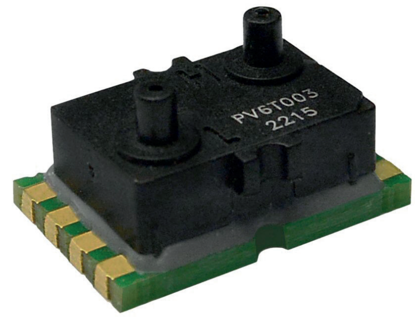
First Sensor

LMI series – digital low differential pressure sensors



The LMI differential low pressure sensors are based on thermal flow measurement of gas through a micro-flow channel integrated within the sensor chip. The innovative LMI technology features superior sensitivity especially for ultra low pressures. The extremely low gas flow through the sensor ensures high immunity to dust contamination, humidity and long tubing compared to other flow-based pressure sensors.

Features

- Ultra-low pressure ranges from 25 to 5000 Pa (0.1 to 20 inH_2O)
- Pressure sensor based on thermal micro-flow measurement
- High flow impedance
  - very low flow-through leakage
  - high immunity to dust and humidity
  - no loss in sensitivity using long tubing
- Outstanding long-term stability and precision with patented real-time offset compensation and linearization techniques
- Total accuracy better than 0.5% FS typical
- On-chip temperature sensor
- Two user-driven modes of operation
  - low power mode (400 µA standby current)
  - continuous mode (5 ms sampling time)
- Ideal for battery-operated applications
- Linearized digital I²C output with 16 bit sigma-delta A/D conversion
- Small footprint, low profile, only 9 mm in height, and robust package
- Pressure ports for direct manifold assemblies
- Highly versatile to fit to application-specific mounting adaptors and manifolds
- Minimized internal volume and manifold mount option allow for fast gas purge time
- No position sensitivity

Certificates

- Quality Management System according to EN ISO 13485 and EN ISO 9001
- RoHS and REACH compliant

Media compatibility

Air and other non-corrosive gases

Applications

Medical
- Ventilators
- Spirometers
- CPAP
- Sleep diagnostic equipment
- Nebulizers
- Oxygen conservers/concentrators
- Insufflators/endoscopy

Industrial
- HVAC
  - VAV
  - Filter monitoring
  - Burner control
- Fuel cells
- Gas leak detection
- Fume hood
- Instrumentation
- Security systems

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Maximum ratings

Parameter			
Supply voltage V_S	2.7	3.6	V_{DC}
Output current		1	mA
Soldering recommendations			
Reflow soldering [1, 2]			
Average preheating temperature gradient		1.5	K/s
Time above 217 °C		74	s
Time above 240 °C		30	
Peak temperature		245	°C
Cooling temperature gradient		-1.4	K/s
Wave soldering, pot temperature		260	°C
Hand soldering, tip temperature		370	
Temperature ranges			
Compensated	0	+70	°C
Operating	-20	+80	
Storage	-40	+80	
Humidity limits (non-condensing)		97	%RH
Vibration [3]		20	g
Mechanical shock [4]		500	

Pressure sensor characteristics

Part no.	Operating pressure	Proof pressure [5]	Burst pressure [5]
LMIS025U...	0...25 Pa / 0...0.25 mbar (0.1 inH_2O)	2 bar (30 psi)	5 bar (75 psi)
LMIS050U...	0...50 Pa / 0...0.5 mbar (0.2 inH_2O)		
LMIS100U...	0...100 Pa / 0...1 mbar (0.4 inH_2O)		
LMIS250U...	0...250 Pa / 0...2.5 mbar (1 inH_2O)		
LMIS500U...	0...500 Pa / 0...5 mbar (1 inH_2O)		
LMIM012U...	0...1250 Pa / 0...12.5 mbar (5 inH_2O)		
LMIM025U...	0...2500 Pa / 0...25 mbar (10 inH_2O)		
LMIM050U...	0...5000 Pa / 0...50 mbar (20 inH_2O)		
LMIS025B...	0...±25 Pa / 0...±0.25 mbar (0.1 inH_2O)		
LMIS050B...	0...±50 Pa / 0...±0.5 mbar (0.2 inH_2O)		
LMIS100B...	0...±100 Pa / 0...±1 mbar (0.4 inH_2O)		
LMIS250B...	0...±250 Pa / 0...±2.5 mbar (1 inH_2O)		
LMIS500B...	0...±500 Pa / 0...±5 mbar (2 inH_2O)		
LMIM012B...	0...±1250 Pa / 0...±12.5 mbar (5 inH_2O)		
LMIM025B...	0...±2500 Pa / 0...±25 mbar (10 inH_2O)		
LMIM050B...	0...±5000 Pa / 0...±50 mbar (20 inH_2O)		

Gas correction factors [6]

Gas type	Correction factor
Dry air	1.0
Oxygen (O_2)	1.07
Nitrogen (N_2)	0.97
Argon (Ar)	0.98
Carbon dioxide (CO_2)	0.56

Specification notes

(1) Recommendations only. Actually reflow settings depend on many factors, for example, number of oven heating and cooling zones, type of solder paste/flux used, board and component size, as well as component density. It is the responsibility of the customer to fine tune their processes for optimal results.

(2) Handling instruction: Products are packaged in vacuum sealed moisture barrier bag with a floor life of 168hours (<30C, 60% R.H.). If floor life or environmental conditions have been exceeded prior to reflow assembly, baking is recommended. Recommended bake-out procedure is 72 hours @ 60C.

(3) Sweep 20 to 2000 Hz, 8 min, 4 cycles per axis, MIL-STD-883, Method 2007.

(4) 5 shocks, 3 axes, MIL-STD-883E, Method 2002.4.

(5) The max. common mode pressure is 5 bar.

(6) For example with a LMIS500... sensor measuring CO_2 gas, at full-scale output the actual pressure will be:

$$\Delta P_{eff} = \Delta P_{Sensor} \times \text{gas correction factor} = 500\text{ Pa} \times 0.56 = 280\text{ Pa}$$

ΔP_{eff} = True differential pressure
ΔP_{Sensor} = Differential pressure as indicated by output signal

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Performance characteristics [7]

(V_S=3.3 V_{DC}, T_A=20 °C, P_{Abs}=1 bara, calibrated in air, output signal is non-ratiometric to V_S)

Parameter			Min.	Typ.	Max.	Unit
Current consumption	**Low-power mode**	**active**		3.5	4.5	
	(default)	**sleep**		0.4	0.75	mA
	Continuous mode			3.5	4.5	
Response time (t_{63})				5		ms
Power-on time					25	

25 Pa devices

Parameter		Min.	Typ.	Max.	Unit
Scale factor [9]	**0…25/0…±25 Pa**		1200		counts/Pa
Noise level (RMS)			±0.01		Pa
Offset warm-up shift				less than noise	
Offset long term stability [8]			±0.02		Pa/year
Offset repeatability			±0.01		Pa
Span repeatability [10, 11]			±0.25		% of reading
Zero pressure offset accuracy [10]			±0.04	±0.1	Pa
Span accuracy [10, 11]			±0.75	±1.5	% of reading
Thermal effects (-20…85 °C)	**Offset**			±0.1	Pa
	Span		±0.2	±0.5	% of reading per 10 °C

50 Pa devices

Parameter		Min.	Typ.	Max.	Unit
Scale factor [9]	**0…50/0…±50 Pa**		600		counts/Pa
Noise level (RMS)			±0.01		Pa
Offset warm-up shift				less than noise	
Offset long term stability [8]			±0.02		Pa/year
Offset repeatability			±0.01		Pa
Span repeatability [10, 11]			±0.25		% of reading
Zero pressure offset accuracy [10]			±0.04	±0.1	Pa
Span accuracy [10, 11]			±0.75	±1.5	% of reading
Thermal effects (-20…85 °C)	**Offset**			±0.2	Pa
	Span		±0.2	±0.5	% of reading per 10 °C

Specification notes (cont.)

(7) The sensor is calibrated with a common mode pressure of 1 bar absolute. Due to the mass flow based measuring principle, variations in absolute common mode pressure need to be compensated according to the following formula:

$$\Delta P_{eff} = \Delta P_{Sensor} \times 1\ \text{bara}/P_{abs}$$

ΔP_{eff} = True differential pressure
ΔP_{Sensor} = Differential pressure as indicated by output voltage
P_{abs} = Current absolute common mode pressure

(8) Figure based on accelerated lifetime test of 1000 hours at 85 °C biased burn-in.
(9) The digital output signal is a signed, two complement integer. Negative pressures will result in a negative output
(10) Zero pressure offset accuracy and span accuracy are uncorrelated uncertainties. They can be added according to the principles of error propagation.
(11) Span accuracy below 10% of full scale is limited by the intrinsic noise of the sensor.

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Performance characteristics (cont.) [7]

(V_S=3.3 V_{DC}, T_A=20 °C, P_{Abs}=1 bara, calibrated in air, output signal is non-ratiometric to V_S)

100 Pa devices

Parameter		Min.	Typ.	Max.	Unit
Scale factor [9]	0...100/0...±100 Pa		300		counts/Pa
Noise level (RMS)			±0.01		%FSS
Offset warm-up shift				less than noise	
Offset long term stability [8]			±0.02		%FSS/year
Offset repeatability			±0.01		Pa
Span repeatability [10, 11]			±0.25		% of reading
Zero pressure offset accuracy [10]			±0.04	±0.1	Pa
Span accuracy [10, 11]			±0.75	±1.5	% of reading
Thermal effects (-20...85 °C)	Offset			±0.2	Pa
	Span		±0.3	±0.5	% of reading per 10 °C

250 Pa devices

Parameter		Min.	Typ.	Max.	Unit
Scale factor [9]	0...250/0...±250 Pa		120		counts/Pa
Noise level (RMS)			±0.01		%FSS
Offset warm-up shift				less than noise	
Offset long term stability [8]			±0.02		%FSS/year
Offset repeatability			±0.02		Pa
Span repeatability [10, 11]			±0.25		% of reading
Zero pressure offset accuracy [10]			±0.08	±0.25	Pa
Span accuracy [10, 11]			±0.75	±1.5	% of reading
Thermal effects (-20...85 °C)	Offset			±0.5	Pa
	Span		±0.3	±0.5	% of reading per 10 °C

500 Pa devices

Parameter		Min.	Typ.	Max.	Unit
Scale factor [9]	0...500/0...±500 Pa		60		counts/Pa
Noise level (RMS)			±0.01		%FSS
Offset warm-up shift				less than noise	
Offset long term stability [8]			±0.02		%FSS/year
Offset repeatability			±0.05		Pa
Span repeatability [10, 11]			±0.25		% of reading
Zero pressure offset accuracy [10]			±0.15	±0.5	Pa
Span accuracy [10, 11]			±0.75	±1.5	% of reading
Thermal effects (-20...85 °C)	Offset			±1	Pa
	Span		±0.3	±0.5	% of reading per 10 °C

Specification notes (cont.)

(7) The sensor is calibrated with a common mode pressure of 1 bar absolute. Due to the mass flow based measuring principle, variations in absolute common mode pressure need to be compensated according to the following formula:

$$\Delta P_{eff} = \Delta P_{Sensor} \times 1 \text{ bara}/P_{abs}$$

ΔP_{eff} = True differential pressure
ΔP_{Sensor} = Differential pressure as indicated by output voltage
P_{abs} = Current absolute common mode pressure

(8) Figure based on accelerated lifetime test of 1000 hours at 85 °C biased burn-in.

(9) The digital output signal is a signed, two complement integer. Negative pressures will result in a negative output

(10) Zero pressure offset accuracy and span accuracy are uncorrelated uncertainties. They can be added according to the principles of error propagation.

(11) Span accuracy below 10% of full scale is limited by the intrinsic noise of the sensor.

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Performance characteristics (cont.) (7, 12)

(V_S=3.3 V_{DC}, T_A=20 °C, P_{Abs}=1 bara, calibrated in air, output signal is non-ratiometric to V_S)

1250 Pa devices

Parameter		Min.	Typ.	Max.	Unit
Scale factor (9)	0...1250/0...±1250 Pa		24		counts/Pa
Noise level (RMS)			±0.5		Pa
Offset warm-up shift				less than noise	
Offset long term stability (8)			±0.5		Pa/year
Offset repeatability			±0.5		Pa
Span repeatability (10, 11)			±0.25		% of reading
Zero pressure offset accuracy (10)			±1	±2.5	Pa
Span accuracy (10, 11)			±1.5	±3	% of reading
Thermal effects (-20...85 °C)	Offset			±2.5	Pa
	Span		±0.3	±0.5	% of reading per 10 °C

2500 Pa devices

Parameter		Min.	Typ.	Max.	Unit
Scale factor (9)	0...2500/0...±2500 Pa		12		counts/Pa
Noise level (RMS)			±0.5		Pa
Offset warm-up shift				less than noise	
Offset long term stability (8)			±0.5		Pa/year
Offset repeatability			±0.5		Pa
Span repeatability (10, 11)			±0.25		% of reading
Zero pressure offset accuracy (10)			±1	±2.5	Pa
Span accuracy (10, 11)			±1.5	±3	% of reading
Thermal effects (-20...85 °C)	Offset			±5	Pa
	Span		±0.3	±0.5	% of reading per 10 °C

5000 Pa devices

Parameter		Min.	Typ.	Max.	Unit
Scale factor (9)	0...5000/0...±5000 Pa		6		counts/Pa
Noise level (RMS)			±1		Pa
Offset warm-up shift				less than noise	
Offset long term stability (8)			±1		Pa/year
Offset repeatability			±1		Pa
Span repeatability (10, 11)			±0.25		% of reading
Zero pressure offset accuracy (10)			±2	±5	Pa
Span accuracy (10, 11)			±1.5	±3	% of reading
Thermal effects	Offset (-20...85 °C)			±10	Pa
	Span (-5...85 °C)		±0.3	±0.75	% of reading per 10 °C
	(-20...-5 °C)		±0.75	±1.5	% of reading per 10 °C

Specification notes (cont.)

(7) The sensor is calibrated with a common mode pressure of 1 bar absolute. Due to the mass flow based measuring principle, variations in absolute common mode pressure need to be compensated according to the following formula:

$$\Delta P_{eff} = \Delta P_{Sensor} \times 1\ \text{bara}/P_{abs}$$

ΔP_{eff} = True differential pressure
ΔP_{Sensor} = Differential pressure as indicated by output voltage
P_{abs} = Current absolute common mode pressure

(8) Figure based on accelerated lifetime test of 1000 hours at 85 °C biased burn-in.

(9) The digital output signal is a signed, two complement integer. Negative pressures will result in a negative output

(10) Zero pressure offset accuracy and span accuracy are uncorrelated uncertainties. They can be added according to the principles of error propagation.

(11) Span accuracy below 10% of full scale is limited by the intrinsic noise of the sensor.

(12) For pressure ranges 1250 Pa and 2500 Pa, more accurate absolute pressure correction procedures than in (6) might be needed. See Application Note "Absolute pressure correction of LME/LMI pressure sensors".

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Performance characteristics (cont.)

Temperature sensor

Parameter	Min.	Typ.	Max.	Unit
Scale factor (digital output)		72		counts/°C

Total accuracy [13]

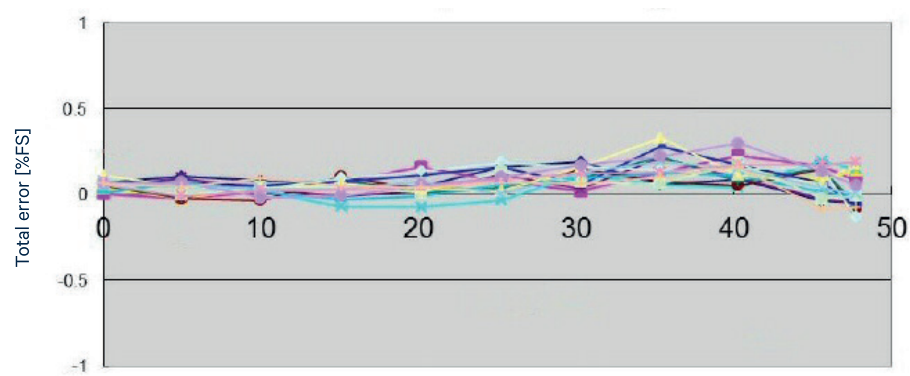

Fig. 1: Typical total accuracy plot of 16 LMI 50 Pa sensors @ 25 °C (typical total accuracy better than 0.5 %FS)

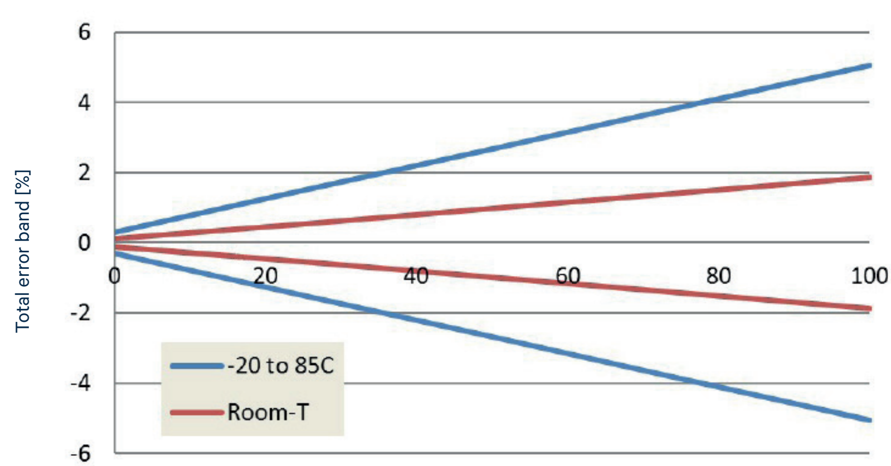

Fig. 2: Maximum total error band of 100/250/500Pa LMI sensors

Specification notes (cont.)

(13) Total accuracy is the combined error from offset and span calibration, non-linearity, repeatability and pressure hysteresis

Noise plot

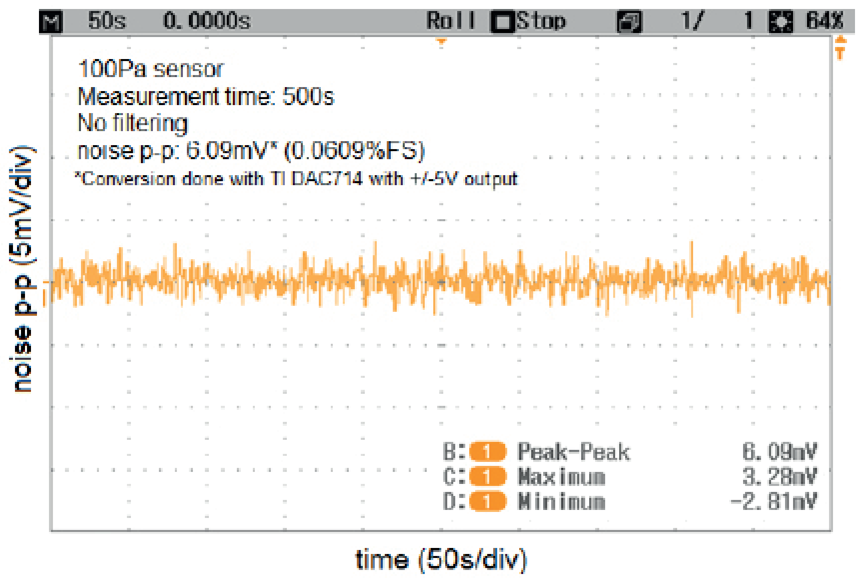

Fig. 3: Typical noise plot of a 100 Pa LMI sensor

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I²C bus interface specifications

Introduction

The LMI serial interface operates using a standard 2-wire I²C bus. For detailed specifications of the I²C protocol, see UM10204 - I²C Bus Specification and User Manual from NXP.

Care should be taken to ensure that the sensor is properly connected to the master microcontroller. Refer to the manufacturer's datasheet for more information regarding physical connections.

Signal control

Bus not busy: During idle periods, both data line (SDA) and

clock line (SCL) remain HIGH.

START condition (S): A HIGH to LOW transition of SDA while SCL is HIGH is interpreted as START condition. START conditions are always generated by the master. Each initial request for a pressure value has to begin with a START condition.

STOP condition (P): A LOW to HIGH transition of SDA while SCL is HIGH defines a STOP condition. STOP conditions are always generated by the master. More than one request for the current pressure value can be transmitted without generation of intermediate STOP conditions.

DATA valid (D): The state of SDA represents valid data when, after a START condition, SDA is stable for the duration of a HIGH period of SCL. SDA should only change during a LOW period of SCL. There is one SCL pulse per bit of data.

Acknowledge (A): Data are transferred as bytes (i.e., 8 bits) on the serial bus, most-significant-bit (MSB) first. After each byte, the receiving device – master or slave – is obliged to pull SDA LOW to acknowledge the reception of data. The master device must generate an extra clock pulse for this purpose. When acknowledge is missed, the slave transmitter becomes inactive. The master device must either re-send the last command, or generate a STOP condition in this case.

Slave address: The I²C-bus master-slave concept requires a unique address for each device. The LMI device's address is modifiable based on the connection of the ADR0 and ADR1 pins. ADRx connected to GND represents logic-0, whereas a connection to VS represents logic-1. This allows for four unique assignable addresses:

Base address (binary)	ADR1	ADR0	7-bit I²C address (binary)	7-bit I²C address (hexadecimal)
10111	0	0	1011100	0x5C
	0	1	1011101	0x5D
	1	0	1011110	0x5E
	1	1	1011111	0x5F

After generating a START condition, the master sends the address byte containing the 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).

MSB							LSB
1	0	1	1	1	ADR1	ADR0	R/W

DATA operation: The sensor starts to send 2 data bytes containing the current pressure value (shown in Fig. 4 as "Readout of result").

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I²C bus interface specifications (cont.)

I²C command set

The LMI device implements the following commands:

Command	Description	Type	Bytes to read from LMI
0x11	Reset firmware	W	N/A
0x20	Start pressure conversion	W/R	2
0x23	Retrieve electronic signature	W/R	54

Reset firmware

Writing this command to the LMI device resets the firmware's program counter. The LMI device does not return any data to be read.

```
/* ===================== PSEUDOCODE - RESET FIRMWARE ===================== */
// Assumption: The sensor's address is defined with ADR0 = ADR1 = 0.
byte sensorAddress = 0x5c;
byte resetCommand = 0x11;

// Write the command to the bus.
i2c.sendStartCondition();
i2c.beginTransmissionToAddress(sensorAddress);     // Send 0xB8 (0x5C with R/W=0).
i2c.writeCommandToBus(resetCommand);               // Send 0x11.
i2c.sendStopCondition();
```

Start pressure conversion

Writing this command to the LMI device starts a conversion of pressure data. When the conversion is complete, the LMI device returns the pressure data in two bytes. The 15-bit conversion result is clocked out least-significant byte first:

Low byte								High byte							
MSB							LSB	MSB							LSB
D7	D6	D5	D4	D3	D2	D1	R	D15	D14	D13	D12	D11	D10	D9	D8

Data are delivered in two's complement format.

Ensure that the bytes are re-ordered and the R bit is kept, padding the value to 16 bits, such that converting output to Pascals via scale factor is correct:

High byte								Low byte							
MSB							LSB	MSB							LSB
D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	R

This command wakes the device from sleep and starts a conversion. This conversion-start command only needs to be sent once; consecutive I²C read commands commands (i.e., the sensor address with the R/W bit set to "1" may be sent to continuously acquire new data from the device.

From the digital sensor output the actual pressure value can be calculated as follows:

$$\text{Pressure [Pa]} = \frac{\text{Digital output [counts]}}{\text{Scale factor}\left[\dfrac{\text{counts}}{\text{Pa}}\right]}$$

I²C bus interface specifications (cont.)

```
/* ==================== PSEUDOCODE - START CONVERSION ==================== */
// The delay between consecutive read commands determines whether or not the
// device works in Continuous or low-power mode.

// Assumption: The sensor’s address is defined with ADR0 = ADR1 = 0.
byte sensorAddress = 0x5c;
byte startConversionCommand = 0x20;
byte lowByte, highByte;
short pressureDataInCounts;

// Write the command to the bus (not shown in Fig. 4).
i2c.sendStartCondition();
i2c.beginTransmissionTo(sensorAddress);   // Send 0xB8 (0x5C with R/W bit = 0).
i2c.writeByte(startConversionCommand);   // Send 0x20.
i2c.sendStopCondition();

// Read the result from the LMI device.
i2c.sendStartCondition();
/* ----- READ1 in Fig. 4 ----- */
i2c.requestDataFrom(sensorAddress);      // Send 0xB9 (0x5C with R/W bit = 1).
/* ---- RESULT1 in Fig. 4 ---- */
lowByte = i2c.readByte();                // Read first byte returned by sensor.
highByte = i2c.readByte();               // Read second byte returned by sensor.
i2c.sendStopCondition();

// Read the result again from the LMI device.
i2c.sendStartCondition();
/* ----- READ2 in Fig. 4 ----- */
i2c.requestDataFrom(sensorAddress);      // Send 0xB9 (0x5C with R/W bit = 1).
/* ---- RESULT2 in Fig. 4 ---- */
lowByte = i2c.readByte();                // Read first byte returned by sensor.
highByte = i2c.readByte();               // Read second byte returned by sensor.
i2c.sendStopCondition();

// Repeat read steps as necessary.
```

I²C bus interface specifications (cont.)

Electronic signature

Writing this command to the LMI devices retrieves the sensor's electronic signature. A sequence of 54 bytes should be read, providing the following information:

Sequence	Parameter	Size	Data type	Comment
0-1	Firmware version	2 bytes	byte[2] array	byte[1] -> major version number, byte[0] -> minor version number
2-12	Part number (11 characters)	11 bytes	char[12] array	
13-19	Lot number (7 characters)	7 bytes	char[7] array	e.g. CV7T001
20-21	Pressure range	2 bytes	unsigned int	0 to 65535, MSB-first
22	Output type	1 byte	char	e.g. U or B
23-24	Scale factor	2 bytes	unsigned int	0 to 65535, MSB-first
25-26	Calibration ID	2 bytes	2 x char	e.g. AA
27	Week number	1 byte	short int	0 to 255
28	Year number	1 byte	short int	0 to 255
29-30	Sequence number	2 bytes	unsigned int	0 to 65535, MSB-first
31-53	Reserved	23 bytes	0xFF	Reserved for future use

Sample output string as CSV:
1,2,76,77,73,83,49,48,48,85,66,51,83,67,86,55,84,48,48,54,0,100,85,1,44,65
,67,7,17,0,1,255,255,255,255,255,255,255,255,255,255,255,255,255,255,255,
255,255,255,255,255,255,255,255;

Bytes 25-30 comprise the sensor's serial number.

The above string would translate to:
- Firmware version 1.2
- Part # LMIS100UB3S
- Lot # CV7T006
- Pressure range 100
- Output type U
- Scale factor 300
- Serial number AC0717-0001

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I²C bus interface specifications (cont.)

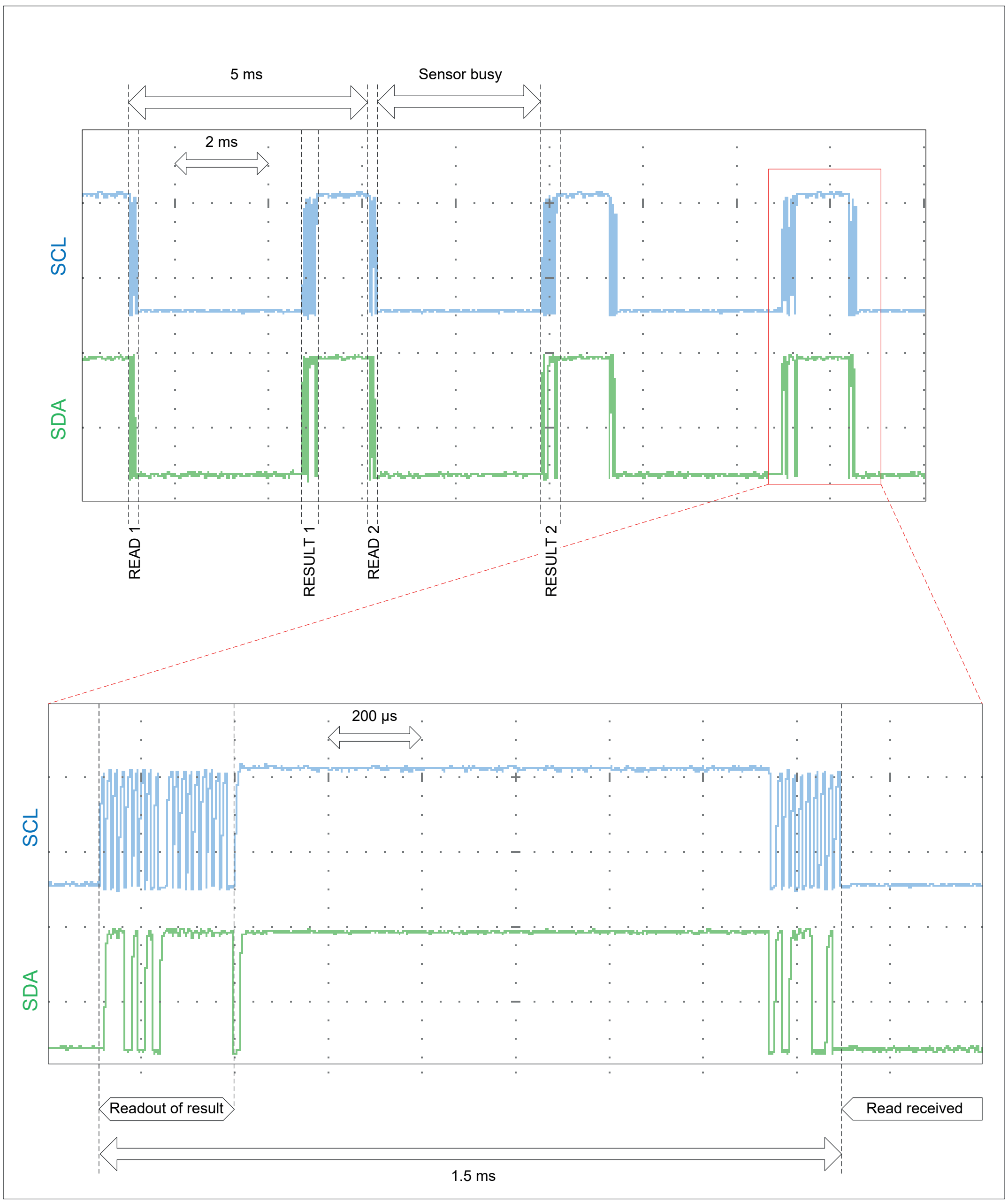

Fig. 4: Continuous mode operation

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I²C bus interface specifications (cont.)

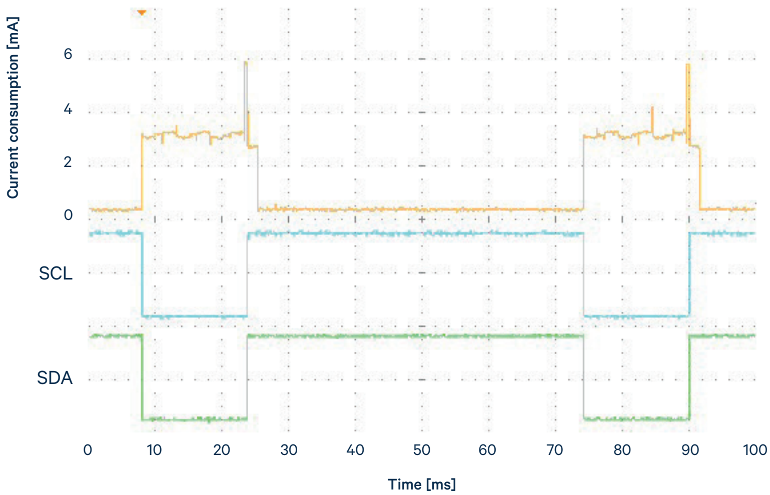


Fig. 5: Low-power mode

Continuous vs low-power mode operation

LMI offers two modes of operation: Continuous mode, which provides a near-continuous stream of pressure data, and low-power mode, which wakes the device from sleep to serve pressure data "on-demand". The first measurement in either mode is available after a warm-up and conversion sequence, which takes approximately 25 ms. The device holds the SCL line low during warm-up and conversion, effectively blocking the I²C bus during this time.

Continuous mode and low-power mode differ only in how quickly subsequent I²C read commands (i.e., the sensor address with the R/W bit set to 1) are sent to the device. Specifically, if the time between the sensor starting to clock out a pressure result (marked as "readout of result" in Figure 4) and the time it fully receives the next I²C read command (marked as "read received" in Figure 4) is 1.5 ms or less, the device enters Continuous mode, which prevents the device from sleeping between conversions. Fresh data are available every 5 ms in this mode of operation.

Conversely, if the time between the sensor starting to clock out a pressure result and the time it fully receives the next I²C read command is greater than 1.5 ms, the device enters low-power mode and returns to sleep until the next I²C read command is fully clocked in. So long as power remains available, the start-conversion command (0x20) does not need to be re-sent. Note that in this mode, the shortest possible refresh rate for data is once every 15-16 ms.

LMI series – digital low differential pressure sensors

I²C bus interface specifications (cont.)

Extended data readout

LMI devices will read out extended sensor data if the user desires. Instead of reading out only two bytes of pressure data, the user may choose to read out four bytes of data, corresponding to:

Byte 1	Byte 2	Byte 3	Byte 4
Pressure		Temperature	
Signed 15-bit value		Signed 16-bit value after offset subtraction and correction	
LSB	MSB	LSB	MSB

From the digital sensor output, the actual temperature can be calculated as follows:

$$\text{Temperature [°C]} = \frac{TS - TS_0 \text{ [counts]}}{\text{Scale factor}_{TS}\left[\frac{\text{counts}}{°C}\right]} + T_0 \text{ [°C]}$$

where

TS is the actual sensor readout;

TS_0 is the sensor readout at known temperature T_0 (14);

Scale factor_{TS} = 72 counts/°C

```
/* ==================== PSEUDOCODE - START CONVERSION ==================== */
// The delay between consecutive read commands determines whether or not the
// device works in Continuous or low-power mode.

// Assumption: The sensor’s address is defined with ADR0 = ADR1 = 0.
byte sensorAddress = 0x5c;
byte startConversionCommand = 0x20;
byte lowByte, highByte;
short pressureDataInCounts;

// Write the command to the bus (not shown in Figure 4).
i2c.sendStartCondition();
i2c.beginTransmissionTo(sensorAddress);   // Send 0xB8 (0x5C with R/W bit = 0).
i2c.writeByte(startConversionCommand);   // Send 0x20.
i2c.sendStopCondition();

// Read the result from the LMI device.
i2c.sendStartCondition();
i2c.requestDataFrom(sensorAddress);      // Send 0xB9 (0x5C with R/W bit = 1).
lowBytePressure = i2c.readByte();        // Read low byte, pressure data.
highBytePressure = i2c.readByte();       // Read high byte, pressure data.
lowByteTemperature = i2c.readByte();     // Read low byte, temperature data.
highByteTemperature = i2c.readByte();    // Read high byte, temperature data.
i2c.sendStopCondition();
```

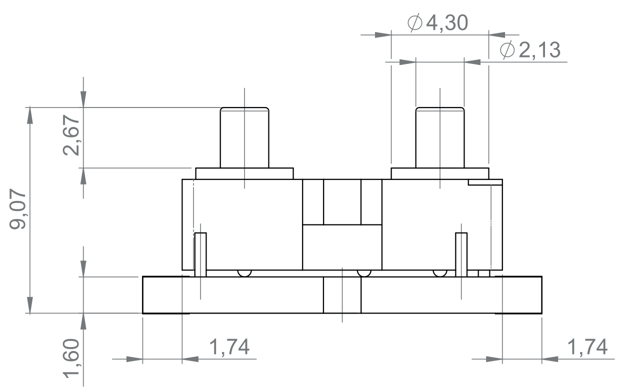
Specification notes (cont.)

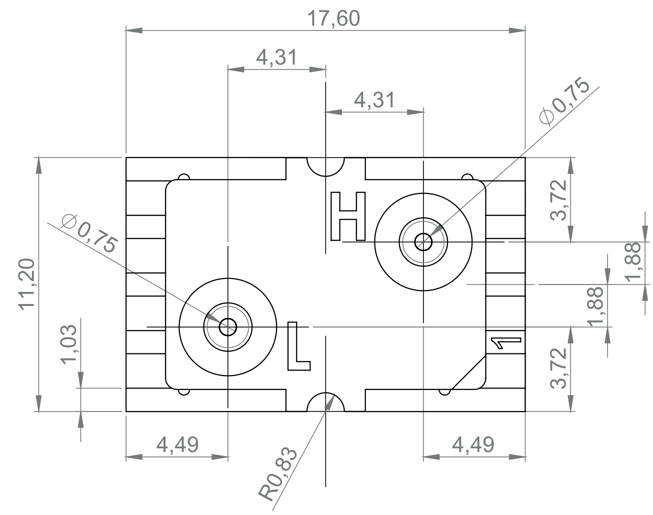
(14) To be defined by user. The results show deviation (in °C) from the offset calibrated temperature.

First Sensor

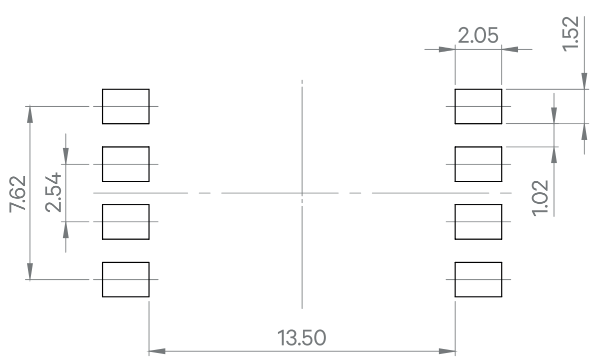
LMI series – digital low differential pressure sensors

Dimensional drawing

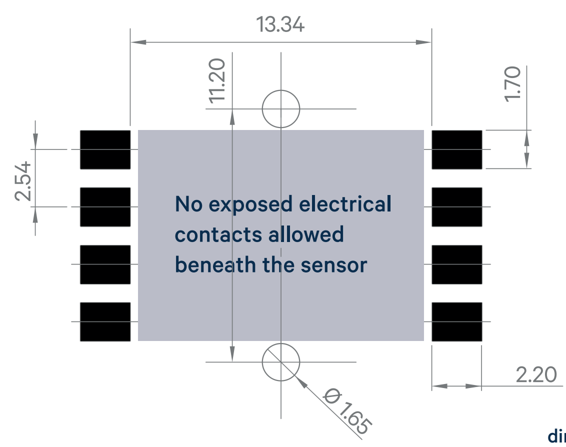




Sensor PCB footprint



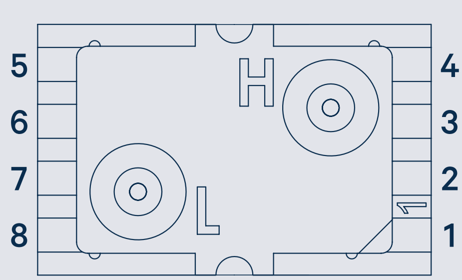
Suggested PCB land pattern



dimensions in mm,
all tolerances ±0.1 mm
unless otherwise noted

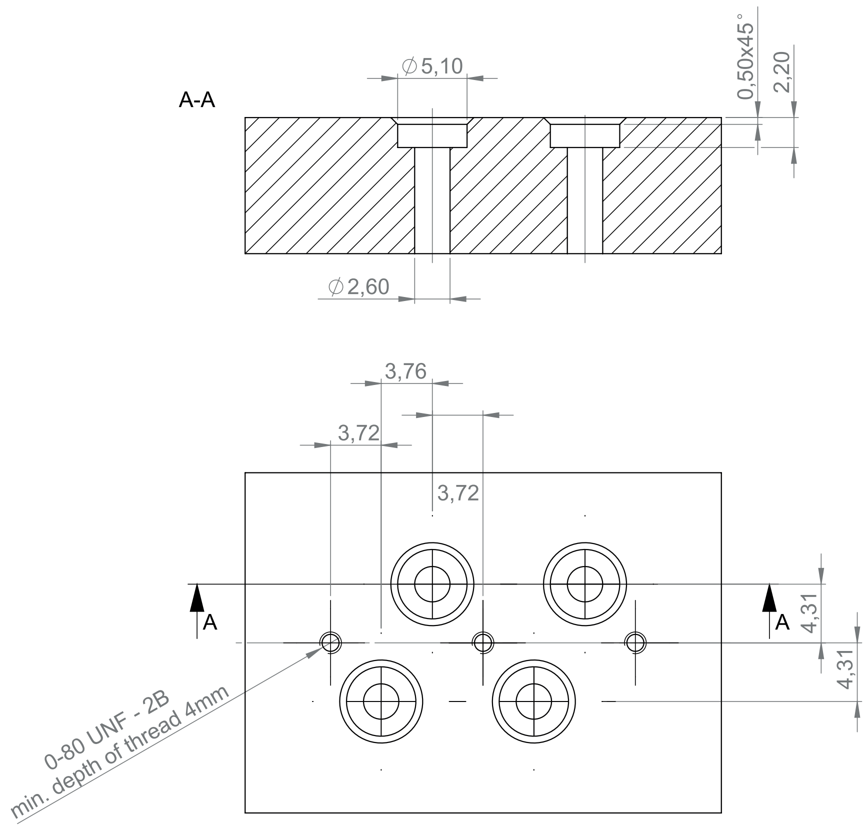
Electrical connection

Pin	Function
1	Reserved
2	Reserved
3	GND
4	V_s
5	ADR0
6	ADR1
7	SCL
8	SDA



LMI series – digital low differential pressure sensors

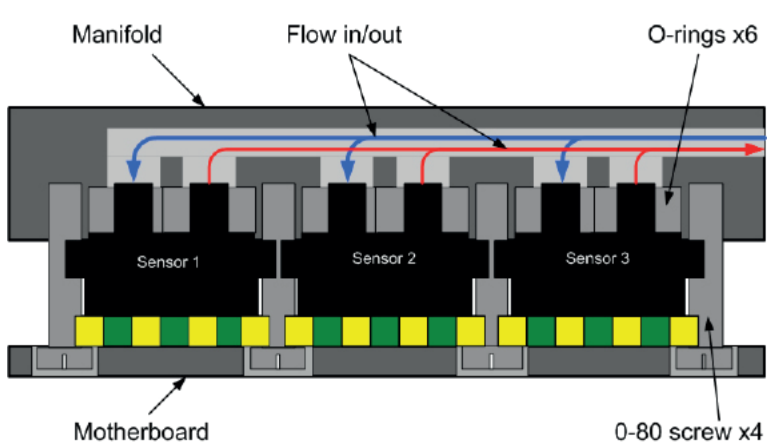
Manifold diagram for two side-by-side mounted sensors



Recommended O-rings:
Part number: 90025K119
www.mcmaster.com

dimensions in mm,
all tolerances ±0.1 mm
unless otherwise noted

Manifold diagram for multiple side-by-side mounted sensors



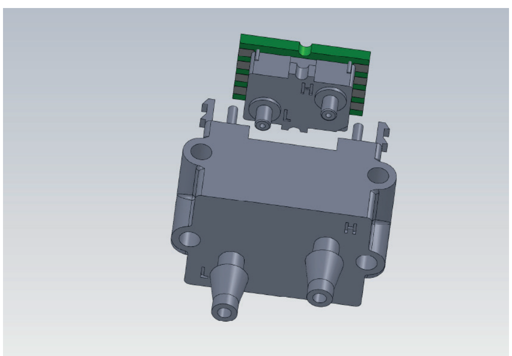
First Sensor

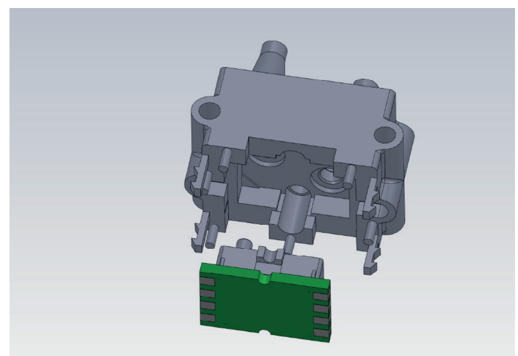
LMI series – digital low differential pressure sensors

Custom adaptor

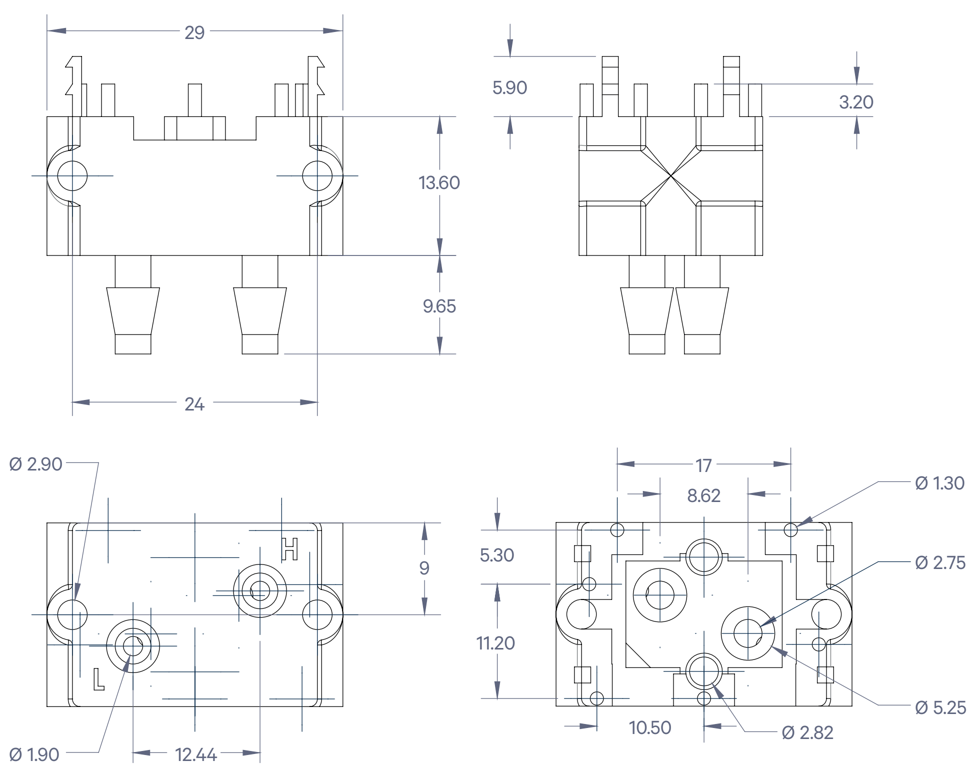
The LMI series pressure sensors can optionally be equipped with a custom adaptor for your application-specific mounting requirements. It is designed for applications where wider port spacing and diameter are needed. Please contact First Sensor for more information.

3D views of a custom adaptor for the LMI pressure sensor





Dimensional drawing ZA009102 plug-in adaptor



Recommended O-rings:
Part number: 90025K119
www.mcmaster.com

dimensions in mm

First Sensor

LMI series – digital low differential pressure sensors

Gas mixture change (purge time)

The LMI series pressure sensors feature minimized internal volume, which allows for fast response to gas mixture change and high pneumatic impedance at the same time. Purge time (T_P) can be estimated by the following equation:

$$T_P = \frac{V_{INT}}{F_{Norm}} = \frac{V_{INT}}{P_{Norm}/Z_P}$$

T_P = Purge time [s]
V_{INT} = Internal volume of the LMI sensor [ml]
F_{Nom} = Nominal flow [ml/s]
P_{Nom} = Nominal pressure [Pa]
Z_P = Pneumatic impedance [kPa/(ml/s)]

The typical internal volume of the LMI sensor (V_{INT}) is 0.04 ml. With a pneumatic impedance (Z_P) of 15 kPa/(ml/s) and a nominal pressure (P_{Nom}) of 250 Pa, the estimated purge time (T_P) is 2.4 seconds.

Ordering information

Series	Pressure range		Calibration		Housing	Output	Grade
LMI	**S025**	25 Pa (0.1 inH_2O)	**B**	Bidirectional	**B** [SMD, 2 ports, axial, same side]	**3** [Non-ratiometric, 3 V supply]	**S** [High]
	S050	50 Pa (0.2 inH_2O)	**U**	Unidirectional			
	S100	100 Pa (0.4 inH_2O)					
	S250	250 Pa (1 inH_2O)					
	S500	500 Pa (2 inH_2O)					
	M012	1250 Pa (5 inH_2O)					
	M025	2500 Pa (10 inH_2O)					
	M050	5000 Pa (20 inH_2O)					

Order code example: LMIS025UB3S

Accessories (order separately)	
ZA009102	**Plug-in adaptor with wider port spacing and diameter**