TI Designs: TIDA-050016
Short Protection Over Type-C Port Reference Design

Description

This USB Type-C Power Delivery (PD) reference design is a TPD6S300A integrated chip set into a USB Type-C passthrough board. With USB Type-C PD advertising up to 100 W with a maximum of 20 V on VBUS, there is an increased need for protection. This design simulates the application where two Type-C ports with short protection circuit are connected and offers an easy way to manually short VBUS to the CC and SBU pins. To demonstrate this functionality, connector sides of both the devices are used in conjunction with push button switches.

Resources

TIDA-050016	Design Folder
TPD6S300A	Product Folder
TPS709	Product Folder

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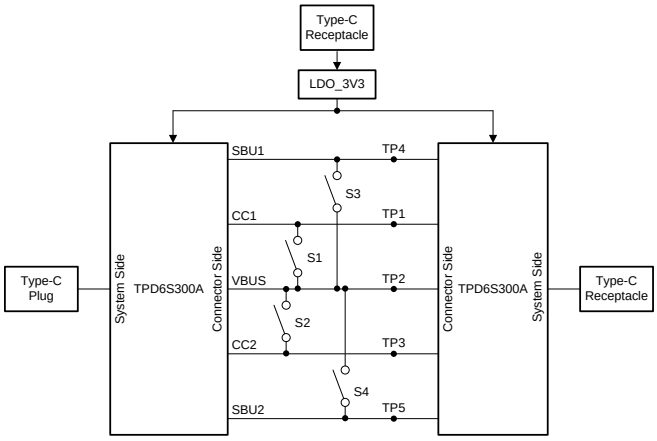
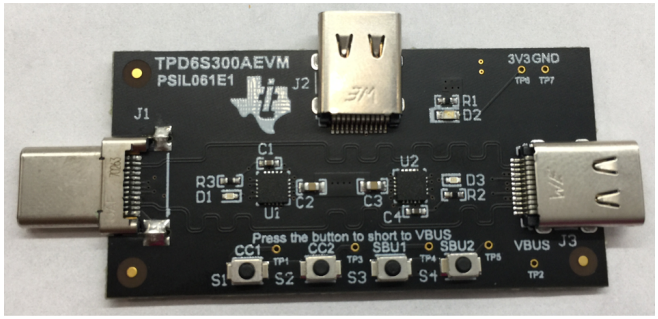
Features

- Buttons to short CC and SBU pins to VBUS
- Test points for CC, SBU, VBUS and VIN3V3 pins
- Overvoltage and ESD protection on CC and SBU pins
- Low power consumption
- Wide input power supply for non-compliant Type-C products

Applications

- Laptop PC
- Tablets
- Docking Station
- Smartphones
- Monitors and TVs





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1 System Description

This design highlights the implementation and importance of short-to VBUS overvoltage protection. This design provides a convenient way of observing the short-to-VBUS overvoltage protection with the use of pushbuttons to manually create VBUS to CC or SBU short, and test points to observe results. In the event of short-to-VBUS, the well designed combination of voltage clamps and 30-V tolerant OVP FETs ensures the TPD6S300A can handle Short-to-VBUS hot-plug events with hot-plug voltages as high as 24-VDC. Additionally, the convenient Type-C receptacles on this passthrough design, allow the user to easily evaluate operation of the TPD6S300A overvoltage protection and ESD protection with their existing USB Type-C systems.

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2 System Overview

2.1 Block Diagram

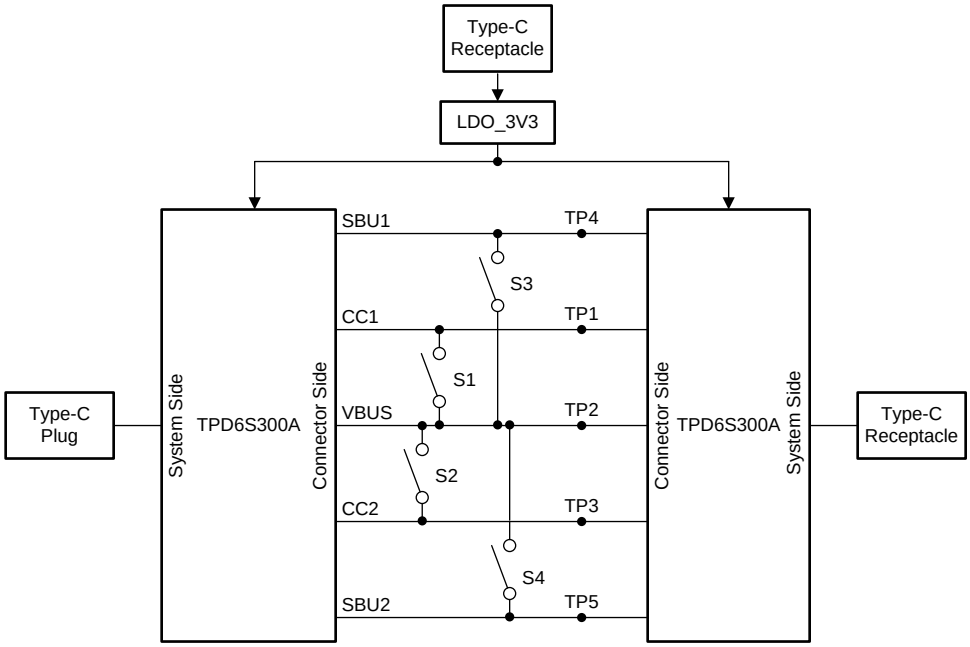

Figure 1. TIDA-050016 Block Diagram

2.2 Design Considerations

Since the release of the USB Type-C specification, many products and accessories for USB Type-C have been released which do not meet the USB Type-C specification. A concern for USB Type-C is the close proximity of CC, SBU and VBUS pins, because of the small pin pitch of the Type-C connector. Mechanical twisting, sliding of the connector, debris and moisture buildup can cause pins in the connector to be shorted together, resulting in 20-V VBUS being shorted to the CC and SBU pins. These non-ideal equipment and mechanical events make it necessary for the CC and SBU pins to be 20-V tolerant, even though they only operate at 5 V or lower.

The TPD6S300A enables the CC and SBU pins to be 20-V tolerant without interfering with normal operation by providing overvoltage protection on the CC and SBU pins. The device places high voltage FETs in series on the SBU and CC lines. When a voltage above the OVP threshold is detected on these lines, the high voltage switches are opened up, isolating the rest of the system from the high voltage condition present on the connector.

Finally, most systems require IEC 61000-4-2 system level ESD protection for their external pins. The TPD6S300A integrates IEC 61000-4-2 ESD protection for the CC1, CC2, SBU1, SBU2, DP, DM pins, removing the need to place high voltage TVS diodes externally on the connector.

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2.3 Highlighted Products

2.3.1 TPD6S300A

The TPD6S300A is a single chip USB Type-C port protection solution that provides 20-V Short-to-VBUS overvoltage and IEC ESD protection. The TPD6S300A provides 4-channels of Short-to-VBUS Overvoltage Protection for the CC1, CC2, SBU1, and SBU2 pins (or the CC1, CC2, DP, and DM pins) of the USB Type-C connector. The TPD6S300A is able to handle 24-VDC on its C_CC1, C_CC2, C_SBU1, and C_SBU2 pins. This is necessary because according to the USB PD specification, with VBUS set for 20-V operation, the VBUS voltage is allowed to legally swing up to 21 V and 21.5 V on voltage transitions from a different USB PD VBUS voltage. The TPD6S300A builds in tolerance up to 24-VBUS to provide margin above this 21.5-V specification to be able to support USB PD adaptors that may break the USB PD specification.

In this reference design, two TPD6S300A chips, with their connector sides tied together are used to showcase the short-to-VBUS overvoltage protection. The design of the passthrough board is to allow users to easily evaluate the TPD6S300A overvoltage protection in their own system, and ensure both their sink and source are protected against the short-to-VBUS caused by the pushbuttons.

2.3.2 TPS709

The power supply for the two TPD6S300A comes from the Type-C receptacle input to the LDO TPS709. In the application, it also can be powered from other integrated LDO in the PD controller since the power consumption is quite low. The resistors on CC1 and CC2 pins are 5.1k which asks for 5 V only from the compliant source. TPS709 is a wide input voltage LDO, which can protect the LDO from noncompatible Type-C sources.

Table 1. Input Voltage Range from Type-C Receptacle

Parameter	Min.	Max.
$V_{EN(HI)}$	0.9 V	6.5 V
VBUS	3.3 V	23.9 V

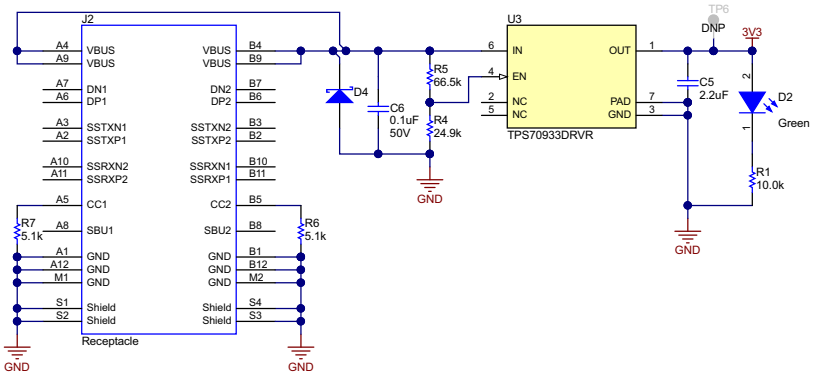

Figure 2. TIDA-050016 Power Supply

2.4 System

The system sides of TPD6S300A are connected to Type-C plug and receptacle respectively, while the connector side is connected together. This kind of connection can simulate the real application where each Type-C port has one short protection device. For example, the Type-C plug is connected to the computer and the receptacle is connected to mobile phone with Type-C cable.

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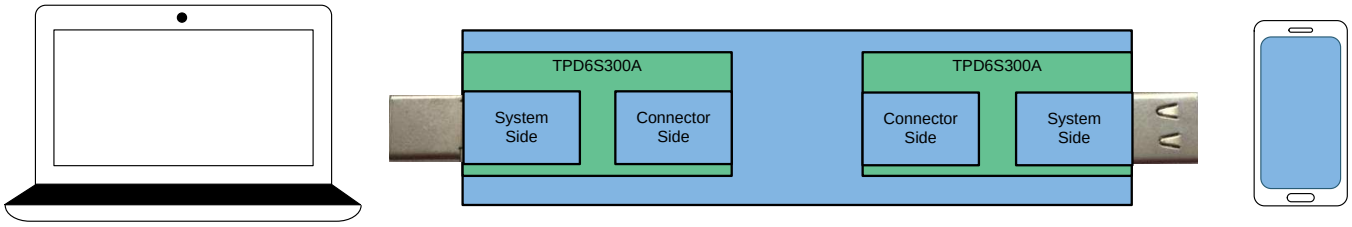

Figure 3. TIDA-050016 Simplified Application Overview

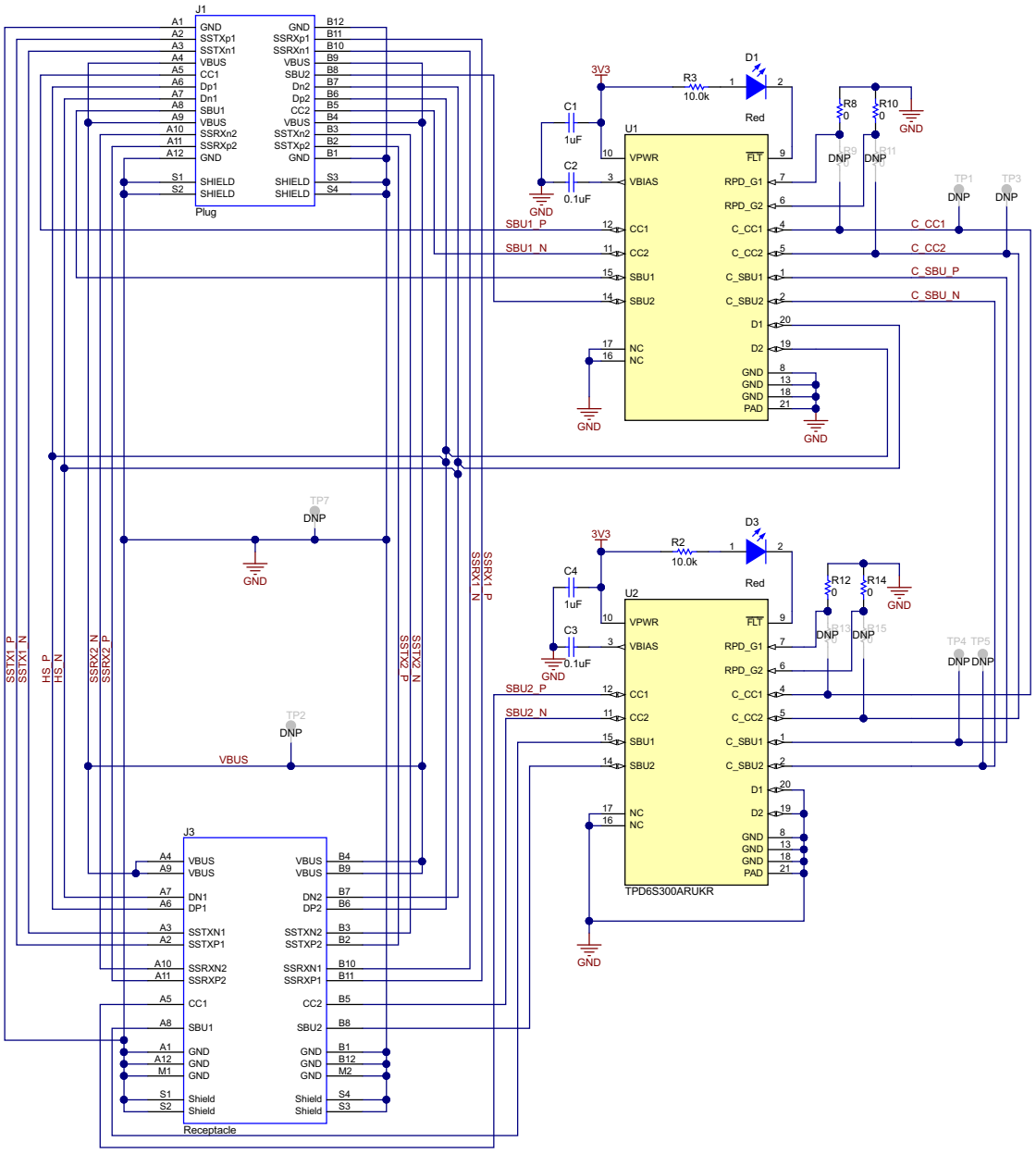

Figure 4. TIDA-050016 Schematic

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3 Hardware, Software, Testing Requirements, and Test Results

3.1 Required Hardware and Software

To fully test the TIDA-050016 board, the following items are required:

1. Windows PC with TPS65988 Application Customization Tool installed
2. TIDA-050016 TI-Design board
3. Type-C input capable of sourcing 20 V
4. Type-C input capable of sourcing atleast 3.3 V
5. PD controller acting as a sink
   a. TPS65988DH used for testing
   b. 20-V Barrel jack connector to power TPS65988DH

3.1.1 Hardware

For observing the clamping effect of TPD6S300A, a Type-C connector input source capable of sourcing 20 V is required. Another Type-C cable, capable of sourcing atleast 3.3 V is required to turn on the OVPFETs inside the TPD6S300A. A 20-V barrel jack connector provides power to the TPS65988DH acting as a sink.

3.1.2 Software

The TPS65988 Application Customization Tool must be installed on the Windows PC used to interface with TPS65988DH acting as a sink. The customization tool allows the TPS65988DH to be configured to accept a 20 V contract, by customizing the sink PDO.

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3.2 Testing and Results

The protective overvoltage clamping effect of the TPD6S300A is observed by manually shorting CC, SBU lines to VBUS with the use of pushbuttons. As specified in the datsheet, the TPD6S300A will clamp the voltage on the SBU and CC lines to approximately 8 V, and within approximately 70 ns of fault persisting, will turn off its OVPFETs to protect the TPS65988DH sink.

3.2.1 Test Setup

1. Sink: 20-V barrel jack connected to J1 of TPS65988DH
2. Sink: TPS65988DH sink PDO configured for 20 V contract, connected to J1 of TIDA-050016
3. Source: Type-C wall adapter capable of sourcing 20 V, connected to J3 of TIDA-050016
4. Type-C cable capable of sourcing atleast 3.3 V connected to J2 TIDA-050016
5. Short CC/SBU pins with the use of pushbuttons
6. Observe results with the use of test points present on TIDA-050016

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Figure 5. Test Setup

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3.2.2 Test Results

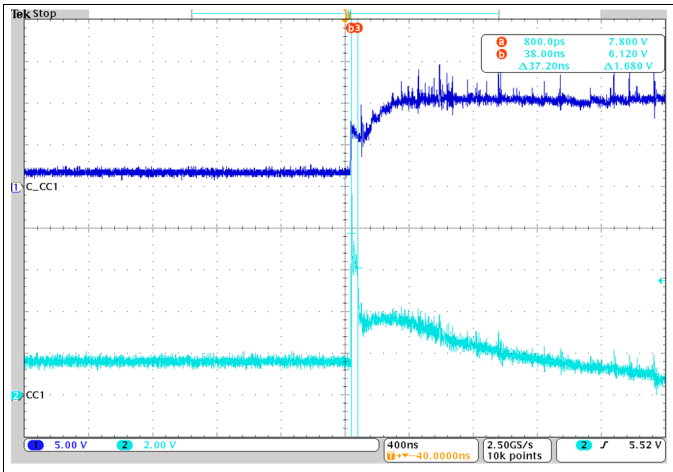

Figure 6. TIDA-050016 CC1 Short to 20 V

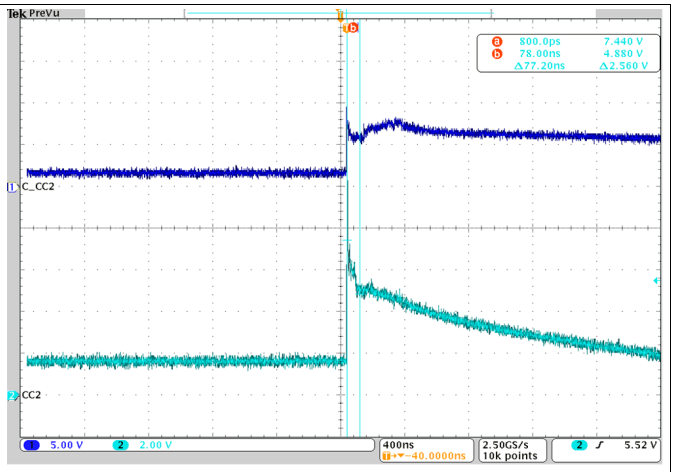

Figure 7. TIDA-050016 CC2 Short to 20 V

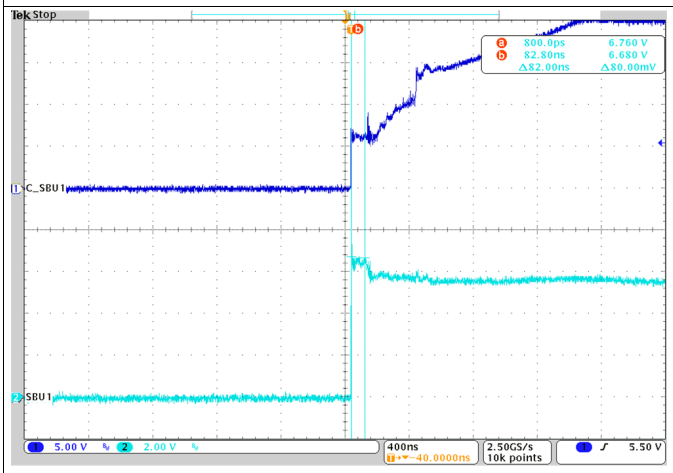

Figure 8. TIDA-050016 SBU1 Short to 20 V

Figure 9. TIDA-050016 SBU2 Short to 20 V

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4 Design Files

4.1 Schematics

To download the schematics, see the design files at TIDA-050016.

4.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDA-050016.

4.3 PCB Layout Recommendations

4.3.1 Layout Prints

To download the layer plots, see the design files at TIDA-050016.

4.4 Altium Files

To download the Altium Designer® project files, see the design files at TIDA-050016.

4.5 Gerber Files

To download the Gerber files, see the design files at TIDA-050016.

4.6 Assembly Drawings

To download the assembly drawings, see the design files at TIDA-050016.

5 Software Files

To download the software files, see the design files at TIDA-050016.

6 Related Documentation

- Circuit Protection for USB Type-C

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7 Terminology

The terminology used in this design guide is all related to the USB Type-C and PD specifications. These specifications can be downloaded from the USB-IF website.

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