How Manufacturing Systems Can Evolve To Enable The Industrial IoT

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Manufacturing is undergoing a transformative revolution as we recognize that the data inherent in the manufacturing flows can be analyzed to benefit overall efficiency and productivity. This will require changes to the automation systems being deployed in the factories – these range from small, connected, and intelligent sensing systems to distributed control at the edge to embedded hardware security and even adaptive manufacturing systems. This post examines different industrial internet of things (IIoT) use cases and explores how systems must evolve to enable this phenomenon.

According to market research firm ARC, "The move to digitization has been sold, at least in part, based on the possibility of significantly improving or transforming the business. About half of the respondents see opportunities for new business models and revenue streams, as well as opportunities for improving business responsiveness and agility."

Indeed, the manufacturing process generates substantial volumes of data. This data, in turn, can be analyzed for some very valuable purposes: to predict faults, optimize equipment lifetimes, derive new revenue streams, and even optimize the production process to better align with market needs. Data capture and analysis mechanisms are clearly critical here, as is a feedback path that allows optimization of the edge devices and the controllers to fine-tune the manufacturing process in response to the data analysis. Automation systems must be small, rugged, and high performing to ensure that the IIoT vision becomes reality.

Tiny, Connected Sensors Fuel Factory Automation
The lifeblood of any digital factory is data, collected from edge sensors as well as from controllers. These edge sensors must be smart, connected, and tiny enough to fit into narrow assemblies or into also tiny valves and actuators. Aside from collecting data, these sensor systems are also expected to perform some real-time processing to clean the data that must be delivered via standard communication links.

With all of the intelligent, connected sensors inside a modern manufacturing facility, it's becoming commonplace for data collection and processing to be distributed. Where we used to see large, central programmable logic controllers (PLCs) has given way to increasingly compact distributed controllers fanned out across the manufacturing flow. At the Siemens Amberg Electronics Plant, a showcase for Industry 4.0, there are multiple distributed PLCs controlling each step of the highly automated production flow. Over the years, PLCs have shrunk from the size of a small room or cabinet back in the 1970s to a device that can fit in the palm of your hand, circa 2000. Today's PLC features a substantially higher processing and interfacing capability than its predecessors.

With smaller systems, however, comes the challenge of dealing with heat dissipation and other aspects of operating in a rugged environment. Industrial systems have to be able to work in 55°C to 75°C ambient operating environments. Often, these are passively cooled, so it's important, when architecting the system, to consider the power consumed by each section. As an example, consider a controller with multiple digital inputs. Figure 1 shows a traditional design consisting of discretes and an opto-coupler for isolation per input channel. With a 2.2Kohm input resistor and 24V V_{IN}, the input current is 11mA, which means that the power consumption per input channel is 264mW. While this figure may seem low, remember that it's not uncommon for a modern PLC to have 8, 16, or even 32 digital IO channels.

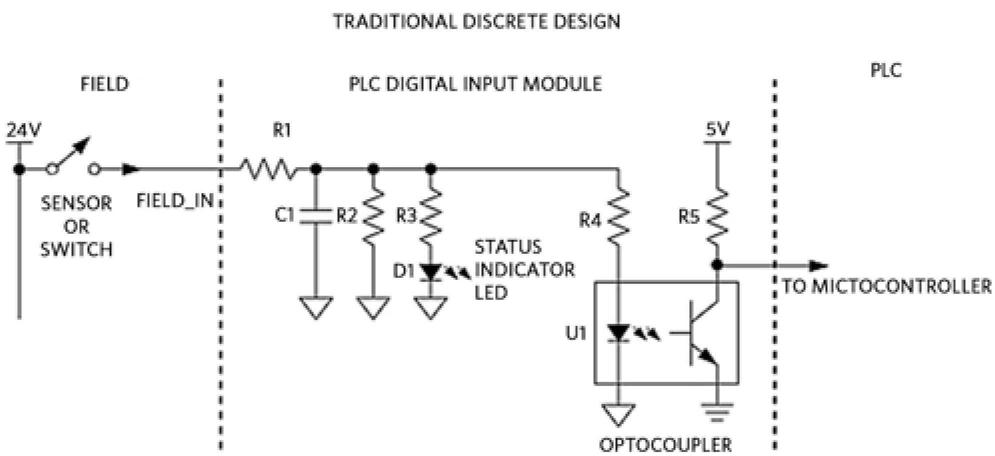

Figure 1. Traditional controller design with discrete components.

As Table 1 reveals, the power consumed by the digital IO module/section of your PLC can go up dramatically. Considering a system with only passive cooling, as your PLC size shrinks, this level of power consumption by only the digital input portion of your design can spell trouble.

Table 1.

# of DI Channels	Estimated Power Consumption (Discrete Implementation)
8	2.1W
16	4.2W
32	8.4W
64	16.9W

There's another option to address the power challenge: replace the discrete logic with an integrated IC, which would allow for configurable input-current limiting. Consider a solution that lets you set the max input current to 2.5mA. At this level, you'll reduce power consumption by one-quarter. Going back to our above example for 32 channels, your digital input section would now have sub-2W maximum power consumption. And, a single IC takes the place of eight channels of discretes (see Figure 2 for a depiction of this alternate controller architecture).

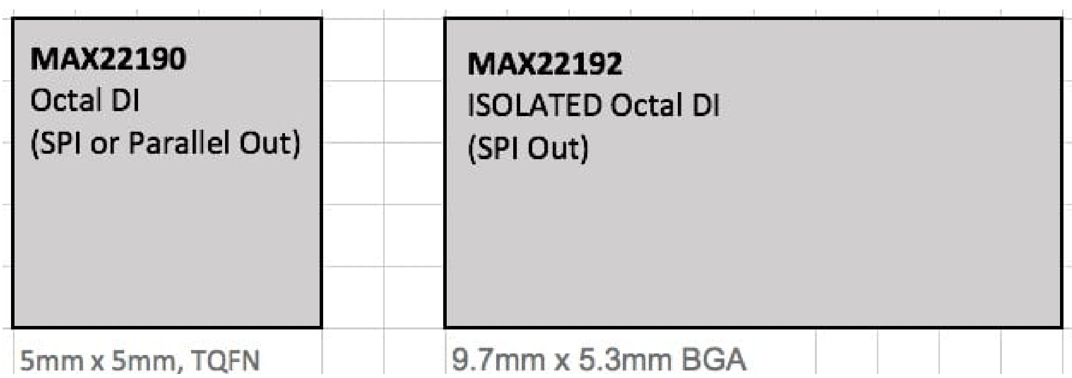

Figure 2. Controller architecture based on integrated IC.

Feature-rich, integrated solutions can be an answer to challenges around solution size, power consumption, and heat dissipation. Digital out modules, which drive actuators, provide another example of this. Many of the loads are inductive, so when the switch is opened, the inductor attempts to keep current flowing (see Figure 3). A free-wheeling diode has to be used across the inductor for back EMF suppression and/or to protect the MOSFET.

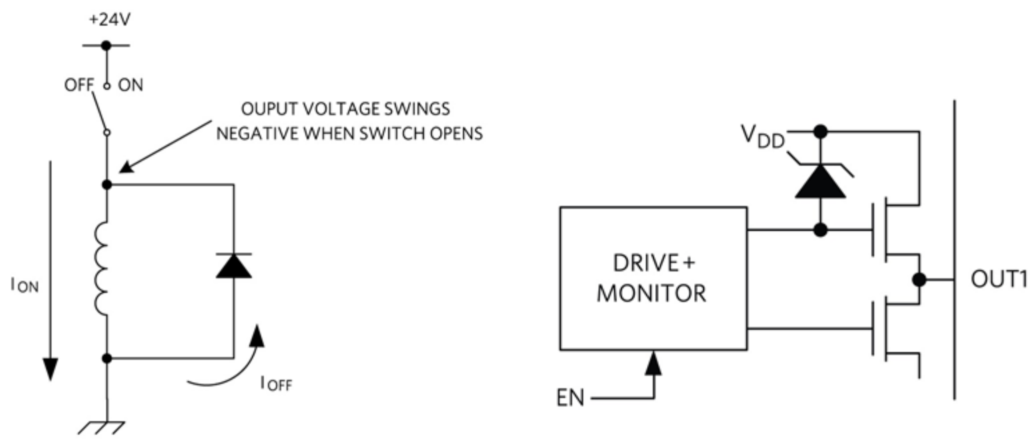

Figure 3. Digital out module in a control system.

Some of the market’s newer digital out drivers incorporate a FET switch that eliminates the need for external free-wheeling diodes. Internal clamping diodes limit the negative excursion to (VDD – VCL) and allow free-wheeling currents to demagnetize the inductive loads quickly, freeing up a good amount of board space.

As with controllers, sensor designs also benefit from components that address size and power dissipation requirements. Sensors now incorporate more signal conditioning as well as advanced communications capability—all while getting smaller. Many sensors now also support IO-Link, a communication protocol that allows the sensor to communicate digitally with the controller. An IO-Link-enabled sensor tells you the exact distance by which the proximity limits have been crossed. IO-Link transceivers are getting smaller and more power-/heat-efficient.

As you can see, as we move toward full realization of the IIoT vision, the underlying components in our automated factories will need to comply with important solution size and power efficiency guidelines. For a deeper dive on the topic, read my article in Planet Analog, “Building Out the Industrial IoT Vision.”