NEWS FOR THE ELECTRONICS INDUSTRY

eTECH JOURNAL

ISSUE 4

ADVANTAGES OF **RAPID INDUSTRIAL IOT**

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PRESSURE SENSORS: DESIGN AND TECHNOLOGY

DIGITAL PRESSURE SENSORS FOR IA

SIMPLIFY THERMOCOUPLE DESIGN

INDOOR AIR QUALITY

INDUSTRIAL SENSORS
SMART SENSING

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WELCOME

Today, sensors are vital to any modern-day Internet of Things (IoT) application. They serve as the eyes and ears in an ecosystem of connected devices, gathering critical information about their surroundings that then allows them to make decisions. Efficient manufacturing technologies, state-of-the-art automotive, innovative medical products, smart power supply systems, or user-friendly building services – none would be conceivable without sensors.

Industry 4.0 requires automation, and as automation develops, so does the demand for more advanced intelligent smart sensors. Focusing on increasing the energy effectiveness and productivity of industrial processes is a response to the intensifying pace of technological advancement. Cutting maintenance costs by continuously monitoring machine and plant components is another crucial area (condition monitoring).

Such sensing and device monitoring functionality can be delivered at various levels of integration based on the number of different sensor types included in a single package or sensor module. Determining the right types of sensors for your application, selecting the optimal technical characteristics such as precision, range of operation, and speed, and ensuring interoperability with the design balance is no easy task.

In this edition of the element14 Tech Journal, we look at how sensor technology advancements are enabling smart industrial automation and how to enable rapid Industrial IoT. Discover the industry's first digital Outdoor Air Quality (OAQ) sensor module with embedded AI output, as well as the various types of pressure sensors, design considerations, and technology options in industrial applications.

We hope you enjoy this edition of element14 Tech Journal.

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OMEGA™

THE ADVANTAGES OF **RAPID INDUSTRIAL IOT**

In manufacturing, there is a consistent aim of reducing downtime, increasing capacity, optimizing the cost of asset care, and using digital transformation to overcome competition. And, as manufacturing experiences growth and resource challenges, being able to do more at a faster rate is at the forefront of some Industrial Internet of Things (IIoT) providers.

Whether it is related to lean investigative science or securing the integrity of drug development studies, Rapid IIoT (RIIoT) is finding a place in manufacturing, drug discovery, and technology development. In a world of control, security, and restrictions, there still exists a Wild West - where the ability to innovate and pivot without restriction are absolute necessities.

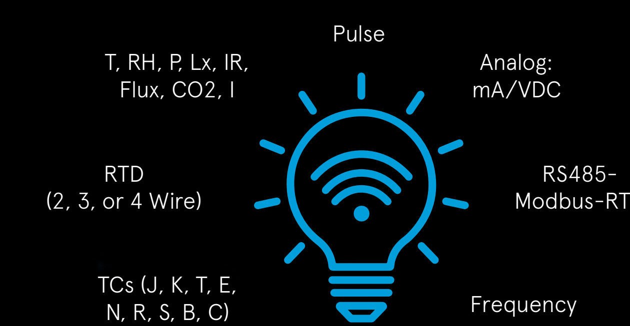
Enter Rapid Industrial IoT.

AN OVERVIEW OF RAPID IOT

What's worse than your business wanting 'it' today? Wanting 'it' yesterday. RIIoT becomes an immediate answer to many urgent and critical needs - for practically any market. It all depends on the urgency and the ability to deploy.

In the world of IIoT, we focus on the creation of a digital twin. A digital twin is a virtual representation of a process or a system for the purpose of parametric monitoring, facility testing and integration, and predictive diagnostics for maintenance. This representation has the essence of being part of your business institution.

RIIoT, however, takes the guard rails off and enables rapid deployment of a pre-configured Sub GHz wireless monitoring system that leverages a cellular gateway path to the cloud. The cellular route eliminates the red tape from your IT Department while providing you with data moments after you boot your gateway. Upstream of the gateway, intelligent Sub GHz sensors deliver continuous data in demanding industrial environments.



Smart Probes

The parameters of measurement are immediately available:

- Temperature, RH, Barometric, Light Intensity
- Differential, Absolute, and Gauge Pressure
- IR surface temperature sensing
- Vibration and power monitoring of motors
- High Accuracy Non-Invasive (HANI) Temperature sensing
- Scaled 4-20 mA analog input and VDC Inputs
- Modbus – RS485 – RTU – BACnet
- Thermocouple input types J, K, T, E, N, R, S, B, and C
- RTD input types for 2, 3, or 4 wire configurations
- Load Cell, Heat Flux, PWM, Totalizer inputs

Type	Range	Operating Conditions	Accuracy
Frequency (Rate)	0.01 Hz to 100 Hz	$T_{PW\ MIN}$ = 200 uS	±0.5%
Frequency (Rate)	100 Hz to 1000 Hz	$T_{PW\ MIN}$ = 200 uS	±1 Hz averaged over 1s
Counter	0 to +8388608	1 kHz Max Rate	±1 count max
Up/Down Counter	-8388608 to +8388608	1 kHz Max Rate	±1 count max
Pulse Width (T_{PW})	200 uS min		±50 uS ±1%
Pulse Width (T_{PW})	200 uS min		±50 uS ±1%
Duty Cycle	1% to 99%	0.01 Hz to 1000 Hz, $T_{PW\ MIN}$ = 200 uS	±1.5% max

Analog (Process) Input Signals

Type	Range	Resolution	Min	Max	Accuracy	Input Impedance
Current Loop	0-24 mA	±0.1 mA	0 mA	24 mA	±0.2 mA	50 ohm
Voltage	0-1.0 V_{DC}	±10 mV	0 V_{DC}	1.20 V_{DC}	±10 mV	100k ohm
Voltage	0-2.0 V_{DC}	±10 mV	0 V_{DC}	2.50 V_{DC}	±20 mV	100k ohm

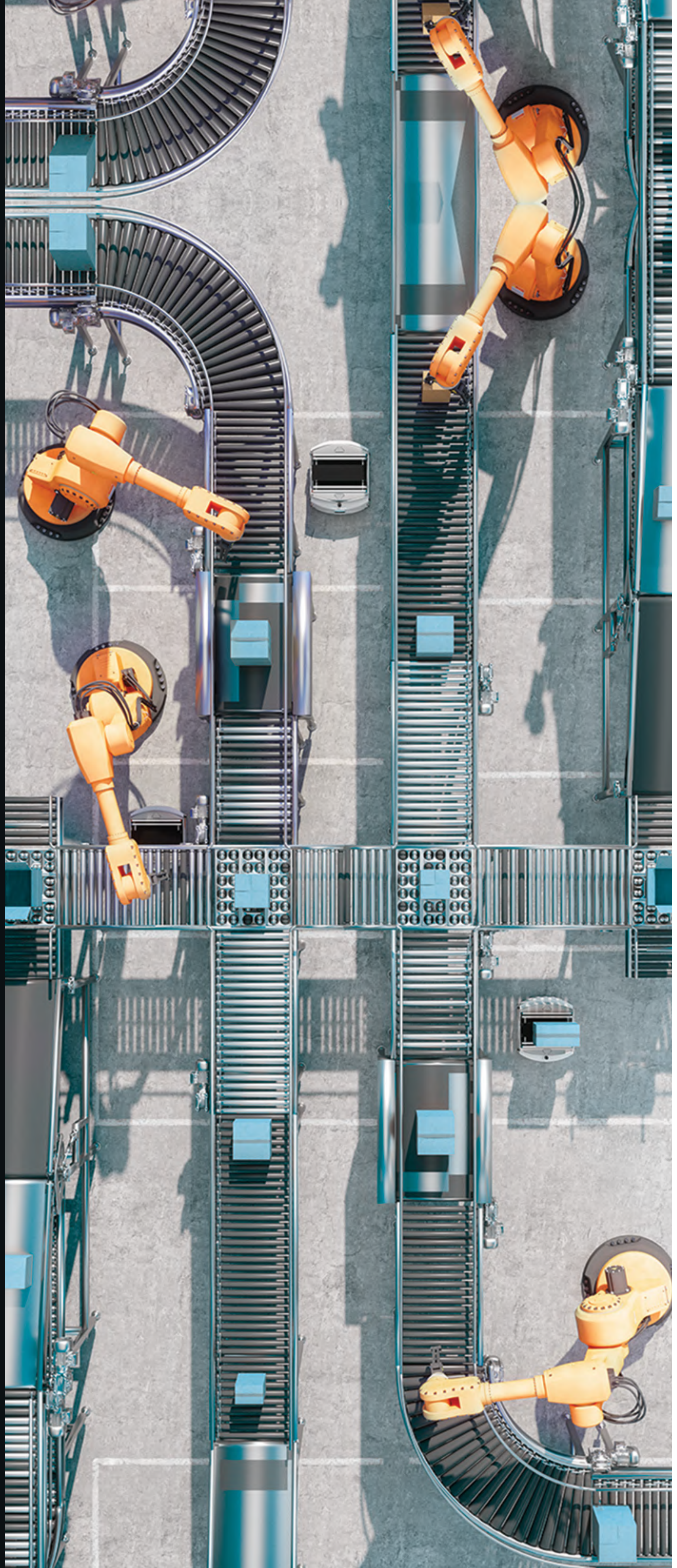
WHAT'S THE STRATEGIC RATIONALE FOR THIS?

To start, let's take a look at how fast the IoT market is growing. This does not necessarily mean that you need to become an IoT champion, but it should reflect how the world around you and your competitors are leveraging this technology to improve productivity, quality, expansion, and reduce downtime.

The barriers of entry for IIoT components at any facility are getting approval from IT, becoming qualified, writing an SOP, and, perhaps, being limited to a single network drop. In the world of Rapid IIoT, limited is a four-letter word.

Some examples to consider:

- Drug Discovery



The cold chain procedures at many facilities have an antiquated twice daily min/max temperature reading that does not reflect the intermittent variations required for temperature control of vaccine refrigerator/freezers. For some vaccines, as an example, the exposure to light becomes a risk to the efficacy of the drug development and trials, as well. High time resolution measurements of multi-zone temperatures and light exposure can provide critical data traceable to NIST for such purposes.

- Process Equipment

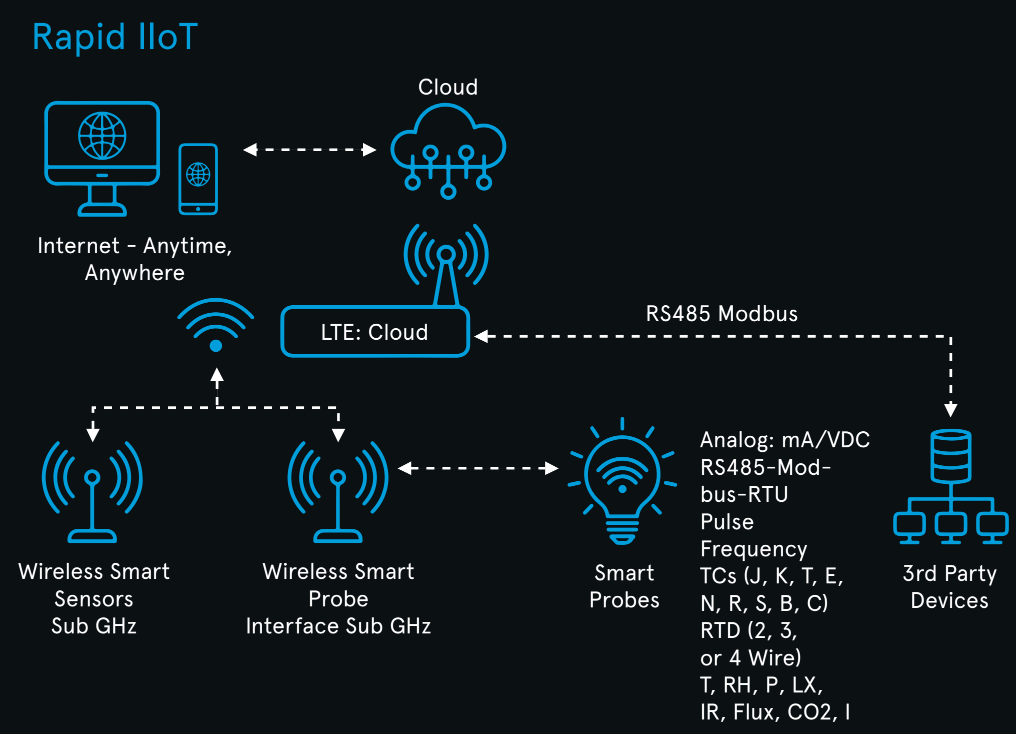
When considering the critical areas where you are challenged to reduce downtime to gain insight into maintenance intervals, having knowledge of vibrational patterns, power consumption, or an ability to connect to any existing thermocouple – as well as the ability to do so quickly and on the fly with wireless sensing – enables facility personnel to get the answers they require sooner rather than later. Case in point – glycol jacket circulation pumps. Failure of such pumps happens suddenly and can waste large volumes or value (or both) of product – ranging from breweries to bioproduction. Many service engineers get removed from the naughty list and become revered as an oracle who can foretell the future – that's the value of knowing when something is about to break.

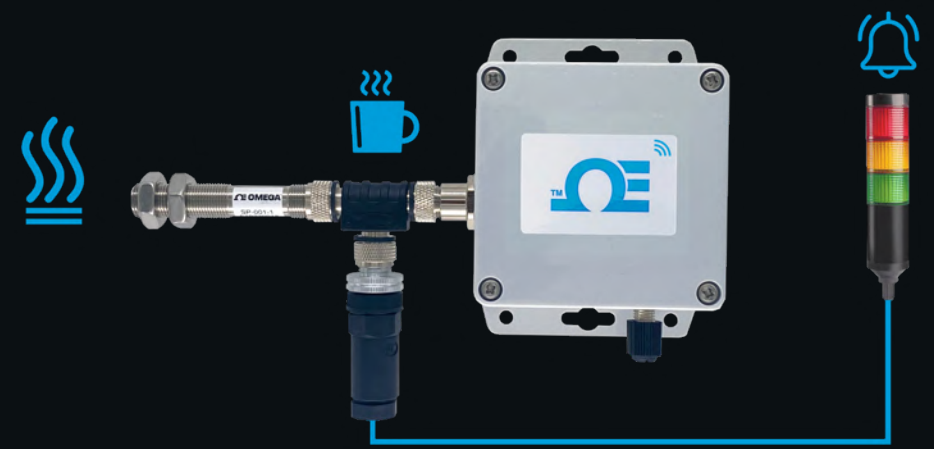
- Automotive Research

Before entering into production of a new commercial model or a new manufacturing process, qualifying a solution under development in this fast-paced industry is now more important than ever – especially within the electric vehicle market. Again, we see that the ability for researchers to tap into or introduce wireless sensing into their process creates an ability for rapid deployment and data gathering they never had before. With a centralized wireless-cellular gateway speaking to sensing points and the cloud simultaneously, data is being made visible faster than ever. With all this data available on the cloud, there is no need to VPN into a network. Rapid IIoT means rapid data, rapid analysis, and rapid solutions which are all meant to enable the pivot to occur.

CAPABILITY

It should also come to no surprise that these RIIoT devices can not only monitor and alert on data limits, but in some cases can also offer local control and visual and/or audible alarms without the need for enterprise software or reliance on interaction with the cloud. RIIoT is not only for monitoring; autonomous pre-configured control also enables creativity to local alerts and control in a deployment.





WHAT IS THE VALUE?

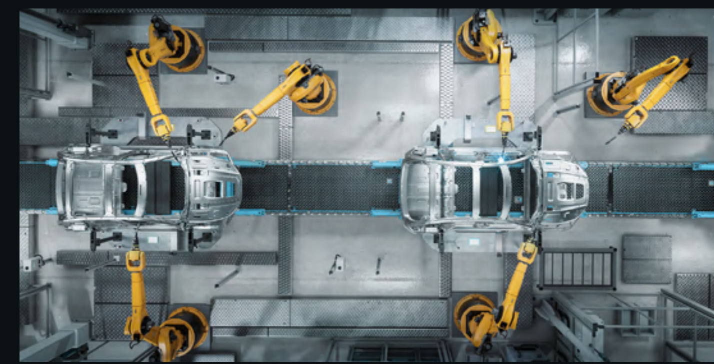
Let's first consider the total IoT market has been estimated to be $462 billion in 2022 and will grow to $1.3 trillion by 2026. This suggests a 28% cumulative annual growth rate of which 46% is attributed to hardware purchases and 36% to associates services - with the remainder spread across platform and software integration.

The value of recognizing the market trend is to be aware and involved in what your business is doing to maintain a competitive edge. Furthermore, predictive systems are estimated to save up to 12% over scheduled repairs, reduce overall maintenance costs up to 30%, and eliminate breakdowns up to 70%.

RIIoT for innovative solutions or to pilot by RIIoT is the new trend to taking acceptable risks before committing to a larger system. It is as easy as taking a test drive - without risk of time or security.

WHAT IS MY TACTICAL PLAN?

In highly innovative industries, the need for RIIoT becomes part of the culture of flexibility to deploy and gather data without restraint. RIIoT are for the engineers that need to live a little in that unlimited wild west space of innovation and with a "now" mentality. It is also for the business of piloting a system free of risk while evaluating the fit. A RIIoT system that uses an LTE Gateway can be expanded and contracted as needed for ongoing innovative development.



It's no surprise that a shrinking workforce and consumer demand for more agility has required manufacturers to embrace new ways of thinking and producing. Yet, the number of companies implementing digital strategies dropped more than 40% during the pandemic, hitting numbers closer to those seen in 2017. The two main factors preventing companies from implementing IoT practices are revenue and worker shortages, which only serves to highlight just how important digital transformation is in the first place.

CONCLUSION

Common industry problems – unplanned downtime, need for increased output, high asset-care costs, and gaining an edge over competitors — can all be addressed by leveraging predictive technologies already available to manufacturers. These challenges can all be met through initiating RIIoT. Failure to fully implement digital transformation compounds the very issues that it's meant to solve.

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PRESSURE SENSORS: **DESIGN CONSIDERATIONS & TECHNOLOGY OPTIONS**

There are many different types of applications for pressure sensors, which create a need for a wide variety in sensor types and characteristics.

Variants are available for harsh or corrosive environments and aimed at high-integrity applications such as use in medical equipment. Others are intended to provide low cost for use in consumer mobile devices. Here's our guide to pressure sensors, how they work and what to look out for.

WHAT IS A PRESSURE SENSOR?

Broadly speaking, pressure sensors convert the pressure of the atmosphere, gas or liquid they are exposed to into an electrical signal.

There are three different types of pressures that can be measured: gauge, absolute and differential.

Gauge pressure (fig 1) is the pressure measured relative to the ambient atmospheric pressure. It can be positive for pressures higher than atmospheric, or negative for lower pressures. Ambient atmospheric pressure is usually sensed via a hole in the packaging. A typical application for a gauge pressure sensor is to measure liquid levels in a vented tank using the difference in hydrostatic pressure and ambient atmospheric pressure.

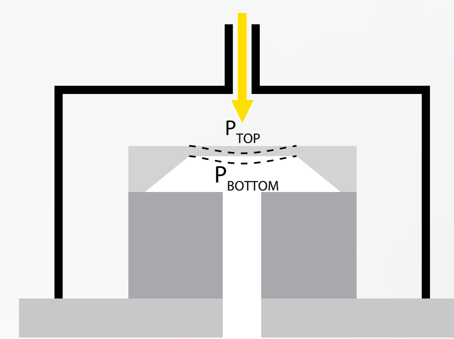


Figure 1: The top side pressure, PTOP, must be higher than the gauge reference, PBOTTOM, and results in positive change of differential output voltage of the pressure sensor. The gauge reference is identical to the local atmospheric pressure level.

Absolute pressure sensors (fig 2) will give the result relative to zero (a perfect vacuum). This is useful in applications that are measuring atmospheric pressure, perhaps to determine altitude. Absolute pressure sensors are also used in pressure measurement applications that will be used at different altitudes; since atmospheric pressure varies with altitude, gauge pressure wouldn't give an accurate reading.

This type of sensor is also used in applications such as tyre pressure monitoring systems to optimise tyre performance.

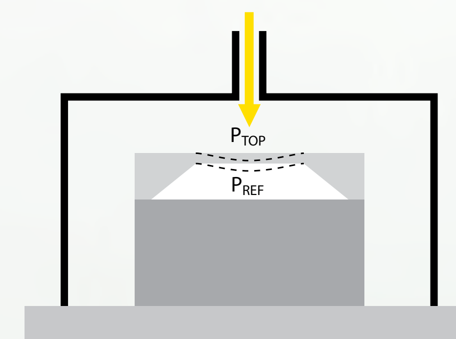


Figure 2: Absolute pressure sensor. Top side pressure, PTOP, results in positive change of differential output voltage of the pressure sensor.

Differential pressure sensors (fig 3) measure the difference in pressure between two samples, similar to how a gauge sensor works, but differential sensors are sometimes used to detect the pressure difference either side of an object, for example. Differential pressure sensors are often used to monitor airflow in HVAC applications.

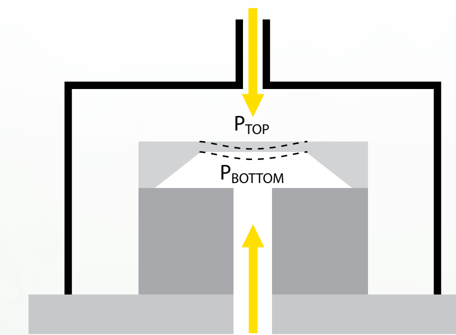


Figure 3: Differential pressure sensor. A top side pressure, PTOP, higher than the bottom side pressure, PBOTTOM, results in positive change of differential output voltage of the pressure sensor. Bottom side pressure being higher than top side pressure results in negative change of differential output voltage of the pressure sensor.

Specifying absolute pressure sensors where they aren't really required is a common mistake; the majority of industrial applications can use gauge pressure. It's important to fully understand the application's requirements before making a selection to ensure an accurate, efficient and economical choice.

Pressure sensors come in several different types. You will see pressure sensors described as sensors, transducers and transmitters, and while these terms are sometimes used interchangeably, the devices they describe aren't technically the same.

Pressure sensors produce an output voltage that varies with the pressure they experience, usually referring to the sensor element that is physically detecting the pressure. Packaged board-mount pressure sensors are available that will require the designer to consider calibration, temperature compensation and amplification separately. Confusingly, the phrase `pressure sensor' is also sometimes used to describe transducers and transmitters in general.

Pressure transducers, like pressure sensors, produce an output voltage that varies with pressure. A transducer in this context is a sensing element combined with signal conditioning circuitry, perhaps to compensate for temperature fluctuations, and most likely an amplifier to allow transmission of signals further from the source. Note that for most applications there is an advantage to specifying pressure transducers that are temperature compensated rather than trying to implement custom temperature compensation on a pressure sensing element, as the testing required can be complicated.

Pressure transmitters are similar to transducers, but their output current varies with pressure, rather than the voltage. Be aware that in portable applications, transmitters can wear the batteries down if they are consistently used at the top end of their pressure range.

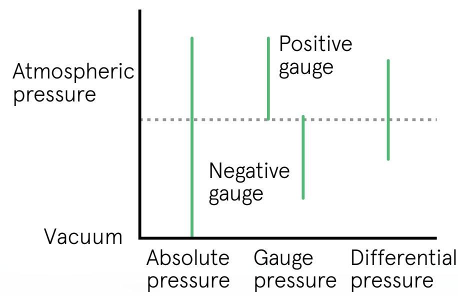


Figure 4: Differences in types of pressure measurement

Absolute pressure sensors (fig 2) will give the result relative to zero (a perfect vacuum). This is useful in applications that are measuring atmospheric pressure, perhaps to determine altitude. Absolute pressure sensors are also used in pressure measurement applications that will be used at different altitudes; since atmospheric pressure varies with altitude, gauge pressure wouldn't give an accurate reading.

TYPES OF PRESSURE SENSING ELEMENT

The most common types of pressure sensing technology around today are strain gauges. These sensors use some kind of diaphragm, which deflects due to the pressure it experiences. A strain gauge is attached to the diaphragm, which changes its resistance as the diaphragm deflects, that is as the pressure changes. This change in resistance is usually measured by a Wheatstone-bridge circuit.

Strain gauge technologies include bonded foil, in which a metal foil gauge is glued or bonded to the metal diaphragm, and then two or four diaphragms are arranged into a Wheatstone bridge. These sensors can resist high pressures over a wide temperature range and they respond quickly to changes in pressure.

Also available are sputtered glass strain gauges, in which a layer of glass is sputtered onto the diaphragm, then a foil strain gauge is sputtered onto the glass – that is, there is a molecular bond between the strain gauge, the insulating layer and the diaphragm, rather than it being simply glued on. These sensors are very robust, suitable for long-term use and harsh environments.Silicon MEMS strain gauges are very common today. They are based on a micromachined silicon diaphragm with a strain gauge or piezoresistive device and temperature sensor grown onto it. These devices can be integrated at chip level with signal conditioning electronics to make pressure transducers or transmitters. The piezoresistive versions (fig 5) use the change in resistance of a material based on strain to record the change in pressure. They employ the same Wheatstone-bridge circuit for measurement as with a conventional strain gauge.

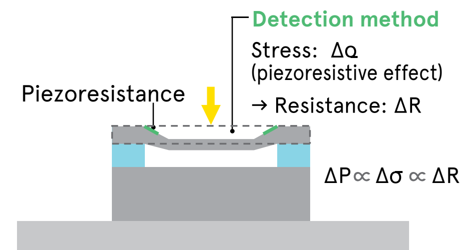


Figure 5: Schematic illustration of a piezoresistive element cross section

Aside from traditional strain gauges, there are also capacitive, piezoelectric and optical pressure sensors. Capacitive pressure sensors (fig 6) use a MEMS diaphragm over a metal surface, which deflects as the pressure changes, changing the system's capacitance.

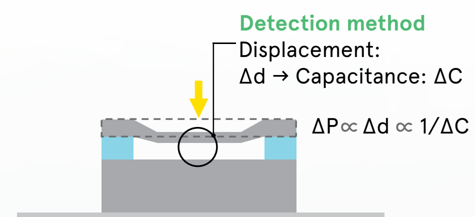


Figure 6: Schematic illustration of a capacitive elementcross section

Piezoelectric sensors use an element made of a material that generates electrical energy when they are under strain, such as quartz or tourmaline. Crucially, they only produce energy when the pressure changes, and are therefore suitable only for dynamic pressure measurements (not static pressure). They are also susceptible to shock and vibration. As with strain gauge and capacitive types, piezoelectric sensors can be made using MEMS techniques.

The optical pressure sensor uses fibre Bragg gratings to measure the deflection in a glass fibre caused by changes in pressure on it. It is a technique that is highly suited to conditions where temperature and electromagnetic compatibility may be a problem.

CHOOSING A PRESSURE SENSOR

RANGE AND ACCURACY

When comparing pressure sensors, there are a number of physical and performance attributes to be considered.

Firstly, you'll want to consider the pressure range each sensor is capable of measuring and how that compares to the pressures you want to measure. You may also wish to consider proof pressure - the maximum pressure the device can withstand and then retain functionality when the pressure returns to the operating range, and burst pressure - the pressure that breaks the component such that fluids can leak (which may be dangerous in some applications).

Pressure sensor accuracy is an important performance attribute, which is typically given as a percentage of full-scale pressure over a certain temperature range. Some sensors also exhibit hysteresis, non-repeatability and non-linearity, which should be described on the data sheet, if they apply. Linearity is generally expressed as a percentage of full scale pressure, but there are two methods of measurement (best fit straight line and terminal point) which are not equivalent, so be sure to compare like with like. Long-term stability of devices is also desirable – look for low drift over time as well as good stability over a wide temperature and humidity range – while shortterm stability after soldering can also be an issue if the device needs to be used straight away (some sensor types can take hours, or even weeks to stabilise).

ENVIRONMENT AND INTEGRATION

Next, consider the environment the sensor will be operating in. Mechanical robustness may be an issue – the sensor's specification may give an idea of its expected cycle life. The ability to withstand liquids or contaminants may be attained by selecting a stainless steel part (note that most gauge pressure sensors have a hole or vent in the packaging for reading atmospheric pressure, which can get clogged with dirt). Sensitivity to shock and vibration is also particularly important to automotive, transportation and industrial applications.

You should consider how long you have to spend on integrating the sensor into your system. If time is short, a transducer with integrated signal conditioning electronics, temperature compensation, self-calibration, internal diagnostic functions and a digital output may be the best choice. However, if your system has specialist needs and you are working with appropriate design resources, your own custom implementation of the electronics could be the right choice, especially if you are prepared to calibrate the sensor after assembly.

Some other vital parameters are the sensor's response time (vital if real time feedback is required), energy efficiency (check the current consumption figures, especially for transmitters), and physical size. For hard to reach areas or portable equipment, you'll be looking for a compact solution. Modern sensors come in a variety of package sizes and options that also need to be investigated. For example, does the sensor need to be surface mounted onto a PCB or does it need to be mounted in a specific orientation? Both obviously have implications for packaging choice.

TECHNOLOGY SELECTION

The different sensing technologies tend to offer performance in different pressure ranges and suit certain environmental conditions.

RANGE AND ACCURACY

The piezoresistive sensor has become a commonly used pressure sensor thanks to the widespread use of MEMS manufacturing technologies. These make the sensors relatively inexpensive to produce, assuming they do not need specialised packaging to handle dirty or hostile environments. However, the sensing elements are sensitive to ambient temperature and their response to changes in temperature is not linear. As a result, the sensors need to be calibrated and their inputs interpreted in the context of temperature. The use of resistance for measurement also presents the issue of demanding a constant current flow while the sensor is active, which increases system energy requirements that may be troublesome in a mobile or IoT context.

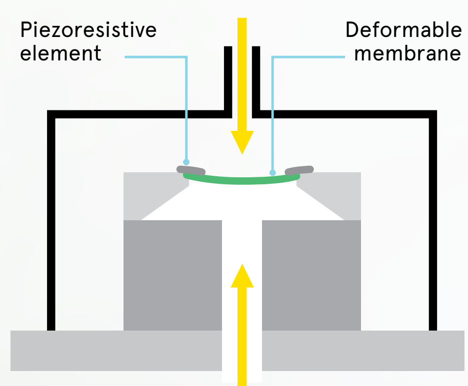


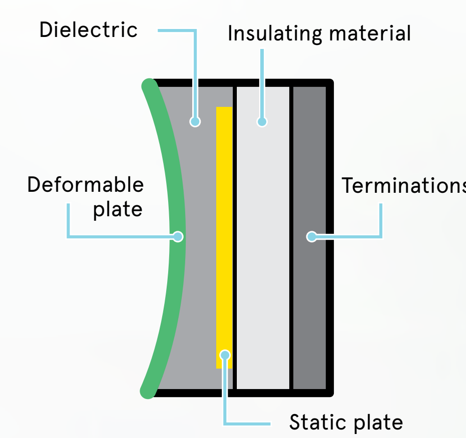
Figure 7: Piezoresistive sensor

Sensors based on strain-gauge principles can be made with lower temperature sensitivity through the use of isoelastic alloys. Another approach is to employ a design that includes a dummy gauge. Specialised designs and materials are often used at higher temperatures because the performance of the alloy changes as the ambient heat levels are pushed far above room temperature.

CAPACITIVE

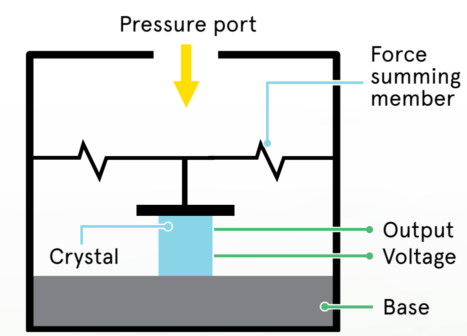
The capacitive sensor employs two types of membranes: one flexible, the other stiff. The relative movement of the conductive membranes leads to changes in capacitance in those cells. The cells that have stiff membranes act as reference devices. The advantage of this structure is that both sensing and reference cells are exposed to the same thermal conditions and so are relatively immune to changes in ambient temperature. The design is highly suited to battery-powered applications because it does not rely on the presence of a constant current.

Capacitive sensors tend to be useful for detecting small changes in pressure, such as those due to altitude. Consumer-class products are able to sense changes of ±0.005hPa, which equates to an altitude change of approximately ±5cm near sea level.



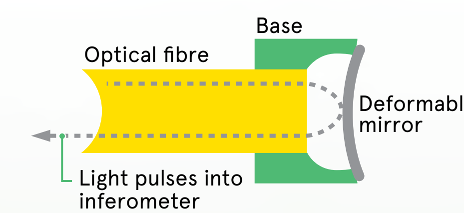
PIEZOELECTRIC

The piezoelectric pressure responds to instantaneous changes in pressure rather than changes compared to a reference such as vacuum or ambient air pressure. They use the production of charge in response to a deflection to operate and so require a dynamic input to operate, unlike the broadly similar piezoresistive technology. A typical application for a piezoelectric sensor is to detect changes in liquid or gas pressure, often within an engine or reactor to measure the efficiency of combustion.



OPTICAL

Optical fibre technology is generally employed in challenging applications where the measurement may be highly remote, under high temperature, or may benefit from technologies inherently immune to electromagnetic interference. The technique works by sending pulses of light through an optical fibre and using interference measurements to analyse the change in time of flight for the return pulses after they have reflected off a deformable mirror at the measurement point. A common use for optical sensors is to measure the pressure inside oil wells or for highly sensitive measurements in medicine.



SUMMARY

Choosing the right pressure sensor can be a complex process regardless of the application, and understanding how pressure sensors are designed and constructed is a key first step to making the best decision. Other technical aspects for consideration include long term stability, energy efficiency, ability to withstand harsh assembly and mounting conditions, form factor, interface and output type. Additionally, commercial considerations include the availability of samples, evaluation boards and technical expertise.

We stocks pressure sensors from a range of leading manufacturers, and our pan-European team of technical specialists can help you find your optimal solution. Visit our Pressure Sensors space to get in touch and discuss your design.

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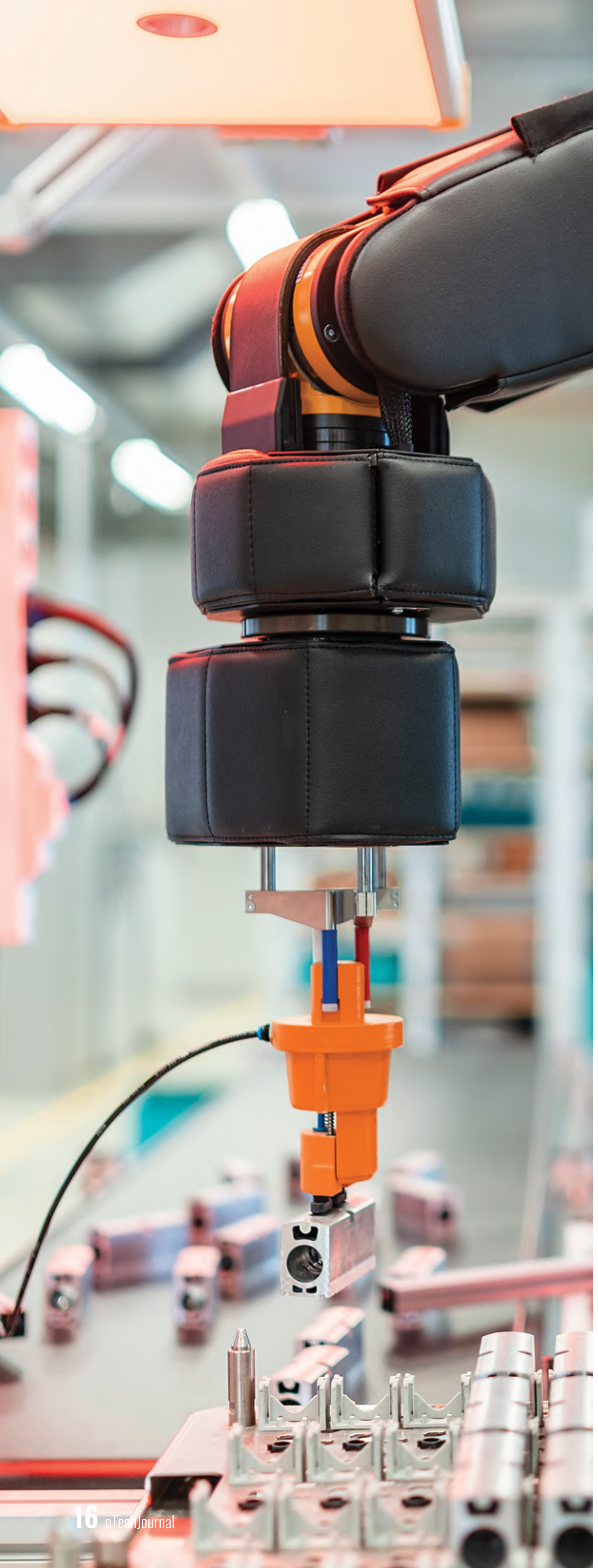


Sensata Technologies

THE ADVANTAGES OF DIGITAL PRESSURE SENSORS **IN INDUSTRIAL APPLICATIONS**

Pressure sensors are used in a variety of industrial applications, ranging from hydraulics and pneumatics; water management, mobile hydraulics and off-highway vehicles; pumps and compressors; air conditioning and refrigeration systems to plant engineering and automation.

They play a critical role in ensuring system pressures are within acceptable ranges and help to ensure reliable operation of the application. There are different advantages to using analog and digital pressure sensors, depending on the installation and system requirements.

WHEN TO USE A DIGITAL VS AN ANALOG PRESSURE SENSOR

SYSTEM DESIGN

One advantage of using analog pressure sensors is the simplicity in set-up if the existing system is based on analog control. If only one signal is needed for measuring dynamic processes, an analog sensor coupled to an analog-todigital (ADC) converter would be a simpler solution as opposed to a digital pressure sensor which requires a specified protocol to establish communication with the device. If system electronics need very fast active feedback control loops, pure analog pressure sensors are the best solution. For systems that do not require a response time of faster than approximately 0.5ms, digital pressure sensors should be considered since they simplify networking with multiple digital devices and make the system more future-proof.

The right time to consider switching to digital pressure sensors in an analog system is when upgrading the components to include programmable microchips. Now that modern microchips are more affordable and more easily programmed, incorporating them into components like pressure sensors simplifies maintenance and system upgrades. This saves on potential hardware costs as digital sensors can then be updated with software instead of replacing entire components.

In applications with battery-operated systems, like in remote locations, digital sensors with low power consumption are preferred over analog pressure sensors, which require constant power. Digital pressure sensors are easier to control and provide power-saving benefits to the system. For example, the ability to schedule when digital pressure sensors record or sleep can reduce power consumption by up to 500x when compared to analog sensors.

The plug-and-play design and shorter cable lengths of digital pressure sensors streamline system set-up and reduce the overall cost of installation in applications that are set up for digital communications. When digital pressure sensors are combined with GPS trackers, remote cloud-based systems can be located and monitored in real-time from afar.

ADVANTAGES OF DIGITAL PRESSURE SENSORS

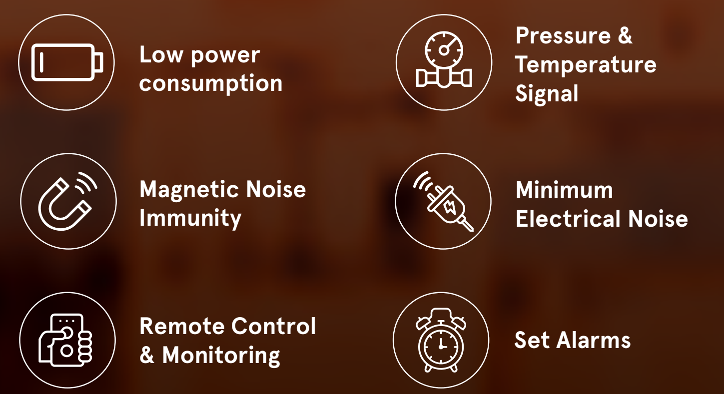


Figure 1: Digital pressure sensors provide many advantages such as lower power consumption, minimum electrical noise, sensor diagnostics and remote monitoring.

Once the user has assessed whether an analog or digital pressure sensor is most appropriate for the given application, understanding some of the beneficial features that digital pressure sensors offer industrial applications will help improve the system's safety, efficiency and reliability.

A BRIEF COMPARISON OF INTER-INTEGRATED CIRCUIT (I^2C) AND SERIAL PERIPHERAL INTERFACE (SPI)

Two common digital communication protocols used in industrial applications are Inter-Integrated Circuit (I^2C) and Serial Peripheral Interface (SPI). I^2C works better with more complex networks as the installation requires fewer wires. In addition, I^2C allows for multiple masters/slaves whereas SPI only allows for a single master/multi-slave network. SPI is the ideal solution for simpler networks and when higher speed and data transfer is required, like reading or writing to an SD-card or recording images.

OUTPUT SIGNALS & SENSOR DIAGNOSTICS

An important distinction between analog and digital pressure sensors is that analog provides only one output signal where digital sensors provide two or more, such as pressure and temperature signals along with sensor diagnostics. In gas cylinder measuring applications for example, the additional temperature information extends the pressure signal into a more comprehensive measurement that allows for the calculation of gas's volume. Digital sensors also provide diagnostic data which includes key information like the reliability of the signal, signal readiness, and live failures, enabling preventive maintenance and reducing potential downtime. This diagnostic data provides the detailed status of the sensor, such as if a sensor element is broken, if a supply voltage was correct, or if there is an updated value in the sensor that can be fetched. Compared to an analog sensor which does not provide detailed information about signal errors, diagnostic data from digital sensors enables better decision-making when trouble-shooting errors.

Another benefit of digital pressure sensors is that they are available with features such as alarms to alert operators of conditions outside of set parameters and the ability to control the timing and intervals of readings which helps to lower overall power consumption. With numerous outputs and diagnostics available in digital pressure sensors, the whole system is more robust and efficient because the data provides the customer with a more comprehensive assessment of the system's operation. In addition to expanding measurement and self-diagnostic capabilities, the use of digital pressure sensors allows for faster development and implementation of IoT and big data applications.

ENVIRONMENTAL NOISE

Electromagnetically noisy environments such as those close to motors, long cable runs, or radio sources could present signal interference challenges for components such as pressure sensors. To prevent Electromagnetic Interference (EMI) in analog pressure sensors, the designs need to include proper signal conditioning like grounded metal shielding or additional passive electrical components, as electrical noise could cause faulty signal readings. All analog outputs are highly susceptible to EMI; however, using a 4-20mA analog output can help to circumvent this interference.

In contrast, digital pressure sensors are not as vulnerable to environmental noise compared to the analog equivalents, so they provide a great solution for applications where EMI is a concern, and the desired output is not specifically 4-20mA. It is important to note that different types of digital pressure sensors provide varying degrees of EMI robustness, depending on the application. Inter-Integrated Circuit (I2C) and Serial Peripheral Interface (SPI) digital protocols are ideal for short distance or compact systems with cable runs under 5m long, though the precise allowable length is highly dependent on the type of cable and pull-up resistors being used.

For systems that require longer cable runs up to 30m, CANopen (optional shielding) or IO-Link digital pressure sensors would be the best option for EMI resistance, though they would require higher power consumption than their I2C and Serial Peripheral Interface (SPI) counterparts.

DATA PROTECTION WITH CYCLIC REDUNDANCY CHECK (CRC) CHECKING

Digital sensors provide the option of including CRC in the chip to help assure customers that they can rely on the signals. The CRC of the communication data is additional to the integrity check of the internal chip memory and allows users to validate 100% of the sensor output, providing an extra measure of data protection for the sensor. CRC features are ideal for pressure sensor applications in noisy environments, like when installed close to a transmitter in a cloud-based system. In such a scenario, there is an increased risk of noise interfering with the sensor's chip and producing a bit flip which could alter the communication message. The CRC on the memory integrity will protect the internal memory from such corruption and repair if needed. Likewise, some digital sensors also provide an additional CRC on the data communication which indicates corruption of data transferred between the sensor and controller and could trigger another attempt to assess a proper sensor readout. In some cases, end users circumvent this by interleaving the communication with the sensor with the external communication (for example to the cloud, a gateway or a controller). CRC simplifies this process and gives the designer more flexibility. In addition to data validity checking, some manufacturers include more electronics that suppress noise from sources such as WiFi, Bluetooth and GSM and ISM bands, further protecting data validity.

FIGURE 2: Digital pressure sensors like Sensata's PTE7300 feature additional electronics onboard that suppress noise from sources such as WiFi, Bluetooth, and GSM and ISM bands. In addition, they feature low power consumption for battery operation, fast response time, increased sensor diagnostics, and sensor communication integrity check using cyclic redundancy check (CRC).

DIGITAL PRESSURE SENSORS AT WORK

ENABLING SMART WATER DISTRIBUTION NETWORKS

The loss of water either through leaks, metering inaccuracies, unauthorized consumption or a combination of the three is an ongoing challenge for large water distribution networks. Applying digital pressure sensors with low power consumption at nodes throughout the distribution network is a practical and cost-effective approach to mapping an area's water distribution network and allows utilities to detect and target areas with unexpected water loss.

Pressure sensors ideal for these applications typically feature either a fully hermetic design rated to IP69K ingress protection or are modular to allow customers more design flexibility. To prevent water leaking into the sensor for the duration of the application's life, some pressure sensor manufacturers utilize a glassto-metal seal connection. A glass-to-metal seal is impervious and creates a hermetic seal on the "top" of the sensor, contributing to a sensor's IP69K rating. This seal means that the sensor is always measuring the pressure difference between what is in the application and the air surrounding it, preventing offset drift.

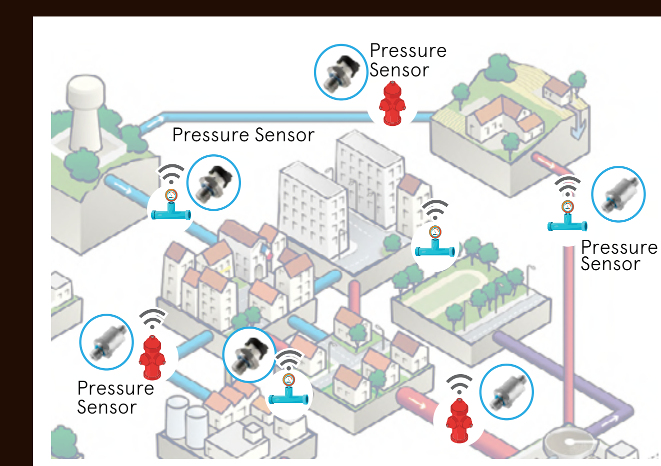


FIGURE 3: When applied at the nodes throughout a water distribution network, digital pressure sensors can help identify areas of unexpected water loss, allowing for effective trouble-shooting and improving system efficiency.

IMPROVING RESSURIZED GAS SYSTEM CONDITIONING

Pressure sensors play several important roles in monitoring and transporting pressurized air and medical gas throughout distribution networks.
In these types of applications, pressure transducers could be responsible for compressor control and a variety of monitoring functions including of the intake and output flow-rate, gas cylinder depletion and air filter status.

While a pressure signal alone gives an indirect measurement of the amount of gas particles at one location of the system, the combination of both pressure and temperature feedback that digital pressure sensors provide delivers a much better estimate of the amount of gas at the location, and therefore better system conditioning and monitoring.

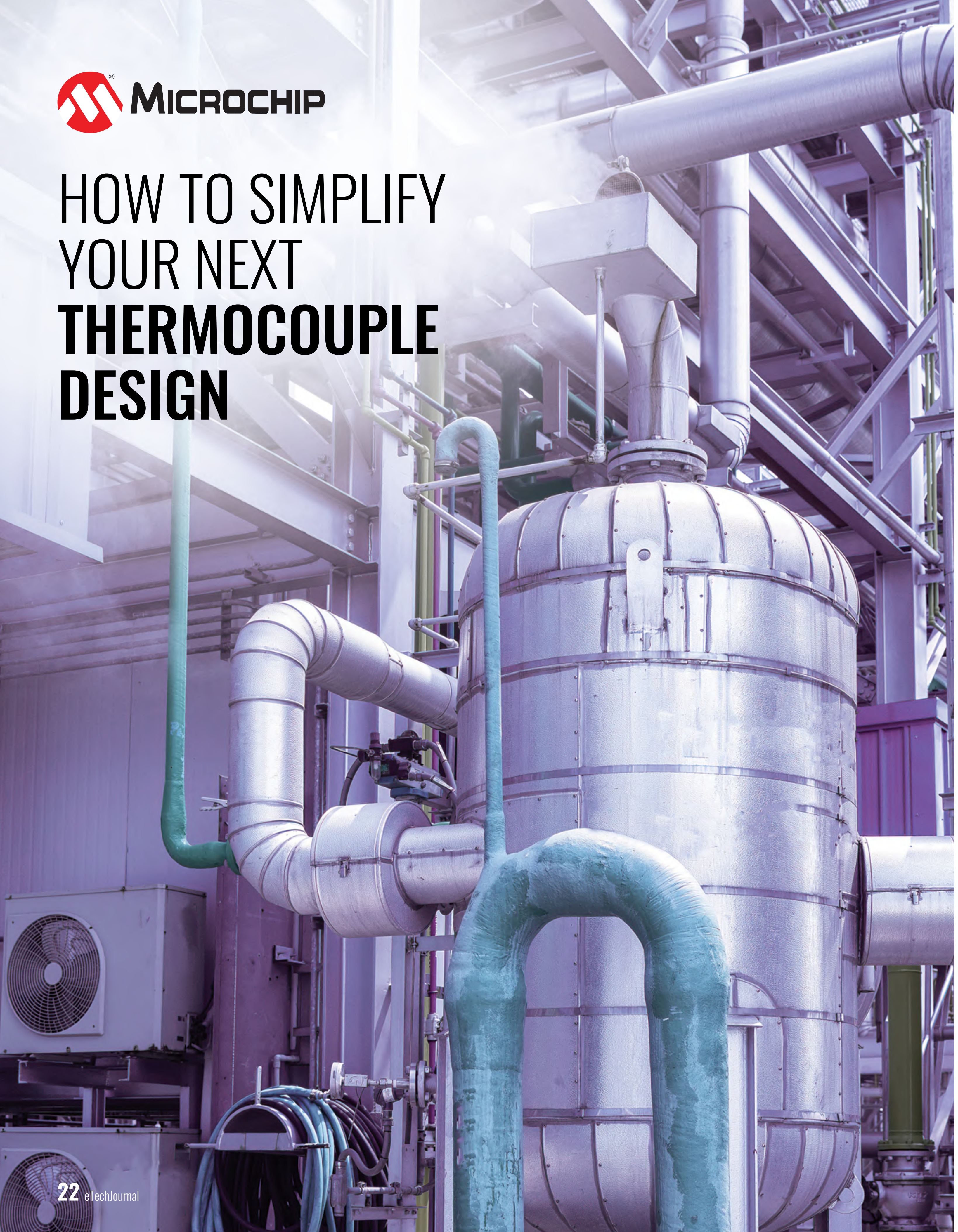
This allows system developers to get closer to the ideal working conditions for the application. Using digital pressure sensors in these systems could enable the creation of custom dashboards that monitor the fullness of gas bottles and their locations, allowing operators to more efficiently troubleshoot and maintain the system.

FIGURE 4: Digital pressure sensors play several important roles in pressurized air and medical gas distribution networks and enable better system conditioning and monitoring.

CONCLUSION

Though there are still installations where using analog pressure sensors make the most sense, there is a growing number of applications in Industry 4.0 that benefit from using their digital counterparts. From EMI resistance and scalable networking to sensor diagnostics and data protection, digital pressure sensors enable remote monitoring and predictive maintenance, increasing the efficiency and reliability of the system. Robust sensor designs that feature specifications such as IP69K ratings, additional data integrity checks and extensive onboard electronics for EMI protection will help prolong service life and reduce potential signal errors.

CLICK HERE



Microchip

HOW TO SIMPLIFY YOUR NEXT **THERMOCOUPLE DESIGN**

MARKET OVERVIEW

Thermocouples are widely used today because of their ruggedness and simplicity (two different wire types connected), making them well-suited for a wide variety of different application areas—from harsh industrial environments like boilers, petrochemical, smelters, and automotive to consumer products, such as coffee/espresso machines, cooktops, ovens, and many others.

Thermocouples are a popular customer design-in choice today because of their many advantages:

- Wide temperature range
- Below -250°C to over 1800°C
- Fast thermal response
- Accurately capture temperature spikes
- Rugged against vibration and dirt
- Simple design
- Self-powered
- No voltage or current excitation required

CLIENT CHALLENGES

Unfortunately, in addition to all the advantages that thermocouples provide, there are a few challenges. Most clients today develop their thermocouple systems using discrete analog components requiring up to 15 or more components, depending on their precision accuracy requirements. Thermocouple systems can be very complex and require long system development times, cost, and resources to develop and support.

Another challenge is that the long thermocouple wires can act as an antenna that can pick up all sorts of electrical noise. Ideally, this noise will couple onto both wires of the thermocouple and hence be common, but this high level of common mode noise can affect the signal conditioning circuitry. The actual voltage created across the thermocouple is very small, in the order of tens of millivolts across a wide temperature range. It is a significant challenge in attempting to measure this very low voltage in the presence of potentially large common mode noise and requires a high-performance front-end solution. Not only does the thermocouple produce a relatively low voltage output, but it also is not linear across the temperature range. Therefore, extracting a small voltage change in the presence of a large common mode voltage can be challenging.

WHY CHANGE?

In many cases, a single-chip solution to replace all these components will not only save board space, but will likely cost less compared to using discrete analog components depending on the precision level of discrete analog components used. The MCP9600 and MCP9601 products integrate the complete analog signal chain which includes a precision high-resolution Analog-to-Digital Converter (ADC), a high-accuracy temperature sensor, and a preprogrammed math engine to signal process in real-time and correct the thermocouple's non-linearity error characteristics to provide customers with an accurate temperature measurement in degrees Celsius, which can be simply read on the I2C bus. Now, that is easy.

WHY NOW?

MCP9600 and MCP9601 products solve the performance, integration, power, and cost challenges for today's thermocouple system analog design engineers. You might be thinking, how is this possible? The MCP9600 and MCP9601 thermocouple conditioning Integrated Circuits (ICs) are the most complete plug-and-play, single-chip solutions on the market today.

WHY MICROCHIP?

Let's face it, developing discrete precision analog circuitry to accurately condition the thermocouple signal is not a trivial task and Microchip has this taken care of for you. Microchip offers complete thermocouple conditioning products available today that you should check out.

While there are a few competitor thermocouple conditioning ICs, they are inferior to the complete plug-and-play thermocouple conditioning solution that the MCP9600 and MCP9601 products offer. Microchip is unique in this product category with its advanced features and functionality. These products reduce the required expertise in analog, mixed-signal, thermal management, and microcontroller design. Our innovative portfolio of highly integrated thermocouple conditioning IC solutions simplifies the client's development and speeds up their product's time to market.

Additionally, the MCP9600 and MCP9601 thermocouple conditioning ICs connect a thermocouple and measure precision temperature measurements in degrees Celsius temperature data via a standard I2C interface. How simple is that? It is because these devices integrate the complete analog signal chain that includes a precision high-resolution ADC, a high-accuracy temperature sensor, and a pre-programmed math engine to correct the thermocouple nonlinear error characteristics of eight different thermocouple types used today.

Please check out Microchip's thermocouple conditioning products if you are looking for flexible, easy-to-use, and complete thermocouple conditioning products that will reduce your development risk and speed up your product's time to market.

The benefits of using MCP9601 products:

- Provides a complete plug-and-play thermocouple conditioning solution
- Simplifies design, reduces development time, lowers overall system cost
- Integrated thermocouple open-circuit and short-circuit detection
- Temperature data digital filter
- Minimizes effects of system noise and Electromagnetic Interference (EMI)
- Shutdown modes
- Reduces overall system power consumption
- Four user-programmable Temperature Alert outputs
- Reduces microcontroller overhead, reduces code space, simplifies design, and enhances product performance.
- Small Package: 20-lead QFN (5_mm x 5_mm)
- Reduces board space and lowers manufacturing costs

WHAT NEXT?

To learn more about Microchip Sensor Interface Integrated Circuits

CLICK HERE

MICROCHIP

Current Sense Amplifiers

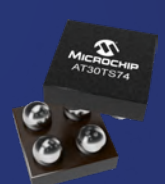
Create robust current monitoring designs that work across a variety of environmental conditions and applications with our flexible high-precision solutions that feature a zero drift architecture.

Power/Current Monitors

Get ahead of the thermal curve using devices that integrate both current and temperature sensors.

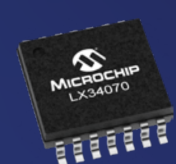
Temperature Sensors

Choose from our selection of single and multi-channel temperature ICs that offer flexible options to meet the specific requirements for monitoring heat in your application.



Inductive Position Sensors

Use these sensor interface ICs to accurately measure linear and angular/rotation movements in a variety of automotive, industrial, aerospace and commercial applications.

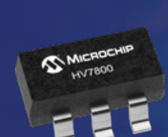


Sensor Interface ICs

Simplify your development process and accelerate time-to-market with our innovative, integrated plug-and-play solutions to precisely measure a thermocouple's microvolt-level signal and converts it to degrees Celsius.

Offline High-Side Current Monitors

These current monitor ICs feature a very wide input voltage range, high accuracy of transfer ratio, small size, low component count, low power consumption, ease of use, and low cost. Offline, battery and portable applications can be served equally well due to the wide input voltage range and the low quiescent current of the HV7800/1/2.



HIGH-ACCURACY SENSORS FOR COMPLEX, REAL-WORLD APPLICATIONS

Are you building a system that needs to measure real-world data accurately and reliably to make intelligent, real-time decisions? Our large portfolio of sensors measure data from the analog world and deliver it to the digital world. These sensors feature high-accuracy, low-power performance, real-time protection, robust interfaces and compact packages to satisfy the requirements of industrial, automotive, consumer, data center and communications applications.

Labfacility are the UK's leading manufacturer of Temperature Sensors, Thermocouple Connectors and associated Temperature Instrumentation and stockists of Thermocouple Cables.

Thermocouple Connectors

We are Europe's largest manufacturer of thermocouple connectors and accessories in IEC, ANSI and JIS Colour codes. A range of connectors are available from stock for immediate despatch.

Thermocouple Cable/Wire

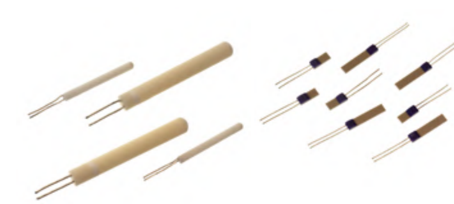
We offer a wide range of thermocouple, PRT and extension cable / wire in stock for immediate despatch. Thermocouple cables are available in IEC or ANSI Colour codes. Insulation types include PFA, PTFE, PVC & Fiberglass.

Temperature Sensors

We manufacture a wide range of temperature sensors to suit your application. An extensive range of Thermocouples in IEC or ANSI calibration, PRT's, Detectors with extended leads, Environmental Sensors and Hand-Held Sensors / Thermometers are available.

RTD Detectors

A selection of Flat Film RTD Detectors; 100, 500 & 1000 Ohm in class A, B or 1/3 DIN A selection of 100 Ohm RTD Wire Wound Detectors, single and dual element types available in class A, B or 1/10 DIN.



Compression Fittings

Adjustable compression fittings are used directly on probes to achieve the required insertion length in the process and to ensure the proper seating of probes into thermowells. Available in brass and stainless steel.

L60+ Thermocouple & Fine Wire Welder and accessories

The L60+ Thermocouple & Fine Wire Welder, manufactured by Labfacility, is a compact, simple-to-use instrument designed for thermocouple and fine wire welding.

It is primarily designed for use by sensor manufacturers to produce commercial grade thermocouple junctions; it is ideal for producing large numbers of exposed junction thermocouples for test and development laboratories.

LABFACILITY 1971 51 YEARS 2022 Celebrates

LABFACILITY
TEMPERATURE & PROCESS TECHNOLOGY

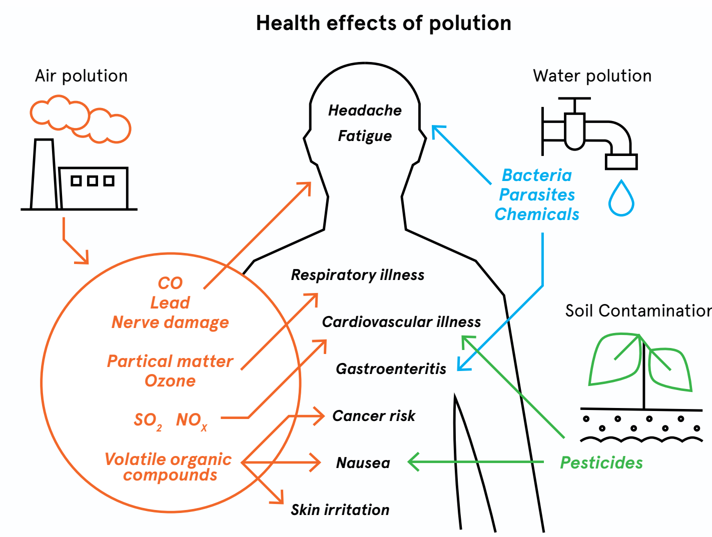
The company celebrates 51 years trading this year, is ISO 9001 accredited, Operates from 2 UK sites, employs over 70 staff, and has been supplying Farnell for over 40 years.

INDOOR AIR QUALITY: CHANGING THE FUTURE WITH SMART SENSOR SYSTEMS

Pollutants and air quality have a long history in civilization. In times of historical economic advances of man, we saw increased levels of pollutants. In the Roman days it was methane and smoke from homes and buildings and during the industrial revolution the smoke meant progress and prosperity.

Where coal and steel cities existed, the problem was recognized in the 1500's. It was not until the 1940's where the correlation of outdoor pollutants and health became a concern in major cities. Outdoor air pollutants began to be measured and the study of how these impacted our health emerged in the 1970's. Today, we have definitions of outdoor pollutants such as Particulate Matter, Ozone & Nitrogen Dioxide. While we don't have accurate systems in place in most areas to measure these pollutants locally, such as a street corner where busses may be idling, we do have generalized tools to alert people of health concerns.

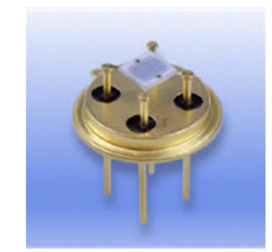
Ironically, for indoor air quality where we spend 90% of our time, there is limited agreement or quantification of acceptable levels of gasses. The current state of indoor air quality is reminiscent of the 1940's where millions of people each year become sick or die due to their air quality. COVID has brought this awareness to many people that previously never considered the air in their homes or work buildings could have been making them sick.



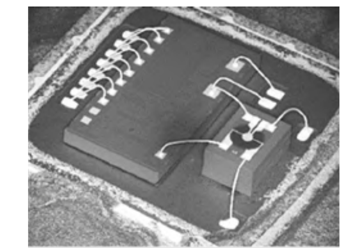
A confluence of both necessity due to recent awareness and technology are quickly changing the way that we consider the air that we breath indoors. The missing piece of the equation is: What are acceptable indoor pollutant levels? Standards for indoor air quality have been limited to specific gasses such as Carbon Monoxide (CO), Carbon Dioxide (CO2) and Formaldehyde (CH2O). This is now changing. Environmental air quality consists of many gasses and particles that interact together. These include Volatile Organic Compounds (VOC's) as well as above mentioned gasses that are carcinogenic or toxic and can kill quickly, slowly or make us sick.

Impacts of technology that has emerged over the past years include:

- Material science: Renesas shifted from ceramic based substrates to measure gasses in the air to silicon based that significantly reduce size, cost, and improve reliability. Additional optical technologies have seen reduction in size and improved performance detecting both particulates as well as Carbon Dioxide.

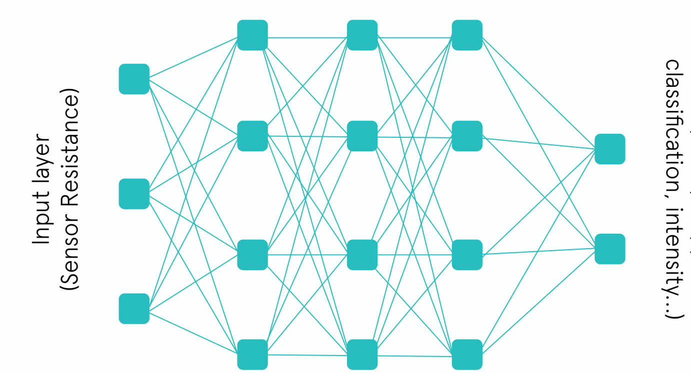


Ceramic-based Analog Gas Sensor



Silicon-based Digital Gas Sensor

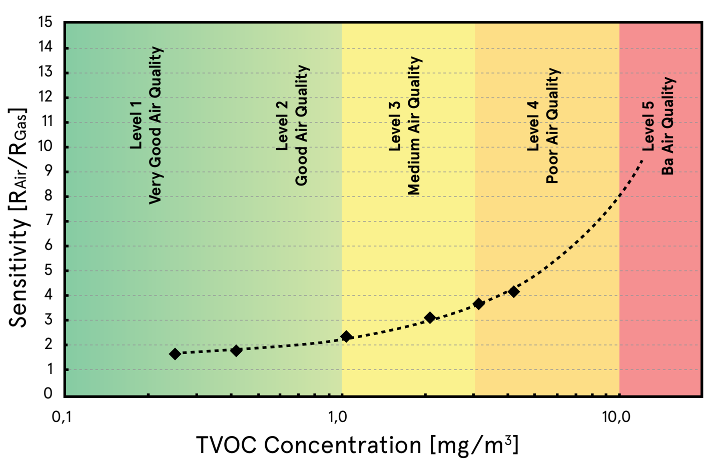
- Artificial Intelligence (AI): The ability to use machine learning algorithms, such as neural networks to quantify targeted performance has enabled firmware configurable platforms providing rapid improvements in output, adherence to emerging standards and ultra-low power for battery powered applications. A Renesas team of engineers have released 10+ firmware AI configurations that use the same hardware and change the behavior of the sensors.



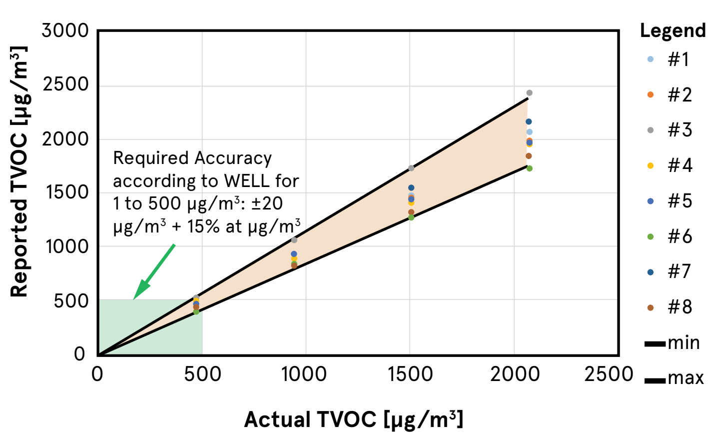
- Economies of scale: Millions of low-cost sensors are being shipped driving down the cost of systems and enabling consumers to monitor their air quality without significant investments. Air quality sensors are now found in HVAC systems, Smoke Detectors, Conference Room equipment, Wireless Access points and Thermostats.

Standards for indoor air quality are emerging but still not universally accepted. In the United States the White House had a summit in October advocating standards and actions targeting air quality in public buildings https://www.whitehouse.gov/cleanindoorair/. Several of the leading IAQ definitions:

- Umweltbundesamt (UBA) from the German Environmental Agency had two indoor air quality (IAQ) studies over the past 20 years that provided a definition of IAQ as well as how long an individual should be exposed to it. The latest study has 5 levels of VOC pollutants as well as other IAQ pollutants that require consideration. Renesas' ZMOD4410 is calibrated to this standard using Ethanol as a gas proxy. As the scale of gasses is quite high, this is a very good air quality definition supporting home use where kitchens, bathrooms and cleaning products typically can significantly elevate poor air quality.

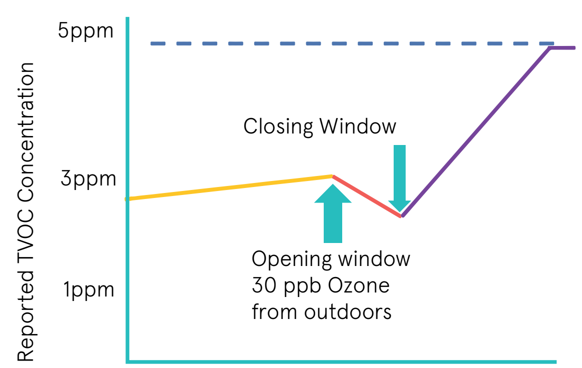


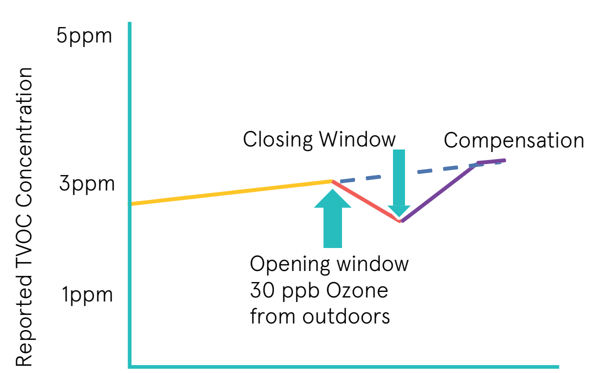
- WELL Standard: Over the past several years, the WELL Building standard has seen strong adoption in commercial buildings, schools, and public indoor areas. The difference between the UBA standard and WELL standard is that the levels of acceptable gasses in extremely low for WELL. This is a definition that is measured in parts per billion (ppb) and is either acceptable or not acceptable. The goal of this definition and sensors is to trigger HVAC systems to always ensure safe air quality.



- RESET standard: This is an IAQ standard that is seeing strong growth in Asia. Over the past years much attention was paid to particulates but not gasses, you could see this by people wearing masks when outside. Indoor gasses as well as particulates are now being targeted as air purifiers integrated into HVAC systems or standalone can remediate many of these gasses.

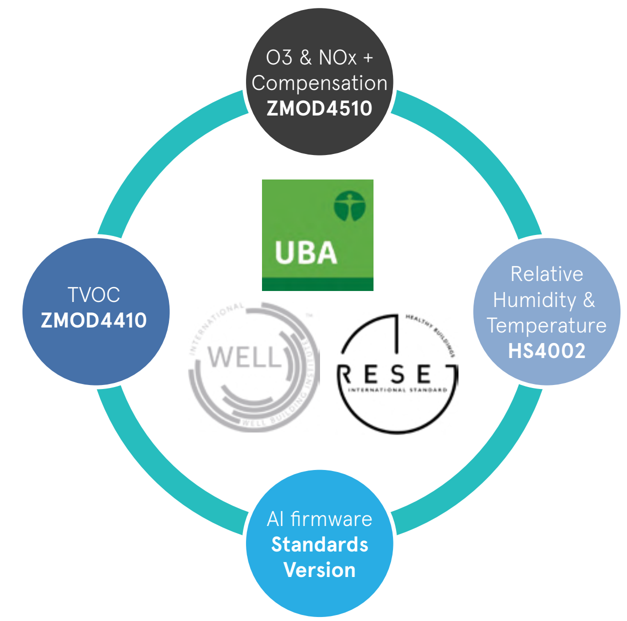
Air quality can be a tricky problem to solve as it is multi-dimensional. This means that Renesas Sensors can quantify gasses and then have their values change by the introduction of other gasses. This is the situation when oxidizing and reducing gases come together. In an indoor environment we quantify VOC levels (reducing gases). When a window is opened or air is drawn in from the outside, the introduction of Ozone which interacts with VOC's. Ozone is an oxidizing gas and will reduce the level of VOC's in a building. This may sound like a positive influence, but the concentration of ozone and how it impacts the baseline measurements of gas sensors is an issue. Changing the baseline of an IAQ sensor with an oxidizing gas will then bias the baseline used to report IAQ. We need to maintain a correct baseline of air quality to quantify levels of all pollutants and report to standards. In the illustration below, we can see a baseline shift due to Ozone entering a building as well as the sensors available to solve this problem. By using Renesas' ZMOD4510, selective Ozone sensor with a ZMOD4410 VOC sensor calibrated to a standard and using a compensation engine, the baseline can be adjusted, and accurate reporting will continue with standards output. Also, elevated levels of Ozone can have a greater impact on health than the VOCs themselves, triggering respiratory issues. Thus, presenting a more complete picture of all pollutants is beneficial.





The solution requires several sensors and compensation engines to measure gasses found indoors as well as outdoors. When reporting to a very low-level ppb measurement, such as the WELL standard we also need relative humidity (RH) and temperature (T) sensors with compensation engines. Fortunately, this is a problem that we can solve with Renesas' ZMOD4410, ZMOD4510 and HS4003 sensors.

The Renesas Indoor Air Quality Sensor Platform Evaluation Kit with ZMOD4410-EVK or ZMOD4510-EVK or the US082-ZMOD4510EVZ board, which enables quick prototyping of the ZMOD4510 gas sensor module for outdoor air quality (OAQ) in a custom system design.



With low-cost sensors, AI and compensation engines the last piece of the puzzle is defining an acceptable air quality. Fortunately, there are groups that have provided studies with clear indoor air quality definitions as well as HVAC industry organizations pushing for agreed upon standards. Over the next several years we will have the ability quantify our air and have systems make decisions on our behalf. AI solutions will decide if outdoor air should be brought into the building based on the Outdoor Air Quality (OAQ) or recirculated using air purifiers that remove harmful gasses. Both neurological and cardiovascular diseases will see a sharp decrease because of measuring and remediating poor air quality. The technology, commercial viability and emerging definitions of standards will ensure that our environment is monitored, and we move on from the time in the 1940's when we recognized a problem but had no options to solve it.

DIGITAL GAS SENSOR PLATFORM (ZMOD)

Renesas' Digital Gas Sensor ZMOD family provides a range of integrated digital sensor modules that provide best-in-class performance and reliability stability. In addition to being chemically and electrically calibrated, the platform's flexible interface enables embedded AI and neural network trained software for configurable indoor, outdoor, and refrigeration air quality sensing solutions for sensing VOCs, ozone and NOx gases.

LEARN MORE