Surge Protection

Using zener diodes and varistors

Based on a suggestion by Peter Lay Engineering Consultants

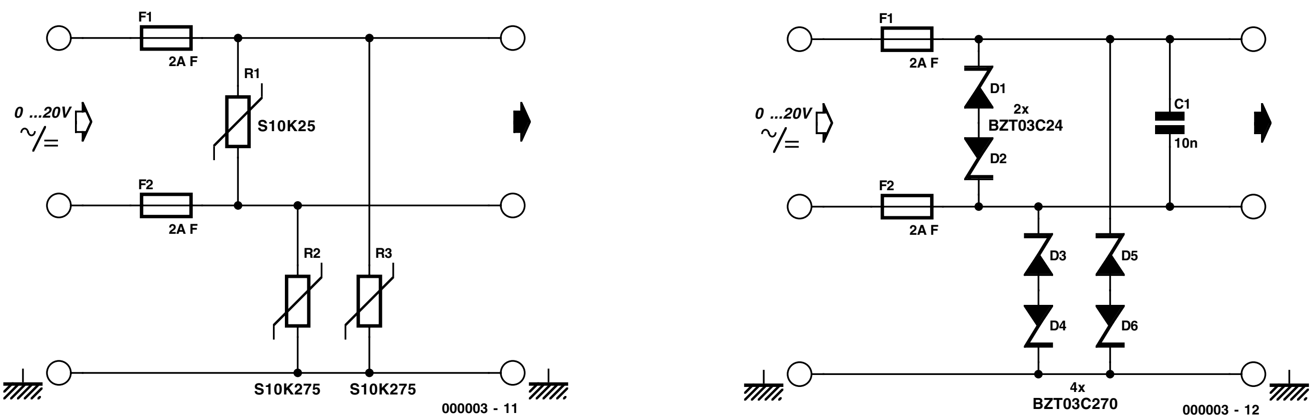

Figure 1. Protective measures on the low-voltage side using varistors and suppressor diodes.

There is no such thing as complete protection against overvoltage damage due to a lightning strike. However, the risk of a valuable piece of equipment being burned out during a thunderstorm can be strongly reduced with the aid of a relatively simple and inexpensive bit of circuitry.

Excessive voltages due to a lightning strike can force their way into a piece of electronic equipment in a variety of ways. They can travel via the telephone cable, an antenna cable or the mains wiring, or simply through the earth. The mains network is especially at risk in the latter case, since its neutral and protective earth leads are after all connected directly to the earth. Fuses and circuit breakers offer precious little help here, since their response time is several orders of magnitude longer than that of semiconductor devices.

There is of course a variety of components that can be used to protect circuitry against excessive voltages, ranging from gas-discharge tubes to special transient suppressor diodes (Transils). However, certain readily-obtainable and inexpensive 'ordinary' components can also be used as voltage limiters: zener diodes and varistors. Varistors function exactly like two back-to-back zener diodes.

In principle, such components could be built right into the mains power connection. However, equipment safety standards (such as BS and VDE) require the live and neutral leads to be insulated from the protective earth lead for voltages up to 2 kV. If any components are connected between the live or neutral lead and the earth lead, they must have a breakdown voltage of at least 2 kV! Such values are not possible even with varistors, let alone with zener diodes.

This restriction can be avoided by moving to the secondary side of the transformer, where the voltages are lower. It is possible to implement effective measures against excessive voltages here without violating any safety standards. The Philips BZT03-series zener diodes, as used in the circuit shown in **Figure 1**, are specially designed for transient suppression and react within 10 μs. The well-known disk-shaped varistors of the Philips SIOV-S series are even faster; they react to excessive voltages in less than 25 ns. Although SIOV-S varistors can handle current pulses of up to 10 kA, they can do so for a only few microseconds. They are not able to handle the power dissipation of a long-duration overvoltage condition. Suppressor diodes have similar characteristics; their maximum current ratings are lower, but their long-term power dissipation capacities are significantly higher.

Regardless of whether you choose to use zener diodes or varistors, there is one vital component in both types of circuit: a fast-acting fuse, which comes into action shortly after the zener diode or varistor responds. Such a fuse will melt in a few milliseconds if the actual current is several times the rated current.

Note that the protective circuit should not react if the mains potential is present on the protective earth lead. This condition need not necessarily result from a fault; it can also occur if a Class-I device with a mains filter is operated with the protective earth lead not connected. To this end, devices that do not start to conduct until around 270 to 275 V have been selected for varistors R2 and R3 and zener diodes D3 through D6. This represents the mains voltage plus its tolerance variation, along with the spread in the characteristics of the varistors and diodes.

In contrast, the breakdown voltage of the component that protects the power supply leads should be chosen to correspond to the secondary voltage, plus an allowance for tolerance margins.

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