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Measuring Large Flows With Small Sensors Improves Accuracy

Flow sensors are critical components in a variety of medical applications, from monitoring the output of gas delivery systems to ensure accurate flow rates to monitoring a patient's breathing. Ventilators, anesthesia delivery, oxygen concentrators, spirometers, insufflators, sleep apnea diagnostic and treatment equipment, pulmonary-function test equipment, and other critical devices all require flow measurement.

Some of the flow-sensing technology available includes differential pressure, positive displacement, and turbine approaches. Today, physicians are requiring electronic measurement to monitor gas flow, which provides greater accuracy and reliability. It also allows for the capture of an accurate log of treatment progress.

MEMS ON THE JOB

Compared to other flow-measurement components that don't integrate signal amplification and temperature compensation, microelectrical-mechanical system (MEMS) mass flow sensors offer easier integration and cost savings. Individually precalibrated at the factory, these MEMS sensors reduce installation time by eliminating the sorting process *(Fig. 1)*. Also, final product calibration often isn't necessary.

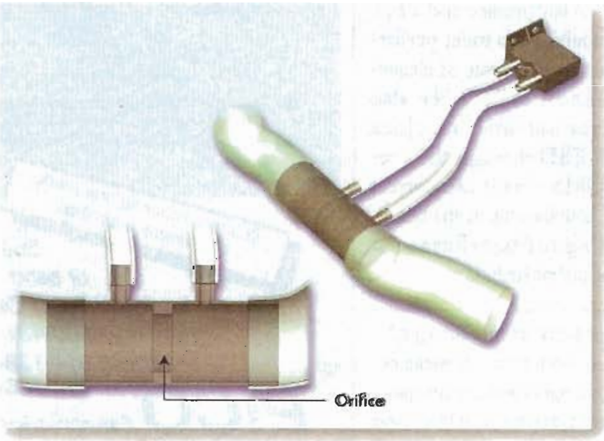
Employing MEMS flow sensors, users can expect highly accurate and stable mass flow measurements. They offer many advantages over other technologies, though MEMS mass flow sensors often come with a higher price tag because of higher flow-rate requirements.

One solution for reducing cost, space requirements, and weight is to configure a low-flow-rate mass flow sensor in a bypass configuration to measure the higher flow rates. A MEMS flow-sensor bypass setup is similar to that of a differential pressure sensor, which is also an indirect method of measuring gas flow *(Fig. 2)*.

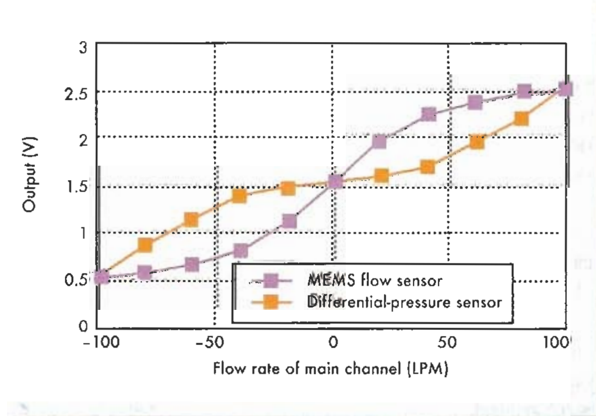
1. Omron's 1-LPM D6F-P series of gas-flow sensors targets medical applications. They're available with bidirectional and unidirectional flow calibrations, with a negative flow indication on the unidirectional version.

The MEMS sensors also deliver a higher resolution at very low flow rates when compared to differential pressure (dP) sensors. Figure 3 illustrates the difference between typical mass flow sensors and dP sensors. At flow rates close to zero, the dP curve flattens out, making it difficult to distinguish low flow readings from no flow or negative flow.

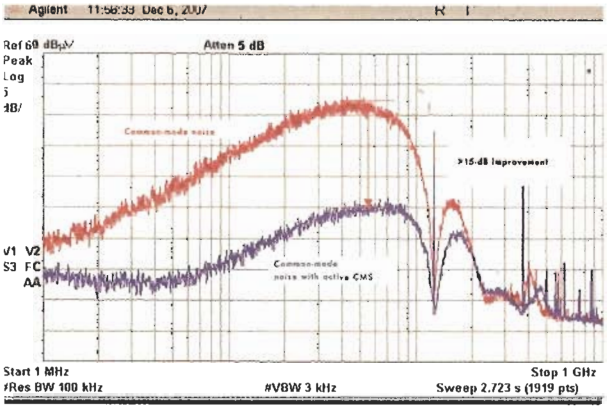
A basic bypass setup consists of two ports inserted into the main flow path with an orifice or some other type of flow



2. To handle high flow rates, a MEMS flow sensor can be set up in a bypass configuration.



3. MEMS mass flow sensors provide significantly higher signal resolutions than dP sensors, even at very low flow rates.



3. Ethernet signal common-mode noise measurement and suppression by the active CMS circuit indicates 15-dB improvement across the transmission band.

receiver. And, it improves longitudinal balance of the line while reducing the effects of manufacturing tolerances.

COMMON-MODE SUPPRESSION PERFORMANCE

Adding active common-mode suppression to Ethernet interfaces significantly reduces in-band common-mode noise. Looking at the common-mode rejection ratio (CMRR), Figure 2a shows a test setup and Figure 2b the CMRR test results. Figure 3 shows the in-circuit reduction of common-mode noise. From figures 2b and 3, we see a nominal 15-dB improvement across the transmission band.

The removal of in-band common-mode noise is critical for high EMI performance since the FCC EMI compliance mask is lowest from 30 to 230 MHz. Filtering in-band noise requires distinguishing between differential data and common-mode noise signals. If necessary, out-of band-noise is suppressible using small ferrite beads.

TRANSIENT THREATS, SOLUTIONS

Silicon devices need protection from overvoltage and overcurrent conditions caused by external inductive coupling or human body discharges. One issue, cable-disconnect discharge, is a new problem resulting from delivery of power over Ethernet (PoE) cable.

Designers must additionally consider cable discharge events (CDEs) caused by charges building up on the cables when pulling them through conduits. The discharge occurs when plugging cables into equipment, enabling a discharge path to earth ground.

A transient overvoltage protection device has two critical requirements. First, it must turn on faster than the device it protects. Second, it must be able to withstand large transient currents.

In an output ESD structure, design hardening and layout techniques significantly reduce inductive and capacitive effects on the output. A low-inductance diode is critical to achieve fast turn-on times. The design uses ferrite beads, less than 35 nH, between the suppressor and the Ethernet PHY. They help direct ESD through the suppressor and prevent ESD flow through the PHY.

The suppressor provides a higher level of ESD protection than CMOS solutions. Test data shows IEC61000-4-2 air discharge performance beyond ±25 kV, contact discharge of +12 kV, cable discharge equivalent performance greater than ±12 kV, and IEC61000-4-4 and 4-5 performance of 2 kV each for fast transient burst and surge.

ETHERNET SIGNAL INTEGRITY

Careful deployment of the EMI/ESD suppressor ensures no signal degradation. The ferrite beads between suppressor and PHY provide a tuning capability to meet performance requirements over a range of Ethernet transformers and PHYs. They also provide filtering for out-of-band clock tones and direct all ESD through the suppressor. And, the CMS circuit can correct for any differential imbalances in the beads, similar to correcting for transformer or other passive-component imbalances. ED

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