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The Customer Magazine of TDK-EPC Corporation

Applications & Cases

Varistors for photovoltaics

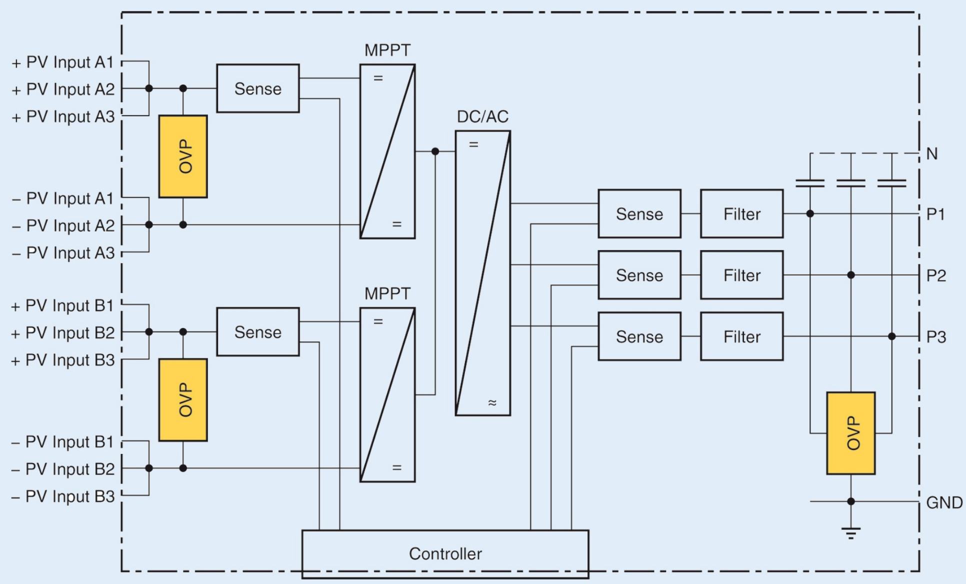
March 2011

Effective protection of valuable solar installations

The reliable protection of valuable photovoltaic installations and their electronics against overvoltages and current surges is gaining in importance. TDK-EPC offers reliable and cost-effective solutions for this purpose: thermally protected varistors and gas-filled surge arresters from EPCOS.

Photovoltaic installations are set up in exposed locations such as roofs, and increasingly also in open spaces. This makes them susceptible to high risks due to overvoltages, which are increased still further by the long leads between the solar modules and inverters at DC level as well as the feed lines to the power network at AC level. Figure 1 shows the structure of a typical solar inverter. It converts the DC voltage coming from the solar module to an AC voltage which can then be fed into the power network.

Figure 1: Block diagram of a solar inverter



Left: Overvoltage protection (OVP) of the solar module and inverter input; right: line-side overvoltage protection inclusive of EMC filtering.

Comprehensive protection at the inverter input

As a rule, metal oxide varistors with a rated voltage of 1000 V DC are used for the DC input of the solar inverter. Depending on the line voltage to be handled, varistors with a voltage of 300 V_{RMS}, for example, are obvious candidates for the inverter output. In both cases, gas-filled surge arresters may also be used to provide additional protection. Figure 2 shows frequently used circuit variants for the DC input of solar inverters. The simplest version (Figure 2a) uses only a single varistor with a rated voltage of 1000 V_{RMS} and a disk diameter of 20 mm, for example. In this case the rated DC voltage is 1414 V DC and the clamp voltage 2970 V at 100 A. The circuit in Figure 2b operates with two varistors connected in series. They should be designed for 550 V_{RMS} (745 V DC) to provide the same protection. This

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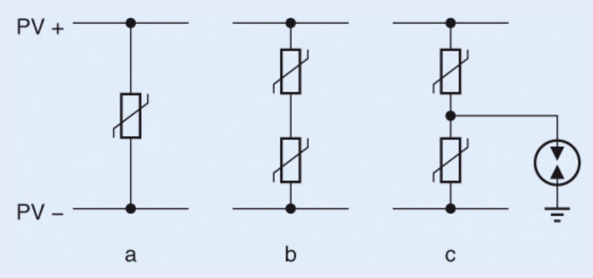
variant offers the advantage that the clamp voltage is only 2710 V at a current of 100 A and thus further limits the overvoltage. In addition, the energy to be absorbed is distributed across both components, thus reducing the stress factor. In the variant shown in Figure 2c, a gas-filled surge arrester is additionally connected between the varistors and ground. This variant still offers sufficient protection, especially in the event of failure or stress-caused aging of one or both varistors. The arrester must be selected so that it does not go over to a continuously conducting state if both varistors should fail.

Figure 2: Circuit variant for overvoltage protection

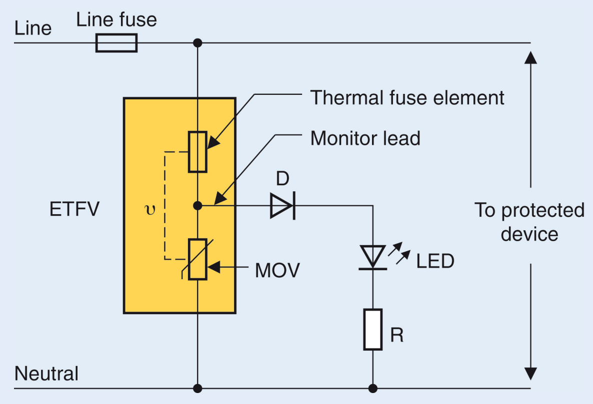


Circuits with one (a), two (b) or two varistors plus an additional gas-filled surge arrester (c) offer protection against overvoltages.

In principle, the power line side offers the same circuit options. For grid voltages of up to 240 V_{RMS} typical in Europe, varistors with rated voltages of 300 or 320 V_{RMS} should be selected in this case. Basically, these circuits are largely identical with the input circuits of standard power supplies designed for line operation.

As solar inverters belong to a relatively young sector of technology, no long-term studies have yet been carried out about their aging behavior and how this affects the protection components used in them. However, it is known from power supplies and other equipment that degradation can occur in semiconductorbased components such as ceramic varistors: This is due to continuously repeated low amplitude pulse loads. Such degradation manifests in a rise of the leakage current. If the resulting higher power loss in the component cannot be dissipated by convection, then in extreme cases continuously increasing heating occurs which can lead to a short circuit and consequent destruction of the varistor.

Figure 3: The EPCOS ETFV has a monitor output. The LED signals the intact state of the varistor.



The EPCOS ETFV has a monitor output. The LED signals the intact state of the varistor.

Tougher requirements of standards and insurers

Various standardization bodies such as UL and IEC have become alert to this safety risk and insist that future applications assure thermal monitoring of the varistors as well as their disconnection in the event of a fault. However, the recently published IEC 62109-1 standard entitled “Safety of power converters for use in photovoltaic power systems – Part 1: General requirements” does not treat this set of problems explicitly. Other standards, such as the most recent revision of IEC 60950-1, specify that exclusive use must be made of varistors that satisfy IEC 61051-2-2 as well as Annex Q (IEC 60950-1). A corresponding fuse must also be provided for the varistors.

The requirements of insurance companies make the situation even more acute: they insist among other things that photovoltaic installations with an output of more than 50 kW must assure overvoltage protection to IEC 61643-11 Category II (coarse protection).

Technical data of the EPCOS ETFV series

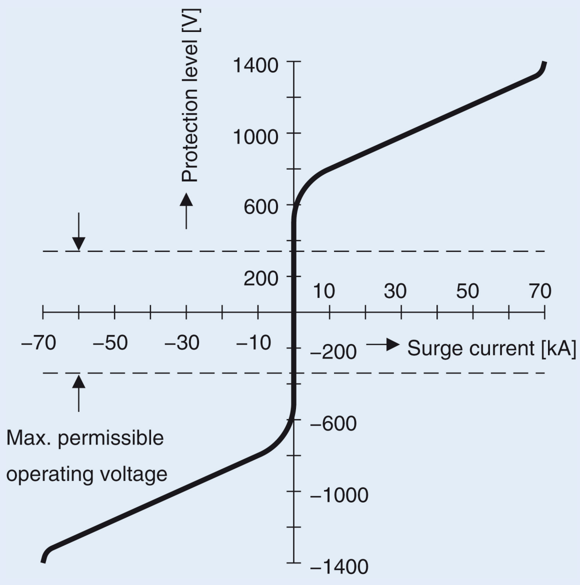
Parameter/Type	
Rated voltage [V AC]	130 to 420; 115 to 1000 (20 mm disk)
Surge current capability [kA]	6, 10 and 20
Response time [ns]	<25
Max. energy absorption (2 ms) [J]	50 to 700
Operating temperature [°C]	–40 to +85

The pins of the EPCOS ETFV series are designed so that they can also be mounted onto the circuit board or outside the equipment via a screw clamp. This greatly simplifies a replacement in the event of a fault. Shown is the ETFV 20 mm disk.

To allow manufacturers of solar inverters to cost-effectively satisfy the rigorous demands of the standards and insurance companies, TDK-EPC has developed the ETFV series (EPCOS ThermoFuse Varistor). These components are built up from a series circuit comprising a varistor and a thermal fuse. If the varistor degradation has advanced so far that the higher leakage current leads to overheating, the fuse blows and disconnects the varistor. A special feature of these components is the monitor lead: it extends the contact point between varistor and thermal fuse out so that it can drive an LED (Figure 3).

Varistors for bidirectional protection

Varistors are voltage-dependent monolithic ceramic resistors. Their behavior is defined by their rated voltage and their current capability. Below the response voltage, the component exhibits very high resistance: only a negligible leakage current in the μA range flows. If the applied voltage exceeds the rated voltage of the component, the varistor becomes conductive, allowing the component to withstand currents in the range of several amperes, and of several kA for brief periods.



From a specific response voltage the varistor becomes conductive and thus limits a further voltage rise. This behavior applies to both positive and negative voltages, thus assuring bidirectional protection.