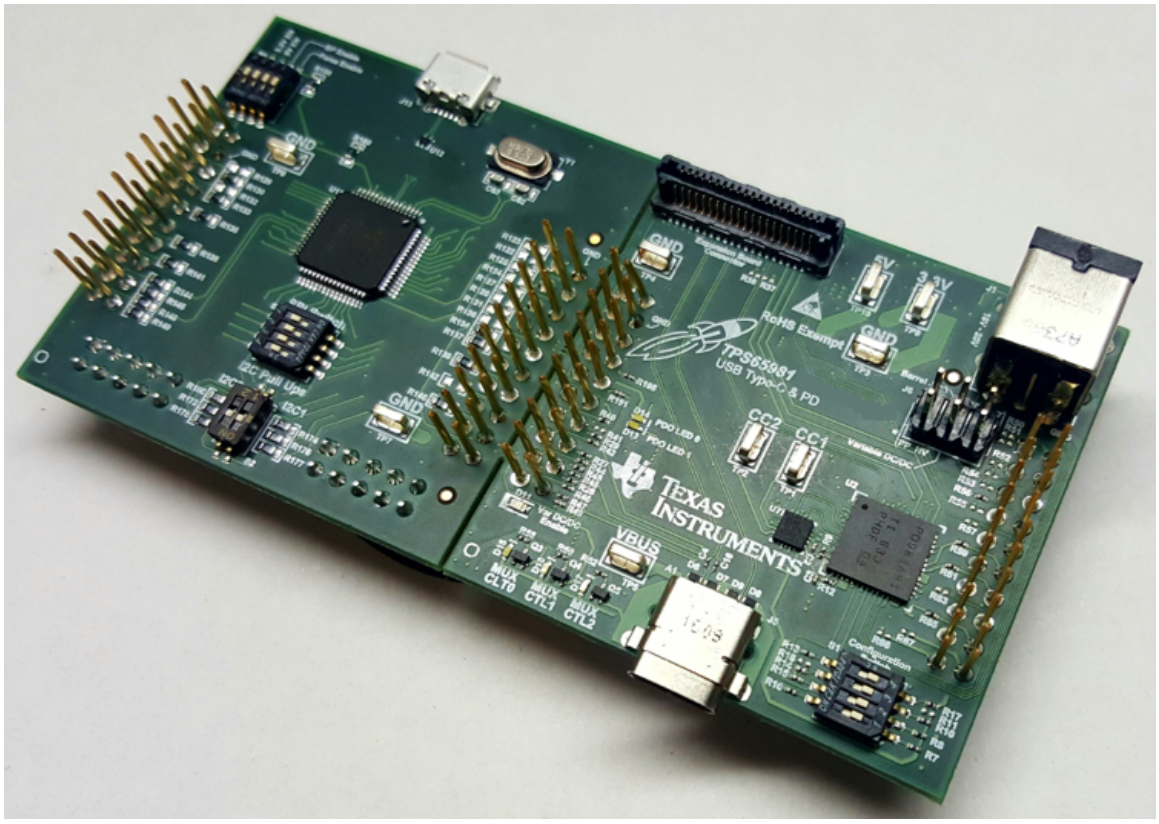
TPS65981EVM User's Guide

This document is the user's guide for the TPS65981 evaluation module (TPS65981EVM). The TPS65981EVM allows for evaluation of the TPS65981 device as part of a stand-alone testing kit and for development and testing of USB Type-C and Power Delivery (PD) end products.



1 About this Manual

This user's guide describes the TPS65981EVM. The guide consists of an introduction, setup instructions, the EVM schematic, board layouts, component views, internal PWR and GND plane layouts, and a bill of materials (BOM).

2 Information About Cautions and Warnings

ATTENTION
STATIC SENSITIVE DEVICES

HANDLE ONLY AT
STATIC SAFE WORK STATIONS

CAUTION

This EVM contains components that can potentially be damaged by electrostatic discharge. Always transport and store the EVM in the supplied ESD bag when not in use. Handle using an antistatic wristband. Operate on an antistatic work surface. For more information on proper handling, refer to *Electrostatic Discharge (ESD)* [SSYA010].

3 Items Required for Operation

The following items are required to use the TPS65981EVM:

- TPS65981 data sheet (*TPS65981 USB Type-C and USB PD Controller, Power Switch, and High Speed Multiplexer*, SLVSDC2)
- TPS65981EVM
- DP-EXPANSION-EVM (*DP-EXPANSION-EVM User Guide*, SLVUAR1)
  - Testing for DisplayPort, USB data, or both
  - Mini DisplayPort to DisplayPort cable
- TPS6598x Application Customization Tool (www.ti.com/tool/tps6598x-config)
- Barrel-jack adapter or DC power supply
- USB micro-B to Type A or TotalPhase Aardvark
- USB Type-C cable
- USB Type-C to Type-A cable

4 Introduction

The TPS65981 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. Upon cable detection, the TPS65981 device communicates on the CC wire using the USB PD protocol. When cable detection and USB PD negotiation are complete, the TPS65981 device enables the appropriate power path and configures alternate mode settings for internal and (optional) external multiplexers.

This user's guide describes the TPS65981EVM and its capabilities with the DP-EXPANSION-EVM. This guide also contains testing procedures of various PD power and alternate mode configurations. The EVM comes with preloaded firmware for *out-of-the-box* functionality and is also customizable through the TPS6598x Application Customization Tool. Additionally, the EVM has a USB micro-B and Aardvark to SPI or I^2C interface for debugging and development. The TPS65981EVM is a module based design, allowing the user to design a custom board to prototype Type-C and PD products using the TPS65981 device.

5 Setup

This section describes the various EVM features and how to test the various configurations.

5.1 Switch, Connector, and Test Point Descriptions

5.1.1 Switch Banks

5.1.1.1 S1: Configuration Switch

The S1 switch bank is used to configure the EVM. By default, all switches should be placed in the *right* or off (pulled down to GND) position. The top switch is tied to BUSPOWERZ and allows the EVM to be powered from dead battery using different the different power paths. The second, third, and fourth switches are bits 0, 1, and 2, respectively. These switches are reserved for future use and, currently, should always be set *right*. Bit 0, bit 1, and bit 2 are connected to DEBUG_CTL1, GPIO6, and GPIO5, respectively. The *left* or *high* position is pulled up through an 11-kΩ resistor to LD0_3V3.

5.1.1.2 S3: FTDI Enable and Disable

The switches labeled *3.3V EN* and *5V EN* pass the supply from the FTDI board to the J8 header. These two switches should be disabled by default and should be in the down position.

The BP Enable and Force Enable switches control the reset on the FTDI device. When BP Enable is set high, the TPS65981 device holds the FTDI in reset until it has successfully loaded the firmware. When set low, a weak pulldown on the FTDI reset pin occurs, holding the device in reset. This switch should be set low by default in the down position.

The Force Enable switch has a weak pullup to the board 3.3-V supply to always enable the FTDI device and a weak pull down on the FTDI reset pin which holds the device in reset when switched low. This switch should be set high in the up position by default.

5.1.2 Connectors

5.1.2.1 J1: Barrel-Jack Power Connector

The barrel-jack power connector accepts a 19-V to 20-V DC supply. A standard Dell or HP notebook adaptor (or similar adapter) provides the required power. This input provides the SYS_PWR with 19 V to 20 V for high-power PD contracts up to 60 W. Be sure to select an appropriate power adapter that is capable of 60-W operation. For example, the Dell 130W part number, 492-BBGP, could be used.

The TPS65981EVM is capable of requesting a power-role swap when the barrel jack is connected on an EVM that is currently bus powered. This is valid for the configurations that are capable of delivering power. The barrel-jack voltage is sensed by a comparator, which drives GPIO2 on the TPS65981 device. To enable barrel-jack detect or other GPIOs, refer to the *TPS6598x Utilities Tool User's Guide* and *TPS65981, TPS65982, and TPS65986 Firmware User's Guide* (SLVUAH7).

5.1.2.2 J3 and J8: Headers

These headers allow the EVM to be connected to any debug board. Additionally, this allows the left and right halves of the board to be stacked, which produces the equivalent connections prior to breaking off. See Figure 27 for names of all connections.

NOTE: Some of the header pins are not connected unless a 0-Ω option resistor is placed.

5.1.2.3 J4: Expansion Board Connector

The connector routes the power, SSTX/RX, USB_RP_P/N, AUX_P/N, HPD, I^2C, and GPIO control signals for the DP-EXPANSION-EVM.

5.1.2.4 J5: Type-C Connector

This receptacle is a full-feature port, with power, SSTX/RX, SBU1/2, and DP/N signals. The TPS65981 device can be used in self-powered and bus-powered configurations for added flexibility. When self-powered, the EVM can provide up to 60 W of power (20 V/3 A). The EVM is also capable of sinking 60 W of power (20 V/3 A) when device is powered or in dead battery or consumer mode.

5.1.2.5 J6: Power Path Connector

This connector allows jumpers to be placed based on which paths are being used for sourcing and sinking. When using the default firmware, the Variable DC/DC pin (bottom-middle) should be connected to the PP_HV pin (left) and the Barrel Jack pin (top-middle) should be connected to PP_EXT (right). See Figure 23 and the EVM labeling for the pin locations and routing.

5.1.2.6 J11: Debug Connector

This connector is only used for TI testing purposes.

5.1.2.7 J13: USB micro-B Connector

J13 is the USB connection to the PC for the TPS6598x Utilities GUI and TPS6598x Application Customization Tool. A standard USB micro-B to Type-A cable can be used to connect the EVM to the USB port on a computer.

5.1.2.8 J14: Aardvark Connector

This connector matches the Aardvark I^2C or SPI master that allows the user to access the I^2C and SPI pins on the TPS6598x EVM. In other words, this allows the user to use the TotalPhase Aardvark.

NOTE: The FT4323 will load the I^2C or SPI pins when powered. TI recommends leaving the FT4323 in reset by having the Force Enable and BP Enable switches in the off (down) position.

5.1.3 Test Points

5.1.3.1 TP1 and TP2: CC1/CC2 Test Points

These test points can be used to tie a PD-protocol analyzer for PD BMC data or to verify the BMC signal integrity with an oscilloscope (depending on the cable orientation). A multimeter or oscilloscope can be used to measure VCONN when an electronically marked Type-C cable is connected. These test points are not intended to provide an external load on VCONN. Figure 1 shows the BMC data oscilloscope capture.

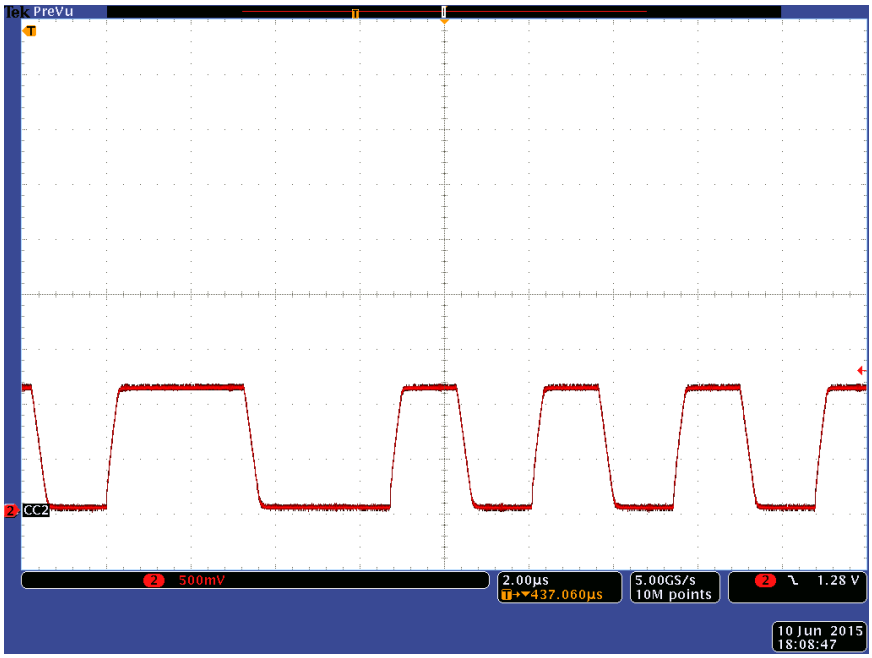


Figure 1. TPS65981 BMC Data

5.1.3.2 TP3, TP4, TPS, TP7, and TP8: GND Test Points

Two GND test points are provided for attaching an oscilloscope, multimeter, or external load GND. These test points are connected to the board GND planes through four vias.

5.1.3.3 TP5: VBUS Test Point

The VBUS test point is used to measure VBUS at the connector. With PD power possibly going up to 20 V, use caution when connecting and disconnecting probes on the TPS65981EVM. The VBUS test point is capable of drawing up to 3 A for an external load. A PD-power contract with the required capability must be negotiated to draw current from the VBUS test point. Refer to the *TPS6598x Application-Customization Tool User Guide* (SLVUAR8) for configuration instruction. Figure 2 shows the VBUS voltage during PD-power negotiation.

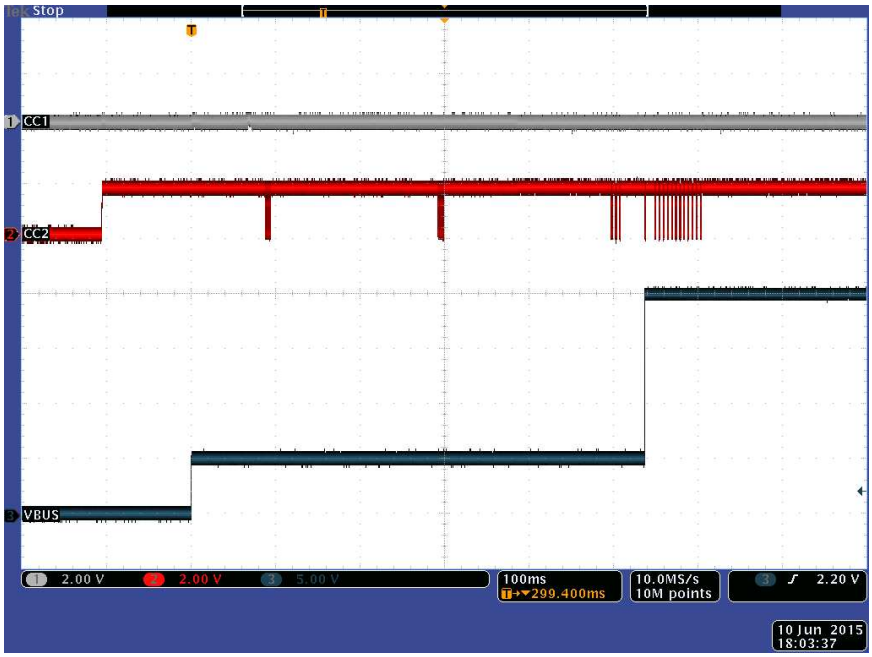


Figure 2. TPS65981 VBUS Voltage Transition

5.1.3.4 TP9 and TP10: 5V and 3.3V Test Points

These test points can be used to measure the output voltage of the DC-DC converters that produce the required functionality of the voltage rails including power delivery, the TPS65981, LEDs, and more.

5.1.4 LED Indicators

5.1.4.1 MXCTL0-2 LEDs (Super-Speed Mux Contol LED)

These LEDs correspond to the GPIOs required to drive a super-speed mux for the SSTX/RX signals to a Type-C connector. Table 1 lists the LED behavior according to the type of connection.

Table 1. MXCTLx LED Functions

LED Indicator	GPIO	Function
MXCTL0	GPIO 0	Type-C Connection
MXCTL1	DEBUG1 (GPIO 15)	HD3SS460 POL
MXCTL2	GPIO 3	HD3SS460 AMSEL

5.1.4.2 Var DC-DC Enable

This LED is high when the variable DC-DC converter is on which occurs when SYS_PWR is approximately 20 V.

5.1.4.3 PDO LED 0 and PDO LED 1

These LEDs are high depending on which high-voltage PDO is negotiated. Table 2 lists the LED behavior.

Table 2. PDO LED Functions

PDO	PDO LED 1	PDO LED 0
PDO 1 (5 V)	0	0
PDO 2 (9 V)	0	1
PDO 3 (15 V)	1	0
PDO 4 (20 V)	1	1

6 Using the TPS65981EVM

This section describes the EVM configurations on the preloaded firmware, getting started, and debugging the EVM.

6.1 Powering the TPS65981EVM

The main power supply for the EVM is J1 barrel jack, which accepts 19 V to 20 V through a barrel jack adaptor. The EVM can also be powered with an external power supply on J6. The input voltage can range from 12 V to 20 V, but the appropriate power profile should be configured in the firmware using the configuration tool. The EVM can also be powered from a TI MCU LaunchPad Development Kit by placing 0-Ω resistors (see Figure 18). If powering with a LaunchPad Development Kit, the EVM does not support high-voltage contracts or provide high currents at 5 V because of the limited power capability. The EVM can also be bus powered from the Type-C connector and accepts 5 V to 20 V on VBUS, depending on the sink configuration.

6.2 Firmware Configurations

The EVM is shipped with a preloaded firmware image that supports various Type-C and PD products: dock and notebook. The firmware is loaded at start-up and the configuration is defined by the state of the third switch on the S1 configuration switch (see Section 5.1.1.1). The top three switches in the switch bank represent B0, B1, and B2, respectively. Table 3 lists the configurations on the EVM.

Table 3. Firmware Configurations

CFG ID	Switch S1	Port Type	Type-C Power	PD Source				PD Sink Capabilities		DP Support	PD Control	Application
		Data Power	A	V at A	V at A	V at A	V at A	V at A	V at A		Initiated DR/PR Swaps	
0	0 → ■ 0 → ■ 0 → ■ 0 → ■	DRP Rp/Rd	3	5 at 3	9 at 3	15 at 3	20 at 3	5 at 0.9	—	UFP_D Config C and D	Initiate DR swap to UFP Initiate PR swap to Src	Docking system
1	0 → ■ 0 → ■ ■ ← 1 0 → ■	DRP Rp/Rd	3	5 at 0.9	—	—	—	5 at 3	12 to 20 at 3	DFP_D Config C, D and E	Initiate DR swap to DFP Initiate PR swap to Snk	Notebook system

6.3 Connecting the TPS65981EVM

Various Type-C cables can be used to connect the EVM to a legacy Type-A host, legacy Type-A device, or Type-C device.

6.3.1 Connecting to a Legacy Type-A Host

Using a Type-A plug to Type-C cable allows connection to a legacy host. When the billboarding and endpoint functions are enabled on the EVM, the user can access the registers and update the firmware by using the TPS6598x Utilities GUI. The EVM can be powered from the Type-A to Type-C cable and does not require a power-supply function with the TPS6598x Utilities GUI. Figure 3 shows how the TPS65981 device is connected to a notebook with the TPS6598x Utilities GUI.

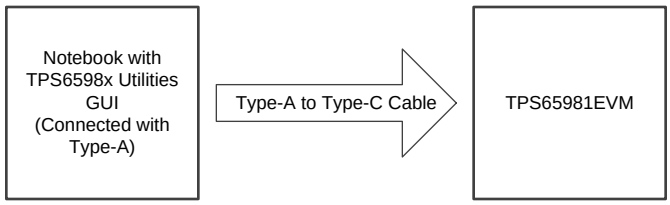


Figure 3. Connecting EVM to Legacy Host

6.3.2 Connecting to a Legacy Type-A Device

Using a Type-C to Type-A receptacle cable allows for connection to a legacy USB device, such as a flash-drive. The TPS65981 device cannot act as a host but can pass the USB connection to a host by using the DP-EXPANSION-EVM (DisplayPort source board). Figure 4 shows how the notebook, DP-EXPANSION-EVM, TPS65981EVM, cable, and flash drive are connected

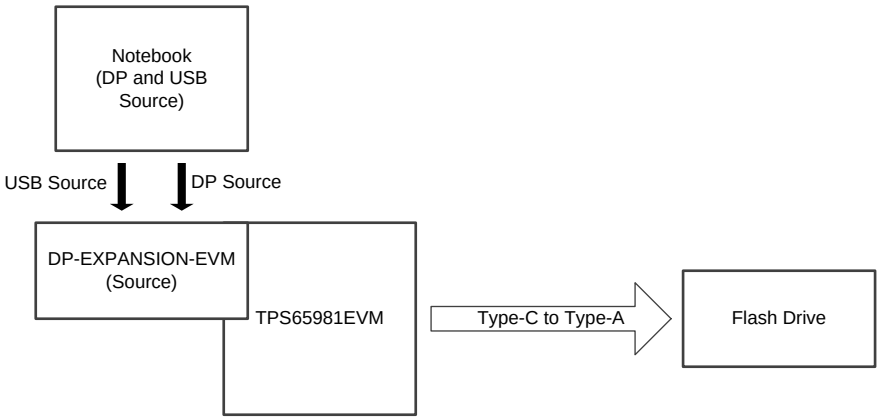


Figure 4. Connecting EVM to Type-A Device

6.3.3 Connecting to Type-C Devices

Using a Type-C cable allows for connection to a Type-C device or host. When two TPS65981EVMs are used with the DP-EXPANSION-EVM (source and sink boards), a complete Type-C system can be verified. The DisplayPort alternate mode is entered when the two setups appropriately configure as defined in Table 3. The source setup requires a USB source with DisplayPort to provide data to the sink board. A monitor can be connected to sink board, along with a USB device to connect to the source board. Figure 5 shows how the boards are connected.

NOTE: Signal integrity can be a factor on USB and DisplayPort video quality because of going through multiple connectors and cables.

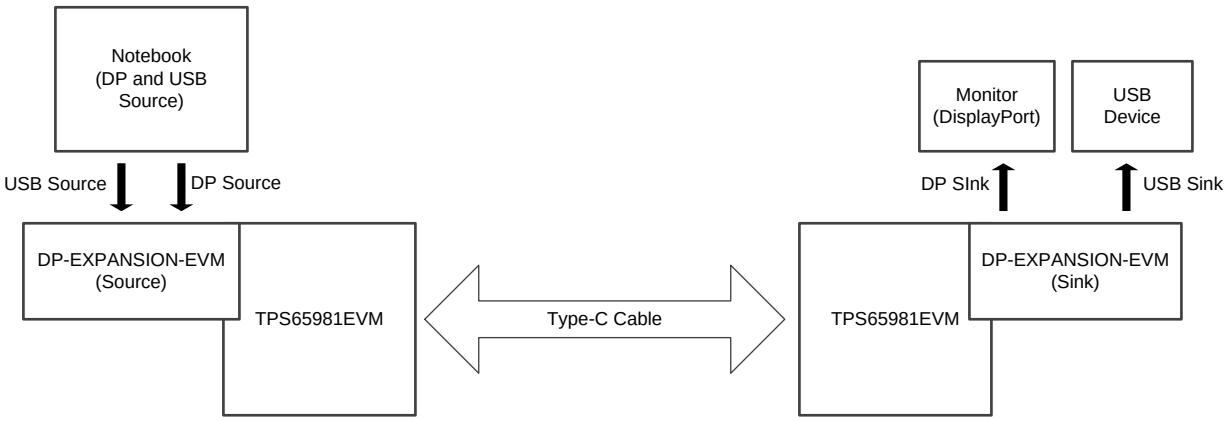


Figure 5. Connecting EVM to EVM for Type-C System

Figure 6 shows how a source setup can be connected to a Type-C device (DisplayPort, USB, or both), such as a Type-C flash drive, Type-C to DisplayPort dongle, Type-C to HDMI, or Type-C docking system.

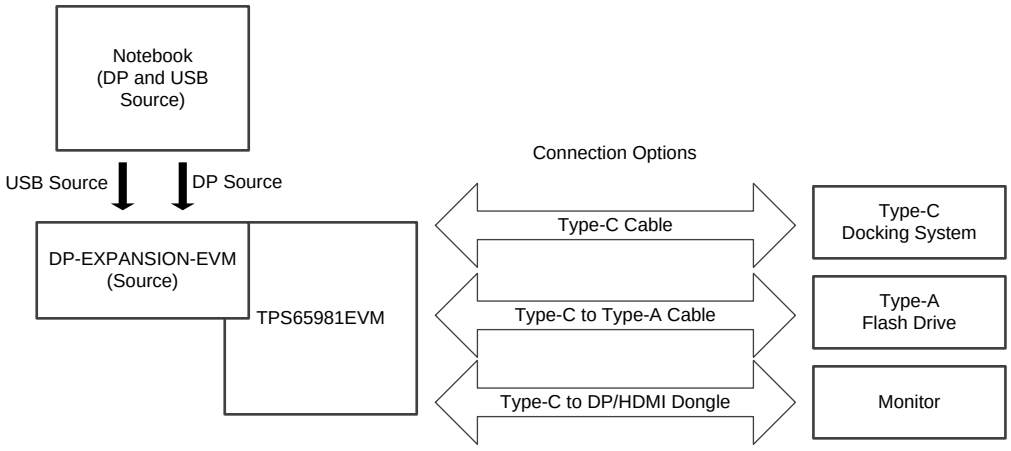


Figure 6. Connecting EVM to Type-C Devices

Figure 7 shows how a sink setup can be connected to a Type-C host, such as MacBook or ChromeBook Pixel, to enter the DisplayPort alternate mode. The sink allows DisplayPort and USB connections to the notebooks.

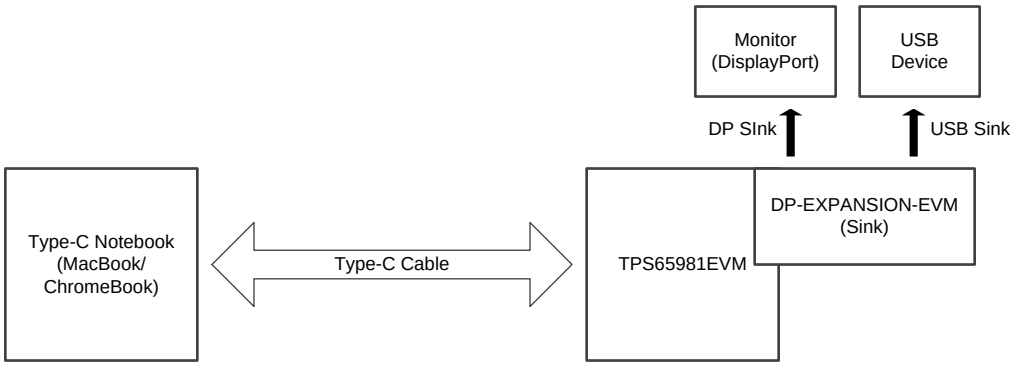


Figure 7. Connecting EVM to Type-C Host

6.3.4 Testing DisplayPort Alternate Mode

The DisplayPort alternate mode can be tested with a non-Type-C notebook, allowing the user to simulate a DisplayPort DFP_D (video source) or UFP_D (video sink). Table 4 lists the testing flow used to verify DisplayPort functionality with two TPS65981EVMs and the DP-EXPANSION-EVM (DIsplayPort source and sink boards).

CAUTION

Do not connect the DP-EXPANSION-EVM to the TPS65981EVM when the barrel jack is connected—this may result in a short if the expansion board connectors are misaligned.

The required hardware is listed as follows:

- A Windows PC with a USB Type-A receptacle and DisplayPort video output
  - USB3.0 Type-A to Type-B cable
  - USB3.0 flash drive
  - USB2.0 Type-A to Type-B cable
- USB Type-C Cable
- 1080p Monitor with DisplayPort input
- Mini DisplayPort to DisplayPort cable
- On board FTDI or Aardvark I^{2}C/SPI Host Adapter (Used for programming the TPS695986-EVM and interfacing with Utilities GUI)
- ACS002 DP-EXPANSION-EVM (source and sink board)
- Two TPS65981EVMs with base firmware (preloaded before shipping)
- Dell laptop power-supply model: DA130PE1-00

Table 4. DisplayPort Testing Table

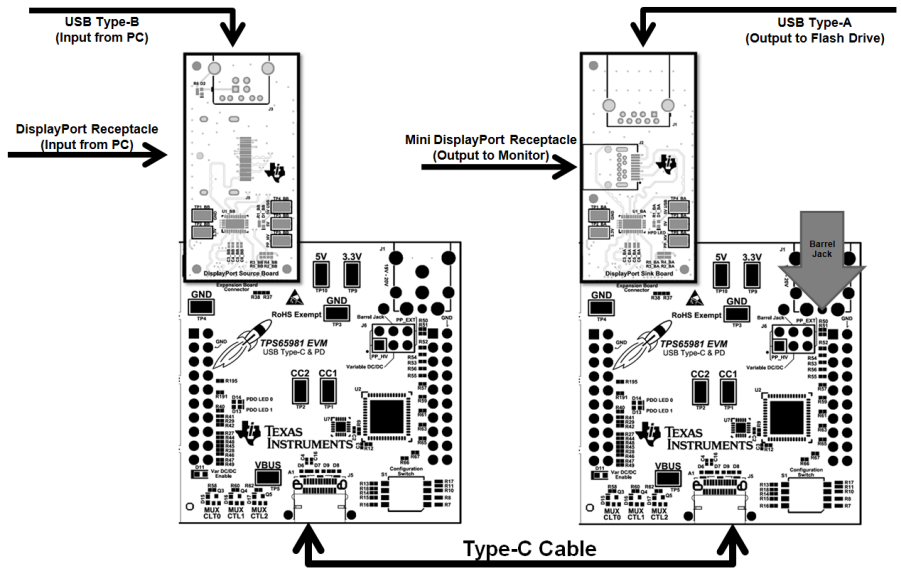
Test Step	Pass Criteria
Left switch setting: 0 → ■ 0 → ■ ■ ← 1 0 → ■ Right switch setting: 0 → ■ 0 → ■ 0 → ■ 0 → ■	
Connect the ACS002 DisplayPort source board to board on left output of the PC and USB3.0 output of the PC.	DisplayPort source board should be connected to the DisplayPort
Connect the ACS002 DisplayPort sink board to board on right of the monitor and to a USB3.0 flash drive.	DisplayPort sink board should be connected to the DisplayPort input

Table 4. DisplayPort Testing Table (continued)

<table>
<tr><th>Test Step</th><th>Pass Criteria</th></tr>
<tr><td>Connect the barrel jack to the device under test (DUT)</td><td>Variable DC-DC LED (blue LED) will turn ON</td></tr>
<tr><td>Connect the Type-C Cable from the DUT to the Tester with Texas Instruments Logo facing DOWN on both</td><td>
<table>
<tr><th>DUT LEDs</th><th>Test LEDs</th></tr>
<tr><td>MXCTL0: ON</td><td>MXCTL1: ON</td></tr>
<tr><td>MXCTL1: ON</td><td>MXCTL2: ON</td></tr>
<tr><td>MXCTL2: ON</td><td>MXCTL3: ON</td></tr>
<tr><td>Variable DC-DC: ON</td><td>Variable DC-DC: ON</td></tr>
<tr><td>PDO 0: ON</td><td>PDO 0: OFF</td></tr>
<tr><td>PDO 1: ON</td><td>PDO 1: OFF</td></tr>
</table>
</td></tr>
<tr><td>Check for video on DisplayPort monitor and verify USB flash drive is accessible</td><td>Successfully copy and paste a file to and from the USB flash drive. Extend the PC to the DisplayPort monitor and play video to verify video stream.</td></tr>
<tr><td>Verify the voltages on the DUT DisplayPort source and sink boards</td><td>
<table>
<tr><th>DUT DisplayPort Source Board</th><th>Tester DisplayPort Sink Board</th></tr>
<tr><td>TP2_BB: 3.3 V</td><td>TP2_BB: 3.3 V</td></tr>
<tr><td>TP3_BB: 5 V</td><td>TP3_BB: 5 V</td></tr>
<tr><td>TP4_BB: 5 V</td><td>TP4_BB: 5 V</td></tr>
<tr><td>TP5_BB: 19 V to 20 V</td><td>TP5_BB: 5 V</td></tr>
</table>
</td></tr>
</table>

6.4 Debugging the EVM

This section describes various debugging examples.

NOTE: The testing and debugging approaches on the EVM can be applied to an actual system to help identify any issues.

6.4.1 Connection Not Established

The following checks can help resolve issues when connecting the EVM to another Type-C device or EVM and no status LEDs are on:

- Verify that a firmware image is loaded in on the TPS65981 device using the TPS6598x Utilities GUI.
- Verify the CC lines are toggling for dual-role port functionality (see Figure 8).
- Verify the following system supplies:
  - VIN_3V3: 3.3 V
  - LDO_3V3: 3.3 V
  - LDO_1V8D/A: 1.8 V
  - PP_5 V0/PP_CABLE: 5 V
  - Barrel Jack: 20 V
- Verify that the devices connected are compatible (see Table 3). Some of the compatible connections are listed as follows:
  - Dual Role Port → UFP
  - Dual Role Port → DFP
  - DFP → UFP
- Verify that VBUS is reaching 5 V when connected (see Figure 9)

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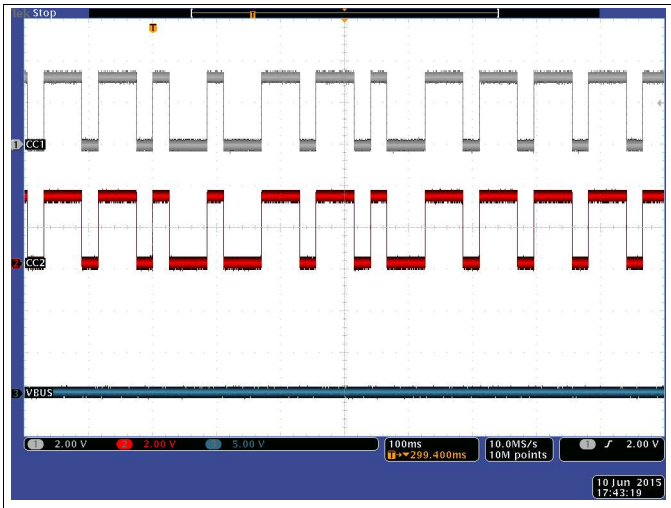

Figure 8. DRP CC1 and CC2 Toggling

Figure 9. Type-C Connection and VBUS

6.4.2 Reseting Behavior

Improper configurations and shorts can cause a Type-C PD system to constantly reset. Use the following checks to debug these types of issues:

- Verify that the required power paths have the correct voltages:
  - PP_5 V0/PP_CABLE: 5 V
  - PP_HV: 20 V (or appropriately configured voltage)
- Probe VBUS, CC1, and CC2 to check for any anomalies. Figure 10 shows a successful power contract.
- When a short occurs on VBUS, the initial 5 V on VBUS is not present.
- Check for a small spike during a cable attach event to verify that the 5-V switch is closed and is opened once the overcurrent event is detected.

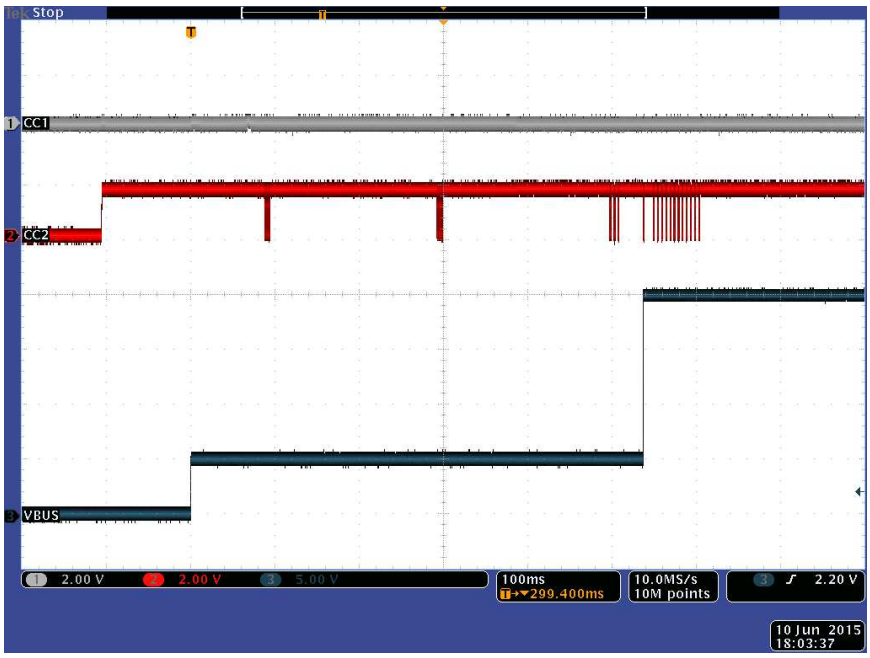

Figure 10. Type-C Connection and PD Negotiation

7 Programming the TPS65981EVM Firmware

This section describes loading firmware onto the TPS65981EVM.

NOTE: Other methods of firmware loading are available and are discussed in the TPS6598x Utilities Tool User Guide.

Step 1. Connect the USB Type-A to micro-B cable from the computer to the TPS65981EVM.

Step 2. Open the TPS6598x Utilities GUI, click the *Configure* link on the left side of the GUI, verify the settings, and confirm the connection by clicking the *Test Configuration Settings* button (see Figure 11).

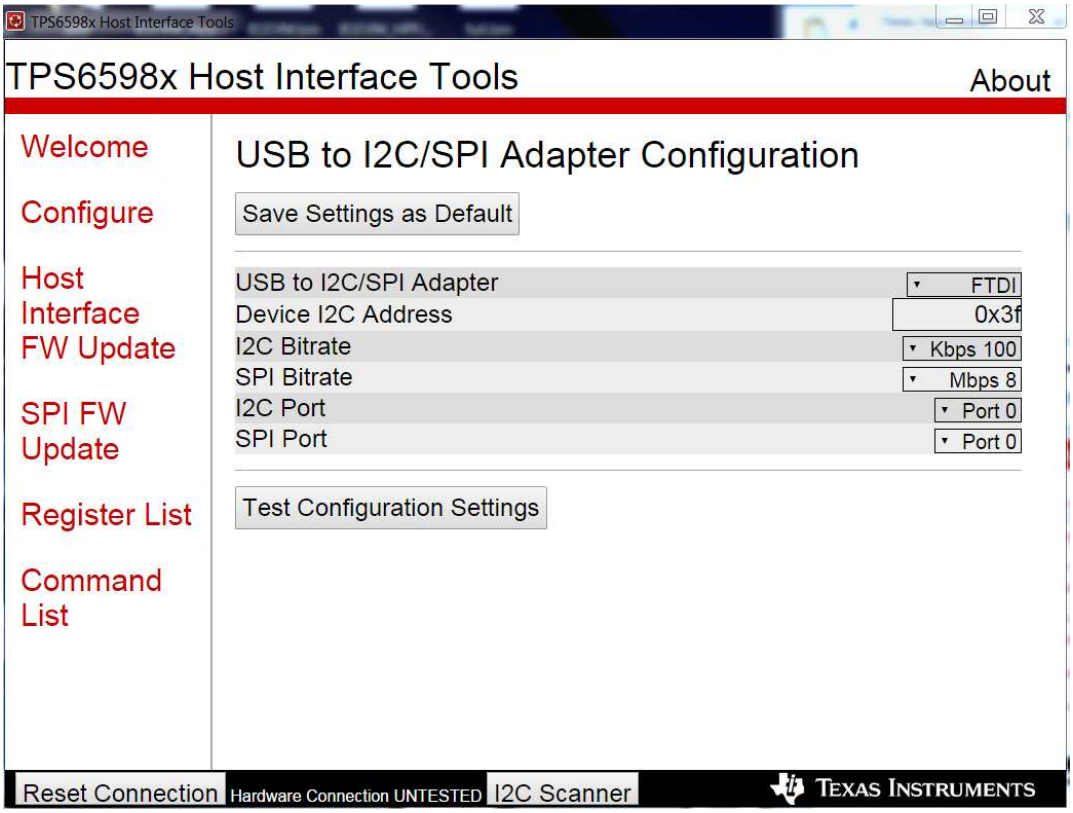

Figure 11. FTDI Configuration Settings

Step 3. Wait until the results are displayed in the *Connection Results* section. An EVM that does not have firmware displays *BOOT* after the *Mode Register returns* field.

Step 4. Click the *Save Settings as Default* button to save configuration settings.

Step 5. Click the *SPI FW Update* link on the left side of the GUI (see Figure 12).

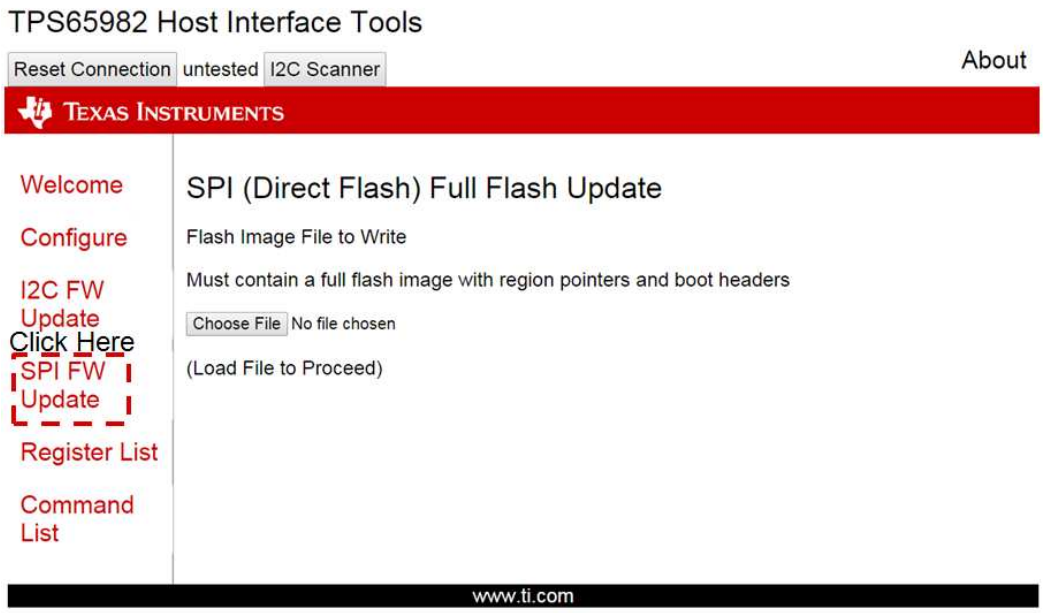

Figure 12. SPI Firmware Update Screen

Step 6. Choose the TPS65981EVM firmware image to load by clicking on the *Choose File* button (see Figure 13). Select the appropriate EVM image (2 region binary file) in the window and verify that it is 191KB in size. Click *Open* to load the file to the TPS6598x Utilities GUI.

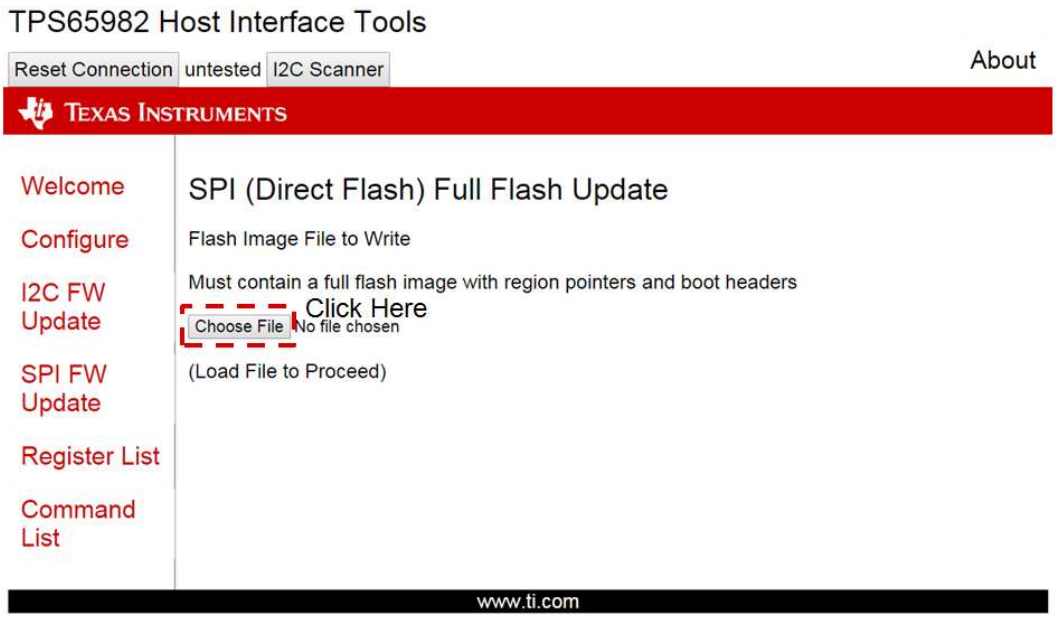

Figure 13. SPI Firmware Update – Choose File

Step 7. Click the *Program Flash Image* (see Figure 14).

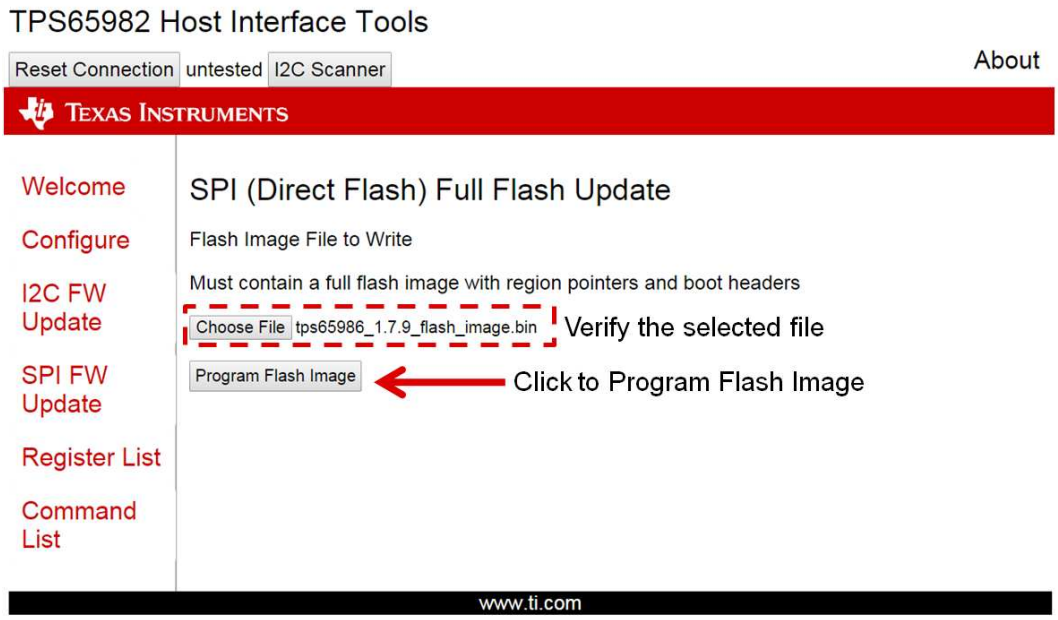

Figure 14. SPI Firmware Update – Start Flash Update

Step 8. Wait until the programming process is complete. Verify that the firmware was successfully loaded. Figure 15 shows a successful firmware update.

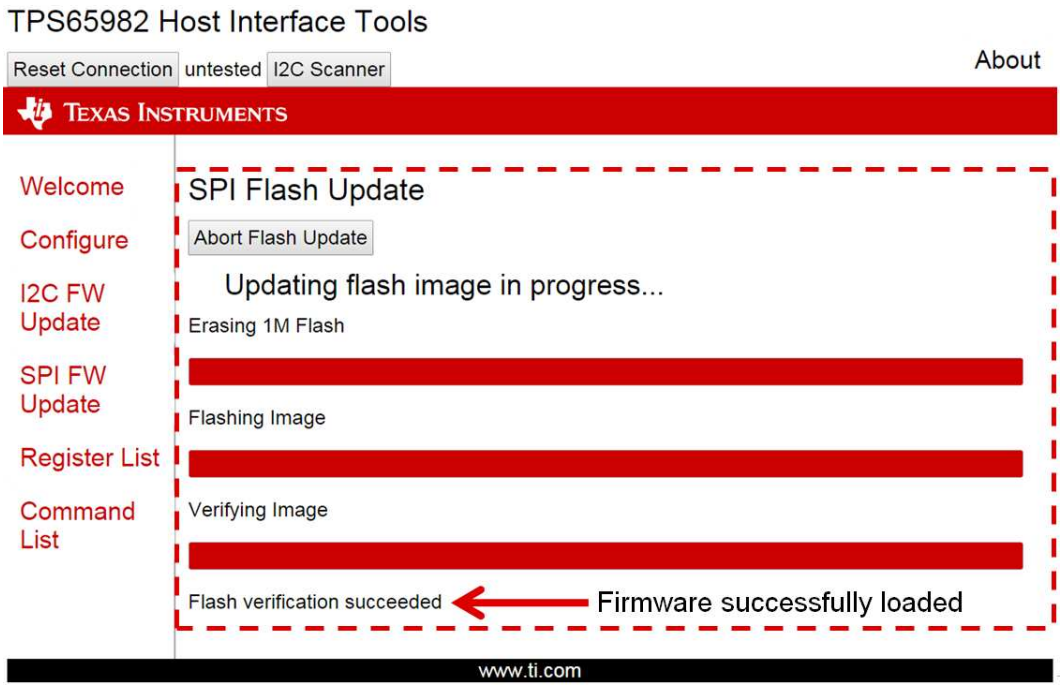

Figure 15. SPI Firmware Update – Firmware Update Complete

Step 9. 8. Power cycle the EVM to load the new firmware image.

Step 10. On the TPS6598x Utilities GUI, click the *Register List* link on the left side of the GUI and then click the *MODE* button (see Figure 16). This register will check the I^2C communication and verify that the firmware was loaded on the EVM.

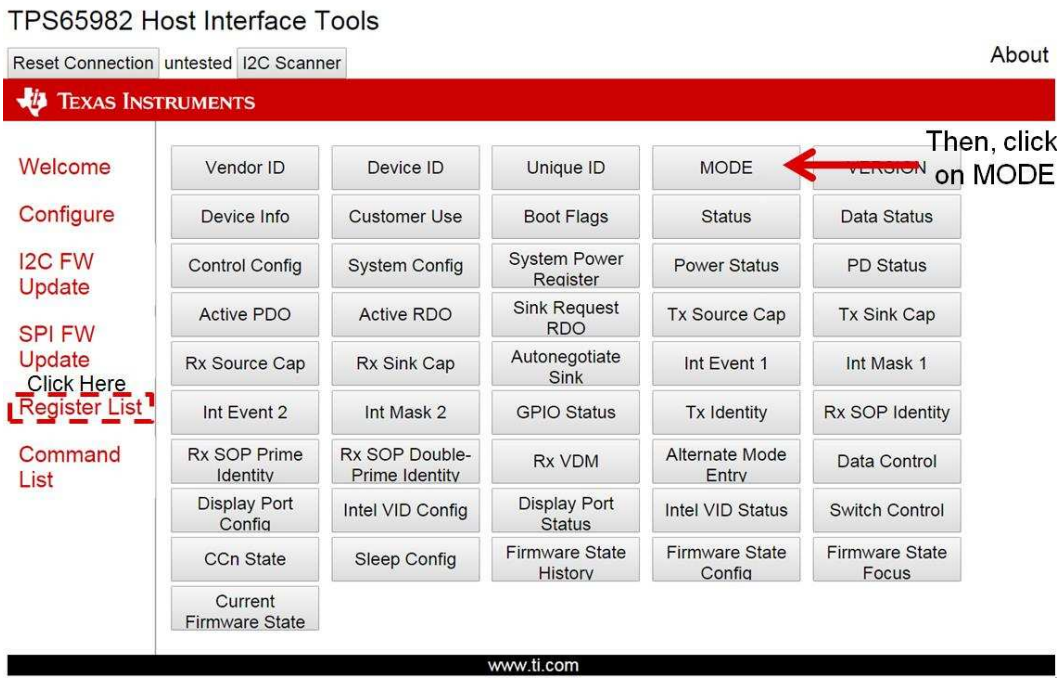

Figure 16. Register List

Step 11. Verify the that the MODE register reads *APP* (see Figure 17).

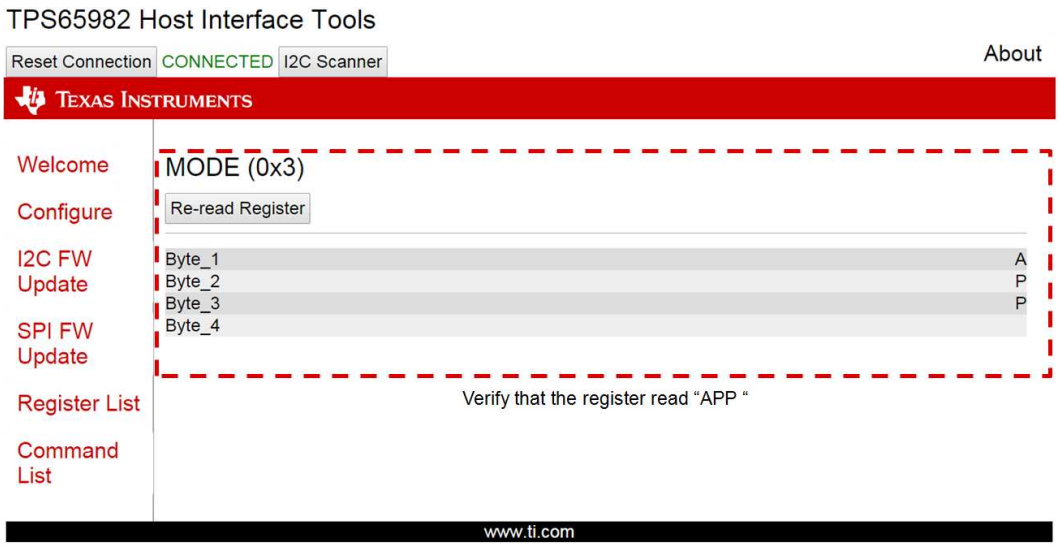

Figure 17. Mode Register

8 TPS65981EVM Schematic

Figure 18 shows the block diagram of the main components of the TPS65981EVM.

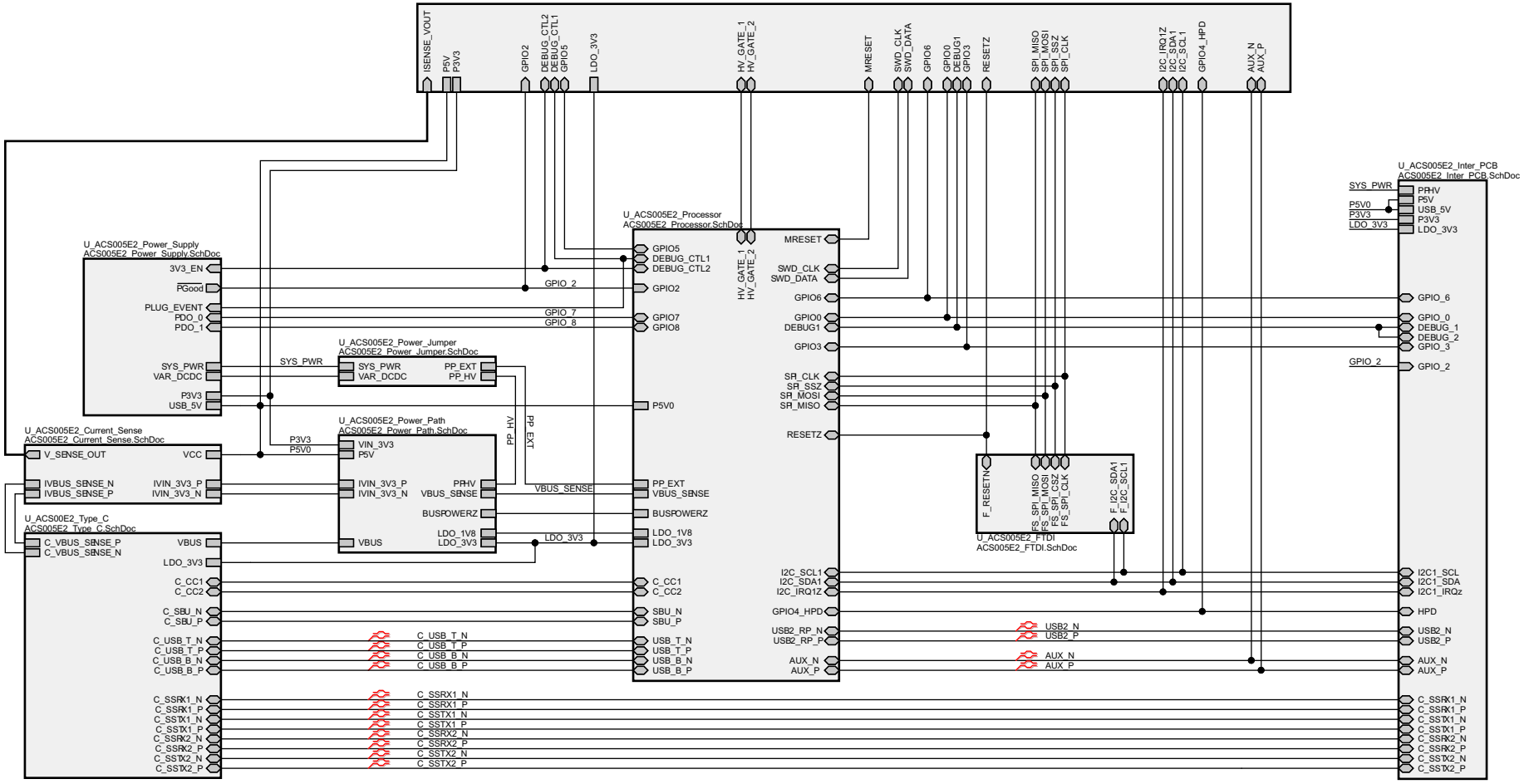

Figure 18. TPS65981EVM Block Diagram

Figure 19 shows the processor block, which contains the TPS65981 PD protocol functions, flash for the TPS65981 device, S2 for the firmware configuration, and the required passives.

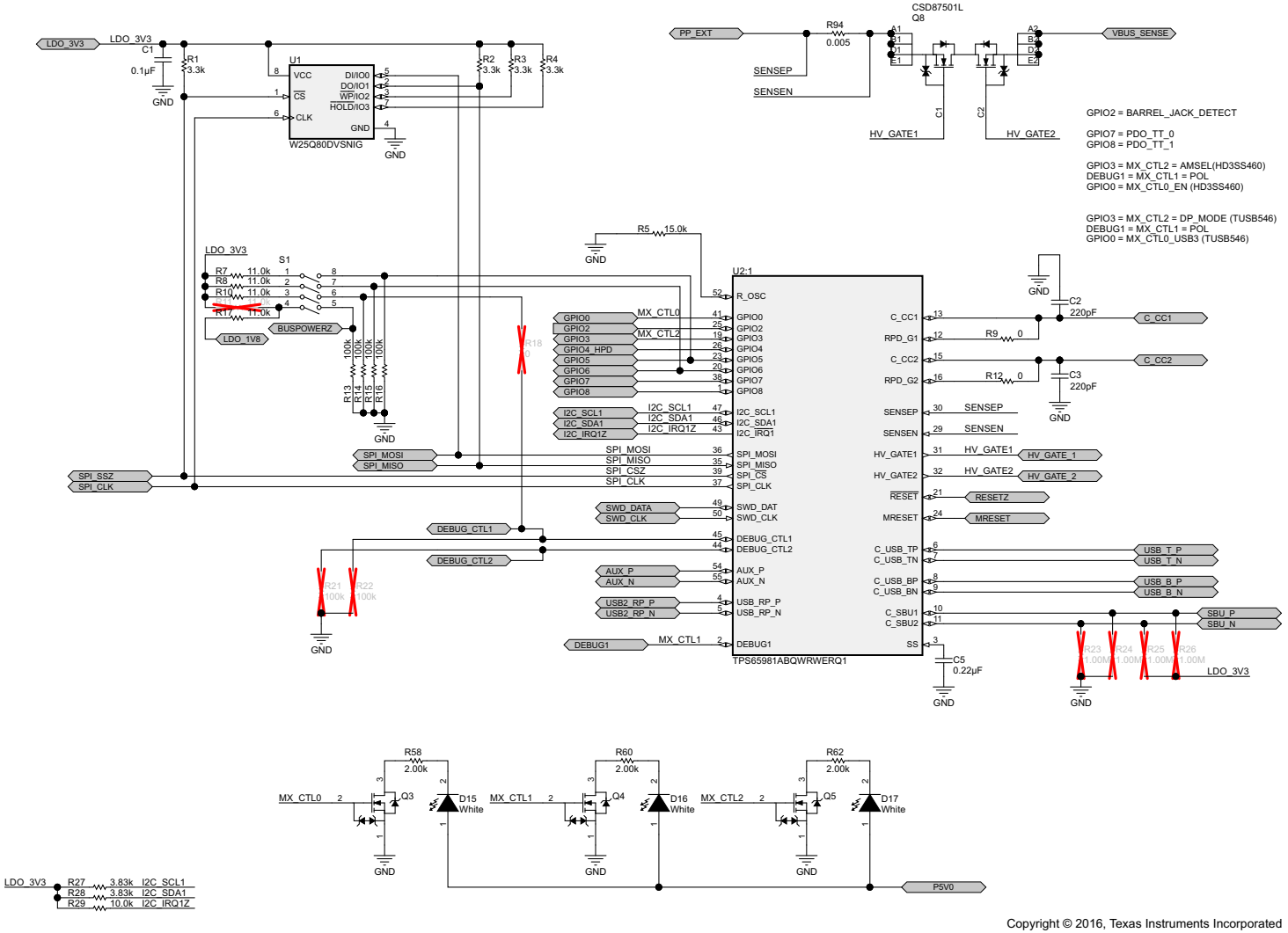

Figure 19. TPS65981EVM Processor Block

Figure 20 shows the FTDI block, which contains circuitry for the USB and Aardvark to SPI or I²C interface.

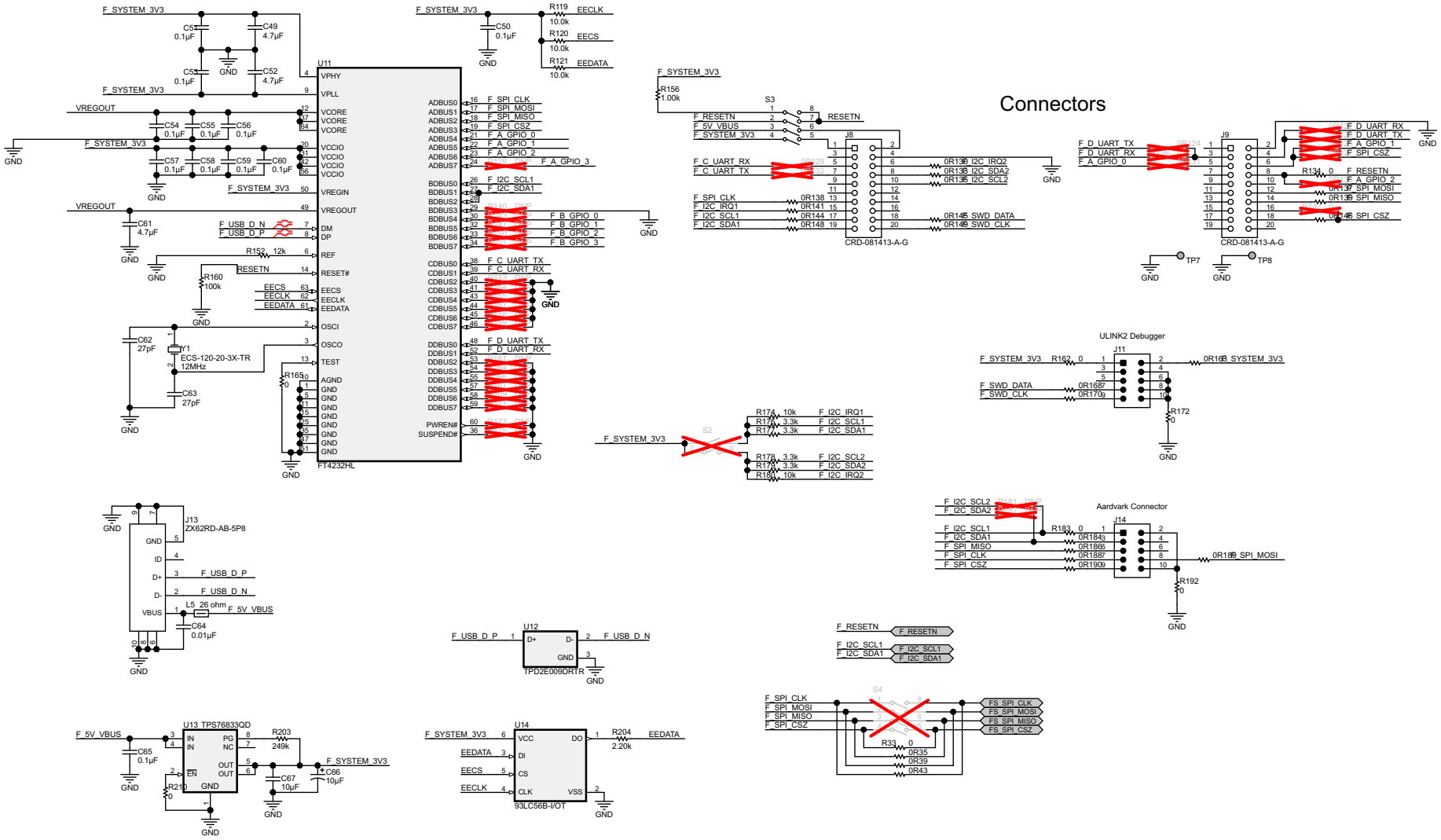

Figure 20. FTDI Block

Figure 21 shows the power-jumper connector, which allows the user to connect the power paths according to the firmware configuration.

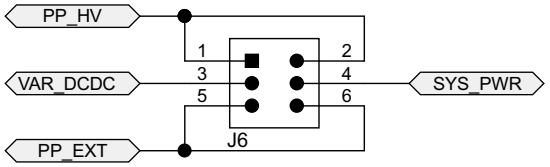

Figure 21. Power Jumper Block

Figure 22 shows the optional current-sense circuitry for VBUS and VIN_3V3.

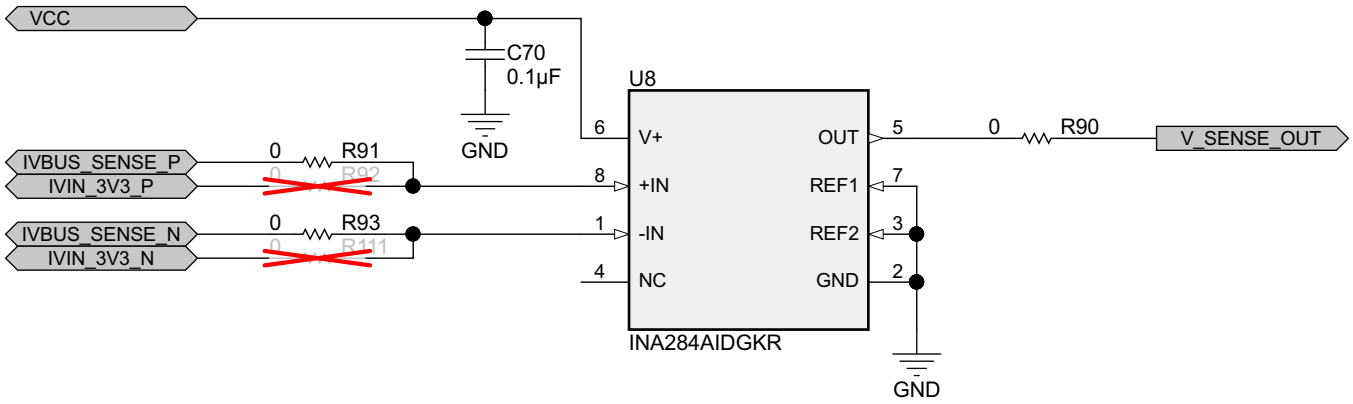

Figure 22. Current-Sense Block

Figure 23 shows the power path block of the TPS65981 and the required passives.

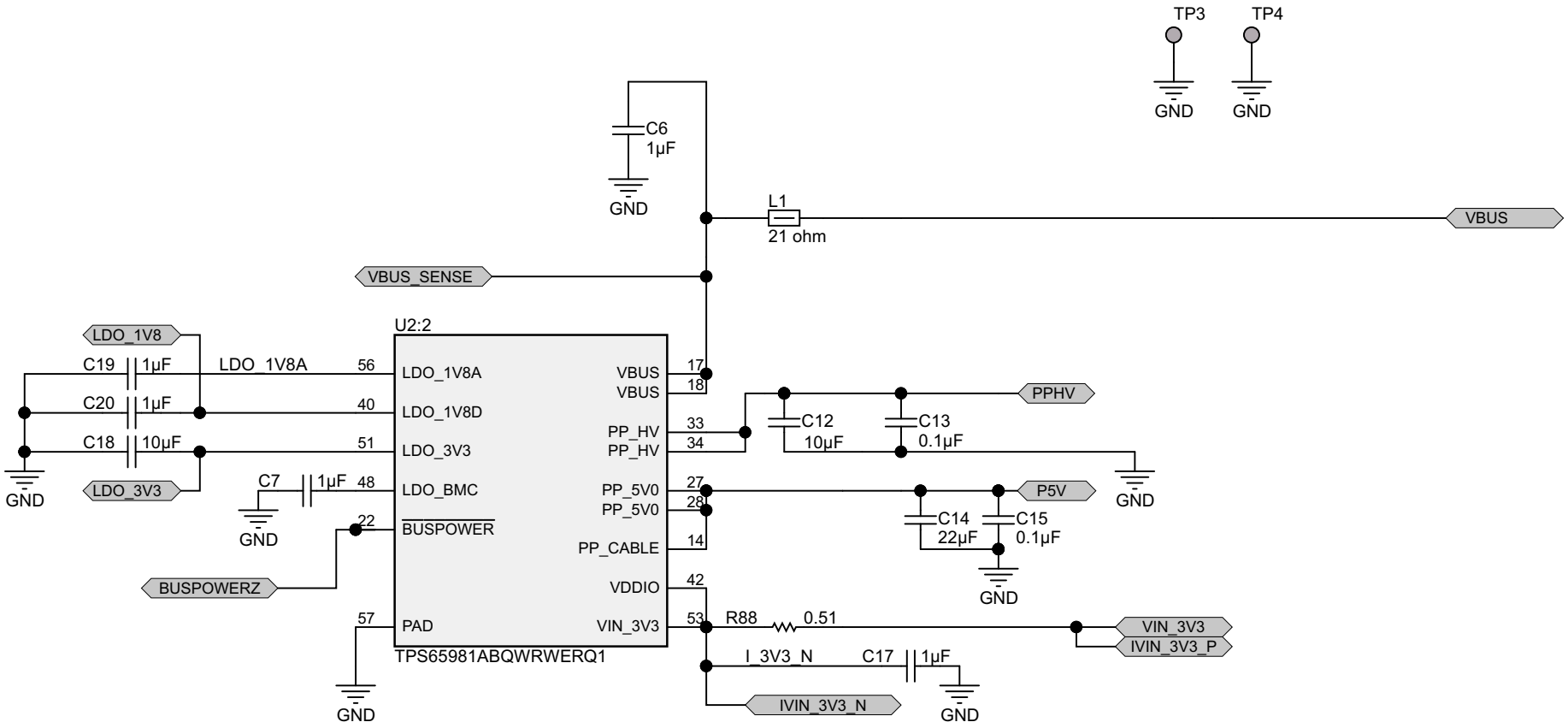

Figure 23. TPS65981EVM Power Path Block

Figure 24 shows the power-supply block, which has all of the board supplies generated and the comparator circuit for barrel jack detection. The P3V3 rail is on in bus-powered and self-powered conditions, and it has the ability to operate at 4 V to compensate for IR drop through the Type-C cable. The P5V supply can operate at 4.5 V at 100% duty cycle, but it is intended to supply the 5 V at 3 A when the barrel jack (J4) is connected to the EVM only. USB_5V is supplied by a boost converter from the main 3.3-V rail and is intended to ensure there is 5 V for the USB DFP port on the DP-EXPANSION_EVM, when acting bus-powered or self-powered.

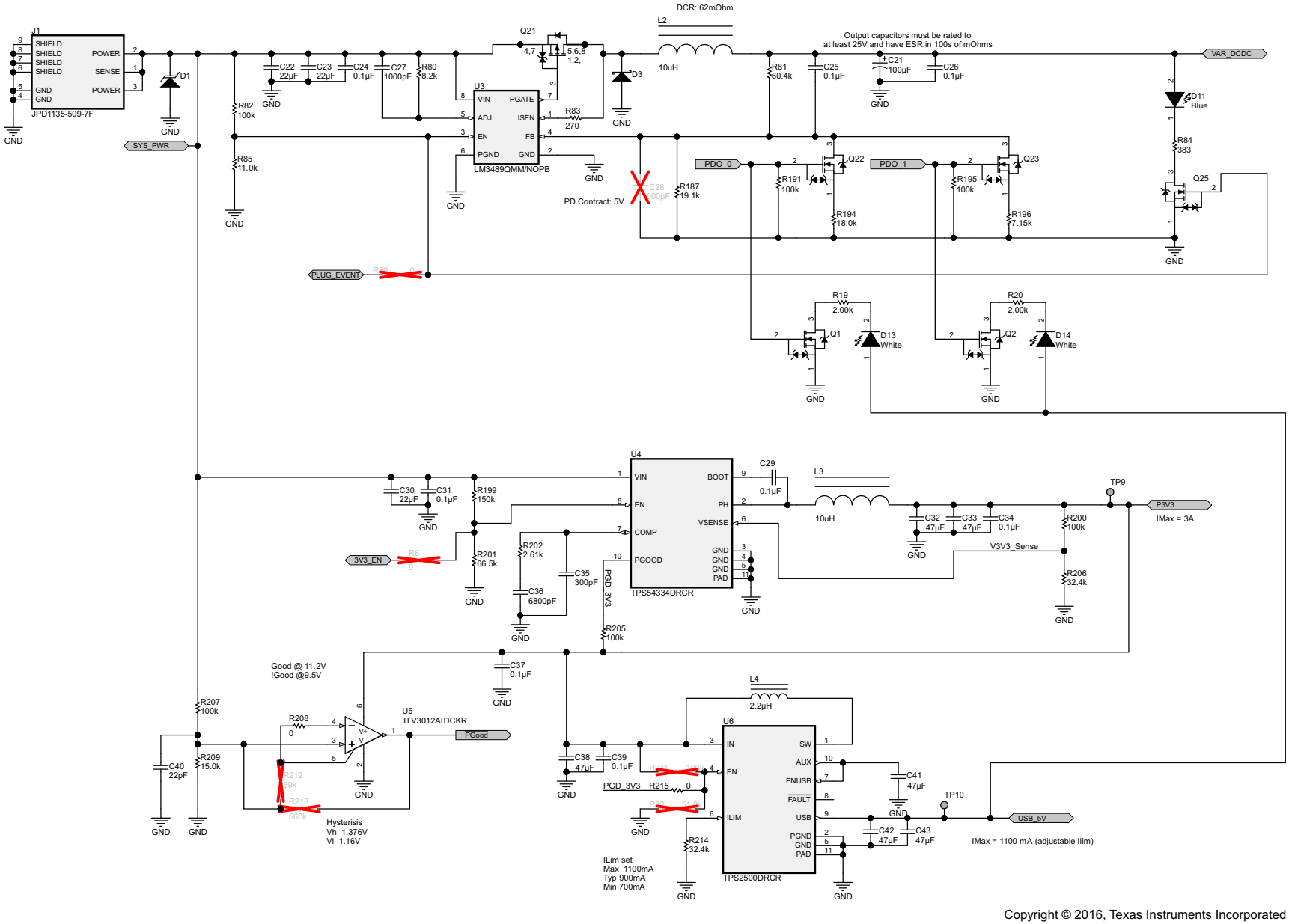

Figure 24. TPS65981EVM Power-Supply Block

Figure 25 shows the Type-C block, which includes the Type-C connector and ESD protection.

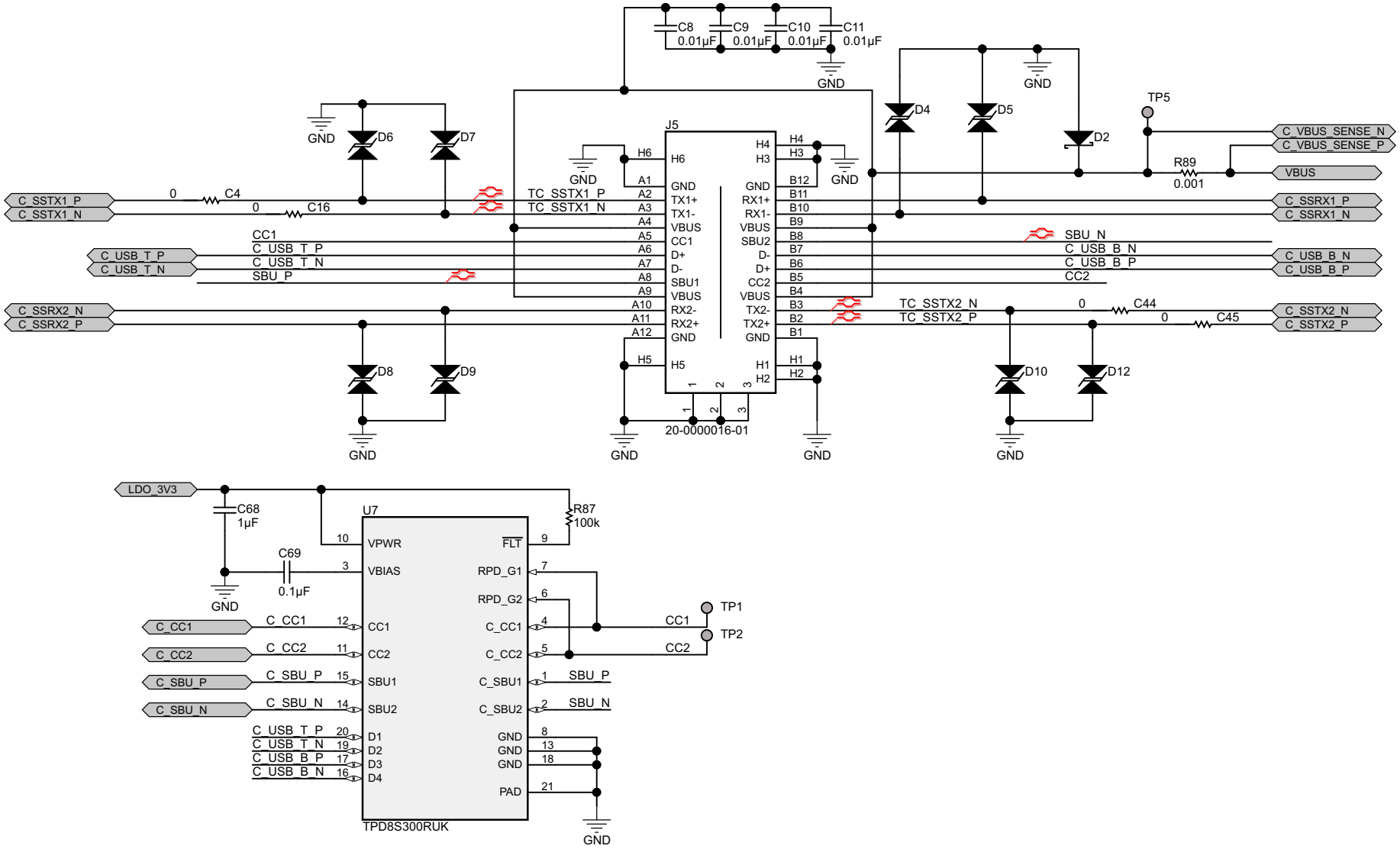

Figure 25. TPS65981EVM Type-C Block

Figure 26 shows the Inter_PCB block, which has the connections that go to the DP-EXPANSION-EVM.

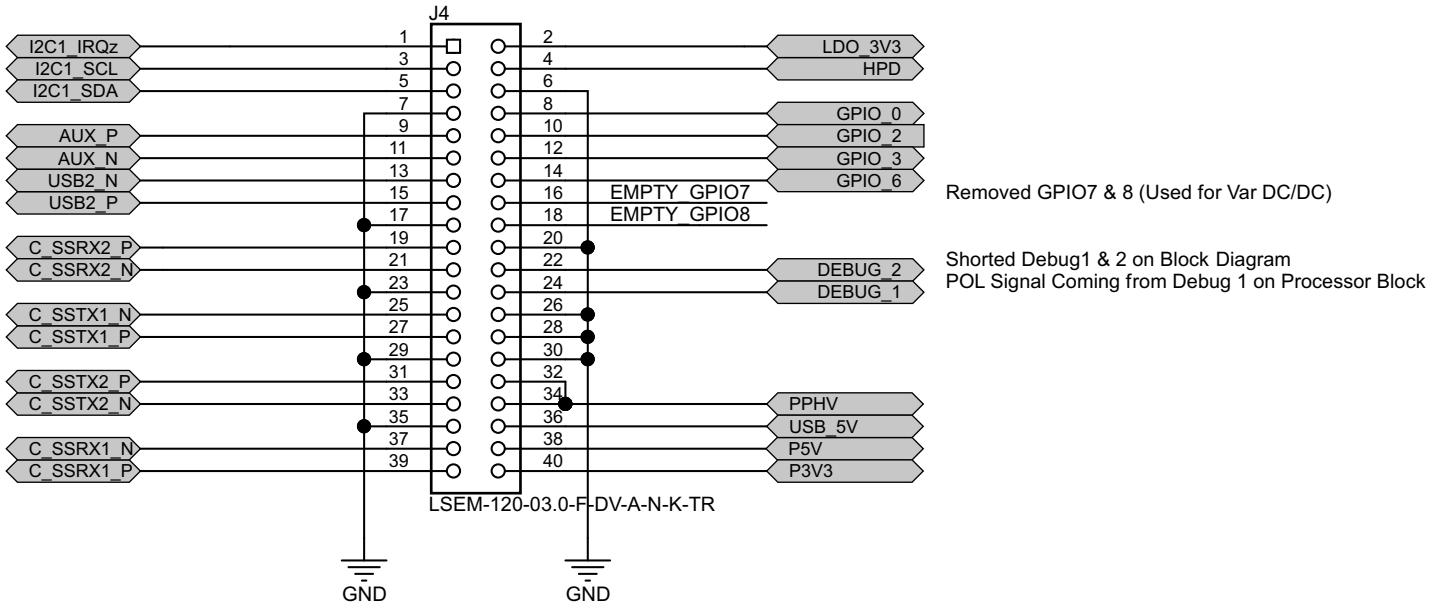

Figure 26. TPS65981EVM Inter PCB Block

Figure 27 shows the Debug_Connectors block, which contain the connections to the debug headers.

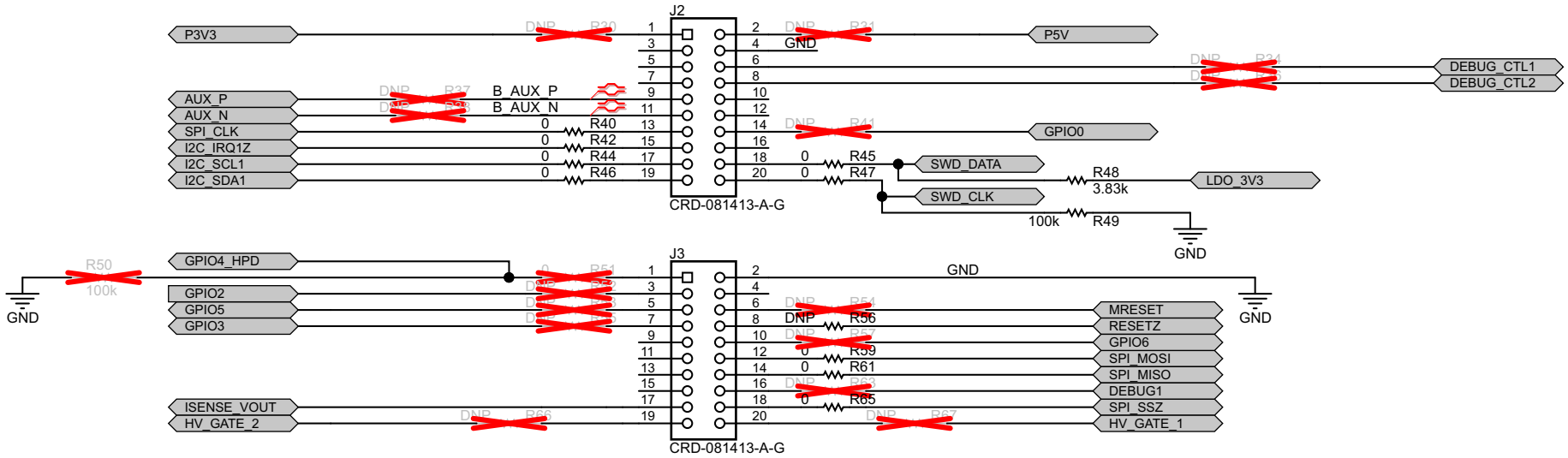

Figure 27. TPS65981EVM Debug Connector Block

9 TPS65981EVM Board Layout

The following figures contain the PCB layouts of the TPS65981EVM.

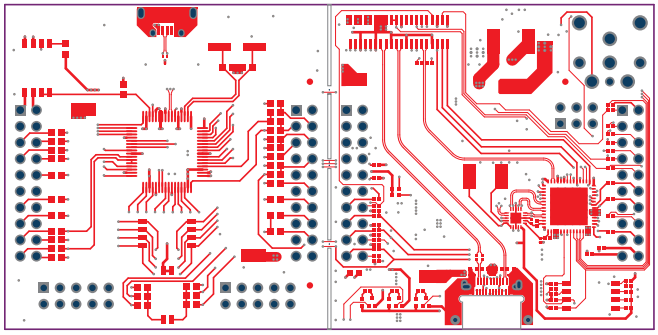

Figure 28. TPS65981EVM Top Layer

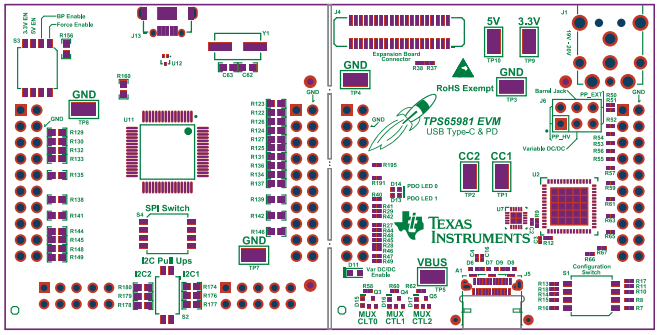

Figure 29. TPS65981EVM Top Layer Component View

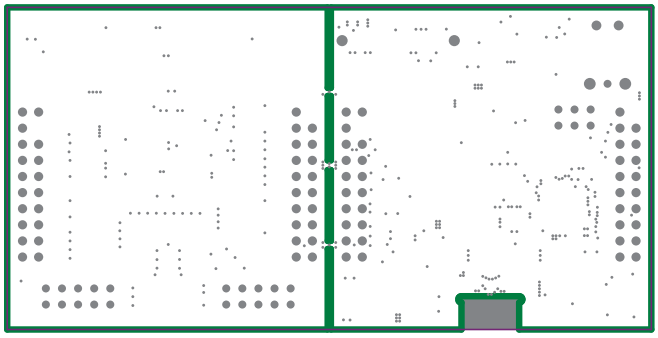

Figure 30. TPS65981EVM GND Plane 1

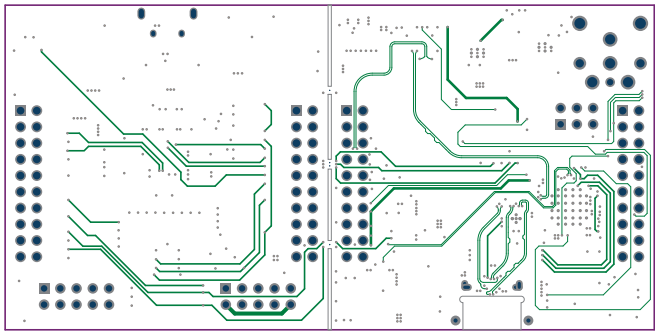

Figure 31. TPS65981EVM Mid Layer 1

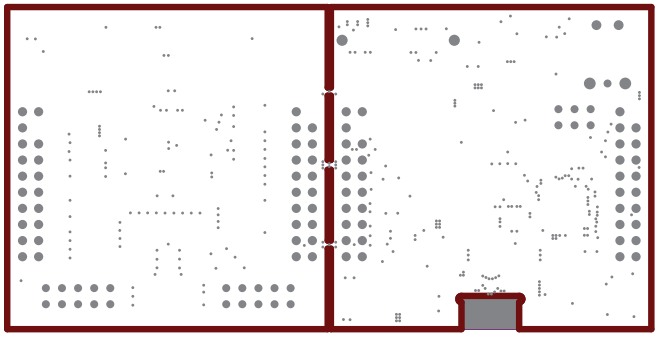

Figure 32. TPS65981EVM GND Plane 2

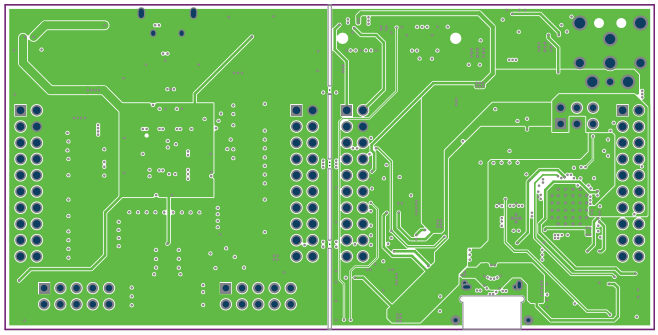

Figure 33. TPS65981EVM Mid Layer 2

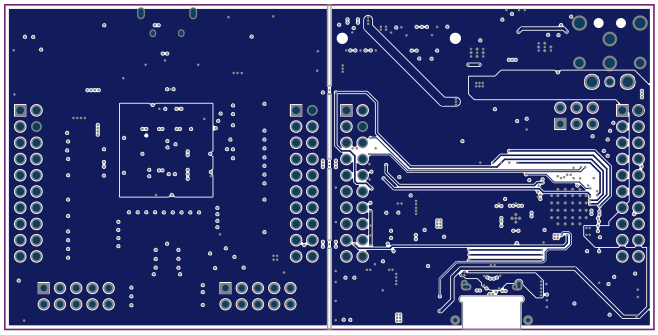

Figure 34. TPS65981EVM Mid Layer 3

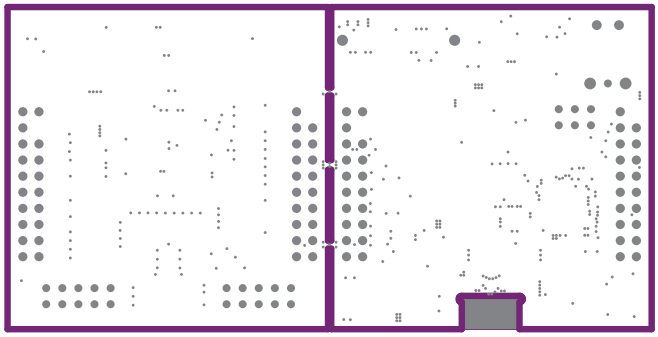

Figure 35. TPS65981EVM GND Plane 3

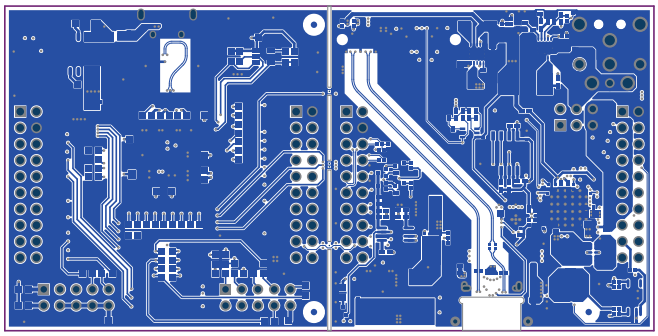

Figure 36. TPS65981EVM Bottom Layer

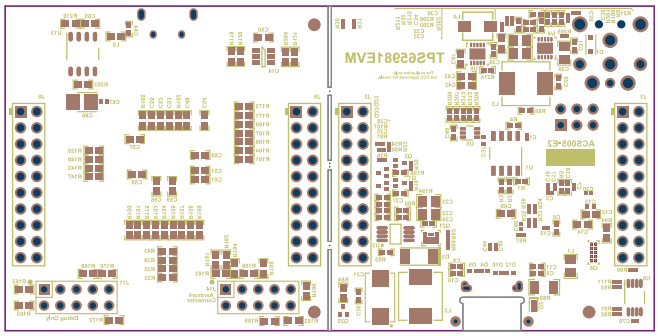

Figure 37. TPS65981EVM Bottom Layer Component View

10 TPS65981EVM Bill of Materials

Table 5 list the bill of materials (BOM) for the TPS65981EVM.

Table 5. BOM

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
!PCB1	1		Printed Circuit Board		ACS005	Any
C1, C15	2	0.1µF	CAP, CERM, 0.1 µF, 10 V, ±10%, X5R, 0201	0201	CL03A104KP3NNNC	Samsung
C2, C3	2	220pF	CAP, CERM, 220 pF, 25 V, ±10%, X7R, 0201	0201	GRM033R71E221KA01D	MuRata
C4, C16, C44, C45, R9, R12, R40, R42, R44, R45, R46, R47, R56, R59, R61, R65, R90, R91, R93, R215	20	0	RES, 0, 5%, 0.05 W, 0201	0201	ERJ-1GE0R00C	Panasonic
C5	1	0.22µF	CAP, CERM, 0.22 µF, 6.3 V, ±20%, X5R, 0201	0201	GRM033R60J224ME90	MuRata
C6	1	1µF	CAP, CERM, 1 µF, 35 V, ±10%, JB, 0402	0402	C1005JB1V105K050BC	TDK
C7, C17, C19, C20	4	1µF	CAP, CERM, 1 µF, 10 V, ±20%, X5R, 0201	0201	CL03A105MP3NSNC	Samsung
C8, C9, C10, C11	4	0.01µF	CAP, CERM, 0.01 µF, 50 V, ±10%, X7R, 0402	0402	GRM155R71H103KA88D	MuRata
C12	1	10µF	CAP, CERM, 10 µF, 25 V, ±20%, X5R, 0603	0603	GRM188R61E106MA73D	MuRata
C13, C37	2	0.1µF	CAP, CERM, 0.1 µF, 35 V, ±10%, X5R, 0402	0402	GMK105BJ104KV-F	Taiyo Yuden
C14	1	22µF	CAP, CERM, 22 µF, 10 V, ±20%, X5R, 0603	0603	GRM188R61A226ME15D	MuRata
C18	1	10µF	CAP, CERM, 10 µF, 10 V, ±20%, X5R, 0402	0402	CL05A106MP5NUNC	Samsung
C21	1	100µF	CAP, TA, 100 µF, 25 V, ±10%, 0.15 ohm, SMD	7343-43	T495X107K025ZTE150	Kemet
C22, C23, C30	3	22µF	CAP, CERM, 22 µF, 35 V, ±20%, X5R, 0805	0805	C2012X5R1V226M125AC	TDK
C24, C25, C26	3	0.1µF	CAP, CERM, 0.1 µF, 50 V, ±10%, X7R, 0402	0402	C1005X7R1H104K050BB	TDK
C27	1	1000pF	CAP, CERM, 1000 pF, 50 V, ±20%, X7R, 0402	0402	C1005X7R1H102M	TDK
C29, C31, C39	3	0.1µF	CAP, CERM, 0.1µF, 50V, +/-20%, C0G/NP0, 0402	0402	C1005X7R1H104M	TDK
C32, C33	2	47µF	CAP, CERM, 47 µF, 6.3 V, ±20%, X5R, 0805	0805	GRM21BR60J476ME15L	MuRata
C34	1	0.1µF	CAP, CERM, 0.1 µF, 25 V, ±10%, X7R, 0402	0402	GRM155R71E104KE14D	MuRata
C35	1	300pF	CAP, CERM, 300 pF, 25 V, ±5%, C0G/NP0, 0402	0402	GRM1555C1E301JA01D	MuRata
C36	1	6800pF	CAP, CERM, 6800 pF, 50 V, ±10%, X7R, 0402	0402	GRM155R71H682KA88D	MuRata
C38, C41, C42	3	47µF	CAP, CERM, 47 µF, 6.3 V, ±20%, X5R, 0603	0603	GRM188R60J476ME15D	MuRata
C43	1	100µF	CAP, TANT, 100µF, 6.3 V, ±20%, 0603	0603	F980J107MMAAXE	AVX
C40	1	22pF	CAP, CERM, 22 pF, 50 V, ±5%, C0G/NP0, 0402	0402	C1005C0G1H220J050BA	TDK
C49, C52, C61	3	4.7µF	CAP, CERM, 4.7 µF, 25 V, ±10%, X5R, 0603	0603	GRM188R61E475KE11D	MuRata
C50, C51, C53, C54, C55, C56, C57, C58, C59, C60, C65	11	0.1µF	CAP, CERM, 0.1 µF, 50 V, ±10%, X7R, 0603	0603	GRM188R71H104KA93D	MuRata
C62, C63	2	27pF	CAP, CERM, 27 pF, 50 V, ±1%, C0G/NP0, 0603	0603	CL10C270FB8NNNC	Samsung Electro-Mechanics
C64	1	0.01µF	CAP, CERM, 0.01 µF, 50 V, ±5%, X7R, 0402	0402	C0402C103J5RACTU	Kemet
C66	1	10µF	CAP, TA, 10 µF, 10 V, ±10%, 2.5 ohm, SMD	3528-21	293D106X9010B2TE3	Vishay-Sprague
C67	1	10µF	CAP, CERM, 10 µF, 10 V, ±20%, X5R, 0402	0402	GRM155R61A106ME21D	MuRata
C68	1	1µF	CAP, CERM, 1 µF, 6.3 V, ±20%, X5R, 0201	0201	GRM033R60J105MEA2D	MuRata
C69	1	0.1µF	CAP, CERM, 0.1 µF, 100 V, ±10%, X7R, 0603	0603	GRM188R72A104KA35D	MuRata
C70	1	0.1µF	CAP, CERM, 0.1 µF, 25 V, ±10%, X5R, 0201	0201	GRM033R61E104KE14J	MuRata
D1	1	24V	Diode, TVS, Bi, 24 V, 200 W, SOD323, 2-Leads, Body 1.9x1.45mm, No Polarity Mark	SOD323, 2-Leads, Body 1.9x1.45mm, No Polarity Mark	PESD24VL1BA,115	NXP Semiconductor

Table 5. BOM (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
D2	1	30V	Diode, Schottky, 30 V, 2 A, 2-XFDFN	2-XFDFN	NSR20F30NXT5G	ON Semiconductor
D3	1	30V	Diode, Schottky, 30 V, 5 A, SOD-128	SOD-128	PMEG3050EP,115	NXP Semiconductor
D4, D5, D6, D7, D8, D9, D10, D12	8		1 Channel ESD Protection Diode for High Speed Data Lines up to 20Gbps, DPY0002A	DPY0002A	TPD1E5B04DPYR	Texas Instruments
D11	1	Blue	LED, Blue, SMD	0.8x1.6mm	19-213/BHC-AN1P2/3T	Everlight
D13, D14, D15, D16, D17	5	White	LED, White, SMD	0402, White	LW QH8G-Q2S2-3K5L-1	OSRAM
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A
J1	1		Connector, DC Power Jack, R/A, 3 Pos, TH	Power connector	JPD1135-509-7F	Foxconn
J2, J3, J8, J9	4		Receptacle, 2.54 mm, 10x2, Gold, TH	Receptacle, 2.54 mm, 10x2, TH	CRD-081413-A-G	Major League Electronics
J4	1		Socket, 0.8mm, 20x2, Gold, SMT	Socket, 0.8mm, 20x2, Gold, SMT	LSEM-120-03.0-F-DV-A-N-K-TR	Samtec
J5	1		Connector, Receptacle, USB Type C, R/A, SMT	Connector, Receptacle, USB Type C, SMT	20-0000016-01	Lintes Technology
J6	1		Header, 100mil, 3x2, Gold, TH	3x2 Header	TSW-103-07-G-D	Samtec
J11, J14	2		Header, 100mil, 5x2, Tin, TH	Header, 5x2, 100mil, Tin	PEC05DAAN	Sullins Connector Solutions
J13	1		Connector, Receptacle, Micro-USB Type AB, R/A, Bottom Mount SMT	Connector, Receptacle, Micro-USB Type AB, R/A, Bottom Mount SMT	ZX62RD-AB-5P8	Hirose Electric Co. Ltd.
L1	1	21 ohm	Ferrite Bead, 21 ohm to 100MHz, 6A, 0805	0805	FBMJ2125HM210NT	Taiyo Yuden
L2, L3	2	10uH		7.2 mm x 6.65 mm	ASPI-0630LR-100M-T15	ABRACON
L4	1	2.2uH	Inductor, Flat Wire, Powdered Iron, 2.2 µH, 4 A, 0.033 ohm, SMD	Inductor, 4.8x2x4mm	SRP4020-2R2M	Bourns
L5	1	26 ohm	Ferrite Bead, 26 ohm to 100 MHz, 6 A, 0603	0603	BLM18SG260TN1D	MuRata
Q1, Q2, Q3, Q4, Q5, Q22, Q23, Q25	8	30V	MOSFET, N-CH, 30 V, 0.1 A, SOT-416	SOT-416	2SK3019TL	Rohm
Q8	1	30V	MOSFET, N-CH, 30 V, A, YJG0010A	YJG0010A	CSD87501L	Texas Instruments
Q21	1	-30V	MOSFET, P-CH, -30 V, -10 A, UDFN6B	UDFN6B	SSM6J507NU,LF	Toshiba
R1, R2, R3, R4	4	3.3k	RES, 3.3 k, 5%, 0.063 W, 0402	0402	CRCW04023K30JNED	Vishay-Dale
R5, R209	2	15.0k	RES, 15.0 k, 1%, 0.063 W, 0402	0402	CRCW040215K0FKED	Vishay-Dale
R7, R8, R10, R17, R85	5	11.0k	RES, 11.0 k, 1%, 0.05 W, 0201	0201	CRCW020111K0FKED	Vishay-Dale
R13, R14, R15, R16, R49, R82, R87, R191, R195, R205	10	100k	RES, 100 k, 1%, 0.05 W, 0201	0201	CRCW0201100KFKED	Vishay-Dale
R19, R20, R58, R60, R62	5	2.00k	RES, 2.00 k, 1%, 0.05 W, 0201	0201	CRCW02012K00FKED	Vishay-Dale
R27, R28, R48	3	3.83k	RES, 3.83 k, 1%, 0.05 W, 0201	0201	CRCW02013K83FKED	Vishay-Dale
R29	1	10.0k	RES, 10.0 k, 1%, 0.05 W, 0201	0201	MCR006YRTF1002	Rohm
R33, R35, R39, R43, R130, R133, R134, R135, R137, R138, R139, R141, R144, R145, R146, R148, R149, R162, R163, R165, R168, R170, R172, R183, R184, R186, R188, R189, R190, R192, R210	31	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R80	1	8.2k	RES, 8.2 k, 5%, 0.063 W, 0402	0402	CRCW04028K20JNED	Vishay-Dale
R81	1	60.4k	RES, 60.4 k, 1%, 0.063 W, 0402	0402	CRCW040260K4FKED	Vishay-Dale
R83	1	270	RES, 270, 5%, 0.063 W, 0402	0402	CRCW0402270RJNED	Vishay-Dale

Table 5. BOM (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R84	1	383	RES, 383, 0.1%, 0.063 W, 0603	0603	CPF0603B383RE	TE Connectivity
R88	1	0.51	RES, 0.51, 1%, 0.125 W, 0402	0402	ERJ-2BQFR51X	Panasonic
R89	1	0.001	RES, 0.001, 1%, 1 W, AEC-Q200 Grade 0, 1206	1206	CSNL1206FT1L00	Stackpole Electronics Inc
R94	1	0.005	RES, 0.005, 1%, 0.25 W, AEC-Q200 Grade 1, 0603	0603	ERJ3LWFR005V	Panasonic
R119, R120, R121	3	10.0k	RES, 10.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0710KL	Yageo America
R152	1	12k	RES, 12 k, 5%, 0.1 W, 0603	0603	CRCW060312K0JNEA	Vishay-Dale
R156	1	1.00k	RES, 1.00 k, 1%, 0.1 W, 0603	0603	CRCW06031K00FKEA	Vishay-Dale
R160	1	100k	RES, 100 k, 5%, 0.1 W, 0603	0603	CRCW0603100KJNEA	Vishay-Dale
R174, R180	2	10k	RES, 10 k, 5%, 0.1 W, 0603	0603	RC1608J103CS	Samsung Electro-Mechanics
R176, R177, R178, R179	4	3.3k	RES, 3.3 k, 5%, 0.1 W, 0603	0603	CRCW06033K30JNEA	Vishay-Dale
R187	1	19.1k	RES, 19.1 k, 1%, 0.063 W, 0402	0402	CRCW040219K1FKED	Vishay-Dale
R194	1	18.0k	RES, 18.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040218K0FKED	Vishay-Dale
R196	1	7.15k	RES, 7.15 k, 1%, 0.063 W, 0402	0402	CRCW04027K15FKED	Vishay-Dale
R199	1	150k	RES, 150 k, 1%, 0.063 W, 0402	0402	CRCW0402150KFKED	Vishay-Dale
R200, R207	2	100k	RES, 100 k, 1%, 0.063 W, 0402	0402	CRCW0402100KFKED	Vishay-Dale
R201	1	66.5k	RES, 66.5 k, 1%, 0.063 W, 0402	0402	CRCW040266K5FKED	Vishay-Dale
R202	1	2.61k	RES, 2.61 k, 1%, 0.063 W, 0402	0402	CRCW04022K61FKED	Vishay-Dale
R203	1	249k	RES, 249 k, 1%, 0.1 W, 0603	0603	CRCW0603249KFKEA	Vishay-Dale
R204	1	2.20k	RES, 2.20 k, 1%, 0.1 W, 0603	0603	RC0603FR-072K2L	Yageo America
R206, R214	2	32.4k	RES, 32.4 k, 1%, 0.063 W, 0402	0402	CRCW040232K4FKED	Vishay-Dale
R208	1	0	RES, 0, 5%, 0.063 W, 0402	0402	CRCW04020000Z0ED	Vishay-Dale
S1, S3	2		DIP Switch, SPST 4Pos, Slide, SMT	6.2x2.0x6.2mm	TDA04H0SB1	C&K Components
SH-J1, SH-J2	2	1x2	Shunt, 100mil, Gold plated, Black		382811-6	AMP
TP1, TP2, TP3, TP4, TP5, TP7, TP8, TP9, TP10	9		Test Point, Miniature, SMT	Test Point, Miniature, SMT	5019	Keystone
U1	1		3V, 8Mbit, Serial Flash Memory with Dual and Qual SPI, SOIC-8	SOIC-8	W25Q80DVSNIG	Winbond
U2	1		USB Type-C and USB PD Controller, Power Switch, and High Speed Multiplexer, RWE0056B	RWE0056B	TPS65981ABQWRWERQ1	Texas Instruments
U3	1		Hysteretic PFET Buck Controller with Enable Pin, 8-pin MSOP, Pb-Free	MUA08A	LM3489QMM/NOPB	Texas Instruments
U4	1		4.2V TO 28V INPUT, 3A OUTPUT, SYNCHRONOUS SWIFT™ STEP DOWN VOLTAGE CONVERTER, DRC0010J	DRC0010J	TPS54334DRCR	Texas Instruments
U5	1		Nanopower, 1.8V, Comparator with Voltage Reference, DCK0006A	DCK0006A	TLV3012AIDCKR	Texas Instruments
U6	1		Integrated USB Power Switch with Boost Converter, DRC0010J	DRC0010J	TPS2500DRCR	Texas Instruments
U7	1		USB Type C Interface Protector: Short-to-VBUS Over Voltage and IEC 61000-4-2 ESD Protection, RUK0020B	RUK0020B	TPD8S300RUK	Texas Instruments
U8	1		High-Accuracy, Wide Common-Mode Range, Bidirectional Current Shunt Monitors, Zero-Drift Series, DGK0008A	DGK0008A	INA284AIDGKR	Texas Instruments
U11	1		Quad High Speed USB to Multipurpose UART/MPSSE IC	LQFP_10x10mm	FT4232HL	FTDI
U12	1		ESD Protection Array for High-Speed Data Interfaces, 2 Channels, -40 to +85 degC, 3-pin SOT (DRT), Green (RoHS and no Sb/Br)	DRT0003A	TPD2E009DRTR	Texas Instruments

Table 5. BOM (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
U13	1		Single Output Fast Transient Response LDO, 1 A, Fixed 3.3 V Output, 2.7 to 10 V Input, with Low IQ, 8-pin SOIC (D), -40 to 125 degC, Green (RoHS and no Sb/Br)	D0008A	TPS76833QD	Texas Instruments
U14	1		2K Microwire Compatible Serial EEPROM, SOT-23-6	SOT-23-6	93LC56B-I/OT	Microchip
Y1	1		CRYSTAL, 12MHz, 20pF, SMD	7x2.3x4.1mm	ECS-120-20-3X-TR	ECS Inc.
C28	0	1000pF	CAP, CERM, 1000 pF, 50 V, ±20%, X7R, 0402	0402	C1005X7R1H102M	TDK
R6, R18, R30, R31, R34, R36, R37, R38, R41, R51, R52, R53, R54, R55, R57, R63, R66, R67, R86, R92, R111	0	0	RES, 0, 5%, 0.05 W, 0201	0201	ERJ-1GE0R00C	Panasonic
R11	0	11.0k	RES, 11.0 k, 1%, 0.05 W, 0201	0201	CRCW020111K0FKED	Vishay-Dale
R21, R22, R50, R211	0	100k	RES, 100 k, 1%, 0.05 W, 0201	0201	CRCW0201100KFKED	Vishay-Dale
R23, R24, R25, R26	0	1.00Meg	RES, 1.00 M, 1%, 0.05 W, AEC-Q200 Grade 0, 0201	0201	RK73H1HTTC1004F	KOA Speer
R32	0	51.0k	RES, 51.0 k, 1%, 0.05 W, AEC-Q200 Grade 0, 0201	0201	RK73H1HTTC5102F	KOA Speer
R122, R123, R124, R125, R126, R127, R128, R129, R131, R132, R136, R140, R142, R143, R147, R150, R151, R153, R154, R155, R157, R158, R159, R161, R164, R166, R167, R169, R171, R173, R175, R181, R182	0	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R212	0	39k	RES, 39 k, 5%, 0.063 W, 0402	0402	CRCW040239K0JNED	Vishay-Dale
R213	0	560k	RES, 560 k, 5%, 0.063 W, 0402	0402	CRCW0402560KJNED	Vishay-Dale
S2	0		Switch, SPST, 2 Pos, 25mA, 24VDC, SMD	3.71x5.8mm	218-2LPST	CTS Electrocomponents
S4	0		DIP Switch, SPST 4Pos, Slide, SMT	6.2x2.0x6.2mm	TDA04H0SB1	C&K Components

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