Automation NOTEBOOK

Your guide to practical products, technologies and applications

SIMULATION HAS ITS ADVANTAGES

Creating an accurate software simulation for a complex system can be difficult, but there are many reasons to do it.

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OHIO STUDENTS IMPROVE ASSEMBLY PROCESS FOR EMPLOYEES WITH DISABILITIES

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Image courtesy of Sandia Labs

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Editor's Note

We are the world!
Remember that song from the mid-80s? The opening lyrics say, "There comes a time, when we heed a certain call; when the world must come together as one."

We've seen a lot of this lately; the tragic earthquake in Nepal, volcanic eruptions in Chile, rioting in many parts of America and weather-related devastation in many parts of the world, just to name a few. But, out of each of these stormy events, flowers of good and of hope blossom.

We have witnessed people joining together to provide aid and support to foreign countries, neighborhoods have banned together to clean up their streets, and businesses, organizations and communities have worked together to help towns and countries return to "normal" life. This support helps restore the hope that is born within each of us.

We at AutomationDirect not only provide great products and award-winning customer support. Over the years, we also have heeded the call during times of tragedy to do our part to help others in need. As the Golden Rule says, "Do unto others as you would have them do unto you." Whether it's someone where you work, live, or even a total stranger, lend them a helping hand. Besides, you never know when you will need it in return.

We have a lot of great material crammed in this issue of NOTEBOOK. In addition to information about new products, our cover story explains the advantages about software simulation for complex systems. We have an awesome User Solution story about a children's museum in Bulgaria and our Student Spotlight is aimed at students of Copley High school in Ohio and their invention to help employees with disabilities at Weaver Industries.

We have all this and more. As always, stop by the ever-popular Break Room for our brainteasers and then compare your answers at **www.automationnotebook.com**

TJ Johns
Coordinating Editor
editor@automationnotebook.com

Table of Contents

NEW C-MORE CONFIGURATION SOFTWARE

The new C-more HMI configuration software version 6.0, from AutomationDirect, delivers more functionality, more usability and more value to our popular C-more HMIs. The new software offers more alarm and recipe features, additional math and tag logic, plus improved Windows compatibility. New menu options, customizable toolbars, and updated graphics provide improved ease of use.

The easy-to-use Event Manager allows actions to be taken on a screen change, a set date or time, a single tag status or value, and now on a combination of tag status or values. These new tag combinations allow for simple logic with multiple events. Users can combine up to four different tags to trigger actions based on logical results, going beyond simple alarm and message functions.

New math functions add more computing power to the project. Create custom formulas with constants or tag values or use the math keypad which provides access to simple and complex operations including log, sine, and square root. Results are placed into a User Defined Tag.

Improved object frame styles and increased formatting options include added color gradient support for most objects to allow for enhanced visibility. Many objects also have added format templates to allow users to quickly choose a color theme; templates can be edited and saved.

An enhanced alarm list offers more options for alarm customization and new alarm filters allow for dedicated alarm summaries. The alarm list object allows operator interaction with alarms that have occurred and allows operators to view, confirm or clear the alarms.

The Alarm List object also allows for custom alarm list, alarm history and alarm count views. Alarm status can be color coded to help operators quickly interpret the status for each alarm; active and confirmation icons also help operators interpret alarm status; alarms can include specific messages with embedded PLC tag data, as well as date and time information.

Among added database tools, Message Preview for the Message database simulates the message as it will appear on the panel. Also, a powerful database filter tool helps users find, edit and sort all four databases:

Tagname Database
Message Database
Event Manager Database
Address Book

Among the added accessibility features, a new Object Layer List window shows all the objects on the active screen and allows the user to lock/unlock, hide/unhide objects or quickly select them for editing. It also allows access to individual objects in a group without ungrouping and contains additional lists for hidden, locked or overlapping objects.

Recipe databases containing 99 recipe sheets, each with 1000 recipes of 256 possible tags or values, can now be modified and saved on-the-fly while the machine is running. Runtime options include adding, deleting or loading recipes to the PLC. And with the Call Recipe object, programmers can determine what recipe editing abilities they want the operator to have when creating recipe objects.

A free demo version of the C-more HMI configuration software is available for download. The demo software has all the features of the purchased version, except that you CANNOT save your project to disk or download it to a panel. The demo software even comes with a demo version of Symbol Factory.

The fully-functional software is priced at $99.00; current C-more EA9 users qualify for a free upgrade. This newest version is compatible with all previous C-more projects (but does not support EA7 series panels). The C-more Remote HMI App, remote access and control on the go, is available for only $4.99 in the Apple® or Android™ app stores. For more information, visit: **www.automationdirect.com/c-more**

Now you can expect more from your HMI!

NEW Improved Software! For EA9 Series Panels

The C-more EA9 HMI software (just $99) now delivers more functionality, usability and value to our popular C-more touch panels. Dozen of new features and upgrades give you MORE for LESS!

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C-more EA9 Software **$99** EA9-PGMSW

C-more®

MORE LOGIC

- New tag combinations allow simple logic with multiple events
- Combine up to four different tags to trigger actions based on logical results

MORE MATH

- New math functions let you create custom formulas with constants or tag values
- The Math Keypad provides both simple and complex operations including log, sine, and square root

MORE ACCESSIBILITY

- The new Object Layer List Window shows all the objects on the active screen and lets you lock/unlock, hide/unhide objects or quickly select them for editing
- The Object Layer List allows access to individual objects in a group; additional lists for hidden, locked or overlapping objects
- Recipe database supports 99 recipe sheets, each with 1000 recipes of 256 possible tags or values; operator can now modify and save while the process is active
- New menu options, customizable toolbars and updated graphics for improved ease of use

MORE ALARMING OPTIONS

- Enhanced Alarm List offers more options for alarm customization
- New alarm filters allow for dedicated alarm summaries

MORE DRIVERS

- C-more panels have drivers for most major brands of PLCs. See the entire list at www.automationdirect.com/c-more-drivers

LESS COST

- With software at $99 and hardware starting at just $499, C-more give you one of the best costs of ownership, considering initial price, features, ease of use, reliability and free award-winning technical support

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* EA9-PGMSW for use with EA9 series panels only; cannot be used with EA7 series panels.

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RECENTLY ADDED PRODUCTS

NITRA® SPECIAL PURPOSE PUSH-TO-CONNECT PNEUMATIC FITTINGS

New NITRA special purpose fittings work inline with 1/4-inch and 5/16-inch flexible pneumatic tubing. Miniature pneumatic pressure regulators have an adjustable psi range and a built-in relief valve to exhaust over-pressure. Also available are pressure gauges with metal gauge housings and pressure indicators with either green or orange pressure indicator buttons. New 2-way and 3-way inline hand (manual shutoff) valves are available with or without locking capability. Quick exhaust valves are ideal for use with pneumatic actuators that require a very fast stroke speed. NITRA inline fittings start at $8.75 and are backed by a one-year warranty.

www.automationdirect.com/special-push-connect

DIRECTSOFT6 PROGRAMMING SOFTWARE FOR DIRECTLOGIC PLCS

Release 6 of DirectSOFT programming software includes over 40 new fill-in-the-blank style instructions (IBoxes) for ladder logic functions such as Memory, Discrete Helper, Analog Helper, Math, Communications and CTRIO. Other enhancements include graphic ladder view, ladder box leg labels, graphic stage view and configurable toolbars. The new Trend View tool allows visual monitoring of controller data elements over time. DirectSoft6 is $395 and supports the entire line of DirectLOGIC CPUs. A $249 upgrade package is available for older DirectSOFT versions and a free version for projects up to 100 words can be downloaded.

www.automationdirect.com/directsoft

HARSH DUTY PROXIMITY SENSORS

PN series IP69K-rated inductive proximity sensors have regular or short-body metal housings. These 10-30 VDC three-wire sensors with LED status indicators are available with an attached two-meter output cable or M12 quick-disconnect. All styles are available with shielded or unshielded housings as well as normally-open or normally-closed and PNP or NPN output types. PN series 12mm, 18mm and 30mm round sensors start at $18.75 and are CE and RoHS approved. Sensors with M12 quick disconnects are also cULus approved and sensors with two-meter cables are also UL approved.

www.automationdirect.com/proximity

MAGNETIC LOCKING, NON-CONTACT RFID SAFETY SWITCHES

The MGL Series of safety switches combines magnetic locking and radio-frequency identification (RFID) technology to provide non-contact operation and high anti-tamper coding. Medium or heavy-duty electromagnet locking force models are available with plastic, die cast metal or stainless steel housings. The

stainless steel housings have an IP69K rating for use in food processing applications. The RFID locking switches use two LEDs to indicate all possible switch states. Two normally-closed safety outputs and one normally-open auxiliary output provide door open indication. MGL series safety switches include both switch and actuator and start at $273.

www.automationdirect.com/safety-switches

GENERAL PURPOSE ELECTROMECHANICAL AND SOLID STATE RELAYS

750R series general purpose electromechanical 10 Amp octal base relays start at $7.75 and have contacts with 1500 Vrms dielectric contact strength. Coil input voltages are 12 and 24 VDC and 12 to 240 VAC. Flag and LED indicators shows relay status and a pushbutton allows manual operation of the relay. DIN rail or panel mountable AD-series solid state relays (starting at $37.50) have contact ratings of 10A, 30A, 45A or 65A. The 750R-series and AD-series relays are UL recognized, CSA and CE / RoHS / REACH approved and have a one-year warranty.

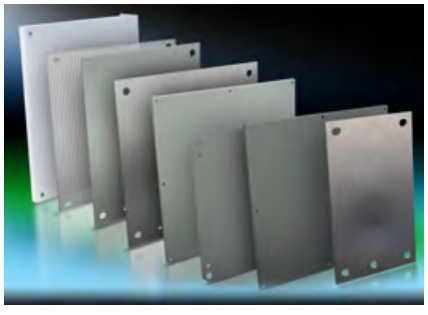
www.automationdirect.com/relays

COMPACT RECTANGULAR INDUCTIVE PROXIMITY SENSORS

Compact APS sensors have a small footprint for simple mounting in tight spaces. Ten high-frequency oscillation type proximity switch models are available. Options include top or front sensing models; NPN, PNP, or NPN / PNP logic outputs; N.O. or N.C. output states and DC 2-wire or 3-wire connections. These IP67 rated sensors have LED status indicators; operate on 10 - 30 VDC supply voltage and have an attached two-meter axial output cable. APS series sensors are $17.50 each, available in sensing ranges of 2.5mm and 4mm and are cURus, CE and RoHS approved.

www.automationdirect.com/proximity

MANY MORE ENCLOSURE SUBPANELS ADDED



We've added over 200 new subpanels to our Hubbell-Wiegmann line of electrical enclosures. Perforated, galvanized and stainless steel subpanels have been added to the existing product lineup. 2D and 3D drawings are now available for all subpanels and 3D renderings added for each part. New HF Series swing-out subpanel kits are available for the Ultimate series NEMA 4/12 enclosures and include the swing panel, brackets and hardware necessary for a tub flange install. HF series enclosure subpanel prices start at $81.

www.automationdirect.com/enclosures

SUREMOTION® SYNCHRONOUS BELT DRIVE COMPONENTS

The new SureMotion line of power transmission products includes timing pulleys (or sprockets), bushings and timing belts that allow speed and torque changes while connecting mechanically rotating components. Starting at $5.25, SureMotion L and XL timing pulleys are available in aluminum or steel, with or without hub and with smooth bore and setscrew. Also available are SureMotion L steel pulleys that are made for use with Taper-Lock® or QD®-style drive steel bushings. The bushings are sold separately, starting at $8.75. SureMotion timing (toothed) belts are made of neoprene with fiberglass reinforcement and are an excellent choice for many industrial applications. Starting at $2.00, the belts are available in several pitches (0.200" to 0.375") and widths (0.25" to 1") to cover a wide range of power transmission requirements.

www.automationdirect.com/power-transmission

INSTRUMENTATION CABLE WITH INDIVIDUAL AND OVERALL SHIELDING

18 AWG instrumentation cable is available in 1, 2, 4, or 8 twisted pairs with an overall shield or in 2, 4, or 8 individually shielded twisted pairs with an overall shield. The cable is dual listed as UL 2250 Type ITC (Instrumentation Tray Cables) and UL 13 Type PLTC (Power Limited Tray Cables) and can be used for instrumentation and control

circuits, Class 2 and Class 3 remote-control, signaling, and power-limited circuits; and in hazardous locations. Cables with both individually shielded pairs and an overall shield have twisted pair foil shields complete with separate tinned copper continuous drain wires. The cable is made in the USA, has a sunlight and moisture resistant black PVC outer jacket and is available in 100 foot, 250 foot, or 1000 foot reels, starting at $32.00.

www.automationdirect.com/wiring-solutions

ADDITIONAL NITRA HOSE, TUBING AND PUSH-TO-CONNECT PNEUMATIC FITTINGS

Yellow nylon coiled hoses, starting at $12.50, are available in 1/4-inch, 3/8-inch and 1/2-inch sizes and in 10 to 40-foot lengths. Hose kits of 100-foot nylon hose and 10 replaceable fittings start at $63. 1/8-inch polyurethane tubing is available in seven colors, including UV-stabilized dark green which is an excellent choice for outdoor use. Tubing, starting at $13.50, is available in 100-foot packs and 500-foot reels. NITRA 1/8-inch and 5/16-inch push-to-connect inline thermoplastic fittings with stainless steel tube gripping claws are also now available starting at $5.25 for a five-pack.

www.automationdirect.com/pneumatic-parts

SIMULATION HAS ITS ADVANTAGES

Creating an accurate software simulation for a complex system can be difficult, but there are many reasons to do it.

By Cindy Green,
AutomationDirect

Creating simulations of automated equipment, processes, and robot sequences is a great way to validate controller programming, test hardware settings, and check HMI configurations—all without cycling the actual equipment. There can be many advantages to simulation, from verifying equipment feasibility to confirming fault logic and generating tested controller code in less time.

Whether the equipment is available, is in development or it doesn't exist yet—simulation can reduce design time, increase performance and ensure a smooth and quick startup. Several advantages are listed in **Table 1**, and expanded upon below.

Advantages of Simulation
1. Faster than testing on actual machine or robot
2. Can be used as a realistic training tool
3. Allows rapid prototyping
4. Can be used when actual system isn't available
5. Shows when application isn't feasible
6. Allows simulation of other vendor's equipment
7. Allows testing of every possible fault
8. Exposes unforeseen issues
9. Doesn't upset current processes and systems
10. Can directly generate controller code

TABLE 1: Advantages of simulation

Table reprinted from Control Design January 2015 Cover story "Simulation Saves Time and Money"

IMAGE 1: Simulating hydraulic motion and fail-safe operation before testing on the actual high-force hydraulic press brake can improve safety and reduce hazards. Image courtesy of Accurpress.

Should You Simulate?

A maker of hydraulic press brakes and shears used in sheet metal fabrication, Accurpress America (**www.accurpress.info**) in Rapid City, SD, uses simulation software to sort out complex machines (**Image 1**). In the Control Design, January 2015, Cover story "Simulation Saves Time and Money", Allen Guernsey, machine control development specialist at Accurpress, explains the complexity of their machines. "Our current version of the PLC for the press brakes can handle 28 axes, and we can link machines together to work in tandem."

"Sometimes the press brakes and shears are parts of cells, and in these cases other machines arrive at the customer from different factories, so simulation is the only way to run the machines together prior to startup," he adds in the article.

The use of simulation has reduced their startup and test time. "Being able to watch machine movement in a simulated environment has enabled better PLC code because, in simulations, more fail safes can be tested without risking machine crashes," explains Guernsey in the article. "For example, I can simulate hydraulic cylinder characteristics, introducing errors such as a stuck cylinder. So far, I have not run into anything that I could not simulate."

In the cover story, Dave Perkon, vice president of advanced technology at AeroSpec (**www.aerospecinc.com**), a machine builder in Chandler, AZ, also uses simulation software. "Most of the top robot suppliers have simulation software," he says. AeroSpec is a custom machine builder of a variety of discrete manufacturing equipment ranging from lean manual assembly stations to high-speed fully automated assembly equipment (**Image 2**, page 10).

"During the concept and quoting stage, simulation software helps keep a project moving in the right direction and keeps the customer engaged as their requirements come to life," notes Perkon in the article. "If the actual equipment doesn't meet the

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- **Lubricators**
- **Combination filter/regulators**
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- **Soft-start/dump valves**
- **Modular assembly brackets**

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Manual or electrically controlled, NITRA's directional control solenoid valve selection offers capacity and form factor flexibility to meet your system configuration needs.

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- **3- to 5-port models**
- **Manual toggle, rotary, push-pull and foot pedal valves**
- **Process (pipeline)**
- **Compact modular**
- **Manifolds, silencers, cables, connectors**
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- **Compact (pancake style)**
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- **Dual-rod guided**
- **All stainless round body style**
- **Position switches**

TUBING AND FITTINGS

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- **Brass adapter fittings**
- **Nylon and polyurethane straight and coiled tubing**

Many fitting styles also available in stainless steel

Pneumatics	AutomationDirect NITRA	vs.	McMaster-Carr Price/Part Number	Grainger Price/Part Number	MSC Price/Part Number
Solenoid Valve 5-port, 2-pos, 1/4" NPT	$29.50 AVS-S312-24D		$87.47 6124K513	$120.05 3JCN6	$99.74 09666884
Filter/Regulator Comb. 1/4" NPT, gauge, bracket	$31.50 AFR-3233		---	$141.35 4ZK92	$127.44 42007401
Air cylinder, nose mount 3/4" bore, 1" stroke	$13.00 A12010SN		$17.78 6498K141	---	$23.31 36696458
Nylon tubing 1/4" OD, black, 100 ft.	$17.50 N14BLK100		$68.00 [1] 5097T411	---	$92.40 NB-4-035-0100-P

1) Sold by foot, price shown for 100 feet

All prices are U.S. published prices. Many other part numbers are available from all vendors. AutomationDirect prices as of 4/15/2015. McMaster-Carr prices are from www.mcmaster.com 4/14/2015. Grainger prices are from www.grainger.com 4/14/2015. MSC prices are from www.mscdirect.com 4/16/2015. Prices subject to change without notice.

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New NITRA inline pneumatic fittings make it possible to perform all pneumatic functions at any point in the circuit.

New NITRA coiled nylon hose comes with spring guards to resist kinking and male NPT swivel fittings. Hose kits also available and include 100 ft. of nylon coiled hose and enough fittings for 5 hoses.

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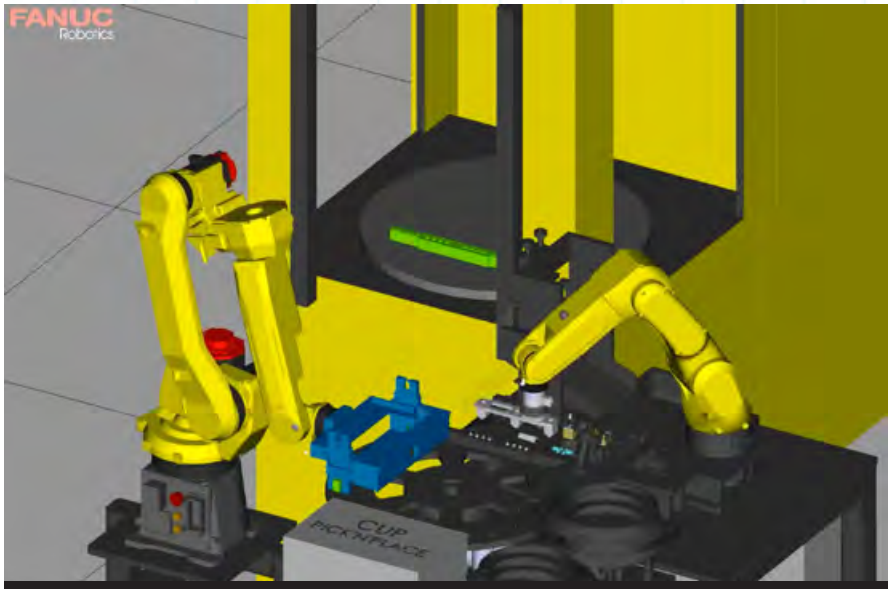

IMAGE 2: A vision-guided, dual-robot welding process was simulated before the equipment was built. Robotic crash proofing, automatic sequencing and cycle time were confirmed through simulation, as was the robots' travel distance and machine footprint. Image courtesy of AeroSpec.

simulation results, it indicates the program needs more work."

Simulations are useful during the quoting stages, but the same simulation can also create usable code. "Although there are configuration differences, the end product from many of these simulation packages are directly downloadable software programming to the robot," Perkon explains in the article.

OEMs of process skids can also benefit from using simulation.

Process Simulations

Malisko Engineering (**www.malisko.com**), a systems integrator in St. Louis, MO, uses simulation to improve control and save time in its process control projects. In the cover story, Tim Malyszko, director of operations, explains: "At Calumet Specialty Chemicals in Louisiana, MO, we automated a manual operation. A mass balance and simple energy balance was written in a simulated environment so operations could run the system in an off-line environment to identify control gaps. The simulation allowed us to do a thorough checkout during FAT (Factory Acceptance Testing), thus reducing commissioning time."

Simulations are used by Sandia Laboratories to test diesel engine systems ahead of time. Before running a test on the actual equipment, the engineers at Sandia can run the simulation to confirm how the system will react to different fuels. These simulations can help reduce wear on expensive equipment and save time. For more, see the sidebar, "Sandia Simulates".

While simulation can verify if the solution will perform as expected, before testing on the actual equipment, it's not without its problems as listed in **Table 2**. OEMs and system integrators, who face these challenges on a regular basis, elaborate further in the following section.

Problems and Challenges

Simulation packages can be difficult to master, as Tim Malyszko of Malisko Engineering points out in the article. "One of the most common challenges I've come across with various simulation packages is the simulation shutting down if there are any errors. In other words, if a simulated device points to a tag that does not exist in the physical or simulated controller, the whole simulation dies."

Using simulation software also takes skill. "Simulation software isn't very intuitive to use and requires a substantial learning curve," he adds in the Control Design article. "Furthermore, some software requires a good understanding of process dynamics to build a good simulation."

And simulations aren't always completely accurate. "There have been times when our actual robotic equipment did not meet the simulated robot cycle time," notes Dave Perkon, of AeroSpec, in the article. "Adjustments to the robot motion profile, and adjusting approach and departure motion profiles, are usually required in the real world. Simulation doesn't perfectly duplicate the real world."

Conclusion

Simulations are becoming an important part of control system design and development. Due to its value early in the design process and during testing, robot and control hardware suppliers are adding simulation functionality into their products. Simulations offer many benefits and are a

Challenges of Simulation
1. Often difficult to precisely simulate operation
2. Safety systems may have to be tested on live equipment
3. Simulations may not be totally accurate
4. Simulations can fail unexpectedly
5. Requires learning of simulation software program
6. Simulation software must be integrated with controller

TABLE 2: Challenges of Simulation

Table reprinted from Control Design January 2015 Cover story "Simulation Saves Time and Money"

valuable tool for machine, robot and process skid design.

However, simulation is not always easy. It takes time to set up a simulation mimicking actual operations, as careful attention to details and functionality are required to match the actual equipment or process and make the results useful.

Although difficult, the benefits of simulation offset the challenges in robotic, motion control, process and discrete applications—especially during equipment design and deployment, and where testing opportunities on live equipment isn't possible, safe or readily available. ■

SIDEBAR: SANDIA SIMULATES

At its Alternative Fuels Laboratory located at the Combustion Research Facility in Livermore, CA, Sandia National Laboratories (**www.sandia.gov**) studies the effects of various fuels used in diesel engines (**Image 3**). Combustion of many different fuel types is analyzed, and tuning the fuel control and monitoring system to account for differences in fuel viscosity and compressibility was too time consuming, so Sandia decided to use offline simulation. The R&D laboratory support technologist, Samuel Fairbanks, now simulates before test, allowing him to make tuning changes in advance.

"Simulating the operation of our high-pressure fuel system using MathCAD allows me to verify hardware requirements for mechanical design of our high pressure fuel system," says Fairbanks in the Control Design January 2015 Cover story "Simulation Saves Time and Money". "It also aids in tuning the system for different fuels by allowing me to adjust PID coefficients in the model, making it possible to get very close to the actual values needed. Being able to tune the system more quickly also reduces component wear, which is accelerated at high pressures."

IMAGE 3: The Alternative Fuels Laboratory at Sandia National Laboratories' Combustion Research Facility tests heavy-duty diesel engines using dual hydraulically-driven diaphragm pumps. Image courtesy of Sandia Labs.

The two diaphragm pumps in the high-pressure fuel system are each driven by a hydraulic cylinder. The two cylinders are controlled using feedback from SSI position transducers using a Delta Computer Systems control system with dual-axis and other I/O modules. The control system modulates hydraulic flow to the cylinders via proportional control valves.

Each pump has a cascaded PID control loop controlling the fuel pressure by adjusting the speed of the hydraulic cylinder stroke. The PID control loop also keeps oil pressure in the diaphragm pump in check, which can spike if the stroke length is too great or frequency is too high.

"I have to retune parts of the system every time we change fuels," adds Fairbanks in the cover story. "We are constantly studying different fuels, so this happens frequently. Being able to streamline this process with simulation is a huge benefit."

Fairbanks can even create hypothetical problems. "I can feed modified pressure data from previous runs and create conditions such as fuel pressure overshoot, oil pressure spikes and others to see if the control program I wrote makes the cylinders respond correctly," he says in the cover story. "It's a very useful way to test the logic of the program, and I've continued to use the simulator while trying to optimize the programming or add new functionality."

While the simulator works well, setup was challenging. "Our high-pressure fuel system is extremely complex, which made creating a numerical simulation as realistic and accurate as possible both tedious and time consuming," explains Fairbanks in the cover story. "It can be difficult to accurately model some of the interactions between hardware and fluid components during our extreme operating conditions."

In the cover story, Fairbanks says, "In the end, we were able to create a simulation that captured all aspects of final system implementation."

As for future improvements, "Providing more user-friendly tools to record data during system operation, and ways to interface this data with simulation tools to make adjustments or corrections in a simulation to use during further development, would be invaluable," concludes Fairbanks in the cover story. ■

FIRST TEAM HONOREE

AutomationWorld's "Leadership in Automation" program highlights preferred suppliers as identified by their readers across more than two dozen automation technology categories. Now in its fifth year, the program remains relevant as technologies change and supplier preferences shift based upon needs, and/or peer recommendations. Allegiance to a particular brand or resentment toward another brand may last for years, or change as often as new technologies emerge. Since the survey is unaided, the write-in results are significant because it doesn't rely on a presumed list of contenders. According to their editor, this serves as a "useful snapshot of current reader preference for certain suppliers in very specific technology categories."

The latest results are in and AutomationDirect was recognized as "First Team" in the "Leadership in Automation 2014" in the categories of Cables, Connectors, I/O; HMI Hardware; PLC/PACs.

As a supplier, we revel in results such as this and hope our programs and product offerings continue to meet and exceed industry expectations. Our goal is to offer products our customers want, with quick order and delivery, at prices well below the industry average, and backed by award-winning service. In an effort to keep our customers smiling, we added more than 1000 part numbers in 2014 across several categories of products. Our goal is to be your preferred supplier for industrial control products.

If you haven't visited the Web store lately, please visit www.automationdirect.com and check out the "What's New" tab. We are frequently launching new products and encourage you to check back often. In addition, we offer customers the ability to review products lines as well as submit reviews for a product. And if you are in search of a product, we welcome suggestions which are promptly routed through the product management team.

Do you have a preferred vendor for specific categories of products? We encourage you to participate in the ongoing "Leadership in Automation" hosted by AutomationWorld. The survey is online and the voting for 2015 will be opening soon at **www.automationworld.com/leadership**. Their editorial team will send reminders later in the year so that you may vote in each relevant category. The input from the survey is appreciated by your peers as well as your suppliers.

AUTOMATION DIRECT RECEIVES HEALTHIEST EMPLOYER AWARD

Employee safety is paramount for all companies big or small and they spend big bucks to keep us safe while working. But, how many of those safety conscious employers place those same concerns on the wellness of their employees? And, at the end of the day does it make a difference? You bet it does, and several employers in the Atlanta, Georgia, area would agree. These top companies are making significant strides with employee participation in the area of improved health and wellness.

Annually the Atlanta Business Chronicle accepts nominations for "Atlanta's Healthiest Employers Awards". This award celebrates health in the workplace and recognizes organizations that are committed to creating a healthy workplace in six key categories: leadership commitment, foundational components, strategic planning, communication and marketing, programming and interventions, and reporting/analysis. This nomination is submitted by those companies who believe they are making a difference, and back up those claims with solid metrics and lasting results.

HEALTHIESTEMPLOYERS

An independent company, Healthiest Employers, LLC, reviews the applications and selects 10 finalists. On February 12, 2015, the Atlanta Business Chronicle recognized AutomationDirect as the third Healthiest Medium Sized Company in Atlanta. At AutomationDirect, human resources representative Mary Brehl discussed the company's progress noting dramatic improvements after implementing a wellness program.

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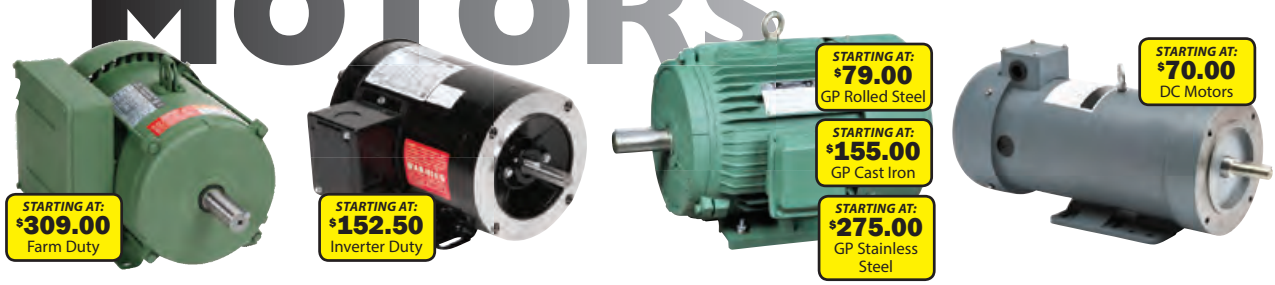

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"We have tracked a direct correlation between increases in the number of rewards earned to the overall health improvement of our team members," Brehl said, "and when comparing our numbers from 2012 to 2014, our overall weight loss by our participants has increased 168%, plus the number of individuals who are now at a healthy weight has increased by 48%."

She said because of the success last year they have a new motto for the program to "Be Your Own Hero" which encourages participants who may be struggling, to take advice from individuals who made changes, found motivation and began their own journey.

One employee, Jerry R. said, "I made the decision to lead a healthier lifestyle after an appointment with my doctor. He advised me that I was at a point where I needed to make some lifestyle changes or my health could be compromised." Jerry said the use of the DirectWellness program at AutomationDirect, along with encouragement from other participants, offered a source of motivation. He tells his story after shedding more than 110 pounds.

Brehl admits the biggest challenge to establishing an ongoing program was over-complication and says, "We had so many options and incentives that people were confused on how to take full advantage of the program." So, the internal committee worked hard to simplify the program to easily guide participants through the path of success. They wanted to make it easy for people to participate by outlining clear goals, providing encouragement through incentives, and sharing personal success stories. The program is entering its third year and has seen participation increase year after year - a trend they expect will continue.

2015 ENGINEERS' CHOICE AWARDS

The annual Control Engineering Engineers' Choice Awards program recognizes categories of control, instrumentation, and automation products, revealing the best of those products as selected by their readers. Established in 1954, Control Engineering is recognized as the global information leader for the automation engineers who design, implement, maintain and manage control/

instrumentation systems, components and equipment. The winners were selected by subscribers across the digital and print audiences of Control Engineering.

AutomationDirect was a recipient of two Honorable Mention Awards for products nominated in the Machine and Embedded Control categories. The Productivity3000® P3-SCM Serial Communication Module, and the Do-more™ T1H Series CPU Module.

The Productivity3000 P3-SCM is a four-port serial communication module that contains three RS-232 (RJ12) half or full duplex ports and one port selectable between RS-232 (RJ12) and RS-485 (four-wire terminal block). The module also features a 16-LED status display to show communication status for each port.

The Do-more T1H Series CPU module won accolades by using the proven Terminator field I/O hardware as a platform, and supports stackable base units, discrete and analog I/O modules. The T1H CPUs high processor speeds not only decrease program execution time, but also allow the CPUs to support Ethernet connectivity and custom communication protocols as built-in functions.

The 2015 Engineers' Choice Awards were presented to the winners on March 23, 2015, in Chicago. To read more about the annual awards program please visit **www.controleng.com/2015-engineers-choice-awards-honorable-mentions**.

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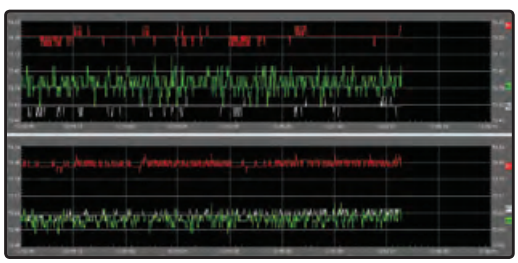

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IMPORTANT CONSIDERATIONS WHEN ADDING AN HMI

By Chip McDaniel,
AutomationDirect

When it comes to industrial automation, one of the key parts is the Human Machine Interface (HMI). With advances in technology, the HMI is becoming more user-friendly, allowing operators to communicate with their machines via graphics, text messages and more. Used as a central control center, an HMI panel provides a visual representation of the control system and provides real time data acquisition and can increase productivity.

Today, an HMI can be used for a wide variety of applications from something as simple as controlling the roasting of coffee beans to something as complex as a nuclear power plant and even NASA avionics.

When you decide to implement an HMI into your application, don't feel intimidated. Here are some tips for you to remember during your planning and implementation.

The following design principles are a great start for any design project (and the four letter acronym is nothing if not memorable):

Contrast - Make sure that items which are different stand out.

Repetition - Make sure that "like" items are treated similarly (or identically).

Alignment - Align items for readability and so they can be scanned quickly. Vertical columns actually enable faster horizontal scanning.

Proximity - Group things that belong together, separate those that do not.

Use Color... Judiciously

You would be amazed how many user applications we see that are a jumble of identical, rectangular, gray buttons. Do they work? Possibly. Could they be better? More intuitive? No question! Use subdued colors (or shades of gray) and positioning to group "like functions" (see Repetition and Proximity above). Use bright, saturated colors only to indicate abnormal conditions.

Add Graphics

The phrase "A picture is worth a 1,000 words" could not be truer for HMI design. Operators really do grasp the meaning of an image faster than they can read the text on a boring gray button. And if there is a language barrier, the images become even more important.

C-more® HMI panels allow overlapping objects, so consider allowing a small graphic to overlap a button. There is also a Bitmap Button Object that allows you to use a built in graphic or your own user graphics for the 'ON' and 'OFF' states. Keep in mind that excessively large graphics and animation effects can slow the performance of a particular screen, so use them appropriately or isolate them on alternate screens to ensure fast response on the primary screens.

Display Appropriate Images

An image of the machine being controlled or other real world images can be incredibly useful to help operators understand the location of problems like blocked actuators or sensors. Consider how a modern office copier can lead a complete novice to the location of a paper jam in seconds using clear images of the machine itself, locational pointers and even animated images of the flaps and hatches that must be accessed to clear the jam. However, resist the temptation to model the entire P&ID piping diagram of the plant (or other process) – ask yourself if it's just a pretty picture with numbers sprinkled over it, or an intuitive display of relevant information (see 'situational awareness' below).

Keep Important Controls (Stop, Start, Setpoints, etc.) Available At All Times

Reserve a portion of the screen for these items; perhaps a band at the top or on the side for these controls, and make sure this area is completely consistent everywhere it is displayed. C-more offers a "background screen" feature that allows designers to create, edit, and maintain such an area in a single location within your project layout, and then display it across multiple screens as desired.

Offer Situational Awareness

Make sure relevant data is displayed clearly, so that operators can grasp the current state of the machine or process at a glance (or as quickly as is practical). A good display answers both questions: "Where is the data/process now?" and "How does that compare to optimal conditions?"

Keep All Information and Controls within 2 to 3 Clicks of the "Home" or Main Screen

For discrete manufacturing, displaying data with respect to the "present state" of the machine may be enough, but for more complex machines or processes the screen design and layout should strive to

help an operator predict the future status of a machine. Is it enough to know the current temperature of the oven, or would a trend graph allow the operator to foresee/prevent a pending disaster?

There are many layout and design factors that can detract from situational awareness. Data overload and focus on the wrong information are two of the most common. If the situational awareness of the operator is critical to the success of a particular HMI project, there is a wealth of additional information available. One particularly good resource is: "*Designing for Situation Awareness: An Approach to User-Centered Design*" by Mica Endsley, Betty Bolté, and Debra Jones, CRC Press, 2003.

Consider the workflow for the application. Which tasks are performed most often, and which are seldom used? Try to optimize the layout to be as efficient as possible. Keep screen menus and/or screen change actions as consistent as possible throughout the application, and have a clear and consistent "back path" so that even the least experienced operator cannot "get lost."

Watch an Actual Machine Operator to Learn Their Interactions with the HMI

Sketch out early ideas on paper and "play act" their operation with an experienced operator. Deploy a prototype of the HMI before final commissioning if possible, and watch how the operator uses the interface.

Look for awkward situations. Is there additional automation that can relieve the operator of needless button presses, or otherwise make them more efficient? Ask the operator for advice and opinion, but filter it, as the operator may not see the big picture. Realize, at the same time, that your engineering knowledge of the machine may cloud your perspective on what is actually required to operate the machine efficiently.

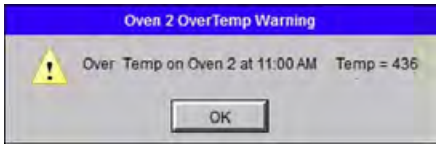
Give Feedback and Lead the Way

Give the operator visual (and audible) clues that buttons have been pressed, or that certain steps have already been performed. Affirmative feedback can build confidence and satisfaction with the system. Use color and/or animation to lead operators step-by-step through complicated processes, but keep things as simple as possible. Long lists of operator tasks may indicate "opportunities" for additional automation or other workflow improvements. Two good questions to ask, from the operator's perspective: "Where were you expecting to find that?" and "What were you expecting to happen?"

Beware of "Pop-up" Alarms or Dialog Boxes

Make sure that "pop-ups" are used sparingly, if at all. Nothing is worse than a cascade of error messages - all of which have to be acknowledged individually - before the operator can get to the screen where the condition can actually be resolved. Other techniques that can be used to draw the operator's attention are simply changing the background color of an object, or section of the screen, or blinking objects. Keep in mind, overuse of blinking or flashing effects can habituate the operator to the effect, and thereby diminish its effectiveness as an alert, or it may even distract the operator from a more important issue elsewhere on the screen.

Date and Time Stamp Alarm Logging



Don't just track the alarms, but also when they occurred. Many seemingly unrelated, recurring issues may actually correlate to shift changes, coffee breaks, or even the startup/shutdown of nearby equipment or other periodic plant operations. Use alarm confirmation requirements to see how quickly operators are reacting to certain conditions, and consider refining the HMI layout/design for faster response, if desired.

Use Password Protection... Appropriately

Carefully consider what screens or objects should be available to all personnel, and which might be restricted to maintenance, engineering or management staff. Consider safety and the complexity of the items in question. Realize that an overly restrictive policy can hurt productivity, or worse: result in the sharing of passwords with unintended personnel simply for the sake of "up-time".

Create a Style Guide

Create a set of common styles to ensure consistency across all HMIs in a particular factory or plant. Consistent use of similar indicators, graphics, trend objects, etc. can increase operator familiarity and improve comprehension. C-more HMI offers both an object library and a screen library, where you can store (and share) proven elements - or entire screens - for easy reuse across multiple projects.

Hopefully this information will help you design an effective HMI for your application. Keep in mind that you want everything as easy to use as possible. So what about implementation? What should you consider to make your HMI implementation successful? The following information will help you ensure a pain-free and non-stressful process.

PICK AND PLACE YOUR HMI

There are many ways to irritate an operator working with automated equipment and poor HMI implementation is one of the worst. Following these guidelines can help you select the right HMI for your application and help your machines and processes run more smoothly and safely.

Many types of HMIs are available in today's market from simple operator interface terminals (OITs) with two-line displays, to more capable embedded HMI graphics terminals, to powerful PC-based HMIs. Here's how to select the best one for your application.

Pick the Right HMI

When selecting an HMI for a small machine, an OIT is typically acceptable—and certainly simple to configure and low in cost. An OIT will connect directly to the machine controller and provide suitable local operator interface functionality, and is >>

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a good choice when adding additional operator displays to large machine lines to offer operators a better view of equipment status and line operation.

With larger machines or complex manufacturing lines, more extensive capabilities may be required, and this is where PC-based HMIs can be the best choice.

With these types of HMIs, the PC can be industrially hardened for environmental reasons or office-grade. PCs today are available with multiple processors, large hard drives, lots of memory, and a wide range of built-in connectivity options. High-end functions such as a historian and the ability to simultaneously supervise multiple production processes can quickly justify the extra cost of this option.

Not Too Big, Not Too Small, Often Just Right

The obvious choice for mid-size equipment and processes is an embedded HMI. However, in many cases, these middle-of-the-road HMIs can also fit the bill for applications from small to large. Even smaller machines can benefit from connection to the cloud, and these 6- to 15-inch embedded HMIs work well in a variety of configurations whether standalone or networked.

Embedded HMIs can go it alone, but they also play well with others. In a dedicated, standalone setup, an embedded HMI connected to small or mid-sized automated equipment is a cost-effective and simple solution. Simply ensure the correct protocol is available to talk to the machine controller, hardwire it to the controller with its included cables, and you're ready to configure the software. Unlike OITs, embedded HMIs have many features including the capability to interface with mobile devices such as smartphones and tablets. If you're working in a networked setup, there are two main network architecture options.

HMI Network Architecture Options

There are two types of networked HMI solutions, one with multiple HMIs connected to one controller, and the other with one HMI connected to multiple controllers. Some applications work best with both options employed simultaneously as multiple HMIs are connected to multiple controllers.

OITs and embedded HMIs fit well into the first scenario, where multiple HMIs are connected to one controller on a single large item of equipment like a printing press, or an assembly line with multiple manual and automated work cells. In either configuration, this networked solution will support many HMIs. If one HMI fails, other HMIs can provide redundant operator interface to minimize downtime. The fallback HMI may be in a less than optimal location, but it can provide needed functionality until repairs are made.

In the second scenario, where one HMI is connected to multiple controllers, a PC-based HMI is typically the focal point as it can connect to many controllers simultaneously, even using different protocols if necessary. A PC-based HMI can contain many screens, limited only by the designer's imagination and available memory, so each controller can have its own set of displays. With this option, OITs and/or embedded HMIs are often used to provide local operator interface, with the PC providing an overall view of operation.

Location, Location, Location

A big consideration is where and how to position the HMIs. It is very important to consider ergonomic and normal operator position. If the operator has a kink in his neck from looking at an awkwardly positioned HMI screen, he or she may start to ignore the screens and follow gut instinct. In general, each HMI should be positioned so the operator doesn't need to look up much, and down just a little.

Speaking of location, it's important to consider where the operator is going to spend most of his or her time. How far will the operator have to walk to view the HMI? HMIs are often mounted in the main control enclosure, often located at the front end of the production line. But if there are locations where there tend to be line disruptions or stoppages, how much time would be saved if the HMI were mounted close to where these problems typically occur?

In order to maximize efficiency, it is good practice to mount the main HMI in a centralized and easily accessible location to keep the operator's steps to a minimum. Fewer steps combined with additional OITs and/or embedded HMIs at strategic problem points can quickly pay for themselves in terms of improved operations and safety.

Another location consideration is how far the HMI will be from the actual equipment area of interest. Being 20 feet away from the tooling station you are trying to operate manually from the HMI is never an enjoyable experience. Consider mounting the HMI on a swing arm if the machine footprint allows, as this will make the viewing experience up close and personal.

There are many considerations when designing and integrating a control system's OITs and HMIs, with some of the leading factors discussed here. Once the type of HMI is selected and communication features and functionality are confirmed, consider how the operator and manufacturing engineer will use the OITs and HMIs. Make sure they are readily accessible, and remember that with OITs and HMIs, more is often better in terms of improved operations and safety.

HMI Product Choices

At AutomationDirect, we offer over 250 operator interface related products. OITs include our LED Message Displays, DirectView and Optimate text panels. For an embedded HMI option, look at our C-more touch panels. We provide PC-based HMI with our Point of View® software, the most powerful choice. All of these options lead the industry in terms of price/performance ratio, allowing you to provide the required number of HMIs in a cost-effective manner.

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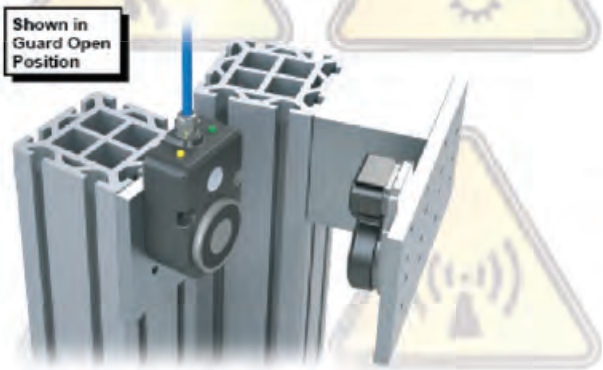

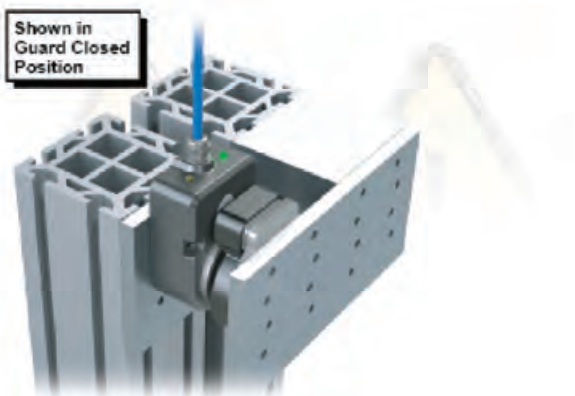

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OHIO STUDENTS IMPROVE ASSEMBLY PROCESS FOR EMPLOYEES WITH DISABILITIES

By TJ Johns,
AutomationDirect

The annual SourceAmerica® Design Challenge is a national engineering competition to design workplace technology for people with disabilities. For this competition, high school students spend months partnering with a nonprofit that employs people with disabilities to invent a device, process, system or software for a more productive work environment.

Kirby Harder, Copley High School's (CHS) Industrial technology teacher, carefully hand-picked seven students to serve as the CHS Engineering Team. Along with Coach Fiona Casida, Harder partnered the team with Weaver Industries, a non-profit organization in Akron, Ohio, to develop a more efficient way to improve productivity at their production facility.

Weaver Industries maximizes the independence and personal fulfillment of individuals with developmental disabilities via vocational training and employment opportunities through community, business, and family partnerships. Their production services division, ProPak, boasts a 40-year history of providing businesses throughout the northeastern Ohio region, and the country, with quality service.

Fomo Products, a manufacturer of low pressure polyurethane foam insulation, sealants, adhesives, and spray foam systems in pressurized packaging, enlists the services of ProPak's employees to produce Fomo Nozzles for their products.

For ProPak's employees, the nozzle assembly procedure was awkward, fatiguing and done entirely by hand. Of their 30 employees, only five could perform the task. The seven-student CHS Engineering Team accepted the task of improving production by automating the assembly process. The team's goal was to design and construct an assembly machine that would enable all ProPak employees to complete the assembly process as well as decrease the production time and cost per assembly.

In order to automate production, the CHS Engineering students visited ProPak's production facility to gather data which would aid them in the design, fabrication and testing of a prototype assembly machine which presses a mixer into a nozzle to a specified depth required by Fomo Products.

IMAGE 1: The Fomo Nozzle Machine

The team quickly observed that the awkward assembly process required a large amount of fine motor skills and upper body strength. The slow and awkward four-step assembly process was as follows:

1. Sixteen empty Fomo nozzles were placed into a wooden assembly jig.
2. A plastic mixer was then inserted into each nozzle.
3. Using a hand tool, the mixer was pressed to a specific depth inside the nozzle.
4. Completed assemblies were checked, removed from the assembly jig, and placed into a bin to be transferred to the packaging station.

The team also collected baseline production numbers, including parts per hour and minute, as well as any other applicable data ProPak had on file. Data was also collected by observing employees on the assembly floor. The fastest nozzle assembler produced one block of 16 nozzles every 64 seconds and four blocks every five minutes. Another employee was timed assembling one block in two minutes and 30 seconds, more than twice the time it took the fastest employee; this provided a better representation of the average employee.

After extensive data collection, the team returned to Copley High School to brainstorm on how to improve the assembly process. The team designed a machine that incorporated a 1-to-1 process, meaning that every preassembly placed into the machine resulted in a final assembly exiting the machine, instead of the current multi-step process. This new assembly machine incorporated the use of computer electronics and pneumatics to complete an effortless assembly process.

IMAGE 2: Thomas Kimmins (Left) and Chris Dugan (Right) make adjustments to the Fomo Nozzle Machine.

Using SolidWorks, the team generated a design and made machine sketches, then began building and testing individual parts. The newly designed Fomo Nozzle assembly machine was constructed of a slotted plywood center wheel and outside path with a cold rolled steel wheel center and axle, and steel tubing wheel frame. The indexer and plunger mechanism consisted of pneumatic cylinders and custom metal parts. Three removable plywood parts hoppers were constructed to contain the nozzle, mixer and completed assembly. Casters were also added to make the machine easily portable. The entire process is controlled by Arduino computer code written by senior Bobby Wagner.

Wagner says, "The biggest thing I learned from this project was that by working together we can accomplish greater things than we ever could alone. For this project, if any of us had attempted it alone, none of us could have achieved a final product of comparable quality as the one we produced."

Of course, not everything comes together as originally planned, or as it may appear on paper. There are always unexpected snafus, and when problems arise, the team has to work together to find the solution.

The team's videographer, junior Aaron Hesketh commented, "Troubleshooting is

often the most important part of a project. Just because you think something is the problem, if it isn't, redoing it six times will not fix it. We encountered a few bugs while developing our machine, and we thought one of them might have been a loose connection in our wiring. So we rewired the whole machine several times, but in the end we just needed a new computer."

Whereas the previous assembly process required employees to stand during the entire process, the team's final design is at a height that either a wheelchair or standard chair can fit, allowing the employee to sit comfortably. The students improved the ergonomics by locating the plywood parts hoppers in convenient easily reachable locations on either side of the operator.

With the new Fomo Nozzle machine design, the operator can easily reach the raw material hoppers, drop the Fomo Nozzle into a slot on the center wheel, followed by a plastic mixer. Then the operator presses a single pushbutton which indexes the machine, presses the mixer to a specified depth and ejects the completed nozzle into the completed parts hopper.

Before the redesign, only five employees had the stamina to produce the Fomo Nozzles. This new process enables all 30 employees to assemble nozzles, a 500% increase in employee involvement. Production numbers have doubled from an average of 450 per hour to 900 per hour.

By automating the assembly process, production time was reduced from an average of eight to 12 seconds each to as little as 3.11 seconds per completed nozzle. With the CHS Engineering team's design, there was also a decrease in part handling, assembly steps, and rejected parts were virtually eliminated.

Teachers know that if you can help your students learn more than just the steps given in a lesson plan, those students will become not only more intelligent but also wiser in the process. This team of students quickly learned that designing and constructing this machine for Weaver Industries was more than an engineering lesson.

Reflecting on the overall project, student video spokesperson senior Chav Maharaj says, "I believe that the biggest thing we learned from this whole experience is to not take things for granted. Throughout the whole project we would often have to rethink concepts to try to make our machine versatile to all the current and future employees at Weaver. In order to complete that, we would have to put ourselves in the perspective of people with disabilities. This allowed us to make our machine do what we needed it to, for anyone who was willing to work on this production line."

IMAGE 3: Team members Rachel Hopkins (Left) and Laura Klions (Right) explain how the Fomo Nozzle Machine improved efficiency and productivity for Weaver industries ProPak employees.

While each team member had a specific position, they also helped in other areas. Team communicator, senior Laura Klions said, "Working on this project provided me with a bunch of new opportunities and experiences that I would not have had otherwise. I really enjoyed learning a bit about construction, specifically how to weld."

The team's metal worker was senior Chris Dugan. He walked away from the final result stating, "Sometimes the biggest reward is not the one you expect. When I joined this team I knew it would be good experience for my future career in engineering. I did not think I would learn so much about people with disabilities, and I did not expect how good it made me feel to help out the workers at Weaver Industries."

With the working model complete, Copley High's engineering team submitted it as their entry in the SourceAmerica High School Design Challenge where they were awarded first place on the national level in Washington, D.C.

"The technology the students create for the SourceAmerica Design Challenge is game changing for the people who benefit from it," said Steven Soroka, president and CEO of SourceAmerica. "Working side-by-side with an individual with a disability, these students implement ideas that change lives. Through their ingenuity, we are getting closer to the day when every person with a disability who wants a job has a job, and has the tools to be successful at it."

IMAGE 4: Copley High School's Engineering Team Takes First Place

"I don't know of any other competition out there like this that has this kind of impact on the community," said Charissa Garcia, Design Challenge Coordinator. "Graduates of this program received a patent for their technology. Participants also helped nonprofits secure contracts, which provide more employment opportunities for people with disabilities."

When asked what it was like working on this project as a team, senior Josh Myers replied, "It was a great experience being on a team that enabled us to work and to function like real world engineers. We all did our best to help each other out, and support one another. This really contributed to our success. If we didn't work so well together it would not have been nearly as easy to put in the long hours of work necessary to complete this project."

Echoing that sentiment, the team's leader, senior Rachel Hopkins stated, "It was a very real world experience; everyone on the team had a specific job to do based on what they could do, which enabled us to create something better than any one of us could have done alone."

Upon congratulating his team on their national victory, Kirby Harper has begun looking forward to forming next year's student engineering team. He is confident they will develop another tool that provides a better way of life for people with disabilities. We can count on seeing that tool in next year's SourceAmerica High School Design Challenge as well.

THE BULGARIAN BAT DETECTOR

By Jay Rees, PE,
Rees Engineering

During my years working as an Automation Systems Integrator, I occasionally get projects that are different from the normal industrial, process and manufacturing systems. I was recently asked to develop the controls for a museum exhibit to simulate a bat's echolocation. The museum, Children's Center of Sofia, in Sofia, Bulgaria, and I promptly named the project "The Bulgarian Bat Detector". In a near dark environment, the museum visitors rotate a viewfinder towards a display depicting an environment for bats. A couple of bats are located in the display and they are the targets for the bat detector. As the viewfinder approaches the bat's position, the sound level of an audio track increases in volume with a maximum level when pointed directly at a bat. The volume level decreases as the viewfinder leaves the bat's position.

IMAGE 1: Bat Exhibit under construction at the Children's Center of Sofia in Sofia, Bulgaria

The control solution devised does require the bats to actually be detected as the controls monitor the direction of the viewfinder to the location of the bats in the display. The volume of the audio track is set based on the position of the viewfinder relative to the bats with volume increasing when approaching the bat and decreased when leaving.

Four main design aspects needed to be developed for this project.

1. Viewfinder direction
2. Audio playback
3. Audio volume adjustment
4. Setup adjustment controls

The biggest hurdle encountered was how to control the audio volume without excessive development and testing while also keeping costs low. As an experienced automation systems integrator, I did not have a volume control solution in my bag of tricks, and it quickly became apparent that some type of hybrid solution was needed. The position detection and process logic would be handled with an AutomationDirect CLICK® PLC, the audio playback would use a commercially available digital audio repeater, and the volume adjustment solution would need to be built using electronic components.

Viewfinder position detection

The viewfinder's position is determined using a touchless encoder. The encoder uses a magnet attached to the rotating shaft of the viewfinder and the encoder (mounted to the support) is a Hall Effect type sensor that determines the rotational position of the magnet. The output of the encoder is a 0.25V to 4.75V DC signal representing 0 to 360 degrees. The encoder's output range is perfectly suited for the CLICK's built in 0V to 5V analog input. The PLC also has a built-in scaling configuration for the analog input providing the position's 0 to 360 degree value and placing it directly into a floating point (real) PLC variable.

Audio playback

For the audio playback, a purchased solution was used. The QuikWave™ EM38A is a unit used by museum exhibit developers and allows MP3 audio files to be played in a variety of ways. For this application we used a playback script to run a single audio file in a continuous loop.

Audio volume adjustment

The most challenging part of the project was how to control the audio volume from a PLC output. I was hesitant to accept this project because I didn't have a clear cost effective solution at hand. During the quoting process, I remembered reading about a few technologies that might work. These included a digitally controlled

IMAGE 2: Museum visitors will use viewfinders to locate bats in the near dark exhibit.

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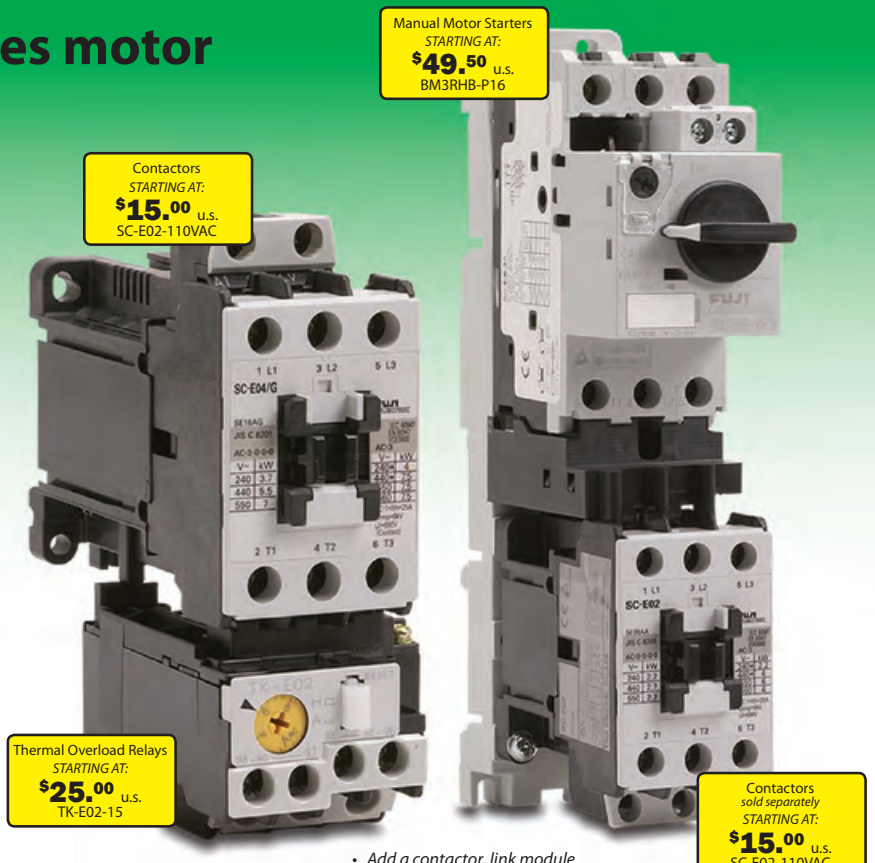

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potentiometer and using IC analog switches to control a voltage divider. Both of these solutions would require a lot of development and testing to prove them out for the application.

My customer, Andrew Tomasulo of Connect Interactives, who is in the museum exhibit business, came across a solution that used Light Dependent Resistors (LDR). The LDR consists of an LED and a photoresistor as a single device. The intensity of the LED regulates the resistance of the photoresistor. Because the only connection between the LED and the photoresistor is light, the photoresistor is an isolated and passive device. The PLC's 0-5V analog output signal is used to vary the device's resistance.

In order to use the LRD solution for volume control, two LDR units are set up as a voltage divider. Two separate 0-5V analog outputs from the PLC provided opposite voltages to the devices (0-5V and 5-0v). The resistance of the LDR's is from 1,200 ohms down to 60 ohms, which provides a full volume control range.

An issue was encountered when the LDR circuit was first connected to the PLC analog outputs. The PLC analog outputs did not provide enough current to drive the LED in the LDR over its full range. The PLC can only source 2.5 mA and the LED needs up to 25 mA. This prompted a quick trip to the "Shack" for an OP Amp. They only had one in stock (LM324) with rail-to-rail output that would work with my single ended power supply.

Setup adjustment controls

The unit uses four potentiometers to set the target locations for the bats in the display. The audio output volume increases and drops within +/- 10 degree range of the target. A 5V power supply voltage regulator (LM7805) was added to the circuit board to power the potentiometers. The outputs of the potentiometers are sent to an analog input module of the CLICK PLC.

Assembly

All of the components were packed into a 12" x 10" x 5" non-metallic enclosure. Field connections are made using Micro (M12) connections and the power cord uses a European Schuko plug (remember this unit is going to Bulgaria). The custom circuit board was hand assembled and mounted on stand-offs. Almost all of the components were from AutomationDirect except the audio playback unit, custom circuit board, potentiometers and (of course) the power cord.

IMAGE 3: The CLICK PLC controls position detection and process logic.

Testing

My responsibility only included factory testing. My customer, the museum exhibit manufacturer, would perform the final testing with the actual equipment. I needed to simulate the external functions using an analog simulator for the encoder signal, an MP3 file found on the Internet (bat noises) and a computer speaker.

IMAGE 4: Target potentiometers adjust for the loudest output volume.

To test the unit, simulated positions were set on the analog simulator (encoder). For each encoder position, a target potentiometer was adjusted for the loudest output volume. After all of the positions were set, the simulated encoder swept over the full range to confirm the volume changes at the targets.

Conclusion

This was a fun project with its share of challenges but in the end it all worked out (and no bats were hurt in the process). I'm thinking of adding a trip to Sofia, Bulgaria, to my bucket list so I can see and hear the unit in operation.

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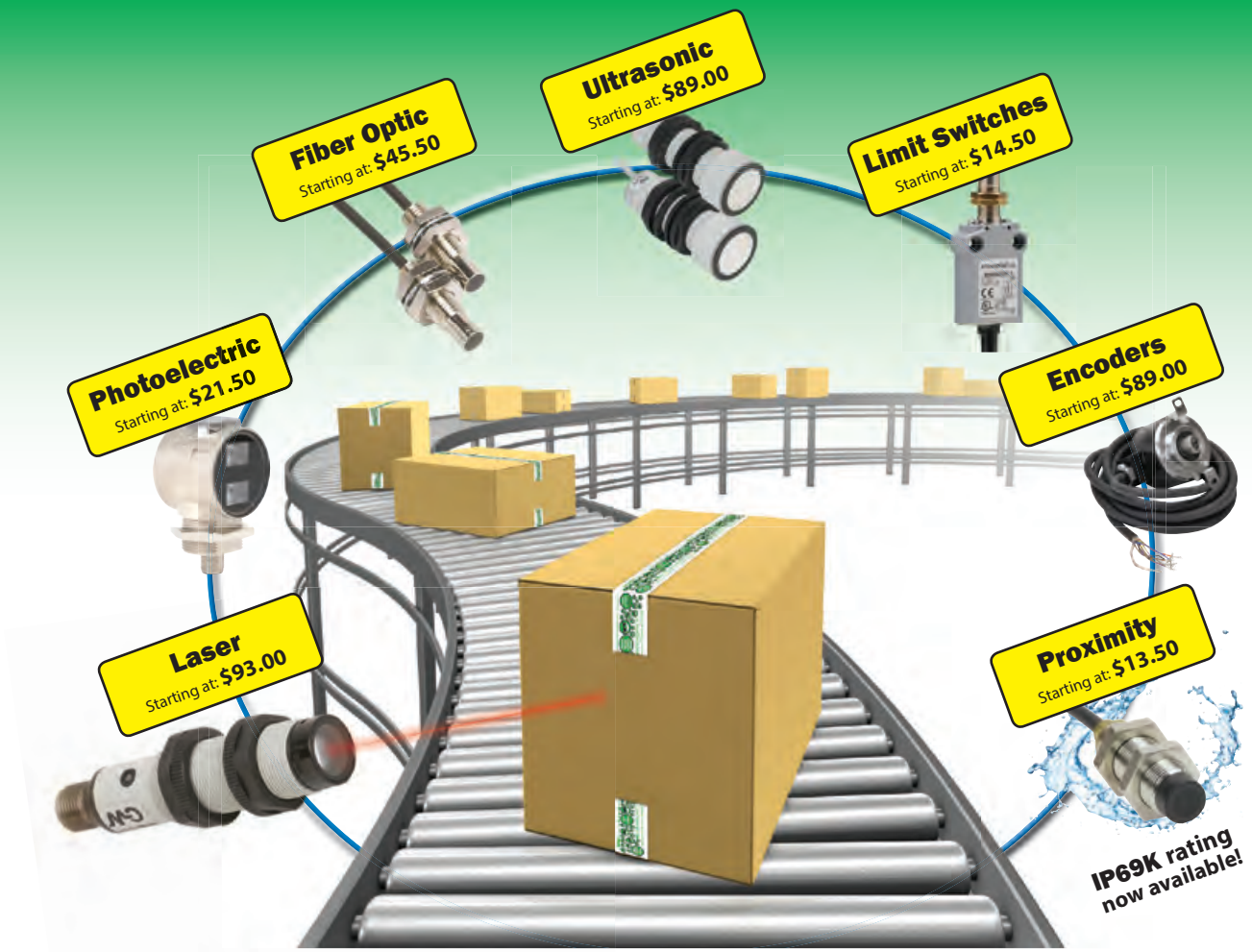

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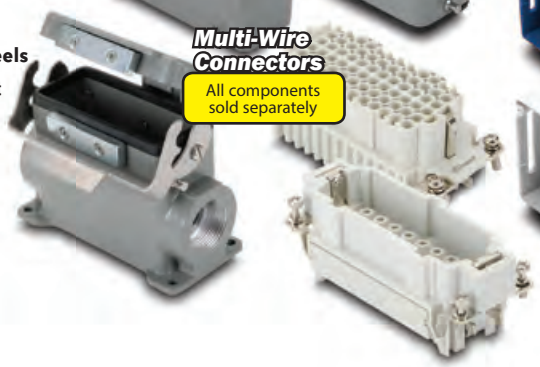

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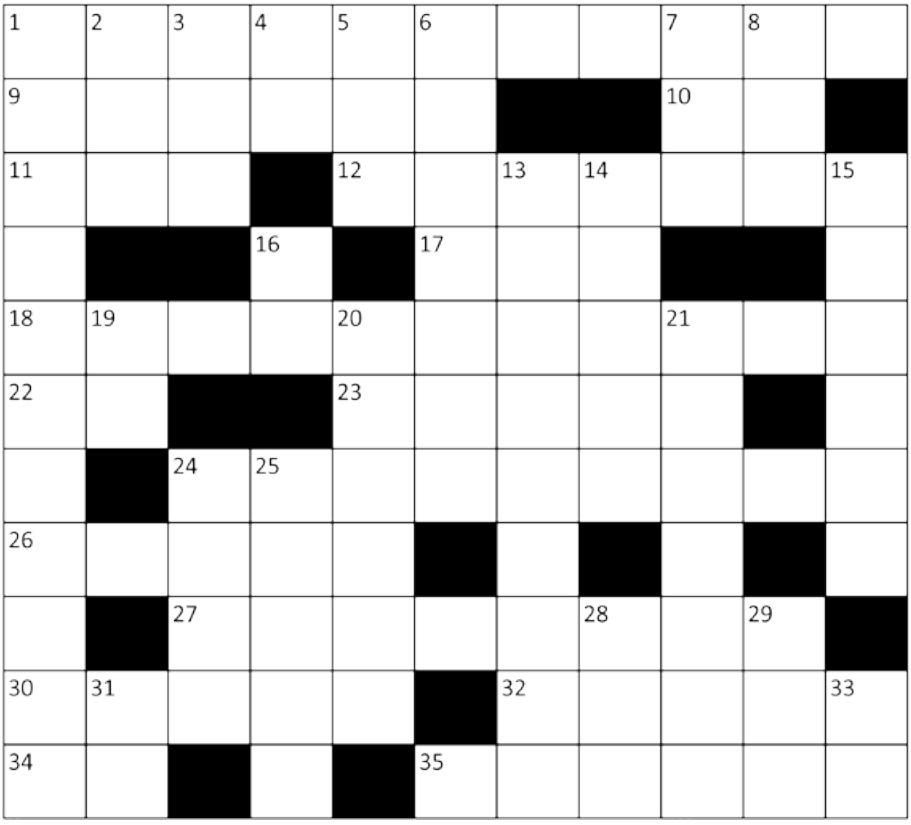

Across

1. Makes known
9. Secret, hidden, or concealed
10. Runs on HW
11. New Deal program (1933-1942)
12. Dismantles
17. An OK airport
18. Rung after rung
22. Home phoner
23. Common converter of electric to kinetic energy
24. Power upper?
26. Along the center of a round body
27. Popular brand of 'green' surfactant
30. Dark hardwood in need of protection
32. Sheet spreader
34. Andalucían affirmative
35. To suppose

Down

1. Gets moving
2. Nuke regulators
3. "If you can make it there…"
4. Power ___
5. Turbidity divisions
6. Word before "system" and "algorithm"
7. Sound of disapproval
8. Like Bo-Peep
13. Combine into one
14. Snooty
15. Deny unauthorized access
16. Put one's finger on (abr.)
19. 2nd Gen PC
20. Use
21. Make face
24. Robotic dog
25. Input power
28. $y=e^x$ for short
29. eStandards?
31. Table entry 83
33. Reports to the captain (abr.)

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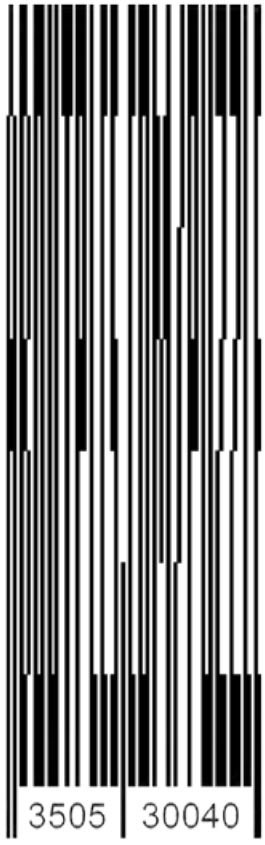

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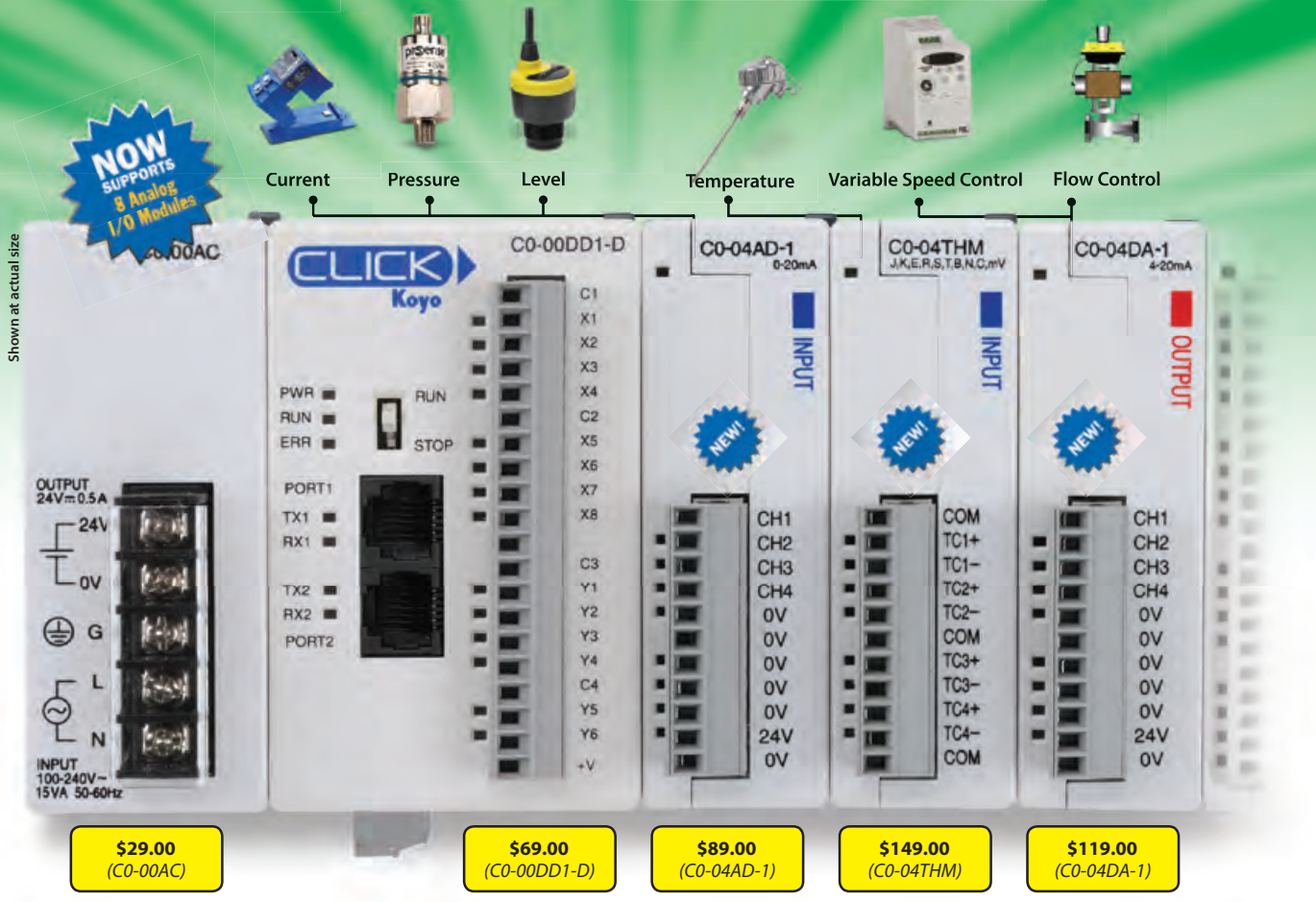

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