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High-End Protection for Low Power

By Jim Montague

Just because some circuits carry less juice doesn't mean they don't need and deserve protection. In fact, 24-V and other lower-power circuits are proliferating in devices and networks, and so are the tools and smarts to safeguard them. As always, the trick is to apply them appropriately for the most benefit.

"Circuit protection is a mainstay of 24-V products, but besides breakers and fuses, we have increasing use of electronic circuit protection (ECP) software and intelligence," says Aaron Henry, North American market manager for Murrelektronik (www.murrelektronik.com). "This is because breakers and fuses don't always work as well as they should when protecting low-voltage components."

Breakers and fuses are older technologies, Henry reminds us. They look for heat to identify current-resistance and other problems, and they have to be replaced frequently. "However, electronic circuit protection can be turned on and off remotely, it keeps people out of potentially hazardous cabinets, monitors entire circuit current levels, handles current intrushes better and immediately notifies users of short circuits without having to go through the usual breaker conditions of resistance and heat. ECP is really the next generation of breaker and fuse functions," he says.

Over the 10 years Murrelektronik has been building ECP devices, Henry reports, it's expanded into broader current and voltage levels, and developed its Mico products, which are similar in shape to breakers, have adjustable current settings and can replace 12 traditional breaker styles. The latest Mico product is a 48-Vdc solution. "The microprocessor and software in an ECP component monitors current, and as its panel approaches 90% of a pre-selected current level, it gives a warning. If the current goes beyond that level, it reports if there's a fault or overload condition, isolates that circuit and cuts the voltage. ECP is a relatively new technology, so we're excited to bring these new products to market with more functionality."

Traditional breakers can monitor for short circuits or over-current conditions, but not both. However, ECP can perform both tasks. "Many circuits are getting more sophisticated and becoming involved with higher-level fieldbuses, and ECP capabilities can assist these changes, which is improving its acceptance," Henry adds. "In the U.S. markets, we still have a lot of education to do, but there's a clear trend to toward avoiding contact with potentially hazardous cabinets and removing consumable components from inside them. Everyone is becoming more aware that they need circuit protection at low-voltage levels."

Mark Stremmel, U.S. systems manager for Turck's (www.turck-usa.com) Engineered Packaged Systems group, adds that, "Old-

school system design and circuit protection was regimented and strict, and we used circuit breakers on the load side of the 24-V supply and on the line side as well, so users could isolate power, test and do maintenance. Breakers would be distributed for all PLCs and HMIs, but as OEMs competed more, many no longer did it because it wasn't required by UL508A."

Stremmel adds that almost all dc power supplies have gained some form of electronic short-circuit protection built into their circuitry over the past 10 to 15 years. "If they read an over-power or short circuit condition, then the output side shuts down until the load or short is removed," he explains. "However, because of this electronic monitoring and protection, many users and OEMs now think they don't need circuit breakers as much on the load side."

While most control systems and circuits also migrated from 120 Vac to 24 Vdc during the same 10 to 15 years, Stremmel reports Turck believes breakers are still essential in many settings. Turck offers circuit protection in all its I/O product categories, including on-machine block, on-machine modular, in-panel block I/O and in-panel modular, which all communicate via multiple Ethernet-based protocols.

"Our view is that if you've got a PLC, HMI, Ethernet switch or other dc device such as field power, then you don't want all of them

to go down when one shorts out,” Stremmel says. “Consequently, a breaker and fuse might be needed ahead of each component, but you also begin to get into a question of economics versus convenience. More breakers can help keep a system running, but most users probably can’t afford so many of them. Some users might want a breaker at every I/O point to disconnect power from the field and aid maintenance, but today this can be seen as overkill. It just depends what market you’re in, such as packaging machinery or material handling, and how much they need to drive prices down. They’ll analyze more closely where they need circuit protection, add fewer where it’s used for connection convenience, but keep all their breakers in safety areas.”

Jerry Watkins, business team leader for power components at Rockwell Automation (www.rockwellautomation.com), reports that circuit protection has gone beyond shielding individual wires, motors and other parts to protecting all-in-one devices more affordably. “Breakers are gaining more sophisticated electronics, so they can do several func-

tions in one device or enable trip settings, so people can work with them more safely,” Watkins says. “Customers also demand higher-rated protection, so we’re focusing on testing controls, circuit boards and related devices together as complete systems.”

Watkins adds that Rockwell launched its 140G circuit breakers in February, which are intended for global applications and carry multiple certifications from UL, IEC and others. “These breakers can be tested and certified to comply with different standards because the small spacings between their phases are adjustable, which allows them to meet the current ratings and voltage ratings required by the North American and international standards organizations.”

Besides benefitting from ECP’s intelligence, many newer circuit breakers or other replacement modules are further protected by molded casings and are configured so they can take the places of earlier, consumable counterparts. “We’re able to exchange our trip units with core breakers to maintain UL certifications,” adds Watkins.

“Because of electronic monitoring and protection, many users and OEMs now think they don’t need circuit breakers as much on the load side.”

Time for Electronic Circuit Protection?

“We provide a lot of after-sales support for our machines. One of our headaches is control circuit (24 V) protection, particularly identifying and troubleshooting blown circuits. The other part of this that’s becoming a pain is stocking and supplying lots of types of fuses and circuit breakers. We know we can justify the extra costs for both our customers and ourselves if we migrate to electronic circuit protection. How do we make that case to our customers?”

—From June '13 *Control Design*

ANSWERS

HERE'S THE CASE TO MAKE

It sounds like you’re experiencing all the common pitfalls of traditional 24 Vdc circuit protection from breakers or fuses that have been adapted to a control-level-sensitive world. Justification to make the leap to electronic circuit protection is easier than you might think. Consider the downtime costs associated with a tripped circuit. First, there’s recognition of a problem. Is it in a cabinet? Which circuit? Where on the circuit? Will the breaker reset, or do I replace the fuse only to have the same problem again when the resistance in the wires reaches a temperature or current draw with enough impact to fault again? How many people need to be involved to diagnose and repair the problem? All this, and you’re still where you were in the beginning.

Sell this to your customer: Mr. Customer, our newly designed control cabinet uses state-of-the-art protection for 24 Vdc circuits. This means better protection for the devices on the circuit, less heat on the cables before a fault is detected, a notification of a fault or warning of potential over-current before a fault happens, and fault detection in milliseconds. Visual indication of the affected channel is possible through an HMI or other device, and you can test and reset without opening the cabinet and disturbing the wiring inside.

Sell this to management: Fewer service calls for “ghost” short circuits, better monitoring of circuit load, reduced inventory, reduced wiring, fewer opportunities for the user to open the cabinet and disturb the wiring. As for the hard costs to the initial build, you should quickly realize savings in assembly, procurement, and inventory costs, which make the switch to electronic protection the easy and right choice. Offer protection and detection not reaction and inspection.

Aaron Henry, marketing manager,
Murrelektronik, www.murrelektronik.com

COMPLEXITY BRINGS VULNERABILITY

The use of analog and digital I/O signals have multiplied greatly, as discrete systems and processes become more integrated and compact. Integrating separate functions and controls, and reducing overall size of the control system is a very desirable goal.

However, by doing this, the control device and process becomes very vulnerable to damage from voltage transients (surges). Because the modernized devices perform more functions, the impact is greater overall system interruption. To ensure system reliability, proper implementation of surge-protection devices (SPD) will improve signal integrity greatly, protecting both devices in the field and in the control panel.

Best practice for mission-critical applications is to protect all wiring that leaves a controlled environment greater than three meters. A controlled environment should be considered a safe place for controls. A controlled environment would be an RTU control panel enclosure or perhaps a room such as a SCADA room. The only way to assure that an RTU or SCADA structure remains a controlled environment is to install appropriate SPDs on all galvanic wiring that enters or leaves that space. If not implemented, these wires are potential points of entry for damaging surge events. If this happens, then technically the space can't be considered as a whole, controlled environment.

Fusing and circuit breakers don't protect against voltage surges, only over-currents that originate on the load end of a circuit. SPDs protect against over-voltage transients. SPDs have extremely fast response times, normally around 25 ns. This is critical as surges are extremely fast. A fuse or

circuit breaker does not come close to the performance or speed of an SPD.

The job of an SPD is to be invisible to the circuit, and at the same time, be a voltage-activated switch that diverts the damaging voltage surge to ground, away from the circuit that is to be protected.

David Torres, product marketing lead specialist,

Phoenix Contact, www.phoenixcontact.com

SEEING IS BELIEVING

Start by assigning a value to the time savings electronic protection devices yield, especially if any after-sales support might incur additional fees (e.g., holidays, evening hours, travel expenses). Obviously, the customer's bottom line is tied to how quickly they resume operation. Also, the more variables you can streamline in your own day-to-day operations, the more competitive you become. For instance, four- and eight-channel electronic circuit breakers (ECBs) can be configured easily up to 10 A per load. This customization enables you to serve multiple customers with one unit, eliminating the need to stock multiple devices and sizes.

Advanced devices like our ECBs have an active output/channel serving as a watchdog. Direct digital signal processing is used for the outputs, so output 1 is linked to an isolated signal contact on select ECBs. Via the ECB's free configuration/visualization software, the signal contact can be programmed to cover multiple fault condi-

tions and diagnose faults. This dramatically simplifies in-the-field troubleshooting. Once a tripped channel is identified, it can be reset via on-unit keys or remotely reset via PLC. This can save the customer (and your service technician) an inordinate amount of time and travel-related resources.

Beyond expedited troubleshooting via visualization and fault diagnostics, the ECBs' free software provides control of Active Current Limitation (short-circuit current limitation at 1.5 times rated current). A convenience traditional fuses and circuit breakers can't match, it prevents a voltage drop in one channel from impacting others during a short-circuit. End-users no longer need to worry about one fault tripping an entire system, the potential loss of production data, and any time-consuming reprogramming. Further, customers can specify current or tripping characteristics of individual channels for precise protection—rated currents are set in 1 A increments for each channel. As part of the feature, power-good threshold and fuse-trip times are also adjustable, providing faster response than typical fuses and circuit breakers.

Often, the lower initial purchase price of mini-CBs and fuses is offset by troubleshooting. Productivity also can be compromised because just one tripped load can trigger a system-wide shutdown that impacts the bottom line. The case is clear: these older technologies simply can't match

the efficiencies provided by an ECB.

Michelle Goeman, product manager;

Wago, www.wago.us

CAP THE PROBLEM

One short-circuit load fault could be a disaster for a multi-load dc system supplied from a switch-mode power supply. Even with individual circuit breakers fitted and rated to protect each load, the fault can occur so fast that, without additional protection, the entire dc voltage supply could collapse. Industry-standard switch-mode power supplies often don't react quickly enough, and might not have sufficient internal capacity to support a sudden fault-current demand.

An innovative method for protecting dc-powered systems from short-circuit or other sudden overload faults is by using a capacity (CAP) module. CAP modules are separate DIN-rail-mounted devices connected into new or existing installations. They're typically used with any nominal 24 Vdc power supply, and fitted between the power supply output and the circuit breakers for the loads. When the CAP module is charged, it waits in a ready state to respond to a sudden high demand for current from any of the connected loads. If this occurs, its capacity will immediately supply the high overload current as a pulse for the few milliseconds necessary to trigger the individual circuit breaker into trip condition. This isolates the faulty load, relieves stress on the

power supply, and preserves the security and operation of the remaining loads in the system.

Effective pulse-triggering relies on using the CAP module and circuit breakers with "no-delay" trip characteristics or faster trip curves such as "B" or "C." It's important to know the breaker's resistance, and to minimize the total resistance of the load circuit, especially minimizing the length of cabling and/or maximizing the conductor size. This provides the best conditions to enable the full overload current to flow in order to achieve sufficiently fast circuit breaker trip action.

CAP modules inevitably increase the cost to an installation, but their worth should appeal to producers of high-value products and users who depend on revenue from fault-free operations.

Alan Balcombe, portfolio marketing manager, electronics, Weidmüller North America; www.weidmuller.com

HAVE TO BE FASTER THAN THE POWER SUPPLY

Control power provided by a modern, switch-mode power supply can benefit from a different type of protection. Most of these power supplies operate at 24 Vdc and are self-protecting to prevent overcurrents and subsequent overheating. However, maintenance engineers could face difficulties as they try to provide protection on the load side of the power supply to locate troubled loads and sensors.

Traditional circuit protection devices, including fuses and circuit breakers, are designed with the expectation of essentially infinite current available. But, when a power supply is applied, only a specific amount of current is available based on the design of the power supply. In some applications, there might not be sufficient current available with sufficient time to operate the protection device. Depending on the condition of the circuit problem, more or less current is needed to trip the fuse or circuit breaker. In some cases, the power supply self-protects and shuts down while the protection device fails to operate.

Electronic circuit protection will operate within the confines of a limited supply of voltage and current, yet it will operate

faster than the power supply would self-protect. OEMs and end users can use products that monitor both supply voltage and current to connected loads, so protection is based on load conditions, current and voltage. Not only would the electronic circuit protection operate faster than the self-protection scheme of the 24 Vdc power supply, it indicates which circuit has an operational problem when one arises. Also, monitoring both the voltage and current helps engineers shut down circuits if the supply voltage drops below specified limits, providing easier and more efficient troubleshooting. OEMs benefit at start-up/commissioning when it's important to rapidly locate miswiring or application issues.

Jon Phillips, product manager,

Rockwell Automation; www.rockwellautomation.com

Smart Electronic Circuit Breakers

Primary-switch-mode power supplies provide very-fast response to overcurrent conditions on the output side, promoting extended operating life. A downside is that selective protection of individual current paths on the secondary side via standard circuit breakers often is ineffective when a Top Boost function, providing excess current for a short time, is not available for high-speed magnetic tripping.

To help solve this problem, Wago announced three new electronic circuit breakers for its line of 787 Series power supplies that will provide selective protection for power supplies without a Top Boost feature.

“The short-circuit current is limited using an active current-limiting circuit breaker, preventing voltage drop across adjacent current paths,” says Michelle Goeman, product manager. “In addition to parameter setting, the display and serial interface control both the integrated fault memory and the instantaneous values of the output current and voltage. So, it can perform not only proactive monitoring and fault diagnostics, but also energy monitoring.”

Such monitoring capabilities are ideal, says Goeman, in applications for which events must be logged, such as those in food, medical or process industries, where loads are separated over long distances, or if remote access is required.

Goeman says the DIN-rail mounted 787-860, 787-861 and 787-862 electronic circuit breakers each separately protect up to four current paths (up to 10 A at 24 Vdc max each), while offering independent programming of appropriate channel- or circuit-specific ratings and trip times via 759-860 Configuration software included free of charge with the hardware.

“In the event of a fault or short circuit, the electronic circuit breakers can shut down the tripped channel within 10 msec,” says Goeman. “Rather than halting the entire system, power is maintained to other loads, for example, to a PLC on one path and HMI on another. This prevents a systemwide shutdown, as well as possible data loss. Afterward, the tripped load may be remotely reset via a control input or from the display.”

With the free visualization software or an on-unit LCD, the 787 series breakers provide independent channel-monitoring of voltage, current, fault diagnostics and energy consumption. “Some additional features include four current channels with delayed switching-in of channels at 250 msec/channel, a rugged metal housing, LED status indication, signal outputs and Cage Clamp, spring-pressure, connection technology for

vibration and maintenance-free terminations,” states Goeman.

The 787-861 electronic circuit breaker features an integrated short-circuit current limitation, which avoids overload of up-

stream power supply units.

This guarantees definite shutdown selectivity. “The 787-860 and 787-862 don’t have short-circuit current limitation,” says Goeman.

“However, they have adjustable trip times for quicker responses.”



FOR MORE INFORMATION
 Call 800/din-rail,
 email info.us@wago.com
 or browse to www.wago.us.

Goeman adds that the electronic circuit breaker modules are optimized for advanced applications or those distrib-

uted over great distances. “The devices can be used behind primary switch mode power supply units with any overload or short circuit behavior,” she states. “If the output of the power supply unit is divided into several circuit paths, the electronic circuit breaker will protect the circuit paths separately. This makes the electronic circuit breakers ideal for control panels or machines powered by a single, larger power supply.”

All three models are 40x127x163 mm and weigh 800 g. The devices conform to UL 1077, UL 2367 (for 787-861), EN 60959, EN 61000-6.2 and EN 61000-6.3, and UL 508 is pending.

The basics of power supplies in industrial machinery

Although power supplies just keep getting better, these well-developed devices still must be properly specified and connected

By Dave Perkon

A variety of power sources are typically required to operate industrial machinery. This includes the plant line side ac voltage down to the electronic devices—power supplies—used to convert the ac to dc voltage. Not only is the type of power supply important, but the requirements for the application must be understood.

There are many power supply configurations available that have made their way into industrial automation such as the ac adapter to power a laptop computer or monitor, the bench-top power supply for precision testing and dc/dc converters for specialty purposes such as providing lower voltages from a bulk supply. However, unregulated, linear and switching power supplies that are designed for control panel or DIN rail mounting, are discussed here due to their widescale use in industry.

An unregulated power supply can be used for applications where high reliability, low cost and high current are needed. They are a good choice for inductive applications that don't require tight regulation of the output voltage or waveform such as dc motors, indicator lamps, solenoids and relays. Although the unregulated power supplies are very rugged, most industrial applications use linear or switching power supplies.

The linear power supply was once very popular—40 years ago—but there are still some applications for it. For example, if the application requires a large inrush current, such as

starting a dc motor, the large transformer, full-wave rectifier, large capacitors and regulator found in these linear supplies may work great. It is also promoted as clean dc voltage source with very low output voltage ripple and noise. However, despite the linear power supply's advantages and low cost, the size, weight and low efficiency has it as a distant second choice in industrial power supply applications—a place where the switching power supply shines.

The switching power supply is by far the most popular power supply for industrial applications today. While it is more complicated electronically, converting the ac input voltage into high-frequency, low-voltage dc, it's much smaller and efficient. Most switching power supplies are only 25% the size of an equivalent linear supply, and they are 25% more efficient. This makes the switching power supply the best choice for most industrial applications.

SPECIFICATIONS AND HOOKUP NOTES

When specifying a power supply, the voltage and current and how it is controlled is obviously critical. In most cases, the input voltage is universal, accepting 85 to 264 Vac, 50/60 Hz and typical outputs are 5, 12 and 24 Vdc with 24 V the most popular for industrial applications.

Power supplies commonly have an adjustable output voltage range and overvoltage

protection and can sense and automatically adjust the output voltage. These are good features to have, but undervoltage can also be a problem, especially with some 5 Vdc TTL circuits. This and many other reasons make it good practice to review the input specifications of the devices connecting to the power supplies. In some cases, a very clean output may be required, or it may need to be isolated on a completely separate power supply.

The power output, Watts, of the power supply is often specified incorrectly. The required dc power for the application should not be a guess. It needs to be calculated, so it's a good practice to list all the power-using devices in a spreadsheet and add up total power required.

For example, each 24-Vdc sensor, solenoid and indicator light use some power. Smart devices, such as drives and controllers, do, as well. Although each 24-Vdc device uses only a small amount of power, with a hundred or more of something, power use adds up quickly, so it's important to write it down and do the math for power requirements. The alternative is to discover at startup that a larger power supply is needed, yet there is not enough room in the control panel for it. Calculate what is needed and upsize the power for spare capacity of at least 25%. You'll need it some day.

When designing and wiring to the power

supply, it is good practice to provide branch circuit protection to the line side (input) of the power and at least supplemental fusing on the output with a grounded common leg. Separate fuses on the power supply output for digital input devices, such as sensors, and digital output devices, such as solenoids, are also a good way to isolate problems if they occur. However, power supplies often have overcurrent protection built-in.

The built-in electronic overcurrent protection, common to many power supplies, may keep output fuses from tripping in an overcurrent situation. Through a variety of

methods, current output of the power supply is limited, by reducing the voltage, when the current threshold, typically 5% to 20% over maximum, is exceeded. With removal of the overload condition, recovery from this current limit protection is often automatic.

This current-limiting capability may also determine the power supply specified. Some power supplies have little current inrush (current overload) capability and other power supplies have a very high inrush capability, up to 400%. If high inrush currents are expected from devices connected to the power supply, size it accordingly.

The switching power supply is by far the most popular power supply for industrial applications today.

Power supplies: Just another detail?

Careful specification can prevent startup problems and maintenance headaches

By Ian Verhappen

As a chemical engineer by training, one aspect of automation that I had to pick up post-graduation was a basic understanding of electrical engineering. Although it wasn't a natural fit for me (my alma mater makes Chem Es take an electrical engineering course and the EEs a thermodynamics course to separate the wheat from the chaff), I managed to get by, but not without learning a few lessons the hard way.

One of the more challenging electrical problems I faced was with the power supply for a continuous emission monitoring (CEM) analyzer system installed at the 200 foot level of a main stack. Fortunately, we had an elevator, and the stack itself was a 26-foot-diameter pipe inside the concrete stack, so we were out of the elements. All the equipment was installed in the annular space between the stack and tower, including the existing step-down transformer from the original analyzer installation.

After installing the system, we had all sorts of noise problems. After some investigation and help from the manufacturer and my electrical engineering colleagues, we ended up having to add a small UPS system as a way to isolate the analyzers from the transformer. Doing so also gave us the added benefit of a more reliable power supply.

What I learned is that the device needed to be connected to a delta versus wye transformer. The wye system is best when there are mostly line-to-neutral loads, and the delta is best

with line-to-line loads. Both systems can supply both types of loads, but in my case, because of location and other loads on the same feeder, it made a difference.

Another time when it's important to pay attention to power supplies is with any sort of fieldbus system, especially one where the signal and power are on the same wire pair, because the frequency, which is how data is transmitted, matters. For Foundation Fieldbus (FF) and Profibus PA, this is a 31.25 kbps signal. Because a 24-V bulk power supply's objective is to provide a linear (i.e. steady) voltage, when it senses these variations, it works to remove them—the opposite of what we're trying to achieve. This is why such systems have a fieldbus power supply, which basically puts an inductive circuit between the bulk power supply and the network.

I did, however, once have someone approach me after a fieldbus presentation to tell me he was having difficulties with his FF network operating sporadically. When I asked what power supply was being used, the response was that he was only using a conventional bulk power supply, and the system, which was small and short, still worked. This is an indication of how robust the system can be.

My final story is about laptop power supplies, which are surprisingly electrically noisy. We discovered this while using a USB-based oscilloscope to capture some FF signals, and noticed that the baseline had a significant low-amplitude, high-frequency noise level. After some head scratching, we made the same measurement running the laptop on its battery, and the noise disappeared. As a result, now, whenever I use a

Now, whenever I use a laptop-based instrument, I always do so using the battery, just to be sure I get the best readings I can.

laptop-based instrument, I always do so using the battery, just to be sure I get the best readings I can.

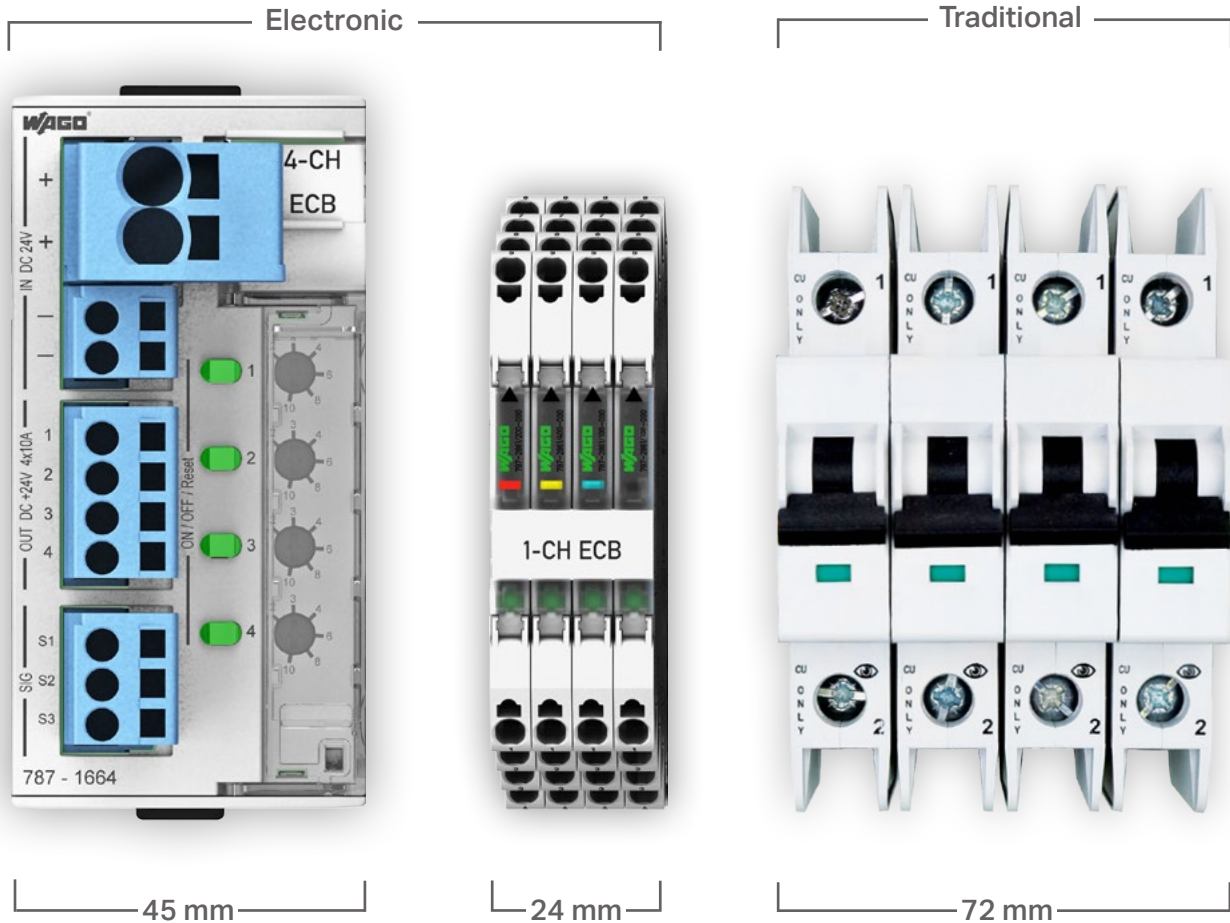
This brings up the last and most challenging item: ground loops. Though not actually part of the power supply, ground loops do affect the signal quality. About 80% of the time there is a network problem, it's a signal problem. Most signal problems are because the physical layer has a problem, and the root cause is related to improper grounding somewhere in the system. As a result, I no longer take grounding for granted.

One other practice I now follow whenever specifying terminal block strips is to always have a way to isolate the circuit. By putting

in a fuse or, at minimum, knife-gate terminal blocks, when necessary I can quickly and easily break the connection between the field device and control system for testing to help resolve problems like those described above. It's just one preemptive action that can be taken to protect the control system, while also making troubleshooting that much easier.

Many automation professionals tend to take the physical layer in their design for granted, however, as I and many others have learned the hard way, when we blithely say, "It's just a power supply," or "just terminal blocks," it's far better that you "just" be sure you check them anyway.

ELECTRONIC OR TRADITIONAL CIRCUIT BREAKERS?

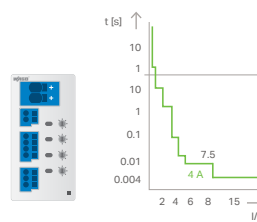


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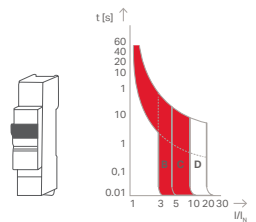
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