Application Report
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Preventing ESD Arcing in a Connector

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1 Introduction

Many interfaces (i.e. cable connectors like HDMI, DVI, USB, etc.) include pins which might not be utilized in a system design. For example, the HDMI Type-A connector's Pin 14 (Utility) can be used for an HDMI Ethernet and Audio Return Channel (HEAC). Without this feature, Pin 14 is unused. For DVI, a Dual-Link connector can be used in a Single-Link system, resulting in 6 unused pins. For a USB 3.0 Micro-B connector, Pin 4 (ID) can be used optionally. For a USB 3.1 Type-C connector, not all signals are required in all platforms or devices. For example, the two Sideband use Pins A8 and B8 are shown, highlighted, as unused in Figure 1.

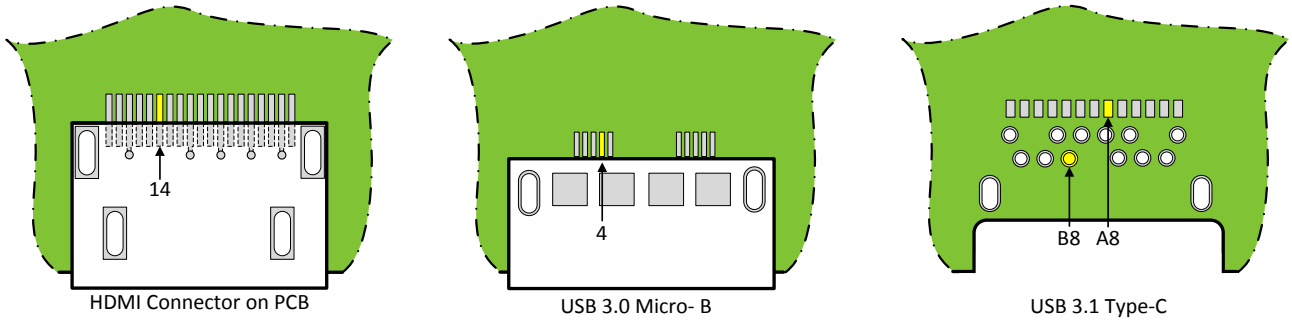

Figure 1. Possible Unused Pins (Highlighted Yellow)

Leaving connector pins floating introduces a susceptibility to an electrical overstress (EOS) event. If the cable being attached becomes charged, the conductor to the floating pin may have enough voltage to discharge, by electrical arc, from the floating pin to any nearby current path. The discharge path is usually a pin adjacent to the floating pin. Once this happens, a large current will flow from the charged cable, resulting in EOS much greater than an electrostatic discharge (ESD) event.

The root cause is the source of the charge for a cable, which can be many things: ESD onto the other end of the cable, plugging the cable into another piece of equipment which has a charge on it, a strong source of EMI next to the cable, or simply handling the cable before plugging it in..

2 Example of an Electrical Overstress Event Caused by a Floating Pin

To show the EOS event, a test was setup as shown in Figure 2. Using an IEC 61000-4-2 compliant ESD source (the "ESD Gun"), 8 kV was applied to a conductor (a wire) on one end of a 2-m HDMI cable. The other end of the cable was plugged into an HDMI Type-A female connector on a printed circuit board (PCB). The connector pin for the conductor being struck by 8-kV ESD was left floating on the PCB . The adjacent pin on the PCB was routed to a 1-Ω resistor connected to ground. The adjacent pin on the PCB was monitored for any current using an oscilloscope.

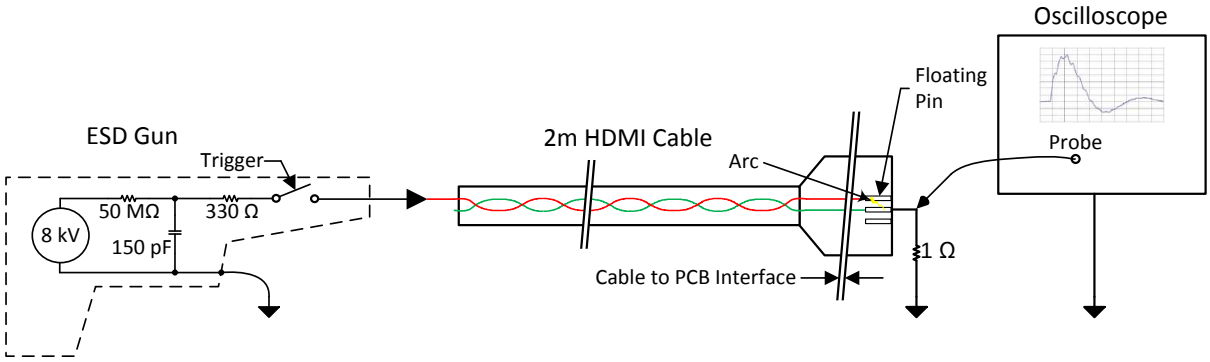

Figure 2. Test Setup for Capturing the EOS Waveform

During the test, an electrical arc was observed emanating from the floating pin. The EOS waveform shown in Figure 3 was captured by the oscilloscope on the pin adjacent to the floating pin.

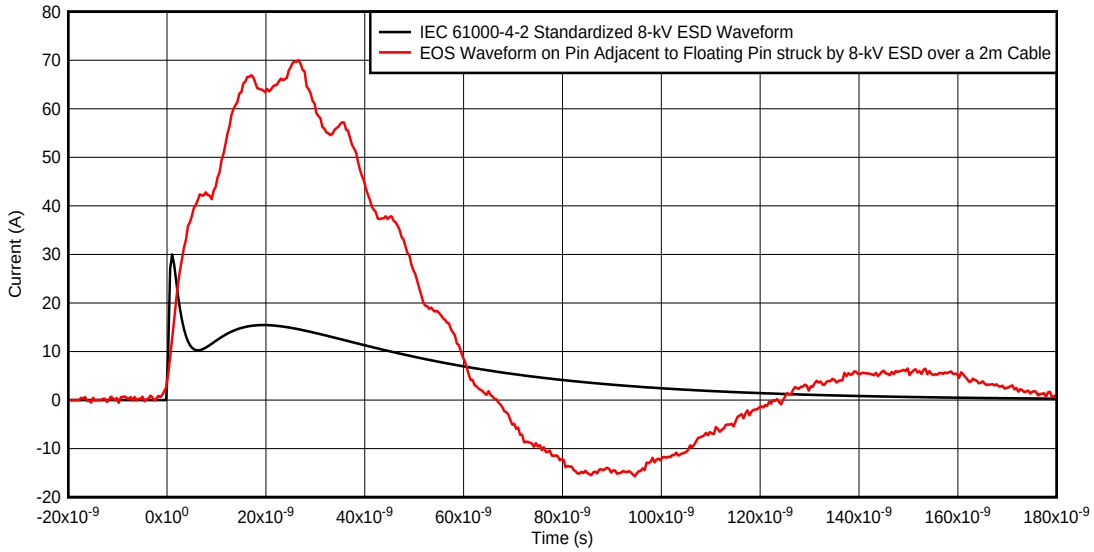

Figure 3. Waveforms Comparing a Standard 8-kV ESD Waveform vs. the EOS if Applied to a Floating Pin

We can see in Figure 3 that the EOS waveform measured in the adjacent pin carries far more energy than the example IEC 61000-4-2 Standardized 8-kV ESD waveform, which is shown for comparison. Thus, designing for IEC 61000-4-2 ESD events, and then leaving a floating pin in the connector, makes the system vulnerable to unexpected EOS that will likely exceed the design parameters. Even if the floating pin arcs to ground, the electrical arc will radiate electromagnetic interference (EMI) within the system, likely inducing unintended voltages across multiple circuits. To solve this, a design should terminate any floating pins on all connectors which are user accessible. To safely terminate floating pins, use a 75-Ω resistor to limit any current in case the pin gets shorted to a voltage source. If a short is not a concern, the floating pin can be tied directly to ground.

3 Conclusion

Following this guideline can help to prevent unexpected field failures. Floating pins in a connector should be avoided. To limit current on that pin in case it shorts to a voltage source, use an appropriate resistor. If shorts are not a concern, then simply tying any unused pin to ground is a no-cost and effective method to help prevent failures.

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