Trends in Motor Management

Rockwell Automation
Allen-Bradley

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A significant amount of effort and resources have been invested in motor management technology in recent years, resulting in greater efficiencies, expanded capabilities, and new levels of sophistication. This paper reviews three major trends that are dramatically advancing the capabilities and delivering substantial benefits in today's industrial process and factory automation systems.

1. **Control Logic is Being Pushed Further Away From the Central Automation System to Plant Floor Devices** (Figure 1) – Manufacturers and automation system users are realizing that even with the smartest control system or fastest processor (if the lower level elements of your process are not adequately protected and managed) productivity will be brought to a standstill. The fact is, a $200 starter can bring down your process just as fast as a $5,000 programmable controller!

2. **A Shift to Smaller, Smarter, More Integrated Devices** – In the past, motor protection was achieved through discrete products – one product for one function. Today's integrated motor management solutions incorporate multiple functions into a single device, resulting in significant cost/benefit advantages.

3. **Expanded Capabilities of Network Communications** – The ability of today's solid state devices to communicate with device-level networks is adding a new dimension to motor control, enabling users to manage processes for greater productivity, less downtime, and lower life cycle costs.

Figure 1 Persistent Technologies Model

In many ways, changes that have taken place in motor management technology closely track broader automation trends. As manufacturers find a need to more tightly manage specific elements of the process, control functions are being broken down into individual, more modular components. This decentralized approach to control will most certainly continue. As electronic components, networking, and software technologies continue to emerge, we'll be capable of further breaking down the control system into its most basic components.

In the early days of automation, most operations were relay-based, with nearly a one-to-one I/O ratio. Cost and complexity drove the industry toward programmable controllers, and as memory, power, and communications capabilities increased, the result was enhanced functionality at lower costs. For example, today's lower level devices such as sensors, relays, and starters are beginning to integrate local intelligence so a central controller can send high-level commands and let a local device coordinate its own work. The ability of these field devices to return non-control information opens an array of new capabilities in terms of diagnostics and preventative maintenance.

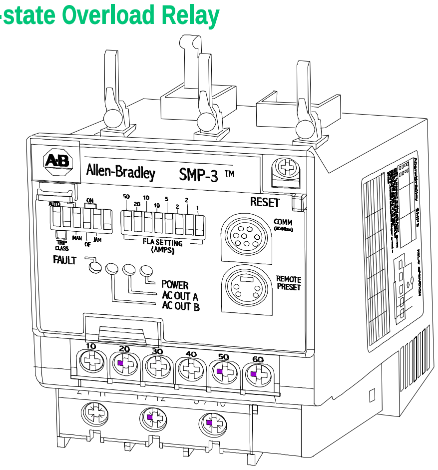
Along with this decentralized approach to control, automation system users have realized that it is "the limits of your equipment" that ultimately determine your level of productivity. For example, you may have the fastest processor around, but if your power is unreliable and motors prone to failure, your productivity (and profits) ultimately will suffer. In other words, it doesn't matter how fast you can think, you can't run faster than your feet will carry you.

The Move To Highly Integrated Devices

Significantly expanding today's motor management capabilities is a trend toward higher functional integration in a single package. By consolidating many protective functions into a single device, installation costs, component costs, panel space, and maintenance time can be significantly reduced, while performance and efficiency of the system can be increased. The use of semiconductors and electronic components in new solid-state devices is resulting in even greater integration and functionality, allowing them to be used in places where it was cost-prohibitive or impractical to apply them in the past.

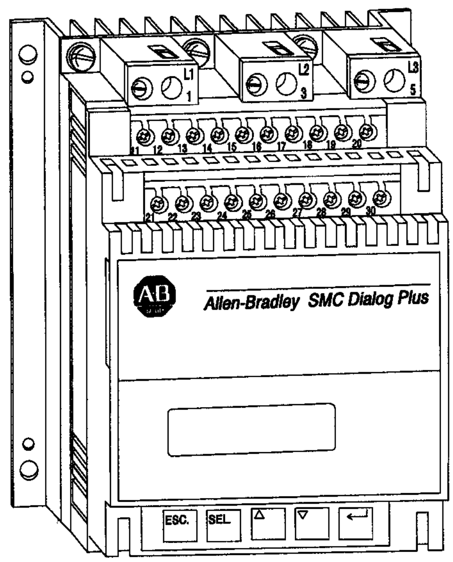
For example, the latest solid-state overload relay technology uses integral current transformers, application-specific integrated circuits (ASIC) and/or microprocessors along with electromechanical design principles to produce a compact, high functionality overload protection solution (Figure 2). Besides basic overload protection, these advanced, cost-effective devices offer a broad range of protective features that previously would have required several additional protection devices to be used in the motor circuit. Recent advancements have expanded the capabilities beyond simply motor protection and now incorporate control and communications functions as well.

Figure 2 Solid-state Overload Relay



The concept of integrating protection and control functions into a single device was further revolutionized with the introduction of the solid-state (soft start) controller (Figure 3). These advanced motor control devices incorporate a full range of motor starting and stopping capabilities to meet a variety of application requirements. They also feature a broad spectrum of advanced protection features, including electronic motor overload protection, as well as expanded fault diagnostics and the ability to communicate with various network protocols. Traditionally, motor starters have relied on a collection of dedicated protective relays to achieve this depth of protection. Now all these protective features have been integrated into one complete package.

Figure 3 Solid-state Motor Controller



Many solid-state controllers offer the choice of four starting modes: soft start, current limit start, dual ramp start, or full voltage start in the same device. You can select the starting mode of the solid state controller and adjust the soft start ramp time, as well as the current limit maximum value, which enables selection of the starting characteristic to meet the application.

Although solid-state controllers can be used for full voltage starting, the majority of applications employ soft starting to provide stepless reduced-voltage starting. Current limit mode can be used where power line limitations or other restrictions require a specific current load. Other features include both stall and jam protection, automatic phase rebalancing, fault indication, and comprehensive power metering capabilities.

As industrial control applications continue to become more decentralized, the integrated functionality offered through today’s solid-state technology will continue to play an increasingly prominent role in delivering cost-effective motor management solutions.

Network Communications Adds New Dimension To Motor Management Capabilities

The same control networks that have revolutionized the design of plantwide automated systems also are bringing substantial motor management benefits in a wide range of applications. The ability of a motor protective device to communicate to a programmable controller or PC provides an entirely new dimension in terms of maximizing productivity and resources, improving quality, and protecting in-process materials and equipment. Compared to communicating with individual, hardwire connections, networks simplify integration and expand the range of data that can be transmitted between motors and controllers.

One of the key drivers of this communications trend is today's highly skilled factory workers who are more involved in maintaining and improving the operation. As a result, putting useful information into the hands of plant floor operators, and also to other parts of the manufacturing enterprise, has become a critical requirement in nearly every automated plant. With an increased demand for system integration, communications networks now connect controllers, as well as other discrete devices.

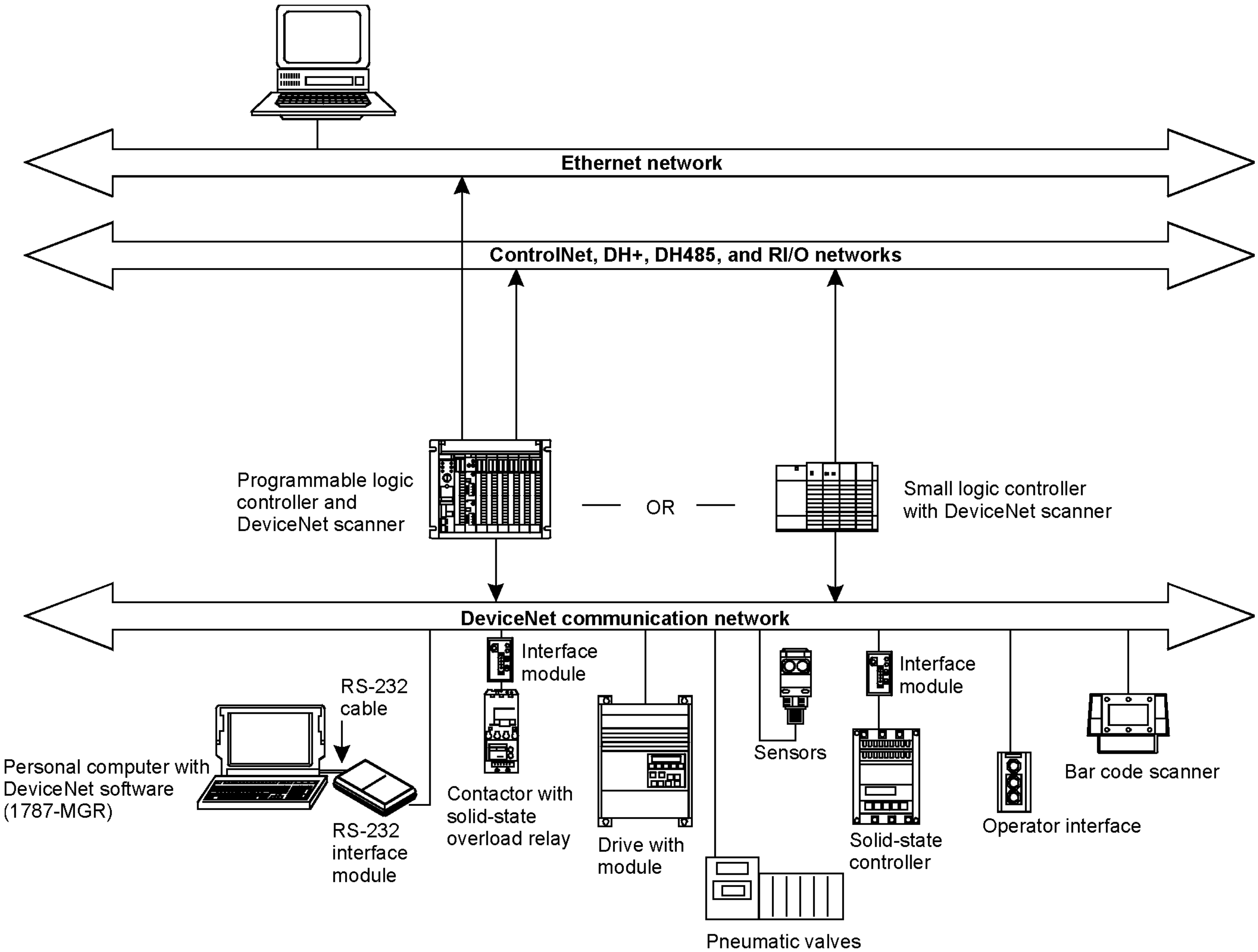
In the past, the architecture of most industrial control systems consisted of a number of sensors and motors connected to a central processing unit. Fault detection was difficult and troubleshooting and repair was time-consuming. Many new devices today now feature communications and control logic capabilities that allow them to assume a larger role in a plantwide control scheme.

Through network communications, vital motor information can be collected, processed, and displayed, including real-time application parameters such as motor voltage and full load current. This information can be helpful for diagnosing problems before they occur, allowing operators to monitor the system to prevent a device from tripping at a critical stage in a process, saving costly unscheduled maintenance and downtime.

A wide variety of information can be communicated from a motor protective device, including phase unbalance, average current, fault cause, and motor thermal capacity, giving intelligence to yesterday's industrial control devices while providing operational feedback for enhanced diagnostics. For example, many solid state devices have prewarning levels for various causes of trip conditions (like ground fault, starting time, underload, or jam) and are also capable of displaying data in the form of LEDs on the devices themselves. In many cases, this communication can take place simultaneously with a programmable controller.

Standard, open networks, like DeviceNet™ network, are promoting interoperability of devices and lending intelligence to industrial sensors, starters, actuators and I/O while providing a motor protection solution that is smarter, faster, more efficient, offering greater life cycle savings. These device-level networks can integrate motors with programmable controllers and other discrete devices for real-time control and expanded diagnostic capabilities (Figure 4).

Figure 4 Typical DeviceNet Configuration



Other benefits of networks like DeviceNet is the significant reduction in installation and wiring costs. Traditionally, systems have typically required a large number of wires and a central control system to perform such tasks as reading the switches and driving the motor to perform the desired action. The large number of wires used for control not only increases development time, but also increases the risk of malfunctions.

The solution is to replace bulky wiring looms with a multiplexed wiring bus. By using a device-level communications link for control, the cost of wiring and installation time is reduced, and the system's reliability is improved. Compared to traditional current-loop setups, installations based on device-level networks typically go together much more quickly.

Applying the Optimum Level of Motor Management

In determining the optimum level of motor management for a particular application, a number of considerations should be addressed including:

- The importance of the motor circuit to the application process; the "total cost" of downtime of the application
- The cost of the motor itself

Dependent on the answers to these and other questions, the process can begin to select the type of products required to adequately protect the motor circuit. For less critical applications such as a fan or blower, where critical manufacturing processes or safety issues are less of a consideration, simply employing fuses and a traditional overload relay may be the ideal solution. On the other hand, in a critical application, where the manufacturing process relies on a continuous flow of materials and downtime can be very costly, the best protection may require a combination of short circuit protection and a solid state controller. Together these devices provide overload, phase loss, and jam/stall protection, as well as network communications to more closely monitor motor operating data and the application itself.

The point is, by properly outlining the application requirements and applying the right technology in the right places, an optimum level of motor management can be achieved to maximize the life of the motor *and* the performance of the application.

The Future of Motor Management

Motor management is the essence of automation. As technological advancements change systems architecture, motor management has become increasingly important as part of plantwide systems. The trend of lower cost, higher functionality, and more intelligence within devices means an even broader array of options for customers to meet specific application needs. In addition, with a continued focus on productivity and efficiency, the information/diagnostics capability provided by network communications continues to expand in popularity and functionality.

Automation users also realize that focusing on initial purchase price is old thinking. Today's users realize there are costs associated with each stage of a product's or system's expected life. This life cycle begins by justifying an investment; then applying, installing, operating and maintaining the equipment; and finally, improving the investment through upgrades.

Figure 5 Automation Investment Life Cycle

Given the tendency for most buyers to focus on initial procurement costs, it's easy to conclude that it would be impossible to help them see beyond the "apply" stage. That may have been true a few years ago. However, as automation products become more sophisticated and interdependent, manufacturers are realizing that there's more to managing costs than getting the lowest purchase price. Other considerations need to be included like reduced installation costs, troubleshooting, downtime, maintenance and repair, as well as maximizing and leveraging current investments.

Conclusion

By understanding the application requirements and implementing the right level of motor management, users can predict, avoid, and remedy the potential adverse affects of today's motors in all applications. New, advanced motor protection and control technologies offer a number of significant benefits: improved productivity; protection of applications and equipment; and improved safety of personnel.

In this age of global competition and increased focus on quality and efficiency, the capabilities and benefits available through today's advanced technology cannot afford to be overlooked. In fact, they should be leveraged to the maximum.

DeviceNet is a trademark of the Open DeviceNet Vendor Association.

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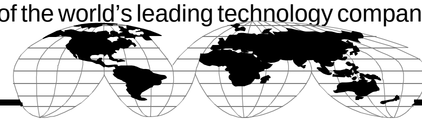

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