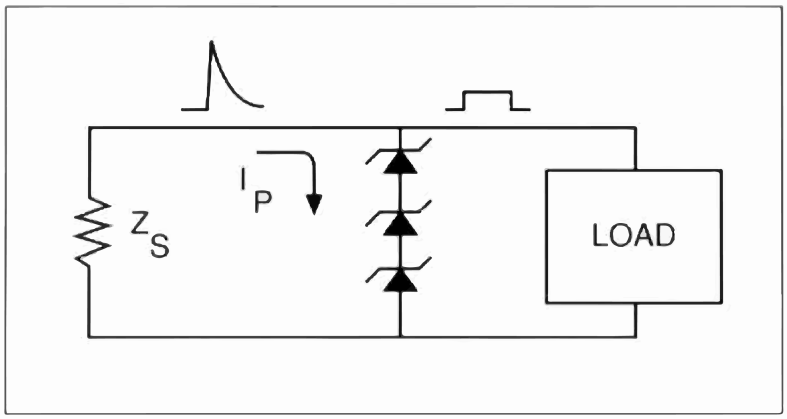
MicroNote 112

Series Stacking of Silicon TVSs For Higher Surge Current and Breakdown Voltage

By Mel Clark and Kent Walters

Although there is a broad range of surge rated transient voltage suppressors (TVSs) from which to choose, occasionally there is a need for a greater peak pulse current (I_{PP}) rating than that of a single device for a given operating voltage (V_{WM}). TVSs can be stacked in series to achieve higher ratings as shown in the following illustration.

Figure 1: Series Stacked Silicon TVSs



An example might be the need for a 100 V operating level with 25 A 10/1000 µs protection; however, the SMCJ100A is rated for only 9.3 A. The datasheet lists the SMCJ33A as having an I_{PP} of 28.1 A, and three of these devices in series would provide the necessary operating voltage of 100 V and also with the desired I_{PP} of 25 A.

The solution was derived from the first by selecting a device that would meet the required I_{PP} of 25 A min; the SMBJ33A was selected for this example. By adding the operating voltage of three SMCJ33As, yielding 99 V total, this becomes acceptable for the 100 V requirement. Clamping voltage is 3 × 53.3 V = 159.9 V, which is adequate for the 163 V max clamping voltage (V_C max) listed for the SMCJ100A.

It is not always possible to use all of the same device types in a string to get the desired voltage. TVS voltages can also be mixed for matching to the desired V_{WM}. For example, you have a need for 60 A, 10/1000 µs protection in a 36 V operating circuit and have SMCJ6.0A and SMCJ15A devices available. The 15 V part is rated for 61.5 A and the 6.0 V device is rated for 145.6 A. The maximum rating for a series string of two 15 V devices and one 6.0 V device is 61.5 A, or the lowest rated part in the string. This will fulfill the operating voltage and surge requirements for the scenario defined.

TVS devices can be series strung almost ad infinitum to achieve higher voltage ratings; however, parasitic inductance contributed by increasing interconnecting lead length will eventually produce significant L (di/dt) effects, reducing the TVS's effectiveness. A practical number of parts in a string ranges from 10 to 20 devices. In one rare exception, a string of 400 V parts was extended to 30,000 V operating level for protecting a cathode ray tube in an experimental laboratory environment.

For series stacking, the following guidelines apply to both unidirectional and bidirectional components:

1. First, try to use multiples of the same device.

2. If mixed device types are used, the I_{PP} will be limited to the lowest value in the series.
3. The maximum clamping voltage (V_C max) will be the sum of the values for each component in the string. If the I_{PP} is significantly derated from its specific value, the V_C will be reduced according to the I_P/I_{PP} relationship described in MicroNote 108.
4. The effective V_{WM} will be the sum of each device in the series string.
5. The minimum breakdown voltage ($V_{(BR)}$) will be the sum of the individual values for each device in the string.
6. Steady-state power dissipation will be the sum of all devices used only if parts are mounted to optimize heat dissipation per the datasheets for individual components.
7. Keep interconnecting leads short to minimize parasitic lead inductance as described in MicroNote 111.

Support

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