White Paper Series

Sensor and Thermostat Selection Fundamentals

Contents

Sensors and Their Relatives

Types of Sensors

In today's buildings, sensors are essential devices in maintaining efficient operation and healthy, comfortable environments for occupants. "Sensors" are used in diverse HVAC and Building Automation System (BAS) applications and are closely related to several other types of devices.

- **Sensors** measure a physical characteristic of an environment and provide a signal corresponding to those properties. Sensors may be stand-alone or integrated within a control device (e.g., a thermostat).

- **Transmitters** are also sensors, but take the relatively small (and passive) sensor signal (e.g., the resistance of a thermistor in response to a temperature) and convert it into an active voltage (e.g., 0–5 VDC) or active current (e.g., 4–20 mA). Boosting the signal allows greater distance between the sensor and the controller.
- **Transducers** convert one kind of energy into another. The physics may be different, but they can function as sensors. In building automation, transducers may convert pressure into voltage or current (or vice versa) or voltage signals into current signals (or vice versa).
- In HVAC and BAS applications, many sensors, transmitters, and transducers perform essentially the same function, sensing a physical characteristic and providing a signal to an external control device. **Thermostats**, on the other hand, contain a sensor integrated with a control device. Thermostat technology ranges from simple bimetallic switches to sophisticated digital devices.

In building automation systems, sensors monitor air (temperature, humidity, CO_2 levels, CO levels, smoke, flow rate or pressure), water (temperature or pressure), or even motion/occupancy of people.

Temperature and Humidity Sensors

Temperature sensors are the most familiar and most common types of sensors in building automation. For example, KMC's compact STE-6000 series room temperature sensors offer various setpoint, override, and display options. The STE-1400 series, furthermore, contains a variety of temperature sensors for a multitude of applications, including the temperature of air inside rooms, inside ducts, and outdoors, as well as the temperature of the heating/cooling water inside pipes.

Depending on the climate, however, temperature alone doesn't tell the whole story about human comfort. A (dry bulb) sensor temperature of 72° would feel very different to us at 10% relative humidity than it would at 90% relative humidity. Too much or too little humidity can be uncomfortable for people or even damaging to materials. KMC's THE-1xxx series humidity sensors can measure humidity in rooms or ducts. NetSensors, FlexStats, and AppStats with the optional humidity sensor measure and display room temperature as well as humidity.

Carbon Dioxide and Motion Sensors

How much ventilating and conditioning of the air is needed for a space depends on how many people are occupying that space...if any at all. For spaces with variable occupancy (such as meeting rooms, classrooms, theaters, gyms, retail stores, and hotels), considerable energy savings can be obtained by determining the

actual, real-time level of occupancy (compared to the "worst-case" design occupancy) and reducing the ventilating and conditioning accordingly (to just the right amount but no more).

Motion sensors can determine a simple yes-or-no occupancy state. NetSensors, FlexStats, and AppStats with the optional motion sensor (with an effective range of up to 33 feet) provide a convenient means of concluding if anybody's home inside a room.

Motion sensors can only determine whether or not at least one person is in a particular space, but the ventilation needs of a few people are very different than the needs of a few dozen or a few hundred people. A complementary and more sophisticated approach to occupancy determination senses the gas that people breathe out. By measuring the levels of CO_2, Demand Control Ventilation (DCV) essentially estimates the amount of occupancy and required (healthy) levels of ventilation and adjusts the ventilation accordingly. KMC SAE-1000 series CO_2 detectors in rooms or return ducts provide CO_2 measurements to external controllers. NetSensors and FlexStats with the CO_2 sensor option integrate DCV with temperature and optional humidity control.

Carbon Monoxide and Smoke Sensors

Excessive levels of CO or combustion particulates mean not just discomfort, but danger! KMC SAE-1100 series CO detectors watch for this deadly and invisible gas. Also, where there's smoke, there's fire, and early detection is critically important. CAE-1003/1103 detectors watch for smoke inside HVAC ducts.

Flow and Pressure Sensors

Although behind the scenes, the amount of and pressure of air and/or water flow are important factors in the efficiency of HVAC operation. KMC SSS-1000 series and SSE-1000/2000 series flow sensors help determine how much air is flowing in the system. The various TPE-1xxx series pressure transducers provide pressure readings of air or water.

Understanding Thermostats

What Is a Thermostat?

We all have one on a wall in our home, but what exactly is it? In its elemental form, a room thermostat contains (at least) a sensor that measures temperature and a (simple or complex) controller that operates HVAC equipment to maintain room temperature at the desired setpoint. Additional bells and whistles might include humidity, motion, and CO_2 sensors, as well as programmable schedules, networking, and other advanced features that maximize occupant comfort while reducing energy and environmental cost.

To meet specific control needs, KMC offers a variety of thermostats that include different digital, analog electronic, and even pneumatic solutions. These sections describe different types of thermostat technology and representative models of each as well as upgrade options. (For details on these thermostats, see their data sheets as well as the KMC product catalogs.)

Digital Power

The BAC-4000 series AppStat combines a controller, multiple sensor options, and BACnet networking into a single, integrated space-mounted device. Appstat offers a cost-effective combination of networking, application, and sensor options along with easy, intuitive installation (with a two-piece design), configuration (with contextual menus and no obscure numeric codes), and operation (with an intuitive interface).

AppStat is an integrated native BACnet Application Specific Controller (B-ASC) for connection with a BACnet network. (No external communication or occupancy modules are required.) If desired, the AppStat can be installed simply as a stand-alone thermostat (with a built-in clock and schedule). An MS/TP network connection to a building automation system can easily be added at a later time. Installation is scalable from a single room to a network of multiple rooms.

AppStat is easily configurable according to the model's factory-programmed application (FCU, HPU, or RTU).

For a more powerful multi-application digital thermostat that is also field-programmable with custom Control Basic programming, the award-winning FlexStat series of intelligent temperature/humidity/motion/CO_2-sensing, wall-mounted, thermostat/controllers are native BACnet Advanced Application Controllers (B-AAC). The FlexStat simplifies networked zone control for common AHU, FCU, HPU, and RTU HVAC equipment, which can be controlled via the on-board libraries of programs built into the FlexStat.

FlexStats can provide flexible, set-and-forget control over the indoor environmental quality (IEQ) in your space without the expense of a large building automation system. FlexStat IEQ control for your space optimizes temperature, humidity, and ventilation for your health and comfort...while saving energy at the same time with advanced energy management control.

For communication with other FlexStats and/or a building automation system, BACnet over MS/TP communication is standard on all FlexStats. "E" versions, with an RJ-45 jack, add BACnet over Ethernet, BACnet over IP, and BACnet over IP as Foreign Device (for communication across the Internet).

Economical Analog Electronic

If you don't need networking, the CTE-5202 has a user-friendly LCD display and push buttons (instead of hard-to-see wire indicators and inexact sliders or dials common on many older electronic thermostats). It has two adjustable-span 0-12 VDC outputs with independent control loops and one external input for morning warmup, changeover, or setback options.

The thermostat is typically used with KMC CEP/CSP-4000 and CSP-5000 series of electronic pressure-independent VAV controllers, MEP-4002 proportional electronic actuators in pressure-dependent VAV applications, and VEB-43/46 series proportional control valves in baseboard, chilled beam, and other heating/cooling applications. Single or dual setpoint, single or dual ducts, and with or without reheat are available configurations.

Venerable Pneumatic Legacy

They may not be considered sexy and cool, but pneumatic thermostats are still reliable workhorses that control temperature in many older buildings across the country. While digital and newer electronic thermostats measure the resistance of a thermistor as it reacts to temperature, CTC-1600 series pneumatic thermostats have a bimetal element. The element deflects as it reacts to temperature, opening or closing a nozzle, which in turn controls air pressure leading to an actuator on a damper or valve.

A more high-tech approach to pneumatics can be found in KMC's OEM relationship with Cypress Envirosystems. KMC builds the pneumatic thermostat heart of their **Wireless Pneumatic Thermostat**. It still uses air pressure to control an actuator, but it also communicates wirelessly with a digital building automation system.

Thermostat Upgrades

But what if you already have a thermostat on the wall that's been working fine for years? A building's brick and mortar can last over a century, but is the original HVAC system going to meet the occupants' needs that long? Would you want a furnace in your home that was installed a century ago? Even if you could still get coal for it, it would be horribly dirty and inefficient by today's standards. Since today's standards exceed those of the past, modern thermostats are generally superior to the older models they replace.

However, even if improved energy-saving replacements exist, some people follow a "if it ain't broke, don't fix it" policy. Thermostats are generally quite

sturdy, but years of wear from people sliding levers or rotating dials (not to mention deliberate vandalism) result in thermostats breaking eventually. By the time most thermostats are replaced, identical models often aren't made anymore. But even if an identical model is available, most people want an upgrade that is more energy efficient, more intuitive, and more attractive.

For upgrading analog electronic thermostats, the highly configurable CTE-5202 easily replaces many older KMC and other manufacturer models. It replaces older KMC CTE-1x0x, CTE-50xx, and CTE-51xx thermostats, as well as Barber Colman (Schneider Electric, TAC, Invensys) TP-8101, TP-8102, TP-8103, TP-8124, and TP-8125 thermostats. It also replaces a large number of other models from Anemostat, Carnes, Metal Industries, Metalaire, Price Industries, ASC/Titus, Honeywell, Johnson Controls, Kele, PEKO, Siemens, and Viconics. (See the CTE-5202 Application Guide for more details.)

For even more advanced capabilities, the networked, digital FlexStat and AppStat thermostats are excellent choices for working with building automation systems. Feature for feature, they are cost competitive and can functionally replace many competitors' products.

Bringing an old pneumatic system closer to current standards is more challenging. One of the CTC-1600 series may be an easy "drop-in" replacement. It replaces most of the older KMC CTC-1xxx/15xx and CTC-5xxx models as well as many competitor products. For a substantial system upgrade, hybrid pneumatic/digital systems keep the parts of the old pneumatic system that are most costly to replace and add digital monitoring and control. Although this approach does not achieve the energy efficiency and control capability of a complete digital system retrofit, it is a far less expensive and time-consuming alternative.

More Information

Tips and Troubleshooting

For tips and troubleshooting about sensor and thermostat mounting, see the **Room Sensor and Thermostat Mounting and Maintenance Application Guide**.

About KMC Controls

For nearly 50 years, KMC has designed and manufactured control system hardware and software for flexible building automation. KMC remains the only privately held U.S. manufacturer to offer a complete line of components and digital automation systems. Learn more at **www.kmccontrols.com** or follow KMC on your favorite social media: