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April 1st, 2010
Renesas Electronics Corporation

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R8C/10 Group

A Software control of I²C-BUS using General-purpose Ports

1. Abstract

This application note describes a software control program of I²C-BUS and its application example. This program can be also used for a control of EEPROM.

2. Introduction

A single master I²C-BUS can be controlled by software using general-purpose ports. The external pull-up resistances should be attached to P12 (SDA) and P13 (SCL).

Table 1 shows the functional performance of I²C-BUS interface.

<table>
<thead>
<tr>
<th>Item</th>
<th>Functional Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication mode</td>
<td>Master transmission (single master)</td>
</tr>
<tr>
<td>SCL Clock Frequency</td>
<td>100kHz approx.</td>
</tr>
</tbody>
</table>

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. **I²C-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](image1.png)  
**Figure 1** START condition generation timing

![Figure 2](image2.png)  
**Figure 2** STOP condition generation timing

<table>
<thead>
<tr>
<th>Timing</th>
<th>START condition</th>
<th>STOP condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set up time</td>
<td>2.0μs approx.</td>
<td>1.6μs approx.</td>
</tr>
<tr>
<td>Hold time</td>
<td>3.0μs approx.</td>
<td>3.0μs approx.</td>
</tr>
</tbody>
</table>

**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.

Table 3  A list of data input / output timing

<table>
<thead>
<tr>
<th>Timing</th>
<th>Data output</th>
<th>Data input</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setup time</td>
<td>3.3µs approx.</td>
<td>-</td>
</tr>
<tr>
<td>Access time</td>
<td>-</td>
<td>Over 1µs approx.</td>
</tr>
<tr>
<td>Clock &quot;H&quot; time</td>
<td>3.0µs approx.</td>
<td>4.7µs approx.</td>
</tr>
</tbody>
</table>

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.
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).

![Connection Diagram](image)

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.

![Data Input Table](image)

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.

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.
5. Flowchart

5.1 Initial Operation and Main loop

main

SFR Initialization (I2C-BUS)

initIicBus

i = (Process like mode setting)

Yes

i==0

No

i==1

Yes

WriteData[0] = 0xFF;
licData_w.iic_DeviceAddress = 0xA0;
licData_w.iic_WordAddress = 0x10;
licData_w.iic_Data = WriteData;
licData_w.iic_NumberOfByte = 1;

I2C-BUS Write
IicBusWrite

No

i==2

Yes

for (i=0; i<8; i++) WriteData[i]=i;
licData_w.iic_DeviceAddress = 0xA0;
licData_w.iic_WordAddress = 0x10;
licData_w.iic_Data = WriteData;
licData_w.iic_NumberOfByte = 8;

I2C-BUS Write
IicBusWrite

No

i==3

Yes

licData_r.iic_DeviceAddress = 0xA0;
licData_r.iic_WordAddress = 0x10;
licData_r.iic_Data = ReadData;
licData_r.iic_NumberOfByte = 1;

I2C-BUS Read
IicBusRead

No

i==4

Yes

licData_r.iic_DeviceAddress = 0xA0;
licData_r.iic_WordAddress = 0x10;
licData_r.iic_Data = ReadData;
licData_r.iic_NumberOfByte = 8;

I2C-BUS Read
IicBusRead

No

i = 0;
5.2 SFR Initial Setting(I²C-BUS)

```c
initIicBus

iic_sda_d = 0;  // SDA input ("H" state)
iic_scl_d = 0;  // SCL input ("H" state)
return
```
5.3 I^2C-BUS Read

```
IicData->iic_DeviceAddress &= 0xFE;
Start Condition
DeviceAddress Write
ByteWrite
Detect NoAck
MemoryAddress Write
ByteWrite
Detect NoAck
IicData->iic_DeviceAddress |= 0x01;
Start Condition
DeviceAddress Write
ByteWrite
Detect NoAck
No
Repeat
i=0; i<byte count; i++
Read(Ack Output)
ByteRead
IicData->iic_Data++;
Read(NoAck Output)
ByteRead
Stop Condition
return(ret)
```
5.4 I²C-BUS Write

IicBusWrite

IicData->iic_DeviceAddress &= 0xFE; ; WRITE Setting Device Address

Start Condition
StartCondition

DeviceAddress Write
ByteWrite

Detect NoAck

No
MemoryAddress Write
ByteWrite

Detect NoAck

No
Repeat
i=0; i<byte count; i++

Write Data
ByteWrite

Detect NoAck

No
IicData->iic_Data++;

Stop Condition
StopCondition

return(ret) ; Stop Condition
5.5 I^2C-BUS Start Condition

```c
StartCondition

    iic_scl = 0;
    iic_scl_d = 1;
    ; SCL="L"
    ; SCL output

    Wait
    _WaitTime1us

    iic_sda_d = 0;
    ; SDA="H"

    Wait
    _WaitTime1us

    Wait
    _WaitTime1us

    iic_scl = 1;
    ; SCL="H"

    Wait
    _Wait_TSU_STA

    iic_sda = 0;
    iic_sda_d = 1;
    ; SDA="L"
    ; SDA output

    Wait
    _Wait_THD_STA

    Wait
    _WaitTime1us

    iic_scl = 0;
    ; SCL="L"

return
```
5.6 I²C-BUS Stop Condition

```
<table>
<thead>
<tr>
<th>StopCondition</th>
</tr>
</thead>
<tbody>
<tr>
<td>iic_scl = 0;</td>
</tr>
<tr>
<td>iic_scl_d = 1;</td>
</tr>
<tr>
<td>; SCL=&quot;L&quot;</td>
</tr>
<tr>
<td>; SCL output</td>
</tr>
<tr>
<td>Wait</td>
</tr>
<tr>
<td>_WaitTime1us</td>
</tr>
<tr>
<td>iic_sda = 0;</td>
</tr>
<tr>
<td>iic_sda_d = 1;</td>
</tr>
<tr>
<td>; SDA=&quot;L&quot;</td>
</tr>
<tr>
<td>; SDA output</td>
</tr>
<tr>
<td>Wait</td>
</tr>
<tr>
<td>_WaitTime1us</td>
</tr>
<tr>
<td>iic_scl = 1;</td>
</tr>
<tr>
<td>; SCL=&quot;H&quot;</td>
</tr>
<tr>
<td>Wait</td>
</tr>
<tr>
<td>_WaitTime1us</td>
</tr>
<tr>
<td>iic_sda_d = 0;</td>
</tr>
<tr>
<td>; SDA=&quot;H&quot;</td>
</tr>
<tr>
<td>Wait</td>
</tr>
<tr>
<td>_WaitTime1us</td>
</tr>
<tr>
<td>iic_sda_d = 1;</td>
</tr>
<tr>
<td>; SDA output</td>
</tr>
<tr>
<td>Wait</td>
</tr>
<tr>
<td>_WaitTime1us</td>
</tr>
<tr>
<td>iic_scl = 0;</td>
</tr>
<tr>
<td>; SCL=&quot;L&quot;</td>
</tr>
<tr>
<td>return</td>
</tr>
</tbody>
</table>
```
5.7 I²C-BUS Byte Write

ByteWrite

- maskData = 0x80;
- ret = ACK;

Loop 8 times

- iic_sda = 0;
- initialize port-latch

This branch is triggered when the condition is not met.

- iic_writeData & maskData

Yes: SDA = "H"

- iic_sda_d = 0;

- Wait _Wait_tSU_DAT / _WaitTime1us

Yes: SCL = "H"

- iic_scl = 1;

No: SCL = "L"

- Wait _Wait_tHIGH / _WaitTime1us

- iic_scl = 0;

- maskData >>= 1;

- Wait _WaitTime1us

- iic_sda_d = 0;

- iic_sda = 0;

- Wait _Wait_tAA / _WaitTime2us

Yes: SDA = "L"

- iic_sda_d = 1;

- nop X 3

No: SDA = "H"

- Wait _Wait_tHIGH / _WaitTime1us

- iic_scl = 0;

- SCL = "L"

- Wait _Wait_tHD_DAT

NoAck Detect

- ret = NOACK;

- Wait _Wait_tHIGH / _WaitTime1us

- iic_scl = 0;

- SCL = "L"

- Wait _Wait_tHD_DAT

return(ret)
5.8 \textit{i}^{2}\textit{C}-BUS Byte Read

```
ByteRead

maskData=0x80;

Loop 8 times

Yes

readData = "iic_readData | maskData;

iic_sda = 0;

Wait
_Wait_tAA

iic_scl = 1;

iic_sda="H"

No

Yes

"iic_readData = readData;

Wait
_Wait_tHIGH/WaitTime1us

iic_scl = 0;

maskData >>= 1;

Wait
_WaitTime1us

ACK

No

Yes

iic_sda = ACK;

iic_sda_d = 1;

Wait
_Wait_tSU_DAT/WaitTime1us

iic_scl = 0;

Wait
_Wait_tHIGH/WaitTime1us

iic_scl = 0;

iic_sda_d = 0;

Wait
_WaitTime1us

return
```

- Initialize maskData to 0x80
- Loop 8 times
- Read data from I\textit{C}-BUS
- Initialize port-latch
- Wait
- SCL = "H"
- SCL = "L"
- Change mask data
- Wait
- SDA = ACK
- SDA = NOACK
- Wait
- SCL = "H"
- SCL = "L"
- SDA input
- SDA output
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 licData_w;
    IicPack licData_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;
                licData_w.iic_DeviceAddress = 0xA0;
                licData_w.iic_MemoryAddress = 0x10;
                licData_w.iic_Data = WriteData;
                licData_w.iic_NumberOfByte = 1;
                p1_4 = 0;
                if (IicBusWrite(&licData_w) == ACK) {
                    p1_4 = 1;
                }
                break;
            case 3: /* Write data 8Bytes */
                for (i=0; i<8; i++) WriteData[i] = i*5; /* Setting write data */
                licData_w.iic_DeviceAddress = 0xA0;
                licData_w.iic_MemoryAddress = 0x10;
                licData_w.iic_Data = WriteData;
                licData_w.iic_NumberOfByte = 8;
                p1_4 = 0;
        }
    }
}
```c
if (licBusWrite(&licData_w) == ACK) {
    p1_4 = 1;
}
break;
case 2: /* Read data 1Byte */
    licData_r.iic_DeviceAddress = 0xA0;
    licData_r.iic_MemoryAddress = 0x10;
    licData_r.iic_Data = ReadData;
    licData_r.iic_NumberOfByte = 1;
    p1_1 = 0;
    if(licBusRead(&licData_r) == ACK) { /* */
        p1_1 = 1;
    }
    break;
case 4: /* Read data 8Bytes */
    licData_r.iic_DeviceAddress = 0xA0;
    licData_r.iic_MemoryAddress = 0x10;
    licData_r.iic_Data = ReadData;
    licData_r.iic_NumberOfByte = 8;
    p1_1 = 0;
    if(licBusRead(&licData_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);
}
```
#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);
```c
#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 */

void initIicBus(void)
{
    iic_sda_d = 0;  /* SDA input ("H" state) */
    iic_scl_d = 0;  /* SCL input ("H" state) */
}
```
unsigned char IicBusRead(IicPack *IicData)
{
    unsigned char i, ret;

    /* Random Read Cycle / Sequential Random 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) */
            ByteRead (IicData->iic_Data++, NOACK); /* Read data (NoAck output) */
    }
    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 */
    licData->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 */
            licData->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 *1 */
    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_STA;             /* 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 storage 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;  /* */
        _Wait_tAA;  /* wait */
        _Wait_tHIGH;  /* 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 */
            }else{
                _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{
            /* No Ack 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 */
}

/************************************************************************
Name  : _WaitTime0us
Parameters : None
Returns : None
Description : a 0us wait
*************************************************************************/
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

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<td>1.00</td>
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