Automation NOTEBOOK

Your guide to practical products, technologies and applications

TRAINING MOVES OUT OF CLASSROOM

Training transitions from the classroom to hands-on and online, providing students with options.

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PNEUMATICS IMPROVE RIDGELINE MACHINE'S EQUIPMENT

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WHY PNEUMATICS?

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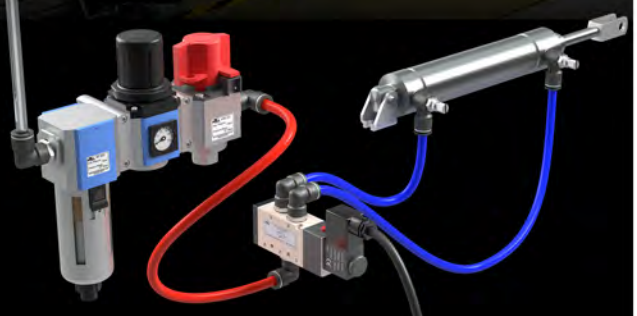

www.AutomationNOTEBOOK.com Winter 2016 | Issue 34

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Your guide to practical products, technologies and applications

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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

"Why be afraid, if I'm not alone?" On March 20, 1990, pop legend Gloria Estefan's world changed forever. After a near-fatal tour bus accident in Pennsylvania, the media and others in the music industry thought her career had come to an end.

With the support of her family, and unending determination, she came back better than ever. At the 1991 American Music Awards, she once again graced the stage with her song, "Coming out of the Dark".

She proved that when you do your best, without backing down, you can overcome the toughest obstacles.

That's what we at AutomationDirect do every day. We are determined to provide you with dependable, quality products, backed with great technical support, so when you complete your industrial application, you will say, "Why be afraid?"

This issue of NOTEBOOK is not only filled with information about our latest products but also interesting technical articles. In our Tech Brief article, we help you understand the basics of ladder logic. We also have a great article which explains why pneumatics can be beneficial in motion applications. Cindy Green provides a great Cover Story on how training is transitioning from the classroom. In our User Solution story, you'll read about how Ridgeline Machine uses pneumatics on a tray making machine. Our Student Spotlight turns toward the University of Idaho where Professor Greg Möller has teamed up with engineers to create a portable water treatment platform.

That's just a taste of what is inside this issue. Of course, we didn't forget to include everyone's favorite -- the Break Room is stocked with more fun, and potentially trying, brainteasers. After you try to solve them, you can compare your answers at **www.automationnotebook.com**

TJ Johns
Coordinating Editor
editor@automationdirect.com

Table of Contents

ETHERNET PLCs ADDED TO CLICK® LINE

With the new Ethernet Basic and Ethernet Standard PLC units added to the CLICK line, now you can connect the CLICK PLC to an Ethernet network directly.

The Ethernet Basic PLC units (starting at only $129.00) and Ethernet Standard PLC units (starting at $149.00) are available with different combinations of built-in I/O types (i.e. DC input/DC output, DC input/relay output, and AC input/relay output).

With 14 built-in I/O points (8 inputs/6 outputs), the PLC units can be used as a ready-to-go PLC control system without any additional I/O modules.

As a bonus, the new Ethernet PLC units are three to ten times faster than the existing CLICK PLC units. Plus, they are 100% upward compatible with the existing models and support all of the CLICK optional I/O modules. The new Ethernet PLC units support up to 142 discrete or 48 analog I/O points as do most of the existing CLICK PLC units. (Analog PLC units can support up to 136 discrete I/O and 52 analog I/O points)

With the new CLICK Ethernet Basic and Ethernet Standard PLC units you get a 10/100 Mbps multipurpose Ethernet port for faster networking and control, and one standard RS-232 serial communications port. Additionally, the Ethernet Standard PLC Units have an RS-485 port for Modbus and ASCII communication.

The built-in Ethernet port allows you to program your system, network your CLICK PLC or control Ethernet-enabled devices. Using the Modbus TCP protocol, the new CLICK PLCs will easily integrate into existing networks and provide a simple, cost effective solution for your application.

Along with the new Ethernet capabilities, these PLC units also support runtime edits, which means edits to the ladder project can be downloaded while the CLICK PLC keeps running.

All of the new CLICK Ethernet PLC units also include a calendar/real time clock and battery backup for the internal SRAM; the battery, sold separately, allows data to be retained for five years.

CLICK PLC units are configured with the easy-to-use programming software, available as a free download or for purchase on CD for $10.

To learn more visit the CLICK in-depth site:
http://www.automationdirect.com/clickplcs

Watch a short video on the new CLICK Ethernet PLCs:
www.automationdirect.com/VID-CL-0028

CLICK PLCs

The mighty micro with a pico price!

Get Ethernet with just a simple CLICK!

In today's world, what can you get for $129? How about a complete stand-alone PLC unit with Ethernet and serial communication plus eight discrete inputs and six discrete outputs. Too good to be true? Not with CLICK! Our new Ethernet PLC units come with a built-in 10/100 Mbps Ethernet port for even more functionality at an unbelievable price! Just check out what $129 will get you:

- (1) 10/100 Mbps Ethernet port, (1) RS-232 serial port (an additional RS-485 serial port is available on CLICK Ethernet Standard PLC units starting at $149)
- Modbus RTU, ASCII, and Modbus TCP communication protocols
- 8 discrete input points and 6 discrete output points built in, capable of expanding to a total of 142 discrete or 48 analog I/O points
- Real time clock and battery backup that allows data to be stored for 5 years (battery sold separately)
- FREE programming software with a simple but practical instruction set
- 2 year warranty
- Basic PLC units are also available starting at $69 and Analog PLC units start at $129

See what others are saying:

"This little PLC is like the little engine that could. It is incredibly easy to program with the FREE software and it just keeps on chugging. It is hands down the best PLC for the dollar available."
Matt in LIVONIA, MI

"Excellent product for the money. We have several that have been running 24/7 at our facility for several years with no issues. Easy to program and install."
Mark in SAINT CHARLES, IL

"I have done several projects with these little units and they are fantastic for their ease of use, free software, and all their features!..."
Gary in CANANDAIGUA, NY

"Excellent product. Easy to program and many features for the price."
Leonardo in MOUNT PROSPECT, IL

You can see even more reviews under the Reviews tab on the CLICK PLC Units product page at www.automationdirect.com

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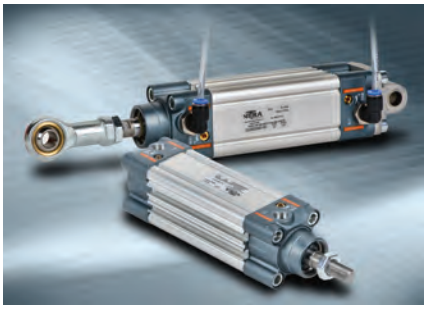
RECENTLY ADDED PRODUCTS

SOCOMEC FUSIBLE AND NON-FUSIBLE DISCONNECT SWITCHES

New Socomec disconnect switches include UL 98 and UL 489 rated fusible and UL 98 and UL 508 rated non-fusible disconnects. Accessories include handles, shafts, shaft guides, auxiliary contacts, shrouds, lugs, cables/operators and blown fuse monitors. Starting at $78.50, UL 98 and UL 489 rated FUSERBLOC fusible disconnect switches are available in Class CC or Class J fuse versions with 30 - 600 Amp ranges and 200kA SCCR. Socomec UL 98 Rated non-fusible disconnects start at $48.50 and include the DIN rail mount SIRCO M Compact Series (30-100 Amps); the panel mount heavy duty SIRCO Series (100-600 Amps), and the UL 98B rated SIRCO DC Series (100-250 Amps). Socomec UL 508 rated non-fusible disconnects, starting at $18.50, include the enclosed, rotary SIRCO M Series (32-63 Amps) and the compact, modular SIRCO M series (16-80A).

www.automationdirect.com/circuit-protection

NITRA G-SERIES ISO 15552 AIR CYLINDERS



Fully metric design ISO 15552 NITRA® G-Series air cylinders have a 145 psi pressure rating in bore sizes from 32mm to 100mm and strokes from 25mm to 600mm. Features include end-of-stroke cushions, internal magnetic material for sensor switching and G-threaded (BSPP) ports. G-series cylinders start at $57.

www.automationdirect.com/air-cylinders

IDEM INTERLOCKING SAFETY SWITCHES

IDEM tongue-operated safety interlock switches fit to the leading edge of sliding, hinged or lift off machine guards while IDEM hinge interlock safety switches fit to the hinged axis of machine guard doors. Four tongue (key) interlock safety switch mounting sizes, 16.5 mm, 22mm, 30mm and 40mm, are available with plastic and stainless steel body and head housing options. The full body stainless model is IEC IP69K washdown rated. New tongue interlock safety switches start at $29.50. IDEM hinge interlock safety switches, starting at $30.00, are shaft (solid or hollow) or lever hinge interlock operated with plastic body and 316 stainless steel body and head material options (IEC IP69K rated); the HC-SS series starts at $90.00.

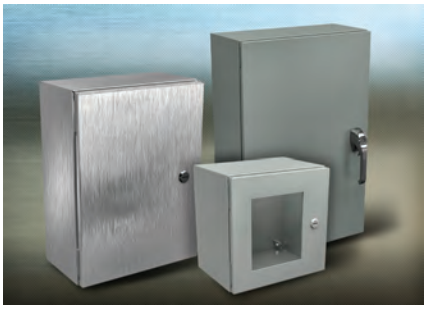
www.automationdirect.com/safety-switches

NEW FULL-COLOR 6-INCH C-MORE MICRO HMI TOUCH PANEL

The EA3-T6CL C-more Micro color TFT touch panel has three communications ports (USB programming, RJ12 and DB15) and five user-defined function keys (with LED indicators) for operator interface. The panel is NEMA 4/4X, IP65 compliant for indoor use and is priced at $299.

www.automationdirect.com/c-more-micro

ULTIMATE SERIES SINGLE-DOOR, WALL MOUNT ENCLOSURES (NEMA 4, 4X, 12 AND 13)



Over 360 new NEMA 4/12 and 4/4X/12 Ultimate Series enclosures have been added to our Hubbell-Wiegmann enclosures lineup. New designs include models with slope top, windows, as well as 1-point and 3-point latch heavy-duty handles; models are available in heavy 14 gauge steel with ANSI gray light-textured or RAL7035 light gray textured finishes, and in 14 gauge 304 stainless steel with smooth-grain finish. Ultimate series enclosures are UL and CSA approved. Pricing starts at $167.00.

www.automationdirect.com/enclosures

STEGO HEATERS FOR ENCLOSURE THERMAL AND MOISTURE MANAGEMENT

Priced from $9.50, positive temperature coefficient (PTC) compact resistor heating elements are IP54-rated with heating capacities from 5W to 13W. STEGO explosion-proof convection heaters in 50W and 100W heating capacities start at $157, and compact PTC fan heaters in the 1000W heating range start at $244.

www.automationdirect.com/enclosure-heaters

SUREMOTION DRIVE COUPLINGS AND BORE REDUCERS

SureMotion Jaw/spider clamp-style couplings have hub bores from 3/16" to 32mm with polyurethane center "spiders". Double loop couplings provide high torsional rigidity in a one-piece design and are available in 1/8" to 16mm bore sizes. Oldham drive couplings have aluminum hubs with bore sizes from 1/4" to 1" and Delrin™ center discs. Beam-style stainless steel servo couplings combine flexibility with strength and torsional stiffness. SureMotion couplings start at $10.50.

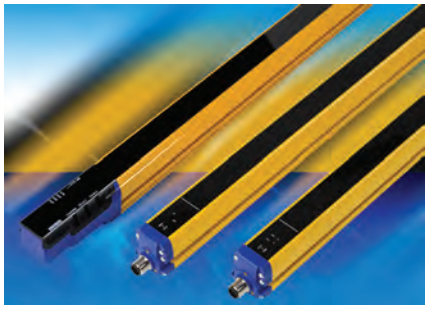
www.automationdirect.com/motion-control

22MM PILOT DEVICES

Fuji Electric's 22mm devices include AR22-series pushbuttons, selector switches and joysticks, and DR22-series pilot lights and buzzers. The compact design occupies less space than traditional 22mm devices and is adjustable to any panel thickness up to 6mm. Devices are mountable in panel cutouts of up to 25.5 mm diameter and can be wired in horizontal or vertical directions, making wiring in narrow spaces easier. Fuji AR22 pilot devices have a snap-on mounting that makes replacing or adding a contact block or transformer unit a cinch. UL listed, CSA and CE/RoHS2 approved, devices include a terminal cover for added safety; available oil and dust-proof operator modules are IP65-rated. Backed with a one-year warranty, Fuji 22mm pilot devices start at $9.00.

www.automationdirect.com/pushbuttons-lights

SAFETY LIGHT CURTAINS WITH BASIC AND ADVANCED FUNCTIONS



Datalogic 14mm resolution (finger protection) safety light curtains provide protected heights from 150 to 900 mm and operating distances of up to 7 meters. 30mm resolution (hand protection) light curtains offer 300 to 1800 mm protected heights and up to 20 meters operating distance. Advanced models feature zero deadzone, selectable operating distance, integrated muting and blanking functions and an advanced configuration mode through included GUI software. All Datalogic safety light curtains include both sender and receiver, are IP65 rated and have Type 4 and Cat 4 PL e safety ratings. Starting at $471.00, Datalogic light curtains are CE, RoHs and REACH compliant and cULus approved.

www.automationdirect.com/light-curtains

NITRA G-THREAD PUSH-TO-CONNECT PNEUMATIC FITTINGS AND FLOW CONTROL VALVES

G-thread fittings are available in G1/8 through G1/2 thread sizes and 4 to 10mm tubing sizes. G-thread fittings start at $4.25 for a 5-pack. NITRA pneumatic G-thread flow control (speed controller) valves are sold in two-packs starting at $11.

www.automationdirect.com/G-Push-Connect

MULTIFUNCTION SAFETY RELAY MODULES

Dold UG6970 and UG6980 safety relay modules are designed to protect people and machines in applications with a variety of safety devices. The UG6970 provides 2 independent, separately adjustable safety functions and the UG6980 provides one function. The selectable safety functions include E-stop, safety gate, two-hand control, safety mat / safety edge, light curtain and exclusive XOR contacts. Features include line fault detection on pushbutton, manual or automatic restart, forcibly guided output contacts, pluggable terminal blocks for easy exchange of devices, and LED operations indicators. The multifunction modules have two N.O. contacts per safety function and one semiconductor output per safety function.

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The two-function UG6970 relay module is $240.00 and the UG6980 is $155.00. The modules are CSA, cULus , CE, RoHS, and TUV listed.

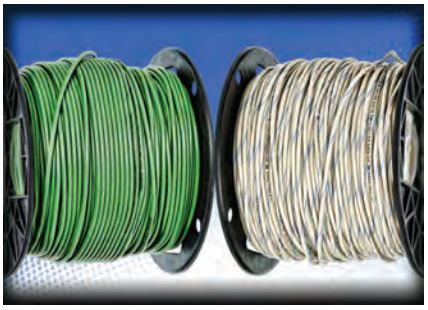
www.automationdirect.com/safety-relays

ROXBURGH EMI / RF FILTERS

Roxburgh 1-phase and 3-phase EMI filters are drive-rated for AC drives and inverters. Drive-rated 3-phase power line EMI / RF filters (starting at $77.00) are specifically designed for 230/460 VAC motor drives, inverters, machine tools and other 3-phase devices. Starting at $41.00, 1-phase EMI / RF line filters are designed for single-phase 120/240V AC and DC drives. Single-phase EMI filters are also now available for general purpose applications.

www.automationdirect.com/power-filters

COLOR CODED SPIRAL-STRIPED MTW WIRE



Striped MTW wire with color-coded PVC heat and moisture-resistant insulating jackets is available in 500-foot spools and in 18, 16 and 14 AWG sizes. Offered in white with blue stripes, blue with white stripes, white with orange stripes and green with or without yellow stripes, MTW wire starts at $40.00 (500 ft. spool).

www.automationdirect.com/wire

REFRIGERANT-FREE VORTEX COOLERS FOR INDUSTRIAL ENCLOSURES

Vortex cooler advantages include small physical size, cooling without refrigerants (no CFCs, HCFCs), exceptional reliability with no moving parts, and suitability for harsh environments. New all-stainless steel Stratus® vortex coolers, priced at only $270.00, have cooling capacities from 500 to 2,500 BTUH and all replacement generators fit any Stratus vortex cooler. The vortex coolers mount in a single 3/4" electrical conduit knockout, and relief valves and seals are built-in, enabling the units to maintain the sealed nature of NEMA 4, NEMA 4X and NEMA 12 enclosures.

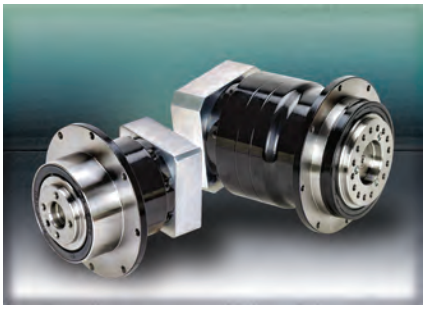
www.automationdirect.com/enclosure-cooling

MAGNETIC-INDUCTIVE FLOW METERS

ProSense FMM series magnetic-inductive flow meters detect flow rates up to 160 GPM. These magmeters have a 4-digit display with pushbutton setup to indicate flow rate, fluid temperature and total flow volume, and two outputs to monitor flow rate and temperature. FMM series flow meters start at $460.00.

www.automationdirect.com/flow-sensors

INLINE SERVO GEARBOXES WITH HUB STYLE OUTPUT



The compact design and hub style output of the PGD series of inline precision servo gearboxes is ideal for equipment requiring high-speed, high-precision indexing movement. Available in six gear ratios ranging from 5:1 to 50:1, the hub style gearboxes feature a backlash rating of less than 3 arc-minutes and exceptional torque handling capabilities. High torsion stiffness and low backlash of the planetary gearing combine to provide outstanding positioning accuracy. Maintenance free, the gearboxes contain high-viscosity, anti-separation grease which does not migrate away from the gears. Starting at $722.00, SureGear PGD-series gearboxes have an IP55 rating and a five-year warranty.

www.automationdirect.com/servo-gearboxes

WHY PNEUMATICS?

By Pat Phillips,
Fluid power and Mechanical Products
Product Manager, AutomationDirect

In manufacturing facilities, compressed air is so widely used that it is often regarded as the fourth utility after electricity, natural gas and water. But compared to electricity, compressed air is more expensive, so why is it so widely used to drive factory automation systems?

The main reasons are lower upfront and maintenance costs, which combine to make pneumatics the most popular and cost-effective choice for executing mechanical motion. While there are some, especially electric actuator vendors, who claim electric motion is better due to its superior energy efficiency, it's hard to beat the simplicity and reliability of pneumatics.

Characteristics	Pneumatic	Hydraulic	Electric
Complexity	Simple	Medium	Medium/High
Peak power	High	Very high	High
Size	Low size/force	Very low size/force	Medium size/force
Control	Simple valves	Simple valves	Electronic controller
Position accuracy	Good	Good	Better
Speed	Fast	Slow	Fast
Purchase cost	Low	High	High
Operating cost	Medium	High	Low
Maintenance cost	Low	High	Low
Utilities	Compressor/power/ pipes	Pump/power/ pipes	Power only
Efficiency	Low	Low	High
Reliability	Excellent	Good	Good
Maintenance	Low	Medium	Medium

TABLE 1: Linear Power Transmission Comparison

Linear Power Transmission Options

Linear power transmission is typically done with fluid (pneumatic with air or hydraulic with oil) or electric power. In electric power systems, electromechanical devices such as belts, pulleys, chains, sprockets and clutches convert rotational motion from motors to linear force. The main exception is linear motors, a relatively expensive specialty technology used to move very light loads.

Although many vendors often promote the competing technology of their choice, the choice of power transmission depends on the application. It's not uncommon for larger machines to have all three of the power transmission technologies in use simultaneously. But many other machines only use pneumatics due to some advantages over other power methods.

Linear Power Transmission Comparison

The Table above lists some of the general advantages associated with pneumatic, hydraulic and electrical means of producing linear mechanical motion.

Pneumatic systems are simpler than hydraulic and electric systems, conferring advantages in upfront costs and maintenance. Fluid power systems produce linear motion with simple pneumatic and hydraulic cylinders and actuators. Converting electrical to linear power often requires one or more mechanical devices to convert the motor rotation.

Pneumatic and hydraulic power transmission methods typically produce more power in a smaller space, so small pneumatic cylinders can be used to provide the high required clamping or positioning force needed to hold a product in certain machining and other applications.

Control of this power is usually easier with pneumatics and hydraulics than with electric systems. A simple valve, regulator and flow controls are usually all that's needed to control cylinder direction, speed and force. An electric actuator often needs an electronic controller, multiple I/O points, communication cables, and possibly encoder feedback, along with more complex automation system programming.

A pneumatic actuator typically has two very repeatable end-of-travel positions which are set by using a hard stop, cushion or shock. Electric actuators are also very repeatable, and can be easily designed with multiple stop positions. With new advances in electronics, pneumatic control of multiple

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stop positions is also now possible. Whether it is end-of-stroke or multiple stop positions, both pneumatic and electrical actuators can attain the desired position at high speeds.

Pneumatic hardware is also much simpler to design, and less expensive to purchase and install.

Operation of a compressor may have additional costs compared to electric, but the availability of clean dry air in a facility is common. And pneumatic components often have the lowest maintenance costs, such as when replacing seals, or a whole cylinder for that matter, which is often much cheaper than servicing, let alone replacing, an electric actuator.

Noise is becoming less of a concern with fluid power devices. Designs have improved over the years, greatly reducing clatter to about the same level as a stepper-driven electric actuator. New improvements in designs and efficiency of compressors, and the standard use and distribution of clean dry air in a manufacturing facility, also make pneumatics a good choice for industrial automated machinery.

A good application for pneumatics

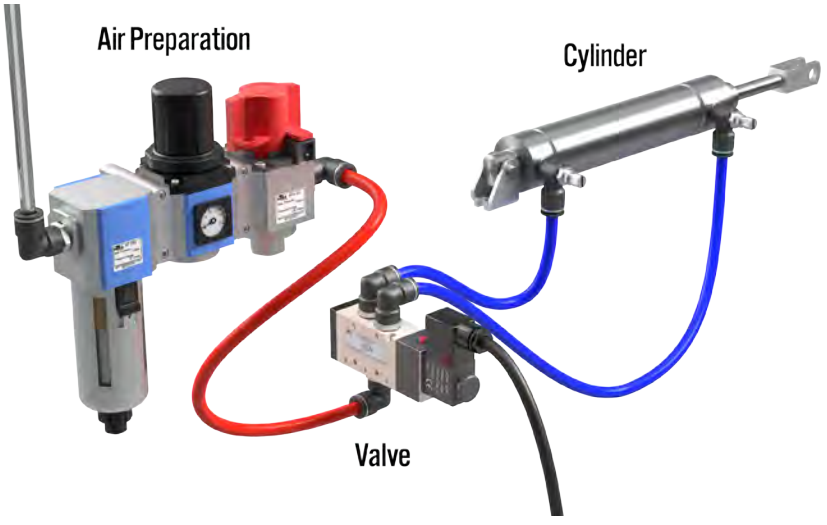
Pneumatic power transmission methods are often the best way to move parts and tooling in industrial machines. These pneumatic systems perform a myriad of tasks in automated equipment such as clamping, gripping, positioning, lifting, pressing, shifting, sorting and stacking.

Some adaptive uses—each of which could include closed loop control for more precise positioning—include tensioning, pressing, labeling, embossing, crimping and cutting.

The tried and true pick-and-place method with horizontal and vertical travel and a gripper is probably one of the most common uses of pneumatics. Clamping or part positioning functions are also widely implemented with pneumatics. If tooling needs to move, a part needs to be held, or a force or tension needs to be applied, pneumatic systems can likely provide a solution.

Basic pneumatic hardware

All pneumatic systems will have certain basic components. The first is a compressor, and then a system to distribute the clean, dry air it produces.



Common pneumatic components on automated machines include:

- air preparation system (shut-off/lock-out, combination filter/regulator, soft start valve)
- control valves and manifolds (manual, air pilot, solenoid operated)
- air cylinders and actuators
- tubing and hoses
- push-to-connect fittings
- cylinder position sensors
- discrete pressure switches
- specialty components and accessories

Since most facilities have a plant air supply, the machine pneumatic system starts with the air preparation unit to which the plant air is connected. The air prep system should include a manual and lockable shutoff valve, filter, water trap and pressure regulator. It should also have an electrically-operated soft start to remove air during an emergency stop, guard open or similar safety event. The air prep system may also include a lubricator, but it's usually not necessary unless pneumatic rotary tools are in use.

The air prep system typically feeds the valves or valve manifold that can include manual, air-piloted and solenoid-operated control valves to turn the air supply off and on. These valves feed control air to a variety of pneumatic cylinders and actuators where power transmission happens.

Pneumatic cylinder position sensors and pressure switches are a common component in pneumatic systems. There are also a wide variety of special pneumatic components such as flow controls, quick exhaust valves, hand valves, check valves, inline pressure regulators, gauges and indicators.

Getting started

With pneumatic systems, a little guessing is okay, but be sure to understand the application. How much force do you need? How fast do you need to move?

With pneumatic power transmission, it is important to define the mass of what is going to be moved along with its velocity and acceleration profile. The required power to be transmitted to the part or tooling must also be specified. With that information and mounting decisions made, the cylinders, tubing and valves can be specified.

Pneumatics is the best choice in many applications, unless you need the highly accurate and programmable motion positioning offered by electric systems, or the very high levels of force provided by hydraulics. But in most cases, pneumatics can provide a simple, reliable, cost-effective solution. So, in your next motion application ask yourself, "Why not pneumatics?"

Best prices on pneumatics!

Buy direct and save on high-quality components

NITRA® PNEUMATICS

AIR PREP

NITRA pneumatic air prep devices' modular design allows for stand-alone applications as well as easy field assembly for combining components.

- Filters
- Regulators
- Combination filter/regulators
- Lubricators
- Manual shut-off relief valves
- Soft-start/dump valves
- Modular assembly brackets

CONTROL VALVES

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

- Poppet and spool valve styles
- 3- to 5-port models
- Manual toggle, rotary, push-pull and foot pedal valves
- Process (pipeline)
- Compact modular
- Manifolds, silencers, cables, connectors

CYLINDERS

NITRA pneumatic cylinders are interchangeable with many other brands, offering styles for various application requirements in popular bore sizes and stroke lengths.

- **New** ISO 15552 (G Series)
- Non-repairable round body style
- Compact (pancake style)
- NFPA heavy-duty, standard and cushioned-end styles
- Dual-rod guided
- Position switches

TUBING AND FITTINGS

Wide array of choices, including:

- Bulkhead unions
- Union straight, reducers, Tee, elbow, Y
- Manual hand valves
- Meter-in and -out flow control
- Quick-disconnect straight and swivel hose couplings
- 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-5312-24D		$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 6/5/15. McMaster-Carr prices are from www.mcmaster.com 5/27/2015. Grainger prices are from www.grainger.com 5/27/2015. MSC prices are from www.mscdirect.com 5/14/2015. Prices subject to change without notice.

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TRAINING MOVES OUT OF CLASSROOM

Training transitions from the classroom to hands-on and online, providing students with options.

By Cindy Green
AutomationDirect

Teachers often cover subject matter at the speed of the least experienced student, which is helpful for them, but is less productive for more advanced trainees.

Classroom training in general can be quite tedious, and also very expensive compared to more modern alternatives. For these and other reasons, machine builders, process skid OEMs and suppliers are transitioning to hands-on and online training.

The advantages of online training compared to the classroom are many (see *Table 1, reprinted from the Control Design, March 2015 cover story "Innovative Methods of Instruction Take Training Out of the Classroom"*). The student controlling the pace of the training is one advantage, as the experienced or advanced students no longer have to wait or fight to stay awake while the teacher explains the basics to the beginners.

In some instances, hands-on instruction has advantages over online training, but it has its own set of issues (see *Table 2, reprinted from the Control Design cover story*). The simulation of real world machines, process and equipment is a great learning tool.

This article discusses how both online and hands-on instruction are changing training for machine automation professionals.

Training Online

As noted in the Control Design cover story and according to the e-Learning Industry web site (**http://elearningindustry.com/top-10-e-learning-statistics-for-2014-you-need-to-know**), online training is growing rapidly:

- In 2011, it was estimated that about $35.6 billion was spent on e-Learning worldwide. Today, e-Learning has become a $56.2 billion industry, and continues to grow at a rapid pace.

Advantages of Online Training
• Paced by student
• Delivered on-demand to fit student schedule
• No need to wait for scheduled course
• Quicker, no time wasted traveling to classroom
• Cheaper for student, no travel expenses
• Cheaper for provider, no classroom needed
• Easy to provide videos and other visual training aids
• Can be revisited as needed
• Prepares students for more in-depth instruction
• Familiar learning method for younger students

TABLE 1: Advantages of Online Training
Table reprinted from Control Design March 2015 Cover story
"Innovative Methods of Instruction Take Training Out of the Classroom"

Hands-On Training Pros and Cons
• Can closely simulate the real world
• More interesting for students
• Allows for in-depth instruction
• Minimizes required training on the actual system
• Expensive to provide
• Travel required for students
• Very time consuming

TABLE 2: Hands-on Training Pros and Cons
Table reprinted from Control Design March 2015 Cover story
"Innovative Methods of Instruction Take Training Out of the Classroom"

- Corporations say e-Learning is their second most valuable training method.
- About 46% of college students are currently taking at least one course online. By 2019, roughly half of all college classes will be e-Learning-based.

Interest in online training is increasing among automation professionals. Located in Mukilteo, Washington, Electroimpact (**www.electroimpact.com**) designs and builds turn-key automation assembly systems for commercial aircraft wings and riveting machines (*Figure 1*).

In the Control Design, March 2015 cover story, "Electroimpact Trains Its EEs," Laurence Durack, lead electrical engineer at Electroimpact, says, "I've taken advantage of some amazing free online lectures from MIT and find them to be of great benefit. In some ways they are better than sitting in class as you can stop and repeat any points you miss. I can see a transformation of the whole education process with tools such as this, and I feel the existing approach is ripe for overhaul." For more from Durack, see the section titled: "How to Train an EE".

In the cover story, Scott Hendrickson, CEO of Olympus Controls (**www.olympus-controls.com**), a systems integrator serving machine builders from their base in Seattle, also sees the value of online instruction. "We've looked at online training programs through a company called BlueVolt (**www.bluevolt.com**) that delivers a web-based learning management system. Their cloud-based platform delivers professional training programs on just about any machine automation technology."

In the same Control Design cover story, Randy Ransom, director of training at Intelligrated (**www.intelligrated.com**), a material handling OEM in Mason, Ohio, has an interesting approach to e-Learning. "Requiring students to complete online e-Learning training modules prior to an instructor-led session provides a baseline of knowledge for all students," he explains. "This allows the instructor to begin training at a deeper level since the basic concepts and terminology have already been covered. Students also tend to ask more probing questions during the instructor-led training sessions when they've been exposed to the initial e-Learning training."

FIGURE 1: Electroimpact's Automated Fiber Placement technology is used to create fuselage panels for the Airbus A350 aircraft. (Image courtesy of Electroimpact).

Virtual hands-on equipment is also available for some courses. Delta Computer Systems (**www.deltamotion.com**) offers two-day online training classes where the students interact with actual Delta RMC motion controllers via the Internet.

"The hands-on, instructor-led training covers setup, tuning, programming and diagnostics of RMC motion controllers for closed-loop position and velocity control through a series of lessons and lab exercises," explains Bill Savela in the cover story. "Closed-loop motion control is a new concept to many hydraulic engineers, and Delta has found that by giving students hands-on experience they can complete their machine development much more quickly and with fewer support requirements," says Savela, marketing director at Delta.

A wide variety of online training is available, with course durations ranging from less than a minute to over one hour. There is also a wide range of pricing from free to several thousand dollars.

An engineer at a mining industry equipment manufacturer noted in the cover story that pricing is a problem. "Online training available on demand is something companies are willing to pay for," he notes in the cover story. "Maybe it's not being offered more widely because organizations doing the training have not been able to determine a realistic value. With courses where there is a signup, if the number of participants does not equal a good return, the class can be cancelled. Once material is out on the web and priced, it may be more difficult to adjust the price after the fact."

Get Your Hands on It

Adding hands-on training to classroom training is a good option since it can help students experience and operate automated systems firsthand. Joseph W. Snyder, president of Process and Data Automation (**www.processanddata.com**), a systems integrator in Erie, Pennsylvania, builds its own process training units (PTUs) to provide this hands-on experience (*Figure 2*).

"While there are options to purchase off-the-shelf configured trainers, we typically use internally-constructed systems," says Snyder in the cover story. "Building these systems ourselves also allows us to use the entire specification and build process of new process skids as an internal training course in project management." For more on how they use skids for training, see the section titled: "Process Training Units".

Hands-on training works best if the staff turnover is low, says Nick Stephens,

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The Allen-Bradley 100W system consists of part numbers shown in table above with prices from www.wernerelectric.com, www.rexelusa.com 5/25/2015.

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managing director for 22solutions (**www.22solutions.com.au**), a systems integrator in Ballarat, Australia. "We believe hands-on training is most effective if the staff attrition rate is low," he explains in the cover story. "With a low attrition rate we generally find the users have been working with similar products so they understand processes and the system. People like this type of one-on-one training as it feels more personal to them to see someone in the flesh who designed/created the system they are about to take responsibility for."

Best in Class

Classroom training has a long history and works best in some instances. "We rely on many of our supplier partners to train our new hires on their specific technology," says Hendrickson in the cover story.

"Parker Hannifin (**www.parker-motion.com**) provides a comprehensive six-week program, which gives our new hires an excellent understanding of the technologies that are the foundation for the automation industry."

"Parker Hannifin was one of the first companies in the motion control industry to establish an intensive immersion program for new college graduates," he continues in the cover story. "The highlight of the training program is the final project week, where students are broken up into teams and assigned projects that tie the six weeks of training into a final test of imagination and creativity requiring mechanical, electrical, and software skills."

It's very common for industry organizations to provide online, hands-on and classroom training or all in combination. In the cover story, Carl Henning, deputy director of PI North America (**www.us.profinet.com**), says they offer 30-60 minute webinars, free Profinet one-day training classes, PROFItelevision with video how-to's and one-minute You Tube discussions.

"MinutePROFINET is the most popular with 5,000 views per month," continues Henning in the cover story. "One-day training classes are held in at least 16 North American cities per year, and attendance has risen every year."

Training Improvements

Training in the basics of automation will also be needed, and trade associations are well placed to provide it. In the cover story, Hendrickson says, "Two of the main trade associations for the automation industry - the Motion Control Association (**www.motioncontrolonline.org**) and the Association for High Technology Distribution (**www.ahtd.org**) - are developing training programs to introduce new hires to technology fundamentals."

In the same cover story, Ben Furnish, division marketing manager at Parker Hannifin, adds, "The Packaging Machinery Manufacturers Institute (**www.pmmi.org**) and their Alliance for Innovation and Operational Excellence are teaming up to develop a curriculum for training workers in the automation field."

Industry will benefit as these organizations create training curricula, as will everyone as training methods expand to fit the desires and needs of students, whether recent graduates or long-time industry veterans. ■

FIGURE 2: System integrator Process and Data Automation builds skids like this one for hands-on training sessions.. (Image courtesy of Endress+Hauser).

Process Training Units (PTU)

As discussed in a sidebar to the cover story, system integrator Process and Data Automation does an impressive amount of training. President Joseph W. Snyder says, "We have 29 total people, with 20 in the controls engineering department. In addition to supplier-run training and continuing education through organizations like ISA and the Project Management Institute, our company has created miniature processing systems here at our site."

The Control Design cover story notes that Process and Data Automation has several simple processing labs used by their technicians and controls engineering department for hands-on training on new field equipment, controllers and control methods. Subjects learned include:

- Instrumentation setup
- Instrumentation integration to controller
- VFD configuration
- Networked I/O commissioning
- Control loop programming
- Complex system programming

"We use home-constructed systems (PTUs) to accomplish this," explains Snyder. "Many of the systems have multiple PLC platforms per skid so we can cross-train staff on more than one control platform, and help them learn how signals are processed differently by various equipment suppliers."

Several of the PTUs were built as part of a cooperative effort between internal personnel and students at Penn State University, the experience serving as part of the students' senior design projects.

Process and Data Automation has built several of these trainers, all of which emulate real-world systems. "The idea is not to mimic everything we encounter in the field, but rather to expand training to include real field devices and applications," notes Snyder.

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PNEUMATICS IMPROVES RIDGELINE MACHINE'S EQUIPMENT

Ridgeline Machine made extensive use of pneumatics when building a low-cost, small-footprint, portable traymaker to replace a manual process for one of their customers.

By Pat Phillips,
Fluid power and Mechanical Products
Product Manager, AutomationDirect

Ridgeline Machine Design, LLC (RMD), founded in 2012, is primarily a packaging machinery producer, and the company's owners have over 40 years experience designing and building custom machinery. RMD builds packaging machinery for a variety of applications for product placement into AFM, FOL, HSC, RSC cases or trays, and they have also branched out into robotics and machinery for consumer cooler production.

Some of the packaging equipment they design and build includes wraparound side-, end- and bottom-loading case packers in many configurations. RMD also builds case erectors, bag-in-box equipment, case sealers and traymakers.

Engineered Equipment

RMD has hundreds of installations in several industries including baking, food, dairy, personal care, chemical and others.

RMD designs packaging equipment for products such as coffee, construction adhesives, aerosol, spices, and cartoned and canned food. Their equipment handles products housed in configurations such as chipboard trays and cartons, corrugated trays, plastic bottles, gable-top cartons, fiberboard caulking tubes, semi-rigid bags, and steel or plastic cans and tubs.

Their packaging equipment typically handles from 10 to 50 cases per minute depending on the application, and they offer a case sealer capable of speeds of up to 114 cases per minute. RMD equipment typically has an open design for easy operation, quick maintenance and simple adjustment.

For example, one of their case erectors builds regular, slotted-case, all-flaps-meet boxes with hot melt closure, and it can be adjusted for a wide range of box sizes using just two hand wheels. Another example is a case packer used where case sealing with pressure-sensitive tape is needed. This flexible machine can be changed over in 15 minutes or less. Some case erectors are designed for many SKU changes and can change over in two minutes.

Their bottom-load case packer works well for applications where a traditional drop-case packer is a poor choice due to possible product breakage during the loading cycle. The machine's design provides a gentle bottom-up feature which results in greatly reduced shock to the product as it's placed into the case.

Leading motion technologies employed in their machines include pneumatic, servo pneumatic and pure servo, each controlled by various PLC platforms. RMD uses the latest 3D software from SolidWorks to design their equipment.

Putting Experience to Work

For one particular project, RMD started with a list of specifications from a manufacturer of custom door locksets and hardware based in the western U.S. RMD set out to meet these specs using pneumatics in a creative design. Pneumatics was selected as the motion control technology for this application due to its low cost, both up front and over time. It is simpler than alternatives such as electromechanical or servos, easy to understand and maintain, and straightforward to control and troubleshoot.

The Model 25 automatic traymaker was developed in partnership with their customer for this project; the machine assembles trays at a rate of 18 per minute with minimal floor space required and at an affordable price (*Figure 1*).

FIGURE 1: Ridgeline Machine Design's Model 25 Traymaker was designed and built in partnership with their customer to fulfill specific requirements in terms of space and cost savings.

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continued from p.16

Traymaker specifications from the client included a small footprint, portability, low cost, easy operation and simple maintenance. The customer also required a finished tray table with 50-count storage.

Because the machine is portable, it operates from 120 VAC to simplify power connection, and to improve safety. Competing machines typically require 208-230/460 VAC, and are quite a bit more expensive. A small portable footprint is needed due to limited floor space and the need to move the traymaker often. Low cost was another requirement, and one of the reasons AutomationDirect hardware was chosen.

The customer needed to automate an operation which traditionally required their plant personnel to make the trays by hand. The production rate was only four trays per minute, and the new machine assembles trays at a rate of 18 per minute, a significant improvement. The automated machine also freed up four workers who are now performing other tasks to further improve the customer's production processes.

The traymaker discharges each tray on its side to help the trays stack better (*Figure 2*), whereas most traymakers on the market discharge the tray upright. RMD's older model traymaker had the tray blank move horizontally before set-up, while this new model has it traveling vertically. This required mechanical reorientation of much of the infeed assemblies.

FIGURE 2: The completed tray is positioned at the machine output on its side for easy stacking with other trays.

Traymaker Ready for Production

The RMD Model 25 traymaker has a small footprint of approximately 7'H x 5'L x 3'W without the discharge table. The discharge table is 6'L x 4'W. The traymaker is controlled with a wide variety of AutomationDirect hardware including power distribution components, motors, drives, and safety relays and switches. AutomationDirect also provided an extensive pneumatic system starting from the main plant connection, proceeding to the flow controls, solenoids, tubing, fittings and cylinders.

Much of the product handling and assembly operations are pneumatic. The traymaker includes vacuum pick-off of tray blanks, vertically positioned to save space. The singulated tray blanks are fed into the system using an AC drive powering a motor and a worm gearbox which drives the tray blank feeding wheels.

The vertical, wheel-delivered tray blanks are fed downward to the assembly area, and are then set up by a pneumatic cylinder pressing the blank through tooling. The formed trays are then pneumatically off-loaded to the discharge table.

Pneumatic Assembly of Trays

The traymaker pneumatic components start with a 3/8-inch size filter, regulator and lubricator feeding a bank of valves operating a mix of round, compact and tie rod cylinders. Air preparation provides the required high air flow, and also filters and lubricates the air coming to the machine. The air prep system includes an electric dump valve to relieve the air supplied to the control valves when a door is opened or an emergency stop is pressed. There is also a manual lockable valve on the inlet, providing the required lockout/tagout functionality when servicing the equipment.

Air valves (*Figure 3*) control all cylinder and vacuum generator operation. The valves are sized for worst case flow for any function on the traymaker. In this case, 4-way valves were specified to control all the cylinders, as their Cv rating of 0.89 is sufficient for the cylinders to operate and maintain proper speed. A 3-way valve was selected to operate the pneumatic vacuum generator for the same reason.

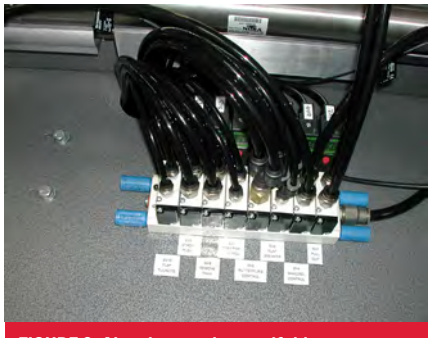

FIGURE 3: Air valves and a manifold provide fluid power to the cylinders that feed, assemble and stack the trays.

RMD prefers to use manifolds to feed air to the pneumatic control valves, and utilizes an 8-station unit on this machine for that purpose. To ensure a high flow air supply, ½" tubing is used to supply air to the valve manifolds. Plastic silencers on both ends of the manifold reduce noise and ensure minimal restriction of exhaust air.

The valves were wired using solenoid cables which include built-in surge suppression and an LED to show when power is present to the solenoid. Surge suppression improves the life of the PLC outputs by eliminating voltage spikes, and the LED indicator clearly shows valve status which simplifies and speeds maintenance.

Pneumatic Cylinder Details

The pneumatic cylinder configurations were specified based on space constraints and required motion. In places where the cylinder is producing rotational motion, either by moving a lever or pushing a rack turning a gear, the machine uses tie rod cylinders with built-in cushions. For other low power or supplemental motion, the machine uses either round-body (*Figure 4*) or compact cylinders.

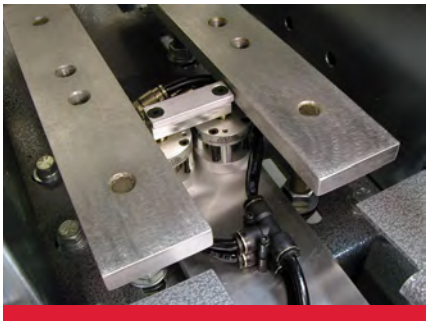

FIGURE 4: These round-body cylinders were selected for their small size, and are some of the many pneumatic cylinders controlling mechanical motion in the traymaker.

Pneumatic cylinders provide all the motion required to feed, assemble and stack the trays (except for the vertical tray blank feed wheel motion, which is electromechanical).

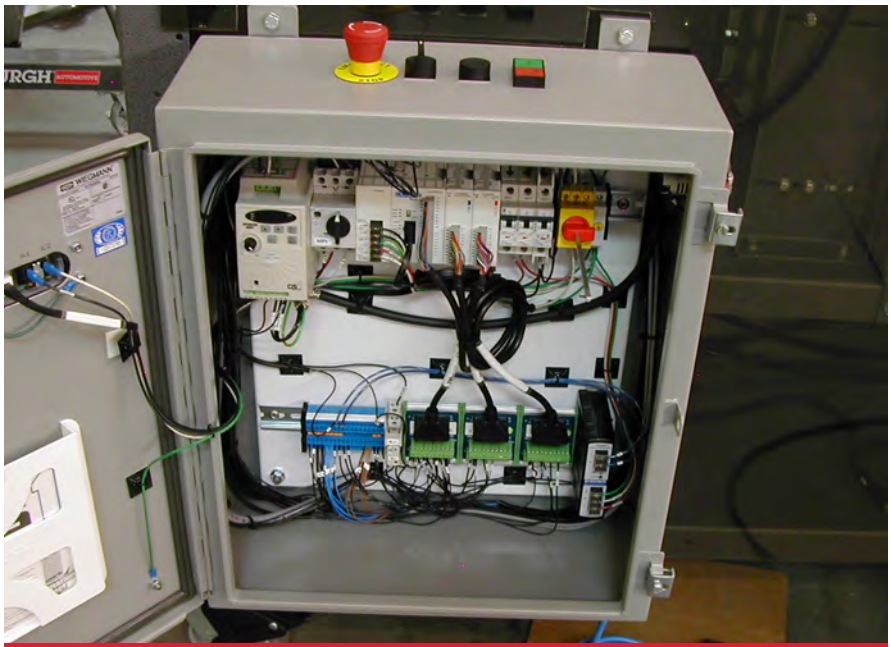

FIGURE 5: Like the rest of the machine, the control panel is fully portable.

All cylinders critical to the assembly/setup of the tray include magnetoresistance sensors along with magnetic pistons in the cylinders. The sensors provide error-proofing of cylinder end-of-stroke motion for each step of the machine assembly sequence.

The Nitra® pneumatics from AutomationDirect work as well as their more expensive competition, and RMD has used them in lubricated and non-lubed applications with great success.

Supplier Selection

RMD chose AutomationDirect as a primary supplier of the traymaker automation, power, pneumatic and other components. They were selected for the affordability and quick availability of the wide variety of products required for this application. AutomationDirect's technical documentation is available 24/7 on their website, and phone support is available without a support contract. Other factors leading to their supplier selection included the free customer support forum, free 2-day shipping and free programming software.

The traymaker is controlled by an AutomationDirect CLICK C0-00DR-D PLC with expansion I/O and terminal blocks for field wiring. A bulkhead programming port with outlet on the control enclosure door simplifies compliance with arc flash regulations as it allows changes to be made to the controller software without opening the door (*Figure 5*).

AutomationDirect also provided the power distribution hardware including a non-fused disconnect switch, branch circuit protection circuit breakers, and a rotary motor protector switch to disconnect power from the motor drive.

Operator control buttons include a selector switch, pushbuttons and an E-stop mushroom pushbutton. To sense the product, background suppression photoeyes and cylinder position sensors were used.

The end result shows that, with strong customer buy-in, you can build a reliable machine using the affordable products provided by AutomationDirect. Other factors valued by this and other customers include simple operation, low maintenance and industry-leading customer support.

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Process and Data Automation also uses supplier classroom instruction and hands-on training to improve technical and engineering knowledge of various subjects such as programming, network configuration and instruments. "Our systems allow us to take what's learned in theory-heavy classes and put that into actual operation," says Snyder. "Our engineers don't need to make the leap from a theory course to directly working on live equipment at a client's site. This allows them to make the proper mental connections and really understand how the theoretical world interacts with physical connections."

How to Train an EE

Electroimpact builds complete automation assembly systems for commercial aircraft wings. They also build riveting machines and tools for wing panel and fuselage assembly, advanced fiber placement machines, robotic assembly systems and spacecraft transportation equipment.

Their new engineering hires need further training in the basics, notes Laurence Durack in the cover story. "The subjects covered by educational institutions are changing, especially for EE degrees," laments Durack, lead electrical engineer. "With the ever increasing areas of specialization, institutions are dropping the fundamentals from the curriculum. I've interviewed many EEs with very good qualifications on paper, but who are in reality are very weak in areas such as basic physics, AC circuit analysis, transformers, etc."

Despite the noted EE weaknesses, most do well with software and can easily work with specialized programs from suppliers. "The problem is they rely on the software to solve everything, when in reality what they are trying to achieve is impossible as they miss some fundamental issues," says Durack in the cover story. "I've had candidates who can't draw a sine wave, have never studied transformers, and have told me it's all DC now and there's no AC."

Electroimpact is motivated to provide its own training. "We use a combination of supplier training and on-the-job training," says Durack in the cover story. "For an initial introduction of a new technology we may use supplier training, but as our knowledge increases we rely mostly on in-house on-the-job training. The in-house training is by far the best as the training is focused directly on the application."

Electroimpact also invites the supplier to provide training onsite. "This is beneficial for two reasons," he explains in the cover story. "The training is focused on our area of application, and groups from different departments can get together for cross pollination of new ideas. As long as the supplier focuses on the technical side, I'm happy. Recently we had a class on Profinet and I had a very positive response. We are just starting the switch from Profibus to Profinet and it was really informative. Furthermore, I put all the information they gave me on our network for online learning. It's not only great for people who missed the class, but also as a general reference for any of our locations around the world."

InterConnecting Automation

In 1996, AutomationDirect teamed up with Doug Bell and InterConnecting Automation to provide training for PLCs and other AutomationDirect products. Through InterConnecting Automation, Doug and his staff provide online and onsite training and seminars across the United States.

InterConnecting Automation online PLC training courses include:

- Introductory Course for PLC-Based Controls
- Advanced PLC Training Course
- PID Computer-Based Training
- Intro Video DVD PLC Training Course
- Analog I/O Video DVD Training Course
- Online PLC Training
- CLICK PLC Trainer

All InterConnecting Automation's technical instruction is delivered in a clear and concise method. The company's videos and tutorials are specific and address points at various levels of training. The tutorials cover time-saving suggestions and advanced programming techniques, as well as showing programming examples that are common on simple automation controls. The company's mission is for students who complete the courses to feel comfortable with basic through advanced PLC programming.

Many participants use the online video training to learn the basics of the products and then move on to the more advanced courses. All the completed courses offer Continuing Education Credit to those who finish and pass the course. The most advanced classes attract those students who want to learn more and attend the training in a classroom with hands-on access to the products, including how to program a machine from scratch. This type of real world use is what people are looking for in this type of high-level training so they can use the knowledge in their everyday work. Bell explains: "We offer most of this type of training on-site at large companies. It's full of information but you also get play time. What could be more fun than a group of engineer types sitting in a room programming?"

To find out more about Doug Bell and InterConnecting Automation, visit his website:

http://www.interconnectingautomation.com/

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UNDERSTANDING LADDER LOGIC.

By Bill Dehner,
Electrical Engineer,
AutomationDirect

PLCs have exploded in the controls market and are used throughout the world. Over time they have advanced to become more user friendly, efficient, smaller, and less expensive. Different types of programming languages have also been developed for PLCs but the most frequently used is still Ladder Logic.

The Need for Change

Imagine for a second it's 1980. You're cruising in your brand new Ford Pinto on the way to your job at the local Rubik's Cube plant. You have a busy day ahead since the plant is being redesigned for the new Rubik's Revenge model due out next year. The relay panels you work on need to be rewired to accommodate the change in production size, from the original 3x3x3 size to the new 4x4x4 model.

These relay panels consist of numerous electromechanical relays that are wired together to perform a certain function in the plant. The simple opening and closing of relay contacts on the panel gives the system the ON/OFF control it needs in the manufacturing process. For instance, when the cube's mold is in position a switch will close. This switch energizes a relay coil, which in turn closes the normally open contact for the injection pump. The pump fills the mold with melted plastic and the cube begins to take shape.

Using this combination of switches, relays, coils and contacts is referred to as Relay Logic. Relay logic is a dependable controls method still in limited use today. But the cost associated with it in terms of time-consuming logic changes, mechanical failures over time and extensive wiring and space requirements has forced many industries to reconsider their control needs. What they discovered was the PLC.

The Structure

The structure behind ladder logic is based on the electrical ladder diagrams that were used with relay logic. These diagrams documented how connections between devices were made on relay panels; they are called "ladder" diagrams because they are constructed in a way that resembles a ladder with two vertical rails and rungs between them. The positive power rail (on the left) flows to the negative power rail (on the right) through the physical devices connected on the rung. The example in *Figure 1* shows a ladder diagram with pushbuttons (PB), control relays (CR), a motor (M) and a light (L).

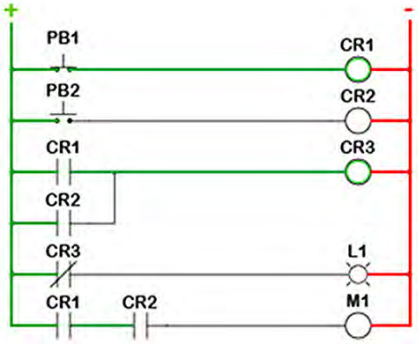

FIGURE 1: Ladder logic resembles the structure of electrical ladder diagrams.

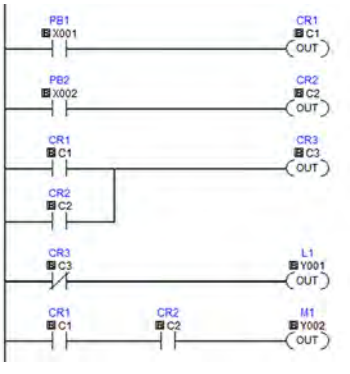

FIGURE 2: Ladder logic replaces physical contacts and coils with memory bits.

The Ins and Outs

Ladder logic was designed to have the same look and feel as electrical ladder diagrams, but with ladder logic, the physical contacts and coils are replaced with memory bits as seen in *Figure 2*.

For this program, the relay logic's ladder diagram is duplicated with ladder logic; no more hard-wired logic, but memory locations instead. Some of these memory locations are used internally and others are used with external inputs and outputs. To monitor and control real world devices, they will need to be wired to I/O modules.

For this particular PLC, these inputs and outputs are assigned to X and Y memory addresses like the X001 seen with PB1. This normally open contact's state is read from the input on the I/O module where the physical pushbutton is connected. On the other hand, each Y bit will have an output device wired to it as seen with the light controlled by Y001. All of the other locations are assigned to internal bits that we can use as needed.

One side note, today's PLC CPUs offer many types of functions, not just simple contacts and coils. Math, Shift Registers, Drum Sequencers, etc., are available to aid in programming.

The Execution

Typically before starting to execute the logic, the CPU reads the physical inputs tied to the I/O modules to update their status in the CPU's memory table. Then, starting at the top left of the program, the CPU works its way down the rail executing each rung or sub rung from left to right. So if PB1 is pressed, the CPU will turn ON CR1. Since CR1 has changed states, in rung 3 the CPU will activate CR3. CR3's normally-closed state is used in rung 4, so the CPU will then turn OFF L1.

Even though we still refer to coils and contacts in ladder logic, remember that they are memory representations, not actual devices. Once the CPU reaches the last rung it will update the real world outputs, then loop back and run it all again. This process will continue as long as the CPU is powered and in the RUN mode.

continued p. 24>>

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The time it takes the CPU to execute one pass and loop back to the beginning is known as scan time. Scan time can be important to applications where timing is critical. Subroutines and special purpose I/O modules can be used to help reduce the scan time if needed.

The Logic Behind the Ladder

So what logic can ladder logic actually perform? With the increasing demand for functionality and ease of use, many of today's PLCs incorporate function blocks with ladder logic. The structure of the program is still ladder with the more complex instructions being function blocks. So to answer the question, let's look at a few examples:

1.) *Boolean Logic:* The ON/OFF, TRUE/FALSE algebra of binary systems, the basics of which are AND, OR, and NOT operators. To put it simply, rung 5 in our code needs CR1(C1) AND CR2(C2) to turn ON motor M1 (Y002).

2.) *Timing:* Timer instructions are available to allow for on-delayed or off-delayed events. Once triggered, the timer will turn its associated output ON (on-delay) or OFF (off-delay) after the set time has elapsed.

3.) *Counting:* Count-up and count-down functions increase or decrease the counter value on every transition of the input.

4.) *Comparisons:* Compare instructions are available to determine if values are less than, equal to, or greater than each other.

5.) *Math:* These instructions not only allow for simple addition and subtraction but also for more complex operations like tangents, square roots, etc.

6.) *Special functions:* These include PID loops, communication instructions, shift registers, drum sequencers, ramp generators, etc.

See for Yourself

If you would like to try an exercise in ladder logic, AutomationDirect has created a beginner's programming exercise. This exercise was actually created for the Boy Scouts of America to help teach ladder logic to future PLC programmers. It uses the simulator included with the Do-more Designer programming software for our Do-more PLC series.

The software is free and you do not need any hardware, so try it. Download the software at:

http://support.automationdirect.com/products/domore.html

To watch the video, go to:

https://youtu.be/8YJBnHK1grU

Learn More

There is a lot more to learn about Ladder Logic; we've only begun to scratch the surface. Our Library.AutomationDirect.com site is full of information on PLCs and PLC programming. So to learn more, please visit: **http://library.automationdirect.com**

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PORTABLE WATER TREATMENT PLATFORM REMOVES PHOSPHORUS ECONOMICALLY

By Chip McDaniel,
AutomationDirect

A trailer-mounted water treatment process controlled by a Productivity®2000 PLC has recently been developed at the University of Idaho. Professor Greg Möller, in the College of Agriculture and Life Sciences, along with engineers from the College of Engineering, have teamed up to build the platform and to further research the economical removal of phosphorus from various wastewater sources. (*Image 1*)

IMAGE 1: Portable water treatment platform

The engineering effort is part of a capstone project involving a number of engineering students and a French industrial water engineering intern from Suez Environment, led by Martin Baker, a mechanical engineer on staff at UI. Gene Staggs is a recent graduate from the engineering school, and is the automation and control lead on the project. Gene contacted AutomationDirect in early June, asking about PLC options to control the project. In addition to the technical criteria, he also explained the accelerated timeline for completion. AutomationDirect technical staff reviewed the capabilities of the Productivity2000, and assured him that his entire bill of materials could ship the day he placed the order. (*Image 2*)

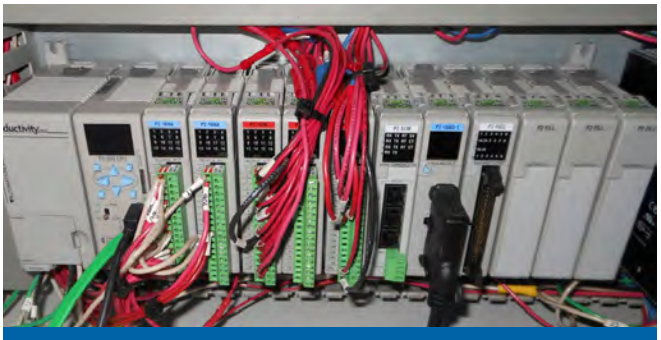

IMAGE 2: Productivity2000 PLC controls water treatment skid

While the primary function of the mobile platform is to go "on-site" for up to a week at various locations (paper mills, lagoons, and larger waste water treatment plants) to process effluent, remove phosphorus and collect samples, the platform is also a STEM Educational vehicle. The development team has already coordinated tours for elementary through high school teachers, and they have plans to take the platform to various professional conferences.

The treatment process is accomplished via a pair of "plug-flow" reactors connected in series, each followed by a corresponding self-cleaning sand filter. The reactors are 45 feet long and constructed from 6" diameter green PVC pipe (*Image 3*). The first reactor introduces low doses of biochar, a less expensive, yet similar material to the activated carbon used for many filtering applications. After moving through the first reactor, samples are taken and the effluent moves into the first sand filter. Samples are taken again, and the effluent moves into the second reactor where precise quantities of ozone are injected. After a third sample is collected, the effluent moves through the second sand filter, a final sample is collected, and processing is complete.

IMAGE 3: Plug-flow reactors treat effluent at 15 gallons per minute

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The entire process is known as "catalytic oxidation"; it allows for destructive removal of most organic contaminants (they are mineralized to carbonates) and it sterilizes the water, killing all microbial life including prions, viruses, and bacterial spores. Mineralized nutrient phosphorus and nitrogen are bound to the biochar and recovered from the water. The nutrient-laden biochar can be recovered and pelletized for use as fertilizer and as a soil amendment in agriculture.

The mobile platform processes about 15 gallons per minute, but because it is based on a commercially proven process, it is scalable to tens of millions gallons per day.

The Productivity2000 PLC controls all aspects of the filtration process, from opening and closing valves, to metering the biochar, ozone, and the sampling operations. A pair of AutomationDirect SureStep® stepping systems are used for preprocessing the biochar (*Image 4*). Commercially available biochar is available in three forms: powdered, slurry, and suspension. The engineers developed a creative approach to manipulate and meter the biochar, regardless of type. Three sets of custom 3D printed parts were designed to fit on the shafts of the stepper motors. A simple auger processes the powdered form, an auger and a linear actuator are used for the slurry form, and a pair of mixer paddles and a peristaltic pump are used for the suspension form of the biochar. The stepper systems are controlled using a high-speed output card (P2-HSO) in the Productivity2000.

IMAGE 4: Stepper controls preprocess the biochar

Additionally, the Productivity2000 is running eight separate PID loops (with auto-tuning); it also communicates with a C-more touch panel HMI for operator control (*Image 5*). "It is a great system to work with – some of the best features were the custom tag names, PID features, and QR codes" (*Image 6*) said Gene, just after completing the three-week build. Gene also reports that the import/export of the tag database was a huge time saver, and the team was even able to use the spreadsheet-style tag data to help document other parts of the project. He pointed out other benefits as well, "because this is also a research vessel, the data logging and network capabilities are invaluable.")

IMAGE 5: Control panel inside mobile structure contains operator interface

IMAGE 6: QR codes on PLC I/O modules take the user directly to online product information

The mobile platform gives the team a great vehicle to further their research and to show wastewater treatment operators the benefits of the new technology. While it is still in the fairly early stages of development, the results are very promising. Existing studies conclude that reactive filtration is one-third to one-half the capital, maintenance, and operation costs of other approaches, plus the process will produce useful fertilizer, clean reusable water, and even carbon trading credits.

Interested parties should contact the University of Idaho (**ott@uidaho.edu**) or professor Greg Möller (**gmoller@uidaho.edu**).

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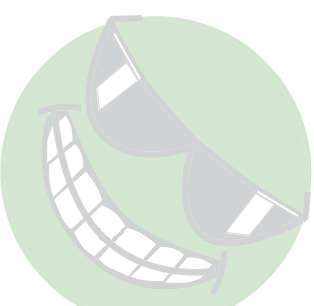

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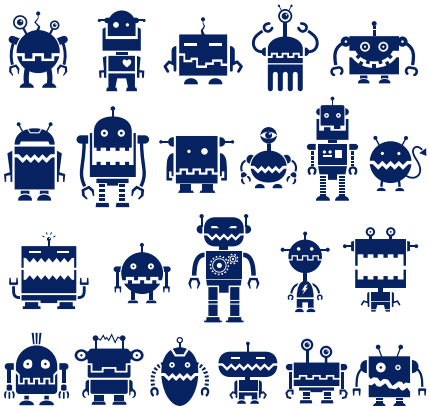

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How many widgets were in each of those four groups?

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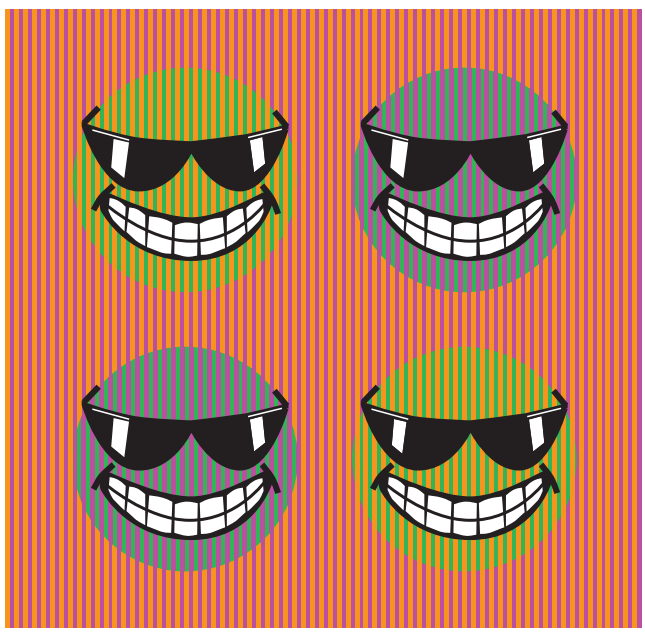

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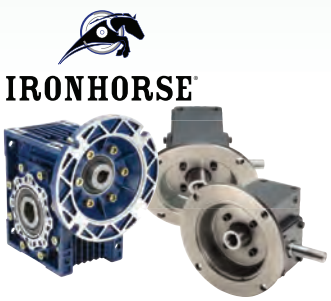

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