FS1015

Air Velocity Sensor Module

The FS1015 mass air velocity module measures the air velocity using the thermo-transfer (calorimetric) principle.

The FS1015 offers key advantages over resistor-based flow solutions. The sensor uses thermopile sensing, which provides an excellent signal-to-noise ratio. The sensor comprises a "solid" thermal isolation technology and silicon-carbide coating to protect it from abrasive wear and provides robustness and long-term reliability.

The FS1015 design allows it to be mounted in a vertical or horizontal position.

Features

- Robust "solid" isolation technology
- Resistant to vibration and pressure shock
- Analog output
- Supply voltage: 5V
- Module operating temperature range: -20°C to +85°C

Applications

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

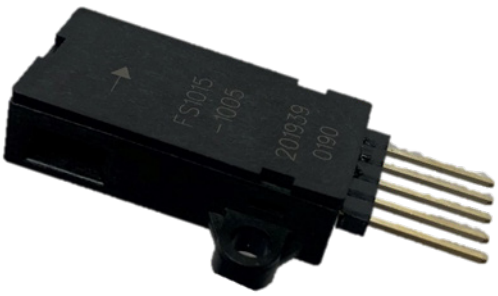


Figure 1. FS1015 Air Velocity Module

Contents

1. Pin Information

1.1 Pin Assignments

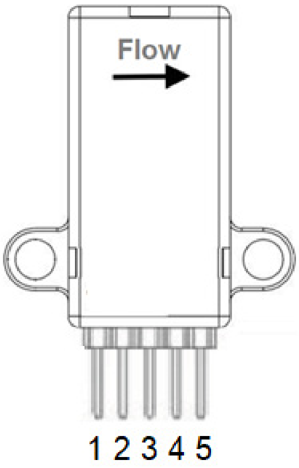


Figure 2. Pin Assignments

1.2 Pin Descriptions

Pin Number	Pin Name	Description
1	V_{IN}	Supply voltage
2	GND	Ground
3	V_{OUT}	Analog Output
4	SDA	Serial Data
5	SCL	Serial Clock

2. Specifications

2.1 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 FS1015 at absolute maximum ratings is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

Table 1. Absolute Maximum Ratings

Symbol	Parameter	Conditions	Minimum	Maximum	Unit
V_{IN}	Supply Voltage			5.5	V
T_{STOR}	Storage Temperature		-20	85	°C

2.2 Recommended Operating Conditions

The FS1015 is optimized for operating at 5V in room temperature. A regulated 5V supply voltage must be used to conform to the output curves provided. Variations in the supply voltage will result in a slightly different output curve.

Table 2. Recommended Operating Conditions

Symbol	Parameter	Minimum	Typical	Maximum	Unit
V_{IN}	Supply Voltage		5.0		V
T_{AMB}	Ambient Operating Temperature	-20		85	°C

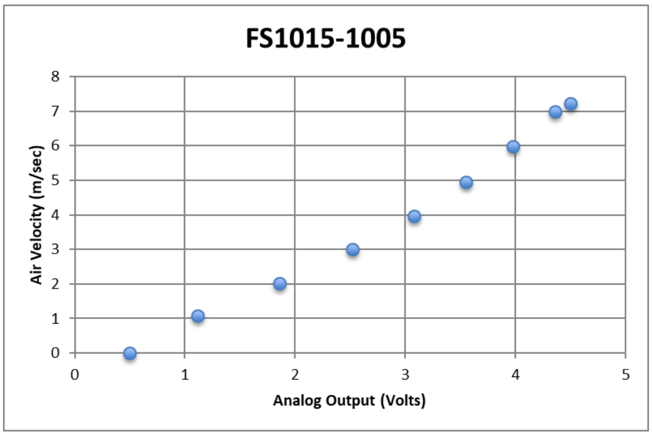
2.3 Electrical Characteristics

Table 3. Electrical Characteristics

Symbol	Parameter	Conditions	Minimum	Typical	Maximum	Unit
I_{VIN}	Current Consumption			22		mA
F_{AIR}	Air Flow Range	FS1015-1005	0		7.23	meter/ sec
		FS1015-1015	0		15	
V_{AOUT}	Analog Voltage Output	Min to Max of Flow Range	0.5		4.5	V
V_{DOUT}	Digital Output	Min to Max of Flow Range	409		3686	Counts
E_{AIR}	Flow Accuracy	At 25°C		5		% of F.S.[1]
t_{RESP}	Response Time			125		ms
f_{SCL}	SCL Clock Frequency				400	kHz
V_{IL}	I2C Input Logic Low Threshold				$0.3V_{DD}$ or 1.5	V
V_{IH}	I2C Input Logic High Threshold		$0.7V_{DD}$ or 3			V
V_{OL}	I2C Output Logic Low Threshold				0.4	V

1. F.S: Full scale flow range.

3. Typical Flow Graphs



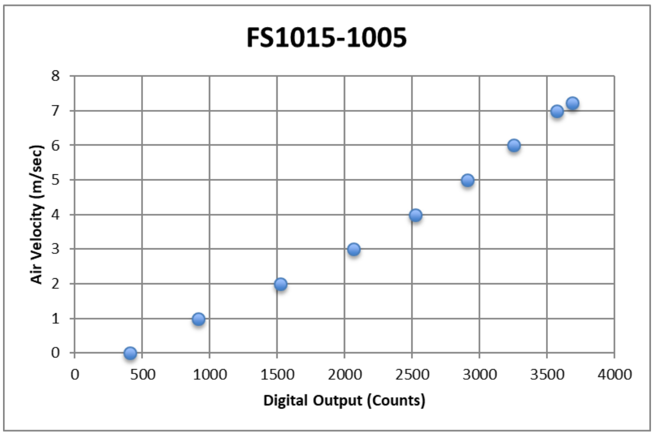


Figure 3. FS1015-1005 Air Velocity Curve

Air Velocity (meter/sec)	Analog Output (Volt)	Digital Output (Count)
0	0.50	409
1	1.12	915
2	1.86	1522
3	2.52	2066
4	3.08	2523
5	3.55	2908
6	3.98	3256
7	4.36	3572
7.23	4.50	3686

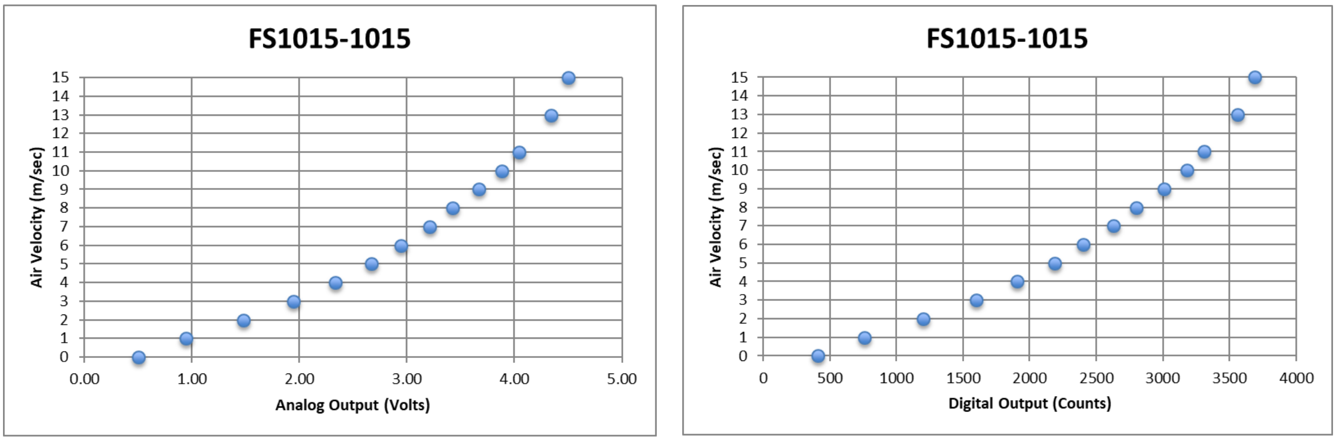


Figure 4. FS1015-1015 Air Velocity Curve

Air Velocity (meter/sec)	Analog Output (Volt)	Digital Output (Count)
0	0.50	409
1	0.95	760
2	1.48	1203
3	1.95	1597
4	2.33	1908
5	2.67	2187
6	2.94	2400
7	3.21	2629
8	3.43	2801
9	3.67	3006
10	3.88	3178
11	4.04	3309
13	4.34	3563
15	4.50	3686

4. I2C Sensor Interface

The FS1015 includes a digital I2C 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 using two pull-up resistors (Rp). The FS1015 operates as a slave device on the I2C bus with support for 100kHz and 400kHz bit rates.

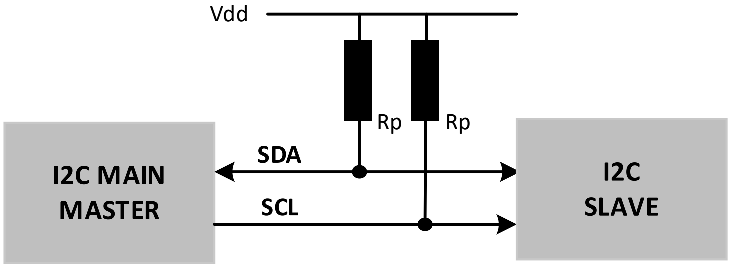


Figure 5. I2C Master-Slave Configuration

The recommended pull-up resistor (Rp) values depend on the system implementation, but a value between 2.2kΩ and 10kΩ 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.

4.1 Sensor Slave Address

The FS1015 default I2C address is 50_{HEX}. The device will respond only to this 7-bit address.

4.2 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 6. START and STOP Condition Waveform

4.3 Digital Output Measurements

The FS1015 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 FS1015.

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 FS1015 (slave) to master (see Figure 7).

The checksum used for data integrity is returned from the FS1015 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 8).

	Byte								
	6	5	4	3	2	1	0		
S	1	0	1	0	0	0	0	R (1)	A
	Device Slave Address (0x50), [6:0]								

Figure 7. Flow Data Read Command

Byte 1									Byte 2									Byte 3								
7	6	5	4	3	2	1	0	A	7	6	5	4	3	2	1	0	A	7	6	5	4	3	2	1	0	A
Checksum [7:0]									Sensor Flow Data, High Byte [3:0]									Sensor Flow Data, Low Byte [7:0]								

Byte 4									Byte 5									
7	6	5	4	3	2	1	0	A	7	6	5	4	3	2	1	0	A	P
Generic Checksum Data [7:0]									Generic Checksum Data [7:0]									

Figure 8. Flow Data from FS1015

S	START Condition
R	READ Mode
P	STOP Condition
A	Acknowledge (ACK)

4.4 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 8 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:

(EQ) 1 $$sum = 0x01 + 0x99 + 0x01 + 0x99 = 0x134$$

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.

(EQ) 2 $$checksum + sum = 0xCC + 0x134 = 0x00$$

5. Package Outline Drawings

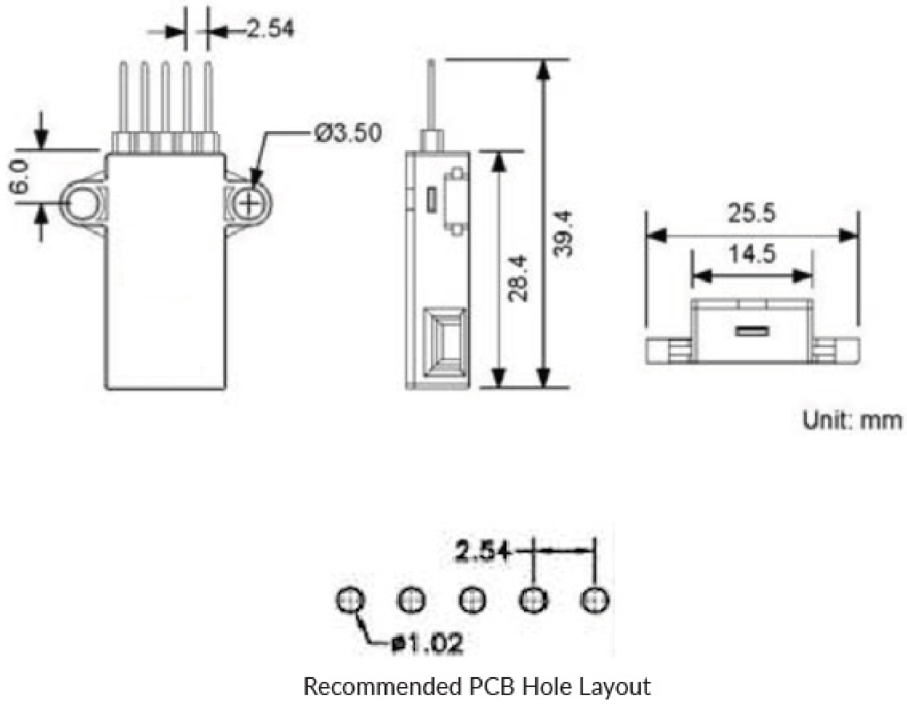


Figure 9. Package Outline Drawings

6. Ordering Information

Part Number	Package Description	Carrier Type	Temperature Range
FS1015-1005	0 to 7 m/sec air velocity module	Box	-20°C to +85°C
FS1015-1015	0 to 15 m/sec air velocity module	Box	

7. Revision History

Revision	Date	Description
1.00	Jun 2, 2022	Initial release.

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