Transient Voltage Suppression Diodes

By: Ivan G. Lawson

Silicon TVS diodes contain a P/N junction similar to a Zener diode but with a larger cross section, which is proportional to its surge power rating. These diodes are clamping devices that limit voltage spikes by the low impedance avalanche breakdown of the P/N junction.

The V-I curve shown in Figure 1 is similar to that of a Zener diode. TVS diodes are designed and characterized for transient voltage *suppression*, while Zener diodes are designed and specified for voltage *regulation*.

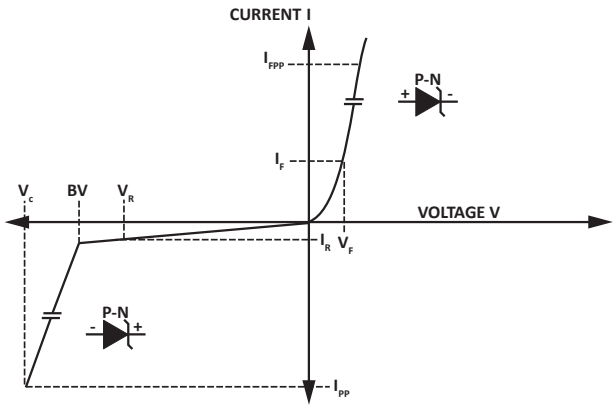


Figure 1. Unidirectional V-I Curve

Longer duration pulses can be suppressed by the TVS diode by increasing the die size and head dissipation. Both voltage and power capability can be increased by stacking parts in series or parallel.

A transient is clamped instantaneously and diverts the damaging current away from the protected device. Figure 2 shows a transient current being diverted to ground.

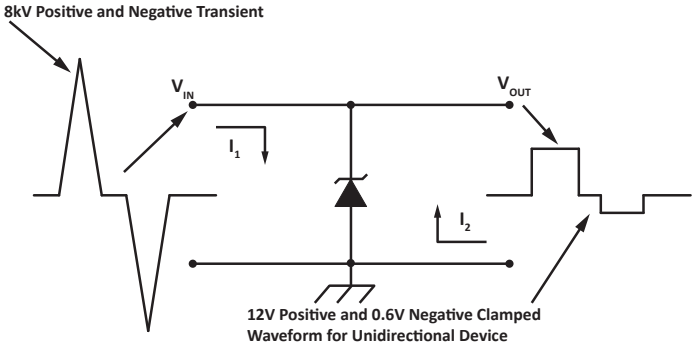


Figure 2. Unidirectional Device (Asymmetrical Clamping)

Deciphering TVS Electrical Characteristics

- Stand-Off Voltage (V_{WM}) - the maximum continuous dc or peak voltage which may be applied over the standard operating temperature range. V_{WM} is normally 10% below the breakdown voltage (V_{BR}).
- Breakdown Voltage (V_{BR}) - the voltage measured across the device at a specified pulsed dc current (I_T or I_{BR}) on the V/I characteristic curve at or near to where the breakdown (avalanche) occurs. Also known as the voltage across the device in the breakdown region prior to the switching point at a specified breakdown current (I_{BR}).
- Leakage Current (I_D) - the maximum current that flows through the device at the rated stand-off voltage (V_{WM}) for a specified temperature. Also known as Reverse Leakage Current (I_R).
- Capacitance (C) - this parameter is associated with high data rate applications and is measured at specific frequency and bias. High capacitance degrades signals.
- Forward Voltage (V_F) - the voltage across the device in the forward conducting state at a specified current I_F.
- Clamping Voltage (V_C) - The peak voltage measured across the device during the application of a pulse current (I_{PP}) for a specified waveform.

Note that Leakage Current and Capacitance should not effect the performance of a circuit.

SUPPRESSOR TYPES

Clamping Devices

Suppressors limit voltage spikes to tolerable levels by either clamping or crowbar action. A suppressor that clamps, begins conducting when its threshold voltage is exceeded, then restores to a non-conducting state when the voltage drops below the threshold. Voltage spikes are clipped off to safe level through clamping. Transient Voltage Suppressors are examples of clamping devices.

There are two major categories of clamping device:
a) those that attenuate transients, thus preventing their propagation into a sensitive circuit - Standard TVS Arrays as shown in Figure 6.

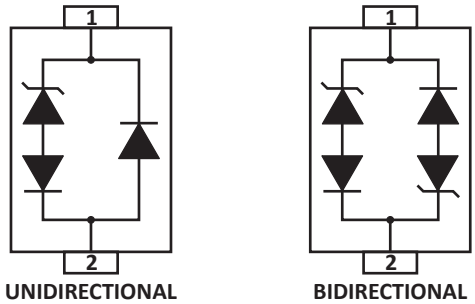


Figure 6. TVS Diode Array - GBLC Series

b) those that divert transient away from sensitive loads, so limiting the residual voltages - Steering Diode Arrays as shown in Figure 7.

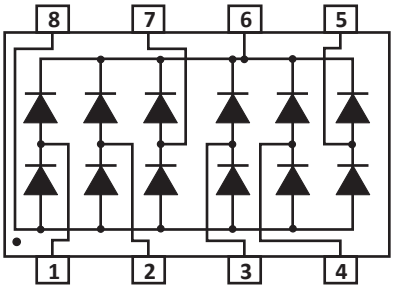


Figure 7. Steering Diode Array - DALC112S1

Crowbar Devices

Crowbar devices conduct when threshold voltages are exceeded and then trigger to an on-state voltage drop for only a few volts, hence the name "crowbar". These devices restore to a non-conducting state when the driving voltage and/or current is reduced with the passing transient. Examples of crowbar devices are Gas Discharge Tubes (GDT) and Thyristors. Figure 8 shows metallic and longitudinal protection using Thyristors (TSS).

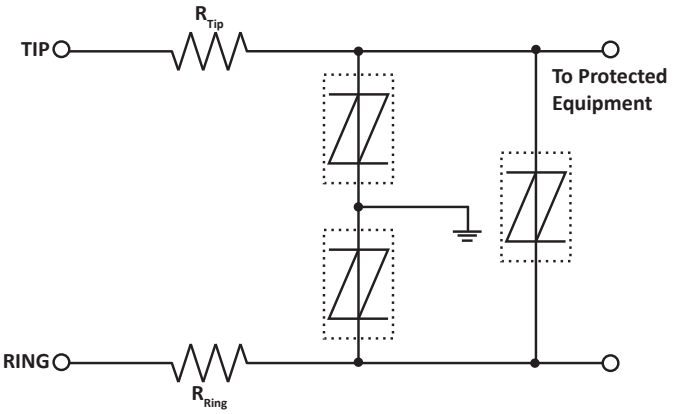


Figure 8. Metallic and Longitudinal Protection - Thyristor (PP-SM Series)

Three equal TSS devices are used in this application for metallic (tip-to-ring) and longitudinal (tip-to-ground and ring-to-ground) protection.

Waveform Characterizations

Most TVS diodes, which are used in low power protection applications are specified according to an 8/20µs waveform as shown in Figure 4. Higher power applications are measured with the 10/1000µs surge waveform.

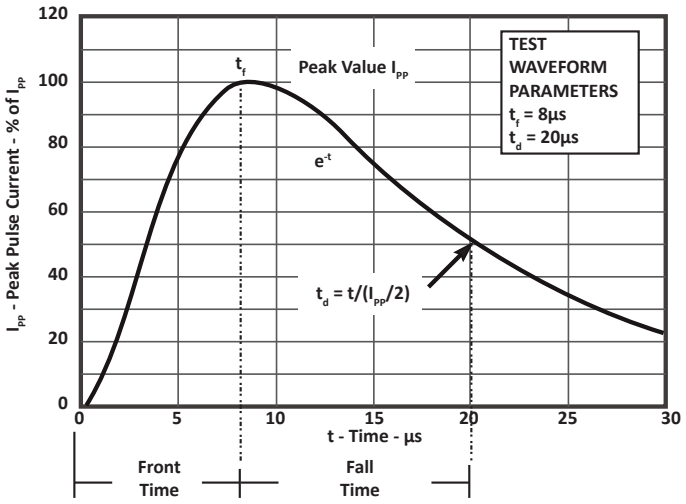


Figure 4. 8/20µs Pulse Waveshape

A TVS diode can have a peak pulse power rating (P_{PP}) ranging from 30 kilowatts to as low as 25 Watts. The power rating is derived from the product of the peak pulse current (I_{PP}) and the clamping voltage (V_C). Figure 5 shows a 400 Watt 8/20µs rated curve. As the surge pulse width decreases the peak pulse power increases logarithmically. For shorter pulse widths, the TVS can handle higher peak pulse currents.

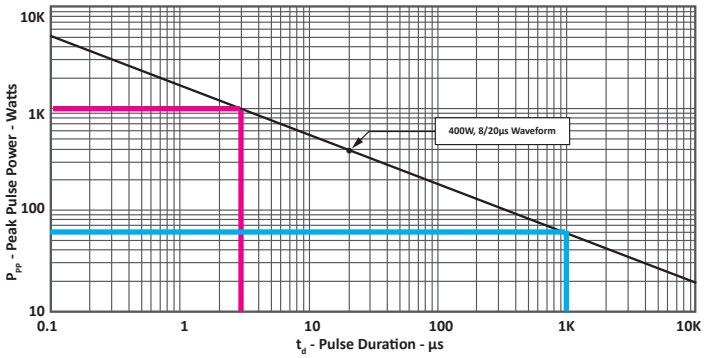
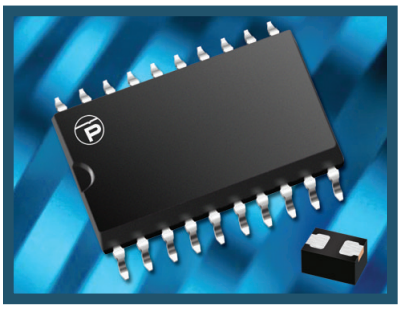


Figure 5. Peak Pulse Power vs Pulse Time

A 3µs surge will have a peak pulse power of approximately 1kW. When the surge pulse is increased, as in the 10/1000µs curve, the peak pulse power will decrease to 60 Watts.



Package Configurations

TVS diodes are available in a variety of sizes from large modules to minature surface mountable flip chips. These devices protect single to multiple line applications in unidirectional or bidirectional configurations.

COMPANY INFORMATION

COMPANY PROFILE

ProTek Devices, based in Tempe, Arizona USA, is a manufacturer of Transient Voltage Suppression (TVS) products designed specifically for the protection of electronic systems from the effects of lightning, Electrostatic Discharge (ESD), Nuclear Electromagnetic Pulse (NEMP), inductive switching and EMI/RFI. With over 25 years of engineering and manufacturing experience, ProTek designs TVS devices that provide application specific protection solutions for all electronic equipment/systems.

ProTek Devices Analog Products Division, also manufactures analog interface, control, RF and power management products.

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