Four of a Kind: The Kings of Control

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Level Applications from the Dark Side—How to Handle the Toughest Measurements www.controlglobal.com/1302_DarkSide.html

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The Automation State

In this issue, we premiere the Automation Index by ARC Advisory Group. This exclusive-to-Control tool is a way for us all to see, not the health of the economy in general—that is what the Dow Jones and the S&P and NASDAQ and the other indices around the world are for—but the health of the automation industry specifically.

This index is developed on a quarterly basis by the analysts at ARC Advisory Group and was formerly reserved for their paying customers. As a part of the ongoing alliance between ARC and Control, we are pleased to bring it to you for the first time. We will bring the Automation Index to you four times a year to help supplement the information in the Control/ARC Top 50 report that we publish every December.

The Automation Index takes the pulse of the process industries, and since we are all employed in either the process industries or the automation companies that serve them, that pulse is extremely important to us all. When the economy is going downhill, the process automation industry lags the economy by nearly a year—the effects of the 2008 recession weren’t really felt until 2009. But the automation industry is on a shorter cycle than the economy. We began to see the effects of the recovery about six to eight months earlier by looking at new or revived automation projects.

If you work in the process industries, the Automation Index can tell you a lot about the possible future of your job and your company’s performance in the marketplace.

This is another example of the continuing tightness of the integration between control systems and the business systems. Automation practitioners, as the late Vernon Trevethan pointed out when he led the development of the Certified Automation Practitioner (CAP) certification program for ISA, need to be skilled in a large number of disparate disciplines, especially on the business side.

It is increasingly difficult to gain funding for automation projects “because it is cool” or because the vendor released a new version. The time for that is long past. The way you get an automation project funded is to make a business case for it in terms of productivity or additional flexibility or increased integration between the plant floor and the business systems. In other words, you have to show how you plan to pay for it.

In addition, you’re going to be competing with other cash-intensive capital projects, such as, oh, repaving the parking lot or putting a new roof on the plant office building. These days, many management staffs do not see the difference between upgrading the control system and doing other capital maintenance projects. Your management needs to be shown that if you repave the parking lot, you don’t get any ongoing payback, but if the control system is upgraded or new sensors and control loops are installed, the payback can be quick and extensive. You need to show how you can do better with fewer people through having a better control system, and show how that will quickly pay, both in increased throughput and in increased profitability. You will also have to show how the project benefits the enterprise at large.

These are very different goals from the goals process automation professionals had when Control was founded a generation ago. As I said in the Readers’ Choice Award article in last month’s magazine (http://www.controlglobal.com/articles/2013/nice-ice-readers-choice-awards.html), there are many differences between the way we worked back then and the way we work now, and even into the future. Our successors will do jobs that are very different than the ones we do now. Our jobs are changing, and we have to change with them.
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Championship Season

It’s that time of the year again. Awards and championships are on everyone’s mind. As of this writing, we’re counting down to the Super Bowl. The cover story of this month’s Control features four more people elected to the Process Automation Hall of Fame. The Academy Awards are also in the offing, and there are hundreds, if not thousands of other smaller contests and award ceremonies going on all over the country.

The date circled in red on my calendar was January 28. That’s the deadline for submitting items for the Azbees—the journalism awards offered by the American Society of Business Press Editors (www.ASBPE.org). It’s not a big deal to anyone who doesn’t work in the trade press, but to us insiders, it’s important. Magazines as well-known as Computerworld and as little-known as Scrap submit items to be judged by a jury of our peers.

Control has won its share of Azbees for editorial and design work. You can sample some of our award-winning entries at ControlGlobal.com.


In addition, 2010 was the year Control was named one of the 10 Best Magazines of the year.


Are we proud of the work we’ve done in the past? You betcha. It keeps us motivated to keep up the good work, and more important, to continue to provide information that is useful to you.
Thoughts on “Without Wires”


I agree that in a vast majority of applications, wireless is not used in place of wires. Wireless is used instead of doing nothing at all or doing it manually. For instance, today essential assets have no health monitoring. Wireless enables essential asset monitoring for heat exchangers, pumps, fan fin coolers, blowers, etc.

Wireless also enables energy conservation measures such as steam trap monitoring and sub-metering of steam and chilled water for cost accounting. It enables health, safety and environmental (HS&E) improvement by liberating field operators from checking well heads and walking the plant reading gauges, variable-area flowmeters, sight glasses, using dipsticks and collecting grab samples, as well as eliminating maintenance rounds with portable vibration testers and temperature guns, etc.

All these applications are “beyond the P&ID.” That is to say, site modernization beyond the P&ID is the “killer app” for wireless. In an existing plant, all that is wired remains wired, but everything which is not automated (and therefore not on the P&ID) can be covered using wireless. A wireless mesh network can be deployed in an existing plant with minimal risk because you install a single gateway at the edge of the plant unit. With a full-mesh topology, nothing has to be installed inside the plant unit itself. A full-mesh minimizes risk.

This compares favorably to star-backbone topology, which requires multiple backbone routers to be installed throughout the plant and which need to be wired up with the backbone and hazardous area power. This has a greater risk of damage to the existing plant. Note that a “full mesh” is required to eliminate the backbone routers, with devices supporting multi-path mesh routing with up to seven hops or more. Just two to four hops will not be sufficient—backbone routers would still be required.

Yes, WirelessHART is the leading wireless protocol. It leads because it was designed specifically to meet user needs gathered at the start of the project, such as those in the NAMUR NE124 specification, and later verified by NAMUR at the BASF plant in Ludwigshafen, Germany. These needs include availability and reliability, real-time capability, security, coexistence, certified interoperability and interchangeability, easy integration in DCS, version and lifecycle management, long battery life, and use of existing, familiar tools for commissioning and maintenance.

Unlike Foundation fieldbus, where the technology is adopted wholesale throughout the entire plant in a new project, we will not see a totally wireless plant for a long time yet. This doesn’t mean that the thousands of sites where WirelessHART has already been deployed are trials (or kicking the tires). Rather, WirelessHART is deployed in existing plants which were fully automated years ago by yesteryear’s definition of fully automated. These plants can, using wireless, enable lots more automation for essential asset monitoring, energy conservation measures, and to improve HS&E.

This is how WirelessHART is solving real plant problems today, and it is a great success by any measure. Some sites have hundreds of wireless transmitters. Other plants can benefit from following these same applications. When these old plants were built, automation was very expensive because of the high cost of I/O cards and running wires for 4-20 mA and on/off signals. Today, automation is lower cost thanks to wireless, and it can be added in an existing plant with much lower risk than running wires.

JONAS BERGE
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The Improved ARC Automation Index

There are many sources of data that can be used to drive your strategic decisions, but understand that your decisions are only as good as the data on which they are based. Common sense, no? You are reading this publication, an excellent source of data. Some of it is vendor-supplied; some of it is delivered through the personal experiences of others or of editors. You will also turn to your own internal sources, acquiring regional opinions, staff opinions and, perhaps, consulting industry peers.

The data you collect needs to be tested for accuracy, bias and fit for purpose. Then there is the problem of reliable and repeatable data to guide your decisions on an ongoing basis. This is especially hard to come by, as few have the incentive to create metrics on an ongoing basis.

Your sources for data will typically include items like the Purchasing Managers Index (PMI), stock market indices, various stock tickers, GDP data, employment data, the Consumer Price Index (CPI), currency rates, trade balances and commodity prices. The challenge comes in interpreting these indicators and relating them to your particular business. Markets, such as the Automation Marketplace, may or may not track these indices in ways that are clear and intuitive. So the challenge remains: Where to get relevant and accurate data on which to base your strategic decisions?

ARC Advisory Group delivers a number of reports designed to give you market data. These reports will be highlighted quarterly, through an exclusive relationship with Control and ControlGlobal.com. These reports are the Automation Index Quarterly, Enterprise Market Quarterly, Automation Market Quarterly and the Capital Expenditures Annual Report. All of these reports offer intelligence and metrics on industry.

The ARC Automation Index
ARC developed its quarterly automation
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index to summarize the current state of automation markets, to enable participants to learn from past developments and to provide a forecast based on major variables such as investment, consumer spending, GDP and other leading economic indicators. ARC bases its index on the publicly available data of major automation companies, including published revenues. Each vendor is included within its region of origin. Extreme values, such as those resulting from acquisitions, are excluded, and all raw data is seasonally adjusted. Seasonal changes in financial reports are frequent, due to incentive structures and are usually strong in the last quarter of a fiscal year.

Each quarter, the report highlights the status of the global market and those in North America, Europe and Asia. The global index and the forecast show the concerns around the debt crisis and fiscal cliff (Figure 1). This data was originally published back in November 2012. Clearly, legislation has helped to avert that scenario, and it would appear the index will continue to improve through 2013.

Looking regionally, another chart offered in the report (Figure 2) highlights the worldwide trend for automation markets, along with those in the Americas, Europe and Asia. In this chart, we see the Americas leading in growth over the same time a year ago, followed by Asia and then Europe. We expect to see a positive growth in America’s economy, while both Asia and Europe will show a decline before recovery. The ARC Report goes into much more detail and supports the graphs with a significant analysis.

The report says, “The situation in North America is currently brighter than previously anticipated as the recovery continues. Currently, political uncertainty with respect to the U.S. fiscal cliff causes many businesses to delay investment. However, ARC expects the uncertainty from this factor to be short-lived. The U.S. government has announced plans to support manufacturing, which promises to be a more sustainable, yet slower growing sector than finance, insurance and real estate. These plans for a manufacturing renaissance are likely to drive North American automation growth in the long run.

“Europe, the current trouble spot, is developing in two directions. The Eurozone core has capital available, and automation markets benefited from investments in 2010 and 2011. This is not the case in the Eurozone periphery, where the overall debt of states and banks currently amounts to €12,000 billion [debt of €9,200 billion of banks and €3,340 billion excluding an overlaps (source: Ifo Institute)], and economies are suffering under austerity packages. It’s likely that the pure size of this debt will ultimately require creditors to take a significant loss themselves and depreciate their books accordingly. Currently, a shortage of new orders and low capacity utilization point to a rocky road ahead for European automation markets.

“In Asia, the slowdown in Chinese GDP development to below 7% challenges the region as China is an increasing importer of goods and services and a growth engine for the entire region. This slowdown impacts automation companies especially hard, as it is accompanied by a more drastic cut in automation-related investments due to earlier overinvestment in selected industries leading to overcapacities.”

Industry-specific market and economic data and analysis is available. This is a small sample of the data available in the ARC Automation Index report, which typically delivers over 25 pages of facts, figures and qualitative analysis. For more information including prices, visit www.arcweb.com.
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Contemplating Couplers, Part 1

Why do we like two-wire buses? Aside from providing power and communications to as many as 32 devices over the same twisted pair, we get to originate all that bus power in a nice climate-controlled rack room. The bus power can easily be made redundant, the bulk DC power is nearly always redundant, and our bulk supplies in turn are fed by one or two UPS systems. With a few simple alarms to alert the crew to any individual component that becomes compromised, it’s an easy and familiar formula for high availability that’s hard to beat.

Before 1999, early adopters seeking to apply fieldbus had few choices beyond ordinary terminal blocks. Terminal blocks of all types would all be perfectly acceptable for two-wire buses such as Profinet PA and Foundation fieldbus (FF). Unlike Ethernet, which requires independently powered, active devices such as hubs or switches at every junction or branch of its network, process fieldbuses share the same two conductors, with no requirement for intervening circuitry or silicon. With the majority of field devices largely deriving their power from the same pair of conductors, this makes two-wire buses such as FF and PA natural choices for the process industries, where the reward for high availability is extraordinary.

A minority of users employ simple terminals for two-wire fieldbus because a short circuit anywhere in the network causes every device on the bus—as many as 32—to lose power and communications and revert to its “shelf” state. While some buses have enough intelligence to accommodate some “graceful degradation” when a device unexpectedly powers down and ceases to function, there’s nothing graceful about a control valve or other final element going to its fail position—which is where it goes on loss of two-wire power. When one or two or more control valves are suddenly traveling to their fail positions and perhaps remaining there for a minute or more, it’s likely to have some immediate and unhappy effects on the reliability and productivity of the process.

In most cases, this is a self-inflicted injury, as when a technician or electrician is servicing a device or adding devices to an existing segment. So it can be argued that a well-trained and disciplined workforce can effectively avoid the consequences. But the traditions and habits from decades of 4-20 mA, as well as the uncertainties of succession in our craft workforce, makes us desire an engineered bit of insurance.

Enter the coupler.

The purpose of a coupler, aside from being a handy gadget for landing the segment’s trunk and spurs, is to imbue the segment with this engineered layer of fault tolerance. Incidently, every coupler listed on the fieldbus.org site works equally well on both FF and Profinet PA networks. The circuitry on the coupler ensures that if a short circuit occurs on any spur, it is prevented from causing the other devices on the segment from failing. They cost a bit more than simple terminals, but the installed cost is still low compared to point-to-point wiring.

As an added benefit, by engineering a current-limiting circuit into spurs, the couplers also provide hazardous-area capability for the installation. Most vendors offer versions that are third-party certified to meet the requirements for NEC non-incendive wiring or various levels of intrinsic safety.

The fieldbus.org site lists 15 couplers that have passed testing and earned a fieldbus “checkmark” for conforming to the foundation’s requirements. So, are they all equal commodities that can be specified and procured on the basis of cost only? It’s interesting that, even on the relatively passive level of fieldbus couplers, distinctions can be significant. From the compact and spartan Cobalt CDC8 (www.cobaltprocess.com) to the clever, redundant-trunk capable offerings of MooreHawke Trunksafe (http://miinet.com), features that address differing priorities, practices and tastes are worth examining. Next month, we’ll survey these offerings.
Plan Ahead for Wireless Success

If you don’t know what you want prior to implementing a project, how will you be able to define success? The folks at BASF in Freeport, Texas, defined success and determined exactly what they wanted by finding out what they had, what they needed, and how they would get from A to B using a planned approach from the beginning.

The Freeport project is a big one that demonstrates that wireless can work in big installations, as well as pilot-size tests. It required the installation of the appropriate backhaul network—in BASF’s case, an IEEE802.11 system for a site-wide wireless suite of applications.

The company wanted to implement a new approach for perimeter security, condition monitoring and workforce mobility using open, license-free wireless technologies, and to deliver the services in a reliable, secure fashion without negatively affecting its neighbors or other site operations.

Chris Witte, site manager at BASF Freeport, explains, “We did not want to create various individual, ‘one-off’ systems—a common mistake when implementing new technology in a phased approach. So we started our wireless initiative with a thorough site analysis and a well-developed plan prior to implementation.”

The project began with Apprion’s (www.apprion.com) team of wireless and industrial experts conducting an on-site survey to develop a plan outlining the required network to support the identified list of application projects. As part of the data gathering and planning, performance measurements, including area coverage and network connectivity, were performed within each zone of the plant.

Using the on-site survey and resulting plan, which included comprehensive radio frequency (RF) spectrum analysis, various grid simulation output scenarios with signal power levels, as well as a technical evaluation of the site’s existing infrastructure and technology, the team was able to determine the proper placement of RF transceivers and network devices that would comprise a facility-wide wireless infrastructure.

The Apprion ION 802.11 industrial Wi-Fi access points were positioned at key locations throughout the plant in anticipation of the future, facility-wide, wireless infrastructure and applications, including backhaul for gate readers, condition monitoring, remote operator handheld devices, plant communications and video applications. These radios/gateways are part of the industrial wireless Apprion ION system that supports a wide range of devices, vendors and protocols.

The ION access points contain two 802.11 radios and two industrial Ethernet ports (10/100), and can be powered by 48VDC PoE (using power injectors), 24-VDC or AC power. Security features include wireless network intrusion detection (WNIDS), rogue access point detection, SSH brute force attack detection, QoS for concurrent applications and real-time policy enforcement. When BASF is ready to implement field level networks, they will be integrated into this backhaul system.

In addition to knowing where you want to go, you’ve got to know what you already have before you can figure out what else you need. So take the time to identify your requirements and potential challenges, including possible wireless dead zones or interferences.

Developing a proper plan will increase your chances of success. It will prevent dumping blame on the technology being implemented rather than on poor engineering design and planning, and it will counter the trend of resistance to using wireless and help accelerate the adoption of wireless technology in the process plant environment.
Using wireless here and there is one thing. But using it across my entire operation? There’s no one I could trust to do that.

See more, do more and be more profitable with the most trusted partner in wireless — Emerson. Emerson is your proven partner with Smart Wireless in more customer sites and with more operating hours than anyone else in the process industry. Smart Wireless has the widest range of technologies to expand your vision into more places across your operations. And its self-organizing mesh network delivers the highest reliability available. It is simply the most intelligent, secure and cost-effective operation-wide wireless option available. See how Smart Wireless can empower your bottom line at EmersonProcess.com/SmartWireless

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The Fieldbus Foundation has released the latest version of the H1 Interoperability Test Kit (ITK) 6.1.0. This tool tests the functionality of an H1 (31.25 kbps) fieldbus device and its conformity with the foundation’s function block and transducer block specifications. Version 6.1.0 includes new features to enhance device intelligence, improve consistency in instrument configuration and simplify replacement of field devices from different automation suppliers. H1 ITK consists of a test engine, communication stack and function block interface card. It includes all hardware and software required to ensure complete device interoperability.

H1 ITK 6.1.0 builds on the extensive library of Foundation fieldbus block test cases, offering a series of standardized function blocks and transducer blocks that enable increased test coverage for device developers. This includes test cases for new blocks that were previously unavailable, such as flow totalizer, analog alarm, control selector and output splitter, which support expanded device applications for control-in-the-field (CIF). A new flow transducer block is intended to simplify device integration within Foundation fieldbus networks. In addition, the release provides updated test cases for existing blocks, including flow, pressure, temperature, analog positioner and discrete positioner.

New H1 ITK test cases are focused on backward compatibility among Foundation fieldbus devices. This enhancement supports device replacement automation, and enables the test kit to verify consistent behavior between device and host implementations in fieldbus-based control systems. Automation of device replacement allows the configuration in an existing field device to be restored in a newer version of that instrument without manual intervention. This plug-and-play solution ensures features are consistent between different generations of devices without reengineering the host configuration or changing any other element of the H1 network other than the new instrument. The use of common transducer blocks also improves interoperability, and simplifies device replacement by enabling a minimum level of configuration across all types of instruments. This results in greater predictability in fieldbus implementation, while reducing integration risks.

H1 ITK 6.1.0 is available to members holding active maintenance agreements and for new purchases. For more information, visit www.fieldbus.org.

Metso Buys ExperTune

Metso (www.metso.com) has acquired U.S. software company ExperTune Inc. (www.expertune.com). ExperTune’s products are software tools used to analyze and monitor the performance of industrial processes, and identify associated maintenance and improvement opportunities.

ExperTune’s acquisition is in line with Metso’s strategy to grow the scope of its services business globally. The acquisition expands and strengthens Metso’s ability to globally provide business-enhancing services to customers. ExperTune’s products will be sold as standalone solutions that can be used in any automation system environment and as part of Metso’s performance business solutions, targeted to optimize plant performance.

“the combination of ExperTune’s products and Metso’s services portfolio extends our capability to offer solutions targeted to improving process and business performance,” says Mikko Keto, president of services at Metso Automation. “With ExperTune we can provide more versatile and cost-effective customer value solutions to our customers, so they can meet their most pressing business challenges, such as reducing raw material consumption, energy use, product variability and environmental impact. ExperTune’s products help our customers find areas of improvement in their processes for which Metso has customer value solutions.”

ExperTune is headquartered in Milwaukee, Wis. Its products include PlantTriage, ProcessApex and PID Loop Optimizer. It will be integrated into Metso’s the automation services business.
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Workforce Safety Is Top Priority for Mining Companies

According to the third annual Mining Executive Insights survey by Ventyx (www.ventyx.com), an ABB company, worker safety and managing capital projects are the highest priorities of today’s mining executives, followed closely by maximizing production effectiveness.

Completed in late 2012, the survey represents the views of 374 mining companies with operations in virtually every world market. The majority of respondents were C-level executives, vice presidents or directors across the full spectrum of mining sectors, including coal, gold, copper, iron ore, zinc and nickel.

When asked to identify their current priorities by level of importance, 31% said workforce safety was most important, while 25% named managing capital projects, and 21% said maximizing production effectiveness was their top priority.

Ensuring reliable and predictable operation of equipment trailed at 8%.

“Our research shows the mining industry remains cautious about the strength of global economic recovery. In response, many mining organizations have begun looking inward, especially in regard to the labor market. In doing so, they have shifted their focus from finding qualified workers anywhere, at any cost, to ensuring the workforce they currently have is efficient, well-informed and safe,” says Bas Mutsaers, senior vice president of Mining Industry Solutions at Ventyx.

“At the same time, these companies aren’t seeing a tradeoff between worker safety and profitability. In other words, the same technologies and best practices that improve safety also improve performance and efficiency,” he adds.

The study demonstrated how closely mining executives correlate worker safety and mine productivity. When asked to identify their primary safety initiatives, 64% of respondents selected “development of skills, best work practices and situation-based decision-making.”

“As companies equip their workforces with new technologies, such as mobility solutions that enable faster access to information regardless of location, they’re finding they can change their traditional approach to training and skill development,” says Mutsaers. “There is definitely an opportunity for mining organizations to leverage emerging technologies to transform how they educate and empower their workers to reduce safety incidents and improve efficiencies. By delivering on-demand information to the point of work, for example, new mobility solutions can reduce the need to train workers for every possible situation, while equipping them to make better on-the-spot decisions.”

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New Solutions to Boost CC-Link Device Development

The CC-Link Partner Association (CLPA, www.cclinka-merca.org) has announced new product solutions designed to lower the cost and to speed development of CC-Link-compatible field devices, including solutions for the 1 GB Industrial Ethernet CC-Link IE Field Network.

Renesas Electronics Corp. (http://am.renesas.com) has developed the R-IN32M3 series of Industrial Ethernet communication chips with support for multiple communication protocols. These application-specific standard ICs (ASSPs) provide high-speed operation with the basic function of the real-time OS in hardware to implement high-speed real-time response and high-precision communication control for industrial Ethernet communication.

Likewise, Altima Corp.’s (www.altima.co.jp) intellectual property (IP) core for CC-Link IE Field is designed for implementation in field-programmable gate arrays (FPGA) manufactured by Altera Corp. (www.altera.com) in the United States.

Altera’s FPGAs are widely used in the industrial equipment field. This Altima IP core is the equivalent of the CP220 CC-Link IE Field intelligent device station ASIC. It supports both cyclic and transient data exchange. Developers can now integrate this Altima IP and their own design IP into one Altera FPGA to produce unique products with CC-Link IE Field networking compatibility. Altima plans to begin selling the IP core in March.

CC-Link IE Field Network, based on the IEEE 802.3 standard, provides an ultra-high-speed data acquisition backbone for manufacturing process improvement, process and part traceability, equipment control and monitoring, and failure detection.

Introduced in 2000 as an open fieldbus network, the original CC-Link enabled high-speed transmission and processing of control and information data to satisfy the requirements of automation control systems. In 2007, the CC-Link IE Control Network was introduced to enable 1-GB industrial Ethernet communications between automation controllers over fiber-optic cable. Now, CC-Link IE Field networking provides 1-GB industrial Ethernet communications to field devices over Cat5E cable.

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**GUIDE TO POWER SYSTEMS PROTECTION**

This 51-page PDF produced by IDC and Control covers concepts that are important and useful to engineers, scientists and technicians, independent of discipline. The substation automation system consists of intelligent electronic devices (IEDs), microprocessor-based relays and/or remote terminal units (RTUs). PLCs also continue to play an important role in some systems. They receive analog inputs from current transformers (CTs), voltage transformers (VTs) and transducers in various switchgear panels, as well as digital inputs from auxiliary contacts, other field devices or IEDs, or the SCADA master. They are able to perform complex logical and mathematical calculations, and provide an output either to the SCADA Master, other field instruments or IEDs, or back to the switchgear to perform some command, for example open a circuit breaker.

This handbook covers power quality and how to maintain it, electrical protection of power systems and power substations. The booklet is free and downloadable, but registration is required. The direct link is at http://tinyurl.com/ae4gnrd3.

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This white paper discusses ways to control and reduce these dangerous harmonics. This paper is free with registration and downloadable at www.controlglobal.com/whitepapers/20135.html.
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Four of a Kind:
The Kings of Control

Four Automation Leaders as Varied as the Suits in a Deck of Cards
By Walt Boyes
Every year, the previous inductees of the Process Automation Hall of Fame nominate and elect the next year’s class of inductees. This fall, an excellent slate of candidates were nominated, and as sometimes happens, we had a tie for third place. So we’ll be inducting four new automation heroes instead of three.

Something usually ties these disparate automation leaders together. In the case of three of them, Peter Martin, Ian Verhappen and John MacGregor, they all played hockey as young men and in later life. But the fourth member of the class of 2013, Dennis Brandl, said, “I played hooky in high school and college, not hockey.” He went on to admit being a strong fan of the NHL franchise, the Carolina Hurricanes, however.

So maybe the intensity, discipline and teamwork required from hockey (and perhaps hooky) are among the threads that intertwine these four giants of automation.

Every February, we profile the new inductees in Control magazine and on ControlGlobal.com. This year, the inductees are

- Dr. Peter G. Martin of Invensys Operations Management;
- Mr. Dennis Brandl of BRandL Consulting;
- Mr. Ian Verhappen of Industrial Automation Networks;
- Dr. John MacGregor of ProSensus Inc.

Anyone can nominate a candidate for the Process Automation Hall of Fame. Just send to Editor-in-Chief Walt Boyes the name and a short CV of the person you believe ought to be in the Hall of Fame. Each nomination is put before the previous inductees, and a short list is derived from which the inductees themselves choose the new class of inductees. This is truly a high honor, because these individuals are all chosen by their peers.

The Road to the Hall

Virtually no one starts out knowing they are going to be an automation engineer. Dennis Brandl is an exception. “I think I was always destined,” he says, “to become an engineer. I was always taking things apart and putting them back together in grade school and high school, usually with only a few extra parts left over.”

Brandl points out that the use of computers, although it is ubiquitous in our society, isn’t very old at all. “It wasn’t until my final year of high school (1969) that I first had access to a computer, and it was a wonderful thing. I could design and build systems entirely out of ideas, and then have the computer interface to real devices to do things that were nearly impossible with gears, lights, and switches.”

Brandl continues, “In college at Carnegie-Mellon University, I was even more immersed in using computers for real-time control, including projects for landing rockets, controlling trains and controlling lab instruments. There were enough of us interested in this at CMU that the university started a master’s degree program in measurement and control in 1973, and I was a member of the first class.”

This evolved into CMU’s Robotics Institute (www.ri.cmu.edu) in 1979. Brandl, however, had taken his “master’s in measurement and control in hand,” and went to work in the space program. His experience in real-time computing led to a job at Modcomp Computers working on steel mills, nuclear reactors, petrochemical plants and other manufacturing systems. Then he worked for Shell Oil, designing control systems and control products for manufacturing at several other end-user and vendor companies.

“I believe that my lifelong interest in building things and making things work better was what led me to process automation,” Brandl says. “Designing and building control systems is an intellectual challenge that can also provide major benefits and value to companies, communities and the world.”

Dr. John MacGregor, now CEO of ProSensus (www.prosensus.ca), says, “I graduated in chemical engineering from McMaster University in 1965, and went to graduate school at the University of Wisconsin—with an interest in modeling, simulation and control. While I was there, I got very interested in the work that George Box and Bill Hunter were doing in engineering statistics—nonlinear modeling and estimation, time series analysis and so forth. Therefore, I switched out of ChE and into statistics, and
completed my MASc in chemical engineering and statistics and a PhD in statistics.”

Like a large number of the inductees in the Hall of Fame, MacGregor’s career path led through Monsanto. “My years at Monsanto in the late 60s were also influential in focusing my interest on real, practical problems. It was there that I also started to look at multivariate statistical methods for extracting information from the control and lab databases. This later became my major focus of research from the late 1980s onward. It was also through my work at Monsanto that I became interested in polymer reactor control, and as a result, I spent many years at McMaster in the 70s and 80s publishing in the area of polymer reaction engineering.”

Of his career journey, Dr. Peter Martin of Invensys Operations Management says, “I certainly did not take a direct path into process automation. I earned my BA and MS in mathematics, and in the early 1970s it was difficult to get work as a mathematician, so I took a job as a computer programmer and learned computer science and programming. From there, I took a job as a mathematician at Factory Mutual Engineering Corp., combining the mathematics and computer science skills. I had some difficulty working in an office, so I switched careers for a year and taught in both high school and college. From there, the Foxboro Co. (now Invensys Operations Management) hired me into its Education Services organization. The combination of teaching, computer science and mathematics seemed to be an ideal fit at the time. Working in Educational Services allowed me to learn automation and control from some of the best in the industry, such as Greg Shinskey and Carroll Ryskamp [both Process Automation Hall of Fame Members] and Lew Gordon. I found process automation to be much more interesting and challenging than software development or information technology, and I have spent the rest of my career learning and working in process automation.”

Unlike Martin, Ian Verhappen was involved in automation from the very beginning of his career. “I started as a chemical engineer working as a field/process/plant engineer in the oil and gas industry, where part of my duties included support for instruments in a gas plant,” he says. “In 1987, I applied with Syncrude Canada Ltd., where Pierre Tremblay was looking for a process analyzer engineer, and believed that analyzer systems were like small process plants, and as a result I became a process analyzer engineer. Pierre proved right, and because process analyzer systems required data transfer I quickly learned about loop diagrams and the wide range of field devices needed to support an analyzer system.”

Verhappen got involved with ISA, the International Society of Automation, and held various posts in the organization. “So when Syncrude wanted to better understand
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Foundation Fieldbus (FF) in 1994, I was asked to lead the team that undertook the world’s first multi-vendor FF pilot test, which ran through 1997,” adds Verhappen.

“In parallel with this, I continued working with ISA in both Standards and Practices and Publications, and when the ISA hosted the International Electrotechnical Commission (IEC) meeting in 1998, I started my involvement with the Standards Council of Canada and with the IEC. While serving as ISA vice president of Publications, I and Augusto Perreira co-authored the first edition of our Foundation fieldbus book, soon to be in its fourth edition in English, Spanish and Portuguese.

“In 2001,” Verhappen continues, “I was asked to lead the Fieldbus Foundation’s Global End User Advisory Council, and served in this capacity until 2006, when I joined MTL as director of Industrial Networks. During this time, as a result of my work on the interoperability project, I was invited to participate in an FF speaking tour of Australia, and this became an ‘annual pilgrimage.’ It was during these trips that I became friends with Steve McKay and, as a result, an instructor for IDC training.”

Still involved with ISA, Verhappen is currently ISA Parliamentarian, as well as District 10 vice president elect. He is currently managing director of Industrial Automation Networks Inc., an obvious pun on his first name. “I am now a regular columnist and blogger for Control, Industrial Networking and several other publications in Australia and Canada.”

Life, the Universe and Everything
“I am the eldest of five children, and a first-generation Canadian,” Verhappen relates. “I remember moving around quite often as I was growing up until we settled down in the Northwest Territories and in particular, Yellowknife.

“Growing up in Yellowknife allowed us to enjoy the outdoors from a cabin 30 minutes from home in the summer, and being encouraged by my father to become a figure skater rather than a hockey player in the winter gave me the chance to participate as an athlete in several Arctic Winter Games as well as one Canada Winter Games.

“I must have had an inkling I would end up in the automation field because in college I took all but one of the chemical engineering program process control courses offered. This was the core of the chemical
process control curriculum after it was announced as a specialization a few years later,” he says.

“In the final year of college, I was also the University of Alberta mascot, and in my final term met Michele just as she was finishing her nursing degree at U of A. We were married upon the completion of my first year engineering.

“After graduation, I took a field engineering position in Wainright, Alberta; Michele became a stay-at-home wife; and we had our two daughters, Ashley and Madeleine. By then we’d moved to Syncrude and Fort McMurray.

And here’s where hockey comes in. “I started playing recreational hockey in Wainright, and after a number of years I switched over to the other side of the whistle and became a referee, something I continue to enjoy doing today,” adds Verhappen.

Peter Martin adds, “I have been married to my wife Liz for over 38 years. We have a son, Derek, and a daughter, Erin, both married. We have two granddaughters.

“Throughout high school and college, I enjoyed sports, playing football, basketball, baseball and hockey. I played hockey through college and was the captain of my college team. I still enjoy all kinds of sports, but lately I spend a bit more time cheering on others than playing—although I still ice skate on occasion.”

John MacGregor says, “I have two sons, one a chemical engineer and the other in business. The whole family has always been very active in sports, and we still get together at Christmas to play pond hockey.”

There’s that hockey thing again.

Dennis Brandl is married to Diane, with four sons who all graduated from the University of North Carolina at Chapel Hill. “Diane and I had always wanted to live in this area,” Brandl says, “because we wanted a place where it did not snow, close to the beach, close to the mountains and...
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with great schools and universities. Our four sons all are working in engineering and software. In fact, I just finished writing a book with my son, Donald, for Momentum Press called Plant IT: Integrating Information Technology into Automated Manufacturing.”

Major Contributions to Automation
Each of the inductees has made major contributions to the automation profession, but it is interesting to note how different those contributions have been. Verhappen is a process analyzer guru and an industrial networking and fieldbus expert. Brandl is a manufacturing IT expert. MacGregor is a past master of engineering statistics and the use of advanced mathematics in process control. Martin is recognized for his contributions to controlling processes through real-time business variables and analytics. Between them, they cover the entire field of automation from the plant-floor devices to the boardroom in the enterprise.

“I think my greatest impact has been my work on developing multivariate latent variable methods for the extraction of information from large industrial databases for use in the analysis, monitoring, control and optimization of processes,” says MacGregor. “My research on the advanced control of batch processes has also been quite unique in the systems engineering area—both from the use of fundamental models for polymer reactor control, and the use of empirical multivariate latent variable models for the analysis, monitoring and control of batch processes.”

Martin believes his contributions “include the invention of dynamic performance measures, real-time, activity-based accounting, enterprise control systems, mathematical models for asset performance measurement and profitable safety. I suppose I would have to say that the invention of dynamic performance measures has realized the greatest contribution to this point.”

Verhappen says, “The largest and most rewarding contributions I have made are as a result of sharing. Through ISA and the Fieldbus Foundation, I was able to share both my process analyzer experiences and industrial networking learnings. Being an end user willing to share my experience—another name for mistakes—to help others have a successful project is what provides me the greatest satisfaction. I am now working as a mentor for new engineers here in Alberta through the Association of Professional Engineers and Geoscientists of Alberta (APEGA). I hope to be able to continue to assist others to understand the importance of the field sensor, final control element and controller communications relationship as the foundation on which all control and automation is based.”

Although Dennis Brandl was the chairman of the ISA88 Batch Standard Committee and the co-author of B2MML and BatchML XML schema standards, he says, “I am most proud of the development and market acceptance of the ISA95 standards for Enterprise/Control System Integration and Manufacturing Operations Management. These five standards have made a major impact in improving manufacturing productivity in all industries. The ISA95 standard and the associated MESA B2MML schemas reduced integration project times by over 80%, and helped to revitalize the MES/MOM industry. This has helped companies around the world improve their manufacturing productivity by 3% to 5% per year, resulting in billions of dollars of savings and in substantially improved use of natural resources.”

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After spending almost four years to find a technical path to converge the WirelessHART specification (IEC 62591) with that of ISA 100 Wireless (ISA/ANSI 100.11a, IEC 62734), the ISA100.12 WirelessHART Convergence Subcommittee has abandoned its work without finding a single convergence solution. The subcommittee had prepared a request for proposal (RFP) asking any organization or group of organizations to propose a technical solution for creating a single specification for a wireless process control network. The hoped-for network specification would replace both WirelessHART and ISA 100 Wireless, but would define ways to address backwards compatibility. Three proposals were received:

- Team E—Based on WirelessHART (IEC 62591); many features of ISA 100 Wireless (ISA100.11a or IEC 62734) added to meet user requirements.
- Team H—Based on ISA 100 Wireless with a HART-based application layer added.
- Team G—Specified a common network management entity that would allow the union of networks based on both WirelessHART and ISA 100 Wireless.

An evaluation team was formed to determine which, if any, of the proposals was acceptable. The selection criteria were based on a set of common user requirements (CURT) developed with the User Working Group. The evaluation team prepared a matrix showing how each user requirement could be met by each of the three proposals. The following is a summary of the evaluation team’s findings:

- Team E’s proposal could meet all user requirements, but only after certain agreed-upon extensions to the current WirelessHART standard and the Team E proposal were added. No backward compatibility with ISA 100 Wireless recommended.
- Team H’s proposal could meet all user requirements after the addition of an application function layer patterned after the one used in the HART specification. No backward compatibility with WirelessHART recommended.
- Team G’s proposal could meet all user requirements because it would allow both the existing and extended WirelessHART and ISA 100 Wireless networks to interoperate through a common network manager. No backward compatibility with either WirelessHART or ISA 100 Wireless.

Since the Team G proposal could use any version of WirelessHART or ISA 100 Wireless, including the newly proposed versions, it was also found to meet all of the CURT requirements.

In the end, no proposal addressed the core problem: definition of a single network specification that could replace both WirelessHART and ISA 100 Wireless and offer backward compatibility with both prior existing networks. The basic incompatibilities between the two networks remained, and neither proposal team could accept the requirements to modify their own base network to adopt the other proposal method.

The following summarizes the basic technical incompatibilities preventing interoperability between WirelessHART and ISA 100 Wireless:

1. Time synchronization: ISA 100 Wireless uses the IEEE 1588 method for distributed network time that is also used by IEEE 802.15.4e, the latest version of the personal area network standard. WirelessHART uses a fixed slot time interval of 10 ms and derives time from that base.
2. Slot time: While the ISA 100 Wireless protocol separates slot times from time synchronization, allowing variable slot times, WirelessHART depends on a single slot time to support time synchronization.

3. Meshing methods: WirelessHART uses a dynamic proprietary method to form mesh associations. ISA 100 Wireless also forms mesh associations dynamically in a proprietary way, including the formation of duocast links. WirelessHART supports redundant paths for the mesh, but does not transmit to the redundant node during the same slot time. The duocast method used by ISA 100 Wireless sends redundant messages to the primary node and the duocast node in the same slot time.

4. Network addressing: WirelessHART uses network addresses based on a unique number series originating with the HART Communications Foundation. The low-order 16 bits are in the device, while the high order 48 bits are in the gateway. ISA 100 Wireless is similar except that the number series originates with the IEEE Standards Registration Authority. In addition, ISA 100 Wireless fully supports Internet Protocol version 6 (IPv6) at the link layer.

5. Transport Layer: WirelessHART created a unique transport layer to assure end-to-end delivery of messages. ISA 100 Wireless uses the Internet-standard UDP method to assure end-to-end delivery of messages.

Unless all five of these differences are resolved, interoperability between ISA 100 Wireless and WirelessHART is not possible without messages being stored in a gateway common to both networks, and forwarded to a receiving node on the other network. Direct communications between nodes on different networks is not possible.

No other methods to find a technical path to converge the two protocols have been proposed, and the subcommittee has been disbanded.

**Alternative to Convergence**

One of the early results of the ISA100.12 meetings was a recommendation by a small group of end users that suppliers could ship products that would be configured by the supplier at the factory, or later by the end user, to operate on either WirelessHART or ISA 100 Wireless. We called this the “dual-boot” solution. Because this was not a communications protocol solution, it was not issued as a work product of the committee. However, since the ISA100.12 committee has now abandoned its convergence search, perhaps users’ needs can be satisfied by a dual-boot vendor offering.

There are three ways to accomplish a dual-boot product:

1. The field instrument can be shipped with both WirelessHART and ISA 100 Wireless communications stacks embedded in ROM. At the time of configuration or provisioning, one of the options to select is the desired communications stack that would then be loaded from ROM. The cost of this method would be a slightly larger ROM.

2. The vendor would ship the field instrument with its favorite communications stack pre-loaded into the instrument memory. During configuration or provisioning, the user would be offered the option to download an alternative communications stack. Since update of the communications stack is required to perform regular maintenance anyway, this would not add any cost to the device. The vendor would only be required to support the download and instantiation of both communications stacks.

3. The field instrument can listen to attempts to solicit it to join a network, use the join frame structure to identify the network protocol, and then begin to use the appropriate communications stack.

The advantages of dual-boot are that a user would need to inventory only one wireless instrument for each function (pressure, temperature, flow, level, etc.) that would work on either network. Since no additional hardware is required, the cost difference should be negligible. The disadvantage would be for the instrument company that would be required to support both communications stacks.

Will the instrument companies offer dual-boot wireless field instruments? Not unless users demand them. Instrument companies have no incentive to offer dual-boot instruments. However, continuous pressure from the users can change this situation when at least one major supplier agrees to supply dual-boot devices.

**Conclusions**

Users do not like the fact that ISA100 has abandoned the WirelessHART convergence effort. Their anger should be redirected to their suppliers of wireless instrumentation and systems in the form of product demands by writing the required functionality into their purchase specifications for wireless instrumentation and DCS.

The fact that their favorite DCS supplier can’t interface/support their chosen wireless network is a business decision of the supplier. User demand can change such business decisions. When user organizations write specifications for new DCS or instrumentation systems, they should specify the wireless protocol they need or to specify functionality that they need, and not be forced to specify only the one network supported by their favorite supplier.

Waiting for a single wireless standard is pointless. It will not happen with the current generation of hardware using IEEE 802.15.4 radios. Meanwhile, both ISA 100 Wireless and WirelessHART can meet most current wireless needs, and there is no reason to wait before using wireless.

Dick Caro is a principal at CMC Associates and a member of the Process Automation Hall of Fame. He was co-chair of ISA100.12.

[For more on this story, go to www.controlglobal.com/1302_Fieldbus.html.]
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Best practices to keep electrodes running at their best.

by Greg McMillan

Maximize pH Response, Accuracy and Reliability

The pH electrode has improved a great deal since the development of the pH concept over 100 years ago and the first extensive use of industrial pH electrodes over 50 years ago. While glass measurement electrodes are still used to provide the highest accuracy and cover the widest range, significant improvements have been made in the glass formulation, reference design, electrode structure, transmitter capability and installation and maintenance methodology. Measurement and reference electrode problems have been largely addressed, improving performance and life expectancy. Diagnostics and practices have been developed to help deal with tough applications. Here we look at some best practices to keep the electrode response fast, efficiency high, and offset and drift low.

Great Expectations and Practical Limitations

The pH electrode offers by far the greatest sensitivity and rangeability of any industrial measurement. A pH measurement with a 0-14 pH scale can cover 14 orders of magnitude change in hydrogen ion activity (hydrogen ion concentration for dilute solutions), and can respond at the popular 7 pH setpoint to changes in hydrogen ion concentration in the eighth digit after the decimal point. But, to achieve their full potential, challenges need to be addressed. Except for unusually harsh streams in terms of high temperatures, low water content or chemical attack of glass, suppliers say most of the reported problems are with the reference electrode.

Measurement Electrode

The measurement electrode depends upon the outer glass surface layer exposed to the process being clean, hydrated, with the same activity as the inside glass surface in contact with the internal 7 pH buffer solution. The activity of the glass surface depends upon the concentration of key alkali ions and the number of active sites for the hydrogen ion exchange with water molecules in the glass surface. The millivolt potential develops from an exchange that can be visualized as a jump of the hydrogen ion between a hydronium ion in the aqueous solution and the hydrated glass surface. Abrasion, aging and dehydration of the glass surface can cause a loss of active sites that results, first, in a slowing of the pH response and, finally, as a decrease in the efficiency (span) of the pH measurement electrode. The glass resistance can become too high, resulting in noise. A slight imperceptible coating can prevent the jump of the hydrogen ion, resulting in a dramatic slowing of the glass response. Just a one-millimeter coating can cause the 86% response time of the glass electrode to increase from seconds to minutes. A loss of active sites can cause the response time to increase to hours.
Reference Electrode
The reference electrode must provide electrical continuity from the internal electrode (e.g., silver-silver chloride) through the reference electrolyte fill (e.g., silver chloride), reference junction and process fluid to the measurement electrode. To accomplish this continuity, there is either a very tiny open junction (aperture) or a porous liquid junction to allow ions in the reference internal electrolyte fill to migrate into contact with the process fluid. Unfortunately, process ions can migrate through the liquid junction pores or opening, clogging the junction and contaminating (poisoning) the internals. Additional liquid junctions are added internally to provide additional barriers to prolong the time until the contamination by process ions reaches the inner sanctum of the silver-silver chloride electrode. Also, the internal fill is changed from a liquid to a gel to slow down migration of process ions. A porous reference such as Teflon provides the ultimate barrier for slowing down poisoning. The electrolyte and internal electrode are changed when the process fluid excessively interacts with the internal electrode or fill. For example, the fill and internal electrode are changed when the process has cyanide because cyanide ions cause precipitation of the silver and attack the internal electrode. The precipitate plugs the liquid junction. A plugging or a coating of the junction slows down the plugging rate and equilibrium rate. Solid reference internal electrolyte fill to migrate into contact with the process fluid. The reference electrode must provide electrical continuity minimizing the offset and drift after repeated cleanings and sterilizations (see Figure 2 online). Use low-sodium ion error glass if excursions occur above 10 \( \text{pH} \) when caustic is present. Use HF-resistant glass if excursions occur below 8 \( \text{pH} \) when HF is present. Note that high temperatures greatly accelerate chemical attack, reducing glass life. Also realize that the benefit of HF-resistant glass is marginal. A few ppm of HF at low \( \text{pH} \) can dramatically reduce the life of the best glass. The best bet is to insure the process stream never drops below 8 \( \text{pH} \).

(2) To minimize plugging and contamination problems, use a solid reference electrode or a readily replaceable reference junction. The entire sleeve of some solid reference electrode designs is the liquid junction helping to ensure electrical continuity minimizing the effect of coatings. Most solid references eliminate the contamination problem. Some liquid reference designs offer a removable reference junction, so the junction and electrolyte can be easily replaced.

(3) Consider a flowing reference junction as a last resort to quickly equilibrate to a constant minimum junction potential. If you must measure accuracies of 0.02 or better \( \text{pH} \) in a stream with a propensity for plugging or a high significant ionic strength, realize that a flowing junction can quickly establish a small constant liquid junction potential, and prevent clogging and contamination. This solution is a last resort because the installation requires the pressurization of an external reservoir of electrolyte for the reference to keep a small flow of electrolyte. Excessive electrolyte flow will contaminate process samples and even buffer solutions.

(4) Use wireless \( \text{pH} \) transmitters to eliminate electrical interference and spikes. The use of wireless transmitters eliminates the ground path that is the cause of much noise and spikes. Wireless transmitters tend to have the latest improvements in transmitter design, including better diagnostics and signal resolution. Wireless transmitters also offer flexibility for testing electrodes in the lab at process conditions and analyzing the results in the data historian.

(5) Compensate or be cognizant of changes in solution \( \text{pH} \) with temperature. The standard \( \text{pH} \) electrode temperature compensator corrects for changes in the millivolts generated by the glass with temperature, but not for changes in the solution \( \text{pH} \), which will change with temperature due to a change in the acid, base and water dissociation constants with temperature. The effect is greatest when the \( \text{pH} \) is near these constants. The actual effect of temperature on a solution \( \text{pH} \) should be quantified by tests on representative lab samples. Smart transmitters offer solution \( \text{pH} \) temperature compensation.

Greg McMillan is a Control columnist, blogger and a member of the Process Automation Hall of Fame.
Orifice Flow Measurement Accuracy

This column is moderated by Béla Lipták (http://belaliptakpe.com/), automation and safety consultant, who is also the editor of the Instrument and Automation Engineers’ Handbook (IAEH). If you would like to become a contributing author of the 5th edition, or if you have an automation related question for this column, write to liptakbela@aol.com

Q: My orifice is sized for a range of 0 in. to 100 in. H2O, and we have purchased a dP cell, which the supplier calibrated at ambient conditions and says that it is accurate to 0.05% of URL. With URL being equal to 750 in. H2O, that amounts to an error of 0.375 in. H2O. I am told that the error contribution of the orifice plate itself is 0.25% AR (AR = actual reading).

I was asked to determine the measurement error, using the square root of sum of squares method (SRSS) if the flow is 50% (ΔP = 25% = 25 in. H2O), the d/p cell is located where the ambient temperature is 120 ºF, and the operating pressure of the flowing fluid is 1000 psig. I was told that we can neglect the error in the receiving instrument (a computer). How do I calculate the zero and span errors caused by the differences in temperatures and pressures between calibration and actual? What will be my total error at 50% flow if I calculate it with the SRSS method?

A: The total error of an orifice based measurement is the square root of the sum of the squares of the following errors:
- \( E_0 \): orifice error;
- \( E_{ref} \): reference error (repeatability in Figure 1) stated by the vendor, which reflects only the linearity, repeatability and hysteresis errors of the d/p cell;
- \( E_{tz}, E_{ts}, E_{pz}, E_{ps} \), which are the errors caused by the differences between calibration and operating pressures and temperatures on the zero and span of the d/p cell. Usually the “zero error” is the greater if the ratio of upper range limit to full scale (URL/FS) is high;
- \( E_{ra} \): “rangeability error,” which rises as the actual flow drops. For linear meters, it rises linearly (Figure 1). For non-linear, orifice type measurement, it rises exponentially (\( \Delta P \sim F^2 \)), and therefore at 35% flow, the \( \Delta P \) is 11% FS;
- \( E_{rc} \): the error of the receiving instrument.

From Figure 1, one can see that if the supplier publishes only \( E_{ref} \), that is much less than the actual total error, which at 35% full scale flow for a typical installation is about 3%. Therefore, if the flow is expected to drop below 33%, we use multiple ranges (Figure 2).

I would advise two approaches to solve this problem:
1) Send your instruments (transmitter and orifice plate) to CEESI, SWRI or NIST for calibration at cost paid by your company. Ask if they would release certificate of accuracy at 1000 psig, 120 ºF first. Ask for the flow determined coefficients.
2) Check the Handbook of Flow Instruments by Dr. Richard Miller. Contact him if necessary. His Flow Consultant software takes thermal expansions of the piping into account, the overall effect of which can influence the accuracy of the instrument by as much as 0.2%.

There are many issues. First the flow rate, \( F \), is a calculated value related to the differential pressure, dP, created by the orifice. You will need a calibration equation...
to convert the measured dP to F. In a mathematically ideal world, F is proportional to the square root of dP. However, many features of the orifice design, installation configuration, flow turbulence number (Reynolds Number), fluid compressibility, transducer discrimination errors, etc. often make the square root idealization inappropriate. Often a power law calibration model, such as \( F = a \cdot dP^b \), where \( b \) is in the 0.4 to 0.55 range, derived from experimental data, leads to both more accurate and precise results.

Second, either the ideal square root or appropriated power law model presumes turbulent flow. For your orifice meter testing, you need to be sure that the flow rate remains in the turbulent region.

Third, turbulence-induced fluctuations on the dP signal create noise on the measured F (F appears measured because it is displayed, but F is actually calculated by the calibration equation and the dP sensor signal). The flow turbulence is greater at higher flow rates, but the square root functionality attenuates in the high F range. Accordingly, at low F, as F increases, the measurement noise will increase, but at high F, as F increases, the noise will decrease. Precision is reported as some measure of variability. But this value of precision would change with the flow rate value. You would need to characterize precision at several F values.

Fourth, you could quantify precision by experimental replicate testing or by propagating uncertainty. Use propagation of uncertainty when you are seeking to estimate the errors related to the pressure- and temperature-induced influences on fluid density—measured F. But you will need models that relate pressure and temperature to each source of variation.

Fifth, understand both aspects of measurement error: precision and accuracy. Both can be reported as rms values. Accuracy is measured by closeness to the true value. To report accuracy, you need to compare the “measured” F to a true value of F. To do this, calibrate the orifice meter, then compare the average of the noisy measured F value to a known standard. Even if accuracy is perfect at some flow rate, because the simple calibration equation will not exactly capture nature’s behavior over the entire range, the measured F will not represent the truth over the entire range. Accuracy will change with F. In contrast to accuracy, precision is related to repeatability, replicate variability or noise-induced fluctuations. To report precision, take many samples at one constant flow rate value and calculate the standard deviation of the replicate measurements.

Finally, after you have quantified either accuracy or precision, something will change. Someone will adjust the noise damping feature of the dP cell or the noise filter on the signal or calculated value, which will change the precision and lag associated with the measurement, or the orifice will erode, corrode, etc., or someone will adjust an upstream feature (thermowell insertion, bypass, etc.) which will shift the F to dP relation within the devices, making the calibration equation inaccurate.

With best practices for calibration, installation and maintenance, handbooks report orifice flowmeter error in the 3% to 5% range. They also indicate that 10% error is not to be unexpected. Accordingly, a major concern about flow rate measurement error might justify consideration of an alternate flowmeter type.

R. RUSSELL RHINEHART
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There’s no doubt that software, PCs and the Internet have revolutionized control and automation and the industries they serve. However, it still takes plenty of programming and configuration to build HMI displays, set up SCADA systems, commission servers and perform web-based monitoring, troubleshooting and control. And, organizing the plug-ins and formatting required to provide monitoring and control on multi-sized displays from big control room screens to tablet PCs and smart phones often makes these tasks even harder. Until now.

To help users overcome these hurdles, Opto 22 has developed its groov platform for building simple, effective, web-based interfaces to monitor and control its equipment using computers and mobile devices. Using only a web browser, groov lets users quickly build and deploy web-based automation, monitoring and control applications for Opto 22 components, and display their data and interact with them on almost any computer or mobile device, regardless of its operating system.

“We’ve all seen the power and capabilities of smart phones and tablets, but it’s still difficult for them to put real web-based control into users’ hands on the plant floor,” says Benson Houglund, Opto 22’s vice president of marketing and product development. “It’s a nice idea to build a mobile-ready, web-based, server-centered monitoring and control application. I tried it myself a few years ago, but I had to call in a web developer and an IT professional to help. Now with groov, we put all the pieces together, and one person using nothing more than a web browser can create displays that can be viewed on any PC, tablet or smart phone.”

To get groov up and running, users only need to know how to plug in an Ethernet cable, how to use a keyboard, mouse and browser, and what information they want to view. Opto 22 reports that groov is “five minutes to mobile” because users just log in with a web browser, point to the controller’s tag database, drag and drop software gadgets on a page, and save the project. Then, any authorized mobile device or computer with a modern web browser can log in to view the application.

Opto 22’s engineers took about 18 months to build groov, which they refer to as a “human-device interface” (HDI) because it augments regular HMIs by allowing them to easily display data on smart phones and other mobile devices. Also, groov and its displays are based on HMI best practices for building screens with prioritized data, minimal graphics and muted colors, as described in The High Performance HMI Handbook by Bill Hollifield and Eddie Habibi of PAS Inc. The initial version of groov is scheduled for release in March, while support for devices from other suppliers via OPC is expected later this year.

The platform’s primary parts include:
• groov Box—a hardened appliance with two Gigabit Ethernet ports and one 802.11n wireless port that interface with Opto 22’s controls and run the groov web application. It contains embedded microprocessors and an SQL database, uses 14-36 V DC power, and can run in 0 °C to 50 °C temperatures;
• groov Build—the web application’s mode for creating a groov interface project. This editing suite, which works within the browser, includes buttons, gauges, indicators, sliders and other interface devices that can be linked to actual data tags and points, as well as gadgets for displaying video streams and images;
• groov View—the web application’s mode for running a groov project in any modern web browser;
• groov View for iOS—the optional iOS app for groov View; and
• groov View for Android—the optional Android app for groov View.

These tools are aided by the fact that groov was built using standard HTML 5 and Scalable Vector Graphics (SVG), which means it doesn’t require software plug-ins such as Java, Flash and Silverlight to translate between different-sized display formats. Likewise, SVG allows sweeping and other touchscreen devices and functions to be scaled up and down just as easily.

Because its own software, hardware and networking are separate from the controls it monitors, groov is inherently secure. However, it further improves its security by using the web-based Secure Socket Layer (SSL) protocol and 128-bit encryption to protect all data moving on its network and prevent any other entities from viewing it.

For more information, contact Opto 22 at 800-321-OPTO (6786) or visit www.opto22.com.

There’s no doubt that software, PCs and the Internet have revolutionized control and automation and the industries they serve. However, it still takes plenty of programming and configuration to build HMI displays, set up SCADA systems, commission servers and perform web-based monitoring, troubleshooting and control. And, organizing the plug-ins and formatting required to provide monitoring and control on multi-sized displays from big control room screens to tablet PCs and smart phones often makes these tasks even harder. Until now.

To help users overcome these hurdles, Opto 22 has developed its groov platform for building simple, effective, web-based interfaces to monitor and control its equipment using computers and mobile devices. Using only a web browser, groov lets users quickly build and deploy web-based automation, monitoring and control applications for Opto 22 components, and display their data and interact with them on almost any computer or mobile device, regardless of its operating system.

“We’ve all seen the power and capabilities of smart phones and tablets, but it’s still difficult for them to put real web-based control into users’ hands on the plant floor,” says Benson Houglund, Opto 22’s vice president of marketing and product development. “It’s a nice idea to build a mobile-ready, web-based, server-centered monitoring and control application. I tried it myself a few years ago, but I had to call in a web developer and an IT professional to help. Now with groov, we put all the pieces together, and one person using nothing more than a web browser can create displays that can be viewed on any PC, tablet or smart phone.”

To get groov up and running, users only need to know how to plug in an Ethernet cable, how to use a keyboard, mouse and browser, and what information they want to view. Opto 22 reports that groov is “five minutes to mobile” because users just log in with a web browser, point to the controller’s tag database, drag and drop software gadgets on a page, and save the project. Then, any authorized mobile device or computer with a modern web browser can log in to view the application.

Opto 22’s engineers took about 18 months to build groov, which they refer to as a “human-device interface” (HDI) because it augments regular HMIs by allowing them to easily display data on smart phones and other mobile devices. Also, groov and its displays are based on HMI best practices for building screens with prioritized data, minimal graphics and muted colors, as described in The High Performance HMI Handbook by Bill Hollifield and Eddie Habibi of PAS Inc. The initial version of groov is scheduled for release in March, while support for devices from other suppliers via OPC is expected later this year.

The platform’s primary parts include:
• groov Box—a hardened appliance with two Gigabit Ethernet ports and one 802.11n wireless port that interface with Opto 22’s controls and run the groov web application. It contains embedded microprocessors and an SQL database, uses 14-36 V DC power, and can run in 0 °C to 50 °C temperatures;
• groov Build—the web application’s mode for creating a groov interface project. This editing suite, which works within the browser, includes buttons, gauges, indicators, sliders and other interface devices that can be linked to actual data tags and points, as well as gadgets for displaying video streams and images;
• groov View—the web application’s mode for running a groov project in any modern web browser;
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**ULTRASONIC IMMERSION SENSOR**

Turbinax CUS71D ultrasonic immersion sensor for interface measurements in processes where suspensions are separated into liquid and solid components by sedimentation can monitor the separation and transition zones continuously. It can include up to eight 4-20mA current outputs, eight relay outputs and two analog inputs. HART, Profibus, Modbus TCP and Modbus 485 digital buses are available as an alternative to analog outputs.

**Endress+Hauser**
888/363-7377; www.us.endress.com

**EXPANDED WAVELENGTH SPECTROMETER**

ARL Optim’x wavelength, dispersive, X-ray, fluorescence (WDXRF) analyzer enables lower limits of detection, two to three times faster analysis, and higher sample throughput. Each unit uses Thermo Scientific’s Oxsas software to support spectrometer operation and data handling. It can be pre-configured with analytical packages based on the unique analysis requirements of the oil industry, cement plants, metallurgy and central laboratories.

**Thermo Fisher Scientific**
800/532 4752; www.thermoscientific.com/optilab

**EXPLOSION-PROOF, TWO-FOR-ONE TRANSMITTER**

Model AST46PT explosion-proof, pressure/temperature transmitter offers both a superior pressure reading and a temperature sensor output for less than the cost of a stand-alone temperature sensor. It generates both a pressure and temperature reading with the power consumption of one sensor. It is CSA-approved for use in Class I Div 1 explosion-proof groups A, B, C and D, and for mining applications, Class 2 Div 1 Groups E, F and G.

**American Sensor Technologies**
973/448-1901; www.astensors.com

**MULTI-VOLT LED BULBS**

The unique feature of the Larson Electronics A19 LED bulb is that it operates on voltages ranging from 120 to 277 V AC. It comes equipped with a food-safe plastic cover, and the LED-A19-10-E26 fits into standard E26 (US) and E27 (Europe) sockets. With 10 watts of power, it produces 1050 lumens. Designed for harsh environments, the Larson A19 LED bulb operates in temperature ranges from -50 °C to +85 °C.

**Larson Electronics**
800/369-6671; www.LarsonElectronics.com

**WAFER CHECK VALVES IN EXTENDED SIZES**

Asahi/America has expanded its offering of PVC wafer check valves to include sizes 4-in., 6-in, and 8-in. The valve’s body, disc and stopper assembly are machined from solid PVC plate stock, which conforms to ASTM D1784 Cell Classification 12454A. It is available in PVC, 4-in. through 12-in. with EPDM seals and no spring standard, and operates at a maximum pressure of 150 psi, while 10-in. and 12-in valves operate at 90 psi and up to 120 °F.

**Asahi/America**
800/343-3618; www.asahi-amERICA.com

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ProSafe-RS R3.02.00 features input/output modules designed to operate reliably in high-temperature conditions—ambient temperatures up to 70 °C (158 °F). It also has support for Ethernet-based Modbus/TCP communications, enhancing its compatibility with other vendors’ distributed control systems. It is designed for use in emergency plant shutdown and fire prevention/fighting in the oil, natural gas, petrochemical and other process industries.

**Yokogawa Corp. of America**
770/254-0400; www.yokogawa.com/us
**ON-MACHINE I/O BLOCK FOR INDUSTRIAL ETHERNET**

BL compact on-machine, flexible block I/O for Industrial Ethernet is an I/O solution for collecting a variety of signals in a single, rugged node on a network. This device makes it possible to obtain analog, digital, thermocouple, RTD, serial, RFID or a mixture of signal types. It may be customized to suit a user’s specific needs, allowing devices to be added to an existing network, and signals gathered on the machine without an enclosure.

Turck
800/544-7769; www.turck.us

**DIRECT DIGITAL CONTROLLER**

BAS-3500BC is a direct digital controller (DDC) with an integrated router, dual Modbus and BACnet interfaces, and auto-mapping to make it one of the most flexible DDCs on the market. With its ability to simultaneously support both the Modbus and BACnet protocols, BAS-3500BC ensures that developers don’t require additional convertors or controllers to connect to environment controllers and meters.

Advantech Industrial Automation Group
888/547-9668; buy.advantech.com

**PRESSURE SWITCHES FOR LOW OPERATING RANGES**

H Series pressure switches can be used in medical, automotive, pump and water system applications. This series includes pressure switches ideal for ultra-low operating pressure ranges down to 0.04 in./H₂O (0.25 psi). The differential switches allow for high operating pressures up to 5000 psi. Vacuum switches are designed to stand up to extended duty applications. They’re field-adjustable, and UL approval and factory calibration is available on most models.

Madison Co.
203/488-4477; www.madisonco.com

**TRACK CONDUCTIVITY, RESISTIVITY, SALINITY**

CX-3000 transmitter measures one of three critical process parameters: conductivity, resistivity or salinity. A simple pushbutton interface enables user programming on-site. The dual-output design eliminates the need for a separate temperature transmitter. Its large backlit LCD screen displays selected parameter and temperature simultaneously. Conductivity is measured from 0.000 uS/cm to 200 mS/cm for extreme applications.

Sensorex
714/895-4344; www.sensorex.com

**MULTI-WIRE CONNECTORS**

ZIPport multi-wire connectors and accessories maintain reliable electrical connections, while providing protection against dirt, moisture and mechanical stress common in industrial environments. New frame sizes include 10A, 16A and 32B made of heavy-duty metal or thermoplastic housings. Accessories include additional IP66 and IP68 cable glands, Pg-to-NPT adapters and blanking plugs. Insert plates are available in blank, reducer and cutout styles.

Automation Direct
800/633-0405; www.automationdirect.com

**EFFICIENT SAFETY FUNCTION PROGRAMMING**

Safeprog 3.00 provides pioneering functions for efficient programming of complex safety functions. It enables the use of the IEC 61131 programming language Structured Text (ST). It is a limited variability language, meaning users can implement safety applications with ST without having to go out of the sector standards. Both Safeprog 3.00 and the included parameterization editor Safegrid comply with IEC 61508:2010 (Second Edition) up to SIL 3.

KW-Software
734/205-5137; www.KW-Software.com
MPC – Past, Present and Future, Part 1

Greg McMillan and Stan Weiner bring their wits and more than 66 years of process control experience to bear on your questions, comments, and problems.

Write to them at controltalk@putman.net.

Greg: I first met Mark Darby, principal at CMiD Solutions, at an ISA Conference years ago. I got his business card and made a mental note that a Control Talk column with him would be fun and productive.

Stan: In this multipart series, Mark will share his thoughts on model-predictive control (MPC) applications, proper use of regulatory level, inferential measurements, model development, economic objectives, support and maintenance. We’re going to roam over these topics like free-range chickens, which foodies tell us are happier and tastier. While we may be happier than cooped up engineers, we hope not to end up at the meat counter, even though upper management may see us as bodies chewing up money better consumed as bonuses.

Greg: Where do we have MPC installations?

Mark: About 60% of MPC applications are in the refineries and petrochemicals. Here the use of MPC is nearly an order of magnitude greater than advanced regulatory control (ARC). For specialty chemicals, MPC applications are growing and are approaching the number of ARC applications. MPC is moving into food processing and has penetrated discrete manufacturing, especially the automotive industry.

Stan: What is the success rate for new applications of MPC?

Mark: Success is nearly 100% in some plants, but it’s uneven, despite significant advances in MPC software. However, implementation naivety and disappointment have led some to reconsider the role of MPC. One of the problems is how do you go to get management support for a new APC application? Different silos make this difficult. A successful MPC application requires management to provide the operations training, regulatory control improvement and MPC expertise on a continuing basis. Even the best MPC software requires knowledgeable people to monitor and maintain the MPC application. Expertise must be readily accessible to insure the MPC performs well despite changes in process conditions and objectives, instrumentation and equipment performance. Even if the MPC is not the cause of a problem, it can be blamed.

Stan: In last October’s Control Talk, “Bringing Advanced Process Control Home” (www.controlglobal.com/CT1012.html), we saw how important the support of a core company group was to success, and how, once a trustful relationship is established with operators, the MPC expert can be virtually present rather than physically in the control room. What about in batch operations?
Mark: While nearly all of the current applications are on continuous processes, we're seeing some in batch operations based on nonlinear hybrid models incorporating fundamental and empirical modeling techniques.

Greg: There are some highly successful linear MPC temperature control applications on batch distillation columns operating in a semi-continuous mode. For fed-batch reactor and bioreactor profile control, I have found that controlling the slope of the profile makes the response self-regulating and more linear. For product concentration control, using the slope of the batch profile as the controlled variable enables negative as well as positive changes that are essential for feedback control. The slope target is changed as the batch progresses.

Stan: Why do you think the role of MPC is increasing and are there any cautionary words?

Mark: Black-box thinking has led to the conclusion that MPC is the total solution. Bottom-up thinking is needed to make sure the measurements provide a good window into the process, and valves provide an effective means of affecting the process. Where flow measurement turndown meets regulatory requirements, flow control should be employed so that the MPC does not have to deal with the nonlinearity of the control valve. Flow ratio control also should be enforced in the regulatory control system, so the MPC only has to correct the ratio instead of using flow as a disturbance variable.

Greg: If the controller gain and derivative settings are high, a PID probably is the best solution for rejecting unmeasured load disturbances. On the other hand, if there is more than one temperature control point (e.g. bottom and top distillation column temperature control or kiln inlet and outlet temperature control), the MPC could provide a more straightforward solution. The dynamic decoupling of PID controllers requires Shinskey type expertise that is increasingly in short supply.

Mark: While knowing dynamics is essential for PID control, getting the steady-state gains right is most important for an MPC. These steady-state gains are critical for analysis, prediction and optimization.

Stan: I realize the software today does a complete analysis and provides solutions, but what can we see in the steady gain matrix that is indicative of problems in the MPC design?

Mark: If the gains in a column of the process model matrix are similar, then the process input X variables (i.e., manipulated variables) may not be truly independent. Some of the inputs may need to be removed or the model reformulated. If the gains in one column exhibit a similar ratio to gains in another column, the process output Y variables (i.e., controlled variables) are interrelated or colinear. Obvious places to look include situations where manipulated variables have a nearly identical response in the controlled variables. A simple example would be multiple temperatures in a catalyst bed.

Greg: What is being done today?

Mark: An approach for dealing with the interrelationships between manipulated and controlled variables is based on a singular value decomposition (SVD) of the gain matrix. A zero singular value corresponds to a 100% colinear relationship. The basic idea is to force small singular values to 0 and recompute the gain matrix. The methods used in practice only treat the steady-state gains.

Stan: Composition is often what you want to control, so what do you do about missing or unreliable analyzers?

Mark: We use inferential measurements. Techniques such as principle component regression (PCR) and partial least squares (PLS), which are akin to PCA, are useful for selecting the most significant components to use to develop an inferential predictor (a regression equation). Dynamic models linking manipulated variables to the inferential predictor are developed using the identification software employed by the MPC. These inferential measurements generally provide faster, smoother, more reliable composition measurements than analyzers. Consequently, even if an online or at-line analyzer is available, these provide better prediction and control. When there is only a lab analyzer, there is a temptation to think the inferential measurement can do the complete job. While some may state that automated correction by a lab analyzer is counterproductive, most would recognize feedback correction is necessary. The correction is often a bias that is fraction of the error between the inferential measurement and an analyzer reading synchronized with the analyzer result. If the task of intelligent analysis and screening of lab signals is shortchanged, so that correction is not chasing noise or a resolution/sensitivity limit, or resulting to bad sample handling, then the correction could do more harm than good, particularly in the short term. It is important to compare the raw inferential predictor (without update) to the analyzed value to gauge the accuracy of the inferential predictor.

Greg: I find it conceptually stupid to think you can have a model that predicts something that is never measured. For me, process control and even life is all about feedback, otherwise we would be unstable. (Go to www.controlglobal.com/CT1302.html to see an extended version of this story and two common myths about advanced process control.)
Dry run protection

The PMP-25 Pump Load Control guards against dry running, cavitation and overload. It monitors true pump power for maximum sensitivity. The display shows pump load, trip points and delays. Its NEMA 4X enclosure is small enough to fit on Size 1 starters and can be door-, panel- or wall-mounted.

Group Network Health

Eternal vigilance isn’t just the price of freedom. It’s the cost of a bunch of other items too, such as responsible parenting, nuclear weapons inspecting, healthy weight loss and industrial network maintenance. And because all these worthwhile efforts are so difficult to do on our own, and because their demands and parameters often change so quickly, it’s vital to have some backup from a supportive group or team.

This was one of the reminders that came from researching and reporting this month’s cover article on maintaining network health in *Industrial Networking*. The first thing I learned was that industrial network components merit the same awareness and maintenance as the controls whose data they convey—and that many end users still need to wake up to giving their networks that same care. However, the second thing I learned is that routine coordination and a little teamwork is what allows these best practices to get established and grow—along with using network management software (NMS) and several longstanding, IT-based diagnostic tools, such as free Wireshark (www.wireshark.org) software, and following Simple Network Management Protocol (SNMP), Internet Group Management Protocol (IGMP) and others.

Likewise, a growing number of suppliers have gone beyond the usual technical support and have developed always-on services and hardware devices to help check and maintain users’ industrial networks. For example, Emerson Process Management (www.emersonprocess.com) is offering its System Health Monitoring (SHM) service that constantly monitors its subscribers’ networks, and emails any problems it detects to the Remote Monitoring Team at Emerson’s Global Services Center (GSE).

Established in 2008 and expanded worldwide in 2011, SHM begins with a Linux-based PC with a 1-megabyte kernel and four Ethernet ports in a hardened box. It’s installed at the subscriber’s facility, which might seem odd in a world of increasingly virtualized and cloud-based computing. However, Kevin Lange, administrator of Emerson’s Lifecycle Care System, reports that each SHM box allows the service to monitor subscribers’ networks from behind their firewalls, and use their email servers, but do it without directly exposing those networks to the Internet or risking the loss of intellectual property.

“SHM is a lot like the OnStar emergency response service for cars, but ours can help find likely root causes of process control problems,” says Lange. “SHM can monitor the many health parameters of PLCs, I/O cards, Ethernet switches, firewalls and other devices from Emerson and other suppliers; filter those values down to core parameters that the user most needs to know about; communicate updates every five minutes; establish critical limits; and perform three retries when communicating to eliminate false positives. When the network has a problem, the remote monitoring team at GSE communicates with the local service department, and it works with the user to solve it.”

Lange adds that parameters that get checked on a managed Ethernet switch include temperature, power, availability, port status, packet errors, and even ages of antivirus signatures for security. “SHM has already had multiple successes, such as pointing out overheating switches in remote cabinets where the air conditioning was down or showing that an invalid laptop was throwing out bad packets while it was plugged into an Ethernet switch,” he says.

Many network users previously used protocols like SNMP on their own to monitor Ethernet switches. However, as these devices multiplied, and their networks grew more complex, many users have sought standard, automated tools such as SHM to manage and support the health of their systems. “Users want to be free to focus on their manufacturing applications, and so services like SHM can help them do it, but still give their networks the assistance they need,” adds Lange.
When our engineers work on a motion project with you, they share everything that's in their heads. Sometimes that means turning over 100 pages of notes, formulas and drawings. Other times, it's simply having straightforward conversations.

At the same time, Yaskawa customers share their proprietary knowledge because they can trust us. Because we give their challenges a lot of thought. Because when they talk to us, they know we are on their side.

Trusting the guys across the table from you with your most important product secrets. That’s noteworthy.
Electronic marshalling eliminates the rework, the redesign and the headaches. With DeltaV Electronic Marshalling, Emerson lets you make I/O changes where and when you need them without costly engineering and schedule delays. Our new DeltaV CHARacterization Module (CHARM) completely eliminates the cross-wiring from the marshalling panel to the I/O card—regardless of signal type—so you’re no longer held to predefined specifications. All those wires, gone. All that time and engineering, gone. See how easy it can be by scanning the code below or by visiting IOonDemandCalculator.com