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RENESAS

H8/300H Tiny Series

LIN (Local Interconnect Network) Application Note: Slave

Introduction

LIN (Local Interconnect Network) Application Note: Slave provides specification and setting examples that use the on-chip peripheral functions of the H8/300H Tiny Series microcomputer to enable communication based on the LIN communication protocol. This application note provides reference information for those users who are involved in software and hardware design.

Target Device

H8/300H Tiny Series H8/3687F

Contents

1. LIN Communication System Overview

This section describes LIN communication for a system that incorporates the sample LIN communication software library (hereinafter referred to as the library) described in this application note.

1.1 Connection to the LIN Bus

When a system is connected to a network through the LIN bus (Figure 1) and via a LIN bus interface circuit (or an LIN transceiver), LIN communication including header frame transmission as the slave node, as well as the transmission and reception of response frames, is performed.

1.1.1 System Configuration

Figure 1 shows a sample LIN bus network system configuration.

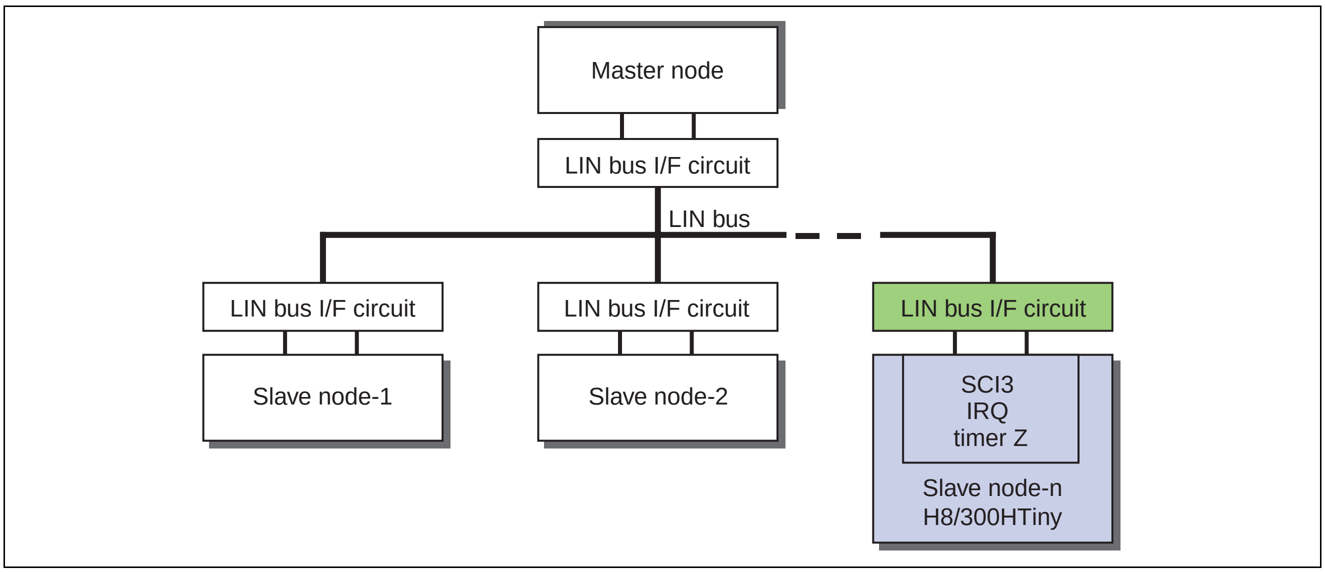

Figure 1 Block Diagram of a System Connected Through the LIN Bus

1.1.2 LIN Bus (Single-Wire Bus) Interface

Figure 2 shows a sample circuit for interfacing the LIN bus to the input/output pins of the on-chip functions of the H8/300H Tiny Series microcomputer (hereinafter referred to as the microcomputer).

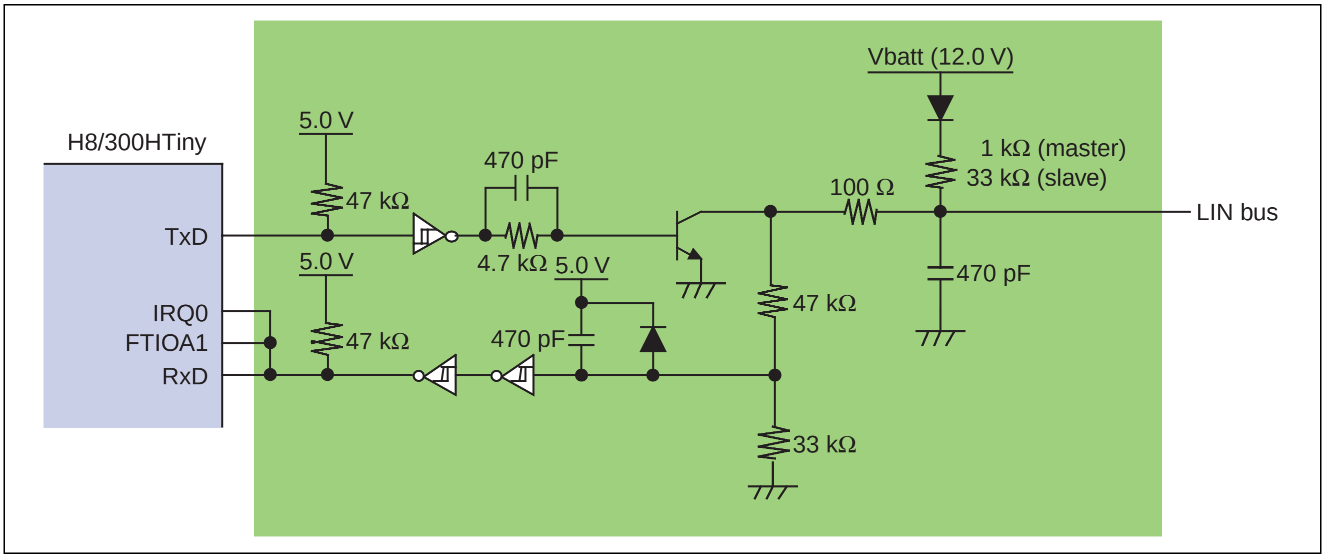

Figure 2 Sample LIN Bus Interface Circuit

1.2 Overview of LIN Communication

This section describes the message frames that are transmitted and received using the LIN communication protocol.

1.2.1 Message Frame Structure

Figure 3 shows the structure of a message frame. Each message frame consists of a header frame transmitted from the master node and a response frame transmitted from the master node or a slave node.

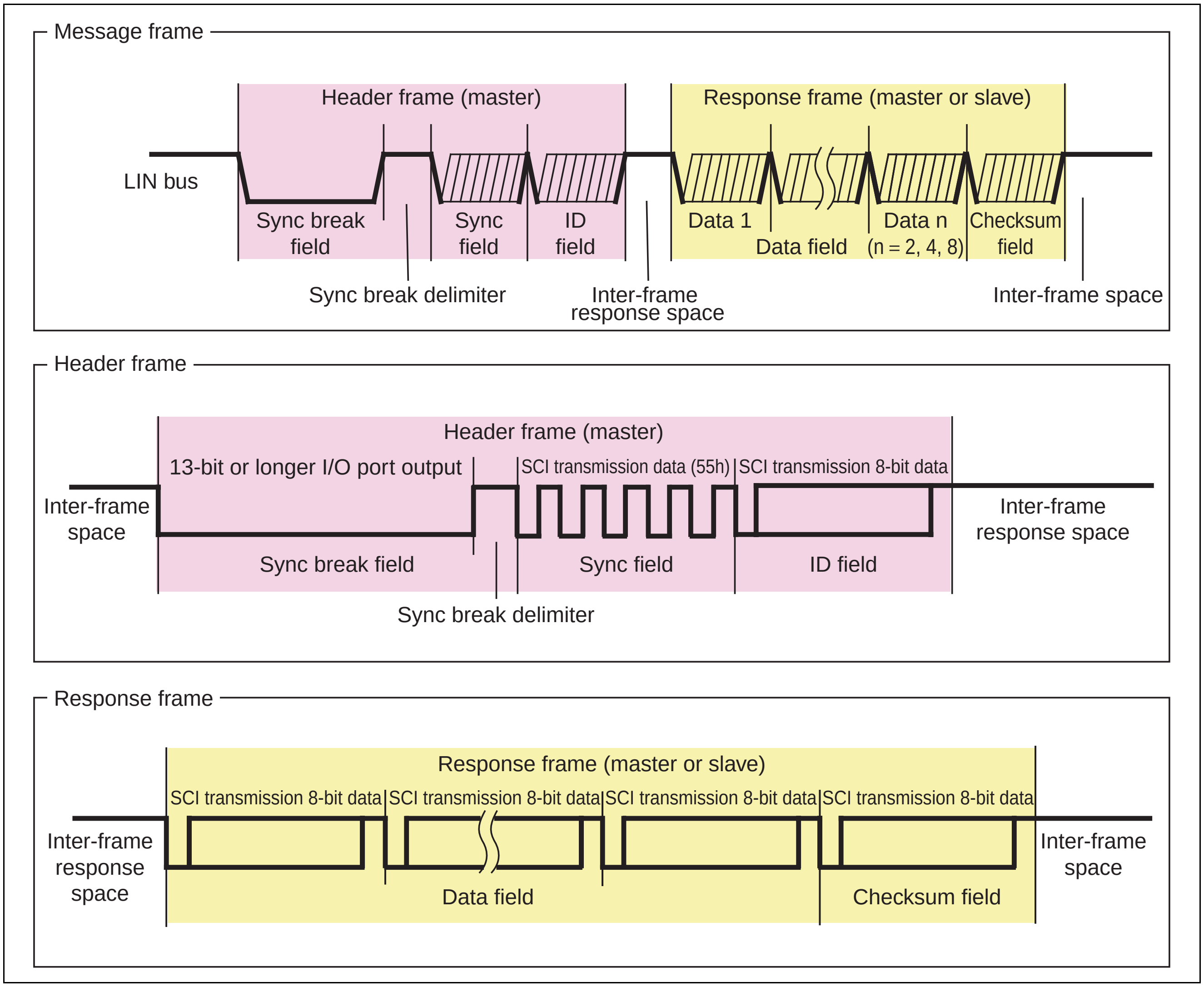

Figure 3 Message Frame Structure

1.2.2 Transmission and Reception of Message Frames

Figure 4 illustrates message frame transmission and reception in the master node and slave nodes.

- The master node transmits a header frame.
- Each slave node determines an ID from the received header frame and, when the ID is of the local node, the node transmits a response.
  (The master node determines the ID at transmission.)

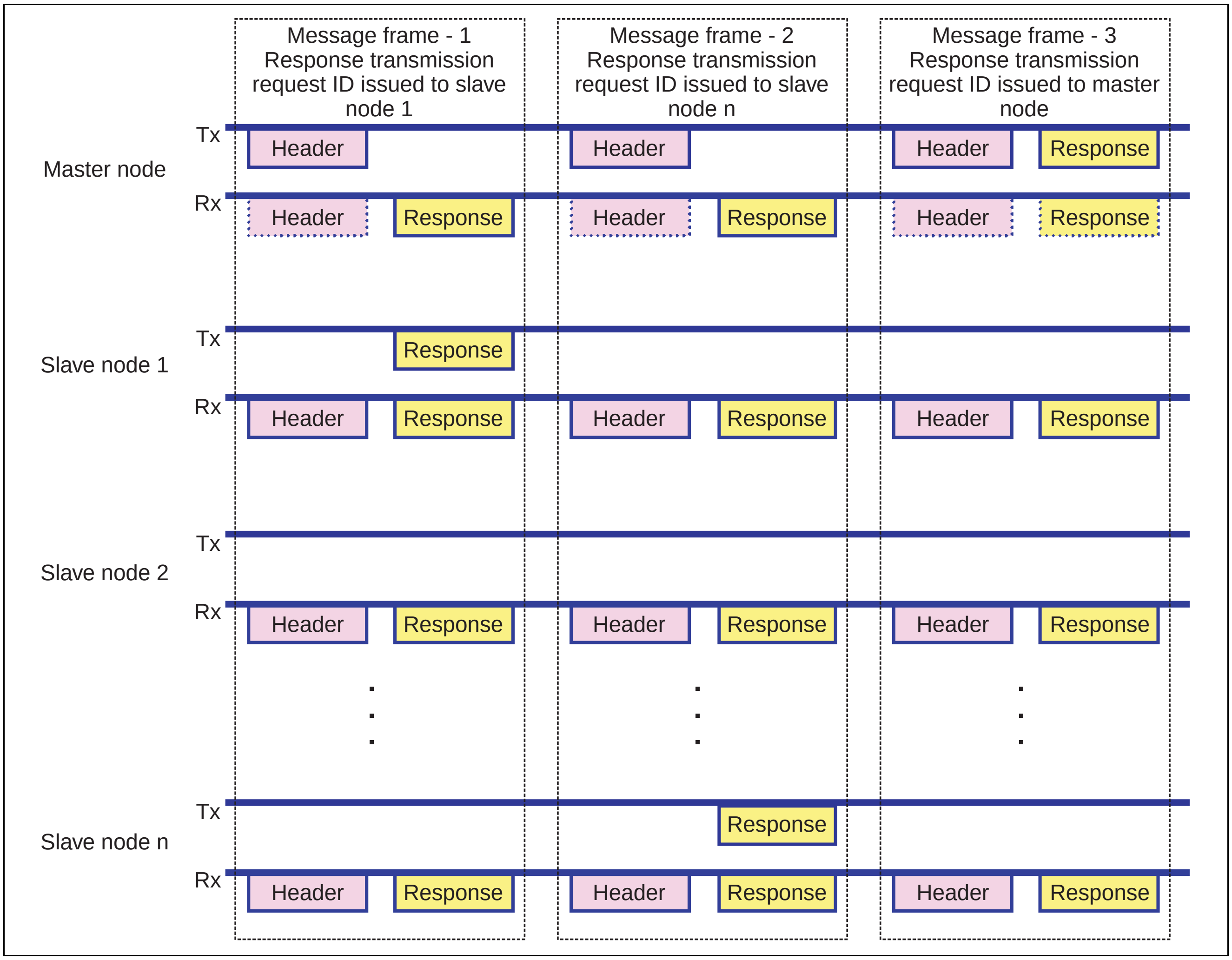

Figure 4 Transmission and Reception of Message Frames

2. Library Software Specifications

By including the library in a user application program, the user application program can use on-chip functions to perform LIN communication as a slave node.

2.1 Operating Environment

Device used: H8/300H Tiny Series microcomputer (H8/3687F)

Operating frequency range (system clock (ϕ osc)): Range equivalent to device operating frequencies. It is necessary to define ϕ osc in LINID.h by considering the LIN communication speed and processing conditions of the user application program. (See Section 2.4.2, "LINID.h File Setting Example".)

Functions used: Table 1 lists the on-chip peripheral functions to be used with the library, together with their uses.

Table 1 Use of On-Chip Peripheral Functions

Function		Pin function (pin No.)	Use	Description
SCI3 (channel-0)	Transmission	TXD (46pin)	Transmission of response frame Transmission of wake-up signal	Asynchronous mode Data length: 8 bits No parity bit 1 stop bit (with start bit added) LSB first
	Reception	RXD (45pin)	Reception of response frame	
			Communication error detection	Error detection function in module
Timer Z (channel-1)		FTIOA1 (37pin)	Measurement of sync break field dominant period Measurement of sync field period Measurement of wait period (internal function of library) Timeout detection	Counting is performed at cycles of ϕ osc/8, and each period is measured.
IRQ		/IRQ0 (51pin)	Wake-up signal detection	In the standby state, the LIN bus is monitored to detect a falling-edge.

2.2 File Organization

- LINslvZ.c (Ver.1.41)
  C source file used for (slave) microcomputer function setting and communication control for LIN communication in the H8/300HTiny Series (versions with built-in timer Z).
- LINID.h (Ver.1.41)
  Include file used to include user-defined items such as the communication transfer rate and ID settings at LINslvZ.c (Ver.1.41) compilation. This file also contains user application interface functions and variable definitions. These must also be included at the time of user application program compilation.
- H8_3687.h (Ver.1.00)
  Internal I/O register definition file for the H8/3687F

2.3 Required ROM/RAM Capacity

(When H8S or H8/300 Series C compiler CH38.exe Ver.2.0C is used)

The ROM/RAM size used varies depending on the number of IDs that are set and so on.

- ROM size: 2.0 Kbytes approximately
- RAM size: 40 bytes approximately

2.4 Functional Specifications

2.4.1 LIN Communication Specifications

- Node: Slave node supported
- ID: User-defined ID
  A. Response transmission ID
     Zero to 61 IDs (00h to 3bh, 3dh) can be set in LINID.h.
     (If nodes having the same ID are set on the same LIN bus, normal operation is impossible.)
  B. LIN protocol definition ID
     a. Master request frame ID 3ch (ID field data: 3Ch)
        A response frame (8-byte data) is transmitted from the master node. If the first byte of the data field is 00h, the reception of a sleep command is assumed, and a status flag (see Table 4) is set.
     b. Slave response frame ID 3dh (ID field data: 7Dh)
        A slave node having this ID transmits a response frame (8-byte data).
     c. Extended frame ID 3eh, 3fh (ID field data: FEh, BFh)
        Not supported by this library (Ver.1.41).
        (Upon receiving these IDs, the node waits for the next message frame (sync break field detection).)
  C. ID setting method
     In LINID.h, delete the definition statements (#define __IDm 0xnn (m = 00h to 3bh, 3dh)) of IDs other than those to be set as response transmission IDs, or set them as comment statements so that only the IDs to be set are defined, and then compile LINslvZ.c.
- Response data length: The DLC (data length control) bits in the reception ID field are determined.
- Communication transfer rate: The communication transfer rate used is defined in LINID.h.
  From the system clock (ϕ osc) definition value and communication transfer rate definition value, the constants used in the library and the SCI3 module setting value are calculated automatically. (Note: The communication transfer rate may be restricted by ϕ osc. For details, refer to "SCI3 Module: BRR Setting Example (Asynchronous Mode) for the Bit Rate" in the hardware manual.)
- Wake-up signal transmission and reception: Wake-up signal transmission and reception functions can be included.
  Including the wake-up signal transmission function
     A definition statement (#define __T_WAKEUP __ON) in LINID.h includes the wake-up transmission function the user application program calls the function (LIN_transmit_wake_up). Theses enable the wake-up signal to be transmitted on the LIN bus.
  Including the wake-up signal reception function
     A definition statement (#define __R_WAKEUP __ON) in LINID.h includes the wake-up reception function. Even when the microcomputer is in the standby state, the wake-up signal on the LIN bus is detected (falling-edge detection) through IRQ0 (external interrupt input).

2.4.2 LINID.h File Setting Example

An example of setting LINID.h is shown below.

1. The node does not transmit a wake-up signal.
2. Wake-up signal detection (falling-edge detection) through IRQ0 (external interrupt) is performed. (A wake-up signal is transmitted from other nodes).
3. Response frames are transmitted to the following two IDs:

ID (ID bit + DLC bits)	(including parity bits)
03h	(03h)
3ah	(D3h)

4. The system clock (ϕ osc) is 20 [MHz].
5. The LIN communication transfer rate is 9600 [bit/sec].
6. Correction of the LIN communication transfer rate by sync field measurement is not performed.

An example of the settings made based on the specifications described in 1. to 6., above, is given below.

(Definition statements other than the statements indicated in boldface must be deleted or set as comment lines.)

```
/***********************************************************************************************/
/*                                                                                             */
/*                         LINID.h    Ver.1.41                                                 */
/*                                                                                             */
/***********************************************************************************************/
#define     __ON           1        /*  This line must not be changed or deleted.       */
#define     __OFF          0        /*  This line must not be changed or deleted.       */

/***********************************************************************************************/
/*      Setting of wake-up signal transmission function                                       */
/*---------------------------------------------------------------------------------------------*/
/*#define   __T_WAKEUP __ON         /*  When transmitting a wake-up signal, define this line.   */
#define     __T_WAKEUP __OFF        /*  When not transmitting wake-up signal, define this line. */

/***********************************************************************************************/
/*      Setting of wake-up signal detecting function                                           */
/*---------------------------------------------------------------------------------------------*/
#define     __R_WAKEUP __ON         /*  When detecting a wake-up signal (falling-edge detection),
define this line.                                                                             */
/*#define   __R_WAKEUP __OFF        /*  When not detecting wake-up signal, define this line.    */

/***********************************************************************************************/
/*      Setting of response transmission IDs                                                   */
/*---------------------------------------------------------------------------------------------*/
/*      2-byte data                                                                            */
/*---------------------------------------------------------------------------------------------*/

#define     __Res2byte_ID   __ON     /*  When using a 2-byte response data transmission ID, define
this line.                                                                                    */
/*#define   __Res2byte_ID   __OFF    /*  When not using a 2-byte response data transmission ID,
define this line.                                                                             */
#if     __Res2byte_ID  ==  __ON

/*#define   __ID00  0x80                                  /*                                  */
```

```
/*#define   __ID01  0xC1                            /*                          */
/*#define   __ID02  0x42                            /*                          */
#define     __ID03  0x03         /*  Transmit response to ID field 03h.         */
/*#define   __ID04  0xC4                            /*                          */
/*#define   __ID05  0x85                            /*                          */
/*#define   __ID06  0x06                            /*                          */
/*#define   __ID07  0x47                            /*                          */
/*#define   __ID08  0x08                            /*                          */
/*#define   __ID09  0x49                            /*                          */
/*#define   __ID0a  0xCA                            /*                          */
/*#define   __ID0b  0x8B                            /*                          */
/*#define   __ID0c  0x4C                            /*                          */
/*#define   __ID0d  0x0D                            /*                          */
/*#define   __ID0e  0x8E                            /*                          */
/*#define   __ID0f  0xCF                            /*                          */
/*#define   __ID10  0x50                            /*                          */
/*#define   __ID11  0x11                            /*                          */
/*#define   __ID12  0x92                            /*                          */
/*#define   __ID13  0xD3                            /*                          */
/*#define   __ID14  0x14                            /*                          */
/*#define   __ID15  0x55                            /*                          */
/*#define   __ID16  0xD6                            /*                          */
/*#define   __ID17  0x97                            /*                          */
/*#define   __ID18  0xD8                            /*                          */
/*#define   __ID19  0x99                            /*                          */
/*#define   __ID1a  0x1A                            /*                          */
/*#define   __ID1b  0x5B                            /*                          */
/*#define   __ID1c  0x9C                            /*                          */
/*#define   __ID1d  0xDD                            /*                          */
/*#define   __ID1e  0x5E                            /*                          */
/*#define   __ID1f  0x1F                            /*                          */

#endif

*-----------------------------------------------------------------------------------------------*/
/*      4-byte data                                                                            */
/*-----------------------------------------------------------------------------------------------*/

/*#define   __Res4byte_ID   __ON     /*  When using a 4-byte response data transmission ID, define
this line.                                                                                    */
#define     __Res4byte_ID   __OFF    /*  When not using a 4-byte response data transmission ID,
define this line.                                                                             */

#if    __Res4byte_ID  ==  __ON

/*#define   __ID20  0x20                            /*                          */
/*#define   __ID21  0x61                            /*                          */
/*#define   __ID22  0xE2                            /*                          */
/*#define   __ID23  0xA3                            /*                          */
/*#define   __ID24  0x64                                                        */
/*#define   __ID25  0x25                            /*                          */
/*#define   __ID26  0xA6                            /*                          */
/*#define   __ID27  0xE7                            /*                          */
/*#define   __ID28  0xA8                            /*                          */
```

```
/*#define   __ID29  0xE9                                        /*                          */
/*#define   __ID2a  0x6A                                        /*                          */
/*#define   __ID2b  0x2B                                        /*                          */
/*#define   __ID2c  0xEC                                        /*                          */
/*#define   __ID2d  0xAD                                        /*                          */
/*#define   __ID2e  0x2E                                        /*                          */
/*#define   __ID2f  0x6F                                        /*                          */

#endif

/*-----------------------------------------------------------------------------------------------*/
/*       8-byte data                                                                            */
/*-----------------------------------------------------------------------------------------------*/

#define     __Res8byte_ID    __ON     /*  When using an 8-byte response data transmission ID, define
this line.                                                                                      */
/*#define   __Res8byte_ID    __OFF    /*  When not using an 8-byte response data transmission ID,
define this line.                                                                               */

#if     __Res8byte_ID  ==  __ON

/*#define   __ID30  0xF0                                        /*                          */
/*#define   __ID31  0xB1                                        /*                          */
/*#define   __ID32  0x32                                        /*                          */
/*#define   __ID33  0x73                                        /*                          */
/*#define   __ID34  0xB4                                        /*                          */
/*#define   __ID35  0xF5                                        /*                          */
/*#define   __ID36  0x76                                        /*                          */
/*#define   __ID37  0x37                                        /*                          */
/*#define   __ID38  0x78                                        /*                          */
/*#define   __ID39  0x39                                        /*                          */
#define     __ID3a  0xBA              /*  Transmit response to ID field BAh.                    */
/*#define   __ID3b  0xFB                                        /*                          */
/*#define   __ID3d  0x7D                                        /*                          */

#endif

/***********************************************************************************************/
/*      System clock (φosc) definition section                                                  */
/*-----------------------------------------------------------------------------------------------*/
#define     OSC_Hz      20000000      /* φ osc=20.000MHz → 20000000                             */
/*#define   OSC_Hz      16000000                                /* φ osc=16.000MHz → 16000000 */
/*#define   OSC_Hz      10486000                                /* φ osc=10.486MHz → 10486000 */
/*#define   OSC_Hz      10000000                                /* φ osc=10MHz     → 10000000 */
/*#define   OSC_Hz      9830400                                 /* φ osc=9.8304MHz →  9830400 */
/*#define   OSC_Hz      8000000                                 /* φ osc=8MHz      →  8000000 */
/*#define   OSC_Hz      7372800                                 /* φ osc=7.3728MHz →  7372800 */
/*#define   OSC_Hz      6000000                                 /* φ osc=6MHz      →  6000000 */
/*#define   OSC_Hz      4915200                                 /* φ osc=4.9152MHz →  4915200 */
/*#define   OSC_Hz      3579545                                 /* φ osc=3.5795MHz →  3579545 */
/*#define   OSC_Hz      2457600                                 /* φ osc=2.4576MHz →  2457600 */

/***********************************************************************************************/
/*       Baud rate definition section                                                           */
```

```
/*-------------------------------------------------------------------------------------------*/
/*#define  B_rate     2400                                       /*  2400bps    →  2400      */
/*#define  B_rate     4800                                       /*  4800bps    →  4800      */
#define    B_rate     9600          /*  9600bps    →  9600                                   */
/*#define  B_rate     10000                                      /* 10000bps    → 10000      */
/*#define  B_rate     14400                                      /* 14400bps    → 14400      */
/*#define  B_rate     15000                                      /* 15000bps    → 15000      */
/*#define  B_rate     19200                                      /* 19200bps    → 19200      */
/*#define  B_rate     20000                                      /* 20000bps    → 20000      */

/*********************************************************************************************/
/*        Setting of baud rate correction function                                           */
/*-------------------------------------------------------------------------------------------*/
#define    __Corrects_baud_rate    __ON   /* To correct the baud rate by the sync field
measurement, define this line.                                                               */
/*#define  __Corrects_baud_rate    __OFF  /* When not correcting the baud rate by the sync field
measurement, define this line.                                                               */

/*********************************************************************************************/
/*        Library constant calculation section    The following must not be changed or deleted. */
/*-------------------------------------------------------------------------------------------*/
#define    t_1_data       ((((OSC_Hz) / (B_rate)) + 0x04) >>3)
#define    t_11_data      ((((11 * ((OSC_Hz) >>2)) / (B_rate)) + 0x01) >>1)
#define    t_128_data     (((((OSC_Hz) <<5) / (B_rate)) + 0x01) >>1)
#define    t_15k_data     (((0xEA6 *  ((OSC_Hz) / (B_rate))) + 0x01) >>1)
#define    t_15k_data     (((0x186A *  ((OSC_Hz) / (B_rate))) + 0x01) >>1)
#define    t_2byte_data   ((((91 *  ((OSC_Hz) >>2)) / (B_rate)) + 0x01) >>1)
#define    t_4byte_data   ((((119 * ((OSC_Hz) >>2)) / (B_rate)) + 0x01) >>1)
#define    t_8byte_data   ((((175 * ((OSC_Hz) >>2)) / (B_rate)) + 0x01) >>1)

#define    baudrate_data  ((((((OSC_Hz) >>4) / (B_rate)) + 0x01) >>1) - 1)

/*********************************************************************************************/
/*        Function and variable definition section       The following must not be changed or
deleted.                                                                                     */
/*-------------------------------------------------------------------------------------------*/
#if    ((__Res2byte_ID)  || (__Res4byte_ID)  ||  (__Res8byte_ID))
#define    __RESPONSE    __ON
#else
#define    __RESPONSE    __OFF
#endif

#ifndef    __LIN_LIB

extern    void    LIN_initialize(void);
extern    void    LIN_end(void);
extern    void    LIN_sleep(void);
extern    void    LIN_error(void);
extern    void    LIN_start(void);
extern    void    LIN_stop(void);

#if    __RESPONSE    ==    __ON
extern    void    LIN_data_Set(void);
#endif
```

```
#if    __T_WAKEUP    ==    __ON
extern    void    LIN_transmit_wake_up(void);
#endif

#if    __R_WAKEUP    ==    __ON
extern    void    LIN_wake_up(void);
extern    void    LIN_wake_up_PR(void);
#endif

#if    __RESPONSE    ==    __ON
extern    volatile    unsigned char    LIN_tx_data[8];
#endif

extern    volatile    unsigned char    LIN_rx_id;
extern    volatile    unsigned char    LIN_rx_data[8];
extern    volatile    union {
                          unsigned char    BYTE;
                          struct {
                              unsigned char    NBA       :1;
                              unsigned char    CSE       :1;
                              unsigned char    ISFE      :1;
                              unsigned char    TOA3B     :1;
                              unsigned char    SNRE      :1;
                              unsigned char    SCI       :1;
                              unsigned char    SUC       :1;
                              unsigned char    SLEEP     :1;
                          }   BIT;
}    LIN_status;
extern    volatile    union {
                          unsigned char BYTE;
                          struct {
                              unsigned char    CBR       :1;
                              unsigned char    wk6       :1;
                              unsigned char    WU        :1;
                              unsigned char    wk4       :5;
                          }   BIT;
}    LIN_control;

#endif
```

2.4.3 User Application Interface

This section describes the specifications of the interface between this library and a user application program.

- Interface by function (module) call

The user application program calls functions in the library to initialize the on-chip peripheral functions that are required for LIN communication control, stop and restart LIN communication control, control wake-up signal transmission, and prepare to receive wake-up signals.

Table 2 Functions in the Library That are Called by the User Application Program

Function name	Description
LIN_initialize	Initializes the required on-chip peripheral functions for LIN communication control and starts communication control. The LIN_start function need not be called.
LIN_stop	Stops LIN communication control.
LIN_start	Restarts LIN communication control. (When turning on the power, call the LIN_initialize function.)
LIN_transmit_wake_up	Transmits a wake-up signal.
LIN_wake_up_PR	Makes preparations needed to receive a wake-up signal.

If functions called by the library are prepared within the user application program, processing is performed at certain event timings (upon the completion of transmission and reception, upon the detection of a communication error, and so forth) during LIN communication.

Table 3 User Application Control Functions Called by the Library

Function name	Description
LIN_wake_up	Function for user application control when a wake-up signal is detected
LIN_sleep	Function for user application control when a sleep command is received
LIN_data_set	Function for user application control before response frame transmission
LIN_end	Function for user application control after the completion of message frame transmission or reception
LIN_error	Function for user application control when a LIN communication error is detected

- Operation overview
  Figure 5 and Figure 6 show the operations.

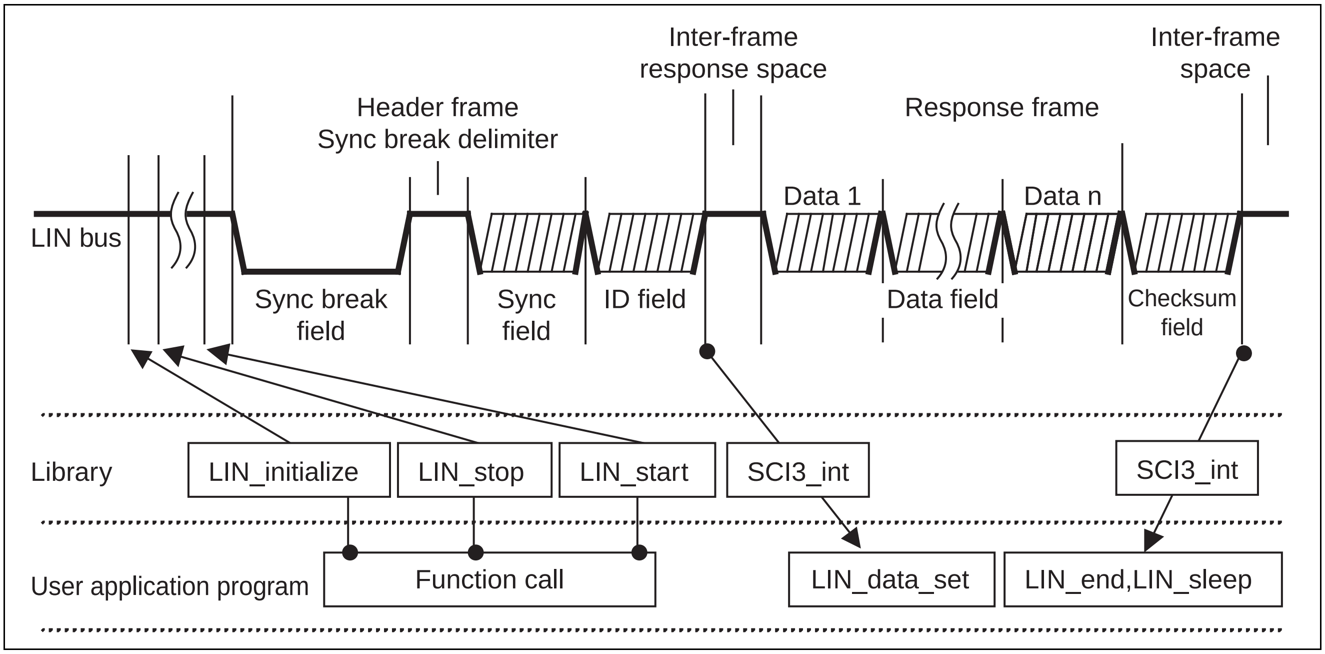

Figure 5 Operation Overview at Message Frame Transmission/Reception

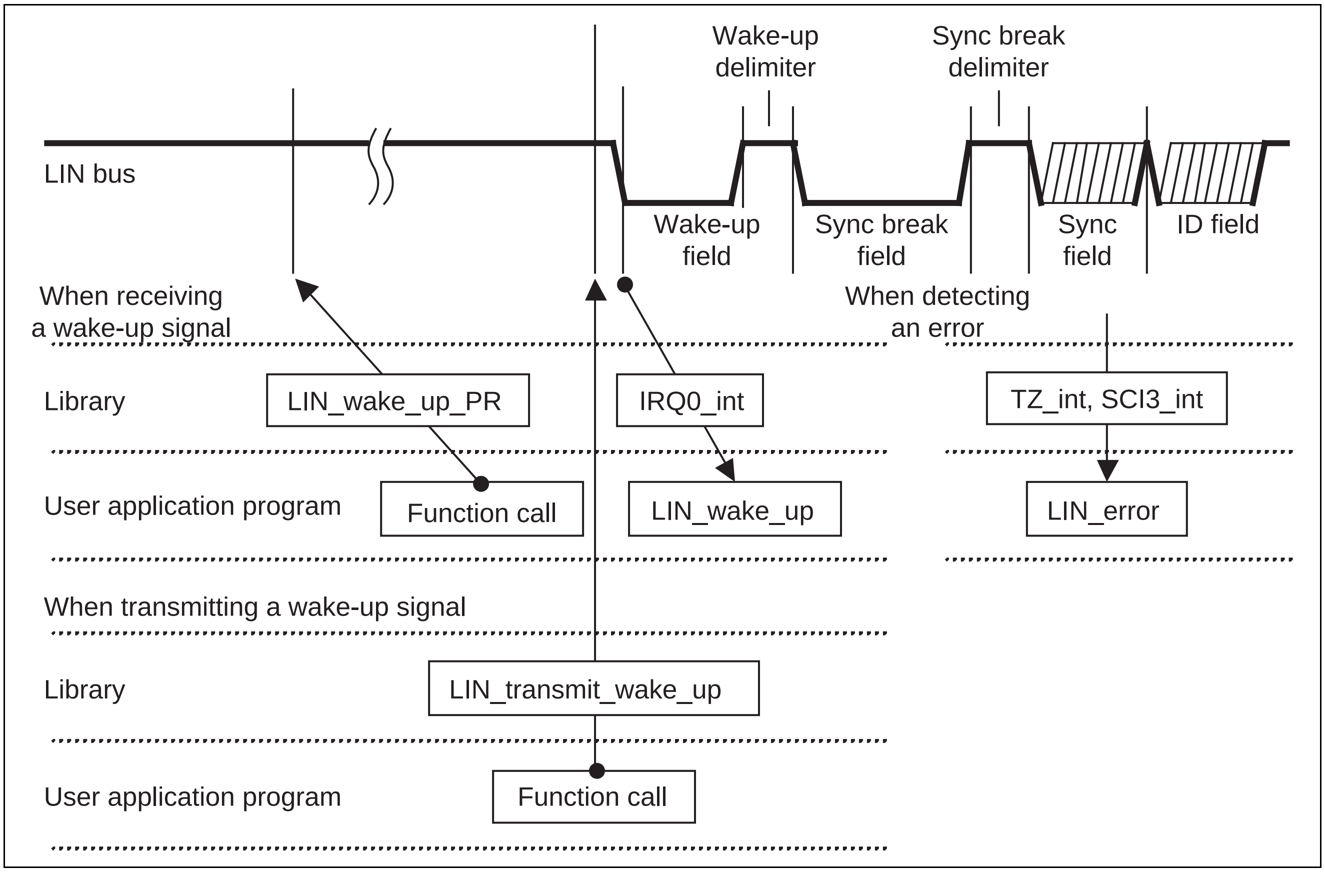

Figure 6 Operation Overview at Error Detection and Wake-up Signal Transmission and Reception

- Interface using global variables (data stored in the RAM area)
  The user application program and the library interface with each other by sharing data.

Table 4 Data (Global Variables) Shared by the User Application and Library

Label name (variable name)	Data type	Description
LIN_tx_data[0] to [7]	unsigned char (array)	Sets the transmission data when transmitting a response frame.
LIN_rx_id	unsigned char	Holds a received ID.
LIN_rx_data[0] to [7]	unsigned char (array)	Holds received response data.
LIN_status	(Structure)	Communication status
LIN_status.BYTE	Byte access unsigned char	
	Bit access	
LIN_status.BIT.NBA	Bit 7	No bus active error Set condition : The LIN bus remains inactive for a certain time.
LIN_status.BIT.CSE	Bit 6	Checksum error flag Set condition : A checksum error is detected when a response is received.

Label name (variable name)	Data type	Description
LIN_status.BIT.ISFE	Bit 5	Sync field error Set condition : The received sync field data (data received by the SCI3 module) is other than 55h.
LIN_status.BIT.TOA3B	Bit 4	Wake-up timeout Set condition : A header frame, transmitted from the master within a certain period after the wake-up retry signal is transmitted (three times, including the first transmission), is not detected.
LIN_status.BIT.SNRE	Bit 3	Slave not responding error Set condition : Reception of a response frame from a slave is not completed within a certain period during message frame transmission/reception.
LIN_status.BIT.SCI	Bit 2	SCI error Set condition : An error in the SCI3 module (overrun error or framing error) is detected.
LIN_status.BIT.SUC	Bit 1	Message frame normal reception completion flag Set condition : A response frame has been received normally. Condition to clear : An ID frame has been received.
LIN_status.BIT.SLEEP	Bit 0	Sleep command reception flag Set condition : A sleep command has been received.
LIN_control	(Structure)	Communication control
LIN_control.BYTE	Byte access unsigned char	
	Bit access	
LIN_control.BIT.CBR	Bit 7	Control of the communication transfer rate correction function (See Section 2.5.1.2, "Reception of a Sync Field".)
LIN_control.BIT.wk6	Bit 6	Reserved bit
LIN_control.BIT.WU	Bit 5	(Wake-up control bit) (See Section 2.5.3, "Transmission and Reception of a Wake-up Signal".)
LIN_control.BIT.wk4	Bits 4 to 0	Reserved bits

2.5 Operation

This section explains the transmission and reception operations performed with the library.

2.5.1 Reception of a Header Frame

1. Detection of a Sync Break Field

   The timer Z input capture function measures the sync break field dominant period.

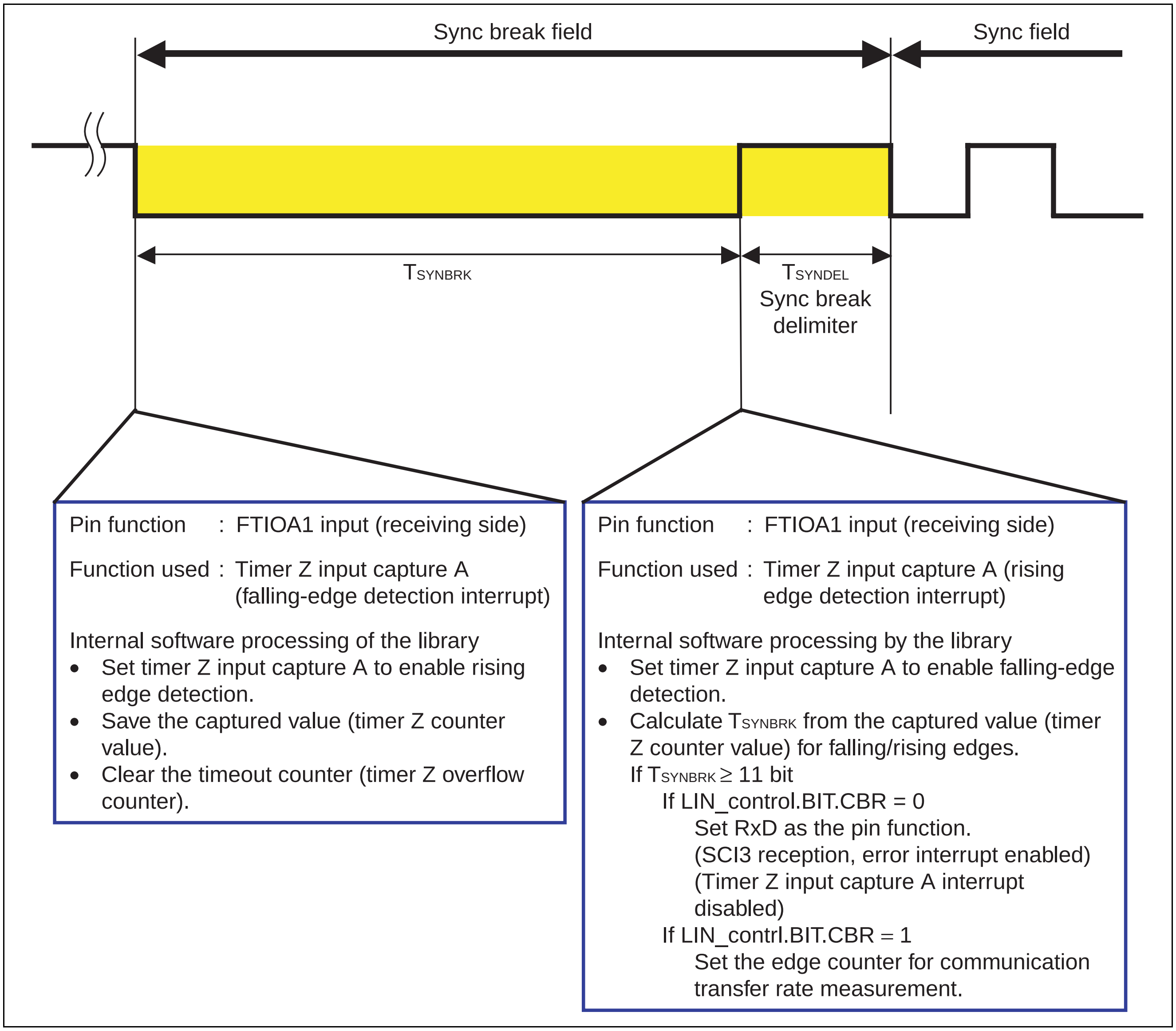

Figure 7 Detection of a Sync Break Field

2. Reception of a Sync Field
   The sync field reception control method is determined according to the setting of the CBR bit in LIN_control, as follows:

   CBR = 0: The SCI3 reception function determines the sync field reception data (55h).
   (Figure 8 Reception and Determination of a Sync Field by the SCI3 Reception Function)

   CBR = 1: The timer Z input capture function measures the bit width of a sync field and corrects the communication transfer rate (by setting BRR in the SCI3 module, and so on).
   (Figure 9 Correction of the Communication Transfer Rate by the Timer Z Input Capture Function)

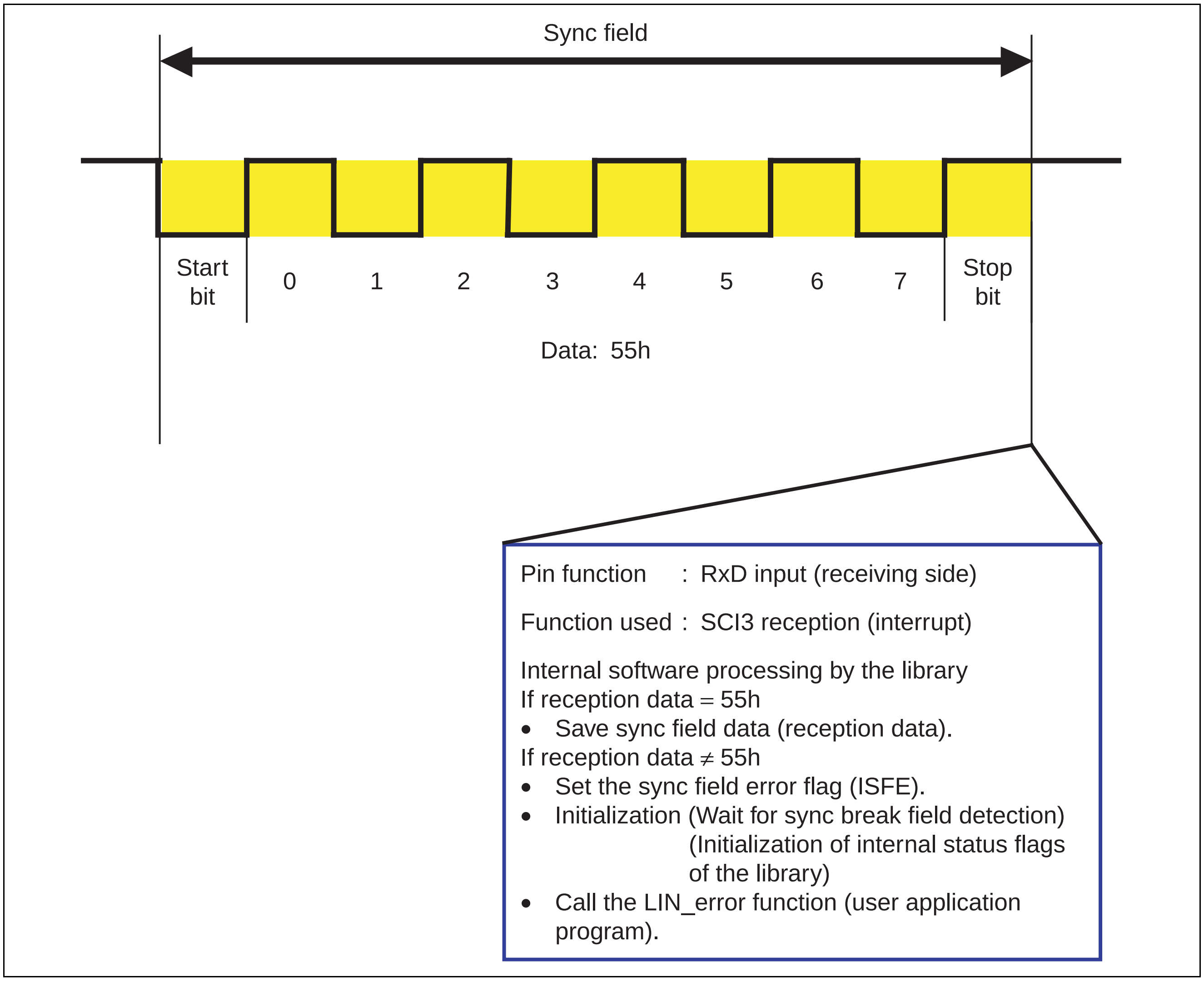

Figure 8 Reception and Determination of a Sync Field by the SCI3 Reception Function

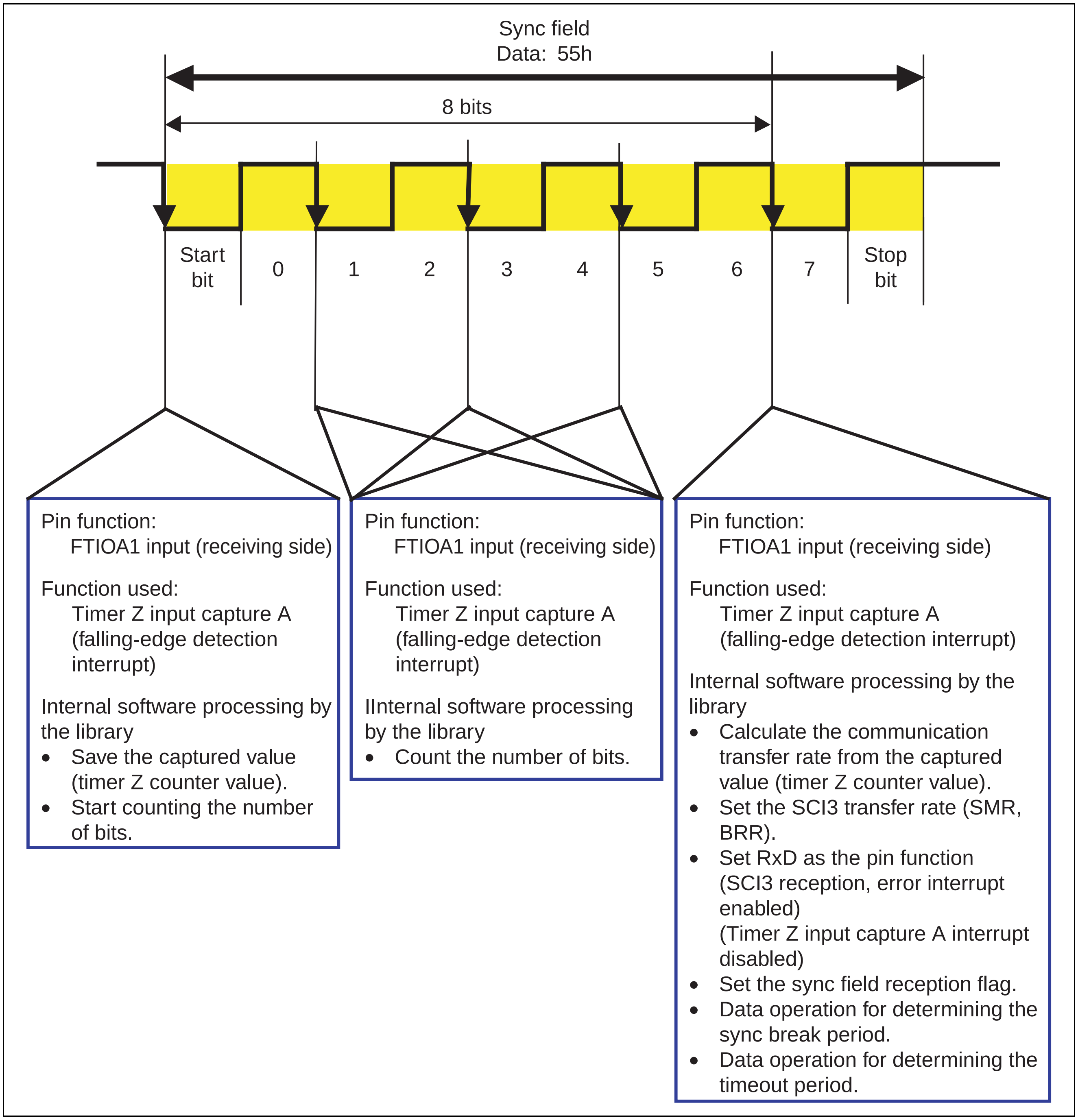

Figure 9 Correction of the Communication Transfer Rate by the Timer Z Input Capture Function

3. Reception of an ID Field
   The SCI3 reception function determines the ID (including the DLC and parity bits) in the ID field reception data.
   If the ID is a response transmission request ID intended for the local node, transmission of a response frame starts.

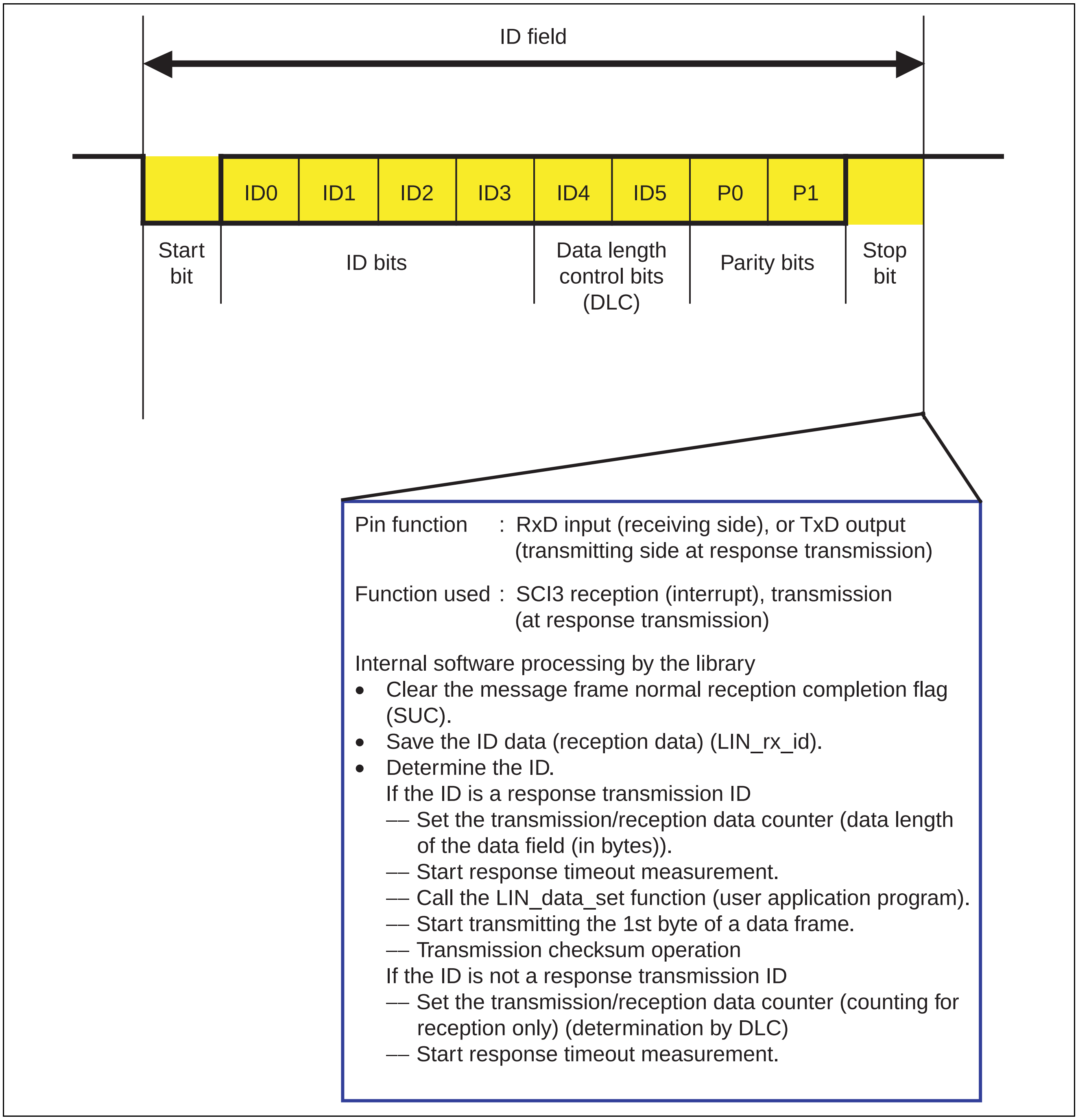

Figure 10 ID Field Reception and Determination

2.5.2 Transmission and Reception of a Response Frame

1. Transmission and Reception of a Data Field (Transmission of a Checksum Field)
   The SCI3 reception function saves received data and performs a reception checksum data operation.
   When a response is transmitted, the subsequent data is transmitted, and a transmission checksum data operation is performed. (Within a reception interrupt)

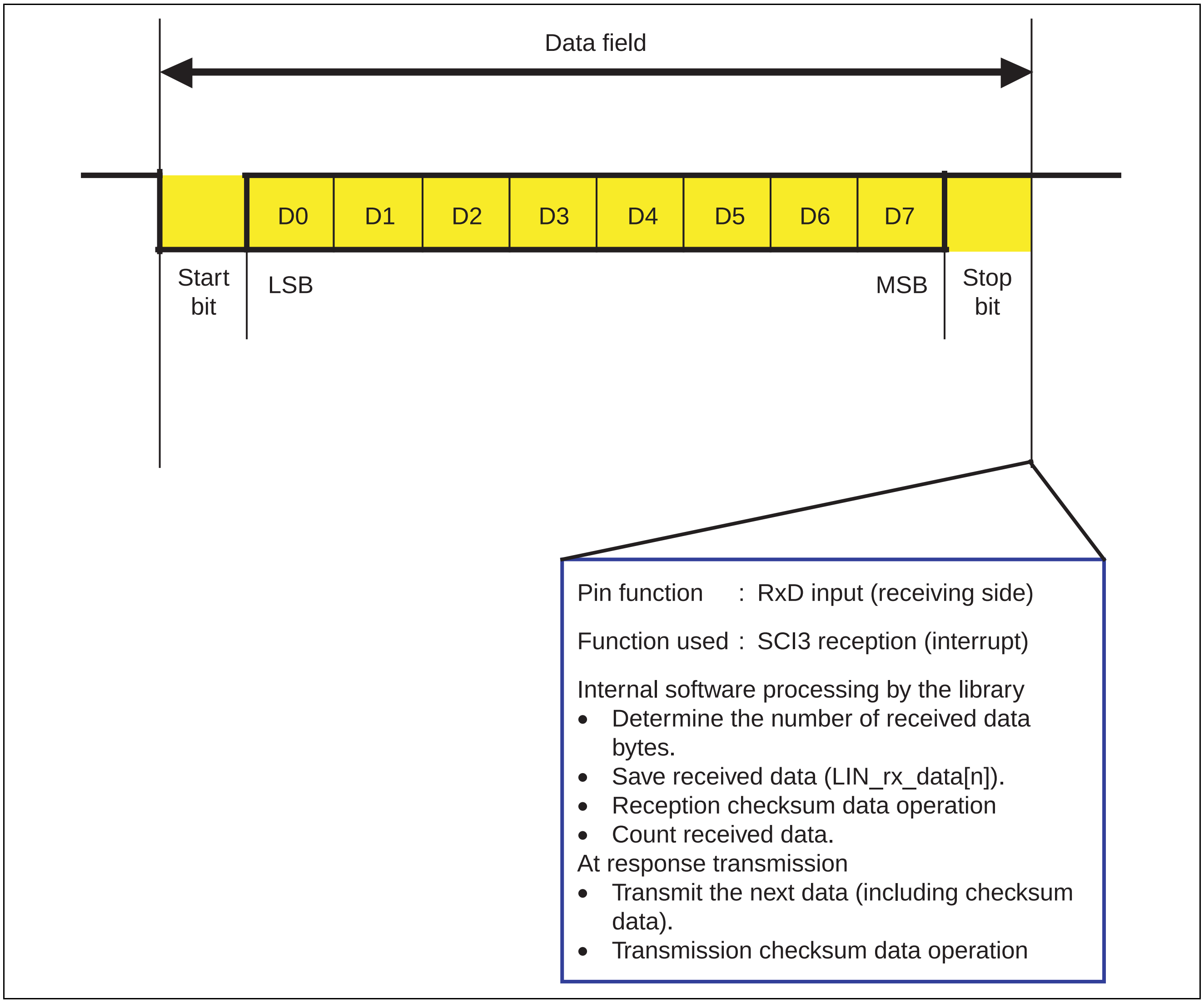

Figure 11 Transmission/Reception of a Data Field and Transmission of Checksum Data

2. Reception of a Checksum Field
   The SCI3 reception function makes a determination from the received checksum field and reception checksum data obtained by an operation from the data field.

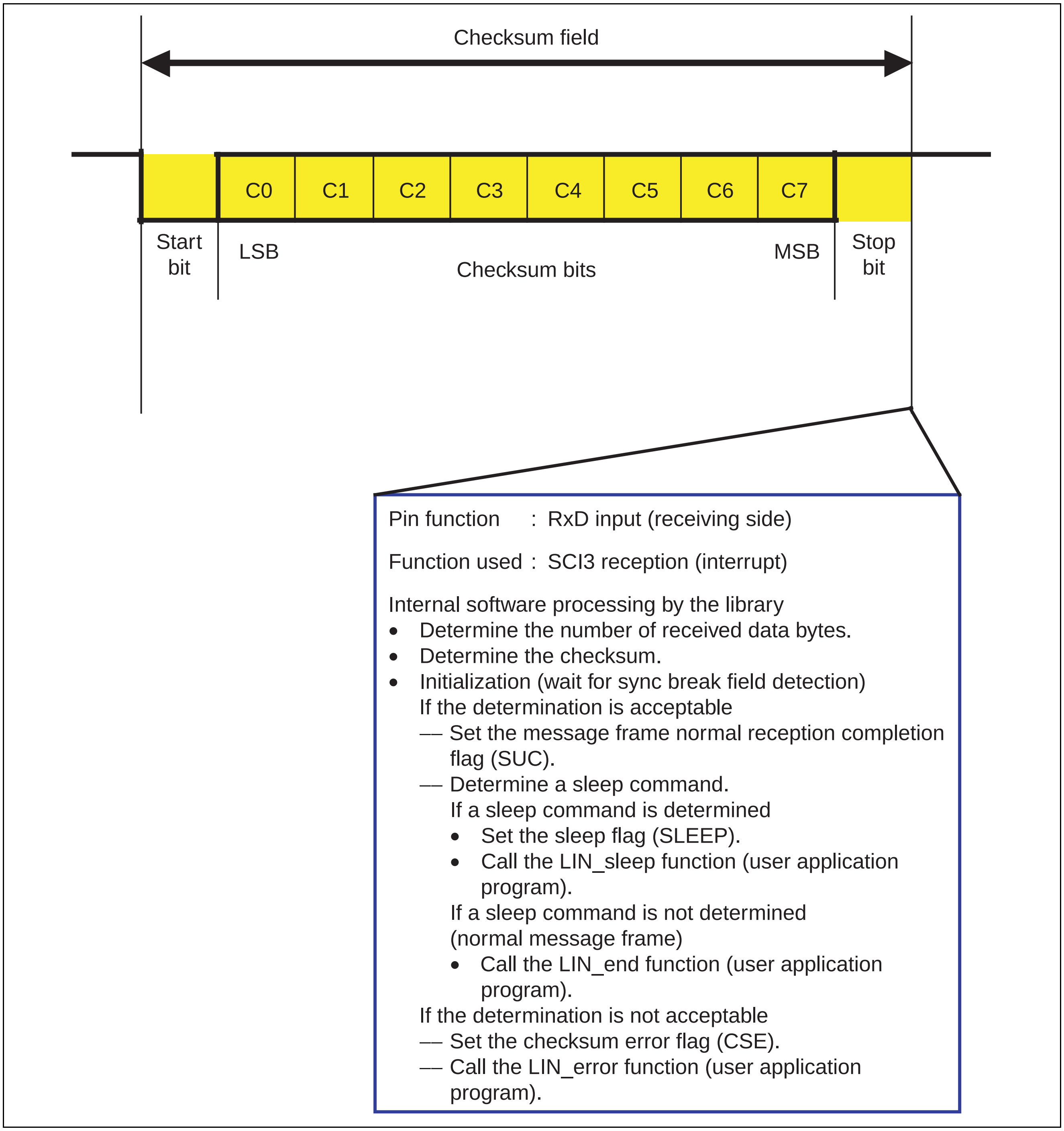

Figure 12 Checksum Field Reception and Determination

2.5.3 Transmission and Reception of a Wake-up Signal

The SCI3 transmission function transmits a wake-up signal (transmission data: 80h).

The IRQ0 falling-edge detection function detects a wake-up signal from another node.

1. Transmission of a Wake-up Signal
   A definition statement in LINID.h (#define __T_WAKEUP __ON) includes the wake-up signal transmission function when compilation is performed, allowing the SCI3 transmission function to transmit a wake-up signal when the user application program calls the LIN_transmit_wake_up function. This library does not perform wake-up delimiter output control.

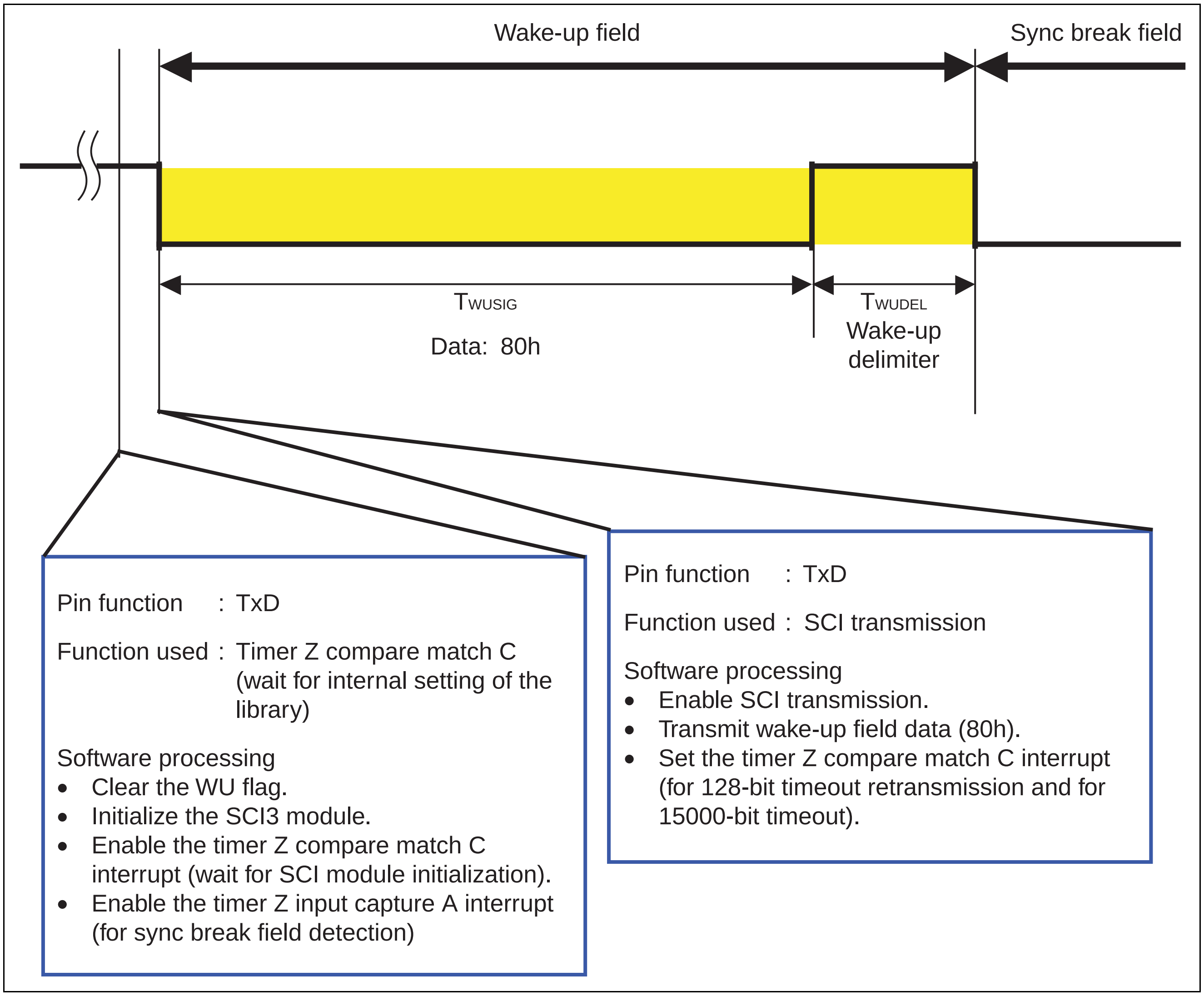

Figure 13 Transmission of a Wake-up Signal

2. Reception of a Wake-up Signal

   A definition statement in LINID.h (#define __R_WAKEUP __ON) includes the wake-up signal reception function when compilation is performed, allowing the IRQ falling-edge detection function to wait for a wake-up signal from another node when the user application program calls the LIN_wake_up_PR function.

   This library detects only falling-edges, without verifying the wake-up field data.

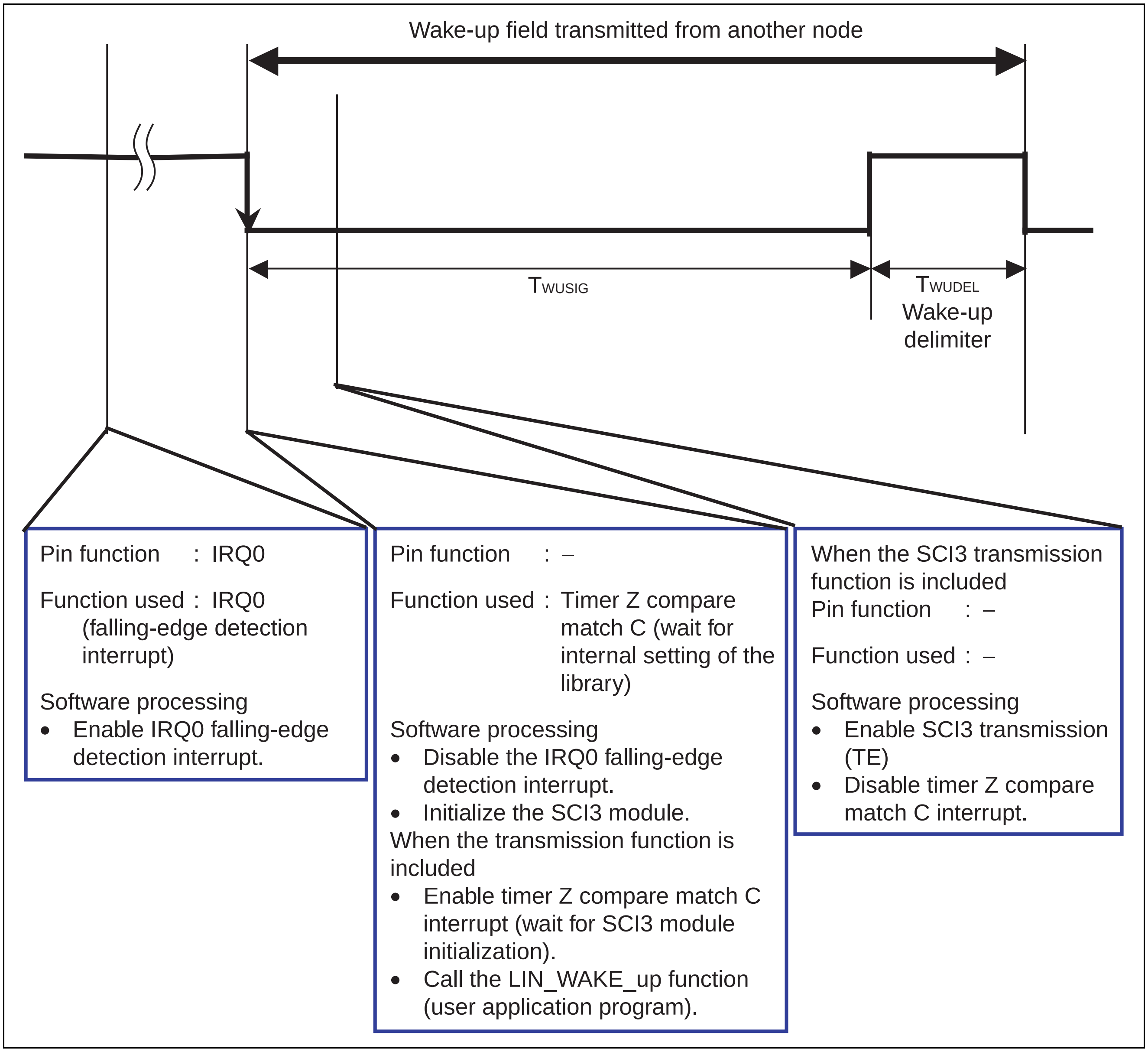

Figure 14 Reception of a Wake-up Signal

2.5.4 Reception of a Sleep Command

After the normal reception of a message frame, if the received ID field data is 3Ch and the first byte of the response data is 00h, the reception of a sleep command is recognized. Then, the sleep flag (SLEEP) is set, and the LIN_sleep function (user application program) is called. (In this case, the LIN_end function is not called in the message frame.)

2.6 Software Description

This section explains the library software.

2.6.1 Including Header Files

Includes the standard library (machine.h), the LIN library definition file (LINID.h), and the on-chip peripheral register definition files (H8_3687f.h).

```
#include    <machine.h>

#define     __LIN_LIB
#include    "LINID.h"

#include    "H8_3687f.h"
```

2.6.2 Defining Functions

Functions (modules) in the library must be defined.

The inclusion of the LIN_data_set function is selected by defining __Res2byte_ID, __Res4byte_ID, or __Res8byte_ID in LINID.h.

The inclusion of the LIN_transmit_wake_up function is selected by the __T_WAKEUP definition.

The inclusion of the LIN_intc_init function, LIN_wake_up function, and LIN_wake_up_PR function is selected by the __R_WAKEUP definition.

```
void    LIN_initialize(void);
void    LIN_system_init(void);
void    LIN_port_init(void);
void    LIN_sci_init(void);
void    LIN_timerZ_init(void);
void    LIN_Sflag_init(void);
void    LIN_end(void);
void    LIN_sleep(void);
void    LIN_error(void);
void    LIN_break_reception_PR(void);
void    LIN_start(void);
void    LIN_stop(void);

#if    __RESPONSE    ==    __ON
void    LIN_data_set(void);
#endif

#if    __T_WAKEUP    ==    __ON
void    LIN_transmit_wake_up(void);
#endif

#if    __R_WAKEUP    ==    __ON
void    LIN_intc_init(void);
void    LIN_wake_up(void);
void    LIN_wake_up_PR(void);
#endif
```

2.6.3 Defining Library Internal Constants and Variables

This section defines the constants and variables that are used in the library.

Table 5 Definition of Library Internal Constants and Variables

Label name (variable name)	Data type	Description
t_1	unsigned short	1-bit counter value (for waiting at SCI3 initialization)
t_11	unsigned long	11-bit counter value (for sync break field detection)
t_128	(Structure)	128-bit counter value (for sync break field detection timeout at wake-up transmission)
t_128.LONG	unsigned long	
t_128.WORD.h	unsigned short	
t_128.WORD.l	unsigned short	
t_15k	unsigned long	15000-bit counter value (for timeout after wake-up retry transmission (3 times)) (LIN_status.BIT.TOA3B)
t_25k	unsigned long	25000-bit counter value (for no bus active detection) (LIN_status.BIT.NBA)
flame_max_2	(Structure)	Maximum response timeout value (LIN_status.BIT.SNRE)
flame_max_2.LONG	unsigned long	
flame_max_2.WORD.h	unsigned short	
flame_max_2.WORD.l	unsigned short	
flame_max_4	(Structure)	
flame_max_4.LONG	unsigned long	
flame_max_4.WORD.h	unsigned short	
flame_max_4.WORD.l	unsigned short	
flame_max_8	(Structure)	
flame_max_8.LONG	unsigned long	
flame_max_8.WORD.h	unsigned short	
flame_max_8.WORD.l	unsigned short	
baudrate	(Structure)	Baud rate setting for SCI3 module
baudrate.WORD	unsigned short	
baudrate.BYTE.smr	unsigned char	
baudrate.BYTE.brr	unsigned char	
ex_counter	(Structure)	Time Z extended counter
ex_counter.LONG	unsigned long	
ex_counter.WORD.h	unsigned short	
ex_counter.WORD.l	unsigned short	
flame_max	unsigned short	Response timeout setting (timer Z overflow count value)
counter	unsigned char	Transmission/reception data counter
t_checksum	(Structure)	Transmission data checksum operation value
t_checksum.WORD	unsigned short	
t_checksum.BYTE.carry	unsigned char	
t_checksum.BYTE.data	unsigned char	
r_checksum	(Structure)	Reception data checksum operation value
r_checksum.WORD	unsigned short	
r_checksum.BYTE.carry	unsigned char	
r_checksum.BYTE.data	unsigned char	

Label name (variable name)	Data type	Description
in_status	(Structure)	Internal status of library
in_status.BYTE	unsigned char	
in_status.BIT.wk7	Bit 7	Reserved bit
in_status.BIT.sync_field	Bit 6	Sync field reception flag
in_status.BIT.wk5	Bit 5	Reserved bit
in_status.BIT.r_id	Bit 4	Response ID determination flag At response data transmission: 1 At reception: 0
in_status.BIT.sci	Bit 3	SCI3 module initialization flag
in_status.BIT.brr	Bit 2	Baud rate correction flag
in_status.BIT.wu	Bits 1 to 0	Wake-up signal transmission flag (transmission counter for internal setting)

```
#if    __Corrects_baud_rate    ==    __ON
static   unsigned short    t_1;
static   unsigned long     t_11;
static   union{
              unsigned short    WORD;
              struct{
                  unsigned char    smr;
                  unsigned char    brr;
              }   BYTE;
}    baudrate;
#elif   __Corrects_baud_rate    ==    __OFF
const    unsigned short    t_1    =    t_1_data;
const    unsigned long     t_11   =    t_11_data;
const    union{
             unsigned short    WORD;
             struct{
                 unsigned char    smr;
                 unsigned char    brr;
             }   BYTE;
}    baudrate    =    baudrate_data;
#endif

const    unsigned long    t_25k    =    t_25k_data;
const    union{
             unsigned long    LONG;
             struct {
                 unsigned short    h;
                 unsigned short    l;
             }   WORD;
}    flame_max_2    =    t_2byte_data;
const    union {
             unsigned long    LONG;
             struct {
                 unsigned short    h;
                 unsigned short    l;
             }   WORD;
```

```
}    flame_max_4    =    t_4byte_data;
const    union {
             unsigned long    LONG;
             struct {
                 unsigned short    h;
                 unsigned short    l;
             }   WORD;
}    flame_max_8    =    t_8byte_data;
static    union {
              unsigned long    LONG;

             struct {
                 unsigned short    h;
                 unsigned short    l;
              }  WORD;
}    ex_counter;
static    unsigned short   flame_max;
static    unsigned char     counter;

#if    __T_WAKEUP    ==    __ON
const    union {
             unsigned long    LONG;
             struct {
                 unsigned short    h;
                 unsigned short    l;
             }   WORD;
}    t_128    =    t_128_data;
const    unsigned long     t_15k    =    t_15k_data;
#endif

#if    __RESPONSE    ==    __ON
static    union {
              unsigned short    WORD;
              struct {
                  unsigned char    carry;
                  unsigned char    data;
              }   BYTE;
}    t_checksum;
#endif

static    union {
              unsigned short    WORD;
              struct {
                  unsigned char    carry;
                  unsigned char    data;
              }   BYTE;
}    r_checksum;
static    union {
              unsigned char    BYTE;
              struct {
                  unsigned char    wk7             :1;
                  unsigned char    sync_field      :1;
                  unsigned char    wk5             :1;
                  unsigned char    r_id            :1;
```

```
                    unsigned char    sci            :1;
                    unsigned char    brr            :1;
                    unsigned char    wu             :2;
                }   BIT;
}    in_status;
```

2.6.4 Defining Global Variables

The variables that are shared between the user application program and library must be defined.

(See Table 4.)

```
#if      __RESPONSE      ==    __ON
volatile    unsigned char    LIN_tx_data[8];
#endif

volatile    unsigned char    LIN_rx_id;
volatile    unsigned char    LIN_rx_data[8];
volatile    union {
                   unsigned char     BYTE;
                   struct {
                        unsigned char    NBA      :1;
                        unsigned char    CSE      :1;
                        unsigned char    ISFE     :1;
                        unsigned char    TOA3B    :1;
                        unsigned char    SNRE     :1;
                        unsigned char    SCI      :1;
                        unsigned char    SUC      :1;
                        unsigned char    SLEEP    :1;
                   }    BIT;
}    LIN_status;
volatile    union {
                   unsigned char BYTE;
                   struct {
                        unsigned char    CBR    :1;
                        unsigned char    wk6    :1;
                        unsigned char    WU     :1;
                        unsigned char    wk4    :5;
                   }    BIT;
}    LIN_control;
```

2.6.5 Initialization Function

This function initializes the H8/3687 on-chip peripheral functions used for LIN communication control and the software flags, as well as other settings used in the library.

Note: Pins P14 (IRQ0), P21 (RxD), P22 (TxD), and P64 (FTIOA1) are used for LIN communication. When a user application uses other pins (P10 to P12, P15 to P17, P20, P23, P24, P60 to P63, and P65 to P67) with ports 1, 2, and 6, the pin settings may be changed by the setting statements of PCR2 and PCR6 in the LIN_port_init function and PCR1 in the LIN_intc_init function in the source file shown below. When using the above-mentioned pins, set each PCR within the user application program, then delete the setting statements of PCR1, PCR2, and PCR6 in the source file below or set them as comments.

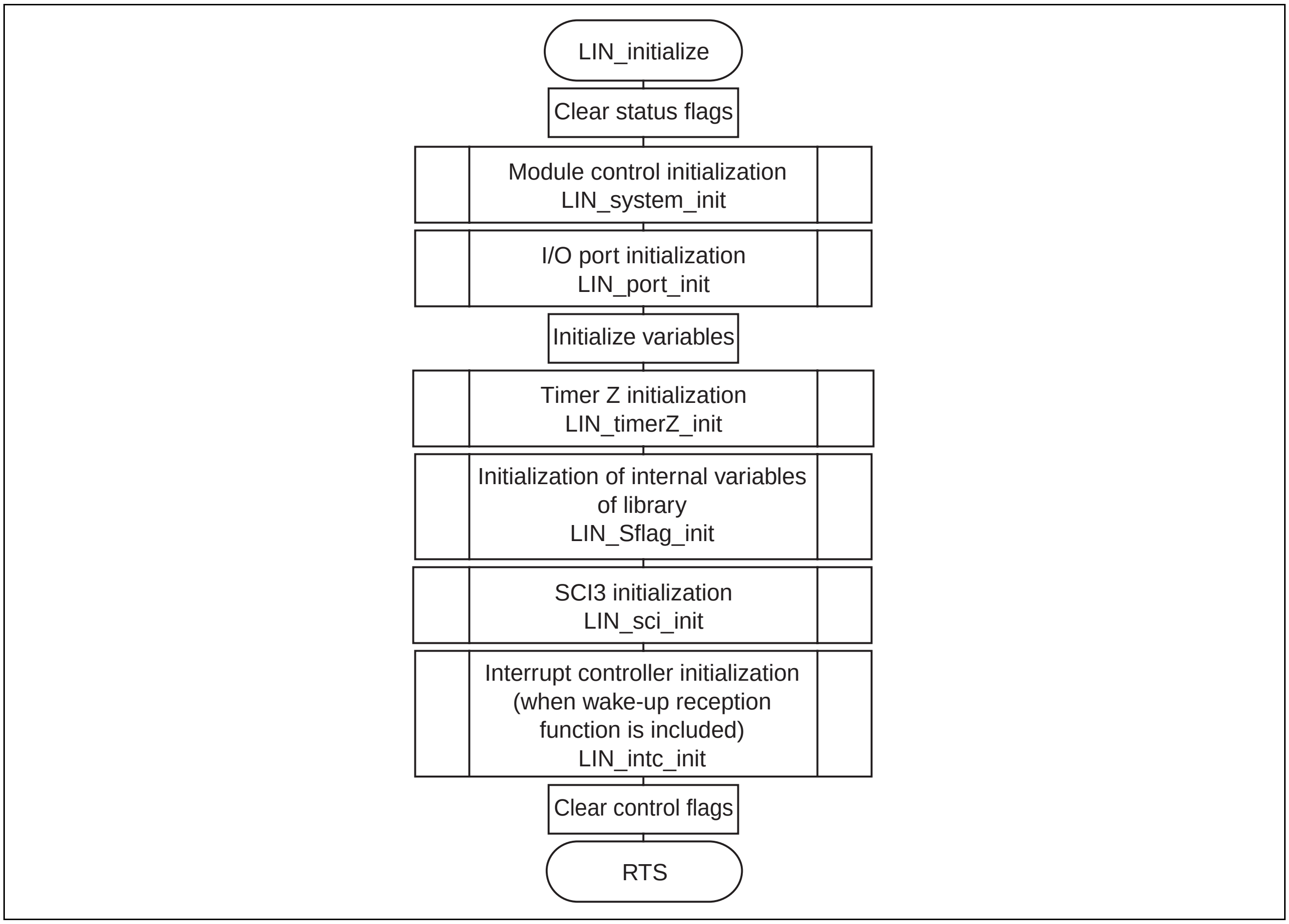

Figure 15 Initialization Function Flowchart

```
void LIN_initialize(void){
     LIN_status.BYTE       =    0;
     LIN_system_init();
     LIN_port_init();

#if    __Corrects_baud_rate    ==    __ON
     t_1      =    t_1_data;
     t_11     =    t_11_data;
     baudrate.WORD    =     baudrate_data;
#endif

     LIN_timerZ_init();
     LIN_Sflag_init();
     LIN_sci_init();

#if    __R_WAKEUP    ==     __ON
     LIN_intc_init();
#endif

     ex_counter.WORD.h     =     0;
     LIN_control.BYTE    =    0;
}


void LIN_system_init(void){
     MSTCR1.BYTE    &=    0x5B;
     MSTCR2.BYTE    &=    0xFD;
}


void LIN_port_init(void){
#if      __R_WAKEUP    ==     __ON
     IO.PMR1.BYTE    |=    0x12;
#elif    __R_WAKEUP    ==     __OFF
     IO.PMR1.BYTE    |=    0x02;
#endif

     IO.PDR2.BIT.B2    =    1;
/*  IO.PCR2    =    0;         /* Note:  When using ports 2 and 6 in a user application, set    */
/*  IO.PCR6    =    0;         /*        the bits for setting the pins used in LIN to 0(input   */
                               /*        pins) in the user application and then delete these    */
                               /*        setting statements to ensure system protection         */

}

void LIN_sci_init(void){
     SCI3.SCR3.BYTE    =    0;
     SCI3.SMR.BYTE    =    baudrate.BYTE.smr;
     SCI3.BRR    =    baudrate.BYTE.brr;

#if    ((__RESPONSE  ==  __ON)  ||  (__T_WAKEUP  ==  __ON))
     TZ.GRC    =    TZ.TCNT    +    t_1;
     TZ.TSR1.BIT.IMFC    =    0;
     TZ.TIER1.BIT.IMIEC    =    1;
```

```
     in_status.BIT.sci    =    1;
#endif
}


void LIN_timerZ_init(void){
     TZ.TSTR.BIT.STR1    =    0;
     TZ.TCR1.BYTE    =    0x03;
     TZ.TMDR.BYTE    =    0x0E;
     TZ.TOER.BYTE    |=    0xF0;
     TZ.TPMR.BYTE    &=    0x8F;
     TZ.TIORA1.BYTE    =    0x8D;
     TZ.TIORC1.BYTE    =    0xF8;
     TZ.TSR1.BYTE    &=    0xC0;
     TZ.TIER1.BYTE    =    0x11;
     TZ.TSTR.BIT.STR1    =    1;
}


#if    __R_WAKEUP    ==    __ON
void LIN_intc_init(void){
/*  IO.PCR1    =    0;         /* Note:  When using port 1 in a user application, set the bits  */
                               /*        for setting the pins used in LIN to 0 (input pins) in  */
                               /*        the user application and then delete this setting      */
                               /*        statement to ensure system protection.                 */
     IEGR1.BIT.IEG0   =    0;
     IRR1.BIT.IRRI0   =    0;
     IENR1.BIT.IEN0   =    0;
}
#endif


void LIN_Sflag_init(void){
     counter    =    0;
     in_status.BYTE    =    0;
}
```

2.6.6 LIN Communication Control Stop Function

This function stops LIN communication control so that it no longer communicates over the LIN bus.

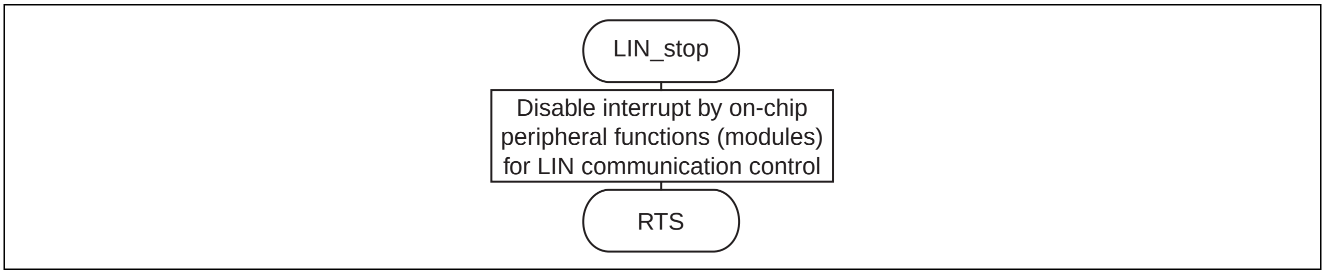

Figure 16 Flowchart of the LIN Communication Control Stop Function

```
void LIN_stop(void){
     SCI3.SSR.BYTE    &=    0x84;
     SCI3.SCR3.BYTE    =    0x00;
     TZ.TIER1.BYTE    &=    0xE0;

#if   __R_WAKEUP      ==    __ON
     IENR1.BIT.IEN0    =    0;
#endif
}
```

2.6.7 Function for LIN Communication Restart Preparation

This function restarts LIN communication control (that has previously been placed in the stopped state by the LIN communication control stop function described in Section 2.6.6 or some other reason), and then LIN communication control waits for the reception of a sync break field.

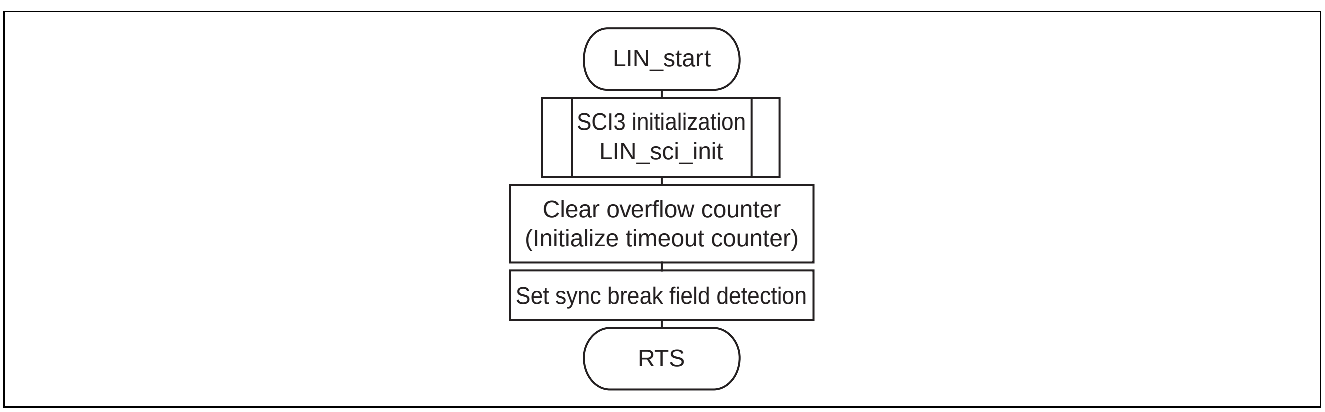

Figure 17 Flowchart of the LIN Communication Control Restart Preparation Functions

```
void LIN_start(void){
     LIN_sci_init();
     ex_counter.WORD.h    =    0;
     TZ.TSR1.BYTE     &=    0xC0;
     TZ.TIER1.BYTE    |=    0x11;
}
```

2.6.8 Wake-up Signal Transmission Function

This function transmits a wake-up signal. If a sync break field is not detected within the 128-bit period after the transmission of the wake-up signal, the function retries transmission up to three times, including the first transmission (transmission is controlled within the timer Z interrupt function). If a sync break field is not detected within the 15000-bit period after the signal has been transmitted three times, the function sets the timeout flag (LIN_status.BIT.TOA3B) and calls the LIN_error function (user application program).

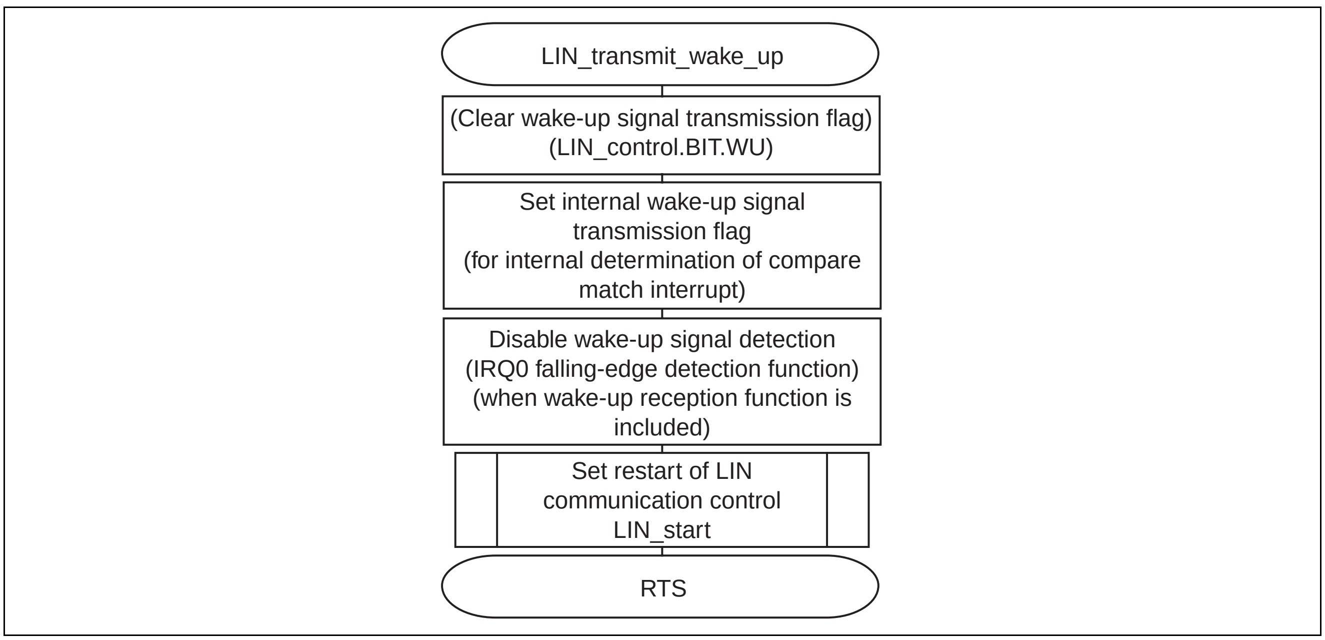

Figure 18 Flowchart of the Wake-up Signal Transmission Function

```
#if    __T_WAKEUP         ==    __ON
void LIN_transmit_wake_up(void){
     LIN_control.BIT.WU    =    0;
     in_status.BIT.wu    =    1;

#if    __R_WAKEUP         ==    __ON
     IENR1.BIT.IEN0      =    0;
#endif

     LIN_start();
}
#endif
```

2.6.9 Function for Preparing for Wake-up Signal Reception

This function prepares for receiving a wake-up signal from another node.

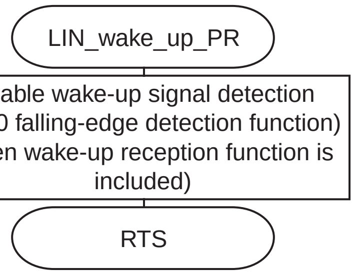

Figure 19 Flowchart of the Wake-up Signal Reception Preparation Function

```
#if     __R_WAKEUP      ==    __ON
void LIN_wake_up_PR(void){
     IRR1.BIT.IRRI0    =    0;
     IENR1.BIT.IEN0    =    1;
}
#endif
```

2.6.10 Function for Preparing to Detect a Sync Break Field in the Library

When message frame transmission or reception is completed, when an extended frame ID is received, or when an error is detected, this function makes the preparations needed to receive the next message frame (preparation for sync break field detection) in the library.

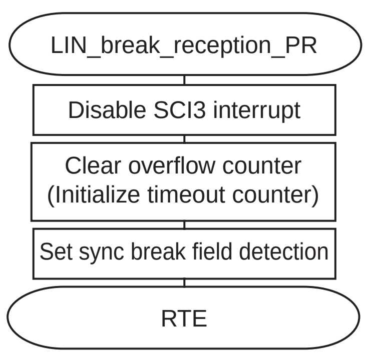

Figure 20 Function for Preparing for Sync Break Field Detection and Reception

```
void LIN_break_reception_PR(void){
     SCI3.SSR.BYTE    &=    0x84;
#if   (( __RESPONSE  ==  __ON)  ||  (__T_WAKEUP  ==  __ON))
     SCI3.SCR3.BYTE    =    0x20;
#else
     SCI3.SCR3.BYTE    =    0x00;
#endif
     ex_counter.WORD.h    =    0;
     TZ.TSR1.BYTE     &=    0xC0;
```

```
    TZ.TIER1.BYTE     =    0x11;
}
```

2.6.11 IRQ Interrupt Function

This function processes the IRQ0 falling-edge detection interrupt. After the settings have been made by the wake-up signal reception preparation function, as described in Section 2.6.9, this function detects a falling-edge on the LIN bus and makes the preparations required for LIN communication control.

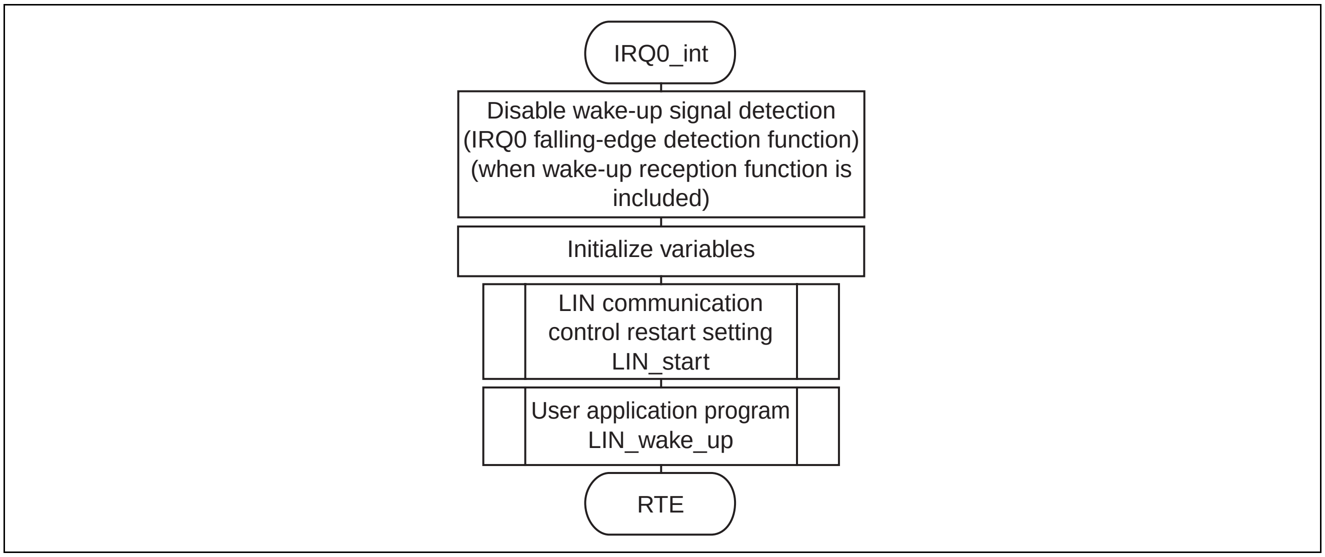

Figure 21 Flowchart of the IRQ Interrupt Function

```
#if    __R_WAKEUP    ==    __ON
#pragma    interrupt(IRQ0_int)
void    IRQ0_int(void){
    LIN_status.BIT.SLEEP    =    0;
    IRR1.BIT.IRRI0    =    0;
    IENR1.BIT.IEN0    =    0;
#if    __Corrects_baud_rate    ==    __ON
    t_1      =    t_1_data;
    t_11     =    t_11_data;
    baudrate.WORD     =     baudrate_data;
#endif
    LIN_start();
    LIN_wake_up();
}
#endif
```

2.6.12 Timer Z Interrupt Function

This function processes the timer Z (channel-1) input capture A interrupt (I/C-A), compare match B interrupt (O/C-B), compare match C interrupt (O/C-C), and overflow interrupt (OVF).

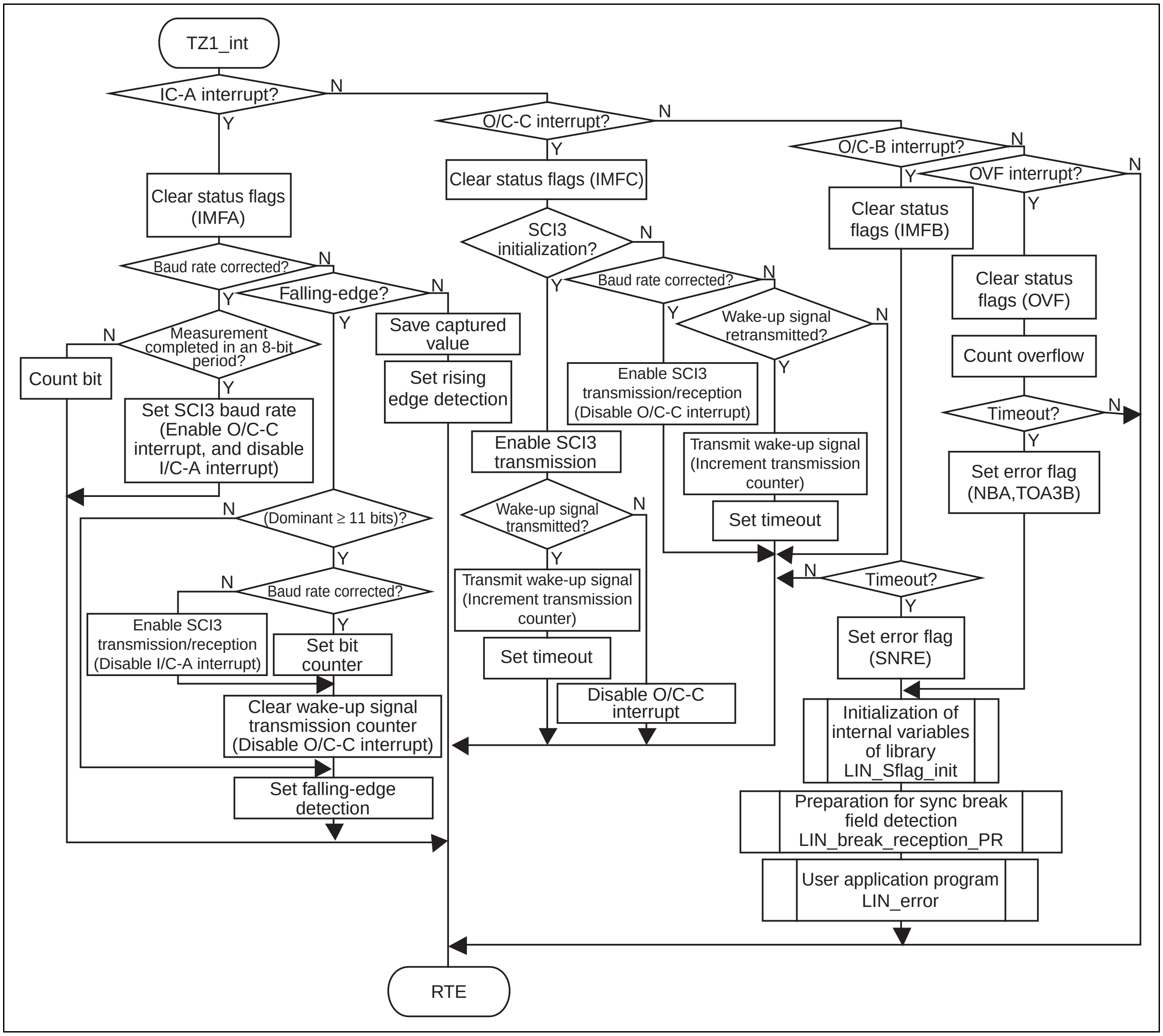

Figure 22 Flowchart of the Timer Z (channel-1) Interrupt Function

```
#pragma    interrupt(TZ1_int)
void    TZ1_int(void){
    unsigned long    i;
    unsigned short    N,w;

    if((TZ.TSR1.BIT.IMFA)  &&  (TZ.TIER1.BIT.IMIEA)){
        TZ.TSR1.BIT.IMFA    =    0;

#if    __Corrects_baud_rate    ==    __ON
```

```
        if(in_status.BIT.brr  ==  0){
#endif

            if(TZ.TIORA1.BIT.IOA0){
                TZ.TIORA1.BIT.IOA0    =    0;
                ex_counter.LONG    =    (unsigned long)TZ.GRA1;
                TZ.GRB1    =    TZ.GRA1;
                if((TZ.TSR1.BIT.OVF)  &&  (ex_counter.WORD.l  <  0x00FF)){
                    TZ.TSR1.BIT.OVF    =    0;
                }
            }else{
                w    =    ex_counter.WORD.l;
                ex_counter.WORD.l    =    TZ.GRA1;
                if((TZ.TSR1.BIT.OVF)  &&  (ex_counter.WORD.l  <  0x00FF)){
                    ex_counter.WORD.h    +=    1;
                    TZ.TSR1.BIT.OVF    =    0;
                }
                ex_counter.LONG    -=    w;
                if(ex_counter.LONG  >=  t_11){

#if    __Corrects_baud_rate    ==    __ON
                    if(LIN_control.BIT.CBR){
                        in_status.BIT.brr    =    1;
                        LIN_control.BIT.CBR    =    0;
                        counter    =    4;
                    }else{
#endif

                        SCI3.SSR.BYTE    &=    0x84;

#if      __RESPONSE    ==    __ON
                        SCI3.SCR3.BYTE    =    0x70;
#elif    __RESPONSE    ==    __OFF
                        SCI3.SCR3.BYTE    =    0x50;
#endif

                        TZ.TIER1.BIT.IMIEA    =    0;

#if    __Corrects_baud_rate    ==    __ON
                    }
#endif

#if    __T_WAKEUP    ==    __ON
                    in_status.BIT.wu    =    0;
                    TZ.TIER1.BIT.IMIEC    =    0;
#endif


                }
                TZ.TIORA1.BIT.IOA0    =    1;
            }

#if    __Corrects_baud_rate    ==    __ON
        }else{
            if(counter){
```

```
                if(counter  ==  4){
                    ex_counter.LONG    =    (unsigned long)TZ.GRA1;
                    SCI3.SCR3.BYTE    =    0;
                    SCI3.SMR.BYTE    =    0;
                    if((TZ.TSR1.BIT.OVF)  &&  (ex_counter.WORD.l  <  0x00FF)){
                        TZ.TSR1.BIT.OVF    =    0;
                    }
                }
                counter    -=    1;
            }else{
                TZ.TIER1.BYTE    =    0xF4;
                w    =    ex_counter.WORD.l;
                ex_counter.WORD.l    =    TZ.GRA1;
                if((TZ.TSR1.BIT.OVF)  &&  (ex_counter.WORD.l  <  0x00FF)){
                    ex_counter.WORD.h    +=    1;
                    TZ.TSR1.BIT.OVF    =    0;
                }
                t_1    =    (ex_counter.LONG    -    w)    >>   3;
                for(N   =   ((t_1  +  2)  >>  2);  N  >  0x0100;  N  >>=  2){
                    SCI3.SMR.BIT.CKS    +=    1;
                }
                SCI3.BRR    =    N    -    1;
                TZ.GRC1    =    (TZ.TCNT1    +    t_1);
                TZ.TSR1.BYTE    &=    0xF0;
                ex_counter.WORD.h    =    0;
                in_status.BIT.sync_field    =    1;
                t_11    =    t_1    *    11;
            }
        }
#endif

    }else if((TZ.TSR1.BIT.IMFC)  &&  (TZ.TIER1.BIT.IMIEC)){
        TZ.TSR1.BIT.IMFC    =    0;
        if(in_status.BIT.sci){
            SCI3.SSR.BYTE    &=    0x84;
            SCI3.SCR3.BIT.TE    =    1;

#if    __T_WAKEUP    ==    __ON
            if(in_status.BIT.wu  ==  1){
                TZ.GRC1    =    TZ.TCNT1    +    t_128.WORD.l;
                SCI3.TDR    =    0x80;
                in_status.BIT.wu    +=    1;
            }else{
#endif

                TZ.TIER1.BIT.IMIEC    =    0;

#if    __T_WAKEUP    ==    __ON
            }
#endif

            in_status.BIT.sci    =    0;

#if    __Corrects_baud_rate    ==    __ON
```

```
        }else if(in_status.BIT.brr){
            SCI3.SSR.BYTE    &=    0x84;

#if    ((__RESPONSE  ==  __ON)  ||  (__T_WAKEUP  ==  __ON))
            SCI3.SCR3.BYTE    =    0x70;
#else
            SCI3.SCR3.BYTE    =    0x50;
#endif

            TZ.TIER1.BIT.IMIEC    =    0;
#endif

#if    __T_WAKEUP    ==    __ON
        }else if((in_status.BIT.wu  ==  2)  &&  (ex_counter.WORD.h  >=  t_128.WORD.h)){
            SCI3.TDR    =    0x80;
            ex_counter.WORD.h    =    0;
            TZ.GRC1    =    TZ.TCNT1    +    t_128.WORD.l;
            in_status.BIT.wu    +=    1;
        }else if((in_status.BIT.wu  ==  3)  &&  (ex_counter.WORD.h  >=  t_128.WORD.h)){
            SCI3.TDR    =    0x80;
            ex_counter.WORD.h    =    0;
            TZ.TIER1.BIT.IMIEC    =    0;
#endif
        }
    }else if((TZ.TSR1.BIT.IMFB)  &&  (TZ.TIER1.BIT.IMIEB)){
        TZ.TSR1.BIT.IMFB    =    0;
        if(ex_counter.WORD.h  >=  flame_max){
            LIN_status.BIT.SNRE    =    1;
            LIN_Sflag_init();
            LIN_break_reception_PR();
            LIN_error();
        }
    }else if((TZ.TSR1.BIT.OVF)  &&  (TZ.TIER1.BIT.OVIE)){
        TZ.TSR1.BIT.OVF    =    0;
        ex_counter.WORD.h    +=    1;
        if((ex_counter.LONG  >  t_25k)){
            LIN_status.BIT.NBA    =    1;
            LIN_Sflag_init();
            LIN_break_reception_PR();
            LIN_error();

#if    __T_WAKEUP    ==    __ON
        }else if((ex_counter.LONG  >=  t_15k)  &&  (in_status.BIT.wu  ==  3)){
            in_status.BIT.wu = 0;
            LIN_status.BIT.TOA3B    =    1;
            LIN_error();
#endif

        }
    }
}
```

2.6.13 SCI3 Interrupt Function

This function processes the SCI3 error detection and reception interrupts.

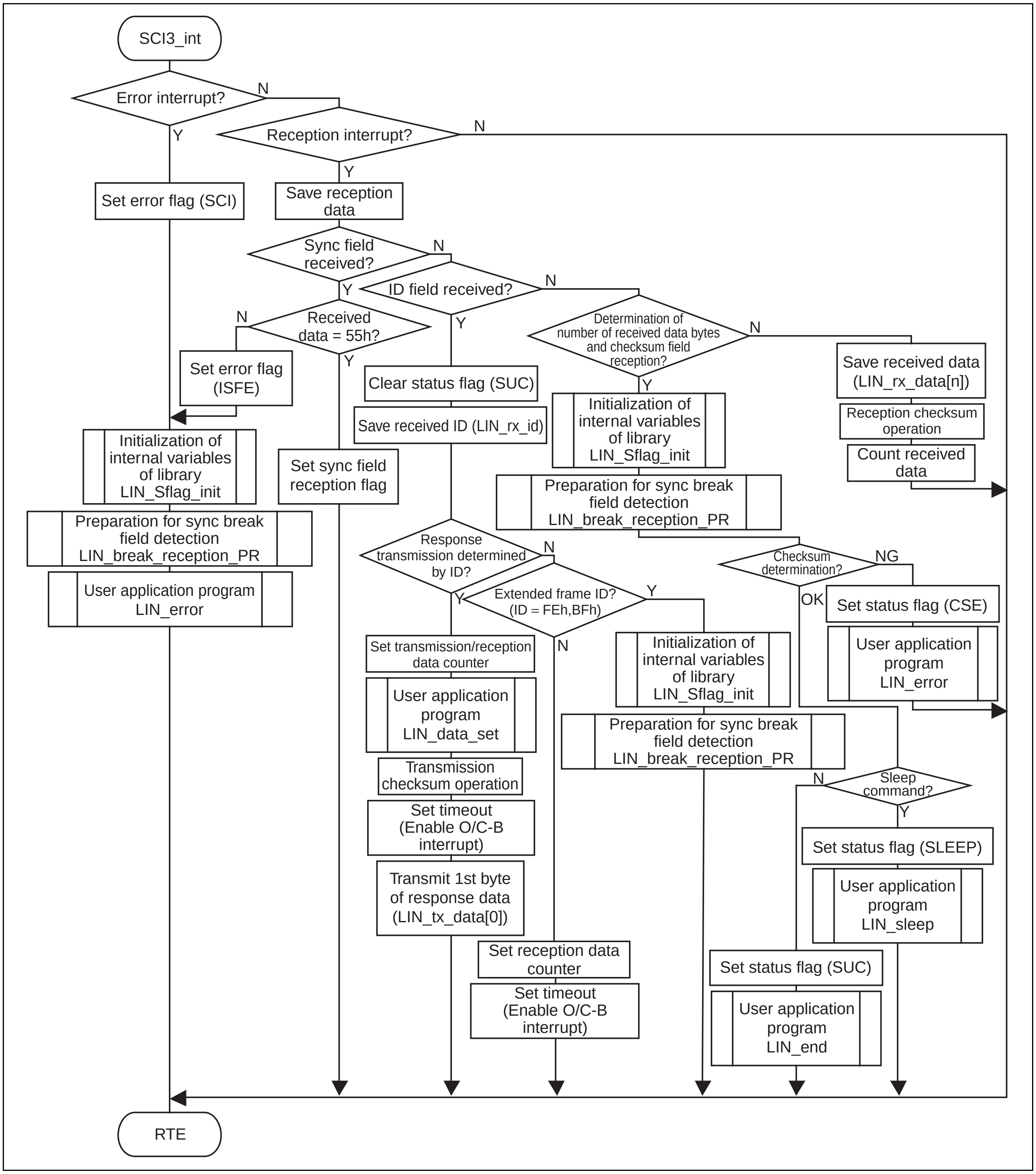

Figure 23 Flowchart of the SCI3 Interrupt Function

```
#pragma    interrupt(SCI3_int)
void    SCI3_int(void){
    unsigned char    buff,nmbr,nm,id,dlc;

    if(SCI3.SSR.BYTE  &  0x38){
        LIN_status.BIT.SCI    =    1;
        LIN_Sflag_init();
        LIN_break_reception_PR();
        LIN_error();
    }else if(SCI3.SSR.BIT.RDRF){
        buff    =    SCI3.RDR;
        if(in_status.BIT.sync_field){
            if(counter){
                nm    =    counter    &    0x0F;
                nmbr    =    (counter    >>    4)    -    nm;
                if(nm){
                    LIN_rx_data[nmbr]    =    buff;
                    r_checksum.WORD    +=    (unsigned short)LIN_rx_data[nmbr];
                    r_checksum.BYTE.data    +=    r_checksum.BYTE.carry;
                    r_checksum.BYTE.carry    =    0;
                    counter    -=    1;

#if    __RESPONSE    ==    __ON
                    if(in_status.BIT.r_id){
                        if(nm  -  1){
                            buff    =    LIN_tx_data[(nmbr  +  1)];
                            SCI3.TDR    =    buff;
                            t_checksum.WORD    +=    buff;
                            t_checksum.BYTE.data    +=    t_checksum.BYTE.carry;
                            t_checksum.BYTE.carry    =    0;
                        }else{
                            t_checksum.BYTE.data    =    ~(t_checksum.BYTE.data);
                            SCI3.TDR    =    t_checksum.BYTE.data;
                            in_status.BIT.r_id    =    0;
                        }
                    }
#endif

                }else{
                    LIN_Sflag_init();
                    LIN_break_reception_PR();
                    if((r_checksum.BYTE.data  ^  buff)  !=  0xFF){
                        LIN_status.BIT.CSE    =    1;
                        LIN_error();
                    }else{
                        if((LIN_rx_id  ==  0x3C)  &&  (LIN_rx_data[0]  ==  0)){
                            LIN_status.BIT.SLEEP    =    1;
                            LIN_sleep();
                        }else{
                            LIN_status.BIT.SUC    =    1;
                            LIN_end();
                        }
                    }
                }
```

```
            }else{
                in_status.BYTE    &=    0x40;
                LIN_status.BIT.SUC    =    0;
                LIN_rx_id    =    buff;
                switch(LIN_rx_id){
#if    __Res2byte_ID    ==    __ON
#ifdef    __ID00
                    case    __ID00:
#endif
#ifdef    __ID01
                    case    __ID01:
#endif
#ifdef    __ID02
                    case    __ID02:
#endif
#ifdef    __ID03
                    case    __ID03:
#endif
#ifdef    __ID04
                    case    __ID04:
#endif
#ifdef    __ID05
                    case    __ID05:
#endif
#ifdef    __ID06
                    case    __ID06:
#endif
#ifdef    __ID07
                    case    __ID07:
#endif
#ifdef    __ID08
                    case    __ID08:
#endif
#ifdef    __ID09
                    case    __ID09:
#endif
#ifdef    __ID0a
                    case    __ID0a:
#endif
#ifdef    __ID0b
                    case    __ID0b:
#endif
#ifdef    __ID0c
                    case    __ID0c:
#endif
#ifdef    __ID0d
                    case    __ID0d:
#endif
#ifdef    __ID0e
                    case    __ID0e:
#endif
#ifdef    __ID0f
                    case    __ID0f:
#endif
```

```
#ifdef    __ID10
                    case    __ID10:
#endif
#ifdef    __ID11
                    case    __ID11:
#endif
#ifdef    __ID12
                    case    __ID12:
#endif
#ifdef    __ID13
                    case    __ID13:
#endif
#ifdef    __ID14
                    case    __ID14:
#endif
#ifdef    __ID15
                    case    __ID15:
#endif
#ifdef    __ID16
                    case    __ID16:
#endif
#ifdef    __ID17
                    case    __ID17:
#endif
#ifdef    __ID18
                    case    __ID18:
#endif
#ifdef    __ID19
                    case    __ID19:
#endif
#ifdef    __ID1a
                    case    __ID1a:
#endif
#ifdef    __ID1b
                    case    __ID1b:
#endif
#ifdef    __ID1c
                    case    __ID1c:
#endif
#ifdef    __ID1d
                    case    __ID1d:
#endif
#ifdef    __ID1e
                    case    __ID1e:
#endif
#ifdef    __ID1f
                    case    __ID1f:
#endif
                        counter    =    0x22;
                        in_status.BIT.r_id    =    1;
                        r_checksum.WORD    =    0;
                        LIN_data_set();
                        buff    =    LIN_tx_data[0];
                        t_checksum.WORD    =    (unsigned short)buff;
```

```
                        TZ.GRB1    +=    flame_max_2.WORD.l;
                        flame_max    =    flame_max_2.WORD.h;
                        TZ.TSR1.BIT.IMFB    =    0;
                        TZ.TIER1.BIT.IMIEB    =    1;
                        SCI3.TDR    =    buff;
                        break;
#endif
#if    __Res4byte_ID    ==    __ON
#ifdef    __ID20
                    case    __ID20:
#endif
#ifdef    __ID21
                    case    __ID21:
#endif
#ifdef    __ID22
                    case    __ID22:
#endif
#ifdef    __ID23
                    case    __ID23:
#endif
#ifdef    __ID24
                    case    __ID24:
#endif
#ifdef    __ID25
                    case    __ID25:
#endif
#ifdef    __ID26
                    case    __ID26:
#endif
#ifdef    __ID27
                    case    __ID27:
#endif
#ifdef    __ID28
                    case    __ID28:
#endif
#ifdef    __ID29
                    case    __ID29:
#endif
#ifdef    __ID2a
                    case    __ID2a:
#endif
#ifdef    __ID2b
                    case    __ID2b:
#endif
#ifdef    __ID2c
                    case    __ID2c:
#endif
#ifdef    __ID2d
                    case    __ID2d:
#endif
#ifdef    __ID2e
                    case    __ID2e:
#endif
#ifdef    __ID2f
```

```
                    case    __ID2f:
#endif
                        counter    =    0x44;
                        in_status.BIT.r_id    =    1;
                        r_checksum.WORD    =    0;
                        LIN_data_set();
                        buff    =    LIN_tx_data[0];
                        t_checksum.WORD    =    (unsigned short)buff;
                        TZ.GRB1    +=    flame_max_4.WORD.l;
                        flame_max    =    flame_max_4.WORD.h;
                        TZ.TSR1.BIT.IMFB    =    0;
                        TZ.TIER1.BIT.IMIEB    =    1;
                        SCI3.TDR    =    buff;
                        break;
#endif
#if    __Res8byte_ID    ==    __ON
#ifdef    __ID30
                    case    __ID30:
#endif
#ifdef    __ID31
                    case    __ID31:
#endif
#ifdef    __ID32
                    case    __ID32:
#endif
#ifdef    __ID33
                    case    __ID33:
#endif
#ifdef    __ID34
                    case    __ID34:
#endif
#ifdef    __ID35
                    case    __ID35:
#endif
#ifdef    __ID36
                    case    __ID36:
#endif
#ifdef    __ID37
                    case    __ID37:
#endif
#ifdef    __ID38
                    case    __ID38:
#endif
#ifdef    __ID39
                    case    __ID39:
#endif
#ifdef    __ID3a
                    case    __ID3a:
#endif
#ifdef    __ID3b
                    case    __ID3b:
#endif
#ifdef    __ID3d
                    case    __ID3d:
```

```
#endif
                        counter    =    0x88;
                        in_status.BIT.r_id    =    1;
                        r_checksum.WORD    =    0;
                        LIN_data_set();
                        buff    =    LIN_tx_data[0];
                        t_checksum.WORD    =    (unsigned short)buff;
                        TZ.GRB1    +=    flame_max_8.WORD.l;
                        flame_max    =    flame_max_8.WORD.h;
                        TZ.TSR1.BIT.IMFB    =    0;
                        TZ.TIER1.BIT.IMIEB    =    1;
                        SCI3.TDR    =    buff;
                        break;
#endif
/*                  case    0x3C:
                        counter    =    0x88;
                        r_checksum.WORD    =    0;
                        TZ.GRB1    +=    flame_max_8.WORD.l;
                        flame_max    =    flame_max_8.WORD.h;
                        TZ.TSR1.BIT.IMFB    =    0;
                        TZ.TIER1.BIT.IMIEB    =    1;
                        break;
*/
                    case    0xFE:
                    case    0xBF:
                        LIN_Sflag_init();
                        LIN_break_reception_PR();
                        break;
                    default :
                        dlc    =    buff    &    0x30;
                        if(dlc  ==  0x20){
                            counter    =    0x44;
                            TZ.GRB1    +=    flame_max_4.WORD.l;
                            flame_max    =    flame_max_4.WORD.h;
                        }else if(dlc  ==  0x30){
                            counter    =    0x88;
                            TZ.GRB1    +=    flame_max_8.WORD.l;
                            flame_max    =    flame_max_8.WORD.h;
                        }else{
                            counter    =    0x22;
                            TZ.GRB1    +=    flame_max_2.WORD.l;
                            flame_max    =    flame_max_2.WORD.h;
                        }
                        r_checksum.WORD = 0;
                        TZ.TSR1.BIT.IMFB    =    0;
                        TZ.TIER1.BIT.IMIEB    =    1;
                        break;
                }
            }
        }else if(SCI3.RDR  ==  0x55){
            in_status.BIT.sync_field    =    1;
        }else{
            LIN_status.BIT.ISFE    =    1;
            LIN_Sflag_init();
```

```
            LIN_break_reception_PR();
            LIN_error();
        }
    }
}
```

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