Air Velocity Digital Sensor

BM62S2301-1

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Features

- Air velocity range: 0~15m/s
- Accurate air velocity sensor
  - Resolution: 12-bit
  - Accuracy: 5% R.D.+ 0.1m/s
- Operating Voltage: 3.3V
- Communication Interface: I²C
- Zero point and full scale factory-calibrated
- The sensor is sturdy and durable and has no movable parts

General Description

The BM62S2301-1 is a sensor which uses the thermal flow sensor chip to measure the air velocity. The chip uses a pair of internal thermopiles to detect blowing rate caused temperature gradient changes, which has high sensitivity. The sensor uses the advanced MEMS chip semiconductor technology, which makes the sensor more sturdy and durable, able to avoid blockage and resist pressure impact.

In communication and applications, this module uses standard I²C communication to provide 12-bit high accuracy digital output, suitable for applications such as HVAC devices and blockage detection.

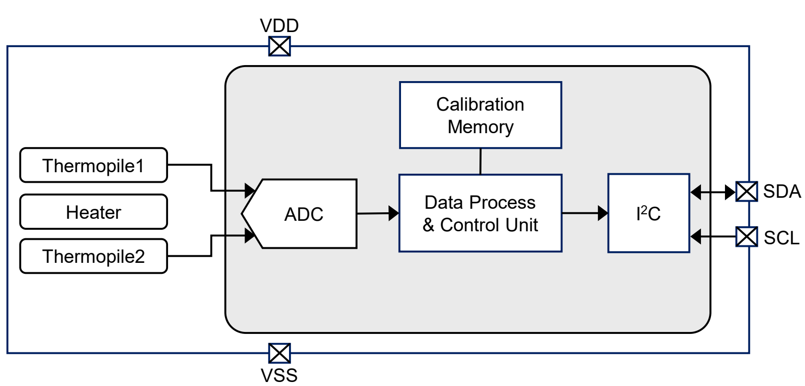
Applications

- Air filtration system
- HVAC control system
- Server blockage detection system
- Data center heat dissipation management system

Selection Table

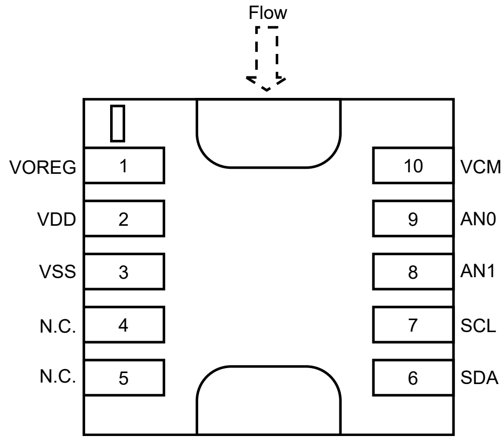
Part No.	Air Velocity Range	Output Signal
BM62S2301-1	0~15m/s	I²C digital output

Block Diagram



Pin Assignment

The BM62S2301-1 pin configuration is shown in the following figure, the sensor size is 9.0×7.6×3.6 (mm).



Top View

Pin Description

Pin No.	Function	Type	Description
1	VOREG	AN	ADC reference input
2	VDD	PWR	Positive power supply
3	VSS	PWR	Negative power supply, ground
4	N.C.	—	Not connected
5	N.C.	—	Not connected
6	SDA	I/O	I^2C data line
7	SCL	I	I^2C clock line
8	AN1	AN	Connect with capacitor
9	AN0	AN	Connect with capacitor
10	VCM	PWR	Common bias

Legend: PWR: Power; I: Digital Input; O: Digital Output; AN: Analog signal.

Absolute Maximum Ratings

Supply Voltage .... V_{SS}-0.3V~V_{SS}+5.5V

Input Voltage .... V_{SS}-0.3V~V_{DD}+0.3V

Storage Temperature........ -40°C~90°C

Operating (Ambient) Temperature .... -5°C~85°C

Operating (Ambient) Humidity........ 5%~95%

Note: These are stress ratings only. Stresses exceeding the range specified under “Absolute Maximum Ratings” may cause substantial damage to the device. Functional operation of the device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect devices reliability.

D.C. Characteristics

Ta=25°C

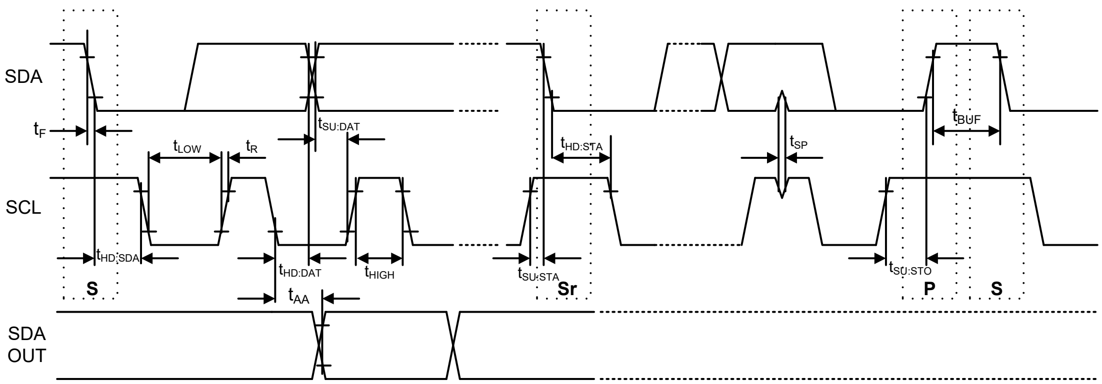
Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V_{DD}	Conditions				
V_{DD}	Supply Voltage	—	—	—	3.3	—	V
I_{DD}	Operating Current	3.3V	Normal operation mode	—	13	—	mA
V_{IL}	Input Low Voltage	5V	—	0	—	1.5	V
		—	—	0	—	$0.2V_{DD}$	V
V_{IH}	Input High Voltage	5V	—	3.5	—	5.0	V
		—	—	$0.8V_{DD}$	—	V_{DD}	V

A.C. Characteristics

I²C Interface Characteristics

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
f_{SCL}	Clock Frequency	—	—	100	—	kHz
t_{BUF}	Bus Free Time	Time in which the bus is free before a new data transmission can start	4.7	—	—	μs
$t_{HD:STA}$	Start Condition Hold Time	After this period, the first clock pulse is generated	4.0	—	—	μs
t_{LOW}	SCL Low Time	—	5.0	—	—	μs
t_{HIGH}	SCL High Time	—	5.0	—	—	μs
$t_{SU:STA}$	Start Condition Setup Time	Only relevant for repeated START condition	4.7	—	—	μs
$t_{HD:DAT}$	Data Hold Time	—	0	—	—	ns
$t_{SU:DAT}$	Data Setup Time	—	250	—	—	ns
t_R	SDA and SCL Rise Time	—	—	—	1	μs
t_F	SDA and SCL Fall Time	—	—	—	0.3	μs
$t_{SU:STO}$	Stop Condition Setup Time	—	4.0	—	—	μs
t_{AA}	Output Valid from SCL Low	—	—	—	3.45	μs
t_{SP}	Input Filter Time Constant (SDA and SCL Pins)	Noise suppression time	—	—	50	ns

Note: These parameters are periodically sampled but not 100% tested.



I²C Timing Chart

Sensor Characteristics

Air Velocity Digital Sensor

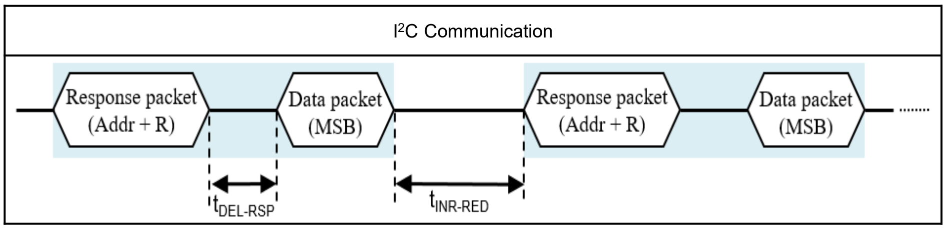
Ta=25°C, V_{DD}=3.3V, unless otherwise specified

Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Digital Output	—	409	—	3686	AD
Resolution	—	—	12	—	bit
Repetitive Accuracy	—	—	1%	—	F.S.
Accuracy	—	—	5% R.D.+0.1m/s	—	—
Response Time	—	—	125	—	ms
Sensor Component Size	—	—	9.0×7.6×3.6	—	mm^2

Timing Specification

Ta=25°C

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$t_{DEL-RSP}$	Response Delay Time	V_{DD}=3.3V	10	—	—	μs
$t_{INR-RED}$	Read Interval Time	V_{DD}=3.3V	5	—	—	ms



I²C Timing Diagram

Functional Description

Air Velocity Detection Principle

The BM62S2301-1 is a digital output air velocity sensor with a measuring range of 0~15m/s and an output value of 409~3686. The air velocity sensor includes a heater and two thermopiles for temperature measurement, which are located in a symmetrical position above and below the heater.

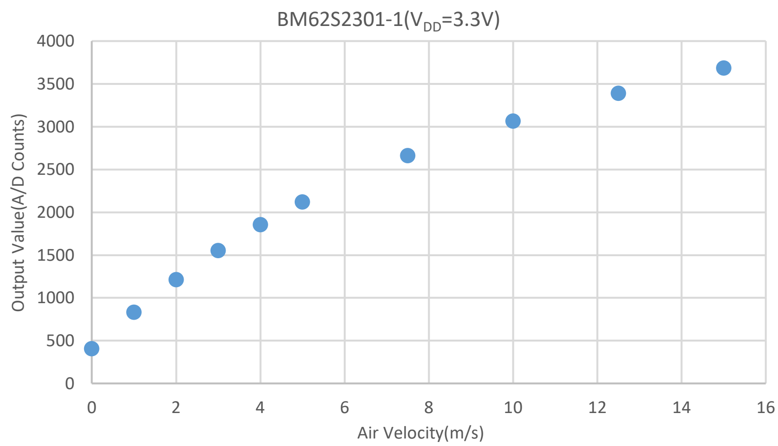
- First, the sensor has a constant current flowing to the heater to generate heat.
- When there is no wind on the sensor surface, the heat distribution around the heater is symmetrical, and the electromotive force of the upstream and downstream thermopiles are equal.
- When there is airflow on the sensor surface, the heat source along with the airflow to the downstream side, the downstream thermopile electromotive force becomes larger. There is a difference between two thermopile output electromotive forces, which is roughly proportional to the air velocity flowing through the heat source.

The BM62S2301-1 provides a standard I²C communication mode, when the Start signal and the Read command are received, the sensor will output an Acknowledge and then send the air velocity data. This sensor is a slave device with two output data modes:

- Air velocity data output mode: Output the sensor air velocity A/D Count data
- Original data output mode: Output the sensor original date and air velocity A/D Count data

Output Curve

Air Velocity Value (m/s)	Output Value (A/D Count)
0	409
1.00	834
2.00	1215
3.00	1554
4.00	1856
5.00	2123
7.50	2664
10.00	3068
12.50	3391
15.00	3686



The BM62S2301-1 outputs the A/D Count values, the master terminal needs to convert them to specific air velocity values (m/s) based on the output curve. The converting mode of the air velocity values are shown below. Take two adjacent points of the output curve as an interval, and approximate the curve as a linear output within the interval. After reading the air velocity A/D Count, find the interval corresponding to that A/D Count and convert it to obtain the specific air velocity value. The specific conversion method is as follows:

Assuming the read A/D Count value is 3000, 3000 is located within the interval between points (7.5, 2664) and (10, 3068)

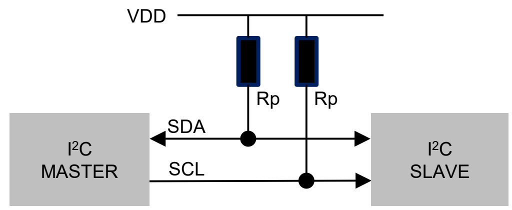
Within this interval, the proportion of duty for 3000 is (3000-2664)/(3068-2664)≈83.2%

The specific air velocity value is: (10-7.5)×83.2%+7.5=9.58m/s

I²C Interface Protocol

I²C Interface Protocol – Interface Connection

The BM62S2301-1 is a slave device for I²C communication, it has a bidirectional data line, SDA, and a unidirectional clock line, SCL, both of which are connected to the power supply voltage via a pull-up resistor (Rp). The resistance value of the pull-up resistor (Rp) ranges from 2.2kΩ to 10kΩ.



I²C Interface Protocol – Slave Address (0x28)

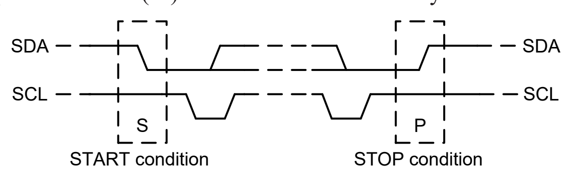
The BM62S2301-1 uses the 7-bit addressing mode. The default slave address is 0x28, and the least significant bit after the address is an R/W bit. If the least significant bit is "0", it indicates that the master writes information to the selected slave. A "1" in this position indicates that the master will read information from the slave.

I²C Interface Protocol – I²C Operation

The master generates a START signal first, and then sends a slave address with an R bit. Wait for the slave to generate an Acknowledge (ACK) signal. When the ACK signal is received, the data will be received. After completing receive the data, the master sends a NACK signal, which indicates that it does not continue to receive data, and then generates a STOP signal to end the transmission process.

I²C Interface Protocol – Start and Stop Signal

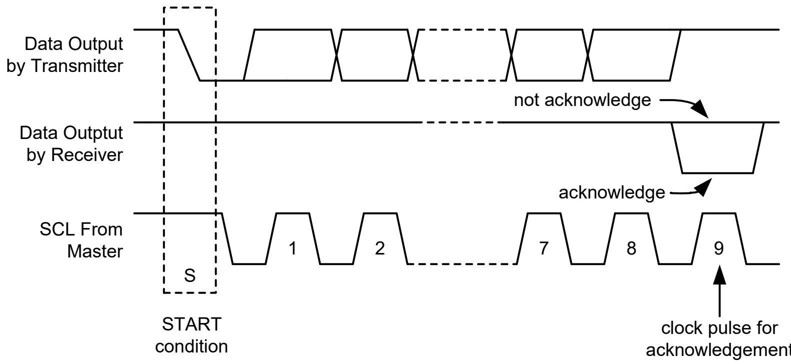
- A high to low transition on the SDA line while SCL is high defines a START condition.
- A low to high transition on the SDA line while SCL is high defines a STOP condition.
- START and STOP conditions are always generated by the master. The bus is considered to be busy after the START condition. The bus is considered to be free again a certain time after the STOP condition.
- The bus remains busy if a repeated START (Sr) is generated instead of a STOP condition. The START(S) and repeated START (Sr) conditions are functionally identical.



I²C Interface Protocol – Acknowledge

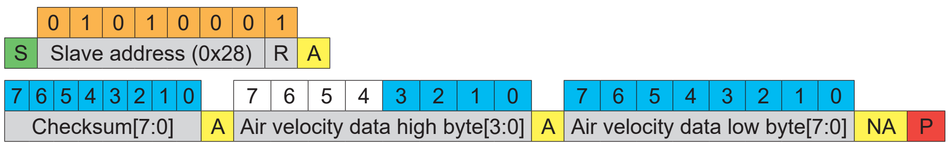
- Each byte of eight bit length is followed by one acknowledge bit. This acknowledges bit is a low level placed on the bus by the receiver. The master generates an extra acknowledge related clock pulse.
- A slave receiver which is addressed must generate an Acknowledge, ACK, after the reception of each byte.
- The device that provides an Acknowledge must pull down the SDA line during the acknowledge clock pulse so that it remains at a stable low level during the high period of this clock pulse.
- A master receiver must signal an end of data to the slave by generating a not-acknowledge, NACK, bit on the last byte that has been clocked out of the slave. In this case, the master receiver

must leave the data line high during the 9th pulse so as to not acknowledge. The master will generate a STOP or a repeated START condition.



I²C Interface Protocol – Data Transfer Format

- Read the sensor air velocity data



S: Start signal

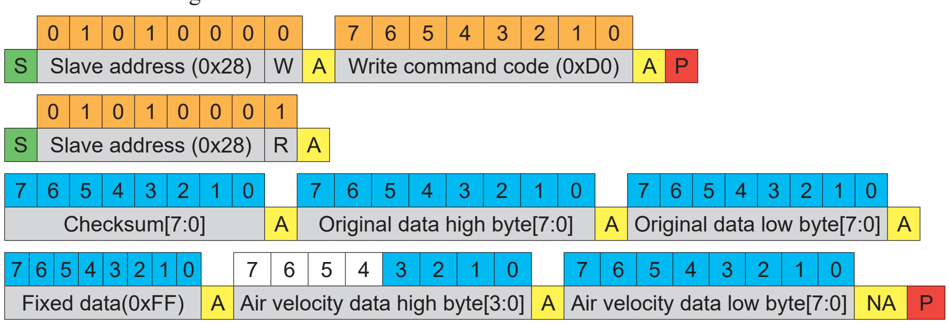
A: ACK bit

NA: NACK bit

P: Stop signal

The BM62S2301-1 continuously measures the air velocity data after power-on. After receiving the Start signal and the Read bit from the master, the BM62S2301-1 will actively send 3-byte data including the checksum to the master.

- Read the sensor original data



S ︰Start signal

A ︰ACK bit

NA ︰NACK bit

P ︰Stop signal

The BM62S2301-1 supports original data output. Before receiving the original data, the master must write the command code (0xD0) first to set the BM62S2301-1 in the original data output mode. In this mode, after receiving the Start signal and the Read bit from the master, the BM62S2301-1 will actively send 6-byte data including the checksum to the master. If the BM62S2301-1 is powered off and restarted, it will return to the air velocity data output mode.

I²C Interface Protocol – Checksum

The Checksum is used to verify the integrity of the data and calculate the checksum of the sensor air velocity data.

The specific calculation is shown below.

Checksum = 1 + ~(Sum)

For example:

- The read sensor air velocity data is:

  0x69(Checksum) + 0x01 + 0x96

  Sum = 0x01 + 0x96 = 0x97

  Checksum = ~(0x97) + 1 = 0x69

- The read sensor original data is:

  0x6A(Checksum) + 0x39 + 0x96 + 0xFF + 0x01 + 0x95

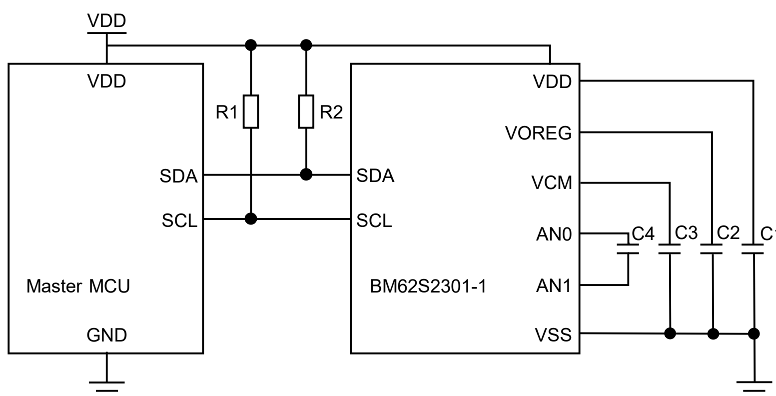
  Sum = 0x01 + 0x95 = 0x96

  Checksum = ~(0x96) + 1 = 0x6A

The following algorithm can also be used to verify the checksum:

Checksum + ~(Sum) = 0x00

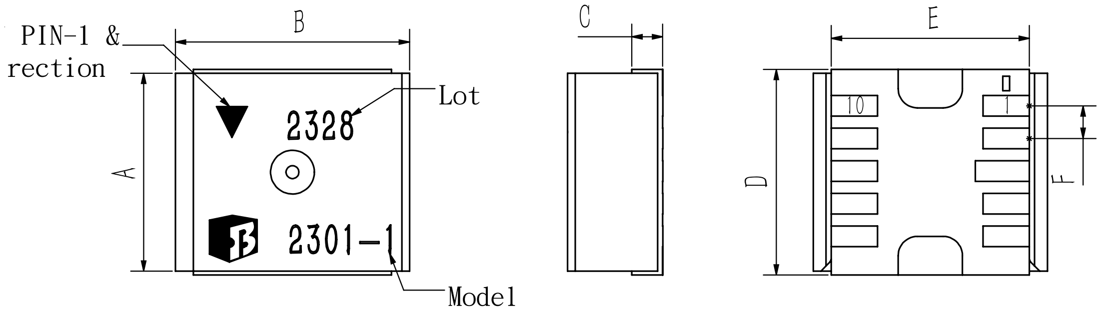
Application Circuits



Note: C1, C3 and C4 are 0.1μF capacitors, C2 is a 1μF capacitor.
R1 and R2 are pull-up resistors, their resistance is generally ranging from 2.2kΩ to10kΩ.

Dimensions

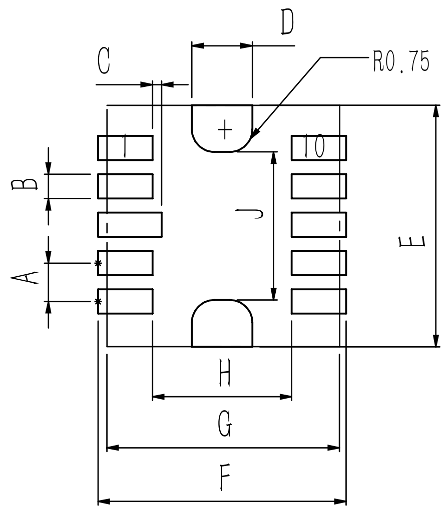
Sensor Outline Dimensions



Symbol	Dimension (mm)		
	Min.	Typ.	Max.
A	—	7.6	—
B	—	9.0	—
C	—	1.2	—
D	—	8.0	—
E	—	7.8	—
F	—	1.27	—
G	—	6.0	—
H	—	3.6	—

Symbol	Dimension (inch)		
	Min.	Typ.	Max.
A	—	0.299	—
B	—	0.354	—
C	—	0.047	—
D	—	0.315	—
E	—	0.307	—
F	—	0.050	—
G	—	0.236	—
H	—	0.142	—

Sensor PCB Dimensions



Symbol	Dimension (mm)		
	Min.	Typ.	Max.
A	—	1.27	—
B	—	0.8	—
C	—	0.3	—
D	—	2.0	—
E	—	8.0	—
F	—	8.2	—
G	—	7.7	—
H	—	4.6	—
J	—	4.9	—

Symbol	Dimension (inch)		
	Min.	Typ.	Max.
A	—	0.050	—
B	—	0.031	—
C	—	0.012	—
D	—	0.079	—
E	—	0.315	—
F	—	0.323	—
G	—	0.303	—
H	—	0.181	—
J	—	0.193	—

Soldering Suggestion

- The BM62S2301-1 has a temperature tolerance of up to 260°C for 30 seconds in reflow furnace.
- The BM62S2301-1 has a maximum temperature tolerance of 350°C in manual soldering, each soldering should not exceed 5 seconds.