RL78/G23

Serial Interface UARTA

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.

Contents

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

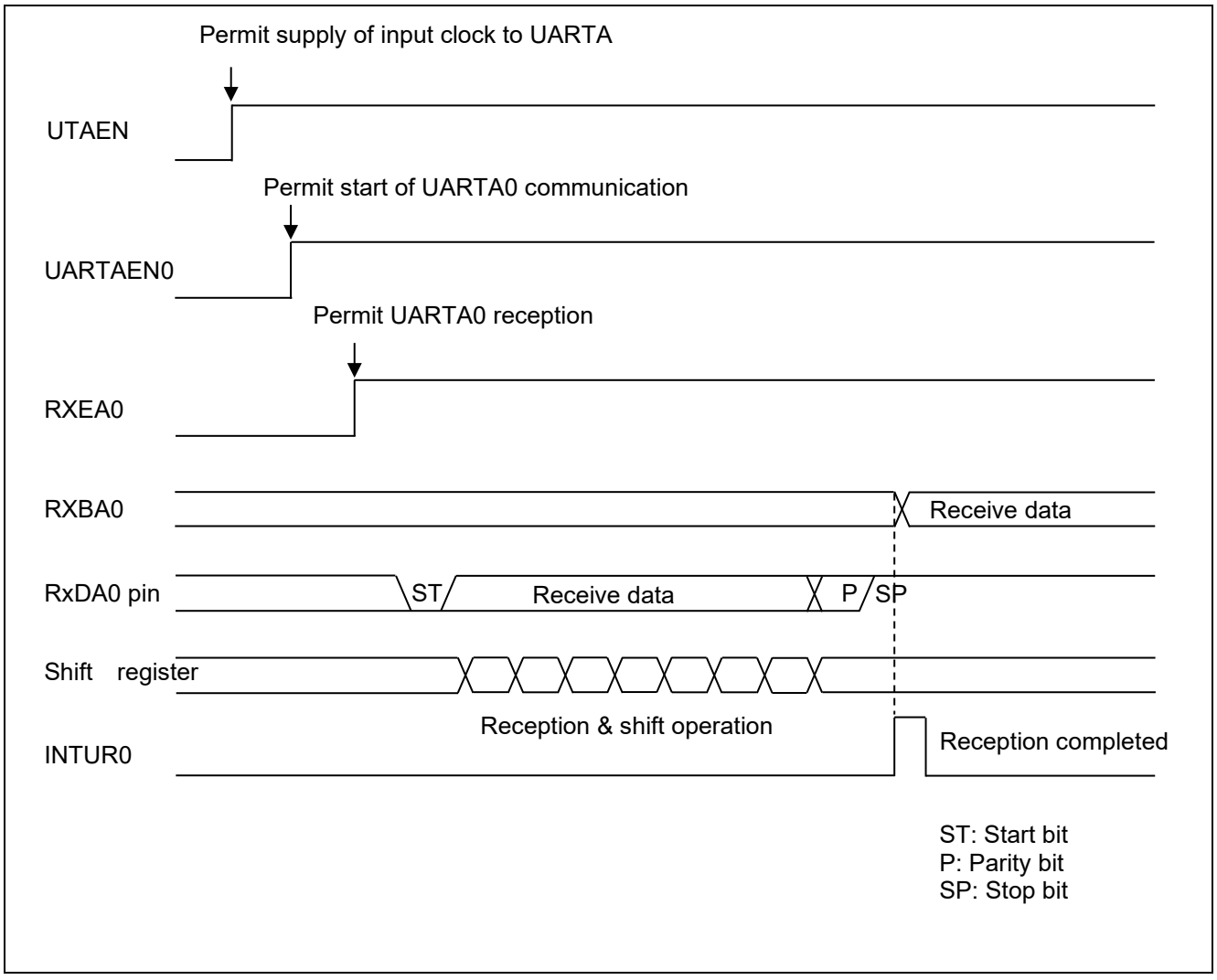
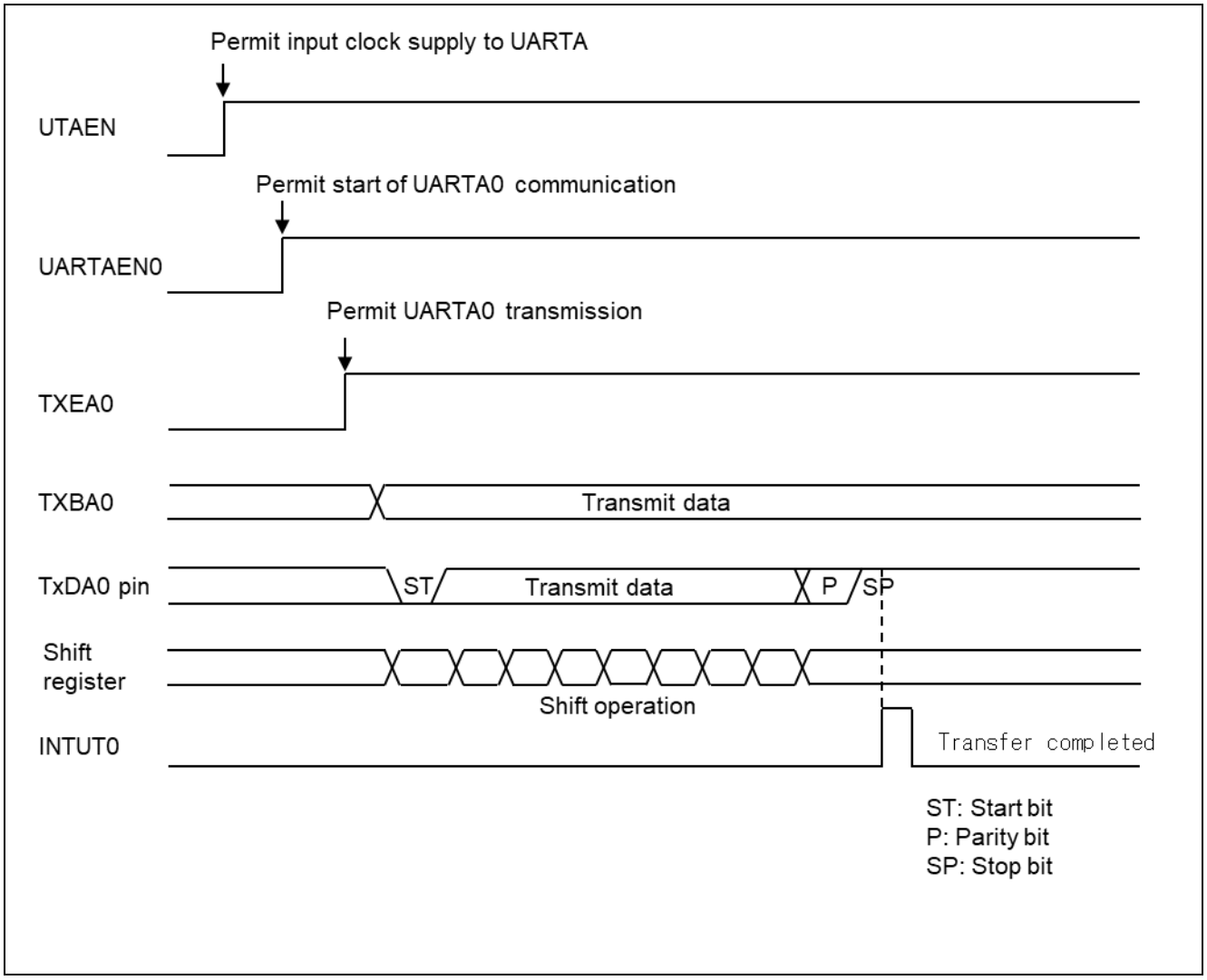


Figure 1.2 UART Transmission Timing Chart



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

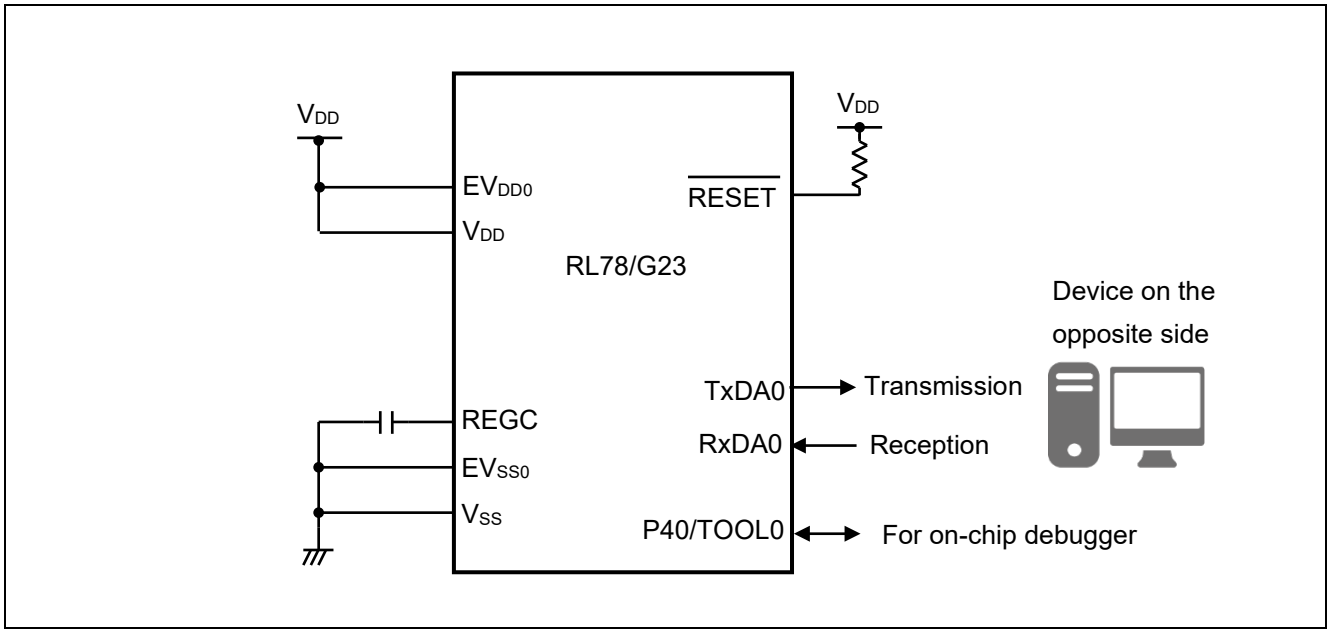
Item	Description
MCU used	RL78/G23 (R7F100GLG)
Board used	RL78/G23 Fast Prototyping Board (RTK7RLG230CLG000BJ)
Operating frequency	High-speed on-chip oscillator clock: 32 MHz CPU/peripheral hardware clock: 32 MHz
Operating voltage	3.3 V (can be operated at 1.8 V to 5.5 V) LVD0 detection voltage: Reset 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+)	CS+ V8.05.00 from Renesas Electronics Corp.
C compiler (CS+)	CC-RL V1.10.00 from Renesas Electronics Corp.
Integrated development environment (e2studio)	e2 studio V2021-04 (21.4.0) from Renesas Electronics Corp.
C compiler (e2studio)	CC-RL V1.10.00 from Renesas Electronics Corp.
Integrated development environment (IAR)	IAR Embedded Workbench for Renesas RL78 V4.21.1 from IAR Systems Corp.
C compiler (IAR)	IAR C/C++ Compiler for Renesas RL78 V4.21.1 from IAR Systems Corp.
Smart configurator (SC)	V1.0.1 from Renesas Electronics Corp.
Board support package (BSP)	V1.00 from Renesas Electronics Corp.

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_{DD} or V_{SS} via a resistor).
2. Connect any pins whose name begins with EV_{SS} to V_{SS} and any pins whose name begins with EV_{DD} to V_{DD}, respectively.
3. V_{DD} must be held at not lower than the reset release voltage (V_{LVD}) that is specified as LVD.

3.2 List of Pins to be Used

Table 3.1lists 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 4.1summarizes 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
Uint8_t	g_uarta0_rx_buffer	Receive data buffer	main()
Uint8_t	gp_uarta0_tx_address	Transmit data pointer	R_Config_UARTA0_Send(), r_Config_UARTA0_interrupt_send()
Uint16_t	g_uarta0_tx_count	Transmit data number counter	R_Config_UARTA0_Send(), r_Config_UARTA0_interrupt_send()
Uint8_t	gp_uarta0_rx_address	Receive data pointer	R_Config_UARTA0_Receive(), r_Config_UARTA0_interrupt_receive()
Uint16_t	g_uarta0_rx_num	Receive data number counter	R_Config_UARTA0_Receive(), r_Config_UARTA0_interrupt_receive()
Uint16_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()

Synopsis	UARTA0 operation start
Header	r_cg_macrodriver.h 、Config_UARTA0.h、 r_cg_userdefine.h
Declaration	void R_Config_UARTA0_Start(void)
Explanation	Starts operation of channel 0 of serial array interface UARTA0 to make the system enter a communication wait state.
Arguments	• None
Return value	• None

[Function Name] R_ Config_UARTA0_Recieve()

Synopsis	UARTA0 reception status initialization function
Header	r_cg_macrodriver.h 、Config_UARTA0.h、 r_cg_userdefine.h
Declaration	MD_STATUS R_Config_UARTA0_Receive (uint8_t * const rx_buf, uint16_t rx_num)
Explanation	Makes initial setting for UARTA0 reception.
Arguments	• uint8_t * const rx_buf : [Receive data buffer address] • uint16_t rx_num : [Receive data buffer size]
Return value	• [MD_OK]: Reception setting is completed • [MD_ARGERROR]: Reception setting failed

[Function Name] R_Config_UARTA0_Send()

Synopsis	UARTA0 data transmission function
Header	r_cg_macrodriver.h 、Config_UARTA0.h、 r_cg_userdefine.h
Declaration	MD_STATUS R_Config_UARTA0_Send (uint8_t * const tx_buf, uint16_t tx_num)
Explanation	Makes initial setting for UARTA0 transmission, and starts data transmission.
Arguments	• uint8_t * const tx_buf : [Transmit data buffer address] • uint16_t tx_num : [Transmit data buffer size]
Return value	• [MD_OK]: Transmission setting is completed • [MD_ARGERROR]: Transmission setting failed

[Function Name] r_Config_UARTA0_interrupt_receive()

Synopsis	UART0 reception end interrupt function
Header	r_cg_macrodriver.h 、Config_UARTA0.h、 r_cg_userdefine.h
Declaration	static void __near r_Config_UARTA0_interrupt_receive (void)
Explanation	Makes a response (data transmission) corresponding to received data.
Arguments	• None
Return value	• None

[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)

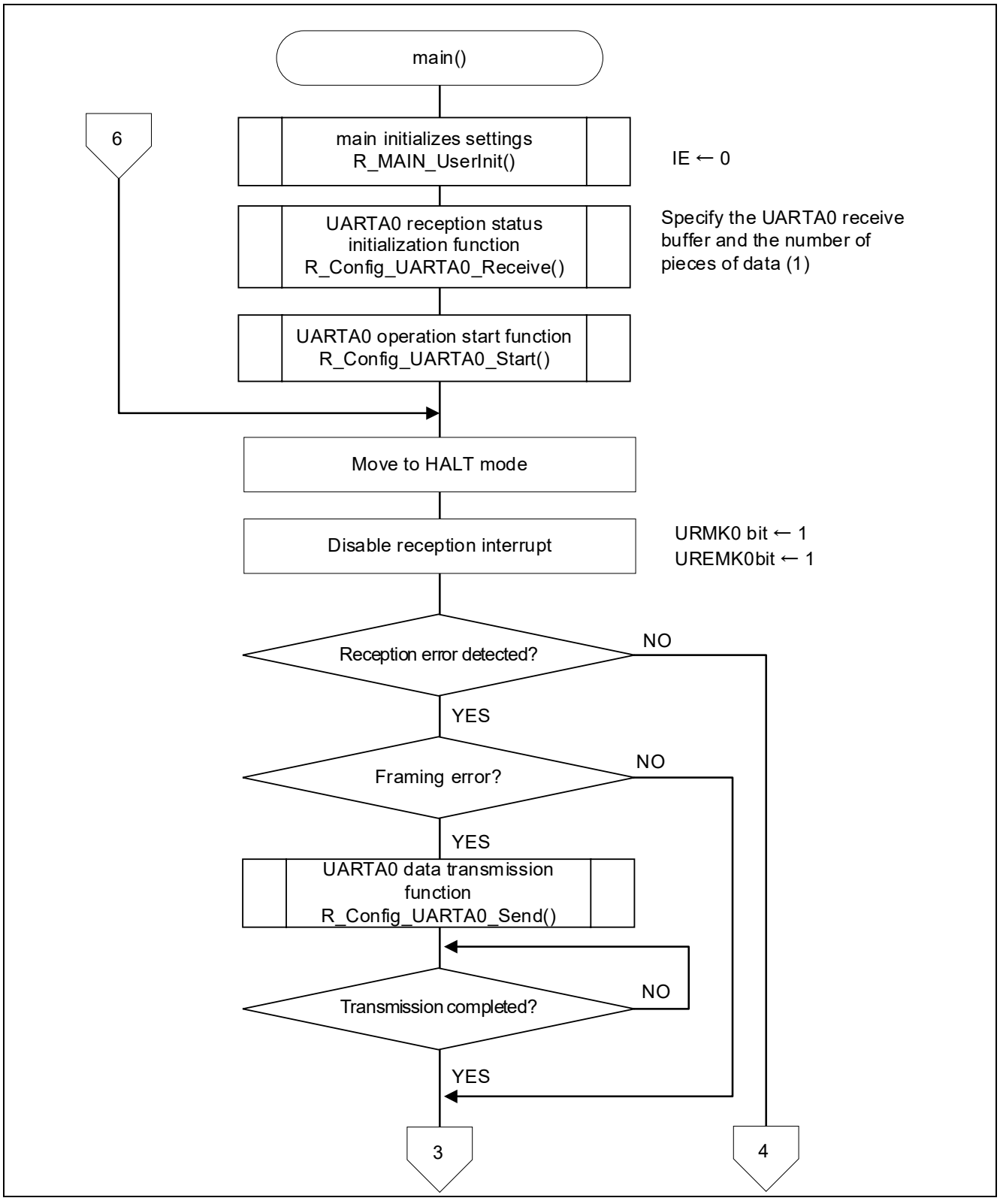


Figure 4.2 Main Function (2/3)

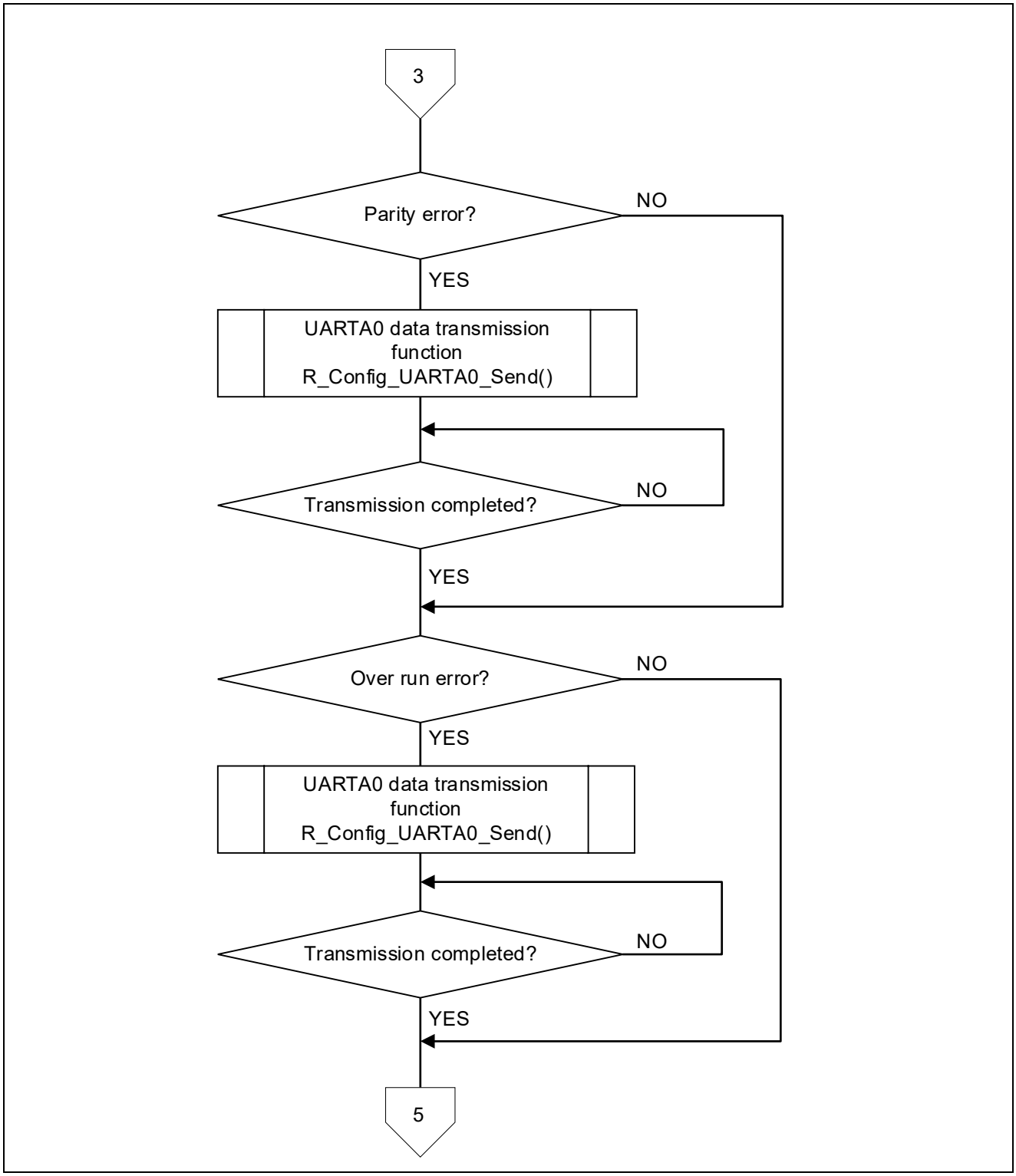
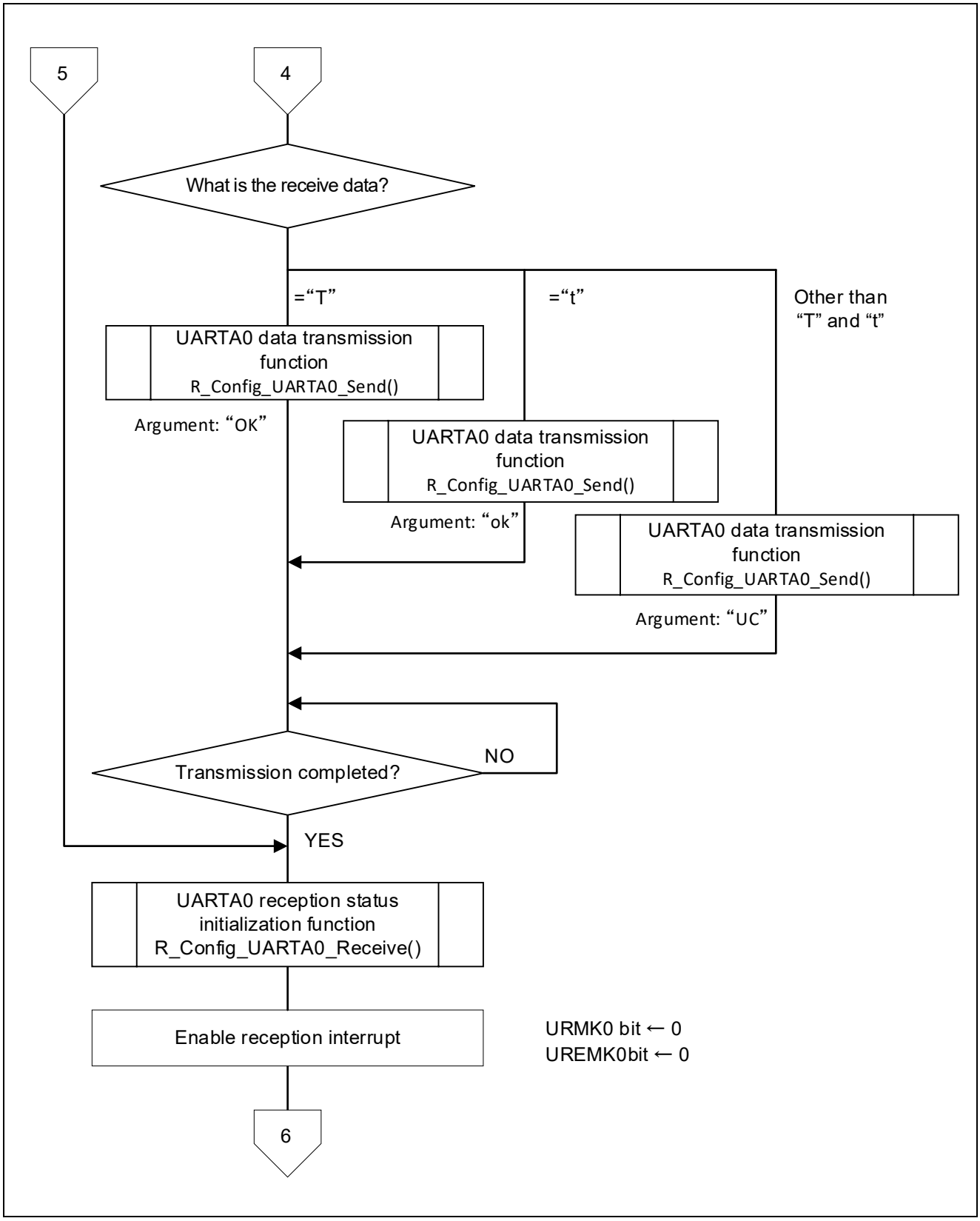


Figure 4.3 Main Function (3/3)



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.)

Technical Update/Technical News

(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
1.01	May.19.21	—	IDE. Revision Update
1.02	June.2.21	—	Correction of transmission end process

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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.).
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