Table of Contents

Table of Contents

Littelfuse®

Table of Contents

Littelfuse®

Table of Contents

RoHS European Union Directive 2002/95/EC Restriction of the use of Hazardous Substances(RoHS), restricts the use of Lead, Mercury, Hexavalent Chromium, Cadmium and Polybrominated Ethers (PBB's and PBDE's).

Pb Littelfuse defines lead-free as products which contain less than 1000ppm (0.1%) Lead, measured by weight of the entire product.

Introduction To Circuit Protection

Fuse Facts

The application guidelines and product data in this guide are intended to provide technical information that will help with application design. Since these are only a few of the contributing parameters, application testing is strongly recommended and should be used to verify performance in the circuit/application. In the absence of special requirements, Littelfuse reserves the right to make appropriate changes in design, process, and manufacturing location without notice.

The purpose of the Fuseology Section is to promote a better understanding of both fuses and common application details. The fuses to be considered are current sensitive devices which are designed as the intentional weak link in the electrical circuit. The function of the fuse is to provide protection of discrete components, or of complete circuits, by reliably melting under current overload conditions. This fuseology section will cover some important facts about fuses, selection considerations, and standards.

FUSE FACTS

The following fuse parameters or application concepts should be well understood in order to properly select a fuse for a given application.

AMBIENT TEMPERATURE: Refers to the temperature of the air immediately surrounding the fuse and is not to be confused with "room temperature." The fuse ambient temperature is appreciably higher in many cases, because it is enclosed (as in a panel mount fuseholder) or mounted near other heat producing components, such as resistors, transformers, etc.

BREAKING CAPACITY: See Interrupting Rating.

CURRENT RATING: The nominal amperage value of the fuse. It is established by the manufacturer as a value of current which the fuse can carry, based on a controlled set of test conditions (See RERATING).

Catalog Fuse part numbers include series identification and amperage ratings. Refer to the FUSE SELECTION GUIDE section for guidance on making the proper choice.

RERATING: For 25°C ambient temperatures, it is recommended that fuses be operated at no more than 75% of the nominal current rating established using the controlled test conditions. These test conditions are part of UL/CSA/ANCE (Mexico) 248-14 "Fuses for Supplementary Overcurrent Protection," whose primary objective is to specify common test standards necessary for the continued control of manufactured items intended for protection against fire, etc. Some common variations of these standards include: fully enclosed fuseholders, high contact resistances, air movement, transient spikes, and changes in connecting cable size (diameter and length). Fuses are essentially temperature-sensitive devices. Even small variations from the controlled test conditions can greatly affect the predicted life of a fuse when it is loaded to its nominal value, usually expressed as 100% of rating.

The circuit design engineer should clearly understand that the purpose of these controlled test conditions is to enable fuse manufacturers to maintain unified performance standards for their products, and he must account for the variable conditions of his application. To compensate for these variables, the circuit design engineer who is designing for trouble-free, long-life fuse protection in his equipment generally loads his fuse not more than 75% of the nominal rating listed by the manufacturer, keeping in mind that overload and short circuit protection must be adequately provided for.

The fuses under discussion are temperature-sensitive devices whose ratings have been established in a 25°C ambient. The fuse temperature generated by the current passing through the fuse increases or decreases with ambient temperature change.

The ambient temperature chart in the FUSE SELECTION GUIDE section illustrates the effect that ambient temperature has on the nominal current rating of a fuse. Most traditional Slo-Blo® Fuse designs use lower melting temperature materials and are, therefore, more sensitive to ambient temperature changes.

DIMENSIONS: Unless otherwise specified, dimensions are in inches.

The fuses in this catalog range in size from the approx. 0402 chip size (.041"L x .020"W x .012"H) up to the 5 AG, also commonly known as a"MIDGET" fuse (13/32" Dia. x 11/2" Length). As new products were developed throughout the years, fuse sizes evolved to fill the various electrical circuit protection needs. The first fuses were simple, open-wire devices, followed in the 1890's by Edison's enclosure of thin wire in a lamp base to make the first plug fuse. By 1904, Underwriters Laboratories had established size and rating specifications to meet safety standards. The renewable type fuses and automotive fuses appeared in 1914, and in 1927 Littelfuse started making very low amperage fuses for the budding electronics industry.

The fuse sizes in the chart below began with the early "Automobile Glass" fuses, thus the term "AG". The numbers were applied chronologically as different manufacturers started making a new size: "3AG," for example, was the third size placed on the market. Other non-glass fuse sizes and constructions were determined by functional requirements, but they still retained the length or diameter dimensions of the glass fuses. Their designation was modified to AB in place of AG, indicating that the outer tube was constructed from Bakelite, fibre, ceramic, or a similar material other than glass. The largest size fuse shown in the chart is the 5AG, or "MIDGET," a name adopted from its use by the electrical industry and the National Electrical Code range which normally recognizes fuses of 9/16" x 2" as the smallest standard fuse in use.

FUSE SIZES				
SIZE	DIAMETER (Inches)		LENGTH (Inches)	
1AG	1/4	.250	5/8	.625
2AG	—	.177	—	.588
3AG	1/4	.250	1 1/4	1.25
4AG	9/32	.281	1 1/4	1.25
5AG	13/32	.406	1 1/2	1.50
7AG	1/4	.250	7/8	.875
8AG	1/4	.250	1	1

TOLERANCES: The dimensions shown in this catalog are nominal. Unless otherwise specified, tolerances are applied as follows:

± .010" for dimensions to 2 decimal places.
± .005" for dimensions to 3 decimal places.

The factory should be contacted concerning metric system and fractional tolerances. Tolerances do not apply to lead lengths.

FUSE CHARACTERISTICS: The characteristic of a fuse design refers to how rapidly the fuse responds to various current overloads. Fuse characteristics can be classified into three general categories: very fast-acting, fast-acting, or Slo-Blo® Fuse. The distinguishing feature of Slo-Blo® fuses is that these fuses have additional thermal inertia designed to tolerate normal initial or start-up overload pulses.

FUSE CONSTRUCTION: Internal construction may vary depending on ampere rating. Fuse photos in this catalog show typical construction of a particular ampere rating within the fuse series.

Fuse Facts

FUSEHOLDERS: In many applications, fuses are installed in fuseholders. These fuses and their associated fuseholders are not intended for operation as a “switch” for turning power “on” and “off ”.

INTERRUPTING RATING: Also known as breaking capacity or short circuit rating, the interrupting rating is the maximum approved current which the fuse can safely interrupt at rated voltage. During a fault or short circuit condition, a fuse may receive an instantaneous overload current many times greater than its normal operating current. Safe operation requires that the fuse remain intact (no explosion or body rupture) and clear the circuit.

Interrupting ratings may vary with fuse design and range from 35 amperes AC for some 250V metric size (5 x 20mm) fuses up to 200,000 amperes AC for the 600V KLK series. Information on other fuse series can be obtained from the factory.

Fuses listed in accordance with UL/CSA/ANCE 248 are required to have an interrupting rating of 10,000 amperes, with some exceptions (See STANDARDS section) which, in many applications, provides a safety factor far in excess of the short circuit currents available.

NUISANCE OPENING: Nuisance opening is most often caused by an incomplete analysis of the circuit under consideration. Of all the “Selection Factors” listed in the FUSE SELECTION GUIDE, special attention must be given to items 1, 3, and 6, namely, normal operating current, ambient temperature, and pulses. For example, one prevalent cause of nuisance opening in conventional power supplies is the failure to adequately consider the fuse’s nominal melting I^2t rating. The fuse cannot be selected solely on the basis of normal operating current and ambient temperature. In this application, the fuse’s nominal melting I^2t rating must also meet the inrush current requirements created by the input capacitor of the power supply’s smoothing filter. The procedure for converting various waveforms into I^2t circuit demand is given in the FUSE SELECTION GUIDE. For trouble-free, long-life fuse protection, it is good design practice to select a fuse such that the I^2t of the waveform is no more than 20% of the nominal melting I^2t rating of the fuse. Refer to the section on PULSES in the FUSE SELECTION GUIDE.

RESISTANCE: The resistance of a fuse is usually an insignificant part of the total circuit resistance. Since the resistance of fractional amperage fuses can be several ohms, this fact should be considered when using them in low-voltage circuits. Actual values can be obtained from the factory. Most fuses are manufactured from materials which have positive temperature coefficients, and, therefore, it is common to refer to cold resistance and hot resistance (voltage drop at rated current), with actual operation being somewhere in between. Cold resistance is the resistance obtained using a measuring current of no more than 10% of the fuse’s nominal rated current. Values shown in this publication for cold resistance are nominal and representative. The factory should be consulted if this parameter is critical to the design analysis. Hot resistance is the resistance calculated from the stabilized voltage drop across the fuse, with current equal to the nominal rated current flowing through it. Resistance data on all Littelfuse products are available on request. Fuses can be supplied to specified controlled resistance tolerances at additional cost.

SOLDERING RECOMMENDATIONS: Since most fuse constructions incorporate soldered connections, caution should be used when installing those fuses intended to be soldered in place. The application of excessive heat can reflow the solder within the fuse and change its rating. Fuses are heat-sensitive components similar to semi-conductors, and the use of heat sinks during soldering is often recommended.

TEST SAMPLING PLAN: Because compliance with certain specifications requires destructive testing, these tests are selected on a statistical basis for each lot manufactured.

TIME-CURRENT CURVE: The graphical presentation of the fusing characteristic, time-current curves are generally average curves which are presented as a design aid but are not generally considered part of the fuse specification. Time-current curves are extremely useful in defining a fuse, since fuses with the same current rating can be represented by considerably different time-current curves. The fuse specification typically will include a life requirement at 100% of rating and maximum opening times at overload points (usually 135% and 200% of rating). A time-current curve represents average data for the design; however, there may be some differences in the values for any one given production lot. Samples should be tested to verify performance, once the fuse has been selected.

UNDERWRITERS LABORATORIES: Reference to “Listed by Underwriters Laboratories” signifies that the fuses meet the requirements of UL/CSA/ANCE 248-14 “Fuses for Supplementary Overcurrent Protection”. Some 32 volt fuses (automotive) in this catalog are listed under UL Standard 275. Reference to “Recognized under the Component Program of Underwriters Laboratories” signifies that the item is recognized under the component program of Underwriters Laboratories and application approval is required.

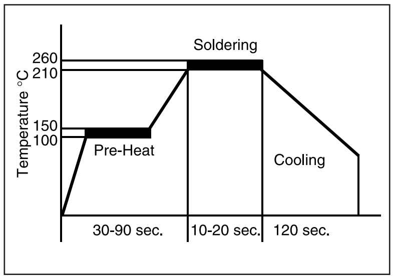
VOLTAGE RATING: The voltage rating, as marked on a fuse, indicates that the fuse can be relied upon to safely interrupt its rated short circuit current in a circuit where the voltage is equal to, or less than, its rated voltage. This system of voltage rating is covered by N.E.C. regulations and is a requirement of Underwriters Laboratories as a protection against fire risk. The standard voltage ratings used by fuse manufacturers for most small-dimension and midget fuses are 32, 63, 125, 250 and 600.

In electronic equipment with relatively low output power supplies, with circuit impedance limiting short circuit currents to values of less than ten times the current rating of the fuse, it is common practice to specify fuses with 125 or 250 volt ratings for secondary circuit protection of 500 volts or higher.

As mentioned previously (See RERATING), fuses are sensitive to changes in current, not voltage, maintaining their “status quo” at any voltage from zero to the maximum rating of the fuse. It is not until the fuse element melts and arcing occurs that the circuit voltage and available power become an issue. The safe interruption of the circuit, as it relates to circuit voltage and available power, is discussed in the section on INTERRUPTING RATING.

To summarize, a fuse may be used at any voltage that is less than its voltage rating without detriment to its fusing characteristics. Please contact the factory for applications at voltages greater than the voltage rating.

Lead-Free Soldering Parameters:
Wave Solder —
260°C, 10 seconds max
Reflow Solder —
260°C, 30 seconds max



1 INTRODUCTION TO CIRCUIT PROTECTION

Fuse Facts and Fuse Selection Guide

DERIVATION OF NOMINAL MELTING I²t: Laboratory tests are conducted on each fuse design to determine the amount of energy required to melt the fusing element. This energy is described as nominal melting I^2t and is expressed as "Ampere Squared Seconds" (A^2 Sec.). A pulse of current is applied to the fuse, and a time measurement is taken for melting to occur. If melting does not occur within a short duration of about 8 milliseconds (0.008 seconds) or less, the level of pulse current is increased. This test procedure is repeated until melting of the fuse element is confined to within about 8 milliseconds. The purpose of this procedure is to assure that the heat created has insufficient time to thermally conduct away from the fuse element. That is, all of the heat energy (I^2t) is used, to cause melting. Once the measurements of current (I) and time (t) are determined, it is a simple matter to calculate melting I^2t. When the melting phase reaches completion, an electrical arc occurs immediately prior to the "opening" of the fuse element. Clearing I^2t = Melting I^2t + arcing I^2t. The nominal I^2t values given in this publication pertain to the melting phase portion of the "clearing" or "opening".

FUSE SELECTION GUIDE

The application guidelines and product data in this guide are intended to provide technical information that will help with application design. Since these are only a few of the contributing parameters, application testing is strongly recommended and should be used to verify performance in the circuit/application.

Many of the factors involved with fuse selection are listed below:

Selection Factors

1. Normal operating current
2. Application voltage (AC or DC)
3. Ambient temperature
4. Overload current and length of time in which the fuse must open.
5. Maximum available fault current
6. Pulses, Surge Currents, Inrush Currents, Start-up Currents, and Circuit Transients
7. Physical size limitations, such as length, diameter, or height
8. Agency Approvals required, such as UL, CSA, VDE, METI, MITI or Military
9. Considerations: mounting type/form factor, ease of removal, axial leads, visual indication, etc.
10. Fuseholder features: clips, mounting block, panel mount, p.c. board mount, R.F.I. shielded, etc.

NORMAL OPERATING CURRENT: The current rating of a fuse is typically derated 25% for operation at 25°C to avoid nuisance blowing. For example, a fuse with a current rating of 10A is not usually recommended for operation at more than 7.5A in a 25°C ambient. For additional details, see RERATING in the previous section and AMBIENT TEMPERATURE below.

VOLTAGE: The voltage rating of the fuse must be equal to, or greater than, the available circuit voltage. For exceptions, see VOLTAGE RATING.

AMBIENT TEMPERATURE: The current carrying capacity tests of fuses are performed at 25°C and will be affected by changes in ambient temperature. The higher the ambient temperature, the hotter the fuse will operate, and the shorter its life will be. Conversely, operating at a lower temperature will prolong fuse life. A fuse also runs hotter as the normal operating current approaches or exceeds the rating of the selected fuse. Practical experience indicates fuses at **room temperature** should last indefinitely, if operated at no more than 75% of catalog fuse rating.

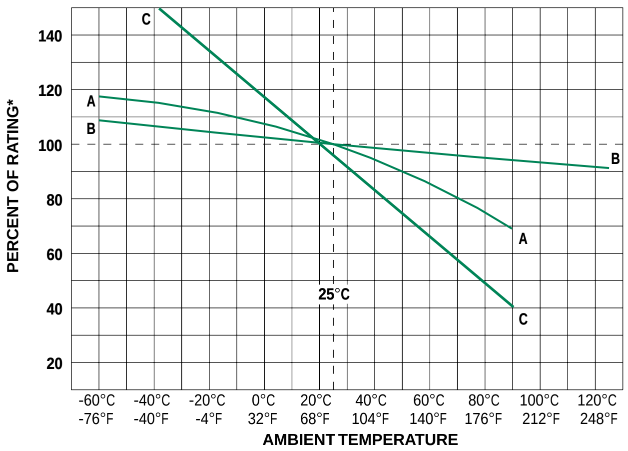
CHART SHOWING EFFECT OF AMBIENT TEMPERATURE ON CURRENT-CARRYING CAPACITY (TYPICAL)

KEY TO CHART:

Curve A: Thin-Film Fuses and 313 Series (.010 to .150A)

Curve B: FLAT-PAK®, TeleLink®, Nano²®, PICO®, Blade Terminal and special purpose and other Leaded and catridge fuses (except 313.010-.150A)

Curve C: Resettable PTC's



*Ambient temperature effects are in addition to the normal rerating, see example.

Example: Given a normal operating current of 2.25 amperes in an application using a 229 series fuse at room temperature, then:

$$\text{Catalog Fuse Rating} = \frac{\text{Normal Operating Current}}{0.75}$$

or

$$\frac{2.25 \text{ Amperes}}{0.75} = 3 \text{ Amp Fuse (at 25°C)}$$

Fuse Selection Guide

Similarly, if that same fuse were operated at a very high ambient temperature of 80°C, additional derating would be necessary. Curve "B" of the ambient temperature chart shows the maximum operating "Percent of Rating" at 80°C to be 95%, in which case;

$$\text{Catalog Fuse Rating} = \frac{\text{Nominal Operating Current}}{0.75 \times \text{Percent of Rating}}$$

or

$$\frac{2.25 \text{ Amperes}}{0.75 \times 0.95} = 3.15 \text{ Amp Fuse (at 80°C)}$$

OVERLOAD CURRENT CONDITION: The current level for which protection is required. Fault conditions may be specified, either in terms of current or, in terms of both current and maximum time the fault can be tolerated before damage occurs. Time-current curves should be consulted to try to match the fuse characteristic to the circuit needs, while keeping in mind that the curves are based on average data.

MAXIMUM FAULT CURRENT: The Interrupting Rating of a fuse must meet or exceed the Maximum Fault Current of the circuit.

PULSES: The general term "pulses" is used in this context to describe the broad category of wave shapes referred to as "surge currents", "start-up currents", "inrush currents", and "transients". Electrical pulse conditions can vary considerably from one application to another. Different fuse constructions may not react the same to a given pulse condition. Electrical pulses produce thermal cycling and possible mechanical fatigue that could affect the life of the fuse. Initial or start-up pulses are normal for some applications and require the characteristic of a Slo-Blo® fuse. Slo-Blo® fuses incorporate a thermal delay design to enable them to survive normal start-up pulses and still provide protection against prolonged overloads. The start-up pulse should be defined and then compared to the time-current curve and I^2t rating for the fuse. Application testing is recommended to establish the ability of the fuse design to withstand the pulse conditions.

Nominal melting I^2t is a measure of the energy required to melt the fusing element and is expressed as "Ampere Squared Seconds" (A^2 Sec.). This nominal melting I^2t, and the energy it represents (within a time duration of 8 milliseconds [0.008 second] or less and 1 millisecond [0.001 second] or less for thin film fuses), is a value that is constant for each different fusing element. Because every fuse type and rating, as well as its corresponding part number, has a different fusing element, it is necessary to determine the I^2t for each. This I^2t value is a parameter of the fuse itself and is controlled by the element material and the configuration of the fuse element. In addition to selecting fuses on the basis of "Normal Operating Currents", "Rerating", and "Ambient Temperature" as discussed earlier, it is also necessary to apply the I^2t design approach. This nominal melting I^2t is not only a constant value for each fuse element design, but it is also independent of temperature and voltage. Most often, the nominal melting I^2t method of fuse selection is applied to those applications in which the fuse must sustain large current pulses of a short duration. These high-energy currents are common in many applications and are described by a variety of terms, such as "surge current", "start-up current", "inrush current", and other similar circuit "transients" that can be classified in the general category of "pulses." Laboratory tests are conducted on each fuse design to determine its nominal melting I^2t rating. The values for I^2t given in this publication are nominal and representative. The factory should be consulted if this parameter is critical to the design analysis.

The following example should assist in providing a better understanding of the application of I^2t.

EXAMPLE: Select a 125V, very fast-acting PICO®II fuse that is capable of withstanding 100,000 pulses of current (I) of the pulse waveform shown in Figure 1. The normal operating current is 0.75 ampere at an ambient temperature of 25°C.

Step 1 — Refer to Chart I (page #6) and select the appropriate pulse waveform, which is waveform (E) in this example. Place the applicable value for peak pulse current (i_p) and time (t) into the corresponding formula for waveshape (E), and calculate the result, as shown:

$$I^2t = \frac{1}{5}(i_p) = I^2t = \frac{1}{5}(ip)^2t$$

$$\frac{1}{5} \times 8^2 \times .004 = 0.0512 \ A^2 \text{ Sec.}$$

This value is referred to as the "Pulse I^2t".

Step 2 — Determine the required value of Nominal Melting I^2t by referring to Chart II (page 6). A figure of 22% is shown in Chart II for 100,000 occurrences of the Pulse I^2t calculated in Step 1. This Pulse I^2t is converted to its required value of Nominal Melting I^2t as follows:

Nom. Melt I^2t = Pulse I^2t/.22
= 0.0512/.22 = 0.2327 A^2 Sec.

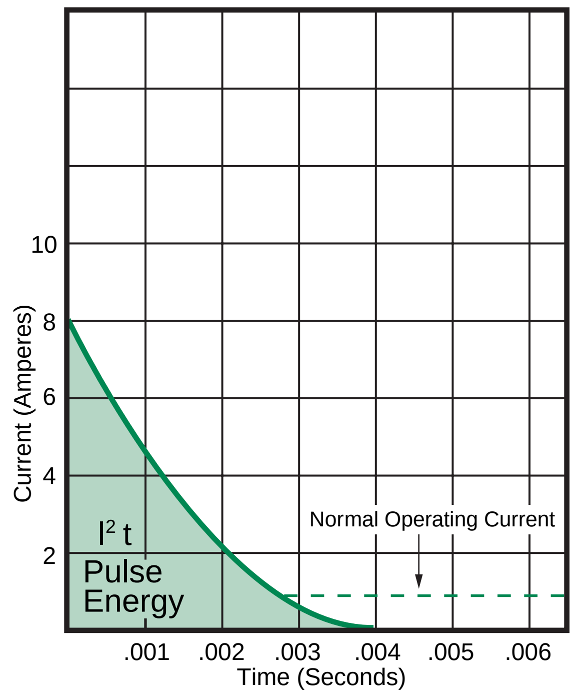
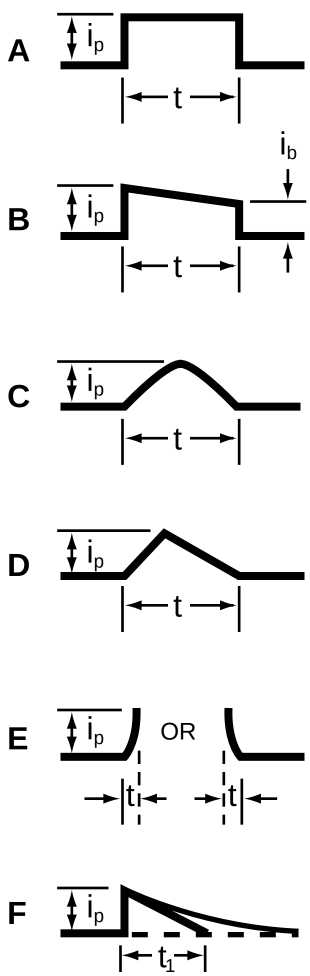


Figure 1

Fuse Selection Guide

CHART I



WAVESHAPES	FORMULAS
A	$i = k$ $I^2t = i_p^2 t$
B	$i = i_p - kt$ $I^2t = (1/3)(i_p^2 + i_p i_b + i_b^2)t$
C	$i = i_p \sin t$ $I^2t = (1/2) i_p^2 t$
D	$I^2t = (1/3) i_p^2 t$
E	$i = kt^2$ OR $i = i_p(1-kt)^2$ $I^2t = (1/5) i_p^2 t$
F	$i = i_p e^{-kt})$ $I^2t \cong (1/2) i_p^2 t_1$

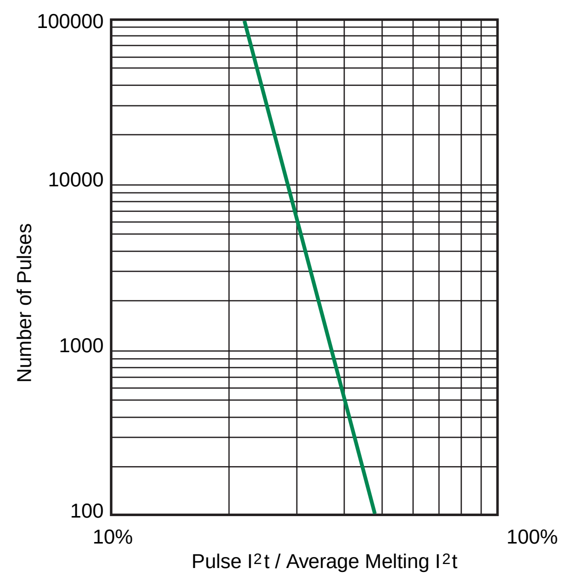
Step 3 — Examine the I^2t rating data for the PICO® II, 125V, very fast-acting fuse. The part number 251001, 1 ampere design is rated at 0.256 A^2 Sec., which is the minimum fuse rating that will accommodate the 0.2327 A^2 Sec. value calculated in Step 2. This 1 ampere fuse will also accommodate the specified 0.75 ampere normal operating current, when a 25% derating factor is applied to the 1 ampere rating, as previously described.

TESTING: The above factors should be considered in selecting a fuse for a given application. The next step is to verify the selection by requesting samples for testing in the actual circuit. Before evaluating the samples, make sure the fuse is properly mounted with good electrical connections, using adequately sized wires or traces. The testing should include life tests under normal conditions and overload tests under fault conditions, to ensure that the fuse will operate properly in the circuit.

CHART II

PULSE CYCLE WITHSTAND CAPABILITY

100,000 Pulses	Pulse I^2t = 22% of Nominal Melting I^2t
10,000 Pulses	Pulse I^2t = 29% of Nominal Melting I^2t
1,000 Pulses	Pulse I^2t = 38% of Nominal Melting I^2t
100 Pulses	Pulse I^2t = 48% of Nominal Melting I^2t



Note: Adequate time (10 seconds) must exist between pulse events to allow heat from the previous event to dissipate.

FUSEHOLDER SELECTION GUIDE

RERATING: For 25°C ambient temperatures, it is recommended that fuseholders be operated at no more than 60% of the nominal current rating established using the controlled test conditions specified by Underwriters Laboratories. The primary objective of these UL test conditions is to specify common test standards necessary for the continued control of manufactured items intended for protection against fire, etc. A copper dummy fuse is inserted in the fuseholder by Underwriters Laboratories, and then the current is increased until a certain temperature rise occurs. The majority of the heat is produced by the contact resistance of the fuseholder clips. This value of current is considered to be the rated current of the fuseholder, expressed as 100% of rating. Some of the more common, everyday applications may differ from these UL test conditions as follows: fully enclosed fuseholders, high contact resistance,air movement, transient spikes, and changes in connecting cable size (diameter and length). Even small variations from the controlled test conditions can greatly affect the ratings of the fuse-holder. For this reason, it is recommended that fuseholders be derated by 40% (operated at no more than 60% of the nominal current rating established using the Underwriter Laboratories test conditions, as previously stated).

Standards

Littelfuse is at your service to help solve your electrical protection problems. When contacting Littelfuse sales engineers, please have all the requirements of your applications available. Requests for quotes or assistance in designing or selecting special types of circuit protection components for your particular applications are also welcome. In the absence of special requirements, Littelfuse reserves the right to make appropriate changes in design, process, and manufacturing location without prior notice.

Fuse ratings and other performance criteria are evaluated under laboratory conditions **and acceptance criteria**, as defined in one or more of the various fuse standards. It is important to understand these standards so that the fuse can be properly applied to circuit protection applications.

UL/CSA/ANCE (Mexico) 248-14 FUSES FOR SUPPLEMENTARY OVERCURRENT PROTECTION (600 Volts, Maximum) (Previously UL 198G and CSA C22.2, No. 59)

UL LISTED

A UL Listed fuse meets all the requirements of the UL/CSA 248-14 Standard. Following are some of the requirements. UL ampere rating tests are conducted at 100%, 135%, and 200% of rated current. The fuse must carry 100% of its ampere rating and must stabilize at a temperature that does not exceed a 75°C rise.

The fuse must open at 135% of rated current within one hour. It also must open at 200% of rated current within 2 minutes for 0-30 ampere ratings and 4 minutes for 35-60 ampere ratings.

The interrupting rating of a UL Listed fuse is 10,000 amperes AC minimum at 125 volts. Fuses rated at 250 volts may be listed as interrupting 10,000 amperes at 125 volts and, at least, the minimum values shown below at 250 volts.

Ampere Rating of Fuse	Interrupting Rating In Amperes	Voltage Rating
0 to 1	35	250 VAC
1.1 to 3.5	100	250 VAC
3.6 to 10	200	250 VAC
10.1 to 15	750	250 VAC
15.1 to 30	1500	250 VAC

Recognized Under the Component Program of Underwriters Laboratories

The Recognized Components Program of UL is different from UL Listing. UL will test a fuse to a specification requested by the manufacturer. The test points can be different from the UL Listed requirements if the fuse has been designed for a specific application. Application approval is required by UL for fuses recognized under the Component Program.

UL 275 AUTOMOTIVE GLASS TUBE FUSES (32 Volts)

UL Listed

UL ampere ratings tests are conducted at 110%, 135%, and 200%. Interrupting rating tests are not required.

CSA Certification

CSA Certification in Canada is equivalent to UL Listing in the United States.

The Component Acceptance Program of CSA is equivalent to the Recognition Program at UL.

METI APPROVAL

METI Ⓐ approval in Japan is similar to UL Recognition in the United States. METI Ⓑ has its own design standard and characteristics.

MITI APPROVAL

MITI Ⓐ approval in Japan is similar to UL Recognition in the United States. MITI Ⓑ has its own design standard and characteristics.

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

Publication 60127, Parts 1, 2, 3, 4, 6

The IEC organization is different from UL and CSA, since IEC only writes specifications and does not certify. UL and CSA write the specifications, and are responsible for testing and certification.

Certification to IEC specifications are given by such organizations as SEMKO (Swedish Institute of Testing and Approvals of Electrical Equipment) and BSI (British Standards Institute), as well as UL and CSA.

IEC Publication 60127 defines three breaking capacity levels (interrupting rating). Low breaking capacity fuses must pass a test of 35 amperes or ten times rated current, whichever is greater, while enhanced breaking capacity fuses must pass a test of 150 amperes and high breaking capacity fuses must pass a test of 1500 amperes.

60127 Part 2

Sheet 1 – Type F Quick Acting, High Breaking Capacity
Sheet 2 – Type F Quick Acting, Low Breaking Capacity
Sheet 3 – Type T Time Lag, Low Breaking Capacity
Sheet 4 – Style Fuses 1/4 x 1 1/4
Sheet 5 – Type T Time Lag, High Breaking Capacity
Sheet 6 – Type T Time Lag, Enhanced Breaking Capacity

The letters 'F' and 'T' represent the time-current characteristic of the fast-acting and time delay fuses. One of these letters will be marked on the end cap of the fuse.

UL/CSA/ANCE (Mexico) 248-14 vs. IEC 60127 Part 2 FUSE OPENING TIMES vs. METI Ⓑ / MITI Ⓑ

Percent of Rating	UL & CSA STD 248-14	IEC TYPE F Sheet 1 (*)	IEC Type F Sheet 2 (*)	IEC Type T Sheet 3 (*)	IEC Type T Sheet 5 (*)	METI/MITI Ⓑ
110	4 Hr. Min.	—	—	—	—	
130	—	—	—	—	—	1Hr. Min.
135	60 Minutes Max.	—	—	—	—	
150	—	60 Minutes Min.	60 Minutes Min.	60 Minutes Min.	60 Minutes Min.	
160	—	—	—	—	—	1 Hr. Max.
200	2 Minutes Max.	—	—	—	—	2 Minutes Max.
210	—	30 Minutes Max.	30 Minutes Max.	2 Minutes Max.	30 Minutes Max.	

(*) Note: The IEC Specification is only written up to 6.3A (8 and 10A will be added soon), any components above these ratings are not recognized by the IEC (although the fuses may have those opening characteristics).

IEC also has requirements at 275%, 400% and 1000%; however, the chart is used to show that fuses with the same ampere rating made to different specifications are not interchangeable. According to the IEC 60127 Standard, a one ampere-rated fuse can be operated at one ampere. A one ampere-rated fuse made to UL/CSA/ANCE 248-14 should not be operated at more than .75 ampere (25% derated — See RERATING section of FUSEOLOGY).

METI Ⓑ covers only one characteristic i.e. there are no 'delay' definitions on other performance variants.

Standards and Packaging Information

Publication IEC 60127-4
(Universal Modular Fuse-Links [UMF])

This part of IEC 60127 covers both PCB through-hole and surface mount fuses. This standard covers fuses rated 32, 63, 125, and 250 volts. This standard will be accepted by UL/CSA making it the first global fuse standard. This specification uses different fusing gates than IEC 60127-2; the gates used here are 125%, 200%, and 1000%.

The fuses must not open in less than one hour at 125% of rated current and open within two minutes at 200% of rated current. The 1000% overload is used to determine the fuse characteristic. The opening time for each rating is listed below.

Type FF:	Less than 0.001 sec.
Type F:	From 0.001 - 0.01 sec.
Type T:	From 0.01 - 0.1 sec.
Type TT:	From 0.1 - 1.00 sec.

These characteristics correlate to the terminology used in IEC 60127-1.

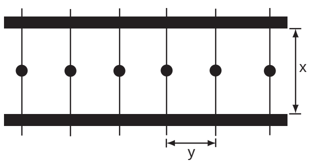
Breaking capacity (interrupting rating) varies based on voltage rating. Parts rated at 32 & 63 volts must pass a test of 35 amperes or ten times rated current, whichever is greater.Parts rated at 125 volts must pass a test of 50 amperes or ten times rated current, whichever is greater. Parts rated at 250 volts are further defined as either low, intermediate or high breaking. The low breaking capacity fuses must pass a test of 100 amperes or ten times rated current, while intermediate breaking capacity fuses must pass a test of 500 amperes and, high breaking capacity fuses must pass a test of 1500 amperes.

Packaging Suffixes

R = Taped & reeled fuses
A/X = 1 unit per bag
V = 5 units per box
T = 10 units per box
H = 100 units per box
U = 500 units per box
M = 1000 units per box
D = 1500 units per box
P = 2000 units per box
E = 2500 units per box
W = 3000 units per box
Y = 4,000 units per box
N = 5000 units per box
K = 10,000 units per box
RT1 = Taped & reeled. Spacing (x) = 2.062 inches (52.4 mm)
RT2 = Taped & reeled. Spacing (x) = 2.50 inches (63.5 mm)
RT3 = Taped & reeled. Spacing (x) = 2.874 inches (73 mm)

Tape and Reel packaging per EIA-296:

- Tape spacing is defined as the width of the tape and reeled fuse (x) as measured from inside tape to inside tape.
- Pitch is defined as the space between two tape and reeled fuses (y) as measured from lead to lead.



MILITARY/FEDERAL STANDARDS
See Table of Contents for Military Product Section.

Fuses and holders approved to the following Military specifications are on the Qualified Products List (QPL) for that specification.

MIL-PRF-15160 and MIL-PRF-23419

These specifications govern the construction and performance of fuses suitable primarily for military electronic applications.

MIL-PRF-19207

This specification governs the construction and performance of fuseholders suitable for military applications.

DSSC Drawing #87108

This drawing governs the construction and performance of .177" x .570" (2AG size) cartridge fuses and axial lead versions suitable for military applications. DSSC #87108 designation is included in the fuse end cap marking.

FEDERAL SPECIFICATION W-F-1814

This specification governs the construction and performance of fuses with high interrupting ratings that are approved for federal applications. Fuses approved to these specifications are on the Federal Qualified Products List.

Write to the following agencies for additional information on standards, approvals, or copies of the specifications.

Underwriters Laboratories Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062
Att: Publications Stock

Canadian Standards Association (CSA)
178 Rexdale Boulevard
Rexdale, Ontario, Canada M9W 1R3
Att: Standard Sales

International Electrotechnical Commission (IEC)
3, Rue de Varembe
1211 Geneva 20
Switzerland
Att: Sales Department

Naval Publications and Military Standards
Form Center (for Military and Federal Standards)
5801 Tabor Avenue
Philadelphia, PA 19120
Att: Commanding Officer

Defense Supply Center Columbus (DSCC)
3990 East Broad Street
Columbus, OH 43216-5000

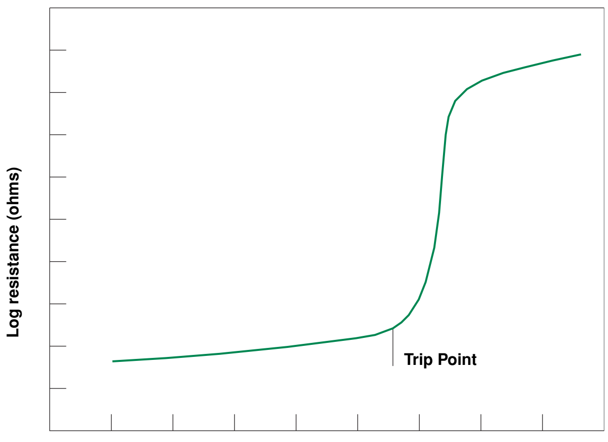
Ministry of Economy Trade and Industry (METI)
Kasumigaseki
Chi-Youda-Ku
Tokyo 100, Japan

PTC Facts

Overcurrent circuit protection can be accomplished with the use of either a traditional fuse or the more recently developed resettable PTC. Both devices function by reacting to the heat generated by the excessive current flow in the circuit. The fuse melts open, interrupting the current flow, and the PTC changes from low resistance to high resistance to limit current flow. Understanding the differences in performance between the two types of devices will make the best circuit protection choice easier.

The most obvious difference is that the PTC is *resettable.* The general procedure for resetting after an overload has occurred is to remove power and allow the device to cool down. There are several other operating characteristics that differentiate the two types of products. The terminology used for PTCs is often similar but not the same as for fuses. Two parameters that fall into this category are leakage current and interrupting rating.

LEAKAGE CURRENT: The PTC is said to have "tripped" when it has transitioned from the low resistance state to the high resistance state due to an overload.



Protection is accomplished by limiting the current flow to some low *leakage* level. Leakage current can range from less than a hundred milliamps at rated voltage up to a few hundred milliamps at lower voltages. The fuse on the other hand completely interrupts the current flow and this open circuit results in no leakage current when subjected to an overload.

INTERRUPTING RATING: The PTC is rated for a maximum short circuit current at rated voltage. This fault current level is the maximum current that the device can withstand keeping in mind that the PTC will not actually interrupt the current flow (see LEAKAGE CURRENT above). A typical PTC short circuit rating is 40A. Fuses do in fact interrupt the current flow in response to the overload and the range of interrupting ratings vary from tens of amperes up to 10,000 amperes at rated voltage.

The circuit parameters may dictate the component choice based on typical device rating differences.

OPERATING VOLTAGE RATING: General use PTCs are not rated above 60V while fuses are rated up to 600V.

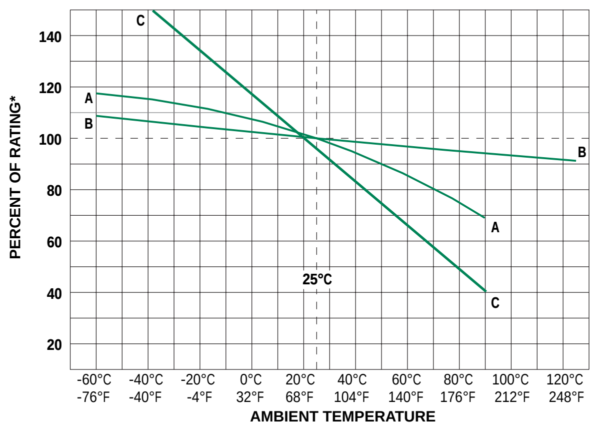
CURRENT RATING: The operating current rating for PTCs can be up to 11A while the maximum level for fuses can exceed 20A.

TEMPERATURE RATING: The useful upper limit for a PTC is generally 85°C while the maximum operating temperature for fuses is 125°C.

The following temperature rerating curves that compare PTCs to fuses illustrate that more rerating is required for a PTC at a given temperature.

Additional operating characteristics can be reviewed by the circuit designer in making the decision to choose a PTC or a fuse for overcurrent protection.

Key to chart: Curve A: Thin-Film Fuses and 313 Series (.010 to .150A)
Curve B: FLAT-PAK®, TeleLink®, Nano²®, PICO®, Blade Terminal and special purpose and other Leaded and catridge fuses (except 313.010-.150A)
Curve C: Resettable PTCs



• Ambient temperature effects are in addition to the normal derating.

AGENCY APPROVALS: PTCs are Recognized under the Component Program of Underwriters Laboratories to UL Standard 1434 for Thermistors. The devices have also been certified under the CSA Component Acceptance Program. Approvals for fuses include Recognition under the Component Program of Underwriters Laboratories and the CSA Component Acceptance Program. In addition, many fuses are available with full "Listing" in accordance with the new Supplementary Fuse Standard UL/CSA/ANCE (Mexico) 248-14.

RESISTANCE: Reviewing product specifications indicates that similarly rated PTCs have about twice (sometimes more) the resistance of fuses.

TIME-CURRENT CHARACTERISTIC: Comparing the time-current curves of PTCs to time-current curves of fuses show that the speed of response for a PTC is similar to the time delay of a Slo-Blo® fuse.

SUMMARY: Many of the issues discussed become a matter of preference, but there is an important area of application where the use of resettable PTCs is becoming a requirement. Much of the design work for personal computers and peripheral devices is strongly influenced by *Microsoft and Intel System Design Guide* which states that "Using a fuse that must be replaced each time an overcurrent condition occurs is unacceptable." And the *Plug and Play SCSI* (Small Computer Systems Interface) Specification for this large market includes a statement that "…must provide a self-resetting device to limit the maximum amount of current sourced".

The PTC / fuse discussion provides some insight as to when PTCs may be the appropriate choice for providing overcurrent circuit protection. A selection guide worksheet appears on the following page as an aid in choosing the best circuit protection component.

Overcurrent Selection Guide Worksheet

1. **Define the circuit operating parameters (Complete the following form).**

   Normal operating current in amperes: ____________________
   Normal operating voltage in volts: ____________________
   Maximum interrupt current: ____________________
   Ambient Temperature: ____________________
   Typical overload current: ____________________
   Required opening time at specified overload: ____________________
   Transient pulses expected (Quarterly) ____________________
   Resettable or one-time: ____________________
   Agency Approvals: ____________________
   Mounting type/form factor: ____________________
   Typical resistance (in circuit): ____________________

2. **Select the proper circuit protection component.**
3. **Determine the opening time at fault.**

   Consult the Time-Current (T-C)Curve to determine if the selected part will operate within the constraints of your application. If the device opens too soon, the application may experience nuisance operation. If the device does not open soon enough, the overcurrent may damage downstream components.To determine the opening time for the chosen device, locate the overload current on the X-axis of the appropriate T-C Curve and follow its line up to its intersection with the curve.At this point read the time tested on the Y-axis.This is the average opening time for that device. If your overload current falls to the right of the curve the device will open. If the overload current is to the left of the curve, the device will not operate.
4. **Verify ambient operating parameters.**

   Ensure that the application voltage is less than or equal to the device's rated voltage and that the operating temperature limits are within those specified by the device.
5. **Verify the device's dimensions.**

   Using the information from the Designer's Guide page, compare the maximum dimensions of the device to the space available in the application.
6. **Test the selected product in an actual application.**

Overcurrent Selection Guide:

	Surface Mount PTC	30V PTC Leaded	60V PTC Leaded	0402 SMF	0603 SMF	1206 SMF	Nano2® Telelink SMF Fuse	PICO® II Fuse	0402,0603, 1206 TFF	3.6 x10mm	TR5®/TE5® Fuses	2AGs	5x20 mm	3AGs/ 3ABs	Midgets
Lead-Free Available	Pb RoHS	N/A	N/A	Pb RoHS	Pb RoHS	Pb RoHS	RoHS	RoHS	Pb RoHS	N/A	Pb RoHS	Pb RoHS	Pb RoHS	Pb RoHS	N/A
Operating Current Range	0.200-2.6A	0.900 - 9A	0.100 - 3.75A	0.250 - 2A	0.250-5A	0.125 - 7A	0.062 - 15A	0.062 - 15A	0.250-7A	0.100-10A	0.40 - 10A	0.100 - 10A	0.032-15A	0.010 - 35A	0.100 - 30A
Maximum Voltage (*)	15V	30V	60V	24V	32V	125V	250V	250V	24-125V	250V	125-250V	250V	250V	250V	600V
Maximum Interupting Rating (**)	40A	40A	40A	35A	50A	50A	50A	50A	35-59A	35-63A	25-100A	10,000A	10,000A	10,000A	200,000A
Temperature Range	-40°C to 85°C	-40°C to 85°C	-40°C to 85°C	-55°C to 90°C	-55°C to 90°C	-55°C to 90°C	-55°C to 125°C	-55°C to 90°C	-55°C to 125°C	-55 to +125°	-40 to 85°C	-55°C to 125°C	-55°C to 125°C	-55°C to 125°C	-55°C to 125°C
Thermal Rerating	High	High	High	Medium	Medium	Medium	Low	Low	Medium	Low	Low	Low	Low	Low	Low
Opening time at 200% of Amp Rating	Slow	Slow	Slow	Fast	Fast	Fast to Medium	Fast to Medium	Fast to Medium	Fast to Medium	Fast to Medium	Fast to Slow	Fast to Medium	Fast to Slow	Fast to Slow	Fast to Slow
Transient Withstand	Low	Low	Low	Low	Low	Low to Medium	Low to Medium	Low to Medium	Low to Medium	Low to Medium	Low to Medium	Low to High	Low to High	Low to High	Low to High
Resistance	Medium	Medium	Medium	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Agency Approvals	UL, CSA, TUV	UL, CSA, TUV	UL, CSA, TUV	UL, CSA	UL, CSA	UL, CSA	UMF, UL, CSA, MITI	UL, CSA, MITI	UL,CSA,	UL,CSA, VDE, CCC	UL, VDE Senko, METI, MITI, CCC, CSA	UL, CSA, MITI	CSA, BSI, VDE, MITI, SEMKO, UL	UL, CSA, MITI	UL, CSA
Operational Uses	Multiple	Multiple	Multiple	One Time	One Time	One Time	One Time	One Time	One Time	One Time	One Time	One Time	One Time	One Time	One Time
Mounting/Form Factor	Surface Mount	Leaded	Leaded	Surface Mount	Surface Mount	Surface Mount	Surface Mount	Leaded	Surface Mount	Leaded	Leaded	Leaded or Cartridge	Leaded or Cartridge	Leaded or Cartridge	Cartridge

(*) Maximum operating voltage in the series, parts may be used at voltages equal to or less than this value.
(**) Maximum interrupting rating at specified voltage which may be less than maximum operating voltage.
(***) Opening time is in relation to other forms of protection. A fast device will typically operate within three seconds at 200% of rated current.
Pb Denotes Lead-Free Product according to Littelfuse standards. Contact factory for availability.
RoHS Denotes Lead-Free product according to RoHS specification. Contact factory for availability.

Overvoltage Suppression Facts

Transient Threats – What Are Transients?

Voltage Transients are defined as short duration surges of electrical energy and are the result of the sudden release of energy that was previously stored, or induced by other means, such as heavy inductive loads or lightning strikes. In electrical or electronic circuits, this energy can be released in a predictable manner via controlled switching actions, or randomly induced into a circuit from external sources.

Repeatable transients are frequently caused by the operation of motors, generators, or the switching of reactive circuit components. Random transients, on the other hand, are often caused by Lightning (Figure 1) and Electrostatic Discharge (ESD) (Figure 2). Lightning and ESD generally occur unpredictably, and may require elaborate monitoring to be accurately measured, especially if induced at the circuit board level. Numerous electronics standards groups have analyzed transient voltage occurrences using accepted monitoring or testing methods. The key characteristics of several transients are shown below in Table 1.

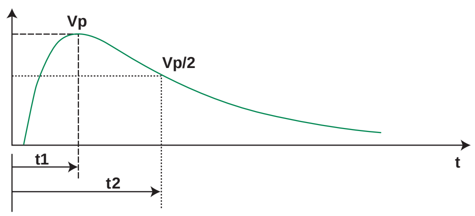


Figure 1. Lightning Transient Waveform

	VOLTAGE	CURRENT	RISE-TIME	DURATION
Lighting	25kV	20kA	10µs	1ms
Switching	600V	500A	50µs	500ms
EMP	1kV	10A	20ns	1ms
ESD	15kV	30A	<1ns	100ns

Table 1. Examples of transient sources and magnitude

Characteristics of Transient Voltage Spikes

Transient voltage spikes generally exhibit a "double exponential" wave form, shown in Figure 1 for lightning and figure 2 for ESD. The exponential rise time of lightning is in the range 1.2µsec to 10µsec (essentially 10% to 90%) and the duration is in the range of 50µsec to 1000µsec (50% of peak values). ESD on the other hand, is a much shorter duration event. The rise time has been characterized at less than 1.0ns. The overall duration is approximately 100ns.

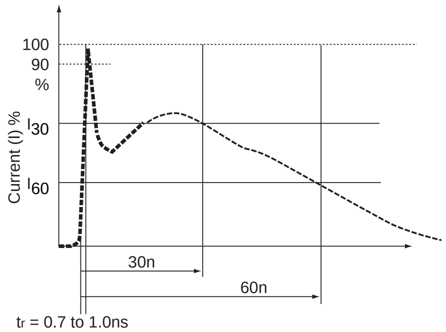


Figure 2. ESD Test Waveform

Why are Transients of Increasing Concern?

Component miniaturization has resulted in increased sensitivity to electrical stresses. Microprocessors for example, have structures and conductive paths which are unable to handle high currents from ESD transients. Such components operate at very low voltages, so voltage disturbances must be controlled to prevent device interruption and latent or catastrophic failures. Sensitive devices such as microprocessors are being adopted at an exponential rate. Microprocessors are beginning to perform transparent operations never before imagined. Everything from home appliances, such as dishwashers, to industrial controls and even toys, have increased the use of microprocessors to improve functionality and efficiency.

Vehicles now employ many electronics systems to control the engine, climate, braking and, in some cases, steering systems. Some of the innovations are designed to improve efficiency, but many are safety related, such as ABS and traction control systems. Many of the features in appliances and automobiles employ items which present transient threats (such as electric motors). Not only is the general environment hostile, but the equipment or appliance can also be sources of threats. For this reason, careful circuit design and the correct use of overvoltage protection technology will greatly improve the reliability and safety of the end application. Table 2 shows the vulnerability of various component technologies.

Device Type	Vulnerability (volts)
VMOS	30-1800
MOSFET	100-200
GaAsFET	100-300
EPROM	100
JFET	140-7000
CMOS	250-3000
Schottky Diodes	300-2500
Bipolar Transistors	380-7000
SCR	680-1000

Table 2. Range of device vulnerability.

Overvoltage Suppression Facts

Transient Voltage Scenarios

ESD (Electrostatic Discharge)

Electrostatic discharge is characterized by very fast rise times and very high peak voltages and currents. This energy is the result of an imbalance of positive and negative charges between objects.

Below are some examples of the voltages which can be generated, depending on the relative humidity (RH):

- **Walking across a carpet:**
  35kV @ RH = 20%; 1.5kV @ RH = 65%
- **Walking across a vinyl floor:**
  12kV @ RH = 20%; 250V @ RH = 65%
- **Worker at a bench:**
  6kV @ RH = 20%; 100V @ RH = 65%
- **Vinyl envelopes:**
  7kV @ RH = 20%; 600V @ RH = 65%
- **Poly bag picked up from desk:**
  20kV @ RH = 20%; 1.2kV @ RH = 65%

Referring to Table 2 on the previous page, it can be seen that ESD that is generated by everyday activities can far surpass the vulnerability threshold of standard semiconductor technologies. Figure 2 shows the ESD waveform as defined in the IEC 61000-4-2 test specification.

Inductive Load Switching

The switching of inductive loads generates high energy transients which increase in magnitude with increasingly heavy loads. When the inductive load is switched off, the collapsing magnetic field is converted into electrical energy which takes the form of a double exponential transient. Depending on the source, these transients can be as large as hundreds of volts and hundreds of Amps, with duration times of 400 milliseconds.

Typical sources of inductive transients are:

- **Generator**
- **Motor**
- **Relay**
- **Transformer**

These examples are extremely common in electrical and electronic systems. Because the sizes of the loads vary according to the application, the wave shape, duration, peak current and peak voltage are all variables which exist in real world transients. Once these variables can be approximated, a suitable suppressor technology can be selected.

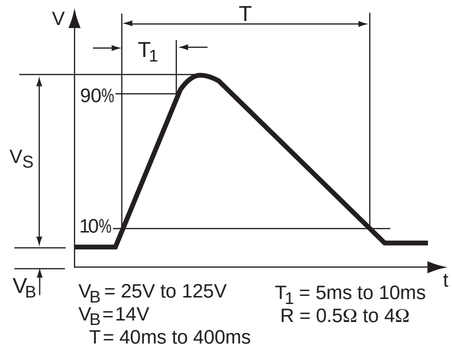


Figure 3. Automotive Load Dump

Figure 3, shows a transient which is the result of stored energy within the alternator of an automobile charging system. A similar transient can also be caused by other DC motors in a vehicle. For example, DC motors power amenities such as power locks, seats and windows. These various applications of a DC motor can produce transients that are just as harmful to the sensitive electronic components as transients created in the external environment.

Lightning Induced Transients

Even though a direct strike is clearly destructive, transients induced by lightning are not the result of direct a direct strike. When a lightning strike occurs, the event creates a magnetic field which can induce transients of large magnitude in nearby electrical cables.

Figure 4, shows how a cloud-to-cloud strike will effect not only overhead cables, but also buried cables. Even a strike 1 mile distant (1.6km) can generate 70 volts in electrical cables.

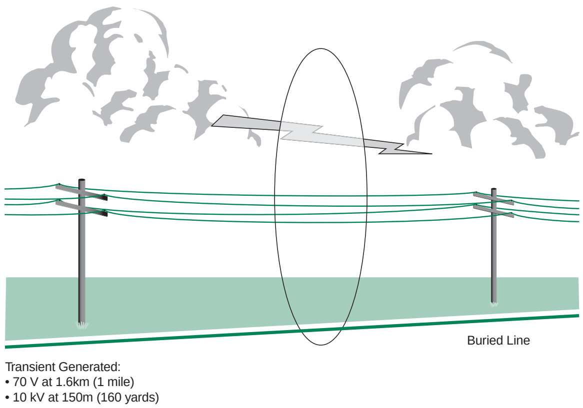


Figure 4. Cloud-to-Cloud Lightning Strike

Overvoltage Suppression Facts

Figure 5, on the following page, shows the effect of a cloud-to-ground strike: the transient-generating effect is far greater.

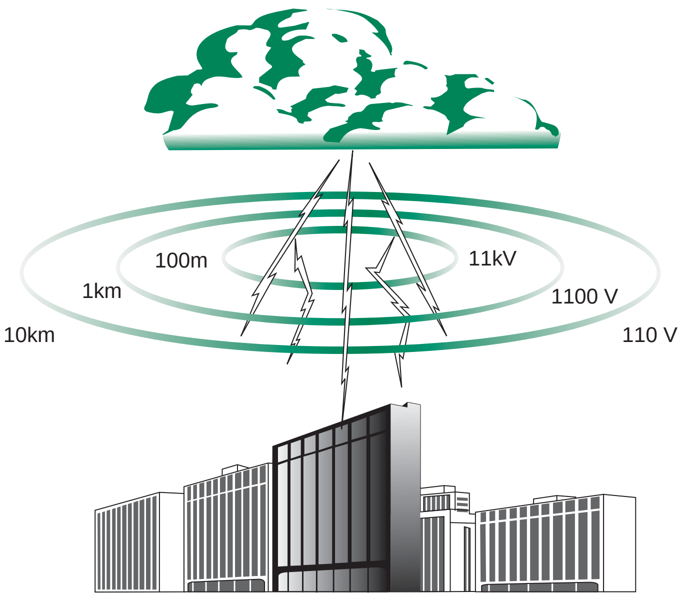


Figure 5. Cloud-to-Ground Lightning Strike

Figure 6, shows a typical current waveform for induced Lightning disturbances.

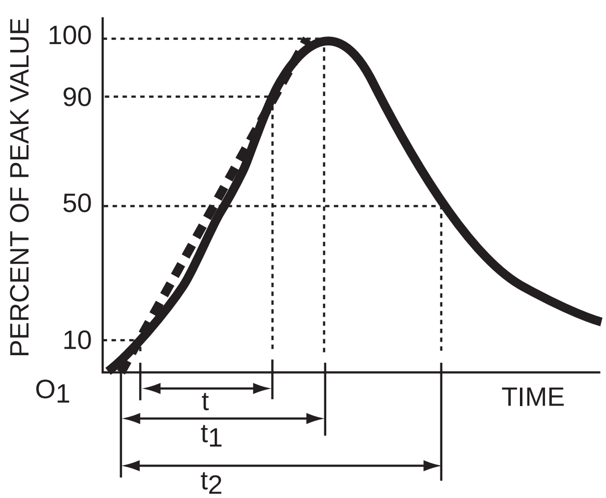


Figure 6. Peak Pulse Current Test Waveform

Technological Solutions for Transient Threats

Because of the various types of transients and applications, it is important to correctly match the suppression solution to the different applications. Littelfuse offers the broadest range of circuit protection technologies to ensure that you get the proper solution for your application. Our overvoltage protection portfolio includes:

Varisitors and Multilayer Varistors

Varistors are voltage dependent, nonlinear devices which have electrical characteristics similar to back to back zener diodes. They are composed primarily of zinc oxide with small additions of other metal oxides. The Metal Oxide Varistor or "MOV" is sintered during the manufacturing operation. This forms a ceramic and results in a crystalline microstructure across the entire bulk of the device. It is this attribute that allows MOVs to dissipate very high levels of transient energy. Therefore, MOVs are typically used for the suppression of lightning and other high energy transients found in industrial or AC line applications. Additionally, MOVs are used in DC circuits such as low voltage power supplies and automobile applications. Their manufacturing process permits many different form factors with the radial leaded disc being the most common.

Multilayer Varistors or MLVs are constructed of zinc oxide material similar to standard MOVs, however, they are fabricated with interleaved layers of metal electrodes and supplied in leadless ceramic packages. As with standard MOVs, Multilayers transition from a high impedance to a conduction state when subjected to voltages that exceed their nominal voltage rating. MLVs are constructed in various chip form sizes and are capable of significant surge energy for their physical size. Thus, data line and power supply suppression are achieved with one technology.

The following parameters apply to Varistors and/or Multilayer Varistors and should be understood by the circuit designer to properly select a device for a given application.

TERMS

Rated AC Voltage ($V_{M(AC)RMS}$)

This is the maximum continuous sinusoidal voltage which may be applied to the MOV. This voltage may be applied at any temperature up to the maximum operating temperature of 85°C.

Overvoltage Suppression Facts

Maximum Non-Repetitive Surge Current (I_{TM})

This is the maximum peak current which may be applied for an 8/20µs impulse, with rated line voltage also applied, without causing greater than 10% shift in nominal voltage.

Maximum Non-Repetitive Surge Energy (W_{TM})

This is the maximum rated transient energy which may be dissipated for a single current pulse at a specified impulse and duration (2ms), with the rated V_{RMS} applied, without causing device failure.

Nominal Voltage ($V_{N(DC)}$)

This is the voltage at which the device changes from the off state to the on state and enters its conduction mode of operation. This voltage is characterized at the 1mA point and has specified minimum and maximum voltage ratings.

Clamping Voltage (V_C)

This is the peak voltage appearing across the MOV when measured at conditions of specified pulse current amplitude and specified waveform (8/20µs).

Operating Temperature Range

The minimum and maximum ambient operating temperature of the circuit in which the Varistor will be applied, allowing for other adjacent components which could effect the surrounding temperature.

Power Dissipation Ratings

When transients occur in rapid succession the average power dissipation is the energy (watt-seconds) per pulse times the number of pulses per second. The power so developed must be within the specifications shown on the Device Ratings and Characteristics table for the specific device. Certain parameter ratings must be derated at high temperatures as shown in Figure 7.

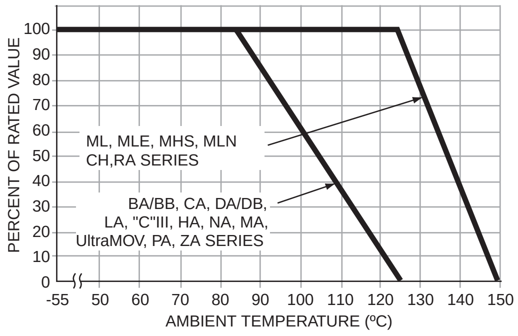


Figure 7. Peak Current, Energy and Power Derating Curves

Voltage Clamping Device

A clamping device, such as an MOV, refers to a characteristic in which the effective resistance changes from a high to low state as a function of applied voltage. In its conductive state, a voltage divider action is established between the clamping device and the source impedance of the circuit. Clamping devices are generally “dissipative” devices, converting much of the transient electrical energy to heat.

PulseGuard® Suppressors

PulseGuard devices are designed for ESD transients. This technology is manufactured utilizing a polymer-over- gap procedure resulting in extremely low capacitance. Likewise, leakage current is essentially non-existent, an important factor for certain portable products. PulseGuard Suppressors, therefore, do not skew fast edge rates or attenuate high speed data signals due to capacitive loading. They are suited to data rate applications ranging beyond 5GHz. The PulseGuard family of devices are fabricated in various surface mount package devices as well as a D-Sub connector insert film. Like Multilayer Varistors, these devices are not applicable for existing safety agency standards listing. PulseGuard devices are intended for the suppression of Human Body Model ESD transients, such as defined in IEC 61000-4-2.

TERMS

Capacitance

The capacitance measured between input pins and the common terminal, at 1 MHz.

Leakage Current

Until the PulseGuard suppressor transitions to the “on” state, it is electrically transparent to the circuit. Leakage current is specified at the rated voltage of the device.

Voltage Rating

PulseGuard suppressors are rated for use in operating environments up to 24 VDC.

Temperature Rating

The operating temperature range is –65°C to +125°C. Unlike the polymer PTCs, these devices do not operate as a result of thermal action; therefore, there is no rerating necessary.

Agency Approvals

At this time, there are no applicable standards for ESD suppressor components. Nonetheless, PulseGuard suppressors have been subjected to all levels of severity of the IEC 61000-4-2 test specification using both the Contact Discharge and Air Discharge injection methods. In all cases, clamping of the ESD transient is provided and the devices survived the multiple ESD events.

Resistance

While in the “off” state, the suppressors remain electrically transparent to the circuit. The measured resistance of the suppressors is 10 MΩ, or greater.

Overvoltage Suppression Facts

Time-Voltage Characteristic

Because the magnitude of the voltage and the time duration vary with the individual ESD event, a general form of this curve is shown below.

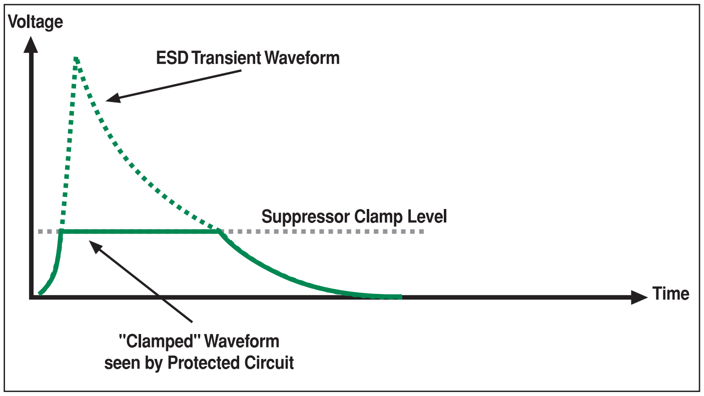


Figure 8. ESD Event.

Silicon Protection (SP) Devices:

Silicon Transient Voltage Suppression (TVS) technology offers a high level of protection (up to 30kV per IEC 61000-4-2 Direct Discharge) with very low capacitance, leakage current and clamp voltage. In addition to a single line 0402 device, high-density arrays are available for up to 18 lines including power rail protection. The next generation of products available offers TVS protection plus filtering and termination. For more robust applications, silicon devices are available for EFT and Lightning threats per IEC-61000-4-4/5. The SP family consists of three main technology types. This includes a single line or array TVS Avalanche diodes, Rail Clamp Diode arrays and filter/protection.

TVS Avalanche Diode Arrays (SPO5X)

The Surface Mount families of TVS Avalanche Diode arrays are specifically designed to protect circuits from Electrostatic Discharge (ESD). This family is rated to exceed the International Electrotechnical Committee (IEC) transient immunity standards, IEC 61000-4-2-4 (20kV Direct Discharge). The devices are typically connected between the sensitive signal lines and ground. When a transient event occurs, the device turns on and directs the transient into the ground plane. These space saving arrays protect multiple data lines in ultra small package sizes including the SC70, SOT23, TSSOP, and MSOP package. The arrays are configured to protect 2,3,4,5 or 6 sensitive digital or analog input circuits on data, signal, or control lines with voltage levels up to 5VDC.

Rail Clamp TVS Diode Arrays (SP7X)

The Rail clamp arrays are low capacitance (3pf), low leakage (10nA) and high-energy structures designed for transient protection. The rail clamp devices are connected to the sensitive signal line and to the power supply rails. When a transient voltage exceeds either supply rail by a diode drop (0.7V), the SCR /diode action directs the transient away from the sensitive line to the power supply. After the transient subsides, the rail clamp device returns to its off state. There are two main product types within the rail clamp technology. This includes a high voltage (35v) SP72x family and lower voltage (5V) SP05x family.

USB Port Terminator with EMI Filter and TVS protection

The newest family of devices offer a highly integrated solution for protecting USB1.1 ports on peripheral products such as digital cameras, MP3 players, printers or scanners.

The design integrates passive components including resistors, capacitors and TVS Avalanche diodes into a monolithic device. To save board space, the device is packaged in an ultra small SC70-6 lead plastic package. The end result of this design is the recommended termination resistance and filter (EMI) characteristic of the USB1.1 specification. The device offers very robust 15kV(IEC 61000-4-2 direct discharge) bi-directional protection of the data and Vbus lines

TERMS

Operating Voltage Range *(Vsupply)*

The range limits of the power supply voltage that may be across the V+ and V- terminals. The SCR/ Diode arrays do not a have a fixed breakover or operating voltage. These devices “float” between the input and power supply rails and thus the same device can operate at any potential within its range.

Forward Voltage Drop

The maximum forward voltage drop between an input pin and respective power supply pin for a specific forward current.

Input Leakage Current

The DC current that is measured at the input pins with 1/2 Vsupply applied to the input.

Quiescent Supply Current

The maximum DC current into V+ / V- pins with Vsupply at its maximum voltage.

Input Capacitance

The capacitance measured between the input pin and either supply pin at 1MHz / $1V_{RMS}$ applied.

Comparing the Technologies

The differences between the families offer the designer specific options to best suit the circuit application. Basic comparisons are listed in the tables on page 20-23 which highlight the fundamental attributes of each.

Overvoltage Suppression Facts

The considerations below restate how the product attributes/offerings can differ as an aid in determining which device family may be most appropriate.

When to choose the Silicon Protection

- The device being protected requires the lowest possible clamp voltage (9.2), low capacitance (3 to 40pF) and low leakage (5nA to 10uA).
- Board space is at a premium and space-savings multi-line protection is needed.
- Additional features such as EMI and termination are required.
- Transients are ESD or beyond such as EFT or Lightning.

When to choose the PulseGuard® Suppressors

- The application cannot tolerate added capacitance (high speed data lines or RF circuits)
- ESD is the only transient threat
- On data, signal, and control lines (not power supply lines)
- The suppression function must be within a Dsub connector (PGD types)

When to choose the ML, MLE or MLN Series

- Surge currents or energy beyond ESD is expected in the application (EFT, Lightning remnants).
- Replacing high wattage TVS Zeners (300-1500W).
- Added capacitance is desirable for EMI filtering (3pF - 6000pF).
- Power supply line or low/medium speed data, signal lines are to be protected.
- Single, leadless SM package is required
- The operating voltage is above the SP or PulseGuard® Suppressor ratings.

Conclusion

Choosing the most appropriate suppressor depends upon a balance between the application, its operation, voltage transient threats expected and sensitivity levels of the components requiring protection. Form factor/package style also must be considered.

The three Littelfuse technologies described offer a comprehensive choice for the designer. Reviewing the attributes of each can result in a suitable ESD suppression solution for most applications. See the individual data sheets for specific electrical and mechanical information.

SIDACtor® Devices

Available in surface mount, axial leaded and TO-220 through hole package options. Offers protection from medium to hight energy transients. SIDACtor® thyristors are specifically designed for transient suppression in telecom and data transmission systems.

Silicon Avalanche Diodes (SADs)

The Transient Voltage Suppressor diode (T.V.S.) is specifically designed to protect electronic circuits against transients and over voltages. It is a silicon avalanche device available in both uni-directional and bi-directional configurations. With a uni-directional, the specified clamping characteristic is only apparent in one direction, the other direction exhibiting a V_F normally experienced with conventional rectifier diodes. All electrical characteristics are specified at 25˚C.

When selecting a TVS device there are some important parameters to be considered, including; Reverse Standoff Voltage (V_R), Peak Pulse Current (I_{PP}) and Maximum Clamping Voltage (V_C max).

The most important is V_R, this is the parameter that is the key to selecting a TVS diode. The V_R of the device should be equal to, or greater than, the peak operating level of the circuit to be protected. This will ensure that the TVS diode does not clip the circuit drive voltage.

The Peak Pulse Current (I_{PP}) is the maximum current the TVS diode can withstand without damage. The required I_{PP} can only be determined by dividing the peak transient voltage by the source impedance. Of course, in many cases, the very nature of transient occurance makes this parameter difficult to determine. The TVS diode failure mechanism is a short circuit, therefore if the device fails due to a transient, the circuit will still be protected.

In secondary protection applications, any series impedances due to resistors, transformers and inductors will have a limiting effect on the peak pulse current. In some cases these may be due to long lengths of interconnecting wire.

The Maximum Clamping Voltage (V_C max) is the peak voltage that will appear across the TVS device when subjected to the Peak Pulse Current (I_{PP}), based on a 1ms exponential waveform. This waveform is a 10/1000 microsecond waveform as shown in Figure 9.

This pulse is a standard test waveform used for protection devices.

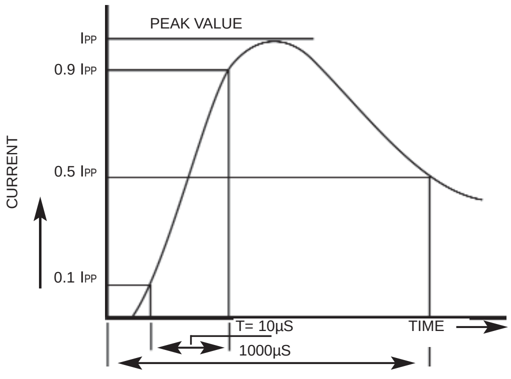


Figure 9. 10x1000µs test waveform

Overvoltage Suppression Facts

Gas Discharge Tubes (Gas Plasma Arrester)

DC SPARKOVER

This is the voltage at which the arrester breaks down when subjected to a slow rising voltage, normally at a rate of 100V / second. The DC Sparkover value maybe specified as an upper and lower limit or a nominal voltage with a tolerance, normally ± 20%, unless otherwise stated.

IMPULSE SPARKOVER

This is the voltage at which the arrester breaks down when subjected to a much faster rate than the DC Sparkover. The rate of rise for the Impulse Sparkover is 1KV/µs. The specified value is the maximum voltage at which the breakdown can occur.

IMPULSE DISCHARGE CURRENT

This is the maximum value of current that the arrester can stand while remaining within the specified limits. This current may be specified as 5kA or 10kA, depending on type. This current has a waveform of 8/20µs, (as specified by IEC 61000-4-5 formerly IEC 801-5) and is applied to the arrester 5 times for each polarity with 3 minute intervals between pulses. This test is considered to be a destructive test and is designed to test the durability of the arrester.

ALTERNATING DISCHARGE

Like the Impulse Discharge Current, this is also considered to be a destructive test. It is designed to simulate a condition where AC mains electricity comes into contact with the telephone line. The arrester is subject to a 1 second burst, 5A @ 50HZ. This is repeated 5 times for each polarity with a 3 minute interval between pulses. After this test, the arrester should stay within specified limits.

INSULATION RESISTANCE

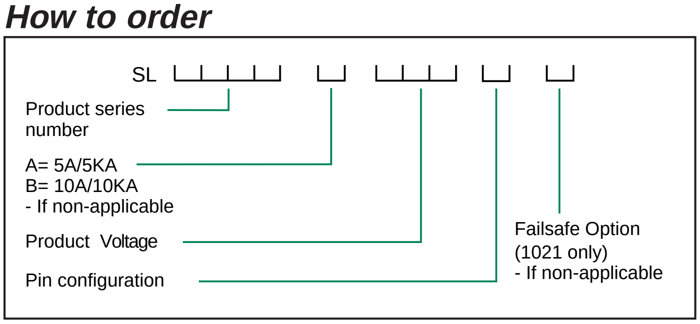
This is the measured resistance of the arrester at a given voltage, which is normally the voltage of the system it is designed to protect.

HOLDOVER VOLTAGE

Once the arrester has broken over due to a transient, it will remain in the low impedance arc mode until the voltage across it falls below a certain value, known as the Holdover Voltage. It is important when selecting an arrester that it has a Holdover Voltage in excess of the system voltage.

Gas Plasma Arresters (G.D.T.s) are manufactured using totally non-radioactive processes and are designed to perform to the stated characteristics of ITU (formally CCITT) K12.

How to order



OPERATION

The Gas Plasma Arrester (G.D.T.) operates as a voltage dependent switch. When a voltage appears across the device which is greater than its breakdown voltage, known as the Sparkover Voltage, an arc discharge takes place within the tube which creates a low impedance path by which the surge current is diverted.

When this arc discharge takes place, the voltage level is maintained irrespective of the discharge current. When the transient has passed, the G.D.T. will reset to its non-conducting state, providing the voltage of the system is below its Holdover Voltage.

The ability to handle very high current surges, while limiting over voltages, is one of the most significant aspects of a G.D.T. performance, typically 5000A and up to 10,000A. This is defined as the Impulse Discharge capability.

The very low capacitance (typically 1-2pF) and very high insulation resistance (greater than 1GΩ) of the G.D.T. ensures that it has virtually no effect on the protected system during normal operating conditions.

Failsafe devices

In normal operation, or when conducting short duration transients (spikes) the G.D.T does not generate any significant or detectable heat.

Under conditions of conducting mains electricity for extended periods (power cross), any G.D.T. will generate excessive thermal energy, even to the point where its electrodes will glow 'cherry red'. If a G.D.T. is to be used in areas where this hazard is a possibility then a failsafe can be fitted. These devices are spring loaded 'switches' which are normally insulated to ensure non-conduction. When the G.D.T. temperature rises, the insulation is destroyed allowing the device to create a short circuit between the G.D.T. center and line terminals. This short circuit is of low resistance and will conduct the fault current without generating any significant heat.

The operation of these devices are tested at the manufacturing facility in accordance with the test methods specified by British Telecom. The testing consists of applying mains electricity with current limiting to certain specified values. At each current value a maximum reaction time is specified.

Two types of failsafe are available. Select 'F' for wrap-around type and 'W' for wire slalom type. (Note: 'W' is only available on the R pin configuration). Type 'F' failsafe devices are not compatible for most wave soldering methods; hand soldering is possible with care.

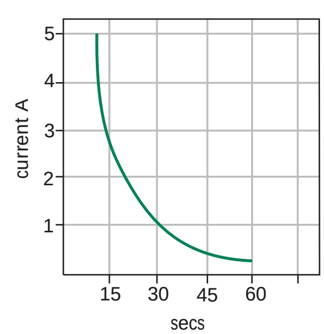


Figure 10 - Failsafe Operation Time vs AC Current

Overvoltage Suppression Facts

UL (Underwriters Laboratories)

UL writes "standards" to which products are investigated. Upon completion of the tests, a "Listing" or "Recognition" to the standard with conditions of acceptability is given under a unique file number. All of Littelfuse applicable Varistors are in the "Recognized Components" category to one or more of the following standards:

- UL1449 Transient Voltage Suppressors.
- UL1414 Across the Line Capacitors, Antenna Coupling and Line By-Pass Capacitors for Radio and Television Type Appliances.
- UL497B Protectors for Data and Communication and Fire Alarm Circuits.

(Note that the terms "Approved" or "Certified" are not correct in referring to devices listed or recognized by UL.)

VDE (Verband Deutscher Electrotechniker)

Based in Germany, this is the Association of German Engineers who develop specific safety standards and test requirements. VDE tests and certifies devices or products, assigning a license number.

Littelfuse Radial Varistors are currently certified under license number 104846 E having successfully met CECC standard 42 201-006 (issue 1/1996).

ESD Standards

Several industry standards and specifications exist that are used to qualify and quantify ESD events. Since many circuits or systems must demonstrate immunity to ESD, these standards are often incorporated in the testing of ESD capability. Of particular concern is the immunity level for semiconductors. The "standards" include Human Body Model (HBM) to MIL-STD-883, Machine Model (MM) such as EIAJ IC121, and Charged Device Model (CDM) such as US ESD DS 5.3. The Human Body Model, Machine Model and Charged Device Model primarily relate to manufacturing and testing process of an IC.

One of the most severe is IEC 61000-4-2 from the International Electrotechnical Commission and referenced in the EMC directive. Level 4 of this test method is the highest level, subjecting the device under test to 8kV contact discharge method (preferred) and/or 15kV air discharge. Each Littelfuse technology is designed for this level. The recommended types are the silicon based SP05x and SP7X, the polymeric VVM based PulseGuard® Suppressor, and the ML, MLE, MHS or MLN Multilayers.

The designer should be aware of the ESD ratings of the semiconductors used in the circuit. For example, semiconductor manufacturers that rate their devices to MIL-STD-883 to 2kV may not pass 2kV when subjected to the more difficult IEC test method (150pF / 330Ω instead of 100pF / 1500Ω). Additionally, even if semiconductors do meet some level of ESD immunity to IEC standards, that does not imply that additional ESD suppression is not required. Real world ESD transients can exceed the peak currents and voltages as defined by the standards and can have much faster rise times.

IEC 61000-4-2 consists of four test severity levels of ESD immunity using both a Contact Discharge and Air Discharge test method. The EUT or DUT may be subjected to increasing levels of severity until failure. Or, a particular level of immunity may be prescribed for EM compatibility of an end product.

For more information about the IEC 61000-4-2 test method, see Application Note AN9734, "IEC Electromagnetic Compatibility Standards for Industrial Process Measurement and Control Equipment."

Overvoltage Suppression Facts

Standards

Applicable Littelfuse Varistors have been investigated and evaluated and are Certified, Recognized or otherwise approved with pertinent safety or standards organizations as shown below. (Due to their intended circuit application, Multilayer Varistors are not covered by existing safety standards).

CECC (CENELEC Electronic Components Committee)

CENELEC is the "European Committee for Electrotechnical Standardization" which provides harmonized standards for the European Community based upon IEC and ISO publications. This group is based in Brussels.

All Littelfuse radial Varistor series are approved to Specification 42201-006.

CSA (Canadian Standards Association)

Based in Canada, this regulatory agency writes standards to which it conducts product safety tests. Upon successful completion, a file number is established, the product is "Certified" and may display the CSA logo as indication. Specific Littelfuse Varistors have been tested to CSA Standard number 22.2, No.1-94. Littelfuse file number is LR91788.

NSAI (National Standards Authority of Ireland)

This Irish testing organization is facilitated and authorized to evaluate products to the various Euro Norms CECC specifications thereby granting declarations of conformity.

AGENCY AND SPECIFICATION NUMBER							
		UL UL1449	**UL** UL1414	**UL** UL497B	**CSA** 22.2-1	**VDE** CECC Spec 42201-006	**NSAI** CECC Spec 42201-006
Device Series	**Package Style/ Technology**	file E75961	file E56529	file E135010	Cert. LR91788	license 104846E	Cert. HI-001
UltraMOV™ Varistor	Radial/MOV	X			X	X	
LA	Radial/MOV	X	X	X	X	X	X
C-III	Radial/MOV	X			X	X	X
ZA	Radial/MOV	X[1]		X		X	X
BA	Industrial/MOV	X					
DA/DB	Industrial/MOV	X					
HA	Industrial/MOV	X			X		
HB, HF, HG, DHB, TMOV34S	Industrial/MOV	X			X[2]		
CH	Leadless Chip/MOV	X[1]		X			
PA	Industrial Base Mount/MOV	X			X		
RA	Low Profile Box/MOV	X	X	X	X		
SIDACtor® Devices	Leaded and Surface Mount/ Protection Thyristor			X			
TMOV® Varistor	Radial/MOV	X					

NOTES:

- The information provided is accurate at the time of printing. Changes can occur based upon new products offered by Littelfuse, revision of an existing standard, or introduction of a new standard or agency requirement. Contact Littelfuse Sales for latest information.
- Not all Littelfuse TVS products require safety listing due to their low operating voltage and intended applications. These include PulseGuard® Suppressor, SP Series, and Multilayer (ML, MLN, MLE, MHS) leadless chips.

1. Not all types within the series are applicable for recognition.
2. Pending completion of testing.

Overvoltage Suppression Facts and Selection Guide

Greentube™ Gas Plasma Arresters (improved GDT) Selection Guide

Family name	TRIGGER SWITCH	OMEGA		BETA								ALPHA		DELTA
Performance Level	High	Standard		High								Ultra		High
Series Name	XT, LT, VS	SL1024B	SL1024A	SL1011A	SL1011B	SL1021A	SL1021B	SL1002A	SL1003A	SL0902	HV	SL1122A	SL1221	SL1026
Technology Type	Gas Plasma (GDT)	Gas Plasma (GDT)	Gas Plasma (GDT)	Gas Plasma (GDT)	Gas Plasma (GDT)	Gas Plasma (GDT)	Gas Plasma (GDT)	Gas Plasma (GDT)	Gas Plasma (GDT)	Gas Plasma (GDT)	Gas Plasma (GDT)	Gas Plasma (GDT)	Gas Plasma (GDT)	Gas Plasma (GDT)
Temperature Range	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-40 to +150	-55 to +150	-55 to +150	-55 to +150
Package Type	2 Terminal	2 Terminal, Button and axial leads	3 Terminal, Core (no pins) and radial leads	2 Terminal, Button and axial leads	2 Terminal, Button and axial leads	3 Terminal, Core (no pins) and radial leads	3 Terminal,, Core (no pins) and radial leads	2 Terminal, Button and surface mount	3 Terminal, Radial and surface mount	2 Terminal, SMT and axial leads	2 Terminal	3 Terminal, SAD/GP Hybrid radial leads	3 Terminal, radial leads	3 Terminal
Mounting Method	SMT & through-hole	through-hole or clip mount	through-hole	through-hole or clip mount	through-hole or clip mount	through-hole	through-hole	SMT	through-hole SMT	through-hole SMT	through-hole	through-hole	through-hole	clip mounted
DC Breakover Voltage	230-800	90-350	90-500	230-600	230-600	200-600	200-500	90-600	90-350	90-350	2,500-2,750	90-450	200	275-1,100
AC Surge Rating	NA	20A	10A*	5A	10A	10A*	20A*	2A	5A	2.5A	NA	10A*	10A*	40A*
Peak Pulse Current (8x20µs)	400A†	20,000A	10,000A*	5,000A	10,000A	10,000A*	20,000A*	5,000A	5,000A	2,500A	3,000A	10,000A*	10,000A*	80,000A*
Max Capacitance	1.5pF	1.5pF	1.5pF	1.5pF	1.5pF	1.5pF	1.5pF	1pF	1pF	1pF	1pF	100-200pF	1.5pF	2.5pF
RoHS Compliant	Yes											Yes		
Pb Lead Free		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes

* total current through center (ground) terminal
† repetitive switching current

TVS Diode Selection Guide

Peak Pulse Power Range	Medium											High			Very High	
Series Name	SA	P6KE	SMBJ	P6SMBJ	1KSMBJ	1.5KE	SMAJ	P4SMA	SMCJ	1.5SMC	P4KE	5KP	SLD	15KP	AK6	AK10s
Technology Type	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode
Operating Temperature	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150
Package Type	DO 15 axial	DO 15 axial & pill	DO 214 AA	DO 214 AA	DO 214 AA	axial & pill	DO 214 AC	DO 214 AC	DO 214 AB	DO 214 AB	axial	axial & pill	axial	axial & pill	axial	axial
Mounting Method	through-hole	through-hole or SMT (pill)	SMT	SMT	SMT	through-hole or SMT (pill)	SMT	SMT	SMT	SMT	through-hole	through-hole or SMT (pill)	through-hole or SMT (pill)	through-hole or SMT (pill)	through-hole	through-hole
Reverse Standoff (working) Voltage	5.0-180	6.3-550	5.0-170	6.8-550	5.5-160	6.8-550	5.0-170	6.8-550	5.0-170	6.8-550	6.8-550	5.0-220	16-30	17-280	58-380	58-380
Peak Pulse Power Range (based on 10/1000µs pulse unless stated otherwise)	500W	600W	600W	600W	1,000W	1,500W	400W	4,000W	1,500W	1,500W	400W	5,000W	2,200 based on 1.00µs/150ms pulse	15,000W	NA	NA
Peak Pulse Current (8x20µs)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6,000Amps	10,000Amps
RoHS Compliant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pb Lead Free	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No

Overvoltage Suppression Facts and Selection Guide

SIDACtor® Thyristor Selection Guide

Series Name	TO-220 CRxxx2*			TO-220 CRxxx3*			CRxxxx*			SMT 50	SMT 100	SMTBJ		T10A	T10B	T10C
Type	AA	AB	AC	AA	AB	AC	SA	SB	SC			A	B			
Technology Type	Protection Thyristors			Protection Thyristors			Protection Thyristors	Protection Thyristors	Protection Thyristors	Protection Thyristors	Protection Thyristors	Protection Thyristors		Protection Thyristors	Protection Thyristors	Protection Thyristors
Operating Junction Temperature Range (deg C)	-40 to +150			-40 to +150			-40 to +150	-40 to +150	-40 to +150	-40 to +150	-40 to +150	-40 to +150		-40 to +150	-40 to +150	-40 to +150
Storage Temperature Range (deg C)	-55 to +175			-55 to +175			-55 to +175	-55 to +175	-55 to +175	-55 to +150	-55 to +150	-40 to +150		-40 to 150	-40 to +150	-40 to +150
Package Type	Modified TO-220 (two die)			Modified TO-220 (three die)			DO-214AA	-DO-214AA	-DO-214AA	DO-214AA	DO-214AA	DO-214AA		DO-15 Axial	DO-15 Axial	3-T
Mounting Method	through-hole			through-hole			SMT	SMT	SMT	SMT	SMT	SMT		through-hole	through-hole	through-hole
Reverse Standoff (working) Voltage	25-275			130-300			15-320	15-320	15-320	62-270	35-270	50-200		56-243	32-240	70-240
Peak Pulse Rating: • 2x10µs									500A		500A					
• 10x160µs	100A	150A	200A	100A	150A	200A	100A	150A	200A							
• 10x560µs	50A	100A		50A	100A		50A	100A	100A							
• 10x1000µs			100A			100A	45A	80A	100A	50A	100A	50A	100A	100A	100A	100A
• 8X20µs										100A	250A	150A	250A	250A	100A	250A
I_{TSM}	20A	30A	60A	20A	30A	60A	20A	30A	60A	30A	55A@50HZ or 60A@60HZ	30A		50A	30A	50A
RoHS Complient	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
Pb Lead Free	No	No	No	No	No	No	No	No	No	No	No	No		No	No	No

* Use Teccor SIDACtor® Device replacement for new designs
* See Electronic Product Selection Guide for SIDACtor offering

Varistor Selection Guide

	Radial Leaded						Packaged					Bare Disc		Surface Mount		Axial Leaded
Series Name	ZA	RA	LA	C-III	UltraMOV™ Varistor	TMOV™/iTMOV™ Varistor	PA	HA	TMOV34S, HB34, DHB34 HF34, HG34	DA/DB	BA/BB	NA	CA	CH	AUML	MA
Technology Type	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Multilayer Zinc Oxide	Zinc Oxide
Operating AC Voltage Range	4-460	4-275	130-1000	130-320	130-625	115-750	130-660	130-750	130-750	130-750	130-2800	250-750	250-2800	14-275	——	9-264
Operating DC Voltage Range	5.5-615	5.5-369	175-1200	——	170-825	——	175-850	175-970	175-970	175-970	175-3500	330-970	330-3500	18-369	18	13-365
Peak Current Range (A)**	50-6,500	150-6,500	1,200-6,500	6,000-9,000	1,750-10,000	6,000-40,000	6,500	25,000 40,000	40,000	40,000	50,000 70,000	40,000	20,000 70,000	250-500	20	40-100
Peak Energy Range (J)	0.1-52	0.4-160	11-360	45-210	12.5-720	35-1050	70-250	200-1050	270-1050	270-1050	450-10000	370-1050	330-10000	1-23	——	0.06-1.7
Temperature Range (Deg.C)	-55 – +85	-55 – +125	-55 – +85	-55 – +85	-55 – +85	-55 – +85	-55 – +85	-55 – +85	-55 – +85	-55 – +85	-55 – +85	-55 – +85	-55 – +85	-55 – +125	-55 – +125	-55 – +85
Lines Protected	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mount/Form Factor	Radial Leaded	Packaged	Radial Leaded	Radial Leaded	Radial Leaded	Radial Leaded	Packaged	Packaged	Industrial Packaged	Industrial Package	Packaged	Bare Disc	Bare Disc	Surface Mount	Surface Mount	Axial Leaded
Disc Size (MOV)	5, 7, 10, 14, 20mm	8,16,22mm	7,10,14 20mm	14,20mm	7,10,14 20mm	14,20, 34 mm	20mm	32,40mm	34mm	40mm	60mm	34mm	32, 40 & 60mm	——	——	3mm
Agency Approvals	UL,VDE	UL,CSA &VDE	UL,CSA, CCC &VDE	UL,CSA, CCC &VDE	UL,CSA, CCC &VDE	UL, CSA	UL&CSA	UL&CSA	UL&CSA	UL	UL	——	——	UL	——	——
RoHS Compliant	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	No
Pb Lead Free	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes	No

* Not an applicable parameter for this technology   ** Not an applicable parameter for Crowbar devices

ESD Suppressor Selection Guide

Littelfuse manufacturers three different surface mount product families for ESD suppression. Each technology provides distinct attributes for compatibility to specific circuit requirements.

1. Review the circuit requirements or parameters from the left hand column and compare them to the Littelfuse product offerings shown.
2. Refer to Littelfuse data sheets and application notes for complete technical information

	PulseGuard® Suppressors	Silicon Protection Arrays			Multilayer Varistors			
	Surface Mount	Surface Mount			Surface Mount			
Series Name	PGB1	SP72X	SP05X	SPUSB1	ML	MLE	MLN	MHS
Technology Type	Polymer	Silicon SCR/Diode	TVS Avalanche Diode	USB Port Terminator (w/ESD Suppression and EMI Filter)	MLV ZnO	MLV ZnO	MLV ZnO	MLV ZnO
Working Voltage	0-24VDC	0-30VDC	0-5.5VDC	0-5.5VDC	0-120VDC range by type	0-18VDC	0-18VDC	0-42VDC
Array Package (No. of Lines)	SOT23 (2), 0805 (4)	DIP, SOIC (6, 14) SOT23 (4)	SC70 (2,4,5), SOT23 (2,4,5), SOT143 (3), TSSOP-8 (4), MSOP-8 (6)	SC70-6 (3)	No	No	0805 (4) 1206 (4)	No
Single Line Package	0603	No	No	No	0402-1210	0402-1206	———	0402, 0603
Typical Device Capacitance	0.05pF	3-5pF	30pF	47pF	40-6000pF	40-1700pF	45-430pF	3-22pF
Leakage Current	<1nA	<20µA	<10µA	<100nA	<25µA	<25µA	<2µA	<5µA
Rated Immunity to IEC 61000-4-2 level 4	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Also Rated for EFT or Lightning Wave	No	Yes	TBD	TBD	Yes	Yes	Yes	Yes
Bidirectional (transients of either polarity)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Performs Low Pass Filtering	–	–	–	Yes	Yes	Yes	Yes	Yes
Pb Lead-Free	Yes	No	No	No	Yes	Yes	Yes	Yes
RoHS Complient	Yes	No	No	No	Yes	Yes	Yes	Yes

Overvoltage Application Guide

	Application Examples	Circuit Examples	Transient Threat	Device Family	Technology
Low/Medium Voltage Electronics	Computers - desktop, laptop, notebook Peripherals - scanner, printer, monitor, disk drive External Broadband hardware - modem, set top box Network hardware - switch, router, hub, repeater Digital camera/camcorder Handheld portables - PDA, cell phone, cordless phone, GPS Video equipment - HDTV, DVD, VCR, set top box Alarm systems - security, fire Metering systems Medical equipment Lighting ballast Remote sensors/transducers	High-speed Interfaces: USB 2.0, IEEE 1394, InfiniBand, HDMI, RF antenna circuits, Gigabit Ethernet, DVI	ESD	PGB1	PulseGuard® Polymer
		Medium-speed Interfaces: USB 1.1, RS 485, Ethernet, video 10 Baset, 100Baset, T1/E1	ESD, EMI, EFT	sSP05x, SP72x MHS, ML, MLE, MLN SPUSB1	TVS diode, SCR/Rail clamp, MLV TVS/filter
			Lightning	PxxxxMC	SIDACtor® Devices
		Low-speed Interfaces: Audio, RS 232, IEEE 1284, push buttons, key pads, switches	Lightning	LCE, SA Pxxxxx	SAD SIDACtor® Devices
			ESD, EMI, EFT	ML, MLE, MLN, sSP05x	MLV, TVS diode
		Power Inputs: 120/240 VAC, up to 120 VDC	Lightning Switching Transients	CH, MA, ZA, RA, UltraMOV SA, P6KE, 1.5PKE SMBJ, 1KSMBJ	MOV SAD SAD
	Avionics/Military Electronics	Power and System Inputs	ESD, EMI, EFT Lightning and System Transients	5KP/SLD Hi-Rel MOVs	SAD MOV

Overvoltage Application Guide

	Application Examples	Circuit Examples	Transient Threat	Device Family	Technology
Power Mains Protection	AC line protection	Uninterruptible Power Supply (UPS)	EFT, Lightning	TMOV®, UltraMOV™ LA, C-III, ZA, 5KP, 15KP, AK6, AK10	MOV MOV SAD
		Power Supply	EFT, Lightning	UltraMOV, LA, TMOV ZA, HA, CH 5KP, 15KP, AK6, AK10	MOV MOV SAD
		Consumer Electronics	EFT, Lightning	UltraMOV, LA, ZA, CH, TMOV 1.5KE, 5KP	MOV SAD
		Power Meter	Lightning	TMOV, UltraMOV, C-III 5KP	MOV SAD
		AC Power Taps	EFT, Lightning	UltraMOV, LA, HA, Hx34	MOV MOV
		AC Panels	EFT, Lightning,	UltraMOV, C-III, HA, HB34, DA/DB, 5KP, 15KP, 8K6, 8K10	MOV MOV SAD
		AC Appliance Control	EFT, Lightning	TMOV, UltraMOV, LA, CH SMBJ, P6KE, 1.5KE	MOV SAD
	TVSS devices	TVSS Protection Modules	Lightning	TMOV, HA, Hx34, UltraMOV 5KP, 15KP, AK6, AK10 SL1002, SL1011, SL0902, SL1003	MOV SAD Gas Plasma
		Circuit Breakers	EFT, Lightning	UltraMOV, LA, ZA	MOV
Industrial Environment	High energy systems	Robotics	EFT, Lightning, Commutative Spikes, Inductive Load Switching	UltraMOV, CH, LA, C-III, ZA SMBJ, P6KE, 1.5KE, 5KP, 15KP	MOV SAD
		Large Motors, Pumps, Compressors	EFT, Lightning, Commutative Spikes, Inductive Load Switching	UltraMOV, CH, HA, Hx34, BA/BB DA/DB, PA, RA	MOV MOV
		Motor Drives	EFT, Lightning, Commutative Spikes, Inductive Load Switching	UltraMOV, TMOV, LA, C-III, RA, CH SMBJ, P6KE, 1.5KE, 5KP, 15KP	MOV SAD
		AC Distribution	EFT, Lightning, Commutative Spikes, Inductive Load Switching	UltraMOV, C-III, HA, Hx34, BA/BB, DA/DB 5KP, 15KP, AK6, AK10	MOV SAD
		High Current Relays	EFT, Lightning, Commutative Spikes	UltraMOV, C-III, HA, Hx34, BA/BB, DA/DB	MOV
Telecom/Datacom	SLIC (subscriber line interface circuit)	Telecom Tip and Ring	Lightning	PXXXI, PXXXIUA/C, PXXXICA2, PXXXLSA/C, BXXXUA/C, BXXXOCA/C, SL1OO2, SL1011, SL0902, SL1003	SIDACtor® Devices Battrax Devices Gas Plasma
	Customer Premise Equipment - Fax machine - Answering machine - xDSL gateway - Dial-up modem - Set top box - T1/E1/ISDN termination equipment - SLIC hardware SIDACtor® Devices - Public phone - Cellular phone - Cordless phone - Phone Line Protector - LAN protection module	High-Speed Data Interfaces: USB 2.0, IEEE 1394, RF antenna circuits	ESD	PGB1	Pulseguard® Polymer
			Lightning	PXXXXIUA/C, PXXXICA2, PXXXISA/C PXXXXSA/B/C, PXXXXSA/B/CMC, PXXXXUA/B/C, PXXX3UA/C, PXXX6UA/C BXXXXUA/C, BXXXOCA/C, SL1002, SL1011, SL0901, SL1003	SIDACtor® Devices Gas Plasma
		Medium/low-speed Data Interfaces: USB 1.1, Ethernet, RS 232	ESD, EMI, EFT	SP05x, SP72x, SPUSB1, ML, MLE, MLN, MHS	TVS diode MLV
		Telecom Interface (secondary): Tip/Ring Circuits	Lightning	ST10A/B/C, PXXXXSA, SL1002, SL1011, SL0902, SL1003	SIDACtor® Devices Gas Plasma
		Power Inputs: 120/240 VAC, up to 120 VDC	Lightning	P6KE, 1.5KE, CH, ZA, UltraMOV	SAD MOV
	Interface Equipment - PBX systems - Internet gateways - DSLAM equipment Conversion Equipment - Cellular base station - Satellite base station - Microwave base station	Telecom Interface (primary): Tip/Ring Circuits	Lightning	PXXXXEA/EB/EC/SA/SB/SC,SL1122 SL1002, SL1003, SL1011, SL0902, SL1026	SIDACtor® Devices Gas Plasma
	Central Office Equipment - Interexchange carrier - Local exchange carrier - Mobile telephone switch - Repeater/node - Railroad signaling - T1/E1/J1 - xDSL - DSLAM	Telecom Interface (primary): Tip/Ring Circuits	Lightning	T10A/B/C, PXXXXUA/B/C, PXXXXSA/B/CMC, PXXX3UA/C, PXXX6UA/C, PXXXXSA/SB/SC, PXXXXEA/EB/EC, SL1002, SL1003, SL0902, SL1011, SL1026, SL1022	SIDACtor® Devices Gas Plasma
		Power Inputs: 120/240 VAC, up to 120 VDC	Lightning	P6KE, 1.5KE CH, ZA, UltraMOV	SAD MOV
Automotive Electronics	Engine Control Module Body/Chassis Control - Body controller - Antilock braking system - Steering sensor - Illumination control - Instrument cluster - Air bag module - Window control module - Wiper module - Door lock module Multimedia systems - Radio/satellite tuner - CD/cassette players - DVD/VCR players - MP3 players - Data interface buses Telematics systems - Wireless communication - GPS receiver - Navigation system - Security system	High-Speed Interfaces: USB 2.0, IEEE 1394, RF antenna Circuits	ESD	PGB1	PulseGuard® Polymer
		Medium/Low-Speed Interfaces: USB 1.1, CAN	ESD, EMI	SP05x, SP72x, SPUSB1, ML, MLE, MLN, MHS	TVS diode MLV
		Power Inputs: Up to 42 VDC	Load Dump and Inductive Switching	AUML, P6K, P6SMBJ, 5KP 1KSMBJ, SLD CH, ZA	MLV SAD SAD MOV
		HID Switching	N/A	XT	Gas Plasma