

RL78/G23

## Serial Interface UARTA

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### Introduction

This application note explains how to use UART communication through the serial interface (UARTA). ASCII characters transmitted from the device on the opposite side are analyzed to make responses.

### Target Device

RL78/G23

When applying the sample program covered in this application note to another microcomputer, modify the program according to the specifications for the target microcomputer and conduct an extensive evaluation of the modified program.

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# 1. Specifications

## 1.1 Specification Outline

In this application note, UART communication is performed through the serial interface UARTA. ASCII characters transmitted from the device on the opposite side are analyzed to make responses.

Table 1.1 shows the peripheral function to be used and its use. Figure 1.1 and Figure 1.2 illustrate UART communication operation.

**Table 1.1 Peripheral Function to be Used and its Use**

Peripheral Function	Use
UARTA0	Perform UART communication using the TxDA0 pin (transmission) and the RxDA0 pin (reception).

**Figure 1.1 UART Reception Timing Chart**

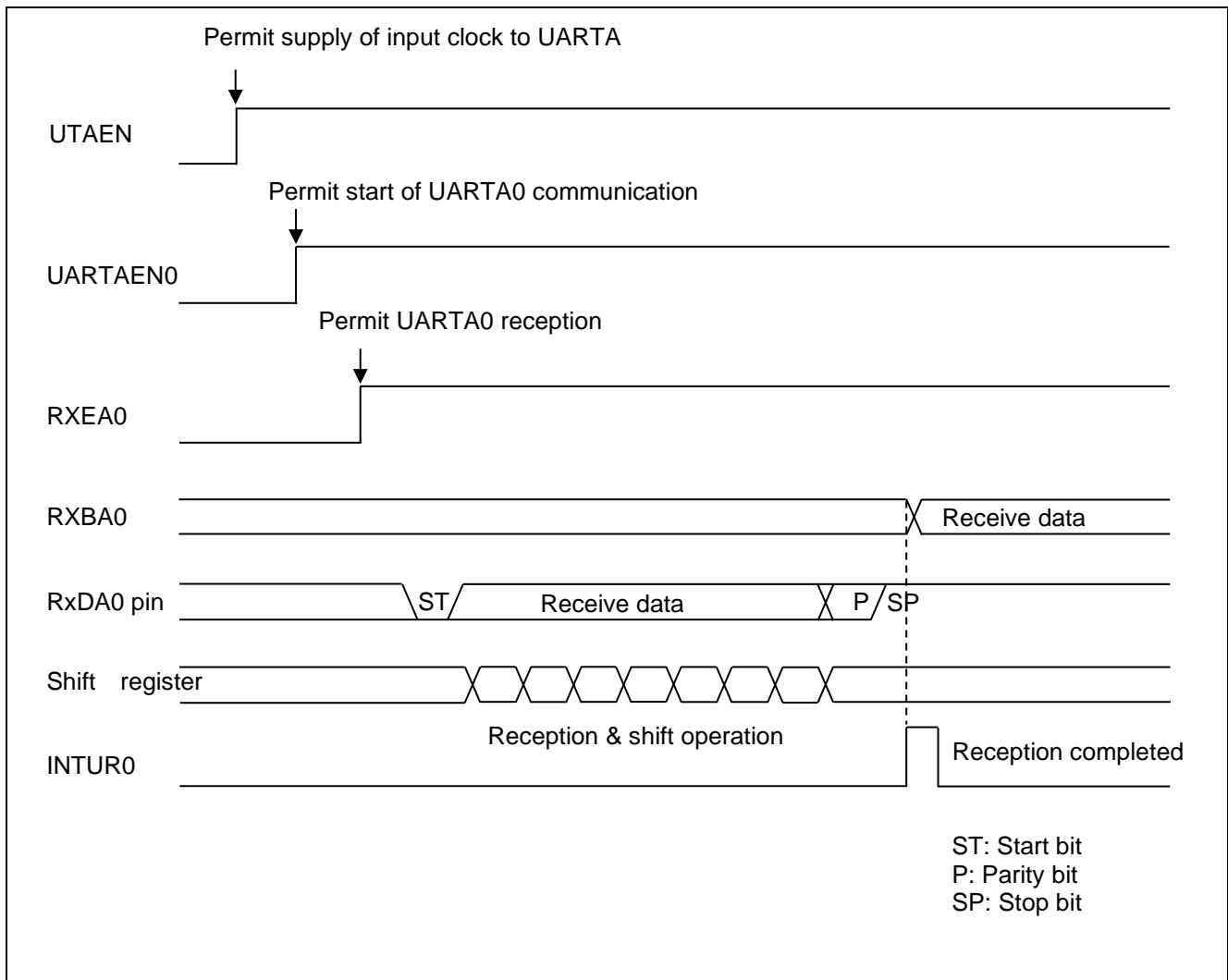
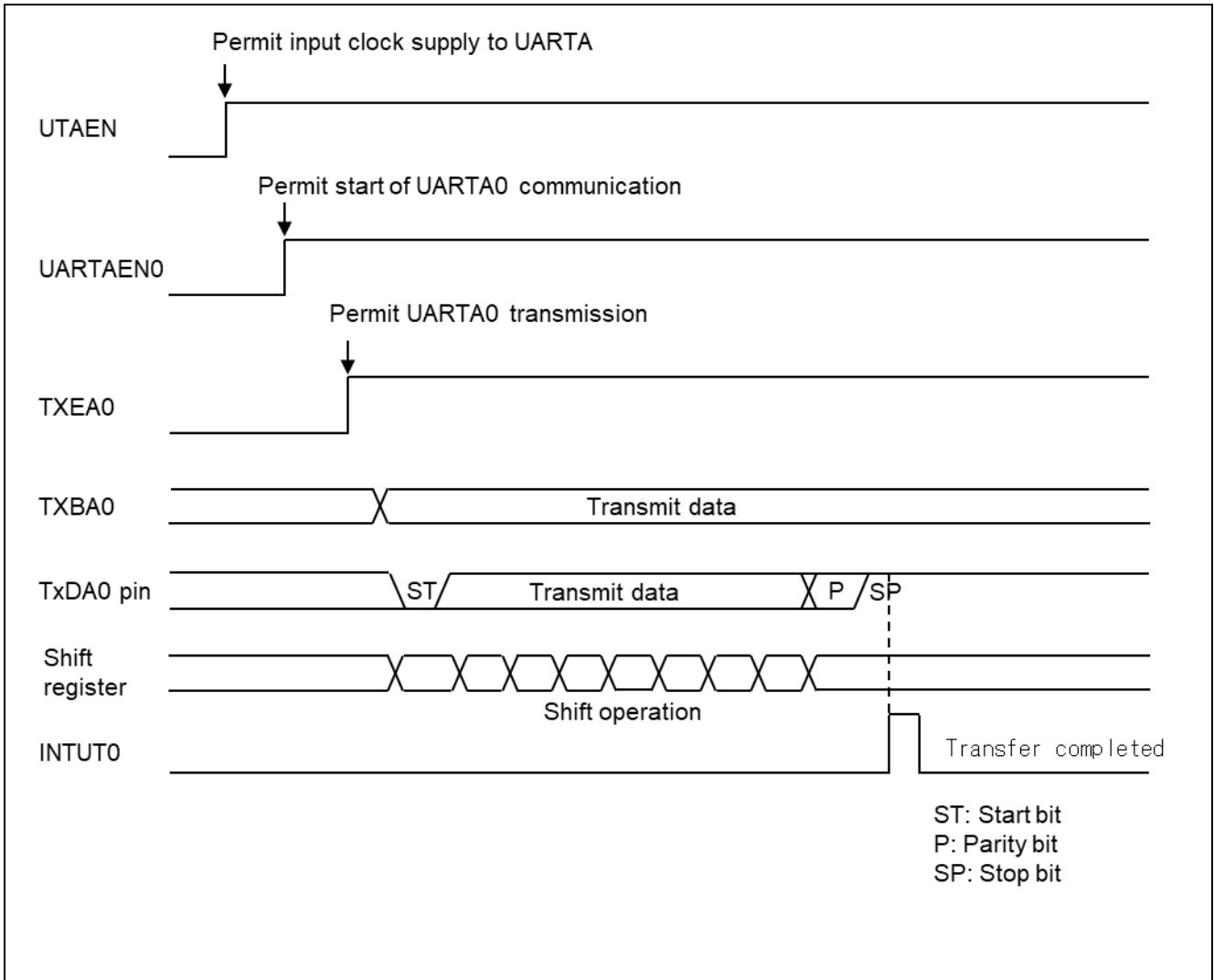


Figure 1.2 UART Transmission Timing Chart



## 1.2 Operation Outline

This sample code transmits, to the device on the opposite side, the data corresponding to that received from the device. If an error occurs, it transmits to the device the data corresponding to the error. Table 1.2 and Table 1.3 show the correspondence between transmit data and receive data.

**Table 1.2 Correspondence between Receive Data and Transmit Data**

Receive Data	Response (Transmit) Data
T (54H)	O (4FH), K (4BH), " CR" (0DH), " LF" (0AH)
t (74H)	o (6FH), k (6BH), " CR" (0DH), " LF" (0AH)
Other than above	U (55H), C (43H), " CR" (0DH), " LF" (0AH)

**Table 1.3 Correspondence between Error and Transmit Data**

Error	Response (Transmit) Data
Parity error	P (50H), E (45H), " CR" (0DH), " LF" (0AH)
Framing error	F (46H), E (45H), " CR" (0DH), " LF" (0AH)
Overrun error	O (4FH), E (45H), " CR" (0DH), " LF" (0AH)

(1) Perform initial setting of UART.

<UART Setting Conditions>

- Use UARTA channels 0.
- Use the P72/TxDA0 pin and the P71/RxDA0 pin for data output and data input, respectively.
- The data length is 8 bits.
- Set the data transfer direction to LSB first.
- Use even parity as the parity setting.
- Set the receive data level to standard.
- Set the transfer rate to 9600 bps.
- Use reception end interrupt (INTUR0), transmission end interrupt (INTUT0), and error interrupt (INTURE0).
- Set the interrupt priority orders of INTUR0, INTUT0, and INTURE0 to low priority.

(2) After the system is made to enter a UART communication wait state by using the serial channel start register, a HALT instruction is executed. Processing is performed in response to reception end interrupt (INTUR0) and error interrupt (INTURE0).

- When an INTUR0 occurs, the received data is taken in and the data corresponding to the received data is transmitted. When an INTURE0 occurs, error handling is performed to transmit the data corresponding to the error.
- After data transmission, a HALT instruction is executed again to wait for reception end interrupt (INTUR0) and error interrupt (INTURE0).

## 2. Operation Check Conditions

The sample code contained in this application note has been checked under the conditions listed in the table below.

**Table 2.1 Operation Check Conditions**

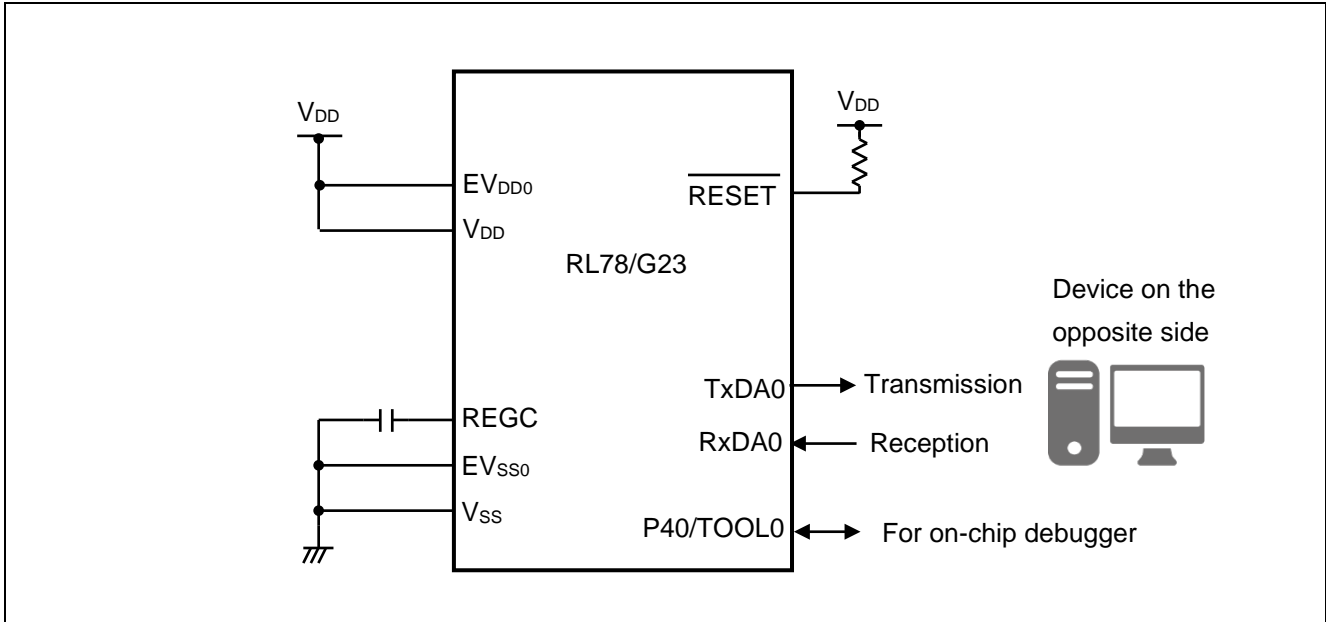
Item	Description
Microcontroller used	RL78/G23 (R7F100GLG)
Operating frequency	<ul style="list-style-type: none"> <li>• High-speed on-chip oscillator (HOCO) clock: 32 MHz</li> <li>• CPU/peripheral hardware clock: 32 MHz</li> </ul>
Operating voltage	5.0 V (can run on a voltage range of 1.8 V to 5.5 V.) LVD operation ( $V_{LVD}$ ): Reset mode At rising edge TYP. 1.90 V (1.84 V to 1.95 V) At falling edge TYP. 1.86 V (1.80 V to 1.91 V)
Integrated development environment (CS+)	Renesas Electronics CS+ for CC V8.05.00
C compiler (CS+)	Renesas Electronics CC-RL V1.09.00
Integrated development environment (e <sup>2</sup> studio)	Renesas Electronics e2 studio V2021-01
C compiler (e <sup>2</sup> studio)	Renesas Electronics CC-RL V1.09.00
Integrated development environment (IAR)	IAR Systems IAR Embedded Workbench for Renesas RL78 V4.20.1
C compiler (IAR)	IAR Systems IAR C/C++ Compiler for Renesas RL78 V4.20.1.2260

### 3. Hardware

#### 3.1 Hardware Configuration Example

Figure 3.1 shows an example of hardware configuration that is used for this application note.

Figure 3.1 Hardware Configuration



- Caution:
1. The purpose of this circuit is only to provide the connection outline and the circuit is simplified accordingly. When designing and implementing an actual circuit, provide proper pin treatment and make sure that the hardware's electrical specifications are met (connect the input-only ports separately to V<sub>DD</sub> or V<sub>SS</sub> via a resistor).
  2. Connect any pins whose name begins with EV<sub>SS</sub> to V<sub>SS</sub> and any pins whose name begins with EV<sub>DD</sub> to V<sub>DD</sub>, respectively.
  3. V<sub>DD</sub> must be held at not lower than the reset release voltage (V<sub>LVD</sub>) that is specified as LVD.

#### 3.2 List of Pins to be Used

Table 3.1 lists the pins to be used and their function.

Table 3.1 Pins to be Used and their Functions

Pin Name	I/O	Description
P72/TS04/KR2/SO21/TxDA0	Output	Data transmission pin
P71/TS03/KR1/SI21/SDA21/RxDA0	Input	Data reception pin

Caution: In this application note, only the used pin is properly connected. When designing and implementing an actual circuit, provide proper pin treatment and make sure that the hardware's electrical specifications are met.

## 4. Software

### 4.1 List of Option Byte Settings

Table 4.1 summarizes the settings of the option bytes.

**Table 4.1 Option Byte Settings**

Address	Value	Description
000C0H / 010C0H	01101110B	Disables the watchdog timer. (Stops counting after the release from the reset state.)
000C1H / 010C1H	11111110B	LVD operation (VLVD): Reset mode At rising edge TYP. 1.90 V (1.84 V to 1.95 V) At falling edge TYP. 1.86 V (1.80 V to 1.91 V)
000C2H / 010C2H	11101000B	HS mode, High-speed on-chip oscillator (HOCO) clock: 32 MHz
000C3H / 010C3H	10000100B	Enables the on-chip debugger.

### 4.2 List of Constants

Table 4.2 lists the constants that are used in this sample program.

**Table 4.2 Constants for the Sample Program**

Constant	Setting	Description
g_messageOK[4]	"OK\r\n"	Response message to reception of "T".
g_messageok[4]	"ok\r\n"	Response message to reception of "t".
g_messageUC[4]	"UC\r\n"	Response message to reception of characters other than "T" or "t".
g_messageFE[4]	"FE\r\n"	Response message to a framing error.
g_messagePE[4]	"PE\r\n"	Response message to a parity error.
g_messageOE[4]	"OE\r\n"	Response message to an overrun error.



### 4.3 List of Variables

Table 4.3 lists the global variable that is used by this sample program.

**Table 4.3 Global Variable**

Type	Variable Name	Contents	Function Used
Uin8_t	g_uarta0_rx_buffer	Receive data buffer	main()
Uin8_t	gp_uarta0_tx_address	Transmit data pointer	R_Config_UARTA0_Send(), r_Config_UARTA0_interrupt_send()
Uin16_t	g_uarta0_tx_count	Transmit data number counter	R_Config_UARTA0_Send(), r_Config_UARTA0_interrupt_send()
Uin8_t	gp_uarta0_rx_address	Receive data pointer	R_Config_UARTA0_Receive(), r_Config_UARTA0_interrupt_receive()
Uin16_t	g_uarta0_rx_num	Receive data number counter	R_Config_UARTA0_Receive(), r_Config_UARTA0_interrupt_receive()
Uin16_t	g_uarta0_rx_total_num	Receive data number	R_Config_UARTA0_Receive(), r_Config_UARTA0_interrupt_receive()
MD_STATUS	g_uarta0_tx_end	Transmit status	main(), r_Config_UARTA0_callback_sendend()
uint8_t	g_uarta0_rx_error	Receive error status	main(), r_Config_UARTA0_callback_receiveend(), r_Config_UARTA0_callback_error()

### 4.4 List of Functions

Table 4.4 lists the functions that are used in this sample program.

**Table 4.4 Functions**

Function Name	Outline
R_Config_UARTA0_Start()	UARTA0 operation start
R_Config_UARTA0_Receive()	UARTA0 reception status initialization function
R_Config_UARTA0_Send()	UARTA0 data transmission function
r_Config_UARTA0_interrupt_receive()	UARTA0 reception end interrupt handling
r_Config_UARTA0_callback_receiveend()	UARTA0 receive data classification function
r_Config_UARTA0_interrupt_error()	UARTA0 error interrupt handling
r_Config_UARTA0_callback_error()	UARTA0 reception error classification function
r_Config_UARTA0_interrupt_send()	UARTA0 transmission end interrupt handling
r_Config_UARTA0_callback_sendend()	UARTA0 transmission end processing function

## 4.5 Function Specifications

This section describes the specifications for the functions that are used in this sample program.

[Function Name] R\_UARTA0\_Start()

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<b>Synopsis</b>	UARTA0 operation start
<b>Header</b>	r_cg_macrodriver.h、Config_UARTA0.h、r_cg_userdefine.h
<b>Declaration</b>	void R_Config_UARTA0_Start(void)
<b>Explanation</b>	Starts operation of channel 0 of serial array interface UARTA0 to make the system enter a communication wait state.
<b>Arguments</b>	<ul style="list-style-type: none"> <li>• None</li> </ul>
<b>Return value</b>	<ul style="list-style-type: none"> <li>• None</li> </ul>

[Function Name] R\_Config\_UARTA0\_Recieve()

---

<b>Synopsis</b>	UARTA0 reception status initialization function
<b>Header</b>	r_cg_macrodriver.h、Config_UARTA0.h、r_cg_userdefine.h
<b>Declaration</b>	MD_STATUS R_Config_UARTA0_Receive (uint8_t * const rx_buf, uint16_t rx_num)
<b>Explanation</b>	Makes initial setting for UARTA0 reception.
<b>Arguments</b>	<ul style="list-style-type: none"> <li>• uint8_t * const rx_buf : [Receive data buffer address]</li> <li>• uint16_t rx_num : [Receive data buffer size]</li> </ul>
<b>Return value</b>	<ul style="list-style-type: none"> <li>• [MD_OK]: Reception setting is completed</li> <li>• [MD_ARGERROR]: Reception setting failed</li> </ul>

[Function Name] R\_Config\_UARTA0\_Send()

---

<b>Synopsis</b>	UARTA0 data transmission function
<b>Header</b>	r_cg_macrodriver.h、Config_UARTA0.h、r_cg_userdefine.h
<b>Declaration</b>	MD_STATUS R_Config_UARTA0_Send (uint8_t * const tx_buf, uint16_t tx_num)
<b>Explanation</b>	Makes initial setting for UARTA0 transmission, and starts data transmission.
<b>Arguments</b>	<ul style="list-style-type: none"> <li>• uint8_t * const tx_buf : [Transmit data buffer address]</li> <li>• uint16_t tx_num : [Transmit data buffer size]</li> </ul>
<b>Return value</b>	<ul style="list-style-type: none"> <li>• [MD_OK]: Transmission setting is completed</li> <li>• [MD_ARGERROR]: Transmission setting failed</li> </ul>

[Function Name] r\_Config\_UARTA0\_interrupt\_receive()

---

<b>Synopsis</b>	UART0 reception end interrupt function
<b>Header</b>	r_cg_macrodriver.h、Config_UARTA0.h、r_cg_userdefine.h
<b>Declaration</b>	static void __near r_Config_UARTA0_interrupt_receive (void)
<b>Explanation</b>	Makes a response (data transmission) corresponding to received data.
<b>Arguments</b>	<ul style="list-style-type: none"> <li>• None</li> </ul>
<b>Return value</b>	<ul style="list-style-type: none"> <li>• None</li> </ul>

---

[Function Name ] r\_Config\_UARTA0\_callback\_receiveend()

---

**Synopsis** UARTA0 reception error flag clear function  
**Header** r\_cg\_macrodriver.h、Config\_UARTA0.h、 r\_cg\_userdefine.h  
**Declaration** static void r\_Config\_UARTA0\_callback\_receiveend (void)  
**Explanation** Clear UARTA reception error flag.  
**Arguments**

- None

**Return value**

- None

---

[Function Name ] r\_Config\_UARTA0\_interrupt\_error

---

**Synopsis** UART error interrupt function()  
**Header** r\_cg\_macrodriver.h、Config\_UARTA0.h、 r\_cg\_userdefine.h  
**Declaration** static void \_\_near r\_Config\_UARTA0\_interrupt\_error (void)  
**Explanation** Save the received error content as err\_type.  
**Arguments**

- None

**Return value**

- None

---

[Function Name] r\_uart0\_callback\_error()

---

**Synopsis** UARTA0 reception error classification function  
**Header** r\_cg\_macrodriver.h、Config\_UARTA0.h、 r\_cg\_userdefine.h  
**Declaration** static void r\_Config\_UARTA0\_callback\_error (uint32\_t err\_type)  
**Explanation** Save the determined error in g\_uarta0\_rx\_error.  
**Arguments** uint32\_t err\_type : Error type  
**Return value**

- None

**Remarks** Called from r\_Config\_UARTA0\_interrupt\_error function

---

[Function Name] r\_Config\_UARTA0\_interrupt\_send()

---

**Synopsis** UARTA0 transmission end interrupt function  
**Header** r\_cg\_macrodriver.h、Config\_UARTA0.h、 r\_cg\_userdefine.h  
**Declaration** static void \_\_near r\_Config\_UARTA0\_interrupt\_send (void)  
**Explanation** Transmits a specified number of pieces of data.  
**Arguments**

- None

**Return value**

- None

---

[Function Name] r\_Config\_UARTA0\_callback\_sendend()

---

**Synopsis** UARTA0 transmission end processing function  
**Header** r\_cg\_macrodriver.h, r\_cg\_serial.h, r\_cg\_userdefine.h  
**Declaration** static void r\_uart0\_callback\_sendend(void)  
**Explanation** Set the transmission completion flag.  
**Arguments**

- None

**Return value**

- None

4.6 Flowcharts

4.6.1 Main Function

Figure 4.1, Figure 4.2 and Figure 4.3 show the flowchart for the main function.

Figure 4.1 Main Function (1/3)

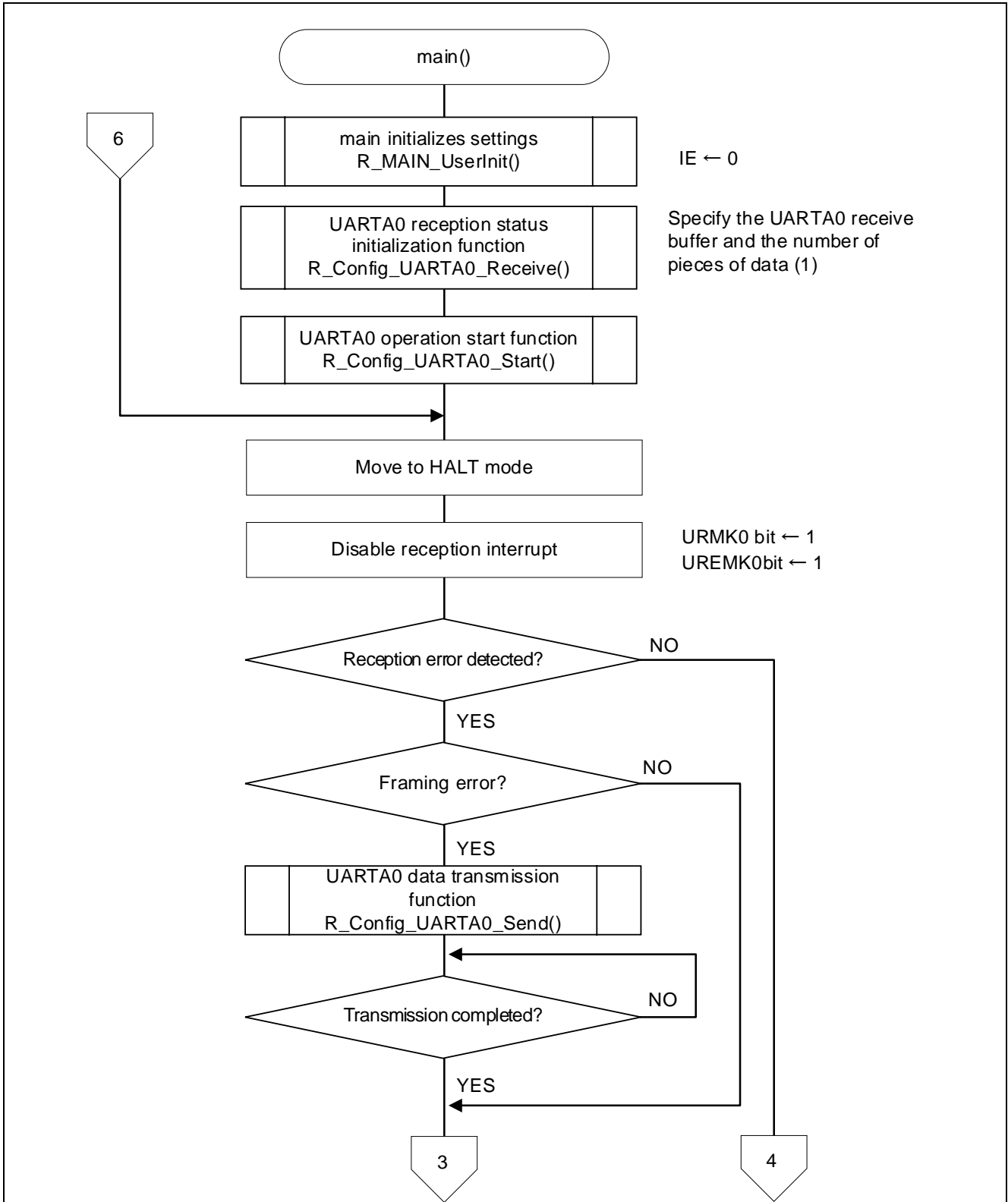


Figure 4.2 Main Function (2/3)

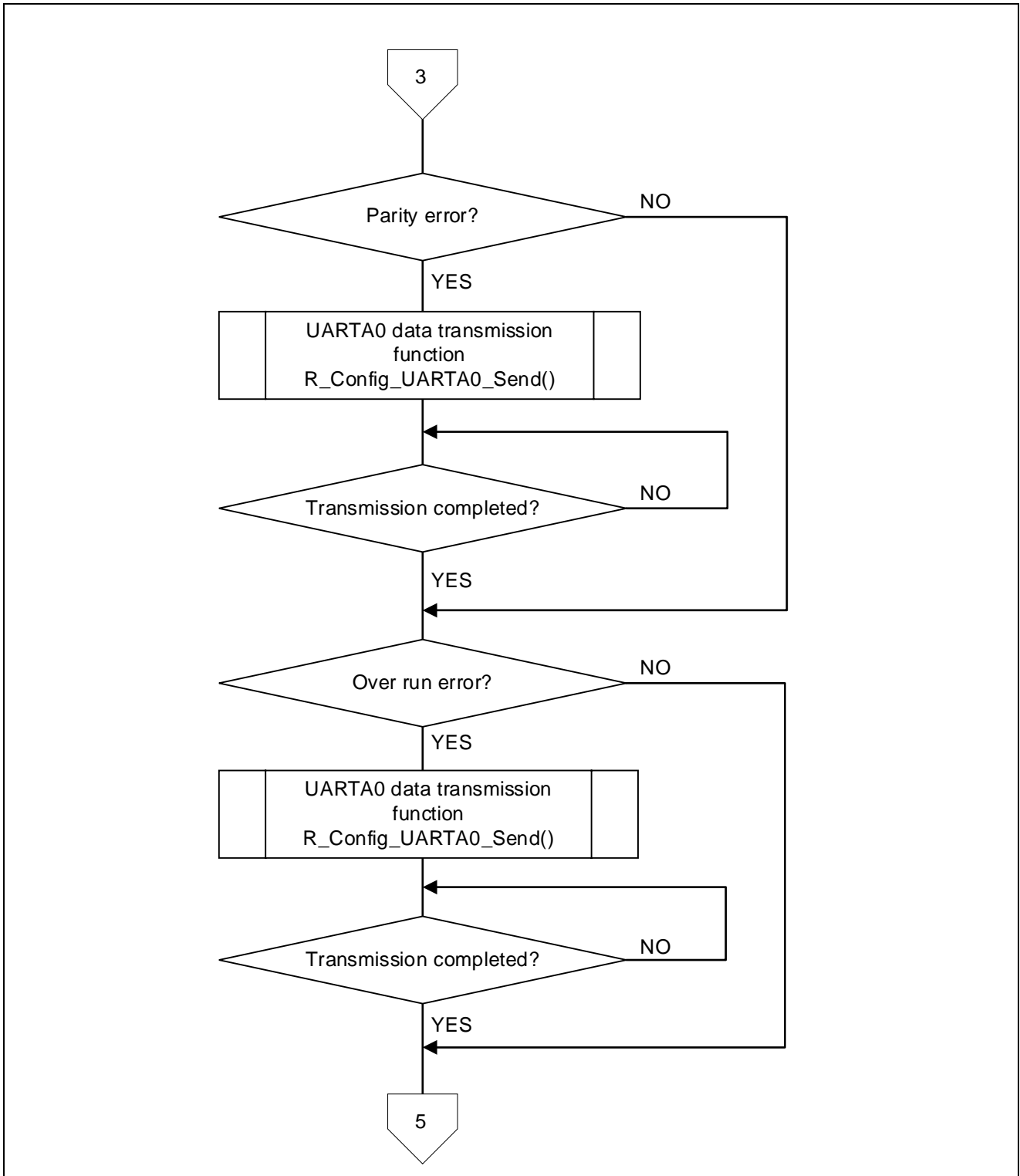
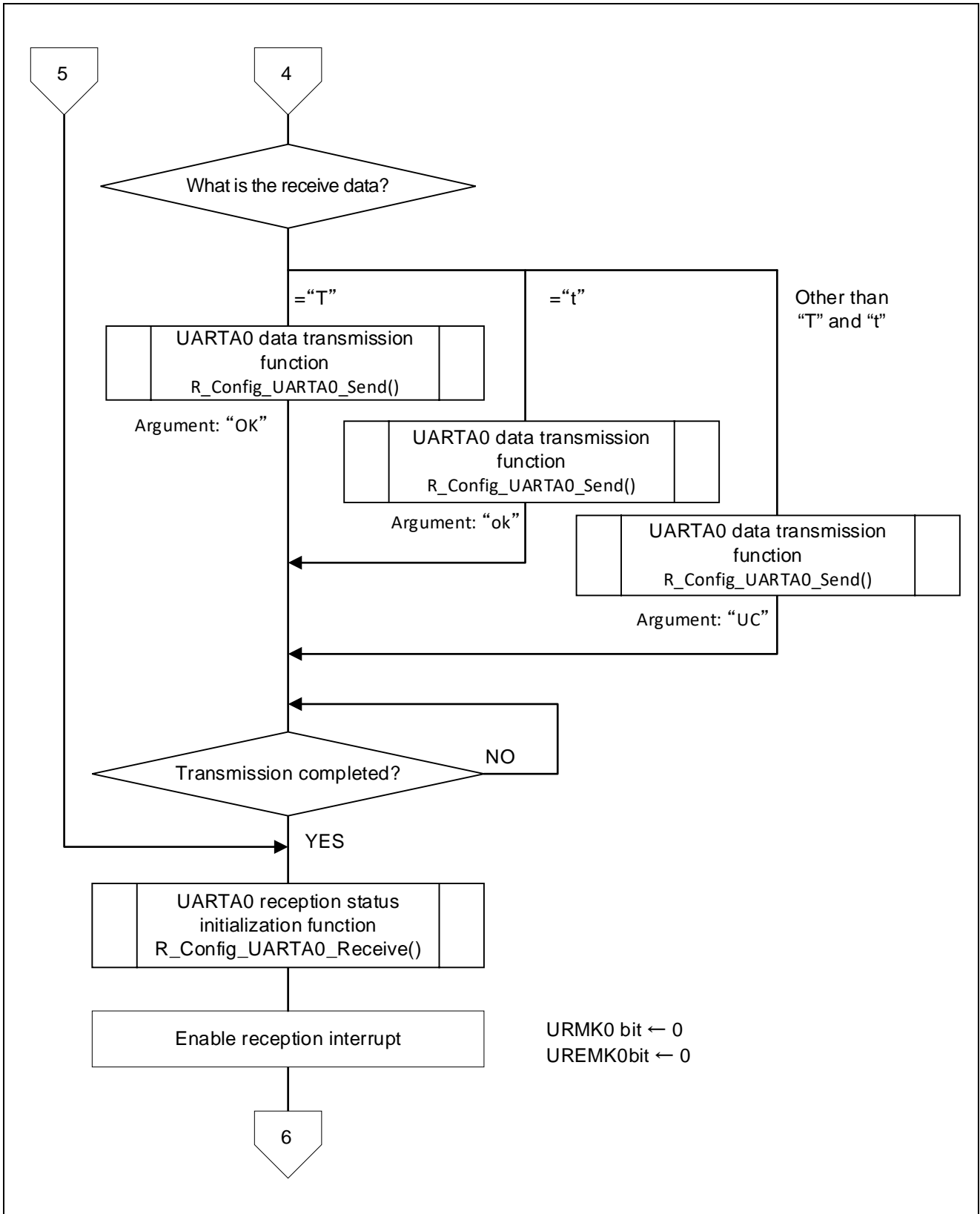


Figure 4.3 Main Function (3/3)



## 5. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

## 6. Reference Documents

RL78/G23 User's Manual: Hardware (R01UH0896)

RL78 family User's Manual: Software (R01US0015)

(The latest version can be downloaded from the Renesas Electronics website.)

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**Revision History**

Rev.	Date	Description	
		Page	Summary
1.00	Apr.13.21	—	First Edition



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### 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.

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

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