

Prevent 24 VDC overloads from stopping production

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Along with the laws of physics, engineers have to be aware of the law of unintended consequences. Take, for example, something as simple as the 24 VDC power supplies that feed the control circuits in automation systems. Years ago, these were linear units containing an input transformer, a bridge rectifier and some filtering, with a series-type voltage regulator. They were rugged and dependable, but big, heavy and not very efficient. Although they handled overloads and rarely failed, linear power supplies wasted energy and pumped heat into control cabinets.

The answer was the switch-mode power supply, which is both smaller and more energy-efficient than the old linear unit. Switch-mode power supplies have become the most common type used today, but they have one characteristic that causes problems that linear supplies did not: The way they respond to overloads or short circuits.

Problem

When a linear power supply is overloaded, it goes out of regulation — its output voltage falls below its specified lower limit — but continues delivering current. When a switch-mode power supply is overloaded — sometimes by as little as 10 percent — it simply shuts down. If the supply is feeding just one load, this is not a problem, but many 24 VDC power supplies feed multiple loads, which could include an HMI, PLC, I/O, contactors, small motors, solenoids and more. Often a fuse or circuit breaker is installed on each load circuit to prevent a short circuit or overload on one from affecting others, but if the supply is operating near capacity, an overcurrent on one load may cause the total load on the supply to exceed its rating. Under these conditions the supply will shut down immediately (faster than a conventional circuit breaker or fuse can trip), shutting off power to all loads. This can cause disruptions in plant operations or interrupt production if enough loads are affected.

Example

For example, a 24 VDC power supply rated at 40 amps feeds four circuits, each drawing 8 amps and each protected by a 10-amp circuit breaker. What will happen if a motor stalls or there is a short somewhere in the wiring and one of those circuits starts to pull 24 amps? In theory the breaker on that circuit should open and clear the fault, but that may take eight seconds or longer, depending on the type of breaker (see Fig. 1). Meanwhile the total load on the power supply has jumped to 48 amps, a 20 percent overload. The power supply may shut down in a couple of seconds, or it may go into current limiting, which will increase the tripping time on the breaker still more, and then shut down. Either way all the loads connected to it lose power.

Some power supplies have a surge rating that enables them to provide current into an overload for a short time, but there is still no guarantee that the breaker will trip before the supply shuts down.

After the power supply has shut down, it may stay that way, or it may try to restart. On a restart it will sense the overload again, and shut back down — over and over again, with possibly damaging consequences for the loads.

At the same time trouble-shooting is very difficult, as there is no way to tell which load circuit caused the overload. All this has the potential to cause significant downtime, which in some plants can cost as much as \$40,000 to \$50,000 per minute.

Solution

It might seem that using an “instantaneous trip” breaker or fuse on each load circuit would prevent the problem, but this type of breaker or fuse is likely to open on inrush surges caused by motors or capacitive loads. A breaker with the tripping curve shown in Fig. 2 would trip in as little as 20 ms with an inrush of twice normal current. What is needed is something that will disconnect an overloaded circuit yet keep unaffected circuits running.

Such devices exist; installed between a power supply and its loads, they provide adjustable overcurrent protection, selective coordination of the load circuits and current limiting. When a heavy overload occurs, they limit current to the affected circuit to prevent the power supply from shutting down, then trip if the overload continues. Some also provide status notification to both humans and control systems. Two types are available: multi-channel units (sometimes called diagnostic modules) that handle a number of loads, and single-circuit units (often referred to as electronic circuit breakers). A block diagram of a multi-channel unit is shown in Fig. 3.

Inrush Currents

As mentioned, some loads (motors or capacitive loads) will have high inrush current pulling several times their running current for several milliseconds on startup. The usual way to handle this is to put a delayed-action circuit breaker or fuse on the load in question, but if the starting inrush current is severe enough, it may require oversizing the power supply. The situation becomes worse if more than one load exhibits high inrush current, which could cause an undervoltage on startup that might cause equipment to malfunction or the power supply to refuse to start. One way around this would be to install an oversized power supply, but some multi-channel diagnostic units offer a sequential connection delay feature to guarantee safe equipment startup when high inrush loads are used (Fig. 5). Outputs can be programmed to start at selected intervals, which cuts down on damaging current spikes and also avoids the danger of a severe voltage drop, which could cause equipment to

malfunction. And, of course, it allows the correct size power supply for the application to be specified without oversizing.

Captions

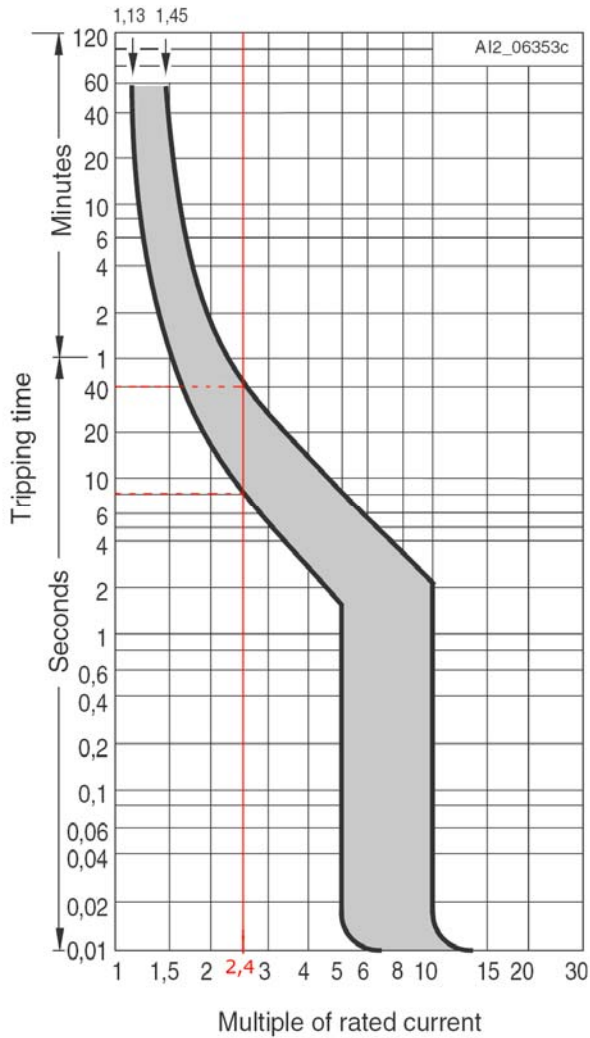


Fig. 1 A conventional circuit breaker may not clear a 240 percent overload for eight seconds or longer, during this time a switch-mode power supply may shut down, killing power to all of its loads.

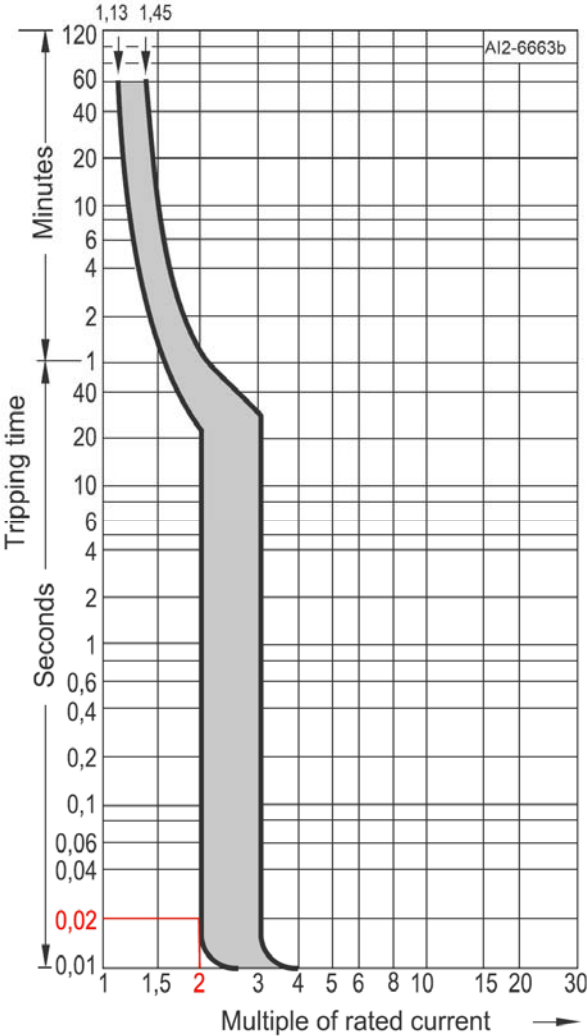


Fig. 2: An "instantaneous trip" breaker can trip in as little as 20 ms with an inrush of twice normal current.

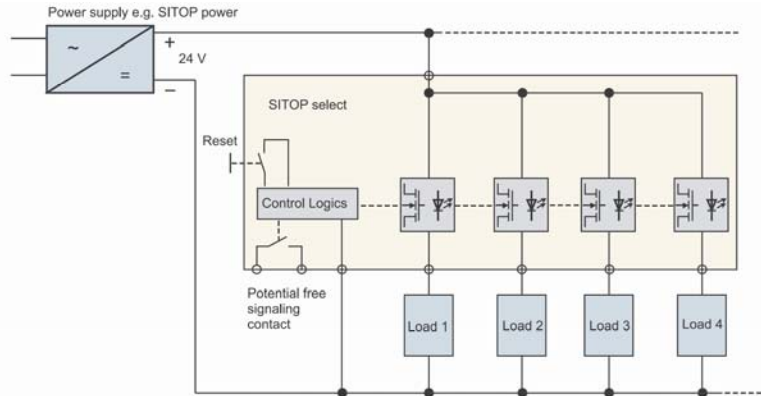


Fig. 3: Block diagram of a the Siemens SITOP Select multi-channel diagnostic module.

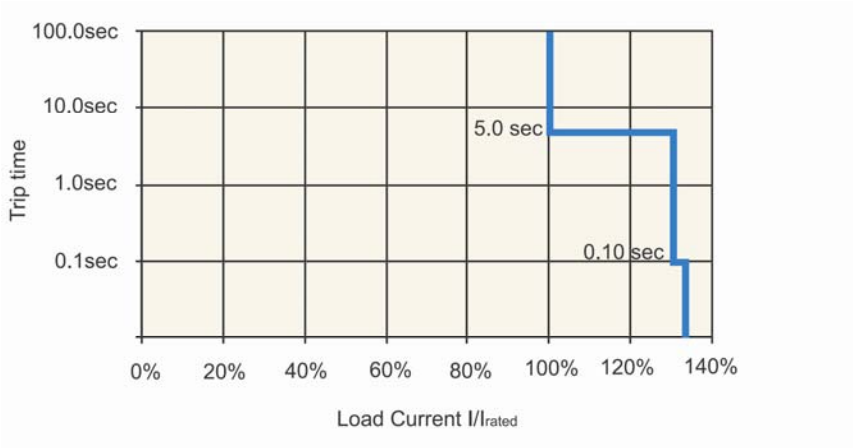


Fig. 4: Variation in trip time with load.

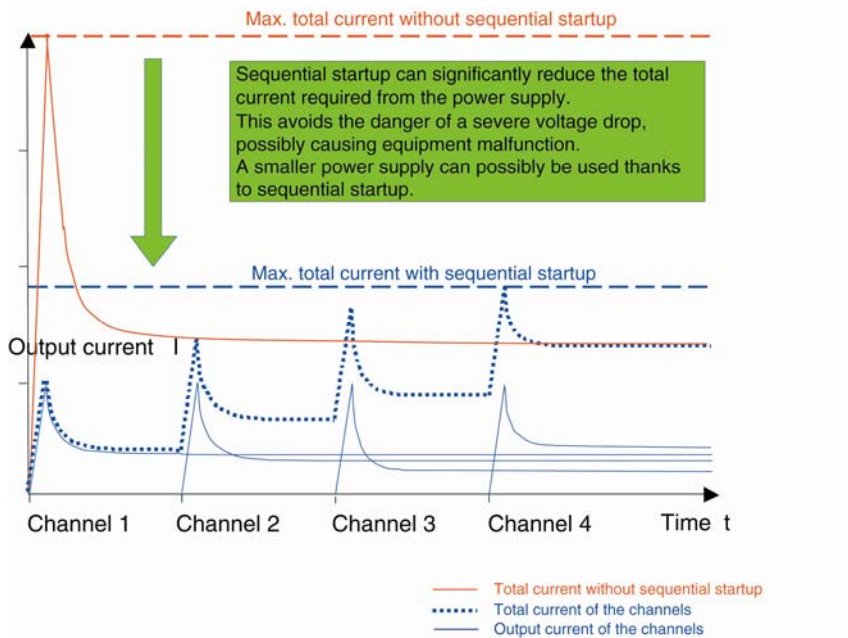


Fig. 5: Sequential connection delay guarantees safe equipment startup when high inrush loads are used.

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