Meeting Sustained Overvoltage Protection Requirements with a Hybrid Drop-In Replacement

WHITE PAPER

Bourns® GMOV™ Devices

INTRODUCTION

Circuit protection on AC and DC power lines is necessary for just about any device. Varying levels of exposure to lightning and switching transients, poor line voltage regulation in rural and developing areas and inconsistency among different grids around the globe means that there is no recognized single universal solution.

The problem can be examined from the standpoint of the reliability and robustness of the protection solution as well as the flexibility to adapt solutions to varying requirements while keeping manufacturing changes to a minimum. Always wanting to achieve higher density and higher performance designs, it can be challenging to address all circuit protection concerns. The Surge Protective Devices (SPDs) standard, UL 1449, sets forth requirements for authorization. Again, there is no single universal solution.

This white paper will examine the use of traditional Metal Oxide Varistor (MOV) devices and their performance and failure modes in various scenarios. Then it will present an innovative component hybrid solution that addresses some of the MOV shortcomings and enables greater flexibility in applications. Bourns has leveraged existing technology to provide a UL 1449 authorized solution that enhances performance and flexibility for front-end circuit protection in a footprint compatible device.

Bourns® GMOV™ Devices

CONVENTIONAL SOLUTION TO WITHSTANDING LINE VOLTAGE OVERVOLTAGE EVENTS

An MOV is a radial leaded varistor device that provides bidirectional protection against overvoltage transients such as lightning, power contact, and power induction. MOVs boast high current handling, high current absorption, and fast reaction time to protect against transient faults up to their rated limits. Power supplies, power systems, line voltage, telecom systems, white goods and appliances are among the applications commonly using MOVs for protection.

While a new MOV is an outstanding transient overvoltage solution on its own, it will degrade over time from exposure to line voltage transients. MOV degradation and failure modes are well documented and UL requires extensive testing to guard against harmful failure modes. Essentially, as the part ages, its maximum continuous operating voltage decreases. The normal failure mode for an MOV that has experienced long-term overvoltage exposure is excessive leakage which leads to power dissipation, and eventually can cause an overtemperature condition. Surge history, time, and temperature all contribute to increased leakage current, which can lead to application damage due to watt loss heating. Therefore, applications that are subject to voltage transients call for more protection than an MOV alone can provide.

Given the thermal nature of MOV failures, some developers specify a Thermally Protected MOV to protect against overvoltage threats. Thermally Protected MOVs are especially common for AC power protection. At the onset of excessive leakage and power dissipation, the thermal fuse in the Thermally Protected MOV is designed to disconnect the MOV from the power source at some elevated, but safe temperature, thus preventing it from burning up or catching fire. However, Thermally Protected MOVs are not designed to prevent the leakage current that drives the power dissipation. They function to stop a very dangerous failure mode. Most Thermally Protected MOV thermal fuses are only tested to 10 A in the UL 1449 limited current abnormal overvoltage test. These types of MOV thermal fuses may not open an actual AC line capable of delivering over 100 A.

Further, a Thermally Protected MOV that successfully disconnects from the power line is no longer protecting the equipment. Some Thermally Protected MOVs have an indicating lead that can be used to sense disconnection. The bottom line is that the associated enunciating circuitry adds cost to the protection scheme without actually increasing the overvoltage protection!

Circuit designers may also choose to lower the chances of a "thermal event" by simply selecting an MOV with a voltage rating far above the application's normal operating voltage. This will indeed reduce the stress on the MOV and drastically slow the aging process. However, the higher voltage rating also means the clamping voltage of the MOV will be much higher. This may force the designer to select higher voltage rated (and more expensive) products downstream as they must be rated to survive the higher voltages let through during a surge event.

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WHY A HYBRID MOV/GDT SOLUTION MAKES SENSE

After observing the shortcomings of simple MOVs, Thermally Protected MOVs and higher voltage rated MOVs, Bourns has engineered an effective and reliable replacement solution. The Company's continued commitment to helping reduce part count and providing space-saving components has led to the development of a hybrid GMOV™ solution that can solve both problems. The GMOV™ device integrates a Bourns® Gas Discharge Tube (GDT) with FLAT® Technology with a high quality conventional MOV. These two devices are packaged in the familiar radial package of standard MOVs, thus providing a drop-in replacement option to a similarly rated MOV.

This innovative combination of an MOV and a GDT provides lower leakage during the life of the MOV and a graceful failure mode that avoids high temperatures. Under normal operating conditions, the line voltage appears largely across the extremely low leakage GDT. This essentially disconnects the MOV from the AC line and protects it from small transients that pose no threat to the protected equipment and would otherwise only serve to age the MOV. During a surge event, the GDT quickly (in less than a microsecond) switches on and connects the MOV across the line to clamp the surge voltage to acceptable levels. Once the surge event has passed, the line voltage falls across the MOV, switching off the GDT. Once the GDT is off, it in turn disconnects the MOV from the line as before. The functionality of the GMOV™ device is a very special "symbiotic" relationship where the GDT and MOV work together to provide a long, useful life of protection.

One way to look at the relationship between the GDT and MOV is to say that the GDT keeps the MOV "on call" but not always "on duty!"

Combining a GDT with an MOV does not impact signal or system operation. The low capacitance of the GDT ensures that the GMOV™ device will not interfere with high speed data running over AC or DC power lines. Power supplies, power systems, line voltage, telecom systems, power line communications, and white goods and appliances are among the applications that can benefit from the longer life and reliability of a Bourns® GMOV™ device.

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STREAMLINING UL 1449 AUTHORIZATION

The UL 1449 lost neutral test demonstrates the value of taking a hybrid approach with the GMOV™ device. Bourns® Model 1251 and 1252 devices are two UL 1449 listed AC SPDs that use a discrete combination of MOV and GDT technology. They have proven fast-response performance and low leakage providing overvoltage protection at 50 kA (8/20 µs). With the GMOV™ device, Bourns combines expertise in UL 1449 authorization with proven components in a standard-sized MOV package to save precious circuit board space.

Using a UL 1449 listed GMOV™ device facilitates time and cost savings for both the design and certification phases of product development. It can eliminate the guesswork of finding the right combination of discrete parts. There is no need for indicating circuitry and its associated costs because the MOV and GDT combination does not have a thermal fuse or any need to disconnect from the line.

EMPOWERING APPLICATIONS

Exposure to line irregularities over time and from multiple surges can reduce circuit protection effectiveness. Leakage current associated with some protection schemes cannot be tolerated by certain applications. The robustness of Bourns® GMOV™ devices combined with their lower leakage current and reduced capacitance deliver application advantages over other types of protection solutions.

Reduced leakage current is also appealing in Energy Star applications, especially in the presence of voltage stress. Reduced leakage current and constant capacitance of the GDT make it optimal for power line communications. And, the capacitance level advantages achieved with the GMOV™ device allow power line communications to attain exceptionally high data rates.

DESIGN CONSIDERATIONS

Specifying a GMOV™ device for an application is virtually identical to the selection process for a conventional MOV. In fact, the part numbering system will be very familiar to designers. The Maximum Continuous Operating Voltage (MCOV) rating is coded directly into the number. Also, the surge handling capacity, dictated by the MOV diameter, is also prominently featured just like standard MOV part numbers.

Physically, the GMOV™ device is slightly thicker than a conventional MOV by about 2 mm. In most through-hole PCB applications, this means the GMOV™ device is a direct drop-in replacement for a conventional MOV. Because the Bourns® GMOV™ device is UL Listed as a Type 5 SPD (as are MOVs), direct substitution with minimal requalification is possible.

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BOURNS® GMOV™ COMPONENTS IN REVIEW

In the presence of voltage transients, a robust, low leakage front-end protection solution is needed. Today, many designs use a discrete combination of MOVs and GDTs. The Bourns® GMOV™ device is the first single component from Bourns to combine the technology of MOV and GDT. Leveraging the breakthrough, space-saving Bourns® FLAT® GDT technology and adding it to an MOV package meets size restrictions while also making it a potential drop-in replacement for MOVs. It delivers the increased reliability needed in clamping voltage transients with the added advantages of low leakage, energy savings, low capacitance, and an extended life.

Harnessing FLAT® GDT technology allows enhanced GMOV™ device performance in the standard MOV package size. Special designs for protection from the high temporary overvoltage condition experienced during a voltage transient are now possible without sacrificing the clamping voltage performance. Plus, UL listed combinations will save engineering and qualification time and cost. The hybrid solution offered by Bourns® GMOV™ devices quite simply and reliably solves the problem of voltage transients with a direct replacement.

The performance of each solution is shown in the table below. The 275 V MOV achieves good performance, but there is increased leakage current with 30 % voltage swell response that could affect some applications. Combining the MOV and GDT offers excellent performance, provided the correct GDT is used. If a compromise is forced between performance and cost, these outcomes should be considered.

BOURNS® GMOV™ DEVICE vs. STANDARD MOV

Technology	Clamping Voltage	Leakage Current	Aging	30 % Voltage Swell Response
130 V MOV	340	Poor	Poor	Possible Fire
275 V MOV	710	Good	Good	Increased Leakage
130 V MOV + TF	340	Poor	Poor	Possible Fire
GDT + MOV	~360	Excellent	Excellent	Excellent*

** requires custom high voltage GDT*

BOURNS®

Americas: *Tel* +1-951 781-5500
Email americus@bourns.com

EMEA: *Tel* +36 88 885 877
Email eurocus@bourns.com

Asia-Pacific: *Tel* +886-2 256 241 17
Email asiacus@bourns.com

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