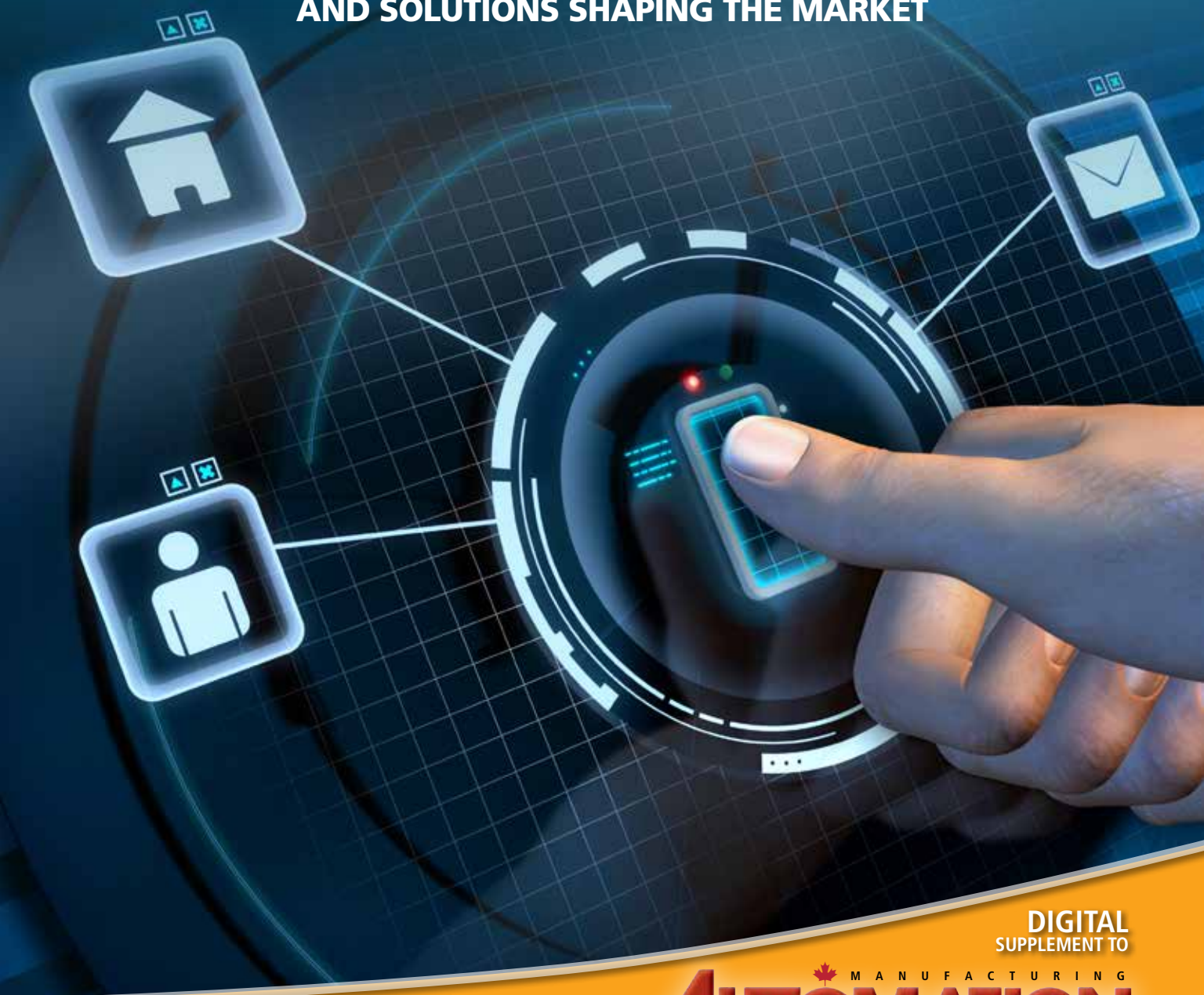
TECHNOLOGY HANDBOOK

# SENSORS

## A LOOK INTO THE PRODUCTS, TECHNOLOGIES AND SOLUTIONS SHAPING THE MARKET



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# Servicing Industry for over 25 Years

In 1988 things were much different. We communicated primarily through phone and fax, teletype machines still haunted a corner of the office but were rarely used. PLC technology was growing exponentially and microprocessors were creeping into many aspects of automation. Communicating primarily with Email was just a notion that seemed to be many years in the future.

It was in 1988 that A-Tech Instruments Ltd was formed. As a manufacturer's representative, the new company would supply physical measurement equipment to the automation industry as well as to aerospace and research.

Based on the principles of engineered technical sales, A-Tech's objective was to provide customers with an alternative to buying their measurement systems as components and assembling the measurement chain themselves. Starting with a couple of key manufacturers it was soon evident that A-Tech Instruments was to become a success.

Using experienced technical sales representatives, they provided their customers with a complete measurement solution from sensors to cables to conditioning to data acquisition.

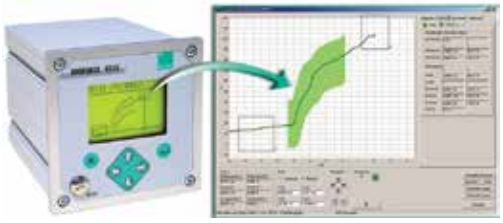
New partnerships with manufacturers were established over the years and now the company has a well-rounded product offering for manufacturing automation. Most measurement challenges could be solved by dipping into A-Tech's toolbox. A service and manufacturing department grew around customers' needs for a complete solution. Today, 25 years later, A-Tech Instruments is a leader in the industry with a competent staff and a comprehensive lineup of products.

Sensor technology has evolved in many areas over the last 25 years, although the basic principles of converting a physical item into an analog signal has been fairly constant, the conversion from analog to a digital value and the signal processing, has seen an incredible evolution. Where 12 and 14 bit A/D's was common, now 16 bit is the norm with some systems boasting 24 bit A/D with DSP (Digital Signal Processing). Moving this digitized data around has become lightening fast with a broad range of field bus and Ethernet options including wireless transmission of signals. A good example is the Burster 8661 contactless rotating torque sensor with option for USB connectivity.

When looking at Press Force monitoring, Torque to Turn or Functional Testing, A-Tech Instruments has a variety of solutions and the staff to assist in making the right choice.

One of the dominate manufacturers of instrumentation for automated processes is Burster, with a range of products that includes sensors, signal conditioning and signature analysis instruments. The start of any measurement chain is the sensors and selecting the correct Burster sensor is easy as there are a variety of styles with a large number of force ranges.

The conventional Hydraulic Press is typically used for Press Fit assembly processes and 100% process monitoring is almost always incorporated with a Press Force Monitoring Controller.



A number of instruments with a variety of features can be selected for most of the standard applications with data display, acceptance limits, tolerance windows, etc., to the complex signature analysis of the more advanced functional testers with graphical displays. The configuration and data storage software makes these systems intuitive, easy to use and incorporates 100% data collection.

In 2013 Burster has introduced the 9110 as a compact system with capability to perform press force monitoring on small machines or hand presses that compliments its very successful 9310 and 9307 Digiforce units.

Where a process requires finer control, A-Tech Instruments offers the Coretec line of Servo Presses and Nut Runners. These actuators were designed not only as a rugged assembly tool, but they also incorporate onboard sensors and monitoring software for 100% on-line quality checking.

With this broad range of products and years of experience A-Tech Instruments Ltd. Is the "go to" source for assembly and process monitoring.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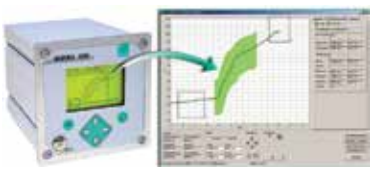

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GEFRAN

Gefran is a world leader in design and production of Sensors, Drives, Systems and Components for Automation as well as Turnkey Solutions. The Gefran group has more than 900 employees worldwide. The Gefran headquarters is located in Italy. The sales and marketing organization has a global presence of 14 branch offices in 5 continents and more than 100 official distributors in those countries. The group counts 7 production sites in 5 different countries.

As a part of the Gefran group, the Sensors Business Unit followed a specific path since the beginning of the Company formation. The Sensors Business Unit started its development with simple temperature sensors and linear potentiometers for plastic injection machines. Today the offerings include a wide range of products for detecting position, pressure, force and temperature, based on several technologies engineered for serving multiple markets and different application requirements.

Gefran owns all rights to the patented technology used for the sensing elements, core design and manufacturing. Collaborations with leading Research Centers and Universities in Europe as well as regular investments in R&D allow the group to develop new technologies and constantly improve on existing technologies.

Gefran's expertise and 40 years of experience has benefitted our clients in determining market trends and anticipation of tomorrow's needs. Gefran addresses these market needs by developing new products designed specifically for each market segment. The following are examples of these products and their benefits.

More than four years ago, Gefran was the first company in the world to release a melt pressure sensor (sensor for measuring the pressure of melted plastic at high temperatures). The sensor is based on a new technological solution, IMPACT, not requiring any fluid to function (mercury, oil or other fluids used for transmitting the pressure variations from high temperatures to lower temperatures where the sensing element works without being damaged). The result is a product with a much longer life cycle than any other product available on the market as compared to traditional fluid-filled technologies.

Three years ago a new technological solution, ONDA, for magnetostrictive position transducers was released. ONDA technology uses a new sensitive element that reads magnetic cursors. The structure of the sensitive element has been simplified and optimized using innovative technological solutions developed and patented by Gefran. Magnetostrictive technology ensures high accuracy of measurement and longer life cycle due to a reading system based on a magnetic, contactless principle.

In 2011, Gefran launched the KS, the new industrial pressure transducer using thick film on steel technology. This is a simple and extremely sturdy device, resistant to shock and vibration, and ideal for numerous hydraulic and pneumatic applications. Due to its extreme reliability and robustness the new KS series obtained the SIL2 certification from the German accredited TÜV laboratory. The SIL2 certification allows the devices to be used in compliance with the current Machinery Directive 2006/42/EC, which defines the Essential Health and Safety Requirements (EHSR) for all types of machinery.

In line with the philosophy of developing new technologies and innovative products for new application solutions, in 2012 Gefran released a new magnetostrictive transducer specifically designed to provide a customized solution for pneumatics applications. Based on ONDA technology, the new ONPP-A transducers fit directly on pneumatic cylinders and measure the position of the standard magnet integrated in the cylinder of all the main manufacturers. The new ONPP-A solves the main problem of the magnet's polarity recognition that can cause an offset when reading its position from outside. The exclusive system of the ONPP-A automatically performs automatic calibration and eliminates any errors in position reading. For more information visit Gefran at www.gefran.com

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## Designed for applications with pneumatic cylinders

The patented ONDA technological solution, ONPP-A detects the position of the integrated magnet without requiring any further modification to the cylinder.

The patented ONDA technological solution, **ONPP-A** detects the position of the integrated magnet without requiring any further modification to the cylinder.

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"Quality and technology are guaranteed by Gefran's experience in sensors manufacturing."

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MOD-TRONIC INSTRUMENTS LIMITED

# RTD, Thermocouple, or Thermistor?

### Resistance temperature detectors (RTDs)

An RTD sensing element consists of a wire coil or deposited film of pure metal. The element's resistance increases with temperature in a known and repeatable manner. RTDs exhibit excellent accuracy over a wide temperature range and represent the fastest growing segment among industrial temperature sensors. Their advantages include:

- **Temperature range:** Minco models cover temperatures from ¬260 to 850°C (¬436 to 1582°F).
- **Repeatability and stability:** The platinum resistance thermometer is the primary interpolation instrument used by the National Institute of Standards and Technology from ¬260 to 962°C. Ordinary industrial RTDs typically drift less than 0.1°C/year.
- **Sensitivity:** The voltage drop across an RTD provides a much larger output than a thermocouple.
- **Linearity:** Platinum and copper RTDs produce a more linear response than thermocouples or thermistors. RTD non¬linearities can be corrected through proper design of resistive bridge networks.
- **Low system cost:** RTDs use ordinary copper extension leads and require no cold junction compensation.
- **Standardization:** Manufacturers offer RTDs to industry standard curves, most commonly 100 0 platinum to EN60751 (Minco element code PD or PE).

### Thermocouples

A thermocouple consists of two wires of dissimilar metals welded together into a junction. At the other end of the signal wires, usually as part of the input instrument, is another junc-tion called the reference junction, which is electronically com-pensated for its ambient temperature. Heating the sensing junction generates a thermoelectric potential (emf) propor-tional to the temperature difference between the two junc-tions. This millivolt¬level emf, when compensated for the known temperature of the reference junction, indicates the tempera-ture at the sensing tip.

Thermocouples are simple and familiar. Designing them into systems, however, is complicated by the need for special extension wires and reference junction compensation. Thermo¬couple advantages include:

- **Extremely high temperature capability:** Thermocouples with precious metal junctions may be rated as high as 1800°C (3272°F).
- **Ruggedness:** The inherent simplicity of thermocouples makes them resistant to shock and vibration.
- **Small size/fast response:** A fine¬wire thermocouple junction takes up little space and has low mass, making it suitable for point sensing and fast response. Note, however, that many Minco RTDs have time constants faster than equivalent thermocouples.

### Thermistors

A thermistor is a resistive device composed of metal oxides formed into a bead and encapsulated in epoxy or glass. A typical thermistor shows a large negative temperature coefficient. Resistance drops dramatically and non¬linearly with temperature. Sensitivity is many times that of RTDs but useful temperature range is limited. Some manufacturers offer thermistors with positive coefficients. Linearized models are also available.

There are wide variations of performance and price between thermistors from different sources. Typical benefits are:

- **Low sensor cost:** Basic thermistors are quite inexpensive. However, models with tighter interchangeability or extended temperature ranges often cost more than RTDs.
- **High sensitivity:** A thermistor may change resistance by tens of ohms per degree temperature change, versus a fraction of an ohm for RTDs.
- **Point sensing:** A thermistor bead can be made the size of a pin head for small area sensing.

| | RTD | Thermocouple | Thermistor |
|---|---|---|---|
| Temp. range | -260 to 850°C (-436 to 1562°F) | -270 to 1800°C (-454 to 3272°F) | -80 to 150°C (-112 to 302°F) (typical) |
| Sensor cost | Moderate | Low | Low |
| System cost | Moderate | High | Moderate |
| Stability | Best | Low | Moderate |
| Sensitivity | Moderate | Low | Best |
| Linearity | Best | Moderate | Poor |
| Specify for: | • General purpose sensing<br>• Highest accuracy<br>• Temperature averaging | • Highest temperatures | • Best sensitivity<br>• Narrow ranges (e.g. medical)<br>• Point sensing |

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# MARKET ANALYSIS: THE FUTURE LOOKS BRIGHT FOR SENSORS

**Various studies have been completed that take a look at growth projections for the sensors market. Whether it's motion, pressure or smart grid sensors in North America or across the globe, one thing is clear — the market for sensors is set to dramatically increase in the coming years. Take a look at some highlights from the various research reports.**

## Ubiquity of electronic devices expands market for motion sensors

Accelerometers are playing an increasingly important role in test and measurement due to the rising demand for better quality and the emergence of more complex testing procedures. Micro electromechanical systems (MEMS) accelerometers and gyroscopes have become critical components in almost all electronic products such as iPhones, iPads, smart phones, tablets and other consumer electronic goods, giving a huge thrust to market revenues.

New analysis from Frost & Sullivan, "Global Accelerometers, Gyroscopes and IMU Sensors Markets," finds that the market earned revenues of US$5.05 billion in 2012, and estimates this to reach US$9.30 billion in 2019, at a compound annual growth rate of 9.1 per cent.

While the establishment of R&D and testing centres in developing regions with a wide variety of research/testing facilities drives the test and measurement accelerometers market, the escalating sales of electronic products bolsters the MEMS motion sensors market. This market is heavily reliant on technological innovations to keep pace with the frantic pace of development in the end-user markets.

"MEMS accelerometers, gyros and inertial measurement units (IMU) are becoming increasingly compact, less power intensive and better performing," said Frost & Sullivan measurement and instrumentation senior industry analyst, V. Sankaranarayanan. "Such advancements not only aid rapid adoption in existing applications, but also help penetrate applications and industries that were not addressed previously due to existing design or technology constraints."

Even though innovations may buoy the market, the intensifying competition is stoking price wars. Further, end users such as automotive manufacturers tend to be price sensitive, partly due to the presence of a large number of competitors and partly due to the cost consciousness of their target customers. As a result, these price pressures ripple towards component suppliers, including sensor manufacturers.

To stand out and succeed in a densely populated market, motion sensor manufacturers are resorting to product differentiation. They have to convince customers about the value they deliver through a unique product with tangible benefits.

"Overall, finding new application areas, improved market promotion and better co-operation with downstream application sectors are crucial for the growth of the accelerometers, gyroscopes and IMU sensors markets," noted Sankaranarayanan.

## Smart grid sensor market set to double in size by 2014

The market for smart grid sensors in North America is expected to grow dramatically during the next two years, according to a study published by IMS Research, now part of IHS Inc.

The report, entitled "The North American Market for Smart Grid Sensors – 2013," shows a major change is occurring in the feeder line sensing market in North America, with emerging technologies being offered from a series of new entrants to the market.

By 2014, IHS predicts that the smart grid sensors market will more than double in size from estimated 2012 levels, with annual revenue topping $100 million for the first time in 2015.

"The market for feeder line sensors is undergoing radical change now," said Michael Markides, associate director of the Smart Utility Infrastructure Group at IHS. "Older devices are being replaced by next-generation technologies that are offered by new market entrants. There are numerous takeaways from this, including the continued growth in distribution-level electronic devices, the continued push toward decentralizing grid intelligence and automation, as well as showing the evolving habits and behaviours of utilities in North America as they adopt new technology from a set of new vendors."

Currently, market growth for smart grid sensors is coming from the replacement of older-style fault circuit indicators (FCIs). These older devices have been sold for decades to utility companies, which have been installing them on vulnerable overhead lines. But new technology, which is rapidly meeting the existing price point of the older technology, is swiftly gaining market share.

"This year is a transitional time for the feeder line sensor market," Markides

observed. "New suppliers are taking share away from traditional sensor suppliers through product offerings which are future-proofed, easily upgradeable, and more dependable and accurate at detecting faults on overhead lines than legacy FCIs."

While the short-term forecast shows dramatic growth for the new generation of smart grid sensors, long-term market growth is expected to be buoyed by the implementation of Volt/VAR Optimization (VVO) schemes across North America.

"The emergence of better fault-detection technology, the unbundling of 'siloed' utility organizations and budgets, and the expected surge in VVO installations are all converging together to create a significantly strong market forecast over the next five years for smart grid sensors," Markides commented. "By 2018, IHS expects smart grid sensors to have grown to well over $200 million in revenue annually."

## Global market for pressure sensors projected to reach US$11.2 billion by 2018

A new report says growth in the pressure sensors market over the next few years will be primarily driven by expanding applications in a range of industries from automotive, oil and gas, petrochemical, food and beverage, to pharmaceutical and pulp and paper.

Technology advancements, particularly the success of MEMS-based pressure sensors, and robust demand from developing markets also augurs well for the market, according to the research report, "Pressure Sensors: A Global Strategic Business Report," by Global Industry Analysts Inc.

The most noticeable innovations in product technology over the years include introduction of microelectromechanical systems (MEMS) and micromachined ultra-low-pressure sensors. With the advent of digital technology, today's pressure sensors are more efficient, which makes them successful in a range of industry segments. Also, given the use of micro and nanotechnology, the sensors are now more compact and relatively inexpensive, and are high on performance and reliability parameters. These advanced technologies also help them consume less power and enable mass production. MEMS pressure sensors especially are expected to register phenomenal

growth, according to the report.

The report also found that Asia-Pacific constitutes the largest regional market worldwide. The region also represents the fastest growing market with sales poised to grow at a compound annual growth rate of about 8.5 per cent over the analysis period. Increasing investments in the manufacturing sector in terms of new plant establishment, expansion, upgrade of industrial equipment, and increase automobile ownership rates, in this region are expected to positively benefit both industrial and automotive pressure sensors. Process control markets in China, India and other Asia-Pacific countries continue to grow at an encouraging pace and the yet untapped potential encourages an optimistic outlook for pressure sensors in this region.

The research report also provides a comprehensive review of market trends, company profiles, mergers, acquisitions and other strategic industry activities. The report provides market estimates and projections in US$ for all major geographic markets including the U.S., Canada, Japan, Europe (France, Germany, Italy, UK and Rest of Europe), Asia-Pacific, Latin America and the rest of the world.

## Global market for sensors to reach $116.1 billion by 2019

The global market for sensors has recovered from the economic downturn and is expected to grow by 7.9 per cent per year to reach US$116.1 billion by 2019, according to a new study.

The study, "Global Markets and Technologies for Sensors," by BCC Research, found that after the downturn in 2009, the global market for sensors recovered from 2010 to 2012. The market was valued at nearly US$68.2 billion in 2012 and is expected to increase to US$79.5 billion in 2014, reaching US$116.1 billion by 2019, at a compound annual growth rate (CAGR) of 7.9 per cent.

Growth within the segment made up of biosensors and chemical sensors is expected to be the highest, with a compound annual growth rate (CAGR) of 9.7 per cent projected from 2014 through 2019, followed by the image, flow and level sensors segment, with a CAGR of 8.4 per cent forecast over the same five-year period.

Market demand for sensors will be fueled by increases in motor vehicle and machinery production, growth in shipment of process equipment, government regulations such as requiring all new light vehicles to be equipped with electronic stability control and tire pressure monitoring systems, and growth in process manufacturers' shipments. Development of new applications for technologies such as microelectromechanical systems (MEMS), optoelectronics and photoelectronics will help grow the sensor market. The maturity of many sensor markets and improved fabrication techniques has led to increased sensing abilities at lower costs, and this also will help increase market growth.

The proliferation of advanced electronic control systems has provided sensor users ongoing advances in sensor accuracy, reliability, response time, robustness, miniaturization, communications capability and efficiencies. This has fueled research and development in the sensor industry, which in turn creates opportunities for technological advancements that open up new applications for sensors.

# PASSIVE SENSORS
## ARE ACTIVE WITH POSSIBILITIES

BY IAN VERHAPPEN

I am still waiting to see the 'killer application' for wireless sensors, though some of the work being done in the areas of RFID and passive wireless sensors is likely to drive this breakthrough. Many of today's applications are simply using wireless networks to replace wires, without thinking, "what else can I do without my tether?" The presenters and participants at the third annual Passive Wireless Sensor Workshop sponsored by the ISA Communications Division in May 2013 are working on that question.

Just what is a passive wireless sensor? Passive wireless sensors (PWS) have no battery, no expensive electronics at the sensor site and, being wireless, no need for a wired connection between the sensor and the data acquisition system. One form of passive wireless sensor, Surface Acoustic Wave (SAW)-based sensors, which are similar to RFID (Radio Frequency Identification) tags, respond to a wireless interrogation signal from a reader. Unlike RFID, SAW sensors provide real-time sensor data along with a unique tag ID, stored information and range.

Like any sensor, it needs to have power as well as the ability to communicate with the associated host controller. As can be expected, the position and placement of the passive RFID tag has a significant impact on performance, both in terms of energy harvesting from the RF signal and communication reliability. Fortunately, there are multiple ways to connect sensors and processes, including the use of magnetic based passive sensing, coupled with techniques to cancel out undesired signals due to locally induced eddy currents. This allows for passive sensing through metal barriers of significant thickness (as well as water) making it possible to passively sense pressure, temperature, strain and other parameters through metal barriers. Aiding in the ability to communicate through these traditional barriers is a "self-tuning" technology that allows the tag to automatically and precisely adapt to the correct geographical frequency and compensate for its surrounding interference (i.e. the item to which it is attached). This same characteristic of adjusting to the environment can also potentially be used for sensing as well.

One additional way that passive wireless sensors are beginning to be used for connecting to the rest of the world is near field communication (NFC), a low-power wireless technology that is being incorporated into all major brands of cell phones. NFC presents significant advantages over Bluetooth and other sensors that require a battery. For example, combining NFC with PWS technology makes it possible to develop ultrathin diagnostic skin patches and a variety of printable sensors for food safety, smart labels and even advanced medical diagnostic sensors that communicate either with or through your smart phone.

NFC health care sensors could allow the hospital to continue monitoring discharged patients even after they leave hospital. Illness onset could be detected much more rapidly, thus minimizing the required effort to treat something more advanced.

Building automation is another high-volume potential market and, as part of the Smart Grid initiative, industry has been asked to respond to the low-cost wireless meter challenge and produce a cost-effective, wireless metering system capable of electrical energy measurement at various locations in a building, and then use wireless communications to a remote data collection point within the building complex to control the facility and integrate into the larger grid.

Temperature sensors are an obvious building automation measurement and with passive surface acoustic wave (SAW) temperature sensors, it is possible to build structures the size of a postage stamp.

More complex measurements are also possible, including selective field detection of diverse gaseous analyte species by combining several multivariable sensors to boost selectivity of individual sensors against chemical interferences (e.g. background vapours) and physical interferences (e.g. temperature), to reduce or eliminate sensor aging effects and to bring these sensors to demanding applications outside laboratory conditions. Current performance characteristics of developed sensors include ppm-ppb-sub-ppb detection sensitivity, rejection of high levels of interferences, and quantitation of individual vapours in their mixtures. A simple moisture-humidity sensor is commercially available from more than one supplier.

In the harsher environment of building structures, roads and highways, and aircraft components, including the turbines, development of electro-mechanical switches on flexible substrates lead to passive wireless stickers that can monitor the shape of deployable structures in aerospace applications. These bi-stable devices hold their state without power, so they can report on the shape of a structure even if polling rates are slow because of energy harvesting system constraints.

Finally, as a result of their ability to communicate in harsh environments, these sensors are suited to applications such as high pressure high temperature (HPHT) oil and gas sensing through pipe walls, sensing temperature through sealed containers, such as nuclear waste storage vessels for long term monitoring or cargo shipping containers for tamper detection.

With its considerable potential read-range (separation distance between reader and device), compatibility with extreme environments, small size, autonomy of sensor installation and "no onboard power" capabilities, passive wireless sensors have a wider application arena than traditional wireless sensors and I am confident we will soon see passive wireless technology in the automotive, aeronautical and very high heat metallurgy and manufacturing markets as well as the traditional less severe environments such as building automation.

**References:**

Passive Wireless Workshop presentations for past three years can be found at www.isa.org/commdiv and then navigate to the appropriate PWSW tab.

*Ian Verhappen, P.Eng. is an ISA Fellow, ISA Certified Automation Professional (CAP), member of the Automation Hall of Fame, and a recognized authority on Foundation Fieldbus and industrial communications technologies. Verhappen provides consulting services specializing in the connection between field devices and controllers especially field level industrial communications, process analytics and heavy oil / oil sands automation. Feedback is always welcome via e-mail at iverhappen@gmail.com.*

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