

Protecting Low Current Loads in Harsh Electrical Environments

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Today's sophisticated electronic systems feature sensors, transducers and microcontrollers which are often placed in harsh environments having exposure to lightning, heavy load switching and other damaging transients.

To protect these vulnerable circuit elements from electrical overstress, high power silicon transient voltage suppressors (TVSs) are usually the first choice as illustrated in Figure 1.

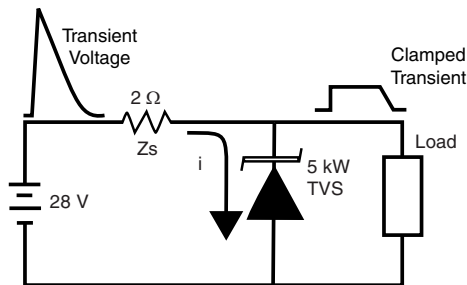


Figure 1. A 5 kW TVS is Required to Handle the High Surge Current

Consider as an example, a pressure transducer which operates at 28 V, placed in an environment in which it encounters a transient voltage of 140 V peak, having a source impedance of 2 Ω and a duration of 10/1000 μs. The failure threshold of the transducer is 40 V, therefore the TVS must clamp at 40 V or less. The current delivered by this transient is:

$$I = (140 \text{ V} - 40 \text{ V}) / 2 \Omega = 50 \text{ A}$$

Note that the voltage clamping action of the TVS results in a voltage divider whereby the open circuit level of the transient appears across the combination of the source impedance and the TVS device. Thus the TVS clamping voltage is subtracted from the transient voltage leaving a net source voltage of 100 V. When the clamping voltage is high compared to the transient peak voltage, the surge current is significantly reduced.

This circuit can be protected with a 5 kW rated suppression device such as the 5KP28A TVS which will easily sustain the surge current.

An alternate and more economical approach is to add a series resistor to effectively increase the source impedance thus limiting surge current as illustrated in Figure 2. Since the current drawn by the transducer under normal operation is small (< 20 mA typical), performance is not adversely affected by reduction in supply current.

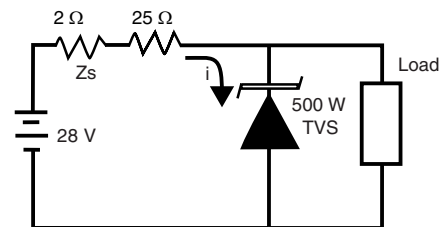


Figure 2. Series Resistor Reduces Transient Current Allowing a Much Smaller TVS to be Used

For a small load current, 10 mA, the voltage drop across the added resistance is minimal, about 0.25 V for a 0.25 Ω resistor. Adding this resistor reduces the surge current to:

$$I = (140 \text{ V} - 40 \text{ V}) / (2 \Omega + 25 \Omega) = 3.7 \text{ A}$$

This is less than one-tenth the surge current without the resistor. A TVS with lower power rating is able to handle the resulting current. In this case a 500 W suppressor, such as the SA28A TVS, replaces the 5 kW device, saving board space and cost.

An SA28A was chosen in this example since its current rating for a 10/1000 μs pulse is 11 A, easily withstanding the 3.7 A surge calculated above. Although the maximum clamping voltage for the SA28A is given on the data sheet as 45.4 V, the reduced surge current is 33 % of the suppressor's peak capability, hence the clamping voltage would be approximately 38 V, within our stated limit.

Carbon composition resistors are recommended for this application, as they have sufficient energy capability for the pulse condition. Steady state power dissipated by the resistor ($E \times I$) is 0.25 W requiring a 0.5 W rated resistor for adequate margin. The examples given are for 25 °C ambient. For elevated temperatures, derate accordingly. Protected circuits derived within these guidelines should be fully evaluated under operating and threat conditions before use.