Protecting for Repetitive Transient Voltages

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While lightning may not strike twice in the same place, in circuits which involve power switching, relays, or motor control, components may be continually subjected to very short transient voltages occurring at regular intervals. Transient Voltage Suppressor (TVS) will effectively limit the transient voltage to a safe level, but some guidelines are needed for selecting the TVS which must handle this repetitive stress.

The average steady state power which the TVS will dissipate can be calculated for recurring short pulse widths. This average power must be within the steady state power rating of the TVS selected for the application. For example, in a motor drive circuit, the switching of current through the inductance of the motor winding continuously generates a pulse which has a 4 ms duration and a 25 A peak current at a frequency of 120 Hz.

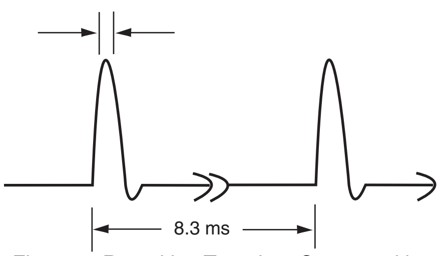

Figure 1. Repetitive Transient Generated by Motor Winding Inductance

In this application a surface mount TVS, part number SMBJ6.5A, is initially selected to protect the control inputs of the motor drive circuitry because it will clamp the single-pulse voltage to a maximum level of 11.2 V. But will this suppressor survive the continuous (120 times per second) application of this transient?

Pulse interval, the inverse of the frequency, is:

$$1/120 \text{ pulse/s} = 0.0083 \text{ s}$$

Peak pulse power is the clamping voltage multiplied by the pulse current:

$$P_{PP} = 11.2 \text{ V} \times 25 \text{ A} = 280 \text{ W}$$

Average power can be closely estimated by multiplying the peak power times the ratio of the pulse width to its interval:

$$P \text{ avg.} = 280 \text{ W} \times (0.000004/0.0083 \text{ s}) = 0.134 \text{ W}$$

The SMBJ6.5A will dissipate at least one watt steady state on a typical printed circuit board. Thus the calculation shows that the suppressor safely dissipates the average power generated in the motor drive, and clamps the transient voltage to a safe level. The SMAJ6.8A device is another option for this application.

Circuit board layout and engineering practices which provide adequate heat sinking for the suppressor should be observed. Higher power dissipation can be achieved by sizing mounting pads proportionately. Where this is not practical, or if calculation results in average dissipation greater than can be safely handled, a transient suppressor with a higher steady state power rating should be selected.

Derating must be observed for operation at elevated temperatures since all electrical ratings are normally specified at 25 °C. For the described electrical conditions an ambient temperature of 75 °C will provide 60 % of the rated steady state capability.

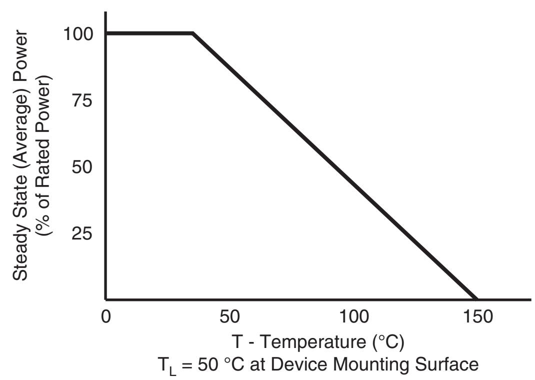

Figure 2. Temperature Derating for Steady-State Power Dissipation

The average power calculation shown here is generally valid for pulses up to 10 ms in duration, occurring at intervals in the range of 100 to 1000 ms. Longer pulse durations approaching 1 ms or more may be sustained only if the interval increases correspondingly.

It may not be possible to determine the exact conditions (current amplitude, pulse width, etc.) in repetitive pulse environments, so some experimentation may be required to optimize the suppressor selection.