sent (data length is 1024 bytes).<br>6. Boot firmware calls ProgramData driver (addr=0x80000400, cnt=1024).<br>7. ProgramData driver returns 512.<br>8. Boot firmware calls ProgramData driver (addr=0x80000600, cnt=512).<br>9. ProgramData driver returns 512.<br>10. Boot firmware finishes the Write command since addr reaches the EAD. |

### 6.32.6 Device State when the Drivers are Called

Table 23 shows the state of the device when external flash memory access drivers are called.

It is necessary for drivers to initialize only I/O ports and Octal SPI registers to access external flash memories, since boot firmware initializes other HW resources beforehand.

**Table 23. Device State when the Drivers are Called**

| Item | State | Notes for drivers |
|------|-------|-------------------|
| CPU Security state | Non-Secure | Drivers can access only to Non-Secure resources. |
| SAU allocation | Following areas are allocated as Non-Secure:<br>• 32008000h–3203FFFFh<br>• 50000000h–50FFFFFFh<br>• 80000000h–9FFFFFFFh<br>Other addresses are allocated as Secure. | Drivers can access only the following:<br>• RAM area for the drivers<br>• Peripherals marked as Non-Secure<br>• External address space allocated for external flash memory |
| Stack pointer | Main stack pointer for Non-Secure is initialized to 3203F000h. | Drivers do not need to initialize SP. |
| SRAM | SRAM0 base+00000h~07FFFh: Marked as Secure.<br>SRAM0 base+08000h~: Marked as Non-Secure. | Drivers can use SRAM0 base+08000h~3FFFFh.<br>(Although 40000h~ is marked as Non-Secure, SAU allocates this address as Secure as described above.)<br>Boot firmware clears this area with 0 before calling Initialize driver. Therefore, drivers can use stack area soon after called without initializing. |
| Clock | Initialized | Drivers do not need to initialize clock registers.<br>OCTACLK depends on specified OCTACLK frequency by this command. |
| Octal SPI | Not initialized.<br>Marked as Non-Secure.<br>Module stop has been released. | Initialize driver needs to initialize Octal SPI registers.<br>Initialize driver does not need to release module stop. |
| I/O Port | Not initialized except LVOCR Marked as Non-Secure (only ports assignable to Octal SPI) | Initialize driver needs to initialize I/O port registers. However, only LVOCR is initialized by boot firmware depending on specified VCC2 voltage by this command. |
| Other HW resources | Marked as Secure | – |

*) Note that drivers cannot use interrupts since interrupt registers are not marked as Non-Secure.

*) Note that interrupts of boot firmware may occur during driver execution. Therefore, it is recommended to avoid timing-depending processing such as wait by nop operation.

## 6.33 Encrypted Data Write Command

This command receives an encrypted image from the host, decrypts the image, and saves the plain-text image on the device.

In addition, this command changes the device to the specified state, PL0 or LCK_BOOT, when saving the data.

Erase processing and write processing of this command are not affected by the block protection settings (BPS, BPS_SEC).

This command requires adherence to conditions described in Command List.

Only the following commands are executable after boot firmware sends status OK to the Command packet of this command until device reset is asserted, regardless of the DLM state at the timing:

| Executable command | Note |
| --- | --- |
| User key setting command | – |
| User key verify command | – |
| Parameter setting command | Depending on parameter ID (PMID), see the command's specifications for details. |
| Parameter request command | |
| Lock bit setting command | – |
| Lock bit request command | – |
| ARC configuration setting command | – |
| ARC configuration request command | – |
| CRC command | – |
| Code certificate update command | – |
| Code certificate check command | – |

### 6.33.1 Sequence Diagram
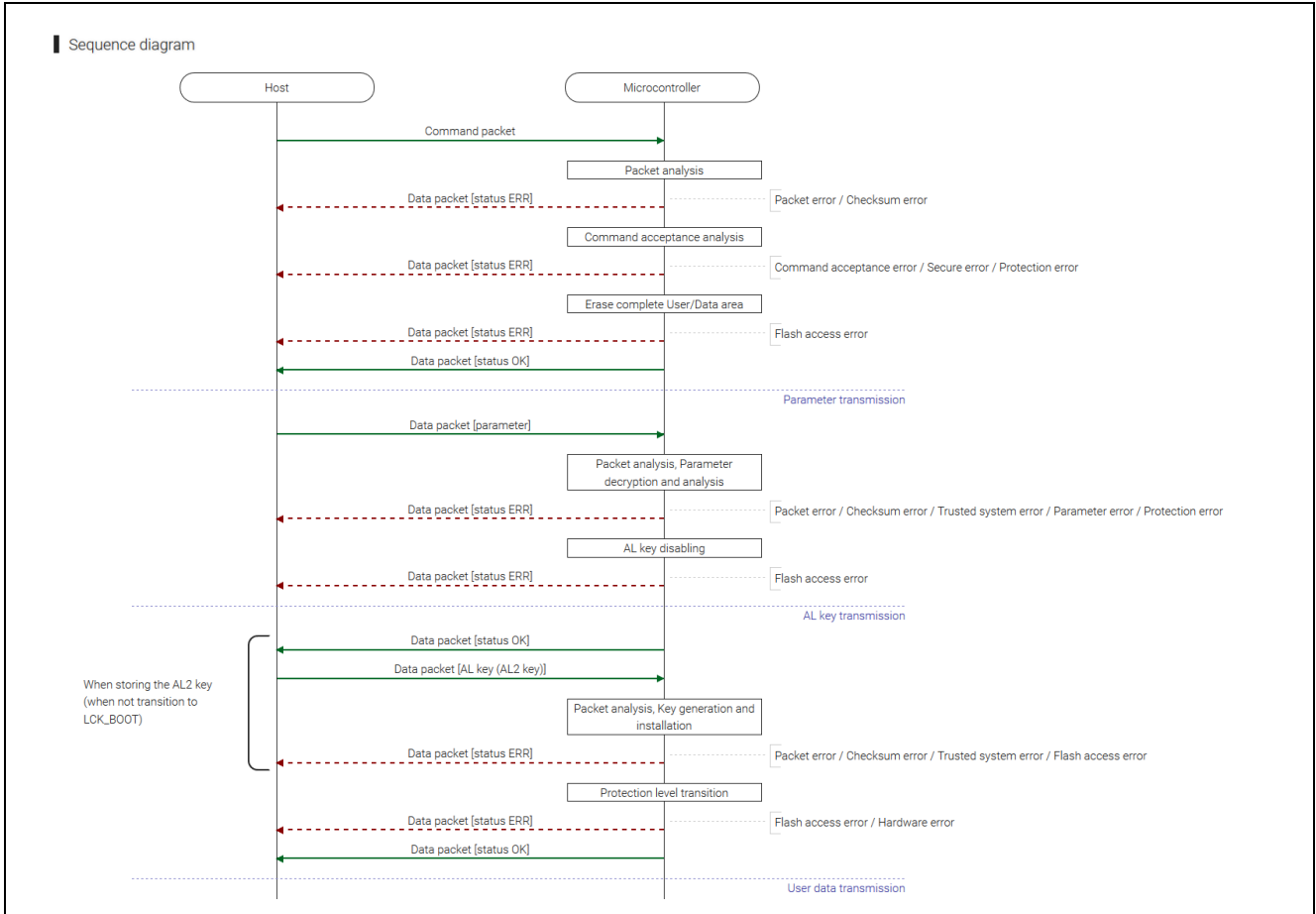


**Figure 52.  Encrypted Data Write Command Sequence Diagram (Part 1)**
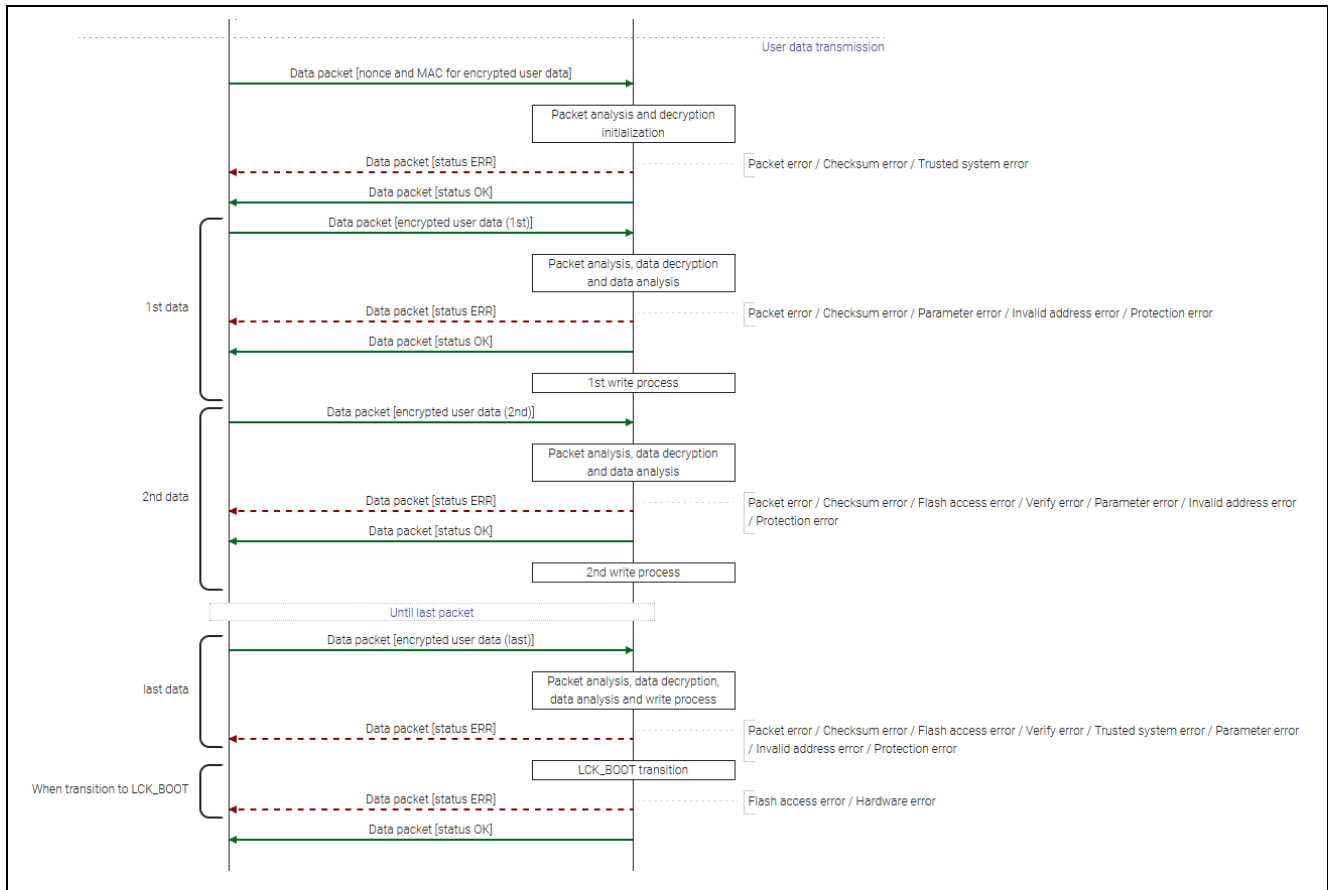
**Figure 53. Encrypted Data Write Command Sequence Diagram (Part 2)**

### 6.33.2 Packets
### 6.33.2.1 Command Packet

| SOH | (1 byte) | 01h |
|------|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 55h |
| CMD | (1 byte) | 1Ah (Encrypted data write command) |
| SKR | (4 bytes) | Shared key ring number |
| ESKY | (32 bytes) | Wrapped install key (W-UFPK) |
| IVEC | (16 bytes) | Initialization Vector used for encrypting ENKY |
| ENKY | (32 bytes) | Encrypted encryption key \| MAC.<br>Encryption method is AES128-CBC with CMAC. |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

## 6.33.2.2 Data Packet [Parameter]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 2Dh |
| RES | (1 byte) | 1Ah (OK) |
| NCE | (12byte) | Nonce is used for encrypting parameters. Nonce length is 12 bytes, and the counter length is 4 bytes. |
| PRM | (16 bytes) | Encrypted parameters. Encryption method is AES128-CCM mode (NIST SP800-38C). Data format before encryption: |

| 1st–4th bytes | 5th byte | 6th–8th bytes |
|---|---|---|
| LOD | TRN | (reserved) |

| 9th–16th bytes | | |
|---|---|---|
| (reserved) | | |

Parameter details:

| LOD (4 bytes) | Total length of "encrypted user data and write address/size"<br>• Must be greater than 0/<br>• Must be multiple of encryption block size (16 bytes for AES128)<br>For example:<br>LOD = 00104000h = 00h, 10h, 40h, 00h when:<br>• Total length of raw image=1MB=100000h<br>• Length of SAD, SIZE, and reserved=4000h(*)<br>*) 16 bytes per packet as described below |
|---|---|
| TRN (1 byte) | Transition pattern:<br>• 01h: PL0 with AL2_key<br>• 02h: LCK_BOOT |
| **reserved** | Reserved data is ignored. Although any value is specifiable, using random numbers or similarly complex values is recommended for security reasons, rather than using simple values such as 00h or FFh. |

| MAC | (16 bytes) | MAC for Encrypted parameters |
|---|---|---|
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

## 6.33.2.3 Data Packet [AL Key]

| SOD | (1 byte) | 81h |
|---|---|---|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 31h |
| RES | (1 byte) | 1Ah (OK) |
| IVEC | (16 bytes) | Initialization Vector |
| EOKY | (32 bytes) | Install data (Encrypted key \| MAC).<br>Encrypted AL key (bytes 0–15) + MAC (bytes 16–31)<br>Encryption method and data format are the same as Key setting command. |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.33.2.4 Data Packet [Nonce and MAC for Encrypted User Data]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 1Dh |
| RES | (1 byte) | 1Ah (OK) |
| NCE | (12byte) | Nonce used for encrypting user data. Nonce length is 12 bytes and counter length is 4 bytes. |
| MAC | (16 bytes) | MAC for Encrypted user data |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.33.2.5 Data Packet [Encrypted User Data]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | N + 1 (Higher 1 byte) |
| LNL | (1 byte) | N + 1 (Lower 1 byte) |
| RES | (1 byte) | 1Ah (OK) |
| DAT | (N bytes) | Encrypted user data and write address/size. Encryption method is AES128-CCM mode (NIST SP800-38C). Data format before encryption: |

| $1^{st}$–4th bytes | $5^{th}$–6th bytes | $7^{th}$–16th bytes |
|---|---|---|
| SAD | SIZE | (Reserved: FFh) |
| **$17^{th}$–(n+16)th bytes (n=16, 32, 48, ... 1024)** | | |
| User data | | |

User data and write address/size details:

| SAD - Write address | Specify write address of the User data/ For example: 02000000h -> 02h, 00h, 00h, 00h |
|---|---|
| SIZE - Write size | Specify size of the User data/ For example: 0400h -> 04h, 00h |
| User data | Length must be both: <br> • 1024 bytes or less <br> • Least common multiple of the following: <br> — WAU of the write address <br> — Encryption block size (16 bytes for AES128) |

| SUM | (1 byte) | Sum data |
|-----|----------|-----|
| ETX | (1 byte) | 03h |

N = 32, 48, 64, ... 1040

### 6.33.2.6 Data Packet [Status OK]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 1Ah (OK) |
| STS | (1 byte) | 00h (OK) |
| ST2 | (4 bytes) | FFFFFFFFh (unused code) |
| ADR | (4 bytes) | FFFFFFFFh (unused code) |
| SUM | (1 byte) | E4h |
| ETX | (1 byte) | 03h |

### 6.33.2.7 Data Packet [Status ERR]

| SOD | (1 byte) | 81h |
|-----|----------|-----|
| LNH | (1 byte) | 00h |
| LNL | (1 byte) | 0Ah |
| RES | (1 byte) | 9Ah (ERR) |
| STS | (1 byte) | Status code |
| ST2 | (4 bytes) | Status details |
| ADR | (4 bytes) | Failure address |
| SUM | (1 byte) | Sum data |
| ETX | (1 byte) | 03h |

### 6.33.3 Processing Procedure

Boot firmware receives and analyzes a command packet:

- The boot firmware recognizes the start of the command packet by receiving SOH.
  If the boot firmware receives something other than SOH, it will wait until it receives SOH.
- If ETX is not added to the received command packet, the boot firmware sends a "Packet error".
- If the SUM of the received command packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received command packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- If the received command packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.

When the processing above is successfully completed, boot firmware executes the acceptance analysis:

- If this command cannot be executed in the current DLM state, the boot firmware sends a "Command acceptance error".
- If the device reset is not asserted after the Encrypted data write command is executed, the boot firmware sends a "Command acceptance error".
- If the current Authentication level is AL1 or AL0, the boot firmware sends a "Secure error".
- If any of the following conditions are met, boot firmware sends a "Protection error":
  — SAS.BTFLG is not 1b
  — BANKSEL.BANKSWP[2:0] is not 111b (only for dual mode supported devices)
  — BANKSEL_SEC.BANKSWP[2:0] is not 111b (only for dual mode supported devices)
- If a Permanent protected block exists (there is a bit that is "0" in PBPS and PBPS_SEC), the boot firmware sends a "Protection error".
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.

When the processing above is successfully completed, boot firmware erases the complete User area and Data area:

- If erasure fails, the boot firmware sends a "Flash access error" and returns to the command waiting state.
- If the above error does not occur, the boot firmware sends "OK".

When the processing above is successfully completed, the boot firmware receives the data packet [parameter] and decrypts and analyzes the parameters:

- Boot firmware receives data packet [parameter].
  * Refer to "Data Packet Reception" below for data packet reception processing.
- Boot firmware decrypts the received parameter.
  If decryption fails, the boot firmware sends a "Trusted system error".
  However, boot firmware sends nothing and becomes unresponsive if the Trusted system becomes abnormal.
- When decryption completes, boot firmware checks PRM:
  — Boot firmware sends "Parameter error" if PRM is unspecified value.
  — Boot firmware sends a "Protection error" if LCK_BOOT is specified for TRN when the transition to LCK_BOOT is disabled.
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.

When the processing above is successfully completed, the boot firmware disables AL keys depending on the parameters:

- Boot firmware disables only AL1_key when TRN is "PL0 with AL2_key" or disables both AL2_key and AL1_key when TRN is "LCK_BOOT".
- If an error occurs while disabling AL keys, boot firmware sends a "Flash access error" and returns to the command wait state.

When the processing above is successfully completed, the boot firmware receives and writes AL keys depending on the parameters:

- Boot firmware receives and writes AL2_key when TRN is "PL0 with AL2_key".
  Boot firmware skips this processing and proceeds to the Protection level transition when TRN is "LCK_BOOT".
- Boot firmware sends "OK".
- Boot firmware receives data packet [AL key].
  * Refer to "Data Packet Reception" below for data packet reception processing.
- Boot firmware generates Key index (Wrapped AL key).
  If the generation of the Key index (Wrapped AL key) fails, the boot firmware sends a "Trusted system error" and returns to the command waiting state.
  However, boot firmware sends nothing and becomes unresponsive if the Trusted system becomes abnormal.
- Boot firmware writes Key index (Wrapped AL key) to the device.
  If an error occurs while writing the Key index (Wrapped AL key), the boot firmware sends a "Flash access error" and returns to the command wait state.

When the processing above is successfully completed, boot firmware transits the Protection level:

- If an error occurs during Protection level transition, boot firmware returns "Flash access error" and waits for the next command.
- If the Protection level after the transition is an invalid value, the boot firmware sends a "Hardware error" and becomes unresponsive.
- When the Protection level transition is successfully completed, boot firmware sends "OK".

When the processing above is successfully completed, boot firmware receives the data packet [nonce and MAC for encrypted user data] and initializes decryption processing:

- Boot firmware receives data packet [nonce and MAC for encrypted user data].
  \* Refer to "Data Packet Reception" below for data packet reception processing.
- Boot firmware initializes decryption processing.
  If initialization fails, the boot firmware sends a "Trusted system error" and returns to the command waiting state.
  However, boot firmware sends nothing and becomes unresponsive if the Trusted system becomes abnormal.
- When initialization is successfully completed, boot firmware sends "OK".

When the processing above is successfully completed, boot firmware receives the data packet [encrypted user data], decrypts received data, and analyzes decrypted data:

- Boot firmware receives data packet [encrypted user data].
  \* Refer to "Data Packet Reception" below for data packet reception processing.
- Boot firmware decrypts received encrypted user data.
  If decryption fails, the boot firmware sends a "Trusted system error" and returns to the command waiting state.
  However, boot firmware sends nothing and becomes unresponsive if the Trusted system becomes abnormal.
- Boot firmware checks SAD/EAD as described below after decryption of encrypted user data:
  — Boot firmware sends "Parameter error" if:
    - SIZE does not match the length of User data.
    - "SAD ~ (SAD+SIZE-1)" specifies outside the areas defined in area information.
    - "SAD ~ (SAD+SIZE-1)" spans different Kinds of area.
    - SAD specifies the area whose WAU=0.
    - SAD is not multiple of WAU.
    - SAD is not multiple of encryption block size.
    - SIZE is not multiple of WAU.
  — Boot firmware sends "Invalid address error" if:
    - The area specified by SAD and SIZE includes an address that is inaccessible with the current boundary setting.
  — Boot firmware sends a "Protection error" if:
    - Area specified with SAD and SIZE includes area for which the Lock bit is set,
  When the error above occurs, the boot firmware does not process and returns to the command waiting state.

When the encrypted user data is not the last write data, boot firmware returns "OK" and executes the write processing:

- Boot firmware returns "OK" and executes the write processing.
- If an error occurs while writing the user data, boot firmware receives a data packet, sends a "Flash access error," and returns to the command wait state.
- If the write value and write result do not match when writing to the Config area or EEP config area, boot firmware sends a "Verify error" and returns to the command waiting state.
- When the write processing is normally finished, the boot firmware receives the next data packet [encrypted user data].

When the encrypted user data is the last write data, the boot firmware executes write processing and then returns a data packet:

- When TRN is "LCK_BOOT", boot firmware also executes LCK_BOOT transition before data packet transmission.
- Boot firmware does not return "OK" but executes write processing.
- If an error occurs while writing the user data, the boot firmware sends a "Flash access error" and returns to the command wait state.
- If the write value and write result do not match when writing to the Config area or EEP config area, boot firmware sends a "Verify error" and returns to the command waiting state.
- When the write processing is successfully completed and the TRN is "LCK_BOOT," boot firmware executes the LCK_BOOT transition.
- If an error occurs during the LCK_BOOT transition, boot firmware returns a "Flash access error" and waits for the next command.
- If the DLM state after the transition is an invalid value, the boot firmware sends a "Hardware error" and becomes unresponsive.
- When the processing above is successfully completed, the boot firmware returns "OK" and waits for the next command.

### 6.33.3.1 Data Packet Reception

Data packet reception processing is described below:

- The boot firmware recognizes the start of the data packet by receiving SOD.
  If the boot firmware receives something other than SOH, it will wait until it receives SOD.
- If ETX is not added to the received data packet, the boot firmware sends a "Packet error".
- If the SUM of the received data packet is different from the sum value, the boot firmware sends a "Checksum error".
- If the received Data packet's LNH and LNL are different from the values specified in the packet format, the boot firmware sends a "Packet error".
- When RES in the received data packet is different from defined values by each command, "Packet error" is returned.
- If the received data packet's LNH and LNL are different from the values specified in each command, the boot firmware sends a "Packet error".
- If the total received size of "Encrypted user data and write address/size" exceeds LOD, the boot firmware sends a "Parameter error".
  *) Only when receiving data packet [encrypted user data].
- When any of the above errors occurs, the boot firmware does not process and returns to the command waiting state.

### 6.33.4  Status Information from the Microcontroller

(Listed in descending order of priority.)

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| The received packet does not have ETX. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Sum data in the received packet is different from the value calculated by the boot firmware. | Checksum error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the packet format. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Packet length in the received packet does not comply with the specifications of this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| Executing this command is unavailable in the current DLM state. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Device reset is not asserted after Encrypted data write command execution. | Command acceptance error | FFFFFFFFh | FFFFFFFFh |
| Authentication level is AL1 or AL0. | Secure error | FFFFFFFFh | FFFFFFFFh |
| Any of the following conditions is met:<br>• SAS.BTFLG is not 1b. | Protection error | FFFFFFFFh | FFFFFFFFh |

| Condition | STS | ST2 | ADR |
|---|---|---|---|
| • BANKSEL.BANKSWP[2:0] is not 111b (only for dual mode supported devices).<br>• BANKSEL_SEC.BANKSWP[2:0] is not 111b (only for dual mode supported devices). | | | |
| There are any blocks protected by permanent block protection (PBPS). | Protection error | FFFFFFFFh | FFFFFFFFh |
| FACI detected an error after the command execution in the disclosed area. | Flash access error | Flash status | FFFFFFFFh |
| The response code of the received data packet is different from the value specified by this command. | Packet error | FFFFFFFFh | FFFFFFFFh |
| The processing below fails:<br>• Decryption processing<br>• Wrapped AL key generation | Trusted system error | FFFFFFFFh | FFFFFFFFh |
| Parameter in Encrypted parameters is an unspecified value. | Parameter error | FFFFFFFFh | FFFFFFFFh |
| "LCK_BOOT" is specified for the Transition pattern when the transition to LCK_BOOT disabled. | Protection error | FFFFFFFFh | FFFFFFFFh |
| Protection level or DLM state is abnormal. | Hardware error | FFFFFFFFh | FFFFFFFFh |
| Any of the following conditions is met:<br>• Total received size of "Encrypted user data and write address/size" exceeds LOD.<br>• SIZE does not match the length of User data.<br>• "SAD ~ (SAD+SIZE-1)" specifies outside the areas defined in area information.<br>• "SAD ~ (SAD+SIZE-1)" spans different Kinds of area.<br>• SAD specifies the area whose WAU=0.<br>• SAD is not multiple of WAU.<br>• SAD is not multiple of the encryption block size (*).<br>• - SIZE is not multiple of WAU.<br>*) 16 bytes for AES128 | Parameter error | FFFFFFFFh | FFFFFFFFh |
| "SAD ~ (SAD+SIZE-1)" contains addresses that are inaccessible to the current boundary settings. | Invalid address error | FFFFFFFFh | FFFFFFFFh |
| "SAD ~ (SAD+SIZE-1)" contains an area where the Lock bit is set. | Protection error | FFFFFFFFh | FFFFFFFFh |
| The written value and the write result do not match when writing to the Config or EEP config area. | Verify error | FFFFFFFFh | FFFFFFFFh |
| An error occurred in the external flash memory access driver. | Flash access error | FFFFFFFFh | FFFFFFFFh |
| Successful completion. | OK | FFFFFFFFh | FFFFFFFFh |

### 6.33.5 Precautions

(1) This command becomes inexecutable after permanent block protection is set.

(2) This command becomes inexecutable if SAS.BTFLG=0b and SAS.FSPR=0b is set.

(3) If the Lock bit in the EEP config area is set, the protected area cannot be rewritten. Therefore, rewrite the protected area before setting the Lock bit.

(4) If permanent block protection in the Config area is written before the protected area, this command abnormally finishes at the writing of the protected area.

To avoid this, data packets [encrypted user data] for the protected areas must be sent earlier than ones for permanent block protection areas.

(5) Do not set permanent block protection of the area where user keys are to be written when the User key setting command will be used.

Do not set permanent block protection of the area where the Code certificate is to be written when the Code certificate update command will be used.

If they are set, both commands become inexecutable due to a Protection error.

(6) When accessing the external flash area, the driver function for access is called, so send the driver code with the "External flash memory setting command" in advance. This command is called the "Program Data driver".

Also, access to addresses to which external flash memory is not allocated is not guaranteed.

### 6.33.6 Device State after Command Execution

Table 24 shows the state of the device after this command is executed.

**Table 24. Device States after Encrypted Data Write Command Execution**

| Command finish timing | | Device state | | | | |
|---|---|---|---|---|---|---|
| | | User/Data area | AL key | Protection level | Area specified by SAD | DLM |
| Fails at | Command acceptance analysis | No change | | | | |
| | Erasing complete User/Data area | Undefined | No change | | | |
| | Decrypting or analyzing the parameter | Erased | | | | |
| | Disabling AL key | | Undefined | No change | | |
| | Generating or writing AL key | | Undefined or disabled depending on TRN | | | |
| | Transiting Protection level | | Written or disabled depending on TRN | Undefined | No change | |
| | Initializing decryption | | | PL0 | | |
| | Decrypting, checking, or writing user data | Erased (Areas specified by SAD are undefined.) | | | Undefined | No change |
| | Transiting to LCK_BOOT | User data written | | | User data written | Undefined |
| Successful completion | | | | | | LCK_BOOT depending on TRN |

### 6.33.7 DLM State Transitions

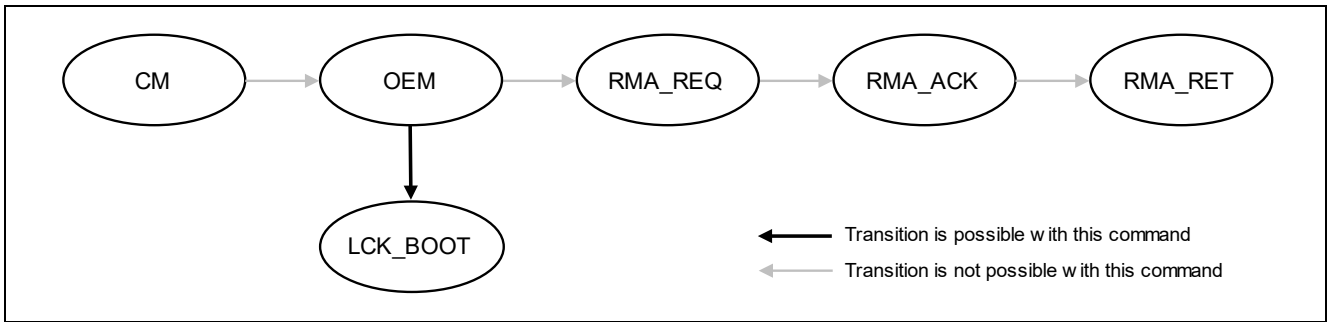Figure 54 shows the DLM states that can be transited by this command.

**Figure 54.  Valid DLM State Transitions for Encrypted Data Write Command**

# 7.   Flow Examples

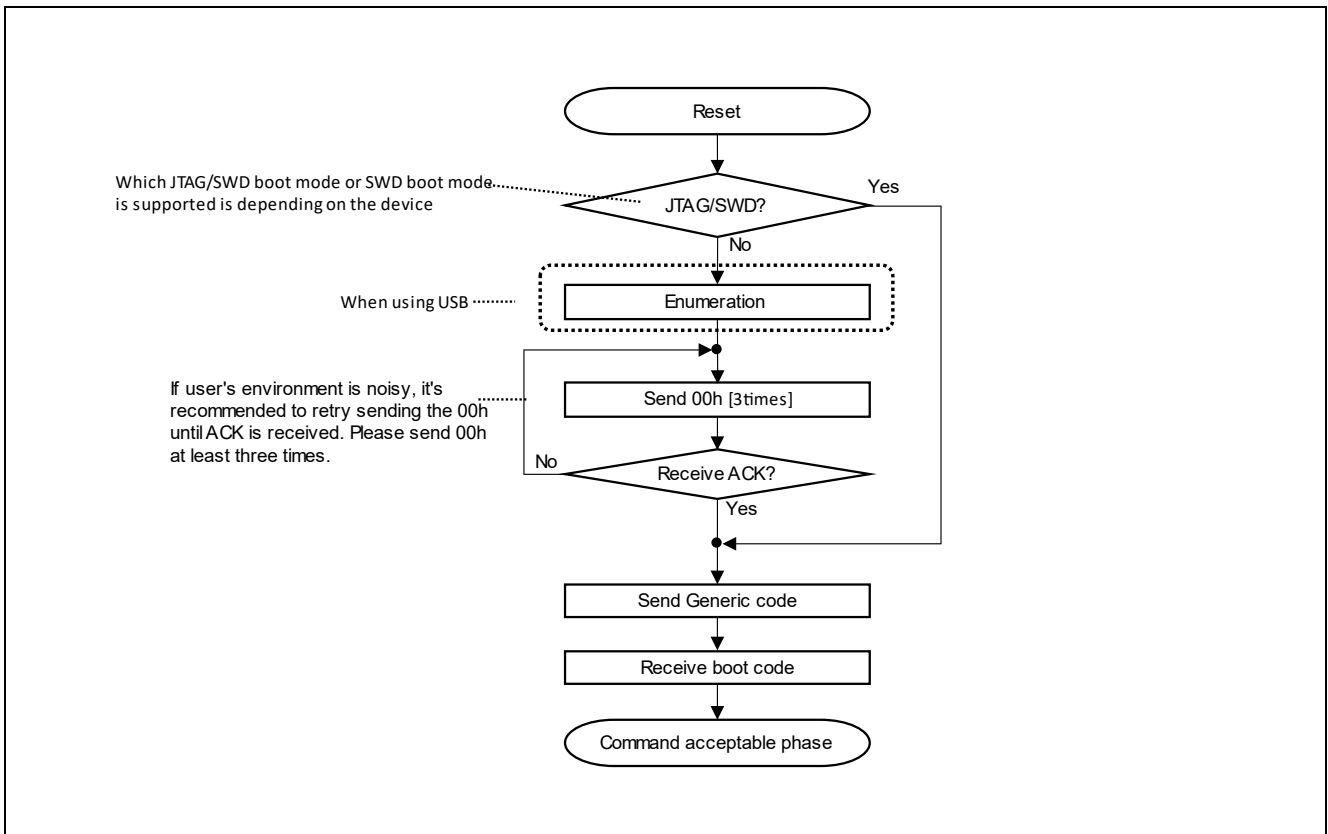## 7.1   Beginning Communication



**Figure 55.  Beginning Communication**

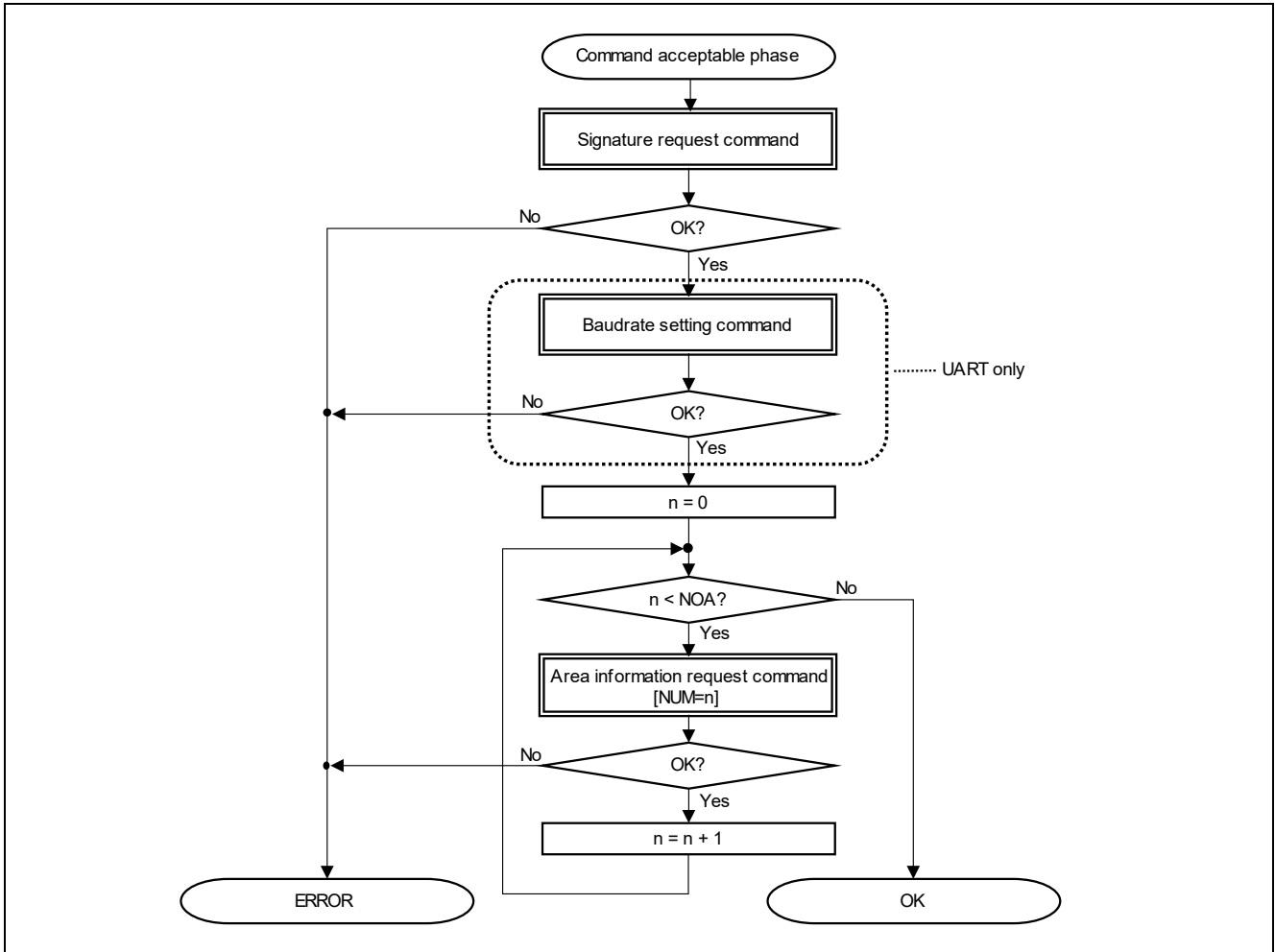## 7.2   Acquisition of Device Information / Baudrate Settings



**Figure 56.  Acquisition of Device Information / Baudrate Settings**
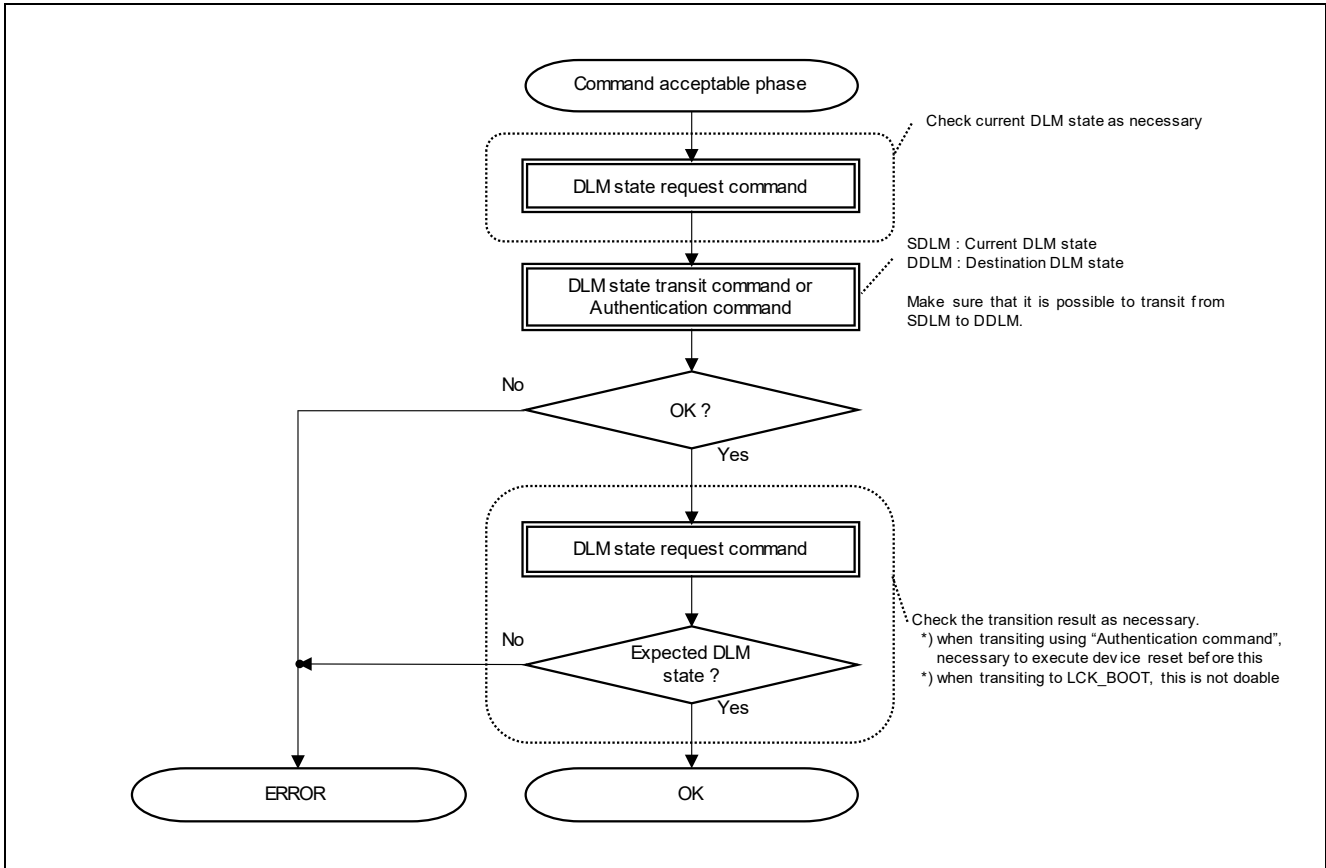
## 7.3   Transiting DLM State



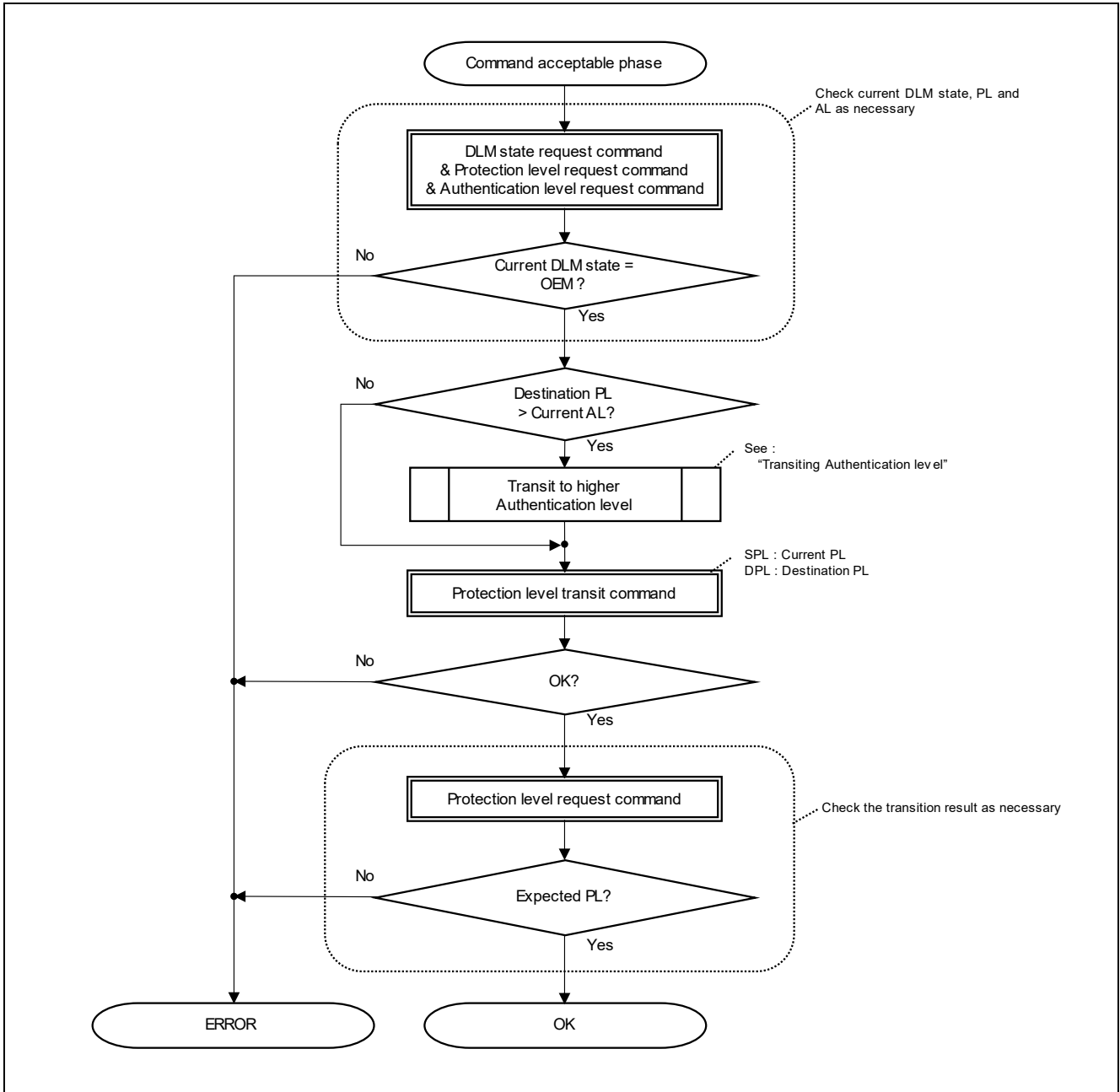**Figure 57. Transiting DLM State**

## 7.4 Transiting Protection Level

**Figure 58. Transiting Protection Level**

## 7.5   Transiting Authentication Level
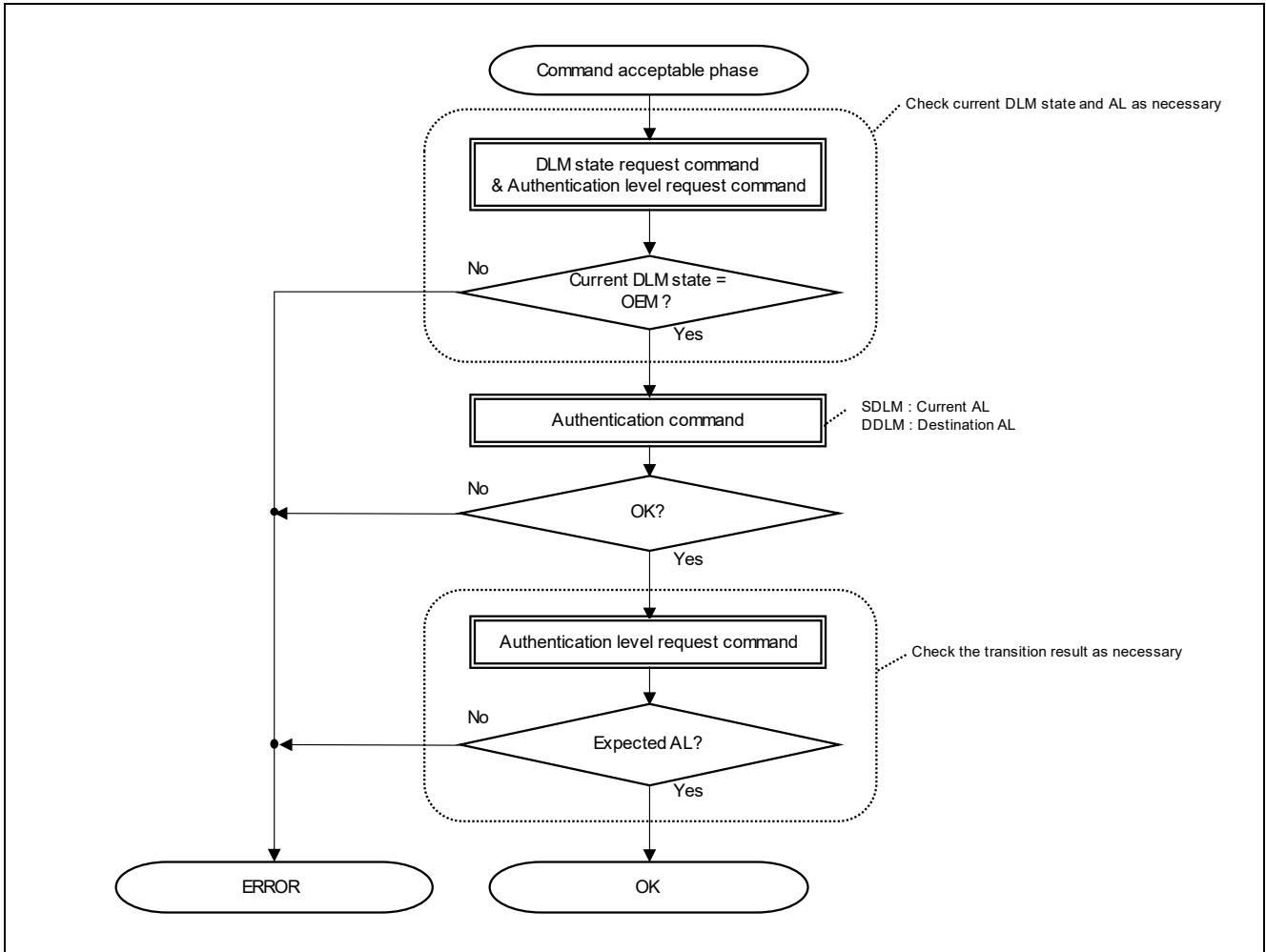


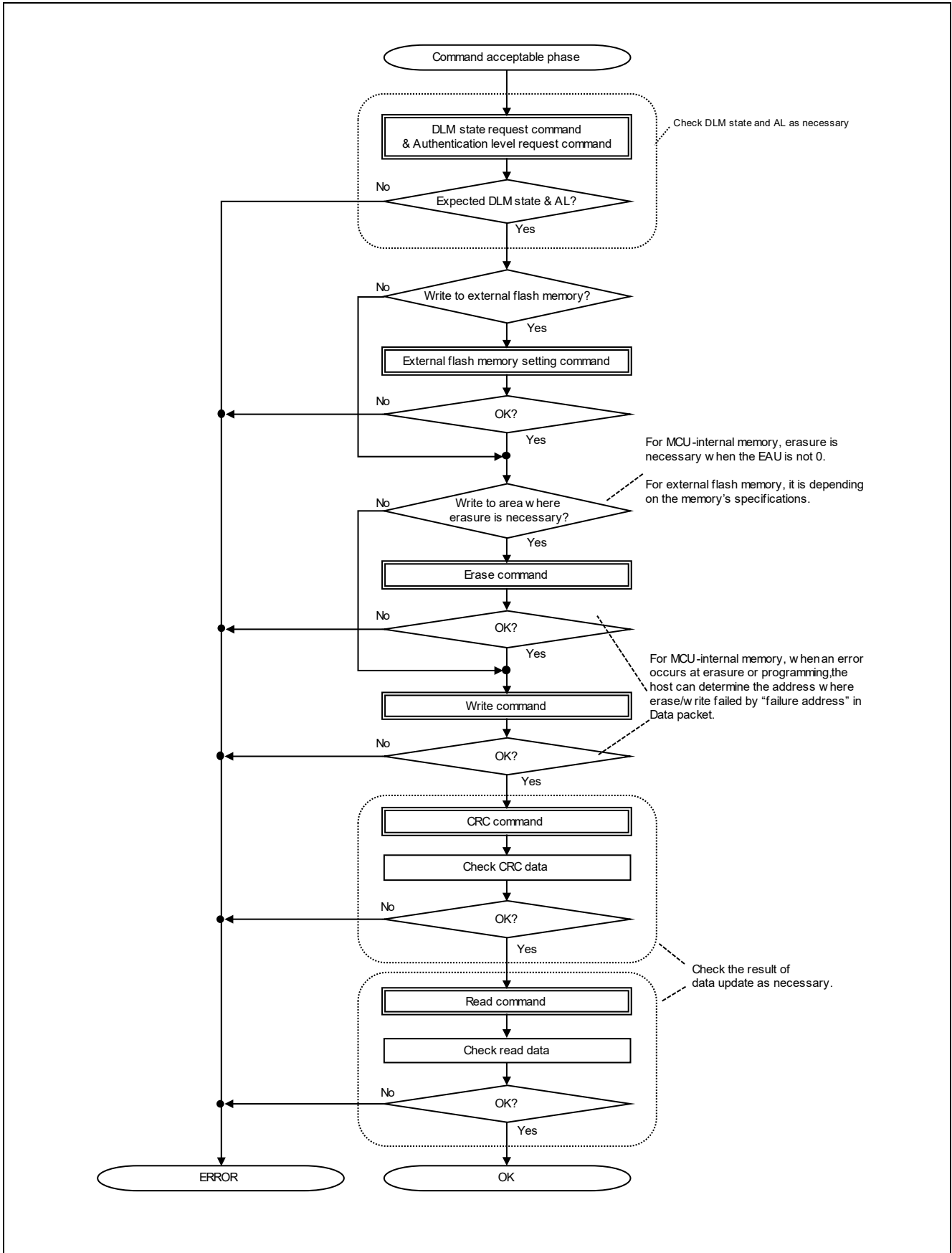**Figure 59.  Transiting Authentication Level**

## 7.6 Data Programming



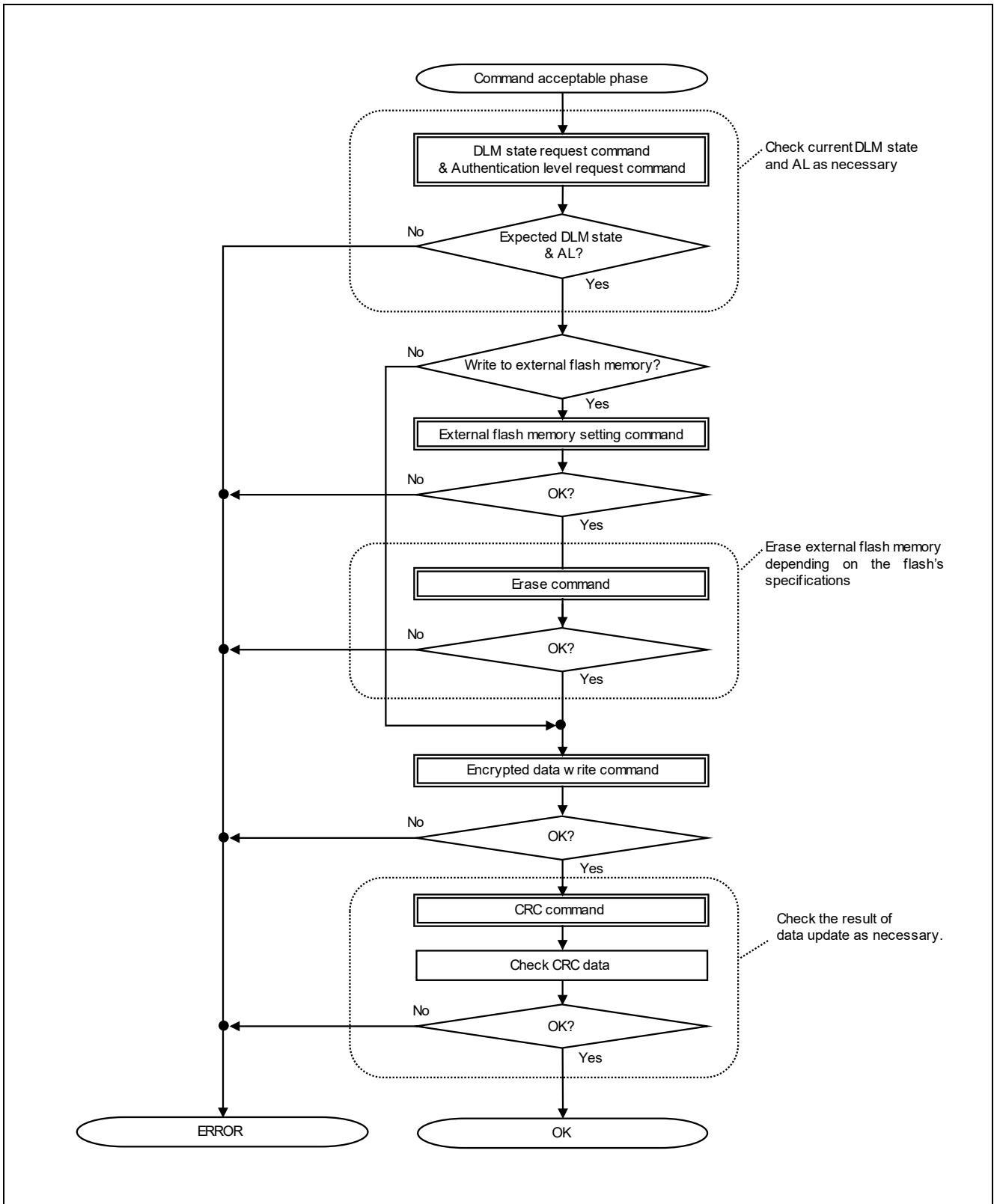**Figure 60. Data Programming**

## 7.7　Encrypted Data Programming



**Figure 61.　Encrypted Data Programming**
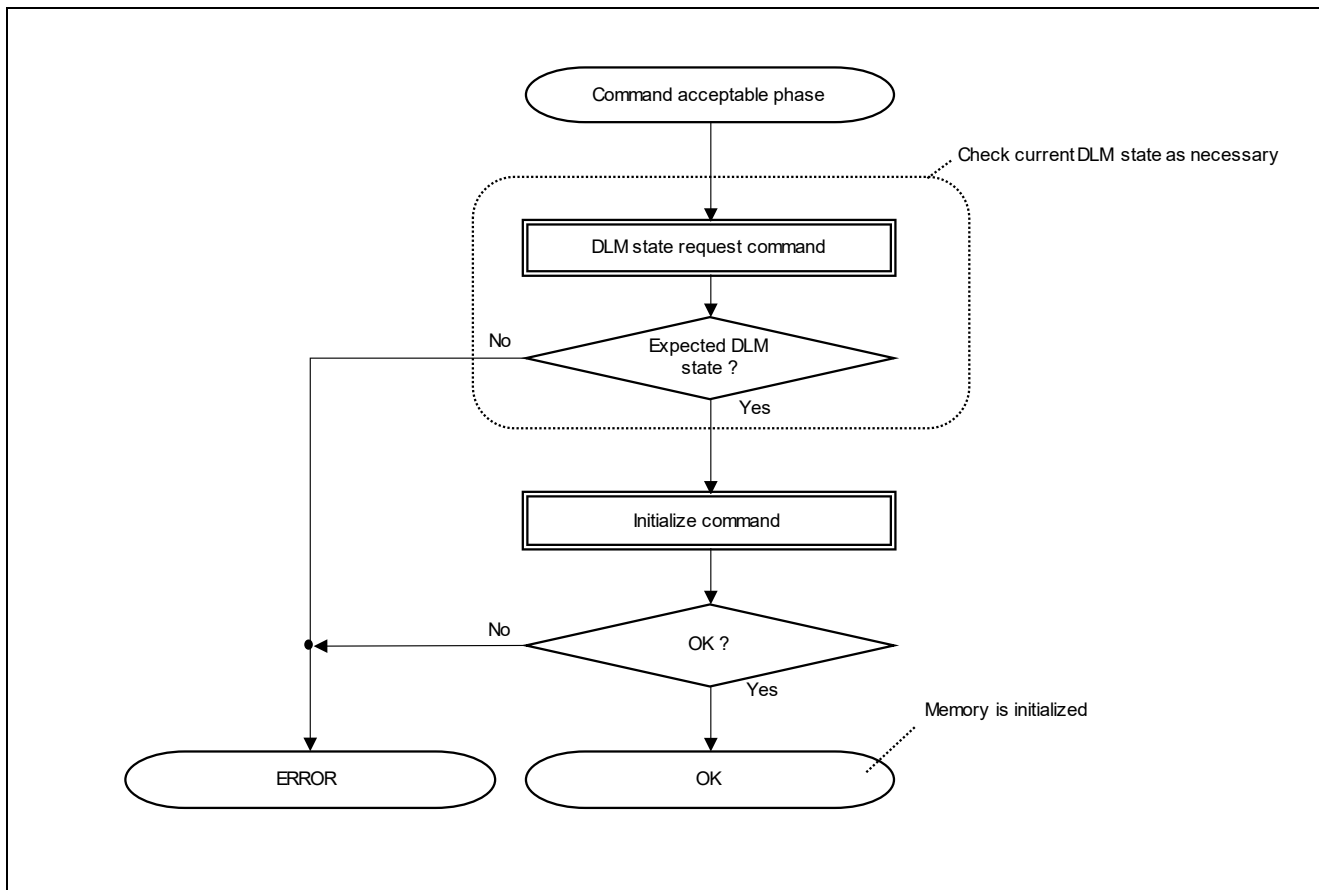
## 7.8 Initializing Memory



**Figure 62. Initializing Memory**
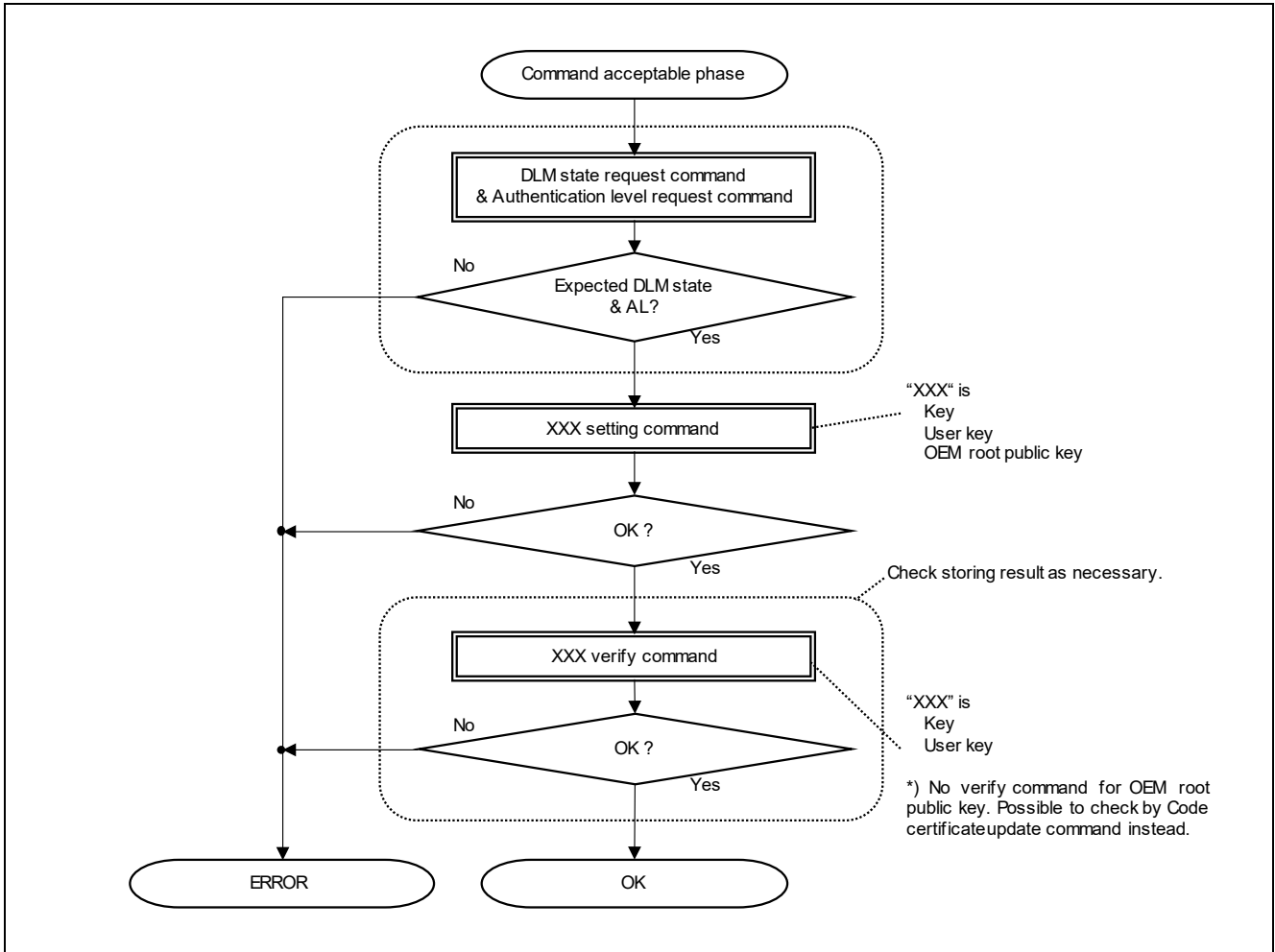
## 7.9 Storing Keys



**Figure 63.  Storing Keys**

## 7.10 Updating Boundary, Parameter, Lock Bit, or ARC Configuration Setting
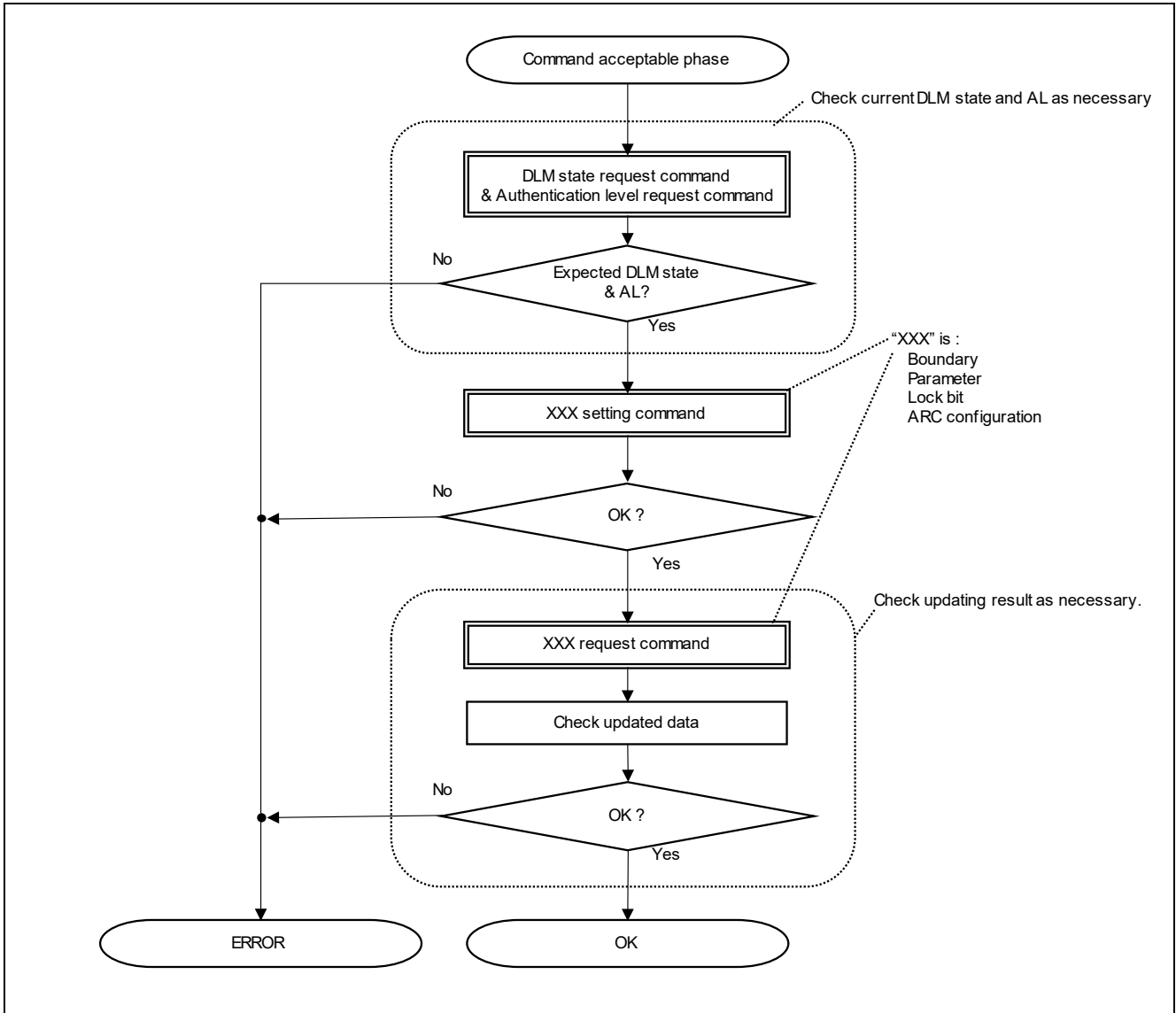


**Figure 64. Updating Boundary, Parameter, Lock Bit, or ARC Configuration Setting**
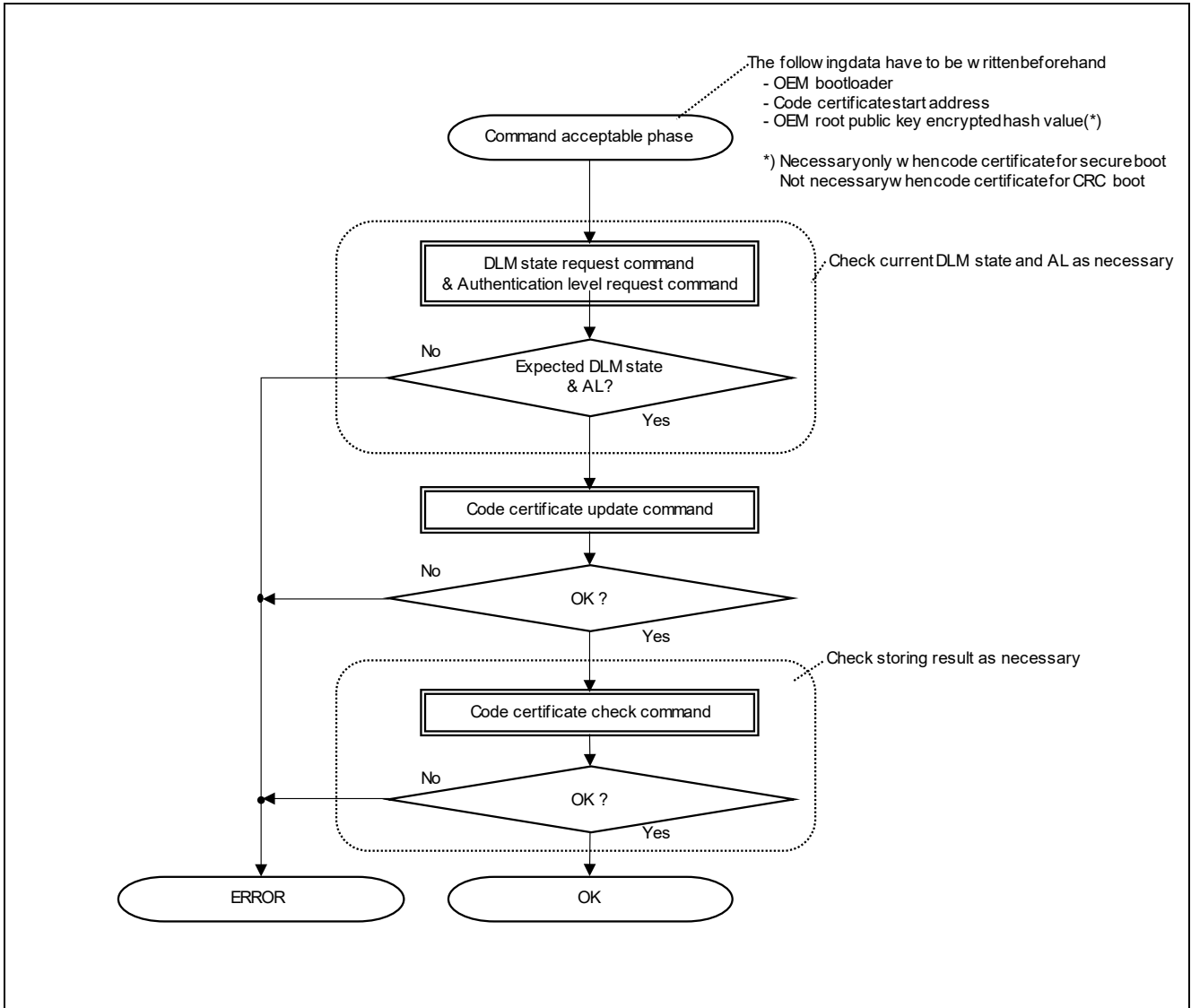
## 7.11 Storing Code Certificate



**Figure 65.　Storing Code Certificate**

## 7.12 Downloading Whole Image
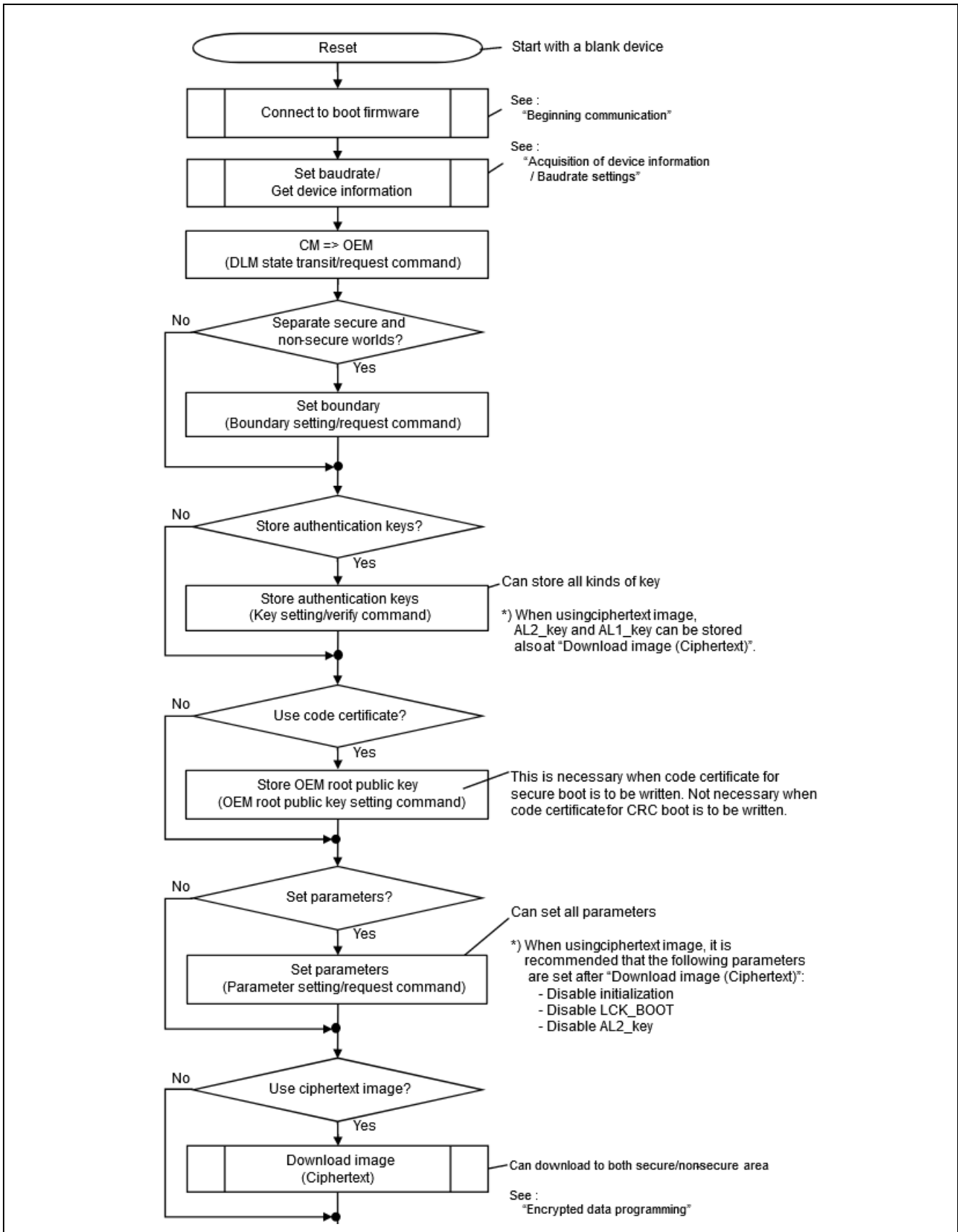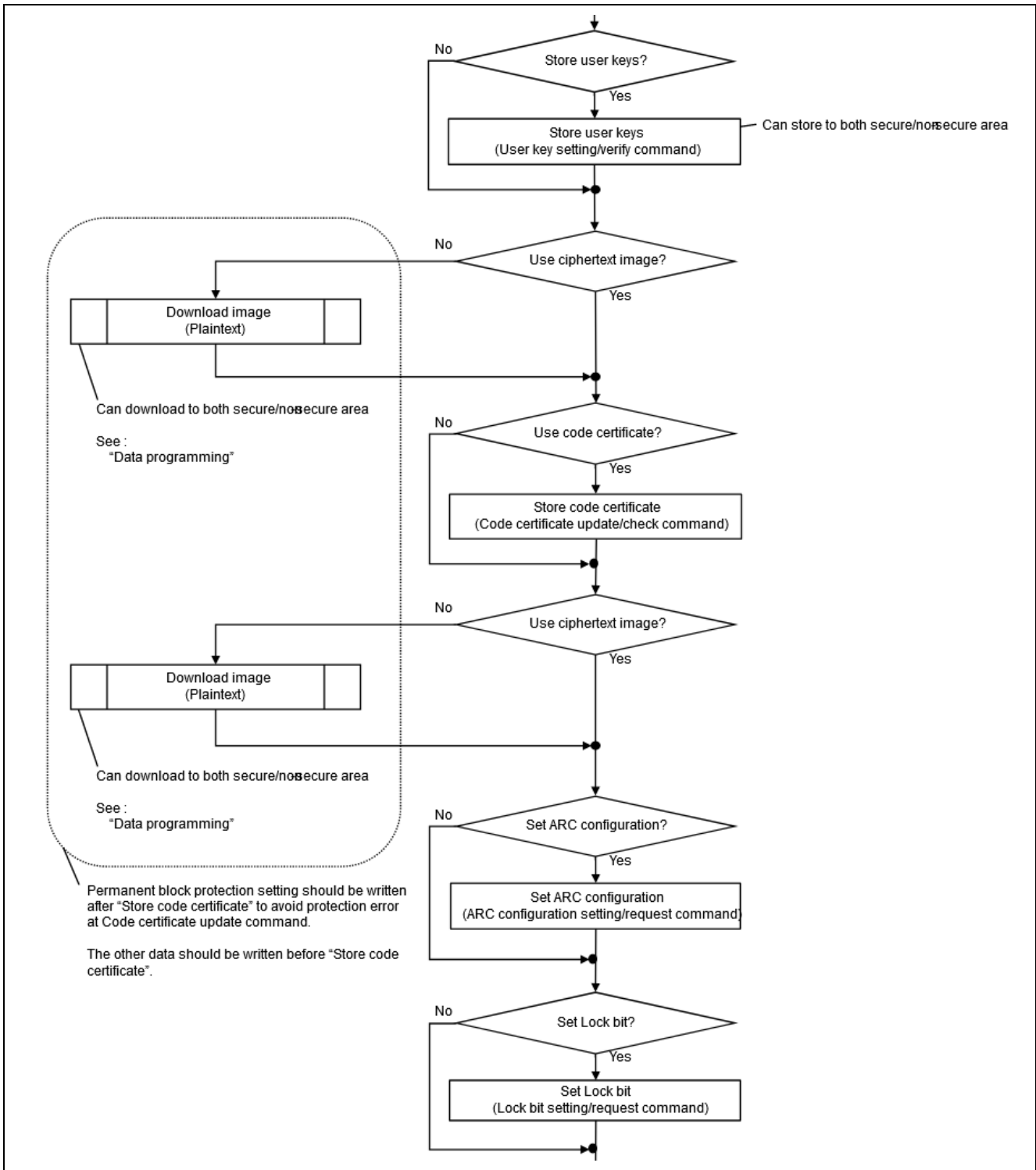


**Figure 66. Downloading Whole Image (Part 1)**
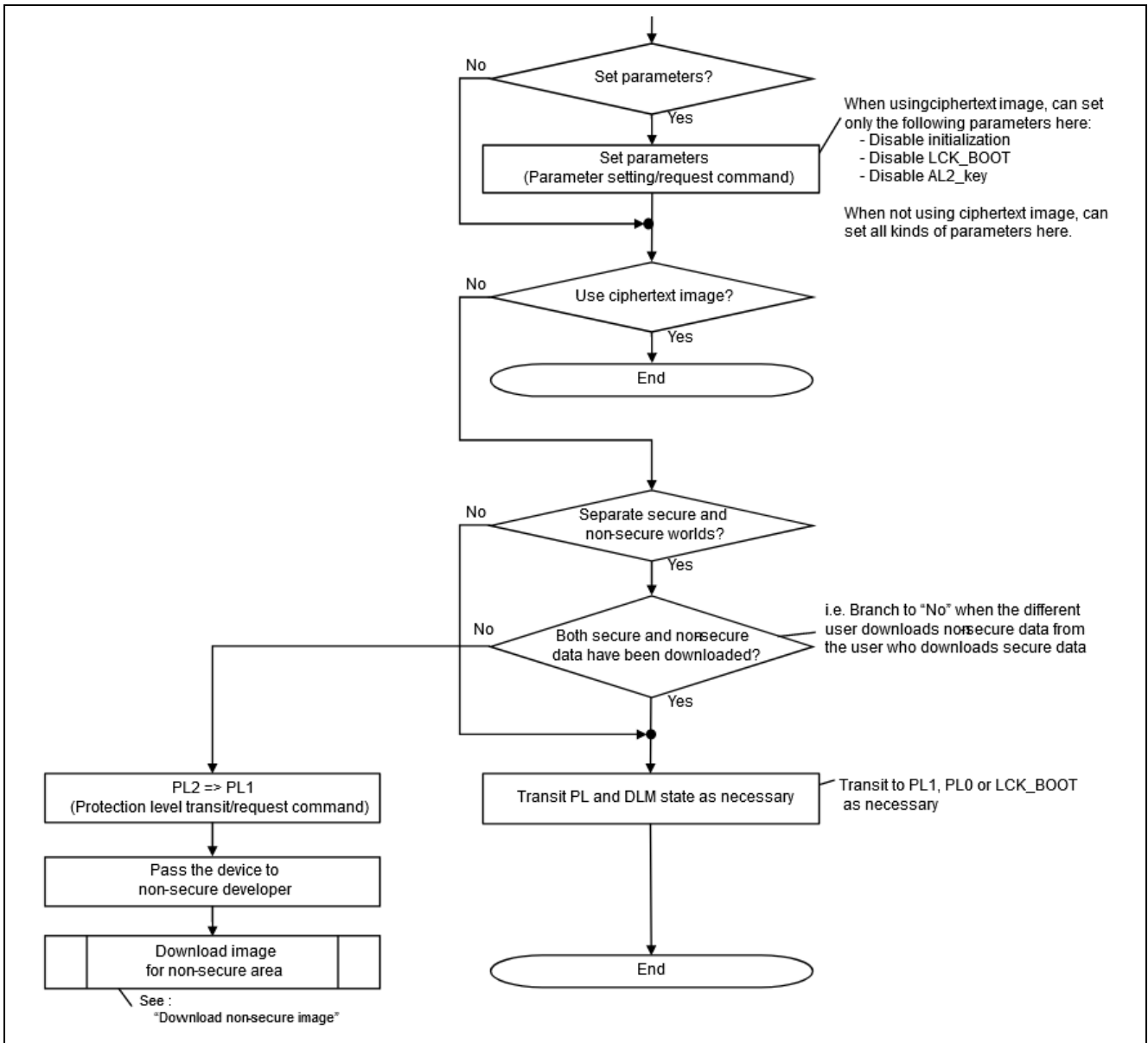
**Figure 67. Downloading Whole Image (Part 2)**

**Figure 68.  Downloading Whole Image (Part 3)**
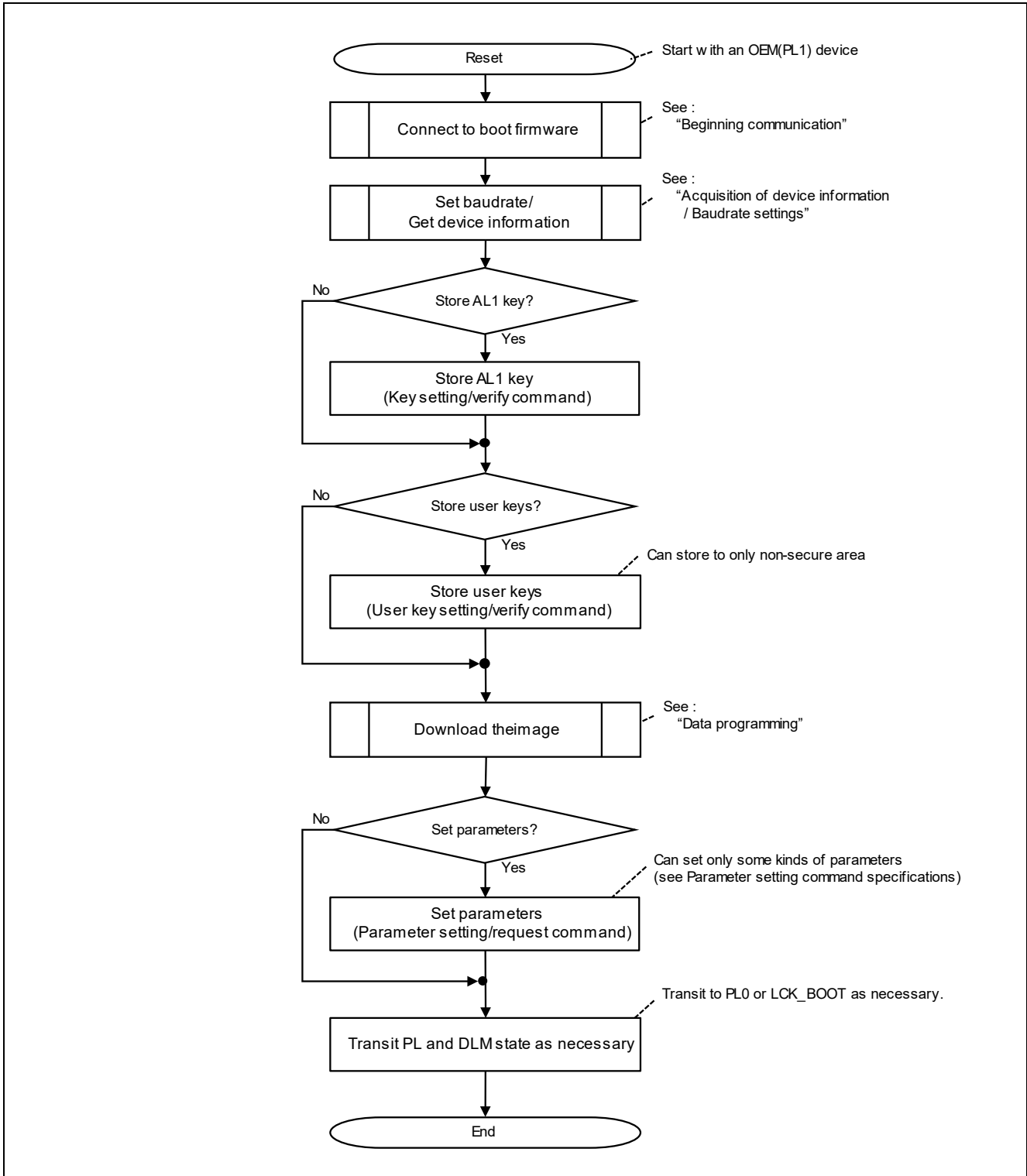
## 7.13 Downloading Non-secure Image



**Figure 69.  Downloading Non-secure Image**

## 7.14 Command Cancel

For commands that continuously send and receive packets, you can end the command by intentionally sending an error packet and return to the Command acceptable phase.
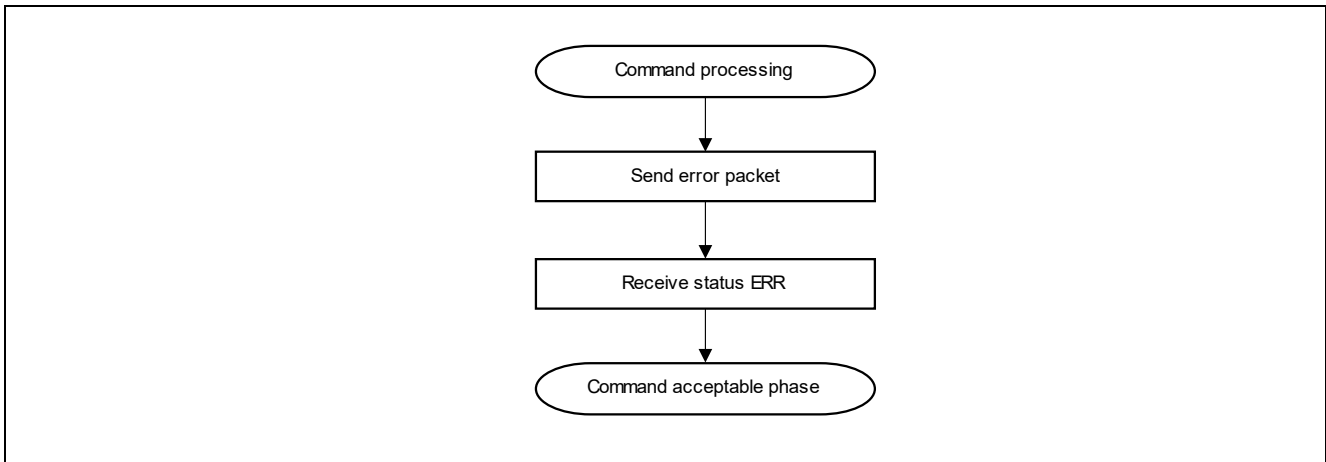


**Figure 70.  Command Cancel**

Example: Error packets to end the command:

| Command | When to send error packets | Example of the error packet | | |
|---|---|---|---|---|
| Authentication command | Data packet [Response value or Authentication code] | SOD | (1 byte) | 81h |
| Key setting command | Data packet [key data] | LNH | (1 byte) | 00h |
| User key setting command | Data packet [key data] | LNL | (1 byte) | 01h |
| Write command | Data packet [write data] | RES | (1 byte) | FFh (ERR) |
| Read command | Data packet [status OK] | SUM | (1 byte) | 00h |
| OEM root public key setting command | Data packet [key data] | ETX | (1 byte) | 03h |
| Code certificate update command | Data packet [Key/Code certificate data] | | | |
| External flash memory setting command | Data packet [driver code] | | | |

# 8.  AC Characteristics

## 8.1.1  Communication Setting Phase
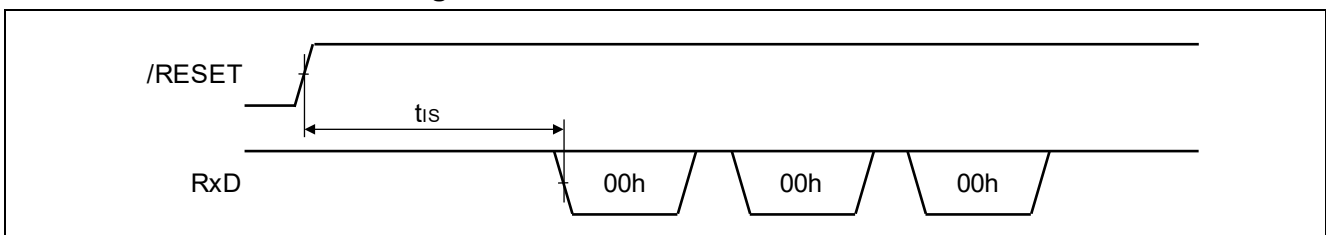


**Figure 71.  2-wire UART Communication**
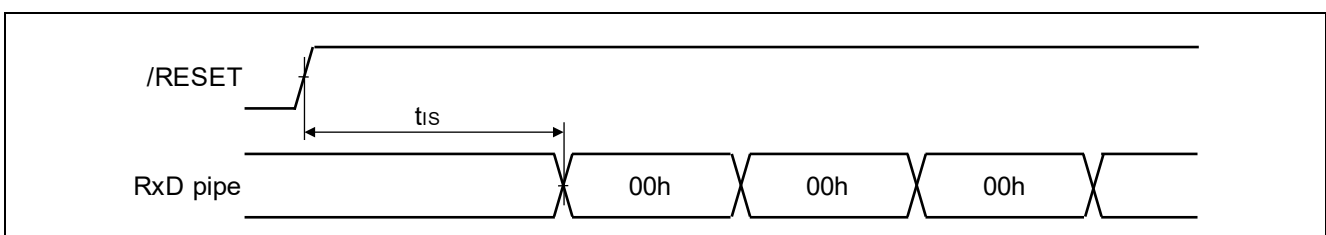


**Figure 72.  USB Communication**
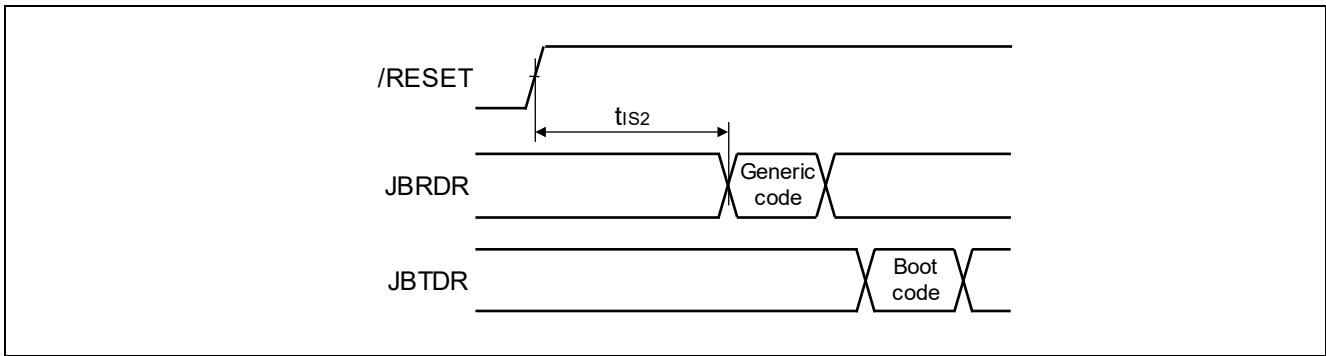
**Figure 73.  JTAG/SWD Communication Initial Setting Time**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Initial setting time (when using Main-OSC) | tIS | - | - | 137 | ms |
| Initial setting time (when using HOCO ) | tIS | - | - | 2773 | ms |
| Initial setting time 2 | tIS2 | - | - | 82 | ms |

## 8.1.2   DLM State Transit Command
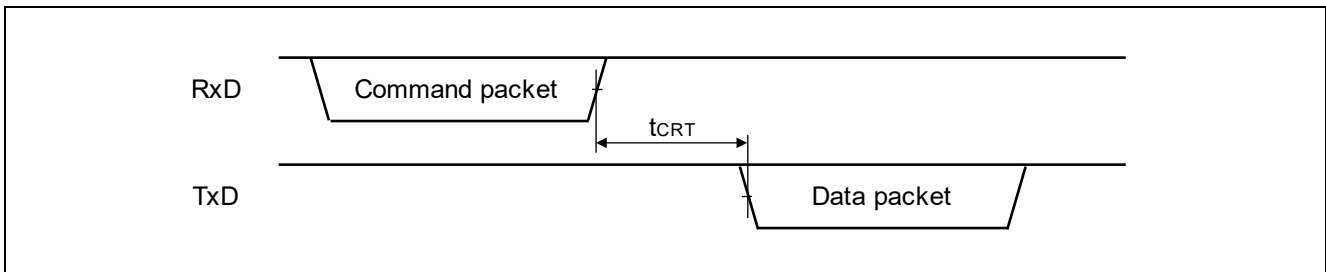


**Figure 74.  DLM State Transit Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |

## 8.1.3   DLM State Request Command
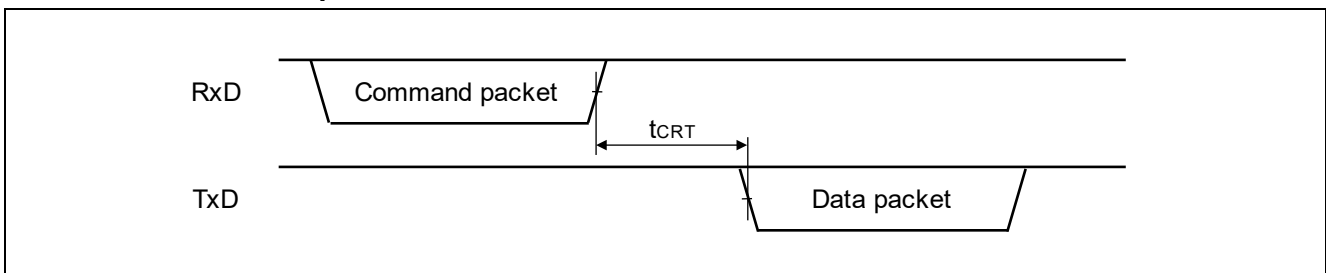


**Figure 75.  DLM State Request Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |

### 8.1.4 Protection Level Transit Command
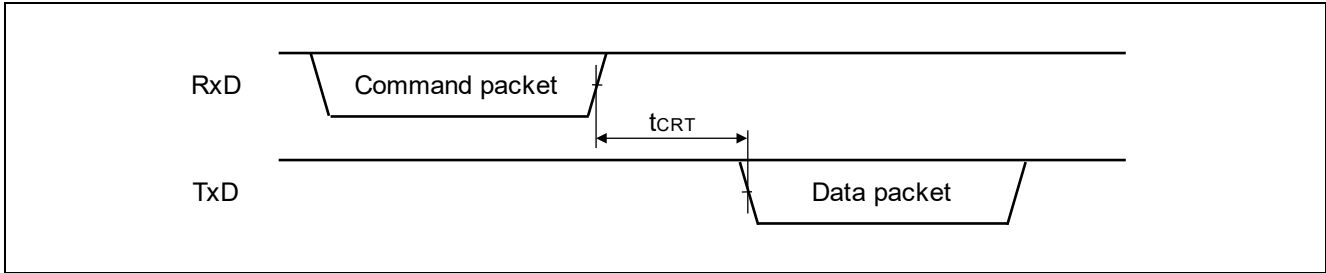


**Figure 76.  Protection Level Transit Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |

### 8.1.5 Protection Level Request Command
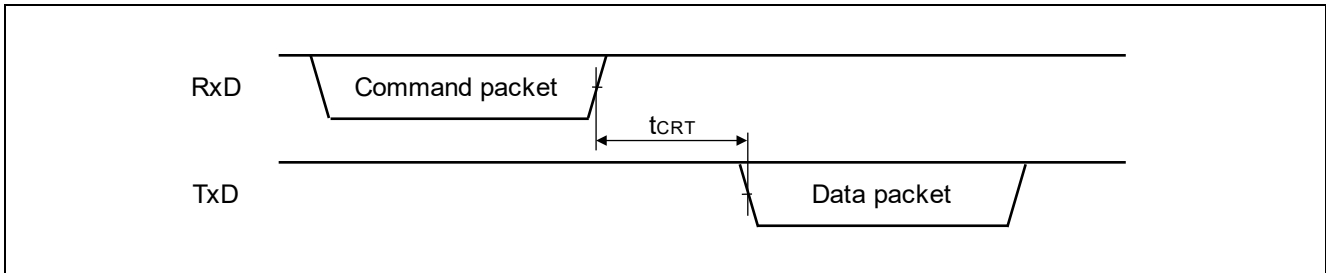


**Figure 77.  Protection Level Request Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |

### 8.1.6 Authentication Level Request Command
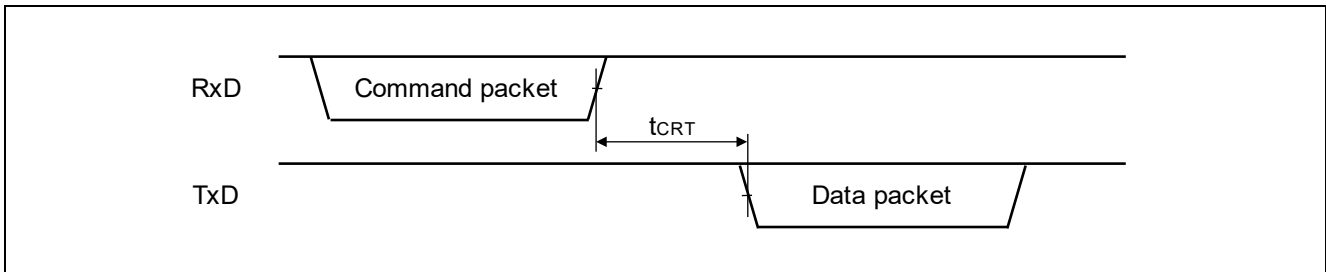


**Figure 78.  Authentication Level Request Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |

### 8.1.7 Authentication Command
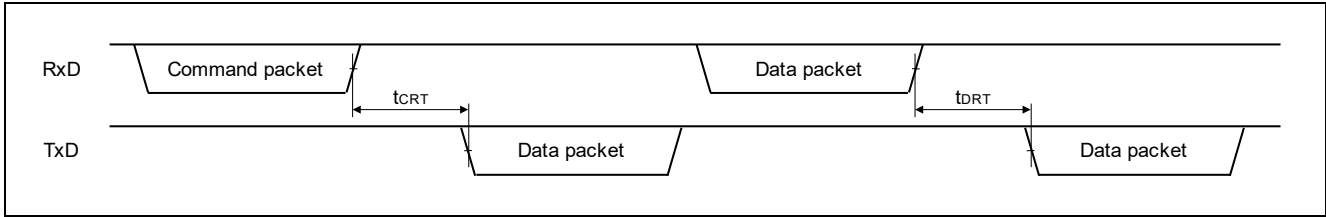


**Figure 79.  Authentication Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |
| Data response time | tDRT | - | - | 120 | s |

### 8.1.8 Key Setting Command
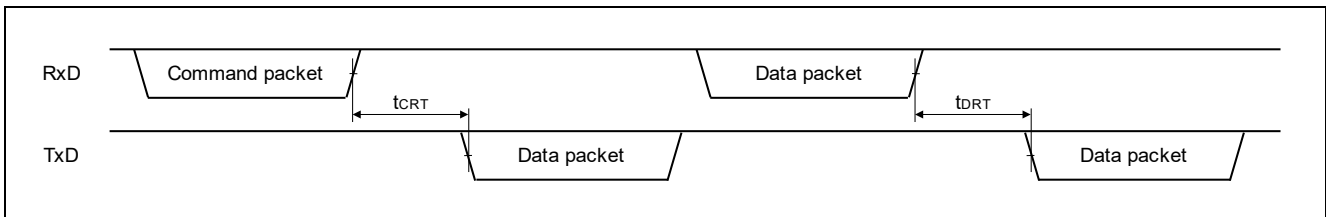


**Figure 80.  Key Setting Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |
| Data response time | tDRT | - | - | 3 | s |

### 8.1.9 User Key Setting Command
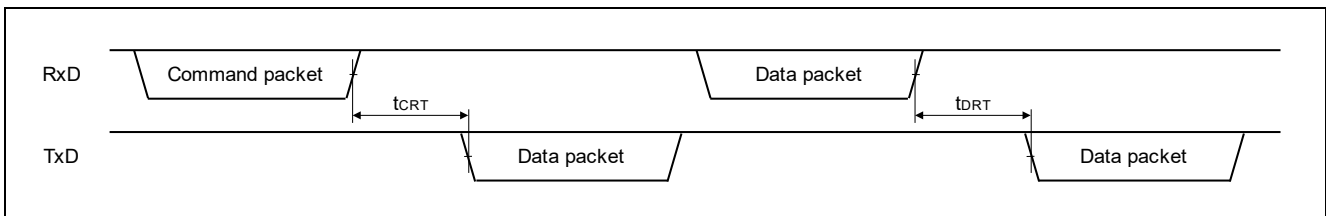


**Figure 81.  User Key Setting Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |
| Data response time | tDRT | - | - | 3 | s |

### 8.1.10 Key Verify Command
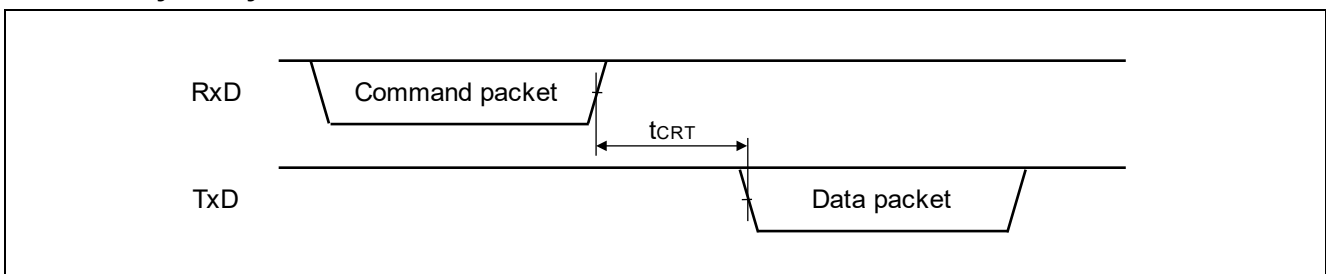


**Figure 82.  Key Verify Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |

### 8.1.11 User Key Verify Command
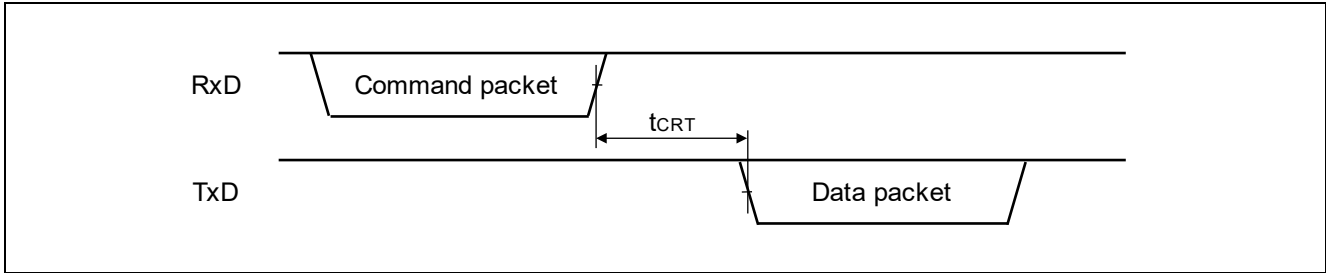


**Figure 83. User Key Verify Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |

### 8.1.12 Initialize Command
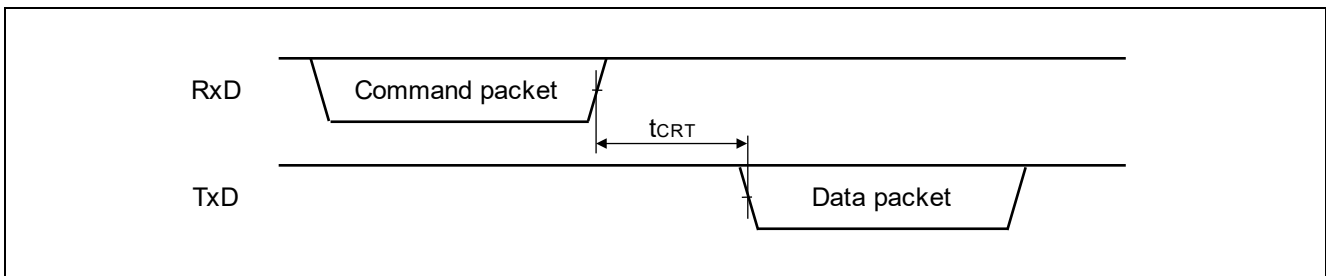


**Figure 84. Initialize Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 120 | s |

### 8.1.13 Boundary Setting Command
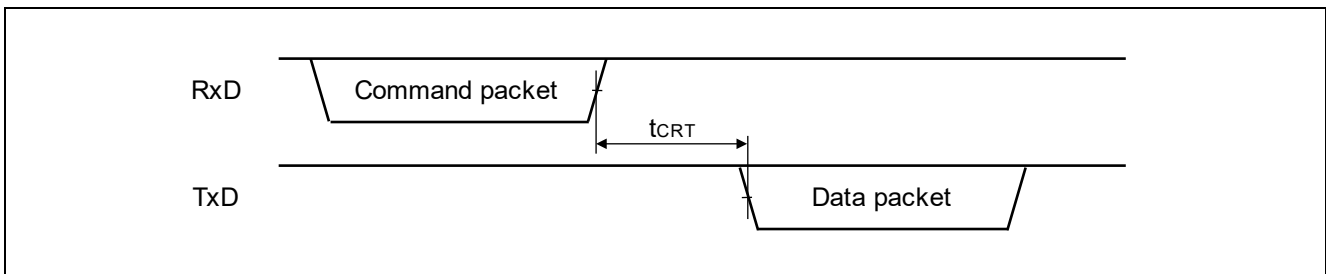


**Figure 85. Boundary Setting Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |

### 8.1.14 Boundary Request Command
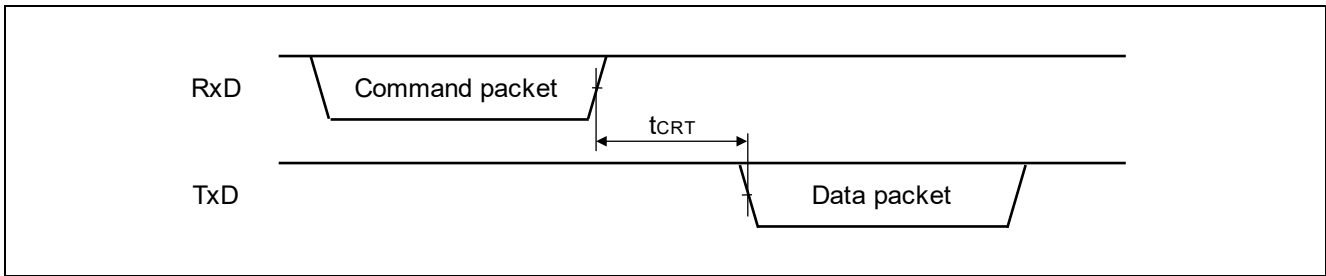


**Figure 86. Boundary Request Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |

### 8.1.15 Parameter Setting Command
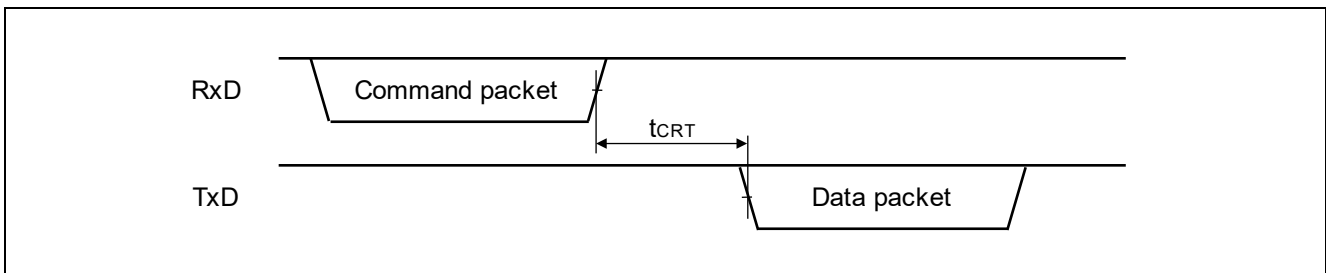


**Figure 87. Parameter Setting Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |

### 8.1.16 Parameter Request Command
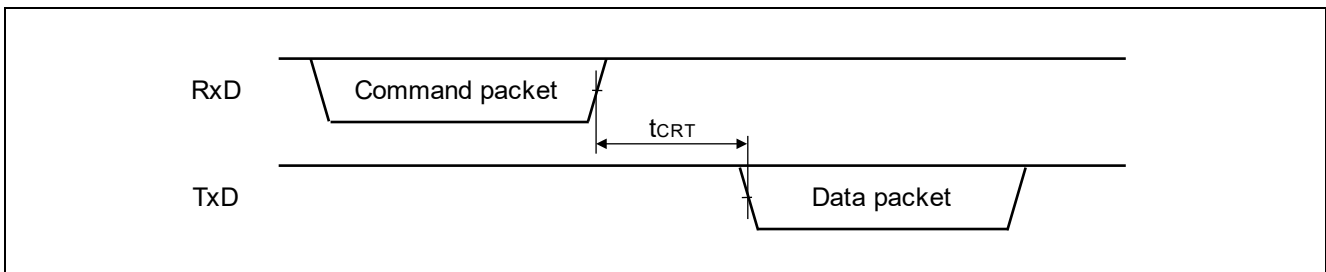


**Figure 88. Parameter Request Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |

### 8.1.17 Lock Bit Setting Command
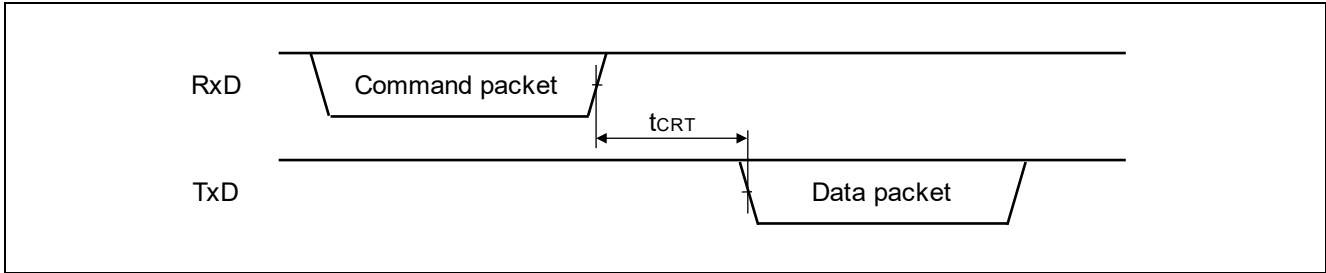


**Figure 89.  Lock Bit Setting Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |

### 8.1.18 Lock Bit Request Command
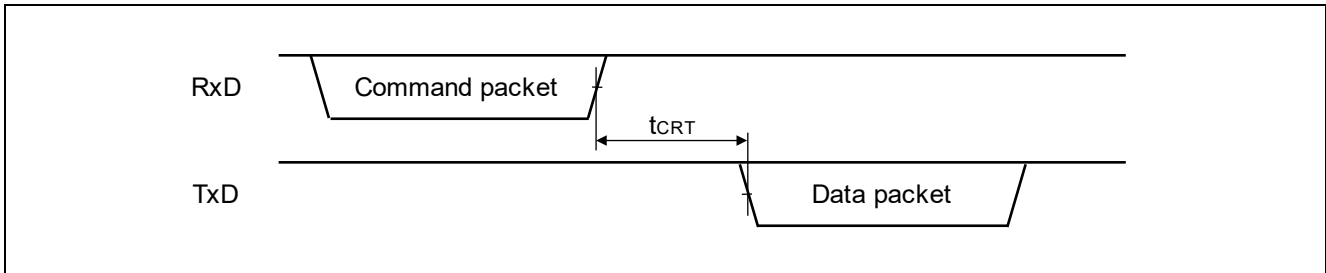


**Figure 90.  Lock Bit Request Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |

### 8.1.19 ARC Configuration Setting Command
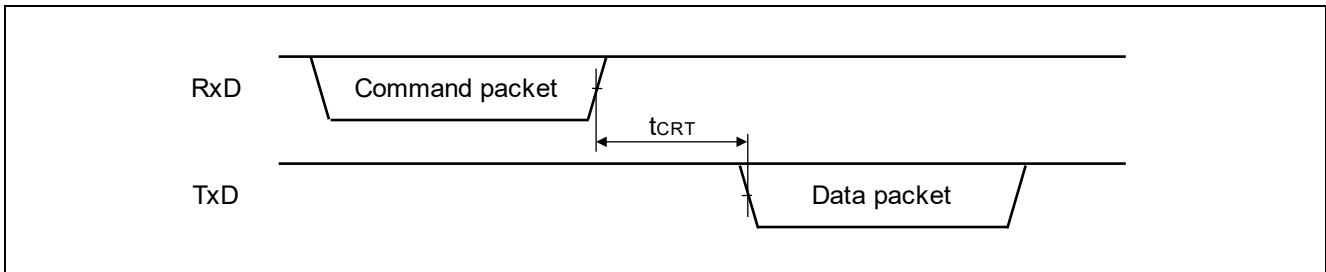


**Figure 91.  ARC Configuration Setting Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |

### 8.1.20 ARC Configuration Request Command
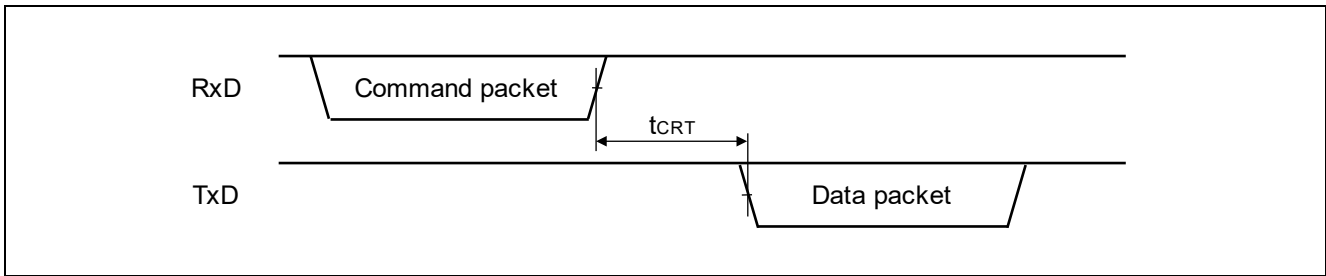


**Figure 92.  ARC Configuration Request Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |

### 8.1.21 Inquiry Command
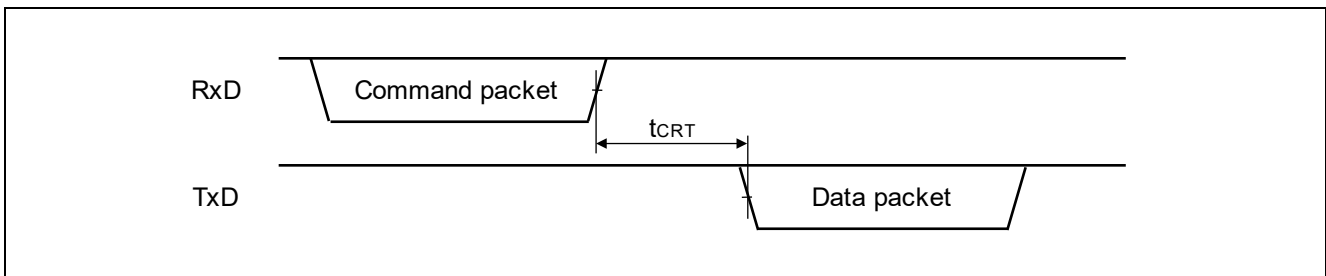


**Figure 93.  Inquiry Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |

### 8.1.22 Signature Request Command
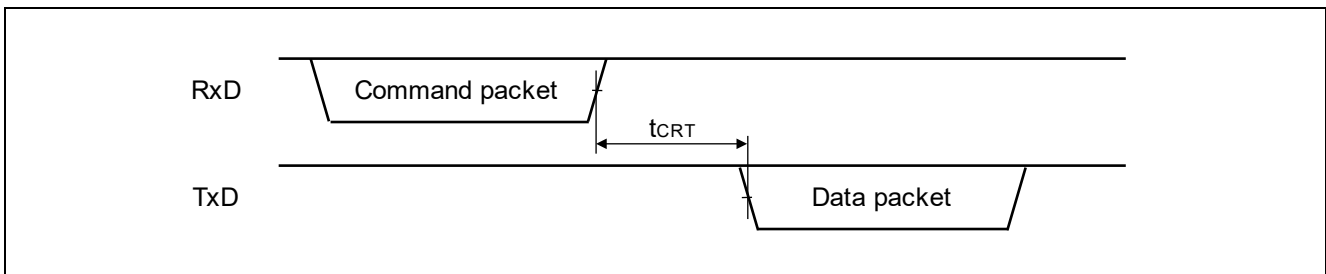


**Figure 94.  Signature Request Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |

### 8.1.23 Area Information Request Command
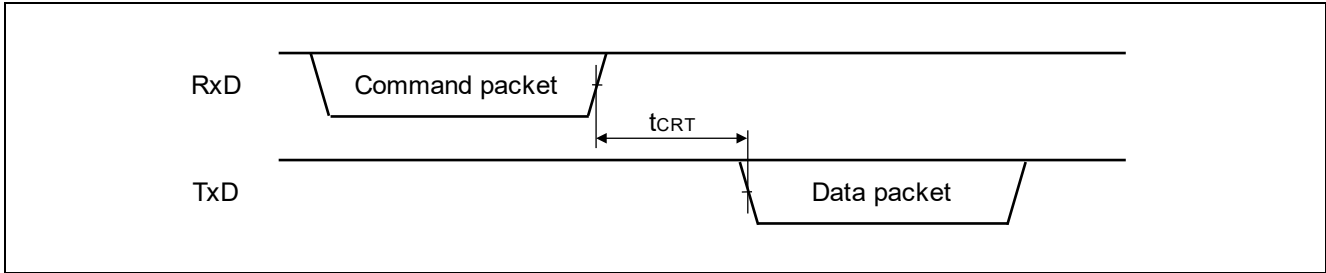


**Figure 95.  Area Information Request Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|-----------|--------|-----|-----|-----|------|
| Command response time | tCRT | - | - | 3 | s |

### 8.1.24 Baudrate Setting Command
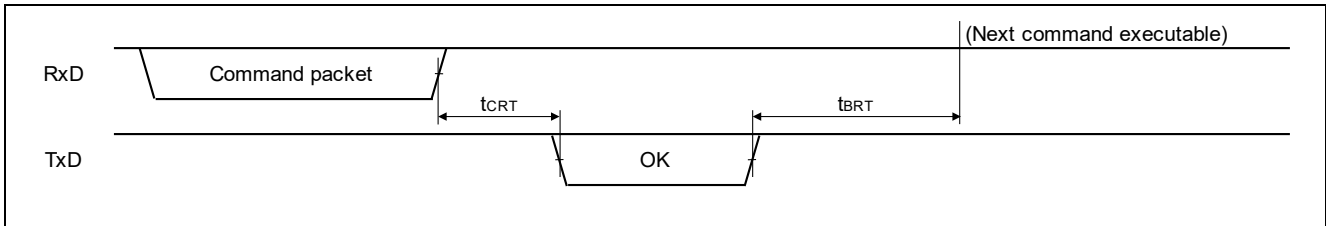


**Figure 96.  Baudrate Setting Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|-----------|--------|-----|-----|-----|------|
| Command response time | tCRT | - | - | 3 | s |
| Baudrate setting time | tBRT | - | - | 1 | ms |

### 8.1.25 Erase Command
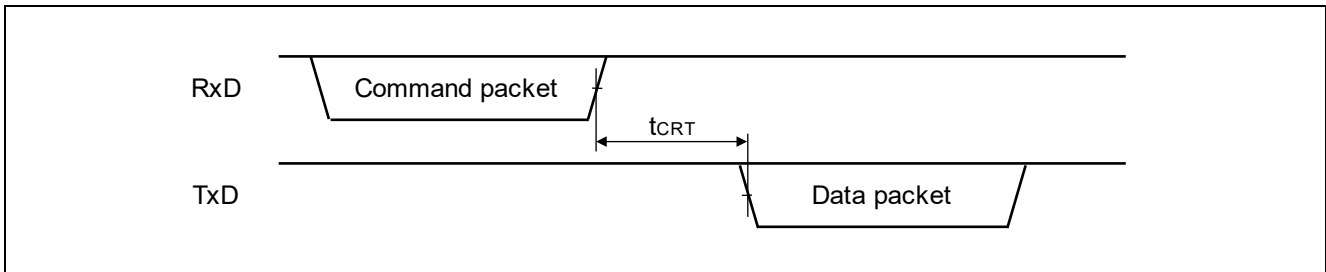


**Figure 97.  Erase Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|-----------|--------|-----|-----|-----|------|
| Command response time | tCRT | - | - | 60 (*1) | s |

*1: Note that the response time when accessing the external flash area depends on the external flash memory access driver and the external flash memory embedded in the user's system.

### 8.1.26 Write Command
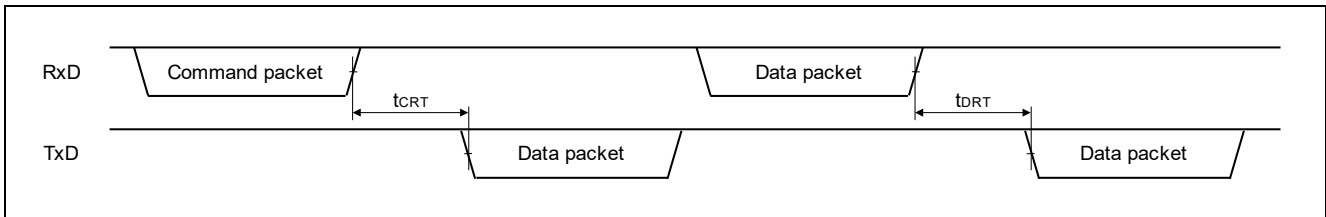


**Figure 98.　Write Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |
| Data response time | tDRT | - | - | 60 (*1) | s |

*1: Note that the response time when accessing the external flash area depends on the external flash memory access driver and the external flash memory embedded in the user's system.

### 8.1.27 Read Command
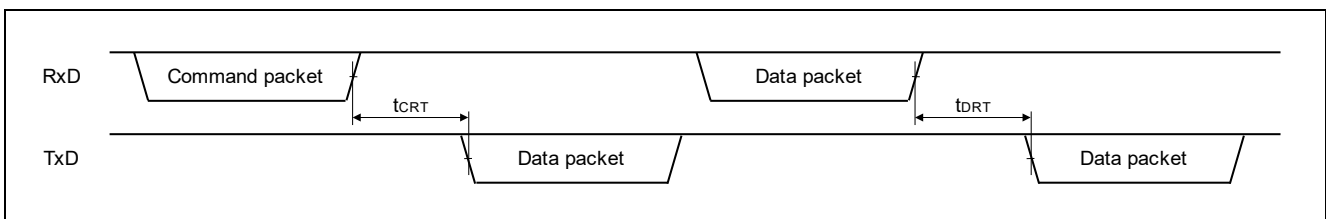


**Figure 99.　Read Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |
| Data response time | tDRT | - | - | 3 (*1) | s |

*1: Note that the response time when accessing the external flash area depends on the external flash memory access driver and the external flash memory embedded in the user's system.

### 8.1.28 CRC Command
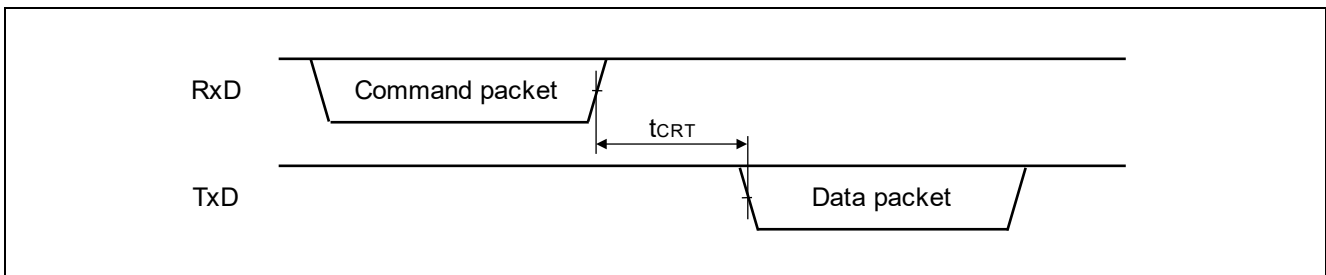


**Figure 100. CRC Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 (*1) | s |

*1: Note that the response time when accessing the external flash area depends on the external flash memory access driver and the external flash memory embedded in the user's system.

### 8.1.29 OEM Root Public Key Setting Command
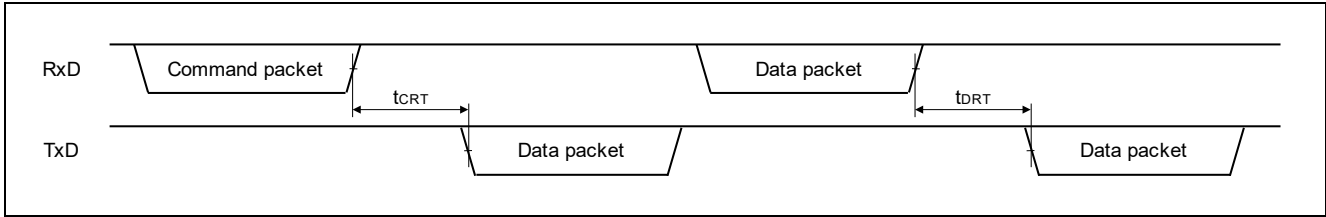


**Figure 101. OEM Root Public Key Setting Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |
| Data response time | tDRT | - | - | 3 | s |

### 8.1.30 Code Certificate Update Command
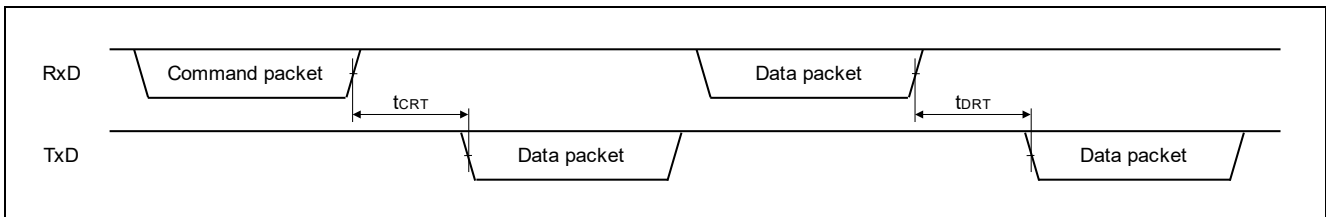


**Figure 102. Code Certificate Update Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |
| Data response time | tDRT | - | - | 60 | s |

### 8.1.31 Code Certificate Check Command
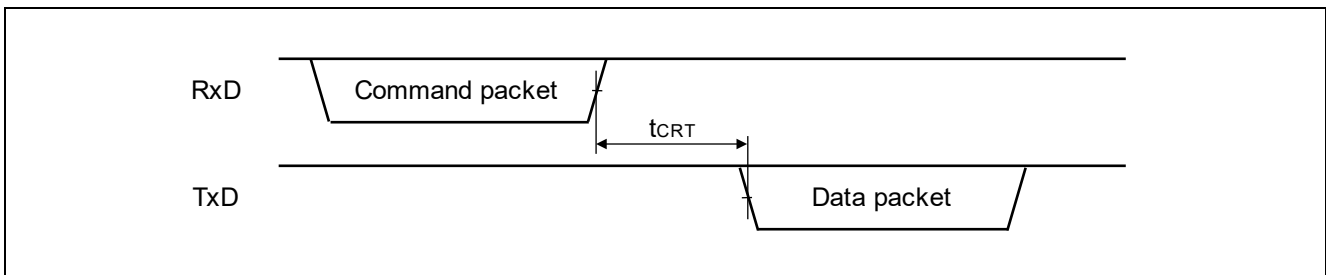


**Figure 103. Code Certificate Check Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |

### 8.1.32 External Flash Memory Setting Command
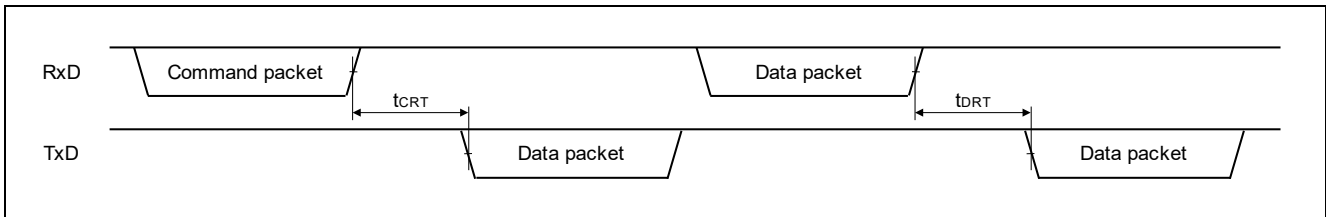


**Figure 104. External Flash Memory Setting Command**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 3 | s |
| Data response time | tDRT | - | - | 3 (*1) | s |

*1: Note that the response time of the last data packet depends on the external flash memory access driver and the external flash memory embedded in the user's system.

### 8.1.33 Encrypted Data Write Command
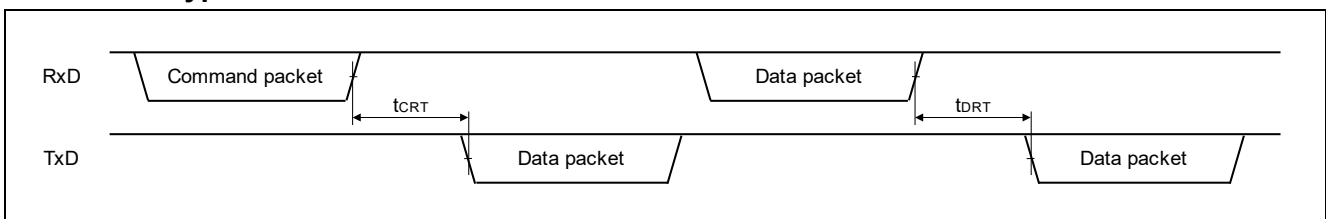


**Figure 105. Encrypted Data Write Command**

*) tDRT specifies the longest time among all the kinds of data packets of this command

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Command response time | tCRT | - | - | 60 | s |
| Data response time | tDRT | - | - | 60 (*1) | s |

*1: Note that the response time when accessing the external flash area depends on the external flash memory access driver and the external flash memory embedded in the user's system.

## 9. Sequencer Command List

Table 25 shows the sequencer commands executed by each communication command.

**Table 25. Sequencer Command List**

| Communication command | Sequencer command | Number of issue times |
|---|---|---|
| DLM state transit command | Configuration set | 1 time |
| | Forced stop <br> *) Use to clear error status. | 1 time |
| Protection level transit command | Configuration set | 1 time |
| | Forced stop <br> *) Use to clear error status. | 1 time |
| Authentication command | Program | Transiting to RMA_REQ: [Size of Data area / 4] times |
| | Block Erase | Transiting to RMA_REQ: <br> [Size of User area(Smaller Size Block) / 8K + <br> [Size of User area(Larger Size Block) / 32K] - <br> [Number of Blocks which PBPS is set] + <br> [Size of Data area / 64 * 2] times |

| Communication command | Sequencer command | Number of issue times |
|---|---|---|
| | Configuration set | Transiting to state other than RMA_REQ: 1 time<br>Transiting to RMA_REQ: 31–80 times<br>• 4 times at BPS initialization<br>• 9–10 times at Config area initialization (depending on FSPR state)<br>• 4–52 times at EEP config area initialization (depending on Lock bit state)<br>• 13 times at Boot region initialization<br>• 1 time at DLM transition |
| | Forced stop<br>*) Use to clear error status | Depends on the DDLM and the result of all erasure at the RMA_REQ transition |
| Key setting command | Configuration set | 4 times |
| | Forced stop<br>*) Use to clear error status | 1 time |
| User key setting command | Program | Depends on the designated address and key type |
| | Forced stop<br>*) Use to clear error status | 1 time |
| Initialize command | Program | [Size of Data area / 4] times |
| | Block Erase | [Size of User area(Smaller Size Block) / 8K] +<br>[Size of User area(Larger Size Block) / 32K] +<br>[Size of Data area / 64 * 2] times |
| | Configuration set | 82 times:<br>• 4 times at BPS initialization<br>• 12 times at Config area initialization<br>• 52 times at EEP config area initialization<br>• 13 times at Boot region initialization<br>• 1 time at PL transition |
| | Forced stop<br>*) Use to clear error status | Depends on the result of all erasure |
| Boundary setting command | Configuration set | 1 time |
| | Forced stop<br>*) Use to clear error status | 1 time |
| Parameter setting command | Configuration set | 1 time |
| | Forced stop<br>*) Use to clear error status | 1 time |
| Lock bit setting command | Configuration set | 2 time |
| | Forced stop<br>*) Use to clear error status | 1 time |
| ARC configuration setting command | Configuration set | 1 time |
| | Forced stop<br>*) Use to clear error status | 1 time |
| Erase command | Block Erase | Depends on designated address |
| | Forced stop<br>*) Use to clear error status | 1 time |
| Write command | Program | Depends on designated address |
| | Configuration set | Depends on designated address |
| | Forced stop<br>*) Use to clear error status | 1 time |
| | Configuration set | 3 times (when PLK=00h)<br>2 times (when PLK=FFh) |

| Communication command | Sequencer command | Number of issue times |
|---|---|---|
| OEM root public key setting command | Forced stop *) Use to clear error status | 1 time |
| Code certificate update command | Program | Depends on Code certificate start address and size of Code certificate |
| | Read counter | Depends on the current and new OEM boot loader version |
| | Increment counter | Depends on the current and new OEM boot loader version |
| | Forced stop *) Use to clear error status | Depend on the result of writing "Code certificate" and "MAC value of Code certificate and OEM boot loader" |
| Encrypted data write command | Program | Depends on the designated address |
| | Block Erase | [Size of User area(Smaller Size Block) / 8K] + [Size of User area(Larger Size Block) / 32K] + [Size of Data area / 64] times |
| | Configuration set | Depends on the designated address |
| | Forced stop *) Use to clear error status | 1 time |

## 10. Precaution List

### 10.1.1 Initialize Command

1. The following parameters are not initialized by this command:
   — Disable of authentication using AL1_KEY
   — Disable transition to LCK_BOOT
   For details on each parameter, refer to the Parameter setting command.
2. The following areas are not initialized by this command.
   — Anti-rollback counter area
   — Lock bit for Anti-rollback counter area(*)
   — External flash area
   In addition, the Lock bit for the Anti-rollback counter is outside the scope of the Protection error. In other words, boot firmware does not return a Protection error but executes initialization even when the Lock bit for the Anti-rollback counter is set.
   (*) There may be other uninitialized bits in the area where the Lock bit for the Anti-rollback counter area is located. Refer to the user's manual of the device for details.

### 10.1.2 Lock Bit Setting Command

1. This command does not set the Lock bit for the Hash of OEM root public key.
   Lock bit data for Hash of OEM root public key in the received LCK is ignored.
   Use the OEM root public key setting command to set the Lock bit for the Hash of the OEM root public key.
2. It is not possible to set 1b to the Lock bit that has already been set to 0b.
   Boot firmware does not return a Protection error or a Flash access error but returns OK in this case.
   Note that the set value of the Lock bit is not changed though boot firmware returns OK.

### 10.1.3 Lock Bit Request Command

1. This command does not send the Lock bit for the Hash of OEM root public key.
   Lock bit data for Hash of OEM root public key in the sent LCK is always all-1.

### 10.1.4 Erase Command

1.  When accessing the external flash area, the driver function for access is called. Therefore, send the driver code with the "External flash memory setting command" in advance. In this command, "EraseChip driver" is called when the entire area of external flash area 0 is specified. Otherwise, the "EraseSector driver" will be called every time a sector is erased.
    Also, access to addresses to which external flash memory is not allocated is not guaranteed.

### 10.1.5 Write Command

1.  If permanent block protection in the Config area is set, the protected area cannot be rewritten. Therefore, rewrite the protected area before setting the permanent block protection.
2.  If the Lock bit in the EEP config area is set, the protected area cannot be rewritten. Therefore, rewrite the protected area before setting the Lock bit.
3.  When accessing the external flash area, the driver function for access is called. Therefore, send the driver code with the "External flash memory setting command" in advance. This command is called the "Program Data driver". Also, access to addresses to which external flash memory is not allocated is not guaranteed.

### 10.1.6 Read Command

1.  To access the external flash area, you need to execute the "External flash memory setting command" in advance. Also, access to addresses that are not assigned external flash memory is not guaranteed.

### 10.1.7 CRC Command

1.  Since the erased Data area's value is undefined, calculated CRC data would be incorrect if the range of calculating CRC data includes the erased Data area.
2.  To access the external flash area, you need to execute the "External flash memory setting command" in advance. Also, access to addresses that are not assigned external flash memory is not guaranteed.

### 10.1.8 Code Certificate Update Command

1.  Use this command after writing "OEM boot loader" to the User area and "Code certificate start address" to the EEP config area with the Write command or Encrypted data write command in advance.
2.  Use this command after saving the "OEM root public key encrypted Hash value" in the device in advance with the OEM root public key setting command.
3.  Verification fails if data of the received Key certificate or Code certificate does not conform to device specifications.
    Refer to the user's manual of the device for certificates' specifications.
4.  Key certificate is not necessary when MAC type = None. Specify KCS = 0 and do not send any data as Key certificate data in this case.

### 10.1.9 Encrypted Data Write Command

1.  This command becomes inexecutable once after permanent block protection is set.
2.  This command becomes inexecutable if SAS.BTFLG=0b and SAS.FSPR=0b.
3.  If the Lock bit in the EEP config area is set, the protected area cannot be rewritten. Therefore, rewrite the protected area before setting the Lock bit.
4.  If permanent block protection in the Config area is written before the protected area, this command abnormally finishes at the writing of the protected area.
    To avoid this, Data packets [encrypted user data] for the protected areas must be sent earlier than Data packets for the permanent block protection area.
5.  Do not set permanent block protection of the area where user keys are to be written when the User key setting command will be used.
    Do not set permanent block protection of the area where the Code certificate is to be written when the Code certificate update command will be used.
    If they are set, both commands become inexecutable due to a Protection error.
6.  When accessing the external flash area, the driver function for access is called. Therefore, send the driver code with the "External flash memory setting command" in advance. This command is called the "Program Data driver".
    Also, access to addresses to which external flash memory is not allocated is not guaranteed.

## 11. Causes for Operation Stop

The boot firmware enters an infinite loop in the following cases.

### 11.1 Initialization Phase

- When the following CPU exceptions occur: NMI / HardFault / MemManage / BusFault / UsageFault / SecureFault / SVCall / DebugMonitor / PendSV / SysTick.
- When the Trusted system goes into an abnormal state.

### 11.2 Communication Setting Phase

- When the USB cable is disconnected when the USB status is "Configured".
- When the following CPU exceptions occur: NMI / HardFault / MemManage / BusFault / UsageFault / SecureFault / SVCall / DebugMonitor / PendSV / SysTick.

### 11.3 Command Acceptable Phase

- When the USB cable is disconnected when the USB status is "Configured".
- When the following CPU exceptions occur: NMI / HardFault / MemManage / BusFault / UsageFault / SecureFault / SVCall / DebugMonitor / PendSV / SysTick.

### 11.4 DLM State Transit Command

- When transition to LCK_BOOT is complete.
- When transition to RMA_RET is complete.
- When Hardware error occurred.

### 11.5 Protection Level Transit Command

- When Hardware error occurred.

### 11.6 Authentication Command

- When the Trusted system goes into an abnormal state.
- When DLM state transition is complete.
- When Hardware error occurred.

### 11.7 Key Setting Command

- When the Trusted system goes into an abnormal state.

### 11.8 User Key Setting Command

- When the Trusted system goes into an abnormal state.

### 11.9 Key Verify Command

- When the Trusted system goes into an abnormal state.

### 11.10 User Key Verify Command

- When the Trusted system goes into an abnormal state.

### 11.11 Initialize Command

- When the command completes successfully.
- When Hardware error occurred.

### 11.12 OEM Root Public Key Setting Command

- When the Trusted system goes into an abnormal state.

## 11.13 Code certificate update command

- When Trusted system goes into an abnormal state.
- When the OEM_BL address pointed to by the Code certificate is invalid.

## 11.14 Code Certificate Check Command

- When Trusted system goes into an abnormal state.
- When the OEM_BL address pointed to by the Code certificate is invalid.
- When the value of the Code certificate start address is invalid.
- When the Code certificate check command is executed even though the Code certificate update command has not been completed normally.

## 11.15 Encrypted Data Write Command

- When Trusted system goes into an abnormal state
- When Hardware error occurred

# 12. Causes for Software Reset

Boot firmware performs software reset in the following cases.

## 12.1 Initialization Phase

- When the DLM state is LCK_BOOT after startup.
- When the DLM state is abnormal after startup.
- When the Protection level is abnormal after startup.

## 12.2 Communication Setting Phase

- When all of the conditions below are met:
  — MD=1.
  — Not JTAG/SWD mode.
  — Top 8 bytes of Code Flash User area are not all-F.

## Website and Support

Visit the following URLs to learn about key elements of the RA family, download components and related documentation, and get support:

| | |
|---|---|
| RA Product Information | renesas.com/ra |
| RA Product Support Forum | renesas.com/ra/forum |
| RA Flexible Software Package | renesas.com/FSP |
| Renesas Support | renesas.com/support |

**Revision History**

| Rev. | Date | Description | |
| | | Page | Summary |
| --- | --- | --- | --- |
| 1.00 | Oct.31.23 | — | First release document |
| 1.20 | Mar.08.24 | 12, all pages, 93 | Made the following updates:<br>• Corrected voltage range in Table 5 and other minor updates.<br>• Corrected table 6.33.2.2, Data Packet [Parameter]. |

# General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)
   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.

2. Processing at power-on
   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.

3. Input of signal during power-off state
   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.

4. Handling of unused pins
   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.

5. Clock signals
   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.

6. Voltage application waveform at input pin
   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between $V_{IL}$ (Max.) and $V_{IH}$ (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between $V_{IL}$ (Max.) and $V_{IH}$ (Min.).

7. Prohibition of access to reserved addresses
   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.

8. Differences between products
   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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