AUTOMATION 2022

VOLUME 3

IIoT and Industry 4.0

- Better Vibration Monitoring
- Advanced Technologies and the Weigand Effect
- Five First Steps Toward Digital Transformation
- Hardy COM-HPC Server-on-modules
- Remote R&D: Headsets, Cameras, Sensors and More

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Introduction

Many Technologies Lead to Digital Transformation

The future is here when it comes to connected plants, smart factories, and Industry 4.0/Industrial Internet of Things (IIoT) technologies, but plants may not be operating at peak efficiency. Upgrading tools and components, gathering and analyzing data, and utilizing other facility optimization tactics can be overwhelming. Operational technology (OT) systems are very different from the automation networks of 10 years ago, and while the many information technology (IT) systems and IIoT devices bring huge benefits to critical infrastructure and industrial organizations, they also bring new smart manufacturing challenges.

Look inside this edition of AUTOMATION 2022: IIoT and Industry 4.0 for ways to enhance condition monitoring using vibration transmitters and programmable logic controllers (PLCs). Explore energy harvesting and motion sensing with the "Wiegand effect." Learn how to use modular 5G cells to enable real-time communications. Find out how to ensure network security while collaborating remotely.There's an abundance of useful technologies that save time and money on the journey to digital transformation.

Jack Smith, Contributing Editor

About AUTOMATION 2022

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Five Keys to Powering Remote Wireless Devices

Consider environment, energy demands, self-discharge rate, and energy density when selecting batteries for remote wireless devices.

By Sol Jacobs, Tadiran Batteries

Battery-powered remote wireless devices are taking industrial automation to increasingly remote locations and extreme environments. The growing list of applications includes supervisory control and data acquisition (SCADA), process control, asset tracking and management, safety systems, field equipment status, flow monitoring, machine-to-machine (M2M), artificial intelligence (AI), and wireless mesh networks.

Identifying the ideal power source for a remote wireless device requires a fundamental understating of each application's unique power requirements, then selecting the ideal battery based on its performance capabilities. This decision-making process typically centers around five key considerations:

- Evaluating the device's specific energy demands
- Choosing the battery chemistry that best suits the needs
- Understanding the importance of battery self-discharge
- Adapting to high pulse requirements
- Doing your homework

Evaluating device energy requirements

If a wireless device is easily accessible and operates within a reasonably mild temperature range, it may allow for the use of an inexpensive consumer-grade alkaline or lithium battery. However, the performance requirements for a battery are far different for long-term deployments in hard-to-access and hostile environments. These devices must conserve energy by operating mainly in a standby state, drawing micro-amps of average current with periodic high pulses in the multi-amp range to power wireless communications. These low-power devices are predominantly powered by industrial grade lithium thionyl chloride ($LiSOCl_2$) batteries (figure 1) that feature very high capacity, high energy density, an extended temperature range, and an exceptionally low annual self-discharge rate.

A relatively small number of remote wireless devices draw milli-amps of average current with pulses in the multi-amp range, draining enough average energy to prematurely exhaust a primary (non-rechargeable) battery. These niche applications are often better suited for an energy harvesting device in combination with an industrial grade Lithium-ion (Li-ion) battery to generate high pulses.

Choosing the best battery type for the application

Numerous primary lithium battery chemistries are available (table 1), each offering unique advantages and disadvantages. At one end of the spectrum are inexpensive alkaline batteries that deliver high

Figure 1. Bobbin-type $LiSOCl_2$ batteries are preferred for remote wireless applications, delivering high energy density, up to 40-year service life, and the widest possible temperature range, making them ideal for use in inaccessible locations and extreme environments.

continuous energy but suffer from a very high self-discharge rate (which limits battery life) as well as low capacity and energy density (which adds size and bulk). In addition to being short-lived, consumer-grade alkaline cells cannot operate in extreme temperatures due to their water-based constituents. For this reason, many remote wireless devices are powered by industrial-grade lithium batteries.

Primary Cell	$LiSOCL_2$ Bobbin-type with Hybrid Layer Capacitor	$LiSOCL_2$ Bobbin-type	Li Metal Oxide Modified for high capacity	Li Metal Oxide Modified for high power	$LiFeS_2$ Lithium Iron Disulfate (AA-size)	$LiMnO_2$ Lithium Manganese Oxide
Energy Density (Wh/Kg)	700	730	370	185	335	330
Power	Very High	Low	Very High	Very High	High	Moderate
Voltage	3.6 to 3.9 V	3.6 V	4.1 V	4.1 V	1.5 V	3.0 V
Pulse Amplitude	Excellent	Small	High	Very High	Moderate	Moderate
Passivation	None	High	Very Low	None	Fair	Moderate
Performance at Elevated Temp.	Excellent	Fair	Excellent	Excellent	Moderate	Fair
Performance at Low Temp.	Excellent	Fair	Moderate	Excellent	Moderate	Poor
Operating life	Excellent	Excellent	Excellent	Excellent	Moderate	Fair
Self-Discharge Rate	Very Low	Very Low	Very Low	Very Low	Moderate	High
Operating Temp.	-55°C to 85°C, can be extended to 105°C for a short time	-80°C to 125°C	-45°C to 85°C	-45°C to 85°C	-20°C to 60°C	0°C to 60°C

Table 1. Numerous primary lithium battery chemistries are available.

As the lightest non-gaseous metal, lithium features an intrinsic negative potential that exceeds all other metals, delivering the highest specific energy (energy per unit weight), highest energy density (energy per unit volume), and higher voltage (OCV) ranging from 2.7 to 3.6 V. Lithium battery chemistries are also non-aqueous and therefore less likely to freeze in very cold temperatures.

Among all commercially available primary lithium chemistries, bobbin-type lithium thionyl chloride ($LiSOCl_2$) stands apart as being overwhelmingly preferred for ultra-long-term deployments. Bobbin-type $LiSOCl_2$ chemistry delivers the highest capacity and highest energy density of all, endures extreme temperatures (-80°C to 125°C), and features an annual self-discharge rate as low as 0.7 percent per year that enables up to 40-year battery life. Bobbin-type $LiSOCl_2$ batteries are specifically designed for use with low-power communications protocols such as WirelessHART, ZigBee, and LoRa, to name a few. The main performance benefits of bobbin-type $LiSOCl_2$ batteries include:

- Higher reliability: Ideal for remote locations where battery replacement is difficult or impossible and highly reliable connectivity is required.
- Long operating life: Since the battery's self-discharge rate often exceeds actual energy usage, high initial capacity and a low self-discharge rate are often critical.
- The widest temperature range: Bobbin-type $LiSOCl_2$ cells can be modified to work reliably in extreme temperatures (-80°C to 125°C).
- Smaller size: Higher energy density could permit the use of smaller batteries.
- Higher voltage: Could allow for the use of fewer cells.
- Lower lifetime costs: A critical consideration since the manpower and logistical expenses to replace a battery far exceed its cost.

Importance of battery self-discharge

A remote wireless device is only as reliable as its battery, so design engineers must specify the ideal power source based on a number of factors, including: the amount of energy consumed in active mode (including the size, duration, and frequency of pulses); energy consumed in standby mode (the base current); storage time (as normal self-discharge during storage diminishes capacity); thermal environments (including storage and in-field operation); equipment cut-off voltage (as battery capacity is exhausted, or in extreme temperatures, voltage can drop to a point too low for the sensor to operate). Often, the most critical consideration can be the battery's annual self-discharge rate, as the amount of current consumed by self-discharge can exceed the amount of energy required to operate the device.

All batteries experience some amount of self-discharge as chemical reactions draw current even while the cell is unused or disconnected. Self-discharge can be minimized by controlling the passivation effect, whereby a thin film of lithium chloride (LiCl) forms on the surface of the lithium anode, separating it from the electrode to reduce the chemical reactions that cause self-discharge. Whenever a current load is placed on the cell, the passivation layer causes initial high resistance and a temporary drop in voltage until the discharge reaction begins to dissipate the passivation layer—a process that continually repeats each time a load is applied.

Passivation can be affected by the cell's current discharge capacity, the length of storage, storage temperature, discharge temperature, and prior discharge conditions, as partially discharging a cell and then removing the load increases the level of passivation over time. Controlling passivation is ideal for minimizing self-discharge but too much of it can overly restrict energy flow.

Competing bobbin-type $LiSOCl_2$ cells vary considerably in terms of their self-discharge rate. For example, the highest quality $LiSOCl_2$ batteries can feature a self-discharge rate as low as 0.7 percent per year, able to retain nearly 70 percent of their original capacity after 40 years.

Conversely, lower quality $LiSOCl_2$ cells can have a self-discharge rate as high as 3 percent per year, exhausting nearly 30 percent of their available capacity every 10 years, limiting maximum battery life to 10 – 15 years.

Adapt for high pulse requirements

To support two-way wireless communications and other advanced functionality, remote wireless devices must generate periodic high pulses up to 15 A. Standard bobbin-type $LiSOCl_2$ cells normally cannot deliver high pulses due to their low-rate design. However, they can be easily modified with the addition of a patented hybrid layer capacitor (HLC) (figure 2). This hybrid solution uses the standard bobbin-type $LiSOCl_2$ cell to deliver low-level background current during standby mode while the HLC delivers the high pulses required to support data queries and transmission. As an added benefit, the HLC features a unique end-of-life voltage plateau that can be interpreted to deliver low battery status alerts.

Supercapacitors perform a similar function with consumer products but are generally ill-suited for industrial applications due to serious limitations including short-duration power, linear discharge qualities that do not allow for the use of all available energy, low capacity, low energy density, and very high self-discharge rates up to

Figure 2. Bobbin-type $liSOCl_2$ batteries can be combined with a patented hybrid layer capacitor (HLC) to deliver up to 40-year service life along with the high pulses required for two-way wireless communications.

60 percent per year. Supercapacitors linked in series require the use of expensive cell-balancing circuits that add bulk and drain additional current to further shorten their operating life.

Do your homework

When designing for a long-term deployment in a highly remote location or extreme environment, it pays to spend a little more for a superior grade battery that can last for the entire lifetime of the device, thus eliminating the need for costly battery change-outs. Accomplishing this cost-saving goal requires careful due diligence as lithium batteries are not created equal.

For example, the annual self-discharge rate of a bobbin-type $LiSOCl_2$ battery can vary significantly based on how it is manufactured and the quality of the raw materials. Unfortunately, a lower quality cell with a high self-discharge rate may be hard to distinguish as capacity losses are not easily measurable for years and theoretical battery life expectancy models tend to underestimate the passivation effect as well as long-term exposure to extreme temperatures.

To properly compare competing battery brands, users must demand fully documented and verifiable test results along with in-field performance data under similar loads and environmental conditions. Learning about the subtle differences between seemingly identical cells can pay huge dividends by reducing your long-term cost of ownership.

ABOUT THE AUTHOR

Sol Jacobs is vice president and general manager at Tadiran Batteries.


IMI SENSORS

Condition Monitoring Using Vibration Transmitters and PLCs

Vibration monitoring is a good application for the Industrial Internet of Things (IIoT) because of its analytics potential.

By Eric Saller, IMI division of PCB Piezotronics

Predictive maintenance techniques are effective strategies to reduce unexpected machinery failure. Vibration monitoring is by far the most widely used predictive maintenance technology due to the significant amount of machinery condition information it provides.

Most plants that implement a vibration monitoring program begin with a portable data collector and a predetermined route of data collection points. Vibration data is gathered and trended. Maintenance action then is determined based on machinery condition trends. Often, the new vibration information is reviewed and compared to trended data, and no anomalies or exceptions are noted. At this point, vibration analysts often realize that they wasted valuable time and resources taking vibration data on healthy machines.

Plant size and the number of measurement points can make implementing a vibration monitoring program a formidable task. Determining the data collection routes and data collection frequency also can be a difficult undertaking. These issues, as well as having machinery with different failure rates (i.e., the time to machinery failure once excessive vibration is detected), direct many plant managers toward investigating continuous vibration monitoring solutions with permanently installed instrumentation. These investigations often reveal that most permanently mounted instrumentation produces a signal that is not compatible with existing plant monitoring instrumentation, such as programmable logic controllers (PLCs), and that proprietary, duplicative equipment must be implemented.

Eliminate duplication

An inline or DIN-rail-mounted vibration transmitter eliminates the need for duplicative equipment by converting the output of a general purpose ICP accelerometer into a 4-20 mA output compatible with a PLC (figure 1). The PLC sends alarms to the vibration analyst when vibration levels become excessive. These alarms alert the predictive maintenance team of the need for closer investigation to pinpoint

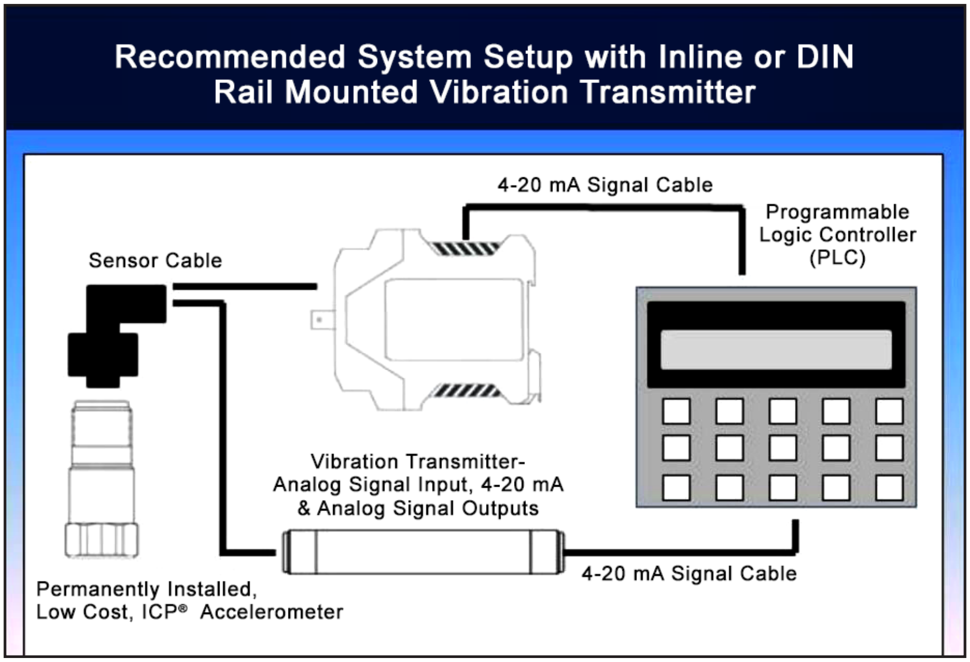


Figure 1. The recommended setup of a vibration monitoring system using an inline or DIN-rail-mounted vibration transmitter includes an ICP accelerometer, vibration transmitter, and PLC, along with appropriate cables.

the exact failure mode. That additional analysis is facilitated by a raw vibration signal also available through the vibration transmitter that can be analyzed with portable diagnostic equipment.

This approach is more cost effective, since plant monitoring instrumentation, such as PLCs, is widely used in many factories. Vibration channels can be added at a fraction of the cost of adding separate redundant vibration monitoring equipment. Other costs, such as installation and training, also are reduced since the monitoring instrumentation already is installed and trained personnel are in place.

Once the decision is made to implement a vibration monitoring program using existing monitoring instrumentation, the next task is to determine the equipment to be monitored and to define the machinery faults that need to be detected.

Answers to the first point are relative to the particular equipment, including repair cost, failure rate, and its importance to the production process. Answers to the second part require a basic understanding of the typical machinery failure modes and their respective vibration signatures.

Typical machinery faults

The first step in implementing any vibration monitoring program is to know the equipment. Research the machinery to be monitored to be familiar with its operation and understand its potential failure modes.

There are many failure modes for machinery. The more complex the equipment, the more complex the failure mode can be. The four most common failure modes found in standard equipment are imbalance, misalignment, bearing faults, and gear mesh failure. Each machinery fault has a unique vibration signature that helps technicians identify the fault. Each fault has specific fault frequencies that help determine the failure mode, while the vibration amplitude helps to determine the severity of the problem.

Imbalance and misalignment most often occur at low frequencies. Mechanical looseness and process loading also can produce faults at low frequencies. These machinery failures demonstrate high vibration at the running speed, as well as two- and three-times running speed. These low frequencies are typically in the 2 to 1,000 Hz range for equipment operating at around 1,800 rpm.

Since the mechanical defect is a result of a physically massive rotor or shaft, the amplitudes are relatively high. A good range for trending vibration is from 0-1 in/sec RMS. Figure 2 shows a basic spectrum plot of potential machinery failures. The units for the frequency and amplitudes have been left off purposely, as the actual values would not allow all the faults to be visible in the limited area.

Bearing faults occur at nonsynchronous multiples of machinery turning speed. Specific bearing fault frequencies are unique to the bearings and depend on the physical bearing parameters. Specific measurements, such as pitch and bearing diameter, number of balls, and turning speed, are needed to calculate the fault frequencies of bearing failures like inner race and outer race defects, as well as ball bearing defects. Bearing defect frequencies are available from most bearing manufacturers. but as a rule of thumb, one can estimate the frequency by calculating the result of the number of balls in the bearing times the machinery turning speed times 50 percent.

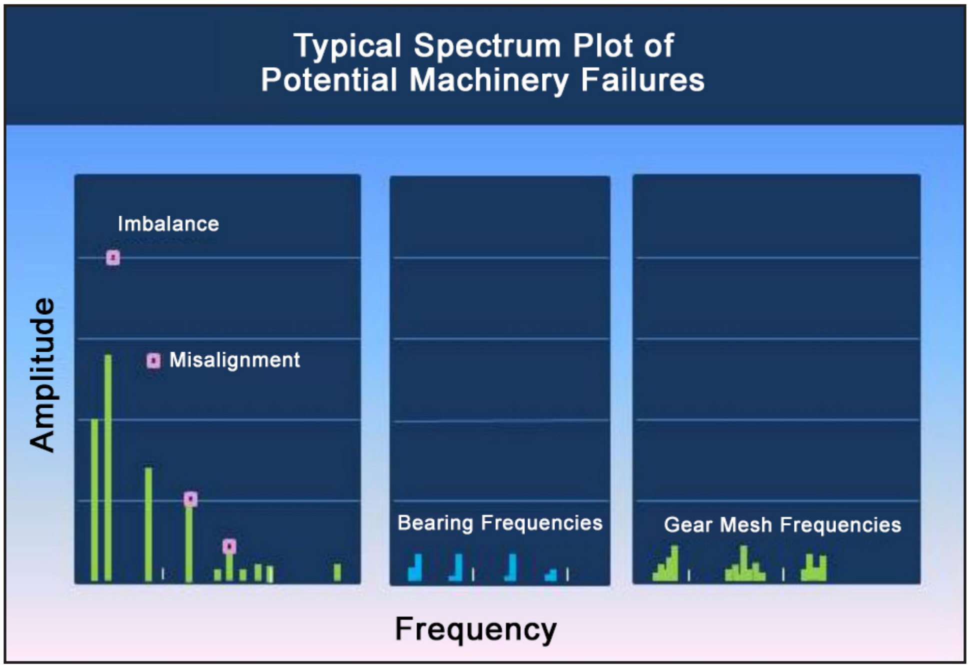


Figure 2. The four most common failure modes found in standard equipment are imbalance, misalignment, bearing faults, and gear mesh failure. Each machinery fault has a unique vibration signature that helps to identify the particular fault. The graph shows a basic spectrum plot of potential machinery failures.

Vibration amplitudes for these faults are very low, as the mass of the moving parts is relatively small compared to the rotor or shaft mass. Bearing fault frequencies range from 200 to 5,000 Hz with relatively low amplitudes. Trending acceleration data instead of velocity data is desired, since velocity accentuates the lower frequency vibration and attenuates the higher frequency vibration, while acceleration data gives stronger signals at higher frequencies and is better able to measure the lower amplitudes of bearing faults. A typical acceleration range for bearing fault detection may be 0 to 10 g peak.

Gear mesh faults occur at higher frequencies than bearing faults. Gear mesh frequencies are the product of the number of teeth times the shaft's turning speed. Depending on the machine, these gear mesh frequencies can range from 100 Hz to more than 10 kHz. As mentioned previously, acceleration data is preferred over velocity data, as the acceleration measurement emphasizes the higher frequency vibration and de-emphasizes and is less sensitive to the lower frequency mechanical defects and process loading conditions. A typical acceleration range for gear mesh fault detection may be 0 to 50 g peak. Figure 3 shows the simple vibration relationship between velocity, acceleration, and displacement over frequency.

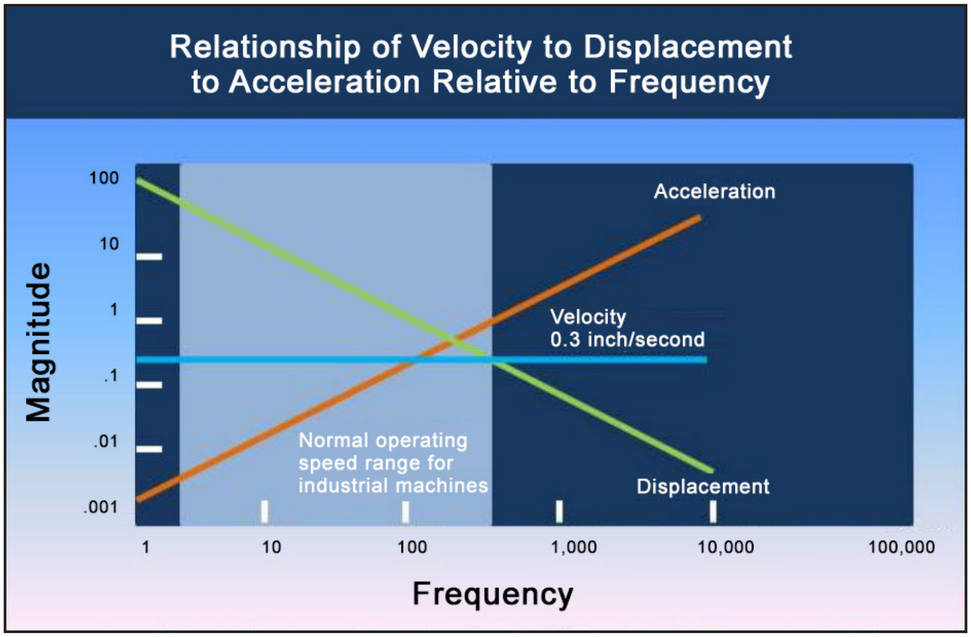


Figure 3. Acceleration data is preferred over velocity data for high-frequency fault detection, as the acceleration measurement emphasizes the higher frequency vibration and de-emphasizes and is less sensitive to the lower frequency mechanical defects and process loading conditions.

Selecting the proper transmitter

It is imperative to know the machinery to effectively implement a vibration monitoring program. Current machinery operating conditions, expected failure modes, and potential machinery faults are factors to consider when monitoring equipment.

Selecting the proper frequency band to trend relative to the fault of interest is critical to actually detect the given machinery fault and eventually predict machinery failure. Determining the amplitude ranges within the given frequency band also is important so that alarms will provide an early warning when machinery condition has degraded. Figure 4 from ISO 10816-1-1995: Mechanical Vibration—Evaluation of Machine Vibration by Measurements on Non-Rotating Parts shows possible alarm levels for general machinery classes.

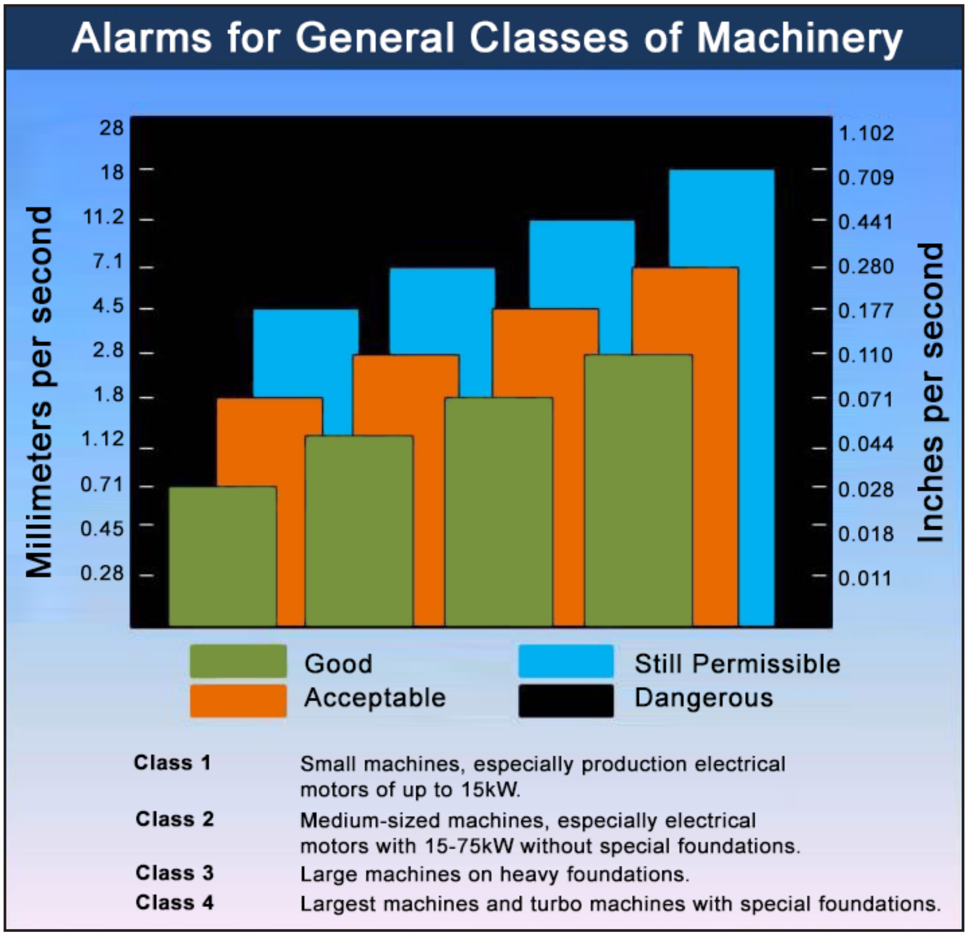


Figure 4. Alarms provide an early warning when machinery condition has degraded. This graph was taken from ISO 10816-1-1995: Mechanical Vibration—Evaluation of Machine Vibration by Measurements on Non-Rotating Parts.

Another critical concern for vibration monitoring equipment and alarms is that a time delay be available for each measurement point. A time delay is used to avoid false alarms that could occur because of transient vibration caused by local traffic, process changes, and even ancillary equipment. Also, the time delay should be sufficient to avoid setting off alarms during machinery startup and coast down. During startup and coast down, the equipment could move through mechanical resonances, and high amplitude vibrations could be present. Transient time delays should be on the order of 5 to 10 seconds, while time delays for machine startup and coast down should be greater at approximately one minute. It may be desirable to deactivate the vibration transmitters and their alarms during startup and coast down to avoid inadvertently setting off alarms.

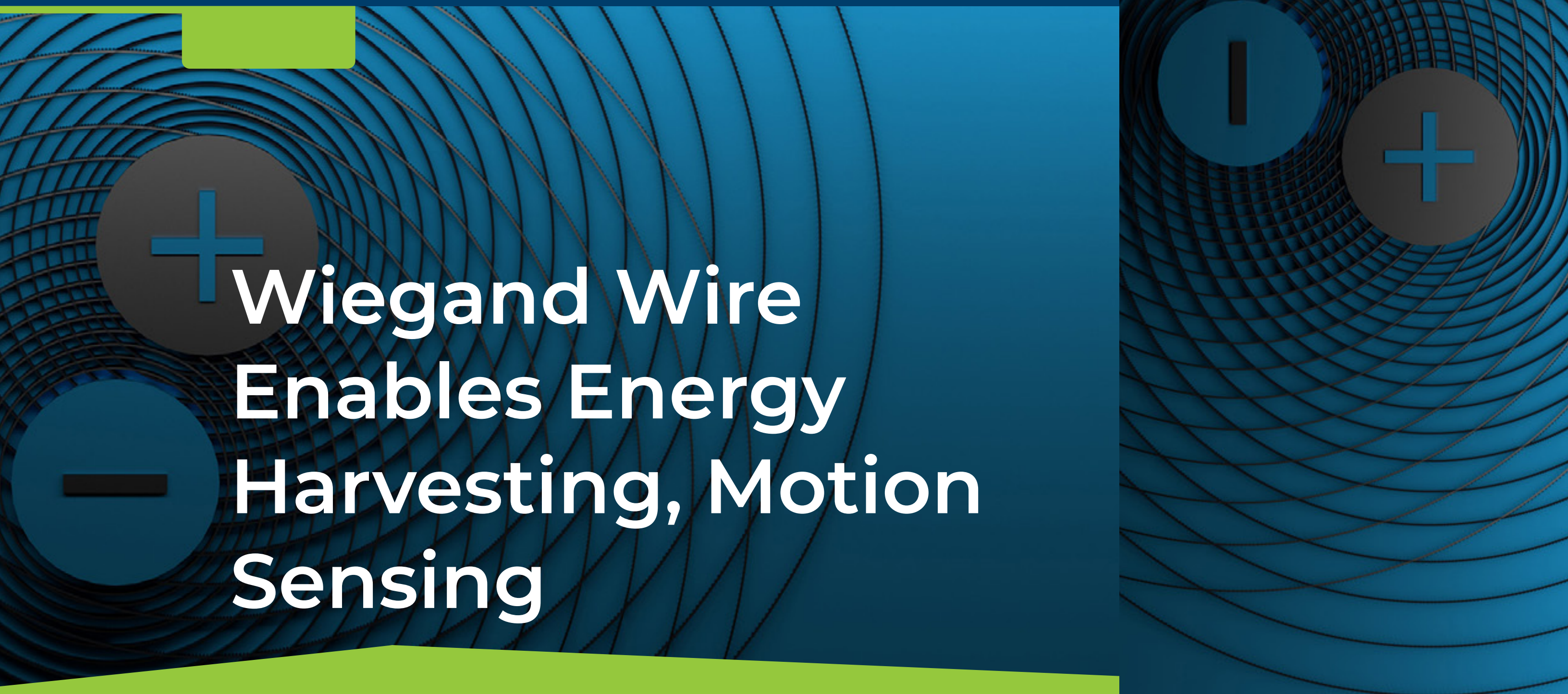
Final thoughts

Machinery condition monitoring is an important facet in modern maintenance. Avoiding unscheduled downtime is critical to maintain corporate competitiveness. Low-cost rotating machinery condition monitoring using general purpose ICP accelerometers, such as Model 603C01, inline or DIN-rail-mounted vibration transmitters, such as Models 682A09 or 682C03, and existing plant monitoring instrumentation is an excellent method to gather information to help determine the overall health of a plant's machinery.

All images courtesy of the IMI division of PCB Piezotronics.

ABOUT THE AUTHOR

Eric Saller is with PCB Piezotronics, www.pcb.com, a wholly owned subsidiary of Amphenol Corporation. PCB is a manufacturer of vibration, pressure, force and strain, shock, and acoustic sensors used by design engineers and predictive maintenance professionals worldwide for test, measurement, monitoring, and control requirements. Primary sensing technologies include piezoelectric (ICP), piezoresistive, and capacitive MEMS.



Wiegand Wire Enables Energy Harvesting, Motion Sensing

By manipulating the magnetic properties of Vicalloy wire, devices that can harvest energy and sense motion have been created.

By Tobias Best,
FRABA PTE. LTD.,
Singapore

The "Wiegand effect" was discovered almost 50 years ago and has been used successfully in several specialized applications. However, its full potential for energy harvesting and signal generation has received only limited recognition. With recent enhancements to the energy output from Wiegand devices and the emergence of a new generation of ultra-efficient electronic chips for wireless communications, the technology is showing significant promise, especially in the realm of the Internet of Things (IoT). UBITO, a member of the FRABA Group of technology companies, is leading research and development projects aimed at fulfilling this promise.

Wiegand Effect explained

The Wiegand effect is a physical phenomenon discovered in the 1970s by John Wiegand, an American inventor who found that by repeatedly stretching and twisting a piece of ferromagnetic wire, he could alter its magnetic properties. When a sample of Wiegand wire is exposed to a reversing external magnetic field, it will initially retain its original magnetic state. However, when the strength of the external field reaches a critical threshold, a region of the wire that is magnetically soft will undergo an abrupt reversal of its polarity. This transition takes place within a few microseconds and can be harnessed to induce a pulse of electric current in a fine copper coil wrapped around the wire.

"The mechanical process that produces Wiegand wires creates a combination of magnetically hard and soft layers in the wire, causing the wire to have a high level of magnetic hysteresis."

The electric pulse generated by a Wiegand wire is very brief, but its strength stays nearly constant, regardless of how quickly or slowly the external magnetic field changes. This is what makes the Wiegand effect special: While simple dynamos, which also use electromagnetic induction, are effective at converting rotary motion into electrical energy, their output power varies with rotation speed. When a dynamo is turned slowly, power levels can be too low to be useful. With a Wiegand wire, however, the amount of electrical energy generated with each reversal of the magnetic field remains consistent over a wide range of speeds.

The combination of a short length of Wiegand wire and a surrounding copper coil is referred to as a Wiegand sensor. These are available commercially from UBITO in surface-mountable device (SMD) packaging.

Using energy harvesting power for innovation

"Energy harvesting" refers to technologies that extract energy from the local environment to power electronic devices. Several are available, including photovoltaics (energy from light), thermoelectric and pyroelectric effects (energy from temperature variations), and piezoelectric and electrostatic devices (energy from mechanical motion).

Wiegand sensors are also a good candidate for energy harvesting. In their basic form, these devices produce modest amounts of energy—about 200 nanojoules. However, recent developments have significantly increased energy output from Wiegand devices and opened possibilities for much more ambitious applications.

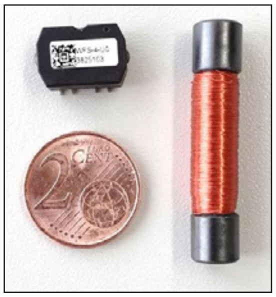


Figure 1. Wiegand harvester (right) and Wiegand sensor (top left).

Building an energy self-sufficient IoT Node.

An R&D program, carried out by a team of researchers at FRABA's technology center and the Rhineland-Westphalia Technical University with support from the German Ministry of Science and Technology, has developed enhanced Wiegand devices that are optimized for power generation. These are called "Wiegand harvesters." The researchers have demonstrated that a set of Wiegand harvesters (figure 1) can generate up to 10 microjoules of energy (approximately 50 times the output from a commercial Wiegand sensor). This was sufficient to energize a low-power ultra-wide-band radio transceiver with a transmission range of 60 meters.

This demonstration points to the feasibility of a new generation of entirely self-powered sensors that would be capable of monitoring a physical action such as a rotary motion or the opening or closing of a door and transmitting a notification signal to a monitoring system through wireless communications. Other condition data such as temperature could also be sent. This type of energy self-sufficient, maintenance-free device could become important components in IoT.

As Christian Fell, FRABA's head of technology development explains: "The vision of the IoT calls for thousands of smart sensors distributed through homes, commercial facilities, and digital factories, collecting data for monitoring, security, and process optimization. If these devices can be made energy self-sufficient, harvesting electricity directly from their surroundings to power both their operation and a wireless communications interface, there will be enormous benefits in terms of simplifying network deployment and reducing maintenance costs, including the cost of installing, checking, and disposing of thousands of backup batteries." The Wiegand effect could provide an excellent power source for remote sensors wherever there are changing magnetic fields present.

Along with an energy source, another key part of a viable IoT node is the communications interface. For their proof-of-concept demonstration, the FRABA-RWTS team used impulse-response, ultra wide band (IR-UWB) technology, based on an SR-1000 UWB transceiver from SPARK Microsystems. This device transmits very short electromagnetic pulses in a 2 to 11 GHz frequency band. Because this technology transmits data in short-duration pulses, it uses less energy than narrow band radio transmitters. This intermittent transmission is also a good fit with the Wiegand effect's characteristic of generating electrical energy with the brief pulses. As noted above, this prototype was able to transmit small data packets over 60 meters in demonstration tests.

Energy harvesting for self-powered sensors

For small Wiegand sensors, the electrical energy produced with each polarity change, while limited, is sufficient to activate a low-power electronic counter circuit. This form of energy harvesting has been used successfully in more than a million encoders (rotation measurement instruments) built by POSITAL and other manufacturers (figure 2). Because of Wiegand energy harvesting, these encoders' rotation counter systems are entirely self-powered with no need for external power sources or backup batteries, significantly reducing maintenance requirements.

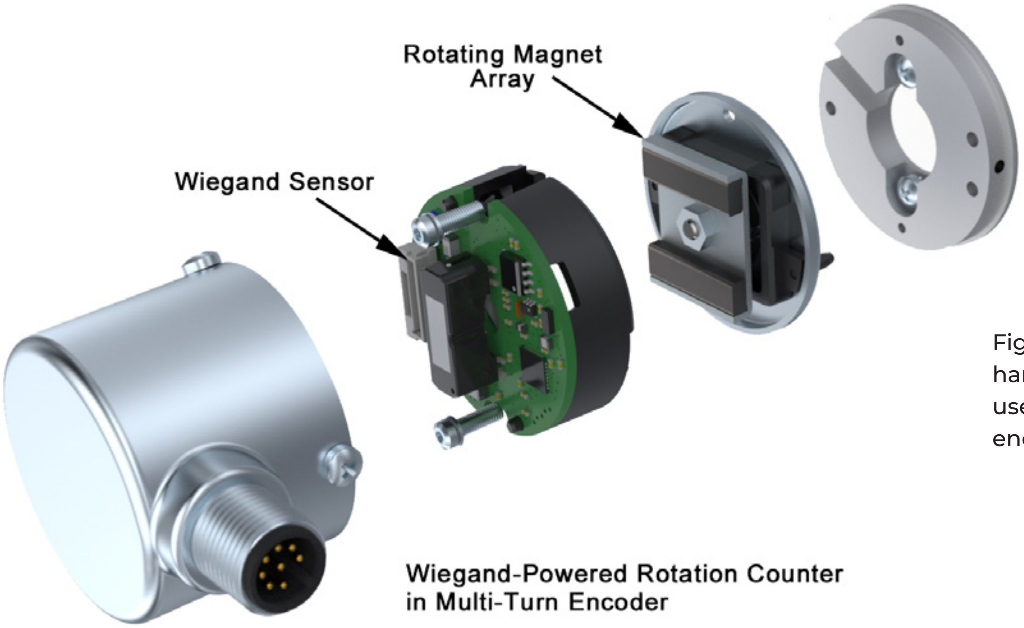


Figure 2. Energy harvesting has been used successfully in encoders.

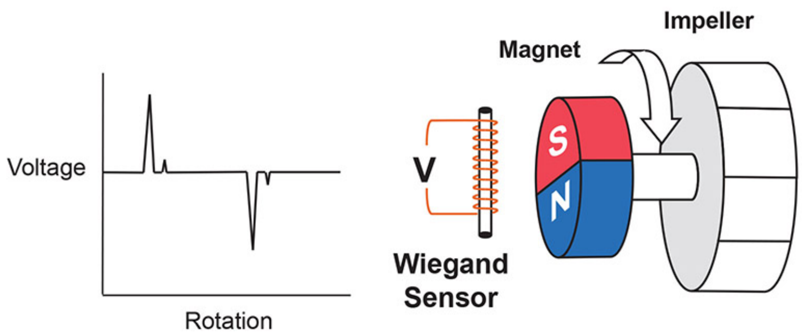


Figure 3. Wiegand sensors for rotation counting in fluid meters.

A similar principle has been used for water or gas meters. Here, a permanent magnet is mounted on the meter's rotating shaft, close to a Wiegand sensor (figure 3). As the shaft turns, the rotation of the magnetic field triggers abrupt polarity reversals in the Wiegand wire, inducing electric current pulses in the copper coil. As the strength and duration of each current pulse is independent of how quickly or slowly the shaft rotates, Wiegand sensors provide much higher signal-to-noise ratios than other analog magnetic sensors (e.g., Hall effect sensors). This ensures that the meter's counter circuit receives clear and unambiguous signals with each rotation of the shaft. Energy from the electrical pulse can also be harnessed to power the rotation counter circuitry, so the counter will keep a reliable record of shaft rotations in the absence of an external energy source.

Wiegand-based event triggering also has been used for tachometers for rail cars and other equipment. For this application, the Wiegand sensor is located near two magnets with the opposite polarity. The presence of a large ferromagnetic (iron) body nearby can neutralize the effect of one of these magnets so the magnetic field at the Wiegand sensor is dominated by the other magnet (N-S in figure 4). As the ferromagnetic body rotates, it neutralizes the

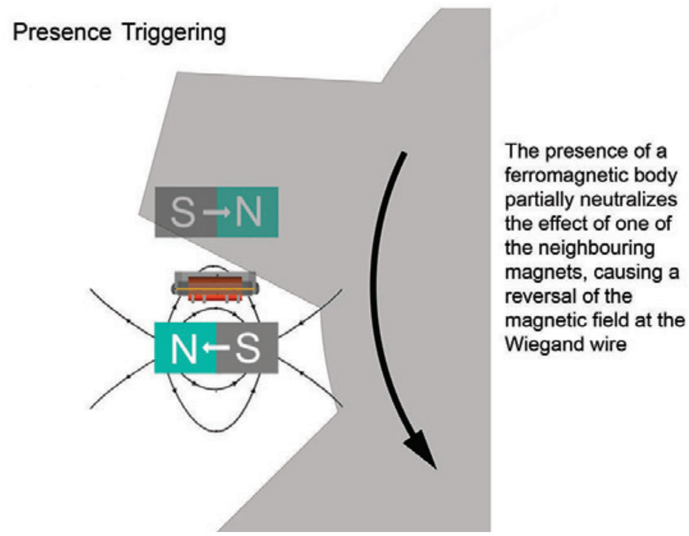


Figure 4. The presence of a large ferromagnetic (iron) body nearby can neutralize the effect of one of these magnets so the magnetic field at the Wiegand sensor is dominated by the other magnet.

other stationary magnet, reversing the field (S-N) and triggering a polarity flip in the Wiegand wire (figure 5). The benefit of Wiegand technology in this application is that it operates reliably over a wide range of rotation speeds. Moreover, with no mechanical contact between the sensor and the moving component, there is no wear, and the systems have service lifetimes of billions of operating cycles.

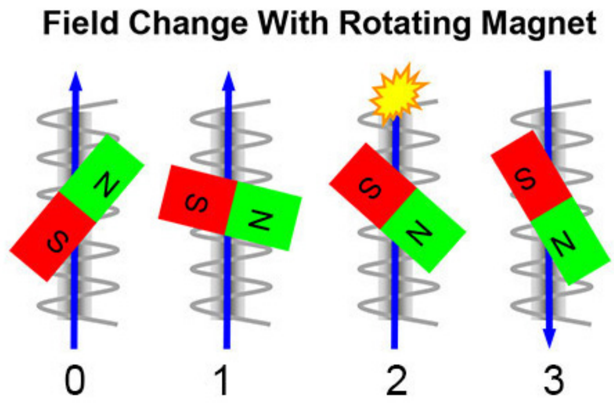


Figure 5. As the ferromagnetic body rotates, it neutralizes the other stationary magnet, reversing the field (S-N) and triggering a polarity flip in the Wiegand wire.

The Wiegand cycle

The mechanical process that produces Wiegand wires creates a combination of magnetically hard and soft layers in the wire, causing the wire to have a high level of magnetic hysteresis (figure 6).

As the external magnetic field changes, the Wiegand wire will at first retain its initial polarity (Point A in figure 6). However, when the strength of the external field reaches a critical threshold, the polarity of the magnetically soft zone of the Wiegand wire suddenly reverses (Point B). As the external field continues to strengthen, the

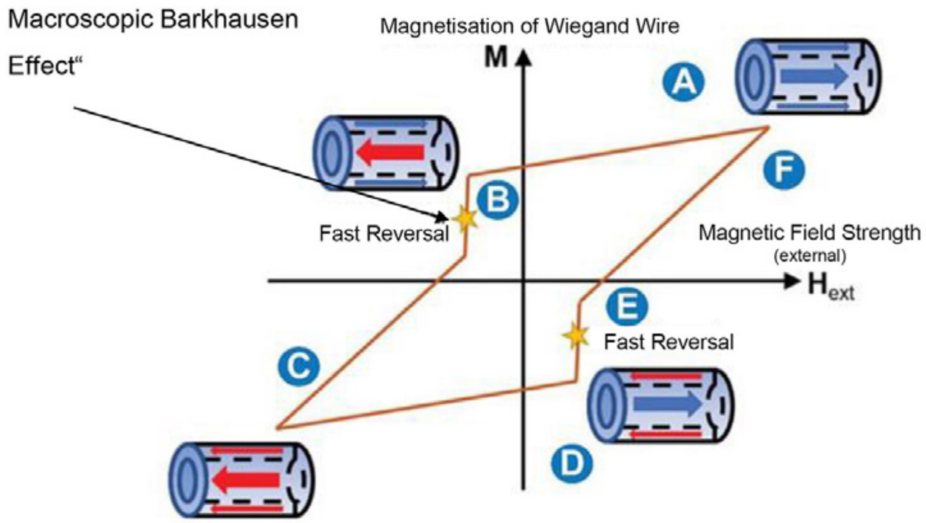


Figure 6. The mechanical process that produces Wiegand wires creates a combination of magnetically hard and soft layers in the wire, causing the wire to have a high level of magnetic hysteresis.

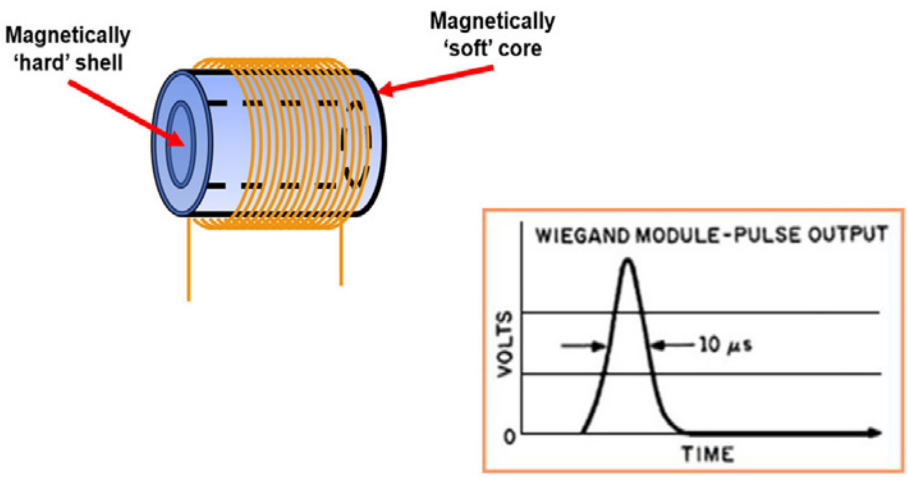


Figure 7. Rapid changes in the magnetic polarity of the wire core induce short pulses of electrical current in the fine copper coil wrapped around the Wiegand wire.

magnetically hard zone will also reverse its polarity, so the whole wire reaches a new magnetic state (Point C). When the external field changes back toward its original polarity, a sudden reversal of the soft material will occur again (Points D, E). The wire will eventually return to its earlier state (Points F, A). These rapid changes in the magnetic polarity of the wire core induce short pulses of electrical current in the fine copper coil wrapped around the Wiegand wire (figure 7).

Manufacturing Wiegand wire

Wiegand wire is produced through a process that involves annealing a spool of Vicalloy wire (an alloy of vanadium, iron, and cobalt), then simultaneously stretching and twisting the wire. This aggressive cold working alters the crystalline structure of the metal and creates two regions—an inner core and outer shell—with significantly different levels of magnetic coercivity. (Coercivity is a property of ferromagnetic materials that defines how easily the material can be magnetized by an external magnetic field. Magnetically soft materials, such as mild steel, have low coercivity and change their magnetic state easily. Magnetically hard material, such as the alloys used to make permanent magnets, will retain their magnetic state unless they are exposed to very strong external fields.) The interaction of these two regions causes the wire to have a high level of magnetic hysteresis.

The “recipe” for producing a satisfactory batch of Wiegand wire was determined by John Wiegand and his collaborators through trial and error. The machine they developed to produce Wiegand wire features a series of rotating frames that stretch, twist, and then untwist the wire at various rates. This machinery was acquired by FRABA, along with John Wiegand’s lab notes. Since then, research carried out by FRABA and its partners has automated this process and optimized it for quality and consitency (figure 8).

Figure 8. Research carried out by FRABA and its partners has automated this process and optimized it for quality and consitency.

Looking ahead

Wiegand technology has a strong track record, with proven successes in niche applications such as fluid metering and rotary encoders. It also has significant potential for more advanced uses, both as a sensor for detecting mechanical motions and as an energy harvesting device for self-contained electronic devices. The advantages of Wiegand technology include consistent performance over a wide range of operating speeds and long-term reliability, since the underlying physical phenomenon is completely non-contacting.

R&D carried out by FRABA’s UBITO business unit is enhancing the energy output from Wiegand generators and creating possibilities for a new generation of self-contained, zero-maintenance wireless sensors designed to operate as nodes on emerging IoT.

ABOUT THE AUTHOR

Tobias Best (tobias.best@fraba.com) is based in the FRABA Group’s Asia Pacific Headquarters in Singapore. Best has been promoting Weigand sensor technology for UBITO globally since 2017.

Getting Started with Digital Transformation

By Divya Prakash, SICK

Smart manufacturing can optimize performance across a network, adapt to and learn from new conditions in real time, and autonomously run production processes.

Manufacturers are on a digital transformation journey toward the smart factory. The smart factory represents a leap forward from more traditional automation to a fully connected and flexible system—one that can use a constant stream of data from connected operations and production systems to learn and adapt to new demands.

To fully realize the digital supply network, manufacturers likely need to unlock several capabilities: horizontal integration through myriad operational systems that power the organization; vertical integration through connected manufacturing systems; and end-to-end, holistic integration through the entire value chain.

SICK's consulting and digital solutions team collaborates with customers in their digital transformation journey. Solutions include smart sensor applications that bridge the gap between the shop floor and the data floor. There are numerous benefits to implementing digital transformation solutions.

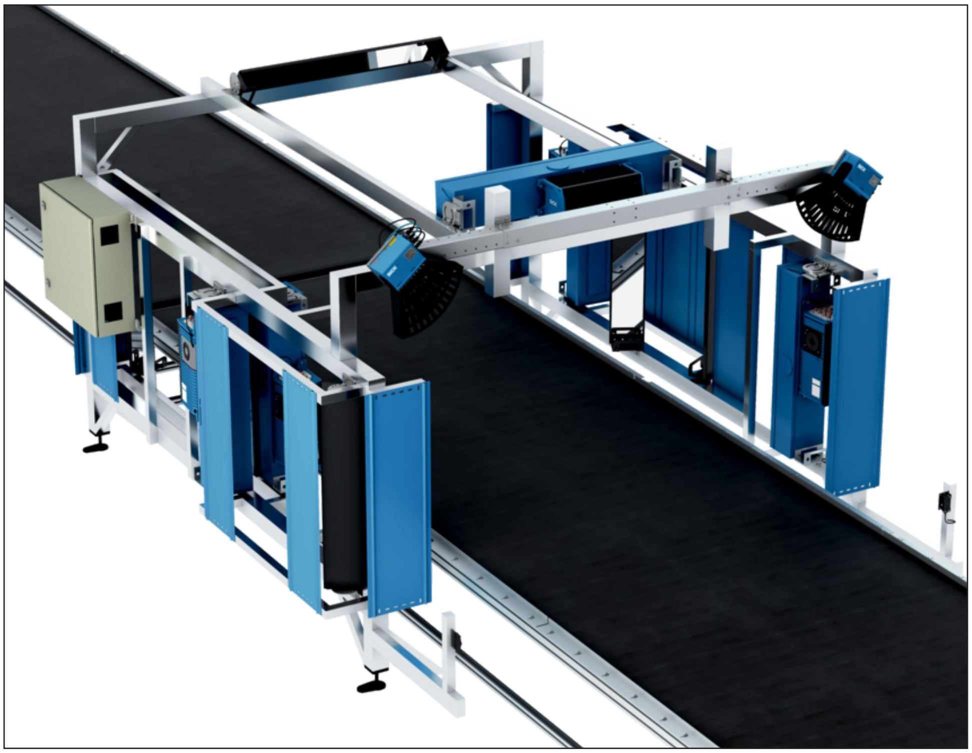


Figure 1. Intelligent camera technologies capture fill level of a supply box whether it is stored on the shelf or has been moved to the production line.

Addressing labor gaps. Since labor is an important cost driver in most industries, improving labor productivity can drive significant value. This value can be captured via levers that reduce waiting time (e.g., completion of previous process step in manufacturing, delayed delivery of a good in manufacturing, or a prototype in R&D) or increase the speed of workers' operations by reducing the strain or complexity of their tasks. Human-robot collaboration allows humans and machines to work near each other without risking worker injury.

Inventory challenges. Too much inventory ties up capital, leading to high capital costs. Reducing excessive supply in stock can lower these. Digital transformation levers target the various drivers of excess inventory, such as inaccurate stock numbers that increase sludge, unreliable demand planning necessitating safety stock, or overproduction. Intelligent camera technologies (figure 1) capture the actual fill level of a supply box whether it is stored on the shelf or has been moved to the production line.

Improved quality. Improving quality is a value driver since scrap and products requiring rework often lead to extra costs (for machine time, material, and labor). These quality inefficiencies are caused by unstable processes in manufacturing, deficient packaging in the supply chain or distribution, and unskilled installation. Statistical process control (SPC), advanced process control (APC), and digital performance management can create value.

Supply/demand match. Only a perfect understanding of the customer demand—regarding both the quantity and product features customers are willing to pay for—maximizes the value captured from the market. Optimizing the match of supply to the actual demand with digital transformation solutions can seize value potential.

Improved resources and processes. A process can be improved in terms of material consumption, speed, or yield-driven value: in the case of material consumption, via decreased material costs; in the cases of speed or yield-driven value, via increased revenues through more output.

Reducing time to market. Reaching the market with a new product earlier creates additional value through increased revenues and potential early mover advantages. Every digital transformation solution that speeds up the development process, such as concurrent engineering or rapid experimentation/prototyping (e.g., through 3-D printing), will help drive this value.

Decrease service costs. Since the costs of operation are driven by service costs (e.g., maintenance or repair) and machine downtimes (e.g., due to unexpected incidents), offering customer solutions that decrease these can open further value potential.

Better asset utilization. In asset-heavy manufacturing businesses, such as those in the automotive industry, asset utilization is a big value driver. Remote monitoring and predictive maintenance (figure 2) play an important role in capturing value. Both are levers to improve asset utilization by decreasing unscheduled downtime.

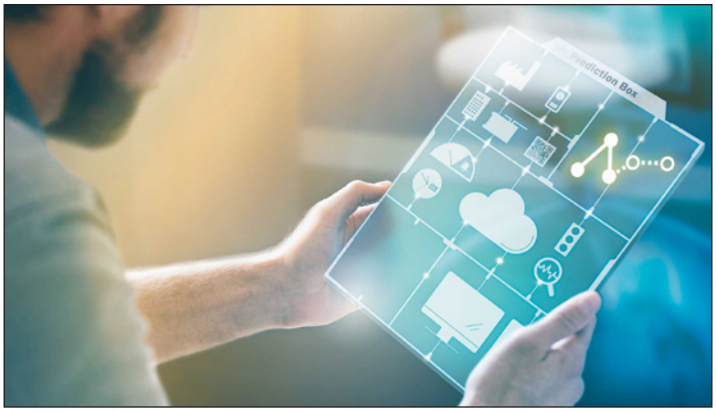


Figure 2. Remote monitoring and predictive maintenance play an important role in capturing value.

Five steps to digital transformation

When users are ready to tackle a digital transformation project in their facilities, what's the best way to start? These five steps can help users reliably increase productivity by unlocking data via digital transformation.

Step 1: Infrastructure and operational assessment.

First, start with an assessment of operations and existing infrastructure. This helps determine the steps to move forward with creating a solution and concept that best meet the needs of the company.

This starts with discussing the business strategy:

- Where is the company headed?
- Is top-line growth the priority?
- Is there a focus on increased capacity to meet demand?
- Is the business focused on reducing costs to remain competitive in a market with tightening margins?
- What about manufacturing flexibility?
- How is the company addressing new market pressures, such as the ability to meet customization demands?

Understanding these strategic objectives is vital to ensure that subsequent discussions of how to achieve these goals stay focused on remaining competitive.

> **"Digital transformation levers** target the various drivers of excess inventory, such as inaccurate stock numbers that increase sludge, unreliable demand planning necessitating safety stock, or overproduction."

Step 2: Solution concept.

Once an assessment is completed, the next step is to create a solution concept. To achieve these previously identified business goals, it is a must to identify digitalization projects that align with the business objectives. Examples include reducing risk and addressing compliance requirements, which align with operational projects that address track-and-trace solutions. To do this, secure automation system connectivity and strategic data movement are critical.

Step 3: Solution design.

The enablers to make a digital transformation solution design feasible include connectivity technology, affordable Internet of Things (IoT) hardware, and standardized communication protocols. Collecting meaningful data and analyzing for implications are still the biggest challenges to driving the impact from digital transformation.

There are different directions in which a digital solution can be implemented:

- Sensor-up (edge-to-cloud): bringing data from the sensor systems up to the data floor on servers and cloud platforms provides added value based on data points.
- Data-down (cloud-to-edge): analyzing and optimizing business processes jointly with the customer creates added value using sensor data.
- Combination of both: Both a sensor-up and a data-down option can be implemented, resulting in a comprehensive solution that accounts for how the business operates and highlights key improvements.

Step 4: Installation and commissioning.

Next is design implementation. “The team at SICK is agile and agnostic to consult with customers on their challenges and potential needs. This helps determine the ideal infrastructure to develop the most suitable enterprise solutions that can adapt to the disruptive industry needs,” said Salim Dabbous, Director of Sensor and Safety Integration at SICK.

An example of an Industry 4.0 enterprise offering is the implementation of a data concentrator methodology into a pre-existing controls platform to connect current machines and push non-process-related data seamlessly upstream to the cloud or an enterprise resource planning (ERP) system. The reliable data pushed upstream might include machine status, part count, or temperature and pressure data. This feeds into dashboards and key performance indicators (KPIs), providing transparency and predictive maintenance measures that optimize processes and increase throughputs.

Step 5: Verification and validation.

Lastly, SICK is a partner from beginning to end on digital transformation projects. Timely and comprehensive services can be provided to ensure that everything remains running in top condition. As a global provider of digital solutions, SICK takes a holistic approach to working with customers to find creative solutions to their problems. This is supported by a multidisciplinary team that spans the expertise required for a digital transformation, including key enabling technologies.

Methodology includes a repeatable, scalable engineering process that focuses on data gathering and reporting to customers in multiple steps to achieve the granularity required to unlock greater production efficiencies (figure 3).

Figure 3. Methodology includes an engineering process that focuses on data gathering and reporting to customers to achieve the granularity required to unlock greater production efficiencies.

Case study: Track-and-trace reduces shipping and picking errors

A supplier increased throughput by more than 300 percent with an automated picking solution and audit system to gain better access to process and sensor data.

An estimated 5 percent of total shipping costs is lost due to shipping and picking errors every year. For businesses with tight margins, this can have a huge impact on the bottom line. One of the most common errors is sending the incorrect items or number of items. These errors most often occur during the picking stage. It could be as simple as two items looking very similar, so the wrong item is picked. Another common error is delivering items to the incorrect address, which is often the result of simply misreading the documentation.

Many shipping and picking errors can be resolved by automating picking processes and implementing automated audit systems to ensure that everything on an order is correct before it is sent out (figure 4). A global manufacturing supply company was looking for a way to automate these processes to ensure that correct quantities of its products are shipped to the correct retail store.

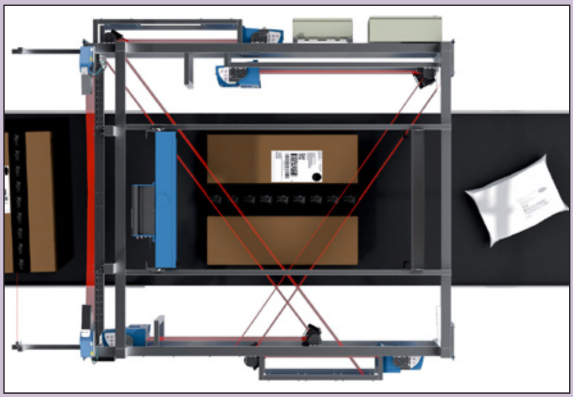


Figure 4. Shipping and picking errors can be resolved by automating picking processes and implementing automated audit systems to ensure that an order is correct before it is sent out.

The challenge

This supplier was having issues with stock being delivered to incorrect retail stores or delivering incorrect quantities. Prior to involving SICK, this process was manual, with no automation, which led to many errors and added costs to resolve the issues. The retailer that was receiving incorrect orders recommended that the supplier contact SICK for a solution, as the retailer had successfully been using SICK's scanning tunnels in its own operations.

The solution

A track-and-trace end-to-end solution called the Pallet Audit System was installed to improve these processes. Using SICK's ICR camera tunnel system, packages can be validated against the manifest to ensure that the correct quantity is shipped and sent to the correct location. The ICR tunnel produces high-resolution image quality for highly accurate read rates for identification applications on sorting processes. It can help increase throughput of more than 18,000 objects per hour at conveyor speeds of up to 4 meters per second. The image quality from the integrated cameras also enables it to be used in optical character recognition (OCR), video coding, and vision applications.

The process starts (figure 5) when the manifest data is received on the local server, the operator scans an LPN using a handheld scanner, and the API populates the pallet results on its display using SICK's SIM2000, a sensor integration

Continued on next page

machine that uses IO-Link technology to enable sensor integration and data transparency. It is a low-cost combination of edge gateway functions and sensor data processing that provides greater access to data from sensors to improve processes.

The operator then loads packages onto the conveyor through the camera tunnel system to validate that the correct SKUs and number of packages are going onto the pallet when compared to the manifest in the system. Once it is verified as accurate, the pallet is complete and ready to ship to the store.

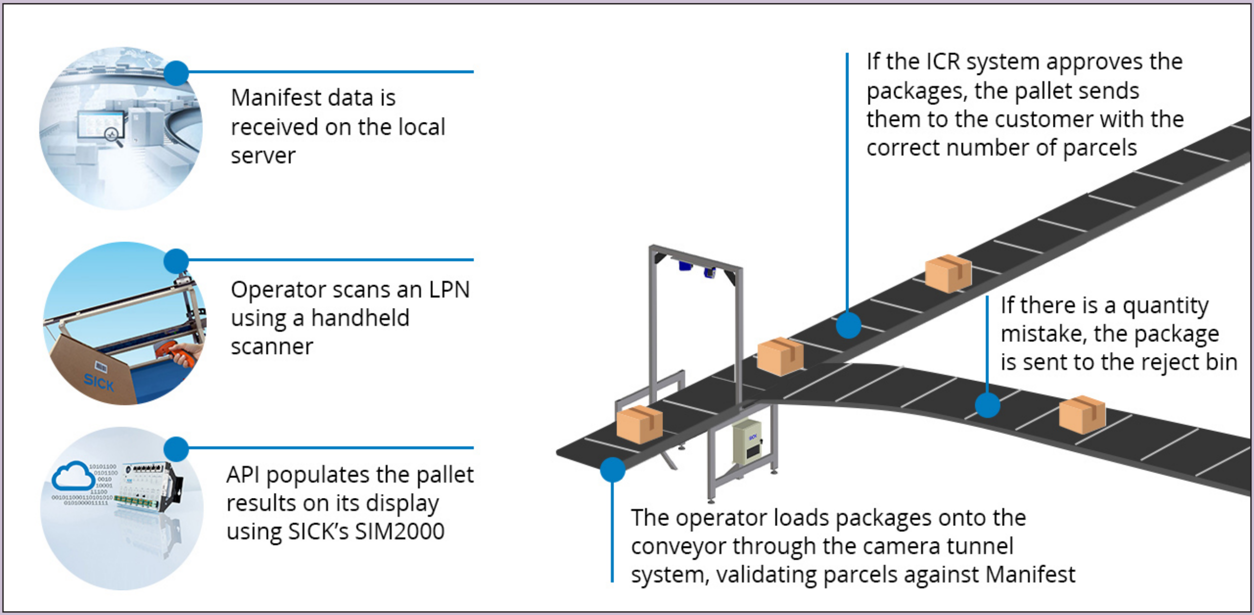


Figure 5. Manifest data is received on the local server, the operator scans an LPN using a handheld scanner, and the API populates the pallet results on its display using a sensor integration machine that uses IO-Link technology to enable sensor integration and data transparency.

ABOUT THE AUTHOR

Divya Prakash, director of business consulting and Industry 4.0 at SICK. With more than 30 years of experience in the industrial automation industry, Prakash has expertise in engineering and business consulting with an emphasis on Industry 4.0 solutions. He has extensive knowledge in digital transformation, supply chain management solutions, and manufacturing operations management solutions.

Understanding Git-Based Version Control for Industrial Automation

By Darren Henry, Copia

Good version control practices are essential for efficient code development. They ensure that users can track changes to files over time, understand why the changes were made and by whom, and revert to specific code versions if needed. As more engineers are assigned to a project or as more time passes between project activities, the benefits of proper version control increase. Less time is required to understand how and why a project arrived at its current state.

For an industrial automation developer, a sound version control system ensures that users can answer these questions:

- Where is the latest version of the programmable logic controller (PLC) code, and can I access it without calling another developer?
- Is this version of code the same as what has been deployed onto the PLC?
- Was the latest version reviewed/approved by the proper people?

When a robust version control system is implemented correctly, teams can focus more on the development activities instead of searching for and investigating code changes.

- What has changed between this file and the previous version? Who made the change and why?
- Can I control who can access the files at different stages of the PLC code's lifecycle?

While there are many different types of version control systems, Git dominates the software industry with more than 80 percent market share and is used by around 100 million developers.

Git explained

Git is a mature and actively maintained open-source tool created in 2005 by Linus Torvalds (the founder of Linux). It is now the most widely used modern version control system globally. Reasons why Git became the standard include:

- Git is distributed, meaning files and history are stored locally and in a central repository. This characteristic enables engineers to work without network access.
- Git is fast. Since history is stored locally on the user's device, changing versions is nearly instant.
- Git is secure. Git uses a hashing algorithm that ensures that every edit is traceable. It is impossible to change a file or directory without Git knowing.

Today's error-prone manual process

For an industrial automation professional who is not familiar with Git, it may be easier to understand if it is compared to the widespread and manual practice of using an "archive folder" to manage industrial automation files.

The typical archive folder workflow steps include:

1. The controls engineer creates project files on the local computer, using an installed integrated development environment (IDE), such as Rockwell Automation Studio 5000 Logix Designer or Siemens

TIA Portal. The names of the files are often a user-created mix of a project name, version, and engineers initial (e.g., Mixer_DAH_V1).

2. Edits are stored by overwriting the previous file (Save) or copying and renaming the new files (Save As).

3. When work is completed to a significant state, the file or entire project folder can be zipped and copied to a central location for sharing and backup.

4. If other team members need to access the files to review or make changes, they need to download them to their local hard drive and use their development environment to view and edit the files.

It is common for controls engineers to “copy and rename” to manage a file’s history, resulting in a list of similar files distinguished by filenames and modification dates. Unfortunately, there are many problems and limitations with this workflow. For example:

Git removes the need to copy, move, and rename files manually. Git stores versions of the project and provides rich context on who, what, and why changes were made.

- There is no inherent information on why a file was updated or changed. Additional work is needed to document and communicate changes.
- Project organization is based on manually naming files, which is prone to human error.
- There is no easy way to see the difference between file versions. Some IDEs provide this capability, but only for their specific file types.
- Local files are not backed up regularly. Work is often lost, and the latest version of a project may not be in the archive folder.
- Collaboration is limited. If teammates copy the same file from the central location and make changes, they cannot easily merge their work.

- It is difficult for managers to understand the progress made on a project since the work is usually kept on local machines.
- There is no inherent method for reviewing and approving files.
- Setting access permissions for specific files can be challenging.
- For large files, copying, pasting, and eventually uploading can take a significant amount of time. This fact may decrease the frequency at which projects are backed up.

Git alleviates these disadvantages. A basic Git-based workflow has many similarities to the archive folder workflow. Work is done locally, changes are saved and committed to the file's history, and these committed changes are synchronized to a centralized location. There are significant benefits as Git removes the need to copy, move, and rename files manually. Git stores versions of the project and provides rich context on who, what, and why changes were made.

Basic Git workflow

Basic Git workflow steps for an Industrial Automation project include:

1. A central repository is created on a server, which is cloud-hosted for most Git providers (GitHub, Copia, etc.).
2. This repository is cloned to the control engineer's local machine. It will appear on the local PC as a standard Microsoft Windows folder.
3. The engineer creates automation files using the local IDE such as Studio 5000, saves the file in the local repository, and commits these changes to the file history when ready.
4. When a development milestone is reached, or the engineer believes it is appropriate, the engineer pushes the committed changes to the central repository.
5. Meanwhile, teammates who also have cloned the central repository locally can "pull" the updated files to their local repository, so they are always working with the latest files.

These steps are outlined in figure 1.

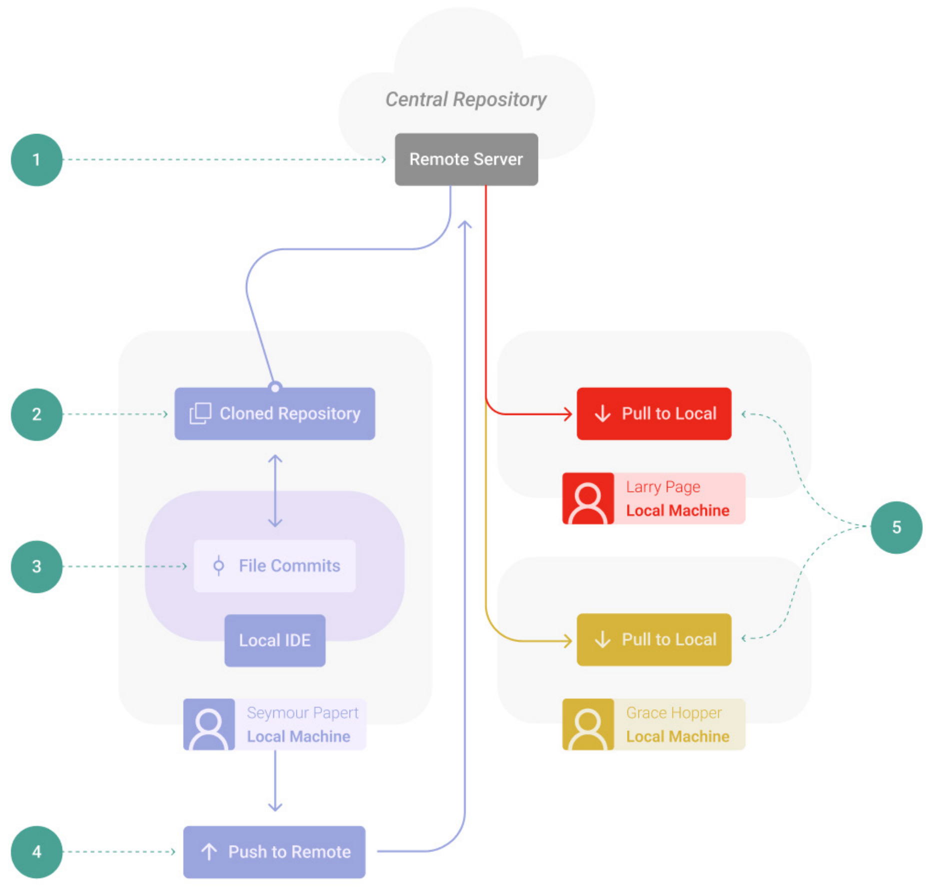


Figure 1. In a Git workflow, filenames stay the same, and commit history is automatically tracked. A simple set of pull and push commands ensure that everyone has access and is working with the latest version.

A PLC file's history can be viewed using a Git commit graph (figure 2). Note that any previous commits can be retrieved if needed.

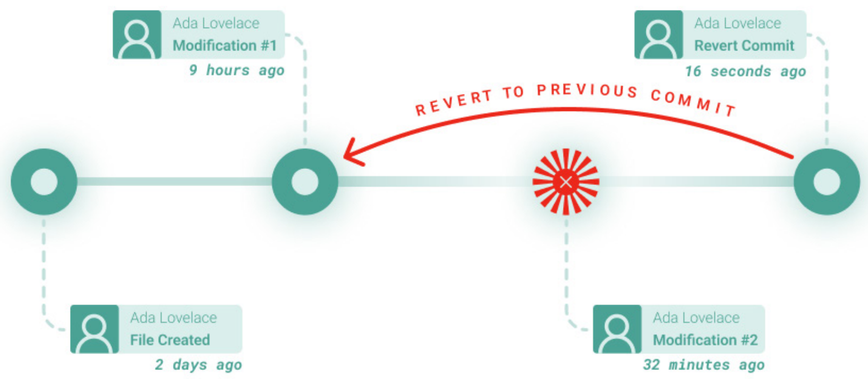


Figure 2. With Git, each committed change is stored with context and can be visualized as a node along a main branch of code. A simple revert command can be used to access previous changes.

While making changes, considerations include:

- As changes are made, filenames can stay the same in Git. There is no reason for the engineer to have to use a filename to describe the project state. Git tracks the difference in each commit.
- Tasks like creating and cloning repositories, committing, pushing, and pulling are fast and usually take only a few mouse clicks. The Git workflow is easy to execute.
- Git never deletes or overwrites files; historical work can always be accessed if needed. (If users accidentally remove a rung and saved the file, they can revert to an earlier version. It's like a post-save undo.)
- A persistent Internet connection is not required. Users can work locally and then push changes later. (This is helpful when making code changes on field-based devices.)

Why Git hasn't been widely adopted (yet)

As previously stated, a benefit of Git version control is tracking when files change and showing what changed. Git does this by displaying file version contents and highlighting the differences in a "diffing" process. "Diffing" is relatively fast and straightforward because most traditional software development uses text-based programming languages. In a Git "diff," red highlight indicates lines of deleted code, and green represents new added code.

Unfortunately, PLC programming evolved differently than traditional software programming. While there are some text-based languages for PLC programming, most are done in visual languages like ladder logic and function block diagrams. This problem was compounded because many PLC vendors use different binary file formats. The inability of standard Git to display these languages reduced much of its value for many controls engineers.

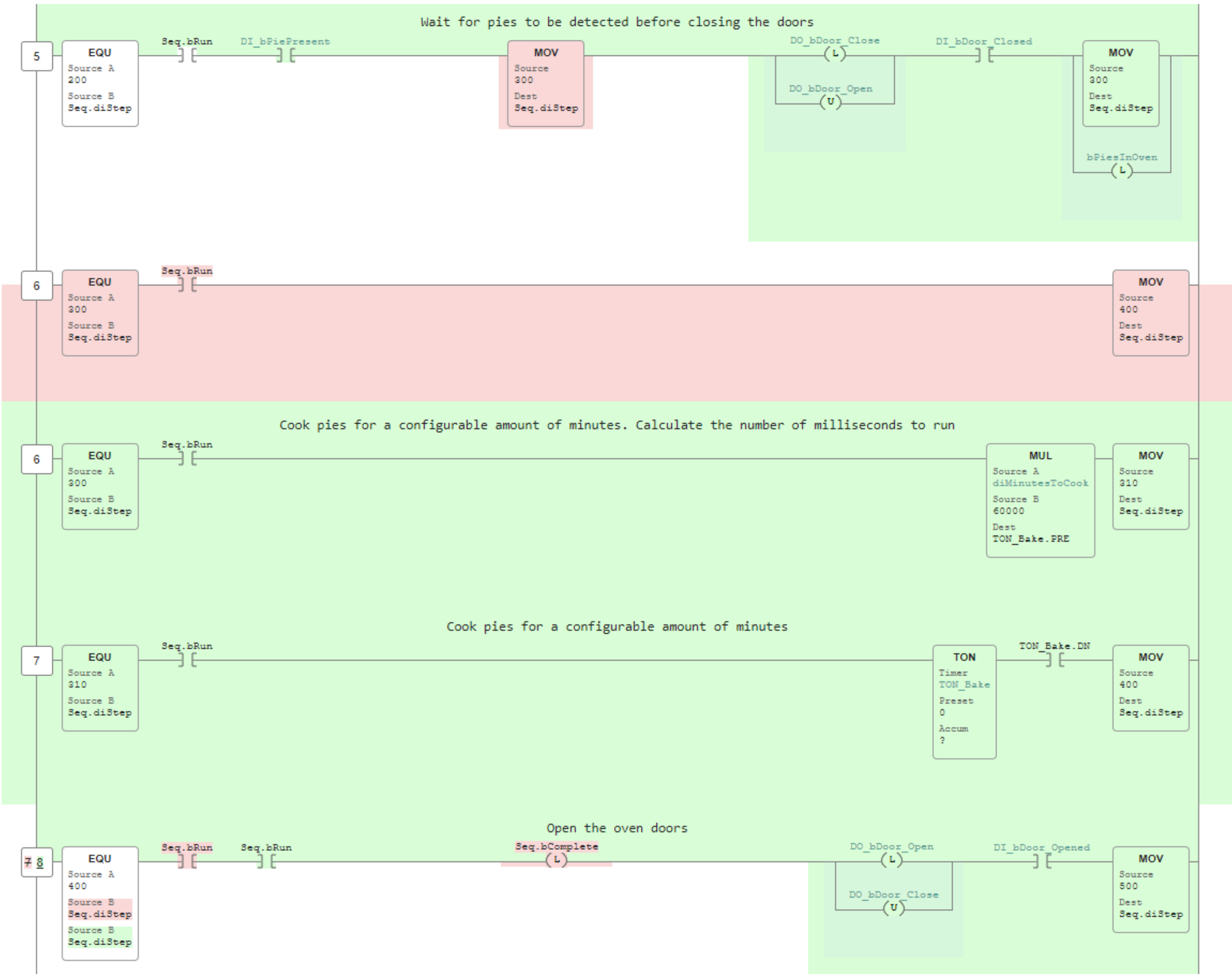
For most industrial control projects, Git can indicate when and who changed files but not how those files changed. The lack of this significant benefit has slowed Git adoption.

Modern developer tools to the rescue

Copia Automation was founded to bring modern developer tools to industrial automation professionals, unlocking the productivity gains already realized in traditional software development. They have started by solving the issue around visualizing and diffing PLC code changes when using Git-based source control.

It is essential to understand that Copia renders the PLC code in its desktop app and web browser. This capability provides freedom to automation teams and accelerates code review and discussions. Consider a junior engineer developing a section of code that controls machine safety and finishes a task late in the day. With only a web link, a manager who needs to review the code can securely log in to the Copia repository from a home computer and see the latest changes directly in a web browser (figure 3).

Figure 3. Copia visually displays changes between commits to ladder logic files. Deleted rungs are displayed in red, and additions are shown in green.



Advanced Git workflows unlock greater value

Git supports advanced workflows that add more control and improve collaboration, known as "branching and merging." An easy way to understand the concept is to envision that every development project has a main branch where the final, error-free code is stored. A parallel branch can then be created, enabling users to make changes without disturbing the main branch, then merge the changes into the master branch when complete.

One of the most powerful aspects of branching and merging is the ability for multiple developers to work on the same project simultaneously. Each developer can create individual branches, and when their work is complete, they can use the merge command to stitch their work together. Branch and merging allow users to add more engineers to a job to meet tight deadlines (figure 4).

Git version control helps businesses succeed

The primary benefits of Git-based source control are centered around employee productivity and shortening product timelines. Individuals spend less time searching for files and investigating how files differ during their lifecycle. Increased collaboration enables the business to utilize their most skilled people more efficiently, as multiple team members can work on the same project simultaneously, and senior

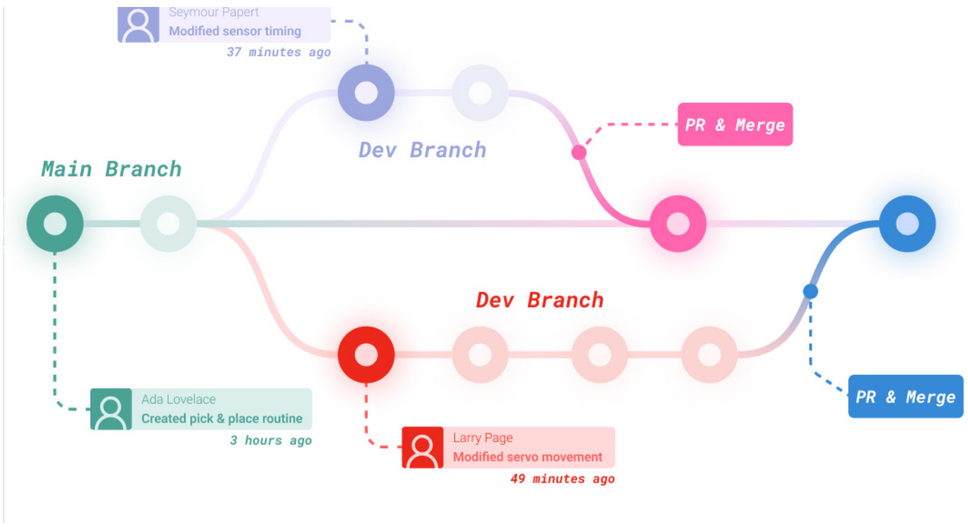


Figure 4. Development branches can exist simultaneously, allowing multiple engineers to work together on the same code. Merging can combine all work together into the main branch.

control engineers can quickly review more junior engineers' work and document feedback continuously via a web app. The time savings can be reinvested in high-value work developing innovative and high-quality code.

Additionally, a solid Git-based version control system can save a business significant budget when dealing with unexpected operational problems. If a major incident disrupts manufacturing, the last working version of the code can always be found quickly and used to restore service.

Next steps

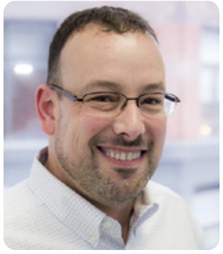
Git is the ubiquitous source control solution for software development, and its use has accelerated the speed at which code is developed and deployed. It is proven to shorten development timelines, increase quality, and maximize operational uptime.

While saving and storing code is slightly different from the traditional archive folder workflow, Git-based source control for industrial automation projects is easy to learn and worth the benefits.

Go to Automation.com for the full text of this article.

All images courtesy of Copia Automation.

ABOUT THE AUTHOR



Darren Henry is vice president of marketing at Copia Automation. With more than 20 years of experience in marketing best-in-class software products, he has a deep knowledge of manufacturing and DevOps solutions. Familiar with both startups and established companies, he has held marketing leadership roles at Atlassian, OpsGenie, Onshape, InVue, and DS SolidWorks. He has also served as an advisor to several manufacturing startups. An expert in 3-D CAD, Henry has a degree in mechanical engineering from the University of Florida.


THIS IS THE EDGE,
protected.
Adapt accordingly.

Modular 5G Cells Enable Real-time Communications

By Farhad Sharifi, congatec

Real-time capable 5G cells with integrated edge servers are a key enabling technology for digital transformation, opening a plethora of new opportunities for the Industrial Internet of Things (IIoT), Industry 4.0, and critical infrastructure applications. However, to be able to process data in real time and with low latency in harsh factory and outdoor environments, such solutions must be specially hardened. For this purpose, the world's first COM-HPC server-on-modules designed for operation outside air-conditioned data centers are now being launched into the industrial field.

> The COM-HPC server standard for developing real-time capable 5G cells with integrated edge servers is key for industrial companies' digital transformation

Digital transformation in industrial manufacturing requires fast real-time networks, yet laying cables everywhere is not always possible. The real-time-capable 5G standard is a revolution for industrial communication as it enables reliable wireless distribution and processing of massive amounts of data in real time and over longer distances than with a wireless local-area network (WLAN). Since both stationary and mobile devices can use the 5G network, connecting entire factories becomes possible.

For such use cases, 5G can manage a large density of networked devices and offers short response and latency times in the millisecond range. With network slicing, 5G also opens the possibility of creating independent virtual networks that are logically separated by a single physical network. 5G also provides the foundation for the introduction of cloud-native architectures, which—with 5G-based edge computing—become real-time-capable fog servers that can communicate wirelessly with many devices.

Private 5G infrastructures for business-critical applications

The opening of the 3.7 to 3.8 GHz frequency range to private mobile networks means that 5G can be used and privately operated by a wide variety of campus networks in Industry 4.0 environments and critical infrastructures in many other industries. The scalability of these private infrastructures and the compatibility of 5G with previous mobile communications standards, which also can be expected for future generations, also offer high investment security. More companies are establishing their own private, on-premises 5G networks to run business-critical applications and to digitalize production—a trend that is expected to intensify in the coming years, according to a recent study by MarketsandMarkets.

"To be able to run different real-time applications independently on only one edge server, users also need server balancing and server consolidation services."

Of course, companies also can use public networks. However, in rural areas where the public base station (aka macro cell) uses the 700 MHz band to achieve ranges of 15 to 20 km, the data rate is limited to 100 to 200 megabits per second (Mbps). While this is enough for a large automotive plant to supply an entire factory site—which in the case of VW in Wolfsburg covers more than 6 square kilometers—with a single 5G cell, the available bandwidth is not sufficient for a fully connected factory.

This would require the full bandwidth of the 5G data throughput capacity, which is why companies want to build their own campus networks. The 3.7 to 3.8 GHz frequency range of such networks allows maximum upstream speeds of 100 to 200 Mbps and download speeds of 200 to 1,000 Mbps. However, the cell range is limited to somewhere

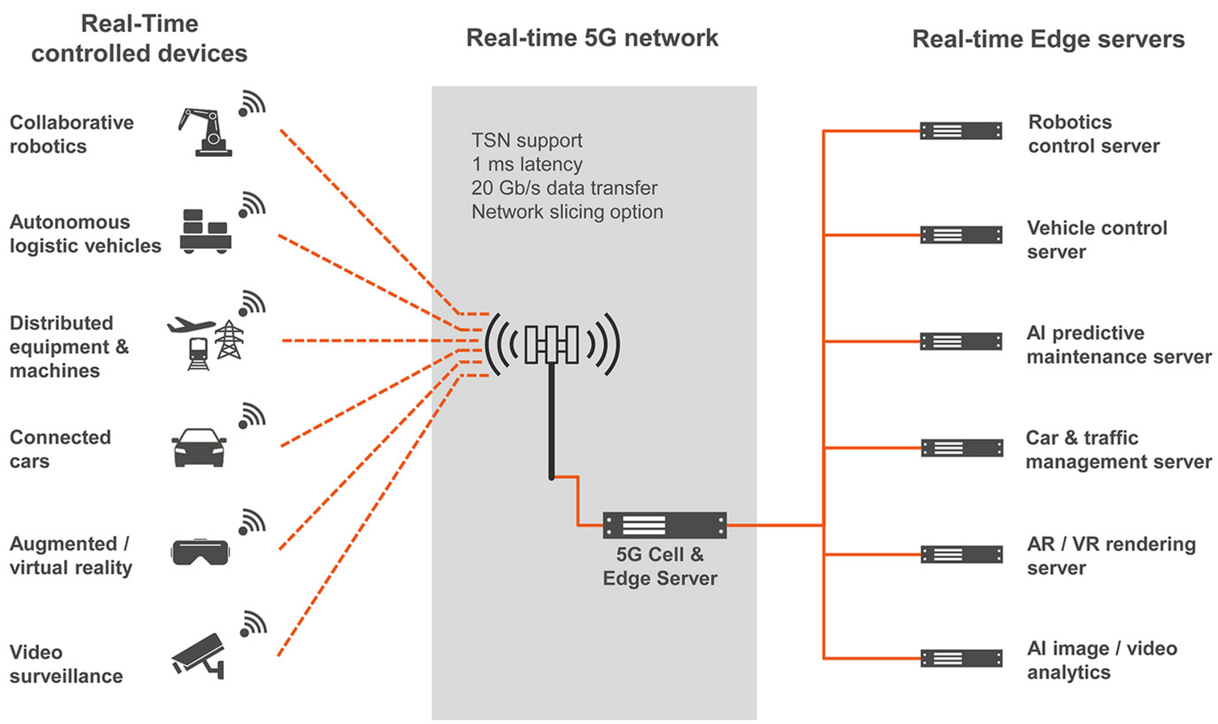


Figure 1. Industrial 5G cells can have extremely diverse tasks. Server-on-Modules, which make 5G network and edge computing performance scalable, enable OEMs to cost efficiently scale the performance of small cells that are barely larger than a pizza box.

between 300 meters and 3 kilometers with a direct line-of-sight. Therefore, plants require more than one cell. These are often highly compact so-called small cells or femtocells. Small cells are about the size of a pizza box (figure 1). Without integrated edge server technology, the even smaller femtocells are about the size of a paperback and available for private purchase.

5G edge server technology performance

In such installations, the edge server infrastructure behind the 5G microcells should ideally be provided directly in, or at the base station/radio access network (RAN), infrastructure by deploying virtual network functions (VNF). Although other deployment scenarios elsewhere in the infrastructure, such as in micro data centers, also are possible provided the latency requirements are met. The advantage of a shared hardware platform is both cloud edge server functionality and network function virtualization (NFV) can be deployed together in a centralized unit (CU).

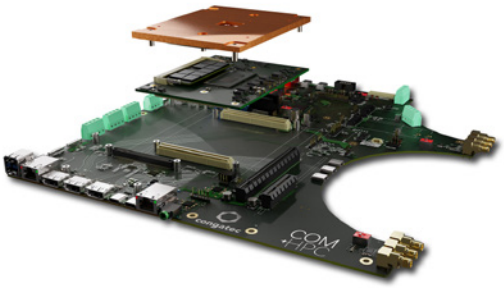


Figure 2. Custom carrier boards can even be designed for 5G cells in lamp posts.

The cells require integration of all necessary hardware to generate and process the 5G signals. This forms the physical interface between the 5G radio network and the digital baseband. In addition, the server performance required for the individual edge server functions also needs integrating. Since functions can vary from application to application, a modular design approach using server-on-modules is recommended. In this case, the application-specific functions can be realized on the carrier board (figure 2), including, for example, implementation of the 5G radio logic with appropriate expansion modules. With server-on-modules based on the PICMG COM-HPC standard and featuring the new Intel Xeon D processors, developers can gain access to a performance class that was previously unattainable for harsh environments. These rugged modules can be operated in the extended temperature range from -40 degrees C to 85 degrees C, are designed for long-term availability, and offer special protection against electromagnetic interference as well as shocks and vibrations.

To provide the necessary performance, the modules feature up to 20 cores, up to 1 TB of memory on up to 8 DRAM sockets at 2,933 megatransfers per second (MT/s), up to 47 PCIe lanes per module in total and 32 PCIe Gen 4 lanes with double throughput per lane, as well as up to 100 GbE connectivity and support for time-coordinated computing (TCC) and time-sensitive networking (TSN) to enable real-time communication between devices.

Further significant performance increases are expected in the future with the release of new modules. However, the performance available today is sufficient for current campus network designs with Open-RAN solutions using five server processors for the backhaul packet core and the midhaul CU/DU servers. These, however, require rack air conditioning and cannot be used in the extended temperature range. By consolidating these functions into a single microcell, it becomes conceivable to implement less performant but real-time-capable small 5G cells on only two virtualized modules.

Deterministic real-time applications

However, to be able to run different real-time applications independently on only one edge server, users also need server balancing and server consolidation services. Both are required as well for the platform-side support of real-time-capable virtual machines, which provide the server functionality for the communication needs of 5G subscribers. Such virtualization enables enterprises to use their private 5G networks for heterogeneous real-time applications hosted on a single server platform by using network slicing. This then allows them to allocate dedicated system resources to individual tasks and processes to ensure determinism. Server-on-modules from congatec are designed for such use cases and can be quickly modified to include the necessary parameterizations for real-time collocation services, where different applications share resources. This allows factory operators to provision real-time capable 5G edge data servers more efficiently for services such as machine automation, robot control, or automated logistics in their manufacturing facilities.

Another advantage of the modules is that they already integrate TSN natively in the processor module. If the 5G core logic also supports TSN (figure 3), the modules enable standardized data exchange and continuous, transparent communication from the sensor to the cloud, for example using OPC UA as an open real-time communication

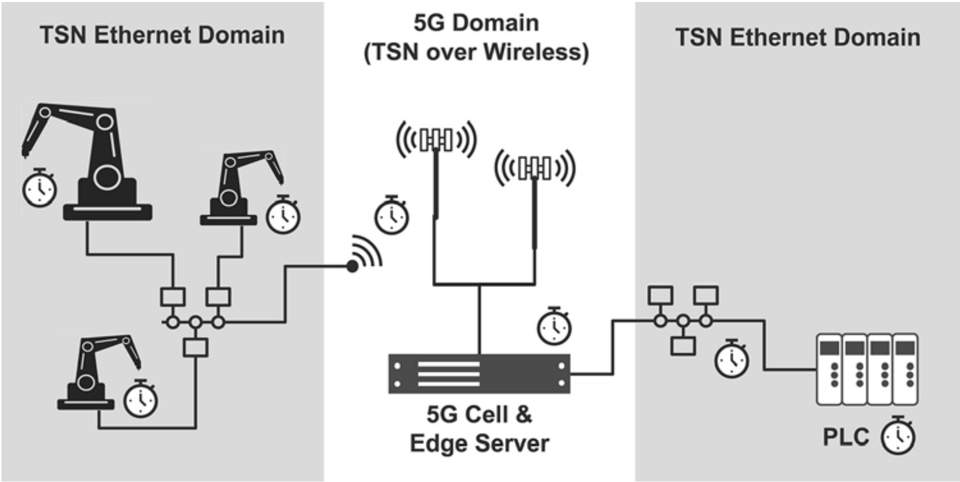


Figure 3. If 5G cells support TSN, they can host real-time applications.

protocol. The 5G Alliance for Connected Industries and Automation (5G-ACIA), a working group of the leading German manufacturers association ZVEI, is developing the necessary specifications for quality of service (QoS), network security, and TSN integration. This should even enable jitter-free isochronous real time, where communication cycle times are precisely clocked and can be synchronized in both directions from 100 µs to 2 ms.

In the future, the COM-HPC specification will be extended to include functional safety. Modules supporting this functionality could then be used as central controllers for autonomous intralogistics vehicles such as tow tugs, unit load carriers, forklifts, assembly line vehicles, pallet trucks, or to orchestrate collaborative robots. This will make it possible to provide pre-certified computer modules that make it easier and faster for customers to realize new safety applications.

COM-HPC server-on-modules for 5G microcells

COM-HPC server-on-modules revolutionize edge server design in three respects: Rugged server designs featuring the new Intel Xeon D processors can be implemented in the microcells of private 5G networks without additional air conditioning. This as well as support for the extended temperature range makes the new designs suitable for use beyond standard industrial environments, including outdoor and mobile applications in the construction industry or agriculture. The world's first COM-HPC server-on-modules provide improved performance and scalability, offering higher memory bandwidth with up to 20 cores (figure 4) and up to 8 DRAM sockets. Besides this industry first, they also enable deterministic real time in IIoT. This makes them the ideal basis for building customized 5G cells with integrated edge server technology as an all-in-one solution.

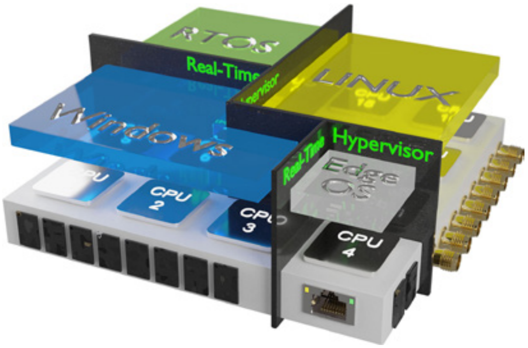


Figure 4. Server consolidation at the industrial 5G edge: Up to 20 cores can host a variety of 5G NVF and industrial real-time applications.

Server-on-modules with Intel Xeon D

Application-ready samples of the server-on-modules (figure 5) are now available including suitable rugged cooling solutions for the given processor thermal design point (TDP). On the software side, the modules come with comprehensive board support packages for Windows, Linux, and VxWorks, as well as the RTS hypervisor. Supported high core count (HCC) and low core count (LCC) flavors of the Intel Xeon D processor series include:

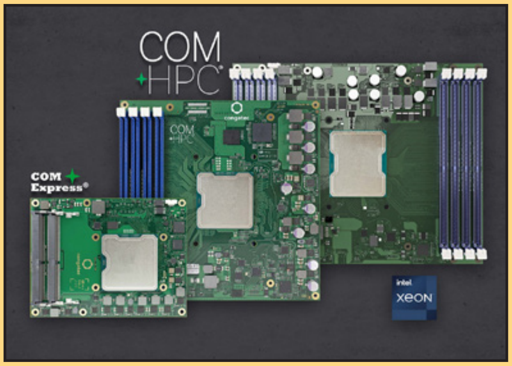


Figure 5. Application-ready samples of the server-on-modules are now available.

HCC variants

The COM-HPC Server Size E modules are offered in five different Intel Xeon D 27xx HCC processor variants with a choice of four to 20 cores, 8 DIMM sockets for up to 1 TByte of 2,933 MT/s fast DDR4 memory with ECC, 32x PCIe Gen 4 and 16x PCIe Gen 3, and 100 GbE throughput plus real-time 2.5 Gbit/s Ethernet with TSN/TCC support at a processor base power of 65-118 Watt.

LCC variants

The COM-HPC Server Size D modules as well as the traditional COM Express Type 7 modules come with five different Intel Xeon D 17xx LCC processors with a choice of four to 10 cores. While the conga B7Xl COM Express server-on-modules support up to 128 GB DDR4 2666 MT/s RAM on up to four SODIMM sockets, the conga-HPC/SILL COM-HPC Server Size D module offers four DIMM sockets for up to 256 GB 2,933 MT/s DDR4 RAM or 128 GB with ECC UDIMM RAM. Both module families offer 16x PCIe Gen 4 and 16x PCIe Gen 3 lanes. For fast networking, they provide up to 50 GbE throughput and TSN/TCC support via 2.5 Gbit/s Ethernet and 40- to 67-Watt processor power.

Looking ahead

For 5G network administrators, the new modules also offer a set of high-quality, application-specific server features: For business-critical designs, these include powerful hardware security features such as Intel Boot Guard, Intel Total Memory Encryption-Multi-Tenant (Intel TME-MT) and Intel Software Guard Extensions (Intel SGX). Comprehensive remote application server (RAS) functionalities support remote hardware management functions such as IPMI and Redfish, for which there is also a PICMG specification that ensures the interoperability of such implementations. Lastly, congatec also provides comprehensive services to help with individual system developments and customer-specific implementations. These services range from COM-HPC design training to personal integration support and compliance testing of customer-specific carrier board designs.

All images courtesy of congatec.

About congatec

congatec is a rapidly growing technology company focusing on embedded and edge computing products and services. The high-performance computer modules are used in a wide range of applications and devices in industrial automation, medical technology, transportation, telecommunications, and many other verticals. Backed by controlling shareholder DBAG Fund VIII, a German midmarket fund focusing on growing industrial businesses, congatec has the financing and M&A experience to take advantage of these expanding market opportunities. congatec is the global market leader in the computer-on-modules segment with an excellent customer base from startups to international blue-chip companies. More information is available at www.congatec.com or via LinkedIn, Twitter and YouTube.

ABOUT THE AUTHOR

Farhad Sharifi (Farhad.Sharifi@congatec.com) is general manager of congatec Americas. He has more than 26 years of experience in embedded computing having worked with several leading embedded computing companies. He has a BS in electrical and computer engineering from San Diego State University.

Pandemic Era Lessons Bolster Global Snack Food Maker

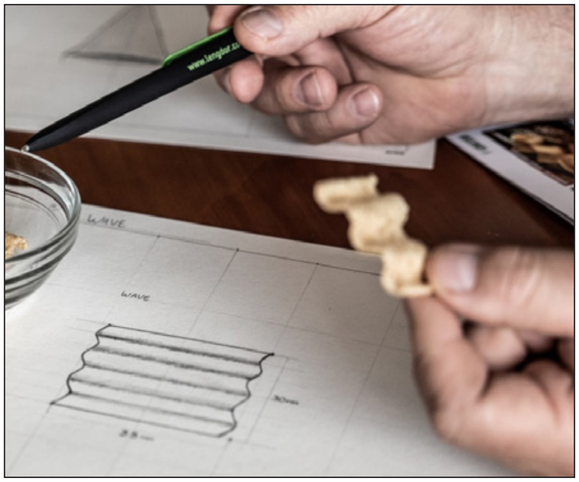
Network security and real-time collaboration supported by advanced technologies ensures productivity.

By Jack Smith, Automation.com

Leng-d'Or, with headquarters in Barcelona, Spain, is a family-run multinational food manufacturing company that makes "snack pellets" for third parties who manufacture a wide range of crunchy snack foods. It has 300 employees spread across Spain, the U.S., Singapore, and Brazil supplying about 800 customers, 80 percent of whom are outside of Spain.

The company continually makes investments in R&D and tries to introduce innovation in all sectors of the organization. Its information technology (IT) department provides the technology infrastructure required to guarantee robustness and security, helping the company produce 24 hours a day, 365 days a year, and drive compliance with industry standards.

The COVID-19 pandemic impacted the global economy at every level, and food producers in particular saw supply chain woes that threatened raw materials such as corn and flour. This forced researchers to seek new ways to update recipes and change formulas.



Leng-d'Or makes "snack pellets" for third parties who manufacture a wide range of crunchy snack foods.

In addition, even though the company would send its Spanish scientists to its U.S. facilities several times a year to collaborate and develop new processes, pandemic restrictions meant that researchers could no longer travel to perform product and process testing. Visibility into the production line, processes, and vital manufacturing machines was blocked. But skilled leadership and a close partnership with Cisco brought advanced technologies into quick and secure use.

According to Enric Cuixeres, Head of Information Technology at Leng-d'Or, travel was the initial problem resulting from the pandemic. "We could not travel to the United States because the American government closed its borders [to travel]," Cuixeres said. "We could not travel and develop new products. The pandemic hit Europe before it hit the U.S. In 2020, we had a very strong lockdown. Our headquarters is in Barcelona, and our research team works here. But we have two big facilities in the U.S. One of the biggest snack facilities in the world is in New Jersey."

"Visibility into the production line, processes, and vital manufacturing machines was blocked, but skilled leadership and a close partnership with Cisco brought advanced technologies into quick and secure use."

Downtime of a network or security breach could mean production downtime and the loss of tens of thousands of dollars per hour for Leng-d'Or; it can be that or more for other major manufacturers. Five to eight hours of downtime could be more expensive than investing in a reliable security landscape. So, manufacturing companies are now starting to realize that, rather than network security being a cost center, it's a cost-avoidance strategy.

Partners for advanced tech

Driven by the need for quality, security, innovation, and globalization, Leng-d'Or partnered with Cisco to meet its core values. In short, "The cost reduction in travel and time, as well as the increase in productivity associated with the project, was remarkable," Cuixeres said. Now that they are able to again, Leng d'Or is traveling 30-40% less than they were pre-pandemic, thanks to the collaboration solutions.

From its headquarters in Spain, Leng-d'Or was also able to collaborate with its U.S. counterparts in real time through the Webex app and Expert on Demand, securely exchanging drawings and formulas.

Cisco used these advanced technologies in the project:

- The snack-food maker tapped Webex Expert on Demand for RealWear headsets, and Cisco Meraki for smart cameras and sensors to allow it to make real-time changes to machines—from a different continent. The technology also helps close the knowledge gap by connecting workers from the factory floor to experts at other locations, while keeping their hands free to work instead of holding a smartphone or tablet.
- Using Cisco SecureX cloud technology, Leng-d'Or was able to deploy an end-to-end security solution that spanned its network, cloud, email, and endpoints to keep the company running as its international supply chain went remote.
- From its headquarters in Spain, Leng-d'Or was also able to collaborate with its U.S. counterparts in real time through the Webex app and Expert on Demand, securely exchanging drawings and formulas.

Using the integration between RealWear, Cisco Meraki Vision, and a personal WebEx meeting room enabled the company to keep developing and testing products every day, even through lockdowns and travel restrictions. “It was a good thing for us because without this kind of technology, we could not develop new products in the U.S.—and it’s better for us to develop in the U.S. for patent reasons,” said Cuixeres. “We are developing new products and flavors and testing new packaging every day.”

Manufacturing companies are now starting to realize that, rather than network security being a cost center, it’s a cost-avoidance strategy.

Webex Expert on Demand is connecting geographically dispersed teams with equipment to achieve improved productivity and higher first-time fix rates while reducing physical travel, Cuixeres said. “A few months before the final lockdown, we bought the RealWear solution and integrated it using the Cisco Webex Expert on Demand add-on into our WebEx landscape. Our employees had been using Webex naturally as a system for the teams,” he explained.

“When our team was concerned with the U.S. closing its borders due to the pandemic, we sent the RealWear tool into our facility in the States,” continued Cuixeres. “We also use this augmented reality technology with our Meraki camera. With two cams and the RealWear solution, we could continuously develop our products without traveling.”

Network security also delivers uptime

The Cisco SecureX cloud technology supported all this productivity-enhancing advanced tech with comprehensive end-to-end physical and cyber security. Leng-d’Or had suffered several cyber-attacks in the past, according to Cuixeres.

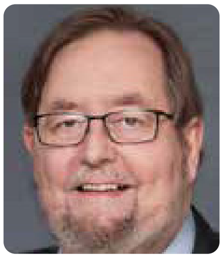
"If email domains are used to launch attacks, it could undermine that trust that took the company many years to establish," Cuixeres added. "It's a problem that can potentially affect every manufacturer. So we increased the attention we paid to protecting emails, as well as protecting the entire production process."

The company did not allow the COVID-19 pandemic and the resulting cybersecurity issues disrupt its workforce. The SecureX solution spanned its network, cloud, email, and endpoints to keep the company running as its international supply chain went remote. The employed solutions allowed Leng-d'Or to detect threats up to 90 percent faster.

"For us, the security and the compliance are a must because the trust between our customers and us as a company is one of the most important things," Cuixeres said. "Leng-d'Or reduced the time to detect threats by 90 percent, thanks to the 'single pane of glass' provided by Cisco SecureX. During a one-week period, there were between two and five confirmed threats blocked. Along with that, between four and six malicious URLs from inbound email were blocked, and as many as four malicious URLs from the Cisco Umbrella virtual appliance or roaming client were blocked during the same period with Cisco SecureX."

According to Cuixeres, during the pandemic, "our work would have come to a complete stop without Cisco technology. Developing a new product is a team job. A lot of people from different areas must come together. SecureX allowed us to collaborate across borders during COVID and know that we were doing so securely. Thanks to that, our business continued, uninterrupted."

ABOUT THE AUTHOR



Jack Smith (jsmith@automation.com) is a contributing editor for Automation.com and ISA's *InTech* magazine. He spent more than 20 years working in industry—from electrical power generation to instrumentation and control, to automation, and from electronic communications to computers—and has been a trade journalist for 22 years.