TECH BRIEF

ESD Suppression Technologies

ESD Suppression Basics

Integrated circuits (IC's) and application specific integrated circuits (ASIC's) are manufactured with various levels of ESD protection incorporated into the silicon die itself. This protection circuitry is designed onto the chip to maximize yields in the chip foundry and in the board manufacturing facility. Examples of these chips (which are the "brains" of today's electronic products) include microprocessors, USB transceiver chips, IEEE 1394 controllers, and video graphics chips. The are used in a host of devices such as computers (and peripherals), cell phones, PDA's, flat panel LCD displays, and network hardware.

The trade-off for the chip designer is ESD protection versus die space. As more ESD protection structures are incorporated into the chip, its survivability is increased, but less space is available for functional circuitry, or the chip has to be made larger. In today's electronic equipment, the overriding philosophy is "smaller is better". So a limited amount of space will be sacrificed for ESD protection.

The typical maximum level of ESD protection included in modern chips is 2,000 V. While this is sufficient to improve survivability in the manufacturing process, much higher ESD levels will be experienced when the final product is put into use. The "base" level of protection is sufficient because the manufacturing environment requires the use of ESD-minimizing treatments. Humidity and ionization controls are used, workspaces are grounded, and personnel wear anti-static or static dissipative clothing.

However, once the end product (computer, PDA, printer, etc.) is put into service, it will be exposed to ESD levels higher than those experienced in the manufacturing environment. Unless ESD is prevented from getting onto the circuit, or supplemental protection is added to circuit, the product can be rendered useless due to interaction with the user. Obviously this represents an issue with respect to product reliability. The "supplemental protection" includes the use of ESD suppressors.

Figures 1 and 2 illustrate how the ESD suppressors "re-routes" the ESD transient so that the chip is not damaged.

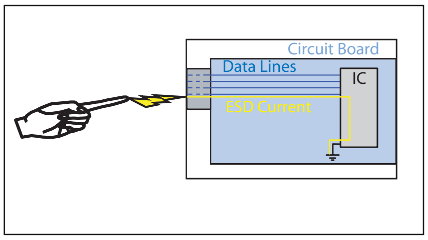

Figure 1. Electronic Device - ESD transient is conducted directly into the chip via an unprotected data line

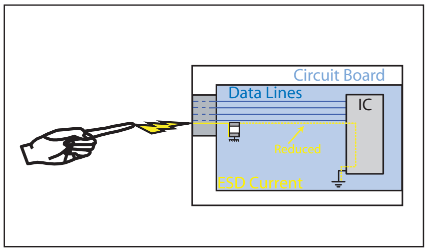

Figure 2. Electronic Device - ESD suppressor clamps the transient, thus limiting ESD current to the chip

ESD Suppression Technologies

Littelfuse offers three distinct product families that can be used for ESD suppression. These include the electroceramic MLV (MultiLayer Varistor), silicon (SP72x and SP050x) and polymer-based PulseGuard® suppressor products. Each family has attributes that differentiate it from the other technologies, but, in general, they are all effective solutions for ESD suppression.

These technologies will protect the sensitive circuitry against external threats (such as user-generated ESD). Further, the MLV and SP72x products can also protect against system generated transients such as EFT's (Electrical Fast Transients) and surges (switching transients and lightning).

These technologies protect the circuit by "clamping" the transient voltage to a safe level, above the circuit operating voltage (3.3, 6, 12VDC, etc.). The energy that would have gone into the circuit (and caused damage) is dissipated by the ESD suppressor and the source of the ESD.

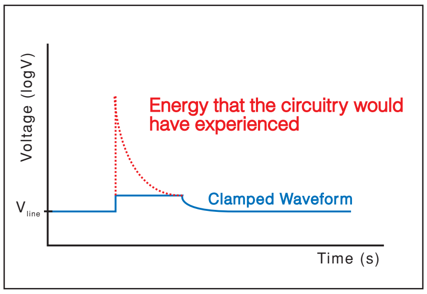

Figure 3. ESD waveform

ESD Suppressor Review

Multilayer Varistors (MLVs)

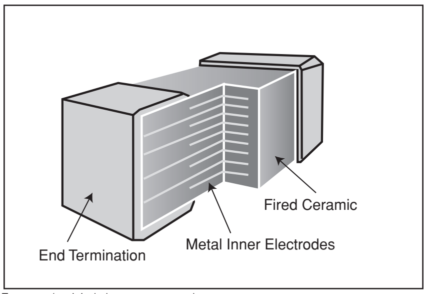

Figure 4. Multilayer internal construction

The MLV products are manufactured by interleaving metal electrodes and Zinc-Oxide ceramic layers. The Zinc-Oxide ceramic acts like an insulator during normal circuit conditions. However, when the voltage is elevated (as in an ESD event), the grain boundaries of the Zinc Oxide crystals transition from high to low resistance to shunt the transient from the protected line to ground.

MLV's are the most robust of the ESD suppression technologies and can be used to protect lines (power and communications) that have operating voltages of 3.5 to 120VDC (2.5 to 107VAC). They can also be used to provide protection against Electrical Fast Transients (EFT's). Additionally, their inherent capacitance (65-4,500 pF) can provide filtering against high frequency interference.

A new family of MLV products has been added which addresses size and capacitance issues. The MHS series is available in the 0402 package size and has capacitance values of 3pF and 12pF. The MHS products can be used where data speed is high (up to roughly 125Mbps) and space is a prime concern.

SP72x Series- SCR/Diode Arrays

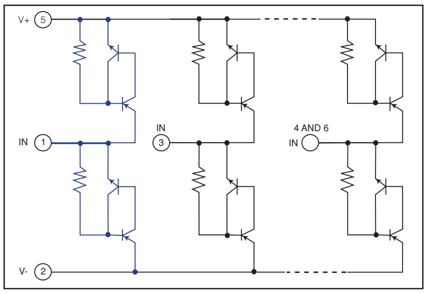

Figure 5. SP72x functional block diagram

The SP72x products are comprised of multiple SCR/Diode cells (one cell is highlighted in blue) that conducts the transient to the power (V+) or ground (V-) rails. Simply put, the cells functions like switches. Using pin 1 as an example, once the transient exceeds the V+ voltage (pin 5) by 0.7V, the upper leg conducts to the V+ rail. Likewise, once a negative transient falls below the ground voltage by 0.7V, the bottom leg will conduct to the V- rail (pin 2). In this manner, the transient is shunted from the protected line (pins 1, 3, 4, and 6 in this example) to V+ or V-.

SP72x products are robust devices that can protect communication lines from ESD, and higher energy transients like Electrical Fast Transients (EFT's) and surge events. They have low capacitance (3-5 pF) and can be used to protect communication lines that operate at high speeds (up to approximately 125Mbps).

SP05xx Series TVS Avalanche Diode Arrays

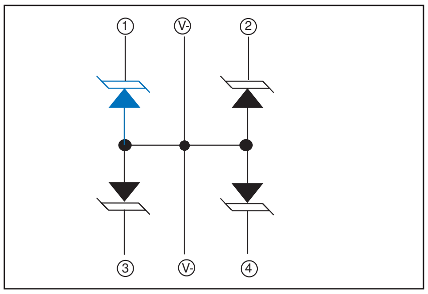

Figure 6. SP05x Series TVS Avalanche Diode Arrays

The SP05xx products are comprised of multiple TVS avalanche diodes (one diode is highlighted in blue) that conduct the transient to the ground (V-) rail. Simply put, the diodes function like a switch. Using channel 1 as an example, once the transient exceeds the breakdown voltage of the diode, the transient's current is conducted to the V- rail. At the same time, the voltage of the transient is clamped to a low value.

SP05xx products are available in a wide variety of package styles and number of lines of protection. Package options include SOT-23, SOT-143, TSSOP, MSOP and chip scale package (CSP). The number of lines of protection range from one to eighteen with capacitance values ranging from 3-39pF, making them suitable for the protection of data lines that operate at medium to high speeds (roughly 100 Kbps to 125Mbps).

PulseGuard® Suppressor Polymer Voltage Variable Material

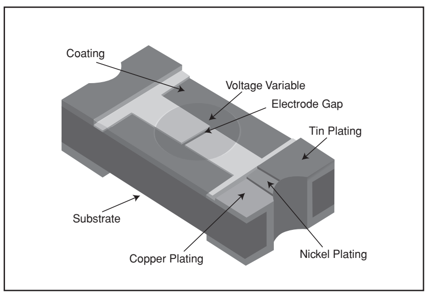

Figure 7. PulseGuard suppressor structure

The PulseGuard suppressor products are manufactured by creating a gap in an electrode that connects two end terminations. The gap causes the two terminations to be electrically discontinuous (current cannot flow). Into the gap, a polymer-based material is back-filled. This voltage variable material (VVM) has similar electrical characteristics to the Zinc-Oxide material of the MLV's. Under normal circuit conditions, the VVM acts like an insulator, but when an ESD transient occurs, the VVM transitions to a conductor and shunts the ESD to ground.

PulseGuard suppressor products differ from the MLV's and SP72x's in that they can only be used for ESD protection. The polymer material is not capable of withstanding the higher energy levels of EFT's and surge transients. On the other hand, PulseGuard products have the lowest capacitance (.050 pF) of the suppressor technologies and can be used to protect communication lines that operate at speeds up to 3-5 Gbps.

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