Design Considerations for Pressure Sensing Integration

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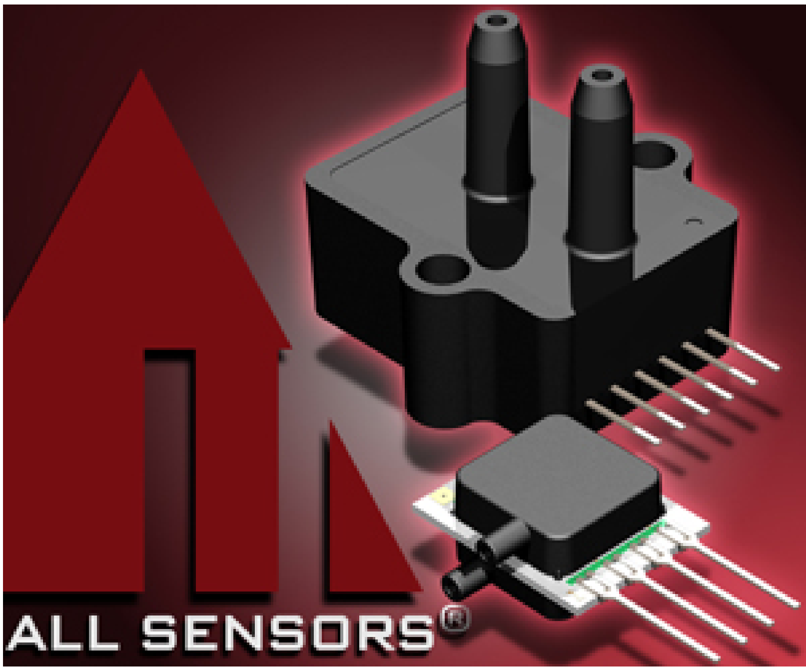
Where required, a growing number of OEM’s are opting to incorporate MEMS-based pressure sensing components into portable device and equipment designs, as a means of ensuring reliability, safety and quality. The choice of pressure sensing type within these applications tends to be highly specific to the intended operating characteristics of both the sensor and device itself.

A handheld battery operated spirometry device, for example, must be able to be turned on and off quickly and instantly, while continuously recording data over a 20-second period with optimized use of available power, thus requiring a low-voltage pressure sensor which is able to use power only as needed. In another instance, pressure sensors for handheld HVAC monitors, due to their portability and manner of use, cannot be overly susceptible to vibration or position changes, which could ultimately affect measurement integrity.

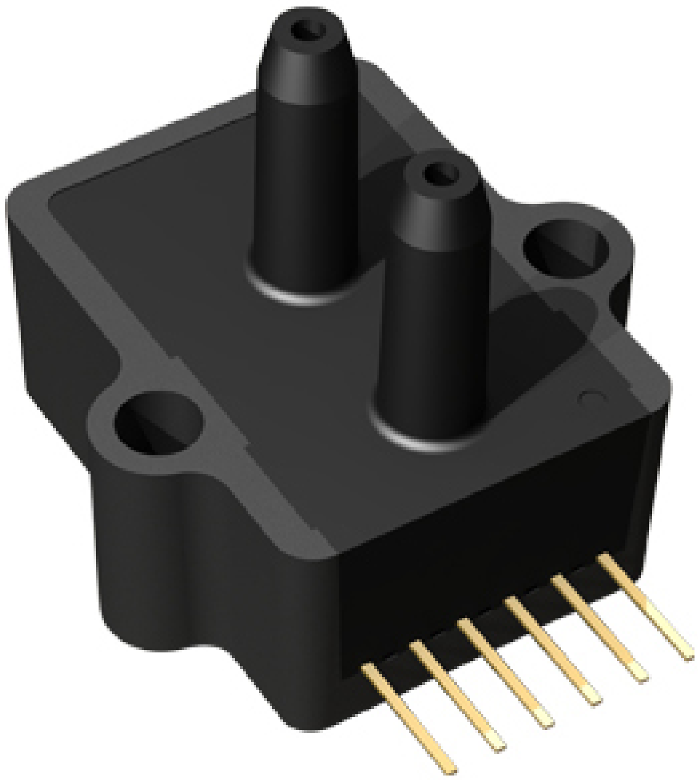


Among the various types of sensing technologies, low-voltage die-based MEMS pressure sensors, such as those manufactured by All Sensors Corporation, offer some of the greatest advantages within portable devices, including high-reliability performance and extended useful service life. This is particularly important for environments characterized by a wide dynamic temperature range, or where external shock and vibration is present. Low-voltage MEMS pressure sensor components are comparatively lower in cost and offer high-quality mass customization and production capabilities. When integrated into assembled portable devices and equipment, they can help achieve exceptional measurement linearity and repeatability, with minimized power consumption and extended service life. All of these factors influence sensor selection for portable OEM devices.

Because of their unique advantages, OEM's are driving new market introduction of MEMS pressure sensing technologies that can be reliably used across a multitude of application environments; which offer ability to apply lower supply voltages to obtain a higher output signal with measurement stability; and which allow for low warm-up shift and low position sensitivity. In addition, these sensors can be isolated from internal device electronics, offering added protection from signal degradation as a result of thermal transfer.

When selecting an appropriate pressure sensor for integration into a portable device, it is important to understand a sensor's own unique performance characteristics as they relate to device operation requirements, as well as the unique operating conditions of the intended device usage environment and collective potential effects on device performance. The following is an overview of these considerations, along with a few application examples of the successful integration of All Sensors low-voltage MEMS pressure sensors into finished portable device and equipment designs.

Sensor Die Design
A typical MEMS pressure sensor is constructed of a body, or "die," and a thin silicon diaphragm with four surface piezoresistors, whose resistance changes in response to mechanical stress. They are generally arranged in a bridge configuration and are precisely located on the diaphragm surface to maximize deflection response. In doing so, pressure differential response is maximized across the diaphragm. MEMS pressure sensor quality and performance within an application environment is most directly tied to sensor die quality. As a result, MEMS pressure sensing manufacturers strive to produce the smallest and highest quality die possible for desired customer sensitivity levels, overall performance stability, and therefore, facilitating highly compact packaging requirements.



Package Size

By definition, a portable device is characterized by its ability to be easily transportable and with on-demand functionality. This typically calls for compact pressure sensor designs which offer performance stability, low voltage requirements, and which can reliably operate in a lightweight, easily transported package. Thus, when incorporating pressure sensing technologies into portable device designs, compactness is a near-absolute requirement. The space constraints within the devices themselves impose certain limitations on sensing technology options within these types of applications. Sensors must not only operate within a small package, they must also be isolated from the internal device electronics to avoid signal degradation.

While traditional low-pressure ceramics products are still in use to satisfy these requirements within some smaller device applications, they are design prohibitive for portable devices, as size and weight remain major considerations. Equally important is for the sensor to be compact enough that it will not cause stress on the sensor package within the assembled device, as this affects overall output signal accuracy, ultimately effecting overall device performance. Recognizing the importance of these considerations, All Sensors has recently introduced its new BLV/BLVR and MLV series. The sensors are manufactured from the industry’s smallest single pressure die for its sensitivity levels, and therefore allows for compact packaging, facilitating easy integration into portable device designs with reduced risk of package stress. Custom packaging requirements are also a core specialty for All Sensors, which routinely works with OEMs on the successful integration of pressure sensors into more challenging environments.

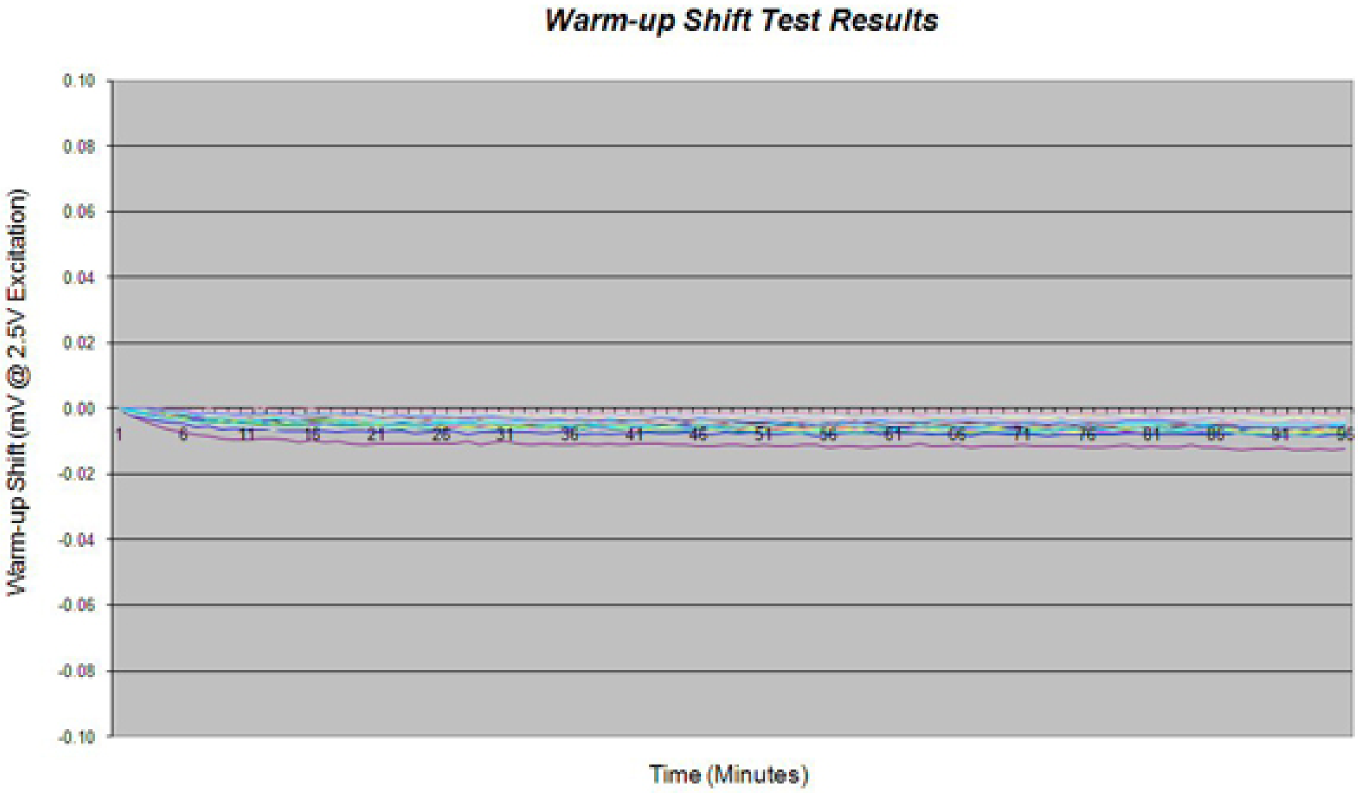
Temperature Variation

Operating temperature variations can also have a direct effect on MEMS pressure sensor offset voltage and output span, and can ultimately affect overall measurement stability. Portable device applications typically require use of a pressure sensor that can reliably operate in moderate temperature excursions of 0 to +50°C, though certain operating conditions can require more extensive ranges. Portable oxygen concentrators are an example of a device featuring integrated pressure sensors that are used in relatively moderate temperatures, though some models may require a sensor with wider, industrial-level temperature ranges of -20 to +85°C. To meet these varying range requirements, manufacturers frequently look for a pressure sensing technology with either user-adjustable or integral temperature compensation options.

MEMS-based pressure sensing component technologies, such as the All Sensors BLV and BLVR Basic Pressure Sensor Series, are commonly offered with customer-applied temperature compensation capability, which allows manufacturers to tailor temperature performance to their own device performance requirements. Alternately, the All Sensors MLV series offers integral temperature compensation of offset and span, via a laser trimmed film compensation network, to satisfy this application consideration.

Sensor Output and Device Stability
Sensor output sensitivity is another parameter that will impact signal strength at a particular operating voltage. Higher sensitivity devices can typically be operated a lower voltages with less signal degradation. The higher output level of the pressure sensing die used offsets the lower operating voltage, thus maintaining comparable signal-to-noise ratios to those found in previous generation devices.

Power/Voltage Supply Requirements and Warm-up Shift
As most portable devices are battery operated, pressure sensor power and voltage supply requirements have traditionally been 5V, though the general trend has been a move toward 3.3V or lower voltages, to help further preserve product battery life. These lower power requirements facilitate easier customer integration of sensors into finished product designs, with increased measurement stability and performance. This is because the risk of internal self-heating and related offset shifts are reduced.



When considering temperature requirements, warm-up shift is also a concern. The warm-up shift of a device is, simply, the effect that power has on device physical characteristics in its warm-up phase. An alternate and preferred approach to reducing supply voltage modulates the sensor supply as required by the system bandwidth. In other words, apply power to the sensor only when needed. This reduces power to the sensor to the time average (duty-cycle) applied and, hence, reduces warm-up drift. The method is slightly more sophisticated but can provide excellent results and without affecting system noise level.

To help manage power requirements, pressure sensors are offered in both compensated and uncompensated versions. Compensated devices offer lower calibration costs, faster production cycles, lower production equipment overhead, and easier design-in capabilities. Uncompensated versions are generally designed to operate a 5V.

Low voltage pressure sensors offer 1.8 and 3.3 V power supply requirements, to facilitate sensor integration into portable device and equipment designs. The All Sensors BLV Series Basic Sensor is designed to provide a high output signal at a low operating voltage of 1.8V, reducing the overall supply voltage while maintaining comparable output levels to traditional equivalent basic sensing elements. The series uses 10% of the power of standard parts, while the BLVR Series offers 40% of power requirements. These lower supply voltages give rise to improved warm-up shift, resulting in improved overall long-term stability. In addition, these sensors offer lower cost and a 90% reduction in position sensitivity as compared to similar type devices. The BLV Series is intended for use with non-corrosive, non-ionic working fluids such as air, dry gases and the like. The output is also ratiometric to the supply voltage and is operable from 0.9 to 1.8 volts DC. The benefit of manufacturers of this technology is improved device efficiencies and performance, as well as longer useful device life.

Cost Savings
Within a finished portable device, the requirement for cost savings in pressure sensor selection is especially important, as both sensors and devices are mass produced for wide commercial availability. The intended price point of the finished device can put certain limitations on the type of pressure sensing technology specified. The BLV series, because of its low power supply requirements and single die configuration, as well as improved warm-up shift and position sensitivity, offers design flexibility and cost savings with greater value for investment, as well as the ability to be used within applications that formerly would require dual pressure sensing die configurations. This allows power requirement reductions, and ultimately, allows OEM’s to offer product performance improvements at roughly the same price point.

Some examples of the successful incorporation of low-voltage MEMS pressure sensors may be found in the following applications:

HVAC Pressure Transmitter for Building Monitoring
A portable industrial airflow measurement device is used for on-demand measurements of low airflow beneath HVAC vents within typical office environments or apartment building setups. Typically, this application requires use of a basic pressure sensor with unconditioned, uncompensated millivolt output signal, and simply provides a raw output signal for the OEM device. Within the intended pressure sensor usage environment, the selected component must offer long-term reliability and stability, as well as relatively good accuracy and low environmental media sensitivity. The device application environment itself is typically characterized by modest temperature variations and humidity. In these types of applications, the requirement for low warm-up shift is also important, as the device needs to operate with stability soon after powered on. Position sensitivity is less important, as the device itself is specifically orientated under duct work. The signal-to-noise ratio (or noise floor) of these sensors must be very low, as very small air pressures are being measured. Low power consumption, due to battery or current loop operation, is also a significant consideration.

Within this application environment, precision low-pressure measurements are required, along with a customer capability to perform any needed pressure sensor temperature compensation. Based on the unique requirements of both device and integrated sensor, the All Sensors BLVR Series Basic Pressure Sensor is recommended, as both offset errors due to temperature shift and warm-up shift are minimal. These sensors are designed to reliably operate in temperature ranges from -25 to +85°C, with 0 to 95% relative humidity ranges (non-condensing).

Medical Breathing Apparatus
An example of an application requiring a higher degree of accuracy and performance can be found in medical breathing apparatus used within critical patient care applications. Device designs must be highly rugged, as well as offer high accuracy and reliability within demanding environments. As medical breathing devices are employed within hospital, urgent care and other clinical settings, they

can be subjected to ongoing high levels of shock, vibration and g-force pressures, as well as wide output ranges. The demands placed upon devices within their intended usage environment would require OEM’s to specify a millivolt output or amplified pressure sensor, fully calibrated and temperature compensated. Low position and shock sensitivity are also requirements.

Also required for this type of device is the integral amplification of the pressure sensor. The amplified pressure sensor component typically houses an onboard ASIC (built-in amplifier with compensation), allowing control of the millivolt output sensor gain, noise and compensation. Amplified devices are scaled to fall into the input range of a common analog-to-digital microprocessor without additional gain. The amplified pressure sensor can be thought of as an accurate, compensated device with an amplified output signal that is more plug-and-play for the OEM. This is typically required when the customer’s analog-to-digital converter does not have a built-in gain feature.

This type of application typically uses a compensated millivolt pressure sensor. Compensated millivolt low-voltage pressure sensors are calibrated to both zero and span and are temperature compensated, to ensure accurate output signal over a specified operating temperature range. A compensated device is typically used in an application were accuracy is a priority and the OEM relies on the pressure sensor manufacturer to provide all temperature compensation and calibration within the pressure sensor itself. In this case, a manufacturer typically requires a clean, low-noise output signal. The OEM would typically provide an amplifier or ASIC somewhere on their PCB to increase the mV output signal.

To meet the demands of both sensor operating performance and overall device performance criteria, All Sensors offers the MLV Series low-voltage compensated pressure sensor. This series offers OEM’s a device with the added flexibility of extended temperature compensation ranges for use in extreme environments, and less external effort by the OEM to successfully incorporate the sensing technology into product prototype designs. The MLV Series Compensated Sensor is based on All Sensors’ CoBeam2 TM Technology. The device provides a high output signal at a low operating voltage, while maintaining comparable output levels to traditional equivalent compensated millivolt sensors operating at higher voltages. This lower supply voltage gives rise to improved warm-up shift while the CoBeam2 Technology itself reduces package stress susceptibility, resulting in improved overall long-term stability. The technology also vastly improves position sensitivity, as compared to conventional single die devices.

These are just a few examples of the active use of All Sensors low voltage MEMS-based pressure sensing technologies within these types of applications. In addition to those referenced here, successful applications have also included avionics, environmental monitoring equipment, portable oxygen therapy machinery and remote sensing applications. For more information, visit www.allsensors.com [1].

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[1] http://www.allsensors.com