Application Report
SLVA713A – June 2015 – Revised November 2015

TPS65982 and TPS65986 Quick Start and System Bring Up

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ABSTRACT

The TPS65982/6 is a stand-alone USB Type-C and Power Delivery (PD) controller providing cable plug and orientation detection at the USB Type-C connector. Upon cable detection, the TPS65982/6 communicates on the CC wire using the USB PD protocol. When cable detection and USB PD negotiation are complete, the TPS65982/6 enables the appropriate power path and configures alternate mode settings for internal and (optional) external multiplexers.

This application note provides the steps to bring up and test a Type-C PD system using the TPS65982/6. The TPS65982-EVM BoosterPack is used to emulate a notebook, dongle, dock, or charger to aid in system validation and verification. The EVMs are used as testing tools in this guide, where one resembles a notebook host and the second is used to simulate connecting to other types of Type-C PD devices. The EVM provides a visual confirmation of the expected behavior. Oscilloscope plots are shown for additional verification. For a full working system the same procedure is used to verify system functionality.

Hardware Required:

Oscilloscope

2 - TPS65982-EVM BoosterPacks (Loaded w/ BoosterPack FW)

Passive Type-C Cable

Contents

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1 Using the TPS65986 on the TPS65982-EVM

The TPS65986 is a pin-to-pin compatible device and is drop-in replaceable with the TPS65982. The following list shows the differences and similarities between the TPS65982 and TPS65986.

- TPS65982 and TPS65986 firmware can be used in both devices
  - Note that some functions may not be present
- TPS65986 does not have the PP_EXT FET control from the TPS65982
- TPS65986 does not have the secondary I^2C port from the TPS65982

2 TPS65982 BoosterPack Thunderbolt™ Notebook Configuration

Configure the TPS65982-EVM to simulate a notebook host. Use notebook configuration (Configuration ID: 1) when using the TPS65986 on the TPS65982-EVM.

Switch Settings

- Low → B0 → (Left)
- High → B1 → (Right)
- Low → B2 → (Left)
- Low → B3 → (Left)

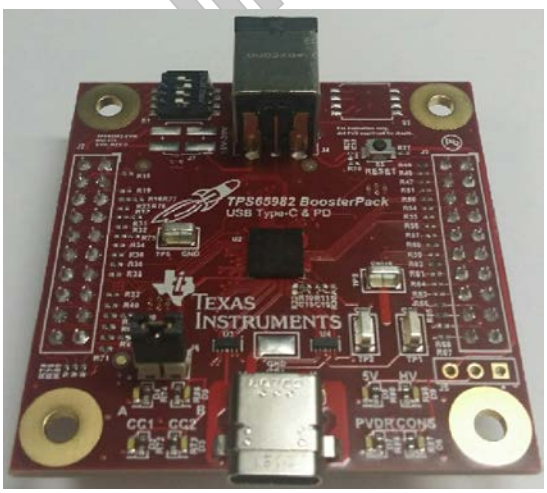

Figure 1. Thunderbolt Notebook Switch Configuration

3 Verification of Firmware Load and CC1/CC2

The TPS65982-EVM BoosterPack uses LED B to notify the user that the application firmware has been loaded. **Figure 2** shows the powered EVM with LED B indicating that the firmware has been successfully loaded. When another firmware build has been loaded to the EVM, LED B may not light up.

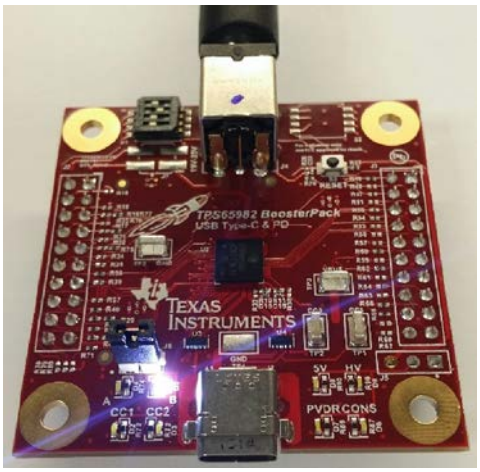

Figure 2. Powered TPS65982-EVM BoosterPack With Application Firmware

The EVM Thunderbolt notebook configuration represents a Dual Role Port system. Dual Role provides the Rp and Rd on CC1/CC2 by alternating between UFP (Upstream Facing Port) and DFP (Downstream Facing Port). The oscilloscope image in Figure **3** shows the CC1/CC2 (**Yellow**) /(**Cyan**) lines toggling between UFP and DFP modes. VBUS (**Magenta**) should remain 0 V while CC1/CC2 are not connected. This signifies that the application firmware is successfully running on the TPS65982/6.

Figure 3. CC1/2 Dual Role Toggling

When the CC lines are not toggling, it is most likely the TPS65982/6 has not successfully read from the flash and is currently in BOOT mode. Debugging for when the CC1/CC2 lines are not toggling:

- Confirm that the firmware is loaded on the external flash:
  - Read flash and verify there is an image
  - Verify that the flash is powered

Checking the appropriate supplies will help indicate that the TPS65982/6 has successfully powered up. If one of the following supplies is not present check for any shorts on the board:

- Verify that VIN_3V3 on the TPS65982 is receiving 3.3 V from the system
- Verify that LDO_3V3 on the TPS65982 is 3.3 V
- Verify that LDO_1V8D on the TPS65982 is 1.8 V
- Verify that LDO_1V8A on the TPS65982 is 1.8 V

Figure 4 shows the TPS65982 supplies. It is possible to measure the voltage on the supplies on their respective capacitors. When 3.3 V is not present on VIN_3V3, verify that the system 3.3-V rail is powered. If VIN_3V3 is present, verify that the TPS65982 is properly soldered to the board by quick visual inspection or x-ray verification.

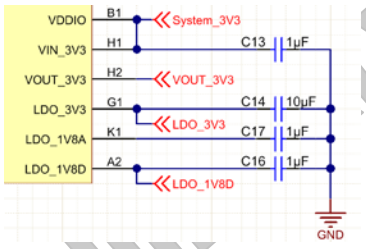

Figure 4. TPS65982-EVM BoosterPack Supplies

When testing as a DFP (Downstream Facing Port), apply Rd (5.1 kΩ to GND) on either CC1/CC2. VBUS (Magenta) should transition from 0 V to 5 V after Rd is detected on CC1/CC2. In **Figure 5,** CC2 (Cyan) is connected. After a certain amount of time after Rd has been detected, the TPS65982 will begin to send out USB PD source capabilities messages. The transitions on CC2 seen towards the end of the waveform are the PD messages. **Figure 7** shows an Rd applied to CC1 (Yellow). **Figures 6 and 8** show the LED behavior when an Rd is connected. CC1/CC2 LEDs will be on according to which is connected and the 5-V LED indicates 5 V on VBUS.

Figure 5. CC2 Connection

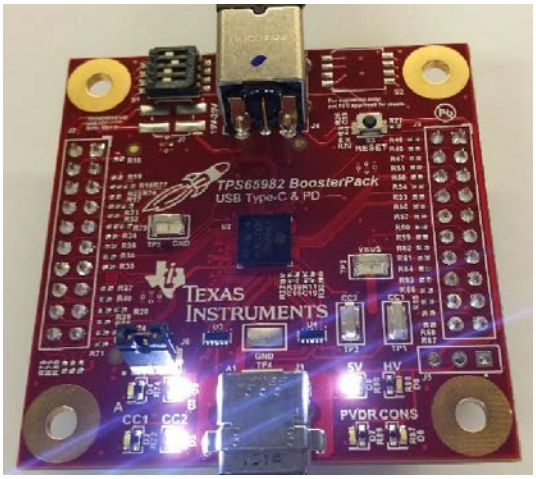

Figure 6. CC2 TPS65982-EVM BoosterPack LED behavior

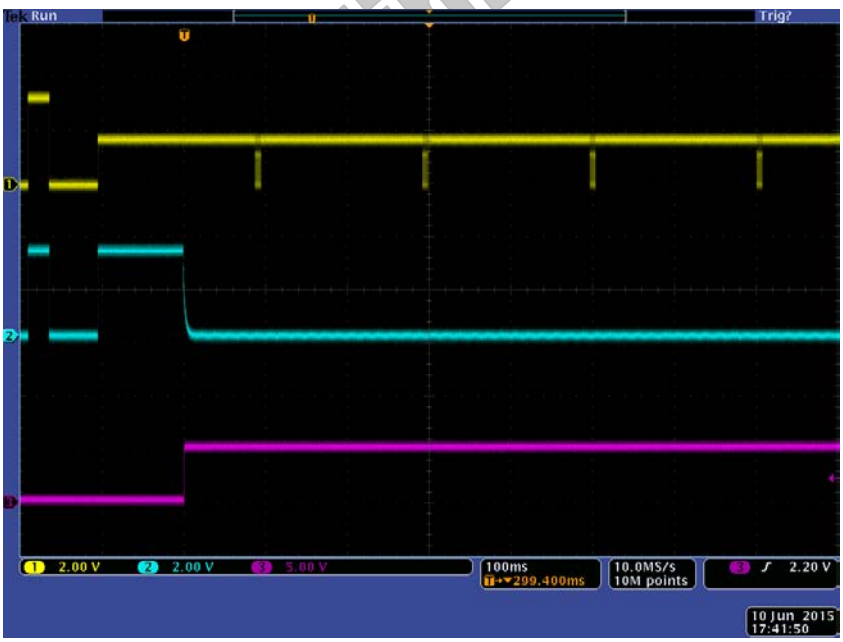

Figure 7. CC1 Connection

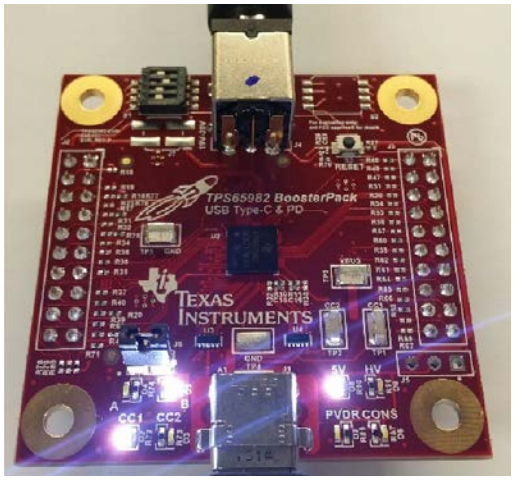

Figure 8. CC1 TPS65982-EVM BoosterPack LED behavior

When a device is not connecting to the system, verifying VBUS ensures that the device connected is receiving power. Use the following steps if CC1/CC2 does not connect or if VBUS does not reach 5 V:

- Verify that PP_5V0 is receiving 5 V from the system **(Figure 9)**
- Verify that there is not a pulldown on CC1/CC2 **(Figure 10)**

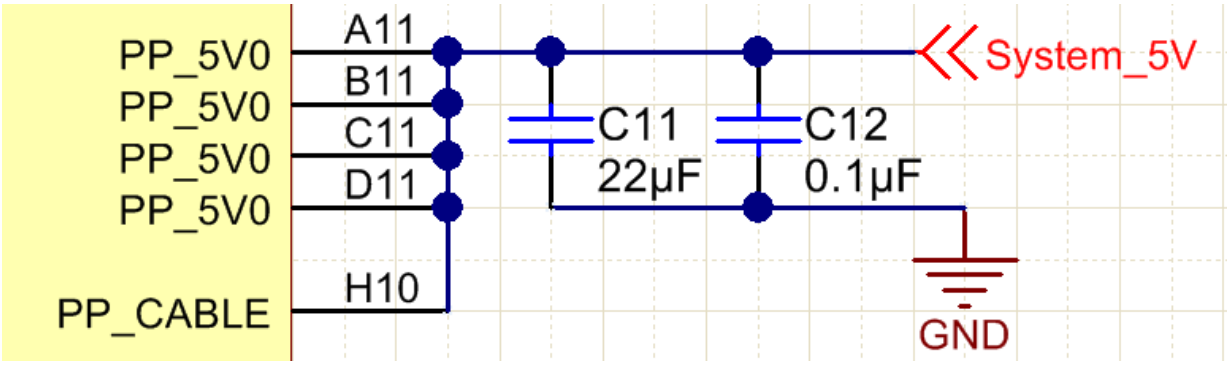

Figure 9. PP_5V0 Supply

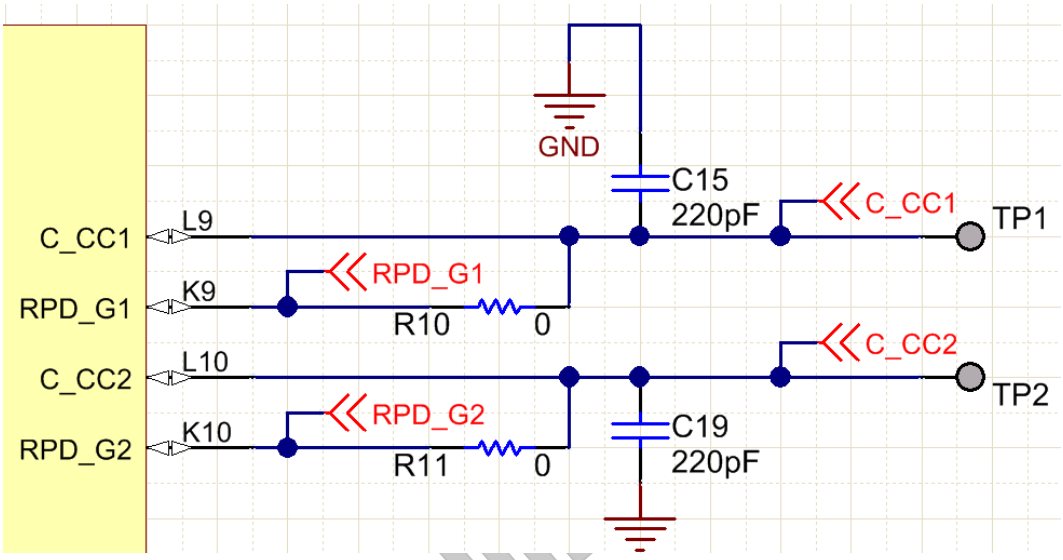

Figure 10. CC1/CC2 Paths

4 Dead Battery & Power Delivery Verification

Dead battery and power delivery can be tested in one setup where the second EVM is configured as Type-C PD charger.

Type-C PD Charger Switch Settings:

- Low → B0 → (Left)
- High → B1 → (High)
- High → B2 → (High)
- Low → B3 → (Left)

The Thunderbolt notebook configuration supports sinking 20 V at 3 A through the PP_EXT path and the Type-C PD charger supports sourcing 20 V at 3 A, check **Figure 12**. With the EVM configured as a Thunderbolt notebook (unpowered with the DC Barrel Jack disconnected) connect it to the second EVM configured as a Type-C PD charger. **Figure 11** shows both boards connected. The left board is acting as the Type-C PD Charger and the right is configured as the Thunderbolt notebook. The HV LEDs (right bottom) on both EVMs are blinking when the power contract is established at 20 V. Note that the Type-C PD Charger has the PVDR LED on and the notebook has the CONS LED on. For the TPS65986, using Configuration ID 1 will sink 20 V at 3 A through the PP_HV internal FET path.

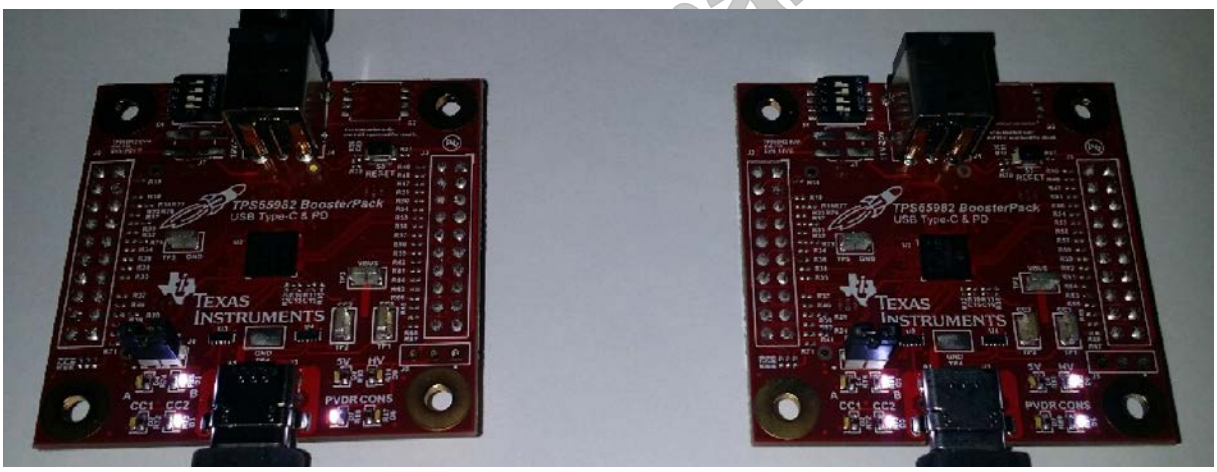

Figure 11. Type-C PD Charger connected to Thunderbolt notebook

Notebook Sink Capabilities	5 V at 0 A fixed	20 V at 3 A fixed	
Charger Source Capabilities	5 V at 3 A fixed	12 V at 3 A fixed	20 V at 5 A fixed

Figure 12. Thunderbolt Notebook and Charger Capabilities

Figure 13 shows the cable connect and the PD contract negotiation. VBUS (Magenta) transfers from 0 V to 5 V, once a cable has been connected. Once a PD contract is established, VBUS transitions from 5 V to HV (20 V).

Figure 13. Established PD Contract

Debugging for when VBUS does not reach 20 V:

- Verify that the VBUS HV is equivalent to the barrel jack voltage
- Verify that that the capacitance on CC1/CC2 is 220 pF **Figure 14**
- Verify that the PD BMC waveform is clean (zoom in on CC2) **Figure 15**

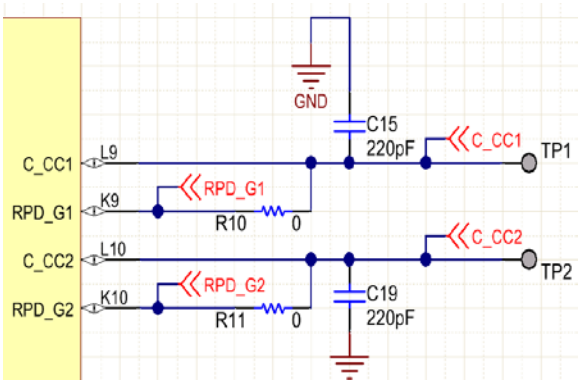

Figure 14. CC1/CC2 Capacitance

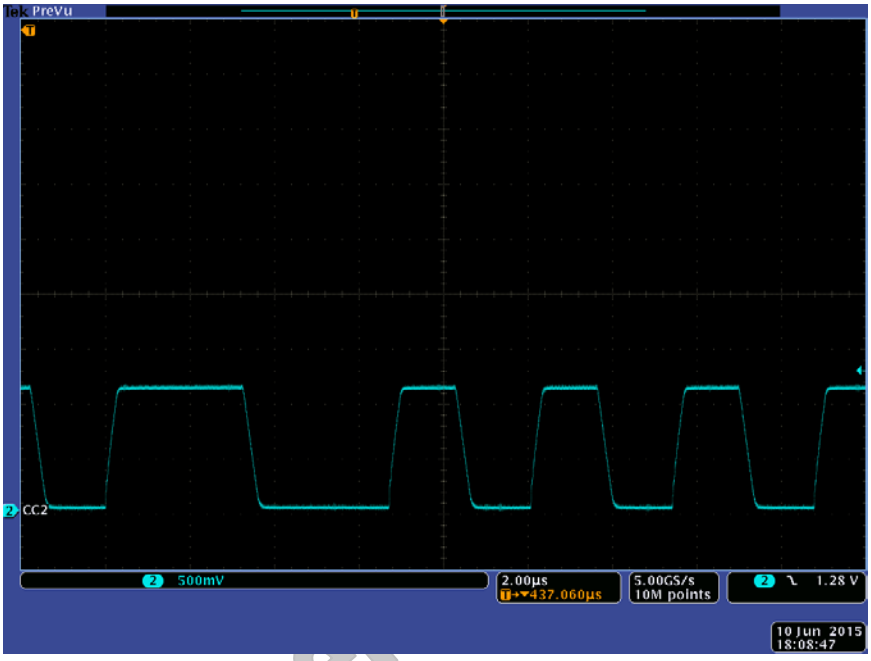

Figure 15. Specification-Compliant PD BMC Waveform

5 DisplayPort Alternate Mode Verification

The Thunderbolt notebook configuration supports three configurations of the DisplayPort alternate mode as a DisplayPort source (DFP_D); DFP_D Pin Assignment C (4ln DisplayPort), DFP_D Pin Assignment D (2ln DisplayPort and USB3), and DFP_D Pin Assignment E (4ln DisplayPort). Depending on the Pin Assignment configured, LED A will either turn on or blink. **Table 1**summarizes the Pin Assignments. For the TPS65986, using Configuration ID 1 supports the same DisplayPort configurations.

Table 1. Pin Assignment Summary

DisplayPort Configuration	Description	LED A Behavior
DFP_D Pin Assignment C	4 Lane DP (Dock)	On
DFP_D Pin Assignment D	2 Lane DP & USB3	Blinking
DFP_D Pin Assignment E	4 Lane DP (Dongle)	On

TPS65982-EVM BoosterPack Dock UFP_D Pin Assignment D Configuration Switch Settings:

- Low → B0 → (Left)
- Low → B1 → (Left)
- Low → B2 → (Left)
- Low → B3 → (Left)

Figure 17 shows the notebook on the left (DC Barrel Jack attached) and a dock (Un-Powered Dock with Pin Assignment D) on the right. LED A blinks indicating that the 2 lane DisplayPort and USB3 configuration was entered. The notebook will be the provider of power (PVDR LED on) and the dock will be the consumer of power (CONS LED on). Note that the LEDs may flicker due to the on-board 5-V DC/DC converter acting in 100% Duty Cycle mode.

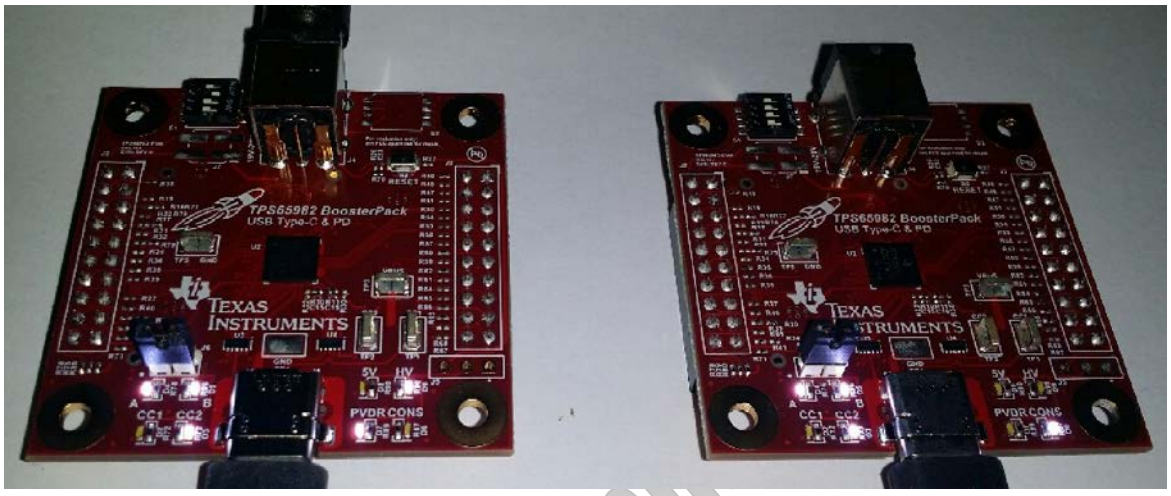

Figure 16. Notebook and Dock: DisplayPort Pin Assignment D

TPS65982 Booster Pack Dongle UFP_D Pin Assignment E Configuration Switch Settings:

- Low → B0 → (Left)
- Low → B1 → (Left)
- High → B2 → (Right)
- Low → B3 → (Left)

Figure 18 shows the notebook on the left and a dongle (Pin Assignment E) on the right. LED A remains on indicating that the 4 lane DisplayPort configuration was entered. The notebook is the provider of power (PVDR LED on) and the dongle isthe consumer of power (CONS LED on). Note that the LEDs may flicker due to the on-board 5-V DC/DC converter acting in 100% Duty Cycle mode.

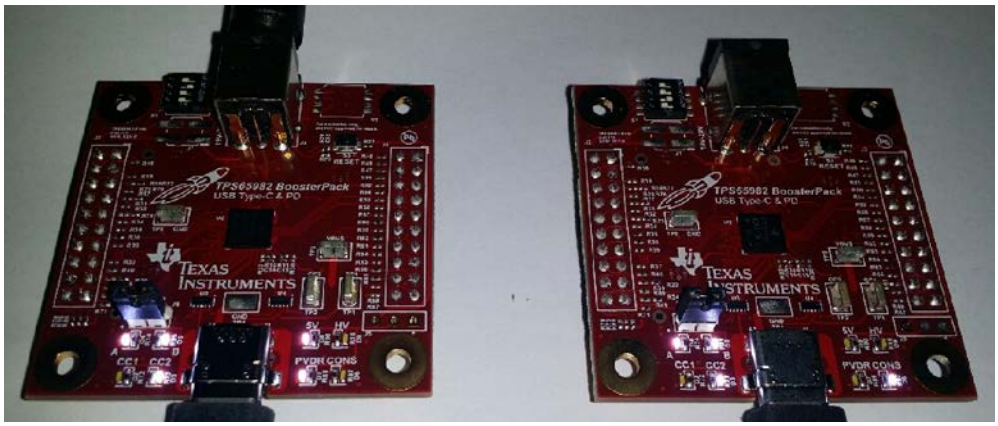

Figure 17. Notebook and Dongle: DisplayPort Pin Assignment E

6 Summary

The same testing procedure can be used on a final system to verify the basic functionality of the TPS65982/6 by using an oscilloscope. When a TPS65982 BoosterPack is used for testing additional functions can be verified such as PD charging and DisplayPort alternate mode.

Using the steps provided the user can verify the following:

- Verify system power up and proper application firmware load
- Understand the typical behavior of a notebook application under common-use cases
- Verify PD communication for power and Alternate-Mode entry
  - Verify USB PD specification-compliant BMC data
  - Negotiate a high-voltage power contract for notebook charging
  - Negotiate DisplayPort alternate mode in different configurations (Dock & Dongle)
- Troubleshoot common system bring-up issues

7 Revision History

Changed text in the Abstract on page 1.

Changed text in Section 1 and added Section 2 on page 3.

Changed paragraph after figure 2 through figure 4 on pages 4 and 5.

Changed paragraph before figure 9 on page 7.

Changed paragraph before figure 11 on page 9.

Changed Section 5 on page 11.

Changed Summary on page 13.

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