

Protecting Relays from Overcurrent and Overvoltage Damage

Relays are frequently used in consumer electronics or industrial equipment to control high currents and voltages with lower level signals or to switch currents that must be isolated from the control circuit. A relay consists of a pair of one or more contacts and a coil, which, when energized, causes the contacts to open or close.

Relay damage can result from excessive voltage or current. A common problem is inductive voltage spikes. When a relay interrupts current to an inductive load, the voltage spike may be severe, ($V = Ldi/dt$). This voltage spike can exceed the relay's contact voltage rating and damage the contacts; sometimes suddenly and severely, or sometimes slowly, over many years of operation. Excessive current through the relay contacts can also damage relays, causing damage when the contacts open and the current is interrupted.

Excessive currents and voltages can also damage the relay coil. If a relay coil is designed to be energized for only a short duration in normal operation, normal operating current may eventually harm it if it is accidentally energized for a long period of time.



Circuit Protection Options

A variety of protection schemes can be used to help protect relays. Overcurrent protection can help limit damage caused by excessive currents during a fault or overload condition. Overvoltage protection can help limit damage caused by voltage spikes, or exposure to steady-state overvoltage conditions.

A popular relay protection component is the PolySwitch resettable overcurrent protection device (Figure 1). PolySwitch devices are made from a carbon black filler that provides conductive chains throughout the device. PolySwitch devices exhibit low-resistance characteristics under normal operating conditions, but when excessive current flows through the device, its temperature increases and the crystalline polymer changes to an amorphous state.

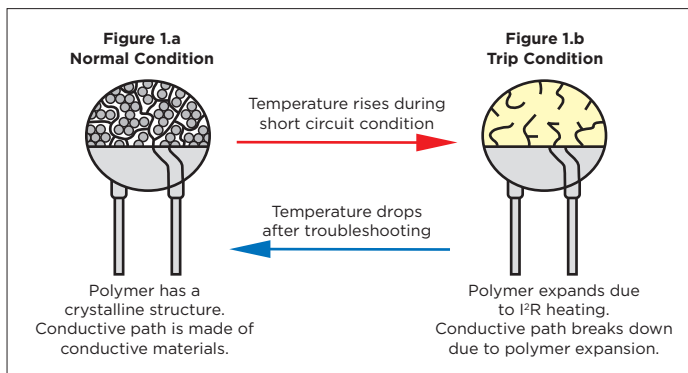


Figure 1. How a PolySwitch device works.

This transition causes the polymer to expand, breaking the conductive paths inside the conductive polymer. The change causes a dramatic increase in the device's resistance. This increase in resistance reduces the amount of current that can flow through the device to minimal levels.

The PolySwitch device will remain in this state until the circuit is opened and the fault is removed. Once this occurs, the device cools, the carbon chains reconnect, and the device returns to a low-resistance state. A traditional fuse can be used instead of a PolySwitch device, but it must be replaced after each trip event. The major advantage of the PolySwitch device is its resettable functionality, which helps reduce costly service calls and warranty returns, and improves customer satisfaction.

A number of overvoltage devices can be used for relay protection. One of the most cost-effective solutions is the MOV (metal oxide varistor) or MLV (multi layer varistor). A varistor is a variable resistor (i.e. a voltage dependent, non-linear device) whose resistance decreases as the voltage applied across the device increases.

MOVs are made of zinc oxide powder, sintered with other metal oxide ceramics. The resulting structure is a polycrystalline ceramic that consists of distributed zinc oxide grains separated by the metal oxide ceramics (Figure 2). The boundary of two adjacent zinc oxide grains creates a p-n junction-like semiconductor characteristic which blocks current conduction at low voltage levels and provides non-linear current conduction at higher voltage levels. This device can be used in protecting power circuits because it does not go to a short circuit when it trips, but decreases in resistance to reduce the voltage across the device.

The MLV uses the same technology as the MOV, but in a small surface mount package with electrodes sandwiched between multiple layers of zinc oxide.

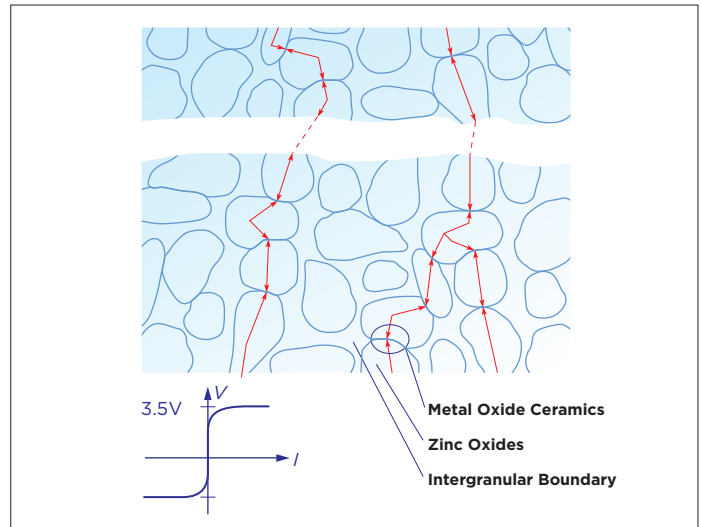


Figure 2. Polycrystalline structure of a Metal Oxide Varistor (MOV).

Circuit Protection Device Selection

Figure 3 shows a typical relay protection circuit. A PolySwitch device is placed in series with the relay coil to limit the current to the relay in case of a fault or accidental overload. This figure also shows a PolySwitch device in series with the relay contacts, where the selection process is the same as for the relay coil.

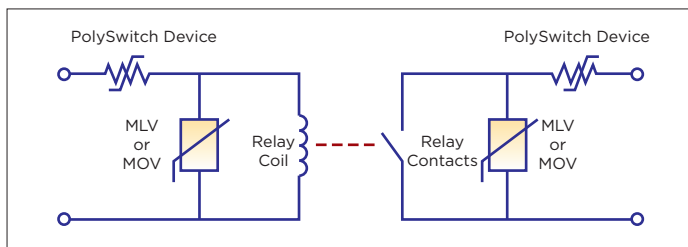


Figure 3. Typical overcurrent/overvoltage relay protection circuit.

It is important to choose a PolySwitch device with a voltage rating equal to or greater than the maximum expected voltage. The device must also have a hold current equal to or greater than the maximum steady-state current in normal operation. Additionally, the maximum ambient temperature must be taken into account because the hold current decreases as the ambient temperature increases.

The Tyco Electronics Circuit Protection Catalog includes thermal derating curves and charts to help designers specify a device with a sufficient hold current at the maximum ambient temperature. The catalog also includes voltage ratings, resistance, and trip-time curves for these devices.

Figure 3 also shows an MOV or MLV in parallel with the relay contacts. These devices are rated according to voltage and maximum surge current. It is important to select a device that is designed to not conduct significant current at the normal peak voltage. The MOV specifications in the Tyco Electronics Circuit Protection Catalog include a maximum allowable AC or DC voltage. Each MOV and MLV device also has a maximum surge current rating. The usual standard for rating surge currents uses an 8/20 microsecond wave shape, i.e. an 8 microsecond rise time and a 20 microsecond decay time to half the peak value. As the varistor size increases, the 8/20 microsecond surge current rating increases. An MOV or MLV can also be used in parallel with the relay coil, as shown in Figure 3.

PolySwitch RXEF, RUEF, RGEF, RHEF and LVR devices are commonly used for relay overcurrent protection when a through-hole device is desired. If a surface mount device is preferred, the PolySwitch SMD, nanoSMDC, microSMD, miniSMDC, decaSMDC, and picoSMD devices can be used.

For overvoltage protection, ROV metal oxide devices can be used if a through-hole device is desired. The MLV1206-700K is often used when a small surface mount device is desired.

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