BALLUFF

White Paper

IO-LINK HELPS MACHINE BUILDERS SAVE UP TO 50%

by Shishir Rege

Employing IO-Link to interface field device I/O, progressive machine builders are modernizing their controls architectures to support the IIoT and I4.0, while at the same time saving up to 50% over traditional control system designs.

IO-Link is an open and standardized sensor-actuator communication technology according to IEC 61131. IO-Link has been around for over ten years, and is primarily known for simplifying the integration of smart sensors because IO-Link communication to field devices can be accomplished over all of the most popular industrial networks. However, many companies are quietly having success utilizing IO-Link as an enabler for innovating cost-saving control system architectures.

In what areas can machine builders expect savings?

Every machine goes through five stages from development through deployment: Design, Build, Programming & Commissioning, Installation & Start-Up, and Maintenance. The table below provides a quick overview of available IO-Link savings.

OVERVIEW OF SAVINGS WITH IO-LINK

Machine Phase	Available Savings
Design	▪ Distributed machine-mounted I/O reduces or eliminates controls cabinets ▪ Distributed I/O architecture enables faster, more efficient modularized machine design ▪ Reduced number of industrial network nodes cuts networking hardware overhead and burden ▪ Standardization of device-level interface across all popular industrial networks cuts design effort ▪ Enablement of IIoT and Industry 4.0 communication via IO-Link architecture ▪ Enablement of error-proofing and traceability features for enhanced user experience ▪ Reduced design time enables faster time-to-market and frees design capacity
Build	▪ Assembly with quick-connects reduces time-intensive wiring terminations ▪ Use of quick-connect cables reduces occurrence of improper wiring terminations / rework time ▪ Modular I/O design shortens cable runs from sensors to I/O modules, cutting installation time ▪ Standardized quick-connect cables simplify component inventory and supply logistics ▪ Shorter overall build time frees plant capacity for larger orders or additional machine builds
Programming & Commissioning	▪ Fewer assembly errors to be located and corrected ▪ Faster identification and correction of remaining assembly errors ▪ Faster troubleshooting of component faults and defects via networked point-level diagnostics ▪ Faster refinement of machine logic through remote device parameterization / configuration ▪ Simplified machine logic via integration of intelligent sensors for distributed task- and error-handling
Installation & Start-up	▪ Modular plug-n-play design simplifies and shortens tear-down, shipping, and re-assembly on site ▪ Reduced start-up time through remote diagnostics and/or enhanced diagnostics with IO-Link
Maintenance	Reduced unplanned downtime through: ▪ Rapid re-configuration of failed field devices via automatic parameterization over IO-Link ▪ Reduced troubleshooting time due to port-level / device-level diagnostics including short-circuit and over-current detection and reporting ▪ Remote- / condition-monitoring data ▪ Enabling predictive maintenance through event logging of field device data ▪ Enabling continuous process improvement through process-related data logging ▪ Easy system expansion to handle additional devices, device upgrades, and device types

The inefficiencies of traditional control system design

The traditional approach to controls architecture is to install a centralized controls cabinet to house the control system components. This methodology requires a lot of design effort to specify controller-specific I/O components, design the component layout in the cabinet, identify and document individual wires with color and gauge, describe wire routing, and ensure full compliance with UL requirements.

During the labor-intensive phase of machine build, electrical technicians spend time routing, cutting, stripping, labeling, crimping, and terminating each wire. The industry estimates an average time of about seven minutes per wire. For (150) terminations, then it could take about (17) hours of labor or the equivalent of $1100. Later on in the programming and commissioning phase, controls engineers must spend additional costly hours to debug termination errors and wiring errors that may have occurred in both the design and assembly phases. The time and money spent on these non-value-added activities could be better applied to reduce machine cost, build additional machines, or improve machine functionality and capability. Any similar controls design approach that involves terminating wires, for example distributed architecture with small controls cabinets mounted around the machine, would entail the same disadvantages. Since status or diagnostics are not readily available, debugging a short circuit takes a long time.

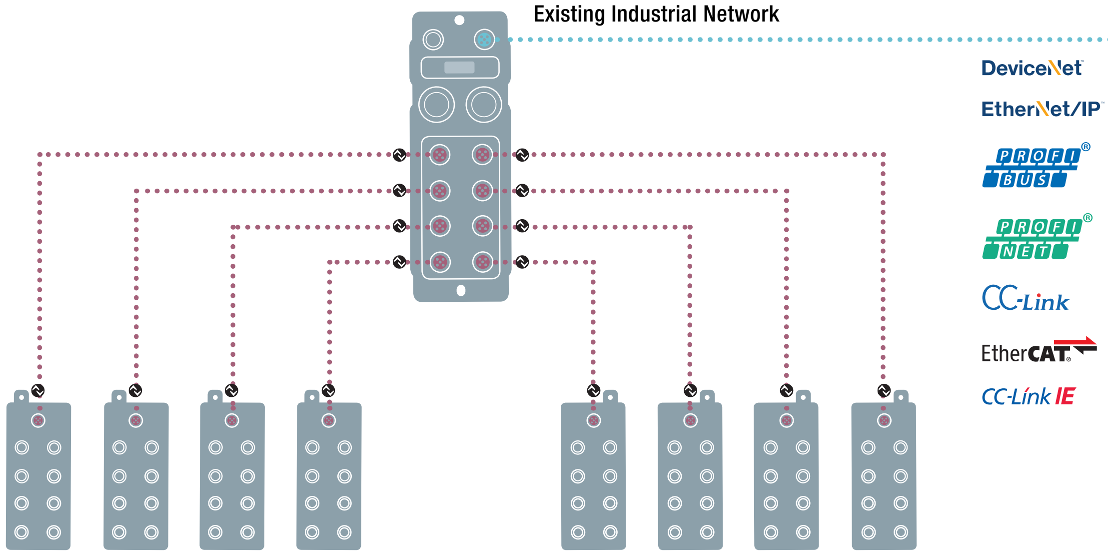
Conventional distributed I/O is not the answer

The next architecture iteration, "distributed I/O" utilizing machine-mounted (outside the cabinet) network blocks, eliminates or significantly reduces terminations by introducing double ended quick-connect cord-sets. Network blocks offer more status and diagnostics information (if offered by the supplier) to speed up the design and build activities. A downside of this approach is that it requires a higher number of network nodes. For example, if the machine requires (5) analog I/O and (17) binary I/O, then at least three network nodes are needed (depending on the supplier and available split of I/O count on each network node). The rising numbers of nodes adds cost quickly.

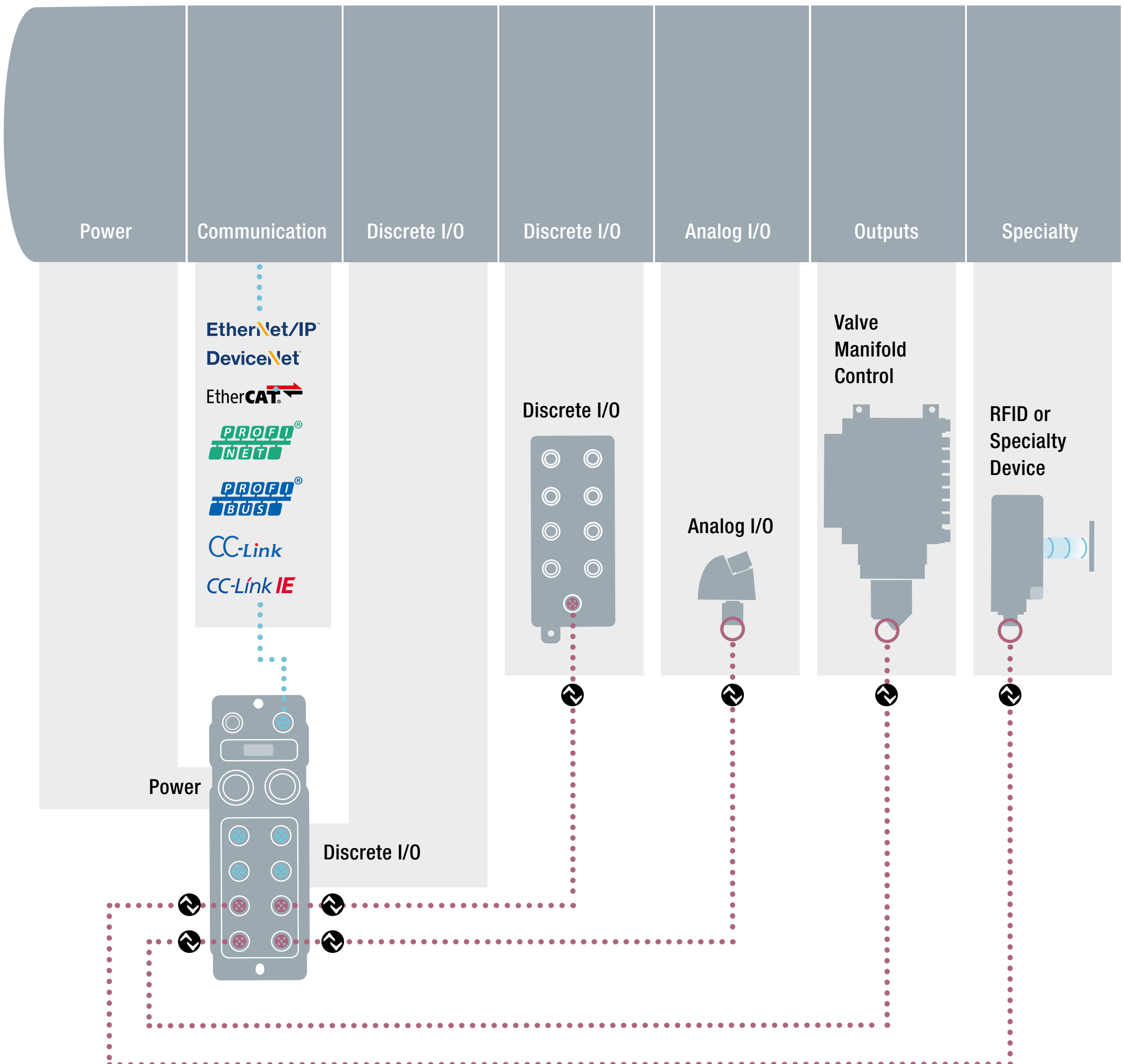
How does IO-Link architecture simplify wiring and reduce associated costs?

With IO-Link, especially machine-mounted IO-Link masters (gateway module), each port offers the ability to add up to (30) discrete I/O points, up to (8) points of analog I/O, or a single smart sensor, allowing the design of a flexible, scalable control system architecture.

For example, IO-Link can accomplish the previously mentioned (5) analog I/O and (17) binary I/O architecture on a single network node, utilizing one 4-port IO-Link master along with one 8-port analog I/O expansion module (a.k.a. "hub") and one 8-port/16-point binary expansion hub. The analog and binary hubs occupy two IO-Link ports on the master, while the 17th point of binary I/O occupies a third. That leaves three unused analog inputs on the expansion hub and one additional IO-Link port on the master for future expansion as a single discrete I/O, a smart sensor input, or an expansion port to provide a larger number of analog or binary I/O points via another expansion hub or single-channel analog adapter.



128-480 Discrete I/O Points on a Single Fieldbus Node



Example of Expandable, Modular IO-Link Architecture

Benefits of cable standardization with IO-Link

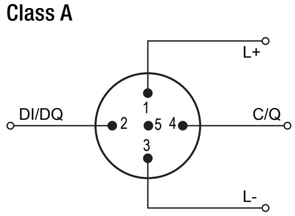
IO-Link is a device-level point-to-point serial communication protocol over a standard proximity sensor cable with 3, 4, or 5 poles depending on the type of IO-Link master port (Class A or Class B). With machine-mount architecture, typically, both sides (master and device) use M12 A-coded connectors that encourage the use of double-ended cordsets. Some suppliers offer both Class A and Class B ports on the master. Actuator devices such as pneumatic valve banks often require isolated output power for safe de-energizing. In that case, a 5-pole cable is required for connection to a Class B, IO-Link master port.

A Class A, IO-Link port defines three poles for Power (Pin 1), Common (Pin 3), and Input (Pin 4); the remaining pole (Pin 2) is manufacturer-defined. It can be designated as Input, Output, or user-selectable Input/Output. This provides the greatest application flexibility as that port can be split to provide two channels of IO-Link, or discrete binary I/O, or to power an output power with Common on Pin 3. This flexible 4-pole layout offers the ability to standardize on 4-pole cables throughout the architecture. To split ports into two different tasks, a Y-splitter cable is used. Since all cables utilized are 4-pole double-ended cordsets differing only in length, machine builders and end users will only need to stock one type of cable in various lengths, helping them reduce the variety of cable types in inventory. This further simplifies design documentation, assembly, maintenance, and logistics…saving cost.

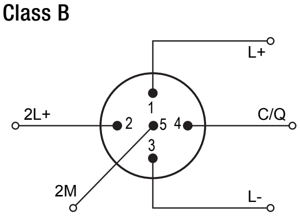
CLASS A AND CLASS B IO-LINK MASTER PORTS

Class A	Class B
Port Characteristics: M12 A-coded connector port with 5-poles (female)	Port Characteristics: M12 A-coded connector port with 5-poles (female)
Pin 1 = +24V DC device power	Pin 1 = +24V DC device power
Pin 3 = OV DC ground for device power	Pin 3 = OV DC ground for device power
Pin 4 = IO-Link communication or configurable as I/O	Pin 4 = IO-Link communication or configurable as I/O
Pin 2 = Manufacturer's discretion for input, output or configurable I/O with common on pin 3	Pin 2 = +24V DC output power
Pin 5 = Not used	Pin 5 = OV DC ground for output power (isolated)

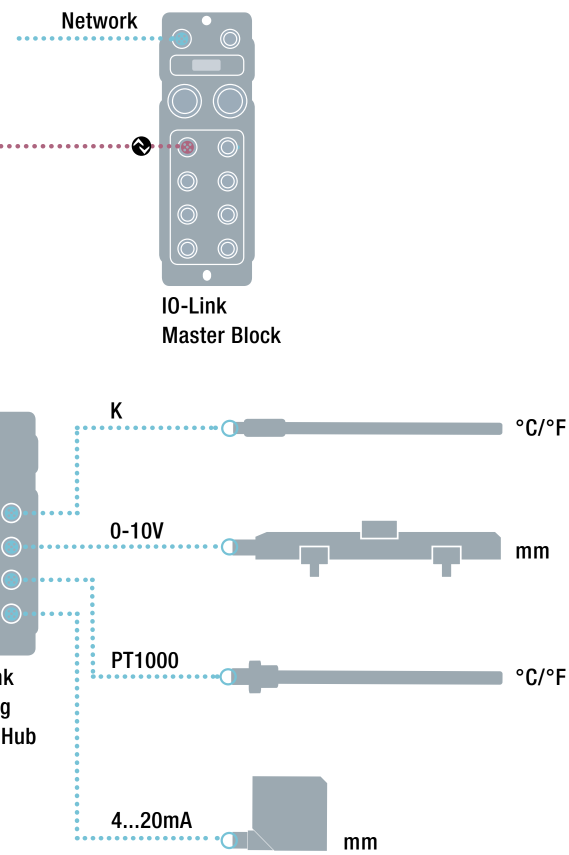
Class A



Class B



When integrating analog I/O with IO-Link, a similar approach to simplified cabling can be adopted. Between the analog I/O hub and the analog device, a double-ended shielded cable can be applied that eliminates need for terminating the cable shielding manually, reducing labor time and the potential for error leading to analog noise problems. Since the analog hub can be mounted closer to the sensors, the shielded cable runs can be much shorter, eliminating need to carefully plan analog cable routing to avoid potential noise and interference issues. Some builders prefer to specify a different jacket color for shielded cables to avoid mixing them up with unshielded cordsets.



How does IO-Link enable modular design and how does that reduce costs?

When IO-Link is used as the basis for the controls architecture, expansion I/O blocks (I/O hubs) can host analog and/or binary I/O on each stand-alone module of the machine. I/O hubs on machine modules communicate to the remote IO-Link master over a single unshielded cordset per hub. Compare this to traditional methods where all I/O wiring must be brought back to a central control cabinet.

If a higher density of I/O is required on the machine module, either a 4-port or 8-port IO-Link master can be mounted on the module and local IO-Link expansion hubs added to handle all local I/O. Communication to each module is accomplished over the industrial control network, interfacing to the IO-Link master acting as a network node.

With either approach, a machine can be built by creating small, transportable sections. Tear-down for packing and shipping involves disconnection of a few power, IO-Link, or network cables vs. potentially dozens or hundreds of discrete wires as with traditional control system design. During the setup at the customer site, all machine modules plug back together quickly, drastically reducing expensive on-site setup time.

Real-world IO-Link success story

Fori Automation, an assembly automation supplier in Shelby Township, Michigan with a global customer base, sees IO-Link as integral to a modular control systems approach. Fori has implemented IO-Link to standardize of their controls architecture, while remaining responsive to their customers' choice of controls platform and network preference. When asked about this approach, Garry Hagar, Controls Engineering Supervisor, stated that "standardization of equipment and controls strategy can easily cut 50% of our engineering time."

According to Hagar, "Modularity is very important, not only for us to be able to quickly tear down, ship, and install at the customer's factory in a short time frame, but also during production. If any problems arise, the ability to quickly troubleshoot is only possible with modular systems. Unplanned downtime is costly in automotive assembly lines."

About the Author

Shishir Rege is Marketing Manager for Networking and Safety for Balluff Inc. and works out of the Balluff Inc. headquarters in Florence, KY. He has over 18 years of experience in robotics and automation in diverse industries including automotive, packaging, aerospace, and medical. Shishir holds a Masters of Science in Electrical Engineering from Western Michigan University and an MBA from Michigan State University. He can be reached at shishir.rege@balluff.com
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About Balluff

Rugged Control Components from Network to Sensor
Balluff specializes in delivering dependable, rugged and precision products for industrial sensing, networking, and identification to help prevent downtime and eliminate errors. We are a complete system and component supplier, offering industrial network and I/O products for use outside of the control cabinet. We add value to automated systems by providing a wide range of enabling technologies that unlock hidden productivity potential.

Our products include a complete line of sensors, transducers, ID systems, and connectivity products. Our sensor lines include photoelectric, inductive, capacitive and magnetic, as well as other more specialized sensor products to fit virtually any sensing application.