Improve Plant Production by Addressing 24VDC Switch-Mode Power Supply Issues

This white paper describes switch-mode power supplies and traditional circuit breakers, and explains the technology behind a new solid-state technology.

Adding Selective Circuit Protection

Let's look at the behavior of a typical 10 A 24 VDC transformer-based power supply. For the sake of discussion, let's say it has four circuits drawing 2 A each, for a baseload of 8 A. Each circuit is protected by a 2 A-rated circuit breaker. In the event that one of these circuits faults and draws 12 A, a typical 2 A thermal-magnetic circuit breaker might not operate fast enough to limit the voltage drop in the power supply. It can take up to five seconds for a standard delay thermal-magnetic circuit breaker to trip at six-times its rating (See Figure 3).

In this example, the total current output of the power supply is 18 A(12 A+2 A+2 A+2 A). This means that the 10 A-rated power supply must be able to deliver 18 A up to five seconds before a standard thermal-magnetic circuit breaker will trip. As shown in Figure 1, a transformer-based power supply is able to provide this power - although at a reduced voltage. After the circuit breaker trips, the voltage output again rises to 24 V in the remaining circuits, and the faulty circuit is indicated by the tripped circuit breaker. If the power supply output voltage dropped below 18 V, all other circuits were disabled for up to five seconds before the circuit breaker tripped.

The Dilemma

Let's look at the same scenario, but substitute a switch-mode power supply with a thermal-magnetic circuit breaker. As described above, the maximum current the switch-mode power supply will provide is 11 A (110% of nominal current).Therefore, an overload on any circuit that increases the total current to more than 11 A will cause the power supply to go into shutdown or hiccup mode. In the same example described above, the circuit breaker does not trip, the voltage drops to zero, and there is no easy way for engineers to tell which circuit is at fault.

One possible solution would be to use a fast-acting circuit breaker. In other words, use a thermal-magnetic circuit breaker that trips at only two-times rating, rather than six-times rating (See Figure 4). The drawback to this approach is that some control components create high, instantaneous inrush currents. While the inrush lasts only for a few milliseconds, a fast-acting circuit breaker can trip immediately at two-times rating, never able to stay closed during normal inrush current.

If a standard delay thermal-magnetic circuit breaker is used, the circuit breaker will not operate at all, causing the power supply to shut down or go into hic-cup mode.

Conventional circuit breakers are effective in many applications, but because switch-mode DC power supplies are current-limiting, no conventional circuit breaker is able to perform both functions: limit the current to a safe value that avoids shutting down the power supply, and distinguish between a momentary inrush and a short circuit.

Electronic Circuit Protection Technology

While the basics of electronic circuit protection are not new, electronic switches are a new technology for circuit protection. Conventional circuit breakers use one of four technologies: thermal, thermal-magnetic, magnetic, and high performance. Circuit breakers using these technologies trip by the movement of a thermally activated bimetal or the movement of a solenoid. In contrast, DC electronic solid-state circuit protectors are transistor based - and all disconnection of a load is done electronically, rather than mechanically.

The Smart Electronic Circuit Protector

A smart device takes advantage of a technique known as "active current limiting". In this approach, the circuit protector monitors the current and commands the device to limit the current to no more than 1.8 times its rating and disconnects the circuit when the current is too high for too long and trips in 3-5 seconds if the current reaches 1.1-1.8 times its rating (See Figure 5). The five-second response time is faster and safer than the response time of a typical thermal-magnetic circuit breaker, which could take 60 seconds to trip at two times its rating, and might not trip at 1.2 times its rating. (See Figure 3).For short circuits the current is electronically shut down immediately, and the design limits inrush currents of input capacitors when the circuit is first turned on. It provides electronic isolation of the circuit after a fault, or when the manual ON/OFF switch is actuated. This sophisticated electronic switch technology would isolate the faulty circuit and aggressively protect control system components, while preserving factory uptime. When an overcurrent condition occurs, the device is resettable by either actuating the ON/OFF switch or remotely resettable at a discrete or group level. Remote reset can be performed by a low-voltage signal to the device, which can be a significant advantage in certain environments such as aseptic clean rooms where access to control cabinets might be restricted.

About E-T-A

E-T-A Circuit Breakers is the world's leading manufacturer of circuit breakers for OEM equipment and is the only resource for all circuit protection technologies: Thermal, thermal-magnetic, magnetic, electronic and high performance. E-T-A circuit breakers are available in more than 150 models and 350,000 different configurations. E-T-A also is a world-leading manufacturer of control and monitoring products, and solid-state remote power controllers (SSRPCs). With Canadian headquarters in Richmond Hill (Toronto), the company serves industrial OEMs and end-users. For additional information and resources focusing on electronic circuit protection technology, visit E-T-A on the web at www.e-t-a.ca