RL78 Family

RL78 Microcontroller (RL78 Protocol B) Serial Programming Guide

Introduction

This application note describes the information necessary to develop a flash memory programmer for the RL78 microcontrollers. If the usage does not conform with the descriptions in this document, correct operation is not guaranteed.

Target Device

RL78 Family

Please refer to the following site for target devices compatible with RL78 protocol B.

https://en-support.renesas.com/knowledgeBase/16979203

Contents

1. Flash Memory Programming 3
1.1 Overview 3
1.2 Communication Modes 3
1.2.1 Single-Line UART Communications 3
1.2.2 Dedicated UART Communications 4
1.3 Command and Status List 6
1.3.1 Command List 6
1.3.2 Status List 6
1.4 Power-on Target Power Supply and Setting Flash Memory Programming Mode 7
1.5 Shutting Down Target Power Supply 8
2. Command Execution Flow 9
2.1 Mode setting 1-byte data command 9
2.2 Write after erase command 10
2.3 CRC check command 12
2.4 Command characteristics 15

1. Flash memory Programming

To rewrite the contents of the internal flash memory of the RL78 family a dedicated flash memory programmer (hereafter referred to as the “programmer”) is usually used.

This Application Note explains how to develop a dedicated programmer.

1.1 Overview

The RL78 Family incorporates the dedicated circuit that controls flash memory programming. The programming to the internal flash memory is performed by transmitting/receiving commands between the programmer and the RL78 Family via serial communication.

1.2 Communication Modes

As serial communications for writing the flash memory, single-line UART and dedicated UART communications can be used.

Note that some RL78 products do not support dedicated UART communication. Please check if the TOOLTxD and TOOLRxD pins are equipped with the microcontroller in the "User's Manual Hardware" of the target microcontroller.

1.2.1 Single-Line UART Communications

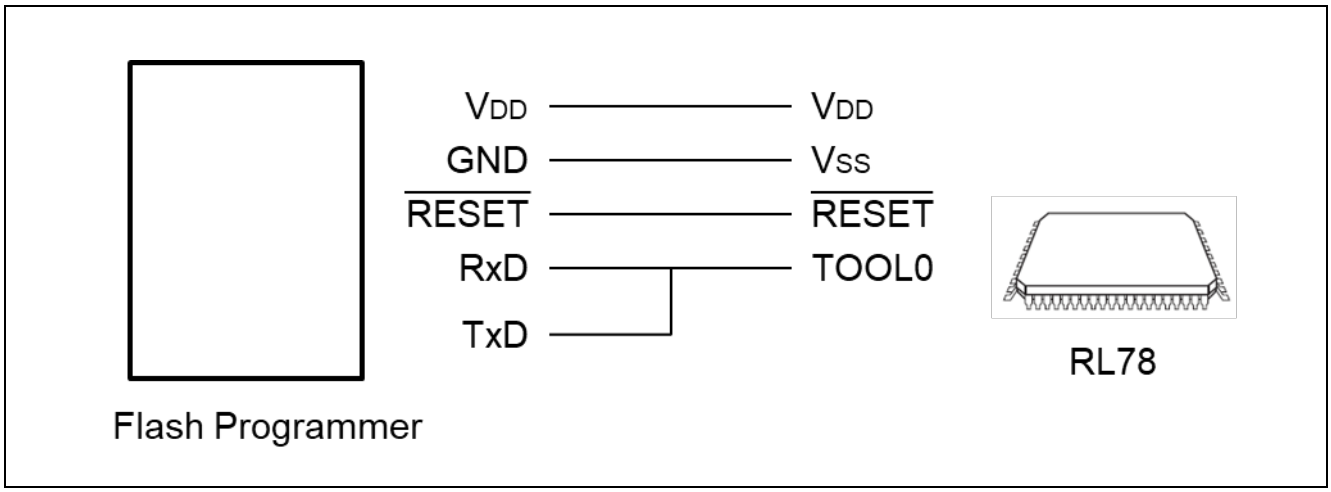


Figure 1 System Outline of Flash Memory Programming (Single-Line UART Communications)

Single-line UART communications use the TOOL0 pin. The following shows the specifications of communications.

Table 1 Single-Line UART Communications Conditions

Item	Descriptions
Baud rate	115,200 bps
Parity bit	Odd parity
Data length	8 bits (LSB first)
Start bit	1 bit
Stop bit	2 bits (programmer → RL78) 1 bit (RL78 → programmer)

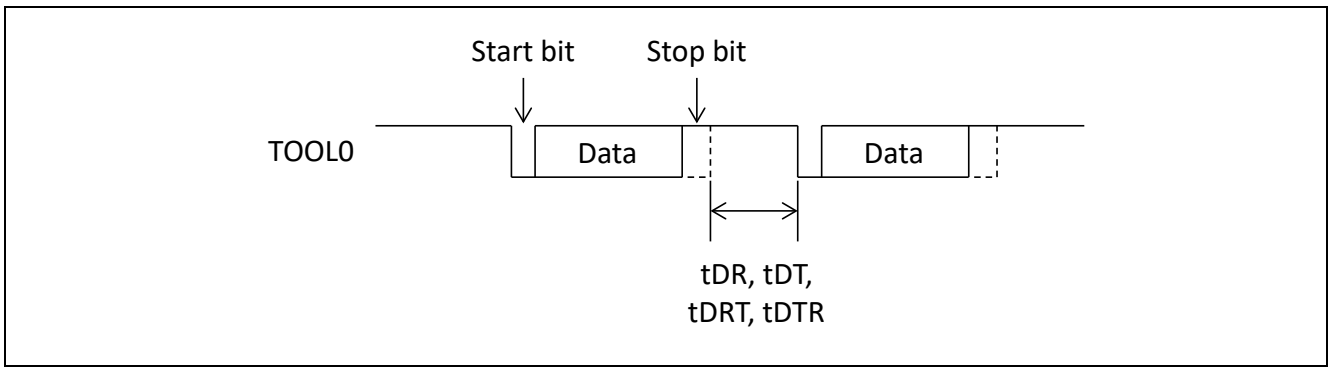


Figure 2 Communication format (Single-Line UART Communications)

Table 2 Communication characteristics (Single-Line UART Communications)

Item	Descriptions	Min	Max
tDR (1)	Data receive interval	104ns (3)	-
tDT (1)	Data transmit interval	104ns	1us (2)
tDRT (1)	Data transmit interval after data received	240ns (3)	1us (2)
tDTR (1)	Data receive interval after data transmitted	104ns (3)	-

Notes: 1. Receive/Transmit operation from the MCU.
2. This value does not include the time of Erase, Program, Verify and CRC process.
3. The programmer must wait this time before transmitting a data.

1.2.2 Dedicated UART Communications

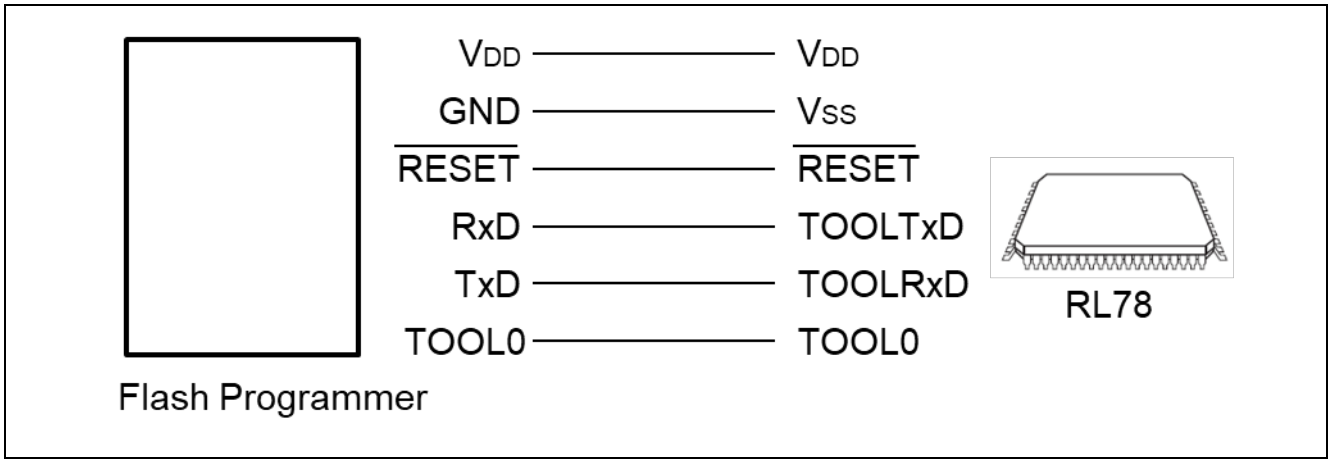


Figure 3 System Outline of Flash Memory Programming (Dedicated UART Communications)

In dedicated UART communication, the RL78 receives mode setting 1-byte data command from the TOOL0 pin, and after sending ACK, the TOOLTxD and TOOLRxD pins are used.

Remark: The TOOL0 pin of the flash programmer can be omitted. By connecting the TxD pin of the flash programmer to the TOOLRxD pin and TOOL0 pin of the RL78 with a wired OR, it is possible to send mode setting 1-byte data to the TOOL0 pin of the RL78 and send data to the TOOLRxD pin of RL78.

Table 3 Dedicated UART Communications Conditions

Item	Descriptions
Baud rate	115,200 bps
Parity bit	Odd parity
Data length	8 bits (LSB first)
Start bit	1 bit
Stop bit	2 bits (programmer → RL78) 1 bit (RL78 → programmer)

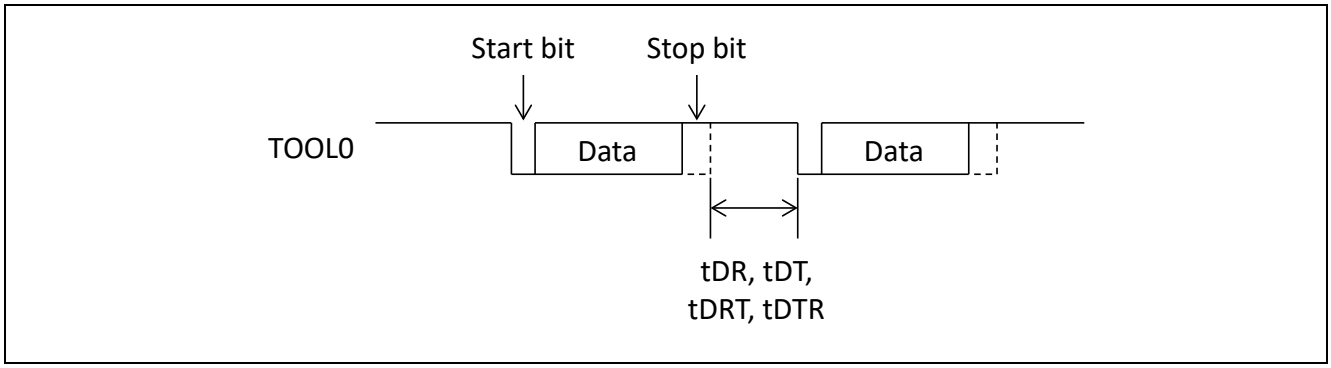


Figure 4 Communication format (Dedicated UART Communications)

Table 4 Communication characteristics (Dedicated UART Communications)

Item	Descriptions	Min	Max
tDR (1)	Data receive interval	104ns (3)	-
tDT (1)	Data transmit interval	104ns	1us (2)
tDRT (1)	Data transmit interval after data received	240ns (3)	1us (2)
tDTR (1)	Data receive interval after data transmitted	104ns (3)	-

Notes: 1. Receive/Transmit operation from the MCU.
2. This value does not include the time of Erase, Program, Internal verify and CRC process.
3. The programmer has to wait this time before transmitting a data.

1.3 Command and Status List

The flash memory in the RL78 has functions to rewrite flash memory. The programmer sends a command that controls these functions to the RL78 and operates the flash memory while checking the response status returned from the RL78.

1.3.1 Command List

The commands used by the programmer and their functions are listed below.

Table 5 List of Command codes

Command Number	Command Name	Function
3AH	Mode setting 1-byte data (Single-line UART)	Entries the flash memory programming mode in single-line UART communications.
00H Note	Mode setting 1-byte data (Dedicated UART)	Entries the flash memory programming mode in dedicated UART communications.
53H	CRC check (Code flash memory)	Calculates the CRC checksums of the code flash memory.
54H Note	CRC check (Data flash memory)	Calculates the CRC checksums of the data flash memory.
60H	Write after erase (Code flash memory)	Erases the entire flash memory and writes the target data to the flash memory.
63H Note	Write after erase (Data flash memory)	Erases the entire flash memory and writes the target data to the flash memory.

Note: Not supported except RL78/G10, RL78/G1M, and RL78/G1N

1.3.2 Status List

The following table lists the status codes the programmer receives from the RL78 MCU.

Table 6 List of Status codes

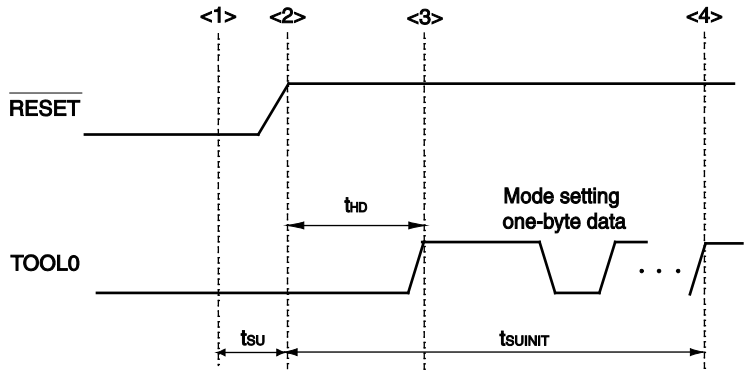
Status Code	Status	Descriptions
04H	Command number error	An unsupported command was received
06H	ACK	Normal reply
36H	ACK	Normal reply When data flash-mounted products set to flash memory programming mode, only the first ACK returns 36H
15H	NACK	Negative acknowledgment
1AH	Erase error	Erase error
1BH Note	Blank error / Verify error	Blank error / Internal verify error
1CH	Write error	Write error

Note : Not supported except RL78/G10, RL78/G1M, and RL78/G1N

1.4 Power-on Target Power Supply and Setting Flash Memory Programming Mode

To rewrite the contents of the flash memory with the programmer, the RL78 MCU must first be set to the flash memory programming mode (serial programming mode). The command number of “Mode setting one-byte data” is described in Table 5 List of Command”.

For the detail of the Flash Memory Programming mode, refer to “Flash memory programming mode” in the chapter “FLASH MEMORY” of “ User’s Manual: Hardware” for the target MCU.



<1> The low level is input to the TOOL0 pin.

<2> The external reset ends (SPOR reset must end before the external reset ends.).

<3> The TOOL0 pin is set to the high level.

<4> Setting of entry to the flash memory programming mode by UART reception.

Figure 5 Setting Flash Memory Programming Mode

Table 7 Timing to enter the flash memory programming mode

記号	Description	Min	Max
tSUINIT	The amount of time to elapse after the external reset is released until the initial communication settings are complete	—	100 [ms]
tSU	The amount of time to elapse after the TOOL0 pin is placed at the low level until the external reset is released	10 [us]	—
tHD	The amount of time to retain the TOOL0 pin at the low level after the external reset is released	1 [ms]	—

1.5 Shutting Down Target Power Supply

After each command execution is completed, shut down the power supply to the target after setting the RESET pin to low level, as shown below. Set other pins to Hi-Z when shutting down the power supply to the target.

Note: Shutting down the power supply and inputting a reset during command processing are prohibited.

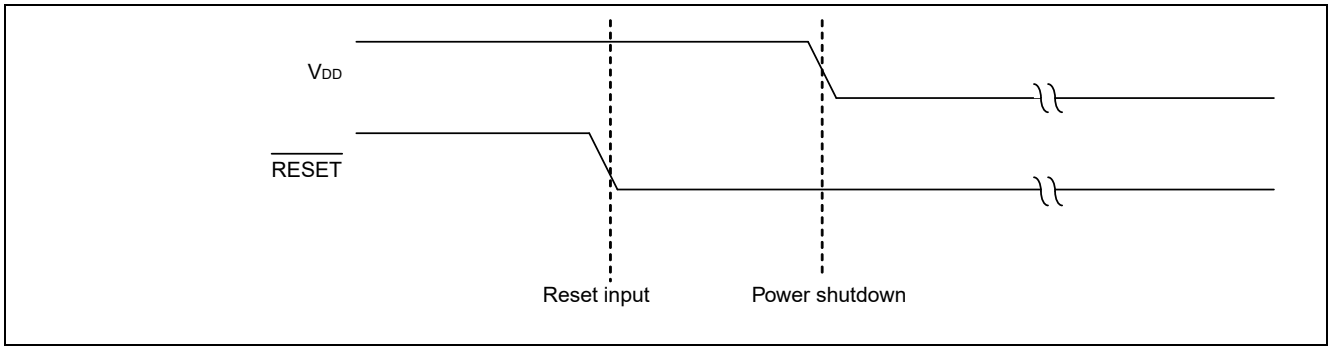


Figure 6 Timing for Terminating Flash Memory Programming Mode

2. Command Execution Flow

2.1 Mode setting 1-byte data command

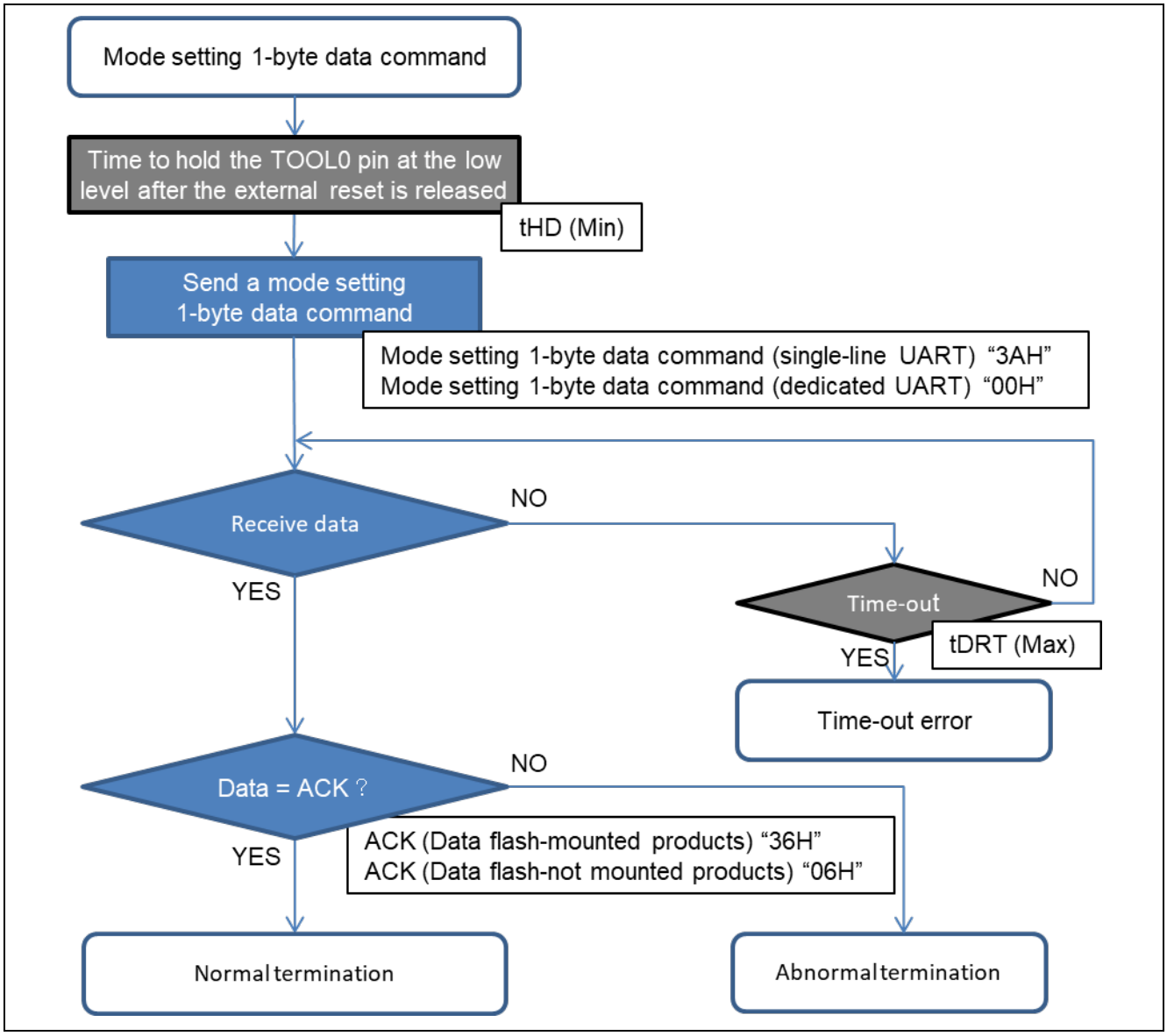


Figure 7 Mode setting 1-byte data command

2.2 Write after erase command

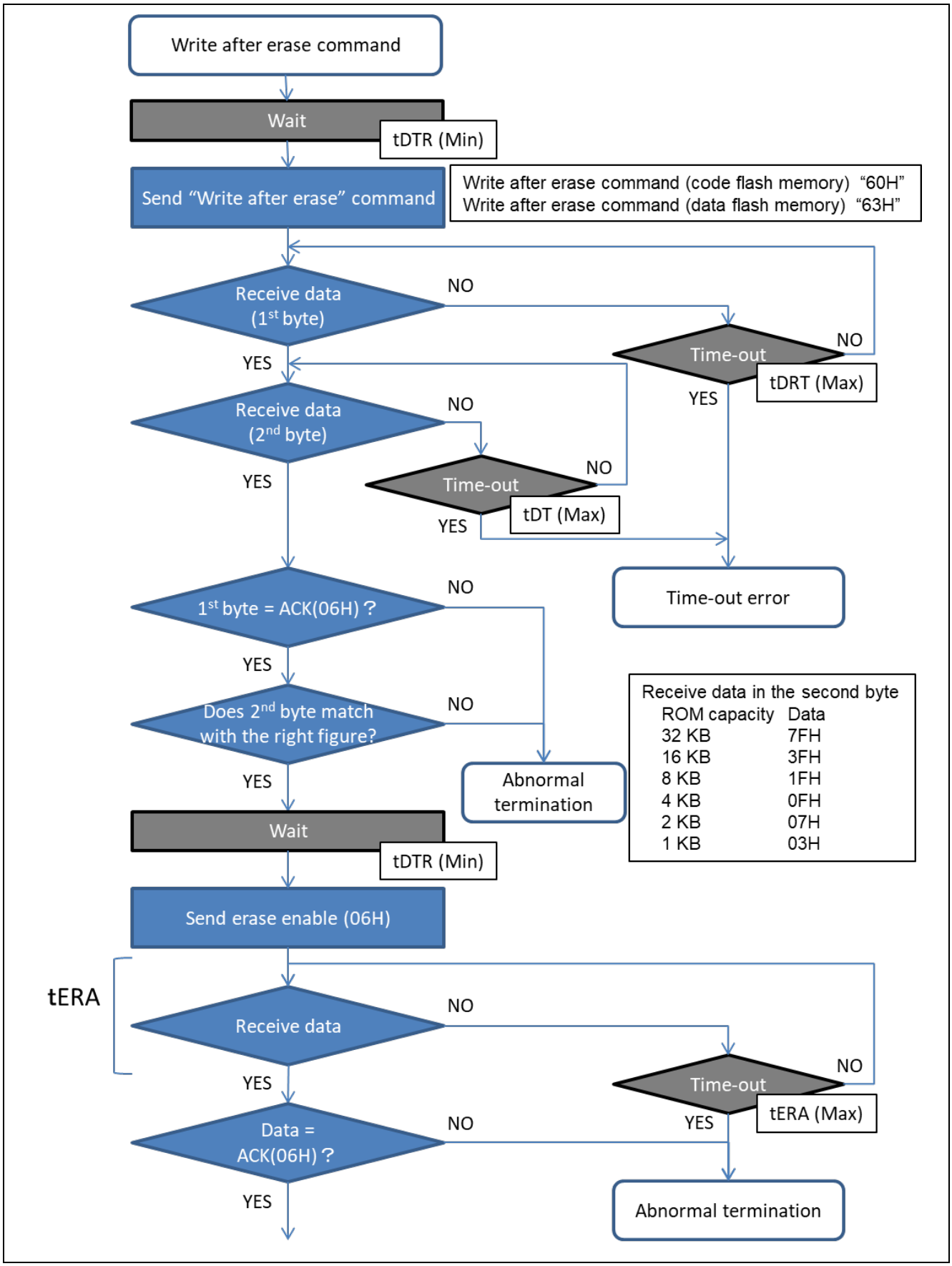


Figure 8 Write after erase command (1 of 2)

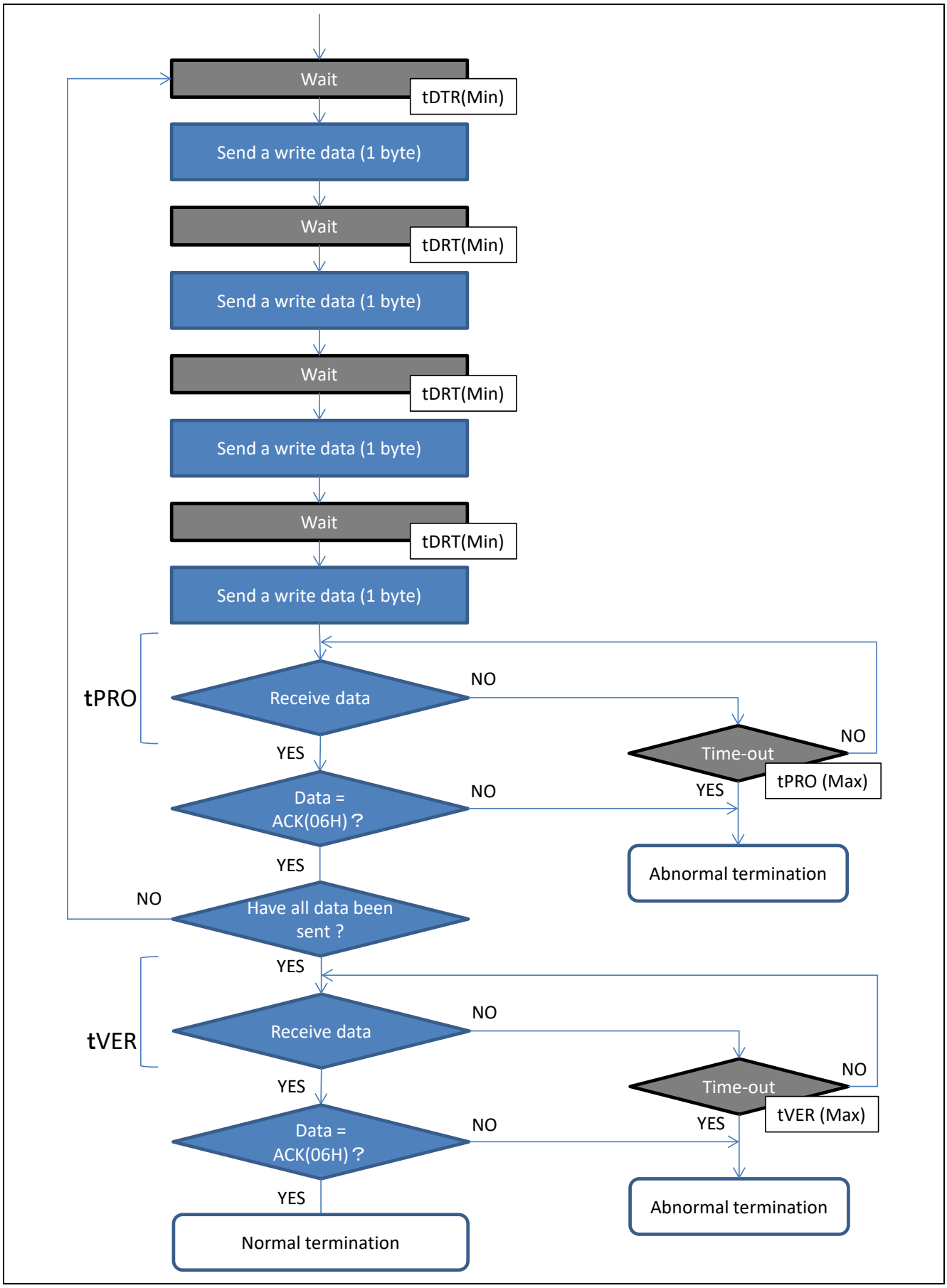


Figure 9 Write after erase command (2 of 2)

2.3 CRC check command

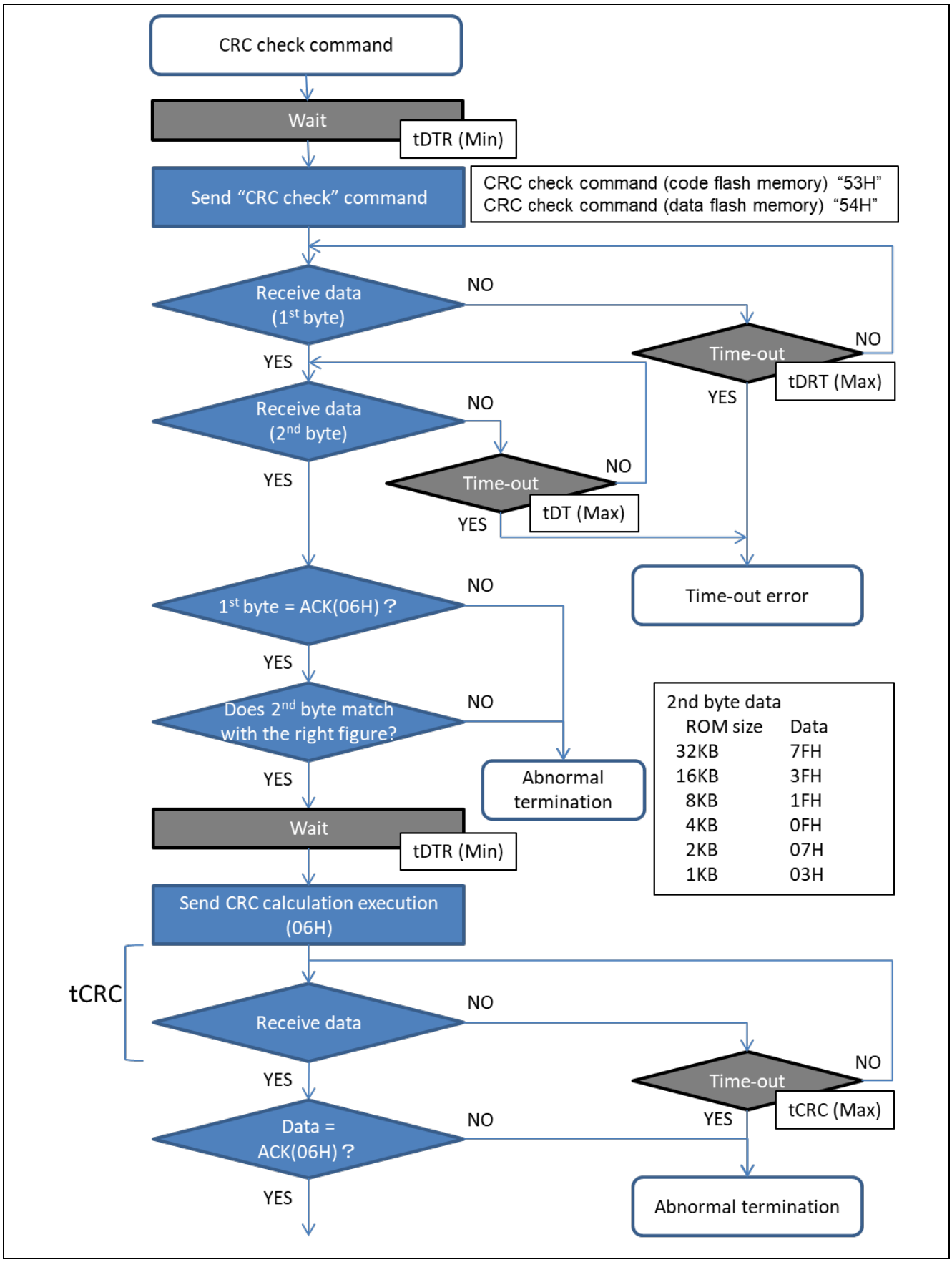


Figure 10 CRC check command (1 of 2)

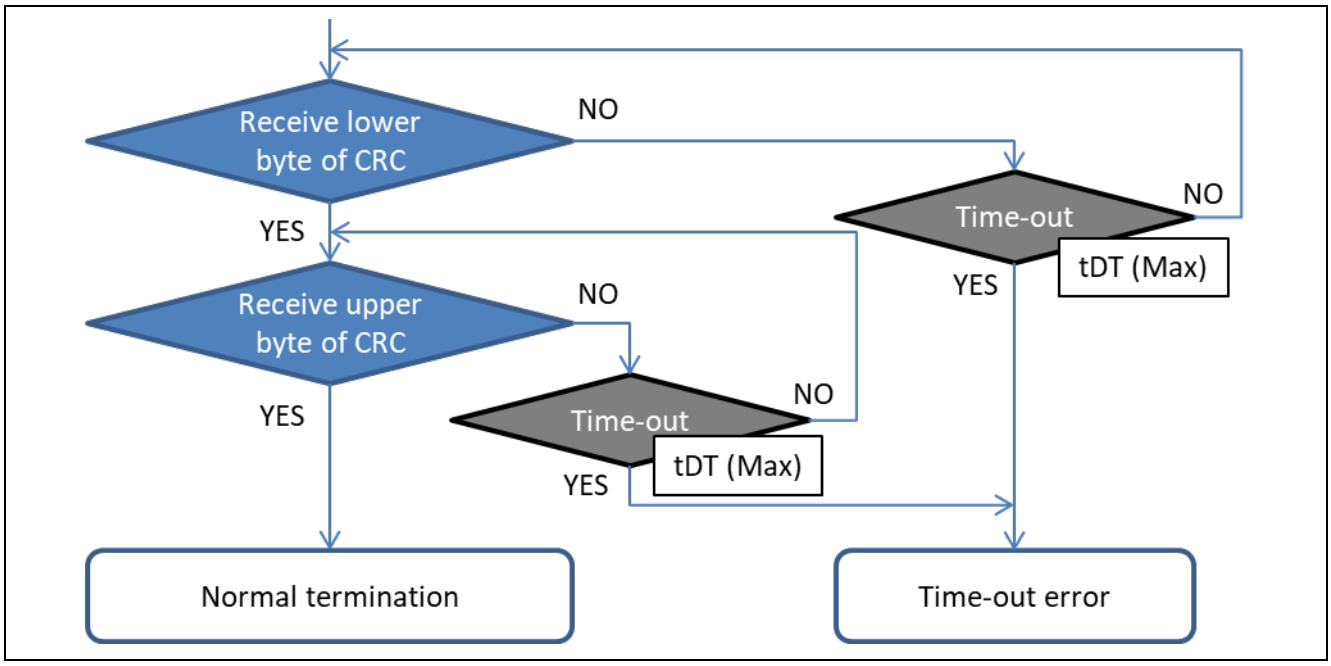


Figure 11 CRC check command (2 of 2)

```
/* The generator polynomial used for this table is: */
/* x^16+x^12+x^5+x^0 according to CCITT-16 standard. */
/* Binary: 0x1021 */
const uint16_t CRC16_Tab [256]= {
        0x0000,0x1021,0x2042,0x3063,0x4084,0x50A5,0x60C6,0x70E7,
        0x8108,0x9129,0xA14A,0xB16B,0xC18C,0xD1AD,0xE1CE,0xF1EF,
        0x1231,0x0210,0x3273,0x2252,0x52B5,0x4294,0x72F7,0x62D6,
        0x9339,0x8318,0xB37B,0xA35A,0xD3BD,0xC39C,0xF3FF,0xE3DE,
        0x2462,0x3443,0x0420,0x1401,0x64E6,0x74C7,0x44A4,0x5485,
        0xA56A,0xB54B,0x8528,0x9509,0xE5EE,0xF5CF,0xC5AC,0xD58D,
        0x3653,0x2672,0x1611,0x0630,0x76D7,0x66F6,0x5695,0x46B4,
        0xB75B,0xA77A,0x9719,0x8738,0xF7DF,0xE7FE,0xD79D,0xC7BC,
        0x48C4,0x58E5,0x6886,0x78A7,0x0840,0x1861,0x2802,0x3823,
        0xC9CC,0xD9ED,0xE98E,0xF9AF,0x8948,0x9969,0xA90A,0xB92B,
        0x5AF5,0x4AD4,0x7AB7,0x6A96,0x1A71,0x0A50,0x3A33,0x2A12,
        0xDBFD,0xCBDC,0xFBBF,0xEB9E,0x9B79,0x8B58,0xBB3B,0xAB1A,
        0x6CA6,0x7C87,0x4CE4,0x5CC5,0x2C22,0x3C03,0x0C60,0x1C41,
        0xEDAE,0xFD8F,0xCDEC,0xDDCD,0xAD2A,0xBD0B,0x8D68,0x9D49,
        0x7E97,0x6EB6,0x5ED5,0x4EF4,0x3E13,0x2E32,0x1E51,0x0E70,
        0xFF9F,0xEFBE,0xDFDD,0xCFFC,0xBF1B,0xAF3A,0x9F59,0x8F78,
        0x9188,0x81A9,0xB1CA,0xA1EB,0xD10C,0xC12D,0xF14E,0xE16F,
        0x1080,0x00A1,0x30C2,0x20E3,0x5004,0x4025,0x7046,0x6067,
        0x83B9,0x9398,0xA3FB,0xB3DA,0xC33D,0xD31C,0xE37F,0xF35E,
        0x02B1,0x1290,0x22F3,0x32D2,0x4235,0x5214,0x6277,0x7256,
        0xB5EA,0xA5CB,0x95A8,0x8589,0xF56E,0xE54F,0xD52C,0xC50D,
        0x34E2,0x24C3,0x14A0,0x0481,0x7466,0x6447,0x5424,0x4405,
        0xA7DB,0xB7FA,0x8799,0x97B8,0xE75F,0xF77E,0xC71D,0xD73C,
        0x26D3,0x36F2,0x0691,0x16B0,0x6657,0x7676,0x4615,0x5634,
        0xD94C,0xC96D,0xF90E,0xE92F,0x99C8,0x89E9,0xB98A,0xA9AB,
        0x5844,0x4865,0x7806,0x6827,0x18C0,0x08E1,0x3882,0x28A3,
        0xCB7D,0xDB5C,0xEB3F,0xFB1E,0x8BF9,0x9BD8,0xABBB,0xBB9A,
        0x4A75,0x5A54,0x6A37,0x7A16,0x0AF1,0x1AD0,0x2AB3,0x3A92,
        0xFD2E,0xED0F,0xDD6C,0xCD4D,0xBDAA,0xAD8B,0x9DE8,0x8DC9,
        0x7C26,0x6C07,0x5C64,0x4C45,0x3CA2,0x2C83,0x1CE0,0x0CC1,
        0xEF1F,0xFF3E,0xCF5D,0xDF7C,0xAF9B,0xBFBA,0x8FD9,0x9FF8,
        0x6E17,0x7E36,0x4E55,0x5E74,0x2E93,0x3EB2,0x0ED1,0x1EF0
};

uint16_t CalcMemoryCRC16 (uint32_t address, uint32_t length)
{
        uint32_t i, rd_ptr;
        uint16_t crc_accum;
        uint8_t byte, data [4];
        crc_accum= 0x0000; /* Init Pattern */
        for (i= 0, rd_ptr= 0; i < length; i++)
        {
                /* Check flash read buffer and fill if needed */
                if (rd_ptr == 0)
                {
                        Memory_Read (address, 4, data);
                        rd_ptr= 4;
                        address+= 4;
                }
                byte= (crc_accum >> 8) ^ data [--rd_ptr];
                crc_accum= (crc_accum << 8) ^ CRC16_Tab [byte];
        }
        return crc_accum;
}
```

Figure 12 16 bits CRC calculation algorithm

2.4 Command characteristics

Table 8 Command characteristics

Item	Descriptions	Min	Max
tERA	Erase time	-	208 + 6 x N [ms]
tPRO	Programming time	-	1 [ms]
tVER	Verify time	-	1.1 x N [ms]
tCRC	CRC calculation time	-	14 x N [us]

Notes: “N” is memory size [KB].

Revision History

		Description	
Rev.	**Date**	**Page**	**Summary**
1.00	Jun. 30, 2022	-	First edition issued
2.00	Aug. 10,2022	1	Corrected description of introduction
		1	Add Target Device description
		3	Add explanation of Communication Modes
		4	Corrected description of dedicated UART communication and added Remarks
		6	Corrected explanation of status code 36H
		9	Integrated Command Execution Flow for single-line UART communication and dedicated UART communication
		9	Added mode setting 1-byte data command in Command Execution Flow
		10	Corrected the ACK value in the first byte of the write after erase command
		12	Corrected the ACK value in the first byte of CRC check command

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.

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall be responsible for determining what licenses are required from any third parties, and obtaining such licenses for the lawful import, export, manufacture, sales, utilization, distribution or other disposal of any products incorporating Renesas Electronics products, if required.
5. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
6. Renesas Electronics products are classified according to the following two quality grades: “Standard” and “High Quality”. The intended applications for each Renesas Electronics product depends on the product’s quality grade, as indicated below.
   "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.
   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

   Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user’s manual or other Renesas Electronics document.
7. No semiconductor product is absolutely secure. Notwithstanding any security measures or features that may be implemented in Renesas Electronics hardware or software products, Renesas Electronics shall have absolutely no liability arising out of any vulnerability or security breach, including but not limited to any unauthorized access to or use of a Renesas Electronics product or a system that uses a Renesas Electronics product. RENESAS ELECTRONICS DOES NOT WARRANT OR GUARANTEE THAT RENESAS ELECTRONICS PRODUCTS, OR ANY SYSTEMS CREATED USING RENESAS ELECTRONICS PRODUCTS WILL BE INVULNERABLE OR FREE FROM CORRUPTION, ATTACK, VIRUSES, INTERFERENCE, HACKING, DATA LOSS OR THEFT, OR OTHER SECURITY INTRUSION (“Vulnerability Issues”). RENESAS ELECTRONICS DISCLAIMS ANY AND ALL RESPONSIBILITY OR LIABILITY ARISING FROM OR RELATED TO ANY VULNERABILITY ISSUES. FURTHERMORE, TO THE EXTENT PERMITTED BY APPLICABLE LAW, RENESAS ELECTRONICS DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THIS DOCUMENT AND ANY RELATED OR ACCOMPANYING SOFTWARE OR HARDWARE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE.
8. When using Renesas Electronics products, refer to the latest product information (data sheets, user’s manuals, application notes, “General Notes for Handling and Using Semiconductor Devices” in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
12. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
13. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
14. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1) “Renesas Electronics” as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.
(Note2) “Renesas Electronics product(s)” means any product developed or manufactured by or for Renesas Electronics.

(Rev.5.0-1 October 2020)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan

www.renesas.com

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.

Contact information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:
www.renesas.com/contact/.

© 2022 Renesas Electronics Corporation. All rights reserved.