TECHNICAL PAPER

The Principles of Varistor Selection

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Abstract

A varistor is an electronic component used to suppress transient voltages to protect electronic circuits. The behavior of varistors in a circuit is similar to TVS diodes, but they are entirely different in design, materials, and construction. There are many kinds of varistors on the market suitable for various applications, making choosing the right one to protect a given circuit challenging.

KYOCERA AVX multilayer varistors, with a unique high-energy multilayer construction, provide state-of-the-art overvoltage circuit protection and protection from voltage transients caused by ESD, inductive switching, automotive-related transients, NEMP, lighting, etc. KYOCERA AVX multilayer varistors also provide EMI/RFI filtering in the off-state, which can replace the need for additional EMC capacitors in the system.

THE PRINCIPLES OF VARISTOR SELECTION

INTRODUCTION

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WHAT ARE VARISTORS?

A varistor is a blend of the words "varying resistor" because its resistance varies as the voltage applied to it changes. At low applied voltages, the varistor's resistance is high, and as the applied voltage increases, the resistance decreases. They behave similarly to a Zener diode, which conducts little to no current when voltages below the breakdown voltage are applied, but a lot of current at voltages above the breakdown voltage. The difference is that varistors are bi-directional.

Multi-Layer Varistors (MLV) are a newer development in the varistor market, constructed with a multi-layer ceramic process in a surface mount package. Below the breakdown voltage, an MLV conducts little to no current but behaves like an EMC capacitor.

Above the breakdown voltage, an MLV conducts current and behaves like a transient voltage suppressor diode. These characteristics are represented in Figure 1.

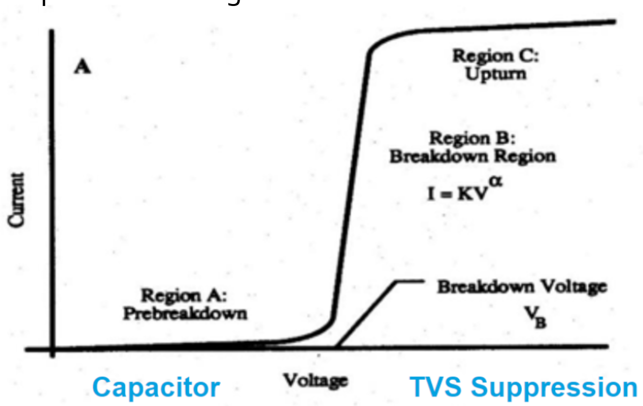


Figure 1: Characteristics of a Multi-Layer Varistor (MLV)

In practice, an MLV is used to clamp voltage transients, as shown in Figure 2.

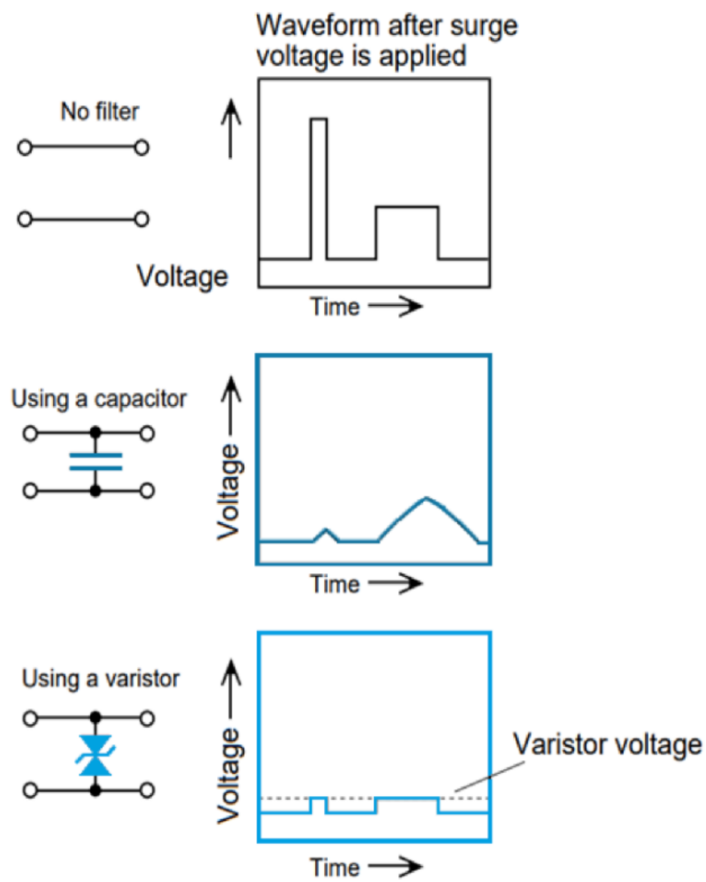


Figure 2: How a Varistor Clamps Transients

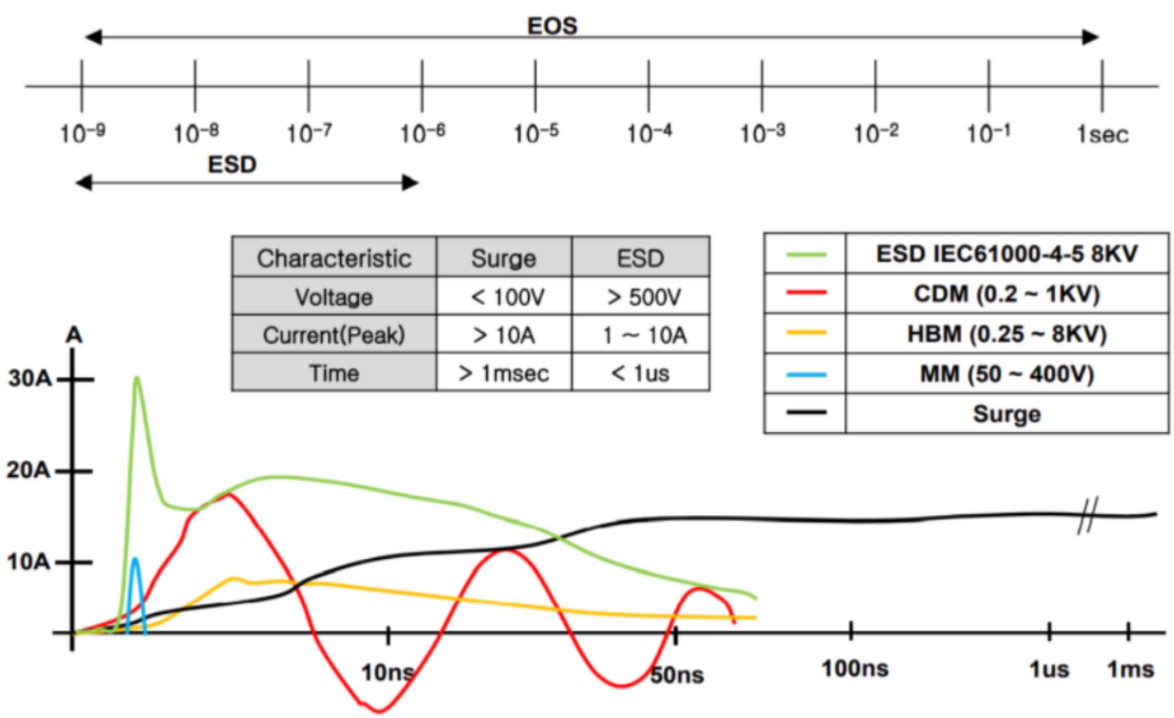
THE PRINCIPLES OF VARISTOR SELECTION

WHAT IS ESD?

Electrostatic Discharge (ESD) is a momentary flow of electricity between two oppositely charged objects. In an ESD event, static charge built up on one object is suddenly discharged to another object when they come into contact (external), or a dielectric breaks down (internal). ESD is one type of electrical over-stress (EOS) that is a danger to electronic components and one that MLVs can help protect against.

There are various ESD event models used to describe and test electrical components. They vary by energy, pulse shape, and size. Figure 3 shows the electrical energy signatures of different ESD models, including the IEC61000-4-5 8kV model, the Charged-Device Model (CDM), the Human Body Model (HBM), and the Machine Model (MM). These are compared against the energy characteristics of an electrical surge.

Knowing the target signal and energy that must be suppressed is key to designing the proper circuit protection.



Characteristic	Surge	ESD
Voltage	< 100V	> 500V
Current(Peak)	> 10A	1 ~ 10A
Time	> 1msec	< 1us

Figure 3: Different ESD Models by Energy Characteristics

ADVANTAGES OF MLVS OVER TVS DIODES

There are many options for suppressing transient voltages like ESD, but the most common alternatives to MLVs are transient voltage suppressor (TVS) diodes and metal oxide varistors (MOV). MLVs, however, offer some significant advantages over these alternatives.

Compared to MLVs, TVS diodes are more susceptible to failure at higher temperatures. For the same peak power current (IPP), a physically larger TVS diode would be required at higher temperatures.

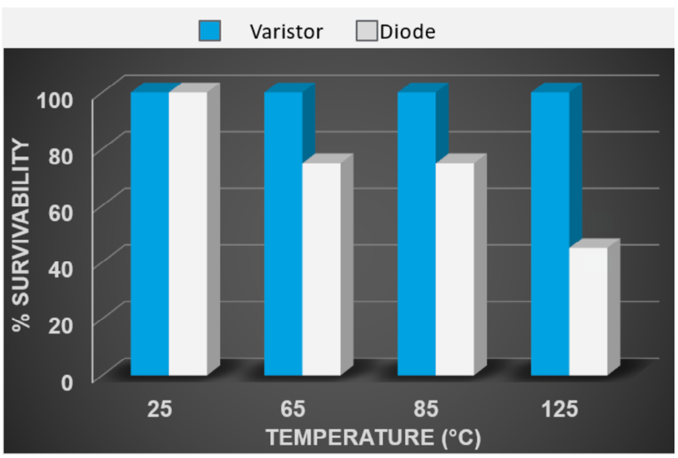


Figure 4: Survivability of Varistors vs. TVS Diodes over Temperature

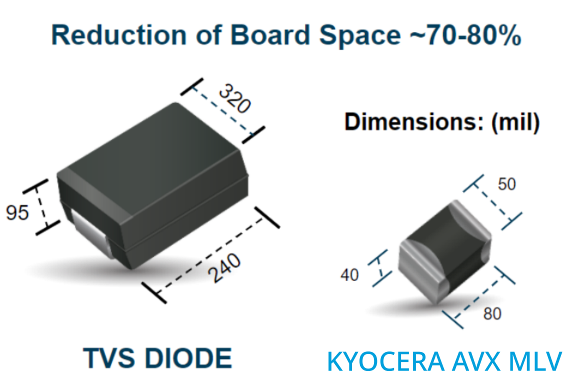


Figure 5: Size Reduction Possible with MLVs

MLVs can also withstand many more strikes before failure than TVS diodes, shown in Figure 6. In this figure, Transguard is a zinc oxide (ZnO)-based ceramic MLV from KYOCERA AVX, while the SOT23 devices referenced are TVS diodes (unidirectional and bidirectional).

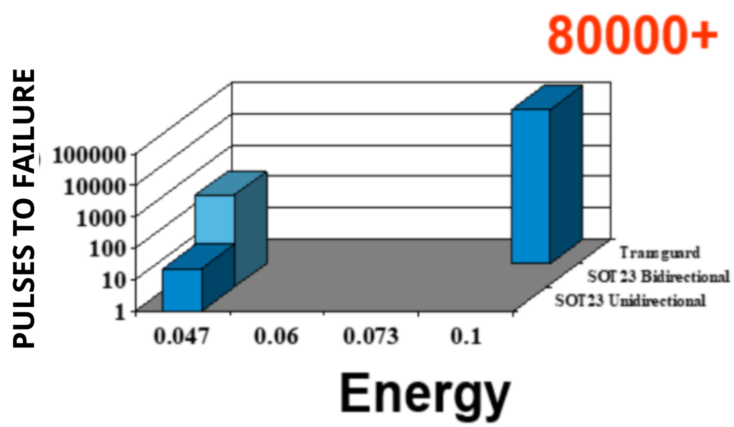


Figure 6: ESD Strikes Until Failure of MLVs vs. Diodes

Finally, MLVs respond faster to ESD events than do TVS diodes. This means MLVs provide better circuit protection than TVS diodes can provide.

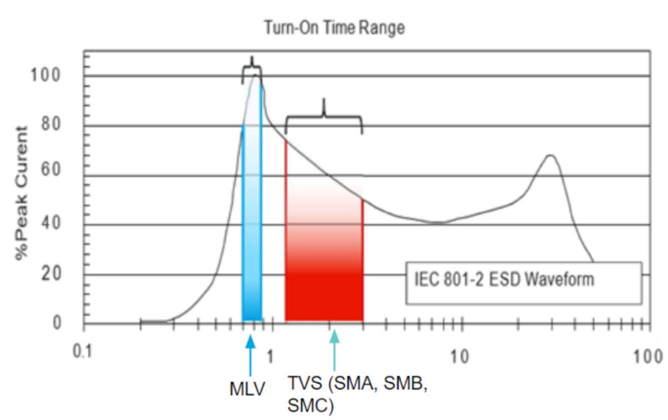


Figure 7: Turn-On Time Range of MLVs vs. TVS Diodes

ADVANTAGES OF MLVS OVER MOVS

Metal oxide varistors (MOVs), also known as leaded disc varistors, are very common. These devices have been around for a long time and have protected many circuits, but the newer ceramic multilayer technology offers a distinct advantage.

Unlike MOVs, MLVs do not exhibit degradation against multiple strikes (if operated within electrical limits). Therefore, they can be stressed with several 100-1000 pulses with almost no impact on the electrical characteristics.

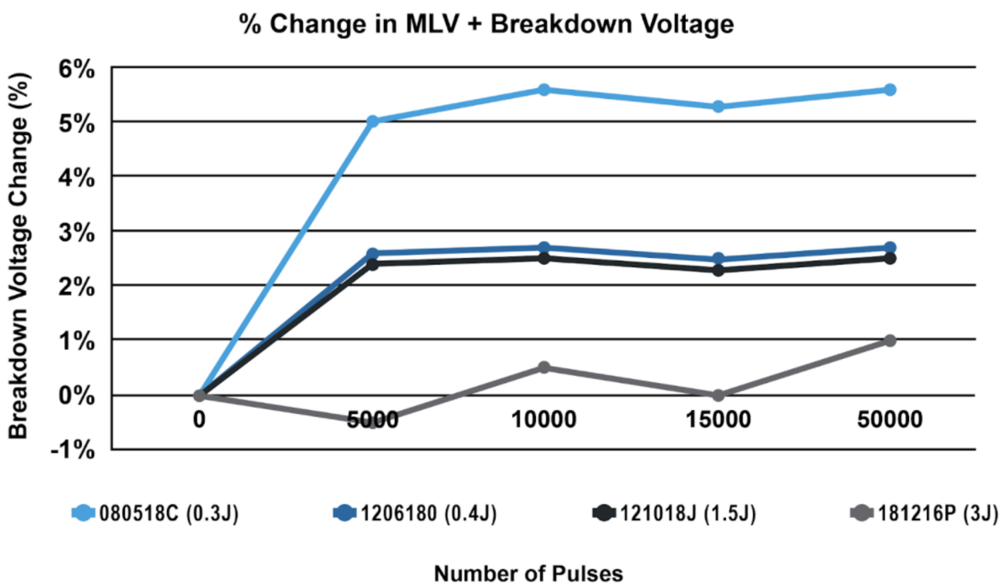


Figure 8: Percent Change in MLV Breakdown Voltage Over Multiple Strikes

THE PRINCIPLES OF VARISTOR SELECTION

SELECTING THE RIGHT MLV

Selecting the right MLV solution for a circuit involves identifying the ESD energy the circuit may experience and then selecting the part that protects against that energy and that best fits into the circuit design. Figure 9 is a flowchart designed to help determine the right varistor for an application.

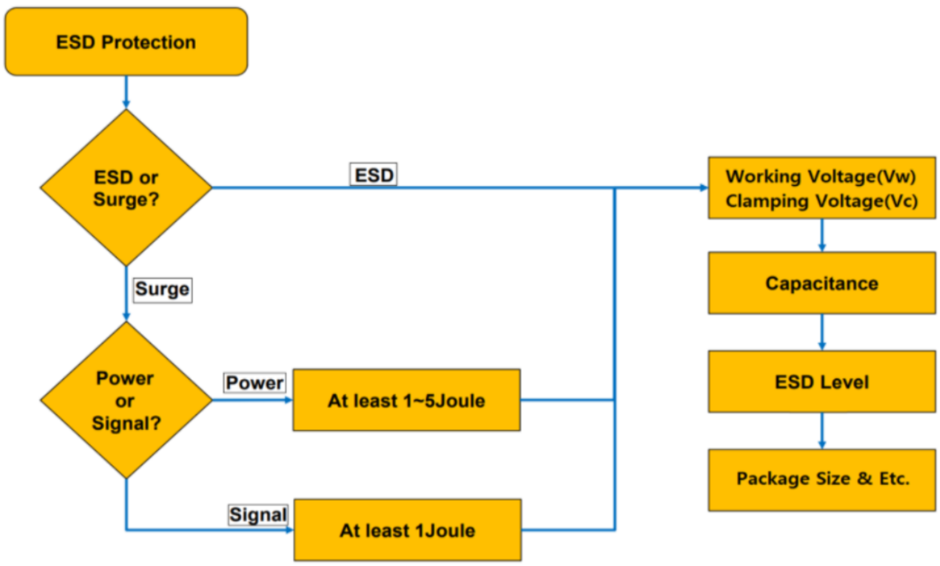


Figure 9: Flowchart for Determining the Right Varistor

Using figure 9, designers can identify the critical parameters for the varistor. The ideal KYOCERA AVX varistor can then be selected for any application using the selection table.

VARISTOR SERIES	BUS	DATA SPEED	
Sub pF AG Automotive Series, Antenna PowerGuard	HDMI T1 Ethernet	3.2 Gbps 1 Gbps	High Speed
AntennaGuard/Sub pF AG Automotive Series, Antenna Power Guard, Miniature AC	1394A MOST TTP	400 Mbps 45 Mbps 25 Mbps	
FlexRay	FlexRay	10 Mbps	
CAN, FlexRay, AntennaGuard	TTCAN CAN	1 Mbps 1 Mbps – 50Kbps	
TransGuard Automotive Series, StaticGuard Automotive Series, Radial Series, Miniature AC	Safe-by-Wire LIN	150 Kbps <20 Kbps	Low Speed
TransGuard Automotive Series, StaticGuard Automotive Series, Radial Series, Miniature AC, TransFeed Automotive Series	ALL		Power Line
TransFeed Automotive Series, Controlled Capacitance	10-100Mbps		Cut Off Frequency
Radial CapGuard	ALL		Power Line Broad Frequency Filtering

Figure 10: KYOCERA AVX Varistor Series Selection Guide

SELECTING THE RIGHT MLV

	Working Voltages and Energy Ratings (10 Strikes)								
Voltage Rating Energy	5V Low	5V High	9V	14V	16V – 26V	30V – 38V	42V – 48V	56V – 65V	85V
VCAS 0402		12kV	16kV	25kV	30 kV				
VCAS 0603		12kV	25kV	30kV	30kV	30kV			
VCAS 0805	16kV	25kV	25kV	30kV	30kV	30kV			
VCAS 1206	16kV	25kV		30kV	30kV	30kV	30kV	30kV	
VCAS 1210					30kV	30kV	30kV	30kV	30kV
VGAS 1210					30kV	30kV	30kV	30kV	30kV
VGAS 1812					30kV	30kV	30kV	30kV	30kV
VGAS 2220					30kV	30kV	30kV	30kV	30kV

Figure 11: KYOCERA AVX Varistor Series Voltage and Energy Matrix

KYOCERA AVX MULTILAYER VARISTORS FOR OVERVOLTAGE PROTECTION

KYOCERA AVX multilayer varistors, with a unique high-energy multilayer construction, provide overvoltage circuit protection and protection from voltage transients caused by ESD. They also offer EMI/RFI filtering in the off-state, replacing the need for additional EMC capacitors in the system. KYOCERA AVX MLVs are available for applications including inductive switching, automotive-related transients, NEMP, lighting, and more.

For more information on KYOCERA AVX multilayer varistors, visit the KYOCERA AVX website.

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