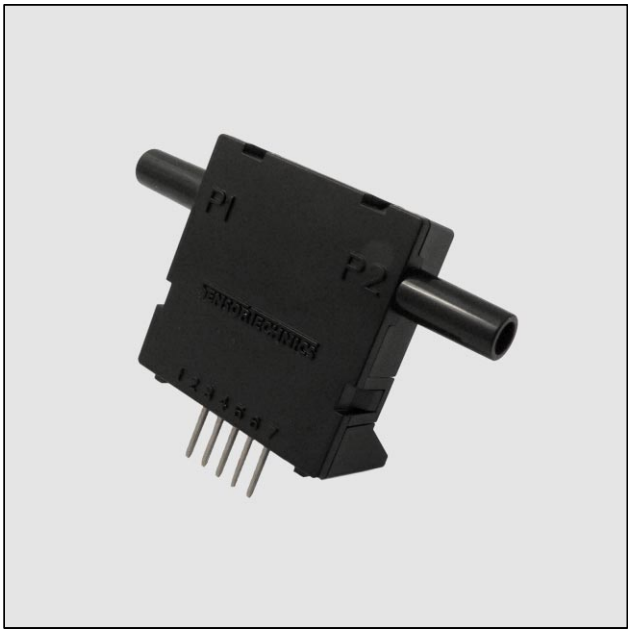
FEATURES

- **Flow ranges 0...200 sccm, 0...±200 sccm, 0...1 slpm, 0...±1 slpm**
- **Thermal mass flow sensing**
- **Digital I²C bus output**
- **RoHS and REACH compliant**
- **Quality Management System according to ISO 13485:2003 and ISO 9001:2008**



MEDIA COMPATIBILITY[7]

To be used with dry gases only.

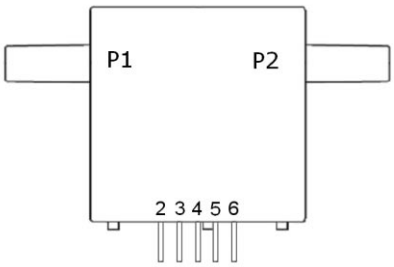
The WBI series is NOT designed for liquid flow and will be damaged by liquid flow through the sensor.

SPECIFICATIONS[6]

Maximum ratings

Supply voltage	2.7 ... 5.5 V
Temperature limits	
Compensated	0 ... 50 °C
Operating	-25 ... 85 °C
Storage	-40 ... 125 °C
Humidity limits (non-condensing)	0 ... 95 %RH
Vibration[1]	20 g
Mechanical shock[2]	30 g

ELECTRICAL CONNECTION



Pin	Connection
2	SDA
3	I / C*
4	+Vs
5	GND
6	SCL

* Internal connection.
Do not connect for any reason

FLOW SENSOR CHARACTERISTICS[7]

(V_S = 5 ±0.01 V, T_A = 20 °C, P_{Abs}= 101.325 kPa)

Part no.	Flow range	Max. flow change	Pressure drop	Max. Common mode pressure
WBIM200DU...	0...200 sccm	5.0 slpm/sec	0.1 mbar @ 200 sccm 0.5 mbar @ 1 slpm	25 psi
WBIM200DB...	0...±200 sccm			
WBIL001DU...	0...1 slpm			
WBIL001DB...	0...±1 slpm			

Note:
sccm denotes standard cubic centimeters per minute.
slpm denotes standard liter per minute.

PERFORMANCE CHARACTERISTICS[6]

(V_S = 5 ±0.01 V, T_A = 20 °C, P_{Abs}= 101.325 kPa, output signal is ratiometric to V_S, media = air)

Characteristics	Min.	Typ.	Max.	Unit
Accuracy[3]			±(2.0 % of reading + 0.25 %FSO)	
Total accuracy (0...50 °C)[4]			±(4.0 % of reading + 0.25 %FSO)	
Repeatability (incl. hysteresis)			0.25	% of reading
Offset long term stability (1 year)		±0.05		%FSS
Noise level			0.1	
Current consumption (no load)		10	12	mA
Response time (t_{90})			5	ms
Warm-up time[8]			70	

Digital output

Characteristics		Min.	Typ.	Max.	Unit
Scale factor	WBIM200...		150		counts/sccm
	WBIL001...		30		
Zero offset tolerance				±0.25	% FSS
Full scale span tolerance				±2.25	

Note:
The sensor's performance is determined by intake flow conditions which depend on mounting and environmental effects. To ensure laminar flow through the sensor, it should be considered to insert a straight tube with a length 10 times the inner diameter of the pneumatic connector or a laminar flow element upstream of the sensor. Additionally, the WBI has to be mounted with both ports horizontally and pins downwards.

DIGITAL I²C BUS

The WBI complies with the following protocol (Fig. 1):

Bus idle (A): Both the series data line and the series clock line are HIGH.

START condition (B): When SCL is HIGH, a change of SDA from HIGH to LOW represents a start condition that initiates data transfer. A start condition must present before any data transfer commands can be executed.

STOP condition (C): When SCL is HIGH, a change of SDA from LOW to HIGH represents a stop condition that ceases data transfer. All the data transfer commands must be accomplished before a stop condition presents.

DATA (D): After the start condition, the series data line must be kept steady when the series clock line is HIGH. The series data line can change during the period when the series clock line is LOW, and each data bit must correspond to a clock pulse.

Each data transfer will begin with a start condition and cease after a stop condition. Every byte put on the series data line must be 8 bits long. The number of bytes that can be transmitted per transfer is unrestricted. Each byte has to be followed by an Acknowledge/not Acknowledge bit. The number of data bytes between a start condition and a stop condition will be decided by the bus master.

Acknowledge bit: The master is initially in the master transmit mode by sending a start bit followed by the slave address that it wishes to communicate with, which is finally followed by a single bit representing whether it wishes to write(0) to or read(1) from the slave.

If the slave exists on the bus then it will respond with acknowledge (ACK) bit (active low for acknowledged) for that address. The master must provide an extra SCL pulse for each ACK bit. The master then continues in either transmit or receive mode (according to the read/write bit it sent), and the slave continues in its complementary mode (receive or transmit, respectively).

Slave address: The I²C-bus master-slave concept requires a unique address for each device on the bus. The WBI has a reserved address (00h) for broadcasting and a second individual address preconfigured to 01h. The sensor will listen to both slave addresses. 00h can only be used for WRITE commands. By programming it is possible to reset the individual adress to any number between 1 and 127 (see Comands).

After generating a START condition the master sends the address byte containing a 7 bit address followed by a data direction bit (R/W). A "0" indicates a transmission from master to slave (WRITE), a "1" indicates a data request (READ).

DATA operation: The address and the data bytes are sent most significant bit first.

If the master wishes to write into the slave then it repeatedly sends a byte with the slave sending an ACK bit. (In this situation, the master is in the master transmit mode and the slave is in the slave receive mode.)

If the master wishes to read from the slave then it repeatedly receives a byte from the slave, the master sending an ACK bit after every byte but the last one. (In this situation, the master is in the master receive mode and the slave is in the slave transmit mode.)

The master then ends transmission with a stop bit, or it may send another start bit if it wishes to retain control of the bus for another transfer (a "combined message").

Note:
The WBI sensor can hold SCL LOW after each data byte **before** ACK. The transaction cannot continue until SCL is HIGH again and therefore the master has to wait.

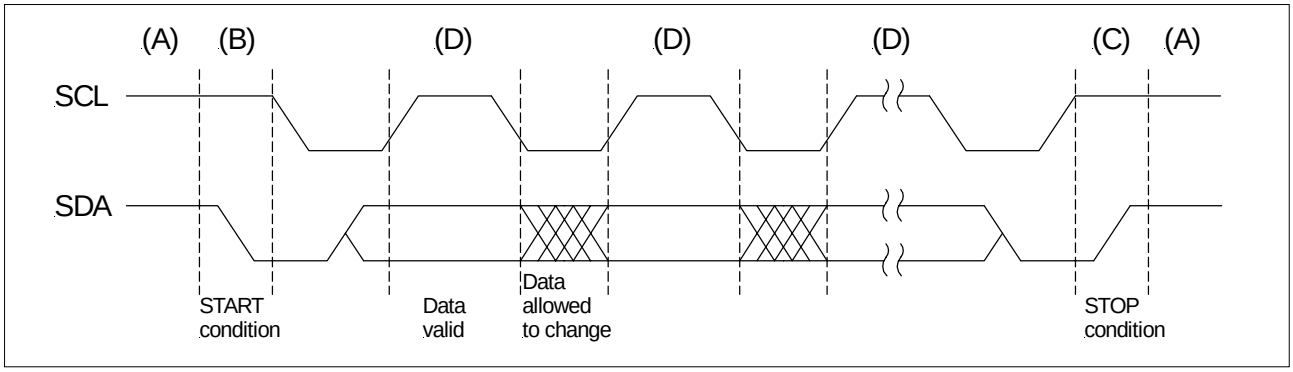


Fig. 1: I²C bus protocol

DIGITAL I²C BUS (cont.)

Commands: The WBI series flow sensors use a communication mode based on the command interpretation mechanism. The data accesses are accomplished through various commands (Fig. 2):

Read instant flow index

S	slave address	R/$\overline{W}$ (0)	A	83h	A	S	slave address	R/$\overline{W}$ (1)	A	data byte 1	A	data byte 2	A	data byte 3	A	data byte 4	$\overline{A}$	P

This command is used for enquiring the current instant flow index. The index consists of four 8-bit values, which are combined to give a 32-bit value as follows:

$$\text{Flow index} = (\text{data byte } 1 \times 16777216) + (\text{data byte } 2 \times 65536) + (\text{data byte } 3 \times 256) + (\text{data byte } 4)$$

The actual flow value can be calculated as the following:

$$\text{Actual flow value} = \frac{\text{flow index}}{\text{scale factor} \times 1000}$$

Negative numbers are represented by the two's complement.

Example for WBIM200DBH5:

Sensor output = FF FE 1D C0
Flow index = -123456

$$\text{Actual flow value} = \frac{-123456}{150 \times 1000} = \underline{\underline{-0.823 \text{ sccm}}}$$

Read I²C address

S	slave address	R/$\overline{W}$ (0)	A	85h	A	S	slave address	R/$\overline{W}$ (1)	A	slave address	0	$\overline{A}$	P

Write I²C address

S	slave address	R/$\overline{W}$ (0)	A	05h	A	new slave address	0	A	P

Auto zero

S	slave address	R/$\overline{W}$ (0)	A	1Ch	A	00h	A	P

generated by master
generated by slave

S = START condition
A = Acknowledge
P = STOP condition

Fig. 2: WBI commands

DIGITAL I²C BUS (cont.)

I²C Interface Parameters

Parameter	Symbol	Min.	Typ.	Max.	Unit
Input high level		90		100	% of Vs
Input low level		0		10	
Output low level				10	
Pull-up resistor		10			kΩ
Load capacitance @ SDA	C_{SDA}			400	pF
Input capacitance @ SDA/SCL	C_{I2C_IN}			10	
SCL clock frequency	F_{SCL}			100	kHz
Bus free time between STOP and START condition	t_{BUF}	4.7			µs
Hold time (repeated) START condition, to first clock pulse	$t_{HD.STA}$	4.7			
LOW period of SCL	t_{LOW}	4.7			
HIGH period of SCL	t_{HIGH}	4.0			
Setup time repeated START condition	$t_{SU.STA}$	4.7			
Data hold time	$t_{HD.DAT}$	0			
Data setup time	$t_{SU.DAT}$	0.25			
Rise time of both SDA and SCL	t_R			1	
Fall time of both SDA and SCL	t_F			0.3	
Setup time for STOP condition	$t_{SU.STO}$	4			

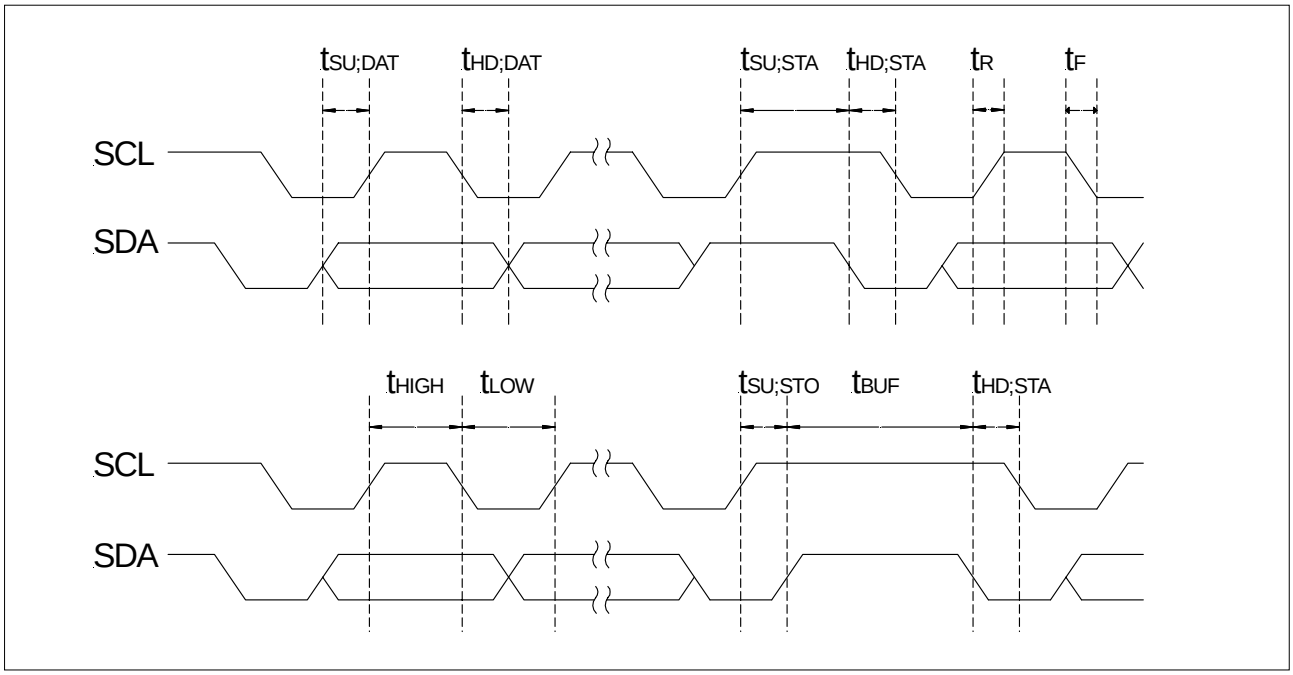
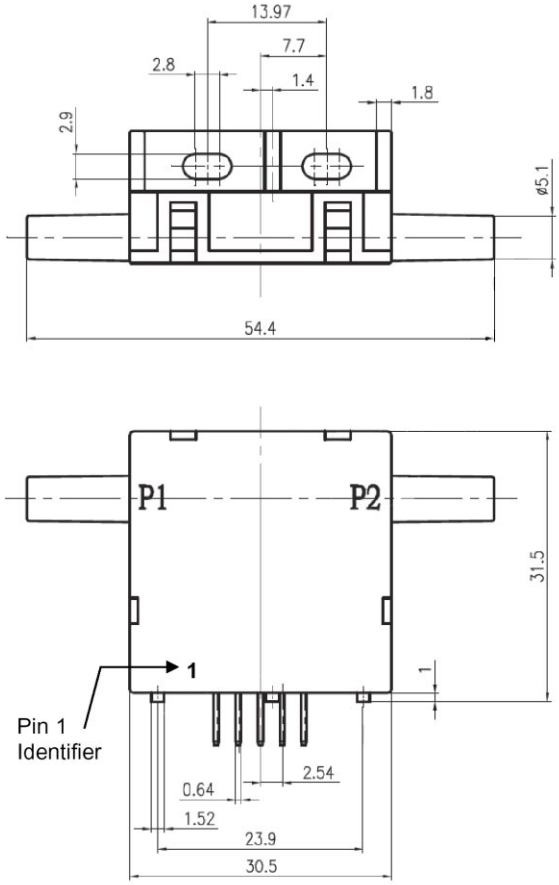


Fig. 3: Timing characteristics

OUTLINE DRAWING



Note:
Positive flow direction is defined as proceeding from P1 to P2 and results in positive output.

third angle projection

dimensions in mm

GAS CORRECTION FACTORS[9]

Gas type	Gas correction factor
Air	1.0
Oxygen (O_2)	1.0
Nitrogen (N_2)	1.0
Argon (Ar)	1.18
Hydrogen (H_2)	*
Carbon dioxide (CO_2)	0.67

* For Hydrogen applications, the actual H_2 calibration is performed whenever possible.

Specification notes:

1. Sweep 20 to 2000 Hz, 8 min, 4 cycles per axis, MIL-STD-883, Method 2007.
2. 5 shocks, 3 axes, MIL-STD-883E, Method 2002.4.
3. Accuracy is the combined error from offset and span calibration, linearity, hysteresis and repeatability.
4. Total accuracy is the combined error from offset and span calibration, linearity, hysteresis, repeatability and temperature effects.
5. Full Scale Span (FSS) is the algebraic difference between the output signal for the highest and lowest specified flow.
6. Specification is preliminary. Data sheet is based on Pre-Series sample verification.
7. A 5 µm filter is recommended to protect the sensing element from dust particles which may be present in some applications.
8. Warm-up time is the time from power on to the first stable reading.
9. To obtain the real flow rates in a specific gas, multiply the readings from the sensor by the gas correction factor in the table. The factors are approximate and should be used as guidelines only. Sensor performance strongly depends on gas dynamics and has to be evaluated in the respective application.

ORDERING INFORMATION

	Series	Flow range		Gas		Flow direction		Grade		Calibration	
Options	**WBI**	**M200**	200 sccm	**D***	Dry air	**B**	Bidirectional	**H**	High	**5**	5 V (V_S=2.7...5.5 V)
		L001	1 slpm			**U**	Unidirectional				
				* other calibration gases on request							
Example:	**WBI**	**M200**		**D**		**U**		**H**		**5**	