

Application Note AN-15.2

I2C Protocol

This Application Note applies to the following
Smate pressure sensors:

Series 52

Version 1.13

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The Sensor Module includes an I²C digital, two-wire interface with a bidirectional data line (SDA) and a clock line (SCL). The two lines are open drain and connected to the supply voltage via two pull-up resistors (Rp). In a system with master-slave configuration, the Sensor Module is the slave.

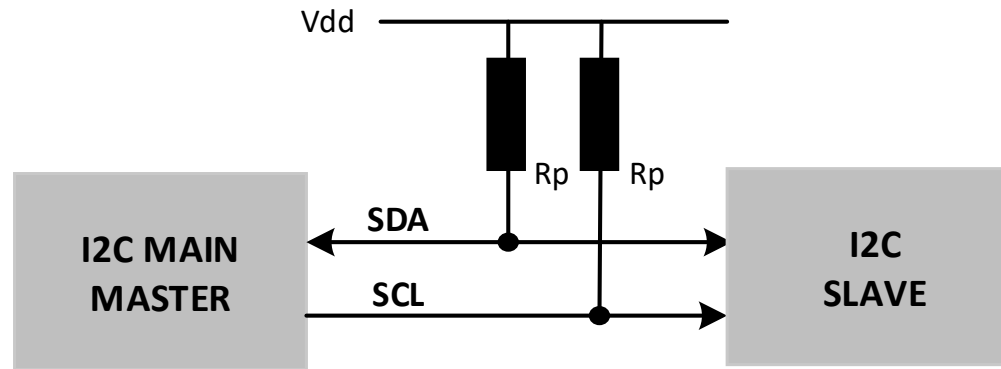


Figure 1: *I²C master-slave configuration*

The recommended pull-up resistor (Rp) values depend on the system implementation, but a value between 2.2k Ω and 10k Ω can be used for prototyping.

The capacitive load on both SDA and SCL should be the same, hence the signal lengths should be similar to avoid asymmetry. It is recommended to use shielded cabled for wire lengths above 10cm and I²C buffers should be used if signal paths are longer than 30cm.

- Read Example(Full Measurement):

Byte#		0								
Send By Master		0x51								
	S	0	1	0	1	0	0	0	1	A
		Address(0x28)							R	

Byte#	0		1		2		3		4		5		6		
Receive From Slave		A	[23:16]	A	[15:8]	A	[7:0]	A	[23:16]	A	[15:8]	A	[7:0]	A	P
	Status		Pressure data						Temperature data						

Command:

0xAA: Measure

0xAC: Oversample-2 Measure

0xAD: Oversample-4 Measure

0xAE: Oversample-8 Measure

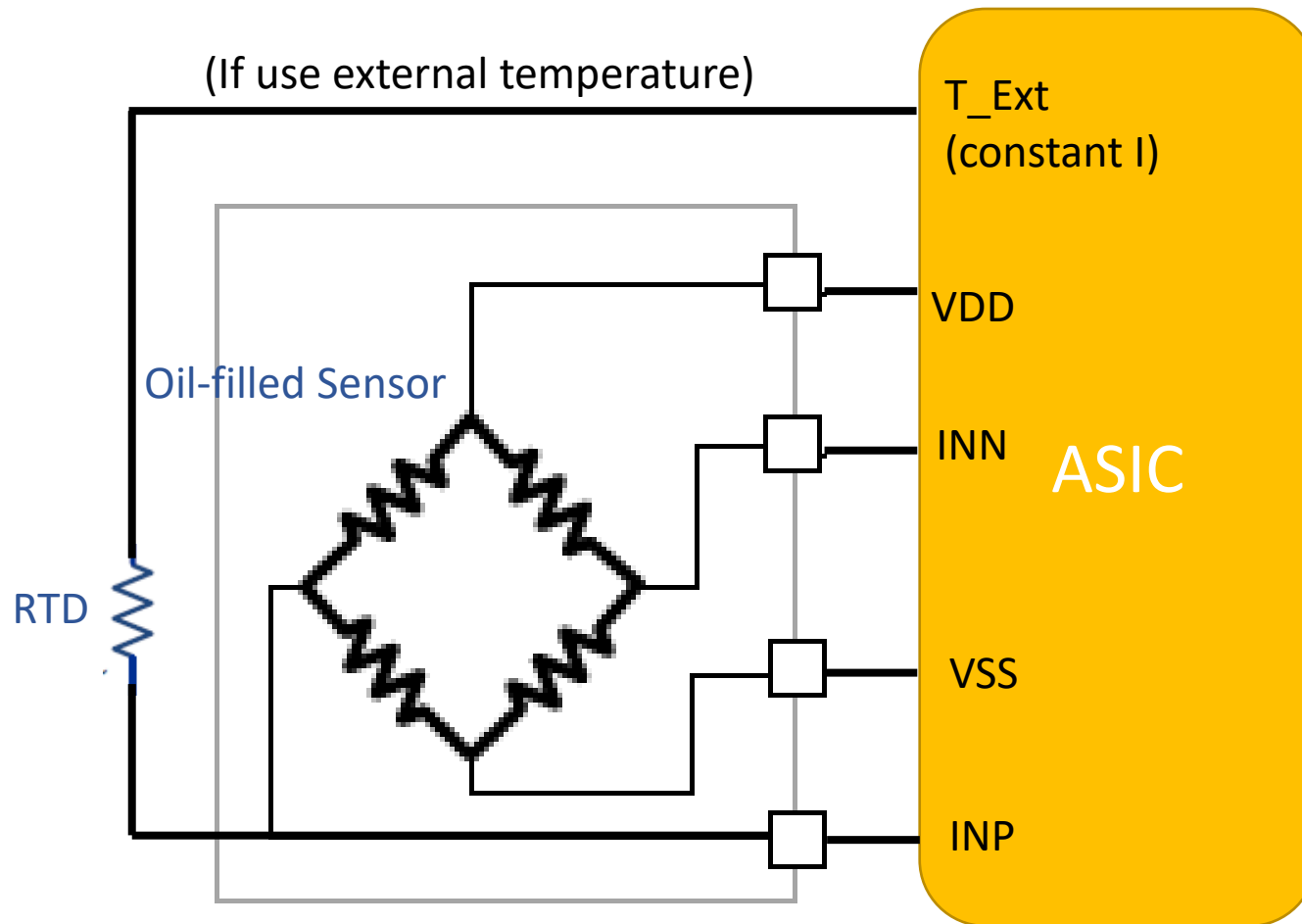
0xAF: Oversample-16 Measure

- S : Start bit
- P : Stop bit
- A : ACK
- W: i2c write mode
- R: i2c read mode
- General Status byte

Status Byte

Bit # →	7	6	5	4	3	2	1	0
Meaning →	0	Power?	Busy?	Mode		Memory Error?	Connection Check Fault?	Math Saturation?

- **Power(bits[6]):** 0 if not powered
- **Busy (bits [5]):** 1, the data for the last command is not available
- **Mode (bits [4:3]) :** 00 = Command Mode, 01 = Cyclic Mode, 10 = Sleep Mode, 11 = reserved
- **Memory Error (bits [2]) :** 1, NVM(EEPROM) is changed unintentionally
- **Connection Check Fault (bits [1]) :** if fault detected, this bit will become 1(need to be enabled)
- **Math Saturation (bits [0]) :** 1 if an SSC-calculation internal saturation occurred



Status byte will become 0b0xxxxx1x
if fault below is detected

Detected Fault
INP Open
INN Open
INP or INN Signals Out of Range
Bridge/Sensor Short (INN=INP)
T_Ext OPEN
T_Ext Out of Range
T_Ext short to INP
T_Ext short to INN
Chip(Asic) crack

Output Conversion

- Conversion equation for “Pressure” :
- 10%~90%(0x199999~0xE66665) is representing 0%FS~100%FS pressure output.
- For example, in case of the rated pressure 100 kPa sensor
- 0 kPa : 11677721 (DEC)→199999(HEX)
- 100 kPa : 15099493 (DEC)→E66665(HEX)

- Conversion equation for “Temperature” :
- 0%~100% is representing -40 deg~125degC.
- Therefore,
- -40 degC : 000000(HEX)
- 125 degC : FFFFFFFF(HEX)

Example

100kPa

- Pressure data : 0x2A3691 (0d2766481)
- Temperature data : 0x892790 (0d8988560)

(24bit→ $2^{24} - 1 = 16777215$)

Pressure

$1717905 / 16777215 = 16.49\%$

$(10.24\% - 10\%) / 80\% * 100\text{kPa} = 8.11 \text{ MPa}$

Temperature

$6809516 / 16777215 = 40.59\%$

$165(\text{degC}) * 53.58\% - 40(\text{degC}) = 26.97 \text{ degC}$

```
// Using Arduino "Wire.h" library to access sensor
int num = 7; // to read 7 bytes from response
define ADDR =0x28; //as default slave address
byte Readbyte[7]; // read buffer

void i2c_command(int num) {
    Wire.requestFrom(ADDR, num);
    for (int i = 0; i < num; i++) {
        Readbyte[i] = 0;
        if (Wire.available()) { // slave may send less than requested
            Readbyte[i] = Wire.read(); // receive a byte as character
        }
        else {
            Readbyte[i] = 0;
        }
    }
}
```

Limitations

The I²C bus is susceptible to noise and can lock up, especially if there are glitches on SCL or the Master does not acknowledge the first byte sent from the Slave.

The following guidelines are best practices for the I²C bus and to avoid lock up:

- Minimize signal length between sensor and microcontroller (< 30cm). Signal lengths over 10cm should be shielded
- Every data read from a Slave should be acknowledged by an ACK from the Master
- It should be possible to hard-reset the sensor should the I²C bus lock up