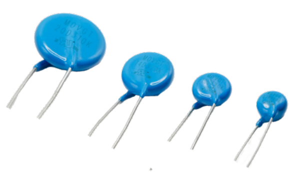
Eaton MOVGT whitepaper

Hybrid metal oxide varistor (MOVGT) for overvoltage protection



Abstract

Overvoltage is an excessive voltage event caused by several factors, including exposure to switching and lightning transients, grid inconsistencies, and inefficient line voltage regulation. This event can lead to significant damages to electronic systems if not efficiently handled due to its common occurrence in AC and DC power lines. Therefore, engineers incorporate components, such as metal oxide varistors (MOVs), into designs to adequately protect these circuits and systems from overvoltage-induced damages. MOVs are non-linear resistor-like components that exhibit high resistance in their off-state, making them ideal for transient overvoltage clamping during a high voltage-induced switch to full on-state.

These voltage-variable resistors (or varistors) return to their highly resistive off-state at the end of overvoltage events. However, the advent of electronic device utilization in uncontrolled and harsh environments has exposed conventional MOVs to a higher frequency of transient events, causing a corresponding higher rate of component degradation and failure. This whitepaper examines the capabilities of existing metal oxide varistors in addressing overvoltage events in electronic systems, proposing a solution that integrates MOVs with gas discharge tubes (GDTs). It also highlights key benefits and applications of the MOVGT integration and compares it with conventional MOV solutions.

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Addressing overvoltage events using metal oxide varistors (MOVs)

With the aid of MOVs, designers can ensure overvoltage protection in circuits up to the varistor device's voltage rating threshold. Varistors provide bidirectional protection from transient overvoltage resulting from power contact, lightning, and power induction. The high current withstand and fast reaction time of MOVs make them ideal for transient protection within their voltage rating in a wide range of applications that require protection. Key applications include line voltage regulation, white goods, power systems, electronic appliances, telecommunication systems, and power supplies. MOVs are not infinite life products, as their zinc oxide formulations exhibit degradation and can reach catastrophic failure due to extended exposure to line voltage transients. Temporary overvoltage (TOV) conditions that frequently exceed the component's working or operating voltage rating are other common causes of MOV degradation and end of life failure.

Some primary implications of MOV degradation and failure include electronic system-based open circuits, short circuits, residual linear resistance, and fire hazard. Some of these issues have been attempted to be addressed, over time, through improvements to conventional MOVs. A couple of these improvements include thermally protected MOVs and higher voltage-rated MOVs. Thermally protected MOVs can help provide a safer option for overvoltage protection by disconnecting MOVs from the power source at elevated temperatures to minimize fire hazards. However, thermally protected MOV-based disconnection makes electronic systems susceptible to faults from transient events after they reach end of life and can lead to cost inefficiencies.

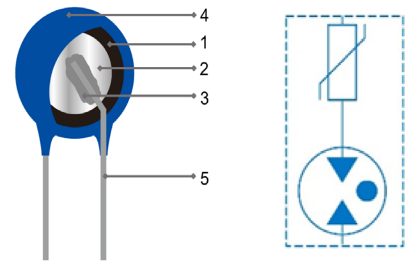
Designers can also significantly minimize MOV degradation and failure by incorporating MOVs with higher working voltage ratings for their overvoltage protection in electronic systems. However, the higher working voltage ratings come at the expense of higher clamping voltages; thus this option sacrifices overvoltage protection and their intent of application. This method can lower the chances of thermal events, but leads to extra costs of incorporating higher voltage-rated components downstream to withstand the sacrificed protection. Therefore, designers must incorporate a more efficient protection solution in light of overall protection efficiency and costs.

Integrating MOVs with GDTs: a hybrid solution

An industry-leading approach to ensuring enhanced reliability and performance for overvoltage surge protection compared to traditional MOV components includes integrating the MOVs with gas discharge tubes (GDTs). This integration (e.g., Eaton's MOVGT series) results in a compact and robust hybrid component that meets industry and customer requirements (including footprint, size, and compatibility) in overvoltage protection. MOVGTs can serve as the ideal solution for high-efficiency and cost-effective transient overvoltage protection in a wide range of applications. This section explores the components of an MOVGT device, its working principle, and key considerations for its design.

Components and construction of MOVGT

As earlier stated, MOVGTs leverage two technologies to ensure reliable and long life overvoltage protection, including metal oxide varistors and gas discharge tubes. Although manufacturers may have previously leveraged a discrete combination of MOVs and GDTs in their designs, there has been limited integration of the two components into a standalone component for overvoltage protection. To achieve the required standards, designers ensure the MOV package meets size restrictions while ensuring maximum reliability for voltage transient clamping, minimal current leakages, and low capacitances for preserving signal integrity in high-speed circuitry, durability, and energy storage optimization. Similarly, designers incorporate GDT technology into the MOV packaging, ensuring maximized MOVGT performance. This technology further limits the need for a trade-off between adequate protection from TOV conditions and clamping voltage performance, resulting in a hybrid solution that efficiently handles overvoltage transients without significant extra costs. It is noteworthy that the size and footprint of the MOVGT remain compatible with standard 7 up to 20 mm MOVs regardless of the two-component integration.



Item	Part	Material
1	MOV disc	Zn, Bi, Sb, Ni Oxides
2	GDT	Ag, Cu, Al combination
3	Solder connection	SnAgCu
4	Encapsulation	Silicon/Epoxy
5	Lead	Sn plated Cu

Figure 1: A typical MOVGT

How the hybrid solution works

The general working principle of the MOVGT device depends on two conditions. The device exhibits a voltage limiting capability equivalent to the sum of the voltage limiting capabilities of each component (i.e., MOV and GDT) under the first condition. Conversely, the second condition, which exhibits a high-rate voltage ramp, triggers a different reaction from the MOVGT device. The transient overvoltage event first appears across the GDT due to its relatively low capacitance. The event then causes the GDT to spark, charging the MOV to clamp the surge voltage to acceptable levels.

Note that during normal operating conditions, the GDT disconnects the MOV from the AC line, protecting it from small transients that are less harmful to the equipment under overvoltage protection. Since these small transients significantly account for MOV degradation and failure in the long run, the disconnection ensures higher reliability and durability of the MOVGT. After voltage clamping, the line voltage across the MOV induces the GDT to return to its off state, thus, disconnecting the MOV from the line till the next overvoltage transient.

MOVGT design considerations

MOVGTs meet industry and customer requirements when incorporating them into specific applications. Additionally, it is industrially acceptable for MOVGTs to meet similar selection criteria with conventional MOVs. In addition to the part numbering system, which most designers are already used to, it's important to consider the maximum continuous operating voltage (MCOV) before incorporating it into designs. The rating is generally coded directly into the part number.

Finally, designers must also consider surge handling capacity when incorporating MOVGTs into equipment protection. This capacity is significantly dependent on the diameter of the MOV. Designers must also consider safety in their designs. MOVGTs must meet the standards of different organizations, including Underwriters Laboratories (UL) and the International Electrotechnical Commission (IEC). For example, MOVGTs must be compliant with the UL 1449 standard, which stipulates various requirements for surge protective devices (SPDs).

Key benefits and applications of MOVGT integration

MOVGTs offer higher performance and reliability for applications that require overvoltage protection. Moreover, the integration offers higher benefits when compared to conventional MOVs in light of performance, design, and safety. Unlike conventional MOVs, MOVGTs ensure virtually zero standby energy consumption, lower leakage current down to <0.1 µA, and lower capacitance.

The continuous isolation of the MOV from the AC/DC line voltage with the aid of the GDT during normal operating conditions significantly minimizes device degradation and failure. The optimal design of the MOVGT integration makes it ideal for drop-in replacement of conventional MOVs. Additionally, the integration reduces the need to oversize conventional MOVs as well as downstream components due to the lower clamping voltages of the MOVGTs, ultimately providing better and more cost-effective overvoltage protection. This combination also offers longer life protection as well as more graceful and safe End of Life (EOL) mode.

MOVGTs are suitable for a wide range of AC/DC line protection, including power line communication systems, high-value consumer goods, white goods, smoke alarm systems, test & measurement equipment, UL1449 SPD, power supply systems, telecom distribution systems, medical electronics, switchboards, uninterrupted power supplies, and solar inverters.

Conventional MOVs vs. MOVGT

Technology	Clamping voltage	Resistance to degredation	Leakage current
150 Vrms MOV	400	Low	Low
250 Vrms MOV	650	Good	Good
150 Vrms MOVGT	350	Excellent	Excellent

Table 1: Comparison MOVs vs. MOVGT in 120 Vac application

Table 1 presents a summary of the performance of various overvoltage protection devices. The 150 Vrms MOV offers the lowest overall performance. The table shows that incorporating a higher voltage-rated MOV can lead to better overall performance. However, designers will encounter extra challenges, such as MOV degradation and failure and increased leakage after an extended period of equipment protection. Consequently, the integration of the MOV and GDT into a single solution provides the best overall performance in light of clamping voltage, aging characteristics, and responses to TOV conditions.

Eaton Bussmann series MOVGTs for overvoltage protection

With the Eaton Bussmann Series MOVGTs, designers can achieve higher performance, safety, and cost-effectiveness for their overvoltage protection while adequately addressing conventional MOV limitations. These radial leaded overvoltage protection devices can serve as a drop-in replacement for basic radial MOVs.

Eaton offers these protection devices in disc sizes ranging from 7 mm to 20 mm and MCOV values ranging from 70 V to 600 V. Thus, Eaton MOVGTs are ideal for the typical Vac voltages of 50 to 480 Vrms. Additionally, the Eaton Bussmann™ Series MOVGTs meet stringent safety standards, such as the UL 1449 certification, making them the best bet for overvoltage protection across a wide range of critical power applications. The MOVGTs also offer a surge current rating (or surge handling capacity) of up to 5 kA nominal surge current (40 times/cycles) on a 1.2/50 µs - 8/20 µs combination waveform for a 20 mm product. As an industry-leading manufacturer of power management technologies, Eaton offers long-lasting and reliable solutions that meet industry and customer requirements in the most uncontrolled and harshest environments prone to temporary overvoltage conditions and/or high-frequency transient events.

Eaton
Electronics Division
1000 Eaton Boulevard
Cleveland, OH 44122
United States
Eaton.com/electronics

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