THE IMPORTANCE OF PRESSURE SENSORS IN HVACR SYSTEMS

How TE Connectivity's (TE) M3200 and Board Mount Pressure Sensors Meet New Performance Standards

Sensors are an integral part of most heating, ventilation, air-conditioning, and refrigeration (HVACR) systems — helping to not only maintain a comfortable indoor climate but also to increase the efficiency of the HVAC systems. They also enable integration of HVAC systems with building automation systems.

Traditional HVAC systems used pressure and temperature sensors and switches to control basic operations of the system such as turning it on or off or for opening or closing valves or vents. HVAC equipment designers are facing mounting challenges to create more accurate systems that consume less energy with higher efficiencies leading to a comparable push for much finer control of the various HVAC subsystems. This has led to advances such as variable air volume, variable refrigerant flow, variable speed motors and blowers, electronic expansion valves, and many other control methodologies to finely tune the system and minimize the overall energy use.

Sensors have played a large role in improving the efficiency of these systems by monitoring various components within the system and confirming that all parts are functioning properly. In fact, an ever-increasing number of sensors are being installed in these systems to monitor the process and maintain accuracy. Reliability has become key to providing precise and consistent data.

The most common sensing types in HVACR systems include temperature and pressure along with a strong push toward using humidity sensors as well as gas and other sensing technologies. So, what happens when these sensors aren't reliable or robust enough? Systems can fail causing thousands of dollars in damages. However, in most situations, sensor failures result in loss of system efficiency, erratic operation, and uneven environmental controls in the building or home.

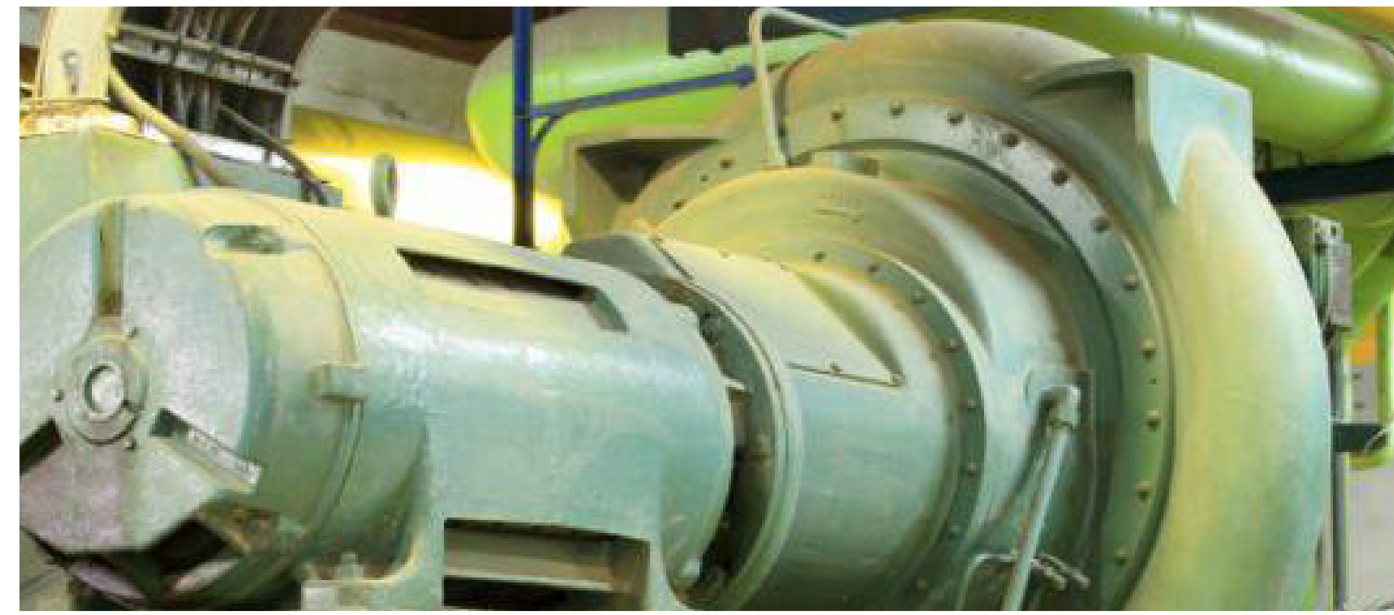
In some cases, the system provides inadequate cooling or heating and causes comfort issues with personnel, resulting in poor productivity and equipment issues. In a worst-case scenario, when temperatures are critical for computer equipment, food preservation or for medicine, drug or organ maintenance, system issues can contribute to expensive equipment failure or even the loss of life. In addition, service calls to diagnose and repair the issues can be very expensive and time consuming.

In this paper, we will concentrate our discussion on two vastly different HVAC pressure sensor applications and two vastly different product ranges that TE manufactures that address some of the challenges faced in this market.

TOUGH ENVIRONMENTS REQUIRE RUGGED, ROBUST, RELIABLE SENSORS

Pressure applications in HVAC include a range of board mount differential pressure sensors that are used in HVAC systems for filter monitoring as well as pressure monitoring throughout a forced air system. Additionally, heavy duty pressure transducers that are used to monitor refrigerant pressure in compressor-based systems as well as water or other liquid pressures in large commercial chillers and other refrigeration systems.

The environment found in commercial and residential HVACR systems can be one of the most challenging industrial environments. With large temperature swings, high moisture levels, dust and debris and, often, electrical noise, the HVACR system requires sensors that are rugged enough to function continuously while providing accurate and repeatable readings.



For board mount pressure sensors in air handling systems, the temperature range is generally narrow but these differential pressure sensors operate at only a few millibars (few inches of H2O column) to measure volumetric air flow. While air is generally considered to be a relatively benign media to measure, most commercial and residential air handling systems can become quite dusty over time with a range of particulates contaminating the air in some portions of the system.

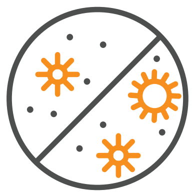
On the other hand, many of the applications on HVAC equipment are designed to monitor refrigerant or other liquid/gas pressures as part of a cooling or heating system. Depending where in the system the pressure transducer is located, it could see very high or very low temperatures as well as significant and swift swings in temperature as part of the HVAC system. Pressures also tend to be significantly higher than for air handling systems with refrigerant pressures ranging from around 50psi on the low side and 250psi on the high side for R-134a to a low side pressure of about 130psi and a high side pressure of 420psi for R-410a.

ADVANCED THERMAL TECHNOLOGY: THE IDEAL CHOICE FOR ULTRA-LOW-PRESSURE MEASUREMENT

TE offers the LDE, LME and LMI series surface mounts and board mount differential pressure sensors that utilize a thermal micro-flow channel technology and are designed for ultra-low-pressure measurements. These advanced thermal differential pressure sensors are based on a silicon chip only about 4 mm2 (0.006 in2) in size. The sensors incorporate innovative MEMS technology that integrates a micro-flow channel within the silicon sensor chip. Advanced thermal sensors can measure ultra-low air or gas pressures from 0.25 millibar (0.1 inches of water column) full scale (FS).

Advanced thermal technology features high dynamic ranges and high sensitivities for very low pressures, especially around zero. The sensors offer digital signal conditioning for calibration, temperature compensation, and amplification. They can be optimized to different application requirements depending on whether a high sensitivity, high dynamic range, or linear output signal is needed.

Two of the most significant advantages of advanced thermal technology is its zero-offset accuracy and very high pneumatic impedance. Typically, differential pressure is created in the system by an air velocity probe that converts air velocity into delta-P which is close to the square function of air velocity (or flow). Thermal sensors have excellent (0.1% FS) offset accuracy and long-term stability. The integration of the miniaturized flow channel with the sensor chip enables the advanced thermal pressure sensor to achieve very high pneumatic impedances up to 20,000 to 50,000 Pa/(ml/s). This performance is up to 100 times higher than comparable sensors. The miniaturized flow channel reduces the gas flow through the sensor to an absolute minimum and offers unique application advantages in dusty and humid environments as well as when using long connection tubes, filters, or other pneumatic elements. Even if these elements change their resistance over time, there will be no negative influence on the measurement accuracy. This capability gives the engineer more flexibility in designing the air handling system.



THE PROBLEM OF DUST

In the past, when traditional thermal pressure sensors were used for volumetric flow measurement in dirty HVAC environments, dust particles might reach the inside of the sensor and the walls of the inner flow channel. This condition would increase the sensor's pneumatic impedance, decrease the output signal, and cause a loss of calibration. In a worst-case scenario, the flow channel might be completely blocked, resulting in sensor failure.

Advanced thermal pressure sensors are highly immune to applications in dusty environments. Due to the very high pneumatic impedance, the air flow through the sensor is extremely small. This means that the total amount of dust-laden gas that streams through the bypass channel for volumetric flow measurement is reduced to an absolute minimum compared to traditional thermal pressure sensors. Additionally, the flow velocity is greatly reduced so the remaining dust quantity will settle in the bypass before it reaches the sensor input.

As a result, the sensor does not require a dust filter and, unlike other mass flow pressures sensors on the market today the advanced thermal technology is unaffected by dust. Its ability to eliminate the ingress of dust ensures highly accurate measurements and very long sensor lifetimes.

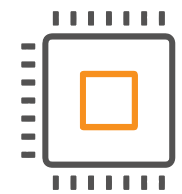
AVOIDING THE "CHIMNEY EFFECT"

Traditional thermal sensors must be installed in a specific orientation to stop the "chimney effect." Advanced thermal sensors eliminate this problem of position dependency by allowing device installation in any desired orientation. Now, the air handling system designer can place the device in any position, greatly improving design flexibility.

The advanced thermal sensor also enhances design flexibility through the accuracy of its flow channel. In traditional thermal sensors, the flow channel and gas flow are determined by the geometry of their plastic housings. These housings are not manufactured as accurately as semiconductor technology, resulting in lower stability. In contrast, the advanced sensor's micro-flow channel is defined at the die level. This permits construction of the sensor housing for high design flexibility, extremely low production tolerances, much smaller and more stable packaging, and reduced manufacturing costs.

MICROFUSED™ TECHNOLOGY TRANSDUCERS FOR HIGHER PRESSURE HVAC MEASUREMENTS

As mentioned before, SMD and board level pressure sensors are ideal for low and ultra-low-pressure measurements for dry non-corrosive gases such as air. For higher pressure measurements and for measuring most types of caustic media a more rugged and sealed pressure sensor is required. TE offers the M3200, the latest in a long line of pressure sensors designed and manufactured using Microfused technology. Microfused technology employs micromachined, silicon piezoresistive strain gages fused with high temperature glass to a stainless-steel diaphragm. The technology is a unique construction of the sensor front end made from a single piece of steel. The result is a hermetic fitting that is free from failure-prone welds and o-rings. Bottom line – it's more reliable. The M3200 is an industrial pressure transducer that reaches a new price performance standard for demanding HVACR pressure applications. Available with a wide range of threaded pressure port and connector options, it has standard pressure ranges available from 100 to 5000psi or 7 to 350bar. The M3200 is designed for ease of installation and reliable performance in harsh environments.



SENSING TECHNOLOGY — SIMPLE AND RELIABLE

At the heart of every pressure transducer is a pressure sensing element. The M3200 uses a proven Microfused™ technology to provide a simple and reliable robust pressure sensor. Manufactured from a solid piece of stainless steel, the part does not require any welds or O-rings that could come in contact with the pressure media.

This makes it compatible with a wide range of fluids including most refrigerants in use today as well as those being proposed for future use. With no moving parts, the cycle life is essentially infinite. The element is robust and offers high over-pressure and burst resistant capability. These technology features result in a simple, elegant design that is suited for harsh industrial applications used in HVACR systems.

OUTPUT OPTIONS INCLUDE DIGITAL

Most industrial pressure sensors use analog output signals, which are easy for customers to implement and are commonly used in the industry. The M3200 is available with a variety of common analog outputs including mV, 0-5V, 0-10V and 4-20mA. We also offer the M3200 with an I2C digital output. Digital sensors are becoming more pervasive in the industry. With benefits including easier integration into systems and very low power operation, they are well suited for wireless and IoT designs as well as many of the new development systems being used today.

TE is one of only a handful of manufacturers which offers a digital output in a fully ruggedized industrial pressure sensor. TE's line of board mount sensor products are also available in both analog and digital (both I2C and SPI) versions and include a range of products that have both an analog as well as a digital output in the same package.

The main advantage of a digital output is that it can be read directly by a microprocessor without the additional cost and complexity of an A-to-D converter. Additionally, a digital output has the full resolution and accuracy with no signal degradation or loss of accuracy with the additional conversion circuitry. For more information, see our product data sheet here.

ASIC COMPENSATION — ACCURATE AND FLEXIBLE

Pressure sensing elements require correction, or compensation, so that they can provide an accurate reading over a wide range of pressures and temperatures. For the M3200, we employ an ASIC-based solution. This uses a digital circuit to correct the raw pressure signal at multiple points in the operating range. Correction coefficients are stored in onboard memory, simplifying manufacturing, and producing a very accurate product.

ROBUST DESIGN RESISTS INTERFERENCES

The HVAC environment for pressure transducers is very harsh with temperature swings, moisture, and high levels of shock and vibration. Making matters worse, if nearby equipment is switching heavy currents, this can cause electrical and EMC spikes that can challenge the precision electronics of most sensors. The M3200 is different. It uses a simple, elegant design that enables it to survive these harsh conditions. It contains a small, light circuit board with minimal interconnects, enabling it to resist high levels of shock and vibration. Additionally, a separate circuit is used to provide protection against electrical surges and noise. The pressure port and body employ a welded steel construction that is more resistant to accidental damage then softer material.

FLEXIBILITY FOR MODIFICATIONS AND FUTURE NEEDS

The M3200's internal design allows for the same basic sensor design for a wide range of configurations or standard options in a single product line. For design engineers, this is an important advantage. It means that engineers can use the M3200 platform to easily modify current designs or extend them to address future market needs or specific customer concerns.

SOLUTIONS THAT GROW WITH YOUR HVACR NEEDS

The HVACR industry is continuously expanding the use of sensor technology to provide more efficient and effective systems. The industry is pushing for sensors that are highly accurate, repeatable, able to survive the harsh HVACR environment all while being cost effective and easy to use. TE Sensor provides a wide range of pressure sensing solutions that are well suited for design engineers to utilize in a variety of HVACR applications. These range from low pressure air handling applications such as VAV, ventilation, and filter monitoring to higher pressure applications in commercial chillers, refrigeration controls, heat pumps, electronic expansion valves, container storage and much more.

The Importance of Pressure Sensors in HVACR Systems

ABOUT TE CONNECTIVITY

TE is a global technology leader, providing sensors and connectivity essential in today's increasingly connected world. We are one of the largest sensor companies in the world. Our sensors are vital to the next generation of data-driven technology. TE's portfolio of intelligent, efficient, and high-performing sensor solutions are used for customers across a wide range of industries including HVACR, automotive, industrial and commercial transportation and aerospace and defense, to medical solutions and consumer applications.

ABOUT THE AUTHOR

Devin Brock is the Manager for Sensor Product Knowledge and Training for TE Connectivity. He has more than 25 years of sensor-related experience. Prior to joining TE Connectivity, he held several roles in design engineering, product and applications engineering, and sales and marketing. His most recent role was as a Field Applications Engineer for distribution within TE.
He holds an Electrical and Computer Engineering Degree from Clarkson University

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