Micro-Flow-Based Differential Pressure Sensor Demonstration

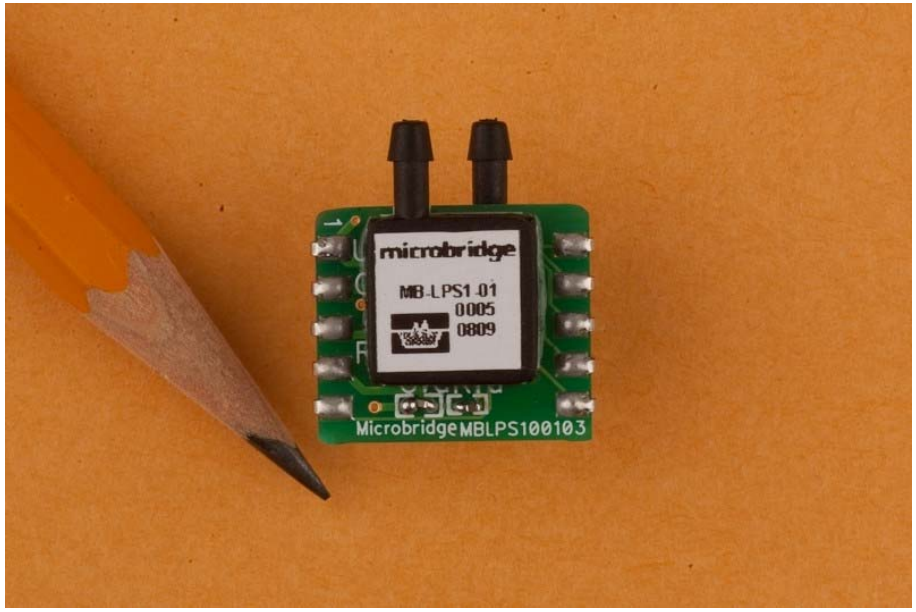
June 2009

Purpose

- To demonstrate Microbridge's micro-flow-based differential pressure sensors:
  - Offering full-scale ranges as low as +/-25 Pa (0.1"H2O, 0.25 mbar).
  - Their ability to sense extremely low differential pressures, with resolution (noise-floor) under 0.05 Pa (0.0005 mbar).
  - Their high flow impedance.

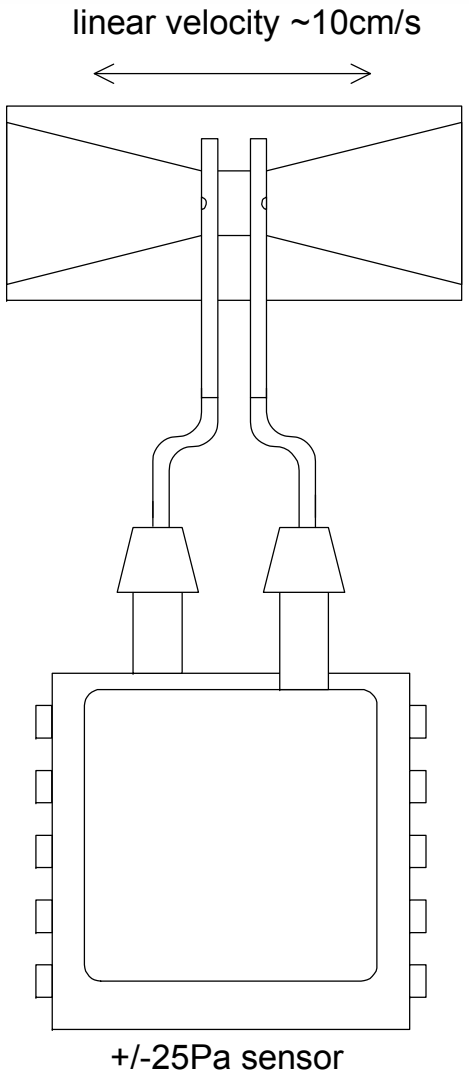
Packaged Sensor

- **MB-LPS1-01-01B** sensor, with full-scale pressure range +/-25Pa (= 0.1”H2O = 0.0036PSI = 0.25mBar).
- Bidirectional flow measurement, analog output between +0.5V and +4.5V (zero-ΔP gives +2.5V output).
- On-chip temperature compensation.



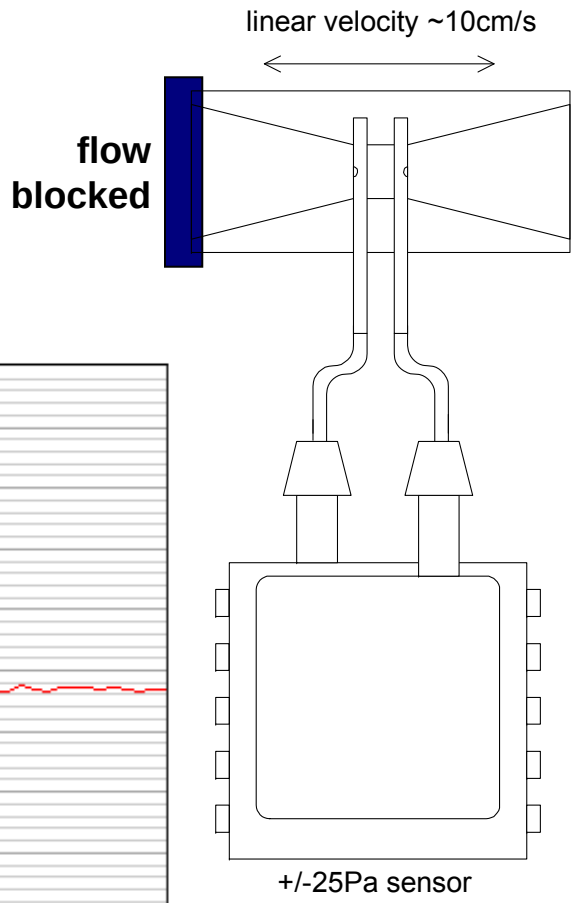
DEMO #1

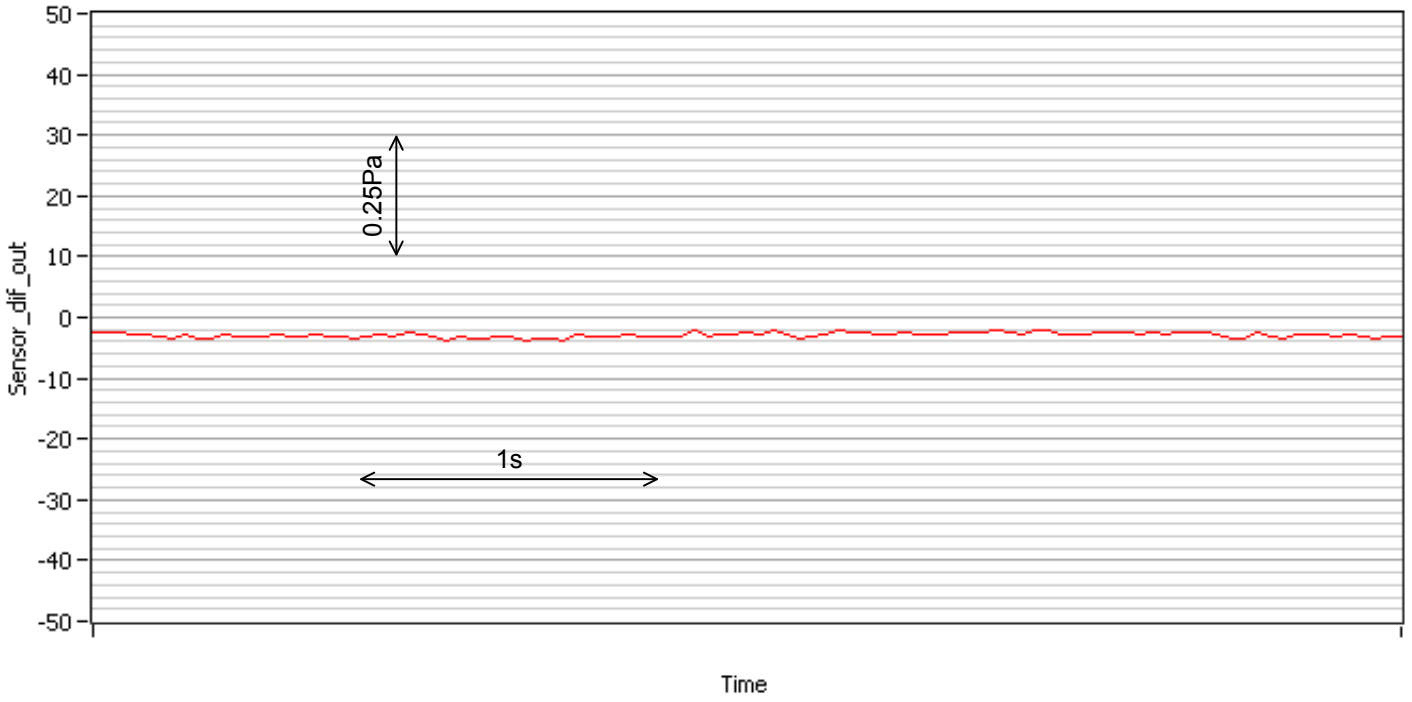
- To show extreme sensitivity.
- +/-25Pa full-scale ΔP sensor measures ΔP between two points inside a simple flow tube.
- The flow tube is tapered as shown, to restrict flow slightly and establish ΔP.



DEMO #1, Blocked Flow

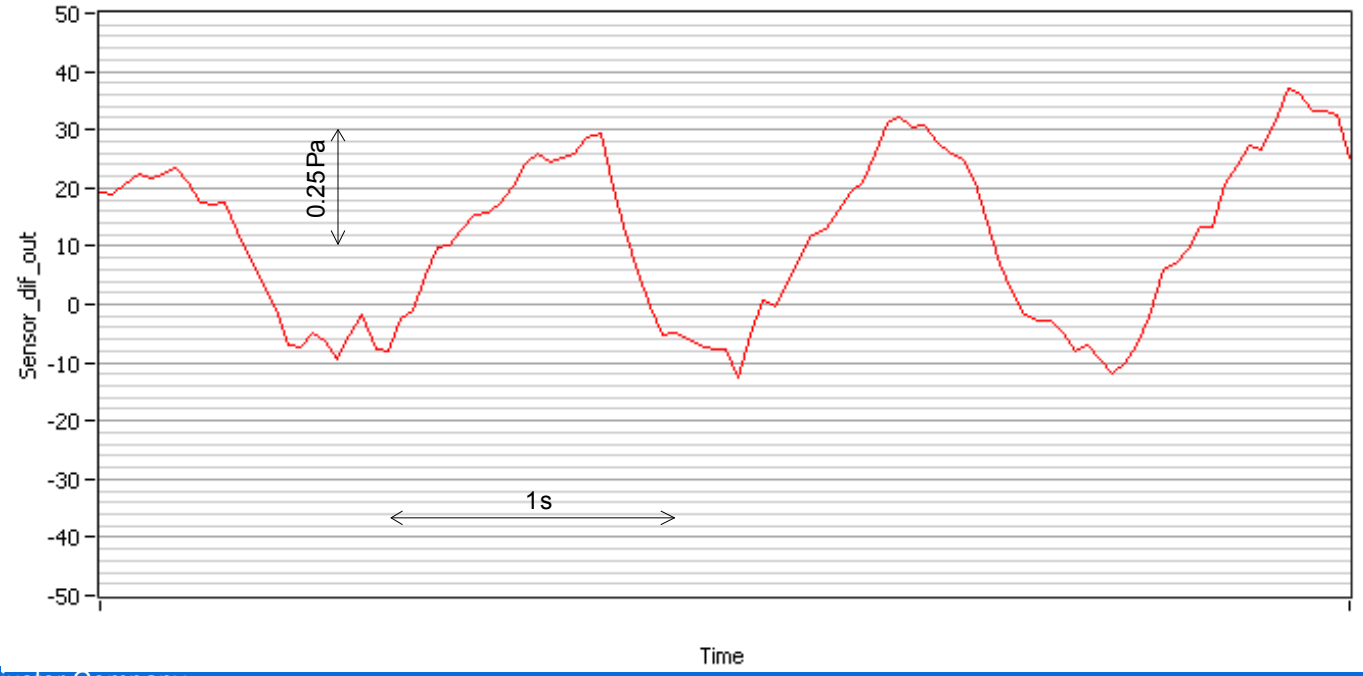
- When the flow is manually blocked, and the sensor is moved side-to-side, up-and-down, no signal is seen above the noise floor of the sensor (<0.05Pa).

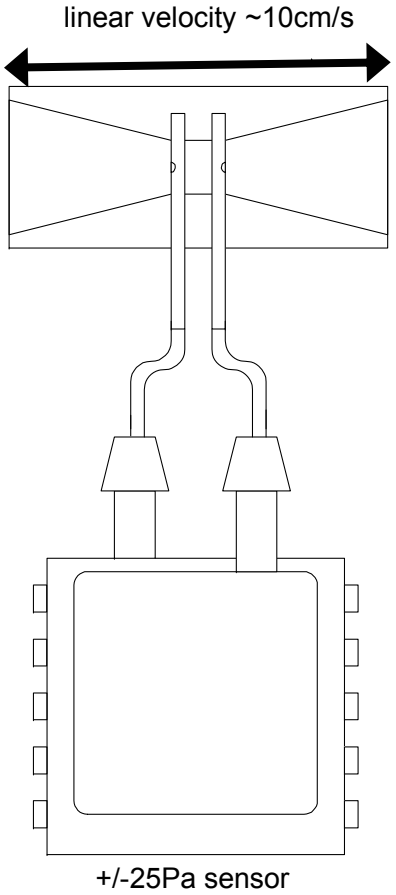




DEMO #1, Low Flow

- With tube open, the sensor-and-tube unit is moved slowly from side to side.
- +/-0.25Pa pressure variations are readily measured, with resolution below 0.1Pa
  ➔ *extreme sensitivity*.





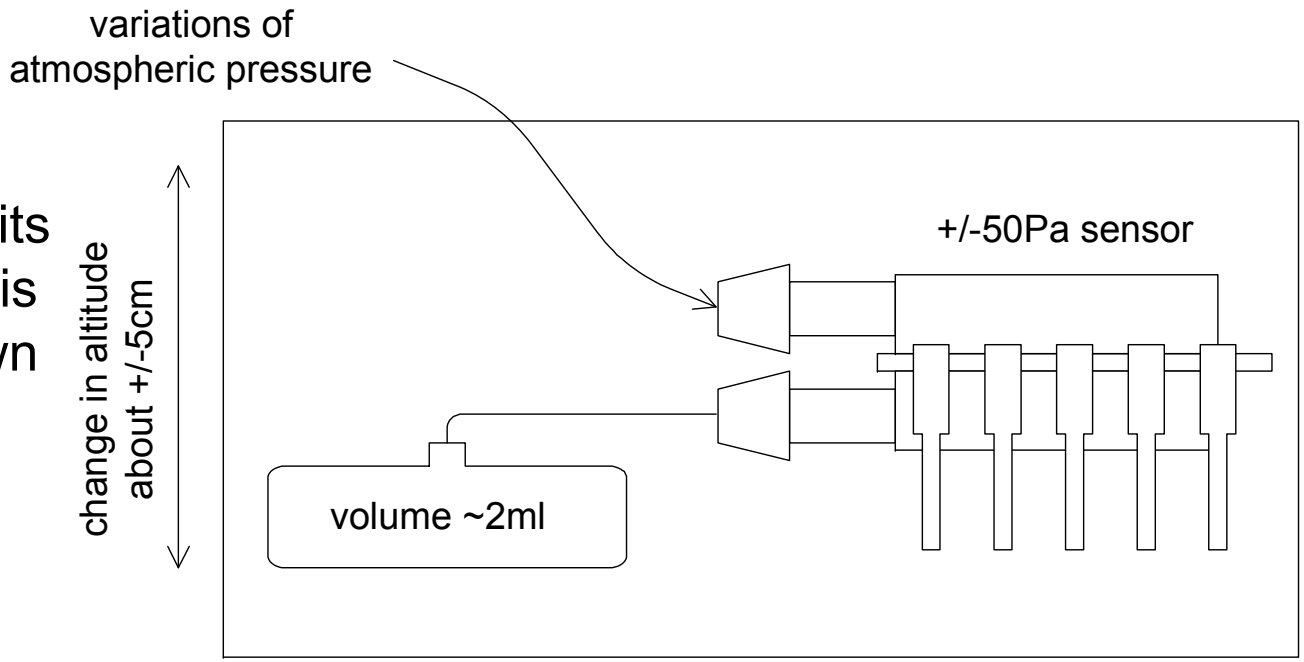
DEMO #2

- To show that the flow sensor can easily sense very small local pressure differences due to elevation (altitude) changes of a few cm (+/-5cm) in normal indoor room air. (~1-2 Pa).
- To show again high resolution at very low differential pressures below 1Pa.

DEMO #2, closed vol.

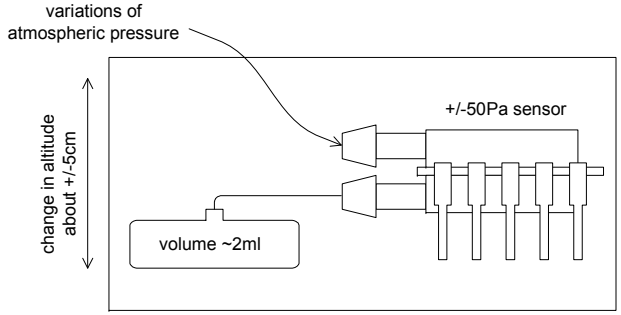
- Now we connect a small (~2ml) closed volume to one pressure port of a +/-50Pa sensor. This provides a reference pressure, for detection of time-variations of absolute pressure at the other (open) pressure port.

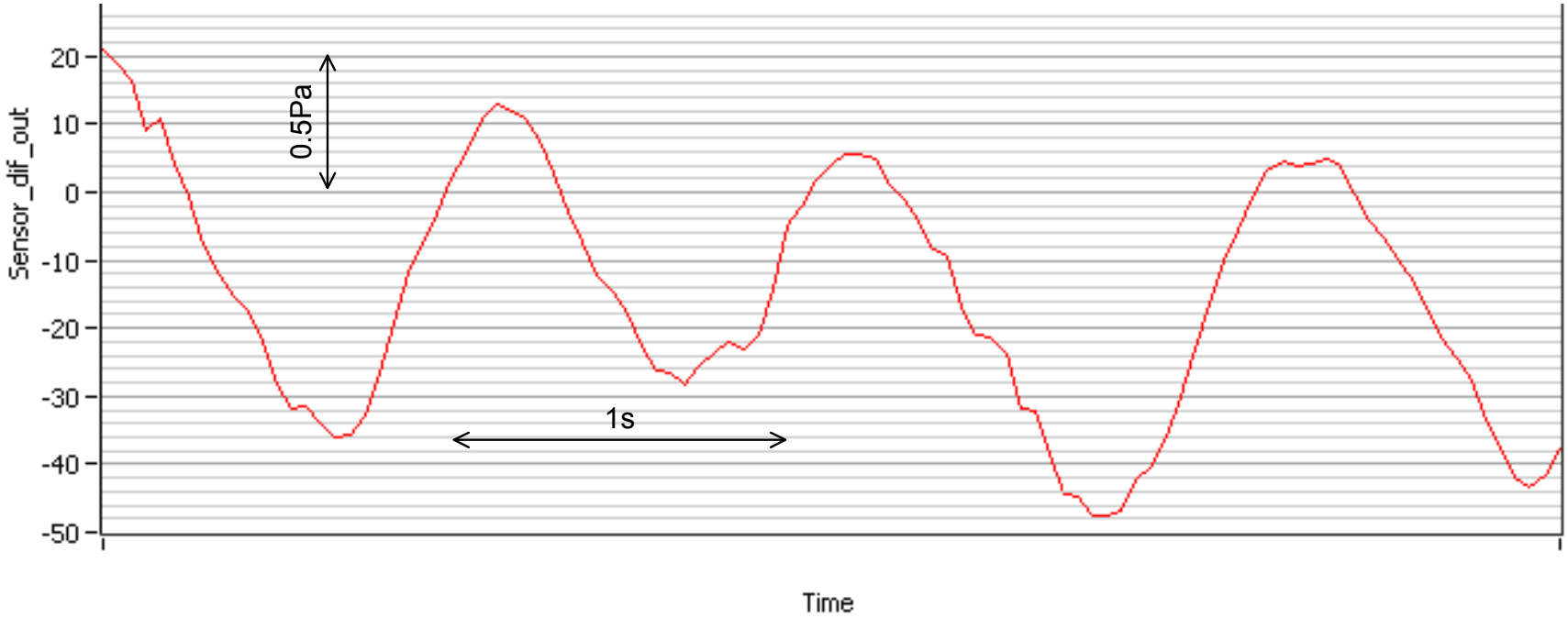
• The sensor, with its reference volume, is moved up and down to sense pressure differences due to elevation.



DEMO #2, Result

- Air movement in and out of the reference volume through the sensor allows sensing of pressure variations due to elevation (altitude) changes.



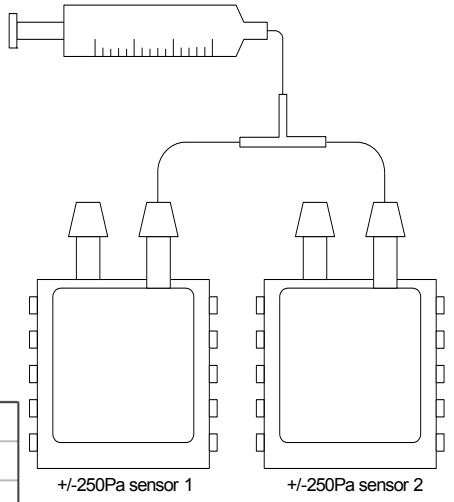


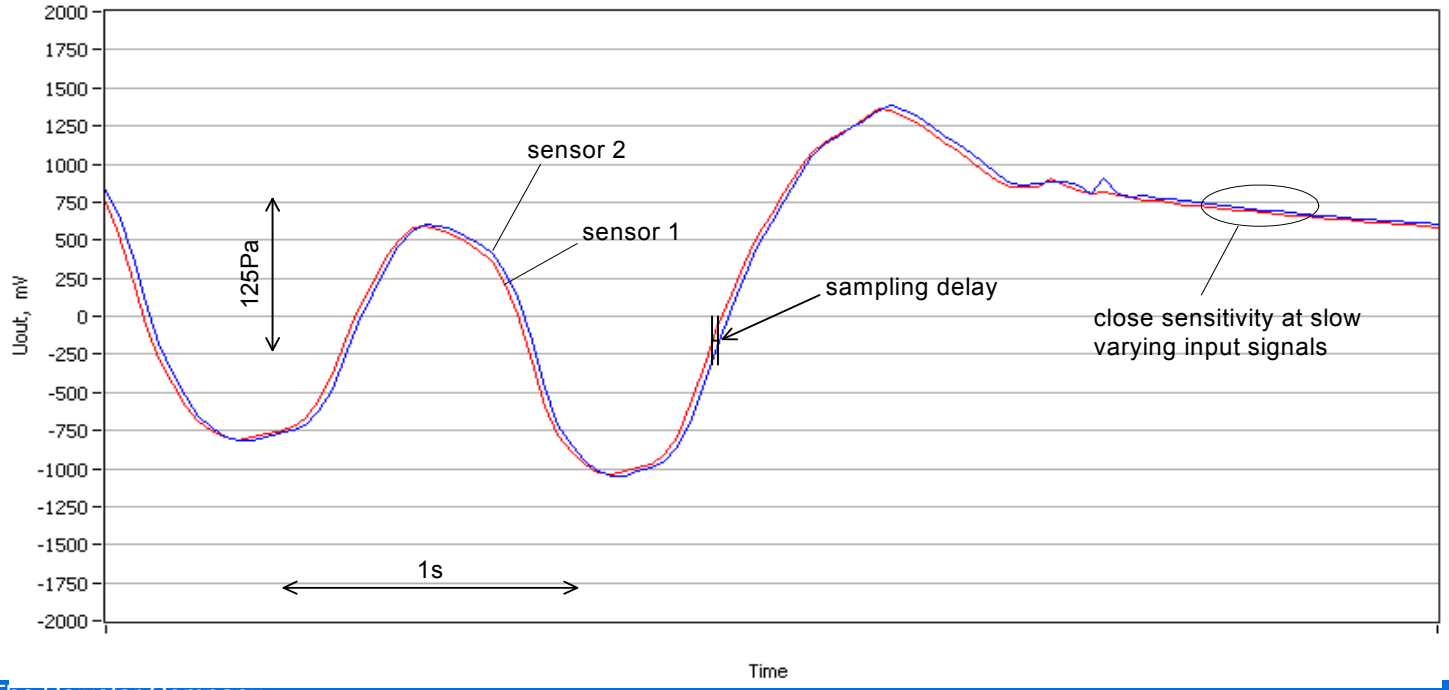
DEMO #3

- To show the sensor's very high pneumatic flow-through impedance, and insensitivity to long tubing between sensor and pressure-source.
- Two sensors connected to a common pressure source should give the same output …
- ➔ … even if the connection to one of the sensors is through 6 meters of 1/16"-ID tubing?!?

DEMO #3, Direct

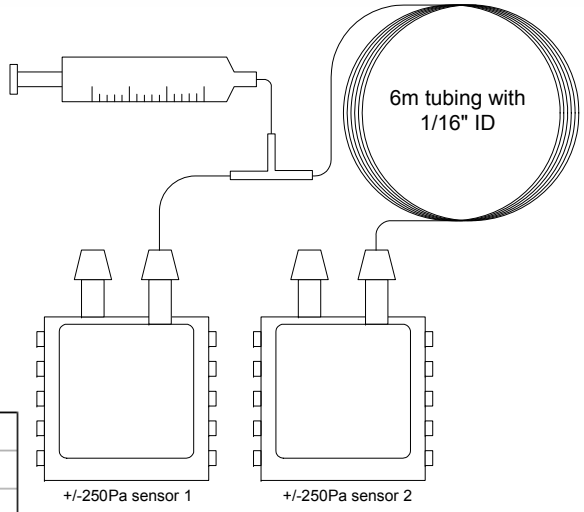
- Both sensors connected directly to a common pressure source …
- ➔ give same output.

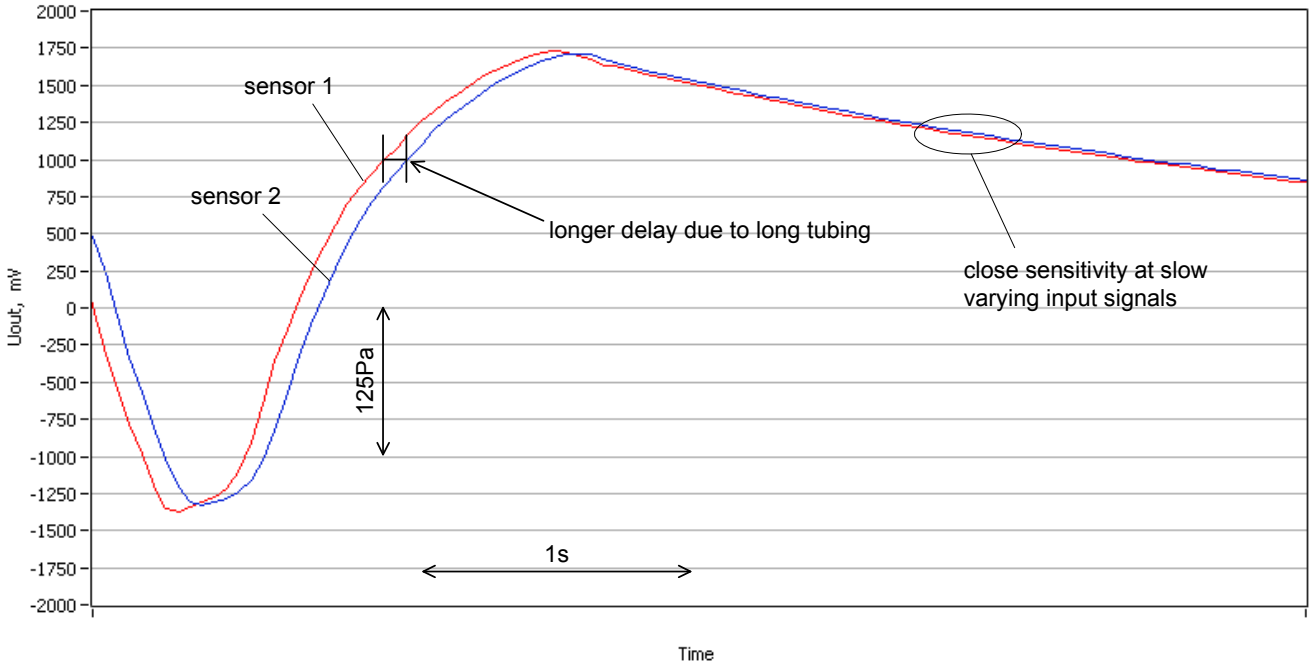




DEMO #3, INdirect

- One sensor connected through 6m of tubing having inner diameter 1/16”…
- ➔ causes slight time delay due to compressibility of gas in the tubing, …





➔… BUT the 6m of tubing doesn’t affect the calibration of the sensor! …

➔ … because the sensor’s flow-thru impedance is above 20kPa/(ml/s).

CONCLUSIONS

- The micro-flow-based differential pressure sensor can resolve very low pressures, below 0.1Pa, with noise floor below 0.05Pa.
- The sensor can readily sense very small time-variations in absolute pressure such as caused by height changes in room air.
- The micro-flow sensor's flow-impedance is very high ➔ greater than 20kPa/(ml/s), …
- ➔ … which makes calibration unaffected by long connection tubing and input filters.

- Thank you for your attention!

- http://www.mbridgetech.com
- http://www.mbridgetech.com/pdfs/microflow1008.pdf
- http://www.mbridgetech.com/datasheets.php

- Excerpts from datasheet below …

MB-LPS1-01 Series

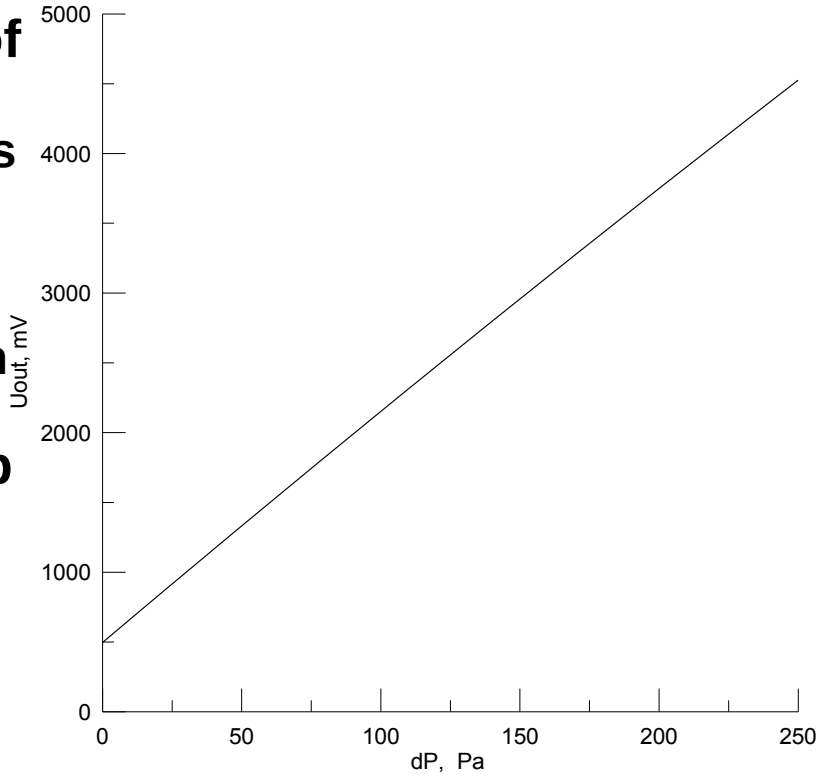
- Microbridge's MB-LPS1-01 series low-pressure sensors sense differential air (or other non-corrosive gas) pressure, inferring differential pressure from nano-liters per second gas-flow through an integrated air-flow channel having high flow-impedance. The transducer is a MEMS-based thermo-anemometer on a monolithic silicon chip. Rejustor technology combined with CMOS circuitry provides on-chip-integrated analog-only compensation and conditioning electronics.

Unit ID	Measurement Range (Full Scale)			Pneumatic Flow-Through Impedance
MB-LPS1-01-01B	+/-25Pa	+/-0.1"H_2O	+/-0.0036PSI	>20kPa/(ml/s)
MB-LPS1-01-01U	0...25Pa	0...0.1"H_2O	0...0.0036PSI	>20kPa/(ml/s)
MB-LPS1-01-02B	+/-50Pa	+/-0.2"H_2O	+/-0.0072PSI	>20kPa/(ml/s)
MB-LPS1-01-02U	0...50Pa	0...0.2"H_2O	0...0.0072PSI	>20kPa/(ml/s)
MB-LPS1-01-10B	+/-250Pa	+/-1"H_2O	+/-0.036PSI	>70kPa/(ml/s)
MB-LPS1-01-10U	0...250Pa	0...1"H_2O	0...0.036PSI	>70kPa/(ml/s)
MB-LPS1-01-20B	+/-500Pa	+/-2"H_2O	+/-0.072PSI	>150kPa/(ml/s)
MB-LPS1-01-20U	0...500Pa	0...2"H_2O	0...0.072PSI	>150kPa/(ml/s)

Other full-scale ranges are available – contact Microbridge – www.mbridgetech.com

FEATURES, BENEFITS

- **Linear Output**
- **High flow-impedance in the range of tens to hundreds of kPa/(ml/s)**
  - **Dominates flow-impedance in series (in-line) configurations.**
  - **Minimizes flow-through in bypass (parallel, shunt) configurations.**
  - **Allows use of filters and connection hoses without losing calibration.**
- **Rejustor-based analog-only on-chip signal conditioning electronics to compensate (Offset, TC-Offset, Span, TC-Span).**



App Brief re DEMO #2

APPLICATION BRIEF: Real-Time Sensing of Time-Variations in Absolute Indoor Air Pressure

- In order to use this sensor to sense time-variations in absolute indoor air pressure, it is sufficient to connect one flow port to a small closed volume, such that that port is not open to the ambient air pressure → the sensor will sense time-variations in absolute air pressure at the other (open) port.
- For example, using the MB-LPS1-01-02B, the sensor's minimum detectable differential pressure is below 0.1Pa, which is roughly 1ppm compared to the ambient indoor air pressure (atmospheric pressure: ~ 105 Pa). When combined with the sensor's 1-2ms time-response, this is sufficient to sense very small transient changes in indoor air pressure.
- For example, if a typical conference room has volume 6m x 8m x 2m ≈ 100 m3 = 100,000,000 cm3, then a change in volume of 100 cm3 corresponds to 1ppm. This would be equivalent to a window having area 2m x 1m being displaced at its center by roughly 0.3mm, such as could happen due to a wind gust at the exterior of the building.
- Microbridge's MB-LPS1-01-XXX sensors routinely demonstrate the ability to sense indoor air pressure changes of this magnitude.

App Brief re DEMO #3

APPLICATION BRIEF: On the Use of Hoses and/or Filters

Microbridge's MB-LPS1-01-XXX series differential pressure sensors feature very high flow-through impedance, greater than 20kPa per (ml/s) of flow-through. This makes the sensor virtually equivalent to membrane-type (dead-end type) differential pressure sensors regarding this important aspect of performance for many applications.

Consider, for example, the sensor being used in a shunt configuration, to sense differential pressure across a flow-restrictive baffle in an air duct, thereby inferring measurement of air flow in the duct. To enhance the immunity of the sensor vs. particulate contaminants and humidity, it is desirable to use connection hoses and/or filters, as shown in the figure below. These hoses and/or filters may add flow-impedance to the shunt path, for example up to 1kPa/(ml/s). Due to the high flow-through impedance of the MB-LPS1-01-XXX series sensors, the change in air flow through the sensor (and therefore the change in the sensor's sensitivity) is small-to-negligible. Even as the filter's characteristics change over time and use, the change will still be small.