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REAL-TIME DATA ANALYSIS

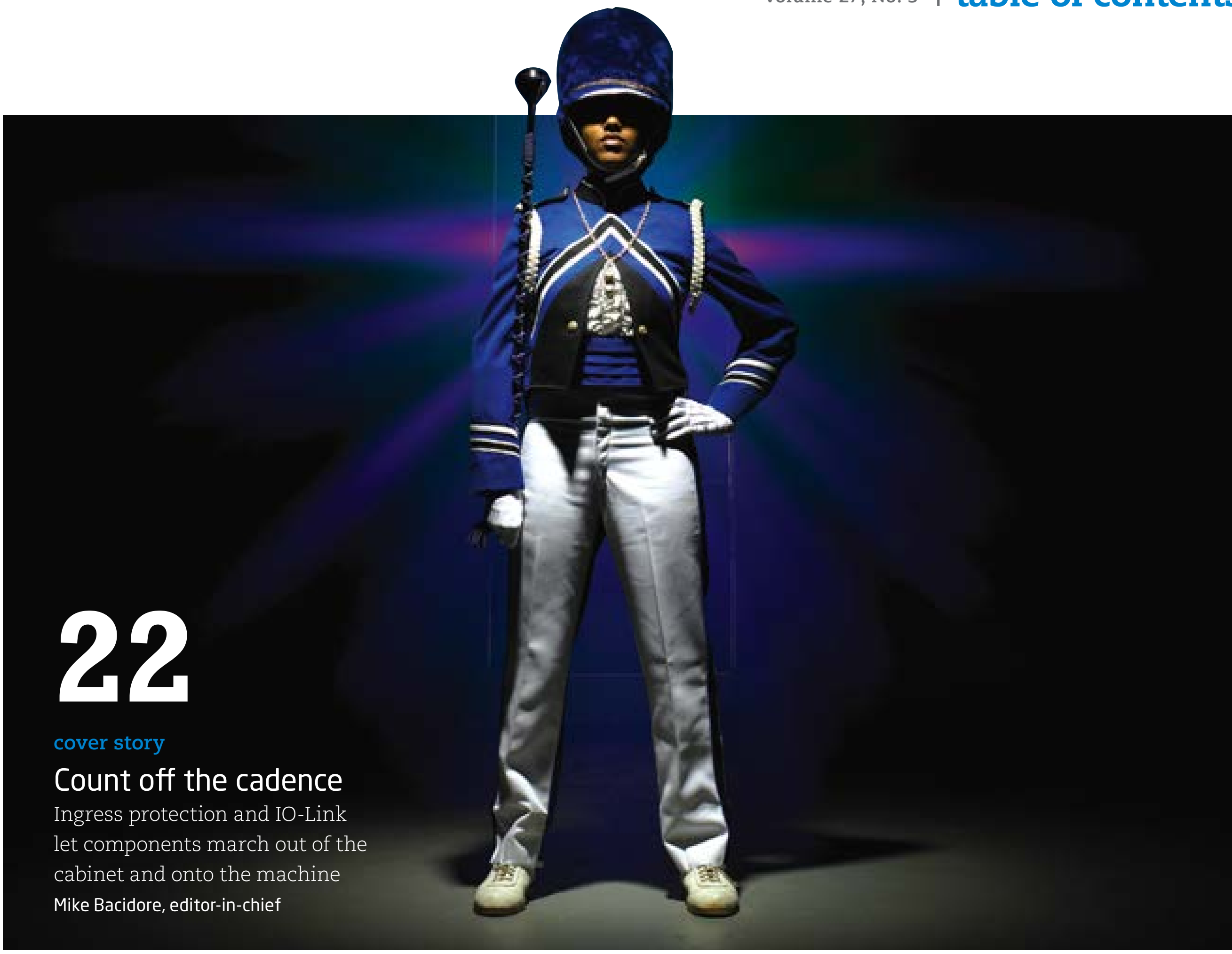
OT CAPABILITIES WITH IT FEEL

HMI SYSTEM SOFTWARE

Count off the cadence

Ingress protection and IO-Link let components march out of the cabinet and onto the machine

MARCH 2023



FEATURES

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3D CAD takes machine global

POOR VISION RESTRICTS many people, especially those in impoverished areas, from learning and working. According to the World Health Organization 2019 global study on vision, approximately 2.2 billion people have vision impairment or blindness, and almost 1 billion of the cases could be prevented. But many people cannot afford eyeglasses or do not have an optician near them.

When this global problem came to the attention of Martin Aufmuth, a math and physics teacher in Erlangen, Germany, he decided to put his expertise in physics and his knowledge of the human eye's characteristics to use and do something to help these people.

His efforts became EinDollarBrille, which literally translates to $1 eyeglasses, the price point Aufmuth's organization strives to stay below to keep its eyewear affordable. Founded more than 10 years ago by Aufmuth, who is also the CEO, EinDollarBrille now provides tools and training to enable its team and partners across 10 countries to manufacture these glasses using equipment that requires no power supply. The revolutionary machine won first prize in the 2013 Siemens Stiftung empowering people Network (epN) Awards. Further development and manufacturing are being accomplished using Solid Edge software from the Siemens Xcelerator portfolio.

There were no 3D CAD models that could be used for the next steps.

"To really offer long-term and sustainable help we didn't want to simply ship out glasses, but rather enable the people in the respective countries to help themselves. That's why our plan was to get the OneDollarGlasses designed and manufactured on-site with a machine that didn't require electricity," says Aufmuth.

After developing his initial concepts, prototypes and sketches using mainly manual and non-digital methods, Aufmuth realized manufacturing processes needed to be set up to achieve production—a process that starts with design, drafting and digitalization. While there were individual sketches and drawings of the wire-frame bending machine, there were no 3D CAD models that could be used for the next steps—for example, providing data that could be transferred to computerized-numerical-control (CNC) manufacturers to aid in the machine build. To solve this, Siemens' Solid Edge and one of Siemens' solution partners, PBU CAD-Systeme, began working together in early 2022. With the help of CAD consultant and volunteer Sabine Adams, the bending machine, now on its 13th generation, was developed further and perfected while other tools and gauges required for glasses production have been optimized.

The organization has grown to around 500 volunteers and employees worldwide. cd

M Bacidore

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How to design safe and functional systems

I REMEMBER the days of hardwired emergency stops (e-stops) and master-control-relay (MCR) circuitry and the litany of devices that were deemed to be critical in the operation of the process. Remembering that the MCR system was to provide L1/L2 power to the control system, one of the most used strategies was to wire in an input to the control system from the powered side of the device. The input light would be on for the devices that had power, and the first one that didn't is the device that caused the MCR to drop out. The main question would be: Where is this device, and what does it do? These devices were normal control devices and not safety-rated as such.

Downtime was huge when this event occurred. Normally there was a handwritten list indicating the location and function since electricians didn't have access to the programmable-logic-controller (PLC) software, I'm assuming.

The main issue here was the reliability of the MCR. If the relay was stuck then an e-stop would not shut down the system. While improbable, it happened.

With the advent of PLCs, the safety relay was born. It replaced the MCR by providing power to the system based on redundant input wiring. Two wires from each device, which was also safety-rated (fail safe) come from redundant contact blocks. The thinking here is that if one wire or contact fails the other one will still function. The standards surrounding safety are broad and deep. If the e-stop head gets knocked off, it trips. With certain devices, if the contact block falls off, it trips. That's solid.

We want centralized monitoring however, don't we? Supervisory control and data acquisition (SCADA) applications want access to it all. Most if not all SCADA or human-machine interface (HMI) can use OPC UA to communicate with any device. But a safety relay typically interfaces with the local process. The PLC will only know that it has tripped, which can be flagged.

This data-anywhere requirement was understood by the safety community. The safety PLC has evolved to become a required component in all controlled processes. Machine control has been a bit slow to the party to implement to this level.

Safety networking also has been evolving over the past 20 years due to the integration of Ethernet into plants and machines. CIP Safety is one protocol that can exist on an Ethernet network, wired or wireless. The safety PLC requires the devices to be direct-connected to the I/O; a safety-networked system can connect various devices on the same cable. Because CIP Safety is a protocol, devices can reside anywhere in the plant.

Communication is key in the interpretation of all safety systems. While some HMI systems may not be able to integrate all safety systems, SCADA systems should have no issue in getting the status of the connected devices and the health of the safety systems.

> **There are many standards and protocols to consider when dealing with safety devices and systems.**

One installation I developed was integrating five safety PLCs with three PLCs, and the process had various touch points. Should one area experience a safety issue, the event is rippled through the system based on what the event was. At the time there was only a networked module that allowed the devices to talk with each other. The PLCs had the ability to monitor the state of the controllers but had no way of accessing the data. We had to hardwire status and control to and from the safety PLC and the control PLC, which was not ideal at the time, and that was less than 10 years ago.

If I had to redo this application, a true networked safety PLC would be used, which would allow for a distributed safety system. This would be much easier to implement and interface with. I had also developed an interface using Visual Studio that would have been able to display the status of the complete system. There were many e-stops that were wired into the control PLCs so they could be reported on.

There are many standards and protocols to consider when dealing with safety devices and systems. With Industry 4.0, the Industrial Internet of Things (IIoT) and of course cybersecurity coming to our future, and the continued integration of systems, communications and devices from different vendors including robotics, a distributed-safety strategy is paramount.

With wireless connectivity available, imagine how engineers can design safe and functional systems to protect machines, processes and people. We are in good hands. 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.

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Position feedback relies on the proper protocol

THE SPEEDS AT WHICH we want our machines to run relies on the ability to accurately represent the current position of a device and use that information to command that device to move to a specific location at a specific time and coordinate that action with other devices similarly controlled. Position feedback is a key part of our control designs.

A sensing device that converts position/motion into an electrical signal is called an encoder. Regardless of linear or rotary motion, the representation of position follows the same principles.

A print head uses an encoder to accurately deposit material at specific point in space. That space could be a piece of paper or on the platen of a 3D printer. A robot uses an encoder on each axis of movement to accurately execute a task. While the type of encoder will vary, the principles are common to all types.

Some thought given to choosing the best interface protocol is worth the effort.

There are two types of encoder output, incremental and absolute. The output of an incremental encoder is a stream of pulses on one or more channels, whereas an absolute encoder output is a multi-bit word. Encoder interface protocols provide a common connection between an encoder and a control system, as well as providing a means by which to interpret the output from the encoder and provide additional information, such as position and speed. Traditional interfaces include parallel and serial, while more modern protocols include fieldbus and Ethernet.

Let's talk about resolution for a moment. The degree of accuracy of the feedback depends on the resolution of the encoder. An 8-bit encoder would provide feedback, or count, of 127 increments. A 16-bit encoder has 65,635 increments, while a 24-bit encoder would provide positional divisions of 16,777,215. The degree of accuracy in the actual position will determine the bits of the desired feedback.

A parallel interface involves a twisted pair—signal high and low—plus power and ground. There is one twisted pair for each bit of information. The number of bits equates to the accuracy of the desired output. The benefit of a parallel interface is all bits are transmitted simultaneously but at the cost of additional wires and opportunities for something to go wrong. For example, a 16-bit encoder would have a wire count of 2x16 bits plus the power and ground for a total of 34 wires.

A serial interface is similar to a parallel with the main difference being that a serial interface uses only one twisted pair to send all data at once, instead of one pair per bit of resolution. Fewer wires, less opportunity for something to go wrong.

A serial interface connects one slave—encoder—to one master—programmable logic controller (PLC)/counter. The PLC holds a clock bit high until it requires an update and then flips the clock bit to solicit a reply in the form of a stream of clock pulses to represent the data from the encoder. This interface is synchronous. Two common interfaces of this type are synchronous serial interface (SSI) and bi-directional serial synchronous interface (BiSSI). Unfortunately, since one master can only talk to one slave, this format does not lend itself to multi-axis machines.

Both the parallel interface and serial interface are referred to as point-to-point protocols because of the physical wiring between the encoder bit and the wiring point on the PLC or counter.

Each bit from the encoder represents one bit of the binary representation of the position. Counting in the usual binary would result in the following sequence:

0=0000
1=0001
2=0010
3=0011
4=0100
5=0101
6=0110
7=0111.

Note that at any one instance, more than one bit may change state, even though the decimal equivalent is only changing by one digit. For example, decimal 3 is represented by binary 011, while decimal 4 is represented by binary 100. The decimal numbers are one digit apart, but all three binary bits change to go from 011 to 100.

The issue with this method of counting is a broken wire or a lag in the update of the incoming bits could end up in a bit jump in the resultant count. Let's consider an 8-bit binary number. Decimal

126 is represented by binary 01111110. What if binary bit 6 has a bad wire, changing the binary count to 01011110? The resultant decimal equivalent suddenly goes from 126 to 94. If you have a motor in motion to 150° and the feedback suddenly changes to a lower number, or a higher number, the motion controller would create an erratic response to try and adjust to that sudden change.

A modified method of counting binary bits, the reflected binary code (RBC), was created where two adjacent numbers differ by only 1 bit. Called the Gray code after its creator, Frank Gray, this method ensures that only one bit change at a time is interpreted by the PLC, or master.

Comparing to the normal binary count mentioned above, the RBC or Gray-code equivalent of counting from 0-7 would go as follows:

0=0000
1=0001
2=0011
3=0010
4=0110
5=0111
6=0101
7=0100.

As can be seen, in this sequence, only 1 bit is changing for each incremental count. Any sequence that doesn't follow this method would be interpreted as extraneous and ignored by the master.

The PLC code, mentioned above, was required to convert the Gray code back into decimal for use in the application.

The fieldbus interface addresses the inherent issues described in the parallel and serial interfaces. A fieldbus enables a master to communicate with multiple devices—slaves—at the same time. Since they reside on the same bus, once a device is active on the bus, it can be seen by any other device on the bus.

Common examples of fieldbus protocols are ones based on controller area network (CAN) and derivatives such as DeviceNet. Interbus, designed by Phoenix Contact, and Profibus, by Siemens, are two other popular protocols. These have been around since the 1980s.

A popular network protocol, Ethernet, follows on the evolution of the fieldbus protocols with higher speeds. With the advent of Ethernet for automation, devices are able to connect across network protocols to provide even greater connectivity and interconnectivity.

One of the main differences between a fieldbus and other protocols is fieldbus is deterministic. When data collisions happen, and they will with this type of network, the transmission will be delayed. The answer to this is advanced network protocols like Profinet, EtherNet/IP and EtherCAT.

Profinet is an industrial Ethernet solution, developed by Profibus and PI. It has been around since the early 2000s. It is the evolution of the popular Profibus protocol. It sits on the application layer of the International Organization for Standardization (ISO) open systems interconnection (OSI) model. As such, it tends to be faster than Ethernet. While not restricted to a particular platform, Profinet is most often used in a Siemens-based control system.

EtherNet/IP is an industrial Ethernet solution supported by and used extensively in Rockwell Automation hardware platforms.

EtherCAT is an industrial Ethernet solution and can be found in the powerful Beckhoff hardware platform. EtherNet/IP and EtherCAT sit on the physical and data link layers of the ISO/OSI model. They differ from each other in that each EtherNet/IP device has a unique address, while EtherCAT nodes are determined by the wiring path from the master.

Both use the inexpensive Cat. 5e media. However, EtherNet/IP uses an asynchronous method of communications, meaning that any device can transmit at any time in any order. EtherCAT, on the other hand, uses a single telegram from the master to all of the slaves, in order of the wiring using a technique called processing on the fly. As the telegram passes through each node, the node reads the data intended for it and attaches outgoing data. Each node does this in succession and then the packet returns to the master.

The processing is achieved by the use of specialized application-specific integrated circuit (ASIC) chips in each slave device. One telegram carrying all the data for every node on the network moving in a single direction in a determined cycle means that this is a synchronous method of communication. The node numbers are assigned upon power-up of the network.

Encoders are at the heart of any current control system, so give some thought to choosing the best interface protocol. Profibus and EtherCAT protocols tend to be a better choice where faster performance is critical, but EtherNet/IP devices tend to be more available due to the popularity of the protocol. Physical media—cables, switches—are similar between the various industrial Ethernet protocols so the choice of protocol is really about what mates up best with the selected PLC or programmable automation controller (PAC) in the control system. cd

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


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How to benefit from real-time data analysis

THE PROCESS OF remote monitoring involves keeping an eye on and gathering data from machinery or equipment from a distance, usually with the use of sensors and communication tools. The gathered information is examined to improve safety, reduce downtime and maximize equipment performance. In order to make educated decisions and act quickly when necessary, companies may use remote monitoring to gain real-time insights into the performance of their equipment.

The benefits of equipment remote monitoring include increased uptime and dependability, increased productivity and efficiency, cost savings, improved safety, better data management and scalability. The performance of equipment is optimized; downtime is decreased; and a safe working environment is guaranteed. As more businesses look for methods to enhance their operations, remote monitoring is becoming increasingly important.

> Sensors collect information on metrics like temperature, pressure and vibration.

A remote-monitoring system consists of essential components, including sensors for data collection, communication tools for data transmission, software for data analysis, data storage for safe access, a user interface for control and access and a power source for continuous operation. The specific components and their capabilities may vary based on the type of equipment being monitored. Together, these elements deliver real-time equipment-performance data that helps businesses run more efficiently and make wise decisions.

Typically, equipment being watched via remote monitoring has sensors attached. Depending on the kind of equipment, these sensors collect information on metrics like temperature, pressure and vibration. Once the data has been collected, it is sent to a central location where it is evaluated and stored using communication methods including satellite, cellular and Wi-Fi. Dashboards, alerts and reports that give real-time information on the performance of the equipment may be included in the software used for data collection and processing. In order to provide safe and flexible access, the data is frequently kept in the cloud.

Through a user interface, which might be a web-based platform or a mobile app, users can access the remote monitoring system. Users may operate the system using the interface, which shows real-time data.

Remote-monitoring systems can be powered by a battery or an external power supply. The power supply guarantees that the system runs continually, allowing ongoing equipment monitoring. In conclusion, remote monitoring gathers data from equipment using sensors, sends the data to a central location, processes the data using software, stores the data in the cloud and makes the data accessible via a user interface.

Remote-monitoring systems offer a way to track equipment performance and gather valuable data. Remote monitoring can increase production and efficiency by detecting problems quickly, reducing downtime and providing real-time data and insights on equipment performance.

Industrial machinery, transportation equipment, medical equipment, agricultural equipment, building systems, power-generation and -distribution equipment and IT equipment are just a few examples of the sorts of equipment that may be monitored remotely.

For instance, if an industrial machine begins to exhibit symptoms of failure, a remote-monitoring system may promptly notify operators and maintenance staff, enabling them to take appropriate action before the problem results in a total breakdown and prolonged downtime.

Additionally, remote monitoring may help businesses to optimize operations, lower energy use and boost general productivity and efficiency by giving them comprehensive data on equipment usage and performance. In general, remote monitoring may be a vital tool for improving how successfully, sustainably and efficiently businesses run.

When selecting a remote monitoring system, consider the following: the type of equipment, data needs, cost, scalability, interaction with other systems, a user-friendly interface, dependability and security. A good system may save expenses, expedite data handling and improve data management and increase the effectiveness and dependability of the equipment. cd

Shawn Cox is a licensed master electrician/PLC programmer. He was co-owner/operator of Bobby Cox Electric for 15 years and is currently employed by BMW Manufacturing as an ESA.

OT-capable HMIs with IT feel

With the right configuration, remote operator interfaces can become troubleshooting tools

by Mike Bacidore, chief editor

THE FUTURE OF OPERATOR INTERFACES (OIs) is as plain as the nose on your face. These veterans of manufacturing automation predict where OI is headed.

Eric Ostini is head of business development, North and Central America at GF Machining Solutions, whose international headquarters is in Biel/Bienne, Switzerland.

Tobey Strauch is an independent principal industrial controls engineer in Fremont, California.

John Dunlap is vice-president of channels and business development at ADISRA. He has more than 35 years' experience in industrial automation, having worked previously for Rockwell Automation, InduSoft and Aveva. He has also worked in the computer-security and semiconductor industries. Dunlap holds a bachelor of science degree in computer engineering and a juris doctor degree from the University of Toledo.

Antonin Deschamps is the global product manager at APEM. He ensures the product roadmap meets market trends and customer needs, and he supports custom product inquiries. Deschamps holds a master's degree in embedded electronics from CESI school of engineering in France.

Bobby Thornton is the product engineer for HMI and Click PLCs at AutomationDirect and a graduate of University of South Alabama. His 30+ years of experience in the industrial automation field include design, installation and support of process instrumentation, ac drives and control systems for the pulp and paper, non-woven and fiberoptics industries. He joined AutomationDirect in 2004.

Linda Htay is automation product manager at IDEC. She is responsible for PLCs, touchscreens and display products. Htay has more than 15 years of experience working with automation and industrial products such as HMIs and PLCs. She holds a bachelor-of-science degree in electrical engineering.

Clark Kromenaker is product manager—HMI, IPC, controllers, software at Omron Automation. Thomas Kuckhoff is product manager—controllers at Omron Automation.

Chris Parkinson is HMI technical lead at Polytron, a CSIA-certified member of the Control System Integrators Association (CSIA).

Ramey Miller is HMI product marketing manager at Siemens. Steven Holmes is international business development manager, motion control—machine tool systems, at Siemens Industry.

Al Letourneau is commercial portfolio manager, visualization & computing platforms at Rockwell Automation. Keith Hogan is principal platform lead at Rockwell Automation.

When will operator interfaces become IT-friendly enough that engineers are no longer required for installation and operation?

Steven Holmes, international business development manager, motion control—machine tool systems, **Siemens Industry**: I sincerely believe that that time is already here. The technology and the tools have been around for a few years now. The concern is adaptation, however.

Many of the larger corporations have utilized these technologies for some time, but the smaller manufactures have been somewhat reluctant to change and adapt to changing manufacturing environments. That, too, is changing, but at a pace that needs to be accelerated, if the United States is going maintain leadership in advanced manufacturing and if reshoring is to be successful.

There is no need for an engineer to upgrade/install system software at all. Anyone can simply upgrade the system software, including the HMI, by plugging in a USB and following a simple menu-driven procedure.

Al Letourneau, commercial portfolio manager, visualization & computing platforms, **Rockwell Automation**: The key to success here is not to eliminate the need for either information technology (IT) or engineers on the operational technology (OT) side, but rather to engage both groups in collaborating to deliver greater value.

For example, deploying domain-based security across both HMI terminals and PCs running as thin clients lets IT manage authentication—who is who—and OT manage authorization—who gets to see what. That way, both groups do what they do best and contribute to the collective success of the enterprise.

Another way to look at this is ease of deployment and device management. In a modern HMI system leveraging thin-client technology, device management has been simplified to the point where you no longer need a technical background in order to load new configurations or replace failed units. In the event of a device failure, someone from IT, OT or maintenance can get the system back up and running in a matter of minutes without requiring assistance from the other teams.

On the flipside, we're bringing IT-centric functionality to the HMI space, like collaborative development in the cloud with versioning and the extensibility with C# and APIs, so HMI developers with a software-centric background will be right at home.

Thomas Kuckhoff, product manager—controllers, **Omron Automation**: This milestone is getting closer every day. While so much of machine programming is rooted in ladder logic, which is becoming ever more IT-friendly with drag-and-drop function blocks, operator interfaces have an inherent visual property.

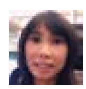
Moving icons around the screen, adding gauges during machine operation and toggling between different screens are becoming more common, especially as these interface types are penetrating more facets of operator life, such as mobile devices, automotive displays and entertainment.

The value here is allowing the operator complete control of the machine to keep production consistent while exceeding quality goals. An example of this is how more operator-interface manufacturers are offering an increasing breadth of features which can be added with just a single tap of the screen.

Eric Ostini, head of business development, North and Central America, **GF Machining Solutions**: Machine manufacturers' future connectivity packages will soon be able to recognize the software version possessed by an end user and be able to determine if that software can run a certain application. Then, if necessary, the package will tell the end user what upgrades are needed and be able to provide them over the air, either for trial, subscription or purchase, via automatic installs in the background.

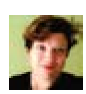
Also in the future, cloud-based shop profiles will list all of a facility's machines, report which have out-of-date software and offer options for software updates. Selective updating will enable a shop to choose the software it needs for the operations it regularly performs without including software for jobs it doesn't or will never do.

Bobby Thornton, product engineer for HMI and Click PLCs, **AutomationDirect**: With various technical and organizational requirements for Ethernet deployment and IP addresses/subnets, creating an operator interface that is completely IT-friendly is a stretch. However, much can be done to ensure operator interfaces are optimized for easy deployment. They can come already configured for dynamic host configuration protocol (DHCP), so setting them up on a network is as easy as plugging the human-machine interface (HMI) into any network with a DHCP server, powering it up and browsing for it using a PC running the associated software. The HMI panel will show up in the software's browse list. Select it, and start transferring your project. No need to set IP address or subnet masks.

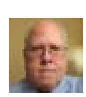


Linda Htay, automation product manager, **IDEC**: By incorporating robust OT-capable HMIs with the IT feel of smartphones, HMIs improve plant productivity, safety and uptime.

Chris Parkinson, HMI technical lead, **Polytron**, a CSIA-certified member of the Control System Integrators Association: It is not just a question of IT-friendliness. Operator-interface development often involves interpreting complex technical concepts and presenting them in a way that is easy to understand. This requires understanding how people comprehend and process information. It requires experience in automation systems so that nuisance data is suppressed and relevant data is transformed into actionable information.



Tobey Strauch, independent principal industrial controls engineer: Virtual machines and server-based applications allow easy remote access. However, the safety issues with controlling a machine remotely are always a concern. Also, there is a depth-of-knowledge gap. Can people that did not build the system or are unfamiliar with operations be able to modify remotely without boots on the ground? Design would have to be better.



John Dunlap, vice-president of channels and business development, **ADISRA**: One can argue that we are already there. Of course, engineers and programmers will still be required to architect the applications, but the installation of the equipment can be done by technicians and the operation of the equipment can be done by plant production personnel—operators. Low-code applications empower users of all types to modify and improve operator interfaces at run time.

What future innovations will impact the use of operator-interface technology in manufacturing operations?

Al Letourneau, commercial portfolio manager, visualization & computing platforms, **Rockwell Automation**: The future is about flexibility that yields greater productivity for developers and operators, as well as greater benefits from your HMI investment.

At every point in the HMI project lifecycle, from specification to procurement, development, testing, use and support, OEMs and end users will be able to choose the specific set of options that works best in that specific application.

For example, when developing a small project you might want to use an installed application for design and deployment; for a larger one you might want to use a cloud-based environment. For the largest you might want multiple developers collaborating in the cloud with shared version control using GitHub.

As you develop the application you could select the individual functions you need and not purchase or load the ones you don't, maximizing system performance and minimizing cost.

When deploying that application you could choose anything from a small, sealed HMI terminal, an Atom-class industrial PC, an iClass PC or even a server. You could deploy the application on an SD card, over a network or through the cloud using VPN. You could execute the application on the device itself and view it on web clients or vice versa. You could maximize uptime by distributing it to highly reliable thin clients with long mean time between failures (MTBF) and short mean time to repair (MTTR).

Best of all, you can make any of these choices independent of the others at any point in the project lifecycle, thus maximizing the benefits to the enterprise. We're truly on the brink of a transformation in the whole HMI space.

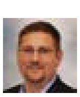
Steven Holmes, international business development manager, motion control—machine tool systems, **Siemens Industry**: Having an interactive handwheel with didactive feedback and an integrated start-stop switch, as well as visual color-coded status display, is most certainly a feature that is a significant improvement to most handwheels currently available on the market. The capability of connecting the digital and real worlds will be the direction of operator interface. It will rely on the development of manufacturing digitalization and digital twin.

Antonin Deschamps, global product manager, **APEM**: Many industries are moving to touchscreen operator-interface panels, and some are experimenting with 3D-gesture technologies. These will continue to improve and find many applications. However, there are also plenty of cases where more physical and tactile feedback—like that offered with joysticks, thumbsticks and associated devices—will continue to provide the optimal user interface.

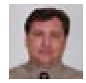
Thomas Kuckhoff, product manager—controllers, **Omron Automation**: Artificial intelligence (AI) has a real ability to impact the use of operator-interface technology. However, AI will have to demonstrate its value before complex algorithms are empowered to make major adjustments to machine performance based on digital twin models.

It's natural that the first step to demonstrating robustness in design, while earning the trust of the plant floor, is to collaborate with operators. The operator interface is a natural location for this common ground to be built. Future innovations can turn the operator interface from a command center into a two-way conversation between operator and machine, both parties making recommendations based on data available to them.

Artificial intelligence will be able to analyze more data more quickly than the operator, which will give the operator the opportunity to make decisions on the plant floor more quickly and with greater confidence.



Ramey Miller, HMI product marketing manager, **Siemens** (new.siemens.com): There are many innovations being introduced that will work well with the operator interface in the future; one is augmented reality (AR). Taking the information being presented to the operator through the interface and integrating it further on the system with AR will lead to many improvements in both operation and maintenance of systems.



Eric Ostini, head of business development, North and Central America, **GF Machining Solutions**: Bar codes or QR codes on uncut workpieces provide huge amounts of information that until recently was processed on the control by the operator. As innovations continue, a QR-code scan will guide a robot to load the workpiece and position it in the machine. It will list initial machining points, such as wire start holes for EDM.

Track-and-trace software will monitor cutting operations and adjust machining parameters to maximize accuracy and efficiency. Sensing and probing technology will judge the acceptability of the final machined part, and a robot will remove it from the machine to be replaced by the next workpiece in line.

The following comments and analysis are my personal speculation and not based on any actual development or visions of GF Machining Systems.

Basically, the amount of human intervention in machining operations is shrinking. Every piece of the progression to truly unattended operation is available; it's just a matter of putting the pieces together.

In the past 15 years, every control manufacturer has developed products intended to make their use easier for the operator. The recent pandemic-driven and economics-based shortage of skilled operators has accelerated that movement.

Major enhancements for machine-tool control will be based on visual assessment of what needs to be done in a manufacturing process. It has to go beyond optical sensing and Renishaw probes.

The machine control of the future needs to have its own set of eyes to make valid decisions based on the massive amount of information available. For example, a "smart" bar feeder could collect information about the bar length available during a process and relay that information to the machine control. The control could then match the information to production requirements, and/or search a library of future jobs to utilize the remaining stock in a prioritized and cost-efficient way.

In another example, machine controls could monitor and store the maintenance status of all of a shop's machines and shuffle output among them when breakdowns or maintenance needs dictate. A truly smart machine control could also vary production volume and timing in response to outside factors, such as peak- and off-peak electrical power costs.

The data are there, and these ideas are doable. Future machine controls will use these data to maximize future productivity and profits.

Bobby Thornton, product engineer for HMI and Click PLCs, **AutomationDirect**: End users, systems integrators and original equipment manufacturers (OEMs) will move to use operator interfaces with:

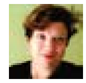
- better security as we connect more devices to the Internet
- faster, more reliable remote access and control
- secure cloud protocols as IIoT needs expand
- powerful Web servers for browser access to operator screens and data
- reliable wireless connectivity like our current mobile devices.

Moving forward, augmented reality (AR) is the next major operator-interface jump. AR can eliminate the physical screen and touch panel. A virtual operator-interface HMI enables users to see process data and make process changes just by looking at any surface like a wall or enclosure where supplementary information is projected. The ability to look at physical process equipment and see it supplemented with virtual data representing pressures, temperatures and speeds will provide new ways for users to perform their work. Similarly, virtual reality (VR) will allow the operator to sit in a remote location and see the process as if they are standing there in person, enabling them to operate the equipment and troubleshoot issues.

John Dunlap, vice-president of channels and business development, **ADISRA**: New technology is being developed by companies such as Texas Instruments (TI), providing low-power, high-performance microprocessor technology designed for implementation in edge devices to implement artificial intelligence (AI). For example, TI has recently introduced its 64-bit Arm Cortex AM62X series of products.

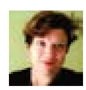
As improved hardware technology such as this is introduced, it will allow cost-effective implementation of predictive-analytics technology at the edge, minimizing the amount of data required to be pushed to the cloud. Of course, data will still need to be communicated to report production results, but innovative technology such as advanced analytics and machine learning will turn data into knowledge and provide actionable information direct to the operator.

Chris Parkinson, HMI technical lead, **Polytron**, a CSIA-certified member of the Control System Integrators Association: Wearable technologies, specifically smart glasses that bring information to the individual where they are at any moment, and augmented reality, with the ability to add information to what an individual is experiencing, will impact the use of OI.



Tobey Strauch, independent principal industrial controls engineer: Eventually, handhelds will take over. This means a wireless infrastructure with a central control, but this paradigm has happened before. It is interesting that with the convergence of information technology (IT) and operational technology (OT), there seems to be less of a demarcation line with distributed control systems and discrete manufacturing systems. Customers want machines connected to material handling, enterprise resource planning (ERP), scheduling, quality and any other acronym system. This means machines no longer stand alone. It also means that, if we provide better automation, one operator may work a whole line. This makes a pocket interface more viable.

Tell us about a state-of-the-art operator-interface technology for manufacturing.



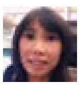
Tobey Strauch, independent principal industrial controls engineer: Operator interface is such a general term because it encompasses hardware and software. The open human-machine-interface (HMI) software packages are taking over. Ignition by Inductive Automation has reset the standard for a prepackaged environment with great custom capabilities.

For hardware, the Touch Panel 600 by Wago has a high international protection rating, an edge computer on the back for programmable-logic-controller (PLC) operations and network ports to allow access to a switch to bring in remote I/O. This is an ideal package for small machine builders that are familiar with e!Cockpit and comfortable with the CoDeSys environment that Wago has built into its platform. The HMI is a computer with a screen and PLC capacity, as well as IIoT and cybersecurity functionality built in. The cost is half of a CompactLogix with no screen.

Open Automation Software (OAS) is also an open system like Ignition that has some depth in a niche part of the industry. The screen graphics are awesome.

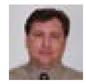
Steven Holmes, international business development manager, motion control—machine tool systems, **Siemens Industry**: The Sinumerik One CNC system from Siemens is the first control designed from the ground up with digitalization and the digital twin in mind. This means that, with the optimized software that allows the control to fully utilize multi-core technology, the true digital twin can finally be obtained.

With the addition of Run MyVirtual Machine, the PC-based virtual machine from Siemens, machine-tool part programs can be fully tested offline. By using this innovative software, errors and machine crashes can be diagnosed and eliminated before the first part is run on the real CNC machine.



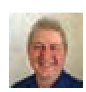
Linda Htay, automation product manager, **IDEC**: While various industrial operator interfaces have been available for many years, IDEC has expanded its extensive product family by adding the HG2J Series 7-inch HMI to add new capabilities. One of the key features of the HG2J is the projected capacitive touchpanel display, which is thinner than traditional analog technologies; robustly resists water, scratches and other conditions common to the industrial environment; and provides a vivid high-performance experience similar to what users are familiar with from their smartphones and tablets (Figure 1). Unlike some older technologies, projected capacitive touchpanel display allows multi-touch gestures like those used with consumer devices, increasing user productivity. The overall result is an HMI platform with an optimal display size providing a high degree of usability in the smallest possible form factor, with appropriate specifications so that designers can incorporate it in all types of challenging environments. Glass faces provide excellent visibility, are extremely durable, retain clarity for years even in outdoor applications and are easy to clean. Regardless of the advanced technologies employed, HMIs for industrial use in the widest range of applications should be able to withstand wide temperatures from -20 to +60 °C, carry an IP66F/67F rating, be suitable for use in Class I, Div. 2 hazardous locations and be certified by UL and CE.

Figure 1: A feature of the HG2J is the projected capacitive touch-panel display.
(IMAGE CREDIT: IDEC)



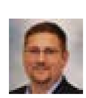
Eric Ostini, head of business development, North and Central America, **GF Machining Solutions**: The present and future of operator-interface technology at GF Machining Systems is the Uniqua human-machine interface. Currently in use on GFMS wire electrical discharge machining (EDM), the Uniqua HMI will be introduced for the company's die-sinking and laser products. It features the Windows 10 64-bit release of the Windows operating system, as well as Intel i5/i7 processors and a solid-state hard drive. The software and hardware together facilitate interfacing with application programming interfaces (APIs) and expedite communication between the unit and the PC, enabling graphic control similar to that of the iPhone system. The resulting responsiveness has permitted GFMS to develop advanced EDM systems, such as automatic slug welding and slug removal, iWire adaptive wire speed function, and Intelligent Spark Protection System (ISPS) that continually measures and adjusts the EDM spark between the upper and lower heads.

The Uniqua HMI also enables drive-system adaptability because the control is the master instead of the drive system. This frees the control to utilize different drive systems if drive component supplies or other considerations make that necessary.



Keith Hogan, principal platform lead, **Rockwell Automation**: Rockwell Automation has always prioritized supporting customers throughout their project lifecycle and beyond. We're about to add a new human-machine-interface (HMI) platform to our portfolio: FactoryTalk Optix, a cloud-enabled HMI platform that allows design, test and deployment of applications using a locally installed design environment or directly from a web browser, connecting through our cloud-based FactoryTalk Hub. This modular platform delivers new options for design, deployment and graphics, with extensibility options that make it flexible enough for any application.

It can be deployed on industrial PCs or, starting in 2023, on a new set of OptixPanel HMI terminals. FactoryTalk Optix is an addition to our visualization-platform set and does not replace any existing Rockwell Automation product. It's a great option for new applications requiring greater flexibility.



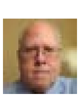
Ramey Miller, HMI product marketing manager, **Siemens**: Simatic WinCC Unified is a completely new visualization system that enables you to successfully master the challenges of digitalization in machine and plant engineering. The latest web and edge technologies combined with open interfaces enable you to implement your ideas flexibly and according to application-specific requirements.

Figure 2: Industrial PCs offer WXGA class resolution and flexibility to run SCADA or run-time visualization software in addition to machine-control capability of the Omron Sysmac controller.

Clark Kromenaker, product manager—HMI, IPC, controllers, software, **Omron Automation**: Omron Automation categorizes operator interface under the Visualization heading. We have a number of visualization solutions with features such as full-color widescreen displays in sizes from 7 inches to 19 inches, projected capacitive touchscreen capability, 1000Base-T Ethernet.

Most meet NEMA 4X/IP65 ratings for use in harsh environments. Our NB series of operator interfaces provides a more basic visualization solution for smaller or simpler machines and applications. Our NA5 series of operator interfaces is our higher-end operator interface and offers wide-extended-graphics-array (WXGA) class resolution. Our NY series of industrial PCs offers WXGA class resolution and has maximum flexibility to run SCADA software or run-time visualization software in addition to machine-control capability of the Omron Sysmac controller (Figure 2).

Omron operator-interface devices operate on a closed operating system (OS), which offers high resistance to malware.



John Dunlap, vice-president of channels and business development, **ADISRA**: ADISRA has developed SmartView for human-machine interface (HMI)/supervisory control and data acquisition (SCADA), InsightView for overall equipment effectiveness (OEE) and advanced analytics and KnowledgeView for predictive analytics/machine learning. These products provide powerful and cost-effective solutions to monitor machine operations and overall production efficiency, along with the tools to optimize production results.

Antonin Deschamps, global product manager, **APEM**: APEM offers a wide variety of human-machine-interface products designed for the toughest industrial applications. With our new XP Series mid-sized joystick, we use the latest contactless Hall effect technology to provide diagnostic capabilities for safety purposes, while delivering extremely high-resolution signaling, even though it is integrated into a robust mechanism. The assembly is configurable with a wide range of optional inputs like triggers, rollers and thumbsticks, and it is ergonomically designed to help operators avoid fatigue (Figure 3).

Bobby Thornton, product engineer for HMI and Click PLCs, **AutomationDirect**: AutomationDirect's C-more EA9-RHMI headless HMI operator interface is the most cost-effective HMI solution on the market. At less than $500 for the HMI, and under $1,000 for an industrial monitor, you can have a complete operator station with a 22-inch pCap touchscreen for less than $1,500. For even less money the HMI can drive any PC or HD TV/monitor. Or, if you do not need a local screen at all, put the EA9-RHMI inside an enclosure and use the remote access feature to operate the HMI from a PC. Even better, you can also use the Remote HMI app on your mobile device from anywhere to operate or check the status of your system. C-more HMIs are easy to program and easy to use but are packed with powerful features including an event manager, email, remote access capability and a built-in Web server. They offer SD and USB data log storage, as well as Ethernet, RS-232 and RS-422/485 communications. These HMIs pair perfectly with AutomationDirect PLCs, as well as other popular PLCs including Allen-Bradley ControlLogix. cd

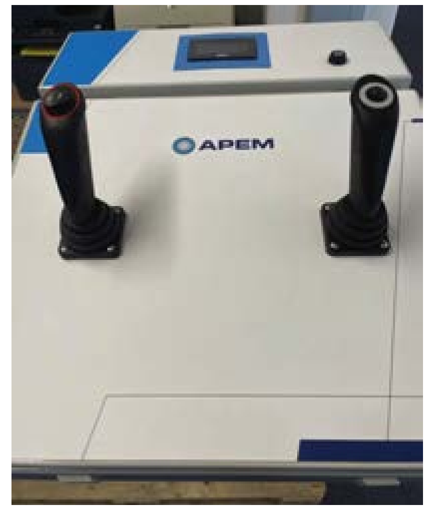
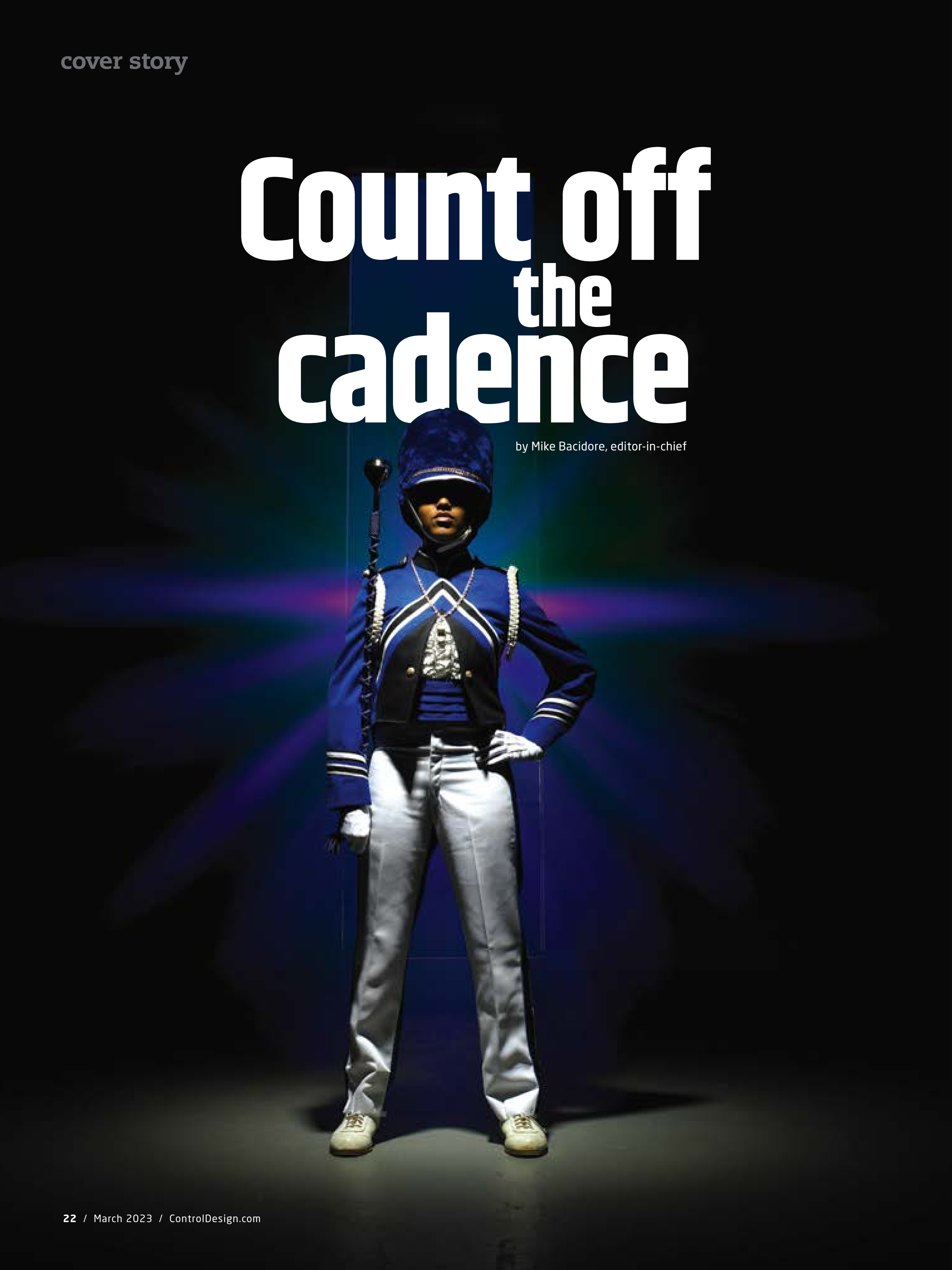


Figure 3: Joystick assembly is configurable with a wide range of optional inputs like triggers, rollers and thumbsticks, and it is ergonomically designed to help operators avoid fatigue.
(SOURCE: APEM).

Count off the cadence

by Mike Bacidore, editor-in-chief



Ingress protection and IO-Link let components march out of the cabinet and onto the machine

This is Part I of a two-part series on the ongoing trend of automation components moving from the cabinet onto the machine.

NOT EVERYONE LOVES A PARADE. We all march to the beat of a different drum. Some are slow, deliberate soldiers, while others move in double-time with the grace of a dancer. But eventually we all march en masse to the prescribed destination.

Automation components have traditionally been placed within the protection of an electrical cabinet. Wiring these industrial control panels is a complex process that requires careful planning and execution, well worth the advantage of the safety and security that the enclosure offers.

However, thermal management of the cabinet and reduced machine-footprint requirements have marshalled a parade of components coming out of the enclosure and onto the machine, thanks largely to ingress protection and the swift advantages of positioning processing power where it's needed.

March on machine

"Power supplies and motor drives help us keep high-heat components out of the cabinet and reduce the cost in cooling the cabinet, as well as the size reduction of the cabinet," says Kevin Davidson, operators manager at Methods Machine Tools' Detroit Technical Center.

Two major benefits sought by original equipment manufacturers (OEMs) and end users are smaller-footprint machines and reducing the cost associated with cabinet building, agrees Sandro Quintero, business development for electric automation, Festo. "They want to have one wire back to the control cabinet via an Ethernet-based fieldbus," he says. "This is a more effective use of a technician's time, as compared to wiring every I/O back to the cabinet. OEMs and end users want the benefits of less wiring for greater reliability and cleaner-looking machines, easier troubleshooting, faster and more trouble-free teardown and setup and higher performance."

Not all components lend themselves to being mounted on the machine, however. Some are more likely than others to find themselves out of the cabinet. "OEMs mount pneumatic valve manifolds on machines to increase performance because the closer the manifold is to the actuator, the faster the response time," explains Quintero. "On the electric side, Festo has integrated a drive, motor and actuator for machine-mounted simplified electric motion and I/O blocks to distribute I/O along with manifolds across the machine." Many sensors are machine-mountable, as well, including pressure, flow, optoelectronic, temperature and vibration, he notes.

"Electrical components can be integrated directly on the machine to simplify the wiring, integration and maintenance and to make the system more cost-effective," says Dan Barrera, product manager, ctrlX Automation, Bosch Rexroth, who lists the most common cabinet-free technology as:

- motor-integrated drives
- cabinet-free drives, including the corresponding power supplies
- input and output modules
- housed display panels with and without an integrated PC, although less common.

Components built specifically for machine-mounting can include sensor junction boxes, communication hubs, controllers, I/O modules and variable frequency drives (VFDs), says Bill Dehner, technical marketing engineer, AutomationDirect. "Any device that has the appropriate housing and sealed connections like M12 can be easily and reliably mounted to machines and other equipment located indoors or even outdoors," he notes.

"Of particular interest, many Ethernet switches and field I/O devices offer M12 connections, enabling machine mounting while providing the network and wired I/O connections necessary," says Dehner. "This helps minimize field wiring, and it simplifies installation and maintenance. For many types of equipment, locally installed components with plug and cord connections provide great advantages."

From classical to post-modern external

Many of the devices classically housed in the control cabinet have been relocated externally, explains Perry Hudson, key account manager, Pepperl+Fuchs. "You can start with communications for the machine," he advises. "Remote I/O blocks, terminal junction blocks, logic converters, Ethernet switches, power supplies and communication masters/gateways are all available for external mounting. Frequency converters, servo controls and smart motor controllers are also available for external mounting, as are safety control modules. Edge computers and PLCs, which have always been housed in the control cabinet, can now be mounted externally when it makes sense to do so. The move is to bring the controls closer to the work, eliminating sources of error and additional costs."

Figure 1: Galco is seeing some remote-mount components such as mounting controllers and I/O products move outside of the cabinet and onto the machine. (SOURCE: GALCO)

Over the past 20 years, there has been a continual march of components out of the cabinet and onto machines, declares Tom Jensen, head of system solutions and technology evangelist at Murr Elektronik. "Sensors are built to live outside the cabinet, but the I/O blocks they connect to have made the transition because they use shorter molded cables, eliminate terminal strips and promote easier assembly," he explains. "The same with motors and the amplifiers that drive them, which are now commonly mounted together as motor modules. The next step has happened with distributed power supplies that provide the dc power bus for motion being remotely mounted to the aforementioned motor modules and finally the controller/PLC itself."

One unintended but inspiring consequence is, when things are removed from a cabinet, all the support components are eliminated, as well. "For example," explains Jensen, "remove the I/O and the terminal strips, overload protection and hand wiring go, as well. Take out the drives and power supplies, and the breakers go, as well—normally integrated into the power supply. OEMs are left with a cabinet and disconnect that are protecting only the PLC, which are now able to be placed out of the cabinet, too. In the market you will find technology providers that have solutions that require no cabinet—entirely IP65, from the 480-Vac input and disconnect to motors and sensors—making machines less expensive with a smaller footprint and quicker to build."

Anything for power distribution and collection of field I/O—sensors, field cabling, passive sensor boxes, networked sensor boxes, power supplies—can be mounted on the machine, adds Jeremy Andrews, product manager, industrial field connectivity, Phoenix Contact. The standardization and acceptance of M8 and M12 circulars allow for reliable, sealed connections in a small form factor outside of the cabinet, he explains.

"With new IEC standards for products like M12 Power and M12 Push-Pull, it becomes even easier for components to be designed in with multiple quick connection points for signal, data and power," says Andrews. "With the trend for compact, IP-rated components to be machine-mounted, fast and easy connection methods will be a key for machine builders. Heavy-duty through-panel connectors also make it easy to wire components to one or a few easy quick connect points at the cabinet wall, allowing for easy installation."

Can you hear me now?

Updates to the IEC 61131-9:2022 standard for digital communication interface technology for small sensors and actuators—IO-Link—coupled with advancements in industrial-communication protocols, enable opportunities for the interface between industrial controllers and field devices, explains Erik Cornelsen, an automation and process control engineer in Switzerland with experience in the construction-materials industry, food-and-beverage and logistics.

"Many well-known manufacturers are developing innovative products embedded with IO-Link technology," says

Cornelsen. "Some interesting examples are safety I/O devices that communicate with the controller over ProfiSafe or I/O devices that can be mounted very close to the machinery, respecting challenging ingress-protection (IP) requirements, such as IP67. These innovations can significantly simplify the electrical wiring of the plant."

Signals that were previously wired to the controller I/O cards or to the distributed remote I/O cards can be replaced by network cables and shorter electrical connections, notes Cornelsen. "Additional process data and diagnostics can be transmitted with the IO-Link technology," he says. "A practical example is when using an IO-Link magnetic-inductive flow meter. Traditionally, this flow meter would be wired to a transmitter that sends a 4-20 mA signal to the controller's analog input card. With IO-Link technology, the analog connection is replaced by a digital communication, and the controller receives not only the reading of the flow, but also the temperature of the fluid, the totalized amount of fluid that passed within a certain amount of time and device status and diagnostics."

Over the past few years, reports published by Profibus and Profinet International (PI) have shown that the number of both IO-Link and Profinet nodes have been growing exponentially. "This is very positive for the industry, as it demonstrates that these technologies are being integrated into factories," explains Cornelsen. "Modern digital interfaces between field devices and controllers, integrated with industrial technical standards for data communication over industrial Ethernet, have among their advantages the simplification of electrical installation with increased process data and diagnostics transmission. This is the real backbone of the Industry 4.0 revolution in the shop floor, and the tendency is to continue to grow."

Plug-and-play performance

This trend depends on which components and applications you are talking about, says Tobey Strauch, an independent principal industrial controls engineer based in Fremont, California. "There is a current push to do plug-and-play," she explains. "Everyone wants things faster, so if you build modular, then you can simplify the interface. This means smart devices in the field."

Take, for example, smart cameras and smart I/O.

"Manufacturers are putting the decision control onboard the camera," explains Strauch. "This alleviates the camera controller in the cabinet. Where is this beneficial? In robotics and gantry operations. Why? Ethernet feedback can show the camera responses. Also, if it's on the arm, the triggers and the feedback can go back to the robot, reducing decision time. Why use a PLC as a traffic cop if you do not need to? This allows systems to be plug-and-play. The robot can do all its functionality in the robot system and just provide feedback to the main process and get triggers from the main process."

Who is taking advantage of this? Look at Universal Robots and its group of partners, says Strauch. "Robotiq allows the purchase of a palletizer, off the shelf," she notes. "Integration is based on minimal feedback from the line, or it can stand alone, and you gate a conveyor to know when traffic is coming into the system."

For smart I/O, IO-Link has an exponential growth since 2013, says Strauch. "Again, this is based on the plug-and-play trend," she emphasizes, and it's also based on economics. "If an integrator can buy three remote I/O blocks and run three Cat. 6 EtherNet/IP cables back to the cabinet, then it alleviates rows of terminal blocks and wiring," she explains.

But, thinking further, if a line can be built modularly and there are IO-Link masters tying groups of field I/O together and bringing it back to the control cabinet, then cabinet costs are reduced, but software costs increase, reasons Strauch. "I/O becomes more database-driven, but the information is readily available," she explains.

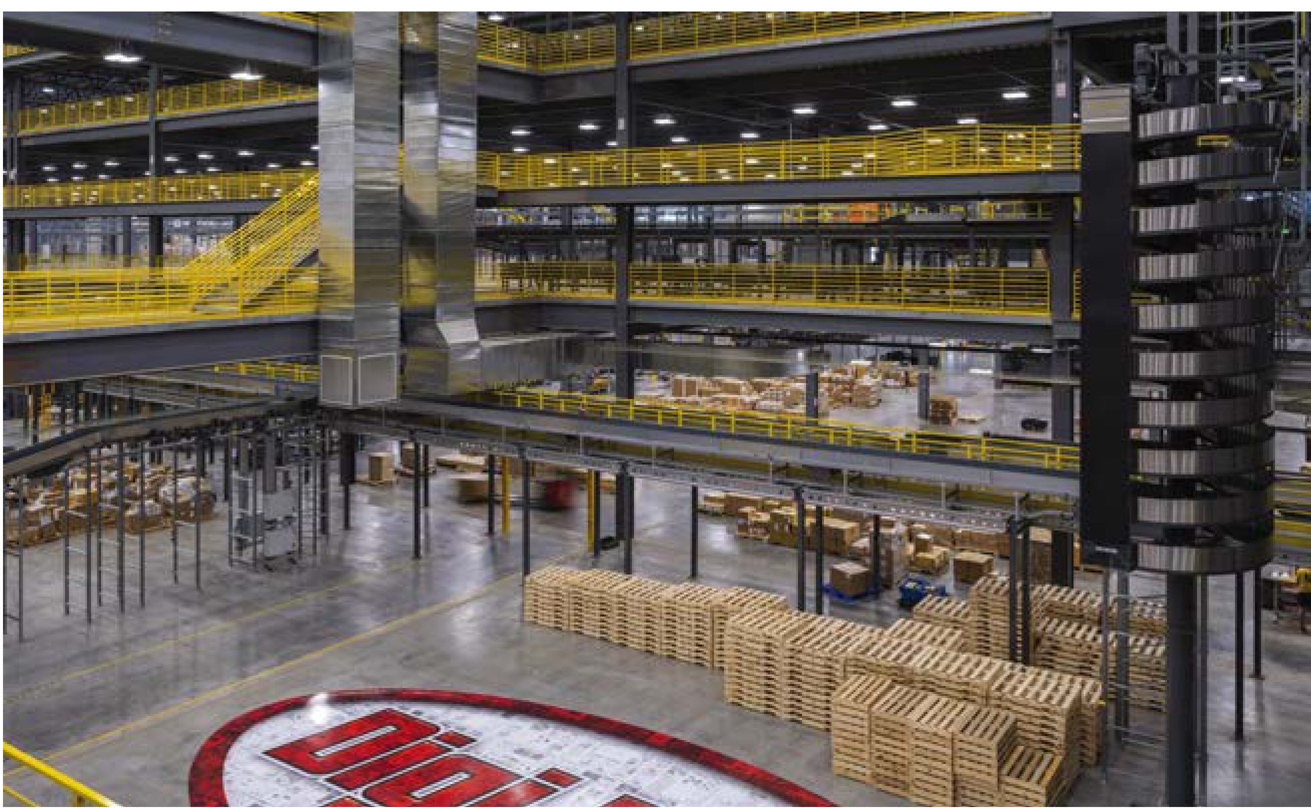


Figure 2: Digi-Key says smaller footprints and higher IP ratings allow devices to be mounted on machinery, freeing up the premium real estate located within enclosures. (SOURCE: DIGI-KEY)

Figure 3: The need for mounting devices directly on machinery is very industry-dependent.
(SOURCE: AIRLINE HYDRAULICS)

Ease of use is another consideration. "What if a manufacturer wants to do a tooling change and can just wheel out the one piece of equipment and wheel in the other? Smart I/O can allow for this," says Strauch. "Also, I'm seeing IO-Link across all PLC platforms. This is cool because it will open the door to more standardization of PLC-type controls. Is it new? No. It's changed media. Modicon was using fiber and coaxial cable to connect remote I/O and daisy-chain nodes back to the control room in 1979."

Keep in step

This out-of-the-cabinet trend will continue where it makes sense with ever-shrinking sensors and devices, notes Heath Stephens, PE, digitalization leader at Hargrove Controls & Automation, a certified member of the Control System Integrators Association (CSIA). "However, the individual field-mount devices will always be more expensive than their cabinet-mount equivalents," he cautions. Also, while the devices may be ruggedized, exposure to harsh operating environments may still mean field-mount devices are prone to higher failure rates and are more difficult to service, says Stephens.

"Most of our jobs require an enclosure due to hazardous-area locations or inclement environments with dust or extreme natural elements," warns Judson Perkins, panel fabrication design at Hargrove. "However, I could see this being a way for end users to save costs. Why spend the money on outfitting an enclosure to support equipment when said equipment can be easily supported by wall-mounting or mounting directly to machinery? Having an enclosure can be beneficial because it provides an extra layer of protection and can support a segregated power distribution/circuit protection plan."

Galco is seeing some remote-mount components such as mounting controllers and I/O products move outside of the cabinet and onto the machine, notes Allison Sabia, president and CEO of Galco (Figure 1). "This reduces cabling, makes troubleshooting easier and increases worker safety as there is no need to open high-voltage cabinets," says Sabia, who also references an uptick in integrated motor-drive combinations that can eliminate panels on simpler systems.

"It's happening for sure," says Jason Andersen, vice president, strategy and business line management, Stratus Technologies, "but not as quickly as we thought it would, for a few reasons. First, I'd say that machine builders' next-generation products were stalled by the pandemic."

However, it is not quite that simple, admits Andersen. "On the end-user side, there are more server-class compute resources being deployed in cabinets and microdata centers, so the end users have more capacity reducing the immediate needs for machine-mounted compute. Also, sometimes these solutions introduce a whole host of data ownership and governance issues that may come along with a machine-mounted computer, so the tech may be a bit ahead of the market-readiness," he explains.

"IO-Link is becoming increasingly more common, resulting in intelligent machine-to-machine communication," explains Eric Halvorson, partnership marketing manager—strategic programs, Digi-Key. "Wireless technology creates freedom with product placement as devices are no longer required to be mounted in a cabinet. Smaller footprints and higher IP ratings allow devices to be mounted on machinery, freeing up the premium real estate located within enclosures (Figure 2). As a result of these advantages, we are starting to see more products transition to wireless protocols."

Closing notes

The controllers needed to run certain equipment such as dc motors or valve manifolds have become smaller, explains Freeman Smith, founder of Nufactur. "By putting the logic directly on the device, rather than in the cabinet, the user benefits from less wiring. This has corresponded with an explosion in I/O equipment and data collection on the plant floor. It is economical to have your I/O field devices mounted closer to the equipment they are monitoring. These two factors have led to less equipment in the cabinet," he explains.

As mobile-connectivity technologies evolve and become less expensive, they'll be used where they're needed most, predicts James Potisk, application engineer at Automation24. For example, monitoring critical processes in very remote or hazardous locations will see more of this technology used as it becomes more available. "However, there are great benefits to the protective nature of mounting devices within an enclosure," he says. "Cost is the motivator; therefore, devices are going to be mounted where it makes the most financial sense. If it takes less wire to mount a device on the equipment, rather than within an enclosure near the equipment, it costs less to produce the equipment." Ultimately, cost will dictate the favored mounting location, explains Potisk.

"We are continuing to see a trend toward having machine-mounted devices reducing or eliminating electrical control panels," counters Sam Hoff, chief executive officer, Patti Engineering, a CSIA-certified system integrator in Auburn Hills, Michigan. "This happens mainly because of speed of commissioning and reduction of labor in assembling panels."

At Prinovis, a print service provider in Liverpool, England, which is due to stop operations this summer, there have been no changes to machinery or new machinery over the past couple of years, so Mark Lee, CHP technical manager, says he hasn't been exposed to any changes like this.

"We've recently seen Ethernet switches and some pneumatic items moving outside of the control enclosures. This gives flexibility of design and in certain cases saves on homeruns to the control panels," notes Jeff Sanders, B.S.M.E., system integration manager at George T. Hall, a certified member of CSIA.

"In our industry, customers still prefer to have devices fitted into a cabinet due to easier central management," says Joseph Yang, director of product management at Advantech.

"The need for mounting devices directly on machinery is very industry-dependent, and our technology meets both needs on a technical basis," explains Mark Steffens, CEO at Airline Hydraulics (Figure 3). "In addition, every customer—more than 8,000 customers yearly—is unique in their requirements, and our 40 outside sales engineers and 35 in-house engineers provide value in customizing their solutions (Figure 4)." cd

Figure 4: Airline Hydraulics works to customize solutions for specific applications. (SOURCE: AIRLINE HYDRAULICS)

How machines develop a sixth sense

Sensors have equipped factories with intelligence, but safety has become a sense of its own

by Mike Bacidore, editor-in-chief

MACHINE SAFETY HAS come a long way, and technology has been a large factor in those advancements. As manufacturers feel the need to heighten safety, specifically with the introduction of robotics and artificial intelligence onto the factory floor, automation used in other domains are being adapted and implemented for safety applications.

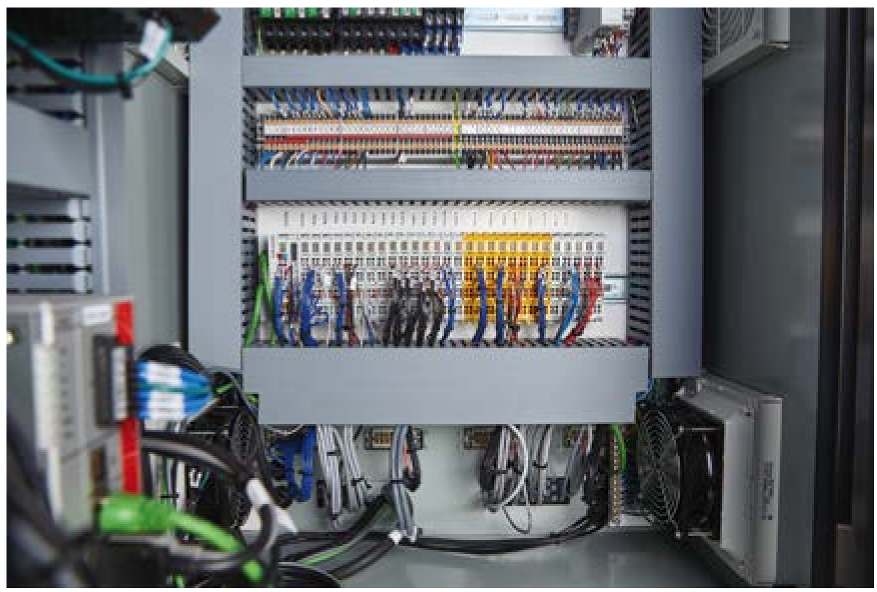


Figure 1: The worlds of safety and non-safety technology continue to converge rapidly.
(SOURCE: BECKHOFF AUTOMATION)

It seems like only yesterday

"In the past five years, there have been a number of significant advances in workplace safety that have revolutionized the way we approach safety protocols," says Brian Kundinger II, vice president at Kundinger, an integrated supplier headquartered in Auburn Hills, Michigan, that specializes in distribution, design, engineering, manufacturing, installation and ongoing service support for technology solutions. "One of the most notable advancements has been the use of light detection and ranging (LiDAR) technologies in collaborative robotics. This technology uses lasers that generate a 3D map of an area and makes robots aware of their position and surroundings to detect obstacles or hazards." LiDAR is being used increasingly often in places such as warehouses and manufacturing facilities where manual labor or hazardous conditions may pose a risk to human workers, notes Kundinger.

Another major advancement has been the development of "safe motion" technology, which slows down production without requiring complete shutdowns. "Through advanced sensors and computer-vision algorithms, these systems can detect potential dangers before they occur, allowing operators or robotics to adjust certain parameters such as speed or power levels to safe conditions," explains Kundinger. "This reduces the potential for serious occupational injuries while keeping production running at optimal speeds."

The worlds of safety and non-safety automation continue to converge, explains Christopher Woller, who has diverse application experience and strong background in functional safety. He joined Beckhoff USA as safety product manager in January 2022. Previously, Woller spent six years at Siemens, starting as an automation consultant and ending as business development manager—building automation products.

"Just five years ago, we were still discussing the merits of a programmable safety controller paired with a safe fieldbus versus safety relays providing rudimentary status information back to the control system," reminisces Woller. "Now we're exploring the possibilities of distributed logic with components seamlessly entering and leaving safety systems as emerging technologies like automated guided vehicles (AGVs) and autonomous mobile robots (AMRs) more closely interact with the control systems and machinery around them."

Ultimately, this has also driven sensors to become smarter (Figure 1). "The safety fieldbus was once only the domain of high-end laser scanners and the like, but now even lower-level sensors and door locks are starting to leverage a fully integrated, networked safety approach," says Woller.

"The most innovative safety application I've been involved with was for a massive television-studio complex in the Philippines," continues Woller. "Each studio held between approximately nine and 50 movable grids that were 4-by-4-meter squares. When fully loaded, they could weigh up to 3,500 lbs. These overhead grids held lighting, sound equipment and scenery, and each one was held by one or two vertical hoists. There were well over 100 of these grids."

Safety-rated wireless human-machine interfaces (HMIs) were used to control them, explains Woller. "While an operator moved between studios or to different areas inside a larger studio, their location would be tracked via safety-rated RFID," he says. "E-stop scope of control and the ability to move grids was entirely based on the operator's location within the facility. In this case, any control HMI could be used in any location and still provide the appropriate safety functions for that location."

Figure 2: Machine-mountable safety solutions provide robust options for functional safety. (SOURCE: BECKHOFF AUTOMATION)

For Kundinger, one of the most innovative and efficient safety applications used laser monitoring devices, safe motion drives and motors to facilitate collaborative workspaces between humans and robots.

"Lasers allowed robots to operate near humans without the need for perimeter guards or segmentation of the facility, allowing for a more efficient workflow and safer overall operation," explains Kundinger. "Additionally, laser monitoring devices allowed for a range of features such as speed control, emergency stops and safety limits, which increased operational accuracy of the collaboration between humans and robots." The use of drives and motors provided an added layer of safety by ensuring that any robotic operation could be halted when a risk was detected.

Safety from a distance

"The importance of diagnostics and visibility cannot be overstated," explains Woller. "The fastest way to get a safety system bypassed is to make it hard to diagnose. Connectivity and remote monitoring make it possible to get the right information to the right person as quickly as possible, even if that person is hundreds or thousands of miles away. Gone are the days of a single output wire to the programmable logic controller (PLC) indicating a fault."

Remote monitoring and connectivity have significantly benefitted safety in multiple ways, says Kundinger. "First, it has enabled a much greater level of plant safety through enhanced surveillance and human intervention," he explains. "For example, with the ability to remotely monitor facilities, grounds, machines and hazardous areas from a single point, multiple facilities can be monitored at once without needing to have someone physically present on-site. This means that fewer people need to be employed as plant safety personnel, which in turn reduces costs and increases efficiency."

Furthermore, since machine shutdown/slowdown is instantaneously detected by these remote-monitoring systems, potential accidents can be spotted quickly and avoided before they become serious issues, notes Kundinger.

Software development has allowed for an unprecedented level of control over the components in a safety system, continues Kundinger. "In the past, it was difficult for a non-technical individual to program safety devices, as it required expertise in controls engineering," he says. "Today, however, much of the safety equipment being produced is equipped with QR codes, which are easily read by a specialized app. This enables anyone—not just those with knowledge in controls engineering—to program these devices with ease. Additionally, software platforms that are open-source allow for seamless integration into building supervisory-control-and-data-acquisition (SCADA) systems with plug-and-play capabilities."

Safety-rated wearables will become increasingly important as AGVs and AMRs proliferate through even more industries.

– Christopher Woller

One of the most notable advancements has been the use of light detection and ranging (LiDAR) technologies in collaborative robotics.

– Brian Kundinger II

Digital twins and IT wins

"Digital-twin platforms provide significant benefits when it comes to managing safety within an organization by offering a complete view of products, machines and production lines through their entire lifecycles," says Kundinger. "This allows manufacturers to detect unsafe conditions early on, so they can address them before they become serious issues. On top of this, when any changes are made to the product or machinery, digital-twin platforms can quickly assess their impact on safety."

Digital-twin platforms also allow for easier communication between different stakeholders involved in safety management, continues Kundinger. "Most, if not all, devices Kundinger offers can communicate via Ethernet and can present information to a SCADA system or the cloud, allowing multiple teams to easily access up-to-date information regarding safety protocols and regulations whenever they need it," he says.

"Quite simply, by definition, without safety you cannot have a digital twin," emphasizes Woller. "Since safety must exist in the real world, a digital twin must consider it, as well. The digital twin is not just a debugger of the PLC, a mechanical or hydraulic force calculator or a mechatronics path simulation. It takes all aspects—a true running controller, safety controller and sensors, machine physics, motion paths—and effectively allows a much faster path to commissioning. An exceptional digital twin lives beyond the commissioning phase as a sandbox that the end user can incorporate with other digital twins to continually optimize the process in a virtual environment."

In addition to the virtual environment, safety is impacted by the IT environment, as well. While individual safety functions are conceivably standardized enough that anyone can drop them in place, the fact remains that the iterative process of "risk assessment-identification-reduction-validation" still requires operators, if required for the process, engineers and safety professionals with knowledge of the application, notes Woller. "And the process needs to happen regularly throughout the life of the machine or system," he says, noting that operators will still be very viable careers for many years to come.

"Many safety components and initiatives can be set up relatively easily through learning functions or predeveloped applications," notes Kundinger. "The increasing prevalence of digital transformation in industry has enabled faster implementation of IT-friendly components, and the technology landscape is changing rapidly to keep up with demand for efficient processes. This shift is driven by advances in automation, as well as improvements in data collection, visualization and analysis capabilities."

The future's so bright

One innovation that is expected to have an impact on safety is machine learning (ML). "This technology has already been used successfully in various industries and can be applied to industrial settings, as well," advises Kundinger. "Machine-learning algorithms can detect hazardous situations and alert operators before they become dangerous or lead to accidents. Additionally, they can monitor worker behavior and alert supervisors if any unsafe practices are occurring."

Robotic systems will continue to advance, as well. "We'll likely see no slow in manual labor being replaced by robotics because the precision, accuracy and speed will be difficult for humans to match safely," says Kundinger. "These advancements represent a significant opportunity for companies to benefit from improved working conditions while still producing high-quality products at an efficient rate."

Wearables and vision will start to play a major role in functional safety, predicts Woller. "As vision and artificial-intelligence (AI) technologies advance and become robust enough to pass muster with safety standards, I see it replacing many sensors, reducing failure points and making architectures even more flexible," he notes (Figure 2). "Safety-rated wearables will become increasingly important as AGVs and AMRs proliferate through even more industries." cd

The poetry of motion

Motors, drives and starters are merely the opening stanza

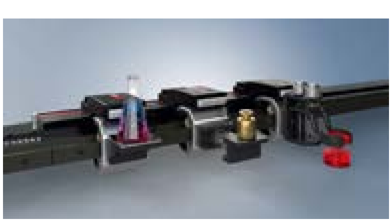
Servo systems

AutomationDirect's L7P servo motors, drives, cables and gearboxes from LS Electric are intermediate-level L7P servo systems that have all the features of the basic L7C servos including setup wizards, auto tuning and built-in indexer, but with a larger range of system sizes and the option for 460 Vac operation. The built-in absolute encoder on each servo motor is also higher resolution at 19-bit (524,288 ppr). The L7P systems are available from 100 W to 7.5 kW with 230-Vac input power and 900 W to 7.5 kW with 460-Vac input power. The 230-Vac systems can operate single-phase up to 2.2 kW. All motors are available with or without a 24-Vdc holding brake. The free Drive CM software is designed to ease setup/configuration and includes autotuning algorithms and an oscilloscope to fully optimize the application. A matched set of LS Electric gearboxes are also available for each motor, with gear ratios of 5:1, 10:1 and 20:1 (7.5-kW systems limited to 15:1). Hook-up cables for motor power and encoder connections are available in standard or flex-rated lengths of 3, 5, 10, and 20 m. All new L7P servo system components come with a 2-year warranty.

AutomationDirect / www.automationdirect.com

XTS mover with No Cable Technology

Beckhoff is taking the next step in mechatronics flexibility with No Cable Technology (NCT), an extension of its eXtended Transport System (XTS). NCT provides contactless power supply and synchronous real-time data communication directly to XTS movers. This solution is designed to enable individual movers to serve as mobile handling and processing stations, essentially turning the intelligent transport system into a flexible multi-robot system. The modular XTS solution has been expanded with NCT to include a special motor module, as well as electronics that mount on the movers. The hardware required for the transmission technology is fully integrated into the motor module to avoid sacrificing existing functionality or expanding equipment footprint. No additional connections or supply lines are needed. The control of the hardware on the mover is fully implemented in standard TwinCAT software. All known TwinCAT functionalities are available for simple project implementation. NCT is designed to make it possible to process and check the quality of products on the XTS mover while the process is running. Sufficient power and fast communication with the TwinCAT control system enable connection of sensors and actuators. The data communication is real-time capable and can synchronize system-wide events with µs accuracy in conjunction with the EtherCAT industrial Ethernet protocol.



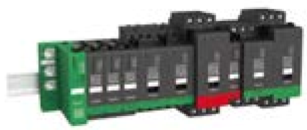
Beckhoff Automation / www.beckhoff.com

Compact servo drive

Festo's range of servo drives includes the CMMT-ST. Complementing the existing CMMT-AS, the CMMT-ST servo drive is equally dependable but much more compact and economical. These characteristics are designed to make it ideal for point-to-point and interpolating motion in applications in assembly and handling technology, packaging machines, or in the electronics industry. The CMMT-ST is designed to enable challenging dynamic motions for small servo motors and all stepper motors with a continuous power requirement of up to 300 W. It has a power capacity of 2.5 kW, so requires less cooling than its big brother and needs just half the installation space. It is suitable for various Ethernet-based bus systems and can be seamlessly integrated into the controller environments of different manufacturers. The CMMT-ST works best in combination with the EMMS-ST stepper motor from Festo. Commissioning the CMMT-ST is designed to take just minutes with the Festo Automation Suite. Although the CMMT-ST offers a more compact, lower cost option than the CMMT-AS, the connection and communication concept, functional modules and standard safety features remain unchanged. The consistent control concept means users can combine the CMMT-AS and CMMT-ST as a servo drive for both large and small axes.

Festo / www.festo.com

Communicating motor starters



Schneider Electric's motor-control solution is designed to eliminate control wiring and PLC I/O with a single ribbon cable click to help users complete projects faster. Schneider Electric's next generation of motor control is designed to be fast to install, easy to configure and provides access to data without having to upgrade to a drive. Digital tools increase efficiency by simplifying design, commissioning and troubleshooting. Current, energy and other critical data are available via Ethernet/IP, Modbus TCP, Profinet and Profibus.

Digi-Key Electronics / www.digikey.com

Drive integration

Many control schemes call for redundancy, requiring intermediary equipment to integrate final control devices such as variable-frequency drives (VFDs). To simplify this common architecture, a Profinet System Redundancy (PNSR) communications card plugs into PACMotion VFDs, simplifying high-availability communications between VFDs and Emerson's PACSystems RX3i programmable logic controllers (PLCs) and edge controllers. PACMotion VFDs are designed to offer plug-and-play startup, auto-tuning and simplified programming via configuration tools incorporated directly within PAC Machine Edition software. An optional PNSR communications card enables direct connection and control of PACMotion VFDs in hot standby PACSystems redundant architectures, improving availability of the VFD in the event of a single controller or communications link loss. The communications card provides high-availability control functionality, maximized uptime and improved availability. The VFD PNSR is designed to allow users to simplify and save up to 15% on integration products and efforts and is compatible with all PACSystems PLCs and edge controllers that support high availability. This communications card, once installed in the VFD option card slot, is designed to ensure easy and seamless direct connection to VFDs without requiring any other intermediary controllers or external components.

Emerson / www.emerson.com/en-us/

Speed starter

Phoenix Contact's Contactron speed starter (CSS) is a type of motor control device. Speed starters occupy a unique market space between conventional across-the-line motor starters and variable-frequency drives. The speed starter is also more than a soft-start device. It offers the ability to control motor ramp-up and ramp-down times while operating under torque and two user-settable output speeds from 0 Hz to 500 Hz. The rotary knob and push-button interface allow rapid commissioning without software or a computer. The speed starter provides ramp-up and ramp-down functions while the motor is under load, and it offers two independently settable operating speeds. The intuitive keypad and rotary knob are designed to allow commissioning in just minutes. Digital inputs activate user-settable output speeds. The speed starter also streamlines safety. The integrated safe torque off (STO) feature has emergency-stop capabilities up to SIL 3/PLe when used with a suitable safety relay or safe PLC. The speed starter is designed for intralogistics applications such as conveyor and material handling systems. The two speeds allow acceleration/deceleration between two points, different forward and reverse speeds, or simple use of the ramp function to avoid toppling product or shock-loading gear drives. It can also optimize motor speed to save energy and improve flexibility.

Phoenix Contact / www.phoenixcontact.com

Servo motors

The 1SA series, which supports safety functions, realizes advanced safety control of people, machines and things. It is possible to reduce equipment downtime and minimize product waste while avoiding the risk of endangering workers. For 1SA series safety function support, the servo driver is equipped with motion safety functions. It is equipped with various safety functions that can be adapted to machine safety: STO, SS1, SS2, SOS, SLS, SLP, SDI, SBC (PLe SIL3) Via FSoE.

Omron Automation Americas / automation.omron.com

Servo drive with integrated functional safety

The KEB S6 servo drive delivers integrated functional safety options, including failsafe-over-EtherCAT (FSoE), safe torque off (STO) and safe limited speed. These safety features can be controlled over the SIL3-rated bus protocol. The S6 supports many of the leading communication protocols and features Safety over EtherCAT to reduce the amount of discrete wiring going in and out of the cabinet. FSoE offers machine builders a way to simplify wiring, shorten installation times, reduce cost and help with diagnostic capabilities. The S6 is designed for high-performance servo applications requiring real-time communication, advanced SIL3 safety functionality and integrated brake control. It is compatible with various motor types, ranging from induction and ac servo motors to linear and synchronous reluctance motors.

KEB America / www.kebamerica.com

VFDs with flexible motor control

IDEC VF1A Doesa VFDs are designed to be suitable for speed control of variable and constant torque applications ranging from fans and pumps to specialized equipment. The VFD is capable of driving an induction motor (IM) or a permanent magnet synchronous motor (PMSM). IMs can be driven in open loop or closed loop, while PMSMs can be driven in open loop only. The product family features a compact form factor in a UL open-type construction, with nickel- and tin-plated bus bars and conformal coatings for corrosion protection. Electrical input is nominally rated as three-phase low-voltage ac 400 V (with an allowable input voltage range of 380-480 Vac), and the VFDs come in 14 models with a capacity range of up to 139 A. Each VFD is quadruple rated for varying duties—normal or heavy overload, and mild 40 °C or high 50 °C temperatures. Other advanced functionality includes control of mechanical brakes, a built-in braking transistor, regeneration avoidance and low-voltage ride through. Safe torque off (STO) capability ensures the VFD fulfills functional safety standard requirements while eliminating the need for external circuit breakers required by conventional VFDs. Logic programming with 55 functions, different calculations and sequences and fast processing intervals lets designers eliminate other small controllers and adapt the VFD to meet special requirements. The logic is configured via graphical software, enabling users to create customized automation applications of up to 200 steps, including PID control.

IDEC / us.idec.com

Variable-frequency drive

The FR-E800 Series micro-drive features a built-in PLC and will include safety functionality meeting IEC 61508 standards and support various networks, including Ethernet/IP, Modbus/TCP and CC-Link IE TSN. The FR-E800 Series is designed for engineering, technology and product managers in industries such as packaging, material handling, food and beverage, and water and pumping, as well as those who are adopting PM motors to improve energy efficiency. The FR-E800 is built upon Mitsubishi Electric's variable-speed-control technology. Additional features include extended programming functions, advanced fault detection features, and auto-tuning of PM motors for applications where energy efficiency is extremely important. The auto-tuning function includes configurable parameters to reach optimum performance, higher torque, faster acceleration and lower noise level for quiet operation. For OEMs that use induction motors in their equipment, the FR-E800 can control both induction and PM motors, helping to consolidate inventory and spare part management. The drive series is also dual-rated for light duty and normal duty, which may help achieve desired performance in smaller frame sizes.

Mitsubishi Electric Automation / us.mitsubishielectric.com/fa/en

Decentralized motor starter

Wieland Electric's motor starter is designed to reduce the complexity of installation and improve the safety of conveyor systems. The podis MS 5HP is a compact, robust and user-friendly drive component with an integrated safe torque off (STO) function. The safety function disconnects the power supply from the emergency-stop circuits completely. As a result, the STO circuits no longer need routing through a central distributor and assignment to a specific energy branch. The system is less susceptible to interference and the installation work is more easily planned and carried out. The combination of starter functions allows for the decentralized assignment of all of the energy of the STO circuits in the field. In addition, a superior level of safety (SIL 3, PL e) can be achieved with less effort. All the motor starters in an emergency-stop circuit connect to the STO female sockets. The STO circuit monitors and operates through an auxiliary voltage generated in the field and also by a two-channel safety relay. Several STO circuits can operate from one power supply. Using an energy bus system such as the podis 5G6 from Wieland Electric further enhances decentralized motor control. The energy distribution for several motors and starters can combine on one line with only a single feed. The podis MS 5HP covers motors with a power range from 0.3 hp to 5 hp (0.25 kW to 4.0 kW), up to five different motors.

Wieland Electric / www.wieland-americas.com

AC servo

Hiwin's flagship E1 series of ac servo motors are designed to provide users with their choice of rated outputs ranging from 200 W to 2 KW. AC servos of all wattages can be configured with different rated speeds (low, standard, high), motor shaft options that include a keyway and/or oil seal, a brake option for vertical applications and 23-bit incremental or absolute encoder options. Wattages are also selectable among inertias (low and middle), capacities (small and middle) and three speeds (low, standard and high-speed). Control bandwidth allows for precise positioning. Based on the model selected, speeds ranging from 2,000 to 6,000 rpm can be achieved. Providing control of the servo motors are Hiwin's E1 series ac servo drives. The E1 series ac servo drives support a wide variety of motors and multiple encoder types. Among the features included are: 3.2 kHz speed response, both tuneless and advanced auto-tune functions, ripple compensation, unique gantry application, network connectivity and built-in safe torque off (STO).

Hiwin / www.hiwin.com

Power- and torque-dense motor

ABB's Baldor-Reliance HydroCool XT motor delivers high efficiency with IE5 efficiency and bearing protection, high power density and low maintenance with water-jacket cooling to eliminate fans and filters. The Baldor-Reliance HydroCool XT motor is designed to offer customers an ideal combination of flexible design, low maintenance and reliable performance in some of the toughest environments. This product line represents a new generation of water-cooled motors developed in response to market demands for improved technical features. HydroCool XT is designed to be quiet, versatile and available with induction or permanent magnet rotor technology. The motor can achieve the highest level (IE5) efficiency rating for energy savings. HydroCool XT is designed to provide versatility for extreme marine duty, pulp and paper, water and wastewater pumping, mining and aggregate applications. The motor is available in four frame sizes from 60-1,250 hp (45-932 kW). Cooling efficiency is maintained even at lower speeds, allowing HydroCool XT to operate directly online or as a variable-speed motor without derating or power loss. Shaft grounding is standard, HydroCool XT is equipped with provisions for ABB Ability Smart Sensor condition monitoring to provide instant information on the health and performance of the motor, providing connectivity and data analytics.

ABB Motion / go.abb/motion

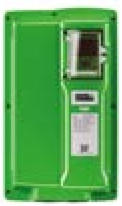
High-performance drive

Fuji Electric's standard inverter for the next generation, the Frenic-Ace, can be used in most types of industrial applications—from fans and pumps to specialized machinery. The Frenic-Ace is designed to be a high-performance, full-featured drive with Fuji Electric's three-year warranty providing compact, powerful multi-rated specification solutions. Fuji Electric drives can operate from single-phase to three-phase up to 460 Vac and can operate at an optimal speed throughout the application, which is designed to reduce overall power and energy consumption in order to minimize operating costs.

Fuji Electric / americas.fujielectric.com

High-IP pump drive

Control Techniques, part of the Nidec group of companies, offers a high-IP variant of its Pump Drive F600, which is designed to deliver flow control in a format suitable for use without additional enclosures in demanding environments. F600 High IP, part of Control Techniques' specialist family of industry and application-specific drives, offers a full IP65 solution with identical features and functionality, dedicated for pump applications, as the standard model. The new High IP drive enables customers to use both standard and High IP drives in the same project. IP65 provides protection from dust ingress and low-pressure water jets from any direction. The F600 High IP drive is enclosed in a sturdy, protective yet light casing, which is designed to allow easy integration in harsh environments. Access to the included LCD keypad is designed to be easy. And the pump drive includes a free five-year warranty.



Control Techniques / www.controltechniques.us

AC drives

Control Techniques' Commander S Series of ac drives are optimized for 5 hp applications and below. Equipped with NFC technology as standard, these drives are designed for ease of installation and use. Drives can be commissioned, monitored, diagnosed and supported via their Marshal app. Designed for repeat builds, drives can be programmed in the box. Commander S features Linear V to F, Square to F, and Resistance Compensation control modes.

Galco / www.galco.com

Actuator for automotive weld-gun applications

Curtiss-Wright Actuation Division's Exlar GTW weld-gun focused electromechanical actuator includes performance and benefits parallel that of the Exlar GTX actuator family of products with additional features to support the demands of automotive weld-gun applications. The GTW weld-gun actuator offers high force repeatability and precision at 20M+ welds. With continuous force ratings up to 30,784 N (6,920 lbf) and speeds up to 1,270 mm/sec (50 in/sec), the GTW can support high duty cycles for increased productivity and energy efficiency. In addition, GTW actuators are compatible with global industrial robot and weld-gun supplier controllers used in the automotive manufacturing markets. The GTW Series features include energy efficient integrated brushless stator (motor) technology; planetary roller screw technology for high-precision positioning and reliable performance over its rated life; high-performance rod seal and dual wiper design to protect critical components from contaminants; built-in mounting features for adaption to a variety of weld-gun configurations; design-in mounting options for ease of installation and adaptability to standard C-Gun, X-Gun, or Pinch weld-gun envelopes; and robot-interface compatibility with industrial weld-gun suppliers.

Curtiss-Wright / www.cw-actuation.com

Cost-efficient premium motor

Portescap's 12ECP48 Ultra EC is part of the Ultra EC platform. As with Portescap's existing ECP motors, this BLDC motor is designed to be ultra cost-optimized and not compromise on premium performance. The 12ECP48 features a 12-mm diameter and an Ultra EC winding, delivers speeds up to 60,000 rpm and weighs 30 grams. Providing up to 8.1 mNm maximum continuous torque, the motor's R13 gearbox compatibility is designed to make it an ideal combination for applications requiring torque up to 0.5Nm. The motor is designed for battery-powered hand tools in the medical and industrial markets, including robotic pipetting, electric grippers, miniature pumps and biopsy and podiatry hand tools. The 12ECP48 is also designed for those looking to migrate from brush dc to brushless dc technologies for longer lifetimes and for companies shifting from manual to powered devices.

Portescap / www.portescap.com

Electric actuator

With multiple styles and drive configurations, Norgren Elion electric actuators are designed to allow fine control for industrial machines of all types. All models are complemented by a range of high-performance ac servo motors that can be mounted axially or in parallel, as well as servo drives. Norgren motors offer standard IP65 protection, torque ranges from 0.16 Nm to 10.5 Nm and a selection of feedback options. Optional holding brakes provide additional control in the event of power loss. As some of the smallest servo drives on the market, Norgren ELION drives are designed to provide exceptional power for their footprint.

Norgren / www.norgren.com CD

Monitor machine health for reliability

A CONTROL DESIGN *reader writes:* We've been kicking around the idea of implementing one remote location for monitoring machine health and production performance in our paper plants, but we're so overwhelmed with the possibilities that we barely know where to start. The idea of reducing downtime seems like low-hanging fruit, but we aren't even up to speed on predictive-maintenance practices as yet, so that will involve a culture change across our four facilities. What types of sensors should we be utilizing to gauge machine health? And what about optimizing performance? Is there sensor data we should be tracking and analyzing?

Answers

Predictive maintenance on a budget

In general, there are two separate ways to increase machine productivity—process optimization and downtime reduction. For process optimization on programmable logic controllers (PLCs), most companies take an "if it ain't broke, don't fix it" approach. I interpret this to mean that the downside risk of breaking something while you're trying to optimize it exceeds the value of the potential gain. In other words, unintended changes could cause significant damage to a machine and result in extensive, expensive downtime to fix it. This outcome means production losses, too.

Predictive maintenance (PdM) requires a system to use an industrial network like EtherNet/IP or Profibus. One of the original design goals of these networks was to expand the data diagnostic capabilities beyond what Modbus or DH+ provided for predictive-maintenance purposes. The reality is that most machines are built without diagnostics. Diagnostic data needs to be defined, programmed and documented just like I/O, almost always resulting in bigger central processing units (CPUs) and more PLC memory. As a result, implementing diagnostics becomes more than a trivial cost. When reducing a machine's price, this cost is the first to get cut.

This question originated in a paper plant, which means the plant already has brownfield machines and is asking how to add predictive maintenance. Integrating predictive maintenance into the existing control system would require replacing the whole control system—meaning new I/O, bigger PLCs and then reprogramming the system. From a cost perspective, this course of action is usually not an option.

But the challenge remains: What can be done in a cost-effective way to add predictive maintenance to an existing machine? Assuming this is a running plant with history, to start, I recommend making a list of the most frequent failures the machine experiences, determining how to monitor each failure mode and then monitoring those points with appropriate sensors for changes.

Most machine failures are not instantaneous; they occur gradually over time. For instance, a bearing will run for years within a certain temperature range. In the event of imminent failure, the temperature will rise over the normal historical value. This increase is the ideal trigger for a maintenance event.

By adding sensors to brownfield machines, the values of those sensors can be loaded into the cloud. From there, a supervisory control and data acquisition (SCADA) package can read the values. If you don't know the values to set alarm points, install the sensors and log data for a few weeks. After you have historical data, you can enter alarm points into the SCADA package based on the collected data. This method will allow you to achieve most of the return on investment (ROI) from predictive maintenance at a fraction of the cost it would take to overhaul the control system. In addition, a key advantage with this approach is that it is entirely separate from the existing control system. If the cloud service is compromised or the monitoring system fails, the machine's production is not affected.

PHILIP MARSHALL
CEO / **Hilscher North America**

Find the unreliable assets and their failure modes

For those in the paper industry, reliability could be the difference between profit and loss, but knowing where to start is often the challenge. To begin, you need a good grasp of how reliable your assets are and understanding where bottlenecks are. You should look at the most common failure modes and that should drive the type of data you're collecting from each piece of equipment.

If you do not know your most unreliable assets and their failure modes, then starting with vibration on rotating equipment is always a good bet. By analyzing the data collected from vibration, it can shift you from reactive to predictive maintenance and give you an idea of how machines are performing. Next, look at your machines to ensure that there is a proper lubrication program in place, with the right amounts of lubrication being added to assets at the right time. The third data point that could be valuable is often thermal imaging for your electrical panels. Finally, look at the types of machines you have, classify them by type and then add levels of service to each asset to ensure they're getting the maintenance that they need. Vibration, thermal and potentially oil analysis for lubrication are the type of sensors you'll want to use, but criticality rankings will help ensure that you prioritize the right assets.

Once you have a good grasp on reliability, you can then move into optimizing performance. Typically, you'll already have the sensors you need in place for process control systems, which will aid in optimization; you'll just need to combine process control with model predictive control. What we've seen is that you might already have that data in those sensors, but not looking at the right variables. To further optimize performance, we'd recommend putting in one remote-monitoring location for machine health per plant, instead of one central location for all plants, because even if you have the same asset in multiple plants, the operating conditions in each will have discrepancies. By leveraging technology like edge-computing platforms in each plant, you'll be able to collect and analyze data to know when machines need to be updated, helping to prevent downtime.

RUDY DE ANDA

head of strategic alliances / **Stratus Technologies**

How to choose the right PdM technology

Predictive maintenance can sound daunting, especially as it is being discussed throughout the industry. It involves improved work practices, trained resources and proper technology selection to support data-driven maintenance practices. However, our mindset must move away from: "Our practices are unacceptable, and we are leaving money on the table," or "I could be spending my time doing other things that impact plant operation," or "I am sick and tired of fixing the same asset for the same problem." It begins with a decision to do maintenance differently than before, and it is common to identify an experienced partner who understands where to capture the most value today. Predictive maintenance is a large space, and it will take time to encompass its full value.

As stated, reducing downtime is the end goal, and achieving improved uptime is where the opportunity lies. Vibration and temperature monitoring are the most widely used PdM tools today with the latest technology. However, lubrication sensors are quickly increasing in popularity, depending on the equipment of importance. If the equipment is critical enough, all three—vibration, temperature and lubrication monitoring—are leveraged for the best uptime results (Figure 1).

There are hundreds of sensors on the market, and all offer value. The first step in technology selection is identifying the characteristics or requirements of a desired solution. This will enable scorecarding each solution on the market. Some of these may include the following.

What technology would you like to start with?

- vibration and temperature
- lubrication
- ultrasound
- thermography
- other technologies

What level of diagnostics is required?

- from overall health only to full diagnostics

What is the preferred method to see the data?

Figure 1: This gearbox is enabled with Industrial-Internet-of-Things (IIoT) monitors for vibration, temperature, speed, oil level and oil condition.
(SOURCE: MOTION)

- in-the-plant network
- cloud-based dashboard
- in the plant but off the network (localized solution)

Do all the sensors need to report through one system, or could multiple technologies coexist?

After identifying the list items, create a matrix to quickly view all technology partners, their value side-by-side and their ROI. Partnering with a qualified organization that regularly performs this work will support the journey to predictive maintenance.

ED DUDA

senior manager—P2MRO / **Motion**

Sensor choices for monitoring machine health

Implementing a remote-monitoring system for machine-health and production performance in your paper plants is a great idea, as it can help reduce down-

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time, optimize performance and increase efficiency. One way to achieve this is to use technologies such as IO-Link, rotary encoders and vibration sensors. Below are a few of these sensors and technologies that can be deployed.

IO-Link: This technology enables sensors and actuators to be connected to a central control system (ERP/MES/SCADA) via a master using a standard communication protocol. By using IO-Link, you can easily collect data from a wide range of sensors and transmit it to a central control system for analysis and decision-making.

Vibration sensors: These sensors can be used to monitor the vibration of equipment, such as motors, pumps and paper machines. By continuously monitoring the vibration, these sensors can help detect potential failures and prevent downtime. Vibration sensors can also be used to optimize the maintenance schedule, as they can indicate when equipment is due for maintenance or repair.

Rotary encoders: These sensors measure the position and speed of moving parts, such as rollers, gears and motors. In the pulp and paper industry, rotary encoders can be used to measure the speed of the paper machine, the position of the dryer cylinders and the position of the cutting devices in the finishing process. By continuously monitoring the position and speed of moving parts, rotary encoders can help optimize the process and reduce waste.

Temperature sensors: These sensors can be used to monitor the temperature of various processes, such as the cooking process in pulp production or the drying process in paper production. By continuously monitoring the temperature, these sensors can help optimize the process and reduce energy consumption.

Pressure sensors: These sensors can be used to monitor the pressure in various processes, such as the pressure of steam in the cooking process or the pressure in the paper machine. By continuously monitoring the pressure, these sensors can help optimize the process and reduce energy consumption.

Flow sensors: These sensors can be used to measure the flow rate of liquids or gases in various processes, such as the flow of water in the pulp and paper process or the flow of steam in the drying process. By continuously monitoring the flow rate, these sensors can help optimize the process and reduce energy consumption.

Level sensors: These sensors can be used to measure the level of liquids or solids in various tanks or vessels, such as the level of pulp in a storage tank or the level of chemicals in a mixing tank. By continuously monitoring the level, these sensors can help optimize the process and reduce waste.

By using these sensors and technologies and integrating them into a comprehensive remote-monitoring system, you can track and analyze sensor data to optimize performance and reduce downtime. You may also want to consider implementing predictive maintenance practices, as this can help you proactively address potential issues before they lead to downtime. While implementing a culture change across your four facilities may be a challenge, the benefits of predictive maintenance are worth the effort. The data collected from these sensors can be used by various employees within your organization, including production personnel, maintenance, engineering, raw materials stores and purchasing and management. Each of these groups can use the data to achieve specific goals, such as increasing throughput, reducing downtime, improving processes, streamlining the ordering process or analyzing company performance. By using these sensors and technologies and collecting and analyzing this data, you can improve efficiency and make informed decisions to drive the success of your paper plants.

JASON BEAN
IIoT market specialist—North America / **Pepperl+Fuchs**

Sensor platform and setup

As with most instances where adopting a new technology is being considered, it's always best to start by contacting a knowledgeable manufacturer and get its recommendation for the intended use such as monitoring machine health from a centralized location. There are different platforms of sensors that incorporate IO-Link technology and can be used for remote condition monitoring and tracking other critical performance data. Remote access via IO-Link-enabled devices connected to an IO-Link master allows users to track performance and change settings from any location to optimize plant production. The IO-Link master can then transmit real-time data to a higher-level control system for further analysis. This enables the user to monitor important parameters like sensor and machine health.

Data from proximity, pressure and flow sensors, for example, can be monitored and then adapted to the specific needs of your application. With IO-Link, you can perform tasks like monitor cycle times, set temperature alarms and setpoints remotely. As a result, the installation of IO-Link sensors helps reduce costs in new and existing applications. Additionally, each adjustable switching distance can be run sequentially in combination. The functions of the two outputs can be set independently of one another—positive, negative, positive (PNP); negative, positive, negative (NPN); normally open (NO) contact; and normally closed (NC) contact. The switching distance and hysteresis can be set individually, and the adjustable switching distance can be set separately for each output, allowing one sensor to replace two other sensors. The integrated temperature measuring provides users with diagnostic features for both the sensor and application area around the sensor. User-defined temperature limits can be configured within the physical and technical minimum/maximum temperature and can be output as alerts in the event of limit overruns. These alerts help prevent possible faults in cooling systems or impending temperature damage to the system. The ability to configure two separate switching points allows the IO-Link sensor to replace two conventional sensors for monitoring different positions. For example, only one IO-Link sensor would be needed to indicate an open/closed state when used for wear monitoring.

JOHN MURPHY

senior product manager / **Turck**

Trending flow over time alerts to failures

Pressure and flow are the key performance indicators (KPIs) of machine health. Trending pressure over time can alert you to this common scenario: Imagine that a machine's control panel has an alert that the timing is off. The operator notices that there is a lag getting one of the cylinders moving and that the cylinder's rod seems "loose" or "wobbly." She raises the machine's operating pressure, which does seem to solve the problem.

This is, of course, a temporary solution. The root cause should be investigated and corrected before the cylinder fails completely. In most factories, there is no mechanism to record unauthorized pressure adjustments, and the situation worsens until the machine breaks down. If pressure had been recorded and analyzed, the time and date of the pressure increase could have triggered an alert so that the problem could have been diagnosed, parts could have been ordered and the repair completed before catastrophic failure occurred.

As a bonus, there is an energy-saving component to tracking pressure. In the scenario above, it is often the case that the pressure never gets restored to its correct value. Since pressure and flow trend together, it is likely that what should have been a temporary pressure increase will cause the machine to forever consume significantly more air than it really needs.

Trending flow over time can also alert you to impending failures. At its most basic level, the flow rate when the machine is idle can be a good indicator of the overall health of the machine. For example, a new machine would typically have a flow rate when idle that is close to zero liters per minute, subtracting any continuous users of air necessary to machine operation. When that flow rate increases, it is typically due to components leaking from physical damage or general wear. Most pneumatic-system failures can be predicted by the leakage rate.

In the scenario described above, the cylinder in question began leaking past its rod seal long before it got "wobbly." It is also likely that cylinders remain pressurized when retracted, so increased flow would typically indicate a problem. Of course, the flow rate when idle does not tell us specifically which component or components are beginning to wear, just that it is happening.

Taking this a step further can get you to condition-based maintenance. If you can trend the flow rate while the machine is running, it is possible to predict the failure well in advance. For example, if you are tracking the flow rate continuously, you can map those data points against the machine's motion profile. If we know that cylinder #3 completes the retract stroke 10 seconds into the machine's normal cycle, an increase in the flow rate at that timestamp would indicate that the rod seal is the culprit since that is the item subject to wear. With a little history, you could predict the time to failure and order the replacement cylinder well in advance.

All of this presumes that you have the capacity to gather this data and transmit it to a system that can analyze it and provide useful, actionable information. At the sensor level, the current trend is to use IO-Link-compatible pressure and flow sensors. The good news is that there are products on the market which can gather this sensor data from multiple machines, transmit it wirelessly to a single hub and provide the data in an open protocol for analysis. This precludes the need to revise the machine's existing programming, making for a low-risk installation. If you do not have the data-analytics capability in-house, there are third-party vendors who can manage this data for you.

This does sound complicated, but, since the data does not need to run through a machine's existing control system, the physical installation can be done quickly. The machine or machines can be back up and running while the data-analytics part of the equation is being worked out. Ideally, you would set your goals first and then begin the process of generating the required data, starting with your most critical machine. You might find value in additional data, such as vibration from rotating machinery or the dewpoint of the compressed air and can plan accordingly. You can also take it in steps, starting with the baseline pressures and flows when the machine is idle, as described above, and adding sophistication as you progress.

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HMI software makes the system

MOST FOLKS in an automation role with a focus on manufacturing understand what it means to use a system and the controls that run it. What is easily overlooked is the impact the software behind the scenes has on the user interface that we interact with daily.

Software plays a crucial yet less obvious role in the human-machine interface (HMI) in automation systems. It is the hidden but determining element for the way in which the system interacts with the operator, making it an important factor in the overall performance of the system.

There are a number of ways that software affects the HMI in automation systems, such as the user-interface design and layout. A well-designed user interface makes it easier for the operator to navigate and use the system, which can increase productivity and reduce the number of errors.

> **The software used in automation systems greatly affects the HMI.**

A poorly laid out or overly complicated design lacks functionality and leads to frustration. The more complicated or confusing a user-interface design is, the less likely the average operator will be successful and efficient in its use. Oftentimes, HMIs get a bad rap because operators fail to grasp the complexities of the system and therefore tend to label the layout as bad.

Anytime a new feature is added to a legacy control there is always resistance from the operators to integrate its benefit into their daily usage. It is not uncommon for it to take a good bit of time and effort before they understand how the new features benefit them.

The greatest features may not be used at all, simply because of operator resistance to learning or relearning what they believe they already know. It seems like it would be much better to simplify the software behind the HMI, so that there is a greater chance of success for the average operator. A great operator will make an average control better, but a poor control will make even a great operator struggle.

Automation systems also use software to collect and analyze data. The HMI is responsible for clearly and consicely presenting this information to operators, making it easy for them to monitor the system and make decisions based on the data.

The ability to make improvements at the machine control level is a real advantage of the modern software that runs HMIs. It is extremely difficult to affect change and improvement without solid data derived in real time from the automation system itself.

Additionally, the software allows us to monitor alarms and notifications by generating alarms and notifications in the HMI. These alerts are critical for informing the operator of any system problems, which helps prevent downtime and increase overall system efficiency. For example, preventive-maintenance warnings on the control can help us stay ahead of scheduled lubrication and coolant demands that the machine or system requires. This allows us to maintain smoother operating automation systems with less downtime, thus increasing uptime for production. Also, the alarms can give us line-of-sight when we are running lights-out operations. When a failure mode happens during an unmonitored run, we can go back and review what happened, when it happened and possibly determine exactly why it happened.

Automation systems often use software to integrate with other systems, such as a control system or a manufacturing execution system (MES). The HMI must provide a seamless interface between these systems, making it easier for the operator to access and use the needed data. As our need for interoperable systems grows, we are seeing that software can help us pull multiple systems together in a cohesive manner.

Overall, the software used in automation systems greatly affects the HMI, and a well-designed HMI can greatly improve the performance and efficiency of the system, while a poorly designed HMI can lead to errors and decreased productivity.

Each system improvement should work to the end goal of reducing frustration for operators, increasing productivity, simplifying operations and generating higher profitability.

Some of the best controls on the market have been designed in response to extensive market research with end users who have given valuable insights to software developers, who have in turn developed some of the greatest software and HMI enhancements. cd

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