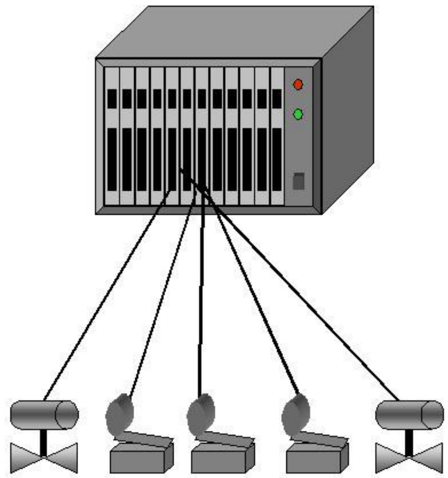
CMC Market Trends and Analysis

Smart I/O For Discrete Manufacturing Automation

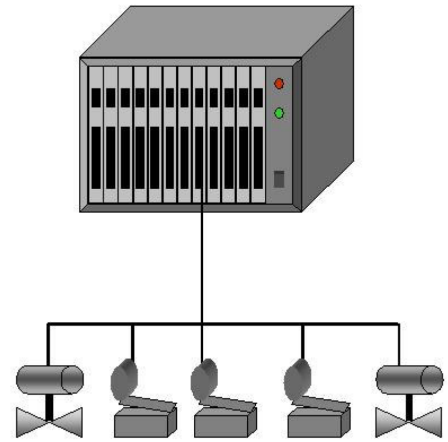
By Dick Caro, CEO, CMC Associates, Acton, MA

Process control has been using smart sensors and actuators connected with HART and other vendor supported protocols since 1992, and is now migrating to Foundation Fieldbus and Profibus-PA. However, very few smart sensors and actuators are used in discrete parts manufacturing and batch process control because they are available from only a few suppliers, and in limited model selections. Fieldbuses such as DeviceNet, SDS, and Profibus-DP, are now widely used for discrete automation applications, and support intelligence at the device level, but smart sensors and actuators for discrete automation are not commonly used. Furthermore, when they are used with PLCs, there is no access to the device intelligence. Some may argue that there is no value in intelligent smart sensors and actuators, but that is true only because we have little or no experience in building systems with intelligence at the device.

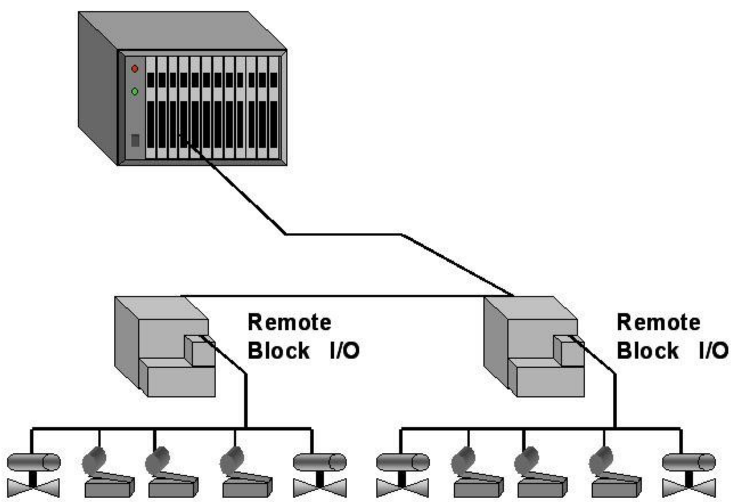
Discrete sensors include simple devices such as limit switches and photocells, and more complex devices such as proximity detectors. Discrete actuators are typically solenoid valves, motor starters and contactors, and linear and rotary effectors, but also may be as complex as variable speed motor drives and motion controllers. Most PLCs connect binary two-state devices through an I/O interface card, and handle signal processing in programmable logic, making it a user responsibility. Large PLCs frequently interface the I/O through remote I/O units connected with a serial connection such as DeviceNet, ControlNet, Modbus+, ABDH+, or even Ethernet, often as EtherNet/IP. When this type of serial connection is used, the PLC scans each remote I/O unit continuously. Due to the delays resulting from the scanning of data, the value of signal processing in the PLC may be diminished due to the time delays from scanning remote I/O.



PLC With Direct I/O



PLC With Bussed I/O



PLC With Remote I/O

`Applications Of Smart Discrete I/O`

Point level diagnostics is the most frequently mentioned application for smart discrete I/O. For example, it is possible to determine contact resistance for limit switches biased with DC sense current. Proximity sensors are truly analog instruments and it is useful to monitor the distribution of signal levels to determine if items are not being detected. Solenoid valves have almost infinite life in the deactivated state, but limited life while activated – it is useful to monitor their cumulative activation time. Photocells used to detect presence of objects are subject to

Type of Device	Application
Digital Input	Contact bounce suppression, ON/OFF delay, pulse counter, PWM sensor, diagnostics
Digital Output	ON/OFF delay, PWM, pulse count, pulse frequency, diagnostics

Applications Smart Discrete I/O

error if the light source burns out, or the detector lens becomes dirty – both conditions are easily detected. These are just a few of the diagnostic applications which can only be done with intelligence located at the device, or at the lowest level I/O interface which is directly connected to the device, but cannot practically be done in a PLC using remote I/O connections.

Signal processing is a function which is best accomplished in a smart field device, or in intelligent, closely coupled I/O interface. Contact bounce filtering for dry contact limit switches is best accomplished close to the device in order to get the fastest response. ON and OFF delays are very common in the control of discrete processes, and are easily implemented at the device level. Pulse counting can be done using ordinary on/off sensors. Pulse width sensing or pulse width modulation (PWM) is a form of telemetry which is easily detected to provide scalar values. Pulse counting over a fixed time period yields frequency measurement, another form commonly used method to transmit scalar values.

Binary two-state output signal processing can provide many valuable applications that have always been possible with PLCs, but are often impractical due to timing limitations. ON and OFF time delays can be applied as needed by the application, and are often provided by PLC programming. Modulated outputs can be achieved with either variable duration pulse outputs called pulse width modulation (PWM), or pulse frequency modulation. Pulsed outputs can also be counted or may be continuous. The output state can be read as a variable returning either the actual instantaneous value, the value after any applied delays, or the modulation value for modulated outputs. Pulsed or modulated outputs require timing that is only possible for PLCs directly connected to the I/O module, but cannot be applied with remote I/O where the time accuracy is often less than the PLC remote I/O scan times.

Many of the benefits of signal processing before the PLC are related to timing – processing data/signals at rates that either be impossible in a PLC, or which would overload the ability of a PLC to process. Other benefits are to extract data from binary signals in ways that the PLC was never designed to do.

Logical Loop Control Applications

Interlocks and safety override logic can easily be built into the smart device or into the device interface. Binary two-state outputs can be made a simple logical function combining a small number of inputs and outputs on the same network segment or in the same I/O interface module. Since, the majority of PLC programs consist of simple interlock statements, these can be implemented at the field device level freeing the PLC for higher level functions and the need to scan remote I/O at high data rates.

Even some simple sequence controls can be accomplished at the I/O or device level. Many timed repetitive sequences can be activated for digital outputs and even activated by local interlock conditions. For example, pulsed impeller operation can be automated when a mixer hatch door is closed and the mixer "Operate" switch is ON.

Benefits of relocating interlock and sequential controls to sensors and actuators below the PLC are focused on reducing the need for high speed response from the PLC, and assigning it to the device(s) at the lowest levels of the network. In many cases, reflexive or very fast operations can be performed for which the PLC was never intended, therefore reducing system cost and improving speed of response. In other cases, many of the control functions are removed from the PLC reducing its size, the number of I/O points required and therefore, its cost. Cost reduction would be a result, rather than an objective. The real objectives are to simplify systems and network design so that real control information need not flow through higher level networks or devices.

Who Is Selling Smart I/O Interface Modules

SDS devices from the Micro Switch Division of Honeywell's Sensing and Control offer many of the applications previously described, but do not offer logical control. Applications for SDS devices, such as Normally Open/Closed and Delay ON/OFF and times are typically set at the time the device is installed and are not changed afterward. The benefit is to reduce the number of devices required in inventory stock. Since Micro Switch is not a system supplier, the benefits of programmable devices are generally not available to the end user, and are rarely used even by systems integrators. Sensors with DeviceNet interfaces are available from Rockwell and Cutler-Hammer, but do not have any functionality.

Echelon, the LonWorks company, has released its series of LonPoint modules which are designed to provide programmable intelligence of the type described previously at their I/O interface module level. Echelon has recognized that it will most likely be several years before embedding even their low cost LonWorks chip in a binary sensor or actuator will become commonplace. In order to pioneer functionality at the I/O level, Echelon's LonPoint modules, each equipped with a Neuron chip, perform the functions of a distributed I/O interface module for conventional discrete sensors and actuators, and can be configured with a variety of computations, functions and processing modules similar to those previously described. LonPoint modules are also available for scalar sensors. OEMs may use the LonMaker tools to build new function blocks. Naturally, the system works only with the LonWorks protocol.

Jetter AG, Ludwigsburg, Germany has released a set of I/O modules with IEC 61131-3 Sequential Function Chart programming. These Jetweb modules are intended to replace much of the functionality of a PLC or motion controller much as previously described. All Jetweb modules are interconnected with standard switched Ethernet. In addition to the programmed functions of the I/O interfaces, they can also provide Internet services using TCP/IP and many internet applications.

Remote I/O units from all of the PLC companies and many of the third party suppliers are being equipped with local processing capability. While this is not on the I/O interface card, it does provide processing capability closer to the device than the PLC. The first examples of this architecture is Schneider Electric's Modicon Momentum I/O which offers web server capability, and the I/O unit from Automation Direct which has a WinCE processor card controlling the I/O with Think N' Do programming.

ZoneWorx, a Silicon Valley startup has released some details of its architecture which places lots of intelligence including application function blocks in the I/O multiplexer device. Zone is focusing on providing high level and user programmable function block programming at the I/O interface level.

CMC views these new developments as irreversible trends toward distributed control for discrete manufacturing

CMC views these new developments as irreversible trends toward distributed control for discrete manufacturing, just as it has been for process control. The primary victim of this new architecture is the centralized PLC, and even the PLC with ordinary remote I/O. In these early stages, most of the implementations are "point solutions" and are not intended to interoperate with other similar solutions. However, the combined incentives of lower purchase price (by reducing the size of the PLC) and higher performance (by doing the interlock and signal processing close to the I/O) will make this form of distributed control popular for new installations in discrete parts manufacturing. It is clear that standards are necessary to achieve interoperability between suppliers, but unlikely to occur in the near future.

Tel: +1.978.635.9449 Mobile: +1.978.764.4728 Fax: +1.978.246.1270
Web: http://www.CMC.us E-mail: info@CMC.us

CMC Associates focuses on product and market strategies to help suppliers succeed in their markets by fully understanding future technology trends, end user needs, and their preferences. We follow the news events and prepare news analyses such as this to raise awareness of market and technology trends for our clients. No inside knowledge was used to prepare this document, and it has not been funded by anyone. If you think that this type of analysis can be of value to your company, supplier or end user, please contact the author, Dick Caro at Dick@CMC.us.