25th Issue of AutomationNotebook

Your guide to practical products, technologies and applications

Automation NOTEBOOK®

Spring 2013

Issue 25

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Robot Use Becomes More Widespread

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New Koyo encoders with inch-size shafts, as well as miniature bodies

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Precision Gearboxes

for Servomotors

SureGear™ Precision Servo Gearboxes

The SureGear PGA series of high-precision planetary servo gear reducers is an excellent choice for applications that require accuracy and reliability at an exceptional value. This in-line planetary servo gearbox has a thread-in mounting style, along with precision and torque capacity that is best in class.

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- **Thread-in mounting style**
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- **Uncaged needle roller bearings for high rigidity and torque**
- **Adapter bushing connection for simple and effective attachment to SureServo motors**
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- **Maintenance free: no need to replace the grease for the life of the unit**
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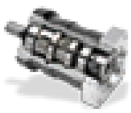

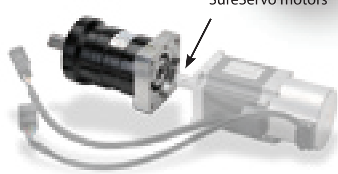

Mates easily to SureServo motors

For complete details and pricing, visit: ***www.automationdirect.com/motion-control***

Use SureGear with our practical SureServo systems

*start under $1,000***

The SureServo family of brushless servo systems from AutomationDirect is fully digital and offers a rich set of features at dynamite prices.

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(100W system)

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Servo Systems	AutomationDirect Price/Part Number	VS. Allen-Bradley Price/Part Number
Digital Servo Drive	$488.00 SVA-2040	$1,050.40 2098-DSD-005
100W Servo Motor with connectorized Leads	$325.00 SVL-201	$536.31 TLY-A130T-HK62AA
Breakout Board Kit for CN1 Control Interface	$79.00 ZL-RTB50+ZL-SVC-CBL50	$211.09 2090-U3BK-D4401
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*SureServo Pro software is FREE when downloaded and is also available for $9 on a CD

All prices are U.S. list prices, AutomationDirect prices are from October 2012 Price List. The Allen-Bradley 100W system consists of part numbers shown in table above with prices from www.rockwellautomation.com/en/e-tools 2/20/12.

Automation NOTEBOOK

Your guide to practical products, technologies and applications

Contributors

Publisher	Tina Gable
Managing Editor	Joan Welty
Coordinating Editor	TJ Johns
Design Manager	Justin Stegall
Contributing Writers	John Armstrong Joe Kimbrell Christine Lesher Chip McDaniel Jeff Payne

CONTACTS
Automationdirect.com Inc.
3505 Hutchinson Road
Cumming, GA 30040

Phone........................1-800-633-0405
or 1-770-889-2858
Fax................................1-770-889-7876

Monday - Friday
9:00 a.m. to 6:00 p.m. EST

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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

Can you believe this is our 25th issue of Automation NOTEBOOK? I guess this is another time when we can truly say, "Time flies when you're having fun." Our staff enjoys providing this magazine for our customers. We are constantly amazed with the material we gather from each of you detailing how award-winning products and customer service from AutomationDirect have improved the quality of your industrial processes.

We have packed this issue of NOTEBOOK with informative technical articles, new product announcements and more. Our Tech Brief article explains the ins and outs of different types of encoders. In our Student Spotlight, we focus on a group of students from the Illinois Institute of Technology and their use of the Productivity3000 in a Hybrid racing competition. Our User Solution story will whet your appetite as you read how Mel-O-Cream Donuts uses AutomationDirect products to improve their packaging process. Plus, our cover story discusses the use of robotics in manufacturing.

Of course, we would not forget to include the ever-popular Breakroom, filled with intriguing mind teasers. But, most of all, sit back, relax, and turn the page…

TJ Johns
Coordinating Editor
editor@automationnotebook.com

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New Product Focus

what's new

New Koyo encoders with inch-size shafts, as well as miniature bodies

Koyo inch-size light and medium-duty encoders have been added to our line of positioning and motion control products. These stainless steel solid-shaft encoders provide a cost-effective solution for many applications.

The TRDA-2E series light-duty encoders have a 0.25-inch diameter stainless steel solid shaft and offer resolutions from 100 to 2,500 pulses per revolution. The encoders are fitted with a two-meter cable with tinned ends and are available with 12-24 VDC open-collector or 5VDC line-driver outputs; the series provides up to 200 kHz response frequency. The TRDA-2E series encoders start at $89.

The TRDA-20 series medium-duty encoders have a 0.375-inch diameter stainless steel solid shaft and offer resolutions from 100 to 2,500 pulses per revolution. The encoders are fitted with a two-meter cable with tinned ends and are available with 5-30 VDC totem-pole (push/pull) or 5VDC line-driver outputs; the series provides up to 200 kHz response frequency. The TRDA-20 series encoders start at $109.

The TRDA-25 series medium-duty encoders have a 0.375-inch diameter stainless steel solid shaft and offer resolutions from 100 to 2,500 pulses per revolution. Fitted with a military-style connector, these encoders also have a removable 2.5-inch round flange. Available with 5-30 VDC totem-pole (push/pull) or 5 VDC line-driver outputs, the series provides up to 200 kHz response frequency. The TRDA-20 series encoders start at $175. Military-style connector cables are available in 10, 20 and 30-foot lengths, starting at $62.

All TRDA encoders feature a reinforced aluminum die cast casing, have an operating temperature range of -10 to +70 degrees C, and have no mounting restrictions. Flexible encoder couplings in aluminum and glass reinforced resin, servo mount brackets, mounting brackets and flanges are also available.

Also added is a series of Koyo miniature encoders, providing cost-effective solutions for size-limited applications.

The TRD-MX series light-duty encoders feature a small body with 25mm diameter and 29mm depth. Constructed with a 4mm diameter solid shaft, the series offers resolutions from 100 to 1,024 pulses per revolution. The encoders are fitted with a two-meter cable with tinned ends and are available with either 5 to 12 or 12 to 24 VDC open-collector or 5 VDC line-driver outputs; the series provides up to 100 kHz response frequency. The TRD-MX series encoders start at $99 and are available for same-day shipping.

Also, all encoder part numbers are now in stock and ready for same-day shipping.

For more information on Koyo encoders, visit:
www.automationdirect.com/encoders.

Precision Motion Control

... in stock and ready for same-day shipping.

Koyo.

TRD-MX series

With small 25mm diameter bodies, rugged solid shafts, and a variety of output types.

- Small body with 25 mm diameter and 29 mm depth
- 4mm diameter solid shaft
- Resolutions from 100 to 1024 pulses per revolution
- Open collector output (5 - 12 or 12 - 24 VDC), or line driver output (5 VDC)
- Up to 100 kHz response frequency
- 2m cable with tinned ends
- IP50 environmental rating
- Mounting bracket and couplings also available

All encoders are in stock for same-day shipping.

TRDA25 series

are IP65 rated, with military-style connectors for easy installation and replacement.

- 2.0 in. diameter and 2.15 in. depth
- 0.375 in diameter solid shaft
- Removable 2.5 in. round flange
- Resolutions from 100 to 2500 pulses per revolution
- Line driver or Totem pole output (has sinking and sourcing capability)
- Up to 100 kHz (totem pole) or 200 kHz (line driver) response frequency
- Military-style connector (mating connectors and pre-made cables sold separately)
- IP65 environmental rating

TRD-N and TRD-NA series

offer a wide range of outputs and resolutions.

- 50 mm diameter and 35 mm depth
- Splash proof (IP65 rating)
- 8 mm solid or hollow shaft
- Incremental models:
  - Resolutions from 3 to 2500 pulses per revolution
  - Line driver or Totem pole output (has sinking and sourcing capability)
  - Up to 100 kHz response frequency
- Absolute models:
  - Resolutions from 32 to 1024 pulses per revolution, expressed in 5 to 10-bit gray code outputs
  - Open collector outputs
  - Up to 20 kHz response frequency

SAE and metric-dimension encoders are also available in more shaft sizes and resolutions.

Also available are hundreds of encoders in mounting frame sizes up to 2.5 inches (SAE) or 78mm (metric).

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Go online or call to get complete information, request your free catalog, or place an order.

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For complete details and pricing, visit: *www.automationdirect.com/encoders*

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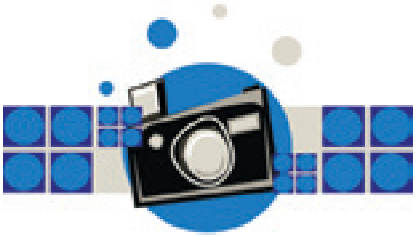
Press Releases



Ultrasonic Liquid Level Sensors and Transmitters now available

The Flowline EchoPod and EchoSonic II are innovative ultrasonic liquid level sensors and transmitters that replace float, conductance and pressure sensors that fail due to contact with dirty, sticky and scaling media in small, medium and large capacity tanks. Ideal for chemical, water and wastewater applications, these general-purpose sensors are available with single and multi-function capabilities including continuous level measurement, switching and control. Flowline ultrasonic liquid level sensors and transmitters prices start at $260.00. All of the Flowline ultrasonic level sensors and transmitters are easily configurable using the WEBCAL PC software (available as a free download or on CD) and the required USB adapter fob is priced at $42.00.

For more information on Flowline ultrasonic liquid level sensors and transmitters, visit: **www.automationdirect.com/ultrasonic-level-sensors**.

Temperature Transmitters added to ProSense line

New to the ProSense line are head-mounted and DIN rail-mounted temperature transmitters in programmable and non-programmable models. Non-programmable versions are available for thermocouple Types J, K, or T and 3-wire RTD type Pt100. Head-mounted models can be mounted in any ProSense connection head or any DIN Form B sensor head and are powered by 8 to 35 VDC; 35mm DIN rail-mount models are powered by 12 to 35 VDC. Output is linearized two-wire 4 to 20mA. Non-programmable transmitters start at $69.00. Programmable models are also available in both head-mount and DIN rail-mount styles. Free downloadable software allows users to easily configure the programmable temperature transmitters that are compatible with a variety of thermocouple and RTD types. Programmable temperature transmitters start at $89.00.

Learn more about ProSense temperature transmitters: **www.automationdirect.com/temperature-transmitters**.

Capacitive proximity sensor lineup expanded

Our line of capacitive proximity sensors now includes 12mm metal round bodied DC models with shielded and unshielded mounting options, PNP normally-open outputs, potentiometer adjustment and M12 quick disconnect. Unshielded 18mm DC plastic bodied models with selectable normally-open/normally-closed outputs feature logic auto detection. Additional unshielded 30mm models feature AC and DC versions with plastic housings and have programmable normally-open or normally-closed outputs. Rectangular plastic DC sensors, ideal for sight glass applications, feature selectable normally-open or normally-closed outputs and are fitted with a two-meter three-wire axial cable. Starting at $59, all units are cULus, CE and RoHS rated and have a limited lifetime warranty. See the full capacitive proximity sensor line at: **www.automationdirect.com/sensors-capacitive.**

More sensor cables available

M12 cables, receptacles, field-wireable connectors, and bulkhead receptacles have been added to the sensor cables lineup. New shielded M12 cables with quick-disconnect plugs in 4, 5 and 8-pole versions and 5 and 10-meter lengths are now available starting at $18.00. The shielded M12 cables have the braided shield located inside the PUR (polyurethane) cord jacket and feature industry standard axial and right-angle M12 screw-lock connectors with open leads. Also added are 4, 5 and 8-pole M12 receptacles in male and female versions and in 0.5 and 1-meter lengths, along with M12 bulkhead connectors. M12 receptacles start at $7.00. Cables, connectors and receptacles come with a one-year warranty and are RoHs compliant and CE and UL approved where applicable.

See the full line of sensor cables at www.automationdirect.com/cables.

More Crossfire Safety Glasses

Crossfire Safety Eyewear combines required eye protection and comfortable fit in a lightweight non-industrial look. All lenses meet or exceed ANSI Z87+ requirements for safety eyewear. The Element Series combines a foam-lined soft touch full frame for added comfort and safety with an adjustable head strap for more secure protection. The series offers clear, yellow or smoke-color anti-fog, lightweight, shatterproof, polycarbonate lenses; all with a scratch-resistant coating. Prices start at $11.25 with microfiber storage bag included. Also new are 1.25 magnification reading safety glasses that add to the existing lineup of 1.5, 2.0 and 2.5 diopter magnification models. Reading safety glasses start $12.50.

View the full line of Crossfire Safety Eyewear at: www.automationdirect.com/safety-glasses.

More RUKO cutting tools

RUKO high-speed steel and cobalt hole saw kits in foam-padded plastic cases start at $38.00 and are available with six, 10, or 15 saws in various diameters and with arbors included. High speed steel Cobalt 5 alloy step drill bits and jobber length drill bits are ideal for harder materials such as stainless steel. Starting at $4.00, bits are available individually, in packs and in kits. New hand taps and tap wrenches in coarse, fine, NPT and conduit thread types start at $3.25. New RUKO high speed steel and bi-metal HSS T-shank jig saw blades fit most popular brands of saws. Prices start

at $5.75 for a five-pack and $21.50 for a 20-pack. Hand held manual deburring tool kits feature a universal handle, blade holder and a variety of blades or countersinks. Deburring tool prices start at $9.00 for a 10-pack of blades and $10.00 for kits.

Learn more at: www.automationdirect.com/hole-cutting-tools.

ZIPport™ Multi-Wire Connectors

ZIPport multi-wire connectors are designed to maintain reliable electrical connections while providing protection against dirt, moisture and mechanical stress common in industrial environments. Newly added 10A, 16A, and 32B frame sizes have heavy-duty metal or thermoplastic housings and connector hoods with top entry and side entry cable passages and Pg threaded cable passages. Connector bases start at $8.25 for 10A frame models. ZIPport multi-wire connectors accessories include

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Product Snapshots cont.

Press Releases

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additional IP66 and IP68 cable glands, Pg to NPT adapters and blanking plugs; insert plates are available in blank, reducer and cutout styles. New code pins kits (starting at $6.00 for a 16-pack) and gold-plated crimp contacts (starting at $87.75 for a 100-pack) have also been added.

Checkout ZIPport multi-wire connectors at: www.automationdirect.com/multi-wire-connectors.

SureStep line adds dual-shaft motors and low-cost micro-stepping drive

The SureStep stepping family has twenty high-torque motors to handle a wide range of automation applications such as woodworking, assembly, and test machines. The motors are available in single and newly released dual-shaft configurations. Our square frame or "high-torque" style stepping motors are the latest technology, resulting in the best torque to volume. We have NEMA 17, 23, and 34 mounting flanges and holding torque ranges from 61 to 1,288 oz·in. Optional 20-foot extension cables with locking connectors are available to interface any of the stepping motors to the microstepping drive. Stepper motor prices start at only $18.00.

Need a low-cost, yet powerful, microstepping drive? The latest SureStep compact stepper drive operates with high-speed pulse input signals (Step and Direction, or jumper-selectable CW/CCW step) and has a selectable resolution range of 200 to 20,000 steps per revolution. Additional features include automatic self test, digital filters to prevent position error from electrical noise on command signals, and optically isolated I/O. Operated with a 24 to 65 VDC power supply, this microstepping drive has a running output current of 0.5 to 7.5 Amps. The standard microstepping drive is priced at $89.00. The SureStep regeneration clamp, available for overvoltage protection, has a built-in 50W braking resistor and features a mounted-on heat sink and 24-80 VDC voltage range. The clamp is priced at $99.00 and an optional 100W braking resistor is available for $49.00.

See the full SureStep line at: www.automationdirect.com/stepper-motors.

Basic CPU and Remote modules added to Productivity3000 line

The P3-530 CPU has five integrated communications ports including Ethernet for programming, monitoring, and networking; a USB port for data logging; USB I/O port for up to four local expansion bases; RS-232 and RS-485 ports for ASCII and Modbus, and is programmed using the free Productivity Suite software. The Productivity3000 P3-530 basic CPU is priced at $419.00. The new P3-RX remote slave module connects to Productivity3000 P3-550 CPU module's Ethernet port for remote I/O expansion. It features four integrated communications ports: Ethernet for connection to the Productivity3000 CPU, USB I/O port that supports up to four additional local I/O bases, and RS-232 and RS-485 ports for connecting to serial devices. The module is priced at $299.00. Both are UL and CE approved and are backed with a two-year warranty.

Learn more about Productivity3000 at: www.automationdirect.com/productivity3000.

All Stainless Steel Pneumatic Air Cylinders

NITRA™ F-Series all stainless steel air cylinders are ideal for wash-down applications. These non-repairable round body pneumatic air cylinders are interchangeable with other popular brands. The double-acting cylinders have a 250 psi operating pressure and are constructed with corrosion resistant 300 series stainless steel and Teflon-based rod and pivot bushings. The Urethane rod wiper keeps wash down solutions out of the cylinder. The series includes bore sizes from 3/4-inch to two inches and stroke lengths from 1/2-inch to 18 inches to meet a broad range of applications. Models feature nose, rear pivot, and double-end mounting options and models are available with magnetic piston for position indication. Prices for NITRA F-series stainless steel air cylinders start at $66.00.

The complete line of NITRA F-series cylinders can be seen by visiting: www.automationdirect.com/stainless-steel-air-cylinder.

Non-Contact Safety Switches

Non-contact magnetic safety switches are interlocking devices designed to protect both people and machines. These non-contact safety switches are available in magnetic and coded magnetic styles and in either plastic or stainless steel housings for all industry applications. Some are suitable for food processing washdown and can withstand being high-pressure hosed at high temperatures. The magnetic safety switches feature two normally-closed and one normally-open circuit and are available with two, five or 10-meter cables. Non-contact coded magnetic safety switches provide even more protection by using coded magnets to close circuits that are only triggered if the code on the actuator matches that of the switch. Non-contact magnetic safety switches start at $69.00.

For more information on IDEM non-contact magnetic safety switches, visit www.automationdirect.com/safety-switches.

Knipex Pliers

KNIPEX pliers are made of high-grade tool steel with polished edges and are available in slip-resistant plastic coated, comfort grip, and insulated comfort grip handle styles. Combination pliers provide the basic functions of gripping and cutting in one tool. Needle nose and electronics gripping pliers are designed for finer gripping and manipulating. Cutting pliers and shears have exceptional cutting capacity and better handling. Also available are crimping pliers and circlip (snap ring) pliers. Adjustable water pump pliers are available in a variety of styles for work on bolts, pipe fittings, nuts, and more. Wire stripping pliers are designed for gripping, bending and wire cutting and additional cable and data cable stripping tools are also available. Backed with a lifetime warranty, individual KNIPEX pliers start at $21.50. Pliers sets are available starting at $89.00.

For more information on the Knipex line of pliers, visit: www.automationdirect.com/pliers.

Hazardous Location Controls

Killark hazardous location control stations are designed to contain and extinguish explosions and are ideal for installations where flammable gases or vapors, combustible dusts or easily ignitable fibers are present. Explosion-proof control devices are available in single or double pushbutton, maintained pushbutton, keyed and non-keyed selector switch, single and double pilot light and combination pilot light/pushbutton styles.

Factory-sealed control device cover assemblies start at $174.00. Also available are unsealed Killark control device assemblies starting at $117.00. Splice/device boxes are available in dead end and feed-through models and are available in single and double-gang styles starting at $36.00. Accessories include legend plates, blank covers, replacement keys and LED lamps, and sealing materials.

To learn more about the KILLARK line of safety devices, visit: www.automationdirect.com/explosion-proof-control-stations.

Cover Story

Robot capabilities

Robot Use Becomes More Widespread

By Christine Lesher
controlspr.com

As robot capabilities expand and costs drop, machine builders and system integrators are creating tightly integrated robot-automation solutions for production lines.

Many dismiss industrial robots as too costly, complex and inflexible. It's true that for many years robots have been an expensive technology used primarily for stacking parts and welding. However, robots are playing an increasing role in manufacturing as technological advances enable them to perform more functions with simpler implementation. Moreover, combining robots with machines creates highly automated production lines that help users control costs and streamline operations.

Even as robots become more advanced, their cost is decreasing, spurring increased use. The Robotic Industries Association (**www.robotics.org**) reports a 20 percent increase in units sold in 2012 over 2011 sales, attributable in part to lower prices. For example, ST Robotics (www.strobotics.com) recently announced that its Tandem R125, with two five-axis vertically articulated robot arms, will sell for $20,000.

Robots on Production Lines

As robots become easier to use and integrate with other systems, many machine builders view them as simply another tool, much like a press or an injection molder. One use is in highly automated production lines where robots and machines are tightly integrated, thus eliminating the need for intermediate material handling tasks.

For example, Intelligrated (**www.intelligrated.com**), which builds material handling solutions in Cincinnati, uses robots to automate production lines. The company utilizes robots for simple, end-of-line palletizing cells, complex multi-line palletizing systems, case packing, depalletizing systems and other material handling applications.

In the Control Design December 2012 cover story "Robots and Machines Become Partners in Motion," Earl Wohlrab, manager of robotic integration at Intelligrated in Cincinnati explains, "Robots become faster and more cost-effective every day. This allows us to move robotics into places that were previously unthinkable."

Concept Systems (**www.conceptsystemsinc.com**) in Albany, Oregon, also contributed to the

Image 1: A Delkor robotic loader, designed for high-speed carton-top loading, is used for the latest upstream equipment, such as the horizontal flow wrappers. (Courtesy of Control Design's cover story "Robots and Machines Become Partners in Motion, December 2012).

Continued, p. 12>>

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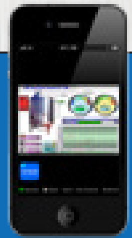
Practical, Powerful and Priced Right

C-more operator touch panels offer:

- Clear TFT 65K color displays *(6-inch STN models also available)*
- Analog touch screen for maximum flexibility
- Easy-to-use software

Our **C-more remote HMI application, for iPad®, iPhone® or iPod touch®, is available on the App Store** for $4.99. It provides remote access and control to a C-more panel (Ethernet-capable models) for mobile users who have a wi-fi or cellular connection.



Control Engineering 2012 Engineers' Choice Awards Finalist

C-more®

C-more touch panels in 6" to 15" sizes are a practical way to give plant personnel easy access to controls and data. Check out the powerful yet easy-to-use configuration software by downloading a demo version at:

http://support.automationdirect.com/demos.html

ALL C-MORE PANELS INCLUDE:

- Analog resistive touch screen with unlimited touch areas
- One USB A-type and one USB B-type port
- Serial communications interface

FULL-FEATURED MODELS ADD:

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REMOTE ACCESS AND CONTROL BUILT-IN

No additional hardware required. The C-more Remote Access feature resides in all panels with Ethernet support, and requires no option modules. Access real-time data or initiate an action on a control system from anywhere, any time. *(Requires software and firmware version 2.4 or later*, and an Ethernet C-more panel)*

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  - *FlexLogix*
  - *SLC® 5/05 Ethernet™*
  - *MicroLogix™*
- Modbus RTU and TCP/IP Ethernet
- GE SNPX
- Omron Host Link Adapter (C200/C500), FINS Serial and Ethernet
- Selected Mitsubishi FX Series, Q Series
- Siemens S7-200 PPI and S7-200/300 Ethernet (ISO over TCP/IP)

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C-more touch panel line-up:

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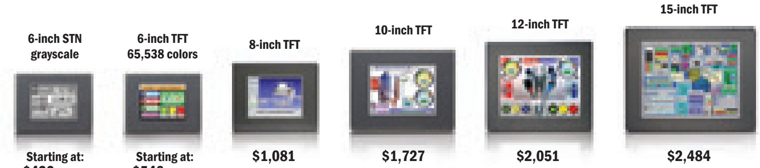

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Cover Story cont.

Robot capabilities

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Image 2: Controlled by a PLC programmed by Intelligrated, the Alvey robot is an example of a complete integrated robotic material handling system. (Courtesy of Control Design's article "Robots and Machines Become Partners in Motion, December 2012). (Courtesy of Control Design's "Design for TCO" article, January 2012).

Control Design cover story. This system integrator uses robots and vision systems to streamline machine design. Michael Gurney, co-CEO at Concept Systems, says robots eliminate the need for mechanical guides and fixtures. This reduces product changeover times, simplifies the parts-feed process and eliminates many mechanical components.

Delkor Systems (**www.delkorsystems.com**) in St. Paul, Minnesota explains in the cover story how robots are improving its packaging equipment (Image 1). "We use robots primarily to load product into trays, cartons or cases. They provide reliable, quality operation and speed, plus allow flexibility to accommodate customer-specific requirements," says Adam Koller, director of engineering at Delkor. He adds, "The robots pick random product off a conveyor using cameras, or pick pre-collated product from a collation belt."

Koller says the lines are built in a modular fashion and consist of a carton-forming machine running anywhere from 30 to 200 cartons per minute, a product collation section, a robotic loading cell, and a carton-closing machine. "Conveyors connect the modules to one another," he adds.

Furthermore, according to the cover story, many robot vendors are customizing robots for machine builders. Tom Hasse, industrial automation and process control consultant at Frost & Sullivan (**http://www.frost.com/prod/servlet/frost-home.pag**) in Mountain View, Calif., says "For special applications that require complex movements and/or interactions with other robots, robot manufacturers will provide a work-cell solution that is more cost-effective for the machine builder."

A Turnkey Offering

Many machine builders and integrators install, commission and service entire integrated machine/robot production lines. These turnkey systems create a single point of responsibility that makes it easier for customers to maintain their production lines.

In the cover story, Koller says this approach, "benefits our customers because we include full line support for the sales and application engineering, service, aftermarket support, system-wide safety risk assessment, and a performance guarantee covering overall operational efficiency."

Staff reductions and the difficulty in finding qualified engineering personnel encourage a turnkey solution because it reduces the manpower needed for a production line. The upfront costs of a turnkey system are higher, but the benefits, including the transfer of risk from the end user to the machine builder, are often substantial enough to make it the more affordable solution in the long run.

Robot Control Options

In general, there are two approaches for robot control: use the robot vendor's controller, or automate the robot with a separate controller. In the second approach, the robot integrator uses programmable logic controllers (PLCs), programmable automation controllers (PACs) or industrial computers to control the robots.

Many machine builders use proprietary control systems from the robot vendor, but others find a general-purpose control system is a better fit for an integrated automation line. There are advantages to both approaches.

The technical and ease-of-use advantages of using robot proprietary control systems often benefit machine builders. Programming is supplied by the robot manufacturer, eliminating the need to write software and shortening development time.

In the cover story, Terry Zarnowski, director of sales and marketing at Schneider Packaging Equipment, explains that using proprietary control, "provides a tight, high-speed, closed-loop control that's needed to ensure the speed and accuracy of the arm and the tooling."

The decision to use proprietary control often rests on the type of robot used. In the cover story, Marvin Tisdale, manager of automotive and mobile solutions for Lenze Americas (**www.lenzeamericas.com**) explains, "Proprietary systems for six-axis robot control are the rule, not the exception. Delta or SCARA-type robots requiring only three or four axes are more likely candidates for general-purpose controls."

PLC-based Control

In many instances, there are distinct advantages to the machine builder or integrator programming the robots themselves. Today, more robotic systems are being controlled and monitored by general-purpose automation systems. Notably, the multicore processors in industrial PCs expand the performance of PC-based controls to accommodate the bundling of many complex functions onto one powerful device. Common PC-based programming environments and industrial Ethernet also have made programming easier.

Arc Specialties (**www.arcspecialties.com**) and Concept Systems have both developed their own robot controls using a general-purpose motion control system. Others prefer to develop their own PLC-based control. For example, Intelligrated uses PLCs to control some of the robots provided with its integrated material handling systems.

In the cover story, Wohlrab says PLCs are gaining traction in the material-handling business. Wohlrab adds, "I envision a future where a single PLC will control small packaging lines that include several robots."

Integrating Robots into Production Lines: Benefits	
1.	Reduces labor costs
2.	Eliminates manual lifting to improve safety
3.	Minimizes manual actions to improve quality
4.	Speeds up line throughput
5.	Decreases product changeover times
6.	Can simplify machine design, particularly when paired with vision
7.	Eliminates the robot proprietary controller in some instances

Table 1: Integrating Robots into Production Lines; Benefits

Continued, p. 14>>

Cover Story cont.

Robot capabilities

Continued from, p. 13

A PLC programmed by Intelligrated controls the company's Alvey robotic palletizer (Image 2). The company states the new control system improves line integration, response time and overall productivity while reducing operator and maintenance training.

Wohlrab also believes PLC-based robotic controls are a good alternative to the traditional proprietary robot controller. In the cover story, he says "These solutions enable our customers to deploy new Alvey robotic palletizing solutions while maintaining a standard and familiar control platform. With minimal training, plant floor personnel can support these robotic applications without becoming robotic experts."

Tighter Integration with Automation Systems

As robots become more multi-purpose and less expensive, there will be increased robot use and tighter integration with general-purpose automation systems. As machine builders seek to increase performance and efficiency, automating robots with the same controller that automates other machine and production line functions will become more prevalent.

End users will benefit from using general-purpose controllers to automate robots as integrating robots with a standard control system helps minimize integration issues. In terms of the automation system, end users will need just a single point of contact to call for troubleshooting and support.

One of the common future predictions for robot integration in automation systems sees standard technologies such as Ethernet being used to connect all equipment in a manufacturing line. There will be embedded robot control, with the controller being a standard PLC or PAC. This will create integrated control solutions with all configuration, programming, kinematics, troubleshooting and operations performed within a single control platform.

Regardless of how robots are controlled in the future, there is one certainty: Robots will become more and more integrated into production lines because of decreasing costs, improved flexibility and simpler implementation.

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Business Notes

AutomationDirect Videos

By Joan Welty

AutomationDirect's YouTube channel, **www.youtube.com/automationdirect**, is expanding rapidly with content that falls into three distinct categories. (Videos are also available at **http://learn.automationdirect.com**.)

"Kickstart" videos are short overviews focusing on newly introduced products – you'll see the parts, learn the basics of the features and applications, all in just a few minutes. They're perfect for getting the highlights of what's new from AutomationDirect. At YouTube, they are all in one playlist called "Kickstart". The man in front of (and behind!) the curtain is Shane Crider, a long-time AutomationDirect techie.

Shane explains, "I came to AutomationDirect with an automated manufacturing degree and background and started on the Tech support team. After four years of helping customers on the phone, fax and email, I was offered the opportunity to help with a new project on Technical webcasts, which we have been presenting now for over nine years. Prerecorded videos have become very popular in addition to the Webcasts. I write, shoot and edit all of the introductory videos on new products called "Kickstart" videos. I love my job and enjoy helping our customers and potential customers learn more about our products and educating them on how to use these products."

More in-depth video series take you from zero to detailed knowledge on a host of popular topics. These series may contain up to 15 videos, leading you through the basics of PLCs, motion control, and process (PID) control, using AutomationDirect products integrated into demonstration systems that relate to real applications. Tom Elavsky, aka "the Professor", draws from years of field experience to make these videos practical and easy to understand.

Tom started his technical career designing relay-based control systems for industrial machinery, and used some of the very first programmable logic controllers. He then worked with metal working machinery, automated production lines, power distribution, water and waste water process control, and even designed animatronics control systems for theme parks. He also taught electrical maintenance classes in the evening at his local technical college.

Here at AutomationDirect, Tom used his forty plus years of experience in industrial automation by starting with Tech Support, then moving into documentation. Most recently Tom joined the marketing team to provide technical content in various forms of video media. Tom takes an application concept, outlines the steps from start to finish as a storyboard, details a hands-on demo, applies the control system components and programming, and conveys the results in a way a viewer can readily grasp. Tom's learning series include downloadable files for further study.

"How to" product-focused tutorials serve up short (two to five minute) snapshots that give specific guidance on using products, particularly ones with programming software. You'll find over 80 videos on ***C-more*** micro touch panel configuration, and many newly posted topics for the Do-more and Productivity3000 controllers, including MATH and DATA instructions, as well as the high-speed counter I/O modules. Playlists are organized by product or feature. Rick Folea is the

voice of these new series. He learns the new products from the ground up, and translates his experience into step-by-step learning guides.

Rick joined AutomationDirect in 2012, bringing over 35 years of programming and electronics design experience. Rick spends his free time mentoring youth in Science, Technology, Engineering and Math (STEM) through competition robotics programs, and works with the Boy Scouts to create new engineering-centric merit badges.

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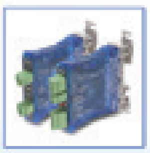

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Tech Brief

Koyo Encoders

Encoders

By Joe Kimbrell
Product Manager, Drives, Motors and Motion

What is an encoder?

An encoder (for industrial controls) is a special sensor that captures position information and relays that data to other devices. The position information can be read in many ways (optically, magnetically, capacitively, etc.). There are two basic geometries for encoders: linear and rotary. A linear encoder typically consists of a scale (a coded strip) and a sensing "head" that reads the spacing between the scales' coding to determine position. A rotary encoder typically consists of an internal coded disc and a sensing head to determine rotary position. A linear encoder is very similar to a tape measure, while a rotary encoder is more like a measuring wheel.

Rotary vs. Linear

Rotary and linear encoders both define their accuracies in similar ways. A linear encoder's resolution is measured in pulses per distance (pulses per inch, pulses per mm, etc.). The scale (coded strip) has a set resolution embedded into it or on it that the head reads. Rotary encoder resolution is measured in pulses per revolution (PPR), also known as "line count". A 2000 PPR encoder has twice the resolution of a 1000 PPR encoder. All the Koyo encoders sold by AutomationDirect are rotary encoders.

Optical

All of the Koyo encoders sold by AutomationDirect are optical rotary encoders. Optical encoders contain a disc within the case with "slots" or "lines" cut into it. The number of slots in the disc varies depending on the resolution of the encoder. A 1000 PPR encoder has 1000 slots cut into the disc. An emitter on one side of the disc emits light through the slots to a receiver on the other. As the slots pass between the emitter and receiver, the receiver alternately detects light and dark; this is how the encoder senses movement and measures position.

Quadrature

Koyo incremental encoders from AutomationDirect are also quadrature encoders. Quadrature encoders utilize two different sets of "slots" on the optical disc inside the case. These different sets of slots are referred to as channels and are typically called "A" and "B". The "A" and "B" slots on the encoder disc are offset so that their outputs are out of phase by 90 degrees. This results in 4 different "states" (see a, b, c, and d in the picture below) that the combination of the outputs could be in for any given disc position. This timing diagram comes directly from an insert that ships with an encoder:

Time slice "a": A = OFF and B = ON
Time slice "b": A and B both OFF
Time slice "c": A = On and B = OFF
Time slice "d": A and B both ON.
(Image 1)

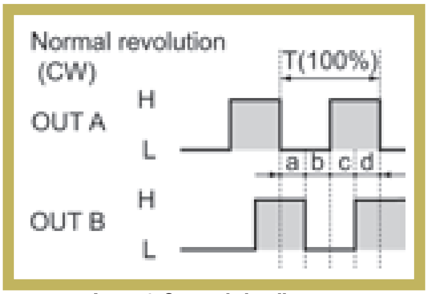


Image 1: Output timing diagram

So, a quadrature encoder with a resolution of 100 pulses per revolution would actually produce 400 different states for each revolution of the encoder. That's why quadrature encoders are sometimes referred to as x4 (times 4) encoders. The pattern of A and B turning ON and OFF also reveals which direction the encoder is turning. Each encoder defines the direction of the quadrature pattern. This encoder has A = ON, then B = ON when rotated in the clockwise direction. If this encoder were to be rotated CCW, B would turn ON first, then A would turn ON.

Z-Pulse

On our incremental encoders, there is another channel called the Index Channel, or Z pulse ("zero position pulse"). This output pulses once per revolution of the encoder. It is used to indicate when the encoder disc crosses the fixed zero position inside the encoder. The Z-pulse can be used to reset a counter, or can be used for very precise homing. Our SureServo servo drive uses an incremental encoder as a feedback device and has a homing mode where the motor is homed to an external signal (a proximity switch, mechanical limit switch, etc.), then the motor proceeds to the next occurrence of the encoder's Z-pulse. This results in extremely accurate positioning. For a more detailed explanation, see Parameters P1-47 thru P1-51 in the SureServo Manual. The encoder's Z-pulse is factory set and cannot be moved. However, several families of our encoders have "servo mounting clamps" that allow the body of the encoder to be rotated, or "clocked", after installation so that the Z-pulse signal occurs in the desired position relative to a machine function. The KM-9D kit provides a servo mount clamp for the TRD-GK encoders; the NM-9D and the NF-55D kits clamp the TRD-N, TRD-NH, and TRD-NA families. (Image 2)

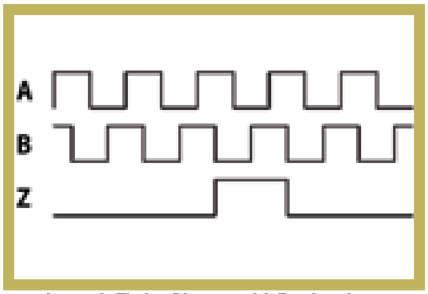


Image 2: Timing Diagram with Z-pulse shown

Image 2 shows a complete timing diagram for a 5 PPR encoder. Notice that the Z pulse stays on for one entire cycle of output B.

Incremental vs. Absolute

Encoders come in incremental and absolute styles. An incremental encoder only reads pulses, and when it powers up, it has no information about location; it can only tell you how far it has moved since being powered up. Think of an incremental encoder as a tape measure with no numbers on it, only tick marks: you can tell how far you've moved, but you don't know exactly where you are unless you measure from a known spot. In contrast, a single turn, rotary, absolute encoder can report back exactly what angle it is at even at power up. Think of an absolute encoder as a compass: you know exactly what position the compass is in when you first look at it. One drawback of single-turn absolute encoders: you know the exact angle the encoder is sitting at when powered up, but you do not know how many turns were made before power was applied. To solve that problem, there are also multi-turn absolute encoders (not offered by AutomationDirect). These encoders usually have a battery or super-capacitor that monitors how many revolutions the encoder has turned even while power is off. Think of a multi-turn absolute encoder as a measuring wheel which increments once per revolution. Multi-turn absolute encoders typically have serial communication and require special receivers to decode their position information.

Our Koyo absolute encoders are single turn encoders. They have a special disc inside that has several channels' worth of information on it. Our encoder with the least resolution has 5 physical outputs (5 bits' worth of data). The TRD-NA32NWD encoder has 2^5 = 2*2*2*2*2 =32 unique positions per revolution (absolute encoders still use PPR). This 5-bit encoder requires 5 digital inputs to a PLC, etc. Currently, our highest resolution absolute encoder, TRD-NA1024NWD, has 10 bits of resolution, or 2^10 = 2*2*2*2*2*2*2*2*2*2 = 1024 pulses per revolution. The 10-bit encoder requires 10 digital inputs to a PLC.

In general, incremental encoders must be wired into high-speed inputs (although our 3 PPR encoder (TRD-N3-RZWD) would not necessarily produce a high speed pulse train). Absolute encoders, however, are designed to be wired to general purpose I/O. So the 10-bit absolute encoder described will wire into 10 general purpose PLC inputs.

Gray Code

There is one more special consideration for our single-turn absolute encoders: they don't count in standard binary. Here is the way binary normally counts up:

Decimal #	Binary code
12	01100
13	01101
14	01110
15	01111
16	10000
17	10001
18	10010

Notice the transition from Decimal 15 to 16: all 5 digits change state at once. In the real world, this could cause serious problems. If the PLC is reading inputs when this transition occurs, a bad value could temporarily be decoded by the PLC (at least for one scan). When outputs on a machine are turned on and off based on encoder position, you can see that this could be a big problem. This may not happen very often, but considering the PLC updates its input image table every scan (hundreds, if not thousands of times per second), any glitch in reading position could be disastrous. To combat this problem of reading multiple transitions, Gray Code was developed. Gray Code is a special kind of binary that only increments one bit at a time. Since only one bit changes each transition, a PLC will not decode erroneous position data. The only drawback to Gray Code is that it is not very intuitive when watching the bits change state.

Decimal #	Binary Code	Gray Code
0	0000	0000
1	0001	0001
2	0010	0011
3	0011	0010
4	0100	0110
5	0101	0111
6	0110	0101
7	0111	0100

However, the logic to decode gray code is very straightforward and can be done with minimal ladder programming. Our Productivity3000, Do-More, and some ***Direct***LOGIC PLCs actually have pre-configured instructions that automatically decode the Gray Code digital inputs into decimal values. For more details on Gray Code, universal ladder logic decoding examples, and special Gray Code PLC instructions, see this Technical Note on our Support homepage:
http://support.automationdirect.com/docs/absolute_encoders.pdf

Electrical Outputs

Our Koyo incremental encoders come with one of several different kinds of electrical outputs: Line Driver, NPN Open Collector, or Push-Pull (Totem Pole). A line driver output is a differential signal and requires two unique output wires per channel. Typical wire designations are A, A^- (A "not"), B, B^- (B "not"). When channel A is ON, there is a positive voltage between A and A^-. When channel A is OFF, there is a negative voltage differential between A and A^-. The magnitude of the voltage differential will be greater than 2.5V. The same happens for the B and Z channels. Line Driver encoders are very straightforward to wire to Line Driver-equipped PLC or motion controller inputs. Each output (A, B, Z) requires two wires, plus two wires for power supply (usually 5VDC). (Image 3)

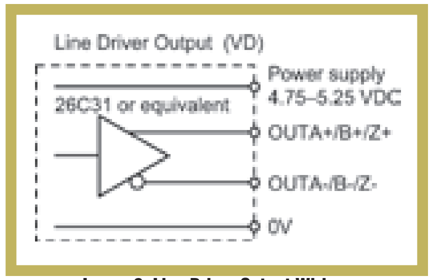


Image 3: Line Driver Output Wiring

A second output type is an open collector. NPN open collector encoders "sink" current from sourcing (PNP) PLC inputs, and require only one wire per channel, plus one 0V (DC common) wire for all the current return. An open collector encoder would have A, B, Z, and 0V wires (and a wire for +DC to power the electronics). NPN Open Collector (sinking) encoders require the master PLC or motion controller to have PNP (sourcing) inputs. Open collector encoders usually accept a wide range of voltage. AutomationDirect offers models with ranges of 5–12VDC, 12-24VDC, and 5-30VDC. (Image 4)

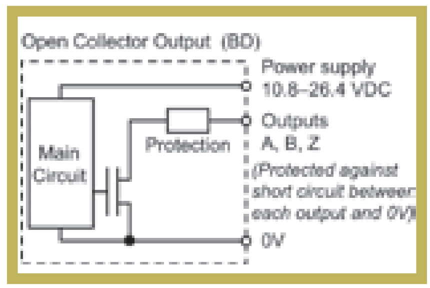


Image 4: Open Collector Output Wiring

The third type of encoder output is a Push-Pull circuit, also known as a Totem Pole output. The Push-Pull output is a special circuit that can sink OR source current to the PLC. The key to this encoder's circuit is the pair of transistors in the encoder. When one transistor is ON, the other is OFF. If the PLC supplies current (the PLC has sourcing, or PNP, inputs), the Push-Pull encoder can sink current through the lower transistor. If the PLC sinks current (the PLC has sinking or NPN inputs), the encoder will source current through the upper transistor.

Continued, p. 33>>

User Solutions

Mel-o-cream donuts

Automating a Donut Packaging and Labeling Line

By John Armstrong,
Director of Technology & Engineering,
Mel-O-Cream Donuts International Inc.,
Springfield, Ill.

When people hear the name Mel-O-Cream, they usually think of donuts. Founded in 1932 as a retail shop in Springfield, Ill, Mel-O-Cream International (**www.mel-o-cream.com**) manufactures bakery products, primarily for wholesale distribution to supermarkets and bakeries.

We currently offer a full line of quality frozen dough and pre-fried thaw-and-finish products. Mel-O-Cream produces more than 80 frozen donut items including specialty, seasonal and jumbo products. Since its debut in 1998, the number of items made on the pre-fried line has increased to more than 40. The pre-fried line makes items such as yeast raised, cake donuts, specialty donuts, and a selection of "Cake Donut of the Month" items. The list of products grows as customers' needs change.

As donut manufacturing capacity and capabilities grew, so did the demands on our product packaging processes. Before this project, preprinted paper labels were manually glued to every case. The "best-if-used-by" date and batch code were also manually rubber-stamped to each case.

This scenario presented several operational issues. It required an extensive inventory of preprinted labels, and not having labels in inventory usually affected the production schedule. Manual label gluing and ink stamping were messy and labor-intensive tasks. For these and other reasons, we needed to automate our manual donut packaging system.

	Sequence of Events for Donut Packaging and Labeling
1.	Cases enter the packaging area
2.	Photoelectric sensors identify cases by detecting presence or absence at two different heights
3.	PC-based HMI displays the current batch number and case count, and allows the operator to select the correct label information to be printed
4.	Visual BASIC application sends UPC codes and target case weight to the PLC
5.	PLC initiates command to the printer applicator to apply the newly printed label
6.	Scanner reads barcode
7.	PLC validates barcode
8.	If barcode data is incorrect or missing, the case is rejected at the checkweigher station
9.	Weight reading from the checkweigher is sent to PLC
10.	PLC compares weight reading with the ideal weight for that product, which is provided by the Visual BASIC application
11.	If case is out of tolerance, PLC activates case rejection
12.	Scanner reads barcode of the labeled and weighed cases
13.	Cases are diverted to the proper conveyor for palletizing

Table 1: Sequence of Events for Donut Packaging and Labeling

We're familiar with the power and reliability of products from AutomationDirect (**www.automation-direct.com**) because we've used them on other projects. For this project, we chose a DL06 PLC, a GS2 variable frequency drive (VFD), a CoProcessor module with Extended BASIC interpreter, and an Ethernet Communications modules—all supplied by AutomationDirect.

Automated Packaging Line Operation

We envisioned an automated packaging line that would do more than just eliminate the messy and labor-intensive gluing and stamping tasks. We needed a single application that would combine labeling, weighing, validating and diverting/routing of cases. Our solution had to be user-friendly, robust and reliable.

The best way for us to ensure that our solution would satisfy our requirements was to keep it simple with as few links in the chain as possible. We accomplished the design engineering, programming, fabrication, and installation in-house—enabling us to create the system exactly the way we wanted it.

We kept our design simple by having one Excel spreadsheet to hold all the data, including label information; one PLC to control all I/O and communications; and one simple PC-based Visual BASIC application developed in-house with no print drivers or Active-X controls.

At the end of the manufacturing process, the donuts are inspected for quality and bulk-packaged in corrugated shipping cases. Filled cases of two different heights are sent from the two production lines that merge into a single conveyor, which transports the cases to the labeling area. From there, they are counted, labeled, validated to ensure proper labeling, weighed, and routed to the appropriate palletizing area (Figure 1).

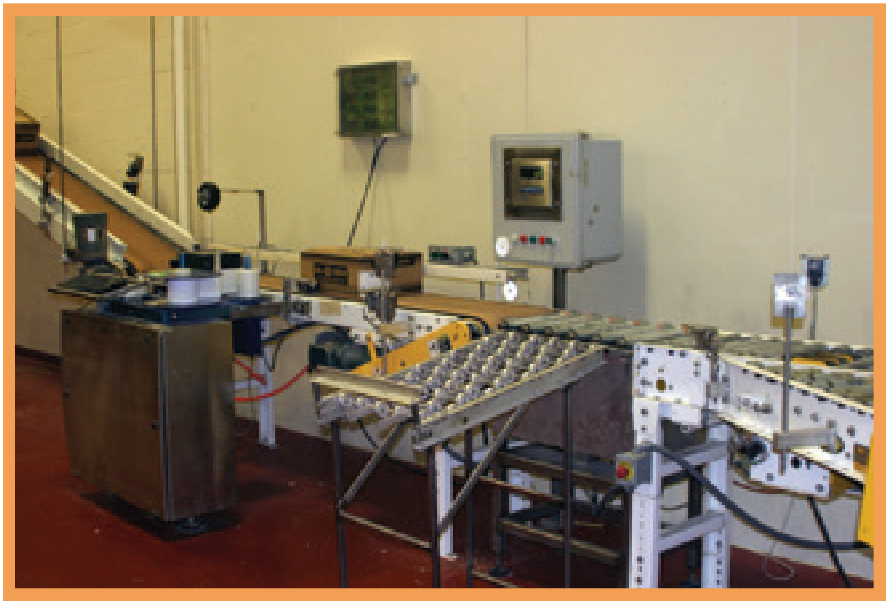


Figure 1. The photo shows most of the automated labeling line. One case has just received its label and is approaching the checkweigher. Another case is coming from the manufacturing line and is approaching the first photoelectric sensor.

Automated Packaging Line Design Details

The automated packaging line doesn't have a traditional HMI; instead, an external PC functions as an operator interface, which is driven by an in-house developed Visual BASIC program (Figure 2). In addition to the Visual BASIC program, the PC also runs the Excel application that contains the individual product data. Both programs interface directly with the label printer/applicator.

The "office type" PC is mounted inside a protective NEMA-4X panel along with the PLC and VFD. This enclosure, which is adjacent to the packaging/labeling conveyor, also supports the back of the label printer/applicator.

Print jobs are sent in ASCII from the Visual BASIC program running on the PC directly to the printer/applicator via an RS-232 serial port. The print jobs are not sent from the PLC. We tried printing from the PLC to the printer/applicator, which functioned well. However, outputting ASCII from the PLC became a daunting task because of our large ingredient legends.

There are only two case sizes that enter the labeling area, with one being taller than the other. Photoelectric sensors mounted at different heights identify which case is present. The packaging operator manually applies a special barcode label on the case whenever there is a batch change.

The PC-based Visual BASIC program increments the case count each time a case passes the photoelectric sensors. As a case passes its respective sensor, which is connected to a discrete input of the PLC, a bit is set in a PLC memory location. The Visual BASIC application running on the PC polls the PLC memory location via ***Direct***Net to determine that a case has passed the sensor (Figure 3, pg. 22).

The PC displays the current batch number and case count, and then allows the operator to select the correct case label information to be printed. The Visual BASIC program provides UPC codes and target case weight to the automated packaging system. In addition to incrementing the case count, the Visual BASIC application also sends the appropriate label print job to the printer, which prints the label and applies it to the case.

The Visual BASIC program is tied to an Excel spreadsheet that contains all of the information to be printed on the label. Label information includes the product name, ingredient legend, UPC codes, best-if-used-by date, and net weight for every product code. There are more than 80 variations.

A scanner reads the barcode from the newly printed and applied label to begin the validation process. If the barcode data is incorrect or missing, the system rejects the case at the checkweigher station. If all is well, the case is weighed and the system compares the reading with the ideal weight for that product type.

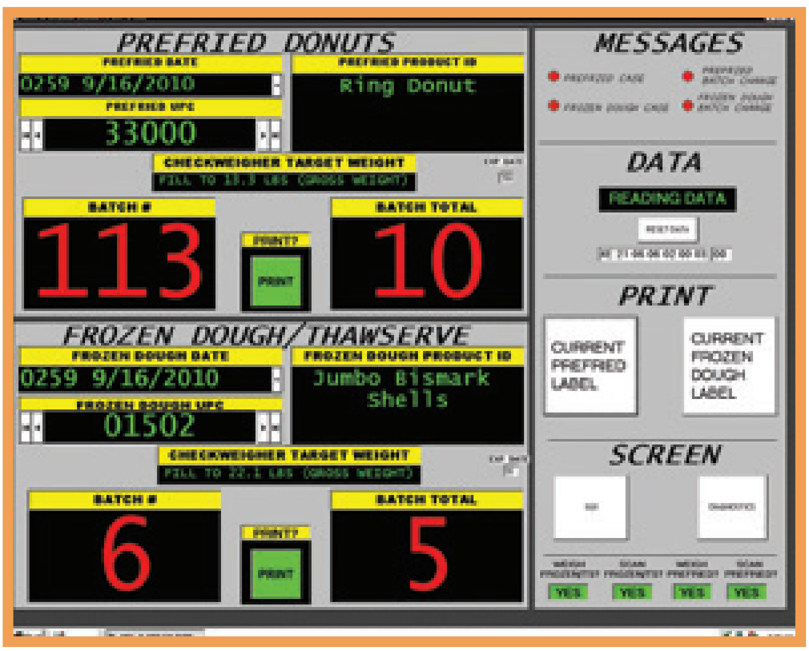


Figure 2. Instead of a traditional HMI, an operator interface is displayed on a PC screen.

Continued, p. 22>>

User Solutions cont.

Mel-o-cream Donuts

Continued from, p. 21

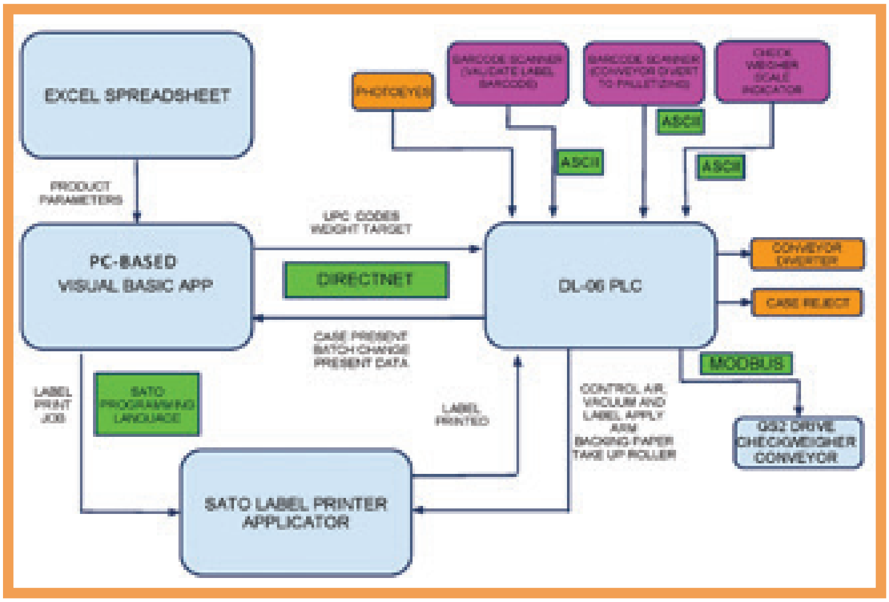


Figure 3. The drawing shows the basic functional elements of the automated labeling line including PLC inputs, PC program operation, communications and signal flow.

The Excel spreadsheet contains the correct case weight and acceptable overweight tolerance. There is zero tolerance for underweight cases. The spreadsheet supplies this weight information to the Visual BASIC program, which writes these values to the PLC when the operator selects the product.

The PLC controls the checkweigher conveyor speed through the VFD. Another set of photoelectric sensors located directly before the checkweigher notifies the PLC that a case is approaching the weighing conveyor. Communicating with the VFD through Modbus, the PLC slows the conveyor speed to stop the case at the scale to obtain its static weight. Measuring static weight is much more accurate than measuring dynamic weight.

The checkweigher sends the case weight to the PLC in ASCII via conventional serial RS-232 connected to a CoProcessor module with the Extended BASIC interpreter. The PLC compares the scale weight to the target weight range, which is the target weight plus the overweight tolerance. If the case is within tolerance, the PLC tells the VFD via Modbus to restart the conveyor to transport the case off of the checkweigher.

A scanner, also connected to a CoProcessor module, reads the barcode of the labeled and weighed case. If the case is within tolerance, the PLC routes the case to the proper conveyor for palletizing by activating the appropriate conveyor diverter mechanism. If it's out of tolerance, the PLC activates the same case rejection mechanism used to reject cases for incorrect barcode labels (Figure 4).

Small Footprint, Giant Capabilities

We've attempted to standardize on one PLC for our automation projects. We chose products from AutomationDirect because they're very feature rich and extremely durable. Their small footprint PLC is a giant in its capabilities. Its communication capability, expansion slots, and a great selection of add-on cards make it a the perfect multitasking PLC for the majority of our automation projects.

We met our objective of designing a user-friendly and robust automated packaging and labeling system. We achieved a single solution that has performed with negligible downtime. We've printed and applied more than 7.5 million labels, and the system is still going strong.

Although learning the syntax of the DirectNet protocol was perhaps the most technically challenging aspect of this project, it was also the most rewarding. AutomationDirect's Web site supplied technical documents, in particular a thorough breakdown of the DirectNet protocol. Knowing these details was critical to implementing the various communication interfaces on the project.

Through trial and error, we gained confidence reading and writing data to and from the PLC and the Visual BASIC program via DirectNet. The payback was a finished application that's very efficient, compact and fast.

Figure 4. The photo shows a case being weighed. Partially visible in the foreground is a case that's been rejected.

PLC Functions for Donut Packaging and Labeling

1.	Detects incoming cases via photoelectric sensors
2.	Controls mechanical operation of label applicator
3.	Controls checkweigher conveyor via VFD
4.	Controls the conveyor diverter after the checkweigher
5.	Receives operator-selected product parameters for barcodes, and weight information from the Visual BASIC program running on the PC
6.	Reads serial weight data from the checkweigher
7.	Reads the serial UPC code data from the barcode scanner
8.	Compares product UPC codes and target weight against received serial data
9.	Rejects case if either weight or label incorrect.

Table 2: PLC Functions for Donut Packaging and Labeling

Albert Einstein said, "Make everything as simple as possible, but not simpler." AutomationDirect caters to those who endeavor to control their applications with as much simplicity as possible. They've created a programming environment that supports users who seek high-level programming, yet accommodates users comfortable with lower level code such as mnemonics.

AutomationDirect provides a large inventory of products with fast delivery, long-term product-line support, a fantastic Web site and stellar documentation. The AutomationDirect knowledge base and user forum provide a wealth of information, and it was a source that we often referred to during this project.

How Mel-O-Cream Donuts are Made

Mel-O-Cream Donuts International produces more than 80 varieties of donuts, all of which are shipped frozen. The process starts by placing the donut ingredients into mixers in the proper amounts as determined by weight.

The dough is mixed and delivered to dough feeders, which begin to manipulate the dough mass into a continuous ribbon. This ribbon of dough is sent by conveyor to a sheeter, which further rolls the dough into a thinner and wider sheet. While on the sheeter, rotary cutters cut the dough into the appropriate shape for sheet goods (rings, bismarks, long johns), or curled and cut the dough into cinnamon rolls or honey buns.

If the donuts are to be sold as frozen dough, they are sent to be flash-frozen in a spiral blast freezer. For pre-fried donut products, the raw dough pieces are transferred to the proofer to allow the dough rise.

The raised dough pieces are sent by conveyor to the tunnel fryer for cooking. The fried, hot donuts are allowed to cool on a spiral conveyor before transferring to the blast freezer.

Upon exiting the blast freezer, the frozen donuts are inspected for quality and bulk-packaged in corrugated shipping cases. The filled cases are conveyed to the labeling area to be counted, labeled, validated, weighed, and diverted to the proper palletizing conveyor.

System Integrator Corner

DG Controls

In this issue of Automation Notebook, we introduce you to Dan Gulley of DG Controls in York, Alabama. With over 30 years of designing and troubleshooting industrial machine controls and system integration, they are experts when it comes to custom control panels and retrofitting equipment.

How did you get started in your Controls/ Engineering career?

My voyage into the field of controls engineering began 40 years ago, in the 12th grade. I had satisfied all but two of my college preparatory course requirements and desired to take a shop class and an extra gym class instead of an afternoon filled with study halls. In spite of being discouraged from that choice by my Guidance Counselor, I insisted on taking Electricity Shop. I did so well in the class, the teacher asked had I ever considered Electrical Engineering. I began researching the field of Engineering and didn't look back. I started the next year at Cleveland State University in the Fenn College of Engineering. I worked in the Cooperative Education Program with Lincoln Electric in Cleveland, Ohio. My future in controls engineering was set.

How long have you been doing Systems Integration work?

The most important part of system integration is listening to machine operators, maintenance workers, supervisors and other engineering disciplines; in other words, your customers. I got a good look at the importance of that early on (probably 37 or so years ago) when I was that co-op student working at Lincoln Electric. I worked with a seasoned electrician building an electrical panel for a machine to be installed on the assembly line. He pointed to a flaw in the design that would prevent the machine from operating properly. When he tried to explain it to the electrical engineer, the engineer wouldn't listen. He only replied, "Build it like the print." The electrician looked at me and said, "Yes sir." We built it like the print, and as predicted, it didn't work. That electrician said to me, "Let this be a lesson to you, son. When you become an engineer, and your electricians tell you something, listen to them, because they know what they're talking about." That is probably the best lesson I've ever learned.

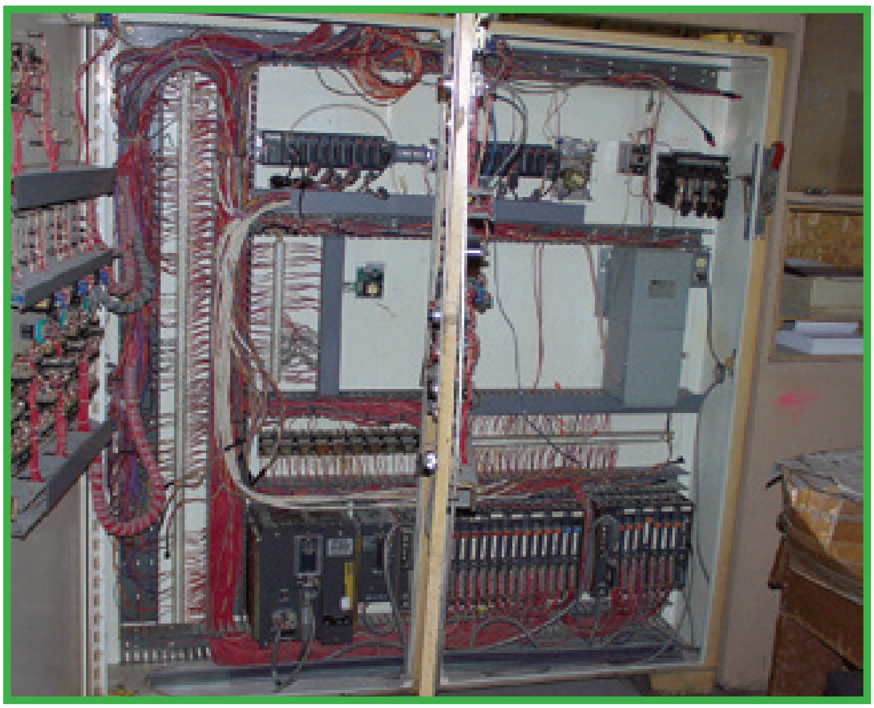
RIM Panel Before Redesign

What has been the most interesting application where you have used AutomationDirect products?

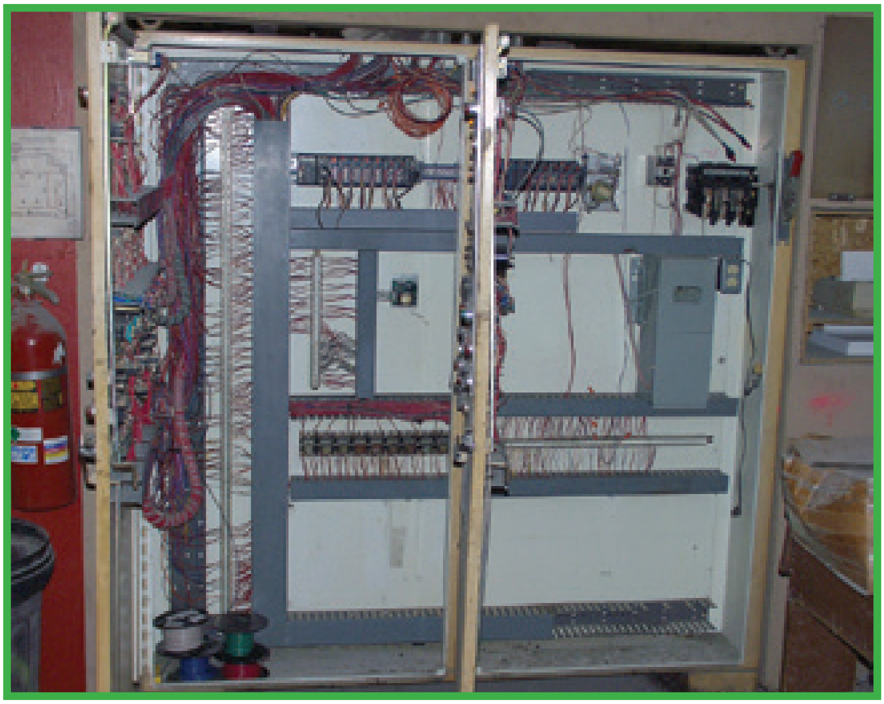
I completed a PLC conversion for CW Ohio in Conneaut, Ohio. They have three old resin extrusion machines which mix resins to make bases for overhang columns for use in housing and other structures. All three machines were controlled with old Allen-Bradley PLC-2 PLCs which had become unreliable. None of their employees knew how to repair them. I converted the machines using AutomationDirect PLCs and C-more Micro-graphic HMI panels. Now they enjoy greater reliability and better control over their process, along with quicker response to breakdowns because of the fault detection and reporting I built into the system.

What made that project unique/ challenging?

Because no one knew the whole story as to how these machines worked, I had to rely on the operators' descriptions as well as decipher the Allen-Bradley program in order to complete the programming of the new PLC.



RIM Panel During Rework


RIM Panel After Upgrade

Another challenge was the conversion when the machines were only down Friday afternoon but still operational the rest of the week on the old system.

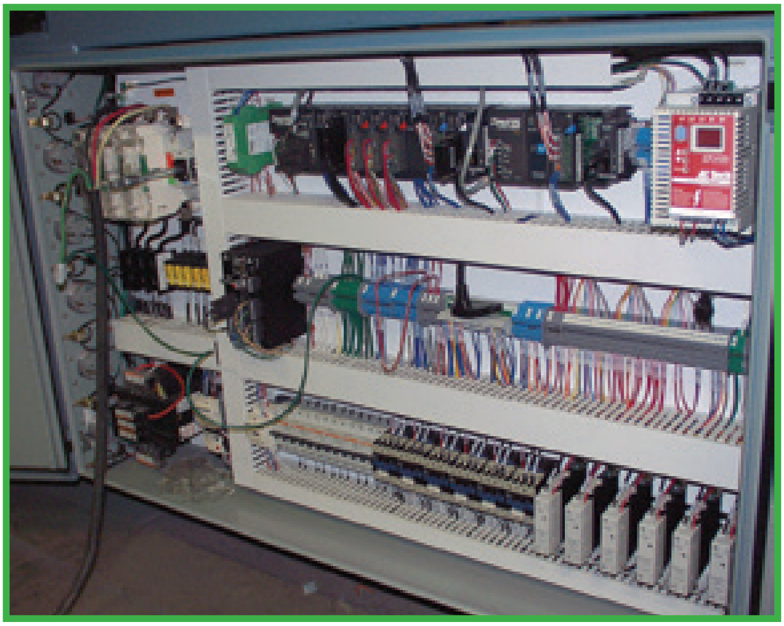
What is a favorite aspect of integration to you?

Seeing the satisfaction of the customer when the project is complete and the system is running better than they expected. To solve a problem with a new system or integrate a solution into an existing system that solves the customer's problem, that's satisfaction personified.

What was the most difficult programming (or engineering) project you ever tackled using PLCs from AutomationDirect?

I had spent my career working with Modicon, Allen-Bradley and Siemens PLCs but had never been exposed to AutomationDirect.

In 2006, after starting my own business, my first customer was a pultrusion machine builder in Twinsburg, Ohio. I built machines, electrically, for them from existing designs, but had to make changes to the wiring, PLC and HMI programs in order to add options to each custom machine. The challenge was to make these changes to an AutomationDirect controller, which was foreign to me. After building and programming eight machines over the course of a year, I became proficient with them.


Pultrusion Machine Main Panel

How did you overcome the obstacles?

Without a doubt, AutomationDirect tech support. They were invaluable to me. I had them on speed dial. I couldn't have done it without them.

Tell about a 'breakthrough' moment for you in your approach to control system applications.

One of my customers had a situation in one of their machines in which the heater output would lock "on", causing the temperature to run out of control if it overshot the setpoint temperature. After discussing and testing the program with AutomationDirect's tech support, we determined the PID block had to be reprogrammed to 12-bit operation. Once that was determined and the changes were made, the system worked flawlessly.

To learn more about DG Controls, visit www.dgcontrols.com. You can also contact them at 216-650-4186, or email **dan@dgcontrol.com**.

Tech Thread

Productivity3000

Productivity3000 FAQs

By Jeff Payne
Product Manager, Automation Controls

Q: What are key differences between the P3-530 vs. the P3-550 CPUs?

Image 1: CPU modules

A: Cost is the key reason to select a P3-530 vs. a P3-550 CPU. The P3-550 does have distinctive advantages in advanced features, as shown in Table 1 on the next page. But in many case the 530's features are more than adequate. (Image 1) The two CPUs program exactly the same[1].

Q: What is the difference between remote I/O and expansion I/O?

A: The primary difference between remote I/O and expansion I/O is the distance of the I/O from the CPU base, and cost. The P3-EX (expansion I/O module) is connected to the CPU via a 2 meter USB cable. The P3-RS and P3-RX (remote slave modules) are connected to the CPU via a 10/100 Ethernet connection and the distance from the CPU is subject to Ethernet standards (~100 meters). Table 2 on the next page gives a more complete comparison. (Table 2 & Image 2)

1 The only instruction not supported by the P3-530 is the LCD instruction. Also, the P3-530's total I/O density is more limited because it only supports expansion I/O and not remote I/O.

Image 2: I/O modules

Q: Are there any I/O module restrictions with the remote I/O and expansion I/O?

A: No, the Productivity3000 system was designed to allow any module to be placed in any slot of any base, regardless of whether it's a local CPU base, expansion I/O base or remote I/O base. (Image 3)

Q: What is the maximum number of remote I/O and expansion I/O bases I can add to one CPU?

A: You can add up to 32 Ethernet remote I/O bases to one CPU. Each of these is called a "Base Group". So you can have a total of 33 Base Groups (1 CPU + 32 remote = 33 Base Groups). Each Base Group can have up to 4 additional USB expansion bases for a total of 165 possible-bases per CPU[2].

Q: Can the GS series and DURApulse drives be connected to the Productivity3000?

A: Yes, and this combination offers many benefits to the user that are not achievable with any other controllers and drives.

By using the GS-EDRV100 Ethernet to serial interface card (required for this configuration), you can connect the drives directly to the Ethernet remote I/O network of the P3-550 CPU. This allows the user to not only auto-discover the drives once connected to the network, but you can also configure all drive parameters through the Productivity Suite programming software and choose to store these parameters with the controller project. The benefit of this is when a drive is replaced in the field, all configuration parameters are then reloaded into the new drive automatically, drastically reducing downtime.

2 Only applies to the P3-550 CPU. The P3-530 CPU only supports expansion bases.

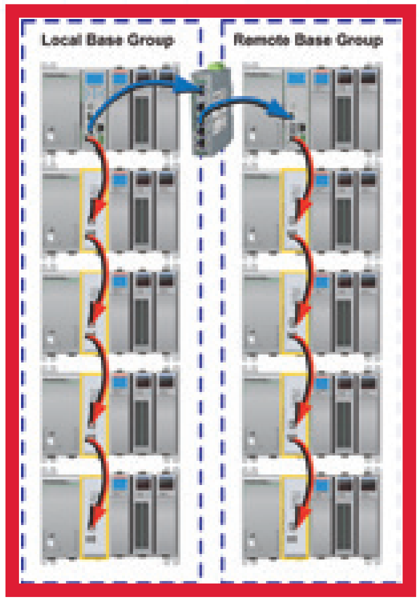


Image 3: Local and Remote I/O

Additional benefits include the use of the GS Drive Read (GSR) and GS Drive Write (GSW) instructions, which greatly simplify the drive's communications and control.
(Image 4)

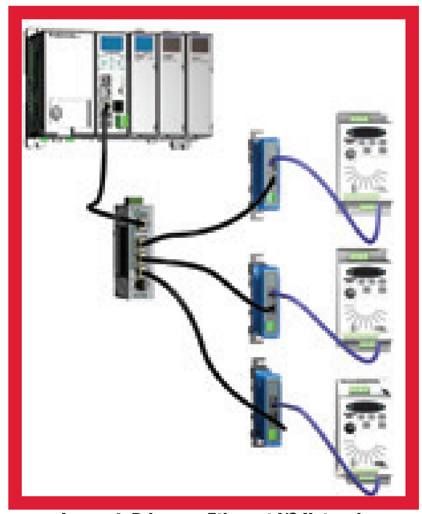


Image 4: Drives on Ethernet I/O Network

Q: How can I keep my rung length shorter so I can see my entire ladder logic?

A: There are new options that allow you to configure your ladder, tag names and comments to better optimize your viewing area. These include 'Wrap Tag Name' which

	P3-530	P3-550
Diagnostic LCD Display/Keyboard	✗	✓
USB Programming/Monitoring port	✗	✓
Ethernet Programming/Peripheral port	✓	✓
Ethernet Remote I/O port	✗	✓
USB Data logging & project transfer port	✓	✓
USB Local Expansion port	✓	✓
RS232/RS485 Serial comm port	✓	✓
User memory size	25Mb	50Mb
List price	**$419**	**$599**

Table 1: Productivity3000 CPU comparison matrix

	P3-EX	P3-RX	P3-RS
Diagnostic LCD Display	✗	✗	✓
USB Programming/Monitor port	✗	✗	✓
USB Local Expansion port	✓	✓	✓
RS232/RS485 Serial communications	✗	✓	✓
Distance from CPU >15 ft.	✗	✓	✓
List price	**$72**	**$299**	**$449**

Table 2: Productivity3000 remote & expansion comparison matrix

allows you to set the maximum number of characters in a line before the tag name wraps to another line. There is also an 'Optimize Rung Lengths' that will remove rung "white space" or empty columns that exceed column 11. *Requires Productivity Suite version 1.7.0.18 or later. (Images 5 & 6)

Q: Can you log data with both the P3-550 and P3-530 CPUs?

A: Yes, both CPUs have the USB data port that allows you to connect a Pen Drive style USB memory device and record application data using a simple utility within the software.

Q: Is it possible to access data log files remotely?

A: Yes, both the P3-550 and P3-530 CPUs have an integrated Web server that allows you to access data log files residing on the memory drive that is connected to the CPU's USB data port from a Web browser. The web server also lets you view system tags, and system event and error history.

Q: What is the benefit of a Tag name database?

A: Documentation and time. In most all practical projects, the programmer is required to document the program for troubleshooting measures. With a Tag name based controller you eliminate a step in this process because each instruction address is a descriptive tag.

Not only are you eliminating a documentation step in the controller process, but if your application also calls for an operator interface panel, PC base HMI, SCADA package or other business system interface software, you have greatly reduced the development time in the overall schedule because of the ability to share the tag databases. This eliminates a huge step in any development project.

Q: What is the benefit of having multiple Ethernet ports on the CPU?

A: A common design flaw in networking programmable controllers is mixing I/O traffic and network traffic. The P3-550 CPU has a dedicated "Internal" Ethernet Remote I/O port that is different from the "External" Networking Ethernet port. Having these dedicated ports allows the processor to prioritize scan-based tasks and asynchronous tasks while reducing the risk of network collisions on your critical data traffic.

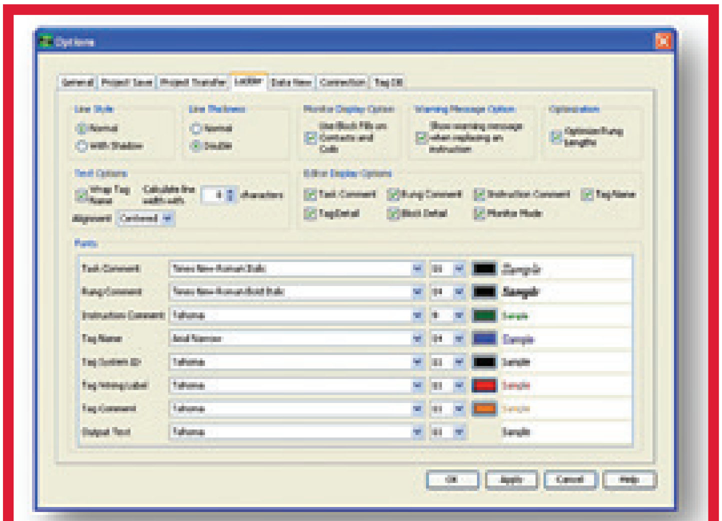


Image 5: New options for configuring your ladder, tag names and comments for better optimization of your viewing area.

Image 6: 'Wrap Tag Name' allows you to set the maximum number of characters in a line before the tag name wraps to another line.

Student Spotlight

Hybrid Racing

Illinois Institute of Technology Competes in Hybrid Racing

By Chip McDaniel

A student team, lead by Donald Ruffatto, from the Illinois Institute of Technology (IIT) SAE International chapter contacted AutomationDirect in late 2011, asking detailed questions about our Productivity3000 Programmable Automation Controller (PAC). They were planning to use it to control an electric car that they were building for the Formula Hybrid International Competition, hosted by the Thayer School of Engineering at Dartmouth, the IEEE, and SAE International, to be held at the New Hampshire Motor Speedway in Loudon, NH, at the end of April 2012.

Thirty-nine teams from universities throughout the U.S. and nine countries registered for the competition, but the challenging requirements narrowed the field to just 30 competitors from the United States, Spain, and Canada by the time of the event.

The competition is intended to foster creative solutions by university-level students to problems in energy efficiency and related vehicle design for hybrid and electric formula racing cars. IIT started preparations for both hybrid and electric racing cars for the competition, but as the competition's deadline approached, the SAE students decided to pour all their efforts into the electric car.

During those initial phone calls, the students' know-how and ambitious plans quickly impressed the technical personnel at AutomationDirect. Within a few days, they agreed to allow the students to become 'Beta testers' for the unreleased P3-HSI (High Speed Input) module that was needed to implement several aspects of their sophisticated control scheme.

The students explained how they planned to use four independent electric 'hub motors', one in each wheel, which would require software functions not needed with a more traditional drive train. All cars require a differential to allow the outside wheels to turn faster than the inside wheels in a turn, otherwise the car will try to flip over.

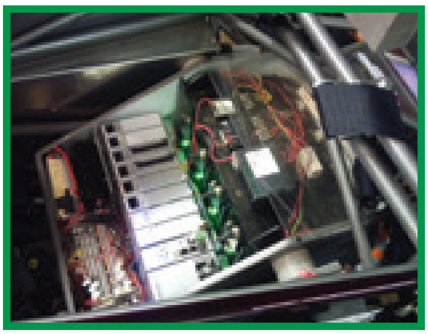
The students needed to create an electronic differential (or 'e-diff') in the PAC, but they went on to explain that the e-diff would be adjustable, and would work in conjunction with other algorithms to actually improve the cornering capabilities of the car even further.

The team detailed their plan to implement 'launch control' and 'traction control', also via software in the PAC. These concepts use high-speed monitoring of AutomationDirect proximity sensors at each wheel to monitor impending wheel spin (in both acceleration and during cornering) and to allow the application of maximum power at each wheel during any maneuver.

"After agreeing to sponsor the team, we didn't hear from them until we called for feedback," said Richard Palmer, a member of the AutomationDirect Business Development team who coordinated the beta testing effort for the P3-HSI and P3-HSO modules. "They were clearly comfortable and competent users of the PAC hardware. After several weeks of testing by the users we called for feedback and received excellent comments on the HSI and HSO modules from all of the beta customers. The IIT team and all the other users who helped us with beta testing certainly contributed to improving the two Productivity3000 high-speed modules that we sell today."

The team also implemented two six-inch ***C-more*** Micro HMI panels on the car, one as an 'e-dashboard' that allowed the driver to view important information from the battery management system, such as the state of charge for the battery pack, and to monitor the four independent motor controllers. The e-dashboard was also used to initiate startup and shutdown sequences (controlled by the PAC) for the car, as well as a standard speedometer function.

The second ***C-more*** Micro was mounted on the rear of the car, and was used in between competition runs to adjust various parameters, including a governor function (for the maximum endurance runs), the electronic differential parameters, and also to 'trim the pots' associated with the steering and pedal feedback values used by the PAC to control the car. The rear mounted ***C-more*** was also used to display lap times, maximum g-forces, and to control the charging of the battery pack while the car was plugged into the power grid. The two ***C-more*** Micro panels were connected to the Productivity3000 via serial communication and all data was supplied through the PAC.



The electric car was built at IIT over a span of about five months, with students working 10 to 12 hours per week and, toward the end of the preparation period, probably that many hours each day.

Pavel Dutov, the President of the IIT SAE International chapter and a PhD candidate in Chemical and Biological Engineering, estimated a rough approximation of labor at about 6,000 hours, or the equivalent of three persons working full-time for a year. At any given time, at least ten students were assembling or testing on the vehicle.

Simply making it to the competition was quite an achievement. Pavel Dutov explained, "The challenge, for a student competition, is to construct a working car with limited resources and time - that can also satisfy all the safety requirements." Dutov said, "It is a student competition, so judges have to be pretty sure that the car is safe before they allow the students to drive it in race conditions. This year there were 30 teams present, but only one-third had functioning cars that were able to pass the technical inspection."

The competition included static judging as well as the on-track competitions:

1. Teams were required to make a 20-minute marketing presentation, outlining features of the car and its design innovations. This presentation was given by team member David Wylen, a junior in Mechanical Engineering. The IIT team was awarded fourth place.

2. Teams then submitted their car to the Design Judging event, in which each of the committee judges inspected the vehicle and questioned team members about a different aspect of the car – suspension and braking, performance, power train, and efficiency. The results of the design judging were used in conjunction with the event results for the overall evaluation of the cars.

Moving to the track, the cars competed in separate Acceleration, Autocross, and Endurance events:

1. The Acceleration event was essentially a drag race, a timed 75-meter run.

2. The Autocross event challenged the driver and the car to maneuver as quickly as possible through a tight, twisting road course, marked with cones, designed to test cornering, speeds, and other aspects of real-time driving.

3. The final event tested the car's endurance; perhaps the most challenging of all. Teams attempted to run their vehicle 36 laps, a total of 15 miles, continuously on the Loudon track. Of all the purely electric cars in the competition, only the IIT entry finished the Endurance portion of the competition.

IIT chapter president, Pavel Dutov, considered the Endurance event the biggest challenge, "Endurance is the biggest, most difficult and important event, and we won it!

"Before the Acceleration event, we still had some issues with the car and worked on it all night," Dutov said, "so even though our car was very powerful and light, we only managed to win fourth place." His teammate Nicolas Crivelli agreed, adding that even though the IIT team had worked on the car around the clock, that some of the electrical power connections hadn't held up under race conditions. Team members are convinced they could have won this event; after all, the power to weight ratio of the car yields a theoretical 0-60mph time of 3.4 seconds. The team is confident that they have achieved actual 0-60 times in the 4 to 5 second range, but just not during the officially timed event.

Their Autocross run was also judged against time. The IIT team completed the Autocross course in 38 seconds which put them in second place; the fastest score recorded was 31 seconds, by the University of Kansas. Here too, the IIT team is convinced that, with a little practice, their

Continued, p. 30>>

Student Spotlight Cont.

Hybrid Racing

Continued from, p. 29

results would have been better "We posted this YouTube video (**http://www.youtube.com/watch?v=hXH3ZWvseIs)** of our official autocross lap," Dutov offered. "It is actually the very first time that anyone had put this car through a corner at speed. Imagine how much faster we got once we became more familiar with the car."

Regarding the Endurance event, team member Stamen Tintikov (now a senior, studying Mechanical Engineering), who was also in charge of IIT's hybrid entry said, "We were the only electric car capable of finishing in this event, and it means something because it's electric-only: hybrids have a combustion engine on-board the vehicle, so they can always switch to gas."

"We designed our all-electric car to go exactly fifteen miles at optimal performance," Dutov added. "If you design it to go any further, then you've over-engineered it."

IIT took second place overall in evaluation of the electric racing car, as well as second place for the Ford Efficiency Award, awarded to the vehicle judged best able to get maximum running results from a minimum amount of fuel or electric energy. They placed among the top six entries contending for the Institute of Electrical and Electronics Engineers (IEEE)'s 'Engineering the Future Award' and the 'Excellence in EV Engineering Award'. In addition, IIT scored several 'firsts' in the judging categories which contributed to these results.

Eleven SAE team members from IIT went to the Competition. Four of them drove the electric car. Many lost a good deal of sleep working all hours to complete last-minute preparations. All their efforts continued: "The reality is, we did pull all-nighters," said Nicolas Crivelli (also a senior in Mechanical Engineering). "Three of those days we had issues with the car and worked nearly around the clock to fix them, and did, which surprised the judges and many other teams."

We asked the team what made the IIT vehicle distinctive, and how it contributes to engineering science for sustainability and efficiency?

"The car is interesting because it was built by engineers who are not familiar with the car industry at all," Donald Ruffatto said, "building it from scratch, using our own ideas and not imitating well-known automotive approaches. We had the innovative idea of hub motors, attaching an individual motor to each of the four wheels, which gave us an independent four-wheel drive system to work with. This is something you cannot get on any gas car.

"The approach has a lot of advantages. We could apply torque to each wheel independently and improve both efficiency and how well the car could handle.

"We also had regenerative braking on this car, which enhances efficiency. Instead of wasting the energy in braking which, in regular cars, gets converted into heat, we used the motor on each wheel as a generator to transfer the kinetic energy back into the electrical system and to recharge the batteries.

"Our system was also unique in that the motors on each wheel were identical. This meant that we created a modular system that was easy to control, easy to troubleshoot."

This design decreased the total weight of the car and provided better weight distribution. Software algorithms enabled greater precision and efficiency in channeling the torque output required for specific maneuvers, such as tight cornering, acceleration, and braking.

Another innovation, at least for a student-built racing vehicle, was the use of a professional-grade material, carbon fiber, in crafting the "A-arms," or "wishbones", which link the wheels to the chassis. "The uniqueness is in the material we used – carbon fiber, which is super-light and is extremely strong," Tintikov said. "We tested each link to 2,000 pounds of tensile stress, which is considerably more than is needed in a race." The use of carbon fiber dramatically decreased the weight of their chassis, compared to a standard automobile. The team boasted that the weight of the vehicle's entire suspension system was less than ten pounds, and the entire car weighed in at 604lbs. at the competition.

One of the competition's goals is student participation in real world problem solving. Dutov explained, "One of the main things was learning from our mistakes. We had front and rear wings on the car that cracked because we hadn't realized that the car could turn so sharply that it would shake the wings violently. It worked perfectly in 2D simulations and in our aerodynamic calculations, but in school you study theory, and real life experience provides an extra degree of freedom which you never know until you face the real application."

"Gas prices go up day by day, and by this point it's obvious the future is for electric and hybrid vehicles. Electric car racing is the best way to test the limits and move the industry forward."

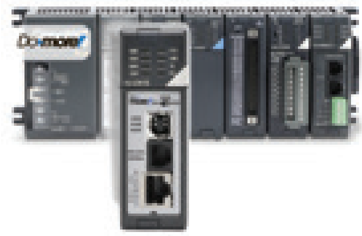
2012 Team members included: Donald Frank Ruffatto, Alexander Luke Lambert, Nicolas Raul Crivelli, Charlie Currier, Frank Iamarca, Bart Patrzalek, David Wylen, Manuel Leon Madrigal, Daniel Milewski, Stamen Tintikov, Anthony Perri, Carlos Sosa, Rodolfo Manotas Ramos, Nicholas Krause, and Nikola Micic.

Event Blog:
http://fhcompetition.wordpress.com/

See additional photos from the event by visiting:
http://www.flickr.com/photos/thayerschool/sets/72157629585325328/

Do-more PLC Trained Integrators

The SI Direct program, managed by AutomationDirect, provides expert system integration service to AutomationDirect customers, with particular emphasis on our Programmable Controller, HMI and Motion Products. Member integrators have demonstrated specific product and application expertise and also receive ongoing training and equipping assistance from AutomationDirect.



The SI Direct member integrators listed here have received specific training on the new Do-more PLC. These integrators are especially qualified as a knowledgeable source for engineering and integration for systems involving the Do-more PLC platform. Contact them today to see how they can meet your automation system needs.

System Integrators Specializing in the Do-more PLC

EPIC ENGINEERING LLC	1925 EAST FRANCISCO BLVD #19 SAN RAFAEL, CA 94901	Website: www.epicengineering.com Contact: JOE HITI Phone: 415-460-9935 E-mail: **joehiti@epicengineering.com**
ALM SYSTEMS AND CONTROLS	40 LINCOLN AVE BOHEMIA, NY 11716	Website: www.almsystemscorp.com Contact: ALLEN DACHINGER Phone: 631-948-6284 E-mail: **allen@almsystemscorp.com**
REES ENGINEERING CORP.	339 CHESTNUT STREET PO BOX 26697 COLLEGEVILLE, PA 19426-0697	Website: www.ReesEngineering.com Contact: JAY REES Phone: 610-454-9900 E-mail: **jay.rees@reesengineering.com**
INDUSTRIAL AUTOMATION	214 VINE STREET LA CROSSE, WI 54602	Website: www.industrialautomation.us Contact: HERB BURFIELD Phone: 608-781-6878 E-mail: **sales@industrialautomation.us**
AAA ABSOLUTE AUTOMATION AND ELECTRICAL SERVICES	ELECTRICAL SERVICES INC. PO BOX 790 COVINGTON, GA 30015	Website: www.AAAelectricalservices.com Contact: BRIAN BARLOW Phone: 770-787-0015 E-mail: **bbarlow@aaaelectricalservices.com**
ARM ENER TECH ASSOCIATES INC	5925 STEVENSON AVE SUITE H HARRISBURG, PA 17112	Website: www.eta-inc.com Contact: SAM MORELLO Phone: 814-288-6654 201 E-mail: **sam.morello@armenertech.net**
AUTOMATION TROUBLESHOOTERS	650 N. ROSE DR. #406 PLACENTIA, CA 92870	Website: www.automationtroubleshooters.com Contact: JOHN ALVEY Phone: 714-308-3010 E-mail: **j@automationtroubleshooters.com**
KCC SOFTWARE	830 ELDORADO AVE HUNTSVILLE, AL 35802	Website: www.kccsoftware.com Contact: SCOTT MARTIN Phone: 256-693-2334 E-mail: **scott@kccsoftware.com**
DAZER DESIGN PRODUCTS INC	44575 GOVERNOR BRADFORD ATTN PETE DAZER AP DEPT PLYMOUTH, MI 48170	Website: www.dazerdesign.com Contact: PETE DAZER Phone: 734-740-1228 E-mail: **pete@dazerdesign.com**
RAYNES ENGINEERING INC	PO BOX 521980 1055 EAST 2100 SOUTH SUITE 203 SALT LAKE CITY, UT 84152	Website: www.raynes.com Contact: JOHN RAYNES Phone: 435-491-0023 E-mail: **john@raynes.com**
RG WEBER CONTROL SYSTEMS INC	11142 LINDBERGH BUS COURT SUITE 117 SAINT LOUIS, MO 63123-7821	Website: www.rgweber.com Contact: BOB WEBER Phone: 314-845-8533 E-mail: **rgweber@rgweber.com**
PRICE TECHNOLOGY	110 MANATAWNY ROAD OLEY, PA 19547	Website: www.pricetechnet.com Contact: KEVIN PRICE Phone: 610-689-0300 E-mail: **kevin@pricetechnet.com**
FEAT ENGINEERING	3704 W. BISMARK DR MERIDIAN, ID 83646	Website: www.featengineering.com Contact: STEVEN JEFFERS Phone: 208-345-1374 E-mail: **sjeffers@featengineering.com**
RPM AUTOMATION INC	10511 140 St EDMONTON, AB T5N 2M1 CANADA	Website: www.rpmautomation.com Contact: STEPHEN GOODWIN Phone: 780-237-5700 E-mail: **info@rpmautomation.com**

Tech Brief Cont.

Koyo Encoders

Continued from, p. 19

The circuitry looks similar to a totem pole, hence the alternate name. (Image 5)

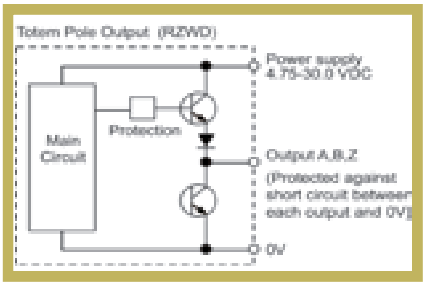


Image 5: Totem Pole Output Wiring

Light, Medium vs. Heavy Duty

One of the first ways AutomationDirect differentiates encoders is by duty: we have Light Duty, Medium Duty, and Heavy Duty encoders. The key difference is how much load may be applied to the shaft. Our smallest encoder, the TRD-MX (4mm shaft), can only handle 10N (2.25 lbf) radial force on the shaft. In contrast, our Heavy Duty encoders, the TRD-GK (10mm shaft), can handle 100N (22.5 lbf) of radial force on the shaft.

Environmental ratings also become more robust as the Duty increases. Our Light Duty encoders are IP40 and IP50 (dust proof). The Medium Duty and Heavy Duty encoders go as high as IP65 (splash proof). This selection guide details the most significant differences between the Koyo encoders offered by AutomationDirect. Note that all the encoders come with a 2m cable except for the TRDA-25 encoders, which come with a military-style connector. AutomationDirect also carries mating connectors and pre-made mating cables for the TRDA-25s.

A selection guide is located under the "Technical Information" tab on any AutomationDirect encoder Web page. **http://www.automationdirect.com/static/specs/encoderselect.pdf** (Image 6)

Speed Limitations

There are two speed limitations when it comes to rotary encoders: mechanical and electrical. The mechanical speed limit is a fixed RPM value for each family which is the maximum speed those encoders can withstand without breaking. There is also an electrical speed limit for each family of encoders which is imposed by the switching speed (frequency response) of the electronics inside the encoder. The switching speed for an encoder's electronics is calculated by how fast the encoder is spinning, and the encoder's resolution. (A 3 PPR encoder spinning at 5000 RPM only produces pulses at 250Hz, while a 1000 PPR encoder spinning at 5000 RPM produces pulses at 83 kHz.) The electrical speed limit is determined by the formula: Max Electrical Speed = (Max Freq Response / pulses per revolution) x 60sec/min

	Duty	Family	Size	Encoder diameter	Shaft diameter	Solid or Hollow Shaft	Operating Voltage (VDC) and Electrical Output*	IP Rating	Max Radial Load (N)	Max Axial Load (N)	Available resolutions
Incremental	Light Duty	TRD-MX	10	25mm	4mm	solid	5V Line Driver or 5-12V OC or 12-24V OC	IP50	10	5	100, 360, 500, 1000, 1024
		TRDA-2E	15	1.5"	1/4"	solid	5V Line Driver or 12-24V OC	IP50	30	20	100, 360, 500, 1000, 1024, 2500
		TRD-S	15	38mm	6mm	solid	5V Line Driver or 12-24V OC	IP40	20	10	100, 200, 250, 300, 360, 400, 500, 600, 800, 1000, 1024, 1200, 2000, 2500
		TRD-SH	15	38mm	8mm	hollow	5V Line Driver or 12-24V OC	IP40	20	10	100, 200, 250, 300, 360, 400, 500, 600, 800, 1000, 1024, 1200, 2000, 2500
	Medium Duty	TRDA-20	20	2"	3/8"	solid	5V Line Driver or 5-30V P/P	IP50	50	30	100, 360, 500, 1000, 1024, 2500
		TRDA-25	25 (w/size 20 body)	2.5" flange (w/ 2.0" body)	3/8"	solid	5V Line Driver or 5-30V P/P	IP65	50	30	100, 360, 500, 1000, 1024, 2500
		TRD-N	20	50mm	8mm	solid	5V Line Driver or 5-30V P/P	IP65	50	30	3, 4, 5, 10, 30, 40, 50, 60, 100, 120, 200, 240, 250, 300, 360, 400, 480, 500, 600, 750, 1000, 1024, 1200, 2000, 2500
		TRD-NH	20	50mm	8mm	hollow	5V Line Driver or 5-30V P/P	IP65	50	30	3, 4, 5, 10, 30, 40, 50, 60, 100, 120, 200, 240, 250, 300, 360, 400, 480, 500, 600, 750, 1000, 1024, 1200, 2000, 2500
	Heavy Duty	TRD-GK	30	78mm	10mm	solid	10-30V P/P	IP65	100	50	30, 100, 120, 200, 240, 250, 300, 360, 400, 500, 600, 800, 1000, 1200, 1500, 1800, 2000, 2500, 3600, 5000
Medium Duty Absolute		TRD-NA	20	50mm	8mm	solid	10-30V OC	IP65	50	30	32. 64. 128, 180, 256, 360, 512, 720, 1024 (grey code)

Image 6: Koyo Encoder Selection Guide

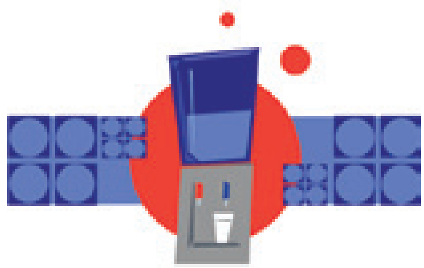
All our encoders feature an integral 2m cable except for the TRDA-25 series which has an MS connector

*Operating Voltage and Electrical Output:
- LD = Line Driver (all Line Drivers require 5VDC supply)
- OC = NPN Open Collector (at Operating Voltage)
- P/P = Push Pull or Totem Pole (at Operating Voltage)

Continued, p. 34>>

The Break Room

Brainteasers



Brainteasers

1.) Circular References

A factory has a circular work cell, which they wish to divide into four equal sections, using three safety curtains, each the same length. ***How might this be done? Extra Credit: What is the length of the three safety curtains?***

2.) The Circling Cart

That same factory has a four wheel cart that rides on a pair of circular tracks. The outside wheels of the cart turn twice as fast as the inner wheels. The cart's axles are 5 feet wide. ***What is the length of the outside track?***

3.) Ancient Riddle

This is a very old story - you may have heard it. It's often told regarding 17 cows, but we couldn't help taking a small liberty:

An eccentric automation tycoon passes away, leaving his empire (consisting of 17 factories) to his children in the following manner: his eldest is to receive half of his factories, his second child - one third of the factories, and his youngest gets one ninth of them. The children do not wish to share or 'break up' a factory, and thus they cannot figure out how to divide the empire.

They consult a wise friend (also an automation expert) who offers to loan them a factory, so that with a total of 18 factories; the eldest can take half (or 9 factories), the second child gets the one third share (6 factories), the youngest child receives the one ninth share (2 factories) AND they can give the 'loaned' factory back to the friend. The three children also realize that they are each better off in the end, than they would have been if they had subdivided one of the factories.

Can you explain the apparent paradox in simple mathematical terms?

4.) Tooling Around

In one well-automated factory, the operators were getting bored, so the foreman offered them a challenge. The factory has 25 CNC machine tools arranged in a neat grid of 5 rows, and 5 columns. Each machine tool has an operator. The foreman offered to let each operator move to a new machine tool as long as they followed certain restrictions. Each operator could only move to a machine tool that was in the position directly in front, or directly behind, or directly to the right side, or directly to the left side - of that operator's original position. All of the operators were required to move, and in the end there must be an operator at each station.

Were the operators able to meet the foreman's restrictions? Why or why not?

Editor's Note: AutomationDirect has recently launched "Inch" style encoders, small 25mm encoders, and changed all the previously "six-week lead time" encoders to in-stock in their warehouse in Cumming, GA.

Tech Brief cont.

Continued from, p. 33

The Maximum Frequency Response is a fixed number (in Hertz) for each encoder family. This is how fast the electronics can switch from OFF to ON. So, each encoder resolution inside that family has a different Maximum Electrical Speed. For example, TRDA-25 encoders have a Maximum Mechanical Speed of 3000 RPM. The Maximum Frequency Response (electrical speed) of the Push-Pull models is 100 kHz.

So, the fastest speed that a 100 PPR TRDA-25 encoder can spin due to the speed of the electronics is (100kHz/100 PPR) x 60s/min = 60,000 RPM (much higher than the mechanical limit of 3,000 RPM).

The fastest speed that a 2500 PPR TRDA-25 encoder can spin due to the speed of the electronics is (100kHz/2500 PPR) x 60s/min = 2,400RPM (lower than the mechanical limit of 3,000RPM).

So, if an application requires high speed or high resolution, both the mechanical and electrical speed limits of the encoder need to be considered.

While the above information is mostly geared toward incremental encoders, the same calculations hold true for absolute encoders. One extra consideration for absolute encoders is that general purpose DC inputs are not high-speed inputs. The OFF-to-ON and ON-to-OFF response times of general purpose DC input cards may limit an absolute encoder's speed more than the encoder's switching frequency.

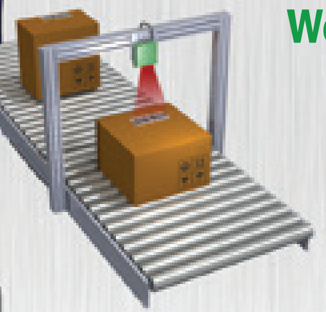
Other Notes

Some other characteristics of Koyo encoders offered at AutomationDirect:

- TRD series encoders have metric dimensions.
- TRDA series encoders have SAE (inch) dimensions.
- Encoder part numbers with a "V" in the suffix are Line Driver models.
- All our encoders come with an integrated 2m cable except the TRDA-25 encoders: they have an MS connector (separate mating cables and connectors are available).
- Shaft couplings are available for all encoder families: metric-to-metric, inch-to-inch, and metric-to-inch.
- Right angle mounting brackets and various round and square flanges are also available.

Get the PRO in

COMMUNICATIONS



We make it easier to communicate

Communicating to ASCII devices can be a hassle with some control systems, but the Productivity3000 controller's user-friendly design makes that job easier. Follow along in this example to set up communications with a bar code scanner:

- **Connect the scanner to one of the Productivity3000 CPU's embedded serial ports**
- **Configure the port through the FREE Productivity Suite programming software. Intuitive dialog boxes let you set parameters such as baud rate, stop bits, and the protocol - in this case, ASCII/Custom - using selection menus.**
- **Configure the ladder logic instruction "ASCII IN" - define number of characters, assign the destination memory, and update the program in the controller.**
- **You're ready to read data from the scanner. It's that easy!**

Watch the bar code scanner tutorial and other informative videos to learn why ...

http://bit.ly/P3vids-scan

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