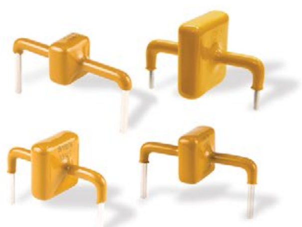
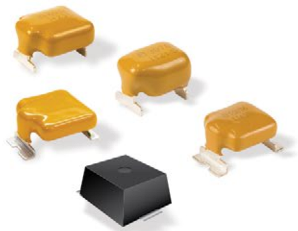
APPLICATION NOTE

Why PTVS Diodes are Optimal Solutions for User System and Power Supply Circuit Protection

High Current PTVS Surface Mount DFN Series



PTVS Through-Hole Series



PTVS Surface Mount Series

INTRODUCTION

Power protection components basically sit unobtrusively in the background - adding cost to a design until a fault event proves their worth. If an inadequate level of protection is selected, however, the system may still be exposed to and could incur considerable damage.

AC and DC power supplies used in telecom and other exposed applications often require protection against potentially damaging events such as power line surges and indirect lightning strikes. Avoiding damage to the power supply by limiting the peak surge voltage to an acceptable level without short circuiting the line for an extended period of time is crucial to minimizing the downtime of critical systems and avoiding costly maintenance calls.

This application note highlights why Power TVS (PTVS) diodes – including Bourns' industry-first DFN package PTVS devices – are worth evaluating for power applications. It will present the many features that make these devices optimal and effective protection solutions for multiple types of power and signal-level circuits.

WHAT TYPE OF PROTECTION IS NEEDED?

When evaluating circuit protection components, the first question to ask is what threats do they protect against? PTVS components are voltage clamping devices. When a PTVS diode experiences a voltage higher than the specified breakdown voltage, it conducts current until the voltage is reduced in amplitude or the surge time has come to an end. A PTVS protection component is rated for the maximum current it can handle (I_{PP}) for the length of time the surge voltage exists. These components protect from excessive voltage resulting from power line transients, voltage spikes due to ESD (electrostatic discharge), motor arcing, and even nearby lightning strikes. Some faults are due to component failure, while others may be caused by a wiring mistake.

Protecting against every type of overvoltage condition is generally not practical, but it is important to consider a variety of potential threats within the context of the design. Design engineers should evaluate the environment within which the protected equipment is installed and select components that will be effective for the threats that are present. The selected protection components must act in the voltage range that would otherwise damage the user's power supply and circuits, without nuisance tripping under normal operating conditions. Due to their relatively higher capacitance, PTVS diodes are better suited for power circuit protection than for protecting high-speed communication lines.

As a global leader in circuit protection, Bourns offers one of the broadest lines of overcurrent and overvoltage protection components on the market – including low capacitance protection solutions for communications applications.

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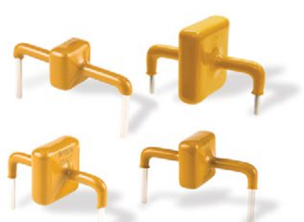

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DIFFERENCES IN POWER PROTECTION SOLUTIONS

As with most design issues, overlapping perspectives exist on the same issue. For power protection, it is advised to look first in terms of potential fault conditions and then at the options for dealing with them, or at the many types of components available and the protection they provide. A circuit typically will need several levels and types of protection. For circuits that require two or more levels of transient protection, coordinating components are frequently needed to allow each protection component to effectively perform to its optimal capability.

As a clamping component, PTVS diodes prevent voltage from exceeding a preset level. Clamps are often referred to as transient voltage suppressors (TVS), which are designed to cut off high voltages that exceed their rated clamping voltage – such as when protecting against a startup transient or inductive transient voltage (see Figure. 1). The TVS clamp function releases when the overvoltage condition clears.

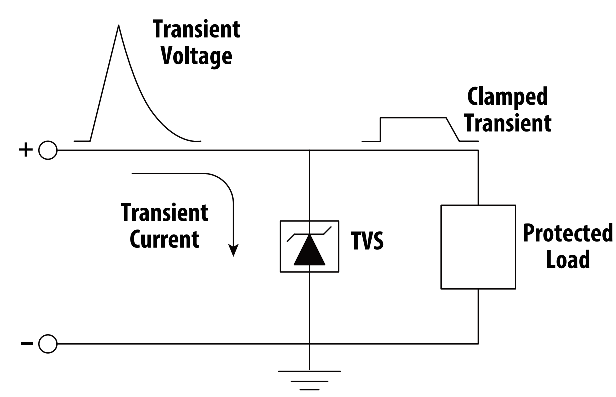

Figure 1. The TVS is placed between the source of the transient and the protected circuit.

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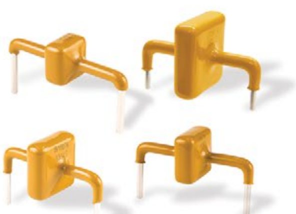

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DIFFERENCES IN POWER PROTECTION SOLUTIONS (Continued)

A clamp conducts current to maintain the voltage across it at a safe value when the transient is above the clamp's conduction voltage. A TVS device is rated for the maximum current and power it will dissipate for a relatively short transient event. The TVS clamp is a silicon bipolar junction device similar to a Zener diode, but designed to survive reverse breakdown voltage situations where high currents are present. A clamping TVS is unlike a crowbar component that holds the voltage across itself at a low value until the surge passes. See Figure 2.

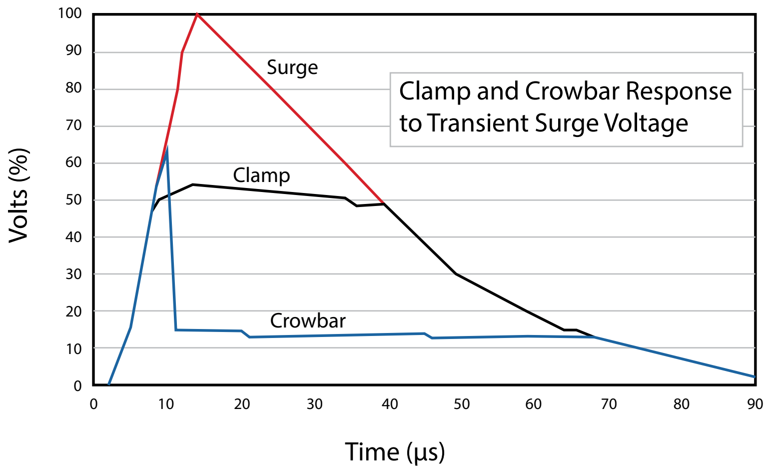

Figure 2. Comparison of the response of crowbar and clamp components.

A clamp can also be built using a metal oxide varistor (MOV), which is a bidirectional semiconductor voltage transient suppressor. MOVs exhibit a response where the voltage across the device continues to rise as the current through it increases. The peak voltage at its maximum rated current could be as much as three times its breakdown voltage at low current. In contrast, after an initial short duration peak, the voltage across a PTVS diode folds back to a lower level and then remains relatively constant as the current through the device continues to increase. A PTVS diode usually has a much lower clamping voltage than an MOV for the same surge current.

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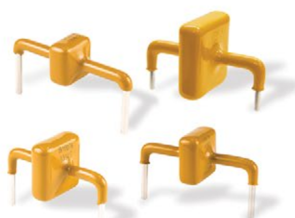

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TVS DIODE TERMINOLOGY

Repetitive Reverse Standoff Voltage (V_{WM})

Also known as maximum working peak voltage, this is the normal operating threshold voltage of the device. The TVS diode will appear as high impedance to the protected circuit when the applied voltage across the diode is less than this threshold.

Breakdown Voltage (V_{BR})

The breakdown voltage is the voltage threshold at which the TVS diode begins to conduct a specified amount of current. Voltage V_{BR} should not exceed the absolute maximum rating for the integrated circuit it is protecting.

Clamping Voltage (V_C)

The overvoltage transient is clipped to the level defined by V_C, which is the maximum voltage level seen across the protected circuit. Voltage V_C is always defined for a given peak pulse current (I_{PP}).

Peak Pulse Current (I_{PP})

This is the maximum surge current the TVS diode can withstand without damage.

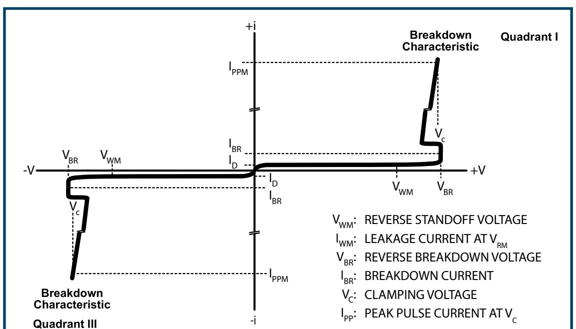

Figure 3. Typical bidirectional TVS diode I-V characteristic curve.

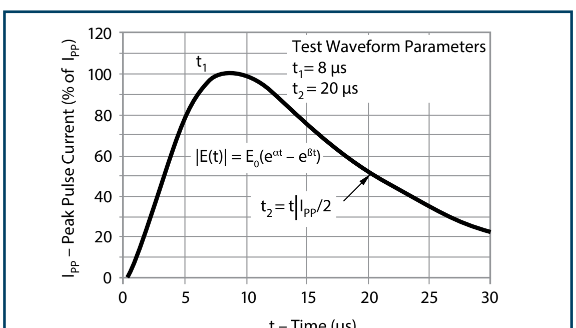

Figure 4. Definition of a surge current waveform.

As shown in Figure 3 and Figure 4, bidirectional PTVS diodes have a typical I-V characteristic curve and are tested as per industry standard IEC 61000-4-5 surge immunity requirements. The peak pulse current is defined based on the surge current transient waveform, which for most industrial applications is rated at 8/20 µs with 8 µs representing rise time (t_1) to peak value and 20 µs representing pulse duration until the current falls to 50 % of the peak value (t_2).

The low clamping characteristics and fast response time as compared to traditional MOV solutions makes the Power TVS product family highly desirable in power supply applications.

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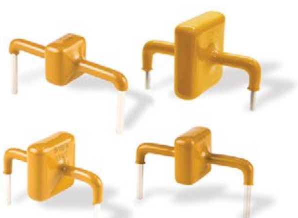

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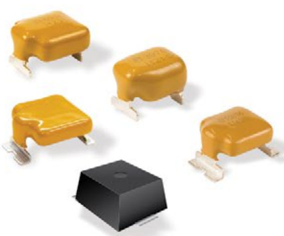

PTVS Surface Mount Series

SELECTING A PTVS DIODE

Most PTVS diode suppliers will include generic selection guidelines in their data sheets. The most important features to consider are the electrical characteristics of the circuit to be protected and the test standard that the circuit needs to meet. The standard most frequently referenced is IEC 61000-4-5. The test criteria are clearly specified, including voltage levels, current levels, and how the transient is applied to a device or system.

To select a PTVS diode, first select a diode with a standoff voltage that is higher than the application's normal operating voltage. Ensure that the maximum clamping voltage is lower than the absolute maximum voltage rating of all the devices on the line to be protected. Verify that the specified peak current I_{PP} exceeds the expected peak current. Diodes that are too small or not designed for a given maximum current may fail to protect the circuit from being destroyed during a surge event.

Choosing between Through-Hole (TH), Standoff Surface Mount (SH) and Surface Mount (M)

The leads on through-hole components may seem short, but they are long enough to generate higher levels of voltage during a surge. This is demonstrated in Figure 5, which plots three 10 kA rated PTVS devices with the same clamping voltage ratings but different packaging/mounting configurations. The through-hole version allows the highest let-through voltage because of the long leads while the surface mount package allows for the lowest let-through voltage.

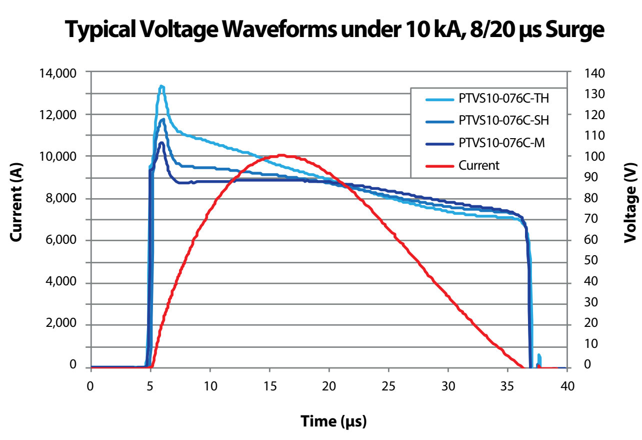

Figure 5. Plotting three different PTVS mounting configuration under the same 10 kA 8/20 µs waveform.

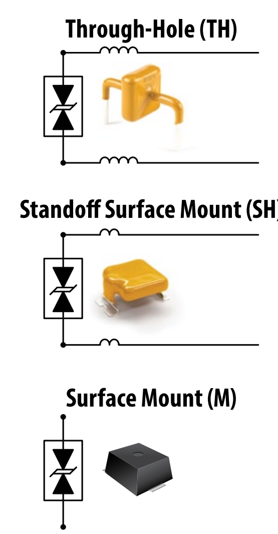

Figure 6. Product Types with Schematics

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APPLICATIONS THAT BENEFIT FROM PTVS DIODES

PTVS diodes are ideal for protecting power ports - for both outputs from the power supplies of the user's applications, and for power inputs - particularly where these two functions are separated by a long distance. When the power connection wires are exposed to surge environments such as remote operations, PoE Power Sourcing Equipment (PSE), and PoE Power Delivery (PD), both ends of the power connections at the RJ-45 connectors need to be protected. Voltage-rated devices are available to protect the maximum telecom and PoE supply voltages of 60 V, as well as 48 V surge protection in 5G small cells.

Within the surface mount DFN packaged Bourns® PTVS1-xxxC-H and PTVS2-xxxC-H model series, part numbers PTVS1-026C-H for 1 kA and PTVS2-026C-H for 2 kA are both effective for 24 V industrial control and telemetry systems. For 28 V test and monitoring systems, Bourns® Model PTVS1-029C-H and PTVS2-029C-H provide effective solutions. Finally, Bourns® Model PTVS1-054C-H is an optimal choice for 48 V telecom systems.

A wide range of PTVS voltage ratings are available – from 15 V to 430 V – featuring 8/20 µs peak pulse currents from 1 kA to 20 kA, suitable for applications with varied voltage protection requirements.

FEATURES

- Robust lighting protection
- 1, 2, 3, 6, 10, 15 & 20 kA peak current rating
- Rigid voltage clamp
- Voltages from 15 V to 470 V
- Axial lead and surface mount packages
- Common PCB footprint for all axial lead devices
- Only DFN surface mount package PTVS on the market
- RoHS compliant*

MOUNTING OPTIONS

- Through-hole
- Surface mount:
  - DFN
  - DO-218
  - Over-molded
  - Standoff

*RoHS Directive 2015/863, Mar 31, 2015 and Annex.

APPLICATIONS

- Various radio installations: Relay links, WiFi nodes, 4G and 5G installations, communication facilities
- Security remote access points, video surveillance equipment, LED security lighting
- Environmental monitoring equipment and remote sensors
- Solar powered transducers and battery chargers
- Solar power inverters, charge controllers, and communication circuits
- Smart grid circuit breaker panels
- Backup power generators and monitoring sensors
- Battery chargers and battery management systems

ADDITIONAL RESOURCES

- Bourns® PTVS1-xxxC-H data sheet
- Bourns® PTVS2-xxxC-H data sheet
- Bourns® PTVS product offering
- Bourns® PTVS Product Training Module
- Bourns® PTVS Parametric Search product selection tool

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BOURNS®

Americas: *Tel* +1-951 781-5500
Email americus@bourns.com

EMEA: *Tel* +36 88 885 877
Email eurocus@bourns.com

Asia-Pacific: *Tel* +886-2 256 241 17
Email asiacus@bourns.com