Automotive electronics advances usher in a greater need for circuit protection

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 Every year, the automotive industry introduces more features that leverage advanced electronics. Many of these new electronics features are marketed for occupant safety, entertainment and conveniences. Vehicles are introduced with systems for blind spot warnings, lane departure warnings, accident warnings, parking assistance, and much more. This is in addition to established electronics systems - stereos, navigation, LCD displays, and critical basic control and power systems. It is more important than ever to protect the circuitry of these advanced automotive electronics systems. Providing proper circuit protection helps ensure safety while reducing warranty and service related costs for manufacturers.

The Automotive Electronics Council (AEC-Q101) provides standards for automotive circuit protection. This includes: AEC-Q101-001 (electrostatic discharge [ESD] test - human body model); AEC-Q101-002 (ESD test - machine model); AEC-Q101-003 (wire bond shear test); AEC-Q101-004 (miscellaneous test methods such as unclamped inductive switching, dielectric integrity, and destructive physical analysis); and AEC-Q101-005 (ESD test - capacitive discharge model).

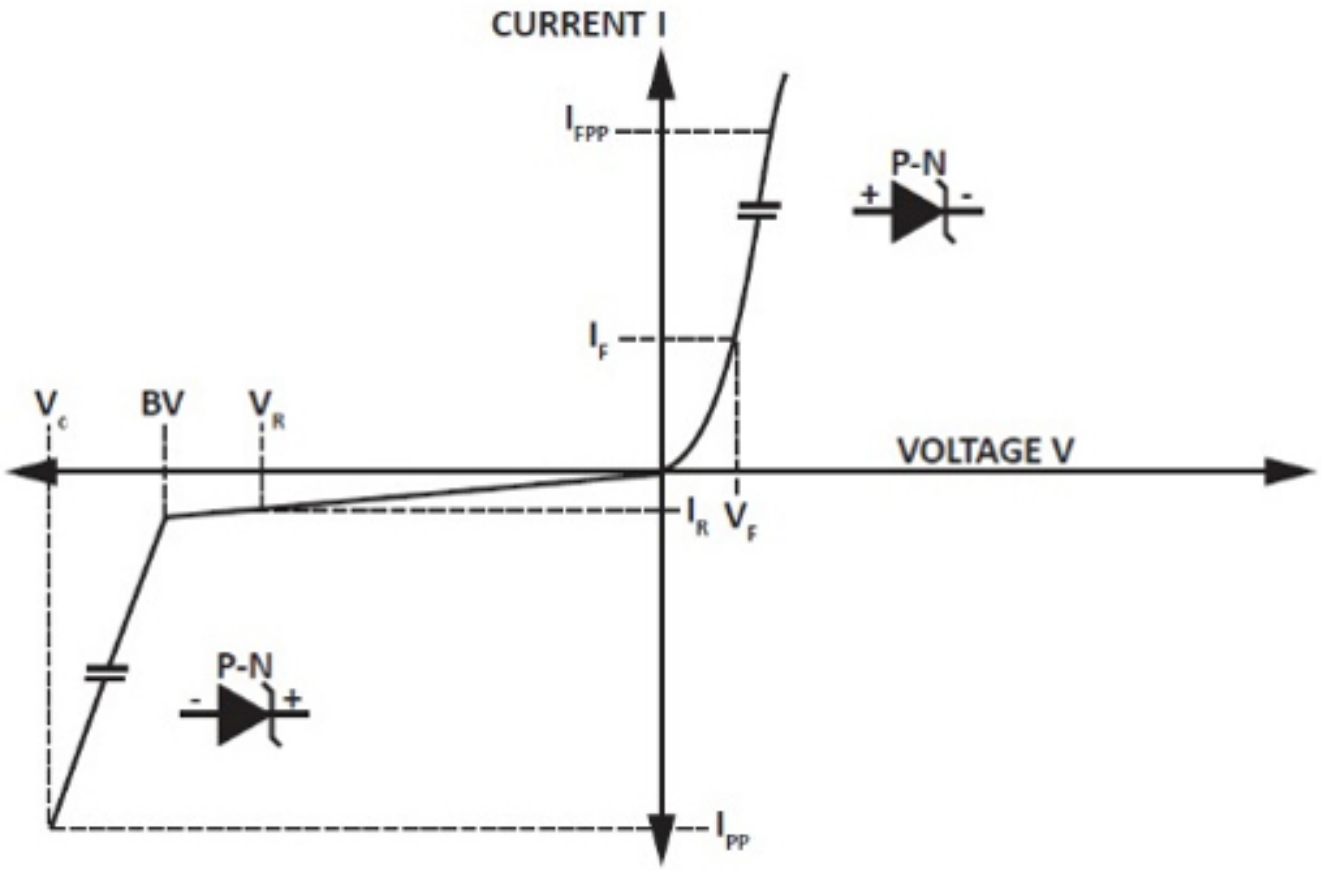
Using these standards, circuit protection component manufacturers can provide solutions to prevent circuits from damage by unexpected electrical fast transients (EFT). There are many critical automotive systems requiring protection. The information / entertainment network system includes high speed optical network information. This system provides traffic and other information, the vehicle communications link, video and audio, etc. The body network includes a low-speed multiplex network for data body messages and switches. This typically covers displays, lighting, power features, HAVC, etc. The chassis network typically consists of a proprietary OEM network for safety-critical systems. This includes steering control, powertrain, chassis control, ABS brakes, etc. Finally, the power network system is made of a power distribution network of 14/42 volts. This covers fusing,

junction boxes, the main power, wheelhouse (W/H), etc.

There are various typical electrical transients that occur inside these automotive environments, which vary in frequency of occurrence, duration time, and more. For this reason, circuits within automotive electronic systems require circuit protection components designed specifically for the likely electrical transient event. Transient voltage suppressor (TVS) diodes have long been used and proven effective for automotive circuit protection.

TIME DURATION	CAUSE	VOLTAGE AMPLITUDE	ENERGY LEVEL	FREQUENCY
200ms	Load Dump (Disconnection of battery while at high charging)	< 125V	> 10J	Infrequent
Steady State	Failed Voltage Regulator	18V	-	Infrequent
< 320?s	Inductive Load Switching	80V to 300V	< 1J	Often
200ms	Alternator Field Decay	-100V to -40V	< 1J	Each Turn-Off
90ms	Ignition Pulse, Battery Disconnected	< 75V	< 0.5J	< 500Hz Infreq
1ms	Harness Coupling	< 200V	< 1J	Often
<50ms	Electrostatic Discharge	< 15kV	< 10mJ	Infrequent

Silicon TVS diodes contain a P/N junction similar to a Zener diode but, with a larger cross section which is proportional to its surge power rating. These diodes are clamping devices that limit voltage spikes by the low impedance avalanche breakdown of the P/N junction.



The V-I curve shown in figure 1 is similar to that of a Zener diode. However, TVS diodes are designed and characterized for transient voltage suppression, while Zener diodes are designed and specified for voltage regulation. With a TVS diode, an electrical transient is clamped instantaneously and diverts the damaging current away from the protected device.

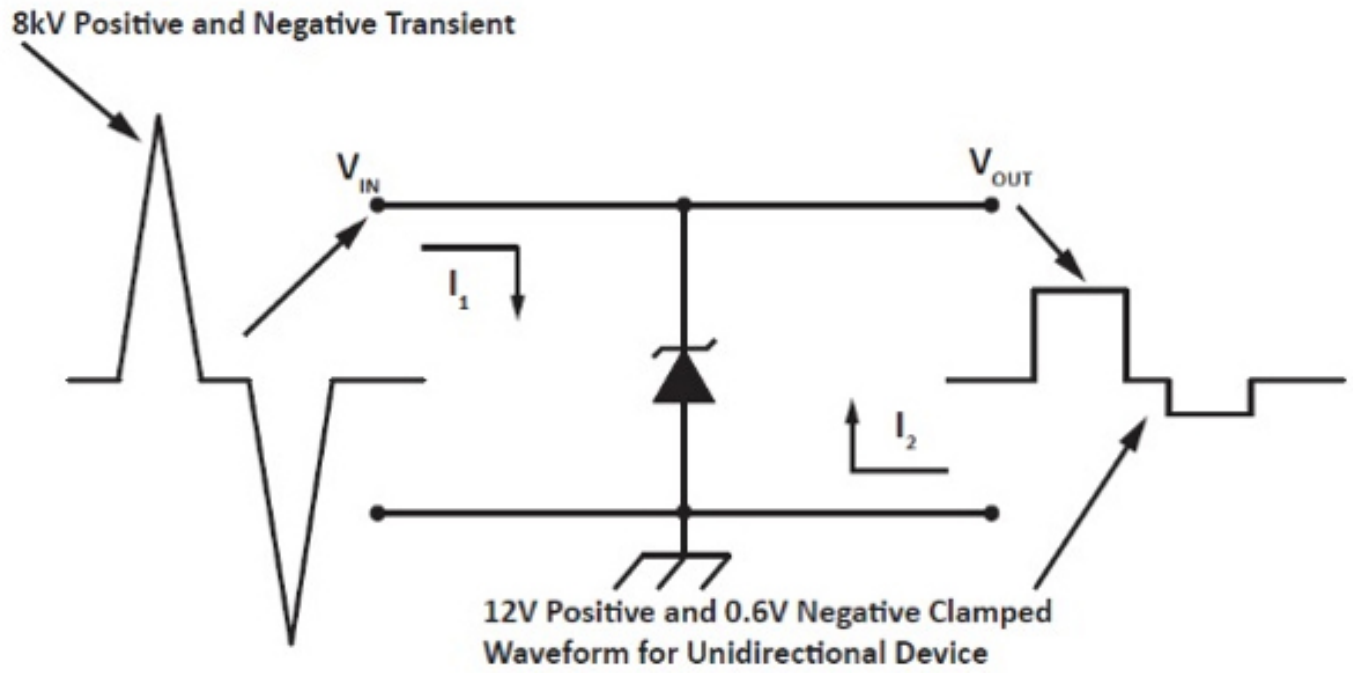


Figure 2 shows an electrical transient current being diverted to ground. Under normal operating conditions, the TVS diode presents a high impedance path to the protected circuit. During the transient event, the TVS diode achieves breakdown. It then presents a low impedance path, which shunts the transient current through the TVS diode device.

TVS diode solutions
The ESD association has estimated the average loss of product due to user-generated ESD at 27% to 33% annually. This is in large part due to improper circuit protection for automotive electronics systems. It is a significant operational cost to the industry. Proper circuit protection is a large opportunity for the automotive industry to reduce these losses. With continued dependence growing on electronics systems, the need for circuit protection will only magnify. TVS diodes can help automotive manufacturers protect their design investments by preventing system and component failures caused by ESD, EFT and other transients.

A TVS device with the proper characteristics for a given automotive application should prevent system / component damage. It should also optimize circuit performance. There are many key parameters for TVS device selections to best suit a specific automotive application. Here’s a summary:

Stand-off voltage

This amounts to the maximum continuous DC or peak voltage that may be applied over the standard operating temperature range. V_{WM} is normally 10 percent below the breakdown voltage (V_{BR}).

Breakdown voltage (V_{BR})

This is the voltage measured across the device at a specified pulsed DC current (I_T

or I_{BR}) on the V/I characteristic curve at or near to where the breakdown (avalanche) occurs. It's also known as the voltage across the device in the breakdown region prior to the switching point at a specified breakdown current (I_{BR}).

Leakage current (I_D)

This is the maximum current that flows through the device at the rated stand-off voltage (V_{WM}) for a specified temperature. It's also known as reverse leakage current (I_R).

Capacitance (C)

This parameter is associated with high data rate applications and is measured at a specific frequency and bias. High capacitance degrades signals.

Forward voltage (V_F)

This is the voltage across the device in the forward conducting state at a specified current (I_F).

Clamping voltage (V_C)

This is the peak voltage measured across the device during the application of a pulse current (I_{PP}) for a specified waveform.

Peak pulse current (I_{PP})

This is the maximum current handling capability for a given pulse duration (td). The current capability is referenced to a specific waveshape – for example 8/20µs or 10/1000µs – and is not constant over time.

Peak pulse power (P_{PP})

This is the maximum clamping voltage (VC) multiplied by the maximum peak pulse current (I_{PP}), where the maximum clamping voltage is considered independent of time.

In addition, automotive manufacturers should ensure the use of lead-free devices. This will help meet many country's restrictions on the use of hazardous substances in electrical equipment as stated in (RoHS) direction, 2002/95/EC. Thus, it's also important that devices meet RoHS and REACH compliance. There are six banned substances not to be used: lead (Pb, <1000ppm); cadmium (Cd, <100ppm); mercury (Hg, <1000ppm); hexavalent chromium (Cr6+, <1000ppm); poly brominated biphenyls (PPB, <1000ppm); and poly brominated diphenyl ethers (PBDE, <1000ppm). In addition there is a requirement that lead not exceed 0.1% by weight in homogeneous materials.

Today’s automobiles leverage electronics systems like never before for convenience, entertainment and important safety features. This will continue to expand as electronics provide automotive manufacturers the opportunity for differentiated features. But with this change comes the reality that improper circuit protection can cost each automotive manufacturer more money in failed devices. Leveraging TVS diode technology for circuit protection is a cost-effective method to corralling such costs and to helping ensure automotive safety.