eHANDBOOK

controldesign.com

control design

FOR MACHINE BUILDERS

The finer points of I/O

SPONSORED BY

BECKHOFF

PutmanMedia®

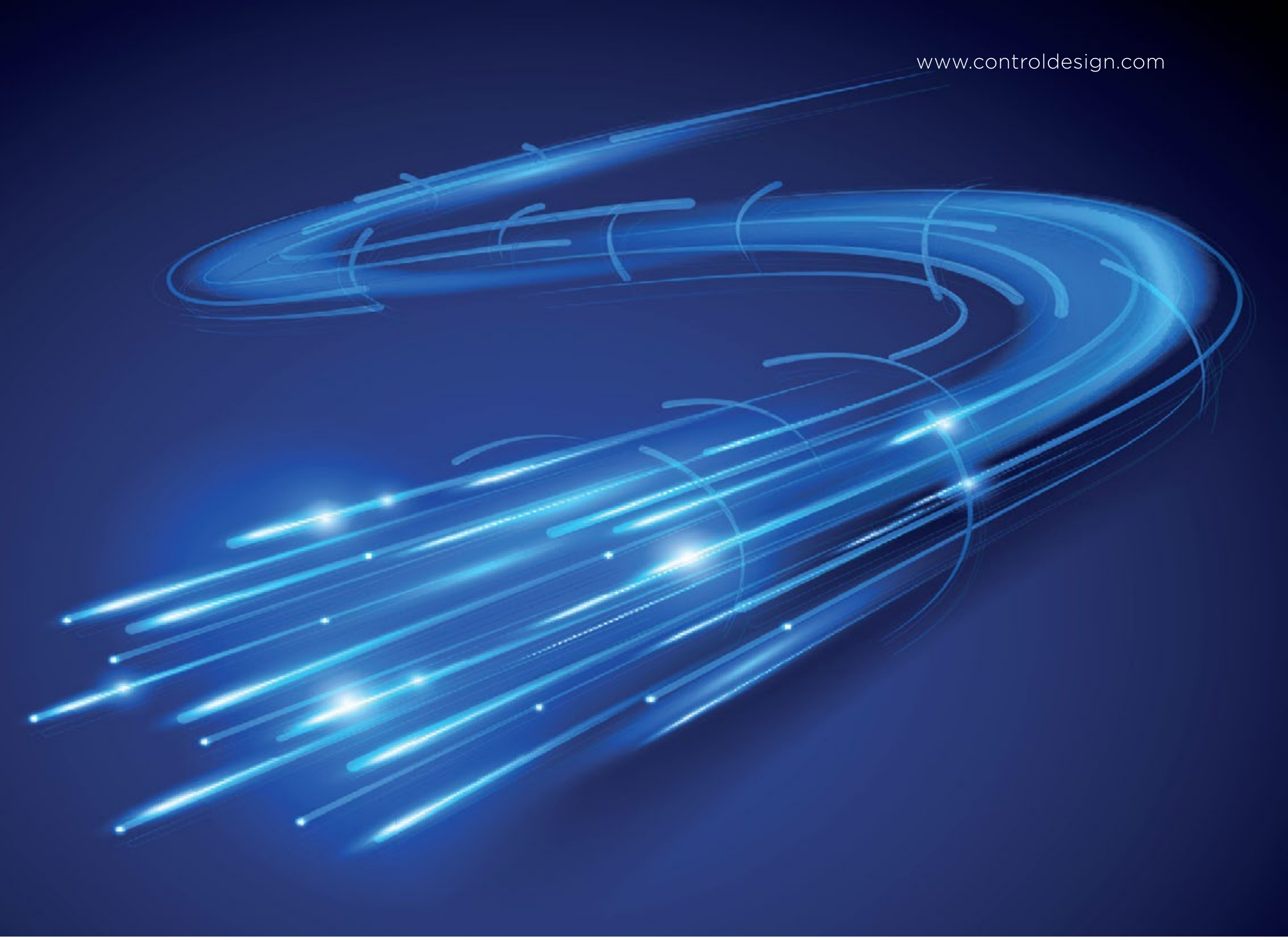


TABLE OF CONTENTS

| EK11-15USA |

Lab-level accuracy. EtherCAT-level speed.

High-end measurement technology in an I/O system.

< 1 µs time synchronous
100 ppm at 23 °C
24 bit
up to 50,000 samples/s

www.beckhoff.us/measurement-technology

With ELM series EtherCAT measurement I/O modules, high-precision, fast and robust measurement technology becomes a system-integrated function of the PC-based control platform from Beckhoff. The ELM modules can be integrated directly into the highly-scalable EtherCAT I/O system, enabling combination with the comprehensive portfolio of more than 500 EtherCAT Terminals.

- fast: sampling rates of 50,000 samples/s
- precise timing: exact synchronization < 1 µs
- precise values: measurement accuracy of 100 ppm at 23 °C
- proactive: integrated functional diagnostics for individual modules
- flexible connector front-end: LEMO, BNC, Push-in
- input circuitry: voltage 20 mV… 60 V, current 20 mA, IEPE, SG, RTD/TC

Control Engineering
2018
ENGINEERS' CHOICE AWARDS
WINNER

A comprehensive measurement system from data acquisition to analysis in the cloud.

New Automation Technology **BECKHOFF**

I/O and PC-based control yield 33% higher controller functionality while reducing cabinet and machine footprints

Edge Automation throws away the box to solve previously unsolvable engineering projects

By Luke McKeen, Edge Automation

Good things come in small packages. There is perhaps no better way to describe Edge Automation (www.edgeautomation.ca), a custom machine builder and automation solutions provider based in London, Ontario. Though our company is small—employing around 47 skilled designers, builders and engineers—it is also nimble, creating and commissioning some of the most technically complex automation projects for a wide variety of industries, taking on many projects where other, larger integrators have said no.

For more than 15 years, Edge Automation has offered complete, vertically integrated automation solutions, designing and building everything from small CNC operations up to the most complex robotic systems. The company serves an incredibly diverse set of markets, with customers hailing from nearly all areas of industry, including automotive, consumer goods, agricultural equipment and food and beverage. Operating as a custom automation provider means that all the products built by Edge are determined by customer requests. Capable design, machining and assembly services on-site bring customer goals of technological advancement and innovation to life.

“Edge Automation offers a wide range of integration options, taking ideas from initial concept design through to final integration and commissioning,” explains Joel Squire, general manager at Edge Automation. “We are a streamlined team of multitaskers from a business standpoint. We don’t delegate work to many different groups, or only offer to build one section of a machine or concept. Our products are complete turnkey systems, designed and built with in-house expertise (Figure 1)."

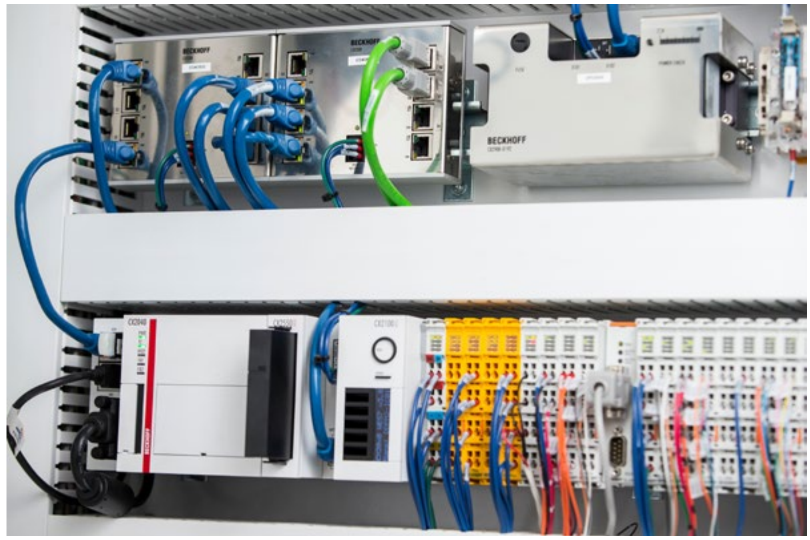
STREAMLINED TEAM
Figure 1: The Edge Automation streamlined engineering team of multitaskers includes (from left) Jason Hooper, electrician; Travis Thomson, machine assembler; Simon Raimbault, machine assembler; Luke McKeen, mechanical design manager; Gerard Regier, president; and Chris Timmermans, senior controls, 309A electrician.

YOU NAME IT, WE CAN BUILD IT

This variety in projects at Edge necessitates an engineering toolbox with a wide range of hardware and software solutions. This led us to seek out an automation partner with a comprehensive lineup of tools, ultimately leading us to Beckhoff Automation. The business relationship has grown steadily, but has risen substantially in the past few years, as Chris Timmermans, senior PLC programmer at Edge Automation explains. "We typically conducted between one and three projects per year with Beckhoff at varying levels of complexity, constituting approximately 10-15% of our business," he says. "In the past three years, however, there has been a dramatic change. Now, around 60-70% of our business involves Beckhoff hardware and software—a testament to the strength of this partnership and the power and flexibility of Beckhoff technology."

Therefore, when a health-care-product manufacturer approached Edge with a difficult manufacturing puzzle, we jumped right in to develop a solution automated by Beckhoff.

Approximately six years ago, the healthcare-product manufacturer commissioned a machine from Edge to assemble plastic parts for a health-product-dispensing system. As sales grew, the current system quickly reached its limit. "At the time, the customer was working around the clock to keep up with demand for the product but was having a hard time keeping enough staff on-site to achieve the desired throughput," explains Timmermans. Even with these difficulties, demand continued to grow and the company needed to scale even higher. "Two years ago, the customer



EMBEDDED CONTROL
Figure 2: Inside the cabinet, the embedded PC provides full system control in a compact, DIN-rail mountable format. The robust embedded PC helped Edge to cut PLC scan times in half.

approached us to build a second-generation machine to help streamline the process and meet growing demand," he adds.

The new machine consists of two assembly cells dubbed "PUC" and "PAC." The PUC, or main assembly cell, assembles a series of plastic and rubber parts to create the dispensing system. The PAC, or subassembly cell, supplies the PUC with parts and pre-installs several rubber components before moving components downstream. A third additional subcell was added to allow on-site production of yet another product flavor for the healthcare line, and this integrates directly into the original two-piece system seamlessly.

We also developed a custom feeding solution for the application. The handling of the rubber components is a point of pride for Edge, as two other integrators turned down the project because they could not find a workable solution to feed the parts into the system. "We knew it would be a challenge, but our group sat down and dissected the issues the previous two competitors encountered, and we were able to build a custom solution that works fantastically," says Timmermans, who jokes that other vendors still ask us how in the world we made the solution work.

"Essentially the reason our competitors fell short of a reliable solution was vision, where they imposed limitations as to how the task was to be accomplished, basically working inside the box," explains Timmermans. "Our group threw the box away altogether and reinvented the way these types of parts are fed."

SYSTEM-INTEGRATED SOLUTIONS

The demanding control requirements of the three assembly cells are handled by a Beckhoff CX2040 Embedded PC, which offers a quad-core 2.1 GHz Intel Core i7 processor and 4 GB DDR3 RAM (Figure 2). This powerful device controls

MODERN INTERFACE
Figure 3: The multi-touch control panel displays the custom HMI developed by Edge, giving machine operators a feature-filled, modern machine interface.

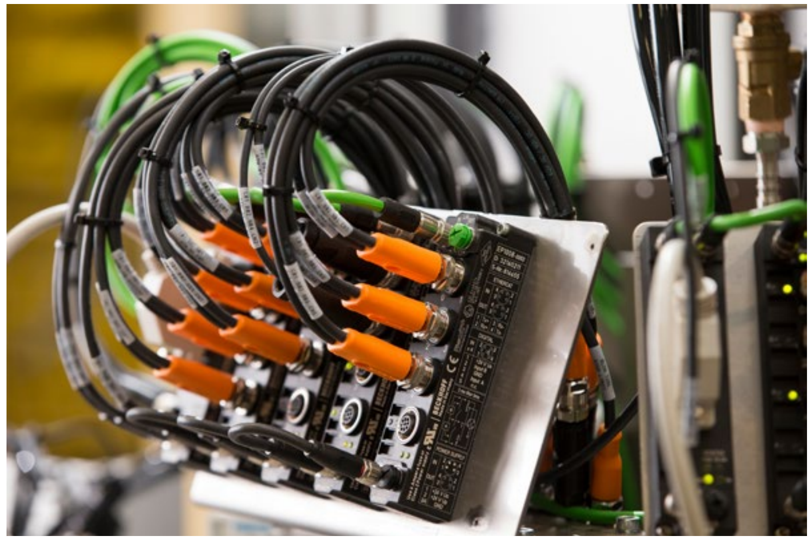
the entire machine, including HMI and motion control functions.

"Assembly process cycle times of 1.8 seconds formed the baseline we wanted to achieve with the assembly machinery," says Timmermans. "By integrating the CX2040 as our controls centerpiece, we meet and even exceed these goals; plus, we reduce costs with a centralized control solution."

Providing HMI operator interfaces around the machine are three 12-inch CP2912 multi-touch control panels running third-party HMI software, which seamlessly integrates with TwinCAT via ADS communication (Figure 3). In addition, a CP2712 multi-touch panel PC is connected to the main cell and provides the display for the CX2040, running a third-party HMI software solution.

"The four multi-touch panels all display the exact same HMI software," explains Timmermans. "In this manner, all operators have access to the rich HMI information via an intuitive multi-touch screen anywhere around the machine. From a design standpoint, this was our goal, to develop an HMI interface one time but deploy it across the entire machine. When the additional cell was added, we were able to bring up an additional HMI interface in minutes with the Beckhoff system."

TwinCAT 3 automation software platform from Beckhoff serves as the CX2040 runtime and programming environment for all automation tasks. TwinCAT has been a huge boon for numerous company projects, notes Timmermans. "On the original machine, we had two separate systems just for the PLC and HMI," he explains. "This was further extended with standalone motion controllers and valve banks requiring setup and configuration. TwinCAT, paired with EtherCAT as its communication backbone, enabled us to bring everything into a single development environment (Figure 4). We eliminated almost all of the device-specific setup and configuration, consolidating our required commissioning toolset down substantially. This drastically improved the serviceability of this equipment over the original design." Features such as core-isolation to intelligently assign separate control tasks to specific cores in multicore processors bring down overall CPU utilization and increase machine performance, says Timmermans.

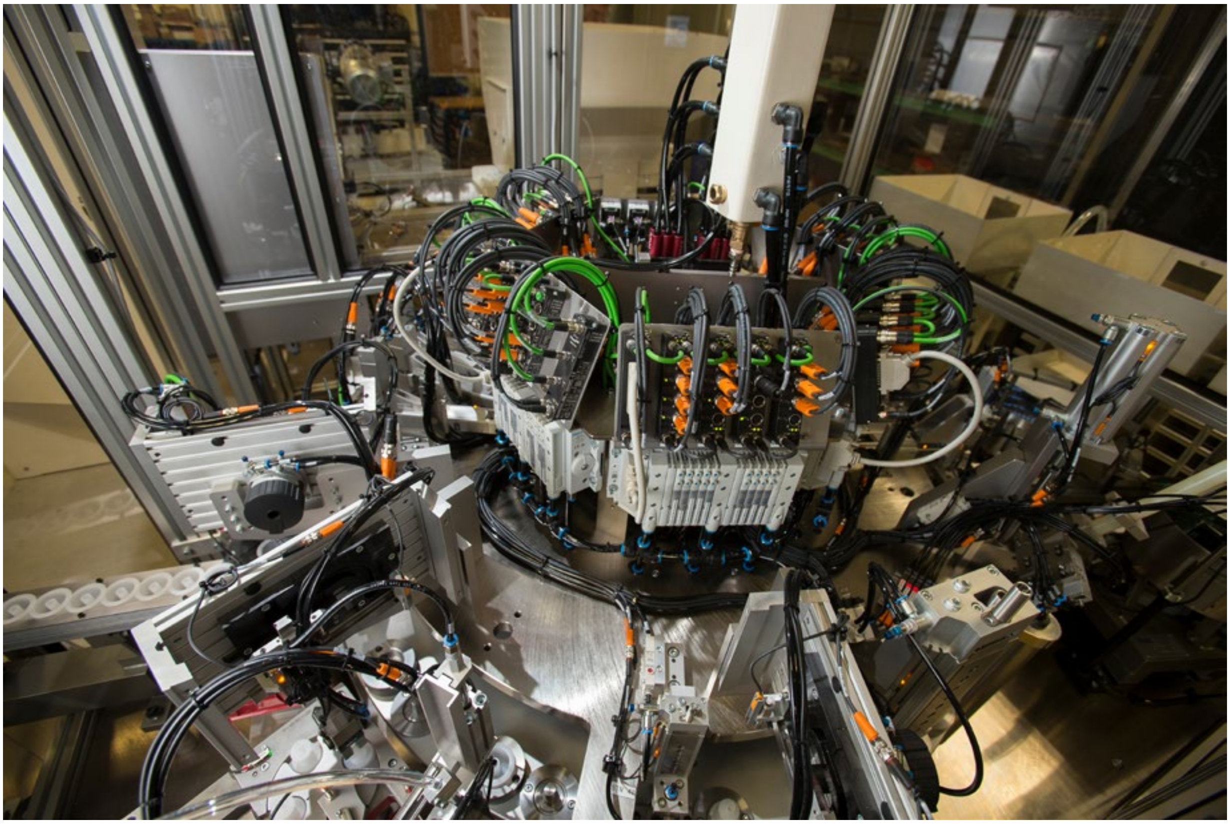


COMMUNICATION BACKBONE
Figure 4: Machine-mounted modules move data acquisition closer to the machine processes, saving cabling costs. The EtherCAT machine communication backbone streamlines cabling and installation processes.

System communication outside of electrical cabinets is handled by a collection of EP Series EtherCAT Box modules (Figure 5). This I/O hardware provides a significant upgrade over previous systems, removing topology limitations in terms of communication system architecture and wiring.

"From a machine layout standpoint, the EP3174 analog input modules provide unique advantages as each input can be parameterized," says Timmermans. In this way, we were able to accommodate multiple voltages (-10...+10 V, 0/4...20 mA and 0...10 V) by configuring each input separately.

Previous systems were limited in terms of fault localization and troubleshooting, explains Timmermans. "The way the EtherCAT Box modules integrate into TwinCAT software offers a



I/O BOX
Figure 5: Edge engineers created a custom communication topology to meet customer needs.

clear advantage for us, particularly with regard to service," he notes. "It is much easier now to determine the exact location of any line or signal interruptions to quickly remedy the situation."

We utilize a series of TwinSafe I/O modules for control of standard safety devices, including guard doors and e-stops. "The whole safety system is driven by the EL6900 TwinSafe logic terminal installed directly into the standard I/O rack," explains Timmermans. "Up to 128 connections to other TwinSafe devices can be established with the EL6900, and it comes at a very competitive price point."

Safety functions are easily integrated via the combination of TwinSafe I/O terminals, EtherCAT and TwinCAT automation software. "We were pleased with the simplicity of safety integrated into the existing EtherCAT system," says Timmermans. "The reduction in safety-related wiring was a great benefit."

In addition to safety, the assembly machinery requires a robust motion control solution, and the Beckhoff AX5000 series servo drives fit the bill. We maintained consistency in safety technology by equipping the AX5000 drives with AX5805 TwinSafe drive option cards. The AX5805 permits the

FOREVER FORWARD
Figure 6: The forever-forward motion profile enabled by the drives and servo motors helped Edge to overcome a significant obstacle in the assembly process.

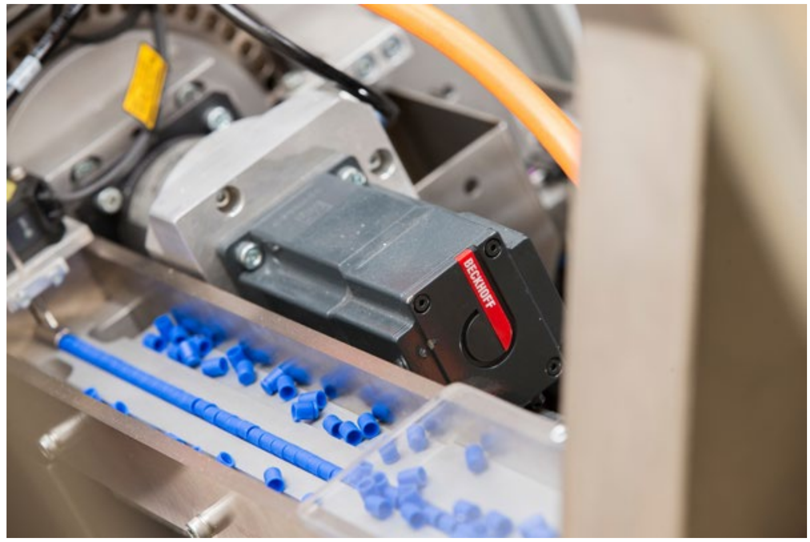
easy addition of motion-specific functions for safe stop, speed, position, acceleration and rotation.

The AX5000 series hardware brought some particularly beneficial features with regard to the modular positioning system. “This project required a forever-forward motion configuration for the dial indexing system,” explains Timmermans (Figure 6). “We achieved the desired results in a matter of minutes, where on previous systems it took us weeks to get it working correctly.”

A collection of AM8000 series servo motors are connected to the AX5000 drives, offering simple integration through TwinCAT software. The AM8000 series represents a sleek, cost-effective motion solution, reducing the necessary cabling and connectors by as much as 50% through the standard One Cable Technology (OCT) found in the motors, notes Timmermans.

PROGRAMMING EFFORT AND PLC SCAN TIMES SLASHED

The Beckhoff system helped Edge to increase performance for the healthcare-product manufacturer without adding costs, all while reducing the overall size of the control cabinet and machine footprint. “From a panel standpoint, I approximate that we have at least 33% higher controller functionality in this system,” notes Timmermans. "However, the control cabinet is actually smaller—largely due to the compact I/O solutions, including the TwinSafe system. The cabling reductions from the OCT-enabled servo system and the implementation of the 12-mm-wide EL7211-0010 servo terminals naturally made significant contributions, as well (Figure 7)."



REDUCED SPACE
Figure 7: Utilizing 12 mm-wide servo terminals for many of the smaller motion requirements coupled with synchronous servo motors for compact drive technology significantly improved machine capability while reducing panel space requirements.

TwinCAT 3, and specifically the system manager, has added value to the Edge toolbox. The ability to quickly and easily add new devices to the control system was game-changing. TwinCAT also allows us to reuse code on future projects, saving a significant programming time and effort. We found the greatest benefit from the Beckhoff system when it came to programming the motion system, reducing the necessary time to achieve the motion goals from a few weeks to five minutes or less.

The software licensing structure offered by TwinCAT was also extremely appealing to us. "The free engineering and development licenses have been great tools to help us service and support our equipment," says Timmermans. "Simply not having to pay thousands of dollars in licensing fees to connect to end-user equipment is a major consideration. Some of our customers also appreciate the flexibility to equip their service techs with the free engineering software and avoid expensive seat licenses."

Perhaps most importantly, we were able to cut our PLC scan times significantly, dropping to 1 millisecond static, down from 30 to 50 milliseconds. "There are actually three key tasks that are scheduled to execute every millisecond, one for each of the three cells," explains Timmermans. "This ensures that a fresh EtherCAT frame is pulled in with updated data of the current machine state prior to executing the machine logic. This is in addition to the motion-control task scheduled every 500 microseconds, which is managing the 10 servos on the system."

RUN THROUGH
Figure 8: Chris Timmermans, senior PLC programmer at Edge Automation, runs the new assembly machine through its paces.

In addition, through the core isolation functions offered in TwinCAT 3, we were able to isolate PLC tasks of the project away from Windows to a dedicated core, utilizing only around 18% of the core processing capacity.

“There are still two completely unutilized cores available to us for future expansion on the CX2040,” comments Timmermans. “This is a far cry from previous systems, where we nearly maxed out the controller. By moving to the more robust Beckhoff control platform, we have much more latitude with machine design and a sizable amount of room to add new functions.”

As Edge continues to push the boundaries of engineering for projects of all sizes, we now have the tools in place to meet the growing demands of our customers. “PC-based control and EtherCAT provide a flexible toolbox that can be used in all foreseeable future projects,” notes Timmermans (Figure 8). “The abilities to quickly and easily integrate new devices in minutes and to reuse machine code help us to continue proving that no custom project is impossible.”

Luke McKeen is engineering manager at Edge Automation. Contact him at lmckeen@edgeautomation.ca.

Design distributed I/O on your machines instead of running bundles of wires

How these design decisions reduce wiring on machines

By Dave Perkon, technical editor

Back in the ’80s and ’90s, when 20 free-standing doors of relay logic panels, lined up in a row, would be replaced by a five-door PLC and power panel with four large racks full of about 1,000 I/O points, it made sense to resist distributed I/O on machine projects. Each of the I/O points ran from the main control enclosure to one of a dozen stations through one or multiple junction boxes on a 90-ft manufacturing line.

A crew of electricians might install miles of 16, 14 and 12 American wire gauge (AWG) copper wire delivered on several pallets—tons of it. Many events can cut, shred, break, step on or drill a hole through a wire or cable causing a failure, so a failed network cable would cause many I/O points or even hundreds, depending on the design, to fail.

The reality is that it only takes a single item failure to stop just about any automated machine. That item can be many things, such as a sensor, solenoid, wire or network cable. When using distributed I/O, it is possible to eliminate literally miles of wire and cable in a large system. Failures will be less frequent as there is less wire to fail and the distributed I/O intelligence also adds another a benefit, of which there are many, if properly designed and documented.

Use of distributed I/O saves wiring and shortens cable runs. It also creates a more modular design that can save floor space and reduce control enclosure size. So it's not just eliminating the bundle of wire by placing the I/O module close to the field device, it's creating a design that can be duplicated and then connected with a network and control power cable.

For best results, create a modular design when using distributed I/O. Breaking it down to its functional pieces and even adding a few more distributed I/O drops can make a system very plug-and-play and reusable. In the past, a large system's fat bundles of I/O wire would often need to be disconnected before shipping and then reconnected at the end user's facility. Distributed I/O significantly reduces the need for field assembly.

Distributed I/O is making its way to servo motors, drives and power distribution. While rack-based drives, along with their shrinking size, make for convenient installation in the main control cabinet, these devices are moving to what some call cabinet-free designs. They can be distributed out to the machine and controlled with just a network cable and power drop. If you don't distribute these devices onto the machine, control them with an industrial Ethernet protocol instead of discrete I/O.

Also, document the distributed I/O drops and device addresses well so that changes or problems are quickly corrected. Documentation includes a spreadsheet of all IP-addressed device drops and I/O addresses, a clearly drawn network diagram, program logic descriptors and human readable tags on the distributed field devices. Some may claim their distributed I/O is self-documenting, but you and other programmers will need a cheat sheet and device labels in addition to the drawings.

To connect all of the distributed I/O, use one of the many industrial Ethernet protocols, or possibly IO-Link and similar for a more local option. The controller typically drives the network and protocol, as distributed I/O is often a well integrated part of the controller family now, whether from the same manufacturer or third-party suppliers. Failed communication cables, network configuration and traffic were all concerns in the past, but network setup for distributed I/O is pretty simple and well-documented. However, network traffic can bite you sometimes. Keep an eye on the distributed I/O scan speed needed for the application.

When using distributed I/O, keep the control network separate from the corporate network, which is best practice. Distributed I/O often needs a separate control network for best performance. Adding a vision system or two, some servo drives, a few robots, an HMI, communication to ERP and MES systems, and maybe remote access, all to one network along with distributed I/O is a poor design decision. Keeping distributed I/O and other real-time devices on a separate network or networks can help. Just beware that, on larger systems, there will probably be multiple control and information Ethernet networks.

Don't hesitate to try distributed I/O on a machine. Pick one that works well with your controller of choice and can be mounted directly to the machine or in a junction box; create a modular design; attach it directly to the machine; connect the network and power cable; plug in the field devices and start controlling that machine with a lot less wire.

Remote I/O becomes smaller, faster, customizable and intelligent

Long used and familiar, remote I/O is undergoing changes and innovations.

By Hank Hogan, contributing editor

Out of sight better not be out of mind, at least when it comes to machine I/O. Whether they're inbound sensor data or outbound actuator commands, real inputs and outputs are an important part of what makes an automation scheme work, even if what's being controlled is a good distance away. In such cases or when otherwise beneficial, there's remote I/O, the distributed digital and analog I/O modules gathering signals in remote locations and connecting them to a central controller.

Long used and familiar, remote I/O is undergoing changes and innovations. It's getting smaller, faster, customizable and intelligent.

REMOTE SPACE

One OEM taking advantage of advances in remote and local I/O technology is Husky Injection Molding Systems. The Bolton, Ontario-based company's machines make many of the preforms that become PET plastic beverage bottles.

The company leverages networked I/O and many other technology innovations in its new designs (Figure 1). The result is that the latest Husky machines have cut materials costs by hundreds of thousands of dollars annually, in line with an industry-wide trend to reduce raw material use. These machines also have provided productivity and cycle time gains of up to 12%, according to Roman Pirog, director of development engineering at Husky.

LOWER COSTS

Figure 1: Husky Injection Molding uses I/O advances to add functionality so users can lower total production cost of plastic bottle preforms.

(Source: Beckhoff Automation)

As part of these improvement efforts, the company is always adding functionality to its machines and so always requires more I/O and I/O modules (Figure 2). The challenge is that the machine footprint and the footprint inside cabinets are fixed. The solution is to deploy higher-density I/O technology, so it's possible to fit many more I/O points in the same or smaller space, explains Endel Mell, electrical design team leader.

(Source: Beckhoff Automation)

BETTER ACCURACY

Figure 2: Exploiting remote and networked I/O and other technologies, Husky improved system accuracy, machine responsiveness and repeatability.

The use of distributed and networked EtherCAT I/O brings other benefits, he adds. The availability of diagnostic tools, for instance, makes it possible to pinpoint problems with both the equipment and the end product. Also, the technology allows signal oversampling because it supports rates of up to 100,000 samples per second. Such advances minimize control loop delays, increase control accuracy and maximize uptime, all of which are valuable to Husky and its customers.

For its machines, Husky uses products from Beckhoff Automation and has been doing so for over 15 years. For instance, one of the company's latest machines, finalized at the end of 2013, includes a range of EtherCAT-based I/O terminal modules from Beckhoff.

Husky's global array of facilities manufacture injection molding machines, hot runners, molds and integrated systems. It has thousands of machines in the field.

Remote build to suit

For medium- to large-sized machine builders, Beckhoff has introduced an I/O system that plugs into customer-specific circuit boards. "It's a remote I/O concept that's been customized to a fine level of detail," says Kurt Wadowick, Beckhoff I/O and safety specialist.

Thus, the modules will be tailored for a given set of relays, process transmitters and other specific I/O. It can include anything currently available in the company's EL terminals. The resulting circuit board will consequently have everything needed for a given machine. The board can be designed by the customer or Beckhoff.

The benefits of this approach are simpler wiring, reduced assembly errors and easier and faster repeat assembly, says Wadowick, who assures there also will be lower overall system cost, although the components of the customized solution may be more expensive than the corresponding discrete components. An added plus is that the new customized I/O modules are smaller by about 40% when compared to Beckhoff's EL equivalent.

Some non-recurring engineering expense is involved in the customized approach because the plug-in board has to be designed. For small runs, this extra expense will overwhelm the cost savings. The crossover point is roughly 100 systems a year, according to Wadowick. For volumes higher than that, the total costs come down significantly.

REMOTE DECISIONS

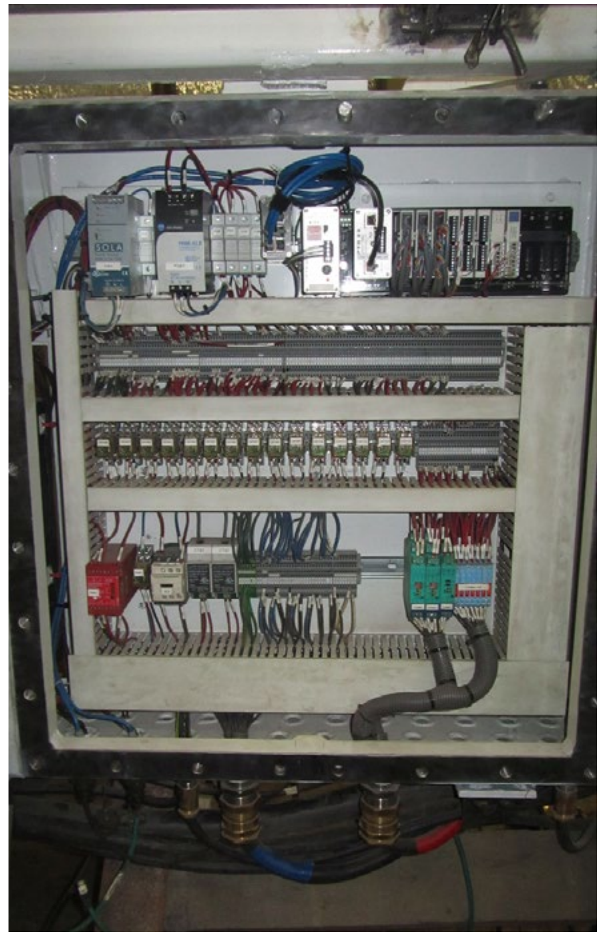
Expansion of remote I/O brings benefits, but it's not the right choice for all situations, says Kevin Wu, distributed I/O product manager at Siemens Industry. If the I/O count is low, then machine-mount solutions may make more sense. The dividing line varies, but generally remote I/O is most cost-effective when 50 channels or more I/O points are involved, he says.

The reason is because remote I/O goes into a cabinet. With a small number of added points, that cost can more than make up for the lesser expense of such I/O as compared to a machine-mount solution. Similarly, it may make more sense to put higher-density I/O in an existing cabinet as a way to expand. The cost of an additional cabinet may tip the balance in favor of a local, non-remote I/O solution.

In the right circumstances, though, remote I/O is the most cost-effective way to add capabilities. Some Siemens innovations should further improve on this advantage. For instance, the company offers bus adapters, a removable module that plugs into a remote I/O interface and allows swapping out Ethernet ports.

Many remote I/O interface modules have integrated Ethernet ports. These ports are the ones into which cables are plugged and unplugged. “Over time, when you do that, you could damage that port,” Wu says.

The result could mean that the entire interface module has to be replaced. That sounds simple, but it involves IP addresses and device configuration. Getting both right can be time-consuming. The Siemens solution avoids such issues because it allows a defective port to be exchanged for a working one. This fix is substantially less expensive than the cost of an entirely new module, Wu says. It also can save time and headaches.



(Source: Helmer Electric)

EXTENDED REACH
Figure 3: Remote I/O has extended the reach of solutions in the cabinets of construction equipment.

On the horizon could be much higher bandwidths. In 2012, Siemens released a new I/O family with a backplane that it says is capable of 40-times-greater bandwidth than existing technology. The new I/O is designed so that its bandwidth can be updated in the future through a firmware change, thereby providing protection against demands for increased bandwidth that may arise over time.

LOCAL CONTROL, REMOTELY

At Fond-du-Lac, Wisconsin-based Helmer Electric, remote I/O has made its projects considerably easier. The electrical contractor designs and installs fully automated PLC systems (Figure 3), some of which are used to control construction, excavation and mining machines. These machines and the distances spanned are not small.

"We have one instance where we had our main processor about a mile away," says Adam Nisler, Helmer lead technician. "It depended on where they were in their construction project, but it was about a mile away."

Getting data for monitoring and control back and forth over such distances in the past meant running long and large specialized cables, which made the solution expensive. What's more, determining when and where such cables failed could be difficult, which made troubleshooting a challenge. Indeed, getting a machine up and running might require a technician to make a trip on-site, which could be costly and time-consuming.

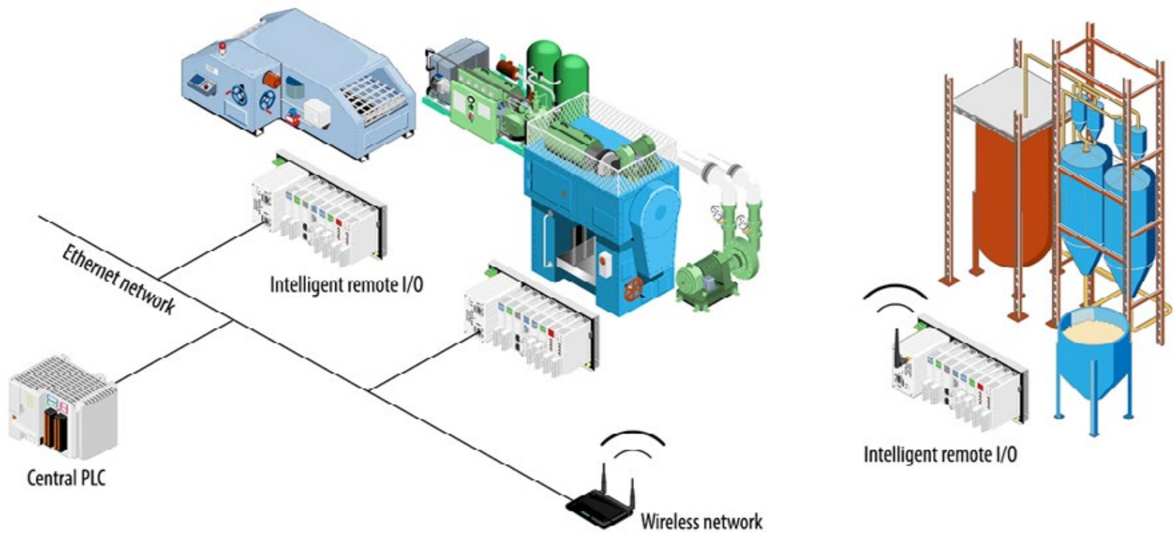
Implementing the right technology changed the situation. "With the remote I/O, we did it through TCP/IP. You're able to run an Ethernet cable wherever you needed to go, and we had a fiber backbone for it, as well, so we didn't have any issues with distances," Nisler says.

"In designing remote I/O solutions, a balance has to be struck," he adds. For instance, sensor data needs to be distributed in time and space so that it paints a complete picture, but too much I/O can create information overload, burden PLCs and cause other problems. Also, Helmer's customers do not want work to stop because a cable is damaged.

Communication between an Opto 22 programmable automation controller (PAC) and the remote I/O processor runs over a standard Ethernet-based network. Data is exchanged using a memory-mapped protocol based on the IEEE 1394 standard. Communication using SNMP, EtherNet/IP and other protocols are also supported.

Opto 22 touts the advantages of intelligent remote I/O (Figure 4). Because the remote I/O is brainy, such a distributed approach lessens the burden on a central controller, makes solutions easier to scale and minimizes single points of failure. Loss of a connection, for instance, does not necessarily lead to such situations as tanks overfilling due to pumps not being shut off.

"If your I/O at a remote location has the intelligence to run PID loops, then even if



(Source: Opto 22)

CUT COMMUNICATIONS
Figure 4: Intelligent remote I/O enables functionality to continue even if communications are cut.

all communication to that remote site is lost, your critical processes will continue to run," says Mary St. John, Opto 22's director of training.

With the advent of wireless communication and Internet-enabled technologies, it's possible to do global remote I/O, as in gathering sensor data from points on the other side of the world. However, since communications can sometimes be unreliable, St. John advises it's best to also log data locally. In this way, even if links go down, critical data is not lost.

This local data logging is similar to having intelligent remote I/O enabling local control functions at distributed locations. This intelligent remote I/O allows the process or machine to remain functional if communication is lost.

A REMOTE FUTURE

"Remote I/O advances could cut the cost of the entire solution," says Eugene Spiropoulos, senior technical solutions consultant and DCS solutions manager at Yokogawa of America, which offers smart configurable I/O technology. "The purpose is to provide remote I/O modules out in the field that can be software configurable for any of the four basic I/O types. You can terminate different types of I/O on one termination strip, one I/O module, and then pretty much tell those channels what they're supposed to be."

Programmatically changing between digital input, digital output, analog input and analog output with a few keystrokes and wiring modifications simplifies the hardware.

The effect is to separate control development from that of the hardware. For example, a program running on a tablet can stand in for the control application and can be used to validate I/O signals. This can happen while development of the control application is underway. If there are changes to the control application that translate into hardware changes, the configuration of the I/O can be adjusted through software alone.

The impetus for this new technology came from customers, Spiropoulos says. “The industry required a change in the way they were executing automation projects.”

This approach means automation projects can be developed in modules. What’s more, those modules are not in the critical path for larger projects, an approach that customers value, according to Spiropoulos, who says this technology can reduce cabinets, wiring and other costs, thereby reducing total install costs. This can be important in remote or offshore locations, where installation can be quite expensive.

While there may be significant cost savings, the real benefit lies elsewhere, Spiropoulos says. “The key thing is project flexibility. You do save a lot on the schedule, but more importantly you save a lot on the risk.”

Does distributed I/O architecture make sense?

Custom builder needs to know the deciding factors for which I/O system to use

By Mike Bacidore, editor in chief

A Control Design reader writes: As a control designer at a large custom machine builder, I regularly define hundreds of I/O points and create electrical drawings for the systems we provide. Most of these points are discrete but some are analog. During this process, I often struggle with whether I should use local rack-based I/O, break it down to remote I/O racks in field control enclosures or use distributed I/O mounted to the machines. In the past, I have usually kept the I/O local, so installation required running large bundles of wires from the main enclosure to the field devices. However, I am considering changing my I/O system architecture to a more distributed one. I'm sure the use of local I/O is fine in some system designs, but what are the deciding factors on the type of I/O system used? Also, some systems are high speed and complex, so speed of any I/O used is very important, which has always been a concern when using a network cable to connect distributed I/O. I'm sure there are other design considerations, but I'm not sure what they are. Please help understand some best practices when specifying I/O.

ANSWERS

EMBED THE I/O

Another option for applications with limited space is to embed the I/O directly on a PCB. It is possible to design a circuit board whereby I/O terminals can be connected without the need for individual wiring—the wiring is designed into the circuit board traces. Traditional wiring processes are replaced with error-free pluggable connections. This option is ideal for high-volume, repeated machine designs where incorrect wiring must be eliminated and installation time reduction is a major goal.

Machine-mountable “box” I/O also brings the added benefit of easy access to the I/O module, which makes troubleshooting much simpler. If everything is sent back to the electrical panel, tracing the wires could be difficult, especially if they are not labeled properly. However, some applications may not have easy access to different parts of the machine required for I/O mounting. In that case, a remote I/O box would be a better choice, though this may incur additional wiring and installation cost and must be considered.

The bottom line is to use local and remote I/O solutions where each makes sense. It really boils down to application requirements and making the best use of the technology to improve efficiency and reduce costs.

Sree Potluri, I/O product specialist, Beckhoff Automation

SINGLE CABLE

Even though the basic concept of I/O is simple—signals in and signals out to accomplish a task—there are myriad factors to consider during the process of component specification. Availability of space, layout of the machine, accessibility of the machine, equipment budget, length of cable runs, required signal types and accuracy requirements all factor into the decision-making process.

The most common practice is to install all of the I/O in a control cabinet and run cable to route the signal to the necessary location. These devices are generally DIN-rail-mountable modules that are IP20-rated and offer diverse connectivity and functionality options. Depending on the number of signals, this type of solution could require a larger panel, which increases equipment costs and demands more space. In addition, if the cable runs are too long, particularly when dealing with analog signals, the system loses precision. These types of applications are where remote and machine-mountable I/O could be beneficial, as the signal from the field device remains very close to the distributed I/O.

Choosing the correct communication protocol is also important in the design process. The ability to seamlessly access and diagnose each channel on every I/O module from your main controller via a single interface offers significant value. A capable protocol in this context is EtherCAT—a deterministic, high-speed Ethernet-based fieldbus that provides synchronization and diagnostics down to the individual I/O modules. The newest expansion of this technology is EtherCAT P, which combines power and communication into a one standard Ethernet cable. EtherCAT P facilitates much greater system simplicity, as it only requires a single cable run to connect back to the controller.

Andy Garrido, I/O product specialist,
Beckhoff Automation

PERFORMANCE, REASSEMBLY AND COST

I/O decisions (local vs. remote) must be based upon a hierarchy of priorities.

First priority is optimal machine performance. Many complex machines have a relatively small amount of critical I/O from a speed-of-processor-update standpoint. For example, you would not put an encoder on a remote I/O network that cannot be reliably scanned at the fastest update rate needed for deterministic machine operation. But you could very likely use a remote output for a stack light as the timing for that operation is not critical. On bottle filling/capping/labeling equipment that I have seen, there are mixes of local with long runs back to the main rack and remote I/O to satisfy the demands of machine performance.

Second priority is ease of machine reassembly. Large custom machines may need to be manufactured in movable subassemblies. When these assemblies are mated to create the final machine, there may very well be a formidable amount of field reconnection needed. In addition to taking time, this also can create a point of failure. Reducing the amount of field wiring reconnect is good design practice. This is also true if the control enclosures are remotely mounted from the actual machine.

Third is cost. Remote I/O always has a cost associated with just the adapter. The more I/O points you have on an adapter, the lower the cost per point for remote.

An additional factor that must be considered is the I/O network itself. There are several options, depending on the control system; some are fine for slower applications, while others are very fast and can act just like local (rack) I/O from a timing perspective (first priority). It is best to research remote I/O networks, as it can be a deciding factor in overall I/O layout.

For example, the newest machine we manufacture has a local rack inside the control enclosure that is actually a remote rack, in that it connects to the controller over a network. The processor and cards slide together, creating an assembly that looks local, but the communication to these cards is over the EtherCAT network. We also can have a small amount of remotely mounted cards also inside the machine-mounted enclosure that use an adapter with a network cable to attached to the main card assembly, depending on the options ordered. As you can see, the performance of this particular network has made the first priority rather meaningless.

Mike Krummey, electrical engineering manager,
Matrix Packaging Machinery, Saukville, Wisconsin

SLOW VS. COMPLEX

Remote I/O is perfectly fine 98% of the time, as it does save longer wiring runs, which can be costly. As long as you are controlling things that are “slow” on remote I/O blocks—relays, blinky lights—remote I/O is fine.

If there are any signal speed requirements for a faster response to or from the PLC, which is sometimes needed for a safety system feature or possibly the analog signals, then these items should go to the I/O rack where the PLC is located as local I/O.

Keep anything “complex” on local I/O, as well. I wouldn’t run I/O to a robot or vision system or anything like that on remote I/O blocks. In general, my personal preference is to run all analog signals to local I/O, as well, as you will be sure to have enough response speed available directly from the PLC for the analog control system. It always depends on the system, of course.

Gray Robbins, senior control system engineer, Toward Zero, Indianapolis and member of Control System Integrators Association (CSIA)

CABINET- VS. MACHINE-MOUNTED

With available industrial network technologies, it just doesn’t make sense to pull copper wires out to devices. These networks are fast enough for any application; they are fast enough for precision, high-speed, synchronized motion control. There are even I/O slices capable of a 1-microsecond response time using onboard intelligence rather than going back to the PLC’s CPU.

Perhaps the main consideration is whether to use cabinet-mounted I/O, machine-mounted IP67-rated I/O or a combination. A base machine configuration might see the I/O housed in the cabinet and options or lengthy conveyors equipped with machine-mounted I/O. Note that the network cable can also perform the role of networked (vs. hardwired) safety, safe motion and safe robotics, providing huge performance and diagnostic benefits—both widely adopted in Europe but relatively unknown in North America, aside from the most progressive OEMs.

The same network can also be used to control machine-mounted motor/drives and motor control modules out on the machine. The motor/drives typically offer the ability to connect I/O on the network, and the motor control modules are being used for applications such as automatically adjustable conveyor guide rails for fast, precise changeovers.

There are so many networked I/O functionalities available—from strain gauge to energy monitoring modules—there is really no reason to hardwire I/O even if the I/O count is low.

That said, there is also no reason to run expensive machine-mounted fieldbus I/O module cables out on the machine. A simpler network implementation is to extend the PLC backplane communications out via cable to the remote I/O modules, a solution that’s been commercially available for many years.

Final word—your I/O and safety network technology should be open source and recognized by standards bodies; and you should therefore not have to pay license fees or royalties.

John Kowal, director, business development,
B&R Industrial Automation

COUNT THE I/O POINTS

In these applications, I usually consider all options in a machine design. If I/O signals are located semi-close to the main control cabinet, I usually continue to parallel-wire them. For the rest of the machine, I intermingle IP20 and IP67 I/O. If the I/O location has fewer than 16 digital I/O points, I consider IP67 direct machine-mount I/O. While the modules are more expensive, they are still cheaper than installing and wiring junction boxes. If the locations have higher I/O counts along with mixed signal types, I go with IP20 in-cabinet I/O. In-cabinet I/O options are usually more flexible and can be customized to match you I/O needs.

The last piece to consider is the layout of the industrial network. With this being a new machine design, I'm making the assumption you are going with an industrial Ethernet protocol. Ethernet is great because of its flexibility, but you need to be careful what other devices are attached to the I/O network. While it is true you lose some throughput with industrial Ethernet networking, this time only has a minimal effect on the application, as long as you are not overloading the Ethernet network with noncritical data. The key is to keep your I/O network isolated from the rest of the network on the plant floor.

An easy way to do this is to place the network security appliance between the machine and the rest of the network. These devices block unwanted data from the plant network affecting the network bandwidth of the machine.

Jason Haldeman, lead product marketing specialist—
I/O & light, I/O and networks, Phoenix Contact

DID YOU FIX IT YET?

If the system has several IO points that can be logically divided into groups, then there are advantages to designing a modular machine consisting of a main control panel and various smaller subpanels. Each subpanel would consist of remote rack-based I/O, where all I/O wiring is close to the field devices. This distributed setup reduces the conduit sizes and helps to simplify the wiring diagram—you will make fewer wiring mistakes, spend less time wiring and can easily make last-minute changes without affecting the rest of the machine. If any issues arise after the machine is deployed, OEMs have the option to quickly replace only the subpanel in question to keep the machine running. You can then troubleshoot the faulty panel off-site without people over your shoulders asking, "Did you fix it yet?" A distributed approach also provides flexibility to add upgrades and new features or accommodate unforeseen changes in the production environment. For complex systems that require fast response times, choose a deterministic network that maintains network integrity without much tuning or expensive managed switches. For example, CC-Link IE Field is a 1-Gbps industrial Ethernet network that transmits large amounts of I/O data in a repeatable time frame and without data collision, regardless of how much explicit message is being transmitted over the network. As a result, you will have reliable and accurate control.

Deana Fu, senior product manager,
Mitsubishi Electric Automation

CONSIDER COST, SPACE AND INSTALLATION

To decide which installation concept is the best fit for your custom machines, you need to take several factors into consideration. These include cost, space and installation time/effort.

Local, rack-based I/O may be the best solution for small machines, but it has several disadvantages when used on medium and large machines. Although the hardware costs for local, rack-based I/O are typically lower than a remote I/O solution, hidden costs such as assembly time and troubleshooting make this option the most expensive.

A remote I/O solution reduces cost and space needed inside the main cabinet since it reduces the quantity of both terminals and protection mechanisms. It reduces wiring efforts, and troubleshooting time is decreased, as well, by the level of diagnostic information offered by the remote I/O devices. Additionally, a solution like this allows you to assemble a machine in parts or to split the machine for transportation. Remote I/O racks do require extra space for enclosures. Additional terminals are required for power distribution and grounding shielded cables. This is a centralized solution that can help to reduce the length of peripheral cables when combined with passive distribution boxes.

Distributed I/O solutions require a larger investment in hardware. But, on the other hand, they reduce assembly time and increase the availability of your machines,often by more that 40%. In combination with pre-wired cables, they drastically reduce wiring mistakes. The I/O devices can be mounted near the peripherals, and expansions are much easier to make.

The best network for your machine is really dependent on the application. When making your selection, take the following factors in consideration:

- What is the cycle time required for the application?
- What topology fits the machine better?
- How many devices will be connected?
- What level of diagnostics is required?

These are just a few of the factors you should take into consideration.

Rafael Calamari, product manager—fieldbus, Murrelektronik

5 FACTORS

Remote I/O systems are designed to not only simplify some of the design challenges faced by machine builders, but also to ease integration and provide increased performance and productivity.

Using distributed or remote I/O gives the machine builders the ability to achieve the best of both worlds—local I/O for those points that are close by and an extension of the local bus to the remote locations to decrease the number of cables that have to be run back to main cabinet.

When choosing a distributed I/O system, keep in mind some of these factors.

1. Bus protocol: This factor not only plays a role in overall speed of the system, but also how much expansion can be done when integrating the machine into a plant network.

In newer distributed I/O systems, the actual speed limitation is the bus protocol. Serial-based protocols such as Profibus/DeviceNet/CANopen are considered much slower, as compared to Ethernet- or IP-based protocols. The distributed I/O systems themselves have a very fast response or scan time. As long as the network cable runs are within the set limits, the local or main controller never sees any delays in response time.

2. I/O mix: This is where it really does get easier and, in many cases, less expensive to use distributed I/O as opposed to local I/O. If using local I/O, the size of the cabinet has to grow in order to accommodate I/O. As well, some cards are very specific as to whether they are inputs or outputs and typically are not easy to configure for different inputs—not to mention, the cost of the cabinet grows and the cost of the cabling is to be taken into account, as well.

Distributed I/O gives the user the ability to keep the central panel to a manageable size and use either smaller IP20 remote I/O solutions or IP67 distributed I/O solutions.

3. Modularity: Distributed I/O systems can be as small or as big as needed. Expansions and higher densities are a given to reduce costs and space. If more power is required, simply add a power block. If the I/O needs to be changed, simply change out the electronics, and program edits are also easily done.

4. Troubleshooting and uptime: How fast do you need to be up and running again in case of a failure? With distributed I/O systems, the electronics are typically easily exchangeable without having to rewire the card itself. No special training or programming requirements needed.

That is normally not the case with a lot of local I/O installations. The full machine has to be taken off-line for longer periods of time as compared to a distributed I/O system. In a distributed I/O system, if there is faulty input or output simply swap the electronics out while the wiring harness stays in place and you're up and running again. The Web server allows technicians to log in and remotely troubleshoot any issues before the decision is made to do a hardware swap. The same thing applies for the IP67 solution, and the advanced diagnostics in distributed I/O systems allows for more accurate troubleshooting—specific input or output short circuits or open loads instead of just a fault.

5. Inventory and customer design: With local I/O systems, if a customer has a specific protocol requirement, as the machine builder, the headache of changing the design and rewiring the I/O and where the sensors are placed is an absolute nightmare.

Distributed I/O to the rescue. Because distributed I/O relies on a main controller in the local I/O panel, the field I/O has very limited smarts. This actually allows the machine builder to keep the I/O wiring and placement of the sensors the same. All that is required is to change out the protocol coupler or head unit of the distributed I/O system and the design is done. To the controller, the field or distributed I/O looks like it's just an extension of its onboard I/O, and nothing is affected. This greatly reduces the cost of inventory for the machine builder because it can have a cookie-cutter design template and just change out the protocol head on an as-needed basis.

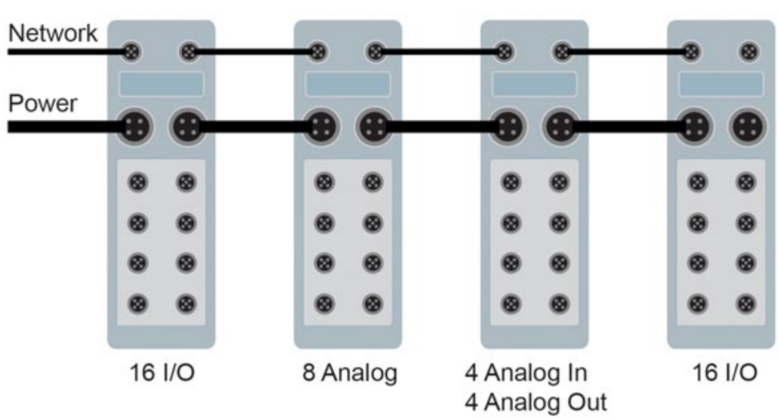
Building or expanding industrial control systems to provide remote-monitoring capabilities can be a challenge. By choosing the right equipment, you can save a lot of time and effort, now and in the future. The points noted above are some of the plus points, and by choosing a reliable and fast distributed I/O system you can choose the best equipment for the challenges faced by reducing wiring efforts, as well as save time, money and work effort.

Andrew Barco, business development and marketing manager—North America, Weidmüller

THE INTEGRATION LINK

When you are looking at the I/O, it is very important to look at the whole picture: the total integration picture. What we mean, and as you described, is the process of laying out a machine requires design time, assembly time, debug time and controls development time, plus the actual cost of the components. Based on the description you provided it appears that in most cases you opt for the central controls cabinet, bringing all the I/O to one single location with a rack-mounted structure. In the design phase, a typical challenge occurs when you need to draw out and define each and every wire and its terminations. Then comes the assembly phase, where you have to physically route, cut, strip crimp, label and terminate each wire. With about 100 sensors, you are talking about a week of wiring time that is in addition to the panel build time. Another drawback with this approach is that you do not have any diagnostics information about short circuits and over-currents or miswirings. Debugging the system takes time and adds no value to your machine besides increasing the cost of assembly. All things considered, a network-based, distributed-I/O architecture appears very appealing.

While the network-based approach offers diagnostics and connectorized solutions that reduce your assembly time, the cost can go up quickly. A typical network I/O block offers only a few points of discrete or analog I/O. The few points could be eight or 16. In your case, when you are looking for a solution for hundreds of I/O points, every 17th I/O point requires a new network node. Another separate network node would be needed for the analog I/O. Every time you add a network node, you need a more expensive network cable and power cable. Even when the network I/O block appears cost-effective, you may end up with a more expensive solution that may not be scalable to your application need (Figure 1).



(Source: Balluff)

NETWORKED DISTRIBUTED I/O

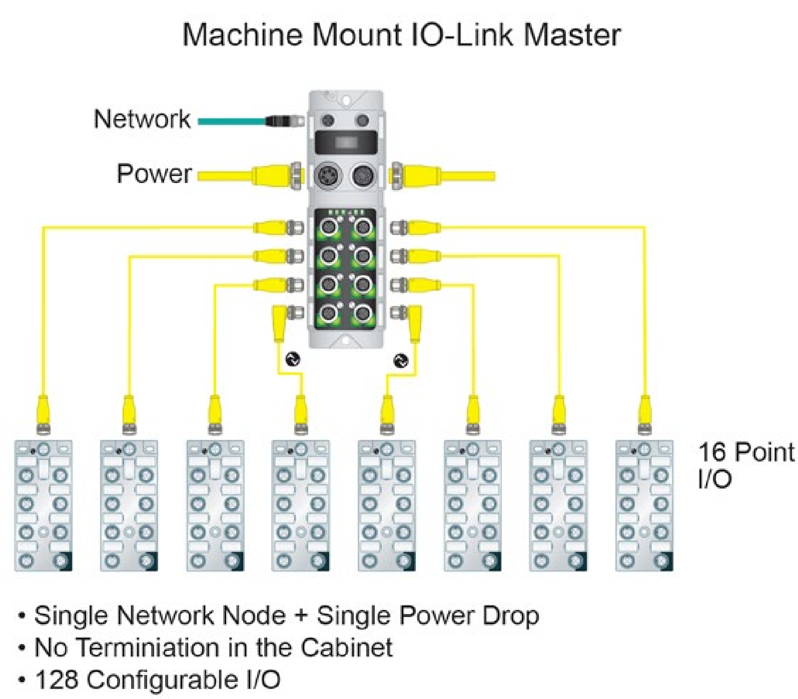
Figure 1: Every time you add a network node, you need a more expensive network cable and power cable. Even when the network I/O block appears cost-effective, you may end up with a more expensive solution that may not be scalable to your application need.

There is a newer—about 10 years old—technology out there that could prove beneficial to your controls architecture. The technology is called IO-Link (www.io-link.com). This is the first standardized (IEC 61131-9) I/O communication technology designed to unify sensor-actuator communication over a standard three- or four-wire sensor cable. On a single network drop you could connect up to 128 I/O points that could be inputs or outputs or any combination thereof (Figure 2). The network gateway is referred to as the IO-Link master, and the I/O hubs are the IO-Link devices that connect to the discrete sensors or actuators. Each I/O hub can be up to 20 m away from the master. Each open IO-Link port on the master can be connected to a multitude of devices. Some technology providers offer analog

I/O hubs that can collect multiple analog sensors and bring them through a single port of the IO-Link master. Or you could simply choose a sensor that is IO-Link capable. Since the I/O hubs do not have network node, and power can be transmitted through the same communication cable, the IO-Link-based architecture usually is a cost-effective solution (Figure 3). The savings for component costs are better when compared with a network I/O approach, and total integration time is a lot less compared to your existing approach. Additionally, all ports are short-circuit-protected; all diagnostics are conveyed through the IO-Link master to the controller, simplifying the total integration of the system.

Now, the second part of your question: the speed of communication for the high-speed requirements of the machine. You are absolutely correct when you implied that network I/O adds additional time because of the network delay. The industrial network technologies have been prominently used on variety of high-speed machines for more than 15 years. There are several industrial-network options, including Gigabit-Ethernet-based EtherCAT and CC-Link IE. With IO-Link architecture, the I/O cycle time could be about 5-10 ms in total from sensor to controller to actuator. In the case of analog sensors, it could be a little higher than that. The suggestion here is that if the I/O cycle-time requirements are less than 10 ms, it would be a good idea to separate the I/O that is essential for real-time processes and and the I/O for non-real-time processes. The I/O required for real-time processes could be kept the same as today, but the rest of the I/O could be consolidated with IO-Link architecture.

Shishir Rege, network marketing manager, Balluff



DISTRIBUTED MODULAR I/O
Figure 2: On a single network drop you could connect up to 128 I/O points that could be inputs or outputs or any combination thereof.

BE FLEXIBLE

When deciding on an I/O configuration, there are a few things to take into consideration.

Environment: Applications in a noisy area will require more robust I/O such as CANbus or other twisted-pair and/or shielded wiring. High humidity, heat, vibration or other environmental conditions would require protection of local connections or the implementation of the remote I/O.

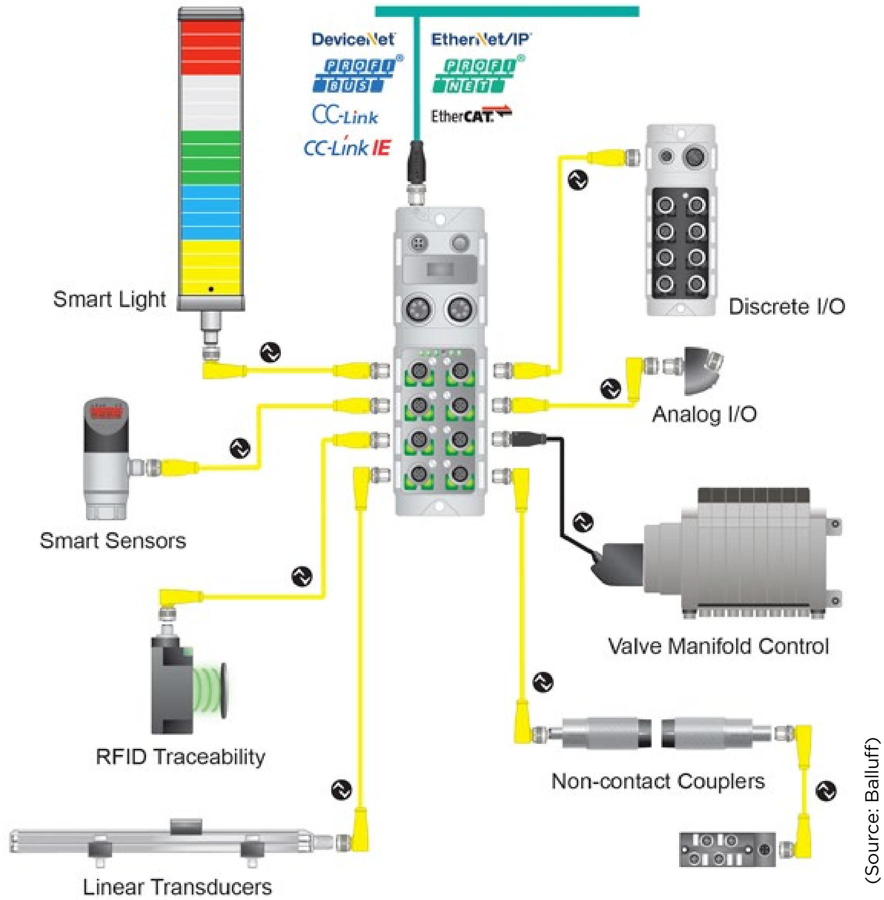
Budget: If cost is a factor, using a distributed I/O with multiple controllers might be out of the question. At the same time, the cost of running long cable can amount quickly, as well.

Volume of I/O: Having a high volume of high-speed I/Os would not fare well over an Ethernet, causing excessive network traffic, ultimately affecting performance of the system. Using local ports or distributing them amongst other controllers may be more efficient, depending on the application.

Type of I/O: High-speed inputs and outputs such as encoders and stepper motors with hardware-level processing must be connected locally or to a remote module somewhere in order for proper function.

Flexibility of infrastructure: If you anticipate potential system growth over time, then using RS-232 doesn't bode well for scalability as it is a 1-to-1 connection. It might be better to setup an RS-485, CANbus or Ethernet network instead.

James Cappelletti, application engineer, Unitronics



IO-LINK ARCHITECTURE WITH VARIETY OF I/O

Figure 3: Since the I/O hubs do not have network node, and power can be transmitted through the same communication cable, the IO-Link-based architecture usually is a cost-effective solution.

CLOSE TO THE PROCESS

It depends on the application. We believe that the highest system performance and reliability can be obtained in systems involving many I/O functions through distributed processing, the practice of placing intelligent control elements as close as possible to the process being controlled. With local controllers handling time-sensitive closed-loop control processes, the need for high speed in the fieldbuses that connect the distributed controllers to central computing resources such as PLCs is reduced, and the bandwidth required is limited if communications are driven by events such as sequence changes or motion profile/program changes, rather than individual motion operations. A fieldbus such as EtherNet/IP generally has more than enough performance to handle supervisory control, data acquisition and HMI data display functions when it is not burdened with the need to pass feedback and control data within the constraints of control loop timing. The advantages of using a fieldbus compared to discrete wiring is that wiring costs are lower, and system reliability is increased and maintenance costs are decreased due to having fewer connections to go bad.

Incorporated in this response is the advice that it is generally not an optimal control solution to have a central PLC performing time-critical and precise control functions in a large machine, even with high-speed point-to-point I/O solutions. PLCs are valuable but designed more for general-purpose computing and supervisory control functions, rather than direct machine control. Dedicated distributed controllers are optimized for the tasks they perform, such as closed-loop motion control, and therefore offer better performance for those tasks, while promoting lower overall system cost. And, with distributed computing elements sharing the workload, a less-costly supervisory PLC can often be used.

Bill Savela, PE, marketing director,
Delta Computer Systems

DON'T DROP THE VOLTAGE

Some of the factors that go through my mind when deciding whether or not to use distributed I/O are the following:

- proximity of the devices to the local rack
- quantity of items
- shipping breaks
- voltage drops
- speed of communications.

The largest determining factors in using distributed I/O is how far the devices are away from the local rack and whether there are enough points of I/O in the same vicinity to warrant:

- the added cost of a communication module
- the added cost of potentially a new enclosure
- the design time to develop a separate I/O control enclosure or distributed I/O scheme.

So what is the distance-to-quantity ratio? In general, once we get out about 50-75 ft from the local rack with about eight to 12 points, we're considering a distributed I/O solution. At that point, the savings in wire and routing simplification begin to offset the additional hardware and design costs incurred.

If a shipping break is involved, unless there are very few I/O points beyond the break, a distributed I/O structure is a fantastic advantage over home runs back to the local rack. The reduced time to break down the machine, set up the machine on-site and debug on startup typically makes the additional cost of the distributed I/O seem like peanuts. The reduced documentation and reduced hardware cost for one less pull box per shipping break can also add to the appeal of distributed I/O.

Another reason for using a distributed I/O scheme would be to mitigate the risk of voltage drop. Our designers get nervous anytime you have low-voltage (24 Vdc) connections more than 200 ft away from the source. At that distance, we start watching our device loads like a hawk, knowing that we're in the range where voltage drop can start to make things stop working. If we have only one or two sensors out there, we may just make sure we're within tolerance, but, if we have enough out there to fill an I/O module or a brick of I/O, we're going to recommend distributed I/O so that our reliability can increase.

Regarding speed of communications, you just need to make sure that your I/O update time is less than your fastest signal. There are several factors that we watch when determining which signals to take to the distributed I/O.

WHAT TYPE OF NETWORK ARE WE USING?

How many devices are we communicating to?
What are the run lengths of the communication cables?
What speeds can our network switches and other network infrastructure support?
As an example, newer Ethernet networks with five or six communication modules attached to a switch or two and with run lengths around 100 ft can usually handle 20-ms I/O update speeds. If you add more wire length and devices to the network, then 50 ms becomes the new level to start watching more closely. So, if you have some signals that need to be faster than this, those would need to go to the local rack.

Determining what model of distributed I/O to use just comes down to the types of signals we're dealing with and what makes the most sense for the application. Around here, we see a lot of Allen-Bradley Flex I/O remote racks, and a fair amount of Allen-Bradley Point I/O mounted in remote enclosures. This is because the number and type of signals we're dealing with are varied, and we like the flexibility of the platforms.

I think that the ArmorBlock style of distributed I/O would work great in a conveyor-type application where you have fewer points per group and simple devices such as limit switches, proximity switches and solenoid valves—things that essentially take one cable to connect and don't have complicated power and wiring needs. I say this because the block-style I/O doesn't allow a lot of flexibility in separating power for the devices, so, if you need something more complicated than just power for outputs and power for inputs, an ArmorBlock setup may not be what works best for you.

Donavan Moore, lead electrical designer, Concept Systems, Portland, Oregon, and member of CSIA

WHAT'S THE SCALE?

Unfortunately there are no concrete rules defining when to implement a distributed I/O control system; however, there are any number of reasons to opt for either a hardwired or distributed I/O architecture. Typical criteria include design, hardware and installation costs, system expandability, layout scope and/or limitations, diagnostic capability, maintenance considerations, knowledge and acceptance.

A primary factor in the decision process is scale. Generally, as a system grows in physical scale and I/O points, the cost/benefit analysis tends to shift in the direction of distributed I/O. Likewise, the variety of signal types needed—particularly specialty signals such as certain analog inputs, high-speed counters, RFID, serial, IO-Link, safety—may itself dictate the need for the flexibility offered by the vast range of fieldbus devices currently available on the market. It is also possible that other application-specific challenges may be aided by the use of a single bus, as opposed to bundled individual conductors. These include complexity of cable runs (junctions/transitions), weight and/or size limitations and dynamic installation (C-track/pivot points).

There are a variety of fieldbus protocols available, each with its own defining benefits and/or drawbacks, which do influence when a particular distributed I/O system is most suitable. Selection of a controller capable of supporting multiple fieldbus options or implementation of protocol independent I/O suppliers may help to extract the most value from distributed I/O systems.

Each case is somewhat unique—fortunately there are plenty of resources available to help users to make an informed decision.

Dan Klein, product manager—fieldbus technology, Turck

Less noise, interference and signal loss

You are correct, in that there are many factors to take into consideration when determining which type of I/O implementation to use within an application. While centralized/local I/O has advantages such as the hardware is removed from the rigors of the testing environment and it's easier to maintain, it also can introduce excessive cost

and complexity to your I/O system, based on the long runs of sensor cable. In addition, with the trend of systems increasing in complexity, it's causing these lengthy wiring schemes to become more difficult and costly to implement. By implementing a distributed system, you can place the I/O close to the system reducing wire cost and only run a single communication cable from the I/O, but more importantly increasing measurement accuracy because the shorter sensor cables are less prone to noise, interference and signal loss. For a distributed approach, localized signal conditioning and I/O are required due to the nature of the system, but other factors such as the ability to synchronize I/O across all the distributed nodes, ruggedness, communication bus and onboard processing/storage can be selected and customized to meet your application needs.
Tommy Glicker, product manager, data acquisition & control, National Instruments

ACTIVE WITH LOGIC

The more complex the system, the better the argument for distributed machine-mounted I/O. Just looking at the cost of installation, the advantages are huge. The connection of sensors and actuators to distributed active I/O blocks using prefabricated double-ended cordsets is four times faster than terminating discrete wires to terminal blocks inside of an enclosure. But the benefits don't stop there. Troubleshooting time is also reduced. The prefabricated, pretested cordsets virtually eliminate wiring errors and the time required to correct them. There are also benefits after the installation. Having to replace a 2M double-ended cordset from a sensor to an active I/O block can be accomplished in minutes. If the system is wired using local rack-based I/O, it can take hours to trace the cable back to the enclosure, find where it is connected inside the enclosure, remove and then replace the cordset. This process also means the enclosure must be opened, which usually requires the complete shutdown of the machine and a call to the electrician to do the work. Hours could be spent just waiting for the electrician to arrive.

Although Ethernet-based active I/O systems do operate at high speeds, very large systems could suffer from a longer-than-required response time. This can be addressed by the recent introduction of active I/O modules that incorporate their very own logic controllers. These distributed control units (DCUs) reduce the response time to 10 ms or less and can function independently or in cooperation with the central PLC. Using DCUs offloads the main PLC so that the overall system can run faster.

DCUs can also be used to control small systems instead of a central PLC.

The use of distributed I/O also reduces the size required for each enclosure. Rows of terminal blocks can be eliminated, because the only connection required is an Ethernet connection to the PLC. Using distributed I/O also means the enclosure can be built in a panel shop rather than wiring it on the factory floor. This typically means fewer wiring errors and additional savings in installation time.

The transition to distributed I/O can be a major change in design philosophy, but the benefits are large and will pay dividends well into the future.

Tim Senkbeil, product line manager,
Belden Industrial Connectivity

PRICE, ENGINEERING AND LATE CHANGES

Here are a few considerations.

Price: If you are just considering the cost of I/O itself, a centralized or multi-channel module approach may be your best bet. Added savings can be had with traditional remote solutions using protocols such as Profibus for remote I/O. However, as you indicated, when you consider the overall project with its multi-core cables, routing design, conduit, cable trays and wiring labor, an Ethernet/network-based solution will be lower-cost overall.

Engineering efficiency: In some Ethernet I/O solutions, the actual installed I/O can be automatically scanned and configured using data imported from the I/O list—for ranges, for example. Test applications can also be automatically generated to allow for parallel work, such as loop checks, to be done. Later this configuration can be automatically digitally marshalled with the actual control strategy configuration.

Late changes: Single-channel I/O solutions on Ethernet with digital marshalling capabilities can handle late changes in projects, such as re-partitioning what runs in which controllers or changing I/O types, by reducing the amount cabinet rework/rewiring.

Roy Tanner, product marketing manager,
control technologies, ABB

Can machines benefit from software-configurable I/O?

Forget about assigned local and remote addresses; in the future, software will help to define types of I/O points

By Rick Rice, contributing editor

One of the biggest struggles that we go through during the design process is how to keep parallel paths in our projects. Generally, it is human instinct to think linearly. We focus on the task before us and move on when that task is done. While this works well in theory, in practice our design process is much more loop-shaped with many circles back to catch features not thought of in the original planning stage. There isn't a designer out there that hasn't tossed out the odd curse at having to change the design long after that ship has left the dock.

Any controls designer will admit that the best projects are those where they can pull together parts of previously designed elements. We have already spent countless hours designing those blocks of circuits and programs, so why reinvent the wheel? Those same designers will also admit that no matter how hard they try, there isn't a good way to make a generic design that will fit everything the concept specialists can throw at them. Or is there? I recently came across a couple of articles about the emerging technology of software-configurable I/O, and it gave cause for serious consideration of the possibilities. Trade shows have started to show some bite on the concept as it applies to industry. The need for configurable I/O isn't new, but the application of software to tell a generic hardware module how to behave is certainly the new kid on the block.

The programmable logic controller (PLC) has evolved over the years. Early models were called "bricks," where there was a single module containing the PLC and a fixed number of inputs and outputs. The next generation of PLCs added the convenience of a rack—of predetermined I/O space—where modules could be added to expand the I/O beyond the brick portion of it. This can be referred to as conventional I/O. Next came expandable I/O, where additional racks of I/O could be added, either in the same electrical enclosure or a remote panel. This was called remote I/O for that reason. Today, remote I/O has evolved to allow for multiple communications protocols connected to a conventional PLC.

Conventional I/O requires that you allocate I/O—by inserting a module in a rack—based on groups usually at the byte level. In the conventional I/O system, typical modules might be an eight-point ac input module or a 16-point, 24-Vdc output module, a two- or four-channel analog module or combinations of inputs and outputs of a similar voltage or type—digital or analog. The downside of this type of I/O is the designer must rely on a relatively accurate list of inputs and outputs at the outset of the design and then build the I/O table of modules to suit the list. Add to that design some additional unassigned addresses of each module type to ensure for future expandability and to allow for design changes. The selection of modules is tied to the product offering of the manufacturer.

The need for more I/O in a conventional I/O system prompted the development of remote I/O. Regardless of the vendor, remote I/O utilizes a communications module in the base rack to interface with the PLC in the main rack. There have been a number of different protocols used to communicate between main and remote racks over the years. Some of the more popular are Data Highway (DH), Data Highway Plus (DH+), ControlNet, DeviceNet, Profibus and Modbus. The general concept is that each remote rack is assigned a block of memory—input and output—in the main PLC, and the remote communications module takes care of mapping the I/O modules into this memory allocation.

An alternative to the main/remote rack style I/O system is to utilize slice I/O. The premise here is to have just a processor in the main rack and a communications module. All other I/O is located in close proximity to the actual devices being controlled. For example, one cluster might be located in the main control panel while others would be located in a remote control panel or field-mounted junction boxes. Another advantage of slice I/O is we can use modules that only have two or four

I/O points, instead of a block of eight, 16 or 32. The benefit to this is not having to leave a chunk of unused I/O bits hanging around gathering up space in the panel. You get what you need, where you need it. With a little bit of foresight, a designer can include null slices to allocate memory (I/O) where future slices may be inserted if needed. I/O slices are limited to eight digital I/O points or less, so make sure to allow for enough space.

A few years back, many automation vendors started offering a different approach to automation where the backplane or rack could contain more than one communications module, and more than one logic controller could be present in the same control system. These are often called programmable automation controllers (PACs). Inputs can be shared between controllers to provide independent yet linked control of a much larger system. The advantage of this technology is to split up the tasks performed by these separate logic controllers to provide an increase in productivity and response. Another advantage of this type of automation platform is the mixing of older and newer technologies, especially with communications protocols. Data Highway devices could exist in the same control system with newer Ethernet or Profibus products.

The trick to any I/O system is to have a plan. Any system that remotely communicates with a block of I/O will have limitations on how much you can stuff into each node, or cluster, of I/O. Familiarizing yourself with the intended system will help tremendously and cut down on the amount of rework needed if the I/O expectations change.

The latest trend in automation is toward soft PLCs, where the programmable logic controller is entirely software-based, residing on a computer or server. The I/O for the controller resides on remote I/O, conveniently located close to the devices they control. The great part about a soft PLC is that the designer is not restricted to just ladder diagram, statement list or function block style programming. The programming algorithms can be in any programming language and then compiled. A logical next step in this trend has been software-configurable I/O.

The need for software-configurable I/O emerged from distributed control systems (DCSs), where the point of control may be in another building, city or even country. Building projects of this nature traditionally require all of the digital and analog devices to be known before the control system can be designed. For a large project containing hundreds or even thousands of I/O points, this could take months or even years to develop to the point where the controls designer could even begin to put pen to paper. The strung-out nature of this alludes to the linear approach to projects. Early players in the configured I/O game included Emerson, Honeywell and Invensys, all of them heavy in DCS. More recently companies such as ABB have gotten into the market for this fascinating product.

The general premise of this type of product is to assign a node of I/O at a particular location and then tell the individual I/O points what type of point they will be at some future point in time. A point can be an input or output and can be digital or analog in nature. The decision of what it will be does not have to be determined at design time. While software-configurable I/O is clearly geared toward the large-scale, DCS-type project, it certainly could be adapted to serve other automation applications.

Imagine, if you will, the possibilities should PLC vendors ever decide to bring this into the machine-level market. Current technologies with logic controllers and automation controllers offer some flexibility down to the byte level but still insist on some rigidity as far as requiring specific modules to perform specific functions. Software-configurable I/O would save tremendously in terms of upfront engineering by allowing for changes all through the design process that don't negatively impact the hardware choices made at the beginning of the process. The flexibility of changing a type or function of an individual point of I/O after the machine has shipped is endless. Rarely does a machine leave the vendor that doesn't need an update somewhere down the road. Inputs changing to outputs, digital signals becoming analog, all without swapping out or adding additional hardware is certainly a future worth looking forward to.

How distributed I/O can work on packaging lines

Alternatives to running servo power and feedback cables, as well as wiring to sensors and solenoids.

By Control Design

A Control Design reader asks: I'm trying to reduce field wiring on the packaging lines that we build. Typically, I might have a dozen servo drives on the equipment. Instead of running servo power and feedback cables, along with wiring to solenoids and sensors, we're looking at using distributed methods.

Any recommendations on I/O methods for the major motion and sensing devices on the machines?

ANSWERS

ALL IN ONE

The good news is that there is a wide range of servo and distributed I/O innovations available today that are designed precisely to tackle these kinds of field wiring and installation challenges. When simplifying difficult applications in the field, we increasingly point our customers to time- and space-saving one-cable solutions. The availability and reach of one-cable technology continues to expand, giving manufacturers the ability to instantly reduce cabling cost and effort by 50%. For example, options include:

- one-cable motors combining power and feedback into a standard motor cable (One Cable Technology servo motors)

- one-cable automation solutions combining industrial Ethernet communication and power in a single four-wire standard Ethernet cable (EtherCAT P)

- single-cable display solutions—DVI signal, USB 2.0 signal and 24 V power supply transferred through one cable (CP-Link 4).

Other options available to machine builders and system integrators include I/O terminals with special integrated functionality. For instance, DIN-rail-mounted servo drive terminals have been available for years that pack motion control functionality into an I/O housing as compact as 12 mm wide. This permits the drive to be simply added to the existing I/O rack, right alongside all the other I/O that connects to the rest of the field devices such as sensors and actuators. This dramatically simplifies installation in difficult, space-constrained application areas. Even better, there are One Cable Technology-compatible versions of these I/O terminals, too, providing even more efficiencies and savings via one-cable control solutions.

— Matt Prellwitz, drive technology application specialist, Beckhoff Automation, www.beckhoff.com

EVERYTHING ON ONE NETWORK

Today there exist more options for distributed vs. centralized motion than ever, and the good news is that they can often be mixed and matched on the same network, even motors, actuators and drives from third-party suppliers that support a given network architecture.

Integrated servo motor/drives have been around several years now, with the drive electronics mounted on the motors. This frees up cabinet space and quite possibly will allow you to run one hybrid motor cable from the cabinet out to the motor/drives, typically in a daisy chain. These motor/drives can also provide onboard I/O options, which can be used in combination with both cabinet-mounted and machine-mounted IP67 I/O modules, all on the same industrial Ethernet network.

A newer distributed option is the machine-mounted drive. This allows you to distribute higher-powered motion out onto the machine because the separate drive doesn't face the same heat dissipation issues as a motor-mounted drive. It also allows you to use different motor types, such as linear or torque motors, third-party motors or stainless-steel motors.

For automated changeovers, there are now stepper drives in the IP67 remotely mounted I/O form factor. This also is great for retrofits on existing lines.

Likewise, distributed motor/drives are great for headless add-ons, such as leaflet inserters or smart belts, controlled by adding or activating a software module in the main automation controller.

Safe motion is also a huge opportunity for packaging machinery builders and line integrators to go into a safe mode instead of stopping the line. This isn't safe torque off, it's safe torque, speed, position, direction, robotics and more.

Integrated motor/drives are great for rotary machines, too, where power and communications go through a slip ring to turret-mounted motor/drives. Other options include micro drives mounted in the turret, both stepper and servo. A common power supply on the stationary portion of the machine saves space in the turret and allows simpler dc power distribution through the slip ring.

Among the latest developments are servo drives the size of a single-axis drive that can run two and now up to three servo motors, thanks to increasingly integrated electronics. Better yet, drives of this type may be designed to power single-cable motors, presenting another way to reduce both cabinet size and cable runs.

You should also be able to mix any and all of these form factors with conventional single and multi-axis drive systems. Some servo drives can also be used as frequency drives if you have some axes that can benefit from the lower cost of induction motors, with or without encoders.

Today's controllers and networks allow you to run everything on one processor and one network. So it's no longer necessary to buy multiple CPUs to run 12, 15, 20 or more drives and no longer necessary to have separate motion and device buses, even for high-axis-count systems.

— John Kowal, director, business development, B&R Industrial Automation, www.br-automation.com

DISTRIBUTED BY DISTRIBUTOR

For the case of distributed I/O and servo systems, you would best look into manufacturers that have an integrated motor drive system. Since you have not specified the type of machine, there are many options—integrated motor and drive VFD for conveyors, integrated motor servo systems even stretching up to 10 hp. Now, if your machine design requires washdown, then I suggest redesigning the machine for a balcony or bathtub design so you don't have to use washdown on stainless steel motors.

There are a number of manufacturers offering machine-mounted servo drives and inverters now. Often these will have extensions/connection points for local I/O at the machine-mounted device for local sensors. I have even used noncontact wireless I/O sensor systems and just run 24 V along the machine. As long as the I/O is not time- or safety-critical, then does it have to have wires? There are many ways to approach the system design and accomplish your goal. I would recommend that you contact a distributor and make sure the communications system has one of these five fieldbuses—Profibus, Profinet, EtherCAT, Ether-Net/IP, SERCOS III.

— David Arens, senior automation instructor, Bosch Rexroth Drives and Controls, www.boschrexroth.com

ISN'T IT OBVIOUS?

You mentioned one of the most obvious ways to reduce wiring: distribute the I/O devices and servo drives throughout the system to reduce the number of discrete conductors and reduce the length and number of power and feedback cables. A secondary benefit of distributing devices is control-cabinet size-and-cost reduction.

Two additional ways to reduce wiring include using a modern network like Ether-CAT to replace discrete conductors with inexpensive CAT5/6 cable and choosing a servo solution that supports a single cable between servo drive and motor containing both motor power and feedback.

Used together, these can reduce system wiring by 80% or more. The more axes and sensors you have, the greater the sav-ings will be. Many solutions support IP54 or higher-rated devices so it is easier than ever to distribute devices, regardless of the operating environment. Some distributed drives also have onboard I/O that can help reduce I/O devices. Distributed technolo-gies that combine both servo power and EtherCAT into a single hybrid cable maxi-mize savings and may result in only one cable going back to the control cabinet. EtherCAT makes it easy to add remote I/O devices and supports network updates of 0.25 milliseconds (4 KHz) or lower to meet requirements of time-demanding applications. Servo drive and I/O device configuration can be changed on the fly and real-time device operating and status information are continuously available to the machine controller.

— Carroll Wontrop, senior system engineer, Kollmorgen, www.kollmorgen.com

THINK IP67

You have a few options when transitioning to a distributed control network. The first option is to move the equipment from a single large cabinet to multiple smaller cabi-nets distributed along the conveyor system. Each of these cabinets can contain power distribution, servo and I/O for that sec-tion of conveyor. These cabinets can then be networked back to the PLC, reducing a large percentage of the parallel wiring.

The second option is to make the leap to a fully IP67 installation using servos and I/O with direct network connections back to the PLC. With this option, you need to look past the initial sticker shock on product cost and evaluate the time savings of not hav-ing to build the individual control boxes. In the end, a combination of both options may work out best. A good starting point would be to evaluate the cable savings by distributing IP67 I/O modules on the conveyor to pick up your solenoids and sensors.

— Jason Haldeman, lead product marketing specialist—I/O & light, Phoenix Contact USA, www.phoenixcontact.com

LINK TO IT

Distributed I/O for sensing and valve connections makes a lot more sense than bringing all the individual wires to the control cabinet. As you already know, the wiring that you currently have requires tremendous amounts of labor efforts, and it is more prone to human errors.

Distributed I/O naturally reduces complexity and wiring. Machine-mountable distributed I/O can further reduce complexity, as you can use standard M12 or M8 connections for all the I/O instead of terminating it. IO-Link-enabled machine-mount distributed I/O certainly adds even more value, as it simplifies connections and adds diagnostic capabilities for sensors and smart sensors, as well as I/O.

Furthermore, IO-Link adds flexibility as you build the I/O architectures. We generally refer to an IO-Link-based architecture as "distributed modular I/O." IO-Link is the first sensor actuator communication standard as described in IEC 61131-9. The communication with IO-Link is over three wires and utilizes a standard M12 prox cable; no special cables are required. An open IO-Link port on the field device can host as many as 30 I/O points or any smart sensor from over 115 IO-Link vendors from across the world. On the three-wire communication that IO-Link offers, you can have your process data, parameter data and even events data on the same line.

There are many more features and functions with IO-Link that a standard approach for a centralized wiring concept cannot offer—automatic parameterization, savings on labor, added diagnostics that can reduce downtime and most importantly reduction in human errors, so that as a machine builder you can get to market faster.

— Shishir Rege, marketing manager, industrial networking, Balluff, www.balluff.com

FOR SAFETY'S SAKE

Traditional servo technology used separate cables for feedback, power and brake control, so each servo needed two or three cables for motor control. With the latest servo and motor feedback technology, users can combine the power, feedback and brake signals into a single cable, thereby reducing wiring cable requirements by up to 60%. This not only helps save on installation time and costs, but also reduces the chances of wiring mistakes and the resulting troubleshooting time.

In addition, modern servo drives leverage network-based safety implementation. Compared to a traditional, hardwired, servo safety system, the network approach helps to reduce overall system wiring, save time during installation and remove potential points of failure, which can result in less downtime and troubleshooting. Modern integrated safety systems allow users to change safety zoning and configurations without needing to physically rewire devices.

— Jim Grosskreuz, global product manager, Rockwell Automation, www.rockwellautomation.com

IN ENCLOSURE OR ON MACHINE

A distributed I/O system can be either an IP20 or IP67 system. IP20 I/O requires mounting inside an enclosure, while IP67 is mounted directly on the machine. Typically, servo controllers are located in the PLC rack and cabled to the servo motors located along the packaging lines. There are numerous servo manufacturers today that have developed Ethernet-based servo systems with embedded servo control, such as CIP Motion, where an Ethernet connection is all that is required for both IP20- and IP67-based resolvers and servo signals.

Power to the servo motors are also available in distributed IP65/67 power cabling or the traditional power feed from an enclosure. Today, many packaging line manufacturers are utilizing IP67 Ethernet-based digital and analog on-machine I/O modules to take advantage of the Ethernet network and reduce field wiring.

In an IP67-based on-machine distributed I/O system, reducing field wiring decreases the typical startup time of a new system installation by removing the field terminations and replacing them with IP67 connections. These on-machine control systems enable you to move into production quickly, which in turn negates the initial higher cost of distributed I/O within the on-machine IP67 system. This is accomplished by simply removing the field wiring terminations, which are typically where most problems occur due to incorrect wiring, improper cable jacket stripping and loose screw terminations from incorrect torque.

— Ray DiVirgilio, machine builder industry manager (North America), Belden, www.belden.com

NEXT-GENERATION SOLUTION

Today's packaging machines require flexible and decentralized solutions to compete and meet the needs of their customers for the future. Many of the major OEM packaging machine builders come to us with the same question: With the cost of engineering, labor and materials ever increasing, how can you help us to improve and simplify our machine design, layout and fabrication?

With the need for machines to be reconfigured on the fly in order to accommodate additional axes, multiple package sizes or products, the need for motion and discrete sensing devices distributed throughout the machine is on the rise.

We have examined the needs for these next-generation machines and designed a flexible motion control solution with distributed I/O to reduce the cabinet size by up to 90% and reduce wiring needs, thus saving costly floor space by reducing and, in some cases, even eliminating the electrical enclosure. Such solutions encompass the entire machine, utilizing a single cable that is daisy-chained from drive to drive or I/O block. This eliminates the need to run every device back to the control cabinet, substantially reducing the wiring, complexity and cost.

The solution utilizes a single cable that transmits the main power for operating servo or induction motors, as well as EtherNet-based fieldbus communications for controlling the motion and I/O devices. This solution is extremely versatile as it utilizes a number of today's most popular protocols including SERCOS, EthernetIP, EtherCAT and ProfiNet with others on the way.

Instead of the machine design described by your reader with the servo controller, VFD and PLC I/O installed in the control cabinet and running costly cables out to each device, the solution mounts the servo controller directly onto the motor. Now, only a single cable is needed to be daisy-chained from drive to drive.

Each motor is equipped with four configurable input/output points that can be used at the OEM's discretion but also allow special functionality like high-speed capture of product or motor position that can be very costly to implement in many traditional PLC designs. Additionally, EtherNet breakout ports are available that allow fieldbus I/O or devices to be connected to the network.

Cabinetless power supply modules eliminate the need for putting high power contactors, inductors, filters and power supply in the control cabinet. Instead, IP65 modules are mounted directly on the machine base.

On bigger machines, this can eliminate the need for air conditioning of the main control panel, as well as reduce its size. These units are fully line-regenerative, which means that the energy used to stop the load/motion is put back into the power line instead of being turned into heat, thereby eliminating the need for resistor banks and providing a greener, more energy-efficient solution that fits well with many of today's corporate mandates.

This cabinetless design also lends itself to some of today's modular designs where the machine designer has divided the machine into function sections that perform a specific task. These modules can then be mixed and matched to meet the specific needs of the end user on the production floor. This also allows a section to be pulled out and replaced if the process changes in the future without the need to rebuild the entire machine.

Another point to consider when evaluating fieldbuses are the emerging requirements to support machine safety. U.S. machine builders are no longer able to sell a machine into the European market without this implemented. Many of the large corporate end users here in the United States are upgrading the internal standards to include machine safety on new machine installations.

Only a few of today's fieldbuses allow support for safety functions to be intermingled on the same bus network as the standard I/O, thereby requiring two networks on the same machine. A good example of this is SERCOS III that has support for safety functions up to SIL3, according to IEC 61508 via CIP Safety for SERCOS. This allows for safe motion, guard doors and light curtains to be on a signal network that operates the indicator lights, pushbuttons and sensors throughout the machine.

— Jeff Bock, senior application engineer, Bosch Rexroth, www.boschrexroth.com