TransGuard®

AVX Multilayer Ceramic Transient Voltage Suppressors
Application Notes: Turn on Time Characteristics of AVX Multilayer Varistors

INTRODUCTION

Due to the growing importance of ESD immunity testing, as required by the EMC Directive, proper selection of voltage suppressor devices is critical. The proper selection is a function of the performance of the device under transient conditions. An ideal transient voltage suppressor would reach its "clamping voltage" in zero time. Under the conditions imposed by the 1991 version of IEC 61000-4-2, the actual turn-on-time must be less than one nanosecond to properly respond to the fast leading edge of the waveform defined in the standard.

It has been found during testing of transient suppressors that the response time is very closely dictated by the packaging of the device. Inductance that is present in the connection between the silicon die and the leads of the device creates an impedance in series with the suppressor device; this impedance increases the overall device response time, reducing the effectiveness of the suppressor device.

The purpose of this paper is to present the Turn on Time characteristics of Multilayer Varistors (MLVs) and to compare the MLV Turn on Time to that of various silicon transient voltage suppressors (SiTVs).

The Turn on Time of a transient voltage suppressor (TVS) is of growing importance since IEC 61000-4-2 now specifies ESD waveform with a rise time < 1 ns. Therefore, TVS's must have a turn on time < 1 ns to effectively suppress ESD. In many, if not all, ESD suppression applications, TVS turn on time can be of more importance than absolute clamping voltage (Vc) of the TVS (assuming that the TVS clamping voltage is less than the damage voltage of the circuit or IC).

To measure the turn on time of today's TVS's, a broad cross section of MLVs and SiTVs were chosen. Only surface mount devices were chosen in order to best represent today's TVS current usage/trends and to keep the test matrix to a reasonable level of simplicity. The following devices were tested:

SMT MLV	SiTVS
	MA141WA
0603	BAV 99
0805	SOT 23 type
1206	SMB - 500W gull-wing SM device
1210	SMC - 1500W gull-wing SM device

TEST PROCEDURE

The TVS device under test (DUT) was placed on a PCB test fixture using SN60/40 solder. The test fixture (see Figure 1) was designed to provide an input region for an 8kV contact ESD discharge waveform (per IEC 61000-4-2 level 4 requirements). In addition, the fixture was designed to provide low impedance connections to the DUTs.

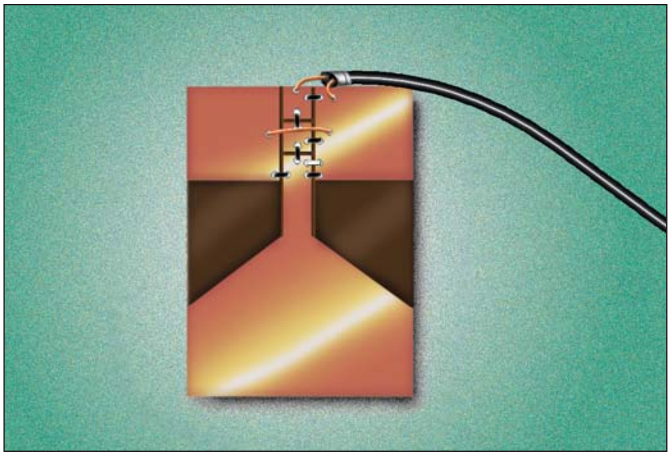

Figure 1. DUT Test Fixture

The ESD pulse was injected to the PCB from a Keytek mini-zap ESD simulator. Additionally, the fixture was to channel the ESD event to a storage oscilloscope to monitor the suppressor's response. Six resistors were used on the PCB to provide waveshaping and an attenuated voltage to the storage scope (see Figure 2):

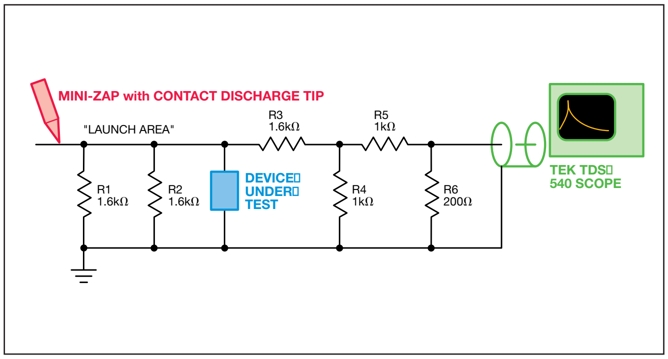

Figure 2. Schematic of Test Set Up

TransGuard®

AVX Multilayer Ceramic Transient Voltage Suppressors Application Notes: Turn on Time Characteristics of AVX Multilayer Varistors

The functions of the resistors are as follows: The resistor values were adjusted in "open circuit" conditions to obtain best open circuit response.

R1, R2 (1.6K) - provide wave shaping during the ESD discharge event

R3 (1.6K), R4 (1K), R5 (1K) - Form a 60 dB Attenuator (1000:1 ratio) for input of Tektronix TDS 540 1 giga sample/second storage oscilloscope

R6 (200 Ω) - provides matching to the 50 ohm coax feeding the TDS 540 oscilloscope.

The open circuit response of the ESD test fixture with a 9kV ESD pulse is shown in Figure 3.

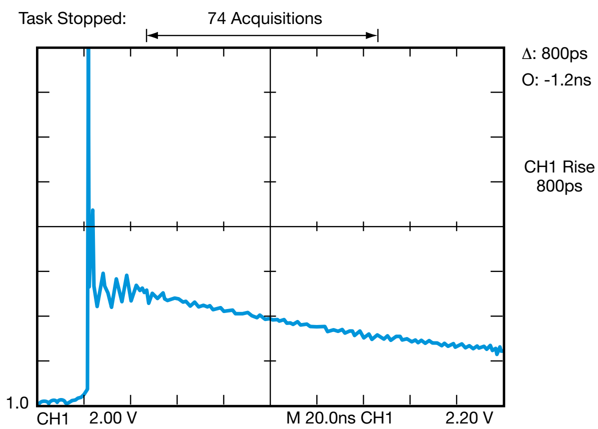

Figure 3. Open Circuit Response of Test Fixture to an Injected ESD Waveform

The graph shows the voltage attenuated by a factor of 1000, with a 800ps risetime for the ESD waveform (this agrees with typical data given by Keytek for equipment performance). It should be noted that only the positive polarity was tested. Prior testing showed turn on time was not dependent upon waveform polarity (assuming that DUTs are bidirectional).

TEST RESULTS

MLV TURN ON TIME TRANSGUARDS®

The turn on time test results for AVX TransGuards® showed that all case sizes were capable of a sub-nanosecond turn on response. This corresponds favorably with the calculated turn on time of less than 1 ns. Specific performance data follows:

AVX TransGuard®	
CASE SIZE	**TURN ON SPEED**
0603	< 0.7 ns
0805	< 0.9 ns
1206	< 0.9 ns
1210	< 0.8 ns

TVS TURN ON TIME

Test results for SiTVs varied widely depending upon the physical size and silicon die mounting configuration of the device. The results agree with several SiTVs manufacturers papers indicating that the absolute response from the silicon die could be < 1 ns. However, when the die is placed in a package, the turn on time delay increases dramatically. The reason for this is the series inductance of the SiTVs packaging decreases the effective response time of the device. Reports of 1-5 ns are frequently referred to in SiTVs manufacturers publications. Further, the turn on times for SiTVs vary dramatically from manufacturer to manufacturer and also vary within a particular manufacturers lot. The data provided in the following table generally agreed with these findings:

SiTVS	
CASE SIZE	**TURN ON SPEED**
MA141WA	0.8ns
BAV 99	0.9ns to 1.2ns
SOT 23 Type	0.8ns
SMB	1.5ns to 2.2ns
SMC	1.5ns to 3ns

SUMMARY

This test confirms calculations that show that AVX TransGuards® have a true sub-nanosecond turn on time. Although the silicon die of a SiTVs has a sub-nanosecond response, the packaged SiTVs typically has a response time much slower than a TransGuard®. If the two devices were directly compared on a single graph (see Figure 4), it could be shown that the TransGuard® diverts significantly more power than even the fastest SiTVs devices. Additionally, TransGuards® have a multiple strike capability, high peak inrush current, high thermal stability and an EMI/RFI suppression capability which diodes do not have.

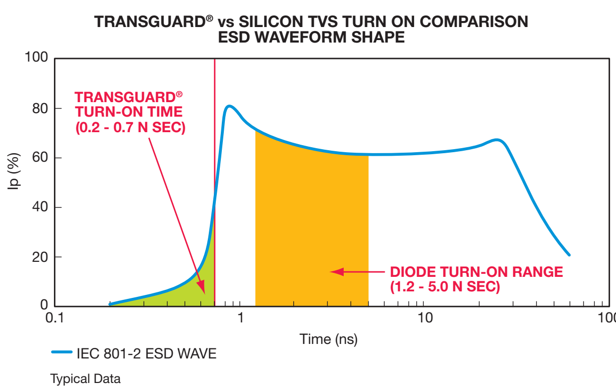

Figure 4.