
GENERAL DESCRIPTION

The MB-LPS2-02 series low-pressure sensors sense differential air (or other non-corrosive gas) pressure, inferring differential pressure from nano-liters per second gas-flow through an integrated air-flow channel having high flow-impedance. The transducer is a MEMS-based thermo-anemometer on a monolithic silicon chip. Rejistor technology combined with CMOS circuitry provides on-chip-integrated analog-only compensation and conditioning electronics. The chips are powered by 5V supply, with fixed (non-ratiometric) output voltage between 0.5V and 4.5V.

FEATURES, BENEFITS

- **Dynamic Range greater than 10000x.**
 - Excellent resolution (0.01% of full-scale) at low ΔP , up to 20% of full-scale.
- **High flow-impedance > 10 kPa/(ml/s).**
 - Dominates flow-impedance in series (in-line) configurations.
 - Minimizes flow-through in bypass (parallel, shunt) configurations.
 - Allows use of filters and long connection hoses without losing calibration.
 - Immunity to dust and humidity.
- **Rejistor-based analog-only on-chip signal conditioning electronics to compensate:**
 - Offset, TC-Offset, Span.
 - TC-Span in range up to 20% of full-scale.

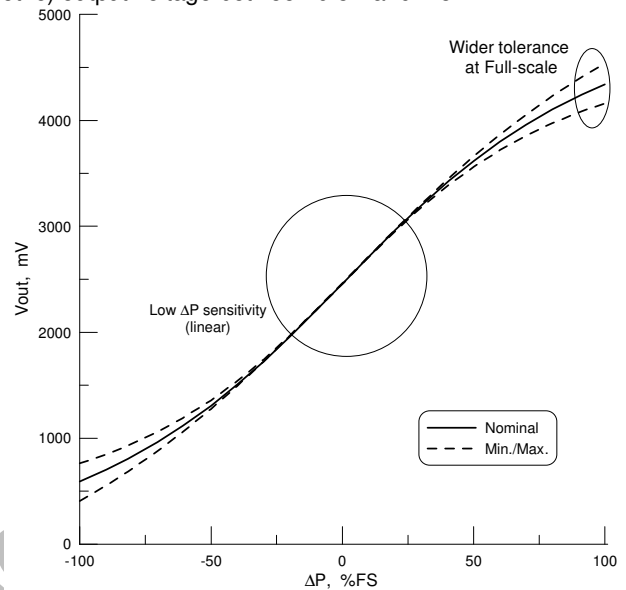


Fig. 1: Typical response for MB-LPS2-02 sensor.
Example: MB-LPS2-02-200B5N → 2" H₂O, bidirectional.
Pneumatic impedance > 20kPa/(ml/s).

PRODUCT FAMILY: MB-LPS2-02-XXXX5N,
FOR APPLICATIONS REQUIRING HIGH DYNAMIC RANGE > 10000x:

Part Number	Measurement Range (Full Scale Pressure Span)**			Low- ΔP Sensitivity***	Pneumatic Flow-Through Impedance
MB-LPS2-02-100B5N	+/-250Pa	+/-1"H ₂ O	+/-0.036PSI	~10mV/Pa	>10kPa/(ml/s)
MB-LPS2-02-100U5N	0...250Pa	0...1"H ₂ O	0...0.036PSI	~20mV/Pa	>10kPa/(ml/s)
MB-LPS2-02-200B5N	+/-500Pa	+/-2"H ₂ O	+/-0.072PSI	~4mV/Pa	>20kPa/(ml/s)
MB-LPS2-02-200U5N	0...500Pa	0...2"H ₂ O	0...0.072PSI	~8mV/Pa	>20kPa/(ml/s)
MB-LPS2-02-500B5N	+/-1250Pa	+/-5"H ₂ O	+/-0.180PSI	~2mV/Pa	>40kPa/(ml/s)
MB-LPS2-02-500U5N	0...1250Pa	0...5"H ₂ O	0...0.180PSI	~4mV/Pa	>40kPa/(ml/s)

For other full-scale ranges, or asymmetric bidirectional measurement ranges, or other custom units → Contact Microbridge

- ** Note: 500Pa = 2.010866"H₂O, which is approximated in this table as 2"H₂O and 0.072PSI.
- *** See Fig. 1. Low- ΔP Sensitivity is the sensitivity at Low ΔP , (at applied pressures smaller than 20% of Full-Scale). MB-LPS2-02 series sensors are calibrated to give best accuracy and linear behavior at low ΔP , with wider tolerances at Full-Scale. Note that the values given for Low- ΔP Sensitivity, for these engineering samples, are approximate. Higher dynamic ranges will correspond to greater Low- ΔP Sensitivity, for a given Full-Scale Pressure Span.
- www.mbridgetech.com

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**TABLE 1: MB-LPS2-02-XXXU5N SPECIFICATIONS:
ANALOG-CONDITIONED LOW DIFFERENTIAL AIR PRESSURE SENSOR (UNDIRECTIONAL)**

Characteristic	Specification
Excitation voltage	$V_{DD} = 5$ VDC (min 4.75V, max 5.25V) (V_{DD} power supply must be externally regulated)
Current consumption	Typ. 3.5 mA (no load)
Output Impedance	Max less than 100 Ω
Minimum output load resistance	5kOhm (less than 1 mA output drive current)
Nominal Output Voltage (with $V_{DD} = 5$ VDC)	MB-LPS2-02-XXXU5N: +0.5V (at zero-Pressure); +4.0V (at Full Scale pressure)
Nominal Full-Scale Output Voltage Span (with $V_{DD} = 5$ VDC)	+3.5V (3500 mV)
Calibrated Zero Offset	Less than +/-5mV
Zero Offset Warmup Shift	Less than +/-2mV
Differential Pressure Resolution	Less than 0.01% Full Scale, at low ΔP up to 20% of Full Scale pressure (minimum detectable differential pressure). Less than 0.1% Full Scale, at high ΔP (near Full-Scale pressure)
Nominal Sensitivity at Low ΔP (Low- ΔP -Sensitivity)	$= [K \times (\text{nominal FS voltage span, mV}) / (\text{nominal FS pressure span, Pa})]$ (nominal sensitivity at $\leq 20\%$ of Full-Scale pressure, where $V_{out} \approx +0.5V$ to +1.5V Note: K is a nominal factor between 1.2 and 2.0, determined by Microbridge to set the dynamic range for a particular product within this product family. As the factor K increases, the dynamic range, non-linearity, tolerance at Full-Scale, and span temperature shift also increase. Higher dynamic ranges will correspond to greater Low- ΔP Sensitivity, for a given Full-Scale Pressure Span.
Tolerance of Low- ΔP -Sensitivity (See Fig. 2.)	Typ. better than +/-1.5% of Low- ΔP -Sensitivity (at room temperature 23°C)
Non-Linearity Error (measured as deviation from straight line corresponding to Low- ΔP -Sensitivity)	Typ. -1% of Full-Scale pressure, up to 20% of Full-Scale pressure (5°C to 55°C) Typ. -22% to -38% of Full-Scale pressure, near 100% of Full-Scale pressure (at 23°C) Note: The non-linear curve has characteristic shape as shown in Fig. 2, and deviation from the Low- ΔP -Sensitivity line has characteristic shape, in Fig. 3.
Tolerance of Output Voltage at Nominal Full-Scale ΔP (See Fig. 3.)	Typ. +/-8% of Full-Scale Output Voltage (at 23°C)
Zero Offset Temperature Shift	Less than +/-5mV (5°C to 55°C)
Low- ΔP -Sensitivity Shift Over Temperature (See Fig. 5.)	Typ. +/-2%, up to 20% of Full-Scale pressure (5°C to 55°C)
Span Shift Over Temperature (See Fig. 5.)	Typ. +/-10% of Full-Scale output voltage, near 100% of Full-Scale pressure (5°C to 55°C). Note: curvature decreases at high temperatures and increases at low temp's.
Response Time	Typ. 2ms
Burst Pressure	Greater than 5 atmospheres
ESD protection	2000V HBM – JESD22-A114, human body model weakest pin pair testing, all lead combinations, Class 2.
RoHS compliant	

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**TABLE 2: MB-LPS2-02-XXXB5N SPECIFICATIONS:
ANALOG-CONDITIONED LOW DIFFERENTIAL AIR PRESSURE SENSOR (BIDIRECTIONAL)**

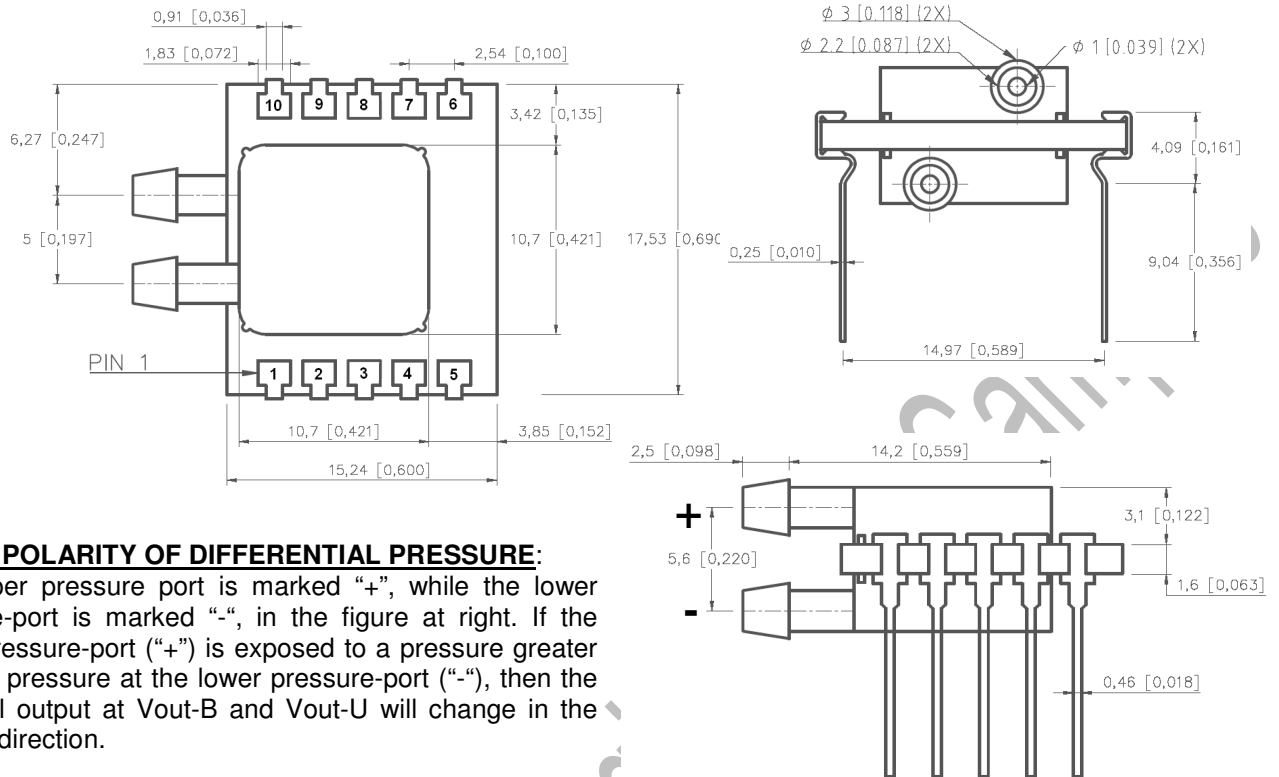
Characteristic	Specification
Excitation voltage	$V_{DD} = 5$ VDC (min 4.75V, max 5.25V) (V_{DD} power supply must be externally regulated)
Current consumption	Typ. 3.5 mA (no load)
Output Impedance	Max less than 100 Ω
Minimum output load resistance	5k Ω m (less than 1 mA output drive current)
Nominal Output Voltage (with $V_{DD} = 5$ VDC)	MB-LPS2-02-XXXB5N: +0.75V (at negative Full Scale pressure); +2.5V (at zero-Pressure); +4.25V (at positive Full Scale pressure) Asymmetric bidirectional measurement ranges are also possible → Contact Microbridge.
Nominal Full-Scale Span (with $V_{DD} = 5$ VDC)	Output Voltage Span: +/-1.75V (defined as 1750 mV) Pressure Span: (magnitude of positive span) = (magnitude of negative span) (e.g. +/-500Pa → Full-Scale Pressure Span is defined to be 500Pa)
Calibrated Zero Offset	Less than +/-5mV
Zero Offset Warmup Shift	Less than +/-2mV
Differential Pressure Resolution	Less than 0.01% of Full Scale pressure, at low ΔP near $V_{out} = 2.5V$, up to +/-20% of Full Scale pressure (minimum detectable differential pressure). Less than 0.1% of Full Scale pressure, at high ΔP (near +/-Full-Scale pressure)
Nominal Sensitivity at Low ΔP (Low- ΔP -Sensitivity)	$= [K \times (\text{nominal FS voltage span, mV}) / (\text{nominal FS pressure span, Pa})]$ (nominal sensitivity at $\Delta P < +/-20\%$ of Full-Scale pressure, near $V_{out} = 2.5V$) Note: K is a nominal factor between 1.2 and 2.0, determined by Microbridge to set the dynamic range for a particular product within this product family. As the factor K increases, the dynamic range, non-linearity, tolerance at Full-Scale, and span temperature shift also increase. Higher dynamic ranges will correspond to greater Low- ΔP Sensitivity, for a given Full-Scale Pressure Span.
Tolerance of Low- ΔP -Sensitivity (See Fig. 1.)	Typ. +/-1.5% of Low- ΔP -Sensitivity (at room temperature 23 $^{\circ}C$)
Non-Linearity Error (measured as deviation from straight line corresponding to sensitivity at Low ΔP)	Typ. +/-1% of Full-Scale pressure up to +/-20% of Full-Scale pressure (5 $^{\circ}C$ to 55 $^{\circ}C$). Typ. +/-22% to +/-38% of Full-Scale pressure, near +/-100% of Full-Scale pressure (at 23 $^{\circ}C$) Note: The non-linear curve has characteristic shape as shown in Fig. 1, and deviation from the Low- ΔP -Sensitivity line has characteristic shape, in Fig. 4.
Tolerance of Output Voltage at Nominal Full-Scale ΔP (See Fig. 4.)	Typ. +/-8% of Full-Scale Output Voltage (at 23 $^{\circ}C$)
Zero Offset Temperature Shift	Less than +/-5mV (5 $^{\circ}C$ to 55 $^{\circ}C$)
Low- ΔP -Sensitivity Shift Over Temperature (See Fig. 5.)	Typ. +/-2%, up to +/-20% of Full-Scale pressure (5 $^{\circ}C$ to 55 $^{\circ}C$)
Span Shift Over Temperature (See Fig. 5.)	Typ. +/-10% of Full-Scale output voltage, near +/-100% of Full-Scale pressure (5 $^{\circ}C$ to 55 $^{\circ}C$). Note: curvature decreases at high temperatures and increases at low temp's.
Response Time	Typ. 2ms
Burst Pressure	Greater than 5 atmospheres
ESD protection	2000V HBM – JESD22-A114, human body model weakest pin pair testing, all lead combinations, Class 2.
RoHS compliant	

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IMMUNITY TO RFI:

Test	Result
Sweep 80MHz - 2.7GHz	<ul style="list-style-type: none"> Less than 0.5% error for any package orientation subjected to 10V/m electric field (by analysis).

PACKAGE AND PINOUT INFORMATION -- (SUBJECT TO CHANGE FOR MB-LPS2-02):



ABOUT POLARITY OF DIFFERENTIAL PRESSURE:

The upper pressure port is marked “+”, while the lower pressure-port is marked “-”, in the figure at right. If the upper pressure-port (“+”) is exposed to a pressure greater than the pressure at the lower pressure-port (“-”), then the electrical output at Vout-B and Vout-U will change in the positive direction.

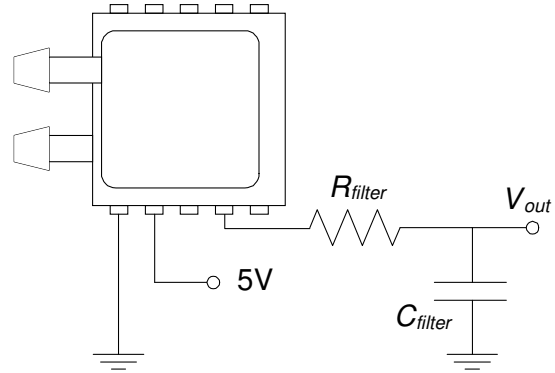
Pin #	Name	Function
1	GND	Main circuit ground for the power supply and analog circuit
2	VDD	Main circuit power supply
3	Vout-B	Output voltage for bidirectional-mode sensors (calibrated in MB-LPS2-02-XXXB5N units)
4	Vout-U	Output voltage for unidirectional-mode sensors (calibrated in MB-LPS2-02-XXXU5N units)
		Note: A subset of the above pins are the only pins used during normal functioning of the sensor (GND, VDD and <i>either</i> Vout-B <i>or</i> Vout-U).
5		Should be connected to ground by the user.
6		Should be connected to ground by the user.
7		Should be connected to ground by the user.
8		Should be connected to ground by the user.
9		Should be connected to ground by the user.
10		Should be connected to ground by the user.
		Note: pins # 5 – 10 should be connected to ground by the user, but no current will be flowing through them in normal operation. These pins are not all connected to each other internally.

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RECOMMENDED OUTPUT VOLTAGE FILTERING:

It is recommended for normal usage that the output of the sensor be connected through an RC low-pass filter as shown in the circuit diagram below. The choice of low-pass cutoff frequency can be made according to the desired response-time.

Note that this filter is connected during calibration of the sensors, with $R_{filter} \sim 5k\Omega$ and $C_{filter} \sim 100nF$.



STANDARD ALTITUDE CORRECTION:

Variations in ambient atmospheric pressure (caused by elevation with respect to sea level), need to be compensated externally to the sensor, according to a simple mathematical expression:

$$True\Delta P = \frac{(Sensor\Delta P) \times (1.00 \text{ Bar})}{(AmbientPabs)}$$

where:

TrueΔP : altitude-adjusted differential pressure

SensorΔP : sensor’s differential pressure as indicated by the output voltage

AmbientPabs : actual ambient absolute pressure (measured in bars)

Note: Units are calibrated such that TrueΔP will equal the SensorΔP when the ambient pressure is 1.00 bar.

PRESSURE NON-LINEARITY:

The MB-LPS2-02 series sensors’ output voltage vs. ΔP behaviour has significant non-linearity with a known basic shape, as illustrated in Fig. 1 on p.1 (for bidirectional sensors), and as illustrated in Fig. 2 (for unidirectional sensors). The curve of output voltage (Vout) vs. differential pressure (ΔP), is close to linear at low-magnitude differential pressures, and becomes progressively more non-linear at high differential pressures. As shown in Fig. 2, the downward curvature grows smoothly as the magnitude of applied pressure increases. As shown in Fig. 1, for negative differential pressures, the curvature is upward.

Since the intent of the sensor is to allow the user to infer ΔP from a Vout reading, the nominal characteristic curve is described (approximated) by ΔP as a function of Vout:

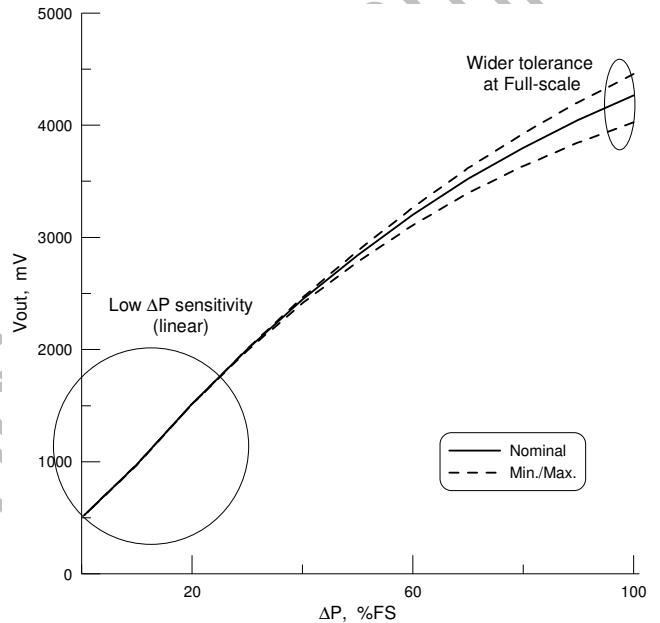


Fig. 2: Typical response for MB-LPS2-02 sensor. Example: MB-LPS2-02-200U5N →2”H₂O, unidirectional.

$$\Delta P = \frac{(Low\Delta P\ Sensitivity) \times |(Vout - Vo - ZeroOffset)|}{1 - \left(\frac{|Vout - Vo - ZeroOffset|}{Vsat}\right)^N}$$

where:

- **Vout** is the output voltage, in mV.
- **Vo** is the nominal output voltage at zero sensor stimulus, i.e. +0.5V for unidirectional sensors, and +2.5V for bidirectional sensors.
- **ZeroOffset** is as specified in Table 1 (Unidirectional) and Table 2 (Bidirectional).
- **LowΔPSensitivity** is the slope of the curve, in mV/Pa, at Low ΔP (ΔP smaller than 20% of Full-Scale).

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- Note: $Low\Delta P\ Sensitivity = [K \times (\text{full-scale voltage span, mV}) / (\text{full-scale pressure span, Pa})]$
- ΔP is the applied differential pressure, in Pa.
- V_{sat} is a positive fitting constant equal to 6650 mV (for unidirectional sensors) and 3325 mV (for bidirectional sensors), at which V_{out} would be expected to saturate.
- N is another positive fitting constant, affecting the curvature of V_{out} vs. ΔP near Full-Scale. As N decreases, the curvature increases. For these sensors having dynamic range 10000x, $N = 2.2$. The behavior of individual sensor units follows this typical form of non-linear curve.
 - This curvature near Full-Scale has some tolerance, corresponding to a tolerance up to approximately +/-5 to 8% of Full-Scale output voltage Span, at Full-Scale Pressure.

Figs. 3 and 4 show the deviation from linearity for unidirectional (Fig. 3) and bidirectional (Fig. 4) sensors. At low ΔP , the response is linear, corresponding to the Low- ΔP -Sensitivity, and the deviation from linearity grows smoothly and monotonically as the applied ΔP becomes larger (in both positive and negative directions for bidirectional sensors). In Fig. 3, for unidirectional sensors with $K \approx 1.4$, at Full-Scale pressure the deviation is approximately -28%, with some tolerance about this nominal value. In Fig. 4, a bidirectional sensor is shown with a smaller value of K .

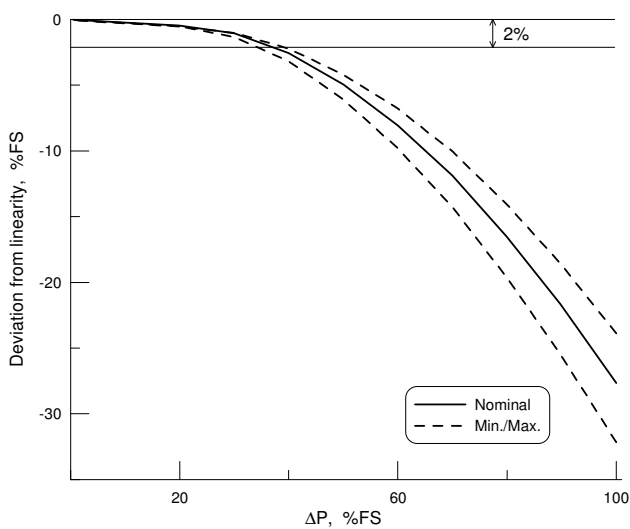


Fig. 3: Typical deviation from linearity for MB-LPS2-02 sensor. Deviation is calculated with respect to the straight line corresponding to Low- ΔP -Sensitivity. Example: MB-LPS2-02-200U5N \rightarrow 2”H₂O, unidirectional.

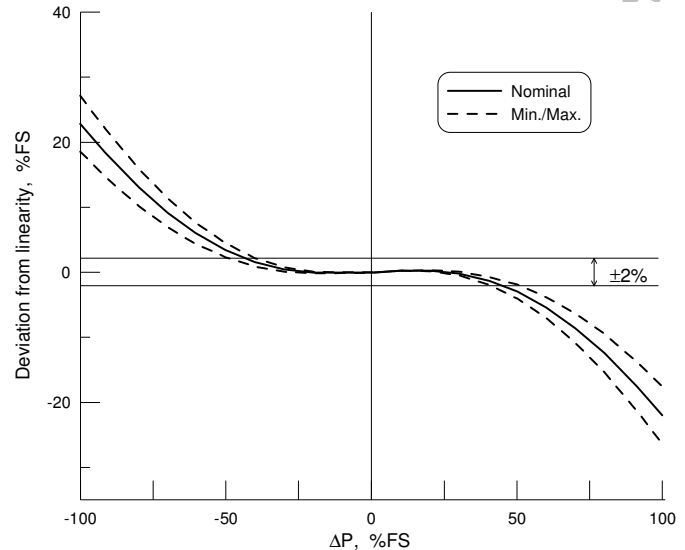


Fig. 4: Typical deviation from linearity for MB-LPS2-02 sensor. Deviation is calculated with respect to the straight line corresponding to Low- ΔP -Sensitivity. Example: MB-LPS2-02-200B5N \rightarrow 2”H₂O, bidirectional.

SENSITIVITY TOLERANCE:

The sensitivity of MB-LPS2-02 series sensors is calibrated to within +/-1.5% of the sensor’s nominal sensitivity at low pressure (Low- ΔP -Sensitivity), (i.e. at applied pressures smaller than approximately +/-20% of Full-Scale). This Low- ΔP -Sensitivity is related to the sensor’s Nominal Full-Scale Span by the equation:

$$Low\Delta P\ Sensitivity = \frac{K \times (Nominal\ Full\ Scale\ Voltage\ Span, mV)}{(Nominal\ Full\ Scale\ Pressure\ Span, Pa)}$$

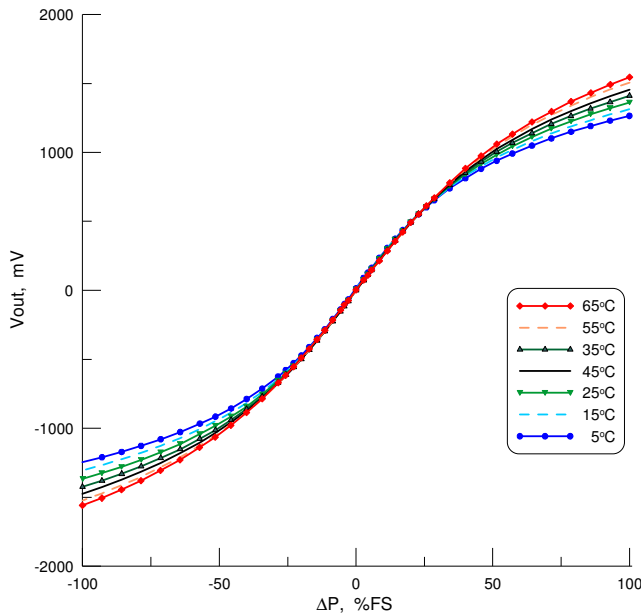
For example, for a unidirectional sensor with Full-Scale 500Pa, calibrated to $K = 1.43$, then $Low\Delta P\ Sensitivity = [K \times (3500mV)/(500Pa)] = 10mV/Pa \ +/-2\%$.

The tolerance of V_{out} near Full-Scale is +/-8%, wider than the tolerance at Low- ΔP , because the output voltage is not calibrated at Full-Scale. Note: K is a nominal factor between 1.2 and 2.0, determined by Microbridge to set the dynamic range for a particular product within this product family. As the factor K increases, the dynamic range, non-linearity, tolerance at Full-Scale, and span temperature shift also increase.

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SENSITIVITY AND SPAN SHIFT OVER TEMPERATURE:

The sensitivity of MB-LPS2-02 series sensors is temperature-compensated to +/-1.5% in the Low-ΔP range up to +/-20% of Full-Scale pressure span, where the output voltage is fairly linear with applied pressure. The sensor's span in the upper pressure range, from +/-20% to +/-100% of Full-Scale pressure span, is not temperature-compensated, and can vary by up to +/-12% as the ambient temperature changes. As shown in Fig. 5, below, the curvature of Vout vs. ΔP decreases at high temperatures and increases at low temperatures.



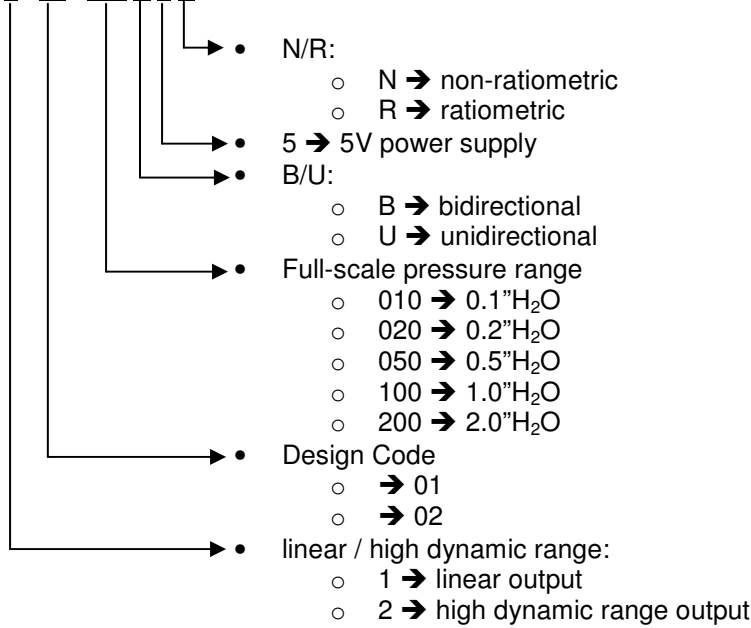
**Fig. 5: Typical deviation of Vout vs. ΔP with temperature for MB-LPS2-02 sensors. While all curves, from 5°C to 65°C coincide at Low-ΔP, up to +/-20% of Full-Scale pressure span, the curves then diverge to a wider tolerance at +/- Full-Scale pressure span.
Example: MB-LPS2-02-200B5N →2”H₂O, bidirectional.**

Preliminary Engineering Samples

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PART NUMBER NAMING CONVENTION:

MB - LPS 2 - 02 - 100 B 5 N



REVISION HISTORY:

- Beginning with: Rev. 2.2, May 28, 2010.

Preliminary Engineering Samples

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