Understanding the Importance of ESD Standards in Designing Automotive Electronics

By: James Colby, Littelfuse, Inc.

Within the past decade, the safety and reliability standards for automotive electronics have changed significantly as new technologies have evolved. Technologies that used to be sold as options, including stability control and antilock brakes, are now offered as standard features in most vehicles. Today's innovative automotive electronics enable lane departure warning, vehicle communications and night vision.

This shift in design and manufacturing mandates that designers understand the demands of the automotive certification standard that extend beyond the protection requirements for consumer electronics. However, designing for the automotive standard involves several technology challenges. As automotive integrated circuits continue getting smaller and faster, they become more susceptible to damage from electrostatic discharge (ESD). In addition, the automotive environment is marked by harsh electrical transients, which are simulated during automotive certification testing.

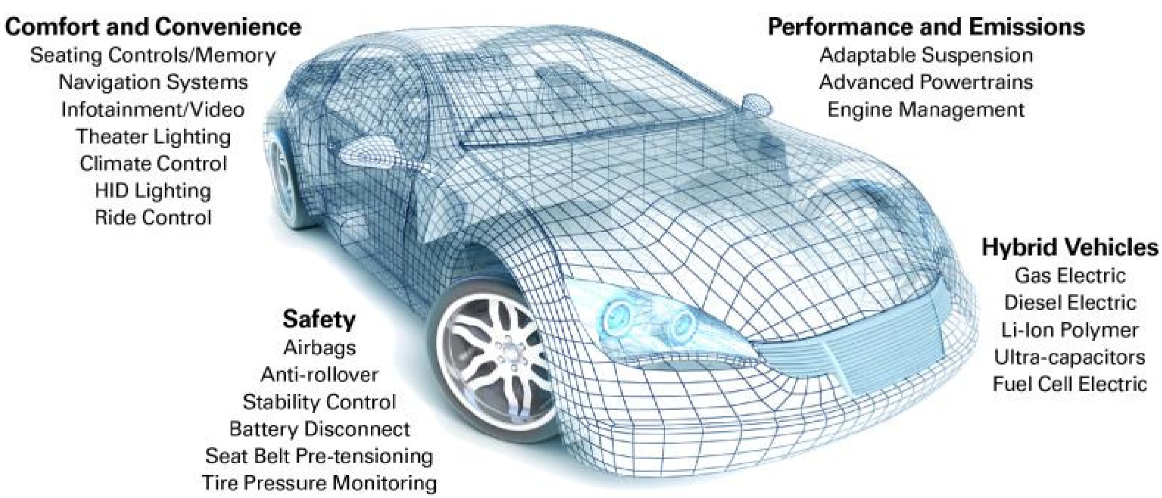

Figure 1. Systems requiring consideration of ESD protection

This article makes practical application of automotive standards, circuits and solutions to help circuit designers create robust, reliable designs. First, it highlights the testing requirements of two test standards and discusses the most common types of automotive circuits requiring protection. Then, it identifies advanced circuit protection technologies for several automotive applications that should be implemented early in the design phase to ensure safety and reliability.

Measuring Up to Automotive Test Standards

Circuit designers must consider the requirements of the ISO 10605 and AEC-Q101 test standards for their advanced vehicle electronics to be qualified for the automotive market.

ISO 10605

This international standard specifies ESD test methods for evaluating electronic modules developed for use in road vehicles. The modules must be able to manage electrical disturbances caused by assembly, maintenance/repair and operation. For ISO 10605 compliance, every circuit and module must be pre-tested before being added to the vehicle. Once the assembled car is ready, it must also be tested to ensure safety and reliability.

AEC-Q101

While ISO 10605 focuses on electrical hazards, AEC-Q101 is an environmental specification. It describes a series of qualification tests that ensure the long-term reliability of semiconductor-based components in the automobile. ESD protection devices such as transient voltage suppression (TVS) diodes and TVS diode arrays must increasingly conform to the AEC-Q101 standard for a vehicle manufacturer to add them to a vehicle. AEC-Q101-compliant components must be able to handle thermal shock and cycling, extreme temperatures and high humidity.

Identifying Automotive Circuits Requiring Protection

All circuits and components are susceptible to damage from electrical transients—regardless of their location within the vehicle. The following list identifies the four most common circuits requiring protection:

1. **Legacy two-wire communication buses:**
    a. **Controller area network (CAN):** This standard allows microcontrollers and devices to communicate within a vehicle without the use of a host computer. CAN systems handle a variety of functions—from power steering to the critical drive-train communications between the engine computer and the transmission.

    b. **Local interconnect network (LIN):** This serial network protocol is used for communication between components in the vehicle. LIN buses manage simple electromechanical functions such as moving the power seats and toggling the cruise control.

    CAN/LIN buses have a high chance of transient surge exposure, which can cause unprotected CAN/LIN transceivers to fail. Figure 2 illustrates practical strategies for CAN and LIN bus protection:

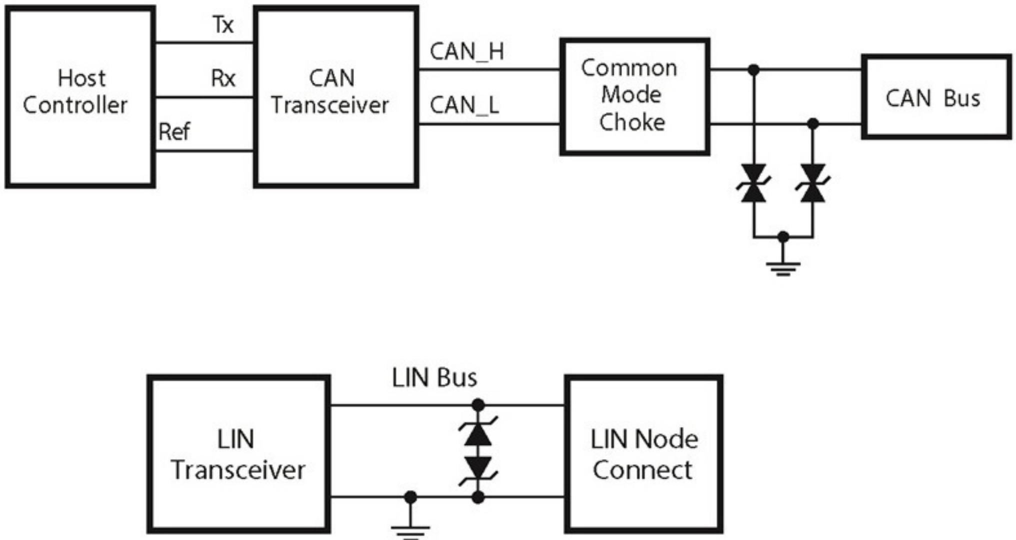

Figure 2. CAN and LIN bus protection schematics

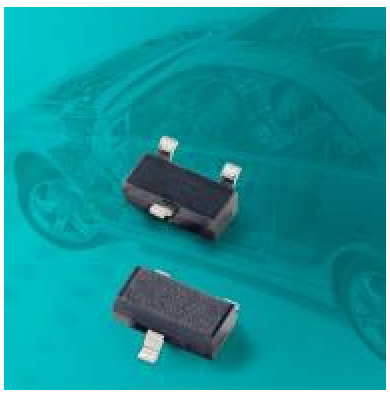

Figure 3. SM24CANA TVS Diode Array from Littelfuse safeguards CAN bus

2. **High-speed digital buses:** USB/HDMI ports support consumer applications within the vehicle. For instance, the dashboard may contain a USB port for passengers to use to charge their phone/tablet or to play music. HDMI ports are also being used for backup and forward-looking cameras in vehicles. With faster throughput and greater chip sensitivity, these ports require outstanding signal integrity and system reliability. USB/HDMI ports could be damaged by relatively small ESD events and short circuits within the automobile.

3. **Wi-Fi communication/SIM socket:** This technology allows the vehicle to offer cellular 3G or LTE communication to the passengers. The SIM module is the intermediary part of the circuit that will convert LTE to Wi-Fi, allowing users to connect to phones, tablets and laptops. The SIM socket requires ESD protection because it will be subjected to human interactions when the module is installed or replaced in the vehicle.

4. **High-frequency communication/RF:** This technology is supported by short-range RF circuits that enable vehicle-to-vehicle or vehicle-to-road communications. The network allows cars to see each other and communicate from vehicle to vehicle, which may help prevent collisions and enable smart traffic systems. The front ends of the RF amplifiers tend to be very sensitive to ESD. Unbiased RF signals will generate positive and negative polarity voltages on the antenna circuit.

Matching Circuit Protection Solutions to Automotive Applications

Automotive circuit designers may struggle to find high-quality circuit protection solutions since the number of companies that are capable of developing products that meet the AEC-Q101 standard is limited. When selecting a manufacturer, it is vital to verify the company's certifications to ensure that its products meet all applicable industry standards. The company should also follow best practices in product design and utilize high-quality manufacturing processes.

Table 1 identifies several circuit protection solutions that should be implemented early in the design phase:

Application	Solution	Characteristics
CAN/LIN bus	TVS diode array (CAN requires two-channel protection; LIN requires one-channel protection)	Offers ESD (30 kV) and surge protection. Low speed so capacitance is not as important. Bidirectional for positive and negative signals. Low clamping voltage. AEC-Q101 qualified.
USB/HDMI	0.50 pF rail clamp, low-capacitance TVS diode array	Low capacitance so it will not distort the high-speed signal. Multiple-channel array with straight-through routing maintains signal integrity and helps simplify board layout. Low clamping. Absorbs repetitive ESD strikes over the maximum level specified by IEC 61000-4-2 without performance degradation. AEC-Q101 qualified.
High-frequency communication/ RF	0.35 pF, 20 kV bidirectional, discrete TVS diode array with 0402 package	Bidirectional so it does not clip the RF waveform. Low loading capacitance makes it ideal for protecting high-frequency data lines. Compact, single-channel solution works well with small RF modules. Absorbs repetitive ESD strikes over the maximum level specified by IEC 61000-4-2 without performance degradation. AEC-Q101 qualified.
Wi-Fi/SIM socket	Miniature, bidirectional TVS diode array	Helps circuit designers economize on both printed circuit board (PCB) space and costs. Bidirectional configuration provides symmetrical ESD protection for data lines when AC signals are present. Promotes high ESD immunity and superior protection.

Table 1. Characteristics of automotive circuit protection solutions

Figure 4. TPSMA6L Series TVS Diode from Littelfuse offers superior electrical performance in a small footprint

Conclusion

Designing robust automotive electronics requires advance planning for the management of environmental and electrical hazards. Successful design starts with understanding the requirements of the ISO 10605 and AEC-Q101 test standards. Adequate protection is required at each layer of electronics since individual modules as well as the completed car will be fully tested for reliability. The circuit designer should also consider the electrical vulnerabilities of the automotive circuits requiring protection, especially those involving innovative communications and networking. With an understanding of automotive test standards and circuits, the designer can choose the best circuit protection solution for his or her application.

About the Author

James Colby is a manager of semiconductor business development at Littelfuse, Inc. His responsibilities include identifying and developing strategic growth markets as well as introducing new products into those markets. He received his BSEE from Southern Illinois University (Carbondale) and his MBA from Keller Graduate School of Management (Schaumburg). He has been with Littelfuse for over 15 years and has worked in the electronics industry for more than 23 years.