Littelfuse®

1 Product Selection Guide

Greentube™ Gas Plasma Arrester Product Description

Greentube gas plasma arresters are manufactured using totally non-radioactive processes and are designed to perform to the stated characteristics of ITU K.12.

Advantages

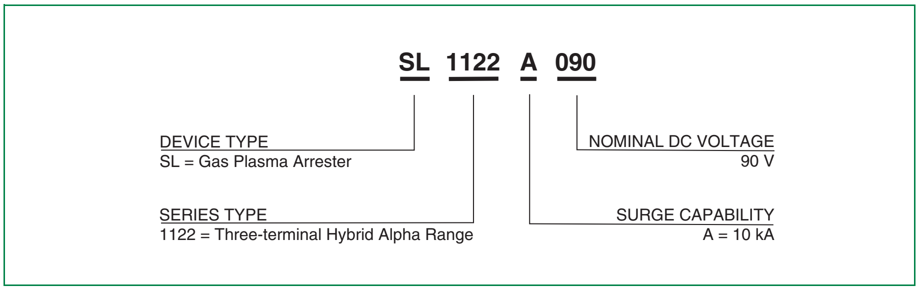
- RoHS compliant
- Low insertion loss
- Excellent response to fast-rising transients
- Ultra low capacitance
- High peak surge current capability

Applications

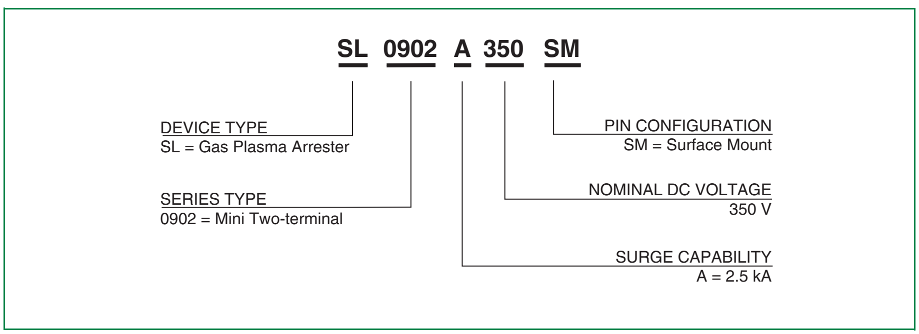
- Broadband equipment
- ADSL equipment
- xDSL equipment
- Satellite and CATV equipment
- General telecom equipment

Greentube™ Gas Plasma Arrester Part Number Description

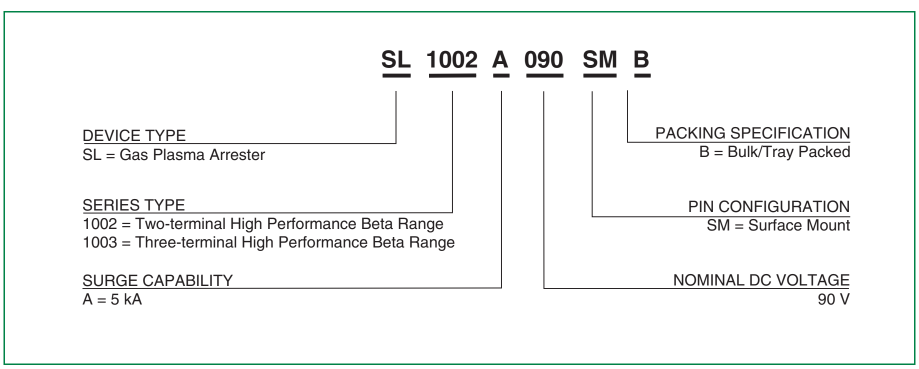
The following illustration shows a description of a sample device part number for the SL1122A series gas plasma arrester.



The following illustration shows a description of a sample device part number for the SL0902A series gas plasma arrester.



The following illustration shows a description of a sample device part number for the SL1002A and SL1003A series gas plasma arrester.



The following illustration shows a description of a sample device part number for the SL1011A and SL1011B series gas plasma arrester.

SL 1011 A 230 A

DEVICE TYPE
SL = Gas Plasma Arrester

SERIES TYPE
1011 = Two-terminal High Performance Beta Range

SURGE CAPABILITY
A = 5 kA
B = 10 kA

NOMINAL DC VOLTAGE
230 V

PIN CONFIGURATION
A = Axial Leaded
C = Core

The following illustration shows a description of a sample device part number for the SL1021A, SL1021B, SL1024A, and SL1024B series gas plasma arrester.

SL 1021 A 200 R F

DEVICE TYPE
SL = Gas Plasma Arrester

SERIES TYPE
1021 = Three-terminal High Performance Beta Range
1024 = Three-terminal Omega Range

SURGE CAPABILITY
A = 5 kA
B = 10 kA

NOMINAL DC VOLTAGE
200 V

PIN CONFIGURATION
R = Radial Leaded
C - Core

FAILSAFE OPTION
F = Plastic
S = Solder
RG = Radial pins/ thermal failsafe option

The following illustration shows a description of a sample device part number for the SL1411A series gas plasma arrester.

SL 1411 A 230 SM

DEVICE TYPE
SL = Gas Plasma Arrester

SERIES TYPE
1411 = Two-terminal Delta Range

SURGE CAPABILITY
A = 5 kA

NOMINAL DC VOLTAGE
230 V

PIN CONFIGURATION
SM = Surface mount
C = Core
A = Axial pins

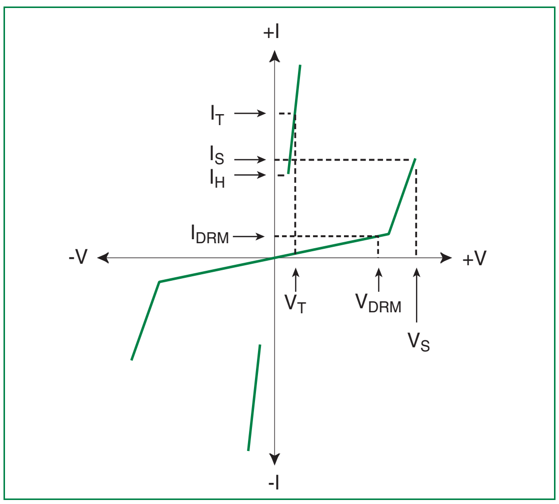
Product Selection Guide

SIDACtor® Product Description

SIDACtor components are solid state crowbar devices designed to protect telecom equipment during hazardous transient conditions. Capitalizing on the latest in thyristor advancements, Littelfuse makes *SIDACtor* devices with a patented ion implant technology. This technology ensures effective protection within nanoseconds, up to 5000 A surge current ratings, and simple solutions for regulatory requirements such as GR 1089, TIA-968-A (formerly known as FCC Part 68), ITU-T K.20, ITU-T K.21, and UL 60950.

Operation

In the standby mode, *SIDACtor* devices exhibit a high off-state impedance, eliminating excessive leakage currents and appearing transparent to the circuits they protect. Upon application of a voltage exceeding the switching voltage (V_S), *SIDACtor* devices crowbar and simulate a short circuit condition until the current flowing through the device is either interrupted or drops below the *SIDACtor* device's holding current (I_H). Once this occurs, *SIDACtor* devices reset and return to their high off-state impedance.



V-I Characteristics

Advantages

Compared to surge suppression using other technologies, *SIDACtor* devices offer absolute surge protection regardless of the surge current available and the rate of applied voltage (dv/dt). *SIDACtor* devices:

- Cannot be damaged by voltage
- Eliminate hysteresis and heat dissipation typically found with clamping devices
- Eliminate voltage overshoot caused by fast-rising transients
- Are non-degenerative
- Will not fatigue
- Have low capacitance, making them ideal for high-speed transmission equipment

Applications

When protecting telecommunication circuits, *SIDACtor* devices are connected across Tip and Ring for metallic protection and across Tip and Ground and Ring and Ground for longitudinal protection. They typically are placed behind some type of current-limiting device, such as the Littelfuse *TeleLink*® lightning tolerant fuse. Common applications include:

- Central office line cards (SLICs)
- T-1/E-1, ISDN, and xDSL transmission equipment
- Customer Premises Equipment (CPE) such as phones, modems, and caller ID adjunct boxes
- PBXs, KSUs, and other switches
- Primary protection including main distribution frames, five-pin modules, building entrance equipment, and station protection modules
- Data lines and security systems
- CATV line amplifiers and power inserters
- Sprinkler systems

For more information regarding specific applications, design requirements, or surge suppression, please contact Littelfuse directly at +1 972-580-7777 or through our local area representative. Access Littelfuse's web site at http://www.littelfuse.com.

SIDACtor® Part Number Description

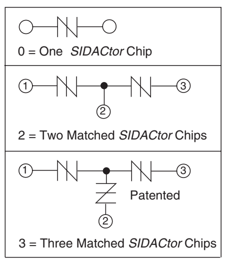
The following illustration shows a description of a sample *SIDACtor* device part number.

P 210 2 A A L 61 RP

DEVICE TYPE
P = *SIDACtor*

MEDIAN VOLTAGE RATING
210 = 210 V

CONSTRUCTION VARIABLE
0 = One chip
1 = Unidirectional part
2 = Two chips
3 = Three chips



PACKING OPTIONS
RP1 = TO-92 reel pack (0.100" lead spacing)
RP2 = TO-92 reel pack (0.200" lead spacing)
AP = Ammo pack
RP = Reel pack
TP = Tube pack

LEAD FORM OPTIONS
TO-220 modified type 60, 61, or 62
For U type:
3 = 3 chips
4 = 4 chips
6 = 6 chips

RoHS COMPLIANT
Absence of "L" in the part number = non-RoHS devices

I_{PP} RATING
A = 50 A (10x560 µs)
B = 100 A (10x560 µs)
C = 500 A (2x10 µs)
D = 1000 A (8x20 µs)
E = 3000 A (8x20 µs)

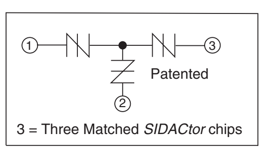
PACKAGE TYPE
A = TO–220
C = Three-leaded DO-214
E = TO–92
M = TO-218
S = DO–214
U = Six-pin SOIC

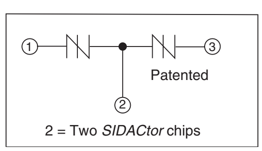
The following illustration shows a description of a sample asymmetrical *SIDACtor* device part number.

A 1806 U C 4 L TP

DEVICE TYPE
A = Asymmetrical *SIDACtor*

MEDIAN VOLTAGE RATING
1806 = 180 V and 60 V





PACKING OPTIONS
AP = Ammo pack
RP = Reel pack
TP = Tube pack

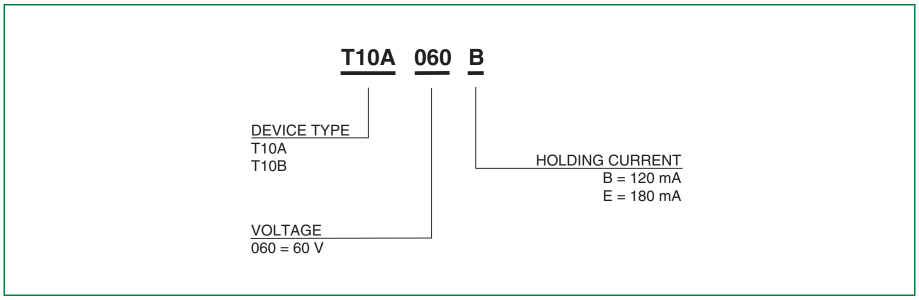
RoHS COMPLIANT
Absence of "L" in the part number = non-RoHS devices

LEAD FORM OPTIONS
TO-220 modified type 60, 61, or 62
For U package:
3 = 3 chips
4 = 4 chips
6 = 6 chips

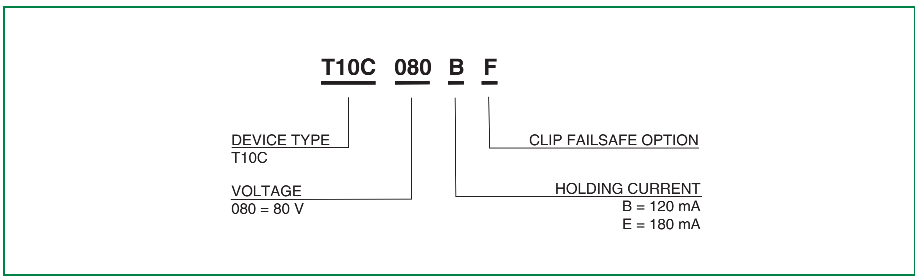
I_{PP} RATING
A = 50 A (10x560 µs)
B = 100 A (10x560 µs)
C = 500 A (2x10 µs)
D = 1000 A (8x20 µs)
E = 3000 A (8x20 µs)

PACKAGE TYPE
A = TO-220
M = TO-218
U = Six-pin SOIC

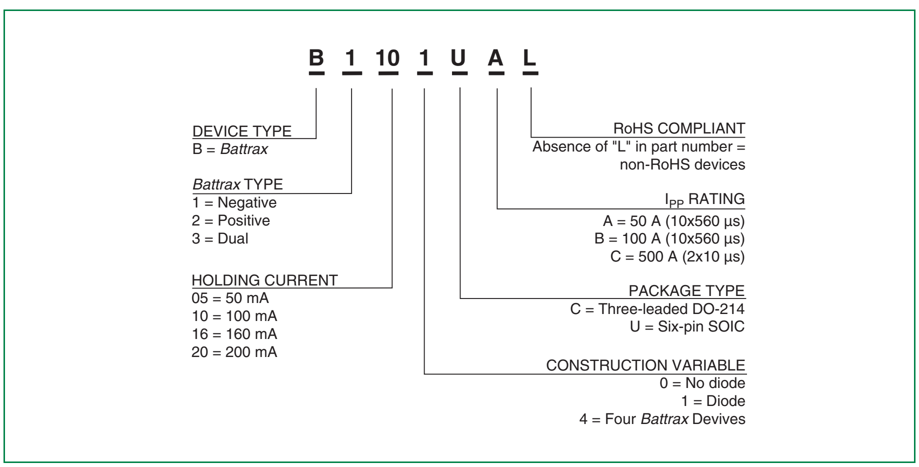
The following illustration shows a description of a sample T10A or T10B device part number.



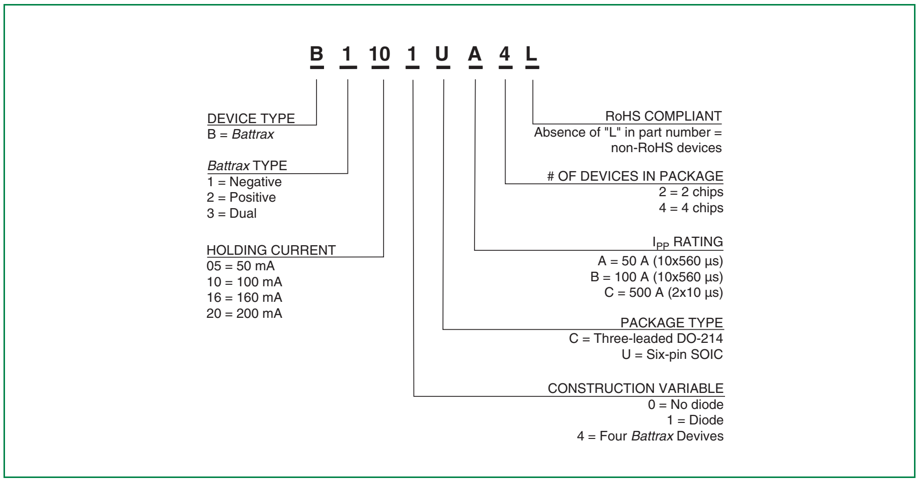
The following illustration shows a description of a sample T10C device part number.



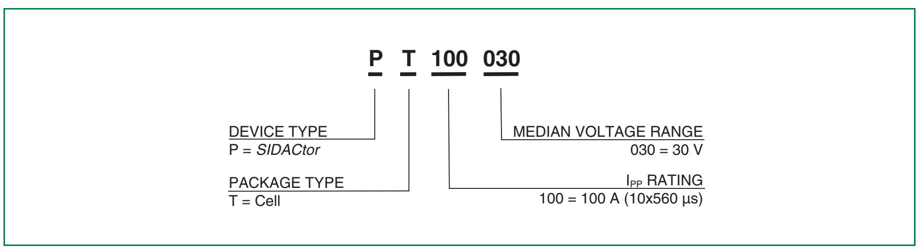
The following illustration shows a description of a sample single port *Battrax* device part number.



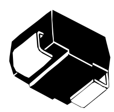
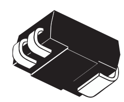
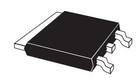
The following illustration shows a description of a sample dual port *Battrax* device part number.

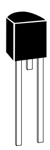
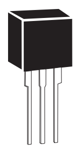
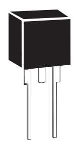
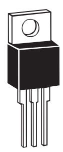
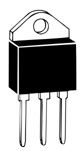
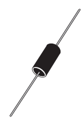
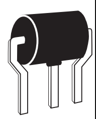


The following illustration shows a description of a sample *SIDACtor* cell device part number.



SIDACtor® Product Packages

	Surface Mount Packages			
	DO-214AA	Modified DO-214AA	Modified MS-013 Six-pin	TO-263 NE (3KA)
				
Balanced *SIDACtor* Device			✓	
Battrax® Single Port Negative SLIC Protector			✓	
Battrax Single Port Positive/Negative SLIC Protector			✓	
Battrax Dual Port Negative SLIC Protector			✓	
Battrax SLIC Protector		✓	✓	
High Surge Current Two-pin *SIDACtor* Device				✓
CATV Line Amplifiers/Power Inserters *SIDACtor* Device				✓
Fixed Voltage SLIC Protector	✓	✓	✓	
High Surge (D-rated) *SIDACtor* Device	✓			
LCAS Asymmetrical Device	✓		✓	
MC Balanced *SIDACtor* Device			✓	
MC *SIDACtor* Device	✓		✓	
Multiport Balanced *SIDACtor* Device			✓	
Multiport Quad SLIC Protector			✓	
Multiport *SIDACtor* Device			✓	
Twin SLIC Protector		✓		

Through-hole Packages								
TO-92	Modified TO-220		TO-220 RE (3KA)	TO-218	T10A T10B	T10C	*SIDACtor* Cells	
								
	✓							Balanced *SIDACtor* Device
								Battrax Single Port Negative SLIC Protector
								Battrax Single Port Positive/Negative SLIC Protector
								Battrax Dual Port Negative SLIC Protector
								Battrax SLIC Protector
		✓		✓				High Surge Current Two-pin *SIDACtor* Device
		✓	✓	✓				CATV Line Amplifiers/Power Inserters *SIDACtor* Device
							✓	Fixed Voltage SLIC Protector
		✓						High Surge (D-rated) *SIDACtor* Device
								LCAS Asymmetrical Device
	✓							MC Balanced *SIDACtor* Device
✓	✓	✓						MC *SIDACtor* Device
								Multiport Balanced *SIDACtor* Device
								Multiport Quad SLIC Protector
								Multiport *SIDACtor* Device
								Twin SLIC Protector

TeleLink® Fuse Product Description

The Littelfuse *TeleLink*® surface mount (SM) surge-tolerant fuse offers overcurrent protection for telecom applications without requiring a series resistor. When it is used in conjunction with a *SIDACtor*® transient voltage suppressor (TVS) or a *Greentube*™ gas plasma arrester, this combination provides a compliant solution for standards and recommendations such as GR 1089–Core, TIA-968-A, UL/EN/IEC 60950, and ITU K.20 and K.21. The coordination requirement contained in GR 1089–Core, and ITU K.20/21 may require a series impedance device.

Operation

The *TeleLink* is designed to carry 100 percent of its rated current for four hours and 250 percent of its rated current for one second minimum and 120 seconds maximum. For optimal fuse performance, the steady state operating current of the application should be less than or equal to 75 percent of the *TeleLink's* rated current.

Advantages

The 04611.25 or 04612.00 fuse is designed to meet the 600 V 60 A power fault requirement of the GR 1089–Core standard. The *TeleLink* is available in 0.5 A, 1.25 A, and 2 A ratings. The *TeleLink* devices are designed to meet the specific environmental requirements of the RoHS directive and the higher temperature solder profiles typical of lead-free solders.

Applications

Common applications for the *TeleLink* fuse include the following:

- T1/E1/J1 and HDSL2/4
- SLIC interface portion of Fibre to the Curb (FTTC) and Fibre to the Premises (FTTP)
- Non-Fibre SLIC interface for Central Office (CO) locations and Remote Terminals (RT)
- xDSL applications such as ADSL, ADSL2+, VDSL, and VDSL2+
- Ethernet 10/100/1000BaseT
- POTS applications such as modems, answering machines, telephones, fax machines, and security systems
- ISDN "U" interface
- Baystation T1/E1/J1, T3 (DS3) trunk cards

DC Power Fuse Product Description

Littelfuse telecom power fuses are fast-acting, extremely current-limiting devices designed for short-circuit protection to telecommunications equipment and power distribution circuits. These products use silver-plated elements with unique geometry that provide reliable protection to sensitive equipment and components.

Advantages

The telecom power fuses offer designers flexibility without sacrificing equipment protection. Compact designs in multiple mounting configurations can be used with fuse holders and disconnect switches that use built-in alarm signaling circuits to identify blown fuses.

Other advantages include:

- UL recognized
- Extremely current limiting
- Very fast-acting
- Low I^2t and peak currents
- Low operating temperature

Applications

Telecommunication circuits are very sensitive to surges and spikes. The current-limiting characteristics of Littelfuse telecom power fuses minimize damage to DC power supplies and distribution equipment within telephone networks. Common applications include:

- Central office power panels
- Cellular base stations
- Satellite relay stations
- Microwave transmission stations
- Cable and other component protection

Part Number Index

For explanation of part numbers, see "*Greentube*™ Gas Plasma Arrester Part Number Description" and "*SIDACtor*® Part Number Description" in this Product Selection Guide.

Electrical Parameters

Greentube™ Gas Plasma Arrester

Gas plasma arrester electrical parameters are based on the following definition of conditions:

V_S	**Dynamic Breakover (Impulse Sparkover (GR 1361 term) or voltage-limiting) Voltage**—maximum breakover voltage measured on a 100 V/1 kVµs ramp rate (whichever is specified)
V_{SDC}	**DC Breakover (Sparkover) Voltage**—nominal breakover voltage measured at a specified ramp rate (typically 100 V/S, but up to 2 kV/s in some specifications)
V_H	**Holdover Voltage**—specific voltage value below which device voltage falls after a device switches on and stays in the low impedance state due to a transient
V_T	**On-state (Arc) Voltage** [similar to V_T parameter for solid-state devices]—maximum voltage measured across the protector when in its low impedance (fully switched on) state, sometimes quoted at a given test current
I_{PP}	**Maximum Surge (Impulse Discharge) Current** [similar to the I_{PP} parameter for solid-state devices]—maximum current a protector can handle without degradation or destruction, usually quoted using industry standard 8/20µs double exponential waveform
I_{TSM}	**Maximum AC Surge (Alternating Discharge) Current**—maximum current a protector can handle without degradation or destruction, usually quoted using a specified number (often 5) of one-second 60 Hz bursts with a three-minute rest period between each burst
I_{DRM}	**Insulation Resistance**—alternative way of quoting leakage current, the effective resistance of a device at a given voltage (50 V, 100 V, 200 V specified in GR 1361); test voltage divided by leakage current (typical value 1x109 Ω)

Use of other general terms related to gas plasma arresters are based on the following definitions:

Failsafe—thermal sensitive switch device which prevents hazards due to thermal run-away by operating at a predetermined temperature and shorting the terminals of the protection device, providing a low resistance path between Ring to Ground and Tip to Ground

Note: Failsafe devices are deployed for power fault conditions.

Crowbar Device—class of suppressors that exhibit a "crowbar" characteristic, usually associated with four-layer NPNP silicon bipolar (*SIDACtor*) or gas plasma arresters

Note: Upon reaching a threshold or breakover voltage, the device transitions to a low impedance state. In essence, the line is either momentarily short-circuited to Ground (for longitudinal events) or the Tip and Ring conductors are momentarily shorted together (for transverse events) throughout the duration of the transient.

Power Fault / Cross—AC power connected accidentally to a communication line or an induced voltage between the AC line and the telecom pair

Capacitance—property of a circuit element that permits it to store an electrical charge

Note: In circuit protection, usually the capacitance is measured between input pins and the common terminal at 1 MHz with a zero-volt bias. Increasing values of capacitance have the effect of limiting high-speed data transmission.

SIDACtor® Devices

SIDACtor electrical parameters are based on the following definition of conditions:

- On state (also referred to as the crowbar condition) is the low impedance condition reached during full conduction and simulates a short circuit.
- Off state (also referred to as the blocking condition) is the high impedance condition prior to beginning conduction and simulates an open circuit.

C_O	**Off-state Capacitance**—capacitance measured in off state @ 2 V bias and 1 MHz
di/dt	**Rate of Rise of Current**—maximum rated value of the acceptable rate of rise in current over time
dv/dt	**Rate of Rise of Voltage**—rate of applied voltage over time
I_S	**Switching Current**—maximum current required to switch to on state
I_{DRM}	**Leakage Current**—maximum peak off-state current measured at V_{DRM}
I_H	**Holding Current**—minimum current required to maintain on state
I_{PP}	**Peak Pulse Current**—maximum rated peak impulse current
I_T	**On-state Current**—maximum rated current for two seconds
I_{TSM}	**Peak One-cycle Surge Current**—maximum rated one-cycle AC current
V_S	**Switching Voltage**—maximum voltage prior to switching to on state
V_{DRM}	**Peak Off-state Voltage**—maximum voltage that can be applied while maintaining off state
V_F	**On-state Forward Voltage**—maximum forward voltage measured at rated on-state current
V_T	**On-state Voltage**—maximum voltage measured at rated on-state current

Commitment to Quality

Littelfuse is committed to meeting customer expectations and providing quality products and services at a competitive price. In support of this commitment, Littelfuse promises to:

Encourage quality awareness and quality performance in all associates at all levels of the Company through management leadership.

Promote the participation of all associates in making individual contributions to the quality improvement process.

Support continuous quality improvement by providing our associates with the necessary training, tools, and information feedback to enable enhancement of the quality of our products and services.

Develop relationships with suppliers who consistently demonstrate their ability to fulfill quality, price and delivery objectives that are mutually beneficial.

Build quality into our products and services, striving for zero defects in everything we do, thereby reducing cost and increasing total customer satisfaction.

Agency Approvals

Littelfuse products are recognized under the Components program of Underwriters Laboratories and certified by CSA. The following table shows agency file numbers for Littelfuse products.

Product	UL File Number	CSA Certificate
Greentube™ Gas Plasma Arresters	E128662	—
SIDACtor® Devices / *Battrax*® [1]	E133083	—
T10A / T10B / T10C	E128662	—
TeleLink®	E10480 (Littelfuse) E191008 (Teccor®)	LR 29862 (Littelfuse) LR 702828 (Teccor®)
2AG *Slo-Blo*® Fuse—229 / 230 Series [2]	E10480	LR 29862
NANO^{2}® Very Fast-Acting Fuse—451 / 453 Series [3]	E10480	LR 29862
NANO^{2}® *Slo-Blo*® Fuse—452 / 454 Series	E10480	LR 29862
NANO^{2}® 250 V UMF Fuse— 464 Series [4]	E184655	—
Alarm Indicating Fuse—481 Series [5]	E71611	LR 29862
Alarm Indicating Fuseholder—482 Series [5]	E14721	LR 29862
SMF *OMNI-BLOK*® Fuse Block, Molded Base Type—154 Series [5]	E14721	LR 07316
L17T Series Telecommunications Power Fuse [5]	E71611	LR 29862
TLN Series Telecommunications Power Fuse	E71611	—
TLS Series Telecommunications Power Fuse	E71611	—
LTFD Series Telecommunications Disconnect Switch	E122674	—
LTFD 101 Series Telecommunications Disconnect Switch	E122674	—

Notes:
1. Recognized component under ‘Conditions of Acceptability’
2. Through 3.5 A listed by UL and certified by CSA; 4 A through 7 A recognized under Components program of UL; 1 A through 7 A approved by METI
3. 1 A through 5 A approved by METI
4. Listed to IEC 60127-4, Universal Modular Fuse-Links (UMF), 250 V; UL Listed; Approved by METI (METI NBK30502-E184655a,b) and CCC. K and VDE approvals pending.
5. Certified under the Components Acceptance Program of CSA

Littelfuse, Inc., manufacturer of Teccor® brand circuit protection devices, is the proprietor of the *SIDACtor*®, *Battrax*®, and *TeleLink*® trademarks. All other brand names may be trademarks of their respective companies. Teccor® brand *SIDACtor* products are covered by these and other U.S. Patents:

4,685,120
4,827,497
4,905,119
5,479,031
5,516,705

NOTES

2

Greentube™ Gas Plasma Arresters

This section presents complete electrical specifications for Littelfuse's *Greentube*™ Gas Plasma Arresters—improved gas discharge tubes (GDTs).

SL1122A Series Three-terminal Hybrid Gas Plasma Arrester

The *Greentube™* SL1122A (Alpha) Series Hybrid Gas Plasma Arrester (improved gas discharge tube (GDT)) features a high-performance gas plasma arrester in conjunction with a high-speed Silicon Avalanche Diode (SAD). These devices are matched so that high speed pulses are initially clamped by the SAD; then, as the current rises, the transient energy is switched through the gas tube.

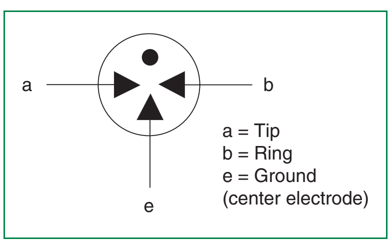
The Hybrid offers high levels of performance on fast-rising transients in the domain of 100 V/µs to 10 kV/µs, eliminating the dv/dt switching delay normally exhibited by standard GDTs.

Extremely robust, these devices can divert a 10,000 A pulse without destruction and are ideal for central office (telephone exchange) protection.

The SL1122A series is used for MDF protection and in alarm panels and general telecom equipment.

Other features include:

- RoHS compliant
- High performance Alpha range
- Totally non-radioactive
- Flat response up to 10 kV/µs
- 10 kA surge capability tested with 8/20 µs pulse as defined by IEC 61000-4-5
- SAD ensures short circuit failure mode in the event of severe transient overload
- Thermal failsafe



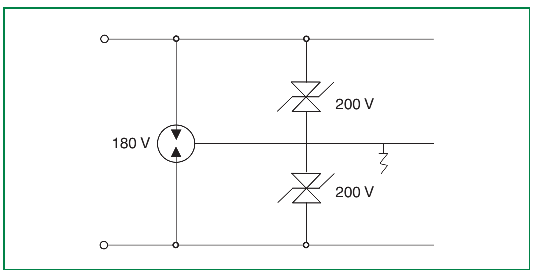
Three-terminal Arrester

Electrical Parameters

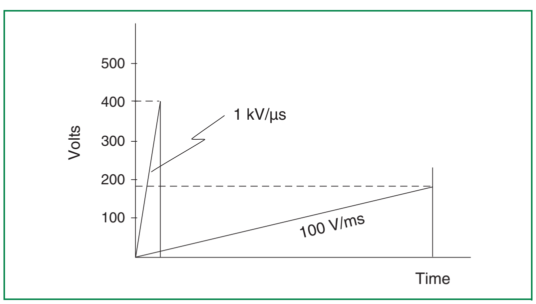
Part Number *	DC Breakover Voltage @ 100 V/s [1,2] Volts		MAX Dynamic Breakover Voltage @ 1 kV/µs Volts	AC Discharge Current [2,3] Amps	MAX Repetitive Impulse Current		MAX Leakage Current [6] nAmps	Holdover Voltage [7] Volts	Nominal On-state Voltage @ 1 A Volts
	MIN	MAX			Notes 2,4 kAmps	Notes 4,5 kAmps			
SL1122A090	70	120	150	5	5	10	50	50	20
SL1122A200	140	250	250	5	5	10	120	120	20
SL1122A230	184	276	350	5	5	10	150	135	20
SL1122A250	200	300	400	5	5	10	150	135	20
SL1122A260	210	350	400	5	5	10	175	135	20
SL1122A350	280	420	600	5	5	10	285	135	20
SL1122A450	420	600	700	5	5	10	350	135	20

* **Max capacitance is 100 pF**, measured at 1 MHz, **except for SL1122A090 which is 200 pF.**

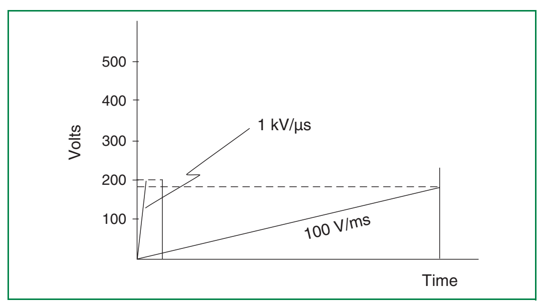
Notes:
1. In ionized mode
2. Either end (Line) electrode to center (Ground) electrode
3. 10 shots, AC 60 Hz, 1 µs duration
4. 10 shots, 8/20 µs waveform
5. Total current through center (Ground) electrode, both line electrodes subject to simultaneous pulses
6. Measured at 100 V, except 90 V dc devices which are measured at 50 V
7. Tested according to ITU-T Rec. K.12



Circuit Diagram



Gas Plasma Arrester Only



Hybrid Gas Plasma Arrester

SL0902A Series *Broadband Optimized* ™ Two-terminal Mini Gas Plasma Arrester

RoHS | Littelfuse

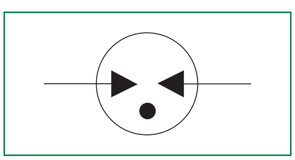
The *Greentube*™ *Broadband Optimized* SL0902A (Beta) Series Gas Plasma Arrester (improved gas discharge tube (GDT)) is designed to offer high surge ratings in a miniature package. Unique design features offer high levels of performance on fast-rising transients in the domain of 100 V/µs to 1 kV/µs (those most likely from induced lightning disturbances).

These devices are extremely robust and able to divert a 2,500 A pulse without destruction.

The SL0902A series can be used in MDF modules, ADSL, xDSL (including ADSL2, VDSL, VDSL2), CATV and satellite equipment, and other telecom applications.

Other features include:

- Lead-free and RoHS compliant
- High performance Beta range
- Totally non-radioactive
- Surface mount
- 2.5 kA surge capability tested with 8/20 µs pulse as defined by IEC 61000-4-5
- Can be used to meet Telcordia GR1089 [Littelfuse recommends using the SL0902A in conjunction with a fuse or PTC for this application.]
- 10/700 6 kV capability, as per ITU-T K.21, enhanced test level
- 2,000 A 2/10 µs surge rating
- Meets TIA-968-A 10/160 µs waveform, 200 A test and 10/560 µs waveform, 100 A test



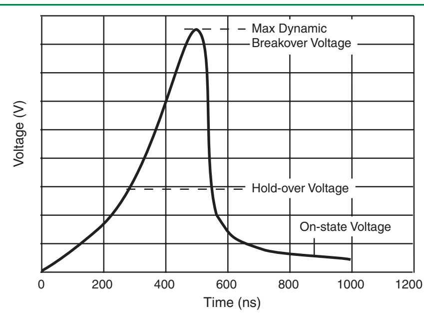
Two-terminal Arrester

Electrical Parameters

Part Number	DC Breakover Voltage @ 100 V/s [1,2] Volts		MAX Dynamic Breakover Voltage [3]		AC Discharge Current [4] Amps	MAX Repetitive Impulse Current [5] kAmps	MAX Leakage Current [6] nAmps	Holdover Voltage [7] Volts	Nominal On-state Voltage @ 1 A Volts
	MIN	MAX	100 V/µs Volts	1 kV/µs Volts					
SL0902A090	72	108	300	550	2.5	2.5	50	50	20
SL0902A230	184	276	400	500	2.5	2.5	100	135	20
SL0902A350	280	420	550	650	2.5	2.5	100	135	20
SL0902A420	350	504	675	800	2.5	2.5	100	135	20

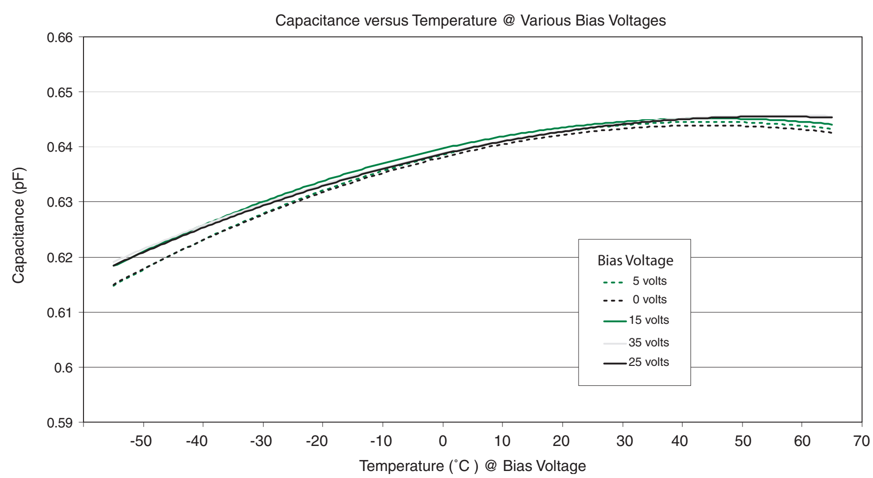
* **Max capacitance is 1.0 pF.**

Notes:
1. At delivery AQL 0.65 level 2, DIN ISO 2859
2. In ionized mode
3. Comparable to the silicon measurement Switching Voltage (V_S)
4. 10 shots, AC 60 Hz, 1 µs duration
5. 10 shots, 8/20 µs waveform per IEC 61000-4-5
6. Measured at 100 V, except 90 V dc devices which are measured at 50 V
7. Tested according to ITU-T Rec. K.12



Voltage versus Time Characteristics

Typical Insertion Loss
@ 1 GHz = 0.01 dB
@ 1.4 GHz = 0.1 dB
@ 1.8 GHz = 0.53 dB
@ 2.1 GHz = 0.81 dB
@ 2.45 GHz = 1 dB
@ 2.8 GHz = 1.2 dB
@ 3.1 GHz = 1.5 dB
@ 3.5 GHz = 2.1 dB



SL0902A Typical Capacitance (pF) versus Temperature at Various Bias Voltages

SL1002A Series *Broadband Optimized* ™ Two-terminal Mini Gas Plasma Arrester

RoHS

Littelfuse®

The *Greentube*™ *Broadband Optimized* SL1002A (Beta) Series Gas Plasma Arrester (improved gas discharge tube (GDT)) is developed for use in broadband equipment. Unique design features offer high levels of performance on fast-rising transients in the domain of 100 V/μs to 1 kV/μs (those most likely from induced lightning disturbances).

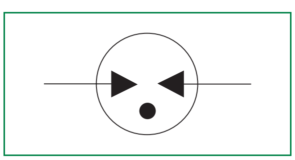
These devices feature ultra low capacitance (typically 1.2 pF or less) and present insignificant signal losses up to 1.5 GHz. They are extremely robust and able to divert a 5,000 A pulse without destruction.

For AC power fault of long duration, overcurrent protection is recommended.

The SL1002A series is used in broadband, ADSL, xDSL (including ADSL2, VDSL, VDSL2), satellite and CATV, and general telecom equipment.

Other features include:

- Lead-free and RoHS compliant
- High performance Beta range
- Totally non-radioactive
- Surface mount
- 5 kA surge capability tested with 8/20 μs pulse as defined by IEC 61000-4-5
- GHz bandwidth compatible
- Can be used to meet Telcordia GR1089 without series resistance
- 10/700 6 kV capability, as per ITU-T K.21, enhanced test level
- 2,000 A 2/10 μs surge rating
- Meets TIA-968-A 10/160 μs waveform, 200 A test and 10/560 μs waveform, 100 A test



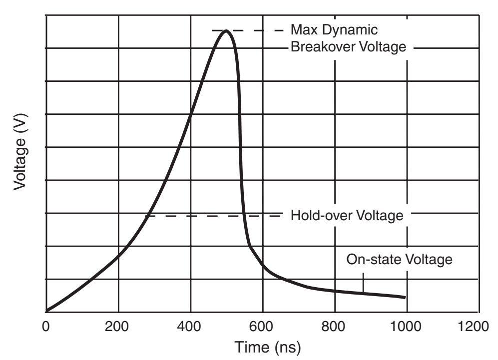
Two-terminal Arrester

Electrical Parameters

Part Number *	DC Breakover Voltage @ 100 V/s Volts		MAX Dynamic Breakover Voltage [1]		AC Discharge Current [2] Amps	MAX Repetitive Impulse Current [3] kAmps	MAX Single Impulse Current		MAX Leakage Current [4] nAmps	Holdover Voltage [5] Volts	Nominal On-state Voltage @ 1 A Volts
	MIN	MAX	100 V/µs Volts	1 kV/µs Volts			2/10 µs kAmps	10/350 µs kAmps			
SL1002A090	70	120	360	700	5	5	2	2	100	50	20
SL1002A230	184	276	400	500	5	5	2	2	100	135	20
SL1002A250	200	300	400	500	5	5	2	2	100	135	20
SL1002A260	210	310	400	500	5	5	2	2	100	135	20
SL1002A350	280	420	500	600	5	5	2	2	100	135	20
SL1002A600	480	720	800	900	5	5	2	2	100	135	20

* **Max capacitance is 1.2 pF**, measured at 1 MHz, zero volt bias.

Notes:
1. Comparable to the silicon measurement Switching Voltage (V_S)
2. 10 shots, AC 60 Hz, 1 µs duration
3. 10 shots, 8/20 µs waveform per IEC 61000-4-5
4. Measured at 100 V, except 90 V dc devices which are measured at 50 V
5. Tested according to ITU-T Rec. K.12



Voltage versus Time Characteristic

Typical Insertion Loss
@ 1 GHz = 0.01 dB
@ 1.4 GHz = 0.1 dB
@ 1.8 GHz = 0.53 dB
@ 2.1 GHz = 0.81 dB
@ 2.45 GHz = 1 dB
@ 2.8 GHz = 1.2 dB
@ 3.1 GHz = 1.5 dB
@ 3.5 GHz = 2.1 dB

SL1003A Series Three-terminal Mini Gas Plasma Arrester

RoHS Pb Littelfuse®

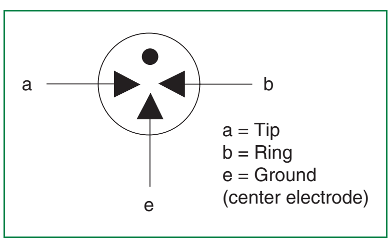
The *Greentube*™ SL1003A (Beta) Series Gas Plasma Arrester (improved gas discharge tube (GDT)) is developed for use in broadband equipment. Unique design features offer high levels of performance on fast-rising transients in the domain of 100 V/μs to 1 kV/μs (those most likely from induced lightning disturbances).

These devices feature ultra low capacitance (typically 1.2 pF or less) and present insignificant signal losses up to 1.5 GHz. They are extremely robust and able to divert a 5,000 A pulse without destruction.

For AC power fault of long duration, overcurrent protection is recommended.

The SL1003A series is used in broadband, ADSL, xDSL (including ADSL2, VDSL, VDSL2), satellite and CATV, and general telecom equipment. Other features include:

- Lead-free and RoHS compliant
- High performance Beta range
- Totally non-radioactive
- Surface mount
- 5 kA surge capability tested with 8/20 μs pulse as defined by IEC 61000-4-5
- GHz bandwidth compatible
- Can be used to meet Telcordia GR1089 without series resistance
- 10/700 6 kV capability, as per ITU-T K.21, enhanced test level
- 2,000 A 2/10 μs surge rating



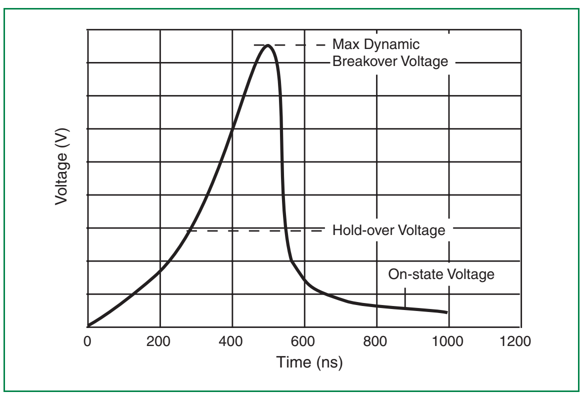
Three-terminal Arrester

Electrical Parameters

Part Number *	DC Breakover Voltage @ 100 V/s Volts		MAX Dynamic Breakover Voltage [1]		AC Discharge Current [2] Amps	MAX Repetitive Impulse Current [3] kAmps	MAX Leakage Current [4] nAmps	Holdover Voltage [5] Volts	Nominal On-state Voltage @ 1 A Volts
	MIN	MAX	100 V/µs Volts	1 kV/µs Volts					
SL1003A090	70	120	600	700	5	5	50	50	20
SL1003A230	184	276	350	500	5	5	100	135	20
SL1003A250	200	300	400	600	5	5	100	135	20
SL1003A260	210	310	420	600	5	5	100	135	20
SL1003A300	240	360	450	650	5	5	100	135	20
SL1003A350	280	420	500	700	5	5	100	135	20
SL1003A400	320	480	550	800	5	5	100	135	20
SL1003A450	360	540	650	800	5	5	100	135	20

* **Max capacitance is 1.2 pF**, measured at 1 MHz, zero volt bias.

Notes:
1. Comparable to the silicon measurement Switching Voltage (V_S)
2. 10 shots, AC 60 Hz, 1 µs duration
3. 10 shots, 8/20 µs waveform per IEC 61000-4-5
4. Measured at 100 V, except 90 V dc which is measured at 50 V
5. Tested according to ITU-T Rec. K 12

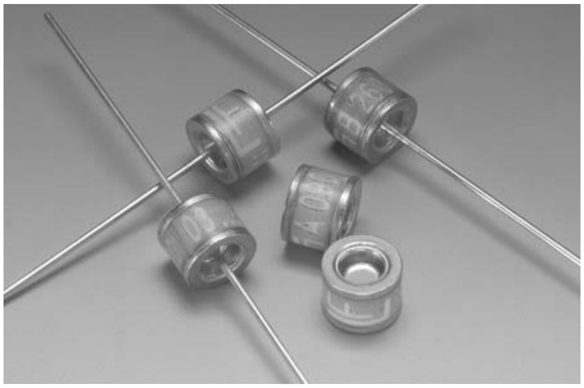


Voltage versus Time Characteristic

Typical Insertion Loss
@ 1 GHz = 0.01 dB
@ 1.4 GHz = 0.1 dB
@ 1.8 GHz = 0.53 dB
@ 2.1 GHz = 0.81 dB
@ 2.45 GHz = 1 dB
@ 2.8 GHz = 1.2 dB
@ 3.1 GHz = 1.5 dB
@ 3.5 GHz = 2.1 dB

SL1011A Series Two-terminal Medium-duty Gas Plasma Arrester

RoHS



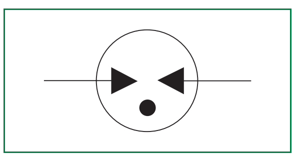
The *Greentube*™ SL1011A (Beta) Series Gas Plasma Arrester (improved gas discharge tube (GDT)) offers high levels of performance on fast-rising transients in the domain of 100 V/µs to 1 kV/µs (those most likely from induced lightning disturbances).

These devices feature ultra low capacitance (typically 1 pF or less), making them ideal for the protection of high-speed transmission equipment. They are extremely robust and able to divert a 5,000 A pulse without destruction.

The SL1011A series is used in broadband, ADSL, xDSL (including ADSL2, VDSL, VDSL2), satellite and CATV, and general telecom equipment.

Other features include:

- Lead-free and RoHS compliant
- High performance Beta range
- Totally non-radioactive
- Low insertion loss
- 5 kA surge capability tested with 8/20 µs pulse as defined by IEC 61000-4-5
- 20,000 A single shot surge capability tested with 8/20 µs pulse as defined by IEC 61000-4-5

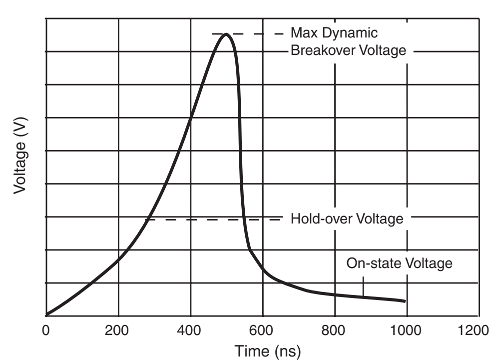


Two-terminal Arrester

Electrical Parameters

Part Number	DC Breakover Voltage @ 100 V/s Volts MIN	DC Breakover Voltage @ 100 V/s Volts MAX	MAX Dynamic Breakover Voltage @ 100 V/µs [1] Volts	AC Discharge Current [2] Amps	MAX Repetitive Impulse Current [3] kAmps	MAX Single Impulse Current 8/20 µs kAmps	MAX Single Impulse Current 10/350 µs kAmps	MAX Leakage Current [4] nAmps	Holdover Voltage [5] Volts
SL1011A075	60	90	500	5	5	20	2.5	50	50
SL1011A090	70	120	500	5	5	20	2.5	50	50
SL1011A145	116	174	500	5	5	20	2.5	50	50
SL1011A150	120	180	500	5	5	20	2.5	50	50
SL1011A230	184	276	375	5	5	20	2.5	100	135
SL1011A250	200	300	400	5	5	20	2.5	100	135
SL1011A260	210	310	420	5	5	20	2.5	100	135
SL1011A350	280	420	500	5	5	20	2.5	100	135
SL1011A400	320	480	600	5	5	20	2.5	100	135
SL1011A470	376	564	650	5	5	20	2.5	100	135
SL1011A500	400	500	700	5	5	20	2.5	100	135
SL1011A600	480	720	800	5	5	20	2.5	100	135

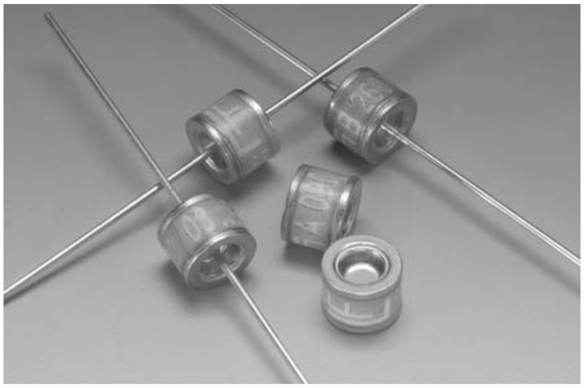
Notes:
1. Comparable to the silicon measurement Switching Voltage (V_S)
2. 10 shots, AC 60 Hz, 1 µs duration
3. 10 shots, 8/20 µs waveform
4. Measured at 100 V, except for devices ≤150 V dc which is measured at 50 V
5. Tested according to ITU-T Rec. K 12



Voltage versus Time Characteristic

SL1011B Series Two-terminal Heavy-duty Gas Plasma Arrester

RoHS Pb Littelfuse®



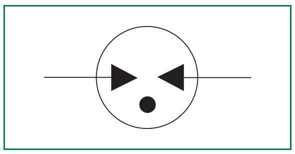
The *Greentube*™ SL1011B (Beta) Series Gas Plasma Arrester (improved gas discharge tube (GDT)) offers high levels of performance on fast-rising transients in the domain of 100 V/μs to 1 kV/μs (those most likely from induced lightning disturbances).

These devices feature ultra low capacitance (typically 1 pF or less), making them ideal for the protection of high-speed transmission equipment. They are extremely robust and able to divert a 10,000 A pulse without destruction.

The SL1011B series is used in broadband, ADSL, xDSL (including ADSL2, VDSL, VDSL2), satellite and CATV, and general telecom equipment.

Other features include:

- Lead-free and RoHS compliant
- High performance Beta range
- Totally non-radioactive
- Low insertion loss
- 10 kA surge capability tested with 8/20 μs pulse as defined by IEC 61000-4-5
- 10,000 A single shot surge capability tested with 8/20 μs pulse as defined by IEC 61000-4-5

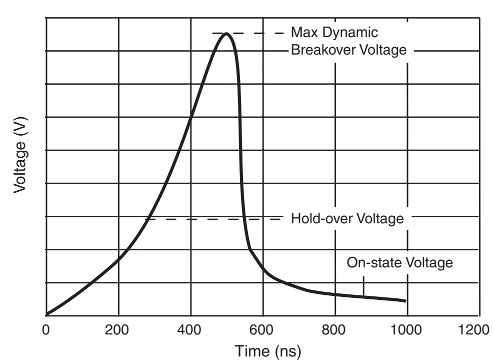


Two-terminal Arrester

Electrical Parameters

Part Number	DC Breakover Voltage @ 100 V/s Volts		MAX Dynamic Breakover Voltage @ 100 V/µs [1]	AC Discharge Current [2] Amps	MAX Repetitive Impulse Current [3] kAmps	MAX Single Impulse Current		MAX Leakage Current [4] nAmps	Holdover Voltage [5] Volts
	MIN	MAX				8/20 µs kAmps	10/350 µs kAmps		
SL1011B075	60	90	500	10	10	20	2.5	50	50
SL1011B090	70	120	500	10	10	20	2.5	50	50
SL1011B145	116	174	500	10	10	20	2.5	50	50
SL1011B150	120	180	500	10	10	20	2.5	50	50
SL1011B230	184	276	375	10	10	20	2.5	100	135
SL1011B250	200	300	400	10	10	20	2.5	100	135
SL1011B260	210	310	420	10	10	20	2.5	100	135
SL1011B350	280	420	500	10	10	20	2.5	100	135

Notes:
1. Comparable to the silicon measurement Switching Voltage (V_S)
2. 10 shots, AC 60 Hz, 1 µs duration
3. 10 shots, 8/20 µs waveform
4. Measured at 100 V, except for devices ≤150 V dc which are measured at 50 V
5. Tested according to ITU-T Rec. K 12



Voltage versus Time Characteristic

SL1021A Series Three-terminal Medium-duty 8 mm Gas Plasma Arrester

RoHS Pb Littelfuse

The *Greentube*™ SL1021A (Beta) Series Gas Plasma Arrester (improved gas discharge tube (GDT)) offers high levels of performance on fast-rising transients in the domain of 100 V/µs to 1 kV/µs (those most likely from induced lightning disturbances).

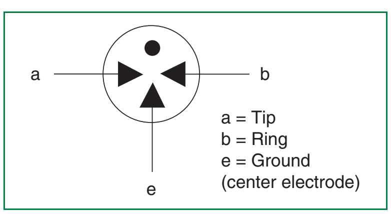
These devices feature ultra low capacitance (typically 1 pF or less) and optimized internal geometry to provide low insertion loss at high frequencies, making them ideal for the protection of broadband equipment. They are extremely robust and able to divert a 10,000 A pulse without destruction.

The failsafe is a heat sensitive device for preventing over-temperature situations. In normal operation or when conducting short duration transients (spikes), the gas plasma arrester does not generate any significant or detectable heat. Under conditions of conducting mains electricity (AC power) for extended periods (power fault), any arrester will generate excessive thermal energy, even to the point where its electrodes glow 'cherry red.' If an arrester is to be used in areas where connection with AC mains is a possibility, then a failsafe can be fitted. These devices are spring-loaded switches held in the open position. When the arrester temperature rises, the device activates to create a short circuit between the arrester center (ground) and line terminals (Tip or Ring). This short circuit is of low resistance and will conduct the fault current without generating any significant heat. The RG failsafe can be used in flow or re-flow solder processes without activating in response to the heat of the process. It is lead-free and can withstand long-term exposure to temperatures up to 100 °C.

The SL1021A series is used in broadband, ADSL, xDSL (including ADSL2, VDSL, VDSL2), satellite and CATV, and general telecom equipment.

Other features include:

- Lead-free and RoHS compliant
- High performance Beta range
- Totally non-radioactive
- 10 kA surge capability tested with 8/20 µs pulse as defined by IEC 61000-4-5
- 20,000 A single shot surge capability tested with 8/20 µs pulse as defined by IEC 61000-4-5
- Available with thermal failsafe option ("F" suffix added to part number)



Three-terminal Arrester

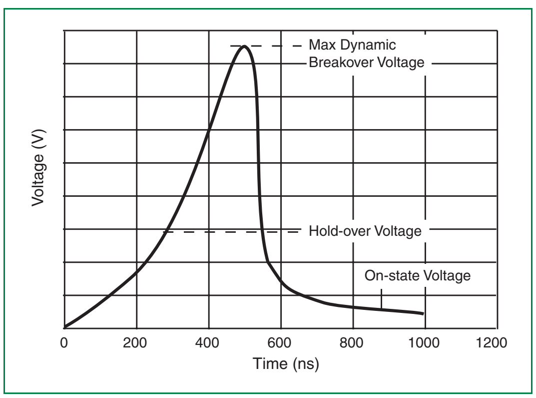
Electrical Parameters

Part Number *	DC Breakover Voltage @ 100 V/s Volts		MAX Dynamic Breakover Voltage [1]		AC Discharge Current		MAX Repetitive Impulse Current		MAX Single Impulse Current [4,6]		MAX Leakage Current [6] nAmps	Holdover Voltage [7] Volts
	MIN	MAX	100 V/µs Volts	1 kV/µs Volts	Notes 2,3 Amps	Notes 2,4 Amps	Notes 3,5 kAmps	Notes 4,5 kAmps	8/20 µs kAmps	10/350 µs kAmps		
SL1021A200 [8]	150	250	350	450	10	5	10	5	20	2.5	100	135
SL1021A230	184	276	400	500	10	5	10	5	20	2.5	100	135
SL1021A250	200	300	450	550	10	5	10	5	20	2.5	100	135
SL1021A260 [9]	210	310	450	550	10	5	10	5	20	2.5	100	135
SL1021A300	240	360	500	650	10	5	10	5	20	2.5	100	135
SL1021A350	280	420	600	700	10	5	10	5	20	2.5	100	135
SL1021A500	400	500	800	900	10	5	10	5	20	2.5	100	135
SL1021A600	480	720	870	960	10	5	10	5	20	2.5	100	135

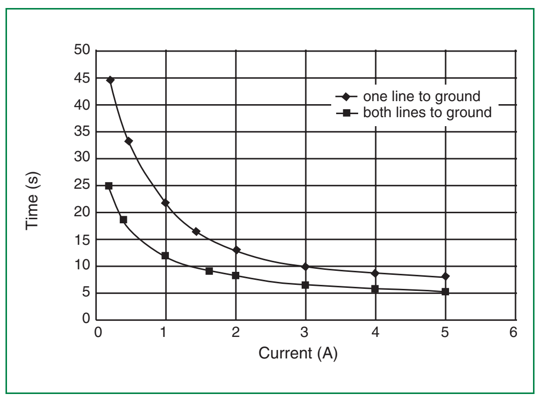
* **Max capacitance is 1.5 pF**, measured at 1 MHz

Life test rating is 100 shots, 100 A, 10/1000 µs pulse; rating does not apply to SL1021A200. (Rating applies to C option devices mounted in a suitable connector with high pressure contacts.)

Notes:
1. Comparable to the silicon measurement Switching Voltage (V_S)
2. 10 shots, AC 60 Hz, 1 µs duration
3. Total current through center (Ground) electrode, both line electrodes subject to simultaneous pulses; half value through each respective Line terminal
4. Either end (Line) electrode to center (Ground) electrode
5. 10 shots, 8/20 µs waveform
6. Measured at 100 V
7. Tested according to ITU-T Rec. K 12
8. Meets the requirements of BT Type 14A; failsafe option meets the requirements of BT Type 14A/1 (“F” suffix added to part number)
9. Meets the requirements of BT Type 21A



Voltage versus Time Characteristic



Time versus Current for Failsafe

SL1021B Series Three-terminal Heavy-duty 8 mm Gas Plasma Arrester

RoHS Pb Littelfuse

The *Greentube*™ SL1021B (Beta) Series Gas Plasma Arrester (improved gas discharge tube (GDT)) offers high levels of performance on fast-rising transients in the domain of 100 V/µs to 1 kV/µs (those most likely from induced lightning disturbances).

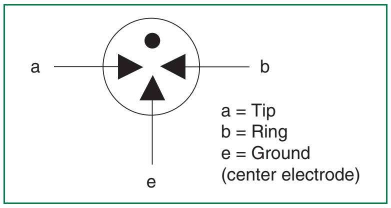
These devices feature ultra low capacitance (typically 1 pF or less) and optimized internal geometry to provide low insertion loss at high frequencies, making them ideal for the protection of broadband equipment. They are extremely robust and able to divert a 20,000 A pulse without destruction.

The failsafe is a heat sensitive device for preventing over-temperature situations. In normal operation or when conducting short duration transients (spikes), the gas plasma arrester does not generate any significant or detectable heat. Under conditions of conducting mains electricity (AC power) for extended periods (power fault), any arrester will generate excessive thermal energy, even to the point where its electrodes glow 'cherry red.' If an arrester is to be used in areas where connection with AC mains is a possibility, then a failsafe can be fitted. These devices are spring-loaded switches held in the open position. When the arrester temperature rises, the device activates to create a short circuit between the arrester center (ground) and line terminals (Tip or Ring). This short circuit is of low resistance and will conduct the fault current without generating any significant heat. The RG failsafe can be used in flow or re-flow solder processes without activating in response to the heat of the process. It is lead-free and can withstand long-term exposure to temperatures up to 100 °C

The SL1021B series is used in broadband, ADSL, xDSL (including ADSL2, VDSL, VDSL2), satellite and CATV, and general telecom equipment.

Other features include:

- Lead-free and RoHS compliant
- High performance Beta range
- Totally non-radioactive
- 10 kA surge capability tested with 8/20 µs pulse as defined by IEC 61000-4-5
- 20,000 A single shot surge capability tested with 8/20 µs pulse as defined by IEC 61000-4-5
- Available with thermal failsafe option ("F" suffix added to part number)



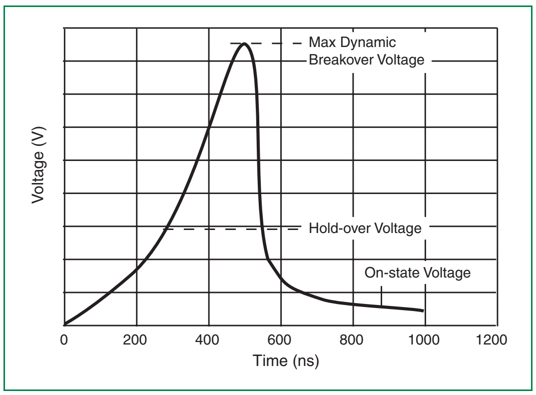
Three-terminal Arrester

Electrical Parameters

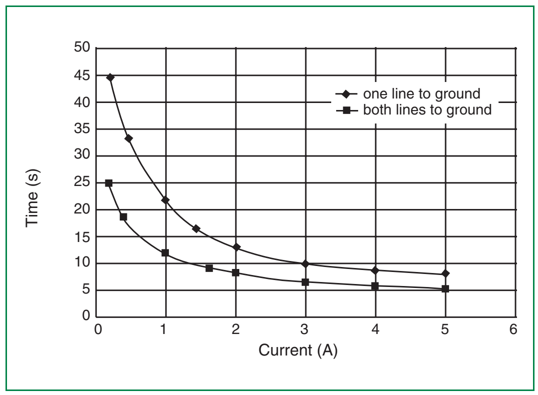
Part Number *	DC Breakover Voltage @ 100 V/s Volts		MAX Dynamic Breakover Voltage [1]		AC Discharge Current [2,3] Amps	MAX Repetitive Impulse Current [3,4] kAmps	MAX Single Impulse Current [3,5]		MAX Leakage Current [6] nAmps	Holdover Voltage [7] Volts
	MIN	MAX	100 V/µs Volts	1 kV/µs Volts			8/20 µs kAmps	10/350 µs kAmps		
SL1021B200	150	250	350	450	10	10	20	2.5	100	135
SL1021B230	184	276	400	500	10	10	20	2.5	100	135
SL1021B250	200	300	450	550	10	10	20	2.5	100	135
SL1021B260	210	310	450	550	10	10	20	2.5	100	135
SL1021B300	240	360	500	650	10	10	20	2.5	100	135
SL1021B350	280	420	600	700	10	10	20	2.5	100	135
SL1021B500	400	500	800	900	10	10	20	2.5	100	135
SL1021B600	480	720	870	960	10	10	20	2.5	100	135

* **Max capacitance is 1.5 pF**, measured at 1 MHz.
Life test rating is 100 shots, 100 A, 10/1000 µs pulse

Notes:
1. Comparable to the silicon measurement Switching Voltage (V_S)
2. 10 shots, AC 60 Hz, 1 µs duration
3. Either end (Line) electrode to center (Ground) electrode
4. 10 shots, 8/20 µs waveform
5. Applies to C option devices mounted in a suitable connector with high pressure contacts
6. Measured at 100 V
7. Tested according to ITU-T Rec. K 12



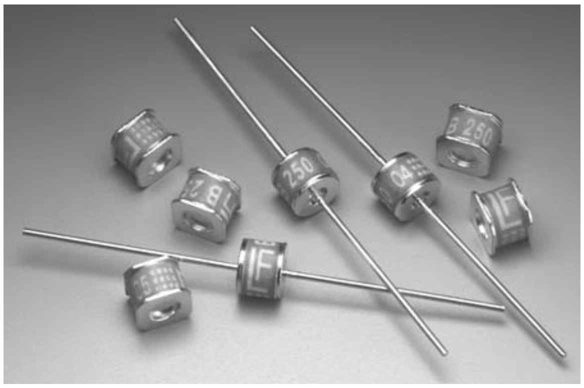
Voltage versus Time Characteristic



Time versus Current for Failsafe

SL1411A Series Two-terminal Gas Plasma Arrester

RoHS



The *Greentube*™ SL1411A (Delta) Series Gas Plasma Arrester (improved gas discharge tube (GDT)) features is a high-performance transient voltage suppressor designed for heavy-duty protection of telecom and industrial equipment.

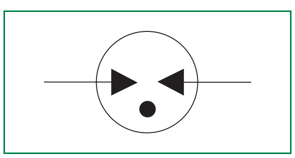
The Delta range offers high levels of performance and durability on fast-rising transients in the domain of 100 V/µS to 1 kV/µS, which are those most likely from induced lightning disturbances. The high surge rating of these devices makes them ideal for arduous service conditions and Outside Plant locations.

The Delta range also features ultra low capacitance (typically 1 pF or less) and optimized internal geometry which provides low insertion loss at high frequencies, so are ideal for the protection of broadband equipment.

The SL1411A series is used for Outside Plant and MDF protector modules, ADSL, xDSL (including ADSL2, VDSL, VDSL2), satellite, CATV, and general telecom equipment, and cell phone base stations.

Other features include:

- High energy Delta range
- Up to 1.5 gHz working frequency
- 10 kA surge capability tested with 8/20µS pulse as defined by IEC 61000-4-5 (20 kA for 90 V)
- 25,000 A single shot surge capability tested with 8/20µS pulse as defined by IEC 61000-4-5
- Excellent service life characteristics



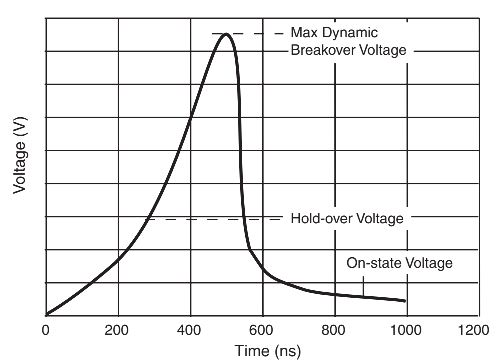
Two-terminal Arrester

Electrical Parameters

Part Number *	DC Breakover Voltage @ 100 V/s [1,2] Volts		MAX Dynamic Breakover Voltage [3]		AC Discharge Current [4] Amps	MAX Repetitive Impulse Current [5] kAmps	MAX Single Impulse Current		MAX Leakage Current [6] nAmps	Holdover Voltage [7, 8] Volts	Nominal On-state Voltage @ 1 A Volts
	MIN	MAX	100 V/µs Volts	1 kV/µs Volts			8/20 µs kAmps	10/350 µs kAmps			
SL1411A075	60	90	450	700	10	10	20	3	50	50	20
SL1411A090	72	108	450	700	10	10	20	3	50	50	20
SL1411A230	184	276	450	650	10	10	20	3	100	135	20
SL1411A250	200	300	475	700	10	10	20	3	100	135	20
SL1411A350	280	420	600	800	10	10	20	3	100	135	20

* **Max capacitance is 1.5 pF**, measured at 1 MHz.

Notes:
1. At delivery AQL 0.65 level II, DIN ISO 2859
2. In ionized mode
3. Comparable to the silicon measurement Switching Voltage (V_S)
4. 10 shots, AC 60 Hz, 1 µs duration
5. 10 shots, 8/20 µs waveform
6. Measured at 100 V, except for devices 90 V dc which are measured at 50 V
7. With network applied, 52 V for 75 V dc and 90 V dc ratings
8. Tested according to ITU-T Rec. K 12



Voltage versus Time Characteristic

SL1024A Series Three-terminal Medium-duty 8 mm Gas Plasma Arrester

RoHS Pb Littelfuse

The *Greentube*™ SL1024A (Omega) Series Gas Plasma Arrester (improved gas discharge tube (GDT)) offers high levels of current handling on fast-rising transients created by induced lightning disturbances.

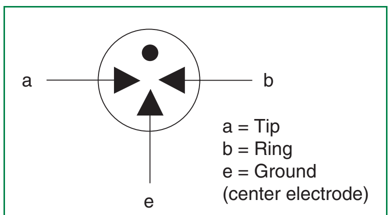
These devices feature ultra low capacitance (typically 1 pF or less), making them ideal for the protection of high-speed transmission equipment. They are extremely robust and able to divert pulses of 10,000 A.

The SL1024A series is used in broadband, ADSL, xDSL (including ADSL2, VDSL, VDSL2), satellite and CATV, splitters, and general telecom equipment.

The failsafe is a heat sensitive device for preventing over-temperature situations. In normal operation or when conducting short duration transients (spikes), the gas plasma arrester does not generate any significant or detectable heat. Under conditions of conducting mains electricity (AC power) for extended periods (power fault), any arrester will generate excessive thermal energy, even to the point where its electrodes glow 'cherry red.' If an arrester is to be used in areas where connection with AC mains is a possibility, then a failsafe can be fitted. These devices are spring-loaded switches held in the open position. When the arrester temperature rises, the device activates to create a short circuit between the arrester center (ground) and line terminals (Tip or Ring). This short circuit is of low resistance and will conduct the fault current without generating any significant heat. The RG failsafe can be used in flow or re-flow solder processes without activating in response to the heat of the process. It is lead-free and can withstand long-term exposure to temperatures up to 100 °C

Other features include:

- Lead-free and RoHS compliant
- Omega range
- Totally non-radioactive
- Low insertion loss
- 10 kA surge capability tested with 8/20 µs pulse as defined by IEC 61000-4-5
- Available with thermal failsafe option ("F" suffix added to part number)



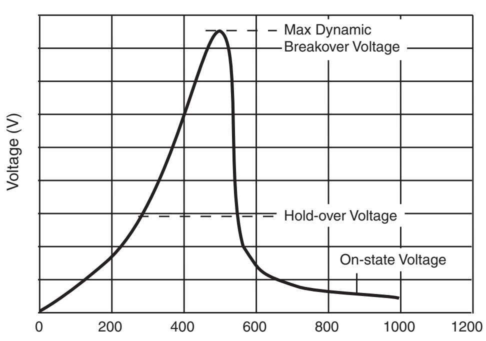
Three-terminal Arrester

Electrical Parameters

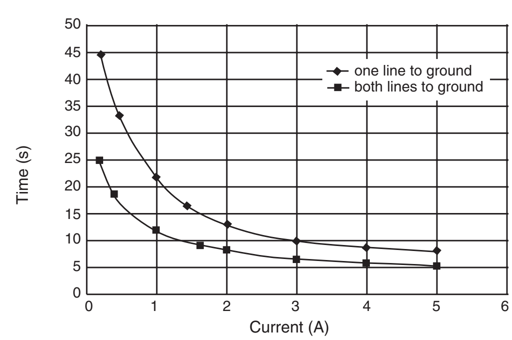
Part Number *	DC Breakover Voltage @ 100 V/s Volts MIN	DC Breakover Voltage @ 100 V/s Volts MAX	MAX Dynamic Breakover Voltage @ 100 V/µs [1] Volts	AC Discharge Current [2,3] Amps	MAX Repetitive Impulse Current [4] kAmps	MAX Single Impulse Current [5,6] 8/20 µs kAmps	MAX Single Impulse Current [5,6] 10/350 µs kAmps	MAX Leakage Current [7] nAmps	Holdover Voltage [8] Volts
SL1024A090	70	120	450	10	10	20	2.5	50	50
SL1024A145	116	174	450	10	10	20	2.5	50	50
SL1024A150	120	180	450	10	10	20	2.5	50	50
SL1024A230	184	276	450	10	10	20	2.5	100	135
SL1024A250	200	300	475	10	10	20	2.5	100	135
SL1024A260	210	310	475	10	10	20	2.5	100	135
SL1024A300	240	360	550	10	10	20	2.5	100	135
SL1024A350	280	420	625	10	10	20	2.5	100	135
SL1024A400	320	480	650	10	10	20	2.5	100	135
SL1024A420	345	500	700	10	10	20	2.5	100	135
SL1024A450	360	540	700	10	10	20	2.5	100	135
SL1024A470	376	564	725	10	10	20	2.5	100	135
SL1024A500	400	500	825	10	10	20	2.5	100	135
SL1024A600	480	720	900	10	10	20	2.5	100	135

* **Max capacitance is 1.5 pF**, measured at 1 MHz.

Notes:
1. Comparable to the silicon measurement Switching Voltage (V_S)
2. Total current through center (Ground) electrode, both line electrodes subject to simultaneous pulses; half value through each respective Line terminal.
3. 10 shots, AC 60 Hz, 1 µs duration
4. 10 shots, 8/20 µs waveform
5. Either end (Line) electrode to center (Ground) electrode
6. Applies to C option devices mounted in a suitable connector with high pressure contacts.
7. Measured at 100 V, except for devices ≤150 V dc which are measured at 50 V
8. Tested according to ITU-T Rec. K 12



Voltage versus Time Characteristic



Time versus Current for Failsafe

SL1024B Series Three-terminal Heavy-duty 8 mm Gas Plasma Arrester

RoHS Pb Littelfuse®

The *Greentube*™ SL1024B (Omega) Series Gas Plasma Arrester (improved gas discharge tube (GDT)) offers high levels of current handling on fast-rising transients created by induced lightning disturbances.

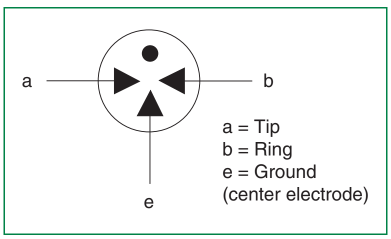
These devices feature ultra low capacitance (typically 1 pF or less), making them ideal for the protection of high-speed transmission equipment. They are extremely robust and able to divert pulses of 20,000 A.

The SL1024B series is used in broadband, ADSL, xDSL (including ADSL2, VDSL, VDSL2), satellite and CATV, splitters, and general telecom equipment.

The failsafe is a heat sensitive device for preventing over-temperature situations. In normal operation or when conducting short duration transients (spikes), the gas plasma arrester does not generate any significant or detectable heat. Under conditions of conducting mains electricity (AC power) for extended periods (power fault), any arrester will generate excessive thermal energy, even to the point where its electrodes glow 'cherry red.' If an arrester is to be used in areas where connection with AC mains is a possibility, then a failsafe can be fitted. These devices are spring-loaded switches held in the open position. When the arrester temperature rises, the device activates to create a short circuit between the arrester center (ground) and line terminals (Tip or Ring). This short circuit is of low resistance and will conduct the fault current without generating any significant heat. The RG failsafe can be used in flow or re-flow solder processes without activating in response to the heat of the process. It is lead-free and can withstand long-term exposure to temperatures up to 100 °C

Other features include:

- Lead-free and RoHS compliant
- Omega range
- Totally non-radioactive
- Low insertion loss
- 20 kA surge capability tested with 8/20 µs pulse as defined by IEC 61000-4-5
- Available with thermal failsafe option ('F' suffix added to part number)



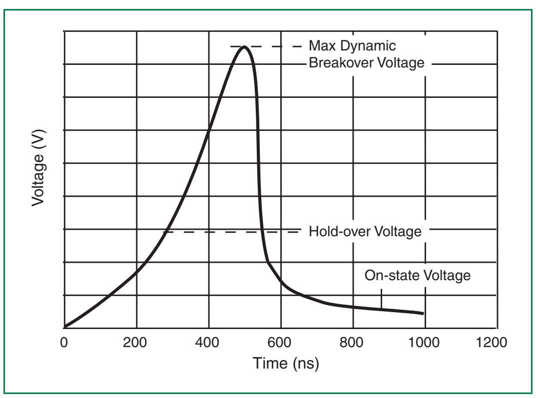
Three-terminal Arrester

Electrical Parameters

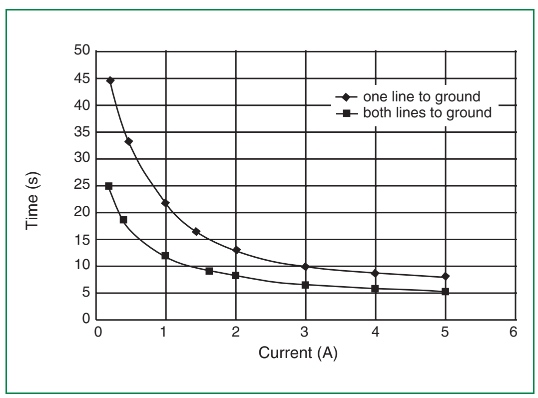
Part Number *	DC Breakover Voltage @ 100 V/s Volts MIN	DC Breakover Voltage @ 100 V/s Volts MAX	MAX Dynamic Breakover Voltage @ 100 V/µs [1] Volts	AC Discharge Current [2,3] Amps	MAX Repetitive Impulse Current [4] kAmps	MAX Single Impulse Current [5,6] 8/20 µs kAmps	MAX Single Impulse Current [5,6] 10/350 µs kAmps	MAX Leakage Current [7] nAmps	Holdover Voltage [8] Volts
SL1024B090	70	120	450	10	10	20	2.5	50	50
SL1024B145	116	174	450	10	10	20	2.5	50	50
SL1024B150	120	180	450	10	10	20	2.5	50	50
SL1024B230	184	276	450	10	10	20	2.5	100	135
SL1024B250	200	300	475	10	10	20	2.5	100	135
SL1024B260	210	310	475	10	10	20	2.5	100	135
SL1024B300	240	360	550	10	10	20	2.5	100	135
SL1024B350	280	420	625	10	10	20	2.5	100	135
SL1024B400	320	480	650	10	10	20	2.5	100	135
SL1024B420	345	500	700	10	10	20	2.5	100	135
SL1024B450	360	540	700	10	10	20	2.5	100	135
SL1024A470	376	564	725	10	10	20	2.5	100	135
SL1024B500	400	500	825	10	10	20	2.5	100	135
SL1024B600	480	720	900	10	10	20	2.5	100	135

* **Max capacitance is 1.5 pF**, measured at 1 MHz.

Notes:
1. Comparable to the silicon measurement Switching Voltage (V_S)
2. Total current through center (Ground) electrode, both line electrodes subject to simultaneous pulses; half value through each respective Line terminal.
3. 10 shots, AC 60 Hz, 1 µs duration
4. 10 shots, 8/20 µs waveform
5. Either end (Line) electrode to center (Ground) electrode
6. Applies to C option devices mounted in a suitable connector with high pressure contacts.
7. Measured at 100 V, except for devices ≤150 V dc which are measured at 50 V
8. Tested according to ITU-T Rec. K 12



Voltage versus Time Characteristic



Time versus Current for Failsafe

NOTES

3 Teccor® Brand *SIDACtor*® Devices

This section presents complete electrical specifications for Littelfuse's *SIDACtor* solid state overvoltage protection devices.

RoHS

DO-214AA *SIDACtor* solid state protection devices protect telecommunications equipment such as modems, line cards, and CPE (telephones, answering machines, and fax machines).

SIDACtor devices enable equipment to comply with various regulatory requirements including GR 1089, ITU K.20, K.21 and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
P0080S_L	6	25	4	5	800	2.2	50
P0220S_L	15	32	4	5	800	2.2	50
P0300S_L	25	40	4	5	800	2.2	50
P0640S_L	58	77	4	5	800	2.2	150
P0720S_L	65	88	4	5	800	2.2	150
P0900S_L	75	98	4	5	800	2.2	150
P1100S_L	90	130	4	5	800	2.2	150
P1300S_L	120	160	4	5	800	2.2	150
P1500S_L	140	180	4	5	800	2.2	150
P1800S_L	170	220	4	5	800	2.2	150
P2100S_L	180	240	4	5	800	2.2	150
P2300S_L	190	260	4	5	800	2.2	150
P2600S_L	220	300	4	5	800	2.2	150
P3100S_L	275	350	4	5	800	2.2	150
P3500S_L	320	400	4	5	800	2.2	150

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For individual "SA", "SB", and "SC" surge ratings, see table below.

General Notes:

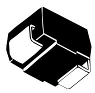
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM} 50 / 60 Hz	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **		
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
A	20	150	150	90	50	75	75	45	75	20	500
B	25	250	250	150	100	100	125	80	100	30	500
C	50	500	400	200	150	200	175	100	200	30	500

* Current waveform in µs
** Voltage waveform in µs

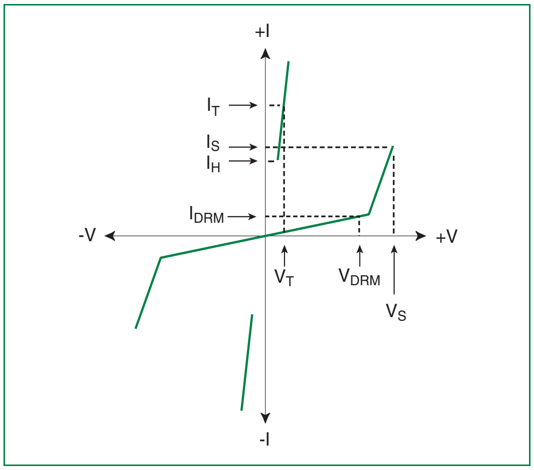
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
DO-214AA 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	90	°C/W

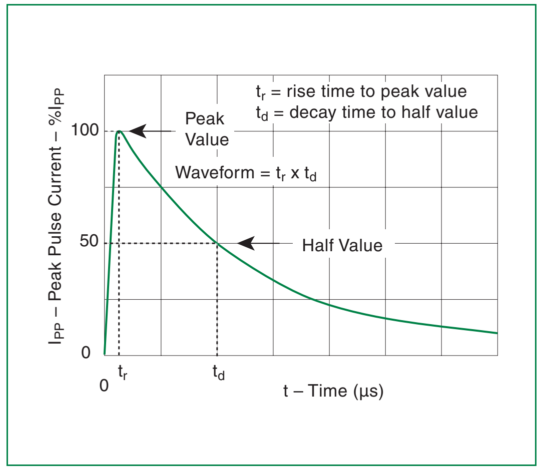
Capacitance Values

Part Number *	pF	
	MIN	MAX
P0080S[A/B]L	25	150
P0080SCL	35	260
P0220SAL	25	150
P0220SBL	25	150
P0220SCL	30	240
P0300S[A/B]L	15	140
P0300SCL	25	250
P0640S[A/B]L	40	60
P0640SCL	55	155
P0720SAL	35	60
P0720SBL	35	75
P0720SCL	50	150
P0900SAL	35	55
P0900SBL	35	70
P0900SCL	45	140
P1100SAL	30	50
P1100SBL	30	70
P1100SCL	45	115
P1300SAL	25	45
P1300SBL	25	60
P1300SCL	40	105
P1500SAL	25	40
P1500SBL	25	55
P1500SCL	35	95
P1800SAL	25	35
P1800SBL	25	50
P1800SCL	35	90
P2100S[A/B]L	20	35
P2100SCL	30	90
P2300SAL	25	35
P2300SBL	25	50
P2300SCL	30	80
P2600SAL	20	35
P2600SBL	20	45
P2600SCL	30	80
P3100SAL	20	35
P3100SBL	20	45
P3100SCL	30	70
P3500SAL	20	35
P3500SBL	20	40
P3500SCL	25	65

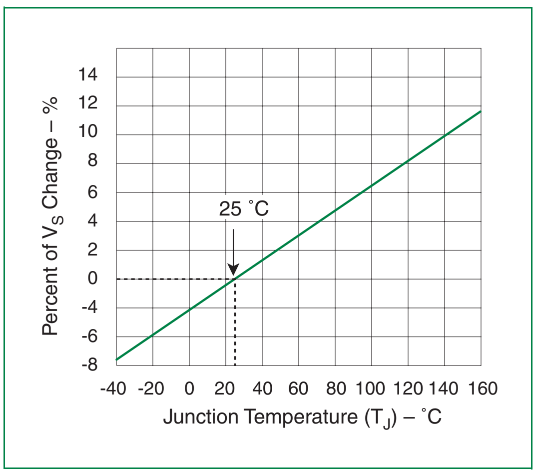
* [A/B] in part number indicates that values are for both A and B surge ratings.
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



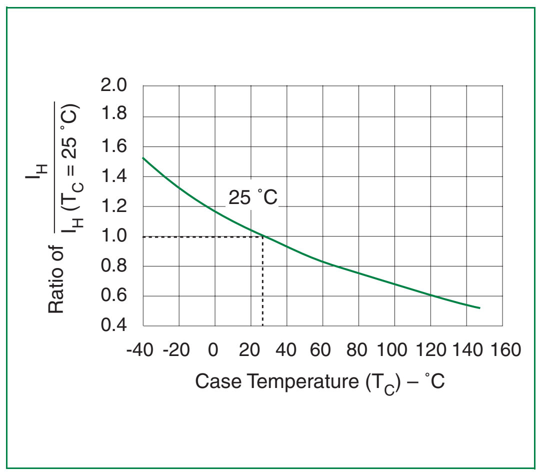
V-I Characteristics



t_r x t_d Pulse Waveform

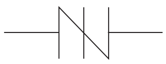


Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

MicroCapacitance (MC) SC *SIDACtor*® Device



These DO-214AA SCMC *SIDACtor* devices are intended for applications sensitive to load values. Typically, high speed connections, such as xDSL and T1/E1, require a lower capacitance. C_O values for the MicroCapacitance device are 40 percent lower than a standard SC part.

This SCMC *SIDACtor* series enables equipment to comply with various regulatory requirements including GR 1089, IEC 60950, UL 60950, TIA-968-A (formerly known as FCC Part 68), and ITU K.20, K.21, and K.45.

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
P0080SCMCL	6	25	4	5	800	2.2	50
P0220SCMCL	15	32	4	5	800	2.2	50
P0300SCMCL	25	40	4	5	800	2.2	50
P0640SCMCL	58	77	4	5	800	2.2	150
P0720SCMCL	65	88	4	5	800	2.2	150
P0900SCMCL	75	98	4	5	800	2.2	150
P1100SCMCL	90	130	4	5	800	2.2	150
P1200SCMCL	100	130	4	5	800	2.2	120
P1300SCMCL	120	160	4	5	800	2.2	150
P1500SCMCL	140	180	4	5	800	2.2	150
P1800SCMCL	170	220	4	5	800	2.2	150
P2000SCMCL	180	220	4	5	800	2.2	120
P2100SCMCL	180	240	4	5	800	2.2	150
P2300SCMCL	190	260	4	5	800	2.2	150
P2500SCMCL	230	290	4	5	800	2.2	120
P2600SCMCL	220	300	4	5	800	2.2	150
P3100SCMCL	275	350	4	5	800	2.2	150
P3500SCMCL	320	400	4	5	800	2.2	150

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For surge ratings, see table below.

General Notes:

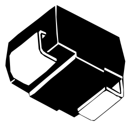
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM} 50 / 60 Hz	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **		
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
C	50	500	400	200	150	200	175	100	200	30	500

* Current waveform in µs
** Voltage waveform in µs

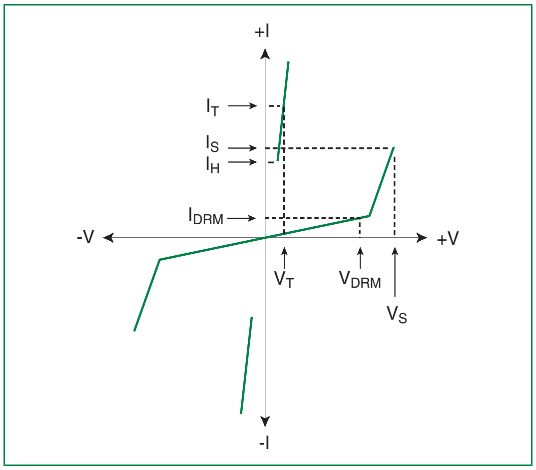
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
DO-214AA 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	90	°C/W

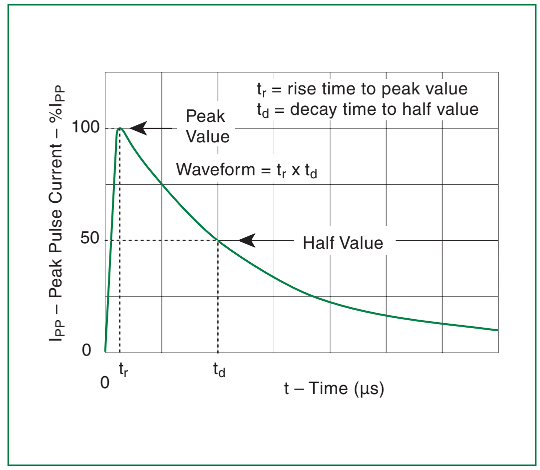
Capacitance Values

Part Number	pF	
	MIN	MAX
P0080SCMCL	35	75
P0220SCMCL	30	65
P0300SCMCL	25	45
P0640SCMCL	55	85
P0720SCMCL	50	75
P0900SCMCL	45	70
P1100SCMCL	45	70
P1200SCMCL	45	65
P1300SCMCL	40	60
P1500SCMCL	35	55
P1800SCMCL	35	50
P2000SCMCL	35	50
P2100SCMCL	30	50
P2300SCMCL	30	50
P2500SCMCL	30	45
P2600SCMCL	30	45
P3100SCMCL	30	45
P3500SCMCL	25	40

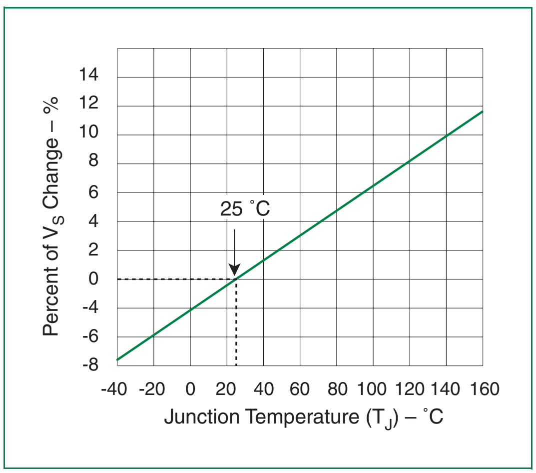
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



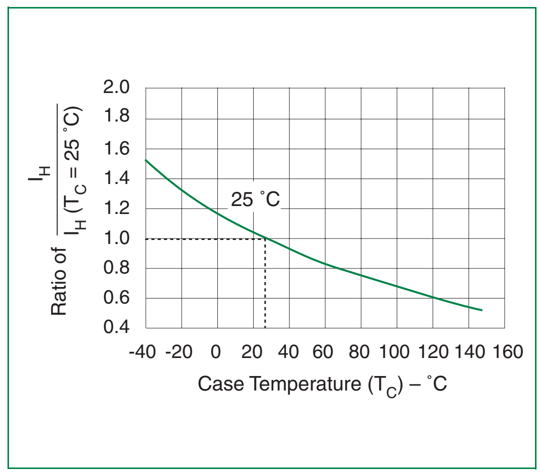
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

MicroCapacitance (MC) SA *SIDACtor*® Device

RoHS

Littelfuse®

These DO-214AA SAMC *SIDACtor* devices are intended for applications sensitive to load values. Typically, high speed connections, such as Ethernet, xDSL, and T1/E1, require a lower capacitance. C_O values for the MicroCapacitance device are 40% lower than a standard SA part.

This SAMC *SIDACtor* series enables equipment to comply with various regulatory requirements including GR 1089, ITU K.20, K.21, and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
P0080SAMCL	6	25	4	5	800	2.2	50
P0220SAMCL	15	32	4	5	800	2.2	50
P0300SAMCL	25	40	4	5	800	2.2	50

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For surge ratings, see table below.

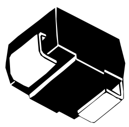
General Notes:
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM} 50 / 60 Hz	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **		
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
A	20	150	150	90	50	75	75	45	75	20	500

* Current waveform in µs
** Voltage waveform in µs

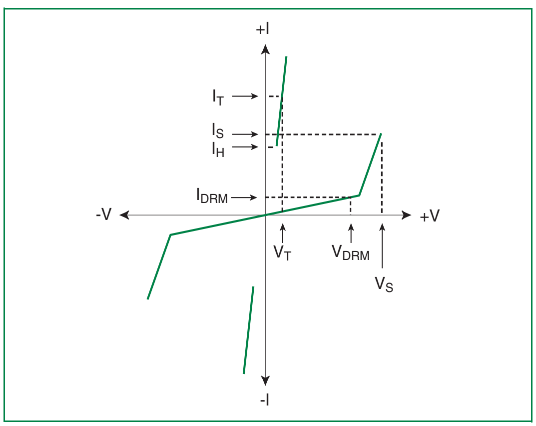
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
DO-214AA 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	90	°C/W

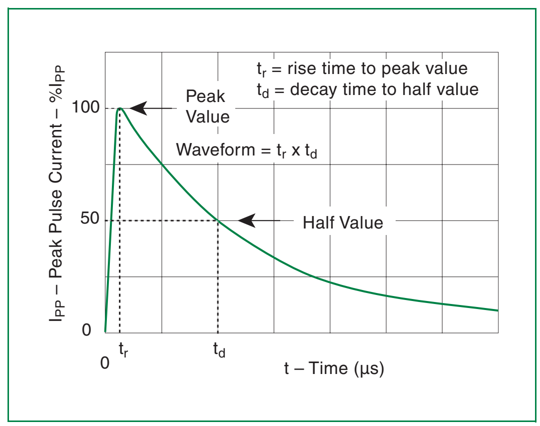
Capacitance Values

Part Number	pF MIN	pF MAX
P0080SAMCL	25	55
P0220SAMCL	25	50
P0300SAMCL	15	35

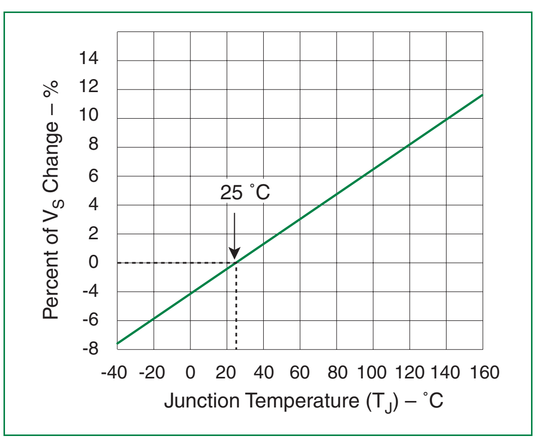
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



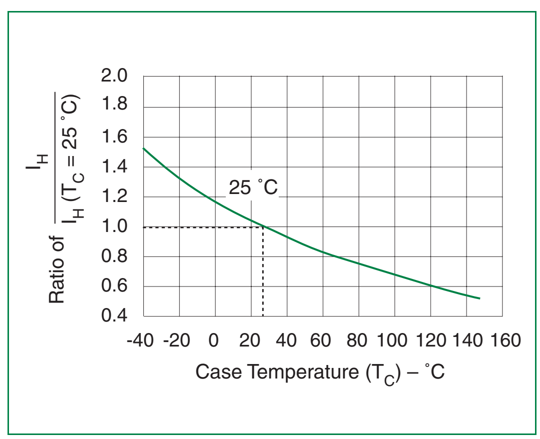
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

High Surge Current (D-rated) *SIDACtor*® Device

RoHS

Littelfuse®

DO-214AA *SIDACtor* solid state protection devices with a D surge rating protect telecommunications equipment located in hostile environments. These *SIDACtor* devices withstand the simultaneous surges outlined in GR 1089 lightning tests. (See “First Level Lightning Surge Test” on page 7-5.) Surge ratings are twice that of a device with a C surge rating. This provides a method for building an SMT version of the balanced ‘Y’ configuration. (US Patent 4,905,119) *SIDACtor* devices enable equipment to comply with various regulatory requirements including GR 1089, ITU K.20, K.21 and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps **	I_H mAmps
P0080SDL	6	25	4	5	800	2	50
P0640SDL	58	77	4	5	800	2.2	50
P0720SDL	65	88	4	5	800	2.2	50
P0900SDL	75	98	4	5	800	2.2	50
P1100SDL	90	130	4	5	800	2.2	50
P1300SDL	120	160	4	5	800	2.2	50
P1500SDL	140	180	4	5	800	2.2	50
P1800SDL	170	220	4	5	800	2.2	50
P2300SDL	190	260	4	5	800	2.2	50
P2600SDL	220	300	4	5	800	2.2	50
P3100SDL	275	350	4	5	800	2.2	50
P3500SDL	320	400	4	5	800	2.2	50

* **“L” in part number indicates RoHS compliance.** For non-RoHS compliant device, delete “L” from part number.
For surge ratings, see table below.

** The 2.2 A version cannot be used to meet 4.4 A requirements.

General Notes:

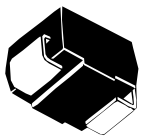
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM}	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **	50 / 60 Hz	
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
D	—	—	1000	—	—	—	—	200	—	50	1000

* Current waveform in µs
** Voltage waveform in µs

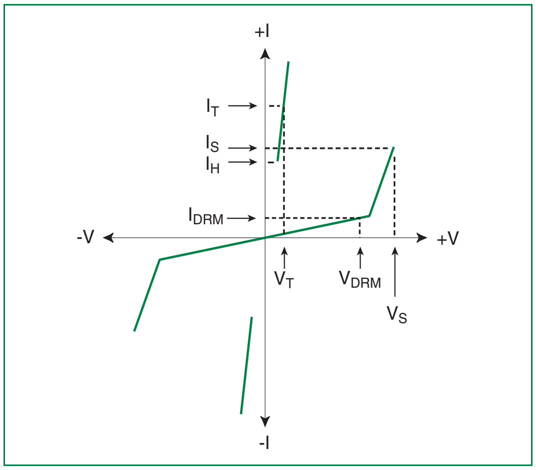
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
DO-214AA 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	90	°C/W

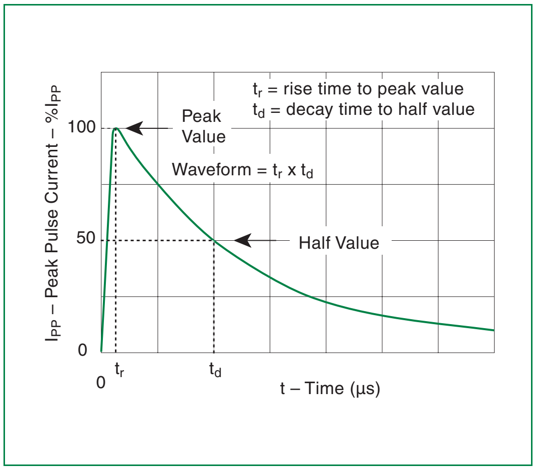
Capacitance Values

Part Number	pF	
	MIN	MAX
P0080SDL	50	110
P0640SDL	100	160
P0720SDL	100	150
P0900SDL	95	140
P1100SDL	75	115
P1300SDL	65	100
P1500SDL	60	90
P1800SDL	50	90
P2300SDL	50	80
P2600SDL	50	75
P3100SDL	45	70
P3500SDL	45	65

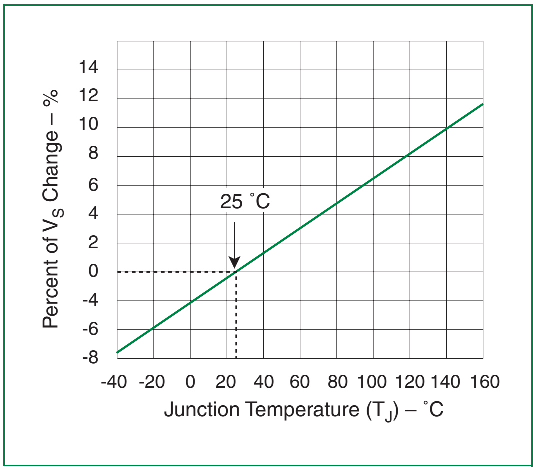
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



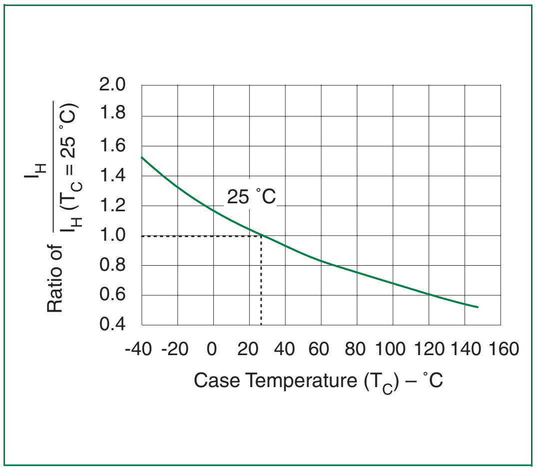
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature

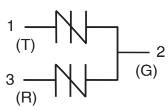


Normalized DC Holding Current versus Case Temperature

Compak *TwinCHIP*™ *SIDACtor*® Device

RoHS

Littelfuse®



The modified DO-214AA *SIDACtor* devices provide low-cost, longitudinal protection.

SIDACtor devices enable equipment to comply with various regulatory requirements including GR 1089, ITU K.20, K.21, and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

Electrical Parameters

Part Number	V_{DRM} Volts	V_S Volts	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
	Pins1-2, 2-3		Pins 1-3						
P1402C_L	58	77	116	154	4	5	800	2.2	120
P1602C_L	65	95	130	190	4	5	800	2.2	120
P2202C_L	90	130	180	260	4	5	800	2.2	120
P2702C_L	120	160	240	320	4	5	800	2.2	120
P3002C_L	140	180	280	360	4	5	800	2.2	120
P3602C_L	170	220	340	440	4	5	800	2.2	120
P4202C_L	190	250	380	500	4	5	800	2.2	120
P4802C_L	220	300	440	600	4	5	800	2.2	120
P6002C_L	275	350	550	700	4	5	800	2.2	120

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For surge ratings, see table below.

General Notes:

- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.
- UL 60950 creepage requirements must be considered.

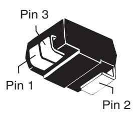
Surge Ratings in Amps

Series	I_{PP}									I_{TSM}	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **	50 / 60 Hz	
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
A	20	150	150	90	50	75	75	45	75	20	500
B	25	250	250	150	100	100	125	80	100	30	500

* Current waveform in µs
** Voltage waveform in µs

Note: Contact factory for release date of Series B.

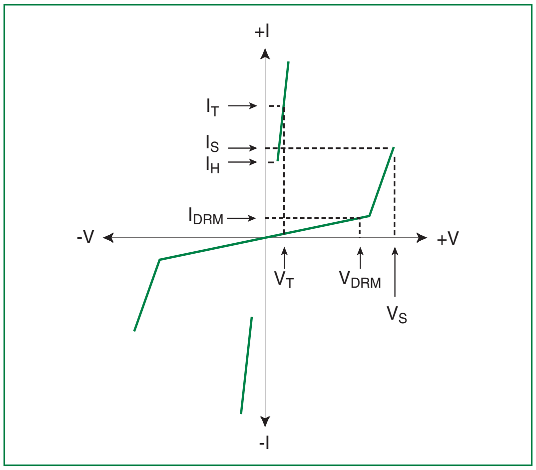
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
Modified DO-214AA 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	85	°C/W

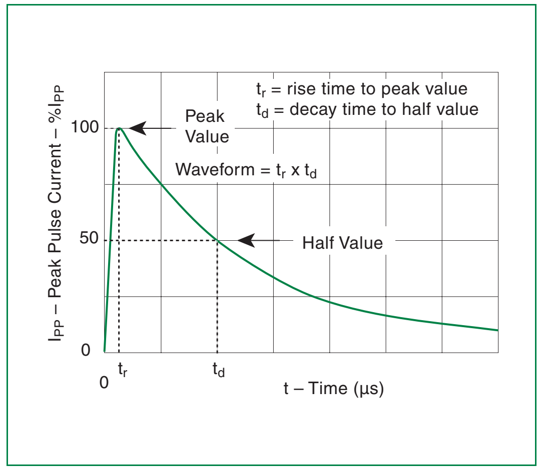
Capacitance Values

Part Number *	pF Pin 1-2 / 3-2 Tip-Ground, Ring-Ground		pF Pin 1-3 Tip-Ring	
	MIN	MAX	MIN	MAX
P1402C[A/B]L	30	55	15	35
P1602C[A/B]L	30	55	15	30
P2202C[A/B]L	25	50	15	30
P2702C[A/B]L	25	45	10	25
P3002C[A/B]L	20	40	10	25
P3602C[A/B]L	20	40	10	25
P4202C[A/B]L	20	40	10	25
P4802C[A/B]L	20	35	10	20
P6002C[A/B]L	15	35	10	20

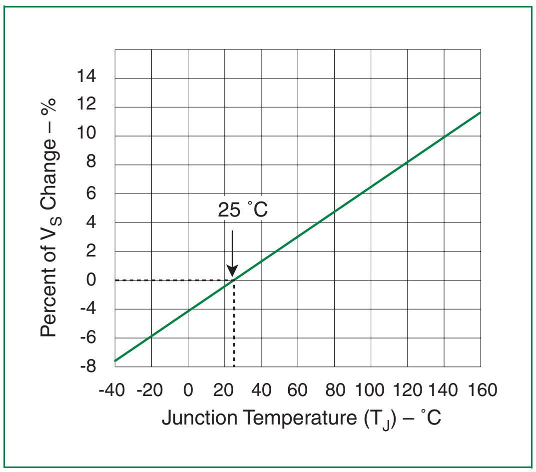
* [A/B] in part number indicates that values are for both A and B surge ratings.
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



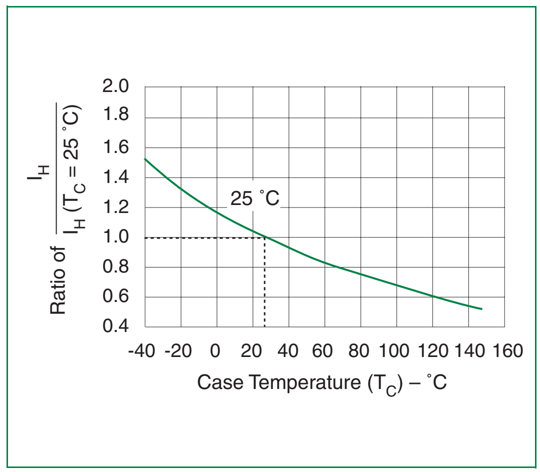
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

Broadband Optimized™ *SIDACtor*® Device

RoHS

Littelfuse®

The DO-214AA *SIDACtor Broadband Optimized* protection devices are intended for applications sensitive to load values. Typically, high speed connections require a lower capacitance. C_O values are 40% lower than standard devices.

SIDACtor devices enable equipment to comply with various regulatory requirements including GR 1089, ITU K.20, K.21 and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
P0642S_L	58	77	4	5	800	2.2	120
P0722S_L	65	88	4	5	800	2.2	120
P0902S_L	75	98	4	5	800	2.2	120
P1102S_L	90	130	4	5	800	2.2	120
P1302S_L	120	160	4	5	800	2.2	120
P1502S_L	140	180	4	5	800	2.2	120
P1802S_L	170	220	4	5	800	2.2	120
P2302S_L	190	260	4	5	800	2.2	120
P2602S_L	220	300	4	5	800	2.2	120
P3002S_L	280	360	4	5	800	2.2	120
P3502S_L	320	400	4	5	800	2.2	120
P4202S_L	190	250	8	5	800	2.2	120
P4802S_L	440	600	4	5	800	2.2	120
P6002S_L	275	350	8	5	800	2.2	120

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For surge ratings, see table below.

General Notes:

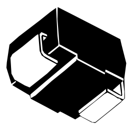
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM} 50 / 60 Hz Amps	di/dt Amps/µs
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **		
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps
A	20	150	150	90	50	75	75	45	75	20	500
B	25	250	250	150	100	100	125	80	100	30	500

* Current waveform in µs
** Voltage waveform in µs

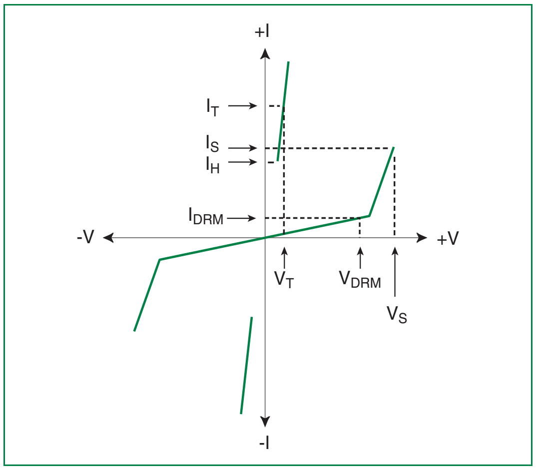
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
DO-214AA 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	90	°C/W

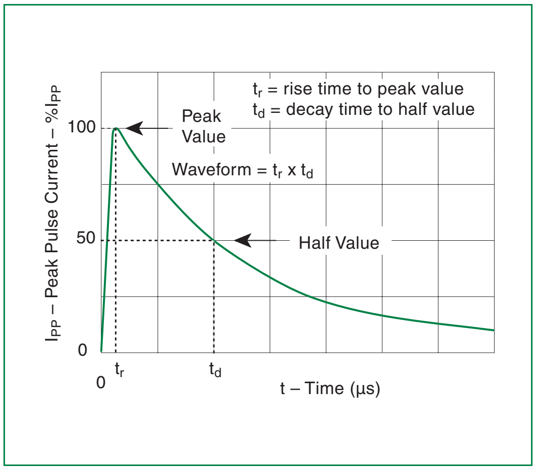
Capacitance Values

Part Number *	pF	
	MIN	MAX
P0642S[A/B]L	25	45
P0722S[A/B]L	20	45
P0902S[A/B]L	20	40
P1102S[A/B]L	15	35
P1302S[A/B]L	15	35
P1502S[A/B]L	15	30
P1802S[A/B]L	10	30
P2302S[A/B]L	10	25
P2602S[A/B]L	10	25
P3002S[A/B]L	10	25
P3502S[A/B]L	10	20
P4202S[A/B]L	10	20
P4802S[A/B]L	5	20
P6002S[A/B]L	5	20

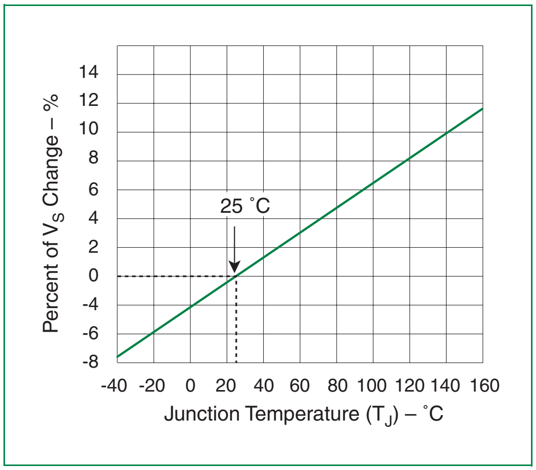
* [A/B] in part number indicates that values are for both A and B surge ratings.
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



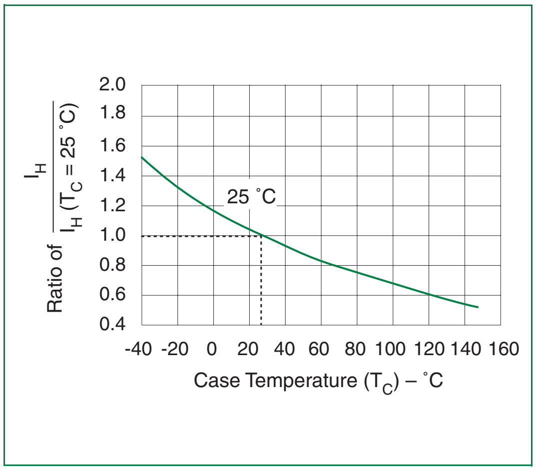
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

RoHS

Littelfuse®

TO-92 *SIDACtor* solid state protection devices protect telecommunications equipment such as modems, line cards, and CPE (telephones, answering machines, and fax machines).

SIDACtor devices enable equipment to comply with various regulatory requirements including GR 1089, ITU K.20, K.21 and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

.

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
P0080E_L	6	25	4	5	800	2.2	50
P0300E_L	25	40	4	5	800	2.2	50
P0640E_L	58	77	4	5	800	2.2	150
P0720E_L	65	88	4	5	800	2.2	150
P0900E_L	75	98	4	5	800	2.2	150
P1100E_L	90	130	4	5	800	2.2	150
P1300E_L	120	160	4	5	800	2.2	150
P1500E_L	140	180	4	5	800	2.2	150
P1800E_L	170	220	4	5	800	2.2	150
P2300E_L	190	260	4	5	800	2.2	150
P2600E_L	220	300	4	5	800	2.2	150
P3100E_L	275	350	4	5	800	2.2	150
P3500E_L	320	400	4	5	800	2.2	150

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For individual "EA", "EB", and "EC" surge ratings, see table below.

General Notes:

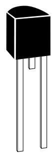
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM}	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **	50 / 60 Hz	
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
A	20	150	150	90	50	75	75	45	75	20	500
B	25	250	250	150	100	100	125	80	100	30	500
C	50	500	400	200	150	200	175	100	200	30	500

* Current waveform in µs
** Voltage waveform in µs

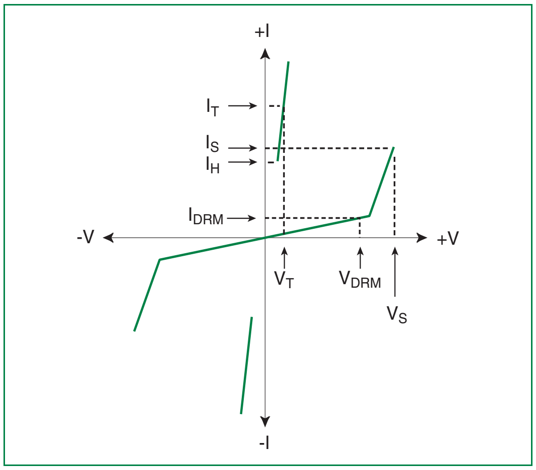
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
TO-92 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	90	°C/W

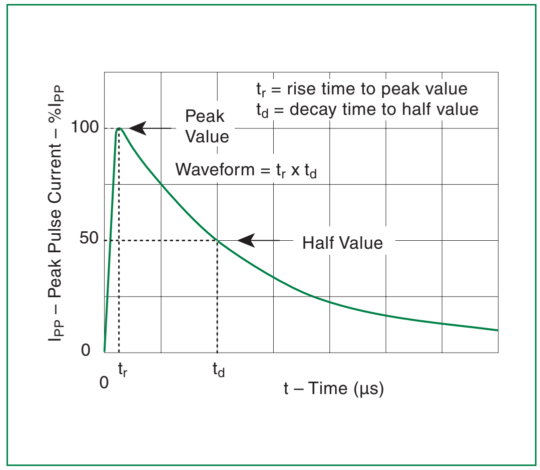
Capacitance Values

Part Number *	pF	
	MIN	MAX
P0080E[A/B]L	25	150
P0080ECL	35	260
P0300E[A/B]L	15	140
P0300ECL	25	250
P0640E[A/B]L	40	60
P0640ECL	55	155
P0720EAL	35	60
P0720EBL	35	75
P0720ECL	50	150
P0900EAL	35	55
P0900EBL	35	70
P0900ECL	45	140
P1100EAL	30	50
P1100EBL	30	70
P1100ECL	45	115
P1300EAL	25	45
P1300EBL	25	60
P1300ECL	40	105
P1500EAL	25	40
P1500EBL	25	55
P1500ECL	35	95
P1800EAL	25	35
P1800EBL	25	50
P1800ECL	35	90
P2300EAL	25	35
P2300EBL	25	50
P2300ECL	30	80
P2600EAL	20	35
P2600EBL	20	45
P2600ECL	30	80
P3100EAL	20	35
P3100EBL	20	45
P3100ECL	30	70
P3500EAL	20	35
P3500EBL	20	40
P3500ECL	25	65

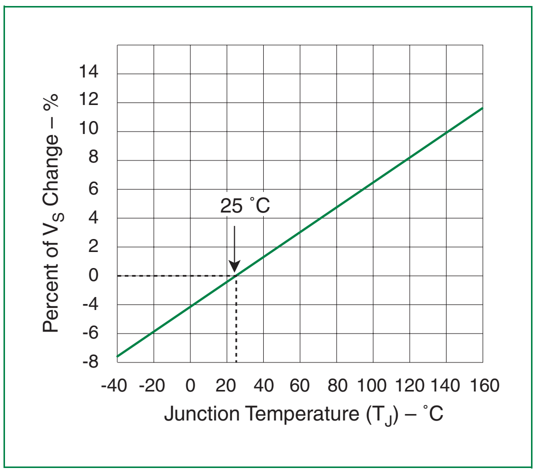
* [A/B] in part number indicates that values are for both A and B surge ratings.
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



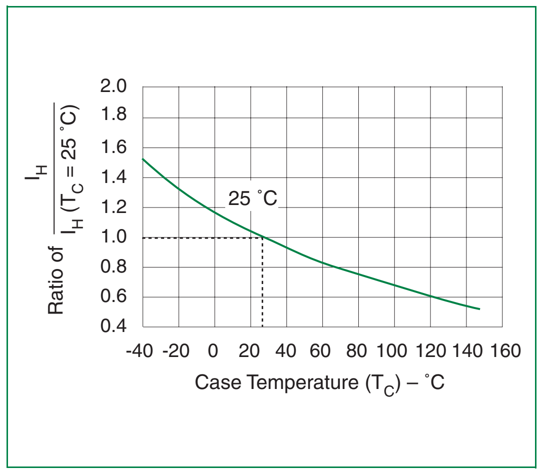
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

MicroCapacitance (MC) *SIDACtor*® Device

RoHS

Littelfuse®

These TO-92 MC *SIDACtor* devices are intended for applications sensitive to load values. Typically, high speed connections, such as xDSL and T1/E1, require a lower capacitance. C_O values for the MicroCapacitance device are 40 percent lower than a standard EC part.

This MC *SIDACtor* series enables equipment to comply with various regulatory requirements including GR 1089, ITU K.20, K.21, and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68) without the need of series resistors.

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
P0080ECMCL	6	25	4	5	800	2.2	50
P0300ECMCL	25	40	4	5	800	2.2	50
P0640ECMCL	58	77	4	5	800	2.2	150
P0720ECMCL	65	88	4	5	800	2.2	150
P0900ECMCL	75	98	4	5	800	2.2	150
P1100ECMCL	90	130	4	5	800	2.2	150
P1300ECMCL	120	160	4	5	800	2.2	150
P1500ECMCL	140	180	4	5	800	2.2	150
P1800ECMCL	170	220	4	5	800	2.2	150
P2300ECMCL	190	260	4	5	800	2.2	150
P2600ECMCL	220	300	4	5	800	2.2	150
P3100ECMCL	275	350	4	5	800	2.2	150
P3500ECMCL	320	400	4	5	800	2.2	150

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For surge ratings, see table below.

General Notes:

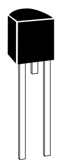
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -+40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM} 50 / 60 Hz	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **		
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
C	50	500	400	200	150	200	175	100	200	30	500

* Current waveform in µs
** Voltage waveform in µs

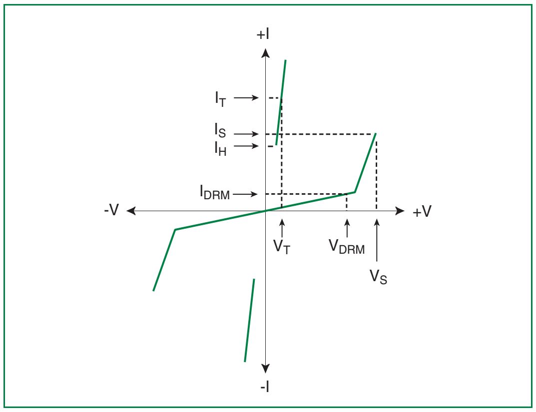
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
TO-92 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	90	°C/W

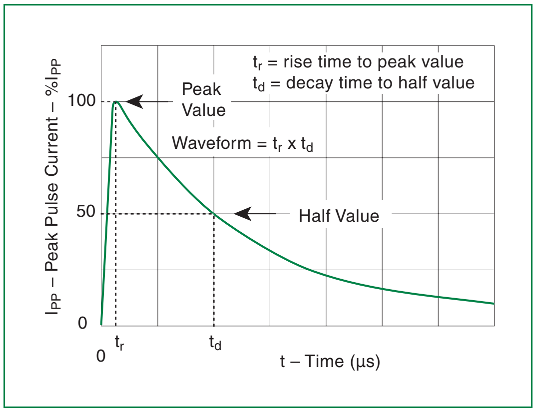
Capacitance Values

Part Number	pF	
	MIN	MAX
P0080ECMCL	35	75
P0300ECMCL	25	45
P0640ECMCL	55	85
P0720ECMCL	50	75
P0900ECMCL	45	70
P1100ECMCL	45	70
P1300ECMCL	40	60
P1500ECMCL	35	55
P1800ECMCL	35	50
P2300ECMCL	30	50
P2600ECMCL	30	45
P3100ECMCL	30	45
P3500ECMCL	25	40

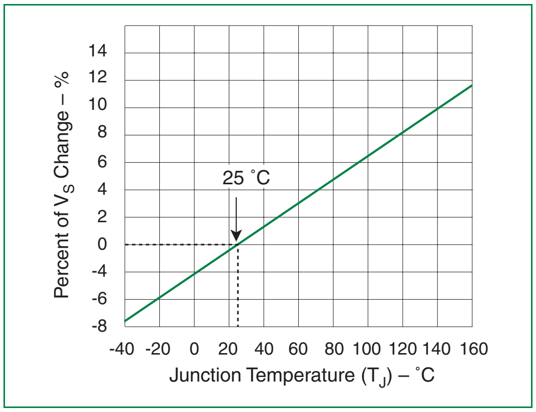
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



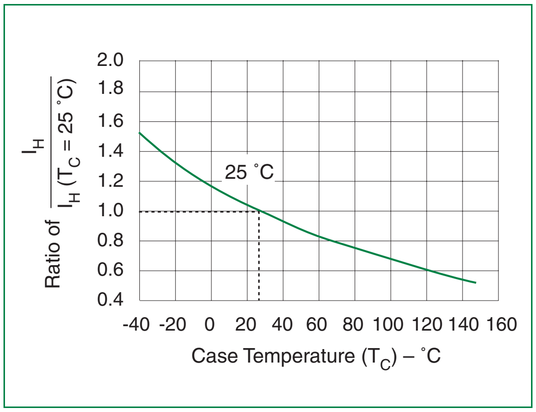
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

T10A *SIDACtor*® Device

RoHS

The bi-directional T10A devices are a through-hole technology *SIDACtor* protector. It is intended for cost-sensitive telecommunication applications. This T10 *SIDACtor* series enables equipment to comply with various regulatory requirements including GR 1089, ITU K.20, K.21, and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

Electrical Parameters

Part Number *	V_{DRM} @ 5 µA Volts	V_S Volts	V_T Volts	I_S mAmps	I_H mAmps	pF TYP
T10A060B	58	80	4	800	120	50
T10A060E	58	80	4	800	180	50
T10A062	60	82	4	800	150	50
T10A068	65	90	4	800	150	50
T10A080B	75	120	4	800	120	43
T10A080E	75	120	4	800	180	43
T10A100	100	133	4	800	150	43
T10A110B	110	135	4	800	120	38
T10A110E	110	135	4	800	180	38
T10A120	120	160	4	800	150	38
T10A130	130	173	4	800	150	38
T10A140B	140	170	4	800	120	34
T10A140E	140	170	4	800	180	34
T10A180	180	240	4	800	150	34
T10A180B	175	210	4	800	120	32
T10A180E	175	210	4	800	180	32
T10A200	200	267	4	800	150	30
T10A220	220	293	4	800	150	30
T10A220B	215	265	4	800	120	30
T10A220E	215	265	4	800	180	30
T10A240	240	320	4	800	150	30
T10A270	270	360	4	800	150	30
T10A270B	270	360	4	800	120	30
T10A270E	270	360	4	800	180	30

* For surge ratings, see table below.

General Notes:

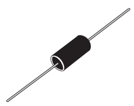
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 0.5 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

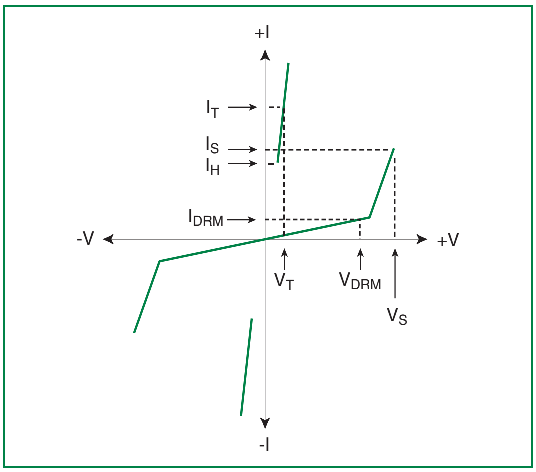
Surge Ratings in Amps

Series	I_{PP}			I_{TSM} 50 / 60 Hz	di/dt
	8x20 * 1.2x50 **	5x310 * 10x700 **	10x1000 * 10x1000 **		
	Amps	Amps	Amps	Amps	Amps/µs
A	100	37.5	50	30	100

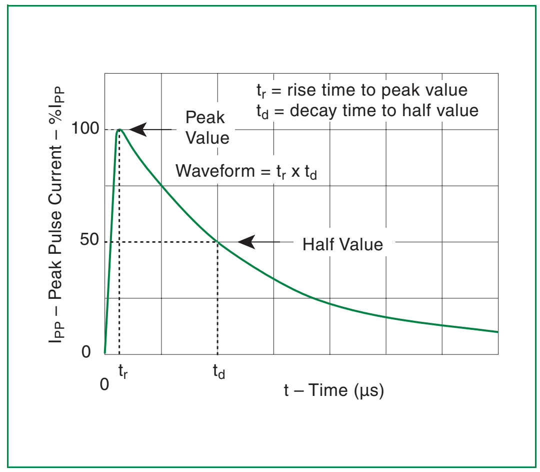
* Current waveform in µs
** Voltage waveform in µs

Thermal Considerations

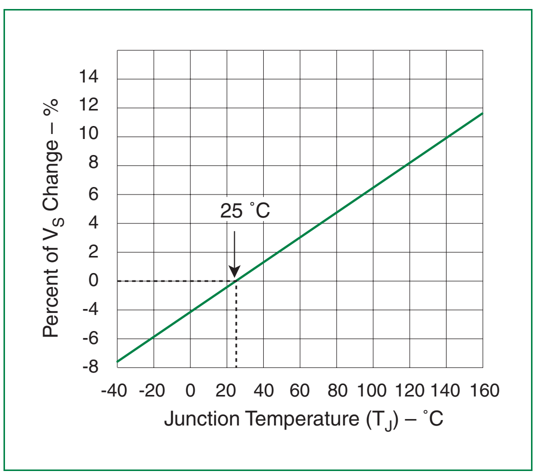
Package	Symbol	Parameter	Value	Unit
DO-15 	T_J	Operating Junction Temperature Range	150	°C
	T_S	Storage Temperature Range	-40 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	60	°C/W



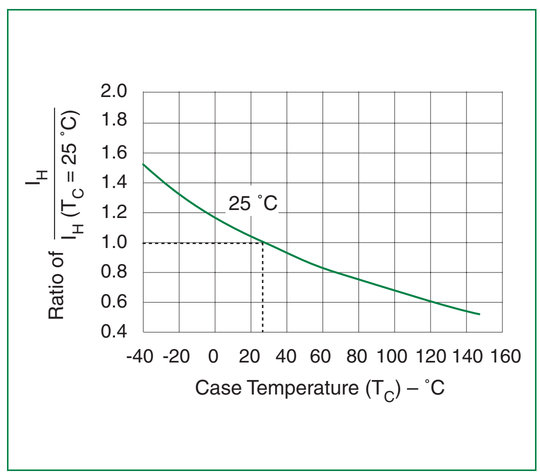
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

T10B *SIDACtor*® Device

RoHS

Littelfuse®

The bi-directional T10B devices are a through-hole technology *SIDACtor* protector. It is intended for cost-sensitive telecommunication applications.

This T10 *SIDACtor* series enables equipment to comply with various regulatory requirements including GR 1089, ITU K.20, K.21, and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

Electrical Parameters

Part Number *	V_{DRM} @ 5 µA Volts	V_S Volts	V_T Volts	I_S mAmps	I_H mAmps	pF TYP
T10B080B	80	120	4	800	120	60
T10B080E	80	120	4	800	180	60
T10B110B	105	135	4	800	120	55
T10B110E	105	135	4	800	180	55
T10B140B	140	170	4	800	120	48
T10B140E	140	170	4	800	180	48
T10B180B	175	210	4	800	120	44
T10B180E	175	210	4	800	180	44
T10B220B	214	265	4	800	120	41
T10B220E	214	265	4	800	180	41
T10B270B	270	360	4	800	120	36
T10B270E	270	360	4	800	180	36

* For surge ratings, see table below.

General Notes:

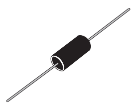
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 0.5 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

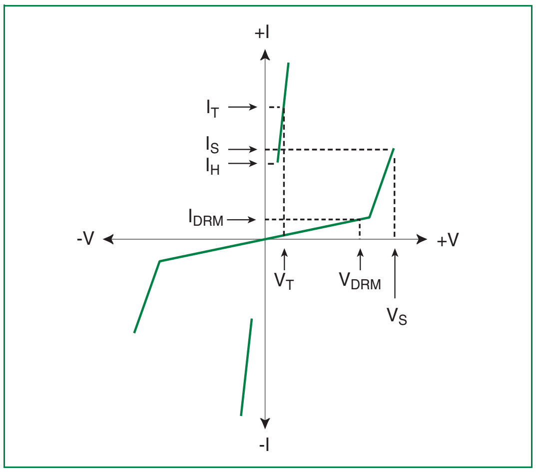
Surge Ratings in Amps

Series	I_{PP}			I_{TSM} 50 / 60 Hz	di/dt
	8x20 * 1.2x50 **	5x310 * 10x700 **	10x1000 * 10x1000 **		
	Amps	Amps	Amps	Amps	Amps/µs
B	250	125	100	50	100

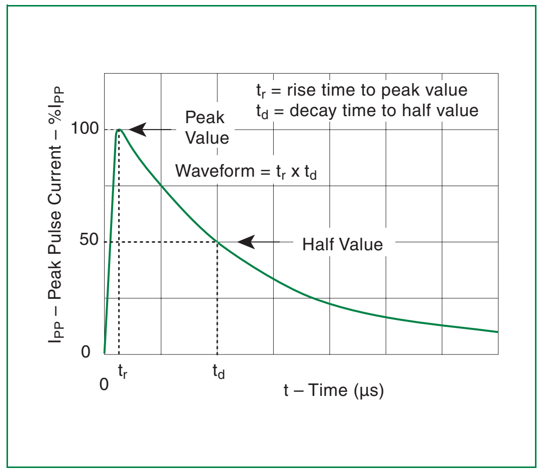
* Current waveform in µs
** Voltage waveform in µs

Thermal Considerations

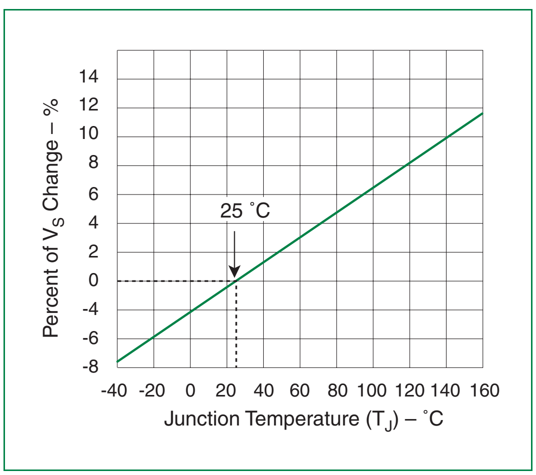
Package	Symbol	Parameter	Value	Unit
DO-201AD 	T_J	Operating Junction Temperature Range	150	°C
	T_S	Storage Temperature Range	-40 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	60	°C/W



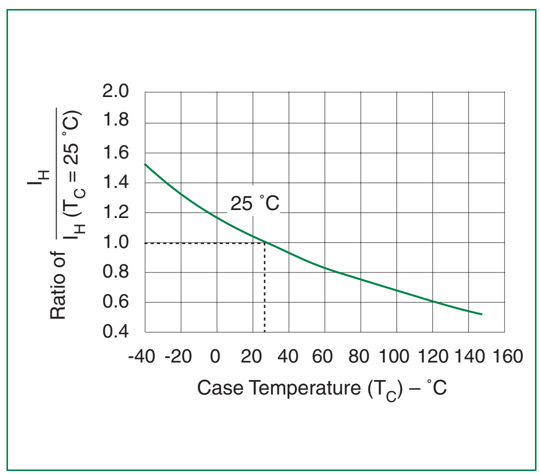
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature

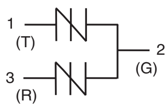


Normalized DC Holding Current versus Case Temperature

T10C *SIDACtor*® Device

RoHS

Littelfuse®



The bi-directional T10C devices are a through-hole technology *SIDACtor* protector. It is intended for cost-sensitive telecommunication applications. The three-terminal configuration matches G.D.T. pin configuration; for plug-in applications, the T10C fits in the KRONE™ three-point connector block (5B).

This T10 *SIDACtor* series enables equipment to comply with various regulatory requirements including GR 1089, ITU K.20, K.21, and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

For primary protection applications, integrated failsafe options are available.

SIDACtor Devices

Electrical Parameters

Part Number *	V_{DRM} @ 5 µA Volts	V_S Volts	V_T Volts	I_S mAmps	I_H mAmps	pF Pin 1-2 / 3-2 Tip-Ground, Ring-Ground TYP	pF Pin 1-3 Tip-Ring TYP
T10C080B	80	120	4	800	120	110	61
T10C080E	80	120	4	800	180	110	61
T10C110B	105	135	4	800	120	90	51
T10C110E	105	135	4	800	180	90	51
T10C140B	140	170	4	800	120	83	48
T10C140E	140	170	4	800	180	83	48
T10C180B	175	210	4	800	120	77	44
T10C180E	175	210	4	800	180	77	44
T10C220B	214	265	4	800	120	74	42
T10C220E	214	265	4	800	180	74	42
T10C270B	270	360	4	800	120	68	38
T10C270E	270	360	4	800	180	68	38

* **For failsafe option, add "F" at end of part number.** See Section 9, "Mechanical Data" for mechanical view of failsafe option.
For surge ratings, see table below.

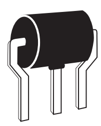
General Notes:
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM} across Pins 1-2 / 3-2.
- V_S is measured at 0.5 V/µs across Pins 1-2 / 3-2.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

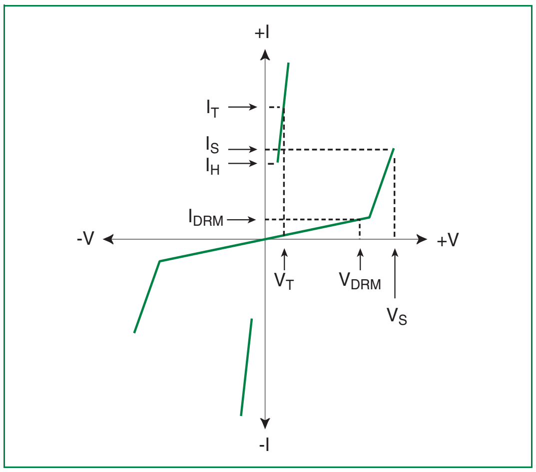
Surge Ratings in Amps

Series	I_{PP}			I_{TSM} 50 / 60 Hz	di/dt
	8x20 * 1.2x50 **	5x310 * 10x700 **	10x1000 * 10x1000 **		
	Amps	Amps	Amps	Amps	Amps/µs
C	250	125	100	50	100

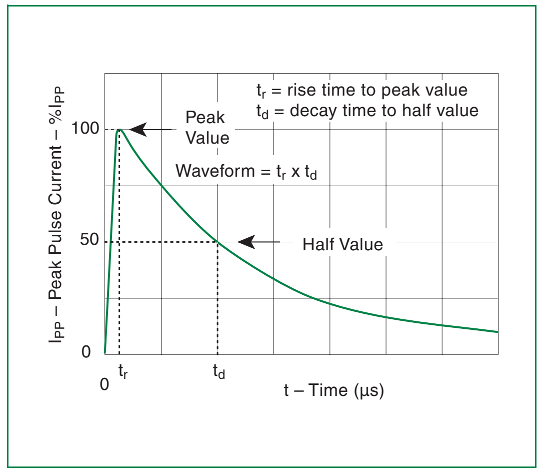
* Current waveform in µs
** Voltage waveform in µs

Thermal Considerations

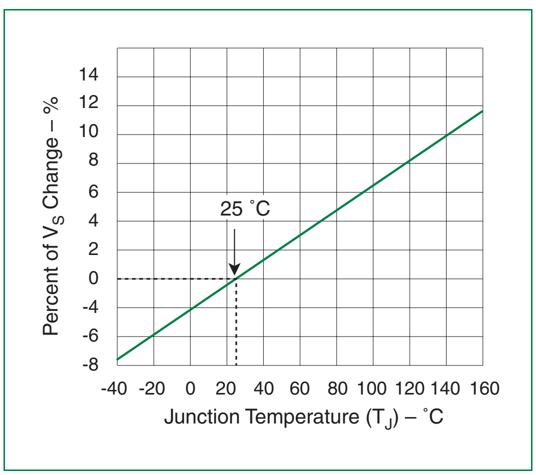
Package	Symbol	Parameter	Value	Unit
[T10C] 	T_J	Operating Junction Temperature Range	150	°C
	T_S	Storage Temperature Range	-40 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	60	°C/W



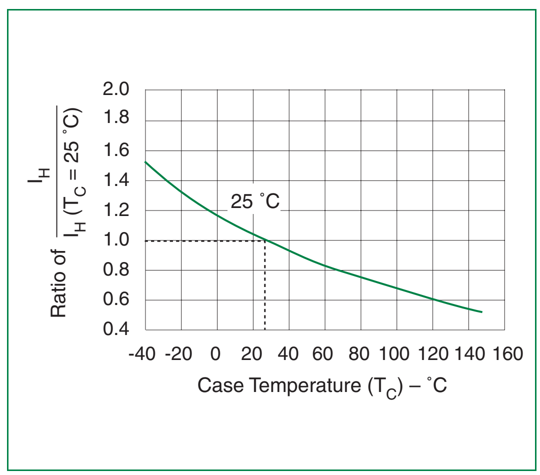
V-I Characteristics



t_r x t_d Pulse Waveform



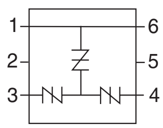
Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

Balanced Three-chip *SIDACtor*® Device

RoHS Littelfuse®



This six-pin SMT package offers a guaranteed balanced protection, based on a Littelfuse patent (US Patent 4,905,119). The 'Y' configuration offers identical metallic and longitudinal protection all in one package.

SIDACtor devices enable equipment to comply with various regulatory requirements including GR 1089, ITU K.20, K.21, and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

Electrical Parameters

Part Number *	V_{DRM} Volts (Pins 1-3, 1-4)	V_S Volts (Pins 1-3, 1-4)	V_{DRM} Volts (Pins 3-4)	V_S Volts (Pins 3-4)	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
P1553U_L	130	180	130	180	8	5	800	2.2	150
P1803U_L	150	210	150	210	8	5	800	2.2	150
P2103U_L	170	250	170	250	8	5	800	2.2	150
P2353U_L	200	270	200	270	8	5	800	2.2	150
P2703U_L	230	300	230	300	8	5	800	2.2	150
P3203U_L	270	350	270	350	8	5	800	2.2	150
P3403U_L	300	400	300	400	8	5	800	2.2	150
P5103U_L	420	600	420	600	8	5	800	2.2	150

Part Number *	V_{DRM} Volts (Pins 1-3, 1-4)	V_S Volts (Pins 1-3, 1-4)	V_{DRM} Volts (Pins 3-4)	V_S Volts (Pins 3-4)	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
A2106U_3L **	170	250	50	80	8	5	800	2.2	120
A5030U_3L **	400	550	270	340	8	5	800	2.2	120

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For individual "UA", "UB", and "UC" surge ratings, see table below.

** Asymmetrical

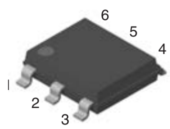
General Notes:
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.
- Device is designed to meet balance requirements of GTS 8700 and GR 974.

Surge Ratings in Amps

Series	I_{PP} 0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **	I_{TSM} 50 / 60 Hz	di/dt
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
A	20	150	150	90	50	75	75	45	75	20	500
B	25	250	250	150	100	100	125	80	100	30	500
C	50	500	400	200	150	200	175	100	200	50	500

* Current waveform in µs
** Voltage waveform in µs

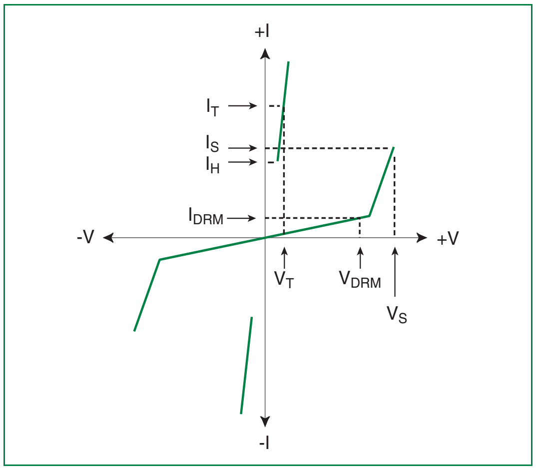
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
Modified MS-013	T_J	Operating Junction Temperature Range	-40 to +125	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	60	°C/W

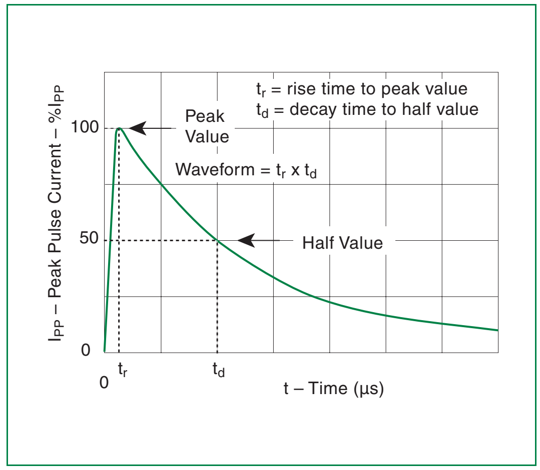
Capacitance Values

Part Number	pF Pin 3-4 Tip-Ring		pF Pin 1-3 (4-6) Tip-Ground, Ring-Ground	
	MIN	MAX	MIN	MAX
P1553UAL	10	95	10	60
P1553UBL	25	95	15	60
P1553UCL	30	95	20	60
P1803UAL	20	85	10	55
P1803UBL	25	85	15	55
P1803UCL	30	85	15	55
P2103UAL	15	85	10	55
P2103UBL	20	85	10	55
P2103UCL	30	85	15	55
P2353UAL	15	75	10	50
P2353UBL	20	75	10	50
P2353UCL	25	75	15	50
P2703UAL	15	75	10	50
P2703UBL	20	75	10	50
P2703UCL	25	75	15	50
P3203UAL	15	70	10	45
P3203UBL	20	70	10	45
P3203UCL	45	70	25	45
P3403UAL	15	65	10	45
P3403UBL	15	65	10	45
P3403UCL	20	65	15	45
P5103UAL	10	60	10	40
P5103UBL	15	60	10	40
P5103UCL	20	60	10	40
A2106UA3L	20	70	10	45
A2106UB3L	20	70	10	45
A2106UC3L	20	70	10	45
A5030UA3L	15	60	10	40
A5030UB3L	15	60	10	40
A5030UC3L	30	60	25	40

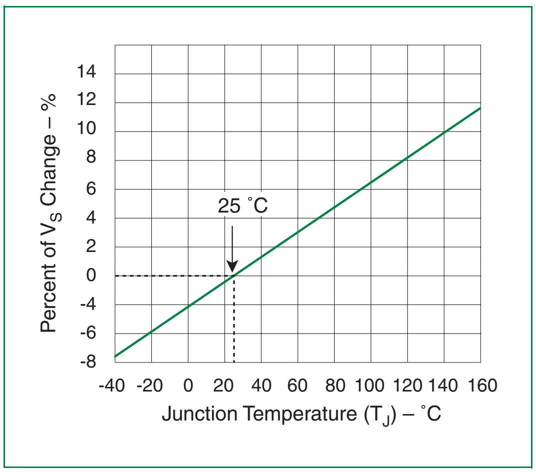
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



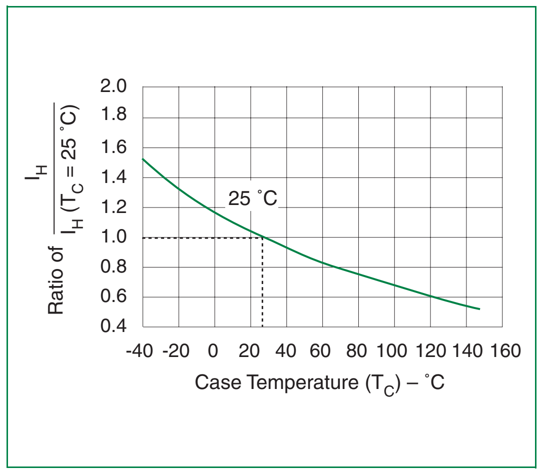
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature



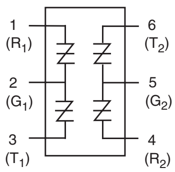
Normalized DC Holding Current versus Case Temperature

SIDACtor Devices

Multiport *SIDACtor*® Device

RoHS

Littelfuse®



The multiport line protector is an integrated multichip solution used for protecting multiple twisted pair from overvoltage conditions. Based on a six-pin surface mount SOIC package, it is equivalent to four discrete DO-214AA. This multiport line protector is ideal for densely populated, high-speed line cards that cannot tolerate PCB inefficiencies nor the use of series power resistors.

SIDACtor devices enable equipment to comply with various regulatory requirements including GR 1089, ITU K.20, K.21, and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
	Pins 1-2, 3-2, 4-5, 6-5		Pins 1-3, 4-6						
P0084U_L	6	25	12	50	4	5	800	2.2	50
P0304U_L	25	40	50	80	4	5	800	2.2	50
P0644U_L	58	77	116	154	4	5	800	2.2	150
P0724U_L	65	88	130	176	4	5	800	2.2	150
P0904U_L	75	98	150	196	4	5	800	2.2	150
P1104U_L	90	130	180	260	4	5	800	2.2	150
P1304U_L	120	160	240	320	4	5	800	2.2	150
P1504U_L	140	180	280	360	4	5	800	2.2	150
P1804U_L	170	220	340	440	4	5	800	2.2	150
P2304U_L	190	260	380	520	4	5	800	2.2	150
P2604U_L	220	300	440	600	4	5	800	2.2	150
P3104U_L	275	350	550	700	4	5	800	2.2	150
P3504U_L	320	400	640	800	4	5	800	2.2	150

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For individual "UA", "UB", and "UC" surge ratings, see table below.

General Notes:

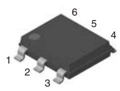
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}, and V_S is measured at 100 V/µs.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM} 50 / 60 Hz	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **		
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
A	20	150	150	90	50	75	75	45	75	20	500
B	25	250	250	150	100	100	125	80	100	30	500
C	50	500	400	200	150	200	175	100	200	50	500

* Current waveform in µs
** Voltage waveform in µs

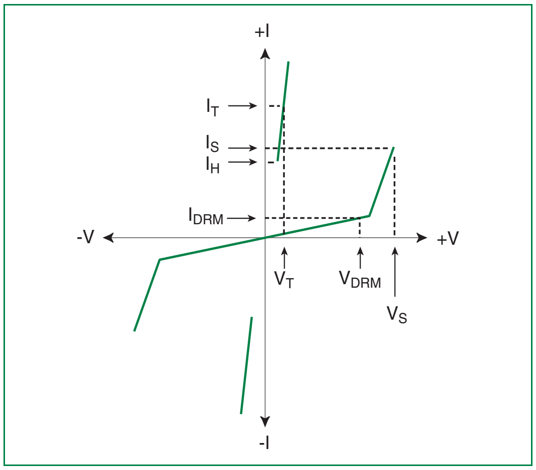
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
Modified MS-013 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	60	°C/W

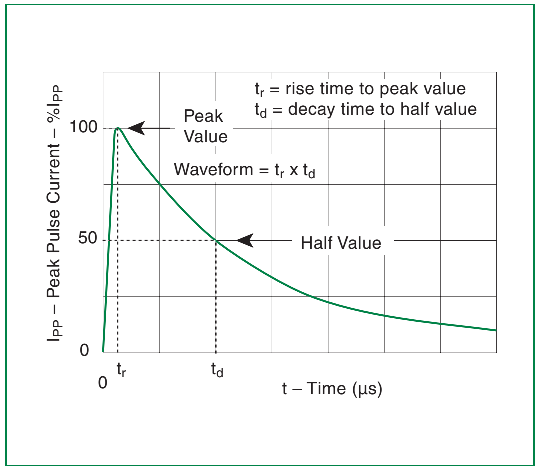
Capacitance Values

Part Number	pF Pin 1-2 / 3-2 (4-5 / 6-5) Tip-Ground, Ring-Ground		pF Pin 1-3 (4-6) Tip-Ring	
	MIN	MAX	MIN	MAX
P0084UAL	25	155	15	90
P0084UBL	25	155	15	90
P0084UCL	35	285	20	165
P0304UAL	15	140	10	90
P0304UBL	15	140	10	90
P0304UCL	25	250	10	145
P0644UAL	40	60	20	35
P0644UBL	40	155	20	90
P0644UCL	55	155	30	90
P0724UAL	35	60	20	35
P0724UBL	50	145	20	85
P0724UCL	50	145	25	85
P0904UAL	35	55	20	30
P0904UBL	35	55	20	30
P0904UCL	45	135	25	80
P1104UAL	30	50	15	30
P1104UBL	30	115	15	65
P1104UCL	45	115	25	65
P1304UAL	25	45	15	25
P1304UBL	25	105	15	60
P1304UCL	40	105	20	60
P1504UAL	25	40	15	25
P1504UBL	25	95	15	55
P1504UCL	35	95	20	55
P1804UAL	25	35	10	20
P1804UBL	25	90	10	50
P1804UCL	35	90	15	50
P2304UAL	25	35	10	20
P2304UBL	25	85	10	50
P2304UCL	30	85	15	50
P2604UAL	20	35	10	20
P2604UBL	20	85	10	50
P2604UCL	30	85	15	50
P3104UAL	20	35	10	20
P3104UBL	20	80	10	45
P3104UCL	30	80	15	45
P3504UAL	20	35	10	20
P3504UBL	20	75	10	45
P3504UCL	25	75	15	45

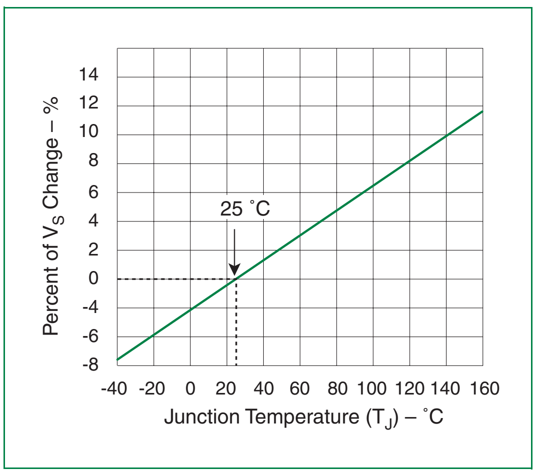
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



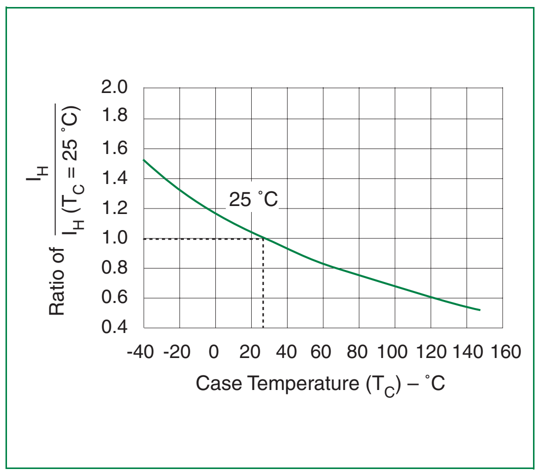
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature

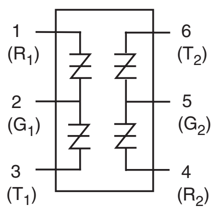


Normalized DC Holding Current versus Case Temperature

Multiport MicroCapacitance (MC) *SIDACtor*® Device

RoHS

Littelfuse®



The multiport MC line protector is an integrated, multichip solution used for protecting multiple twisted pair from overvoltage conditions. It is intended for applications sensitive to load values. Typically, high speed connections require lower capacitance. C_O values for the MC devices are 40% lower than standard UC devices.

This six-pin surface mount SOIC is equivalent to four discrete DO-214AA, which makes it ideal for densely populated, high-speed line cards that cannot tolerate PCB inefficiencies nor the use of series power resistors. Surge current ratings up to 500 A are available.

SIDACtor devices enable equipment to comply with various regulatory requirements including GR 1089, ITU K.20, K.21, and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
	Pins 1-2, 3-2, 4-5, 6-5		Pins 1-3, 4-6						
P0084UCMCL	6	25	12	50	4	5	800	2.2	50
P0304UCMCL	25	40	50	80	4	5	800	2.2	50
P0644UCMCL	58	77	116	154	4	5	800	2.2	150
P0724UCMCL	65	88	130	176	4	5	800	2.2	150
P0904UCMCL	75	98	150	196	4	5	800	2.2	150
P1104UCMCL	90	130	180	260	4	5	800	2.2	150
P1304UCMCL	120	160	240	320	4	5	800	2.2	150
P1504UCMCL	140	180	280	360	4	5	800	2.2	150
P1804UCMCL	170	220	340	440	4	5	800	2.2	150
P2304UCMCL	190	260	380	520	4	5	800	2.2	150
P2604UCMCL	220	300	440	600	4	5	800	2.2	150
P3104UCMCL	275	350	550	700	4	5	800	2.2	150
P3504UCMCL	320	400	640	800	4	5	800	2.2	150

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For surge ratings, see table below.

General Notes:

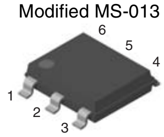
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM} 50 / 60 Hz	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **		
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
C	50	500	400	200	150	200	175	100	200	50	500

* Current waveform in µs
** Voltage waveform in µs

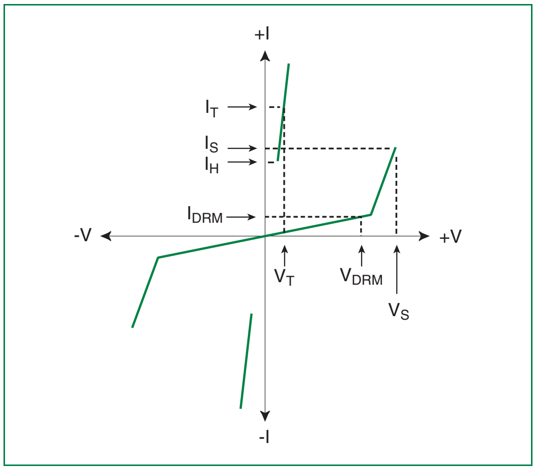
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
Modified MS-013 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient63	60	°C/W

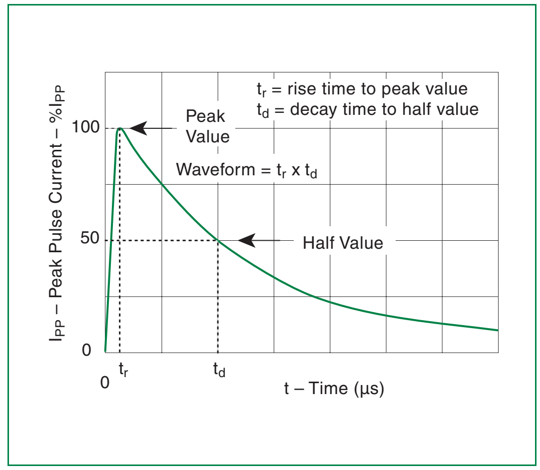
Capacitance Values

Part Number	pF Pin 1-2 / 3-2 (4-5 / 6-5) Tip-Ground, Ring-Ground		pF Pin 1-3 (4-6) Tip-Ring	
	MIN	MAX	MIN	MAX
P0084UCMCL	35	75	20	45
P0304UCMCL	25	45	10	25
P0644UCMCL	55	85	30	50
P0724UCMCL	50	75	25	45
P0904UCMCL	45	70	25	40
P1104UCMCL	45	70	25	40
P1304UCMCL	40	60	20	35
P1504UCMCL	35	55	20	35
P1804UCMCL	35	50	15	30
P2304UCMCL	30	50	15	30
P2604UCMCL	30	45	15	30
P3104UCMCL	30	45	15	25
P3504UCMCL	25	40	15	25

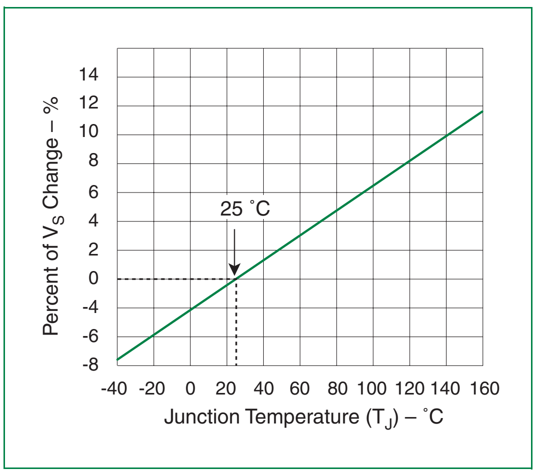
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



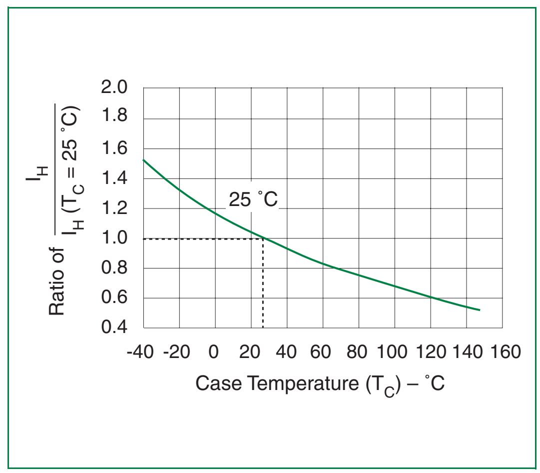
V-I Characteristics



t_r x t_d Pulse Waveform



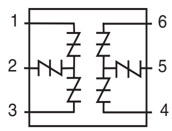
Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

Multiport Balanced *SIDACtor*® Device

RoHS



This six-pin SMT package offers a guaranteed balanced protection, based on a Littelfuse patent (US Patent 4,905,119). The ‘Y’ configuration offers identical metallic and longitudinal protection all in one package. *SIDACtor* devices enable equipment to comply with various regulatory requirements including GR 1089, ITU K.20, K.21, and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_{DRM} Volt	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
	Pins 1-2, 2-3, 1-3		Pins 4-5, 5-6, 4-6						
P1556U_L	130	180	130	180	8	5	800	2.2	150
P1806U_L	150	210	150	210	8	5	800	2.2	150
P2106U_L	170	250	170	250	8	5	800	2.2	150
P2356U_L	200	270	200	270	8	5	800	2.2	150
P2706U_L	230	300	230	300	8	5	800	2.2	150
P3206U_L	270	350	270	350	8	5	800	2.2	150
P3406U_L	300	400	300	400	8	5	800	2.2	150
P5106U_L	420	600	420	600	8	5	800	2.2	150

Part Number *	V_{DRM} Volts	V_S Volts	V_{DRM} Volt	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
	Pins 1-2, 2-3, 4-5, 5-6		Pins 4-6, 1-3						
A2106U_6L	170	250	50	80	3.5	5	800	2.2	120
A5030U_6L	400	550	270	340	3.5	5	800	2.2	150

* **“L” in part number indicates RoHS compliance.** For non-RoHS compliant device, delete “L” from part number.
For individual “UA”, “UB”, and “UC” surge ratings, see table below.

General Notes:

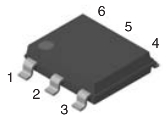
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.
- Device is designed to meet balance requirements of GTS 8700 and GR 974.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM}	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **	50 / 60 Hz	
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
A	20	150	150	90	50	75	75	45	75	20	500
B	25	250	250	150	100	100	125	80	100	30	500
C	50	500	400	200	150	200	175	100	200	50	500

* Current waveform in µs
** Voltage waveform in µs

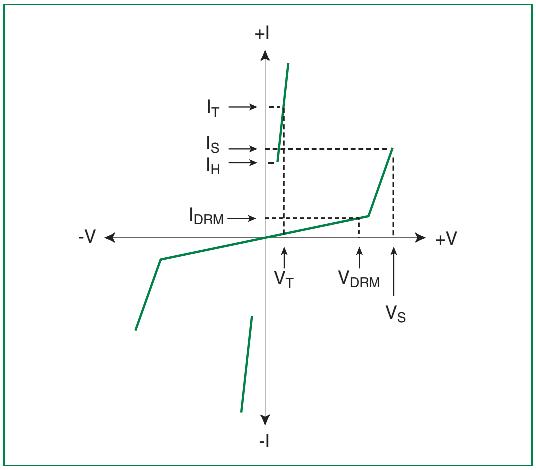
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
Modified MS-013 	T_J	Operating Junction Temperature Range	-40 to +125	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	60	°C/W

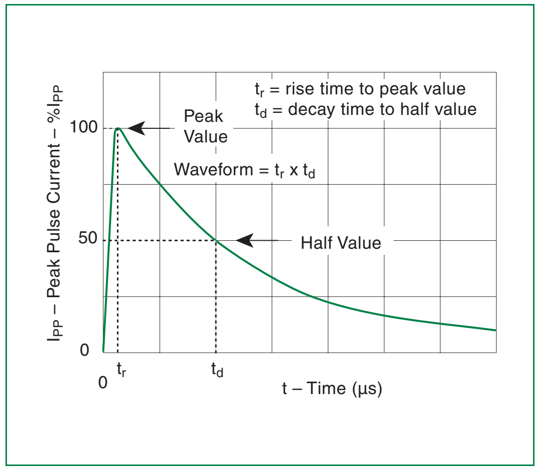
Capacitance Values

Part Number	pF Pin 1-2 / 3-2 (4-5 / 6-5) Tip-Ground, Ring-Ground		pF Pin 1-3 (4-6) Tip-Ring	
	MIN	MAX	MIN	MAX
P1556UAL	10	30	10	45
P1556UBL	15	60	25	95
P1556UCL	20	60	30	55
P1806UAL	10	55	20	85
P1806UBL	15	55	25	85
P1806UCL	15	55	30	85
P2106UAL	15	55	15	85
P2106UBL	20	55	20	85
P2106UCL	15	55	30	85
P2356UAL	15	50	15	75
P2356UBL	15	50	20	75
P2356UCL	15	50	25	75
P2706UAL	10	50	15	75
P2706UBL	10	50	20	75
P2706UCL	15	50	25	75
P3206UAL	10	45	15	70
P3206UBL	10	45	20	70
P3206UCL	25	45	45	70
P3406UAL	10	45	15	65
P3406UBL	10	45	15	65
P3406UCL	15	45	20	65
P5106UAL	10	45	15	35
P5106UBL	10	45	15	35
P5106UCL	30	45	25	40
A2106UA6L	10	30	20	60
A2106UB6L	10	30	20	60
A2106UC6L	10	45	20	70
A5030UA6L	10	45	15	35
A5030UB6L	10	45	15	35
A5030UC6L	20	35	25	40

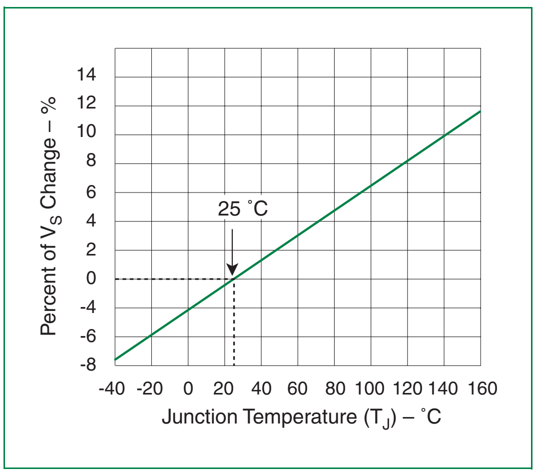
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



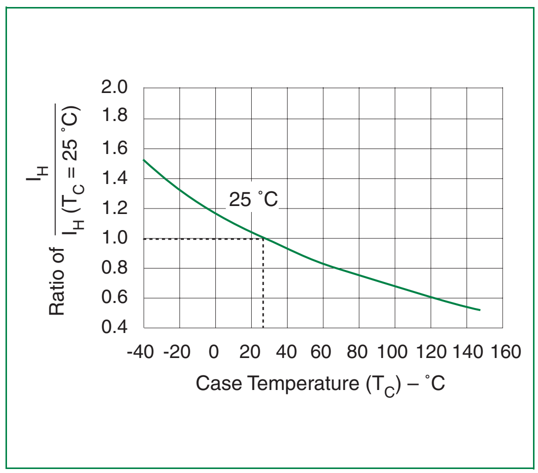
V-I Characteristics



t_r x t_d Pulse Waveform



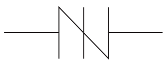
Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

SIDACtor® Device

RoHS



This modified TO-220 package with Type 61 lead spacing offers a through-hole technology *SIDACtor* protection solution.

SIDACtor devices enable equipment to comply with various regulatory requirements including GR 1089, ITU K.20, K.21 and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
P2000AA61L	180	220	4	5	800	2.2	150
P2200AA61L	200	240	4	5	800	2.2	150
P2400AA61L	220	260	4	5	800	2.2	150
P2500AA61L	240	290	4	5	800	2.2	150
P3000AA61L	270	330	4	5	800	2.2	150
P3300AA61L	300	360	4	5	800	2.2	150

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For surge ratings, see table below.

General Notes:

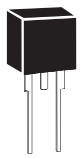
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM}	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **	50 / 60 Hz	
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
A	20	150	150	90	50	75	75	45	75	20	500

* Current waveform in µs
** Voltage waveform in µs

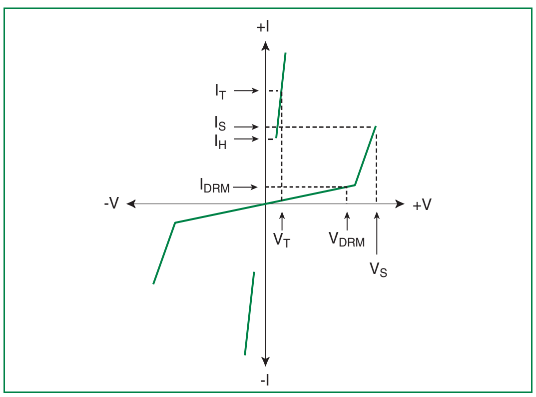
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
Modified TO-220 Type 61 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	50	°C/W

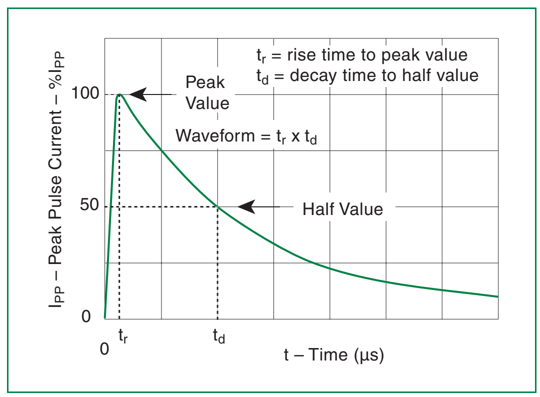
Capacitance Values

Part Number	pF MIN	pF MAX
P2000AA61L	25	35
P2200AA61L	25	35
P2400AA61L	25	35
P2500AA61L	20	35
P3000AA61L	20	35
P3300AA61L	20	35

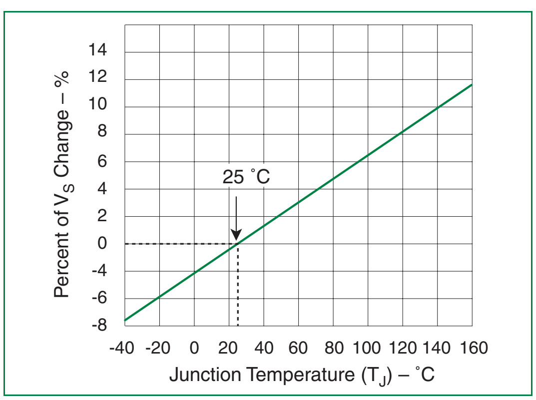
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



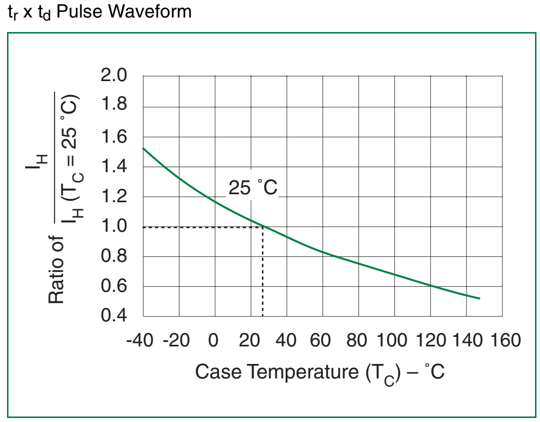
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature

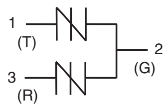


Normalized DC Holding Current versus Case Temperature

Two-chip *SIDACtor*® Device

RoHS

Littelfuse®



The two-chip *SIDACtor* design provides a through-hole technology protection solution. It is intended for telecom applications that do not require a balanced solution. For primary protection applications, devices with higher holding current and integrated failsafe options are available.

SIDACtor devices enable equipment to comply with various regulatory requirements including GR 1089, ITU K.20, K.21 and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
	Pins 1-2, 3-2		Pins 1-3						
P0602A_L	25	40	50	80	4	5	800	2.2	50
P1402A_L	58	77	116	154	4	5	800	2.2	150
P1602A_L	65	95	130	190	4	5	800	2.2	150
P2202A_L	90	130	180	260	4	5	800	2.2	150
P2702A_L	120	160	240	320	4	5	800	2.2	150
P3002A_L	140	180	280	360	4	5	800	2.2	150
P3602A_L	170	220	340	440	4	5	800	2.2	150
P4202A_L	190	250	380	500	4	5	800	2.2	150
P4802A_L	220	300	440	600	4	5	800	2.2	150
P6002A_L	275	350	550	700	4	5	800	2.2	150

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For individual "AA", "AB", and "AC" surge ratings, see table below.

General Notes:

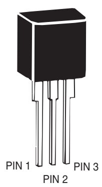
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM} 50 / 60 Hz	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **		
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
A	20	150	150	90	50	75	75	45	75	20	500
B	25	250	250	150	100	100	125	80	100	30	500
C	50	500	400	200	150	200	175	100	200	50	500

* Current waveform in µs
** Voltage waveform in µs

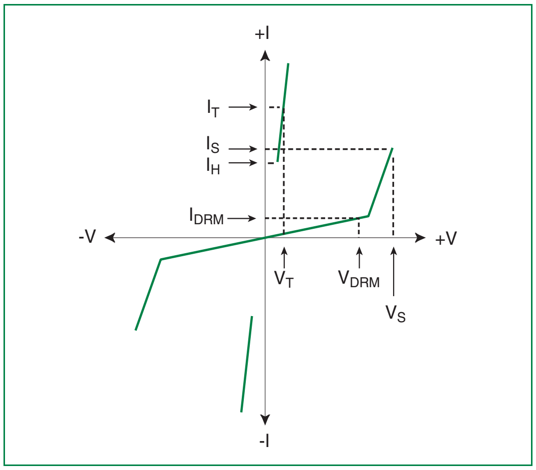
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
Modified TO-220 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	50	°C/W

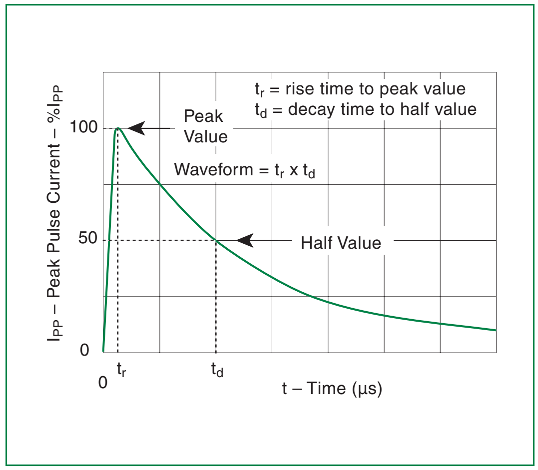
Capacitance Values

Part Number	pF Pin 1-2 / 3-2 Tip-Ground, Ring-Ground		pF Pin 1-3 Tip-Ring	
	MIN	MAX	MIN	MAX
P0602AAL	15	145	10	90
P0602ABL	15	250	10	145
P0602ACL	25	250	10	145
P1402AAL	40	60	20	35
P1402ABL	40	155	20	90
P1402ACL	55	155	30	90
P1602AAL	35	60	20	35
P1602ABL	35	145	20	85
P1602ACL	45	145	25	85
P2202AAL	30	50	15	30
P2202ABL	30	115	15	65
P2202ACL	45	115	25	65
P2702AAL	25	45	15	25
P2702ABL	25	105	15	60
P2702ACL	40	105	20	60
P3002AAL	25	40	15	25
P3002ABL	25	95	15	55
P3002ACL	35	95	20	55
P3602AAL	25	35	10	20
P3602ABL	25	90	10	50
P3602ACL	35	90	15	50
P4202AAL	25	35	10	20
P4202ABL	25	85	10	50
P4202ACL	30	85	15	50
P4802AAL	20	35	10	20
P4802ABL	20	85	10	50
P4802ACL	30	85	15	50
P6002AAL	20	35	10	20
P6002ABL	20	80	10	45
P6002ACL	30	80	15	45

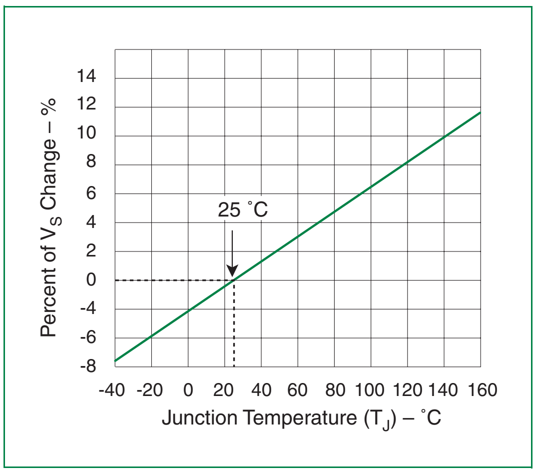
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



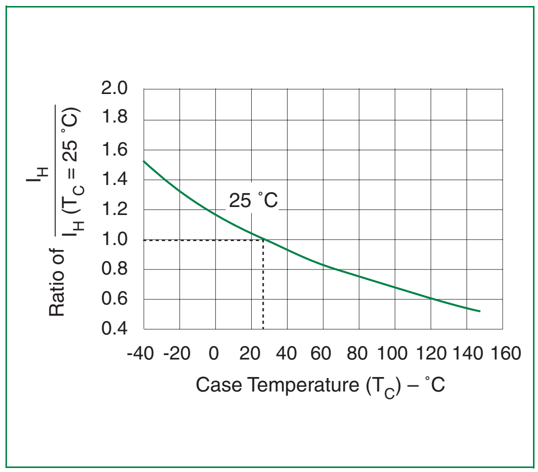
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature

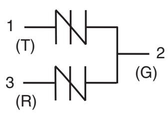


Normalized DC Holding Current versus Case Temperature

Two-chip MicroCapacitance (MC) *SIDACtor*® Device

RoHS

Littelfuse®



This two-chip MicroCapacitance *SIDACtor* design provides a through-hole technology protection solution. It is intended for telecom applications that do not require a balanced solution. For primary protection applications, devices with higher holding current and integrated failsafe options are available.

SIDACtor devices enable equipment to comply with various regulatory requirements including GR 1089, ITU K.20, K.21 and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
	Pins 1-2, 3-2		Pins 1-3						
P0302AAMCL	6	25	12	50	4	5	800	2.2	50
P0602AAMCL	25	40	50	80	4	5	800	2.2	50

Part Number *	V_{DRM} Volts	V_S Volts	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
	Pins 1-2, 3-2		Pins 1-3						
P0602ACMCL	25	40	50	80	4	5	800	2.2	50
P1402ACMCL	58	77	116	154	4	5	800	2.2	150
P1602ACMCL	65	95	130	190	4	5	800	2.2	150
P2202ACMCL	90	130	180	260	4	5	800	2.2	150
P2702ACMCL	120	160	240	320	4	5	800	2.2	150
P3002ACMCL	140	180	280	360	4	5	800	2.2	150
P3602ACMCL	170	220	340	440	4	5	800	2.2	150
P4202ACMCL	190	250	380	500	4	5	800	2.2	150
P4802ACMCL	220	300	440	600	4	5	800	2.2	150
P6002ACMCL	275	350	550	700	4	5	800	2.2	150

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For surge ratings, see table below.

General Notes:

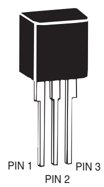
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM}	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **	50 / 60 Hz	
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
A	20	150	150	90	50	75	75	45	75	20	500
C	50	500	400	200	150	200	175	100	200	50	500

* Current waveform in µs
** Voltage waveform in µs

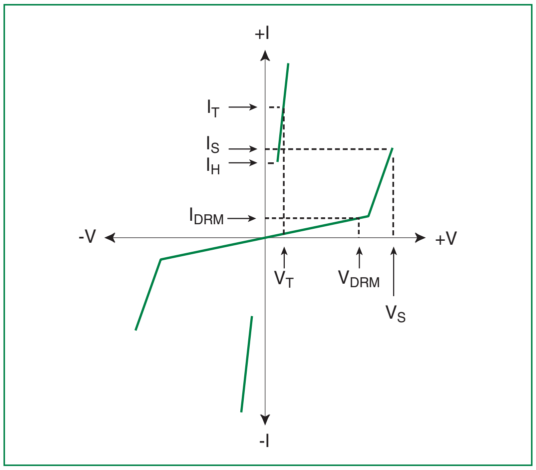
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
Modified TO-220 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	50	°C/W

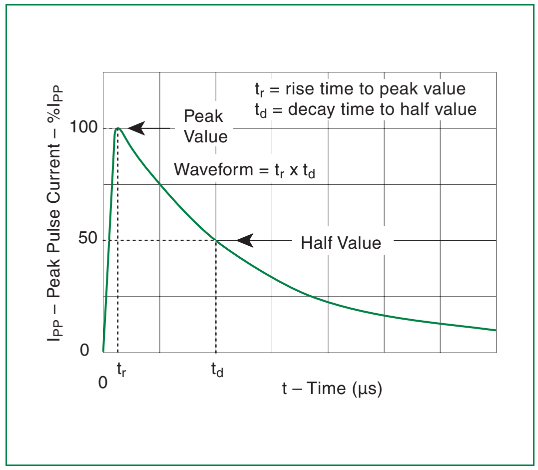
Capacitance Values

Part Number	pF Pin 1-2 / 3-2 Tip-Ground, Ring-Ground		pF Pin 1-3 Tip-Ring	
	MIN	MAX	MIN	MAX
P0302AAMCL	25	55	15	35
P0602AAMCL	15	35	10	20
P0602ACMCL	25	45	10	25
P1402ACMCL	40	60	20	35
P1602ACMCL	35	55	20	35
P2202ACMCL	45	70	25	40
P2702ACMCL	40	60	20	35
P3002ACMCL	35	55	20	35
P3602ACMCL	35	50	15	30
P4202ACMCL	30	50	15	30
P4802ACMCL	30	45	15	30
P6002ACMCL	30	45	15	25

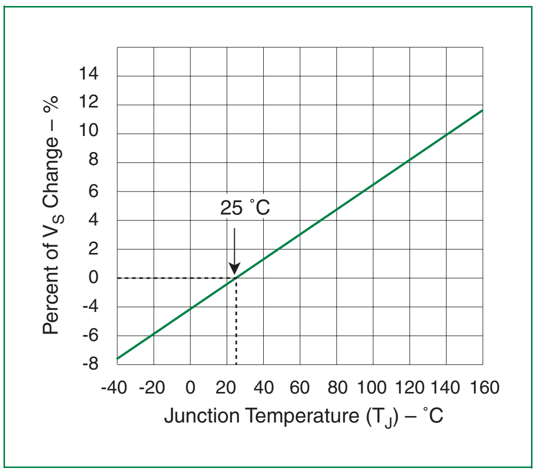
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



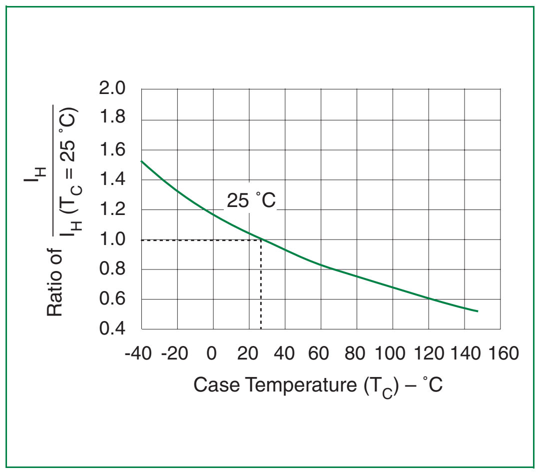
V-I Characteristics



t_r x t_d Pulse Waveform



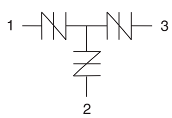
Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

Balanced Three-chip *SIDACtor*® Device

RoHS



This three-chip *SIDACtor* solution offers a guaranteed balanced protection, based on a Littelfuse patent (US Patent 4,905,119). The ‘Y’ configuration offers identical metallic and longitudinal protection in one through-hole modified TO-220 package. For primary protection applications, devices with higher holding current and integrated failsafe options are available.

SIDACtor devices enable equipment to comply with various regulatory requirements including GR 1089, ITU K.20,K.21 and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
	Pins 1-2, 2-3		Pins 1-3						
P1553A_L	130	180	130	180	8	5	800	2.2	150
P1803A_L	150	210	150	210	8	5	800	2.2	150
P2103A_L	170	250	170	250	8	5	800	2.2	150
P2353A_L	200	270	200	270	8	5	800	2.2	150
P2703A_L	230	300	230	300	8	5	800	2.2	150
P3203A_L	270	350	270	350	8	5	800	2.2	150
P3403A_L	300	400	300	400	8	5	800	2.2	150
P5103A_L	420	600	420	600	8	5	800	2.2	150
A2106A_3L **	170	250	50	80	8	5	800	2.2	120
A5030A_3L **	400	550	270	340	8	5	800	2.2	150

* **“L” in part number indicates RoHS compliance.** For non-RoHS compliant device, delete “L” from part number.
For individual “AA”, “AB”, and “AC” surge ratings, see table below.

** Asymmetrical

General Notes:

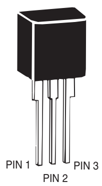
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.
- Device is designed to meet balance requirements of GTS 8700 and GR 974.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM} 50 / 60 Hz	di/dt Amps
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **		
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
A	20	150	150	90	50	75	75	45	75	20	500
B	25	250	250	150	100	100	125	80	100	30	500
C	50	500	400	200	150	200	175	100	200	50	500

* Current waveform in µs
** Voltage waveform in µs

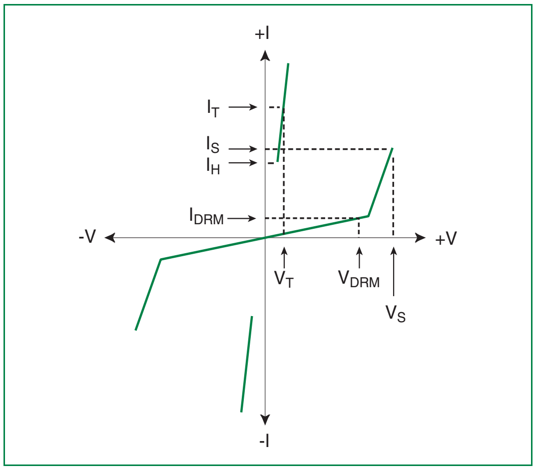
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
Modified TO-220 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	50	°C/W

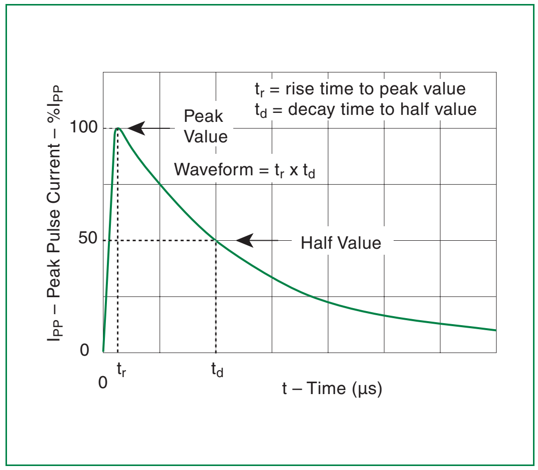
Capacitance Values

Part Number	pF Pin 1-2 / 3-2 Tip-Ground, Ring-Ground		pF Pin 1-3 Tip-Ring	
	MIN	MAX	MIN	MAX
P1553AAL	10	45	10	30
P1553ABL	25	95	15	60
P1553ACL	30	95	20	60
P1803AAL	20	40	10	30
P1803ABL	25	85	15	55
P1803ACL	30	85	15	55
P2103AAL	15	35	10	25
P2103ABL	20	85	10	55
P2103ACL	30	85	15	55
P2353AAL	15	35	10	25
P2353ABL	20	75	15	50
P2353ACL	25	75	15	50
P2703AAL	15	35	10	25
P2703ABL	20	75	10	50
P2703ACL	25	75	15	50
P3203AAL	15	30	10	20
P3203ABL	20	70	10	45
P3203ACL	25	70	15	45
P3403AAL	15	30	10	20
P3403ABL	15	65	10	45
P3403ACL	20	65	15	45
P5103AAL	10	60	10	40
P5103ABL	15	60	10	40
P5103ACL	20	60	10	40
A2106AA3L	15	35	10	45
A2106AB3L	20	35	10	45
A2106AC3L	30	45	15	45
A5030AA3L	15	35	25	40
A5030AB3L	20	35	25	40
A5030AC3L	30	45	25	40

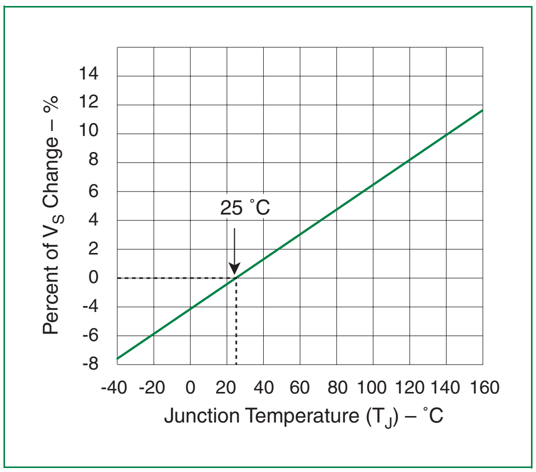
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



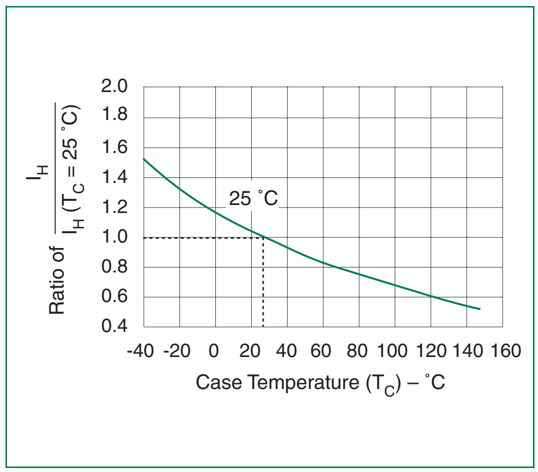
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature

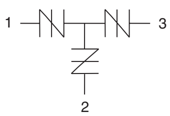


Normalized DC Holding Current versus Case Temperature

Balanced Three-chip MicroCapacitance (MC) *SIDACtor*® Device

RoHS

Littelfuse®



This three-chip MicroCapacitance *SIDACtor* solution offers a guaranteed balanced protection, based on a Littelfuse patent (US Patent 4,905,119). The 'Y' configuration offers identical metallic and longitudinal protection in one through-hole modified TO-220 package. C_O values for the MC are 40% lower than a standard AC part. For primary protection applications, devices with higher holding current and integrated failsafe options are available.

This MC *SIDACtor* series enables equipment to comply with various regulatory requirements including GR 1089, ITU K.20, K.21, and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68) without the need of series resistors.

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
	Pins 1-2, 2-3		Pins 1-3						
P1553ACMCL	130	180	130	180	8	5	800	2.2	150
P1803ACMCL	150	210	150	210	8	5	800	2.2	150
P2103ACMCL	170	250	170	250	8	5	800	2.2	150
P2353ACMCL	200	270	200	270	8	5	800	2.2	150
P2703ACMCL	230	300	230	300	8	5	800	2.2	150
P3203ACMCL	270	350	270	350	8	5	800	2.2	150
P3403ACMCL	300	400	300	400	8	5	800	2.2	150
P5103ACMCL	420	600	420	600	8	5	800	2.2	150

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For surge ratings, see table below.

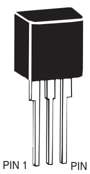
General Notes:
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.
- Device is designed to meet balance requirements of GTS 8700 and GR 974.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM}	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **	50 / 60 Hz	
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
C	50	500	400	200	150	200	175	100	200	50	500

* Current waveform in µs
** Voltage waveform in µs

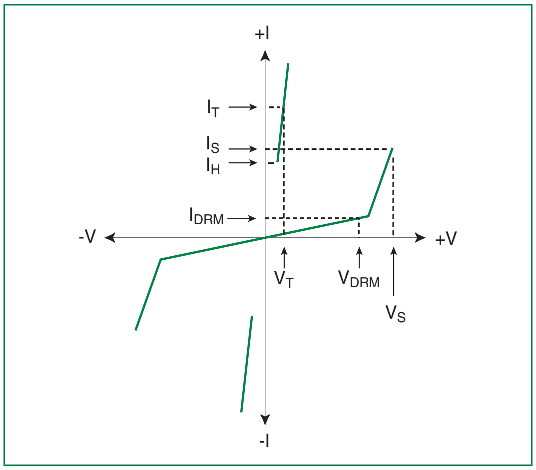
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
Modified TO-220 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	50	°C/W

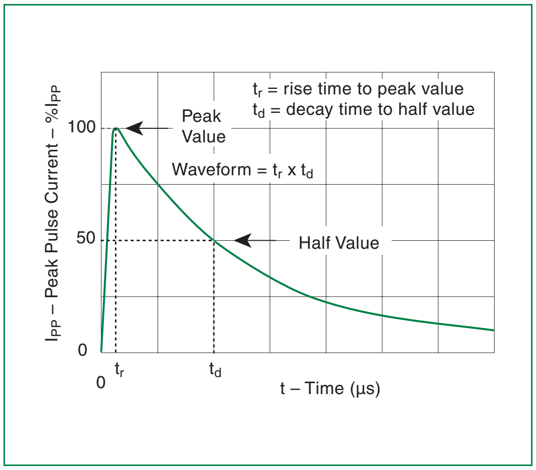
Capacitance Values

Part Number	pF Pin 1-2 / 3-2 (4-5 / 6-5) Tip-Ground, Ring-Ground		pF Pin 1-3 (4-6) Tip-Ring	
	MIN	MAX	MIN	MAX
P1553ACMCL	30	55	20	35
P1803ACMCL	25	60	15	50
P2103ACMCL	30	45	15	30
P2353ACMCL	25	45	15	30
P2703ACMCL	25	40	15	30
P3203ACMCL	25	40	15	30
P3403ACMCL	20	35	15	25
P5103ACMCL	20	50	10	30

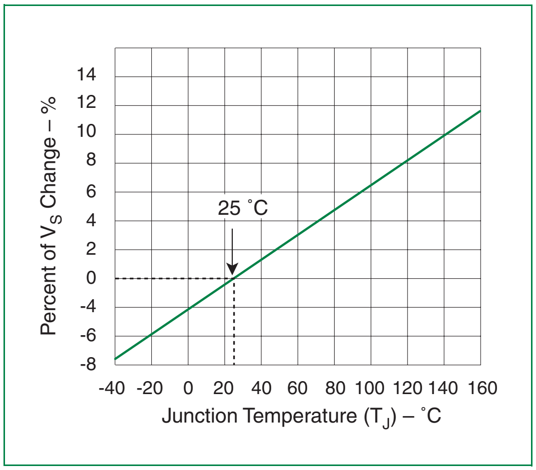
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



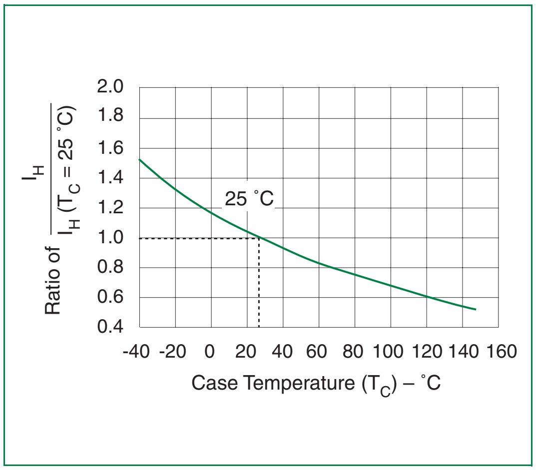
V-I Characteristics



t_r x t_d Pulse Waveform



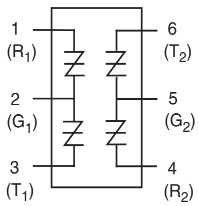
Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

LCAS Asymmetrical Multiport Device

RoHS Littelfuse



This is an integrated multichip asymmetrical solution for protecting multiple twisted pair from overvoltage conditions. Based on a six-pin surface mount SOIC package, it is equivalent to four discrete DO-214AA or two TO-220 packages. Available in surge current ratings up to 500 A, the multiport line protector is ideal for densely populated line cards that cannot afford PCB inefficiencies or the use of series power resistors.

For a diagram of an LCAS (Line Circuit Access Switch) application, see the following illustrations in Section 6, “Reference Designs” of this *Telecom Design Guide*: Figure 6.31, Figure 6.34 through Figure 6.36, Figure 6.41, Figure 6.43, and Figure 6.44.

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
	Pins 3-2, 6-5		Pins 1-2, 4-5						
A1220U_4L	100	130	180	220	4	5	800	2.2	120
A1225U_4L	100	130	230	290	4	5	800	2.2	120

* **“L” in part number indicates RoHS compliance.** For non-RoHS compliant device, delete “L” from part number.
For individual “UA”, “UB”, and “UC” surge ratings, see table below.

General Notes:

- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor®* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

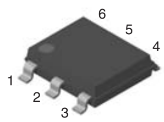
Surge Ratings in Amps

Series	I_{PP}									I_{TSM}	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **	50 / 60 Hz	
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
A	20	150	150	90	50	75	75	45	75	20	500
B	25	250	250	150	100	100	125	80	100	30	500
C	50	500	400	200	150	200	175	100	200	50	500

* Current waveform in µs
** Voltage waveform in µs

Thermal Considerations

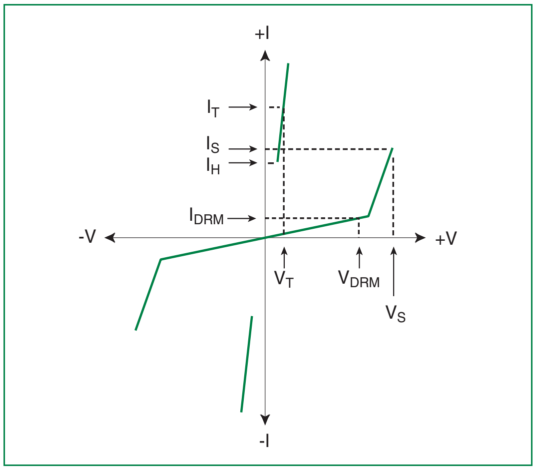
Package	Symbol	Parameter	Value	Unit
Modified MS-013	T_J	Operating Junction Temperature Range	-40 to +125	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	60	°C/W



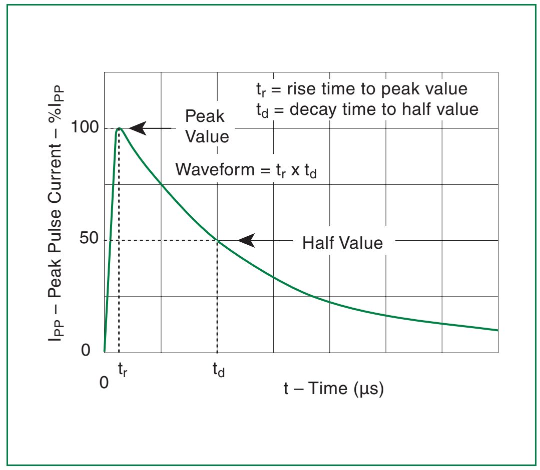
Capacitance Values

Part Number	pF Pin 1-2 / 4-5 Ring-Ground		pF Pin 3-2 / 6-5 Tip-Ground		pF Pin 1-3 (4-6) Tip-Ring	
	MIN	MAX	MIN	MAX	MIN	MAX
A1220UA4L	15	25	30	50	5	20
A1220UB4L	15	55	30	110	5	35
A1220UC4L	15	55	30	110	10	35
A1225UA4L	15	25	30	50	5	20
A1225UB4L	15	50	30	90	5	35
A1225UC4L	15	50	30	90	10	35

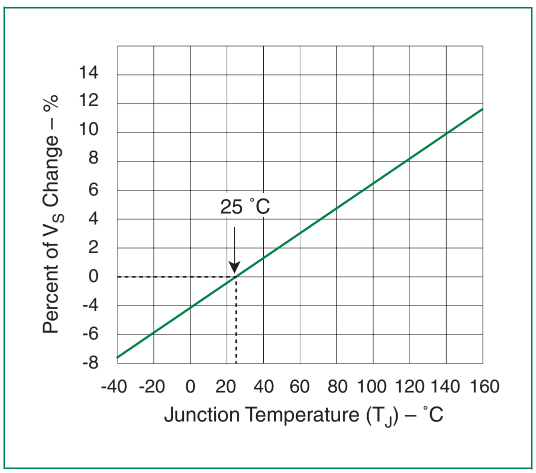
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



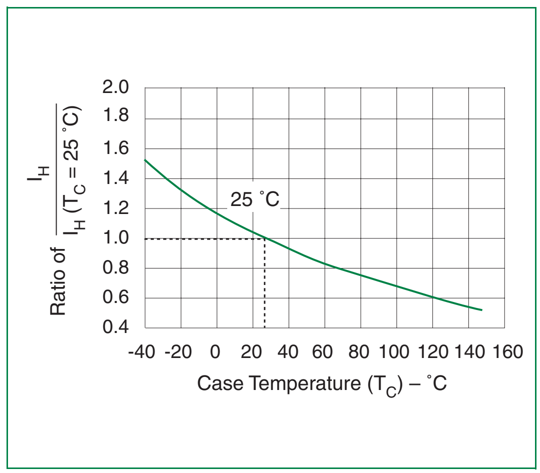
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

LCAS Asymmetrical Discrete Device

RoHS

Littelfuse®

These DO-214AA *SIDACtor®* devices are intended for LCAS (Line Circuit Access Switch) applications that require asymmetrical protection in discrete (individual) packages. They enable the protected equipment to meet various regulatory requirements including GR 1089, ITU K.20, K.21, K.45, IEG 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
P1200S_L	100	130	4	5	800	2.2	120
P2000S_L	180	220	4	5	800	2.2	120
P2500S_L	230	290	4	5	800	2.2	120

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number. For individual "SA", "SB", and "SC" surge ratings, see table below.

General Notes:

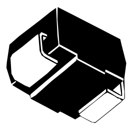
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor®* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM}	
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **	50 / 60 Hz	di/dt
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
A	20	150	150	90	50	75	75	45	75	20	500
B	25	250	250	150	100	100	125	80	100	30	500
C	50	500	400	200	150	200	175	100	200	50	500

* Current waveform in µs
** Voltage waveform in µs

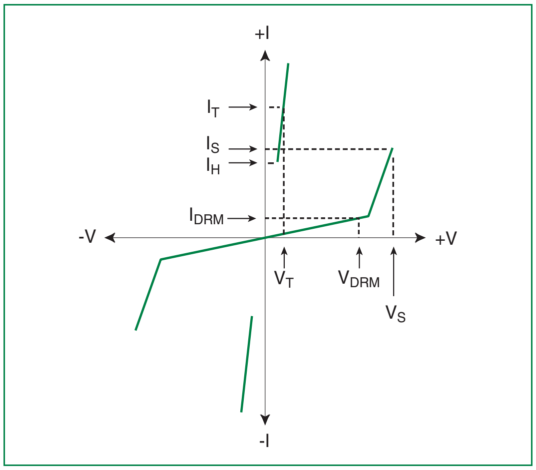
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
DO-214AA 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	90	°C/W

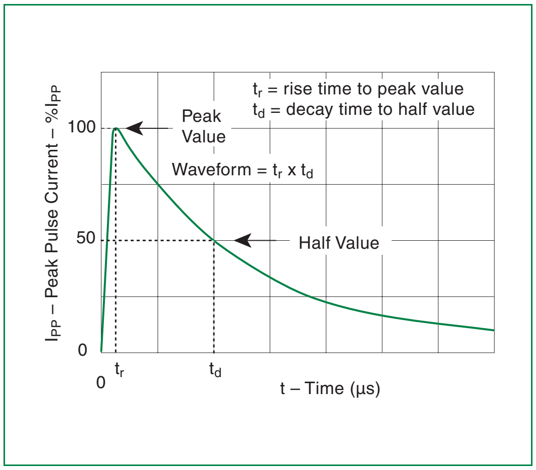
Capacitance Values

Part Number	pF	
	MIN	MAX
P1200SAL	30	45
P1200SBL	30	65
P1200SCL	45	110
P2000SAL	25	35
P2000SBL	25	95
P2000SCL	35	95
P2500SAL	20	35
P2500SBL	20	35
P2500SCL	30	85

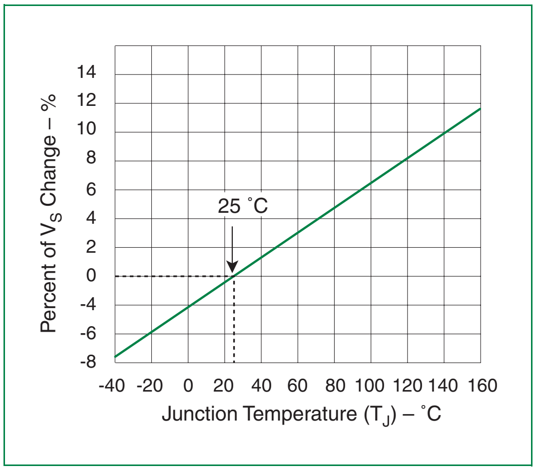
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



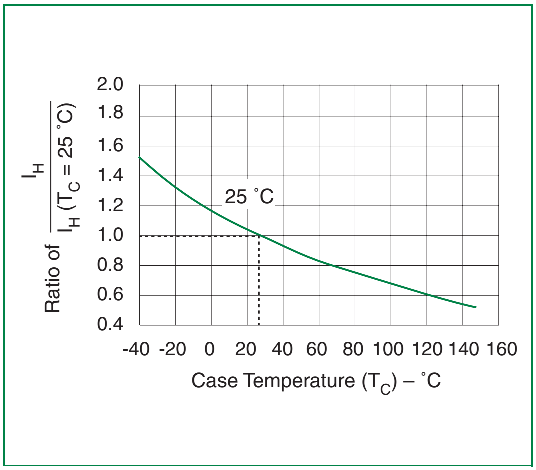
V-I Characteristics



t_r x t_d Pulse Waveform



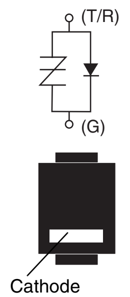
Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

Fixed Voltage SLIC Protector

RoHS



These DO-214AA unidirectional protectors are constructed with a *SIDACtor®* device and an integrated diode. They protect SLICs (Subscriber Line Interface Circuits) from damage during transient voltage activity and enable line cards to comply with various regulatory requirements including GR 1089, ITU K.20, K.21 and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

For details of specific design criteria, see Figure 6.31 in Section 6, "Reference Designs" of this *Telecom Design Guide*).

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	V_F Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
P0641S_L	58	77	4	5	5	800	1	120
P0721S_L	65	88	4	5	5	800	1	120
P0901S_L	75	98	4	5	5	800	1	120
P1101S_L	95	130	4	5	5	800	1	120
P1301S_L	120	160	4	5	5	800	1	120
P1701S_L	160	200	4	5	5	800	1	120

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For individual "SA" and "SC" surge ratings, see table below.

General Notes:

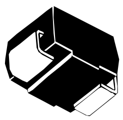
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- V_{DRM} is measured at I_{DRM}.
- V_S and V_F are measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.
- Parallel capacitive loads may affect electrical parameters.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM} 50 / 60 Hz	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **		
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
A	20	150	150	90	50	75	75	45	75	20	500
C	50	500	400	200	150	200	175	100	200	50	500

* Current waveform in µs
** Voltage waveform in µs

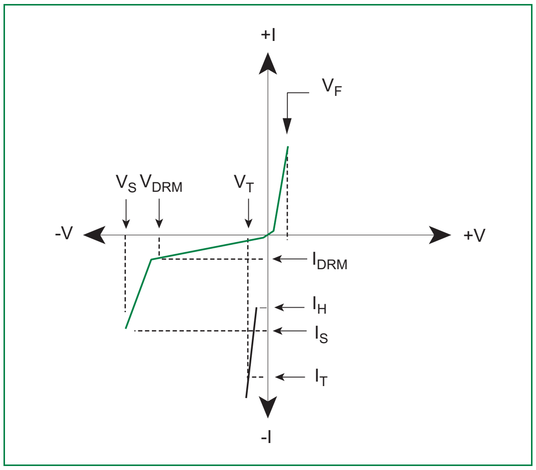
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
DO-214AA 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	90	°C/W

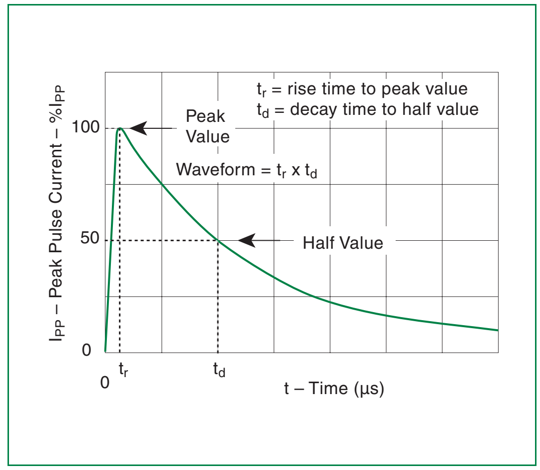
Capacitance Values

Part Number	pF	
	MIN	MAX
P0641SAL	50	90
P0641SCL	65	200
P0721SAL	45	85
P0721SCL	60	190
P0901SAL	45	80
P0901SCL	60	180
P1101SAL	40	70
P1101SCL	50	160
P1301SAL	40	70
P1301SCL	50	160
P1701SAL	30	55
P1701SCL	40	130

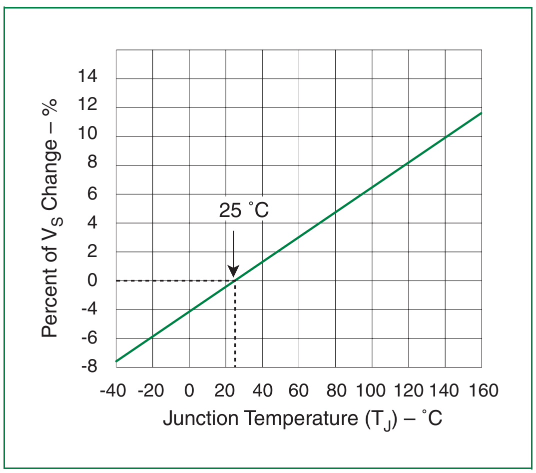
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



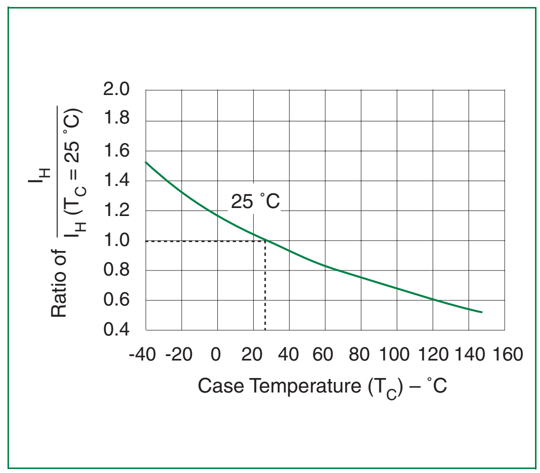
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature

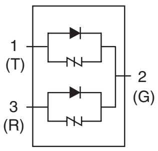


Normalized DC Holding Current versus Case Temperature

SIDACtor Devices

RoHS

Littelfuse®



This *TwinSLIC* DO-214AA unidirectional protector is constructed with a *SIDACtor*® device and an integrated diode. It protects SLICs (Subscriber Line Interface Circuits) from damage during transient voltage activity and enables line cards to comply with various regulatory requirements including GR 1089, ITU K.20, K.21 and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

For details of specific design criteria, see Figure 6.40 through Figure 6.43 in Section 6, "Reference Designs" of this *Telecom Design Guide*.

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	V_F Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
	Pins 1-2, 3-2							
P0641CA2L	58	77	4	5	5	800	1	120
P0721CA2L	65	88	4	5	5	800	1	120
P0901CA2L	75	98	4	5	5	800	1	120
P1101CA2L	95	130	4	5	5	800	1	120
P1301CA2L	120	160	4	5	5	800	1	120
P1701CA2L	160	200	4	5	5	800	1	120

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For surge ratings, see table below.

General Notes:

- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- V_{DRM} is measured at I_{DRM}.
- V_S and V_F are measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.
- Parallel capacitive loads may affect electrical parameters.
- Compliance with GR 1089 or UL 60950 power fault tests may require special design considerations. Contact the factory for further information.

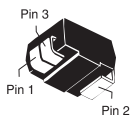
Surge Ratings in Amps

Series	I_{PP}									I_{TSM}	
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **	50 / 60 Hz	di/dt
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
A	20	150	150	90	50	75	75	45	75	20	500

* Current waveform in µs
** Voltage waveform in µs

Thermal Considerations

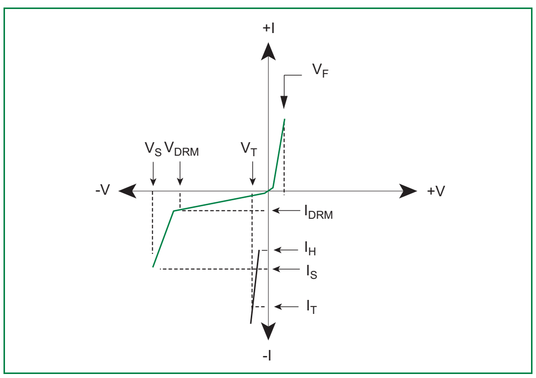
Package	Symbol	Parameter	Value	Unit
Modified DO-214AA	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	85	°C/W



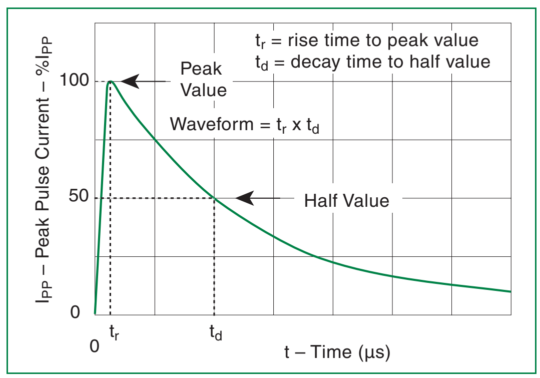
Capacitance Values

Part Number	pF Pin 1-2 / 3-2 Tip-Ground, Ring-Ground		pF Pin 1-3 Tip-Ring	
	MIN	MAX	MIN	MAX
P0641CA2L	40	200	20	105
P0721CA2L	35	190	20	105
P0901CA2L	30	180	20	105
P1101CA2L	25	160	15	105
P1301CA2L	25	125	15	105
P1701CA2L	25	125	15	105

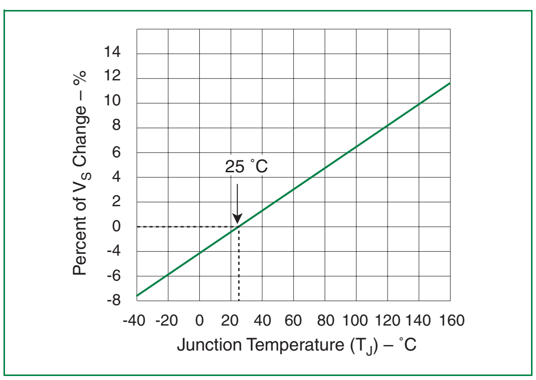
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



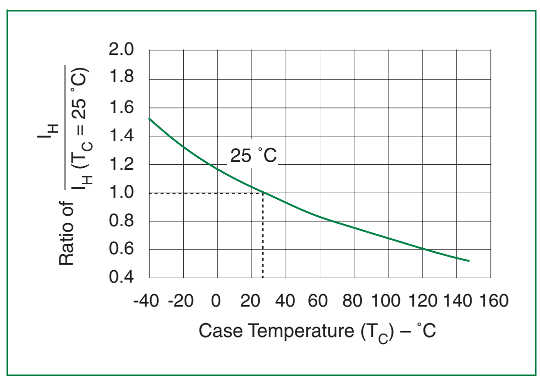
V-I Characteristics



t_r x t_d Pulse Waveform



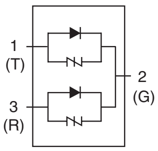
Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

Two-chip SLIC Protector Modified TO-220

RoHS



This two-chip SLIC modified TO-220 unidirectional protector is constructed with a *SIDACtor*® device and an integrated diode. It protects SLICs (Subscriber Line Interface Circuits) from damage during transient voltage activity and enables line cards to comply with various regulatory requirements including GR 1089, ITU K.20, K.21 and K.45, IEC 60950, UL 60950, and TIA-968-A (formerly known as FCC Part 68).

For details of specific design criteria, see Figure 6.40 through Figure 6.43 in Section 6, “Reference Designs” of this *Telecom Design Guide*.

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	V_F Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
	Pins 1-2, 3-2							
P0641A_2L	58	77	4	5	5	800	2.2	120
P0721A_2L	65	88	4	5	5	800	2.2	120
P0901A_2L	75	98	4	5	5	800	2.2	120
P1101A_2L	95	130	4	5	5	800	2.2	120
P1301A_2L	120	160	4	5	5	800	2.2	120
P1701A_2L	160	200	4	5	5	800	2.2	120

* **“L” in part number indicates RoHS compliance.** For non-RoHS compliant device, delete “L” from part number.
  For surge ratings, see table below.

General Notes:

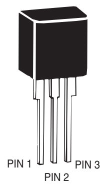
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- V_{DRM} is measured at I_{DRM}.
- V_S and V_F are measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.
- Parallel capacitive loads may affect electrical parameters.
- Compliance with GR 1089 or UL 60950 power fault tests may require special design considerations. Contact the factory for further information.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM} 50 / 60 Hz	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **		
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
A	20	150	150	90	50	75	75	45	75	20	500
C	50	500	400	200	150	200	175	100	200	50	500

* Current waveform in µs
** Voltage waveform in µs

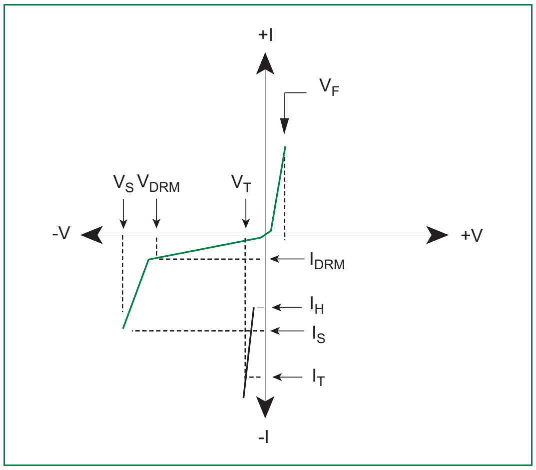
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
Modified TO-220 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	50	°C/W

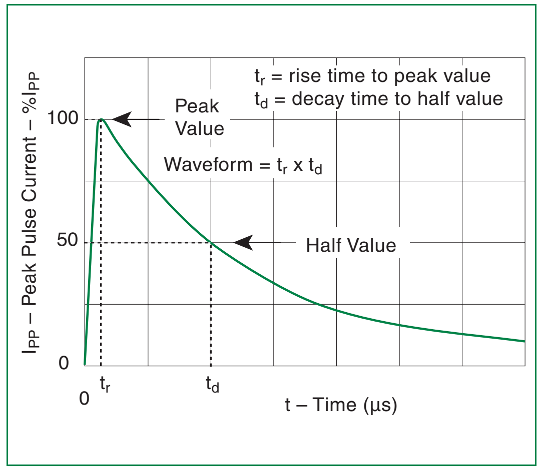
Capacitance Values

Part Number	pF		pF Pin 1-2 / 3-2 (4-5 / 6-5) Tip-Ground, Ring-Ground	
	MIN	MAX	MIN	MAX
P0641AA2L	40	200	20	105
P0641AC2L	40	200	20	105
P0721AA2L	35	190	20	105
P0721AC2L	35	190	20	105
P0901AA2L	30	180	20	105
P0901AC2L	30	180	20	105
P1101AA2L	25	160	15	105
P1101AC2L	25	160	15	105
P1301AA2L	25	160	15	105
P1301AC2L	25	160	15	105
P1701AA2L	25	125	15	105
P1701AC2L	25	125	15	105

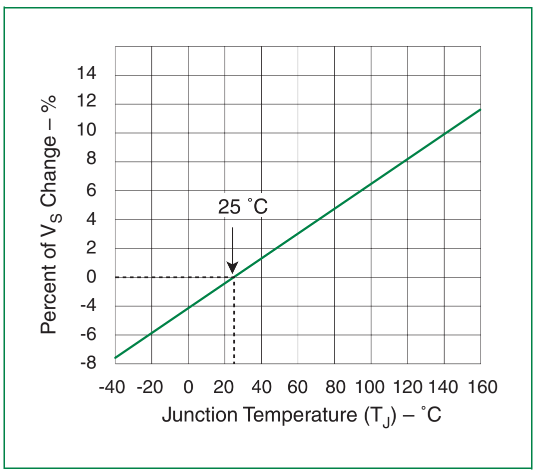
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



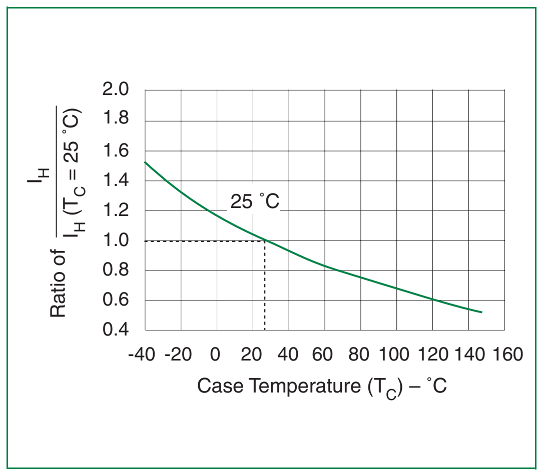
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature

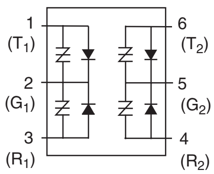


Normalized DC Holding Current versus Case Temperature

Multiport SLIC Protector

RoHS

Littelfuse®



This multiport line protector is designed as a single-package solution for protecting multiple twisted pair from overvoltage conditions. Based on a six-pin SOIC package, it is equivalent to four discrete DO-214AA packages. Available in surge current ratings up to 500 A for a 2x10 µs event, the multiport line protector is ideal for densely populated line cards that cannot afford PCB inefficiencies or the use of series power resistors.

For details of specific design criteria, see Figure 6.44, Figure 6.45, and Figure 6.46 in Section 6, “Reference Designs” of this *Telecom Design Guide*.

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	V_F Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
	Pins 1-2, 2-3, 4-5, 5-6							
P0641U_L	58	77	4	5	5	800	2.2	120
P0721U_L	65	88	4	5	5	800	2.2	120
P0901U_L	75	98	4	5	5	800	2.2	120
P1101U_L	95	130	4	5	5	800	2.2	120
P1301U_L	120	160	4	5	5	800	2.2	120
P1701U_L	160	200	4	5	5	800	2.2	120

* **“L” in part number indicates RoHS compliance.** For non-RoHS compliant device, delete “L” from part number.
For individual “UA” and “UC” surge ratings, see table below.

General Notes:

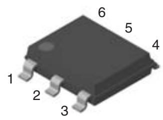
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- V_{DRM} is measured at I_{DRM}.
- V_S and V_F are measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.
- Parallel capacitive loads may affect electrical parameters.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM} 50 / 60 Hz	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **		
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
A	20	150	150	90	50	75	75	45	75	20	500
C	50	500	400	200	150	200	175	100	200	50	500

* Current waveform in µs
** Voltage waveform in µs

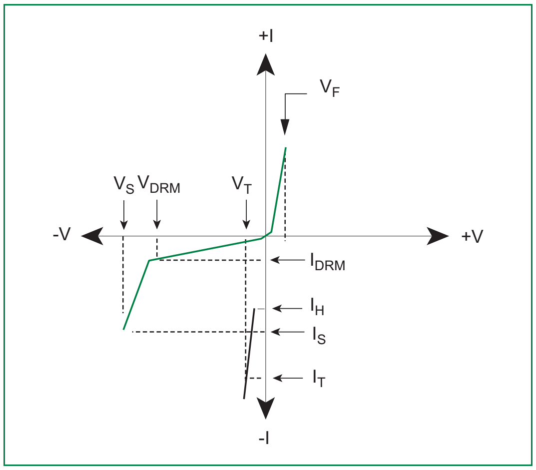
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
Modified MS-013 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	60	°C/W

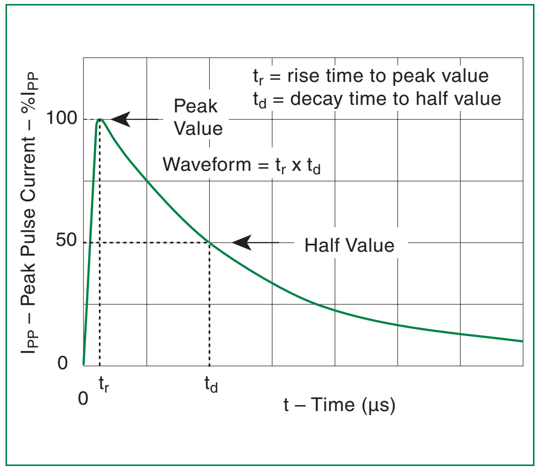
Capacitance Values

Part Number	pF Pin 1-2 / 3-2 (4-5 / 6-5) Tip-Ground, Ring-Ground		pF Pin 1-3 (4-6) Tip-Ring	
	MIN	MAX	MIN	MAX
P0641UAL	50	200	20	105
P0641UCL	65	200	20	105
P0721UAL	45	190	20	105
P0721UCL	60	190	20	105
P0901UAL	45	180	20	105
P0901UCL	60	180	20	105
P1101UAL	40	160	15	105
P1101UCL	50	160	15	105
P1301UAL	40	160	15	105
P1301UCL	50	160	15	105
P1701UAL	30	125	15	80
P1701UCL	40	125	15	80

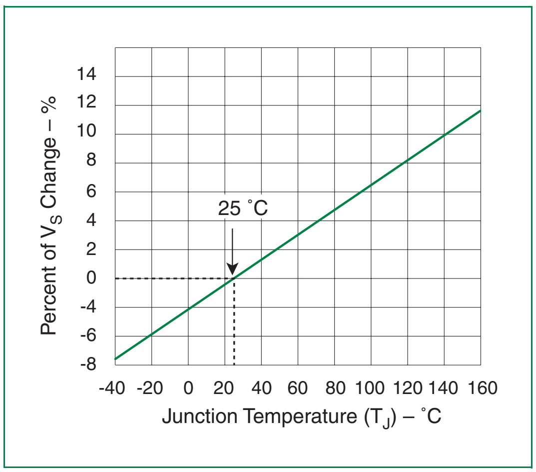
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



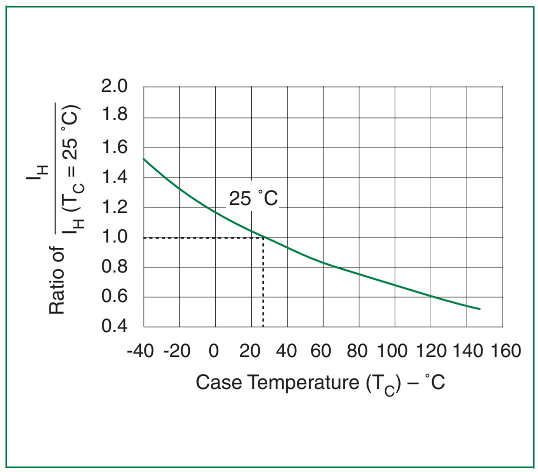
V-I Characteristics



t_r x t_d Pulse Waveform



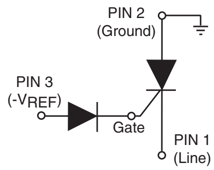
Normalized V_S Change versus Junction Temperature



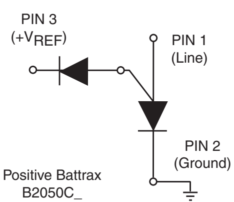
Normalized DC Holding Current versus Case Temperature

RoHS

Littelfuse®



Negative Battrax
B1xx0C_



Positive Battrax
B2050C_

The *Battrax* SLIC protector is offered in a negative *Battrax* version and a positive *Battrax* version. The B1xx0C_ is for a -V_{REF} and the B2050C_ is for a +V_{REF}. Designed using an SCR and a gate diode, the B1xx0C_ *Battrax* begins to conduct at $|-V_{REF}| + |-1.2\ V|$ while the B2050C_ *Battrax* begins to conduct at $|+V_{REF}| + |1.2\ V|$.

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_{GT} mAmps	I_T Amps	I_H mAmps
B1100C_L	$|-V_{REF}| + |-1.2\ V|$	$|-V_{REF}| + |-10\ V|$	4	5	100	2.2	100
B1160C_L	$|-V_{REF}| + |-1.2\ V|$	$|-V_{REF}| + |-10\ V|$	4	5	100	2.2	160
B1200C_L	$|-V_{REF}| + |-1.2\ V|$	$|-V_{REF}| + |-10\ V|$	4	5	100	2.2	200

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_{GT} mAmps	I_T Amps	I_H mAmps
B2050C_L	$|+V_{REF}| + |1.2\ V|$	$|+V_{REF}| + |10\ V|$	4	5	50	2.2	5

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For individual "CA" and "CC" surge ratings, see table below.

General Notes:

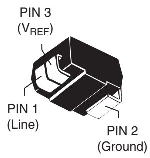
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- I_{PP} ratings assume V_{REF} = ±48 V.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Positive *Battrax* information is preliminary data.
- V_{REF} maximum value for the negative *Battrax* is -200 V.
- V_{REF} maximum value for the positive *Battrax* is 110 V.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM}	
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **	50 / 60 Hz	di/dt
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
A	20	150	150	90	50	75	75	45	75	20	500
C	50	500	400	200	150	200	175	100	200	50	500

* Current waveform in µs
** Voltage waveform in µs

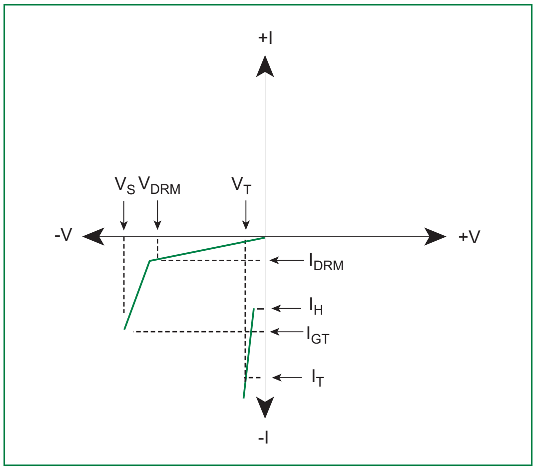
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
Modified DO-214AA 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	85	°C/W

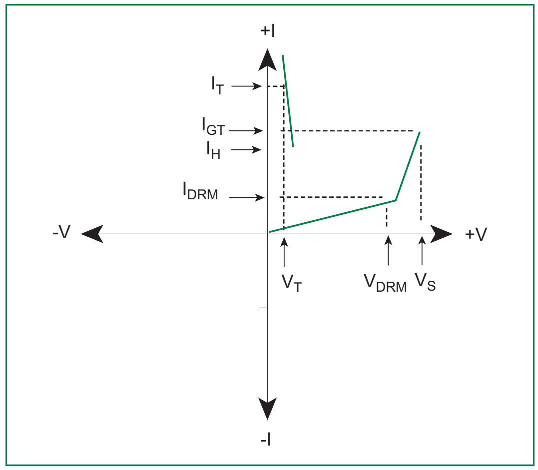
Capacitance Values

Part Number	pF	
	MIN	MAX
B1100CAL	50	200
B1100CCL	50	200
B1160CAL	50	200
B1160CCL	50	200
B1200CAL	50	200
B1200CCL	50	200
B2050CAL	50	200
B2050CCL	50	200

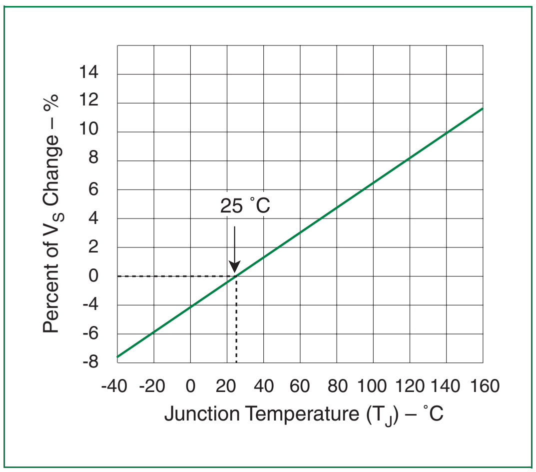
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



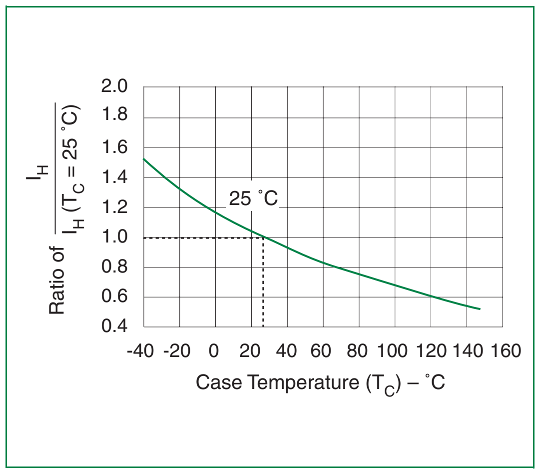
V-I Characteristics for Negative Battrax



V-I Characteristics for Positive Battrax



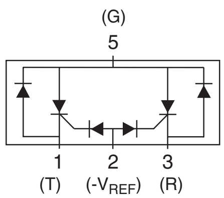
Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

Battrax® Single Port Negative SLIC Protector

RoHS



This programmable *Battrax* device is referenced to a negative voltage source. This dual-chip package includes internal diodes for transient protection from positive surge events.

For a diagram of a *Battrax* application, see Figure 6.47 in Section 6, “Reference Designs” of this *Telecom Design Guide.*

SIDACtor Devices

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	V_F Volts	I_{DRM} μAmps	I_{GT} mAmps	I_T Amps	I_H mAmps
B1101U_L	$\lvert -V_{REF}\rvert + \lvert -1.2V\rvert$	$\lvert -V_{REF}\rvert + \lvert -10V\rvert$	4	5	5	100	2.2	100
B1161U_L	$\lvert -V_{REF}\rvert + \lvert -1.2V\rvert$	$\lvert -V_{REF}\rvert + \lvert -10V\rvert$	4	5	5	100	2.2	160
B1201U_L	$\lvert -V_{REF}\rvert + \lvert -1.2V\rvert$	$\lvert -V_{REF}\rvert + \lvert -10V\rvert$	4	5	5	100	2.2	200

* **“L” in part number indicates RoHS compliance.** For non-RoHS compliant device, delete “L” from part number.
For individual “UA” and “UC” surge ratings, see table below.

General Notes:

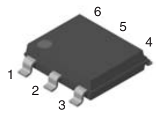
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- I_{PP} ratings assume a V_{REF} = -48 V.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/μs.
- V_{REF} maximum value for the B1101, B1161, and/or B1201 is -200 V.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM}	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **	50 / 60 Hz	
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/μs
A	20	150	150	90	50	75	75	45	75	20	500
C	50	500	400	200	150	200	175	100	200	50	500

* Current waveform in μs
** Voltage waveform in μs

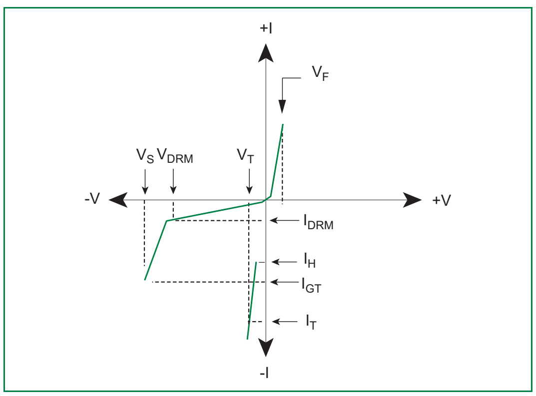
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
Modified MS-013 	T_J	Operating Junction Temperature Range	-40 to +125	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	60	°C/W

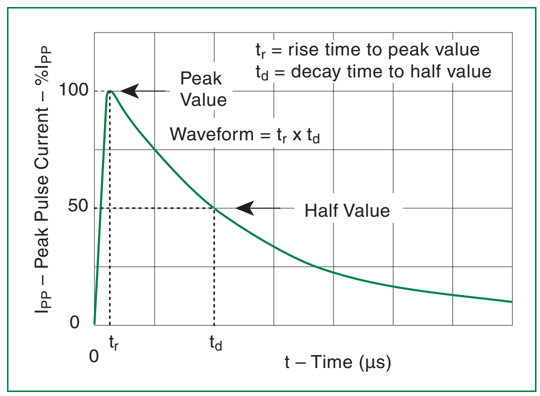
Capacitance Values

Part Number	pF	
	MIN	MAX
B1101UAL	50	200
B1101UCL	50	200
B1161UAL	50	200
B1161UCL	50	200
B1201UAL	50	200
B1201UCL	50	200

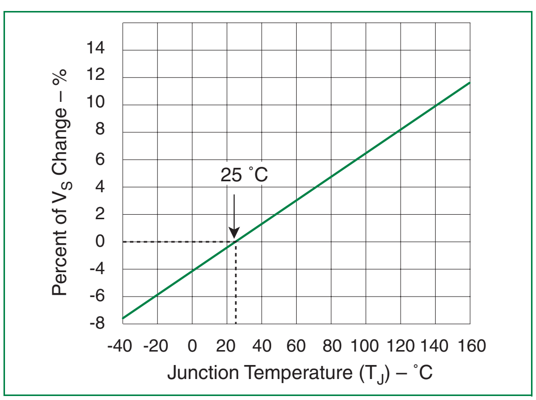
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



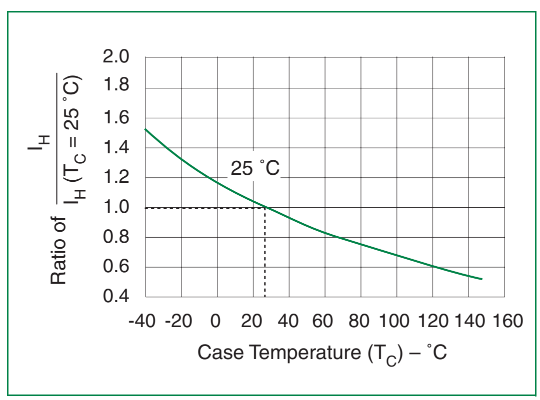
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature

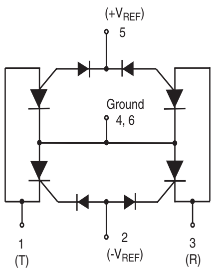


Normalized DC Holding Current versus Case Temperature

Battrax® Single Port Positive/Negative SLIC Protector

RoHS

Littelfuse®



This six-pin surface mount package contains programmable protection devices for both negative and positive voltage references.

It is constructed using four SCRs and four gate diodes. The SCRs conduct when a voltage that is more negative than $-V_{REF}$ or more positive than $+V_{REF}$ is applied to Pin 1 or 3 of the SCR. During conduction, the SCRs appear as a low-resistive path which forces all transients to be shorted to ground.

For a diagram of a *Battrax* application, see Figure 6.49 in Section 6, "Reference Designs" of this *Telecom Design Guide*.

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_{GT} mAmps	I_T Amps	I_H mAmps
B3104U_L	$\lvert -V_{REF} \rvert + \lvert \pm 1.2V \rvert$	$\lvert -V_{REF} \rvert + \lvert \pm 10V \rvert$	4	5	100	2.2	100
B3164U_L	$\lvert -V_{REF} \rvert + \lvert \pm 1.2V \rvert$	$\lvert -V_{REF} \rvert + \lvert \pm 10V \rvert$	4	5	100	2.2	160
B3204U_L	$\lvert -V_{REF} \rvert + \lvert \pm 1.2V \rvert$	$\lvert -V_{REF} \rvert + \lvert \pm 10V \rvert$	4	5	100	2.2	200

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For individual "UA" and "UC" surge ratings, see table below.

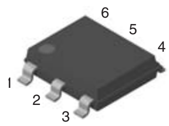
General Notes:
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- I_{PP} ratings assume a V_{REF} = ±48 V.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Positive *Battrax* information is preliminary data.
- V_{REF} maximum value for the negative *Battrax* is -200 V.
- V_{REF} maximum value for the positive *Battrax* is 110 V.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM} 50 / 60 Hz	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **		
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
A	20	150	150	90	50	75	75	45	75	20	500
C	50	500	400	200	150	200	175	100	200	50	500

* Current waveform in µs
** Voltage waveform in µs

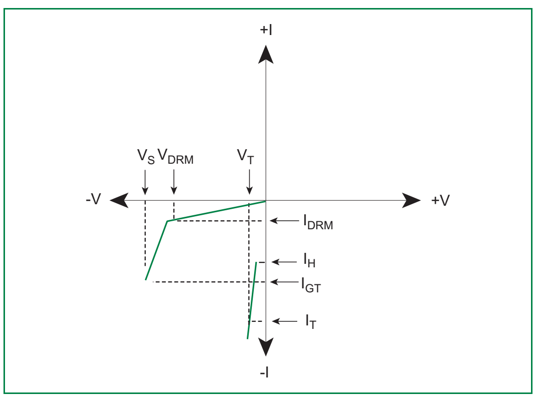
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
Modified MS-013 	T_J	Operating Junction Temperature Range	-40 to +125	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	60	°C/W

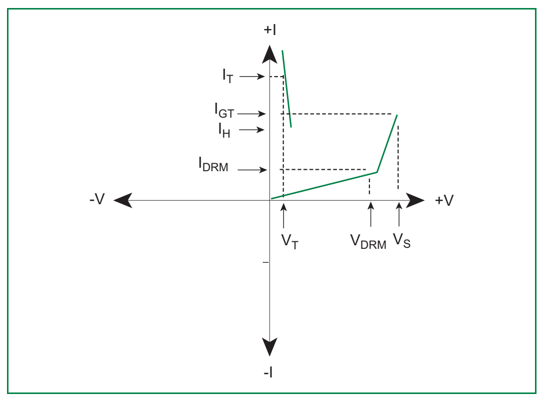
Capacitance Values

Part Number	pF	
	MIN	MAX
B3104UAL	50	200
B3104UCL	50	200
B3164UAL	50	200
B3164UCL	50	200
B3204UAL	50	200
B3204UCL	50	200

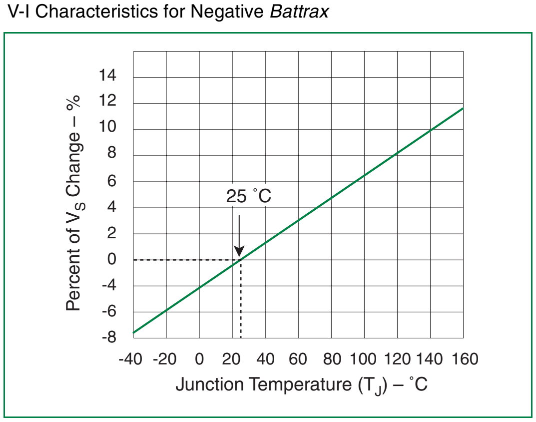
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



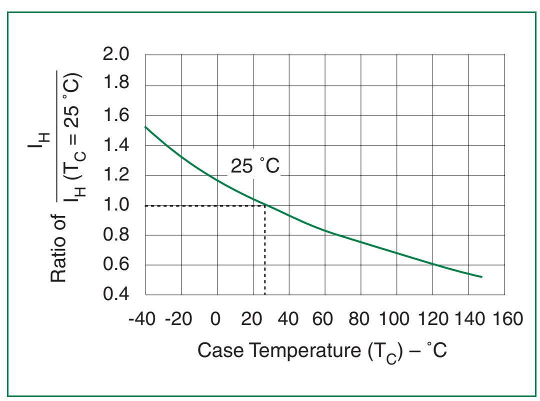
V-I Characteristics for Negative *Battrax*



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature

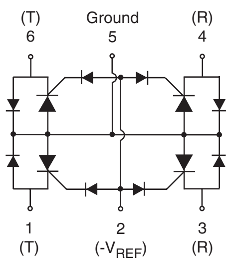


Normalized DC Holding Current versus Case Temperature

Battrax® Dual Port Negative SLIC Protector

RoHS

Littelfuse®



This *Battrax* device is an integrated overvoltage protection solution for SLIC-based (Subscriber Line Interface Circuit) line cards. This six-pin device is constructed using four SCRs and four gate diodes.

The device is referenced to V_{BAT} and conducts when a voltage that is more negative than -V_{REF} is applied to the cathode (Pins 1, 3, 4, or 6) of the SCR. During conduction, all negative transients are shorted to Ground. All positive transients are passed to Ground by the diodes.

For specific diagrams showing these *Battrax* applications, see Figure 6.48 in Section 6, “Reference Designs” of this *Telecom Design Guide*.

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_{GT} mAmps	I_T Amps	I_H mAmps
B1101U_ 4L	$\lvert -V_{REF}\rvert + \lvert -1.2V\rvert$	$\lvert -V_{REF}\rvert + \lvert -10V\rvert$	4	5	100	2.2	100
B1161U_ 4L	$\lvert -V_{REF}\rvert + \lvert -1.2V\rvert$	$\lvert -V_{REF}\rvert + \lvert -10V\rvert$	4	5	100	2.2	160
B1201U_ 4L	$\lvert -V_{REF}\rvert + \lvert -1.2V\rvert$	$\lvert -V_{REF}\rvert + \lvert -10V\rvert$	4	5	100	2.2	200

* **“L” in part number indicates RoHS compliance.** For non-RoHS compliant device, delete “L” from part number.
For individual “UA” and “UC” surge ratings, see table below.

General Notes:

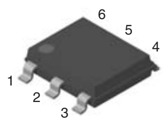
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- I_{PP} ratings assume a V_{REF} = ±48 V.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- V_{REF} maximum value for the negative *Battrax* is -200 V.

Surge Ratings in Amps

Series	I_{PP}									I_{TSM} 50 / 60 Hz	di/dt
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **		
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
A	20	150	150	90	50	75	75	45	75	20	500
C	50	500	400	200	150	200	175	100	200	50	500

* Current waveform in µs
** Voltage waveform in µs

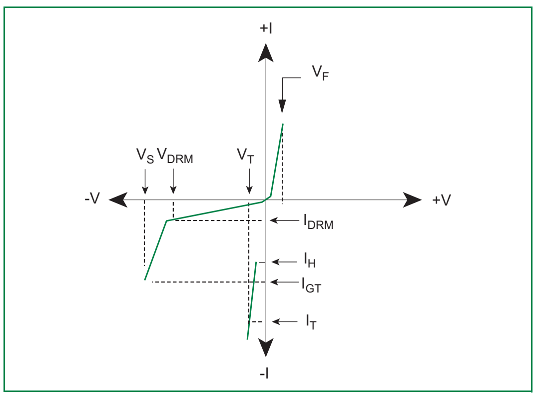
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
Modified MS-013	T_J	Operating Junction Temperature Range	-40 to +125	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	60	°C/W

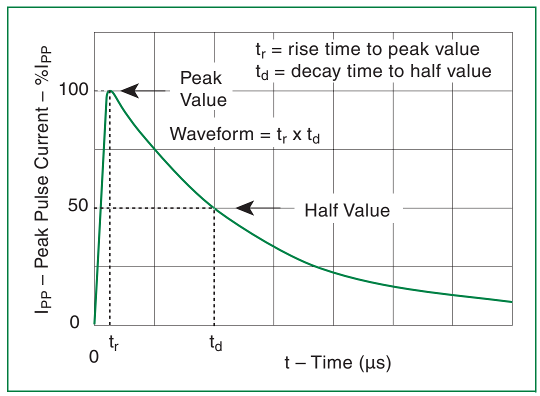
Capacitance Values

Part Number	pF	
	MIN	MAX
B1101UA 4L	50	200
B1101UC 4L	50	200
B1161UA 4L	50	200
B1161UC 4L	50	200
B1201UA 4L	50	200
B1201UC 4L	50	200

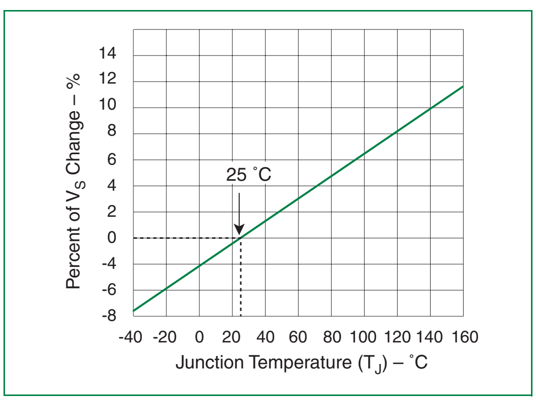
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



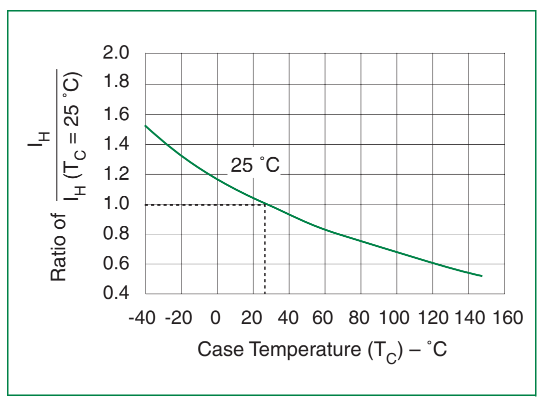
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

High Surge Current Two-pin *SIDACtor*® Device

RoHS

Littelfuse®

This *SIDACtor* device is intended for very hostile environments such as CATV (Community Antenna TV) systems and electronics connected to external antennas.

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
P1400ADL	120	160	3	5	800	2.2	50
P1800ADL	170	220	3	5	800	2.2	50

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For surge ratings, see table below.

General Notes:

- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

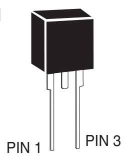
Surge Ratings in Amps

Series	I_{PP} 8x20 * 1.2x50 **	I_{PP} 10x1000 * 10x1000 **	I_{TSM} 50 / 60 Hz	di/dt
	Amps	Amps	Amps	Amps/µs
D	1000	250	120	500

* Current waveform in µs
** Voltage waveform in µs

Thermal Considerations

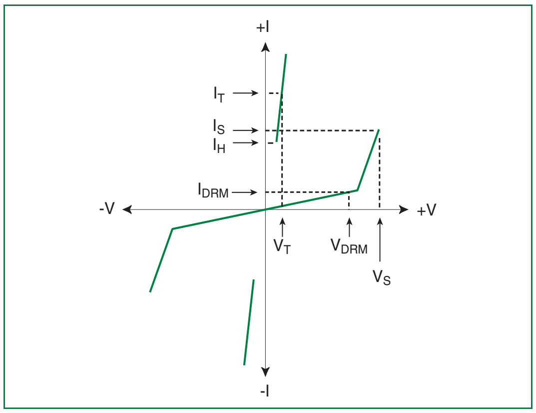
Package	Symbol	Parameter	Value	Unit
Modified TO-220	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	60	°C/W



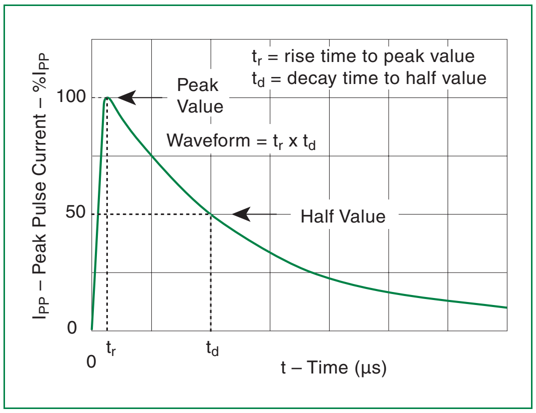
Capacitance Values

Part Number	pF	
	MIN	MAX
P1400ADL	140	200
P1800ADL	120	180

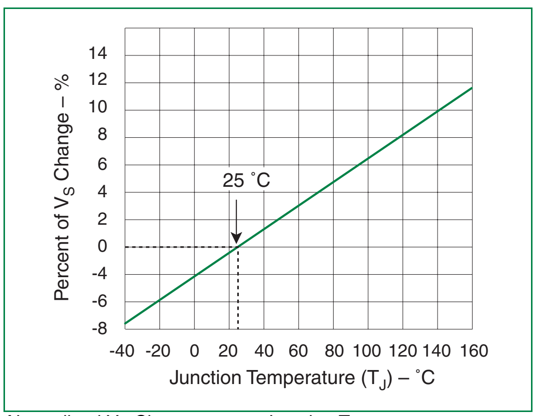
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



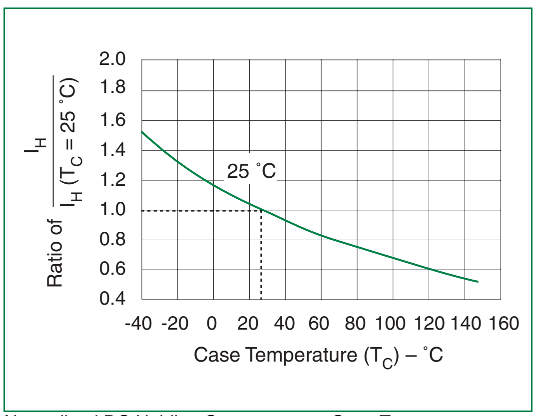
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature

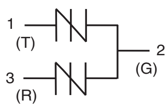


Normalized DC Holding Current versus Case Temperature

High Surge Current Three-pin *SIDACtor*® Device

RoHS

Littelfuse®



This *SIDACtor* device is a 1000 A solid state protection device offered in a TO-220 package. It protects equipment located in the severe surge environment of CATV (Community Antenna TV) systems and antenna locations.

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
P6002ADL	550	700	5.5	5	800	2.2	50

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For surge ratings, see table below.

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
P3100ADL	280	360	5.5	5	800	2.2	150

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For surge ratings, see table below.

General Notes:

- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

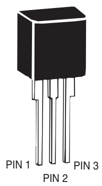
Surge Ratings in Amps

Series	I_{PP} 8x20 * 1.2x50 **	I_{PP} 10x1000 * 10x1000 **	I_{TSM} 50 / 60 Hz	di/dt
	Amps	Amps	Amps	Amps/µs
D	1000	250	120	500

* Current waveform in µs
** Voltage waveform in µs

Note: P6002AD is shown. P3100AD has no center lead.

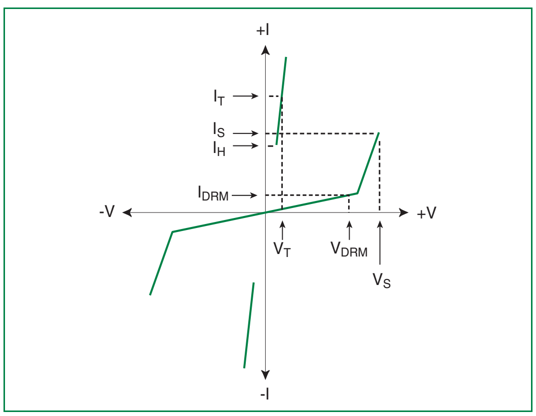
Thermal Considerations

Package	Symbol	Parameter	Value	Unit
Modified TO-220 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	60	°C/W

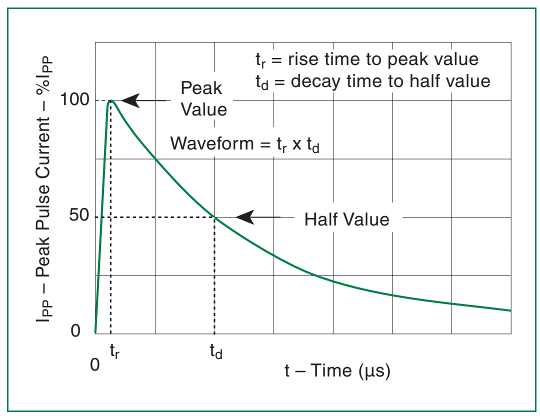
Capacitance Values

Part Number	pF	
	MIN	MAX
P6002ADL	60	200
P3100ADL	100	150

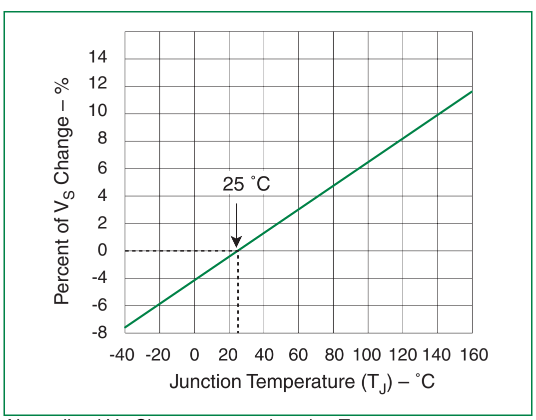
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



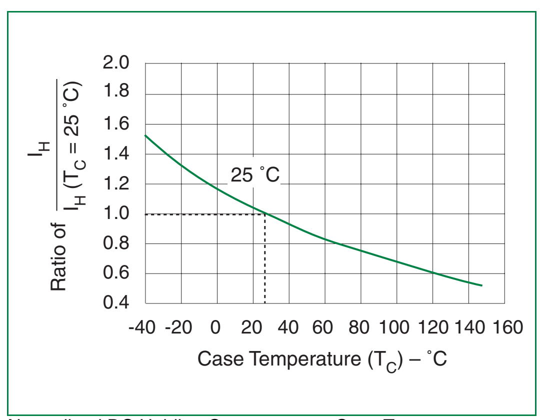
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

CATV Line Amplifiers/Power Inserters 3 kA *SIDACtor*® Device

RoHS

Littelfuse®

This *SIDACtor* device is a 3000 A solid state protection device offered in a non-isolated TO-263 (D^2) package. It protects equipment located in the severe surge environment of CATV (Community Antenna TV) systems and antenna locations.

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps **	I_H mAmps
P1500NEL	140	180	4	5	800	2.2/25	50
P1900NEL	140	220	4	5	800	2.2/25	50
P2300NEL	180	260	4	5	800	2.2/25	50

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For surge ratings, see table below.

** I_T is a free air rating; heat sink I_T rating is 25 A.

General Notes:

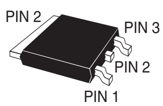
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

Surge Ratings in Amps

Series	I_{PP}	I_{TSM}	di/dt
	8x20 * 1.2x50 **	50 / 60 Hz	
	Amps	Amps	Amps/µs
E	3000	400	500

* Current waveform in µs
** Voltage waveform in µs

Thermal Conditions

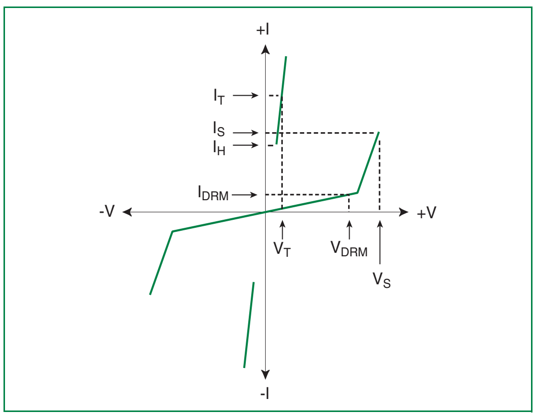
Package	Symbol	Parameter	Value	Unit
TO-263 D^2PAK 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	T_C	Maximum Case Temperature	100	°C
	$R_{\theta JC}$ *	Thermal Resistance: Junction to Case	1.7	°C/W
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	56	°C/W

* $R_{\theta JC}$ rating assumes the use of a heat sink and on state mode for extended time at 25 A, with average power dissipation of 29.125 W.

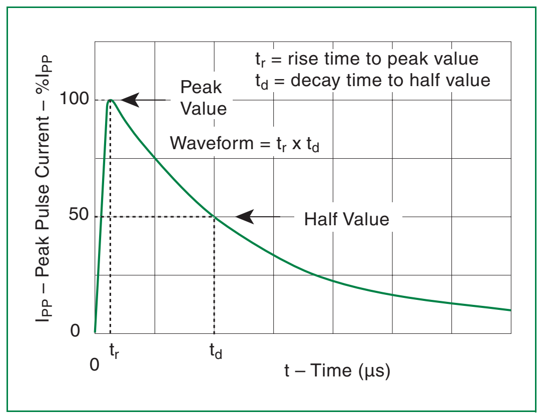
Capacitance Values

Part Number	pF	
	MIN	MAX
P1500NEL	260	650
P1900NEL	260	650
P2300NEL	350	600

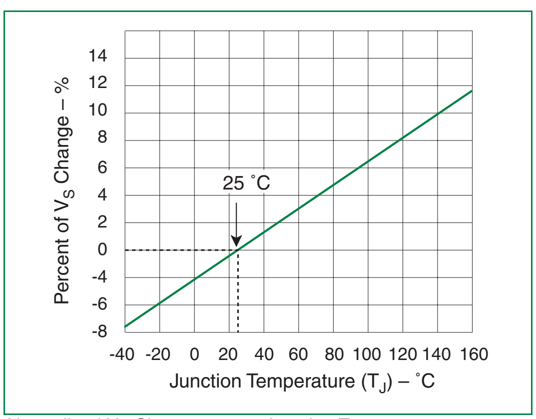
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



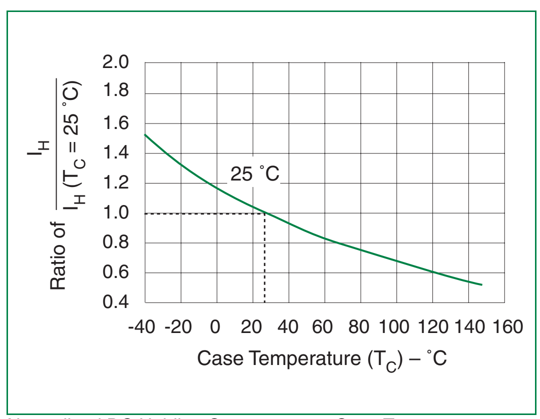
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

CATV Line Amplifiers/Power Inserters 3 kA *SIDACtor*® Device

RoHS

1  2

This *SIDACtor* device is a 3000 A solid state protection device offered in a non-isolated TO-220 package. It protects equipment located in the severe surge environment of CATV (Community Antenna TV) systems and antenna locations.

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps **	I_H mAmps
P1500REL	140	180	4	5	800	2.2/25	50
P1900REL	140	220	4	5	800	2.2/25	50
P2300REL	180	260	4	5	800	2.2/25	50

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For surge ratings, see table below.

** I_T is a free air rating; heat sink I_T rating is 25 A.

General Notes:

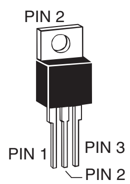
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

Surge Ratings in Amps

Series	I_{PP} 8x20 * 1.2x50 **	I_{TSM} 50 / 60 Hz	di/dt
	Amps	Amps	Amps/µs
E	3000	400	500

* Current waveform in µs
** Voltage waveform in µs

Thermal Considerations

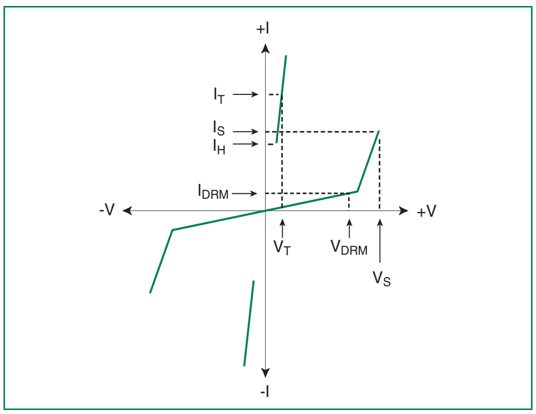
Package	Symbol	Parameter	Value	Unit
TO-220 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	T_C	Maximum Case Temperature	100	°C
	$R_{\theta JC}$ *	Thermal Resistance: Junction to Case	1.7	°C/W
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	56	°C/W

* $R_{\theta JC}$ rating assumes the use of a heat sink and on state mode for extended time at 25 A, with average power dissipation of 29.125 W.

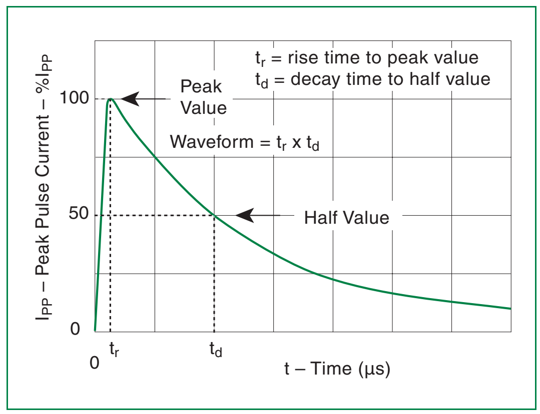
Capacitance Values

Part Number	pF	
	MIN	MAX
P1500REL	260	650
P1900REL	180	290
P2300REL	170	270

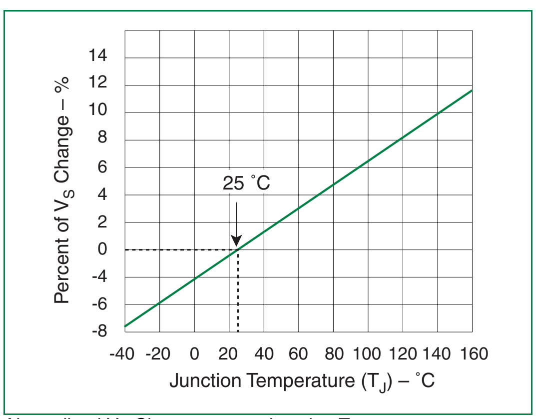
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



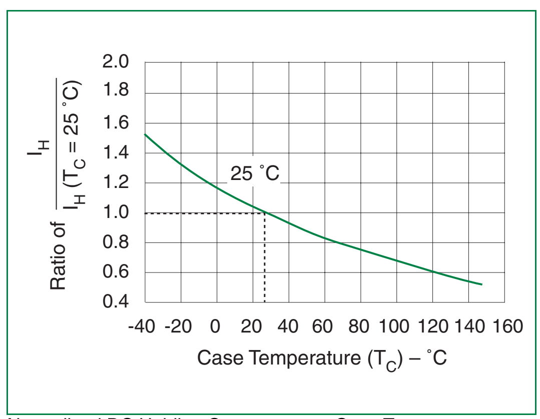
V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

CATV Line Amplifiers/Power Inserters 5 kA *SIDACtor*® Device

RoHS

Littelfuse®

1 2

This *SIDACtor* device is a 5000 A solid state protection device offered in a non-isolated TO-218 package. It protects equipment located in the severe surge environment of CATV (Community Antenna TV) systems and antenna locations.

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} μAmps	I_S mAmps	I_T Amps **	I_H mAmps
P1500MEL	140	180	4	5	800	2.2/25	50
P1900MEL	140	220	4	5	800	2.2/25	50
P2300MEL	180	260	4	5	800	2.2/25	50

* **"L" in part number indicates RoHS compliance.** For non-RoHS compliant device, delete "L" from part number.
For surge ratings, see table below.

** I_T is a free air rating; heat sink I_T rating is 25 A.

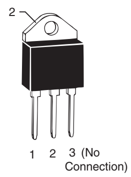
General Notes:
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/μs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

Surge Ratings in Amps

Series	I_{PP} 8x20 * 1.2x50 **	I_{TSM} 50 / 60 Hz	di/dt
	Amps	Amps	Amps/μs
E	5000	400	630

* Current waveform in μs
** Voltage waveform in μs

Thermal Conditions

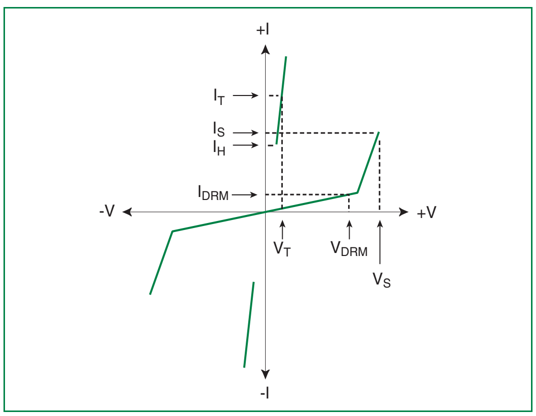
Package	Symbol	Parameter	Value	Unit
TO-218 	T_J	Operating Junction Temperature Range	-40 to +150	°C
	T_S	Storage Temperature Range	-65 to +150	°C
	T_C	Maximum Case Temperature	100	°C
	$R_{\theta JC}$ *	Thermal Resistance: Junction to Case	1.7	°C/W
	$R_{\theta JA}$	Thermal Resistance: Junction to Ambient	56	°C/W

$R_{\theta JC}$ rating assumes the use of a heat sink and on state mode for extended time at 25 A, with average power dissipation of 29.125 W.

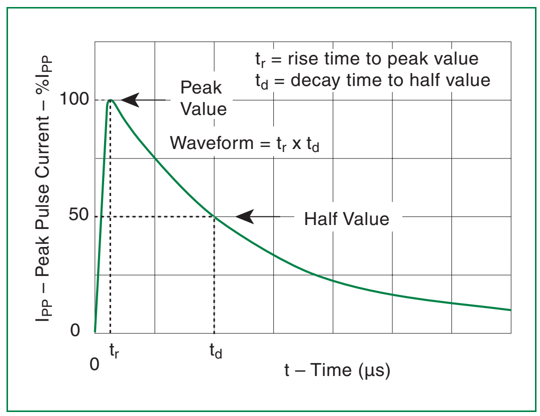
Capacitance Values

Part Number	pF MIN	pF MAX
P1500MEL	400	650
P1900MEL	400	650
P2300MEL	350	600

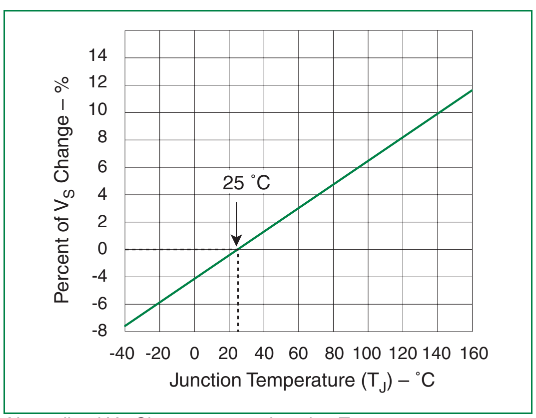
Note: Off-state capacitance (C_O) is measured at 1 MHz with a 2 V bias.



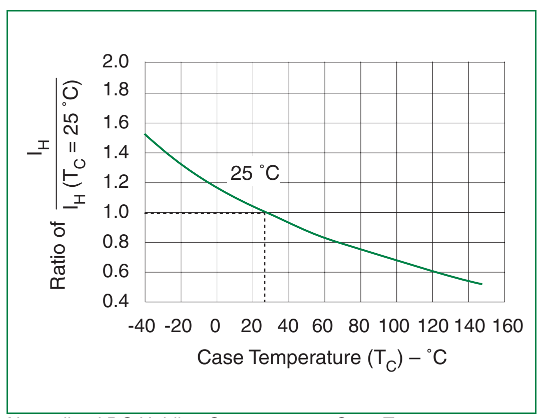
V-I Characteristics



t_r x t_d Pulse Waveform



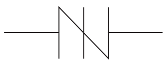
Normalized V_S Change versus Junction Temperature



Normalized DC Holding Current versus Case Temperature

SIDACtor® Cell

RoHS



SIDACtor cells are used in primary or secondary protection modules.

Electrical Parameters

Part Number *	V_{DRM} Volts	V_S Volts	V_T Volts	I_{DRM} µAmps	I_S mAmps	I_T Amps	I_H mAmps
P-T100-030	25	40	4	5	800	2.2	150
P-T100-064	58	77	4	5	800	2.2	150
P-T100-090	75	98	4	5	800	2.2	150
P-T100-150	140	180	4	5	800	2.2	150
P-T100-230	190	260	4	5	800	2.2	260
P-T100-350	320	400	4	5	800	2.2	260

General Notes:

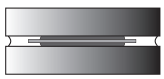
- All measurements are made at an ambient temperature of 25 °C. I_{PP} applies to -40 °C through +85 °C temperature range.
- I_{PP} is a repetitive surge rating and is guaranteed for the life of the product.
- Listed *SIDACtor* devices are bi-directional. All electrical parameters and surge ratings apply to forward and reverse polarities.
- V_{DRM} is measured at I_{DRM}.
- V_S is measured at 100 V/µs.
- Special voltage (V_S and V_{DRM}) and holding current (I_H) requirements are available upon request.

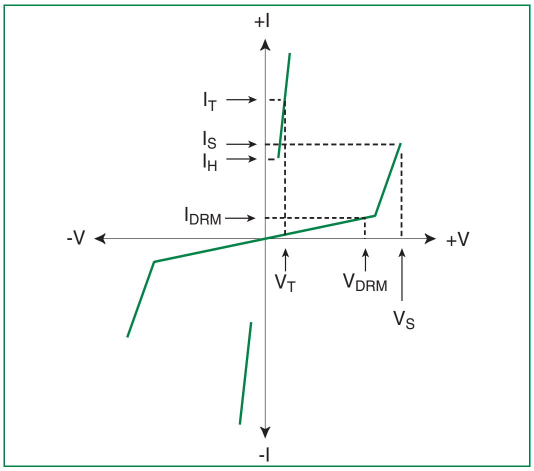
Surge Ratings in Amps

Series	I_{PP}									I_{TSM}	
	0.2x310 * 0.5x700 **	2x10 * 2x10 **	8x20 * 1.2x50 **	10x160 * 10x160 **	10x560 * 10x560 **	5x320 * 9x720 **	10x360 * 10x360 **	10x1000 * 10x1000 **	5x310 * 10x700 **	50 / 60 Hz	di/dt
	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps	Amps/µs
C	50	500	400	200	150	200	175	100	200	30	500

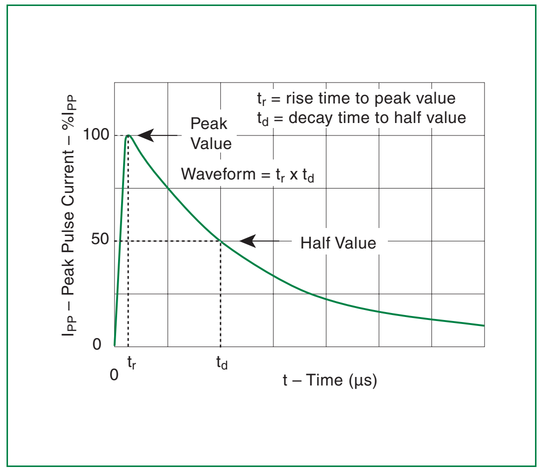
* Current waveform in µs
** Voltage waveform in µs

Thermal Considerations

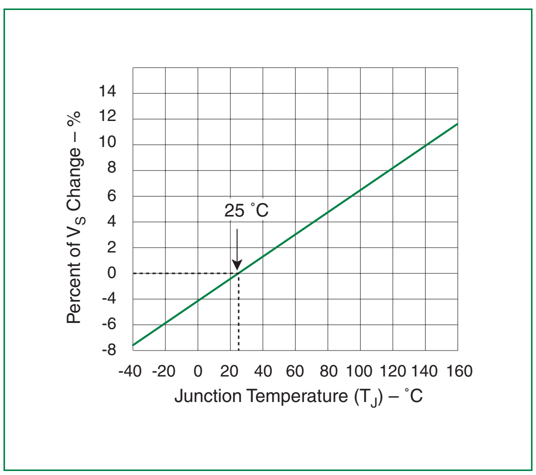
Package	Symbol	Parameter	Value	Unit
[Cell]	T_J	Operating Junction Temperature Range	-40 to +65	°C
	T_S	Storage Temperature Range	-65 to +150	°C



V-I Characteristics



t_r x t_d Pulse Waveform



Normalized V_S Change versus Junction Temperature

4 Electronic Fuses

This section presents complete electrical specifications for Littelfuse's board-level electronic fuses.

461 Series *TeleLink*® Fuse

RoHS

The *TeleLink* Surface Mount (SM) surge resistant fuse offers circuit protection without requiring a series resistor. When used in conjunction with the *SIDACtor*® Transient Voltage Suppressor (TVS), the *TeleLink* SM fuse and the *SIDACtor* TVS provide a complete regulatory-compliant solution for standards such as GR 1089, TIA-968-A (formerly known as FCC Part 68), UL 60950, and ITU K.20 and K.21. No series resistor is required for the 04611.25 and 0461002. to comply with these standards.

Contact factory for enhanced K.20 and K.21 details.

Surge Ratings

TeleLink SM Fuse	I_{PP} 2x10 µs Amps	I_{PP} 10x160 µs Amps	I_{PP} 10x560 µs Amps	I_{PP} 10x1000 µs Amps
0461.500	100	65	45	35
04611.25	500	160	115	100
0461002.	500	160	115	100

Interrupting Values

TeleLink SM Fuse *	Voltage Rating	Current Rating	I^2t Measured at DC Rated Voltage	Interrupting Rating			
				Voltage, Current	MIN	TYP	MAX
0461.500	600 V	.500 A	1.3 A^2Sec	600 V, 40 A	1 ms	2 ms	60 ms
04611.25	600 V	1.25 A	22.2 A^2Sec	600 V, 60 A	1 ms	2 ms	60 ms
0461002.	600 V	2 A	30 A^2Sec	600 V, 60 A	1 ms	2 ms	60 ms

* For non-RoHS tin/lead device, add "T" suffix.

Notes:
- The *TeleLink* SM fuse is designed to carry 100% of its rated current for four hours and 250% of its rated current for one second minimum and 120 seconds maximum. Typical time is four to 10 seconds. For optimal performance, an operating current of 75% or less is recommended.
- I^2t is a non-repetitive RMS surge current rating for a period of 16.7 ms.

Resistance Ratings

TeleLink SM Fuse	Typical Voltage Drop @ Rated Current	DC Cold Resistance	
		MIN	MAX
0461.500	0.471 V	0.420 Ω	0.640 Ω
04611.25	0.205 V	0.107 Ω	0.150 Ω
0461002.	0.110 V	0.050 Ω	0.100 Ω

Notes:
- Typical inductance < 40 nH up to 500 MHz.
- Resistance changes 0.5% for every °C.
- Resistance is measured at 10% rated current.

Qualification Data

The 04611.25 and 0461002. meet the following test conditions per GR 1089 **without** additional series resistance. However, in-circuit test verification is required. Note that considerable heating may occur during Test 4 of the Second Level AC Power Fault Test.

First Level Lightning Surge Test

Test	Surge Voltage Volts	Wave-form µs	Surge Current Amps	Repetitions Each Polarity
1	±600	10x1000	100	25
2	±1000	10x360	100	25
3	±1000	10x1000	100	25
4	±2500	2x10	500	10
5	±1000	10x360	25	5

Second Level Lightning Surge Test

Test	Surge Voltage Volts	Wave-form µs	Surge Current Amps	Repetitions Each Polarity
1	±5000	2x10	500	1

Electronic Fuses

First Level AC Power Fault Test

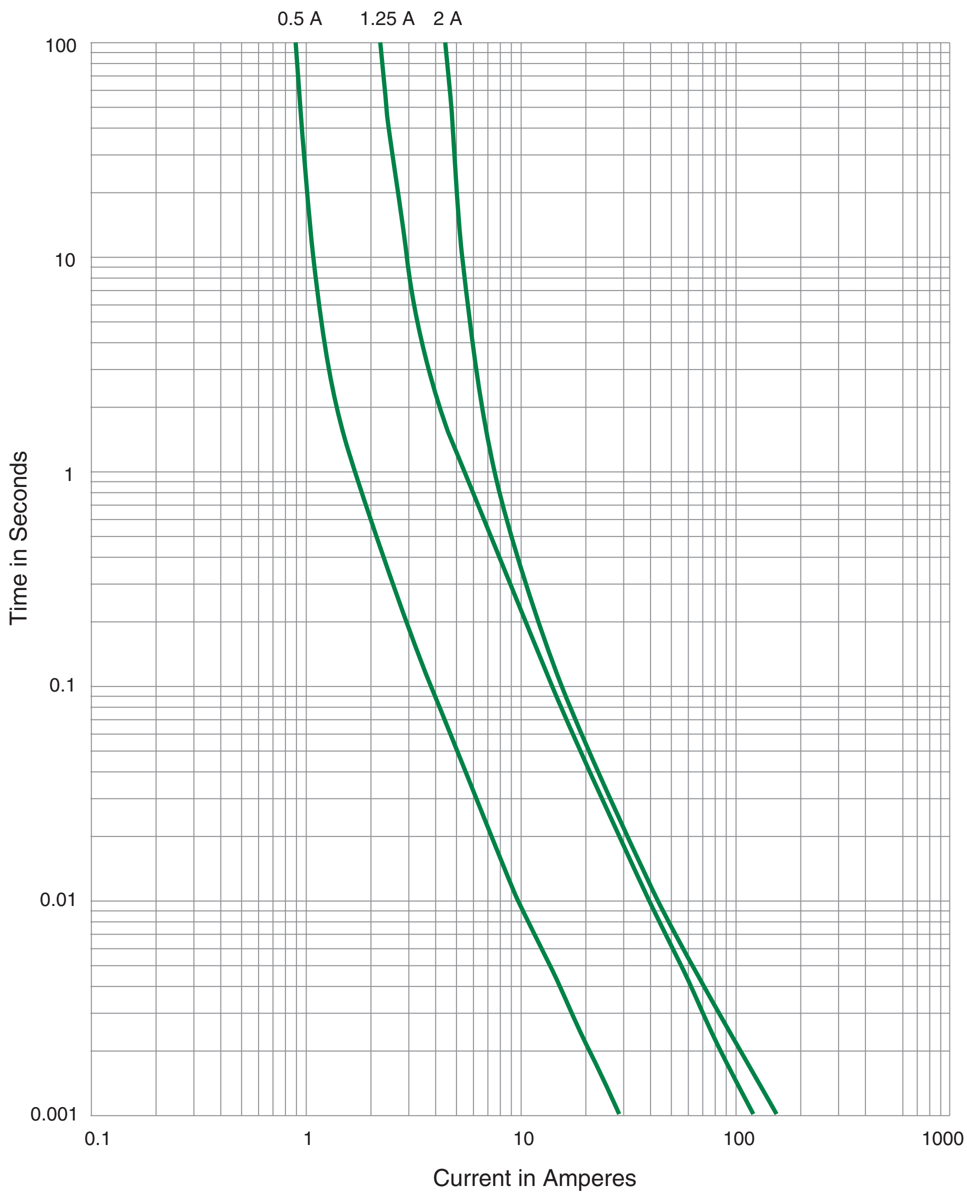
Test	Applied Voltage, 60 Hz V_{RMS}	Short Circuit Current Amps	Duration
1	50	0.33	15 min
2	100	0.17	15 min
3	200, 400, 600	1 at 600 V	60 applications, 1 s each
4	1000	1	60 applications, 1 s each
5	*	*	60 applications, 5 s each
6	600	0.5	30 s each
7	600	2.2	2 s each
8	600	3	1 s each
9	1000	5	0.5 s each

* Test 5 simulates a high impedance induction fault. For specific information, contact Littelfuse, Inc.

Second Level AC Power Fault Test for Non-customer Premises Equipment

Test	Applied Voltage, 60 Hz V_{RMS}	Short Circuit Current Amps	Duration
1	120, 277	30	30 min
2	600	60	5 s
3	600	7	5 s
4	100-600	2.2 at 600 V	30 min

Notes:
- Power fault tests equal or exceed the requirements of UL 60950 3rd edition.
- Test 4 is intended to produce a maximum heating effect. Temperature readings can exceed 150 °C.
- Use caution when routing internal traces adjacent to the 04611.25 and 0461002.



Time Current Curve

Temperature Derating Curve

Operating temperature is -55 °C to +125 °C with proper correction factor applied.

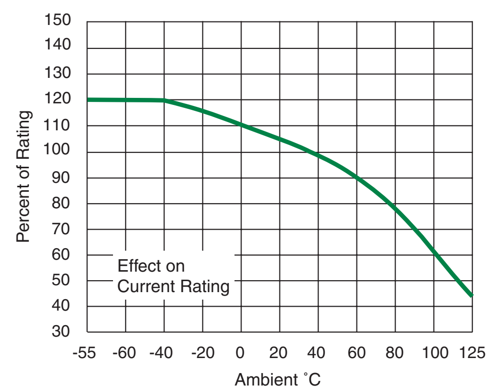


Chart of Correction Factor

Maximum Temperature Rise

TeleLink Fuse	Temperature Reading
0461.500	≤ 75 °C (167 °F) *
04611.25	≤ 82 °C (180 °F) *
0461002.	≤ 50 °C (122 °F) *

* Higher currents and PCB layout designs can affect this parameter.

Notes:

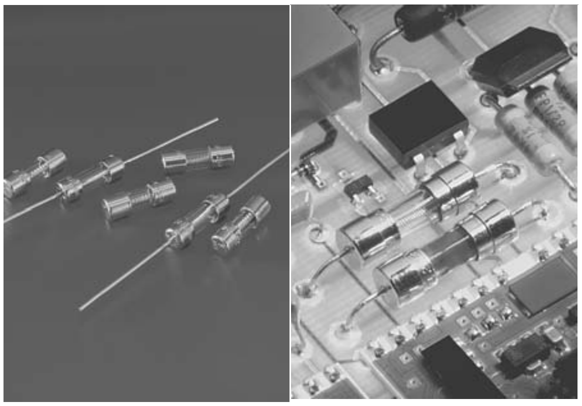
- Readings are measured at rated current after temperature stabilizes
- The 04611.25 meets the requirements of UL 248-14. However, board layout, board trace widths, and ambient temperature values can cause higher than expected rises in temperature.

Electronic Fuses

229P / 230P Series 2AG *Slo-Blo*® Fuse

RoHS

Littelfuse®



The 2AG *Slo-Blo* fuses are available in cartridge form or with axial leads (board washable). The "P" suffix indicates that the fuse is a lead-free, RoHS-compliant device. These fuses provide the same performance characteristics as the 3AG counterpart while occupying one-third the space.

The fuses combine conventional overcurrent protection with the ability to withstand high-current, short-duration pulses. They meet demanding telecom requirements and comply with the short circuit requirements of UL 1459. An insulating sleeve option is available.

For environmental and physical specifications and soldering parameters, see www.littelfuse.com.

The 2AG Indicating *Slo-Blo* fuse instantly identifies itself upon opening by showing a discoloration of its glass body, eliminating guesswork and time-consuming circuit testing.

Electrical Characteristics

% of Ampere Rating	Opening Time	
	MIN	MAX
100	4 hours	—
135	—	1 hour
200	3 s	20 s

Note: Short circuit capabilities for 60 A, 40 A, 7 A, and 2.2 A are 600 V ac.

Interrupting Values

Current Rating Amps	Interrupting Values V ac
0.25–3.5	10,000 A at 125
4–7	400 A at 125
0.25–1	35 A at 250
1.25–3.5	100 A at 250

Surge Ratings

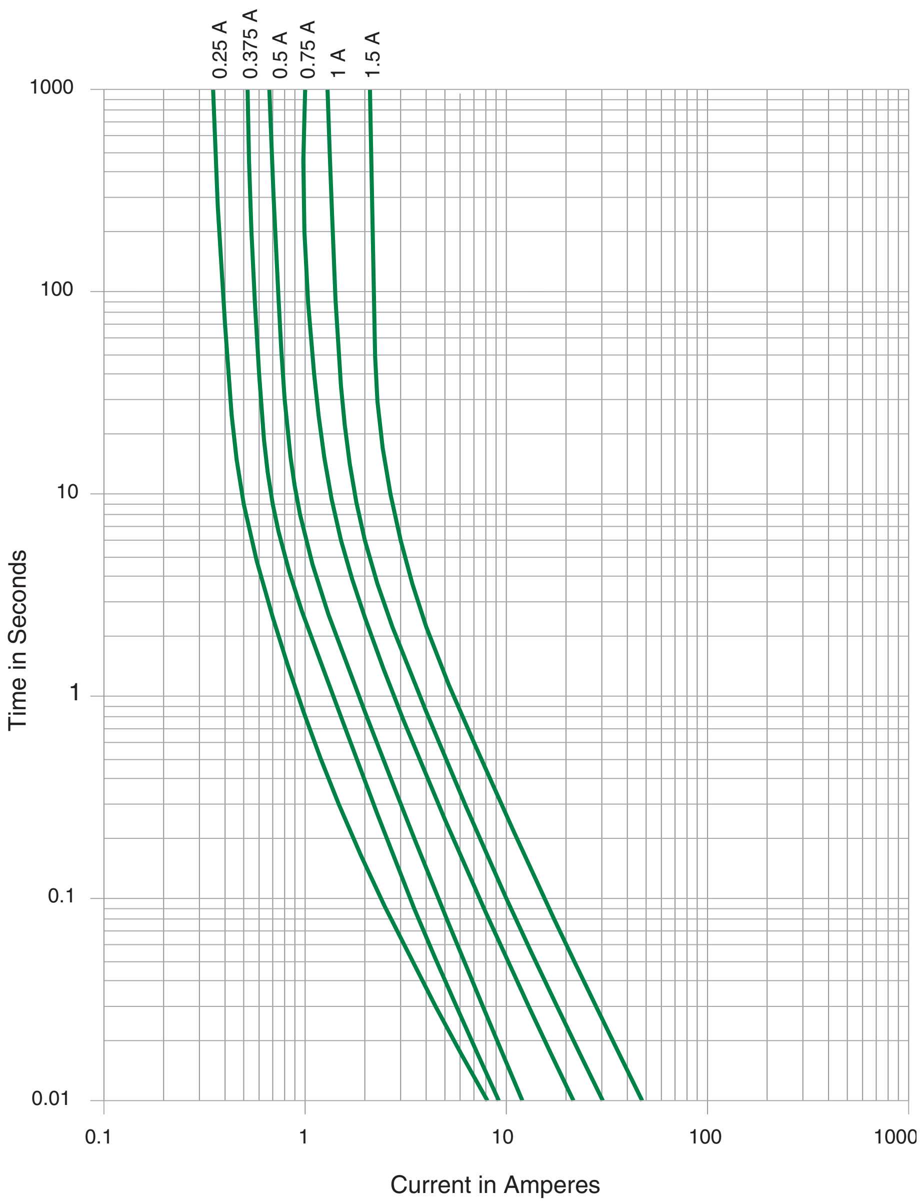
Cartridge Part Number	Axial Lead Part Number	I_{PP} 2x10 µs @ 2500 V Amps	I_{PP} 10x160 µs @ 1500 V Amps	I_{PP} 10x560 µs @ 800 V Amps	I_{PP} 10x1000 µs @ 1000 V Amps
0229.250P	**0230.250P**	not rated	23	16.6	12.4
0229.350P	**0230.350P**	not rated	34	25.8	19.3
0229.375P	**0230.375P**	not rated	40	25.4	19
0229.500P	**0230.500P**	not rated	60	37.7	28.2
0229.600P	**0230.600P**	not rated	71	47.2	35.3
0229.750P	**0230.750P**	not rated	91	65.5	49
0229.800P	**0230.800P**	not rated	104	68.9	51.6
0229001.P	**0230001.P**	not rated	130	88.6	66.3
02291.25P	**02301.25P**	500	162	118.1	100

Notes:
- Fuses withstand 50 repetitions of a double exponential impulse wave at listed currents and voltages, except that the 02291.25P / 02301.25P fuse withstands 20 repetitions at 2x10 µs @ 2500 V.
- To order an indicating 2AG *Slo-Blo* fuse, add an "S" at the end of the part number (for example, 0230001S.P).

Electronic Fuses

Electrical Parameters

Cartridge Part Number	Axial Lead Part Number	Voltage Rating	Current Rating Amps	I^2t Measured at DC Rated Voltage A^2Sec	Typical DC Cold Resistance Ohms
0229.250P	**0230.250P**	250	0.25	0.216	2.41
0229.350P	**0230.350P**	250	0.35	0.49	1.3
0229.375P	**0230.375P**	250	0.375	0.58	1.17
0229.500P	**0230.500P**	250	0.5	1.16	0.688
0229.600P	**0230.600P**	250	0.6	1.75	0.477
0229.750P	**0230.750P**	250	0.75	2.95	0.340
0229.800P	**0230.800P**	250	0.8	3.45	0.304
0229001.P	**0230001.P**	250	1	5.64	0.212
02291.25P	**02301.25P**	250	1.25	9.8	0.145

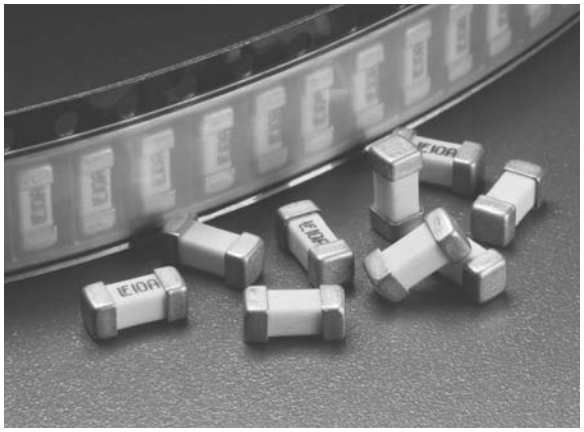


Time Current Curve

451 / 453 Series *NANO*^{2}® Very Fast-Acting Fuse

RoHS

Littelfuse®



The *NANO*^{2} SMF fuse is a very small, square surface mount fuse also available in a surface mount holder.

For environmental and physical specifications and soldering parameters, see www.littelfuse.com.

The recommended fuse block for the 451 / 453 Series fuse is the SMF *OMNI-BLOK*® Holder, Series 154000.

Electronic Fuses

Electrical Characteristics

% of Ampere Rating	Ampere Rating	Opening Time MIN	Opening Time MAX
100	0.625–15 A	4 hours	—
200	0.625–10 A	—	5 s
	12–15 A	—	20 s

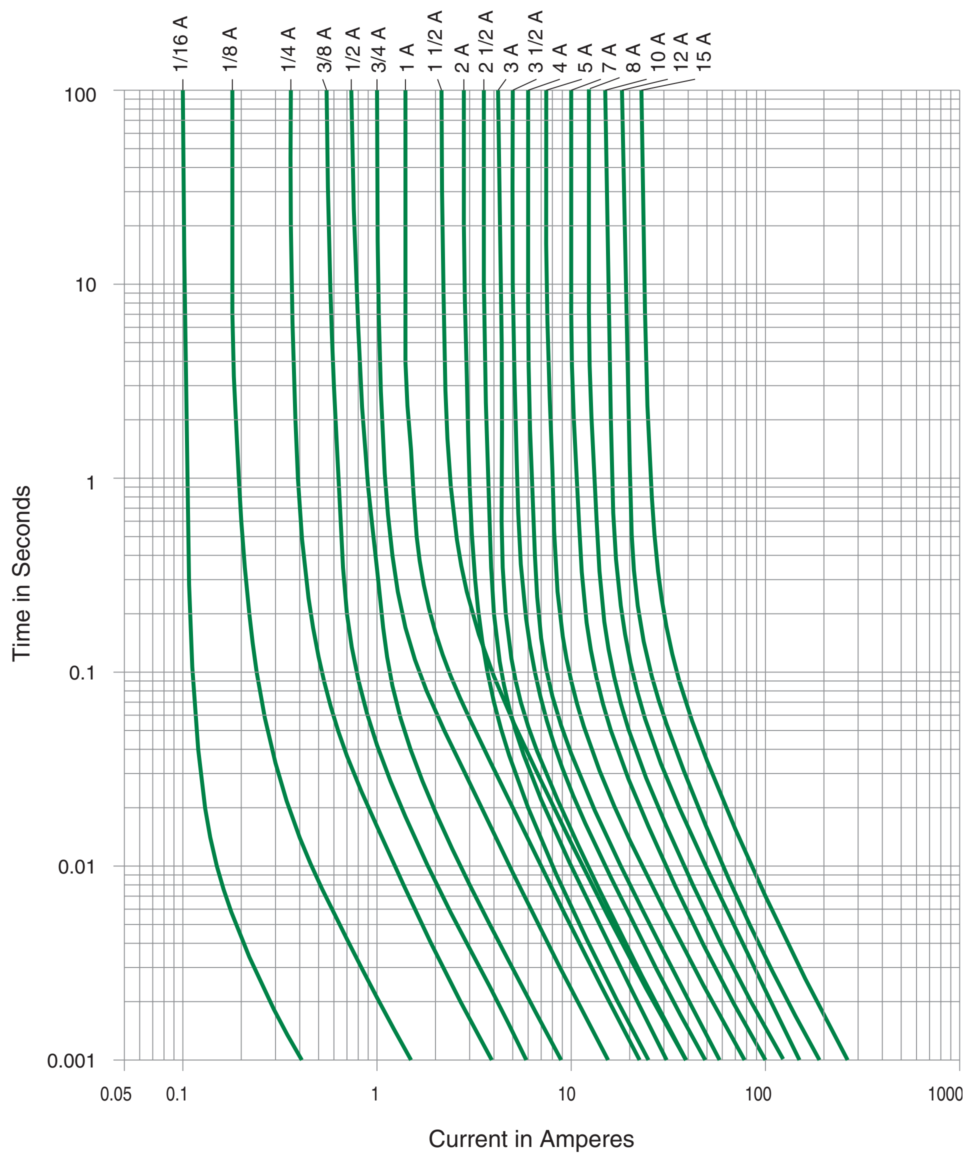
Interrupting Values

Current Rating Amps	Interrupting Values
0.625–8	50 A at 125 V ac / V dc
	300 A at 32 V dc
10	35 A at 125 V ac / 50 A at 125 V dc
	300 A at 32 V dc
12–15	50 A at 65 V ac / V dc
	300 A at 24 V dc

Electrical Parameters

Tin-lead Plated Part Number *	Silver Plated Part Number *	Voltage Rating	Current Rating Amps	I^2t Measured at DC Rated Voltage A^2Sec	Typical DC Cold Resistance Ohms
—	**0451.062**	125	0.062	0.00019	5.5
—	**0451.080**	125	0.080	0.00033	4.05
—	**0451.100**	125	0.100	0.00138	3.10
—	**0451.125**	125	0.125	0.00286	1.70
0451.160	**0453.160**	125	0.160	0.00306	1.80
0451.200	**0453.200**	125	0.200	0.00652	1.40
0451.250	**0453.250**	125	0.250	0.01126	1.05
0451.315	**0453.315**	125	0.315	0.0231	0.78
0451.375	**0453.375**	125	0.375	0.0425	0.61
0451.400	**0453.400**	125	0.400	0.0484	0.56
0451.500	**0453.500**	125	0.500	0.0795	0.42
0451.630	**0453.630**	125	0.630	0.143	0.305
0451.750	**0453.750**	125	0.750	0.185	0.245
0451.800	**0453.800**	125	0.800	0.271	0.212
0451001.	**0453001.**	125	1	0.459	0.153
04511.25	**04531.25**	125	1.25	0.664	0.078
045101.5	**045301.5**	125	1.5	0.853	0.063
045101.6	**045301.6**	125	1.6	1.06	0.058
0451002.	**0453002.**	125	2	0.53	0.0367
045102.5	**045302.5**	125	2.5	1.029	0.0286
0451003.	**0453003.**	125	3	1.65	0.0227
04513.15	**04533.15**	125	3.15	1.92	0.0215
045103.5	**045303.5**	125	3.5	2.469	0.0200
0451004.	**0453004.**	125	4	3.152	0.0160
0451005.	**0453005.**	125	5	5.566	0.0125
045106.3	**045306.3**	125	6.3	9.17	0.0096
0451007.	**0453007.**	125	7	10.32	0.009
0451008.	**0453008.**	125	8	20.23	0.0077
0451010.	**0453010.**	125	10	26.46	0.0056
0451012.	**0453012.**	65	12	47.97	0.0049
0451015.	**0453015.**	65	15	97.82	0.0037

* For RoHS compliant 451 series parts, add the letter “L” to the end of the packaging suffix. For example, 0451001.MRL indicates RoHS compliant 1 A, 1,000 pieces per reel.

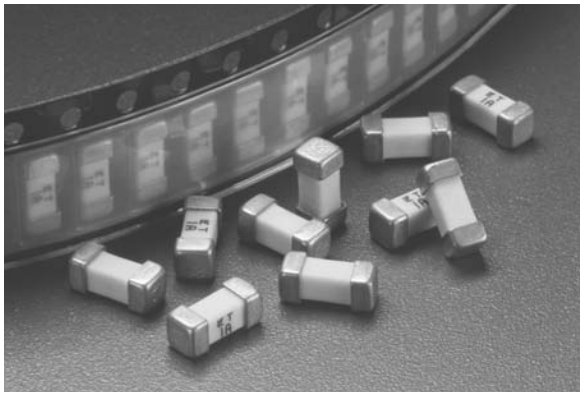


Time Current Curve

Electronic Fuses

452 / 454 Series *NANO*^{2}® *Slo-Blo*® Fuse

RoHS



The *NANO*^{2} *Slo-Blo* fuse has enhanced inrush withstand characteristics over the *NANO*^{2} fast-acting fuse. The unique time delay feature of this fuse design helps solve the problem of nuisance "opening" by accommodating inrush currents that normally cause a fast acting fuse to open.

The recommended fuse block for the 452 / 454 Series *Slo-Blo* fuse is the SMF *OMNI-BLOK*® Holder, Series 154000T.

Electrical Characteristics

% of Ampere Rating	Opening Time	
	MIN	MAX
100	4 hours	—
200	1 s	60 s
300	0.2 s	3 s
800	0.02 s	0.1 s

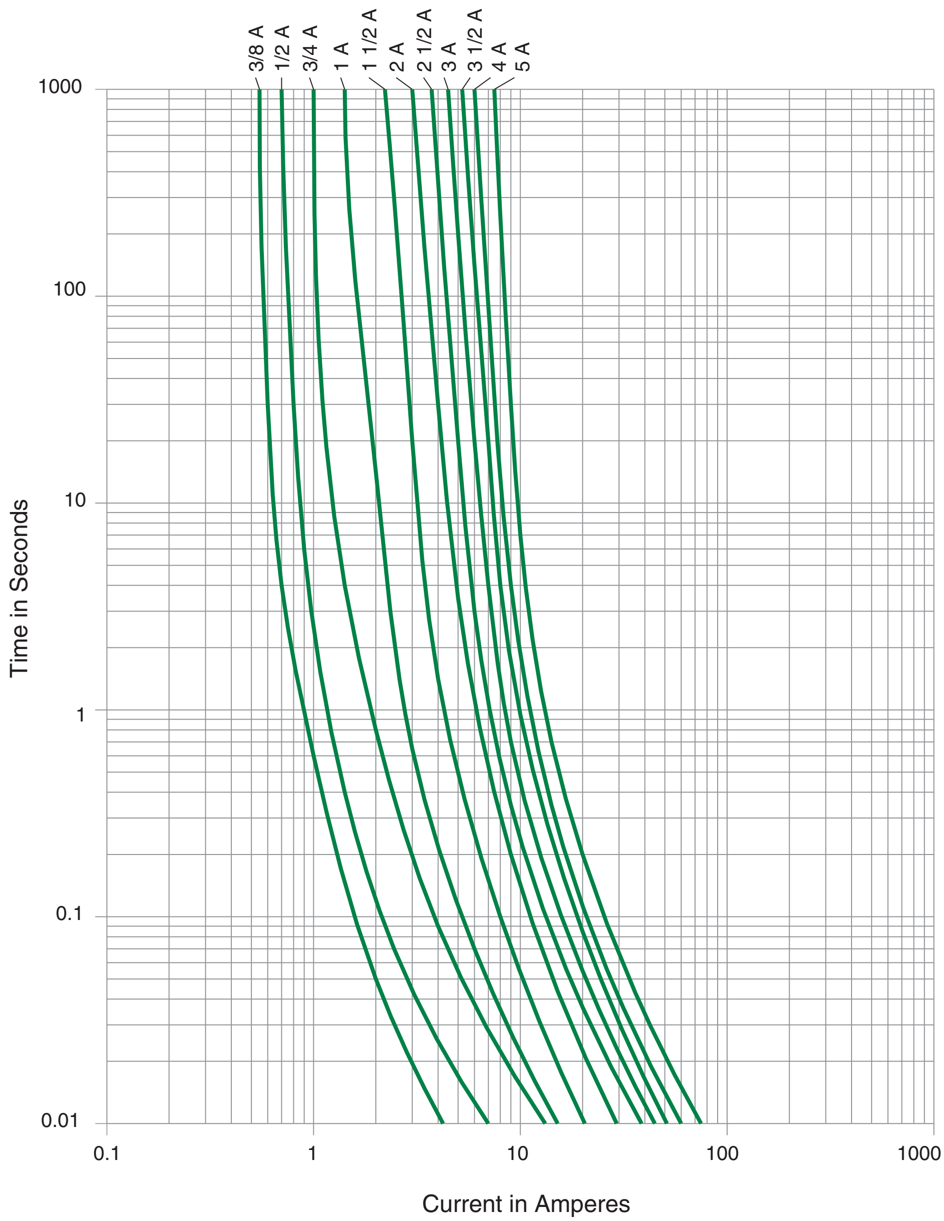
Interrupting Values

Current Rating Amps	Interrupting Values V ac / V dc
0.375–5	50 A at 125

Electrical Parameters

Tin-lead Plated Part Number *	Silver Plated Part Number *	Voltage Rating	Current Rating Amps	I^2t Measured at DC Rated Voltage A^2Sec	Typical DC Cold Resistance Ohms
0452.375	**0454.375**	125	0.375	0.101	1.2
0452.500	**0454.500**	125	0.5	0.240	0.7
0452.750	**0454.750**	125	0.75	0.904	0.36
0452001.	**0454001.**	125	1	1.98	0.225
045201.5	**045401.5**	125	1.5	3.65	0.093
0452002.	**0454002.**	125	2	8.2	0.0625
045202.5	**045402.5**	125	2.5	15	0.045
0452003.	**0454003.**	125	3	20.16	0.034
045203.5	**045403.5**	125	3.5	26.53	0.0224
0452004.	**0454004.**	125	4	34.4	0.0186
0452005.	**0454005.**	125	5	53.72	0.0136

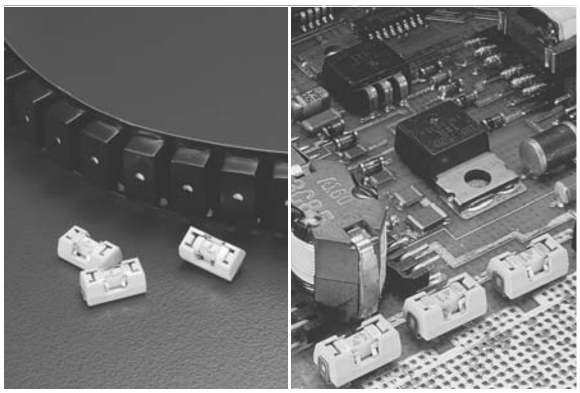
* For RoHS compliant 452 series parts, add the letter "L" to the end of the packaging suffix. For example, 0452001.MRL indicates RoHS compliant 1 A, 1,000 pieces per reel.



Time Current Curve

154 Series SMF *OMNI-BLOK*® Fuse Block

RoHS



The SMF *OMNI-BLOK* fuseholder permits quick and easy replacement of *NANO*$^{2®}$ SMF surface mount fuses. The fuse block and pre-installed fuse combination can be placed on the PC board in one efficient manufacturing operation. Fuses can be replaced without exposing the PC board to the detrimental effects of solder heat.

Electrical Parameters

Fuseholder with Very Fast-Acting Fuse		Fuseholder with *Slo-Blo* Fuse		
Fuseholder Part Number	Very Fast-Acting Fuse Furnished *	Fuseholder Part Number	*Slo-Blo* Fuse Furnished **	Current Rating Amps
154.062	0453.062	—	—	0.0625
154.125	0453.125	—	—	0.125
154.250	0453.250	—	—	0.25
154.375	0453.375	154.375T	0454.375	0.375
154.500	0453.500	154.500T	0454.500	0.5
154.750	0453.750	154.750T	0454.750	0.75
154001.	0453001.	154001T	0454001.	1
15401.5	045301.5	15401.5T	045401.5	1.5
154002.	0453002.	154002T	0454002.	2
15402.5	045302.5	15402.5T	045402.5	2.5
154003.	0453003.	154003T	0454003.	3
15403.5	045303.5	15403.5T	045403.5	3.5
154004.	0453004.	154004T	0454004.	4
154005.	0453005.	154005T	0454005.	5
154007.	0453007.	—	—	7
154008.	0453008.	—	—	8
154010.	0453010.	—	—	10

* 453 Series fuse has silver-plated end caps, installed to accommodate solder reflow process.

** 454 Series fuse has silver-plated end caps, installed to accommodate solder reflow process.

464 Series *NANO*^{2}® 250 V UMF Fast-Acting Fuse

RoHS

Littelfuse®

The Surface Mount *NANO*^{2} 250 V UMF product family is based on the proven *NANO*^{2} fuse product technology.

It complies with IEC Publication IEC 60127-4- Universal Modular Fuse-Links (UMF). This IEC standard is accepted by UL/CSA, making it the first global fuse standard.

This fuse family is RoHS compliant and compatible with lead-free solders and higher temperature profiles.

For environmental and physical specifications and soldering parameters, see www.littelfuse.com.

Electrical Characteristics

% of Ampere Rating	Opening Time	
	MIN	MAX
125	1 hour	—
200	—	2 min
1000	0.001 s	0.01 s

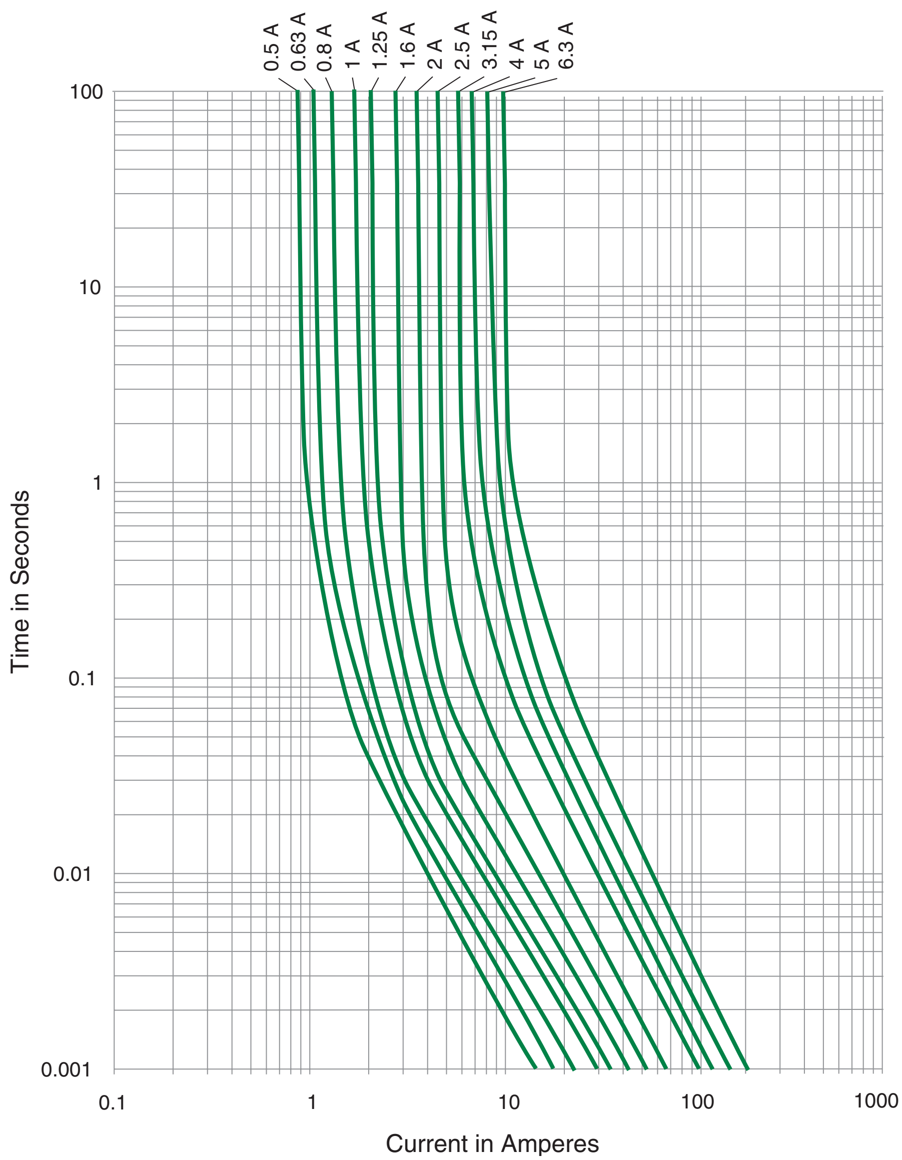
Interrupting Values

Current Rating Amps	Interrupting Values V ac
0.5–6.3	100 A at 250

Electrical Parameters

Part Number	Voltage Rating	Current Rating Amps	I^2t Measured at DC Rated Voltage A^2Sec	Typical DC Cold Resistance Ohms
0464.500	250	0.5	0.3	0.283
0464001.	250	1	0.8	0.1
04641.25	250	1.25	1.2	0.059
046401.6	250	1.6	1.9	0.048
0464002.	250	2	2.8	0.038
046402.5	250	2.5	4.5	0.032
04643.15	250	3.15	9.4	0.024
0464004.	250	4	15.1	0.018
0464005.	250	5	23.1	0.014
046406.3	250	6.3	40	0.011

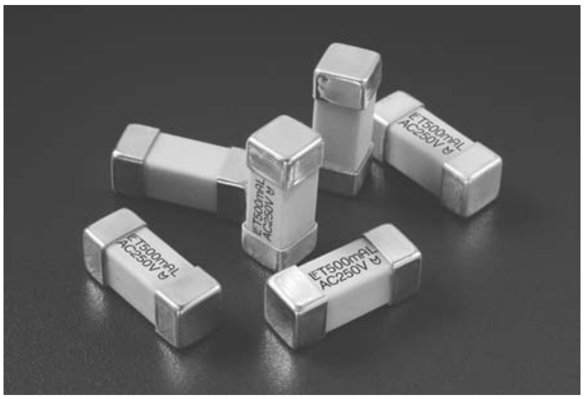
Note: For information and availability of additional ratings, contact Littelfuse.



Time Current Curve

465 Series *NANO*$^{2®}$ 250 V UMF Time Lag Fuse

RoHS



The Surface Mount *NANO*^{2} 250 V UMF product family is based on the proven *NANO*^{2} fuse product technology.

It complies with IEC Publication IEC 60127-4-Universal Modular Fuse-Links (UMF). This IEC standard is accepted by UL/CSA, making it the first global fuse standard.

This fuse family is RoHS compliant and compatible with lead-free solders and higher temperature profiles.

For environmental and physical specifications and soldering parameters, see www.littelfuse.com.

Electronic Fuses

Electrical Characteristics

% of Ampere Rating	Opening Time	
	MIN	MAX
125	1 hour	—
200	—	2 min
1000	0.01 s	0.1 s

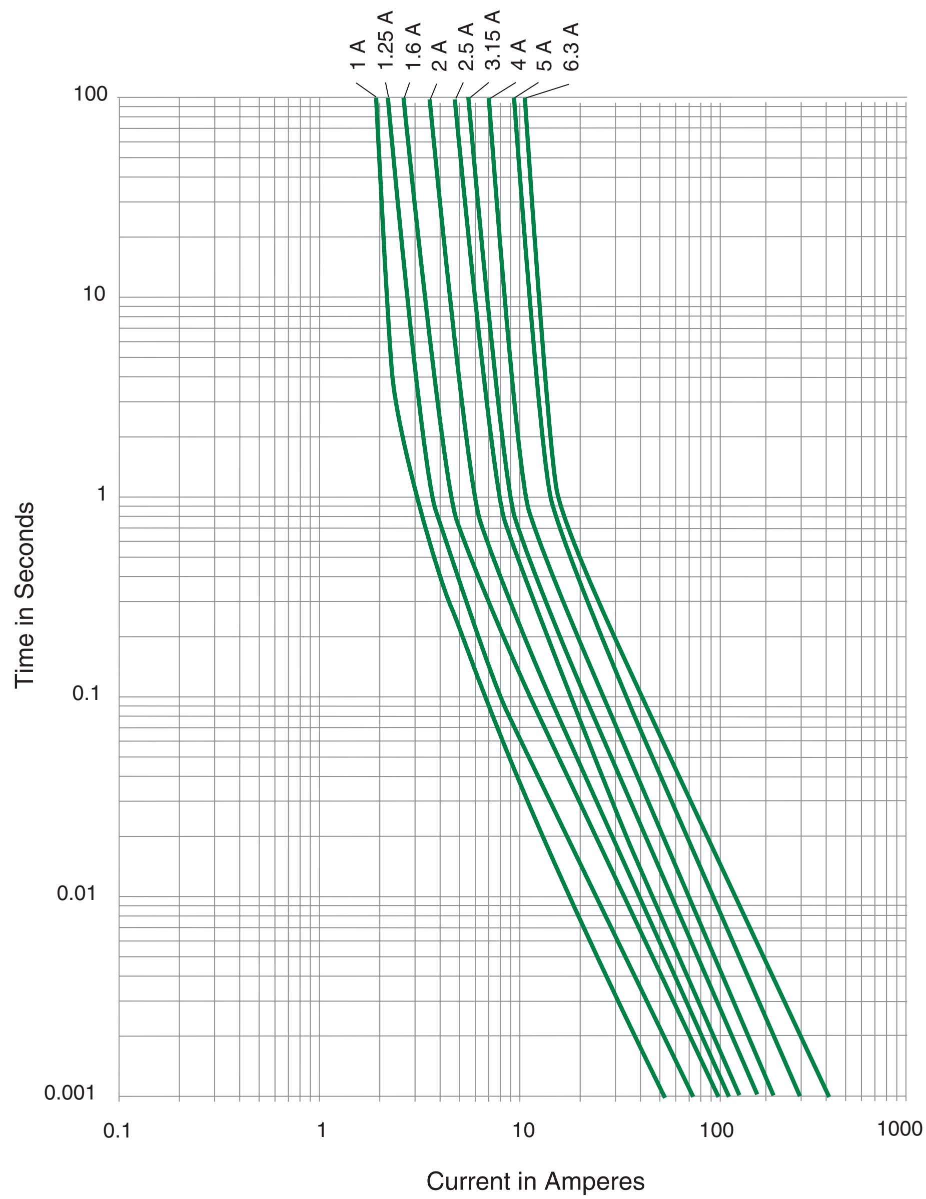
Interrupting Values

Current Rating Amps	Interrupting Values V ac
1–6.3	100 A at 250

Electrical Parameters

Part Number	Voltage Rating	Current Rating Amps	I^2t Measured at DC Rated Voltage A^2Sec	Typical DC Cold Resistance Ohms
0465001.	250	1	2.8	0.107
04651.25	250	1.25	5.6	0.083
046501.6	250	1.6	9.2	0.056
0465002.	250	2	14.9	0.039
046502.5	250	2.5	21	0.026
04653.15	250	3.15	31.7	0.021
0465004.	250	4	48.4	0.016
0465005.	250	5	87	0.013
046506.3	250	6.3	144.4	0.0088

Note: For information and availability of additional ratings, contact Littelfuse.



Time Current Curve

481 Series Alarm Indicating Fuse

The 481 Series Alarm Indicating Fuse is ideal for telecommunications and control panel circuits. It eliminates down time by immediately pinpointing the blown (open) circuit, triggering LED or audio alarm while placed in mating holder (482 Series).

A clear plastic lens option is available for additional safety.

For environmental and physical specifications, see www.littelfuse.com.

Electronic Fuses

Electrical Characteristics

% of Ampere Rating	Opening Time	
	MIN	MAX
100	10 min	—
150	—	5 min

Interrupting Values

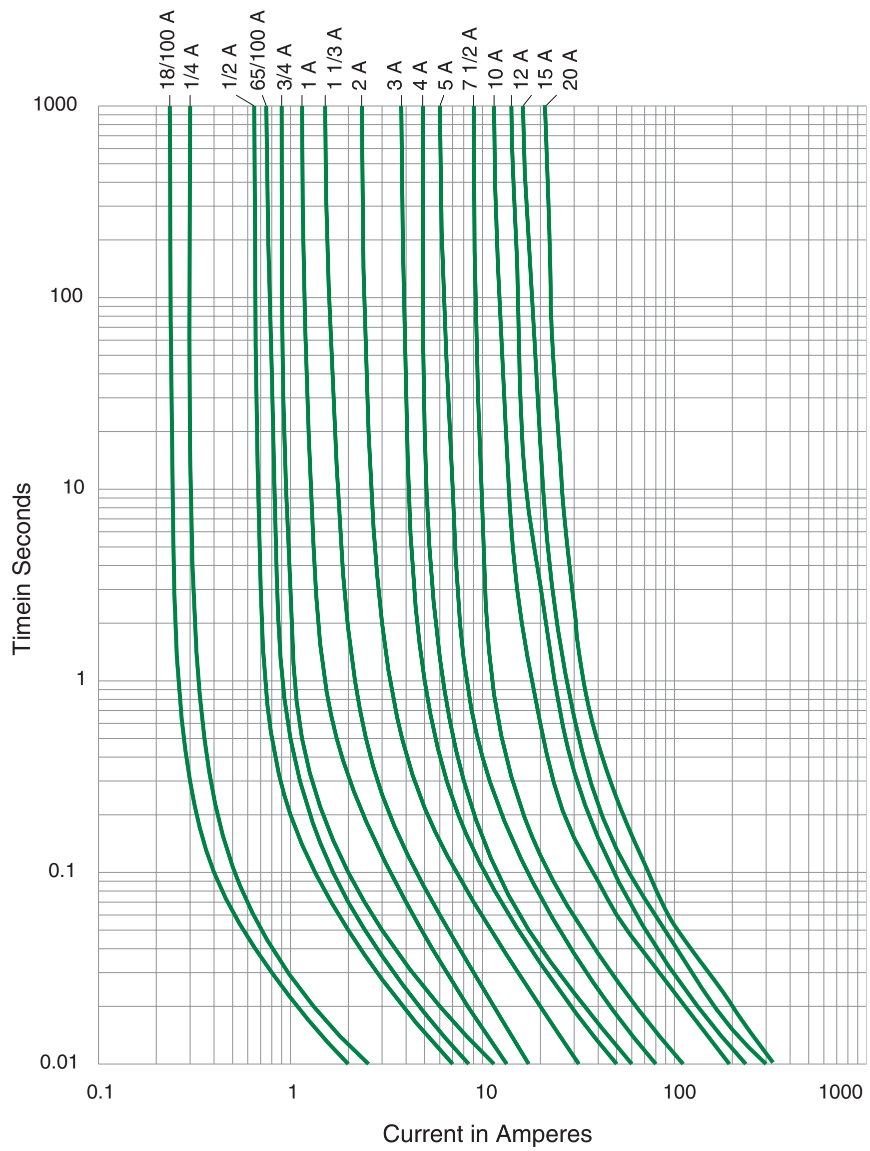
Current Rating Amps	Interrupting Values
—	450 A at 60 V dc
Up to 20	300 A at 125 V ac
Up to 15	300 A at 125 V dc
Up to 20	200 A at 125 V dc

Electrical Parameters

Part Number	Voltage Rating V AC & V DC	Current Rating Amps	Body Color Code	I^2t Measured at DC Rated Voltage A^2Sec	Typical DC Cold Resistance Ohms
0481.180	125	0.18	Yellow	0.00808	6.25
0481.200	125	0.2	Red / Black	0.0140	5.7
0481.250	125	0.25	Violet	0.0356	4.2
0481.375	125	0.375	Gray / White	0.028	2
0481.500	125	0.5	Red	0.139	1.52
0481.650	125	0.65	Black	0.278	1.25
0481.750	125	0.75	Brown	0.363	0.98
0481001.	125	1	Gray	0.733	0.665
04811.33	125	1.33	White	1.58	0.48
048101.5	125	1.5	Yellow / White	2.55	0.385
0481002.	125	2	Orange	5.29	0.12
048102.5	125	2.5	Orange / White	9.46	0.0904
0481003.	125	3	Blue	11.2	0.067
048103.5	125	3.5	Blue / White	10.5	0.0415
0481004.	125	4	Brown / White	15.4	0.035
0481005.	125	5	Green	26.2	0.0285
048107.5	125	7.5	Black / White	42.8	0.0113
0481010.	125	10	Red / White	115.3	0.0084
0481012.	125	12	Green / Yellow	222.5	0.0066
0481015.	125	15	Red / Blue	294.22	0.0058
0481020.	125	20 *	Green / White	570	0.00394
0481000.	125	Dummy	Ø	—	—

* For information and availability of additional ratings, contact Littelfuse.

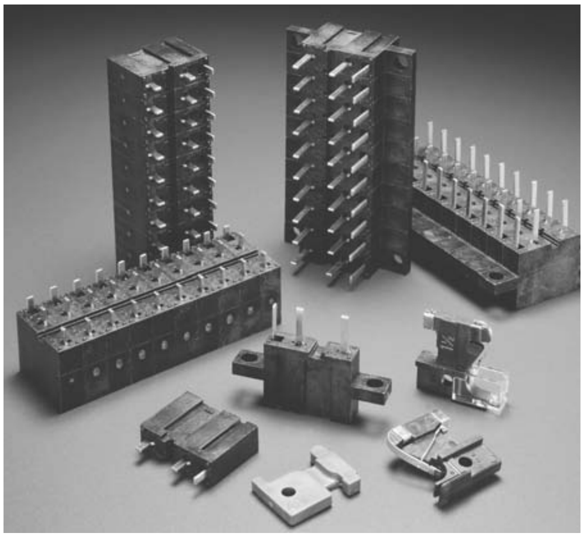
** Use 20 A fuseholder. Fuse is keyed to prevent insertion in lower-rated holders. (The 20 A fuseholder is designed to accept all ratings up to 20 A).



Time Current Curve

482 Series Alarm Indicating Fuseholder

Littelfuse®



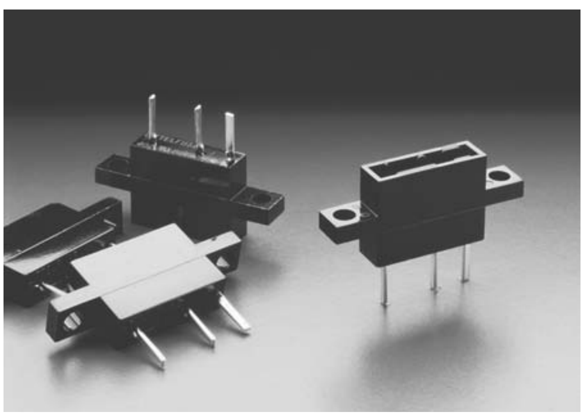
The 482 Series Alarm Indicating fuseholder is designed for use with the Littelfuse 481 Alarm fuse as well as with other manufacturers' replacement fuses.

Ideal for telecommunications and control panel circuits, this fuseholder is available in three types of mounts.

The **PCB mount** can be soldered directly to a printed circuit board. Rated up to 15 A, it is available in single pole or gangable up to 20 poles. It is keyed to prevent insertion of a 20 A fuse.

The **20 A panel mount** is available in a single pole version rated up to 20 A. Large leads allow wire attachment.

The **15 A panel mount** is a 15 A gangable version of the 482 Series fuseholder. It is keyed to prevent insertion of a 20 A fuse.



20 A Panel Mount

Note: To ensure proper heat dissipation under normal operation, space the 20 A fuseholders 0.5" (12.7 mm) apart, center to center, when loaded to maximum capacity. Heatsinking may be required for operation in higher ambient temperatures or alternate configurations.

For specifications, see www.littelfuse.com. For additional ordering information, contact Littelfuse.

Electrical Parameters

PCB Mount Part Number	PCB Mount Flush Part Number	15 A Panel Mount Part Number	15 A * Panel Mount Flush Part Number	Number of Poles	Length Inches (Millimeters)
04820001ZXB	04820001ZXBF	04820001ZXP	04820001ZXPF	1	0.25 (6.4)
04820002ZXB	04820002ZXBF	04820002ZXP	04820002ZXPF	2	0.5 (12.8)
04820003ZXB	04820003ZXBF	04820003ZXP	04820003ZXPF	3	0.75 (19.05)
04820004ZXB	04820004ZXBF	04820004ZXP	04820004ZXPF	4	1 (25.4)
04820005ZXB	04820005ZXBF	04820005ZXP	04820005ZXPF	5	1.25 (31.75)
04820006ZXB	04820006ZXBF	04820006ZXP	04820006ZXPF	6	1.5 (38.1)
04820007ZXB	04820007ZXBF	04820007ZXP	04820007ZXPF	7	1.75 (44.45)
04820008ZXB	04820008ZXBF	04820008ZXP	04820008ZXPF	8	2 (50.8)
04820009ZXB	04820009ZXBF	04820009ZXP	04820009ZXPF	9	2.25 (57.15)
04820010ZXB	04820010ZXBF	04820010ZXP	04820010ZXPF	10	2.5 (63.5)
04820011ZXB	04820011ZXBF	04820011ZXP	04820011ZXPF	11	2.75 (69.85)
04820012ZXB	04820012ZXBF	04820012ZXP	04820012ZXPF	12	3 (76.2)
04820013ZXB	04820013ZXBF	04820013ZXP	04820013ZXPF	13	3.25 (82.55)
04820014ZXB	04820014ZXBF	04820014ZXP	04820014ZXPF	14	3.5 (88.9)
04820015ZXB	04820015ZXBF	04820015ZXP	04820015ZXPF	15	3.75 (95.25)
04820016ZXB	04820016ZXBF	04820016ZXP	04820016ZXPF	16	4 (101.6)
04820017ZXB	04820017ZXBF	04820017ZXP	04820017ZXPF	17	4.25 (107.95)
04820018ZXB	04820018ZXBF	04820018ZXP	04820018ZXPF	18	4.5 (114.3)
04820019ZXB	04820019ZXBF	04820019ZXP	04820019ZXPF	19	4.75 (120.65)
04820020ZXB	04820020ZXBF	04820020ZXP	04820020ZXPF	20	5 (127)

* To order the 20 A panel mount, use part number 04822001ZXPF.

NOTES

5

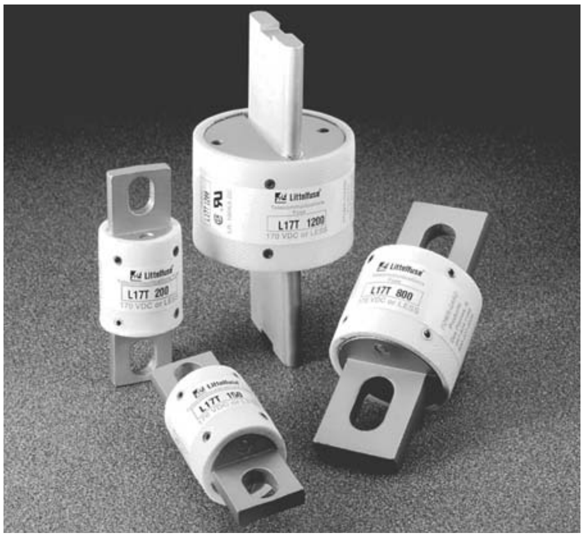
DC Power Fuses

This section presents complete electrical specifications for Littelfuse's Telecom DC power fuses.

Note: For information about the alarm indicating fuse, refer to "481 Series Alarm Indicating Fuse" on page 4-19.

L17T Series Telecommunications Power Fuse

Littelfuse®



Specifically designed for short circuit protection of telecom circuits, Littelfuse L17T Series fuses provide reliable protection of sensitive DC power distribution systems. Constructed with silver-plated elements for low I^2t and peak let-through, these advanced fuses virtually eliminate equipment damage due to surges and spikes. The L17T Series fuse's unique element geometry also provides cooler running temperatures, helping to minimize heat within enclosures.

Specifications and features include:

- Low I^2t
- Extremely current limiting
- Low operating temperature

Recommended fuse blocks for the L17T Series fuse are the LTFD6001 and LTFD1200 Series.

Electrical Parameters

Part Number	Voltage Rating V DC	Interrupting Rating in Amps	Current Rating Amps	Competitor A Part Number	Competitor B Part Number
L17T 70	170	100,000	70	TPL-BA	TGL-BA
L17T 90	170	100,000	90	TPL-BC	TGL-BC
L17T 100	170	100,000	100	TPL-BD	TGL-BD
L17T 125	170	100,000	125	TPL-BE	TGL-BE
L17T 150	170	100,000	150	TPL-BF	TGL-BF
L17T 175	170	100,000	175	TPL-BG	TGL-BG
L17T 200	170	100,000	200	TPL-BH	TGL-BH
L17T 225	170	100,000	225	TPL-BK	TGL-BK
L17T 250	170	100,000	250	TPL-BL	TGL-BL
L17T 300	170	100,000	300	TPL-CN	TGL-CN
L17T 350	170	100,000	350	TPL-CO	TGL-CO
L17T 400	170	100,000	400	TPL-CR	TGL-CR
L17T 450	170	100,000	450	TPL-CU	TGL-CU
L17T 500	170	100,000	500	TPL-CV	TGL-CV
L17T 600	170	100,000	600	TPL-CZ	TGL-CZ
L17T 800	170	100,000	800	TPL-CZH	TGL-CZH
L17T 900	170	100,000	900	—	—
L17T 1000	170	100,000	1000	—	—
L17T 1100	170	100,000	1100	—	—
L17T 1200	170	100,000	1200	—	—

TLN Series Telecommunications Power Fuse

Littelfuse®

TLN Series fuses are specifically designed for the protection of telecommunications DC power distribution circuits. Fast-acting and current limiting, they are similar in dimension to 250 V Class R fuses.

The recommended fuse block for the TLN Series fuse is the LR250 Series.

Electrical Parameters

Part Number	Voltage Rating V DC	Current Rating Amps	Interrupting Rating Amps
TLN 1	170	1	100,000
TLN 3	170	3	100,000
TLN 5	170	5	100,000
TLN 6	170	6	100,000
TLN 10	170	10	100,000
TLN 15	170	15	100,000
TLN 20	170	20	100,000
TLN 25	170	25	100,000
TLN 30	170	30	100,000
TLN 35	170	35	100,000
TLN 40	170	40	100,000
TLN 45	170	45	100,000
TLN 50	170	50	100,000
TLN 60	170	60	100,000
TLN 70	170	70	100,000
TLN 80	170	80	100,000
TLN 90	170	90	100,000
TLN 100	170	100	100,000
TLN 110	170	110	100,000
TLN 125	170	125	100,000
TLN 150	170	150	100,000
TLN 175	170	175	100,000
TLN 200	170	200	100,000
TLN 225	170	225	100,000
TLN 250	170	250	100,000
TLN 300	170	300	100,000
TLN 350	170	350	100,000
TLN 400	170	400	100,000
TLN 450	170	450	100,000
TLN 500	170	500	100,000
TLN 600	170	600	100,000

TLS Series Telecommunications Power Fuse

Littelfuse®

TLS Series fuses are designed specifically for the protection of telecommunications equipment. TLS fuses are engineered to operate up to 170 V dc to provide current limiting short circuit protection for cables and components found in the DC power distribution circuits of telecom systems. The compact design of the TLS provides superior protection and high power density in an extremely compact package.

The body is constructed of glass melamine. The caps are made of silver-plated brass. Multiple mounting configurations are available.

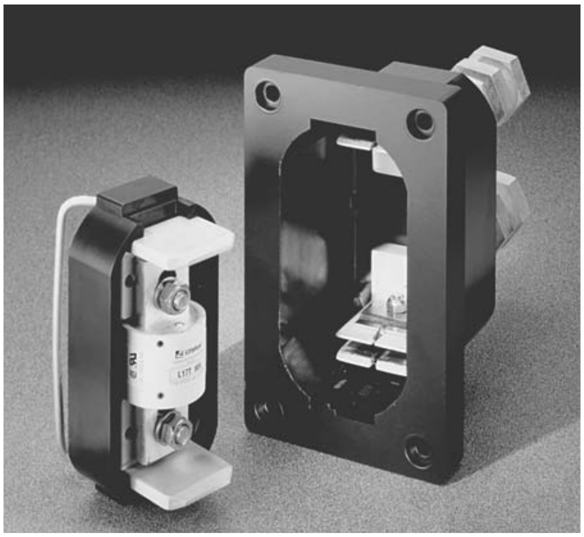
The recommended fuse block for the TLS Series fuse is the LTFD Series disconnect switch.

Electrical Parameters

Part Number	Leaded Version Part Number *	Voltage Rating V DC	Current Rating Amps	Interrupting Rating Amps
TLS001	**TLS001L**	170	1	100,000
TLS003	**TLS003L**	170	3	100,000
TLS005	**TLS005L**	170	5	100,000
TLS006	**TLS006L**	170	6	100,000
TLS010	**TLS010L**	170	10	100,000
TLS015	**TLS015L**	170	15	100,000
TLS020	**TLS020L**	170	20	100,000
TLS025	**TLS025L**	170	25	100,000
TLS030	**TLS030L**	170	30	100,000
TLS035	**TLS035L**	170	35	100,000
TLS040	**TLS040L**	170	40	100,000
TLS050	**TLS050L**	170	50	100,000
TLS060	**TLS060L**	170	60	100,000
TLS070	**TLS070**	170	70	100,000
TLS080	**TLS080L**	170	80	100,000
TLS090	**TLS090L**	170	90	100,000
TLS100	**TLS100L**	170	100	100,000
TLS125	**TLS125L**	170	125	100,000

* Used for circuit board applications

LTFD Series Telecommunications Disconnect Switch



Littelfuse's compact LTFD Series holders are designed for use as a combination fuseholder and disconnect switch for telecommunications equipment. The rugged unit uses a pull-out fuse carrier to safely disconnect power and to provide easy fuse replacement.

Other features include:

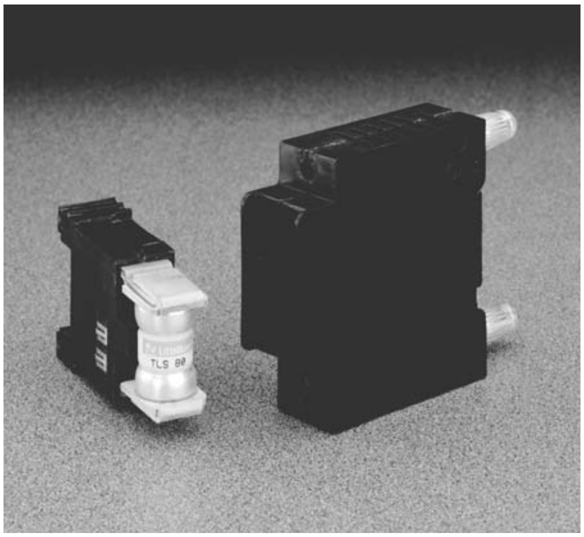
- Thermoplastic housing material
- Alarm signaling circuit

The LTFD Series holders are recommended for use with the L17T Series fuses.

Electrical Parameters

Part Number	Voltage Rating V DC	Current Rating Amps	Contact Nut Maximum Torque
LTFD6001-00	145	70–600	100 feet-pound
LTFD6001-01	145	70–800	100 feet-pound
LTFD1200-01	60	900–1200	100 feet-pound
LTFD1200-01A	60	900–1200	100 feet-pound

LTFD 101 Series Telecommunications Disconnect Switch



Littelfuse's compact LTFD 101 fuseholders are designed for quick installation into telecom equipment panels. The modular design fits into spaces originally designed for circuit breakers; they can be front panel mounted or rear mounted using bullet connectors.

It is extremely compact and replaces circuit breakers.

The innovative new pull-out design eliminates the need for tools to replace fuses and includes an alarm signaling circuit to identify the blown fuse.

The LTFD 101 Series holders are recommended for use with the TLS Series fuses and the 481 Series Alarm fuses.

Electrical Parameters

Part Number	System Number	Voltage Rating V DC	Current Rating Amps	Terminal Type
LTFD101-1	LTFD0101ZX1	80	1–125	Bullet
LTFD101-2	LTFD0101ZX2	80	1–125	Screw
LTFD101-3	LTFD0101ZX3	80	1–125	Stud
LTFD101-4	LTFD0101ZX4	80	1–125	Clip

6 Reference Designs

This section offers specific examples of how *SIDACtor*® devices can be used to ensure long-term operability of protected equipment and uninterrupted service during transient electrical activity. For additional line interface protection circuits, see "Regulatory Compliant Solutions" on page 7-46.

Note: The circuits referenced in this section represent typical interfaces used in telecommunications equipment. *SIDACtor* devices are not the sole components required to pass applicable regulatory requirements such as UL 60950, GR 1089, or TIA-968-A (formerly known as FCC Part 68), nor are these requirements specifically directed at *SIDACtor* devices.

Customer Premises Equipment (CPE)

CPE is defined as any telephone terminal equipment which resides at the customer's site and is connected to the Public Switched Telephone Network (PSTN). Telephones, modems, caller ID adjunct boxes, PBXs, and answering machines are all considered CPE.

Protection Requirements

CPE should be protected against overvoltages that can exceed 800 V and against surge currents up to 100 A. In Figure 6.1 through Figure 6.6, *SIDACtor*® devices were chosen because their associated peak pulse current (I_{PP}) rating is sufficient to withstand the lightning immunity test of TIA-968-A without the additional use of series line impedance. Likewise, the fuse shown in Figure 6.1 through Figure 6.6 was chosen because the amps^{2}time (I^2t) rating is sufficient to withstand the lightning immunity tests of TIA-968-A without opening, but low enough to pass UL power fault conditions.

The following regulatory requirements apply:

- TIA-968-A (formerly known as FCC Part 68)
- UL 60950

All CPE intended for connection to the PSTN must be registered in compliance with TIA-968-A. Also, because the National Electric Code mandates that equipment intended for connection to the telephone network be listed for that purpose, consideration should be given to certifying equipment with an approved safety lab such as Underwriters Laboratories.

CPE Reference Circuits

Figure 6.1 through Figure 6.6 show examples of interface circuits which meet all applicable regulatory requirements for CPE. The P3100SB and P3100EB are used in these circuits because the peak off-state voltage (V_{DRM}) is greater than the potential of a Type B ringer superimposed on a POTS (plain old telephone service) battery.

$$150\ V_{RMS}\ \sqrt{2} + 56.6\ V_{PK} = 268.8\ V_{PK}$$

Note that the circuits shown in Figure 6.1 through Figure 6.6 provide an operational solution for TIA-968-A. However TIA-968-A allows CPE designs to pass non-operationally as well.

For a non-operational solution, coordinate the I_{PP} rating of the *SIDACtor* device and the I^2t rating of the fuse so that (1) both will withstand the Type B surge, and (2) during the Type A surge, the fuse will open. (See Table 8.2, Surge Rating Correlation to Fuse Rating on page 8-17.)

Note: For alternative line interface protection circuits, see "Regulatory Compliant Solutions" on page 7-46.

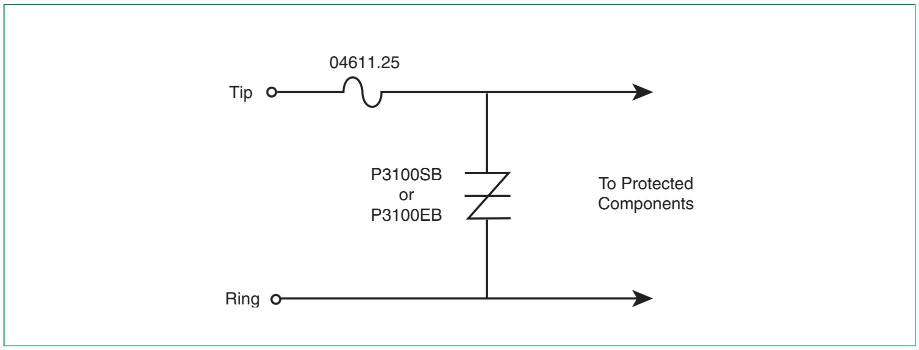


Figure 6.1 Basic CPE Interface

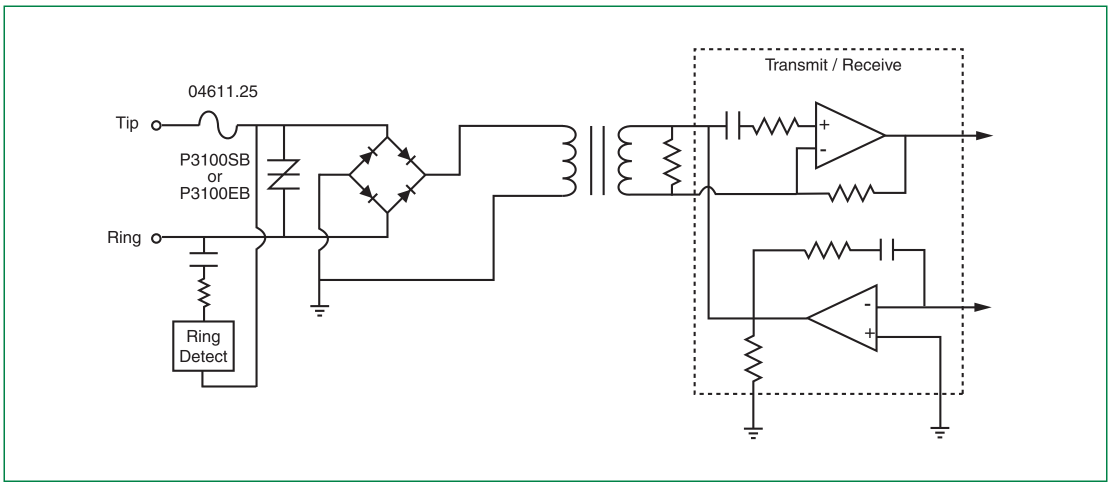


Figure 6.2 Transformer Coupled Tip and Ring Interface

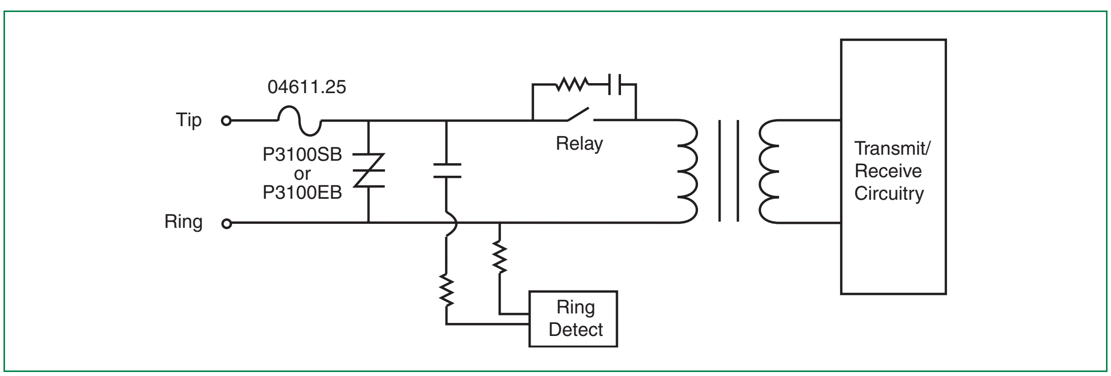


Figure 6.3 Modem Interface

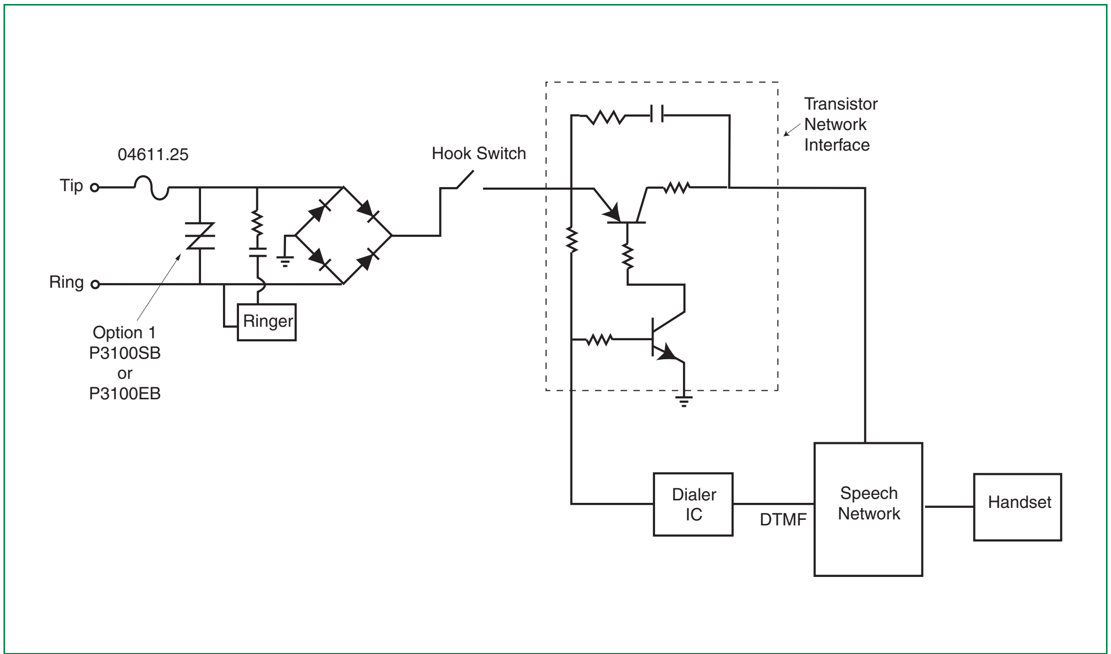


Figure 6.4 CPE Transistor Network Interface—Option 1

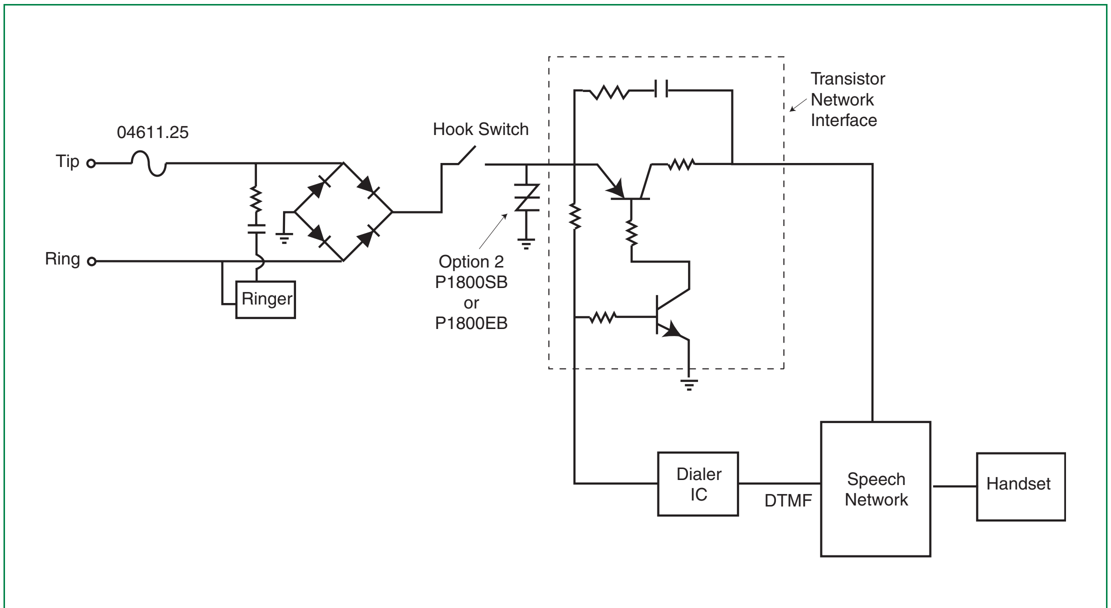


Figure 6.5 CPE Transistor Network Interface—Option 2

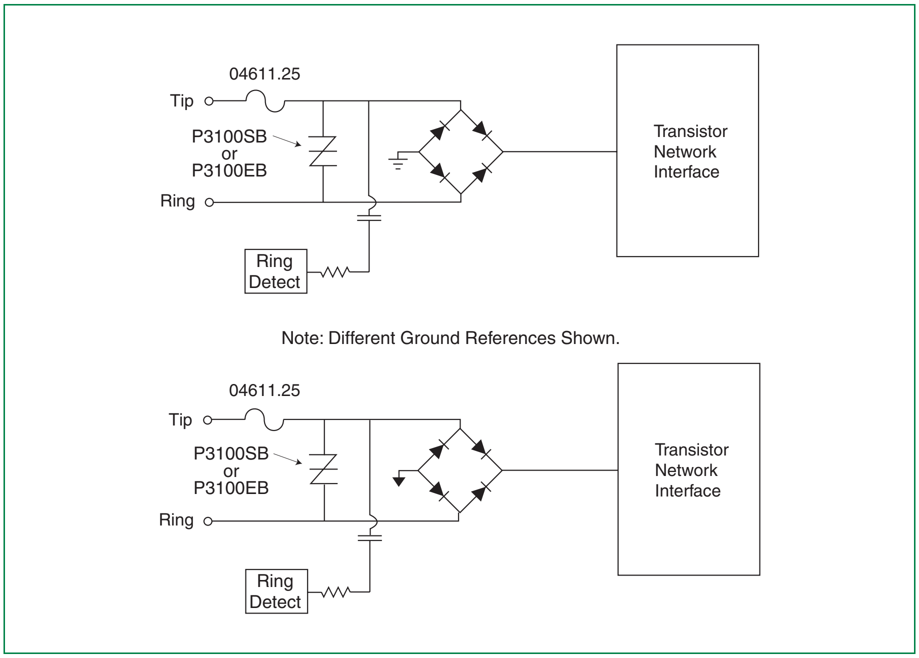


Figure 6.6 Two-line CPE Interface

Digital Set-top Box Protection

The set-top box consists of power supply and signal ports. Some of the more recent high-end designs also can have a hard drive to facilitate program recording. Unlike traditional analog boxes, the digital devices are more like computers and so have many of the same system and port features.

Cable, satellite, and terrestrial set-top boxes are similar designs with software variations. Digital broadband media (DBM) devices are home gateway devices, offering services including Video On Demand, TV web browsing, email, and communication services.

Figure 6.7 shows an example of the use of Littelfuse products in a set-top box design. (Data sheets for the protection solutions highlighted in the illustration can be found in this *Telecom Design Guide*.)

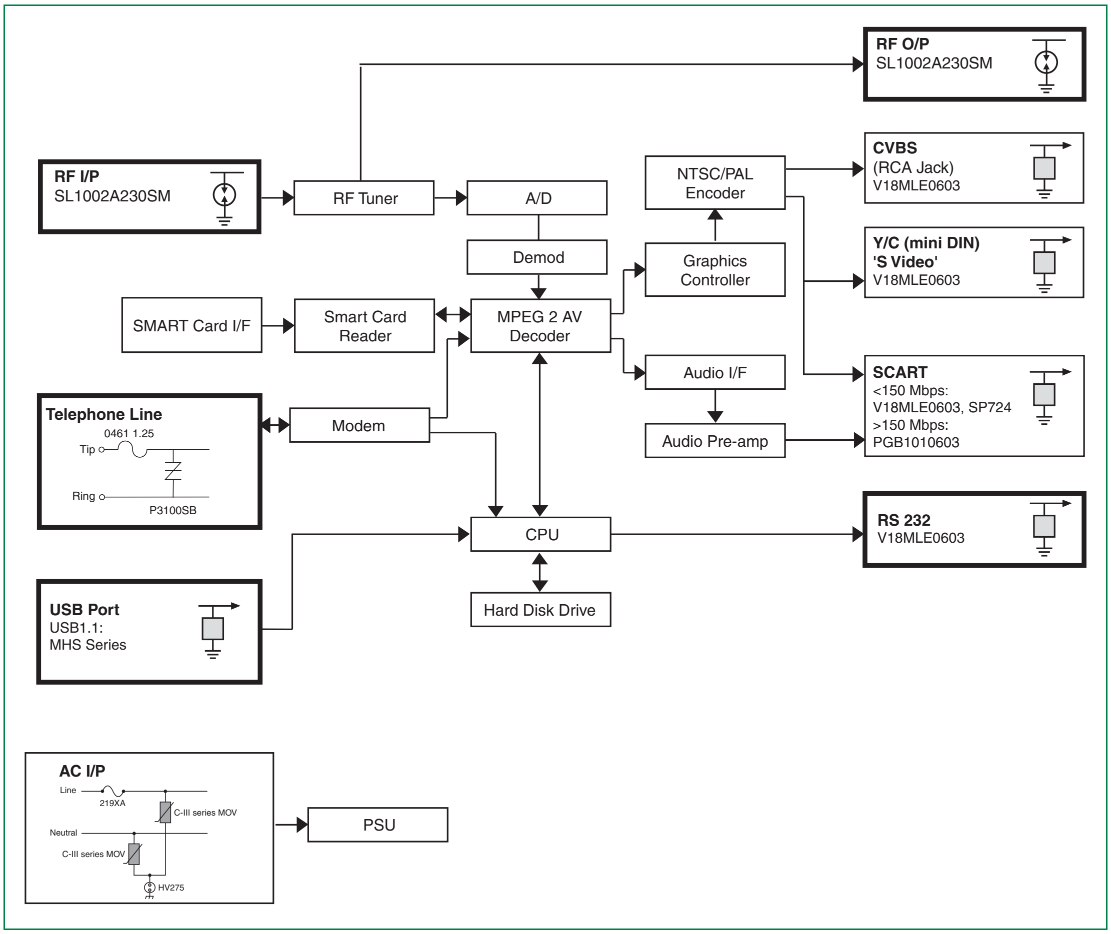


Figure 6.7 Block Diagram of Set-top Box

The following agency standards and industry regulations may apply to digital set-top boxes:

- IEC 61000-4
- ANSI/IEEE C62.41
- TIA-968-A
- UL 60950
- Telcordia GR 1089
- ITU K.20 and K.21

Power Supply

The AC connection can be either a two-wire design (either a live or hot with neutral) or a three-wire design that additionally uses the Ground (earth) connection. In both designs using a fuse for overcurrent protection may be mandatory and using varistors (MOVs) to provide overvoltage protection may be beneficial.

A two-wire solution is a 219XA series 5x20 mm glass fuse used with a C-III series MOV (up to two parts).

In a three-wire system it is possible to connect MOVs across all three conductors (H-N, H-G, and N-G (or L-N, L-G, and N-G). For use in the United States, the device must meet UL 1414 standards, requiring no leakage from H-G (L-G) through the MOV. Typically, an isolation device is used in series with the MOV to pass the UL certification.

The Littelfuse HV 275 device meets the requirement for a 120 V AC system: 219XA series 5x20 mm glass fuse used with a C-III series MOV (up to three parts) along with the HV 275.

Signal Ports

Various communication ports are applicable.

Video Signal Input

The video signal feeds into the set-top box through a co-ax connector from a satellite receiver, a cable company, or a terrestrial antenna. Because of the high frequency of these signals, only very low capacitance protectors can be deployed. Because the feed is from an external source, a high surge rating is usually required and virtually all solutions use a gas plasma arrester for protection. Figure 6.8 shows the recommended solution for satellite receiver protection.

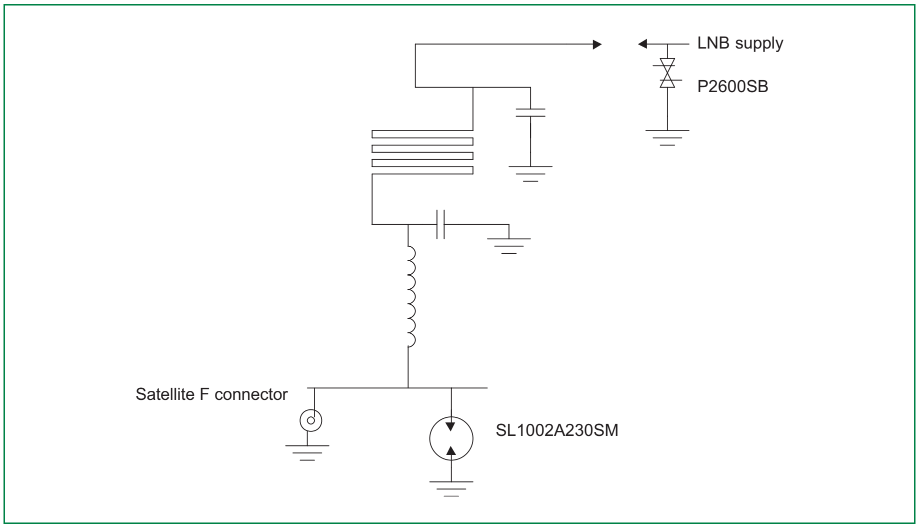


Figure 6.8 Satellite Receiver Protection

Some boxes have both the standard UHF connector to accept terrestrial antenna and the F-type connector used for cable and satellite connections and can support both inputs. In these cases both satellite and the UHF co-ax inputs can use gas plasma arresters for protection.

Solutions include SL1002A090SM or SL1002A230SM.

Video Output

The set-top box has to connect to either a conventional TV set or monitor. The two most common connectors are co-ax or SCART (Syndicat des Constructeurs d'Appareils Radiorécepteurs et Téléviseurs). Like the co-ax inputs, the co-ax output will need a low-capacitance device to be protected.

The multi-pin SCART is a suitable application for a low-capacitance array. On some designs using two SCARTs facilitates recording and viewing. A six-pin device is common.

One solution is the SP05xx series diode array.

Modem Port

A modem port is featured on many designs to facilitate interactive services such as Pay Per View (PPV) and Interactive Pay Per View (IPPV). The modem port requires similar threat protection as the conventional twisted pair telephone connections. The classic overvoltage protection and resettable overcurrent protection can be deployed in this circuit.

Solution examples include *SIDACtor*® P3100SB, SL1002A600SM, PTC, and *TeleLink*® fuse. Solutions may vary depending on the end market.

Audio Output

A stereo jack socket often is provided for home theater applications. While the signal frequency is low and a variety of overvoltage protection can be used, the main concern is electrostatic discharge (ESD).

Solutions include TVS diode Arrays, or Multilayer Varistors.

USB Port

USB ports are provided to support digital cameras, printers, and MP3 players as well as legacy devices. New designs use USB 2.0.

USB 1.1 solutions include Multilayer Varistors or TVS diode Arrays. The USB 2.0 solution uses the PGB1010603.

RS 232

RS 232 serial ports are used for game pads, upgrades, and diagnostics as well as legacy devices.

One protection solution for the RS 232 interface is a Multilayer Varistor.

Ethernet Ports

Ethernet ports enable connection to LANs and so need medium to low energy protectors of low capacitance.

High Speed Transmission Equipment

High speed transmission equipment encompasses a broad range of transmission protocols such as T1/E1, ADSL, ADSL2, ADSL2+, VDSL, VDSL2, and ISDN. Transmission equipment is located at the central office, customer premises, and remote locations.

Protection Requirements

Transmission equipment should be protected against overvoltages that can exceed 2500 V and surge currents up to 500 A. In the illustrations shown in Figure 6.9 through Figure 6.22, *SIDACtor®* devices were chosen because their associated peak pulse current (I_{PP}) rating is sufficient to withstand the lightning immunity tests of GR 1089 without the additional use of series line impedance. Likewise, the fuse shown in each of the following illustrations (Figure 6.9 through Figure 6.22) was chosen because the amps^{2}time (I^2t) rating is sufficient to withstand the lightning immunity tests of GR 1089, but low enough to pass GR 1089 current limiting protector test and power fault conditions (both first and second levels).

The following regulatory requirements apply:
- TIA-968-A (formerly known as FCC Part 68)
- GR 1089-CORE
- ITU-T K.20/K.21
- UL 60950

Most transmission equipment sold in the US must adhere to GR 1089. For Europe and other regions, ITU-T K.20/K.21 is typically the recognized standard.

ADSL / VDSL Circuit Protection

Asymmetric digital subscriber lines (ADSLs) and very high speed digital subscriber lines (VDSLs) employ transmission rates up to 30 Mbps from the Central Office Terminal (COT) to the Remote Terminal (RT) and up to 30 Mbps from the RT to the COT. (Figure 6.9)

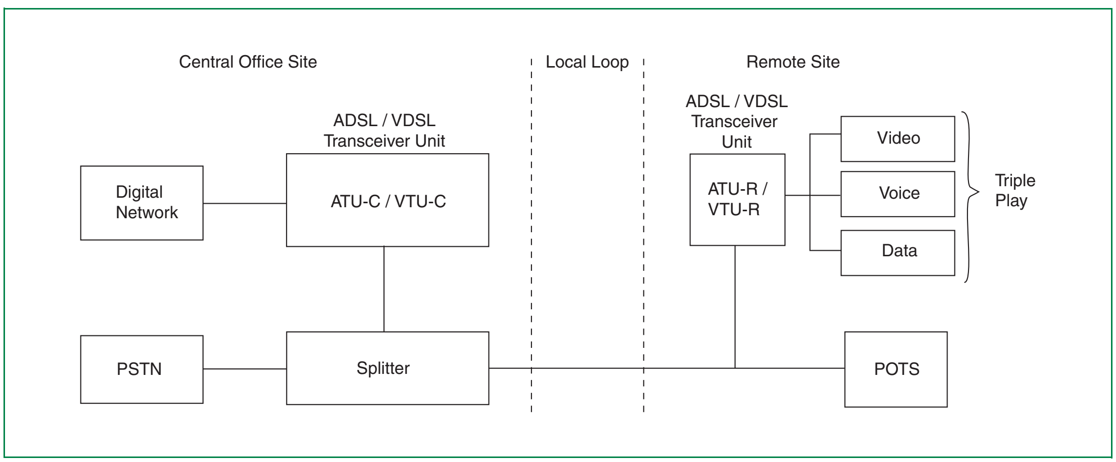


Figure 6.9 ADSL Overview

Protection Circuitry

Longitudinal protection was not used at either the ADSL / VDSL Transceiver Unit–Central Office (ATU-C / VTU-C) interface or the ADSL / VDSL Transceiver Unit–Remote (ATU-R / VTU-R) interface due to the absence of earth ground connections. (Figure 6.10 and Figure 6.12) In both instances, the SL1002A350SM gas plasma arrester or the P3500SCMC *SIDACtor®* device and the 04611.25 *TeleLink®* fuse provide metallic protection. For xTUs not isolated from earth ground, reference the HDSL protection topology.

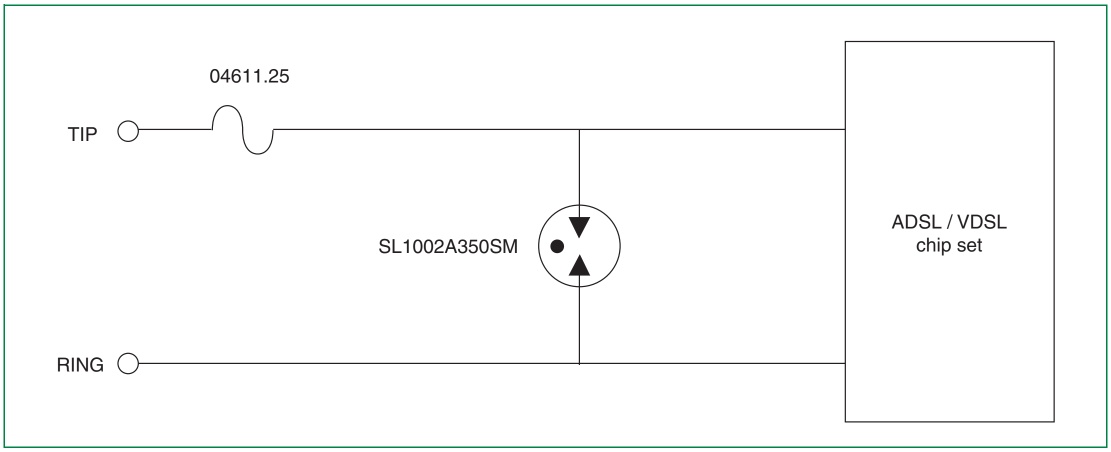


Figure 6.10 Gas Plasma Arrester ADSL Protection

Alternate ADSL Protection and VDSL Protection

Figure 6.11 shows the SL1002A350SM gas plasma arresters connected in the Delta configuration to provide Tip to Ground, Ring to Ground (longitudinal), and Tip to Ring (metallic) protection.

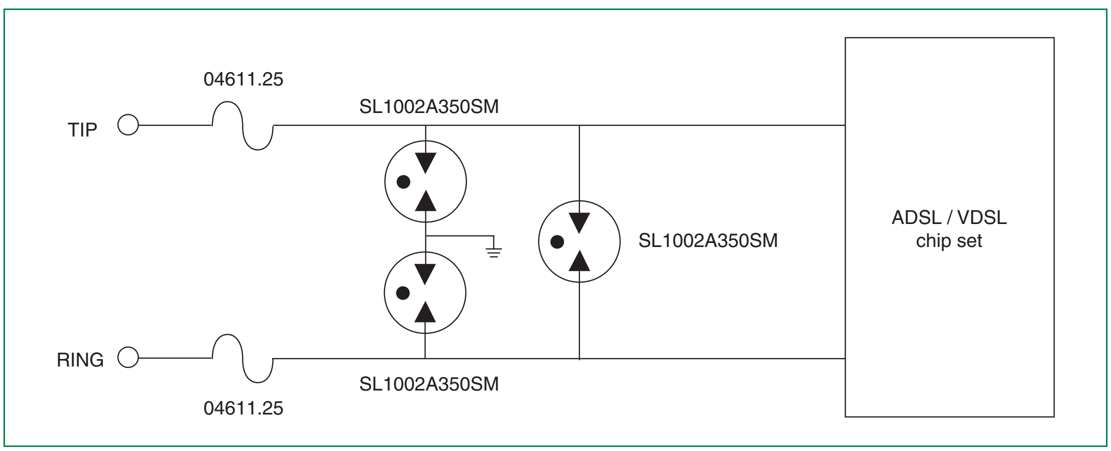


Figure 6.11 Single Port Delta Solution Providing Metallic and Longitudinal Protection

Protection Circuitry

The capacitance of this device is low (typically 0.8 pF) so this solution provides very low insertion loss.

The 04611.25 fuse provides protection against power fault events, but it is specifically designed not to open during induced lightning surges. This eliminates nuisance blowing while maintaining the ultimate protection needed for safety.

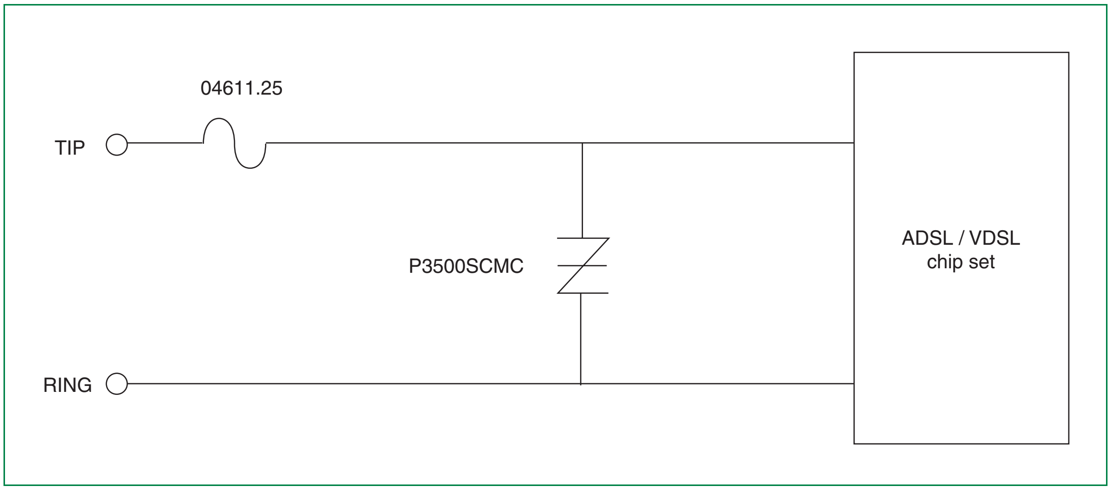


Figure 6.12 *SIDACtor* ADSL / VDSL Protection

Component Selection

The P3500SCMC *SIDACtor* device and 04611.25 *TeleLink* fuse were chosen to protect the ATUs because both components meet GR 1089 surge immunity requirements without the use of additional series resistance. Although the P3100 series *SIDACtor* device may be used to meet current ANSI specifications for xDSL services offered with POTS, Littelfuse recommends the P3500 series to avoid interference with the 20 V_{P-P} ADSL signal on a 150 V rms ringing signal superimposed on a 56.5 V battery. The VDSL signal is smaller than a typical ADSL signal, so the P3100 may be an appropriate solution.

HDSL Circuit Protection

HDSL (High-bit Digital Subscriber Line) is a digital line technology that uses a 1.544 Mbps (T1 equivalent) transmission rate for distances up to 12,000 feet, eliminating the need for repeaters. The signaling levels are a maximum of ±2.5 V while loop powering is typically under 190 V. (Figure 6.13)

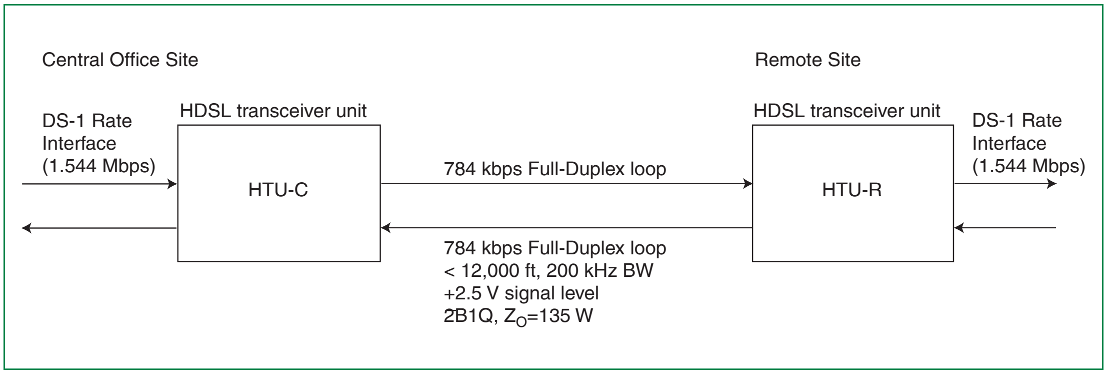


Figure 6.13 HDSL Overview

Protection Circuitry

Longitudinal protection is required at both the HDSL Transceiver Unit–Central Office (HTU-C) and HDSL Transceiver Unit–Remote (HTU-R) interfaces because of the ground connection used with loop powering. Two P2300SCMC *SIDACtor* devices provide overvoltage protection, and two 04611.25 *TeleLink* fuses (one on Tip, one on Ring) provide overcurrent protection. (Figure 6.14 and Figure 6.15) For the transceiver side of the coupling transformer, additional overvoltage protection is provided by the P0080SA *SIDACtor* device. The longitudinal protection on the primary coil of the transformer is an additional design consideration for prevention of EMI coupling and ground loop issues.

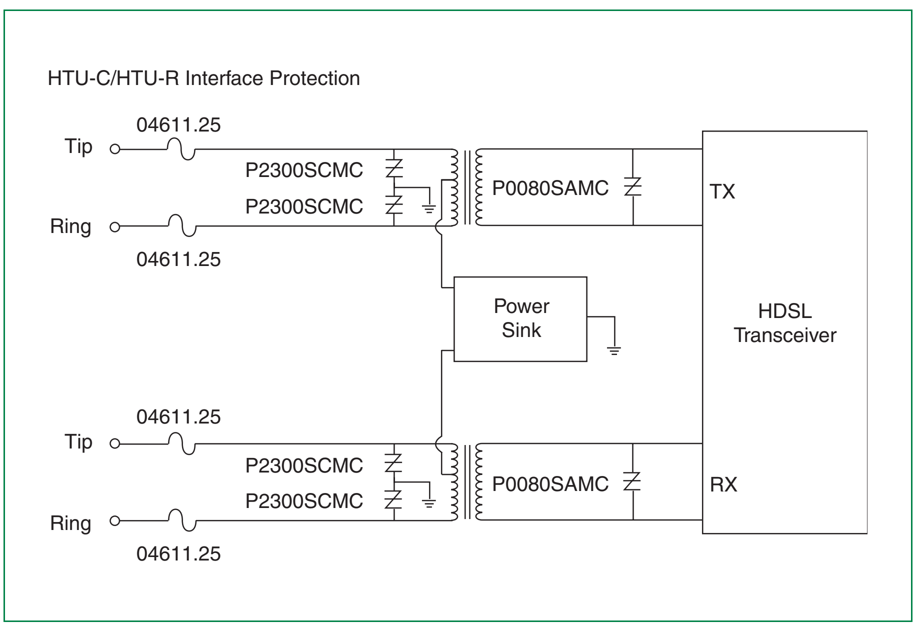


Figure 6.14 HDSL Protection

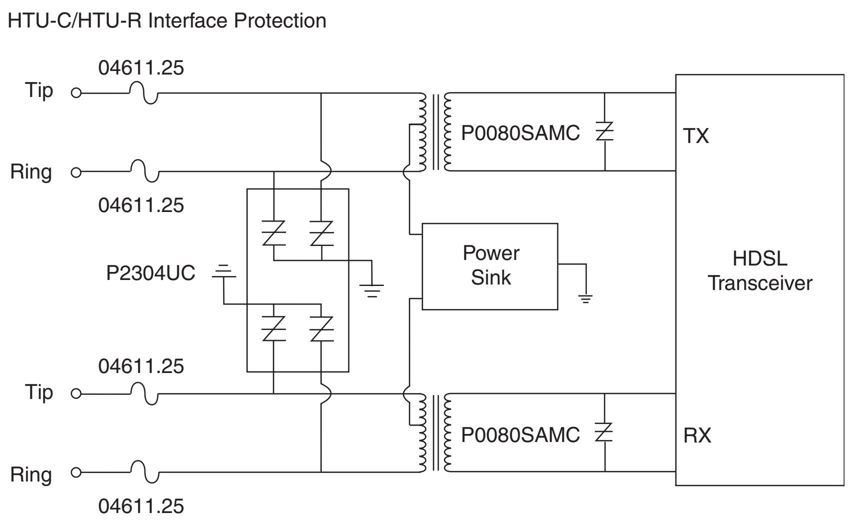


Figure 6.15   HDSL Quad Protection

Component Selection

The P2304UC or P2300SCMC *SIDACtor* device and the 04611.25 *TeleLink* fuse were chosen because both components meet GR 1089 surge immunity requirements without the use of additional series resistance. The P2300SCMC voltage rating was selected to ensure loop powering up to 190 V. For loop powering greater than 190 V, consider the P2600SCMC. The P0080SAMC *SIDACtor* device was chosen to eliminate any sneak voltages that may appear below the voltage rating of the P2300SCMC.

ISDN Circuit Protection

Integrated Services Digital Network (ISDN) circuits require protection at the Network Termination Layer 1 (NT1) U-interface and at the Terminating Equipment (TE) or Terminating Adapter (TA) S/T interface. Signal levels at the U-interface are typically ±2.5 V; however, with sealing currents and maintenance loop test (MLT) procedures, voltages approaching 150 V rms can occur. (Figure 6.16)

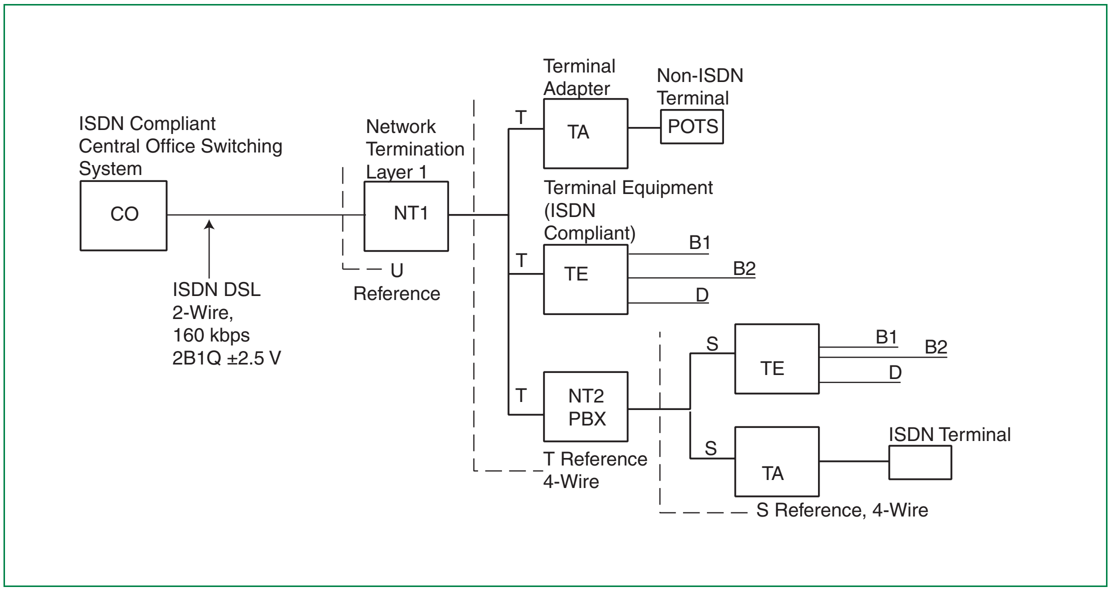


Figure 6.16 ISDN Overview

Protection Circuitry

Longitudinal protection was not used at either the U- or the TA/TE-interface due to the absence of an earth-to-ground connection. (Figure 6.17) At the U-interface, the P2600SCMC *SIDACtor* device and 04611.25 *TeleLink* fuse provide metallic protection, while the TA/TE-interface uses the P0640SCMC *SIDACtor* device and 04611.25 *TeleLink* fuse. Figure 6.17 also shows interfaces not isolated from earth ground.

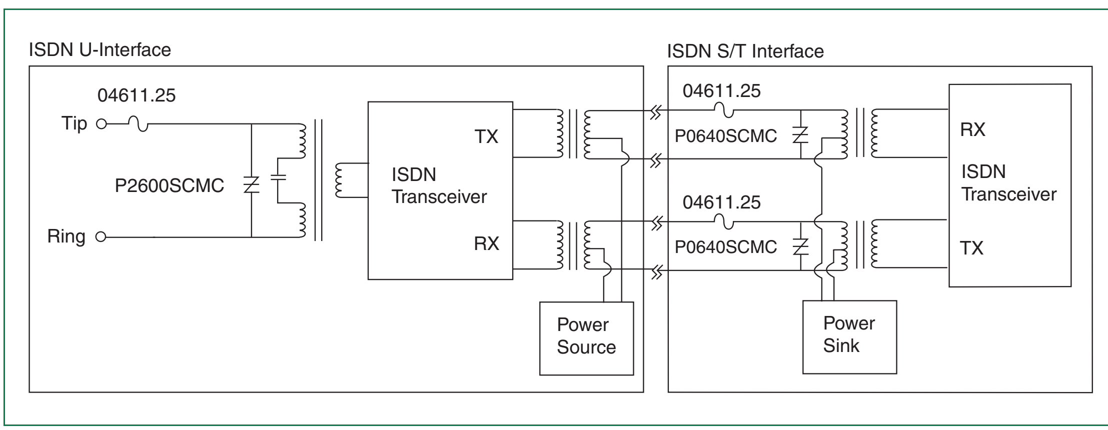


Figure 6.17 ISDN Protection

Reference Designs

Component Selection

The "SCMC" *SIDACtor* devices and 04611.25 *TeleLink* fuse were chosen because these components meet GR 1089 surge immunity requirements without the use of additional series resistance. An MC is chosen to reduce degradation of data rates. The P2600SCMC voltage rating was selected to ensure coordination with MLT voltages that can approach 150 V rms. The voltage rating of the P0640SCMC was selected to ensure coordination with varying signal voltages.

Pair Gain Circuit Protection

A digital pair gain system differs from an ISDN circuit in that ring detection, ring trip, ring forward, and off-hook detection are carried within the 64 kbps bit stream for each channel rather than using a separate D channel. The pair gain system also uses loop powering from 10 V up to 145 V with a typical maximum current of 75 mA. (Figure 6.18)

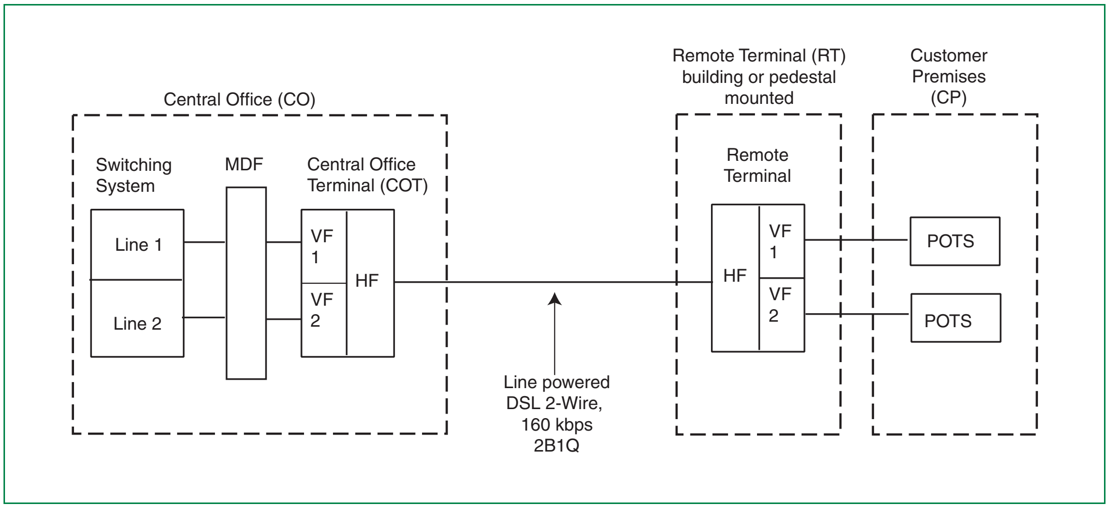


Figure 6.18 Pair Gain Overview

Protection Circuitry

Longitudinal protection is required at the Central Office Terminal (COT) interface because of the ground connection used with loop powering. (Figure 6.19) Two P1800SCMC *SIDACtor* devices provide overvoltage protection, and two 04611.25 *TeleLink* fuses (one on Tip, one on Ring) provide overcurrent protection. For the U-interface side of the coupling transformer, the illustration shows the P0080SAMC *SIDACtor* device used for additional overvoltage protection.

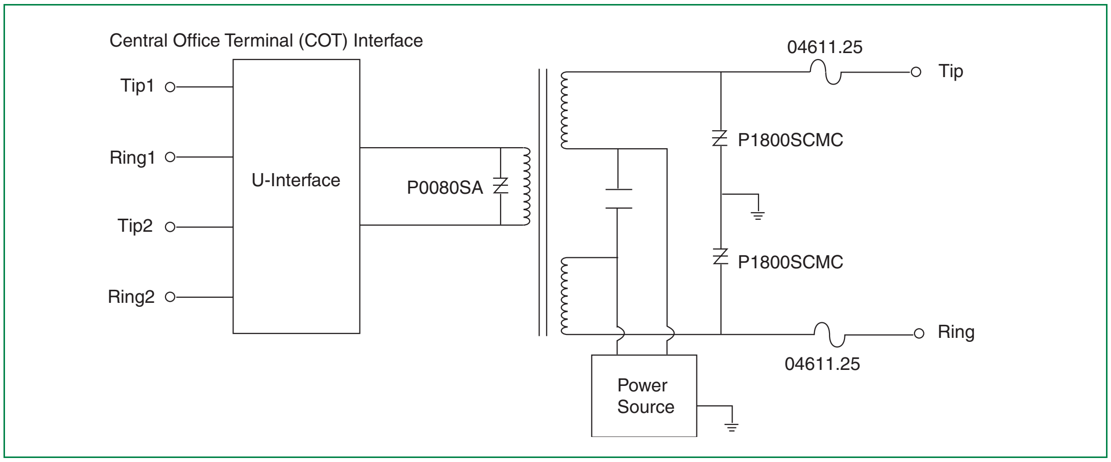


Figure 6.19 Pair Gain COT Protection

For Customer Premises (CP) and Remote Terminal (RT) interfaces where an earth ground connection is not used, only metallic protection is required. Figure 6.20 shows metallic protection satisfied using a single P3100SCMC across Tip and Ring and a single 04611.25 on either Tip or Ring to satisfy metallic protection.

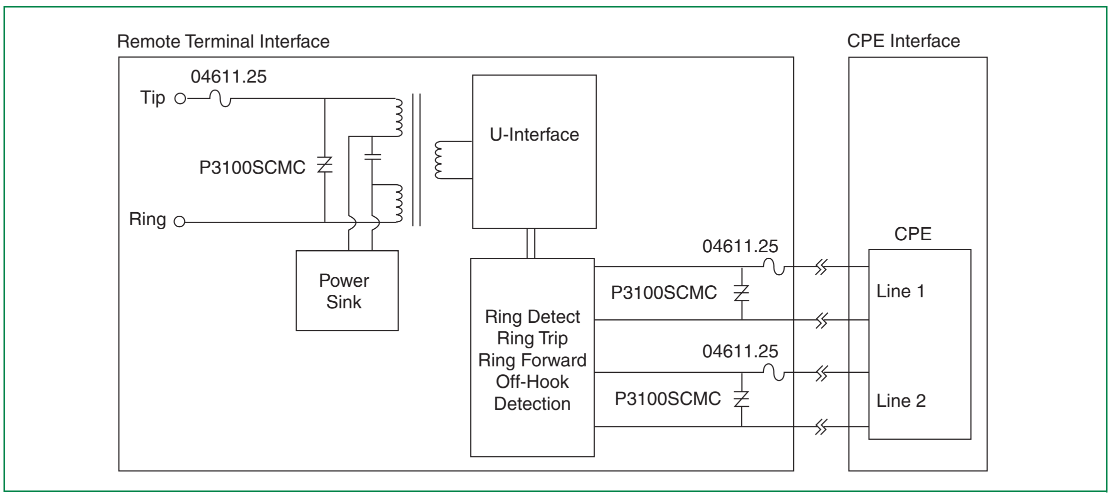


Figure 6.20 Pair Gain RT Protection

Component Selection

The "SCMC" *SIDACtor* device and 04611.25 *TeleLink* fuse were chosen because both components meet GR 1089 surge immunity requirements without the use of additional series resistance. An MC is chosen to reduce degradation of data rates. The voltage rating of the P1800SCMC was selected to ensure coordination with loop powering up to 150 V.

The voltage rating of the P3100SCMC was selected to ensure coordination with POTS ringing and battery voltages.

T1/E1/J1 Circuit Protection

T1/E1 networks offer data rates up to 1.544 Mbps (2.058 for E1) on four-wire systems. Signal levels on the transmit (TX) pair are typically between 2.4 V and 3.6 V while the receive (RX) pair could go as high as 12 V. Loop powering is typically ±130 V at 60 mA, although some systems can go as high as 150 V. (Figure 6.21)

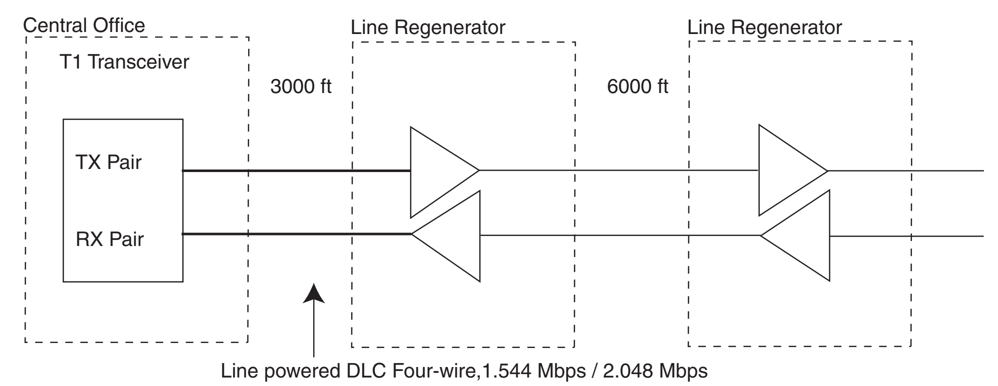


Figure 6.21 T1/E1 Overview

Protection Circuitry

Longitudinal protection is required at the Central Office Terminal (COT) interface because of the ground connection used with loop powering. (Figure 6.22, Figure 6.23, Figure 6.24) Two P1800SCMC (or P1804UC or P2106UC) *SIDACtor* devices provide overvoltage protection, and two 04611.25 *TeleLink* fuses (one on Tip, one on Ring) provide overcurrent protection. The P1800SCMC device is chosen because its V drm is compliant with TIA-968-A regulations, Section 4.4.5.2, "Connections with protection paths to ground." These regulations state:

> Approved terminal equipment and protective circuitry having an intentional dc conducting path to earth ground for protection purposes at the leakage current test voltage that was removed during the leakage current test of section 4.3 shall, upon its replacement, have a 50 Hz or 60 Hz voltage source applied between the following points:
>
> a. Simplexed telephone connections, including Tip and Ring, Tip-1 and Ring-1, E&M leads and auxiliary leads
> b. Earth grounding connections
>
> The voltage shall be gradually increased from zero to 120 V rms for approved terminal equipment, or 300 V rms for protective circuitry, then maintained for one minute. The current between a. and b. shall not exceed 10 mA_{PK} at any time. As an alternative to carrying out this test on the complete equipment or device, the test may be carried out separately on components, subassemblies, and simulated

circuits, outside the unit, provided that the test results would be representative of the results of testing the complete unit.

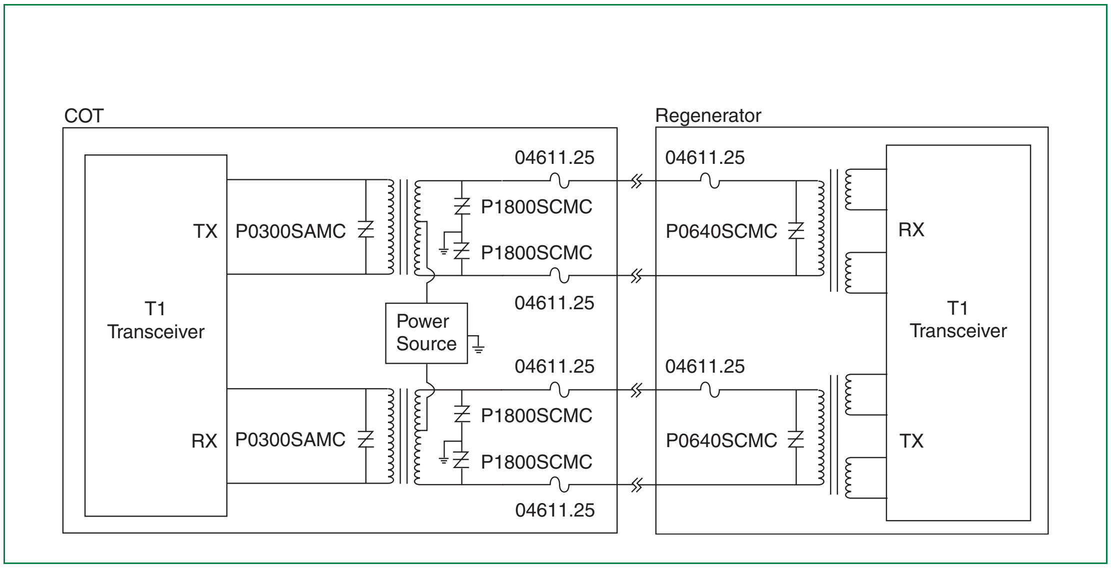


Figure 6.22 T1/E1 Protection

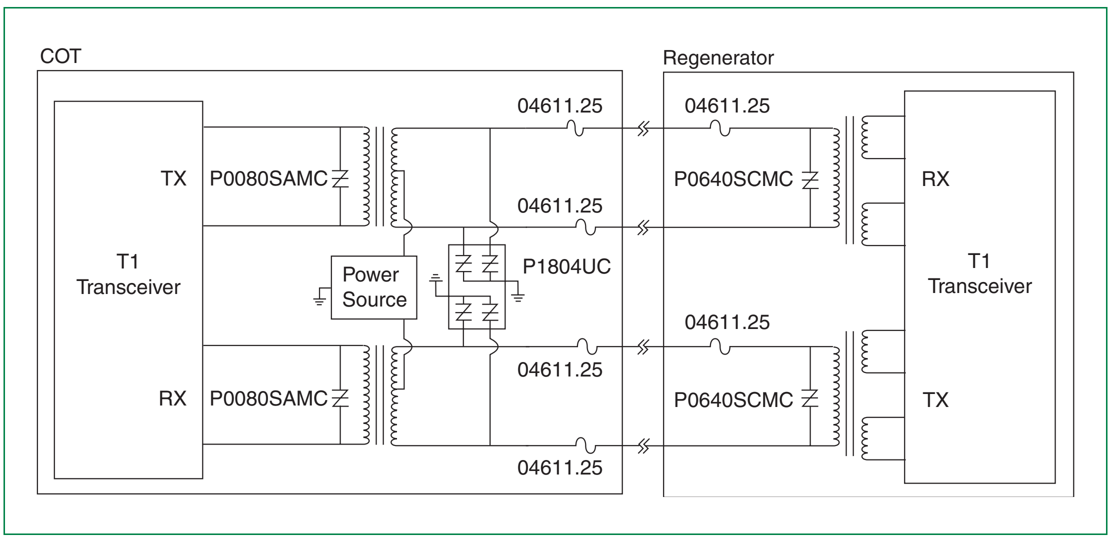


Figure 6.23 T1/E1 Quad Protection

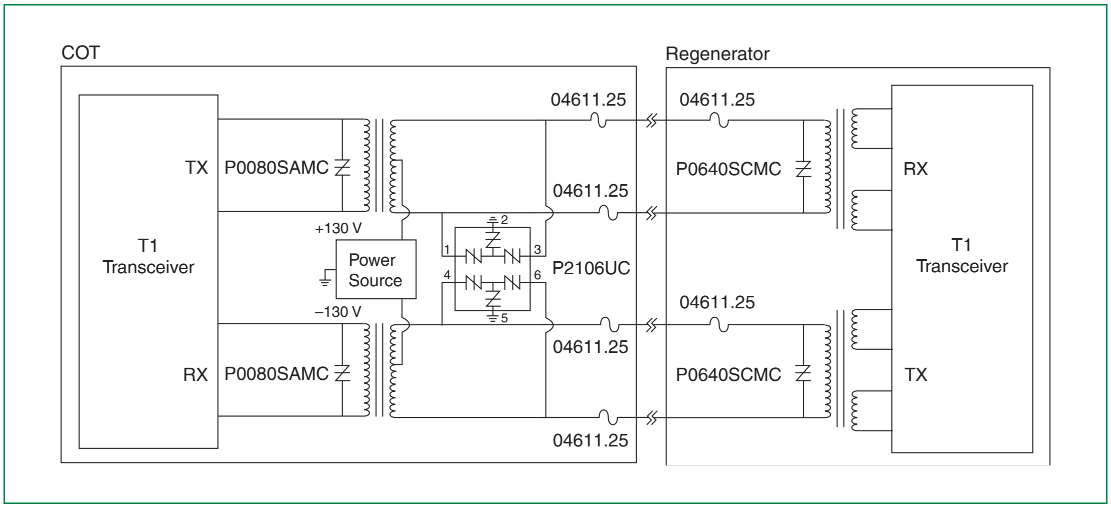


Figure 6.24 T1/E1 Symmetrical Protection

The peak voltage for 120 V rms is 169.7 V. The minimum stand-off voltage for the P1800 (or P1804 and P2106) is 170 V, therefore, the P1800SCMC will pass the test in Section 4.4.5.2 by not allowing 10 mA of current to flow during the application of this test voltage.

For the transceiver side of the coupling transformer, additional overvoltage protection is shown in Figure 6.22 using the P0300SA *SIDACtor* device. When an earth ground connection is not used, only metallic protection is required. Metallic protection is satisfied using a single P0640SCMC *SIDACtor* device across Tip and Ring and a single 04611.25 *TeleLink* fuse on either Tip or Ring.

Component Selection

The "SCMC" *SIDACtor* device and 04611.25 *TeleLink* fuse were chosen because these components meet GR 1089 surge immunity requirements without the use of additional series resistance. An MC is chosen to reduce degradation of data rates. The voltage rating of the P1800SCMC (or P1804UC or P2106UC) was selected to ensure loop powering up to 150 V. The voltage rating of the P0640SCMC was selected to ensure coordination with varying voltage signals.

T1/E1/J1 Asymmetrical Circuit Protection

The A2106UC6 Surface Mount *SIDACtor* device provides asymmetrical protection for T1/E1/J1 transceivers. (Figure 6.25) Metallic events are limited to less than 80 V on the line side of the transformer. The minimum turn on voltage for the A2106 is 170 V from Tip to Ground and Ring to Ground. This is compliant with TIA-968-A. The secondary side of the transformer has the P0080SAMC *SIDACtor* device that limits differential voltages to less than 25 V.

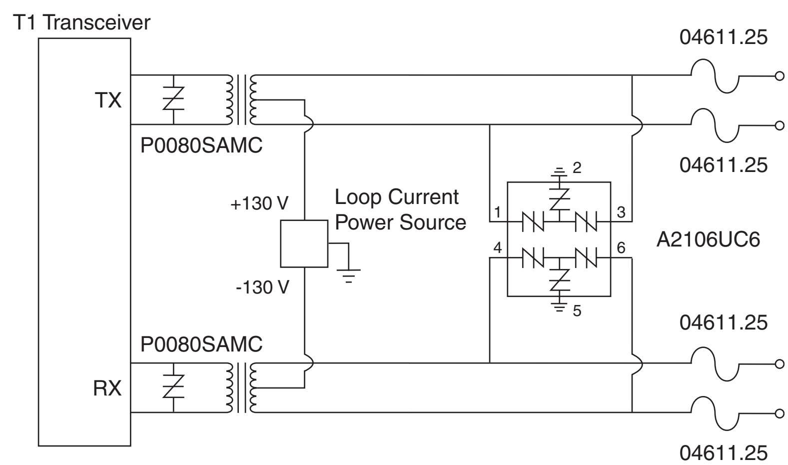


Figure 6.25 T1/E1/J1 Asymmetrical Protection

Protection Circuitry

The T1/E1 transceiver circuit is protected from AC power fault events (also known as over current events) by the 04611.25 *TeleLink* fuses. The *TeleLink* fuses in combination with the *SIDACtor* devices are compliant with the requirements of GR 1089, TIA-968-A, and UL 60950.

Additional T1 Design Considerations

A T1 application can be TIA-968-A approved as two different possible device types. An XD device means an external CSU is used, and while the unit does not have to meet the TIA-968-A environmental test conditions, it must connect only behind a separately registered DE device. This XD equipment does not have to meet the T1 pulse template requirements. If not classified as an XD device, then typically the application must adhere to TIA-968-A environmental test conditions.

T3 Protection

The SL1002A090 in combination with the *TeleLink* fuse (Figure 6.26) is one low off-state capacitance solution. Figure 6.27 shows an alternate solution. The capacitance across the pair of wires = (D1 || D2) + P0640EC/SC. The diode capacitance is approximately (10 pF || 10 pF) 20 pF. Then adding the capacitive effect of the P0640EC/SCMC, which is typically 60 pF, the total capacitance across the pair of wires is approximately 15 pF. The MUR 1100E diodes are fast-switching diodes that will exhibit this level of capacitance. MURS160T3 is a surface mount equivalent. (Figure 6.27)

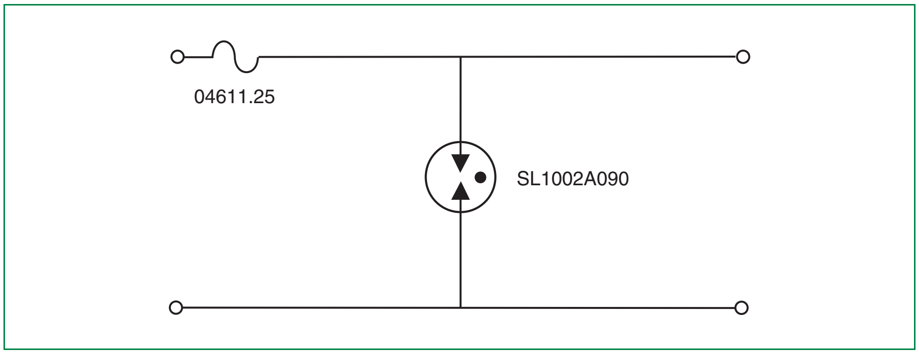


Figure 6.26 T3 Protection—Gas Plasma Arrester

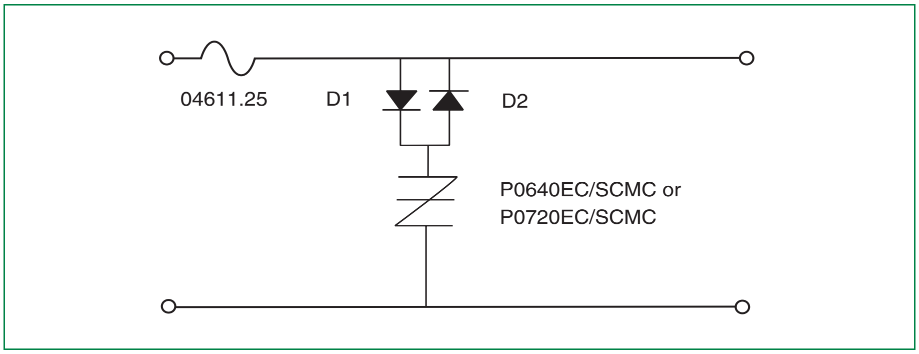


Figure 6.27 T3 Protection—*SIDACtor* Device and Diodes

Alternately, the advanced P0642SA exhibits very low capacitance and can be used as a stand-alone device. (Figure 6.28)

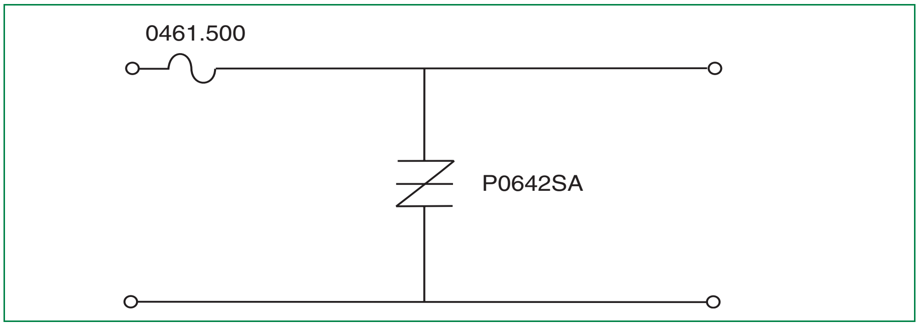


Figure 6.28 T3 Protection—*SIDACtor* Device

Coordination Considerations

Coordination between the primary protection and the secondary protection may require the addition of a resistor. (Figure 6.29)

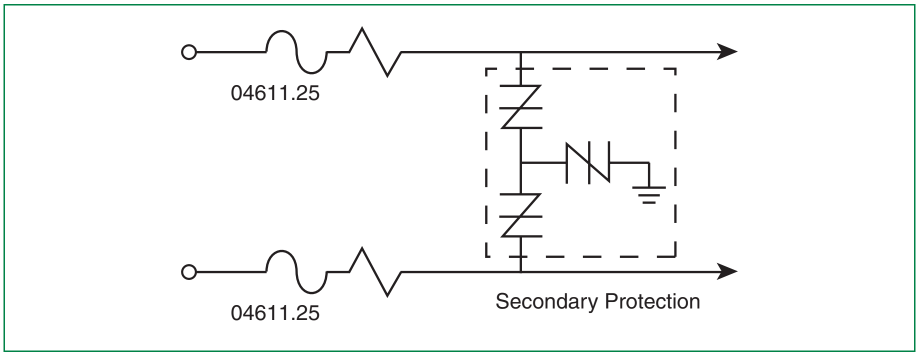


Figure 6.29 Coordination Solution with Resistor

The coordinating resistor value depends on:

- Distance between the primary and secondary protector
- Turn-on characteristics of the primary and secondary protector
- Surge rating of the secondary protector

For compliance with the GR 1089 requirement, the additional component is not required IF the peak pulse surge rating of the secondary protector is at least 100 A for a 10x1000 event. The ITU recommendations have an alternative solution as well, depending on whether Basic or Enhanced compliance is desired.

For Basic compliance, if the secondary protector has a peak pulse surge rating of at least 1000 A for an 8x20 event, then the additional component is not required. For the Enhanced level, it must be able to withstand a 5000 A for an 8x20 event. Otherwise, a coordinating component is required. This component allows the primary protector to turn on during surge events even though the secondary protector may turn on first. The power rating of this resistor can be reduced by including the *TeleLink* overcurrent protection device. However, it must not open during the surge events. Typically, a 1-3 W resistor will be sufficient.

Analog Line Cards

Given that line cards are highly susceptible to transient voltages, network hazards such as lightning and power fault conditions pose a serious threat to equipment deployed at the central office and in remote switching locations. To minimize this threat, adequate levels of protection must be incorporated to ensure reliable operation and regulatory compliance.

Protection Requirements

When designing overvoltage protection for analog line cards, it is often necessary to provide both on-hook (relay) and off-hook (SLIC) protection. This can be accomplished in two stages, as shown in Figure 6.30.

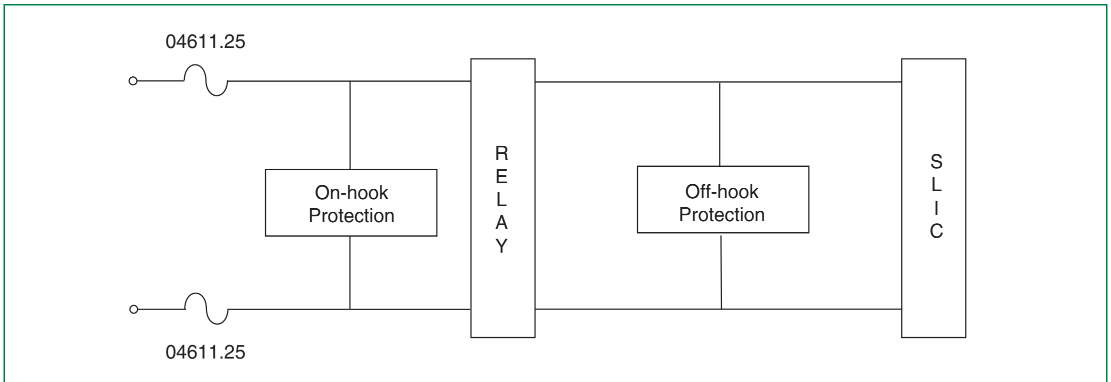


Figure 6.30 SLIC Overview

The following regulatory requirements may apply:

- GR 1089-CORE
- ITU-T K.20/K.21
- UL 60950
- TIA-968-A (formerly known as FCC Part 68)

On-Hook (Relay) Protection

On-hook protection is accomplished by choosing a *SIDACtor*® device that meets the following criteria to ensure proper coordination between the ring voltage and the maximum voltage rating of the relay to be protected.

$V_{DRM} > V_{BATT} + V_{RING}$

$V_S \leq V_{Relay\ Breakdown}$

This criterion is typically accomplished using two P2600S_ *SIDACtor* devices (where _ denotes the surge current rating) connected from Tip to Ground and Ring to Ground. However, for applications using relays such as an LCAS (Line Card Access Switch), consider the P1200S_ from Tip to Ground and the P2000S_ from Ring to Ground.

Off-Hook (SLIC) Protection

Off-hook protection is accomplished by choosing a *SIDACtor* device that meets the following criteria to ensure proper coordination between the supply voltage (V_{REF}) and the maximum voltage rating of the SLIC to be protected.

$V_{DRM} > V_{REF}$

$V_S \leq V_{SLIC\ Breakdown}$

This criterion can be accomplished in a variety of ways. Applications using an external ringing generator and a fixed battery voltage can be protected with a single P0641CA2 or two P0641SA *SIDACtor* devices or with any of the following, depending on the actual value of the battery reference voltage:

- P0721UA or two P0721CA2 or four P0721SA
- P0901UA or two P0901CA2 or four P0901SA
- P1101UA or two P1101CA2 or four P1101SA
- P1301UA or two P1301CA2 or four P1301SA
- P1701UA or two P1701CA2 or four P1701SA

Use the SC version for applications complying to GR 1089 inter-building or ITU K20/21 Enhanced Recommendations. For ring-generating SLIC chipsets, the *Battrax*® protector (B1xxx 6-pin devices) can be used.

I_{PP} Selection

The I_{PP} of the *SIDACtor* device must be greater than or equal to the maximum available surge current ($I_{PK(available)}$) of the applicable regulatory requirements. Calculate the maximum available surge current by dividing the peak surge voltage supplied by the voltage generator (V_{PK}) by the total circuit resistance (R_{TOTAL}). The total circuit resistance is determined by adding the source resistance (R_S) of the surge generator to the series resistance in front of the *SIDACtor* device on Tip and Ring (R_{TIP} and R_{RING}).

Reference Designs

$I_{PP} \geq I_{PK(available)}$

$I_{PK(available)} = V_{PK} / R_{TOTAL}$

For metallic surges:

$R_{TOTAL} = R_S + R_{TIP} + R_{RING}$

For longitudinal surges:

$R_{TOTAL} = R_S + R_{TIP}$

$R_{TOTAL} = R_S + R_{RING}$

Reference Diagrams

Littelfuse offers a wide variety of protection solutions for SLIC applications. Some non-ringing SLIC applications require an asymmetrical type of protection, while others require a balanced protection solution. The ringing SLIC applications can be protected with fixed voltage *SIDACtor* devices or with programmable *Battrax* devices. Figure 6.31 through Figure 6.53 illustrate these many different solutions. The *TeleLink* fuse is also included in these illustrations so that GR 1089-compliant overvoltage and overcurrent protection is provided.

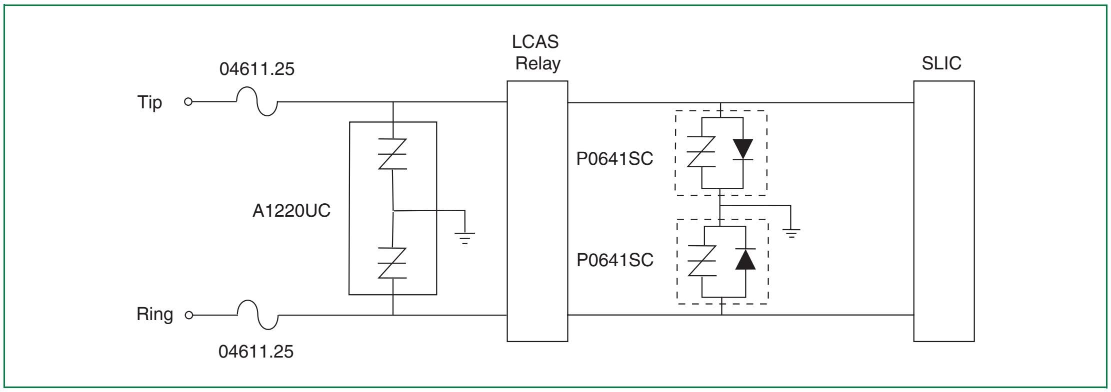


Figure 6.31 SLIC Protection for LCAS

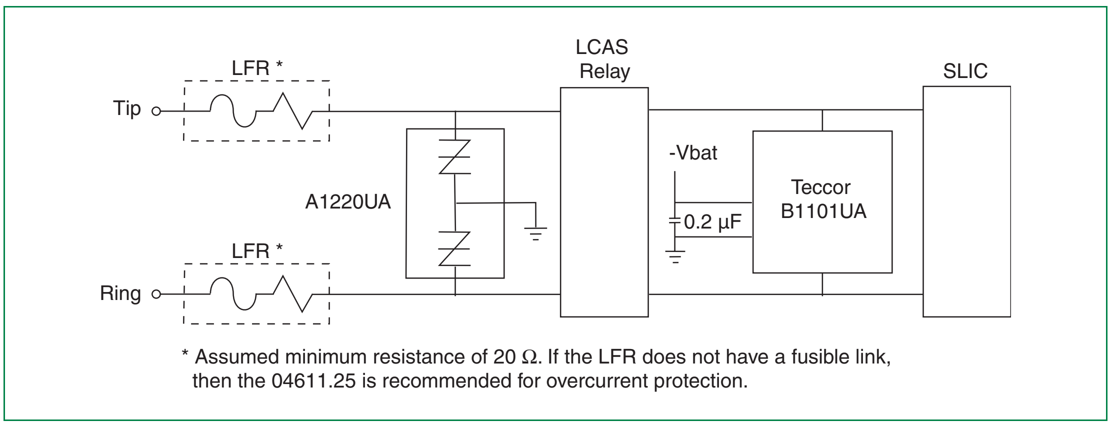


Figure 6.32 SLIC Protection with Limiting Resistance

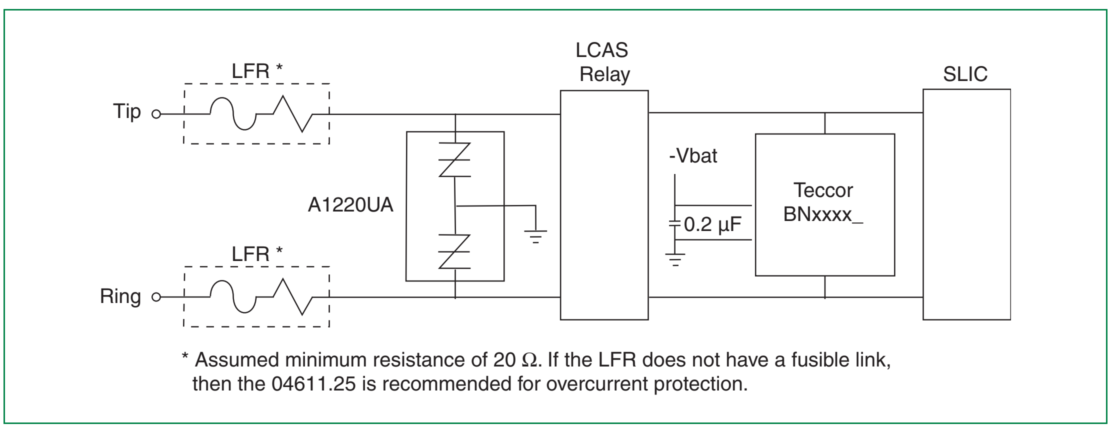
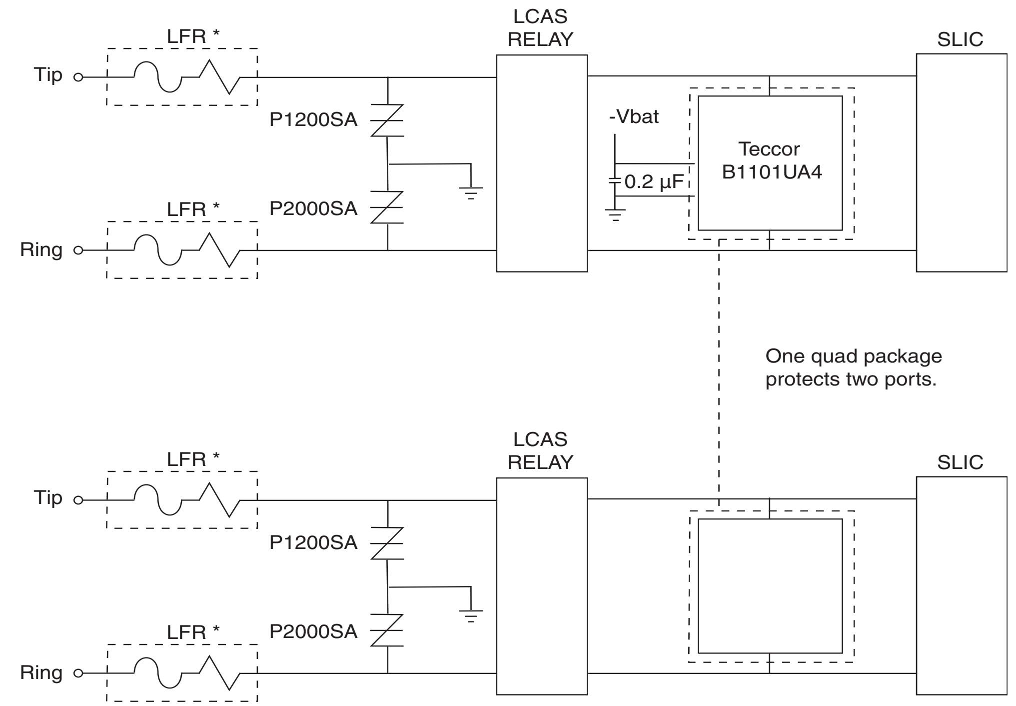
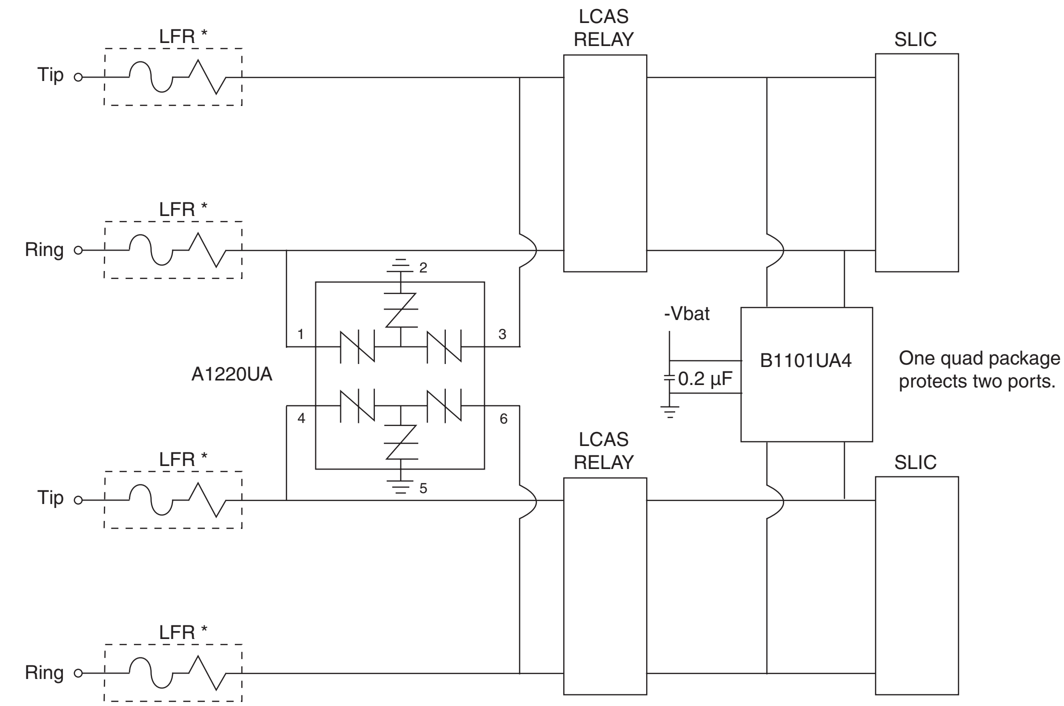


Figure 6.33 SLIC Protection with Limiting Resistance—Buffered *Battrax*



* Assumed minimum resistance of 20 Ω. If the LFR does not have a fusible link, then the 04611.25 is recommended for overcurrent protection.

Figure 6.34 SLIC Protection with Quad *Battrax*



* Assumed minimum resistance of 20 Ω. If the LFR does not have a fusible link, then the 04611.25 is recommended for overcurrent protection.

Figure 6.35 SLIC Protection with Quad *Battrax* and Balanced Relay Protector

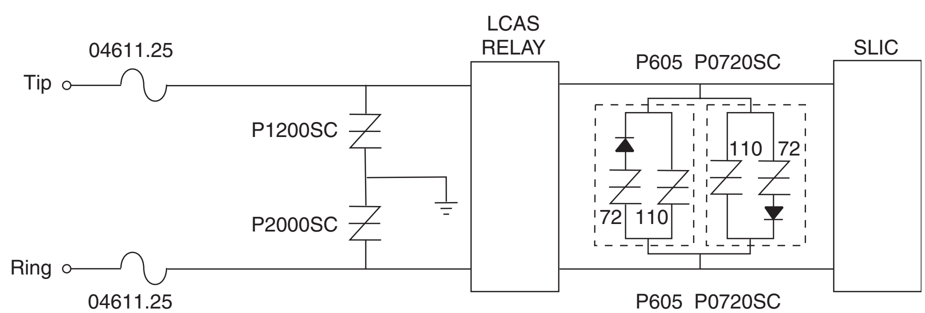


Figure 6.36 SLIC Protection with Asymmetrical Devices

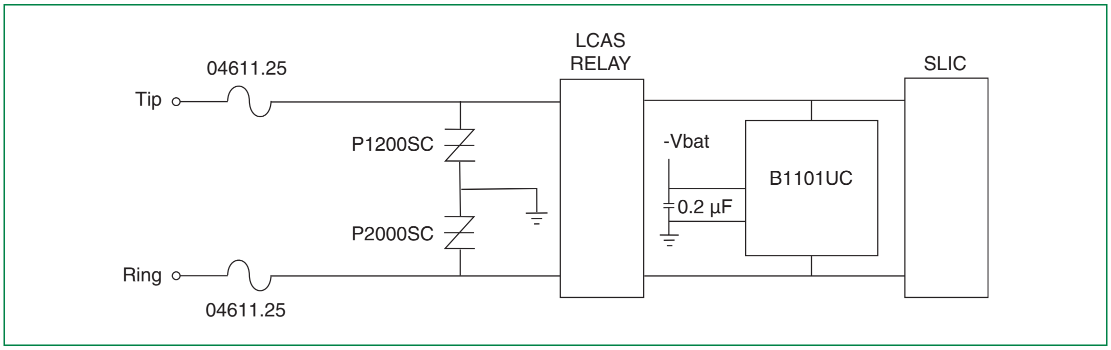


Figure 6.37 SLIC Protection with *Battrax*

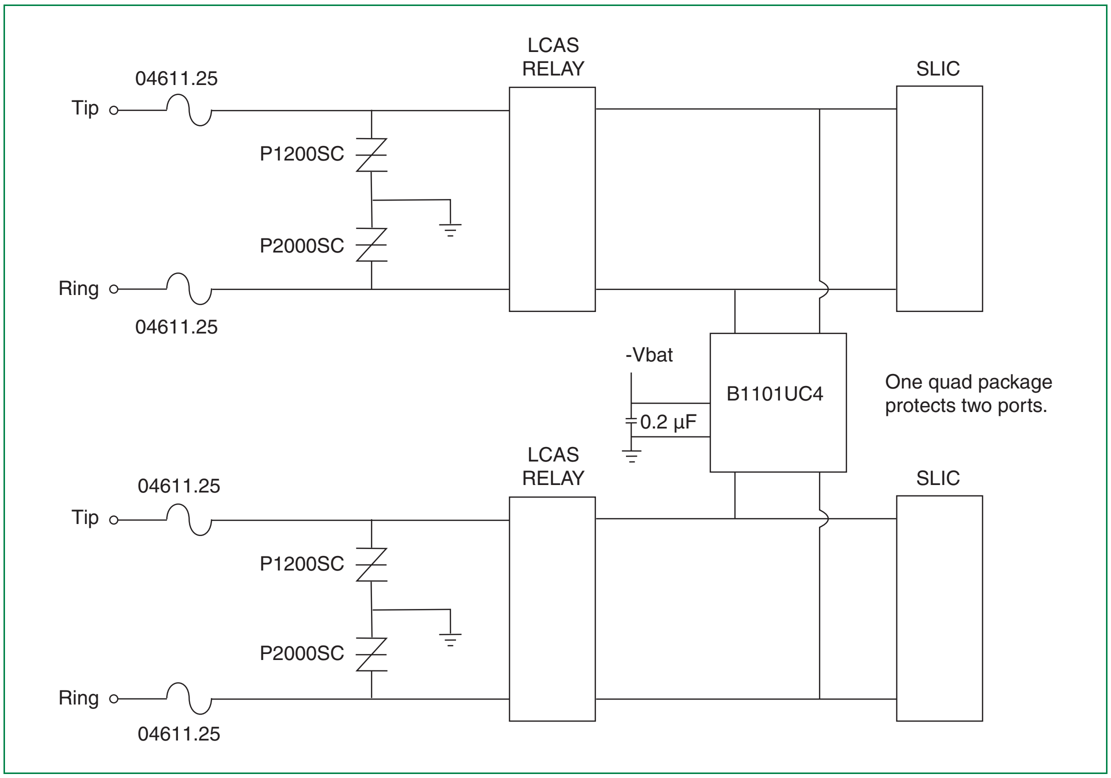


Figure 6.38 SLIC Protection with Quad *Battrax* with Asymmetrical Relay Protection

Figure 6.39 illustrates uses of asymmetrical *SIDACtor* protection for overvoltage conditions and the 04611.25 for overcurrent conditions.

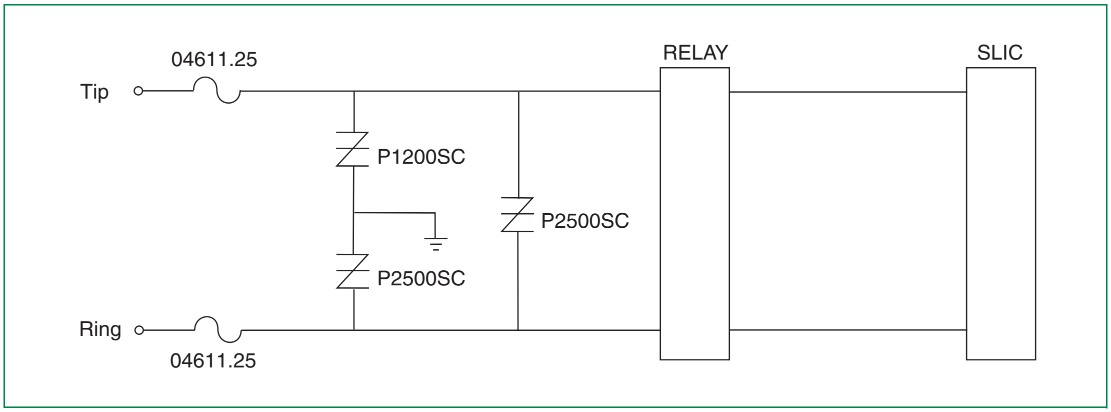


Figure 6.39 SLIC Asymmetrical Protection

Figure 6.40 illustrates the use of the P2600SA and P0721CA2 for overvoltage protection and the 0461.500 for overcurrent protection in addition to 20 Ω of series resistance on both Tip and Ring. The series resistance is required to limit the transient surge currents to within the surge current rating of the "A" series *SIDACtor* devices and the 0461.500 *TeleLink®* fuse.

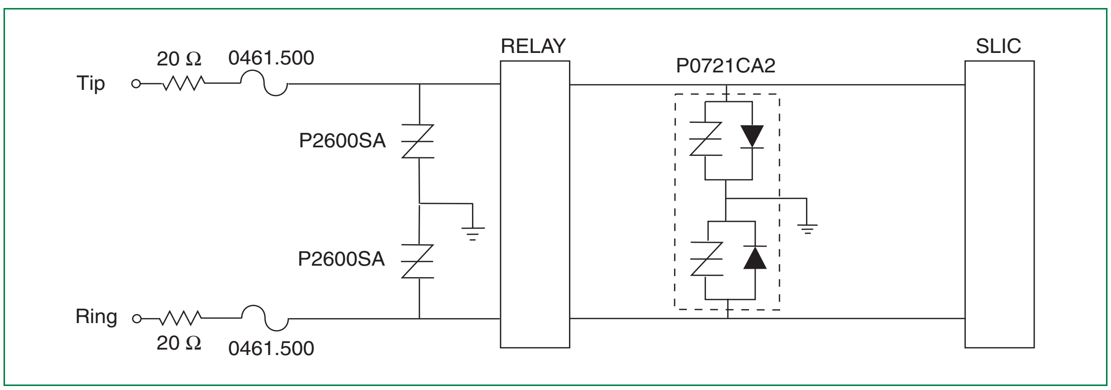


Figure 6.40 SLIC Protection with Fixed Voltage *SIDACtor* Devices

Figure 6.41, Figure 6.42, and Figure 6.43 illustrate the use of different circuits to coordinate overvoltage and overcurrent protection when protecting the LCAS family of solid state switches. Figure 6.41 illustrates the use of the *TeleLink* and the *SIDACtor*. The *TeleLink* is a surface mount, surge resistant fuse that saves cost and PCB real estate over more traditional solutions.

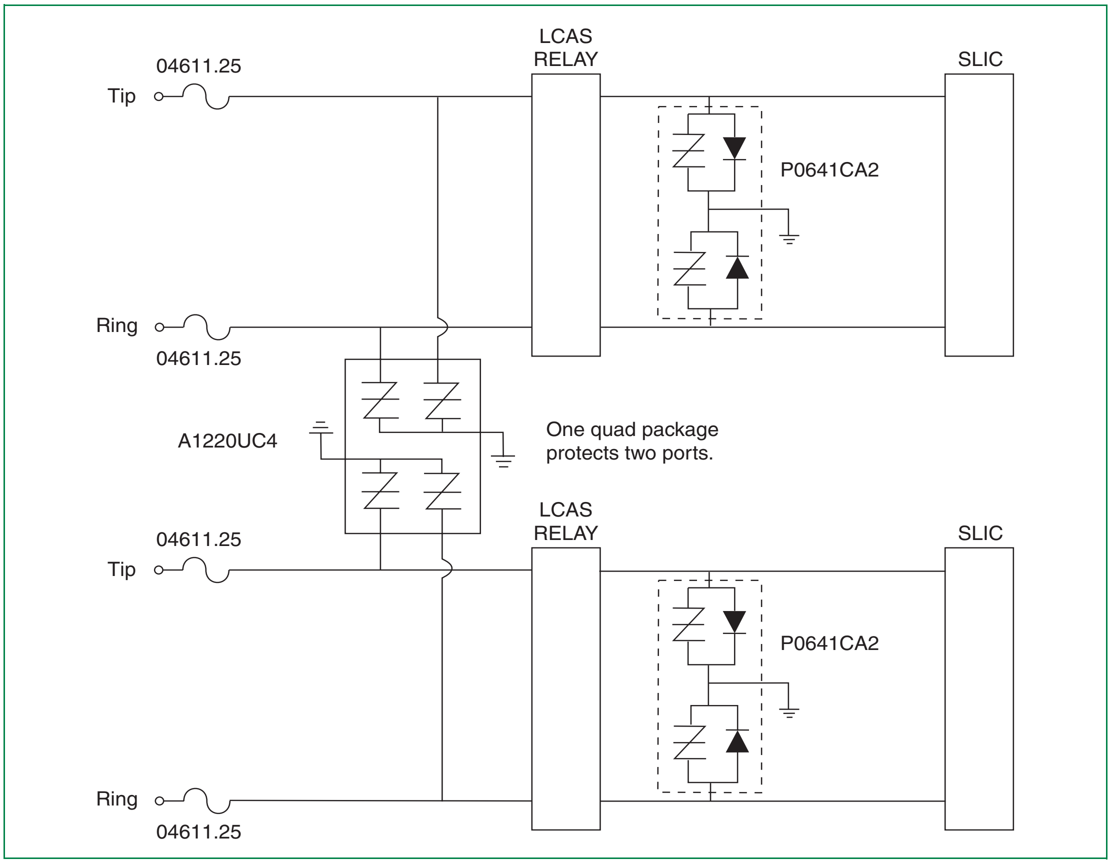
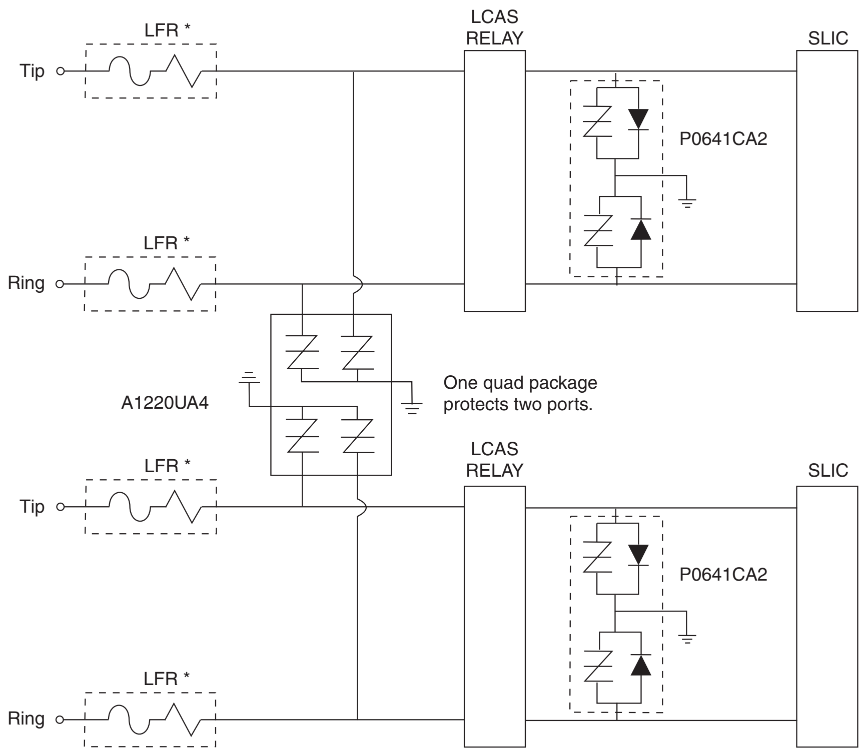


Figure 6.41 SLIC Protection with *TeleLink* Multiport

Figure 6.42 illustrates the use of a line feed resistor with a thermal link and the *SIDACtor*. The advantage of using an LFR is that it attenuates surge currents, allowing use of a *SIDACtor* with a lower surge current rating.



* Assumed minimum resistance of 20 Ω. If the LFR does not have a fusible link, then the 04611.25 is recommended for overcurrent protection.

Figure 6.42 SLIC Protection with LFR Multiport

Figure 6.43 illustrates a single port version with the *TeleLink* and discrete *SIDACtors*.

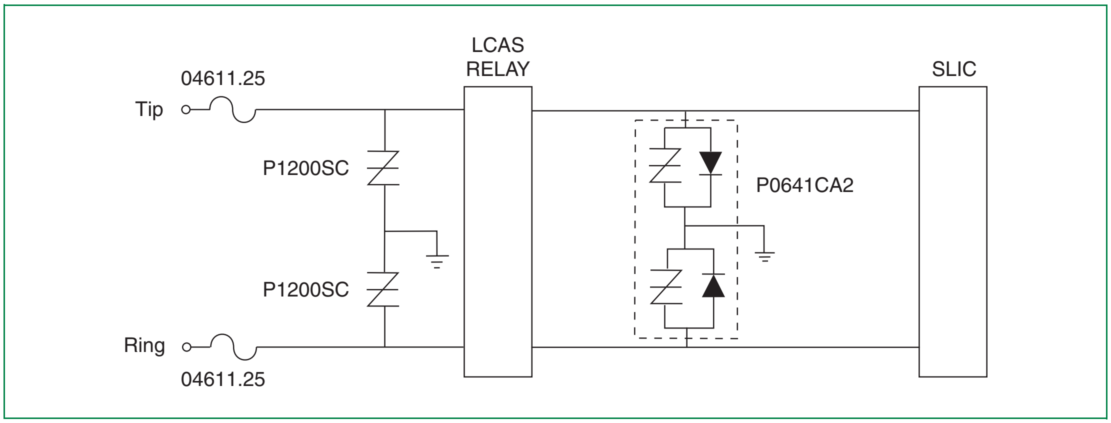


Figure 6.43 SLIC Protection with Single Port Discrete

Figure 6.44 shows protection of a SLIC using 20 Ω series resistors on both Tip and Ring in addition to Littelfuse's *Battrax* (B1100CC) and a diode bridge (General Semiconductor part number EDF1BS). However, the overshoot caused by the diode bridge must be considered. The series resistance (a minimum of 20 Ω on Tip and 20 Ω on Ring) limits the simultaneous surge currents of 100 A from Tip to Ground and 100 A from Ring to Ground (200 A total) to within the surge current rating of the SA-rated *SIDACtor* device and *Battrax*. The diode bridge shunts all positive voltages to Ground, and the B1100CC shunts all negative voltages greater than $|-V_{REF} - 1.2 \text{ V}|$ to Ground.

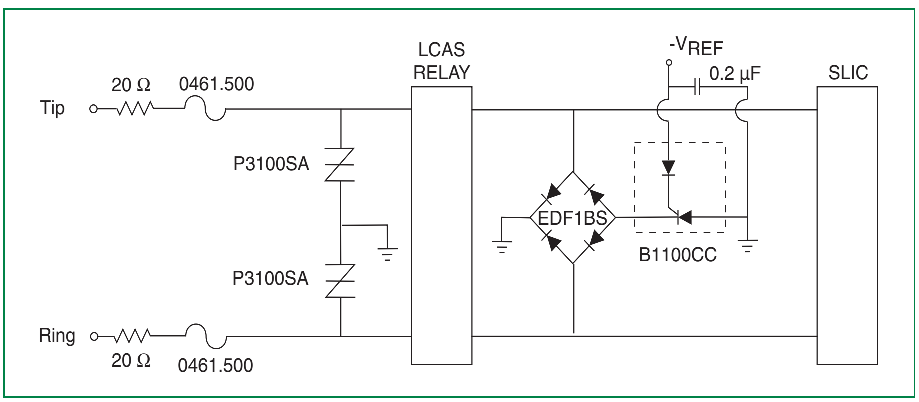


Figure 6.44 SLIC Protection with a Single *Battrax* Device

Reference Designs

In Figure 6.45 and Figure 6.46 an application that requires 50 Ω Line Feed Resistors (LFR) uses one B1160CC and two EDF1BS diode bridges in place of multiple SLIC protectors. The overshoot caused by the diode bridge must be considered; however, with this approach it is imperative that the sum of the loop currents does not exceed the *Battrax*'s holding current. In the application shown in Figure 6.45 and Figure 6.46, each loop current would have to be limited to 80 mA. For applications requiring the protection of four twisted pair with one *Battrax*, use the B1200CC and limit each individual loop current to 50 mA.

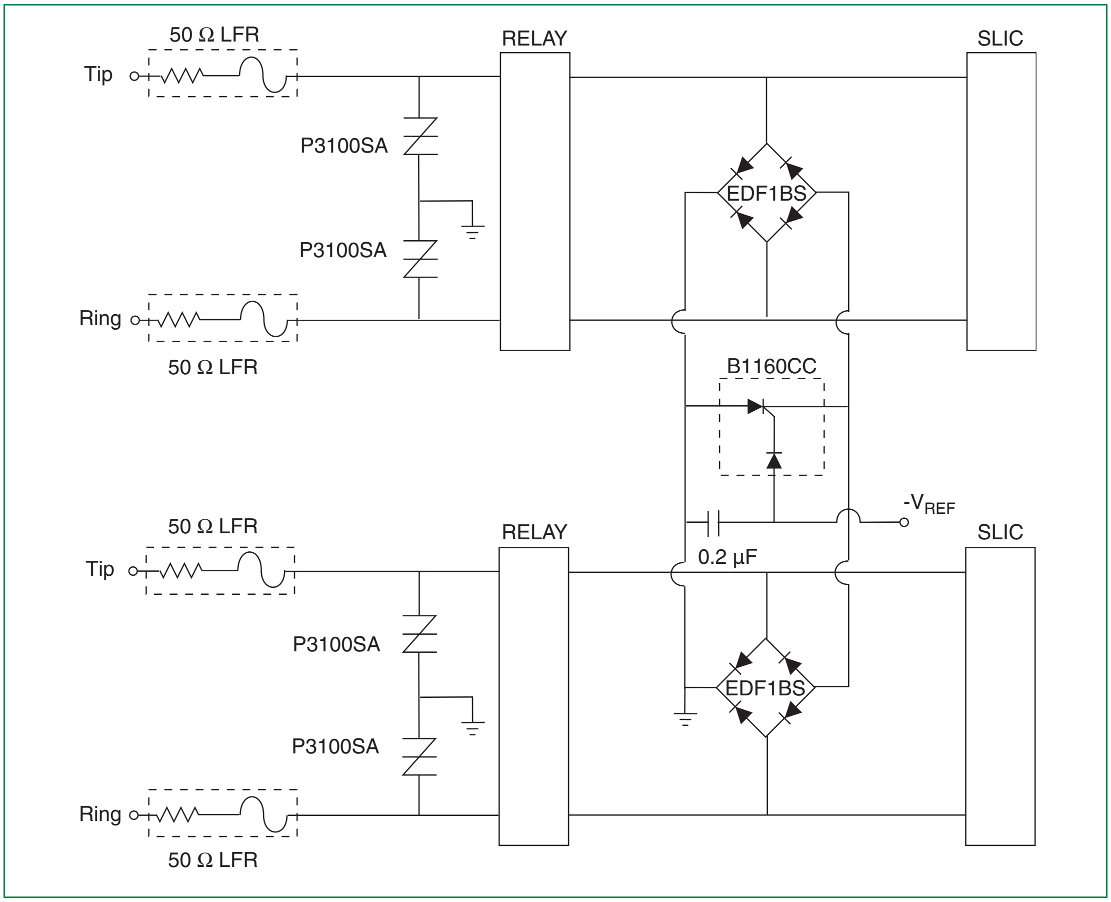


Figure 6.45 SLIC Protection with a Single *Battrax* Device

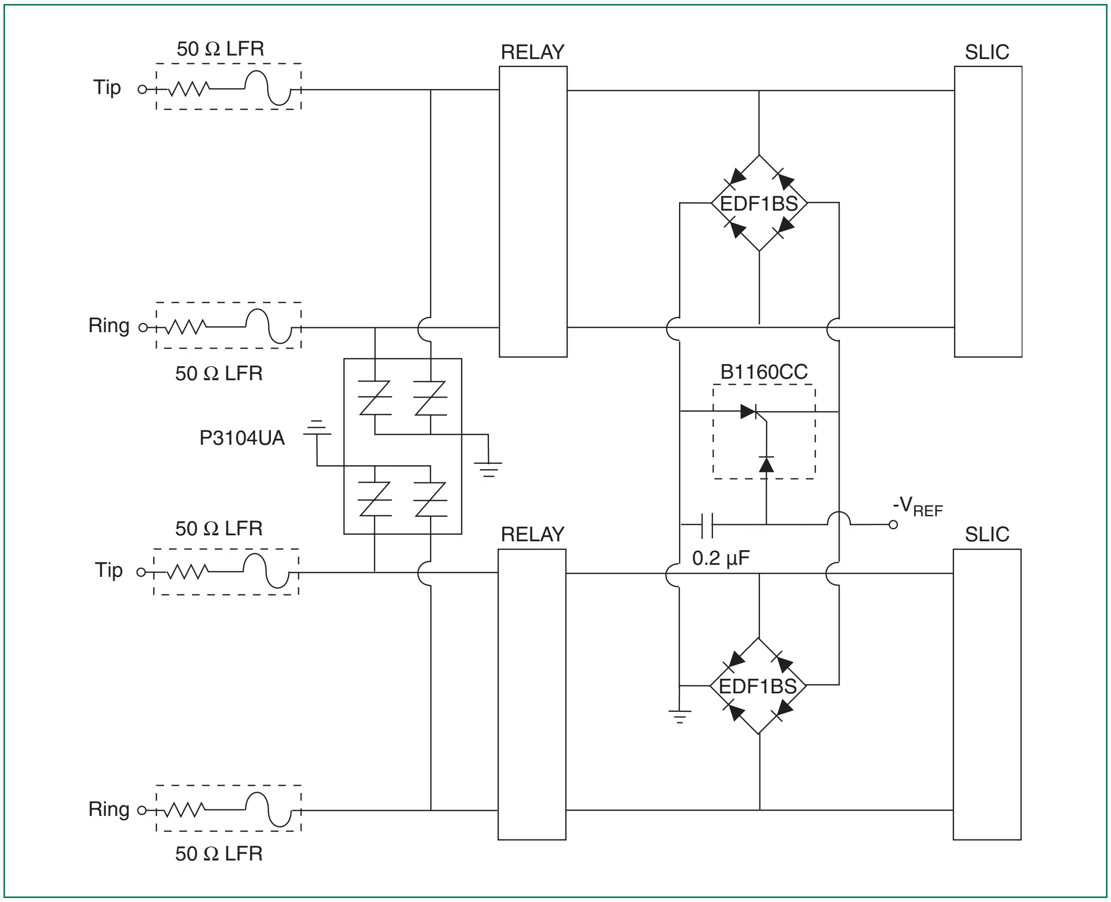


Figure 6.46 SLIC Protection with Diode Bridge

Figure 6.47, Figure 6.48, and Figure 6.49 show circuits that use negative *Battrax* devices containing an internal diode for positive surge protection. This obviates using the discrete diodes shown in Figure 6.44, Figure 6.45, and Figure 6.46.

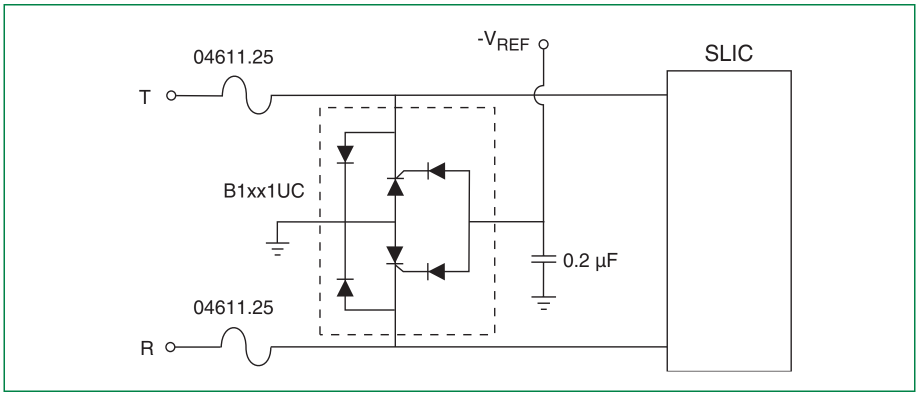


Figure 6.47 SLIC Protection with a Dual *Battrax* Device

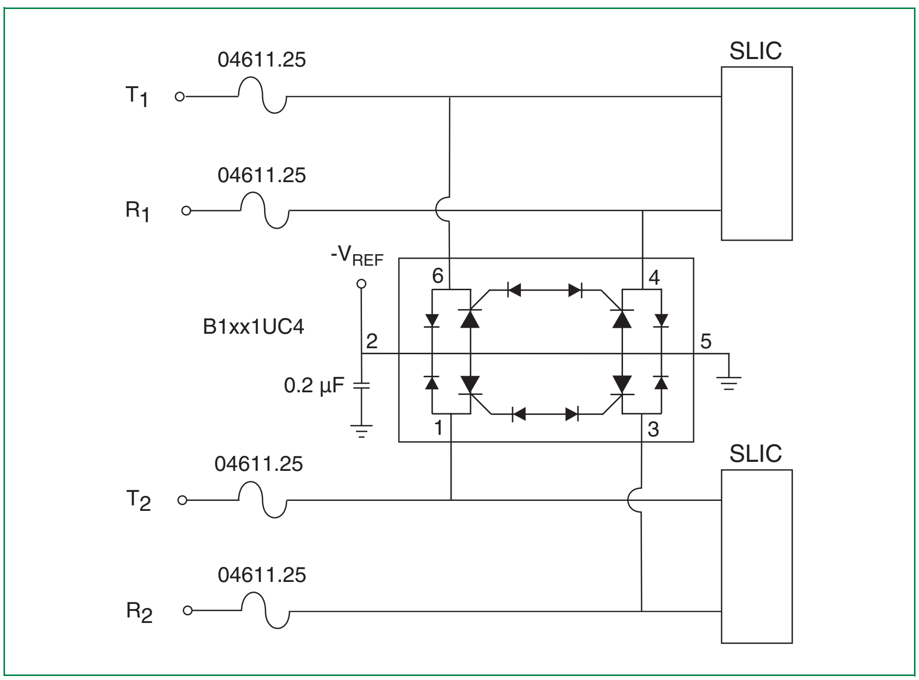


Figure 6.48 SLIC Protection with a Single *Battrax* Quad Negative Device

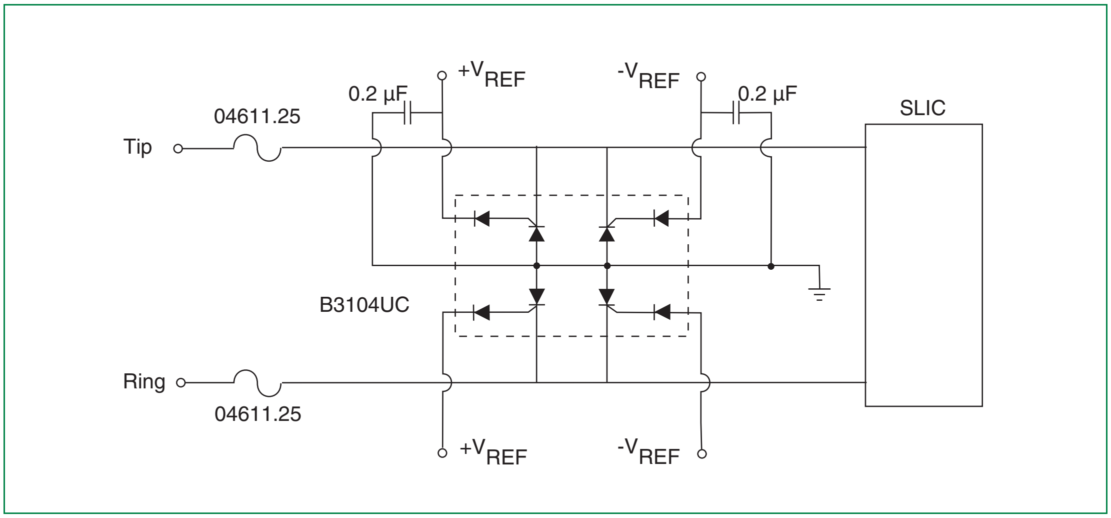


Figure 6.49 SLIC Protection with a *Battrax* Dual Positive/Negative Device

Figure 6.50 shows a SLIC application protected by the BN1718C *Battrax* device and two *TeleLink* fuses. This surface mount arrangement provides a minimum footprint solution for both overcurrent and overvoltage protection. The BN1718C Battrax protects against both positive and negative induced surge events. The integrated diode within this package provides the positive polarity protection.

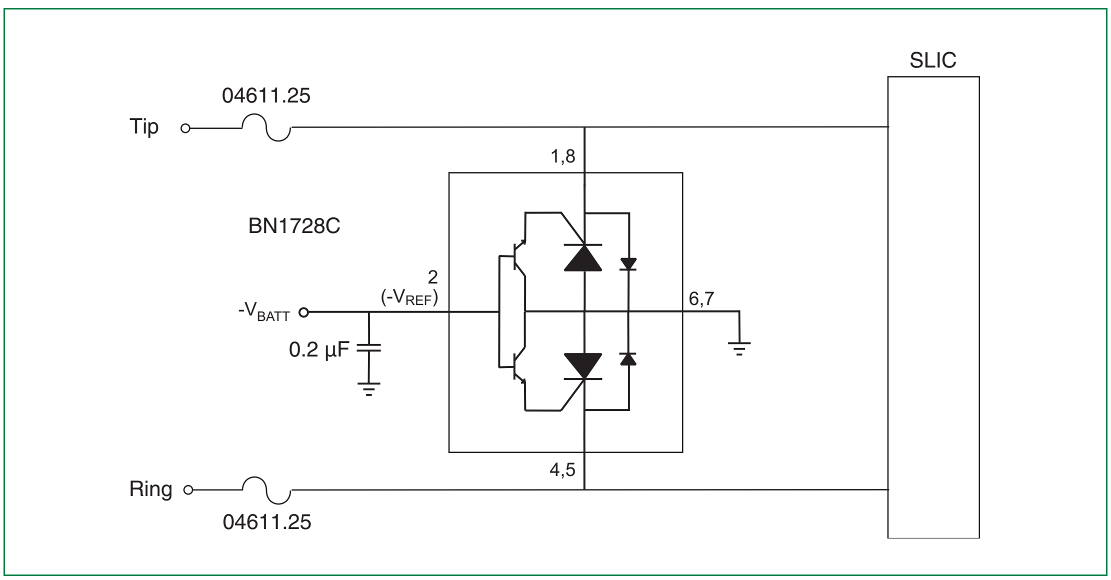


Figure 6.50 SLIC Protection with an 8-pin *Battrax* Dual Positive/Negative Device

SLIC Protection Options

Figure 6.51 through Figure 6.54 illustrate SLIC protection options.

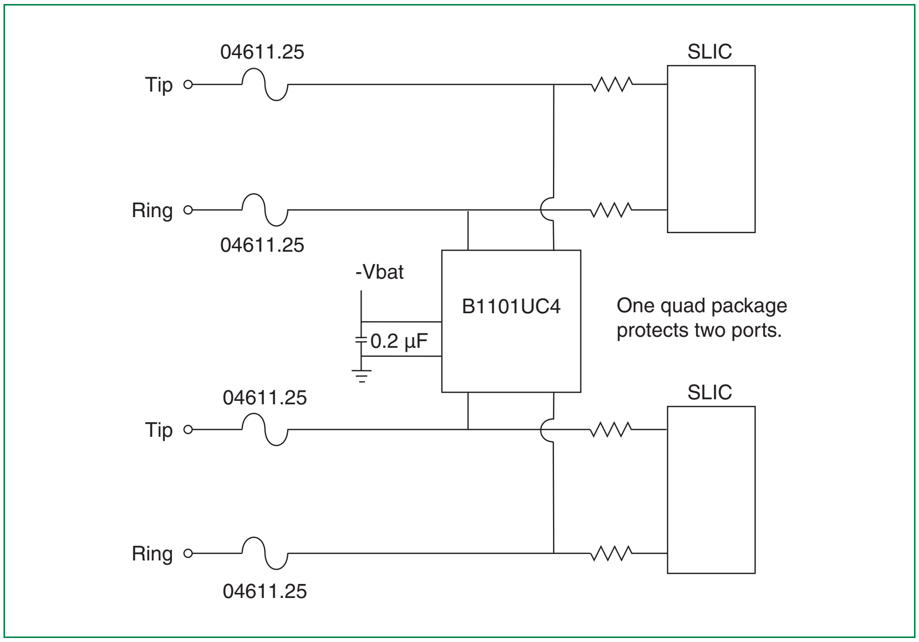


Figure 6.51 SLIC Protection with Quad *Battrax*

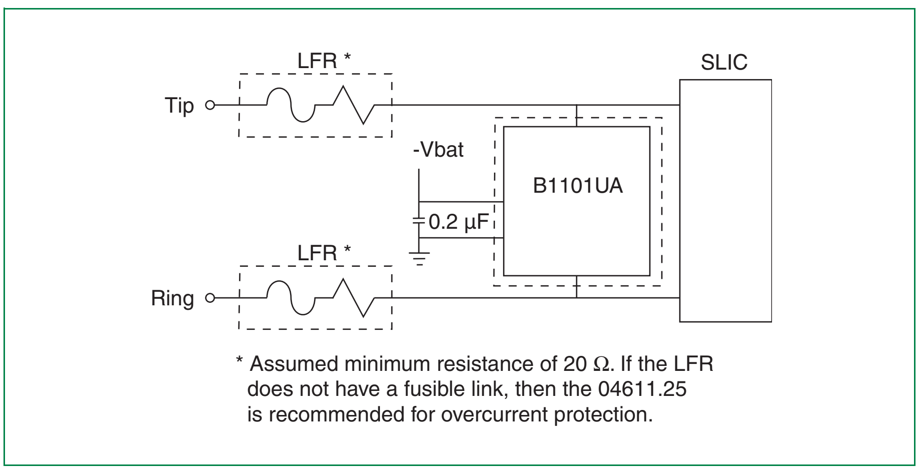


Figure 6.52 SLIC Protection with Series R and *Battrax*

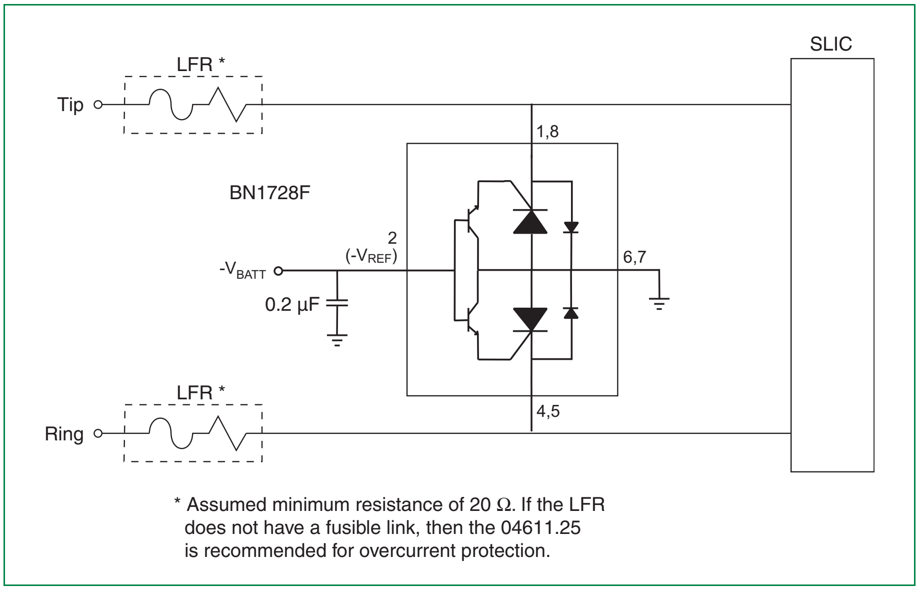


Figure 6.53 SLIC Protection with Series R and 8-pin *Battrax*

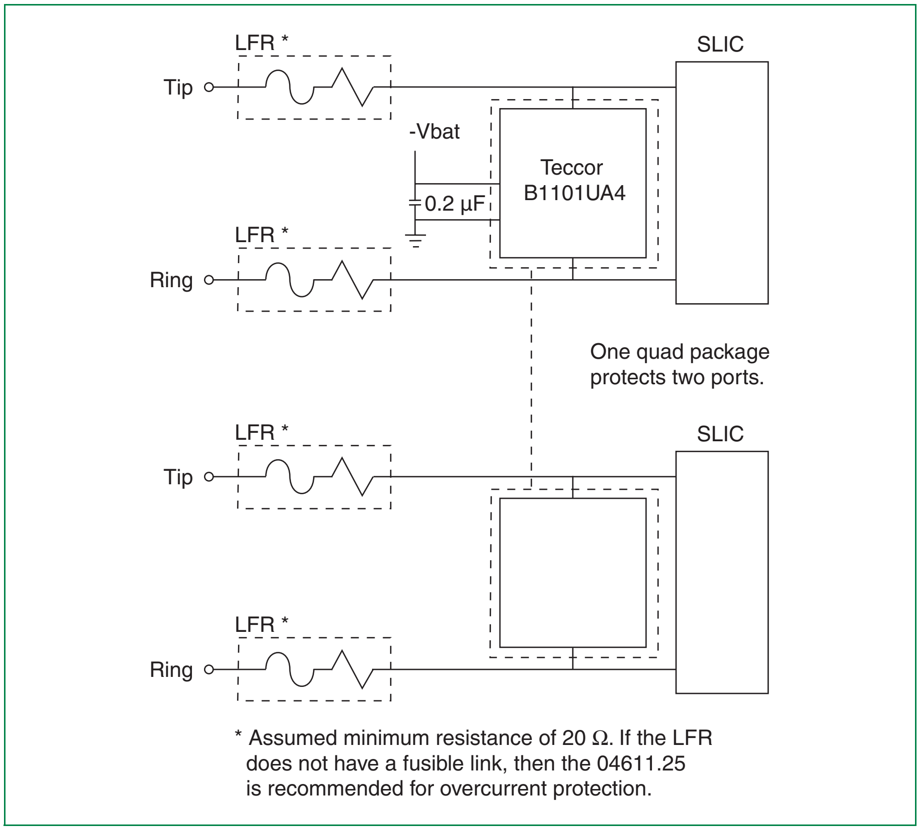


Figure 6.54 SLIC Protection with Series R and Quad *Battrax*

Battrax® Protection Gate Buffer Circuit

Many SLIC card designs do not require the *Battrax* protection gate buffer circuit shown in Figure 6.55. This circuit is useful to improve the voltage overshoot performance during AC power fault events. There is no impact on lightning surge performance as the gate capacitor is the only current source required during high dv/dt events.

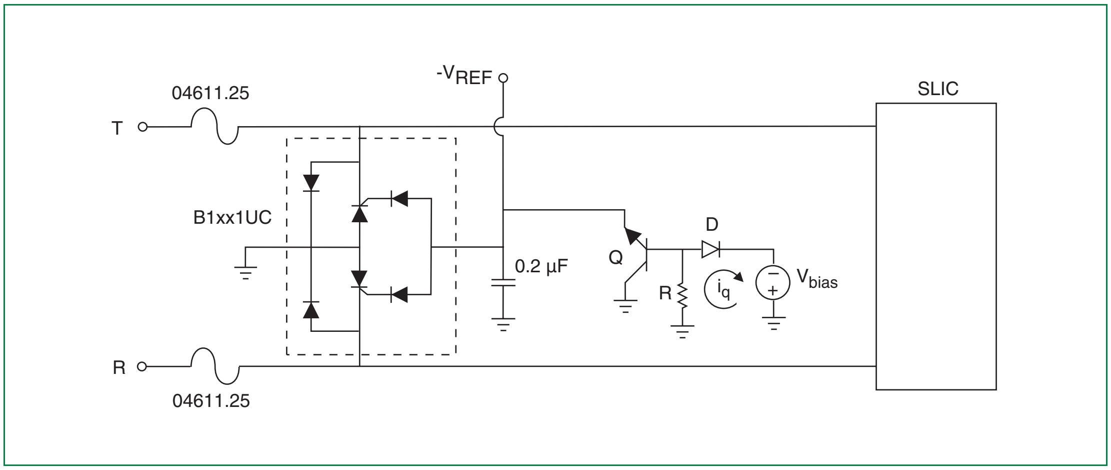


Figure 6.55 *Battrax* Protection Gate Buffer Circuit

During slower events (such as power fault), the current from the capacitor (C x dv/dt) may not source the needed current (100 mA max) to gate the SCR on. This does not apply to the BNxxxx series as its gate trigger valve is 5 mA. Under these conditions, this buffer circuit will source the needed current. The SLIC card bias supply is a negative (sinking) supply and cannot source any current.

In many designs, the bias supply is also the main supply powering the SLIC card. As such, the supply has a significant load at all times. This is the source of the gate current. When sourcing the gate current, the bias supply is actually being relieved of the load. As long as the load on the bias supply is 100 mA for each line protected, this buffer circuit is not needed. For lightly loaded bias supplies, this circuit may be useful.

Protection Circuitry

The buffer circuit consists of a diode, a resistor, and a transistor connected as shown. A small current i_q circulates constantly from the supply through the resistor and diode. When required to source current (during a fault condition where the emitter is being pulled more negative than the V_{bias} supply), the transistor Q will turn on because i_q is available as base current and Q will provide the needed current from its collector, out the emitter and into the gate of the *Battrax* device. One buffer circuit may provide current to several *Battrax* devices if properly designed.

Component Selection

Transistor Q should be selected to have a collector breakdown voltage well in excess of the bias supply voltage. The current available from Q will be H_{fe} x V_{bias} / R where H_{fe} is the gain of the transistor. The current available should be at least 100 mA per line protected. Selection of a Darlington pair transistor with a large gain can greatly increase the allowed value of R, reducing the quiescent dissipation.

The diode D need only be a small signal diode and may not be needed if the supply has its own source current protection built in.

The resistor R should be selected by the equation above to yield the needed source current. Keep in mind that it will dissipate V_{bias}^2 / R and should be sized appropriately. If there is ANY constant load on the V_{bias} supply due to the SLIC card design, the equivalent resistance of that load may be lumped into the R calculation and, in many cases, make R unnecessary.

This buffer circuit is not required for the new BNxxxx series *Battrax* devices. The internal structure of this device accomplishes the function of this darlington pair circuit.

PBX Systems

Branch Exchange Switches

PBXs, KSUs, and PABXs contain line cards that support various transmission protocols such as ISDN, T1/E1, HDSL, and ADSL (Figure 6.56). PBXs also have features such as a POTS (plain old telephone service) pull-through which allows stations to have outside line access in the event of power failure. All incoming lines to the PBX are subject to environmental hazards such as lightning and power fault.

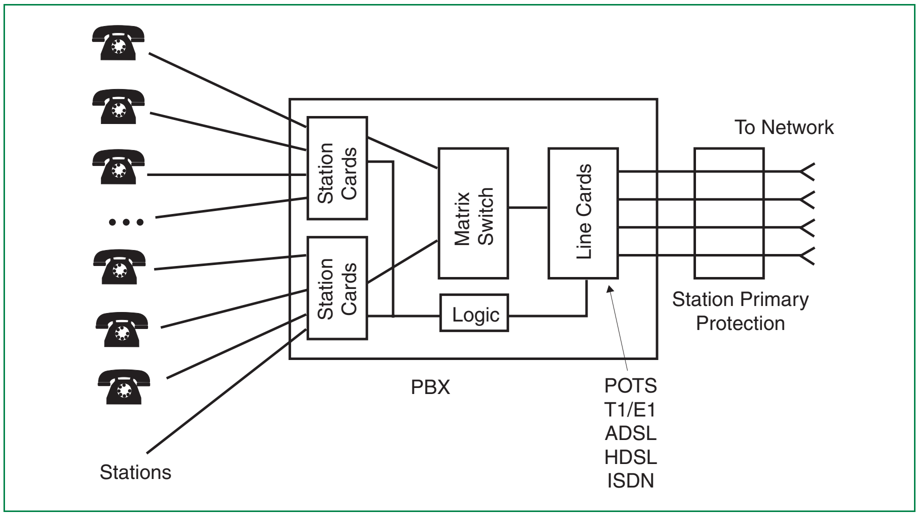


Figure 6.56 PBX Overview

Protection Requirements

Branch exchange switches should be protected against overvoltages that can exceed 800 V and surge currents up to 100 A.

The following regulatory requirements apply:
- TIA-968-A (formerly known as FCC Part 68)
- UL 60950

Branch Exchange Reference Circuit

Refer to the following for information on interface circuits used to protect of PBX line cards:
- For POTS protection, see "Customer Premises Equipment (CPE)" on page 6-2.
- For ADSL protection, see "ADSL / VDSL Circuit Protection" on page 6-10.
- For HDSL protection, see "HDSL Circuit Protection" on page 6-12.
- For ISDN protection, see "ISDN Circuit Protection" on page 6-14.
- For T1/E1 protection, see "T1/E1/J1 Circuit Protection" on page 6-18.
- For Station Protection, see "Analog Line Cards" on page 6-24.

CATV Equipment

As cable providers enter the local exchange market, protection of CATV (Community Antenna TV) equipment becomes even more critical in order to ensure reliable operation of equipment and uninterrupted service.

Protection Requirements

CATV line equipment should be able to withstand overvoltages that exceed 6000 V and surge currents up to 5000 A. CATV station protectors should be able to withstand overvoltages that exceed 5000 V and surge currents up to 1000 A. The *SIDACtor®* devices illustrated in Figure 6.57 through Figure 6.61 meet these requirements.

The following regulatory requirements may apply:

- UL 497C
- SCTE IPS-SP-204
- SCTE Practices
- NEC Article 830

Power Inserter and Line Amplifier Reference Circuit

Figure 6.57 and Figure 6.59 show how the P1900ME *SIDACtor* device is used to protect line amplifiers and power supplies versus using two SCRs and one *SIDACtor* device, as shown in Figure 6.60. The P1900ME is used because the peak off-state voltage (V_{DRM}) is well above the peak voltage of the CATV power supply (90 V_{RMS} $\sqrt{2}$), and the peak pulse current rating (I_{PP}) is 3000 A.

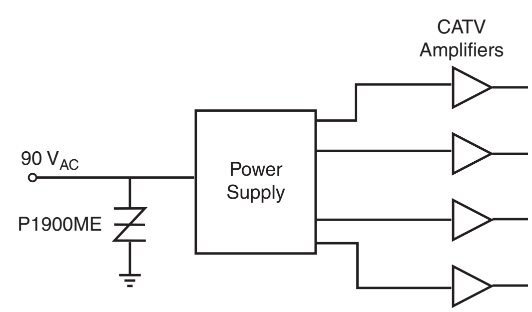


Figure 6.57 CATV Amplifier Diagram

The circuits shown in Figure 6.58, Figure 6.59, and Figure 6.60 may be covered by one or more patents.

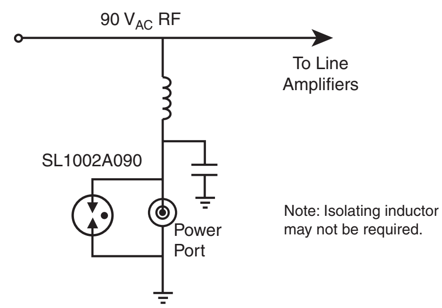


Figure 6.58 Gas Plasma Arrester CATV Amplifier Protection (incorporated into a power inserter module)

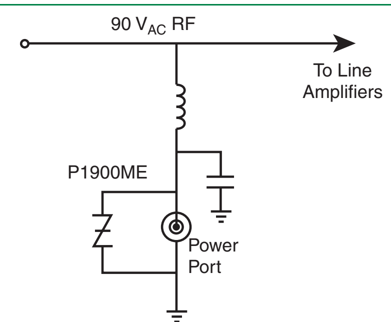


Figure 6.59 *SIDACtor* CATV Amplifier Protection (incorporated into a power inserter module)

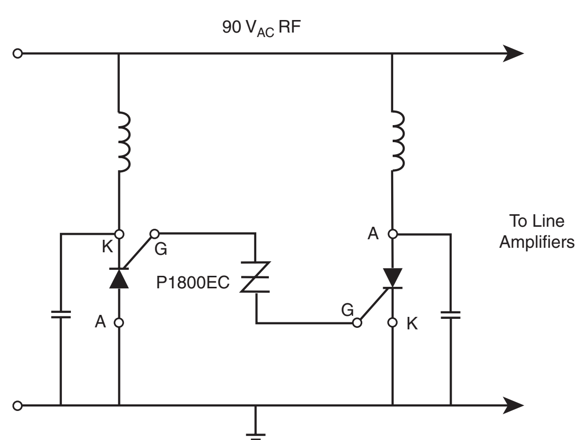


Figure 6.60 CATV Amplifier Protection

CATV Station Protection Reference Circuit

Figure 6.61 shows a P1400AD *SIDACtor* device used in a CATV station protection application. Note that a compensation inductor may be required to meet insertion and reflection loss requirements for CATV networks. If so, the inductor should be designed to saturate quickly and withstand surges up to 200 V and 1000 A. An inductor with a core permeability of approximately 900 Wb/A·m and wound with 24-gauge wire to an inductance of 20 µH to 30 µH is an example of a suitable starting point, but the actual value depends on the design and must be verified through laboratory testing.

Figure 6.62 is a protection circuit that does not require the compensating inductor.

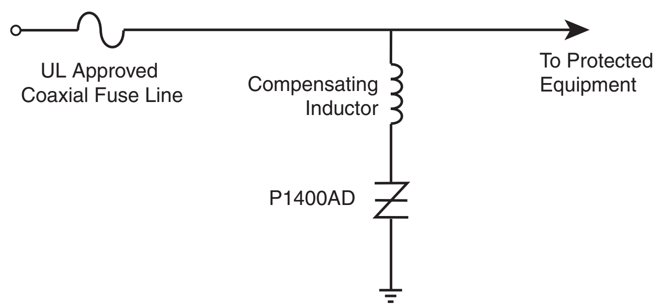


Figure 6.61 *SIDACtor* CATV Station Protection

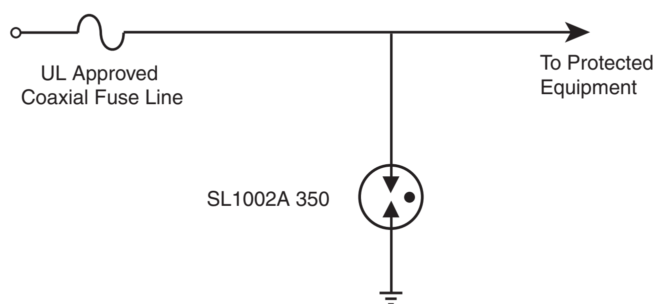


Figure 6.62 Gas Plasma Arrester CATV Station Protection

Primary Protection

Primary telecommunications protectors must be deployed at points where exposed twisted pairs enter an office building or residence. This requirement is mandated in North America by the National Electric Code (NEC) to protect end users from the hazards associated with lightning and power fault conditions.

Primary protection is provided by the local exchange carrier and can be segregated into three distinct categories:
- Station protection—typically associated with a single twisted pair
- Building entrance protection—typically associated with multiple (25 or more) twisted pair
- Central office protection—typically associated with numerous twisted pair feeding into a switch

Station protectors provide primary protection for a single-dwelling residence or office. The station protector is located at the Network Interface Unit (NIU), which acts as the point of demarcation, separating the operating company's lines from the customer's.

Building entrance protection is accomplished by installing a multi-line distribution panel with integrated overvoltage protection. These panels are normally located where multiple twisted pairs enter a building.

A five-pin protection module plugged into a Main Distribution Frame (MDF) provides Central and Remote Office protection. Like station and building entrance protection, the MDF is located where exposed cables enter the switching office.

Littelfuse offers components used in five-pin protectors. For further details, contact factory.

Protection Requirements

Station protectors must be able to withstand 300 A 10x1000 surge events. The building entrance protectors and CO protectors must be able to withstand 100 A 10x1000 surge events. Figure 6.64 shows building entrance protector and CO protector asymmetrical solutions. Figure 6.66 shows building entrance protector and CO protector balanced solutions.

The following regulatory requirements apply:
- UL 497
- GR 974-CORE
- ITU K.28

Primary Protection Reference Circuit

Figure 6.63 through Figure 6.66 show different configurations used in primary protection. Note that the peak off-state voltage (V_{DRM}) of any device intended for use in primary protection applications should be greater than the potential of a Type B ringer superimposed on a POTS (plain old telephone service) battery.

$$150\ V_{RMS} \sqrt{2} + 56.6\ V_{PK} = 268.8\ V_{PK}$$

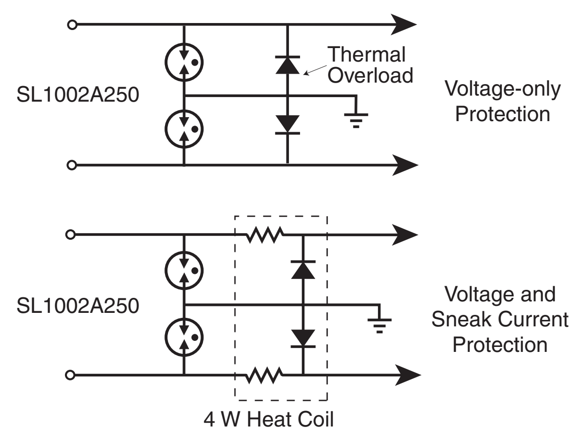


Figure 6.63 Gas Plasma Arrester Primary Protection

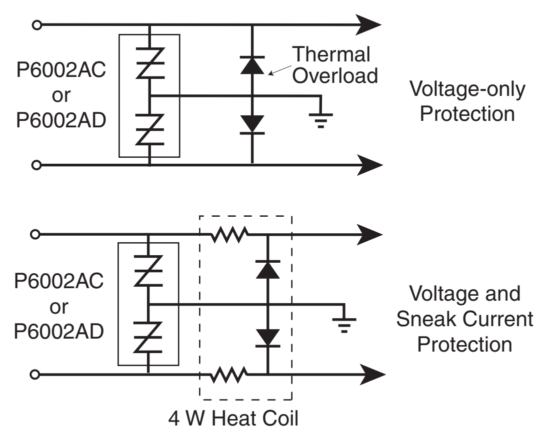


Figure 6.64 *SIDACtor* Primary Protection

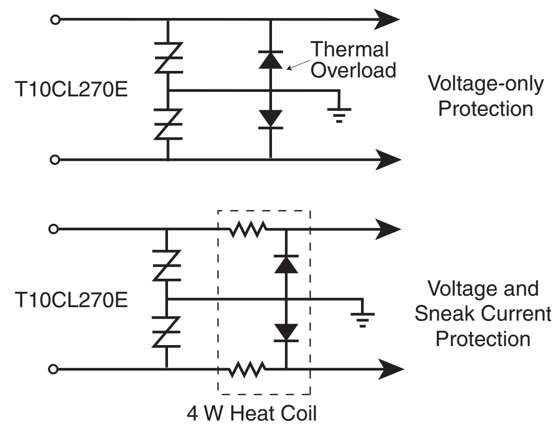


Figure 6.65 *SIDACtor* Cell Primary Protection

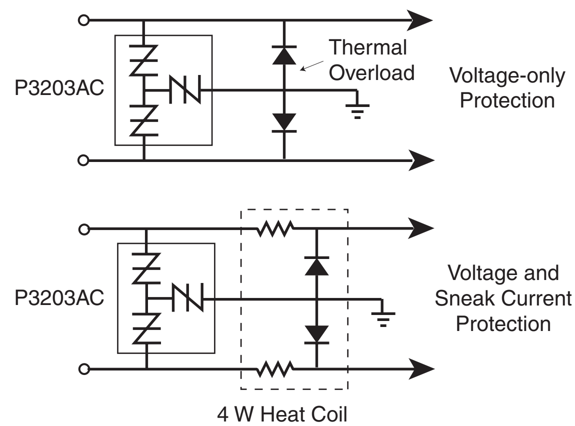


Figure 6.66 Balanced *SIDACtor* Primary Protection

Reference Designs

Secondary Protection

Secondary protectors (stand alone units or integrated into strip protectors and UPSs) are adjunct devices used to enhance the protection level of customer premise equipment (CPE). Due to the inadequate level of protection designed into CPE, secondary protectors often are required to prevent premature failure of equipment exposed to environmental hazards. (Figure 6.67)

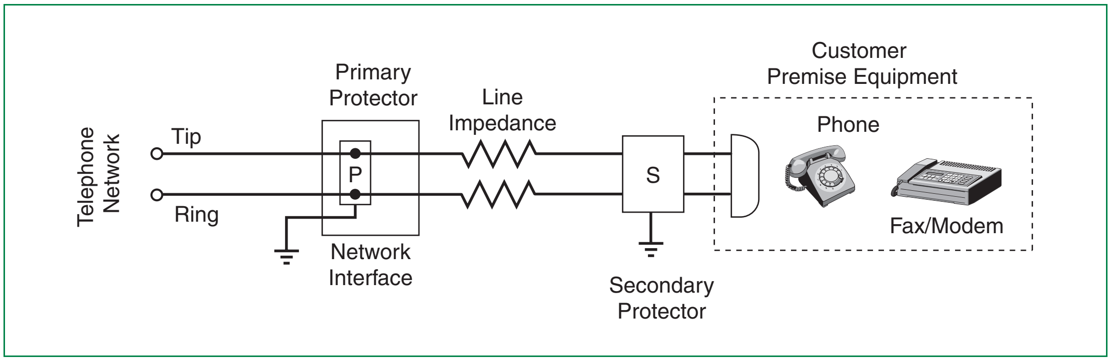


Figure 6.67 CPE Secondary Protection

Protection Requirements

Secondary protectors should be able to withstand overvoltages that can exceed 800 V and surge currents up to 100 A. Figure 6.68 illustrates a *SIDACtor*® device selected because the associated peak pulse current (I_{PP}) is sufficient to withstand the lightning immunity tests of TIA-968-A (formerly known as FCC Part 68) without the additional use of series line impedance. Likewise, Figure 6.68 illustrates a fuse selected because the amps^{2}time (I^2t) rating is sufficient to withstand the lightning immunity tests of TIA-968-A, but low enough to pass UL power fault conditions.

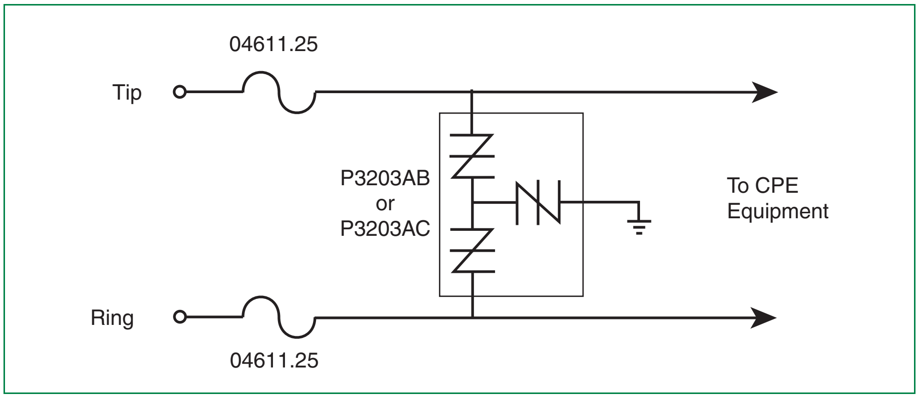


Figure 6.68 CPE Protection

Secondary Protection Reference Circuit

Figure 6.67 also shows an example of an interface design for a secondary protector. The P3203AB *SIDACtor* device is used because the peak off-state voltage (V_{DRM}) is greater than the potential of a Type B ringer signal superimposed on the POTS (plain old telephone service) battery.

$$150\ V_{RMS}\sqrt{2} + 56.6\ V_{PK} = 268.8\ V_{PK}$$

Coordination between the station protector and the secondary protector occurs due to the line impedance between the two devices. The line impedance helps ensure that the primary protector will begin to conduct while the secondary protector limits any of the let-through voltage to within the V_S rating of the *SIDACtor* device.

Triac Protection

Thyristors

Damage can occur to a thyristor if the thyristor's repetitive peak off-state voltage is exceeded. A thyristor's repetitive peak off-state voltage may be exceeded due to dirty AC power mains, inductive spikes, motor latch up, and so on.

Thyristor Reference Circuit

Figure 6.69 and Figure 6.70 show two different methods of protecting a triac. In Figure 6.69 a *SIDACtor®* device is connected from MT2 to the gate of the triac. When the voltage applied to the triac exceeds the *SIDACtor* device's V_{DRM}, the *SIDACtor* device turns on, producing a gate current which turns the triac on.

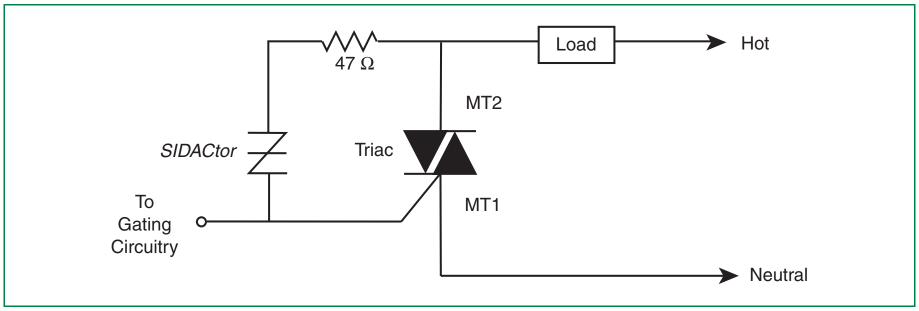


Figure 6.69 Triac Protection

The circuit in Figure 6.70 places a *SIDACtor* device across MT2 and MT1 of the triac. In this instance the *SIDACtor* device protects the triac by turning on and shunting the transient before it exceeds the V_{DRM} rating of the triac.

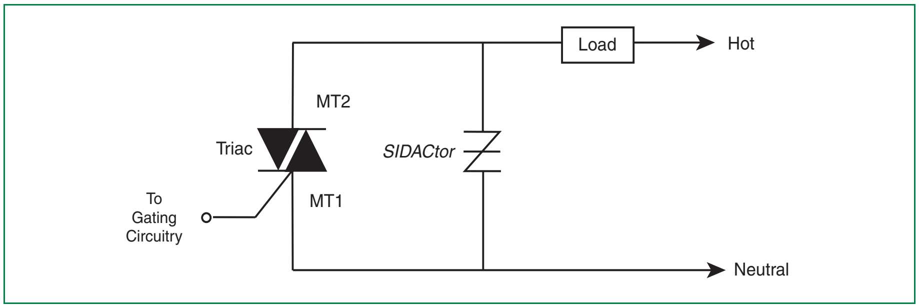


Figure 6.70 Triac Protection

With both methods, consider the following designs when using a *SIDACtor* device to protect a thyristor:

- V_{DRM} of the *SIDACtor* device < V_{DRM} of Triac
- *SIDACtor* device V_{DRM} > 120% $V_{PK(power\ supply)}$
- *SIDACtor* device must be placed behind the load

Data Line Protectors

In many office and industrial locations, data lines (such as RS-232 and ethernet) and AC power lines run in close proximity to each other, which often results in voltage spikes being induced onto the data line, causing damage to sensitive equipment.

Protection Requirements

Data lines should be protected against overvoltages that can exceed 1500 V and surge currents up to 50 A.

Data Line Reference Circuit

Figure 6.71 shows how a *SIDACtor* device is used to protect low voltage data line circuits.

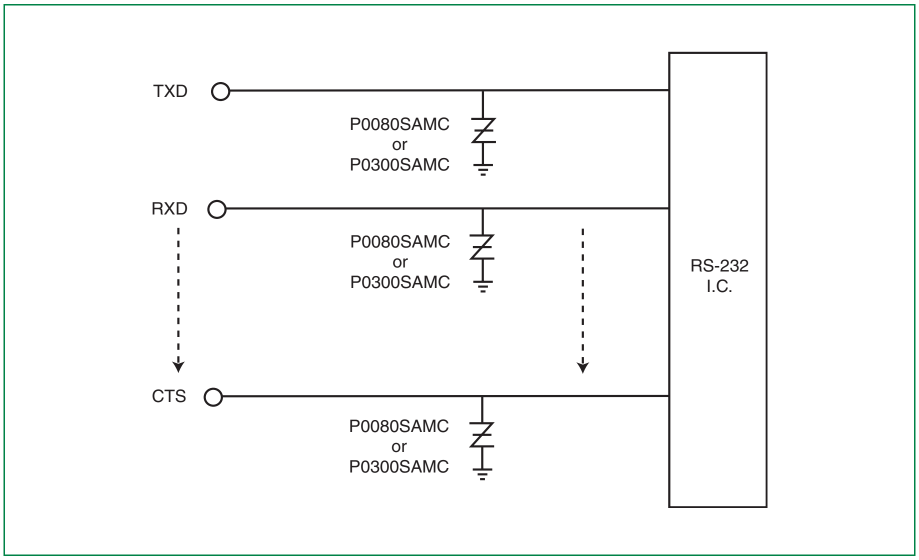


Figure 6.71 Data Line Protection

LAN and VoIP Protectors

10Base-T Protection

Capacitance across the pair of wires = (D1 || D2) + P0640EA/SA

The MUR 1100E diodes capacitance is approximately (10 pF || 10 pF) 20 pF. Then, adding the capacitive effect of the *SIDACtor* (typically 35 pF), the total capacitance across the pair of wires is approximately 14 pF. This provides a GR 1089 intra-building compliant design. (Figure 6.72)

Note: MURS160T3 is an SMT equivalent of the MUR 1100E.

Figure 6.73 shows an application requiring longitudinal protection.

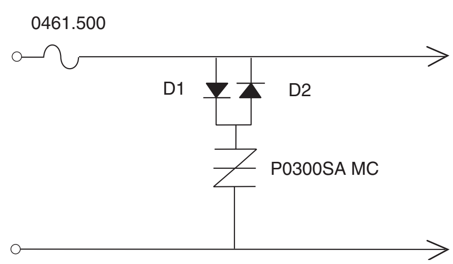


Figure 6.72 10Base-T Metallic-only Protection

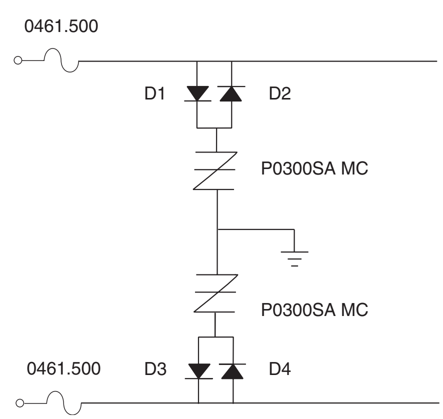


Figure 6.73 10Base-T Metallic and Longitudinal Protection

100Base-T Protection

Capacitance across the pair of wires = (D1 || D2) + P0640EA/SA + (D3 || D4)

The MUR 1100E pair of diodes capacitance is approximately (10 pF || 10 pF) 20 pF. Then, adding the capacitive effect of the P0300SA MC (typically 35pF), the total capacitance across the pair of wires is approximately 8 pF. This will provide a GR 1089 intra-building compliant design. (Figure 6.74)

Note: MURS160T3 is a SMT equivalent of the MUR 1100E.

The P0642SA is a very low capacitance device that requires no compensating diodes. (Figure 6.75)

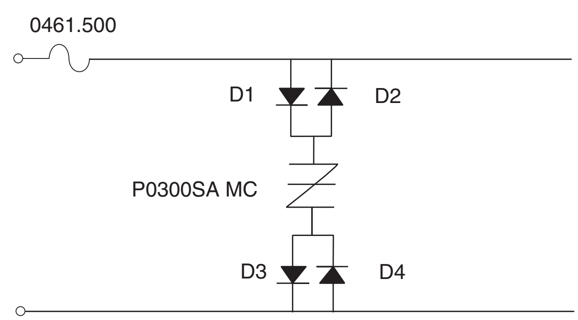


Figure 6.74 100 Base-T Protection

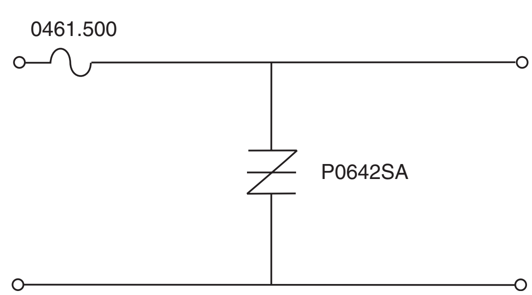


Figure 6.75 100 Base-T Protection Without External Compensation

NOTES

7

Regulatory Requirements

Due to the enormous cost of interrupted service and failed network equipment, telephony service providers have adopted various specifications to help regulate the reliability and performance of the telecommunications products that they purchase. In Europe and much of the Far East, the most common standards are ITU-T K.20 and K.21. In North America, most operating companies base their requirements on GR 1089, TIA-968-A (formerly known as FCC Part 68), and UL 60950.

Note: This section is a paraphrase of existing documents and does not cover the listed regulatory requirements in their entirety. This information is intended to be used only as a reference. For exact specifications, obtain the referenced document from the appropriate source.

GR 1089–Core

In the United States, the telecommunication network is primarily operated by the Regional Bell Operating Companies (RBOC) who follow the standards set by GR 1089 or a derivative thereof. GR 1089–Core (often referred to as GR 1089), "Electromagnetic Compatibility and Electrical Safety Generic Criteria for Network Telecommunications Equipment," covers the requirements for telecommunications equipment connected to the outside world through twisted pair. It also addresses the criteria for protection from lightning and AC power fault disturbances.

Because twisted pair are metallic conductors exposed to lightning and AC power faults, GR 1089 documents the requirements to be met by manufacturers of public switched telephone network (PSTN) equipment to ensure safe and reliable operation.

The criteria for these standards are based on transient conditions at exposed sites, such as remote facilities, central offices, and customers' premises where operating companies provide some type of primary voltage protection to limit transient voltages to 1000 V peak for surge conditions and 600 V rms for power fault conditions.

All network equipment shall be listed by a Nationally Recognized Testing Laboratory (NRTL) if the equipment is directly powered by Commercial AC. Network equipment located on customer premises shall be listed by NRTL.

In conjunction with primary voltage protectors, operating companies also may incorporate fuse links if there is the possibility of exposing the twisted pair to outside power lines. These fuse links are equivalent to 24- or 26-gauge copper wire and are coordinated with the current-carrying capacity of the voltage protector.

The last element of protection that may be provided by the operating company are current limiters which, if provided, are found on the line side of the network equipment after the primary voltage protection device. These current limiters typically come in the form of heat coils and have a continuous rating of 350 mA.

Requirements

Equipment required to meet GR 1089 must be designed to pass:

- Both First and Second Level Lightning Surge and AC Power Fault Tests
- Current Limiter Test
- Short Circuit Test

Also, changes to Chapter 4 of the GR 1089 in October 2002 now require conformance with additional definitions and tests:

- Ethernet (including 10BaseT, 100BaseT, and 1000BaseT) are considered telecommunications lines and GR 1089 requirements apply.
- The 2x10 surge is not used for systems having primary protectors mounted on the side of the enclosure or within the enclosure. It also is not used if the length of the conductors between the primary protector and the circuit pack is less than one meter **if** a metallic enclosure is used and all terminals are bonded to the enclosure and the longest dimension of the enclosure is less than three meters.
- The 600 V and 1000 V 100 A 10x1000 surge events voltage level may be reduced for CO equipment using solid state protectors.

- The secondary protector must coordinate with the primary protector OR have a 100 A 10x1000 rating. This requirement becomes effective January 2006; until then it is only an objective.
- First level power fault adds a 440 V 2.2 A two-second test and a 600 V 3 A 1.1-second test.
- Second level testing allows the wiring simulator fuse to be either the MDL 2 A or the MDQ 1.6 A. The second level requirement is the same for either the CPE or non-CPE. Additional 15-minute test conditions of 3 A, 3.75 A, 5 A, 10 A, 12.5 A, 20 A, and 30 A conditions have been added. However, compliance with UL 60950 Annex NAC conditions 3, 4, and 5 are still accepted. The 2 A and 2.6 A tests are conducted without the simulator fuse. However, it must meet applicable time-current curve.

A minimum of three units are tested for each of the operating states in which the Equipment Under Test (EUT) may be expected to function—idle, transmit, receive, on-hook, off-hook, talking, dialing, ringing, and testing. Table 7.1 and Table 7.2 show test connections, and Figure 7.1 shows the connection appearances.

Table 7.1 Test Conditions

Test	Two-wire Interface	Four-wire Interface
A	1. Tip to Generator, Ring to Ground 2. Ring to Generator, Tip to Ground 3. Tip and Ring to Generator simultaneously	1. Each lead (T, R, T_1, R_1) to the Generator with the other three leads grounded 2. Tip and Ring to Generator, simultaneously; T_1 and R_1 to Ground 3. T_1 and R_1 to Generator, simultaneously; Tip and Ring to Ground
B	Tip and Ring to Generator simultaneously	T, R, T_1, R_1 to Generator simultaneously

Notes:
- When performing longitudinal tests, the test generator will have a dual output.
- Refer to Table 7.2 for switch positions for each test condition.

Table 7.2 Connections to Test Generator

Condition	S1	S2	S3	S4
Condition A-1 of Table 7.1	Closed	Open	Open	Closed
Condition A-2 of Table 7.1	Open	Closed	Closed	Open
Condition A-3 of Table 7.1	Closed	Open	Closed	Open

Note: Other outside plant leads associated with the unit should be grounded during the test and the test repeated with these leads terminated as in service. Leads that do not connect to outside plant should be terminated as appropriate for the operating mode(s) of the unit.

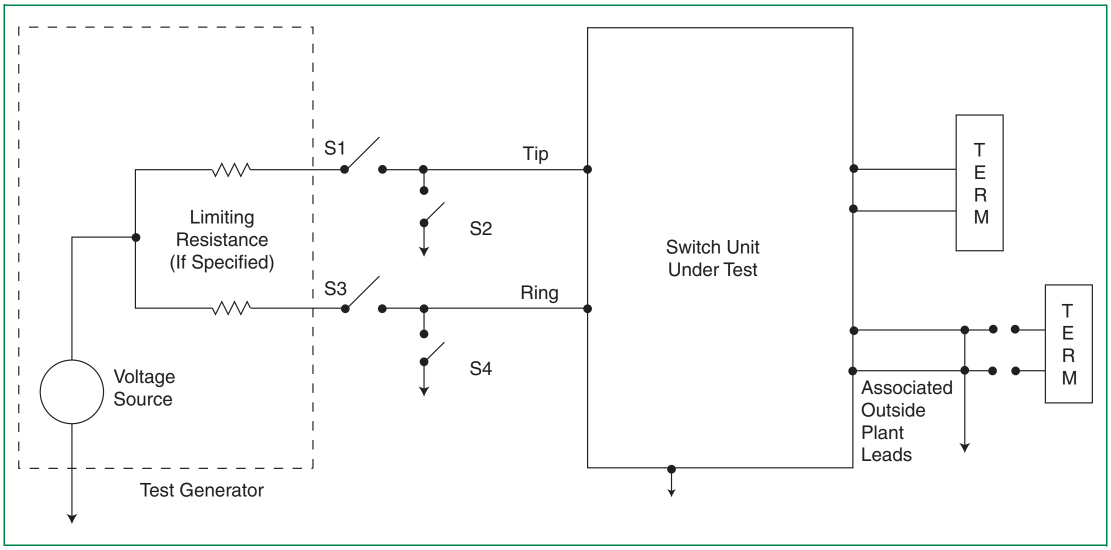


Figure 7.1 Connection Appearances

Passing Criteria

Passing criteria for the First Level Lightning Surge Test and the First Level AC Power Fault Test is that the EUT will not be damaged and that it will operate as intended after the stress is removed. Passing criteria for the Second Level Lightning Surge Test and Second Level AC Power Fault Test is that the EUT may be damaged, but it may not become a fire, fragmentation, or electrical safety hazard. Passing criteria for the Current Limiter Test is that the EUT may be damaged but it may not exceed the acceptable time/current criteria (that is, cannot cause the wiring simulator as shown in Figure 7.2 to open) nor become a fire, fragmentation, or electrical safety hazard.

The indicator used in measuring fire, fragmentation, and electrical safety hazards is a bleached, untreated cotton cheesecloth wrapped around the EUT. Compliance with testing is determined by the absence of ignition, charring, and the ejection of molten material or fragments.

It is recommended that equipment containing secondary protection do one of the following:

- Coordinate with the primary protection that is provided by the telecommunication service provider
- Have a surge withstand capability of 100 A for a 10x1000 μs surge event

Littelfuse's C-, D-, and E-rated *SIDACtor®* devices and *Greentube™* gas plasma arresters meet or exceed this surge rating. If this type of robust secondary protection is not used, then a coordination test must be applied to demonstrate compliance. (Table 7.3)

Table 7.3 Protection Coordination Lightning Surge Test

Peak Voltage V	Peak Current A	Waveform µs	Repetitions
400–2000	100 A at 1 kV	10x1000	10

Refer to the equipment supplier documentation for specifications on the primary protection with which the equipment is designed to coordinate. The maximum switching voltage threshold value for this primary protector must comply with GR 974 (1 kV for a 1 kV/µs event). This coordination test procedure requires that the peak voltage of this test start at the primary protector's specified voltage-limiting value. This value must be a minimum of 400 V and a maximum of 1000 V. The primary protector must effectively turn on during each of these conditions

First Level Lightning Surge Test

To pass the First Level Lightning Surge Test, the EUT must be undamaged and continue to operate properly after the stress is applied. This is referred to as passing "operationally." Table 7.4 presents the conditions for the First Level inter-building criteria. Applicants have the option to submit their equipment to meet surges 1, 2, 4, and 5 or surges 3, 4, and 5. Table 7.5 presents the conditions for the intra-building criteria.

Table 7.4 First Level Lightning Surge Test

Test (Notes 1 & 2)	Surge Voltage (V_{PK})	Waveform (µs)	Surge Current per Conductor (A)	Repetitions Each Polarity	Test Connections (Table 7.1, Figure 7.1)
1	±600	10x1000	100	25	A
2 (Note 3)	±1000	10x360	100	25	A
3 (Note 3)	±1000	10x1000	100	25	A
4 (Note 4)	±2500	2x10	500	10	B
5 (Note 5)	±1000	10x360	25	5	B

Notes:
1. Primary protectors are removed for all tests.
2. For EUT containing secondary voltage limiting and current limiting protectors, tests are to be performed at the indicated voltage(s) and repeated at a reduced voltage and current just below the operating threshold of the secondary protectors.
3. Test 1 and 2 can be replaced with Test 3 or vice versa.
4. Alternatively, a surge generator of 1.2x50 µs open-circuit voltage waveform (8x20 µs short-circuit current waveform) per IEEE C62.41 may be used. The current shall be limited by the inclusion of a series 3 Ω resistor placed externally to the surge generator.
5. This test is to be performed on up to 12 Tip and Ring pairs simultaneously.

Table 7.5 Intra-building Lightning Surge Test

Test	Surge Voltage (V_{PK})	Wave-form (µs)	Surge Current per Conductor (A)	Repetitions Each Polarity	Test Connections (Table 7.1, Figure 7.1)
1	±800	2x10	100	1	A1, A2
2	±1500	2x10	100	1	B

Notes:
- For EUT containing secondary voltage limiting and current limiting protectors, tests are to be performed at the indicated voltage(s) and repeated at a reduced voltage and current just below the operating threshold of the secondary protectors.
- Alternatively, a surge generator of 1.2x50 µs open-circuit voltage waveform (8x20 µs short-circuit current waveform) per IEEE C62.41 may be used. The current shall be limited by the inclusion of a series 6 Ω resistor for Test 1 and a 12 Ω resistor for Test 2, placed externally to the surge generator.

Second Level Lightning Surge Test

The Second Level Lightning Surge Test, presented in Table 7.6, does not require the EUT to pass operationally, but GR 1089 does require that the EUT not become a fire, fragmentation, or electrical safety hazard. This is referred to as passing “non-operationally.”

Table 7.6 Second Level Lightning Surge Test

Test	Surge Voltage (V_{PK})	Waveform (µs)	Surge Current (A)	Repetitions Each Polarity	Test Connections (Table 7.1, Figure 7.1)
1	±5000	2x10	500	1	B

Notes:
- Primary protectors are removed.
- For EUT containing secondary voltage limiting and current limiting protectors, tests are to be performed at the indicated voltage(s) and repeated at a reduced voltage and current just below the operating threshold of the secondary protectors.
- Alternatively, a surge generator of 1.2x50 µs open-circuit voltage waveform (8x20 µs short-circuit current waveform) per IEEE C62.41 may be used. The current shall be limited by the inclusion of a series 8 Ω resistor placed externally to the surge generator.

AC Power Fault Tests

Power companies and telephone operating companies often share telephone poles and trenches; therefore, network equipment is often subjected to the voltages seen on power lines. If direct contact between the telephone line and the primary power line occurs, the operating company’s network equipment may see as much as 600 V rms for five seconds, by which time the power company’s power system should clear itself. If direct contact occurs with the secondary power line, voltages will be limited to 277 V rms; however, these voltages may be seen indefinitely because the resultant current may be within the operating range of the power system, and the power system will not reset itself.

Another risk involved with power lines is indirect contact. Because of the large magnetic fields created by the currents in the power lines, large voltages may be induced upon phone lines via electro-magnetic coupling. In this instance voltages should be limited to 1000 V peak and 600 V rms using primary protectors, while the current will be limited by the current-carrying capacity of the 24-gauge wire.

First Level AC Power Fault Criteria

Table 7.7 presents test conditions for the First Level AC Power Fault Test. The EUT is required to pass operationally.

Table 7.7 First Level AC Power Fault Test

Test	Applied Voltage, 60 Hz (V_{RMS})	Short Circuit Current per Conductor (A)	Duration	Primary Protectors	Test Connections (Table 7.1, Figure 7.1)
1 (Note 1)	50	0.33	15 min	Removed	A
2 (Note 1)	100	0.17	15 min	Removed	A
3 (Note 1)	200, 400, 600	1A at 600 V	60 applications, 1 s each	Removed	A
4 (Note 4)	1000	1	60 applications, 1 s each	In place	B
5 (Note 2)	N/A	N/A	60 applications, 5 s each	Removed	N/A
6 (Note 3)	600	0.5	30 s	Removed	A
7 (Note 3)	440	2.2	2 s	Removed	A
8 (Note 3)	600	3	1 s	Removed	A
9 (Note 3)	1000	5	0.5 s	In place	B

Notes:
1. For EUT containing secondary voltage limiting and current limiting protectors, tests are to be performed at the indicated voltage(s) and repeated at a reduced voltage and current just below the operating threshold of the secondary protectors.
2. Test 5 simulates a high impedance induction fault. For specific information, contact Littelfuse, Inc.
3. Sufficient time may be allowed between applications to preclude thermal accumulation.
4. This test is intended to establish compatibility of the EUT with the primary protector. The maximum current is limited to 1 A rms as in Test 3, but the voltage is increased to 1,000 V to permit operation of the protector. Sufficient time may be allowed between applications to preclude thermal accumulation.

Second Level AC Power Fault Criteria

Test conditions for the Second Level AC Power Fault Test are dependent on whether the EUT is intended for customer premises equipment or non-customer premises equipment. In both instances, although the EUT is not required to pass operationally, it may not become a fire, fragmentation, or electrical safety hazard.

Second Level AC Power Fault Criteria for Non-customer Premises Equipment

Table 7.8 presents test conditions for non-customer premises equipment. (Note that test conditions 1, 3, and 4 may be omitted if the EUT has previously met UL 60950.) See Figure 7.1 for test connection appearances.

Table 7.8 Second Level AC Power Fault Test for Non-Customer Premises Equipment

Test (Notes 1, 2)	Applied Voltage, 60 Hz (V_{RMS})	Short Circuit Current per Conductor (A) (Note 5)	Duration	Test Connections (Table 7.1, Figure 7.1)
1 (Note 6)	120, 277	25	15 min	A
2	600	60	5 s	A
3	600	7	5 s	A
4 (Note 3)	100-600	2.2A at 600 V	15 min	A
5 (Note 4)	N/A	N/A	15 min	N/A

Notes:
1. Primary protectors are removed for all tests.
2. For EUT containing secondary voltage limiting and current limiting protectors, tests are to be performed at the indicated voltage(s) and repeated at a reduced voltage and current just below the operating threshold of the secondary protectors.
3. This test is to be performed between the ranges of 100 V to 600 V and is intended to produce the greatest heating effect.
4. Test 5 simulates a high impedance induction fault. Specific information regarding this test is available upon request.
5. These tests are repeated using a short-circuit value just below the operating threshold of the current limiting device, or, if the EUT uses a fuse as current limiting protection, the fuse may be bypassed and the short circuit current available adjusted to 135 percent of the fuse rating.
6. Intra-building, second level power fault test uses test condition 1 only. The applied voltage is at 120 V rms only.

Second Level AC Power Fault for Customer Premises Equipment

For customer premises equipment, the EUT is tested to the conditions presented in Table 7.9 and connected to a circuit equivalent to that shown in Figure 7.2. During this test, the wiring simulator cannot open. For equipment that uses premises type of wiring, the wiring simulator is a 1.6 A Type MDQ fuse from Bussman. For equipment that is connected by cable, the wiring simulator is a piece of 26-gauge copper wire.

Table 7.9 Second Level AC Power Fault for Customer Premises Equipment

Test	Applied Voltage, 60 Hz (V_{RMS}) (Notes 2, 3)	Source Impedance Ohms	Test Connections (Table 7.1, Figure 7.2)
1	300	20	(Note 1)
2	600	20	A

Notes:
1. Applied between exposed surfaces and Ground
2. The 60 Hz signal is applied with an initial amplitude of 30 V rms and increased by 20 percent every 15 minutes until one of the following occurs:
   — Voltage reaches the maximum specified
   — Current reaches 20 A or the wiring simulator opens
   — EUT fails open circuit
3. If the EUT fails open circuit, the test continues for an additional 15 minutes to ensure that another component of the EUT does not create a fire, fragmentation, or electrical safety hazard.

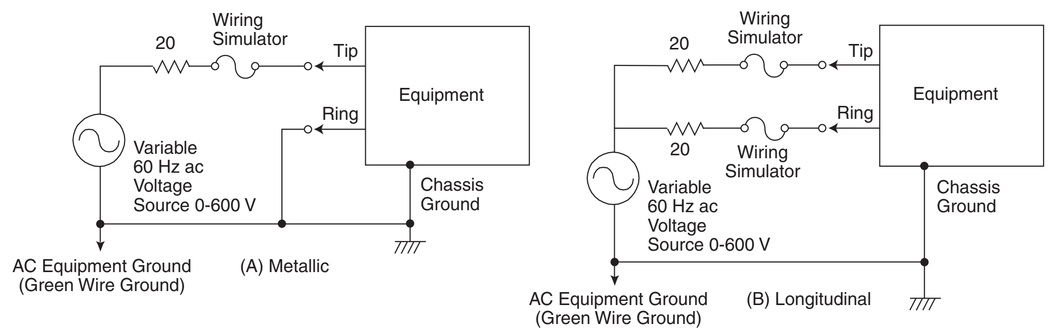


Figure 7.2 Second Level AC Power Fault and Current Limiter Connection

Current Limiting Protector Test

The purpose of the Current Limiting Protector Test presented in Table 7.10 is to determine if the EUT allows an excessive amount of current flow under power fault conditions. During this test, the EUT is connected to a circuit equivalent to that shown in Figure 7.2 with a 1.6 A Type MDQ fuse from Bussman used as the wiring simulator. If the EUT draws enough current to open the fuse, then the acceptable time/current criteria have not been met, and external current limiting protectors must be specified for use with that equipment in the manufacturer's documentation. This test is conducted at 2.2 A and 2.6 A without the wiring simulator. It is then tested at 3 A, 3.75 A, 5 A, 7 A, 10 A, 12.5 A, 20 A, 25 A, and 30 A for 15 minutes at each subsequent value until the wiring simulator opens. At 2.2 A and 2.6 A the acceptable time-current curve cannot be exceeded.

Table 7.10 Current Limiting Protector Test

Test	Applied Voltage, 60 Hz (V_{RMS})	Source Impedance Ohms	Duration	Test Connections (Table 7.1, Figure 7.2
1	600	2	15 min	A

Short-circuit Test

In addition to the AC Power Fault and Current Limiter Tests, equipment must also pass a Short-circuit Test to comply with GR 1089. During this test, a short-circuit condition is applied to the following Tip and Ring appearances for 30 minutes while the EUT is powered and under operating conditions:

- Tip-to-Ring, Tip-to-Ground with Ring open circuit
- Ring-to-Ground with Tip open circuit
- Tip- and Ring-to-Ground simultaneously for 30 minutes

At no time will the short circuit exceed 1 Ω. For equipment with more than one twisted pair, the short circuit is applied to all twisted pair simultaneously. To comply with the short circuit test, the EUT must function normally after the short-circuit condition is removed, and a fire hazard may not be present. The equipment shall not require manual intervention to restore service.

ITU-T K.20 and K.21

Although the International Telecommunication Union (ITU) does not have the authority to legislate that organizations follow their recommendations, their standards are recognized throughout Europe and the Far East.

ITU-T, the Telecommunication Standardization Sector of the ITU, developed fundamental testing methods that cover various environmental conditions to help predict the survivability of network and customer-based switching equipment. The testing methods cover the following conditions:

- Surges due to lightning strikes on or near twisted pair and plant equipment (excluding a direct strike)
- Short-term induction of AC voltage from adjacent power lines or railway systems
- Direct contact between telecommunication lines and power lines (often referred to as AC power fault)

Two ITU-T standards apply for most telecommunications equipment connected to the network:

- ITU-T K.20
- ITU-T K.21

ITU-T K.20 is primarily for switching equipment powered by the central office; however, for complex subscriber equipment, test administrators may choose either K.20 or K.21, depending on which is deemed most appropriate.

Note: Both standards are intended to address equipment reliability versus equipment safety. For specific concerns regarding equipment safety, research and follow national standards for each country in which the equipment is intended for use.

K.21 covers telecommunication equipment installed in customer premises. Equipment submitted under these requirements must meet one of two levels: basic or enhanced. Guidelines for determining under which level the equipment under test (EUT) falls can be found in ITU-T K.11, but note that the final authority rests with the test administrator. ITU-T K.44 describes the test conditions used in K.20 and K.21.

ITU-T defines the following acceptance criteria:

- **Criterion A** states that equipment shall withstand the test without damage and shall operate properly after the test. It is not required to operate correctly during the test.
- **Criterion B** states that a fire hazard shall not occur as a result of the tests. Any damage shall be confined to a small part of the equipment.

Table 7.11 shows the lightning surge test conditions for ITU K.20. Figure 7.3 shows the connection schematic for the lightning surge tests. Table 7.12 shows the power fault test conditions for ITU K.20. Figure 7.4 shows the connection schematic for the power fault tests. Table 7.13 and Table 7.14 show the same test conditions respectively for ITU K.21.

Table 7.11 K.20 Lightning Test Conditions for Telecom Equipment in Central Office/Remote Terminal

Voltage (10x700 µs)					
Single Port Metallic and Longitudinal Basic/Enhanced	Multiple Ports Longitudinal Only Basic/Enhanced	Current (5x310 µs) Basic/Enhanced (A)	Repetitions *	Primary Protection	Acceptance Criteria
1 kV/1.5 kV		25/37.5	±5	None **	A
4 kV/4 kV		100/100	±5	Installed if used	A
	1.5 kV/1.5 kV	37.5/37.5	±5	None	A
	4 kV/6 kV	100/150	±5	Installed if used	A

* One-minute rest between repetitions
** Test not conducted if primary protection is used

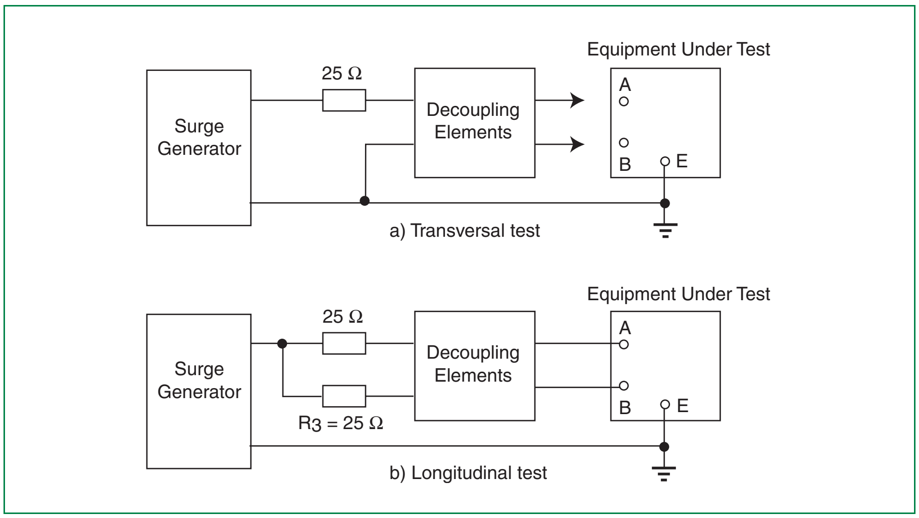


Figure 7.3 Connection Appearances

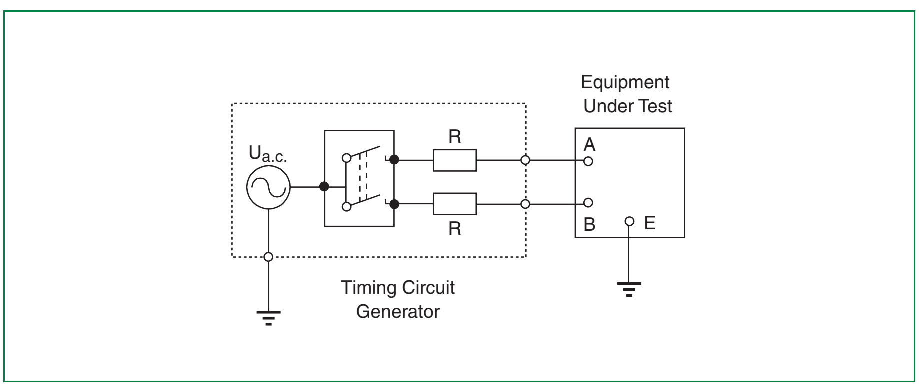


Figure 7.4 Connection Appearances (R = 10 Ω, 20 Ω, 40 Ω, 80 Ω, 160 Ω, 300 Ω, 600 Ω, and 1000 Ω for the various power fault tests)

Regulatory Requirements

Table 7.12 K.20 Power Fault Test Conditions for Telecom Type Ports, Metallic, and Longitudinal

Voltage Basic/Enhanced	Current Basic/Enhanced (A)	Duration Basic/Enhanced	Repetitions *	Primary Protection	Acceptance Criteria Basic/Enhanced
600 V/600 V 50 Hz or 60 Hz	1/1	0.2 s	5	None	A/A
600/1.5 kV 50 Hz or 60 Hz	1/7.5	1 s/2 s	5	None	A/A
230/230 V 50 Hz or 60 Hz	23/23	15 min	1	None	B/B
	11.5/11.5				B/B
	5.75/5.75				B/B
	2.875/2.875				B/B
	1.44/1.44				B/A
	0.77/0.77				B/A
	0.38/0.38				B/A
	0.23/0.23				B/B

* One-minute rest between repetitions

Table 7.13 K.21 Lightning Test Conditions for Telecom Equipment on Customer Premises

Voltage (10x700 μs)			Current (5x310 μs) Basic/Enhanced (A)	Repetitions *	Primary Protection	Acceptance Criteria
Single Port		Multiple Ports Longitudinal Only (kV) Basic/Enhanced				
Longitudinal (kV) Basic/Enhanced	Metallic (kV) Basic/Enhanced					
1.5/6 **			37.5/150	±5	None	A ***
4/6			100/150	±5	Installed if used	A
	1.5/1.5	1.5/1.5	37.5/37.5	±5	None	A ***
	4/6	4/6	100/150	±5	Installed if used	A

* One-minute rest between repetitions
** Reduce to 1.5 kV if SPD connects to Ground
*** Does not apply if primary protectors are used

Table 7.14 K.21 Power Fault Test Conditions for Telecom Type Ports, Metallic, and Longitudinal

<table>
<tr><th>Voltage Basic/Enhanced</th><th>Current Basic/Enhanced (A)</th><th>Duration Basic/Enhanced</th><th>Repetitions *</th><th>Primary Protection</th><th>Acceptance Criteria Basic/Enhanced</th></tr>
<tr><td>600 V / 600 V
50 Hz or 60 Hz</td><td>1/1</td><td>0.2 s</td><td>5</td><td>None</td><td>A/A</td></tr>
<tr><td>600 V / 1.5 kV
50 Hz or 60 Hz</td><td>1/7.5</td><td>1 s/2 s</td><td>5</td><td>Installed if used</td><td>A/A</td></tr>
<tr><td rowspan="8">230 V / 230 V
50 Hz or 60 Hz</td><td>23/23</td><td rowspan="8">15 min</td><td rowspan="8">1</td><td rowspan="8">None</td><td>B/B</td></tr>
<tr><td>11.5/11.5</td><td>B/B</td></tr>
<tr><td>5.75/5.75</td><td>B/B</td></tr>
<tr><td>2.875/2.875</td><td>B/B</td></tr>
<tr><td>1.44/1.44</td><td>B/A</td></tr>
<tr><td>0.77/0.77</td><td>B/A</td></tr>
<tr><td>0.38/0.38</td><td>B/A</td></tr>
<tr><td>0.23/0.23</td><td>B/B</td></tr>
</table>

* One-minute rest between repetitions

Enhanced power fault test condition of 1.5 kV 200 W 2 second test must meet the time current curve shown in Figure 7.5.

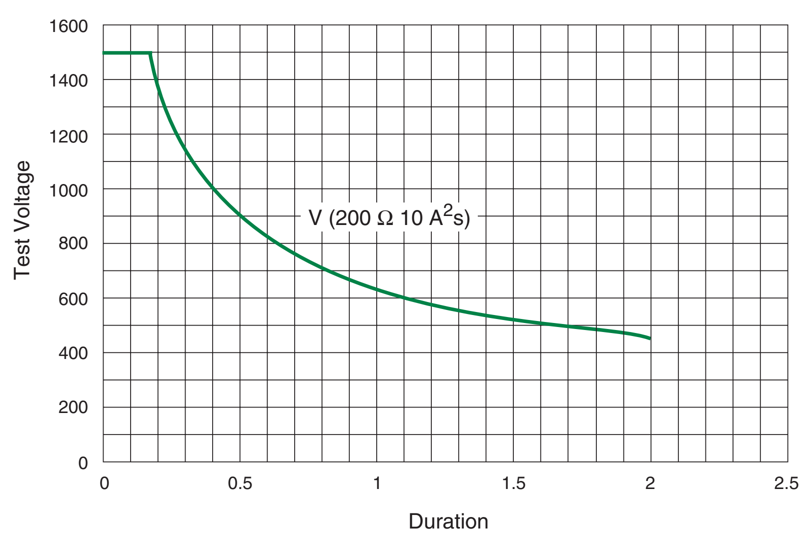


Figure 7.5 Test Voltage Versus Duration for Specific Energy / Source Resistance

Regulatory Requirements

TIA-968-A (formerly known as FCC Part 68)

TIA-968-A applies to all terminal equipment connected to the Public Switched Telephone Network (PSTN) and holds the “rule of law” by congressional order.

The purpose of TIA-968-A is to provide a set of uniform standards to protect the telephone network from any damage or interference caused by the connection of terminal equipment. This standard includes environmental simulations such as vibration tests, temperature and humidity cycling, drop tests and tests for hazardous voltages and currents, as well as tests for signal power levels, line balance, on-hook impedance, and billing protection. All these standards must be met before and after the environmental tests are applied.

Overvoltage Test

TIA-968-A compliant equipment must undergo an overvoltage test that includes a Type A and Type B Metallic Voltage Surge and a Type A and Type B Longitudinal Voltage Surge. These surges are part of the environmental simulation, and although a provision does allow the EUT to reach an open circuit failure mode during the Type A tests, failures must:

1. Arise from an intentional design that will cause the phone to be either disconnected from the public network or repaired rapidly
2. Be designed so that it is substantially apparent to the end user that the terminal equipment is not operable [A common example of an acceptable failure would be an open circuit due to an open connection on either Tip or Ring.]

For Type B surges, equipment protection circuitry is not allowed to fail. The EUT must be designed to withstand Type B surges and continue to function in all operational states.

Metallic Voltage Surge

The Type A and Type B Metallic Voltage Surges are applied in both the positive and negative polarity across Tip and Ring during all operational states (on-hook, off-hook, ringing, and so on). The Type A surge is an 800 V, 100 A peak surge while the Type B surge is a 1000 V, 25 A peak surge, as presented in Table 7.15.

Table 7.15 TIA-968-A Voltage Surge

Surge Type	Peak Voltage (V_{PK})	Rise & Decay Time (Voltage Waveform)	Peak Current (A)	Rise & Decay Time (Current Waveform)	Repetitions Each Polarity
Metallic A	±800	10x560 µs	100	10x560 µs	1
Longitudinal A	±1500	10x160 µs	200	10x160 µs	1
Metallic B	±1000	9x720 µs	25	5x320 µs	1
Longitudinal B	±1500	9x720 µs	37.5	5x320 µs	1

Notes:
- For Type A surges, the EUT may pass either “operationally” or “non-operationally.”
- For Type B surges, the EUT must pass “operationally.”
- The peak current for the Type A longitudinal surge is the total available current from the surge generator.
- The peak current for the Type B longitudinal surge is the current supplied to each conductor.

Longitudinal Voltage Surge

The Type A and Type B Longitudinal Voltage Surges are applied in both positive and negative polarity during all operational states. The Type A surge is a 1500 V, 200 A peak surge applied to the EUT with Tip and Ring tied together with respect to Ground. The Type B Longitudinal Voltage Surge is a simultaneous surge in which 1500 V and 37.5 A are applied concurrently to Tip with respect to Ground and Ring with respect to Ground, as presented in Table 7.15.

Note: Type B surge requirements guarantee only a minimum level of surge protection. For long term reliability of terminal equipment, consideration should be given to complying with Type A surges operationally.

On-hook Impedance Limitations

Another important aspect of TIA-968-A is on-hook impedance, which is affected by transient protection. On-hook impedance is analogous to the leakage current between Tip and Ring, and Tip, Ring, and Ground conductors during various on-hook conditions. "On-hook Impedance Measurements" (next paragraph) outlines criteria for on-hook impedance and is listed as part of the Ringer Equivalent Number (REN). The REN is the largest of the unitless quotients not greater than five; the rating is specified as the actual quotient followed by the letter of the ringer classification (for example, 2B).

On-hook Impedance Measurements

On-hook impedance measurements are made between Tip and Ring and between Tip and Ground and Ring and Ground. For all DC voltages up to and including 100 V, the DC resistance measured must be greater than 5 MΩ. For all DC voltages between 100 V and 200 V, the DC resistance must be greater than 30 kΩ. The REN values are then determined by dividing 25 MΩ by the minimum measured resistance up to 100 V and by dividing 150 kΩ by the minimum measured resistance between 100 V and 200 V.

On-hook impedance is also measured during the application of a simulated ringing signal. This consists of a 40 V rms through 150 V rms ringer signal at frequencies ranging from 15.3 Hz to 68 Hz superimposed on a 56.5 V dc for a class “B” ringer. During this test, the total DC current may not exceed 3 mA. In addition, the minimum DC resistance measured between Tip and Ring must be greater than 1600 Ω, while the DC resistance measured between the Tip and Ring conductors and Ground must be greater than 100 kΩ. The REN values for the simulated ringing test are determined by dividing the maximum DC current flowing between Tip and Ring by 0.6 mA, and by dividing 8000 Ω by the minimum impedance value measured.

UL 60950 3rd Edition

After the divestiture of the AT&T/Bell system, the National Electric Code (NEC) implemented Article 800-4, which mandates that "all equipment intended for connection to the public telephone network be listed for that purpose" in order to ensure electrical safety. A manufacturer can meet this requirement by listing their product with Underwriters Laboratories under UL 60950 (based on IEC 60950, 3rd edition).

The NEC requires all telecommunication wiring that enters a building to pass through a primary protector, which is designed to limit AC transients in excess of 600 V rms. These transients are due to the fact that telephone lines run in close proximity to AC power lines. Most telecommunication equipment uses a secondary overvoltage protector such as the *SIDACtor®* device. The secondary devices typically limit transients in excess of 350 V rms. Therefore, a potentially dangerous condition exists because of the voltage threshold difference of the primary protector and the secondary protector. To minimize this danger, compliance with UL 60950 overvoltage tests is required.

UL 60950 covers equipment with a rated voltage (primary power voltage) not exceeding 600 V and equipment designed to be installed in accordance with the NEC NFPA 70. This standard does not apply to air-conditioning equipment, fire detection equipment, power supply systems, or transformers.

The effective date of UL 60950 allows new products submitted through April 1, 2003 to be evaluated using the requirements of either UL 60950 or UL 1950, 3rd edition. After April 1, 2003, all new product submittals must be evaluated using only UL 60950.

Products certified by UL to requirements of UL 1459 prior to April 1, 2000 may continue to be certified without further reinvestigation until April 1, 2005, provided no significant changes or revisions are made to the products. Products certified by UL to requirements of UL 1950 3rd edition prior to April 1, 2003 may continue to be certified without further reinvestigation until April 1, 2005.

In order to have the UL Mark applied after April 1, 2005, all products, including those previously certified by UL, must comply with UL 60950.

UL 60950 is intended to prevent injury or harm due to electrical shock, energy hazards, fire, heat hazards, mechanical hazards, radiation hazards, and chemical hazards.

It defines three classes of equipment:

- Class 1—protection achieved by basic insulation
- Class 2—protection achieved by double or reinforced insulation
- Class 3—protection relying upon supply from SELV circuits (voltages up to 40 V peak or 60 V dc)

UL 60950 also defines five categories of insulation:

- Functional
- Basic
- Supplementary
- Reinforced
- Double

UL 60950 Terminology

The following definitions assist in understanding UL 60950:

SELV	Secondary circuit whose voltage values do not exceed a safe value (voltage less than hazardous levels of 42.4 V peak or 60 V dc)
TNV	Telecommunication Network Voltage (a secondary circuit)
TNV3	≥ SELV but with exposure to surges
TNV2	≥ SELV but without exposure to surges
TNV1	≤ SELV with exposure to surges

Creepage distance is the shortest distance between two conductors, measured along the surface of the insulation. DC voltages shall be included in determining the working voltage for creepage distances. (The peak value of any superimposed ripple or short disturbances, such as cadenced ringing signals, shall be ignored.)

Clearance distance is the shortest distance between two conductive parts or between a conductive part and the outer surface of the enclosure measured through air. DC voltages and the peak value of any superimposed ripple shall be included in determining the working voltage for clearance distances.

Creepage and clearance distances are also subject to the pollution degree of the equipment:

- Pollution degree 1—components and assemblies sealed to prevent ingress of dust and moisture
- Pollution degree 2—generally applicable to equipment covered by UL 60950
- Pollution degree 3—equipment subject to conductive pollution or to dry non-conductive pollution, which could become conductive due to expected condensation

To ensure safe operating conditions of the equipment, UL 60950 focuses on the insulation rating of the circuit(s) under consideration. Table 7.16 and Table 7.17 indicate the required creepage and clearance distances depending on material group, pollution degree, working voltage, and maximum transient voltage in the secondary circuit. For a typical telecommunication application with a working voltage of 200 V, pollution degree 2, material group IIIb, the creepage distance is 2 mm. The clearance distance is 2 mm for reinforced insulation.

Table 7.16 Minimum Clearances in Secondary Circuits (millimeters)

Working Voltage up to and including		Nominal AC Mains Supply Voltage ≤ 150 V (transient rating for Secondary Circuit 800 V)						Nominal AC Mains Supply Voltage > 150 V ≤ 300 V (transient rating for Secondary Circuit 1500 V)						Nominal AC Mains Supply Voltage > 300 V ≤ 600 V (transient rating for Secondary Circuit 2500 V)			Circuit Not Subject to Transient Overvoltages		
		Pollution Degrees 1 and 2			Pollution Degree 3			Pollution Degrees 1 and 2			Pollution Degree 3			Pollution Degrees 1, 2, and 3			Pollution Degrees 1 and 2 only		
V *	V **	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R
71	50	0.4	0.7	1.4	1	1.3	2.6	0.7	1	2	1	1.3	2.6	1.7	2	4	0.4	0.4	0.8
140	100	0.6	0.7	1.4	1	1.3	2.6	0.7	1	2	1	1.3	2.6	1.7	2	4	0.6	0.7	1.4
210	150	0.6	0.9	1.8	1	1.3	2.6	0.7	1	2	1	1.3	2.6	1.7	2	4	0.6	0.7	1.4
280	200	F 1.1; B/S 1.4; R 2.8												1.7	2	4	1.1	1.1	2.2
420	300	F 1.6; B/S 1.94; R 3.8												1.7	2	4	1.4	1.4	2.8

* Voltage peak or DC
** Voltage rms (sinusoidal)

Note: F = Functional
B/S = Basic/Supplementary
R = Reinforced

Table 7.17 Minimum Creepage Distances (millimeters)

Working Voltage V RMS or DC	Functional, Basic, and Supplementary Insulation						
	Pollution Degree 1	Pollution Degree 2			Pollution Degree 3		
	Material Group	Material Group			Material Group		
	I, II, IIIa, or IIIb	I	II	IIIa or IIIb	I	II	IIIa or IIIb
≤ 50	Use the Clearance from the appropriate table	0.6	0.9	1.2	1.5	1.7	1.9
100		0.7	1	1.4	1.8	2	2.2
125		0.8	1.1	1.5	1.9	2.1	2.4
150		0.8	1.1	1.6	2	2.2	2.5
200		1	1.4	2	2.5	2.8	3.2
250		1.3	1.8	2.5	3.2	3.6	4
300		1.6	2.2	3.2	4	4.5	5
400		2	2.8	4	5	5.6	6.3
600		3.2	4.5	6.3	8	9.6	10
800		4	5.6	8	10	11	12.5
1000		5	7.1	10	12.5	14	16

Note: Linear interpolation is permitted between the nearest two points, the calculated spacing being rounded to the next higher 0.1 mm increment.

The following separations require the specified insulation grade:

- TNV3 from TNV3—functional insulation
- TNV3 from SEL—basic insulation
- TNV3 from TNV1—basic insulation
- TNV3 from TNV2—basic insulation

The application must meet the creepage and clearance distances and electric strength of Section 5.3.2 of UL 60950 for functional insulation. The electric strength test (Table 5B of

UL 60950) lists 1 kV to 1.5 kV as the test voltages for functional and supplementary grade of insulation and 2 kV to 3 kV for reinforced grade of insulation.

Separation requirements are tested (Section 6.2.2.1 of UL 60950) by applying an impulse test and an electric strength test:

- Impulse test allows for the *SIDACtor* device to turn on (either a 10x700 2.5 kV 62.5 A or 1 kV 37.5 A 10 times with 60-second rest period).
- Electric strength test allows the *SIDACtor* device to be removed (60 Hz at rated voltage for 60 seconds).

These are applied between Ground and all Tip and Rings connected together, and/or between Ground and all conductors intended to be connected to other equipment connected together.

Basic insulation is not required if all the following conditions are met:

- SELV, TNV1 circuit is connected to the protective earth.
- Installation procedures specify that protective earth terminal shall have a permanent connection to earth.
- Any TNV2 or TNV3 circuit with an external port connection intended to receive signals in excess of SELV (60 V dc or 50 V peak) will have the maximum normal expected operating voltage applied to it for up to 30 minutes without deterioration. (If no maximum normal specification exists, then 120 V 100 mA 60 Hz is applied.)

(In other words, if a permanent Ground connection is made, then creepage distances may not be required.)

Any surge suppressor that bridges the insulation (connects to Ground) shall have a minimum DC turn-on voltage of 1.6 times the rated voltage **UNLESS** one of the following occurs (Section 6.1.2.2 of UL 60950):

- Equipment is permanently connected or uses an industrial plug and socket-outlet.
- Equipment is installed by service personnel.
- Equipment has provision for a permanently connected protective earth.

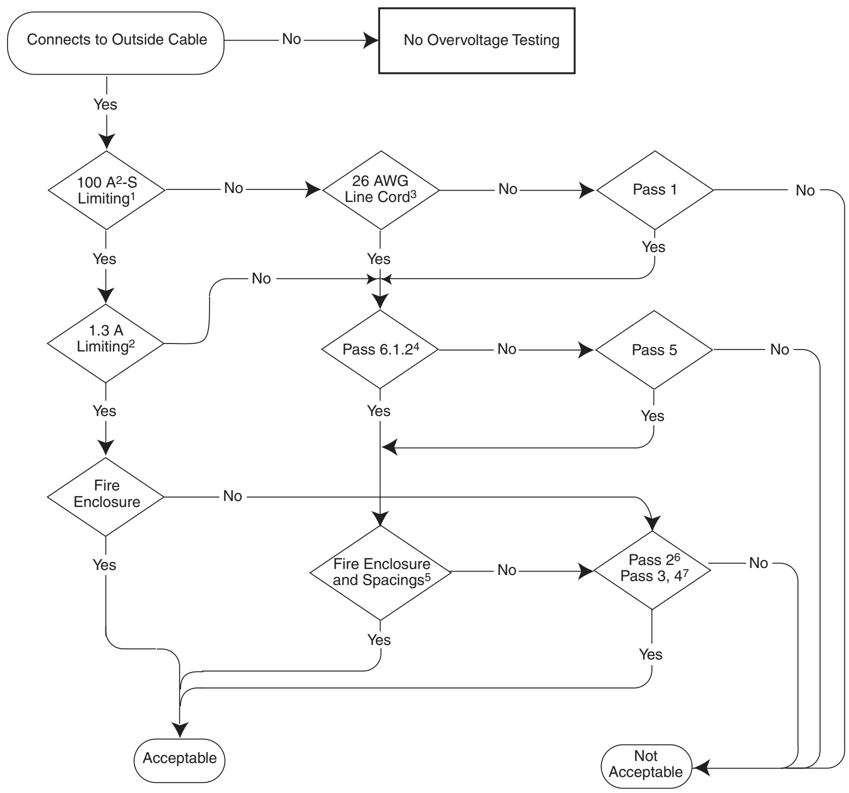
ANNEX C of UL 60950 covers transformers.

The secondary side is loaded for maximum heating effect. The maximum working voltage is applied to the primary. The DC peak value of any superimposed ripple shall be included. The permitted temperature limits for the windings depend on the classification:

- Class A limit is 150 °C.
- Class B limit is 175 °C.
- Class E limit is 165 °C.
- Class F limit is 190 °C.
- Class H limit is 210 °C.

Overvoltage Flowchart

The overvoltage flowchart in Figure 7.6 shows specific guidelines for determining overvoltage requirements applicable to specific designs.



Notes:

1. Current Limiting — Equipment that has a method for limiting current to an I^2t rating of $100A^2s$
2. Current Limiting — Equipment that has a method for limiting current to 1.3 A max steady state
3. 26 AWG Line Cord — Minimum 26 American Wire Gauge (AWG) telecommunications line cord either supplied with the equipment or described in the safety instructions
4. Clause 6.3.3 — The telephone line must be adequately isolated from earth for the operating mode being considered and at a voltage of 120 V rms. Refer to Section 6.1.2 of UL 60950.
5. Fire Enclosure and Spacing — Fire enclosures minimize fire hazards by containing any emission of flame, molten metal, flaming drops, or glowing particles that could be emitted by the equipment under fault conditions. Fire enclosure construction is covered in Section 4.4.6 of UL 60950. Spacing applies to parts in the TNV circuits that might ignite under overvoltage conditions. Spacing requirements mandate that parts be separated from internal materials of flammability class V-2 or lower, by at least 25 mm of air or a barrier material of flammability class V-1 or better. Parts also should be separated from openings in the top or sides of the enclosure by at least 25 mm of air or a material barrier.
6. Test Condition 2 is not required for equipment with 1.3 A limiting.
7. Test Conditions 3 and 4 are not required for connections limited to outside cable less than 1,000 m.

Figure 7.6 Overvoltage Flowchart

Passes 1, 2, 3, 4, and 5 shown in Figure 7.6 refer respectively to Tests L1 and M1, L2 and M2, L3 and M3, L4 and M4, and L5 shown in Table 7.18.

Equipment may be subject to the overvoltage tests shown in Table 7.18. The tests are designed to simulate the following:

- Contact with primary power
- Short-term induction as a result of a primary power fault to a multi-earth neutral
- Long duration power fault to Ground
- Direct contact between the power mains and a telecommunications cable

Table 7.18 UL 60950 Overvoltage Test

Test	Voltage (V_{RMS})	Current (A)	Time	Comments
L1	600 V	40	1.5 s	
L2	600 V	7	5 s	
L3	600 V	2.2	See Note 2	Reduce to 135% fuse rating
L4	See Note 1	2.2	See Note 2	Reduce to 135% fuse rating
L5	120 V	25	See Note 2	
M1	600 V	40	1.5 s	
M2	600 V	7	5 s	
M3	600 V	2.2	See Note 2	Reduce to 135% fuse rating
M4	See Note 1	2.2	See Note 2	Reduce to 135% fuse rating

Note 1: Voltage < conduction voltage of protection
Note 2: Test for 30 minutes or until an open circuit occurs unless it appears possible that a risk of fire or safety hazard will eventually result; then continue test until ultimate results are obtained (maximum of seven hours).

General Notes:

- ISDN S/T interface only L1, L2, L5, M1, and M2.
- Reduce to 135% rated value of fuse if Test 3 resulted in open condition.
- L4 and M4 are conducted only if *SIDACtor* $V_S \geq 285$ V_S and then run at voltage level just below V_S.
- For test conditions M1, L1, M5, and L5 a wiring simulator (MDL 2 A fuse) is used.
- Compliance means no ignition or charring of the cheesecloth, and/or the wiring simulator does not open.
- If the secondary protector simulator is used (MDQ 1.6), it is allowed to open.
- Tests 2, 3, and 4 are required only if the unit is not a fire enclosure.
- Figure 7.7 and Figure 7.8 show the M (metallic) and L (longitudinal) test connections.

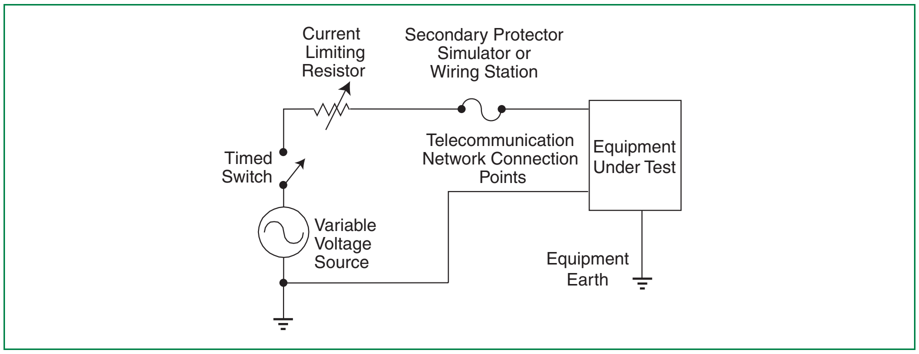


Figure 7.7 Metallic Connection Appearances

Regulatory Requirements

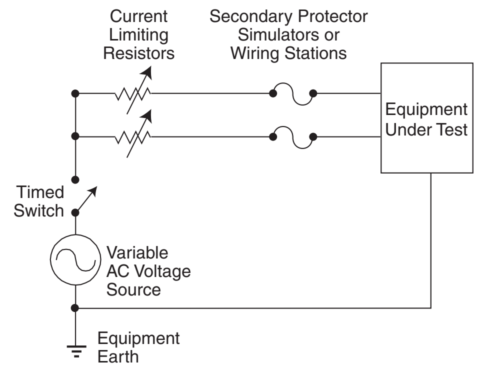


Figure 7.8 Longitudinal Connection Appearances

Overvoltage Test Procedures

Use the following criteria when applying the overvoltage tests presented in Table 7.18.

1. Test Set-up—Equipment is to be mounted as it is intended to be used. Tests may be conducted on either the equipment as an assembly, individual subassemblies, or a partial assembly containing those components which may be exposed to an overvoltage condition.
2. Indicators—Before testing, two single pieces of cheesecloth are to be wrapped tightly around the assembly, subassembly, or partial assembly. The cheesecloth acts as an indicator for conditions that may result in fire.
3. Line Cords—Equipment with a removable telecommunications line cord is to be connected to the test circuit with a line cord having 0.4 mm (26 AWG) or larger copper wire conductors and not more than 1 Ω total resistance.
4. Functional Circuitry—UL mandates that functional circuitry must be used for each overvoltage test conducted. This allows repair or replacement of damaged circuitry before subsequent testing. Alternatively, separate samples may be used for each test.
5. Wiring Simulators—A wiring simulator is used to indicate whether the maximum I^2t imposed upon telecommunications wiring has been exceeded. For Tests 1 and 5, a wiring simulator is to be used unless the equipment is specified for use with a suitable secondary protector or a secondary protector simulator. The wiring simulator can consist of one of the following:
   a. 50 mm length of 0.2 mm (32 AWG) bare or enameled solid copper wire (for test condition 1)
   b. Bussman Mfg. Co. Type MDL-2A fuse (for test condition 1)
   c. 300 mm length of 0.4 mm (26 AWG) solid copper wire which connects to a representative installation (includes wiring and connectors)
   [This option is used when the manufacturer specifies the complete installation from the network interface to the equipment.]
   d. Current probe used with a 300 mm length of 0.5 mm (24 AWG) copper wire (for test condition 1)

Note: Test conditions 2, 3, and 4 do not require the use of a wiring simulator or a secondary protector simulator. Any secondary protection simulators used in Tests 1 and 5 should be similar to the test fuse used in UL 497A, “Standard for Secondary Protectors for Communications Circuits.”

Overvoltage Test Compliance

Equipment is deemed compliant if each of the following conditions are met during test:

- Absence of ignition or charring of the cheesecloth indicator
  (Charring is deemed to have occurred when the threads are reduced to char by a glowing or flaming condition.)
- Wiring simulator does not open during test condition 1 or 5
- For test condition 1, presented in Table 7.18, the integral I^2t measured with a current probe is less than 100 A^2s.

After completion of the overvoltage tests, equipment must comply with either the Dielectric Voltage-withstand Test requirements with all components in place or the Leakage Current Test requirements.

Special Considerations Regarding the *SIDACtor®* Device and UL 60950

The epoxy used for *SIDACtor* devices is UL recognized and the encapsulated body passes UL 94V-0 requirements for flammability.

The only specific requirements of UL 60950 that pertain to the *SIDACtor* device itself are the impulse test and the mandate that components be UL recognized. All other UL 60950 requirements pertain to the equipment being evaluated.

UL 497

UL 497 Series of Safety Standards

The UL 497 series is a family of three safety standards that provides requirements for protection devices used in low-voltage circuits.

- UL 497 addresses requirements for primary protectors used in paired communications circuits.
- UL 497A covers secondary protectors for use in single or multiple pair-type communications circuits.
- UL 497B addresses protectors used in data communication and fire alarm circuits.
- UL 497C addresses protectors for coaxial circuits.

The focus of UL 497 is to ensure that paired communication circuit protectors do not become a fire or safety hazard. The requirements in UL 497 cover any protector that is designed for paired communications circuits and is employed in accordance with Article 800 of the National Electric Code. The protectors covered in UL 497 include solid state primary and station protectors. These circuit protectors are intended to protect equipment, wiring, and service personnel against the effects of excessive voltage potential and currents in the telephone lines caused by lightning, power fault, power induction, and rises in Ground potential.

UL 497 Construction and Performance Requirements

The “Construction” section covers the following requirements:

- General
- Enclosures
- Protection Against Corrosion
- Field-wiring Connections
- Components
- Spacing

The “Performance” section covers the following requirements:

- General
- Line Fuse Test
- Instrument Fuse Test
- Arrester Test
- Polymeric Material Test
- Rubber Materials Test
- Corrosion Test, Outdoor Use Protector
- Jarring Test
- Water Spray Test
- Drop Test
- Cover Replacement Test
- Strain Relief Test
- Replacement Arresters Installation Test
- Appliqué Assemblies Installation Test
- Dielectric Voltage-withstand Test
- Manufacturing and Production Tests
- Marking

Performance Tests

Key performance tests which concern overvoltage protectors are detailed in the arrester test section. Specific requirements are:

- Breakdown Voltage Measurement—*A*rresters are to be tested in the protector blocks or panels in which they are intended to be employed. Arresters are required to break down within ±25% of the manufacturer's specified breakdown rating. In no case shall the breakdown voltage exceed 750 V peak when subjected to the strike voltage test. (Figure 7.9) At no time during this test will the supply voltage be increased at a rate greater than 2000 V/µs.
- Impulse Spark-over Voltage Measurement—The arrester must break down at less than 1000 V peak when subjected to a single impulse potential. Arresters are to be tested in each polarity with a rate of voltage rise of 100 V/µs, ±10%.
- Abnormal Operation—Single pair fuseless arresters must be able to simultaneously carry 30 A rms at 480 V rms for 15 minutes without becoming a fire hazard. A fire hazard is determined by mounting the arrester on a vertical soft wood surface and covering the unit with cheesecloth. Any charring or burning of the cheesecloth results in test failure. During this test, although the arresters may short, they must not have an impulse spark-overvoltage or DC breakdown voltage greater than 1500 V peak.
- Discharge Test—Protectors must comply with the strike voltage requirements after being subjected to five successive discharges from a 2 µF capacitor charged to 1000 V dc. (Figure 7.10).
- Repeated Discharge Test—The arrester must continue to break down at or below its maximum rated breakdown voltage after being subjected to 500 discharges from a 0.001 µF capacitor charged to a potential of 10,000 V dc. The interval between pulses is five seconds. Arresters are to be tested in each polarity, and it is acceptable for the protector to short circuit following the discharge testing. (Figure 7.10)

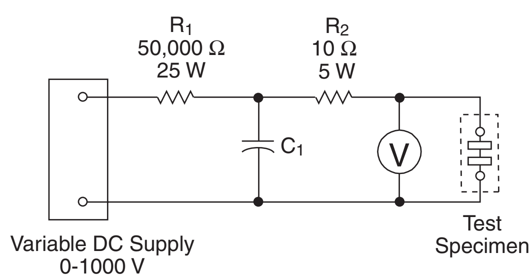


Figure 7.9   UL 497 Breakdown Voltage Measurement

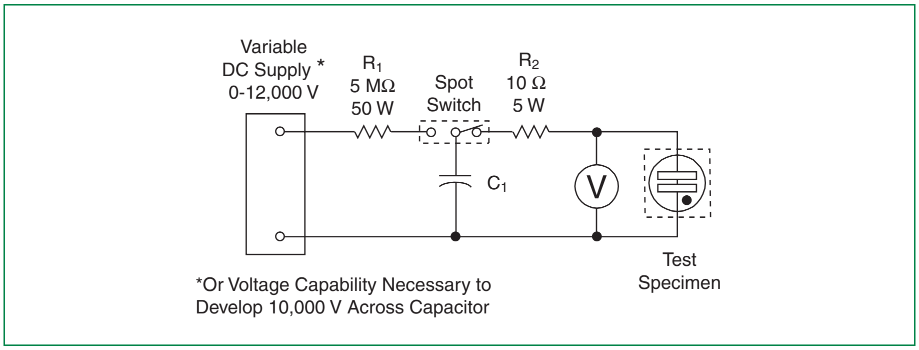


Figure 7.10 UL 497 Discharge Test

UL 497A

UL 497A addresses secondary protectors for use in single or multiple pair-type communication circuits intended to be installed in accordance with Article 800 of the National Electric Code (NEC) and to have an operating voltage of less than 150 V rms with respect to Ground. The purpose of UL 497A is to help reduce the risk of fire, electric shock, or injury resulting from the deployment and use of these protectors. UL 497A requirements do not cover telephone equipment or key systems.

UL 497A Construction, Risk of Injury, and Performance Requirements

The “Construction” section covers the following requirements:
- General
- Product Assembly
- Enclosures
- Internal Material
- Accessibility and Electric Shock
- Protection Against Corrosion
- Cords
- Current-carrying Parts
- Internal Wiring
- Interconnecting Cords and Cables
- Insulating Material
- Printed Wiring
- Spacing

The “Risk of Injury” section covers the following requirements:
- Modular Jacks
- Sharp Edges
- Stability
- Protection of Service Personnel

The “Performance” section covers the following requirements:
- General
- Impulse Voltage Measurement
- Overvoltage Test
- Endurance Conditioning
- Component Temperature Test
- Drop Test
- Crush Test
- Leakage Current Test
- Dielectric Voltage-withstand Test
- Rain Test
- Maximum Moment Measurement Test
- Weather-o-meter and Micro Tensile Strength Test
- Thermal Aging and Flame Test
- Electric Shock Current Test
- Manufacturing and Production Line Test
- Marking, Installation, and Instructions

Performance Tests

The following key performance tests relate to overvoltage protection of the secondary protectors:

1. Impulse Voltage Measurement Test—Secondary protectors must break down within ±25% of the manufacturer's breakdown rating when tested in each polarity with a rate of voltage rise of 100 V/µs, ±10%. Note that the manufacturer may assign separate breakdown voltage ratings for the Breakdown Voltage Measurement Test. This requirement only applies to secondary protectors that connect between Tip and Ring of the telephone loop.
2. Breakdown Voltage Measurement Test—Secondary protectors must break down within ±25% of the manufacturer's breakdown rating when tested in each polarity with a rate of voltage rise no greater than 2000 V/s. The secondary protector is to be mounted in accordance with the manufacturer's installation instructions and then subjected to the test circuit shown in Figure 7.11. This requirement applies only to secondary protectors connected between Tip and Ring or Tip/Ring and Ground of the telephone loop.
3. Overvoltage Test—Secondary protectors must limit current and extinguish or open the telephone loop without loss of its overvoltage protector, indication of fire risk, or electric shock. Upon completion of this test, samples must comply with the Dielectric Voltage-withstand Test.

The overvoltage test is used to determine the effects on secondary protectors and is shown in Table 7.19. Test connections are shown in Figure 7.12.

Test Compliance

Compliance with the overvoltage test is determined by meeting the following criteria:

- Cheesecloth indicator may not be either charred or ignited
- Wiring simulator (1.6 A Type MDQ fuse or 26 AWG line cord) may not be interrupted
- Protector meets the applicable dielectric voltage withstand requirements after the completion of the overvoltage tests

Table 7.19 UL 497A Overvoltage Test

Test	Voltage (V_{RMS})	Current (A)	Time	Connection
L1	600	40	1.5 s	(Note 1, Figure 4.11)
L2	600	7	5 s	(Note 1, Figure 4.11)
L3	600	2.2, 1, 0.5, 0.25	30 min at each current level	(Note 2, Figure 4.11)
L4	200 V rms or just below the breakdown voltage of the overvoltage protection device	2.2 A or just below the interrupt value of the current interrupting device	30 min	(Note 2, Figure 4.11)
L5	240	24	30 min	(Note 1, Figure 4.11)

Notes:
1. Apply Tests L1, L2, and L5 between Tip and Ground or Ring and Ground.
2. Apply Tests L3 and L4 simultaneously from both Tip and Ring to Ground.

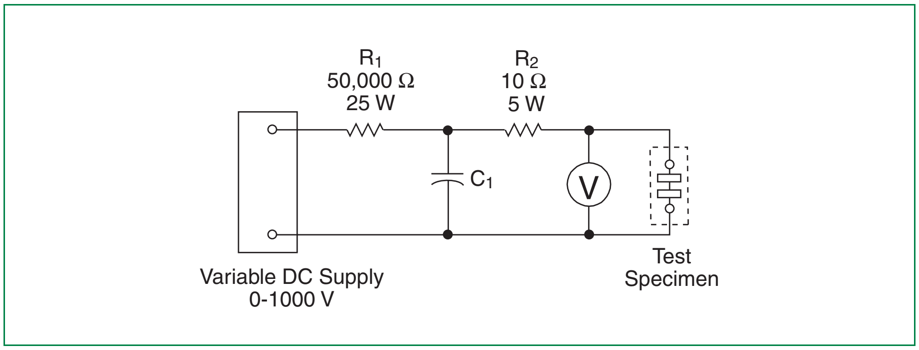


Figure 7.11 UL 497A Breakdown Voltage Measurement Test

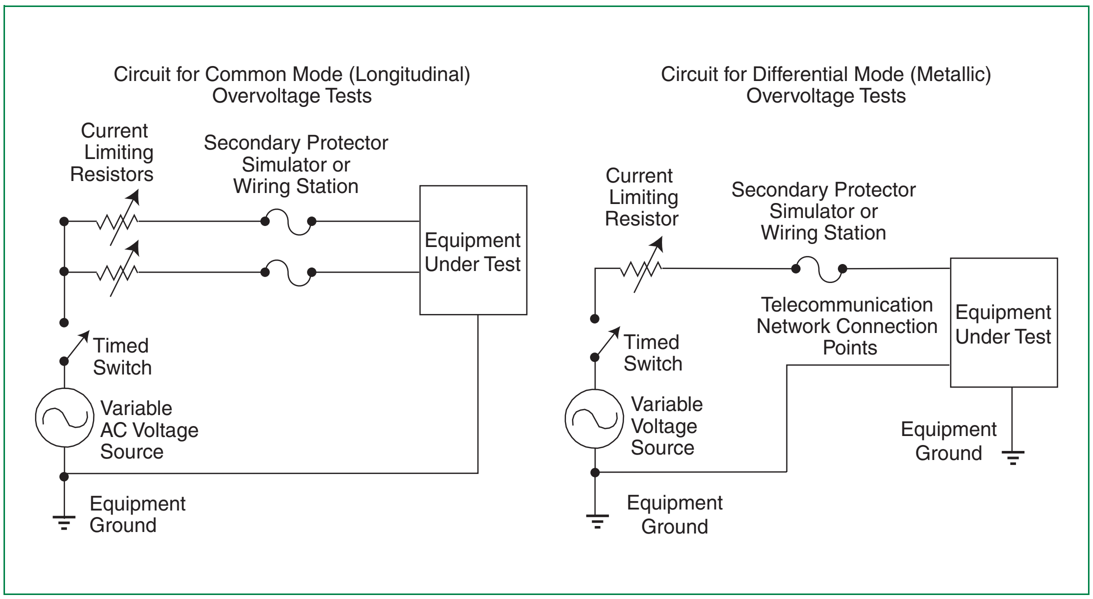


Figure 7.12 UL 497A Overvoltage Test

Regulatory Requirements

UL 497B

UL 497B provides requirements for protectors used in communication and fire alarm circuits. This standard does not cover devices for primary protection or protection devices used on telephone lines. *SIDACtor®* devices are components recognized in accordance with UL 497B under UL file number E133083.

Construction and Performance Requirements

The “Construction” section covers the following requirements:

- General
- Corrosion Protection
- Field-wiring Connections
- Components
- Spacing
- Fuses

The “Performance” section covers the following requirements:

- General
- Strike Voltage Breakdown
- Endurance Conditioning
- Temperature Test
- Dielectric Voltage-withstand Test
- Vibration Conditioning
- Jarring Test
- Discharge Test
- Repeated Discharge Test
- Polymeric Materials Test
- High Temperature Test
- Marking

Performance Requirements Specific to *SIDACtor®* Devices

1. Strike Voltage Breakdown Test—Protectors are required to break down within the manufacturer’s specified breakdown range or within 10% of a nominal single breakdown voltage rating. (Figure 7.13)
2. Endurance Conditioning—Protectors are subjected to 50 impulse cycles. Each cycle is a 1000 V peak, 10 A, 10x1000 μs pulse. Pulses are applied in one polarity at 10-second intervals and then repeated in the opposite polarity.
3. Variable Ambient Conditioning—Protectors must comply with the strike voltage requirements after being subjected to an ambient temperature of 0 °C for four hours and again after being subjected to an ambient temperature of 49 °C for an additional four hours.
4. Discharge Test—Protectors must comply with strike voltage requirements after being subjected to five successive discharges from a 2 μF capacitor charged to 1000 V dc. (Figure 7.14)
5. Repeated Discharge Test—Protectors must not break down at a voltage higher than the manufacturer’s maximum rated breakdown voltage nor lower than rated stand-off voltage after being subjected to 500 discharges from a 0.001 μF capacitor charged to

10,000 V dc. The discharges are applied in five-second intervals between one side of the protector and Ground. Upon completion of the discharge tests, protectors are once again required to meet the strike voltage requirement. (Figure 7.14)

Note: The epoxy used to construct a *SIDACtor* device body meets UL 94V-0 requirements for flammability.

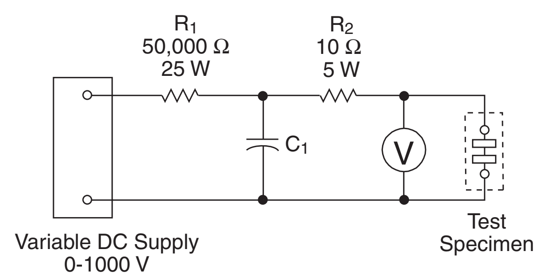


Figure 7.13 UL 497B Strike Voltage Breakdown Test

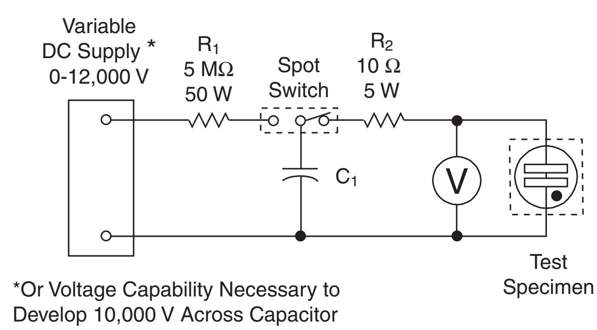


Figure 7.14 UL 497B Discharge Test

UL 497C

UL 497C requirements cover protectors for use on coaxial cable circuits. This standard covers construction and performance requirements.

UL 497C Construction and Performance Requirements

The “Construction” section covers the following requirements:

- General
- Corrosion Protection
- Field-wiring Connections
- Components
- Spacing
- Enclosures

The “Performance” section covers the following requirements:

- General
- I^2t Limiting
- Abnormal Sustained Current
- Component Temperature Test
- Breakdown Voltage Measurement
- Impulse Spark-over Voltage Measurement
- Limited Short-circuit Test
- High Current Ground Path Test
- Cable Shield Fuse Test
- Endurance Conditioning Test
- Induced Low Current Test
- Distortion Test
- Flame Test
- Impact Test (Polymeric Enclosures)
- Jarring Test
- Water Spray Test
- Leakage Current Test
- Dielectric Voltage-withstand Test
- Ultraviolet Light and Water Exposure
- Tensile Strength and Elongation Tests
- Air Oven Aging
- Ozone Exposure

Performance Requirements Specific to *SIDACtor*® Devices

1. Strike Voltage Breakdown Test—Protectors are required to break down within ±25% of the manufacturer’s specified breakdown range but no higher than 750 V at ≤ 2 kV/s rise time.
2. Endurance Conditioning—Protectors are subjected to 500 impulse cycles. Each cycle is a 1000 V peak, 10 A, 10x1000 µs pulse. Pulses are applied in one polarity at 10-second intervals and then repeated in the opposite polarity. Then, 100 cycles of 1000 V peak, 100 A, 10x1000 µs pulse are applied to three new protectors. Finally, two cycles of 1000 V peak, 5000 A, 8x20 µs pulse are applied to three new protectors, with a rest period of one minute between surges.

3. Variable Ambient Conditioning—Protectors must comply with the strike voltage requirements after being subjected to an ambient temperature of 25 °C for four hours and again after being subjected to an ambient temperature of 90 °C for an additional four hours.
4. Discharge Test—Protectors must comply with strike voltage requirements after being subjected to a discharge of 1000 V, 100 ± 10 V/µs, 10 A impulse.

Mainland China Standard—YD/T 950-1998

YD/T 950-1998 establishes the technical requirements and test methods for protection against overvoltages and overcurrents on telecommunication switching equipment for Mainland China.

This Standard is based on the ITU-T Recommendation K.20 "Resistibility of Telecommunication Equipment Installed in a Telecommunications Center for Overvoltages and Overcurrents" (1996 version).

It was approved by the Ministry of Information Industry of the People's Republic of China on August 7, 1998 and has been in effect since September 1, 1998.

Technical Requirements

The following major transmission parameters and interface feature parameters of the equipment should comply with requirements contained in GF 002-9002 or YD 344:

- Transmission loss
- Loss frequency distortion
- Gains changing with input level
- Cross talk
- Scratching noise
- Return loss
- Unbalanced earth impedance

After the following tests are conducted, the equipment should provide normal communications functions and comply with these requirements.

Without primary protection:

1. When the lightning waveform is 10/700 µs and the peak voltage is 1 kV
2. When the induction voltage of the power line is 600 V rms and the duration is 0.2 s

With primary protection:

1. When the lightning waveform is 10/700 µs and the peak voltage is 4 kV
2. When the induction voltage of the power line is 600 V rms and the duration is 1 s

Without primary protection, the equipment should be fireproof when it is in contact with power lines with a voltage of 220 V rms for a duration of 15 minutes and should provide normal communications functions after the test.

After the equipment is tested for contact discharge at an electrostatic voltage of 6 kV or for air discharge at 8 kV, it should provide normal communications functions.

Test Methods

All tests should be conducted in the following standard atmospheric conditions:

- Temperature: 15 °C ~ 35 °C
- Relative humidity: 45% ~ 75%
- Air pressure: 86 ~ 106 kPa

Test procedure sequence is as follows:

1. Normal equipment operation
2. Characteristics and parameters
3. Simulation of lightning strike
4. Check of functions
5. Power line induction
6. Check of functions
7. Check of functions
8. ESD
9. Check of functions
10. Power line contact
11. Characteristics and parameters

Table 7.20 Simulation of Lightning Strike

Testing Terminals	V/I Waveform	Peak Voltage	Peak Current	Number of Tests	Primary Protection
Tip to Ring Grounded	10x700 / 5x310	1 kV	25 A	±5	No
Ring to Tip Grounded	10x700 / 5x310	1 kV	25 A	±5	No
Tip and Ring to Ground	10x700 / 5x310	1 kV	25 A	±5	No
Tip to Ring Grounded	10x700 / 5x310	4 kV	100 A	±5	Yes
Ring to Tip Grounded	10x700 / 5x310	4 kV	100 A	±5	Yes
Tip and Ring to Ground	10x700 / 5x310	4 kV	100 A	±5	Yes
Tip and Ring to Ground *	10x700 / 5x310	1 kV	25 A	±5	No

* Simultaneous surge for 50% of the ports

Power Line Induction

Without primary protection:

600 V, 1 A, 0.2 s applied between Tip and Ring to Ground five times

With primary protection:

600 V, 1 A, 1 s applied between Tip and Ring to Ground five times

Time between successive events shall be one minute. Characteristics and parameters shall be tested within 30 minutes after the completion of these events.

Power Line Contact

Without primary protection:

220 V rms @ 0.367 A, 1, 1 A, 22 A for 15 minutes applied between Tip and Ring to Ground one time each

With primary protection:

220 V rms 0.367 A for 15 minutes applied between Tip and Ring to Ground five times

ESD

±5 repetitions direct contact with one-second duration between successive discharges

±5 repetitions indirect contact (0.1 m distance) with one-second duration between successive discharges

Table 7.21 Waveform Parameters

Indicated Voltage	Peak of Initiation of the Discharge Currents I_p	Time of Rising During Discharge Switch On / Off t_r	Current at 20 ms I_1	Current at 60 ns I_2
6 kV	22.5 A ± 10%	0.7–1 ns	12 A ± 30%	6 A ± 30%

Mainland China Standard—YD/T 993-1998

YD/T 993-1998 establishes the technical requirements and test methods for lightning protection of telecommunication terminal equipment for Mainland China.

This Chinese Standard parallels the ITU-T K.21 “Resistibility of Subscriber’s Terminal to Overvoltages and Overcurrents” (1996) document very closely. This standard is the technical basis for simulated lightning induced event testing requirements for Telecommunication Terminal Equipment such as modems, fax machines, telephone sets, and so on.

Table 7.22 Surge Simulations for Tip and Ring Connections

Lightning Surge Test Conditions			Voltage and Current Waveform µs	Test Voltage / Current * (kV/A)
Without Primary Protection	Metallic Test	Single Tip and Ring Pair	10x700 / 5x310	1.5/37.5
			10x700 / 5x310	1.5/37.5
	Longitudinal Test	Single Tip and Ring Pair	10x700 / 5x310	1/25
			10x700 / 5x310	1/25
		All Tip and Ring Pair	10x700 / 5x310	1/25
			10x700 / 5x310	1/25
With Primary Protection	Metallic Test	Single Tip and Ring Pair	10x700 / 5x310	4/100
			10x700 / 5x310	4/100
	Longitudinal Test	Single Tip and Ring Pair	10x700 / 5x310	4/100
			10x700 / 5x310	4/100
		All Tip and Ring Pair	10x700 / 5x310	4/100
			10x700 / 5x310	4/100

* All tests are conducted ±5 times with at least one minute between events.

Table 7.23 Surge Simulations for Power Line Connections

Lightning Surge Test Conditions			Voltage and Current Waveform µs	Test Voltage / Current * (kV/A)
Without Primary Protection	Metallic Test	Power Line	1.2x50 / 8x20	1.5/750
			1.2x50 / 8x20	1.5/750
	Longitudinal Test	Power Line	1.2x50 / 8x20	1/83.3
			1.2x50 / 8x20	1/83.3
With Primary Protection	Metallic Test	Power Line	1.2x50 / 8x20	4/2000
			1.2x50 / 8x20	4/2000
	Longitudinal Test	Power Line	1.2x50 / 8x20	4/333.3
			1.2x50 / 8x20	4/333.3

* All tests are conducted ±5 times with at least one minute between events.

Normal operation of EUT is not required during the lightning surge simulation test. However, all functions of the EUT should meet the requirements of relevant standards after the completion of these tests. All lightning surge simulation tests should be conducted at:

- Temperature: 15 °C – 35 °C
- Relative humidity: ±5% – ±75%
- Air pressure: 86 – ±56 kPa

Once the lightning surge simulation testing is completed, an electric isolation test is conducted. The power is removed from the unit for this test.

Table 7.24 Electrical Insulation Test

Equipment Type	Voltage / Current	V&I Waveform µs	Repetition
Handheld	2.5 kV / 62.5 A	10x700 / 5x310	±5
Non-handheld	1.5 kV / 37.5 A	10x700 / 5x310	±5

Measure the insulation with 500 V dc voltage after the completion of the insulation test. The resistance should be no less than 2 MΩ.

Mainland China Standard—YD/T 1082-2000

YD/T 1082-2000 establishes the technical specifications on overvoltage and overcurrent protection of access network equipment for Mainland China.

This Chinese Standard parallels the ITU-T K series. This Standard specifies the technical requirements and test methods for overvoltage and overcurrent protection and the basic environmental adaptability of access network equipment. This Standard does not deal with protection against radiated electromagnetic fields.

The specifications as presented here are a succinct summary of the lightning surge, power fault, and ESD testing required by this document.

The ports of the Network equipment are classified into five categories:

I. Ports used to connect the twisted pairs introduced from outside of the building, namely analog user interface, ISDN-BRA interface, ADSL interface, and so on

II. Twisted pair ports used to interconnect the different equipment inside the building, namely V.24 interface, V.35 interface, 2048 kbits/s interface connected to twisted pairs, 10/100 Base-T Ethernet interface, and so on

III. Coaxial cable port: 2048 kbits/s interface connected to coaxial cables, ISDN-PRA interface, and so on

IV. AC Power interface

V. DC power interface

The sequence of testing shall follow this order:

ESD ⇒ EFT ⇒ simulation of lightning strike ⇒ power line induction ⇒ power line contact

ESD Testing

The environmental conditions for ESD testing shall be:

- Temperature—15 °C ~ 35 °C
- Relative humidity—30% ~ 60%
- Air pressure —86 ~ 106 kPa

The waveform of the generator should meet the requirements of YD/T 950 as shown in the following table.

Table 7.25 Waveform Parameters

Indicated Voltage	Peak of Initiation of the Discharge Currents I_p	Time of Rising During Discharge Switch On / Off t_r	Current at 20 ms I_1	Current at 60 ns I_2
6 kV	22.5 A ± 30%	0.7–1 ns	12 A ± 30%	6 A ± 30%

Regulatory Requirements

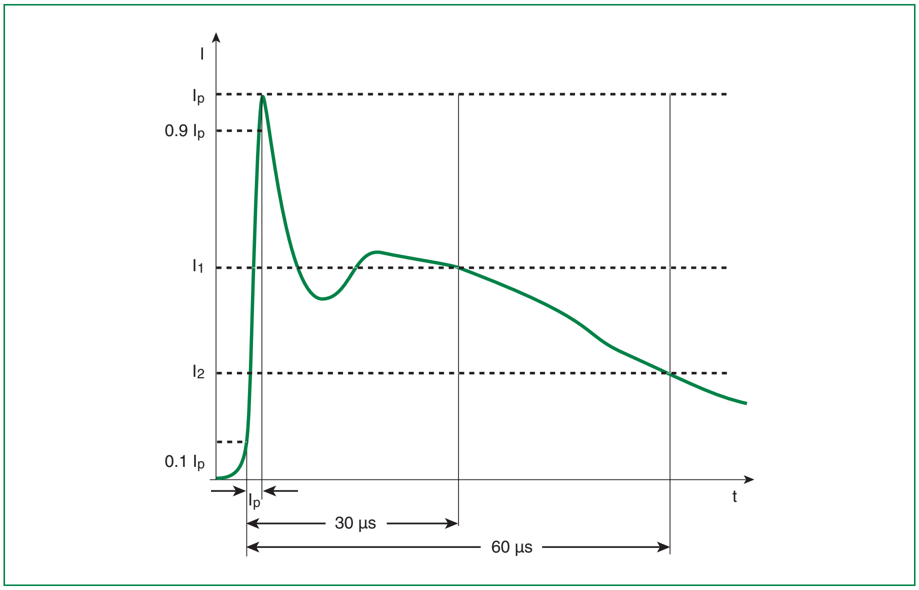


Figure 7.15 ESD Waveform

Establish a communications link via any port of the EUT before the test. The communications link should be capable of normal use without being attended to manually after the test.

EFT (Electrically Fast Transient)

Waveform of the generator should meet the requirements of ITU-T K.34.

Table 7.26 EFT

Tested Port	Number of Ports		Test Conditions
	Remote	Central Office	
I	1	—	1 kV, 5 kHz, ≥ 1 min
II	1	1	1 kV, 5 kHz, ≥ 1 min
III	1	1	1 kV, 5 kHz, ≥ 1 min
IV	1	—	2 kV, 2.5 kHz, ≥ 1 min
V	—	1	2 kV, 2.5 kHz, ≥ 1 min
VI	—	1	2 kV, 2.5 kHz, ≥ 1 min

Table 7.27 Lightning Surge Test Conditions

Class of Port	Number of Ports		Voltage and Current Waveforms µs	Amplitude *
	Central Office	Remote		
I	—	3	10/700 – 5/310	4 kV
		8	1.2/50 – 8/20	6 kA
II	1	1	1.2/50 – 8/20	500 V
III	1	1	1.2/50 – 8/20	500 V
IV	—	1	1.2/50 – 8/20	10 kV, 5 kA
V	1	1	1.2/50 – 8/20	500 V

* All tests are conducted ±5 times with at least one minute between events.

Table 7.28 Power Line Induction and Power Line Contact Testing

Tested Port	Number of Ports		Test Conditions
	Remote	Central Office	
I	3	—	600 V, 600Ω, 50 Hz, 1 s
I	1	—	220 V, 50 Hz, 1 h, 600/200/10Ω

Regulatory Requirements

Certification and Accreditation Administration of the People's Republic of China

Type testing and initial inspection of the factory and follow-up inspection similar to UL standards shall be required in China.

The formal application shall be submitted with the following documents:

1. Circuit diagram and/or system block
2. List of critical components and/or materials
3. Description of the difference between the different model/type of products in the same application unit.
4. Service manual and user's manual in Chinese
5. Nameplate and warnings in Chinese
6. Other necessary documents

Testing standards are as follows:

1. GB4943-1995 *Safety of Information Technology Equipment Including Electrical Business Equipment*
2. YD/T993 *Technical Requirements and Test Methods of Lightning Resistibility for Telecommunication Terminal Equipment*
3. GB9254-1998 *Information Technology Equipment—Radio Disturbance Characteristics – Limits and Methods of Measurement*
4. YD1103 *Requirements and Measurement Methods of Electromagnetic Compatibility for Cordless Telephone*
5. YD1032 *Limits and Measurement Methods of Electromagnetic Compatibility for 900/ 1800 MHz Digital Cellular Telecommunications System Part 1: Mobile Station and Ancillary Equipment*
6. YD1169.1 *Requirement and Measurement Method of Electromagnetic Compatibility for 800 MHz CDMA Digital Cellular Telecommunications System Part 1: Mobile Station and Ancillary Equipment*

These documents require:

1. Test items for safety
   Note: The test items for safety shall include all appropriate items specified in standards of GB4943-1995.
2. Testing items for lightning, lightning test of telecommunication interface, and lightning test of power line
3. Testing items for EMC

Standard	Testing Item
GB9254	Radiated emissions Conducted emissions

Standard	Testing Item
YD1103	Radiated emissions Conducted emissions Electrostatic discharge (ESD) immunity Radiated radio-frequency electromagnetic field immunity Electric fast transient / burst immunity Immunity to conducted disturbance, induced by radio-frequency fields
YD1032	Conducted spurious emissions Radiated spurious emissions Radiated emissions Conducted emissions Electrostatic discharge (ESD) immunity Electric fast transient / burst immunity Surge immunity
YD1169.1	Conducted spurious emissions Radiated spurious emissions Radiated emissions Conducted emissions Electrostatic discharge (ESD) immunity Radiated radio-frequency electromagnetic field immunity Electric fast transient / burst immunity Surge immunity

YD1103 only applies to cordless telephone and YD1032 applies to GSM mobile terminal while YD1169.1 only applies to CDMA mobile terminal.

The following parameters outline testing procedures for lightning-induced surges and power fault events:

- Surge requirements:
  100 A 10x1000 waveform
  10 A, 50 Hz, 1 s
  5 A, 50 Hz, 30 s
  260 V on 100 kV/s
  400 V on 1 kV/µs
- Temperature limits: -40 to 65 °C
- Insulation leakage requirements: 0.1 µA @ 100 V dc
- Maximum load capacitance: 200 pF

The following is actual text of the circular from the Certification and Accreditation Administration of the People's Republic of China (CNCA).

Circular Relevant to the Implementation of the Compulsory Product Certification System

by the Certification and Accreditation Administration of the People's Republic of China (CNCA)
December 3, 2001

The Compulsory Product Certification System (CPCS) is jointly announced for statutory implementation by the State General Administration for Quality Supervision and Inspection and Quarantine of the People's Republic of China (AQSIQ) and the Certification and Accreditation Administration of the People's Republic of China (CNCA). This new system consists of Regulations for Compulsory Product Certification, Regulations for Compulsory Product Certification Mark, and the First Catalogue of Products Subject to Compulsory

Certification (hereinafter referred to as the Catalogue), and so on. The Old System, namely, the Safety License System for Import Commodities administered by the former State Administration for Entry-Exit Inspection and Quarantine of the People's Republic of China (CIQ), and the Compulsory Supervision System for Product Safety Certification administered by the former China State Bureau of Quality and Technical Supervision (CSBTS), will be replaced. The following circular is announced concerning the transition from the Old System to the New System.

1. *The time when the New System is implemented and the Old System is annulled*
   Regulations for Compulsory Product Certification stipulates that the New System be implemented on May 1, 2002 and the Old System be annulled on May 1, 2003 so as to ensure a smooth transition and an effective safeguard of the legitimate rights and interests of all the parties concerned.
2. *Supervision of products applicable to either the New System or the Old System*
   1) Starting from May 1, 2003, the Catalogue products either marketed by domestic manufacturers or imported must obtain the certificate for compulsory product certification (hereinafter referred to as the New Certificate) and be applied China Compulsory Certification mark (hereinafter referred to as the New Mark) before they are imported or marketed.
   2) Starting from May 1, 2003, the sales outlets or importers are not permitted to purchase, import or sell the Catalogue products that do not bear the New Certificate and the New Mark. Whereby the Catalogue products that are purchased or imported before April 30, 2003 and bear either the Import Safety License and CCIB Mark or the Safety Certificate and the Great Wall Mark (hereinafter referred to as the Old Certificate and the Old Mark) may still be sold under the supervision of the AQSIQ local branches with which such products are filed.
   3) Starting from May 1, 2003, if the Catalogue products that have obtained the New Certificate and the New Mark need continue to use the outer packing applied with the Old Mark, they can be marketed or imported only when the New Mark is applied along with the Old Mark.
   4) Prior to April 30, 2003, the Catalogue products for which the Old Certificate and the Old Mark is compulsory can be marketed or imported by either the Old Certificate and the Old Mark or the New Certificate and the New Mark.
   5) Starting from May 1, 2002, with regard to products for which the Old Certificate and the Old Mark was compulsory but being no longer covered by the Catalogue this time, the Old Certificate and the Old Mark will not be required when they are marketed or imported.
3. *The acceptance of the certification application*
   1) Starting from May 1, 2002, the certification bodies designated by CNCA (hereinafter referred to as DCBs) begin to accept applications for the New Certificate and the New Mark relevant to the Catalogue products and will no longer accept applications for the Old Certificate and the Old Mark.
   2) Prior to April 30, 2002, the Catalogue products for which the Old Certificate and the Old Mark is compulsory may continue to apply for the Old Certificate and the Old Mark.
4. *Supplements*
   1) With regard to the Catalogue products for which the application has already been filed but the Old Certificate is yet to be granted, or for which the Old Certificate has been granted, the New Certificate and the New Mark can be granted upon further application by the applicant and the confirmation of the product's qualification by the DCB.
   2) The cost incurred for the New Certificate an the New Mark referred to in 4.1 will be

borne by the applicant based on the actual items required according to the fee chart of the New System.

Regulations for Compulsory Product Certification
Chapter I General Provisions

Article 1

Based on relevant laws and regulations covering product safety licensing and product quality certification so as to improve and enhance regulatory functions in the field of compulsory product certification as well as to effectively safeguard national and public interests in a feasible manner, the following regulations are announced for statutory implementation in accordance with the functions of the State General Administration for Quality Supervision and Inspection and Quarantine of the People's Republic of China (AQSIQ) and the Certification and Accreditation Administration of the People's Republic of China (CNCA) authorized by the State Council.

Article 2

The Compulsory Product Certification System (hereinafter referred to as CPCS) is applied to products related to human life and health, animals, plants, environmental protection and national security.

Article 3

Authorized by the State Council, CNCA is in charge of nation-wide certification and accreditation activities.

Article 4

With regard to CPCS, one Catalogue of Products Subject to Compulsory Product Certification (hereinafter referred to as the Catalogue), one set of applicable technical regulations, national standards and conformity assessment procedures, one obligatory mark and one structural fee chart will be announced for statutory implementation.

Article 5

Any product covered by the Catalogue must first be certified by a certification body designated by relevant competent authorities (hereinafter referred to as DCB). The subject product must obtain the certificate and be applied the certification mark before it can be marketed, imported or used for any commercial purposes.

Regulatory Compliant Solutions

When determining the most appropriate solution to meet the lightning and AC power fault conditions for regulatory requirements, coordination is essential between the *SIDACtor®* device, fuse, and any series impedance that may be used.

Figure 7.16 and Figure 7.17 show templates in which this coordination is considered for the most cost effective and reliable solutions available. For exact design criteria and information regarding the applicable regulatory requirements, refer to the *SIDACtor* device and fuse selection criteria in this Section 7, "Regulatory Requirements", and in Section 8, "Technical Notes".

GR 1089 and ITU-T K.20 and K.21

Figure 7.16 and Figure 7.17 show line interface protection circuits to meet GR 1089 surge immunity requirements without the additional use of series resistance. Use the "C" series *SIDACtor* device and 04611.25 to meet GR 1089 surge immunity requirements. Use the "A" series *SIDACtor* device and 0461.500 to meet ITU-T K.20 and K.21 basic surge immunity requirements without the additional use of resistance.

The enhanced surge immunity requirements of ITU K.20 and K.21 require the use of "C" rated *SIDACtor* devices if no series resistor is used.

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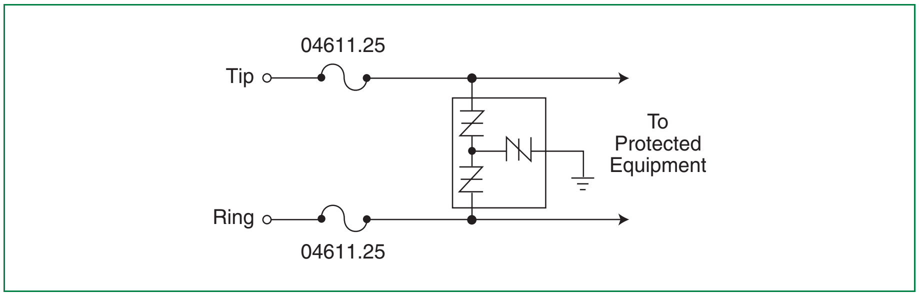

Figure 7.16 Balanced Line Protection using Littelfuse's "AC" or "AA" series

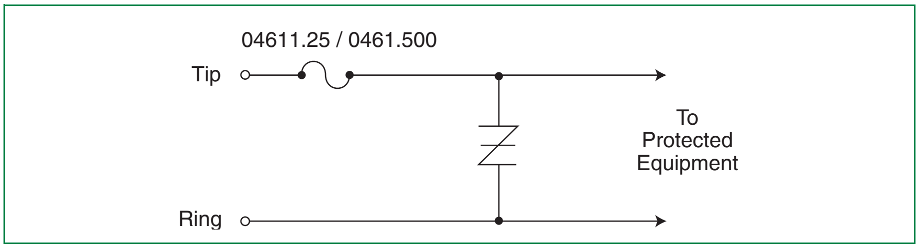

Figure 7.17 Metallic-only Solution using Littelfuse's "SC" or "SA" series

Coordination Considerations

Coordination between the primary protection and the secondary protection may require the addition of a resistor. (Figure 7.18)

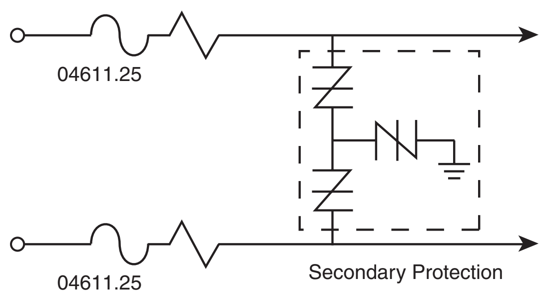

Figure 7.18 Coordination Solution with Resistor

The coordinating resistor value depends on:

- Distance between the primary and secondary protector
- Turn-on characteristics of the primary and secondary protector
- Surge rating of the secondary protector

For compliance with the GR 1089 requirement, the additional component is not required IF the peak pulse surge rating of the secondary protector is at least 100 A for a 10x1000 event. The ITU recommendations have an alternative solution as well, depending on whether Basic or Enhanced compliance is desired.

For Basic compliance, if the secondary protector has a peak pulse surge rating of at least 1000 A for an 8x20 event, then the additional component is not required. For the Enhanced level, it must be able to withstand a 5000 A for an 8x20 event; otherwise, a coordinating component is required. This component allows the primary protector to turn on during surge events even though the secondary protector may turn on first. The power rating of this resistor can be reduced by including the *TeleLink*® overcurrent protection device. However, it must not open during the surge events. Typically, a 1-3 W resistor will be sufficient.

TIA-968-A (formerly known as FCC Part 68) and UL 60950

Because equipment that is tested to TIA-968-A specifications is also generally tested to UL 60950 specifications, it is easiest to look at a solution that meets both FCC and UL requirements simultaneously.

TIA-968-A Operational Solution and UL 60950

Figure 7.19 and Figure 7.20 show line interface protection circuits that meet UL 60950 power fault requirements and pass TIA-968-A Type A and Type B lightning immunity tests operationally.

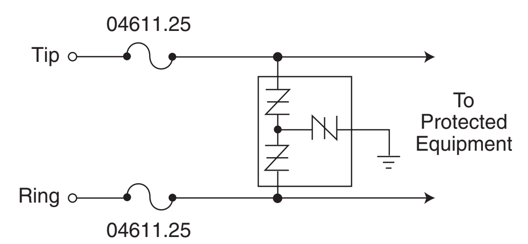

Figure 7.19 Balanced Line Protection using Littelfuse's "AC" Series

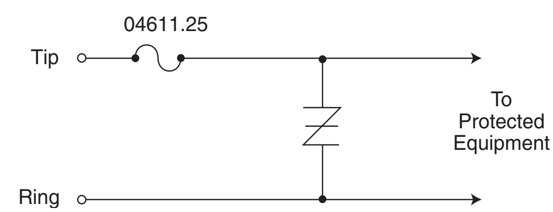

Figure 7.20 Metallic-only Solution using Littelfuse's "SB" or "EB" Series

TIA-968-A Non-Operational Solution and UL 60950

Although the circuits shown in Figure 7.19 and Figure 7.20 provide an operational solution for TIA-968-A, TIA-968-A allows telecommunications equipment to pass Type A surges non-operationally as well. For non-operational TIA-968-A solutions, coordinate the I_{PP} rating of the *SIDACtor* device and the I^2t rating of the fuse so that both will withstand the TIA-968-A Type B surge, but that during the Type A surge the fuse will open.

Figure 7.21 and Figure 7.22 are line interface protection circuits that meet UL power fault requirements and pass TIA-968-A lightning immunity surge A tests "non-operationally."

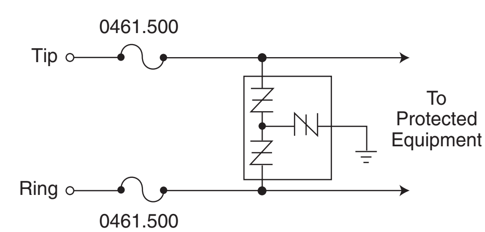

Figure 7.21 Balanced Line Protection using Littelfuse's "AA" Series

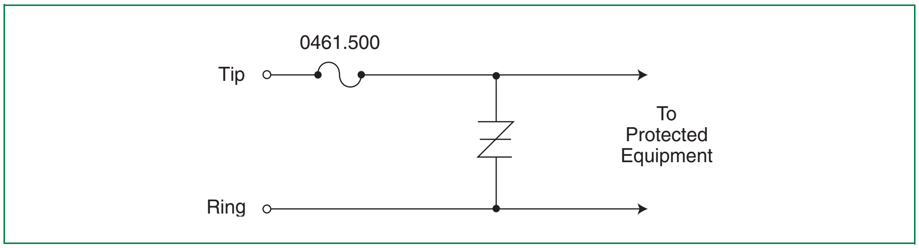

Figure 7.22 Metallic-only Solution using Littelfuse's "SA" or "EA" Series

Surge Waveforms for Various Standards

TIA-968-A now replaces FCC Part 68, except for hearing aid compatibility (HAC), volume control, and indoor cabling. This has become harmonized with Canadian requirements. Various countries around the world have adopted this regulation.

GR 1089 is a standard generally supported by the US Regional Bell Operating Companies (RBOC). It is updated by Telcordia Technology (formerly Bellcore). The RBOC typically requires compliance with GR 1089 for any of their telecom purchases.

ITU is a specialized agency of the UN devoted to international harmonization. Most European countries recognize the ITU standards.

CNET is the Centre National d'etudes de Telecommunications, a French organization.

VDE is the Verband Deutsher Elektrotechniker, a Federation of German electrical engineers. VDE is very similar to the IEEE (Institute of Electrical and Electronics Engineers) but is national in scope rather than global.

ANSI is the American National Standards Institute, which is a non-government organization. The British equivalent to this is BSI.

IEC is the International Electrotechnical Commission, a result of Europe's move toward a single market structure and its drive to formalize and harmonize member countries' requirements.

FTZ R12 is a German specification.

Table 7.29 shows the recommended *SIDACtor®* device surge rating for each standard.

Table 7.29 Surge Waveforms for Various Standards

Standard		Voltage Volts	Voltage Waveform µs	Current Amps	Current Waveform µs	*SIDACtor* Device w/o series R
TIA-968-A	Surge A Metallic	800	10x560	100	10x560	B or C
	Surge A Longitudinal	1500	10x160	200	10x160	C
	Surge B Metallic	1000	9x720	25	5x320	A, B, or C
	Surge B Longitudinal	1500	9x720	37.5	5x320	A, B, or C
GR 1089	Test 1	600	10x1000	100	10x1000	C
	Test 2	1000	10x360	100	10x360	B or C
	Test 3	1000	10x1000	100	10x1000	C
	Test 4	2500	2x10	500	2x10	C
	Test 5	1000	10x360	25	10x360	A, B, or C
CNET 131-24		1000	0.5x700	25	0.8x310	A, B, or C
VDE 0433		2000	10x700	50	5x310	A, B, or C
VDE 0878		2000	1.2x50	50	1x20	A, B, or C
IEC 61000-4-5		2000	1.2x50	50	8x20	A, B, or C
		4000	1.2x50	100	8x20	A, B, or C
		4000	10x700	100	5x310	B or C
FTZ R12		2000	10x700	50	5x310	A, B, or C
YD/T 993-1998	Without Primary Protection Metallic, Single Tip and Ring Pair	1500	10x700	37.5	5x310	A, B, or C
		1500	10x700	37.5	5x310	A, B, or C
	Without Primary Protection Longitudinal, Single Tip and Ring Pair	1500	10x700	37.5	5x310	A, B, or C
		1500	10x700	37.5	5x310	A, B, or C
	Without Primary Protection Longitudinal, All Tip and Ring Pair	1000	10x700	25	5x310	A, B, or C
		1000	10x700	25	5x310	A, B, or C
	With Primary Protection Metallic, Single Tip and Ring Pair	4000	10x700	100	5x310	C
		4000	10x700	100	5x310	C
	With Primary Protection Longitudinal, Single Tip and Ring Pair	4000	10x700	100	5x310	C
		4000	10x700	100	5x310	C
	With Primary Protection Longitudinal, All Tip and Ring Pair	4000	10x700	100	5x310	C
		4000	10x700	100	5x310	C
		Without Primary Protector / With Primary Protector				
ITU K.20	Basic single port	1000 / 4000	10x700	25 / 100	5x310	A, B, C / B, C
	Enhanced single	1500 / 4000	10x700	37.5 / 100	5x310	A, B, C / B, C
	Basic multiple ports	1500 / 4000	10x700	37.5 / 100	5x310	A, B, C / B, C
	Enhanced multiple	1500 / 6000	10x700	37.5 / 100	5x310	A, B, C / C
	Basic power fault	600	50 Hz, 60 Hz	1	0.2 s	04611.25
	Enhanced power fault	600 / 1500	50 Hz, 60 Hz	1 / 7.5	0.2 s / 2 s	04611.25
ITU K.21	Basic single port	1500 / 4000	10x700	37.5 / 100	5x310	A, B, C / B, C
	Enhanced single	6000 / 6000	10x700	37.5 / 150	5x310	A, B, C / C
	Basic multiple ports	1500 / 4000	10x700	37.5 / 100	5x310	A, B, C / B, C
	Enhanced multiple	1500 / 6000	10x700	37.5 / 150	5x310	A, B, C / C
	Basic power fault	600	50 Hz, 60Hz	1	0.2 s	04611.25
	Enhanced power fault	600 / 1500	50 Hz, 60Hz	1 / 7.5	0.2 s / 2 s	04611.25

NOTES

8

Technical Notes

This section is offered to help answer any questions not previously addressed in this data book regarding the *SIDACtor* device and its implementation.

Greentube™ Gas Plasma Arrester Construction and Operation

Littelfuse *Greentube* Gas Plasma Arresters (improved gas discharge tubes (GDTs)) are manufactured using totally non-radioactive processes.

Key Parameters

Gas plasma arrester technology involves three key parameters. (Figure 8.1)

The V_H (holdover voltage) is the most key parameter since the operating voltage of the protected system should be above this value to ensure that latch-up does not occur. Latch-up means the device stays in the low impedance state, and therefore the line is shorted. With the exception of 75 V and 90 V devices that have a holdover voltage of 50 V, all other devices have a holdover voltage of 135 V, which means they can be applied to virtually all telecom systems without any concern of latch-up.

The V_{SDC} (DC breakover (sparkover) voltage) is measured at a slow rate of rise, usually 100 V per second. In terms of design parameters, it is important to make sure that the lower (minimum) DC breakover voltage is above the system voltage.

The V_S (dynamic breakover (impulse sparkover) voltage) is a key feature since it determines the level of protection on offer. As with all protection devices, it is important that the transient is clamped to the lowest possible voltage—the lower the clamping voltage, the lower the level of potentially damaging energy let through to the system. It is important to note that the DC breakover (sparkover) voltage is not a guide to the dynamic breakover (impulse sparkover) voltage; for example, a 230 V dc device from various manufacturers will have various values of impulse sparkover—the lower this value, the better the level of protection. It is also important to make sure that the ramp speeds used to test this value are comparable. Typically, either 100 V/μS or 1 kV/μS is used. Values for 100 V/μS will be lower since these devices have sensitivity to ramp speeds. Good quality devices are less sensitive and, therefore, better.

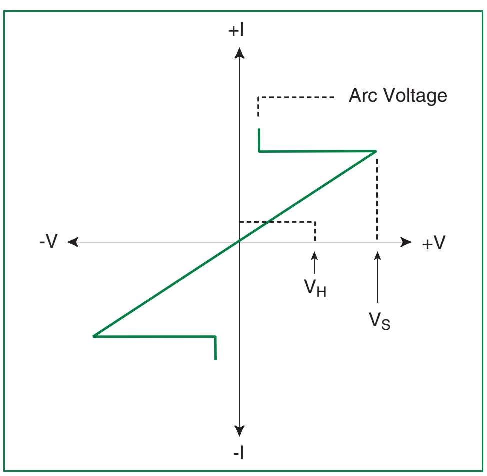

Figure 8.1 Gas Plasma Arrester V-I Characteristic Curve

Operation

The gas plasma arrester operates as a voltage-dependent switch. When a voltage appears across the device greater than its breakdown voltage, known as the sparkover (breakover) voltage, an arc discharge takes place within the tube, which creates a low impedance path by which the surge current is diverted.

When this arc discharge takes place, the voltage level is maintained irrespective of the discharge current. When the transient has passed, the gas plasma arrester resets to its non-conducting state if the voltage of the system is below the holdover voltage of the gas plasma arrester.

The gas plasma arresters can typically handle between 5 kA and 20 kA levels. This is defined as the Impulse Discharge capability, or maximum surge rating.

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

Somewhat related to the low capacitance, these devices have low insertion loss at high speeds and therefore will not degrade high-speed signal lines.

Physics

The functional operation of the gas plasma arrester is similar to the solid-state *SIDACtor*®. However, in the gas plasma arrester, the current flows through an inert gas, whereas in the *SIDACtor* it flows through silicon. The gas is contained in a ceramic envelope between metal electrodes. In its simplest form the device has two terminals. (Figure 8.2) The device operates as a voltage triggered switch, where the voltage applied between the two electrodes (after exceeding a certain value) causes the device to go from a high impedance state to a low impedance state. Figure 8.3 shows a gas plasma arrester with three terminals.

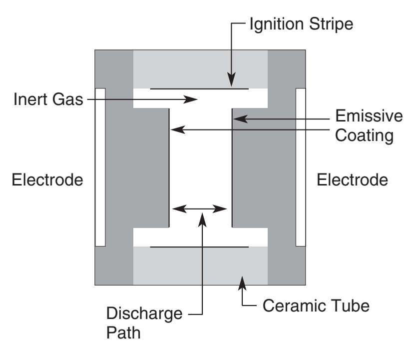

Figure 8.2 Two-terminal Gas Plasma Arrester

Technical Notes

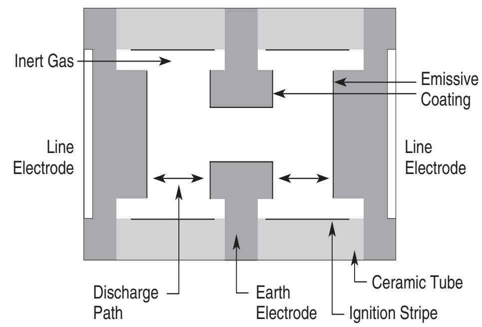

Figure 8.3 Three-terminal Gas Plasma Arrester

Up to a certain voltage, the device is essentially passive and high impedance. Beyond this point, the applied voltage causes the gas to ionize, causing electrons to flow. The voltage across the device then falls to the glow voltage, intrinsically linked to the holdover voltage and between 50 V and 130 V (depending on type) with a current of about 200 mA. A further increase in current (glow to arc transition current) causes the device to transition into the arc mode (on-state voltage). At this point, the device is at its lowest impedance and provides a path for unwanted electrical energy, such as that due to a transient.

The ignition stripes are used to aid the initial ignition and improve response to high-speed transients. The electrodes are coated with chemical compounds that impart certain characteristics to the device, in particular speed of response, current capability, and life characteristics.

A significant feature of these devices is not only that the capacitance value is low (typically 0.8 pF) but that the capacitance value does not vary with changes in voltage. This is particularly important on high-speed circuits. Littelfuse designs gas plasma arresters to provide better voltage limiting on high-speed transients and employs proprietary chemical and design techniques to achieve this.

The Littelfuse *Broadband Optimized™* range of gas plasma arresters incorporate all the features required for transparent operation on high-speed circuits.

Failsafe Devices

In normal operation or when conducting short duration transients (spikes) the gas plasma arrester does not generate any significant or detectable heat.

When conducting mains electricity (AC power) for extended periods (power fault), any arrester will generate excessive thermal energy, even to the point where its electrodes glow ‘cherry red.’ If an arrester is to be used in areas where connection with AC mains is a possibility, then a failsafe can be fitted. (Figure 8.4) These devices are spring-loaded switches held in the open position. When the arrester temperature rises, the device activates to create a short circuit between the arrester center (Ground) and line terminals (Tip or Ring). This short circuit is of low resistance and will conduct the fault current without generating any significant heat. The RG failsafe can be used in flow or re-flow solder processes without activating in response to the heat of the process. It is lead-free and can withstand long-term exposure to temperatures up to 100 °C.

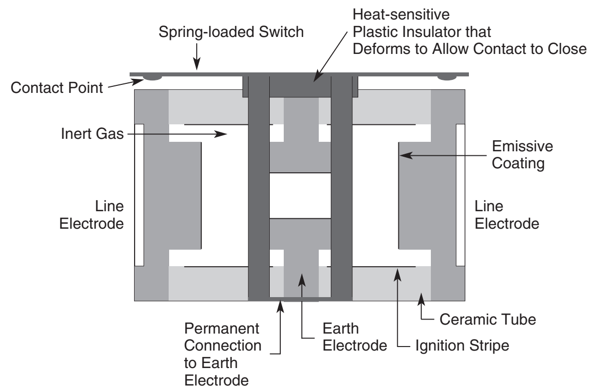

Figure 8.4 Three-terminal Gas Plasma Arrester with Failsafe

Classification of Gas Plasma Arresters

Littelfuse classifies gas plasma arresters in four range categories, based on response speed and performance.

Alpha Range (Super-fast, Premium)

Alpha gas plasma arresters provide extremely fast response to overvoltage transients, especially in the range from 1 kV/µs to 10 kV/µs. Alpha devices are appropriate for applications that are particularly sensitive to overvoltage events.

These devices are engineered to provide the best possible switching performance, responding rapidly to transient voltages. These devices keep transient voltages low and divert the transient current to Ground.

The Littelfuse gas plasma arrester included in this category is the SL1122A (hybrid series—gas plus SAD (Silicon Avalanche Diode))

Beta Range (Fast-response, Quality)

Beta gas plasma arresters are premium-quality devices offering high performance. The speed of these devices (which ultimately determines the effectiveness of a protector) is demonstrably better than traditional designs.

The Beta range includes mini devices which, although smaller, still offer very high surge-handling capabilities.

The following Littelfuse gas plasma arresters are included in this category:

- SL1002A (*Broadband Optimized*™ two-terminal, 6mm series available in SMT)
- SL1003A (three-terminal, 6mm series available in SMT)
- SL1011A (two-terminal, 8mm series)
- SL1011B (two-terminal, 8mm heavy duty series)
- SL1021A (three-terminal, 8mm series)
- SL1021B (three-terminal, 8mm heavy duty series)

The *Broadband Optimized*™ SL1002A series are especially developed for broadband equipment. Their off-state capacitance is compatible with bandwidths into the gigahertz range.

Delta Range (High-energy, Premium)

Delta gas plasma arresters provide very high current handling capability. They can divert up to 55 kA and 40 A ac (tested in accordance with ITU K.12) without loss of protection levels and so are ideally suited to outside plant applications. They are especially designed for high-energy, long-duration pulses (10/350 μs).

The Littelfuse gas plasma arrester included in this category is the SL1411A (two-terminal, 8mm series).

Omega Range (Cost-competitive)

Omega gas plasma arresters benefit from much of the technology used in the Beta range and are optimized for cost-conscious applications. Omega devices still offer performance advantages over many of the products available in the market from other sources.

The following Littelfuse gas plasma arresters are included in this category:

- SL1024A (three-terminal, 8mm series)
- SL1024B (three-terminal, 8mm heavy-duty series)

SIDACtor® Construction and Operation

SIDACtor devices are thyristor devices used to protect sensitive circuits from electrical disturbances caused by lightning-induced surges, inductive-coupled spikes, and AC power fault conditions. The unique structure and characteristics of the thyristor are used to create an overvoltage protection device with precise and repeatable turn-on characteristics with low voltage overshoot and high surge current capabilities.

Key Parameters

Key parameters for *SIDACtor* devices are V_{DRM}, I_{DRM}, V_S, I_H, and V_T, as shown in Figure 8.5. V_{DRM} is the repetitive peak off-state voltage rating of the device (also known as stand-off voltage) and is the continuous peak combination of AC and DC voltage that may be applied to the *SIDACtor* device in its off-state condition. I_{DRM} is the maximum value of leakage current that results from the application of V_{DRM}. Switching voltage (V_S) is the maximum voltage that subsequent components may be subjected to during a fast-rising (100 V/µs) overvoltage condition. Holding current (I_H) is the minimum current required to maintain the device in the on state. On-state voltage (V_T) is the maximum voltage across the device during full conduction.

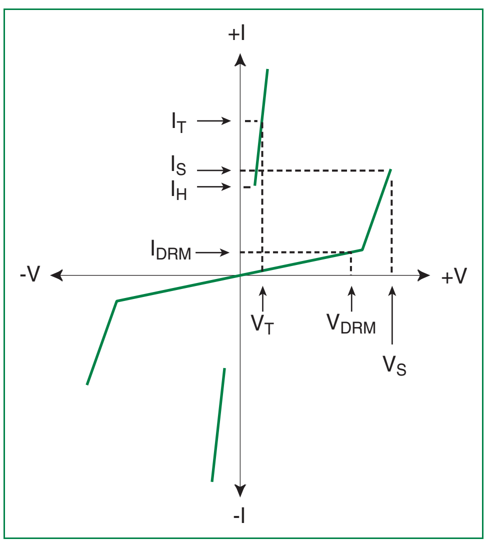

Figure 8.5 V-I Characteristics

Operation

The *SIDACtor* device operates much like a switch. In the off state, the device exhibits leakage currents (I_{DRM}) less than 5 µA, making it invisible to the circuit it is protecting. As a transient voltage exceeds the *SIDACtor* device's V_{DRM}, the device begins to enter its protective mode with characteristics similar to an avalanche diode. When supplied with enough current (I_S), the *SIDACtor* device switches to an on state, shunting the surge from the circuit it is protecting. While in the on state, the *SIDACtor* device is able to sink large amounts of current because of the low voltage drop (V_T) across the device. Once the

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current flowing through the device is either interrupted or falls below a minimum holding current (I_H), the *SIDACtor* device resets, returning to its off state. If the I_{PP} rating is exceeded, the *SIDACtor* device typically becomes a permanent short circuit.

Physics

The *SIDACtor* device is a semiconductor device characterized as having four layers of alternating conductivity: PNPN. (Figure 8.6) The four layers include an emitter layer, an upper base layer, a mid-region layer, and a lower base layer. The emitter is sometimes referred to as a cathode region, with the lower base layer being referred to as an anode region.

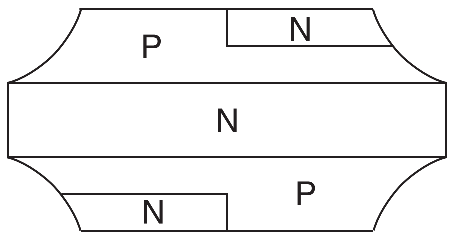


Figure 8.6 Geometric Structure of Bidirectional *SIDACtor* devices

As the voltage across the *SIDACtor* device increases and exceeds the device's V_{DRM}, the electric field across the center junction reaches a value sufficient to cause avalanche multiplication. As avalanche multiplication occurs, the impedance of the device begins to decrease, and current flow begins to increase until the *SIDACtor* device's current gain exceeds unity. Once unity is exceeded, the *SIDACtor* device switches from a high impedance (measured at V_S) to a low impedance (measured at V_T) until the current flowing through the device is reduced below its holding current (I_H).

Greentube™ Gas Plasma Arrester Selection Criteria

When selecting a *Greentube* gas plasma arrester, the following criteria is determined by the location and equipment in which it is installed and defines the robustness of the device.

Surge Rating (Impulse Discharge Rating or MAX I_{PP})

This parameter determines the peak pulse current the protector is able to withstand; it is expressed as kiloamps (kA) and relates to a double exponential waveform, typically an 8/20 μs duration (8 μs to peak value, 20 μs to half value). Gas plasma arresters are typically available in 2.5 kA, 5 kA, 10 kA, and 20 kA devices.

The location of the protector has a large influence on the choice of surge rating. Devices located outside of buildings (known as outside plant) need higher ratings because they will be nearer the source of the transient, and consequently, the surges will be of higher magnitude. Geography also plays a part since certain areas of the world get more lightning surges and of higher energy. Typically, a rating of 5 kA is the minimum for outside plant protectors, and the rating can be as high as 20 kA in areas of severe lightning conditions.

The Main Distribution Frame (MDF) is the first point of entry for external cables. Protectors in the MDF can be rated anywhere from 5 kA to 500 A, depending on the geographic area. Generally, the relevant Telecom authority defines the level of surge rating for a telecom circuit.

AC Surge Rating (AC Discharge Rating or Power Fault Rating)

This parameter determines the maximum AC current the protector is able to take without destruction; it is expressed as amps and usually relates to a number of cycles or a duration of exposure. Gas plasma arresters are typically available in 2.5 kA, 5 kA, 10 kA, and 20 kA devices. Normally, the AC rating of a gas plasma arrester is tied to the IPP surge rating (in other words, 5 A/5 kA, 10 A/10 kA, and so on).

SIDACtor® Device Selection Criteria

When selecting a *SIDACtor* device, use the following criteria:

Off-state Voltage (V_{DRM})

The V_{DRM} of the *SIDACtor* device must be greater than the maximum operating voltage of the circuit that the *SIDACtor* device is protecting.

Example 1:

For a POTS (Plain Old Telephone Service) application, convert the maximum operating Ring voltage (150 V_{RMS}) to a peak voltage, and add the maximum DC bias of the central office battery:

$150\ V_{RMS}\sqrt{2} + 56.6\ V_{PK} = 268.8\ V_{PK}$
$\therefore\ V_{DRM} > 268.8\ V$

Example 2:

For an ISDN application, add the maximum voltage of the DC power supply to the maximum voltage of the transmission signal (for U.S. applications, the U-interface will not have a DC voltage, but European ISDN applications may):

$150\ V_{PK} + 3\ V_{PK} = 153\ V_{PK}$
$\therefore\ V_{DRM} > 153\ V$

Switching Voltage (V_S)

The V_S of the *SIDACtor* device should be equal to or less than the instantaneous peak voltage rating of the component it is protecting.

Example 1:

$V_S \leq V_{Relay\ Breakdown}$

Example 2:

$V_S \leq SLIC\ V_{PK}$

Peak Pulse Current (I_{PP})

For circuits that do not require additional series resistance, the surge current rating (I_{PP}) of the *SIDACtor* device should be greater than or equal to the surge currents associated with the lightning immunity tests of the applicable regulatory requirement (I_{PK}):

$I_{PP} \geq I_{PK}$

For circuits that use additional series resistance, the surge current rating (I_{PP}) of the *SIDACtor* device should be greater than or equal to the available surge currents associated with the lightning immunity tests of the applicable regulatory requirement ($I_{PK(available)}$):

$I_{PP} \geq I_{PK(available)}$

The maximum available surge current is calculated by dividing the peak surge voltage (V_{PK}) by the total circuit resistance (R_{TOTAL}):

$I_{PK(available)} = V_{PK}/R_{TOTAL}$

For longitudinal surges (Tip-Ground, Ring-Ground), R_{TOTAL} is calculated for both Tip and Ring:

$R_{SOURCE} = V_{PK}/I_{PK}$

$R_{TOTAL} = R_{TIP} + R_{SOURCE}$

$R_{TOTAL} = R_{RING} + R_{SOURCE}$

For metallic surges (Tip-Ring):

$R_{SOURCE} = V_{PK}/I_{PK}$

$R_{TOTAL} = R_{TIP} + R_{RING} + R_{SOURCE}$

Example 1:

A modem manufacturer must pass the Type A surge requirement of TIA-968-A without any series resistance.

I_{PK} = 100 A, 10x560 µs

$I_{PP} \geq$ 100 A, 10x560 µs

Therefore, either a "B" rated or "C" rated *SIDACtor* device would be selected.

Example 2:

A line card manufacturer must pass the surge requirements of GR 1089 with 30 Ω on Tip and 30 Ω on Ring.

I_{PK} = 100 A, 10x1000 µs

V_{PK} = 1000 V

$R_{SOURCE} = V_{PK}/I_{PK} = 10\ \Omega$

$R_{TOTAL} = R_{SOURCE} + R_{TIP} = 40\ \Omega$

$I_{PK\ (available)} = V_{PK}/R_{TOTAL} = 1000\ V/40\ \Omega$

$\therefore I_{PP} \geq 25$ A

Holding Current (I_H)

Because TIA-968-A 4.4.1.7.3 specifies that registered terminal equipment not exceed 140 mA dc per conductor under short-circuit conditions, the holding current of the *SIDACtor* device is set at 150 mA.

For specific design criteria, the holding current (I_H) of the *SIDACtor* device must be greater than the DC current that can be supplied during an operational and short circuit condition.

Off-State Capacitance (C_O)

Assuming that the critical point of insertion loss is 70 percent of the original signal value, the *SIDACtor* device can be used in most applications with transmission speeds up to 30 MHz. For transmission speeds greater than 30 MHz, the new MC series is highly recommended.

Fuse Facts

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

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

Ambient Temperature

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

Breaking Capacity

See "Interrupting Rating" on page 8-14.

Current Rating

The current rating is the nominal amperage value of the fuse. The rating is established by the manufacturer as a value of current which the fuse can carry based on a controlled set of test conditions. (See *Rerating*.)

Catalog fuse part numbers include series identification and amperage ratings 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 percent of the nominal current rating established using the controlled test conditions. These test conditions are part of the UL/CSA/ANCE (Mexico) 248-14 "Fuses for Supplementary Overcurrent Protection," whose primary objective is to specify common test standards necessary for the continued control of manufactured items intended for protection against fire, and so on. 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 percent 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 the engineer must account for the variable conditions of the application. To compensate for these variables, the circuit design engineer designing for trouble-free, long-life fuse protection in equipment generally loads a fuse not more than 75 percent of the nominal rating listed by the manufacturer, keeping in mind that overload and short circuit protection must be adequately provided for.

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

The ambient temperature will have an effect on the nominal current rating of a fuse. Most traditional *Slo-Blo*® Fuse designs use lower melting temperature materials and, therefore, are more sensitive to ambient temperature changes.

Dimensions

Unless otherwise specified, dimensions are in inches.

The fuses in this catalog range in size from the approximately 0402 chip size (0.041” L x 0.020” W x 0.012” H) up to the 5 AG, also commonly known as a “MIDGET” fuse (13/32” diameter x 1-1/2” length). As new products were developed throughout the years, fuse sizes evolved to fill the various electrical circuit protection needs. The first fuses were simple, open-wire devices, followed in the 1890s 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 shown in Table 8.1 began with the early “Automobile Glass” fuses, thus 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.

Table 8.1 Fuse Sizes

Size	Nominal Diameter (Inches)		Nominal Length (Inches)	
1AG	¼	0.250	5/8	0.625
2AG	—	0.177	—	0.588
3AG	¼	0.250	1¼	1.25
4AG	9/32	0.281	1¼	1.25
5AG	13/32	0.406	1½	1.50
7AG	¼	0.250	7/8	0.875
8AG	¼	0.250	1	1

Tolerances

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

- ±0.010” for dimensions to two decimal places
- ±0.005” for dimensions to three decimal places

Contact the factory concerning metric system and fractional tolerances. Tolerances do not apply to lead lengths.

Fuse Characteristics

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

Fuse Construction

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

Fuseholders

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

Interrupting Rating

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

Interrupting ratings may vary with fuse design and range from 35 A ac for some 250 V metric size fuses (5x20 mm) up to 200,000 A ac for the 600 V 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 A. Some exceptions, in many applications, provide 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 criteria considered, special attention must be given to normal operating current, ambient temperature, and pulses. For example, one prevalent cause of nuisance opening in conventional power supplies is the failure to adequately consider the fuse’s nominal melting I^2t rating. The fuse cannot be selected solely on the basis of normal operating current and ambient temperature. In this application, the fuse’s nominal melting I^2t rating must also meet the inrush current requirements created by the input capacitor of the power supply's smoothing filter. For trouble-free, long-life fuse protection, it is good design practice to select a fuse so that the I^2t of the waveform is no more than 20 percent of the nominal melting I^2t rating of the fuse.

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, consider this fact 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 percent of the fuse's nominal rated current. Consult with the factory if this parameter is critical to the design analysis. Hot resistance is the resistance calculated from the stabilized voltage drop across the fuse, with current equal to the nominal rated current flowing through it. Resistance data on all Littelfuse products are available on request. Fuses can be supplied to specified controlled resistance tolerances at additional cost.

Soldering Recommendations

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

Test Sampling Plan

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

Time-current Curve

The graphical presentation of the fusing characteristic, time-current curves are generally average curves which are presented as a design aid but are not generally considered part of the fuse specification. Time-current curves are extremely useful in defining a fuse, since fuses with the same current rating can be represented by considerably different time-current curves. The fuse specification typically will include a life requirement at 100 percent of rating and maximum opening times at overload points (usually 135 percent and 200 percent 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 V fuses (automotive) in this catalog are listed under UL Standard 275. Reference to "Recognized under the Component Program of Underwriters Laboratories" signifies that the item is recognized under the component program of Underwriters Laboratories and application approval is required.

Voltage Rating

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

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 V or 250 V ratings for secondary circuit protection of 500 V or higher.

As mentioned under *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. See *Interrupting Rating* for a discussion on the safe interruption of the circuit as it relates to circuit voltage and available power.

To summarize, a fuse may be used at any voltage that is less than its voltage rating without detriment to its fusing characteristics. 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 eight milliseconds (0.008 seconds) or less, the level of pulse current is increased. This test procedure is repeated until melting of the fuse element is confined to within about eight 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.

Electronic Fuse Selection Criteria

A fuse can be relied upon to operate safely at its rated current, at or below its rated voltage. This voltage rating is covered by the NEC regulations and is a requirement of UL as protection against fire risk. The standard voltage ratings used by fuse manufacturers for most small dimension fuses are 32 V, 63 V, 125 V, 250 V, and 600 V.

Fuses are not sensitive to changes in voltage; however, they are sensitive to changes in current. The fuse will maintain "steady-state" operation from zero volts to the maximum voltage rating. It is not until the fuse element melts and internal arcing occurs, that circuit voltage and available power become an issue. The interrupt rating of the fuse addresses this issue. Specifically, the voltage rating determines the ability of the fuse to suppress internal arcing that occurs after the fuse link melts.

For telecommunication applications, a voltage rating of 250 V is chosen because of the possibility of power line crosses. A three-phase voltage line will have voltage values up to 220 V. It is desirable for the voltage rating of the fuse to exceed this possible power fault event.

UL 60950 has a power fault test condition that requires a fuse to have an interrupt rating of 40 A at 600 V. GR 1089 contains a power fault test condition that requires a fuse to have an interrupt rating of 60 A at 600 V. A 125 V-rated part will not meet this requirement. **A 250 V part with special design consideration, such as Littelfuse's 04611.25 *TeleLink*® fuse, does meet this requirement.**

Because fuses are rated in terms of continuous voltage and current-carrying capacity, it is often difficult to translate this information in terms of peak pulse current ratings. To simplify this process, Table 8.2 shows the surge rating correlation to fuse rating.

Table 8.2 Surge Rating Correlation to Fuse Rating

Fuse Rating mAmps	Equivalent I_{PP} Rating		
	10x160 µs Amps	10x560 µs Amps	10x1000 µs Amps
250	23	16.6	12.4
350	34	25.8	19.3
400	40	25.4	19
500	60	37.7	28.2
600	71	47.2	35.3
750	91	65.5	49
800	104	68.9	51.6
1000	130	88.6	66.3
1250	162	118.1	100

Peak Pulse Current (I_{PP})

For circuits that do not require additional series resistance, the surge current rating (I_{PP}) of the fuse should be greater than or equal to the surge currents associated with the lightning immunity tests of the applicable regulatory requirement (I_{PK}):

$$I_{PP} \geq I_{PK}$$

For circuits that use additional series resistance, the surge current rating (I_{PP}) of the fuse should be greater than or equal to the available surge currents associated with the lightning immunity tests of the applicable regulatory requirement ($I_{PK(available)}$):

$$I_{PP} \geq I_{PK(available)}$$

The maximum available surge current is calculated by dividing the peak surge voltage (V_{PK}) by the total circuit resistance (R_{TOTAL}):

$$I_{PK(available)} = V_{PK}/R_{TOTAL}$$

For longitudinal surges (Tip-Ground, Ring-Ground), R_{TOTAL} is calculated for both Tip and Ring:

$$R_{SOURCE} = V_{PK}/I_{PK}$$

$$R_{TOTAL} = R_{TIP} + R_{SOURCE}$$

$$R_{TOTAL} = R_{RING} + R_{SOURCE}$$

For metallic surges (Tip-Ring):

$$R_{SOURCE} = V_{PK}/I_{PK}$$

$$R_{TOTAL} = R_{TIP} + R_{RING} + R_{SOURCE}$$

Overvoltage Protection Comparison

The four most commonly used technologies for overvoltage protection are as follows:

- *SIDACtor®* devices
- Gas Plasma Arresters (GDTs)
- Metal Oxide Varistors (MOVs)
- TVS diodes

All four technologies are connected in parallel with the circuit being protected, and all exhibit a high off-state impedance when biased with a voltage less than their respective blocking voltages.

SIDACtor devices

A *SIDACtor* device is a PNPN device that can be thought of as a TVS diode with a gate. Upon exceeding its peak off-state voltage (V_{DRM}), a *SIDACtor* device will clamp a transient voltage to within the device's switching voltage (V_S) rating. Then, once the current flowing through the *SIDACtor* device exceeds its switching current, the device will crowbar and simulate a short-circuit condition. When the current flowing through the *SIDACtor* device is less than the device's holding current (I_H), the *SIDACtor* device will reset and return to its high off-state impedance.

Advantages

Advantages of the *SIDACtor* device include its fast response time (Figure 8.7), stable electrical characteristics, long term reliability, and low capacitance. Also, because the *SIDACtor* device is a crowbar device, it cannot be damaged by voltage and it has extremely high surge current ratings.

Restrictions

Because the *SIDACtor* device is a crowbar device, it cannot be used directly across the AC line; it must be placed behind a load. Failing to do so will result in exceeding the *SIDACtor* device's surge current rating, which may cause the device to enter a permanent short-circuit condition.

Applications

Although found in other applications, *SIDACtor* devices are primarily used as the principle overvoltage protector in telecommunications and data communications circuits. For applications outside this realm, follow the design criteria in "SIDACtor® Device Selection Criteria" on page 8-10.

Gas Plasma Arresters

Gas plasma arresters are either glass or ceramic packages filled with an inert gas and capped on each end with an electrode. When a transient voltage exceeds the DC breakdown rating of the device, the voltage differential causes the electrodes of the gas tube to fire, resulting in an arc, which in turn ionizes the gas within the tube and provides a low impedance path for the transient to follow. Once the transient drops below the DC holdover voltage and current, the gas tube returns to its off state.

Advantages

Gas plasma arresters have high surge current and low capacitance ratings. Current ratings can be as high as 500 A for 200 impulses, and capacitance ratings can be as low as 1 pF with a zero-volt bias.

Applications

Gas plasma arresters are typically used for primary protection due to their high surge rating. However, their low interference for high frequency components make them a candidate for high speed data links.

Metal Oxide Varistors

Metal Oxide Varistors (MOVs) are two-leaded, through-hole components typically shaped in the form of discs. Manufactured from sintered oxides and schematically equivalent to two back-to-back PN junctions, MOVs shunt transients by decreasing their resistance as voltage is applied.

Advantages

Since MOVs surge capabilities are determined by their physical dimensions, high surge current ratings are available. Also, because MOVs are clamping devices, they can be used as transient protectors in secondary AC power line applications.

Applications

Although MOVs are restricted from use in many telecom applications (other than disposable equipment), they are useful in AC applications where a clamping device is required and tight voltage tolerances are not.

TVS Diodes

Transient Voltage Suppressor (TVS) diodes are clamping voltage suppressors that are constructed with back-to-back PN junctions. During conduction, TVS diodes create a low impedance path by varying their resistance as voltage is applied across their terminals. Once the voltage is removed, the diode will turn off and return to its high off-state impedance.

Advantages

Because TVS diodes are solid state devices, they do not fatigue nor do their electrical parameters change as long as they are operated within their specified limits. TVS diodes effectively clamp fast-rising transients and are well suited for low-voltage applications that do not require large amounts of energy to be shunted.

Applications

Due to their low power ratings, TVS diodes are not used as primary interface protectors across Tip and Ring; they are used as secondary protectors that are embedded within a circuit.

dv/dt Chart

Figure 8.7 shows a peak voltage comparison between *SIDACtor* devices, gas discharge tubes, MOVs, and TVS diodes, all with a nominal stand-off voltage rating of 230 V. The X axis represents the dv/dt (rise in voltage with respect to time) applied to each protector, and the Y axis represents the maximum voltage drop across each protector.

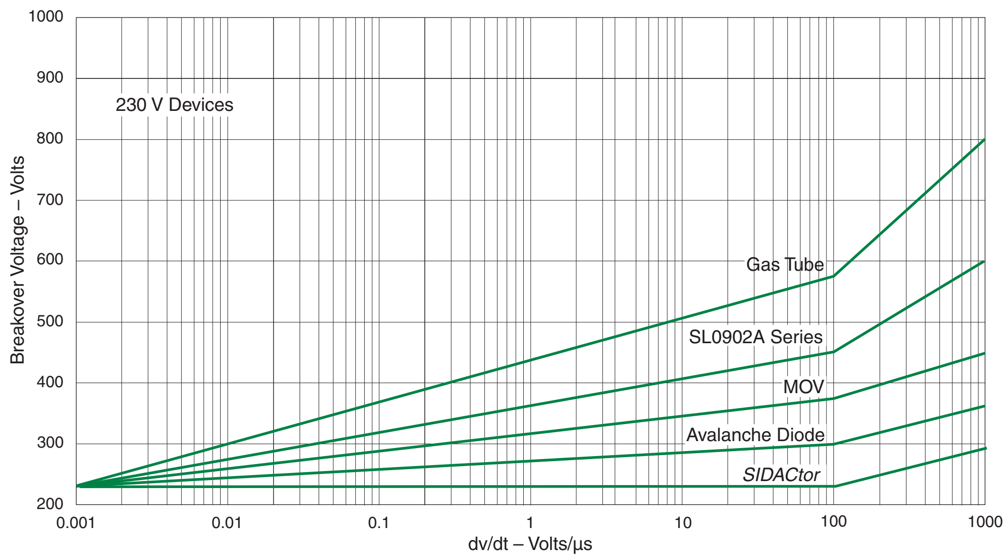


Figure 8.7 Overshoot Levels versus dv/dt

Technical Notes

Overcurrent Protection

In addition to protecting against overvoltage conditions, equipment should also be protected from overcurrent conditions using either PTCs, fuses, power/line feed resistors, or flameproof resistors. In all instances the overcurrent protector is a series element placed in front of the overvoltage protector on **either** Tip **or** Ring for metallic (closed loop) applications and on **both** Tip **and** Ring for longitudinal (grounded) applications.

PTCs

PTCs are positive temperature coefficient thermistors used to limit current. During a fault condition, heat is generated at a rate equal to I^2R. When this heat becomes sufficient, the PTC increases its resistance asymptotically until the device simulates an open circuit, limiting the current flow to the rest of the circuit. As the fault condition drops below the PTC's holding current, the device begins to reset, approximating its original off-state value of impedance.

Advantages

Because PTCs are resettable devices, they work well in a variety of industrial applications where electrical components cannot withstand multiple, low-current faults.

Applications

PTCs are used in a variety of applications. In addition to protecting telecommunications equipment, PTCs are also used to prevent damage to rechargeable battery packs, to interrupt the current flow during a motor lock condition, and to limit the sneak currents that may cause damage to a five-pin module.

Fuses

Due to their stability, fuses are one of the most popular solutions for meeting AC power fault requirements for telecommunications equipment. Similar to PTCs, fuses function by reacting to the heat generated due to excessive current flow. Once the fuses I^2t rating is exceeded, the center conductor opens.

Advantages

Fuses are available in both surface mount and through-hole packages and are able to withstand the applicable regulatory requirements without the use of any additional series impedance. Chosen correctly, fuses only interrupt a circuit when extreme fault conditions exist and, when coordinated properly with an overvoltage protector, offer a very competitive and effective solution for transient immunity needs.

Advantages include:
- Elimination of series line resistance enabling longer loop lengths
- Precise longitudinal balance allowing better transmission quality
- Robust surge performance which eliminates costly down time due to nuisance blows
- Greater surge ratings than resettable devices, ensuring regulatory compliance
- Non-degenerative performance
- Available in surface mount packaging which uses less Printed Circuit Board (PCB) real estate, eliminates mixed technologies, and reduces manufacturing costs

Weaknesses

Because a fuse does not reset, consideration should be given to its use in applications where multiple fault occurrences are likely. For example, AC strip protectors and ground fault interrupting circuits (GFIC) are applications in which an alternative solution might be more prudent.

Applications

Telecommunications equipment best suited for a fuse is equipment that requires surface mount technology, accurate longitudinal balance, and regulatory compliance without the use of additional series line impedance.

Selection Criteria

For circuits that do not require additional series resistance, the surge current rating (I_{PP}) of the *TeleLink*® SM fuse should be greater than or equal to the surge currents associated with the lightning immunity tests of the applicable regulatory requirement (I_{PK}).

$$I_{PP} \geq I_{PK}$$

For circuits that use additional series resistance, the surge current rating (I_{PP}) of the *TeleLink* SM fuse should be greater than or equal to the available surge currents associated with the lightning immunity tests of the applicable regulatory requirement ($I_{PK\ (available)}$).

$$I_{PP} \geq I_{PK\ (available)}$$

The maximum available surge current is calculated by dividing the peak surge voltage (V_{PK}) by the total circuit resistance (R_{TOTAL}).

$$I_{PP} \geq I_{PK\ (available)} = V_{PK}/R_{TOTAL}$$

For longitudinal surges (Tip-Ground, Ring-Ground), R_{TOTAL} is calculated for both Tip and Ring.

$$R_{TOTAL} = R_{TIP} + R_{SOURCE}$$

$$R_{TOTAL} = R_{RING} + R_{SOURCE}$$

For metallic surges (Tip-Ring):

$$R_{TOTAL} = R_{TIP} + R_{RING} + R_{SOURCE}$$

To select the most appropriate combination of *TeleLink* SM fuse and *SIDACtor*® device, decide the regulatory requirement your equipment must meet:

Regulatory Requirement	*TeleLink* SM Fuse	*SIDACtor* Device
GR 1089	04611.25	C Series
TIA-968-A, Type A	04611.25	B Series
TIA-968-A, Type B	04611.25	A Series
ITU K.20 Basic/Enhanced	04611.25	A Series / C Series
ITU K.21 Basic/Enhanced	04611.25	A Series / C Series
UL 60950	All	All
YD/T 950-1998	04611.25	A, B, or C Series *
YD/T 993-1998	04611.25	A, B, or C Series *
YD/T 1082-2000	04611.25	A, B, or C Series *

* Depends on the particular application

For applications that do not require agency approval or multiple listings, contact the factory.

Power/Line Feed Resistors

Typically manufactured with a ceramic case or substrate, power and line feed resistors have the ability to sink a great deal of energy and are capable of withstanding both lightning and power fault conditions.

Advantages

Power and line feed resistors are available with very tight resistive tolerances, making them appropriate for applications that require precise longitudinal balance.

Restrictions

Because power and line feed resistors are typically very large and are not available in a surface mount configuration, these devices are less than desirable from a manufacturing point of view. Also, because a thermal link is typically not provided, power and line feed resistors may require either a fuse or a PTC to act as the fusing element during a power fault condition.

Applications

Power and line feed resistors are typically found on line cards that use overvoltage protectors that cannot withstand the surge currents associated with applicable regulatory requirements.

Flameproof Resistors

For cost-sensitive designs, small (1/8 W – 1/4 W), flameproof metal film resistors are often used in lieu of PTCs, fuses, and power or line feed resistors. During a transient condition, flameproof resistors open when the resultant energy is great enough to melt the metal used in the device.

Advantages

Flameproof resistors are inexpensive and plentiful.

Restrictions

Flameproof resistors are not resistive to transient conditions and are susceptible to nuisance blows.

Applications

Outside of very inexpensive customer premise equipment, small resistors are rarely used as a means to protect telecommunications equipment during power fault conditions.

PCB Layout

Because the interface portion of a Printed Circuit Board (PCB) is subjected to high voltages and surge currents, consideration should be given to the trace widths, trace separation, and grounding.

Trace Widths

Based on the Institute for Interconnecting and Packaging Electronic Currents, IPC D 275 specifies the trace widths required for various current-carrying capacities. This is very important for grounding conditions to ensure the integrity of the trace during a surge event. The required width is dependent on the amount of copper used for the trace and the acceptable temperature rise which can be tolerated. Littelfuse recommends a 0.025-inch trace width with one ounce copper. (For example, a 38-AWG wire is equal to approximately 8 mils to 10 mils. Therefore, the minimum trace width should be greater than 10 mils.)

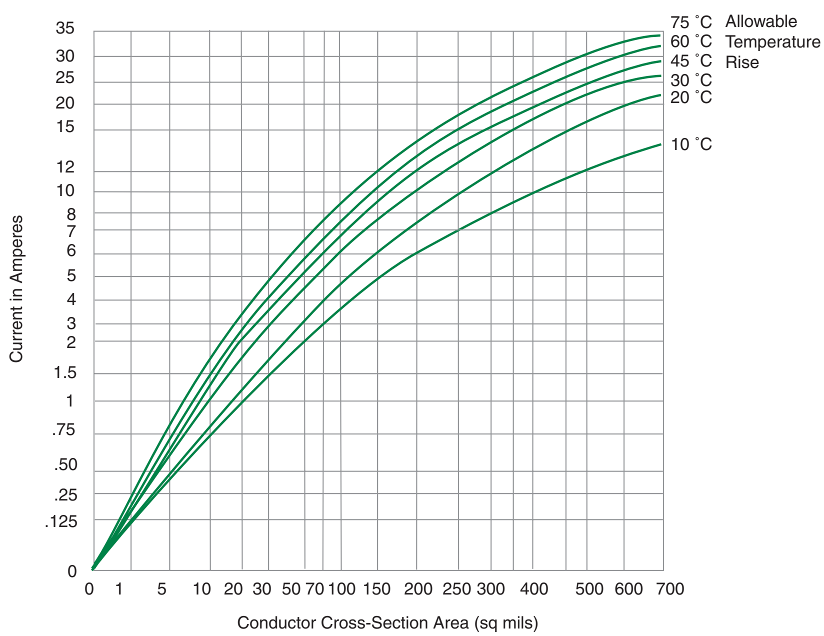


Figure 8.8 Current versus Area

The minimum width and thickness of conductors on a PCB is determined primarily by the current-carrying capacity required. This current-carrying capacity is limited by the allowable temperature rise of the etched copper conductor. An adjacent ground or power layer can significantly reduce this temperature rise. A single ground plane can generally raise the allowed current by 50 percent. An easy approximation can be generated by starting with the information in Figure 8.8 to calculate the conductor cross-sectional area required. Once this has been done, refer to Figure 8.9 for the conversion of the cross-sectional area to the required conductor width, dependent on the copper foil thickness of the trace.

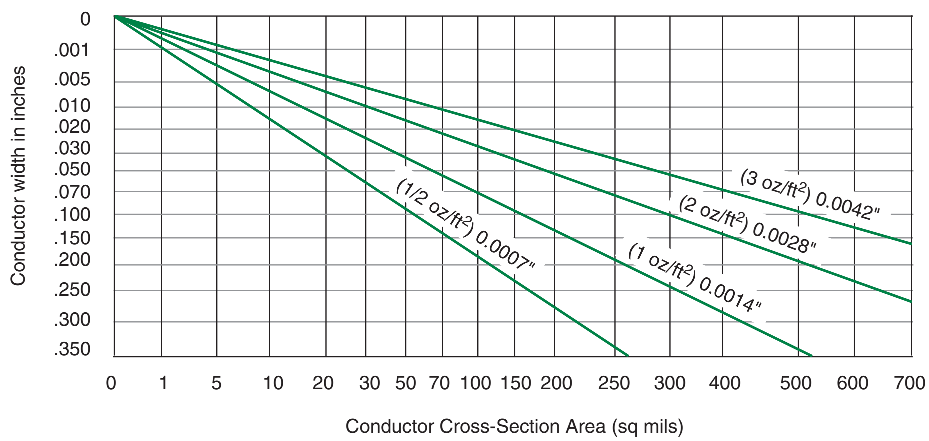


Figure 8.9 Conductor Width versus Area

Trace Separation

Tip and Ring traces are subjected to various transient and overvoltage conditions. To prevent arcing between traces, minimum trace separation should be maintained. UL 60950 provides additional information regarding creepage and clearance requirements, which are dependent on the Comparative Tracking Index (CTI) rating of the PCB, working voltage, and the expected operating environment. See "UL 60950 3rd Edition" on page 7-16 of this *Telecom Design Guide*.

A good rule of thumb for outside layers is to maintain a minimum of 18 mils for 1 kV isolation. Route the Tip and Ring traces towards the edge of the PCB, away from areas containing static sensitive devices.

Grounding

Although often overlooked, grounding is a very important design consideration when laying out a protection interface circuit. To optimize its effectiveness, several things should be considered in sequence:

1. Provide a large copper plane with a grid pattern for the Ground reference point.
2. Decide whether to use a single-point or a multi-point grounding scheme. A single-point (also called centralized) grounding scheme is used for circuit dimensions smaller than one-tenth of a wavelength (λ = 300,000/frequency) and a multi-point (distributed) grounding scheme is used for circuit trace lengths greater than one-fourth of a wavelength.
3. Because traces exhibit a certain level of inductance, keep the length of the ground trace on the PCB as short as possible in order to minimize its voltage contribution during a transient condition. In order to determine the actual voltage contributed to trace inductance, use the following equations:

$V = L\ (di/dt)$

$L = 0.0051\ \rho\ [\log_e 2\ \rho/(t+w) + ½ - \log_e G]$ in µH

where ρ = length of trace

G = function of thickness and width (as provided in Table 8.4)

t = trace thickness

w = trace width

For example, assume circuit A is protected by a P3100SC with a V_S equal to 300 V and a ground trace one inch in length and a self-inductance equal to 2.4 µH/inch. Assume circuit B has the identical characteristics as Circuit A, except the ground trace is five inches in length instead of one inch in length. If both circuits are surged with a 100 A, 10x1000 µs wave-form, the results would be as shown in Table 8.3:

Table 8.3 Overshoot Caused by Trace Inductance

	$V_L = L\ (di/dt)$	*SIDACtor* device V_S	Total protection level ($V_L + V_S$)
Circuit A	V_L = 2.4 µH (100 A/10 µs) = 24 V	300 V	324 V
Circuit B	V_L = 12 µH (100 A/10 µs) = 120 V	300 V	420 V

Other practices to ensure sound grounding techniques are:

1. Cross signal grounds and earth grounds perpendicularly in order to minimize the field effects of “noisy” power supplies.
2. Make sure that the ground fingers on any edge connector extend farther out than any power or signal leads in order to guarantee that the ground connection invariably is connected first.

Table 8.4 Values of Constants for the Geometric Mean Distance of a Rectangle

t/w or w/t	K	Log_eG
0.000	0.22313	0.0
0.025	0.22333	0.00089
0.050	0.22346	0.00146
0.100	0.22360	0.00210
0.150	0.22366	0.00239
0.200	0.22369	0.00249
0.250	0.22369	0.00249
0.300	0.22368	0.00244
0.350	0.22366	0.00236
0.400	0.22364	0.00228
0.450	0.22362	0.00219
0.500	0.22360	0.00211
0.500	0.22360	0.00211
0.550	0.22358	0.00203
0.600	0.22357	0.00197
0.650	0.22356	0.00192
0.700	0.22355	0.00187
0.750	0.22354	0.00184
0.800	0.22353	0.00181
0.850	0.22353	0.00179
0.900	0.22353	0.00178
0.950	0.223525	0.00177
1.000	0.223525	0.00177
0.000	0.0	0.0

Note: Sides of the rectangle are t and w. The geometric mean distance R is given by:
$\log_e R = \log_e(t+w) - 1.5 + \log_e G$. $R = K(t+w)$, $\log_e K = -1.5 + \log_e G$.

Technical Notes

Greentube™ Gas Plasma Arrester Soldering Recommendations

Reflow Soldering

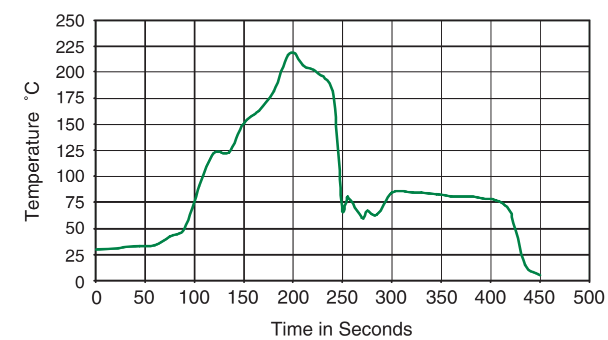
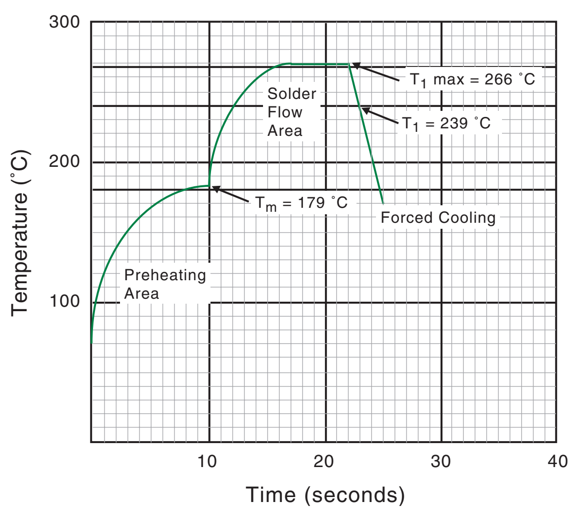


Figure 8.10 Profile for Reflow Soldering

Wave Soldering



Notes:
T_1 max (maximum tab temperature) = 266 °C
T_1 (flow temperature of solder) = 239 °C
T_m (melting point of solder) = 179 °C
T_{amb} = 25 °C

Maximum permissible rate
of temperature change = °C/s

[Not for AF style SL1024 Series devices]

Figure 8.11 Profile for Wave Soldering

SIDACtor® Soldering Recommendations

When placing surface mount components, a good solder bond is critical because:

- The solder provides a thermal path in which heat is dissipated from the packaged silicon to the rest of the board.
- A good bond is less subject to thermal fatiguing and results in improved component reliability.

Reflow Soldering

The preferred technique for mounting the DO-214AA package is to reflow-solder the device onto a PCB-printed circuit board, as shown in Figure 8.12.

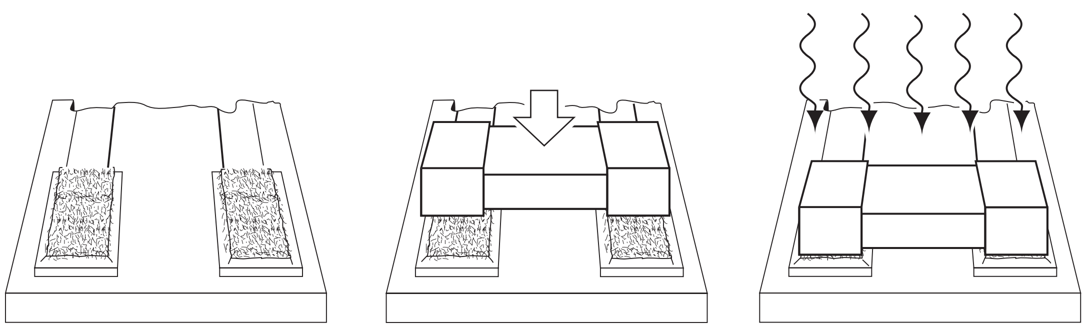


Figure 8.12 Reflow Soldering Procedure

For reliable connections, the PCB should first be screen printed with a solder paste or fluxed with an easily removable, reliable solution, such as Alpha 5003 diluted with benzyl alcohol. If using a flux, the PCB should be allowed to dry to touch at room temperature (or in a 70 °C oven) prior to placing the components on the solder pads.

Relying on the adhesive nature of the solder paste or flux to prevent the devices from moving prior to reflow, components should be placed with either a vacuum pencil or automated pick and place machine.

With the components in place, the PCB should be heated to a point where the solder on the pads begins to flow. This is typically done on a conveyor belt which first transports the PCB through a pre-heating zone. The pre-heating zone is necessary in order to reduce thermal shock and prevent damage to the devices being soldered, and should be limited to a maximum temperature of 165 °C for 10 seconds.

After pre-heating, the PCB goes to a vapor zone, as shown in Figure 8.13. The vapor zone is obtained by heating an inactive fluid to its boiling point while using a vapor lock to regulate the chamber temperature. This temperature is typically 215 °C, but for temperatures in excess of 215 °C, care should be taken so that the maximum temperature of the leads does not exceed 275 °C and the maximum temperature of the plastic body does not exceed 260 °C. (Figure 8.14)

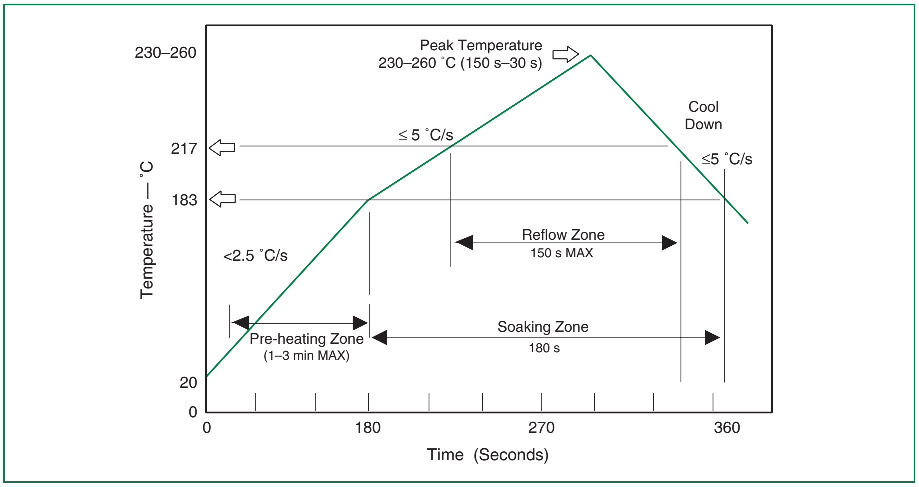


Figure 8.13 Reflow Solder Profile for RoHS-compliant Devices or Non-RoHS-compliant Devices

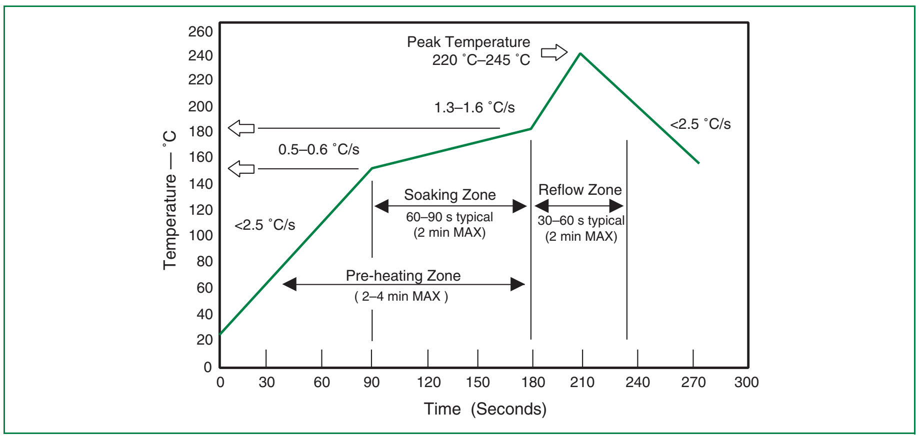


Figure 8.14 Reflow Soldering Profile for Non-RoHS-compliant Devices Only

During reflow, the surface tension of the liquid solder draws the leads of the device towards the center of the soldering area, correcting any misalignment that may have occurred during placement and allowing the device to set flush on the pad. If the footprints of the pad are not concentrically aligned, the same effect can result in undesirable shifts as well. Therefore, it is important to use a standard contact pattern which leaves sufficient room for self-positioning.

After the solder cools, connections should be visually inspected and remnants of the flux removed using a vapor degreaser with an azeotrope solvent or equivalent.

Wave Soldering

Another common method for soldering components to a PCB is wave soldering. After fluxing the PCB, an is adhesive applied to the respective footprints so that components can be glued in place. Once the adhesive cures, the board is pre-heated and then placed in contact with a molten wave of solder with a temperature between 240 °C and 260 °C and permanently affixes the component to the PCB. (Figure 8.15 and Figure 8.16)

Although a popular method of soldering, wave soldering does have drawbacks:

- A double pass is often required to remove excess solder.
- Solder bridging and shadows begin to occur as board density increases.
- Wave soldering uses the sharpest thermal gradient.

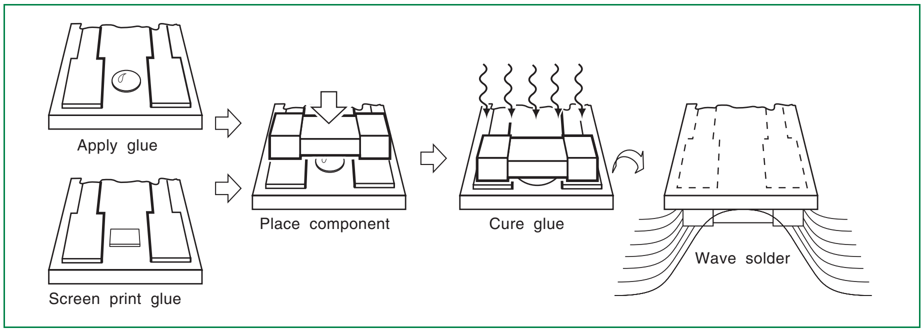


Figure 8.15 Wave Soldering Surface Mount Components Only

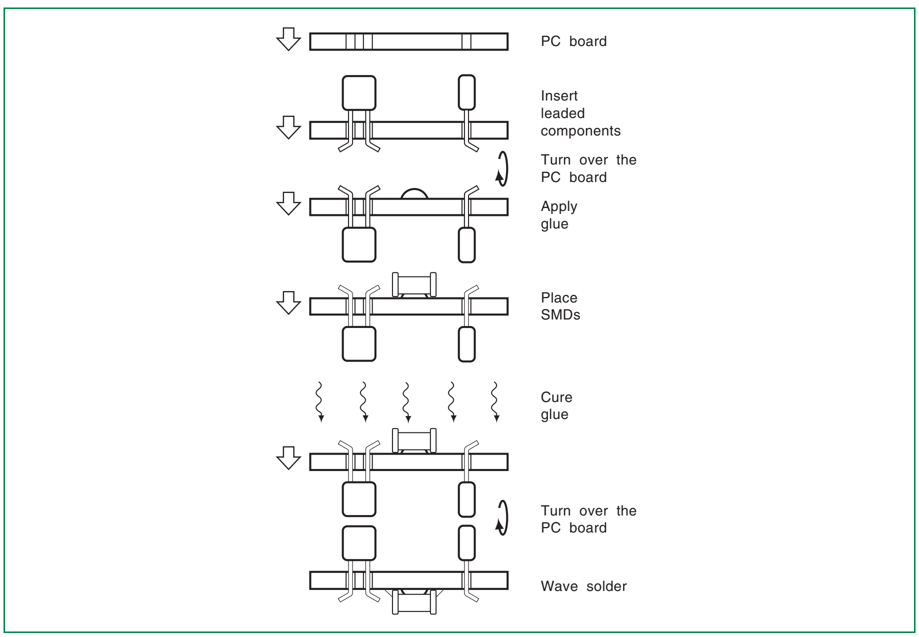


Figure 8.16 Wave Soldering Surface Mount and Leaded Components

Technical Notes

TeleLink® Fuse Soldering Recommendations

For wave soldering a *TeleLink* fuse, the following temperature and time are recommended:

- Reservoir temperature of 260 °C (500 °F)
- Time in reservoir—three seconds maximum

For infrared, the following temperature and time are recommended:

- Temperature of 260 °C (464 °F)
- Time—30 seconds maximum

Hand soldering is not recommended for this fuse because excessive heat can affect the fuse performance. Hand soldering should be used only for rework and low-volume samples.

Note the following recommendations for hand soldering:

- Maximum tip temperature of 240 °C (464 °F)
- Minimize the soldering time at temperature to achieve the solder joint. Measure the fuse resistance before and after soldering. Any fuse that shifts more than ±3% should be replaced. An increase in resistance above this amount increases the possibility of a surge failure, and a decrease in resistance may cause low overloads to exceed the maximum opening times.
- Inspect the solder joint to ensure that an adequate solder fillet has been produced without any cracks or visible defects.

Sn-Pb Wave Soldering Recommendations

Table 8.5 Sn-Pb Soldering Parameters

Sn-Pb Wave Parameter	Recommendation
Equipment	NU/ERA wave solder machine by Technical Devices
Solder Alloy	Alpha Metals Sn36Pb37
Flux Type	NC130 No-Clean flux by Florida CirTech, Inc.
Belt Speed	3.8 ft/min
Parameters	Pre Heater Temp Setting = 296 °C Solder Pot Temp = 249 °C Dwell Time = 1.5 seconds

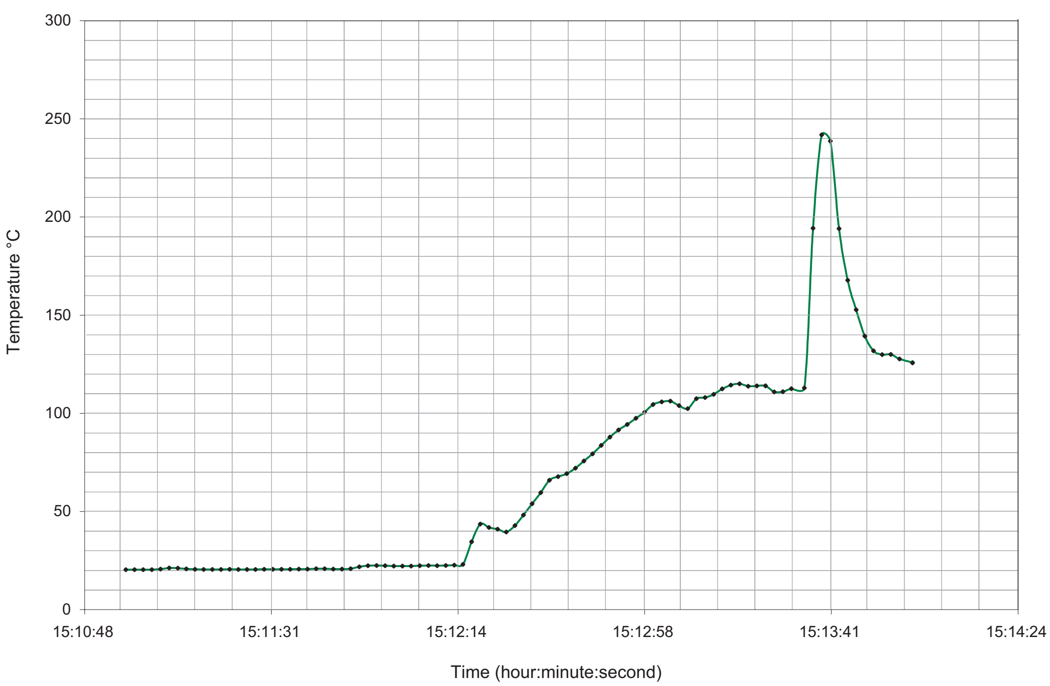


Figure 8.17 Profile for Sn-Pb Wave Soldering

Technical Notes

Lead-free Soldering Recommendations

As the electronics industry undergoes conversion from SnPb to lead-free soldering processes, Littelfuse will develop lead-free replacements or RoHS-compliant replacements for all electronic products. This conversion will require our customers to change established board-mounting process parameters for two reasons:

- The wettability (how well the molten solder flows on solderable surfaces) is degraded for Sn-Ag-Cu alloys (industry-preferred lead-free solder) as compared to Sn-Pb eutectics.
- The melting point for Sn-Ag-Cu alloys is typically around 220 °C (varying slightly among different alloys), much higher than the 183 °C melting point of conventional Sn-Pb eutectic solder.

Increasing profile temperatures and/or dwell times typically overcomes these issues.

This board-mounting standard serves as a design guideline for the electronics business unit relative to lead-free or RoHS-compliant product development across all Littelfuse facilities worldwide. This design guideline is applicable to all new product development programs as well as modifications of existing products.

Convection Reflow (SMD)

Table 8.6 defines the reflow parameter and lead-free requirements for convection reflow (SMD) soldering.

Table 8.6 Convection Reflow (SMD) Parameters and Lead-free Requirement

Reflow Parameter	Lead-free Requirement
Preheat Temperature Min Temperature Max Time (Min to Max)	 150 °C 200 °C 60–180 seconds
Thermal Ramp-up Rate	3 °C/second (Max)
Time above 217 °C	60–120 seconds
Peak Temperature	255 +5/-0 °C
Time within 5 °C of Peak Temperature	10–30 seconds
Thermal Ramp-down Rate	-6 °C/second (Max)

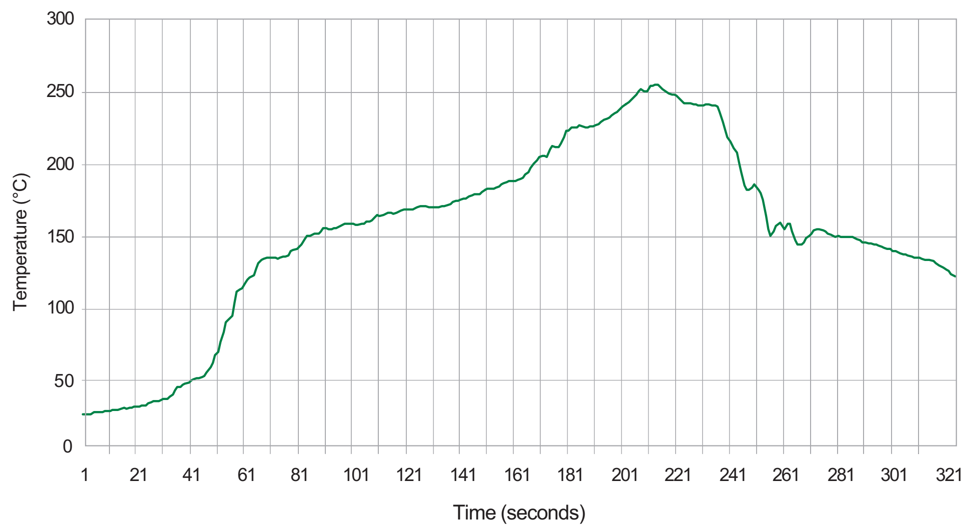


Figure 8.18 Profile for Lead-free Reflow Soldering

Wave Solder (THD)

Table 8.7 defines the wave parameter and lead-free requirements for wave (THD) soldering.

Table 8.7 Wave Solder (THD) Parameters and Lead-free Requirement

Reflow Parameter	Lead-free Requirement
Preheat (depending on flux only) Temperature Min Temperature Max Time (Min to Max)	 100 °C 150 °C 60–180 seconds
Solder Pot Temperature	260–265 °C (Max)
Solder Dwell Time	2–3.5 seconds
Cooling	-6 °C/second (Max)

Technical Notes

Telecommunications Protection

Because early telecommunications equipment was constructed with components such as mechanical relays, coils, and vacuum tubes, it was somewhat immune to lightning and power fault conditions. But as cross bar and step-by-step switches have given way to more modern equipment such as digital loop carriers, repeater amplifiers, and multiplexers, an emphasis has been put on protecting this equipment against system transients caused by lightning and power fault conditions.

Lightning

During an electrical storm, transient voltages are induced onto the telecommunications system by lightning currents which enter the conductive shield of suspended cable or through buried cables via ground currents.

As this occurs, the current traveling through the conductive shield of the cable produces an equal voltage on both the Tip and Ring conductors at the terminating ends. Known as a longitudinal voltage surge, the peak value and waveform associated with this condition is dependent upon the distance the transient travels down the cable and the materials with which the cable is constructed.

Although lightning-induced surges are always longitudinal in nature, imbalances resulting from terminating equipment and asymmetric operation of primary protectors can result in metallic transients as well. A Tip-to-Ring surge is normally seen in terminating equipment and is the primary reason most regulatory agencies require telecom equipment to have both longitudinal and metallic surge protection.

Power Fault

Another system transient that is a common occurrence for telecommunications cables is exposure to the AC power system. The common use of poles, trenches, and ground wires results in varying levels of exposure which can be categorized as direct power fault, power induction, and ground potential rise.

Direct power fault occurs when a power line makes direct contact to telecommunications cables. Direct contact is commonly caused by falling trees, winter icing, severe thunderstorms, and vehicle accidents. Direct power fault can result in large currents being present on the line.

Power induction is common where power cables and telecommunications cables are run in close proximity to one another. Electromagnetic coupling between the cables results in system transients being induced onto the telecommunications cables, which in turn can cause excessive heating and fires in terminal equipment located at the cable ends.

Ground potential rise is a result of large fault currents flowing to Ground. Due to the varying soil resistivity and multiple grounding points, system potential differences may result.

Lightning

Lightning is one of nature's most common and dangerous phenomena. At any one time, approximately 2,000 thunderstorms are in progress around the globe, with lightning striking the earth over 100 times per second. According to IEEE C.62, during a single year in the United States lightning strikes an average of 52 times per square mile, resulting in 100 deaths, 250 injuries, and over 100 million dollars in damage to equipment property.

The Lightning Phenomenon

Lightning is caused by the complex interaction of rain, ice, up drafts, and down drafts that occur during a typical thunderstorm. The movement of rain droplets and ice within the cloud results in a large build up of electrical charges at the top and bottom of the thunder cloud. Normally, positive charges are concentrated at the top of the thunderhead while negative charges accumulate near the bottom. Lightning itself does not occur until the potential difference between two charges is great enough to overcome the insulating resistance of air between them.

Formation of Lightning

Cloud-to-ground lightning begins forming as the level of negative charge contained in the lower cloud levels begins to increase and attract the positive charge located at Ground. When the formation of negative charge reaches its peak level, a surge of electrons called a stepped leader begins to head towards the earth. Moving in 50-meter increments, the stepped leader initiates the electrical path (channel) for the lightning strike. As the stepped leader moves closer to the ground, the mutual attraction between positive and negative charges results in a positive stream of electrons being pulled up from the ground to the stepped leader. The positively charged stream is known as a streamer. When the streamer and stepped leader make contact, it completes the electrical circuit between the cloud and ground. At that instant, an explosive flow of electrons travels to ground at half the speed of light and completes the formation of the lightning bolt.

Lightning Bolt

The initial flash of a lightning bolt results when the stepped leader and the streamer make connection resulting in the conduction of current to Ground. Subsequent strokes (3-4) occur as large amounts of negative charge move farther up the stepped leader. Known as return strokes, these subsequent bolts heat the air to temperatures in excess of 50,000 °F and cause the flickering flash that is associated with lightning. The total duration of most lightning bolts lasts between 500 millisecond and one second.

During a lightning strike, the associated voltages range from 20,000 V to 1,000,000 V while currents average around 35,000 A. However, maximum currents associated with lightning have been measured as high as 300,000 A.

10 Key Facts about Lightning

1. Lightning strikes the earth on an average of 100 times per second.
2. Lightning strikes can affect computers and other electronic equipment as far as a kilometer away.

3. Lightning causes transient overvoltages (very fast electrical surges) on power, data communication, and signal and telephone lines. These surges then carry to and affect vulnerable equipment.
4. At-risk electronic equipment includes computers, building management systems, PABX telephone exchanges, CCTV equipment, fire and burglar alarms, uninterruptible power supplies, programmable logic controllers, and data acquisition equipment.
5. Transient overvoltages can cause instant damage to equipment and its circuitry, leading to costly and lengthy stoppages to operation and latent damage, and can result in breakdowns weeks or months later.
6. Even equipment in a building with structural lightning protection is still at great risk, as structural protection is designed to prevent damage to the building and to prevent loss of life.
7. While most businesses are at risk, campus or multi-building sites tend to be especially vulnerable.
8. Lightning can and does strike in the same place and can strike the same place multiple times. Sites that have suffered once are proven vulnerable and often suffer again within a matter of months.
9. Protecting electronic systems from transient overvoltage damage costs only a fraction of the cost of damage.
10. Littelfuse designs and manufactures quality lightning protection equipment.

9 Mechanical Data

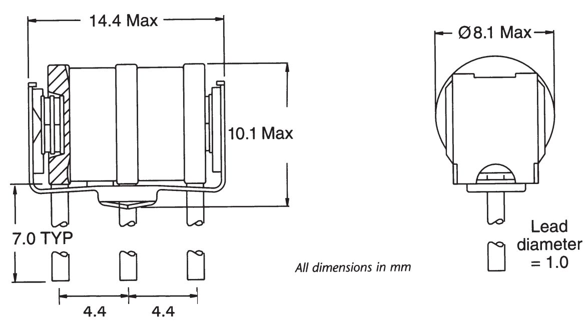
The following section describes the mechanical specifications of products in this *Telecom Design Guide*.

Gas Plasma Arresters—Package Dimensions/Specifications

The following illustrations show package dimensions and mechanical specifications for each of the gas plasma arresters.

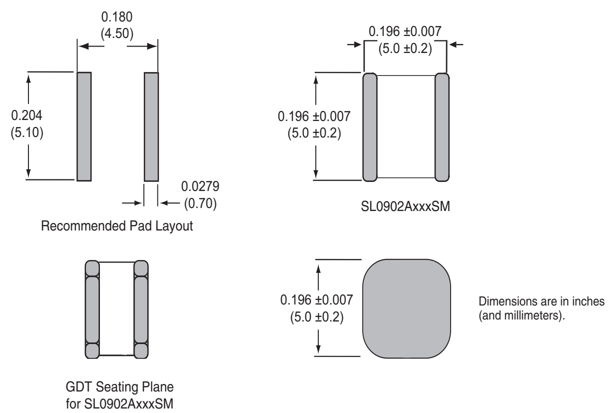
SL1122A Series

The SL1122A series device weighs 2.7 grams (0.095 ounces). Body material is ceramic. The electrode base is made of nickel iron alloy, and the electrode plating material is bright Sn. Each device is marked with an LF logo, voltage, and date code.



SL0902A Series

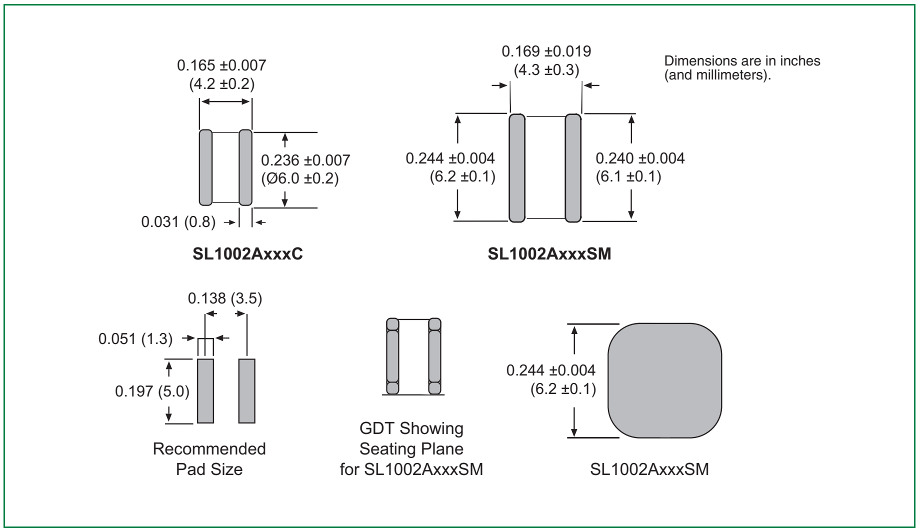
The SL0902A series device weighs 0.33 grams (0.011 ounces). Body material is ceramic. The electrode base is made of copper alloy, and the electrode plating material is bright Sn. Each device is marked with an LF logo, voltage, and date code.



Mechanical Data

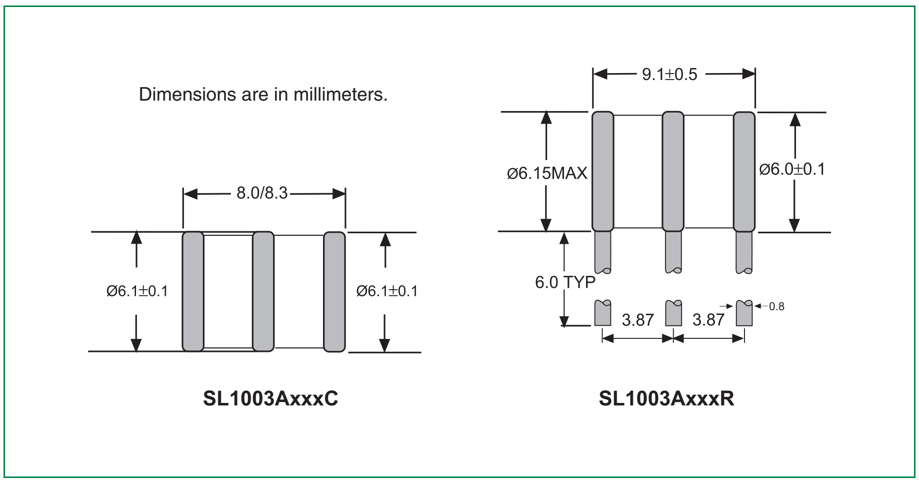
SL1002A Series

The SL1002A series device weighs 0.63 grams (0.022 ounces). Body material is ceramic. The electrode base is made of nickel iron alloy, and the electrode plating material is bright Sn. Each device is marked with an LF logo, voltage, and date code.



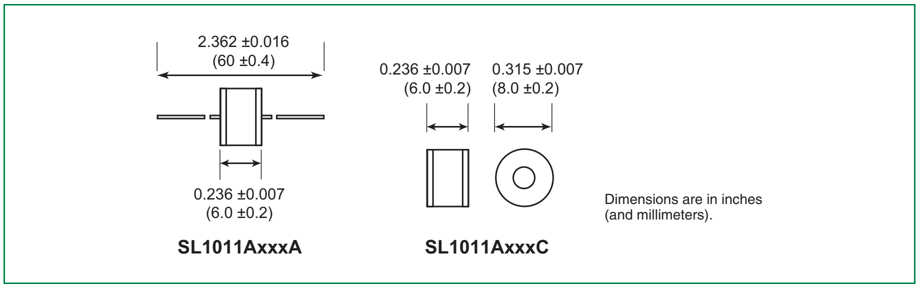
SL1003A Series

The SL1003A series device weighs 1.5 grams (0.083 ounces). Body material is ceramic. The electrode base is made of nickel iron alloy, and the electrode plating material is bright Sn. Each device is marked with an LF logo, voltage, and date code.



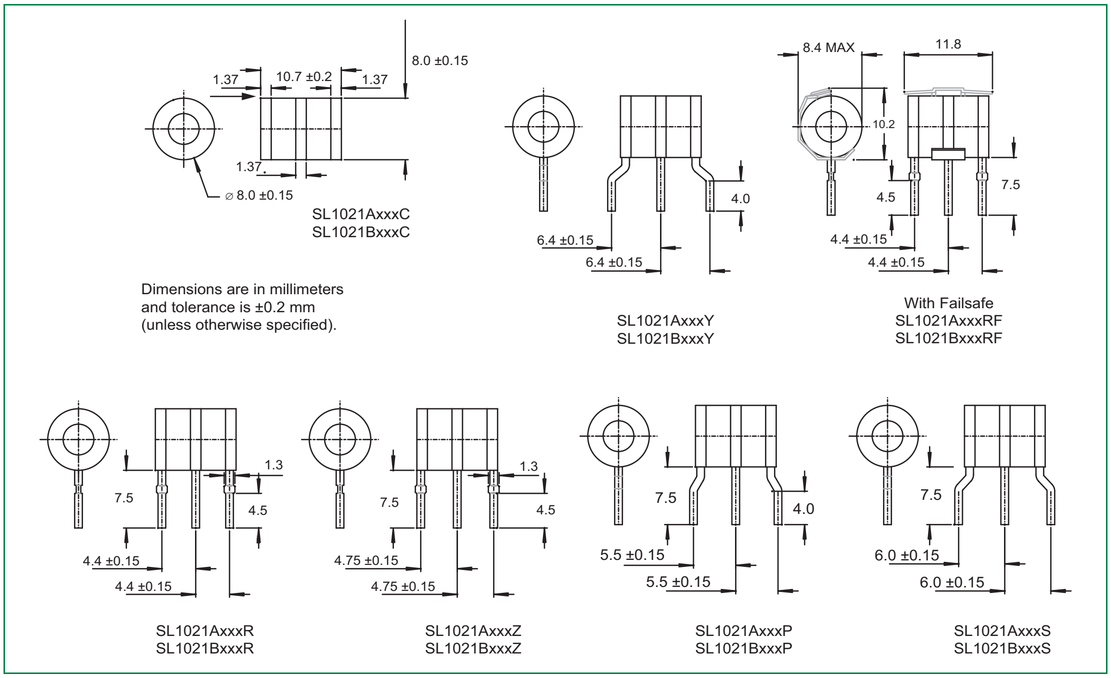
SL1011A and SL1011B Series

The SL1011A series device and the SL1011B series device weigh 2.7 grams (0.095 ounces). Body material is ceramic. The electrode base is made of nickel iron alloy, and the electrode plating material is bright Sn. Each device is marked with an LF logo, voltage, and date code.



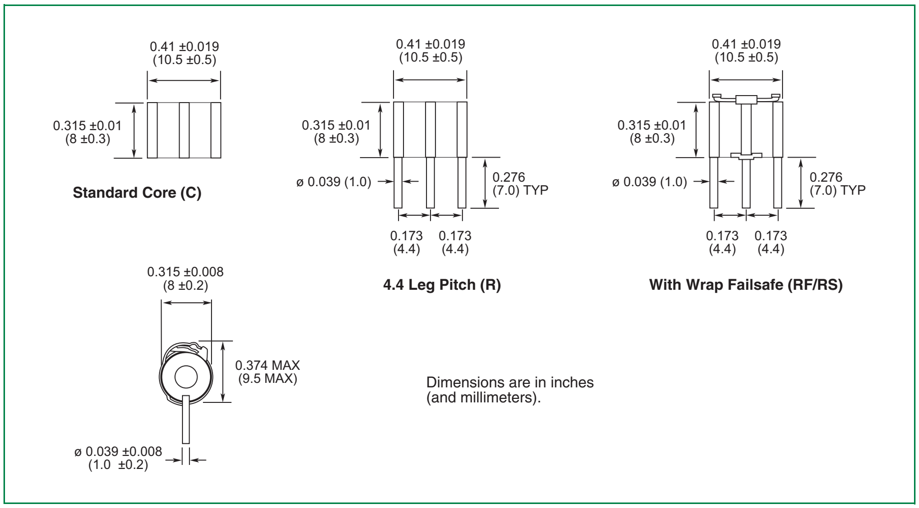
SL1021A and SL1021B Series

The SL1021A series device weighs 2.7 grams (0.095 ounces). The SL1021B series device weighs 0.63 grams (0.022 ounces). Body material is ceramic. The electrode base is made of nickel iron alloy, and the electrode plating material is bright Sn. Each device is marked with an LF logo, voltage, and date code. The SL1021B series markings are in blue.



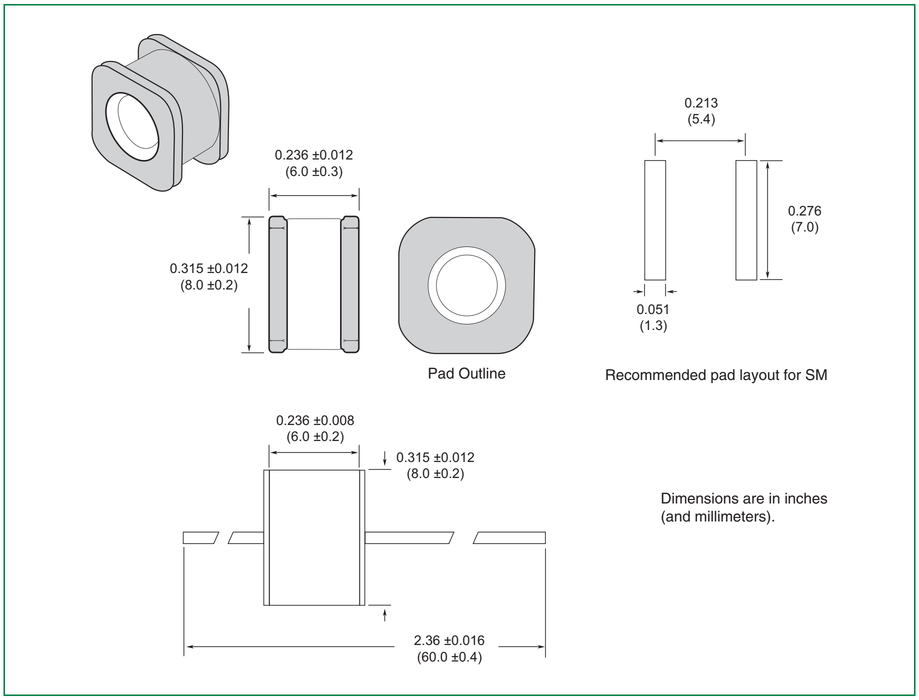
SL1024A and SL1024B Series

The SL1024A series device and the SL1024B series device weigh 2.7 grams (0.095 ounces). Body material is ceramic. The electrode base is made of nickel iron alloy, and the electrode plating material is bright Sn. Each device is marked with an LF logo, voltage, and date code in red.



SL1411A Series

The SL1411A series device weighs 2.7 grams (0.095 ounces). Body material is ceramic. The electrode base is made of nickel iron alloy, and the electrode plating material is bright Sn. Each device is marked with an LF logo, voltage, and date code.



SIDACtor® DO-214AA Package Symbolization

Note: Date code is located below the symbolized part number.

Part Number	
Catalog	Symbolized
P0080SAL	P-8A
P0080SAMCL	P-8AM
P0080SBL	P-8B
P0080SCL	P-8C
P0080SDL	P-8D
P0080SCMCL	P-8CM
P0300SAL	P03A
P0300SAMCL	P03AM
P0300SBL	P03B
P0300SCL	P03C
P0300SCMCL	P03CM
P0640SAL	P06A
P0640SBL	P06B
P0640SCL	P06C
P0640SDL	P06D
P0640SCMCL	P06CM
P0641CA2L	P62A
P0641SAL	P61A
P0641SCL	P61C
P0720SAL	P07A
P0720SBL	P07B
P0720SCL	P07C
P0720SDL	P07D
P0720SCMCL	P07CM
P0721CA2L	P72A
P0721SAL	P71A
P0721SCL	P71C
P0900SAL	P09A
P0900SBL	P09B
P0900SCL	P09C
P0900SDL	P09D
P0900SCMCL	P09CM
P0901CA2L	P92A
P0901SAL	P91A
P0901SCL	P91C
P1100SAL	P11A
P1100SBL	P11B
P1100SCL	P11C
P1100SDL	P11D
P1100SCMCL	P11CM
P1101CA2L	P02A
P1101SAL	P01A

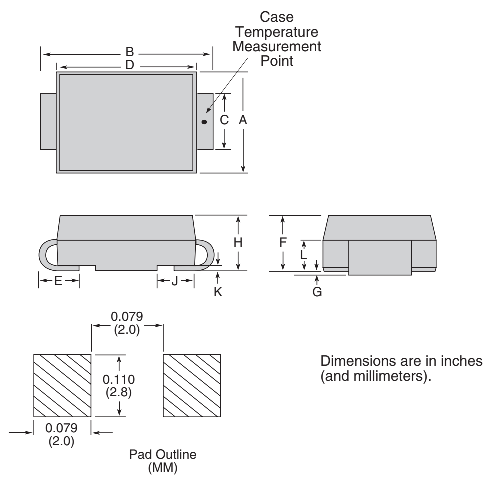
Part Number	
Catalog	Symbolized
P1101SCL	P01C
P1200SAL	P12A
P1200SBL	P12B
P1200SCL	P12C
P1200SDL	P12D
P1200SCMCL	P12CM
P1300SAL	P13A
P1300SBL	P13B
P1300SCL	P13C
P1300SDL	P13D
P1300SCMCL	P13CM
P1302SAL	P132A
P1402CAL	P14A
P1500SAL	P15A
P1500SBL	P15B
P1500SCL	P15C
P1500SDL	P15D
P1500SCMCL	P15CM
P1502SAL	P152A
P1602CAL	P16A
P1800SAL	P18A
P1800SBL	P18B
P1800SCL	P18C
P1800SDL	P18D
P1800SCMCL	P18CM
P1802SAL	P182A
P2000SAL	P20A
P2000SBL	P20B
P2000SCL	P20C
P2000SCMCL	P20CM
P2202CAL	P22A
P2300SAL	P23A
P2300SBL	P23B
P2300SCL	P23C
P2300SDL	P23D
P2300SCMCL	P23CM
P2302SAL	P232A
P2500SAL	P25A
P2500SBL	P25B
P2500SCL	P25C
P2500SDL	P25D
P2500SCMCL	P25CM

Part Number	
Catalog	Symbolized
P2600SAL	P26A
P2600SBL	P26B
P2600SCL	P26C
P2600SDL	P26D
P2600SCMCL	P26CM
P2602SAL	P262A
P2702CAL	P27A
P3002CAL	P30A
P3002CBL	P30B
P3002SAL	P30A
P3002SBL	P30B
P3100SAL	P31A
P3100SBL	P31B
P3100SCL	P31C
P3100SDL	P31D
P3100SCMCL	P31CM
P3500SAL	P35A
P3500SBL	P35B
P3500SCL	P35C
P3500SDL	P35D
P3500SCMCL	P35CM
P3502SAL	P352A
P3602CAL	P36A
P4202CAL	P42A
P4202SAL	P422A
P4802CAL	P48A
P4802SAL	P482A
P6002CAL	P60A
P6002CBL	P60B
P6002SAL	P602A
B1100CAL	B10A
B1100CCL	B10C
B1160CAL	B16A
B1160CCL	B16C
B1200CAL	B12A
B1200CCL	B12C
B2050CAL	B25A
B2050CCL	B25C

SIDACtor® Devices—Package Dimensions

DO-214AA

The DO-214AA package is designed to meet mechanical standards as set forth in JEDEC publication number 95, except for F and G dimensions.



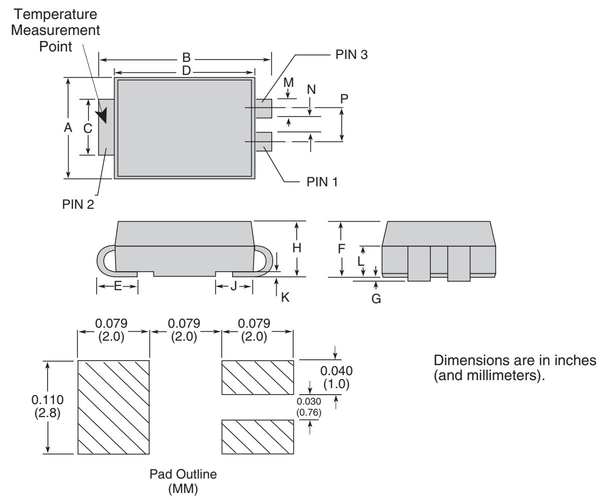
Note: A stripe is marked on some parts, to indicate the cathode. IPC-SM-782 recommends 2.4 instead of 2.0.

Dimension	Inches		Millimeters	
	MIN	MAX	MIN	MAX
A	0.140	0.155	3.56	3.94
B	0.205	0.220	5.21	5.59
C	0.077	0.083	1.96	2.11
D	0.166	0.180	4.22	4.57
E	0.036	0.063	0.91	1.60
F	0.066	0.083	1.67	2.11
G	0.004	0.008	0.10	0.20
H	0.077	0.086	1.95	2.18
J	0.043	0.053	1.09	1.35
K	0.008	0.012	0.20	0.30
L	0.027	0.049	0.69	1.24

Notes:
- Dimensions and tolerances per ASME Y14.5M-1994
- Mold flash shall not exceed 0.13 mm per side.
- Dimensions B and C apply to plated leads.
- All leads are insulated from case. Case is electrically non-conductive. (Rated at 1600 V ac rms for one minute from leads to case over the operating temperature range)
- Dimension C is measured on the flat section of the lead.

Modified DO-214AA

The Modified DO-214AA package is a three-leaded surface mount (SM) package.



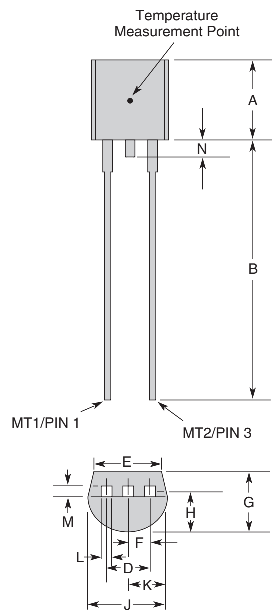
Note: A stripe is marked on some parts, to indicate the cathode. IPC-SM-782 recommends 2.4 instead of 2.0.

Dimension	Inches		Millimeters	
	MIN	MAX	MIN	MAX
A	0.140	0.155	3.56	3.94
B	0.205	0.220	5.21	5.59
C	0.077	0.083	1.96	2.11
D	0.166	0.180	4.22	4.57
E	0.036	0.063	0.91	1.60
F	0.066	0.083	1.67	2.11
G	0.004	0.008	0.10	0.20
H	0.077	0.086	1.95	2.18
J	0.043	0.053	1.09	1.35
K	0.008	0.012	0.20	0.30
L	0.027	0.049	0.69	1.24
M	0.022	0.028	0.56	0.71
N	0.027	0.033	0.69	0.84
P	0.052	0.058	1.32	1.47

Notes:
- Dimensions and tolerancing per ASME Y14.5M-1994
- Mold flash shall not exceed 0.13 mm per side.
- Dimensions B and C apply to plated leads.
- All leads are insulated from case. Case is electrically non-conductive. (Rated at 1600 V ac rms for one minute from leads to case over the operating temperature range)

TO-92

The TO-92 is designed to meet mechanical standards as set forth in JEDEC publication number 95.



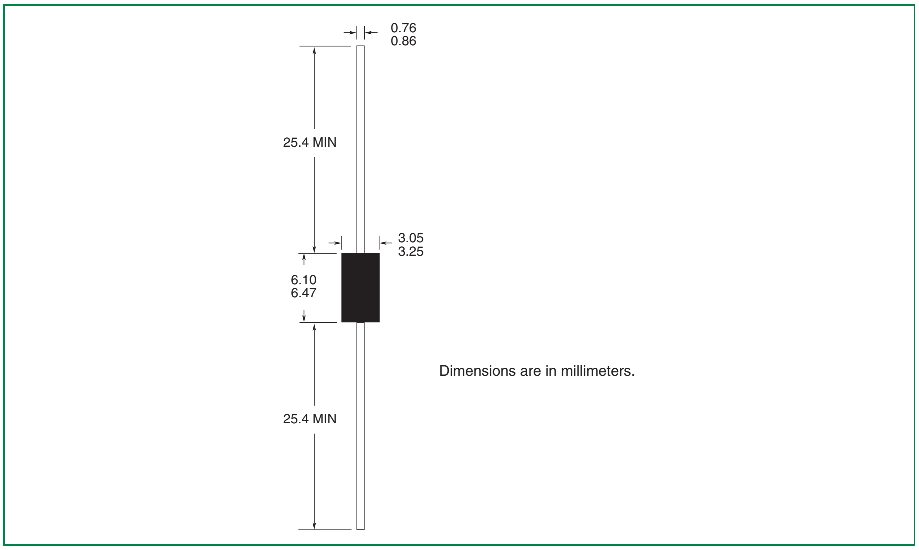
Dimension	Inches		Millimeters	
	MIN	MAX	MIN	MAX
A	0.176	0.196	4.47	4.98
B	0.500		12.70	
D	0.095	0.105	2.41	2.67
E	0.150		3.81	
F	0.046	0.054	1.16	1.37
G	0.135	0.145	3.43	3.68
H	0.088	0.096	2.23	2.44
J	0.176	0.186	4.47	4.73
K	0.088	0.096	2.23	2.44
L	0.013	0.019	0.33	0.48
M	0.013	0.017	0.33	0.43
N		0.060		1.52

Notes:

- Type 70 lead form as shown is standard for the E package.
- All leads are insulated from case. Case is electrically non-conductive. (Rated at 1600 V ac rms for one minute from leads to case over the operating temperature range)
- Mold flash shall not exceed 0.13 mm per side.

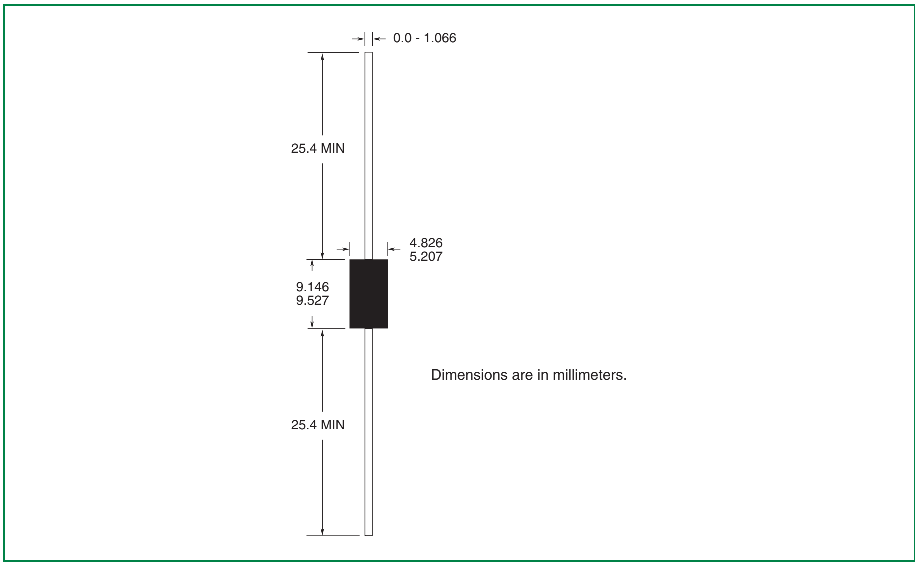
T10A

The T10A device is designed to meet mechanical standards as set forth in JEDEC publication number 95.



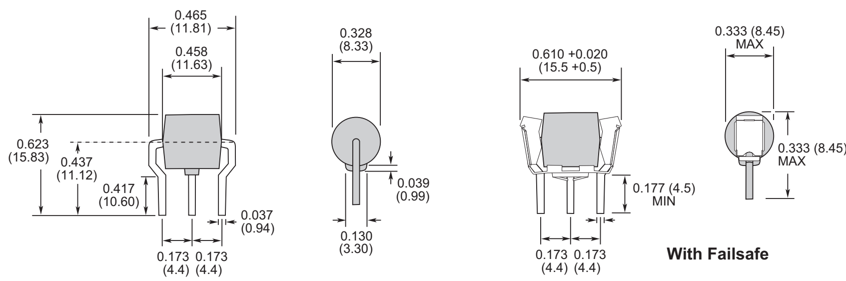
T10B

The T10B device is designed to meet mechanical standards as set forth in JEDEC publication number 95.



T10C

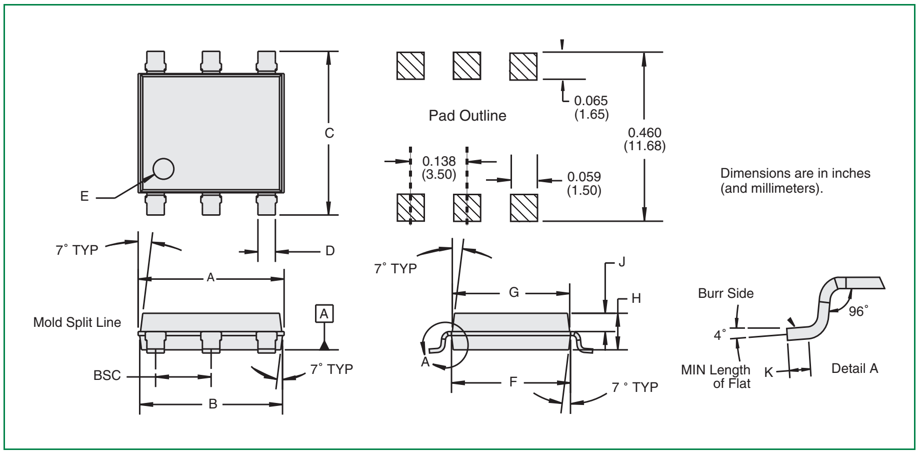
The T10C device design is not referenced to any JEDEC standard.



Dimensions are in inches
(and millimeters).

Modified MS-013

The Modified MS-013 is designed to meet mechanical standards as set forth in JEDEC publication number 95.

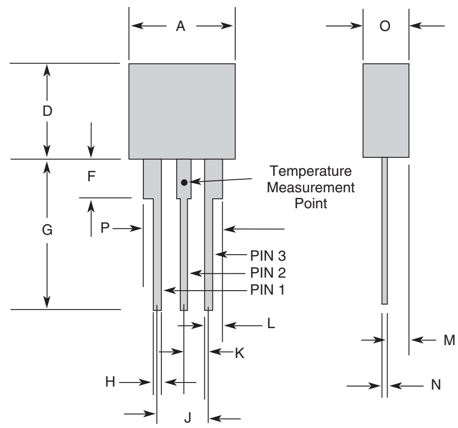


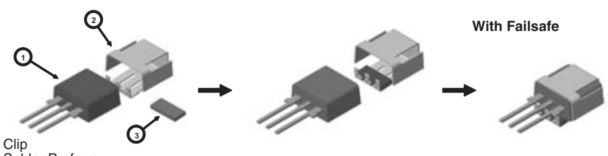
Dimension	Inches		Millimeters	
	MIN	MAX	MIN	MAX
A	0.360	0.364	9.14	9.25
B	0.352	0.356	8.94	9.04
C	0.400	0.412	10.16	10.46
D	0.043	0.043	1.09	1.09
E	0.047	0.055	1.19	1.40
F	0.293	0.297	7.44	7.54
G	0.289	0.293	7.34	7.44
H	0.089	0.093	2.26	2.36
J	0.041	0.049	1.04	1.24
K	0.020		0.51	
BSC	0.133	0.143	3.38	3.63

Notes:
- Dimensions and tolerances per ASME Y14.5M-1982
- Mold flash shall not exceed 0.13 mm per side.
- All leads are insulated from case. Case is electrically non-conductive. (Rated at 1600 V ac rms for one minute from leads to case over the operating temperature range)
- D dimension tolerance is ± 0.005 in (0.127 mm).

Modified TO-220

The Modified TO-220 package is designed to meet mechanical standards as set forth in JEDEC publication number 95.



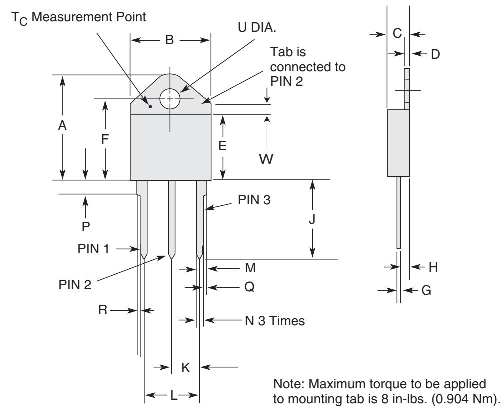


Dimension	Inches		Millimeters	
	MIN	MAX	MIN	MAX
A	0.400	0.410	10.16	10.42
D	0.360	0.375	9.14	9.53
F	0.110	0.130	2.80	3.30
G	0.540	0.575	13.71	14.61
H	0.025	0.035	0.63	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.075	0.085	1.90	2.16
M	0.070	0.085	1.78	2.16
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.290	0.310	7.37	7.87

Notes:
- All leads are insulated from case. Case is electrically non-conductive. (Rated at 1600 V ac rms for one minute from leads to case over the operating temperature range)
- Mold flash shall not exceed 0.13 mm per side.

TO-218

The TO-218 package is designed to meet mechanical standards as set forth in JEDEC publication number 95.

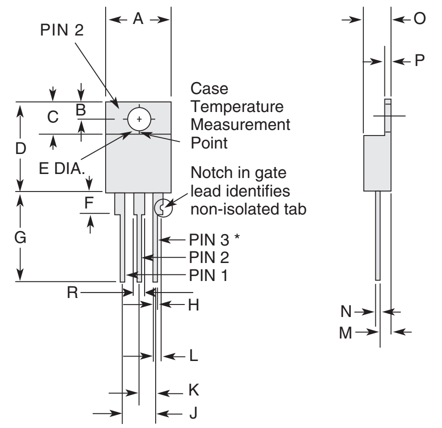


Dimension	Inches		Millimeters	
	MIN	MAX	MIN	MAX
A	0.810	0.835	20.57	21.21
B	0.610	0.630	15.49	16.00
C	0.178	0.188	4.52	4.78
D	0.055	0.070	1.40	1.78
E	0.487	0.497	12.37	12.62
F	0.635	0.655	16.13	16.64
G	0.022	0.029	0.56	0.74
H	0.075	0.095	1.91	2.41
J	0.575	0.625	14.61	15.88
K	0.211	0.219	5.36	5.56
L	0.422	0.437	10.72	11.10
M	0.100	0.110	2.54	2.79
N	0.045	0.055	1.14	1.40
P	0.095	0.115	2.41	2.92
R	0.008	0.016	0.20	0.41
S	0.038	0.048	0.97	1.22
T	0.025	0.032	0.64	0.81
U	0.159	0.163	4.04	4.14
V	0.090	0.100	2.29	2.54

Notes:
- Mold flash shall not exceed 0.13 mm per side.
- Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).
- Pin 3 has no connection.
- Tab is non-isolated (connects to middle pin).

R Package—TO-220AB

The R Package TO-220 is designed to meet mechanical standards as set forth in JEDEC publication number 95 except for L and P dimensions.



* Gate pin is not used.

Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

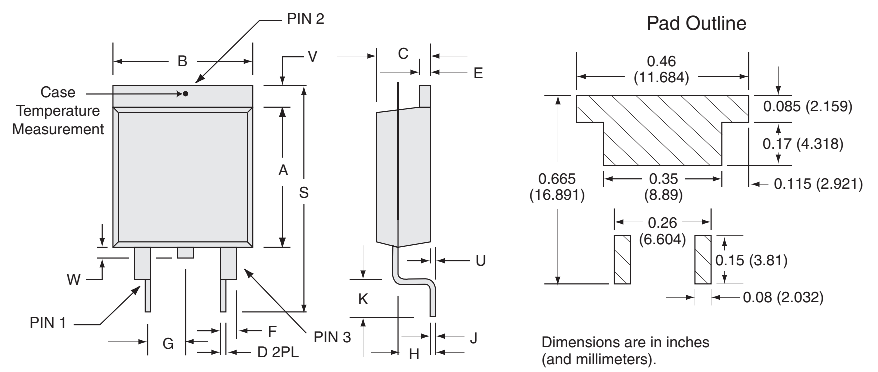
Dimension	Inches		Millimeters	
	MIN	MAX	MIN	MAX
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.66	2.92
C	0.230	0.250	5.85	6.35
D	0.590	0.620	14.98	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.80	3.30
G	0.540	0.575	13.71	14.60
H	0.025	0.035	0.63	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.070	0.085	1.78	2.16
N	0.018	0.024	0.45	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.53
R	0.038	0.048	0.97	1.22

Notes:
- Mold flash shall not exceed 0.13 mm per side.
- Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).
- Pin 3 has no connection.
- Tab is non-isolated (connects to middle pin).

Mechanical Data

N Package—TO-263

The N Package TO-263 is designed to meet mechanical standards as set forth in JEDEC publication number 95 except for B and F dimensions.

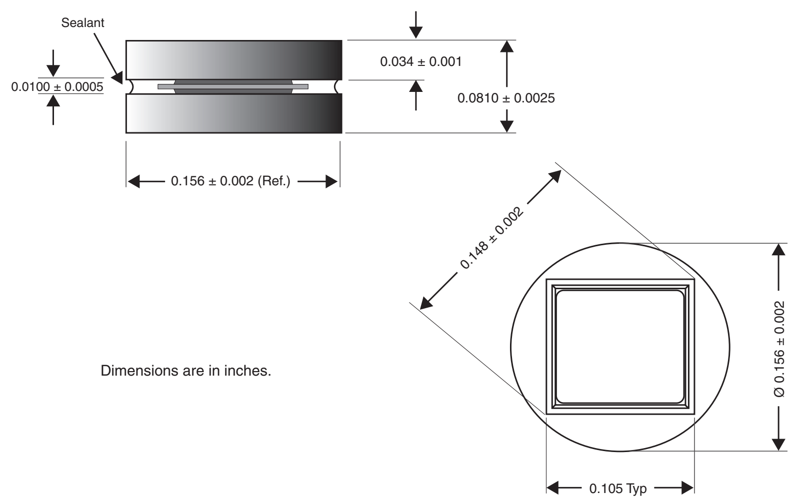


Dimension	Inches		Millimeters	
	MIN	MAX	MIN	MAX
A	0.360	0.370	9.14	9.40
B	0.380	0.420	9.65	10.67
C	0.178	0.188	4.52	4.78
D	0.025	0.035	0.63	0.89
E	0.048	0.055	1.22	1.40
F	0.060	0.075	1.52	1.91
G	0.095	0.105	2.41	2.67
H	0.083	0.093	2.11	2.36
J	0.018	0.024	0.46	0.61
K	0.090	0.110	2.29	2.79
S	0.590	0.625	14.99	15.87
V	0.035	0.045	0.89	1.14
U	0.002	0.010	0.05	0.25
W	0.040	0.070	1.02	1.78

Notes:
- Mold flash shall not exceed 0.13 mm per side.
- Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).
- Pin 3 has no connection.
- Tab is non-isolated (connects to middle pin).

SIDACtor® Cell

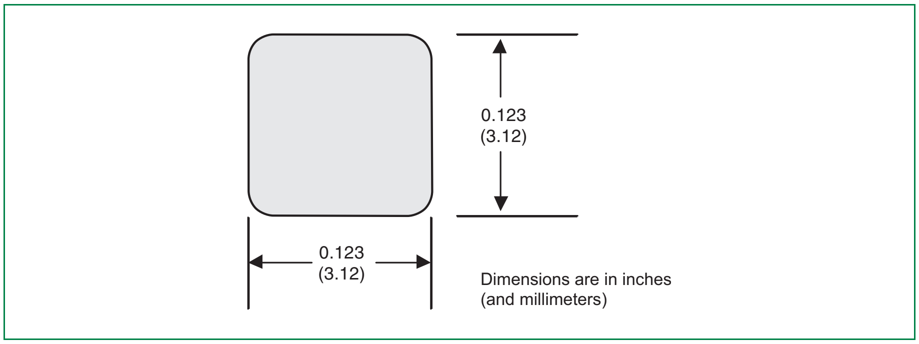
The following illustration shows the dimensions of the *SIDACtor* cell.



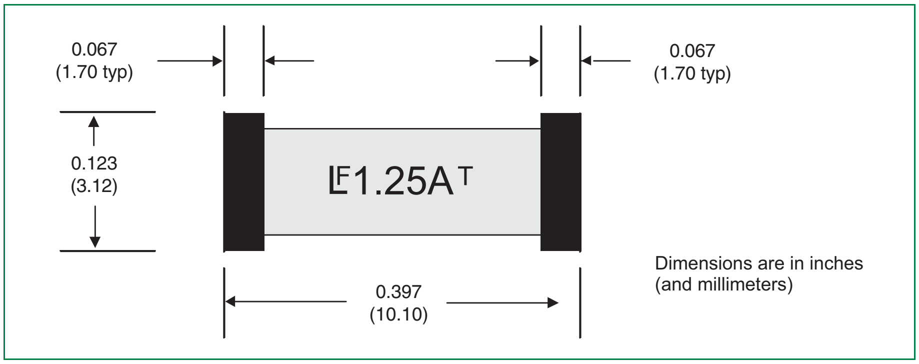
Dimensions are in inches.

TeleLink® Surface Mount Fuse—Package Dimensions

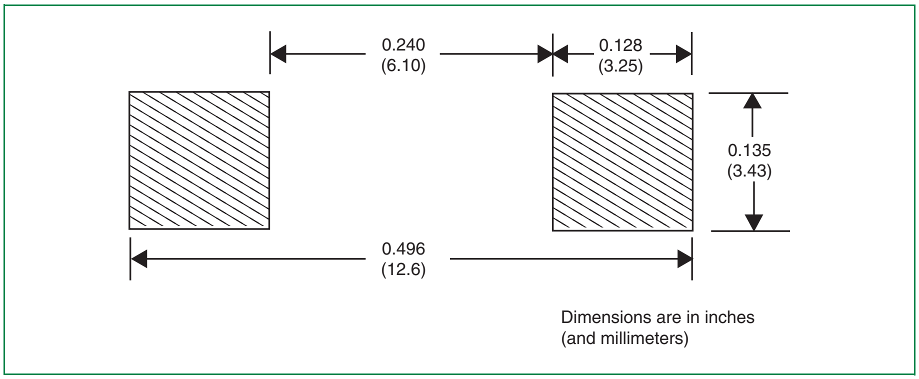
The following illustration shows the end view dimensions of a *TeleLink* fuse.



The following illustration shows the top view or side view dimensions of a *TeleLink* fuse.



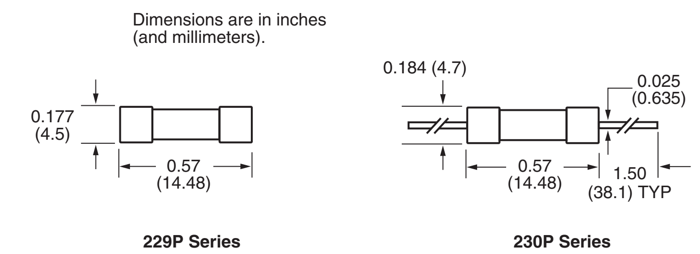
The following illustration shows the footprint dimensions of a *TeleLink* fuse.



Electronic Fuses—Package Dimensions

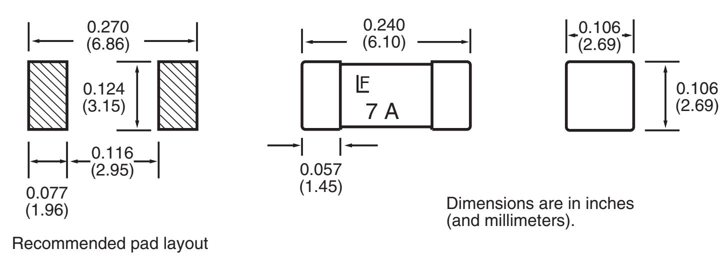
2AG *Slo-Blo*® Fuse—229P / 230P Series

The following illustration shows the dimensions of the 2AG *Slo-Blo* Fuse—229P / 230P series. The body is glass with nickel-plated brass fuse caps. Axial lead material is solder coated copper.



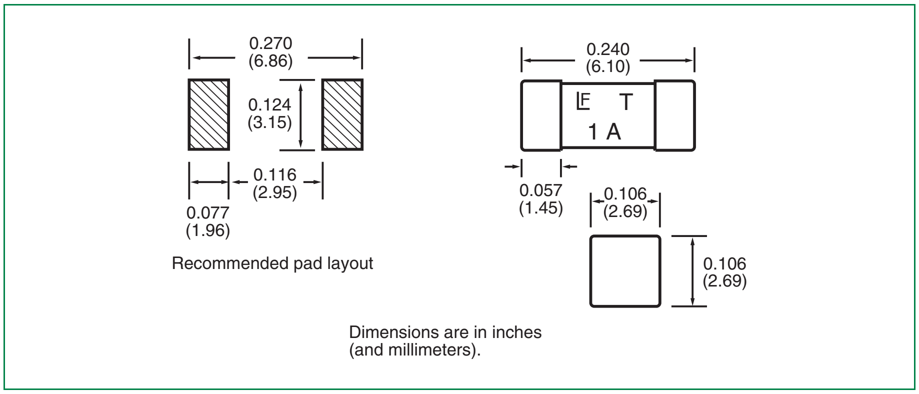
*NANO*2® Fuse—451 / 453 Series

The following illustration shows the dimensions of a *NANO*2 Fuse—451 / 453 series. The body is ceramic with tin-lead alloy or silver-plated caps. RoHS compliant terminations (451L series) are gold over nickel-plated caps.



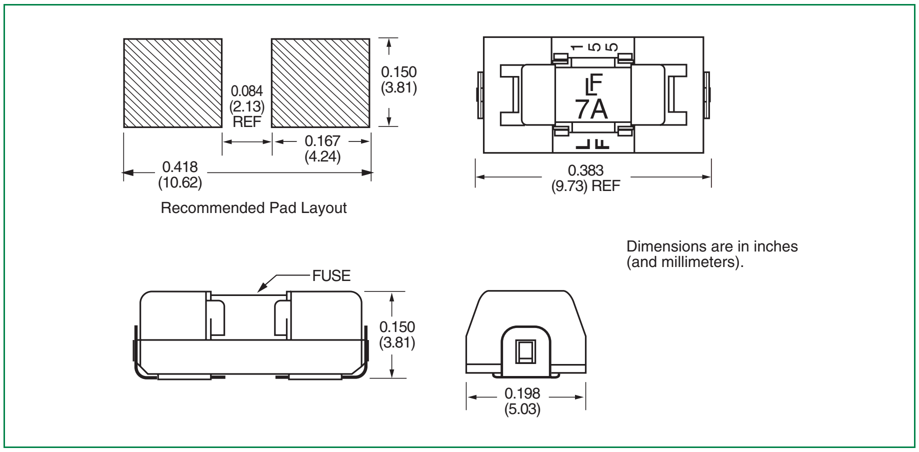
NANO$^{2®}$ Fuse—452 / 454 Series

The following illustration shows the dimensions of a *NANO*^{2} Fuse—452 / 454 series. The body is ceramic with tin-lead alloy or silver-plated caps. RoHS compliant terminations (452L series) are gold over nickel-plated caps.



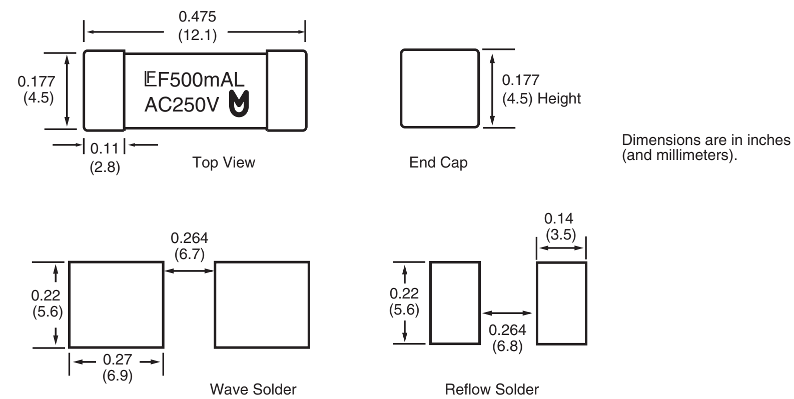
SMF *OMNI-BLOK*® Fuse Block—154 Series

The following illustration shows the dimensions of the SMF *OMNI-BLOK* Fuse Block—154 series.



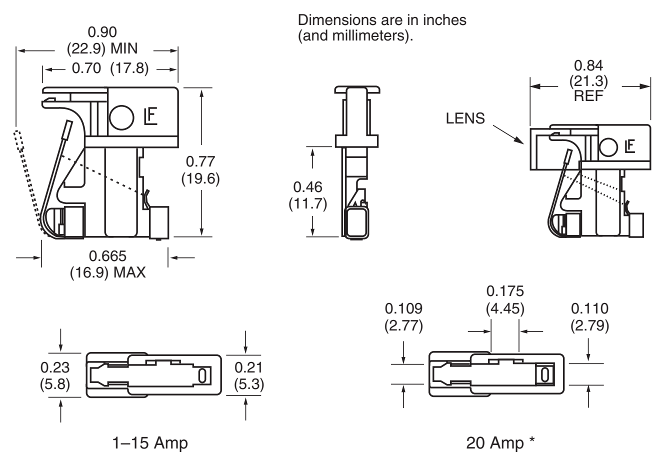
NANO$^{2®}$ 250 V UMF Fuse—464 / 465 Series

The following illustration shows the dimensions of the *NANO*^{2} 250 V Fuse—464 / 465 series. The body is high-performance ceramic, and the terminations are silver-plated brass.



481 Series Alarm Indicating Fuse

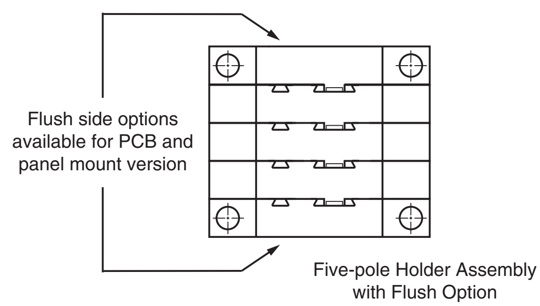
The following illustration shows the dimensions of the 481 series alarm indicating fuse. The body is polyphenylene sulfide (UL94V0), and the terminations are beryllium copper / tin plated. Optional lens are nylon.



* 20 A fuseholder must be used and is designed to accept all ratings up to 20 amps.
Fuse is keyed to prevent insertion in lower rated holders

482 Series Alarm Indicating Fuseholder

The following illustration shows the 482 series alarm indicating fuseholder. The body is black phenolic. The fuse terminals are tin-plated beryllium copper, and the alarm terminal is tin-plated brass.

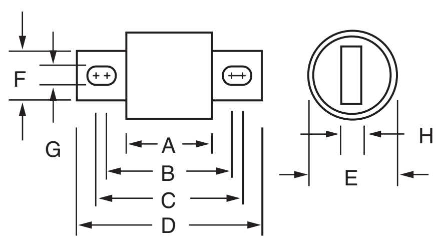


DC Power Fuses—Package Dimensions

L17T Series

The following illustration shows the dimensions of the L17T series telecommunications power fuse.

Contact Littelfuse for characteristic curves.



Dimensions	70 A – 250 A		300 A – 800 A		1000 A – 1200 A	
	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters
A	1.156	29.4	1.25	31.8	1.344	34
B	1.875	47.6	1.938	49.2	—	—
C	2.188	55.6	2.563	65.1	—	—
D	—	67.5	3.5	88.9	4.063	103.12
E	1.656	25.4	1.5	38.1	—	—
F	0.875	22.2	1	25.4	1.5	38.1
G	0.313	7.9	0.406	10.3	—	—
H	0.188	4.8	0.25	6.35	0.25	6.35

TLN Series

The following illustrations show the dimensions of the TLN series telecommunications power fuse. (The TLN series replaces competitors' TPN and TGN series.)

Contact Littelfuse for characteristic curves.

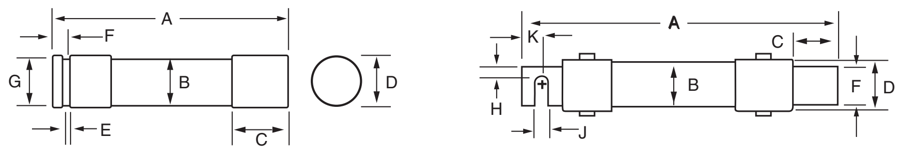


Figure 1   Figure 2

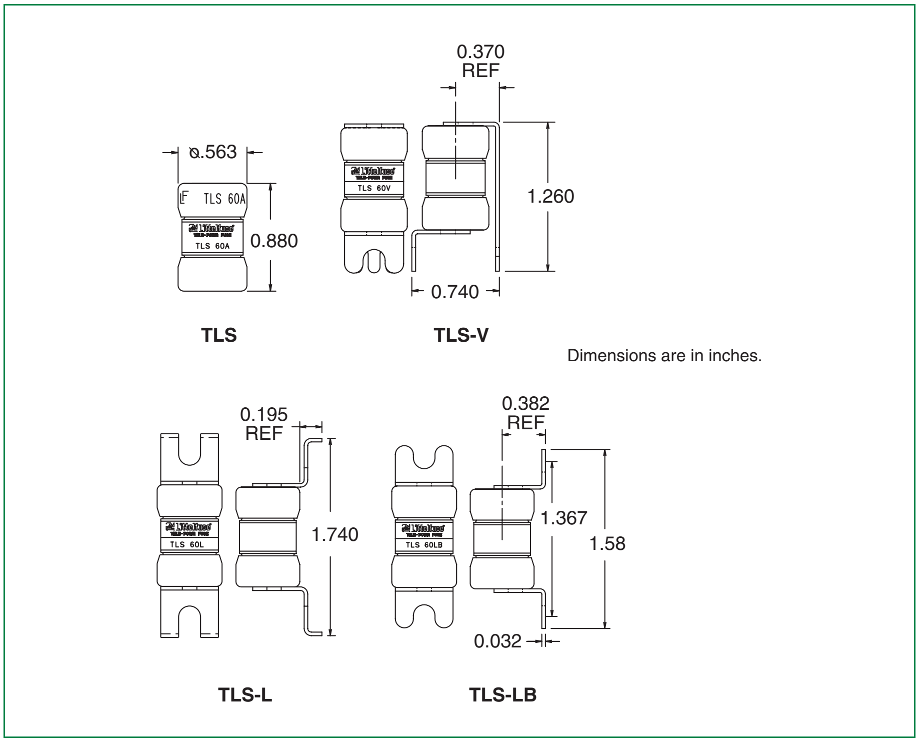
Figure 1 Dimensions	1 A – 30 A		35 A – 60 A	
	Inches	Millimeters	Inches	Millimeters
A	2	50.8	3	76.2
B	0.5	12.7	0.75	19.1
C	0.5	12.7	0.625	15.9
D	0.563	14.3	0.813	20.6
E	0.078	2	0.094	2.4
F	0.156	4	0.188	4.8
G	0.375	9.5	0.625	15.9
H	—	—	—	—
J	—	—	—	—
K	—	—	—	—

Figure 2 Dimensions	70 A – 100 A		110 A – 200 A		225 A – 400 A		450 A – 600 A	
	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters
A	5.875	149.2	7.125	181	8.625	219.1	10.375	263.5
B	1	25.4	1.5	38.1	2	50.8	2.5	63.5
C	1.063	27	1.469	37.3	1.938	49.2	2.375	60.3
D	1.063	27	1.594	40.5	2.094	53.2	2.594	65.9
E	0.125	3.2	0.188	4.8	0.25	6.4	0.25	6.4
F	0.75	19.1	1.125	28.6	1.625	41.3	2	50.8
G	1.25	31.6	1.844	46.8	2.344	59.5	2.844	72.2
H	0.25	6.4	0.438	11.1	0.625	15.9	0.75	19.1
J	0.281	7.1	0.281	7.1	0.406	10.3	0.531	13.5
K	0.5	12.7	0.688	17.5	0.938	23.8	1.125	28.6

TLS Series

The following illustration shows the dimensions of the TLS series telecommunications power fuse. (The TLS series replaces competitors' TPS and TGS series.)

Note: Contact Littelfuse for characteristic curves and additional mounting configurations.

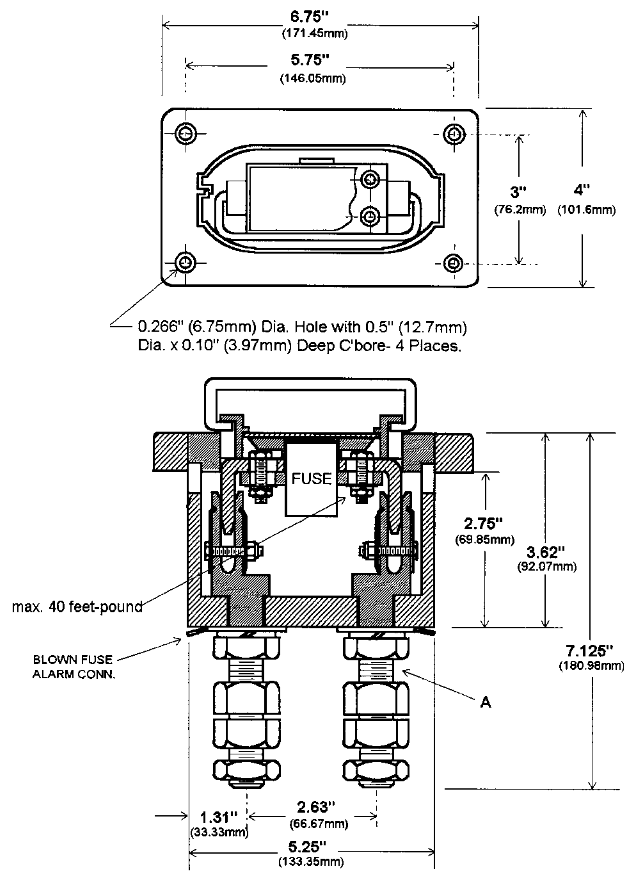


LTFD Series

The following illustration shows the dimensions of the LTFD 6001 series (0 A – 800 A) telecommunications power fuse. Stud size is as follows:

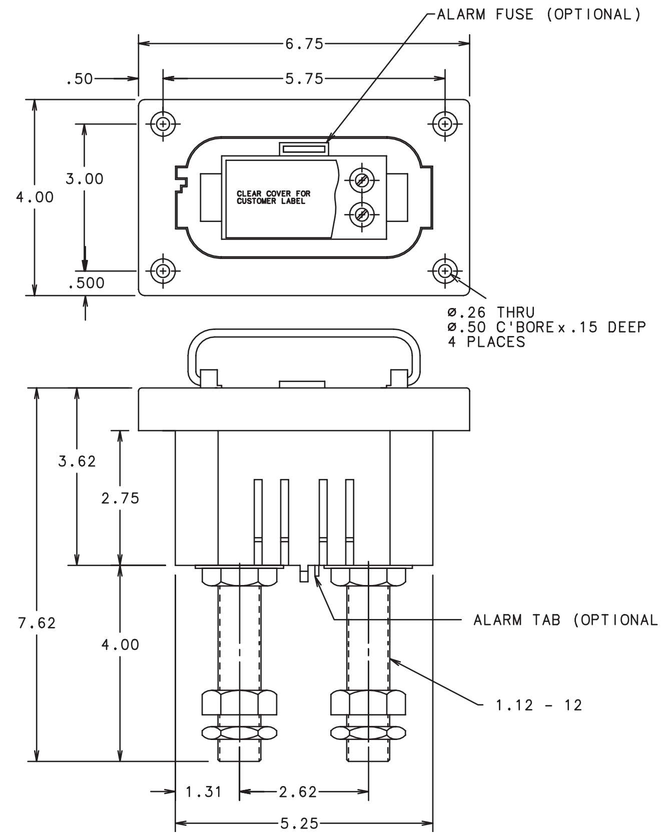
- 0.75 – 16x3.5 inches
- 0.875 – 14x3.5 inches

Dimensions are for reference only.



The following illustration shows the dimensions of the LTFD 1200 series (900 A – 1200 A) telecommunications power fuse. Stud size is 1.12 – 12x4 inches.

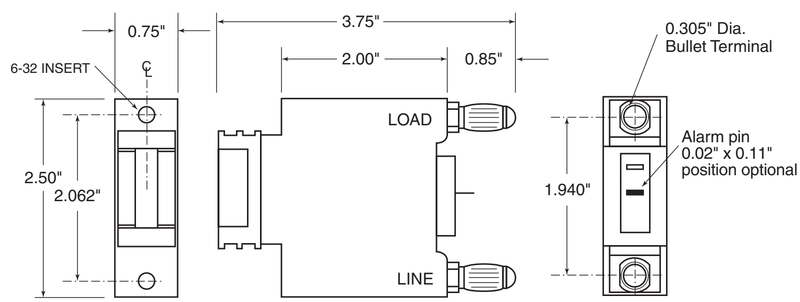
Dimensions are for reference only.



LTFD 101 Series

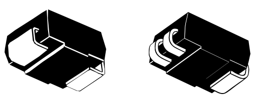
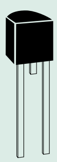
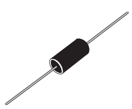
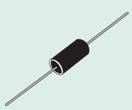
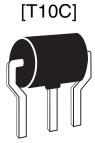
The following illustration shows the dimensions of the LTFD 101 series telecommunications power fuse. Contact Littelfuse for additional options and dimensions.

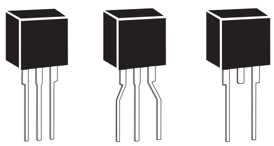
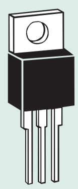
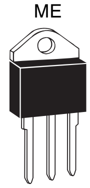
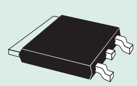
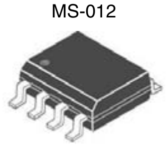
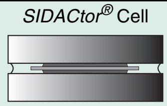
Dimensions are for reference only.



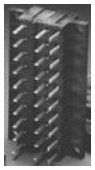
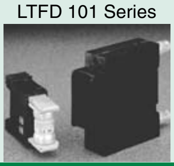
Summary of Packing Options

Package Type	Description	Packing Quantity	Added Suffix	Industry Standard
SL1122A Series 	Bulk Pack (10 x Trays of 100)	1000	Standard	EIA-RS-296
SL0902A Series 	Tape and Reel Pack	1500	SM	EIA-481-2
	Bulk Pack	1000	C	N/A
SL1002A Series 	Tape and Reel Pack (tape width 16 mm)	1000	SM	EIA-481-2
	Bulk Pack	1000	C	N/A
SL1003A Series 	Tape and Reel Pack	700	SM	EIA-481-2
	10 x Trays of 100	1000	R	N/A
	Bulk Pack	1000	C	N/A
SL1011A/B Series 	Tape and Reel Pack	1000	A	EIA-RS-296
	Bulk Pack	1000	C	N/A
	Bulk Pack (10 x Trays of 100)	1000	Formed Options	N/A
SL1021A/B Series 	Bulk Pack (10 x Trays of 100)	1000	R, RF, RS	EIA-RS-296
SL1024A/B Series 	Bulk Pack (10 x Trays of 100)	1000	R, RF, RS	N/A

Package Type	Description	Packing Quantity	Added Suffix	Industry Standard
SL1411A Series 	Tape and Reel Pack	1000	A	EIA-296
	Bulk Pack	1000	C	N/A
DO-214AA SA, SB, SC, SD, including MC  3-lead	Embossed Carrier Reel Pack	2500	RP	EIA-481-1
TO-92 EA, EB, EC, including MC  Note: Standard lead spacing for TO-92 reel pack is 0.200" (RP2).	Bulk Pack	2000	Standard	N/A
	Tape and Reel Pack	2000	RP1, RP2	EIA-468-B
	Ammo Pack	2000	AP	EIA-468-B
T10A [DO-15] 	Tape and Reel Pack	5000	RP	EIA-468-B
	Bulk Pack	1000	N/A	N/A
T10B [DO-201AD] 	Tape and Reel Pack	1000	RP	EIA-468-B
	Bulk Pack	500	N/A	N/A
[T10C] 	Bulk Pack (10 x Trays of 100)	1000	N/A	N/A
Modified MS-013 	Tape and Reel Pack	1500	RP	EIA-481-1
	Tube Pack	50 per tube, 10 tubes per container	TP	EIA-481-1

Package Type	Description	Packing Quantity	Added Suffix	Industry Standard
TO-220 AA, AB, AC, AD  Type 60 Type 61	Bulk Pack	500	Standard	N/A
	Tape and Reel Pack	700	RP	EIA-468-B
	Bulk Pack for Type 60 lead form	500	BP	N/A
	Tape and Reel Pack for Type 61 lead form	700	RP	EIA-468-B
	Tube Pack	50 per tube, 10 tubes per container	TP	EIA-468-B
TO-220AB 	Bulk Pack	500	Standard	N/A
TO-218 ME 	Bulk Pack	250	Standard	N/A
TO-263 D^2PAK 	Tube Pack	50 per tube, 10 tubes per container	TP	
	Tape and Reel Pack	500	RP	EIA-481-2
MS-012 	Tape and Reel Pack	5000	Standard	EIA-481-1
SIDACtor® Cell 	Bulk Pack (25 x Trays of 200)	5000	—	N/A

Package Type	Description	Packing Quantity	Added Suffix	Industry Standard
TeleLink® Surface Mount Fuse 461 Series 	Embossed Carrier Reel Pack	2500	RP	EIA-481-B
	Bulk Pack	5000	BP	N/A
	Tape and Reel Pack (16 mm)	2500	ERT16	
229P / 230P Series 	Bulk Pack	1000	M	EIA-296
	Tape and Reel Pack	1500	DRT1	EIA-296
	Tape and Reel Pack	2500	ERT1	EIA-296
451 / 453 Series 	Tape and Reel Pack (12 mm)	1000	MR	EIA-RS481-1
	Tape and Reel Pack (12 mm)	5000	NR	EIA-RS481-1
452 / 454 Series 	Tape and Reel Pack (12 mm)	1000	MR	EIA-RS481-1
	Tape and Reel Pack (12 mm)	5000	NR	EIA-RS481-1
154 Series 	Tape and Reel Pack (16 mm)	1500	DR	EIA-481
464 Series 	Tape and Reel Pack (24 mm)	1500	DR	EIA-RS481-1
465 Series 	Tape and Reel Pack (24 mm)	1500	DR	EIA-RS481-1
481 Series 	Bulk Pack	Five-pack	V	
	Bulk Pack	100-piece box	H	

Package Type	Description	Packing Quantity	Added Suffix	Industry Standard
482 Series 	Contact Littelfuse for packing and ordering information.			
L17T Series 	Contact Littelfuse for packing and ordering information.			
TLN Series 	Contact Littelfuse for packing and ordering information.			
TLS Series 	Contact Littelfuse for packing and ordering information.			
LTFD Series 	Contact Littelfuse for packing and ordering information.			
LTFD 101 Series 	Contact Littelfuse for packing and ordering information.			

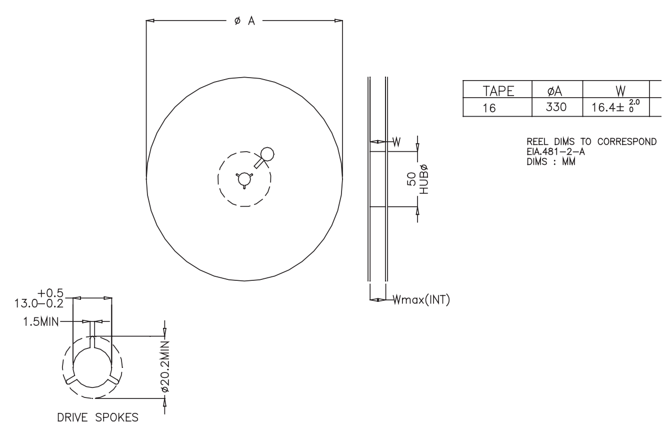
Packing Options

SL1122A Series

Tape and reel packing options meet all specifications as set forth in EIA-481-1. Bulk pack quantity is 1000 (10 trays of 100). Depth of tray with lid is 22 mm; width of tray is 222 mm x 222 mm.

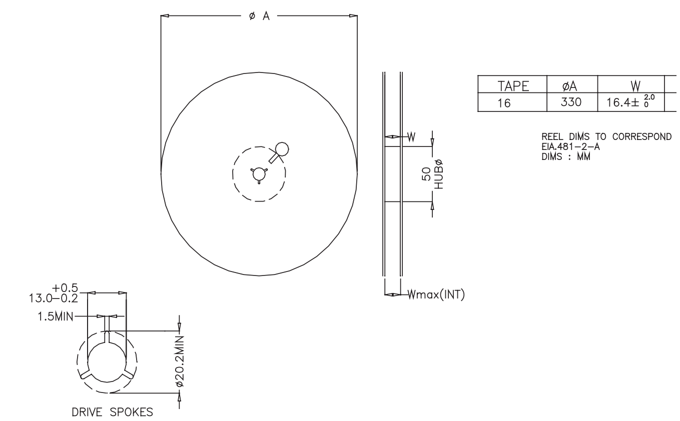
SL0902A Series

Tape and reel packing options meet all specifications as set forth in EIA-481-2. Standard reel pack quantity is 1500. Bulk pack quantity is 1000.



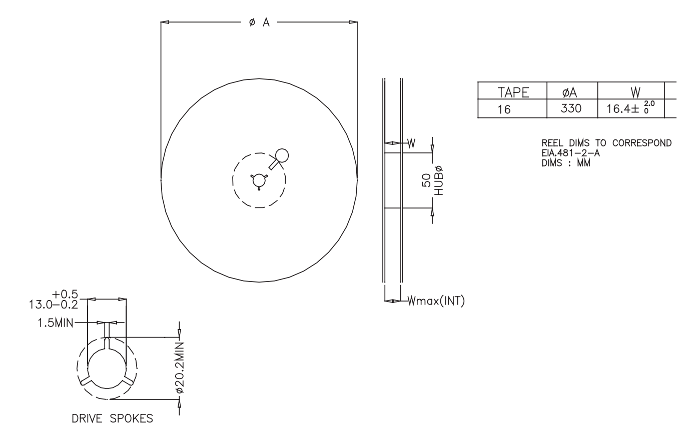
SL1002A Series

Tape and reel packing options meet all specifications as set forth in EIA-481-2. Standard reel pack quantity is 1000. Bulk pack quantity is 1000.



SL1003A Series

Tape and reel packing options meet all specifications as set forth in EIA-481-2. Standard reel pack quantity is 700. Bulk pack quantity is 1000.



Mechanical Data

SL1011A/B Series

Tape and reel packing options meet all specifications as set forth in EIA-296. Standard reel pack quantity is 1000. Bulk pack quantity is 1000.

SL1021A/B Series

Bulk pack quantity is 1000 (10 trays of 100). Depth of tray with lid is 22 mm; width of tray is 222 mm x 222 mm.

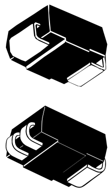
SL1024A/B Series

Bulk pack quantity is 1000 (10 trays of 100). Depth of tray with lid is 22 mm; width of tray is 222 mm x 222 mm.

SL1411A Series

Tape and reel packing options meet all specifications as set forth in EIA-296. Standard reel pack quantity and bulk pack quantity for axial-leaded devices is 1000 pieces.

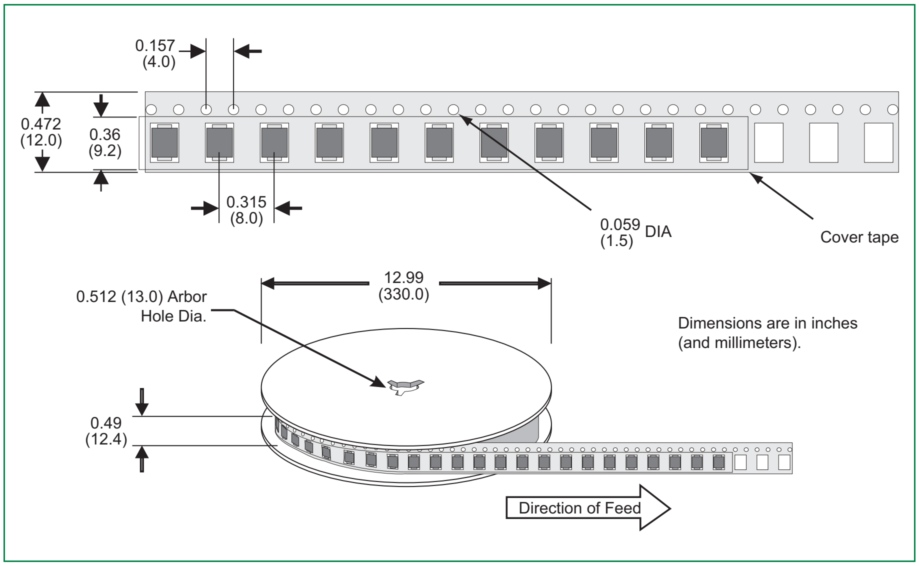
Contact Littelfuse for surface mount packaging information.



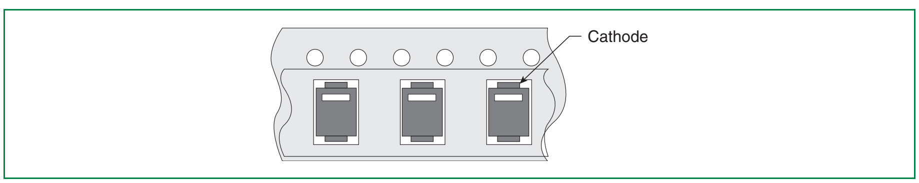
3-lead

DO-214AA

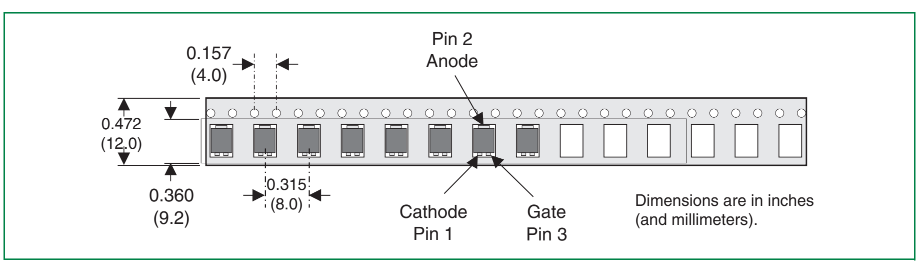
Tape and reel packing options meet all specifications as set forth in EIA-481-1. Standard reel pack quantity is 2500. Bulk pack quantity is 1000.

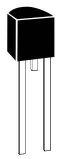


The following illustration shows the DO-214AA component orientation for P0641S, P0721S, P0901S, P1101S, P1301S, P1701S:



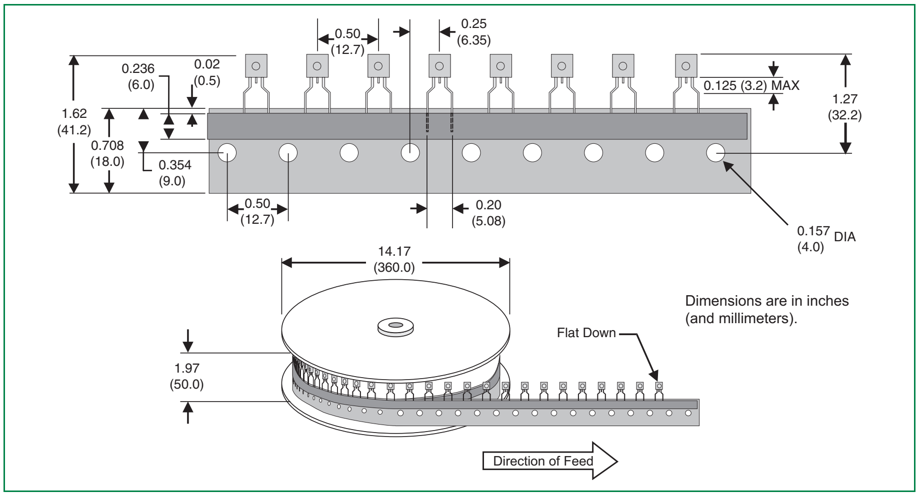
The following illustration shows the modified DO-214 tape and reel:





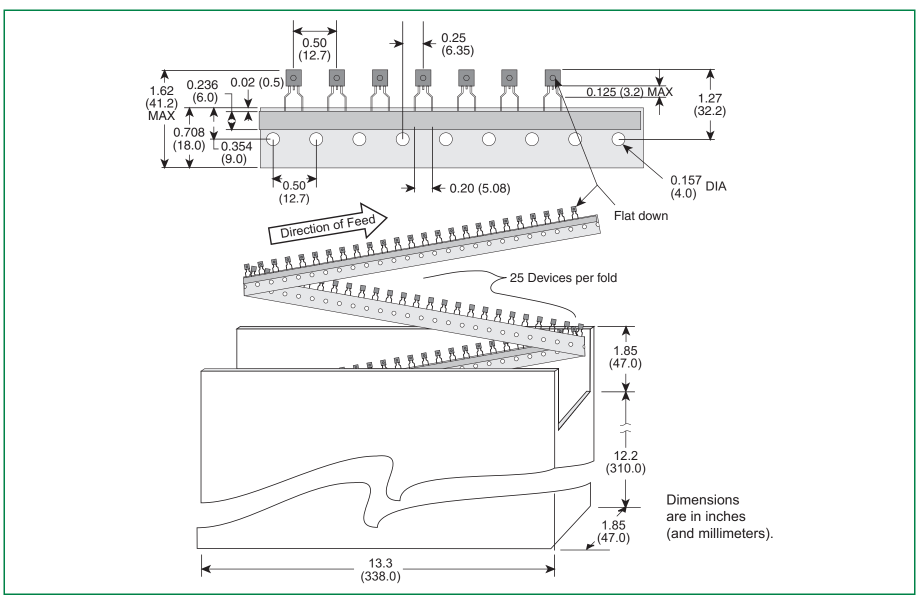
TO-92

Tape and reel packing options meet all specifications as set forth in EIA-468-B. Standard reel pack quantity is 2000.

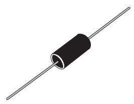


Notes:
- Part number suffix RP2 denotes 0.200” (5 mm) lead spacing and is Littelfuse’s default value.
- Part number suffix RP1 denotes 0.100” (2.54 mm) lead spacing and is available upon request.

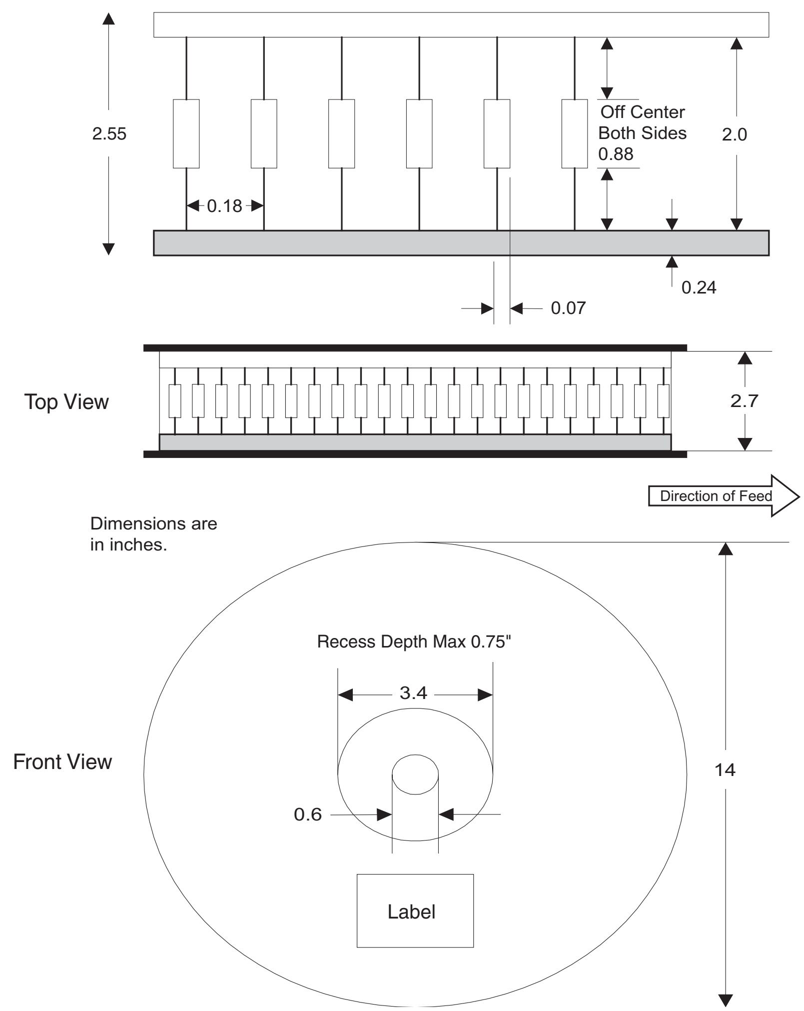
The following figure shows the TO-92 Ammo Pack option:



T10A

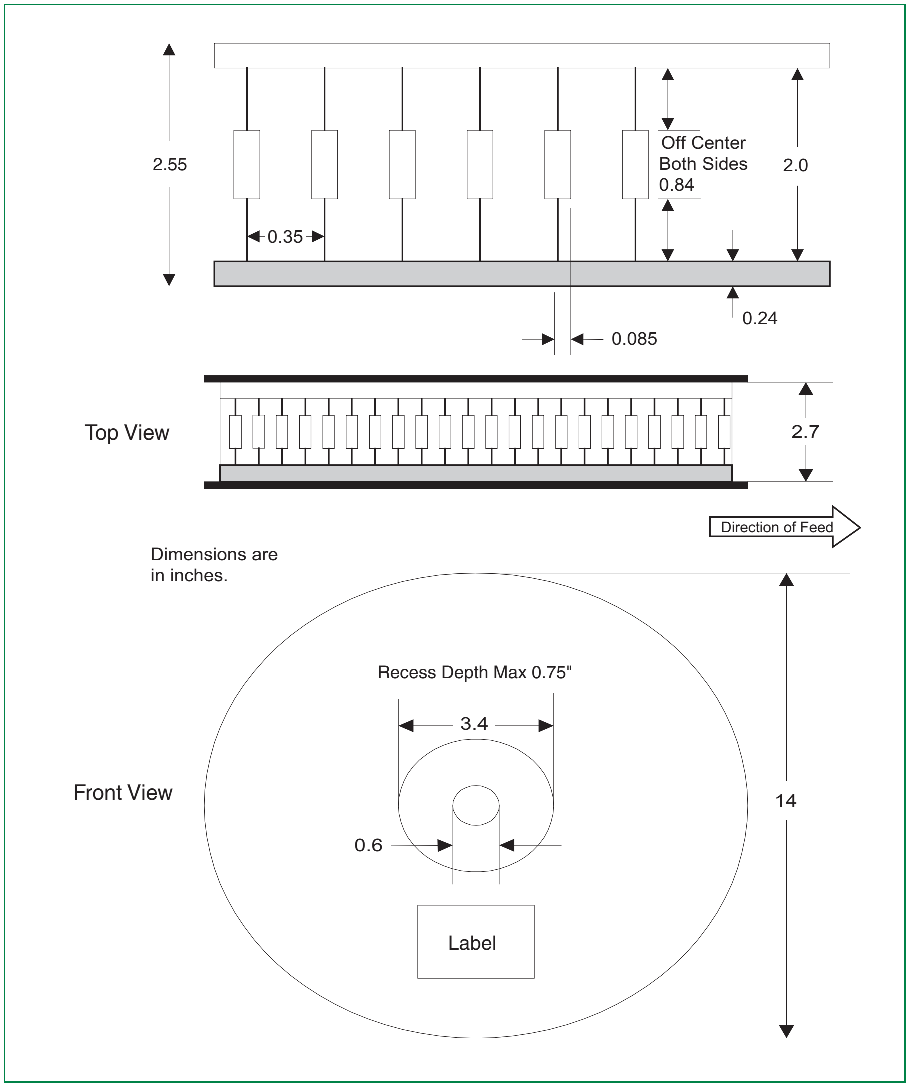


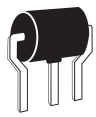
Tape and reel packing options for the T10A meet all specifications as set forth in EIA-468-B. Standard reel pack quantity is 5000. Bulk pack quantity is 1000.



T10B

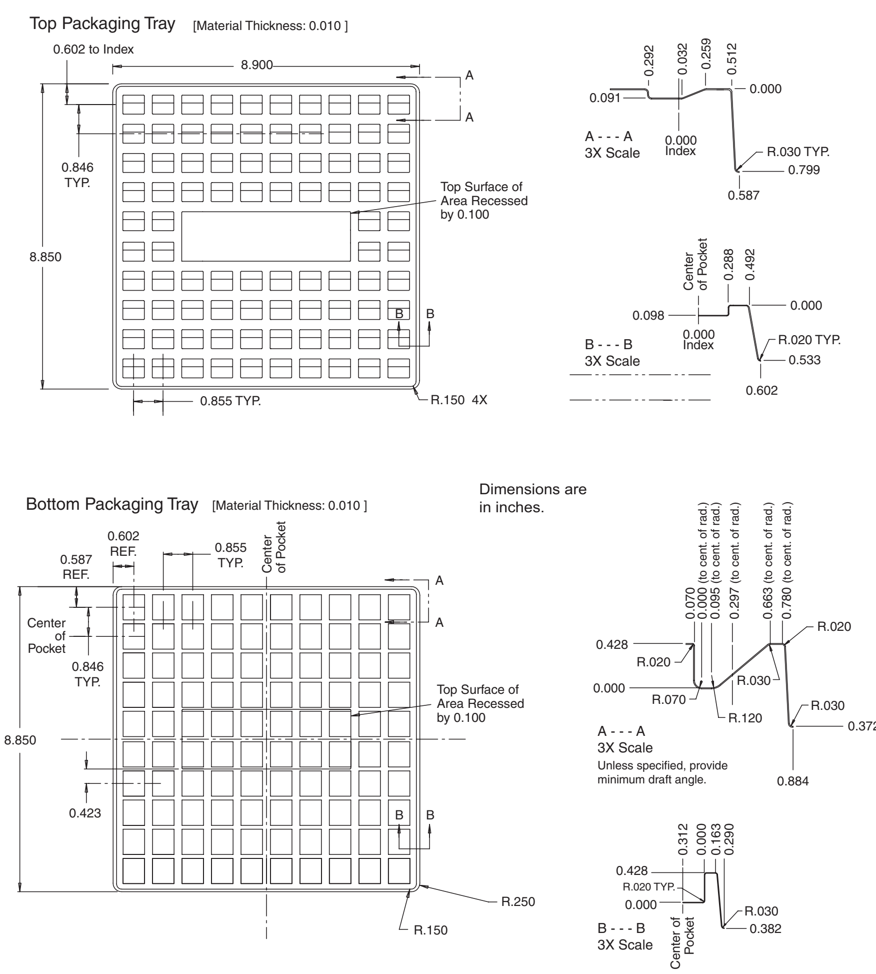
Tape and reel packing options for the T10B meet all specifications as set forth in EIA-468-B. Standard reel pack quantity is 1000. Bulk pack quantity is 500.

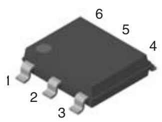




T10C

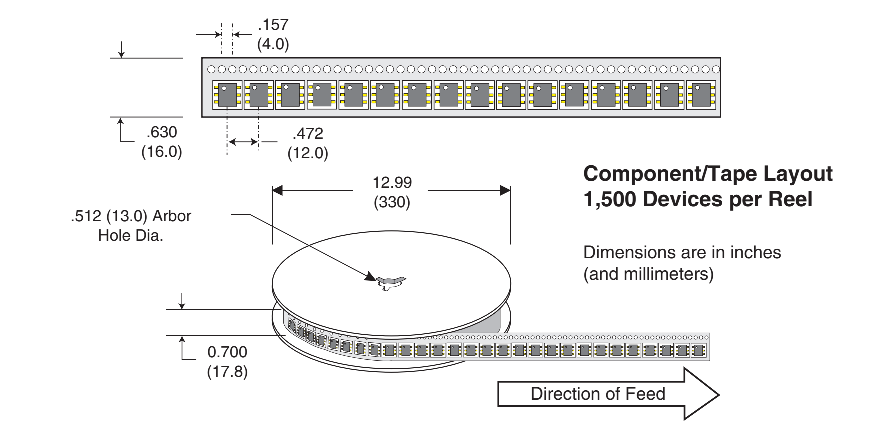
The following illustration shows the tray for the T10C. Standard tray quantity is 1000 per box (10 trays of 100 each).



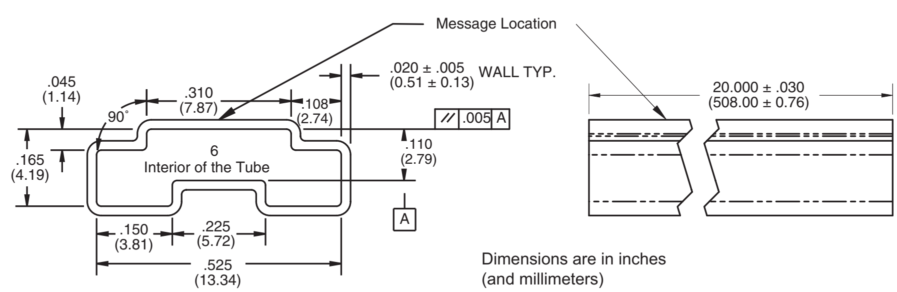


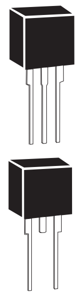
Modified MS-013 Six-pin

Tape and reel packing options meet all specifications as set forth in EIA-468-B. Standard reel pack quantity is 1500.



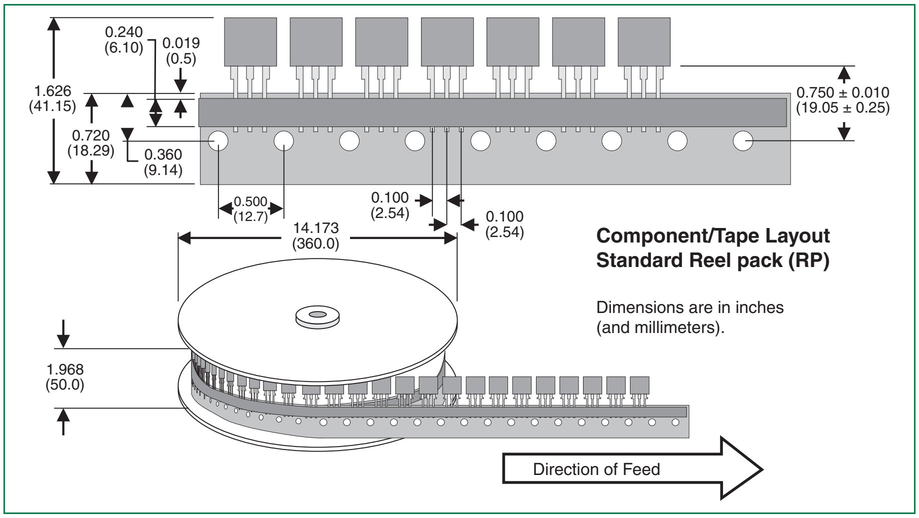
The following illustration shows the tube pack:



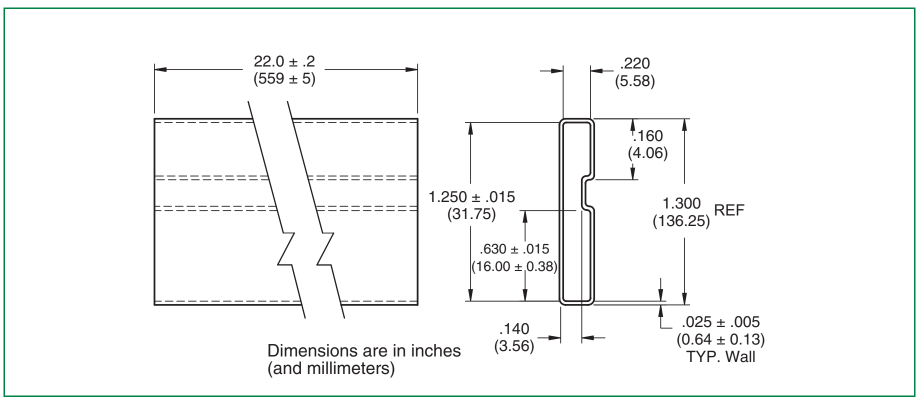


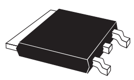
Modified TO-220

Tape and reel packing options meet all specifications as set forth in EIA-468-B. Standard reel pack quantity is 700.



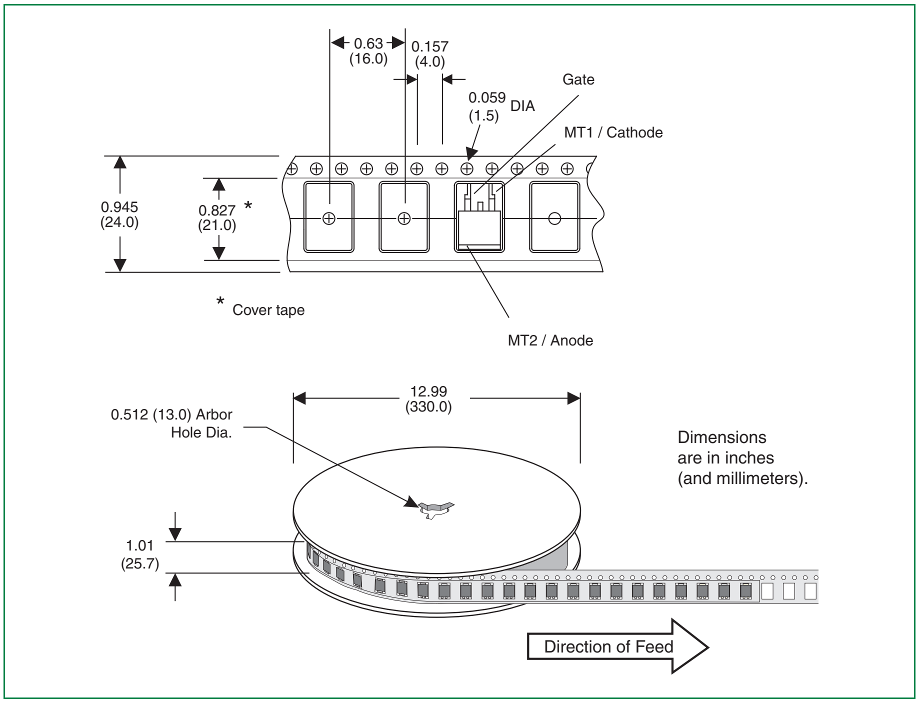
The following illustration shows the tube pack:





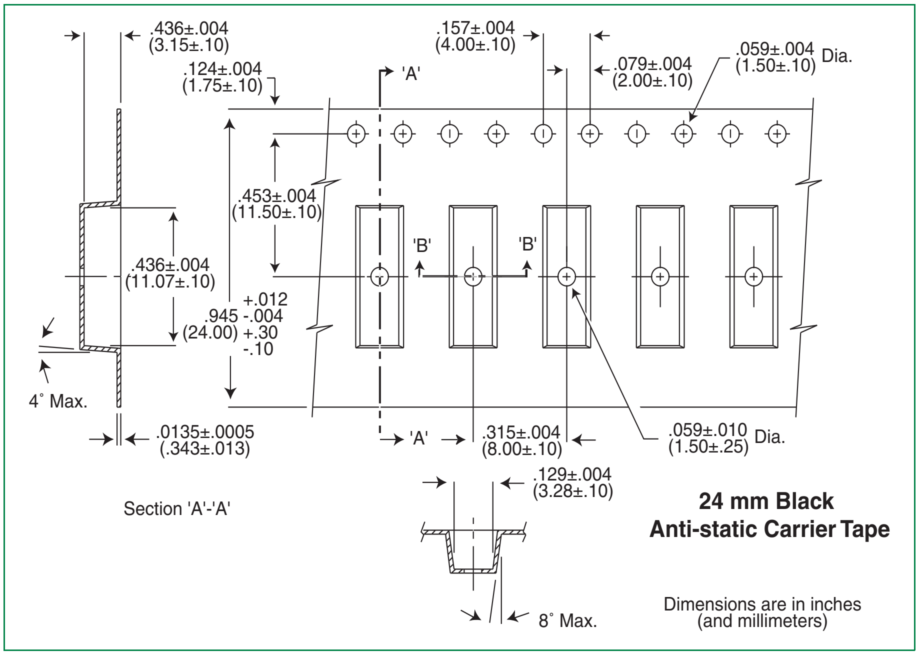
TO-263

Tape and reel packing options meet all specifications as set forth in EIA-481-2. Standard reel pack quantity is 500.

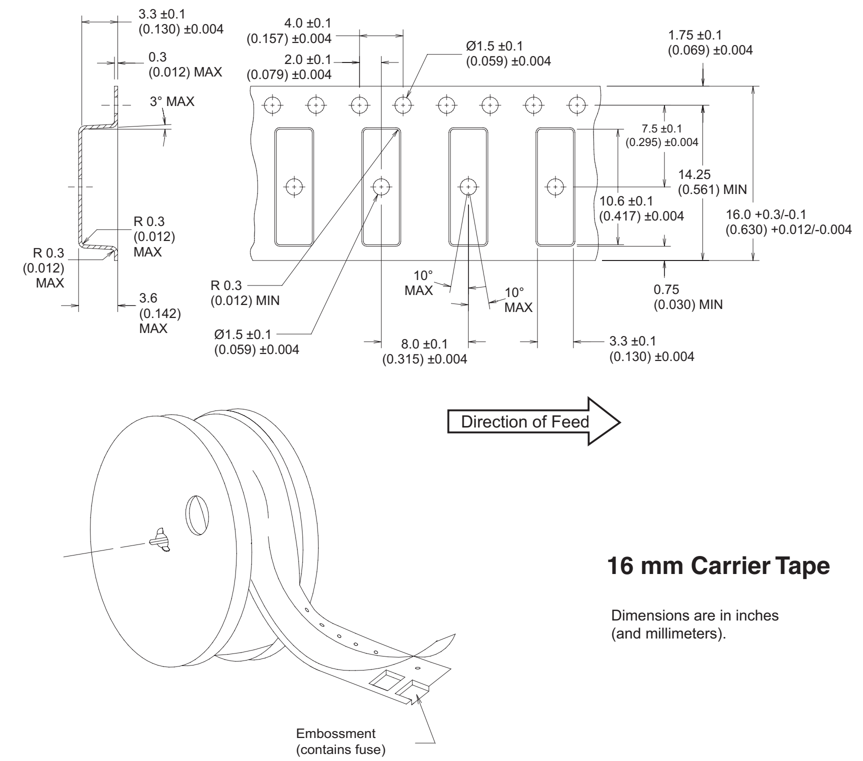


TeleLink® Surface Mount Fuse

The following illustration shows the dimensions of the 24mm *TeleLink* embossed carrier tape.



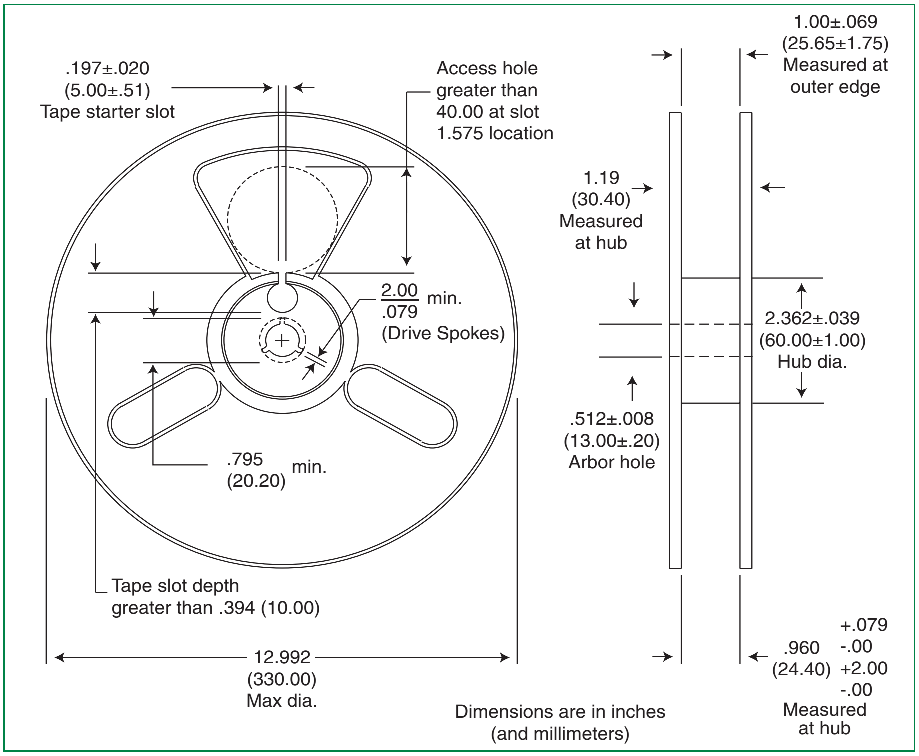
The following illustration shows the dimensions of the *TeleLink* 16 mm carrier tape.



16 mm Carrier Tape

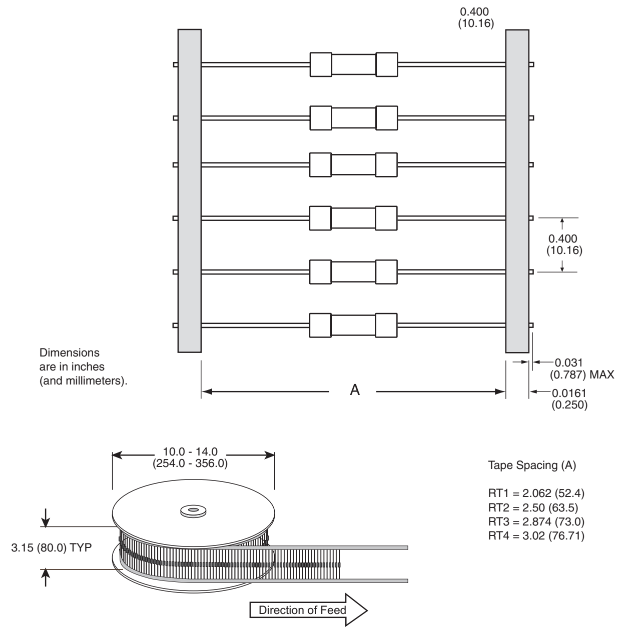
Dimensions are in inches
(and millimeters).

The following illustration shows the *TeleLink* 13-inch (330 mm), injection-molded, high-impact, anti-static, white, plastic reel. Material conforms to EIA-481-1. Surface resistivity is 1011 Ω/square. Materials comply with ASTM D-257.



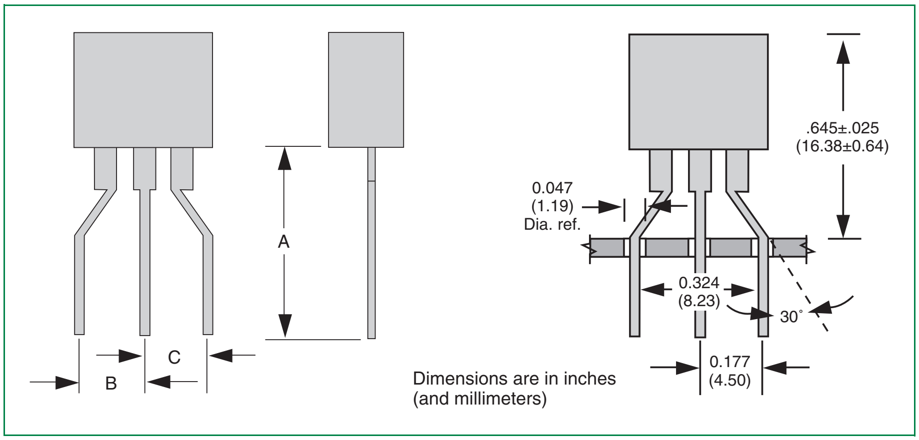
229P / 230P Series

Tape and reel packing options meet all specifications as set forth in EIA-296. Standard reel pack quantity is 1500 and 2500. Bulk pack quantity is 1000.



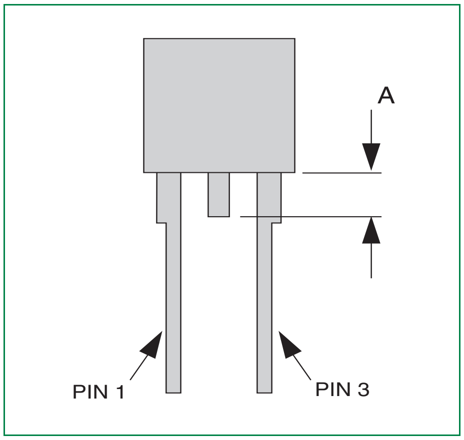
Lead Form Options

Modified TO-220 Type 60



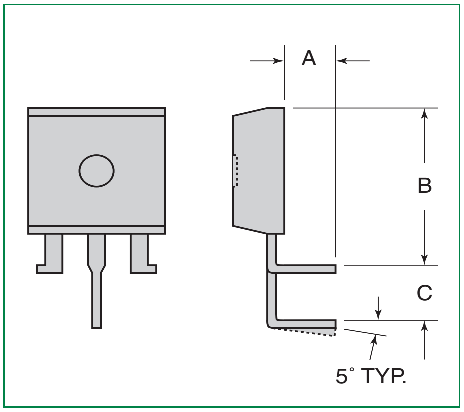
Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.485		12.32	
B	0.162	0.192	4.11	4.88
C	0.162	0.192	4.11	4.88

Modified TO-220 Type 61



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.030	0.060	0.762	1.52

Modified TO-220 Type 62



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.172	0.202	4.37	5.13
B	0.440	0.460	11.18	11.68
C	0.120	0.130	3.05	3.30