APPLICATION NOTE

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PMF Series I²C Specification

The information in this document applies to the PMF2000, PMF4000, PMF5000m and PMF6000 series of mass air flow sensors. It is not applicable to the PMF83000 and PMF86000 series.

1 Interface Connection

Posifa Technologies' PMF series mass air flow sensors include 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 (3.3V) via two pull-up resistors (Rp). In a system with a master/slave configuration, the PMF series mass air flow sensor is the slave.

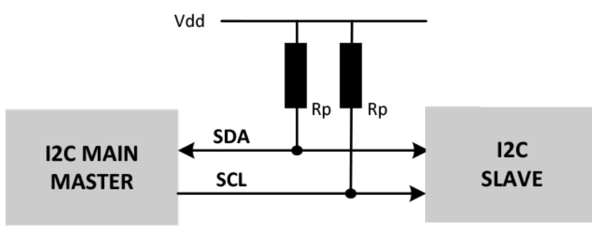

Figure 1: I²C master/slave configuration

The recommended Rp values depend on the system implementation, but a value between 2.2 kΩ and 10 kΩ can be used for prototyping. Please refer to NXP Semiconductor's I²C specification for more information.

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

2 I²C Address

PMF series mass air flow sensors use a 7-bit addressing scheme. The address is always followed by a READ (1) or WRITE (0) bit. The default I²C address for the sensors is 0x50.

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3 I²C Communication

Each I²C transaction consists of a start bit, followed by the 7-bit address and a READ or WRITE bit. At the end of a transmission, a stop bit is sent from the master to terminate the communication. An acknowledgement is expected from the slave in between each byte (8 bits) in a transmission.

3.1 Transmission START Condition (S)

The START condition is used to initiate I²C communication by the master. A HIGH-to-LOW transition on the SDA line, while the SCL is HIGH, indicates the beginning of a transmission.

3.2 Transmission STOP Condition (P)

The STOP condition is used to stop I²C communication by the master. A LOW-to-HIGH transition on the SDA line, while the SCL is HIGH, indicates the end of a transmission. The bus is free after a STOP condition.

3.3 Acknowledge (ACK) / Not Acknowledge (NACK)

The master expects an ACK back from the slave after each byte is transmitted over the I²C bus. The slave pulls the SDA low to indicate that it has received a byte, and then it frees the I²C bus again. If the slave does not initiate an ACK, it is considered a NACK.

3.4 Data Transfer Format

The I²C protocol transfers data in byte packages. Each byte is followed by an ACK from the slave. The most significant bit (MSB) is transmitted first.

The master initiates the communication by sending a START condition, followed by the 7-bit address and a READ/WRITE (R/W) bit. The R/W determines the direction of the transfer: A WRITE is from master to slave and a READ is from slave to master.

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4 Command Set and Data Transfer Sequences

4.1 Read Sensor Data

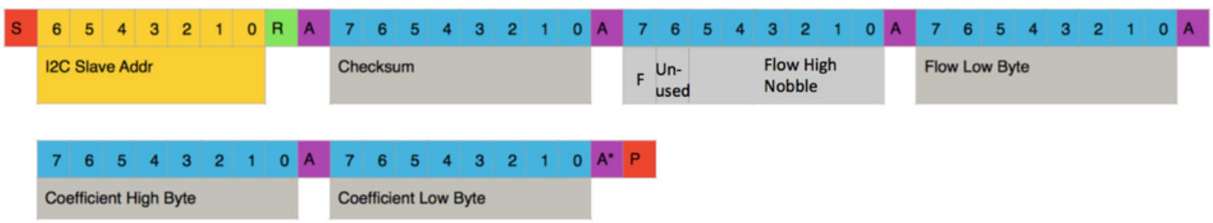

Figure 2: I^2C Read flow sensor data

Reading flow sensor data is initiated by sending the I^2C address followed by a READ bit. The slave will then transmit five bytes, as per Figure 2. The checksum is to ensure data integrity and is described in a following section. Bit F is the red flag. When the flag is cleared (0), the current data is being read for the first time from the I^2C bus. The bit is set (1) after completing the first read operation. Subsequent reads before the output buffer is updated will include the F bit set. The bit will be cleared on the next update of the I^2C output buffer. Updates occur at a 1-ms rate asynchronous to I2C events. A NACK from the master that occurs before the Coefficient Low Byte will result in a reset of the I^2C logic and the device will stay idle (SDA released, pulled HIGH) until the next start bit. The value of the (N)ACK (identified by *) after the Coefficient Low Byte is considered a "Don't Care" value from the device.

4.1.1 Converting Measurement Result to Measured Values

The flow sensor data is converted per the following equation:

Zero flow = 256, Full-scale = 16124

Flow rate = (flow reading – 256) / (16124 – 256) * full-scale flow rate

Flow reading below 256 indicates possible reverse flow. Flow reading above 15868 indicates flow rate exceeding full scale.

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5 Checksum

The checksum used for data integrity is the 2's complement (negative) of the 256-modulo (8-bit) sum of the data bytes (does not include I²C address). This can be calculated using:

checksum = 1 + ~(sum)

Example:

If the I2C payload bytes from a normal read operation are { 0xC9, 0x0B, 0x28, 0x04, 0x00 }, the 256-modulo (8-bit) sum is calculated as:

sum = 0x0B + 0x28 + 0x04 + 0x00 = 0x37

Then the checksum is calculated as:

checksum = 0x01 + ~(0x37) = 0x01 + 0xC8 = 0xC9

Validating the data payload is done by calculating the sum and adding it to the checksum. If the result is 0x00, then the data is valid.

checksum + sum = 0xC9 + 0x37 = 0x00

6 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 in order to avoid lockup:

- Minimize signal length between the sensor and microcontroller (< 30 cm). Signal lengths over 10 cm 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

7 Revision history

Date	Author	Version	Changes
October 2016		0.2	Pre-release