PARASITIC CAPACITANCE IN TRANSIENT VOLTAGE SUPPRESSORS

A silicon transient voltage suppressor (TVS) has an inherent capacitance resulting from electrons and holes collecting on opposite sides of the pn junction. These are equivalent to parallel plates having an intervening dielectric of silicon, thus providing the elements of a capacitor. When a reverse bias is applied, the charge depleted region widens, decreasing the capacitance as the bias is increased.

Low voltage devices, 5V to 8V, have a high concentration of dopant resulting in a narrow separation of the capacitor "plates" producing high capacitance values. Progressively higher voltage devices have exponentially decreasing levels of dopant with a corresponding reduction in capacitance. Figure 1 depicts capacitance vs stand-off voltage for both unidirectional and bidirectional devices. The latter have two junctions in series, which further reduce capacitance.

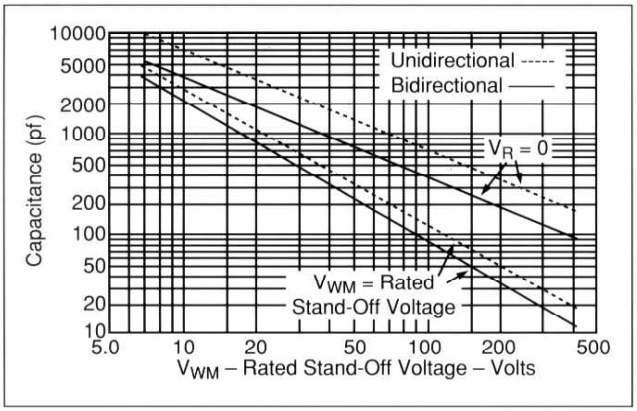

Figure 1. Capacitance vs Stand-Off Voltage For 1500W TVSs

Similar capacitance graphs for different power rated TVS devices will vary proportionally to their rated peak pulse power or effective area of the pn junction. A 500W device will typically have one third of the capacitance of a 1500W device while a 5kW device will have a three and one third times greater amount when comparing the same operating or breakdown voltage.

Typical values for capacitance vs bias voltage are shown in Figure 2 for three device types; 1.5KE36A, 1.5KE56A and 1.5KE170A. Capacitance drops exponentially as reverse bias is increased.

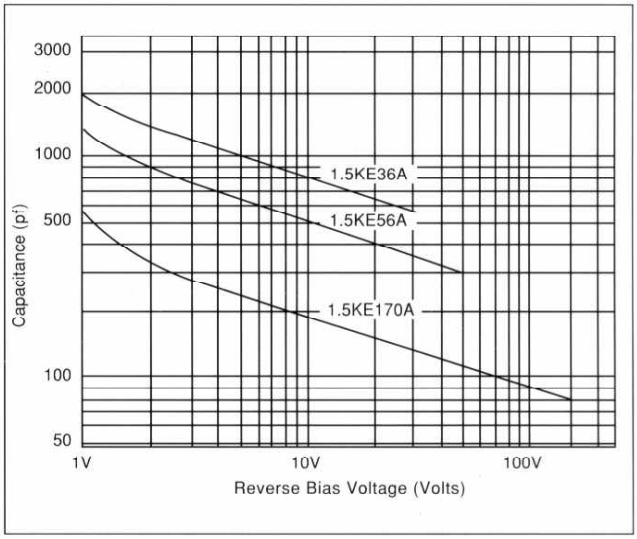

Figure 2. Capacitance vs Reverse Bias Voltage

At dc voltage and low frequencies, the capacitance of a silicon transient voltage suppressor (TVS) does not affect performance; however, at higher frequencies of 100kHz and above, there is a risk of signal attenuation.

For high frequency or high data rate applications, capacitance can be effectively reduced by

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MCC Note Series D003

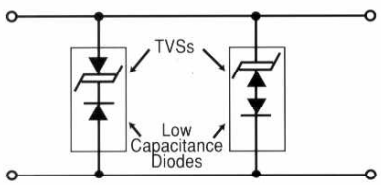

Figure 3A
Bidirectional

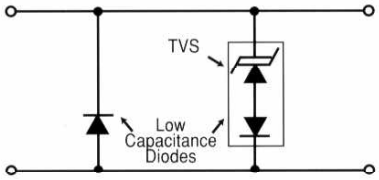

Figure 3B
Unidirectional

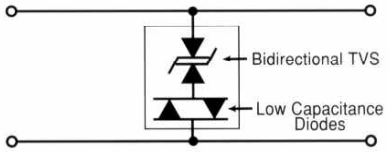

Figure 3C
Single Component
Bidirectional

placing a low capacitance rectifier chip within the same package and in series but opposite polarity to the TVS chip. The LC, LCE (100pf), and SAC (50pf) low capacitance devices are configured in this manner. Two of these devices are required in a back-to-back parallel configuration for bidirectional protection as shown in Figure 3A.

Unidirectional protection is illustrated in Figure 3B with a 1 Amp rated rectifier clamping transients (in the forward direction) originating on the negative line. The 50pf SAC TVS series can operate in the 1MHz plus range. For space saving applications, bidirectional and low capacitance features can be integrated into the same package as shown in Figure 3C.

The total capacitance of the series diode and TVS configuration can be calculated in the same manner as series capacitors as illustrated:

$$C_t = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2}} = \frac{C_1 \times C_2}{C_1 + C_2}$$

where: C_t = total capacitance
C_1 = capacitance of suppressor
C_2 = capacitance of rectifier

From inspection, it is observed that the total value of capacitors in series will be less than the smallest component. However, capacitors in parallel are additive, e.g., $C_t = C_1 + C_2$.