I²C Communication with SMI Protocol-A

1. Description

This document is a reference for a possible coding method to achieve pressure, temperature, and status for SMI part readings using I²C. This SMI Protocol-A is used on but not limited to SMI parts SM9541, SM9543, SM3041, etc. Please check part data sheet for the correct SMI I²C protocol used. For more general information on how to interface using the I²C protocol please refer to http://en.wikipedia.org/wiki/I%C2%B2C. Note that the current example serves as only a "pseudo-code" meaning that it will not work by itself, needs additional work, and is only meant for guidance purposes. Therefore this example may look different depending on which coding language is used.

2. Retrieving data

1: If applicable, include any necessary libraries for I²C communication or other needed protocol with your microcontroller/device.

2: Assign variables and create any setup features.

```
i2cv.pressure    (14 bit Pressure in counts)
i2cv.temperature (11 bit Temperature in counts)
i2cv.status      (2 bit Status)
i2c_byte1
i2c_byte2
i2c_byte3
i2c_byte4
(*ETC*)
```

3: Send I²C initialize command (Initialize I²C bus to set up communication with device)

```
i2c_init();
```

4: Send I^2C start command (Send start I^2C condition to begin communication with device)

```
i2c_start_bus();
```

5: To address and read the SMI sensor, the master must write 8 bits total through I^2C. The 8 bits consist of the device address and a read command. Send the 7 bit I^2C device address command and a least significant bit (LSB) of 1 to tell the master what address to read from. This will give you an 8 bit address with 7 bit part address shifted left and a LSB of 1 added to end of byte. (Please check part data sheet for correct device address.)

```
Device_Read_Byte = (Device Address << 1) + 1;
i2c_write(Device_Read_Byte);
```

6: Read the SMI part at the device address to gather measurements. This can be done by setting the master into a receiving state. 4 bytes will have to be read to gather all measurement information. An acknowledge will have to be sent after each of the first 3 bytes and not acknowledge on the fourth byte to stop transmission.

```
i2c_byte1 = i2c_read_ack();
i2c_byte2 = i2c_read_ack();
i2c_byte3 = i2c_read_ack();
i2c_byte4 = i2c_read_nack();
```

7: Stop bus, this ends communication with bus, this can be a reset if trying to receive multiple readings.

```
stop_i2c_bus();
```

3. Converting Bytes

To collect pressure, temperature, and status, 4 bytes of data have to be read. These bytes will be converted and rearranged to be able to read temperature, pressure, and status of the device. If only 1 or 2 of the 3 device output values are needed, reading less bytes may be sufficient. For example If only pressure is needed, only 2 bytes can be read to obtain the full 14 bit pressure reading. See diagram below in section 3 for more details.

1: Converting Temperature Reading.

Temperature conversion consists of a right-shift of the fourth byte by 5 bits (last 5 bits will not contain any data). Then taking the third byte and shifting it left by 3 bits. This is done by multiplying by 8 ($8 = 2^3$). Adding both these values together achieves an 11 bit temperature reading.

```
i2c_byte4 >>= 5;
i2cv.temperature = (i2c_byte3 * 8) + i2c_byte4;
```

2: Converting Pressure Reading.
Pressure conversion consists of left-shifting the first byte by 8, this can be done by multiplying the first byte by 256 (256 = 2^8), then adding the second byte with eight lower order bits (LSBs) of the full 14 bit pressure reading. A bit-wise AND-operation with $3FFF_{hex}$ is then applied to remove the first two bits that contain part status information by setting those bits to a binary “00”. (If needed further inspect the device data sheet)

```
i2cv.pressure = 0x3fff & ((i2c_byte1 * 256) +
i2c_byte2);
```

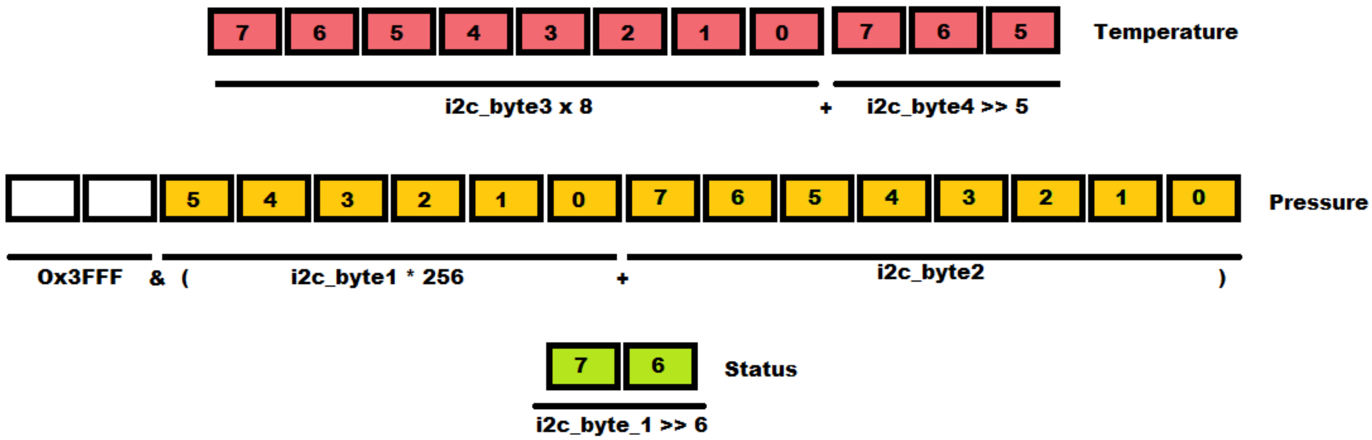
3: Converting Status Reading.
Status conversion consists of a right-shift of the first byte by 6 bits. This will remove pressure data leaving only the relevant two status bits.

```
i2cv.status = i2c_byte_1 >> 6;
```

Below is a visual diagram to aid in the process of converting bytes.

Each color represents a different type of bit. Green bits are Status, yellow bits are Pressure, and red bits are Temperature.

Rearranging these bytes produces 3 outputs, Tempature, Pressure and Status as seen below.



4. Handling of Data

Once the 4 bytes of data have been rearranged and converted, extrapolate the bytes to be able to achieve data values for the device. Use i2cv.temperature and i2cv.pressure count values from the SMI device to calculate actual temperature and pressure values. These calculated values will give temperature in degrees Celsius and pressure in counts or percent full scale (%FS) of the device will need to be converted into unit based values depending on the model number. Refer to data sheet for exact range and limitations of part.

1: Pressure Reading

To convert to pressure in the appropriate pressure unit from the byte counts, a line fit from the target count and pressure values has to be created. Creating a line fit from maximum and minimum device points allows for the extrapolation of data values from all count readings.

min_press	Minimum pressure
max_press	Maximum pressure
min_count	Minimum pressure count reading
max_count	Maximum pressure count reading

Pressure_reading = (((max_press – min_press)/(max_count – min_count))* (**i2cv.pressure** - min_count) + min_press)

For example using the SM9541-100C-S-C-3 and inspecting the corresponding data sheet, the maximum and minimum spec count values can be found. The minimum pressure count of 1638 at 10% of the output range and maximum pressure count of 14745 at 90% of the output range. This results in a FS span of 80% of the output range which is equal to 13107 counts. These minimum and maximum relate to -5 cmH_20 and 100 cmH_20 pressure readings for this part, as found in the data sheet. Assuming you receive a count of 8191 from device, the calculations in $cmH_2 0$ are as follows.

Pressure in $cmH_2 0$ = (100 – (-5))/ (13107 - 1638)* (8191– 1638) + (-5)
Pressure in $cmH_2 0$ = 55

2: Temperature Reading

To convert to temperature from byte counts, use the equation below and evaluate it using the counts of **i2cv.temperature**. The resulting temperature will be in degrees Celsius.

Temperature_reading = (**i2cv.temperature**/ (2^{11}) *200) - 50

Using a count value of 1024 received from the part, the temperature reading of the part can be achieved. The calculations for temperature are as follows.

Temperature in Celsius = (1024/ (2^{11}) *200) - 50
Temperature in Celsius = 50

3: Status Reading

SMI part status consists of 2 bits. These 2 bits gives 4 possible status readings. The 4 status readings are as follows:

00	Normal Operation
01	Command Mode
10	Stale Data
11	Diagnostic condition exists

For additional questions, please consult sales@si-micro.com.

PRESSURE SENSORS

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