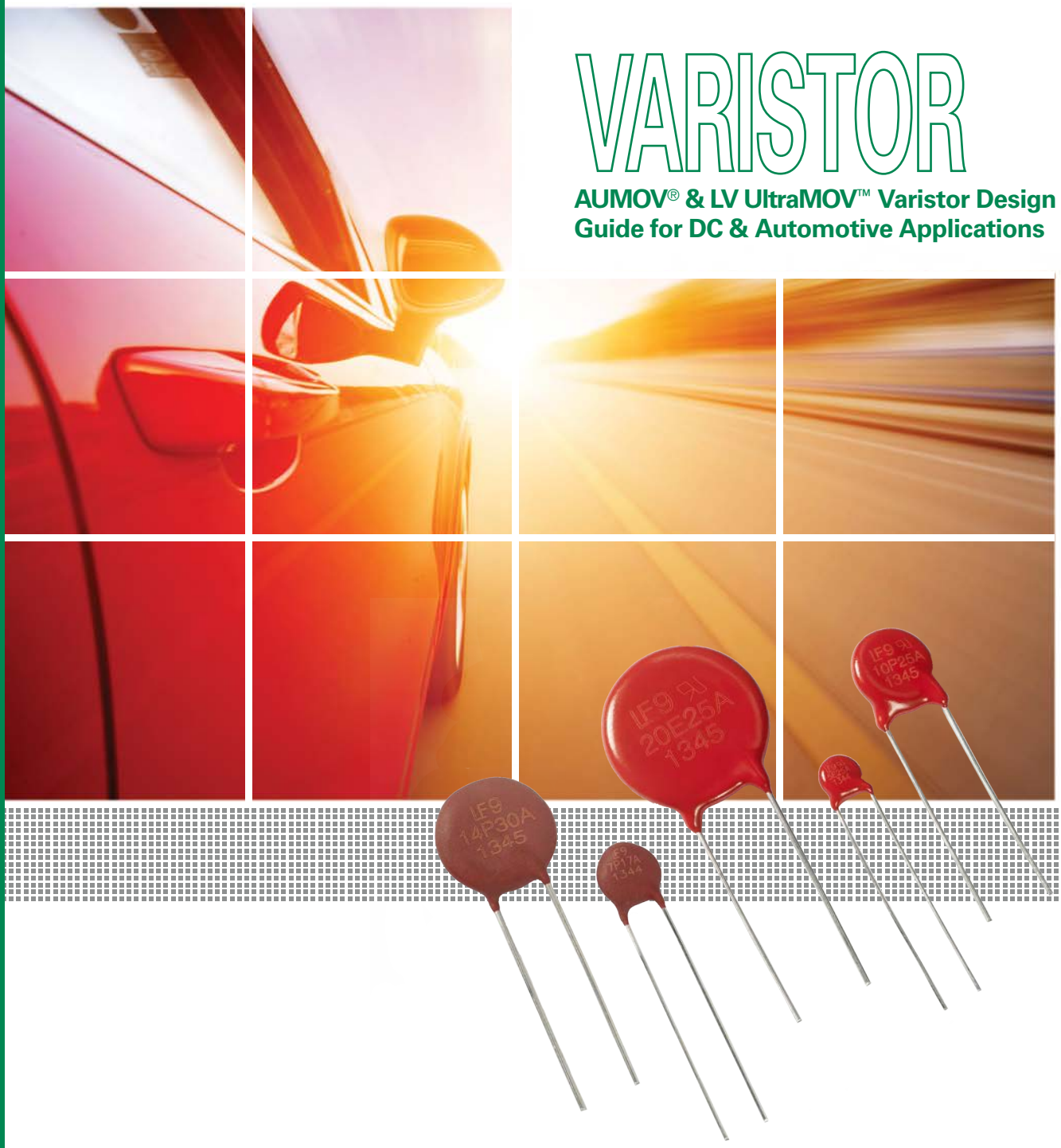
VARISTOR

AUMOV® & LV UltraMOV™ Varistor Design Guide for DC & Automotive Applications



Littelfuse®

Expertise Applied | Answers Delivered

High Surge Current Varistors Design Guide for Automotive AUMOV® Varistor & LV UltraMOV™ Varistor Series

About the AUMOV® Varistor Series

The AUMOV® Varistor Series is designed for circuit protection in low voltage (12VDC, 24VDC and 42VDC) automotive systems. This series is available in five disc sizes with radial leads with a choice of epoxy or phenolic coatings. The Automotive MOV Varistor is AEC-Q200 (Table 10) compliant. It offers robust load dump, jump start, and peak surge current ratings, as well as high energy absorption capabilities.

These devices are available in these sizes and ratings:

- Disc sizes: 5mm, 7mm, 10mm, 14mm, 20mm
- Operating Voltage Ratings: 16–50VDC
- Surge Current Ratings: 400–5000A (8/20µs)
- Jump Start Ratings: 6–100 Joules
- Load Dump Ratings: 25–35 VJump

AUMOV® Varistor Series Features

- AEC–Q200 (Table 10) compliant
- Robust load dump and jump start ratings
- High operating temperature: up to 125°C (phenolic coating option)
- High peak surge current rating and energy absorption capability

AUMOV® Varistor Series Benefits

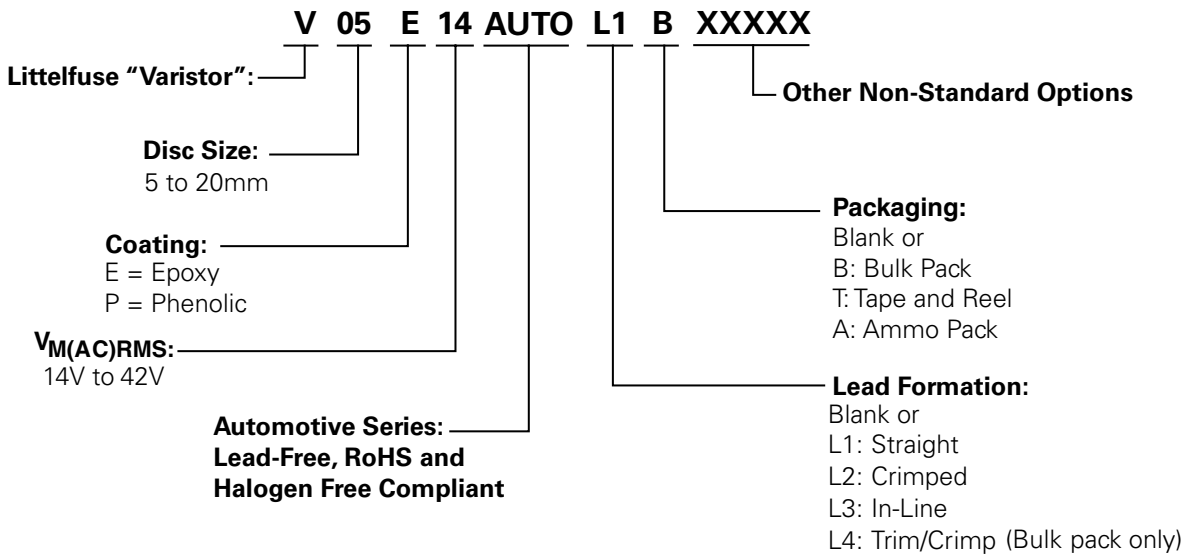
- Meets requirements of the automotive industry
- Complies with ISO 7637-2
- Offers options suitable for higher temperature environments and applications
- Enhances product safety as a result of superior surge protection and energy absorption
- ISO/TS 16949 Certified manufacturing facilities

About the AUMOV® Varistor Series (continued)

AUMOV® Varistor Series Applications

The AUMOV® Varistor Series is well suited for circuit protection in a variety of automotive electronics applications, including electronic modules designed for safety systems, body electronics, powertrain systems, heating/ventilation/air-conditioning control, navigation, center console, and infotainment systems.

AUMOV® Varistor Series Part Numbering System



About the LV UltraMOV™ Varistor Series

The LV UltraMOV™ Varistor Low Voltage, High Surge Current Varistor Series provides an ideal circuit protection solution for lower DC voltage applications by offering a superior surge rating in a smaller disc size. The maximum peak surge current rating can reach up to 10kA (8/20µs pulse) to protect against high peak surges, including lightning strike interference, electrical fast transients on power lines, and inductive spikes in industrial applications.

These devices are available in these sizes and voltage ranges:

- Disc Diameter: 5mm, 7mm, 10mm, 14mm and 20mm
- Maximum Continuous Voltage (VDC): 14V to 125V
- Varistor Voltage (Vnom) at 1m A: 18V to 150V

LV UltraMOV™ Varistor Series Features

- Breakthrough in low voltage varistor design provides high peak surge current rating
- Reduced footprint and volume required for surge protection
- High energy absorption capability
- High resistance to temperature cycling
- Optional phenolic coating
- Lead-free, halogen-free, and RoHS compliant

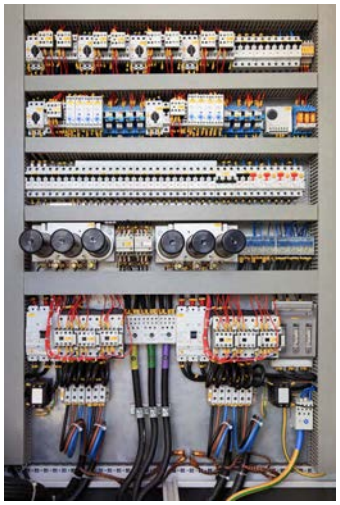
LV UltraMOV™ Varistor Series Benefits

- Increased long-term reliability due to the ability to handle higher surges over the end product's lifetime
- More board space is available for higher value functional components
- Lower weight and cost for end product from use of a smaller disc
- Higher surge handling density in critical surge protection device module solutions
- Higher operating temperature range—up to 125°C
- Environmentally friendly product

About the LV UltraMOV™ and Varistor Basics

Enhanced protection level—Higher surge withstanding and longer life

An LV UltraMOV™ Varistor can withstand higher surge current/energy and more surge strikes than the same size varistor from the standard Littelfuse series. For example, a new 10mm LV UltraMOV™ Varistor is rated at 2000A max. surge current, which is four times higher than a standard one. The higher surge rating also can provide longer life and reliability because there will be less degradation of the MOV over its lifetime.



Reduced component size—More compact designs

An LV UltraMOV™ Varistor is smaller than a standard Littelfuse varistor with the same surge capability. This reduces both PCB space requirements and component height. For example, an ordinary 10mm MOV capable of 500A maximum surge current could be replaced by a new 5mm LV UltraMOV™ Varistor with the same 500A surge rating; MOV size is reduced from 10mm to 5mm and mounting height is reduced from 14mm to 10mm.

Higher operating temperature range

An LV UltraMOV™ Varistor with the phenolic coating option can be operated in environments up to 125°C, making it suitable for use in more severe conditions such as industrial applications.

Varistor Basics

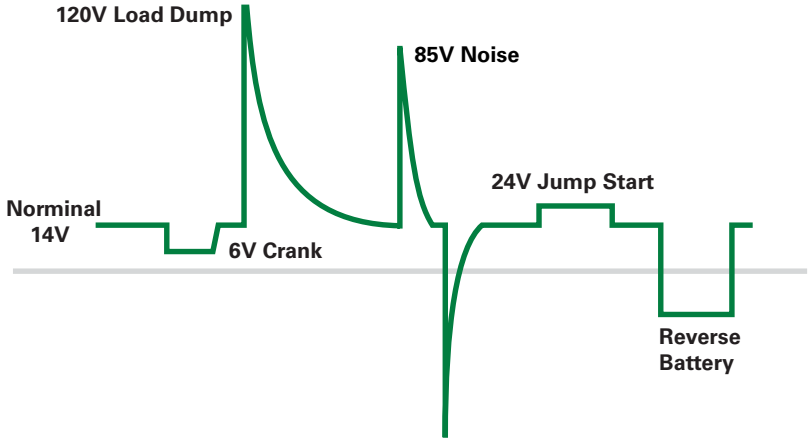
Varistors are voltage dependent, nonlinear devices that behave electrically similar to back-to-back Zener diodes. The symmetrical, sharp breakdown characteristics shown here enable the varistor to provide excellent transient suppression performance. When exposed to high voltage transients, the varistor impedance changes many orders of magnitude—from a near open-circuit to a highly conductive level—thereby clamping the transient voltage to a safe level. The potentially destructive energy of the incoming transient pulse is absorbed by the varistor, thereby protecting vulnerable circuit components.

Terminology Used in Varistor Specifications

Terms and Descriptions	Symbol
Clamping Voltage. Peak voltage across the varistor measured under conditions of a specified peak V_C pulse current and specified waveform. NOTE: Peak voltage and peak currents are not necessarily coincidental in time.	V_C
Rated Peak Single-Pulse Transient Currents. Maximum peak current which may be applied for a single 8/20µs impulse, with rated line voltage also applied, without causing device failure.	I_{TM}
Lifetime Rated Pulse Currents. Derated values of I_{TM} for impulse durations exceeding that of an 8/20µs waveshape, and for multiple pulses which may be applied over device rated lifetime.	-
Rated RMS Voltage. Maximum continuous sinusoidal RMS voltage which may be applied.	$V_{M(AC)}$
Rated DC Voltage. Maximum continuous DC voltage which may be applied.	$V_{M(DC)}$
DC Standby Current. Varistor current measured at rated voltage, $V_{M(DC)}$.	I_D
For certain applications, some of the following terms may be useful.	
Nominal Varistor Voltage. Voltage across the varistor measured at a specified pulsed DC current, $I_{N(DC)}$, of specific duration. $I_{N(DC)}$ is specified by the varistor manufacturer.	$V_{N(DC)}$
Peak Nominal Varistor Voltage. Voltage across the varistor measured at a specified peak AC current, $I_{N(AC)}$, of specific duration. $I_{N(AC)}$ is specified by the varistor manufacturer.	$V_{N(AC)}$
Rated Recurrent Peak Voltage. Maximum recurrent peak voltage which may be applied for a specified duty cycle and waveform.	V_{PM}
Rated Single-Pulse Transient Energy. Energy which may be dissipated for a single impulse of maximum rated current at a specified waveshape, with rated RMS voltage or rated DC voltage also applied, without causing device failure.	W_{TM}
Rated Transient Average Power Dissipation. Maximum average power which may be dissipated due to a group of pulses occurring within a specified isolated time period, without causing device failure.	-
Varistor Voltage. Voltage across the varistor measured at a given current, I_X.	V_X
Voltage Clamping Ratio. A figure of merit measure of the varistor clamping effectiveness as defined by the symbols $(V_C) \div (V_{M(AC)})$, $(V_C) \div (V_{M(DC)})$.	V_C / V_{PM}
Nonlinear Exponent. A measure of varistor nonlinearity between two given operating currents, I_1 and I_2, as described by $I = kV_a$ where k is a device constant, $I_1 \leq I \leq I_2$, and $a_{12} = (\log I_2 / I_1) \div (\log V_2 / V_1)$	a
Dynamic Impedance. A measure of small signal impedance at a given operating point as defined by: $Z_X = (dV_X) \div (dI_X)$	Z_X
Resistance (Varistor). Static resistance of the varistor at a given operating point as defined by: $R_X = (V_X) \div (I_X)$	R_X
Capacitance (Varistor). Capacitance between the two terminals of the varistor measured at specified frequency and bias.	C_X
AC Standby Power. Varistor AC power dissipation measured at rated RMS voltage $V_{M(AC)}$.	P_D
Voltage Overshoot. The excess voltage above the clamping voltage of the device for a given current that occurs when current waves of less than 8µs virtual front duration are applied. This value may be expressed as a % of the clamping voltage (V_C) for an 8/20µs current wave.	V_{OS}
Response Time. The time between the point at which the wave exceeds the clamping voltage level (V_C) and the peak of the voltage overshoot. For the purpose of this definition, clamping voltage as defined with an 8/20µs current waveform of the same peak current amplitude as the waveform used for this response time.	-
Overshoot Duration (Varistor). The time between the point at voltage level (V_C) and the point at which the voltage overshoot has decayed to 50% of its peak. For the purpose of this definition, clamping voltage is defined with an 8/20µs current waveform of the same peak current amplitude as the waveform used for this overshoot duration.	-

Automotive MOV Background and Application Examples

Threats on Low Voltage Line

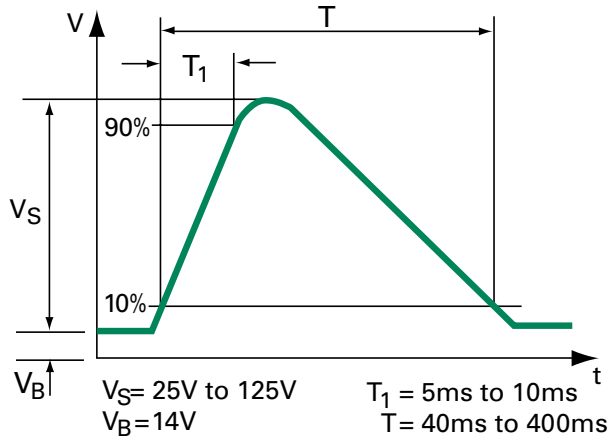


Automotive EMC transient requirements from ISO 7637:

Pulse 1	Interruption of inductive load – refers to disconnection of the power supply from an inductive load while the device under test (DUT) is in parallel with the inductive load
Pulse 2	Interruption of series inductive load – refers to the interruption of current and causes load switching
Pulse 3	Switching spikes 3a negative transient burst 3b positive transient burst Refers to the unwanted transients in the switching events
Pulse 4	Starter crank – refers battery voltage drop during motor start. This always happens in cold weather
Pulse 5	Load dump – refers to the battery being disconnected when it is charged by the alternator.
Pulse 6	Ignition coil interruption
Pulse 7	Alternator field decay
Pulses 1, 2, 3a, 3b, 5, 6, 7	Related to high voltage transient getting into the supply line; Pulse 4 defines minimum battery voltage.

Load Dump

Load dump is what happens to the supply voltage in a vehicle when a load is removed. If a load is removed rapidly (such as when the battery is disconnected while the engine is running), the voltage may spike before stabilizing, which can damage electronic components. In a typical 12V circuit, load dump can rise as high as 120V and take as long as 400 milliseconds to decay—more than enough time to cause serious damage.



Load dump waveform (from ISO 7637)

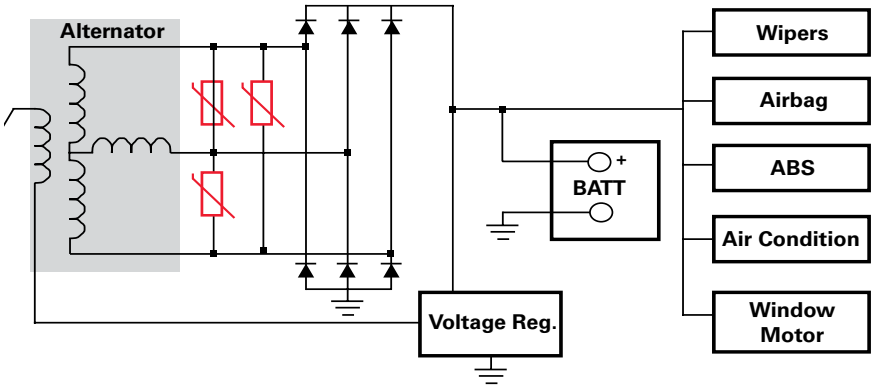
Automotive MOV Background and Application Examples (continued)

Automotive Applications

System Protection against Alternator Transients

The alternator causes most of the transients in a vehicle's electrical system.

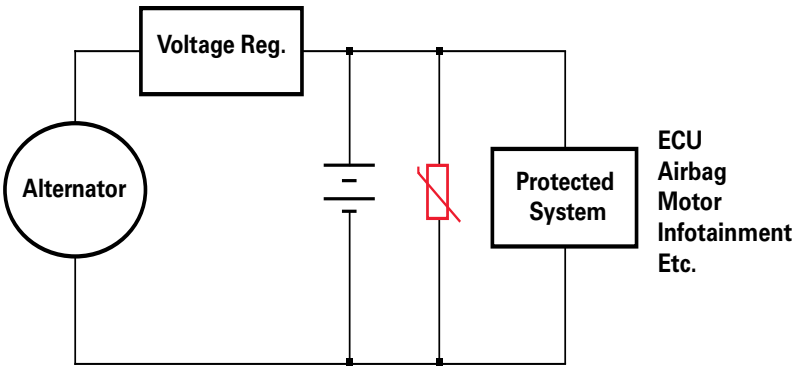
Littelfuse automotive MOVs can be connected in a Y or Delta configuration with the winding coil of the alternator to clamp the transients.



Vehicle subsystem module transient protection

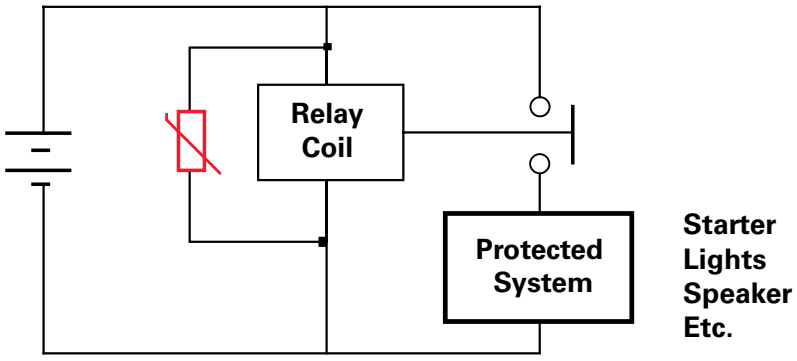
Vehicles subsystems such as the ECU, airbag, etc. can be damaged by the transient caused when the alternator provides power to the electronics.

Littelfuse automotive MOVs can be used as a shunt for the transient surge for the DC power line.



Automotive Relay Surge Protection

Typical relay operation would generate arcing during the switch of the relay contacts, thereby damaging the IC and other sensitive electronic devices. Littelfuse automotive MOVs will absorb the arcing energy released from the magnetic fields of the relay.



LV UltraMOV™ Varistor Application Examples

A variety of applications employ 12VDC–96VDC circuits, including telecom power, sensing, automation, control, and security systems. Transients on these lines can be caused by lightning interference, inductive spikes from power switching, and fast transients from induced power line fluctuations. For example, a relay switching on/off can cause a magnetic transient in the coil inductance, which produces a high voltage spike.

Compared with the other clamping and crowbar technologies that are used for voltage suppression, varistor technology is still one of the most cost-effective ways to protect against high energy surges on these 12VDC–96VDC lines.

LV UltraMOV™ Varistors are widely used in a number of application areas:

Clamping Lightning-induced Transients in Power Supplies

Most transients induced by nearby lightning strikes result in an electromagnetic disturbance on electrical and communication lines connected to electronic equipment.

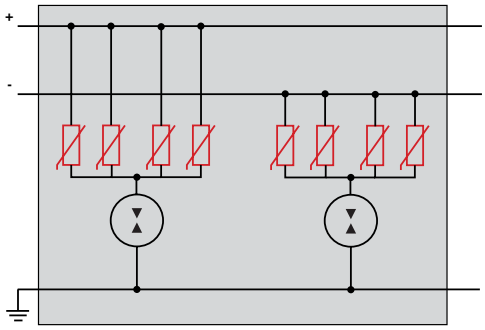
Inductive Load Switching

Switching of inductive loads, such as those that occur with transformers, generators, motors and relays, can create transients up to hundreds of volts and amps, and can last as long as 400 milliseconds.

LV UltraMOV™ Varistor Application Examples (continued)

Telecom/SPD Application

Telecom Power Supply Units (PSUs) typically range from 36VDC to 72VDC on the high end of the voltage range. The LV UltraMOV™ varistor can be used for applications where the voltage is less than 125VDC. Low Voltage Surge Protective Device (SPD) modules are used in telecom and industrial applications to provide module-based surge protection of complete systems.



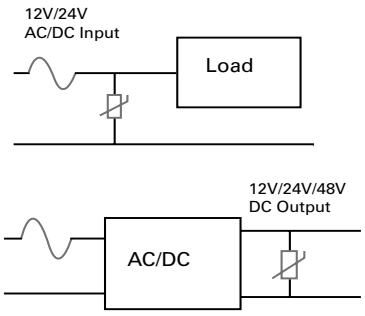
In telecom power applications, multiple LV UltraMOVTM varistors are used in a single SPD to provide surge protection. Several varistors are connected in parallel to provide the desired level of energy handling. The varistors are connected in series with a GDT to provide additional transient protection to earth/ground.

Outdoor Low Voltage Application

12VAC/DC and 24VAC/VDC are the voltages commonly used for security system components such as motion sensors, IP cameras, and DVRs.

Demand for energy savings is helping to drive the adoption of LED lighting. LED light bulbs powered at 24V are widely used for home and commercial applications. The use of LV UltraMOV™ varistors at the input circuit will enhance the surge capability and protect the lifetime of the LED light.

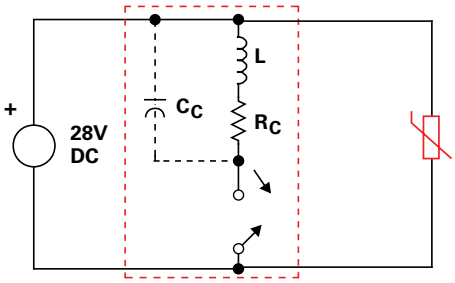
Security System/LED Protection



Industrial/Process Control Application

For industrial applications, relay coils are commonly used for valve switching for fluid/gas control.

Inductive Surge Protection



C_C = Stray Capacitance
L = Relay Coil Inductance
R_C = Relay Coil Resistance

When the relay switches, the relay coil attempts to maintain current flow, causing temporary high voltage spikes.

The use of an LV UltraMOV™ Varistor in parallel with the relay switch would extend the life of the relay and reduce arcing during switching of the relay contacts. The UltraMOV™ varistor will absorb the arcing energy from the energy released from the magnetic fields of the relay.

How to Select a Low Voltage DC MOV

Example of MOV selection process for surge protection:

Circuit conditions and requirements:

- 24VDC circuit
- Current waveform for surge is 8/20µs; voltage is 1.2/50µs
- Peak current during the surge is 1,000A
- Requirement is to survive 40 surges
- Other components (control IC, etc.) are rated to withstand 300V maximum.

Approach to finding a solution:

To find the voltage rating of the MOV, allow for 20% headroom to account for voltage swell and power supply tolerances.

- 24V DC × 1.2 = 28.8V DC
- So look at 31V DC rated MOVs
- Determine which MOV disc size to use – identify those that minimally meet the 1,000A surge requirement.
  - Use the *Pulse Rating Curves in the LV UltraMOV™ Varistor Series datasheet* to determine pulse capabilities of each series per the 40 pulses @ 1,000A requirement
  - Use *V-I Curve in the datasheet* of the selected MOV to verify that the peak voltage will be below the 1,000V ceiling.

How to Select a Low Voltage DC MOV (continued)

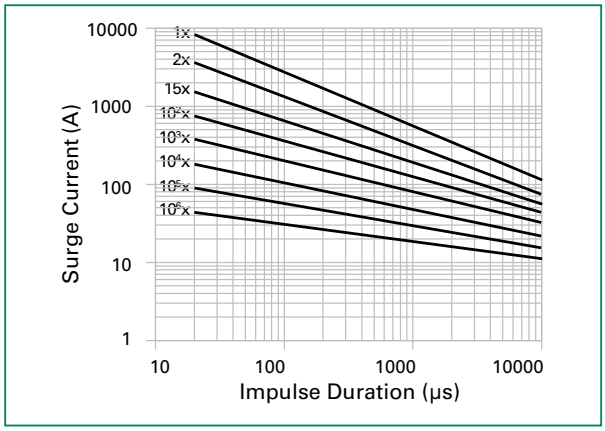
- Determine the LV UltraMOV™ Varistor disc size needed by confirming the surge rating will meet the application requirement. In the following table, we have selected a 14mm MOV with a 31V DC max continuous voltage rating as a possible solution to meet our need. Then, we will use the Pulse Rating curves and V-I curves to verify that the selected MOV can meet the requirements.

Part Number (Base part)	Part Number (Base part)	Size (mm)	Vrms (V)	Vdc (V)	Min (V)	Nom (V)	Max (V)	Vc (V)	I_{TM} (A)
V14E23P	**V14P23P**	**14**	23	28	32.4	36	39.6	71	4000
V05E25P	**V05P25P**	**5**	25	31	35.1	39	42.9	77	500
V07E25P	**V07P25P**	**7**	25	31	35.1	39	42.9	77	1000
V10E25P	**V10P25P**	**10**	25	31	35.1	39	42.9	77	2000
V14E25P	**V14P25P**	**14**	25	31	35.1	39	42.9	77	4000
V20E25P	**V20P25P**	**20**	25	31	35.1	39	42.9	77	8000
V10E30P	**V10P30P**	**10**	30	38	42.3	47	51.7	93	2000
V14E30P	**V14P30P**	**14**	30	38	42.3	47	51.7	93	4000
V20E30P	**V20P30P**	**20**	30	38	42.3	47	51.7	93	8000

Pulse Rating Curves:

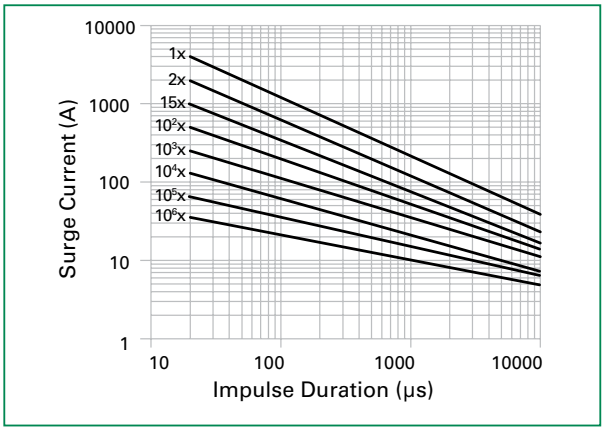
Pulse Rating Curve for 20mm

V20x11P - V20x40P



Pulse Rating Curve for 14mm

V14x11P - V14x40P



How to Select a Low Voltage DC MOV (continued)

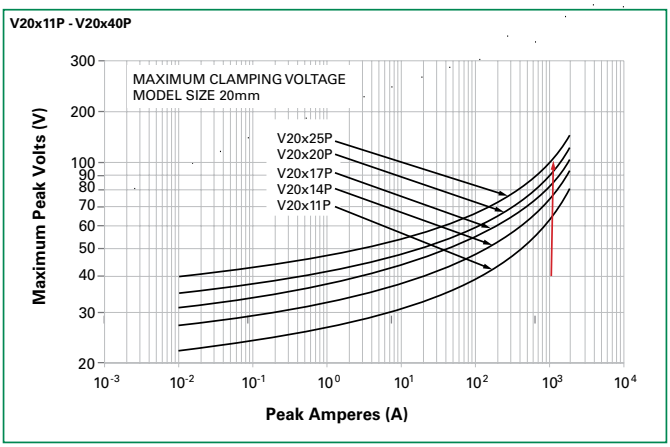
Determine if the 14mm LV UltraMOV™ Varistor Surge Rating is sufficient to meet the requirements:

1. Using the Repetitive Surge Capability (Pulse Rating) Curves in the LV UltraMOV™ Varistor datasheet, locate the pulse with (20µs) on the x-axis (see Fig 1 for 14mm MOV and Fig 2 for 20mm MOV). This signifies an 8/20µsec waveform shape.
2. Find where the vertical line intercepts the 1,000A point, which is our required surge rating for 40 hits.
3. In this case, we find that the 14mm LV UltraMOV™ Varistor can only survive a little more than 10 hits. However, the 20mm choice can survive 100 pulses. Therefore, we select the more conservative choice, which is the 20mm MOV (V20E25P).

Determine if the 20mm LV UltraMOV™ varistor is suitable to meet the clamping requirements:

1. Locate the peak current on the X-axis (1000A) in the LV UltraMOV™ varistor V-I curve.
2. Find where it intercepts the curve for the V20E25P product.

Maximum Clamping Voltage for 20mm Parts



3. In this case, the maximum clamping voltage is at 130V, which is beneath the 300V damage threshold for the sensitive components in the circuit. Our LV UltraMOV™ varistor selection will protect us to the correct level.

Conclusion:

The V20E25P can meet the 24V DC, 1000A, 40-hit 8/20µs surge requirement with clamping voltage at 130V.

Transient Suppression Techniques

There are two different approaches to suppressing transients: attenuation and diversion. Attenuation techniques are based on filtering the transient, thus preventing their propagation into the sensitive circuit; diversion techniques redirect the transient away from sensitive loads and thereby limit the residual voltages.

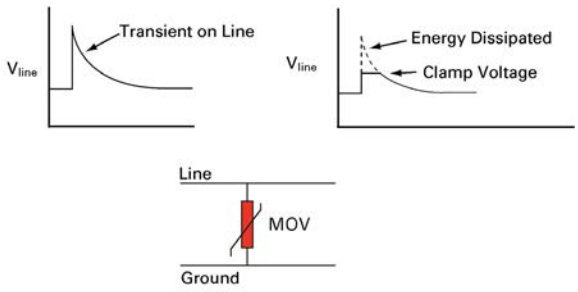
Clamping- and crowbar-type devices are often used to divert a transient:

- Crowbar devices, primarily gas tubes or protection thyristors, are widely used in the communication field where power-follow current is less of a problem than in power circuits. These types of devices employ a switching action to divert the transient and reduce voltage below line condition by starving the circuit of power. These devices require auto resetting.
- Clamping devices are components with a variable impedance that depends on the voltage across the terminal. These devices exhibit a nonlinear impedance characteristic. The variation of the impedance is continuous. A clamping device is designed to maintain "normal" line conditions. It typically dissipates some energy within the body of the device.

Overvoltage Suppression Comparison

The most suitable type of transient suppressor depends on the intended application; in addition, some applications require the use of both primary and secondary protection devices. The function of the transient suppressor is to limit the maximum instantaneous voltage that can develop across the protected loads in one way or another. The choice depends on various factors but ultimately comes down to a trade-off between the cost of the suppressor and the level of protection needed.

When it's used to protect sensitive circuits, the length of time a transient suppressor requires to begin functioning is extremely important. If the suppressor is slow acting and a fast-rising transient spike appears on the system, the voltage across the protected load can rise to damaging levels before suppression kicks in. On power lines, a Metal Oxide Varistor is usually the best type of suppression device. TVS Diodes and Gas Discharge Tubes are also used occasionally.



Transient Suppression Techniques (continued)

Technology	Key Features and Protection Characteristics	Surge Energy Rating Range	Typical Voltage Clamping Speeds	Typical Capacitance/ Insertion Loss	Mounting Size/ Packaging Options
Multi-Layer Varistors (MLVs)	Compact and capable of handling significant surges for their size	Low thru Medium	Moderate	High	Miniature Surface Mount
Metal-Oxide Varistors (MOVs)	Capable of withstanding very high energy transients; wide range of options	Medium thru Very High	Moderate	High	Radial Leaded, Industrial Terminal
Gas Discharge Tubes (GDTs)	Switches that turn to on state and shunt overvoltage to ground using a contained inert gas as an insulator	Medium thru High	Fast	Low	Surface Mount, Axial Leaded, 2/3 Lead Radial
Pulse-Guard® ESD Suppressors	Extremely low capacitance; fast response time; compact size	Low	Moderate	Low	Miniature Surface Mount
PLED LED Protectors	Shunt function bypasses open LEDs; ESD and reverse power protection	Low	Very Fast	Medium	Miniature Surface Mount
TVS Diode Array SPA® Diodes	Low capacitance / low clamping voltage; compact size	Low thru Medium	Very Fast	Low	Extensive range of surface mount options
TVS Diodes	Fast response to fast transients; wide range of options	Medium thru High	Fast	High	Axial Leaded, Radial Leaded, Surface Mount
SIDACtor® Protection Thyristors	Specifically designed to serve stringent telecom/ networking standards	Medium thru High	Very Fast	Low	Extensive range of surface mount and thru-hole options

MOV General Applications

- Metal Oxide Varistors (MOVs) are commonly used to suppress transients in many applications, such as Surge Protection Devices (SPD), Uninterruptible Power Supplies (UPSs), AC Power Taps, AC Power Meters or other products.
- Lightning, inductive load switching, or capacitor bank switching are often the sources of these overvoltage transients.
- Under normal operating conditions, the AC line voltage applied to an MOV is not expected to exceed the MOV's Maximum AC RMS Voltage Rating or Maximum Continuous Operating Voltage (MCOV).
- Occasionally, overvoltage transients that exceed these limits may occur. These transients are clamped to a suitable voltage level by the MOV, provided that the transient energy does not exceed the MOV's maximum rating.

Introduction to Metal Oxide Varistors (MOVs)

How to Connect a Littelfuse Varistor

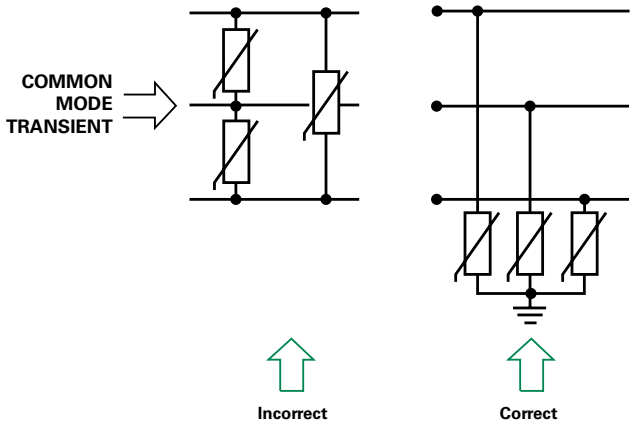
Transient suppressors can be exposed to high currents for short durations (in the range of nanoseconds to milliseconds).

Littelfuse varistors are connected in parallel to the load, and any voltage drop in the leads to the varistor will reduce its effectiveness. Best results are obtained by using short leads to reduce induced voltages.

DC Applications

DC applications require connection between plus and minus or plus and ground and minus and ground.

For example, if a transient towards ground exists on all three phases (common mode transients), only transient suppressors connected phase to ground would absorb energy. Transient suppressors connected phase to phase would not be effective.



Series and Parallel Operation of Varistors

In most cases, a designer can select a varistor that meets the desired voltage ratings from the standard models listed in the catalog. Occasionally, however, the standard catalog models do not fit the requirements of the application, either due to voltage ratings or energy/current ratings. When this happens, two options are available: varistors can be arranged in series or parallel to make up the desired ratings or a "special" can be requested from the manufacturer to meet the unique requirements of the application.

Series Operation of Varistors

Varistors are applied in series for one of two reasons: to provide voltage ratings higher than those available or to provide a voltage rating between the standard model voltages. As a side benefit, higher energy ratings can be achieved with series connected varistors over an equivalent single device. For instance, assume the application calls for a radial leaded varistor with a VDC rating of 75VDC and an I_{TM} peak current capability of 4000A. The designer would like to have the varistor size fixed at 14mm. When we examine the LV UltraMOV™ Varistor series voltage ratings for 14mm size discs, part number V14E35P has a maximum voltage of 45VDC. In order to support a 75VDC requirement, we will need to place two MOVs in series. In this basic example, we would have the additive effects of both varistors to get a total stand-off voltage of 45V + 45V = 90VDC. Therefore, we get greater than 20% tolerance headroom over 75VDC, so this solution should be okay. The clamping voltage (V_C) is now the sum of the individual varistor clamping voltages or 220V at 10A. The peak current capability is still 4000A because the surge current will be conducted through both varistors in series mode.

Parallel Operation of Varistors

Application requirements may necessitate higher peak currents and energy dissipation than the high energy series of varistors can supply individually. When this occurs, the logical alternative is to examine the possibility of configuring varistors in parallel. Fortunately, all Littelfuse varistors have a property at high current levels that makes this feasible. This property is the varistor's series resistance, which is prominent during the "upturn region" of the V-I characteristic. This upturn is due to the inherent linear resistance component of the varistor characteristic. It acts as a series balancing (or ballasting) impedance to force a degree of sharing that is not possible at lower current

For example, at a clamp voltage of 600V, the difference in current between a maximum specified sample unit and a hypothetical 20% lower bound sample would be more than 20 to 1. Therefore, there is almost no current sharing and only a single varistor carries the current. Of course, at low current levels in the range of 10A–100A, this may well be acceptable.

Series and Parallel Operation of Varistors (continued)

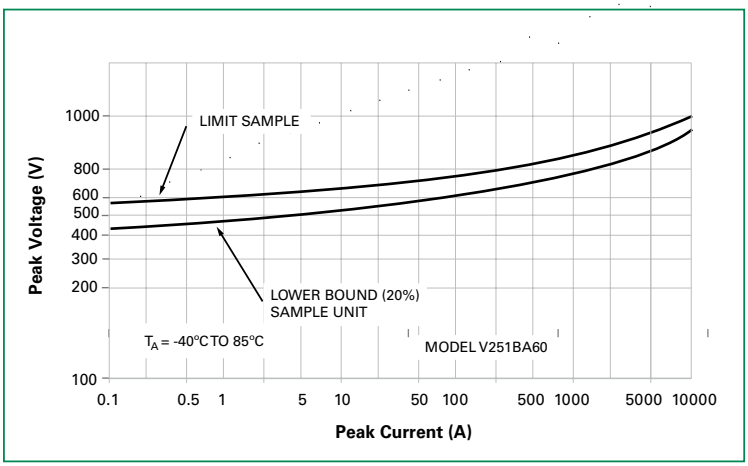


Figure 22. Parallel operation of varistors by graphical technique

With this technique, current sharing can be considerably improved from the near worst-case conditions of the hypothetical example given in the preceding figure.

In summary, varistors can be paralleled, but good current sharing is only possible if the devices are matched over the total range of the voltage-current characteristic.

In applications requiring paralleling, Littelfuse should be consulted. The following table offers some guidelines for series and parallel operation of varistors.

	Series	Parallel
Objective	Higher voltage capability. Higher energy capability. Non-standard voltage capability.	Higher current capability. Higher energy capability.
Selection Required	No	Yes
Model Applicable	All, must have same Itm rating.	All models
Application Range	All voltage and currents.	All voltages - only high currents, i.e., >100A.
Precautions	Itm ratings must be equal.	Must be identical voltage rated models. Must test and select units for similar V-I characteristics.
Effect on Ratings	Clamp voltages additive. Voltage ratings additive. Current ratings that of single device. Energy Wtm, ratings additive.	Current ratings function of current sharing as determined graphically. Energy ratings as above in proportion to current sharing. Clamp voltages determined by composite V-I characteristic of matched units. Voltage ratings that of single unit.

AUMOV® Varistor Series Specifications and Part Number Cross-References

Dimension	Vrms Voltage Model	5mm Size		7mm Size		10mm Size		14mm Size		20mm Size	
		Min. mm (in.)	Max. mm (in.)	Min. mm (in.)	Max. mm (in.)	Min. mm (in.)	Max. mm (in.)	Min. mm (in.)	Max. mm (in.)	Min. mm (in.)	Max. mm (in.)
A	All	-	10 (0.394)	-	12 (0.472)	-	16 (0.630)	-	20 (0.787)	-	26.5 (1.043)
A1	All	-	13 (0.512)	-	15 (0.591)	-	19.5 (0.768)	-	22.5 (0.886)	-	29 (1.142)
ØD	All	-	7 (0.276)	-	9 (0.354)	-	12.5 (0.492)	-	17 (0.669)	-	23 (0.906)
e	All	4 (0.157)	4 (0.157)	6 (0.236)	6 (0.236)	6.5 (0.256)	8.5 (0.335)	6.5 (0.256)	8.5 (0.335)	6.5 (0.256)	8.5 (0.335)
e1	11 - 30	1 (0.039)	3 (0.118)	1 (0.039)	3 (0.118)	1 (0.039)	3 (0.118)	1 (0.039)	3 (0.118)	1 (0.039)	3 (0.118)
	35 - 40	1.5 (0.059)	3.5 (0.138)	1.5 (0.059)	3.5 (0.138)	1.5 (0.059)	3.5 (0.138)	1.5 (0.059)	3.5 (0.138)	1.5 (0.059)	3.5 (0.138)
E	11 - 30	-	5.0 (0.197)	-	5.0 (0.197)	-	5.0 (0.197)	-	5.0 (0.197)	-	5.0 (0.197)
	35 - 40	-	5.6 (0.220)	-	5.6 (0.220)	-	5.6 (0.220)	-	5.6 (0.220)	-	5.6 (0.220)
Øb	All	0.585 (0.023)	0.685 (0.027)	0.585 (0.023)	0.685 (0.027)	0.76 (0.030)	0.86 (0.034)	0.76 (0.030)	0.86 (0.034)	0.76 (0.030)	0.86 (0.034)
L	All	25.4 (1.00)	-	25.4 (1.00)	-	-	25.4 (1.00)	-	25.4 (1.00)	-	25.4 (1.00)
Ltrim	All	2.41 (0.095)	4.69 (0.185)	2.41 (0.095)	4.69 (0.185)	2.41 (0.095)	4.69 (0.185)	2.41 (0.095)	4.69 (0.185)	2.41 (0.095)	4.69 (0.185)

AUMOV® Varistor Series Specifications and Part Number Cross-References (continued)

AUMOV® Varistor Series Part Number Cross-Reference

	Size Disc Dia. (mm)	Max. Continuous Voltage		Varistor Voltage at 1mA		Energy (Load Dump, 10 pulses (J)	Jump Start DC Vjump (5 min.) (V)	Littelfuse Auto Series				Supplier X			Supplier Z		
		Vrms (V)	Vdc (V)	Vv (1mA)	ΔVv (1mA) %			P/N (Max. Op. Temp. 85°C)	P/N (Max. Op. Temp. 125°C)	Max. Peak Current (8×20µs, 1 pulse (A)	Energy Rating (2ms, 1 pulse) (J)	P/N (SIOV-)	Surge Rating 8/20µs, 1× (A)	Energy Rating (2ms, 1 pulse) (J)	P/N (TVR-)	Surge Rating 8/20µs, 1× (A)	Energy Rating (2ms, 1 pulse) (J)
For 12VDC System	5	14	16	22	±10%	6	25	V05E14AUTO	V05P14AUTO	400	1						
	7	14	16	22	±10%	12	25	V07E14AUTO	V07P14AUTO	800	2.2	S07K11AUTO	250	0.9	TVR07220-Q	500	
	10	14	16	22	±10%	25	25	V10E14AUTO	V10P14AUTO	1500	5	S10K11AUTO	500	2	TVR10220-Q	1000	
	14	14	16	22	±10%	50	25	V14E14AUTO	V14P14AUTO	3000	10	S14K11AUTO	1000	4	TVR14220-Q	2000	
	20	14	16	22	±10%	100	25	V20E14AUTO	V20P14AUTO	5000	28	S17K11AUTO	2000	12	TVR20220-Q	3000	
	5	17	20	27	±10%	6	30	V05E17AUTO	V05P17AUTO	400	1.4						
	7	17	20	27	±10%	12	30	V07E17AUTO	V07P17AUTO	800	2.8						
	10	17	20	27	±10%	25	30	V10E17AUTO	V10P17AUTO	1500	6.5	S10K17AUTO	500	2.5	TVR10270-Q	1000	
	14	17	20	27	±10%	50	30	V17E17AUTO	V17P17AUTO	3000	13	S14K17AUTO	1000	5	TVR14270-Q	2000	
	20	17	20	27	±10%	100	30	V20E17AUTO	V20P17AUTO	5000	35	S20K17AUTO	2000	14	TVR20270-Q	3000	
For 24VDC System	5	25	28	39	±10%	6	40	V05E25AUTO	V05P25AUTO	400	2.5						
	7	25	28	39	±10%	12	40	V07E25AUTO	V07P25AUTO	800	5.5						
	10	25	28	39	±10%	25	40	V10E25AUTO	V10P25AUTO	1500	13						
	14	25	28	39	±10%	50	40	V25E25AUTO	V25P25AUTO	3000	25				TVR14390-Q	2000	
	20	25	28	39	±10%	100	40	V20E25AUTO	V20P25AUTO	5000	77	S20K25AUTO	2000	22	TVR20390-Q	3000	
	5	30	34	47	±10%	6	45	V05E30AUTO	V05P30AUTO	400	3.1						
	7	30	34	47	±10%	12	45	V07E30AUTO	V07P30AUTO	800	7						
	10	30	34	47	±10%	25	45	V10E30AUTO	V10P30AUTO	1500	15.5						
	14	30	34	47	±10%	50	45	V30E30AUTO	V30P30AUTO	3000	32	S05K30AUTO	1000	9	TVR14470-Q	2000	
	20	30	34	47	±10%	100	45	V20E30AUTO	V20P30AUTO	5000	90	S07K30AUTO	2000	26	TVR20170-Q	3000	
For 48VDC System	5	42	50	68	±10%	6	50	V05E42AUTO	V05P42AUTO	400	5						
	7	42	50	68	±10%	12	50	V07E42AUTO	V07P42AUTO	800	11	S07K42AUTO		3			
	10	42	50	68	±10%	25	50	V10E42AUTO	V10P42AUTO	1500	25	S10K42AUTO		6.4	TVR10680-Q	1000	
	14	42	50	68	±10%	50	50	V42E42AUTO	V42P42AUTO	3000	50	S14K42AUTO		13	TVR14680-Q	2000	
	20	42	50	68	±10%	100	50	V20E42AUTO	V20P42AUTO	5000	140	S20K42AUTO		37	TVR20680-Q	3000	

LV UltraMOV™ Varistor Series Specifications and Part Number Cross-References

The following excerpt is from the LV UltraMOV™ Varistor Series datasheet. There is also a comparison of specifications for the LV UltraMOV™ Varistor Series vs. the Littelfuse ZA Series and another well-known MOV supplier.

Model Number		Size (mm)	Max. Continuous Voltage		Varistor Voltage at 1mA			Max. Clamping Voltage		Max. Peak Current (8×20μs, 1 pulse) (A)	Energy Rating (2ms, 1pulse) (J)	Typical Capacitance f=1MHz (pF)
Part Number (Base part)	Branding		Vrms (V)	Vdc (V)	Min (V)	Nom (V)	Max (V)	Vc (V)	Ipk (A)			
V05E17	5E17	5	17	22	24.3	27.0	29.7	53	1	500	1.4	950
V07E17	7E17	7	17	22	24.3	27.0	29.7	53	2.5	1000	2.8	2100
V10E40	10E40	10	40	56	61.2	68.0	74.8	135	5	2000	25	1850
V14E40	14E40	14	40	56	61.2	68.0	74.8	135	10	4000	50	4000
V20E40	20E40	20	40	56	61.2	68.0	74.8	135	20	8000	140	8500

			Supplier X Standard Series		Littelfuse ZA Series	Littelfuse LV UltraMOV™ Varistor Series	
Diameter (mm)	Vrms (V)	Vdc (V)	Imax (8/20)(A)	Wmax (2ms)(J)	Imax (8/20)(A)	Imax (8/20)(A)	Wmax (2ms)(J)
5	11~40	14~56	100	0.3~1.3	100	500	0.8~5
7	11~40	14~56	250	0.8~3.0	250	1000	2~11
10	11~40	14~56	500	1.7~6.4	500	2000	42~25
14	11~40	14~56	1000	3.2~13	1000	4000	8~50
20	11~40	14~56	2000	10~37	2000	8000	25~140

			Supplier X Standard Series		Littelfuse ZA Series	Littelfuse LV UltraMOV™ Varistor Series	
Diameter (mm)	Vrms (V)	Vdc (V)	Imax (8/20)(A)	Wmax (2ms)(J)	Imax (8/20)(A)	Imax (8/20)(A)	Wmax (2ms)(J)
5	50~95	65~125	400	1.8~3.4	400	800	5~9
7	50~95	65~125	1200	4.2~7.6	1200	1750	10~18
10	50~95	65~125	2500	8.4~15	2500	3500	20~36
14	50~95	65~125	4500	15~25	4500	6500	40~75
20	50~95	65~125	6500	27~50	6500	10000	80~150

LV UltraMOV™ Varistor Series Specifications and Part Number Cross-References (continued)

LV UltraMOV™ Varistor Series Part Number Cross-Reference

			Supplier X Standard Series			Supplier Y Standard Series			Littelfuse LV UltraMOV™ Varistor Series			
Diameter (mm)	Vrms (V)	Vdc (V)	P/N (SIOV-)	Imax (8/20) (A)	Wmax (2ms)(J)	P/N (ERZV-)	Imax (8/20) (A)	Wmax (2ms)(J)	P/N (Max. Op. Temp. 85°C)	P/N (Max. Op. Temp. 125°C)	Imax (8/20) (A)	Wmax (2ms)(J)
5	11	14	S05K11	100	0.3	ERZV05D180	250	0.4	V05E11P	V05P11P	500	0.8
7	11	14	S07K11	250	0.8	ERZV07D180	500	0.9	V07E11P	V07P11P	1000	2.0
10	11	14	S10K11	500	1.7	ERZV10D180	1000	2.2	V10E11P	V10P11P	2000	4.2
14	11	14	S14K11	1000	3.2	ERZV14D180	2000	4.3	V14E11P	V14P11P	4000	8
20	11	14	S20K11	2000	10	ERZV20D180	3000	12	V20E11P	V20P11P	8000	25
5	14	18	S05K14	100	0.4	ERZV05D220	250	0.5	V05E14P	V05P14P	500	1
7	14	18	S07K14	250	0.9	ERZV07D220	500	1.1	V07E14P	V07P14P	1000	2.2
10	14	18	S10K14	500	2	ERZV10D220	1000	2.6	V10E14P	V10P14P	2000	5
14	14	18	S14K14	1000	4	ERZV14D220	2000	5.3	V14E14P	V14P14P	4000	10
20	14	18	S20K14	2000	12	ERZV20D220	3000	14	V20E14P	V20P14P	8000	28
5	17	22	S05K17	100	0.5	ERZV05D270	250	0.7	V05E17P	V05P17P	500	1.4
7	17	22	S07K17	250	1.1	ERZV07D270	500	1.3	V07E17P	V07P17P	1000	2.8
10	17	22	S10K17	500	2.5	ERZV10D270	1000	3.2	V10E17P	V10P17P	2000	6.5
14	17	22	S14K17	1000	5	ERZV14D270	2000	6.5	V14E17P	V14P17P	4000	13
20	17	22	S20K17	2000	14	ERZV20D270	3000	17	V20E17P	V20P17P	8000	35
5	20	26	S05K20	100	0.6	ERZV05D330	250	0.8	V05E20P	V05P20P	500	2
7	20	26	S07K20	250	1.3	ERZV07D330	500	1.6	V07E20P	V07P20P	1000	4.2
10	20	26	S10K20	500	3.1	ERZV10D330	1000	4	V10E20P	V10P20P	2000	10
14	20	26	S14K20	1000	6	ERZV14D330	2000	7.9	V14E20P	V14P20P	4000	20
20	20	26	S20K20	2000	18	ERZV20D330	3000	21	V20E20P	V20P20P	8000	58
5	23	28	-						V05E23P	V05P23P	500	2.2
7	23	28	-						V07E23P	V07P23P	1000	5
10	23	28	-						V10E23P	V10P23P	2000	12
14	23	28	-						V14E23P	V14P23P	4000	23
20	23	28	-						V20E23P	V20P23P	8000	70
5	25	31	S05K25	100	0.7	ERZV05D390	250	0.9	V05E25P	V05P25P	500	2.5
7	25	31	S07K25	250	1.6	ERZV07D390	500	1.9	V07E25P	V07P25P	1000	5.5
10	25	31	S10K25	500	3.7	ERZV10D390	1000	4.7	V10E25P	V10P25P	2000	13
14	25	31	S14K25	1000	7	ERZV14D390	2000	9.4	V14E25P	V14P25P	4000	25
20	25	31	S20K25	2000	22	ERZV20D390	3000	25	V20E25P	V20P25P	8000	77
5	30	38	S05K30	100	0.9	ERZV05D470	250	1.1	V05E30P	V05P30P	500	3.1
7	30	38	S07K30	250	2	ERZV07D470	500	2.3	V07E30P	V07P30P	1000	7
10	30	38	S10K30	500	4.4	ERZV10D470	1000	5.6	V10E30P	V10P30P	2000	15.5
14	30	38	S14K30	1000	9	ERZV14D470	2000	11	V14E30P	V14P30P	4000	32
20	30	38	S20K30	2000	26	ERZV20D470	3000	30	V20E30P	V20P30P	8000	90
5	35	45	S05K35	100	1.1	ERZV05D560	250	1.3	V05E35P	V05P35P	500	4
7	35	45	S07K35	250	2.5	ERZV07D560	500	2.7	V07E35P	V07P35P	1000	9
10	35	45	S10K35	500	5.4	ERZV10D560	1000	6.7	V10E35P	V10P35P	2000	20
14	35	45	S14K35	1000	10	ERZV14D560	2000	13	V14E35P	V14P35P	4000	40
20	35	45	S20K35	2000	33	ERZV20D560	3000	36	V20E35P	V20P35P	8000	115
5	40	56	S05K40	100	1.3	ERZV05D680	250	1.6	V05E40P	V05P40P	500	5
7	40	56	S07K40	250	3	ERZV07D680	500	3.3	V07E40P	V07P40P	1000	11
10	40	56	S10K40	500	6.4	ERZV10D680	1000	8.2	V10E40P	V10P40P	2000	25
14	40	56	S14K40	1000	13	ERZV14D680	2000	16	V14E40P	V14P40P	4000	50
20	40	56	S20K40	2000	37	ERZV20D680	3000	44	V20E40P	V20P40P	8000	140

LV UltraMOV™ Varistor Series Specifications and Part Number Cross-References (continued)

LV UltraMOV™ Varistor Series Part Number Cross-Reference (continued)

			Supplier X Standard Series			Supplier Y Standard Series			Littelfuse LV UltraMOV™ Varistor Series			
Diameter (mm)	Vrms (V)	Vdc (V)	P/N (SIOV-)	Imax (8/20) (A)	Wmax (2ms)(J)	P/N (ERZV-)	Imax (8/20) (A)	Wmax (2ms)(J)	P/N (Max. Op. Temp. 85°C)	P/N (Max. Op. Temp. 125°C)	Imax (8/20) (A)	Wmax (2ms)(J)
5	50	65	S05K50	400	1.8	ERZV05D820	800	2.5	V05E50P	V05P50P	800	5
7	50	65	S07K50	1200	4.2	ERZV07D820	1750	5	V07E50P	V07P50P	1750	10
10	50	65	S10K50	2500	8.4	ERZV10D820	3500	10	V10E50P	V10P50P	3500	20
14	50	65	S14K50	4500	15.0	ERZV14D820	6000	20	V14E50P	V14P50P	6500	40
20	50	65	S20K50	6500	27	ERZV20D820	10000	40	V20E50P	V20P50P	10000	80
5	60	85	S05K60	400	2.2	ERZV05D101	800	3	V05E60P	V05P60P	800	6
7	60	85	S07K60	1200	4.8	ERZV07D101	1750	6	V07E60P	V07P60P	1750	12
10	60	85	S10K60	2500	10	ERZV10D101	3500	12	V10E60P	V10P60P	3500	24
14	60	85	S14K60	4500	17	ERZV14D101	6000	25	V14E60P	V14P60P	6500	50
20	60	85	S20K60	6500	33	ERZV20D101	10000	50	V20E60P	V20P60P	10000	100
5	75	100	S05K75	400	2.5	ERZV05D121	800	3.5	V05E75P	V05P75P	800	7
7	75	100	S07K75	1200	5.9	ERZV07D121	1750	7	V07E75P	V07P75P	1750	14
10	75	100	S10K75	2500	12	ERZV10D121	3500	14.5	V10E75P	V10P75P	3500	29
14	75	100	S14K75	4500	20	ERZV14D121	6000	30	V14E75P	V14P75P	6500	60
20	75	100	S20K75	6500	40	ERZV20D121	10000	60	V20E75P	V20P75P	10000	120
5	95	125	S05K95	400	3.4	ERZV05D151	800	4.5	V05E95P	V05P95P	800	9
7	95	125	S07K95	1200	7.6	ERZV07D151	1750	9	V07E95P	V07P95P	1750	18
10	95	125	S10K95	2500	15	ERZV10D151	3500	18	V10E95P	V10P95P	3500	36
14	95	125	S14K95	4500	25	ERZV14D151	6000	37.5	V14E95P	V14P95P	6500	75
20	95	125	S20K95	6500	50	ERZV20D151	10000	75	V20E95P	V20P95P	10000	150

LV UltraMOV™ Varistor Series Specifications and Part Number Cross-References (continued)

LV UltraMOV™ Varistor Series Cross-Reference (by I_{TM})

			Supplier X Standard Series			Supplier Y Standard Series			Littelfuse LV UltraMOV™ Varistor Series			
Imax (8/20) (A)	Vrms (V)	Vdc (V)	Diam. (mm)	P/N (SIOV-)	Wmax (2ms) (J)	Diam. (mm)	P/N (ERZV-)	Wmax (2ms)(J)	Diam. (mm)	P/N (Max. Op. Temp. 85°C)	P/N (Max. Op. Temp. 125°C)	Wmax (2ms) (J)
100	11	14	5	S05K11	0.3							
	14	18		S05K14	0.4							
	17	22		S05K17	0.5							
	20	26		S05K20	0.6							
	25	31		S05K25	0.7							
	30	38		S05K30	0.9							
	35	45		S05K35	1.1							
	40	56		S05K40	1.3							
250	11	14	7	S07K11	0.8	5	ERZV05D180	0.4				
	14	18		S07K14	0.9		ERZV05D220	0.5				
	17	22		S07K17	1.1		ERZV05D270	0.7				
	20	26		S07K20	1.3		ERZV05D330	0.8				
	25	31		S07K25	1.6		ERZV05D390	0.9				
	30	38		S07K30	2		ERZV05D470	1.1				
	35	45		S07K35	2.5		ERZV05D560	1.3				
	40	56		S07K40	3		ERZV05D680	1.6				
500	11	14	10	S10K11	1.7	7	ERZV07D180	0.9	5	V05E11P	V05P11P	0.8
	14	18		S10K14	2		ERZV07D220	1.1		V05E14P	V05P14P	1
	17	22		S10K17	2.5		ERZV07D270	1.3		V05E17P	V05P17P	1.4
	20	26		S10K20	3.1		ERZV07D330	1.6		V05E20P	V05P20P	2
	23	28		-			-			V05E23P	V05P23P	2.2
	25	31		S10K25	3.7		ERZV07D390	1.9		V05E25P	V05P25P	2.5
	30	38		S10K30	4.4		ERZV07D470	2.3		V05E30P	V05P30P	3.1
	35	45		S10K35	5.4		ERZV07D560	2.7		V05E35P	V05P35P	4
	40	56		S10K40	6.4		ERZV07D680	3.3		V05E40P	V05P40P	5
1000	11	14	14	S14K11	3.2	10	ERZV10D180	2.2	7	V07E11P	V07P11P	2
	14	18		S14K14	4		ERZV10D220	2.6		V07E14P	V07P14P	2.2
	17	22		S14K17	5		ERZV10D270	3.2		V07E17P	V07P17P	2.8
	20	26		S14K20	6		ERZV10D330	4		V07E20P	V07P20P	4.2
	23	28		-			-			V07E23P	V07P23P	5
	25	31		S14K25	7		ERZV10D390	4.7		V07E25P	V07P25P	5.5
	30	38		S14K30	9		ERZV10D470	5.6		V07E30P	V07P30P	7
	35	45		S14K35	10		ERZV10D560	6.7		V07E35P	V07P35P	9
	40	56		S14K40	13		ERZV10D680	8.2		V07E40P	V07P40P	11
6500	50	65	20	S20K50	27				14	V14E50P	V14P50P	40
	60	85		S20K60	33					V14E60P	V14P60P	50
	75	100		S20K75	40					V14E75P	V14P75P	60
	95	125		S20K95	50					V14E95P	V14P95P	75

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