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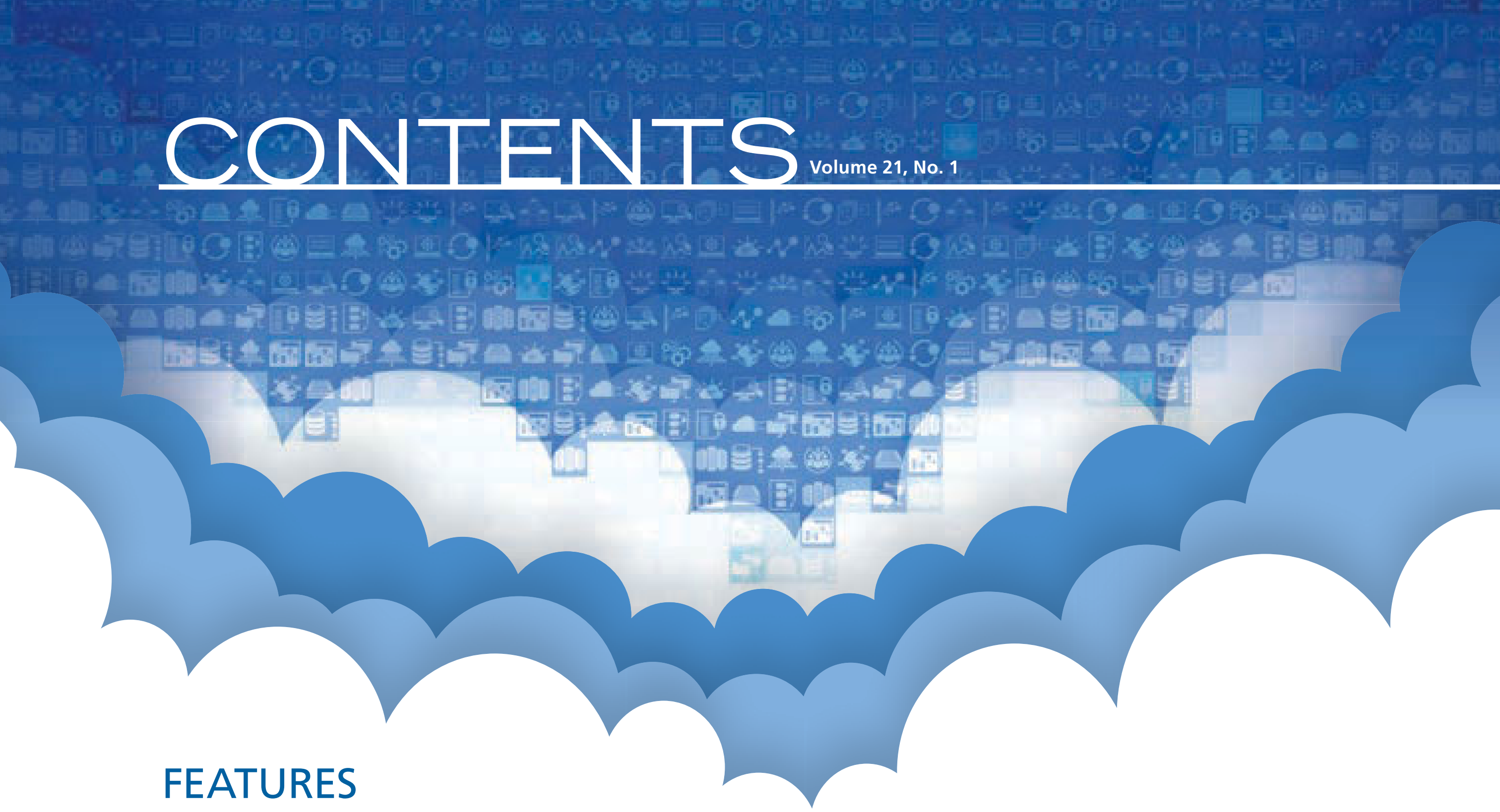

FEATURES

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FOR MACHINE BUILDERS

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Infrastructure architecture

OPC UNIFIED ARCHITECTURE could soon support time-sensitive networking (TSN) as part of the publish/subscribe architecture, addressing seamless interoperability between disparate devices in the IoT environment. The expectation is, with the high-speed performance of time-sensitive networking, there will be significant opportunities for embedded OPC UA devices to talk to other OPC UA embedded devices, giving the ability for devices that currently exist on one particular industrial fieldbus to be able to seamlessly interoperate and share information with other devices on a different industrial fieldbus network. In the short term, vendors on the same industrial Ethernet fieldbus network will use that respective industrial Ethernet fieldbus to have their devices communicate. "But, with the power of OPC UA and the information model that will probably change over time, you will see more and more OPC UA-enabled devices providing information exchange between different types of devices on the same fieldbus network," says Tom Burke, president of OPC Foundation (www.opcfoundation.org). The real use case will be the ability to connect devices on different fieldbus networks, to do it deterministically and to achieve a significant increase in communication bandwidth over TSN.

In November, at the SPS IPC Drives exhibition in Nuremberg, Germany, Sercos demonstrated its unmodified protocol over Ethernet TSN. "This demonstrator is a proof of concept to show the interconnectivity of Sercos III devices, Ethernet devices and TSN devices without any impact on the real-time performance," says Dipl.-Ing. Peter Lutz, managing director, Sercos International (www.sercos.org), which has a 25-year history in real-time communication supported by companies such as Bosch Rexroth, Schneider Electric and Rockwell Automation.

The demonstrator showed how a Sercos-driven machine can be connected to a TSN infrastructure and controlled remotely by a TSN-based Sercos master that can be freely positioned in the network to control the machine and interface to the connected IT systems. "Sercos has not only migrated from a digital drive interface to a universal automation bus, but it has also been working on a convergence of the technology with OPC UA and TSN," explains Lutz.

"OPC UA is all about both communications and more importantly secure information-integration opportunities where you can now have data and metadata easily exchanged between systems without having both systems have precompiled information about the information being exchanged," says Burke. "OPC UA information can be modeled and distributed to other devices and applications without those other devices and applications having any knowledge of the information model, but they're still able to consume that information because there is an exchange protocol that provides the syntax and semantics of the data, so the consuming application or device can understand and process the information accordingly." cd

With the high-speed performance of time-sensitive networking, there will be significant opportunities.

Ask the right question

I know you are not a networking expert, but I am. I found it difficult to read your cover article for the November 2016 edition. Let me explain.

Ethernet is a communications technology widely used to solve problems in industrial Fieldbus communications. Let me illustrate—EtherNet/IP, Profinet, PowerLink, EtherCAT, Sercos III, Foundation Fieldbus HSE and CC-Link IE are all fieldbuses and use Ethernet technology at layers 1 and 2 (physical and data link layer). Why do I say they are fieldbuses? They are all in the International Electrotechnical Committee (IEC) Standard 61158 that defines industrial fieldbuses. Each has different ways to use Ethernet, but none of them tolerate any collisions because it is collisions that caused old-fashioned coaxial cable Ethernet to be nondeterministic. Therefore all of these forms of Ethernet are fieldbuses and are deterministic. Twenty years ago, offices and industry stopped using 10Base-2 coaxial-cable-based Ethernet because it just didn't work well in the office and not at all in the factory. Since then, all Ethernet networks have used full duplex switches to buffer all messages and prevent collisions. While many industrial networks have used ruggedized Ethernet switches, several very high-speed machine control fieldbuses such as EtherCAT, PowerLink and Sercos III use Ethernet switch chips at each node and have the capability to form lightning-fast deterministic networks based on unmodified Ethernet protocol, and they call themselves fieldbuses.

By the way, anyone who refers to full duplex switched Ethernet in any form as nondeterministic is just behind times. We are so far advanced from those days, but there are some who are stuck in the old folklore that they cannot accept modern technical facts.

All of the Ethernet-based fieldbuses avoid the use of transmission control protocol (TCP) because it is nondeterministic. Instead, for real-time communications they use different applications of user datagram protocol (UDP) with Internet-protocol (IP) addressing. Some, such as Foundation Fieldbus HSE, do not allow any TCP-encoded messages, while others allocate fixed time slots for such TCP messages. This is only one type of time-sensitive networking (TSN) mentioned but not defined in your article.

So, it is not Ethernet vs. fieldbus. The question is: Will old non-IP fieldbus protocols go away? That would mean implementing IP at the edge device itself. This has already begun in both factory automation and process control, but there are many millions, or perhaps billions, of existing not-very-smart devices in the field that are not going away overnight.

Dick Caro, CEO, CMC Associates (www.cmc.us), Arlington, Massachusetts; ISA life fellow; author of "Automation Network Selection" and "Wireless Networks for Industrial Automation"

Sercos III generation

I just read your interesting article on Ethernet vs. fieldbus in Control Design. Unfortunately, information about Sercos and its positioning to OPC UA and time-sensitive networking (TSN) was not mentioned.

First, let me address the major differentiators between device/fieldbus networks and Ethernet networks. So far, we can distinguish two generations of fieldbus networks. The fieldbuses of Generation 1 were based on different physical and data link layers (not Ethernet) and designed for dedicated purposes, such as drive communication (Sercos), I/O communication (Profibus, Interbus, DeviceNet) or safety communication (for example, Safetybus-p). This led to the situation that within a manufacturing unit, or between manufacturing units, different buses were required to meet the application requirements, such as a combination of Sercos + Profibus, or Sercos + DeviceNet. Ethernet was not used at all at the field level, but only when connecting machines via the machine controls to the superior IT systems (MES/ERP/SCADA). The disadvantages were not only the large number of heterogeneous and incompatible interfaces, but also the high total cost of ownership—different tools for engineering, monitoring and diagnosis, high overall complexity.

The fieldbuses of Generation 2, developed in the early 2000s, were based on Ethernet and could be used, because of the high bandwidth of > 100 Mbit/s,

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for universal purposes (motion + safety + I/O over one bus). Ethernet-based networks were supporting higher speeds, but, due to the non-determinism of Ethernet, different variants of real-time Ethernet were created as successor technologies of fieldbus technologies of Generation 1 (Sercos III for Sercos I/II; Profinet for Profibus; Ethernet/IP for DeviceNet). Also, new protocols were created by automation companies. For exmple, B&R created PowerLink, and Beckhoff created EtherCAT. To reach a high performance—short run times, short cycle times, high protocol efficiency, sub-microsecond synchronicity—special hardware is needed for Profinet IRT, Sercos III and EtherCAT. The disadvantages of Generation 2 fieldbuses are that these RTE technologies are not interoperable, and most RTE do not even support multiple protocols to coexist in one network infrastructure. Because of this, the networks for IT and automation are still separate and many RTE technologies need the network exclusively for real-time traffic—no protocol coexistence.

Ethernet TSN now will be the basis for the next-generation fieldbuses—Generation 3. This is an exciting milestone because, for the first time, after 43 years, Ethernet by itself becomes deterministic. As no modified hardware is required to achieve network determinism, TSN will support and enable the convergence of IT and OT networks. Because TSN allows different Ethernet protocols to coexist and share the network infrastructure—no gateways, only switches, are needed. Thus, a consistent and transparent access from sensor to cloud and vice versa becomes possible. TSN not only will support real-time communication but also higher-speeds and lower costs because of the cross-industry support of the TSN technology from automotive, multimedia, automation.

SERCOS FOR TIME-SENSITIVE NETWORKS

Dipl.-Ing. Peter Lutz, managing director of Sercos International, says TSN will support real-time communication at higher speeds and lower costs.

Sercos has been using time-triggered and time-slot-based communication since the introduction of the Sercos technology in the late 1990s in order to meet the requirements for high-speed real-time communication for all kinds of production machines and demanding automation applications. Sercos I/II was mainly used for drive communication. Ethernet-based Sercos III became a universal automation bus supporting motion, safety, I/O, vision, TCP/IP and other Ethernet protocols over one single network. In the future, Sercos will rely on deterministic Ethernet (Ethernet TSN), which will lead to significant advantages, including standardized hardware, lower cost, higher speeds and IT connectivity, for the users of the technology.

At the same time, Sercos supports the requirements of Industry 4.0/ IoT, regarding semantic interoperability, For this, a standardized OPC UA Sercos information model was defined that brings together the well-defined device profiles of Sercos (semantic for drives, I/Os, encoders, energy) with the information model and data exchange standard of OPC UA. With this approach, the functions and data of Sercos devices are made available and accessible via OPC UA.

Use cases cover a broad range from device parameterization and network configuration up to energy management and preventive maintenance. The mapping rules specified by Sercos can be used for different implementation approaches. On the one hand, the OPC UA server functionality can be implemented in a Sercos master device—for example, CNC or PLC. On the other hand, it is possible to implement this functionality in a Sercos slave device. In the latter case, the OPC UA accesses are executed in parallel to the Sercos real-time communication or even without any Sercos real-time communication.

Dipl.-Ing. Peter Lutz, managing director,
Sercos International (www.sercos.org),
Suessen, Germany cd

SIEMENS

Microbox (IPC427D) and Micropanel PC (IPC477D) will be first units assembled

Siemens announces first IPC Assembly Center in the U.S.

Siemens is proud to begin assembly of select Industrial Personal Computers out of the Lebanon, Ohio facility starting April 1, 2016.

As the demand for IPCs in the U.S. continues to grow, Siemens is making it easier for customers to get the units they order faster.

The units selected for initial assembly represent the most popular configurations from our U.S. based customers and will result in significantly reduced lead times. Additional IPC models will be added over time to the Lebanon, OH facility to further meet customer needs.

These U.S. assembled units will be built with the same rigorous standards as those units produced in Germany, with more than 50 tests, including a 36 hour burn in test, to guarantee the highest quality.

You can continue to order Siemens full line of IPC products. Those configurations not produced in the Lebanon facility will continue to be manufactured in Germany.

What IPCs will be produced at this location and when?

Microbox / Micropanel PC
- IPC427D / IPC477D: Spring 2016
- IPC427E / IPC477E: Winter 2016

Nanobox / Nanopanel PC
- IPC227E / IPC277E: Summer 2016

Rack PC
- IPC547G: Spring 2017

What is the customer benefit?

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Why engineers are smarter than doctors

I WOKE UP one morning, and something was out of whack with me physically. My body didn't want to move. Something was wrong, and the main symptoms were joint pain, stiffness and weakness. Alone in a hotel, 1,800 miles from home, it took me 30 minutes to get out of bed. With a lot of fear and worry, I went to the doctor.

At the initial doctor visit, the doctor carefully listened, took some notes, some incorrect, and promptly ignored my suggestions. That started the caution light flashing because, as an engineer, it is very important to listen to your customers.

The doctor had no diagnosis but made a guess and sent me to a specialist. Sometimes a guess is fine, but, if guessing, an engineer would likely consider performing a design of experiment or, at a minimum, take the time to do a little more research to learn more—the proactive engineer. The specialist made an educated guess on my diagnosis—arthritis— and prescribed a toxin. Literally, if taken every day, it's toxic.

I asked the doctor what specific medical evidence indicated I had arthritis, and she provided none. So, I had a diagnosis with zero medical evidence to back it up. Zero! Other than a blood test showing I had inflammation, which just confirmed the obvious symptoms I had, I also had an elevated white blood cell count. I thought I had an infection somewhere, but my opinion didn't matter.

As an engineer with limited data, I thought it was important to test the solution to a problem to make sure the root cause was corrected. After all, what the doctor prescribed for me was suppressing my immune system, and I thought I had an infection. The treatment made me feel worse—I felt it was killing me.

The testing did not support diagnosis. An engineer would follow up with additional questions, study the problem and then test the solution again. Get the data; don't ignore it; and find the root cause.

The root cause

Despite eight doctor visits and dozens of medical tests, I found the root cause was a tooth. When my tooth had a bad day, my "arthritis" symptoms were worse. It took me a while to make the connection, and the doctors never asked, but they should have, because I told them all about my year-long symptoms many times.

After several return visits, all the standard diagnostic steps the dentist took said there was nothing wrong with the tooth. As an engineer, I thought the dentist had some flawed procedures or methods and nothing was fixed, so I asked to be referred to a specialist.

After a fancy 3D x-ray of my teeth, the endodontic specialist said I had an abscessed tooth, and a second root canal procedure was performed. Two days after the procedure removed the infection from my tooth, the year-long symptoms I had been suffering ended abruptly. I went from feeling like an 80-year-old, slightly crippled man every minute of every day back to a normal middle-aged guy.

To me, the tooth was the obvious cause, and the dentist quietly agreed. However, the endodontist wouldn't even consider that an infection in a tooth could cause arthritis-like symptoms. He ignored the facts. My symptoms were gone, that is until the endodontist performed the final root filling in the tooth causing a massive infection to reoccur three days after the procedure. Of course, the endodontist blamed it on a sinus cold. He said, "It's going around."

In engineering, it is good practice to contract experts from system integrators and machine builders to fix the difficult problems. Knowing that, I decided to go to an ear, nose and throat (ENT) specialist. I told the ENT specialist my history, and he laughed and said it's the tooth. He estimated that 50% of the patients visiting his office have sinus pain due to problem teeth or dental implants, and it can cause many different health problems. It seems like doctors should talk more and pull more teeth.

Clearly, it is not all properly engineered because poorly operating equipment would not be tolerated.

I cannot help but think that engineers are smarter than doctors. While doctors listen, get the data and try to understand the problems before making decisions, it's still just the practice of medicine. Many of the doctors have built a career hiding behind the practice, and some use it to ignore the facts. Clearly, it is not all properly engineered because poorly operating equipment would not be tolerated.

Accepting a decision without the data to back it and ignoring facts can lead to an improper diagnosis or solution. It doesn't really take an engineer to figure that out; a doctor should be able to tell you that. CD

A single source of responsibility

MAVERICK TECHNOLOGIES HAS been bought by Rockwell Automation. I have met Paul Galeski, founder of Maverick. I found him to be a very genuine individual, as well as a person who really does want to have our industries succeed. He got very involved in ISA, trying to allow them to redefine themselves. He organized the last ISA shows, as such, in an attempt to revitalize the general automation and process conferences and to bring it up to par to the user group conferences that have sprung up everywhere since Rockwell's Automation Fair proved to be so successful.

Just this week, I spoke with a good friend of mine, whom I haven't seen in almost eight years. We lamented about the lack of automation-type conferences but agreed that, due to the dilution of innovation in our business, the stars of the show were always getting bought, and then the innovation would die and become something else.

I relate this to product more than anything. Maverick is a service provider. But, regardless of what anyone says, Maverick will now use Rockwell products and technologies in all of its domain-expertise projects and applications.

Rockwell Automation has always been a supporter of its users, integrators and Encompass partners, and it has seemingly dealt with them at arm's length, sort of.

Back in the good old days, when I worked for Rockwell Automation (Allen-Bradley), the graphics solutions we presented and sold were private labeled from a Canadian company called Dynapro. No one knew this, and they didn't have to.

It was sold and supported by Rockwell Automation. That's all the customers needed to understand. The innovation was driven by customers and Dynapro, via its partnership with Rockwell Automation. And the relationship was good. It didn't hurt the customers.

Fast forward a few years. I now find myself in a situation that so reflects the mindset from those 30-plus years ago.

A customer of mine is building a new distribution center with lots of square feet using modern and innovative technology. But here's the thing: This company went to a single source company and said, "Give us the best innovative technology to do what we need. And here is what we need it to do."

While I haven't received the final tally yet, there are more than 20 companies involved, with five major components being represented by five different companies, and the customer is building a component.

The deal here is that my customer has, as one person puts it, one throat to choke—single-source responsibility. We used that line when selling into large corporations with graphics solutions, PLCs, MCCs and the like. It will all work together.

With my customer's new distribution center, the holder of the throat is relying on this one group of people to provide them with the knowledge and innovation to do the best for them. Let's face it though, they know what they know, but not what they don't.

Did my customer indicate to the throat that we want to use Rockwell Automation PLCs, for instance? Nope. The AGVs that were to be used were specified by my customer because they have experience with them. I have no idea if the throat has had any experience with them, but they will learn.

So in the end my customer will be given a system of someone else's true design and will rely on the throat to solve any issues and provide the service level that the warranty contract suggests.

The deal here is that my customer has, as one person puts it, one throat to choke—single-source responsibility.

But did my customer get the best solution for its business, and can the system be supported by the maintenance and project departments, or is my customer forever tied to the throat because of the proprietary nature of most of the solution?

And will Maverick now give its customer base the benefit of all it has done in the past by implementing the best solution for the task, or will it now just simply provide the solutions it is told to provide by the mother ship? As author John Kenworthy asked: Would you expect a GM truck to use a Ford turn signal light?

I don't profess to know the resulting business model, but it seems that we have reverted back to what was the norm 30 years ago. I hope I am wrong. cd

JEREMY POLLARD, CET, has been writing about technology and software issues for many years. Pollard has been involved in control system programming and training for more than 25 years.

What to look for in a display

AS CONTROLS ENGINEERS, we seldom make component selection decisions based on how a human operator interacts with the products we choose. If we do our job well, humans rarely need to see or touch the control devices. We may think about maintenance requirements and use connector-style sensors versus hardwired versions. We may choose a computer-programmable VFD rather than one that requires manually entering all the parameters. One aspect of our job that does need to take human interaction into account is the human-machine interface (HMI). Other than designing operation panels with logical button and switch layout and HMI screens that are informative and easy to understand, the physical location of the control panels also requires some forethought.

The HMI display and other actuators must be rated for the environment where they're installed, and the enclosure should match level of resistance of the HMI. Some HMI manufacturers offer optional environmental covers to increase resistance to the environment.

Standard machines and equipment typically have well-defined operator interface designs, refined over the machine's development cycle. Special machines and custom applications often have an evolutionary aspect to design. Additional controls and I/O are often added as the system is tuned and finalized. Designing an HMI enclosure with ample room for expansion and additions will result in a more finished look and feel at the end of commissioning.

The positioning of the display height and viewing angle are detailed in ANSI/HFES 100-2007, Human Factors Engineering of Computer Workstations and ISO 9241. These documents are written for computer workstation design, but many of the concepts and recommendations are applicable to industrial installations.

When using a touch-sensitive display, the viewing angle of the display and the size of touch areas are particularly important. Looking up or down at an HMI also contributes to increased worker fatigue and eye strain (www.controldesign.com/workstationmonitors).

If the HMI application includes manual machine control, mounting the display on a swing arm allows the operator to be in multiple locations during operation. Visual feedback from the actuators is often helpful. A swing-arm-mounted HMI may also offer the ability to be moved completely out of the way when not being used. Using high-quality equipment to build the swing arm is not wasted money.

Some manufacturers offer handheld devices that attach to the control system with an umbilical-cord-like cable. The devices may include buttons, switches and hardwired emergency-stop buttons. These portable HMIs usually have a rugged housing . Similar to a robot teach pendant, these devices allow greater freedom of movement around the machine while visually monitoring manual operation. The display area of these devices is limited; simple screen design with a larger number of pages is preferable to complex screens with small text and icons.

HMI software is becoming available for tablets and smartphones. While they cannot offer a wired emergency stop, they do offer complete freedom to move around equipment while monitoring and controlling machine operation. Security issues that arise when using wireless technology in a control system are addressed in ANSI/ISA-100.11a-2011 and parts of IEC 62443.

Standard machines and equipment typically have well-defined operator interface designs, refined over the machine's development cycle.

A console-style workstation allows ample room to mount an HMI and control devices without crowding too many mechanisms in a small space. A desk-like console naturally appears to be a main area of control and can be an excellent place to coordinate overall machine operation. A console workstation often provides additional enclosure space. If using the extra space to mount additional equipment—PLCs, drives, power supplies—consider the maintenance person who must work on the equipment. Most electricians would likely prefer not to lie on the plant floor to do voltage checks.

As controls engineers, one of our customers are the operators who operate the machine or system. We must produce our designs with their comfort and efficiency in mind. The goal of our design should address ease of use as much as efficient production. cd

THOMAS STEVIC is a controls engineer at Star Manufacturing (www.starmanufacture.com), an engineering and production company in Cincinnati. Contact him at tstevic@putman.net.

Rick Rice · rrice@putman.net

Discovery of the missing IO-Link

FOR ANY OF us grey beards, the introduction of yet another "universal" I/O system is sure to be met with rolling eyes and a big sigh. Like the proverbial better mouse trap, what could another way to connect automation devices have that would be better than all the other innovations? CANbus, DeviceNet, Profibus, ControlNet, Ethernet, AS-i—how do we sort through all the offerings and figure out what is best? How about all the media choices to connect these? Can't we just have one protocol that can be used with all?

First introduced a few years ago in Europe, IO-Link seems to be gaining traction in the North American market of late. An extension of the globally recognized PLC standard, IEC 61131, IO-Link (IEC 61131-9) is an open standard protocol that is the first system designed with legacy in mind. We've been connecting to sensors and actuators with the familiar brown, blue and black wires for years. More recently we have taken to connecting these with an M12 connector to make them quick connect/replacement. What a brilliant concept it was to use those same three wires to carry other information along the line without compromising the true purpose of a sensor or actuator.

IO-Link enables the transmission of process and service data, as well as events, all in a familiar physical connection format.

1. Process data shows the latest state of a device or communicates the desired state of an actuator. This critical data is updated every communication cycle.
2. Service data allows the user to access detailed information about the particular sensor and device. This can be as limited as manufacture, model and serial number but can contain as much as 16,000 blocks worth of data per device. Some blocks are protocol-defined, while others can be custom to a particular manufacturer.
3. Events that occur too rarely to include in the process data but should happen more frequently than a service-data request can be delivered using an event. This provides a means by which standard or vendor-specific data about alarms or information messages can be delivered as things happen.

Most users of automation have no idea that a large selection of the sensors and actuators that they use every day in their design/builds already have IO-Link capabilities built in. Such was the case for me when I recently enjoyed a visit with one of my local vendors. I've been using the particular brand of products since the early '80s and was a little leery about the prospect of some young "fella" coming into my meeting room to tell me about a new way to connect my stuff. I immediately had flashbacks to some of the early nightmares of setting up a DeviceNet network and the trials and tribulations of early Profibus. What could this new technology offer me that I hadn't already rejected so many years ago?

Now, to be fair, I have come to a détente, we shall say, about networking. There is a time and place for them, and, let's face it, most of the bugs have been worked out to the point where it's commonplace to just hook the field I/O up to a block of some sort and plug the homerun cable in. Like any newfangled thing, it takes a bit of time to sort it all out, and I think we are there.

The nice thing about IO-Link is we don't have to jump in right away. For those of us who are reluctant to put our feet to the fire, we can start by just selecting the same good sensors and actuators that we already use. In many cases, your favorite photoeye or proximity switch already has IO-Link embedded. The great part about an IO-Link device is it will behave like the same old "dumb" device we always use, if it isn't connected to an IO-Link master. The magic truly happens when that same device is connected to the I/O protocol device.

Tap into the smarts of your sensor to determine not just if it is turning off and on, but how well it is doing it.

Once connected, we enter the world of advanced diagnostics, automatic device configuration, multiple profiles, statistical trending and descriptive tags, all embedded in the device. Data from each device can be used to evaluate the performance and improve uptime by implementing predictive measures and activities.

The significance of technology such as IO-Link is that the investment can be gradual. As a designer of control systems, we probably have a preferred way of doing things. From the moment of our first-ever design, we are looking to create systems that we are familiar with. We don't want to have to do a detailed evaluation of components and features every time we start a new job. How would we make any profit? Profit comes from repeatability and using pre-canned solutions as part of our designs.

The parade of products and solutions before IO-Link relied on a configured system from start to finish. Master and slave modules, mapping the memory exchange from the master to the PLC, specific physical media from panel to field and specialized sensors and actuators that communicated with the desired protocol—all for a significant increase in price to deploy. Remember all the different connection methods? Every new I/O system had its own connectors and shells. How about if you made a machine with DeviceNet components and your next client wanted the same machine but with Profibus? Head drops, a big sigh and you start all over. Learning the protocol, choosing the media, going through the trials and tribulations of figuring it out all over again.

At present there are 127 member companies in the IO-Link Consortium (www.io-link.com). Nearly every major automation company is represented. It is a virtual who's who of connectivity. For perhaps the first time, the industry has lined up behind a single protocol. To a controls designer, this is a key development. No longer will you have one hand tied behind your back because you are loyal to a particular PLC brand. You will no longer have to stick with a particular sensor manufacturer because it favors AS-i or DeviceNet or Profibus. The IO-Link Consortium isn't heavy on European or Asian or North American hardware manufacturers. It is truly a united federation of automation suppliers.

So, where do you start? Start by reaching out to your vendors of choice. Ask them what they have in their stable that is IO-Link compatible. You will be surprised by the answer, much as I was. My photoeye guy? He's there. My proximity switch of choice? Yep, there, too. My favorite cable and connector suppliers? Yes, they are all there. Guess what? My favorite actuators, both of them, are represented in the consortium. Many of these products have had IO-Link embedded for some time, so there is no change in the cost of deployment. These are the same sensors and actuators you have in your stock room right now. Once you have compiled your list of field devices that can use IO-Link, delve into the architecture to make use of the features. Remember that the connection to the field device is still that same three-wire cordset that you know and love.

Jumping into the world of IO-Link isn't just about climbing on the latest bandwagon. Adopting a standard helps to streamline your concept-to-product journey. Any foray into quick-connect technology also brings you to the next level of manufacturing, and, when that quick-connect technology includes a potential stream of data to and from a device, you have automatically made your product smarter. Use as little or as much of that data as you like. You could start by just replacing your current I/O array with IO-Link. Simple digital devices sending 1s and 0s back to the PLC. The PLC sending 1s and 0s out to your actuators. Then, when you feel good about those transactions, add some smarts. Tap into the smarts of your sensor to determine not just if it is turning off and on, but how well it is doing it. Is your photoeye positioned to give you the best on-off signal? Are you close to the sensor edge? Is your actuator responding appropriately to the command you send it? What is that device? Who makes it? What is the part number? Imagine how convenient it would be for the maintenance person to have that information supplied on the operator screen. Imagine your system telling the maintenance person that the part that was just installed doesn't match the part that it is intended to replace. The possibilities are endless.

The IO-Link Consortium isn't heavy on European or Asian or North American hardware manufacturers. It is truly a united federation of automation suppliers.

Most of the mainline PLC platforms have software tools embedded in their products to take advantage of the IO-Link protocol. Gone are the days of figuring out the input, output and configuration data blocks and mapping the bits and bytes out into meaningful information. When a manufacturer enters into a common marketplace where everyone has access to the same technology and the same connectivity, that manufacturer is compelled to spend time and resources to make the product stand out from the competition. This is a win-win situation for manufacturer and controls designers alike. If a manufacturer wants you to buy its component and the component has the same basic functions, connection and protocol in common, the manufacturer is going to make the product easier to use than its competitors'. The designer benefits from the healthy competition between the various manufacturers. CD

RICK RICE is a controls engineer at Crest Foods (www.crestfoods.com), a dry-foods manufacturing and packaging company in Ashton, Illinois. Contact him at rrice@putman.net.

A sense of machine health

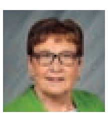
Sensors provide early indication of equipment degradation

by Mike Bacidore, editor in chief

DIAGNOSING MACHINE PROBLEMS before they happen can translate into significant savings for end users. In fact, some machine builders have capitalized on the ability to monitor their machines remotely by providing service agreements or even going so far as to sell machine production/output, rather than the capital equipment itself.

New sensing technologies have a lot to do with what machine builders are able to offer. Our roundtable of industry experts explains the impact that everyone is anticipating.

What impact do sensing technologies have on the ability to diagnose machine problems?



Paula Hollywood
senior analyst at ARC Advisory Group
(www.arcweb.com)

In the case of diagnosing machine health, monitoring sensors, specifically, vibration and/or temperature sensors, have no impact on the machine's ability to perform its function. In this case, the purpose of the sensors is to monitor the machine's internal components to provide an early indication of degradation in machine performance. The data from the monitoring sensors provides owner/operators with indications of machine health well in advance of failure. The broad availability of smarter, lower-cost sensors, wireless connectivity and big-data processing tools make it cheaper and easier to collect performance data and monitor equipment health parameters.

Michael Howard
project engineer at Digital Manufacturing and Design Innovation Institute (DMDII, www.dmdii.org) in Chicago, Illinois

Sensors can monitor machines in real time and give the machine the ability to notify an operator of an error as soon as there is a problem or, in some cases, even before the problem occurs. Spindle vibration sensors or temperature sensors generate data that can be analyzed to determine if the machine is operating in a normal state or if some operator intervention is required. Sensors can also help to reduce the amount of machine downtime required for routine maintenance, as an operator will have some advance insight into which parts of a machine require more attention or may require replacement or repair.

Adrian Messer
manager of U.S. operations at UE Systems
(www.uesystems.com)

Ultrasound technology is very capable of finding early-stage bearing failures in rotating equipment. Because we can identify these failures early, it allows for proper planning of repairs, thus decreasing repair costs and avoiding costly downtime due to unplanned outages.

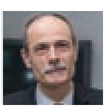
Jill Oertel
national product manager at Sick
(www.sick.com)

Intelligent sensors are often self-diagnosing through health output monitoring, which allows machine problems to be easily diagnosed. Via remote connectivity, a sensor can report on various aspects of its condition, from build-ups of dirt and grease that can interfere with performance to operational inconsistencies that may increasingly become worse and require component replacement. Alignment changes resulting from wear or impacts with objects can also be reported.

For example, safety laser scanners that safeguard workers from process hazards can be remotely checked and adjusted so maintenance employees can address conditions such as dirty or obscured screens, infringed scanner fields and conditions where a reset may be required, such as the need for device replacement. Signals can be tied back to a PLC via a serial port on the front of the scanner. The scanner can also be connected to a safety controller, and then the data is transmitted via a gateway, for example.

Some intelligent sensors offer the flexibility to alert owners to the need for maintenance for a specified condition, such as minimal vs. excessive dirt build-up. Often, owners can adjust the sensor's parameters to compensate for these conditions, keeping the system operational long enough to coincide with a more convenient, less costly and disruptive maintenance and downtime schedule. And, with the advantage of stored settings, the sensors can easily be reset in conjunction with an overhaul or other major maintenance effort, or to redeploy a machine for a new task.

The health output monitoring abilities allow sensors to diagnose machine problems, allowing longer machine operational time and less unscheduled maintenance.



Helge Hornis

Ph.D., technology director—factory automation at Pepperl+Fuchs (www.pepperl-fuchs.us)

There will be significant changes as new sensing technologies make use of measuring data internally and communicating to the outside through IO-Link externally. Here is an example. Take a retro-reflective photoelectric sensor frequently used in material handling systems such as conveyers. It works by shining light on a reflector and detecting the returned signal. In the past, the sensor determined that it saw the reflector by evaluating the amount of light returned. Since an object that passes through—let's say a cardboard box—is much less reflective than the reflector, the amount of light returned is low and the object is detected. But what if we are detecting packing that is metalized and quite shiny and reflective? What about a silver metallic car body or an item made of chrome? Still, a reflector should return more light, but the situation is a bit more challenging. Make this even tougher by having stickers on the box that are reflectors? Modern, marketing-driven designs may demand that even this kind of packaging is securely detected. This is where measuring comes in. Take, for instance, a sensor with pulse ranging technology. In this case, we are not just evaluating the returned signal, but the distance to the reflector. With this technology, the sensor can reliably determine that the reflective material is passing through, but the reflection is not the same intensity and not at the same distance as the reflector. Now add IO-Link and the ability to transmit the real distance to the object or the reflector. In this case a diagnostics system can continuously evaluate those values and know when the reflector is losing alignment or is getting dirty. Looking at the strength of the returned reflector signal, one can determine when it is time to clean the reflector or lens of the sensor. Looking at the distance to the reflector makes it possible to identify mechanical changes. In either case, predictive maintenance is possible.

Jason Tranter

founder and managing director of Mobius Institute (www.mobiusinstitute.com)

Rule 1 is that you need vibration sensors that provide accurate, repeatable measurements across the frequency range of interest. Rule 2 is that you need those sensors to be mounted as close to the bearings as possible and, ideally, in positions that capture the three axes of vibration motion. Rule 3 is that the sensors must be able to withstand the environment. Therefore, the costs of those sensors, including the installation, mounting and wiring costs, are critically important. If they are too expensive, then fewer sensors will be mounted on the machine. Technologies that reduce cost, utilizing wireless communication, for example, increase the likelihood that early and accurate diagnosis can be made because an adequate number of sensors can be installed on rotating machinery. And, if it is possible to incorporate additional data, such as temperatures, speed and operating states, the ability to perform the diagnosis with more complicated machinery will be enhanced.

Weishung Liu

product planner at Fluke Industrial Group (www.fluke.com)

Sensing technologies can play an important role in diagnosing problems, but further inspection with other technologies is often required.

Tools capture electrical measurements to aid in troubleshooting. By baselining and trending data, we can begin to understand where and when problems occur. We can also correlate electrical measurements with thermography and vibration, for example.

Brett Burger

principal marketing engineer at National Instruments (www.ni.com)

If you can't measure it, you can't fix it. Sometimes the bottleneck in the ability to measure is technology, and sometimes its lack of practicality or business models. Either way, it is imperative for machine diagnostics to get pertinent information, not just data, to the subject matter experts who know how to diagnose machines.

Joe Van Dyke

vice president of operations at Azima DLI (www.azimadli.com)

Sensing technologies have a huge impact on the ability to diagnose machines. Especially impactful are the latest advances that put more and more intelligence right at the machine where, combined with sensor fusion, they can produce accurate diagnostics and send actionable information upstream. This kind of refined data is far more valuable than raw readings. The ability to be flexible and allow for saving and forwarding the raw data should not be overlooked, however, because the raw data on demand may be required for advanced diagnostics. Sensing technology that reduces power consumption, harnesses or scavenges power from the environment, reduces sensor size and allows remote connectivity continues to enhance our ability to instrument industrial machinery and improve condition-monitoring effectiveness.

Bob Drexel

product manager, process sensors, at ifm efector (www.ifmefector.com/us)

The majority of sensors have moved to being microcontroller-based. This has pushed sensors to functionality that has not been possible in the past. Sensors today are combining various sensing values, such as pressure, temperature, acceleration and electromagnetic field. This combining of units of measure aids in increasing the accuracy of the targeted purpose and also opens the possibility to use these different measurements for extended purposes. This includes things like flow sensors that can give BTU-usage information or pressure sensors that also track vibration patterns. Coupled with a microcontroller, this allows for digital communication that can send multiple values that will provide operational condition status information to optimize machine performance, longevity, operation condition and granular intelligence about specific aspects of the manufactured components and completed assemblies. Therefore, sensing technologies with dual purpose will continue to aid in the evaluation of the total cost of ownership, as well as flexible business practices.

Mitesh Patel

head of Internet of Things for the manufacturing industry solution unit at TCS (www.tcs.com)

Sensing provides the ability to detect and quantify existence or changes of certain phenomena. Diagnostics rely on this very foundational aspect of any measurement or control system. With the advent of a new sensing technology or type of sensor, a huge number of applications and opportunities to diagnose and improve existing equipment is unlocked. Our skin is a fantastic sensor. While it protects us, it senses various phenomena in our environment. If it becomes possible to have a similar sensor for every machine around us, it will unlock tremendous potential to diagnose machine problems.

Barry Po

Ph.D, senior director, product and business development, at NGrain (www.ngrain.com)

In the past, machine maintenance was a costly, labor-intensive activity. By enabling maintainers to anticipate and respond to machine issues before they happen, sensing technologies today are enabling maintenance activities in the enterprise to be done much more quickly and at a much lower operational cost.

Stew Thompson

technical writer at CAS Data Loggers (www.dataloggerinc.com)

Today's sensors have the accuracy, sampling speed and connectivity to provide real-time data to users working in fault diagnostics applications. When manufacturers and other businesses are able to catch instances of machine wear and damage as they happen, they realize savings, not only on further equipment damage, but also on costly process delays and shutdowns otherwise caused by failures.

Tim Senkbeil
product line manager, Industrial Connectivity Division, at Belden (www.belden.com)

Sensors are key in diagnosing machine problems. Common in most machines, position sensors are used to guide items through the process, whether that's material handling such as conveyor systems, assembly lines, packaging, manufacturing process control or others. Position sensors allow the system to identify jams or other faults that prevent the item from completing the process. Other types of sensors also provide useful feedback for locating a fault within a machine.

Smart sensors or actuators—those that provide additional digital information about the function and health of the sensor itself—can further assist with troubleshooting by eliminating the sensor as the source of the fault. Smart sensors or actuators also improve uptime by providing engineers with health information that can be used to perform preventive maintenance before a component failure causes a system downtime incident.

Sensor data, in conjunction with testing and observation, is indispensable in diagnosing machine problems.

Tom Edwards
senior applications engineer at Opto 22 (www.opto22.com)

Diagnosing machine problems quickly and accurately has a direct effect on a machine's operation and uptime, or, in other words, its value as an organizational asset. Sensor data, in conjunction with testing and observation, is indispensable in diagnosing machine problems. Obtaining detailed operational information—both immediate and historical—on a malfunctioning machine can mean the difference between, for example, a technician making an approximate diagnosis and removing the machine for service versus using additional data to make a detailed diagnosis that indicates an on-site repair is possible.

Cloud Configuration

The how-to behind IIoT implementations and their big-picture results

BY MIKE BACIDORE, EDITOR IN CHIEF

FOR AUTOMATION AND technology, the Industrial Internet of Things (IIoT) and wireless sensor networks (WSNs) are two of the biggest investment areas, according to a study by On World.

"Post-U.S.-election optimism, maturing standards combined with ubiquitous cloud platforms and open-source initiatives continue to advance WSN innovations for the Internet of Things," says Jeff Kreegar, chief technologist at On World (www.onworld.com), a research firm headquartered in San Diego.

According to the study, 30% more individuals believe investment in an IoT platform is important than the number who thought so in 2014. Two-thirds of participants said investement is important. WSN applications are planned by 80% of respondents in the next year-and-a-half, with asset monitoring, equipment health and safety and environmental monitoring as the fastest-growing applications.

Plans are one thing, but execution and results are another thing altogether. These two organizations have embraced the IIoT and now have the financial rewards to prove it.

Automotive parts supplier launches IIoT initiative

For more than 50 years, vehicle producers such as General Motors and Mazda have used industrial manufacturing concepts and systems from Hirotec America (www.hirotecamerica.com) in Auburn Hills, Michigan.

"Hirotec is a Tier-One component and tooling supplier for the automotive industry, giving us a very unique perspective on how both sides of the industry operate," says Justin Hester, senior researcher, Hirotec. "We've used this insight to benefit both our business and our customers' by designing and building a wide array of state-of-the-art solutions that are based on proven concepts. In our dedication to our customers' success, we pride ourselves on our ability to supply the highest-quality automotive equipment and services to customers around the world."

Operational downtime is a significant issue facing original equipment manufacturers (OEMs). In most cases, the machinery involved runs without condition-based monitoring—essentially operating until a failure occurs. At that time, appropriate personnel are contacted to assess the situation and make the repairs as expeditiously as possible to prevent dramatically delaying production schedules. Outside factors such as weather or traffic patterns might also add to possible downtime scenarios and lead to organizational inefficiencies or misallocation of resources.

Hirotec sought to eliminate this trend of reactive maintenance and lost opportunities by utilizing the information and systems it had on hand to gain deeper insight into its operations and processes. The automotive supplier had long collected industrial data from sensors and machines across customer production facilities and its own systems to support its decisions and track business progress. However, volumes of this data were manually separated and stored across multiple sources, making it inaccessible to collective and systematic analysis. In order to improve quality, reduce downtime and optimize production schedules, Hirotec needed to implement a modern, automated solution that could gather maintenance and operational information into one source and offer actionable recommendations to its quality professionals (Figure 1).


(SOURCE: HIROTEC)

INFORMATION INTERFACE

Figure 1: Hirotec needed to implement a modern, automated solution that could gather maintenance and operational information into one source and offer actionable recommendations to its quality professionals.

"A lack of data was never an issue for us," says Hester. "As one of the largest automotive manufacturing suppliers in the world, we collect volumes of data sets on a daily basis. The problem we were faced with was transitioning from a data-heavy organization to a data-smart organization. We realized that in order to bolster profits from untapped machine-generated information, we needed to look toward modern solutions that automated the process and enabled timely, data-driven decisions."

How do you leverage IIoT?

"Hirotec did extensive research and met with many of the large factory automation solution providers to discuss IoT tools and solutions before selecting PTC ThingWorx and Kepware," says Hester. "This decision was based on PTC's clear vision for IoT in manufacturing, the comprehensive solution ecosystem that PTC provides and its universality in being able to connect with any automation control system or data stream across the enterprise."

Not wanting to waste time and effort integrating multiple solutions across several business functions, Hirotec finally turned to Kepware's KEPServerEX and the ThingWorx IoT Platform—both solutions from PTC—to enable company-wide device-to-cloud connectivity through one overarching toolset. Working together to deploy a single source of smart solutions for the IIoT, the ThingWorx platform would be able to provide analytical insight into Hirotec's data through industrial data streamed from the IoT gateway for KEPServerEX, a plug-in capable of pushing information from KEPServerEX into big-data and analytic software applications. To support the company's long-term IIoT vision, Hirotec collaborated with representatives at PTC to build an IoT framework supported by short, six -week Agile sprints.

"A growing trend in the industrial sector is the desire to take an agile approach to the implementation of software," explains Hester. "With an agile approach, you define a very specific problem or user story you want to solve, and then you take a short period of time—two to six weeks, a sprint—to implement the hardware and software to solve the use case."

This approach is in contrast to the typical manufacturing execution system (MES) or enterprise resource planning (ERP) implementation where you take many months or years to perform plant or corporate-wide technology rollouts. "IIoT technologies are allowing this to happen at this fast pace at a reasonable price point and allowing the solution to scale as more user stories are implemented in a factory," says Hester.

Operational downtime is a significant issue facing original equipment manufacturers.

"Scrum is a subset of agile and is useful for the rapid delivery of high-quality software," explains Hester. "It is an agile software development process based on multiple small teams working in an intensive and interdependent manner. Hirotec leveraged the scrum model in its North American shop in Detroit, the test bed for the first small sprint."

Scrum and visibility

Where a full IoT implementation may have taken years to generate a proof of concept, the scrum model provided company executives with visible and quantifiable progress in just weeks. "We see and speak with many manufacturing organizations," says Hester. "It is clear they are interested in the Internet of Things. They see the potential and would like to do something with the technology. Despite the desire that exists, many remain frozen because the prospect of a full-blown implementation is so daunting and uncertain."

This is why Hirotec advocates so strongly for the short-sprint model it's adopted, explains Hester. "We don't want to boil the ocean; we want to start with low-hanging, solvable problems and build out our case and experience," he says.

Hirotec's North American shop in Detroit was chosen as the testbed for the first small sprint because of the unique data types generated among its eight computer numerical control (CNC) machines. Kepware's IoT Gateway for KEPServerEX collects data from the CNC machines and streams it in real-time to the cloud, where the ThingWorx IoT Platform provides analytics and data visualizations. This solution gives Hirotec labor-free access to a customized visualization of both the operations and conditions of its industrial devices and systems.

Since implementing Kepware's IoT Gateway and the ThingWorx IoT Platform, Hirotec has gained increased visibility into the processes of its CNC shop and deeper insight into operations. The company realized early on that having access to CNC machine uptime data significantly impacted the shop's scheduling process, which was previously set on conjecture and after-the-fact analysis. Manufacturing leadership can now leverage real-time data from the shop floor and tie it to the scheduling ERP system, optimizing the scheduling of parts to CNC modules. This process also provides greater insight into asset and resource allocation by automatically formulating smarter questions about current needs and priorities and determining the most effective course of action. Because of this, Hirotec has improved productivity across the shop and increased its ROI. The company has also improved collaboration between its operations and information technology (IT) departments. By working daily with research and development engineers, IT teams quickly gained access to corporate roadmaps and strategic goals and were empowered to contribute at a more strategic level. Not only has the development of cross-functional teams improved communications across the entire business, but the added perspective helps to promote quicker and more efficient responses to IT jobs. Hirotec anticipates its IIoT efforts to impact every aspect of its business—from operations and IT to financial forecasting, customer relations and sales.

Fog computing in an industrial context

Flextronics (www.flextronics.com) is a global sketch-to-scale company with more than 100 sites in 30 countries, providing ideation, manufacturing, assembly and logistics. Its 200,000 employees, 2,500 of them engineers, manufacture connected products for a connected world, explains Ofer Ricklis, vice president of global automation at Flex.

"Flex decided to explore and to deploy the connected factory strategy about two years ago," explains Ricklis. "This was part of several efforts under the IIoT/Industry 4.0 initiatives which we ran with key customers. About a year ago, we refined our strategy and, from the manufacturing automation perspective, we defined our automation building blocks, which include the hardware and software solutions enabling the fog-computing approach, among others. We are already deploying our systems, which are connected to both our internal factory and shop-floor management systems and to other software platforms. These systems are running in our sites in the United States, Mexico, India, Israel and Europe. Our plan is to have flex sites fully connected and managed by our Smart software platforms by 2020."

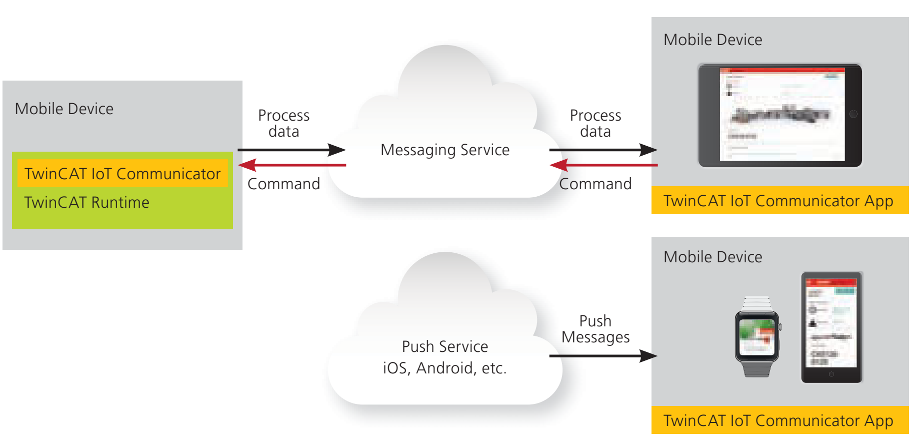
OEMs have different needs than end users, explains Daymon Thompson, automation specialist, North America, at Beckhoff Automation (www.beckhoff.us). "What are the business goals that apply to IoT and Industry 4.0 implementation in your manufacturing or OEM operations?" he asks.

In the fog

A fog-computing strategy provides decentralized computing by bringing the intelligence of the cloud closer to the end devices. It is one of many options that machine builders and factories can consider. A central server requires high costs for hardware and software, and cloud-computing services offer new possibilities and connectivity options. Local data processing captures more process data but requires data transport, exchange, storage, analysis and security; however, it reduces data traffic. The fog stack gets data from sensors to the machine controller, but you can't do analytics locally.

"But what if we could take the analytics and put them into PLC code? Many automation controllers are quite powerful, even offering quad-core Intel Core i7 processors. This provides more than enough capability to do all the processing on the machine," says Thompson. "Local condition monitoring has been around for many years, and the model of having processing power on the machine enables the user to bring in and analyze temperature, acoustics, vibration, voltage or current data. Combining this with IIoT and doing data analysis locally enables threshold monitoring of digital and analog values, timing analysis, lifecycle monitoring, RMS calculation, state analysis and energy calculation."

Previously, a server-client model needed a VPN connection to tunnel back to the PLC or device in an end-user facility, explains Thompson. "Now, we can use a message broker, and the outside devices



COMMUNICATION IS KING

Figure 2: Whether you're using a public cloud service or your own private cloud, you can use an IIoT protocol for communication. (SOURCE: BECKHOFF)

don't touch the internal device," he says. "It could even be on a cloud server. The device can publish to the broker, and it doesn't care about the end device."

Whether you're using a public cloud service, such as Azure or your own private cloud, you can use an IIoT protocol for communication. "If you have a legacy system or third-party device, you can pull data from it in its native language and convert to an IIoT protocol, such as MQTT, AMQP or OPC-UA," suggests Thompson. "From a machine builder's perspective, you want to know the varying differences in time between states of the machine. These analytics calculations can run in real-time without another platform. If you don't want the data to leave your enterprise, you can use a message broker in your enterprise network or private cloud, which can include logging in to a database and analytics platform, or you can use a public cloud. This enables the machine builder to access the data and analytics, as well. The infrastructure depends on the application, whose side you're looking from and the business goals."

From scope to technology selection

As a machine builder, Flex, for example, started with scale and global infrastructure. "Then we added scope," explains Ricklis. "Then we added speed for real-time information about the market and about our business. It gives us real-time, end-to-end visibility of our supply chain. This allows us to have cross-functional innovation."

Flex created an interconnected, touchless assembly operation called the Smart Automation project. “We have hundreds of people involved from around the world,” says Ricklis. “Our main business goals are to standardize, to have machine-to-machine communication, to eliminate the human touches along the manufacturing and assembly processes and to leverage and improve asset utilization. We are partnering with a lot of hardware and software partners to run these process lines.”

Flex selected Beckhoff to provide the control and IIoT infrastructure (Figure 2). “Our Flex robotic cell is fully automated and fully connected,” explains Ricklis. “It can do pick-and-place, automated screwing and automated assembly by leveraging EtherCAT and Beckhoff Industrial PCs (IPCs). Flex Smart Automation gives us traceability, real-time control and predictive analytics. Real-time detection gives us opportunities to monitor, control and predict processes and then communicate with the supply chain if there’s a problem. Once the line runs hundreds or thousands of parts, it can also run analytics.”

The Flex robotic cell product family and related Smart accessories are using several hardware and software platforms, including industrial robots, motion drivers and additional tools such as automatic screwdrivers, glue dispensers, soldering systems and visual inspection software and hardware.

Smart Automation gives Flex the real-time information it desires. “We understand why things are happening before we have information from sensors and predefined logic,” says Ricklis. “Our next step, which is right on the horizon, is to predict, with the goal of reducing the human touches, and allowing the machines to back-feed the information and corrections in the IPC or in the cloud. This allows us to create end-to-end or fully automated processes and technology.”

The strategy allows Flex to scale and standardize automation globally, having flexible solutions that can be easily reutilized for many applications in sites all over the world, explains Ricklis. “We gain faster deployment times and shortening of NPI processes,” he says. Flex is able to support its sketch-to-scale strategy by designing automated manufacturing lines as part as the product development process. cd

BY BRYAN DECELLES & ZACH MARINELLA, AEROSPEC

PLC+HMI enables critical stress testing

AeroSpec's medical device test system simulates actual use to verify reliable operation of critical components

MEDICAL DEVICES USED in hospitals and clinics around the world must undergo a series of rigorous tests to evaluate their reliability before coming into contact with patients. With the high stakes involving patient health, sometimes life-or-death situations, there is no room for mistakes or faulty devices. Each tool in a medical staff's arsenal must function flawlessly every time.

With these demanding requirements in mind, AeroSpec (www.aerospecinc.com), a custom equipment manufacturer in Chandler, Arizona, developed its medical device test system (Figure 1). This system is designed to perform endurance tests on new medical devices to ensure high-quality performance when met with load and stress from actual use. The system helps medical device manufacturers run extensive tests to ascertain optimal designs, verify reliability and ensure robust products.

AeroSpec started as a machine shop more than 30 years ago and quickly evolved into a full-service custom equipment supplier for a variety of industries including automotive, semiconductor, medical and others. AeroSpec's OEM equipment provides customers with low-cost and efficient methods to verify their medical devices have been tested and are ready for use in the field, clinic or operating room.

Initial design

The AeroSpec medical device test system is a cost-effective, pre-designed solution based around the IDEC FT1A PLC+HMI controller and operator interface unit. Versatility is a strength of the system, as it can be adapted to run tests on a wide variety of medical devices.

Using the PC-based programming software supplied with the PLC+HMI unit, AeroSpec developed a powerful program to control the unit, and a key feature of this design is the test system's ability to operate lean assembly and testing fixtures.

AeroSpec began work on the test system based upon client-requested specifications. The client needed a system to run endurance tests on the new product, a cosmetic surgery device used for cellulite reduction, with the ability to simulate the load on the product and measure the stress endured by the device.

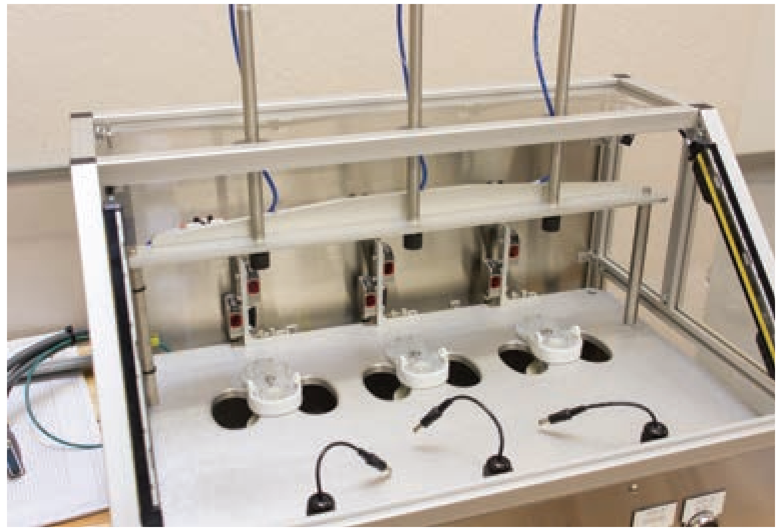
Initially, the request was for a test system that would measure current draw through the power cable of the tested device, but the client changed direction on the product to move to a wireless model, making the original request obsolete.

To comply with client requirements, AeroSpec opted to add an rpm sensor to measure and chart the change in velocity of the motor in the device. The rpm sensor would also provide the client's engineers with critical data verifying the device could withstand real-

PLC+HMI

Figure 1: The heart of this medical device test system is the PLC+HMI, which performs control and monitoring of the system and provides operator interface.

world usage. This system was designed to allow AeroSpec's client to run tests with wired devices, determine an optimal running current and copy that model to the wireless versions of the devices to continue testing.



MEDICAL TEST FIXTURES

Figure 2: Medical devices are installed in three test fixtures and subject to conditions simulating actual operation in the field.

Functionality and features

The test system is designed to execute endurance tests that assist medical-device manufacturers in the development of new products. The test system accomplishes this by simulating actual operating scenarios and by measuring the stress on the devices installed in the text fixtures to gauge how they perform (Figure 2).

The test system has three channels running in parallel with each other. When testing the endurance of medical devices, the test system controls and monitors three pneumatic actuators, three high-speed sensors that gauge rpm on the motor modules and three electromagnetic brakes. The brakes are used to simulate a load on the device, and the pneumatic actuators are used to activate and deactivate the devices.

The test system provides two main fault-condition alerts. The first condition—failed to activate part—occurs when the test system attempts to switch a device on and observes that the rpm reading from the motor module is not increasing. When this occurs, the test system tries to reactivate the device. If it fails to activate a device three times in a row, the test system provides a fault message. The second fault condition—failed to deactivate part— occurs when the test system attempts to turn off a device and doesn't observe the rpm dropping to an acceptable level.

For both fault conditions, the test system flashes a red light for the station that failed to activate or deactivate a device. In a situation where one of the stations fails, or if the user attempts to initiate a cycle with the part incorrectly secured, the HMI screen will also display an alarm.

Hundreds of alarms can be recorded in the PLC+HMI unit alarm log file. Each alarm is accompanied by a brief description to inform the operator of the nature of the fault, and by a time and date stamp. The operator can select a particular alarm and click on the help button, which opens an alarm help screen. This makes the process of troubleshooting different faults intuitive and enables the user to take corrective action promptly.

To reset the test system, the operator simply pulls the device out of the test fixture and then reinserts it, or presses the reset button. In both cases, this will reinitiate the test cycle.

Combo PLC+HMI

AeroSpec's medical device test system is responsible for critical product testing, and it's powered by IDEC's FT1A Touch, a combined PLC+HMI in a single housing. AeroSpec felt the IDEC unit was the best option for its test system as it allowed AeroSpec to attain design goals with a compact form factor unit at a competitive cost.

Another reason for selecting the unit is that the PLC part of the FT1A Touch provides the intelligence and logic needed to control the test processes as it's a 32-bit-based controller with built-in arithmetic, trigonometric, exponential and logarithmic functions to handle the required high-level mathematical calculations.

The PLC also has a USB port to allow AeroSpec's customer to download programs to the unit and monitor the test system.

The HMI part of the FT1A Touch has all the features needed for

HMI AND OPERATOR CONTROLS

Figure 3: The HMI screen is configured to show all of the test parameters of interest and to guide the operator through the test procedures.

executing tests and for observing results visually and efficiently. The HMI provides the test system with the graphical capabilities required to set up the tests and displays the current cycle and test number for each station (Figure 3).

The HMI sets the parameters used to run the tests, including minimum and maximum test cycle times, number of tests performed and simulated load amounts. There is a screen for each station that displays an active trend of the rpm and the current test cycle. Located to the right of the screen are options to navigate to the parameters for each station including a histogram of the rpm, test cycles, use-life cycles and torque set points.

The test system requires very little training for an operator to use it effectively. An operator simply places the device in a test fixture, and, with no further input from the operator, the machine automatically cycles and tests the device.

When testing is complete, a green light for that station begins blinking, and the operator removes the tested product. The system is fast and efficient, and an operator can be trained in less than five minutes to operate it.

Due to the nature of the testing, the cycle time can be high, but it is also completely variable. Since the machine possesses three stations, the operator can test three devices simultaneously, tripling the number of devices that can be tested.

Test system specs

The entire test system is compact enough for desktop operation. Despite its compact size, the system houses impressive capabilities. It continuously logs each station's test data, such as rpm, electromagnetic brake force and station count, at a sample rate of about 500 ms. Data is logged for the duration of the test cycle, which is typically 10 minutes with 25 tests per cycle.

The test system is offered at prices starting at $5,000 and can be made to order in five to six weeks. In addition to the control and monitoring features, the test system includes the electromechanical components required to secure and test products.

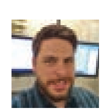
The test system can be expanded to include features such as thermal and vibration readings.

The test system includes:

- a PLC with up to 24 discrete inputs, 12 discrete outputs, six analog inputs, four analog outputs and four high speed counters
- an HMI touchscreen
- test fixtures
- three variable-force electromagnetic brakes capable of supplying forces from 0.01 Nmm to 20 Nmm with 0.01 Nmm resolution
- pneumatic and solenoid valves
- other components as required for testing unique medical devices.

This initial implementation of the test system is only the beginning. Several of AeroSpec's customers are currently working with them to adapt the system to meet some very specific medical-device test requirements.

This flexibility of the test system, powered by the PLC+HMI unit, makes these types of adaptations feasible, and it also allows for new implementations designed to meet customer demands. CD



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In-the-field turf handling

A sod palletizing system built for use on the farm reduces operating costs and increases productivity

by Dave Perkon, technical editor

TECHNOLOGY IN THE FIELD

Figure 1: FireFly combined technology with a design based on customer needs to the field of turf harvesting.

(SOURCE: FIREFLY)

BRINGING A HIGH-END control system, programming and mechanical design to FireFly's automated turf harvesting machine proves technology and automation work well in agriculture applications. Not only is the FireFly ProSlab 155 more efficient and productive compared to what was originally available in industry, it also connects to the Internet of Things (IoT) to bring even more technology to the field (Figure 1).

Things started slowly but moved quickly for FireFly (www.fireflyequipment.com) in North Salt Lake, Utah. "We started in business in 2010 building aftermarket parts for the turf farming industry," says Steve Aposhian, CTO and president at FireFly Equipment. "Having grown up on a farm and with my brothers identifying problems with existing harvesting equipment, we designed in some improvements. Feedback from customers in the industry triggered the design of the ProSlab 155 machine." FireFly made the leap of using advanced controls to solve a number of problems customers were facing in the industry.

Aposhian is a mechanical engineer with an emphasis in software development and controls design. Using engineering knowledge, the FireFly team observed that there were machines out there dedicated to cutting flat slabs of turf that worked under some conditions. However, the machines weren't very productive; they were slow and had reliability issues requiring high maintenance. The existing turf machines were also not very flexible.

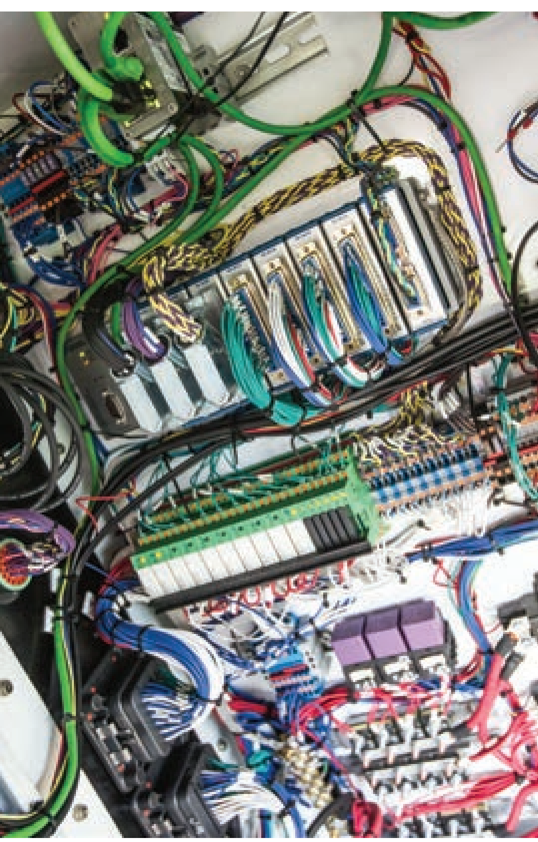
There are a wide range of conditions in the field. "Sod is perishable and is grown all over the country and close to most metropolitan areas, so there are different soils and different grass types," says Aposhian. "The industry needed a machine that worked in a wide variety of field conditions."

Instead of a turf harvesting system based on hydraulic activation and simplistic control algorithms, a higher level of control was needed, continues Aposhian. "Looking at the needs of the industry, we determined the use of advanced controls, including servo systems, was the solution, even though it is not normally done on mobile equipment," he says (Figure 2).

A new design begins

FireFly started the design of a high-performance servo motor control system for its turf stacker movements, which addressed two needs of the market—neatness and durability. "The precision motion of our machine made it easy to create neat pallet stacks," says Aposhian. "It also helped durability when the system was sped up. When original manufacturers tried to speed up, the result was rough, moving mechanisms that didn't place the turf accurately in a stack. This rough, jerky motion also tended to tear up the turf square. The servo motion provided excellent positioning capability and speed and was gentle with the turf due to the smooth velocity control. This smooth control also helped the durability of the equipment that could see millions of cycles a year." That's a lot of 450-square-foot pallets—a common size—that can be stacked in a little over 2 minutes.

Another benefit of the servo control is it is much more fuel efficient, says Aposhian. "Taking a look at the industry and with the team's background in other areas of automation, we saw the opportunity to bring a higher level of control design to an industry that really needed it," he says.



ADVANCED CONTROL

Figure 2: An advanced control platform was one of the keys to improved efficiency and productivity.
(SOURCE: FIREFLY)

The first machine

"We started design in 2010 on a part-time basis and went to full-time design with me and three other engineers in June 2011," notes Aposhian. "We completed the design and build of the first machine and brought it to a trade show in April 2012. There were a lot of long hours in completing it in less than a year."

Aposhian focused on the software, electrical and hydraulics, and three other engineers focused on the mechanical and motion during this rapid development cycle. Six machines were built, and then a revision created an improved model as part of the development cycle, and more machines were built during the first year.

The control system helped speed the development cycle. "Part of the testament to the National Instruments platform used is that it allowed us a rapid development cycle when implementing some fairly sophisticated controls," says Aposhian. "Having a strong background with National Instruments helped with the choice of the control system, but there were many reasons. I had been doing LabView for 14 years, but, more importantly, the LabView CompactRIO platform was ideally suited for the requirements we were faced with. The turf machine is really a collection of small machines all on one piece of equipment."

An up-close look

In the front, the machine cuts and singulates the sod (Figure 3). The cutter extricates the grass from the ground consisting of two different processes. One process controls the blade that cuts underneath the grass—the skim cut—and one that cuts vertically to cut the piece to length similar to a flying cutoff process. These cutting mechanisms feed the conveyor, which delivers and positions the turf for the stacker to grab.

The turf is positioned at the high-speed stacker using encoders on the conveyors and photo-eyes to register the position and coordinate pickup with the servo-controlled stacker mechanism. This provides some buffering, and the turf can be picked up on the fly without stopping the conveyor.

The stacker has the servo motion control hardware to pick the pieces off the conveyor, move them to the pallet and stack them. This is a very high-speed and high-performance pick and place. At the pallet, there are forks and an empty magazine system for up to 20 pallets. The forks and magazine work in tandem, lowering the pallet incrementally as the turf is stacked and then placing a completed pallet on the field.

The tractor itself is another major system including the drive system, propulsion and steering that the control system can monitor and control. This self-propelled tractor moves all the automated systems through the field.

Control coordination

All of the systems must work in parallel since this is a continuous flow operation. "While the stacker is stacking, the cutter in front cannot stop cutting," says Aposhian. "The LabView CompactRIO is well-suited in handling these parallel systems simultaneously. It also enables very rich transfer of data between each system. There is significant coordination between each parallel system, where synchronizing conveyor speed with tractor propulsion speed is one of many examples."

Creating parallel control loops in the same software program enabled excellent coordination of the individual processes, continues Aposhian. "The LabView CompactRIO showed great capability in controlling both high-speed and medium-speed asynchronous processes and bringing them together into one unified system," he says.

The turf machine has both hydraulically and electrically controlled motion. It's a mixture depending on the system. The

PRECISION CUT AND STACK

Figure 3: The turf cut depth, length and delivery conveyor are just a few of the many systems that make up the turf-harvesting machine.
(SOURCE: FIREFLY)

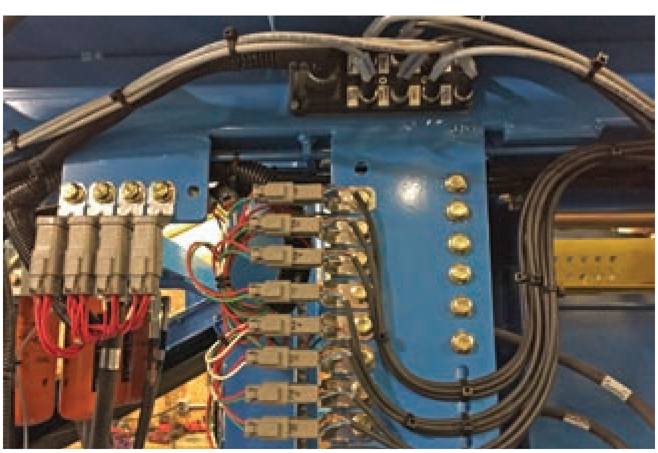
conveyors, pallet forks and pallet magazine system are hydraulically controlled. The high-speed stacker x, y, z and rotate axes are all servo-controlled using Kollmorgen AKD drives and motors. The cutter combines hydraulic and electric servo control—the cut depth is hydraulic and turf cut-to-length axis is servo for turf length accuracy.

"Electric servos are used where high-speed and high-accuracy position control is needed," says Aposhian. "Hydraulic is used where high power density is needed without the need for accurate position control. The pallet forks are a good example. The forks are very similar to a fork truck where a simple valve and cylinder do a lot of work with reasonable speed and accuracy."

The wide variety of actuators on the turf machine includes five axes of servo control and more than 30 hydraulic valves tied to motors or actuators, continues Aposhian. "There is the balance of cost when selecting servo electric or hydraulic," he says. "The hydraulic valve and motor are a fairly inexpensive system compared to a servo axis. It's cost versus performance. Overall there are more than 30 feedback control loops on the machine. These control the blade, conveyors, hydraulic valves, speed control valves and proportional valves."

Sensing the turf

The sensors use similar cost vs. performance decisions. "We use two different CAN buses for sensors, as well as discrete and analog sensors," says Aposhian. "Overall the machine uses almost 80 digital and analog sensors and approximately 100 digital outputs (Figure 4). There are a variety of other analog sensors on the machine including Hall effect sensors on the joystick and a load cell to measure the weight of the pallet. There are also hydraulic pressure and temperature sensors monitoring the hydraulic oil. All critical systems are monitored."



(SOURCE: FIREFLY)

SENSOR & OUTPUT CONNECTIONS

Figure 4: Photo-eyes, pressure, temperature and valves are just some of the nearly 200 inputs and outputs on the machine.

"The base control-system platform and mechanics of the machine are so capable, we will be able to offer advances, and customers will continue to see improvements in the machine."

One of the CAN buses connects to J1939 devices, such as a keypad, and is an in-vehicle bus common in trucks and off-road vehicles used in agriculture. A CANopen network is used for time-critical devices such as encoders. Aposhian says it depends on the system, and all the sensing methods fit easily into the LabView CompactRIO.

Encoders are used on conveyors for position and speed control, and there is a roller on the front of the machine that measures the turf for closed loop cut-to-length control. Steering can also be closed-loop-controlled. Although the operator has manual control of the tractor steering, the machine can also follow the edge of the grass that was already cut.

The machine uses a steering shoe that is spring-held to the edge of the previous cut. An encoder senses the position of the shoe and thus the edge to control the cut width and position. There is little need for the operator to steer the machine during much of the cut process since the edge position is fed to a steering control algorithm.

When selecting the encoders for the turf-harvesting machines, FireFly needed to find equipment that could operate reliably under the hot, dirty and damp conditions typically encountered during the turf-harvesting operation. The machine is also periodically cleaned with a pressure wash system—a concern for all sensors and actuators.

FireFly uses Posital IXArc absolute magnetic encoders with environmental protection levels up to IP68/IP69K. The available CANopen electronic interfaces simplified integration of these encoders with the LabView CompactRIO while the relatively compact form factor made them easy to fit into the machine.

HMI, setup and safety

The cut depth is controlled using an electric mini-actuator that adjusts the position of the blade relative to the roller on the ground. The operator has control over a variety of cut parameters and uses an HMI to adjust them. In the seat, there is also a joystick and keypad for greater control such as starting and stopping the cutter, lifting the cutter head and other functions where it is not necessary to touch the HMI screen. All of these devices are inputs to the LabView CompactRIO controller.

Some grasses are grown from seed; some grow back from the roots; and some grasses are grown from a strip of grass remaining in the field after harvest, called a ribbon. It's all dependent on the grass variety. The turf machine can harvest any grass. It's just a quick operator adjustment for cut depth, ribbon width or to do a clean cut.

A lot of safety is designed into the machine, notes Aposhian. "There are three emergency-stop pushbuttons on the machine that stop motion, disable valves and remove hydraulic power when activated," he says. "The safety system is designed as a redundant, control reliable system. The main disconnect is simply the operator turning off the engine, as both power and electric are generated there."

The machine also includes remote diagnostics. "We do a couple of different things with remote diagnostics," notes Aposhian. "Each machine is capable of connecting to the Internet, and a secure VPN network is used to connect to each machine. With the connection, we can perform software updates and advanced diagnostics not available on the HMI. We are also exploring condition monitoring. As we build this historical data, we will push out recommended service intervals for the various systems on the machine. As part of the machine learning process, we need to collect the data before it can be analyzed and used from a maintenance standpoint."

Cutting the grass

Results and performance of the equipment has been very good. "We have received great response from the industry and sales are increasing," says Aposhian. "It's exciting for us to know that we have a platform that is capable of much more as we continue to develop the machine."

A good example is, a couple months ago, a new software update gave customers 5% more productivity, continues Aposhian. "The base control-system platform and mechanics of the machine are so capable, we will be able to offer advances, and customers will continue to see improvements in the machine," he says. "It's not just machine control improvements; this will also include benefits from the Internet of Things and related improvements to the customers' logistics. There is a lot of potential."

(SOURCE: FIREFLY)

PLAYING IN THE FIELD

Figure 5: The environment can be harsh and rugged where the sensors, valves, motors, conveyors and actuators must operate.

FireFly's strength is a team approach to making a machine like this. "It was really a marriage of software, electronics, electrical, hydraulic and mechanical design to make the mechatronic system," says Aposhian. "We are really good at bringing the different disciplines together. With the technology and our cross-discipline team and the ability to design and implement the machine, there are many related areas we can explore. It's exciting for us. The sod and turf grass industry has unique needs. It's not a giant industry, but there is more to do out there. The next machine is probably a variation—sod in rolls and other sod production equipment. In the long term, we are an automation company, specifically focused in the agriculture world (Figure 5)." CD

Bueller? Bueller?

Presence-sensing devices never take a day off

EXTENDED AND TRIPLE-DISTANCE PROXIMITY SENSORS

The Contrinex DW series of extended and triple-distance proximity sensors in 3- to 30-mm cylindrical and 20-mm rectangular styles offer 10- to 30-Vdc operating voltage and sensing distances ranging from 1 to 40 mm. Cylindrical sensors are available in shielded and unshielded models with nickel silver, nickel silver/chrome, chrome-plated brass or stainless steel housings. The 3-mm proximity sensors are fitted with a 2-m axial cable; other sizes offer 2-m axial cable, M8 or M12 quick disconnects. The sensors are designed with an LED status indicator and are available with NPN and PNP, as well as normally open or normally closed outputs.

AutomationDirect; 800/633-0405; www.automationdirect.com

COMPACT ULTRASONIC SENSORS

These compact ultrasonic sensors are suitable for both position- and level-sensing applications. They can detect a target at long ranges (up to 2.2 m), regardless of the target's color, transparency or surface reflectivity, and are not subject to interference from UV light or direct sunlight. Ultrasonic sensors perform well in level applications using liquids and materials with uneven surfaces, such as granules and powders.

ifm efector; www.ifm.com

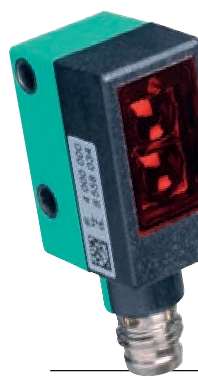
NONFLUSH INDUCTIVE PROXIMITY SENSORS

This line of nonflush inductive sensors is an E2-certified general-purpose range. Users can choose from two short-body sizes (12 or 18 mm) or the renewed 30-mm sensors. The sensors carry a safety rating of up to IP69K (for the connector version) and operate in temperature ranges from -25 to 70 °C. They are compact and durable enough to fit in almost any environment and can be used for mobile equipment, material handling, packaging, automatic assembly and other demanding applications.

Telemecanique; www.tesensors.com

SUBMINIATURE PHOTOELECTRIC SENSORS

ML6 series subminiature photoelectric sensors come with dual-sensor redundant detection and independent outputs. These models provide dual beams from two emitter LEDs that reflect light to two receivers, while two independent outputs indicate the state of each separate beam. Because these models act as two sensors in one housing, users can align or guide translucent paper, plastic and fabric webs and detect a gap between two objects to suppress the detection of small particles such as textile fibers. The sensors also are available in long-range background suppression sensing models and retroreflective models with no sensing deadband.



Pepperl+Fuchs; 330/486-0001; www.pepperl-fuchs.us

LOW-PROFILE WELD NUT SENSOR

This low-profile weld nut sensor uses magnetic inductive technology and can be programmed to detect the presence of a metallic nut. An optional teach pendant can be used to program the sensor to differentiate between the sheet metal material and the weld nut. When the nut is placed properly, the sensor sends a signal to the PLC, which allows the robotic welder to weld the nut to the sheet metal. The sensor measures 61 mm, with a probe tip diameter of 4 mm to accommodate down to a

5-mm weld nut. It has a titanium nitride-coated probe for strength and protection in harsh applications.
Turck; 800/544-7769; www.turck.us

without a retroreflector.
Banner Engineering; 888/373-6767; www.bannerengineering.com

LASER DISTANCE SENSOR WITH FLUSH-MOUNT CONFIGURATION

The Q4X laser distance measurement sensor now includes a flush-mount configuration. The sensor offers ambient light resistance and detection of sub-millimeter changes in distances ranging from 35 to 310 mm. Using a CMOS imager for measurements, it can handle highly reflective and multi-color surfaces or light-absorbing materials and low contrasts, such as black foams or rubber combined with black plastics or metals. With dual teach mode, the sensor uses a combination of intensity and distance, making it suitable for error-proofing applications and detection of challenging targets, such as clear packaging and transparent object detection

IO-LINK SENSORS AND MASTERS

IO-Link sensors and masters help make it easy to collect and report performance data. Information is collected from the sensor/actuator through the IO-Link Master via a fieldbus network into the host controller. By connecting presence sensors and controllers via IO-Link, all necessary information for stable sensor operations are visible, including component identification, cable disconnections, sensor output status, light incidence and fault conditions. The IO-Link products are photoelectric sensor E3Z-IL, cylindrical inductive proximity sensor E2E-IL, spatter-resistant proximity sensor E2EQ-IL, color mark photoelectric sensor E3S-DCP21-IL and IO-Link master units GX-ILM08C for M12 connectors and NX-ILM400 for flying leads.
Omron; 866/88-omron; www.omron247.com cd

Which enclosure fits my needs?

A CONTROL DESIGN reader asks: I'm a recent college graduate and controls engineer at a system integrator who specializes in remote monitoring and process skid design, so I'm constantly selecting control enclosures for a variety of applications from office-like environments to outdoors in the rain and hot sun. I'm trying to standardize on a single enclosure type, but that doesn't seem possible. While stainless steal is great, it is expensive, and, while plastic works well, I find cracks or holes smashed in the doors of the enclosures at remote sites.

Obviously, the size of the enclosure is important, but what are some other considerations when selecting an enclosure, and what are some common mistakes I should watch out for? I don't want to purchase 100 enclosures that crack, melt, rust or otherwise are not suitable for the application. What do you think? Just get a battleship gray, NEMA 12 enclosure and hope for the best?

ANSWERS

Dimensions and environment

This is a battle we've been fighting for decades. The key to driving production consistency and end-product availability is standardizing your enclosure dimensions and environmental ratings wherever possible.

Indoor Type 1 general purpose enclosures have advantages, such as knockouts for easier installation of pilot operators and conduit entry. However, as environments get dustier, Type 12 enclosures come into play. With washdown or hose-down applications, material type and size become very important. Certain washdown chemicals can erode and cause cracking to polycarbonate or fiberglass enclosures if material types are not selected appropriately. Stainless steel, polycarbonate and fiberglass can become costly, especially with larger enclosure dimensions. Type 4 painted steel enclosures are typically a good compromise for most applications as they cover 1, 12 and 3R enclosures.

Wall mounts are optimal for cabinets up to 50 inches tall. Cabinets that are taller than this may run into installation issues. Enclosures taller than 50 inches are ideal in a floor-standing construction, which allows for features like baying multiple enclosures, removable conduit-entry gland plates and side walls for easier access. Keep in mind that Type 4 UL testing is very aggressive and can increases costs for floor-standing enclosures. Typically, Type 3R are much more cost competitive in floor-standing, 50-inch enclosures and higher.

Standardizing on Type 4 is probably the best solution for enclosures smaller than 50 inches tall, and Type 3R is best for floor-standing or larger enclosures. If cost is your main concern, Type 1 will be your strongest contender for general-purpose indoor. The 4X applications will need more caution in the selection process as it will depend on the chemicals present.

Ahmad Omari, product manager,
Rockwell Automation, www.rockwellautomation.com

True costs

It's wise to explore all the enclosure materials and options. There is not one solution for all environments.

With the variety of materials available for enclosures, it is important to look at the true cost, not just acquisition, but use and operating costs. A plastic enclosure, in your example, which needs to be replaced from damage in remote sites, may have a lower acquisition cost, but higher use and operating costs. A balance between economics, utility and performance can ensure the ROI of the investment.

It sounds like you have considered the environmental exposure your enclosures will be subject to. Corrosive stress occurs even in benign installations, where even water and oxygen can be mildly damaging. In addition to the corrosive elements present, remember the byproducts such as wastewater and steam can also pose a threat.

Of the different enclosure materials available, stainless steel provides the longest lifespan for indoor/outdoor rating. But even here, with Type 304 or Type 316, you have some flexibility for your industry. In general, stainless steel delivers consistent performance in virtually all environments, but it is a more expensive material. Carbon steel, on the other hand, is less expensive, but its corrosion protection relies on the maintained integrity of the enclosure paint/coating. This should always be considered for any outdoor application involving carbon steel enclosures.

A good source of information is the NEMA 250 standards publication, which provides data that can permit a potential user to determine the type of enclosure appropriate for the application. Keep in mind that some enclosure manufacturers apply multiple ratings (for example, NEMA 12 and 4) to the enclosure to allow for greater flexibility during the specification and selection process.

Other aspects of the enclosure, such as gasketing and grounding, are sometimes overlooked in the specification process. Foreign substances entering the enclosure can ruin your equipment so features such as foam-in-place gaskets deliver a tight, continuous seal. Since safety is always a primary concern, enclosures that ground the enclosure through grounding straps, or, better yet, through the smart use of integrated/automatic system grounding in the panels and plates, create an optimal safety environment.

Scalability in your enclosures assures that, as your center expands, you can easily adapt. Choose a modular enclosure which can be bayed side-to-side, back-to-back or side-to-back. Knowing your enclosure can adapt to infrastructure changes extends its lifetime and usage costs.

Once you have narrowed down your enclosure selection, drill down into hidden costs. Take into account the time required for assembly and integration. Some enclosures require no specialized training, while others require fabrication techniques (cutting/welding/bending) to modify the enclosure. Compare the mounting panels. Are they accessible from the front, side, back? Can accessories be easily added? If extensive modifications need to be made, what will the labor/maintenance cost be?

Keep your true cost in mind during your selection process. When specifications for control panels and other applications are written, the true costs and benefits of utilizing one enclosure solution over another must be fully considered—especially in today's economic climate where every penny counts. Consider not only your current needs but project and account for your future expansion. Either you or another member of your team will be looking at power, cooling and accessory/rack options. When you bring all these factors into the decision, you'll find the right answer for your company.

Troy Miesse, North American product management, enclosures, Rittal, www.rittal.com

Standardize on a standard size

Enclosure selection is an important element when developing control solutions. It increases the reliability of the system, reduces maintenance and ensures the life expectancy of the components installed.

To make the proper selection of a control enclosure, it is necessary to first consider environmental factors. The environment can create multiple sources of risk for equipment to fail; for example, solar heat, humidity/condensation, rain, snow and other adverse climates factors. All these factors will determine the level of protection required.

The next step will be the sizing of the enclosure. The ideal scenario is to have the most accurate bill of materials together with a 3D modeling software. Make sure that you always select standard-sized enclosures that allow you to have alternatives when considering different enclosure materials. By standardizing your enclosure size, you create the ability to select multiple vendors who can offer more competitive solutions.

The most common mistake is overlooking or not being aware of particular devices within the enclosure that cannot stand excessive cold, heat or corrosive atmospheres.

Furthermore, make sure your enclosure always maintains a suitable working temperature. Certain electric components can generate high amounts of heat; when combined with adverse climate, this could lead to a situation in which heat-sensitive components fail. If required, a cooling or heating element should be installed accordingly. Furthermore, if you perceive uncertainty in your application, it is also a good idea to consider some extra room for your enclosure to grow.

Regarding standardization, the type of enclosure is always associated with the protection option. For NEMA 4X protection type, stainless steel is only one option available. You can also explore aluminum, fiberglass or polycarbonate enclosures. Restrictions must be considered in terms of size, structural rigidity and functionality, but each alternative could help you to deliver the protection required while staying in budget.

Carlos Ojeda, project engineer for customer solutions, Festo, www.festo.com

FMEA to define requirements

Your question on enclosure selection is interesting in that it is a question of reliability/durability and total cost of ownership. Based upon your comment that stainless steel is expensive, you imply that the design and application are not cost-insensitive. Picking a battleship gray NEMA 12 enclosure is a valid option, but since NEMA 12 is rated for indoor use, you will be overdesigned for some applications and may still be underdesigned in others,. The idea of standardizing is a good one; however, you describe a vast range in environments. Unless you accept the cost of design for the worst case, you cannot really achieve a single enclosure design independent of the system design. I would suggest that you do an assessment of the different applications and their environments. You can then develop a standardized enclosure to support each environment as a first step. You can then work with your system designers and see if you can provide structure to support your enclosure in the more harsh environments to allow you to start to standardize the enclosures. I would suggest that you develop a failure mode and effects analysis (FMEA) for your different applications as this will help you clarify the enclosure failure mechanisms and allow you to define the enclosure requirements.

For more information on NEMA enclosure types, visit www.controldesign.com/nema.

Daniel C. Conrad, Ph.D., CRE,
Director of reliability & testing

Step by step

Probably the most important thing is, first, they need to evaluate the environment the enclosure is going in—outdoor/indoor.

You must make sure you select a material type that withstands the environmental conditions. It could be galvannealed/galvanized, carbon steel powder coated, stainless steel 304 or 316, polycarbonate or fiberglass.

Next, determine what type of rating/seal you want or need on the enclosure—NEMA 4X, NEMA 4, NEMA 12, NEMA 3R, NEMA 1. Once this is determined, it is always most cost-effective to look at manufacturers' standard sizes. Standardization often helps with cost and lead time/availability.

Another important factor is that sunlight plays a huge role in an enclosure's performance, especially when putting a sealed NEMA 4/4X enclosure in an outdoor environment where rain/sleet/snow is present. Maybe people do not know, but, if you stick an enclosure in the sun, the internal temperature vs. external temperature can create huge issues.

The most common mistake is overlooking or not being aware of particular devices within the enclosure that cannot stand excessive cold, heat or corrosive atmospheres.

For example, put an enclosure outside in the sun and you may have the inside temperature easily reach 120 °F on a hot 90 °F summer day. If a sudden rainstorm blows in and cools the air down to 60 °F, now you've created a huge difference from inside to outside temperature. The enclosure inside starts to cool down quickly, causing the air molecules inside the enclosure to contract creating a vacuum type effect on a sealed enclosure. Somehow someway, the enclosure must neutralize the pressure from outside to inside and ends up pulling air/moisture/water through the weakest link, which is typically going to be some point along the gasketing/seal around the door. In this scenario, it doesn't matter whose enclosure you are using; this can and does happen often. That is why, in outdoor applications where a NEMA 4 or 4X enclosure is used, we always recommend using a UL-approved NEMA 4/4X-rated drain/breather vent. In reality these probably only get installed on 5-10% of the enclosures that should be getting one.

For more enclosure design considerations, visit www.controldesign.com/enclosures.

Also, the ratings are often geared toward a type of industry:

- NEMA 3R = often in the agriculture/pumping industries
- NEMA 12 = typical industrial plant where dust, debris and oils are present
- NEMA 1 = typically found in clean rooms/houses/environments when there is not dust/debris around
- NEMA 4 = many outdoor applications where harsh chemicals and sale spray are not present
- NEMA 4X = food and beverage, near salt water, off shore, wastewater, any type of washdown environment; consider the environment to decide between 304/316 stainless steel and fiberglass/polycarbonate.

There are many factors that go into selecting an enclosure, but these are probably the things that are missed the most.

Scott Baldauf,
vice president of sales & marketing,
Saginaw Control & Engineering,
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Consider the four elements

I understand a desire to standardize, but please know it is really not a viable solution. For instance, no one vehicle—from a Mack dumptruck to a Chevy Corvette—is suitable for all transportation needs.

When selecting an enclosure for any electrical application, there are four critical elements to consider, those being location, environment, contents and size.

Location and environment: First you must determine if the enclosure will be located indoors or outdoors, and in either instance if it will be subjected to hose-down, rain, excessive dust or corrosive elements.

Determination of these factors will help to guide you toward a suitable rating and material.

In this instance, the most common mistake is overlooking or not being aware of an element of the environment that may do damage either to the box or the equipment within.

Contents: Next, you must determine if the prevailing environment around the enclosure will damage the equipment within the enclosure unless the enclosure is pressurized. You must also consider if the equipment is sturdy or delicate in any respect.

In this instance, the most common mistake is overlooking or not being aware of particular devices within the enclosure that cannot stand excessive cold, heat or corrosive atmospheres.

Size: Finally you must determine if you can find a size and shape that meets your needs or if a custom fabricated enclosure is necessary.

In this instance, the most common mistakes revolve around two-dimensional layouts that do not show overlapping equipment that is occupying the same space (what we call “collidus”) and/or a lack of spare space to accommodate future needs and permit free ventilation with the enclosure.

NEMA Standard 250 provides a full range of enclosure ratings that most manufacturers follow, to offer a wide variety of shapes and sizes in a variety of materials that will be suitable for a particular location and environment.

Once a NEMA rating is determined, you can then easily browse to find multiple manufacturers of an enclosure rated to meets your needs, and then among them you can find reasonable variations to address secondary concerns like ergonomics or security.

You then need only provide a suitable environment within the enclosure by adding ventilation, heating, cooling and/or filtration as necessary to ensure the longevity of the components you place within the box.

Mike Baucom, executive director,
Bebco Environmental Controls,
www.exphvac.com cd

control design
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Washdown-ready distributed I/O

MANY PACKAGING CUSTOMERS use distributed I/O, but packaging OEM design is moving closer to the food-processing-equipment design area. The FDA Food Safety Modernization Act (FSMA) is pushing these requirements on manufacturers. "In response, the packaging OEMs are starting to follow some of the same requirements," says Shishir Rege, networking marketing manager at Balluff. "As a result, washdown ratings and requirements are affecting machine design."

Many benefits found in Balluff's new machine-mount distributed I/O network blocks were not available to the machine builder or food and beverage manufacturers in a washdown environment, says Rege. "They had to rely on centralized, cabinet-mounted technology, which takes a long time to develop and install," he explains.

Rege believes machine-mount technology is an easier and more cost-effective way to connect field I/O and build modular systems. "This machine-mount technology is popular in automotive applications," he says. "Automotive started the trend; general packaging and food and beverage is a bit behind often using cabinet mount I/O. The washdown environment may have driven that trend, keeping common NEMA 4X enclosures all along the line, for example. Now, having these IP69K blocks with ECOLAB certification helps to get the I/O out of the cabinets and onto the machines, improving modularity and flexibility to connect a variety of smart sensors and devices."

Balluff's machine-mount network blocks offer IP69K protection. "This allows customers in the food, dairy and beverage industries to pressure-wash this distributed modular I/O block," explains Rege. "It's no longer necessary to install all the hardware in a pressure-wash-rated enclosure or locate the distributed modular I/O outside the pressure-wash zone."

The network block also reduces the possibility of human error because this new design provides connections, not terminations. "The I/O and communication are connected directly to the block using M12 connectors commonly found on sensor cables," says Rege. "Power connections use 7/8-in connectors."

Balluff's network blocks daisy-chain power in one cable connection and network signals in a second cable connection. The network blocks also come with a built-in Web server, which can be used to configure each device, troubleshoot devices and read diagnostic and status information.

FOR MORE INFORMATION

Call 800/543-8390, email balluff@balluff.us or browse to www.balluff.us.

Distributed architecture

The machine-mount distributed I/O network blocks are available in three network block configurations and two communication protocol options EtherNet/IP and Profinet. Two of the network block configurations are I/O only with 16 inputs, or 16 configurable inputs or outputs. The third configuration provides eight IO-Link ports (IO-Link master).

Alongside the IO-Link master, Balluff is also introducing IO-Link I/O hubs with the IP69K protection rating and ECOLAB certification. Each I/O hub can collect up to 16 inputs or control 16 outputs. Together, the IO-Link master and the I/O hubs can control up to 240 I/O points on a single network node, designed to reduce significant costs for I/O by reducing the number of network nodes and cables.

The network blocks with IO-Link master enable connecting IO-Link smart sensors or I/O hubs, such as valve manifolds, on the machine. In addition to sensor information, IO-Link provides automatic configuration, parameterization and diagnostics for the I/O blocks and a variety of smart sensors such as temperature, color, RFID and photoelectrics.

To speed integration of the network blocks, add-on instructions and function blocks are available for free from Balluff. "This makes it easier to configure and communicate with the block or related smart devices on a variety of control platforms," says Rege. cd

Simply smarter flow measurement

THE BEST FOOD is only delicious if you get it to the table, and the best process controls are only effective if users can easily employ them. So, to serve its comprehensive flow measurement technologies on the proverbial silver platter, Endress+Hauser is launching its Proline 300/500 smart Coriolis mass and electromagnetic flow instruments that simplify installation, speed commissioning and streamline operation and maintenance.

"Users always seek more performance and accuracy, but now they also need better digital communications and flow devices that can be used by staff with less experience or expertise," says Nathan Hedrick, flow products marketing manager at Endress+Hauser. "This is why our new Proline 300/500 instruments are optimized for maximum safety, enhanced measurement quality and device accessibility and availability."

Proline Promass Coriolis mass flowmeters are available in 11 models from $^{1}/_{24}$ to 14 inches in diameter for measuring flows up to 100,000 tons per day. Proline Promag flowmeters are available in sizes from $^{1}/_{12}$ to 78 inches for volume flows up to 634 mgd. Equipped with aluminum, hygienic stainless-steel or cast stainless-steel housings, Proline offers flexibility for all environments including high temperatures, corrosive fluids, hygienic and sterile. Hedrick adds 300 series are compact with the transmitter mounted integrally to the sensor, while 500 series provides remote accessibility of the transmitter from sensors.

"Proline 300/500 have capabilities tailored to meet the needs of different industries, but we want to assure our customers this is a natural product extension and evolution for Proline and our Promass and Promag sensors, which have been tried and tested for decades," explains Hedrick. "One advance is implementation of redundant, traceable references to avoid undetected drift in measurement. At the same time, we maintained the same dimensions of the sensors for easy drop-in replacement. This means users can experience new benefits without big changes or risks."

Proline 300/500 lets users access signals and data through HMIs to match plant preference. Access is through a local, four-line, backlit, optical display, embedded Web server, digital communication protocol, handheld device, asset management or other solutions, such as Endress+Hauser's W@M lifecycle management software or secure WLAN. It was integrated into the optical displays to permit access from handhelds like tablet PCs or smart phones from a common Web browser.

One of Proline 300/500's new innovations is its three-part Heartbeat Technology with remedy-based diagnostics, monitoring and verification for satisfying regulatory, contractual, quality, safety or fiscal requirements. First, Heartbeat Diagnostics provides permanent self-monitoring for all Proline instruments meeting NAMUR NE107 requirements for event categorization and device remedies. Second, optional Heartbeat Monitoring identifies device trends from process influences, such as buildup, settling solids or liquids, erosion, corrosion and multi-phase fluid flows. Third, TÜV-attested Heartbeat Verification is an in-situ verification method that can be triggered from anywhere to provide electronic quality reports. It's also the only method that's achieved third-party accreditation per traceable ISO metrological standards in operation.

"These remedy-based diagnostics tell users on the display or any HMI what steps are needed to resolve the event faster and safer than ever," says Hedrick. "Also, having Heartbeat Verification in the transmitter means device verification with audit safe documentation takes 5 minutes or less, where they used to take at least 15 minutes and often longer."

All Proline instruments comply with cCSAus, ATEX, NEPSI, INMETRO, EAC, IEC/EN 61326, NAMUR NE21, and EU and ACMA directives with options for custody transfer (NTEP). They're also approved for SIL 2 and SIL 3 applications. cd

FOR MORE INFORMATION

Browse to www.us.endress.com/proline-300-500.

Dave Perkon • technical editor • dperkon@putman.net

Invite drives to join the motor team

WHEN YOUR INDUSTRIAL motor requirements move beyond a single-speed application to a variable-speed application with adjustable acceleration and deceleration, and possibly precision position or torque control, the motor and drive need to team up for a winning solution.

The motor drives connect to and provide enhanced operation to dozens of different types of motors. These include dc, ac, stepper and servo motors. There are definitions to be found online along with the advantages and disadvantages of each type of motor. However, a big thing to keep in mind is that many of the motors are designed for a specific application or their applications are limited.

There are also many characteristics to know when it comes to motor selection. This includes things such as when a dc motor's speed is high, its torque is low and vice versa. Another characteristic is that running an ac motor slower using a variable frequency drive (VFD) is a common way to save energy when operating fans, pumps or similar devices. Another is that the stepper motor typically has maximum torque at zero speed, and the servo motor is known for its dynamic speed control and precision position and torque control.

The motor drives connect to and provide enhanced operation to dozens of different types of motors.

Fortunately today automation vendors have a wide selection of motors and drives for just about any application. If you need a motor and drive, get with a local industrial distributor or motor manufacturer. Leveraging their knowledge is often the best option.

Add the drive

With the motor selected, a matching drive is often required. All drives typically allow adjustment of minimum and maximum speed, current (torque) limit and acceleration and deceleration time.

In addition to these adjustments, the dc drive converts ac power to dc power and regulates the armature current and voltage to control the torque and speed of the dc motor. The nonregenerative dc drive operates the motor in one direction only and requires reversing the armature leads to change motor direction. The regenerative dc drive can reverse the motor internally and provide a regenerative braking function, a useful feature when starting, stopping or reversing often.

The ac drive also converts ac power to dc power but then inverts it back to a controlled voltage and frequency (Volts/frequency ratio) that is output to the ac motor. The pulse width modulated (PWM) drive is the most common ac drive and most popular of all drives. It works well for most industrial applications due to its performance, simple design and low cost. These PWM ac drives operate common three-phase ac induction motors for a low-maintenance and low-cost design.

A higher-performance ac drive is a vector drive. It also uses PWM but can individually control the motor speed and torque. Encoders can be added to ac drives closing the loop for improved speed regulation. Adding an encoder to a vector drive enables use of 100% or more of the rated ac motor torque at zero speed, which is desirable when holding a load in a crane application.

The most dynamic and precise motor and drive applications include the stepper and servo motor paired with the appropriate drive. The stepper motor and drive provide precise position or speed control modes whether open or closed loop. The closed-loop servo motor and drive add a torque control mode.

While most drives are controlled using analog, step and direction signals or the drive's built-in indexer function, many drives now offer various communication methods. Some only offer configuration and monitoring via this communication link; other drives provide real-time control, coordinated motion and safety functions integrated with the controller.

Which motor do you use, and how do you size it? That may be a question beyond the basics, but before you contact the vendor, be sure to have some application information available.

The vendor will need to know about the application and will ask for speed, torque and inertia information. You'll need to know how fast you want to run the system. The inertia needed can be difficult to calculate and requires rotational mass and radius measurements, gearbox information and mechanical linkage configuration. The vendor is going to ask lots of questions and then use a software package to calculate the inertia. Other variables may include load, duty cycle, environment and positional accuracy requirements. A defined motion profile is important, as well. CD