Technical Article

Avoid These Challenges When Implementing USB Type-C™ Protection

TEXAS INSTRUMENTS

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By now, many people have heard of the USB Type-C connector. At a high level, it's a new connector defined by the latest USB standard that combines power delivery, data, audio and video into a single reversible connector. Sounds simple enough, right? However, what seems simple and flexible to consumers has added design challenges on the engineering side. In this post, I'll describe the challenges associated with protecting the USB Type-C connector using discrete components.

The USB Type-C connector differs from its older counterparts, Type-A, Type-B, Micro-B, in many ways. The connector is symmetrical and enables reversible plug orientation in a 24-pin, 8.4mm-by-2.6mm form factor. Unlike previous connectors defined by the USB standard, which can only deliver power up to 2.5W (USB 2.0) or 5W (USB 3.0), USB Type-C can deliver up to 100W, enabling many fast charging applications while simultaneously delivering data across other connector pins.

I see two main challenges associated with USB Type-C protection:

- **A small pin pitch increases risk of short circuits**. To support all of this functionality in such a small form factor, the pin pitch of USB Type-C connectors is 0.5mm, which is much smaller than the 2.5mm pin pitch in the USB Type-A connector. This tiny pin pitch increases the likelihood of a pin-to-pin short circuit. If debris becomes caught in the connector, or if the consumer pulls the connector out of the receptacle at an angle, a short could easily occur. These shorts are especially devastating for the sideband use (SBU) and configuration channel (CC) pins, which are directly adjacent to the V_{BUS} pins, shown in Figure 1, and are only tolerant to 5V. The V_{BUS} lane can deliver up to 20V and 5A for 100W fast charging power delivery, as I mentioned, which could seriously damage the sensitive components connected to the SBU and CC pins.

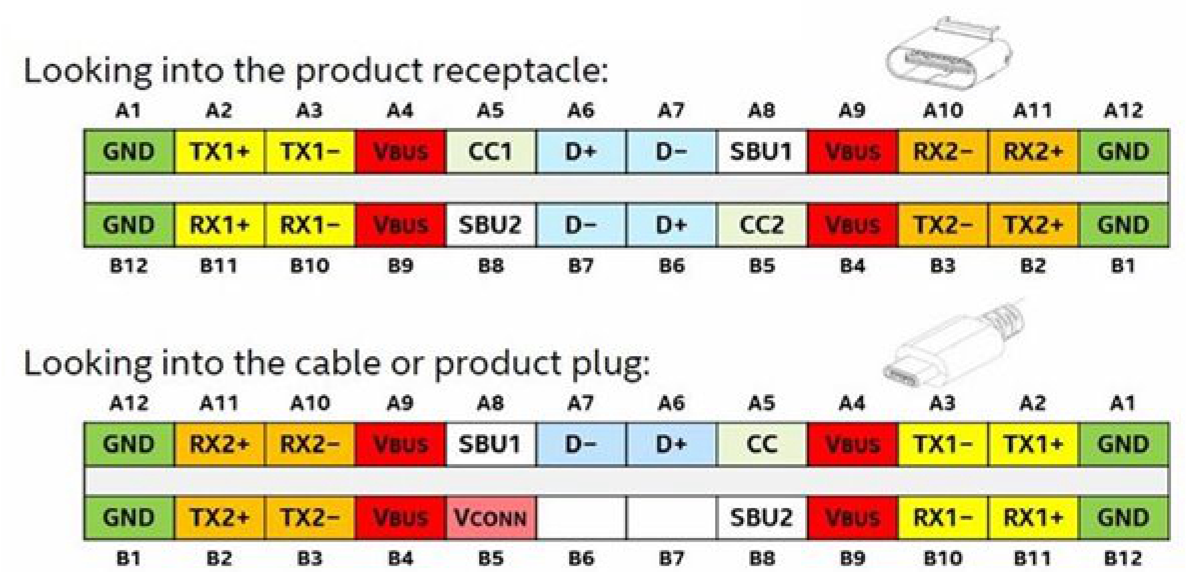

Figure 1. USB Type-C Connector Pinout

- **Noncompliant cables and adapters risk damaging internal circuitry**. In a survey of USB Type-C cables available on Amazon, 28% of cables were not compliant to the USB interface specification. Although faulty cables have been banned by some sellers, the risk that users will purchase faulty or non-compliant cables still exists. Thus, the system must include overvoltage protection in addition to standard electrostatic discharge (ESD) protection. Noncompliant cables are not the only source of worry, either. There are noncompliant power adapters that put out 20V onto the V_{BUS} path without proper USB Power Delivery (PD) negotiation. If the system is designed to handle only 5V, or if the CC pins were pulled up to the V_{BUS} rail, the downstream circuitry could be permanently damaged.

Two Approaches to USB Type-C Protection Challenges

Designers can address these and other protection challenges by combining several discrete port protection circuits, but at the cost of the designer's time and the system's board space and complexity. Texas Instruments is the first to offer integrated USB Type-C port protectors to help system designers address the protection and design challenges. The TPD8S300 family of USB Type-C port protectors incorporates overvoltage protection, ESD protection, short protection and control logic in a 3mm-by-3mm (9mm^2) quad flat no-lead (QFN) package. This solution not only saves considerable design time and board space, but also provides state-of-the-art port protection for end equipment. If you were to try to implement a protection solution discretely, the solution would include more than 13 separate components and take up 39mm^2 of board space.

USB Type-C is a very powerful and flexible interface, but it comes with new protection design challenges that did not exist for USB Type-A or USB Type-B. A discrete protection solution is possible, but it can be expensive, complex and occupy significant board space. The TPD8S300 family offers a simple solution that uses 75% less printed circuit board (PCB) space than a discrete implementation.

For more detailed information about USB Type-C protection, see the white paper, "Circuit Protection for USB Type-C™" or the additional resources below.

Additional Resources

- Start designing now with the TPD8S300 evaluation module.
- Learn more about the TPS65983B USB Power Delivery 3.0 controller.
- Check out the TPD4E02B04 device for high-speed data-line ESD protection.

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