SENSIRION
THE SENSOR COMPANY

Application Note for SFM3000

Sample Code

Summary

Sensirion's SFM3000 flow sensor is based on a 5th generation CMOSens® mass flow sensor chip called SF05. The sensor can directly be connected to a microcontroller. This application note contains a C++ sample code to implement the basic commands.

1. Sample Code

Due to compatibility reasons the I²C interface is implemented as "bit-banging" on normal I/O's. This code is written for an easy understanding and is neither optimized for speed nor code size. A copy of the code may be found on the following pages of this application note.

The source code is available as zip archive on our webpage.

2. Revision history

Date	Version	Changes
November 2012	1.0	Initial release
August 2015	1.1	Minor updates
August 2015	1.2	Minor bug fix in sf05.c & sf05.h

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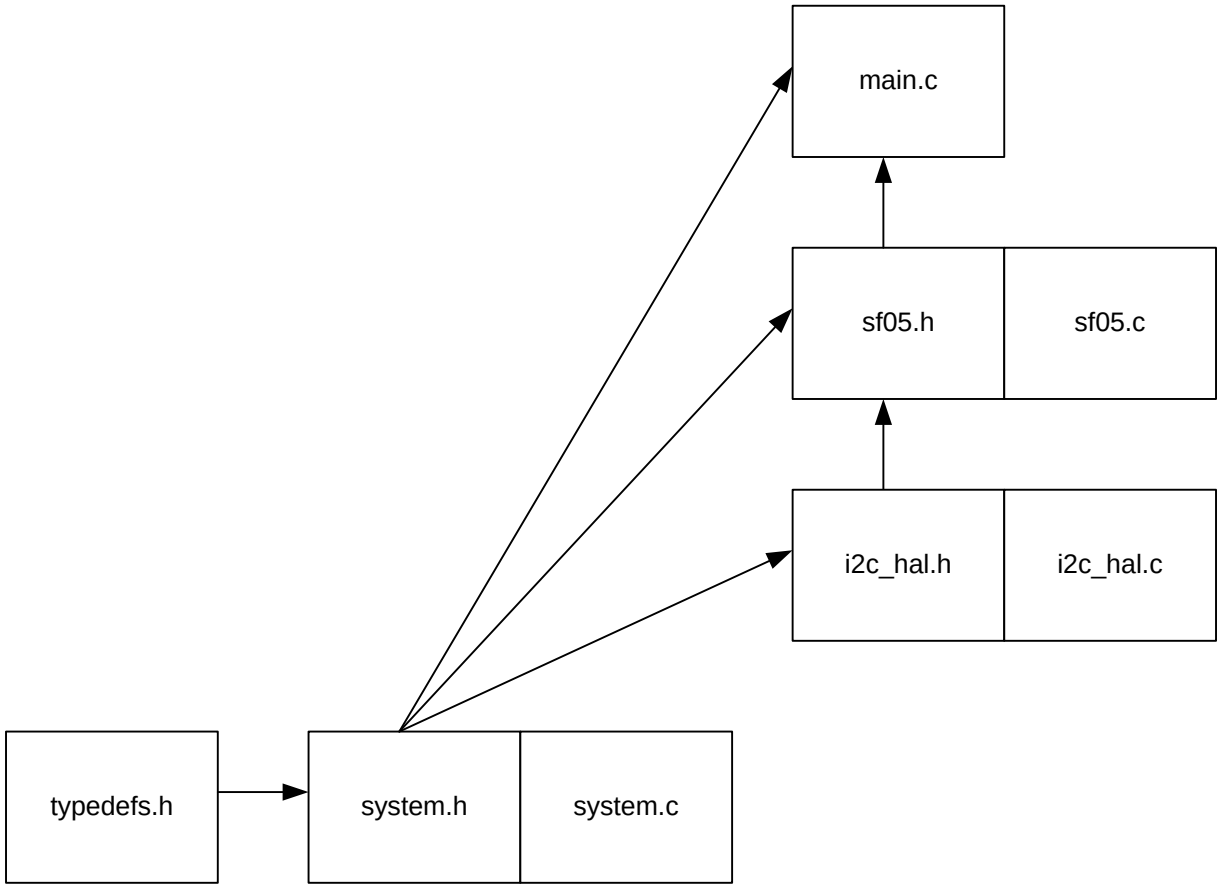
To find your local representative, please visit www.sensirion.com/contact

Structure SF05 Sample Code



Revision History

Revision	Date	Changes
V1.0	08.11.12 / RFU	Initial draft

```c
//===============================================================================
//    S E N S I R I O N   AG,  Laubisruetistr. 50, CH-8712 Staefa, Switzerland
//===============================================================================
// Project   :  SF05 Sample Code (V1.1)
// File      :  main.c (V1.1)
// Author    :  RFU
// Date      :  26-Jul-2015
// Controller:  STM32F100RB
// IDE       :  µVision V4.60.0.0
// Compiler  :  Armcc
// Brief     :  This code shows how to implement the basic commands for a
//              flow or differential pressure senor based on SF05 sensor chip.
//              Due to compatibility reasons the I2C interface is implemented
//              as "bit-banging" on normal I/O's. This code is written for an
//              easy understanding and is neither optimized for speed nor code
//              size.
//
// Porting to a different microcontroller (uC):
//   - the definitions of basic types may have to be changed  in typedefs.h
//   - change the port functions / definitions for your uC    in i2c_hal.h/.c
//   - adapt the timing of the delay function for your uC     in system.c
//   - adapt the SystemInit()                                 in system.c
//   - change the uC register definition file <stm32f10x.h>   in system.h
//===============================================================================

//-- Includes ------------------------------------------------------------------
#include "system.h"
#include "sf05.h"

//-- Defines -------------------------------------------------------------------
// Offset and scale factors from datasheet (SFM3000).
#define OFFSET_FLOW 32000.0F   // offset flow
#define SCALE_FLOW    140.0F   // scale factor flow

//===============================================================================
void Led_Init(void){
//===============================================================================
  RCC->APB2ENR |= 0x00000010;  // I/O port C clock enabled
  GPIOC->CRH   &= 0xFFFFFF00;  // set general purpose output mode for LEDs
  GPIOC->CRH   |= 0x00000011;  //
  GPIOC->BSRR   = 0x03000000;  // LEDs off
}

//===============================================================================
void UserButton_Init(void){
//===============================================================================
  RCC->APB2ENR |= 0x00000004;  // I/O port A clock enabled
  GPIOA->CRH   &= 0xFFFFFFF0;  // set general purpose input mode for User Button
  GPIOA->CRH   |= 0x00000004;  //
}

//===============================================================================
void LedBlueOn(void){
//===============================================================================
  GPIOC->BSRR = 0x00000100;
}

//===============================================================================
void LedBlueOff(void){
//===============================================================================
  GPIOC->BSRR = 0x01000000;
}

//===============================================================================
void LedGreenOn(void){
//===============================================================================
  GPIOC->BSRR = 0x00000200;
}

//===============================================================================
void LedGreenOff(void){
//===============================================================================
  GPIOC->BSRR = 0x02000000;
}

//===============================================================================
u8t ReadUserButton(void){
//===============================================================================
```

```
  79     return (GPIOA->IDR & 0x00000001);
  80   }
  81
  82   //===========================================================================
  83   int main(void){
  84   //===========================================================================
  85     etError  error;        // error code
  86     u32t     serialNumber; // sensor serial number
  87     ft       flow;         // measured flow value
  88
  89     SystemInit();
  90     Led_Init();
  91     UserButton_Init();
  92     SF05_Init();
  93
  94     // read serial number from sensor
  95     error = SF05_GetSerialNumber(&serialNumber);
  96
  97     while(1)
  98     {
  99       error = NO_ERROR;
 100
 101       if(ReadUserButton() == 0)
 102       // if the user button is not pressed
 103       {
 104         // read flow from sensor
 105         error = SF05_GetFlow(OFFSET_FLOW, SCALE_FLOW, &flow);
 106
 107         // the blue LED lights if a weak flow is detected
 108         if(flow > 1.0) LedBlueOn();
 109         else           LedBlueOff();
 110       }
 111       else
 112       // if the user button is pressed
 113       {
 114         // green and blue LED off
 115         LedGreenOff();
 116         LedBlueOff();
 117
 118         // perform a soft reset on the sensor
 119         error = SF05_SoftReset();
 120
 121         // wait until button is released
 122         while(ReadUserButton() != 0);
 123       }
 124
 125       // the green LED lights if no error occurs
 126       if(!error)     LedGreenOn();
 127       else           LedGreenOff();
 128
 129       // wait 100ms
 130       DelayMicroSeconds(100000);
 131     }
 132   }
 133
```

```
1   //===========================================================================
2   //    S E N S I R I O N   AG,  Laubisruetistr. 50, CH-8712 Staefa, Switzerland
3   //===========================================================================
4   // Project   :  SF05 Sample Code (V1.1)
5   // File      :  sf05.h (V1.2)
6   // Author    :  RFU
7   // Date      :  20-Aug-2015
8   // Controller:  STM32F100RB
9   // IDE       :  µVision V4.60.0.0
10  // Compiler  :  Armcc
11  // Brief     :  Sensor Layer: Definitions of commands and functions for sensor
12  //                            access.
13  //===========================================================================
14
15  #ifndef SF05_H
16  #define SF05_H
17
18  //-- Includes ---------------------------------------------------------------
19  #include "system.h"
20
21  //-- Defines ----------------------------------------------------------------
22  // CRC
23  #define POLYNOMIAL  0x131    // P(x) = x^8 + x^5 + x^4 + 1 = 100110001
24
25  //-- Enumerations -----------------------------------------------------------
26  // Sensor Commands
27  typedef enum{
28    FLOW_MEASUREMENT        = 0x1000, // command: flow measurement
29    READ_SERIAL_NUMBER_HIGH = 0x31AE, // command: read serial number (bit 31:16)
30    READ_SERIAL_NUMBER_LOW  = 0x31AF, // command: read serial number (bit 15:0)
31    SOFT_RESET              = 0X2000  // command: soft reset
32  }etCommands;
33
34  //===========================================================================
35  void SF05_Init(void);
36  //===========================================================================
37  // Initializes the I2C bus for communication with the sensor.
38  //---------------------------------------------------------------------------
39
40  //===========================================================================
41  etError SF05_WriteCommand(etCommands cmd);
42  //===========================================================================
43  // Writes command to the sensor.
44  //---------------------------------------------------------------------------
45  // input:  cmd          command which is to be written to the sensor
46  //
47  // return: error:       ACK_ERROR = no acknowledgment from sensor
48  //                      NO_ERROR  = no error
49
50  //===========================================================================
51  etError SF05_ReadCommandResult(u16t *result);
52  //===========================================================================
53  // Reads command results from sensor.
54  //---------------------------------------------------------------------------
55  // input:  *result      pointer to an integer where the result will be stored
56  //
57  // return: errror:      ACK_ERROR      = no acknowledgment from sensor
58  //                      CHECKSUM_ERROR = checksum mismatch
59  //                      NO_ERROR       = no error
60
61  //===========================================================================
62  etError SF05_ReadCommandResultWithTimeout(u8t maxRetries, u16t *result);
63  //===========================================================================
64  // Reads command results from sensor. If an error occurs, then the read will be
65  // repeated after a short wait (approx. 10ms).
66  //---------------------------------------------------------------------------
67  // input:  maxRetries    maximum number of retries
68  //         *result       pointer to an integer where the result will be stored
69  //
70  // return: errror:       ACK_ERROR      = no acknowledgment from sensor
71  //                       CHECKSUM_ERROR = checksum mismatch
72  //                       NO_ERROR       = no error
73  //
74  // remark: This function is usefull for reading measurement results. If not yet
75  //         a new valid measurement was performed, an acknowledge error occurs
76  //         and the read will be automatical repeated until a valid measurement
77  //         could be read.
78
```

```
  79  //==============================================================================
  80  etError SF05_GetFlow(ft offset, ft scale, ft *flow);
  81  //==============================================================================
  82  // Gets the flow from the sensor in a predefined unit. The "flow measurement"
  83  // command will be automatical written to the sensor, if it is not already set.
  84  //------------------------------------------------------------------------------
  85  // input:  offset         offset flow
  86  //         scale          scale factor flow
  87  //         *flow          pointer to a floating point value, where the calculated
  88  //                        flow will be stored
  89  //
  90  // return: errror:        ACK_ERROR      = no acknowledgment from sensor
  91  //                        CHECKSUM_ERROR = checksum mismatch
  92  //                        NO_ERROR       = no error
  93  //
  94  // remark: The result will be converted according to the following formula:
  95  //         flow in predefined unit = (measurement_result - offset) / scale
  96
  97  //==============================================================================
  98  etError SF05_GetSerialNumber(u32t *serialNumber);
  99  //==============================================================================
 100  // Gets the serial number from the sensor.
 101  //------------------------------------------------------------------------------
 102  // input:  *serialNumber  pointer to a 32-bit integer, where the serial number
 103  //                        will be stored
 104  //
 105  // return: error:         ACK_ERROR      = no acknowledgment from sensor
 106  //                        CHECKSUM_ERROR = checksum mismatch
 107  //                        NO_ERROR       = no error
 108
 109  //==============================================================================
 110  etError SF05_SoftReset(void);
 111  //==============================================================================
 112  // Forces a sensor reset without switching the power off and on again.
 113  //------------------------------------------------------------------------------
 114  // return: error:         ACK_ERROR      = no acknowledgment from sensor
 115  //                        NO_ERROR       = no error
 116
 117  //==============================================================================
 118  etError SF05_CheckCrc(u8t data[], u8t nbrOfBytes, u8t checksum);
 119  //==============================================================================
 120  // Calculates checksum for n bytes of data and compares it with expected
 121  // checksum.
 122  //------------------------------------------------------------------------------
 123  // input:  data[]         checksum is built based on this data
 124  //         nbrOfBytes     checksum is built for n bytes of data
 125  //         checksum       expected checksum
 126  //
 127  // return: error:         CHECKSUM_ERROR = checksum does not match
 128  //                        NO_ERROR       = checksum matches
 129
 130  #endif
 131
```

```c
//===========================================================================
//    S E N S I R I O N   AG,  Laubisruetistr. 50, CH-8712 Staefa, Switzerland
//===========================================================================
// Project   :  SF05 Sample Code (V1.1)
// File      :  sf05.c (V1.2)
// Author    :  RFU
// Date      :  20-Aug-2015
// Controller:  STM32F100RB
// IDE       :  µVision V4.60.0.0
// Compiler  :  Armcc
// Brief     :  Sensor Layer: Implementation of functions for sensor access.
//===========================================================================

//-- Includes ---------------------------------------------------------------
#include "sf05.h"
#include "i2c_hal.h"

//-- Global Variables -------------------------------------------------------
u16t currentCommand = 0x0000;

//===========================================================================
void SF05_Init(void){
//===========================================================================
  I2c_Init(); // init I2C
}

//===========================================================================
etError SF05_WriteCommand(etCommands cmd){
//===========================================================================
  etError error; // error code

  // write command to sensor
  I2c_StartCondition();
  error  = I2c_WriteByte(I2C_ADR << 1 | I2C_WRITE);
  error |= I2c_WriteByte(cmd >> 8);
  error |= I2c_WriteByte(cmd & 0xFF);
  I2c_StopCondition();

  // if no error, store current command
  if(error == NO_ERROR)
    currentCommand = cmd;

  return error;
}

//===========================================================================
etError SF05_ReadCommandResult(u16t *result){
//===========================================================================
  etError error;    // error code
  u8t     checksum; // checksum byte
  u8t     data[2];  // read data array

  // read command result & checksum from sensor
  I2c_StartCondition();
  error    = I2c_WriteByte(I2C_ADR << 1 | I2C_READ);
  data[0]  = I2c_ReadByte(ACK);
  data[1]  = I2c_ReadByte(ACK);
  checksum = I2c_ReadByte(NO_ACK);
  I2c_StopCondition();

  // checksum verification
  error  |= SF05_CheckCrc (data, 2, checksum);

  // if no error, combine 16-bit result from the read data array
  if(error == NO_ERROR)
    *result = (data[0] << 8) | data[1];

  return error;
}

//===========================================================================
etError SF05_ReadCommandResultWithTimeout(u8t maxRetries, u16t *result){
//===========================================================================
  etError error; //variable for error code

  while(maxRetries--)
  {
    // try to read command result
```

```
79        error = SF05_ReadCommandResult(result);
80
81        // if read command result was successful -> exit loop
82        // it will only be successful if a new valid measurement was performed
83        if(error == NO_ERROR) break;
84
85        // if it was not successful -> wait a short time and then try it again
86        DelayMicroSeconds(10000);
87      }
88
89      return error;
90    }
91
92    //-----------------------------------------------------------------------------
93    etError SF05_GetFlow(ft offset, ft scale, ft *flow){
94    //-----------------------------------------------------------------------------
95      etError error = NO_ERROR; // error code
96      u16t    result;           // read result from sensor
97
98      // write command if it is not already set
99      if(currentCommand != FLOW_MEASUREMENT)
100       error = SF05_WriteCommand(FLOW_MEASUREMENT);
101
102     // if no error, read command result
103     if(error == NO_ERROR)
104       error = SF05_ReadCommandResultWithTimeout(20, &result);
105
106     // if no error, compute the flow
107     if(error == NO_ERROR)
108       *flow = ((ft)result - offset) / scale;
109
110     return error;
111   }
112
113   //-----------------------------------------------------------------------------
114   etError SF05_GetSerialNumber(u32t *serialNumber){
115   //-----------------------------------------------------------------------------
116     etError error = NO_ERROR; // error code
117     u16t result;              // read result from sensor
118
119     // write command "read serial number (bit 31:16)"
120     error = SF05_WriteCommand(READ_SERIAL_NUMBER_HIGH);
121
122     // if no error, read command result
123     if(error == NO_ERROR)
124       error = SF05_ReadCommandResult(&result);
125
126     // if no error, copy upper 16 bits to serial number
127     if(error == NO_ERROR)
128       *serialNumber = result << 16;
129
130     // if no error, write command "read serial number (bit 15:0)"
131     if(error == NO_ERROR)
132       error = SF05_WriteCommand(READ_SERIAL_NUMBER_LOW);
133
134     // if no error, read command result
135     if(error == NO_ERROR)
136       error = SF05_ReadCommandResult(&result);
137
138     // if no error, copy lower 16 bits to serial number
139     if(error == NO_ERROR)
140       *serialNumber |= result;
141
142     return error;
143   }
144
145   //-----------------------------------------------------------------------------
146   etError SF05_SoftReset(void){
147   //-----------------------------------------------------------------------------
148     etError error; // error code
149
150     error = SF05_WriteCommand(SOFT_RESET);
151
152     return error;
153   }
154
155   //-----------------------------------------------------------------------------
156   etError SF05_CheckCrc(u8t data[], u8t nbrOfBytes, u8t checksum){
```

```
157   //=========================================================================
158     u8t bit;     // bit mask
159     u8t crc = 0; // calculated checksum
160     u8t byteCtr; // byte counter
161
162     // calculates 8-Bit checksum with given polynomial
163     for(byteCtr = 0; byteCtr < nbrOfBytes; byteCtr++)
164     {
165       crc ^= (data[byteCtr]);
166       for(bit = 8; bit > 0; --bit)
167       {
168         if(crc & 0x80) crc = (crc << 1) ^ POLYNOMIAL;
169         else           crc = (crc << 1);
170       }
171     }
172
173     // verify checksum
174     if(crc != checksum) return CHECKSUM_ERROR;
175     else                return NO_ERROR;
176   }
177
178
```

```
1   //===============================================================================
2   //    S E N S I R I O N   AG,  Laubisruetistr. 50, CH-8712 Staefa, Switzerland
3   //===============================================================================
4   // Project   :  SF05 Sample Code (V1.1)
5   // File      :  i2c_hal.h (V1.0)
6   // Author    :  RFU
7   // Date      :  07-Nov-2012
8   // Controller:  STM32F100RB
9   // IDE       :  µVision V4.60.0.0
10  // Compiler  :  Armcc
11  // Brief     :  I2C hardware abstraction layer
12  //===============================================================================
13
14  #ifndef I2C_HAL_H
15  #define I2C_HAL_H
16
17  //-- Includes ------------------------------------------------------------------
18  #include "system.h"
19
20  //-- Defines -------------------------------------------------------------------
21  // I2C IO-Pins
22  // SDA on port C, bit 6
23  #define SDA_LOW()  (GPIOC->BSRR = 0x00400000) // set SDA to low
24  #define SDA_OPEN() (GPIOC->BSRR = 0x00000040) // set SDA to open-drain
25  #define SDA_READ   (GPIOC->IDR  & 0x0040)     // read SDA
26
27  // SCL on port C, bit 7
28  #define SCL_LOW()  (GPIOC->BSRR = 0x00800000) // set SCL to low
29  #define SCL_OPEN() (GPIOC->BSRR = 0x00000080) // set SCL to open-drain
30  #define SCL_READ   (GPIOC->IDR  & 0x0080)     // read SCL
31
32  //-- Enumerations --------------------------------------------------------------
33  // I2C header
34  typedef enum{
35    I2C_ADR     = 64,   // default sensor I2C address
36    I2C_WRITE   = 0x00, // write bit in header
37    I2C_READ    = 0x01, // read bit in header
38    I2C_RW_MASK = 0x01  // bit position of read/write bit in header
39  }etI2cHeader;
40
41  // I2C acknowledge
42  typedef enum{
43    ACK    = 0,
44    NO_ACK = 1,
45  }etI2cAck;
46
47  //===============================================================================
48  void I2c_Init(void);
49  //===============================================================================
50  // Initializes the ports for I2C interface.
51  //-------------------------------------------------------------------------------
52
53  //===============================================================================
54  void I2c_StartCondition(void);
55  //===============================================================================
56  // Writes a start condition on I2C-Bus.
57  //-------------------------------------------------------------------------------
58  // remark: Timing (delay) may have to be changed for different microcontroller.
59  //         _____
60  // SDA:         |_____
61  //         _______
62  // SCL:           |___
63
64  //===============================================================================
65  void I2c_StopCondition(void);
66  //===============================================================================
67  // Writes a stop condition on I2C-Bus.
68  //-------------------------------------------------------------------------------
69  // remark: Timing (delay) may have to be changed for different microcontroller.
70  //                 _____
71  // SDA:   _____|
72  //               _______
73  // SCL:   ___|
74
75  //===============================================================================
76  etError I2c_WriteByte(u8t txByte);
77  //===============================================================================
78  // Writes a byte to I2C-Bus and checks acknowledge.
```

```
79  //-----------------------------------------------------------------------------
80  // input:  txByte       transmit byte
81  //
82  // return: error:       ACK_ERROR = no acknowledgment from sensor
83  //                      NO_ERROR  = no error
84  //
85  // remark: Timing (delay) may have to be changed for different microcontroller.
86
87  //==============================================================================
88  u8t I2c_ReadByte(etI2cAck ack);
89  //==============================================================================
90  // Reads a byte on I2C-Bus.
91  //-----------------------------------------------------------------------------
92  // input:  ack          Acknowledge: ACK or NO_ACK
93  //
94  // return: rxByte
95  //
96  // remark: Timing (delay) may have to be changed for different microcontroller.
97
98  #endif
99
```

```c
//===========================================================================
//    S E N S I R I O N   AG,  Laubisruetistr. 50, CH-8712 Staefa, Switzerland
//===========================================================================
// Project   :  SF05 Sample Code (V1.1)
// File      :  i2c_hal.c (V1.0)
// Author    :  RFU
// Date      :  07-Nov-2012
// Controller:  STM32F100RB
// IDE       :  µVision V4.60.0.0
// Compiler  :  Armcc
// Brief     :  I2C hardware abstraction layer
//===========================================================================

//-- Includes ---------------------------------------------------------------
#include "i2c_hal.h"

//===========================================================================
void I2c_Init(void){
//===========================================================================
  RCC->APB2ENR |= 0x00000010;  // I/O port C clock enabled

  GPIOC->CRL   &= 0x00FFFFFF;  // set open-drain output for SDA and SCL
  GPIOC->CRL   |= 0x55000000;  // port C, bit 6,7

  SDA_OPEN();                  // I2C-bus idle mode SDA released
  SCL_OPEN();                  // I2C-bus idle mode SCL released
}

//===========================================================================
void I2c_StartCondition(void){
//===========================================================================
  SDA_OPEN();
  DelayMicroSeconds(1);
  SCL_OPEN();
  DelayMicroSeconds(1);
  SDA_LOW();
  DelayMicroSeconds(10);  // hold time start condition (t_HD;STA)
  SCL_LOW();
  DelayMicroSeconds(10);
}

//===========================================================================
void I2c_StopCondition(void){
//===========================================================================
  SCL_LOW();
  DelayMicroSeconds(1);
  SDA_LOW();
  DelayMicroSeconds(1);
  SCL_OPEN();
  DelayMicroSeconds(10);  // set-up time stop condition (t_SU;STO)
  SDA_OPEN();
  DelayMicroSeconds(10);
}

//===========================================================================
etError I2c_WriteByte(u8t txByte){
//===========================================================================
  u8t     mask;
  etError error = NO_ERROR;
  for(mask = 0x80; mask > 0; mask >>= 1)// shift bit for masking (8 times)
  {
    if((mask & txByte) == 0) SDA_LOW(); // masking txByte, write bit to SDA-Line
    else                     SDA_OPEN();
    DelayMicroSeconds(1);               // data set-up time (t_SU;DAT)
    SCL_OPEN();                         // generate clock pulse on SCL
    DelayMicroSeconds(5);               // SCL high time (t_HIGH)
    SCL_LOW();
    DelayMicroSeconds(1);               // data hold time(t_HD;DAT)
  }
  SDA_OPEN();                           // release SDA-line
  SCL_OPEN();                           // clk #9 for ack
  DelayMicroSeconds(1);                 // data set-up time (t_SU;DAT)
  if(SDA_READ) error = ACK_ERROR;       // check ack from i2c slave
  SCL_LOW();
  DelayMicroSeconds(20);                // wait to see byte package on scope
  return error;                         // return error code
}

```

```
  79   //============================================================================
  80   u8t I2c_ReadByte(etI2cAck ack){
  81   //============================================================================
  82     u8t mask;
  83     u8t rxByte = NO_ERROR;
  84     SDA_OPEN();                             // release SDA-line
  85     for(mask = 0x80; mask > 0; mask >>= 1) // shift bit for masking (8 times)
  86     {
  87       SCL_OPEN();                           // start clock on SCL-line
  88       DelayMicroSeconds(3);                 // SCL high time (t_HIGH)
  89       if(SDA_READ) rxByte = rxByte | mask; // read bit
  90       SCL_LOW();
  91       DelayMicroSeconds(1);                 // data hold time(t_HD;DAT)
  92     }
  93     if(ack == ACK) SDA_LOW();               // send acknowledge if necessary
  94     else           SDA_OPEN();
  95     DelayMicroSeconds(1);                   // data set-up time (t_SU;DAT)
  96     SCL_OPEN();                             // clk #9 for ack
  97     DelayMicroSeconds(5);                   // SCL high time (t_HIGH)
  98     SCL_LOW();
  99     SDA_OPEN();                             // release SDA-line
 100     DelayMicroSeconds(20);                  // wait to see byte package on scope
 101     return rxByte;                          // return error code
 102   }
 103
```

```
1  //===========================================================================
2  //    S E N S I R I O N   AG,  Laubisruetistr. 50, CH-8712 Staefa, Switzerland
3  //===========================================================================
4  // Project   :  SF05 Sample Code (V1.1)
5  // File      :  system.h (V1.0)
6  // Author    :  RFU
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8  // Controller:  STM32F100RB
9  // IDE       :  µVision V4.60.0.0
10 // Compiler  :  Armcc
11 // Brief     :  System functions, global definitions
12 //===========================================================================
13
14 #ifndef SYSTEM_H
15 #define SYSTEM_H
16
17 //-- Includes ---------------------------------------------------------------
18 #include <stm32f10x.h>             // controller register definitions
19 #include "typedefs.h"              // type definitions
20
21 //-- Enumerations -----------------------------------------------------------
22 // Error codes
23 typedef enum{
24   NO_ERROR       = 0x00, // no error
25   ACK_ERROR      = 0x01, // no acknowledgment error
26   CHECKSUM_ERROR = 0x02  // checksum mismatch error
27 }etError;
28
29 //===========================================================================
30 void SystemInit(void);
31 //===========================================================================
32 // Initializes the system
33 //---------------------------------------------------------------------------
34
35 //===========================================================================
36 void DelayMicroSeconds(u32t nbrOfUs);
37 //===========================================================================
38 // Wait function for small delays.
39 //---------------------------------------------------------------------------
40 // input:  nbrOfUs   wait x times approx. one micro second (fcpu = 8MHz)
41 // return: -
42 // remark: smallest delay is approx. 15us due to function call
43
44 #endif
45
```

```c
//============================================================================
//    S E N S I R I O N   AG,  Laubisruetistr. 50, CH-8712 Staefa, Switzerland
//============================================================================
// Project   :  SF05 Sample Code (V1.1)
// File      :  system.c (V1.0)
// Author    :  RFU
// Date      :  07-Nov-2012
// Controller:  STM32F100RB
// IDE       :  µVision V4.60.0.0
// Compiler  :  Armcc
// Brief     :  System functions
//============================================================================

//-- Includes ----------------------------------------------------------------
#include "system.h"

//============================================================================
void SystemInit(void)
//============================================================================
{
  // no initialization required
}

//============================================================================
void DelayMicroSeconds(u32t nbrOfUs)
//============================================================================
{
  u32t i;
  for(i = 0; i < nbrOfUs; i++)
  {
    __nop();  // nop's may be added or removed for timing adjustment
    __nop();
    __nop();
    __nop();
  }
}
```

```
  1  //===========================================================================
  2  //    S E N S I R I O N   AG,  Laubisruetistr. 50, CH-8712 Staefa, Switzerland
  3  //===========================================================================
  4  // Project   :  SF05 Sample Code (V1.1)
  5  // File      :  typedefs.h (V1.0)
  6  // Author    :  RFU
  7  // Date      :  07-Nov-2012
  8  // Controller:  STM32F100RB
  9  // IDE       :  µVision V4.60.0.0
 10  // Compiler  :  Armcc
 11  // Brief     :  Definitions of typedefs for good readability and portability.
 12  //===========================================================================
 13
 14  #ifndef TYPEDEFS_H
 15  #define TYPEDEFS_H
 16
 17  //-- Defines ------------------------------------------------------------------
 18  //Processor endian system
 19  //#define BIG ENDIAN   //e.g. Motorola (not tested at this time)
 20  #define LITTLE_ENDIAN  //e.g. PIC, 8051, NEC V850
 21  //===========================================================================
 22  // basic types: making the size of types clear
 23  //===========================================================================
 24  typedef unsigned char   u8t;      ///< range: 0 .. 255
 25  typedef signed char     i8t;      ///< range: -128 .. +127
 26
 27  typedef unsigned short  u16t;     ///< range: 0 .. 65535
 28  typedef signed short    i16t;     ///< range: -32768 .. +32767
 29
 30  typedef unsigned long   u32t;     ///< range: 0 .. 4'294'967'295
 31  typedef signed long     i32t;     ///< range: -2'147'483'648 .. +2'147'483'647
 32
 33  typedef float           ft;       ///< range: +-1.18E-38 .. +-3.39E+38
 34  typedef double          dt;      ///< range:            .. +-1.79E+308
 35
 36  //typedef bool            bt;       ///< values: 0, 1 (real bool used)
 37
 38  typedef union {
 39    u16t u16;               // element specifier for accessing whole u16
 40    i16t i16;               // element specifier for accessing whole i16
 41    struct {
 42      #ifdef LITTLE_ENDIAN  // Byte-order is little endian
 43      u8t u8L;              // element specifier for accessing low u8
 44      u8t u8H;              // element specifier for accessing high u8
 45      #else                 // Byte-order is big endian
 46      u8t u8H;              // element specifier for accessing low u8
 47      u8t u8L;              // element specifier for accessing high u8
 48      #endif
 49    } s16;                  // element spec. for acc. struct with low or high u8
 50  } nt16;
 51
 52  typedef union {
 53    u32t u32;               // element specifier for accessing whole u32
 54    i32t i32;               // element specifier for accessing whole i32
 55   struct {
 56      #ifdef LITTLE_ENDIAN  // Byte-order is little endian
 57      u16t u16L;            // element specifier for accessing low u16
 58      u16t u16H;            // element specifier for accessing high u16
 59      #else                 // Byte-order is big endian
 60      u16t u16H;            // element specifier for accessing low u16
 61      u16t u16L;            // element specifier for accessing high u16
 62      #endif
 63    } s32;                  // element spec. for acc. struct with low or high u16
 64  } nt32;
 65
 66  #endif
 67
```