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Ambiguity of the Peak Power Rating of TVS Devices

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APPLICATION NOTE

Introduction

One of the most prominent ratings of Transient Voltage Suppressors (TVS) is the peak power dissipation. The peak power dissipation is measured by forcing a specified current waveform through the TVS at progressively higher stress levels while monitoring the current through the device and the voltage across the device. The peak power is the product of the peak measured current and the peak measured voltage for the highest stress waveform which does not damage the TVS device. The most common waveforms used in peak power measurements are 8/20 μs and 10/1000 μs current waveforms. (In the electromagnetic compatibility (EMC) field stress waveforms are often described in an xx/yy fashion. The xx value describes the waveform's rise time in μs and the yy value describes the time in μs at which the waveform falls to half of its peak value.) While the peak power of a TVS device is an important property of the TVS, its value is often not a good measure of the TVS's ability to protect sensitive components. This application note will describe why the peak power dissipation may not be a good measure of a TVS's protection ability.

How TVS Devices Protect

If an electrical stress is applied to the input or output of an electrical system the voltage or current of the stress can damage sensitive components. Figure 1 illustrates how a TVS device protects a sensitive input. TVS devices work by providing a low resistance path between an input or output line and ground if the voltage on a sensitive node exceeds the normal voltage range for the circuit. This is illustrated in Figure 2 which shows the TVS device's IV properties in relation to the voltage and current properties of the circuit being protected.

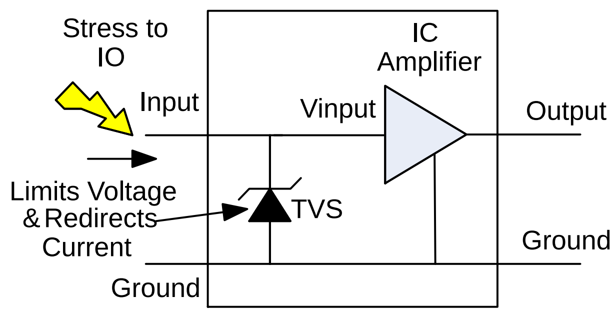

Figure 1. How TVS Devices Provide Protection

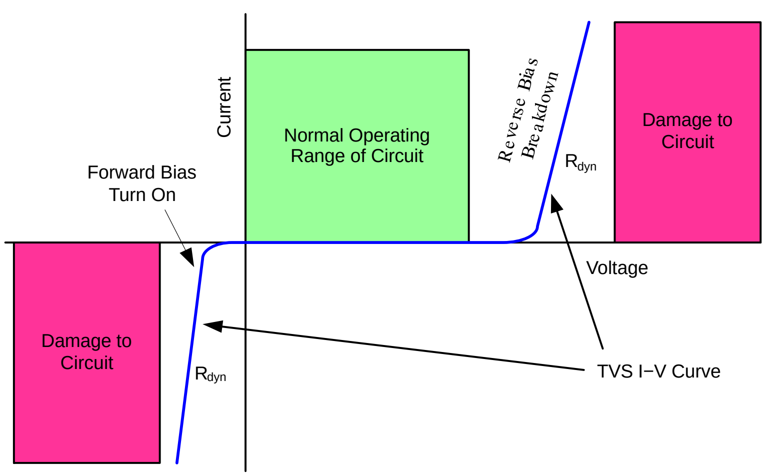

Figure 2. Properties of TVS Device Relative to Circuit it is Protecting

TVS Parameters and Protection

Figure 2 illustrates some of the most important properties of a TVS with regard to its suitability for the application and its protection ability. First of all, the forward turn on voltage and reverse bias breakdown voltage must be outside of the normal range of operation for the circuit being protected or normal circuit function will be compromised. Secondly, the lower the dynamic resistance of the TVS device after turn on, the higher the current which the TVS can carry without allowing damaging voltages on the sensitive node.

How does this relate to the peak power dissipation of the TVS? Peak power dissipation of a TVS is a measure of the energy the TVS can absorb without damage and does not directly relate to how well the TVS protects sensitive nodes. Consider the two TVS devices illustrated in Figure 3. The two devices have the same breakdown voltage and both fail with a maximum current of 20 A. The dynamic resistance of the two devices are, however, quite different. TVS A has only 10 V across it at 20 A while TVS B has 14 V across it at 20 A. The peak power dissipations are therefore 200 W for TVS A and 280 W for TVS B. Based solely on peak power dissipation one would expect TVS B to be the better protection device but the lower dynamic resistance of TVS A makes it clearly the better protection device.

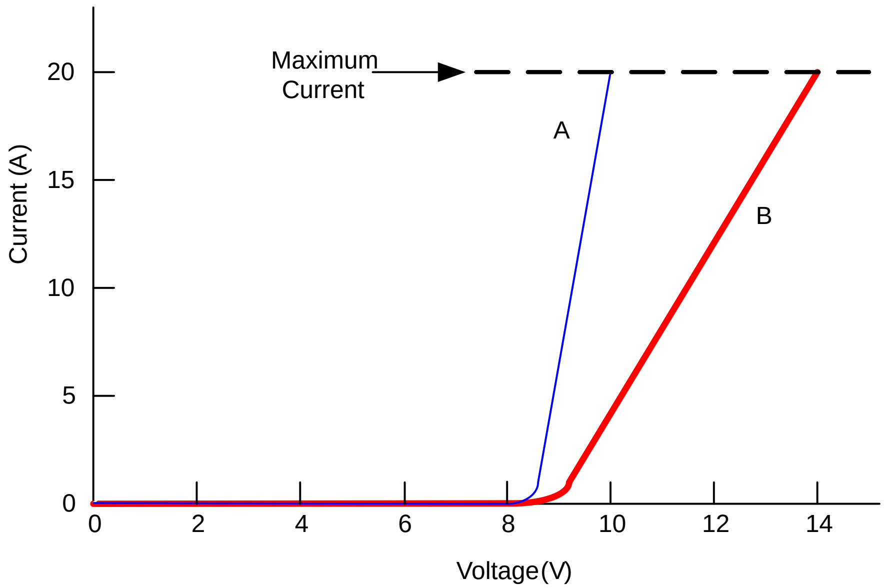

Figure 3. Comparison of Two TVS Devices with the Same Breakdown Voltage and Same Peak Current but with Different Dynamic Resistances

Comparing the voltage and power versus time between two products for a similar current pulse is a dramatic way to demonstrate how power dissipation can be a misleading indicator of protection capability. Figures 4 and 5 compare input to ground stress for two TVS protection products, ON Semiconductor's ESD1014 and a competitor's device designed for the same application. Figure 4 shows the measured current and voltage pulses versus time for 8/20 μs pulses. The current pulses are almost identical in size, but the measured voltages are quite different. The ESD1014 shows a peak voltage of about 10 V, while the competitor's device has a peak voltage over 15 V. The ESD1014 will clearly provide better protection during a surge input resulting from a lightning strike or power-cross fault, because of a lower transient voltage on the line being protected. Figure 5 shows the voltage as well as power versus time. Since power is voltage multiplied by current the similar current levels with different voltage results in the competitor's part dissipating considerably more power for the same current stress. The higher power dissipation for the same current stress provides no protection benefit, but only highlights the higher clamping voltage for the competitor's device. Datasheets often tout the power-dissipation capability of the protection device, but it should be clear to the reader that here is an example where a higher power dissipation is hardly an advantage − it is the result of higher (worse) transient voltages for a given current surge.

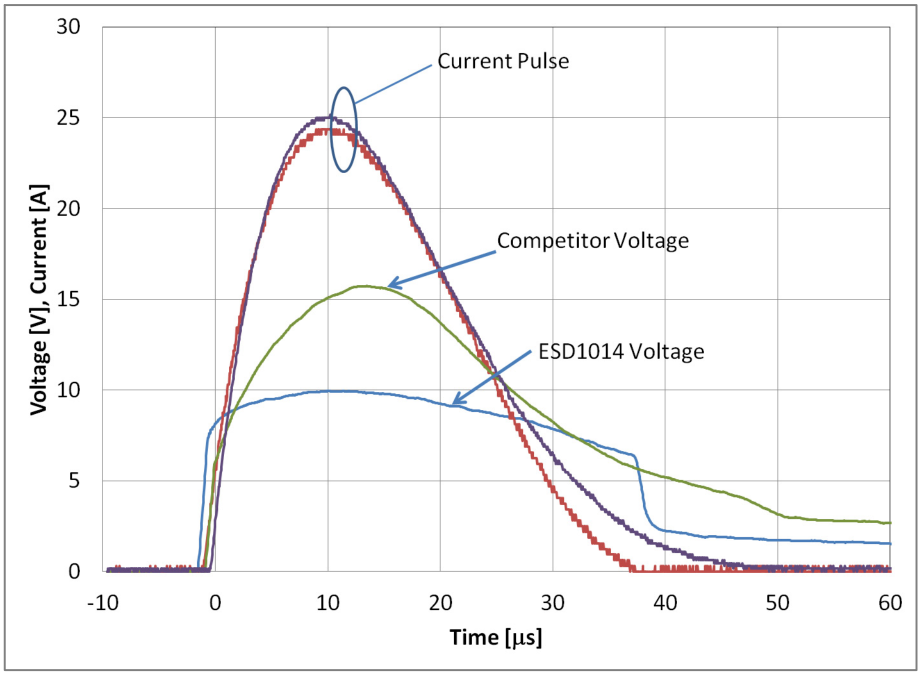

Figure 4. Input to Ground Voltage and Power Dissipation Comparison for ESD1014 and a Competitor's Product

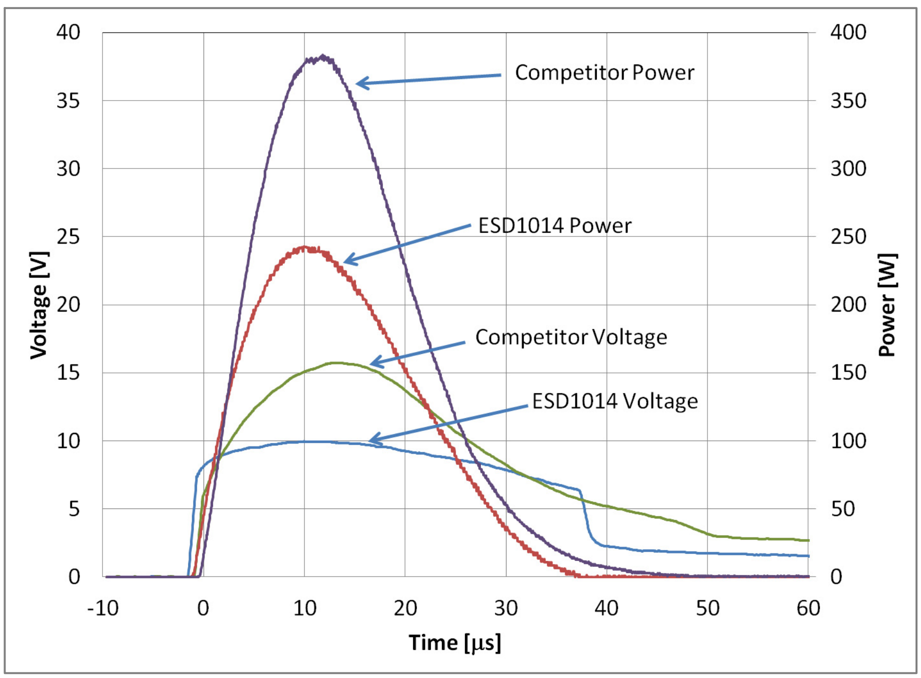

Figure 5. Input to Ground Voltage and Power Dissipation Comparison for ESD1014 and a Competitor's Product

Summary

There are two important properties of a TVS device during an electrical stress. The TVS must be able to self-protect and survive the stress current, and the TVS must clamp the protected line to a low voltage during the stress. Power ratings of TVS devices do not provide a good measure of clamping effectiveness because this metric is artificially enhanced by a higher, less desirable, clamping voltage. It is true that TVS devices with high peak power ratings are often larger diodes and may therefore also have low dynamic resistance and low clamping voltage but there are exceptions, and one such exception has been highlighted in this note. It is therefore important to always consider the dynamic resistance or the clamping voltage at specific currents levels, rather than focusing solely on the peak power rating when selecting a TVS device.

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