Understanding Circuit Protection Devices

BASE

A BASE Design Guide for helping to make the choice in using PTCs, Fuses, or Circuit Breakers for Low Voltage Distributed Power Systems used in Security, CCTV, and Access Control.

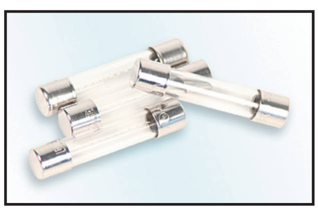
The main job for a circuit protection device is to limit excessive current from flowing in a circuit that could result in permanent damage to other circuit components. In the past, this was the job of just fuses or circuit breakers. Recent improvements in the size, cost and performance of PTC devices have spread their use to a wide variety of low voltage circuits. This design guide is written to help the Low Voltage System designer in the understanding of these devices enabling him to choose the right device for the job.

This guide is written as a crash course on the subject, eliminating much detail to get the main point across quickly. For those interested in exploring more details, a significant amount of information is available on the Internet from the major manufacturers of circuit protection devices such as Littelfuse, Bourns, Raychem, and many others.

A branch-circuit protection device is intended to be the *weak link* in the circuit. Unfortunately, a common service cure for a frequently blowing fuse is to replace it with a bigger fuse! Proper troubleshooting will find the *real* cause of the problem, then it can be fixed. Only use a protection device rated for just higher than the current needed to operate the devices in the circuit.

Facts, Common Terms and Clarifications

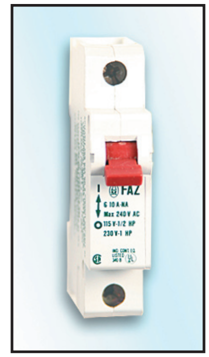
Fuses



Fuses are available in many sizes and types and are generally the least expensive circuit protection device. When a fuse ‘blows’, it cannot be reset or fixed, and it must be replaced. Therefore, the availability of fuses for quick replacement can be a factor in choosing this method of circuit protection. The 3AG fuse style (¼” x 1¼” as shown above) is arguably the least expensive and widest available fuse out there - the primary reason BASE uses them in many of our products. In a pinch, you might find one in a food store in 5 minutes.

A Fuse *is* a circuit breaker - the circuit opens when a fuse blows, and cannot be powered again until the blown fuse is replaced. Trouble-shooting a circuit with a blown fuse is easy. Usually, you can see the fuse that is blown (if its a see-thru glass type), or you can use a digital meter on the protected side of the fuse to verify that the circuit is open. Generally, if you need to work on the protected circuit, you can pop a fuse out and quickly pop it back in when you are done with your work. A fuse blows quickly as the rising current flow reaches the rated value of the fuse, generally within a fraction of a second, although there are slow-blow versions that extend this time a bit more to varying degrees.

Circuit Breakers

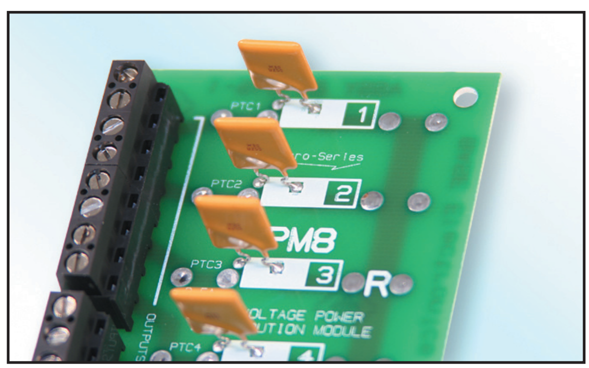


Push button or switch style circuit breakers are generally much more expensive and larger than PTCs or Fuses. As their name implies, they break the circuit when they trip. Like a fuse, with a tripped circuit breaker, the circuit is open and is equally easy to trouble shoot.

A circuit breaker can be manually tripped or turned off to enable work to be done to a protected circuit, but you will pay more for that convenience. After a circuit breaker trips, it will latch off requiring a manual reset to restore power to the protected circuit.

PTCs

The full meaning of this device’s nick name is polymeric positive temperature coefficient. The common term *resettable fuse* is misleading because a PTC is not a fuse. Nor is it a circuit breaker. This device is actually a non-linear thermistor. When an overcurrent condition occurs on a PTC protected output, the PTC device will heat and its resistance will increase, thus limiting current flow. When tripped, though current will be reduced, the circuit is not open (like it is with a blown fuse), and a digital meter on the output will likely and normally indicate some voltage and current flow, which is necessary to maintain the tripped condition of the PTC.



A PTC is usually soldered into a circuit board. It cannot be replaced quickly. In a distributed power system with PTCs, detecting which circuit is tripped can be troublesome and there are no visual clues. The device cannot be removed or turned off to enable modifications to the protected circuit. To enable this, the power source to the PTC must be turned off.

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A PTC may or may not trip as the current flow rises above its rated *hold* value. A PTC begins to heat as the current flow rises. How fast this heating occurs is the key to how fast the device will enter its high resistance state, eventually limiting current flow. Trip time may vary from miliseconds to even minutes depending on the nature of the overcurrent condition. While waiting for the device to trip, the current flowing through the protected circuit could actually rise *to the current limit of the power source* - so the circuit components and cabling must be able to handle that flow until the device trips.

The device can reset itself, but only after it has cooled to its normal temperature *after the overcurrent condition has been corrected or if the power source is turned off*. Since temperature is a major player in the performance of the device, the ambient temperature of the device's location also plays a role. Its hold and trip specs are downrated when ambient temperature goes up - so it can trip sooner and at a lower current value if located in a hot cabinet, and vice versa.

Low Voltage Distributed Power Systems using PTCs
Some potential problems can be foreseen in using PTC-protected distributed power systems. One example is given when using DC power and the other is shown when using an AC transformer. In either example given, distributed power using fuses rather than PTCs might be a better choice and would eliminate the need for a main fuse. Refer to the schematic below in the discussion of the examples.

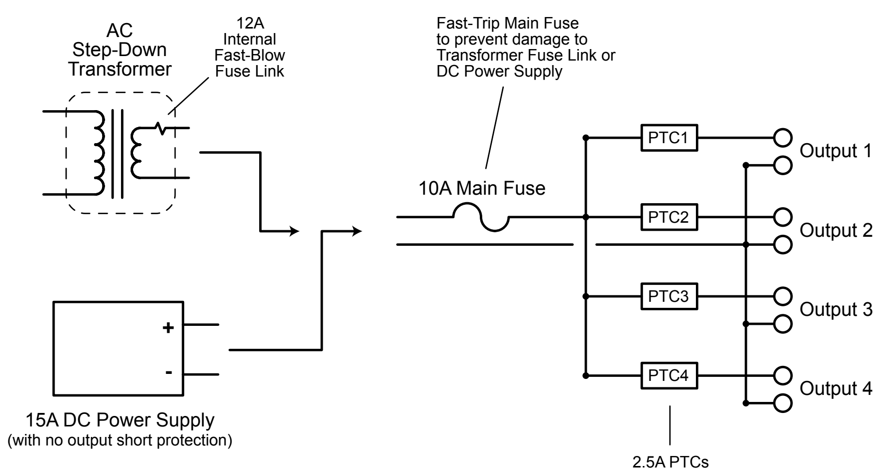
Example 1.

A large DC power source is used that does not have a short protected output[1] or main output fuse. During a short condition at an output device, the maximum current of the power supply might flow into the PTC protected circuit before the slow-trip PTC finally heats up and trips. Without a main fuse, damage to the power supply or output wiring could occur first.

This problem would not be an issue with smaller DC power supplies that have built-in output short protection. A short on the distributed output would likely force the power supply to clamp its output to nearly 0 volts, giving the PTC time to heat up and trip - after which the power supply output may return to normal while the tripped PTC remains tripped.

Example 2.

An AC Stepdown Transformer is used as the power source. Most transformers include a fuse link in their internal secondary wiring[2]. During an output short condition, while waiting for the downstream PTC to trip, the current may increase to the limit of the fuse link, thus destroying it and requiring that the transformer must be replaced. A slightly smaller rated main fuse placed after the transformer but before the PTCs would complete the necessary circuit protection.



Notes.
1. All BASE DC power supplies include on-board output short circuit protection as well as fused AC input protection.
2. All BASE AC Stepdown Transformers include internal safety fuse links in secondary windings.