TE connectivity

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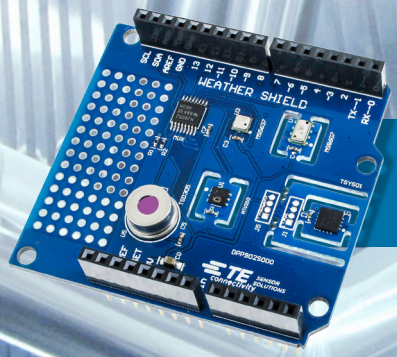
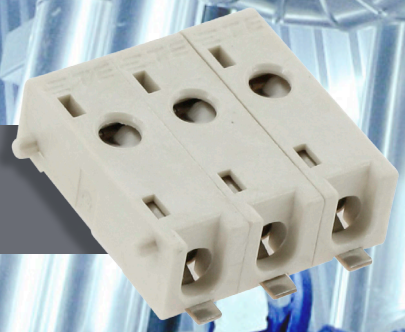
Building Intelligent Automation





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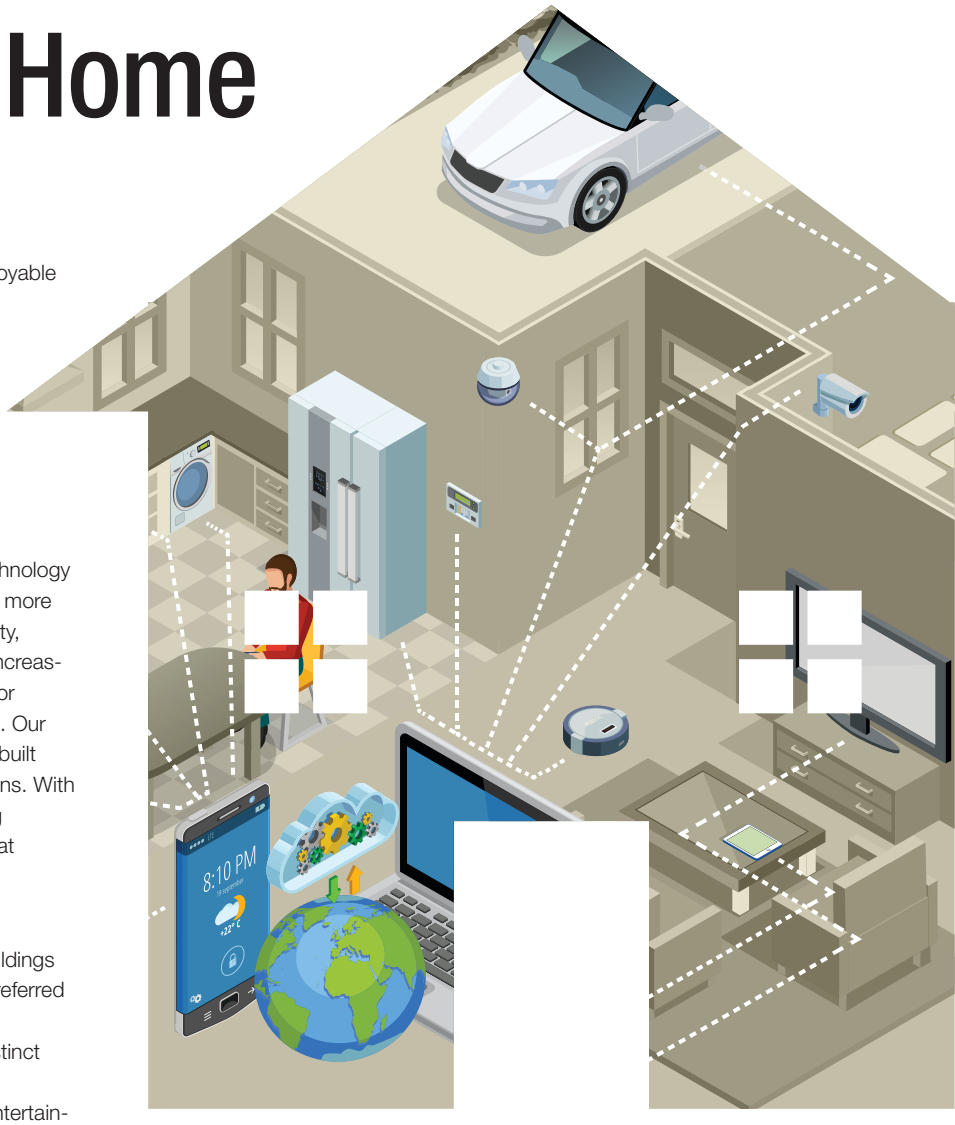
Turning Home Sweet Home into Home Smart Home



Our homes are the places where we live and have our most enjoyable and intimate human relationships. They are places of comfort, security, and human connection. As innovation continues to move forward, we must ensure that technologies used within our homes promote that sense of comfort, well-being, and connectedness by way of innovating solutions that are safe, reliable, energy-efficient, and cost-efficient.

For over 75 years, TE Connectivity™ (TE) has been a global technology leader, as demonstrated by our extensive portfolio that includes more than 14,000 patents. TTE designs and manufactures connectivity, sensor, relay, and switch solutions that are essential in today's increasingly connected world. We help our customers solve the need for intelligent, efficient, and high-performing products and solutions. Our commitment to technological advancements within buildings is built upon our unmatched breadth of connectivity and sensor solutions. With 75,000 people—including more than 7,000 engineers—working alongside customers in nearly 150 countries, we help ensure that EVERY CONNECTION COUNTS™.

TE is leading the way in transforming connected homes and buildings into *smart homes and buildings*. Just a few years ago, "smart" referred to individual electronic devices that could connect to a home or building's wireless network. Now, "smart" no longer refers to distinct connected devices, but rather to entire systems of connected appliances, lighting, security, HVAC, access, power systems, entertainment systems, and more that all communicate with each other and work together.

These smart systems don't just communicate and work with each other; they can respond to sensor input. Offering one of the broadest sensor portfolios in the industry, TE's innovations enable the measurement of power, signals, and sensing data, including pressure, temperature, position, vibration, and humidity while delivering high reliability and performance. Smart homes and buildings can use these connections, sensor data, and environmental inputs to adjust connected devices to ensure comfort, well-being, and connectedness…and do so all while delivering high reliability and performance.

These emerging markets demand innovation and industry leadership to ensure comfort, security, and connectedness are at the core of increasingly complex and connected systems underpinning where we live, work, and play. Whether you are looking to design next-generation panel displays, door alarms, interior track lighting, or enhanced security features, we welcome you to see in the following pages how TE Connectivity is empowering you to make your connected home and building ideas a reality.

David Barrington

TE Connectivity Channel Sales Manager Americas

Intelligent Buildings Business Unit

Wisdom and Brilliance:

TE Connectivity™ Enabling Smart and Intelligent Electromechanical and Electronic Lighting Solutions

By Paul Golata, Mouser Electronics

Wisdom is being able to employ knowledge skillfully. TE Connectivity (TE) is a wise choice for providing electromechanical products to integrate with your electronic lighting solutions. This article discusses specific electromechanical components that might be considered in any lighting design and provides insight to how they can be integrated together to provide the brightest, longest lasting, and most robust energy efficient solution for continuous lighting.

Leading electronic component suppliers including Texas Instruments, Microchip, and ON Semiconductor have introduced a variety of innovative products that allow AC/DC, DC/DC, or direct AC linear LED lighting power solutions for a wide variety of LED illumination applications.

Enabling Smart Solutions

Solid-state lighting has taken over applications ranging from street lights and outdoor luminaries to every aspect of indoor lighting as well. Whether creating new systems or enhancing an existing one, design engineers need electronic components that can be seamlessly integrated into larger solutions.

Until recently, most advances have been focused on Optical (O) and Electronic (E) improvements—or simply O&E. For example, we've seen developments in optical properties of LEDs including their output wavelengths, as well as advances in providing consistent and tight correlated color temperatures (CCT), lumen output (lm), and efficacy (lm/W). In addition to optimizing optical parameters, designs have focused on developing efficient electronic drivers to operate and control the LEDs and LED arrays. The third component of smart solutions—mechanical (M)—has evolved primarily in the areas of heat dissipation, and mounting and accessibility considerations. With the advent of smart lighting for offices and industrial applications, there is a need to further standardize and consolidate technological gains. This need to provide seamless integration compels all future oriented designs to focus on M+O&E—or MOE.

Connectors: Because Every Connection Counts™

Connectors are necessary coupling devices joining the mechanical realm to the electronic realm. Because every connection counts, the highly engineered connectors in TE's expansive portfolio reliably transmit data, power, and signal in the harshest environments, under the most extreme uses. Going a step further, these products offer a higher level of integration by providing a solderless connection to array and Chip-on-Board (CoB) LEDs. Similarly, other components provide power filtering and switching as required. Receptacles provide an electromechanical object and space to contain electronic lighting components. And modules take it a step further and integrate all electromechanical products, less power supply, into one assembly.

The following are some of the newest products from TE that are enabling cutting edge, intelligent lighting solutions:

BUCHANAN WireMate Poke-In Connectors

BUCHANAN WireMate Poke-In Connectors are surface mount poke-in connectors for LED lighting applications. These 1-, 2-, or 3-position connectors feature either 400VAC or 600VAC voltage and can handle 5A, 6A, or 9A current. The series features a -40°C to +125°C operating temperature range.

SlimSeal™ Sealed Lighting Connectors

TE's SlimSeal connectors provide low power, sealed solutions for free hanging, wire-to-wire interconnects and for robust, stable, electrical and mechanical wire-to-board connections used in solid state lighting (**Figure 1**). The SlimSeal connector maintains an IP67 seal rating—making it suitable for indoor and outdoor residential, commercial, and architectural applications that are exposed to wet environments. Key features include UV-resistant wire-to-wire and wire-to-board configurations, SMT and thru-hole headers, positive integral latching, and pre-assembled seals. The polarized connector—available in two, three and four positions—accepts 18 through 24 AWG stranded wire.

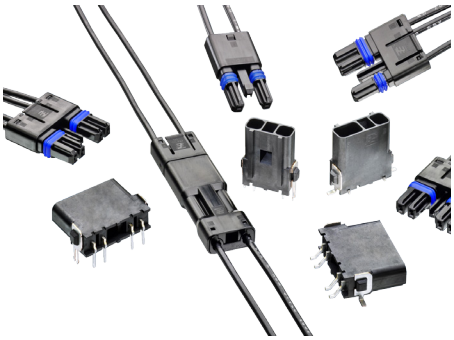


Figure 1: *Where low profile is critical, SlimSeal™ SSL Sealed Lighting Connectors get the job done.*

Figure 2: *Because they are able to withstand harsh environments IP67/68 Sealed Circular Plastic Connectors from TE Connectivity are the right choice to ensure excellent connections are established despite against many natural weather related elements.*

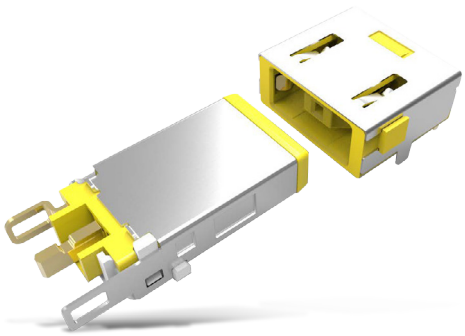


Figure 3: *With 4 contacts and high reliability TE Connectivity's Rectangular DC Power Connectors get power and current where it is needed.*

2-Position LIGHT-N-LOCK™ Standard Connectors

TE's 2-Position LIGHT-N-LOCK Standard Connectors use poke-in wiring technology, enabling tool-free installation for field applications. This TE Connectivity connector provides a reliable connection with its small, low-profile design and is designed for Safe Touch connection per UL2459. It is applicable for size 18–22AWG solid or tin-dipped stranded wires. This TE Connectivity connector is ideal for indoor LED lighting applications, especially for downlighting.

3-Position LIGHT-N-LOCK™ Modular Latched Connectors

Also ideal for indoor lighting applications, TE's 3-Position LIGHT-N-LOCK Modular Latched Connectors feature a compact design and are available in four colors for easy identification. These connectors also employ a poke-in termination for a fast, easy installation. No special tools are required.

SlimSeal™ IP67/68 Sealed Circular Plastic Connectors

These IP67/68 Sealed Circular Plastic Connectors are engineered specifically for power and signal wire-to-wire connection systems in a wide range of harsh environment applications (**Figure 2**). These connectors are IP67/68 rated and are able to withstand the harshest environments. This connection system offers a pre-positioned 1/4 (0.25) turn coupling ring with positive lock and alignment features that make installation easy. With a unique contact pattern for each position size, accidental mating with other position sizes is prevented.

Rectangular DC Power Connectors

TE Connectivity's rectangular DC power connectors provide four contact points for enhanced reliability and current capacity (**Figure 3**). The rectangular DC jacks feature either 7A or 10.7A power, with 25VDC maximum voltage and durability of 5,000 cycles. Double contacts (power and ground) enhance reliability, louvre contacts in the receptacle provide maximum power transmission, and the plug detection contact allows for electrical switching. The symmetrical plug design allows for 180° insertion.

Thus far, we've seen a variety of wise products for excellent connectivity within the electromechanical domain. Now let's explore some of the ways TE Connectivity solutions are a smart addition to any electronic lighting design, no matter how demanding the application.

LUMAWISE™ LED Holders— The Name Says It All

Smart lighting is being incorporated everywhere in an effort to increase operational efficiency and reduce expenses. To achieve this, TE has introduced a full line up of LED holders and sockets—called LUMAWISE—in partnership with leading LED and LED array manufacturers, including Lumileds, Cree, and Osram Opto Semiconductors, among others. By working with so many LED types and brands, TE's LED holders and sockets are leading the way in intelligent building solutions.

LUMAWISE LED Holders integrate a wide variety of specifically designed M advantages into the O&E products supplied from other suppliers so that they can all work together. For instance, LUMAWISE LED Holders promote efficiency and versatility by providing solderless connections and three termination methods: Poke-in, Insulation-Displacement Contact (IDC), and separable.

Sockets allow the LED to be directly attached to a PCB or heat sink using a few standard screws. They have a multi-point connection, accept optics, include fast attachment features, and provide proper orientation. It is easy to attach secondary optics, which reduces customer concerns about electric shorts. They feature high reflectivity polymer housing along with ultrasonic welding for increased reliability and robustness. Such design features enable lighting designers to use these products with many different OE packages so the final solution is customized for each lighting application.

Roadway And Area Lighting, ANSI C136.41

ANSI 136.41 is the prevailing standard for roadway and area lighting equipment. It describes methods of light level control between an external locking photo control cell (or similar device) and a dimmable ballast or driver for street and area lighting equipment. TE has a number of products that are ANSI C136.41 compliant, including receptacles and modules.

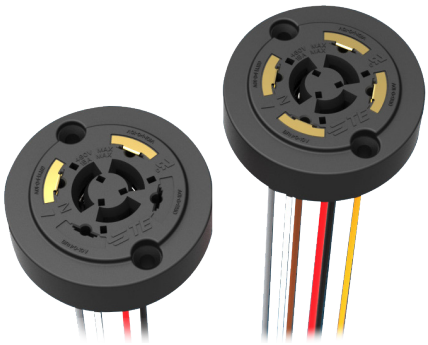


Figure 4: *An ANSI C136.41 Dimming Receptacle from TE Connectivity is useful for roadway and area lighting applications and is rotatable.*

Figure 5: *LUMAWISE Endurance S Modules are a reliable and robust product for outdoor luminaires.*

LUMAWISE™ Rotatable Dimming Receptacles

TE has met this need and provides an ANSI C136.41 compliant LUMAWISE dimming receptacle with spring leaf contacts that provide an electrical and mechanical interconnection between an ANSI C136.41-2013 photo control cell and an LED luminaire (**Figure 4**).

Ideal for outdoor commercial and utility lighting, the ANSI C136.41 compliant LUMAWISE dimming receptacle is available with two or four dimming contacts to support either 0–10VDC dimming methods or Digital Addressable Lighting Interface (DALI), while providing a reliable power interconnect with three robust twist lock contacts.

Other ANSI 136.41 compliant products are available, including a 76mm diameter LUMAWISE photo control base assembly and dome cover that provides total power and signal interface between the photo control and dimming receptacle. TE's LUMAWISE base assembly solution includes power twist lock terminals, spring leaf signal terminals, and a separately packaged foam gasket. When coupled with the TE LUMAWISE dome cover, the assemblies provide an IP66-rated photo control enclosure with a 5VA rated transparent cover.

LUMAWISE Endurance S Modules: Designed to go the Distance

TE Connectivity makes outdoor modules designed to endure. They have created a lineup specifically suited for LED light sources and drivers in outdoor luminaires. The LUMAWISE™ Endurance S modules are comprised of an IPX6-rated receptacle assembly, a sealing cap, and two bases sized in 40mm and 80mm diameters that, together, provide a complete electrical interface between the receptacle and associated sensor modules (**Figure 5**). When used in conjunction with sensor ready certified drivers, the receptacle assembly accepts a twist-to-lock, pluggable sensor module and provides DC power to the module and a DALI 2.0 or derivative two-wire bus for communication and data transfer. The fourth connection is allocated as a digital I/O port. The compact design, with improved sealing capability, facilitates mounting the sensor module upwards, sideways or downward on roadway, street and area lighting luminaires.

Figure 6: *NECTOR™ S Power System from TE Connectivity*

NECTOR™ S POWER SYSTEM

The NECTOR S Power System is a small, easy-to-install power-to-luminaire solution designed to easily fit through openings as small as 8mm in diameter (**Figure 6**). The compact circular design provides users with the flexibility to create innovative lighting fixtures because the size of the connector does not interfere with the design. The offering supports plug-and-play functionality for ease of use and meets UL 1977 standards. A power distributor connector offers IDC crimp tap contacts for quick termination, or crimp style pin and socket terminals for cable assembly lead connections. The NECTOR S Power System is keyed for 125VAC high-voltage, 7Amp, 6Amp and 42VDC low-voltage applications and is ideal for applications that require a power connection and coupling between lamps such as under-cabinet lighting, refrigeration lighting systems, displays, signage, retail, and residential SSL solutions.

Conclusion

TE Connectivity is a wise choice for providing electromechanical products to integrate with your electronic lighting solutions. TE Connectivity brings together the best electromechanical components necessary for LED lighting designs and provides full solutions that seamlessly integrate together in order to provide the best solid-state lighting solution. TE Connectivity's sockets and holders, connectors, roadway and outdoor lighting, and compact circular indoor lighting provide easy-to-integrate, robust, and efficient components to meet any lighting solution. Brilliantly illuminate and enable your next electromechanical and electronic lighting design.

Limitations to Connected Home Adoption

The ecysystem is in place to drive growth in the connected home market, including:

- Established communication protocols
- Hardware that supports these protocols
- Hardware that interfaces with all main home automation systems (HVAC, Security, Safety, Entertainment, Lighting)
- Cloud-based access for mobile devices
- Cloud-based inter-protocol translation
- Improving price points

However, a number of roadblocks currently limit widespread adoption:

Data security

Data security is an issue for home automation and across all Internet of Things (IoT) connected devices. Whenever a new system or product is released, it becomes a new target for cyberattackers. It is unlikely that an ironclad solution to attacks on connected home systems will be developed in the near future. However, today's connected consumer is accustomed to these risks and accepts them in exchange for the benefits offered by connectivity.

Standardization

The lack of cohesiveness and standardization across a broad group of competitors may also limit the adoption of home automation technology. Consumers have expressed concerns about committing to a specific system that is not interoperable with other devices – they do not want to commit to a product, only to discover that they cannot integrate it with other systems. These differences in protocol and communication limit economies of scale but are characteristic of any new technology revolution.

Fortunately, hardware remains the same across protocols – so the hardware currently in development by companies such as TE will help drive adoption of home automation, no matter which protocols become standard.

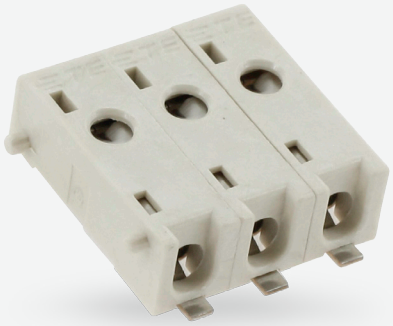
Consumer awareness

Though many devices for home automation are on store shelves today, many consumers are confused about the value proposition. For example, a consumer who is in the market for a new refrigerator will need a knowledgeable retail sales associate and comprehensive content on the Internet to explain the benefits and value of a connected home appliance. Without front-line education during the sales cycle, a consumer could opt out, and the connected home capabilities and value would go unrealized.

The connected home market is still in the early adopter phase, and many startup companies are jockeying for position and for consumer attention. Manufacturers such as TE can help accelerate development of new and attractive home automation products by partnering in product design.

BUCHANAN WireMate Poke-In Connectors

These modular releasable poke-in connectors are designed for LED lighting. They are available with 1, 2, or 3 positions and rated to 600V_{AC} and up to 9A current.



Learn More »

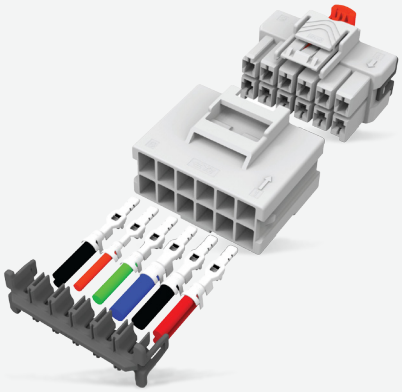
Splash-Proof USB Type-C Connectors

IPX4 rated for harsh environments in consumer and industrial devices, with a 25% smaller footprint than other TE Connectivity USB Type-C connectors.

Learn More »

POWER TRIPLE LOCK™ Connectors

Specifically developed for better power and signal applications. For 3-in-1 reliability, the system offers 3 enhanced methods of connectivity, making your design connections better in every way.



Learn More »

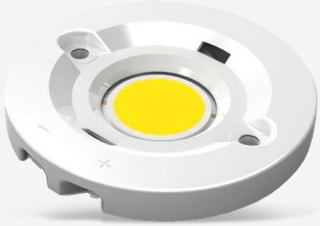
Potter & Brumfield Relay T9G Relays

Up to 30A switching in a package 30% smaller than T9A and T9E relays. Applications include HVAC, appliances, industrial controls, and energy management.

Learn More »

LUMAWISE™ LED Sockets/Holders

Electrically connect a LED to a luminaire without the need to solder. Sockets allow the LED to be directly attached to a PCB or heat sink using a few standard screws and include a multi-point connection, accept optics, fast attachment features, and provide proper orientation.



Learn More »

NECTOR™ M Power System

TE's NECTOR™ M Power System is a flexible, fully pluggable, modular wiring connectors and cabling solution for permanent & temporary power and control electrical installations. The NECTOR™ M power system offers an indoor solution as well as a sealed version for outdoor. With the NECTOR M system, one connector solution addresses power, data, and control requirements.

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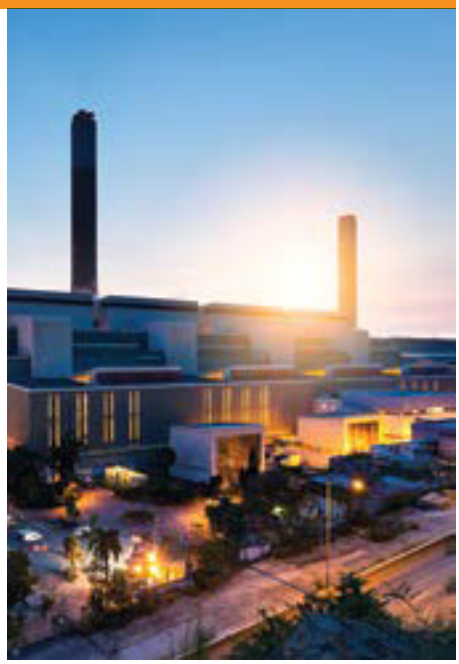
SENSING CHANGE: SIX HVACR TRENDS MOVING THE INDUSTRY FORWARD



The biggest trends in commercial HVACR right now are tied to building systems becoming more connected, efficient and responsive.

And it's not just because of tightening regulatory constraints.

While the Department of Energy (DOE) and other agencies have set their sights on reducing the impact commercial buildings have on the environment, building owners have their own reasons to demand more innovation and efficiency from their HVACR systems. Namely, this: commercial buildings use more than $190 billion in energy every year.

Inside this report, we'll examine these two sources of pressure and the trends that have emerged as a result. They include:

- Evolving Regulations
- Getting Smart
- Human Comfort
- Integrations and Connections
- Open Systems
- Industrial Internet of Things

As front-line components in HVACR systems, sensors are playing an ever-expanding role in helping drive many of these trends forward. Read on to learn more about how that's happening.

Trend 1: Evolving Regulations

Over the last several years, there's been pressure to cut commercial energy consumption. The pressure's been so steady, in fact, that by 2023, HVACR efficiencies will be required to have improved by 50% over 20 years ago.

This may read as old news to some, but many of the newer regulations are just now going into effect. And with that, new solutions will be needed to expand upon existing efficiency efforts. Sensors are often at the core of those solutions.

Take, for example, the DOE's Direct Final Rule 79 FR 17725 which went into effect in March 2017. The rule requires maximum daily energy consumption for certain commercial refrigeration products to be reduced by 30-60%.

In the rule, the DOE called for greater efficiency to defrost mechanisms. There was debate as to whether the rulemaking committee's compliance date was achievable, because some thought there'd be too much research and development needed to improve defrost sensors to meet the DOE's goal. The DOE, meanwhile, responded by outlining a solution that would use an optical sensor or temperature sensor to detect the temperature differential across the evaporator coil.

While the two sides disagreed on what technology was needed, the debate underscored a fine point: sensors were core to solving the problem.

Trend 2: Integration and Connections

The ability to tie together multiple building components—along with other systems—is certainly not a new trend. And for good reason: Enabling heating, cooling, and lighting systems to work together can mean big gains in efficiencies for commercial buildings.

Much attention is being paid to the role occupancy sensors can play in helping better control the systems (and the energy savings that comes along with it). But there's also a lot of room for better interoperability even within HVACR: combining temperature sensors, pressure sensors, and humidity sensors to create more efficient heating and cooling solutions that are also more comfortable for those who work in the spaces.

Of the three, humidity sensors have been the biggest change to the equation, as they directly correspond to human comfort while allowing systems to put less stress on temperature control.

Another under-discussed piece of the puzzle: wireless sensors for future flexibility.

Systems-wide integrations often require more sensors in more places. If those sensors are analog, they can require more effort and hardware for the sensor interface, with limited flexibility for future modifications and improvements.

Digital sensors, on the other hand, have improved the resolution they can offer in recent years and are approaching the levels of resolution offered by analog sensors. They also offer more flexibility in terms of the amount and type of information they can provide to the control system. This helps create systems that can be more easily adjusted and upgraded throughout their lifecycles.

Trend 3: Getting Smart

Similar to the industry's move toward greater integration is its move toward smarter systems and increased smart communication with energy grids.

Smart systems allow for better monitoring of usage based on a variety of factors—such as time of day, occupancy, and external conditions. That data can be used to automatically deliver heating, cooling and ventilation (among other things) only when needed.

A popular approach to smart systems among building owners is to add a level of automation to zoned commercial HVACR. In these set-ups, commercial HVACR systems rely on a variety of sensors placed throughout the building to heat, cool or circulate air in those specific zones.

Because HVACR systems in these setups only run under certain conditions (when, say, people are in a room or the temperature rises above a certain temperature), they operate with increased efficiency and building owners realize improved energy savings.

Smart HVACR systems go one step further than the "on/off" zoned approach: They learn how much heating, cooling, and ventilation is needed by collecting data and automate that functionality so manual tweaking of thermostats is no longer needed.

Sensors offer advantages to maintaining smart systems.

Pressure sensors, for example, can monitor maintenance needs in real-time for things like airflow, blocked filters and the like. In a commercial building with hundreds of zones (or even room-specific zones), this ability to closely monitor maintenance needs helps systems meet their promised levels of efficiency.

For zoned systems to be efficient and effective, they require accurate and reliable sensors to control each zone. When paired with smart grid systems, this allows key usage data to be sent back to the utility companies

Trend 4: Open Systems

As the industry continues to focus on improving integrations and developing smarter systems, another trend is developing as a result: increased open systems.

Open systems rely on industry-standard protocols that allow for simpler integration and connections throughout HVACR systems and commercial buildings, in general—without the need to worry about manufacturers' proprietary technology.

These advantages are leading to a substantial increase in market share for open systems.

In 2014, according to IHS, 14% of controllers still used proprietary protocols. That number was expected to drop to 12.6% in 2015, the latest year data was available.

While HVACR cross-system integrations may still be possible with proprietary protocols, there's still a risk for building owners to inadvertently handicap themselves in these efforts under certain circumstances.

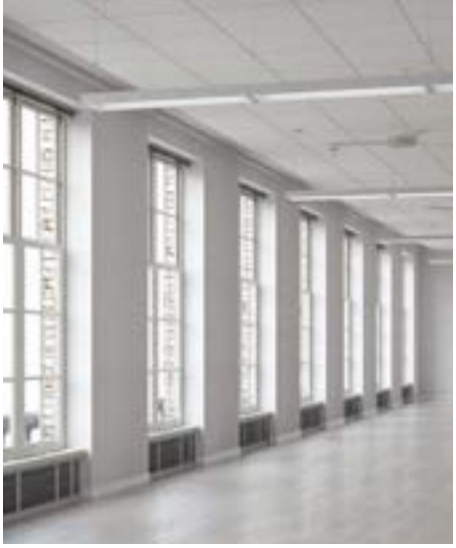
These limitations can quickly become apparent when trying to connect HVACR systems to other systems within buildings, like lighting. And as more and more building owners look to those types of integrations, there will be more pressure to provide more open protocols.

Trend 5: Human Comfort

Throughout this report, we've been discussing the role of sensors in HVACR system efficiency.

But saving money isn't the only reason building owners are upping their sensor game. Sensors can also deliver an enhanced level of human comfort that's quickly gaining in recognition.

Green-building rating systems, such as LEED, are increasingly emphasizing human-centric factors, like thermal comfort and enhanced HVACR controllability.



In this sense, humidity, temperature and pressure sensors play a significant role in delivering energy savings and improved comfort for building occupants.

Though comfort is relative to each person, there is guidance for building owners on how they are most likely to provide comfortable working conditions for many people. OSHA recommends temperatures between 68-76° F and humidity between 20-60%. ASHRAE also offers guidance, and the University of Connecticut's Division of Environmental Health and Safety provides a helpful chart that shows the ideal combinations of humidity and temperature.

And it's no wonder so many sources aim to provide building owners with this type of help: Studies have also shown that optimizing human comfort in the workspace can increase productivity by up to 3%, while improved ventilation systems can help create

healthier workspaces.

Trend 6: Industrial Internet of Things

Much of the attention being paid to the "Internet of Things" (IoT) is its relationship with consumer's household appliances. But there's significant potential within commercial buildings and HVACR systems, as well.

Internet-connected HVACR systems offer several advantages, including better performance monitoring, more timely maintenance, and better integrations with other systems. To deliver on their potential, though, these systems require sensors that can collect the necessary data and share it not just with controls, but with systems managers and technicians.

In addition, these systems can tie into a single infrastructure to handle building management solutions and require far less in the way of manual operations.

The trend around developing and implementing HVACR systems that are IoT-connected are more like a confluence of many of the trends outlined above.

Conclusion

Improvements and innovations in sensors—especially newer sensor types, newer uses or how and where to use them, and newer capabilities to pass data in a variety of ways—are driving the HVACR industry forward.

These improvements in sensors allow for more efficient, more intelligent HVACR systems and deliver a host of benefits, including cost savings, energy savings and improved comfort for building occupants.

Across the industry, sensors are a driving force behind making the trends explored in this report part of the mainstream.

For information about TE Connectivity's HVACR sensor solutions, visit us here.

Smart Buildings Are Thrifty Buildings:

A Building Automation Retrofit Project

By Mike Parks, PE

Once the realm of science fiction, building automation is expected to reach a market value of approximately $100 billion in five short years. That's up from just over $50 billion in 2016 according to a MarketsandMarkets report. The explosive, $10 billion per year growth in the building automation market is being fueled by an unprecedented availability of inexpensive sensors, a proliferation of nearly ubiquitous Internet connectivity, and easy-to-use yet powerful microcontroller platforms.

For facility managers, one of the major appeals of Building Automation Systems (BAS) is monitoring and controlling Heating, Ventilation, and Air Conditioning (HVAC) systems. Energy costs associated with heating and cooling a building are a major component of a facility's operational and maintenance costs. While new construction has the advantage of incorporating the latest in HVAC and control technologies from the get go, existing facilities can still take advantage of emerging building automation systems through retrofits. For engineers and facilities professionals looking for more information on specifying building automation systems with respect to HVAC systems, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) publishes ASHRAE Guideline 13-2015, Specifying Building Automation Systems.

To demonstrate just how easy it is to connect building systems to the Internet of Things (IoT), we are going to design a solution that allows us to retrofit a manual damper, one you might find as part of a HVAC system, with automated intelligence (**Figure 1**). By doing so, we can help reign in the energy costs associated with heating and cooling a building. Dampers allow us to adjust the airflow of an HVAC system so air only goes to the spaces that need heating or cooling at any given time.

In this article, we will look at some of the products available to help you quickly prototype a custom solution for your existing HVAC ductwork system. Specifically, we will leverage the TE Connectivity Weather Shield, a device that incorporates five different sensor packages to monitor environmental conditions such as temperature, humidity, and atmospheric pressure. Then, using an ESP8266-based Wi-Fi solution, we will wirelessly transmit our weather data to the cloud where it can be stored and

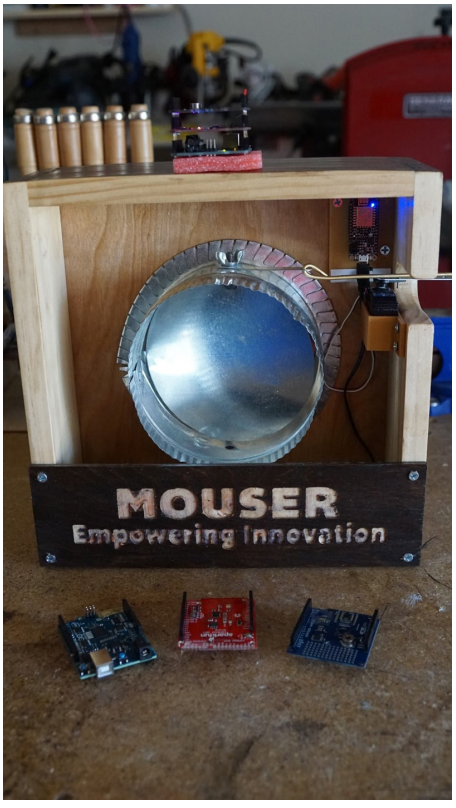


Figure 1: *Mockup of an HVAC damper and the embedded hardware needed to add intelligence.*

Table 1: Bill of Materials

Mouser Part Number	Description	Quantity
474-WRL-13287	Wi-Fi / 802.11 Development Tools: Wi-Fi Shield ESP8266 Shield ESP8266	1
607-ARDUINO101	Development Boards & Kits: x86 Arduino 101 learning and development board based on the Intel Curie Compute Module	1
824-DPP902S000	Multiple Function Sensor Development Tools: ARDUINO / GENUINO Weather Shield by TE Connectivity	1
485-2821	Wi-Fi / 802.11 Development Tools: Adafruit Feather HUZZAH with ESP8266 Wi-Fi	1
490-SWI10-5-N-MUB	Wall Mount AC Adapters: 10W 5V 2A US blade micro USB	1
490-SWI5-5-N-P5	Wall Mount AC Adapters: 10W 5V 2A US blade micro USB	1
619-900-00005	AC, DC & Servo Motors: SERVO ASSEMBLY	1
854-ZW-MM-10	Jumper Wires: ZipWire Male-Male 40 Unzipp Wires x 10cm	1

distributed to other smart devices. For the purposes of this demonstration, we will leverage temperature data to remotely control a damper that will be retrofitted with a microcontroller and servo to automatically open and close a damper inside the ductwork.

Materials

By utilizing Commercial Off-The-Shelf (COTS) components, we can rapidly prototype a working system using just a handful of components. Once we have proven the concept of operations, custom hardware could be built to help drive down the unit costs of our solution. Thus, our bill of materials for this project is listed in **Table 1**. (or click here for our pre-built project shopping cart over at Mouser.com)

Project Overview

This project presents a two-part solution for a temperature control mechanism that will be automating an air duct damper, thus controlling the airflow into various rooms in a building. The first part is our weather sensor package that will monitor the environmental conditions in our spaces, including temperature, humidity, and atmospheric pressure (**Figure 2**). The sensors communicate with our microcontroller over the I2C bus. Once the sensors have digitized and transmitted weather data to the microcontroller, we can perform additional work on the data. For example, we could convert temperature measurements from Celsius to Fahrenheit if so desired. Once we are satisfied with our data format, we can send it to a cloud-based IoT backend using the ESP8266 hardware and an HTTP-based RESTful API. Of note, the latest update to BACnet standard (BACnet Standard ASHRAE 135-2016) includes support for such RESTful HTTP-based web service interfaces.

At the heart of the weather sensor shield are the following five sensors:

- HTU2xD(F) (Temperature and Humidity)
- MS5637 (Temperature and Pressure)
- MS8607 (Temperature, Humidity and Pressure)
- TSYS01 (Temperature)
- TSD305 (Temperature and Contactless Temperature)

The second portion of the system is a control unit for the damper. It will contain a second wireless microcontroller platform, Adafruit's Huzzah Feather, which is equipped with a servo motor and the appropriate mechanical linkages to the manual hardware of the damper (**Figure 3**). The Huzzah will reach up to the Ubidots server and request the necessary data, in this case temperature. The demonstration code shows a single set point temperature (74°F) for determining whether to open or close the damper. It might be desirable to include two different set points so that as the ambient temperature fluctuates above and below the set point temperature that the damper is not repeatedly opening and closing. For example, open the damper when the temperature reaches 78°F and close it when it reaches 72°F.

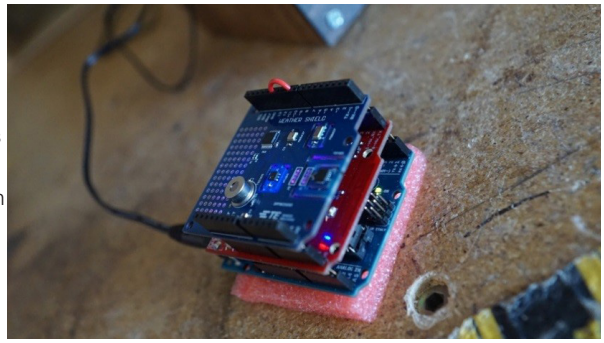


Figure 2: *Board stack for sensor package. From bottom: Arduino, Wi-Fi Shield, TE Connectivity Weather Shield.*

The Build

One problem that can sometimes arise from using pre-built breakout boards is that there can be I/O pin hardware conflicts. This just happens to be the case for this project. However, it is possible to cleverly hack a solution together so that we can get the prototype up and running. If this were to become a finished product, the engineering team would likely create a custom circuit board and design out the pin conflict.

For this particular project, both the WRL-13287 Wi-Fi Shield and the TE Connectivity Weather Shield have hardwired GPIO pin D9 for their own needs. For the Wi-Fi shield, pin 9 is being used as the TX pin for the software-based serial port that connects the development board to the ESP8266 SoC. On the weather shield, the same pin is part of a chip select multiplexer design along with pins 10 and 11.

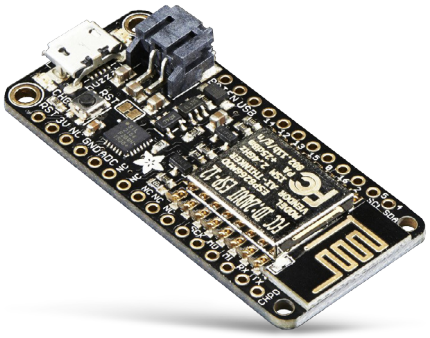


Figure 3: *The Huzzah Feather receives weather data and makes an informed decision on controlling HVAC dampers.*

Looking through the software for both shields, it was decided to alter the weather shield code. From a software perspective, the chip select multiplexer inputs were moved from pins 9, 10, and 11 to pins 10, 11, and 12. The code change occurred in the file titled TEWeatherShield.cpp which is a part of the TE Weather Shield library. Then, on the physical weather shield itself, the male header for pin 9 was removed and jumper wire was inserted to connect pin 12 to pin 9. In the end, while the Arduino would toggle pins 10, 11, and 12 to cycle through the various sensors, the weather shield itself saw no difference. Removing pin 9 ensured that there would be no conflict between the two shields both trying to drive pin 9. The only other impact to the final design was that this solution necessitated the board stack to follow the strict

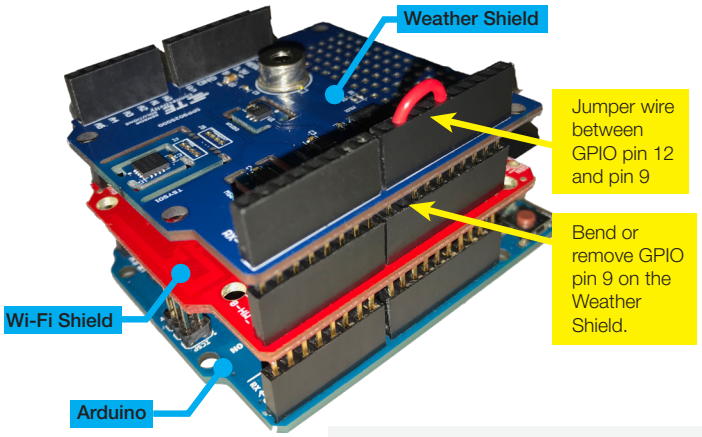


Figure 4: *Note that pin 9 on the weather shield must be removed and a jumper wire is placed between pin 9 and 12.*

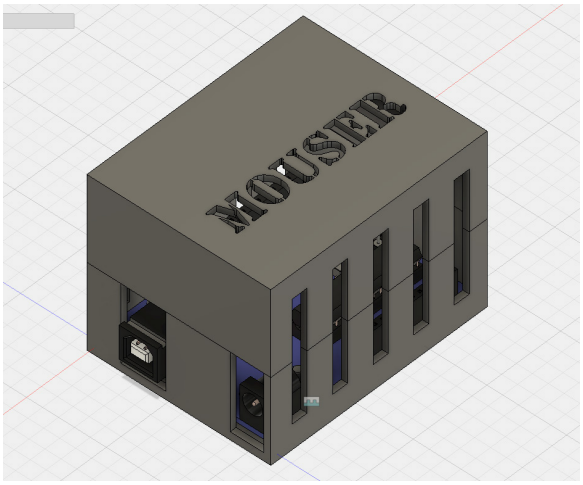


Figure 5: *STL files for a 3D printable project enclosure is available in the project repository.*

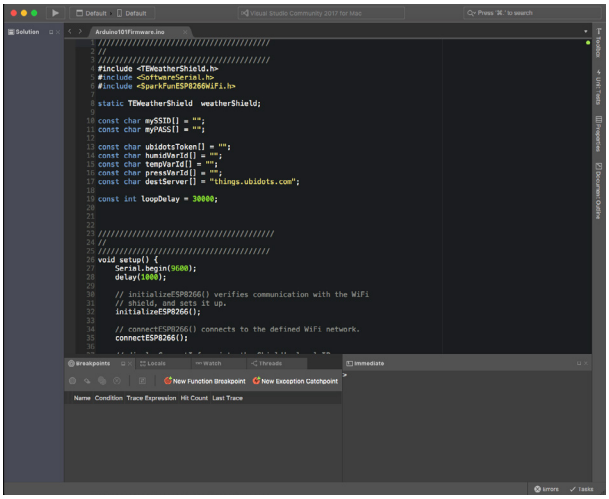


Figure 6: *Visual Studio Code is powerful code editor that adds professional programming features atop the standard Arduino IDE.*

order of Arduino dev board, Wi-Fi shield, and then the weather shield sitting on top (**Figure 4**).

The Huzzah has an operating voltage of 3.3V, but when powered via USB, it is possible to tap into the USB's 5V via the V_USB pin. This allows us to power the 5V servo motor without a separate supply. The Pulse Width Modulated (PWM) signal wire of the servo can remain at 3.3V.

In the provided GitHub repository, we provide both a schematic and board layout that breaks out the Huzzah pins and provides some male header pins for easily connecting the servo to the Huzzah. One thing to note is that the GPIO pins of the Huzzah are not sequentially numbered; they are clearly labeled on the board itself, so be certain you are wiring to the correct pins. For this project, GPIO pin 2 is using to provide the PWM control signal to the servo.

Lastly, if you intend to mount this design permanently, we have provided STL files for enclosures that can be 3D printed to keep the electronic hardware protected (**Figure 5**).

Software

The software for this project was developed using Microsoft's Visual Studio Code, an extensible code editor that supports a variety of languages including C/C++ and the derivative wiring language used in the Arduino IDE (**Figure 6**). Visual Studio Code offers more robust development features such as code completion and breakpoints. However, this project can be accomplished just as easily in the standard Arduino Integrated Development Environment (IDE) if so desired.

Libraries

First, we will grab the support libraries necessary to work with the chosen dev boards and shields. Thankfully, the hardware manufacturers for both the weather shield and the ESP8266 Wi-Fi shield provide the code on their respective GitHub repositories (**Figure 7**).

The libraries we will be using include:

- TE Connectivity Weather Shield
- HTU2xD(F) (Temperature and Humidity)
- MS5637 (Temperature and Pressure)
- MS8607 (Temperature, Humidity and Pressure)
- TSYS01 (Temperature)
- TSD305 (Temperature and Contactless Temperature)
- ESP8266 Wi-Fi Shield

In addition to these libraries, we will also be using two standard libraries included as part of the Arduino IDE: SoftwareSerial.h and Servo.h.

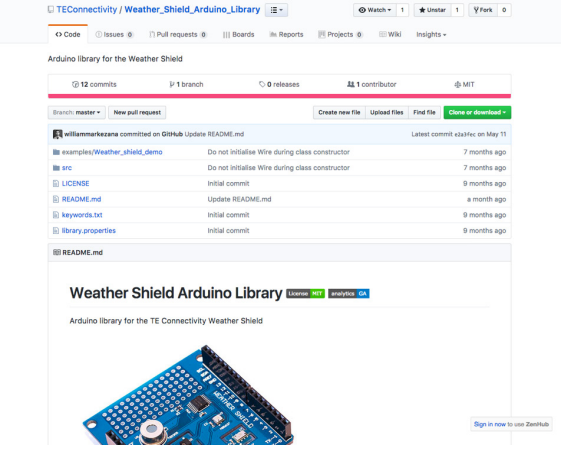


Figure 7: *TE Connectivity provides all the needed software libraries on their GitHub repository.*

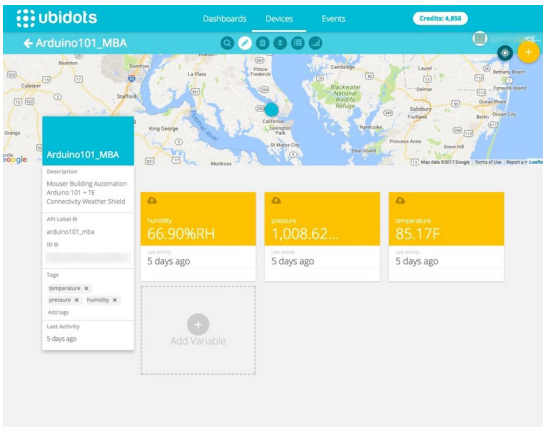
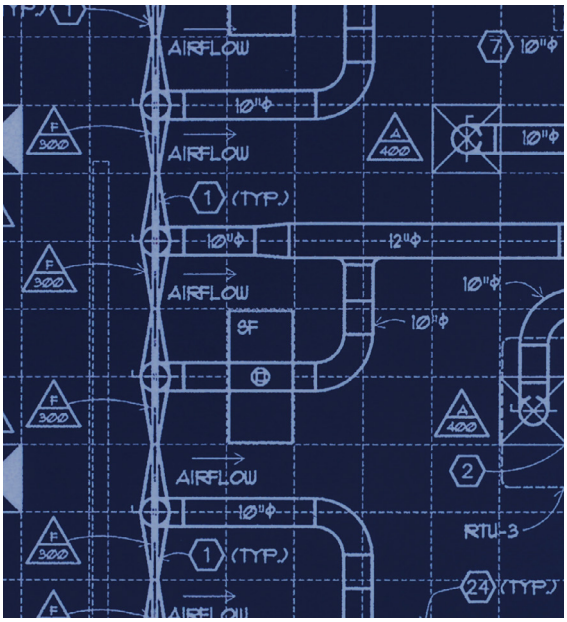


Figure 8: *Ubidots provides for a simple yet powerful and inexpensive IoT backend.*



Getting Some REST

RESTful APIs are an increasingly popular mechanism for allowing devices to communicate on the Internet, sans human involvement. For Web-based services, RESTful API is realized through HTTP methods such as `POST`, `GET`, `PUSH`, and `DELETE`.

In a nutshell, a RESTful API leverages what looks like a website address (URL) to exchange requests with a Web server. It is a simple yet elegant method to achieve autonomous communication between the Internet and the "Things" that comprise the IoT. Every Web service will provide their own API, but in general the format is fairly consistent. For this project, the Ubidots IoT backend service was selected (**Figure 8**). They have a well-documented API that is very easy to use. The documentation can be found here.
In both devices, when uploading or downloading the sensor readings, the data itself is passed as a JSON message (JSON is short for JavaScript Object Notation), which is an open standard file format that has the benefit of being both efficient for digital transmission but also is humanly readable. For uploading the weather data to the Ubidots server, we use the POST method:

```
POST /api/v1.6/collections/values/?token=<Your Token>
        HTTP/1.1
Host: things.ubidots.com
Content-Type: application/json
Content-Length: <String Length of JSON Message>
[{"variable": "TemperatureVariableID", "value":79.5},
{"variable": "PressureVariableID", "value":1010.2},
{"variable": "<HumidityVariableID>", "value":54.67}]
```

Where `<TemperatureVariableID>`, `<PressureVariableID>`, and `<HumidityVariableID>` would be replaced with a unique alphanumeric string for each variable that is generated by Ubidots for your particular account. `<Your Token>` will be replaced with a unique, account-based token from the Ubidots service. Think of the token as a random, very hard to guess account name. Lastly, `<String Length of JSON Message>` must be calculated for each message. It is the number of characters, including the letters, numbers, spaces, and special characters.

There are software libraries to parse JSON messages or a custom lightweight function can be created that is application specific. For embedded developers that are accustomed to total control of their device, RESTful APIs present a paradigm shift in that the API provider can (and often will) update their API occasionally. This means the embedded system developer must respond with firmware updates to ensure the devices and IoT backend can continue to communicate.

To download the temperature data into the servo-connected Huzzah, we use GET:

```
GET /api/v1.6/devices/<Your Device Name>/temperature/
   values?page_size=1&token=XXX HTTP/1.1
Host: things.ubidots.com
Connection: close
```

In this example, `<Your Device Name>` would be replaced with the name you created for your device on the Ubidots website. Also, the part of the GET request that reads "`?page_size=1`" means that we are only interested in getting the most recent sensor readings. If it read "`?page_size=5`" then the server would return the data from the five most recent sensor readings.

Use

To simplify the mechanical aspects of this design, we are using a simple linkage that translates the move of the servo arm directly to the manual lever of the damper.

The sensor device can be placed anywhere in the room since it is a standalone device. This is helpful so that it can be placed away from air registers or windows that might inadvertently affect sensor readings for the purpose of regulating room temperature.

The Huzzah is powered with a standard micro-USB DC power supply—the same kind that power many of today's smartphones and other portable electronics. The weather shield stack is powered with a 5V DC barrel jack power supply. Power supplies that provide sufficient power are included in the project shopping cart for your convenience.

Of course, this project could be altered to fit any number of scenarios or system configurations. For example, instead of opening and closing dampers, the system could be repurposed to open and close window blinds based on temperature. Or this could be done in addition to the damper control by simply adding a second control unit. The possibilities are endless.

Other Resources

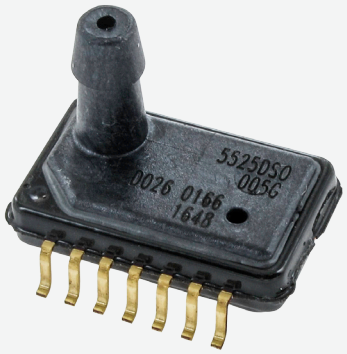
Are you interested in building this project yourself or using it as a starting point for further development? If so, we have put together a few resources to help.

- Building Automation GitHub
- YouTube Video
- Mouser.com Shopping Cart

If you do build this project or make modifications to it, we would love to see the results. You can find us on Twitter, Facebook, and Google+.

MS5525DSO Pressure Sensors

These sensor modules include a pressure sensor and an ultra-low power 24-bit sigma-delta ADC with internal factory-calibrated coefficients. The MS55525DSO includes different operation modes that allow the user to optimize for conversion speed and current consumption.



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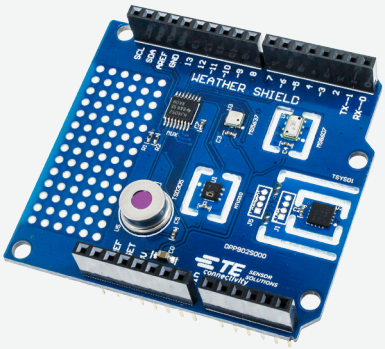
MEAS™ Weather Shield Development Kit

Provides the necessary hardware to interface sensors to any system that utilizes Arduino compatible expansion ports configurable for I²C communication.



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M5600 Bluetooth® Pressure Transducers

Modular Microfused line 24-bit analog-to-digital converter (ADC) digital output wireless transducers enclosed in a stainless steel and polycarbonate housing. M5600 eliminates hard wiring and provides remote process control and monitoring through Bluetooth® 4.0 technology.

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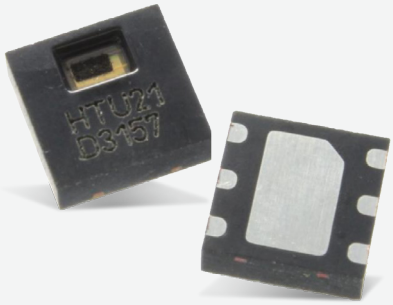
HTU21D Digital Relative Humidity Sensor

The HTU21D provides calibrated, linearized signals in a digital, I²C format. HTU21D sensors are dedicated humidity and temperature plug and play transducers for OEM applications. Direct interface with a micro-controller is enbled with the modular humidity and temperature digital outputs.



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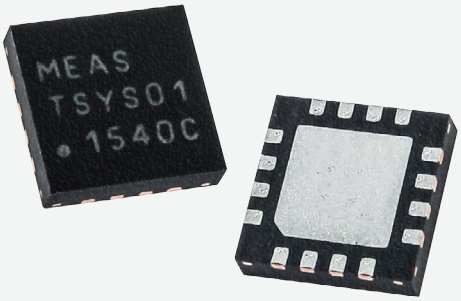
PTF Platinum Temperature Sensors

ideal for extreme temperature environments from -200°C to +600°C. The sensors combine a group of resistance temperature detectors (RTD) using a Platinum resistor in thin film technology as the sensing element.

Learn More »

TSYS01 Digital Temperature Sensor

Ideal for extreme temperature environments from -200°C to +600°C. The sensors combine a group of resistance temperature detectors (RTD) using a Platinum resistor in thin film technology as the sensing element.



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The Premise of Premise Security

by JPaul Carpenter, Mouser Electronics

Premises security solutions aim to meet the following goals:

- Deter a potential threat
- Detect an actual threat
- Asses the detected threat
- Alert the end user or controller
- Respond to the threat

Premises with the potential for widespread detrimental effects of a security breach are particularly vulnerable, as are those not secured by onsite security staff or are otherwise monitored remotely. And for premises that have high levels of Electromagnetic Interference (EMI), the security challenges increase exponentially. Companies like TE Connectivity™ have designed advanced security solutions to address all aspects of premises security, especially detecting, assessing, alerting, and responding.

Deterring Potential Violators

The first line of defense for any security solution is deterring those who don't belong by installing physical barriers and communicating restrictions and potential consequences. Often, deterrents such as signage, chain link fencing, 20-gauge barbed wire, strategic lighting, remote-access locks, and motion detection sensors are layered to provide multiple security barriers between potential violators and the protected assets.

Recently, the focus has shifted toward the methodology of deterring, while also striking a balance with aesthetics due to NIMBY (Not In My Back Yard), which refers to opposition to new development that's perceived as being too close to nearby residents. Most advancements have focused on increasing the difficulty of getting past the fence, increasing the visibility of intrusion, providing a two-way live communication system, and improving lighting solutions.

Security cameras often serve more than one purpose within a system; even the presence of a camera can serve as a deterrent. Behind the scenes, large scale video monitoring systems allow security professionals to view thousands of people, track their entire route on premises, and analyze faces and walking gaits. For this use, TE Connectivity has simplified camera system wiring with the Cloudsplitter Connector System, which can deliver up to 250W of power and Internet connectivity in a single cable, reducing component count and points of failure.

Detecting Violators

Detection is the next key element in any security design solution. This concept is explained in signal detection theory (**Figure 1**), which identifies the idea that there is a stimulus or there isn't, and the system can correctly or incorrectly identify that fact. Opportunities for failure can be introduced from sensor and connection failure (resulting in a False Alarm), or a person (yeilding the Miss result).

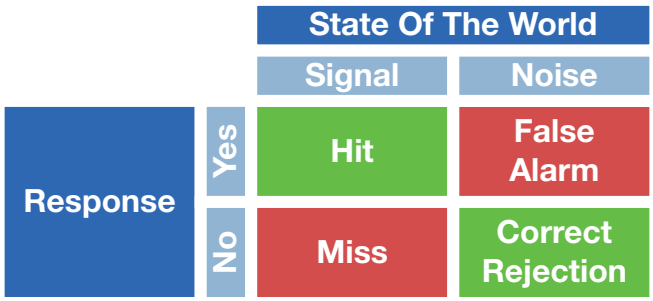

Figure 1: *There are two successful outcomes and two opportunities for failure. (Source: Abdelhamid, et al. 2004)*

The oldest detection was done with living, breathing things. Whether animal or human, they all suffer from a few common problems: They all need to sleep, eat, take breaks, have hearing limitations, and can simply become distracted. This is where technology has come in, offering solutions that are more reliable, more sensitive, and faster to detect and alert. Support sensors such as PIR/occupancy sensors, radar, and beam break all still serve valid, essential functions and are becoming smaller and smarter, thus increasing a building's overall intelligence.

Furthermore, imagine if the security system were connected to other smart building components. What if the system could identify abnormal use, and thus detect potential threats, based on data incorporated into its machine learning algorithm from lighting and occupancy sensors? Due to recent advances in maching learning technology, this is now possible, and automated systems able to detect normal human activity patterns and adjust the system accordingly will become increasingly commonplace.

A common scenario is integrating lighting, thermostat, and security systems. Smart lighting and thermostat systems learn human activity patterns and become smarter, keeping people comfortable and rooms lit when there is activity. Now let's say an irregular event occurs: The phone or power goes down, a vibration or glass-break sensor goes off, a motion or light sensor is tripped, or a door sensor is activated. In an integrated security design, one sensor can heighten the reaction of the others and communicate to a centralized controller, which can then provide more information to help assess threat credibility.

But even technology-based detection solutions have downsides. In particular, they're not human and, as a result, can't always accurately determine acceptable and unacceptable access. Additionally, sensors can go bad, and wires can fail or corrode—all leading to false alarms. TE Connectivity addresses these concerns with their Power Triple Lock connector™ system. It comes in many varieties allowing it to withstand both high temperatures and strong vibration, and has auditory and mechanical feedback with a click sound confirming that its snag-less primary lock is secured. Connection mismatch is avoided by optional keyed connections that eliminate installer issues, and a triple lock insert can safeguard against powerful vibrations and accidental disconnects.

Assessing The Detection

Assessing detection is a critical factor, as this phase determines threat credibility. Until recent years, humans have been at the core of threat assessment, but it has evolved into the comprehensive network of sensors and output that we have today.

However, sensor output in a security system produces a new challenge: The sheer amount of data produced that needs to be collected and analyzed, as well as potentially stored for further analysis and insights. Historically, data collected from these sensors was rarely kept for any analytics purpose, but today's "smart" or "intelligent" systems use this data to predict and assess threats. We want to detect unusual events, but doing so is often complicated by irrelevant data. With the help of Artificial Intelligence (AI), computers can recognize acceptable or normal use, thus only bringing credible threats to the human monitoring the system.

Alerting After Detected Threat

While alerting the end user to a verified, credible threat may seem straight-forward, this phase has its challenges as well. Returning to the scenario: The phone line or power goes down, a vibration or glass-break sensor goes off, a motion or light sensor in your learning thermostat is tripped, and finally a door sensor is activated. At what point did this experience not fit the ordinary course of events? At what point does the alarm alert the user or company? Based on user preference and premises needs, the system can alert them at a pre-determined point in the sequence.

Responding To A Threat

The final component of a security solution is responding to a confirmed threat. Goals here include preventing further loss, recovering goods, and identifying the perpetrator. Security systems initiate the communications—such as automatic calls to 911 and the end user—necessary to respond to confirmed threats, though the primary response comes from security personnel and/or police. Throughout the response step, sensor data is collected, summarized, and relayed to give responders as clear a picture as possible. This allows their responses to be as effective and safe as possible.

Conclusion

An effective security solution must address all five stages of threat mitigation. Failure to deter, detect, or accurately assess a threat could lead to delays in communicating with and alerting responders, thus increasing the likelyhood of significant asset loss. Unlike the systems of yesteryear, a modern system can be highly sophisticated, able to learn from its environment and respond accordingly. But remember: When implementing a premises security solution, any system is only as good as its components. Fortunately, TE Connectivity offers numerous high quality, reliable security solutions such as occupancy, magnetic, and contact sensors; security cameras and connecting wires, Cloudsplitter, and Power Triple Lock. While there will always be a need for security systems, designers and manufacturers alike are working to meet those needs with cutting edge technology. When every connection counts, designers can count on TE Connectivity.