

FS3000

Air Velocity Sensor Module

The FS3000 is a surface-mount type air velocity module that uses a MEMS thermopile-based sensor.

The FS3000 features a digital output with 12-bit resolution. The sensor comprises a "solid" thermal isolation technology and silicon-carbide coating to protect it from abrasive wear and water condensation.

The module features a compact design fit for low profile enclosures.

Features

- Robust "solid" isolation technology
- Resistant to surface contamination
- Resistant to vibration and pressure shock
- Low power application
- Digital output: I²C
- Supply voltage: 3.3V
- Module operating temperature range: -20°C to +85°C
- Module size: 8 x 9 x 4 mm

Applications

- Data center and servers
- HVAC and air control systems
- Laminar flow control systems
- Air filtration and collection systems

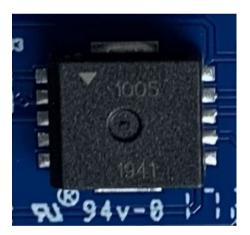


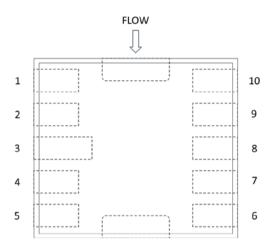
Figure 1. FS3000 Air Velocity Module

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1. Pin Information

1.1 Pin Assignments

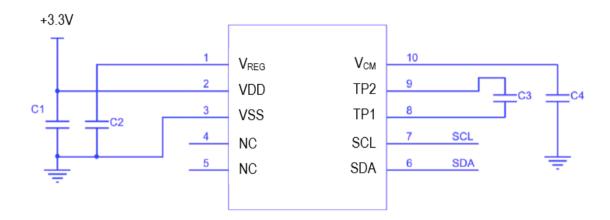


1.2 Pin Descriptions

Table 1. Pin Descriptions

| Pin Number | Pin Name | Туре | Description |
|---|-----------------|-----------------|-------------------------|
| 1 V _{REG} Input | | Input | ADC reference input. |
| 2 V _{IN} Input Supply voltage. | | Supply voltage. | |
| 3 | GND | Ground | Ground. |
| 4 | NC | - | Do not connect. |
| 5 | NC | - | Do not connect. |
| 6 | SDA | Input/Output | Serial data. |
| 7 | SCL | Input | Serial clock. |
| 8 TP1 Input/Output | | Input/Output | Connect with capacitor. |
| 9 | TP2 | Input/Output | Connect with capacitor. |
| 10 | V _{CM} | Output | Common bias. |

2. Application Circuit



Note:

- C1, C2, C3 are 0.1µF capacitors
- C4 is a 1µF capacitor

3. Specifications

3.1 Absolute Maximum Ratings

The absolute maximum ratings are stress ratings only. Stresses greater than those listed below can cause permanent damage to the device. Functional operation of the FS3000 at absolute maximum ratings is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

| Symbol | Parameter | Conditions | Minimum | Maximum | Unit |
|-------------------|---------------------|------------|---------|---------|------|
| V _{IN} | Supply Voltage | - | - | 5.5 | ٧ |
| T _{STOR} | Storage Temperature | - | -40 | 105 | °C |

3.2 Recommended Operating Conditions

| Symbol | Parameter | Minimum | Typical | Maximum | Unit |
|------------------|-------------------------------|---------|---------|---------|------|
| V _{IN} | Supply Voltage [1] | - | 3.3 | - | ٧ |
| T _{AMB} | Ambient Operating Temperature | | - | 85 | °C |

^{1.} Must be regulated; changes in supply voltage will affect accuracy.

3.3 Electrical Characteristics

| Symbol | Parameter | Conditions | Minimum | Typical | Maximum | Unit |
|-------------------|---|--------------------------|-------------------------|---------|---------------------------|-----------|
| I _{VIN} | Current Consumption | - | - | 10 | - | mA |
| _ | Air Flow Range | FS3000-1005 | 0 | | 7.23 | m/sec |
| F _{AIR} | | FS3000-1015 | 0 | - | 15 | |
| V _{out} | Digital Output | Min to Max of Flow Range | 409 | • | 3686 | Count |
| RES | Resolution | - | - | - | 12 | bit |
| E _{AIR} | Flow Accuracy | At 25°C | 1 | 5 | | % of F.S. |
| t _{RESP} | Response Time | - | - | 125 | | ms |
| f _{SCL} | SCL Clock Frequency | - | • | | 400 | kHz |
| V _{IL} | I ² C Input Logic Low Threshold | - | 1 | • | 0.3V _{DD} or 1.5 | V |
| V _{IH} | I ² C Input Logic High Threshold | - | 0.7V _{DD} or 3 | | - | V |
| V _{OL} | I ² C Output Logic Low Threshold | - | - | - | 0.4 | V |

^{1.} m/sec: meter per second.

^{2.} F.S: Full scale flow range.

4. Typical Flow Graphs

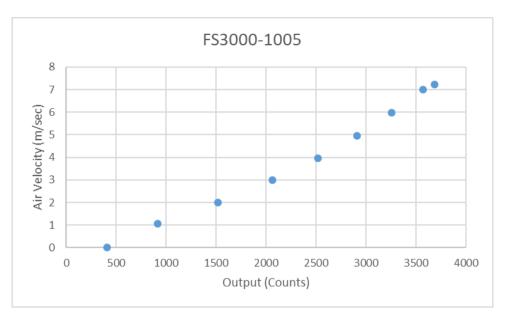


Figure 2. FS3000-1005 Output

| Air Velocity (m/sec) | Output (Count) |
|----------------------|----------------|
| 0 | 409 |
| 1.07 | 915 |
| 2.01 | 1522 |
| 3.00 | 2066 |
| 3.97 | 2523 |
| 4.96 | 2908 |
| 5.98 | 3256 |
| 6.99 | 3572 |
| 7.23 | 3686 |

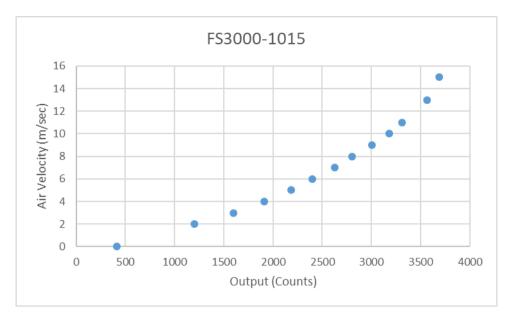


Figure 3. FS3000-1015 Output

| Air Velocity (m/sec) | Output (Count) |
|----------------------|----------------|
| 0 | 409 |
| 2.00 | 1203 |
| 3.00 | 1597 |
| 4.00 | 1908 |
| 5.00 | 2187 |
| 6.00 | 2400 |
| 7.00 | 2629 |
| 8.00 | 2801 |
| 9.00 | 3006 |
| 10.00 | 3178 |
| 11.00 | 3309 |
| 13.00 | 3563 |
| 15.00 | 3686 |

5. Functional Description

5.1 I²C Sensor Interface

The FS3000 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). The FS3000 operates as a slave device on the I²C bus with support of 100kHz and 400kHz bit rates.

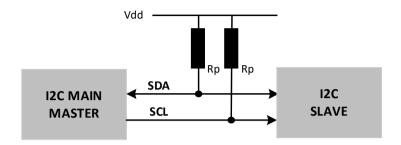


Figure 4. I²C Master-Slave Configuration

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

The capacitive load on both SDA and SCL should be the same; therefore, the signal lengths should be similar to avoid asymmetry.

5.1.1. Sensor Slave Address

The FS3000 default I²C address is 28_{HEX}. The device will respond only to this 7-bit address.

5.1.2. I²C Communication

The START condition is used to initiate I²C communication by the master. The sensor transmission is initiated when the master sends a 0 START bit (S). A HIGH-to-LOW transition on the SDA line while the SCL is HIGH indicates the beginning of a transmission.

The STOP condition is used to stop I²C communication by the master. The transmission is terminated when the master sends a 1 STOP bit (P). A LOW-to-HIGH transition on the SDA line while the SCL is HIGH indicates the end of a transmission.

All transfers consist of 8 bits and a response bit: 0 for Acknowledge (ACK) or 1 for Not Acknowledge (NACK). After the ACK is received, another data byte can be transferred or the communication can be stopped with a STOP bit.

The master expects an ACK back from the slave after each byte is transmitted. 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 then it will consider it a NACK.

Data on the SDA line is always sampled on the rising edge of the SCL line and must remain stable while SCL is HIGH to prevent false START or STOP conditions.

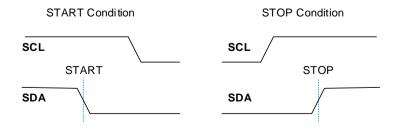


Figure 5. START and STOP Condition Waveform

5.2 Digital Output Measurements

The FS3000 continuously measures during operation. The data is sent in byte packages. Each byte is followed by an ACK from the slave. The most significant bit (MSB) is transmitted first.

To read the data, the following command is sent to the FS3000.

After the START bit, the master device sends the 7-bit slave address followed by an eighth bit = 1 (READ). The READ bit indicates a transmission from the FS3000 (slave) to master (see Figure 6).

The checksum used for data integrity is returned from the FS3000 followed by the two bytes of flow data.

The flow data is a 12-bit integer. Only the least significant four bits in the high byte are valid (see Figure 7).

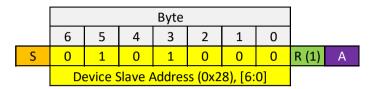


Figure 6. Flow Data Read Command

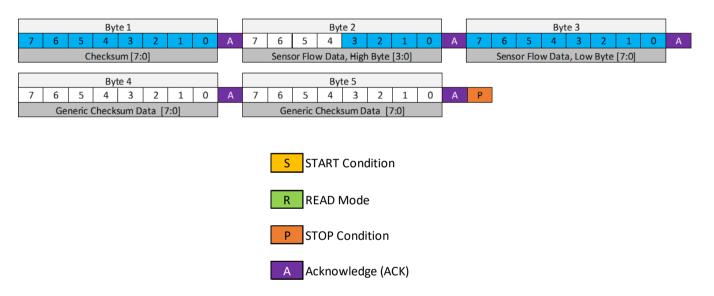


Figure 7. Flow Data from FS3000

5.3 Calculating 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).

Figure 7 shows the 5 bytes read:

Example:

Byte 1, 0xCC (Checksum)

Byte 2, 0x01

Byte 3, 0x99

Byte 4, 0x01 or 0x00

Byte 5, 0x99 or 0x00

The 256-modulo (8-bit) sum is calculated as:

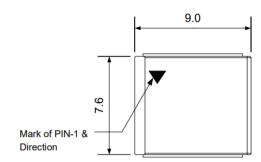
$$sum = 0x01 + 0x99 + 0x01 + 0x99 = 0x134$$

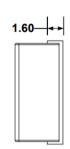
Validating the data payload is done by calculating the sum and adding it to the checksum. If the result is 0x00, then the data is valid.

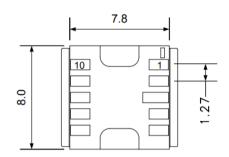
$$checksum + sum = 0xCC + 0x134 = 0x00$$

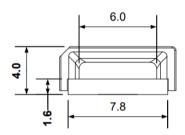
6. Module Drawings

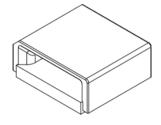
All dimensions are in mm.



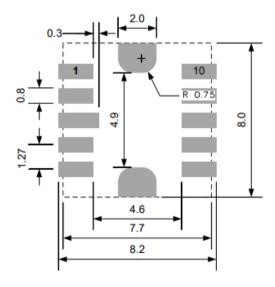








PCB Footprint



7. Ordering Information

| Part Number Description | | MSL Rating | Carrier Type | Temperature Range | |
|--|-----------------------------------|------------|--------------|-------------------|--|
| FS3000-1005 0 to 7 m/sec air velocity module | | 3 | Reel | -20°C to +85°C | |
| FS3000-1015 | 0 to 15 m/sec air velocity module | 3 | Reei | -20 C to +65 C | |

Revision History 8.

| Revision Date 1.01 Feb 6, 2023 1.00 May 31, 2022 | | Description |
|--|--|--|
| | | Corrected module dimension height in Features description on first page. |
| | | Initial release. |

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