



# Circuit Protection

## Solutions Guide



Reach your local sales team at 1.800.CALL.TTI

# Table of Contents

What is Circuit Protection? .....3

Common Circuit Protection Threats .....5

Electrostatic Discharge (ESD).....7

**AVX**<sup>®</sup> .....9

**BOURNS**<sup>®</sup> .....10

**EATON** .....12  
*Powering Business Worldwide*

Electronic Components  
**KEMET**<sup>®</sup> .....13  
*CHARGED.*

**KOA**<sup>®</sup> .....13  
*KOA SPEER ELECTRONICS, INC.*

**Littelfuse**<sup>®</sup> .....14  
*Expertise Applied | Answers Delivered*

**muRata** .....16  
*INNOVATOR IN ELECTRONICS*

**Panasonic** .....17

**TDK** .....18

**VISHAY** .....19

Products and Suppliers.....20



# What is Circuit Protection?

Circuit protection is an insurance policy. Most customers buy circuit protection never planning to use it, but it is critical to protect circuits from unexpected, damaging surges of current and voltage. Two types of circuit protection are available: overcurrent and overvoltage.

## What is Overcurrent Protection?

An overcurrent condition is caused by excessive current (more than the maximum amount of current a product is designed to withstand under normal conditions) passing through a circuit. Overcurrent conditions have the potential to cause severe damage to a circuit, possibly leading to fire. Overcurrent protection is placing a component, usually a standard fuse, a Polymer Positive Temperature Coefficient (PPTC) resettable fuse, a Positive Temperature Coefficient (PTC) thermistor, or a Transient Current Suppressor (TCS) in series with the device being protected. Standard fuses interrupt the current flow and PPTC resettable fuses and PTC thermistors limit the current to an acceptable level during overcurrent conditions, thus preventing catastrophic events. When no overcurrent condition exists, these products lie dormant within the circuit with a minimal amount of resistance to the circuit.

## What Technologies are Available to Provide Overcurrent Protection?

TTI carries four technologies classified as overcurrent devices to provide protection to customers: **fuses, PPTC resettable fuses, PTC thermistors, and the Transient Current Suppressors (TCS).**

## How Overcurrent Protection Products Operate?

**Standard Fuses:** Fuses are an intentionally weak link in a circuit. A standard, one-time fuse with the correct rating will open or “blow” before the circuit reaches a damaging level or fire hazard. The event of the opening breaks the circuit and prevents current from flowing past that point. A standard fuse will open once and then must be replaced.

**Resettable Fuses:** A resettable fuse does not open like a standard fuse. Rather it creates a very high resistance that prevents most of the current from flowing past it into the device on the circuit being protected. The resettable fuse then “resets,” as the name implies, once the overcurrent condition subsides.

**PTC Thermistor:** Similar in function to a resettable fuse, a PTC thermistor creates a very high resistance to the current at a particular temperature caused by additional current. This temperature (called “switching temperature”) shelters the device from overheat or overcurrent. Once the overheat or overcurrent event is removed, the thermistor will cool down and reset, just like a resettable fuse.

**Transient Current Suppressor (TCS):** Works in conjunction with TVS diodes to protect high-speed, low voltage applications that must withstand severe levels of lightning surge and ESD.

## Why is Overcurrent Protection Important?

There are three main reasons why overcurrent protection is needed in a circuit: **safety, reliability and compliance.**

**Safety:** Using circuit protection helps guarantee safety as it protects from catastrophic events such as large surges of current that could cause fires.

**Reliability:** Using overcurrent protection provides the reliability that components will be protected in the event that an overcurrent condition occurs. It also provides assurances that when the condition is cleared; the product will continue to function.

**Compliance:** Many agencies (e.g. UL, CSA, VDE, etc.) now require circuit protection in electronic devices.

## Where is Overcurrent Protection Needed?

All circuits and applications need overcurrent protection.

## What is Overvoltage Protection?

Like overcurrent protection, overvoltage protection is the safeguarding of products from overvoltage conditions. Overvoltage conditions are often called “transients,” and are defined as short duration spikes in voltage resulting from a sudden release of previously stored energy. Overvoltage conditions can be short or prolonged. Most applications will require both overvoltage and overcurrent protection for the circuit.

## What Causes an Overvoltage Condition?

An overvoltage condition is caused by a variety of factors, including but not limited to: transformers converting energy from one voltage to another, lightning, electrostatic discharge (ESD), motor start-ups, and automotive load dumps.

# What is Circuit Protection?

## Why is Overvoltage Protection Important?

There are many factors that require overvoltage protection. They include, but are not limited to the following:

- 75% of field equipment failure is caused by Electrical Overstress (EOS)
- With increasing speeds, semiconductor devices are becoming increasingly sensitive to voltage transients
- Lightning strikes even several miles away can induce transient voltages into equipment
- ESD events at 8kV or higher can be damaging to ICs that are internally protected to 2kV

## What Overvoltage Protection Devices are Offered by TTI?

TTI offers several options to limit excessive voltage experienced in today's circuits. These are: metal-oxide varistors (MOV), multilayer varistors (MLV), protection thyristors, TVS diodes, diode arrays, Transient Blocking Units (TBU), gas discharge tubes (GDT), and polymer suppression devices.

## How do Overvoltage Protection Devices Work?

These devices can either clamp or crowbar the undesired voltage to protect the circuit.

Clamping devices are devices placed parallel to components being protected. When an overvoltage condition arises, the device goes from an extremely high impedance to one of almost zero, permitting the transient to follow the path of least resistance through the clamping device. The device then clamps at a voltage above the standard operating voltage, but below the level that would damage the device being protected. This additional voltage is dissipated by absorbing part and shunting the rest to ground. TTI offers clamping devices that include MOVs, MLVs, TVS diodes, diode arrays and polymer suppression devices.

Crowbar devices are placed parallel to components being protected and change from very high impedance to very low impedance during an overvoltage event, but energy is dissipated differently. During an overvoltage condition, these devices operate like a switch, turning on to a low voltage state that is well below the normal operating voltage of the circuit. All energy is then shunted straight to ground and dissipated. TTI offers three crowbar devices that include GDTs, TBUs, and protection thyristors.

CIRCUIT PROTECTION COMPONENTS AVAILABLE FROM TTI												
Supplier	Overcurrent				Overvoltage							
	Resettable Fuse	Standard Fuse	TCS	Thermistors	Varistors	Thyristors	GDT	TVS Diodes	Diode Arrays	ESD Suppression	Polymer Suppression	TBU
Amphenol				◆								
AVX		◆		◆	◆			◆				
Bourns	◆	◆	◆		◆	◆	◆	◆	◆	◆		◆
Eaton Bussmann	◆	◆			◆			◆		◆	◆	
KEMET					◆							
KOA	◆	◆		◆	◆							
Littelfuse	◆	◆		◆	◆	◆	◆	◆	◆	◆	◆	
Murata				◆	◆					◆		
Panasonic		◆		◆	◆					◆		
Rohm Semiconductor								◆		◆		
TDK				◆	◆		◆					
Toshiba								◆	◆	◆		
Vishay		◆		◆	◆			◆	◆	◆		

# Common Circuit Protection Threats

## Overcurrent



### Product Safety

#### Ground Faults

Occur when electricity travels to ground outside the design's intended pathway.

#### Current Transients

Occur momentarily in response to a change in the equilibrium of a circuit and frequently when power is applied to, or removed from, a circuit.

#### Circuit Overload

Occurs when an electric circuit is carrying more current than it's designed to handle, potentially creating a fire hazard due to overheating.

## Overvoltage



### Product Reliability

#### Lightning Transients

Can produce direct or more commonly "induced" current and voltage transients.

#### Electrostatic Discharge (ESD)

The sudden and momentary flow of electricity between objects with different electrical potentials caused by direct contact or induction.

#### Inductive Load Switching

Switching of inductive loads within motors, generators, relays and transformers can create damaging current and voltage transients.

## Circuit Protection Threat Solution Matrix

Circuit Threats	Applications	Protection Needs	Protection Components
Overcurrent and Ground Faults	Grounded circuits and circuits near AC power lines	Current interrupting and voltage capability	Fuses, Resettable Fuses, Thermistors
Lightning	Any circuit connected to the outside environment	Quick responsiveness, switching, and surge capabilities	Protection Thyristors, Varistors, TVS Diodes, Gas Discharge Tubes
Electrostatic Discharge (ESD)	Circuits with human interfaces	Quick response with high peak voltage rating	Polymer ESD suppressors, ESD Diode Arrays, Multilayer Varistors
Electrical Fast Transients (EFT)	Circuits with inductive loads	Repetitive fast rise time and recovery	TVS Diodes, Varistors
Inductive Load Switching	Motors, pumps, compressors, relays & AC distribution	High energy rating	Varistors, GDTs, TVS Diodes
Datacom Voltage Transients	Ethernet, DSL, data bus, telecom	Quick response, low parasitic capacitance	ESD Diode Arrays, Protection Thyristors
Current Switching	Various electronic and electrical circuits	Proper blocking voltage and current carrying capacity	Switching Thyristors

# Common Circuit Protection Threats

## Overcurrent Events

Excessive current events can lead to catastrophic failures in electronic circuits. These failures can result in safety hazards such as fire, shock or explosion. Common types of overcurrent threats include:

### Overload

Overloads can occur when more current is allowed to flow through a circuit path than it was designed to carry. This excess current can generate and accumulate heat and result in complete circuit destruction and possible fire, electrocution or explosion. Sources of overload include:

- Construction hazards cutting across power lines
- Equipment failure in the power grid
- Environmental hazards in the power grid
- Short spikes of energy within the circuit as a result of turning equipment on and off

### Short Circuit

Short circuits occur when one conducting path comes in contact with another conducting path or with ground, such as may occur due to a loose wire, insulation breakdown or contact with water. These conditions can increase the likelihood of arcs, shock or fire hazards.

The principle forms of protection against overcurrent conditions include standard fuses, resettable fuses and PTC thermistors.

Their function is to limit current to acceptable levels and prevent catastrophic events, and during acceptable conditions act dormant with a minimal amount of resistance to the circuit.

Fuses will completely stop the flow of current when opened, which may be desired with sensitive, expensive or critical applications.

PPTC resettable fuses and PTC thermistors offer the ability to reset and withstand most common and recurring overcurrent events. They will allow safe levels of current to pass continuously, and during major overcurrent events, increase in resistance as they heat to restrict the flow of current. When the overcurrent event ends, the device resets to its normal operating state.

## Voltage Transient Events

Voltage transients are temporary short duration shortages or spikes. Unsuppressed, they may damage circuits and components and result in complete system failure. Below are descriptions of common types of voltage transients and technologies to reduce their effects:

### Electrostatic Discharge (ESD)

Damage from ESD is generally caused by the transfer of static electrical charge from a human body to an electronic circuit. It may result in faulty circuit operation, latent defects and even catastrophic failure of sensitive components. ESD suppressors must have very fast response times and handle high peak voltages and currents for short durations.

Many modern ICs are ESD tested for protection using the human body model (HBM), otherwise known as MIL-STD-883.

### Inductive Load Switching

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

### Lightning Induced Transient

Most transients induced by nearby lightning strikes result in an electromagnetic disturbance on electrical and communication lines connected to electronic equipment. Devices that protect against these transients must have a fast response time and must be able to dissipate a large amount of energy.

### Automotive Load Dump

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

# Electrostatic Discharge

## Threat of ESD

Electrostatic Discharge (ESD) is an electrical transient that poses a serious threat to electronic circuits. As integrated circuits continue to shrink in size, they become more susceptible to less powerful transients and require additional circuit protection to guard against ESD. The threat of ESD is also greater as data communication rates continue to increase in speed, therefore requiring more specific ESD suppression solutions to ensure signal integrity.

Inherent capacitance of a device will disrupt data and can be a determining factor when selecting a device or the technology (silicon, polymer, etc.) for use.

## ESD Protection Solutions

### Ceramic

Multilayer Varistors (MLVs) are examples of ceramic-based electronic components used to protect circuits from transient voltages. MLVs are capable of handling significant surge energy for their size with wide operating voltages and are best suited for low to medium speed data signals (<125Mbps). MLVs higher capacitance rating is useful in applications that may have EMI filtering problems.

### Silicon

TVS Diodes and Diode Arrays are silicon-based ESD protection components. Silicon solutions are typically used when board space is critical and multi-line protection is necessary. Silicon has properties of very low capacitance and leakage and are suited for both ESD and other transients such as lightning. Silicon ESD components cover the full range of data signals from 0-5 Gbps.

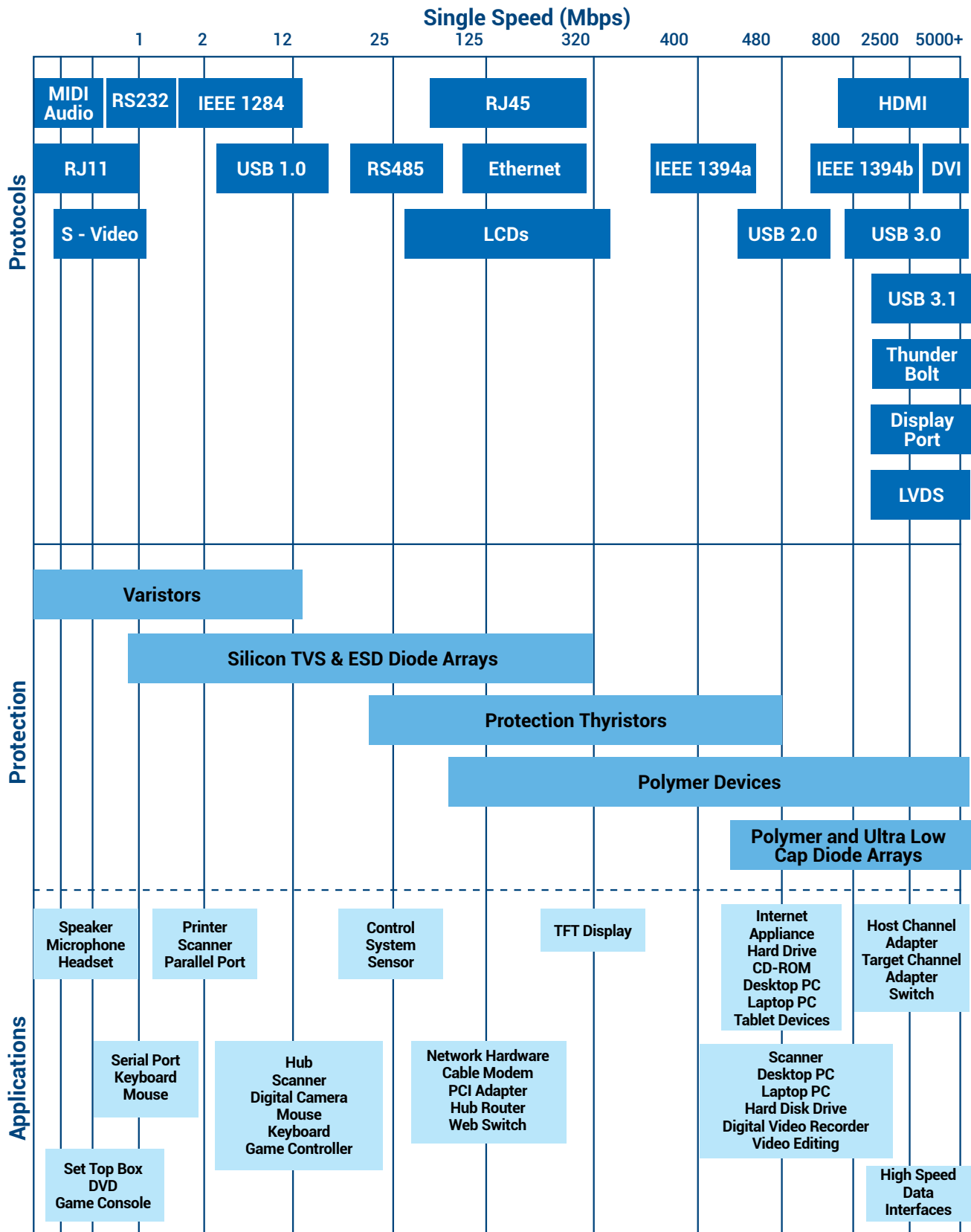
### Polymer

Polymer-based ESD components are known for their extremely low capacitance, low leakage current and fast turn on time. Ultra-fast applications with high-speed data signals between 125 Mbps and 5 Gbps are targets for a polymer-based solution. Polymer-based solutions have lower capacitance and are currently less expensive than silicon-based solutions.

## Protect the Connection

Interconnect	Data Rate Protocol
USB	1.5 to 12 Mbit/s
USB 2.0	480 Mbit/s
USB 3.x	Up to 5 Gbps
Coaxial Port	Up to 10 Gbps
MIDI Port	Below 1 Mbit/s
HDMI	800 Mbit/s - 8.16 Gb/s
RJ11	Up to 1.1 Mbit/s
Display Port	1.6 Gb/s - 2.7 Gb/s
IEEE 1394 FireWire	400-3200 Mbit/s
DVI	3.9 Gb/s
RJ45	75 - 320 Mbit/s
D-Subminiature	1 - 7 Mbit/s
S-Video	.1 - .5 Mbit/s
DIN 41612	10 - 100 Mbit/s
Tactile Switch	Human interface
SIM Card	Human interface

# Protection Protocols







AVX is a worldwide, leading supplier of circuit protection components for automotive, industrial and commercial applications.

## Overcurrent



**Fuses**  
**AccuGuard® – Highly Accurate Surface Mount Thin Film Fuses**  
Offered in case sizes from 0402 through 1206, and current ratings from 0.05A to 5A, and temp rating -55 °C to +125 °C.



**Thermistors**  
**NTC Thermistors**  
Suitable for automotive (AEC-Q200 qualified) and commercial/industrial applications. AVX NTC thermistors include SMT thermistors in case sizes from 0603 to 1206, leaded disc thermistors, high accuracy radial and chip thermistors ( $\pm 1\%$ ) and leadless disc thermistors.

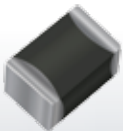
## Overvoltage



**Varistors**  
**Multilayer Varistors**  
Available in standard EIA surface mount case sizes from 0201 to 3220, 2-element arrays in 0405 and 0508 cases, 4-element arrays in 0612 configuration, as well as a conformally coated axial and radial leaded configurations for use in through-hole applications.

In addition, AVX varistors also offer:

- Low capacitance and Sub-pF varistors for high speed data lines, RF circuits and other capacitance sensitive applications
- Communication Bus varistors for CAN Bus, Flexray and other capacitance sensitive applications
- Controlled capacitance varistors for targeted EMI/RFI filtering
- CapGuard™, TransGuard®, and TransFeed Varistors – varistors with feedthru construction for ESD protection and enhanced EMI/RFI filtering



**AVX Varistors for Automotive Applications**  
High-temp 175 °C MLVs designed for under-hood and do not require any de-rating over specified temperature range. Features include:

- AEC-Q200 Qualified
- EMI/RFI filtering in the off-state
- 0603 and 0805 case sizes
- 18Vdc and 31Vdc working voltages



**TVS Diodes**  
**TVS Diodes**  
Available in unidirectional and bi-directional configurations in industry standard sizes: SMA (400W), SMB (600W) and SMC (1500W).



**Schottky Barrier Rectifier Diodes**  
AVX's innovative range of lead-less chip packaging Schottky diodes range from 0603 to 3220 case sizes with low-profile, high current capability and low VF design for commercial and industrial applications.

# BOURNS®

Bourns offers world-class technology and applications expertise that is the result of many years of circuit protection engineering, design and support. Bourns' global reputation for extensive application knowledge, quality products, innovative protection strategies and a wide range of technologies ensures that we can provide the right circuit protection solution for your needs.

## Overcurrent



### TBU® High-Speed Protectors (HSPs)

Circuit protection devices are constructed using MOSFET semiconductor technology. When placed in series in the system, the TBU® HSP monitors the current flowing through the line. If the current exceeds a preset level, the TBU® HSP device triggers, providing an effective barrier to large, destructive voltages or currents during surge events (up to rated limits), thereby protecting sensitive electronics.



### Transient Current Suppressors (TCS™)

Typically used in conjunction with low capacitance TVS devices to form an extremely low let-through energy barrier to excessive voltages or currents during surge events which may damage high-speed, low voltage driver and receiver components. By limiting the maximum current to a safe level, Bourns® TCS™ HSPs offer superior protection for very high data rate differential lines against faults caused by short circuits, induction and lightning surges, up to rated limits.



### Multifuse® PPTC Resettable Fuses

Bourns® freeXpansion™ technology makes it an obvious choice for overcurrent protection circuits. Bourns® Multifuse® products are available in SMT, through-hole and strap packages. They are rated as high as 125 °C and are AEC-Q200 compliant.



### SinglFuse™ SMD Fuses

These parts are offered in industry standard sizes (0402, 0603, 1206, 1210, 2410, 2923 and 3812) and fusing types including fast acting, slow blow, time lag, high current, high voltage, and inrush withstand.



### Mini-Breakers

#### (Miniature Thermal Cutoff Devices)

Mini-Breakers are Thermal Cutoff (TCO) devices which are used as safety devices to help prevent heat and fires caused by excess current, in lithium polymer and prismatic cells. The key to the mini-breaker's design is the PTC that operates in parallel with the arm terminal. When the bimetal disc causes the arm to open, current flows through the bimetal disc and into the PTC. This design allows the device to stay tripped (operated) during abnormal temperatures, and then recover when power is cut and the temperature returns to a safe level. Other features include:

- UL and TÜV safety standard certifications
- Wide range of temperature operation



### Polymeric Thermal Cutoff Devices (P-TCO)

P-TCO devices are resettable devices designed to protect USB Type-C connectors and other charging cables from destructive and potentially dangerous thermal runaway events. Available in EIA 1210 and 1206 size SMD footprints, the P-TCO product family provides effective overtemperature protection from heat generated in charging cable connectors due to unintended faults within the connector circuitry.

Typical applications include, but are not limited to:

- USB Type-C cable configurations
- USB 3.2, 3.1, 3.0 and 2.0 protocols

## Overvoltage



### Thyristor Surge Protectors

Bourns® TISP® Thyristor Surge Protectors are designed to meet Telcordia GR-1089, UL 60950, FCC (TIA), ITU-T, IEC and YD/T compliance standards.



### Power TVS Products

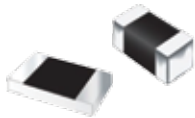
High current bidirectional Transient Voltage Suppressor (TVS) diodes designed for use in AC line protection and high power DC bus clamping applications. These devices offer bidirectional port protection from 58 volts to 470 volts, and peak surge currents up to 15 kA (8/20  $\mu$ s). Available in through-hole and surface mount packages.



### TVS Diodes

Bourns® expanded line of diodes are available in 8L NSOIC, 16L NSOIC, SOT23, SOT23-6, and 16L WSOIC packages.

Bourns® AEC-Q101 compliant diodes are available for DC power ports, signal lines and CANbus protection with peak pulse power as high as 7000 Watts (10/1000  $\mu$ s).



### ChipGuard® ESD Suppressors

The Bourns® ChipGuard® ESD suppressors comprise both ceramic MLV devices and ultra-low capacitance polymer protection devices. MLV devices are bidirectional and as small as 0201 package. Both series are available as AEC-Q200 qualified and as 4-line arrays.

With capacitance as low as 0.05pF the polymer devices (MLU, MLC series) can help protect:

- USB 3.0/USB OTG
- IEEE 1394 applications
- HDMI 1.4
- Antennas
- DVI



### Diode Arrays

Provide Electrostatic Discharge (ESD), Electrical Fast Transients (EFT), and surge protection for high-speed data ports (up to rated limits), aiding compliance with IEC 61000-4-5 standards. Bourns® diode arrays can protect up to eight lines and have capacitances as low as 0.02pF.



### LED Shunt Protectors (LSPs)

Placing a Bourns® LSP device across LEDs allows the remaining LEDs in a string to continue to work when an LED fails open circuit. LSP devices in active mode dissipate less power than the LED.



### Gas Discharge Tube (GDTs) Surge Arrestors

Bourns® offers both 2 and 3-electrode devices in both surface mount and through-hole packages. Bourns® low profile GDTs with FLAT® technology sit just over 2mm above the circuit board and are available with two or three electrodes.



### Metal Oxide Varistors (MOVs)

Available in 7, 10, 14 and 20mm radial leaded varistor devices from 18 V to 1800 V.



### GMOV™ Hybrid (GDT + MOV) Protection Device

Combination of the patented GDT with FLAT® technology and an MOV ideally suited for any number of AC and DC power applications where a high level

of performance is required over time.

- Reduces likelihood of degradation/catastrophic failure from surges exceeding an MOV's maximum rated value.
- Drop-in replacement for standard 14 and 20mm MOVs.
- Features low leakage to mitigate damage due to watt loss heating.
- UL 1449 Type 5 rated and RoHS compliant.



Powering Business Worldwide

With a history of nearly 100 years of innovation, Eaton features a broad variety of Bussmann™ Series circuit protection products. Eaton has set the standard for circuit protection in many markets around the globe. Eaton has the right products to fit your application.

## Overcurrent



### Brick Fuses

Eaton offers a wide range of Bussmann® Series Brick fuses designed to carry high levels of current as low as 500mA up to 50A. Available in fast-acting, time-delay and high surge current telecom protection.



### Chip Fuses

Eaton provides 0603 and 1206 size chip fuses with current ratings from 250mA up to 30A. Available in fast-acting, time-delay and high I<sup>2</sup>t.



### Cartridge/Ferrule Fuses, Holders, and Clips

Eaton has a wide array of ferrule fuses for AC and DC primary side input power protection. Each fuse has leaded options for through-hole mounting or can be paired with a variety of PC board mountable clips. A full line of panel mount and in-line fuse holders for wiring harness protection are also available. Available sizes include ¼", 5mm and 3mm.



### Hazardous Area Fuse

The Eaton C308F series of fast acting ceramic tube fuses for hazardous applications provide a space-saving solution for intrinsic safety relay barriers with a high interrupting rating for primary and secondary circuit protection up to 250 volts AC or DC and 250 mA.



### Radial Fuses

The radial fuse line provides reliable fault protection for cost sensitive applications like LED lighting and white goods. A full line of SS-5,SS-R, PC-Tron, and GMW products are available in both fast-acting and time delay versions. Now available in 350Vac/100A rating, for higher voltage and breaking capacity needs.



### PolyTron™ PTC device

Ideally suited for protecting applications sensitive to high ambient operating temperatures or subject to frequent overcurrent conditions. Available in radial (16, 30, and 60Vdc) or surface mount (1206 and 1812).

## Overvoltage

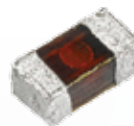


### TVS Diodes

Available in 0201 and 0402 packages

### Multilayer Varistors

Available in 0201, 0402, and 0603 packages



### PolySurg™ Ultra-Low

### Capacitance ESD Suppressors

Available with capacitance as low as 0.05pF and AEC-Q200 qualified. Also available in a four-channel ESD Suppressor

KEMET Electronics Corporation is a leading global supplier of electronic components. KEMET offers a wide range of surface mount and leaded standard and automotive grade varistors.

## Overcurrent



### MLV – Multilayer Varistor

Transient suppressors with temperature independent suppression characteristics enabling protection from -55 °C to +125 °C. Package sizes range from 0603 to 4320. Available in standard or AEC-Q200 qualified Grade 1.



Koa Speer Electronics' circuit protection components include thermal sensors, chip fuses, air flow sensors, and varistors.

## Overcurrent



### Fuses Fusing Flat Chip Resistors – RF73

- RF73 is a fusing flat chip resistor available in a resistance range of 0.2Ω~510Ω and ±5% tolerance
- Sizes available 0603~2512 and power rating from 0.063W to 1.0W



### Thin Film Chip Fuses – TF

- The TF series are 32V chip fuses rated from 0.2A – 5.0A
- Available in 0402 and 0603 sizes
- TF16VN is AEC-Q200 Qualified (-55 °C – 125 °C)



### Chip Fuse - CCP, CCF1N, CCF1F

- The CCP chip fuse series are current rated from 0.4A~5.0A in both 24 and 72 voltage ratings
- CCFIN series are rated at 60/65/160V with a current of 0.4A~15.0A
- CCF1F are 125V with current rating of 0.4A to 15A



### Thermistors Thermal Sensors – Standard and AEC-Q200 Qualified

- NT73 – NTC Thermistors (12 Values)
- SDT – Platinum Thin Film Thermal Chip and Leaded Sensors
- LP – Leaded and SMD Thin Film Resistance Thermal Sensors (±1%)
- AFS – Air Flow sensor units
- LA73, LT73, LT73V – Linear PTC Thermistors
- ST – Custom Thermal Sensors in various shapes

## Overvoltage



### Varistors

#### Varistors – Standard and AEC-Q200 Qualified

- NV73 – Multilayer varistors – Range from 8.2V to 150V
- NV73DS – MLV suitable for automotive load dump surge protection
- NV73DL – AEC-Q200 Qualified MLV for ESD protection

Littelfuse is recognized around the world as the number one brand in circuit protection. With the industry's broadest and deepest portfolio of circuit protection technologies, backed by unparalleled design support, Littelfuse is the company that engineers trust to answer their most critical circuit protection questions.

## Overcurrent



### Fuses

Operating characteristics of electronic application fuses include:

- Current ranges from .010A~40A
- Maximum voltage ranges from 24V~600V
- Interrupting ratings from 24A~50,000A

Fuse installation and replacement is easy with the Littelfuse comprehensive line of fuse blocks, fuse holders, and fuse accessories for automotive, electronic and industrial applications.



### PolySwitch and POLY-FUSE Resettable PTCs

Littelfuse offers a full range of surface mount, radial leaded and axial leaded (battery strap) PTC resettable overcurrent suppression devices. Surface mount PTCs are available with a broad range of hold currents from 50mA to 7.0A while footprints vary from 0402 to 3425. Radial PTCs are rated from 6VDC to 600VDC and are designed for use in higher voltage applications.



### Thermistors

Littelfuse offers a broad range of NTC and PTC thermistors, RTDs, probes and assemblies for demanding temperature sensing applications. Products include:

- Standard and customized Thermistor probe assemblies
- High temperature axial leaded glass encapsulated thermistors and glass coated radial leaded chip thermistors
- Surface Mount Chip and MELF Style Thermistors
- Temperature Sensor RTDs (Resistance Temperature Detectors)

## Overvoltage



### Varistors

#### Metal Oxide Varistors

With peak current ratings ranging from 40A to 70,000A and peak energy from 0.1J to 10,000J, Littelfuse varistors are available in radial leaded, axial leaded, surface mount and bare-disc options. MOVs are designed to suppress transient voltages such as lightning and other high level transients found in industrial and AC line applications or lower level transients found in automotive DC line applications.



#### TMOV® and iTMOV® Thermal Varistor Series

This device uses a patent pending thermal element internal to the MOV. The TMOV® and iTMOV® varistor's integrated thermal element, in conjunction with appropriate enclosure design, helps facilitate SPD module compliance to UL1449 for both cord connected and permanently connected applications. Overall, the integrated MOV-thermal fuse technology reduces part count, saves space and is UL1449 recognized.

## Overvoltage



### Surface Mount and Multilayer Varistors - MLVs

Available in arrays and surface mount options as small as 0402 size, MLVs offer a low voltage range (5.5~135VDC) as well as enhanced performance and filtering characteristics in a small package. AEC-Q200 qualified parts (MLA, AUMOV®) also available.



### Hybrid MOV/PTC 2Pro Devices-

Combination MOV and resettable PTC in a single device for overcurrent, overvoltage, and overtemperature protection. Available for AC Line or Telecom protection.



### Gas Discharge Tubes (GDTs)

Available in small footprint (1206 size) surface mount and leaded, GDTs have the ability to handle very high current surges – up to 40,000A – with low capacitance (typically 1–2pF). Available in two and three terminal packages.



### ESD Protection Diodes TVS Diodes

Available with peak power ratings from 200W to 30kW, and reverse standoff voltages from 5V to 512V. AEC-Q101 qualified and high reliability parts also available. The AK series of high power TVS diode is specially designed to meet the severe surge test environments of both AC and DC line protection applications. Available in surface mount and through-hole.



### TVS Diode Arrays (SPA® Devices)

TVS diode arrays are designed to protect analog and digital signal lines from ESD (IEC61000-4-2, ±30kV contact, ±30kV air), electrical fast transients (EFT), and lightning-induced surge currents. Offered in single and multi-channel (up to 8 channels) SMD packages. AEC-Q101 qualified also available.



### PulseGuard® Polymer ESD Suppressors

With a capacitance value as low as 0.04 pF, PulseGuard® suppressors can protect high-speed digital I/O lines (HDMI, USB2.0, eSata, Ethernet) without causing signal distortion. Specified to protect against ESD transients per the IEC 61000-4-2 (Level 4) test method. Available in single or multi-line arrays; AEC-Q200 qualified also available.



### SIDACTor® Devices

Designed to suppress overvoltage transients in telecom and datacom equipment, and are able to divert currents as high as 5,000A to ground within nanoseconds of reaching their breakover voltage. SIDACTor devices help equipment meet U.S. and international standards such as TIA968-A, GR-1089, ITU, CNET, VDE and IEC.



### Thyristors

#### Switching Thyristors

Switching thyristors are solid state switches (SCRs, TRIACs, Quadracs, and SIDACs) and electrically isolated rectifiers that are normally open circuits used to control the flow of electrical currents in applications. Applications include lighting controls, dimmers, motor speed controls, power supplies, smoke alarms, battery chargers, engine ignition and flash units.

Murata offers positive-temperature coefficient (PTC) and negative-temperature coefficient (NTC) thermistors as well as ceramic and silicon ESD protection devices.

## Thermistors



### PTC Thermistor

Posistor™ is Murata's trademark for a positive temperature coefficient (PTC) thermistor. At specified temperatures, the resistance of PTC thermistors rises sharply. Engineers can use this characteristic to create an overheating-protection circuit.

### PTC Benefits and Varieties:

Posistors offer several advantages. Unlike thermal fuses, Posistors have no parts that expand and do not have to be replaced. They also do not generate noise or suffer contact failures. Unlike bi-metal thermostats, Posistors do not have any contacts. They also exhibit large gain and can control power devices directly using transistors, including field effect transistors (FETs).

### PTC Target Applications

- Overcurrent protection for HDMI port and USB port
- Overcurrent and over-temperature protection for LEDs
- Over-temperature protection for voltage regulator of CPU and GPU
- Over-temperature protection for battery, PCB and chassis



### NTC Thermistors

The resistance value of NTC thermistors decreases as the temperature rises, giving its temperature coefficient a negative value. NTC thermistors are often used as temperature sensors in many kinds of devices because they offer a sharp change in the resistance value, relative to the temperature change.

## ESD Suppression



### ESD Protection Devices

Manufactured to function in compliance with IEC61000-4 part 2, Level 4 devices, and are able to withstand up to 8kV direct contact and 15kV air discharge, making them ideal for high-speed ESD protection.

Murata's LXES series features ceramic or silicon based ESD protection devices. A capacitance as low as 0.25pF can be provided with silicon versions. These silicon versions are available in single or multi-channel configurations and offer very low trigger and clamping voltages.

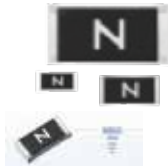
### ESD Protection Devices Target Applications

- Mobile communications (cellphones, smart phones, PA modules, etc.)
- Digital cameras, network and storage equipment
- Electronic data processing equipment
- Energy (i.e. power meters)



Panasonic Electronic Components offers a variety of solutions for circuit and thermal protection. See offering below.

## Overcurrent



### Micro Chip Fuse

Available in 0402, 0603 and 1206 case sizes. Panasonic chip fuses withstand in-rush current and have a fast acting and one-time blow characteristic. Panasonic also offers leaded, metal film fusing resistors.



### Multilayer NTC Chip Thermistors

ERT-J multilayer NTC chip thermistors are used in a variety of applications including battery charging and LED lighting for over-temperature protection

as well as temperature compensation. They are available in 0201, 0402 and 0603 case sizes.

Features:

- Highly reliable multilayer / monolithic structure
- Wide temperature range (-40 °C to +125 °C)

## Thermal Management Sheets



### Pyrolytic Graphite Sheet (PGS) and Semi-Sealing Material (SSM)

Pliable Elastomer layer that helps to facilitate the spread of heat generated by a PC board



### NASBIS Insulating & Heat Isolating Pliable Sheets

Protect thermally weak products from heat and works to maintain a uniform temperature throughout a device



### EYG-T Series "Graphite-PAD" Thermal Interface Material

High Through-plane Thermal Conductivity in The Z-Direction With Superior Flexibility



### Soft PGS Thermal Interface Material (TIM) Compressible Type EYG-S Series

Designed Specifically For Use With IGBT Modules

## Overvoltage



### Varistors

#### ZNR Transient / Surge Absorber (Metal Oxide Varistor)

Panasonic invented the ZNR surge absorber in 1968 and is a pioneer in

the use of zinc oxide as a surge absorber. ZNR stands for Zinc-oxide Non-linear Resistor.

Features:

- 40,000A Peak Current (8x20 μs)
- Voltages up to 17,000 V



### Multilayer Varistors (MLVs)

Panasonic MLVs are available in standard, Automotive AEC-Q200, and Load Dump

Surge (Test ISO7637-2 and ISO16750-2) grades. Package sizes as small as 0201 as well as two-line arrays are available.

## ESD Protection

### TVS Diodes - ESD Suppressor

Panasonic has developed Chip Size Package (CSP) technology for TVS Diodes which

offers industry-leading ESD protection, and ultra small and thin (<1mm) packaging. Complies with IEC 61000-4-2 (ESD) ±30kV (air and contact).



TDK manufactures a broad and deep range of high quality products to solve all of your circuit protection and thermal management needs.

## Overcurrent

### Thermistors



#### Surface Mount NTC Thermistors

Simple but very sensitive and accurate sensing elements for temperature measurement and control circuits. Available in 0402 to 1206 case size and resistance values ranging from 1k to 680k with tolerances as low as 1%.



#### PTC Thermistors

Ceramic PTC thermistors are used as overcurrent protection, motorstart protection, heating elements, telecom protection and temperature limit protection. Available in surface mount, leaded disk, bare disk and many custom configurations.



#### Inrush Current Limiters

ICLs provide protection from high inrush currents but features low power consumption during continuous operation. Perfect for home appliances, consumer electronics, industrial, power supplies and motors.

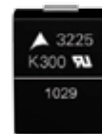
## Overvoltage

### Varistors



#### Multilayer Varistors (MLV)

Available as standard or AEC-Q200 qualified and include single components as well as multi-element arrays. Available in 0201 to 2220 case sizes and multi-element arrays, voltage ratings from 5V to 85V with temperature ratings up to 150 °C. These varistors are suitable for all applications from automotive to consumer and communications, industrial, medical, energy, lighting, etc.



#### Surface Mount Disk Varistors (CU Varistors)

Available in 3225 and 4032 case size with voltage ratings up to 385V. Used for overvoltage protection and transient suppression in automotive, home appliance, power supply, industrial and lighting applications. AEC-Q200 qualified parts also available.



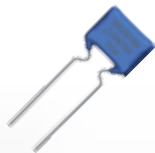
#### Ceradiodes

Multilayer semiconductor ceramic components for ESD protection and are alternatives to silicon-based semiconductor protection devices for the protection of data, audio and video lines, analog and digital interfaces, ICs and I/O ports in consumer electronic devices.



#### ThermoFuse Varistors

The ThermoFuse varistor consists of a disk varistor and a ThermoFuse connected in series to protect domestic applications and switch mode power supplies from surge voltage and excessive heating. The ThermoFuse disconnects the varistor when damaged by excessive current. A monitor output can be used to indicate a malfunction. UL 1449 approved.



#### Super High Capacitance Varistors (SHCV)

SHCV are leaded components consisting of a multilayer varistor and multi-layer ceramic capacitor for a combined protection device and capacitor against transients and RFI suppression in a single component. SHCV replaces two components in a single device. They are used for RFI suppression in electromotors for automotive and industrial electronics.

### Gas Discharge Tubes



#### GDT Surge Arresters

Protect communications and information installations as well as power lines from failure or destruction against voltage surges caused by lightning, electrostatic or electromagnetic discharges.



#### Metal Oxide Varistors (MOV)

MOVs have a wide range of use in telecom, industrial, home appliance, power supply, lighting and automotive applications. AEC-Q200 qualified parts are available, along with a large offering of disk, block or strap MOVs.



#### Switching Spark Gap

A switching spark gap is a powerful switch which can transmit capacitive stored energy with low losses. Switching spark gaps have a highly reliable and robust design that is not affected by vibration or high temperature up to 170 °C. Can be used in all applications where a high voltage impulse needs to be generated such as gas cookers, central heating systems, HID lamps, industrial lighting, stadium lighting, outdoor lighting, etc.



Vishay's circuit protection products include automotive and industrial-grade transient voltage suppressor families as well as a host of diode array products for ESD and EMI protection.

## Overcurrent



### Fuses

#### MFU Series Thin Film Chip Fuses

Available in 0402, 0603, 0805, and 1206 packages.



#### High-Current Thermal Fuse

The HCTF series is especially designed for high current applications with an operation temperature up to 160 °C. In case of excess

heat in the range of the functioning temperature ( $235 \pm 15$  °C) the thermo fuse opens automatically and disconnects the circuit. Typical applications are automotive power electronics that are connected to steady battery power.



### Thermistors

#### NTC (Negative Temperature Coefficient) Thermistors Include:

- Refrigerator sensors
- Ice cube sensors
- Flex foil sensors
- Mini-chip sensors with flexible leads
- Miniature immersion sensors
- Variety of radial leaded thermistors
- Steel-capped sensors (Including Automotive Grade)
- Long immersion sensors with connectors
- Surface mount glass-protected thermistors
- Standard lug sensors
- MELF glass-encapsulated thermistors
- Thermal-gradient lug sensors
- Surface-mount chip thermistors
- Mini-lug sensors
- Thermistors for high-temperature applications
- Screw-threaded sensors
- Naked thermistor chips



#### PTC (Positive Temperature Coefficient) Thermistors Include:

- Parts for over-temperature protection
- Motor start packages
- Overload protection
- Motor start pellets
- Heating applications
- Nickel film linear thermistors
- Time delay for lighting

#### NTCALUG03A Mini Lug NTC Thermistor

Surface temperature sensing and control in remote locations and for various environmental conditions.



## Overvoltage



### Varistors

#### Multilayer SMD and Thru-hole Varistors

Providing a reliable and efficient way to protect against high-voltage transients and surges with the capability to absorb higher transient energies and suppress both positive and negative transients. Certified for operation up to 125 °C.

### TVS & ESD

#### Protection Diodes

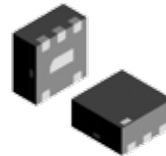
##### TVS TransZorb®

Vishay's TransZorb® Transient Voltage Suppressors (TVS) use state-of-the-art technology to offer the highest voltage range in the industry.



##### TVS PAR® Automotive TVS

Uses the patented PAR® process which result in superior stability and power handling capability over a wider temperature range (up to 185 °C) than other avalanche TVS diodes. The product portfolio includes devices specifically designed for load dump surge protection in both axial and surface-mount packages.



#### ESD Protection Diodes

Devices range from a single line to eight-line protection in a single package, including the industry's first ESD protection array to integrate eight diodes in the very small, leadless LLP1713 package. The device protects up to eight signal or data lines in bidirectional asymmetrical (BiAs) mode, and can also be used as a seven-line protection device in bidirectional symmetrical (BiSy) mode.

# Products and Suppliers



## Resettable Fuses

Bourns KOA  
Eaton Bussmann Littelfuse



## Surface Mount Fuses

AVX Littelfuse  
Bourns Panasonic  
Eaton Bussmann Vishay  
KOA



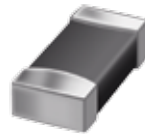
## Leaded One-time Fuses

Eaton Bussmann Littelfuse



## Power Fuse/Electrical Fuse

Eaton Bussmann Littelfuse



## Multilayer Varistor (MLV)

AVX Littelfuse  
Bourns Murata  
Eaton Bussmann Panasonic  
KEMET TDK EPCOS  
KOA Vishay



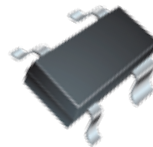
## Thru-hole Varistors (MOV)

Bourns Panasonic  
KOA TDK EPCOS  
Littelfuse Vishay



## TVS Diodes

AVX Panasonic  
Bourns Rohm  
Eaton Bussmann Toshiba  
Littelfuse Vishay



## ESD Suppression

Bourns Panasonic  
Littelfuse Toshiba  
Murata Vishay



## Polymer Suppression

Eaton Bussmann Littelfuse



## Thermistors

AVX Panasonic  
Murata TDK EPCOS  
KOA Vishay



## Gas Discharge Tubes (GDT)

Bourns TDK EPCOS  
Littelfuse



## Protection Thyristors

Bourns Littelfuse/Teccor



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Expertise Applied | Answers Delivered



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