MAKING HVAC SYSTEMS MORE EFFICIENT AND RELIABLE WITH SENSORS

Some of the largest costs associated with buildings center around HVAC operation. If energy costs are low, some areas may have infrastructure limitations or regulations on power consumption. Additionally, there are unseen costs. For example, HVAC is linked to ...

- Employee productivity
- Employee health
- Maintaining quality and efficacy of materials and electronics

Cost, grid limitations, and other factors are leading more companies to search for accurate and reliable sensors to drive HVAC and building automation solutions. While considering all sensor technology capabilities, there are some important requirements that are critical within HVAC applications. These include:

HVAC Sensor Customer Requirements

Pressure Sensors

- Immunity to dust and clogging
- Long term stability/Maintenance free
- High accuracy below 500 Pa (0.07psi)
- Large dynamic range for flow calculations
- Built in temperature and barometric corrections

Temperature

- Fast response time
- Long term stability even in high moisture and freeze/thaw conditions
- Compact size
- Available in a wide range of base resistance values, curves, and configurations

Humidity

- Resistance to free water
- Fast recovery from condensing humidity
- Electro-static discharge resistance
- High accuracy, repeatability, and low hysteresis

Scaling Intelligent HVAC Solutions

While wireless technology can help expand HVAC and Industrial Internet of Things (IIoT) solutions over wider areas, it introduces another requirement: low power consumption. As more sensors are integrated into automation and monitoring solutions, it becomes increasingly important for sensors to draw less power. End users are looking for sensors that deliver long term stability and high-performance signal processing that improves accuracy and reliability. OEMs are looking for sensors that support wireless standard communication protocols (example BLE, LoRaWAN) to reduce integration time and cost.

For example, TE Connectivity (TE) offers wireless single and triaxial accelerometers with Bluetooth Low Energy 5 (BLE5) and LoRa for low power and quick integration. Additionally, TE antennas, switches, connectors, and labeling products help to integrate wireless sensor technology into the IoT for HVAC automation and monitoring solutions. TE's unique lines of wireless and circuit-board mountable sensors can help customers and OEMs meet their needs for low-cost, scalable HVAC solutions that enable continuous performance monitoring and systems automation.

HVAC Evolution

Traditional HVAC systems implemented climate control via a thermostat that turned the system on and off according to a temperature range. Eventually, controls advanced to allow for heating or cooling according to a programmable schedule, and even by occupancy. Smart thermostats could change temperature based on the time, day, or motion. The thermostat was

only controlling the temperature of a large area, possibly multiple rooms, without the ability to control subsystems or other environmental aspects such as air quality.

Today, advanced technology makes it more cost-effective and easier to scale electronic devices and methods to create subsystems and more precise controls. Reliable sensors are driving HVAC trends including advanced and efficient heating and cooling, humidity control, variable refrigerant flow, variable speed motors and blowers, and electronic expansion valves. Today's sensors operate over a wide range of conditions with increased reliability, better accuracy, and little to no drift. Not only are building owners able to control temperatures, but they're able to control the humidity levels and airflow, as well. Most people are aware of how humidity can affect personal comfort but controlling humidity in HVAC systems is important for other reasons as well.

Improved HVAC and Health with Humidity Sensing

While cooling systems inherently extract humidity from the air, these systems are only effective when cooling is needed. Additionally, if air becomes too dry that can lead to other problems that include eye strain, vocal strain, allergies, asthma, employee performance, mental acuity, and perceived comfort ("humidex").

Research also shows links between low humidity and the increase of flu transmission. Studies show that infection rates for influenza are five times greater in dry air with 7 to 23% relative humidity (RH) than at 43% RH. Ideal humidity levels for people are between 30 to 50%. To provide the best indoor environment, modern HVAC systems include specific components, such as sensors, that monitor and control humidification and dehumidification.

The Role of Humidity on Buildings and Inventory

Another problem associated with dry air or low humidity levels is the increased risk of electro-static discharge (ESD) for electronics and negative effects on hygroscopic materials, such as paper, plastic, glue, leather, paint, and wood. Humidity monitoring and control can prevent cracking, dry rot, gluing failure, warping, and other effects.

Humidity sensors play an integral role in modern HVAC systems to improve performance, reduce energy consumption, and increase safety. In industrial environments where employee comfort and productivity is important and where material moisture levels can effect performance or quality, humidity monitoring and control should be considered. There are three main types of humidity sensors which are defined around what approach is used to sense humidity and deliver an electrical signal that can be used to establish the value. The three types include capacitive, resistive, and thermal conductivity technologies with each technology having advantages and disadvantages. TE manufactures humidity sensors utilizing a special capacitive based technology that provides stable readings over time and can detect a wide range in relative humidity and also provides near linearity with signal amplitude over the range of humidity. TE offers humidity sensing products ranging from board mountable components to PCB modules to humidity sensor assemblies that include both analog and digital solutions. Additionally, TE delivers...

- Full RH range from 0 to 100%
- Quick response and recovery times
- Minimal hysteresis
- Self-diagnostic capabilities
- High accuracy
- Low power consumption
- Ratings for full water immersion

Combination Sensing Products

For OEMs designing HVAC solutions, reducing SKUs, assemblies, and simplifying installations are also important. Companies offering manufacturing capabilities for combining sensor products can help OEMs deliver significant value to clients.

For example, the **HTU31** by TE, is a 2.5 x 2.5 x 0.9 mm package, individually calibrated, high accuracy sensor that is serialized for traceability and provides ±2% accuracy for relative humidity and ±0.2°C for temperature. It comes in a compact 6-pin DFN package, provides a fast response time, and has a typical power consumption of only 3.78µW. The sensors are available in both a digital Inter-integrated Circuit (I2C) format with a configurable address as well as a model with an analog output 0.5-4.5V output.

Reliable Pressure Sensing for Advancing HVAC

With an increasing adoption of IIoT, Cloud, and wireless solutions, sensors must be designed with ruggedness, flexibility, and connectivity in mind. For heat pump applications, sensors must operate in extreme conditions while providing long-term reliable data. For example, TE's board mount differential (**SM7000, SM8000, and HCLA**) and board mount (**LMI** and **LHD**) microflow pressure sensors are immune to dust and fumes and provide excellent long-term stability.

For applications that require high precision and extended measuring range, the TE LHD sensor provides this functionality in a single component. This pressure sensor measures pressure over a wide range of -5,000 Pa to +5,000 Pa with sub-pascal accuracy. All the LDE/LME/LMI sensors are based on a silicon sensor chip that is only about 4 mm^2 (0.006 in^2) in size. The sensor's design contains a micro-flow channel that provides a very high pneumatic impedance of up to 200,000 Pa/(ml/s), which is up to 1000 times higher than comparable sensors. This miniaturized flow channel reduces the gas flow through the sensor which offers many advantages in dusty and humid environments as well as when using long connection tubes or filters.

For high pressure applications, TE's **M3200 transducers** come with a range of threaded pressure port and connector options with standard pressure ranges available from 100 to 5,000 psi or 7 to 350bar. The M3200 is designed for modularity, accuracy, and high-performance signal processing. Additionally, the M3200 is available with a variety of analog outputs including mV, 0-5V, 0-10V and 4-20mA. The M3200 is also available with a with an I2C digital output.

Dependable Temperature Sensing in HVAC Applications

Temperature sensors follow many of the same trends covered in pressure sensing: Reliability, accuracy, ease of installation, flexibility, etc. An example of this in temperature sensors is the single insulated TPE OM (Thermoplastic elastomer overmolded) probe by TE. With an operating range of -35°C to +105°C and its IP67 rating this NTC thermistor assembly offers multiple connector options as well as customizable accuracies and base resistance value. The TPE overmold design is sealed against moisture and is designed to deliver reliable, accurate temperature monitoring for both heating and cooling applications.

Typically, OEMs look for sensor manufacturers with the broadest range of temperature sensing products available. For HVAC temperature sensors, there are many types of technologies in use including NTC thermistor, platinum and nickel RTDs, digital temperature sensors, thermocouples and thermopile elements. There are some tradeoffs between accuracy, time response, moisture resistance, cost, and other parameters within the different temperature technologies. Sensor assemblies for HVAC applications come in a wide variety of options designed to measure surface or air temperatures or as immersion sensor designed to measure liquid temperature. These sensors must be in contact with the medium to be measured while remote or non-contact temperature sensors like thermopiles can monitor temperature from a distance.

While temperature, pressure and humidity sensors are the most common sensors found in HVAC and refrigeration applications, there is also an increasing use of sensors for vibration, liquid level, fluid property and position.

Vibration and Position to Advancing HVAC Solutions

HVAC equipment and systems will typically contain several motors, compressors and other machinery that rotates or moves. Vibration sensors can detect an array of issues common with these types of equipment including worn bearings, imbalance, misalignment, and others that can reduce system efficiencies and potentially cause the system to fail altogether. TE manufactures both board mounted vibration sensors as well as packaged vibration sensors and is also releasing a family of wireless vibration sensor products. The 820M1-0050 is a board mount accelerometer that is available in ranges from +\- 25g to ±500g dynamic ranges and features a flat frequency response up to >10kHz. The TE model 8911 wireless accelerometer combines a sensor, data collector, digital signal processor, and radio into one compact, battery-operated device that measures both vibration and temperature data. The model 8911 incorporates a piezo-electric accelerometer which offers a wide bandwidth to >10kHz, outstanding measurement resolution and superior long-term stability

On the position side, key applications include feedback for valves and actuators, motor feedback as well as building damper feedback and control. TE's position sensing technologies include a range linear variable differential transformer or LVDT sensors which are suitable for detecting very small linear displacements in very demanding environments. TE also has an anisotropic magnetoresistive (AMR) line of rotary and linear position sensing products that is well suited for noisy, dirty industrial environments and provides reliable accurate non-contact position sensing.

TE manufacturers a family of rugged, reliable, and cost-effective sensing solutions that have been proven in some of the most demanding applications such as large and small chillers, heat pumps, PTAC's boilers, furnaces, compressors, air handlers, zone controls and many more heating and cooling products.which are suitable for detecting very small linear displacements in very demanding environments. TE also has an anisotropic magnetoresistive (AMR) line of rotary and linear position sensing products that is well suited for noisy, dirty industrial environments and provides reliable accurate non-contact position sensing.

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