Introduction

This document describes how to use the following I\textsuperscript{2}C optimized examples:

- Hardware configuration example of a common I\textsuperscript{2}C bus
- Master firmware examples in polling mode
- Master firmware examples with interrupt
- Slave firmware examples.

Reference documents

- I\textsuperscript{2}C-bus specification, version 2.1, January 2000, NXP
- STM8S series and STM8AF series 8-bit microcontrollers reference manual (RM0016)
- STM8L051/L052 Value Line, STM8L151/L152, STM8L162, STM8AL31, STM8AL3L MCU lines reference manual (RM0031)
- STM8L101xx microcontroller family reference manual (RM0013)
- STM8TL5xxx microcontroller family reference manual (RM0312).
Contents

1 Hardware configuration example of a common I²C bus .......................... 5
2 Software of I²C firmware examples ..................................................... 6
3 Master firmware examples in polling mode ......................................... 7
   3.1 Application layer example in polling mode ...................................... 7
   3.2 Data link layer example in polling mode ...................................... 7
       3.2.1 Functions predefined to control the data flow on master firmware
                in polling mode (to be customized) ...................................... 7
4 Master firmware examples with interrupt ........................................... 14
   4.1 Master application layer example with interrupt .............................. 14
   4.2 Master data link layer example with interrupt .............................. 14
       4.2.1 Functions predefined to control the data flow on master firmware
                with interrupt (to be customized) ...................................... 14
5 Slave firmware examples with interrupt ............................................ 18
   5.1 Slave application layer example with interrupt .............................. 18
   5.2 Slave data link layer example with interrupt .............................. 18
       5.2.1 Functions predefined to control the data flow on slave firmware
                with interrupt (to be customized) ...................................... 18
   5.3 Data link layer flowchart ......................................................... 21
6 Revision history ................................................................. 22
List of tables

Table 1. Document revision history ........................................ 22
List of figures

Figure 1. Hardware configuration example of a common I²C bus ............................................. 5
Figure 2. N-data byte write sequences preceded by a one-command byte .................................... 8
Figure 3. One-datum or command byte write sequence .......................................................... 8
Figure 4. Flowchart of data-write sequences made by the I²C_WriteRegister() function .................. 9
Figure 5. N-data byte read sequences preceded by a one-command byte .................................... 10
Figure 6. N-data byte random read sequences (without any command) ..................................... 11
Figure 7. Flowchart of data read sequences made by the I²C_RandomRead() function ................. 12
Figure 8. I²C state machine flowchart .................................................................................... 16
Figure 9. Data link layer flowchart ......................................................................................... 21
1 Hardware configuration example of a common I²C bus

The firmware examples provided within this application note illustrate the basics of the I²C communication protocol on the STM8 microcontrollers. In these examples, the I²C peripheral is used to communicate between two STM8 devices.

The I²C can also be reused and customized to fit a specific application which requires an I²C communication with another device using the I²C protocol. In these examples, the master and slave work together and transmit data through the bus.

At all times, the I²C protocol is respected (see the I²C-bus specification). Figure 1 shows the hardware configuration that must be followed.

Figure 1. Hardware configuration example of a common I²C bus

Legend:
- VCC = supply voltage, typically ranging from 1.8 V to 5 V
- SDA = Serial data (I²C data line)
- SCL = Serial clock (I²C clock line)
- Rp1, Rp2 = Pull-up resistor used to set the bus idle voltage to VCC. Also called the I²C termination.
- Rs1, Rs2 = Optional 100 Ohm serial resistor used to ease differentiation between master and slave when analyzing communication waveforms on the oscilloscope. These resistors must be placed on one extremity of the bus (on the master or slave side).
2 Software of I²C firmware examples

The software of all I²C firmware examples is divided into two basic levels:

- **An application layer** (main.c) - which is an example of how to implement all the I²C procedures. It must be replaced by the user code in the final application.

- **A data link layer** (I2C_xxx.c) - which manages the data flow process and hardware control. The user should not change the software at this level. All processes at data link level are managed by a set of predefined functions contained in the data link layer. These functions are called from the application level.
3  Master firmware examples in polling mode

3.1 Application layer example in polling mode

This layer simulates an I²C memory access with an offset command. It should be used with the example of the provided I²C slave.

After peripheral initialization, the program runs in a testing loop. This sends a succession of bytes to be stored in the slave memory and then reads them back. After each loop, all sent and received values are compared for integrity checking purposes. The first byte of every message is used as a memory offset command for the data storage register.

All read and write procedures performed on the I²C bus are managed by calling dedicated functions from the data link layer. Their execution times are guarded by a timeout which is serviced by a dedicated timer. This timeout is reset at the start of every testing loop and is checked at the end of every loop. If the timer counter reaches 0, it means that one I²C communication is stuck.

3.2 Data link layer example in polling mode

All I²C activities of the data link layer (except errors) are performed and checked by polling. Errors are handled by the I²C interrupt service. The specific functions for I²C flow control are predefined in this part of the firmware. They are called by the application layer to control all I²C processes and they can be customized by the user according to the application needs.

The address of the slave is fixed in form of a compilation parameter. These procedures follow specific processes which cover all the known I²C errata issues (see Figure 4 and Figure 7).

3.2.1 Functions predefined to control the data flow on master firmware in polling mode (to be customized)

I²C_WriteRegister function

This function sends an offset/command byte followed by a defined number of data bytes from a specific data field. This function can also be used to send one byte if it is called with zero number of data bytes. In the example in Figure 2, the first (command) byte is interpreted as an offset from which data is stored in the slave device.

Prototype

```c
void Function I2C_WriteRegister (u8 offset_command, u8 number_of_data_bytes, u8 *data_field_address).
```

Parameters

- offset_command: first byte to send during communication. Can be used as offset, command, or first datum.
- number_of_data_bytes: number of bytes to be sent. Value from 0 to 255.
- *data_field_address: pointer to first address of data to be sent.
Return value

None.

Figure 2. N-data byte write sequences preceded by a one-command byte

<table>
<thead>
<tr>
<th>7-bit address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
</tr>
<tr>
<td>Slave</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10-bit address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
</tr>
<tr>
<td>Slave</td>
</tr>
</tbody>
</table>

1. Legend: S = start, P = stop, H = high, L = low

Figure 3. One-datum or command byte write sequence

<table>
<thead>
<tr>
<th>7-bit address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
</tr>
<tr>
<td>Slave</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10-bit address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
</tr>
<tr>
<td>Slave</td>
</tr>
</tbody>
</table>

1. Legend: S = start, P = stop, H = high, L = low
Figure 4. Flowchart of data-write sequences made by the I2C_WriteRegister() function

1. Legend: SB = start bit, RW = read/write bit
I2C_ReadRegister function

This function sends one byte (offset_command value) to the slave. It then restarts the bus and continues communication by reading a defined number of data bytes. Bytes are stored in a specific data field starting from a specified address. The offset_command value depends on the slave device interpretation. In this example, it is used as a memory offset. It can be used in other applications as a command for specific I2C peripherals.

Prototype

void Function I2C_ReadRegister (u8 offset_command, u8 number_of_data_bytes, u8 *data_field_address).

Parameters

- offset_command: first byte to send during communication. Can be used as offset, command, or first datum.
- number_of_data_bytes: number of bytes to read. Value from 0 to 255.
- *data_field_address: pointer to first address of data to store received data.

Return value

None.

Figure 5. N-data byte read sequences preceded by a one-command byte

1. Legend: S = start, P = stop, H = high, L = low
2. Stop is not mandatory in this sequence and can be skipped by defining the “NO_RESTART” constant in the driver header file (I2C_master_poll.h).
**I2C_RandomRead function**

This function reads directly the requested data from the slave. No offset or command byte is written previously. It can be used as a standard or continuous read (where auto-incrementation of addresses is available on the slave side). Received bytes are stored in data fields starting from specified data field addresses.

**Prototype**

```c
void Function I2C_RandomRead (u8 number_of_data_bytes, u8 *data_field_address).
```

**Parameters**

- `number_of_data_bytes`: number of bytes to read. Value from 0 to 255.
- `*data_field_address`: pointer to first address to store received data.

**Return value**

None.

---

**Figure 6. N-data byte random read sequences (without any command)**

1. Legend: S = start, P = stop, H = high, L = low
Figure 7. Flowchart of data read sequences made by the I2C_RandomRead() function

1. Legend: SB = start bit, RW = read/write bit
The I²C read register function is the succession of one I²C write register function call and one I²C random read function call (see Figure 4: Flowchart of data-write sequences made by the I2C_WriteRegister() function and Figure 7: Flowchart of data read sequences made by the I2C_RandomRead() function).
4 Master firmware examples with interrupt

4.1 Master application layer example with interrupt

The function and purpose of this layer is the same as for polling mode. After peripheral initialization, the program stays in a testing loop. This sends a succession of bytes to be stored into the slave memory and then reads back from the slave. After each loop, all sent and received values are compared for integrity checking purposes. For more details, please refer to Section 3.1: Application layer example in polling mode.

4.2 Master data link layer example with interrupt

All I²C activities of the data link layer are handled by the I²C interrupt service. This interrupt routine is managed by the internal state machine (see Figure 8 on page 16). The procedures included in this flowchart follow specific processes which cover all known I²C errata issues (see Figure 4 on page 9 and Figure 7 on page 12).

It is highly recommended not to change this layer to ensure that the application handles specific states on the I²C bus. The specific functions for I²C flow control are predefined in this part of the firmware. They are called by the application layer to control all I²C processes and can be customized by the user according to the application needs.

4.2.1 Functions predefined to control the data flow on master firmware with interrupt (to be customized)

I2C_WriteRegister function

This function sets up and starts the state machine to perform an I²C write process. It returns 1 when the process is started or 0 when the peripheral or line is busy.

Prototype

u8 I2C_WriteRegister (u16 SlaveAdd, u8 AddType, u8 NoStop, u8 NumByteToWrite, u8 *DataBuffer).

Parameters

- SlaveAdd: unsigned short number address of the slave.
- AddType: 7-bit (SEV_BIT_ADDRESS) or 10-bit addressing (TEN_BIT_ADDRESS).
- NoStop: stop is/is not performed after the transmission (STOP; NOSTOP).
- NumByteToWrite: number of bytes to be sent.
- DataBuffer: first data buffer address.

Return value

- 0 is returned if the write process is not started due to other I²C operations.
- 1 is returned if the write process is started.
I2C_ReadRegister function

This function sets up and starts the state machine to perform an I2C read process. It returns 1 when the process is started or 0 when the peripheral or line is busy.

Prototype

u8 I2C_ReadRegister(u16 SlaveAdd, u8 AddType, u8 NoStop, u8 NumByteToRead, u8 *DataBuffer);

Parameters

• SlaveAdd: unsigned short number address of the slave.
• AddType: 7-bit (SEV_BIT_ADDRESS) or 10-bit addressing (TEN_BIT_ADDRESS).
• NoStop: stop is/is not performed before the transmission (used for 10-bit addressing. mode when the complete address or header is sent depending on the STOP or NOSTOP flag).
• NumByteToRead: number of bytes to be received.
• DataBuffer: first data buffer address.

Return value

• 0 is returned if the read process is not started due to other I2C operations.
• 1 is returned if the read process is started.

ErrProc function

This function is called from I2C interrupt routines each time an error is detected. It can be customized according to the application needs.

Prototype

void ErrProc (void).

Parameters

None.

Return value

None.
Figure 8. $I^2$C state machine flowchart

1. Legend: SB = start bit, W = write, R = read

2. The text in blue indicates the parts of this State machine which must be protected from interrupt by software disabling (see the device errata sheet).

Note: For a 10-bit address random read, a WriteRegister function call (without data and STOP) should be performed before a ReadRegister function call.
Example

// Send 10-bit slave address
I2C_WriteRegister (0x3F0,TEN_BIT_ADDRESS,NOSTOP,0,Buff);

// Read data from slave
I2C_ReadRegister (0x3F0,TEN_BIT_ADDRESS,STOP,3,Buff);
5 Slave firmware examples with interrupt

5.1 Slave application layer example with interrupt

This layer simulates an I\(^2\)C memory with an offset command example. The first datum received is interpreted as a command (memory offset). Interaction with the data link layer is made using specific customizable callback functions (see Section 5.2.1: Functions predefined to control the data flow on slave firmware with interrupt (to be customized)). These functions can be modified depending on the application needs.

5.2 Slave data link layer example with interrupt

All I\(^2\)C activities of the data link layer are handled by the I\(^2\)C interrupt service. All procedures in this interrupt service follow specific processes which cover all known I\(^2\)C errata issues (see Figure 4 and Figure 7). It is highly recommended not to change this layer to ensure that the application handles specific states on the I\(^2\)C bus.

5.2.1 Functions predefined to control the data flow on slave firmware with interrupt (to be customized)

I\(^2\)C_transaction_begin

This function is called every time a transaction with the slave begins (slave address recognized).

Prototype

void I2C_transaction_begin (void).

Parameters

None.

Return value

None.
**I2C_transaction_end**
This function is called every time a transaction with the slave ends (stop or Nack detected).

*Prototype*
void I2C_transaction_end (void).

*Parameters*
None.

*Return value*
None.

**I2C_byte_received**
This function is called every time a byte is received by the I2C peripheral. This example stores data in the memory.

*Prototype*
void I2C_byte_received (u8 u8_RxData).

*Parameters*
None.

*Return value*
None.

**I2C_byte_write**
This function is called every time a byte needs to be sent. It must return a u8 value which corresponds to the byte to be written on the I2C line. In this example, the function returns selected stored data from the memory.

*Prototype*
u8 I2C_byte_write(void).

*Parameters*
None.

*Return value*
To be customized according to the application needs. The returned value is the datum which is written on the I2C line.
**ErrProc function**

This function is called from the I²C interrupt routines each time an error is detected. It can be customized according to the application needs.

**Prototype**

void ErrProc (void).

**Parameters**

None.

**Return value**

None.
5.3 Data link layer flowchart

Figure 9. Data link layer flowchart
6 Revision history

Table 1. Document revision history

<table>
<thead>
<tr>
<th>Date</th>
<th>Revision</th>
<th>Changes</th>
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<td>20-Oct-2010</td>
<td>1</td>
<td>Initial release</td>
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<tr>
<td>20-Nov-2012</td>
<td>2</td>
<td>Document updated to include STM8AL and STM8TL5 devices.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Added Table 1: Applicable products.</td>
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<tr>
<td></td>
<td></td>
<td>Updated Reference documents.</td>
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<tr>
<td>09-May-2016</td>
<td>3</td>
<td>Modified Figure 8 and Figure 9.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Added Section 5: Slave firmware examples with interrupt.</td>
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