

Application Brief

Automotive SerDes ESD Protection



Matthew Smith

Multiplexers and Protection Devices

Introduction

Automotive display or camera systems typically require serializers and deserializers (SerDes) for data transmission. When using automotive SerDes protocols, it is important to design for protection from ESD strikes to the [IEC 61000-4-2](#) or [ISO 10605](#) standards since these protocols have external connectors. When the cabling is connected to these external connectors, the built-up charge on the cables can possibly cause a high-voltage ESD strike. ESD strikes without adequate protection could lead to catastrophic system failures. ESD diodes are a very efficient and robust way of protecting the systems. In the event of an ESD strike, the ESD diode breaks down and creates a low impedance path that limits the peak voltage and current by diverting the current flow to ground, thereby protecting the ICs in the signal chain. However, to ensure adequate protection, it is important to understand how to properly select and place an ESD diode.

ESD Locations in Automotive SerDes

At a high level, automotive SerDes applications consist of 3 main sections: a serializer, a deserializer, and the cabling connecting the serializer and the deserializer. The cabling in the middle is where ESD events are most likely to occur. The cabling connects the DOUT pins on the serializer side to the RIN pins on the deserializer side. This cabling comes in different configurations; some of them could be: coax, twisted pair, or star quad. Along with the different types of cabling, the signaling comes in the form of single ended or differential.

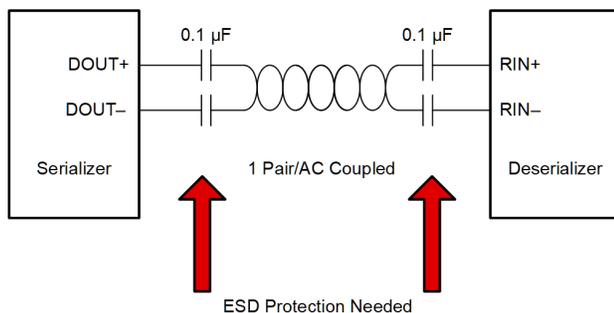


Figure 1. SerDes Block Diagram

Working Voltage Considerations

When using an ESD diode, do not allow the normal operating voltage levels across the line it is protecting to exceed the VRWM of the diode; otherwise, the diode will fail and short the signal to ground. In some automotive SerDes applications, there could be a DC bias across the bus that powers the downstream circuitry. For example, a serializer datasheet might state that the max bus voltage on the output pin is around 2 V, but in ADAS applications using power over coax (PoC), the DC bias can increase the common-mode voltage of the bus up to 9 V. One possible solution to this issue would be to select an ESD diode with a higher VRWM that can handle the additional DC bias. However, having a higher VRWM will result in a higher clamping voltage, which means the output pins of the serializer are more likely to be damaged during an ESD event.

Component Placement for Optimized Protection

In automotive SerDes applications, there is an AC coupling capacitor at the end of each bus line, near the pins of the device. An alternative ESD solution for automotive SerDes applications with an additional DC bias, like PoC, is to place the diode on the SerDes side of the AC coupling cap. In this configuration, the capacitor will be able to filter out the DC bias and lower the voltage back down to normal levels. If there is no DC bias, place the diode as close to the external connector as possible.

One final aspect to consider is the internal ESD protection circuitry the SerDes devices have. According to the [SEED](#) method, the on-chip ESD cell and any external ESD protection, such as a diode, are combined together to give you the total system-level ESD robustness. However, with some automotive SerDes devices, the internal protection circuitry might start conducting before the external diode during an ESD event. This lowers the overall ESD rating of your system since the diode does not conduct. To ensure the diode conducts first during an ESD event and improves the ESD rating of your system, an isolating series resistor might be needed between the ESD source and the DUT pin. A typical

value for an isolating resistance in these applications is about 2-3 Ohms. To determine whether or not an additional resistor is needed, check the pin & bond wire resistance of the SerDes device, the trace resistance on the board, and any other resistive components like common-mode chokes to determine if the total resistance between the diode and the IC equals the minimum required isolation value. Refer to [Figure 2](#) and [Figure 3](#) for more details.

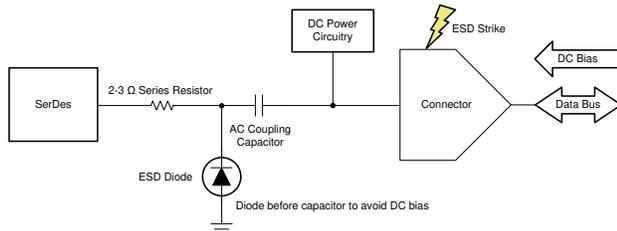


Figure 2. Powered Over Cable

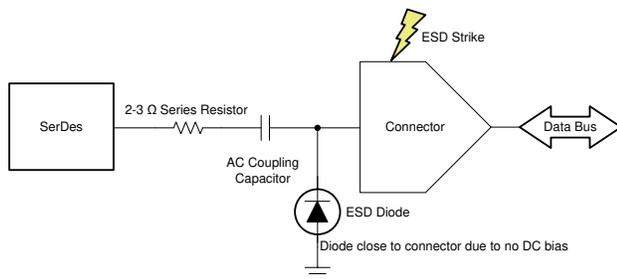


Figure 3. Non-powered Over Cable

Device Recommendations

Automotive SerDes applications require high signal speeds, so keeping the line capacitance of the ESD diodes very low is important to maintaining signal integrity. The diodes also must have good IEC-61000-4-2 ratings and low clamping voltages. TI offers two ESD devices that protect automotive SerDes applications and other high-speed applications such as USB 3.2 very well. [TPD1E01B04-Q1](#) can support signals up to 20 Gbps, and [TPD4E02B04-Q1](#) can support signals up to 10 Gbps. Refer to [Table 1](#) for more details.

Table 1. Device Parameters

	TPD1E01B04-Q1	TPD4E02B04-Q1
# of Channels	1	4
V_{RWM}	3.6 V	3.6 V
Capacitance	0.2 pF	0.25 pF
IEC 61000-4-5 Contact Rating	15 kV	12 kV
Clamping Voltage at 1 A	7 V	6.6 V
Comments	Best for single line protection (ADAS)	Best for infotainment protection (blocks of 4 wires)

Related Documentation

- [System Level ESD Protection Guide](#)
- [ESD Protection for Automotive Infotainment application brief](#)

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to TI's Terms of Sale (<https://www.ti.com/legal/termsofsale.html>) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2021, Texas Instruments Incorporated