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April 1st, 2010
Renesas Electronics Corporation

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APPLICATION NOTE

R8C/10 Group

A Software control of I^{2}C-BUS using General-purpose Ports

1. Abstract

This application note describes a software control program of I^{2}C-BUS and its application example. This program can be also used for a control of EEPROM.

2. Introduction

A single master I^{2}C-BUS can be controlled by software using general-purpose ports.
The external pull-up resistances should be attached toP1$_2$(SDA) and P1$_3$(SCL).
Table 1 shows the functional performance of I^{2}C-BUS interface.

Table 1 Functional performance of single master I^{2}C-BUS interface

Item	Functional Performance
Communication mode	Master transmission (single master)
SCL Clock Frequency	100kHz approx.

Note 1 This is a value for a CPU clock operated at 16MHz when no interrupt is used.
When a CPU clock operates at other than 16MHz, some adjustment is necessary to set this value.

This program can also be used when operating other microcomputers within the M16C family, provided they have the same SFR (Special Function Registers) as the R8C/10 microcomputers. However, some functions may have been modified. Refer to the User's Manual for details. Use functions covered in this Application Note only after careful evaluation.

3. I^{2}C-BUS

3.1 START Condition / STOP Condition

(1) START Condition
Change SDA from high to low when SCL is high.
Later, change SCL to low.
(2) STOP Condition
Change SDA from low to high when SCL is high.
Later, change SCL to low.

Figure 1 shows a configuration of START condition generation timing, and Figure 2 shows a configuration of STOP condition generation timing.　A list of START condition / STOP condition generation timing is shown in Table 2 below.

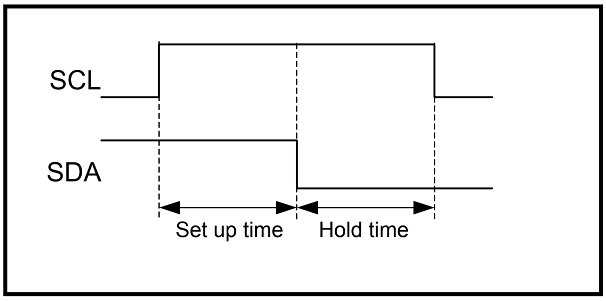


Figure 1　START condition generation timing

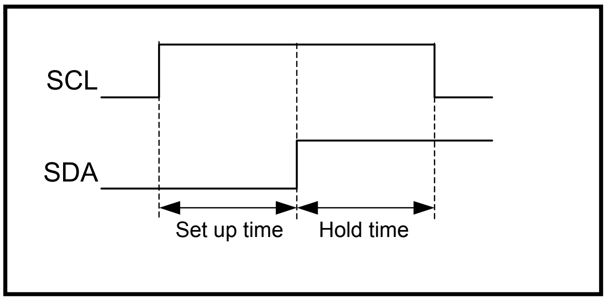


Figure 2　STOP condition generation timing

Table2　a list of START condition / STOP condition generation timing

Timing	START condition	STOP condition
Set up time	2.0μs approx.	1.6μs approx.
Hold time	3.0μs approx.	3.0μs approx.

Note 1　This is a value for a CPU clock operated at 16MHz when interrupt is not used
When a CPU clock operates at other than 16MHz, some adjustment is necessary to set this value.

3.2 Data Input / Output

(1) Data output
Data is output to SDA pin. After data setup time passes, a clock is output from SCL pin. ("L"→"H"→"L")
(2) Data input
Input data after driving SCL high, and then drive SCL low.

Figure 3 shows a configuration of data input/output timing , and Table 3 shows a list of data input/output timing.

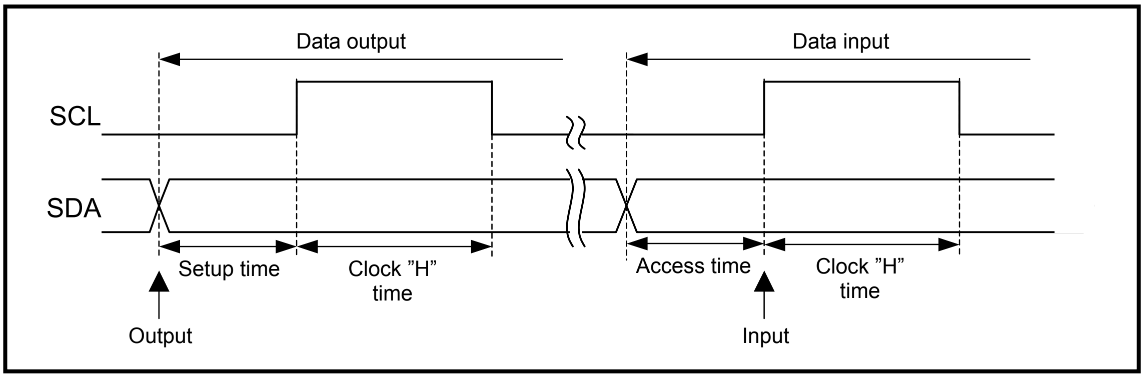


Figure 3 A configuration of data input /output timing

Table 3 A list of data input / output timing

Timing	Data output	Data input
Setup time	3.3µs approx.	-
Access time	-	Over 1µs approx.
Clock "H" time	3.0µs approx.	4.7µs approx.

Note 1 This is a value for a CPU clock operated at 16MHz when interrupt is not used
When a CPU clock operates at other than 16MHz, some adjustment is necessary to set this value.

3.3 Byte Format

1 byte consists of 8-bit-length data and 1-bit-length Acknowledge.

Acknowledge is a signal to indicate whether data is normally transferred or not. When Acknowledge indicates "L", data is normally transferred. When it is "H", data is not normally transferred.

When the master device transfers the data to the slave device, the master device releases SDA line (high-impedance) at the 9th transmit clock pulse and the slave device returns an acknowledge signal. When the master device receives the data from the slave device, the slave device releases SDA line (high-impedance) at the 9th transmit clock pulse and the master device returns an acknowledge signal.

Figure 4 shows a configuration of byte format.

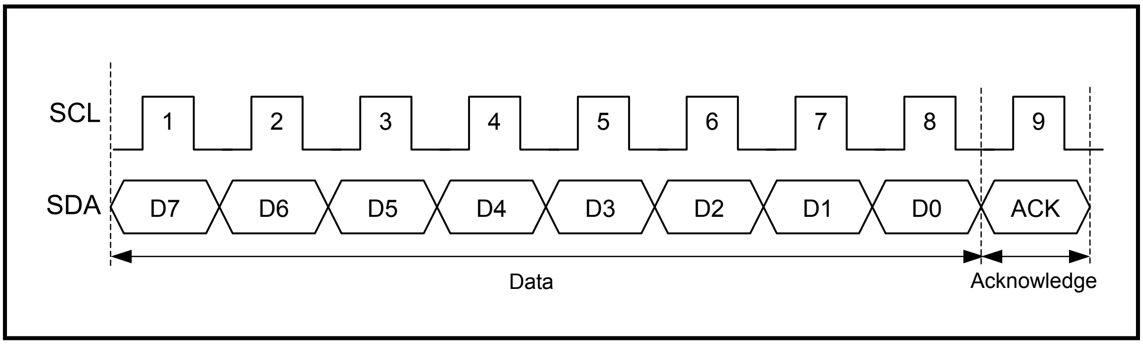


Figure 4 Byte Format

4. Application Example(a control of EEPROM)

Write / read the data to 2k-bit EEPROM(HN58X2402SI).

In 7 bit addressing mode, Device Address Code (A2,A1,A0)can be assigned by the lower 3 bit of Device Address Word.

Figure 5 shows an example of connection between a microcomputer and EEPROM(HN58X2402SI).

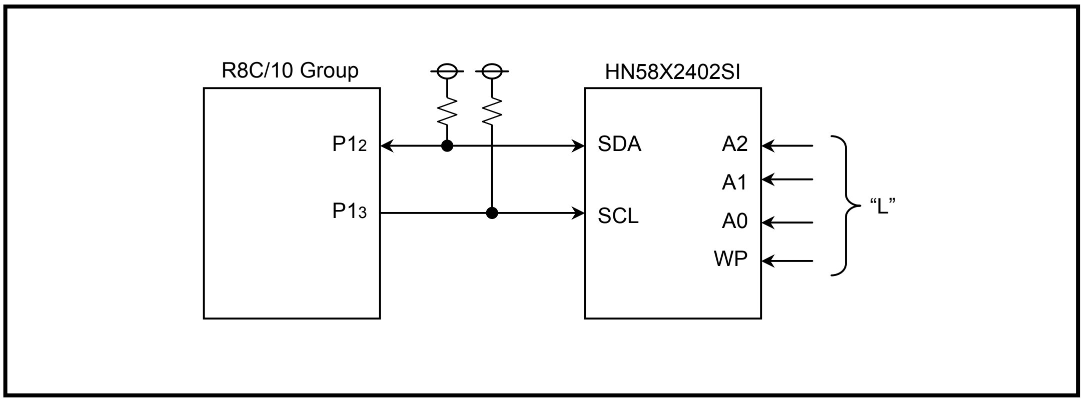
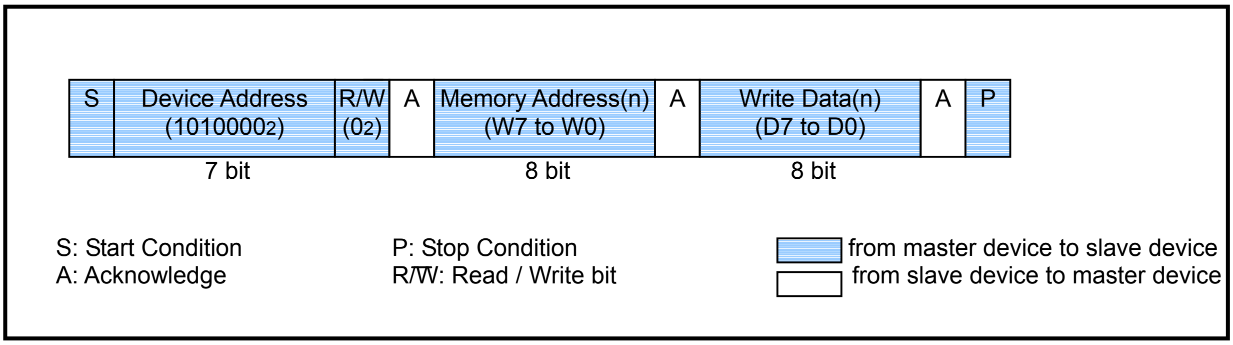


Figure 5 An example of connection

4.1 Byte Write

Write "Write Data" to an address (n) assigned to Memory Address(W7 to W0).
Confirm Acknowledge and generate Stop Condition after 8-bit Write Data is output.



S	Device Address (1010000_2)	R/W (0_2)	A	Memory Address(n) (W7 to W0)	A	Write Data(n) (D7 to D0)	A	P
	7 bit			8 bit		8 bit		

S: Start Condition
A: Acknowledge

P: Stop Condition
R/$\overline{W}$: Read / Write bit

▨ from master device to slave device
□ from slave device to master device

Figure 6 Byte Write

4.2 Page Write

Write multi-bytes (m+1) of “Write Data” to address assigned to Memory Address(W7 to W0).*
Confirm Acknowledge and generate Stop Condition after the assigned byte of “Write Data” is output.

*Page Write provides a sequential write of up to 8 byte-data.
Refer to EEPROM(HN58X2402SI) datasheet for details.

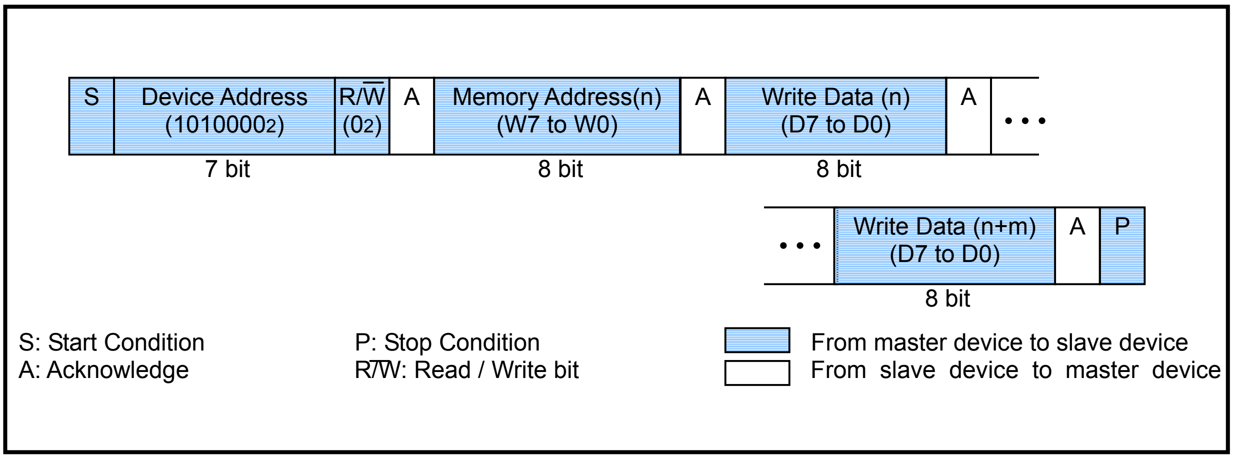

S
Device Address (10100002)
R/W̄ (02)
A
Memory Address(n) (W7 to W0)
A
Write Data (n) (D7 to D0)
A
• • •
7 bit
8 bit
8 bit
• • •
Write Data (n+m) (D7 to D0)
A
P
8 bit
S: Start Condition
A: Acknowledge
P: Stop Condition
R/W̄: Read / Write bit
From master device to slave device
From slave device to master device

Figure 7 Page Write

4.3 Sequential Read

Read “Read Data” from an address (n) assigned to Memory Address(W7 to W0).
Output Acknowledge “0” to read multi-byte (m+1) of Read Data after Read Data is input.
Output Acknowledge “1” and generate Stop Condition after the assigned byte of Read Data is input.

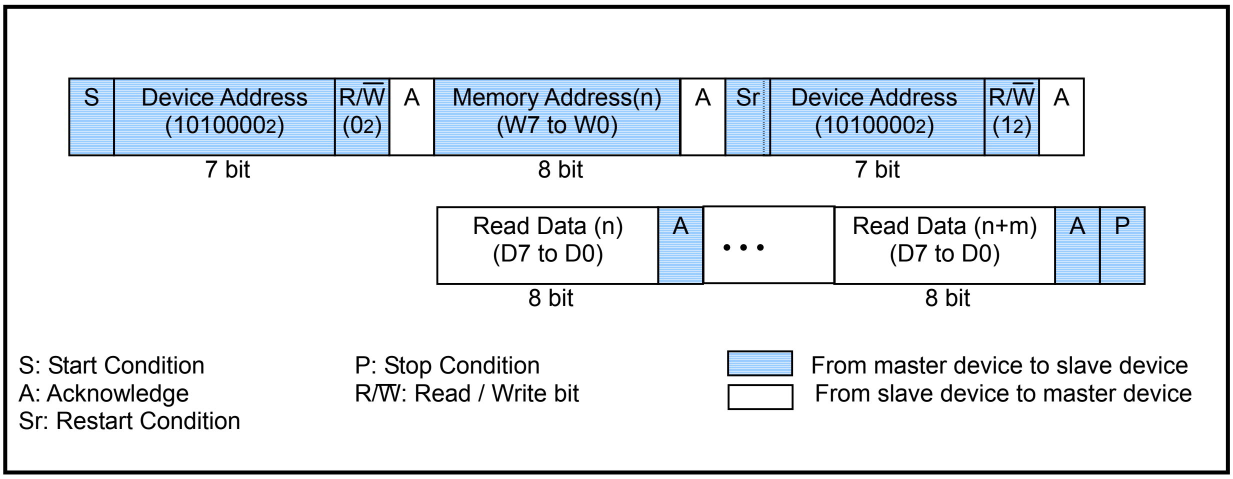
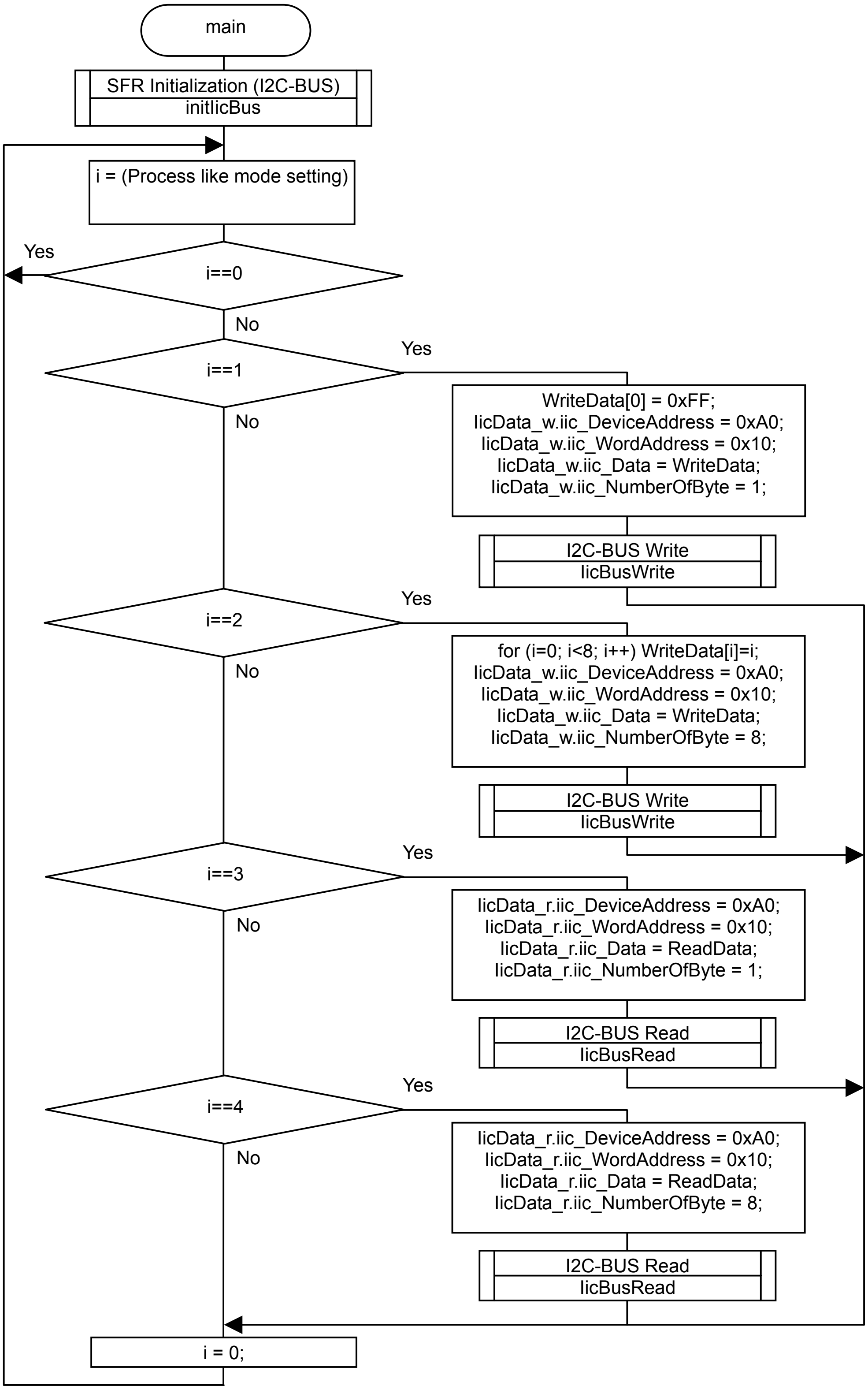


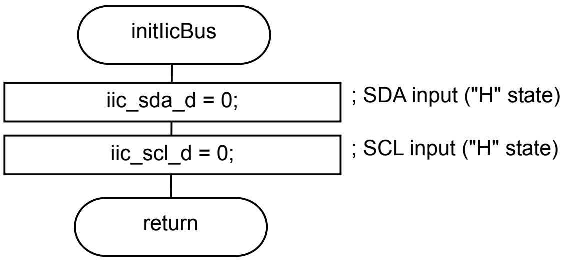
Figure 8 Sequential Read Cycle

5. Flowchart

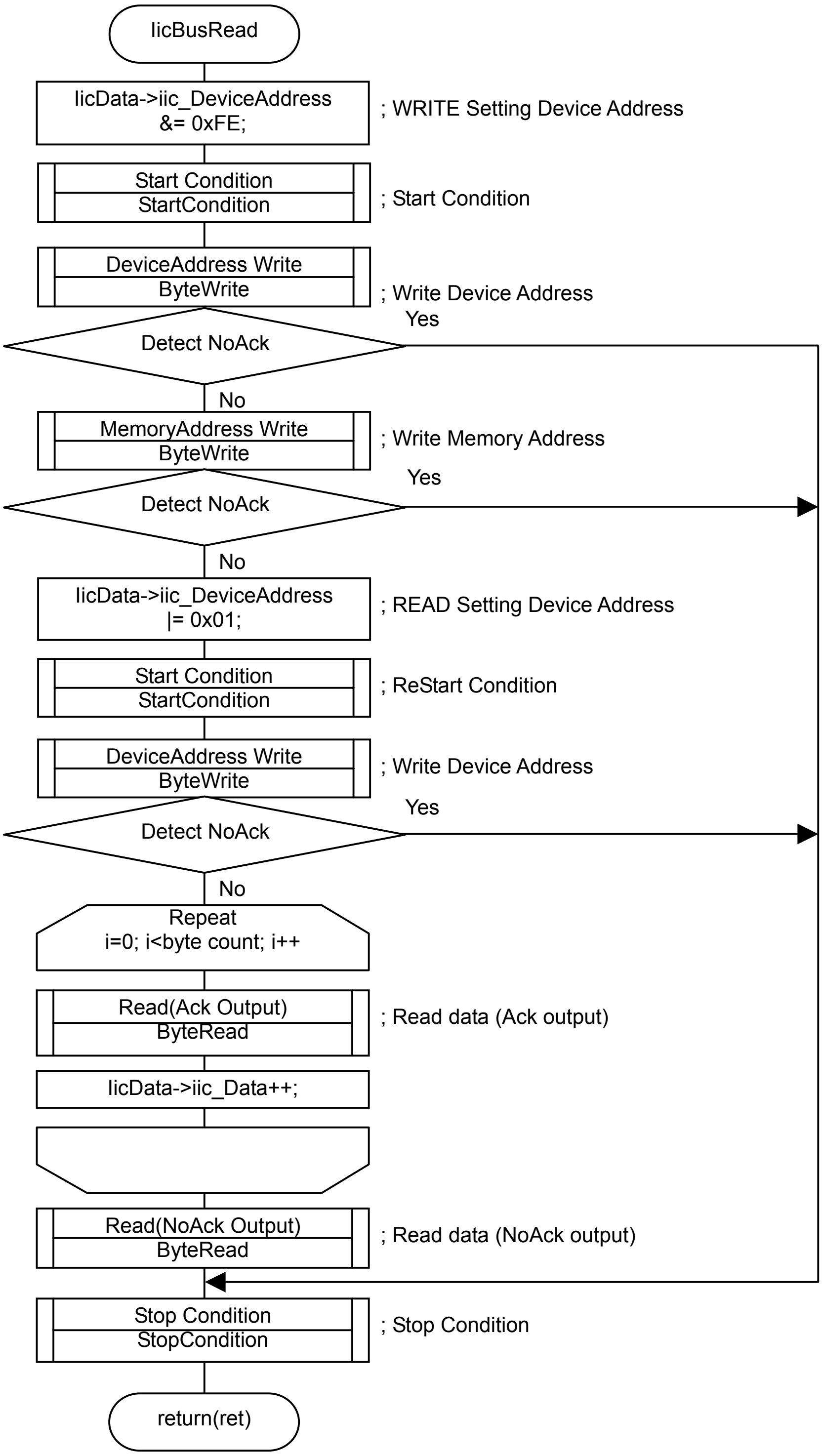
5.1 Initial Operation and Main loop


main
SFR Initialization (I2C-BUS)
initIicBus
i = (Process like mode setting)
i==0
Yes
No
i==1
Yes
No
WriteData[0] = 0xFF;
IicData_w.iic_DeviceAddress = 0xA0;
IicData_w.iic_WordAddress = 0x10;
IicData_w.iic_Data = WriteData;
IicData_w.iic_NumberOfByte = 1;
I2C-BUS Write
IicBusWrite
i==2
Yes
No
for (i=0; i<8; i++) WriteData[i]=i;
IicData_w.iic_DeviceAddress = 0xA0;
IicData_w.iic_WordAddress = 0x10;
IicData_w.iic_Data = WriteData;
IicData_w.iic_NumberOfByte = 8;
I2C-BUS Write
IicBusWrite
i==3
Yes
No
IicData_r.iic_DeviceAddress = 0xA0;
IicData_r.iic_WordAddress = 0x10;
IicData_r.iic_Data = ReadData;
IicData_r.iic_NumberOfByte = 1;
I2C-BUS Read
IicBusRead
i==4
Yes
No
IicData_r.iic_DeviceAddress = 0xA0;
IicData_r.iic_WordAddress = 0x10;
IicData_r.iic_Data = ReadData;
IicData_r.iic_NumberOfByte = 8;
I2C-BUS Read
IicBusRead
i = 0;

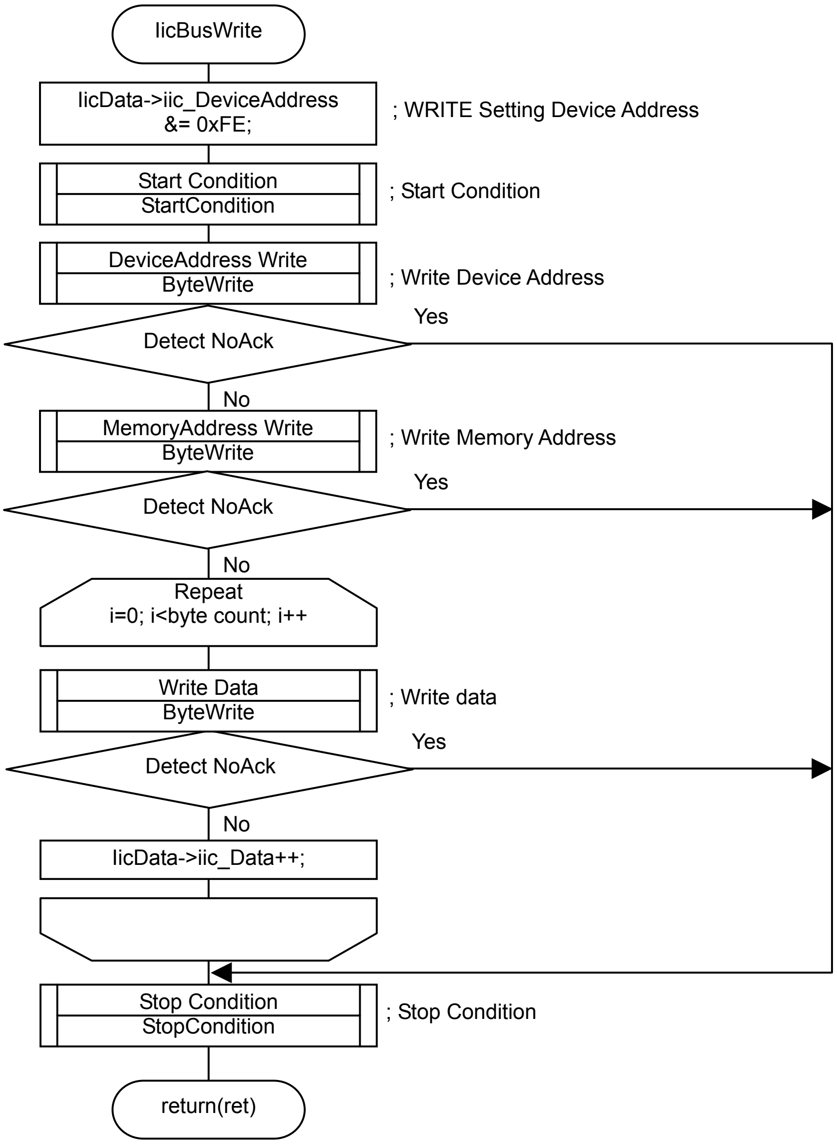
5.2 SFR Initial Setting(I^{2}C-BUS)



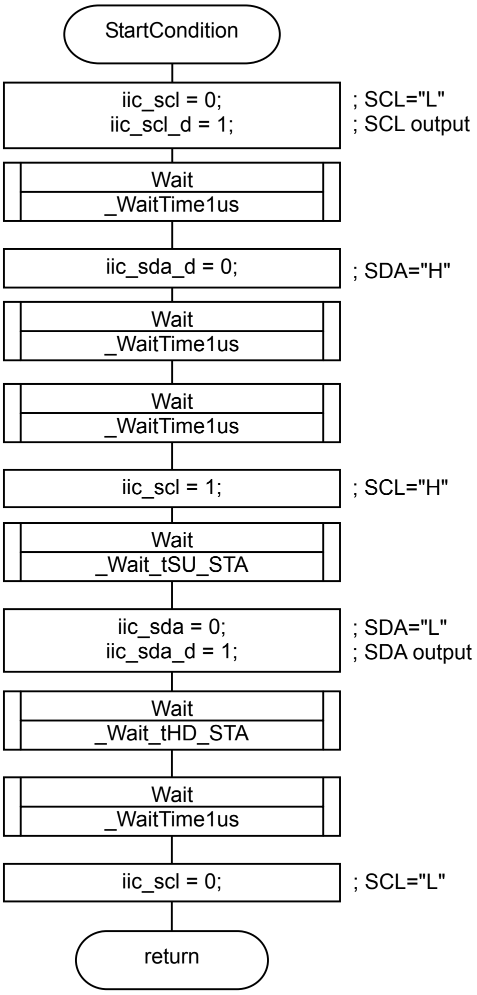
5.3 I^{2}C-BUS Read



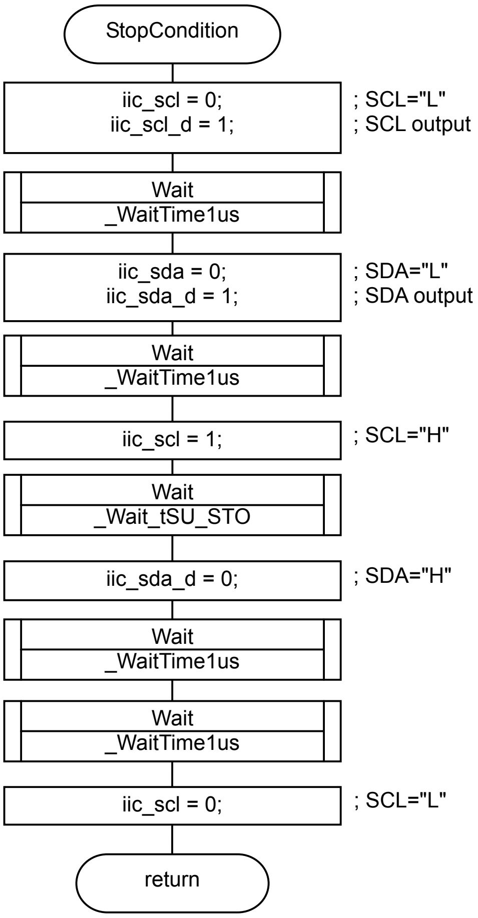
5.4 I^{2}C-BUS Write



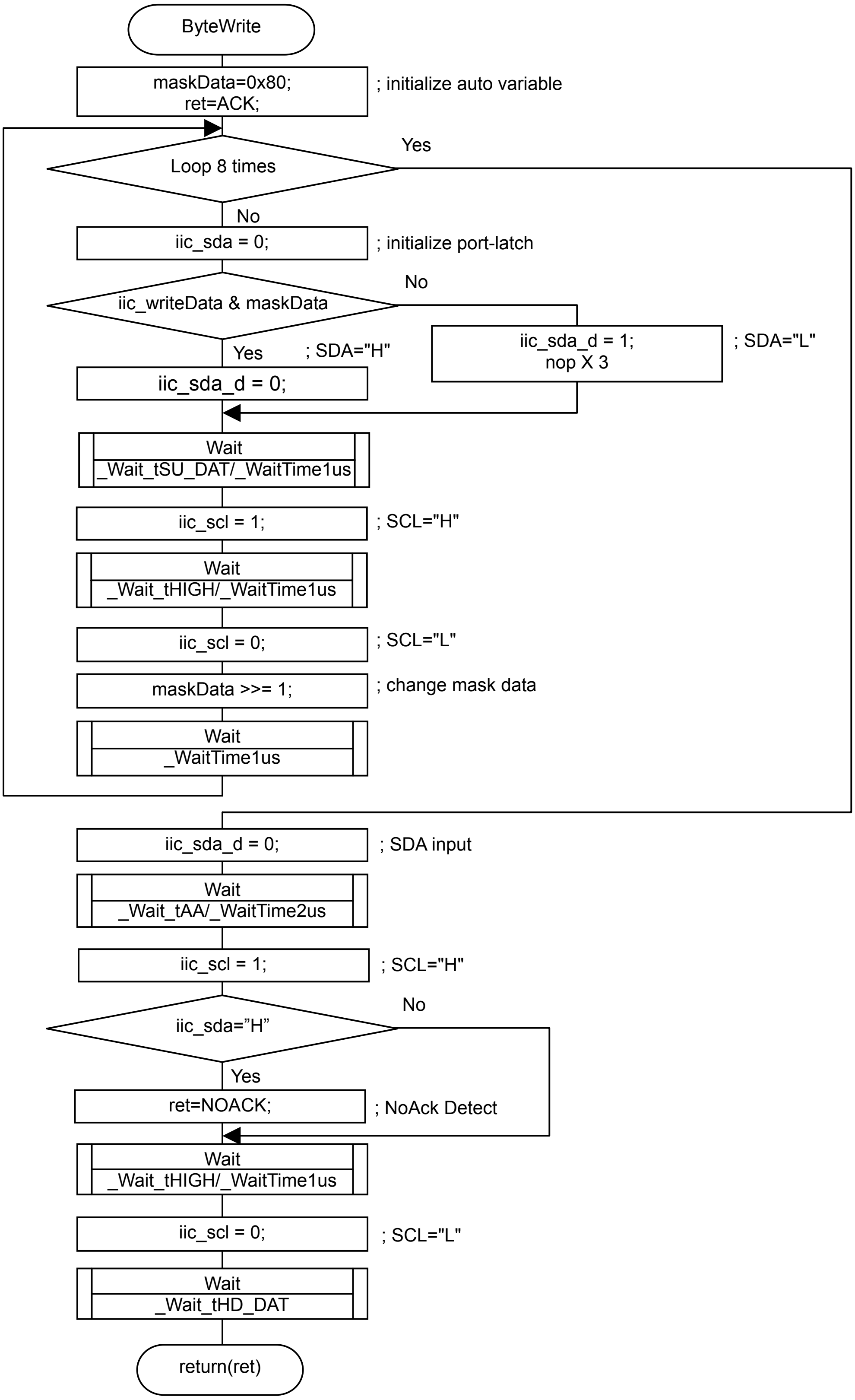
5.5 I^{2}C-BUS Start Condition



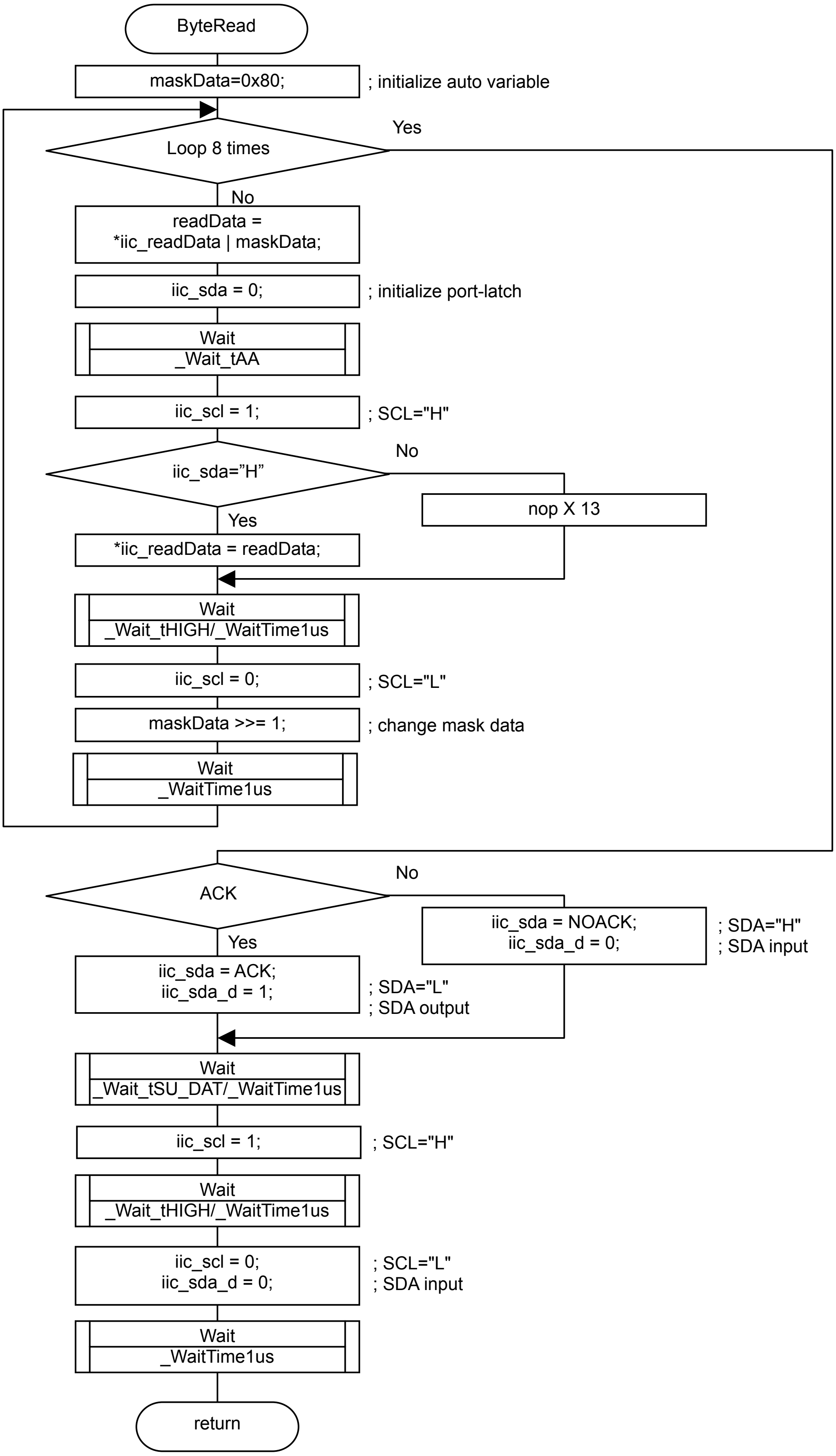
5.6 I^{2}C-BUS Stop Condition



5.7 I²C-BUS Byte Write



5.8 I^{2}C-BUS Byte Read



6. Program

```
/***************************************************************
 *                                                                          *
 *         File Name : main.c                                     *
 *         Contents  : main file                                  *
 *         Copyright : RENESAS TECHNOLOGY CORPORATION           *
 *                          AND RENESAS SOLUTIONS CORPORATION       *
 *         Version            : 1.0                                     *
 *         note               :                                         *
 *                                                                          *
***************************************************************/

#include "sfrr8c10.h"
#include "Iic_Bus.h"

void main (void)
{
    static unsigned char i=0;
    static unsigned char WriteData[8];
    static unsigned char ReadData[8];
    IicPack IicData_w;
    IicPack IicData_r;

    p1_4 = 1;                          /* test port */
    pd1_4 = 1;                         /* test port */
    p1_1 = 1;                          /* test port */
    pd1_1 = 1;                         /* test port */

    while(1){
        while(i==0) {
            i = mode();                                     /* Setting Access Mode */
        }
        p1_4 = 1;
        switch (i) {
        case 1:                                                      /* Write data 1Byte */
            WriteData[0] = 0xAA;                            /* Setting write data */
            IicData_w.iic_DeviceAddress = 0xA0;
            IicData_w.iic_MemoryAddress = 0x10;
            IicData_w.iic_Data = WriteData;
            IicData_w.iic_NumberOfByte = 1;
            p1_4 = 0;
            if (IicBusWrite(&IicData_w) == ACK) {
                p1_4 = 1;
            };
            break;
        case 3:                                                      /* Write data 8Bytes */
            for (i=0; i<8; i++) WriteData[i]=I*5;       /* Setting write data */
            IicData_w.iic_DeviceAddress = 0xA0;
            IicData_w.iic_MemoryAddress = 0x10;
            IicData_w.iic_Data = WriteData;
            IicData_w.iic_NumberOfByte = 8;
            p1_4 = 0;
}           if (IicBusWrite(&IicData_w) == ACK) {
                p1_4 = 1;
            };
            break;
        case 2:                                                     /* Read data 1Byte */
            IicData_r.iic_DeviceAddress = 0xA0;
            IicData_r.iic_MemoryAddress = 0x10;
            IicData_r.iic_Data = ReadData;
            IicData_r.iic_NumberOfByte = 1;
            p1_1 = 0;
            if(IicBusRead(&IicData_r) == ACK) {   /*   */
                p1_1 = 1;
            }
            break;
        case 4:                                                     /* Read data 8Bytes */
            IicData_r.iic_DeviceAddress = 0xA0;
            IicData_r.iic_MemoryAddress = 0x10;
            IicData_r.iic_Data = ReadData;
            IicData_r.iic_NumberOfByte = 8;
            p1_1 = 0;
            if(IicBusRead(&IicData_r) == ACK) {   /*   */
                p1_1 = 1;
            }
            break;
        default:
            asm("nop");
            break;
        }
        p1_4 = 0;
        p1_1 = 0;
        i = 0;
    }
}

void init(void)
{
    asm("fclr       i");
    prcr = 0x01;
    cm0 = 0x08;
    cm1 = 0x28;
    ocrd = 0x00;
    prcr = 0x00;
}

unsigned char mode(void)
{
    unsigned int loop;
    static unsigned char mode=0;

    for (loop=1; 0!=loop; loop++) {}                    /* about 82ms at 16MHz/1 */
    if (++mode > 4) mode=0;                             /* change mode */
    return(mode);
}
```

```
/****************************************************************
 *                                                                          *
 *          File Name : Iic_bus.h                            *
 *          Contents  : IIC Bus Definition file              *
 *          Copyright : RENESAS TECHNOLOGY CORPORATION          *
 *                               AND RENESAS SOLUTIONS CORPORATION     *
 *          Version              : 1.0                                     *
 *          note                 :                                         *
 *                                                                          *
****************************************************************/

#define ACK           0
#define NOACK         1

#define WRITE_MODE          0
#define READ_MODE           1

typedef unsigned char uchar;
typedef struct {
        unsigned char iic_DeviceAddress;
        unsigned char iic_MemoryAddress;
        unsigned char *iic_Data;
        unsigned char iic_NumberOfByte;
}IicPack;

void initIicBus(void);
unsigned char IicBusRead(IicPack *);
unsigned char IicBusWrite(IicPack *);
void StartCondition(void);
void StopCondition(void);
unsigned char ByteWrite(unsigned char);
void ByteRead (unsigned char *, unsigned char);
```

```
/**************************************************************
 *                                                                                  *
 *          File Name : Iic_bus.c                              *
 *          Contents  : IIC Bus file                                   *
 *          Copyright : RENESAS TECHNOLOGY CORPORATION          *
 *                                   AND RENESAS SOLUTIONS CORPORATION     *
 *          Version                 : 1.0                                            *
 *          note                    :                                                *
 *                                                                                  *
 **************************************************************/

#include "sfrr8c10.h"
#include "Iic_Bus.h"

#define iic_sda_d     pd1_2
#define iic_sda                  p1_2
#define iic_scl_d     pd1_3
#define iic_scl                  p1_3

void _WaitTime0us(void);
void _WaitTime1us(void);
void _WaitTime2us(void);

#define _Wait_tHIGH              _WaitTime1us()       /* Clock pulse width high */
#define _Wait_tLOW _WaitTime2us()       /* Clock pulse width low */
#define _Wait_tHD_STA          _WaitTime1us()       /* Start hold time */
#define _Wait_tSU_STA          _WaitTime1us()       /* Start setup time */
#define _Wait_tHD_DAT          _WaitTime0us()       /* Data in hold time */
#define _Wait_tSU_DAT          _WaitTime1us()       /* Data in setup time */
#define _Wait_tAA    _WaitTime1us()       /* Access time */
#define _Wait_tSU_STO          _WaitTime1us()       /* Stop setup time */
#define _Wait_tBUF  _WaitTime2us()       /* Bus free time for next mode */


/********************************************************
 Name                  : initIicBus
 Parameters          : None
 Returns  : None
 Description          : initialize I2C-BUS port
********************************************************/
void initIicBus(void)
{
      iic_sda_d = 0;                 /* SDA input ("H" state) */
      iic_scl_d = 0;                 /* SCL input ("H" state) */
}
```

```
/******************************************************
 Name                   : IicBusRead
 Parameters             : structure IicPack pointer
 Returns  : Acknowledge
 Description            : Sequential Ramdom Read Cycle (I2C-BUS)
******************************************************/
unsigned char IicBusRead(IicPack *IicData)
{
    unsigned char i,ret;

    /* Ramdom Read Cycle / Sequential Ramdom Read Cycle */
    IicData->iic_DeviceAddress &= 0xFE;            /* WRITE Setting DeviceAddress */
    StartCondition();                              /* Start Condition */
    while (1) {
        if ((ret=ByteWrite(IicData->iic_DeviceAddress)) == NOACK)
                                                           /* WRITE DeviceAddress */
            break;                                 /* NoAck Detect */
        if ((ret=ByteWrite(IicData->iic_MemoryAddress)) == NOACK)
                                                           /* WRITE MemoryAddress */
            break;                                 /* NoAck Detect */
        IicData->iic_DeviceAddress |= 0x01;        /* READ Setting DeviceAddress */
        StartCondition();                          /* ReStart Condition */
        if ((ret=ByteWrite(IicData->iic_DeviceAddress)) == NOACK)
                                                           /* DeviceAddress WRITE */
            break;                                 /* NoAck Detect */
        for (i=1; i<IicData->iic_NumberOfByte; i++) {   /* specified bytes as loop */
            ByteRead (IicData->iic_Data, ACK);     /* Read data (Ack output) */
            IicData->iic_Data++;                   /*    */
        }
        ByteRead (IicData->iic_Data, NOACK);       /* Read data (NoAck output) */
        break;
    }
    StopCondition();                               /* Stop Condition */
    return(ret);
}
```

```
/********************************************************
 Name                : IicBusWrite
 Parameters          : structure IicPack pointer
 Returns  : Acknowledge
 Description         : Byte Write or Page Write Cycle (I2C-BUS)
********************************************************/
unsigned char IicBusWrite(IicPack *IicData)
{
    unsigned char i,ret;

    /* Byte Write / Page Write */
    IicData->iic_DeviceAddress &= 0xFE;             /* WRITE Setting DeviceAddress */
    StartCondition();                                         /* Start Condition */
    while (1) {
        if ((ret=ByteWrite(IicData->iic_DeviceAddress)) == NOACK)
                                                                        /* WRITE DeviceAddress */
            break;                                            /* NoAck Detect */
        if ((ret=ByteWrite(IicData->iic_MemoryAddress)) == NOACK)
                                                                        /* WRITE MemoryAddress */
            break;                                            /* NoAck Detect */
        for (i=0; i<IicData->iic_NumberOfByte; i++) {         /* specified bytes as loop */
            if ((ret=ByteWrite(*(IicData->iic_Data))) == NOACK)         /* Write Data */
                break;                                                  /* NoAck Detect */
            IicData->iic_Data++;                              /*    */
        }
        break;
    }
    StopCondition();                                          /* Stop Condition */
    return(ret);
}
```

```
/*********************************************************
 Name                 : StartCondition
 Parameters           : None
 Returns  : None
 Description          : Output Start Condition (I2C-BUS)
 Note                 : *1 adjust a wait time
*********************************************************/
void StartCondition(void)
{
     iic_scl = 0;                              /* SCL="L" */
     iic_scl_d = 1;                            /* SCL output */
     _WaitTime1us();                           /* wait *1 */
     iic_sda_d = 0;                            /* SDA="H" */
     _WaitTime1us();                           /* wait */
     _WaitTime1us();                           /* wait *! */
     iic_scl = 1;                              /* SCL="H" */
     _Wait_tSU_STA;                                       /* wait */
     iic_sda = 0;                              /* SDA="L" */
     iic_sda_d = 1;                            /* SDA output */
     _Wait_tHD_STA;                                       /* wait */
     _WaitTime1us();                           /* wait *1 */
     iic_scl = 0;                              /* SCL="L" */
}

/*********************************************************
 Name                 : StopCondition
 Parameters           : None
 Returns  : None
 Description          : Output Stop Condition (I2C-BUS)
 Note                 : *1 adjust a wait time
*********************************************************/
void StopCondition(void)
{
     iic_scl = 0;                              /* SCL="L" */
     iic_scl_d = 1;                            /* SCL output */
     _WaitTime1us();                           /* wait *1 */
     iic_sda = 0;                              /* SDA="L" */
     iic_sda_d = 1;                            /* SDA output */
     _WaitTime1us();                           /* wait *1 */
     iic_scl = 1;                              /* SCL="H" */
     _Wait_tSU_STO;                                       /* wait */
     iic_sda_d = 0;                            /* SDA="H" */
     _WaitTime1us();                           /* wait */
     _WaitTime1us();                           /* wait *1 */
     iic_scl = 0;                              /* SCL="L" */
}
```

```
/*******************************************************
 Name               : ByteWrite
 Parameters         : Write data
 Returns  : Acknowledge
 Description        : byte data Output (I2C-BUS)
 Note               : *1 adjust a wait time
*******************************************************/
unsigned char ByteWrite(unsigned char iic_writeData)
{
    unsigned char maskData=0x80;                  /* MSB first */
    unsigned char ret=ACK;                        /* Ack/NoAck */

    while (maskData) {                                      /* 8times as loop */
        iic_sda = 0;                              /* initialize port-latch */
        if (iic_writeData & maskData) {  /* "H" output ? */
            iic_sda_d = 0;                        /* Yes SDA="H" */
        }else{
            iic_sda_d = 1;                        /* No   SDA="L" */
            asm("nop");                                     /* wait *1 */
            asm("nop");                                     /* wait *1 */
            asm("nop");                                     /* wait *1 */
        }
        _Wait_tSU_DAT;                                      /* wait */
        _WaitTime1us();                                     /* wait *1 */
        iic_scl = 1;                              /* SCL="H" */
        _Wait_tHIGH;                                        /* wait */
        _WaitTime1us();                                     /* wait *1 */
        iic_scl = 0;                              /* SCL="L" */
        maskData >>= 1;                                     /* change mask data */
        _WaitTime1us();                                     /* wait *1 */
    }
    iic_sda_d = 0;                                /* SDA input */
    _Wait_tAA;                                              /* wait */
    _WaitTime2us();                               /* wait *1 */
    iic_scl = 1;                                  /* SCL="H" */
    if (iic_sda) ret=NOACK;                       /* NoAck Detect */
    _Wait_tHIGH;                                  /* wait */
    _WaitTime1us();                               /* wait *1 */
    iic_scl = 0;                                  /* SCL="L" */
    _Wait_tHD_DAT;                                          /* wait */
    return(ret);
}
```

```
/*******************************************************
 Name                : ByteRead
 Parameters          : Read data strage location pointer, Select Ack/NoAck
 Returns   : None
 Description         : byte data input with Ack output (I2C-BUS)
 Note                : *1 adjust a wait time
*******************************************************/
void ByteRead(unsigned char *iic_readData, unsigned char ackData)
{
    unsigned char maskData=0x80;              /* MSB first */
    unsigned char readData;

    *iic_readData = 0;                                  /*    */
    while (maskData) {                                  /* 8times as loop */
        readData = *iic_readData | maskData;  /*    */
        iic_sda_d = 0;                                  /* initialize port-latch */
        _Wait_tAA;                            /* wait */
        iic_scl = 1;                          /* SCL="H" */
        if (iic_sda) {                        /* SDA="H" ? */
            *iic_readData = readData;         /* Yes    */
        }else{
            asm("nop");                                 /* wait *1 */
            asm("nop");                                 /* wait *1 */
            asm("nop");                                 /* wait *1 */
            asm("nop");                                 /* wait *1 */
            asm("nop");                                 /* wait *1 */
            asm("nop");                                 /* wait *1 */
            asm("nop");                                 /* wait *1 */
            asm("nop");                                 /* wait *1 */
            asm("nop");                                 /* wait *1 */
            asm("nop");                                 /* wait *1 */
            asm("nop");                                 /* wait *1 */
            asm("nop");                                 /* wait *1 */
            asm("nop");                                 /* wait *1 */
        }
        _Wait_tHIGH;                                    /* wait */
        _WaitTime1us();                                 /* wait *1 */
        iic_scl = 0;                          /* SCL="L" */
        maskData >>= 1;                                 /* Change mask data */
        _WaitTime1us();                                 /* wait *1 */
    }
    if (!ackData) {                           /* Ack output ? */
    /* Ack output */
        iic_sda = ACK;                                  /* Yes SDA="L" */
        iic_sda_d = 1;                                  /* SDA output */
    }else{
    /* NoAck output */
        iic_sda = NOACK;                      /* No    SDA="H" */
        iic_sda_d = 0;                                  /* SDA input */
    }
    _Wait_tSU_DAT;                                      /* wait */
    _WaitTime1us();                           /* wait *1 */
    iic_scl = 1;                              /* SCL="H" */
	_Wait_tHIGH;                                    /* wait */
	_WaitTime1us();                                 /* wait *1 */
	iic_scl = 0;                                    /* SCL="L" */
	iic_sda_d = 0;                                  /* SDA input */
	_WaitTime1us();                                 /* wait *1 */
}


/*******************************************************
 Name                 : _WaitTime0us
 Parameters           : None
 Returns  : None
 Description          : a 0us wait
*******************************************************/
void _WaitTime0us(void)
{
}


/*******************************************************
 Name                 : _WaitTime1us
 Parameters           : None
 Returns  : None
 Description          : a 1us wait
*******************************************************/
void _WaitTime1us(void)
{
	/* +14cycle */
	asm("nop");                     /* +1cycle */
	asm("nop");                     /* +1cycle = 16cycle */
}


/*******************************************************
 Name                 : _WaitTime2us
 Parameters           : None
 Returns  : None
 Description          : a 2us wait
*******************************************************/
void _WaitTime2us(void)
{
	/* +14cycle */
	asm("nop");                     /* +1cycle */
	asm("nop");                     /* +1cycle */
	asm("nop");                     /* +1cycle */
	asm("nop");                     /* +1cycle */
	asm("nop");                     /* +1cycle */
	asm("nop");                     /* +1cycle */
	asm("nop");                     /* +1cycle */
	asm("nop");                     /* +1cycle */
	asm("nop");                     /* +1cycle */
	asm("nop");                     /* +1cycle */
	asm("nop");                     /* +1cycle */
```

```
    asm("nop");                 /* +1cycle */
    asm("nop");                 /* +1cycle */
    asm("nop");                 /* +1cycle */
    asm("nop");                 /* +1cycle */
    asm("nop");                 /* +1cycle */
    asm("nop");                 /* +1cycle */
    asm("nop");                 /* +1cycle = 32cycle */
}
```

7. Reference

Hardware Manual

R8C/10 Group Hardware Manual
(Acquire the most current version from Renesas web-site)

8. Web-site and contact for support

Renesas Web-site

http://www.renesas.com/

Information on Renesas Products

Mail to : csc@renesas.com (Customer Support Center)

Contact for technical information on M16C family

Mail to:support_apl@renesas.com (M16C family MCU technical support)

REVISION HISTORY

Rev.	Date	Description	
		Page	Summary
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