USB Type-C™: Will Your ESD Solution Protect the Port?

Kim Devlin-Allen

If you are a designer tasked with migrating the USB ports in your system to the latest USB standard and USB Type-C connector, you have likely already considered a couple of things.

ESD Protection

First, as with all systems where a connector is exposed externally to users, your system would need to have International Electrotechnical Commission (IEC) 61000-4-2 electrostatic discharge (ESD) protection. You will also need to protect more signal pins than in the previous USB Type-A or USB Micro-B connectors. The 24-pin USB Type-C connector (Figure 1) requires ESD protection for two differential pairs (D+/D-) for USB 2.0 data, four pairs for a SuperSpeed data bus capable of up to 20Gbps (TX/RX), two side-band-use (SBU) pins and two configuration channel (CC) pins for detecting cable orientation.

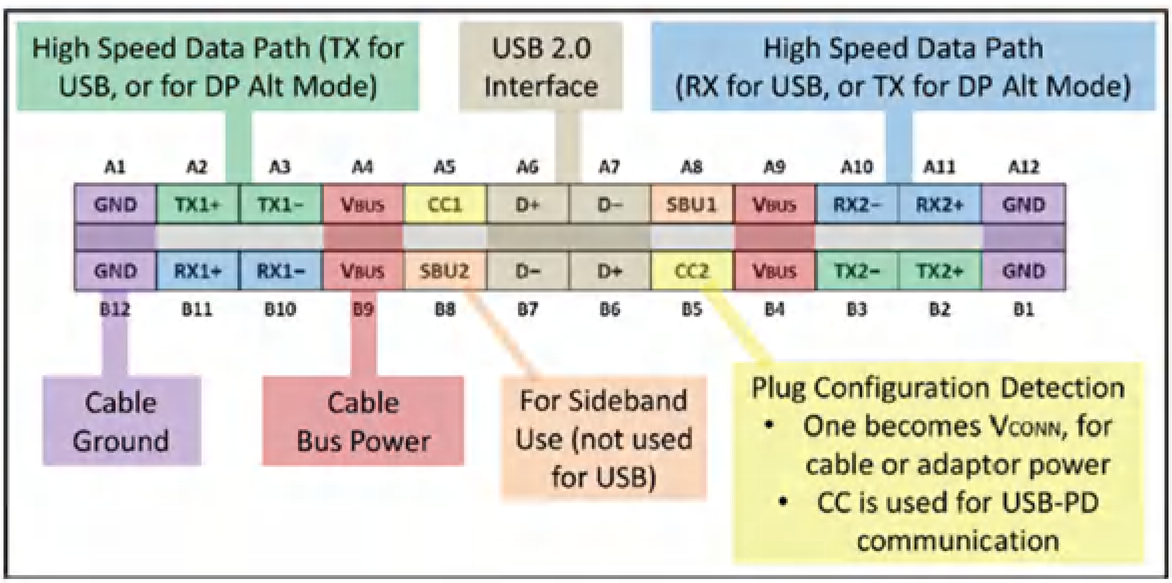

Figure 1. A Full-featured USB Type-C Plug-in Pinout

Overvoltage Protection

Second, with the introduction of up to 100 W USB Power Delivery (PD), the V_{BUS} pins can now carry up to 20V, a voltage level that could do considerable damage to the downstream USB Type-C controller if V_{BUS} shorts to the adjacent CC or SBU pins. To prevent hard system failure, overvoltage protection is needed at the connector in addition to ESD protection. Sounds straightforward, right?

Consider that with the risk of an overvoltage protection (OVP) event, the ESD diode itself must also be tolerant to $20V_{DC}$. Many higher-voltage tolerant protection options available today clamp at voltages too high to protect the downstream controllers in the event of an IEC ESD strike. Now consider the impact to the system in a short-to-V_{BUS} event when a cable is present at the connector (or when a cable is not present). The solution must protect the system when the cable induces ringing that could exceed 40V. In short, robust USB Type-C

Copyright © 2023 Texas Instruments Incorporated

connector protection will require not just a standard ESD diode but a higher voltage, DC-tolerant transient voltage suppressor (TVS) diode.

System protection at the connector with OVP and IEC ESD protection is necessary, but a full USB Type-C port-protection solution should enable your system to comply with the specifications of the new USB standard. For example, if your system takes advantage of the new capabilities of USB Type-C, such as supporting SuperSpeed communication, the USB Type-C specification requires V_{CONN} support on the CC lines to power the active cable. For an OVP solution to function on the CC lines, it must support passing a $5.5V_{DC}$ power rail. The port protection also must have low on-resistance (R_{ON}) to ensure that the total voltage drop on the power rail does not exceed what the USB specification requires.

If your system is battery-powered, relying on a Type-C connector as the power source, the solution has to protect the CC lines from an overvoltage condition even in the case of a dead battery.

These and other complex scenarios make a robust solution to protect a USB Type-C port not as straightforward as adding an ESD protection diode and an OVP FET. The OVP FET needs to withstand the clamping voltage given by a high-voltage discrete TVS diode, which makes the FET costly and bulky with a lower R_{ON} requirement. This makes the discrete implementation complex and costly, while consuming a large footprint around the tight dimensions of the USB Type-C connector.

Finally, if you are reading this and thinking to yourself, “My system is straightforward because it does not support the higher wattage (>15W) PD capability and is fully compliant to the specification for <15W PD,” note that a large percentage USB Type-C cables and adapters in the market have been found to be noncompliant to the standard, while others can be faulty (Figure 2). Even in a 5V system, there is a risk that a short-to-V_{BUS} up to 20V can occur before a PD negotiation with the controller. Just like that, the system is damaged and your product’s reputation is compromised.

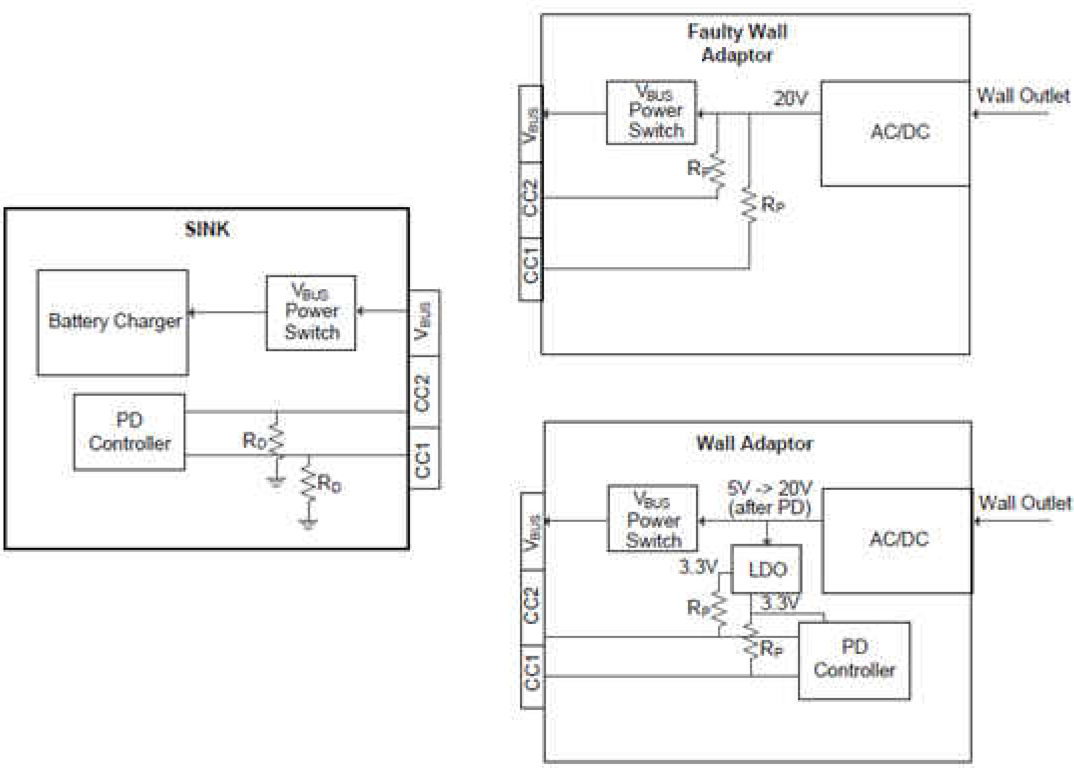

Figure 2. CC Pin Exposure for Regular and Faulty Wall Adapters

To learn more about the design considerations for USB Type-C port protection, read “Circuit Protection USB Type-C™.” Integrating a device from TI’s family of USB Type-C port protectors, such as the TPD8S300 or TPD6S300, removes the complexity that comes from migrating your USB ports to the new USB Type-C connector.

Copyright © 2023 Texas Instruments Incorporated

Additional Resources

- Download the TPD8S300 or TPD6S300 data sheets.
- Read this Analog Wire blog post to "Learn what challenges to avoid when implementing USB Type-C™ protection."
- Start designing now with the TPD8S300 evaluation module.
- Check out the TPD1E01B04 single-channel ESD protection diode for super-speed data lines.
- Learn more about the TUSB1046-DCI and TUSB546-DCI USB Type-C Alternate Mode linear redrivers.

Copyright © 2023 Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), 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, regulatory 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 or other applicable terms available either on 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.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2023, Texas Instruments Incorporated