R8C/54E Group

Hardware LIN in Slave Mode

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Abstract

This document describes using hardware LIN in slave mode.

Products

R8C/54E Group

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

Contents

1. Specifications

Use the hardware LIN while in slave mode.

Table 1.1 lists the Peripheral Function and Its Application and Figure 1.1 shows a Block Diagram.

Table 1.1 Peripheral Function and Its Application

Peripheral Function	Application
Hardware LIN channel 0 (HW-LIN_0)	Transmit and receive data in slave mode.

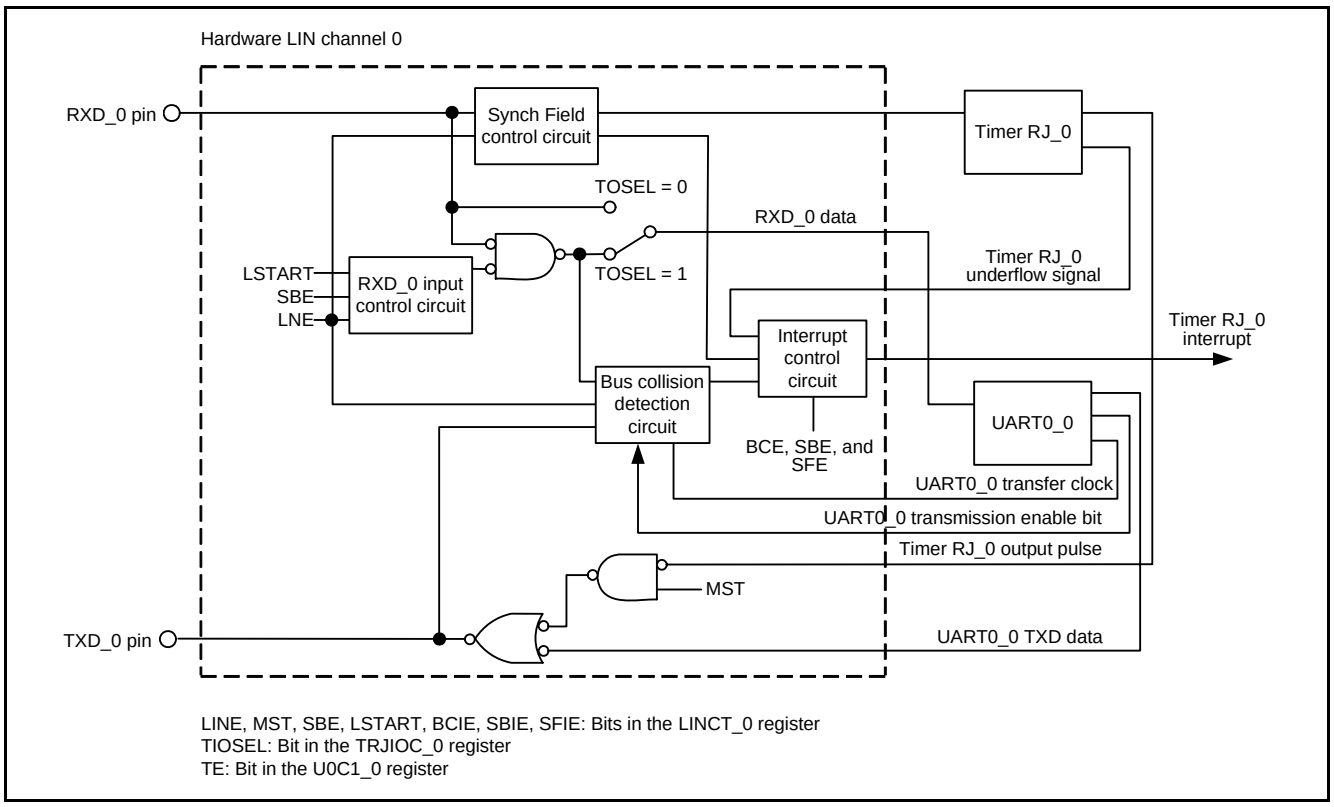

Figure 1.1 Block Diagram

2. Operation Confirmation Conditions

The sample code accompanying this application note has been run and confirmed under the conditions below.

Table 2.1 Operation Confirmation Conditions

Item	Contents
MCU used	R8C/54E Group
Operating frequencies	• XIN clock: 20 MHz • System clock: 20 MHz • CPU clock: 20 MHz
Operating voltage	5.0 V (2.7 to 5.5 V)
Integrated development environment	Renesas Electronics Corporation High-performance Embedded Workshop Version 4.09
C compiler	Renesas Electronics Corporation M16C Series, R8C Family C Complier V.5.45 Release 01
	Compile options -D__UART0__ -c -finfo -dir "$(CONFIGDIR)" -R8C (Default setting is used in the integrated development environment.)

3. Software

This is a sample program to perform LIN communication in slave mode.

3.1 Operation Overview

Settings

- Use channel HW-LIN_0. HW-LIN_0 performs LIN communication in cooperation with timer RJ_0 and UART0_0.
- Operate the hardware LIN in slave mode.
- Use the P1_5/RXD_0 pin for the receive data input.
- Use the P1_4/TXD_0 pin for transmit data output.
- Set the bit rate to 9615 bps (formula for bit rate calculation: 9615 bps = 20 MHz × 1/1 × 1/130 × 1/16)
- This sample program does not have a program to calculate and reset the bit rate using the data measured by the Synch Field.
- Use the timer RJ_0 interrupt. The timer RJ_0 interrupt is generated when a Synch Break is detected. The timer RJ_0 interrupt is not generated when the Synch Field measurement is completed.
- Use the UART0_0 interrupt. The UART0_0 interrupt is generated when data is received at the Synch Field, ID field, data field, or checksum field.
- Use the timer RB2_0 interrupt. The main cycle flag (u1s_main_cycle_flag) is set to 1 every 5 ms.
- This sample program does not perform processing when bus collision is detected.
- A Synch Field signal is also input to UART0_0 RXD.
- Communication direction (transmit or receive) and number of transmit/receive data at a response field are determined by the ID data received at the ID field (see Table 3.1).
- Store data received at the data field to u1s_msg1[2], u1s_msg2[4], and u1s_msg3[8].
- Set data transmitted from the data field to u1s_msg1[2], u1s_msg2[4], and u1s_msg3[8].
- The main cycle is 5 ms. It is generated by timer RB2_0.

Table 3.1 lists the Communication Specification Example and Figure 3.1 shows a Transfer Format.

Table 3.1 Communication Specification Example

Receive ID	Communication Direction	Number of Data	Data Field							
			DATA0	DATA1	DATA2	DATA3	DATA4	DATA5	DATA6	DATA7
01h	Receive	2	XXh	XXh						
21h	Receive	4	XXh	XXh	XXh	XXh				
31h	Receive	8	XXh	XXh	XXh	XXh	XXh	XXh	XXh	XXh
02h	Transmit	2	00h*	00h*						
22h	Transmit	4	00h*	00h*	00h*	00h*				
32h	Transmit	8	00h*	00h*	00h*	00h*	00h*	00h*	00h*	00h*

Note: The initial value is 00h.

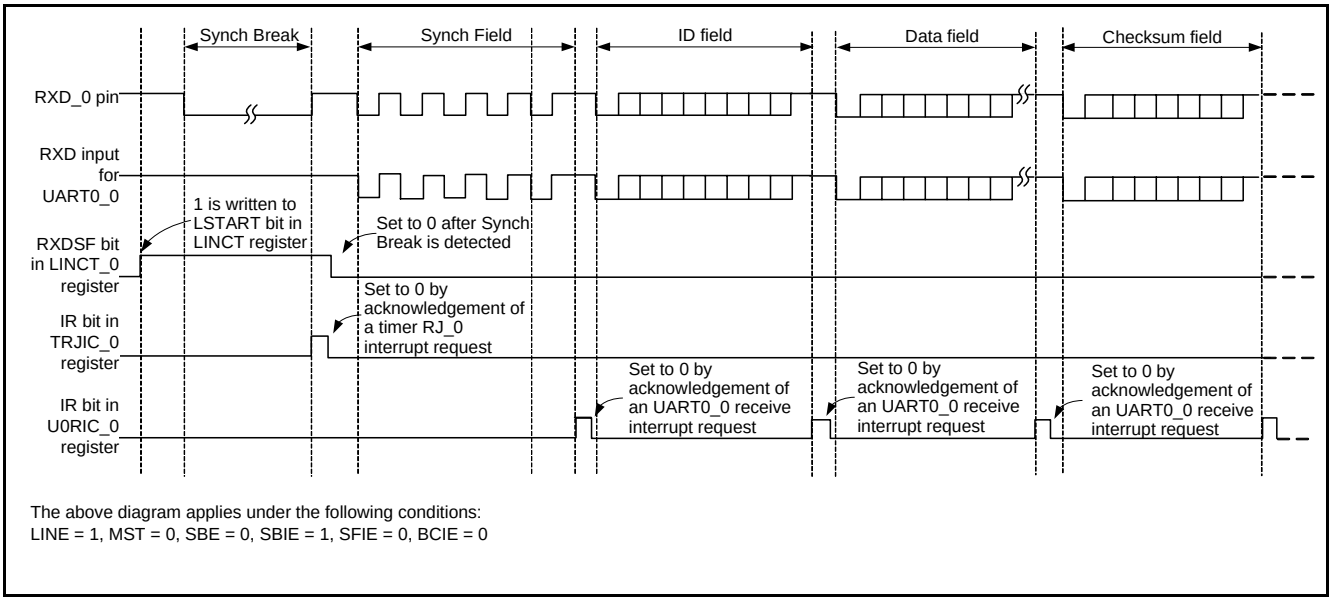

Figure 3.1 Transfer Format

3.2 Required Memory Size

Table 3.2 lists the Required Memory Size.

Table 3.2 Required Memory Size

Memory Used	Size	Remarks
ROM	1056 bytes	In the main.c module and lin.c module
RAM	33 bytes	In the main.c module and lin.c module
Maximum user stack usage	42 bytes	

Note: The required memory size varies depending on the C compiler version and compile options.

3.3 File Composition

Table 3.3 lists the Files Used in the Sample Code. Files not generated by the integrated development environment should not be listed in this table.

Table 3.3 Files Used in the Sample Code

File Name	Outline	Remarks
lin.h	Include file associated with LIN	
lin.c	LIN control program	
main.c	Main control program	

3.4 Constants

Table 3.4 lists the Constants Used in the Sample Code.

Table 3.4 Constants Used in the Sample Code

Constant Name	Setting Value	Contents
LIN_ERR_NONE	0	LIN error state: No error detected
LIN_ERR_FRAMING	1	LIN error state: Framing error detected
LIN_ERR_CHKSUM	2	LIN error state: Checksum error detected
LIN_STS_WAIT_BREAK	0	LIN communication phase: Synch Break
LIN_STS_WAIT_SYNCH	1	LIN communication phase: Synch Field
LIN_STS_WAIT_ID	2	LIN communication phase: ID field
LIN_STS_WAIT_DATA	3	LIN communication phase: Data field
LIN_STS_WAIT_SUM	4	LIN communication phase: Checksum field
JUDGE_NONE	0	Receive/transmit judgement result: No judgement
JUDGE_SEND	1	Receive/transmit judgement result: Transmit
JUDGE_RECEIVE	2	Receive/transmit judgement result: Receive

3.5 Structure/Union List

Figure 3.2 shows the Structure/Union Used in the Sample Code.

```
/*** Variables ***/
/** ID **/
union UID{
    struct{
        unsigned char id:6;
        unsigned char parity:2;
    }bit;
    unsigned char u1_id;                    /* temporary buffer for ID */
};

/** Data **/
union UDATA{
    struct{
        unsigned short b0:1;
        unsigned short b1:1;
        unsigned short b2:1;
        unsigned short b3:1;
        unsigned short b4:1;
        unsigned short b5:1;
        unsigned short b6:1;
        unsigned short b7:1;
        unsigned short b8:1;
        unsigned short b9:1;
        unsigned short b10:1;
        unsigned short b11:1;
        unsigned short b12:1;
        unsigned short b13:1;
        unsigned short b14:1;
        unsigned short b15:1;
    }bit;
    unsigned short u2_word;                 /* temporary buffer for data */
    unsigned char u1_data[2];               /* temporary buffer for data */
};

/** Checksum **/
union UCHECKSUM{
    struct{
        unsigned char lo;
        unsigned char hi;
    }byte;
    unsigned short u2_chksum_word;          /* buffer for checksum */
};

/** Message **/
struct SMSG{
    unsigned char u1_data[8];               /* temporary buffer for data */
    union UID uid;                          /* temporary buffer for ID */
    unsigned char u1_dlc;                   /* temporary buffer for data length */
    unsigned char u1_checksum;
};

union UDATA udata;                          /* temporary buffer for data */
struct SMSG smsg;                           /* temporary buffer for data */
```

Figure 3.2 Structure/Union Used in the Sample Code

3.6 Variables

Table 3.5 lists the Global Variables.

Table 3.5 Global Variables

Type	Variable Name	Contents	Function Used
unsigned char	l_u1g_err_sts	LIN error buffer	ls_vog_init_drv ls_vog_int_recv
unsigned char	ls_u1s_state	LIN communication phase buffer	ls_vog_int_recv ls_vog_break_recv
unsigned char	ls_u1s_judge	Receive/transmit judgement result buffer	ls_vog_init_drv ls_vog_int_recv ls_vog_send_msg ls_vog_recv_msg
unsigned char	ls_u1s_count_data	Receive/transmit data counter	ls_vog_init_drv ls_vog_int_recv ls_vog_send_msg
unsigned char	u1s_main_cycle_flag	Main cycle flag 0: 5 ms not elapsed 1: 5 ms has elapsed	main vos_init_var vog_int_trb2
unsigned char	u1s_recv_frame	Number of receive data flag 0: No received data 1: 2 bytes 2: 4 bytes 3: 8 bytes	vos_init_var ls_vog_header_hook ls_vog_recv_hook
unsigned char	u1s_msg1[2] u1s_msg2[4] u1s_msg3[8]	Receive/transmit data buffer 1 Receive/transmit data buffer 2 Receive/transmit data buffer 3	vos_init_var ls_vog_header_hook ls_vog_recv_hook

3.7 Functions

Table 3.6 lists the Functions.

Table 3.6 Functions

Function Name	Outline
vos_init_cpu	Initial setting of peripherals except for HW-LIN_0
vos_init_var	Initial setting of global variables
ls_vog_init_drv	HW-LIN_0 initial setting
vog_int_trj_0	Timer RJ_0 interrupt handling
ls_vog_break_recv	Synch Break detection processing
vog_int_recv	UART0_0 receive interrupt handling
ls_vog_int_recv	UART0_0 receive processing
ls_vog_header_hook	ID data judgement
ls_vog_recv_msg	Data receive preparation
ls_vog_send_msg	Data transmission
ls_vog_send_hook	Transmission completion processing
ls_vog_recv_hook	Reception completion processing
vog_int_trb2_0	Timer RB2_0 interrupt handling

3.8 Function Specifications

The following tables list the sample code function specifications.

vos_init_cpu	
Outline	Initial setting of peripherals except for HW-LIN_0.
Header	None
Declaration	static void vos_init_cpu(void)
Description	Perform settings of the clocks, timer RB2, interrupts, and ports.
Arguments	None
Returned Value	None

vos_init_var	
Outline	Initial setting of global variables
Header	None
Declaration	static void vos_init_var(void)
Description	Clear the global variables (u1s_main_cycle_flag, u1s_recv_frame, u1s_msg1[ ], u1s_msg2[ ], and u1s_msg3[ ]) to 0.
Arguments	None
Returned Value	None

ls_vog_init_drv	
Outline	HW-LIN_0 initial setting
Header	None
Declaration	void ls_vog_init_drv(void)
Description	Perform initial setting to use HW-LIN_0.
Arguments	None
Returned Value	None

vog_int_trj_0	
Outline	Timer RJ_0 interrupt handling
Header	None
Declaration	void vog_int_trj_0(void)
Description	Timer RJ_0 interrupt. Call Synch Break detection processing function (ls_vog_break_recv).
Arguments	None
Returned Value	None

ls_vog_break_recv	
Outline	Synch Break detection processing
Header	None
Declaration	void ls_vog_break_recv(void)
Description	Detect a Synch Break signal.
Arguments	None
Returned Value	None

vog_int_recv

Outline	UART0_0 receive interrupt handling
Header	None
Declaration	void vog_int_recv(void)
Description	UART0_0 receive interrupt handling. Call UART0_0 receive processing function (ls_vog_int_recv).
Arguments	None
Returned Value	None

ls_vog_int_recv

Outline	UART0_0 receive processing
Header	None
Declaration	void ls_vog_int_recv(void)
Description	UART0_0 receive processing. Processing for receive error is not included. Add error check as needed.
Arguments	None
Returned Value	None

ls_vog_header_hook

Outline	ID data judgement
Header	None
Declaration	void ls_vog_header_hook(unsigned char id)
Description	Determine the communication direction (transmit or receive) and the number of transmit/receive data at the response field by the ID data received at ID field.
Arguments	unsigned char id
Returned Value	None

ls_vog_recv_msg

Outline	Data receive preparation
Header	None
Declaration	void ls_vog_recv_msg(unsigned char dlc)
Description	Prepare to receive data at the response field. Set JUDGE_RECEIVE (receive) to receive/transmit judgement result buffer (ls_u1s_judge) and data length to data length temporary buffer (u1_dlc).
Arguments	unsigned char dlc : Receive data length
Returned Value	None

ls_vog_send_msg

Outline	Data transmission
Header	None
Declaration	void ls_vog_send_msg(unsigned char dlc, unsigned char* msg)
Description	Transmit data at the response field.
Arguments	unsigned char dlc Transmit data length unsigned char* msg Transmit data buffer
Returned Value	None

ls_vog_send_hook

Outline	Transmission completion processing
Header	None
Declaration	void ls_vog_send_hook(void)
Description	No processing is performed in this program. Add processing as needed.
Arguments	unsigned char id
Returned Value	None

ls_vog_recv_hook

Outline	Reception completion processing
Header	None
Declaration	void ls_vog_recv_hook(void)
Description	No processing is performed in this program. Add processing as needed.
Arguments	unsigned char id
Returned Value	None

vog_int_trb2_0

Outline	Timer RB2_0 interrupt handling
Header	None
Declaration	void vog_int_trb2_0(void)
Description	Timer RB2_0 interrupt handling. The main cycle flag (u1s_main_cycle_flag) is set to 1 every 5 ms.
Arguments	None
Returned Value	None

3.9 Flowcharts

3.9.1 Main Processing

Figure 3.3 shows the Main Processing.

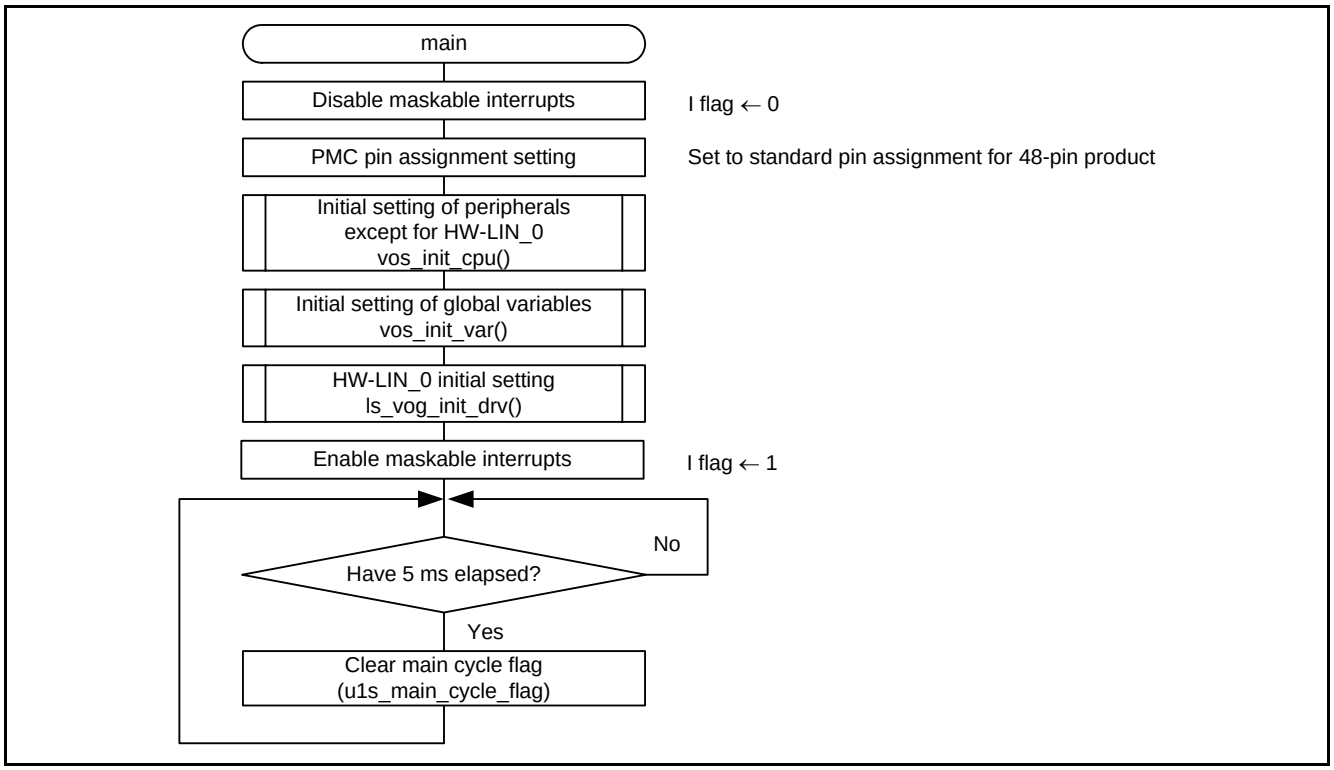

Figure 3.3 Main Processing

3.9.2 Initial Setting of Peripherals Except for HW-LIN_0

Figure 3.4 shows the Initial Setting of Peripherals Except for HW-LIN_0.

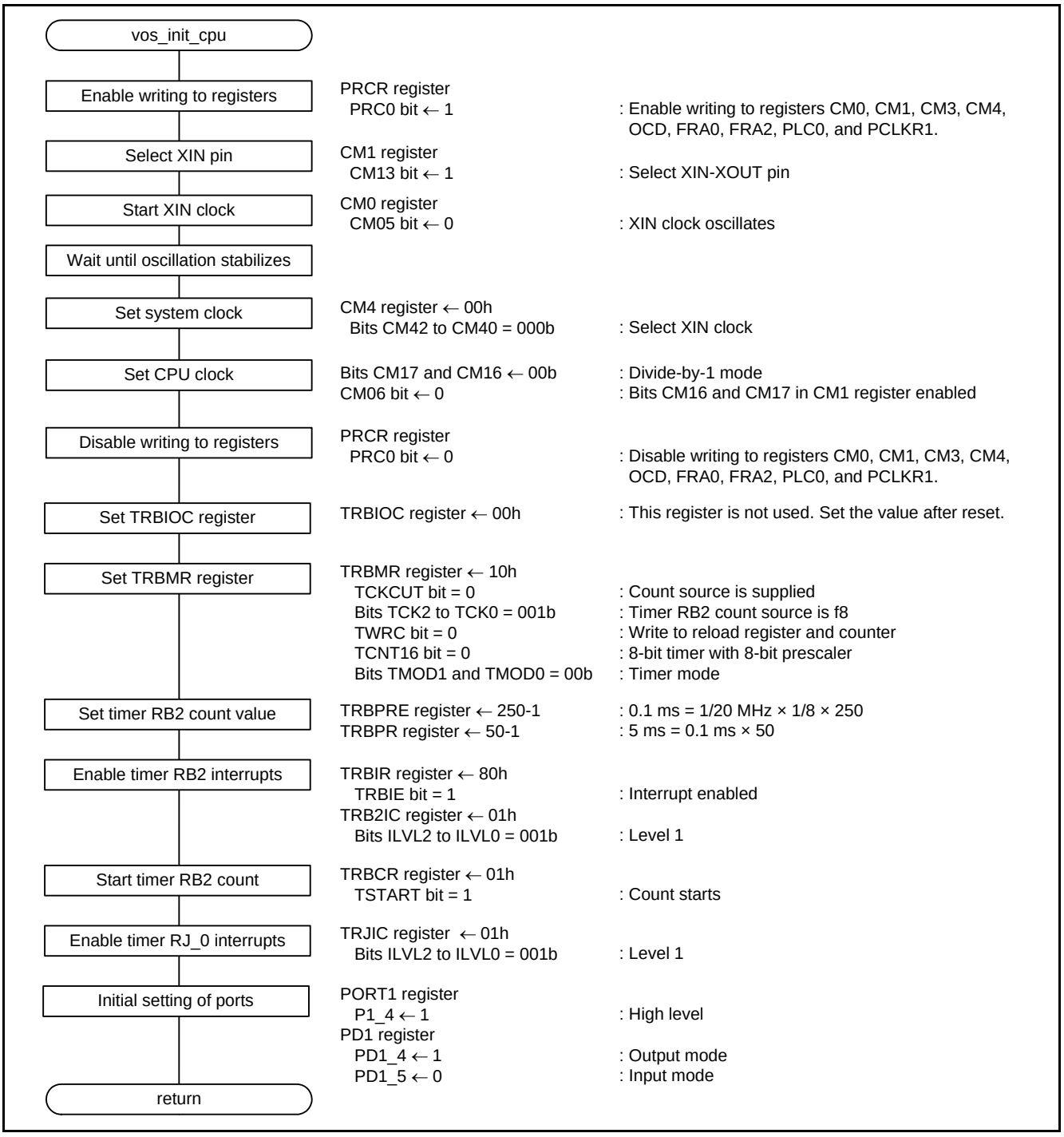

Figure 3.4 Initial Setting of Peripherals Except for HW-LIN_0

3.9.3 Initial Setting of Global Variables

Figure 3.5 shows the Initial Setting of Global Variables.

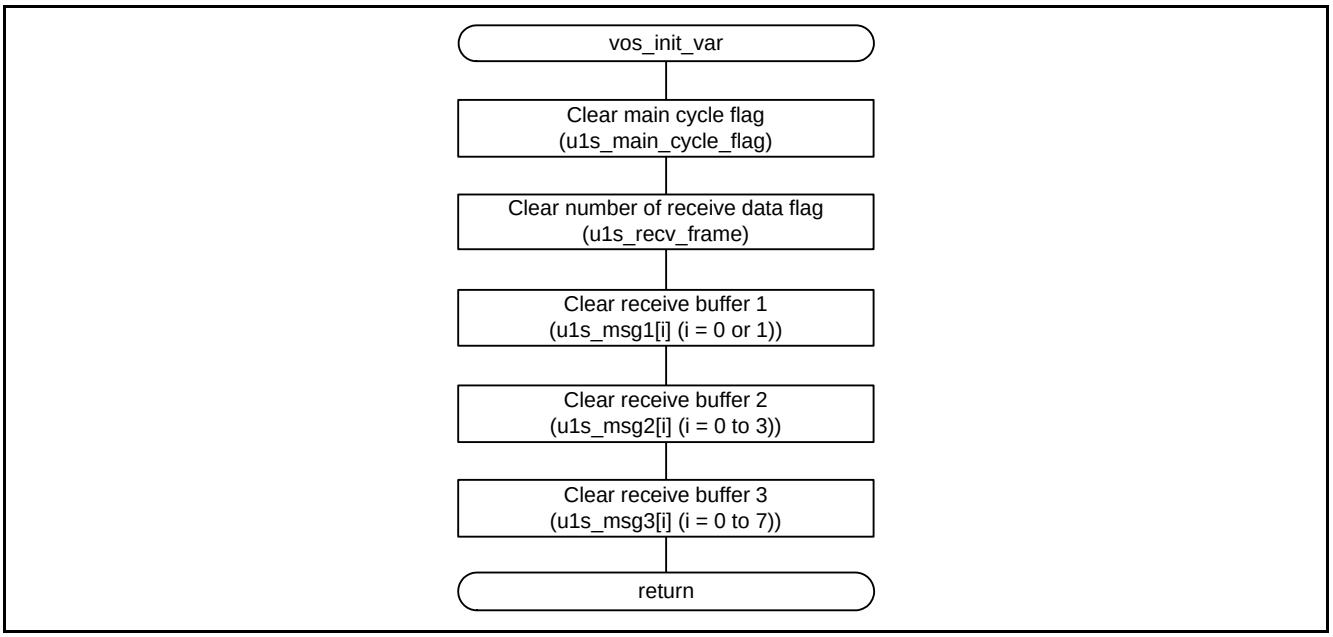

Figure 3.5 Initial Setting of Global Variables

3.9.4 HW-LIN_0 Initial Setting

Figure 3.6 shows the HW-LIN_0 Initial Setting.

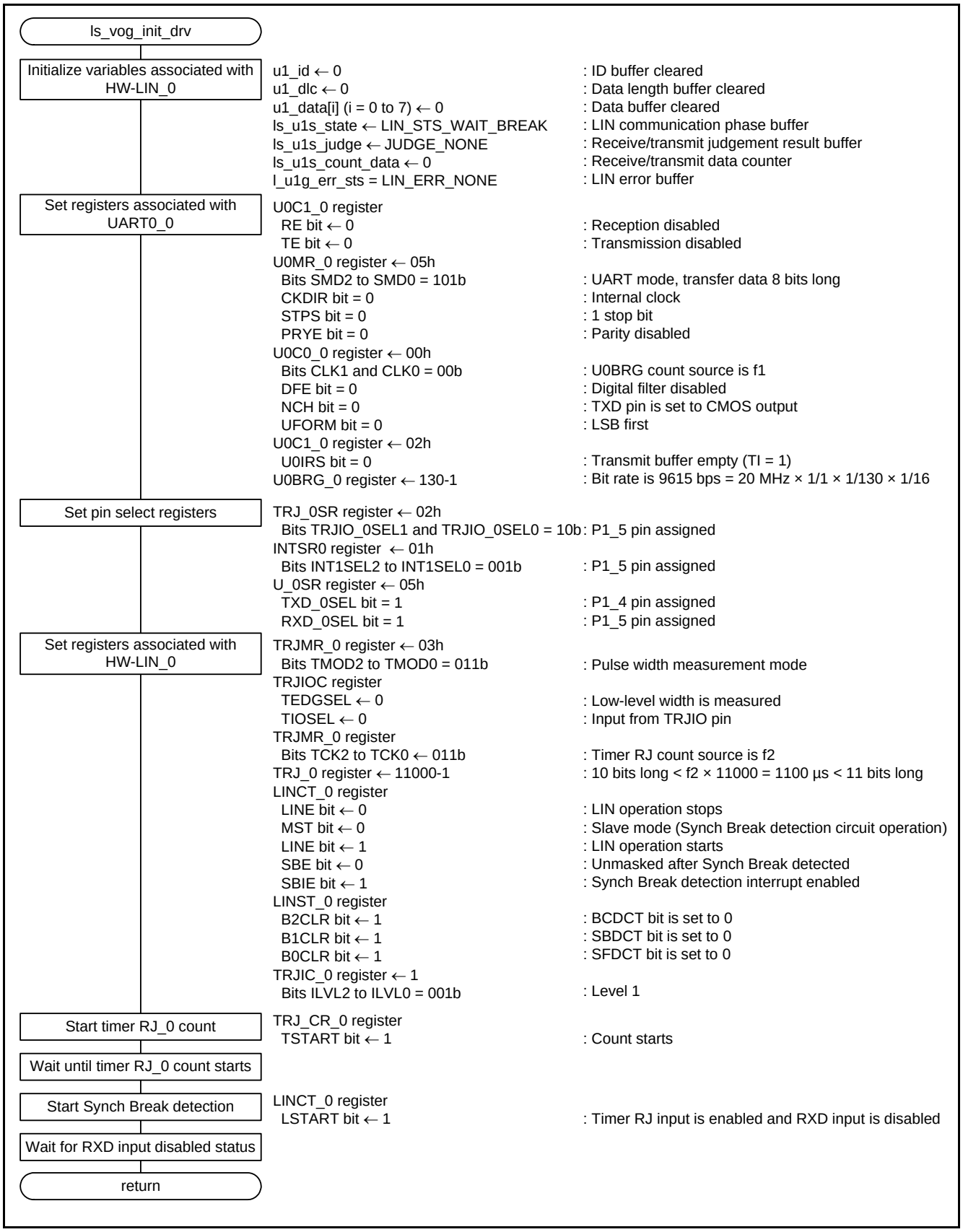

Figure 3.6 HW-LIN_0 Initial Setting

3.9.5 Timer RJ_0 Interrupt Handling

Figure 3.7 shows the Timer RJ_0 Interrupt Handling.

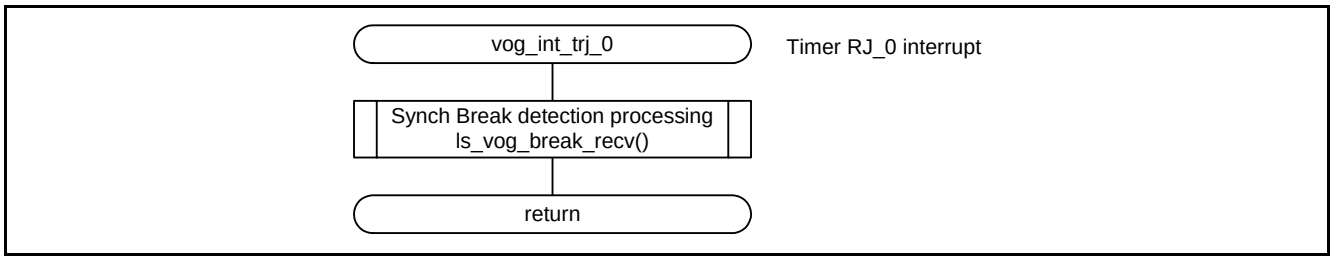

Figure 3.7 Timer RJ_0 Interrupt Handling

3.9.6 Synch Break Detection Processing

Figure 3.8 shows the Synch Break Detection Processing.

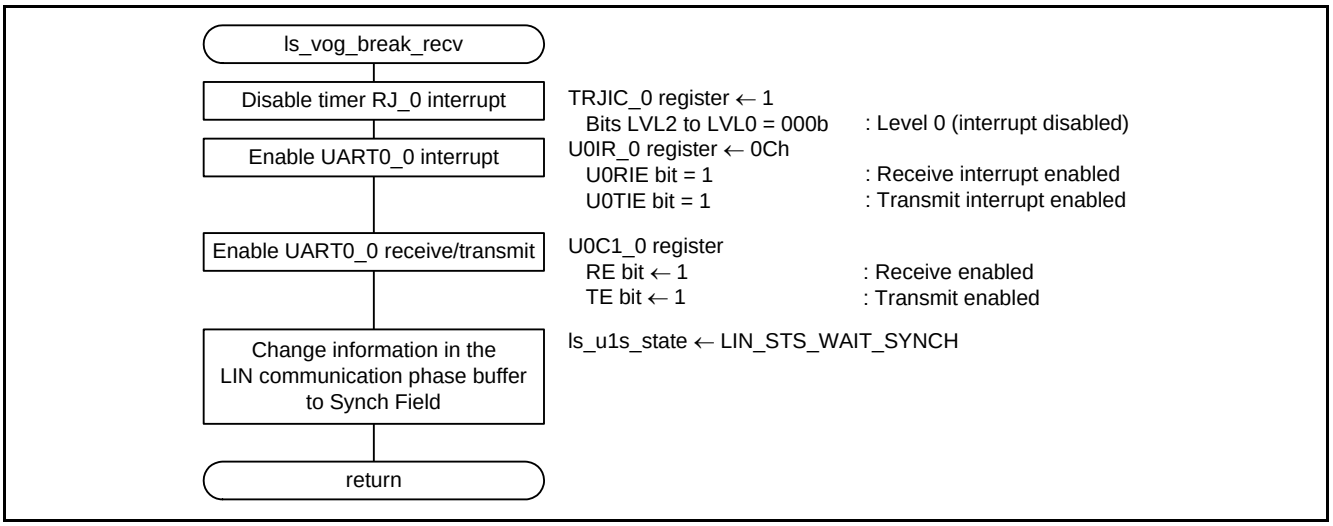

Figure 3.8 Synch Break Detection Processing

3.9.7 UART0_0 Receive Interrupt Handling

Figure 3.9 shows the UART0_0 Receive Interrupt Handling.

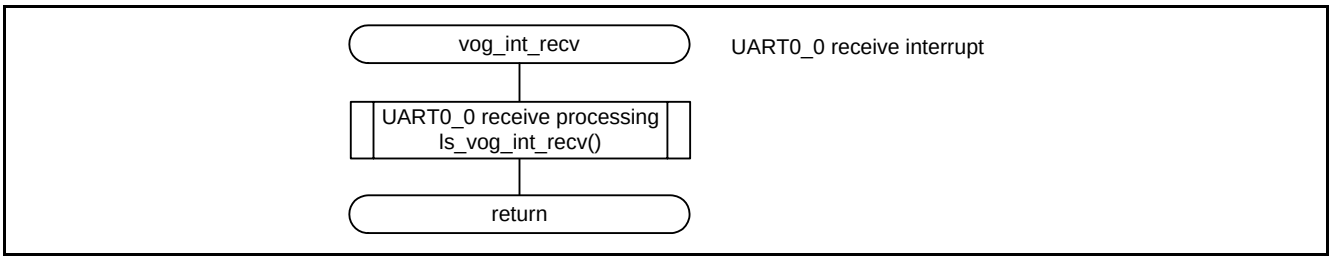

Figure 3.9 UART0_0 Receive Interrupt Handling

3.9.8 UART0_0 Receive Processing

Figure 3.10 and Figure 3.11 show the UART0_0 Receive Processing.

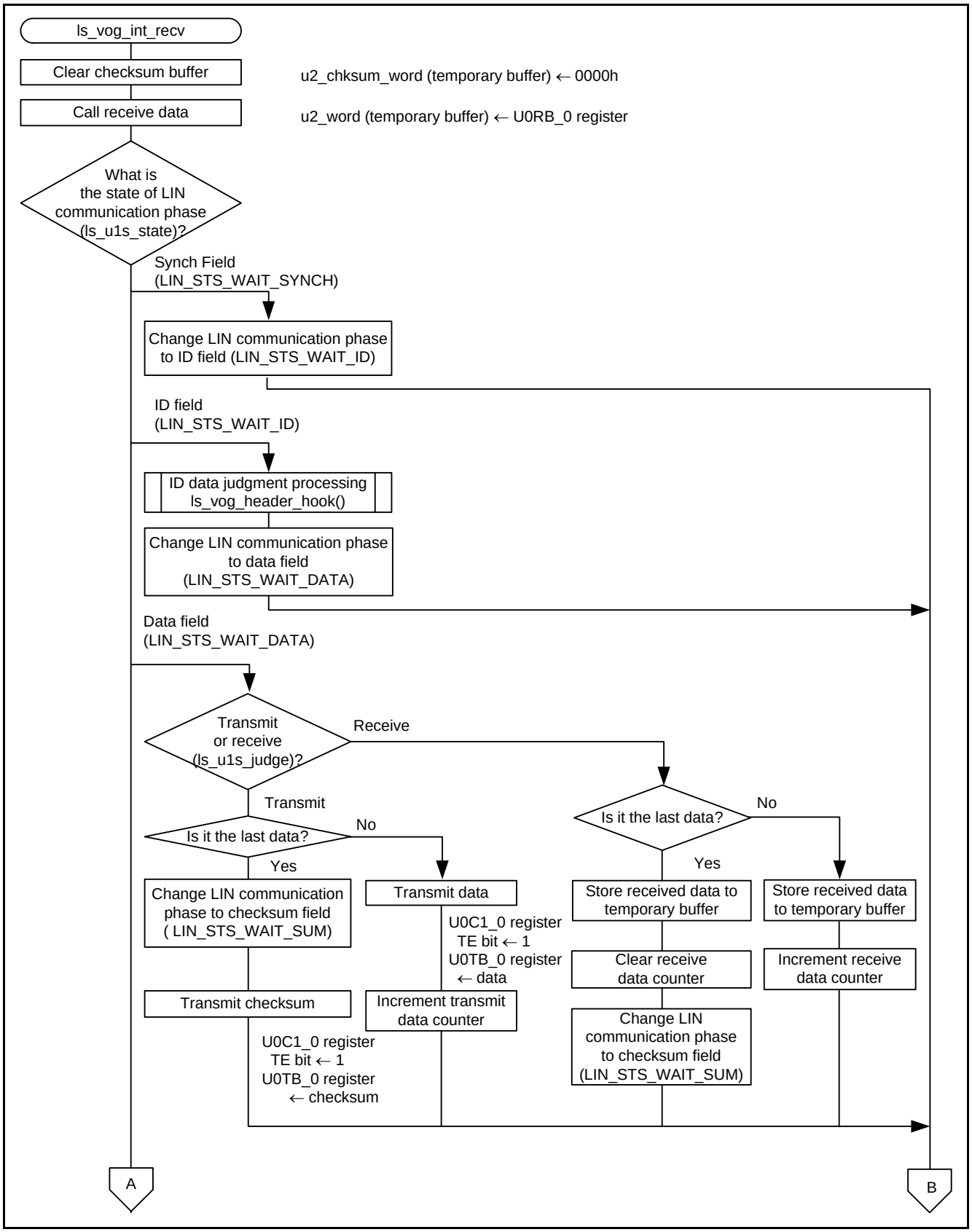

Figure 3.10 UART0_0 Receive Processing 1/2

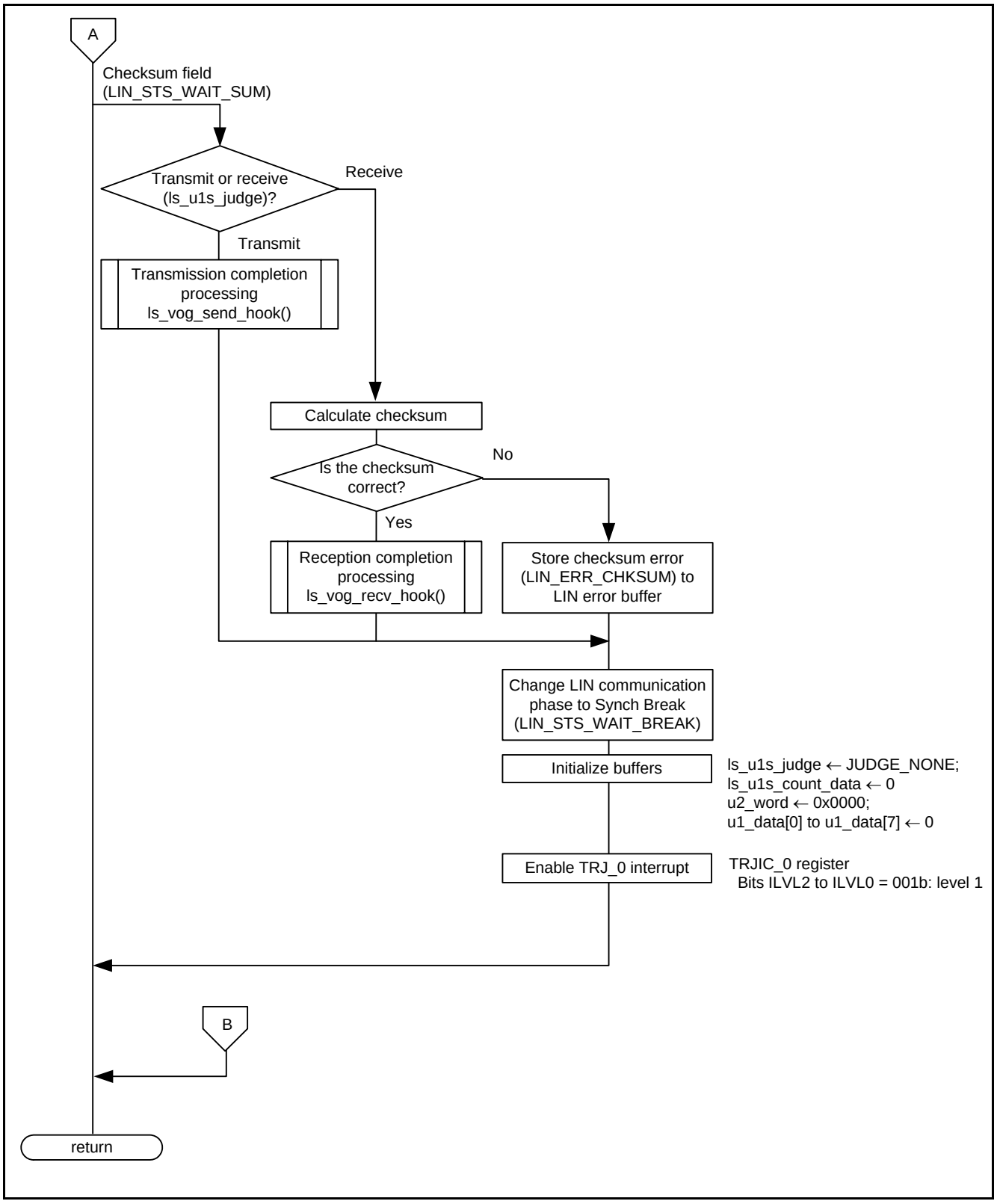

Figure 3.11 UART0_0 Receive Processing 2/2

3.9.9 ID Data Judgement

Figure 3.12 shows the ID Data Judgement.

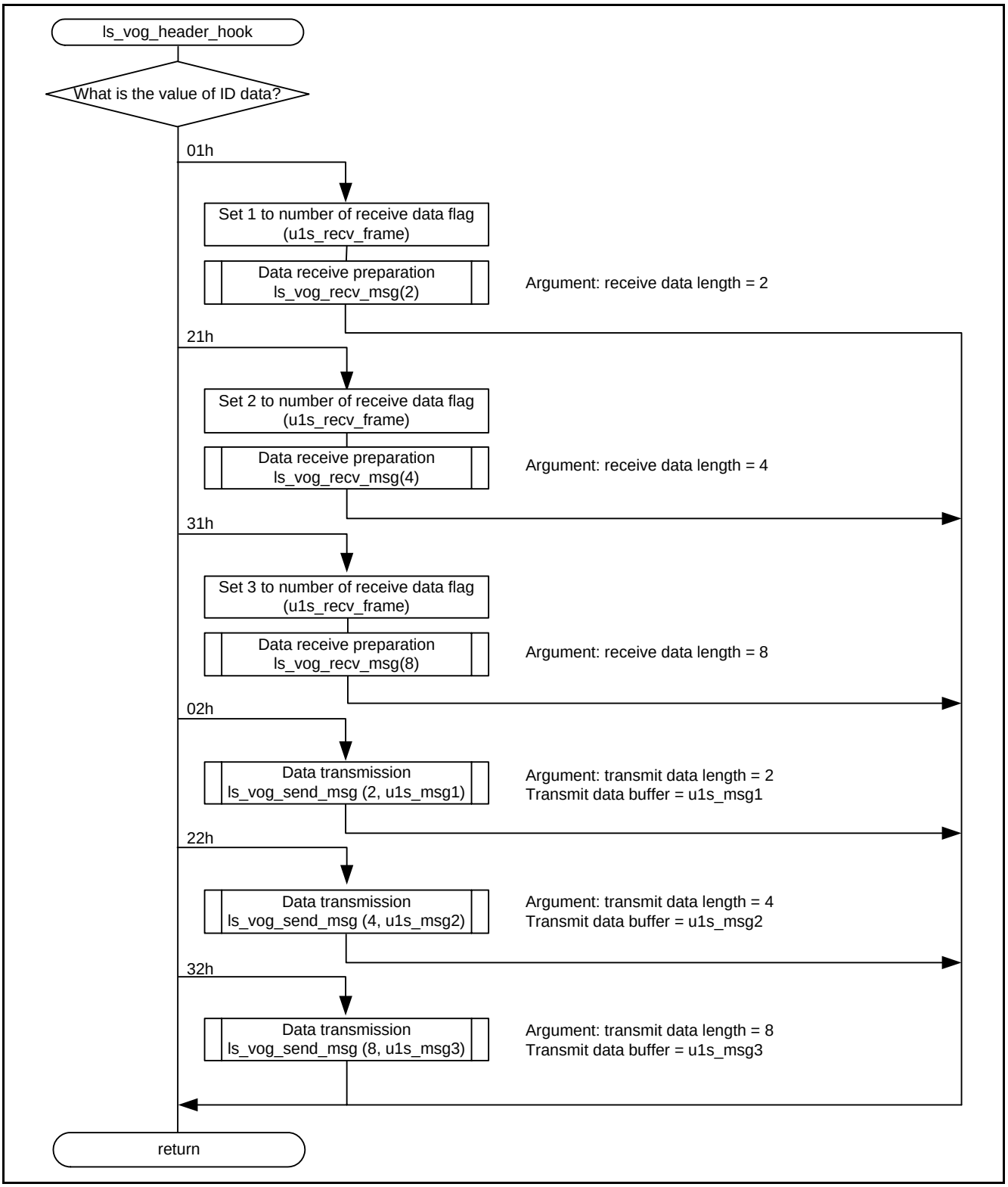

Figure 3.12 ID Data Judgement

3.9.10 Data Receive Preparation

Figure 3.13 shows the Data Receive Preparation.

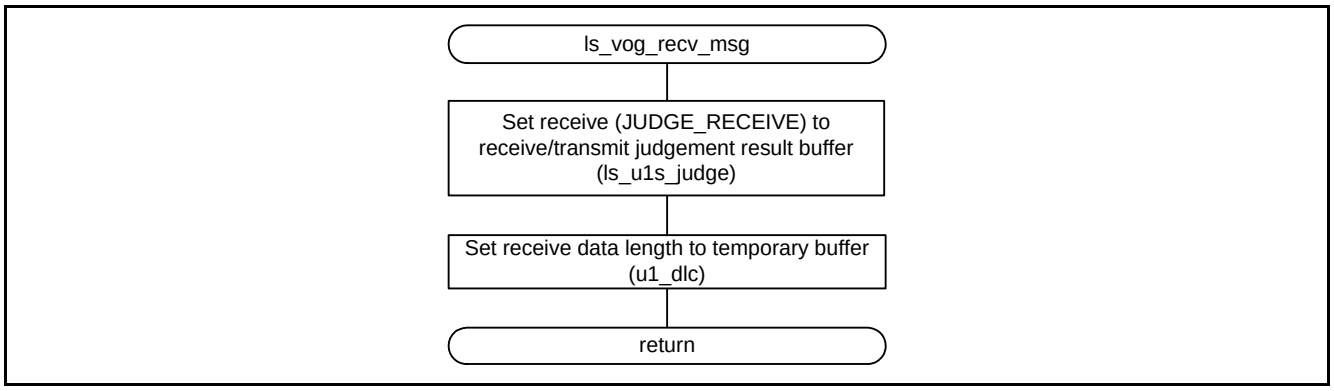

Figure 3.13 Data Receive Preparation

3.9.11 Data Transmission

Figure 3.14 shows the Data Transmission.

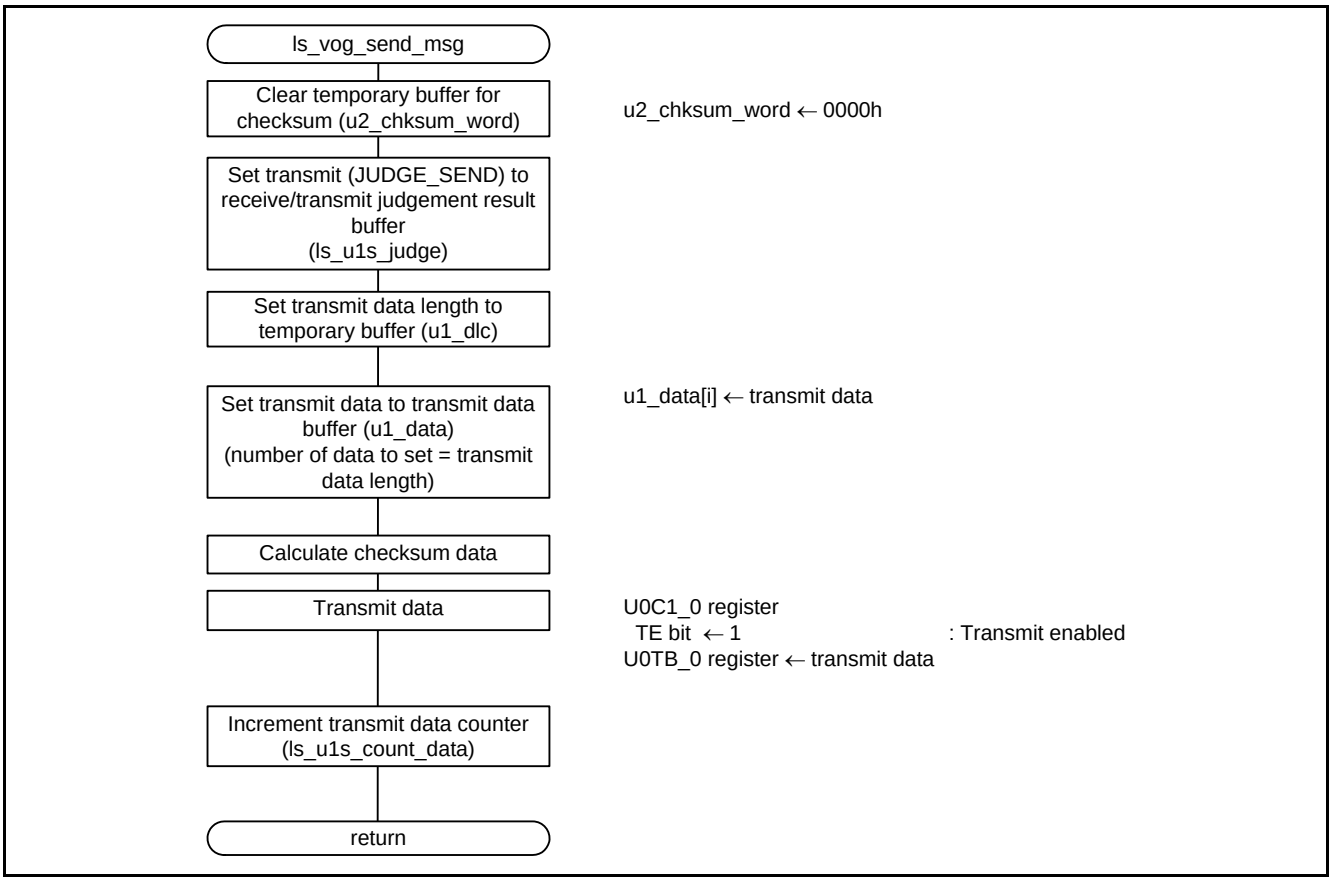

Figure 3.14 Data Transmission

3.9.12 Timer RB2_0 Interrupt Handling

Figure 3.15 shows the Timer RB2_0 Interrupt Handling.

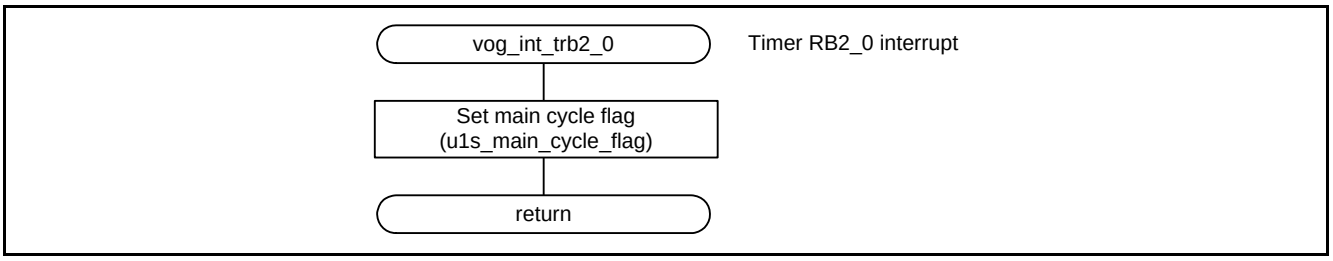

Figure 3.15 Timer RB2_0 Interrupt Handling

4. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

5. Reference Documents

User's Manual: Hardware

R8C/54E Group 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.

Website and Support

Renesas Electronics website

http://www.renesas.com

Inquiries

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REVISION HISTORY	R8C/54E Group Application Note Hardware LIN in Slave Mode

Rev.	Date	Description	
		Page	Summary
1.00	Aug 31, 2012	—	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 manual, refer to the relevant sections of the manual. If the descriptions under General Precautions in the Handling of MPU/MCU Products and in the body of the manual differ from each other, the description in the body of the manual takes precedence.

1. Handling of Unused Pins
   Handle unused pins in accord 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 one with a different type number, confirm that the change will not lead to problems.
   — The characteristics of MPU/MCU in the same group but having different type numbers may differ because of the differences in internal memory capacity and layout pattern. When changing to products of different type numbers, implement a system-evaluation test for each of the products.

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