TPS65982 Charging Port Over USB Type-C

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ABSTRACT

The TPS65982 device is a stand-alone USB Type-C and power delivery (PD) controller providing cable-plug and orientation detection at the USB Type-C connector. When the upstream facing port (UFP) device Type C-to-MicroB dongle is plugged in, the port supports connection of Type-B receptacle devices such as a smartphone, mouse, keyboard, external hard drive, and others. As these devices monitor the USB2.0 data line (D+/D–), the TPS2544 USB charging port controller can be added to provide the electrical signatures on D+/D– to support BC1.2 and non-BC1.2 compliant charging schemes. This application note presents the design solution which can offer fast charging of popular mobile phones, tablets, and media devices over the USB Type-C port.

Contents

List of Figures

List of Tables

1 Introduction

The focus of this application note is to present the design solution for the TPS65982 device to offer fast charging of popular mobile phones, tablets, and media devices over the USB Type-C port. Most existing USB devices such as a smartphone, mouse, keyboard, external hard drive and other device use the Type-B receptacle. To support Type-B receptacle devices on the USB Type-C port, a Type C-to-MicroB dongle must be connected between the device and port. When the Type C-to-MicroB dongle is plugged into the Type-C port, the TPS65982 device broadcasts current capability over the CC lines. This current capability is not received by the Type-B receptacle device, which monitors USB2.0 data line (D+/D–), leading to the device drawing 500 mA maximum as defined by USB2.0 or 900 mA as defined by USB3.0. This current level must become insufficient for many handset and personal media players which require a higher charging rate. By adding the USB charging port controller, the TPS2544 device, the device provides the electrical signatures on D+/D– to support BC1.2 and non-BC1.2 compliant charging schemes. The TPS2544 device allows host and client devices to acknowledge the protocol handshake and draw additional current beyond 500 mA or 900 mA maximum as defined by USB2.0 or USB3.0. (respectively) The non-BC1.2 compliant charging scheme is defined in the TPS2544 data sheet (see Section 5). The support of protocol the handshakes, charging downstream port (CDP) and dedicated charging port (DCP), are explored in this application note.

The CDP is a USB port that follows USB BC1.2 and supplies a minimum of 1.5 A to each port while maintaining USB2.0.0 data line (D+/D–) communication.

The DCP only provides power and does not support data connection to the upstream facing port. The DCP is identified by the electrical characteristics of the data lines. In the DCP Auto state the charge-detection state machine of the device activates to selectively implement charging schemes involved with the Shorted, Divider1, Divider2, and 1.2V modes.

For a general understanding before reading this application note, see the TPS65982 data sheet, TPS2544 data sheet, and USB Type-C documentation.

2 Implementation

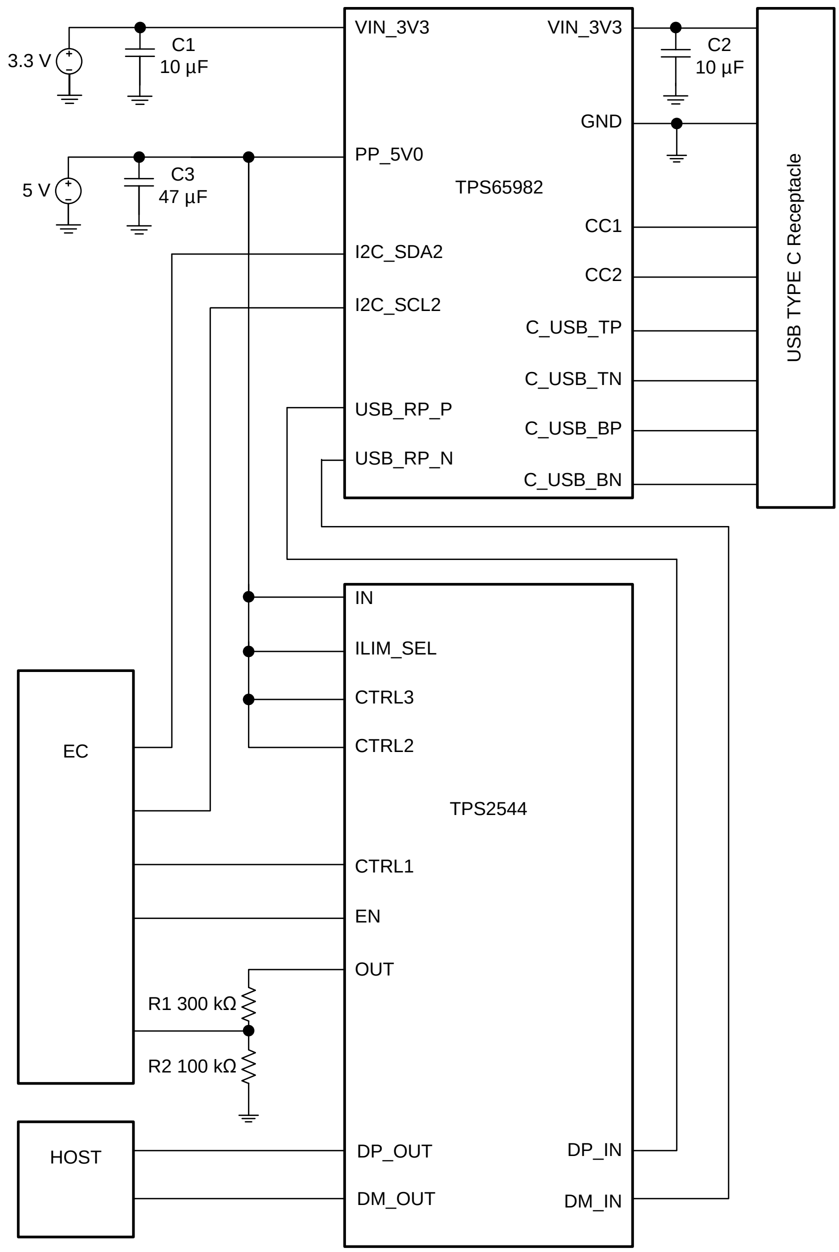

Figure 1. TPS65982 Charging Port Over USB Type-C Circuit Using TPS2544

The operation of the charging over Type-C port circuit shown in Figure 1 uses the TPS2544 device to provide the electrical signatures on the D+/D– data line to support BC1.2 and non-BC1.2 compliant charging schemes. The internal switch of the TPS65982 device is connected between the 5-V power source and the Type-C connector VBUS, while the internal switch of the TPS2544 device is not connected.

The TPS2544 OUT pin is connected to the EC GPIO input. Therefore, when the TPS2544 OUT pin is low, the EC can issue an I^2C command to the TPS65982 device to discharge the VBUS. When the TPS2544 OUT pin is high, the EC controls the TPS65982 device to re-establish VBUS voltage. The TPS65982 VBUS discharge is required for mode changes between CDP and DCP and between DCP Auto mode.

When a human interface device (HID) such as a mouse or keyboard is detected, no output discharge occurs as the TPS2544 device changes state between CDP and DCP Auto. Therefore the D+/D– lines remain connected to a system to support the mouse and keyboard wake function. See the TPS2544 data sheet for details of this operation.

While in DCP Auto mode, the TPS2544 device can selectively implement charging schemes involved with the Shorted, Divider1, Divider2, and 1.2V modes.

The internal switch of the TPS2544 device is not connected in series with the TPS65982 device because the Rdson of both the TPS65982 and TPS2544 devices is too large and violates the minimum specification of 4.75 V when a 3-A current is drawn. As no load current is drawn from the TPS2544 switch, Divider2 mode support is unavailable because it requires >750 mA.

The DP_IN and DM_IN signals of the TPS2544 device are connected to a connector through the low-speed MUX USB_RP_P and USB_RP_N of the TPS65982 device for better USB2.0.0 signal quality.

Table 1 summarizes the test performed for various popular smartphone devices such as the Apple iPhone 6S, Samsung Galaxy Note 5, Blackberry Bold 9700, and HTC Sense.

Table 1. Test Summary

Mode	Samsung Galaxy Note 5	Apple iPhone 6S	HTC Sense	Blackberry Bold 9700
CDP		O		
DCP Auto	O	O	O	O

The HTC Sense and BlackBerry Bold9700 smartphones do not support CDP mode. These smartphones would have to use a standard downstream port (SDP) which bypasses both the TPS65982 and TPS2544 D+/D– pins to the host. The Samsung Galaxy Note 5 only supports CDP when host communication is present, and therefore was tested using the EVM setup for this application note.

Taking into consideration that two plug in sequences occur, the following test cases were performed for each phone:

Case 1—Type C-to-MicroB dongle connected to host then plugged into device.

Case 2—Type C-to-MicroB dongle connected to device then plugged into host.

Figure 2 shows the Type C-to-MicroB dongle. Section 3 refers to these test conditions as case1 and case2.

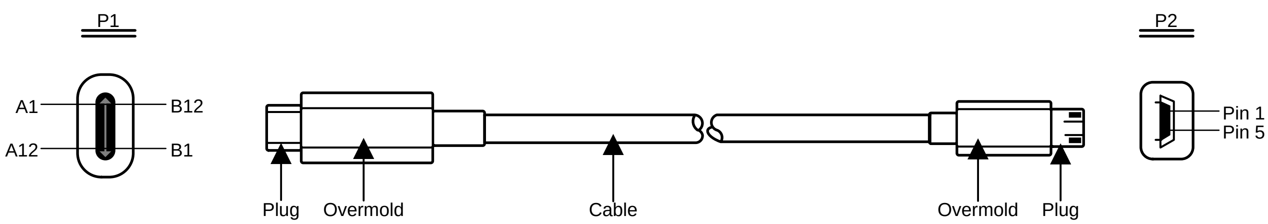

Figure 2. Type C-to-MicroB Dongle

3 Device Tests

3.1 Charging Dedicated Mode (CDP) Mode

A CDP is a USB port that follows USB BC1.2 and supplies a minimum of 1.5 A to each port. This mode provides power and meets USB2.0 requirements for device enumeration. USB2.0 communications is supported, and the host controller must be active to allow charging. What differentiates a CDP from a standard USB downstream port (SDP) is the host-charge handshaking logic that identifies this port as a CDP. A CDP is identifiable by a compliant BC1.2 client device and allows for additional current draw by the client device.

For the following test scheme, the control pin (CTL1-CTL3/ILIM_SEL) settings of the TPS2544 device are programmed to 1111 for CDP mode.

The tested device that supports CDP is the Apple iPhone 6S smartphone. The observed result is that the Apple iPhone 6S successfully detects CDP mode to draw over 500 mA. Tests were performed for case1 and case2. For case1, the V_{OUT} 5 V was already established as the TPS65982 device detects the UFP Type C-to-MicroB dongle (see Figure 3). For case2, the V_{OUT} 5 V was provided after the UFP was attached (see Figure 4). The maximum charging current (I_{OUT}) consumed by the device is also measured in the scope shots.

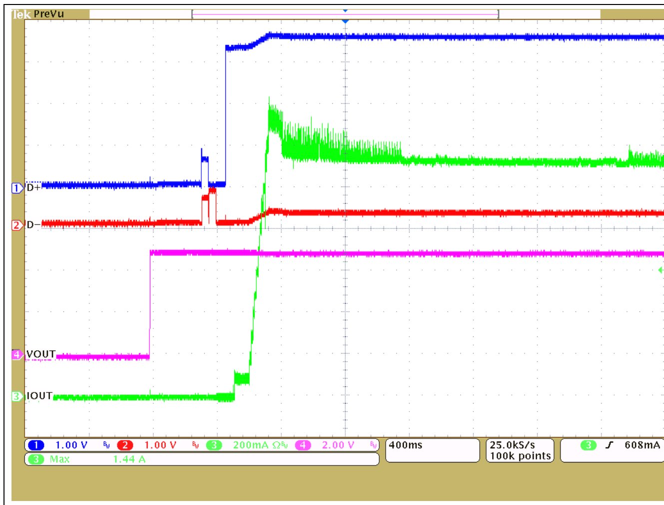

Figure 3. TPS65982 and TPS2544 (CDP Mode) Test With iPhone 6S With Case1

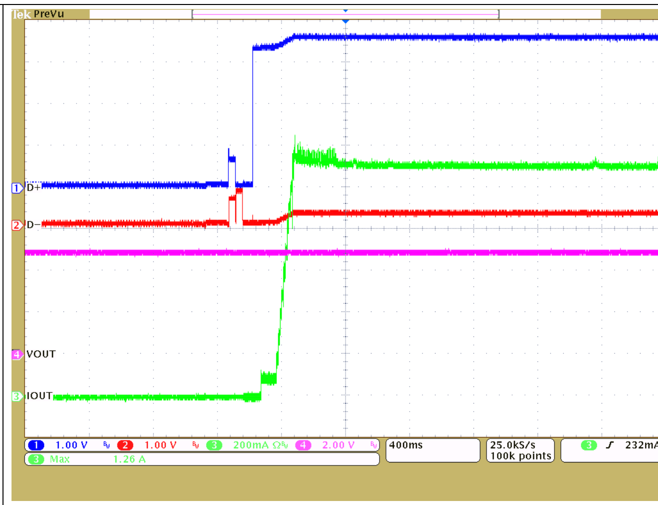

Figure 4. TPS65982 and TPS2544 (CDP Mode) Test With iPhone 6S With Case2

3.2 Dedicated Charging Port (DCP) Auto mode

A DCP only provides power and does not support data connection to an upstream port. In the DCP Auto state of the TPS2544 device, the charge-detection state machine activates to selectively implement charging schemes involved with the Shorted, Divider1, Divider2, and 1.2V modes. Shorted DCP mode complies with BC1.2 and the Chinese Telecommunications Industry Standard YD/T 1591-2009, while the Divider and 1.2V modes are used to charge devices that do not comply with the BC1.2 DCP standard.

For the following test scheme, the control pin (CTL1-CTL3/ILIM_SEL) settings of the TPS2544 device are programmed to 0111 for DCP Auto mode. The tested devices include the following smartphones: Apple iPhone 6S (Divider1), Samsung Galaxy Note 5 (1.2V mode), HTC Sense (DCP shorted) and Blackberry Bold 9700 (DCP shorted). The observed result is that all devices successfully detect CDP mode to draw over 500 mA.

Figure 5 and Figure 6 show the Apple iPhone 6S tests.

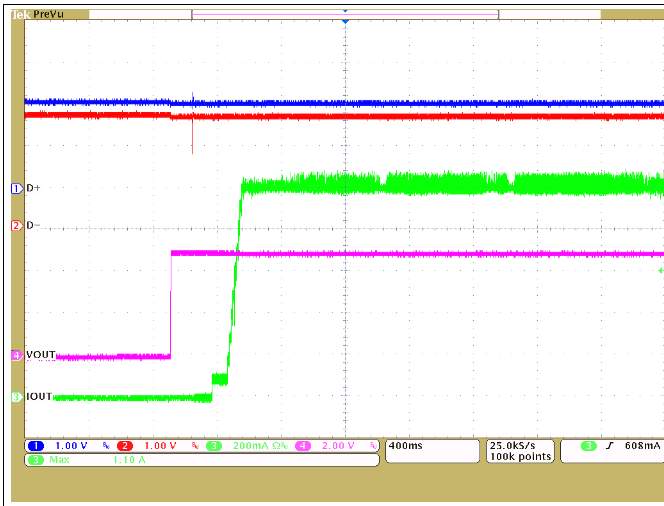

Figure 5. TPS65982 and TPS2544 (DCP Auto Mode) Test With iPhone 6S With Case1

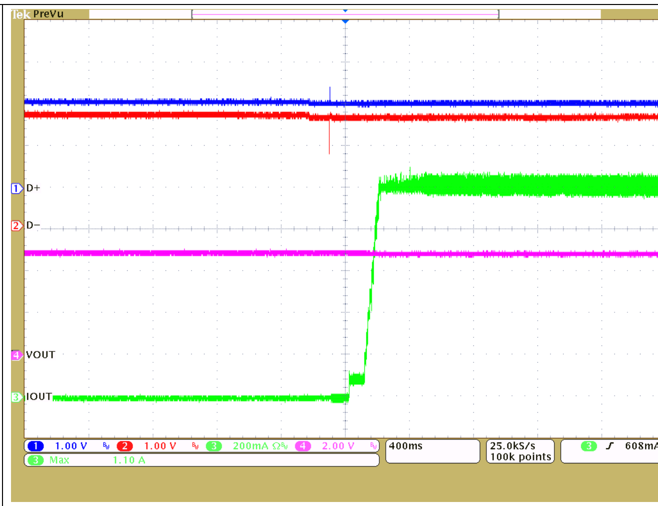

Figure 6. TPS65982 and TPS2544 (DCP Auto Mode) Test With iPhone 6S With Case2

Figure 7 and Figure 8 show the Samsung Galaxy Note 5 tests.

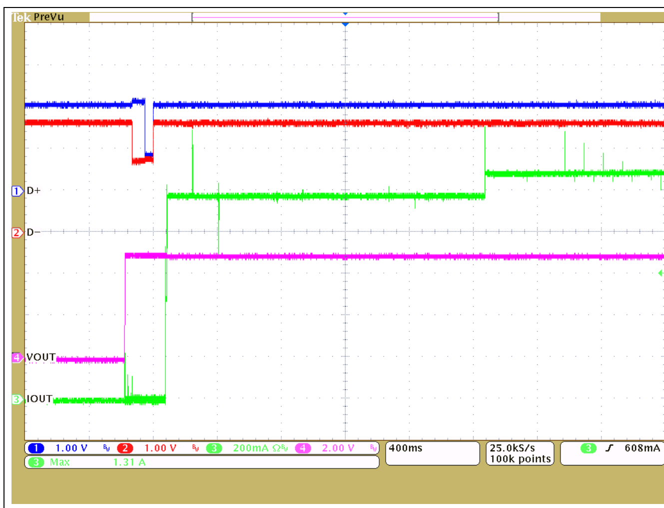

Figure 7. TPS65982 and TPS2544 (DCP Auto Mode) Test With Galaxy Note 5 With Case1

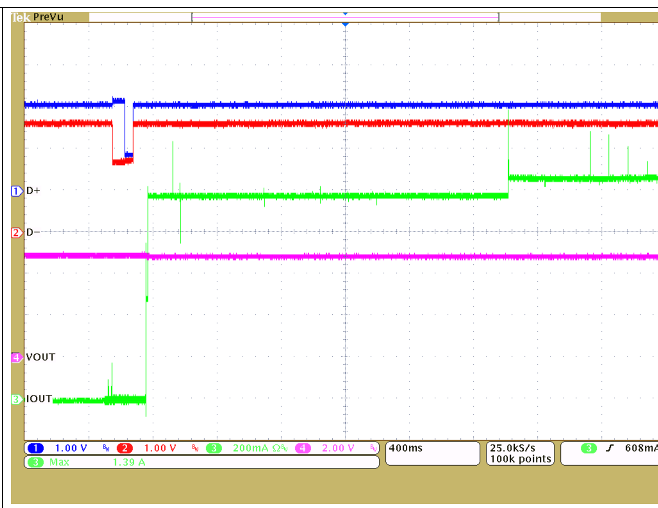

Figure 8. TPS65982 and TPS2544 (DCP Auto Mode) Test With Galaxy Note 5 With Case2

Figure 9 and Figure 10 show the HTC Sense tests.

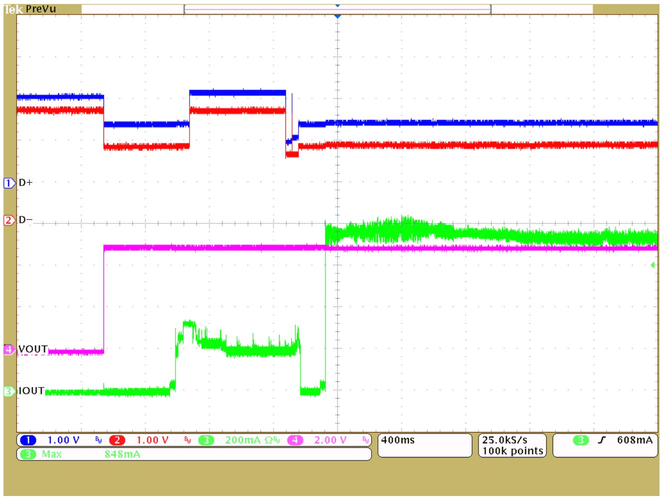

Figure 9. TPS65982 and TPS2544 (DCP Auto Mode) Test With HTC Sense With Case1

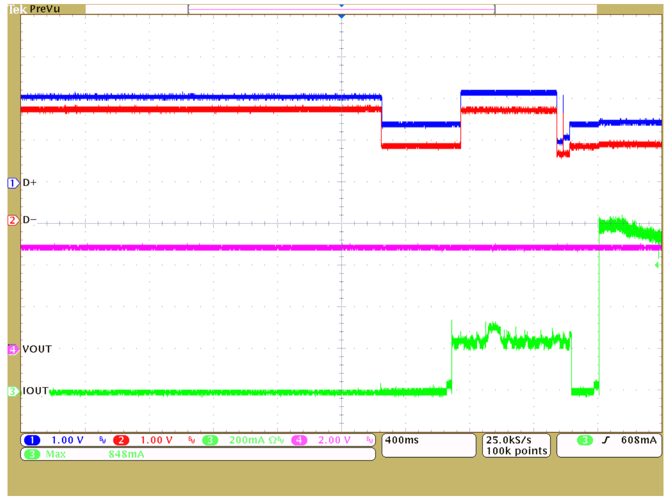

Figure 10. TPS65982 and TPS2544 (DCP Auto Mode) Test With HTC Sense With Case2

Figure 11 and Figure 12 show the Blackberry Bold 9700 tests. As shown with the Blackberry device test waveform, the V_{OUT} 5 V is discharged for the device to redetect the new DCP short setting from the TPS2544 device. This detection is achieved by the EC writing TPSS65982 0x28[24:25] = 00 to disable the PP_5V0 switch when the TPS2544 OUT pin is low. The EC then writes 0x28[24:25] = 01 to enable the PP_5V0 switch when the TPS2544 OUT pin is high. The following shows an example pseudo code:

```
Boolean TPS2544_OUT;
Boolean OUT_previous_status;
Void VBUS_Discharge(){
        If (TPS2544_OUT==TRUE && OUT_previous_status==FALSE){
                Write 0x28[24:25]=01;
                OUT_previous_status=TRUE}
        else if (TPS2544_OUT==FALSE && OUT_previous_status==TRUE){
                Write 0x28[24:25]=00;
                OUT_prevoius_status=FALSE}
        }
```

The VBUS_Discharge function in the previous example can run every 10 to 30 ms to check for changes in the status of the TPS2544 OUT pin which requires a VBUS discharge. Because of a time delay between receiving the TPS2544 OUT signal and the EC executing the I^2C command to the TPS65982 device, the discharge timing of fthe VBUS connector is slightly different from the TPS2544 OUT.

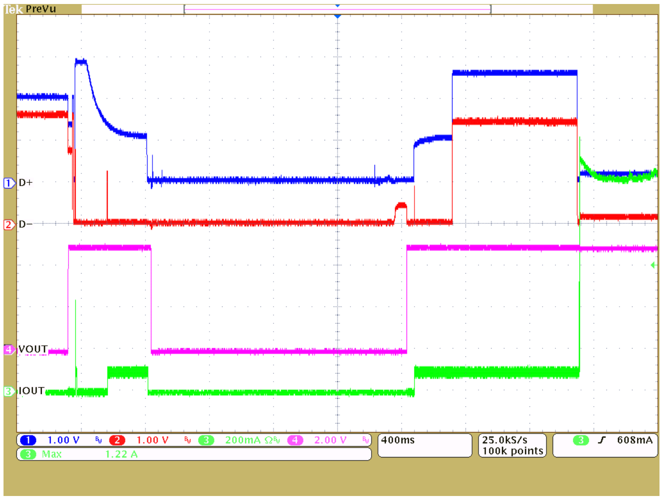

Figure 11. TPS65982 and TPS2544 (DCP Auto Mode) Test With Blackberry Bold 9700 With Case1

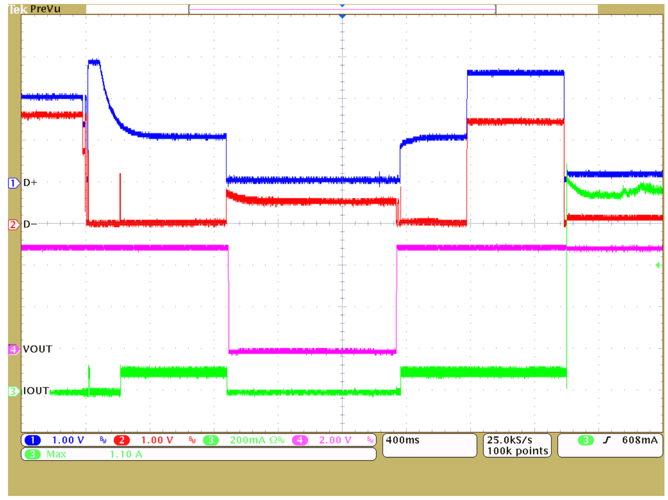

Figure 12. TPS65982 and TPS2544 (DCP Auto Mode) Test With Blackberry Bold 9700 With Case2

4 Summary

Table 2 summarizes the results for each device and lists the maximum current drawn from each device. By adding the TPS2544 device to the TPS65982 device, large charging currents can be achieved on the USB Type-C port.

Table 2. Summary of Results

Mode	Samsung Galaxy Note 5	Apple iPhone 6S	HTC Sense	Blackberry Bold 9700
CDP	—	1.44 A	—	—
DCP Auto	1.39 A	1.1 A	0.848 A	1.22 A

5 References

For additional reference, see the following:

- *TPS65982 USB Type-C and USB PD Controller, Power Switch, and High Speed Multiplexer*, SLVSD02
- TPS2544 *USB Charging Port Controller and Power Switch*, SLVSBU8
- USB Type-C Documentation, http://www.usb.org/developers/usbtypec/

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