RL78/F13, F14

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Serial Communication in UART Mode Using LIN/UART Module (RLIN3)

Abstract

This document describes how to setup UART communication using LIN/UART module (RLIN3) in RL78/F13 and F14.

Target device

RL78/F13, F14

When using this application note with other Renesas MCUs, careful evaluation is recommended after making modifications to comply with the alternate MCU.

Contents

1. Specification

This application note provides an example of using RIIN3 module in UART communication mode.

Once a message in ASCII format is received from the counterpart device, the MCU will analze the received command and send a respond message.

Peripheral function and operation used are listed in Table 1.1, and RLIN3 communication operation is described in Figure 1.1.

Table 1.1 Peripheral Function and Operation

Peripheral Function	Operation
UART communication mode enabled	UART communication using LTXD0 pin (transmit) and LRxD0 pin (receive)

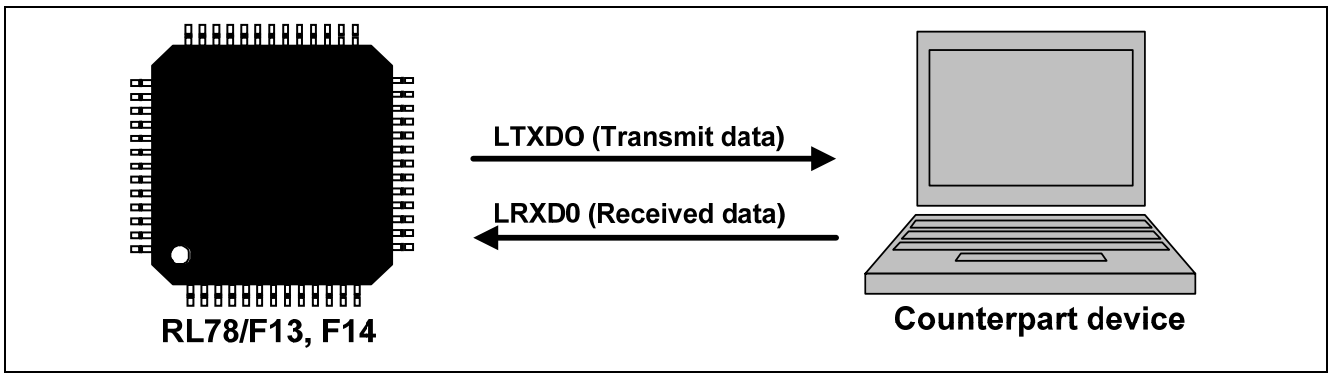

Figure 1.1 Communication Operation

2. Requirement and Tools

Requirements and tools for the example are listed in Table 2.1.

Table 2.1 Requirements and Tools

Item	Contents
MCUs used	RL78/F13, F14
Operating frequencies	High-speed on-chip oscillator (HOCO) clock: 32 MHz CPU/peripheral hardware clock: 32MHz
Operating voltage	5.0V (operable at 3.0 to 5.5V) LVD operation (VLVI): reset mode at 2.81V (2.76 to 2.97V)
Integrated development environment	Renesas Electronics Corporation CubeSuite+V1.03.00
C compiler	Renesas Electronics Corporation CA78KR V1.50
Operation mode	—
Sample code version	1.0
Used circuit board	QB-R5F10PMFK-TB
Used device	R5F10PMFK

3. Hardware

3.1 Pins

Pins and Corresponding Functions used in the example are listed in Table 3.1.

Table 3.1 Pins and Corresponding Functions

Pins	I/O	Functions
P13/TI04/TO04/TRDIOA0/TRDCLK0/SI01/SDA01/LTXD0	Output	Data transmission
P14/TI06/TO06/TRDIOC0/SCK01/SCL01/LRXD0	Input	Data reception

4. Software

4.1 Operation Specification

Corresponding message is transmitted after a message is received, and a data response message is sent when a communication error occurs. Correspondence of Transmit/Received Message is listed in Table 4.1, and Correspondence of Error/Response Message is in Table 4.2.

Table 4.1 Correspondence of Transmit/Received Message

Received message	Response message (transmit)
T (54H)	O(4FH), K(4BH), _(5FH), 0(30H), “CR”(0DH), “LF”(0AH)
Other than T (54H)	O(4FH), K(4BH), _(5FH), 1(31H), “CR”(0DH), “LF”(0AH)

Table 4.2 Correspondence of Error and Response (Transmit) Data

Error	Response message (Transmit)
Bit error	B(42H), E(45H), “CR”(0DH), “LF”(0AH)
Overrun error	O(4FH),E(45H), “CR”(0DH), “LF”(0AH)
Framing error	F(46H), E(45H), “CR”(0DH), “LF”(0AH)
Parity error	P(50H), E(45H), “CR”(0DH), “LF”(0AH)
Expansion bit detection	E(45H), X(58H), B(42H), “CR”(0DH), “LF”(0AH)

Detail settings of RLIN3 module are as follows.

<Settings for UART mode>

LIN0 channel is used as UART module.

Use 4 bits of the peripheral I/O redirection register 4 (PIOR4). PIOR4 register setting is changed manually.

The P13/LTXD0 port is used for data output, and the p14/LRxD0 port is used for data input.

8-bit data length

Data transmit direction is set with LSB first.

Parity is set in even parity.

Received data level is set to normal.

Transfer rate is set to 38400bps.

Receive complete interrupt (INTLIN0RVC), transmit complete interrupt (INTLIN0TRM) and receive status interrupt (INTLIN0STA) are used.

INTLIN0TRM, INTLIN0RVC, and INTLIN0STA are set to high-priority interrupt.

4.2 Option Byte Settings

Option Byte Settings are listed in Table 4.3. User can set optimal values to the system as necessary.

Table 4.3 Option Byte Setting

Option bytes	Setting values	Contents
000C0H/020C0H	00H	Watchdog timer unused
000C1H/020C1H	FFH	LVD off mode setting, clock monitor stop
000C2H/020C2H	E8H	P130 as RESOUT pin High-speed on-chip oscillator frequency: 32MHz

4.3 Constants

The constants used in the example are listed in Table 4.4.

Table 4.4 Constants List

Constants	Setting value	Contents
messageOK_0[6]	“OK_0¥r¥n”	Return message when receiving T
messageOK_1[6]	"OK_1¥r¥n"	Return message when receiving other than T
messageBE[4]	"BE¥r¥n"	Return message at bit error
messageOE[4]	"OE¥r¥n"	Return message at overrun error
messageFE[4]	"FE¥r¥n"	Return message at framing error
messagePE[4]	"PE¥r¥n"	Return message at parity error
messageEXB[5]	"EXB¥r¥n"	Return message at enlargement bit detection

4.4 Variables

Global variables in the sample software are listed in Table 4.5.

Table 4.5 Global Variable List

Type	Variable Name	Contents	Used Function
u8(unsigned char)	g_UartRxBuf	Received data buffer	main()
MD_STATUS (unsigned short)	g_UartTxEnd	Transmit complete flag	main() R_UART_Callback_SendEnd()
u8(unsigned char)	g_UartTxAddress	Transmit data pointer	R_UART_Send() R_UART_Interrupt_Send()
u8(unsigned char)	g_UartTxCnt	Transmit byte number counter	R_UART_Send() R_UART_Interrupt_Send()
u8(unsigned char)	g_UartRxAddress	Received data pointer	R_UART_Receive() R_UART_Interrupt_Receive() R_UART_Interrupt_Error()
u8(unsigned char)	g_UartRxCnt	Receive byte number counter	R_UART_Receive() R_UART_Interrupt_Receive()
u8(unsigned char)	g_UartRxLen	Number of receive bytes	R_UART_Receive() R_UART_Interrupt_Receive()
u8(unsigned char)	g_UartRxError	Receive error type	main() R_UART_Callback_ReceiveEnd() R_UART_Callback_Error(type)

4.5 Functions

Table 4.6 lists functions in the sample software.

Table 4.6 Function List

Function Name	Function Usage
R_PORT_Init()	Initial value setting of port
R_LIN0_Init()	Initial value setting of LIN0
R_UART_Init()	Initial value setting of LIN0-UART
R_UART_Start()	LIN0-UART start operation
R_UART_Stop()	LIN0-UART stop operation
R_UART_Receive()	initial value setting of LIN0-UART receive status
R_UART_Send()	LIN0-UART data transmission operation
R_UART_Interrupt_Send()	LIN0-UART transmit interrupt operation
R_UART_Callback_SendEnd()	LIN0-UART transmit completion
R_UART_Interrupt_Receive()	LIN0-UART receive interrupt operation
R_UART_Callback_ReceiveEnd()	LIN0-UART received data classification
R_UART_Interrupt_Error()	LIN0-UART receive status interrupt operation
R_UART_Callback_Error(type)	LIN0-UART receive error classification

4.6 Function Specifications

The following tables list function specifications.

R_PORT_Init	
Outline	Initial value setting of ports
Header	r_macrodriver.h, r_port.h
Declaration	void R_PORT_Init(void)
Description	Initialization of pins LTXD0 and LRxD0
Argument	None
Returned value	None

R_LIN0_Init	
Outline	Initial value setting of LIN0
Header	r_macrodriver.h, r_serial.h
Declaration	void R_LIN0_Init(void)
Description	Initialization of LIN channel 0
Argument	None
Returned value	None

R_UART_Init	
Outline	Initial value setting of LIN0-UART
Header	r_macrodriver.h, r_serial.h
Declaration	void R_UART_Init(void)
Description	Initialization of LIN0 (UART mode)
Argument	None
Returned value	None

R_UART_Start	
Outline	LIN0-UART start operation
Header	r_macrodriver.h, r_serial.h
Declaration	void R_UART_Start(void)
Description	UART mode of LIN channel0 start (communication standby status)
Argument	None
Returned value	None

R_UART_Stop	
Outline	LIN0-UART stop operation
Header	r_macrodriver.h, r_serial.h
Declaration	void R_UART_Stop(void)
Description	UART mode of LIN channel0 stop (communication stop status)
Argument	None
Returned value	None

R_UART_Receive	
Outline	Initial value setting of LIN0-UART receive status
Header	r_macrodriver.h, r_serial.h
Declaration	MD_STATUS R_UART_Receive(u8 *rxbuf, u8 rxnum)
Description	Initialization of LIN channel0 (UART reception)
Argument	U8 *rxbuf: received data buffer address U8 rxnum: received data buffer size
Returned value	MD_OK: receive setting complete MD_ARGERROR: receive setting fail

R_UART_Send	
Outline	LIN0-UART data transmission operation
Header	r_macrodriver.h, r_serial.h
Declaration	MD_STATUS R_UART_Send(u8 *txbuf, u8 txnum)
Description	Initialization of LIN channel0 (UART transmission), data transmission start
Argument	U8 *txbuf: transmit data buffer address U8 txnum: transmit data buffer size
Returned value	MD_OK: transmission setting complete MD_ARGERROR: transmittion setting fail

R_UART_Interrupt_Send	
Outline	LIN0-UART transmit interrupt operation
Header	r_macrodriver.h, r_serial.h
Declaration	__interrupt void R_UART_Interrupt_Send(void)
Description	Data transmission (specified numbers)
Argument	None
Returned value	None

R_UART_Callback_SendEnd	
Outline	LIN0-UART transmit complete operation
Header	r_macrodriver.h, r_serial.h
Declaration	void R_UART_Callback_SendEnd(void)
Description	Setting of transmit complete flag
Argument	None
Returned value	None

R_UART_Interrupt_Receive	
Outline	LIN0-UART receive interrupt operation
Header	r_macrodriver.h, r_serial.h
Declaration	__interrupt void R_UART_Interrupt_Receive(void)
Description	Message transmission responding to received data
Argument	None
Returned value	None

R_UART_Callback_ReceiveEnd	
Outline	LIN0-UART received data classification operation
Header	r_macrodriver.h, r_serial.h
Declaration	void R_UART_Callback_ReceiveEnd(void)
Description	Receive error flag clear
Argument	None
Returned value	None

R_UART_Interrupt_Error	
Outline	LIN0-UART receive status interrupt operation
Header	r_macrodriver.h, r_serial.h
Declaration	__interrupt void R_UART_Interrupt_Error(void)
Description	Message transmission responding to detected error
Argument	None
Returned value	None

R_UART_Callback_Error	
Outline	LIN0-UART receive error classification operation
Header	r_macrodriver.h, r_serial.h
Declaration	void R_UART_Callback_Error(u8 err_type)
Description	Message transmission flag setting responding to error
Argument	U8 err_type: error type
Returned value	None

4.7 Operation Flow

The Operation Flow Chart is described in Figure 4.1.

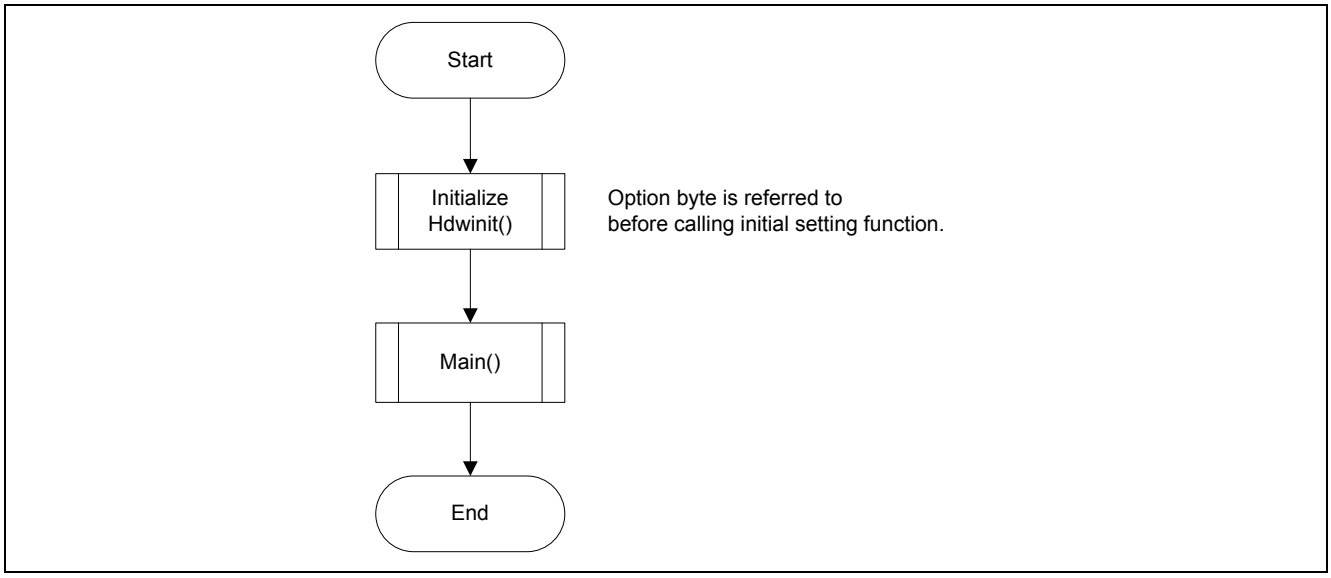

Figure 4.1 Operation Flow Chart

4.7.1 Initialization

The flow chart of initialization is described in Figure 4.2.

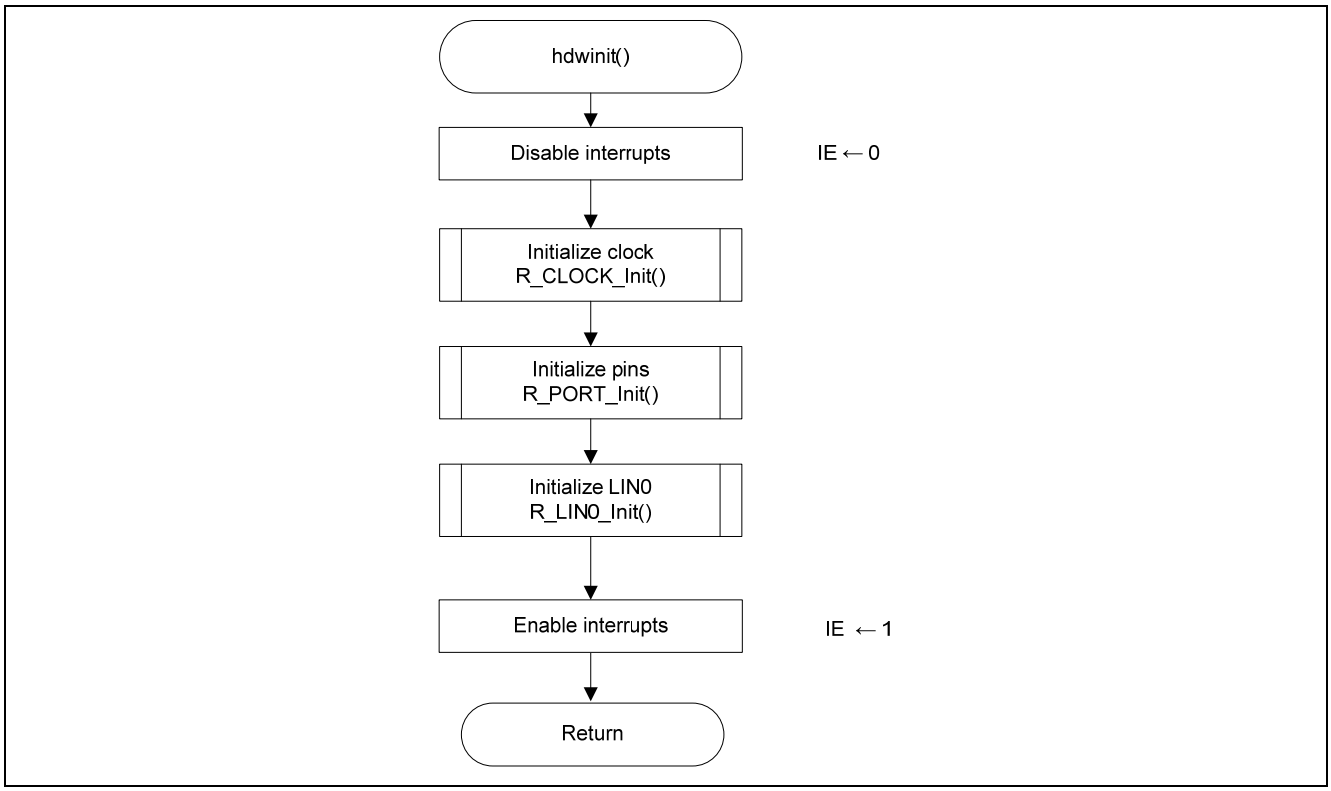

Figure 4.2 Initialization

4.7.2 CPU Clock Setting

The flow chart of CPU Clock Setting is described in Figure 4.3.

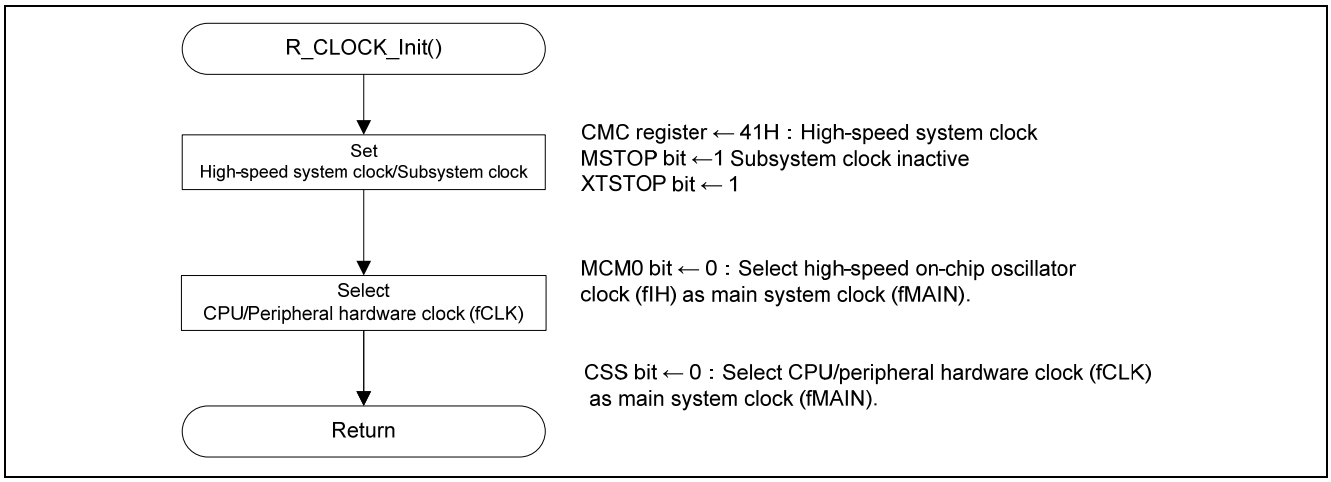

Figure 4.3 CPU Clock Setting

4.7.3 I/O Port Setting

The flow chart of I/O Port Setting is described in Figure 4.4.

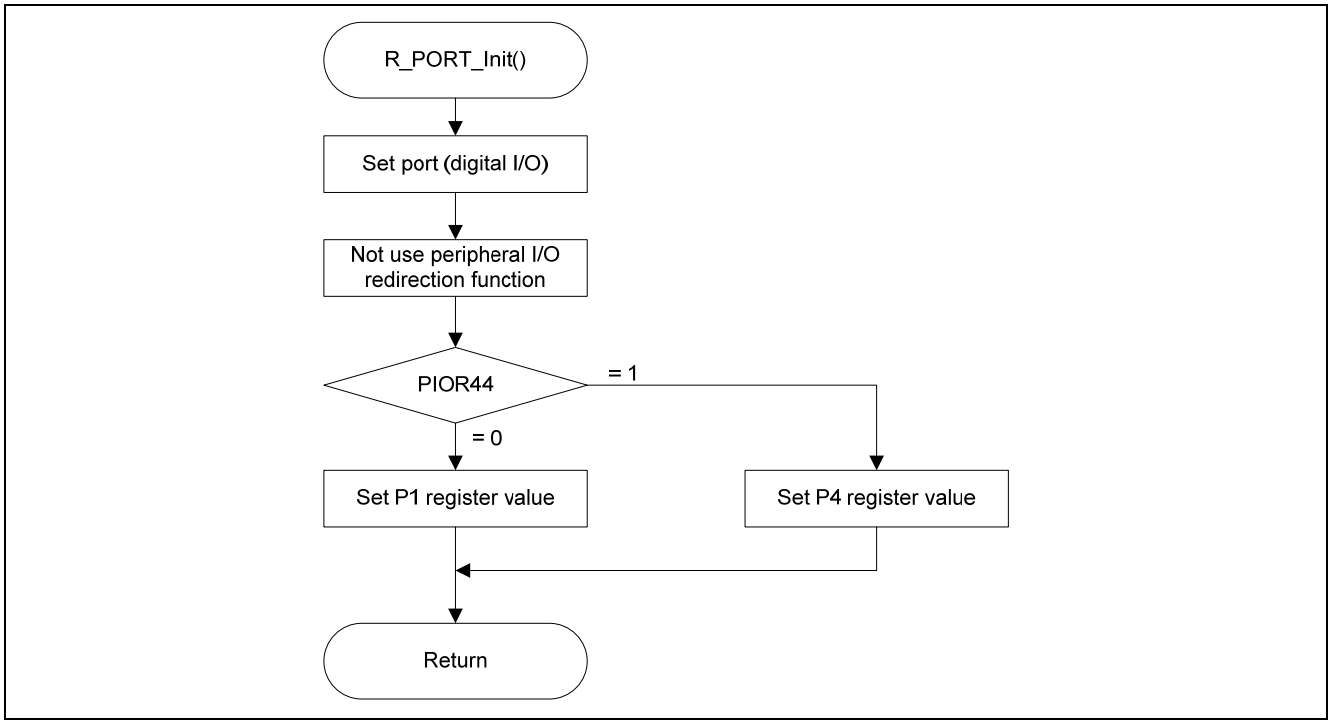

Figure 4.4 I/O Port Setting

<Setting of the Pins LTXD0 and LRXD0>

Target registers: Port register 1 (P1), Port mode register 1 (PM1), Pull-up resistor option register 1 (PU1)
Select I/O mode and output latch for each port.

Symbol: P1

7	6	5	4	3	2	1	0
P17	P16	P15	P14	P13	P12	P11	P10
×	×	×	**1**	**1**	×	×	×

Bit 3

P13	Output data control (in output mode)	Input data reading (in input mode)
0	Output low	Input low
1	Outputs high	Input high

Symbol: PM1

7	6	5	4	3	2	1	0
PM17	PM16	PM15	PM14	PM13	PM12	PM11	PM10
×	×	×	**1**	**0**	×	×	×

Bit 4

PM14	P14 I/O mode control
0	Output mode (output buffer ON)
1	Input mode (Output buffer OFF)

Bit 3

PM13	P13 I/O mode control
0	Output mode (Output buffer ON)
1	Input mode (Input buffer OFF)

Symbol: PU1

7	6	5	4	3	2	1	0
PU17	PU16	PU15	PU14	PU13	PU12	PU11	PU10
×	×	×	**1**	**1**	×	×	×

Bit 4 – 3

PU14	PU13	On-chip pull-up resistor selection
0	0	Does not connect On-chip pull-up resistor
1	1	Conntects On-chip pull-up resistor

Note: For details of the register settings, refer to the updated version of RL78/F13, F14 User's Manual: Hardware.

4.7.4 Setting of LIN0

The flow chart for Setting of LIN0 is described in Figure 4.5.

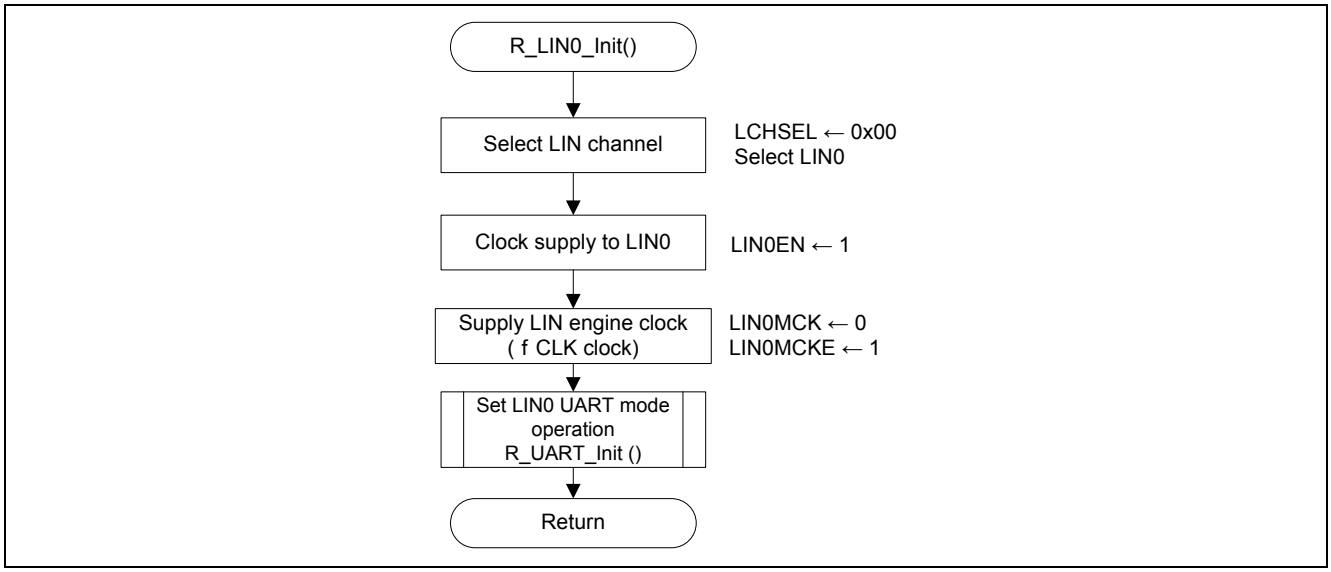

Figure 4.5 Setting of LIN0

<LIN Channel Setting>

LIN channel select register (LCHSEL)

Select the appropriate LIN channel.

Symbol: LCHSEL

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	LSEL0
0	0	0	0	0	0	0	**0**

Bit 0

LSEL0	LIN channel select bit
0	Selects LIN0 (LIN0 register accessible)
1	Selects LIN1 (LIN1 register accessible)

Note: For details of the register settings, refer to the updated version of RL78/F13, F14 User's Manual: Hardware.

<Clock Supply to LIN0>

Peripheral enable register 2 (PER2)

Start clock supply to LIN0.

Symbol: PER2

7	6	5	4	3	2	1	0
0	0	0	0	LIN1EN	LIN0EN	0	CAN0EN
0	0	0	0	×	**1**	0	×

Bit 2

LIN0EN	Control of input clock to LIN
0	Stops input clock supply
1	Enables input clock supply

Note: For details of the register settings, refer to the updated version of RL78/F13, F14 User's Manual: Hardware.

<Engine Clock Supply to LIN0>

LIN clock select register (LINCKSEL)

Start engine clock supply to LIN0.

Symbol: LINCKSEL

7	6	5	4	3	2	1	0
0	0	LIN1MCKE	LIN0MCKE	0	0	LIN1MCK	LIN0MCK
0	0	×	**1**	0	0	×	**0**

Bit 4

LIN0MCKE	Control of suppllying/stopping LIN0 engine clock source
0	Stops LIN engine clock supply
1	Enables LIN engine clock supply

Bit 0

LIN0MCK	Control of selecting LIN0 engine clock source
0	Selects fCLK clock
1	Selects fMX clock

Note: For details of the register settings, refer to the updated version of RL78/F13, F14 User's Manual: Hardware.

4.7.5 Operation Setting of LIN0 in UART Mode

The flow chart Operation Setting of LIN0 in UART Mode is described in Figure 4.6.

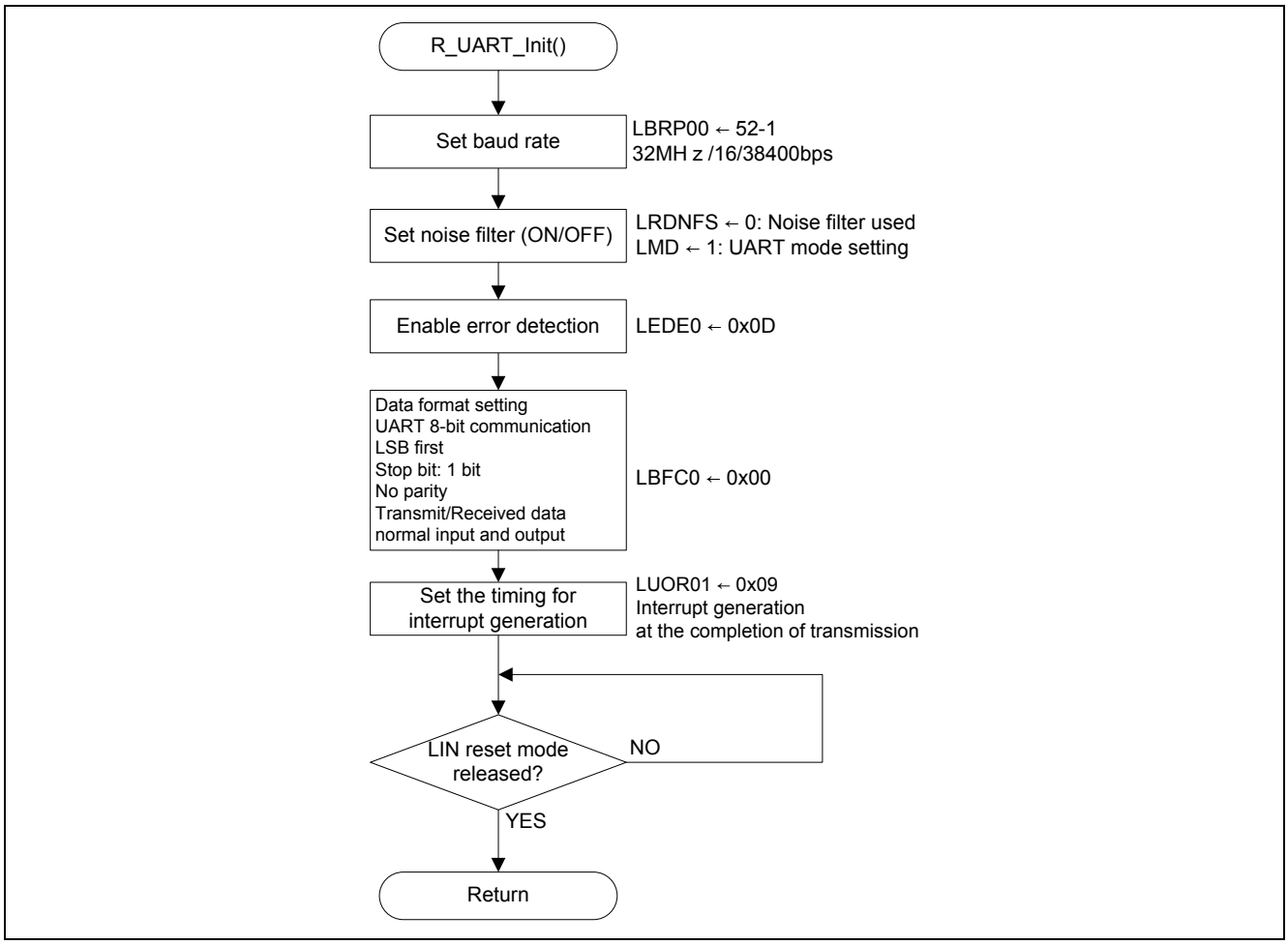

Figure 4.6 Operation Setting of LIN0 in UART Mode

<LIN Baud Rate Prescaler Setting>

LIN baud rate prescaler 0 register (LBRP00)

Set the baud rate prescaler in reset mode. Calculation example in the operation frequency of 32MHz is described in Figure 4.7 (Target baud rate: 38400 bps, LBRP00 = (32MHz/16/38400bps)-1 = 51).

Symbol: LBRP00

7	6	5	4	3	2	1	0

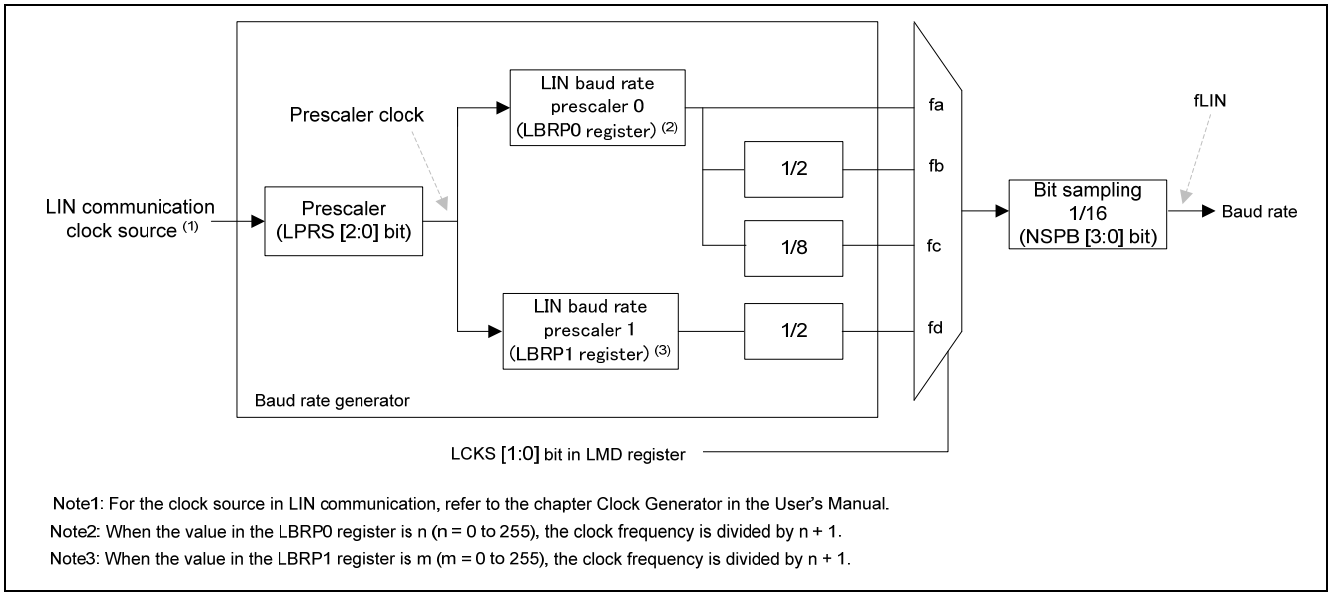

Figure 4.7 Block Diagram of Baud Rate Generation

<Mode Setting of LIN Module>

UART mode register 0 (LMD0)

Select the mode of LIN module and enable/disable the noise filter (when receiving data) in LIN reset mode.

Symbol: LMD0

7	6	5	4	3	2	1	0
0	0	LRDNFS	0	0	0	LMD[1:0]	
0	0	**0**	0	0	0	**0**	**1**

Bit 1-0

LMD[1:0]	LIN/UART mode select bit
00	LIN master mode
01	UART mode

Bit 5

LRDNFS	LIN reception data noise filtering disable bit
0	Enables noise filter
1	Disables noise filter

Note: For details of the register settings, refer to the updated version of RL78/F13, F14 User's Manual: Hardware.

<UART Communication Error Detection Setting>

UART error detection enable register 0 (LEDE0)

Enable/disable error detection for UART communication in LIN reset mode.

Symbol: LEDE0

7	6	5	4	3	2	1	0
0	0	0	0	FERE	OERE	0	BERE
0	0	0	0	**1**	**1**	0	**1**

Bit 3

FERE	Framing error detection enable bit
0	Disables framing error detection
1	Enables framing error detection

Bit 2

OERE	Overrun error detection enable bit
0	Disables overrun error detection
1	Enables overrun error detection

Bit 0

BERE	Bit error detection enable bit
0	Disables bit error detection
1	Enables bit error detection

Note: For details of the register settings, refer to the updated version of RL78/F13, F14 User's Manual: Hardware.

<Data Format Setting>

UART configuration register 0 (LBFC0)

Set the data format for UART communication in LIN reset mode.

Symbol: LBFC0

7	6	5	4	3	2	1	0
0	UTPS	URPS	UPS[1:0]		USBLS	UBOS	UBLS
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Bit 6

UTPS	UART output polarity select bit
0	Transmits data output as is
1	Inverts output of transmit data

Bit 5

URPS	UART input polarity select bit
0	Inputs received data as is
1	Inverts output of received data

Bit 4-3

UPS[1:0]	UART parity select bit
00	Does not output parity bit
01	Outputs even parity
10	Outputs 0 parity
11	Outputs odd parity

Bit 2

USBLS	UART stop bit length select bit
0	Stop bit: 1 bit
1	Stop bit: 2 bits

Bit 1

UBOS	UART transfer format select bit
0	LSB first
1	MSB first

Bit 0

UBLS	UART character length select bit
0	UART 8-bit character communication
1	UART 7-bit character communication

Note: For details of the register settings, refer to the updated version of RL78/F13, F14 User's Manual: Hardware.

<LIN Reset Mode Release Setting>

UART control register 0 (LCUC0)

Relase LIN reset mode. As for LCUC0, execute subsequent writings after confirming that the written value is reflected in the register.

Symbol: LCUC0

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	OM0
0	0	0	0	0	0	0	**1**

Bit 0

OM0	LIN reset bit
0	LIN reset mode
1	Not LIN reset mode

Note: For details of the register settings, refer to the updated version of RL78/F13, F14 User's Manual: Hardware.

<Option Setting for UART Communication>

UART option register 1 (LUOR01)

Set the timing of transmit interrupt generation and the values of the expansion bit.

Symbol: LUOR01

7	6	5	4	3	2	1	0
0	0	0	UECD	UTIGTS	0	UEBDL	UEBE
0	0	0	**0**	**1**	0	**0**	**1**

Bit 4

UECD	Expansion bit comparison disable bit
0	Enables expansion bit comparison
1	Disables expansion bit comparison

Bit 3

UTIGTS	Transmission interrupt generation timing select bit
0	Generates interrupt at the start of transmission
1	Generates interrupt at the completion of transmission

Bit 1

UEBDL	Expansion bit detection level select
0	Sets expansion bit detection level to 0
1	Sets expansion bit level to 1

Bit 0

UEBE	Expansion bit enable bit
0	Disables expansion bit operation
1	Enables expansion bit operation

Note: For details of the register settings, refer to the updated version of RL78/F13, F14 User's Manual: Hardware.

4.7.6 Main Function

The flow chart for operation of Main Function is described in Figure 4.8 and 4.9.

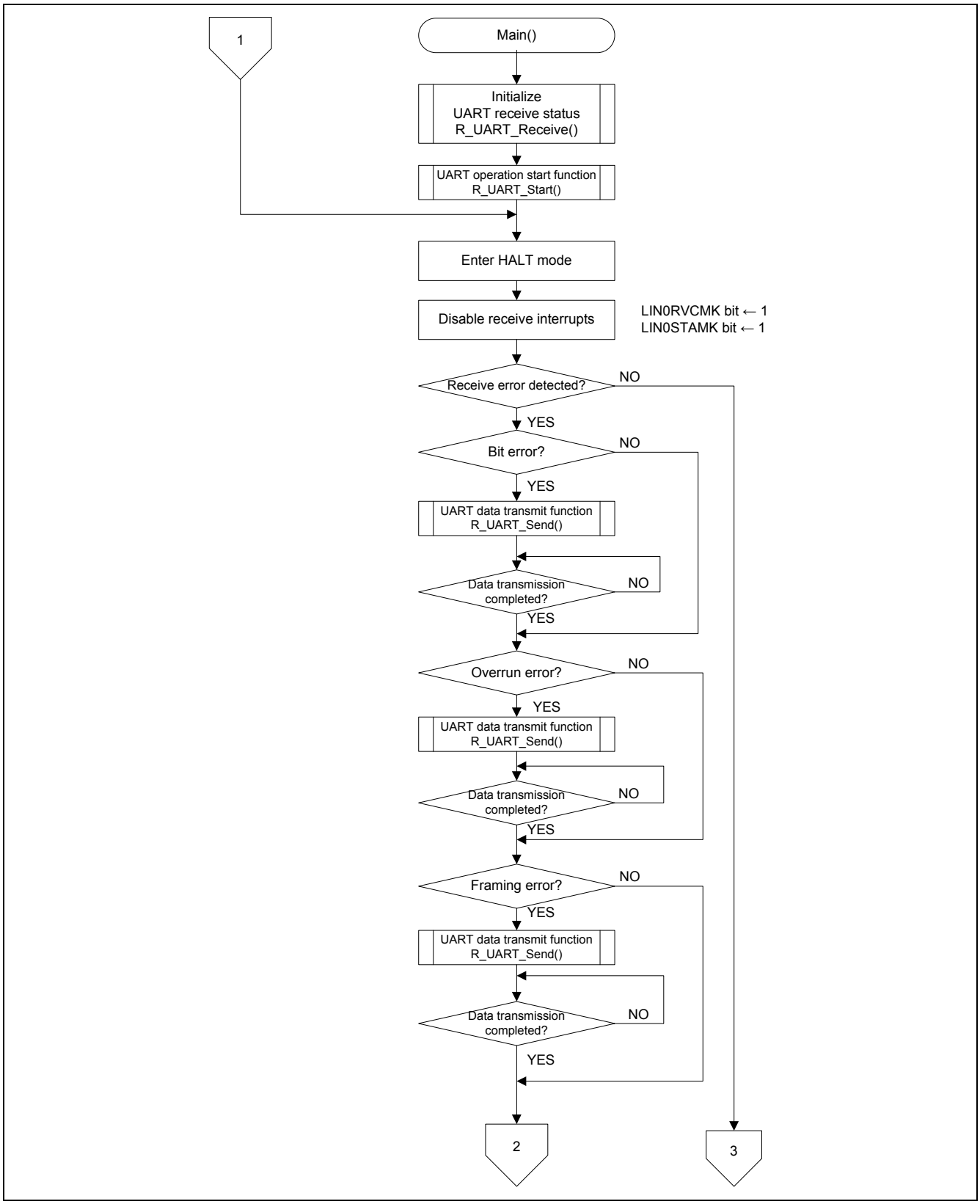

Figure 4.8 Main Function (1/2)

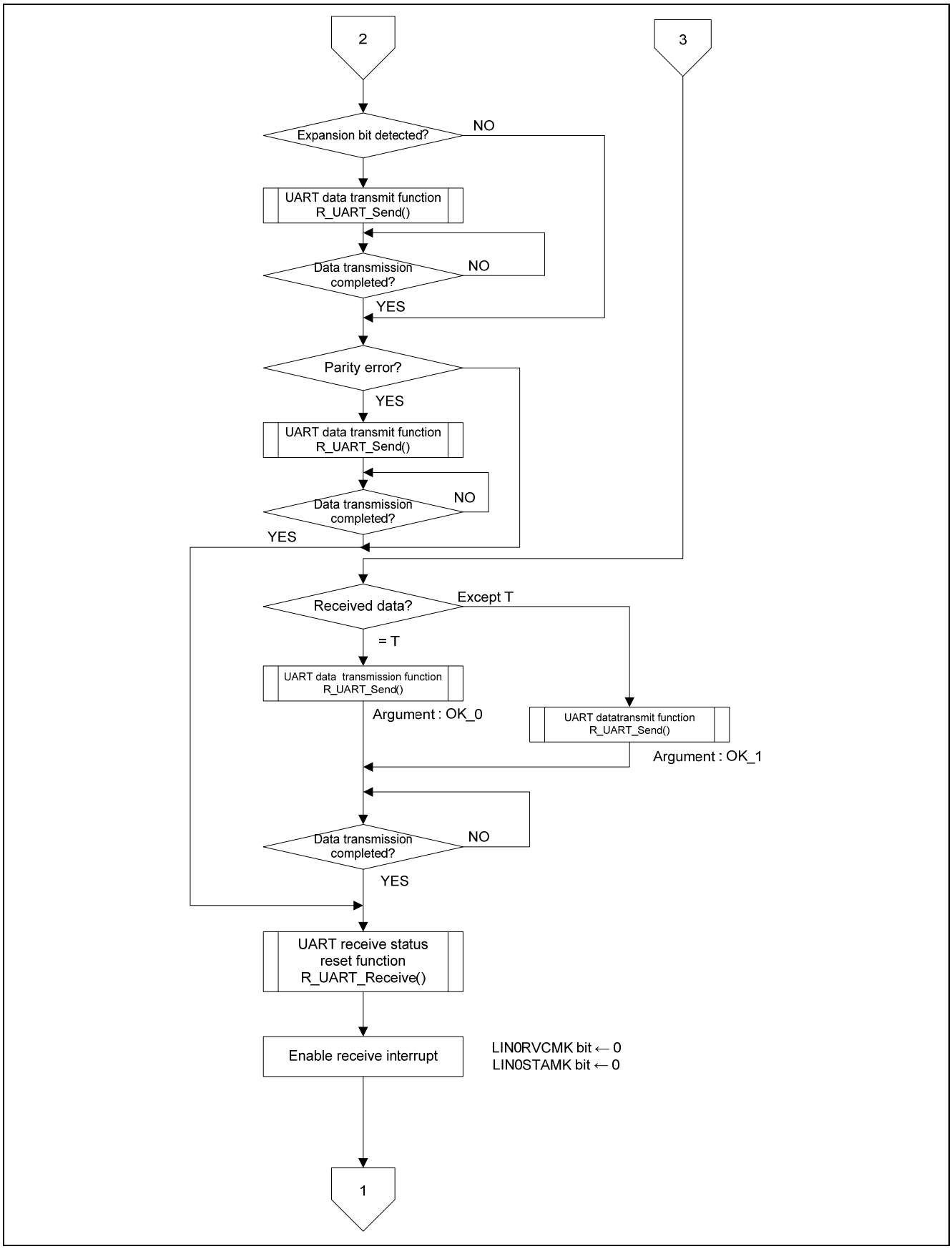

Figure 4.9 Main Function (2/2)

4.7.7 Initialization of UART Receive Status

Figure 4.10 describes Initialization of UART Receive Status.

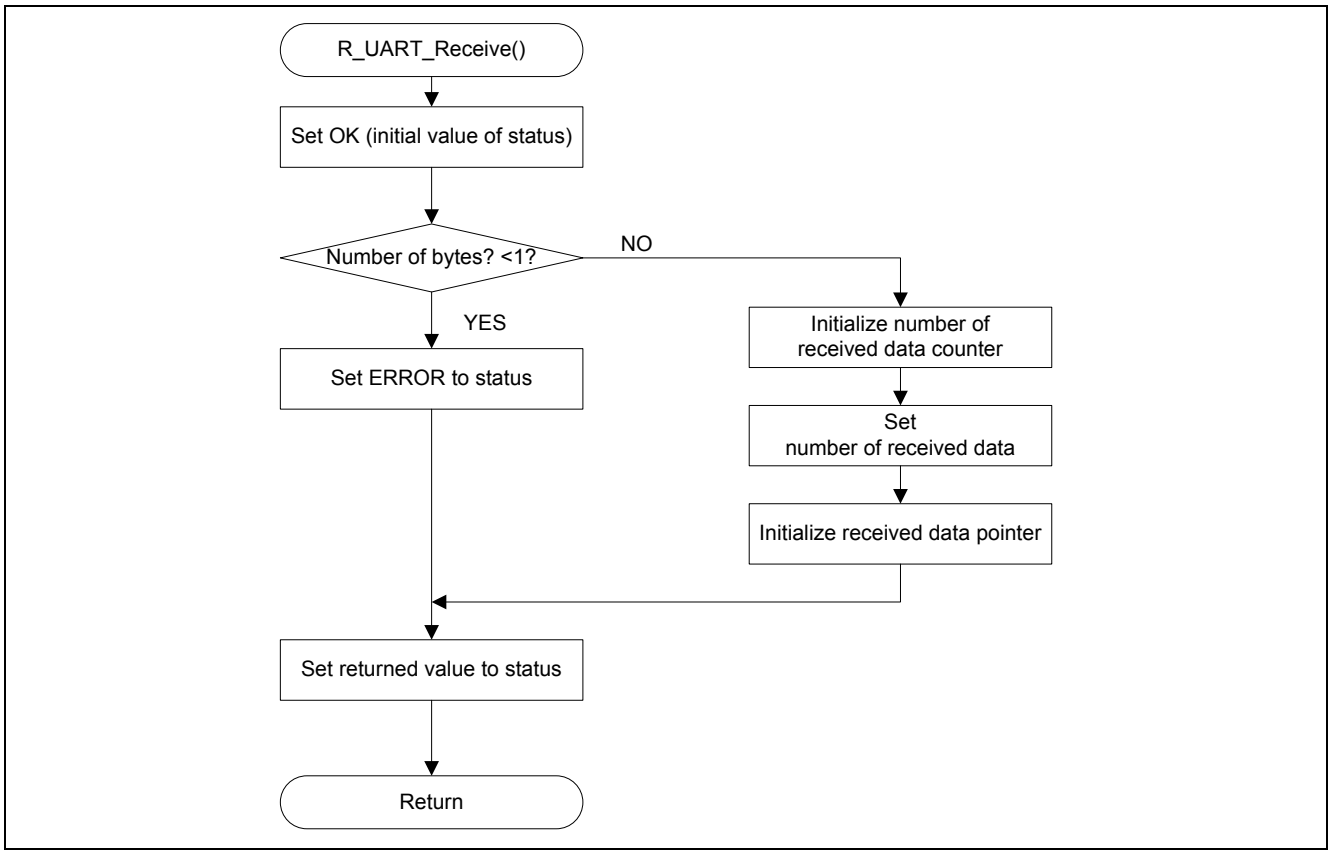

Figure 4.10 Initialization of UART Receive Status

4.7.8 UART Communication Start operation

Figure 4.11 is the flow chart of UART Communication Start Operation.

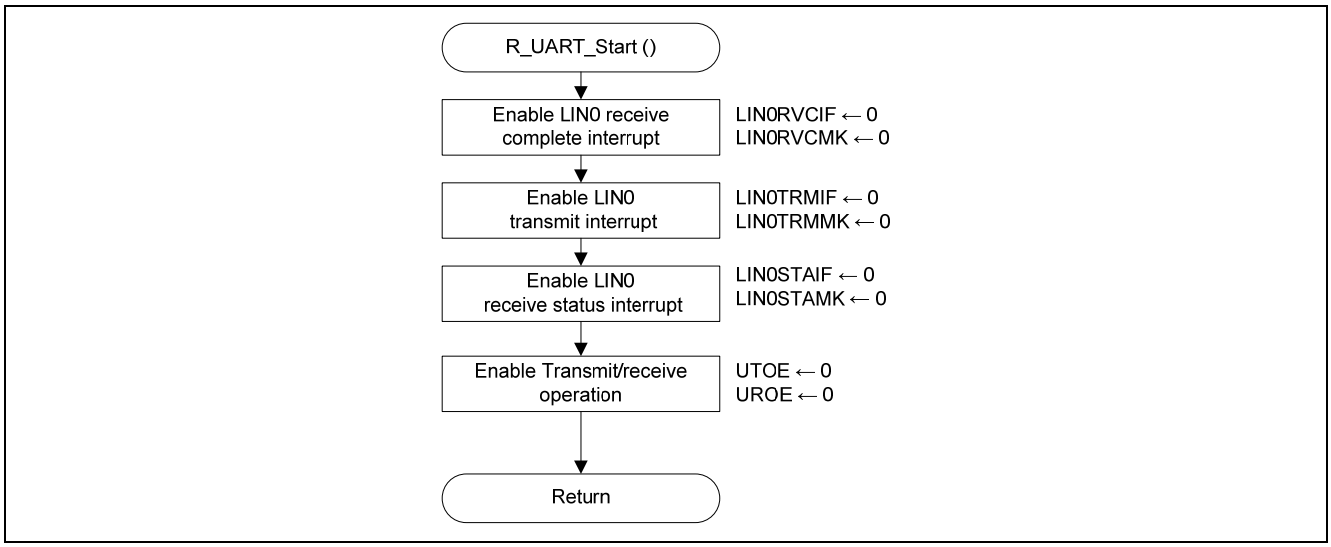

Figure 4.11 UART Communication Start Operation

<UART Communication Operation Enable Setting>

UART operation enable register 0 (LUOER0)

Enable UART transmit/receive operation.

Symbol: UOER0

7	6	5	4	3	2	1	0
0	0	0	0	0	0	UROE	UTOE
0	0	0	0	0	0	**1**	**1**

Bit 1

UROE	Reception enable bit
0	Disables reception
1	Enables reception

Bit 0

UTOE	Transmission enable bit
0	Disables transmission
1	Enables transmission

Note: For details of the register settings, refer to the updated version of RL78/F13, F14 User's Manual: Hardware.

4.7.9 UART Receive Complete Interrupt Operation

The flow chart of UART Receive Complete Interrupt Operation is described in Figure 4.12.

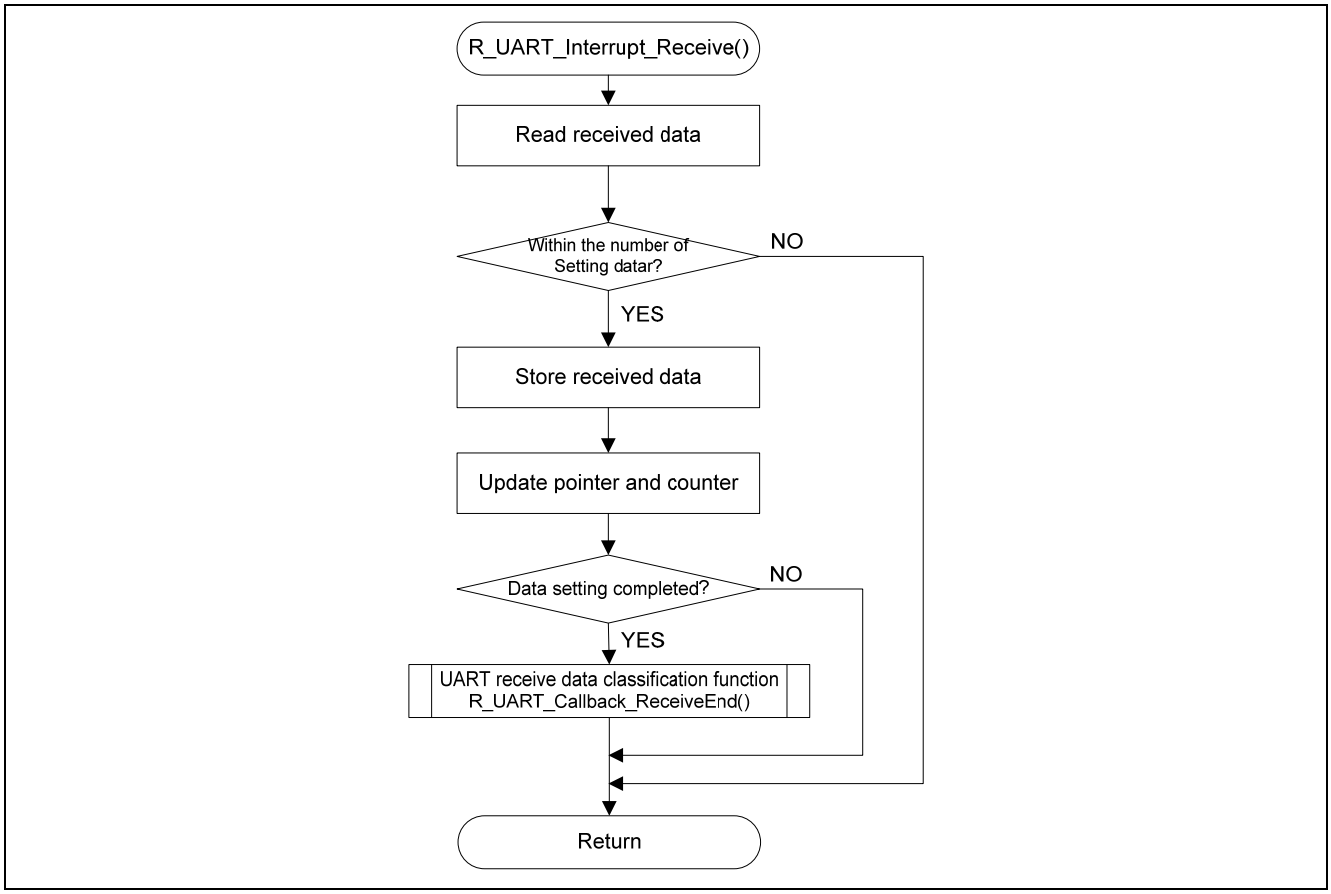

Figure 4.12 UART Receive Complete Interrupt Operation

4.7.10 UART Received Data Classification Operation

The flow chart of UART Received Data Classification is described in Figure 4.13.

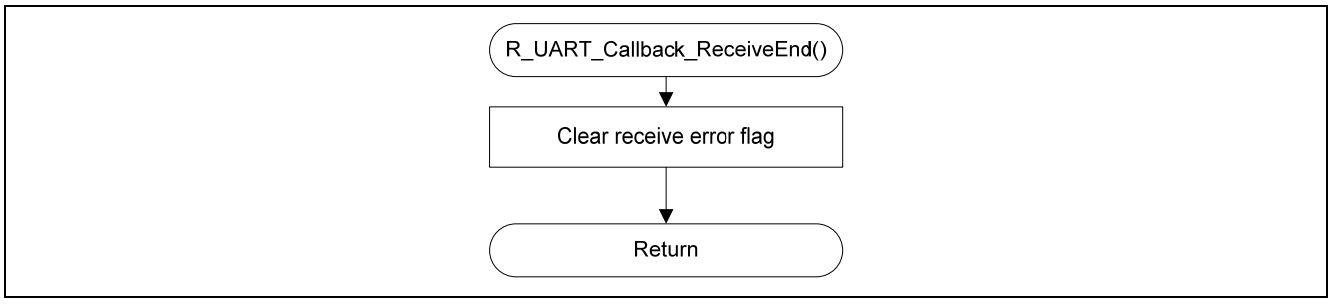

Figure 4.13 UART Received Data Classification Operation

4.7.11 UART Data Transmit Operation

The flow chart of UART Data Transmit Operation is described in Figure 4.14.

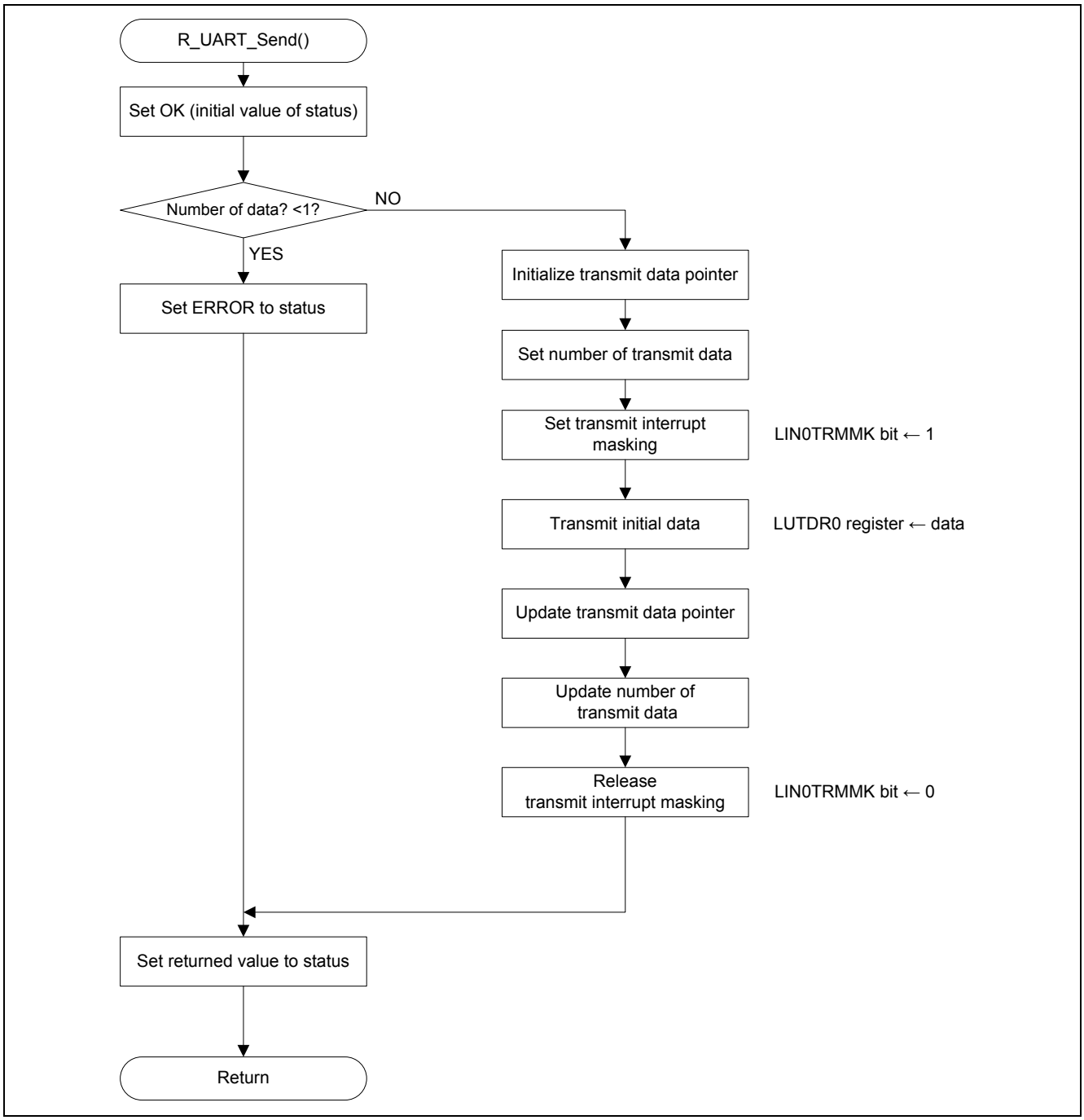

Figure 4.14 UART Data Transmit Operation

4.7.12 UART Transmit Interrupt Operation

The flow chart of UART Transmit Interrupt Operation is described in Figure 4.15.

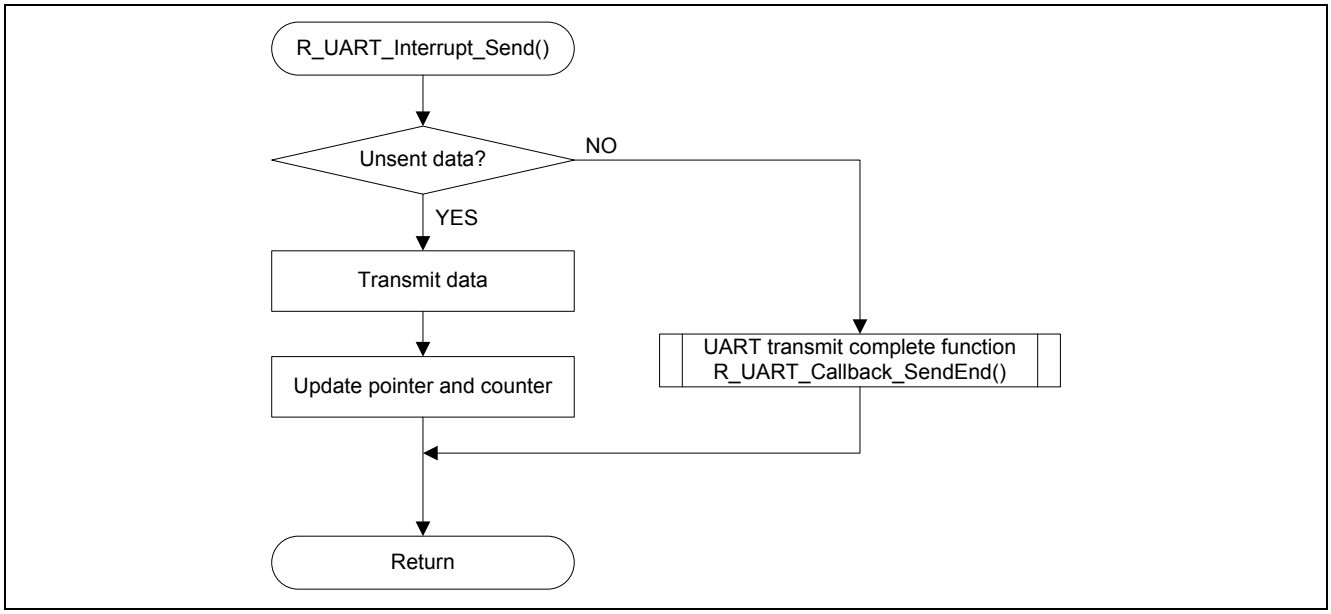

Figure 4.15 UART Transmit Interrupt Operation

4.7.13 UART Transmit Complete Operation

The flow chart of UART Transmit Complete Operationis described in Figure 4.16.

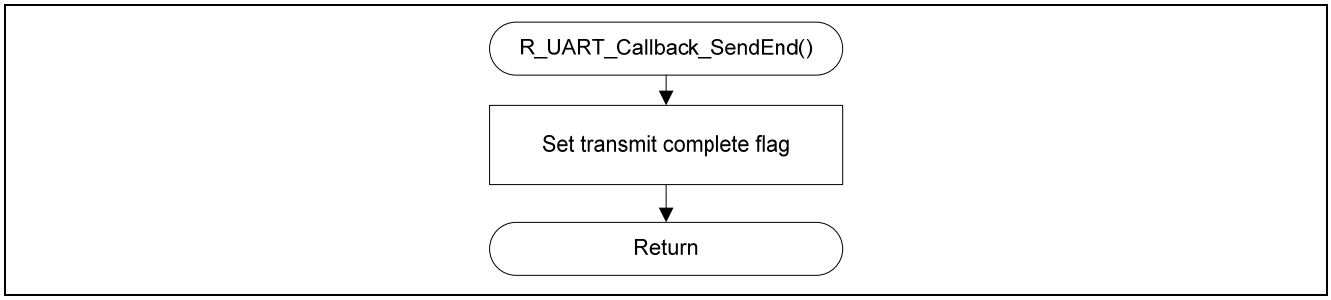

Figure 4.16 UART Transmit Complete Operation

4.7.14 UART Receive Status Interrupt Operation

The flow chart of UART Receive Status Interrupt Operation is described in Figure 4.17.

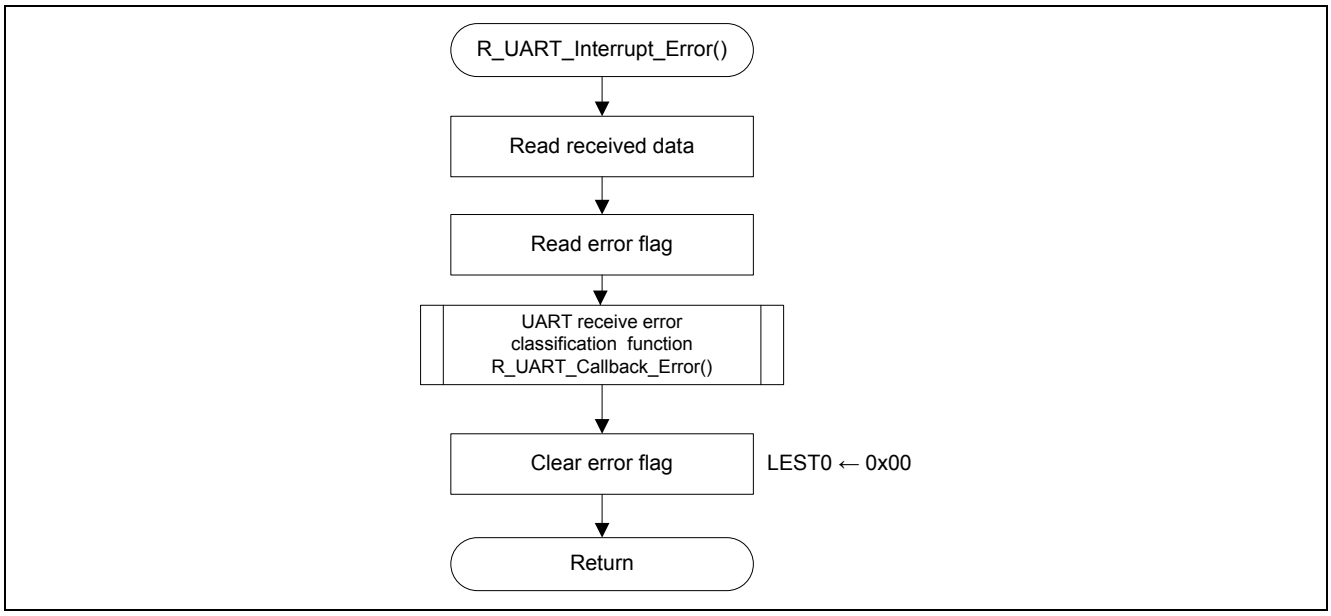

Figure 4.17 UART Receive Status Interrupt Operation

4.7.15 UART Receive Error Classification Operaion

The flow chart of UART Receive Error Classification is described in Figure 4.18.

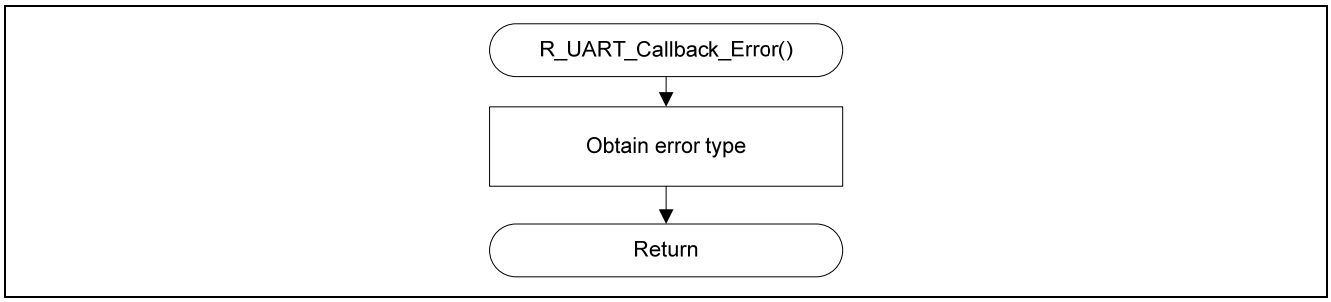

Figure 4.18 UART Receive Error Classification Operation

5. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

6. Reference Documents

User's Manual: Hardware

RL78/F13, 14 User's Manual: Hardware Rev.1.00

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

Technical Update/Technical News

The latest information can be downloaded from the Renesas Electronics website.

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Revision History

		Description	
Rev.	**Date**	**Page**	**Summary**
1.02	Dec 24, 2013	—	First edition issued

General Precautions in the Handling of MPU/MCU Products

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

1. 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 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. Unused pins should be handled as described under Handling of Unused Pins in the manual.

2. Processing at Power-on

   The state of the product is undefined at the moment 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 moment 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 moment 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 moment when power is supplied until the power reaches the level at which resetting has been specified.

3. Prohibition of Access to Reserved Addresses

   Access to reserved addresses is prohibited.

   — The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

4. Clock Signals

   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has 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. Moreover, 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.

5. Differences between Products

   Before changing from one product to another, i.e. to a product with a different part number, confirm that the change will not lead to problems.

   — The characteristics of an MPU or MCU in the same group but having a different part number may differ in terms of the 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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