

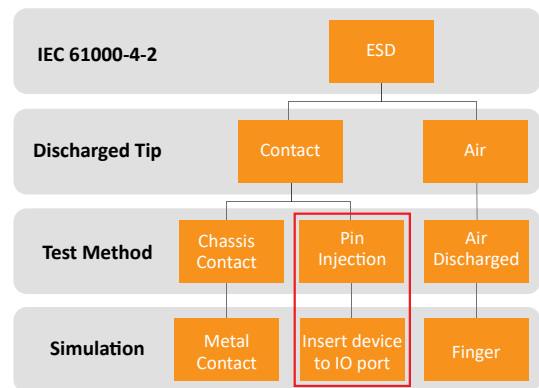
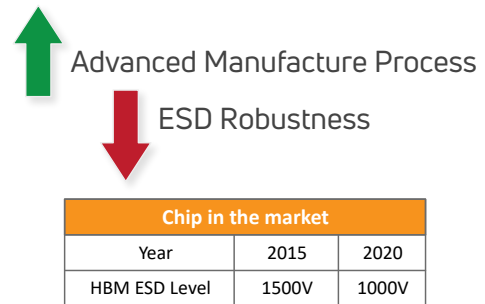
Transient Voltage Suppressor : Best ESD protection solution for advanced application.

- William Huang, FAE

ESD protection – An unavoidable design task in the future

With higher transistor density of an IC, Electrostatic Discharge (ESD) robustness level of an IC is lower than before. This low component-level robustness can only protect the chip in a well controlled environment such as factory or laboratory. IC cannot take higher transient events when it is used in field. To prevent the IC from damage at the end customers, product designers use the system-level ESD test method based on IEC 61000-4-2 (ESD) to verify the product before it is released. ESD air discharge and ESD contact discharge are common ESD test method. Besides, designers may additionally do EOS test based on IEC 61000-4-5 to simulate the power switching surge or lightning couple.

In other words, product will still take strict test but chip robustness is weaker than before. Adding effective external clamping components in device becomes a basic and important design.



Varistor - ESD protection solution in the past

Several years ago, IC robustness was high enough to take high energy ESD strike. Besides, large PCB area and metal chassis helped the device discharge overloading energy to ground smoothly and quickly. All benefit for grounding condition made the devices stable when it faced ESD events. Therefore, designer chose to add varistors as protection components in case the energy of the transient event was higher than maximum tolerance of the device.

Varistors are protection components made by ceramic, and varistors will not be triggered before voltage reached its trigger voltage. Once the transient event voltage is

higher than trigger voltage, varistors will create a conductive path and bypass current to ground. Also, varistors will clamp the voltage at its clamping voltage to keep system working normally. After the transient event, varistors will turn off and wait for next ESD event.

However, trigger voltage and clamping voltage of varistors are both high. Even though the destructive current is released to ground, high clamping voltage of varistors may also damage the system sometimes. Furthermore, because of the material and structure, aging issue of varistors should be considered as a severe reliability issue.

TVS – Best Solution for modern application

Transient Voltage Suppressor, TVS, is a clamping component with low clamping voltage and low trigger voltage. Besides, lots of data traces are used in advanced application, and TVS can be easily designed in multi-channel array package; therefore array package TVS can be easily used to some applications like USB, HDMI or Display Port. In addition, TVS is manufactured by semiconductor process, so there is no aging issue of it.

Nowadays, because IC is manufactured by advanced semiconductor process and embedded more transistors in it, IC is more susceptible to the disturbance from the surroundings than before. High voltage transient events may induce system unpredictable reaction and it may result in temporary software faults or permanently hardware damaged.

Besides, more companies regards “pin injection” as an ESD qualification method. This is a rigorous ESD contact discharge method used to simulate customers’ operation like cable or portable device plugging.

TVS is the best solution of protecting the system from ESD events because of its low trigger voltage and low

clamping voltage. Low trigger voltage of a TVS makes it trigger immediately once there is a transient high voltage. After TVS is triggered, it will clamp the voltage at suitable level to keep the system working normally or prevent it from damage. Then TVS will turn off, and wait for another transient event.

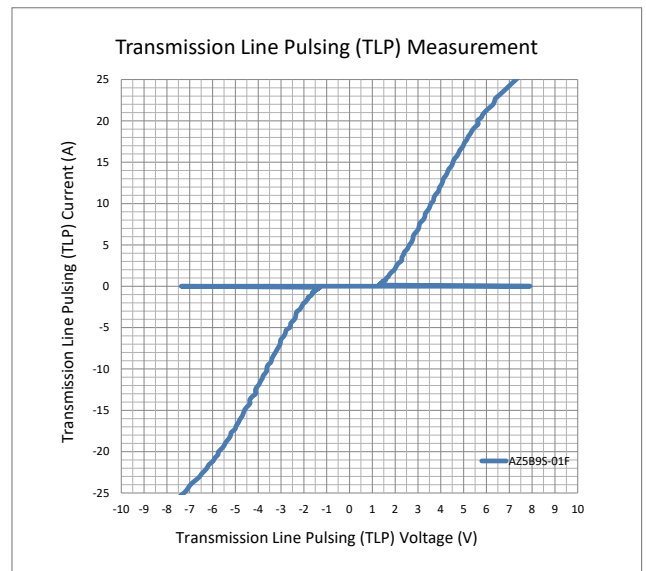


Figure 1. TLP curve of TVS products AZ5B95-01F

	Varister	TVS	Comments
Trigger Voltage	High	Low	Turn on condition
Clamping Voltage	High	Low	Protection ability
Aging issue	Yes	No	Stability
Package	Single channel	Array	Cost and Design

AMAZING and ESD

Amazing Microelectronic has been doing the research on ESD or EOS for more than 20 years. We keep following up the latest trend of application and making the product meets customers’ require the most. Now we have ESD protection solutions for USB4, HDMI 2.1 and DP 2.0. We also have automotive transceiver IC and ESD solution for CAN Bus or LIN Bus. In addition to common solutions, we have some special designed TVS to save PCB area and BOM cost. We designed different electrical

characteristics TVS in one package to make layout simple, and we also designed an additional back-drive diode inside to save BOM cost.

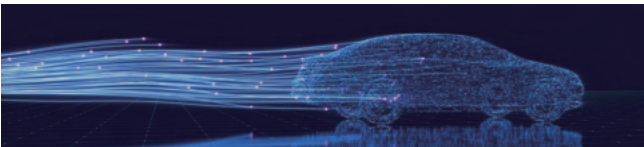
Amazing Microelectronics is specialized in ESD protection solution and our market share of ESD protection devices stands in top 3 in the world. Directly collaborating with brand and ODM customers make us always follow up the latest trend of market.

Application



1. USB4

USB type-C connector is used for USB4 application. There are TX/RX, D+/D-, CC/SBU and power pins inside this connector. For TX/RX, AZ5B9S-01F is one of the most powerful TVS with ultra low capacitance (0.18pF) and AZ5B9S-01F can be used to protect 20Gbps data transmission. D+/D- and CC/SBU can be protected by another small, low capacitance and good clamping voltage TVS – AZ5B85-01B.



2. Automotive

CAN Bus and LIN bus are data transmission standard designed for devices communicating with each other in a vehicle. AZ9424-02S is an AEC-Q101 qualified two-channel TVS for CAN_H and CAN_L of CAN Bus. AZ9424-02S can protect both CAN_H and CAN_L in one TVS and its clamping voltage is low. AZ9824-01L is AEC-Q101 qualified as well and it can be used for LIN Bus.

Besides CAN Bus and LIN Bus, some entertainment interface, like USB, are set in infotainment system for charging or data transmission. AZ9143-04F is AEC-Q101 qualified TVS for USB 3.0 .



3. HDMI 2.1

The TMDS/FRL differential pairs are always pulled high to 3.3V; therefore, it should be protected by 3.3V TVS. HDMI 2.1 can support up to 48Gbps, so lower capacitance TVS is necessary. AZ1123-04F is one of Amazing powerful 3.3V TVS array with ultra-low capacitance and low clamping voltage TVS. The high peak pulse current tolerance makes it robust enough for high transient energy. For the other lines of HDMI, we offer a special TVS – AZC199-04S. It can be used to protect control pins and Vcc pin. The most special design of AZC199-04S is that there is a backdrive diode embedded inside. In other words, AZC199-04S saves PCB area, cost, and one backdrive diode as well.



4. 10G LAN

Ethernet always need to do higher transient energy test like IEC61000-4-5, GR 1089 and so on. The surge robustness of a TVS should be considered. AZ5B0S-01F maximum peak pulse current tolerance is 7A. Besides, AZ5B0S-01F is a special designed TVS with low capacitance for high speed transmission. Therefore, it can be used in 10G LAN application.

How to pick up the right TVS?

1. Operation voltage

In normal operation condition of system, TVS should not be triggered, so operation voltage of a TVS is the parameter which must be considered first. When the TVS is at off state, its leakage is under $1\mu\text{A}$. Once it was triggered, it will quickly become a low impedance component and bypass most of energy to ground.

2. Clamping voltage

This is the parameter used to describe the protection capability of a TVS. When ESD event happens, TVS will turn on immediately. Then it will bypass most of energy to ground, and clamp the voltage at suitable level to keep the system stable. If the TVS clamp the voltage at a high value, system may still be disturbed or damaged. Therefore, lower clamping voltage TVS is the better TVS.

Clamping voltage is the data we get from TLP (Transmission Line Pulse) diagram. TLP diagram can help us to know detailed electrical information of a TVS. Besides, we can easily compare two different TVS clamping voltage in different ESD condition by TLP diagram. Then we follow “The lower clamping voltage, the better TVS” rule, we can pick up the TVS we need.

3. Capacitance

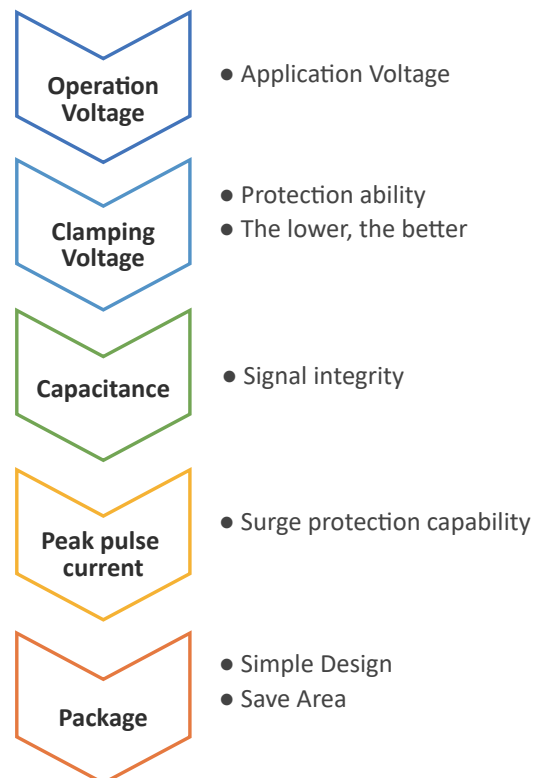
This is the factor which will affect signal integrity and quality. In some super-speed data transmission applications, it is necessary to use low capacitance TVS to avoid data distortion. Also, some specifications will list the impedance test, like TDR test, and capacitance is one of the factors which will affect the results.

4. Peak pulse current(Ipp)

This parameter represents surge transient energy robustness of a TVS. If you conduct the surge test according to IEC 61000-4-5, peak pulse current should be considered when you are picking up the TVS. Sometimes, this parameter will be written as peak pulse power; however, we advise to directly check this parameter with current unit.

5. Package

Even though single channel TVS is the most common package in the market, it takes lots of PCB area comparing to array package TVS especially for high speed applications with lots of data traces. TVS array package makes design simple, and it is flexible for different applications. Array package can be designed as a total solution for some specific applications by combining different electrical characteristic TVS.



Conclusion

The scaling trend of the semiconductor industry leads to a reduction in IC component-level ESD robustness. The phenomenon that system-level protection device change varistors to TVS shows that external protection is becoming more and more important. Amazing Microelectronic is one of the top companies which

specialized in ESD protection solutions. With the knowledge, experience and always following the hi-tech trends, Amazing will always provide the best products to the latest applications.

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