

TPS65982 Charging Port Over USB Type-C

Andrew Hung

Taiwan Field Application Engineer

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

1	Introduction	2
2	Implementation	3
3	Device Tests	5
	3.1 Charging Dedicated Mode (CDP) Mode	5
	3.2 Dedicated Charging Port (DCP) Auto mode	6
4	Summary	8
5	References	8

List of Figures

1	TPS65982 Charging Port Over USB Type-C Circuit Using TPS2544	3
2	Type C-to-MicroB Dongle	4
3	TPS65982 and TPS2544 (CDP Mode) Test With iPhone 6S With Case1	5
4	TPS65982 and TPS2544 (CDP Mode) Test With iPhone 6S With Case2	5
5	TPS65982 and TPS2544 (DCP Auto Mode) Test With iPhone 6S With Case1	6
6	TPS65982 and TPS2544 (DCP Auto Mode) Test With iPhone 6S With Case2	6
7	TPS65982 and TPS2544 (DCP Auto Mode) Test With Galaxy Note 5 With Case1	6
8	TPS65982 and TPS2544 (DCP Auto Mode) Test With Galaxy Note 5 With Case2	6
9	TPS65982 and TPS2544 (DCP Auto Mode) Test With HTC Sense With Case1	7
10	TPS65982 and TPS2544 (DCP Auto Mode) Test With HTC Sense With Case2	7
11	TPS65982 and TPS2544 (DCP Auto Mode) Test With Blackberry Bold 9700 With Case1	7
12	TPS65982 and TPS2544 (DCP Auto Mode) Test With Blackberry Bold 9700 With Case2	7

List of Tables

1	Test Summary	4
2	Summary of Results	8

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

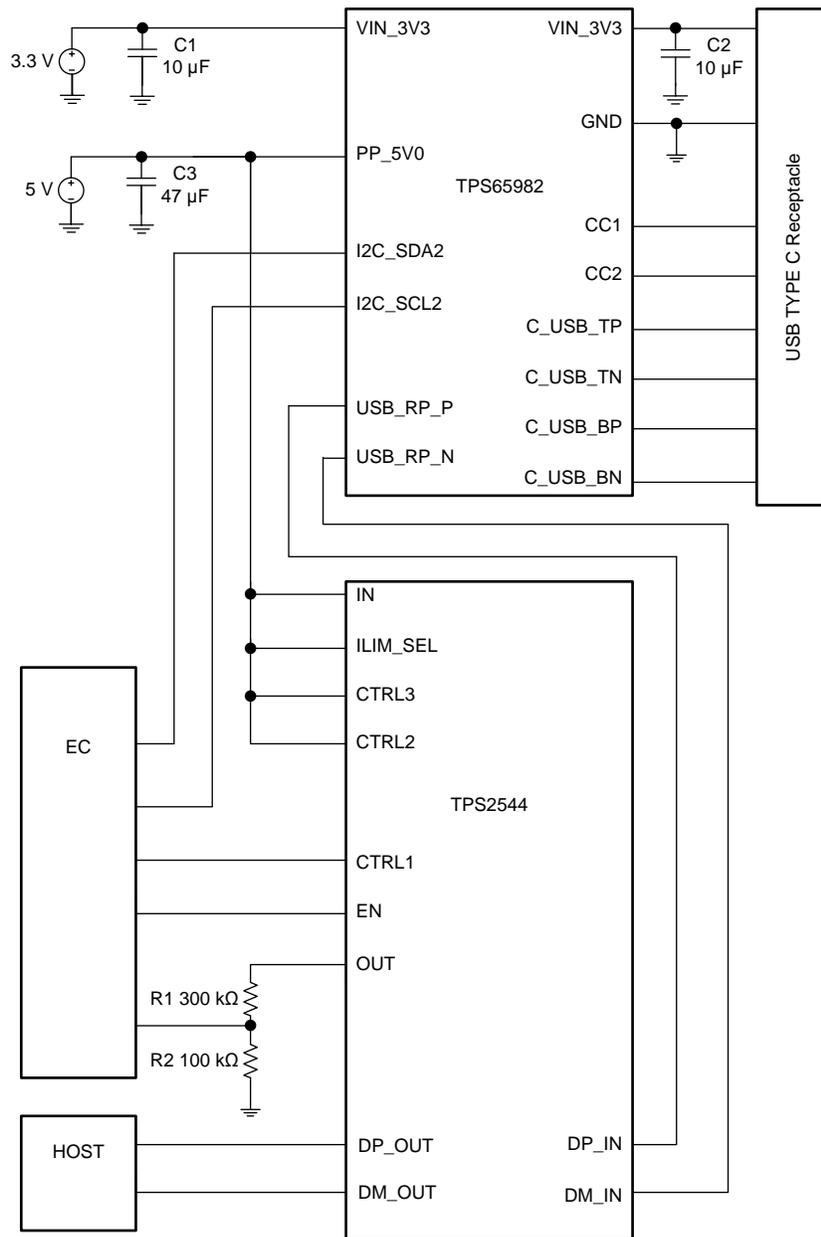


Figure 1. TPS65982 Charging Port Over USB Type-C Circuit Using TPS2544

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 I²C 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 R_{dson} 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.

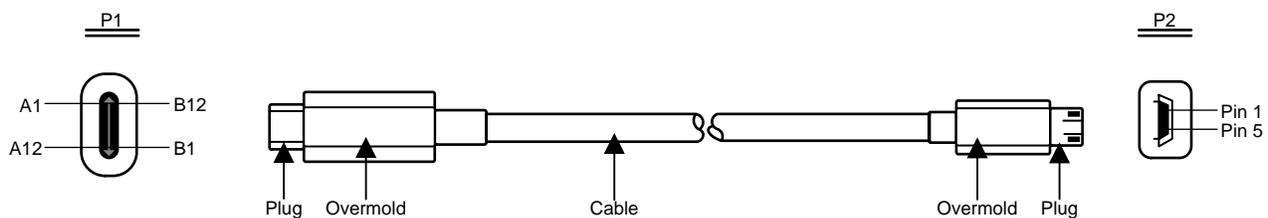


Figure 2. Type C-to-MicroB Dongle

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.

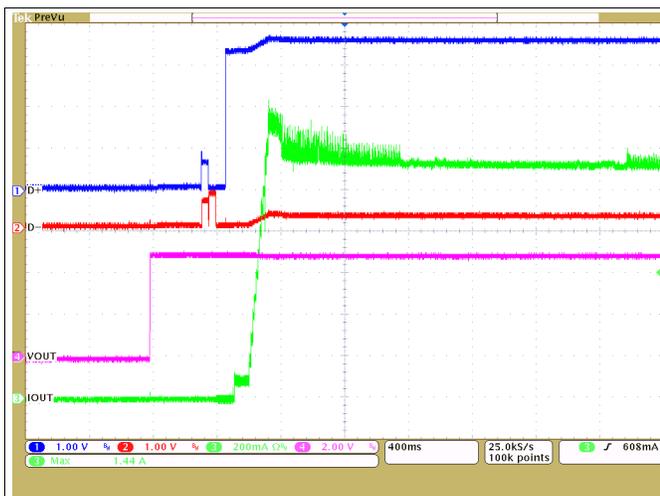


Figure 3. TPS65982 and TPS2544 (CDP Mode) Test With iPhone 6S With Case1

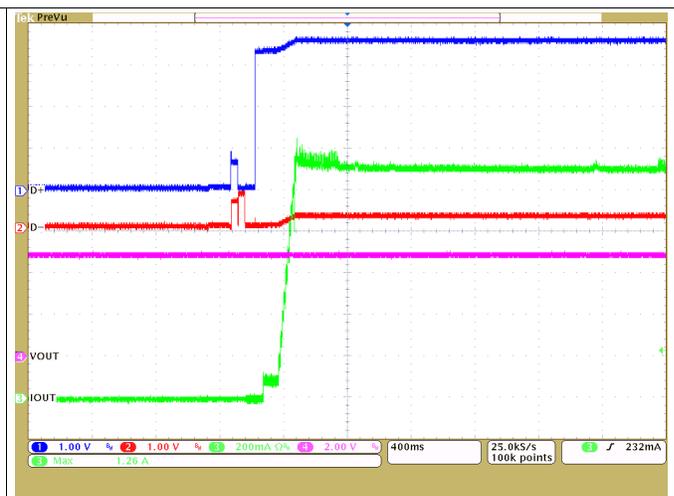


Figure 4. TPS65982 and TPS2544 (CDP Mode) Test With iPhone 6S With Case2

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.

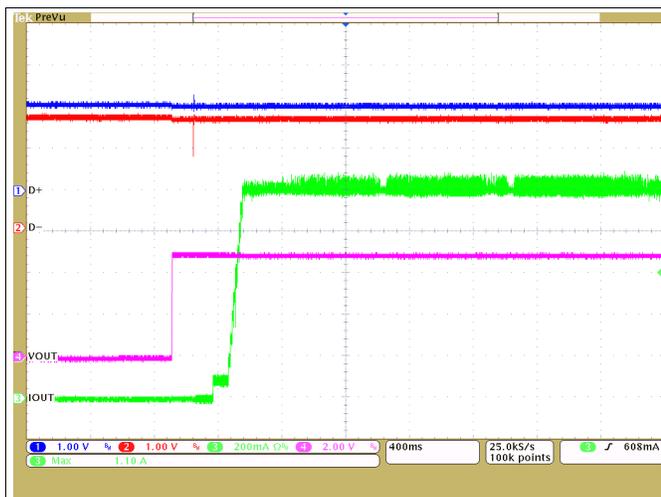


Figure 5. TPS65982 and TPS2544 (DCP Auto Mode) Test With iPhone 6S With Case1

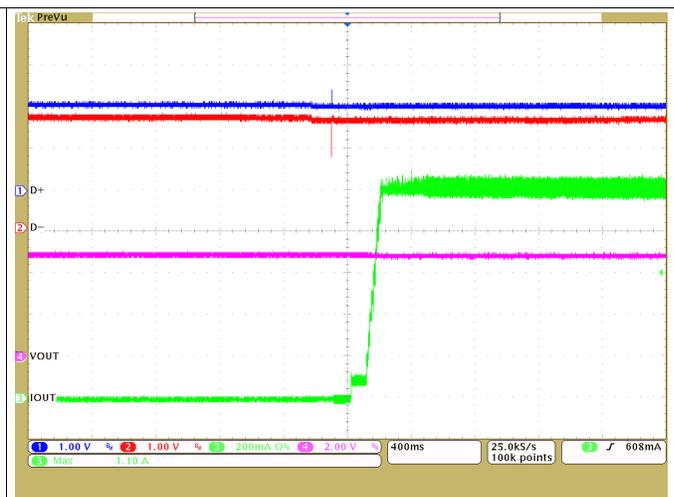


Figure 6. TPS65982 and TPS2544 (DCP Auto Mode) Test With iPhone 6S With Case2

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

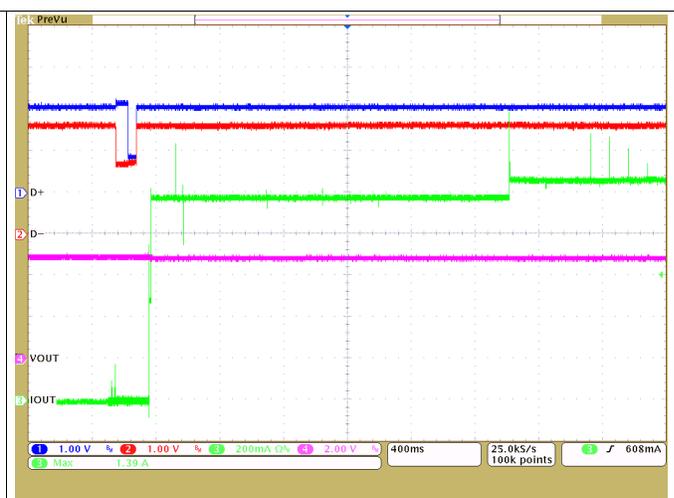


Figure 8. TPS65982 and TPS2544 (DCP Auto Mode) Test With Galaxy Note 5 With Case2

Figure 9 and Figure 10 show the HTC Sense tests.

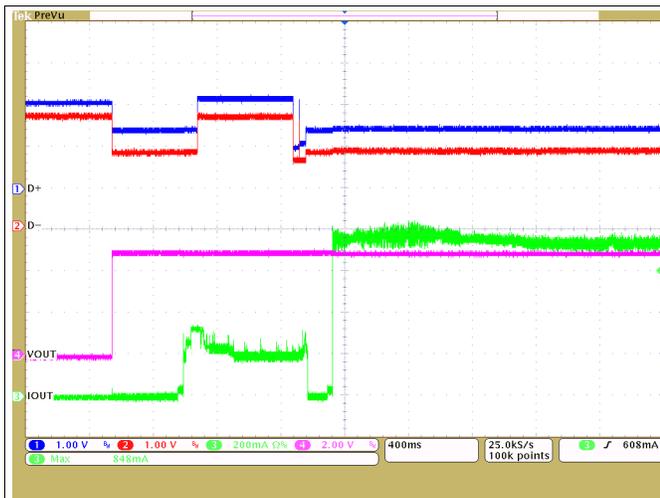


Figure 9. TPS65982 and TPS2544 (DCP Auto Mode) Test With HTC Sense With Case1

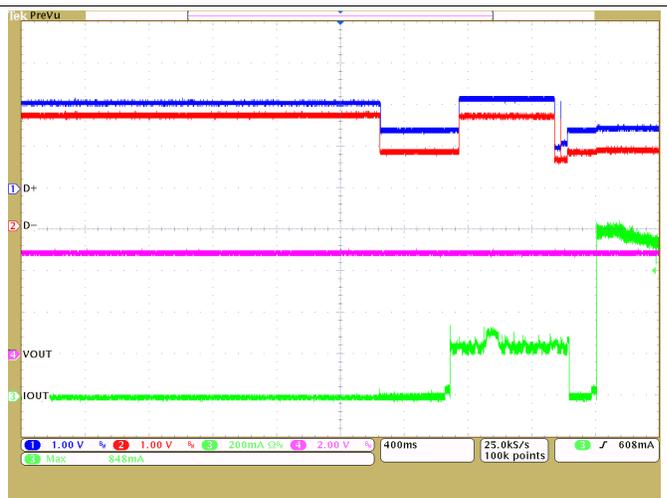


Figure 10. TPS65982 and TPS2544 (DCP Auto Mode) Test With HTC Sense With Case2

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_previous_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 I²C command to the TPS65982 device, the discharge timing of the VBUS connector is slightly different from the TPS2544 OUT.

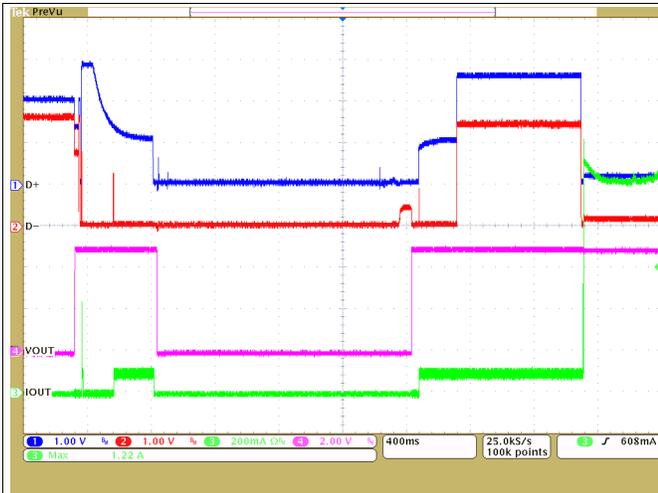


Figure 11. TPS65982 and TPS2544 (DCP Auto Mode) Test With Blackberry Bold 9700 With Case1

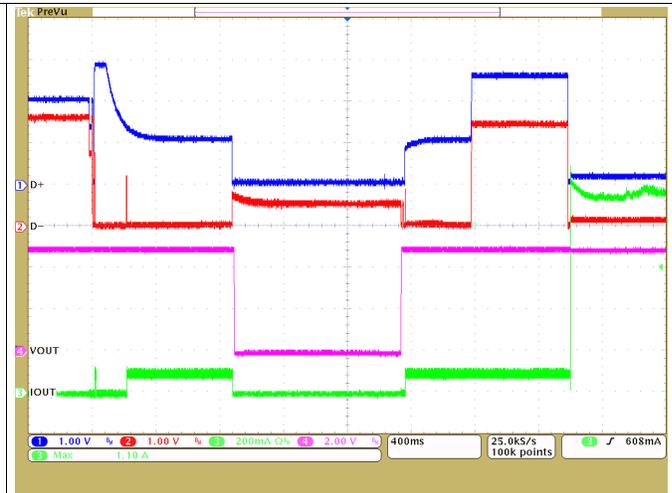


Figure 12. TPS65982 and TPS2544 (DCP Auto Mode) Test With Blackberry Bold 9700 With Case2

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, [SLVSB08](#)
- USB Type-C Documentation, <http://www.usb.org/developers/usbtpec/>

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com