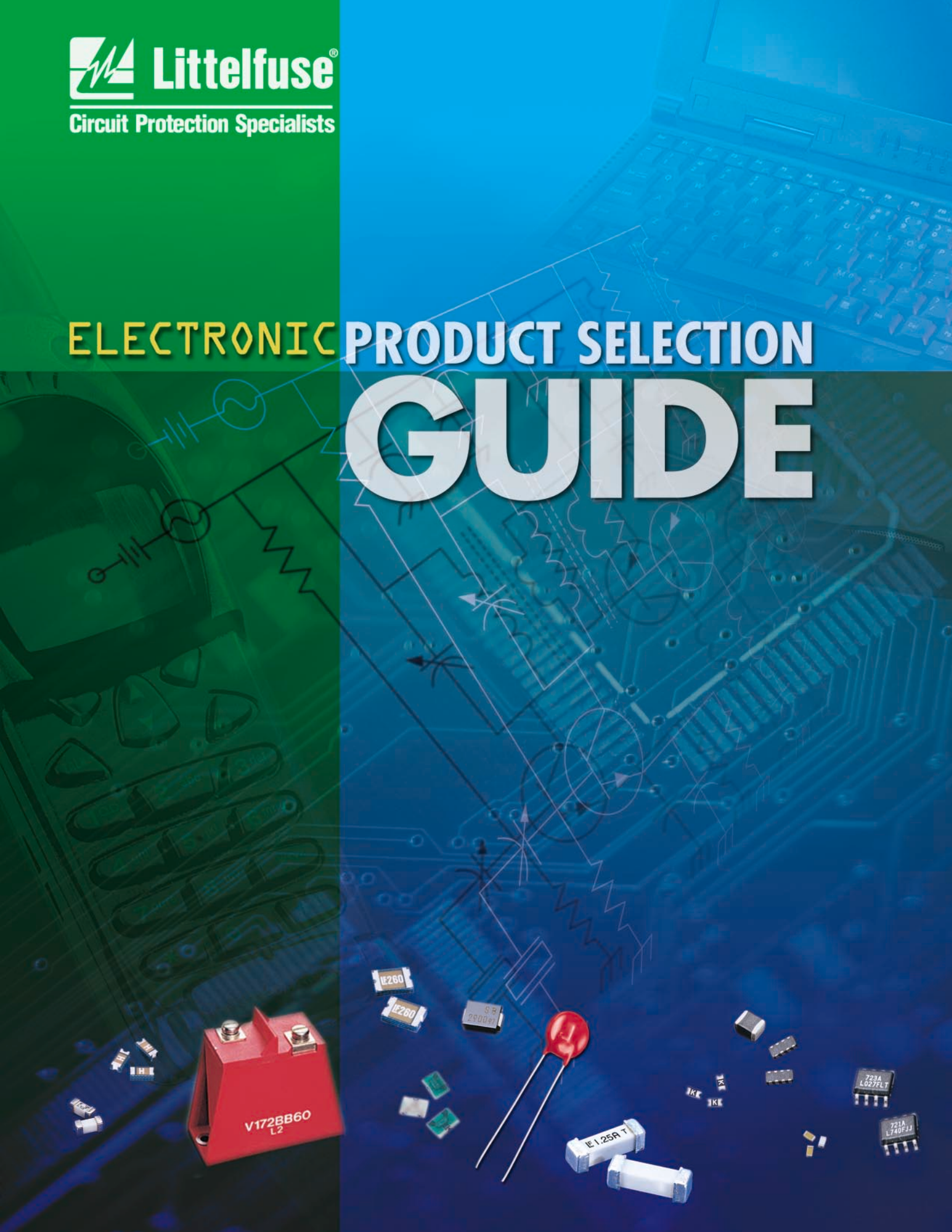
Littelfuse®

Circuit Protection Specialists

ELECTRONIC PRODUCT SELECTION GUIDE



Littelfuse is a global company offering the broadest line of circuit protection products in the world. Littelfuse products are vital components in literally every product that uses electrical energy. Computers, cell phones, telecommunications and networking equipment, medical and test equipment, DVDs, televisions and satellite television receivers typify the fast growing, high volume markets served by Littelfuse. The company is also the leading worldwide provider of circuit protection for the automotive industry and the third largest producer of power fuses in North America.

Littelfuse is the world's leading supplier of circuit protection products for the electronics industry, providing both overcurrent and overvoltage protection. Overcurrent products such as fuses and resettable PTCs protect devices when current in a circuit exceeds a predetermined value. Overvoltage products like electrostatic discharge (ESD) suppressors, thyristors and metal oxide varistors protect devices from transients caused by lightning, electrostatic discharge (ESD) and electrical load switching.

Choosing Littelfuse as your Circuit Protection Partner provides you with a number of distinct advantages:

- A broad range of products and technologies from a single source means fewer compromises and more optimum solutions. With our wide selection, the need to approximate or trade off disappears.
- Littelfuse Circuit Protection Products meet or exceed all applicable industry and government standards, so you benefit from our uncompromising approach to quality and reliability.
- Industry leading application-specific solutions provide you with assurance that your most demanding requirements will be met.
- The Technical Solutions Group (TSG) is dedicated to providing industry leading, application specific, technical support services for Littelfuse customers around the world.

No matter the application, Littelfuse has a circuit protection solution to meet your needs. We offer extremely competitive solutions based on extensive research and development and an uncompromising approach to quality. Littelfuse continues to enhance our products and manufacturing processes to stay on the leading edge of technology to meet the ever-increasing compliance and reliability standards while continuing to add value to our electronic partner's products. Make Littelfuse your circuit protection specialist.

Littelfuse®
Circuit Protection Specialists

TABLE OF CONTENTS

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 Fuse Facts 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.

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 OVERCURRENT 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 on page 7 illustrates the effect that ambient temperature has on the nominal current rating of a fuse. Fuse designs which use lower melting temperature materials are 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	1¼	1.25
4AG	9/32	.281	1¼	1.25
5AG	13/32	.406	1½	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.

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 upon request. Fuses can be supplied to specified controlled resistance tolerances at additional cost.

FUSE FACTS

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 the N.E.C. 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.

Derivation of Nominal Melting I^2t

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."

Standards

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 at 100%.

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. This CSA Program allows the manufacturer to declare a specification. CSA then verifies the test results.

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, Sheet 1, 2, 3, 4, 5, 6 (250 Volts)
The IEC organization is different from UL and CSA, since IEC only writes specifications and does not certify. UL and CSA write the specifications, are responsible for testing, and give 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 finally high breaking capacity fuses must pass a test of 1500 amperes.

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 – UMF Style Fuses

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.

PTC FACTS

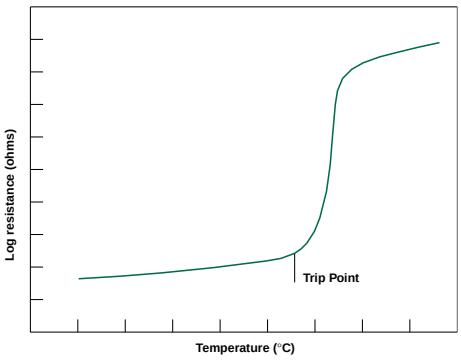
Overcurrent circuit protection can be accomplished with the use of either a traditional fuse or the more recently developed resettable PTC. Both devices function by reacting to the heat generated by the excessive current flow in the circuit. The fuse melts open, interrupting the current flow, and the 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 "0" leakage current when subjected to an overload.



PTC FACTS

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 but 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 goes from hundreds 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.

Agency Approvals

PTCs are Recognized under the Component Program of Underwriters Laboratories to UL Thermistor Standard 1434. 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

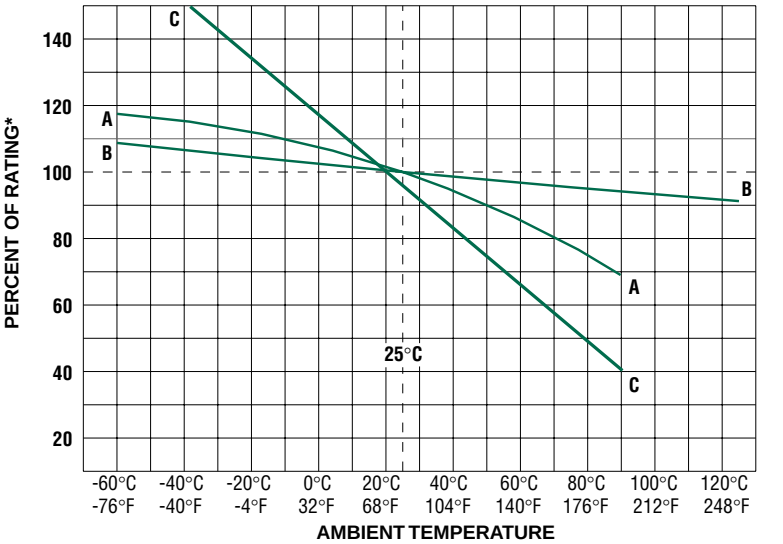
Comparing the time-current curves of PTCs to time-current curves of fuses show that the speed of response for a PTC is similar to the time delay of a Slo-Blo® fuse.

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 work-sheet appears on the following page as an aid in choosing the best circuit protection component.

Key to chart: Curve A: Thin-Film Fuses and 313 Series (.010 to .150A)
Curve B: Very Fast-Acting, Fast Acting and Spiral Wound Slo Blo® Fuses
Curve C: Resettable PTCs



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

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/Rerating: _____

Typical overload current: _____

Required opening time at specific overload: _____

Transient pulses expected: _____

Resettable or one-time: _____

Agency Approvals: _____

Mounting type/form factor: _____

Typical resistance (in circuit): _____

2. Select the proper circuit protection component (see chart.)

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

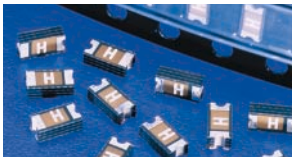
	Surface Mount PTC	30V PTC Leaded	60V PTC Leaded	0402 SMF	0603 SMF	1206 SMF	Nano²® SMF Fuse	PICO® II Fuse	2AGs	5x20mm	3AGs/3ABs	Midgets
Operating Current Range	0.200 - 3.0A	0.900 - 9A	0.100 - 3.75A	0.250 - 2A	0.250 - 5A	0.125 - 7A	0.062 - 15A	0.062 - 15A	0.100 - 10A	0.032 - 15A	0.010 - 35A	0.100 - 30A
Maximum Voltage (*)	15V	30V	60V	24V	32V	125V	250V	250V	250V	250V	250V	600V
Maximum Interrupting Rating (**)	40A	40A	40A	35A	50A	50A	50A	50A	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 125°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	Low	Low	Low	Low
Opening time at 200% IN (***)	Slow	Slow	Slow	Fast	Fast	Fast to Medium	Fast to Medium	Fast to Medium	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 High	Low to High	Low to High	Low to High
Resistance	Medium	Low to Medium	Medium	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	UL, CSA, MITI	UL, CSA, MITI	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
Mounting/Form Factor	Surface Mount	Leaded	Leaded	Surface Mount	Surface Mount	Surface Mount	Surface Mount	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.

RESETTABLE PTCs

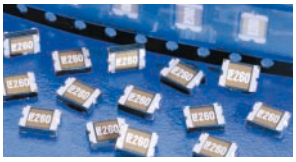
NEW 1206L Series
Surface Mount

Ihold (A)	Vmax (VDC)
0.20	15.0
0.25	15.0
0.35	6.0
0.50	6.0
0.75	6.0
1.10	6.0
1.50	6.0



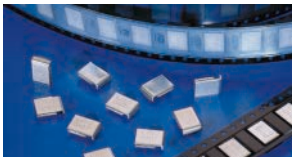
1812L Series
Surface Mount

Ihold (A)	Vmax (VDC)
0.50	15.0
0.75	13.2
1.10	6.0
1.25	6.0
1.50	6.0
NEW 1.60	6.0
NEW 2.00	6.0
2.60	6.0



3425L Series
Surface Mount

Ihold (A)	Vmax (VDC)
1.50	15
2.00	15
2.50	15
NEW 3.00	6



30R Series
Radial Lead

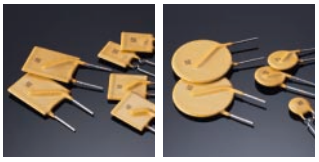
Vmax 30VDC

Ampere Range 0.90 – 9.0A

60R Series
Radial Lead

Vmax 60VDC

Ampere Range 0.10 – 3.75A



SURFACE MOUNT FUSES

SlimLine™ 1206
Very Fast-Acting Thin-Film Fuse
433 Series

VOLTAGE RANGE: 32 – 125V
AMPERE RANGE: 0.125 – 3.0A

INTERRUPTING RATINGS:

.125 – .375A	50A @ 125VAC/VDC
0.5 – 2A	50A @ 63VAC/VDC
2.5 – 3A	50A @ 32VAC/VDC

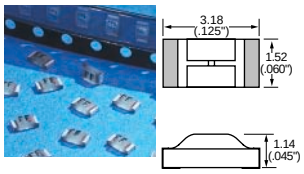
1206
Very Fast-Acting Thin-Film Fuse
429 Series

VOLTAGE RANGE: 24V
AMPERE RANGE: 4.0 – 7.0A

INTERRUPTING RATINGS:

4 – 7A	35A @ rated VAC/VDC

For new designs below 4A use 433 Series

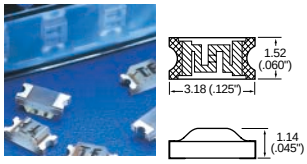


1206
Slo-Blo® Thin-Film Fuse
430 Series

VOLTAGE RANGE: 32 – 63V
AMPERE RANGE: 0.5 – 3.0A

INTERRUPTING RATINGS:

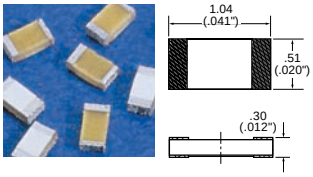
0.5 – 1.5A	50A @ 63VAC/VDC
2A	35A @ 63VAC/VDC
3A	50A @ 32VAC/VDC



SlimLine™ 0402
Very Fast-Acting Thin-Film Fuse
435 Series

VOLTAGE RANGE: 24V
AMPERE RANGE: 0.25 – 2.0A

INTERRUPTING RATINGS: 35A @ 24VAC/VDC

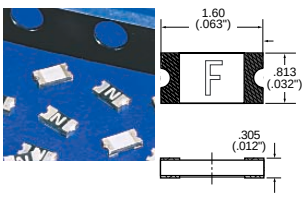


SlimLine™ 0603
Very Fast-Acting Thin-Film Fuse
434 Series

VOLTAGE RANGE: 32V
AMPERE RANGE: 0.25 – 5.0A

INTERRUPTING RATINGS:

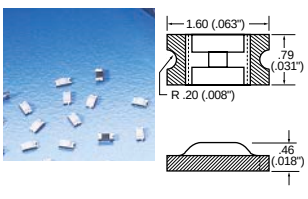
0.25 – 1A	50A @ 32VAC/VDC
1.25 – 5A	35A @ 32VAC/VDC



0603
Very Fast-Acting Thin Film Fuse
431 Series

32V
0.25 – 5.0A

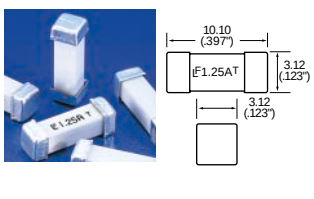
For new designs use the 434 Series.



Telecom NANO²® Fuse
Miniature
461 Series

VOLTAGE RANGE: 250V
AMPERE RANGE: 0.5 – 2.0A

INTERRUPTING RATINGS:
50A @ 250VAC
60A @ 600 VAC*
*See data sheet for test conditions.



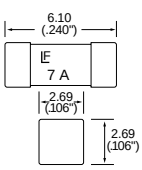
SURFACE MOUNT FUSES

NANO²®
Very Fast-Acting Type Fuse
451/453 Series

VOLTAGE RANGE: 65 – 125V
AMPERE RANGE: 0.062 – 15.0A

INTERRUPTING RATINGS:
- 0.062 – 8A: 50A @ 125VAC/VDC, 300A @ 32VDC
- 10A: 35A @ 125VAC, 50A@125VDC, 300A @ 32VDC
- 12 – 15A: 50A @ 65VAC/VDC, 300A @ 24VDC

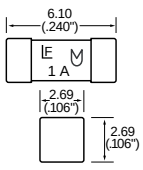




NANO²® UMF
Fast-Acting Type Fuse
455 Series

VOLTAGE RANGE: 125V
AMPERE RANGE: 0.40 – 1.6A

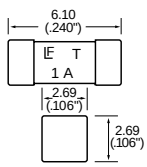
INTERRUPTING RATINGS: 50A @ 125VAC/VDC

NANO²®
Slo-Blo® Type Fuse
452/454 Series

VOLTAGE RANGE: 125V
AMPERE RANGE: 0.375 – 5A

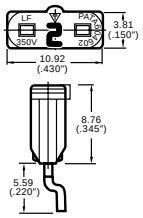
INTERRUPTING RATINGS:
50A @ 125VAC/VDC
300A @ 32VDC

EBF – 350V
Fast Acting Type Fuse
446/447 Series

VOLTAGE RANGE: 350V
AMPERE RANGE: 2 – 10A

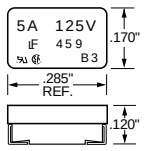
INTERRUPTING RATINGS:
100A @ 350VAC
50A @ 125VDC
450A @ 60VDC

PICO® SMF
Very Fast-Acting Type Fuse
459 Series

VOLTAGE RANGE: 125V
AMPERE RANGE: 0.062 – 5.0A

INTERRUPTING RATINGS:
50A @ 125VAC
300A @ 125VDC

PICO® SMF
Slo-Blo® Type Fuse
460 Series

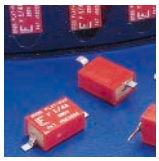
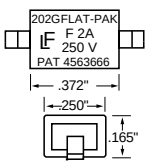
VOLTAGE RANGE: 125V
AMPERE RANGE: 0.5 – 5.0A

INTERRUPTING RATINGS: 50A @ 125VAC/VDC

FLAT-PAK®
Fast Acting Type Fuse
202 Series

VOLTAGE RANGE: 250V
AMPERE RANGE: 0.062 – 5.0A

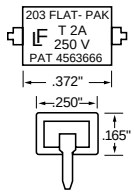
INTERRUPTING RATINGS: 50A @ 250VAC

FLAT-PAK®
Slo-Blo® Type Fuse
203 Series

VOLTAGE RANGE: 250V
AMPERE RANGE: 0.25 – 5.0A

INTERRUPTING RATINGS: 50A @ 250VAC

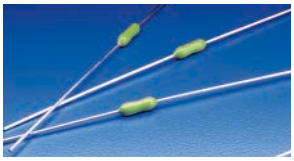
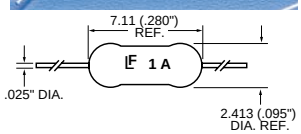



AXIAL LEADED FUSES

PICO® II
Very Fast-Acting Type Fuse
251/253 Series

VOLTAGE RANGE: 32 – 125V
AMPERE RANGE: 0.062 – 15A

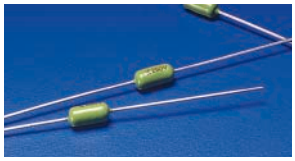
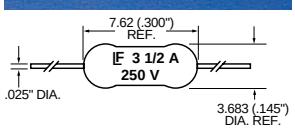
INTERRUPTING RATINGS:
300A @ Rated VDC
50A @ Rated VAC

PICO® II 250V
Very Fast-Acting Type Fuse
263 Series

VOLTAGE RANGE: 250V
AMPERE RANGE: 0.062 – 5.0A

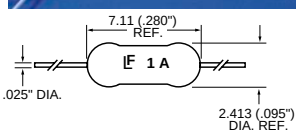
INTERRUPTING RATINGS: 50A @ 250VAC

PICO® II
Time Lag Type Fuse
471 Series

VOLTAGE RANGE: 125V
AMPERE RANGE: 0.5 – 5.0A

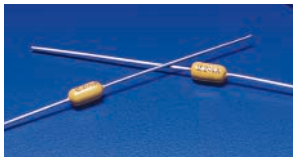
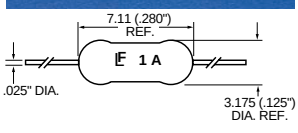
INTERRUPTING RATINGS: 50A @ 125VAC/VDC

PICO® II
Slo-Blo® Type Fuse
473 Series

VOLTAGE RANGE: 125V
AMPERE RANGE: 0.375 – 7.0A

INTERRUPTING RATINGS: 50A @ 125VAC/VDC

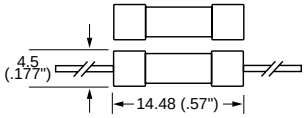



AXIAL LEADED AND CARTRIDGE FUSES

2AG
Fast-Acting Type Fuse
224/225 Series

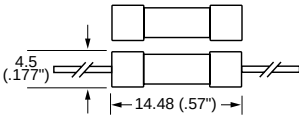
MIL

VOLTAGE RANGE:	125 – 250V
AMPERE RANGE:	0.10 – 10.0A
INTERRUPTING RATINGS:	0.1 – 10A 10,000A @ 125VAC 0.1 – 1A 35A @ 250VAC 1.5 – 3.5A 100A @ 250VAC



2AG Special 350V
Fast-Acting Type Fuse
220 007 Series

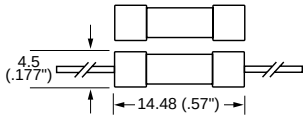
VOLTAGE RANGE:	350V
AMPERE RANGE:	0.10 – 10.0A
INTERRUPTING RATINGS:	100A @ 350VAC



2AG
Slo-Blo® Type Fuse
229/230 Series

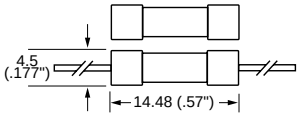
MIL

VOLTAGE RANGE:	125 – 250V
AMPERE RANGE:	0.25 – 7.0A
INTERRUPTING RATINGS:	0.25 – 3.5A 10,000A @ 125VAC 4 – 7A 400A @ 125VAC 0.25 – 1A 35A @ 250VAC 1.25 – 3.5A 100A @ 250VAC



2AG
Surge Withstand Type Fuse
229/230 Series (Select Ratings)

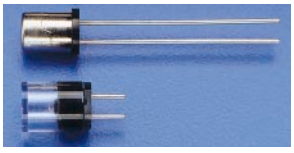
VOLTAGE RANGE:	125 – 250V
AMPERE RANGE:	0.250 – 1.25A
INTERRUPTING RATINGS:	40-60A @ 600VAC

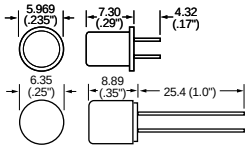


MICRO
Very Fast-Acting Type Fuse
272/273/274/278/279 Series

QPL

VOLTAGE RANGE:	125V
AMPERE RANGE:	0.002 – 5.0A
INTERRUPTING RATINGS:	10,000A @ 125VAC/VDC

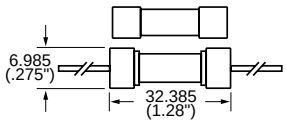




3AG
Fast-Acting Type Fuse
312/318/392 Series

QPL

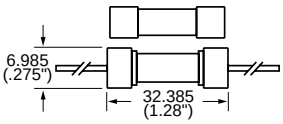
VOLTAGE RANGE:	32 – 250V
AMPERE RANGE:	0.031 – 35.0A
INTERRUPTING RATINGS:	10,000A @ 125VAC 35A @ 250VAC



3AG
Slo-Blo® Type Fuse
313/315/393 Series

QPL

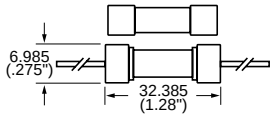
VOLTAGE RANGE:	32 – 250V
AMPERE RANGE:	0.01 – 30.0A
INTERRUPTING RATINGS:	0.01 – 8A 10,000A @ 125VAC 10 – 30A 300A @ 32VAC 0.1 – 1A 35A @ 250VAC



3AB
Fast-Acting Type Fuse
314/324/394 Series

QPL

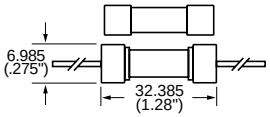
VOLTAGE RANGE:	125 – 250V
AMPERE RANGE:	0.125 – 30.0A
INTERRUPTING RATINGS:	0.125 – 15A 10,000A @ 125VAC 20 – 30A 400A @ 125VAC 0.125 – 1A 35A @ 250VAC 2 – 3A 100A @ 250VAC 4 – 10A 200A @ 250VAC 12 – 15A 250A @ 250VAC 20A 1000A @ 250VAC



3AB
Slo-Blo® Type Fuse
326/314/325 Series

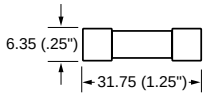
QPL

VOLTAGE RANGE:	125 – 250V
AMPERE RANGE:	0.010 – 30A
INTERRUPTING RATINGS:	10,000A @ 125VAC 400A @ 250VAC



3AB
Special Very Fast-Acting Type Fuse
322 Series

VOLTAGE RANGE:	65 – 250V
AMPERE RANGE:	1 – 30A
INTERRUPTING RATINGS:	1 – 10A 10,000A @ 125VAC 1 – 10A 100A @ 250VAC 12 – 30A 200A @ 65VAC

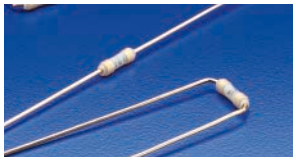


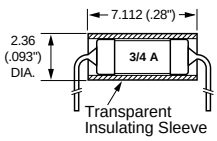
HIGH RELIABILITY

PICO®
Very Fast-Acting Type Fuse
265/266 Series

QPL

VOLTAGE RANGE: 32 – 125V
AMPERE RANGE: 0.062 – 15.0A
INTERRUPTING RATINGS: 300A @ rated VDC
50A @ rated VAC

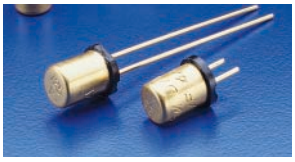


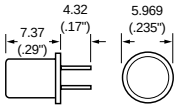


MICRO
Very Fast-Acting Type Fuse
262/268 Series

QPL

125V
.002 – 5.0A
10,000A @ 125VAC/VDC

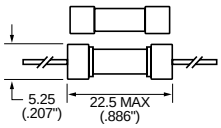




AXIAL LEADED CARTRIDGE FUSES

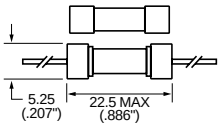
5 x 20mm
IEC Fast-Acting Type Fuse
217/227 Series

250V
0.032 – 10A
35A or 10 times rated current; whichever is greater



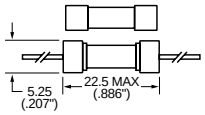
5 x 20mm
IEC Slo-Blo® Type Fuse
218/228/213 Series

250V
0.032 – 15A
35A or 10 times rated current; whichever is greater



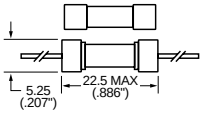
5 x 20mm
IEC Fast-Acting Type Fuse
216/226 Series

VOLTAGE RANGE: 250VAC
AMPERE RANGE: 0.050 – 10A
INTERRUPTING RATINGS: 1500A



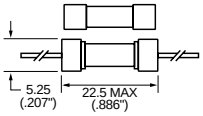
5 x 20mm
IEC Slo-Blo® Type Fuse
215/221 Series

250V
0.200 – 10A
1500A



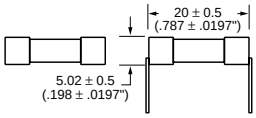
5 x 20mm
IEC Slo-Blo® Type Fuse
219 Series

250V
0.125 – 6.3A
150A



5 x 20mm
MITI Medium-Acting
232 Series

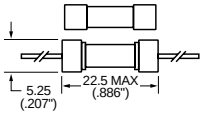
125/250V
1 – 10A
500A @ 125VAC
100A @ 250VAC



5 x 20mm
UL/CSA Fast-Acting Type Fuse
235/236 Series

VOLTAGE RANGE: 125 – 250V
AMPERE RANGE: 0.10 – 6A
INTERRUPTING RATINGS:

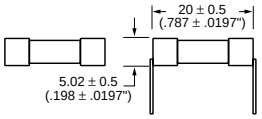
0.10 – 1A	10,000A @ 125VAC 35A @ 250VAC
1.25 – 3.15A	10,000A @ 125VAC 100A @ 250VAC
4 – 6A	10,000A @ 125VAC



5 x 20mm
UL/CSA Medium-Acting
Type Fuse 233/234 Series

125 – 250V
1 – 10A

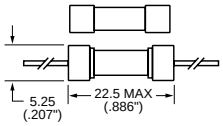
1A	10,000A @ 125VAC 35A @ 250VAC
1.25 – 3.5A	10,000A @ 125VAC 100A @ 250VAC
4 – 10A	10,000A @ 125VAC 200A @ 250VAC



5 x 20mm
UL/CSA Slo-Blo® Type Fuse
238/239 Series

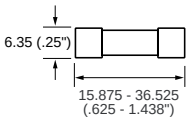
125 – 250V
0.200 – 5A

0.20 – 1A	10,000A @ 125VAC 35A @ 250VAC
1.25 – 3.15A	10,000A @ 125VAC 100A @ 250VAC
4 – 5A	10,000A @ 125VAC



SFE
Low Voltage, Fast-Acting
307 Series

32V
4 – 30A

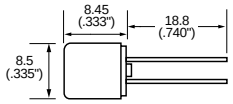


SUBMINIATURE CARTRIDGE FUSES

LT-5
Fast-Acting Type Fuses
662 Series

VOLTAGE RANGE:	250V
AMPERE RANGE:	0.050 – 5.0A
INTERRUPTING RATINGS:	35A or 10 times rated current, whichever is greater

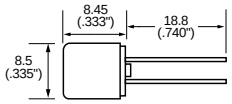
Note: 4.3mm Lead length also available



LT-5
Time Lag Type Fuses
663 Series

VOLTAGE RANGE:	250V
AMPERE RANGE:	0.050 – 6.3A
INTERRUPTING RATINGS:	35A or 10 times rated current, whichever is greater

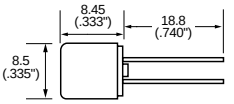
Note: 4.3mm Lead length also available



LT-5
Time Lag Extended Break Capacity 664 Series

VOLTAGE RANGE:	250V
AMPERE RANGE:	0.80 – 6.3A
INTERRUPTING RATINGS:	100A @ 250VAC

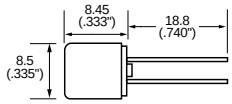
Note: 4.3mm Lead length also available



LT-5
Time Lag Type Fuses
665 Series

VOLTAGE RANGE:	250V
AMPERE RANGE:	0.25 – 6.3A
INTERRUPTING RATINGS:	50A @ 250VAC

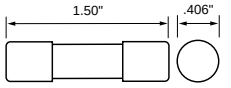
Note: 4.3mm Lead length also available



CARTRIDGE FUSES – Midget

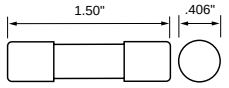
AC
Fast-Acting Type Fuse
KLK Series

VOLTAGE RANGE:	600V
AMPERE RANGE:	0.10 – 30A
INTERRUPTING RATINGS:	100,000A @ 600VAC (capable of 200,000A)



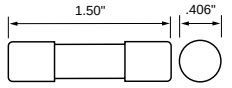
DC
Fast-Acting Type Fuse
KLKD Series

VOLTAGE RANGE:	600V
AMPERE RANGE:	0.10 – 30A
INTERRUPTING RATINGS:	10,000A @ 600VDC 100,000A @ 600VAC (capable of 200,000A)



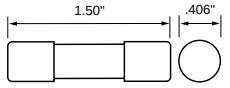
250 Volt
Slo-Blo® Type Fuse
FLM Series

VOLTAGE RANGE:	250V
AMPERE RANGE:	0.10 – 30A
INTERRUPTING RATINGS:	10,000A @ 250VAC



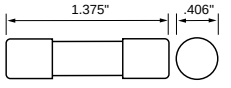
500 Volt
Slo-Blo® Type Fuse
FLQ Series

VOLTAGE RANGE:	500V
AMPERE RANGE:	0.10 – 30A
INTERRUPTING RATINGS:	10,000A @ 500VAC



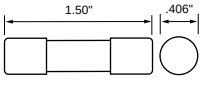
1⅜" Long
Fast-Acting Type Fuse
BLS Series

VOLTAGE RANGE:	250 – 600V
AMPERE RANGE:	0.20 – 10A
INTERRUPTING RATINGS:	10,000A @ rated VAC



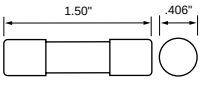
Slo-Blo®
Indicating Type Fuse
FLA Series

VOLTAGE RANGE:	125VAC
AMPERE RANGE:	0.10 – 4.5A
INTERRUPTING RATINGS:	10,000A @ rated VAC



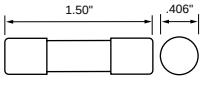
Laminated
Fast-Acting Type Fuse
BLF Series

VOLTAGE RANGE:	125 – 250V
AMPERE RANGE:	0.50 – 30A
INTERRUPTING RATINGS:	10,000A @ rated VAC



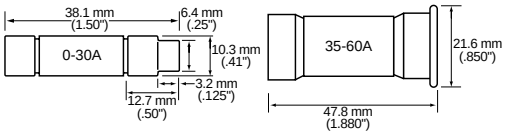
Fiber Body
Fast-Acting Type Fuse
BLN Series

VOLTAGE RANGE:	250V
AMPERE RANGE:	1.0 – 30A
INTERRUPTING RATINGS:	10,000A @ 250VAC



Class CC
Fast-Acting & Slo-Blo® Type Fuses
CCMR/KLDR/KLKR Series

VOLTAGE RANGE:	600VAC, 250 – 300VDC
AMPERE RANGE:	0.10 – 60A
INTERRUPTING RATINGS:	AC: 200,000A DC: 20,000A

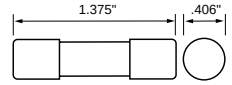


CARTRIDGE FUSES – Midget

KLQ
Increased Time-Delay
KLQ Series

QPL

VOLTAGE RATING:	600VAC
AMPERE RANGE:	1.0 – 6.0A
INTERRUPTING RATINGS:	10,000A @ rated VAC



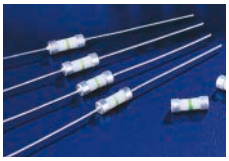
FLU
Multimeter Protection
FLU Series

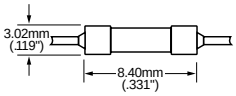
	1000VAC/VDC
	0.44A, 11A
	1000VAC/VDC

Hazardous Area Fuses

BARRIER NETWORK
242 Series

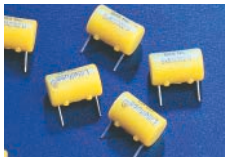
	250V
	0.050 – 0.25A
	4000A @ 250VAC/VDC

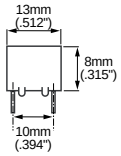




SAFE-T-PLUS
259 Series

	250V
	0.062 – 1A
	50A @ 125VAC 300A @ 125VDC

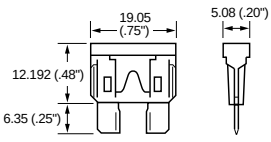




BLADE TERMINAL AND SPECIAL PURPOSE FUSES

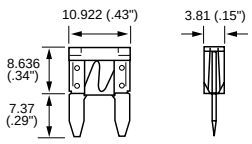
ATO®
Fast-Acting Type Fuse
257 Series

VOLTAGE RATING:	32V
AMPERE RANGE:	1.0 – 40A
INTERRUPTING RATINGS:	1000A @ 32VDC



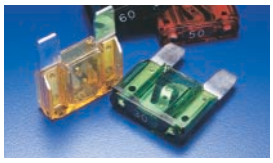
MINI®
Fast-Acting Type Fuse
297 Series

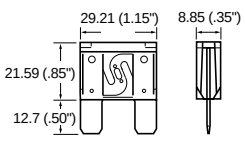
	32V
	2.0 – 30A
	1000A @ 32VDC



MAXI™
Slo-Blo® Type Fuse
299 Series

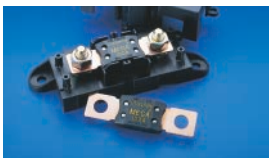
	32V
	20 – 80A
	1000A @ 32VDC

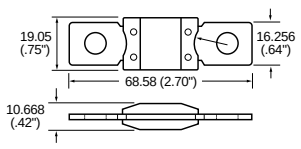




MEGA®
Fast-Acting
Ultra High Current Fuse
298 Series

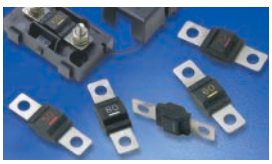
	32V
	100 – 250A
	2000A @ 32VDC

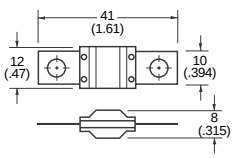




MIDI®
Fast-Acting
High Current Fuse
998 Series

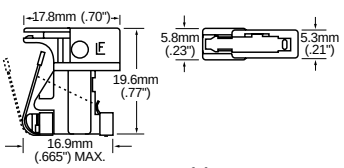
VOLTAGE RATING:	32V
AMPERE RANGE:	40 – 150A
INTERRUPTING RATINGS:	1000A @ 32VDC





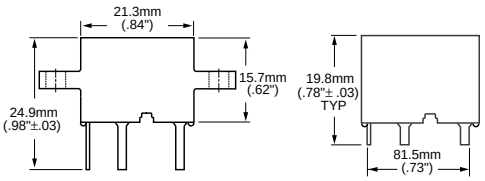
481
Alarm Indicating Fuse
481 Series

	125VAC/VDC
	0.18 – 20A
	450A @ 60VDC 300A @ 125VAC 300A @ 125VDC (up to 15A) 200A @ 125VDC (up to 20A)

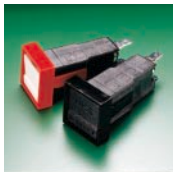
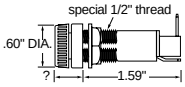
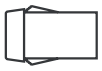
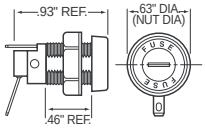
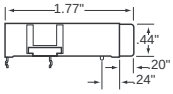
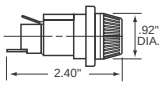
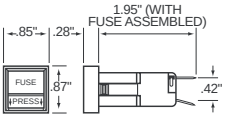


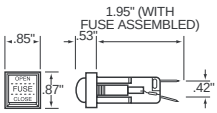
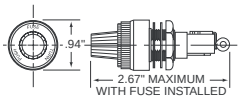
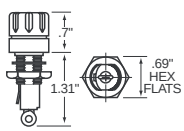
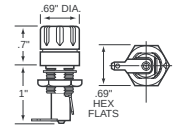
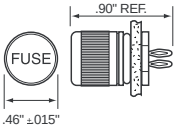
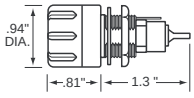
Fuseholders
Alarm Indicating
482 Series

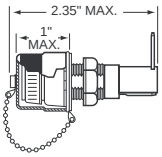
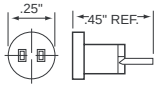
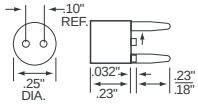
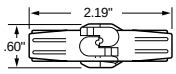
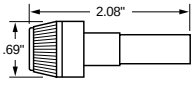
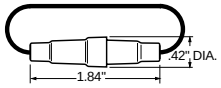
MOUNTING TYPE:	PCB and Panel
FUSE TYPE:	481 Alarm Indicating



FUSEHOLDERS

	International Shock-Safe 345 Series	Flip-Top Shock-Safe 346/286 Series	Shock-Safe 245 Series	Shock-Safe 345 Series	Shock-Safe 571 Series	Low Profile 348 Series
MOUNTING TYPE:	Panel Mount	Panel Mount	Panel Mount	PC Board Mount	Panel Mount	Snap Mount
FUSE TYPE:	3AG, 5x20mm, 2AG	3AG, 5x20mm, 2AG	2AG	3AG, 5x20mm, Midget	Midget	3AG
						
						

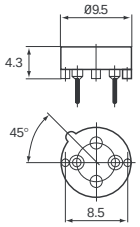
	Blown Fuse Indicating Type 344 Series	Blown Fuse Indicating Type 344 Series	Traditional 342 Series	RF Shielded 282 Series	Watertight 342 Series
MOUNTING TYPE:	Snap Mount	Panel Mount	Panel Mount	Front/Rear Panel	Panel Mount
FUSE TYPE:	3AG	3AG	3AG	Micro™ Plug-ins	3AG
						
						

	RF Shielded/ Watertight 340 Series	"Push-On" Retaining Nut 281 Series	Vertical/ Horizontal 281 Series	Twist-Lock 155 Series	Heavy-Duty Bayonet 155 Series	Special Type 150 Series
MOUNTING TYPE:	Panel Mount	Chassis Mount	PC Board Mount	In-Line Mount	In-Line Mount	In-Line Mount
FUSE TYPE:	3AG	MICRO™ & PICO®II Fuses	MICRO™ & PICO®II Fuses	Low Voltage 3AG, SFE	Low Voltage 3AG, SFE	2AG, 5x20mm
						
						

FUSEHOLDERS

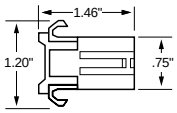
For LT-5™ Fuses
280 Series

MOUNTING TYPE: PC Board Mount
FUSE TYPE: LT-5 (662 – 665 Types)



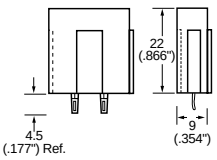
For ATO® Fuses
155 Series

In-Line Mount
ATO® Fuses



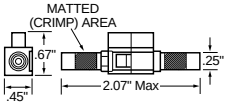
For ATO® Fuses
445 Series

PC Board Mount
ATO® Fuses



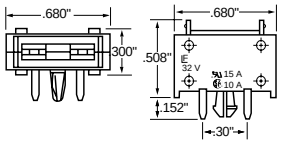
For MINI® Fuses
153 Series

In-Line, Easy Crimp
MINI® Fuses



For MINI® Fuses
153 Series

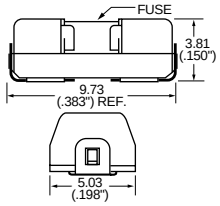
PC Board Mount
MINI® Fuses



FUSE BLOCKS AND CLIPS

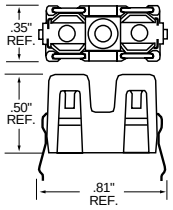
SMF Omni-Blok® Fuse Block
154 Series

MOUNTING TYPE: Molded Base
FUSE TYPE: NANO²® Fuse
See NANO²® Fuse for electrical characteristics.



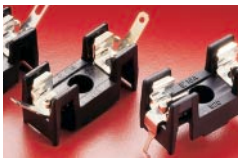
Omni-Blok® Fuse Block
254 Series

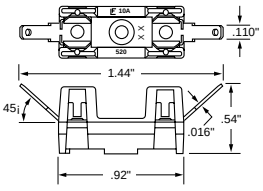
Molded Base
2AG



Metric Omni-Blok® Fuse Block
520 Series

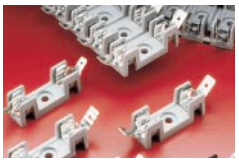
Molded Base
5 x 20mm

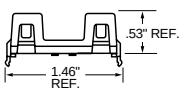




3AG Omni-Blok® Fuse Block
354 Series

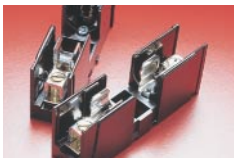
Molded Base
3AG

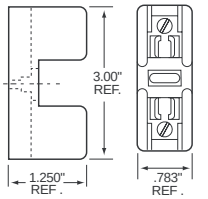




600 Volt
L600 Series

Molded Base
1½" long Midget, CC





3AG Screw Terminal

MOUNTING TYPE: Laminated Base
FUSE TYPE: 3AG

¼"–13/16" Diam. Fuses

Rivet/Eyelet Mount
3AG, Midget, NEC 1-60 amp

¼" Diam. Fuses
101 Series

Rivet/Eyelet Mount Solder Type
3AG

¼" Diam. Fuses

P.C.Board
Traditional

Bowed Tab

Low Profile (2)

Various Diam. Fuses

P.C.Board
ATO® Fuse

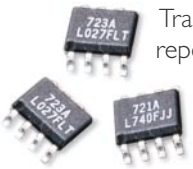
2AG or 5mm

5mm

5mm, Auto. Insertion Type

OVERVOLTAGE SUPPRESSION FACTS

Voltage Transients can be defined as short duration excursions or surges of electrical energy. Transients result from the sudden release of previously stored energy. In terms of electrical or electronic circuits, this energy can be released through intentional, controlled switching action, or induced into a circuit from external sources. If the voltage magnitude of the transient is large enough, circuit component damage or malfunction of circuit may result.



Transients occur in either repeatable fashion or as random impulses. Repeatable transients, such as commutative voltage spikes or inductive load switching are more readily observable, characterized, and suppressed as required. These might be caused from the operation of motors, generators, or the switching of reactive circuit components. Examples of random transients are lightning (Figure 1) and ElectroStatic Discharge (ESD) (Figure 2) which generally occur unpredictably, and may require more elaborate monitoring means to be accurately measured if induced at the circuit board level.

As stated, three common sources of transients are caused by the switching of a charged reactance, lightning, or ESD. In order to properly suppress these events it becomes necessary to quantify the various parameters of the transient. Numerous standards groups related to the electrical and electronic industries have analyzed these voltage transient occurrences using accepted monitoring or test methods.

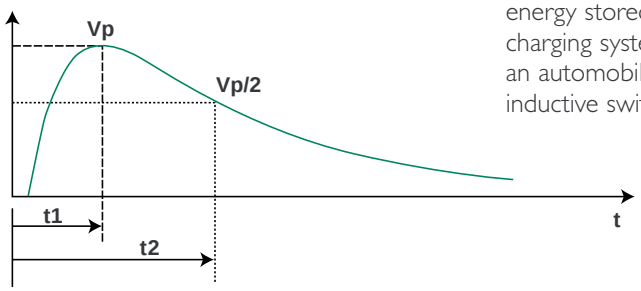


Figure 1. Lightning Transient Waveform

Transient voltage spikes most often exhibit a "double exponential" wave form. This is shown in Figure 1 for the open circuit waveshape of lightning.

The exponential rise time is about 1.2 µSec (essentially 0 to 90%) and the duration is defined as 50 µSec (50% of peak values). It is referred to as the "1.2x50" open circuit voltage when it occurs on an AC service line. As a short circuit current waveform it becomes 8x20 µSec. However, this same event can be observed as 10x560 µSec or 5x310 µSec when it occurs on telephone twisted pair lines.

Likewise, electrostatic discharges from the human body can be represented, or modeled, differently. Figure 2 characterizes the current waveform of this very fast transient as developed by the International Electrotechnical Commission (IEC).

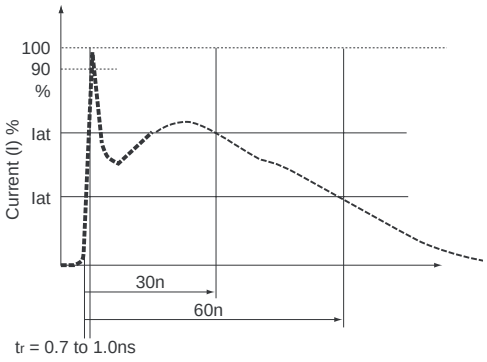


Figure 2. ESD Test Waveform

While the voltage rise time and shape will be a function of the circuit into which it is induced, ESD can reach 10 kV to 30 kV under low humidity and with the combination of certain triboelectric materials.

A third waveform standard example (Figure 3) represents the discharge of energy stored within an alternator charging system for the DC system of an automobile. It represents a random inductive switching transient and is

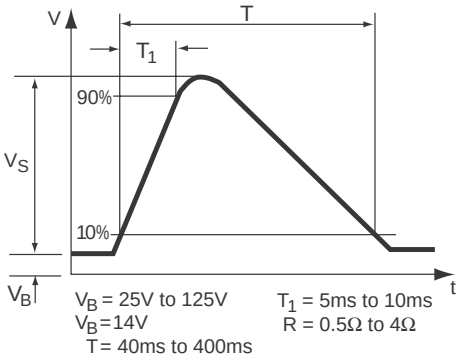


Figure 3. Load Dump Transient

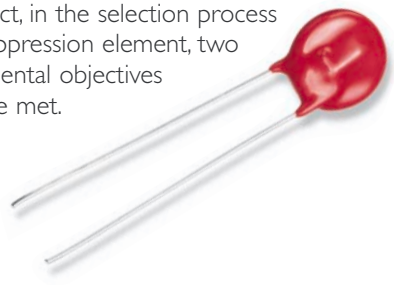
termed "Load Dump". It may reach 120V peak amplitude and have a duration of 400 milliseconds.

These few examples illustrate the wide variation in characteristics of real world transients. The waveshape, duration, and peak amplitude are three variables that must be known in order to properly choose a suppressor technology.

From analysis of voltage transients such as those examples described above, the required attributes of a suppressor device can be defined in terms of adequate surge current and energy ratings.

Secondly, the electrical characteristics of the application circuit in which the transient is induced will affect suppressor selection since it would serve no purpose to attenuate a transient if in doing so the circuit itself could not function properly. Knowledge of items such as line impedance, stray capacitance or inductance and susceptibility of adjacent components to over-voltage can aid in the determination of the suppression element.

Since there are numerous sources of voltage transients with widely varying characteristics and endless circuit applications, each with specific tolerance or sensitivity, no single suppression technology can possibly solve them all. In fact, in the selection process of a suppression element, two fundamental objectives must be met.



First is to choose a suppressor that is appropriately designed for the specific conditions presented by the expected transient, Secondly, it must be compatible to the application circuit by not adversely affecting normal function or performance.

To meet these criteria, Littelfuse offers the widest selection of suppression technologies. A brief description of each is presented on the following pages.

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 do not apply to 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.

UL *(Underwriters Laboratories, Incorporated)*
This is a US-based not-for-profit testing laboratory. UL writes "standards for public safety" 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 report. 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.)

AGENCY AND SPECIFICATION NUMBER							
		UL UL1449[2]	**UL** UL1414	**UL** UL497B	**CSA** 22.2-1	**VDE** CECC Spec 42201-006	**NSAI** CECC Spec 42201-006
Device Series[1]	**Package Style/ Technology**	file E75961	file E56529	file E135010	Cert. LR91788	license 104846E	Cert. HI-001
UltraMOV	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[3]		X		X	X
BA	Industrial/MOV	X					
DA/DB	Industrial/MOV	X					
HA	Industrial/MOV	X			X		
HB	Industrial/MOV	X			X[4]		
CH	Leadless Chip/MOV	X[3]		X			
PA	Industrial Base Mount/MOV	X			X		
RA	Low Profile Box/MOV	X	X	X	X		
Surgector™ Suppressor	DO-214			X			
TMOV	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. See Littelfuse data book for complete part descriptions.
2. Per Second Edition version.
3. Not all types within the series are applicable for recognition.
4. Pending completion of testing.

OVERVOLTAGE SUPPRESSION FACTS

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).

Varistors and Multilayer Varistors

Littelfuse 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, Varistors are typically used for the suppression of lightning and other high level transients found in industrial or AC line applications. Additionally, Varistors 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 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.

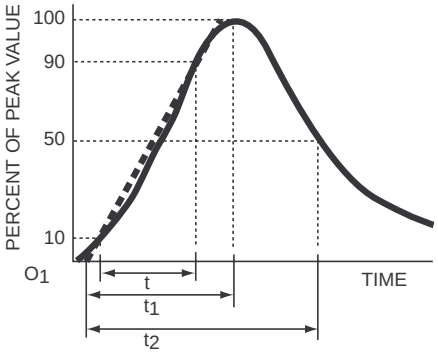


Figure 4. Peak Pulse Current Test Waveform

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 (2µs), with the rated VRMS 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 5.

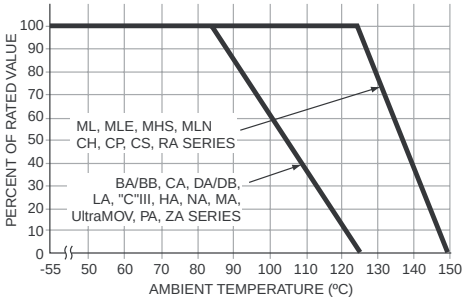


Figure 5. Current, Energy, Power Derating v/s Temperature.

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 for data rate applications beyond 5GHz. The PulseGuard family of devices are fabricated in various surface mount package form 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 passing through the device is less than 1 nA.

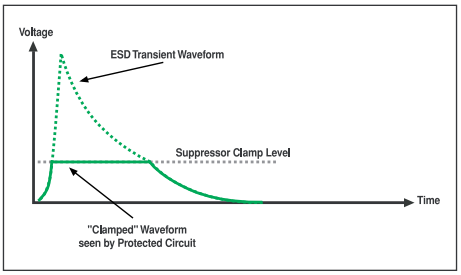
Voltage Rating
PulseGuard suppressors are rated for use in operating environments up to 24 VDC.

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.

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.



Surgector™ Suppressors

The telephone twisted wire pair infrastructure is subject to lightning transients. At the same time, the modern silicon chip interface circuits may not be rated for high voltage thereby limiting the usage of a clamping suppression device. Littelfuse Surgector™ Suppressors are SCR structures and as such they exhibit a "crowbar" action for suppression. Once triggered by the transient voltage, the Surgector's rapid conduction state allows only a few volts across the line it protects until the transient subsides.

Surgectors are offered in various voltage ranges and replace industry" Sidactor" types. Littelfuse Surgectors may be combined with Littelfuse 461 telecom fuses for coordinated over-voltage and over-current protection for products connected to telco lines. Surgectors are recognized components to Underwriters Laboratories UL497B specification.

TERMS

V_{DRM}
Maximum Off-State Voltage (DC or Peak) which may be applied continuously.

I_{DRM}
Maximum Reverse Current measured with V_{DRM} applied (Off-State Current).

V_T
Forward voltage drop at the specified Forward Current I_T. In the On-Stage Latch Mode.

V_{BO}
Maximum Breakover Voltage at which the device switches to the On-State latched mode.

I_H
Minimum On-State Current required to maintain the device in the latched-on state.

C_O
Terminal Capacitance measured at the specified off-state bias Voltage.

I_{TSM}
Maximum Peak Surge Current at the specified AC cycle waveform.

I_{PP}
Peak Pulse Surge Current rating of a designated waveform.

Crowbar Device
The class of suppressors that exhibit a "crowbar" characteristic is usually associated with a 4-layer NPNP silicon bipolar devices or spark gap devices. Upon reaching a threshold or Breakover Voltage, further increase in current flow will cause the device to rapidly conduct with only a few volts of forward drop. In essence, the line is momentarily "short-circuited" during the duration of the transient.

OVERVOLTAGE SUPPRESSION FACTS

Silicon Protection (SP)

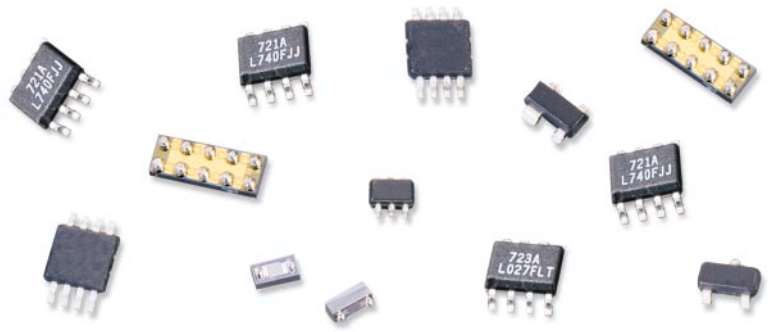
Silicon Transient Voltage Suppression (TVS) technology offers a high level of protection (up to 30kV per IEC 61000-4-2) with very low capacitance, leakage current and clamp voltage. In addition to a single line 0402 device, high density arrays are available for up to 18 lines including power rail protection.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

TVS Avalanche Diode

The Surface Mount family of TVS Avalanche Diode arrays are specifically designed to protect circuits from Electrostatic Discharge (ESD). This family is rated per the International Electrotechnical Compatibility (IEC) transients immunity test method IEC 61000-4-2 for level 4 (8kV Direct Discharge). The devices are typically connected between the sensitive signal line and ground. When a transient event occurs, the device turns on and directs the transient into the ground plane. The space saving arrays protect multiple data lines in the ultra small 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. The devices feature low capacitance (39pF), low clamping voltage, leakage current and very fast response time. Both unipolar and bipolar versions are available.

Rail Clamp TVS Diode Arrays

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 (30V) SP72x family and lower voltage (5V) SP05x family.



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 input current that is measured at maximum Vsupply 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 / 1VRMS 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 23 which highlight the fundamental attributes of each.

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 high density single line (0402) or multi-line protection is needed.
- 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)
- ESD is the primary 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 in EIA sizes. (MLN is 4-line)
- The operating voltage is above the SP or PulseGuard® Suppressor ratings.

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 or IEC 61000-4-2, 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

Test Severity Level		
Level	Test Voltage Contact Discharge	Test Voltage Air Discharge
1	2kV	2kV
2	4kV	4kV
3	6kV	8kV
4	8kV	15kV
X	Special	Special

Notes:
1. X is an open level.
2. The test severity levels shall be selected in accordance with the most realistic installation and environmental conditions.

types are the silicon based SP05x, SP723 and SP724 SCR/Diode Arrays, the polymeric VVM based PulseGuard® Suppressor, and the V18ML, 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 semicon-ductors 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 EMC 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."

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.

Overvoltage Application Guide

Application Segment	Typical Applications and Circuit Examples	Typical Transient Threats	Device Family or Series	Technology
Low Voltage, Board Level Products	* EDP * Computer * Hand-Held/Portable Devices * Instrumentation * Controllers * Remote Sensors * Mobile Communications * I/O Port and Interface * Medical Electronics, etc. * Broad Band * USB 1.1 * Ethernet * Security and Alarm Systems	ESD, EFT, EMI	CH, MA, ZA, RA	MOV
			ML, MLE, MLN, MHS	Multilayer MOV
			SP7X	SCR/Diode Array
		ESD	PGB, PGD, SP05X	Voltage Variable Polymer TVS Avalanche Diodes
High-Speed Dataline Protection	* USB 2.0 * Gigabit Ethernet * RF Antenna Circuits * InfiniBand℠ * IEEE 1394	ESD	PGB	Voltage Variable Polymer,
AC Line,TVSS Products	* UPS * Power Meters * AC Appliance/Controls * Power Supplies * AC Power Taps * Circuit Breakers * TVSS Devices * AC Panels * Consumer Electronics	Lightning, Inductive Load Switching, Commutative Pulses	CH, TMOV™, UltraMOV™, LA, C-III, HA, HB and RA Varistors	MOV
Automotive Electronics	* ABS * EEC * Body Controllers * Multiplex Bus * EFI * Instrument Cluster * Air Bag/Window Control/Wiper Modules	Load Dump	CH, ZA	MOV
			AUML, ML	Multilayer MOV
		ESD	SP72X, SP05X	SCR/Diode Array
			PGB, PGD	Voltage Variable Polymer
			ML	Multilayer MOV
Telecom Products	* Cellular/Cordless Phone * Repeaters * Line Cards * Modems * Data Line Connectors * COE * Secondary Phone Line * T1/E1/ISDN Protectors	Lightning	CH,ZA, SP72X	MOV
			Surgector™ (SGT)	Thyristor
		ESD, EFT, EMI	SP72X, SP05x	SCR/Diode Array
			ML, MLE, MLN, MHS	Multilayer MOV
		ESD	SP05X, PGB	TVS Avalanche Diode, Voltage Variable Polymer
Industrial, High Energy AC Product	* Robotics * Large Motors, Pumps, Compressors * High Current Relays * Motor Drives * AC Distribution Panel	Lightning, Switching, Commutative Pulses	DA/DB, BA,BB, CA, HA, HB, NA, PA	MOV

OVERVOLTAGE SUPPRESSION FACTS

Overvoltage Suppression Selection Guide

	PulseGuard® Suppressors	Silicon Protection						Surgector™ Suppressors		Metal Oxide Varistors (MOV)						
	Surface Mount	Chip Scale Package (CSP)	Surface Mount				Leaded	Surface Mount	Leaded	Surface Mount	Surface Mount Multilayer					Axial Leaded
Series Name	PGB	SP05X	SP72X	SP05X	SP05X	SP05X	SP72X	SGT	SGT	CH	ML	MLE	AUML	MLN	MHS	MA
Technology Type	Voltage Variable Polymer	TVS Avalanche Diodes	Rail Clamp SCR/Diode Array	TVS Avalanche Diode	Rail Clamp	Rail Clamp w/ Avalanche Diode	Silicon SCR/Diode Array	Silicon Thyristors	Silicon Thyristors	Zinc Oxide	Multilayer Zinc Oxide	Multilayer Zinc Oxide	Multilayer Zinc Oxide	Multilayer Zinc Oxide	Multilayer Zinc Oxide	Zinc Oxide
Operating AC Voltage Range	———	———	———	———	———	———	———	———	———	14-275	2.5-104	———	———	———	———	9-264
Operating DC Voltage Range	0-24	0-5.5	0-30	0-5.5	0-5.5	0-5.5	0-30	58-300	33-270	18-369	3.5-120	0-18	18	5.5-18	0-42	13-365
Peak Current Range (A)**	45	———	45	———	———	———	45	600	600	250-500	30-250	20	———	20	———	40-100
Peak Energy Range (J)	*	**	**	**	**	**	**	**	**	1-23	0.1-2.0	0.5	———	0.05	0.025	0.06-1.7
Temperature Range (Deg.C)	-65 – +125	-40 – +85	-55 – +125	-20 – +85	-20 – +85	-20 – +85	-55 – +125	-40 – +85	-40 – +85	-55 – +125	-55 – +125	-55 – +125	-55 – +125	-55 – +125	-55 – +125	-55 – +85
Lines Protected	1-8	1, 4, 8, 16	4,6,14	2, 3, 4, 5, 6	6, 18	2, 4, 6, 18	6,14	1	1	1	1	1	1	4	1	1
Mount/Form Factor	Surface Mount	Surface Mount	SOIC	SOT23, SOT143, MSOP8, TSSOP8	SOT143, QSOP8, MSOP8, SOIC8	MSOP8, SOIC8, QSOP24	PDIP	Mount DO-214AA	Modified TO-202	Surface Mount	Surface Mount	Surface Mount	Surface Mount	Surface Mount	Surface Mount	Axial Leaded
Disc Size (MOV)	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	3mm
Agency Approvals	———	———	———	———	———	———	———	UL	UL	UL	———	———	———	———	———	———

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

Overvoltage Suppression Selection Guide

	Metal Oxide Varistors (MOV)												
	Radial Leaded						Packaged					Bare Disc	
Series Name	ZA	RA	LA	C-III	UltraMOV	TMOV	PA	HA	HB34	DA/DB	BA/BB	NA	CA
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
Operating AC Voltage Range	4-460	4-275	130-1000	130-320	130-625	130-320	130-660	130-750	130-750	130-750	130-2800	130-750	130-2800
Operating DC Voltage Range	5.5-615	5.5-369	175-1200	———	170-825	170-420	175-850	175-970	175-970	175-970	175-3500	175-970	175-3500
Peak Current Range (A)**	50-6,500	150-6,500	1,200-6,500	6,000-9,000	1,750-10,000	6,000-10,000	6,500	25,000 40,000	30,000 40,000	30,000 40,000	50,000 70,000	40,000	20,000 70,000
Peak Energy Range (J)	0.1-52	0.4-140	11-360	45-220	12.5-400	50-273	70-250	200-1050	270-1050	270-1050	450-10000	270-1050	200-10000
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
Lines Protected	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
Disc Size (MOV)	5, 7, 10, 14, 20mm	8,16,22mm	7,10,14 20mm	14,20mm	7,10,14 20mm	14,20mm	20mm	32,40mm	34mm	40mm	60mm	34mm	32, 40 & 60mm
Agency Approvals	UL,VDE	UL,CSA &VDE	UL,CSA &VDE	UL,CSA &VDE	UL,CSA	UL	UL&CSA	UL&CSA	UL&CSA	UL	UL	———	———

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

ESD Suppressor Selection Guide

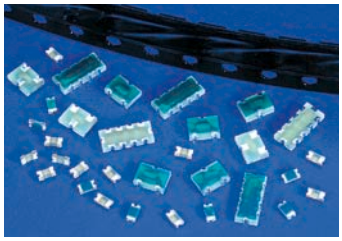
Littelfuse manufacturers three different surface mount product families for ESD suppression. Each technology provides distinct attributes for compatibility to specific circuit requirements.
1. Review the circuit requirements or parameters from the left hand column and compare them to the Littelfuse product offerings shown.
2. Refer to Littelfuse data sheets and application notes for complete technical information.

	PulseGuard® Suppressors	Silicon Protection					Multilayer Varistors			
	Surface Mount	Chip Scale Package (CSP)	Surface Mount				Surface Mount			
Series Name	PGB	SP05X	SP72X	SP05X	SP05X	SP05X	ML	MLE	MLN	MHS
Technology Type	VVM	TVS Avalanche Diode	Silicon SCR/Diode	TVS Avalanche Diode	Rail Clamp	Rail Clamp w/ Avalanche Diode	MLV ZnO	MLV ZnO	MLV ZnO	MLV ZnO
Working Voltage	0-24VDC	0-5VDC	0-30VDC	0-5VDC	0-5VDC	0-5VDC	0-120VDC range by type	0-18VDC	0-18VDC	0-42VDC
Array Package (No. of Lines)	SOT23 (2), CA10 (8), 0805 (4)	CSP (4, 8, 16)	DIP, SOIC (6, 14) SOT23 (4)	SOT23 (2), SOT143 (3), SOT23-5 (4), SOT23-6 (5), TSSOP-8 (4), MSOP-8 (6)	SOT143 (2), MSOP-8 (6), SOIC-8 (6), QSOP-24(18)	MSOP-8 (6) SOIC-8 (6), QSOP-24(1,8)	No	No	1206 (4)	No
Single Line Package	0402, 0603	0402	No	No	No	No	0402-1210	0402-1206	——	0402
Typical Device Capacitance	0.05pF	39pF	3-5pF	30pF	3-7pF	3-7pF	40-6000pF	40-1700pF	45-430pF	3-12pF
Leakage Current	<1nA	<10µA	<20µA	<10µA	<1µA	<1µA	<5µA	<10µA	<2µA	<5µA
Rated Immunity to IEC 61000-4-2 level 4	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Also Rated for EFT or Lightning Wave	No	TBD	Yes	TBD	TBD	TBD	Yes	Yes	Yes	Yes
Bidirectional (transients of either polarity)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Performs Low Pass Filtering	–	–	–	–	–	–	Yes	Yes	Yes	Yes

OVERVOLTAGE SUPPRESSION PRODUCTS

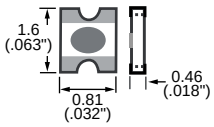
Surface Mount PulseGuard® ESD Suppressor

PGB Series

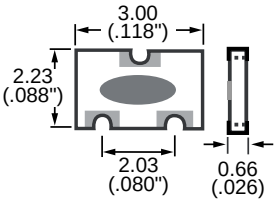


OPERATING VOLTS: 24VDC, maximum
PEAK CURRENT: 45A @ 15kV
CAPACITANCE: 0.05pF @ 1MHz
LEAKAGE: **<1.0 nA @ 5VDC**
OFF STATE RESISTANCE: **10MΩ, minimum @ 5VDC**
CLAMPING: **150V, typical @ 8kV**

PGB0010603



PGB002ST23



SCR/Diode Arrays

SP720, SP721, SP723, SP724

FEATURES:

- High energy ratings
- Very low clamping
- 4/6/14 line protection
- High speed

Surgectors™

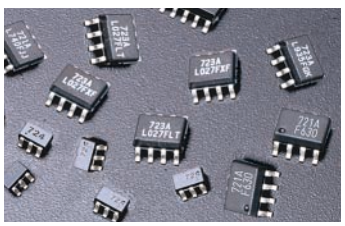
SGT-TVS – Thyristor/Zener

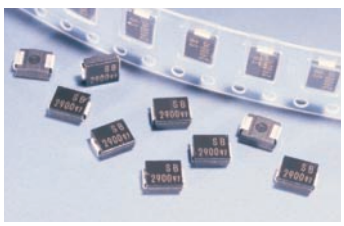
FEATURES:

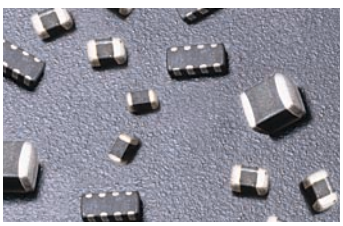
- Low profile
- Nanosecond response time
- Automatic reset
- Crowbar action

Surface Mount Varistors

FEATURES:	CH	ML	MLE	MHS	AUML	MLN
• Leadless	X	X	X	X	X	X
• Surge rated 8x20 µsec	X	X				X
• High peak surge current	X	X			X	
• Automotive series					X	
• 4 Line Array						X







OVERVOLTAGE SUPPRESSION PRODUCTS

MOVs/Industrial/Axial

FEATURES:

UltraMOV

- High peak surge current rating
- High energy absorption capability
- 7, 10, 14 and 20mm

C-III

- High energy absorption capability
- High pulse life rating
- 14, 20mm

LA

- Designed for continuous operation in AC lines
- High energy absorption capability
- 7, 10, 14 and 20mm

ZA

- Designed for protection of low- and medium-voltage circuits and systems
- 5, 7, 10, 14 and 20mm

TMOV™ Varistor NEW

- UltraMOV with built-in thermal element for sustained abnormal overvoltage conditions
- High peak surge current rating
- High energy absorption capability
- 14, 20mm

BA/BB

- High energy absorption capability
- Wide operating voltage ranges
- Designed for motor controls and power supplies

MA

- Wide operating voltage ranges capability
- Protects component and signal/data lines from energy transients where the small axial lead is required

CA/NA

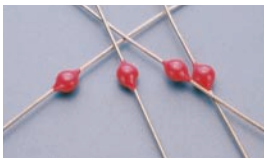
- Wide operating voltage ranges
- High energy capability

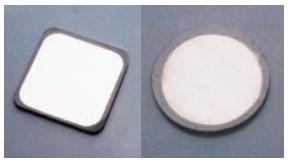
RA

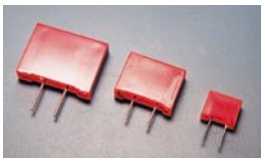
- High energy absorption
- Wide operating voltage ranges
- For use in applications requiring unique electrical contact or packaging methods

PA

- Wide operating voltage
- Ideal for applications which are subject to vibrations
- Increased mechanical stability for secure circuit board mounting and vibration-critical applications

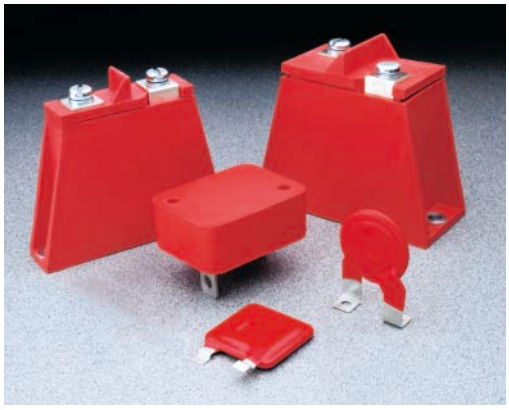






HA/HB34/DA/DB

- High energy absorption capability
- Wide operating voltage ranges
- High peak current capability
- Designed to provide surge protection for motor controls and power supplies



NEW TVS SILICON PROTECTION

Surface Mount

FEATURES:

- 2, 3, 4 and 5 channel arrays
- Offered in small SOT-23, TSSOP and MSOP packages
- Industry Standard device footprint and function

Chip Scale Package

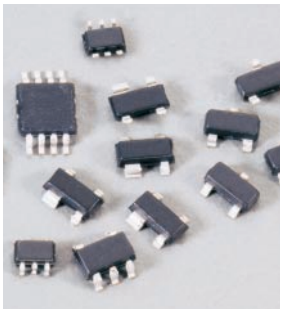
FEATURES:

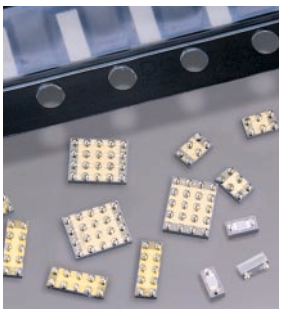
- The Chip is the package
- 1, 4, 8 and 16 channel arrays
- Single channel device is 0402 size
- Ultra small footprint arrays

Rail Clamp Device

FEATURES:

- 2, 6 and 18 channel arrays
- Smaller package options (SOT-143, MSOP, QSOP and SOIC)
- Optional internal TVS avalanche diode for power rail protection
- Broadens SP72x family of 4, 6 and 14 channel arrays





INDEX

Littelfuse, Inc.
800 E. Northwest Highway
Des Plaines, IL 60016, USA
www.littelfuse.com

International Sales, Distribution and Engineering Facilities:

North America

- Des Plaines, Illinois USA
  Technical Assistance and
  Phone: (800) 999-9445
  Fax: (847) 391-0459

Europe

- Utrecht, The Netherlands
  Phone: (+31) 30-299-9900
  Fax: (+31) 30-299-9800
- Washington, England
  Phone: (+44) 191-415-8181
  Fax: (+44) 191-415-8189

Asia/Pacific

- Singapore
  Phone: (+65) 746-9666
  Fax: (+65) 742-8178
- Hong Kong, China
  Phone: (+85) 22-810-5099
  Fax: (+85) 22-810-5500
- Seoul, Korea
  Phone: (+82) 2-463-6073
  Fax: (+82) 2-463-3273
- Yokohama, Japan
  Phone: (+81)45-478-1088
  Fax: (+81)45-478-1089

Central and South America

- Sao Paulo, Brasil
  Phone: (+55)11-3977-0909
  Fax: (+55)11-3976-6690
- Piedras Negras, Mexico
  Phone: (+52) 8-782-5330
  Fax: (+52) 8-782-3398

Research and Manufacturing Facilities:

- Arcola, Illinois USA
- Centralia, Illinois USA
- Des Plaines, Illinois USA
- Dundalk, Ireland
- Grenchen, Switzerland
- Malvar, Philippines
- Piedras Negras, Mexico
- Seoul, Korea
- Suzhou, China
- Taipei, Taiwan R.O.C.
- Washington, England

FORM NO. EC102

Littelfuse®
Circuit Protection Specialists