User's Manual

16

RL78 Family

EEPROM Emulation Library Pack02

Japanese Release

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16-Bit Single-Chip Microcontroller

Supported Devices:

RL78/D1A RL78/G1A

RL78/F12 RL78/I1A

RL78/F13 RL78/L13

RL78/F14 RL78/L1C

RL78/G13

RL78/G14

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NOTES FOR CMOS DEVICES

(1) 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 VIL (MAX) and VIH (MIN) due to noise, etc., 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 VIL (MAX) and VIH (MIN).

(2) HANDLING OF UNUSED INPUT PINS: Unconnected CMOS device inputs can be cause of malfunction. If an input pin is unconnected, it is possible that an internal input level may be generated due to noise, etc., causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using pull-up or pull-down circuitry. Each unused pin should be connected to VDD or GND via a resistor if there is a possibility that it will be an output pin. All handling related to unused pins must be judged separately for each device and according to related specifications governing the device.

(3) PRECAUTION AGAINST ESD: A strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it when it has occurred. Environmental control must be adequate. When it is dry, a humidifier should be used. It is recommended to avoid using insulators that 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 should be grounded. The operator should be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with mounted semiconductor devices.

(4) STATUS BEFORE INITIALIZATION: Power-on does not necessarily define the initial status of a MOS device. Immediately after the power source is turned ON, devices with reset functions have not yet been initialized. Hence, power-on does not guarantee output pin levels, I/O settings or contents of registers. A device is not initialized until the reset signal is received. A reset operation must be executed immediately after power-on for devices with reset functions.

(5) POWER ON/OFF SEQUENCE: In the case of a device that uses different power supplies for the internal operation and external interface, as a rule, switch on the external power supply after switching on the internal power supply. When switching the power supply off, as a rule, switch off the external power supply and then the internal power supply. Use of the reverse power on/off sequences may result in the application of an overvoltage to the internal elements of the device, causing malfunction and degradation of internal elements due to the passage of an abnormal current. The correct power on/off sequence must be judged separately for each device and according to related specifications governing the device.

(6) INPUT OF SIGNAL DURING POWER OFF STATE : Do not input signals or an I/O pull-up power supply while the device is not powered. 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. Input of signals during the power off state must be judged separately for each device and according to related specifications governing the device.

How to Use This Manual

Target Readers

This manual is intended for users who wish to understand the features of the RL78 microcontrollers EEPROM Emulation Library Pack 02 and to use the library in designing and developing application systems.

The target products are as follows.
RL78/D1A, RL78/F12, RL78/F13, RL78/F14, RL78/G13, RL78/G14, RL78/G1A, RL78/I1A, RL78/L13, RL78/L1C

Purpose

This manual is intended to give users understanding of how to use EEPROM Emulation Library Pack 02 to rewrite the flash data memory in RL78-family microcontrollers (i.e. write constant data by the application).

Organization

The RL78 EEPROM Emulation Library Pack 02 user's manual is separated into the following parts
:

- Overview of EEPROM Emulation
- Using EEPORM Emulation
- EEPROM Emulation Function

How to Read This Manual

It is assumed that the readers of this manual have general knowledge of electrical engineering, logic circuits, and microcontrollers.

- To gain a general understanding of features
  -> Read this manual in order of the table of contents.
- For details on the functions of the library
  -> Refer to section 5, User Interface, of this user's manual.

Conventions

Data significance: Higher-order digits to the left and lower-order digits to the right
Active low representations: $\overline{xxx}$ (overscore over pin and signal name)
Note: Footnote for item marked with **Note** in the text.
Caution: Information requiring particular attention
Remark: Supplementary information
Numeral representation: Binary ... xxxx or xxxxB
Decimal ... xxxx
Hexadecimal ... xxxxH or 0xXXXX

Contents

Chapter 1 Overview

1.1 Outline

EEPROM emulation is a feature used to store data in the on-board flash memory in the same way as EEPROM. During EEPROM emulation, the Data Flash library and EEPROM emulation library are used, and the data flash memory is written to and read from.

The Data Flash library is a software library used to perform operations on the data flash memory. The EEPROM emulation library is a software library used to execute EEPROM emulation from a user-created program. The Data Flash library and EEPROM emulation library are placed in the code flash memory for use.

The EEPROM emulation library is free software to rewrite the data flash through the user program.

In this user's manual, processing of the EEPROM emulation library includes processing of the Data Flash library.

Be sure to use this user's manual together with the release note supplied with the package of this EEPROM emulation library and the user's manual for the target device.

1.2 Target Devices

For the latest device information, please contact our distributors or sales representatives.

1.3 Definition of Terms

The terms used in this manual are defined below.

- **Pack**

"Pack" is an identification name representing an EEPROM emulation library type. Use the pack corresponding to your device.

- **EEL**

An abbreviation of the EEPROM Emulation library.

In this user's manual, the RL78 EEPROM emulation library Pack02 is hereafter referred to as EEL.

- **FDL**

An abbreviation of the Data Flash library.

- **FSL**

An abbreviation of the Flash Self Programming library.

- **EEL function**

A generic term for the functions offered by the EEL.

- **FDL function**

  A generic term for the functions offered by the FDL.

- **FSL function**

  A generic term for the functions offered by the FSL.

- **Block number**

  A number which identifies a block of Flash memory.

- **EEL Blocks**

An abbreviation of blocks that the EEPROM emulation library accesses. In this user's manual, EEPROM emulation blocks are hereafter referred to as EEL blocks.

- **CF**

  Code Flash

- **DF**

  Data Flash

Chapter 2 EEPROM Emulation

2. 1 Specifications of EEPROM Emulation

By calling the EEL function provided by the EEL from a user-created program, use is possible without the awareness of data flash memory operations.

For the EEL, a one-bye identifier (data ID: 1 to 64) is assigned by the user for each data item, and reading and writing using any unit from 1 to 255 bytes are possible on an assigned identifier basis.(The EEL can handle up to 64 identifiers.)

Note that three or more continuous block area of data flash memory (recommended) [Note] are used to store the data. These blocks are called EEL blocks. Data written by EEPROM emulation is divided into reference data and user-specified data, and the reference data is written to the target blocks from the lower block address, while the user data is written from the higher block address.

Note: At least two blocks are necessary for EEPROM emulation. When two blocks are specified, if a write error occurs even once, only reading of normally written data is possible but writing is no longer possible. After that, the two target blocks must be formatted when the EEL is used to write data. Written data is erased completely. Since a contingency (such as voltage drop) may occur in the system, we recommend that you specify at least three blocks.

2. 2 Outline of Function

The EEL provides basic read/write functions having the following features.

- Up to 64 data items settable
- A data size of 1 to 255 bytes settable
- Supporting the back ground operation (BGO)
- Consumption of memory for management data
  (10 bytes per EEL block and 2 bytes per EEL block write data)
- Reset resistance (EEL_CMD_WRITE, EEL_CMD_REFRESH)
- Block rotation (averaging data flash use frequency)

Renesas Electronics also provides RL78 EEPROM Emulation Library Pack 01 (EEL Pack01) as another EEL. EEL consumes smaller amount of resource than EEL Pack01. Other functional differences are listed in the table below. (For details of functions, see the RL78 Microcontroller EEPROM Emulation Library Pack 01 user's manual R01US0054EJ0102.)

Item	EEL Pack01	EEL
User data length	1 to 255	1 to 255
Amount of stored user data Note 1	1 to 255	1 to 64
Data ID range	1 to 255	1 to 64
Number of EEPROM emulation blocks Note 2	4 to 255	3 to 255
Recommended user data size Note 1	980 x total number of blocks x 1/4 - 980/2 bytes	1014/2 bytes
Enforce mode and TimeOut mode	Supported	Not supported
Back ground maintenance processing	Supported	Not supported
Data ID number	Can be set arbitrarily	Cannot be set arbitrarily
Auto-checksum for data	Supported	Not supported

Note1: The total size of user data must be within 1/2 of each block when all user data are written to an EEL block. Therefore, the range used for the number of stored user data items differs depending on the size of the stored user data. It is also necessary to consider the size of the reference data provided for each data item for management use when determining the total size. For details about the number of stored user data items and total size, see 4.2 Number of stored user data items and total user data size.

Note 2: EEL blocks cannot be set more than maximum number of blocks of on-board data flash memory.

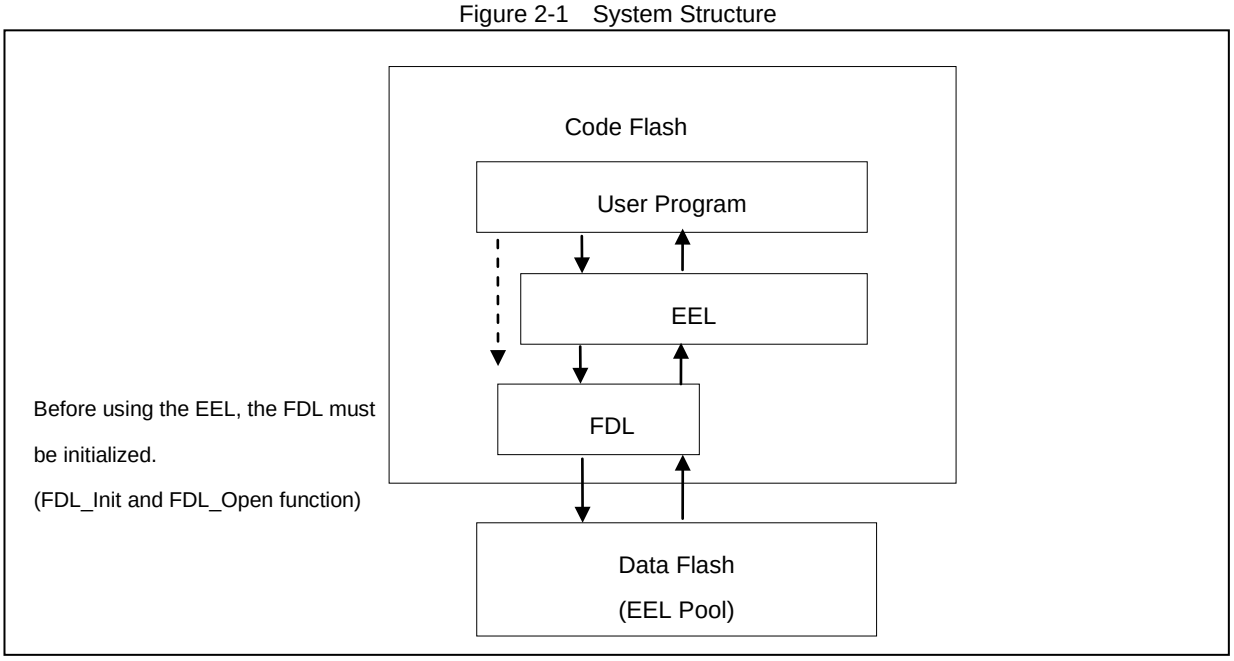
2. 3 EEL architecture

This chapter describes the EEL architecture required for the user to rewrite data flash (the EEL pool) by using the EEL.

2. 3. 1 System Structure

The EEL offers interface for accessing the data flash area defined by the user. The arrows shown in the figure 2-1 below indicate the flow of processing.

Figure 2-1 System Structure



2. 3. 2 EEL Pool

The EEL pool is a user-defined data flash area that is accessible by the EEL. The user program can access the data flash only by using this EEL pool in the data flash via the EEL. The EEL pool size must be specified with the number of blocks in the data flash of the target device. For the procedure to specify the number of blocks, see section 4.3, Initial Values to be set by User.

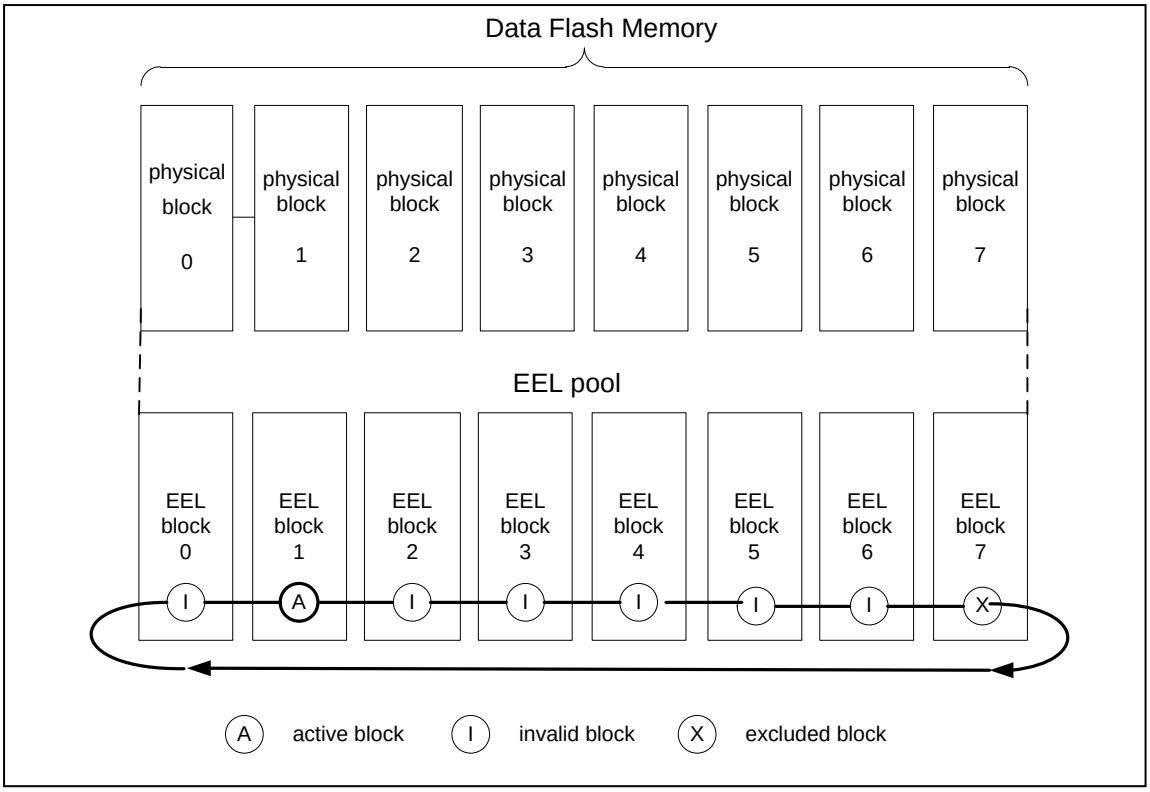
The EEL pool is divided into 1024-byte blocks. Each block has a state which indicates the current usage of the block.

State	Description
Active	Only a single EEL block is active at a time to store defined data. The active block circulates in data flash blocks allocated in the EEL pool.
Invalid	No data is stored in invalid blocks. EEL blocks are marked as invalid by the EEL or become invalid in the case of erasure blocks.
Excluded	If functional operation failed and possibility of a data flash failure is clarified, the EEL excludes the relevant block and the block is no longer used for EEPROM emulation.

Figure 2-2 shows an exemplary pool configuration for a device with 8 KB data flash.

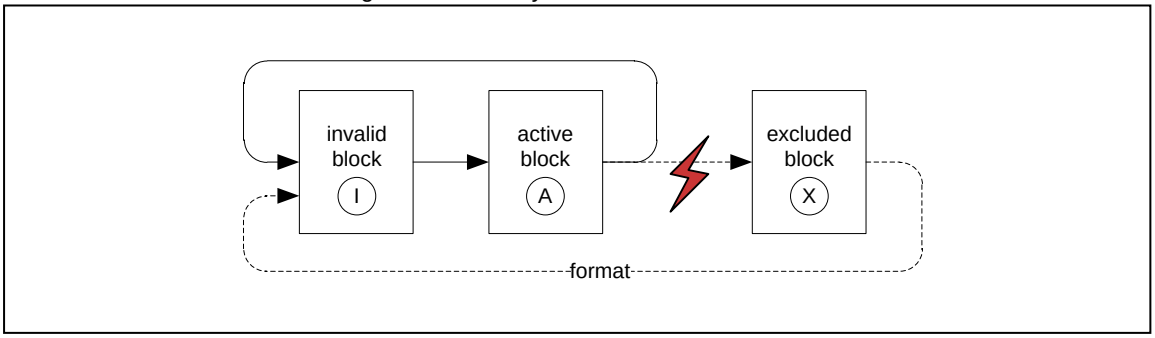
When no writable area is remaining in the active block (block 1 in the example) and data can no longer be stored (failure in write command), a new active block is selected in a cyclic manner and the current valid data set is copied to this new active block. This process is referred to as refresh. After the EEL_CMD_REFRESH command is executed, the previous active block becomes invalid and only a single active block exists. Excluded blocks (like block 7 in the example) are ignored during this process and not considered as candidates for the selection of the next active block.

Figure 2-2 EEL pool structure



The overall life cycle of a block in the EEL pool is shown in Figure 2-3. During normal operation, the block switches between active and invalid state. When an error occurs during an access to the EEL block, the error EEL block is marked as excluded. This block will not enter the lifecycle again. However, the user can try to reanimate the block by a format of the complete pool which also erases all existing data content.

Figure 2-3 Life cycle of an EEL block



The EEL pool has the four states shown below.

Table 2-1 States of the EEL Pool

State	Description
Pool operational	This is the usual case during EEL operation. All commands are available and can be executed.
Pool full	Free space for data write is insufficient in the active block in use. This state indicates that a refresh needs to be executed.
Pool exhausted	No continuously usable EEL block is left. (At least two blocks that are not excluded are necessary for EEL operations.)
Pool inconsistent	There is a mismatch in the pool state and the data structure in the EEL block does not match the user-set data structure. The EEL block is in the undefined state (e.g. no active block is present).

2. 3. 3 Structure of EEL Block

The detailed block structure used by the EEL is depicted in Figure 2-4. In general, an EEL block is divided into three utilized areas: the block header, the reference area and the data area.

Figure 2-4 ELL Block Structure (Example of RL78/G13 Data Flash Block 0)

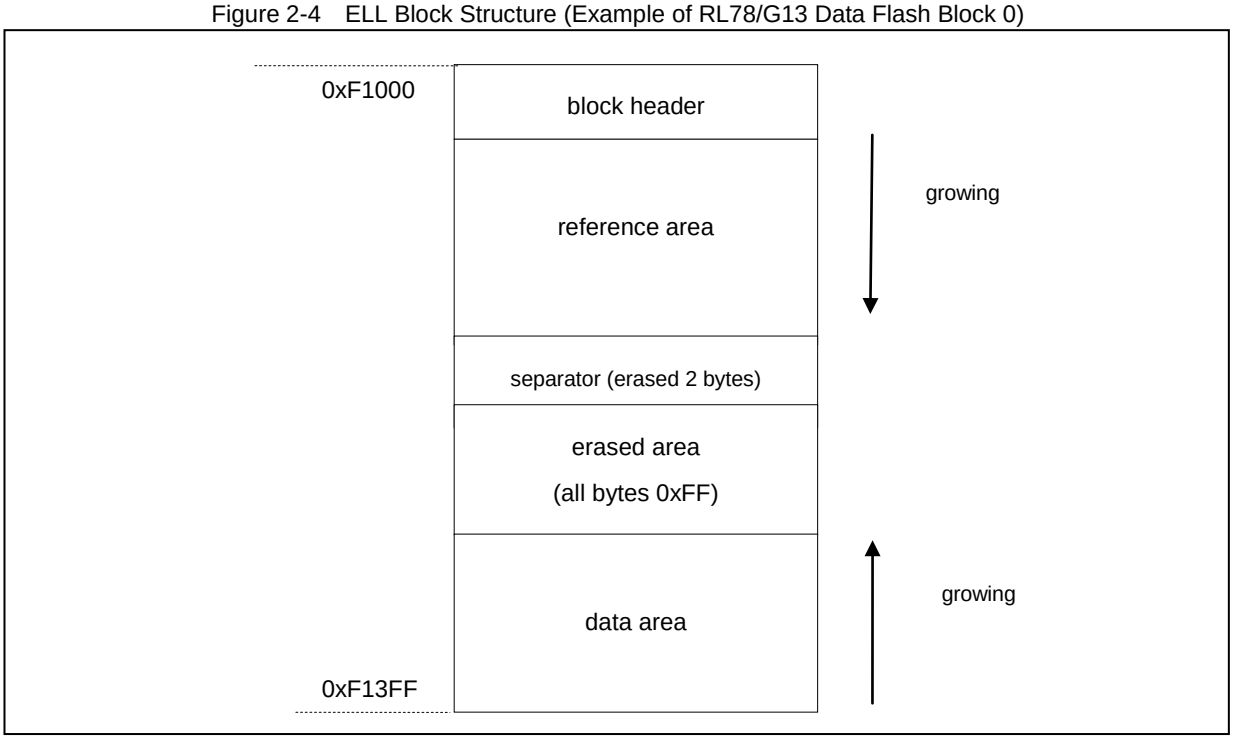


Table 2-2 Configuration of Each EEL Block

Name	Description
block header	The block header contains all block status information needed for the block management within the EEL-pool. It has a fixed size of 8 bytes.
reference area	The reference area contains reference data which are required for the management of data. When data is written, this area extends in the address increment direction.
data area	The data area contains user data. When data is written, this area extends in the address decrement direction.

Between reference area and data area, there is an erased area. With each EEL data update (i.e. the data is written), this area is reduced successively. However, at least two bytes of space always remain between reference area and data area for management and separation of these areas. This is indicated by the separator in Figure 2-4.

The EEL block header is detailed in 2.3.4, EEL Block Header, while the structure of data stored in the reference and data area are described in Section 2.3.5, Structure of Stored Data.

2. 3. 4 EEL Block Header

The structure of the block header is depicted in Figure 2-5. It is composed of eight bytes, four of which are reserved for the system.

Figure 2-5 Structure of EEL block header

relative byte index within block		
0x0000	A	N
0x0001	B	0xFF - N
0x0002	I	0x00
0x0003	X	0x00
0x0004	-	Reserved
0x0005	-	Reserved
0x0006	-	Reserved
0x0007	-	Reserved

The block status flags start at the beginning of the block and include the A flag, B flag, I flag, and X flag, each of which is one byte, for a total of 4 bytes of data. The combination of flags indicates the EEL block status.

Figure 2-5 shows the placement status of flags, and Table 2-3 shows the combination status of flags.

Table 2-3 Overviews of Block Status Flags

Block Status Flag				State	Description
A Flag	B Flag	I Flag	X Flag		
0x01	0xFE	0xFF	0xFF	Active	Currently used block After the EEL_CMD_REFRESH command is executed, the A flag of a new active block is set to 0x02.
0x02	0xFD	0xFF	0xFF		Currently used block After the EEL_CMD_REFRESH command is executed, the A flag of a new active block is set to 0x03.
0x03	0xFC	0xFF	0xFF		Currently used block After the EEL_CMD_REFRESH command is executed, the A flag of a new active block is set to 0x01.
Data other than the above		0xFF	0xFF	Invalid	Invalid block
--		other than 0xFF	0xFF		
--		--	other than 0xFF	Excluded	Excluded block

2. 3. 5 Structure of Stored Data

The structure of stored data when user data is written to an EEL block is shown in the figure below. A data is composed of three parts: the start-of-record (SoR) field and the end-of-record (EoR) field and the data field. The EEL descriptor table can be used to set data for use in the EEL. Each data is referred to by an identification number (ID) and can have a size between 1 and 255 byte. (The exact specification of the format of the EEL descriptor can be found in Section 4.3)

Each time data is written, stored data increase in the EEL block and multiple units of stored data exist in the EEL block, but only the most recent stored data is referenced.

SoR and EoR build up the so-called reference data which is required for the management of the data. The reference data and user data values are stored in different sections of the active block, namely the reference area and the data area, respectively. Figure 2-6 shows the overview of the entire structure of stored data.

Figure 2-6 Structure of Stored Data

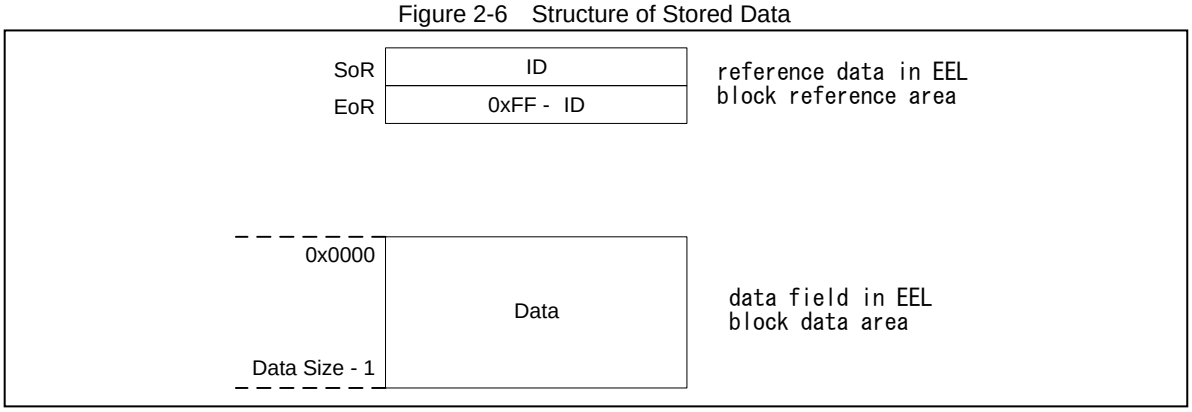


Table 2-4 Description of Each Field of Data Area

Name	Description
SoR field (Start of Record)	The one-byte SoR field contains the ID of data. This field indicates the start of write processing. Data IDs 0x00 and 0xFF are not used to avoid patterns of erased cells.
EoR field (End of Record)	The one-byte EoR field contains a 0xFF – data ID value. This field indicates successful end of write processing. If writing does not end normally due to a device reset or other reasons, the corresponding stored data is ignored by the EEL.
data field	The data field contains the user data. The size of user data is 1 to 255 bytes. When data of two bytes or more is stored, the smallest address of the data is allocated to the smallest address of the data field (as shown in figure 2-7)

Data is written to the EEL block in the order of SoR -> data field -> EoR. If write processing does not end successfully, the immediately previous data becomes valid.

Note1: The total size of the reference consumed by each stored data is 2 bytes. This should be considered when evaluating the free space in a block before writing the data through the EEL_GetSpace function.

Note2: No checksum is added to user data. If a checksum is needed, add it to user data and check through the user program.

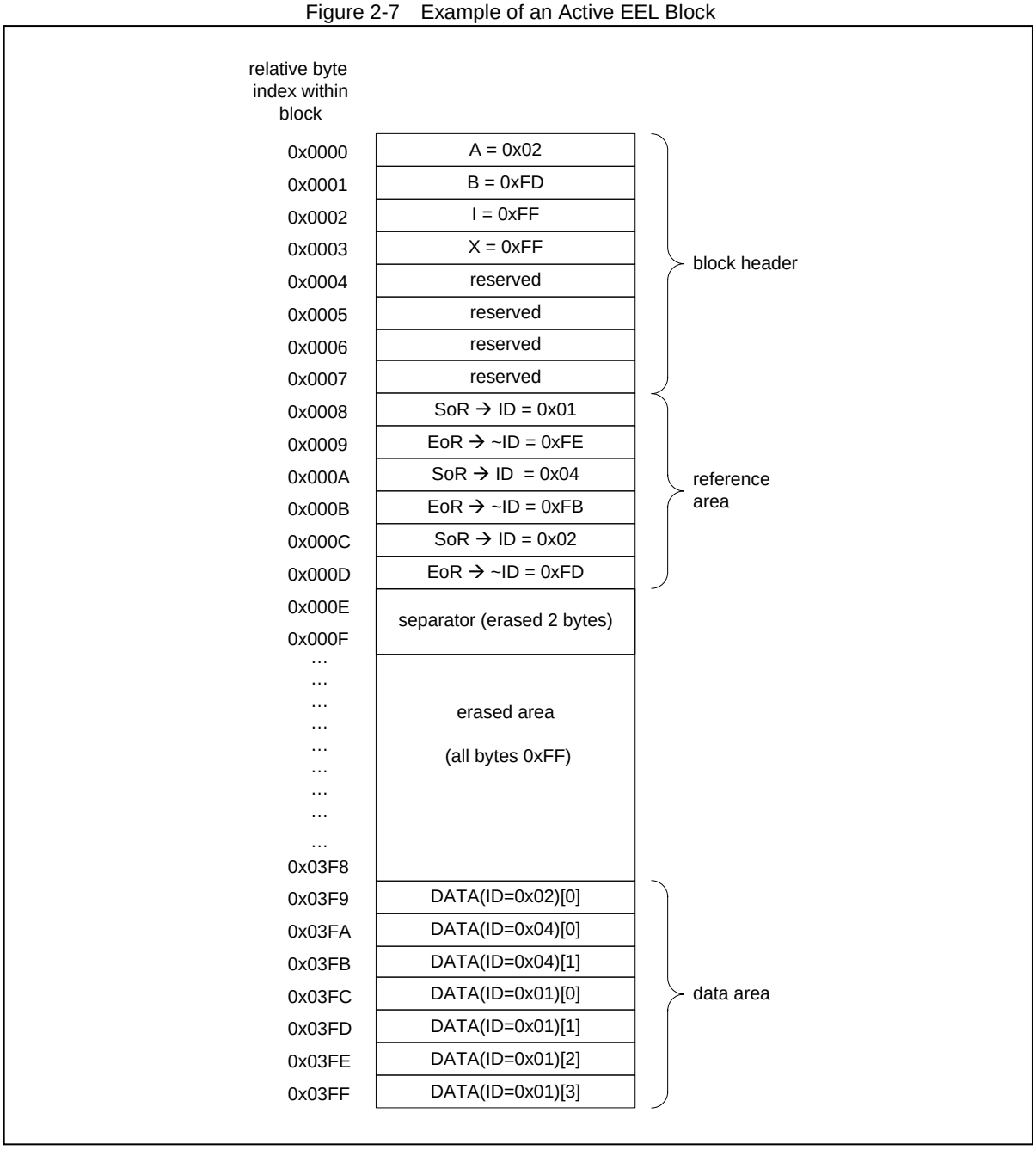
2. 3. 6 EEL Block Overview

Figure 2-7 shows an example of an EEL block that contains multiple units of stored data:

- •Data ID 0x01 with size = 0x04,
- •Data ID 0x02 with size = 0x01
- •Data ID 0x03 is defined but not written here,
- •Data ID 0x04 with size = 0x02

The data have been written in the sequence ID 0x01 -> ID 0x04 -> ID 0x02. In this example, the data with ID 0x03 has not been written yet.

Figure 2-7 Example of an Active EEL Block



Chapter 3 EEL Functional Specifications

This chapter describes the functional specifications of the EEL required for the user to execute EEPROM emulation.

3.1 EEL Functions / Commands of the EEL_Execute Function

The table below summarizes the EEL functions offered by the EEL.

Table 3-1 EEL Functions

EEL function name	Functional overview
FDL_Init	Initializes the FDL.
FDL_Open	Preparation processing of FDL
FDL_Close	End processing of FDL
EEL_Init	Initializes the EEL
EEL_Open	Preparation processing of EEL
EEL_Close	End processing of EEL
EEL_Execute	Manipulates data flash with commands. Command : EEL_CMD_STARTUP EEL_CMD_WRITE EEL_CMD_READ EEL_CMD_REFRESH EEL_CMD_VERIFY EEL_CMD_FORMAT EEL_CMD_SHUTDOWN
EEL_Handler	Controls the EEL while it is running.
EEL_GetSpace	Checks free space in the EEL block
EEL_GetVersionString	Obtains EEL version information.

With the EEL_Execute function, the following commands can be executed.

3. 1. 1 EEL_CMD_STARTUP command [Startup processing]

This checks the block status and sets the system to the EEPROM emulation start (started) state.

3. 1. 2 EEL_CMD_SHUTDOWN command [Shutdown processing]

Set the EEPROM emulation operation to the stopped state (opened).

3. 1. 3 EEL_CMD_REFRESH command [Refresh processing]

The latest stored data is copied from the active block (copy source block) to the next block (copy destination block) in the EEL pool after the erase processing. This makes the copy destination block active.

3. 1. 4 EEL_CMD_FORMAT command [Format processing]

This initializes (erases) everything, including the data recorded in the EEL blocks. Be sure to use this command before using EEPROM emulation for the first time.

3. 1. 5 EEL_CMD_WRITE command [Write processing]

Write the specified data to an EEL block.

3. 1. 6 EEL_CMD_READ command [Read processing]

Read the specified data from an EEL block.

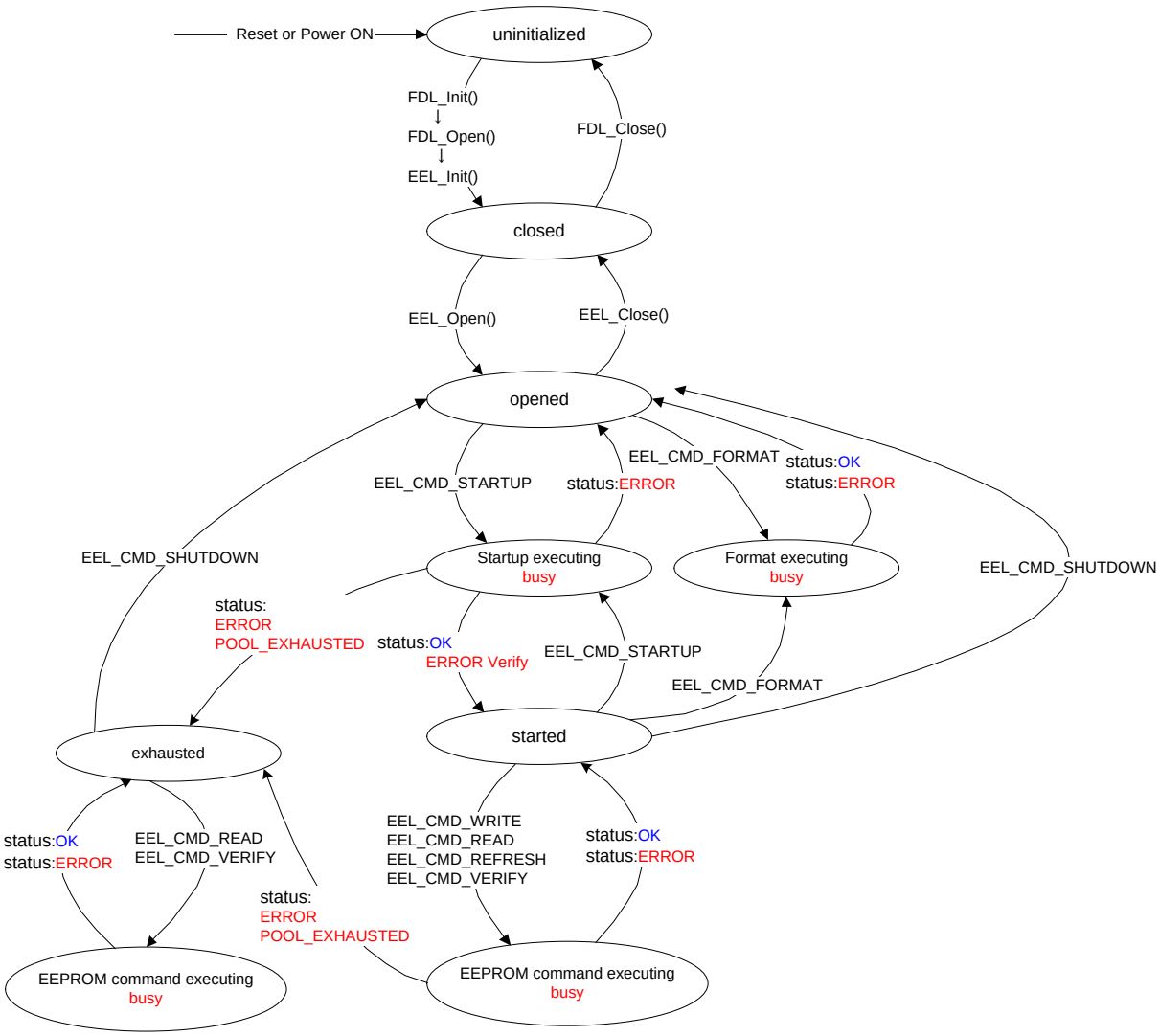
3. 1. 7 EEL_CMD_VERIFY command [Verify processing]

This command performs internal verification to check signal levels of the active block.

3.2 State Transitions

To use EEPROM emulation from a user-created program, it is necessary to initialize the EEL and execute functions that perform operations such as reading and writing on EEL blocks. Figure 3-1 shows the overall state transitions, and Figure 3-2 shows an operation flow for using basic features. When using EEPROM emulation, incorporate EEPROM emulation into user-created programs by following this flow.

Figure 3-1 State transitions diagram



Note 1: EEL_Close and EEL_Init can be called from every state. Please note however, that this interrupts any EEL processing and can lead to unpredictable behavior.

Note 2: Once the EEL_CMD_FORMAT command is started, be sure to finish it.

[Overview of state transitions diagram]

To use EEL to manipulate the data flash memory, it is necessary to execute the provided functions in order to advance the processing.

(1) uninitialized

This is the state after turning the power on or resetting.

(2) closed

This is the state in which the data to perform EEPROM emulation is initialized by executing the FDL_Init, FDL_Open, and EEL_Init functions (no ongoing operation to the data flash memory).

To execute FSL, STOP mode, or HALT mode processing after executing EEPROM emulation, execute EEL_Close in the opened state to switch to the closed state.

(3) opened

This state is switched to by executing EEL_Open in the closed state and makes it possible to perform operations on the data flash memory. It is not possible to execute FSL, STOP mode, or HALT mode processing until EEL_Close is executed and the system switches to the closed state.

(4) started

This state is switched to by executing the EEL_CMD_STARTUP command in the opened state and makes it possible to execute EEPROM emulation. Writes and reads that use EEPROM emulation are performed in this state.

(5)exhausted

This state is made from the opened or started state when continuously usable EEL blocks have been exhausted during command execution. In this state, only EEL_CMD_READ, EEL_CMD_VERIFY, and EEL_CMD_SHUTDOWN commands are executable.

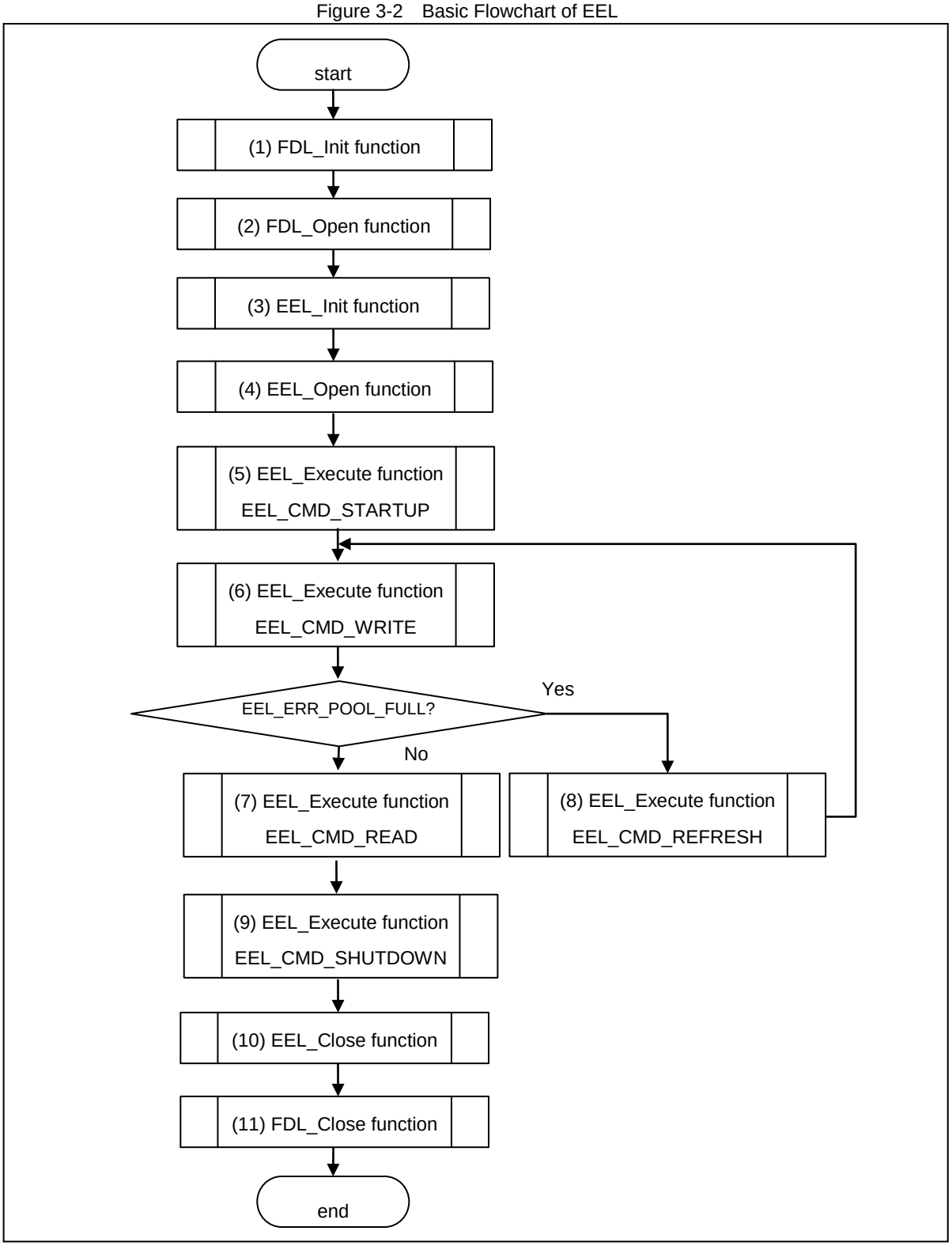
(6) busy

This is the state used when executing a specified command. The state that is switched to differ depending on which command is executed and how it terminates.

3.3 Basic Flowchart

Figure 3-2 below shows the basic procedure to perform read and write operations for the data flash by using the EEL.

Figure 3-2 Basic Flowchart of EEL



Note 1: When using the EEPROM emulation for the first time, be sure to execute the EEL_CMD_FORMAT command.

Note 2: Error processing is omitted in the above flowchart.

[Overview of basic operation flow]

(1)FDL initialization processing (FDL_Init)

Because it is necessary to initialize the FDL parameters (RAM) if using the EEL to access the data flash memory, the FDL_Init function must be executed in advance. If FSL processing was executed after this initialization finished, the initialization processing must be re-executed.

(2) FDL preparation processing (FDL_Open)

Set the Data Flash Control Register (DFLCTL) to the state where accessing the data flash memory is permitted(DFLEN = 1).

(3) EEL initialization processing (EEL_Init)

Initialize the parameters (RAM) used by the EEL.

(4) EEPROM emulation preparation processing (EEL_Open)

Set the data flash memory to a state (opened) for which control is enabled to execute EEPROM emulation.

(5) EEPROM emulation execution start processing (EEL_Execute: EEL_CMD_STARTUP command)

Set the system to a state (started) in which EEPROM emulation can be executed.

(6) EEPROM emulation data write processing (EEL_Execute: EEL_CMD_WRITE command)

Write the specified data to an EEL block.

(7) EEPROM emulation data read processing (EEL_Execute: EEL_CMD_READ command)

Read the specified data from an EEL block.

(8) EEPROM emulation refresh processing (EEL_Execute: EEL_CMD_REFRESH command)

The latest stored data is copied from the active block (copy source block) to the next block (copy destination block) in the EEL pool after the erase processing. This makes the copy destination block active

(9) EEPROM emulation execution stop processing (EEL_Execute: EEL_CMD_SHUTDOWN command)

Set the EEPROM emulation operation to the stopped state (opened).

(10) EEPROM emulation end processing (EEL_Close)

Set the data flash memory to a state (closed) for which control is disabled to stop EEPROM emulation.

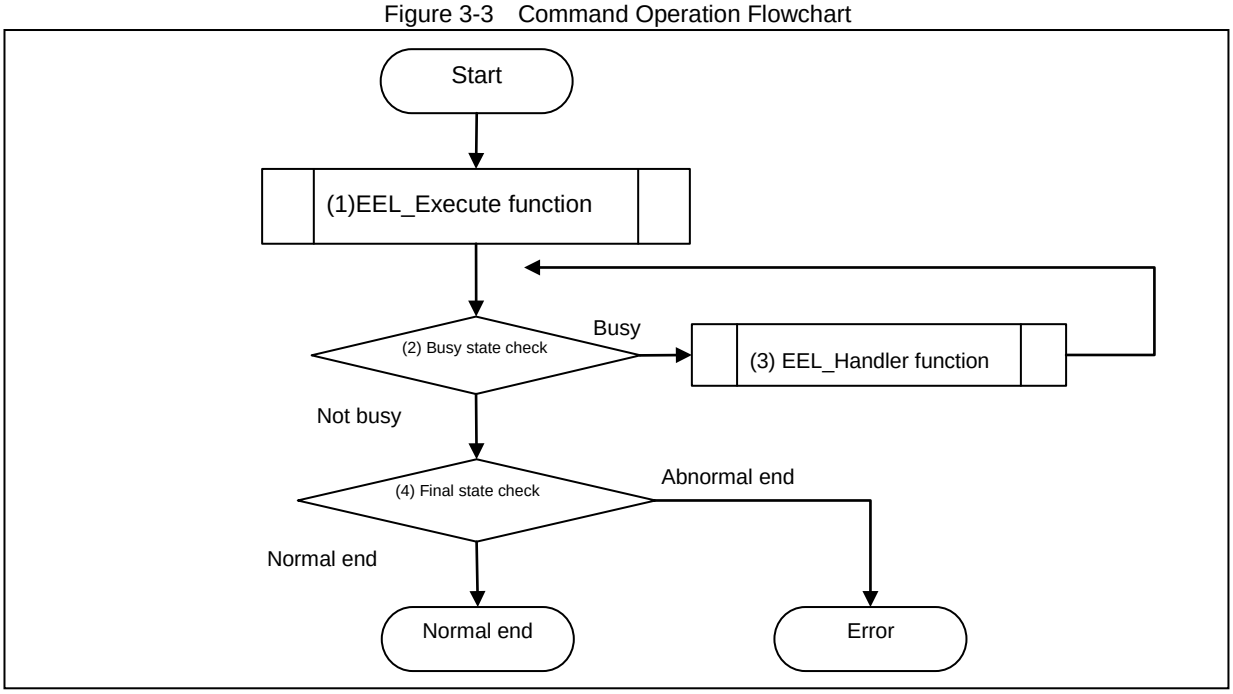
(11) FDL end processing (FDL_Close)

Set the Data Flash Control Register (DFLCTL) to the state where accessing the data flash memory is inhibited (DFLEN = 0).

3.4 Command Operation Flowchart

The figure below shows the basic procedure to perform read and write operations for data flash by using the EEL.

Figure 3-3 Command Operation Flowchart



(1) EEL_Execute function

Perform operations for data Flash.

(2) Busy state check

Check status_enu of the request structure (eel_request_t). When status_enu is EEL_BUSY, continue the data flash operation. If status_enu is other than EEL_BUSY, terminate the data flash operation with an error.

(3) EEL_Handler function

Control the EEL while it is running. By repeating the execution of the EEL_Handler function, continue the data flash operation.

(4) Final state check

If the final state is EEL_OK, the operation ends normally. Otherwise, it will be terminated with an error.

3.5 BGO（Back Ground Operation）function

The EEL_Execute function starts command processing and then immediately returns the control to the user program. This allows the user program to run during the data flash operation and so is called back ground operation (BGO).

The data flash read or write command processing is started by executing the EEL_Execute function, and the processing is continued and completed by executing the EEL_Handler function. For this reason, the EEL_Handler function must be executed continuously until the processing is completed.

To see if the processing requested from the EEL_Execute function has been successfully completed, call the EEL_Handler function from the user program and check the status of ongoing processing.

The EEL_CMD_SHUTDOWN command does not require calling of the EEL_Handler function. However, we recommend that you follow the command operation flowchart shown in figure 3-3.

Chapter 4 Using EEPROM Emulation

EEPROM emulation can store a maximum of 64 [Note] data items each consisting of 1 to 255 bytes in the flash memory by using three or more blocks (recommended) of flash memory.

EEPROM emulation can be executed by incorporating the EEL into a user-created program and executing that program.

Note: For details about the number of user data items that can be stored, see 4.2 Number of stored user data items and total user data size.

4.1 Caution Points

EEPROM emulation is achieved by using a feature for manipulating the on-board microcontroller data flash memory. Therefore, it is necessary to note the following

Table 4-1 Points for Caution (1/2)

No	Caution Points
1	All EEL codes and constants must be placed in the same 64-Kbyte flash block.
2	Initialization by the FDL_Init function must be performed before the FDL_Open, FDL_Close, or any EEL function is executed.
3	The EEL must be initialized by the EEL_Init function before any EEL function is executed.
4	The data flash memory cannot be read during data flash memory operation by the EEL.
5	Do not execute STOP mode or HALT mode processing while the EEPROM emulation is being used. If it is necessary to execute STOP mode or HALT mode processing, be sure to execute all of the processing up to and including the EEL_Close function and FDL_Close function to finish EEPROM emulation.
6	The watchdog timer does not stop during the execution of the EEL.
7	The request structure (eel_request_t) must be placed at an even address.
8	Do not destroy the request structure (eel_request_t) during command execution.
9	Initialize the argument (RAM) that is used by the EEPROM emulation library function. When not initialized, a RAM parity error is detected and the RL78 microcontroller might be reset. For a RAM parity error, refer to the user's manual of the target RL78 microcontroller.
10	All members of the request structure (eel_request_t) must be initialized once before a command is executed. If any unused member exists in the request structure (eel_request_t), set a desired value for the member. If any member is not initialized, the RL78 microcontroller may be reset due to a RAM parity error. For details, see the User's Manual: Hardware for the RL78 microcontroller in use.
11	The EEL does not support multitask execution. Do not execute the EEL functions during interrupt processing.

Table 4-2 Points for Caution (1/2)

No	Caution Points
12	After the FDL_Close and EEL_Close functions have been executed, the requested command and ongoing command stop and cannot be resumed. Before calling the FDL_Close and EEL_Close functions, finish all ongoing commands.
13	Before using the EEPROM emulation library, always close the FSL. Also, do not run the FSL while the EEPROM emulation library is being used. When using the FSL, be sure to execute all of the processing up to and including the EEL_Close function and FDL_Close function to finish EEPROM emulation. When using EEPROM emulation after executing FSL processing, it is necessary to start processing from the initializing function (the FDL_Init function).
14	Before starting the EEPROM emulation, be sure to start up the high-speed on-chip oscillator first. The high-speed on-chip oscillator must also be activated when using the external clock.
15	In address above 0xFFE20 (0xFE20), do not place data buffer (argument) or stack which is used by EEL functions and FDL functions.
16	When using data transfer controller (DTC) during EEPROM emulation, do not place RAM area used by DTC in self-RAM and in address above 0xFFE20 (0xFE20).
17	Until EEPROM emulation is finished, do not corrupt RAM area (including self-RAM) used by EEPROM emulation.
18	No checksum is added to user data. If a checksum is needed, add it to user data and check through the user program.
19	When the FDL descriptor or EEL descriptor is changed, the EEPROM emulation can no longer be executed. In that case, the EEL pool must be formatted by the EEL_CMD_FORMAT command in addition to initialization of FDL and EEL. When adding data, however, the EEPROM emulation can be continuously executed.
20	Do not operate the Data Flash Control Register (DFLCTL) during the execution of the EEL.
21	To use the data flash memory for EEPROM emulation, it is necessary to execute the EEL_CMD_FORMAT command upon first starting up to initialize the data flash memory and make it usable as EEPROM emulation blocks.
22	It is recommended that at least three blocks be provided in the data flash memory to use the EEL.
23	Do not destroy EEL blocks by the user program that uses other EELs or FDLs.
24	The EEL does not support multitask execution. When executing an EEL function on the OS, do not execute in from two or more tasks.
25	About an operation frequency of RL78 microcontrollers and an operation frequency value set by the initializing function (FDL_Init), be aware of the following points: -When using a frequency lower than 4 MHz as an operation frequency of RL78 microcontrollers, only 1 MHz, 2 MHz and 3 MHz can be used (frequencies other than integer values like a 1.5 MHz cannot be used). Also, set an integer value 1, 2, or 3 to the operation frequency value set by the initializingfunction. - When using a frequency of 4 MHz or higher Note1 as an operation frequency of RL78 microcontrollers, a certain frequency can be used as an operation frequency of RL78 microcontrollers. - This operation frequency is not the frequency of the high-speed on-chip oscillator.

Note 1: For a maximum frequency, see the target RL78 microcontroller user's manual.

4.2 Number of stored user data items and total user data size

The total size of user data that can be used in the EEPROM emulation is limited. The size required for writing all user data to an EEL block must be within 1/2 of the block. Therefore, the number of stored data items that can be used differs depending on the size of user data that is actually stored. The following shows how to calculate the size that can be used when actually writing user data, as well as the total user data size.

[Maximum usable size of one block that can be used to write the user data]

Size of one block of data flash memory: 1024 bytes
Size required for EEPROM emulation block management: 8 bytes
Free space necessary as termination information (separator): 2 bytes

Maximum usable size of one block = 1024 bytes - 8 bytes - 2 bytes = 1014 bytes

[Maximum size and recommended size]

Data must be held in one block. Therefore, the maximum size is the maximum usable size of one block but the following relational expression should be met. To enable all data to be updated at least once, we recommend that the data be within the half size of the maximum usable size of one block.

Maximum size = the basic total user data size + maximum data size + 2 ≤ 1014
(Assumed that the largest data can be updated once after all data have been written.)

Recommended size = 1014 / 2
(Assumed that all data can be updated once after all data have been written.)

[Calculating the size for writing each user data item][Note]

Size of each written user data item = data size + reference data size (2 bytes)
Note: For details, see 2.3.5 Structure of Stored Data.

[Calculating the basic total user data size]

Basic total size = (user data 1 + 2) + (user data 2 + 2) ... + (user data n + 2)

4.3 Initial Values to be set by User

As the initial values for the EEL, be sure to set the items indicated below. In addition, before executing the EEL, be sure to execute the high-speed on-chip oscillator. The high-speed on-chip oscillator must also be activated when using the external clock.

・Number of stored data items, and specific data IDs and data size

<Data flash library user include file (fdl_descriptor.h)> Note 1,2

```
#define   FDL_SYSTEM_FREQUENCY    32000000    :(1) Operation frequency
#define   FDL_WIDE_VOLTAGE_MODE               :(2) Voltage mode
#define   FDL_POOL_BLOCKS         0           :(3) FDL pool size
#define   EEL_POOL_BLOCKS         4           :(4) EEL pool size
```

<EEPROM emulation library user include file (eel_descriptor.h)>Note 1, 2

```
#define   EEL_VAR_NO      8                   :(5)  Number of stored data items
```

<EEPROM emulation library user program file (eel_descriptor.c)>Note 2

```
__far const eel_u08 eel_descriptor[EEL_VAR_NO+2] =
{
 (eel_u08)(EEL_VAR_NO),  /* variable count   */  ¥
 (eel_u08)(sizeof(type_A)),  /* id=1           */  ¥
 (eel_u08)(sizeof(type_B)),  /* id=2           */  ¥
 (eel_u08)(sizeof(type_C)),  /* id=3           */  ¥
 (eel_u08)(sizeof(type_D)),  /* id=4           */  ¥
 (eel_u08)(sizeof(type_E)),  /* id=5           */  ¥
 (eel_u08)(sizeof(type_F)),  /* id=6           */  ¥
 (eel_u08)(sizeof(type_X)),  /* id=7           */  ¥
 (eel_u08)(sizeof(type_Z)),  /* id=8           */  ¥
 (eel_u08)(0x00),        /* zero terminator   */  ¥
};
```

:(6) Data size of the identifier (data ID)

Note 1: The macros and macro names that are being used have common parameters with the EEL, so changes should be made to numerical values only.

Note 2: After initializing the EEPROM emulation blocks (after executing the EEL_CMD_FORMAT command), do not change the values. If the values are changed, reinitialize the EEL blocks (by executing the EEL_CMD_FORMAT command).

(1) Operation frequency

This sets an operation frequency which is used in RL78 microcontrollers. Note1

The setting value is set to the FDL_Init frequency parameter by the following expressions (The frequency is calculated by raising its decimals. The result calculated omits its decimals.).

Setting value of FDL_Init operation frequency = ((FDL_SYSTEM_FREQUENCY + 999999)/1000000)

Ex.1: When FDL_SYSTEM_FREQUENCY is 20000000 (20 MHz),
((20000000 + 999999)/10000000) = 20.999999 = 20

Ex.2: When FDL_SYSTEM_FREQUENCY is 4500000 (4.5 MHz),
((4500000 + 999999)/10000000) = 5.499999 = 5

Ex.3: When FDL_SYSTEM_FREQUENCY is 5000001 (5.000001 MHz),
((5000001 + 999999)/10000000) = 6.000000 = 6

Note1: This setting is a value required to control data flash memory. This setting does not change the operation frequency of RL78 microcontrollers. In addition, this operation frequency is not the frequency of the high-speed on-chip oscillator.

(2) Voltage mode Note 2

This sets the voltage mode of data flash memory. Note 3

When FDL_WIDE_VOLTAGE_MODE is not defined: Full-speed mode

When FDL_WIDE_VOLTAGE_MODE is defined: Wide voltage mode

Note 2: The FDL_WIDE_VOLTAGE_MODE is commented out and not defined in the initial setting. To use RL78 microcontrollers in the wide voltage mode, cancel the comment-out to define the mode.

Note 3: For details of the voltage mode, see the corresponding RL78 microcontrollers user's manual.

(3) FDL pool size

Specify 0.

(4) EEL pool size **Note 4**

The number of blocks in the data flash memory of the target device must be specified as the number of blocks in the EEL pool.

Note 4: Specify 3 (3 blocks) or a greater value (recommended).

(5) Number of stored data items

Specify the number of data items to be used in the EEPROM emulation. A value of 1 to 64 can be set.

(6) Data size of each data identifier (data ID)

A table to define the data size of each identifier is provided below. This is called an EEL descriptor table. The EEL can only add identifiers while the program is running. Data to be written must be registered in the EEL descriptor table in advance.

Figure 4-1 EEL Descriptor Table (When there are eight different data)

__far const eel_u08 eel_descriptor [Number of stored data items + 2]

EEL_VAR_NO
Byte size of data ID1
Byte size of data ID2
Byte size of data ID3
Byte size of data ID4
Byte size of data ID5
Byte size of data ID6
Byte size of data ID7
Byte size of data ID8
0x00

・EEL_VAR_NO

User-specified number of data items used in the EEL

・Byte size of Data IDx

User-specified size of user data (in bytes)

・Termination area (0x00)

Specify 0 as the termination information.

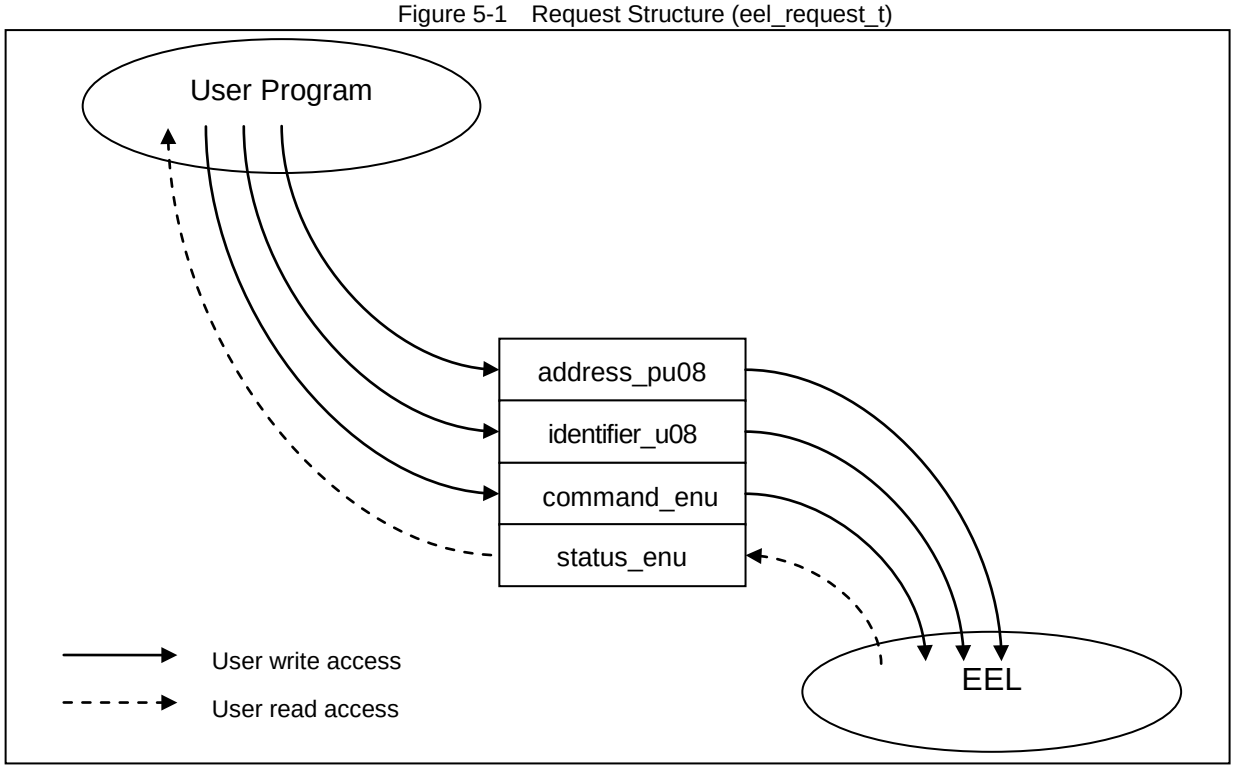
Chapter 5 User Interface

5. 1 Request Structure (eel_request_t) Settings

Basic operations such as reading from and writing to the data flash are performed by a single function. The function transfers commands and data ID to the EEL via the request structure (eel_request_t). Furthermore, the EEL state and error information are acquired via the request structure (eel_request_t).

In subsequent sections, write access to the request structure (eel_request_t) from the user is called user write access, and read access to it from the user is called user read access.

Figure 5-1 Request Structure (eel_request_t)

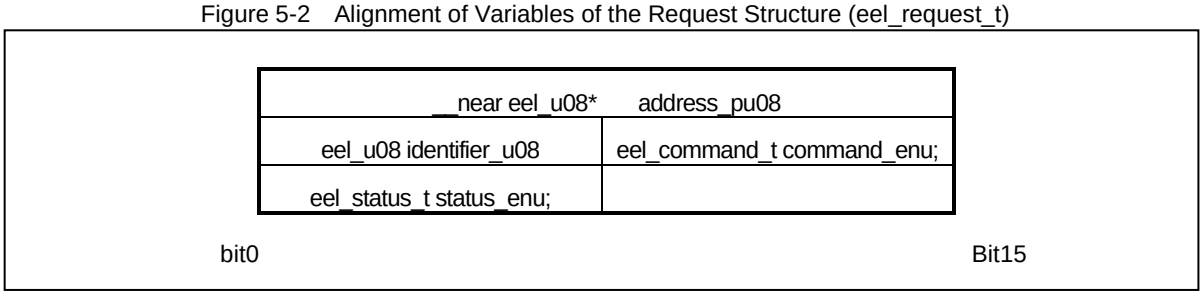


The request structure (eel_request_t) is defined in the eel_types.h file. It should not be changed by the user.

[Definition of the request structure (eel_request_t)]

```
typedef struct
{
    __near eel_u08*          address_pu08;
           eel_u08           identifier_u08;
           eel_command_t     command_enu;
           eel_status_t      status_enu;
} eel_request_t;
```

Figure 5-2 Alignment of Variables of the Request Structure (eel_request_t)



5.1.1 User Write Access

(1) address_pu08

Specify the start address of the data buffer used for EEL_CMD_WRITE command and EEL_CMD_READ command execution.

Associated command (macro name)	Setting
EEL_CMD_WRITE	Start address of the data buffer[Note 1]
EEL_CMD_READ	Start address of the data buffer[Note 2]

Note 1: Buffer which contains data written by the user

Note 2: Buffer which contains data read from the data flash

(2) identifier_u08

Specify the data ID used for each command. For more information about how to do this, see the description of the EEL_ Execute function in section 5.4, EEL Functions.

Associated command (macro name)	Setting
EEL_CMD_WRITE	ID of write data
EEL_CMD_READ	ID of read data

(3) **command_enu**

Commands to be set in the common executable function.

Associated command (macro name)	Description
EEL_CMD_STARTUP	Startup processing
EEL_CMD_WRITE	Write processing
EEL_CMD_READ	Read processing
EEL_CMD_REFRESH	Refresh processing
EEL_CMD_VERIFY	Verify processing
EEL_CMD_FORMAT	Format processing
EEL_CMD_SHUTDOWN	Shutdown processing

5.1.2 User Read Access

- **status_enu**

EEL status and error information. For information about the status and errors which might occur during the execution of the functions, see the description of the EEL_Execute function in section 5.4, EEL Functions.

5. 2 EEL Function Calls

This section describes how to call the EEL functions from a user program written in C or assembly language.

- C language

When an EEL function is called from a user program in C language in the same way as a normal C function is called, the EEL function's parameters are passed to the EEL as arguments and the required processing is performed.

- Assembly language

Before calling an EEL function from a user program in assembly language, take necessary procedures (such as setting parameters or return addresses) based on the function-calling rules for the C compiler package used by the user as a development environment. The EEL function's parameters are passed to the EEL as arguments and the required processing is performed.

Remarks 1: To call the EEL functions offered by the EEL from a user program, you should define the following standard header file and include it in that program:

C language

fdl.h: FDL header file

fdl_types.h: FDL definition setting header file

eel.h: EEL header file

eel_types.h: EEL definition setting header file

Assembly language

fdl.inc: FDL header file

eel.inc: EEL header file

eel_types.inc: EEL definition setting header file

Remarks 2: If an EEL function other than EEL_Init is called before EEL_Init is called, the correct operation is not guaranteed.

Remarks 3: If an EEL function other than FDL_Init is called before FDL_Init is called, the correct operation is not guaranteed.

5. 3 Data Types

Below are the data types of the parameters to be specified for calling the EEL functions offered by the EEL.

Macro name	Description
eel_u08	Unsigned 8-bit integers (unsigned char)
eel_u16	Unsigned 16-bit integers (unsigned short)
eel_u32	Unsigned 32-bit integers (unsigned long)

5. 4 EEL Function

The subsequent sections describe the EEL functions offered by the EEL. These functions appear in the following format.

Name

[Function]

Describes the function overview of this function.

[Format]

<C language>

Describes the format to call this function from a user program described in the C language.

<Assembler>

Describes the format to call this function from a user program described in the Assembly language.

[Pre-conditions]

Describes the precondition of this function.

[Post-conditions]

Describes the post condition of this function.

[Cautions]

Describes the cautions of this function.

[Register status after calling this function]

Describes the register status after this function is called.

[Arguments]

Describes the argument of this function.

[Return values]

Describes the return values from this function.

FDL_Init

[Function]
FDL initialization processing

[Format]
<C language>

```
fdl_status_t __far FDL_Init(const __far fdl_descriptor_t* descriptor_pstr)
```

<Assembler>

```
CALL !FDL_Init or CALL !!FDL_Init
```

Remark Call this function by using ! if placing the FDL at 00000H to 0FFFFH or by using !! if not.

[Pre-conditions]

1. The FSL and EEL processing must be either not executing or finished.
2. The high-speed on-chip oscillator has been started up.

[Post-conditions]

Execute the FDL_Open function.

[Cautions]

1. Be sure to execute this function when starting EEPROM emulation to make it possible to start accessing the data flash memory.
2. This function is mutually exclusive with the FSL. Before executing this function, be sure to end FSL. Also, never use any FSL functions during EEPROM emulation.
3. To use FSL after this function is executed, the RAM must be reinitialized, so always execute this function when restarting the EEL.
4. To execute this function again, always be sure to end EEL.
5. The descriptor table used for this function cannot be modified. Be sure to use a defined descriptor table.

[Register status after calling this function]

Return Value : C

Corrupted registers: AX (argument), BC (argument)

[Arguments]

Argument	Type	Description
descriptor_pstr	fdl_descriptor_t* (far)	Pointer to the descriptor table

[Return values]

Type	Symbol Definition	Description
fdl_status_t	FDL_OK	Normal end
	FDL_ERR_CONFIGURATION	Initialization error. The setting is incorrect. Or high-speed on-chip oscillator does not run. Make sure that the defined data has not been changed and the high-speed on-chip oscillator has been started up.

Remark Assembly language return values are stored in register C.

FDL_Open

[Function]
FDL preparation processing

Set the Data Flash Control Register (DFLCTL) to the state where accessing the data flash memory is permitted (DFLEN = 1).

[Format]
<C language>

```
void __far FDL_Open(void)
```

<Assembler>

```
CALL !FDL_Open or CALL !!FDL_Open
```

Remark Call this function by using ! if placing the FDL at 00000H to 0FFFFH or by using !! if not.

[Pre-conditions]

The FDL_Init function must have finisehed normally.

[Post-conditions]

Execute the EEL_Init function.

[Cautions]

None

[Register status after calling this function]

No registers are corrupted.

[Arguments]

None

[Return values]

None

FDL_Close

[Function]

FDL end processing

Set the Data Flash Control Register (DFLCTL) to the state where access to the data flash memory is inhibited (DFLEN = 0). All ongoing EEL processing stop.

[Format]

<C language>

```
void __far FDL_Close(void)
```

<Assembler>

```
CALL !FDL_Close or CALL !!FDL_Close
```

Remark Call this function by using ! if placing the FDL at 00000H to 0FFFFH or by using !! if not.

[Pre-conditions]

The FDL_Init, FDL_Open, EEL_Init, EEL_Open, and EEL_Close functions must have finished normally.

[Post-conditions]

None

[Cautions]

None

[Register status after calling this function]

No registers are corrupted.

[Arguments]

None

[Return values]

None

EEL_Init

[Function]
Processing to initialize the RAM used for EEPROM emulation

[Format]
<C language>

```
eel_status_t   __far EEL_Init (void)
```

<Assembler>

```
CALL !EEL_Init or CALL !!EEL_Init
```

Remark Call this function by using ! if placing the EEL at 00000H to 0FFFFH or by using !! if not.

[Pre-conditions]

1. The FSL and the EEL processing must be either not executing or finished.
2. The FDL_Init and FDL_Open function must have finished normally.

[Post-conditions]

Execute the EEL_Open function.

[Cautions]

1. When starting EEPROM emulation, always execute this function to initialize the RAM to be used.
2. This function is mutually exclusive with FSL. Before executing this function, be sure to close FSL. Also, never use any FSL functions during EEPROM emulation.
3. To use FSL after this function is executed, the RAM must be reinitialized, so always execute this function when restarting EEL.
4. To execute this function again, always close EEL.

[Register status after calling this function]

Return values: C

[Arguments]

None

[Return values]

Type	Symbol Definition	Description
eel_status_t	EEL_OK	Normal end
	EEL_ERR_CONFIGURATION	Initialization error. The EEL cannot be executed with the values set by the FDL_Init and EEL_Init functions. Check the current setting referring to section 4.3, Initial Values to be set by User.

Remark Assembly language return values are stored in register C.

EEL_Open

[Function]

EEPROM emulation preparation processing

This function makes the EEPROM emulation executable.

[Format]

<C language>

```
void   __far EEL_Open(void)
```

<Assembler>

```
CALL !EEL_Open or CALL !!EEL_Open
```

Remark Call this function by using ! if placing the EEL at 00000H to 0FFFFH or by using !! if not.

[Pre-conditions]

1. The FDL_Init, FDL_Open, and EEL_Init functions must have finished normally.
2. If EEPROM emulation was executed, the processing up to EEL_Close and FDL_Close function must be executed to stop the EEPROM Emulation processing.

[Post-conditions]

None

[Cautions]

After the EEL_Open function is executed and the EEPROM emulation has been transitioned to the opened state, the FSL cannot be executed. In addition, STOP mode and HALT mode cannot be executed. To execute the FSL, STOP mode, or HALT mode, execute the EEL_Close and FDL_Close functions to transition the EEPROM emulation to the uninitialized state.

[Register status after calling this function]

No registers are corrupted.

[Arguments]

None

[Return values]

None

EEL_Close

[Function]

EEPROM emulation end processing

This function makes the EEPROM emulation unexecutable.

[Format]

<C language>

```
void __far EEL_Close(void)
```

<Assembler>

```
CALL !EEL_Close or CALL !!EEL_Close
```

Remark Call this function by using ! if placing the EEL at 00000H to 0FFFFH or by using !! if not.

[Pre-conditions]

If EEPROM emulation was executed, the EEL_CMD_SHUTDOWN command must be used to set EEPROM emulation to the stopped state (the opened state).

[Post-conditions]

Execute the FDL_Close function to exit the EEPROM emulation.

[Cautions]

None

[Register status after calling this function]

No registers are corrupted.

[Arguments]

None

[Return values]

None

EEL_Execute

[Function]

EEPROM emulation execution function

Each type of processing for performing EEPROM emulation operations is specified for this function as an argument in the command format, and the processing is executed.

[Format]

<C language>

```
void __far EEL_Execute(__near eel_request_t* request_pstr);
```

<Assembler>

```
CALL !EEL_Execute or CALL !!EEL_Execute
```

Remark Call this function by using ! if placing the EEL at 00000H to 0FFFFH or by using !! if not.

[Pre-conditions]

The FDL_Init, FDL_Open and EEL_Init, EEL_Open functions must have finished normally.

[Post-conditions]

1. While status_enu of the request structure (eel_request_t) is EEL_BUSY, execute the EEL_Handler function repeatedly.
2. The EEL_Execute function starts command processing and then immediately returns the control to the user program. The command processing is continued by executing the EEL_Handler function. Therefore, the EEL_Handler function must be executed continuously until the command processing is completed.

[Cautions]

None

[Register status after calling this function]

Corrupted register: AX (argument)

[Arguments]

Argument	Type	Description
request_pstr	eel_request_t* (near)	Pointer to the request structure (eel_request_t)

eel_request_t Details

Member	Type	Description
eel_request_t.address_pu08	eel_u08 * (near)	Pointer to the data buffer for storing write and read data [Note]
eel_request_t.identifier_u08	eel_u08	Parameter for setting command to be executed
eel_request_t.command_enu	eel_command_t	Command to be executed
eel_request_t.status_enu	eel_status_t	Command execution status

Note: Specify this parameter only for a command that requires the parameter. Set up the data buffer size according to the byte sizes of the write and read data.

Execution Commands (eel_command_t)

Command	Description
EEL_CMD_STARTUP	This checks the block status and sets the system to the EEPROM emulation start (started) state. If two active blocks exist, the incorrect block is changed to an invalid block. Be sure to execute this command before executing commands other than the EEL_CMD_FORMAT command and make sure that the command finishes normally.
EEL_CMD_WRITE Note 1	This writes the specified data to the EEL blocks. * The following arguments must be specified prior to execution. ・address_pu08:Specifies the start address of the RAM area where the write data is stored. ・identifier_u08: Specifies the data ID of the write data.
EEL_CMD_READ Note 1	This reads the specified data from the EEL blocks. *The following arguments must be specified prior to execution. ・address_pu08:Specifies the start address of the RAM area where the read data is stored. ・identifier_u08:Specifies the data ID of the read data.
EEL_CMD_VERIFY Note 1,2	This performs internal verification to check signal levels of the active block. This command verifies whether signal levels of flash memory cells are appropriate or not.
EEL_CMD_REFRESH Note1,3	This copies the latest stored data from the active EEL block (copy source block) to the next block (copy destination block) in the EEL pool after the erase processing. This makes the copy destination block active.
EEL_CMD_FORMAT	This initializes (erases) everything, including the data recorded in the EEL blocks. Be sure to use this command before using EEPROM emulation for the first time. Furthermore, use this command to initialize the entire blocks when an error (such as no active block) has occurred in EEL blocks or when modifying values in the descriptor table (unchangeable fixed values). Because EEPROM emulation switches to the stopped state (opened) regardless of the results after the processing finishes, execute the EEL_CMD_STARTUP command to continue using EEPROM emulation.
EEL_CMD_SHUTDOWN Note1	This sets EEPROM emulation to the stopped state (opened).

Note 1: Do not execute this command until the EEL_CMD_STARTUP command has finished normally.

Note 2: This command is not used to perform processing for reading written data and compare it. To compare written data, use the EEL_Execute (EEL_CMD_READ) function through the user program.

Note 3: The erase processing is performed by executing the EEL_CMD_REFRESH command.

Command Execution statuses of EEL_Execute/EEL_Handler (eel_status_t) (1/2)

Command Execution Status	Category	Description	Corresponding Commands
EEL_OK	Meaning	Normal end	All commands
	Cause	None	
	Action to be taken	None	
EEL_BUSY	Meaning	A command is being executed.	All commands
	Cause	None	
	Action to be taken	Keep calling EEL_Handler function until the status changes.	
EEL_ERR_POOL_FULL	Meaning	Pool full error	EEL_CMD_WRITE
	Cause	There is no area that can be used to write the data.	
	Action to be taken	Execute EEL_CMD_REFRESH command and restart writing data.	
EEL_ERR_INITIALIZATION	Meaning	Initialization error	All commands
	Cause	The FDL_Init, FDL_Open, EEL_Init, and EEL_Open functions have not been finished normally.	
	Action to be taken	Normally finish the FDL_Init, FDL_Open, EEL_Init, and EEL_Open functions.	
EEL_ERR_ACCESS_LOCKED	Meaning	EEPROM emulation lock error	Commands other than EEL_CMD_STARTUP and EEL_CMD_FORMAT
	Cause	EEPROM emulation cannot be executed.	
	Action to be taken	Make sure that the EEL_CMD_STARTUP command has finished normally.	
EEL_CMD_UNDEFINED		Command error A command that does not exist has been specified.	---
EEL_ERR_VERIFY	Meaning	When the EEL_CMD_STARTUP command was executed: An error occurred during the internal verification processing for the block header or the finally written data. When the EEL_CMD_VERIFY command was executed: An error occurred during the internal verification processing for the active block.	EEL_CMD_STARTUP EEL_CMD_VERIFY
	Cause	Some signal levels of flash memory cells were not appropriate.	
	Action to be taken	Execute the EEL_CMD_REFRESH command.	
EEL_ERR_PARAMETER	Meaning	Parameter error	All commands
	Cause	An incorrect command parameter has been specified.	
	Action to be taken	Revise the specified parameter.	
EEL_ERR_REJECTED	Meaning	Reject error	All commands
	Cause	A different command is being executed.	
	Action to be taken	Call the EEL_Handler function to terminate the ongoing command.	

Command Execution statuses of EEL_Execute/EEL_Handler (eel_status_t) (2/2)

Command Execution Status	Category	Description	Corresponding Commands
EEL_ERR_NO_INSTANCE	Meaning	No-write-data error	EEL_CMD_READ
	Cause	The specified identifier data has not been written.	
	Action to be taken	Write data to the identifier specified using the EEL_CMD_WRITE command.	
EEL_ERR_POOL_INCONSISTENT	Meaning	EEL block inconsistency error	EEL_CMD_STARTUP
	Cause	An EEL block has the undefined state (such as because there are no active blocks).	
	Action to be taken	Execute the EEL_CMD_FORMAT command to initialize the EEL blocks.	
EEL_ERR_POOL_EXHAUSTED	Meaning	EEL block exhaustion error	EEL_CMD_STARTUP EEL_CMD_FORMAT EEL_CMD_REFRESH EEL_CMD_WRITE
	Cause	There are no more EEL blocks that can be used to continue.	
	Action to be taken	Stop EEPROM emulation. You can try restoration by executing the EEL_CMD_FORMAT command (erasing all existing data) or read existing data.	
EEL_ERR_INTERNAL	Meaning	Internal error	Commands other than EEL_CMD_SHUTDOWN
	Cause	An unexpected error has occurred.	
	Action to be taken	Check the device state.	

[Return values]

None

EEL_Handler

[Function]

Continuous EEPROM emulation execution processing

This function continues executing the EEPROM emulation processing specified for the EEL_Execute function.

[Format]

<C language>

```
void __far EEL_Handler(void);
```

<Assembler>

```
CALL !EEL_Handler or CALL !!EEL_Handler
```

Remark Call this function by using ! if placing the EEL at 00000H to 0FFFFH or by using !! if not.

[Pre-conditions]

1. The FDL_Init, FDL_Open, and EEL_Init,EEL_Open functions must have finished normally.
2. The EEL_Execute function should execute [Note], and status_enu of the request structure (eel_request_t) should be EEL_BUSY.

Note: Execution of the EEL_CMD_SHUTDOWN command does not need execution of the EEL_Handler function. However, we recommend that you follow the command operation flowchart shown in figure 3-3.

[Post-conditions]

While status_enu of the request structure (eel_request_t) is EEL_BUSY, execute this function repeatedly. If the EEL_Handler function is executed while no command is executed, status_enu of of the request structure (eel_request_t) is not updated.

[Cautions]

The command execution status of the EEL_Handler function is set for the ”eel_request_t* request” used as an argument of the EEL_Execute function. Therefore, when using the EEL_Handler function, do not free the “eel_request_t* request” variable. For the execution state of the command specified by the EEL_Handler function, see the list of the EEL_Execute/EEL_Handler command execution state (eel_status_t)

[Register status after calling this function]

No registers are corrupted.

[Arguments]

None

[Return values]

None

EEL_GetSpace

[Function]

This obtains the free EEL block space.

[Format]

<C language>

```
eel_status_t   __far EEL_GetSpace(__near eel_u16* space_pu16)
```

<Assembler>

```
CALL !EEL_GetSpace or CALL !!EEL_GetSpace
```

Remark Call this function by using ! if placing the EEL at 00000H to 0FFFFH or by using !! if not.

[Pre-conditions]

The FDL_Init,FDL_Open,EEL_Init, and EEL_Open functions, and theEEL_Execute function(EEL_CMD_STARTUP command) must have finished normally.

[Post-conditions]

None

[Cautions]

1. When the EEL pool has been exhausted, 0 is always returned to indicate that there is no free space.
2. When an error value is returned, the free space information remains unchanged.

[Register status after calling this function]

Return value: C

Corrupted register: AX (argument)

[Arguments]

Argument	Type	Description
space_pu16	eel_u16* (near)	The address at which the free space information of the current active block is input

[Return values]

Type	Symbol Definition	Description
eel_status_t	EEL_OK	Normal end
	EEL_ERR_INITIALIZATION	EEL_Init has not been executed.
	EEL_ERR_ACCESS_LOCKED	The EEL_CMD_STARTUP command has not finished normally.
	EEL_ERR_REJECTED	A command is being executed.

Remark Assembly language return values are stored in register C.

EEL_GetVersionString

[Function]

This obtains the version information of the EEL.

[Format]

<C language>

```
__far eel_u08*  __far EEL_GetVersionString(void)
```

<Assembler>

```
CALL !EEL_GetVersionString or CALL !!EEL_GetVersionString
```

Remark Call this function by using ! if placing the EEL at 00000H to 0FFFFH or by using !! if not.

[Pre-conditions]

None

[Post-conditions]

None

[Cautions]

None

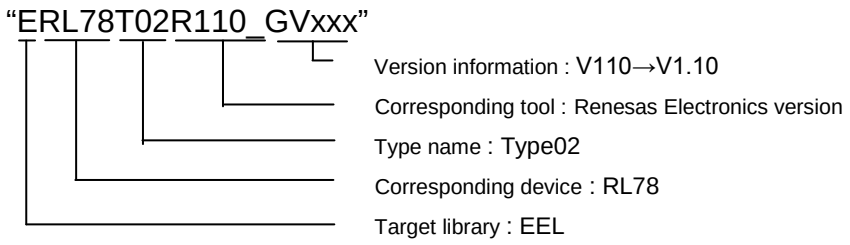
[Register status after calling this function]

None

[Arguments]

None

[Return values]

Type	Description
eel_u08* (far)	The address at which the version information of the EEL is input (24-bit address area) Example: For EEPROM emulation library Pack02 V1.00 (ASCII code) 

Chapter 6 Software Resources and Processing Time

6. 1 Processing Time

This section describes the EEL processing time.

Figure 6-1 shows the concept of EEL function response time and total processing time. The total processing time in the figure is the case of successful completion and does not include the processing time in the case of abnormal end (such as incorrect input data or error). Delay time due to execution of the EEL_Handler function is not included either. If the EEL_Handler function calling interval time is extended, the maximum total processing time may be exceeded.

Figure 6-1 Overview of Processing Time

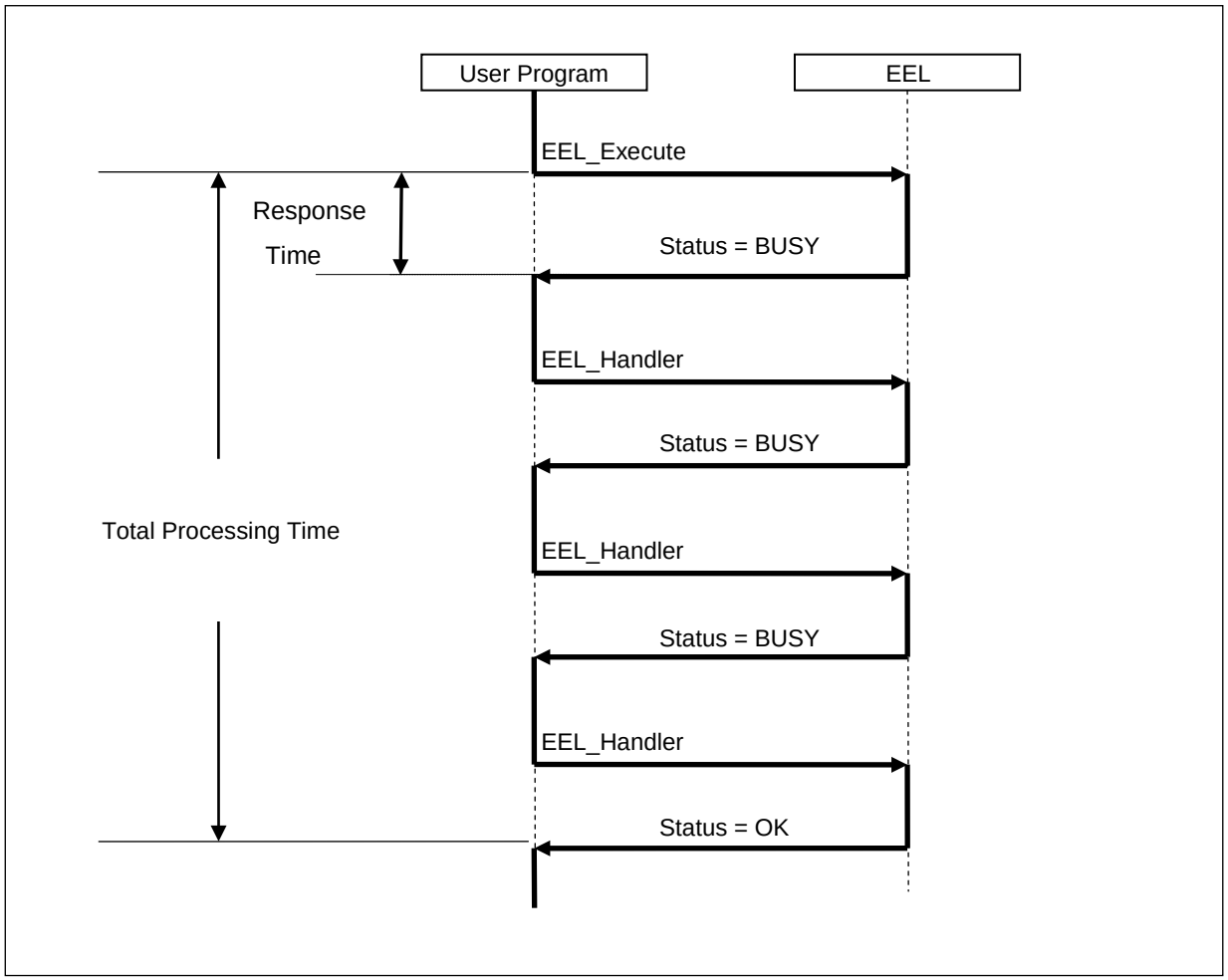


Table 6-1 EEL Function Response Time of EEPROM Emulation Library Pack02

Functions	MAX time(Full Speed Mode)	MAX time(Wide Voltage Mode)
FDL_Init	1199 / fcpu	1199 / fcpu
FDL_Open	27 / fcpu + 14us	27 / fcpu + 14us
FDL_Close	836 / fcpu + 444us	791 / fcpu + 969us
EEL_Init	3268 / fcpu	3268 / fcpu
EEL_Open	14 / fcpu	14 / fcpu
EEL_Close	17 / fcpu	17 / fcpu
EEL_GetSpace	47 / fcpu	47 / fcpu
EEL_GetVersionString	14 / fcpu	14 / fcpu
EEL_Execute	320 / fcpu	320 / fcpu
EEL_Handler	4582 / fcpu	4582 / fcpu

Table 6-2 Total Processing Time of EEPROM Emulation Library Pack 02

Functions	MAX time(Full Speed Mode)	MAX time(Wide Voltage Mode)
EEL_Execute / EEL_Handler		
EEL_CMD_STARTUP	(280530 + 235 * Block Num) / fcpu + 1612 us	(277604 + 235 * Block Num) / fcpu + 8798 us
EEL_CMD_FORMAT	(67102 + 288981 * Block Num) / fcpu + (266627 * Block Num) us	(67102 + 256218 * Block Num) / fcpu + (303359 * Block Num) us
EEL_CMD_REFRESH 1. Finished normally	5163828 / fcpu + 774424 us	5072479 / fcpu + 1421917 us
EEL_CMD_REFRESH 2. REFRESH processing failed until Block Num -1	(1554000 + 7538406 * (Block Num - 1)) / fcpu + (1548404 * (Block Num - 1)) us	(1554000 + 7355752 * (Block Num - 1)) / fcpu + (2842866 * (Block Num - 1)) us
EEL_CMD_VERIFY	30869 / fcpu + 4126 us	19605 / fcpu + 29754 us
EEL_CMD_WRITE	303387 / fcpu + 111858 us	289240 / fcpu + 253342 us
EEL_CMD_READ	5102 / fcpu	5102 / fcpu
EEL_CMD_SHUTDOWN	219 / fcpu	219 / fcpu

Remarks fcpu: CPU/peripheral hardware clock frequency (for example, at 20 MHz, fcpu = 20)

Block Num: Number of EEPROM emulation blocks

6. 2 Software Resources

In the EEL, program areas corresponding to parts of the library to be used, RAM areas for variables to be used in the library, and RAM areas for work area (self-RAM) are used to assign an appropriate program to the user area. Also, since the FDL will be used, the EEL must have a separate area for use by the FDL.

Tables 6-3 and 6-4 list required software resources Note 1, 2. Figures 6-2 and 6-3 show the images of allocating software resources to the RAM.

Table 6-3 Software Resources Used by EEL

Item	Size(byte)	Restrictions on Allocation and Usage Note1,2		
Self-RAM Note3	0 to 1024 Note3	RL78/D1A	RAM 4KB ROM 64KB	FEF00H to FF2FFH
			RAM 16KB ROM 256KB	FBF00H to FC2FFH
		RL78/F12	RAM 4KB ROM 64KB	FEF00H to FF2FFH
		RL78/F13	RAM 4KB ROM 64KB (R5F10AmE (m = 6, A, B, G, L))	FEF00H to FF2FFH
			RAM 8KB ROM128KB	FDF00H to FE2FFH
		RL78/F14	RAM 8KB ROM 96KB (R5F10PmF (m = G, L, M))	FDF00H to FE2FFH
			RAM 20KB ROM 256KB	FAF00H to FB2FFH
		RL78/G13	RAM 4KB ROM 64KB	FEF00H to FF2FFH
			RAM 20KB ROM 256KB (R5F100xJ (x = F, G, J, L, M, P))	FAF00H to FB2FFH
			RAM 32KB ROM 512KB	F7F00H to F82FFH
		RL78/G14	RAM 5.5KB ROM 48KB	FE900H to FECFFH
			RAM 5.5KB ROM 64KB	FE900H to FECFFH
			RAM 24KB ROM 256KB	F9F00H to FA2FFH
		RL78/G1A	RAM 4KB ROM 64KB	FEF00H to FF2FFH
		RL78/I1A	RAM 4KB ROM 64KB	FEF00H to FF2FFH
		RL78/L13	RAM 8KB ROM 128KB	FDF00H to FE2FFH
		RL78/L1C	RAM 16KB ROM 192KB	FBF00H to FC2FFH
			RAM 16KB ROM 256KB	FBF00H to FC2FFH
		ALL Note 1,2	Products other than the above	Contact us.
Stack	80	Can be allocated to a RAM area other than the self-RAM and the area from FFE20H to FFEFFH		
Data buffer Note4	1 to 255			
Request Structure	5			
SADDR RAM work area	SADDR : 3 (fdl:2) (eel:1)	Can be allocated to a short-addressing RAM area		
Library size	3400 (fdl:600) (eel:2800)	Can be allocated to any program area other than the self-RAM and the area from FFE20H to FFEFFH (ROM is recommended)		
Data table	3 to 68			
Fixed-parameter area (default)	14 (fdl:10) (eel:2)			
EEL Blocks	3,072 or more (at least 3 blocks)	Only data flash memory can be used.		

Note 1: Please contact about products added after this document is issued.

2: The RL78/G12, L12 and G1C product does not support the EEL

3: An area used as the working area by the EEL is called self-RAM in this manual and the release note. The self-RAM requires no user setting because it is an area that is not mapped and automatically used at execution of the EEL (previous data is discarded). When the EEL is not used, the self-RAM can be used as a normal RAM space.

For the RL78 microcontroller with self-RAM, the chapter of "memory space" in the user's manual of the RL78 microcontroller has a note on an area (self-RAM) whose usage is prohibited during self-programming. If the above table does not include the target RL78 microcontroller, refer to the user's manual of the target RL78 microcontroller.

4: The data buffer is used as the working area for EEL internal processing or the area where the data to be set is allocated in the EEL_Execute function. The required size depends on the function to be used.

Table 6-4 Data Buffer Size Used by EEL Functions

Function Name	Bytes	Function Name	Bytes
FDL_Init	0	EEL_Close	0
FDL_Open	0	EEL_Execute Note	0 to 255
FDL_Close	0	EEL_Handler Note	0 to 255
EEL_Init	0	EEL_GetSpace	2
EEL_Open	0	EEL_GetVersionString	0

Note: An additional 5-byte area is used by the request structure.

Figure 6-2 Arrangement Example of Self-RAM and Addresses FFE20H to FFEFFH

(RL78/G13: product with 4-Kbyte RAM and 64-Kbyte ROM)

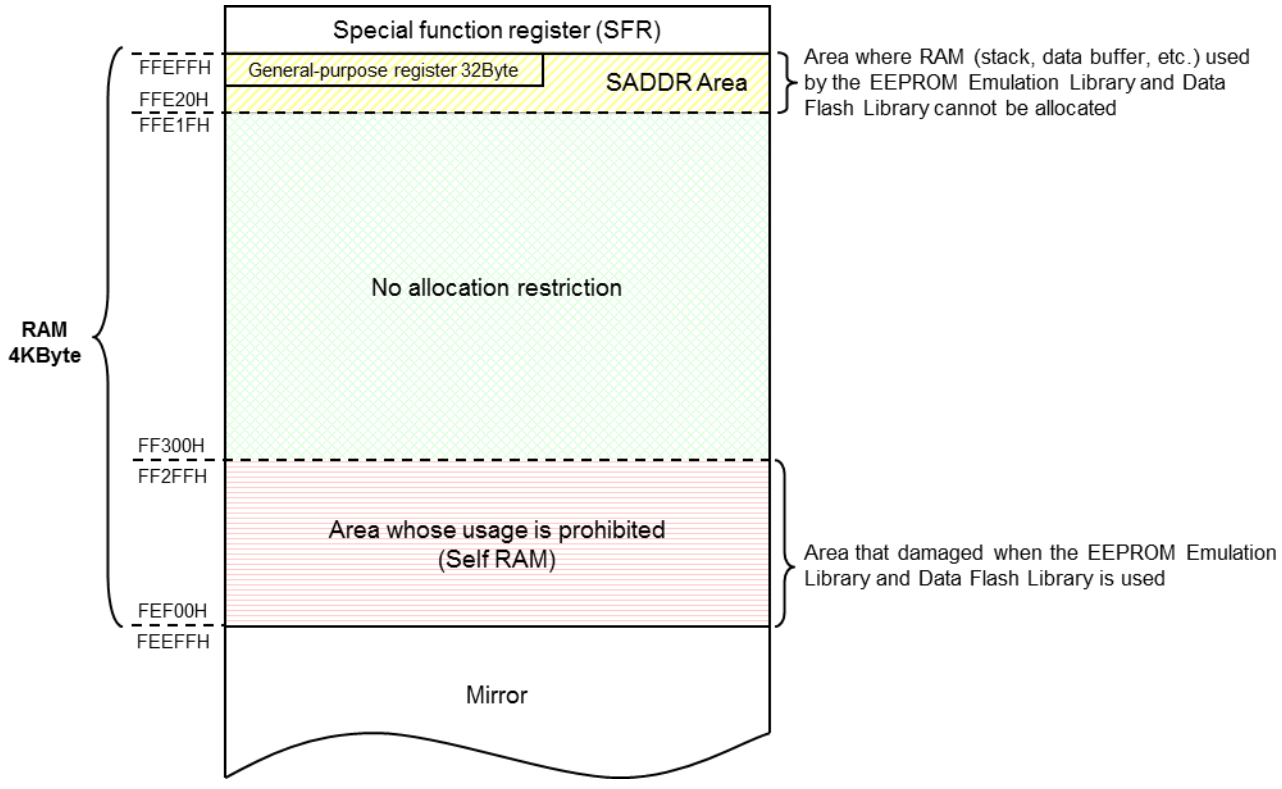
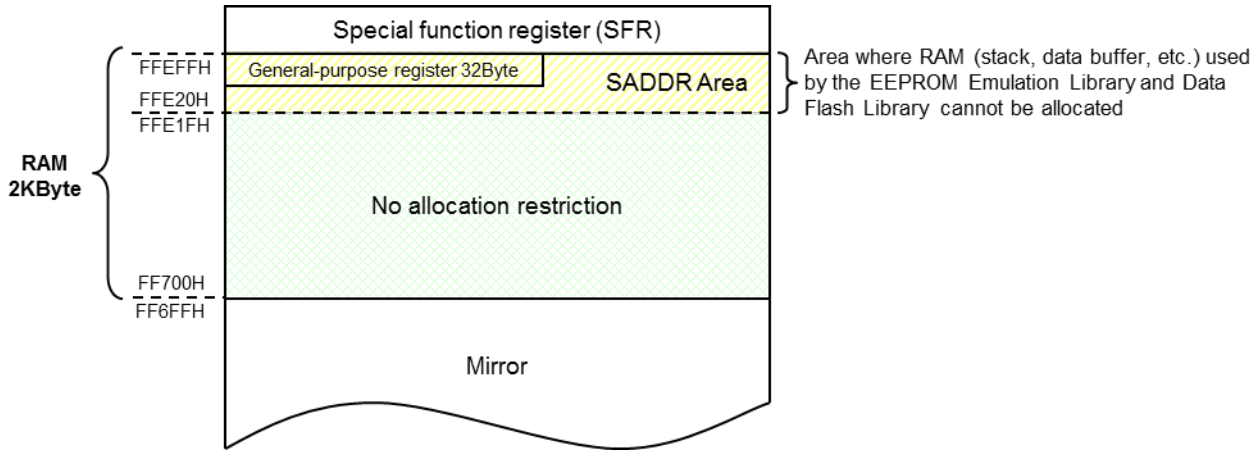


Figure 6-3 Arrangement Example of Addresses FFE20H to FFEFFH

(RL78/G13: product with 2-Kbyte RAM and 32-Kbyte ROM)



6. 2. 1 Sections

Functions, constants, and variables to be used are allocated to specified sections in the EEL and FDL.

The following table lists sections defined by the EEL and FDL.

Table 6-5 Sections Used in the EEL/FDL

Section name	Description
FDL_CODE	FDL's code section that contains FDL programs.
FDL_SDAT	FDL's variable data section that contains variable data used in the FDL. Place this section in the short addressing RAM area.
FDL_CNST	FDL's constant data section that contains constant data used in the FDL.
EEL_CODE	EEL's code section that contains EEL programs.
EEL_SDAT	EEL's variable data section that contains variable data used in the EEL. Place this section in the short addressing RAM area.
EEL_CNST	EEL's constant data section that contains constant data used in the EEL.

Appendix A Revision History

Major Changes in This Document

Page	Change/Addition	Type
All	Newly created	-

Remark: "Type" in the above table indicates types of revisions.

(a): Correction of erroneous description

(b): Addition/change to specifications

(c): Addition/change to description or notes

(d): Addition/change to the package, order name, or classification

(e): Addition/change to related documents

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EEPROM Emulation Library Pack 02

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