Littelfuse®
Circuit Protection Specialists

Electronic Product Selection Guide

At Littelfuse, we focus on what we do best — developing and manufacturing devices that protect electronic circuits and applications from harm caused by overcurrent and overvoltage events. It's this focus that has enabled us to consistently lead the industry in innovative, high-quality circuit protection technologies. Something we've been doing for over 75 years.

Open the cover on nearly any electronic device you can think of and inside you'll find a Littelfuse product. Computers, cell phones, telecommunications equipment, televisions, appliances, automotive components — all these and many more are safeguarded by Littelfuse technology.

Today, we offer the broadest line of circuit protection products in the world for both overcurrent and overvoltage applications. As the leading global provider of circuit protection devices for the automotive industry and the third largest producer of power fuses in North America, we deliver the innovation, expertise, quality, capacity and service you would expect from an industry leader.

Protecting Circuits from Excessive Current and Voltage

Littelfuse provides both overcurrent and overvoltage circuit protection products:

- Our overcurrent line of products includes fuses and resettable PTCs which protect electrical circuits and devices when current exceeds a predetermined value.
- Our overvoltage line of products includes electrostatic discharge (ESD) suppressors, SiBOD™ thyristors, gas plasma protectors/GDTs, silicon avalanche diodes (SADs) and metal oxide varistors (MOVs) which provide a resistive shield against transient voltage surges.

Why Littelfuse?

When you choose Littelfuse as your supplier of circuit protection solutions, you gain from a full range of important benefits:

- A broad selection of products and technologies from a single source means optimal solutions and fewer compromises. Our wide range of choices minimizes the need to approximate or trade off.
- 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.
- Our Technical Solutions Group (TSG) is dedicated to providing customer-focused, application-specific technical support services for Littelfuse customers around the world.

Littelfuse offers innovative solutions, based on extensive research and development, and an uncompromising approach to quality. We continue to enhance our products and manufacturing processes to stay on the leading edge of technology and meet today's ever-increasing compliance and reliability standards.

We hope this publication will provide the information you need to make the right choices in circuit protection products. If you have any questions about our products, feel free to call us at: 847.824.1188.

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FUSE FACTS

The following Fuse Facts section will provide a better understanding of both fuses and common applications. The fuses described are current-sensitive devices that serve as an intentional weak link in an electrical circuit and provide protection against overheating by reliably melting under current-overload conditions. They can be used to protect discrete components or complete circuits.

Although this guide provides technical information that will help you design your circuit protection application, such as product data and design guidelines, it is not intended to be comprehensive. Testing is strongly recommended and should be conducted to verify application performance.

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

In the absence of special requirements, Littelfuse reserves the right to make appropriate changes in design, process, and manufacturing location without notice.

Ambient Temperature

The temperature of the air immediately surrounding the fuse. 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 the current the fuse can carry, based on a controlled set of test conditions. (See RERATING).

Most 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 controlled test conditions. These test conditions are part of UL/CSA/ANCE (Mexico) 248-14 "Fuses for Supplementary Overcurrent Protection", the primary objective of which is to specify common test standards 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 must account for the variable conditions of the specific application.

To compensate for these variables, the circuit design engineer who is designing for trouble-free, long-life fuse protection, generally loads the fuse no 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 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.

Slo-Blo® Thin-Film fuse designs, which use lower melting temperature materials, are more sensitive to ambient temperature changes.

Dimensions

All dimensions are given in inches unless otherwise specified. 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 have been developed over the years, fuse sizes evolved to fill 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, hence the term "AG". The numbers were applied chronologically as different manufacturers started making a new size. For example, "3AG" 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	Length		Diameter/Width	
	mm	in	mm	in
0402	1.04	.041	.51	.020
0603	1.60	.063	.813	.032
1206	3.18	.125	1.52	.060
1AG	15.875	.625	6.35	.250
2AG	14.48	.57	4.5	.177
3AG	32.385	1.28	6.985	.275
4AG	31.75	1.25	7.14	.281
5AG	38.1	1.50	10.31	.406
7AG	22.22	.875	6.35	.250
8AG	25.4	1	6.35	.250

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® fuses. The distinguishing feature of Slo-Blo® fuses is their additional thermal inertia and their ability to tolerate normal initial or start-up overload pulses.

Fuse Construction

Internal fuse 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 its 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 at 125 VAC, 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. A fuse cannot be selected solely on the basis of normal operating current and ambient temperature.

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. In such an application, the fuse's 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 for which 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 is available upon request. Fuses can be supplied to specified controlled resistance tolerances at additional cost.

FUSE FACTS (cont.)

Soldering Recommendations

Since most fuse constructions incorporate soldered connections, caution should be used when installing 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, overload 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. Most common voltage ratings used by fuse manufacturers for most small-dimension and midget fuses are 24, 32, 63, 125, 250, 300, 350 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, under an overload condition, 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 1 millisecond (0.001 seconds) or less for thin-film fuses; 8 milliseconds (0.008 seconds) or less for axial and cartridge fuses; 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 at 125 volts AC minimum. 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

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.

Recognized Under the Component Program of Underwriters Laboratories

Canadian Recognized Component Mark

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

CSA

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 tests to this specification.

METI/ MITI Approval

METI/MITI approval in Japan uses similar requirements as those covered in the UL/CSA/ANCE 248-14. METI/MITI also uses special testing similar to that covered in the IEC standards.

International Electrotechnical Commission (IEC)

IEC 60127-2, Sheet 1, 2, 3, 5, 6 (250 Volts)

The IEC is different from UL and CSA, since IEC is an international organization that writes specifications and does not certify. UL and CSA write the specifications, are responsible for testing and give certification in the US and Canada, respectively.

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

IEC 60127-2 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 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.

The newest addition to IEC 60127 is part 4 which covers UMF (Universal Modular Fuse) products for both through-hole and surface mount fuse types. The standard allows for both through-hole and surface mount fuses with voltage ratings of 32, 63, 125 and 250 volts.

Breaking capacities for the 32, 63, and 125 volt fuses are the same as low breaking capacity fuses covered by IEC 60127 Part 2. The 250 volt UMF fuse is available in a low breaking capacity (100A), intermediate breaking capacity (500A), and high breaking capacity (1500A).

PTC FACTS

Overcurrent circuit protection can be accomplished with the use of either a traditional one time 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 element melts open, interrupting the current flow, while 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

A PTC is said to have "tripped" when it has transitioned from the low resistance state to the high resistance state due to an overload (see figure #1 below). 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 after being subjected to an overload.

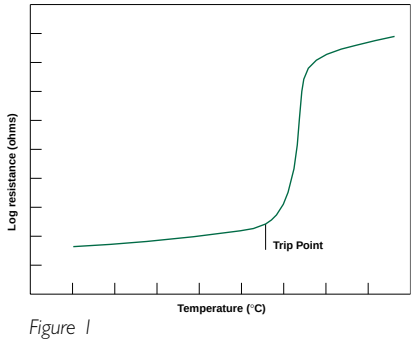


Figure 1

PTC Facts (cont.)

Interrupting Rating

PTCs are rated for a maximum short circuit current at rated voltage. This fault current level is the maximum current that the device can withstand. A typical PTC short circuit rating is 40A. PTCs will not actually interrupt the current flow (see LEAKAGE CURRENT above), whereas fuses do interrupt the current flow in response to the overload. The range of interrupting ratings for fuses 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 is 60A, in accordance with UL/CSA/ANCE 248-14.

Temperature Rating

The useful upper limit for a PTC is generally 85°C while the maximum operating temperature for fuses is 125°C. The temperature rerating curves (see fig. 3) 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. These devices have also been certified under the CSA Component Acceptance Program.

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. (see figure #2)

Summary

Many circuit protection issues are 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 the *Microsoft and Intel System Design Guide* which states that "Using a fuse that must be replaced each time an overcurrent condition occurs is unacceptable." In addition, the Plug and Play SCSI (Small Computer Systems Interface) Specification for this large market includes the statement, "...must provide a self-resetting device to limit the maximum amount of current sourced."

A selection guide work-sheet appears on the following page as an aid in choosing the best circuit protection component and determining when PTCs may be the appropriate choice for providing overcurrent circuit protection.

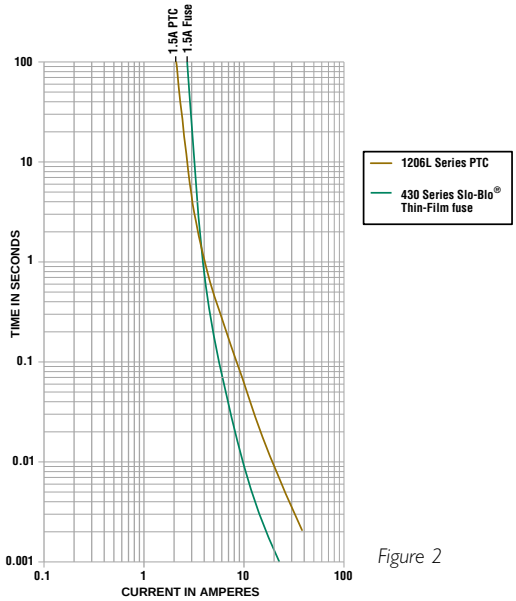


Figure 2

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

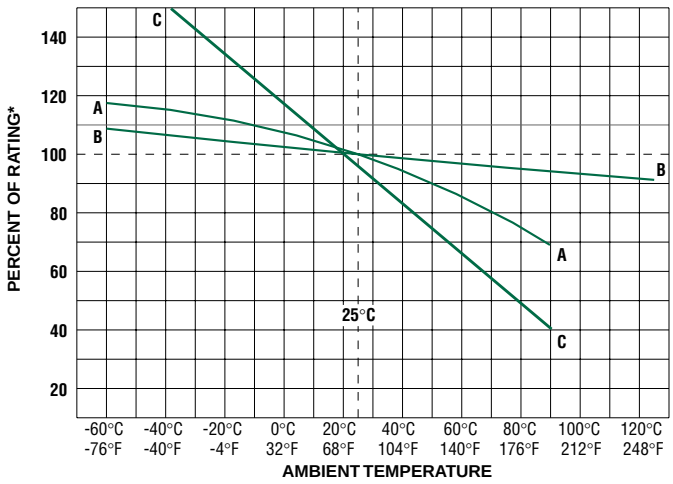


Figure 3

• 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

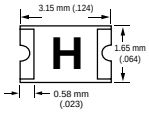
	Surface Mount PTC	30V PTC Leaded	60V PTC Leaded	0402 SMF	0603 SMF	1206 SMF	Nano²® SMF Fuse	PICO® II Fuse	2AGs	5x20mm	3AGs/3ABs	Midgets
Operating Current Range	0.200 - 3.0A	0.900 - 9A	0.100 - 3.75A	0.250 - 2A	0.250 - 5A	0.125 - 7A	0.062 - 15A	0.062 - 15A	0.100 - 10A	0.032 - 15A	0.010 - 35A	0.100 - 30A
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	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	UMF, 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

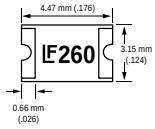
1206L Series
Surface Mount

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

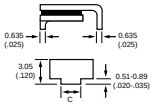
1812L Series
Surface Mount

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

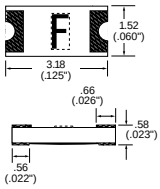
SURFACE MOUNT FUSES

NEW SlimLine™ Lead-Free 1206
Very Fast-Acting Thin-Film Fuse
466 Series

VOLTAGE RANGE: 24-125V
AMPERE RANGE: 0.125 – 7.0A

INTERRUPTING RATINGS:

0.125 – .375A	50A @ 125VAC/VDC
0.5 – 2A	50A @ 63VAC/VDC
2.5 – 3A	50A @ 32VAC/VDC
4 – 7A	35A @ 24VAC/VDC

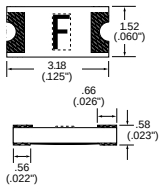



SlimLine™ 1206
Very Fast-Acting Thin-Film Fuse
433 Series

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

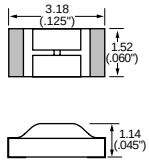
INTERRUPTING RATINGS:

0.125 – .375A	50A @ 125VAC/VDC
0.5 – 2A	50A @ 63VAC/VDC
2.5 – 3A	50A @ 32VAC/VDC
4 – 7A	35A @ 24VAC/VDC

1206
Very Fast-Acting Thin-Film Fuse
429 Series

For new designs use 433 or 466 Series

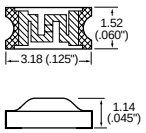



1206
Slo-Blo® Thin-Film Fuse
430 Series

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

INTERRUPTING RATINGS:

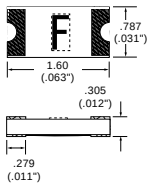
0.5 – 1.5A	50A @ 63VAC/VDC
2A	35A @ 63VAC/VDC
3A	50A @ 32VAC/VDC

NEW SlimLine™ Lead-Free 0603
Very Fast-Acting Thin-Film Fuse
467 Series

32V
0.25 – 5.0A

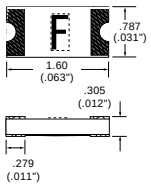
0.25 – 1A	50A @ 32VAC/VDC
1.25 – 5A	35A @ 32VAC/VDC

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

32V
0.25 – 5.0A

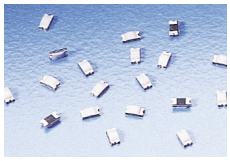
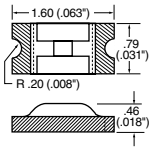
0.25 – 1A	50A @ 32VAC/VDC
1.25 – 5A	35A @ 32VAC/VDC

SURFACE MOUNT FUSES

0603
Very Fast-Acting Thin-Film Fuse
431 Series

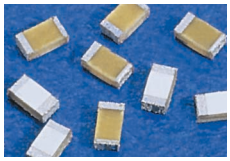
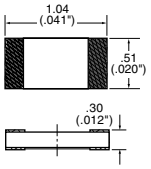
VOLTAGE RANGE: *For new designs*
AMPERE RANGE: *use 434 or*
INTERRUPTING RATINGS: *467 Series*

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

24V
0.25 – 2.0A

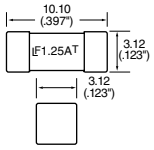
35A @ 24 VDC

Telecom NANO²®
Minature Fuse
461 Series

250V
0.5 – 2.0A

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

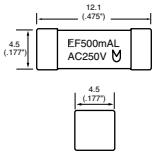



NEW NANO²® 250V UMF
Fast-Acting Fuse
464 Series

VOLTAGE RANGE: 250V
AMPERE RANGE: 1 – 6.3A

INTERRUPTING RATINGS: 100A @ 250VAC

*Available in 2003

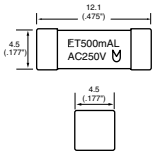



NEW NANO²® 250V UMF
Time Lag Fuse
465 Series

250V
1 – 6.3A

100A @ 250VAC

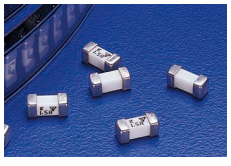
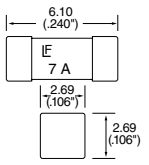
*Available in 2003

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

65 – 125V
0.062 – 15.0A

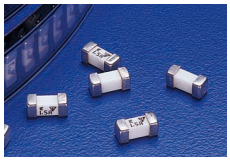
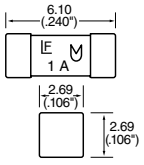
0.062 – 8A	50A @ 125VAC/VDC 300A @ 32VDC
10A	35A @ 125VAC 50A@125VDC 300A @ 32VDC
12 – 15A	50A @ 65VAC/VDC 300A @ 24VDC

NANO²® UMF
Fast-Acting Type Fuse
455 Series

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

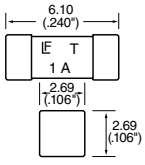
INTERRUPTING RATINGS: 50A @ 125VAC/VDC

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

125V
0.375 – 5A

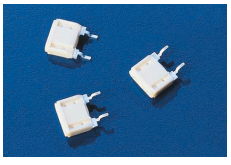
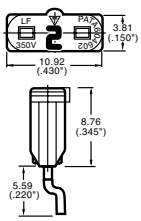
50A @ 125VAC/VDC
300A @ 32VDC

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

350V
2 – 10A

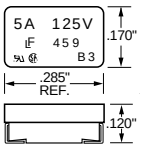
100A @ 350VAC
50A @ 125VDC
450A @ 60VDC

SURFACE MOUNT FUSES

PICO® SMF
Very Fast-Acting Type Fuse
459 Series

VOLTAGE RANGE: 125V
AMPERE RANGE: 0.062 – 5.0A
INTERRUPTING RATINGS: 50A @ 125VAC
300A @ 125VDC

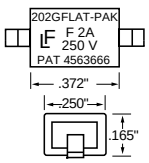



PICO® SMF
Slo-Blo® Type Fuse
460 Series

VOLTAGE RANGE: 125V
AMPERE RANGE: 0.5 – 5.0A
INTERRUPTING RATINGS: 50A @ 125VAC/VDC

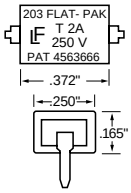
FLAT-PAK®
Fast Acting Type Fuse
202 Series

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

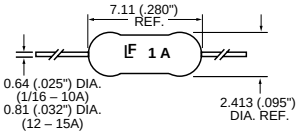



AXIAL LEADED FUSES

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

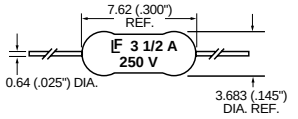
QPL

VOLTAGE RANGE: 32 – 125V
AMPERE RANGE: 0.062 – 15A
INTERRUPTING RATINGS: 300A @ Rated VDC
50A @ Rated VAC

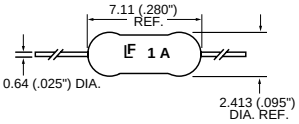
PICO® II 250V
Very Fast-Acting Type Fuse
263 Series

VOLTAGE RANGE: 250V
AMPERE RANGE: 0.062 – 5.0A
INTERRUPTING RATINGS: 50A @ 250VAC

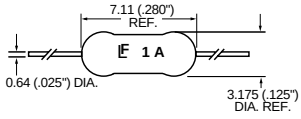
PICO® II
Time Lag Type Fuse
471 Series

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

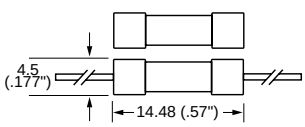
AXIAL LEADED AND CARTRIDGE FUSES

2AG
Fast-Acting Type Fuse
224/225/288/289 Series

MIL

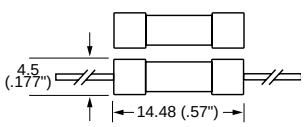
VOLTAGE RANGE: 125 – 250V
AMPERE RANGE: 0.10 – 10.0A
INTERRUPTING RATINGS:

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

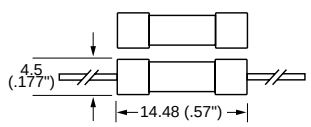



2AG
Slo-Blo® Type Fuse
229/230/290/291 Series

MIL

VOLTAGE RANGE: 125 – 250V
AMPERE RANGE: 0.25 – 7.0A
INTERRUPTING RATINGS:

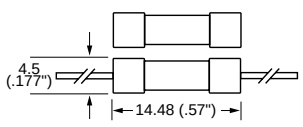
0.25 – 3.5A	10,000A @ 125VAC
4 – 7A	400A @ 125VAC
0.25 – 1A	35A @ 250VAC
1.25 – 3.5A	100A @ 250VAC

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

VOLTAGE RANGE: 125 – 250V
AMPERE RANGE: 0.250 – 1.50A
INTERRUPTING RATINGS:

0.25 – 1.25A	10,000A @ 125VAC
0.25 – 1A	35A @ 250VAC
0.25A	100A @ 250VAC
1.25 – 1.50A	60A @ 600VAC

AXIAL LEADED AND CARTRIDGE FUSES

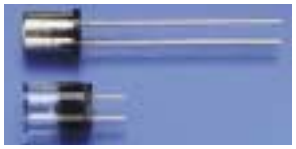
MICRO
Very Fast-Acting Type Fuse
272/273/274/278/279 Series

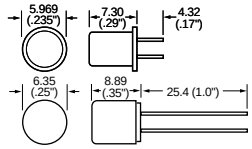
QPL

VOLTAGE RANGE: 125V

AMPERE RANGE: 0.002 – 5.0A

INTERRUPTING RATINGS: 10,000A @ 125VAC/VDC





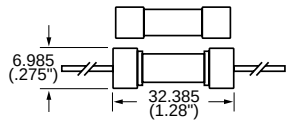
3AG
Fast-Acting Type Fuse
312/318/392 Series

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

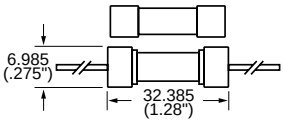
QPL

VOLTAGE RANGE: 32 – 250V

AMPERE RANGE: 0.01 – 30.0A

INTERRUPTING RATINGS:

0.01 – 8A	10,000A @ 125VAC	4 – 8A	200A @ 250VAC
.01 – 1A	35A @ 250VAC	10 – 30A	300A @ 32VAC
1.25 – 3.2A	100A @ 250VAC		



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

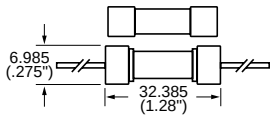
QPL

VOLTAGE RANGE: 125 – 250V

AMPERE RANGE: 0.125 – 30.0A

INTERRUPTING RATINGS:

0.125 – 20A	10,000A @ 125VAC/DC
25 – 30A	400A @ 125VAC/DC
0.125 – .75A	35A @ 250VAC
1 – 3A	100A @ 250VAC
4 – 15A	750A @ 250VAC
20A	1,000A @ 250VAC
25 – 30A	100A @ 250VAC



3AB
Slo-Blo® Type Fuse
326/325/390 Series

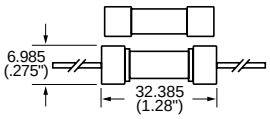
QPL

VOLTAGE RANGE: 125 – 250V

AMPERE RANGE: 0.010 – 30A

INTERRUPTING RATINGS:

0.010 – 3.24A	10,000A @ 125VAC
	100A @ 250VAC
4 – 20A	10,000A @ 125VAC
	400A @ 250VAC
25 – 30A	400A @ 125VAC



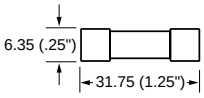
3AB
Special Very Fast-Acting Type Fuse
322 Series

VOLTAGE RANGE: 65 – 250V

AMPERE RANGE: 1 – 30A

INTERRUPTING RATINGS:

1 – 10A	10,000A @ 125VAC
	100A @ 250VAC
12 – 30A	200A @ 65VAC



HIGH RELIABILITY

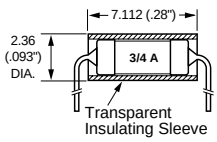
PICO®
Very Fast-Acting Type Fuse
265/266/267 Series

QPL

VOLTAGE RANGE: 32 – 125V

AMPERE RANGE: 0.062 – 15.0A

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



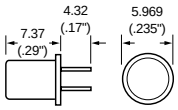
MICRO
Very Fast-Acting Type Fuse
262/268/269 Series

QPL

VOLTAGE RANGE: 125V

AMPERE RANGE: .002 – 5.0A

INTERRUPTING RATINGS: 10,000A @ 125VAC/VDC



Also available in 25.4mm lead length

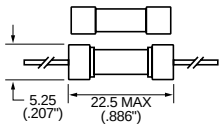
AXIAL LEADED CARTRIDGE FUSES

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

VOLTAGE RANGE: 250V

AMPERE RANGE: 0.032 – 10A

INTERRUPTING RATINGS: 35A or 10 times rated current; whichever is greater

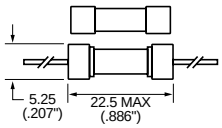


5 x 20mm
IEC Slo-Blo® Type Fuse
218/228/213 Series

VOLTAGE RANGE: 250V

AMPERE RANGE: 0.032 – 15A

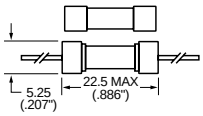
INTERRUPTING RATINGS: 35A or 10 times rated current; whichever is greater



AXIAL LEADED CARTRIDGE FUSES

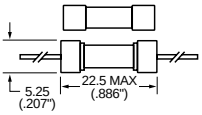
5 x 20mm
IEC Fast-Acting Type Fuse
216/226 Series

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



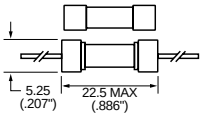
5 x 20mm
IEC Slo-Blo® Type Fuse
215/221 Series

VOLTAGE RANGE: 250V
AMPERE RANGE: 0.200 – 10A
INTERRUPTING RATINGS: 1500A



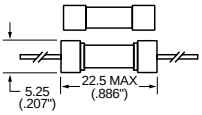
5 x 20mm
IEC Slo-Blo® Type Fuse
219 Series

VOLTAGE RANGE: 250V
AMPERE RANGE: 0.125 – 6.3A
INTERRUPTING RATINGS: 150A



5 x 20mm
MITI Medium-Acting
232 Series

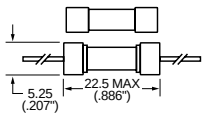
VOLTAGE RANGE: 125/250V
AMPERE RANGE: 1 – 10A
INTERRUPTING RATINGS: 500A @ 125VAC
100A @ 250VAC



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

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

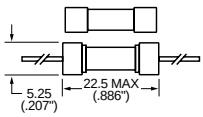
0.10 – 1A	10,000A @ 125VAC 35A @ 250VAC
1.25 – 3.15A	10,000A @ 125VAC 100A @ 250VAC
4 – 6A	10,000A @ 125VAC



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

VOLTAGE RANGE: 125 – 250V
AMPERE RANGE: 1 – 10A
INTERRUPTING RATINGS:

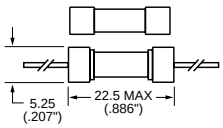
1A – 3.5A	10,000A @ 125VAC 100A @ 250VAC
4 – 10A	10,000A @ 125VAC 200A @ 250VAC



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

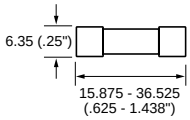
VOLTAGE RANGE: 125 – 250V
AMPERE RANGE: 0.20 – 5A
INTERRUPTING RATINGS:

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

VOLTAGE RANGE: 32V
AMPERE RANGE: 4 – 30A

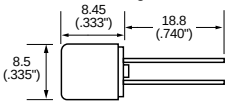


SUBMINIATURE CARTRIDGE FUSES

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

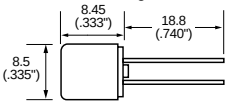
Note: 4.3mm Lead length also available



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

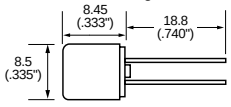
Note: 4.3mm Lead length also available



LT-5
Time Lag Extended Break Capacity 664 Series

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

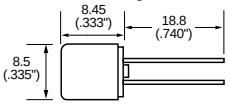
Note: 4.3mm Lead length also available



LT-5
Time Lag Type Fuses
665 Series

VOLTAGE RANGE: 250V
AMPERE RANGE: 0.050 – 6.3A
INTERRUPTING RATINGS: 50A @ 250VAC

Note: 4.3mm Lead length also available

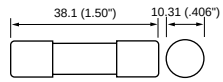


CARTRIDGE FUSES – Midget

AC
Fast-Acting Type Fuse
KLK Series (F60C)

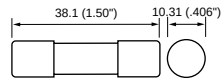
QPL

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

AC/DC
Fast-Acting Type Fuse
KLKD Series

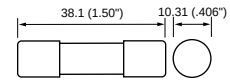
VOLTAGE RANGE:	600V
AMPERE RANGE:	0.10 – 30A
INTERRUPTING RATINGS:	10,000A @ 600VDC 100,000A @ 600VAC (capable of 200,000A)

250 Volt
Slo-Blo® Type Fuse
FLM Series (F09B)

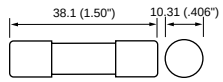
QPL

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

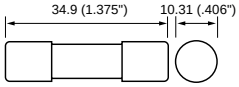
500 Volt
Slo-Blo® Type Fuse
FLQ Series

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

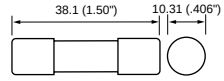
1⅜" Long
Fast-Acting Type Fuse
BLS Series

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

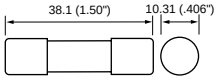
Slo-Blo®
Pin Indicating Type Fuse
FLA Series

VOLTAGE RATING:	125VAC
AMPERE RANGE:	0.10 – 30A
INTERRUPTING RATINGS:	10,000A @ rated VAC *12-30A are dual tube

Laminated
Fast-Acting Type Fuse
BLF Series

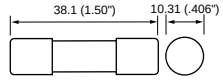
VOLTAGE RATING:	125 – 250V
AMPERE RANGE:	0.50 – 30A
INTERRUPTING RATINGS:	10,000A @ rated VAC

Fiber Body
Fast-Acting Type Fuse
BLN Series (F09A)

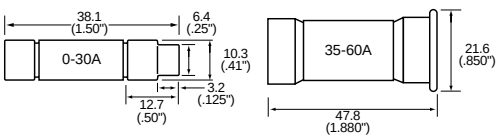
QPL

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

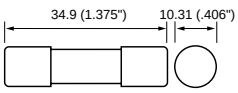
Class CC/CD
Fast-Acting & Slo-Blo® Type Fuses
CCMR/KLDR/KLKR Series

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

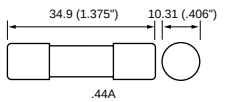
KLQ
Increased Time-Delay
KLQ Series

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

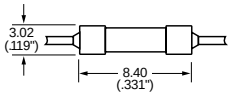
FLU
Multimeter Protection
FLU Series

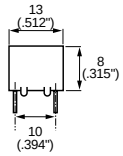
VOLTAGE RATING:	1000VAC/VDC
AMPERE RANGE:	0.44A, 11A
INTERRUPTING RATINGS:	1000VAC/VDC

HAZARDOUS AREA FUSES

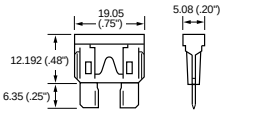
	BARRIER NETWORK 242 Series	SAFE-T-PLUS 259 Series
VOLTAGE RATING:	250V	250V
AMPERE RANGE:	0.050 – 0.25A	0.062 – 1A
INTERRUPTING RATINGS:	4000A @ 250VAC/VDC	50A @ 125VAC 300A @ 125VDC

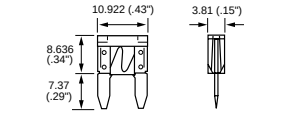


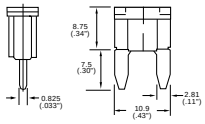


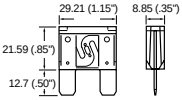
BLADE TERMINAL AND SPECIAL PURPOSE FUSES

	ATO® Fast-Acting Type Fuse 257 Series	MINI® Fast-Acting Type Fuse 297 Series	MINI® 42V Fast-Acting Type Fuse 997 Series	MAXI™ Slo-Blo® Type Fuse 299 Series
VOLTAGE RATING:	32V	32V	58V	32V
AMPERE RANGE:	1.0 – 40A	2.0 – 30A	2.0 – 30A	20 – 80A
INTERRUPTING RATINGS:	1000A @ 32VDC	1000A @ 32VDC	1000A @ 58VDC	1000A @ 32VDC

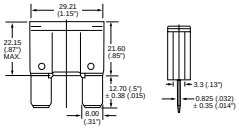


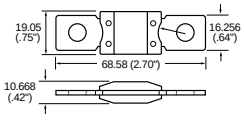


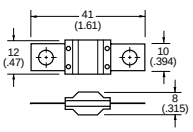


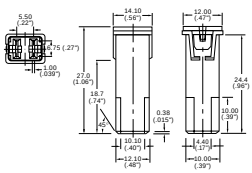


	MAXI™ 42V Slo-Blo® Type Fuse 999 Series	MEGA® Slo-Blo® Type Fuse 298 Series	MIDI® Fast-Acting High Current Fuse 498 Series	JCASE™ 42V Slo-Blo® Cartridge Fuse 995 Series
VOLTAGE RATING:	58V	32V	32V	58VDC
AMPERE RANGE:	20 – 80A	100 – 250A	40 – 150A	20 – 60A
INTERRUPTING RATINGS:	1000A @ 58VDC	2000A @ 32VDC	1000A @ 32VDC	1000A @ 58VDC





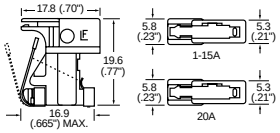




FUSEHOLDERS

481
Alarm Indicating Fuse
481 Series

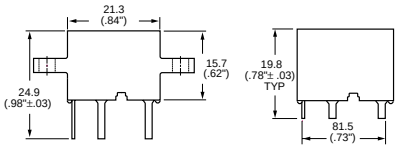
VOLTAGE RATING: 125VAC/VDC
AMPERE RANGE: 0.18 – 20A
INTERRUPTING RATINGS: 450A @ 60VDC
300A @ 125VAC
300A @ 125VDC (up to 15A)
200A @ 125VDC (up to 20A)



482
Alarm Indicating
482 Series

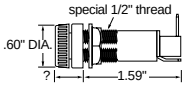
MOUNTING TYPE: PCB and Panel
FUSE TYPE: 481 Alarm Indicating

- Single pole and gangable versions available (1-15A)
- 20A version is single pole only



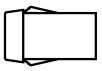
International Shock-Safe
345 Series

MOUNTING TYPE: Panel Mount
FUSE TYPE: 3AG, 5x20mm, 2AG



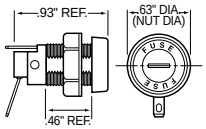
Flip-Top Shock-Safe
346/286 Series

MOUNTING TYPE: Panel Mount
FUSE TYPE: 3AG, 5x20mm, 2AG



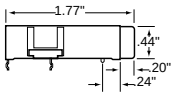
Shock-Safe
245 Series

MOUNTING TYPE: Panel Mount
FUSE TYPE: 2AG



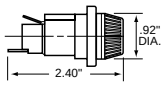
Shock-Safe
345 Series

MOUNTING TYPE: PC Board Mount
FUSE TYPE: 3AG, 5x20mm, Midget



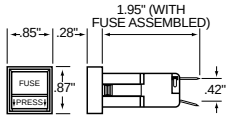
Shock-Safe
571 Series

MOUNTING TYPE: Panel Mount
FUSE TYPE: Midget



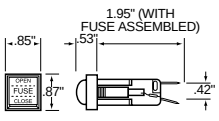
Low Profile
348 Series

MOUNTING TYPE: Snap Mount
FUSE TYPE: 3AG



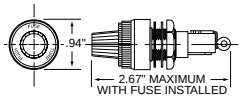
Blown Fuse
Indicating Type
344 Series

MOUNTING TYPE: Snap Mount
FUSE TYPE: 3AG



Blown Fuse
Indicating Type
344 Series

MOUNTING TYPE: Panel Mount
FUSE TYPE: 3AG



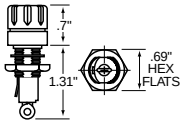
FUSEHOLDERS

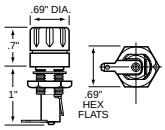
Traditional
342 Series

QPL

MOUNTING TYPE: Panel Mount
FUSE TYPE: 3AG

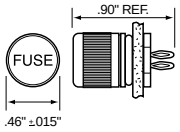






RF Shielded
282 Series

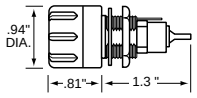
MOUNTING TYPE: Front/Rear Panel
FUSE TYPE: Micro™ Plug-ins

Watertight
342 Series

QPL

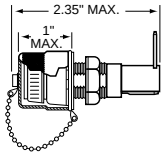
MOUNTING TYPE: Panel Mount
FUSE TYPE: 3AG

RF Shielded/ Watertight
340 Series

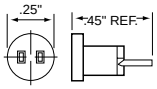
QPL

MOUNTING TYPE: Panel Mount
FUSE TYPE: 3AG

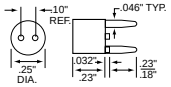
"Push-On" Retaining Nut
281 Series

MOUNTING TYPE: Chassis Mount
FUSE TYPE: MICRO™ & PICO®II Fuses

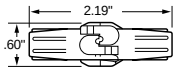
Vertical/ Horizontal
281 Series

MOUNTING TYPE: PC Board Mount
FUSE TYPE: MICRO™ & PICO®II Fuses

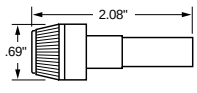
Twist-Lock
155 Series

MOUNTING TYPE: In-Line Mount
FUSE TYPE: Low Voltage 3AG, SFE

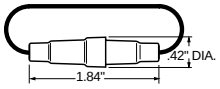
Heavy-Duty Bayonet
155 Series

MOUNTING TYPE: In-Line Mount
FUSE TYPE: Low Voltage 3AG, SFE

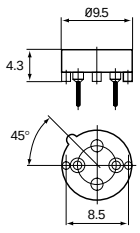
Special Type
150 Series

MOUNTING TYPE: In-Line Mount
FUSE TYPE: 2AG, 5x20mm

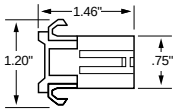
For LT-5™ Fuses
280 Series

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



For ATO® Fuses
155 Series

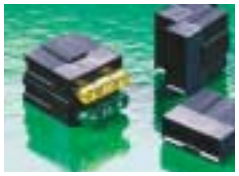
MOUNTING TYPE: In-Line Mount
FUSE TYPE: ATO® Fuses

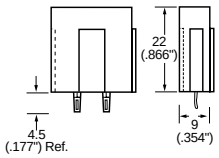



FUSEHOLDERS

For ATO® Fuses
445 Series

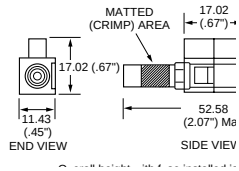
MOUNTING TYPE: PC Board Mount
FUSE TYPE: ATO® Fuses





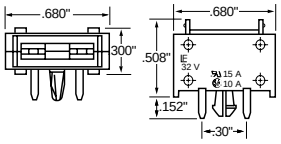
For MINI® Fuses
153 Series

In-Line, Easy Crimp
MINI® Fuses



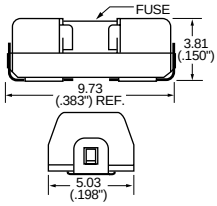
For MINI® Fuses
153 Series

PC Board Mount
MINI® Fuses



SMF Omni-Blok® Fuse Block
154 Series

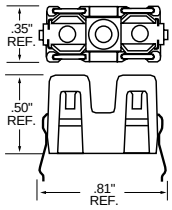
Molded Base
NANO²® Fuse
See NANO²® Fuse for electrical characteristics.



FUSE BLOCKS AND CLIPS

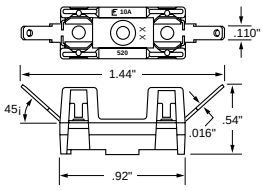
Omni-Blok® Fuse Block
254 Series

MOUNTING TYPE: Molded Base
FUSE TYPE: 2AG



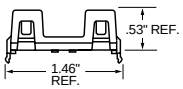
Metric Omni-Blok® Fuse Block
520 Series

Molded Base
5 x 20mm



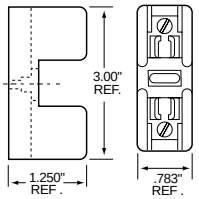
3AG Omni-Blok® Fuse Block
354 Series

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

Transient Threats – What Are Transients?

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

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

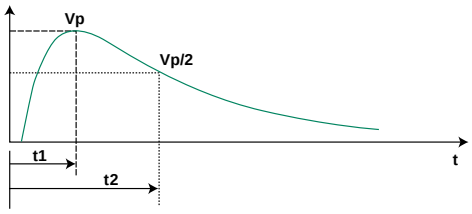


Figure 1. Lightning Transient Waveform

	VOLTAGE	CURRENT	RISE-TIME	DURATION
Lighting	25kV	20kA	10µs	1ms
Switching	600V	500A	50µs	500ms
EMP	1kV	10A	20ns	1ms
ESD	15kV	30A	1-5ns	100ns

Table 1. Examples of transient sources and magnitude

Characteristics of Transient Voltage Spikes

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

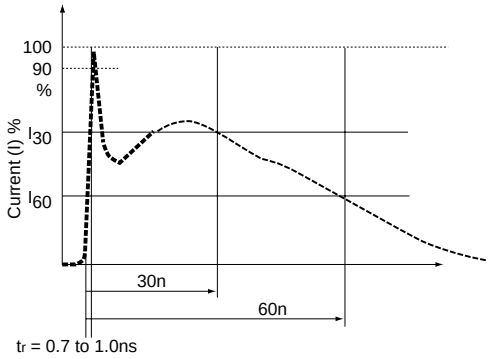


Figure 2. ESD Test Waveform

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

Table 2. Range of device vulnerability.

Why are Transients of Increasing Concern?

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

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

Transient Voltage Scenarios

ESD (Electrostatic Discharge)

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

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

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

Referring to Table 2 on the previous page, it can be seen how much of a hazard ESD presents. Figure 2 shows the ESD waveform as defined in the IEC 61000-4-2 test specification.

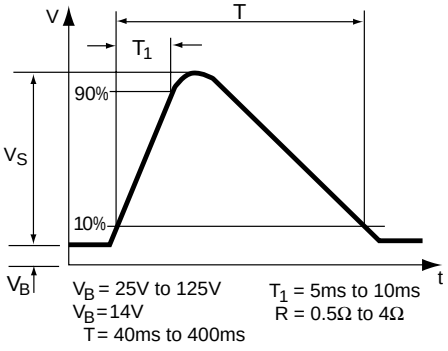


Figure 3. Automotive Load Dump

Inductive Load Switching

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

Typical sources of inductive transients are:

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

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

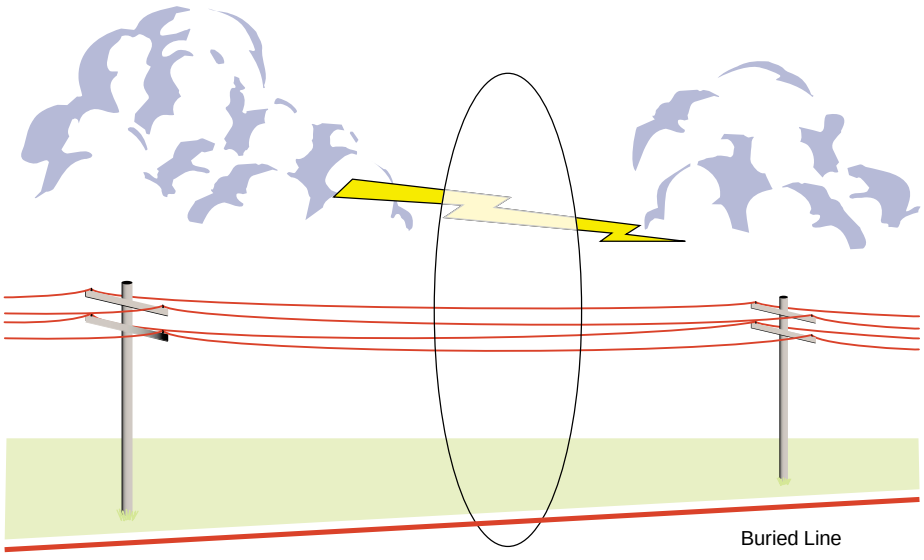
Figure 3, bottom left, shows a transient which is the result of stored energy within the alternator of an automobile charging system. A similar transient can also occur as a result of transients caused by other DC motors in a vehicle. For Example, DC motors power amenities such as power locks, seats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

Lightning Induced Transients

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

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

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



Transient Generated:
- 70 V at 1.6km (1 mile)
- 10 kV at 150m (160 yards)

Figure 4. Cloud-to-Cloud Lightning Strike

OVERVOLTAGE SUPPRESSION FACTS (cont.)

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

Technological Solutions for Transient Threats

Because of the various types of transients and applications, it is necessary to employ protection devices with different characteristics in different applications. Littelfuse offers the broadest range of circuit protection technologies. Our overvoltage protection portfolio includes:

MOVs
Metal Oxide Varistors (MOV)
Ceramic Technology
Available in screw terminal, radial, square and axial leaded and connections. Offers medium to very high energy ratings for a wide range of applications.

Surface mount MOV
Metal Oxide Varistor (MOV)
Ceramic Technology
Available in a wide range of voltage ratings. Offers low to medium energy ratings for a variety of applications.

MLV
Multilayer Metal Oxide Varistor Ceramic Technology
Available in a wide range of surface mount packages. Offers a lower voltage range and enhanced performance and filtering characteristics for applications requiring protection from low to medium energy transients.

PulseGuard®
Voltage Variable Polymer Technology
Available in surface mount and 'D-Sub connector' format packages. Specifically designed for high data-rate applications requiring ESD protection and the lowest possible capacitance.

TVS Diode Arrays
Silicon Avalanche Diode Technology
Available in surface mount multi-pin packages or CSP (chip scale package) arrays. Designed for applications requiring multiline ESD protection and the lowest possible clamp voltage.

Discrete TVS Diode
Silicon Avalanche Diode Technology
Available in surface mount and axial leaded packages. Offers protection from medium to very high energy transients and can be used in wide range of applications.

SiBOD™
Thyristor Breakover Technology
Available in surface mount, axial leaded and TO-220 through hole package options. Offers protection from medium to high energy transients. SiBOD thyristors are specifically designed for transient suppression in telecom and data transmission systems.

Gas Plasma Protector/ Gas Discharge Tube
Gas Plama Technology
Available in surface mount, axial leaded, radial leaded and special packages. The Littelfuse Gas Plasma technology offers high surge ratings and very low capacitance for use in telecommunication and broadband systems.

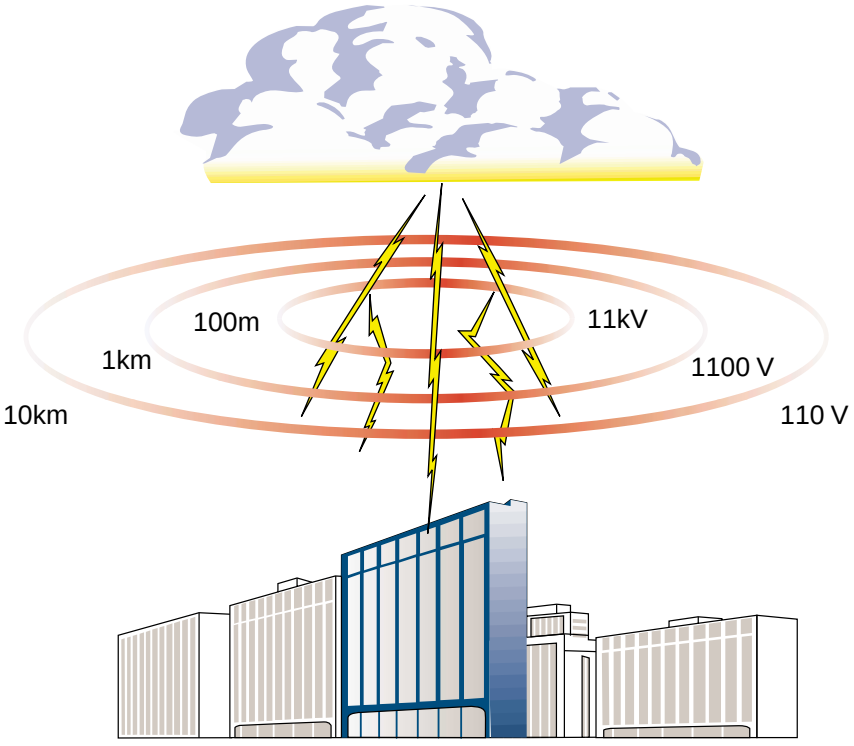


Figure 5. Cloud-to-Ground Lightning Strike

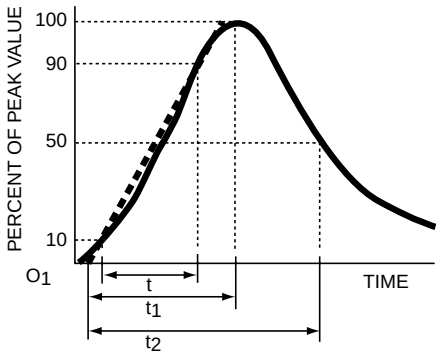


Figure 6. 5kA 8/20μS pulse

Deployment of Protection Devices

Typically, suppression devices are used singly in line-to-neutral (V_{supply} to V_{gnd}, Rx to V_{gnd}, etc.) or line-to-line (tip to ring, etc.) configurations. However, in some cases, it is necessary to employ protection devices in a cascaded (staged) configuration. Cascaded solutions exploit the best features of each technology to ensure the most comprehensive solution.

Figure 7, below shows a typical cascaded environment. With careful design it a cascaded solution can be provided in a single unit or module.

Figure 8, below shows a '5 pin' design, which incorporates multiple devices and functions into a single device.

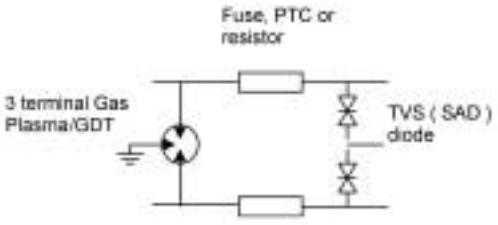
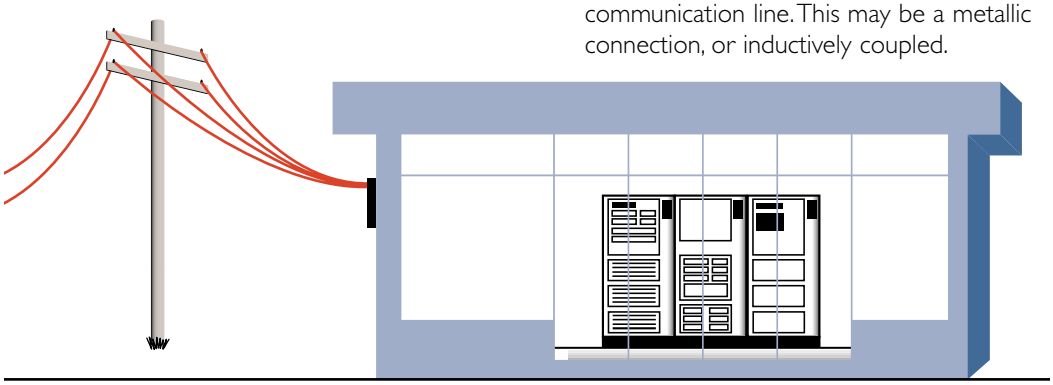


Figure 8. '5 Pin' design incorporating Littelfuse GDT, TVS Diode and overcurrent protection (if fuse or PTC).



Primary and/or Secondary Examples in MDF:
- MOVs
- TMOV™ Varistors
- TVS Diodes
- Gas Plasma Technology/GDT

Tertiary Protection at Board Level Examples:
- SiBOD™ Thyristors
- Gas Plasma Technology
- TVS Diodes
- TVS Diode Arrays
- PulseGuard® Suppressors
- Multilayer Varistors
- Surface Mount Varistors
- MOVs
- TMOV™ Varistors

Figure 7. Typical staged solution configuration for data or telephone transmission lines in a central office.

Glossary of Terms

The following are general terms that apply to all overvoltage technologies in the Littelfuse product offering.

Crowbar Device

The class of suppressors that exhibit a "crowbar" characteristic is usally associated with 4-layer NPNP silicon bipolar devices or gas plasma/GDT 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" throughout the length of the transient.

Operating Temperature Range

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

Capacitance

The property of a circuit element that permits it to store an electrical charge. In circuit protection, the capacitance is usually measured between input pins and the common terminal, at 1 MHz.

Power Cross

A condition where the AC power becomes accidentally connected to a communication line. This may be a metallic connection, or inductively coupled.

The following are more specifically used to describe the parameters of gas technology devices:

Dynamic Breakover

(also referred to as Impulse sparkover) The maximum breakover voltage measured on a 100V/µs or 1kV/µs ramp rate (whichever is specified).

DC Breakover

(also referred to as DC sparkover) The nominal breakover voltage measured on a 100V/s ramp rate.

Holdover Voltage

Once the device has switched due to a transient, it will stay in this low impedance state until the voltage across it falls below a specific value, known as the holdover voltage. When selecting one of these devices, it is important to make sure the voltage of the protected system is less than the holdover voltage value of the protector.

On-state Voltage

(also referred to as Arc Voltage) The maximum voltage measured across the protector when in it's low impedance state (fully switched on). Sometimes specified at a given test current.

Maximum Surge Current

(also referred to as impulse discharge current) The maximum transient surge current the protector can handle without degradation or destruction. Usually quoted using the industry standard 8x20µs double exponential waveform.

Maximum AC Surge Current

(also referred to as alternating discharge current) The maximum AC surge current the protector can handle without degradation or destruction. Usually quoted using a number of 1 second, 60Hz bursts (often 5 such bursts), with a 3 minute rest period between each burst.

Insulation Resistance

An alternative way of quoting leakage current. It is the effective resistance of the device at a given voltage: the test voltage divided by the leakage current. A typical value would be given as 1×10^9 ohms.

OVERVOLTAGE SUPPRESSION FACTS (cont.)

Failsafe
Refers to a device which prevents hazards due to thermal run-away. The device is a thermal sensitive switch which operates at a predetermined temperature, shorting the terminals of the protection device (normally gas plasma device, sometimes SiBOD™ thyristor) providing a low resistance path. A failsafe is used in conjunction with overcurrent protection devices to protect against the consequences of power cross conditions.

The following are more specifically (but not exclusively) used to describe the parameters of silicon avalanche diodes (SAD) and TVS Arrays:

TVS diode
TVS is an abbreviation for transient voltage suppressor. Devices which are termed as TVS diodes (or diode arrays) typically use Silicon Avalanche Diode technology.

Reverse Standoff Voltage (V_R)
In the case of a uni-directional TVS diode, this is the maximum peak voltage that may be applied in the 'blocking direction' with no significant current flow. In the case of a bi-directional transient, it applies in either direction. It is the same definition as Maximum Off-state Voltage and Maximum Working Voltage.

Breakdown Voltage (V_{BR})
Breakdown voltage measured at a specified DC test current, typically 1mA. Usually a minimum and maximum is specified.

Maximum peak pulse current (I_{PP})
Maximum pulse current which can be applied repetitively. Usually a 10x1000µs double exponential waveform, but can also be 8x20µs, if stated.

Maximum Clamping Voltage (V_C or V_{CI})
Maximum voltage which can be measured across the protector when subjected to the Maximum Peak Pulse Current.

Peak Pulse Power (P_{PP})
Expressed in Watts or Kilowatts, for a 1ms exponential transient (see fig. 1, pg. 19) it is I_{PP} multiplied by V_{CL}.

The following are more specifically used to describe the parameters of Silicon (thyristor based) breakover devices (SiBOD thyristor):

Maximum Breakover Voltage (V_{BO})
The voltage measured across the device as it makes a transition from its avalanche mode to the fully conductive, low impedance state (V_T).

Switching Voltage (V_S)
The same as V_{BO}.

Forward Voltage Drop (V_T)
The voltage measured across the device when in the fully switched on state and conducting a specified current level (I_T)

Holding current (I_N)
Once a SiBOD thyristor has switched to V_T, a certain level of current through the device is needed for it to maintain this condition; this is specified as the Minimum Holding Current. If the current is not reduced below this level, the device with remain 'latched'.

The following are more specifically used to describe the parameters of Metal Oxide Varistors (MOV):

Maximum Non-Repetitive Surge Current (I_{TM})
This is the maximum peak current which may be applied for an 8x20µs 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 (8x20µs).

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. Power developed in this fashion must be within the specifications shown on the Device Ratings and Characteristics table for the specific device.

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.

Overvoltage Application Guide

	Application Examples	Circuit Examples	Transient Threat	Device Family	Technology
Low/Medium Voltage Electronics	Computers - desktop, laptop, notebook Peripherals - scanner, printer, monitor, disk drive External Broadband hardware - modem, set top box Network hardware - switch, router, hub, repeater Digital camera/camcorder Handheld portables - PDA, cell phone, cordless phone, GPS Video equipment - HDTV, DVD, VCR, set top box Alarm systems - security, fire Metering systems Medical equipment Lighting ballast Remote sensors/transducers	High-speed Interfaces: USB 2.0, IEEE 1394, InfiniBand, RF antenna circuits, Gigabit Ethernet, DVI	ESD	PGB	PulseGuard® Polymer
		Medium-speed Interfaces: USB 1.1, RS 485, Ethernet, video Low-speed Interfaces: Audio, RS 232, IEEE 1284, push buttons, key pads, switches	ESD, EMI, EFT	sSP05x SP72x MHS, ML, MLE, MLN SPUSB1	TVS diode SCR/Rail clamp MLV TVS/filter
			Lightning	LCE, SA	SAD
		Power Inputs: 120/240 VAC, up to 120 VDC	ESD, EMI, EFT	ML, MLE	MLV
			Lightning Switching Transients	CH, MA, ZA, RA, UltraMOV SA, P6KE, 1.5PKE SMBJ, 1KSMBJ	MOV SAD SAD
	Avionics/Military Electronics	Power and System Inputs	ESD, EMI, EFT Lightning and System Transients	ICTE/MPTE 1N56/1N60, 5KP/SLD Hi-Rel MOVs	SAD SAD MOV
Power Mains Protection	AC line protection	Uninterruptible Power Supply (UPS)	EFT, Lightning	TMOV™, UltraMOV™ LA, C-III, ZA, 5KP, 15KP, AK6, AK10	MOV MOV SAD
		Power Supply	EFT, Lightning, Commutative Spikes	UltraMOV, LA, TMOV ZA, HA, CH 5KP, 15KP, AK6, AK10	MOV MOV SAD
		Consumer Electronics	EFT, Lightning	SL1002A, SL1003A, SL1011A UltraMOV, LA, ZA, CH, TMOV 1.5KE, 5KP	GDT MOV SAD
		Power Meter	Lightning	TMOV, UltraMOV, C-III 5KP	MOV SAD
		AC Power Taps	EFT, Lightning	UltraMOV, LA, HA, HB34	MOV MOV
		AC Panels	EFT, Lightning, Commutative Spikes	UltraMOV, C-III, HA, HB34, DA/DB, 5KP, 15KP, 8K6, 8K10	MOV MOV SAD
		AC Appliance Control	EFT, Lightning	TMOV, UltraMOV, LA, CH SMBJ, P6KE, 1.5KE	MOV SAD
	TVSS devices	TVSS Protection Modules	Lightning	TMOV, HA, HB34, UltraMOV 5KP, 15KP, AK6, AK10 SL1011A, SL1021A	MOV SAD GDT
		Circuit Breakers	EFT, Lightning, Commutative Spikes	UltraMOV, LA, ZA	MOV
Industrial Environment	High energy systems	Robotics	EFT, Lightning, Commutative Spikes, Inductive Load Switching	UltraMOV, CH, LA, C-III, ZA SMBJ, P6KE, 1.5KE, 5KP, 15KP	MOV SAD
		Large Motors, Pumps, Compressors	EFT, Lightning, Commutative Spikes, Inductive Load Switching	UltraMOV, CH, HA, HB34, BA/BB DA/DB, PA, RA	MOV MOV
		Motor Drives	EFT, Lightning, Commutative Spikes, Inductive Load Switching	UltraMOV, TMOV, LA, C-III, RA, CH SMBJ, P6KE, 1.5KE, 5KP, 15KP	MOV SAD
		AC Distribution	EFT, Lightning, Commutative Spikes, Inductive Load Switching	UltraMOV, C-III, HA, HB34, BA/BB, DA/DB 5KP, 15KP, AK6, AK10	MOV SAD
		High Current Relays	EFT, Lightning, Commutative Spikes	UltraMOV, C-III, HA, HB34, BA/BB, DA/DB	MOV
Telecom/Datacom	Customer Premise Equipment - Fax machine - Answering machine - xDSL gateway - Dial-up modem - Set top box - T1/E1/ISDN termination equipment - SLIC hardware - Public phone - Cellular phone - Cordless phone - Phone Line Protector - LAN protection module	High-Speed Data Interfaces: USB 2.0, IEEE 1394, RF antenna circuits	ESD	PGB	PulseGuard® Polymer
		Medium/low-speed Data Interfaces: USB 1.1, Ethernet, RS 232	ESD, EMI, EFT	SP05x, SP72x, SPUSB1, ML, MLE, MLN, MHS	TVS diode MLV
		Telecom Interface (secondary): Tip/Ring Circuits	Lightning	SMT50, SMT100, SMTBJ, T10A/B/C, CRxxxxSA/SB/SC	SiBOD™ Thyristor
		Power Inputs: 120/240 VAC, up to 120 VDC	Lightning	P6KE, 1.5KE, CH, ZA, UltraMOV	SAD MOV
	Interface Equipment - PBX systems - Internet gateways - DSLAM equipment Conversion Equipment - Cellular base station - Satellite base station - Microwave base station Central Office Equipment - Interexchange carrier - Local exchange carrier - Mobile telephone switch - Repeater/node - Railroad signaling	Telecom Interface (primary): Tip/Ring Circuits	Lightning	SL1002, SL1003, SL1011, SL1021, SL1026	Glass Plasma OV Protector
		Telecom Interface (secondary): Tip/Ring Circuits	Lightning	SMT50, SMT100, SMTBJ, T10A/B/C CRxxxxSA/SB/SC	SiBOD™ Thyristor
		Power Inputs: 120/240 VAC, up to 120 VDC	Lightning	P6KE, 1.5KE CH, ZA, UltraMOV	SAD MOV
Automotive Electronics	Engine Control Module Body/Chassis Control - Body controller - Antilock braking system - Steering sensor - Illumination control - Instrument cluster - Air bag module - Window control module - Wiper module - Door lock module Multimedia systems - Radio/satellite tuner - CD/cassette players - DVD/VCR players - MP3 players - Data interface buses Telematics systems - Wireless communication - GPS receiver - Navigation system - Security system	High-Speed Interfaces: USB 2.0, IEEE 1394	ESD	PGB	PulseGuard® Polymer
		Medium/Low-Speed Interfaces: USB 1.1, CAN	ESD, EMI	SP05x, SP72x, SPUSB1, ML, MLE, MLN, MHS	TVS diode MLV
		Power Inputs: Up to 42 VDC	Load Dump and Inductive Switching	AUML, P6K, P6SMBJ, 5KP 1KSMBJ, SLD CH, ZA	MLV SAD SAD MOV

OVERVOLTAGE SUPPRESSION FACTS (cont.)

Gas Plasma OVP/GDT Selection Guide

Family name	OMEGA		BETA						ALPHA		DELTA
Performance Level	Standard		High						Ultra		High
Series Name	SL1012A	SL1024A	SL1011A	SL1011B	SL1021A	SL1021B	SL1002A	SL1003A	SL1122A	SL1221	SL1026
Technology Type	Gas Plasma(GDT)	Gas Plasma(GDT)	Gas Plasma(GDT)	Gas Plasma (GDT)	Gas Plasma(GDT)	Gas Plasma(GDT)	Gas Plasma(GDT)	Gas Plasma(GDT)	Gas Plasma(GDT)	Gas Plasma(GDT)	Gas Plasma(GDT)
Temperature Range	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150
Package Type	2 Terminal, Button and axial	3 Terminal, Core (no pins) and radial leads	2 Terminal, Button and axial leads	2 Terminal, Button and axial leads	3 Terminal, Core (no pins) and radial leads	3 Terminal, Core (no pins) and radial leads	2 Terminal, Button and surface mount	3 Terminal, Radial and surface mount	3 Terminal, SAD/GP Hybrid radial leads	3 Terminal, radial leads	3 Terminal,
Mounting Method	through-hole or clip mount	through-hole	through-hole or clip mount	through-hole or clip mount	through-hole	through-hole	SMT	through-hole SMT	through-hole	through-hole	clip mounted
DC Breakover Voltage	90 -350	90 - 500	145 -600	145 -600	200 - 500	200 - 500	90 -350	90 -350	90 - 450	200	275-700
AC Surge Rating	5A	10A*	5A	10A	10A*	20A*	5A	10A*	10A*	10A*	40A*
Peak Pulse Current (8x20µs)	5,000A	10,000A*	5,000A	10,000A	10,000A*	20,000A*	5,000A	10,000A*	10,000A*	10,000A*	80,000A*
Max Capacitance	1.5pF	1.5pF	1.5pF	1.5pF	1.5pF	1.5pF	1pF	1pF	100-200pF	1.5pF	2.5pF

* total current through centre (ground) terminal

TVS Diode Selection Guide

PP Power Range	Medium								High			Very High	
Series Name	SA	P6KE	SMBJ	P6SMBJ	1KSMBJ	1.5KE	ICTE/MPTE	1N56/1N60	5KP	SLD	15KP	AK6	AK10s
Technology Type	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode	Silicon Avalanche Diode
Operating Temperature	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150	-55 to +150
Package Type	DO 15 axial	DO 15 axial & pill	DO 214 AA	DO 214 AA	DO 214 AA	axial & pill	axial	DO13 metal	axial & pill	axial	axial & pill	axial	axial
Mounting Method	through-hole	through-hole or SMT (pill)	SMT	SMT	SMT	through-hole or SMT (pill)	through-hole	through-hole	through-hole or SMT (pill)	through-hole or SMT (pill)	through-hole or SMT (pill)	through-hole	through-hole
Reverse Standoff (working) Voltage	5.0-170	5.5-376	5.0-188	5.5-185	5.5-160	5.5-376	5.0-45	5.5-185	5.0-180	5.0-30	17-240	43-380	43-380
Peak Pulse Power Range (based on 10/100µs pulse unless stated otherwise)	500W	600W	600W	600W	1,000W	1,500W	1,500W	1,500W	5,000W	2,200 based on 100µs/150ms pulse	15,000W	NA	NA
Peak Pulse Current (8x20µs)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6,000 Amps	10,000 Amps

SiBOD™ Thyristor Selection Guide

Series Name	TO-220 CRxxx2			TO-220 CRxxx3			CRxxxx			SMT 50	SMT 100	SMTBJ		T10A	T10B	T10C
Type	AA	AB	AC	AA	AB	AC	SA	SB	SC			A	B			
Technology Type	Silicon Thyristors			Silicon Thyristors			Silicon Thyristors	Silicon Thyristors	Silicon Thyristors	Silicon Thyristors	Silicon Thyristors	Silicon Thyristors		Silicon Thyristors	Silicon Thyristors	Silicon Thyristors
Operating Junction Temperature Range (deg C)	-40 to +150			-40 to +150			-40 to +150	-40 to +150	-40 to +150	-40 to +150	-40 to +150	-40 to +150		-40 to +150	-40 to +150	-40 to +150
Storage Temperature Range (deg C)	-55 to +175			-55 to +175			-55 to +175	-55 to +175	-55 to +175	-55 to +175	-55 to +175	-55 to +175		-55 to +175	-55 to +175	-55 to +175
Package Type	Modified TO-220 (two die)			Modified TO-220 (three die)			DO-214AA	-DO-214AA	-DO-214AA	DO-214AA	DO-214AA	DO-214AA		DO-15 Axial	DO-15 Axial	3-T
Mounting Method	through-hole			through-hole			SMT	SMT	SMT	SMT	SMT	SMT		through-hole	through-hole	through-hole
Reverse Standoff (working) Voltage	25-275			130-300			15-320	15-320	15-320	62-270	62-270	50-200		80-243	62-230	70-240
Peak Pulse Rating:																
• 2x10µs									500A		500A					
• 10x160µs	100A	150A		100A	150A		100A	150A	200A							
• 10x560µs	50A	100A		50A	100A		50A	100A	100A							
• 10x1000µs			100A			100A	45A	80A	100A	50A	100A	50A	100A	100A	100A	
• 8X20µs										100A	250A	150A	250A	150A	100A	250A
I_{TSM}	20A	30A	60A	20A	30A	60A	20A	30A	60A	30A	55A@50HZ or 60A@60HZ	30A		50A	30A	50A

Ceramic Products Selection Guide

	Metal Oxide Varistors (MOV)															
	Radial Leaded						Packaged					Bare Disc		Surface Mount		Axial Leaded
Series Name	ZA	RA	LA	C-III	UltraMOV™ Varistor	TMOV™/iTMOV™ Varistor	PA	HA	HB34	DA/DB	BA/BB	NA	CA	CH	AUML	MA
Technology Type	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Zinc Oxide	Multilayer Zinc Oxide	Zinc Oxide
Operating AC Voltage Range	4-460	4-275	130-1000	130-320	130-625	130-320	130-660	130-750	130-750	130-750	130-2800	130-750	130-2800	14-275	——	9-264
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	18-369	18	18-365
Peak Current Range (A)**	50-6,500	100-6,500	1,200-6,500	6,000-9,000	1,750-10,000	6,000-10,000	6,500	25,000 40,000	40,000	40,000	50,000 70,000	40,000	20,000 70,000	250-500	20	40-100
Peak Energy Range (J)	0.1-52	0.4-160	11-360	45-210	12.5-400	50-273	70-250	200-1050	270-1050	270-1050	450-10000	270-1050	200-10000	1-23	——	0.06-1.7
Temperature Range (Deg.C)	-55 – +85	-55 – +125	-55 – +85	-55 – +85	-55 – +85	-55 – +85	-55 – +85	-55 – +85	-55 – +85	-55 – +85	-55 – +85	-55 – +85	-55 – +85	-55 – +125	-55 – +125	-55 – +85
Lines Protected	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mount/Form Factor	Radial Leaded	Packaged	Radial Leaded	Radial Leaded	Radial Leaded	Radial Leaded	Packaged	Packaged	Industrial Packaged	Industrial Package	Packaged	Bare Disc	Bare Disc	Surface Mount	Surface Mount	Axial Leaded
Disc Size (MOV)	5, 7, 10, 14, 20mm	8,16,22mm	7,10,14 20mm	14,20mm	7,10,14 20mm	14,20mm	20mm	32,40mm	34mm	40mm	60mm	34mm	32, 40 & 60mm	——	——	3mm
Agency Approvals	UL,VDE	UL,CSA &VDE	UL,CSA &VDE	UL,CSA &VDE	UL,CSA	UL	UL&CSA	UL&CSA	UL&CSA	UL	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.

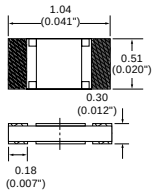
	PulseGuard® Suppressors	Silicon Protection Arrays						Multilayer Varistors			
	Surface Mount	Chip Scale Package (CSP)	Surface Mount					Surface Mount			
Series Name	PGB	SP05X	SP72X	SP05X	SP05X	SP05X	SPUSB1	ML	MLE	MLN	MHS
Technology Type	VVM	TVS Avalanche Diode	Silicon SCR/Diode	TVS Avalanche Diode	Rail Clamp	Rail Clamp w/ Avalanche Diode	USB Port Terminator (w/ESD Suppression and EMI Filter)	MLV ZnO	MLV ZnO	MLV ZnO	MLV ZnO
Working Voltage	0-24VDC	0-5.5VDC	0-30VDC	0-5.5VDC	0-5.5VDC	0-5.5VDC	0-5.5VDC	0-120VDC range by type	0-18VDC	0-18VDC	0-42VDC
Array Package (No. of Lines)	SOT23 (2), 0805 (4)	CSP (4, 8, 16)	DIP, SOIC (6, 14) SOT23 (4)	SC70 (2,4,5), SOT23 (2,4,5), SOT143 (3), TSSOP-8 (4), MSOP-8 (6)	S0T143 (2), MSOP-8 (6), SOIC-8 (6), QSOP-24(18)	MSOP-8 (6) SOIC-8 (6), QSOP-24(1,8)	SC70-6 (3)	No	No	1206 (4)	No
Single Line Package	0402, 0603	No	No	No	No	No	No	0402-1210	0402-1206	——	0402
Typical Device Capacitance	0.05pF	39pF	3-5pF	30pF	3-7pF	3-7pF	47pF	40-6000pF	40-1700pF	45-430pF	3-12pF
Leakage Current	<1nA	<10µA	<20µA	<10µA	<1µA	<1µA	<100nA	<5µA	<10µA	<2µA	<5µA
Rated Immunity to IEC 61000-4-2 level 4	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Also Rated for EFT or Lightning Wave	No	TBD	Yes	TBD	TBD	TBD	TBD	Yes	Yes	Yes	Yes
Bidirectional (transients of either polarity)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Performs Low Pass Filtering	–	–	–	–	–	–	Yes	Yes	Yes	Yes	Yes

OVERVOLTAGE SUPPRESSION PRODUCTS

PulseGuard®
Polymeric ESD Suppressors - PGB Series

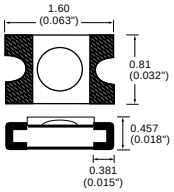
OPERATING VOLTAGE:	0-24VDC
PEAK CURRENT:	45A@15kV
CAPACITANCE:	0.05pF@1MHz
LEAKAGE CURRENT:	<1.0nA
OFFSTATE RESISTANCE:	10MΩ
CLAMPING:	150V,TYPICAL@8KV
LINES PROTECTED:	

PGB0010402 NEW



1-line

PGB0010603



1-line

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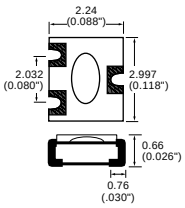
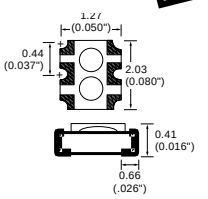


2-lines

PGB0040805 NEW



4-lines

MULTILAYER VARISTORS

	MHS Series	ML Series	MLE Series	MLN Series	AUML Series
OPERATING VOLTAGE:	0 – 42 VDC	2.5-104 VAC 3.5-120 VDC	0-18 VDC	5.5-18 VDC	18 VDC
PEAK CURRENT:	N/A	30-250A	20A	20A	N/A
LEAKAGE CURRENT:	<5µA	<5µA	<10µA	<2µA	
PEAK ENERGY:	N/A	1-2.0J	0.5J	0.05J	N/A
LINES PROTECTED:	1	1	1	4	1
CAPACITANCE:	3, 12pF	40-6000pF	40-1700pF	45-430pF	
PACKAGE SIZE:	0402, 0603	0402-1210	0402-1206	1206	1206-2220



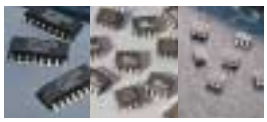


SILCON PROTECTION DEVICES

	SPO5X Series TVS Avalanche Diode	SPO5X Series TVS Avalanche Diode	SPO5X Series Rail Clamp Array	SPO5X SERIES Rail Clamp w/Avalanche Diode
OPERATING VOLTAGE:	0-5.5 VDC	0-5.5 VDC	0-5.5 VDC	0-5.5 VDC
LEAKAGE CURRENT:	<10µA	<10µA	<1µA	<1µA
LINES PROTECTED:	2,3,4,5,6	1,4,8,16	2,6,18	6,18
CAPACITANCE:	30pF	39pF	3-7 pF	3-7pF
PACKAGE SIZE:	SC70, SOT23, SOT143, TSSOP-8, MSOP-8	CSP	SOT143, MSOP-8, SOIC-8, QSOP-24	MSOP-8, SOIC-8, QSOP-24




	SP72X Series SCR/Diode Array	SPUSB1 Series NEW Upstream USB Port Terminator with ESD suppression and EMI Filtering
OPERATING VOLTAGE:	0-30VDC	5.5 VDC
LEAKAGE CURRENT:	<20µA	<1µA
LINES PROTECTED:	4,6,14	3
CAPACITANCE:	3-5pF	47pF
PACKAGE SIZE:	DIP, SOIC, SOT23	SC70-6




Surface Mount SiBOD™ Thyristors NEW
CRxxxx, SMT50, SMT100 Series

MAX OPERATING VOLTAGE:	15.0 to 320.0
PEAK PULSE CURRENT:	50A to 500A
FORM FACTOR:	DO 214 AA

SILCON PROTECTION DEVICES

	Through-hole NEW SiBOD™ Thyristor T10A, T10B Series	Through-hole NEW SiBOD™ Thyristor TO-220 Series	Through-hole NEW SiBOD™ Thyristor T10 C Series	Through-hole NEW TVS Diode SA, P6KE, 1.5KE, 5KP, 15KP, FSLD, SLD Series	Surface Mount NEW TVS Diode SMBJ, P6SMBJ, 1KSMBJ Series
MAX OPERATING VOLTAGE:	32.0 to 243.0	25.0 to 300.0	70.0 to 240.0	5.0 to 380.0	5.0 to 188.0
PEAK PULSE CURRENT:	50A to 100A	50A to 500A	50A to 100A	N/A	N/A
FORM FACTOR:	Axial leaded	Modified to 220	3 pin 'gas tube'	Axial leaded	DO 214 AA
PEAK PULSE POWER:	N/A	N/A	N/A	500W to 5kW	600W to 1kW
					

	Hi-Power NEW TVS Diode AK6, AK10 Series	Metal NEW TVS Diode 1N56, 1N60 Series	Button NEW TVS Diodes 15KP, 5KP Series	Flip Chip NEW TVS Diodes	Metal Stud NEW Diode BZY91, BZY93 Series
MAX OPERATING VOLTAGE:	17.0 to 380.0	5.5 to 185.0	5.0 to 240.0	7.5 to 75.0	7.5 to 75.0
PEAK PULSE CURRENT:	6,000A - 10,000A	N/A	N/A	N/A	N/A
FORM FACTOR:	Axial leaded	DO 13	Button (cell/pill)	Die and Die with tabs	DO 4 and DO 5
STEADY STATE POWER:	N/A	N/A	N/A	N/A	20W to 75W
PEAK PULSE POWER:	5000W +	1.5kW	600W to 15,000W	600W to 5kW	1.5kW to 5kW
					

GAS DISCHARGE TUBES

	Alpha Ultra NEW Performance Gas Plasma OVP & Hybrid SL1221, SL1122A Series	Beta High NEW Performance Gas Plasma OVP SL1011A, SL1011B, SL1021A, SL1021B Series	Mini & smt NEW Beta High Performance Gas Plasma OVP SL1002A, SL1003A Series	Omega Range NEW Gas Plasma OVP SL1012A, SL1024A Series
PEAK PULSE CURRENT:	5kA to 10kA	5kA to 10kA	5kA to 10kA	5kA to 10kA
FORM FACTOR:	3 terminal radial	2 terminal axial & button, 3 terminal radial	2 terminal smt, 3 terminal radial	2 terminal axial & button, 3 terminal radial
NOM. DC BREAKOVER VOLTAGE:	90.0 to 350.0	90.0 to 600.0	90.0 to 350.0	90.0 to 600.0
				

INDUSTRIAL VARISTOR PRODUCTS

	NEW TMOV™/iTMOV™ Varistor Series	UltraMov™ Varistor Series	C-III Series	LA Series	ZA Series
OPERATING VOLTAGE:	130-320 VAC 170-420 VDC	130-625 VAC 170-825 VDC	130-320 VAC	130-1,000 VAC 175-1200 VDC	4-460 VAC 5.5-615 VDC
PEAK CURRENT:	6,000-10,000A	750,10,000A	6,000-9,000A	1,200-6,500A	50-6,500A
PEAK ENERGY:	50-273	50-273J	45-220J	11-360J	0.1-52J
MOUNT/FORM FACTOR:	Radial Leaded	Radial Leaded	Radial Leaded	Radial Leaded	Radial Leaded
DISC SIZE:	14, 20mm	7, 10, 14, 20mm	14, 20mm	7,10,14, 20mm	5, 7, 10, 14, 20mm
INDICATING:	iTMOV Varistor Only	N/A	N/A	N/A	N/A
					

	MA Series	RA Series	CH Series	CA Series	NA Series
OPERATING VOLTAGE:	4-264 VAC 13-365 VDC	4-275 VAC 5.5-364 VDC	14-275 VAC 18-369 VDC	130-2800 VAC 175-3500 VDC	130-750 VAC 175-970 VDC
PEAK CURRENT:	40-100A	150-6,500A	250-500A	20,000-70,000A	40,000A
PEAK ENERGY:	0.06-1.7J	0.4-140J	1-23J	200-10,000J	270-1,050J
MOUNT/FORM FACTOR:	Axial Leaded	Packaged	Surface Mount	Bare Disc	Bare Disc
DISC SIZE:	3mm	8, 6, 22mm	N/A	32, 40, 60mm	34mm
					

	PA Series	HB34 Series	HA Series	DA/DB Series	BB/BA Series
OPERATING VOLTAGE:	130-660 VAC 175-850 VDC	130-750 VAC 175-970 VDC	130-750 VAC 175-970 VDC	130-970 VAC 175-970 VDC	130-2800 VAL 175-350 VDC
PEAK CURRENT:	6,500A	40,000A	25,000-40,000A	40,000A	50,000-70,000A
PEAK ENERGY:	70-250J	270-1,050J	200-1,050J	270-1,050J	450-10,000J
MOUNT/FORM FACTOR:	Packaged	Industrial Packaged	Packaged	Industrial Packaged	Packaged
DISC SIZE:	20mm	34mm	32, 40mm	40mm	60mm
					

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