RL78/F13, F14 Group

LIN Slave Mode (RLIN3)

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Rev.1.02
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Introduction

This document describes how to use the RLIN3 hardware in slave mode.

Target Device

RL78/F13,F14 Group(R5F10PPJ)

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

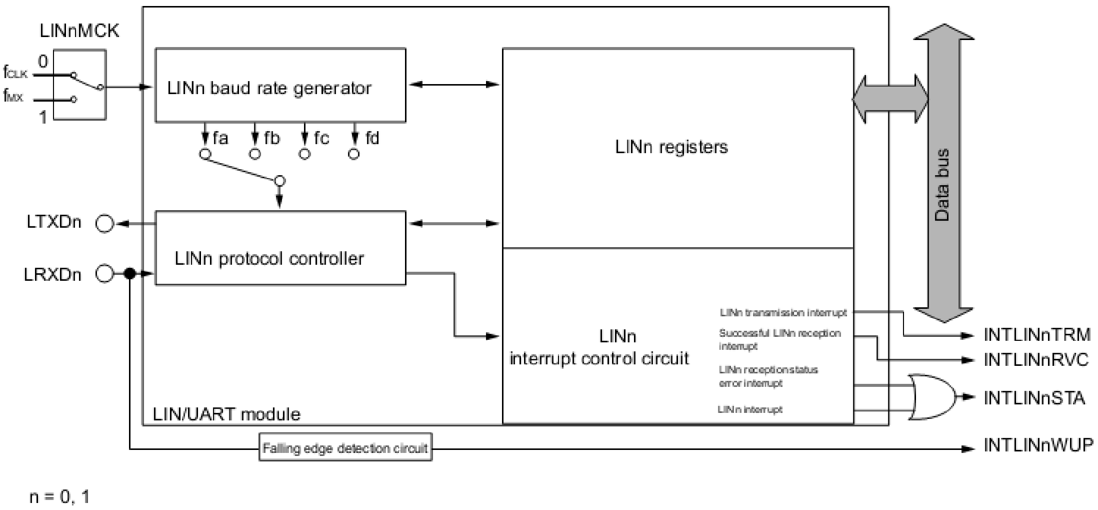
Development environment

IAR Embedded workbench for Renesas RL78 V1.30.3

Contents

1. RLIN3 hardware module specifications

The RLIN3 interface is a dedicated UART interface supporting LIN slave and master functionality

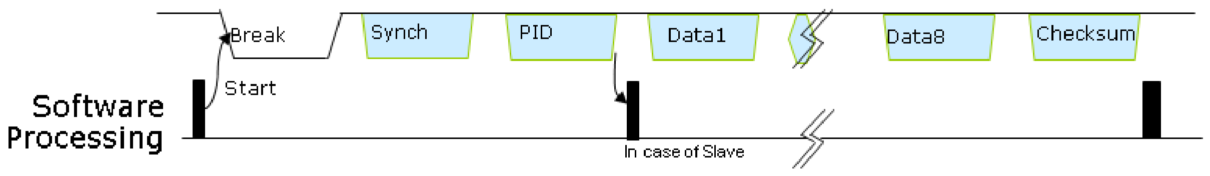


Figue1.1 RLIN3 Module Block Diagram

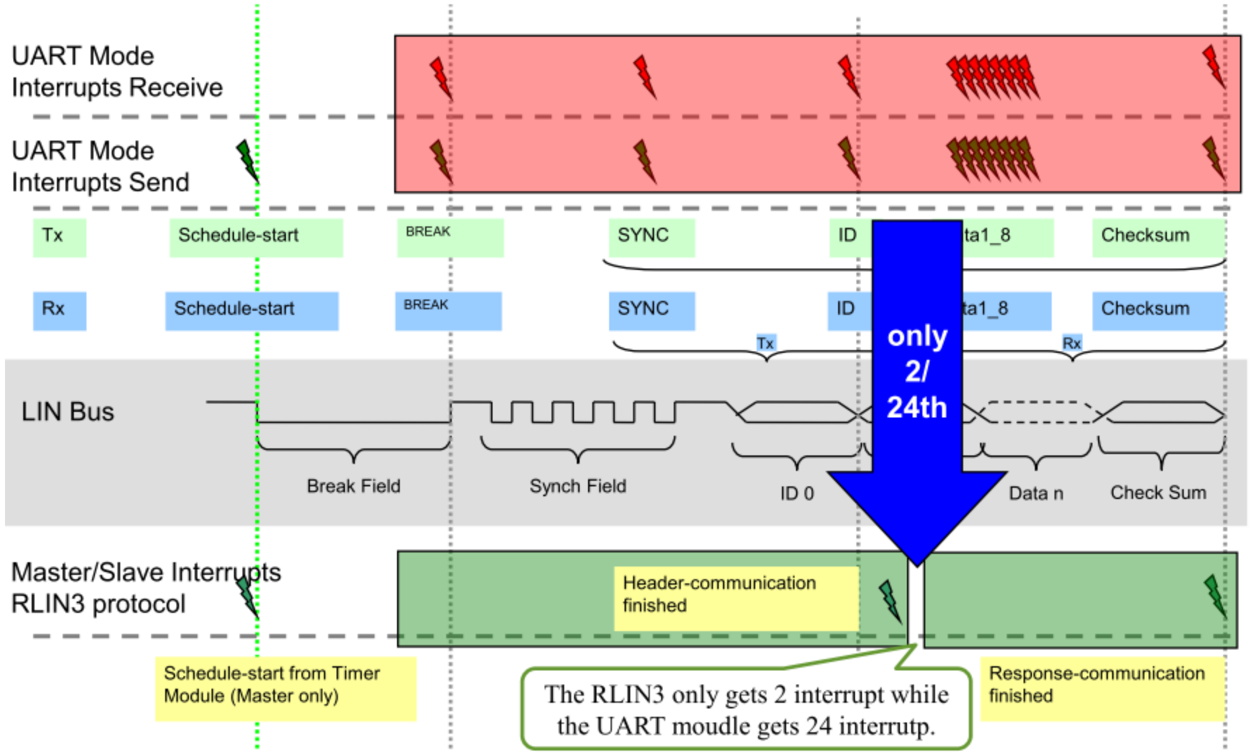
Features of the RLIN3 interface

- LIN Slave mode support
  - Basic LIN functionality
    - Conform to LIN Specification Package Revision 1.3, 2.0, 2.1 and SAEJ2602
    - Automatic baud rate detection or fixed baud rate mode
    - Wakeup transmission and reception(LIN WakeUp mode)
    - Automatic classic or enhanced checksum generation/verification
    - Break field reception while frame is being transmitted/received
- Advanced features for LIN
    - Extended response reception and transmission (extension to any data count by software)
    - LIN Self-Test mode
    - Various settings for LIN frame timing (spacing, break/delimiter timing)
    - LIN Error detections
      - Bit errors (commonly, or in break/wakeup field [“physical bit error”])
      - Frame error (wrong STOP bit level)
      - Checksum error (received does not match internally calculated)
      - Timeout error (either frame or response, threshold automatically set)
        Response preparation error (for LIN master – on response if not yet triggered)

- Software processing flow
  - During a complete LIN message only two interrupts are generated. The first one after the successful PID reception and the second one after the complete message.



  - Due to this enhanced LIN functionality the interrupt load will be drastically reduced compared to a standard UART.



2. Development environment

The sample code described in this application note runs under the conditions below.

Table 2.1 Development environment

Item	Contents
MCU	RL78/F14 R5F10PPJ (WS2.0)
Operating frequencies	Xin : 4MHz System clock: 32MHz (PLL) CPU clock: 32MHz
Operating voltage	5.0V for MCU, 12V for LIN transceiver
Integrated development environment	IAR Embedded workbench for Renesas RL78 V1.30.3
LIN protocol versions	V2.1
Evaluation Board	See figure 2.1

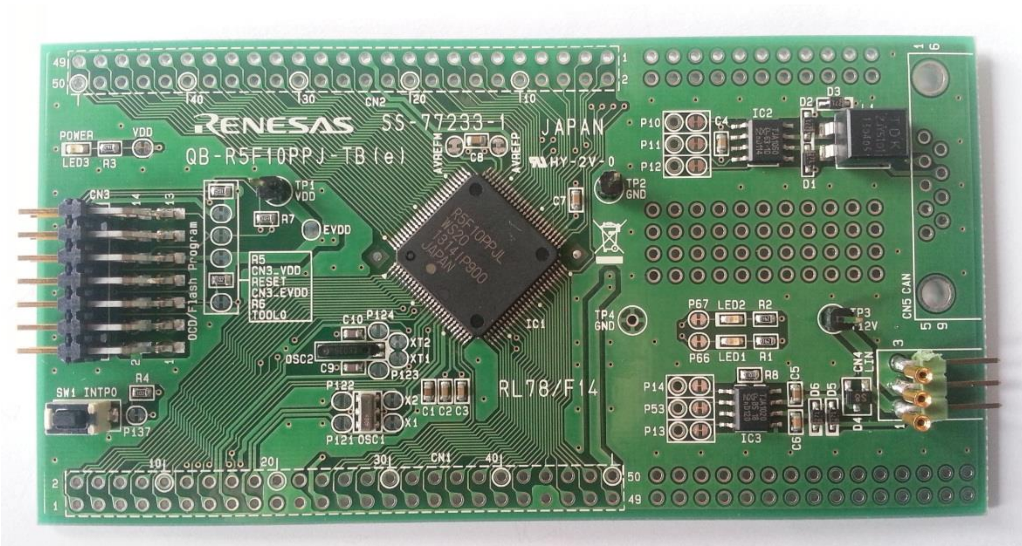


Figure 2.1 Evaluation board

3. Software

The sample code demonstrates the usage of the RLIN3 interface in LIN slave mode. The sample code runs on the QB-R5F10PPJ-TB, which is a target board for the RL78F13,F14 microcontroller family including a LIN transceiver. In slave mode, the RLIN3 waits for reception of header frame from the master. Upon detection of the header frame, the slave checks ID and response with a transmission or reception according to ID. A proper communication will be indicated by LED1 and LED2 mounted on the target boards.

3.1 Operation overview

Settings:

- Use channel of the RLIN3 to perform LIN communication in slave mode.
- Use the P1.3/LTXD0 pin for the transmit data output.
- Use the P1.4/LRXD0 pin for the receive data input.
- Set the auto baud rate for slave mode, RLIN3 can automatically measure synch field and setting baud rate by itself .
- Use the INTLIN0RVC interrupt; The INTLIN0RVC interrupt is generated after a LIN successful header reception or response reception.
- Use the INTLIN0TRM interrupt; The INTLIN0TRM interrupt is generated after a LIN successful response transmission.
- Use the INTLIN0 interrupt; The INTLIN0 interrupt is generated when an Error on the bus was detected. A complete error handling is not implemented.
- Communication direction and number of transmit/receive date at a response field are determined by the ID data received at the ID field.
- ID data store in the ID buffer register LIDB0.
- Auto store data received at the field to data buffer register LDB01-LDB08, then get data from ID Buffer and store to Slave_RxData1[ ], Slave_RxData2[ ], Slave_RxData3[ ]according to ID and clear the Data buffer.
- Set Slave_TxData[ ] to data buffer LDB01-LDB08 and setting RTS bit to start transmission.

3.2 Functions and Resource Consumption

Function Name	Outline	Code size (bytes)
RLIN_Slave_Init	Initial setting	91
RLIN_Slave_HeaderReceive	Header receive preparation	11
RLIN_Slave_Transmit	Data transmission preparation	57
RLIN_Slave_Receive	Data reception preparation	22
RLIN_Slave_NoResponse	No response to LIN bus	5
Clear_DataBuffer	Setting all data buffer to 0	26
Get_response_RxData	Store data to variables array from Data buffer	41

Table 3.1 lists the Functions

3.3 Function Specifications

The following tables list the sample code function specifications

RLIN_Slave_Init	
Outline	Initial setting of RLIN3's registers in slave mode
Header	None
Declaration	void RLIN_Slave_Init(void)
Description	Setting of channe1, clock, baud rate, interrupts, header format.
Arguments	None
Returned value	None

Table 3.2 RLIN_Slave_Init

RLIN_Slave_HeaderReceive	
Outline	Header receive preparation
Header	None
Declaration	void RLIN_Slave_headerReceive(void)
Description	Set RLIN3 to slave mode, set header reception start
Arguments	None
Returned value	None

Table 3.3 RLIN_Slave_HeaderReceive

RLIN_Slave_Transmit		
Outline	Data transmission preparation	
Header	None	
Declaration	void RLIN_Slave_Transmit(uint8_t * databuf, uint8_t data_length)	
Description	Setting data buffer and response transmission start	
Arguments	uint8_t * databuf	Transmit data
	uint8_t data_length	Transmission data length
Returned value	None	

Table 3.4 RLIN_Slave_Transmit

RLIN_Slave_Receive		
Outline	Data reception preparation	
Header	None	
Declaration	void RLIN_Slave_Receive(uint8_t data_length)	
Description	Clear data buffer, setting reception format, response reception start	
Arguments	uint8_t data_length	Receive data length
Returned value	None	

Table 3.5 RLIN_Slave_Receive

RLIN_NoResponse	
Outline	No response to LIN bus
Header	None
Declaration	void RLIN_Slave_NoResponse(void)
Description	Slave node does not response anything when ID invalid
Arguments	None
Returned value	None

Table 3.6 RLIN_NoResponse

Clear_DataBuffer	
Outline	Clear all data buffer to 0
Header	None
Declaration	void Clear_DataBuffer(void)
Description	Clear the complete data buffer
Arguments	None
Returned value	None

Table 3.7 Clear_DataBuffer

Get_response_RxData		
Outline	Store data to variable array from ID buffer	
Header	None	
Declaration	uint8_t Get_response_RxData(uint8_t * RxData)	
Description	Get reception data to variable array	
Arguments	uint8_t * RxData	Data variable array
Returned value	RxData[1]	

Table 3.8 Get_response_RxData

3.4 Flowcharts

3.4.1 Main flowchart

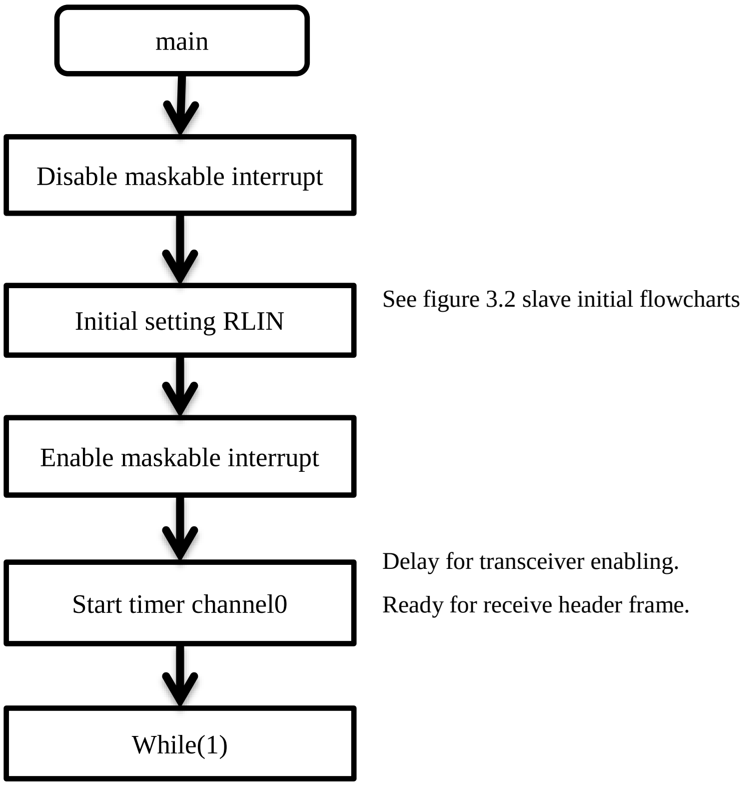
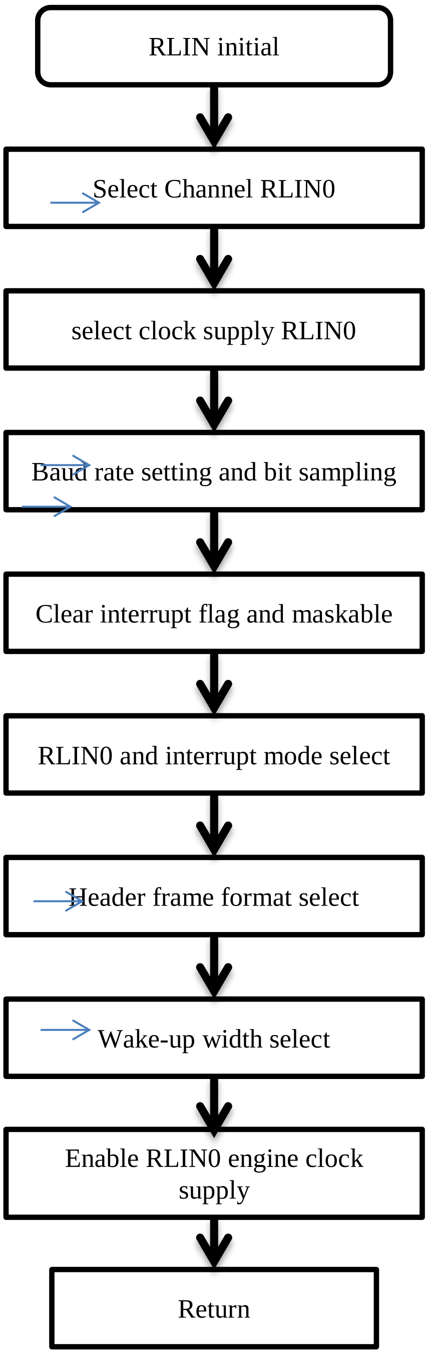


Figure 3.1 show the main processing

3.4.2 Initial RLIN flowchart



0x00 LCHSEL selects RLIN0

Enable clock by PER2

Select Fclk=32MHz to RLIN0

0x34 LWBR0, prescaler clock to 8MHz, 4 bit sampling.

1 0 LMD[1:0] LIN slave mode (auto baud rate)

LIOS=1; Transmission interrupt, successful reception interrupt, and reception status interrupt are used.

BLT=0, reception break of 9.5/10 or more Tbit is detected.

0x24 LSC0, setting 4Tbit for response space , 1Tbit for inter-Byte space

0x30 LWUP0,wake up transmission low width is 4Tbit

LIN0MCKE=1, enable LIN engine clock supply.

Figure 3.2 show the RLIN initial processing

3.4.3 Slave transmit flowchart

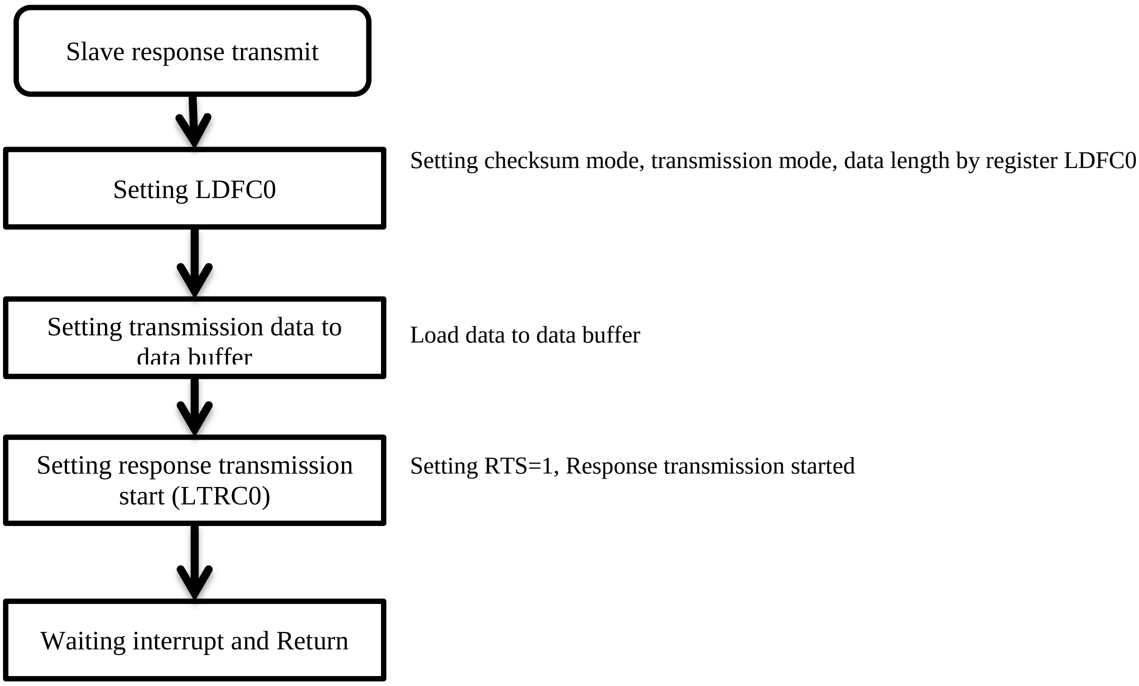


Figure 3.3 show the slave transmit processing

3.4.4 Slave receive flowchart

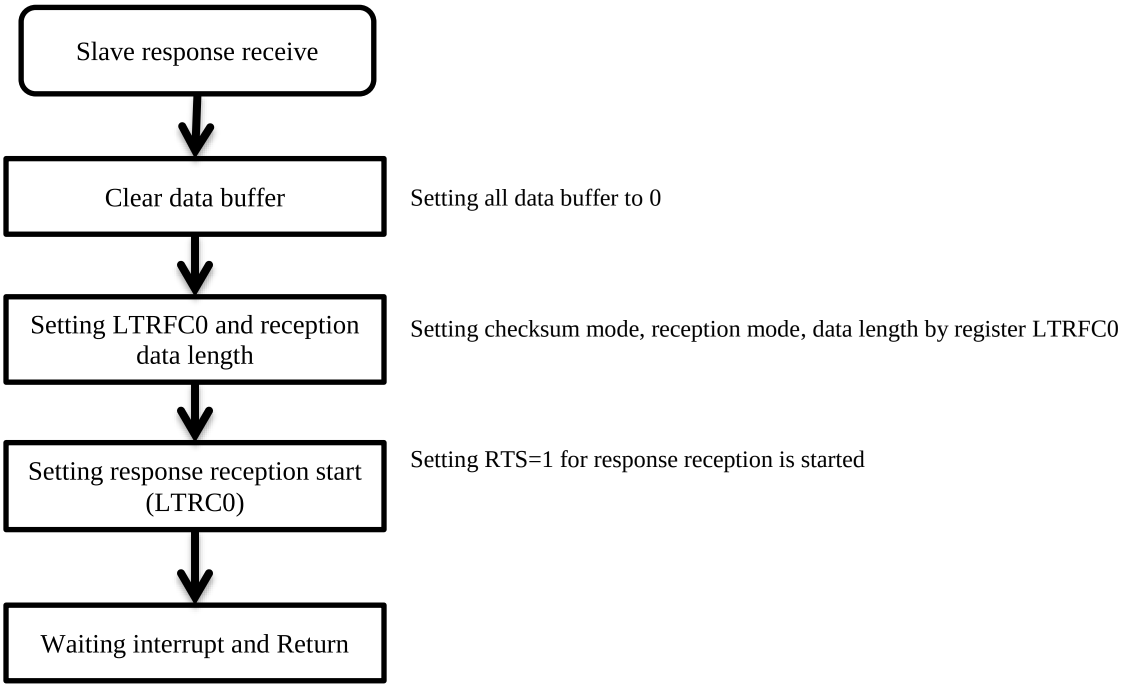


Figure 3.4 show the slave receive processing

3.4.5 Slave interrupt flowchart

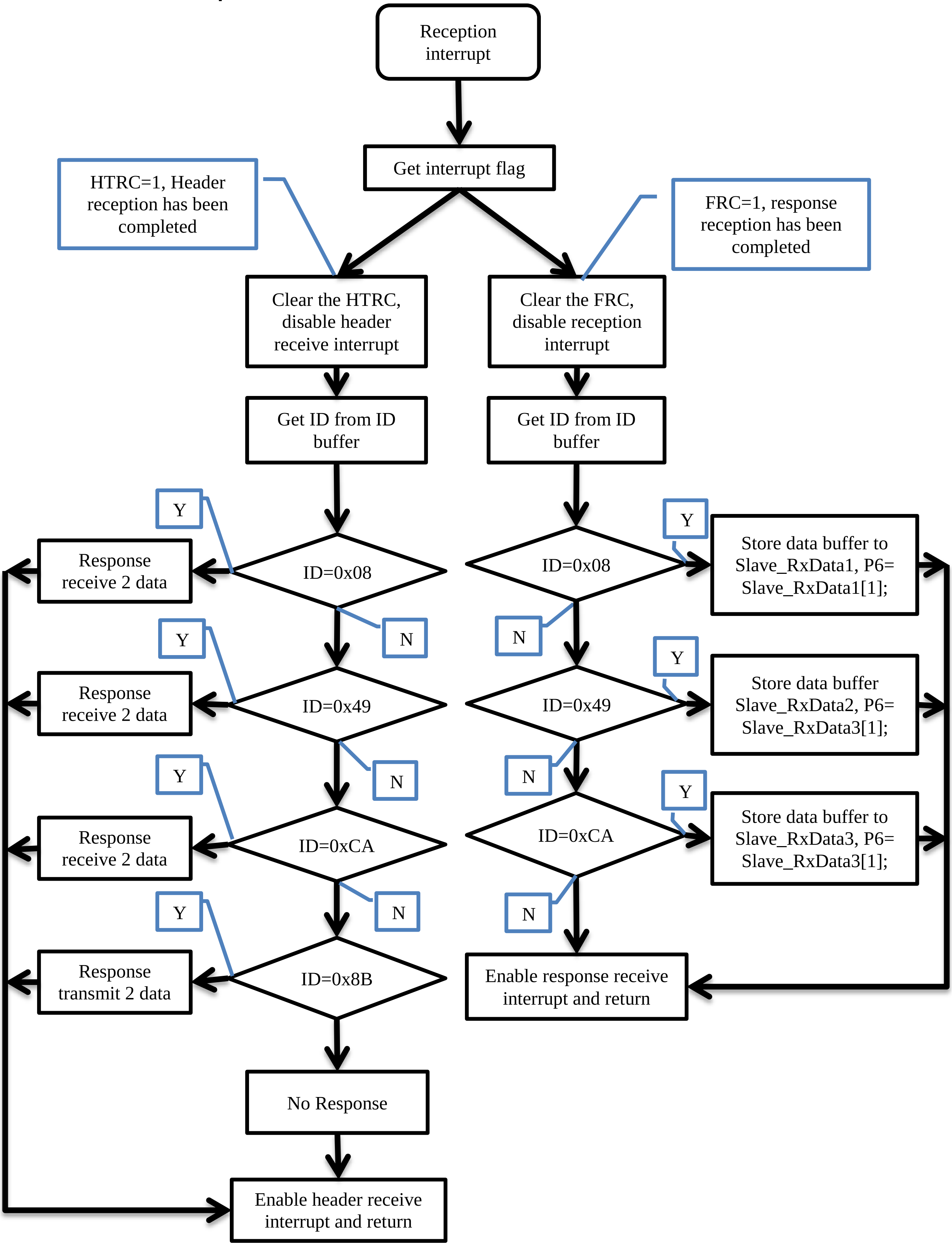


Figure 3.5 show the reception interrupt processing

4. Demo system

The below pictures shows the demo system consists out of two RL78 F14 target boards. One board is runningn in master mode and the second one in slave mode. The software from the slave mode is part of this application note, where the master mode is described in a separate document. Both boards are connected via the LIN interface. The slave is indicating proper data communication via the two LEDs mounted on the target boards

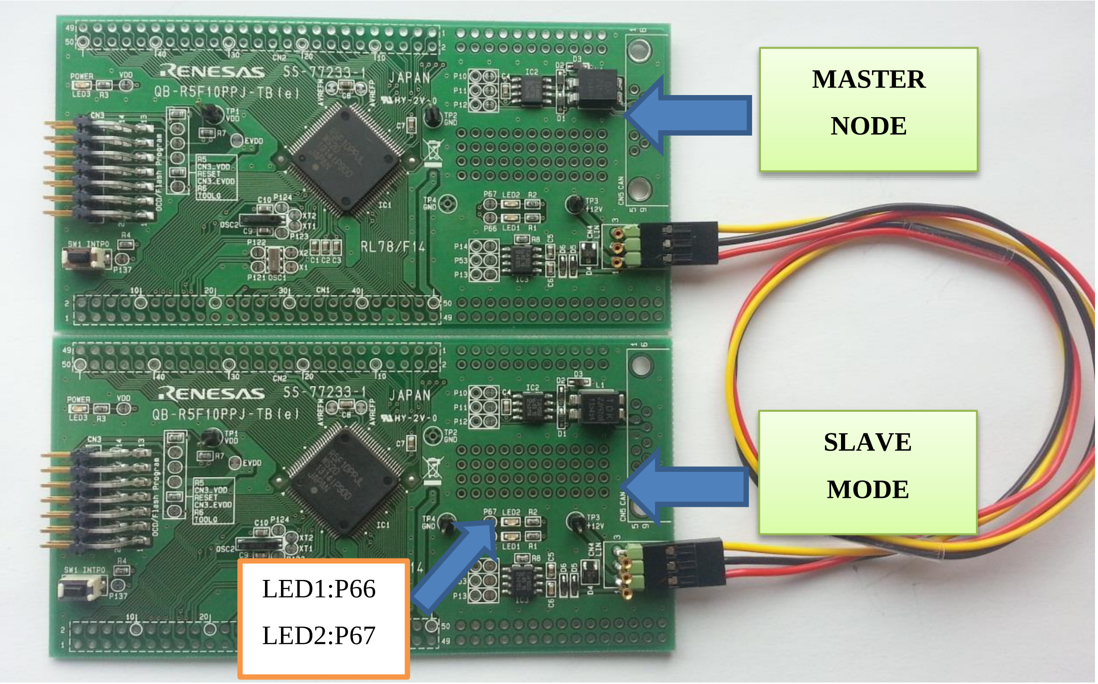


Figure 4.1 Picture of the demo system

In the below state diagram of the slave you will find the different internal states of the slave demo with the corresponding LED

Slave Demo :

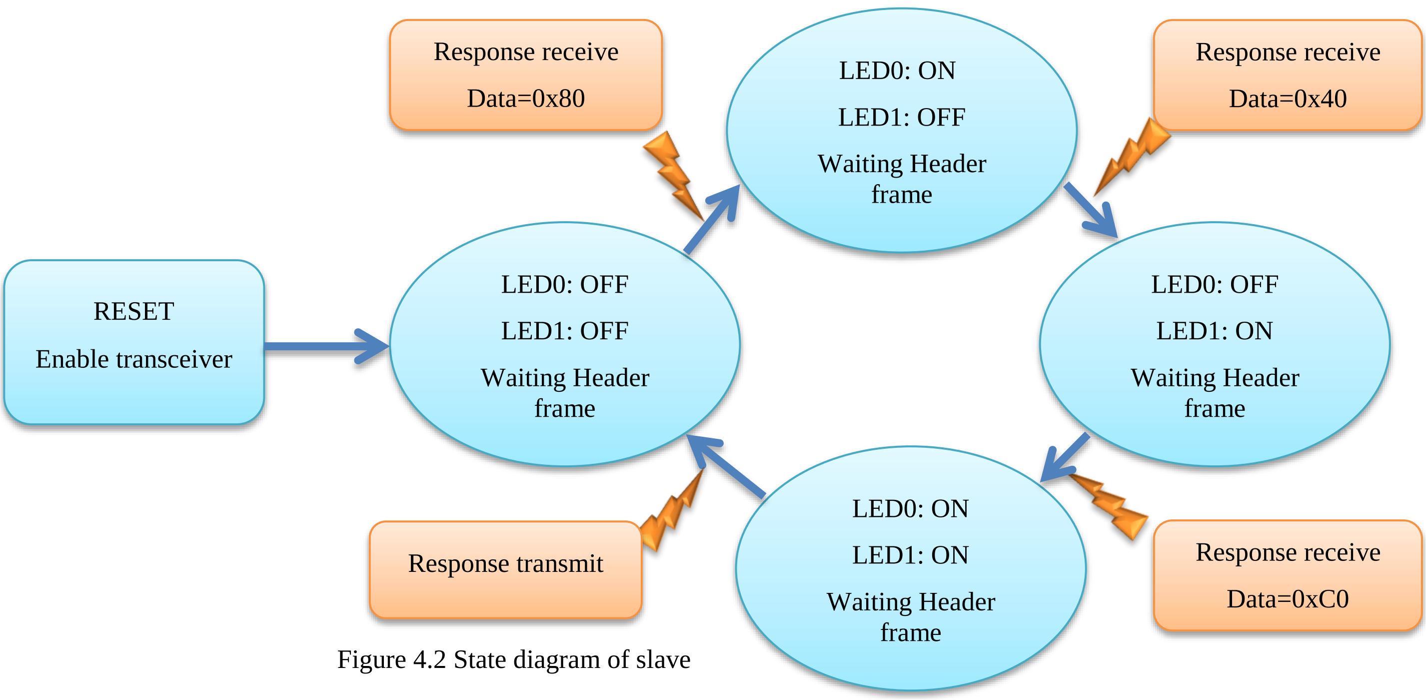


Figure 4.2 State diagram of slave

5. Sample code

5.1 RLIN_driver.c

```
/*******************************************************************************************
* File Name    : RLIN_driver.c
* Device(s)    : R5F10PPJ
* Tool-Chain   : IAR Systems iccrl78
* Description  : This file implements device driver for PORT module.
* Creation Date: 15.07.2013
*******************************************************************************************/

/*******************************************************************************************
Includes
*******************************************************************************************/
#include "RLIN_macrodriver.h"
#include "RLIN_driver.h"
#include "RLIN_userdefine.h"
/*******************************************************************************************
* Function Name: RLIN_Slave_Init(void)
* Description  : This function initializes the RLIN Slave node, setting clock supply,baud rate,ect.
* Arguments    : None
* Return Value : None
*******************************************************************************************/

void RLIN_Slave_Init(void)
{

  LCHSEL = 0x00;      /*  Selects RLIN0 */
  PER2  |= 0x04;      /*  Enable input clock supply RLIN0*/
  LINCKSEL=0x00;      /*  selects the  fclk=32MHz  clock to RLIN0.*/
  LWBR0 =  0x34;      /*  b3-b1=010: Prescaler Clock Selcet 32/4, bit sampling count select b7-b4=0011 : 4 sampling.
*/
  LBRP00 = 0x67;      /*  lower 8bit : 0X67=103D, Baud rate= 32M/ (103+1)*16= 19230 bps*/
  LBRP01 = 0x00;      /*  upper 8 bits in the 16bit counter of the baud rate prescaler*/

  LIN0RVCIF = 0U;      /*  Clear interrupt request signal */
  LIN0TRMIF = 0U;      /*  Clear interrupt request signal */
  LIN0WUPIF = 0U;      /*  Clear interrupt request signal */
  LIN0RVCMK = 0U;      /*  interrupt servicing enable */
  LIN0TRMMK = 0U;      /*  interrupt servicing enable */
```

```
  LIN0WUPMK = 0U;      /*  interrupt servicing enable */
  LIE0  |=  0x0F;      /*  Enable successful response/wake-up reception interrupt, enable all interrupt*/
  LEDE0 |=  0xC9;      /*  Enable error detection */

  /*Header format setting*/
  LMD0  =  0x12;       /*  b1b0=10; LIN Slave mode (Auto baud rate),transmission interrupt,sucessful reception
interrupt..., The noise filter is enable.*/
  LBFC0 =  0x00;       /*  Reception break of 9.5/10 or more Tbits*/
  LSC0  =  0x24;       /*  Response space 4bit; inter-byte space 1bit;*/
  LWUP0 =  0x30;       /*  Wake-up Transmission low width 4 bits.*/
  LIDB0&=  0x00;       /*  Clear the ID buffer */

  ISC   =  0x04;       /*  LRXD0 pin input signal is set as external interrupt input,*/
  LINCKSEL|=0x10;      /*  Enable RLIN0 engine clock supply,*/

}

/**********************************************************************************************
* Function Name: RLIN_Slave_HeaderReceive(void)
* Description  : This function is setting in slave mode, enable header reception is started.
* Arguments    : None
* Return Value : None
**********************************************************************************************/
void RLIN_Slave_HeaderReceive(void)
{
  LCUC0 = 0x03;        /* 01: RLIN rest mode is canceled; 03:RLIN operation mode  */
  LTRC0 |= 0x01;       /* FTS=1; Header reception or wake up transmission/reception is started.*/
}


/**********************************************************************************************
* Function Name: RLIN_Slave_Transmit(void)
* Description  : This function seting data buffer for response transmission start
* Arguments    : uint8_t* databuf    : variable array data.
               uint8_t Data_length : transmit data length.
* Return Value : None
**********************************************************************************************/

void RLIN_Slave_Transmit(uint8_t* databuf,uint8_t Data_length)
{
```

```
  uint8_t i;
  uint16_t  Databuf_adr;
  LDFC0=0x30;                    /*b5=1:enhanced checksum mode; b4=1:transmission*/
  LDFC0|=Data_length;            /* b4-b0=Data_length: response data lengh select byte*/
  Databuf_adr=RLIN_DateBuffer;   /* get the data buffer address*/
  for(i=0;i<Data_length;i++)            /* setting tansmission data to date buffer*/
  {
    *((uint8_t *)(Databuf_adr+i))=databuf[i];
  }
  LTRC0=0x02;                    /*setting RTS=1;Response transmission start*/
}

/*******************************************************************************************
* Function Name: RLIN_Slave_Receive(void)
* Description  : This function clear data buffer for response reception start
* Arguments    : uint8_t Data_length : receive data length.
* Return Value : None
*******************************************************************************************/

void RLIN_Slave_Receive(uint8_t Data_length)
{
    Clear_DataBuffer();
    LDFC0=0x20;                  /*b5=1:enhanced checksum mode; b4=0:Reception*/
    LDFC0|=Data_length;          /* b4-b0=Data_length: response data lengh select byte*/
    LTRC0=0x02;                  /*setting RTS=1,response reception is started*/
}
void RLIN_Slave_NoResponse(void)
{
  LTRC0=0x04;                    /* setting LNRR=0, No response request*/
}

/*******************************************************************************************
* Function Name: Clear_DataBuffer
* Description  : This function setting all data buffer to some value
* Arguments    : uint8_t x : setting data buff value
* Return Value : None
******************************************************************************************/
```

```
void Clear_DataBuffer()
{
  uint8_t i;
  uint16_t Databuf_adr;
  Databuf_adr=RLIN_DateBuffer;
  for(i=0;i<8;i++)
  {
   *((uint8_t *)(Databuf_adr+i))=0U;
  }

}

/*********************************************************************************************
* Function Name: Get_reponse_RxData
* Description  : This function get data buffer value to a variable array
* Arguments    : uint8_t * RxData : a avriable array for store Data
* Return Value : RxData[1]
*********************************************************************************************/
uint_8  Get_reponse_RxData(uint8_t * RxData)
{
  uint8_t i,k;
  uint16_t Databuf_adr;
  k=LDFC0&0x0F;
  Databuf_adr=RLIN_DateBuffer;
  for(i=0;i<k;i++)
  {
    RxData[i]=(*((uint8_t *)(Databuf_adr+i)));
  }
Return RxData[1];
}
```

5.2 RIN_driver_user.c

```
/***********************************************************************************************
* File Name    : RLIN_driver_user.c
* Device(s)    : R5F10PPJ
* Tool-Chain   : IAR Systems iccrl78
* Description  : This file implements device driver for Interrupt module.
* Creation Date: 02.08.2013
***********************************************************************************************/
#include "RLIN_macrodriver.h"
#include "RLIN_driver.h"
#include "RLIN_userdefine.h"
uint8_t GetIDbuffer;
uint8_t Slave_RxData1[8];          /*reception data store array*/
uint8_t Slave_RxData2[8];          /*reception data store array*/
uint8_t Slave_RxData3[8];          /*reception data store array*/
uint8_t Slave_TxData[]={0x55,0xC0};  /*Transmission data store array*/
/***********************************************************************************************
* Function Name: RLIN0_Transmission_interrupt
* Description  : This function is RLIN0 Transmission interrupt service routine.
* Arguments    : None
* Return Value : None
***********************************************************************************************/
#pragma vector = INTLIN0TRM_vect
__interrupt static void RLIN0_Transmission_interrupt(void)
{
    LST0&=0xFE;
}
/***********************************************************************************************
* Function Name: RLIN0_Reception_interrupt
* Description  : This function is RLIN0 Reception interrupt service routine.
* Arguments    : None
* Return Value : None
***********************************************************************************************/
#pragma vector = INTLIN0RVC_vect
__interrupt static void RLIN0_Reception_interrupt(void)
{
  uint8_t receive_header_flag;
  uint8_t receive_reponse_flag;
  receive_header_flag=LST0 & 0x80;        /* get header reception flag */
```

```
  receive_reponse_flag=LST0 & 0X02;        /* get response rception flag*/

GetIDbuffer=LIDB0;
if(receive_header_flag)  /* Header successful receive*/
{
  LST0&=0X7F;    /*clear successful header reception flag*/

switch(GetIDbuffer)
{
   case 0x08: RLIN_Slave_Receive(2);
          break;
  case 0x49: RLIN_Slave_Receive(2);
          break;
  case 0xCA: RLIN_Slave_Receive(2);
          break;
  case 0x8B: RLIN_Slave_Transmit(Slave_TxData,2);
            P6=Slave_TxData[1];
          break;
 default:   RLIN_Slave_NoResponse();
          break;
}
}

if(receive_reponse_flag)
{
  LST0 &= 0xFD;      /* clear response reception successful flag*/

  switch(GetIDbuffer)
{
  case 0x08: P6 = Get_reponse_RxData(Slave_RxData1);
            break;
  case 0x49: P6  =  Get_reponse_RxData(Slave_RxData2);
            break;
  case 0xCA: P6 = Get_reponse_RxData(Slave_RxData3);
            break;
default: break;
}

}
LTRC0=0x01;    /*enabled header reception interrupt*/
```

```
}
/**************************************************************************************************
* Function Name: RLIN0_Status_interrupt
* Description  : This function is RLIN0 Status interrupt service routine.
* Arguments    : None
* Return Value : None
**************************************************************************************************/

#pragma vector = INTLIN0_vect
__interrupt static void RLIN0_Status_interrupt(void)
{
while(1U)
{  ;
}
}
/**************************************************************************************************
* Function Name: RLIN0_Wakeup_interrupt
* Description  : This function is RLIN0 Wakeup interrupt service routine.
* Arguments    : None
* Return Value : None
**************************************************************************************************/
#pragma vector = INTLIN0WUP_vect
__interrupt static void RLIN0_Wakeup_interrupt(void)
{
 LCUC0=0x03;
 LED1=ON;
 LED2=ON;
}
```

5.3 RLIN _driver.h

```
/**************************************************************************************************
* File Name    : RLIN_Driver.h
* Device(s)    : R5F10PPJ
```

```
* Tool-Chain   : IAR Systems iccrl78
* Description  : This file implements device driver for PORT module.
* Creation Date: 15.07.2013
***********************************************************************************************/

#include "RLIN_userdefine.h"

void Clear_DataBuffer(void);
uint_8  Get_reponse_RxData(uint8_t * RxData);
void RLIN_Slave_Init(void);      /* init Slave RLIN0*/
void RLIN_Slave_HeaderReceive(void);
void RLIN_Slave_Transmit(uint8_t* databuf,uint8_t Data_length);
void RLIN_Slave_Receive(uint8_t Data_length);
void RLIN_Slave_NoResponse(void);
```

5.4 RLIN_main.c

```
/***********************************************************************************************
* File Name    : RLIN_main.c
* Version      : Applilet3 for RL78/F14 V1.00.00.02 [10 Sep 2012]
* Device(s)    : R5F10PPJ
* Tool-Chain   : IAR Systems iccrl78
* Description  : This file implements main function.
* Creation Date: 02.08.2013
***********************************************************************************************/

/***********************************************************************************************
Includes
***********************************************************************************************/
#include "RLIN_macrodriver.h"
#include "RLIN_cgc.h"
#include "RLIN_port.h"
#include "RLIN_timer.h"
#include "RLIN_wdt.h"
#include "RLIN_driver.h"
#include "RLIN_userdefine.h"

/***********************************************************************************************
Global variables and functions
```

```
***********************************************************************************************/
/* Set option bytes */
#pragma location = "OPTBYTE"
__root const uint8_t opbyte0 = 0x7AU;
#pragma location = "OPTBYTE"
__root const uint8_t opbyte1 = 0xFFU;
#pragma location = "OPTBYTE"
__root const uint8_t opbyte2 = 0xE8U;
#pragma location = "OPTBYTE"
__root const uint8_t opbyte3 = 0x84U;

/* Set security ID */
#pragma location = "SECUID"
__root const uint8_t secuid[10] =
    {0x00U, 0x00U, 0x00U, 0x00U, 0x00U, 0x00U, 0x00U, 0x00U, 0x00U, 0x00U};

/* Secure trace RAM area */
__no_init __root unsigned char ocdtraceram[512] @ 0xFE300U;

/* Secure hot plug-in RAM area */
__no_init __root unsigned char hotpluginram[48] @ 0xFE500U;

void R_MAIN_UserInit(void);

/***********************************************************************************************
* Function Name: main
* Description  : This function implements main function.
* Arguments    : None
* Return Value : None
***********************************************************************************************/
void main(void)
{
    R_MAIN_UserInit();
    RLIN_Enable=TRUE;
    LED1=OFF;
    LED2=OFF;
    R_TAU0_Channel0_Start();  /*Delay times for transiver wake up */
      while (1U)
     {
      R_WDT_Restart();
```

```
    }
}
/***********************************************************************************************
* Function Name: R_MAIN_UserInit
* Description  : This function adds user code before implementing main function.
* Arguments    : None
* Return Value : None
***********************************************************************************************/
void R_MAIN_UserInit(void)
{
   RLIN_Slave_Init();
  EI();
}
```

Website and Support

Renesas Electronics Website
http://www.renesas.com/

Inquiries
http://www.renesas.com/contact/

Revision History of RL78/F13, F14 Group, LIN Slave Mode (RLIN3)

Rev.	Date	Description	
		Page	Summary
1.00	25.Sep.2013		First edition issued
1.01	29.May 2015		1st revision, source code changed on page 20 , control of LIE0 register removed.
1.02	24 Jan 2017		2nd revision setting of LWUP and ISC corrected

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 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 a product with a different type 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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