AN1148

DPO2039 Application Note

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Introduction

The USB-C has become the standard for charging and high-speed data transferring in the electronic market due to its fast speed, high power delivery capability, and compact and reversible connections. Because of its high power flow and compact size, it is prone to pin-to-pin short, especially shorting the low voltage tolerated communication pins to the adjacent high voltage VBUS pin, causing damage to the device and system. Therefore, protection must be incorporated into the design. The DPO2039 is a four-channel MOSFET device designed to work with the USB-C system to support robustness, communication and power delivery needs.

DPO2039 works with USB-C System as Protection

Referring to Figure 1 below, DPO2039 is placed between the connector and the system sides of the USB PD system. When the voltage at the connector side rises above the overvoltage threshold, the MOSFET switch which connects the two sides will be turned off, isolating the system side devices from exposing to the overvoltage connector side. FAULTB will output low to flag the fault condition. When the voltage falls below the overvoltage threshold, the switch will be turned back on followed by FAULTB high again.

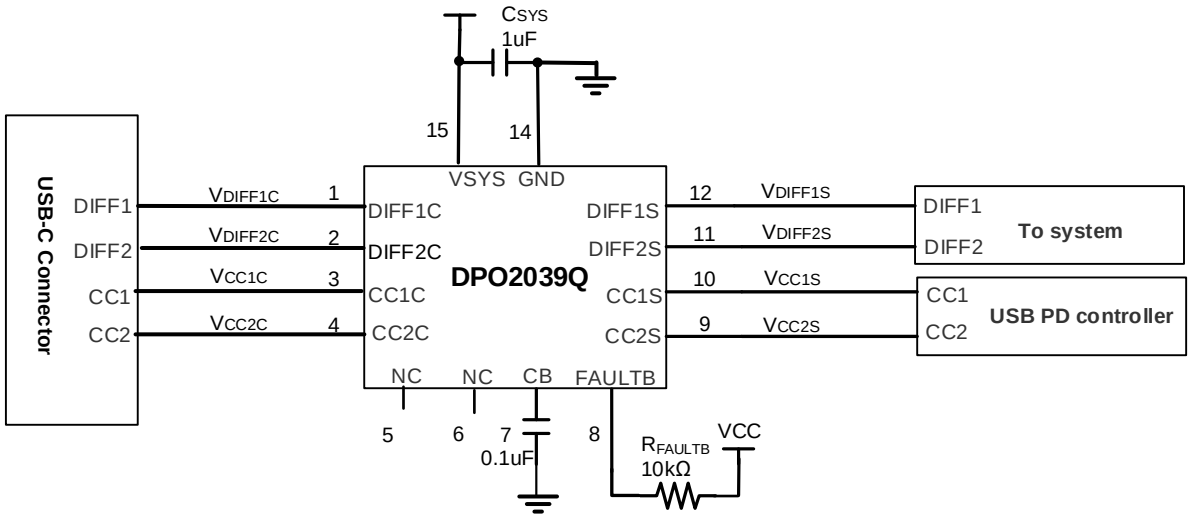

Figure 1. DPO2039 in USB-C System

Pin Description and Functionality

VSYS and GND pins

The VSYS and GND pins form the power and return path for the signal. A 1µF MLCC capacitor is required to be placed between the two pins to provide clean and stable input power to DPO2039. The recommended working voltage range for VSYS is 2.7 – 5.5V.

CB pin

For surge and ESD protection, a 0.1µF capacitor is required to be placed close to the CB pin to ground.

FAULTB pin

This is the status report pin. Connect a 1KΩ - 10KΩ pull-up resistor from this pin to VCC (3.3V or 5V). FAULTB will be pulled low in response to overvoltage, overtemperature, shorted to VBUS and ESD events.

DIFF1C, DIFF2C, DIFF1S and DIFF2S pins

The DIFF1C/2C pins go to the connector side of the USB-C connector; DIFF1S/2S pins connect to the system side connector. DIFF1C and DIFF1S, DIFF2C and DIFF2S are two pairs of MOSFET switches in series with the DIFF1 and DIFF2 lines, respectively. Not only do they support video signals, such as DisplayPort and HMDI in a USB-C system, but they also provide protection to the system side devices from being damaged in the event of connector side overvoltage or short to VBUS. When the voltage at the connector side rises above the overvoltage threshold, the switch will be turned off to isolate the system side from the connector side to avoid damages. Whenever the voltage falls back to normal range, the switch will be turned on again. Table 1 shows the recommended voltage range in normal operation. When not use, DIFF1C/2C shall be tied to GND and must never be left floating, however, the system side DIFF1S/2S pins can.

CC1C, CC2C, CC1S and CC2S pins

Similar to the DIFF1C/2C, the CC1C/2C pins connect to the connector side, and CC1S/2S pins connect to the system side of the connector. CC1C and CC1S, CC2C and CC2S are two pairs of power switches in series with the CC1 and CC2 lines that perform cable detection, high-speed data communication, power negotiation and deliveries over the USB-C system. Incorporated with overvoltage, short to VBUS and ESD protections, these switches safe guard the system side components from exposing to voltage and current surges at the connector end. Table 1 shows the recommended voltage range in normal operation. When not use, CC1C/CC2C shall be tied to GND or connected to VSYS pin for improving DIFF1/DIFF2 channels 3dB bandwidth. The CC1C/2C pins must never be left floating, however, the system side CC1S/2S pins may.

Short to VBUS Protection

The USB-C connector's small pin-to-pin pitch has put it at high risk of shorting the low voltage tolerated signal pins to the adjacent high-voltage VBUS pin when a USB device is attached to the connector. If the short is occurred at the connector, large surge current will incur. If the short is at the cable end, large voltage spike will impose to the line. The DPO2039 has incorporated TVS diodes to quickly clamp the voltage to a safe level before turning off the switch to prevent damage.

Figure 2 below shows when the connector side DIFF1C shorted to 20V VBUS voltage, the voltage is being clamped to 7V before switch turning off.

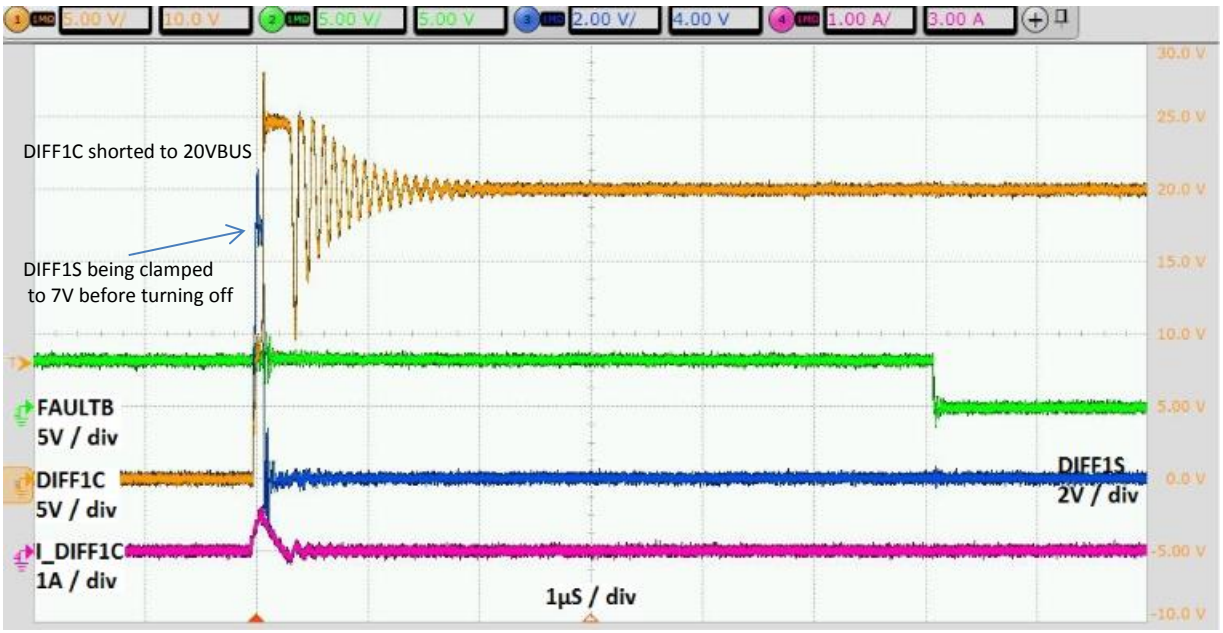

Figure 2 DIFF1C Short to 20V VBUS at the Cable End

Signal Operation Range and Output Status

Tables 1 and 2 show signal operation ranges for CC1/CC2 and DIFF1/2 and the corresponding output status.

Table 1 Signal Operation Range for CCx

0V ~ UVLO (Invalid)	0V ~ 5.85V	OFF: Dead Battery R_{PD} Inserted if Enabled
	5.85V ~ 20V	OFF: Dead Battery R_{PD} Inserted if Enabled
2.7V ~ 5.5V (Valid)	0V ~ 5.85V	ON
	5.85V ~ 20V	OFF: FAULTB Asserted (OVP detected)

Table 2 Signal Operation Range for DIFFx

0V ~ UVLO (Invalid)	0V ~ 4.35V	OFF
	4.35V ~ 20V	OFF
2.7V ~ 5.5V (Valid)	0V ~ 4.35V	ON
	4.35V ~ 20V	OFF: FAULTB Asserted (OVP detected)

Please refer to DPO2039 datasheet for more information.

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