MicroNote 103

What Is a Silicon Transient Voltage Suppressor and How Does it Work?

By Kent Walters and Mel Clark

Silicon transient voltage suppressors (TVSs) are clamping devices that limit voltage spikes by low impedance avalanche breakdown of a rugged silicon pn junction. They are used to protect sensitive components from electrical overstress such as that caused by induced lightning, inductive load switching, and electrostatic discharge.

When a transient appears, the TVS becomes active, clamping it to a harmless level. Its electrical parameters—such as breakdown voltage ($V_{(BR)}$), leakage current (I_D), and capacitance—should be "invisible" to the circuit and have no effect on performance.

The reverse standoff voltage (V_{WM}), which approximates the circuit operating voltage, is normally 10% below breakdown voltage. This assures minimal standby leakage current and compensates for voltage excursions caused by temperature variations. The TVS clamps instantly when transients occur, limiting the spike voltage to a safe level while diverting damaging currents away from the protected part. These functions are illustrated in Figure 1 (see page 1) and Figure 2 (see page 2).

Figure 1: Clamping a Lethal Transient to a Safe Level

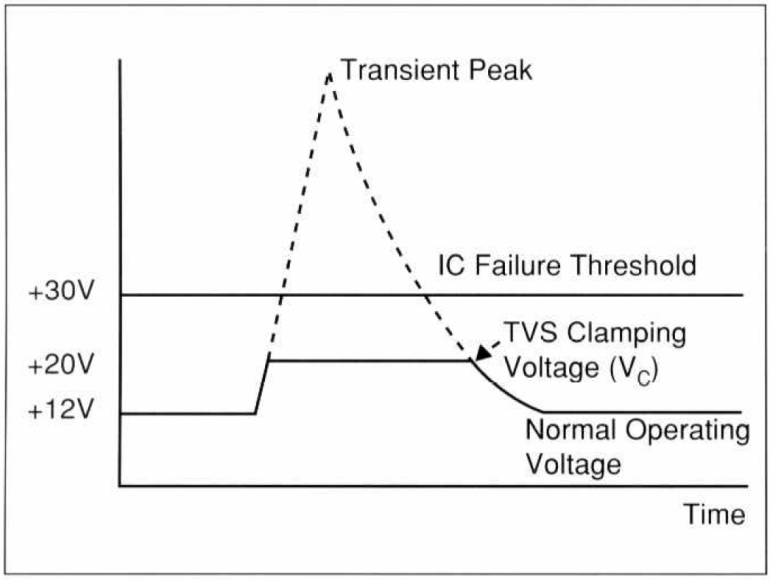
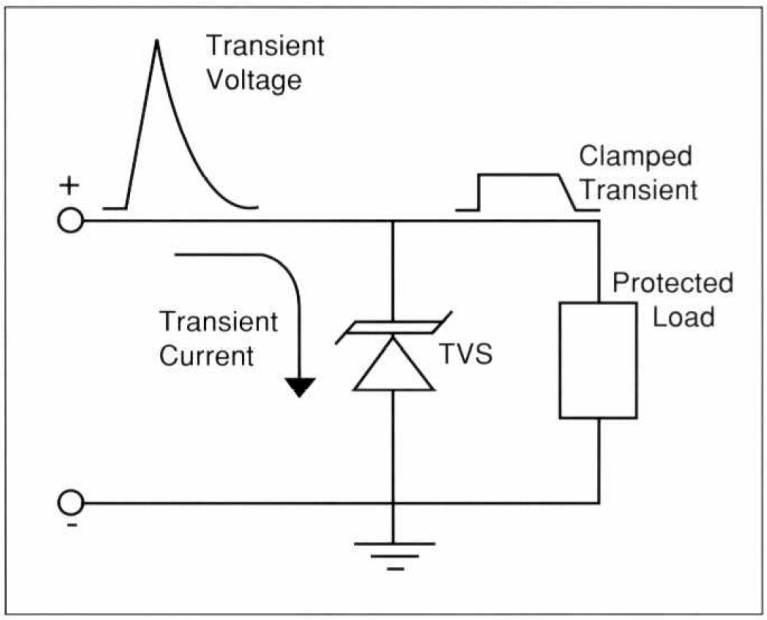


Figure 2: Diverting Transient Current to Ground



Surge current and surge power are proportional to junction area. Long duration or repetitive surges require adequate heat sinking.

Most devices are specified with a 10/1000 µs surge waveform (10 µs rise to peak and 1000 µs exponential decay to one-half peak), with recent changes to incorporate 8/20 µs for some parts. TVS families are normally specified in kilowatts of peak pulse power (P_{PP}) ranging from 15 kW down to 300 W. Power rating is derived from the product of the peak pulse current (I_{PP}) and the clamping voltage (V_C).

Packaging covers a broad spectrum to fit most needs. Axial lead components are available in ratings of 400 W, 500 W, 600 W, 1.5 kW, 5 kW, and 15 kW. Surface mount devices are available in ratings of 300 W, 400 W, 500 W, 600 W, 1.5 kW, and 3 kW. The lower power devices are normally used for ESD, while the higher power devices are used across power buses.

In addition to chips and cells, suppressor arrays and MELF packages are available for high-density packaging. Metallization options for wire bonding or solder attachment are available for chips. Low capacitance TVSs are available to prevent attenuation in high-data-rate or high-frequency circuits.

TVSs are available for operating voltages ranging from 5 V through 376 V. They are used in a remarkable number of applications, from aircraft instrumentation and telephone systems to implantable medical devices.

Although integrated circuits contain on-chip protection consisting of diode-resistor networks or thyristors, there is insufficient space to provide more than a minimal amount. Hence, supplemental protection provided by a TVS is required for environments posing damaging transient threats.

Losses to industry from transient-voltage-related failures have been significantly reduced and equipment reliability vastly improved with effective application of TVS devices. Microsemi has responded to growing needs in this arena by increasing product offerings and technical support.

Support

For additional technical information, please contact Design Support at:
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