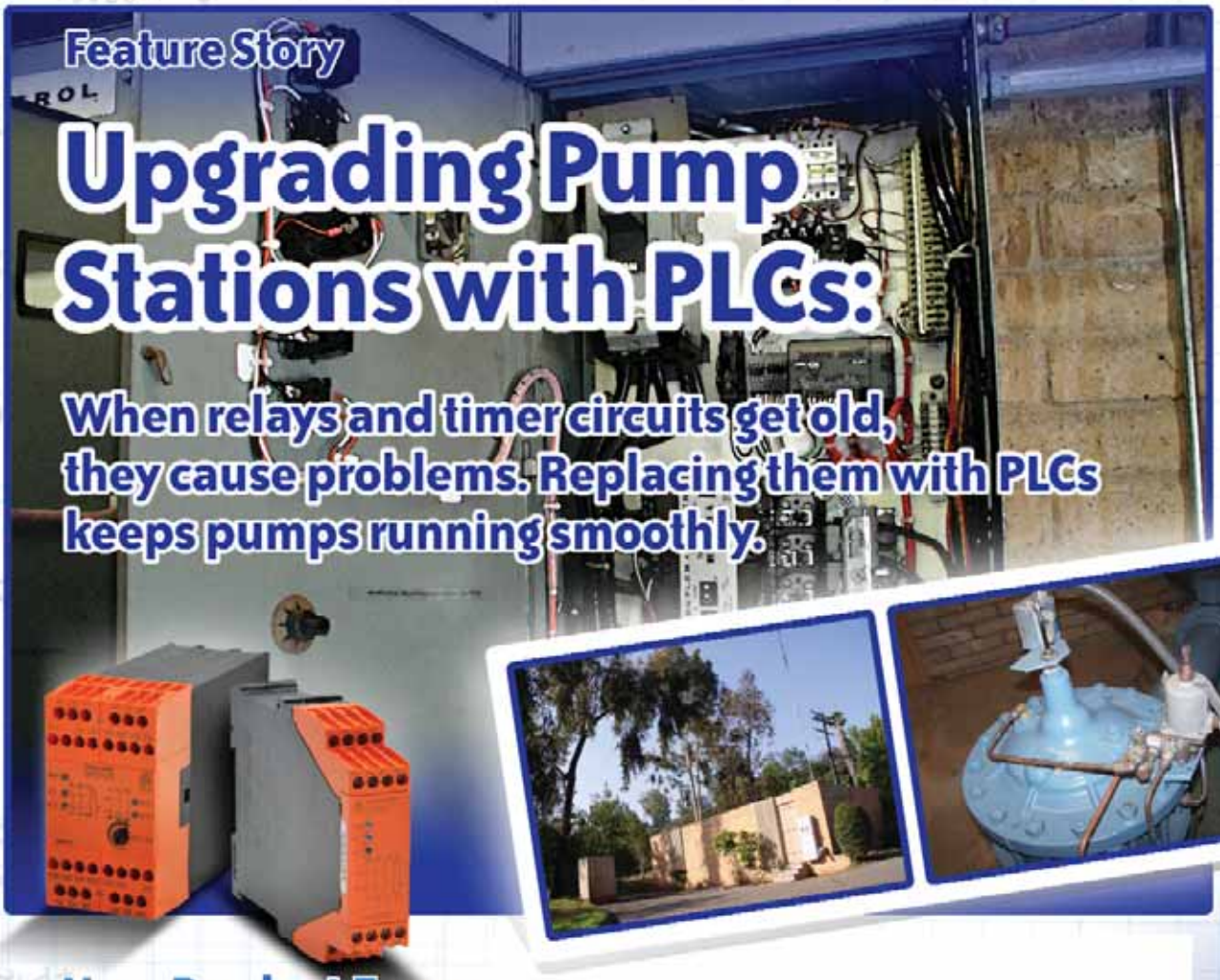
Your guide to practical products, technologies and applications

Automation NOTEBOOK®

Summer 2011 Issue 20



Feature Story

Upgrading Pump Stations with PLCs:

When relays and timer circuits get old, they cause problems. Replacing them with PLCs keeps pumps running smoothly.

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House Theater of Chicago

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Top 10 Tips: Specifying VFDs (Part one of a two-part series)

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For those who prefer to speak with us in person, please call 1-800-633-0405 x1845. Thanks for your interest, and we look forward to hearing from you.

Editor's Note

We hear in the news every day about skyrocketing gasoline prices. As fuel prices continue to soar, we also hear of new ways people are conserving. More people are telecommuting more often to save money. Others are finding more fuel efficient modes of transportation. They take the bus or train more often. Others choose to carpool. Many are buying alternative fuel vehicles. Whether it's biodiesel or electric energy, if it reduces the amount of gasoline being used, we're all becoming more open to the idea of not only saving money but also saving our energy resources. In what ways are you conserving?

Do any of your energy-saving applications use AutomationDirect products? We'd love to hear about them. Drop us a line explaining your industrial processes. You never know, your story just might find its way onto the pages of a future issue of Automation NOTEBOOK.

This issue of NOTEBOOK is filled with interesting articles and bits of information that just might inspire you to try something differently. We have lots of information regarding our newest products. An informative application story shows us how a theater group in Chicago used pneumatic cylinders to tell their story. Our Student Spotlight section provides details about a group of kids using our products to help capture energy from the sun.

There's a lot more, including the ever-popular Breakroom. Test your wits to see if you can solve the mind teasers. But, most of all sit back, relax, and turn the page…

TJ Johns
Coordinating Editor
editor@automationnotebook.com

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New Product Focus

what's new

Dold safety relays now available

AutomationDirect's safety product line now includes Dold safety relay devices for use in industrial applications. Used in conjunction with our light curtains and safety limit switches, these relays offer reliable control for machine safety applications.

LG5924 Series relays are single-channel E-stop relays designed to protect people and machines in applications with emergency stop buttons. Available with 24 VDC, 110 VAC, and 230 VAC coil voltages, the Category 2-rated relays are equipped with internal positive temperature coefficient resistor short circuit protection. Output configuration options include either two normally-open contacts, or three normally-open and one normally-closed contact. The normally-open contacts are safety contacts. Prices for LG5924 series safety relays start at $88.

LG5925 Series relays are dual-channel E-stop/safety gate relays designed for applications with emergency stop buttons and safety gates. Available with 24 VAC/DC, 110 VAC, and 230 VAC coil voltages, the Category 4-rated relays are equipped with internal positive temperature coefficient resistor short circuit and voltage-dependent resistor overvoltage protection. Designed with three normally-open positive guided safety contacts and one normally-closed monitoring contact, LG5925 relays provide a feedback circuit to monitor external contactors used for reinforcement of contacts, and feature monitored manual restart. Prices for LG5925 series safety relays start at $115.

The BH5928 Series relays are also designed for applications with emergency stops and safety gates. This dual-channel series provides one or two channels which can be monitored with the time delay function. Output configuration options include either three normally-open time delay positive guided safety contacts, or two instantaneous positive guided safety contacts and one normally-closed instantaneous monitoring contact. Three time delay options with potentiometer adjustment are available (depending on model) ranging from 0.1 to 30 seconds. The 24 VDC Category 4 relays are equipped with internal positive temperature coefficient resistor short circuit and voltage-dependent resistor overvoltage protection, and can be wired with or without cross-fail monitoring in the E-stop loop. Prices for the BH5928 series safety relays start at $198.

The BG5933 and BH5933 Series relays offer protection for applications with two-hand buttons or production machinery with dangerous closing movements. Available with 24 VAC/DC, 110 VAC, and 230 VAC coil voltages, the Category 4-rated relays are equipped with internal positive temperature coefficient resistor short circuit and voltage-dependent resistor overvoltage protection. These safety relays provide inputs for two pushbuttons, each with one normally-open and one normally-closed positive guided contact. Output configuration options include either two normally-open positive guided safety contacts and one normally-closed monitoring contact, or three normally-open positive guided safety contacts and one normally-closed monitoring contact. Prices for BG5933 and BH5933 series safety relays start at $139.

Category-4 rated light curtain controllers have also been added. Designed for light curtains with symmetric or asymmetric outputs, the LG5925 24 VDC light curtain controller features three normally-open positive guided safety contacts and one normally-closed monitoring contact and provides single or two-channel operation. The LG5925 light curtain controller is priced at $115. A multi-function features two normally-open positive guided safety contacts and one normally-closed monitoring contact; the controller can connect up to three light curtains, and offers protection, muting, and stepping modes. The multi-function light curtain controller is priced at $339.

The LG5929 extension module provides additional contacts for emergency-stop modules and safety gate monitors. Designed for one-channel or two-channel connection, the Category-4 rated extension module features five normally-open positive guided safety contacts and one normally-closed monitoring contact. The LG5929 extension module is priced at $95.

See the full line of Dold safety relay products at:
www.automationdirect.com/safety-relays

Safety is vital

and now everyone can afford more!

Don't let price stand in the way of making a machine or process as safe as possible

It could cost you a lot more in the long run. But you don't need to overpay to get reliable, high-performance safety devices that conform to all the latest standards. Our prices on safety relays, switches and light curtains mean you can do even more to protect what's important.

Safety relays protect people and machines.

- Single and dual channel safety relays for E-stop and safety gate applications
- Two-hand Control units for positive protection
- Light curtain controller modules are used in conjunction with light curtains for monitoring/control

Safety switches with key or hinge interlocks, limit switches and cable pull switches give precise, quick action.

- Visible operation
- Immunity to electromagnetic disturbances
- Electrically separated contacts with positive opening operation on N.C. contacts
- Actuation speeds of 0.5 m/s (max) to 0.01 m/s (minimum)
- IEC 947-5-1, EN 60947-5-1, UL 508, CSA C22.2 No 14 approvals

Safety light curtains in finger (14mm) or hand (30mm) protection resolutions

- Protective height: **14mm resolution - 142 to 1045mm**
  30mm resolution - 279 to 1827mm
- Operating distance: **14mm resolution - up to 3.5 mches**
  30mm resolution - up to 12 mches
- Double PNP outputs
- M12 quick-disconnect models (order cable separately)
- IP65 rated; Type 4 and Category 4 PL e

JUST A FEW PRICES ON SAFETY DEVICES

Product Description	AutomationDirect Price/Part Number
Safety light curtain with 30mm resolution - 24VDC, sender and receiver pair (sold separately) 0.25 to 12 meter operating distance, 279mm protective height, safety category 4	$250.00 YBB-30S4-0250-G012 (sender) $275.00 YBB-30R4-0250-G012 (receiver)
Safety limit switch, pull-reset action, plunger actuator, 30mm plastic body, 1/2 NPT	$12.75 AP2R11X11
Safety relay module, single channel, for E-stop circuits, 24 VDC, 2 N.O. contacts	$88.00 LG5924-02-61-24

AutomationDirect prices are U.S. published prices as of March 2011.
Prices subject to change without notice.

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Press Releases

AutomationDirect renews partnership with Kepware for communications

Kepware Technologies, the leader in Communications for Automation, has renewed its contract as AutomationDirect's communications supplier. AutomationDirect will deliver a single branded version of KEPServerEX called "KEPDirect OPC Server" for use with AutomationDirect controllers and remote I/O.

KEPDirect OPC Server connects your preferred Windows client software by providing a flexible and scalable communications and OPC server solution for connecting, managing, monitoring, and controlling AutomationDirect Ethernet remote I/O, DirectLOGIC PLCs, and Productivity3000 PACs. Communications is managed through a robust platform that supports an array of open standards, proprietary communication protocols, API's, and various automation system interfaces. KEPDirect OPC Server ($399) enables improved operations and decision making throughout all levels of an organization.

As a "Connected with Kepware" company, AutomationDirect will work with Kepware to ensure that the best communication support is developed for AutomationDirect products. "AutomationDirect has been an exceptional partner of Kepware for many years," said Tony Paine, President of Kepware Technologies. "We are not only extremely excited to renew our partnership, but also to expand on it by delivering additional connectivity to their new Productivity3000 PAC."

The companies will work together to support their joint customers through the partnership. Kepware will develop drivers for use on Windows™ desktop operating systems (Workstation and Server). The KEPDirect OPC Server will be available through AutomationDirect's website and their channel partners.

"The Kepware relationship is very important for us, as factory floor to boardroom data flow has become an integral part of manufacturing systems," said Jeff Payne, Product Manager for PLC, I/O, and PC Control of AutomationDirect. "The support for our Productivity3000 PAC is key for applications that can take advantage of its robust communications platform."

About Kepware Technologies

Kepware Technologies develops a wide range of communication and interoperability software solutions for the Automation industry. Our solutions allow you to connect disparate software and hardware systems, providing applications with quality, ease of use, and high performance. Furthermore, our in-depth experience with software design, development, support, and maintenance allows us to provide high-performance communications software without sacrificing quality and ease of use.

Learn more about KEPDirect OPC Server at:
www.automationdirect.com/kepdirect

Encapsulated transformers line expanded

The Hammond line of HPS Fortress commercial encapsulated single phase power transformers has been expanded to offer two new input voltage groups and to increase our existing voltage group up to 25kVA. The new voltage input groups include

277/240/208/120 VAC and 220/208/200/190x440/416/400/380 VAC. These new models allow for a broader range of input voltages and still maintain the 120x240 VAC output. All units are encapsulated with electrical grade silica sand and resin compounds to protect the core and coils, sealing out moisture and airborne contaminants and eliminating corrosion and deterioration. The NEMA 3R enclosures meet or exceed NEMA and ANSI standards for indoor and outdoor applications, and are UL and CSA listed as well as CE approved. The Fortress series encapsulated power transformers are backed with a 10-year limited warranty. Prices start at $77.

To see the full line of HPS Fortress commercial encapsulated power transformers, visit:
http://www.automationdirect.com/power-transformers

Inductive DC proximity sensors

The PEW series of stainless steel DC proximity sensors are flush-mountable shielded 8mm sensors with a 2mm sensing range. Available with either M8 or M12 quick disconnects, they are equipped with LED status indicators visible at wide angles, and have PNP outputs. PEW series inductive proximity sensors are priced at $45.

Also added are the LF40 series rectangular inductive DC proximity sensors. Two shielded and two unshielded models are available with 20mm or 35mm sensing ranges. The rectangular plastic

PNP sensors provide either normally-open or normally-open/normally-closed complementary outputs. LF40 series sensor prices start at $39.

To see the complete line of proximity sensors, visit : www.automationdirect.com/proximity

Compact fusible switches available

Gladiator™ compact fusible switches have been added to our line of circuit protection devices. The single-pole, two-pole and triple-pole AC devices are available in Class CC and Midget fuse models; single-phase DC devices are also available. The 35mm DIN rail mountable switches' compact size takes up only one-third the space of a molded circuit breaker and two-thirds the space of traditional fusible switches, saving space in control panels. The full

voltage rating of up to 600 VAC (80 VDC) allows installation flexibility in many applications where feeder and branch circuit protection are required.

Equipped with lockout/tagout capability and finger safe construction, Gladiator switches promote safe work-place practices by preventing contact with live components. Open fuse indication provides faster troubleshooting and reduced downtime.

Starting at $18, Class CC fuse models are UL98 listed and have a 200kA Short-Circuit Current Rating; Midget Class fuse models are UL 508 listed and have a 10kA Short-Circuit Current Rating. A 5A auxiliary contact with one normally-open and one normally-closed contact is also available for $9.

View the full line at: www.automationdirect.com/disconnect-switches

Current sensing line expands with ground fault sensors and DC current transducers and switches

The acuAMP® line of current sensors now includes AC ground fault sensors and DC current transducers and switches.

The GFS series of ground fault sensors monitors all current-carrying conductors in grounded single and three-phase delta or wye systems. Available in fixed-core models, the GFS series features jumper-selectable setpoints of 5, 10 or 30 mA. The sensors can accommodate up to 14 AWG copper wire and feature mechanical relay outputs with either manual or auto reset. The UL and CE approved GFS series of ground fault sensors start at $136.

The DCT series of DC current transducers combines a Hall Effect sensor and signal conditioner into a single package for use in DC current applications up to 400A. Designed to be compatible with most PLCs, data loggers and SCADA systems, the DCT series features jumper-selectable current input ranges and industry standard 4-20 mA or +/- 10 VDC outputs. Available in split-core or fixed-core models, DCT current transducer prices start at $117. DCS100 series DC current switches feature jumper-selectable current input ranges up to 100A and are available in normally-open solid-state and SPDT

relay output models. The switches are equipped with removable terminal blocks which accept up to 12 AWG solid or stranded wire. Prices for DCS100 DC current switches start at $90.

All acuAMP sensors are panel-mountable; convenient DIN rail adaptor accessories are also available.

The complete acuAMP series offers outstanding features, flexibility, and durability. Backed with a five-year warranty, the complete line of current transducers and switches provides dependable service for virtually any application.

See the full line of acuAMP current sensing products at: www.automationdirect.com/current-sensors

Photoelectric sensor line expanded

AutomationDirect's photoelectric sensor offering now includes 18mm rectangular plastic DC models. The IP67 rated sensors, available in 12 models, feature an 18mm diameter threaded lens and M12 quick-disconnect.

The GX3 series is a diffuse photoelectric available with either NPN or PNP light-on outputs and features background suppression technology with fixed sensing distances of 100 mm or 150 mm. GX3 series prices start at $49.

The GXP series is a polarized reflective photoelectric available with either PNP light-on output or NPN or PNP dark-on output and feature fixed sensing distances of up to 20 meters. GXP sensors include one round reflector. GXP series

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with lifetime warranty

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- **MQMJ** Control Series: 50 VA to 1.5kVA, 230x460 primary, 115x230 secondary
- **PG** Control Series: 50VA to 1kVA, 120x240 primary, 24x12 secondary

www.automationdirect.com/power

Encapsulated Transformers

The Fortress series of encapsulated transformers are single phase units, now available in 100VA up to 25kVA ratings.

The NEMA 3R enclosure makes them ideal for indoor and outdoor applications, such as schools, sports complexes, office buildings and lighting.

- 100VA to 25kVA sizes
- Input voltage ranges from 120 to 480 VAC
- Output voltages of 240 and 120 VAC
- NEMA 3R enclosure
- 10-year warranty

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prices start at $39.

The GXR/E series are through-beam photoelectric models available with either NPN or PNP light-on or dark-on outputs and offer fixed sensing distances of up to four meters. GXR series receiver prices start at $35. GXE receiver-dependent emitters are available for $30.

65mm mushroom head metal pushbuttons now available

Fuji Command 30mm metal push-buttons with 65mm mushroom-style operators are momentary non-illuminated pushbuttons available in four colors and come with either a single normally-open contact block (red available as normally-closed) or with one normally-open and one normally-closed contact block.

Replacement contact blocks are available in single packs. UL listed and CSA certified, prices start at $19. See the Fuji Command 30mm pushbuttons at: www.automationdirect.com/pushbuttons

"A committee is a cul-de-sac down which ideas are lured and then quietly strangled."

– Sir Barnett Cocks (1907–1989)

"The government's view of the economy could be summed up in a few short phrases: If it moves, tax it. If it keeps moving, regulate it. And if it stops moving, subsidize it."

– Ronald Reagan (1911–2004)

"What's another word for Thesaurus?"

– Steven Wright

Feature Story

Trends in Automation

Upgrading Pump Stations with PLCs: When relays and timer circuits get old, they cause problems. Replacing them with PLCs keeps pumps running smoothly.

By Henry Palechek
Process Control Supervisor

One of the most important jobs of a water distribution system is to reliably deliver water to its customers. At our water district in California, we had pumping stations (*Figure 1*) with relay-based controls that were more than 30 years old, and the vintage of the controls caused a definite reliability issue.

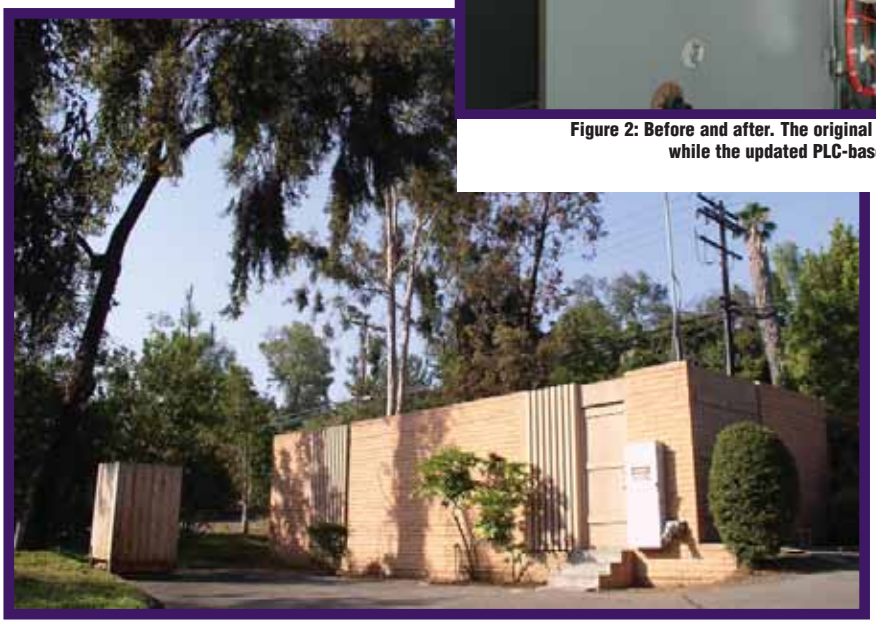

Figure 1: Typical pumping station in the water distribution system.

A typical pump station has three or four pumps, each powered by 100 or 125 horsepower motors. Because of the relatively large motor size, a part winding motor starting system is used with two motor starters. When the pump is turned on, the first motor starter is energized. Then, after a time delay, the second starter is energized.

Two types of timers were used in the control logic, pneumatic and electronic. As the pneumatic timers aged, they lost their timing repeatability. It was common to hear the motor strain while waiting for the second starter to pull in.

Figure 2, Before replacement

Figure 2: Before and after. The original relay-based system (above) was cluttered, while the updated PLC-based controls are much cleaner.

Electronic timers were sometimes even worse as their electrolytic capacitors failed over time. When the timers failed it was hard on the motor because it was running on only one starter until the overload tripped.

Personally, I've had to replace more of the electronic timing relays than any other device in the control circuit. I thought it was time to upgrade the pump controls and my company agreed, so we decided to investigate alternatives.

Taking a Test Drive

We decided to do a pilot test on two stations over a one-year period. We replaced all the pneumatic and electrical relays with DL05 PLCs from AutomationDirect (*Figure 2*). The PLCs were installed inside the motor control center (MCC) buckets by our in-house district electricians.

When the first pilot pump control circuit was changed over to PLC control, I set the delay time between the activation of the two motor starters to

0.5 seconds. Our control electrician didn't like the way the motor sounded, so with one quick edit I set the timer to 0.4 seconds. We've never had to readjust them since, and there's no longer any drift in the timing because the PLC is a digital device.

We were concerned about how well a PLC would hold up in the hot and electrically noisy environment of an MCC without cooling or a UPS, but they have proven to be very robust. The only failure we had was when a pump control valve's solenoid shorted out and pulled an excessive amount of current. Installing a fuse on the output solved the problem. It should be noted that this failure was our fault as we should have installed an output fuse in the first place.

We've since installed about 55 DL05 PLCs in our pumping stations, one on each motor, with no reliability issues in more than a decade of service.

Another advantage is the PLC simplifies and enhances pump operation. A typical MCC had hundreds of wires and dozens of relays (*Figure 3*) in multiple buckets. In some cases the wire numbers had fallen off over time, which made troubleshooting very difficult. In addition, the control logic only provided one alarm pump timeout. When a pump failed to start properly, we were never sure why it had failed.

Figure 3: The pile of parts left over when a PLC replaced relays in an MCC.

The specific problem was that when a pump failed to operate properly, it would time out and couldn't be restarted until manually reset by an operator. This reset cleared the timeout relay logic, making it hard for the technician to troubleshoot the problem.

Now, the PLC is programmed so the alarm can be reset by the operator; this allows the pump to run, while maintaining failure information in the ladder logic until the relevant area of the PLC program is reset by the technician. This gave us better flexibility in that a failed pump can be returned to service without losing information vital to the troubleshooting process.

Another enhancement was to expand the type of alarms sent back to the central SCADA system. Now, the alarm is defined three different ways: pump fail, MCC fail, or pump control valve fail. Before the upgrade, it was common to have a few pumps fail to start every week, but that's no longer the case.

Dealing with water hammer

In a water distribution system, another area of concern is always water hammer. Water hammer occurs when water flow is halted abruptly, causing a shock wave to travel through the line. The force of the shock wave can cause severe damage to critical control parts. When a large pump is started in our water pumping application, a pump control valve is used on the output of the pump to stop the possibility of a water hammer (*Figure 4*).

The motor is started into a closed pump control valve, and the valve is allowed to open slowly. On shutdown, the valve is closed slowly and a microswitch notifies the controller to turn off the motor.

Here's the sequence of events that occur when a large pump is started:

1. The first motor starter pulls in
2. The second motor starter pulls in
3. The pump control valve is commanded to open
4. The pump control valve is monitored to ensure it fully opens

Every step is timed, and if there's any failure of the proper sequence the motor is automatically turned off. The pump is then held out of service until an operator investigates the problem and pushes a reset button.

The old system was a nightmare to troubleshoot with its pneumatic and electrical relays. Now, with the PLC, finding the source of the problem is much easier.

The PLCs have allowed us to solve our control issues at a low cost with high

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Figure 4: A pump control valve prevents water hammer by opening and closing according to a careful timing sequence.

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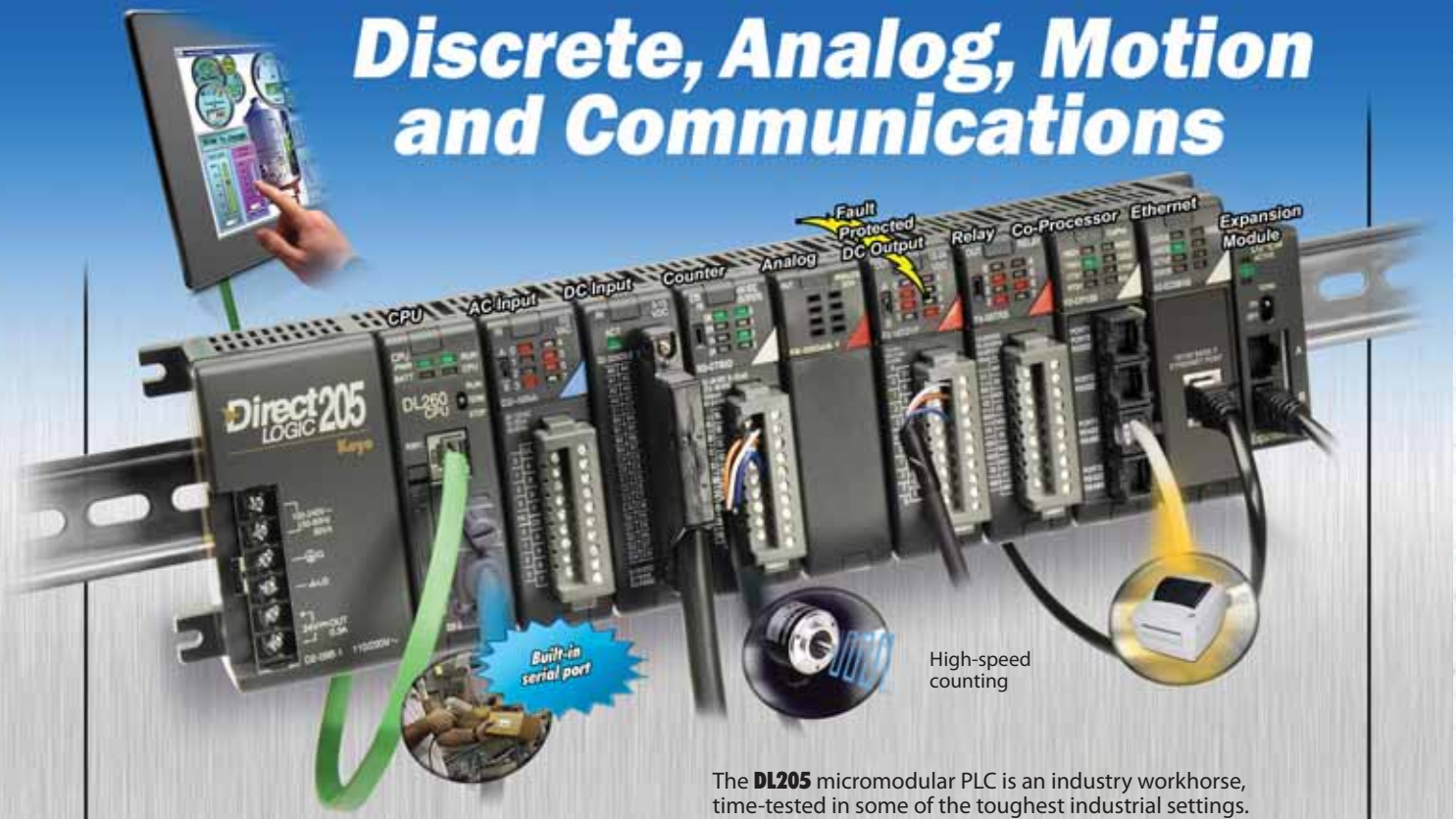

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DISCRETE: Choose from **25 discrete modules** that support AC, DC and relay I/O types. All modules have removable terminal blocks for easy wiring and module replacement. Our newest DC output module performs electronic short circuit protection.

ANALOG: 19 analog modules offer interfaces to current and voltage signals, as well as thermocouples and RTDs. Connect devices such as process transmitters, proportional valves and AC drives.

HIGH-SPEED/MOTION: Counter modules include a simple counting input module or a high-speed input/pulse output module for interfacing to stepper or servo drives. Using our SureServo or SureStep motion systems with the DL205 gives you a very cost-effective motion control system.

COMMUNICATIONS: The DL205 series makes **Ethernet communications** easy and inexpensive. Get fast peer-to-peer access to HMI, other PLCs and PCs on the factory floor at one of the lowest costs per node in the industry.

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DC 16-pt. input	$86		$236	
DC 16-pt. output	$94		$308	
Isol. relay 8-pt. out	$99		$284	
Analog Modules				
4-channel input (current)	$199		$476	
4-channel thermocouple in	$299		$967 (6-ch)	
8-channel output (voltage)	$269		$1,430	
Communications				
Ethernet interface	$299		$783	

* All prices are U.S. published prices. Prices and specifications may vary by dealer and configuration. AutomationDirect prices are from March 2011 Price List. Allen-Bradley prices are based on www.rockwellautomation.com/en/e-tools 3/7/11.

www.automationdirect.com/plcs

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Feature Story Cont.

Trends in Automation

Continued from, p. 11

reliability. We still use the brick style *Direct*LOGIC DL05 PLC in existing MCCs, but in our new MCCs we've upgraded to the DL06 PLC, which has more expandability and a local LCD display option. We expect similar reliability from the DL06 PLCs, along with continued ease of use and superior vendor support.

About the Author

Henry Palechek is the information systems and process control supervisor at a water utility in California. He's been with the utility for over 16 years. He holds a Bachelor of Science in Information Systems, and has been teaching water technology courses at the local community college since the mid 90s. He also holds a California T3 Operator license.

"Arithmetic is being able to count up to twenty without taking off your shoes."

– Mickey Mouse (1928–)

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Auxiliary power supply (0.5A), 100-240 VAC input, 24 VDC 0.5A output	$29.00 C0-00AC
AC input module, eight 100-120 VAC points	$40.00 C0-08NA

AutomationDirect prices are U.S. published prices as of March 2011. Prices subject to change without notice.

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System Integrator Corner

UL 508A Certified Panel Shops

By Tim Roberts,
AutomationDirect

Several member integrators in AutomationDirect's SIDirect program have UL 508A certified panel shops. Although many installations and applications do not specify adherence to the UL 508A standard, it's good to be aware of the benefits of UL listing for your control panels.

The UL listing mark on an industrial control panel provides evidence of third party certification. It indicates that the panel complies with an accepted and specific safety standard. The listing mark may be applied to a wide variety of designs – from custom built to standardized designs with minor modifications.

While there is a confusing array of electrical safety standards to contend with, from the overarching national electrical code (NEC) to specific areas affecting control panels, such as NEC Article 409, the most commonly referenced standard for industrial automation applications is UL 508A. Briefly stated, UL 508A is the standard for Safety of Industrial Control Panels. The requirements specified in UL 508A are in turn based on UL 508, the standard for Safety of Industrial Control Equipment, the NEC, NFPA 70 and the standard for industrial machinery, NFPA 79. One important service a certified UL 508A panel shop offers is to apply these standards to customer applications and designs.

Out of the 38 system integration firms in the USA that are members of AutomationDirect's SIDirect Program, the following ten are UL 508A certified Panel Shops.

Please contact them to find out how they can meet your UL 508A panel requirements.

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MILWAUKIE, OR 97267
Contact: Bill Pascoe
Phone: 971-506-9338
Web site: www.YourAPS.com

HEYWOOD ENGINEERING, INC
RENO, NV 89511
Contact: Lance Heywood
Web site:
www.heywoodengineering.com

ICAD
Fresno, CA 93725
Contact: Cliff Taylor
Web site: www.icadautomation.com

ROBEY CONTROLS
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Contact: Timothy Robey
Web site: www.robeycontrols.com

AI CONTROL SYSTEMS
Reading, PA 19605
Contact: Sales
Web site: www.aicontrols.com

INDUSTRIAL AUTOMATION
La Crosse, WI 54602
Contact: Herb Burfield
Web site:
www.industrialautomation.us

ONEIL ELECTRIC CO
Greeley, CO 80631
Contact: Greg O'Neil
Web site: www.oneilelectric.net

PACIFIC COAST AUTOMATION, INC
Modesto, CA 95356
Contact: John Keller
Web Site: www.pca-inc.com

S&L AUTOMATION, INC
Lenoir, NC 28645
Contract: Lori Pless
Web site: www.sandlautomation.com

ENER TECH ASSOCIATES, INC
Harrisburg, PA 17112
Contact: Sam Morello
Web site: www.eta-inc.com

"If there's anything unsettling to the stomach, it's watching actors on television talk about their personal lives."

– Marlon Brando (1924–2004)

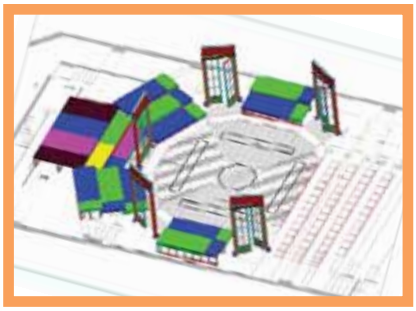
User Solutions

creative control solution

House Theatre of Chicago

By Ryan Poethke

House Theatre of Chicago's original-script production of The Nutcracker demanded moving, changing scenery that magically transformed the set at the push of a button. AutomationDirect's extensive line of pneumatic and electrical components helped us realize these design elements easily, elegantly, and reliably.



<u>The doors:</u>

The set design consisted of five sets of custom built French door units which were completely freestanding. These door units provided the "theatre-in-the-round" entrances for the actors. At the climax of the show, when young Clara's world is about to fall apart, scenic designer Collette Pollard envisioned the world physically cracking and beginning to come apart.

Using AutomationDirect's single-acting pneumatic cylinders, the "door toppers," situated above the doors, pivoted from one side, pushed up by the cylinder.

The cylinders were embedded in the vertical doorframe posts. The frames were constructed of 2" square steel box tube to provide a hollow space for the cylinders, and then cased in wood to provide the proper dimensions and appearance.

To prevent binding, the cylinder was topped with a plastic ball which allowed the end to slide as the cylinder extended. The air line ran down the frame and out to the control panel upstage.

<u>The tree:</u>

The closing scene of Nutcracker called for a small Christmas tree to magically grow from the stage on command. The design team wanted a

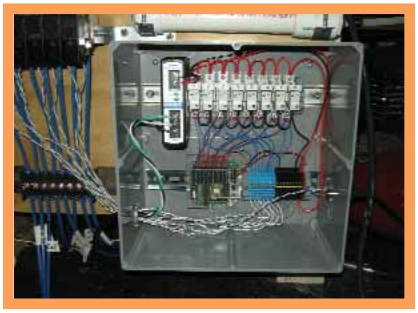
tree that grew from nothing to approximately 18 inches. The tree planter, filled with fake snow, had a false bottom which the tree punched through to magically appear when desired. Our "Charlie Brown Tree" was built from various diameters of polyethylene tubing wrapped with soft iron wire and covered with painted heatshrink tubing. The hinges at the base of the branches were simply short lengths of extension spring which allowed the tree to collapse into a piece of 1.5" PVC pipe.

The tree was pushed up through the floor by a 1" bore, 18" stroke double-acting cylinder. The double-acting feature allowed the stage crew to easily retract and reset the tree between performances.

The cylinder was able to push the tree around the 90-degree bend because the tree's "trunk" was also made of poly tubing; flexible yet rigid enough to withstand pushing by the cylinder.

There are three air lines attached to the under-stage tree mechanism; one each to extend and retract, as well as a purge line that was used to blow the

fake snow out of the tree storage tube before retraction. The purge line was added after we found that the fake plastic snow which fell into the tube prevented the tree from moving smoothly. It is important to note that the tree itself remained vertical and never "turned the corner." The horizontal portion contained only the travel of the cylinder and the poly tubing "pushrod."



The control panel:

The AutomationDirect three-way pneumatic valves were operated by an eight-way MIDI-to-relay card through single-pole interposing relays. MIDI control was chosen as it is a control protocol native to the audio world; since the effects had to fire in time with sound effects, it made sense to allow the audio playback computer to control the actuation of the valves.

It might be noticed that even though we have a double-acting cylinder for the tree, all eight valves are 3-way, and not necessarily suited to controlling a double-acting cylinder. We simply used two 3-way valves, one for each side of the cylinder, to minimize air loss around the seals of the cylinders. Because we could not run our compressor during the show due to noise, our air supply was limited. Use of the single-acting cylinders was limited to a rather short time, and the tree's cylinder did not need air once it was extended or

retracted. The purge line used to blow the fake snow out from around the tree was only used post-show, and thus we were able to run the compressor as needed for additional air.

A large white cylinder was mounted to the left of the panel to serve as a muffler; it silenced the sound of venting air as the cylinders were extended and retracted. It was built from 3" diameter PVC pipe and fuzzy paint rollers with their center tubes glued closed. This forced the air through the nap of the rollers and out through a grate on the bottom of the pipe.

Our use of AutomationDirect's extensive line of pneumatic and electric supplies and parts allowed House Theatre to tell the tale of The Nutcracker in ways that truly brought the audience into the story. Without support from AutomationDirect, House Theatre would not have been able to add this dimension of scenery movement and magic to our storytelling.

Tech Thread

temperature control

PLC-based system works where single loop temperature controllers fell short

By Tim Hanes,
AutomationDirect
Process Instrumentation Equipment
Product Engineer

In many applications, single loop temperature controllers are sufficient to provide control of heating and cooling. But in some applications, including the one detailed in this article, closely coordinated control among many temperature control loops is needed. In those cases and others, PLC-based temperature control can be the best solution.

A meltblown machine, a melted polymer extrusion machine used in manufacturing nonwoven materials, consists of four main components. An extrusion system provides a steady supply of molten polymer, and a heated spinbeam distributes the polymer into an even sheet or web. A heated process air system is used to attenuate or stretch the fibers, and a vacuum system removes the process air as the nonwoven web is formed.

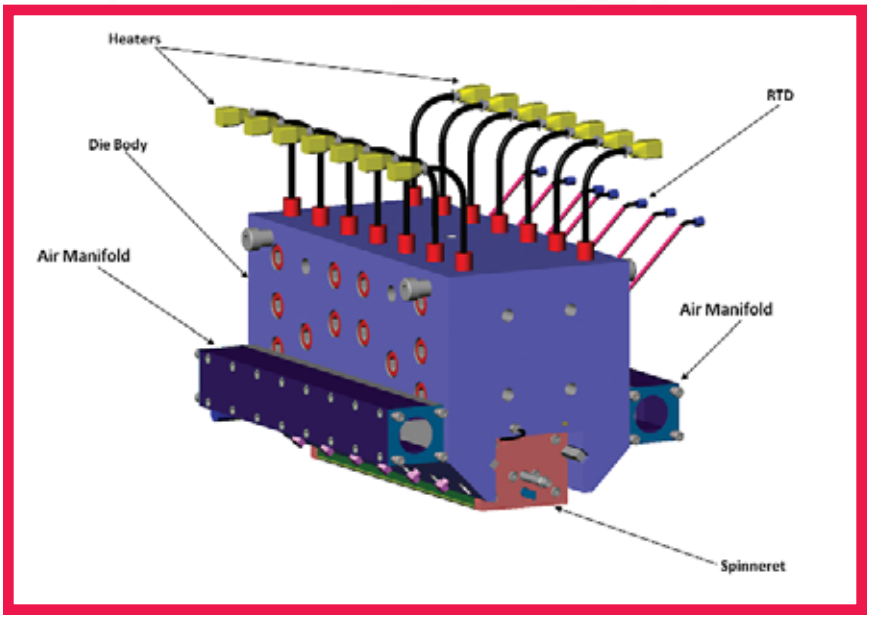


Figure 2, Example of Meltblown Die Assembly

The spinbeam consists of a large 304 stainless steel die body block weighing approximately 8 tons, and heated by 72 1.1 kW electric cartridge heaters. The heaters are paired into 36 zones spaced on 4" intervals down the length of the block.

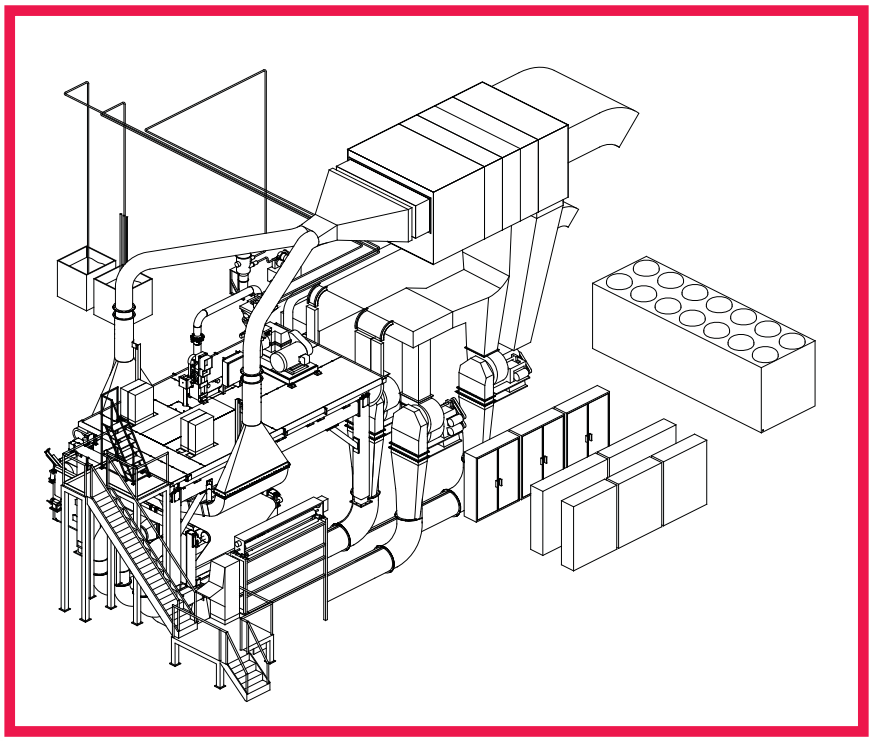


Figure 1, Machine diagram.

On this machine, each of the 36 zones had a PT100 RTD temperature sensor for feedback to that zone's single loop temperature controller. An output from each controller switched a pair of cartridge heaters to maintain an average block temperature around 425°F. Biasing setpoints for each of the 36 individual zone temperature controllers could be entered by the operators of the machine to adjust the temperature profile across the length of the spinbeam.

Process air heated by a 320 kW electric circulation heater is delivered by a low pressure blower through large air manifold assemblies. These assemblies are constructed of 0.75" thick 304 stainless steel plate attached to the die body using 28 12mm grade-8 bolts.

Varying Rates of Thermal Expansion

Thermal expansion of metal as it is heated is normally not a problem if all assembled parts expand at the same rate, or if clearances with tolerances down to the thousandths of an inch aren't required. But in this case, there were

Figure 3, Example HMI Screen

significantly different rates of thermal expansion for the die body and the air manifold. This was causing these two components to separate to the extent that the bolts connecting the assemblies were shearing.

When the meltblown machine was started, the solid die body was heated with the cartridge heaters at a rate of 2° per minute. The air manifold assemblies were heated only by the pre-heated process air, and were thus increasing in temperature at a rate of about 1° per minute. With the two different heating rates, it didn't take long to develop a significant temperature differential between the die body and the air manifold assemblies.

Because the solid stainless steel die body was more efficient at conducting heat than the hollow air manifolds, it could expand in length by as much as 1% (or 1.4 inches) before the air manifolds could expand. Something had to give, and in this case it was often one or more of the 28 bolts attaching the air manifold assemblies to the sides of the spinbeam.

The workaround solution was continuous intervention from the machine operators to monitor the die body and air manifold temperatures, and to adjust the temperature setpoints on the 36 individual controllers as required. A better solution was needed, one that replaced constant operator attention with automated control.

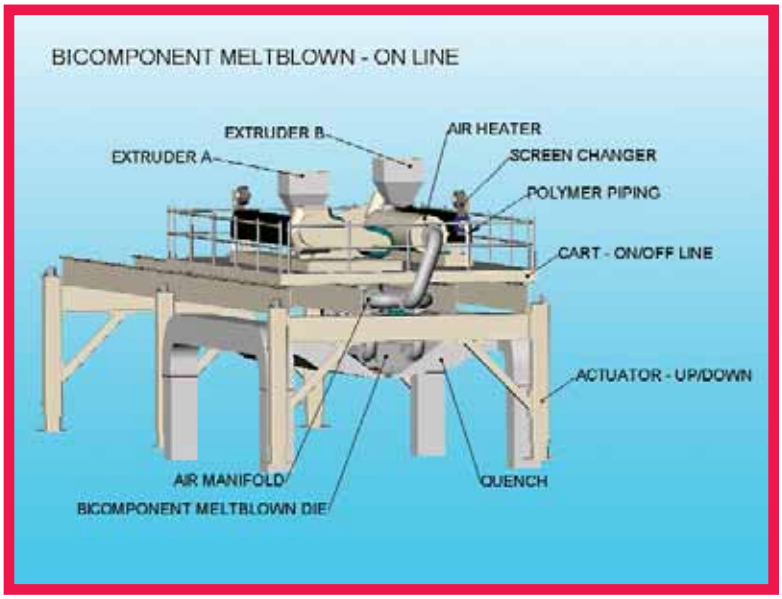


Figure 4, Example Bicomponent Meltblown Machine

The Power of the PLC

After analysis and process trials, it was determined that the system could handle a maximum temperature differential of about 50°F between the die body and the air manifolds without shearing the bolts.

One possible solution to maintain a maximum temperature differential was to install heaters and additional controls on the air manifold assemblies. However, due to their complex shape and space limitations, this solution was cost prohibitive.

A better solution was an improved automation system in the form of a PLC and a Human Machine Interface (HMI). Historically, PLCs were used for discrete control applications, but today's powerful PLCs have greatly expanded capabilities, particularly in the area of analog monitoring and closed loop control. These capabilities are provided in compact and low cost controllers featuring ease-of-use and a high degree of connectivity.

On the meltblown machine, the individual single loop controllers were eliminated and the 36 RTD zone temperature sensors were wired to individual analog inputs at the PLC. Also, temperature sensors were added to monitor the incoming temperature of the pre-heated process air entering the air manifolds.

Using the PLC's internal math functions, the 36 die body zone temperatures are averaged and compared to the incoming air temperature in the air manifolds. Based on the measured temperature differential, the PLC automatically

Continued, p. 21>>

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Tech Thread Cont.

temperature control

Continued from, p. 19

ramps the setpoints of the die body zones to individually control each zone's pair of cartridge heaters. Specifically, the PLC determines the correct setpoint for each of 36 PID control loops. Each loop reads an RTD input as the process variable, and uses the internally derived setpoint to modulate a control variable analog output to control the heaters.

This PLC-based control solution allows the machine to automatically heat at a rate that is compatible with the thermal expansion of the different components. The bolt shearing problem was solved, and the need for constant operator intervention was eliminated.

In addition, pre-programmed biased setpoint temperature profiles in the PLC can now be automatically used as required, eliminating the need for machine operators to enter separate biasing setpoints in the individual single loop controllers.

In addition to the improved control functionality, the PLC continuously provides and trends valuable data to the HMI, such as the process variable, the setpoint including any biasing, and the loop output control variable. Alarm points and conditions, either globally or for each loop, can also be viewed at the HMI. Touch screen HMI inputs allow changes depending on different conditions such as the polymer type.

Prior to the use of PLC-based control, constant operator intervention was required to provide safeguards against damage and to manually track various process conditions. By introducing PLC-based control, possible machine damage due to varying rates of thermal expansion has been eliminated, and valuable insight provided by tracking and trending data that wasn't readily available from the single loop controllers.

For complex temperature control applications with different heating or cooling profiles, PLC-based control offers a versatile, powerful and cost-effective solution. When paired with a touch screen HMI, additional process data can be viewed and analyzed, with adjustments to improve operations easily entered through the touch screen.

"Success is liking yourself, liking what you do, and liking how you do it."

– Maya Angelou (1928–)

"Instant gratification takes too long."

– Carrie Fisher (1956–)

"Money can't buy happiness, but neither can poverty."

– Leo Rosten (1908–1997)

Business Notes

Goings-on in the Industry

By Joan Welty,
Managing Editor

Kickstart and other new videos

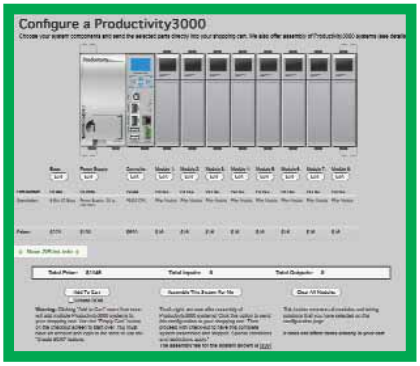
Have you seen the newest products launched by AutomationDirect? Now you can watch short videos with product descriptions, features and tips. Our new "KICKSTART" video program can be found on our Learn site and on our YouTube channel. Check out these short two-minute videos on products such as our new compact air cylinders, coiled air hoses, compact fuse switches and more.

Visit:
http://learn.automationdirect.com and look for the Kickstart tab along the top.

Or, go to:
www.youtube.com/automationdirect, where you can subscribe to our YouTube channel and leave comments on each video.

Other videos released recently include a four-part tutorial series where product manager Jeff Payne shows you how to use the many features of the Productivity3000 PAC programming software. Watch these under the Software tab on the Learn site.

Value Added Services



In keeping with our objective to provide the best value in industrial control products, AutomationDirect's new Value Add Services department provides customers with cost savings by packaging some of our high-quantity packaged products into smaller pre-defined quantities. Product areas where this has been done include fuses, supplementary protectors, DIN rail, and flexible cord.

Other services include some pre-assembly and customization. We can pre-assemble Productivity3000 controller racks with I/O modules based on your specifications. For a nominal charge, this service can save you time and effort, allowing you to complete projects or machine assembly more quickly. For more information on this assembly service, please visit the Productivity3000 Web site. (www.aboutplcs.com/p3000)

For OEMs, we offer a service to apply customer-supplied logo overlays to our products, which gives the equipment a custom look. We're continuing to find more ways to meet your specific needs. If there is something we could do for you, we welcome the opportunity to evaluate the idea.

Give us your 2 cents

Our newest online Customer Forum category is where you can tell us what you think. The Give Us Your 2 Cents forum is the place to provide feedback and make requests on anything from Web seminar topics to Web store features to our company in general, you name it. You'll have opportunities to participate in brief surveys, provide application story ideas and answer occasional questions. Go to http://forum.automationdirect.com and look for the "Give Us Your 2 Cents" Forum.

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We have tried to make our product return process one of the easiest and least stressful you've experienced. As a matter of fact, we get "love letters" from customers telling us how pleasant it was to return a product to us! (We love to hear that, but we don't recommend doing it just for the experience.) But when you really do need to return a product that is under warranty, you can now obtain the Return Authorization

under your account via the Web. (All date codes and/or serial numbers must be supplied before the RA can be issued.) The process is this easy:

1. After you have logged in to your AutomationDirect account, visit our Returns page and choose the appropriate return reason.
2. You'll see a list of your orders which fall within the selected return window. Choose the order which contains the items you wish to return.
3. Verify your contact information, view the list of items from your order, and enter the quantities you need to return. Then "Submit" the return.
4. The Returns Team will look over your return request, and if everything checks out, the necessary paperwork and instructions will be sent to you immediately. (You can also obtain a 30-day money-back return authorization online.)

AutomationDirect sponsors VEX Robotics World Championships

AutomationDirect was pleased to sponsor the recent VEX Robotics World Championships at the ESPN Wide World of Sports Complex (within Disney World) near Orlando, Florida April 14-16. Over 500 teams comprised of 3500 high school, middle school, and collegiate students came together to celebrate their accomplishments and compete with (and against) the best of the best. These were the top robotics teams from over 200 VEX tournaments that took place around the world from May 2010 to March 2011.

Eleven teams from our local school system (Forsyth County, GA) qualified to attend, and one of those teams (from North Forsyth High) made it to the semifinal round! Congratulations to all the teams who made it to Orlando.

After a series of intense back-to-back matches and elimination rounds, the High School Champion alliance emerged with teams comprised of Massachusetts' Green Egg Robotics Club, Washington's W.A.S.A.B.I. 2 and Ontario, Canada's Simbotics teams.

The Middle School Champion represented an alliance of China teams from Sichuan Chengdu Longjiang Road Primary School and the Shanghai Luwan Teenagers Activity Center.

The College Championship title went to Massey University from New Zealand. In addition, one team from each of the three divisions was presented with an Excellence Award, the highest honor in the VEX Robotics Competition, given to the team with the most well-rounded VEX Robotics Program. Middle School, High School and College Excellence Award winners included, the VEXMEN: NightCrawler team from Downingtown Area Robotics in Downingtown, Pennsylvania, the Cheesy Poofs from Bellarmine College Prep in San Jose, California, and Massey University in New Zealand.

Learn more about VEX: http://www.vexrobotics.com

Tech Brief

variable frequency drives

Top 10 Tips: Specifying VFDs (Part one of a two-part series)

By Joe Kimbrell,
AutomationDirect
Drives, Motors, and Motion Control
Product Manager

Variable frequency drives — or VFDs — can reduce energy consumption, improve real-time control, and lengthen motor life; selecting the right one for your application requires asking the correct questions. Here are some expert tips to consider.

Determine if a VFD is right for your application.

The primary function of a variable frequency drive is to vary the speed of a three-phase ac induction motor. VFDs also provide nonemergency start and stop control, acceleration and deceleration, and overload protection. In addition, VFDs can reduce the amount of motor startup inrush current by accelerating the motor gradually. For these reasons, VFDs are suitable for conveyors, fans, and pumps that benefit from reduced and controlled motor operating speed.

A VFD converts incoming ac power to dc, which is inverted back into three-phase output power. Based on speed setpoints, the VFD directly varies the voltage and frequency of the inverted output power to control motor speed. There is one caveat: Converting ac power to a dc bus — and then back to a simulated ac sine wave — can use up to 4% of the power that would be directly supplied to a motor if a VFD were not used. For this reason, VFDs may not be cost-effective for motors run at full speed in normal operation. That said, if a motor must output variable speed part of the time, and full speed only sometimes, a bypass contactor used with a VFD can maximize efficiency.

Consider your reasons for choosing a VFD.

Typical reasons for considering VFDs include energy savings, controlled starting current, adjustable operating speed and torque, controlled stopping, and reverse operation. VFDs cut energy consumption, especially with centrifugal fan and pump loads. Halving fan speed with a VFD lowers the required horsepower by a factor of eight, as fan power is proportional to the cube of fan speed. Depending on motor size, the energy savings could pay for the cost of the VFD in less than two years.

Using VFDs to operate fans and pumps can significantly reduce energy consumption, because they can tailor fan speed to the application. Fan horsepower is proportional to the cube of fan speed, so depending on motor size, energy savings can compensate for the initial VFD purchase price in less than two years.

Starting an ac motor across the line requires starting current that can be more than eight times the full load amps (FLA) of the motor. Depending on motor size, this could place a significant drain on the power distribution system, and the resulting voltage dip could affect sensitive equipment. Using a VFD can eliminate the voltage sag associated with motor starting, and cut motor starting current to reduce utility demand charges.

Controlling starting current can also extend motor life because across-the-line inrush current shortens life expectancy of ac motors. Shortened life cycles are particularly prominent in applications that require frequent starting and stopping. VFDs substantially reduce starting current, which extends motor life, and minimizes the necessity of motor rewinds.

The ability to vary operating speed allows optimization of controlled processes. Many VFDs allow remote speed adjustment using a potentiometer, keypad, programmable logic controller (PLC), or a process loop controller. VFDs can also limit applied torque to protect machinery and the final product from damage.

Controlled stopping minimizes product breakage or loss, as well as equipment wear and tear. Because the output phases can be switched electronically, VFDs also eliminate the need for a reversing starter.

In addition to varying speeds, conveyor applications typically require frequent starting and stopping. Here, VFDs substantially reduce starting current to extend motor life.

Select the proper size for the load.

When specifying VFD size and power ratings, consider the operating profile of the load it will drive. Will the loading be constant or variable? Will there be frequent starts and stops, or will operation be continuous?

Consider both torque and peak current. Obtain the highest peak current under the worst operating conditions. Check the motor Full Loads Amps (FLA), which is located on the motor's nameplate. Note that if a motor has been rewound, its FLA may be higher than what's indicated on the nameplate.

Continued, p. 28>>

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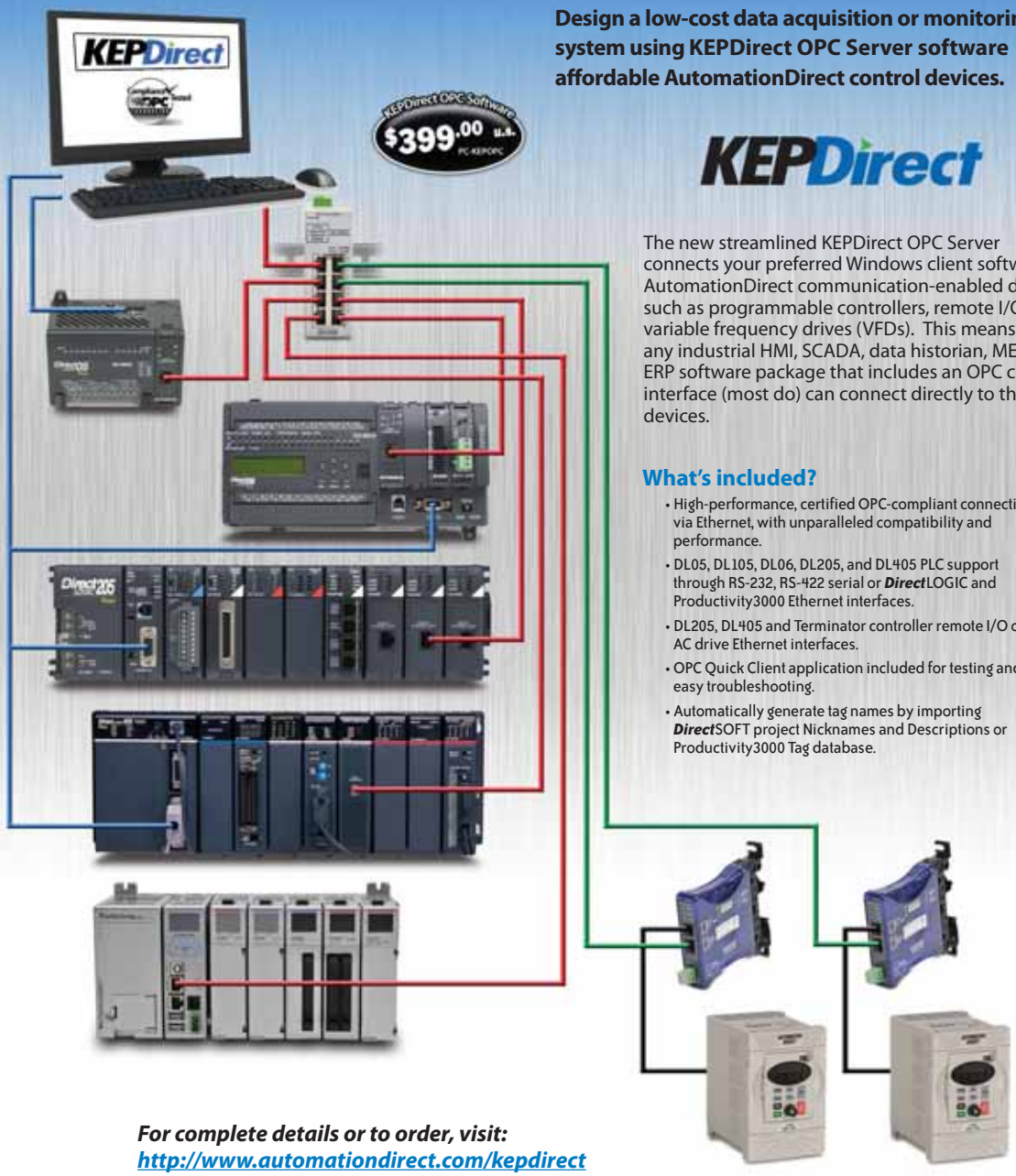

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Student Spotlight

The Future of Technology

Multi-mirror Solar Array

Pleasantville High School
Pleasantville, Iowa

Provided by Chip McDaniel,
AutomationDirect

The Industrial Technology students at Pleasantville High School, in Pleasantville, Iowa (southeast of Des Moines), have spent the last three years building a multi-mirror solar array. Students from four different technology classes have contributed to the project over the three year period; the AutoCAD and drafting classes have helped design and document the project, students in the metals class performed much of the welding and other fabrication tasks, while students in the electronics class have wired the machine and programmed the PLC. Instructor Frank Vanderpool has been the teacher and mentor who has championed the project from its inception.

Sunlight is focused on a solar heat exchanger positioned at the focal point of the array. Water is warmed inside the solar heat exchanger and then piped indoors to a storage tank and radiator in the nearby school shop where it is used to heat the room, before circulating back out to the solar heat exchanger to be reheated.

The array consists of 96 one-foot-square mirrors positioned in a 10x10 array. The four mirrors in the center of the array were omitted – because they would always be occluded from the sun by the solar exchanger. The array/exchanger assembly is hinged and fitted with wheels so that it can track the sun with both altitude and azimuth motions during each day. Two SureStep stepping systems from AutomationDirect are used to power these two axes of motion via custom gearboxes designed and built by the students.

Three simple photo-resistors are used as sunlight detectors to monitor the position of the sun. These photo-resistors are enclosed in narrow tubes, each with a slit facing skyward. The tubes are aimed ever so slightly away from the angle of the array - so that when sunlight reaches the bottom of the tubes and excites the photo-resistor, this light signals a need to move the array to keep alignment with the sun. One detector is used to monitor the azimuth axis, as the sun only moves in one direction across the sky each day, but two are required for the altitude axis, as the sun rises in the sky during the morning and then falls in the afternoon.

Figure 1

A *Direct*LOGIC DL06 PLC accepts discrete inputs from the sunlight detectors and uses that information to control the motion of the two stepper systems via H0-CTRIO modules. Additional logic in the PLC is used to approximately position the array on cloudy days so that if/when the clouds dissipate the array is positioned to begin its automatic operation. The PLC controls the flow of water through the solar heat exchanger, and also controls a pump inside the storage tank. Analog inputs to the PLC allow the monitoring of temperatures in four locations: at the solar exchanger, at the point where the water enters the building, inside the storage tank, and the temperature of the air inside the shop. Based on the various temperatures, the PLC opens and closes a valve to regulate the flow of water through the loop, and most importantly to stop the flow of water if the array is not producing heat for some reason (perhaps a cloud is blocking the sunlight). The PLC also controls the flow of water across a second heat exchanger inside the storage tank in order to maximize the heat transfer into the storage tank when possible.

Figure 2

On a sunny day the results can be more than impressive. In fact, on several occasions, the water has boiled and pressurized steam (measured at over 104°C) has caused problems such as blown hoses, requiring the team to reevaluate their design and method of operation. Other issues involved the inadvertent focusing of sunlight on a wooden component which actually caught on fire. Today, they have those issues resolved and water temperatures in the storage tank average about 165-180°F even on moderately sunny days. They routinely heat the shop exclusively with solar energy throughout the day and even for a few extra hours after the sun goes down due to the thermal energy stored in the tank.

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Tech Brief Cont.

variable frequency drives

Continued from, p. 24

Web printing presses, paper mills, and material converting applications require the precise speed regulation of closed-loop control. For such cases, VFDs can be run in a closed-loop control mode. Elsewhere, volts-per-Hertz (V/Hz) and sensorless (or open-loop vector) modes are used.

Don't size the VFD according to horsepower ratings. Instead, size the VFD to the motor at its maximum current requirements at peak torque demand. The VFD must satisfy the maximum demands placed on the motor.

Consider the possibility that VFD oversizing may be necessary. Some applications experience temporary overload conditions because of impact loading or starting requirements. Motor performance is based on the amount of current the VFD can produce. For example, a fully-loaded conveyor may require extra breakaway torque, and consequently increased power from the VFD.

Many VFDs are designed to operate at 150% overload for 60 seconds. An application that requires an overload greater than 150%, or for longer than 60 seconds, requires an oversized VFD. Altitude also influences VFD sizing, because VFDs are air-cooled. Air thins at high altitudes, which decreases its cooling properties. Most VFDs are designed to operate at 100% capacity up to an altitude of 1,000 meters; beyond that, the drive must be derated or oversized.

Be aware of braking requirements.

With moderate inertia loads, overvoltage during deceleration typically won't occur. For applications with high-inertia loads, the VFD automatically extends deceleration time. However, if a heavy load must be quickly decelerated, a dynamic braking resistor should be used.

When motors decelerate, they act as generators, and dynamic braking allows the VFD to produce additional braking or stopping torque. VFDs can typically produce between 15 and 20% braking torque without external components. When necessary, adding an external braking resistor increases the VFD's braking control torque — to quicken the deceleration of large inertia loads and frequent start-stop cycles.

Determine I/O requirements.

Most VFDs can integrate into control systems and processes. Motor speed can be manually set by adjusting a potentiometer or via the keypad incorporated onto some VFDs. In addition, virtually every VFD has some I/O, and higher-end VFDs have multiple I/Os and full-feature communications ports; these can be connected to controls to automate motor-speed commands.

Control mode comparison

	V/Hz	Sensorless vector	Closed loop
Operating complexity	Low	Moderate	High
Performance	Good	Good	High
Starting torque (typical)	150 to 175%	200%	200%
Speed regulation (typical)	±2%	±1%	±0.2%

Figure 4, VFD Control Modes

Most VFDs include several discrete inputs and outputs, and at least one analog input and one analog output. Discrete inputs interface the VFD with control devices such as pushbuttons, selector switches, and PLC discrete output modules. These signals are typically used for functions such as start/stop, forward/reverse, external fault, preset speed selection, fault reset, and PID enable/disable.

Discrete outputs can be transistor, relay, or frequency pulse. Typically, transistor outputs drive interfaces to PLCs, motion controllers, pilot lights, and auxiliary relays. Relay outputs usually drive ac devices and other equipment with its own ground point, as the relay contacts isolate the external equipment ground. The frequency output is typically used to send a speed reference signal to a PLC's analog input, or to another VFD running in follower mode.

Typically, general-purpose outputs of most VFDs are transistors. Sometimes one or more relay outputs are included for isolation of higher-current devices. Frequency pulse outputs are usually reserved for higher-end VFDs.

Analog inputs are used to interface the VFD with an external 0 to 10 VDC or 4 to 20 mA signals. These signals can represent a speed setpoint and/or closed loop control feedback. An analog output can be used as a feedforward to provide setpoints for other VFDs so other equipment will follow the master VFD's speed; otherwise, it can transmit speed, torque, or current signals back to a PLC or controller.

In Part Two, we will discuss selecting the proper control mode, understanding your control profile requirements, and more.

This article originally appeared in the February 2011 issue of MSD magazine and on:
http://motionsystemdesign.com/motors-drives/top-10-specifying-vfds-0211/?imw=Y

Student Spotlight Cont.

The Future of Technology

Continued from, p. 27

Future plans include switching the plumbing over to steam fittings to take advantage of the higher temperatures and pressures which have already been proven possible. Once they make that leap, they even envision the potential to run a small steam engine and produce electricity from the system. Frank Vanderpool is understandably proud of what his students have achieved this far. He reports, "The project has been, and continues to be, a wonderful learning experience for all of the students involved. The Multi-Mirror Solar Array has become a symbol of cooperative learning at Pleasantville High."

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The Break Room

Brainteasers & Humor

By Chip McDaniel

BrainTeasers

Shopping Cart Jumble

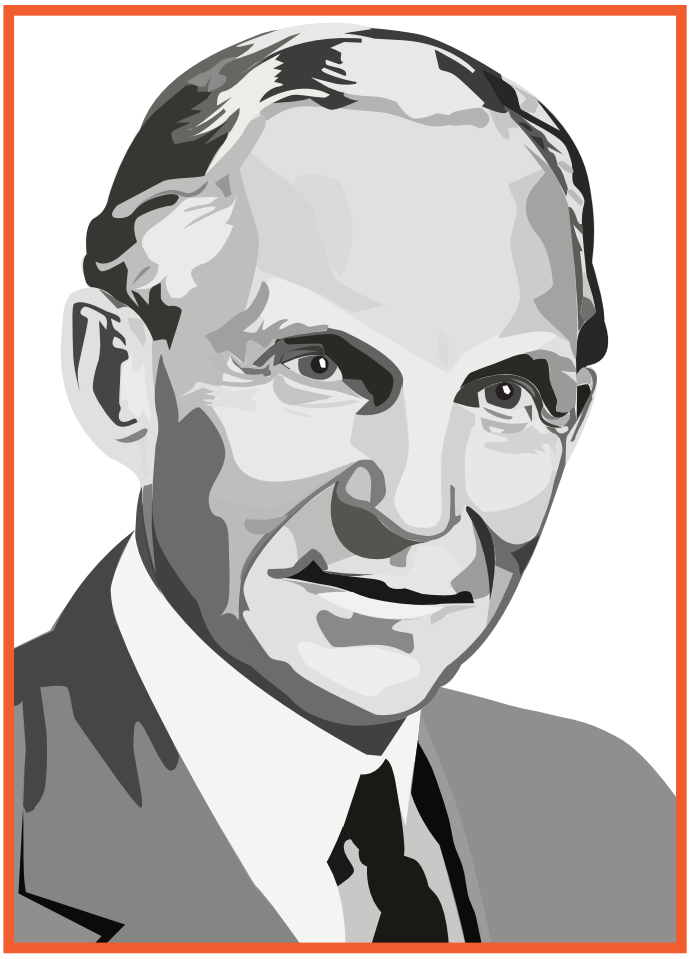
1.) An engineer went to: www.AutomationDirect.com to purchase some high-value automation parts. She purchased various quantities of three parts: proximity sensors at $50 each, Stable motor mounting bases at $10 each, and Nitra pneumatic fittings at $0.50 each. She purchased a total of 100 parts, and spent exactly $1000 dollars (qualifying her order for free 2-day shipping). *Can you calculate how many of each part she purchased?*

IO, IO, It's off to Work We Go

2.) A PLC system contains 36 I/O modules and a total of 100 I/O points. All the input modules are 4 point, and all the output modules are 2 point – except for one 6 point input and one 4 point output. *Can you discern the number of input vs. output modules in the system?*

Quarter Time

3.) The hopper of a packaging machine is filled with widgets on Monday morning. Each day the machine packages a single widget as a test sample, and then proceeds to package one quarter of the remaining widgets from the hopper. Recordkeeping is minimal, but it is noted that the number of widgets packaged on Monday and Wednesday is exactly 100 more than the number packaged on Tuesday and Thursday. *At the end of the day, Thursday, the production manager asks how many widgets remain in the hopper. Can you tell him?*



Henry Ford

Don't judge a driver by the car!

As told by a tour guide at the Edison & Ford Winter Estates Museum in Ft. Myers, FL. The tour guide prefaced the story by admitting that they couldn't verify it, so read it at your own risk!

It seems that Henry Ford was driving on a remote road one day and happened upon a stranded motorist with a broken-down car by the side of the road. As Mr. Ford was a very competent engineer and mechanic, he stopped to help. Without being recognized (or introducing himself) he rolled up his sleeves and spent more than a few minutes diagnosing and ultimately fixing the car's engine. Once he was finished, the impressed motorist thanked him, and tried to offer him some money for his time and effort. Mr. Ford had to decline the offered money several times saying, "No thank you, I have all the money in the world – it's simply not necessary." The motorist apparently got somewhat annoyed by that repeated phrase, and finally retorted "If you have all the money in the world, then why are you driving a Ford?"

If you are ever in the Ft. Myers, Florida area, be sure to visit the Edison & Ford Winter Estates. It's a fascinating museum for anyone interested in technology or history. Learn more at: www.edisonfordwinterestates.org

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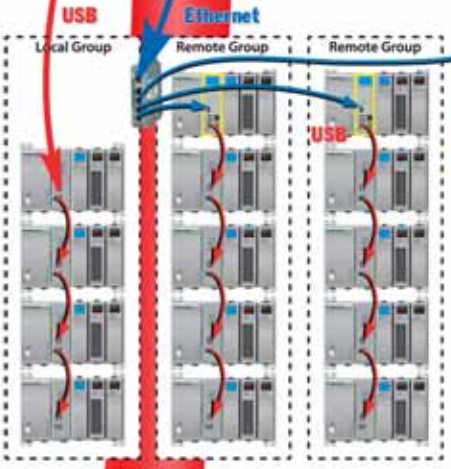

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