

EVM User's Guide: TPS26750EVM

TPS26750 Evaluation Module



Description

The TPS26750EVM is designed to test USB-PD for sink-only, source-only, or DRP applications, in both USB-PD SPR and EPR ranges. The TPS26750EVM can operate as a sink only with no power provided, or as a source, sink, or DRP with a power supply of 15V. The TPS26750EVM supports sourcing and sinking up to 48V at 5A, in accordance with the USB-PD specification, as well as supporting battery charging applications in conjunction with the BQ25756EVM.

Get Started

1. Order the [TPS26750EVM](#)
2. Start development with the [Application Customization Tool](#)
3. Refer to the [data sheet](#), [Technical Reference Manual](#), or E2E for questions and support

Features

- PD controller is certified by the USB-IF for PD3.1
- Up to 240W (28V/5A) source and sink applications
 - 15W (5V/3A) Source and 240W (48V/5A) sink as standalone EVM
 - 240W (48V/5A) Source and 240W (48V/5A) sink with BQ25756EVM
- Easy-to-use GUI with pre-configured firmware to configure:

- Programmable Power Supply (PPS) for 5V-21V range
- Liquid detection and corrosion mitigation
- BC1.2 charging schemes (requires populating resistors on board)
- Integrated I2C control for BQ25756 battery charger
- Interfacing connector for BQ25756EVM
- Multiple test points and headers for quick and easy debug
 - Exposed VBUS and CCx test points to monitor PD traffic
 - VBUS, VBUS_LV, PPHV, and VSYS test points available
 - GPIO, I2C, and power supplies available on 100mil header
 - 100 mil header pins scaled to 5V to support 5V or 10V digitizers for easier debug

Applications

- [Battery pack for cordless power tools, power banks, retail automation and payment](#)
- [e-Bikes, wireless speakers, cordless vacuum cleaners](#)
- [Personal and portable electronics, industrial applications](#)
- [Medical applications, personal care and fitness](#)

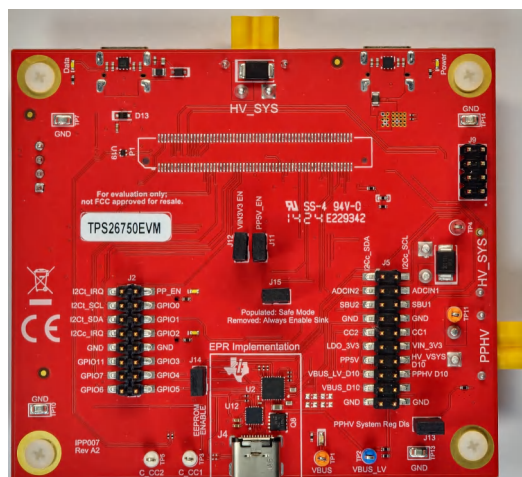


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Note

Jumpers J11, J12, and J13 control the ENABLE signal of their respective LDO or switch, and are not connected to the output of their respective LDO or switch. The jumpers are shown in the block diagram at the outputs of their respective LDO or switch to simplify and clarify the overall behavior of the device when the jumper is removed.

Figure 1-1. TPS26750EVM Block Diagram

The TPS26750EVM can be used in conjunction with the BQ25756 with minimal setup to test battery charging by utilizing, as shown in [Figure 1-2](#):

- TPS26750 and BQ25756 I2C capability
- The ability of the Application Customization GUI to configure the TPS26750 to work with the BQ25756 by selecting only a few parameters from a questionnaire
- The provided 4x2 IDC cable
- The BQ25756 connector board

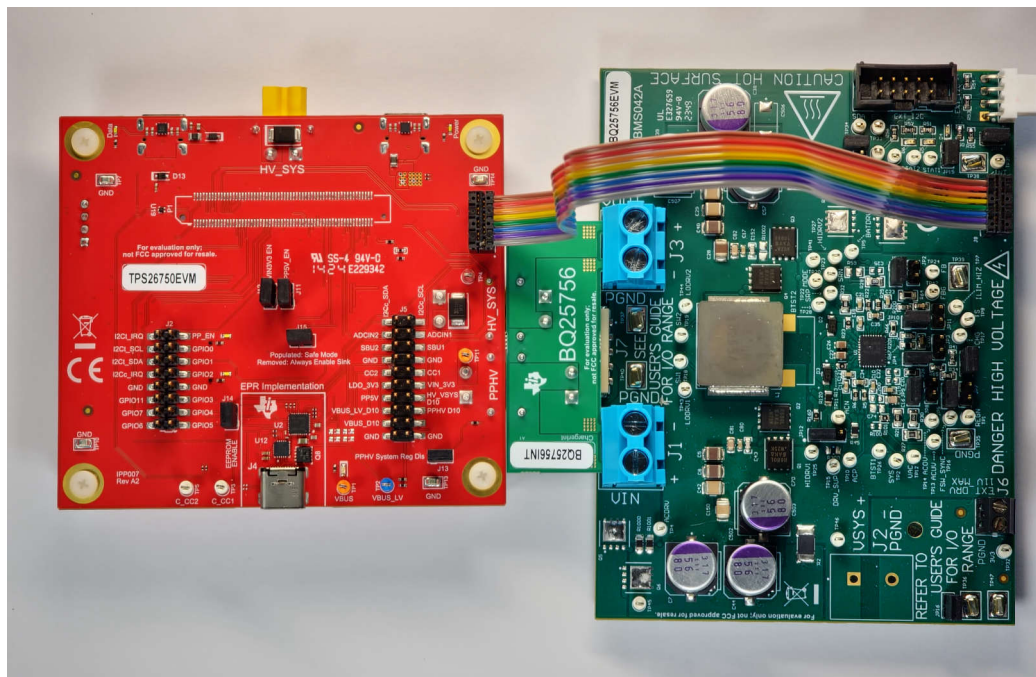


Figure 1-2. TPS26750EVM and BQ25756EVM Hardware Setup

1.4 Device Information

The TPS26750 is a single-port, USB Type-C PD controller with an integrated 5V source power path and the ability to control an EPR capable external power path for power-only applications. The TPS26750 PD controller is an excellent choice for single port power applications operating in the USB-PD EPR for Dual Role Power (DRP) applications up to 240W (48V/5A).

The TPS26750 PD controller is configurable through the Web-based GUI for application specific requirements, architectures, power roles, and data roles. The GUI tool provides additional optional firmware configuration to integrate control for the BQ25756 Battery Charger IC. For more information on BQ25756 configuration, refer to [Section 4.2](#).

Table 1-1. Devices on TPS26750EVM

Designator	Device Name	Description
U2	TPS26750RSMR	USB Type-C and USB PD controller with integrated source power switch
U1, U3	TLV75733PDRVR	1A Low-Quiescent-Current Low-Dropout (LDO) Regulator
U4	TPS259814ARPWR	2.7 - 16V, 10A, 7mΩ eFuse with transient overcurrent blanking timer
U6	LM2765M6X/NOPB	Switched capacitor voltage converter
U7	TPS25750DRJK	USB Type-C and USB PD controller with integrated power switches optimized for power applications
U8	TVS2200DRVR	22V precision surge protection clamp
U9	LM76005RNPR	0.5V to 60V 5A synchronous step-down voltage regulator
U10	LTC7004IMSE#TRPBF	Fast high side N-channel MOSFET gate driver
U12	TPD4S480RUKR	USB Type-C 48V EPR port protector: short-to-VBUS Overvoltage and IEC ESD protection
U13	CAT24C512WI-GT3	I2C supported EEPROM Serial 512-Kb
U14	TUSB2036VFR	2 / 3-Port Hub for USB with Optional Serial EEPROM Interface
U15	TPD2EUSB30DRTR	ESD design for super-speed (6Gbps) USB 3.0 interface
U17	TVS0500DRVR	5V precision surge protection clamp
U18, U19	TPD2EUSB30DRTR	Dual 0.7pF, 5.5V ±8kV ESD protection diode with 5A surge rating for USB 3.0
U20	TPS7A1650DRBR	100mA, 60V, ultra-low-IQ, low-dropout (LDO) voltage regulator with power good and enable
U22	TM4C123GH6PMTR	32-bit Arm Cortex-M4F based MCU with 80 -MHz, 256 -KB Flash, 32 -KB RAM, 2 CAN, RTC, USB, 64-pin

Table 1-2. Connector and Interface Descriptions

Designator	Connector or Interface	Purpose
J6	Data Type C	Interface to GUI for configuration and USB to I2C
J3	Power Type C	Provide a 20V/5A board power interface from a Type-C power source
J8	XT30F (Power)	5V to 48V Power Input for EVM and boards attached to generic power converter. XT30 to banana jack cables are readily available to attach battery models or power sources
J1, J7, and J9	Generic Power Converter	Collection of three connectors that allow connection to external EVMs with minimal parasitics
J4	DUT Type C	USB-C connector to test configuration and functionality of the TPS26750 and TPD4S480
TP[Number]	Probe Points	Support connection of lab equipment to EVM

2 Hardware

2.1 Additional Images

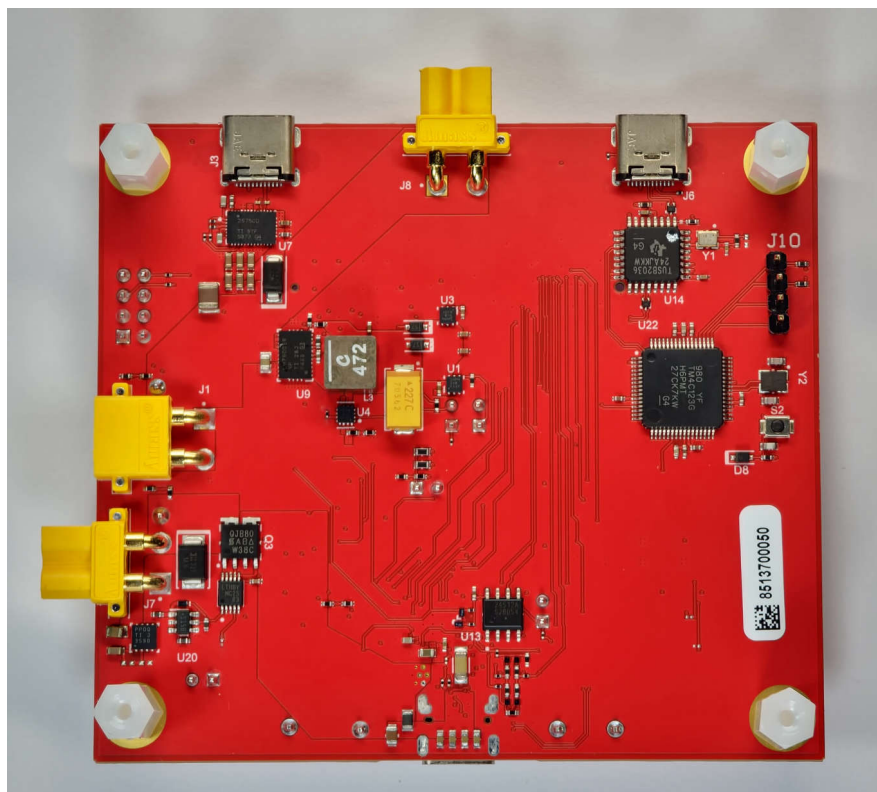


Figure 2-1. EVM (Bottom View)

2.2 Power Requirements

For standalone PD evaluation, the main power supply for the TPS26750EVM is through either the Type-C sink-only Power port (J3), which accepts up to 100W Type-C PD source (5V to 20V) or the XT30 connector on the top of the board (J8). The EVM can be powered on from an external bench supply connected to HV_SYS (J1), with the bench supply providing power in the 5V-48V range. Connector J1 supports up to 48V at 10A.

Additionally, the TPS26750EVM can be powered directly through the DUT (Device Under Test) Type-C connector (J4) to simulate powering the TPS26750 in a dead battery scenario. When the TPS26750EVM is powered only through port J4, the EVM acts as a sink only.

For battery charging applications, the BQ25756EVM can be used to power on the TPS26750EVM. The TPS26750EVM comes with an interfacing board (TPS26750EVM to BQ25756EVM connector board) to connect to the J1 and J7 connector on the TPS26750EVM. If the BQ25756EVM is connected, then the VAC net of the BQ25756EVM is connected to the high-voltage bidirectional power path (PPHV) of the TPS26750EVM. For more information on setting up and programming TPS26750 for battery charger application, refer to [Section 4.2](#).

2.3 Setup

Note

The following incorrect silk screen printing on the A2 revision of the TPS26750EVM must be noted:

1. The silk screen label for J11 is partially incorrect. Jumper J11 is located underneath the silk screen text *VIN3V3 EN* near the center of the board. The jumper is used for disabling the LDO that provides 3.3V to pin *VIN_3V3* of the TPS26750. However, to the left of Jumper J11, *J12* is printed, which is incorrect. *J11* needs to be printed instead.
 2. The silk screen label for J12 is partially incorrect. Jumper J12 is located underneath the silk screen text *PP5V_EN* near the center of the board. Jumper J12 is used for disabling the switch that provides 5V to pin *PP5V* of the TPS26750. However, to the right of Jumper J12, *J11* is printed, which is incorrect. *J12* needs to be printed instead.
 3. *VBUS_D10* on header J5 is incorrectly labeled on the silk screen as *VBUS_LV_D10*.
 4. *VBUS_LV_D10* on header J5 is incorrectly labeled on the silk screen as *VBUS_D10*.
-

All references in this document to the respective jumpers and signals above are made in reference to the actual location, and not to the location inferred by the incorrect silk screen printing.

Out of the box, the TPS26750EVM is configured for 15W (5V/3A) sourcing and 240W (48V/5A) sinking, utilized through the DUT Type C connector (J4). If a different configuration is required, then utilize the Application Customization Tool to create and/or load a different configuration. For detailed instructions on how to use the Application Customization Tool (also used interchangeably with the term *GUI* throughout this document), refer to [Section 3](#).

Flashing Firmware Configuration to the TPS26750EVM

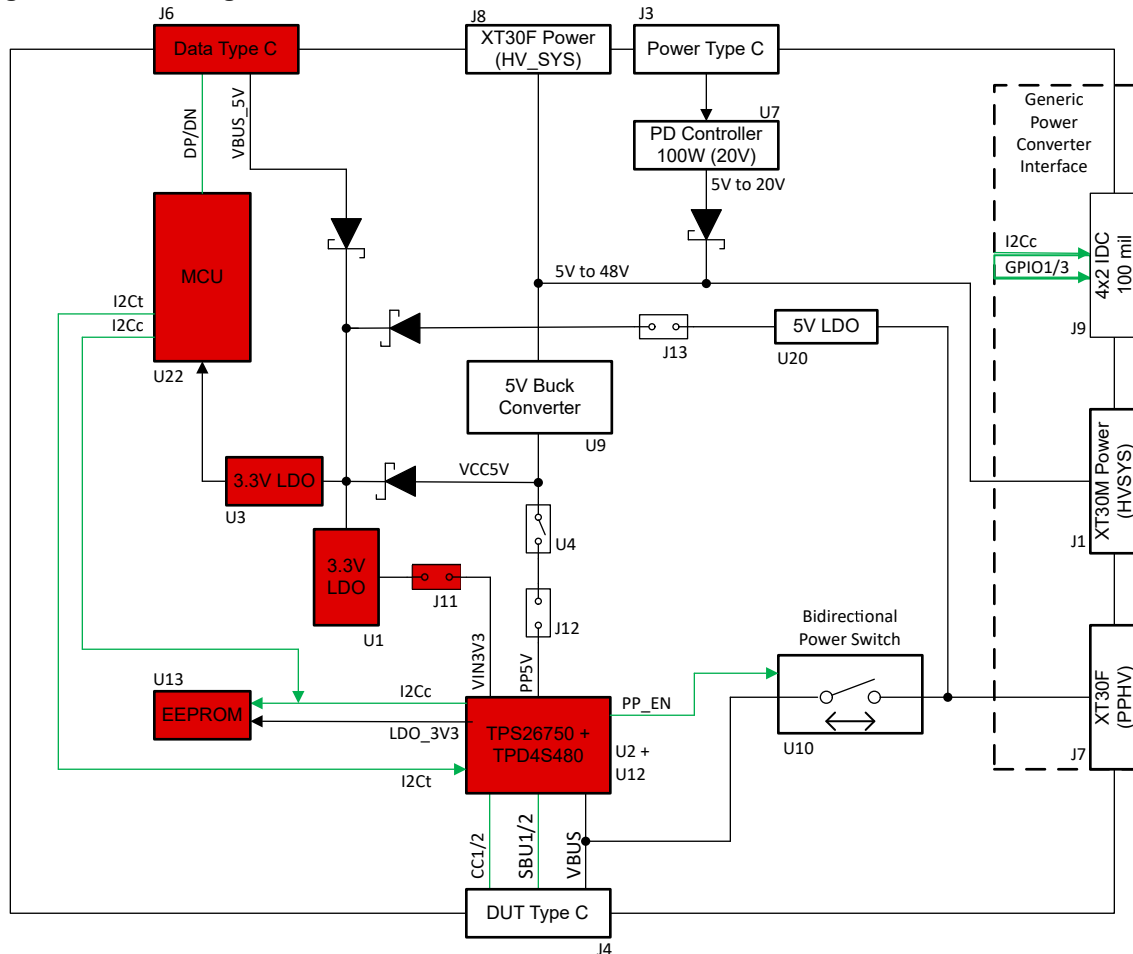


Figure 2-2. EVM Flashing Block Diagram

Note

The red highlighting shows *active* or powered portions of the EVM for the specific setup in [Figure 2-2](#) and subsequent block diagrams.

Required hardware setup:

1. Ensure jumper J11 (erroneously labeled as J12 on EVM) is connected.
2. Connect USB-C end of USB-C to USB-C cable or USB-A to USB-C cable to Data Type C port (J6).
3. Connect other end of cable to computer.

When flashing a new configuration to the TPS26750EVM, the binary configuration file is written to U13, the EEPROM. More details are provided in [Section 3.4.6.3](#).

Stand Alone Testing

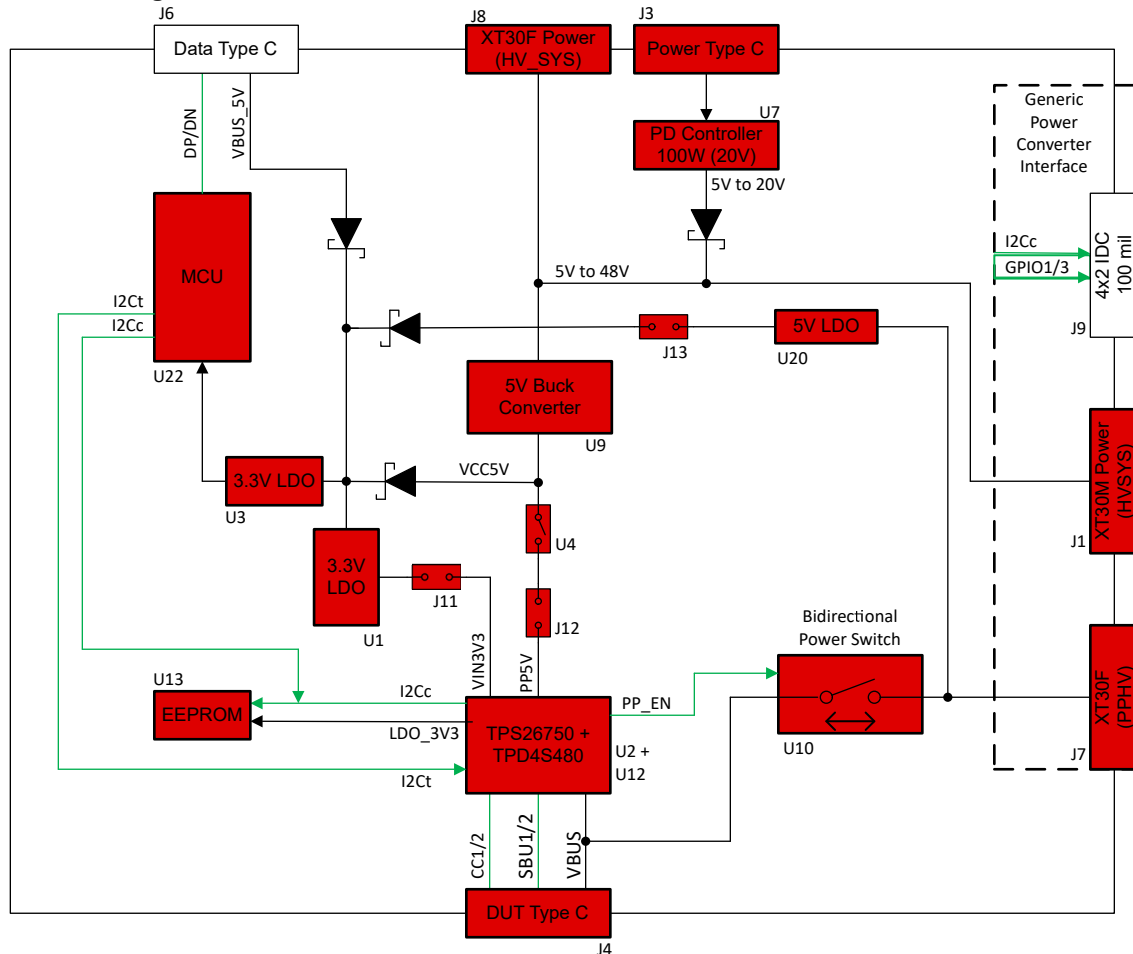


Figure 2-3. Stand Alone Testing Block Diagram

Supported functionality as a stand alone device:

1. 5V sourcing (DFP)
2. 5 - 48V sinking, both SPR and EPR capable (UFP)
3. 5V sourcing, 5V to 48V sinking (DRP)

To test the TPS26750EVM as a stand-alone device, users need to connect a power source to the Power Type C connector (J3) or one of the XT30 Power connectors (J1 or J8).

If users want to support 5V sourcing, then the power supply needs to provide at least 18W of power, due to the following board requirements:

- 5V/3A for PP5V Power Path
- 5V/120mA for VCONN
- 5V/100mA for Board MCU (U22)

If users only want to support a powered sinking setup, then 5W is all that is required to be provided to the Power Type C port (J3). When sinking, the output of the sinking power path can be accessed from the XT30F (PPHV) connector (J7). The portions of the EVM are powered, highlighted in red, when testing the device in Stand Alone mode and are shown in Figure 2-3.

The example setup in Figure 2-4 shows the *Aergiatech 140W 3 Port PD3.1 Supported Wall Adapter*, whose USB-C2 port is capable of providing 100W (20V at 5A) of power, connected to a *USB-C to USB-C 100W capable cable*, which is in turn connected to the Power Type C port (J3) of the TPS26750EVM. This example setup is capable of sourcing 5V of power to the DUT Type C port (J4) and sinking from 5V to 48V of power (both SPR and EPR capable) to the DUT Type C port (J4).



Figure 2-4. Stand Alone Testing Example Hardware Setup

Note

Note that all referenced products in the example setups in this document are not officially endorsed or recommended by Texas Instruments. Due to the complex nature of USB-PD, the products are provided as a means to further the reader's understanding and highlight EPR functionality. The products do not represent a specific, required component for the TPS26750EVM to function.

Dead Battery Safe Mode

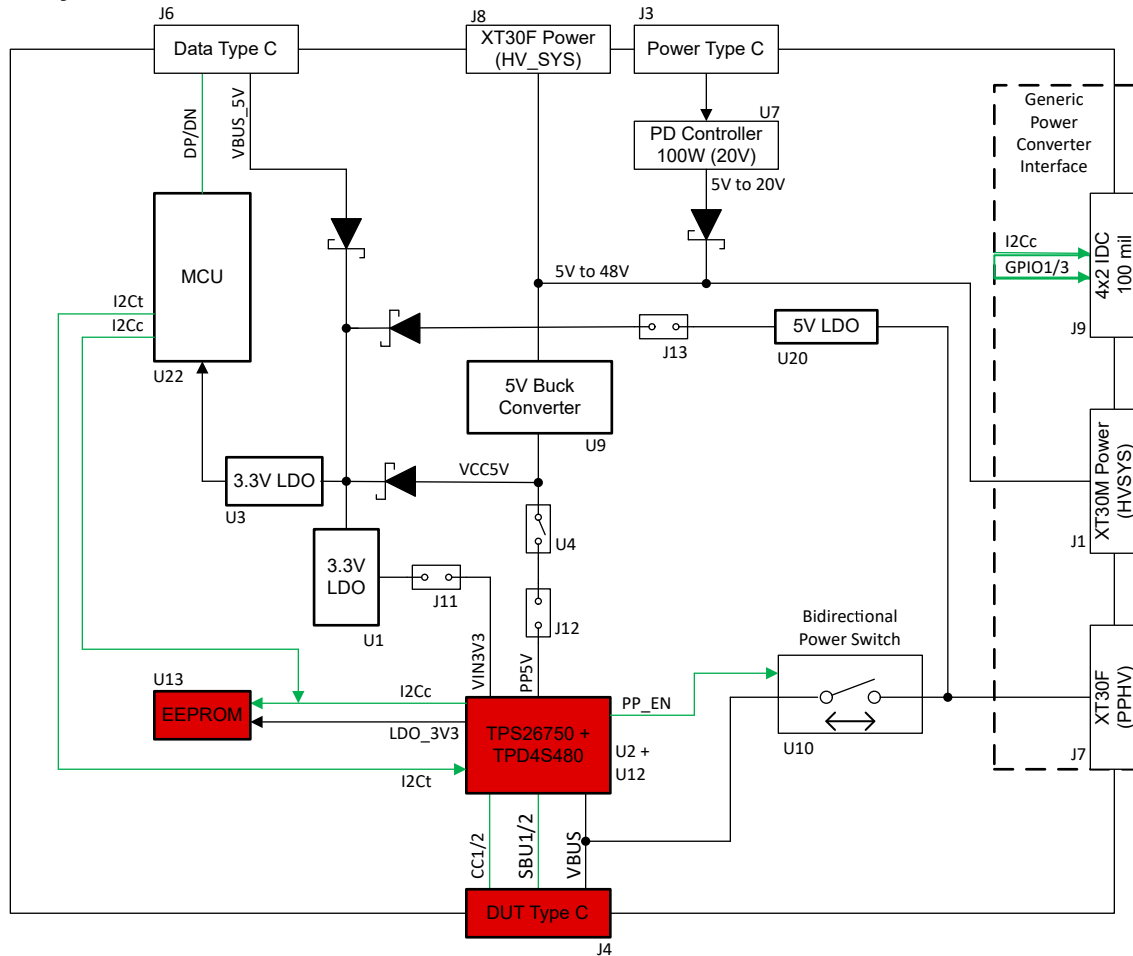


Figure 2-5. Dead Battery Safe Mode

The portions of the EVM highlighted in red, are powered upon TPS26750 boot up when testing the device in Dead Battery Safe Mode, as shown in [Figure 2-5](#). This mode occurs when the VIN_3V3 pin of the TPS26750 is unpowered and a USB-PD capable source is connected to the DUT Type C (J4) connector, when jumper J15 is populated. During Dead Battery Safe Mode, the Bidirectional Power Switch (U10) remains open during the period of time that the TPS26750 boots and loads the configuration. In this mode, the TPS26750 can only operate as a sink and can sink between 5V and 48V (both SPR and EPR capable). After the configuration is loaded and the device is finished booting, the Bidirectional Power Switch closes (or remains open) based upon the configuration loaded and the capabilities of the attached source.

To successfully test the USB-PD Extended Power Range (EPR) with the TPS26750EVM and successfully negotiate an EPR contract (a USB-PD contract with a voltage greater than 20V), a [USB-IF compliant 240W](#) rated USB-C to USB-C cable must be used.

The example setup in [Figure 2-6](#) shows the *Aergiotech 140W 3 Port PD3.1 Supported Wall Adapter*, whose USB-C1 port is capable of providing 140W (28V at 5A) of power, connected to a *USB-C to USB-C 240W capable cable*, which is in turn connected to the Power Type C port (J3) of the TPS26750EVM. This example setup is capable of sinking 28V of power (as the wall adapter can provide at maximum 28V; the TPS26750EVM is not limited to 28V) to the DUT Type C port (J4), which is in the USB-PD Extended Power Range.

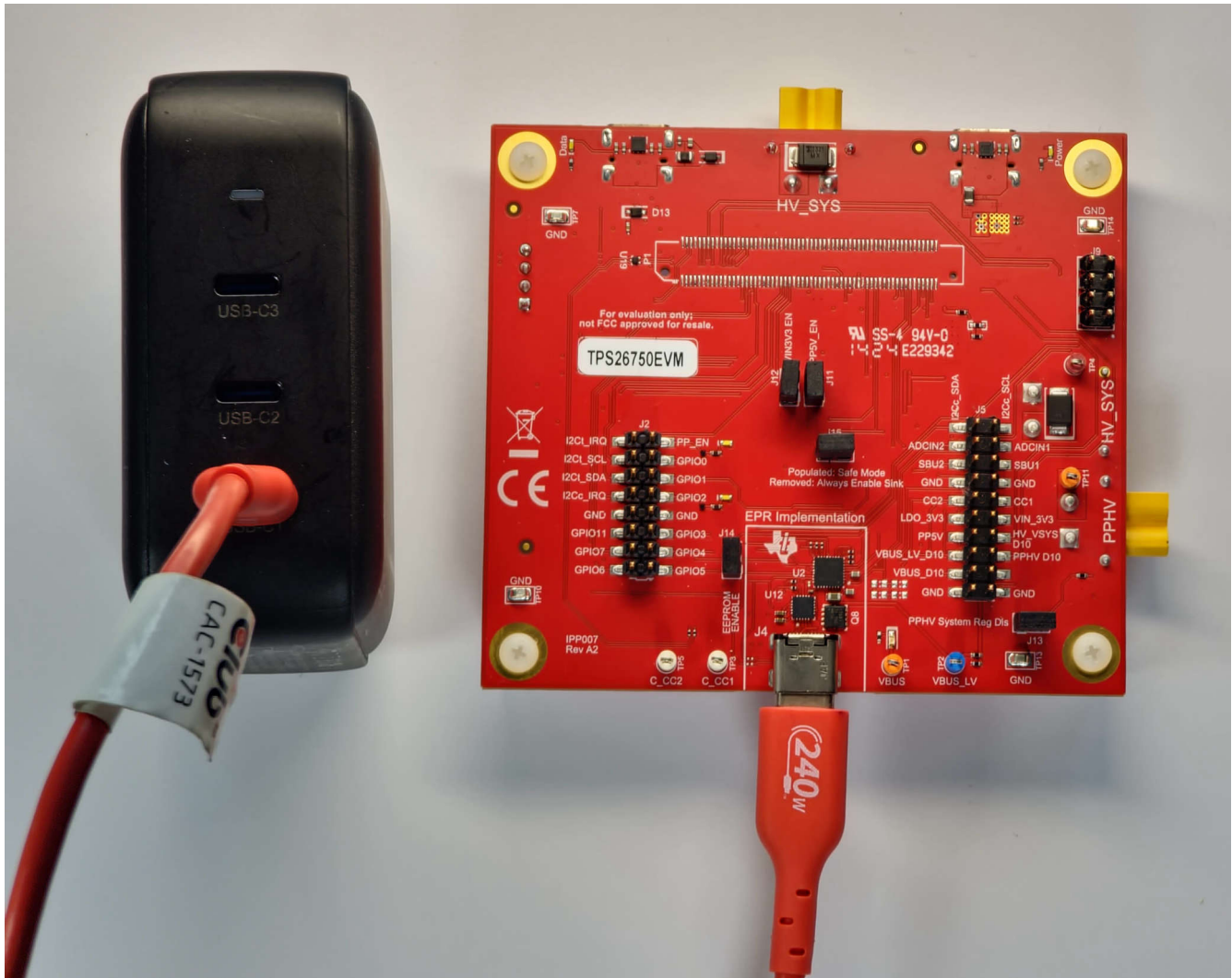


Figure 2-6. Dead Battery Safe Mode Example Hardware Setup

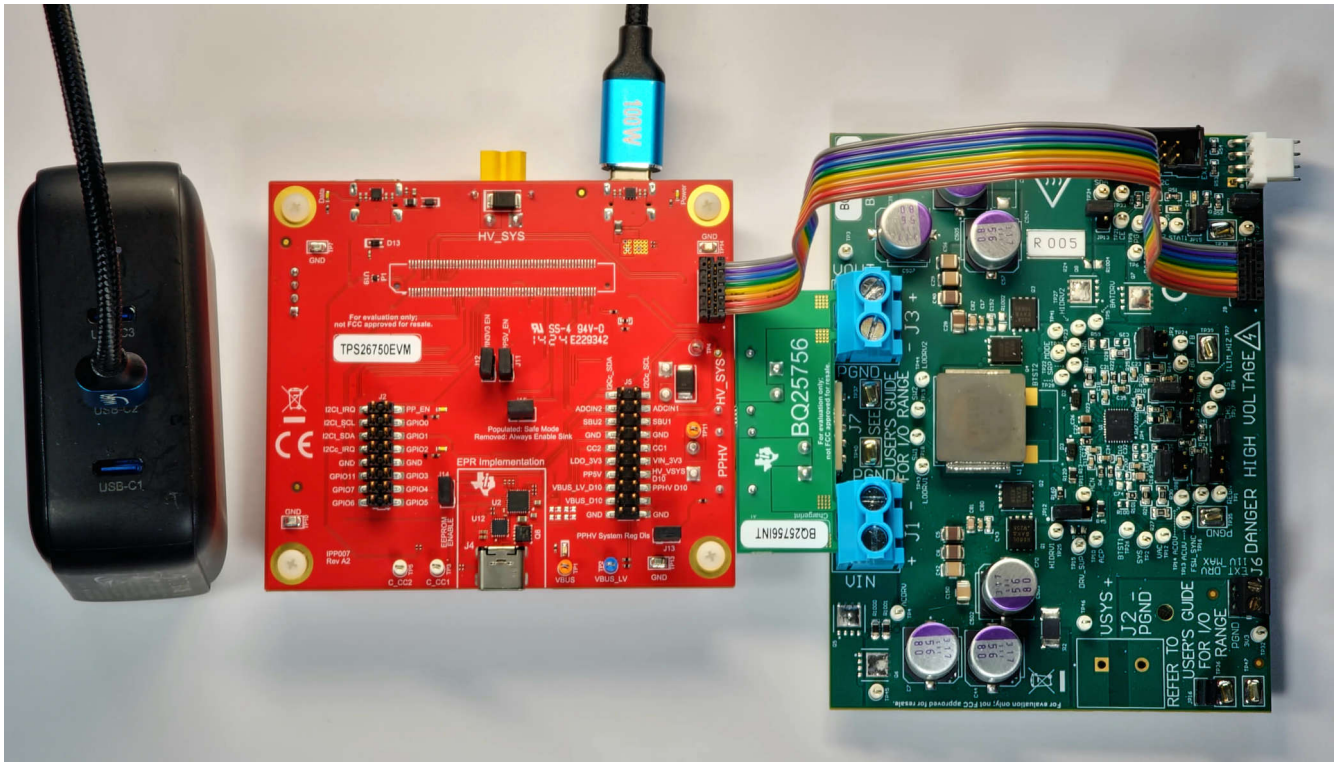


Figure 2-9. TPS26750EVM and BQ25756EVM Example Hardware Setup

2.4 Header Information

The J2 and J5 headers are setup for ease of use with 5V and 10V level logic analyzers. The most pertinent signals and power rails for testing the TPS26750 are pulled out to these headers. If utilizing the Liquid Detection feature, note that pins SBU1 and SBU2 on Header J5 are not the SBU signals directly at the DUT Type-C connector (J4), but are instead the SBU signals from the Liquid Detection circuit to the SBUx pins of the TPD4S480, as shown in [Figure 5-2](#).

Table 2-1. J2 (TPS26750 Digital)

Pin	Name
1	GPIO5 (lower right-most pin if able to read J2 on silk screen)
2	GPIO6
3	GPIO4
4	GPIO7
5	GPIO3
6	GPIO11
7	GND
8	GND
9	EPR_EN (GPIO2)
10	I2Cc_IRQ
11	GPIO1
12	I2Ct_SDA
13	GPIO0
14	I2Ct_SCL
15	PP_EN (Buffered POWER_PATH_EN output)
16	I2Ct_IRQ

Table 2-2. J5 (Digitizer)

Pin	Description
1	I2Cc_SDA (upper left-most pin if able to read J5 on silk screen)
2	I2Cc_SCL
3	ADCIN2
4	ADCIN1
5	SBU2
6	SBU1
7	GND
8	GND
9	CC2
10	CC1
11	LDO_3V3
12	VIN_3V3
13	PP5V
14	HV_SYS_D10 (HV_SYS divided by 11)
15	VBUS_D10 (VBUS divided by 11) (labeled as VBUS_LV_D10 on silk screen)
16	PPHV__D10 (PPHV divided by 11)
17	VBUS_LV_D10 (VBUS_LV divide by 11) (labeled as VBUS_D10 on silk screen)
18	No Connect
19	GND
20	GND

Note

The label suffix *_D10* implies that the signal has been divided by 10. However, the actual value that the original signal has been divided by is 11; that is, if VBUS measures 48V, then VBUS_D10 measures approximately 4.36V.

2.5 Jumper Information

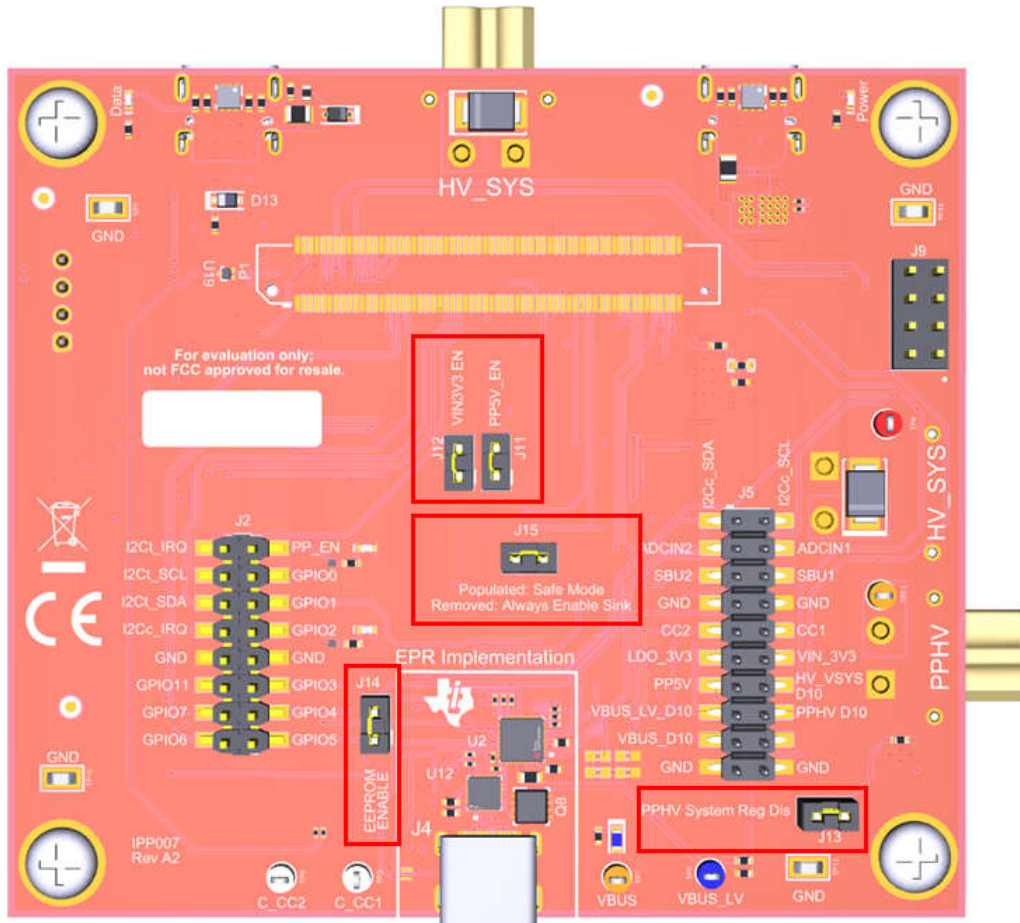


Figure 2-10. Jumper Locations

Table 2-3. Jumpers (2)

Jumper	Name	Behavior	
J11 ⁽¹⁾	VIN_3V3 EN	Populated	The 3.3V LDO (U1) is enabled, providing 3.3V to the VIN_3V3 pin of the TPS26750
		Removed	The 3.3V LDO (U1) is disabled, providing 0V to the VIN_3V3 pin of the TPS26750
J12 ⁽¹⁾	PP5V_EN	Populated	Switch U4 is enabled, connecting the 5V buck converter (U9) to the PP5V pin of the TPS26750
		Removed	Switch U4 is disabled, disconnecting the 5V buck converter (U9) from the PP5V pin of the TPS26750
J13	PPHV System Reg Dis	Populated	5V LDO (U20) is enabled
		Removed	5V LDO (U20) is disabled
J14	EEPROM ENABLE	Populated	EEPROM is connected to TPS26750 and System MCU (U22)
		Removed	EEPROM is disconnected from TPS26750 and System MCU (U22)
J15	Dead battery configuration	Populated	Safe mode enabled
		Removed	Always enable sink enabled

(1) Please refer to the following [note](#) regarding a silk screen error to avoid confusion

(2) Refer to [Pin Strapping to Configure Default Behavior](#) in the [TPS26750 USB Type-C® and USB PD Controller With Extended Power Range Support](#) data sheet for more detailed information about Dead Battery Configuration.

2.6 Push Buttons

Table 2-4. Buttons and Dip Switches

Instance Name	Type	Function
S2	Momentary push button	Used to put the System MCU into programming mode. Not intended for User functionality and can result in MCU not functioning if used

CAUTION

Use of S2 can result in the MCU not functioning, thus preventing the loading of configurations to the TPS26750EVM. Do not use.

2.7 Interfaces

Type-C Data Connection

J6 is a USB Type-C port that is configured as a 5V/3A legacy sink that provides a full speed USB connection to the EVM. J6 is used to interface with the GUI for part configuration and debug. For instructions on how to use the GUI, see [Section 3.3](#).

Generic Power Converter Interface

This set of three connectors is intended to allow various power converter boards to interface with the TPS26750EVM.

The three connectors are listed below

1. J7 XT30 connector: Power Path (PPHV) connector (power pin and ground)
2. J1: XT30 system power (HV_SYS) (power pin and ground)
3. J9: 4x2 100 mil 90 degree IDC connector

The connectors are placed at a 600mil pitch between pin 1 of each connector. The generic power converter interface is on the right side of the board, as shown in [Figure 1-1](#). The connectors for J9 are placed from bottom to top as follows (see schematic [Figure 5-9, DC2DC Interface](#), for pinout):

Table 2-5. IDC Connector Pinout

Pin Number	Signal
1 (denoted by a white dot to the lower right of the pin)	PP5V
2	GND
3	GND
4	I2Cc_SCL
5	GPIO1
6	I2Cc_SDA
7	GPIO3
8	LDO_3V3

2.8 Debug Information

One of the most valuable tools users can utilize when debugging USB-PD capable systems for a faster time-to-market is a USB-PD protocol analyzer. The USB-PD specification details how information is sent on the Configuration Channel (CC) lines between port partners, and the above mentioned analyzers can decode this traffic into an easily navigable log of events. These tools also show the voltage on the CC pins of the DUT for reviewing the Type-C implicit contract behavior. Utilizing this tool in conjunction with a 5V or 10V logic analyzer to view the signals available on headers J2 and J5, is a good place to start with debugging the TPS26750EVM.

When deciding which USB-PD analyzer to use, make sure that the analyzer is designed for use with EPR capable devices. The only one on the market below 200 USD, at the time of this document's initial publication, is the Power-Z KM003C. To log USB-PD traffic between port partners with the Power-Z KM003C, use the device in passthrough mode in conjunction with a computer. For information on how to use the Power-Z KM003C in passthrough mode, refer to the documentation manufacturer.

This device can also step through USB-PD contracts (Power Data Objects or PDOs) when acting as a power sink to relation to the port partner, the TPS26750 DUT (source), to test the TPS26750EVM's ability to source each PDO. This device is shown with a setup that allows users to test the configured USB-PD contracts (PDOs) of the TPS26750EVM with integrated control of the BQ25756EVM; see [Figure 2-11](#).

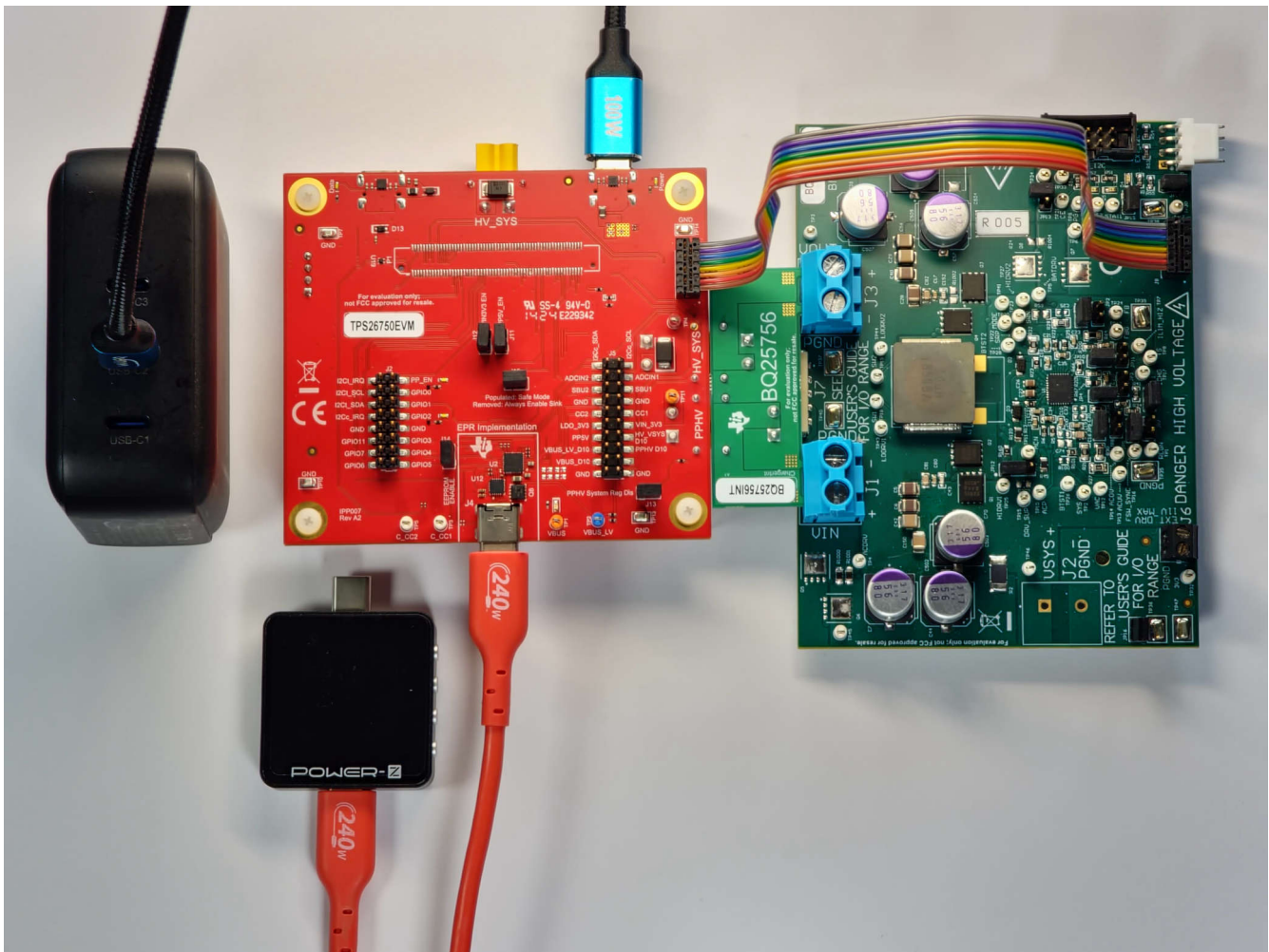


Figure 2-11. Testing Setup Utilizing the Power-Z to Test Source PDOs of TPS26750EVM

Targeted Debugging

If users are not seeing expected behavior after configuring the TPS26750 using the Application Customization Tool, then one of the first places to start is to monitor the I2C lines when the TPS26750EVM is first powered up to see if the EEPROM is successfully writing the configuration of the device to the TPS26750. There must be I2C traffic (from the EEPROM to the TPS26750) that matches the contents of the binary that is exported from the *Export Full Flash Binary* tool in the GUI.

To successfully test the USB-PD Extended Power Range (EPR) with the TPS26750EVM, successfully negotiate an EPR contract (a USB-PD contract with a voltage greater than 20V), a [USB-IF compliant](#) 240W rated USB-C to USB-C cable must be used. If users are able to negotiate SPR contracts, but not EPR contracts, make sure the USB-C to USB-C cable is 240W rated.

If VBUS is falling (hitting UVLO) after a USB-PD EPR contract is negotiated while sourcing and utilizing the BQ25756EVM, then check to see if the power source connected to the HV_SYS net (either through J8 or J3) is capable of supplying sufficient current for the contract negotiated. For details on using the BQ25756EVM in conjunction with the TPS26750EVM, see [Section 4.2](#).

2.9 Test Points and LEDS

LED Information

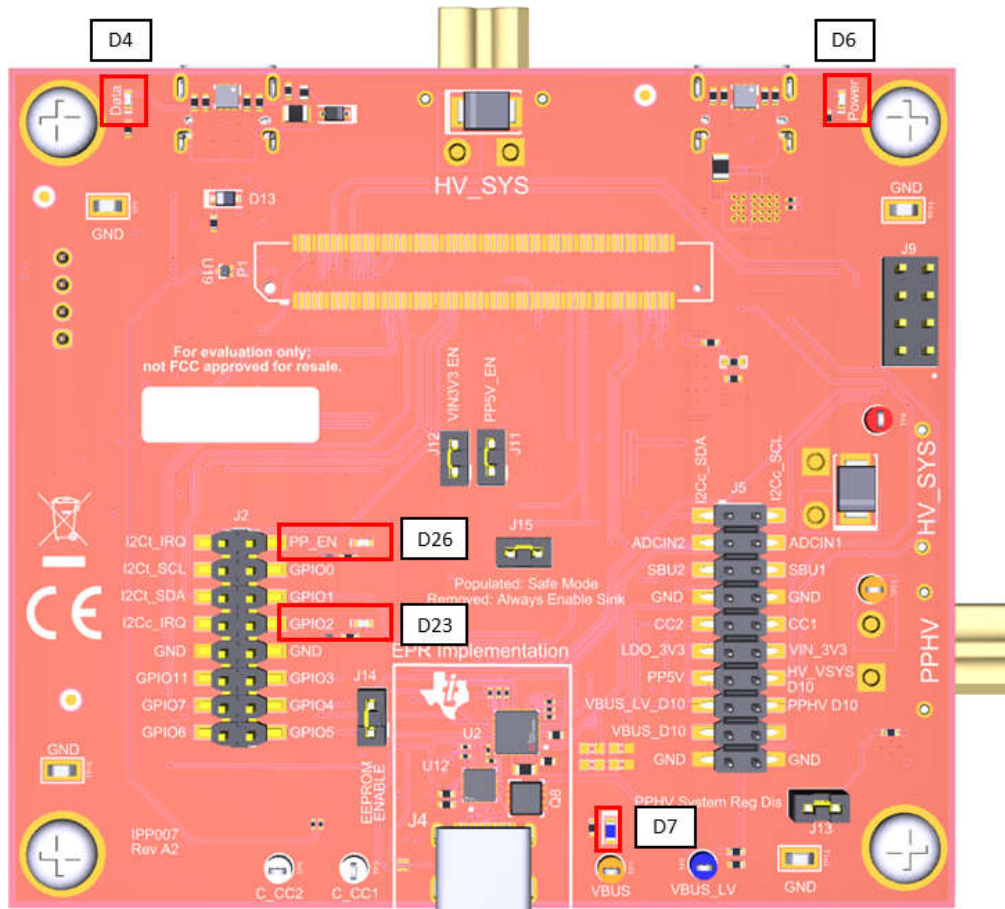


Figure 2-12. Location of LEDS

Table 2-6. LEDS

Designator	Net Label	Description
D4	RP_VBUS	Blue LED that turns on when USB Type-C is connected to Data Type C Port (J6).
D6	TC_VBUS_C	Blue LED that turns on when USB Type-C is connected to Power Type C Port (J3).
D26	NetD26_2	Blue LED that shows when POWER_PATH_EN is driven high to enable the Bidirectional power path (PPHV).
D23	NetD23_2	Blue LED that shows when GPIO2 (EPR_EN) is driven high to show that the TPS26750 is in EPR Mode.
D7	NetD7_2	Blue LED that lights when VBUS is driven at or above 5V.

Table 2-7. Test Points

Name	Test Point	Description
VBUS	TP1	VBUS (5V to 48V)
VBUS_LV	TP2	VBUS_LV. Either VBUS in SPR Mode or (VBUS x 42.18750%) in EPR Mode
PPHV	TP11	High voltage power path
HV_VSYS	TP4	High voltage system power
C_CC1	TP3	Connector side (J4) CC1
C_CC2	TP5	Connector side (J4) CC2
GND	TP7, TP10, TP13, TP13	Ground

3 Software

3.1 Software Description

The required software is available at the [TI Gallery](#) and can be run in a browser or installed to the computer and run natively. Browser requirements:

1. Google Chrome®, Firefox®, or Safari®.
2. Install TI Cloud Agent as a browser extension and on the PC.
 - a. When the application is first launched, instructions appears for installing TI Cloud Agent.

PC requirements:

1. Install GUI Composer Runtime.
 - a. To install GUI Composer Runtime, click on the downwards-facing arrow inside one of the applications listed in the Gallery, and look towards the bottom set of links that appear. After selecting the native operating system, open the installer and follow the prompts to install the program.

3.2 Software Installation

3.2.1 Web Browser

1. Navigate to [Developer Gallery](#).
2. Type `USBCPD_Application_Customization_Tool` into the Search Bar in the Gallery.
3. Once found, click on the title of the card that says `USBPD_Application_Customization_Tool`.
4. A new tab opens and automatically launches the application. If TI Cloud Agent is not already installed, then instructions appear for installing the required software.

3.2.2 Native Application

1. Navigate to [Developer Gallery](#).
2. Search for the USBCPD Application Customization Tool in the Gallery.
3. Once found, click on the downwards-facing arrow on the bottom left side of the card, and look towards the top set of links that appear. Select the native operating system and open the installer. See figure below for the download button.

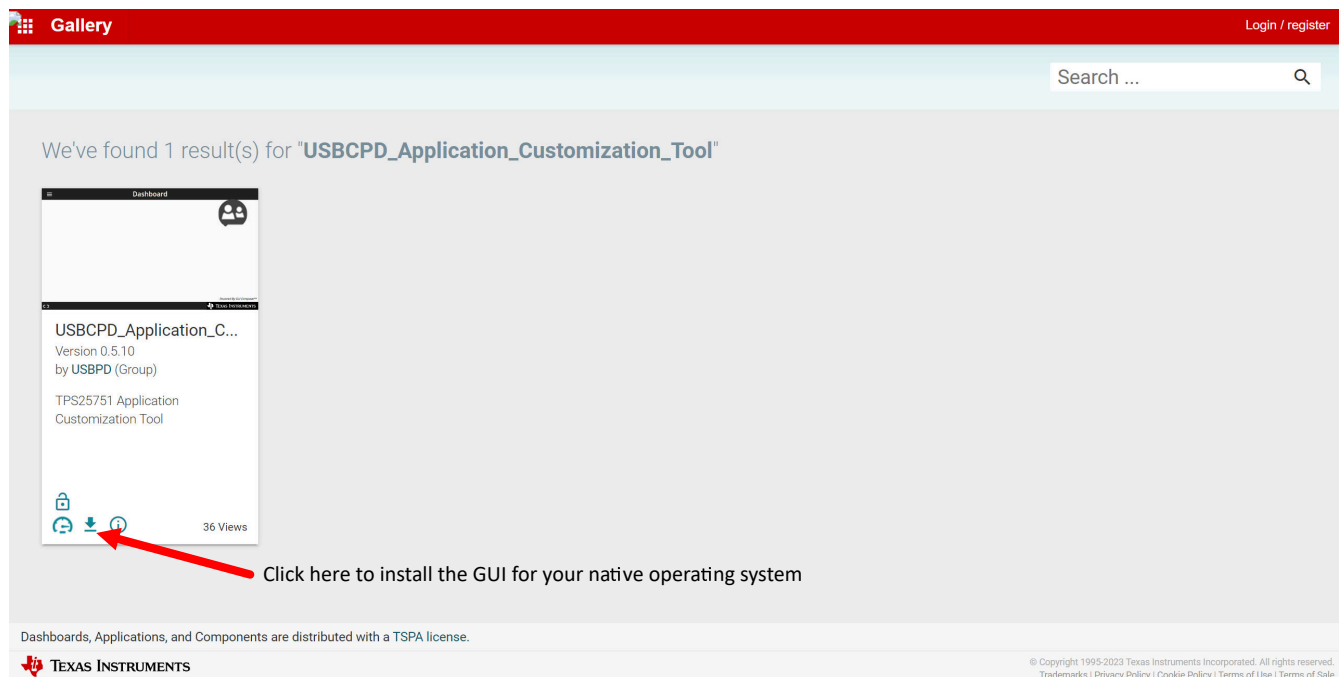


Figure 3-1. Application Customization Tool Download

4. Once the installer is open, follow the directions to install the application.

3.3 Software Development

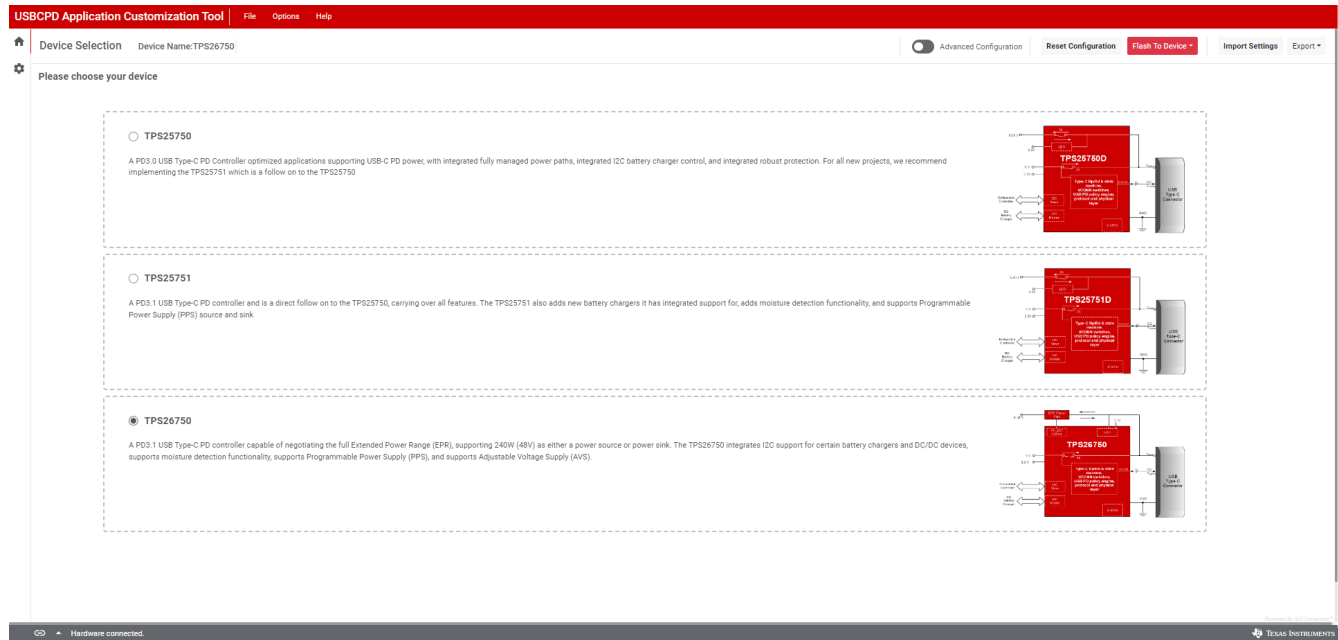
The Application Customization Tool provides users with the following capabilities:

- Generate new configuration settings.
- Load configuration settings to a device.
- Save configuration settings in JSON format.
- Export configuration settings in Binary and C format.
- Enter Debug Mode. More information in [Section 2.8](#)

3.4 Using the Application Customization Tool

3.4.1 Default View

After launching the Application Customization Tool, a page appears with device selections for TPS25750, TPS25751, and TPS26750. Select TPS26750 to start configuring.



3.4.2 Selecting a Configuration

The first question of the GUI asks to select a configuration the TPS26750 is used for. The 5 configurations are separated into three main categories based on power role:

1. Power Source (provider) and Power Sink (consumer), also referred to as Dual Role Power (DRP)
2. Power Sink (consumer) only
3. Power Source (provider) only

Based on the configuration selected, certain questions are disabled. See the image and table below for a breakdown of each configuration.

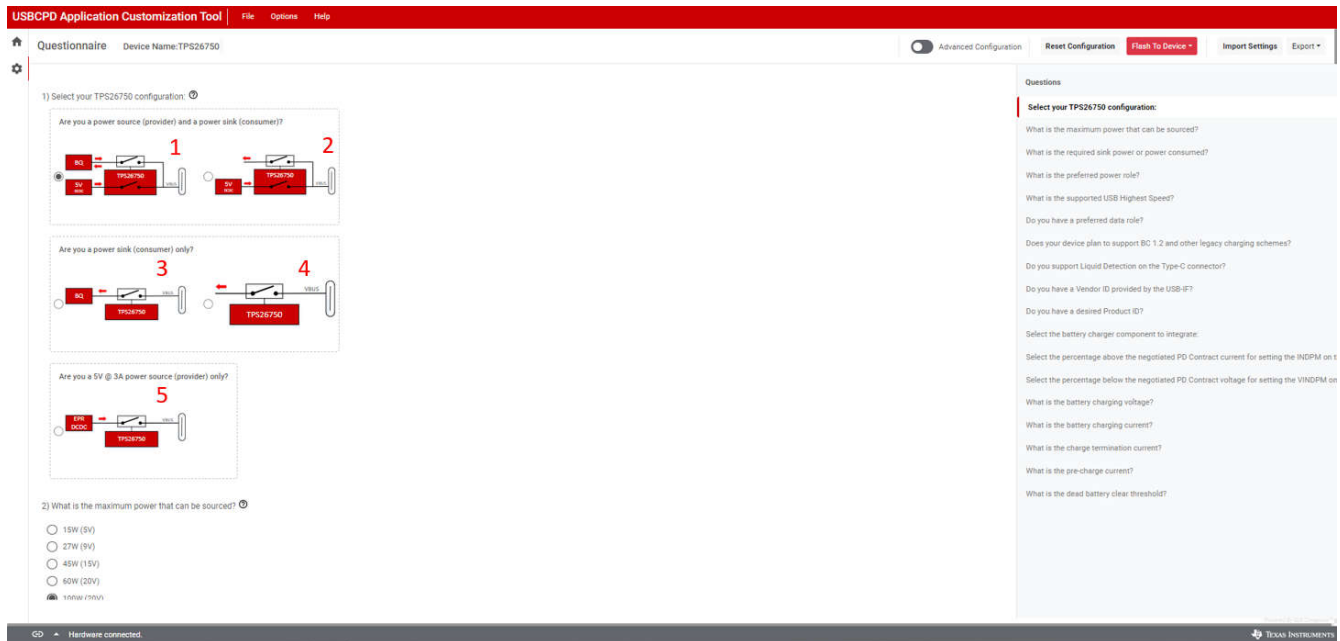


Figure 3-2. Application Customization Tool Configuration

Table 3-1. TPS26750 Configuration

Configuration Index	Power Role	BQ Support
1	Source and Sink (DRP)	Yes
2	Source and Sink (DRP)	No
3	Sink Only	Yes
4	Sink Only	No
5	Source Only	No

3.4.3 Filling Out the Questionnaire

After making a selection for Question 1, answer the remaining questions to enable flashing a TPS26750EVM or to generate and save a full configuration. Based on the selection for Question 1, some of the remaining questions can be unavailable for selection.

Questionnaire Explanation

Question 1: [Section 3.4.2](#)

Question 2: What is the maximum power in Watts that you want to source from the TPS26750EVM using the DUT Type C Port (J4)? If a sink only configuration was selected, this question is not selectable.

When selecting the maximum power that can be sourced, the Transmit Source Capabilities register (0x32) of the TPS26750 is configured by adding default Source PDOs (each PDO is also referred to as a USB-PD contract) as shown in [Figure 3-6](#).

Note

All registers referenced in this section can be accessed and modified manually by entering Advanced Configuration Mode. This is detailed in [Section 3.4.4](#).

Question 3: What is the maximum power in Watts that you want to sink to the TPS26750EVM using the DUT Type C Port (J4)? If a source only configuration was selected, then this question is not selectable.

When selecting the maximum power that can be sinked, the Transmit Sink Capabilities register (0x33) of the TPS26750 is configured by adding default Sink PDOs (each PDO is also referred to as a USB-PD contract).

Table 3-2. PDOs Associated with Selected Power in Questions 2 and 3

Power Option Selected	Default SPR PDOs
15W (5V)	5V/3A
27W (9V)	5V/3A, 9V/3A
45W (15V)	5V/3A, 9V/3A, 15V/3A
60W (20V)	5V/3A, 9V/3A, 15V/3A, 20V/3A
100W (20V)	5V/3A, 9V/3A, 15V/3A, 20V/5A

The PDOs included in Registers 0x32 and 0x33 are correlated with the selected power option in [Table 3-2](#).

If required power is greater than 100W, and an option greater than 100W is selected, then the PDOs greater than 100W are EPR PDOs, and the default generated PDOs are shown in [Table 3-3](#). The PDOs are listed in order. A single fixed PDO is listed in the format [PDO Voltage value]V/[PDO Current value]A:

Table 3-3. EPR Power Ranges

Power Option Selected	Default SPR PDOs	Default EPR PDOs
140W (28V)	5V/3A, 9V/3A, 15V/3A, 20V/5A	28V/5A, AVS PDO
180W (36V)	5V/3A, 9V/3A, 15V/3A, 20V/5A	28V/5A, 36V/5A, AVS PDO
240W (48V)	5V/3A, 9V/3A, 15V/3A, 20V/5A	28V/5A, 36V/5A, 48V/5A, AVS PDO

Question 4: If a DRP configuration is selected in question 1 (Configuration Index 1 or 2), then question 4 determines which power role (source or sink) is *preferred* by the TPS26750EVM. If Configuration Index 3,4, or 5 was selected, then this question is not selectable. The meaning of *preferred* in this context is the following:

- If the TPS26750EVM prefers to be a source, and after connection to a port partner, is acting as a sink, then the TPS26750 requests to the port partner to swap roles (power role swap) in an attempt to become a power source.
- If the TPS26750EVM prefers to be a sink, and after connection to a port partner, is acting as a source, then the TPS26750 requests to the port partner to swap roles (power role swap) in an attempt to become a power sink.

Question 5: What is the supported USB speed of the DUT? Based on the selection, this determines what USB speed is enumerated during PD negotiation. If USB data is not required, then select *No USB data is being used*.

Question 6: What is the preferred data role (UFP, DFP, or Dual Role Port (different from Dual Role Power, a power role)) of the DUT? When an implicit Type-C contract (this occurs before the explicit USB-PD contract) is made the Power-role and Data-role is either Source and DFP or Sink and UFP. If this combination does not meet the USB Data Role needs for the application, then selecting the preferred data role allows the TPS26750 to request a data role swap when appropriate. If there is no preference, then select *No*. This information is stored in the Port Control register (0x29).

Note

For more details on the registers of the TPS26750, refer to the TPS26750 Technical Reference Manual.

Question 7: Is USB Battery Charging 1.2 (BC1.2) and legacy charging supported in the application? Based on the selection, the TPS26750 can enumerate different BC1.2 charging schemes. Refer to the [TPS26750 USB Type-C® and USB PD Controller with Integrated Power Switches Optimized for Power Applications](#) data sheet for more details on BC1.2 implementation.

Note

The TPS26750EVM does not support BC1.2 out of the box. To use the TPS26750EVM in conjunction with BC1.2, populate resistors R77 and R78 with 0Ω resistors (located on the top of the board to the right of TP3 and to the left of J4, as shown in [Figure 3-3](#)), and depopulate resistors R25 and R26 (located on the bottom of the board, beneath U13, as shown in [Figure 3-4](#)).

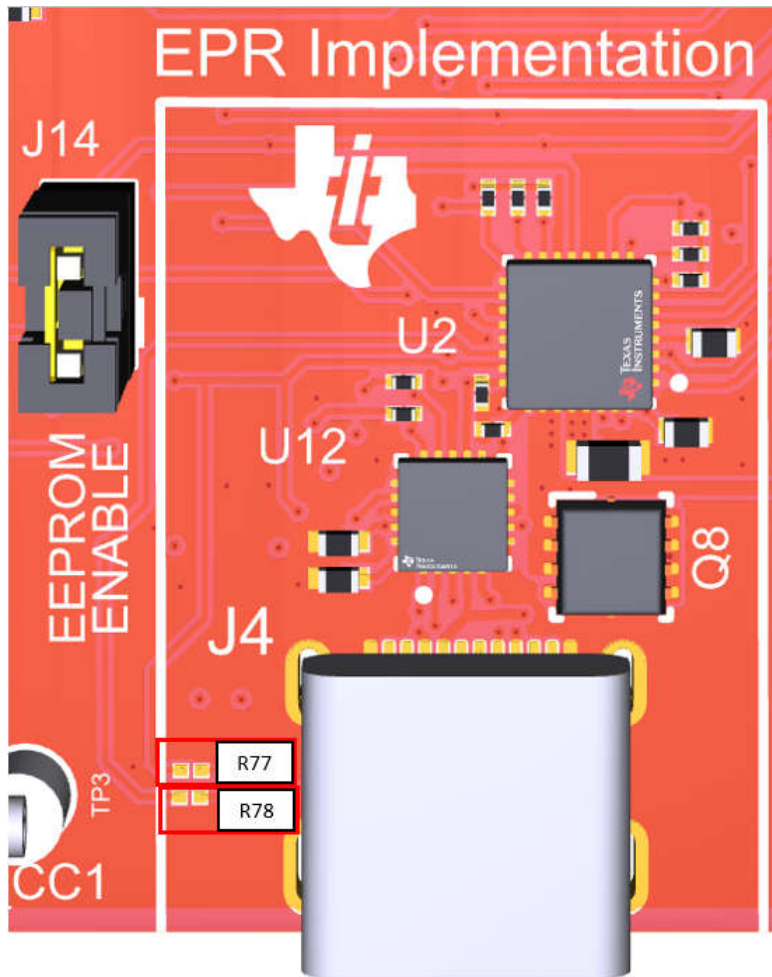


Figure 3-3. Resistor 77 and 78 Location

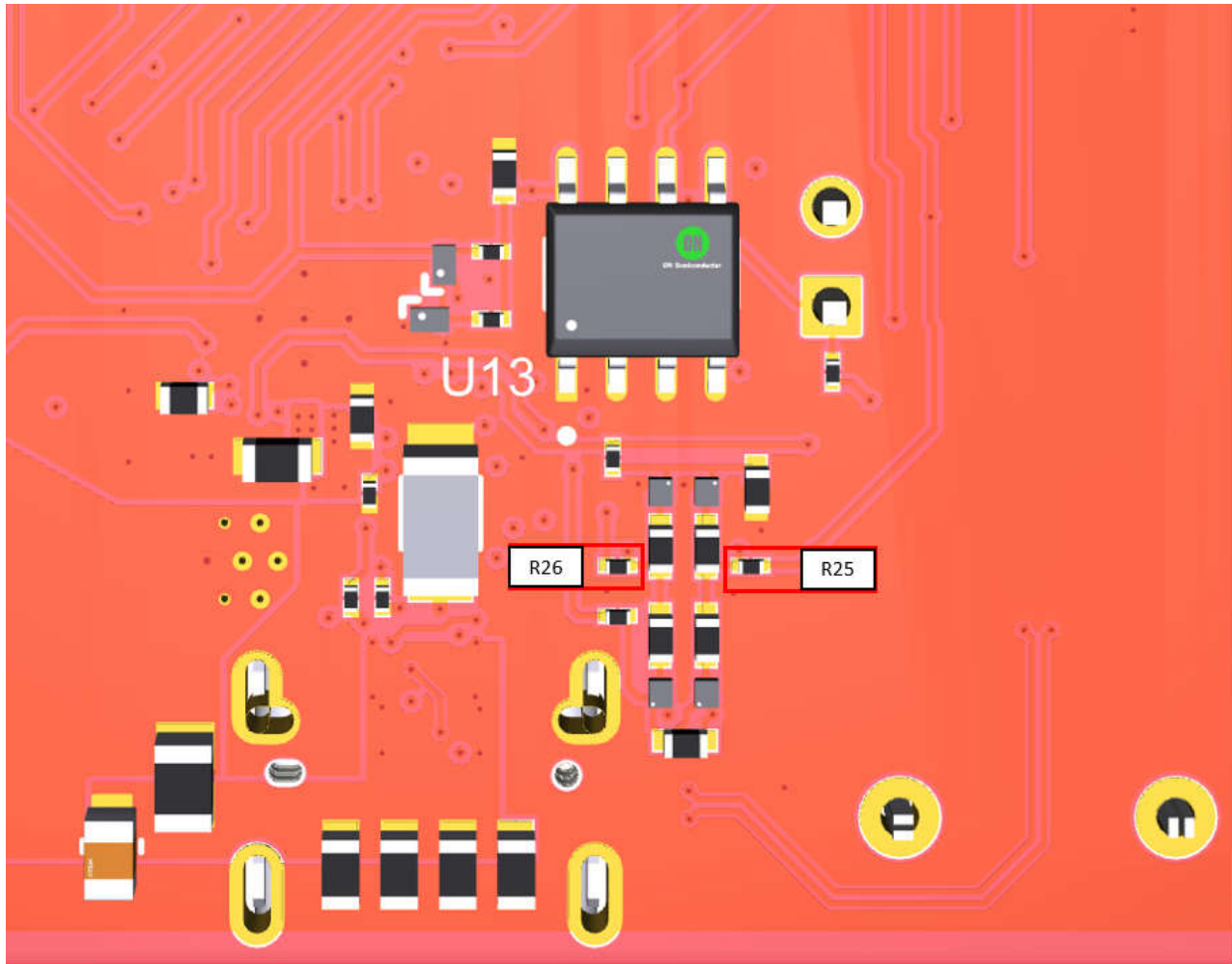


Figure 3-4. Resistor 25 and 26 Location

Question 8: Enables or disables Liquid Detection support. This is a new feature of the TPS26750 based on the Type-C specification for Liquid Detection and Corrosion Mitigation. For more details, refer to [Section 4.1](#).

Note

The TPS26750 is not able to support BC1.2 and Liquid Detection simultaneously, since both features utilize the same GPIO pins (GPIO4 and GPIO5).

Question 9: Allows the ability to enter a Vendor ID. The Vendor ID is given by the USB-IF, and is a 4-digit hexadecimal value. Select Yes option to enter the desired Vendor ID, otherwise select *No*.

Question 10: Allows the ability to enter a Product ID, which is a 4-digit hexadecimal configuration identifier, after selecting Yes. If unused, select *No*.

Questions 11 through 18 corresponds to configuring the selected BQ (Battery Charger) device if applicable. These questions are only available for use if a configuration was selected in the first question that includes a BQ block. For all other configurations (TPS26750 without a BQ block), these questions are disabled. For more details on each question, refer to [Section 4.2.2](#).

The TPS26750 supports integration with the BQ25756 IC. If using the BQ25756EVM in conjunction with the TPS26750EVM, then any configuration in Question 1 with a BQ block can be used.

3.4.4 Advanced Configuration Mode

To configure additional fields and registers such as I2C Interrupt Masking, GPIO events, or making custom changes to Source/Sink PDOs, click on the *Advanced Configuration* slider at the top of the tool. After clicking on the slider, a message appears asking for confirmation before enabling *Advanced Configuration*.

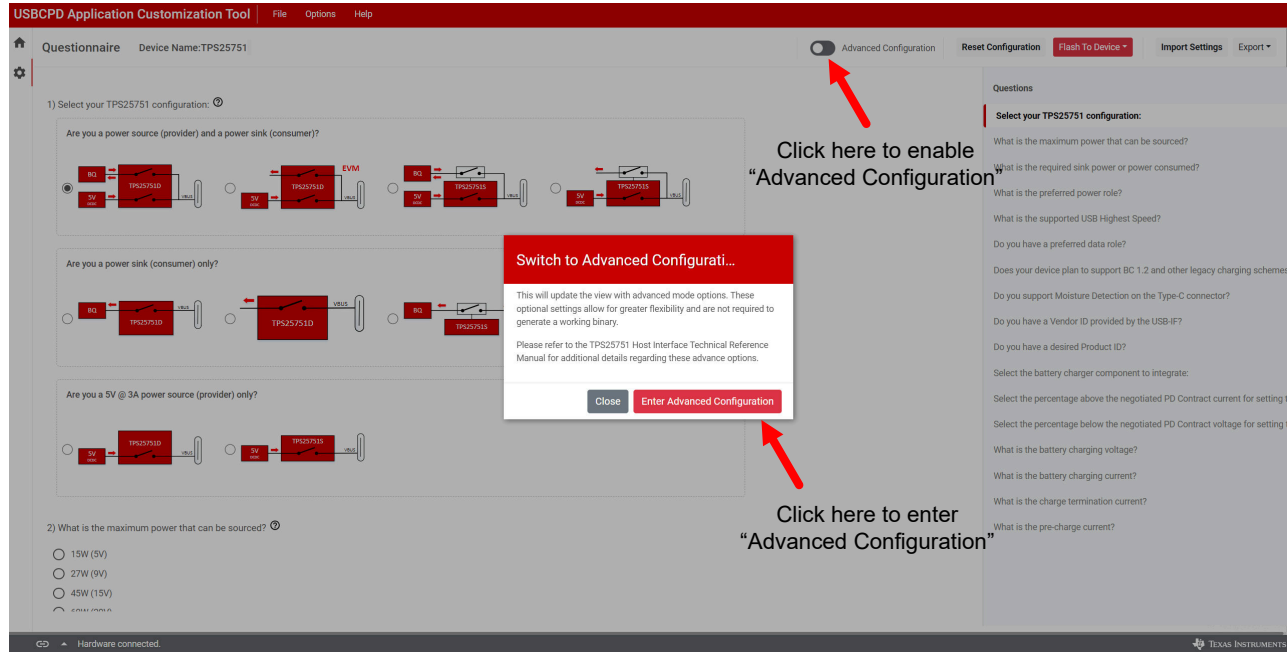


Figure 3-5. Enabling Advanced Configuration

Once Advanced Configuration is enabled, an Advanced Icon appears on the left side underneath the gear icon to go back to the questionnaire. Within Advanced Configuration, users have the ability to configure specific registers on the TPS26750. For details on register fields and the description, refer to the TPS26750 Technical Reference Manual. See the example below of configuring the Source_PDO_4 under Transmit Source Capabilities (0x32).

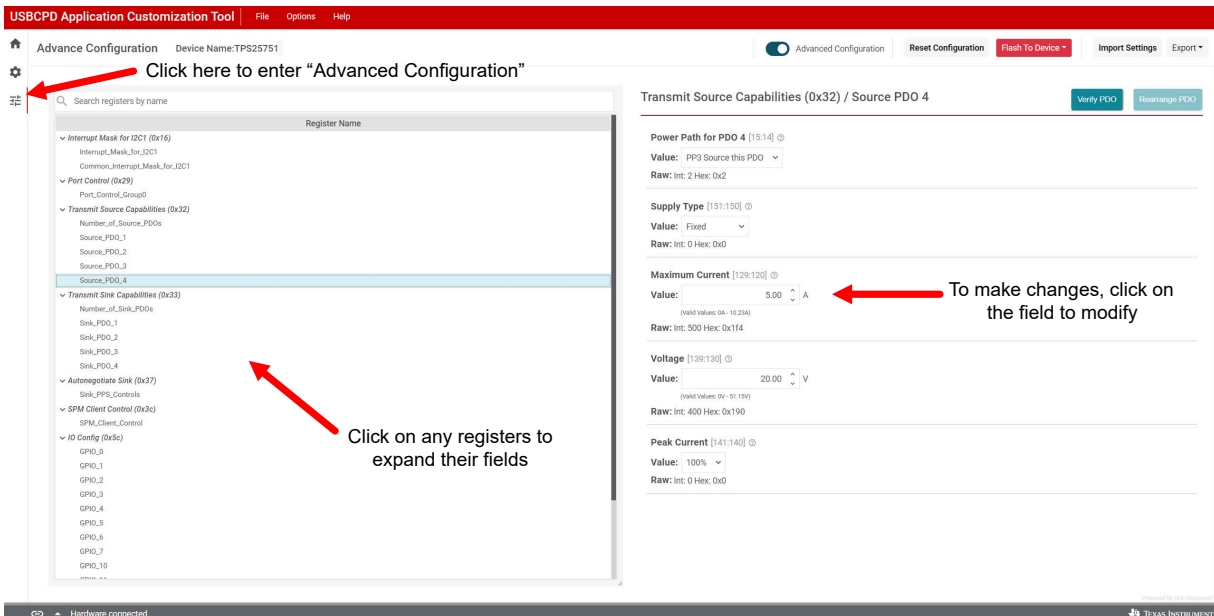


Figure 3-6. Using Advanced Configuration

3.4.5 Flashing Configuration to TPS26750

The Application Customization Tool is used to directly load a configuration onto the TPS26750. To flash a configuration, perform the following steps:

1. Open the Application Customization Tool
2. Connect the USB-C end of either a USB-A to USB-C cable or a USB-C to USB-C cable to the Data Type-C port (J6).
3. Connect the other end of the cable to a laptop or computer with the Application Customization Tool open.
4. Make sure jumper J11 is populated on the TPS26750EVM.

Note

For evaluating battery charging applications with the BQ25756EVM, connect the BQ25756EVM to the TPS26750EVM *after* configuration has been successfully loaded AND both Power Type-C and Data Type-C connections have been removed from ports J8 and J6, respectively. Also, make sure nothing is connected to J4. If a new configuration needs to be loaded to the TPS26750EVM, then all connections to the BQ25756EVM **must** be removed until the new configuration is loaded and ports J4, J8, and J6 are disconnected.

Open the Application Customization Tool and complete the questionnaire; for details on each question, refer to [Section 3.4.3](#). Once the questionnaire is complete and the TPS26750EVM is connected properly, click on Options → Serial Port Configuration to make sure the correct COM port is selected (*Texas Instruments, Inc* needs to be listed next to the COM port). For reference, see [Figure 3-7](#).

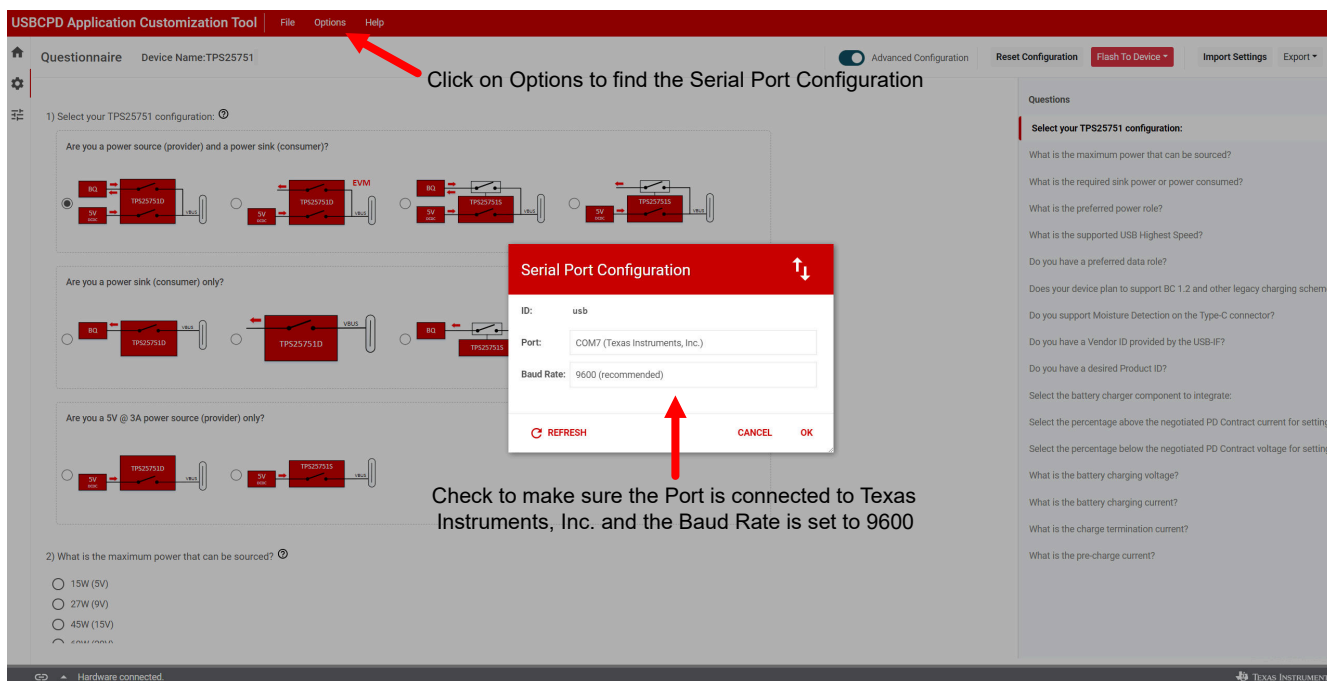


Figure 3-7. Serial Port Configuration Settings

If the TPS26750EVM is unable to connect to the Application Customization Tool, then go through the following debug recommendations:

1. Make sure the cable connecting the computer to the TPS26750EVM supports data.
2. Make sure only one tab (or instance, if using the natively run application) of the Application Customization Tool is running at any given time. Multiple tools running simultaneously can cause communication issues.

Once the questionnaires are completed and the TPS26750EVM is connected to the Application Customization Tool, click on Flash To Device → Flash to device from current configuration.

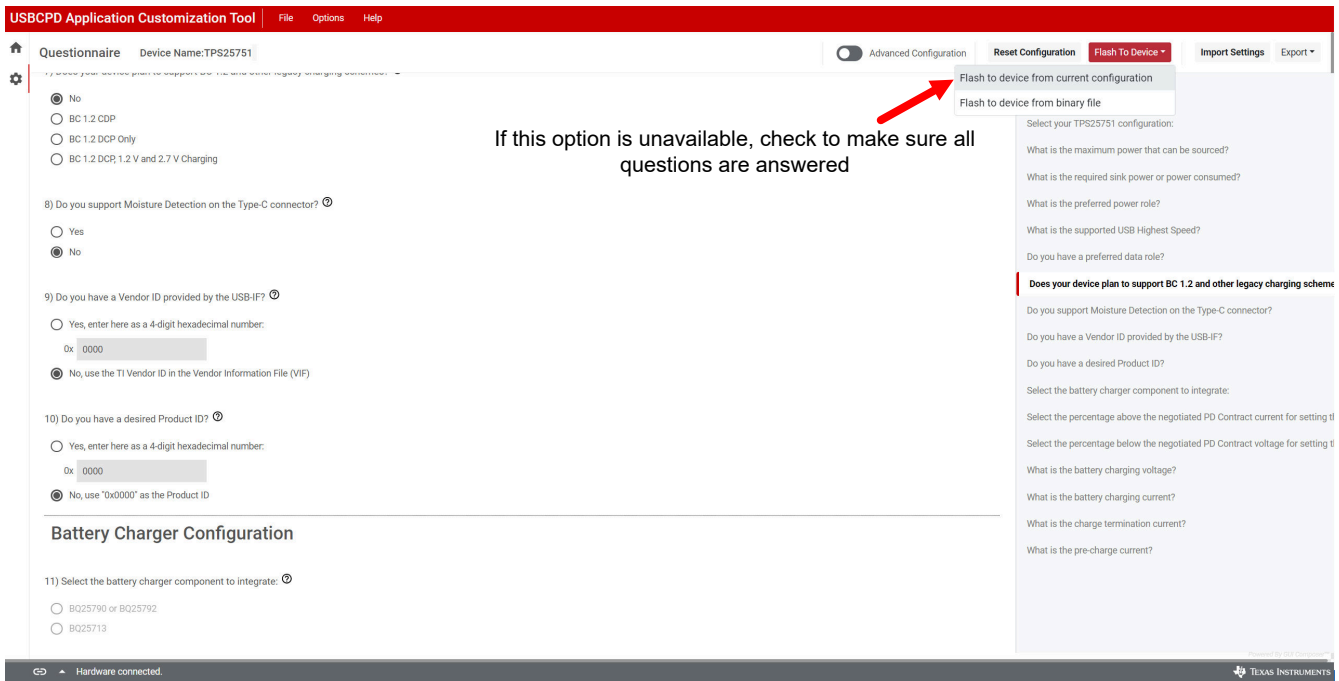


Figure 3-8. Flash to Device from Current Configuration

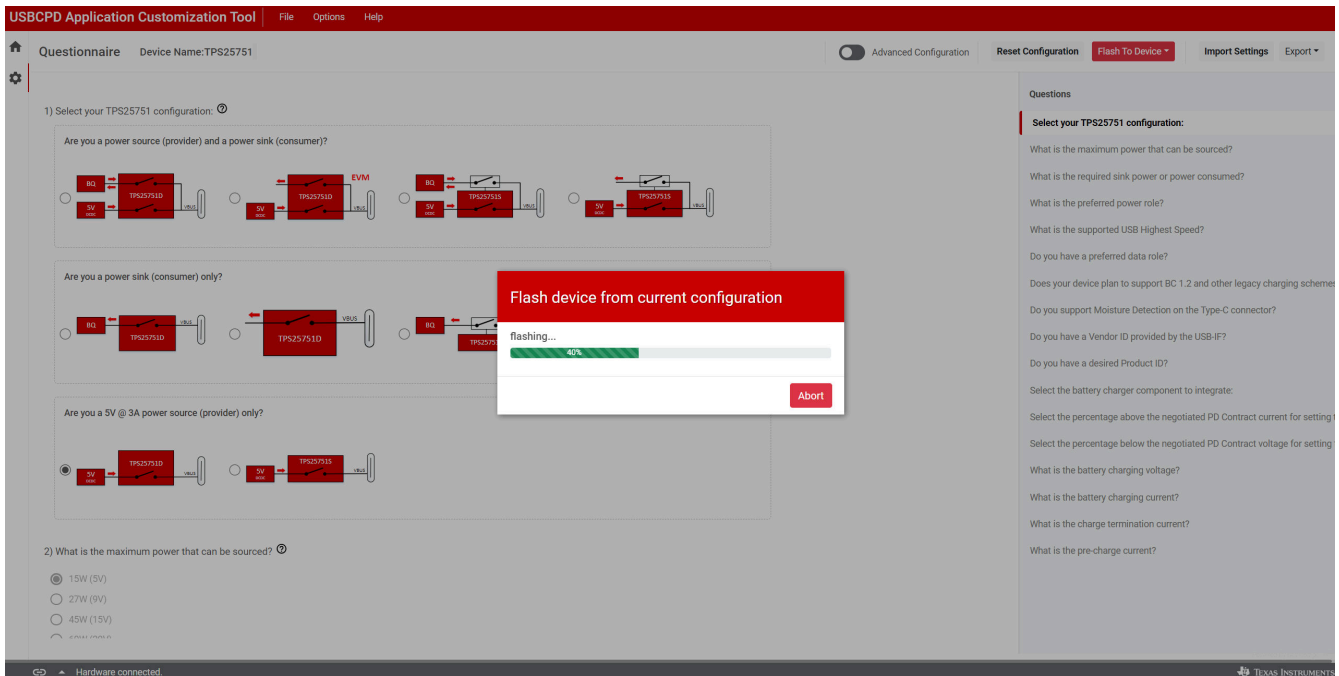


Figure 3-9. Flash to Device from Current Configuration

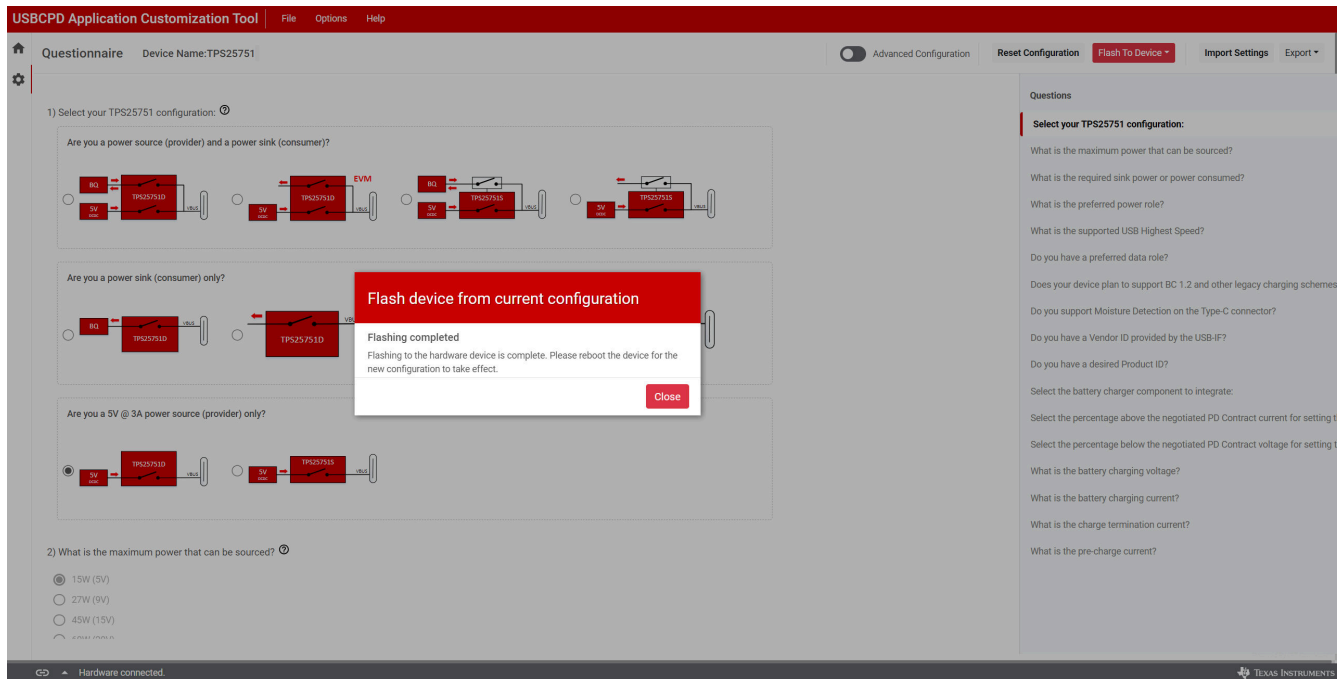


Figure 3-10. Flash to Device from Current Configuration

Note

When the tool is flashing the configuration, DO NOT connect or disconnect any cables on the TPS26750EVM. Connecting or disconnecting any cables can cause errors when flashing.

Flashing to Device from an Existing Binary File

If a binary file has previously been generated, then the binary can be loaded directly to the TPS26750EVM instead of filling out the questionnaire again. Make sure the TPS26750EVM is detected and connected to the Application Customization Tool using the above steps, and instead of choosing *Flash to Device from Current Configuration* under the *Flash to Device* heading, select *Flash to Device From Binary File*. Select the desired .bin file from your directory and click OK.

Note

When flashing to the TPS26750EVM from an existing binary, make sure the binary is a *Full Flash Binary* and not a *Low Region Binary*. For further details, see [Section 3.4.6.3](#).

3.4.6 Additional Settings

3.4.6.1 Generating a New Configuration

To generate a new configuration for the TPS26750EVM, click the *Reset Configuration* button on the top right side of the tool (this is next to the *Flash To Device* drop-down menu). This button erases the existing configuration and resets the form back to the default settings. TI recommends to export the existing form before resetting, so that the existing configuration is not lost. For details on how to save configurations, refer to [Section 3.4.6.2](#).

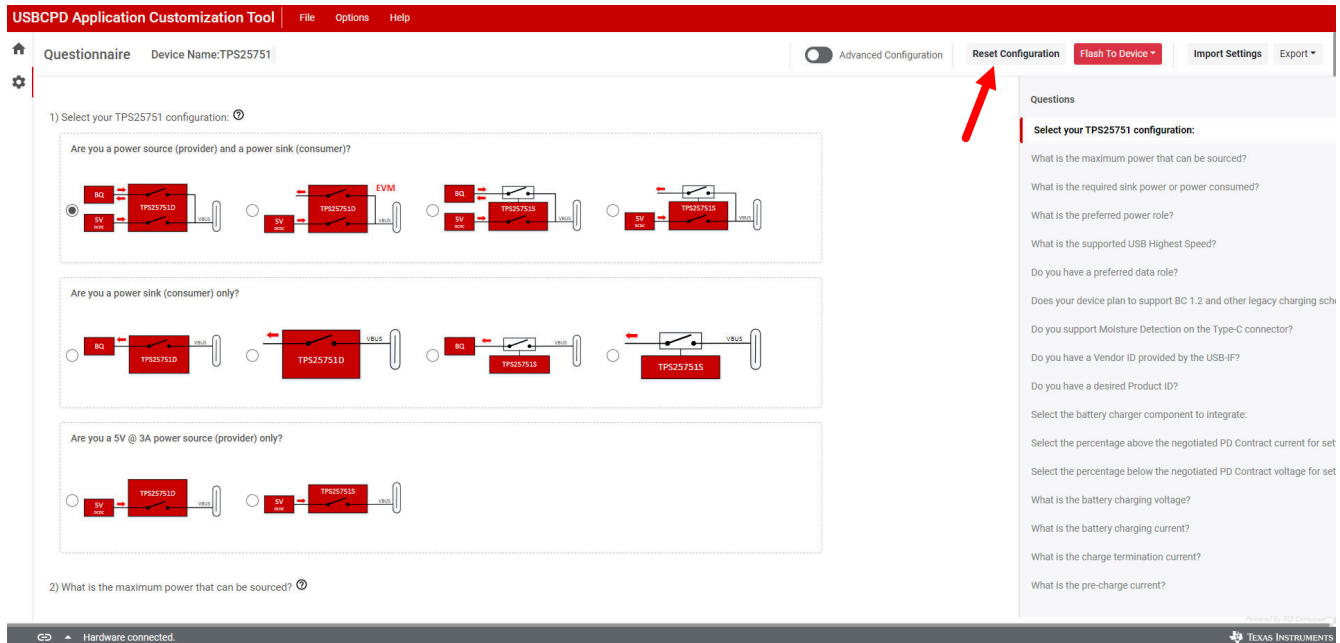


Figure 3-11. Resetting Configuration

3.4.6.2 Exporting and Importing Settings

To save the current tool settings including the current configuration of the device as indicated by the form, click on the *Export* drop-down button on the top-right side of the tool and click on *Export settings*. This opens a window where the user changes the file name of the settings. Enter a file name and click *Export* to export a JSON file.

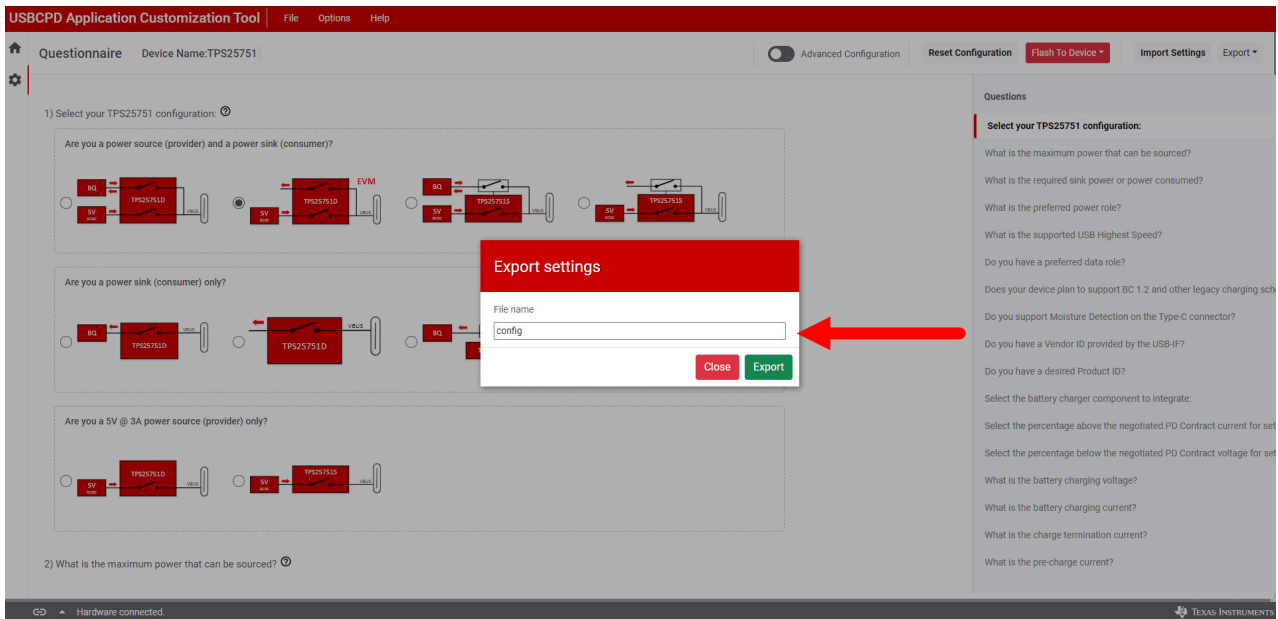
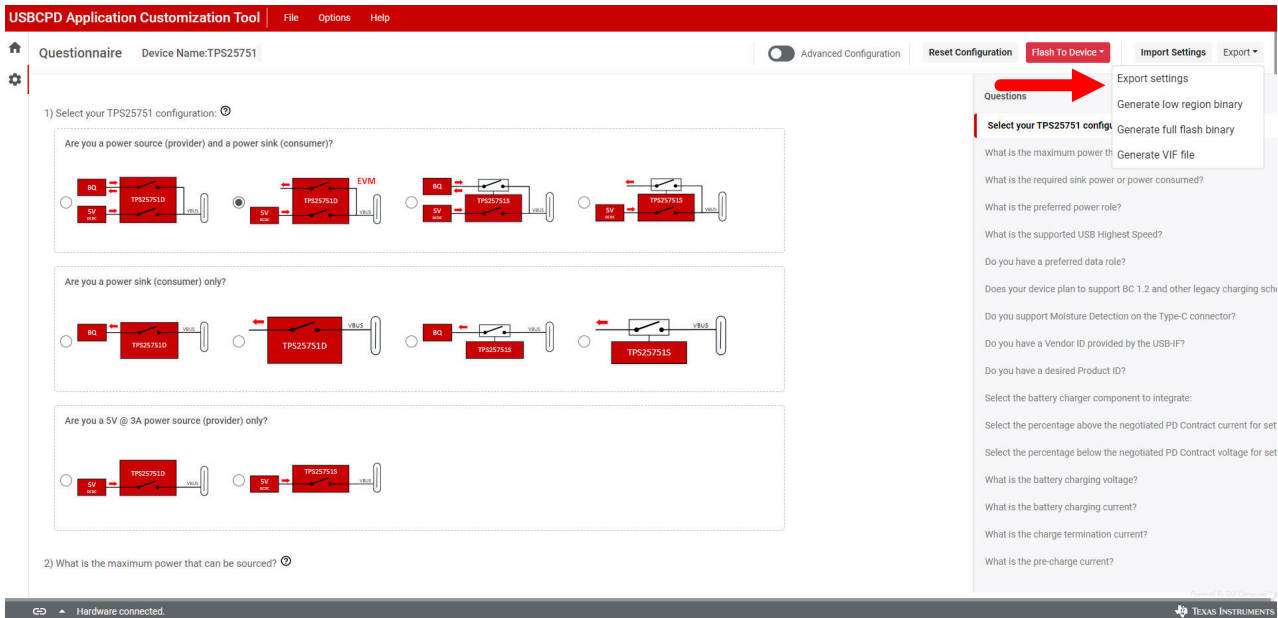


Figure 3-12. Export Settings in Application Customization Tool

To import current tool settings including the current configuration of the device as indicated by the form, click the *Import settings* button on the top-right side of the tool. Select from the directory where the JSON setting file is and click the *Import File* button. The settings are restored in the Application Customization Tool.

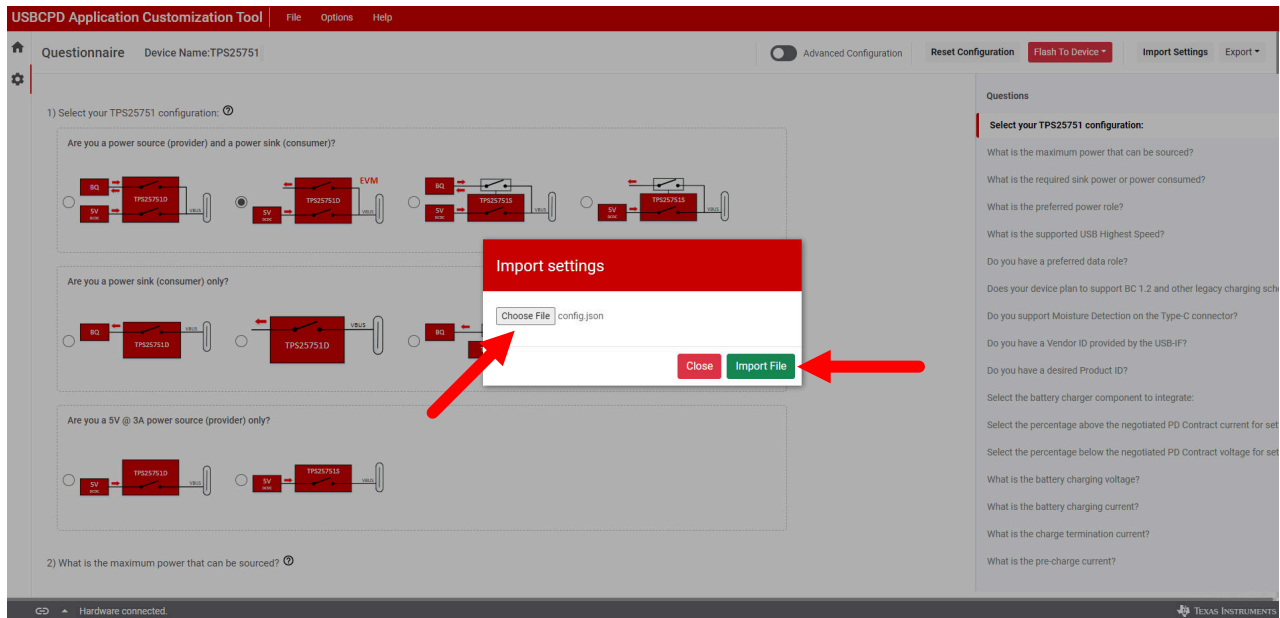
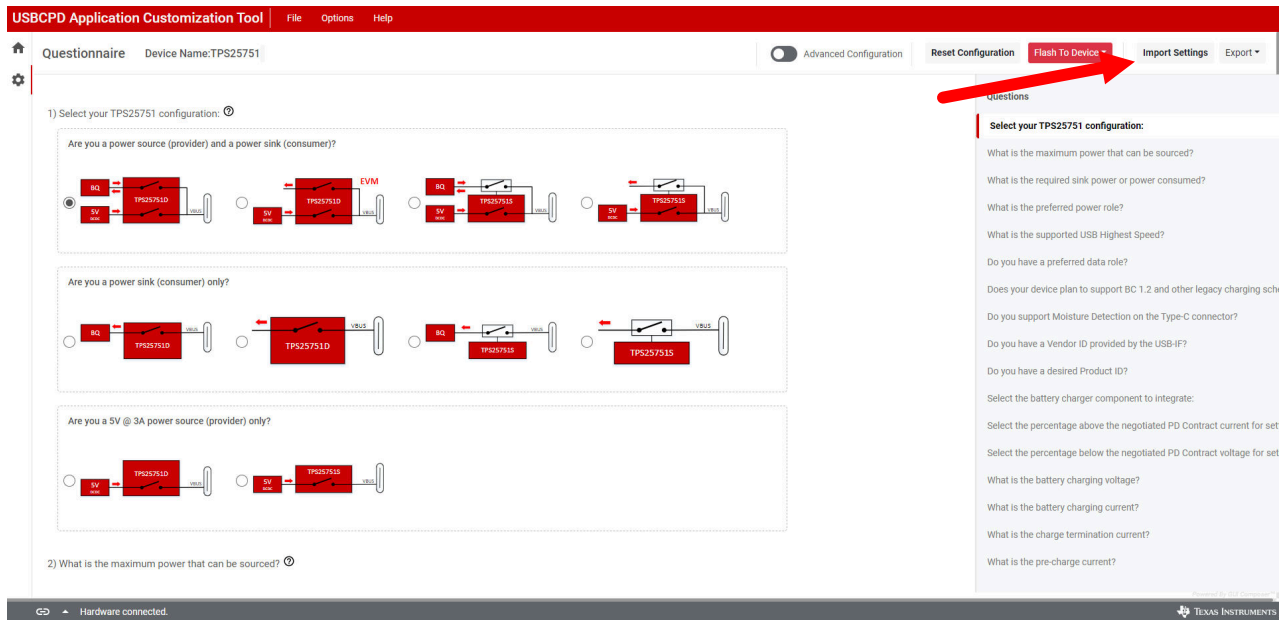


Figure 3-13. Import Settings in Application Customization Tool

Table 3-4. Export Options

Option under <i>Export</i> Header	Output Format	Output Extension	Description
Export settings	JSON	.json	Settings in this format can be loaded into the GUI.
Generate low region binary	binary	.bin	This format is used for booting the TPS26750 from an External Controller (EC). For more details, refer to TPS26750 Technical Reference Manual , PBMx section.
Generate low region binary	C source file	.c	This format is used for booting the TPS26750 from an External Controller (EC). For more details, refer to TPS26750 Technical Reference Manual , PBMx section.
Generate full flash binary	binary	.bin	This format is written to an EEPROM on the TPS26750EVM using the GUI. The TPS26750 reads from this EEPROM for configuration at boot.
Generate full flash binary	C source file	.c	This format is used to write the firmware to an EEPROM using custom code.
Generate VIF file	XML	.xml	Information on this file can be found in the pdf included in the USB Vendor Info File Generator .

3.4.6.3 Generating the Binary

To generate a binary of the current tool settings including the current configuration of the device as indicated by the form, click on the *Export* drop-down button on the top-right side of the tool and click on *Generate low region binary* or *Generate full flash binary*.

Note

Low Region Binary includes the firmware base image and AppConfig, this is used for EC patch loading. Full Flash Binary includes the Low Region and High Region, this is used for EEPROM configuration loading. For more information, refer to the Technical Reference Manual.

Users have the option to generate a .bin or .C file. Select a file format, enter the file name and click the *Download* button to download the binary file.

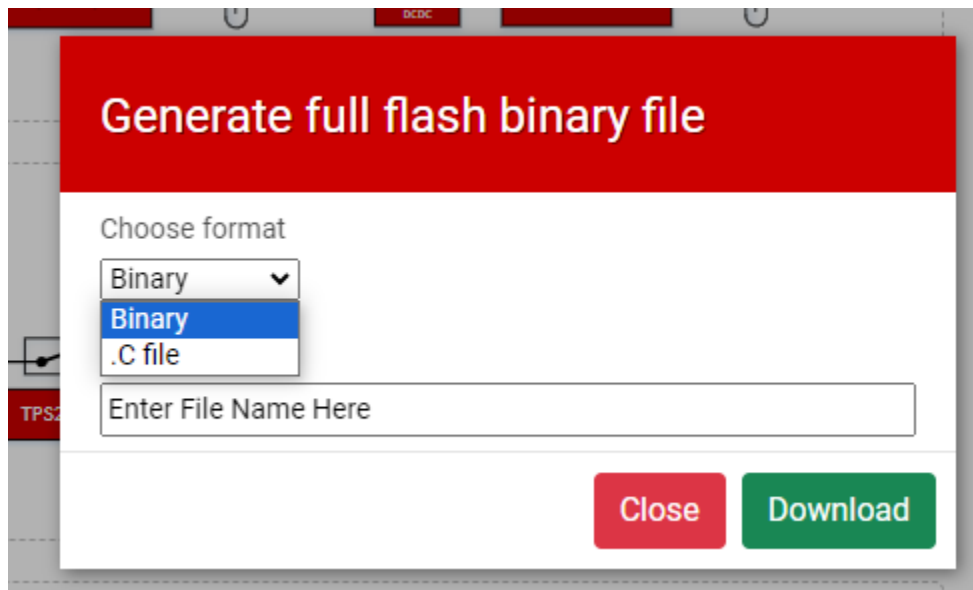
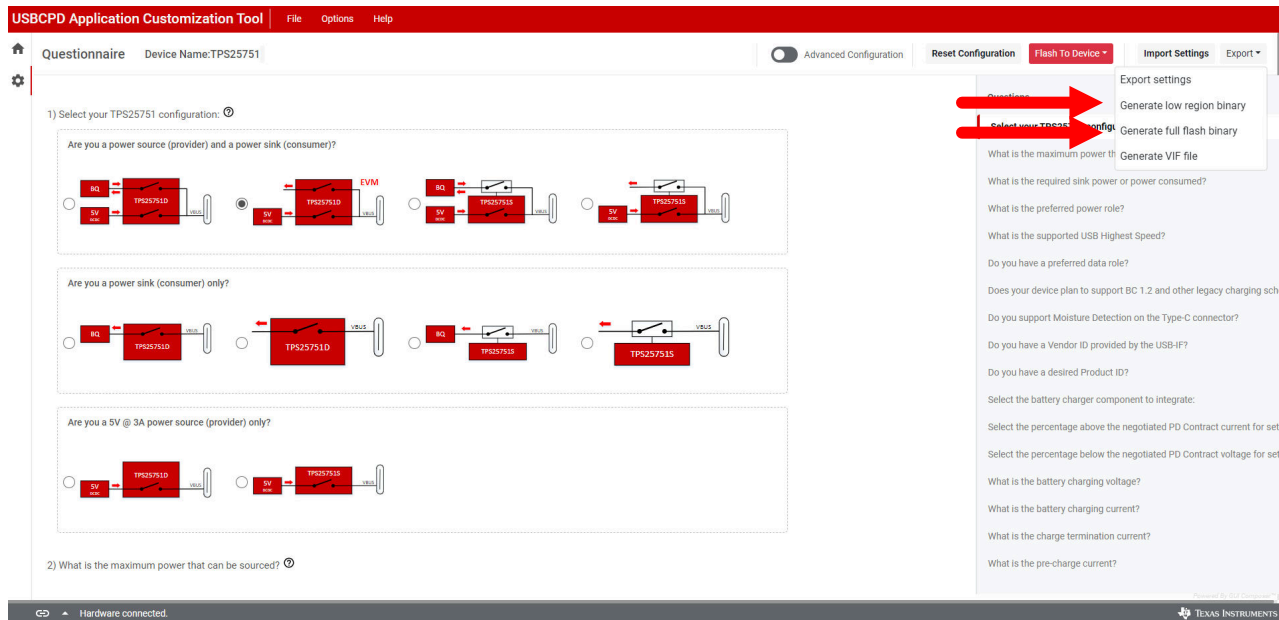


Figure 3-14. Generating Binary Configuration Using the Application Customization Tool

3.4.6.4 Generating the VIF File

To generate a VIF file of the current tool settings including the current configuration of the device as indicated by the form, click on the *Export* drop-down button on the top-right side of the tool and click on *Generate VIF file*. This automatically generates a VIF file to the default save directory on the user's computer. The VIF file is required for Compliance Testing specified by the *USB Power-Delivery Certification Process*. For more information on compliance testing, refer to [USB Power Delivery - Compliance Tests Application Note](#).

Note

The generated VIF file is to be used as the starting point only, additional changes/modifications are required to match the user's PD configuration and the application design. TI recommends using the [VIF Generator Tool](#) from the [USB-IF](#) to create or modify VIF files.

4 Application Specific Use Cases

This section explains in more detail how to set up the following application specific use cases:

1. Battery charging application with the BQ25756
2. Liquid Detection and Corrosion Mitigation.

4.1 Liquid Detection and Corrosion Mitigation Overview

The TPS26750 supports Liquid Detection and Corrosion Mitigation as described in section A.3.1 of the *USB Type-C® Cable and Connector Specification Revision 2.3* to protect the system from unexpected shorts (liquid, moisture, debris) on the USB Type-C port. The TPS26750 uses the SBU1 and SBU2 pins on the connector as measurement pins and toggles the known bias level between Ground (0V) and 3.3V when taking measurement samples. When the SBU lines are biased to 3.3V (pulled-high) the TPS26750 is checking for any unknown shorts to Ground (0V) pins. When the SBU lines are biased to Ground (pulled-low to 0V), the TPS26750 is checking for unknown shorts to positive voltage pins (that is, VBUS, CC, Vconn). At any point if the expected voltage reading does not meet the known bias level (thresholds are configurable through the GUI), the TPS26750 determines a short is detected.

The TPS26750EVM supports Liquid Detection and Corrosion Mitigation out-of-the box. To enable both Liquid Detection and Corrosion Mitigation, select *Yes* under *Question 8* in the Questionnaire when setting up the device configuration. Once the configuration has been flashed to the TPS26750EVM, no further steps are needed to enable this feature.

If Corrosion Mitigation is enabled, then the TPS26750 automatically disables the USB Type-C connector by removing voltage from VBUS and the CC lines (corrosion mitigation can be turned off, while leaving liquid detection on; see [Section 4.1.3.1](#)). During this time, the TPS26750 continues to sample the voltage reading from SBU line. When the voltage reading passes the *Dry* threshold, the TPS26750 resumes normal operation and applies voltage back to VBUS and the CC lines (if necessary, based on the USB-C and USB-PD state machines).

Refer to the block diagram below for the hardware implementation. Note that for the TPS26750EVM, GPIO6 is configured to GPIOx, and GPIO7 is configured to GPIOy. For individual designs with the TPS26750, GPIOx and GPIOy can be moved to other available GPIOs, hence the use of a variable naming convention.

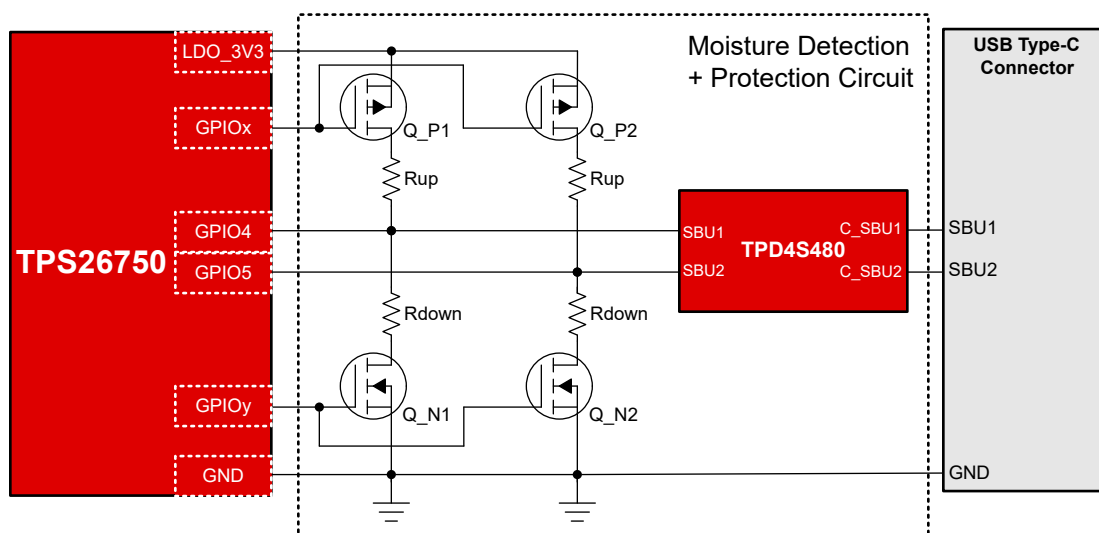


Figure 4-1. Liquid Detection/Corrosion Mitigation Setup

Note

Liquid Detection, Corrosion Mitigation and BC1.2 cannot be configured in the same system. Both applications utilizes GPIO4 and GPIO5 of TPS26750 for different functions.

4.1.1 Liquid Detection and Corrosion Mitigation Hardware Setup

Out of the box, the hardware on the TPS26750EVM is set up for Liquid Detection and Corrosion Mitigation. R27 and R28 are populated to connect J4 Type-C SBU pins to TPS26750 GPIO4 and GPIO5 for liquid detection. R77 and R78, used for BC1.2, are not populated. TPD4S480 (U12) is in between the TPS26750 and the J4 Type-C port for short protection.

Resistors R27 and R28 are located to the left of U2, located in the *EPR Implementation* box. Pads for resistors R77 and R78 are located to the left of J4, in the *EPR Implementation* box. For location details, refer to [Figure 4-2](#).

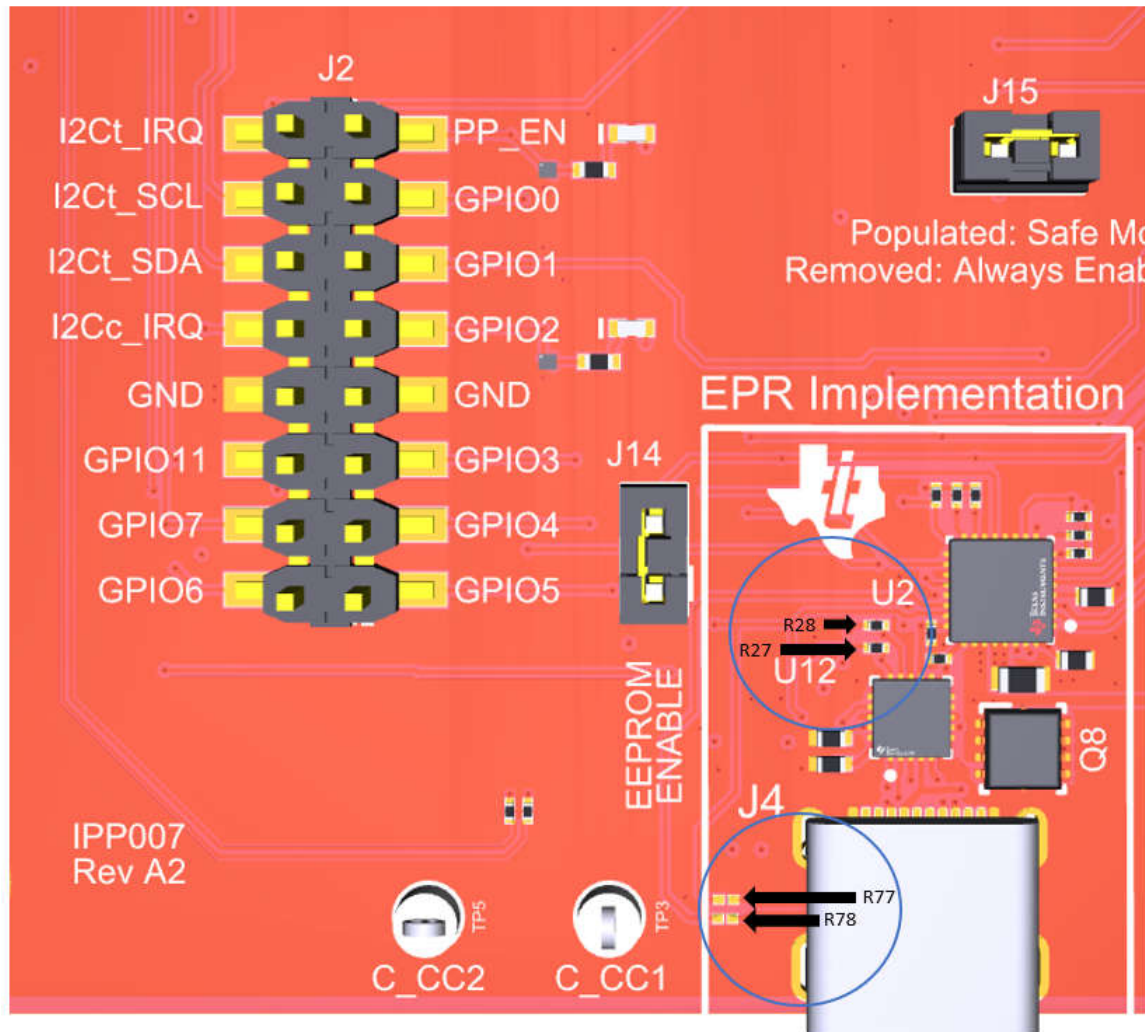


Figure 4-2. Liquid Detection Resistor Location

Note

Liquid Detection or Corrosion Mitigation and BC1.2 cannot be configured in the same system. Make sure R77, R78 and R27, R28 are not both populated at the same time.

On the TPS26750EVM, the hardware is set to use specific GPIOs for MOSFET control and Liquid Detection feature. For user applications, some GPIOs can be configured differently while some are required for all designs. For details on specific test point and the configurability for custom designs, refer to [Table 4-1](#). To setup liquid detection evaluation on the TPS26750EVM, refer to [Section 4.1.2](#).

Table 4-1. Liquid Detection Test Points

Test Point on EVM	Description	Configurability
GPIO4	Connected to SBU1 for Liquid Detection 1 (LD1)	Not configurable for custom designs
GPIO5	Connected to SBU2 for Liquid Detection 2 (LD2)	Not configurable for custom designs
SBU1	Connected to GPIO4 for Liquid Detection 1 (LD1)	Not configurable for custom designs
SBU2	Connected to GPIO5 for Liquid Detection 2 (LD2)	Not configurable for custom designs
GPIO6	Connected to PFET (QP1 and QP2) to enable pull-up, when enabled PD is detecting short to GND	Configurable for custom designs
GPIO7	Connected to NFET (QN1 and QN2) to enable pull-down, when enabled PD is detecting short to VBUS/CC	Configurable for custom designs
GPIO1	When Liquid Detect support is turned on in the questionnaire, this GPIO is the default output for the liquid_detected GPIO event. See TPS26750 Technical Reference Manual for details.	Configurable for custom designs

4.1.2 Liquid Detection and Corrosion Mitigation Software Setup

To set up Liquid Detection and Corrosion Mitigation software, follow the instructions below:

1. Open the [Application Customization Tool](#) and fill out the questionnaire. For more details on each question configuration, refer to [Section 3.4.3](#).
2. For Question 8, select Yes. Selecting Yes enables key registers and fields in Advanced Configuration. The default Liquid Detection configuration is shown below:

Table 4-2. Liquid Detection and Corrosion Mitigation Default Configuration

Register	Field	Description
Interrupt Mask for I2C1 (0x16)	Liquid Detection [60]	Enable interrupt event for <i>Liquid Detection</i> [60].
IO Config (0x5c)	GPIO_1	Set to <i>LIQUID_DETECTED</i> (157). When liquid is detected at J4 Type-C port, GPIO1 toggles high until liquid is no longer present.
IO Config (0x5c)	GPIO_4	Set to <i>Pin multiplexed to ADC</i> for detecting liquid on SBU1.
IO Config (0x5c)	GPIO_5	Set to <i>Pin multiplexed to ADC</i> for detecting liquid on SBU2.
IO Config (0x5c)	GPIO_6	Set to <i>LIQUID_PMOS_CONTROL</i> (155). GPIO6 is used to toggle the PFET to enable pull-up to detect short to GND.
IO Config (0x5c)	GPIO_7	Set to <i>LIQUID_NMOS_CONTROL</i> (156). GPIO7 is used to toggle the NFET to enable pull-down to detect short to VBUS/CC.
Liquid Detection Config (0x98)	Enable Corrosion Mitigation [81]	Enable feature to automatically disable J4 Type-C port if liquid is detected.
Liquid Detection Config (0x98)	Enable Liquid Detection [82]	Enable feature to detect liquid at J4 Type-C port.

3. Refer to [Section 3.4.4](#) to make additional configuration changes by enabling Advanced Configuration.
4. Refer to the [TPS26750 USB Type-C® and USB PD Controller with Integrated Power Switches Optimized for Power Applications](#) data sheet and the [TPS26750 Technical Reference Manual](#) for in-depth details of each register and their respective fields.

4.1.3 Liquid Detection Detailed Implementation

The USB CPD Application Customization Tool allows the user to configure the number of samples, timing, and hysteresis voltage range of liquid detection to fit with the system requirements. Increasing the number of samples and timing can result in more accurate readings, but can take longer for the detection cycle to be completed. Conversely, decreasing the number of samples and timing can allow the PD to be able to detect liquid faster but can produce higher levels of false detections. This section goes through every Liquid Detection related register and field on the TPS26750, example configurations with scope captures, and recommendations for optimizations to accuracy, power consumption, and systems with an external microcontroller. For more details on register mapping, refer to the [TPS26750 Technical Reference Manual](#).

Interrupt Event/Mask/Clear for I2C1 (Registers 0x14/0x16/0x18)

The interrupt event, interrupt mask, and interrupt clear register is intended for systems with an external microcontroller acting as the I2C controller to the TPS26750 acting as the I2C target. The interrupt mask is initialized and configured through the USBPCPD Application Customization Tool. The Liquid Detection interrupt event [60] asserts when the PD controller detects an unknown short through the GPIO/SBU measurement pin. If this event is asserted, then the voltage reading on the GPIO or SBU line has cleared the *Dry* threshold and the PD assumes liquid is present on the USB Type-C connector. When an I2C interrupt event is asserted, the microcontroller reads the Interrupt Event (0x14) register to determine which events have triggered. After the microcontroller has read the events and performed any necessary actions, the microcontroller can clear the interrupt event by writing a '1' to the asserted event in the Interrupt Clear (0x18) register. TI highly recommends to have the interrupt masking set through the USBPCPD Application Customization Tool and included in the GUI generated configuration file (either binary or C array). The masking can be modified on the fly when PD is in operation, but this is not recommended.

GPIO Config (Register 0x5C)

The GPIO Config register allows the user to configure the GPIO pins of the TPS26750. In total, there are four required GPIOs for the liquid detection function to work properly and one optional GPIO event to indicate if liquid is detected (similar to the interrupt event). GPIO Config needs to be configured through the USBPCPD Application Customization Tool and included in the GUI generated configuration file (either binary or C array), GPIOs cannot be modified on the fly when the PD is already in operation (after the configuration is loaded at boot). These GPIOs are configured automatically when selecting *Yes* to *Question 8* in the Questionnaire, however further detail is provided below for assistance with debugging and design.

GPIO4 and GPIO5 are tied to the SBU pins of the USB Type-C connector (with the TPD4S480 in between the aforementioned GPIO pins and the SBU pins of the Type-C connector). These GPIOs are multiplexed to the ADC functionality to measure the voltage on the SBU measurement pins. Both GPIO4 and GPIO5 must have the *Multiplexing for GPIO 4/5 Pin [1:0]* field set for *Pin Multiplexed to ADC (0x1)* and the *GPIO 4/5 Analog Input Control [228/9]* needs to be set to *Pin to ADC (0x1)*. GPIO4 and GPIO5 are not configurable for custom designs. For the liquid detection feature to function, these are required to be set as the ADC pins connected to the SBU pins on the USB Type-C connector.

GPIO6 and GPIO7 are tied to the gate pins of the PMOS and NMOS FETs, respectively. GPIO6 (connected to the PMOS gate) needs to set the *GPIO Mapped Event [343:336]* as *LIQUID_PMOS_CONTROL (155)* and GPIO7 (connected to the NMOS gate) needs to set the *GPIO Mapped Event [351:344]* as *LIQUID_NMOS_CONTROL (156)*.

An optional GPIO event *LIQUID_DETECTED (157)* can be tied to any available GPIO pins. If configured, then the specific GPIO outputs high when the PD enters a Liquid Detected state and goes low when the PD exits the Liquid Detected state (similar to the interrupt event Liquid Detection). The TPS26750EVM sets GPIO1 by default to the *LIQUID_DETECTED (157)* event when selecting *Yes* to *Question 8* in the Questionnaire.

4.1.3.1 Liquid Detection Config Register (0x98)

The Liquid Detection Config register contains all the configurable settings for liquid detection including number of samples, timing between sampling, hysteresis range for entering and exiting liquid detected state, and the enable bits for Liquid Detection and Corrosion Mitigation. This section goes through the register field in more detail based on the [TPS26750 Technical Reference Manual](#).

Sleep and Delays

The Sleep Time fields allows for customizable delay between each sampling period. Higher sleep time can result in less power consumption but can take more time to enter or exit the liquid detected state depending on when the short occurred and when the sampling takes place. Likewise, shorter sleep time allows the TPS26750 to detect liquid faster, but increases power consumption.

Sleep Time in Seconds No Liquid [15:0] - The sleep timer or delay between each interval of sampling (in units of seconds) when there is no liquid or short detected on the USB Type-C connector. During this timer or delay, VBUS and CC are active and the PD is in normal operation.

Sleep Time in Seconds Liquid [31:16] - The sleep timer or delay between each interval of sampling (in units of seconds) when liquid/short is detected on the USB Type-C connector. During this timer or delay, VBUS and CC are disabled (if corrosion mitigation is enabled) and the TPS26750 is in the Liquid Detected state.

Number of Samples [39:32] - The number of samples to take for both high and low measurements. This field value needs to be in terms of 2^n samples. For example, if this field is configured to be 0x3, the TPS26750 calculates this as $2^3 = 8$ samples and takes 8 high samples (when SBU lines are pulled high) and 8 low samples (when SBU lines are pulled low) during the sampling intervals.

High and Low Threshold Measurements

After the TPS26750 has collected 2^n samples for both high and low samples, the TPS26750 computes two average values, one for the high and one for the low measurements, and compares against the set high and low thresholds. The TPS26750 allows the user to configure the high and low threshold to enter and exit the Liquid Detected state. The high measurement average is compared against the High Threshold to see if there are any shorts to ground. The low measurement average is compared against the Low Threshold to see if there any shorts to positive voltage. The high and low threshold value ranges from 0V to 3.3V for the register fields.

The Application Customization GUI already has liquid detection threshold values that have been tested with the TPS26750EVM and that are automatically set when the Liquid Detection feature is enabled. However, when setting up the high and low thresholds for custom designs, take into consideration hardware implementation (resistor value, board impedance, layout) and how this implementation aligns with the configurable thresholds. Once the custom design is complete, comparing the firmware voltage threshold against actual analog readings is important. If set incorrectly, then the TPS26750 can be stuck in an infinite cycle of falsely detecting liquid. For example, if the high threshold voltage is set to 3.0V, but the analog voltage on the SBU line (in non-liquid condition) is actually 2.7V, then this leads to the TPS26750 detecting a false Liquid Detection event.

Low Threshold ADC No Liquid [47:40] - The low voltage threshold to exit the Liquid Detected state. The TPS26750 uses this value to compare against the low samples to determine if there are shorts to positive bias voltage pins. This field needs to be less than or equal to the *Low Threshold ADC Liquid* field, otherwise the TPS26750 is not able to exit the Liquid Detected state.

High Threshold ADC No Liquid [55:48] - The high voltage threshold to exit the Liquid Detected state. The TPS26750 uses this value to compare against the high samples to determine if there are shorts to ground level pins (0V). This field needs to be greater than or equal to the *High Threshold ADC Liquid* field, otherwise the TPS26750 is not able to exit the Liquid Detected state.

Low Threshold ADC Liquid [63:56] - The low voltage threshold to enter the Liquid Detected state. The TPS26750 uses this value to compare against the low samples to determine if there are shorts to positive bias voltage pins. This field needs to be greater than or equal to the *Low Threshold ADC No Liquid* field, otherwise the TPS26750 is not able to enter the Liquid Detected state.

High Threshold ADC Liquid [71:64] - The high voltage threshold to enter the Liquid Detected state. The TPS26750 uses this value to compare against the high samples to determine if there are shorts to ground level pins (0V). This field needs to be less than or equal to the *High Threshold ADC No Liquid* field, otherwise the TPS26750 is not able to enter the Liquid Detected state.

Sample Timing

The Sample Time field allows for customizable delays before the TPS26750 takes the voltage measurement from high to low and low to high. Increased sample time allows for the voltage reading to settle and can produce more accurate measurements but takes more time for the sampling interval to complete. Likewise, low sample time allows for faster sampling intervals but can produce less accurate measurements if the voltage hasn't fully settled. The sample timing needs to be taken into consideration with the number of samples. For example, if sample time is set to 10ms with 2^3 samples (8 high and 8 low samples), the total time for each sampling interval can be calculated using the following equation:

$$(8 \text{ high samples} * 10\text{ms}) + (8 \text{ low samples} * 10\text{ms}) = 160\text{ms total sampling interval} \quad (1)$$

Sample Time in 10ms No Liquid [75:72] - The time for each pulse to settle (configurable in 10ms steps) before the TPS26750 samples when there is no liquid or short is detected on the USB Type-C connector. This value applies to both high and low pulse sample durations.

Sample Time in 10ms Liquid [79:76] - The time for each pulse to settle (configurable in 10ms steps) before the TPS26750 samples when liquid or short has been detected on the USB Type-C connector. This applies to both high and low pulse sample durations.

Additional Fields

Liquid Detection State [80] - Read only bit to inform if the TPS26750 is in a Liquid Detected state. '1' represents that liquid is present, '0' represents that no liquid is present. This bit acts the same as the GPIO event *LIQUID_DETECTED [157]* and the I2C interrupt *Liquid Detection [60]*.

Enable Corrosion Mitigation [81] - If enabled, the TPS26750 automatically handles corrosion mitigation. When liquid is detected, the TPS26750 disconnects and disables the port by removing VBUS and pulling down the CC pins. If this bit is disabled, the TPS26750 continues normal operation if liquid is detected on the USB Type-C connector. An external microcontroller can enable or disable this feature on the fly when the TPS26750 is operating. Any modification to this field only takes effect the next time the appropriate policy is invoked in the Type-C policy engine.

Enable Liquid Detection [82] - The main control bit to enable the Liquid Detection feature. An external microcontroller can enable or disable this feature on the fly when the TPS26750 is operating. Any modification to this field only takes effect the next time the appropriate policy is invoked in the Type-C policy engine.

4.2 Use With the BQ25756EVM

To use the TPS26750EVM and BQ25756EVM, the following items are needed:

1. TPS26750EVM
2. Ribbon cable (included with TPS26750EVM)
3. BQ25756 interposer board (included with TPS26750EVM)
4. Application customization tool
5. BQ25756EVM
6. BQ25756EVM [user's guide](#) and [data sheet](#)
7. [BQStudio with EV2400](#) [optional]
8. DC power supply or battery simulator

4.2.1 Hardware Setup with BQ25756EVM

To set up the hardware, follow the instructions below:

1. Connect the J1 and J7 mating connectors of the TPS26750EVM to the reciprocal connectors on the provided BQ25756 interposer board. The silk-screen *BQ25756* on the BQ25756 Interposer Board must be oriented on the same plane as the top of the TPS26750EVM. See [Figure 1-2](#)
2. Unscrew the screws on headers J1 and J3 of the BQ25756EVM enough for the BQ25756 interposer board prongs to fit into the aforementioned headers.
3. Insert the other side of the BQ25756 interposer board to headers J1 and J3 on the BQ25756EVM. Make sure the prongs are inserted all the way into the headers.

Note

Repeated insertion and removal of TPS26750EVM mating connectors from the BQ25756 interposer board (depending upon how the boards are grasped and pulled) can cause the prongs on the side of the interposer board connected to the BQ25756EVM to come out of the J1 and J3 headers enough to cause an insufficient electrical connection between the BQ25756EVM and the TPS26750EVM. **Please recheck interposer board connections when detaching and re-attaching BQ25756EVM from the TPS26750EVM.**

4. Tighten the screws on headers J1 and J3 of the BQ25756EVM.
5. Attach the ribbon cable to header J9 on the TPS26750EVM as shown in [Figure 1-2](#) . Attach the other end of the ribbon cable to header J8 of the BQ25756EVM.
6. Connect the other end of the ribbon cable to J8 header of the BQ25756(E)EVM.
7. To power the board using a simulated battery, connect the simulated battery to header J3 in the orientation shown on the silkscreen (+ and - symbols next to J3).
8. For setting the proper jumper for battery charging application, refer to [BQ25756 Evaluation Module User's Guide](#). Incorrect jumper settings or insufficient input power can result in a faulty evaluation.

4.2.2 Software Setup with the BQ25756EVM

To setup the software configuration, follow the instructions below.

1. Open the [Application Customization Tool](#) and select Configuration Index 1 or 3 for Question 1 (A figure with a BQ block included).
2. Fill out the questionnaire from Q2 to Q10. For more details on each question configuration, refer to [Section 3.4.3](#). All the questions must be filled out to flash or export.
3. Questions 11 through 18 pertain to Battery Charger (BQ) settings.
4. For Question 11, select BQ25756.
5. For Question 12, select the INDPM configuration for the BQ25756.
 - a. For example, if the user selects *5% - INDPM is set to 5% above the negotiated PD Contract Current* and TPS26750 negotiates a PD contract at 3A, then the INDPM is set to 3.15A.
 - b. This questionnaire configures register 0x06 - IAC_DPM of the BQ25756.
6. For Question 13, select the VINDPM configuration for the BQ25756.
 - a. For example, if the user selects *5% - VINDPM is set to 5% below the negotiated PD Contract Voltage* and TPS26750 negotiates a PD contract at 5V, the VINDPM is set to 4.75V.
 - b. This questionnaire configures register 0x08 - VAC_DPM of the BQ25756.
7. For question 14, enter the FB Voltage Regulation Limit in units of Voltage (1.504V through 1.566V, 2mV/bit).
 - a. This questionnaire configures register 0x00 - VFB_REG of the BQ25756.
8. For question 15, enter the Charge Current Limit in units of Ampere (0.4A through 20A, 50mA/bit)
 - a. This questionnaire configures register 0x02 - ICHG_REG of the BQ25756.
9. For question 16, enter the Charge Termination Current Limit in units of Ampere (0.25A through 10A, 50mA/bit).
 - a. This questionnaire configures register 0x12 - ITERM of the BQ25756.
10. For question 17, enter the Precharge Current Limit in units of Ampere (0.25A through 10A, 50mA/bit).
 - a. This questionnaire configures register 0x10 - IPRECHG of the BQ25756.
11. For question 18, enter the Dead Battery Clear Threshold in units of Voltage (2.88V through 19.2V, 64mV/bit).
 - a. This questionnaire configures register 0x27 - Global System Configuration of the TPS26750 and sets the *Enable Dead Battery Clear [111]* field to '1'.
 - b. Upon boot-up from dead battery mode (The TPS26750 receives power from VBUS first instead of VIN_3V3), the TPS26750 reads register 0x33 - VBAT_ADC of the BQ25756.
 - c. If VBAT voltage is greater or higher than set threshold in Q18, then the TPS26750 automatically clears the dead battery flag, otherwise the dead battery flag remains. Refer to the TPS26750 Technical Reference Manual for details.
12. For flashing the configuration to the TPS26750EVM or exporting the binary, refer to [Section 3.4.6](#).

5 Hardware Design Files

5.1 Schematics

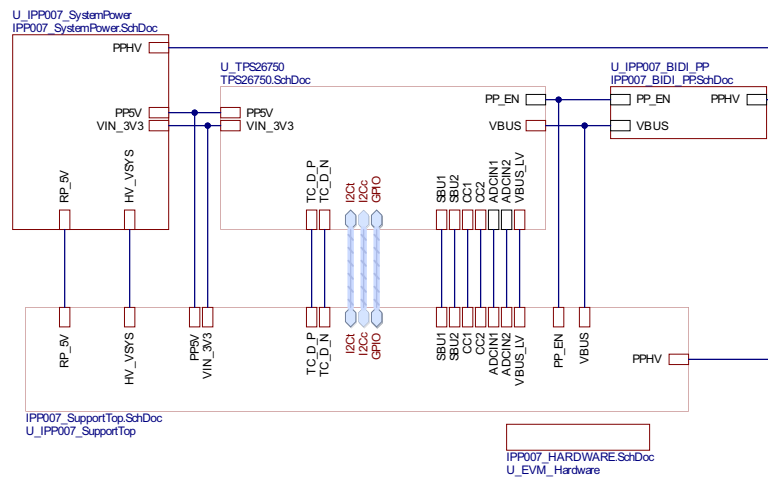


Figure 5-1. Block Diagram (Top Level)

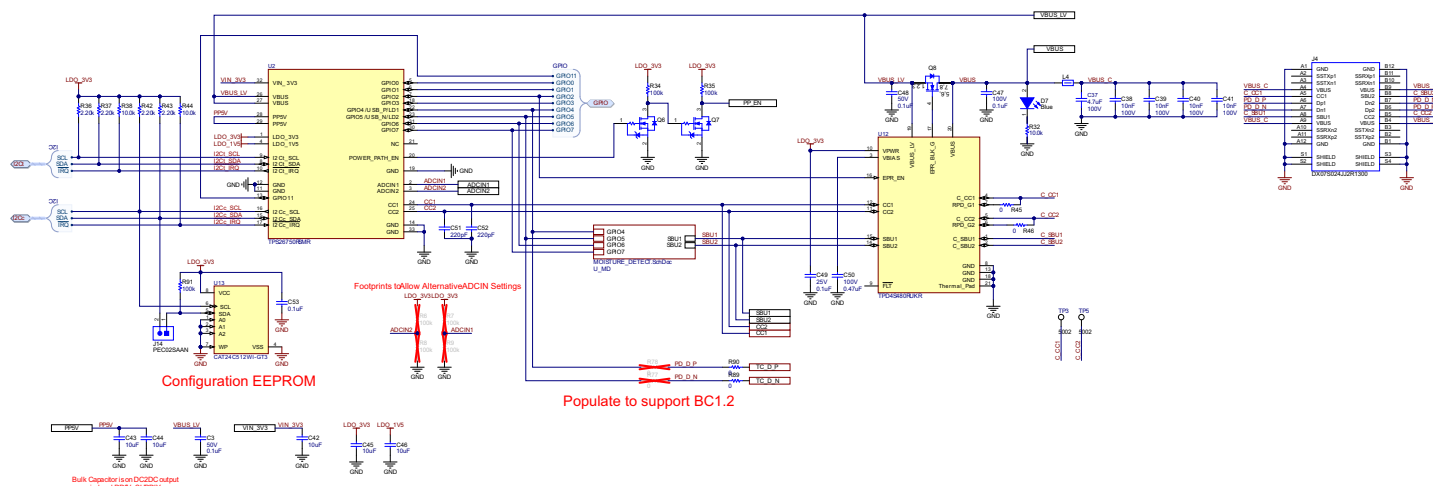


Figure 5-2. TPS26750

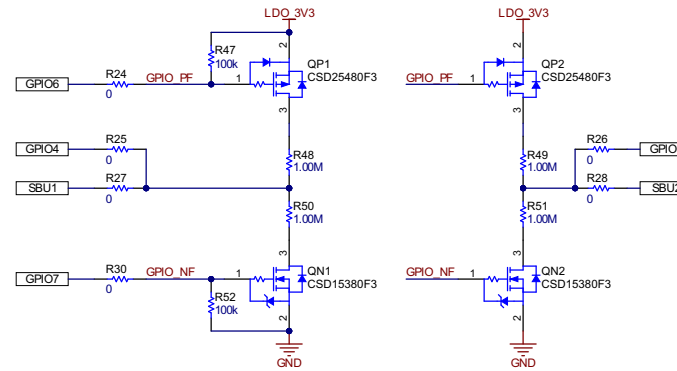


Figure 5-3. Liquid Detection

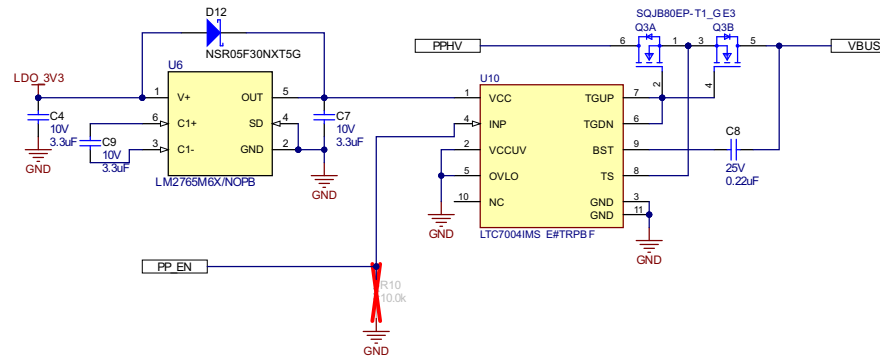


Figure 5-4. Bidirectional Power Path

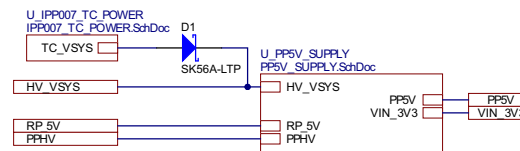


Figure 5-5. System Power

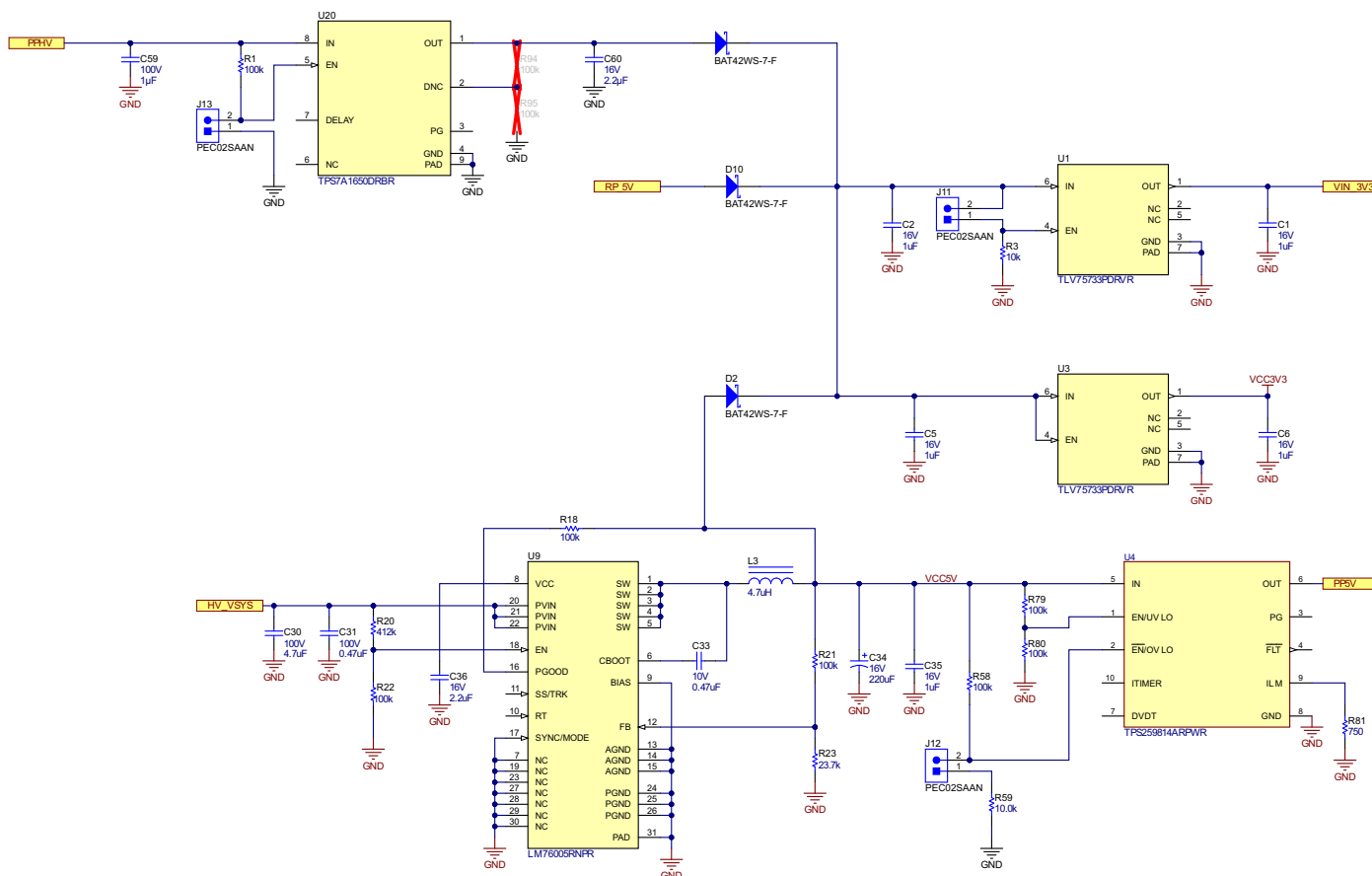


Figure 5-6. System Power Supplies

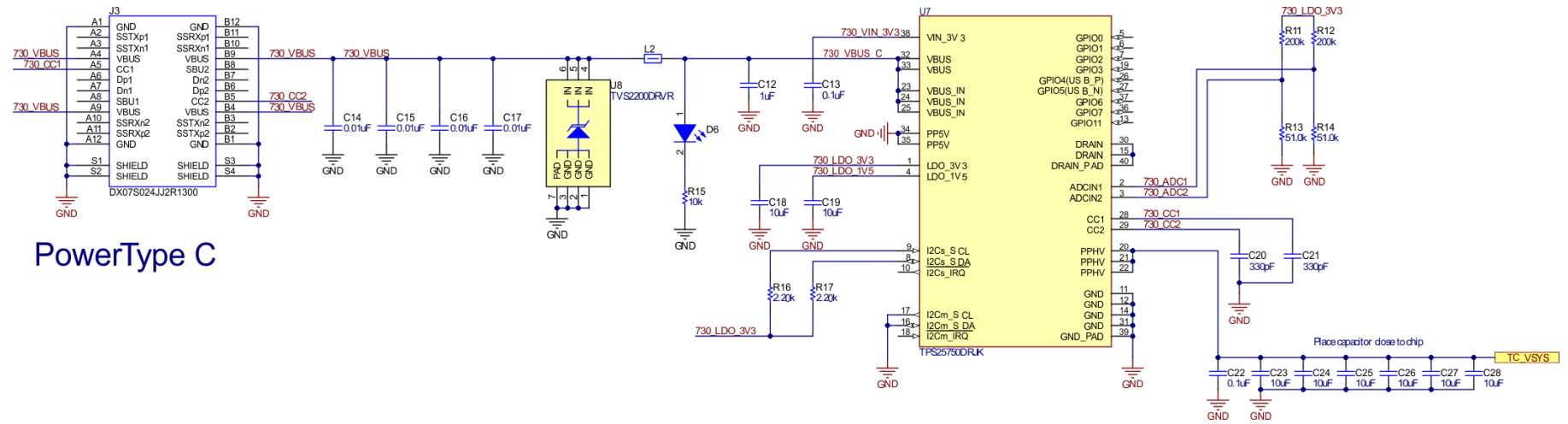


Figure 5-7. Type-C Power Input

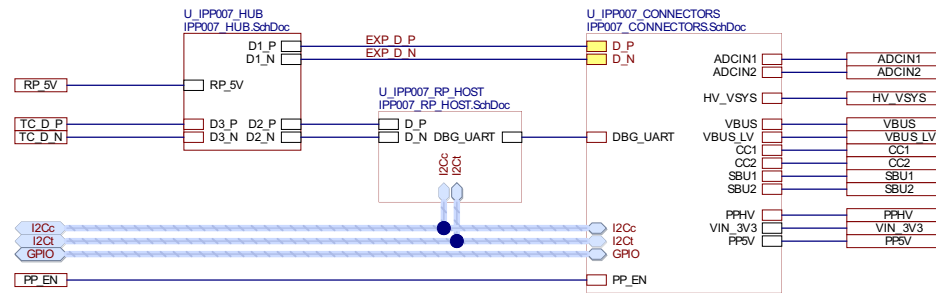


Figure 5-8. Support Circuits Top Level

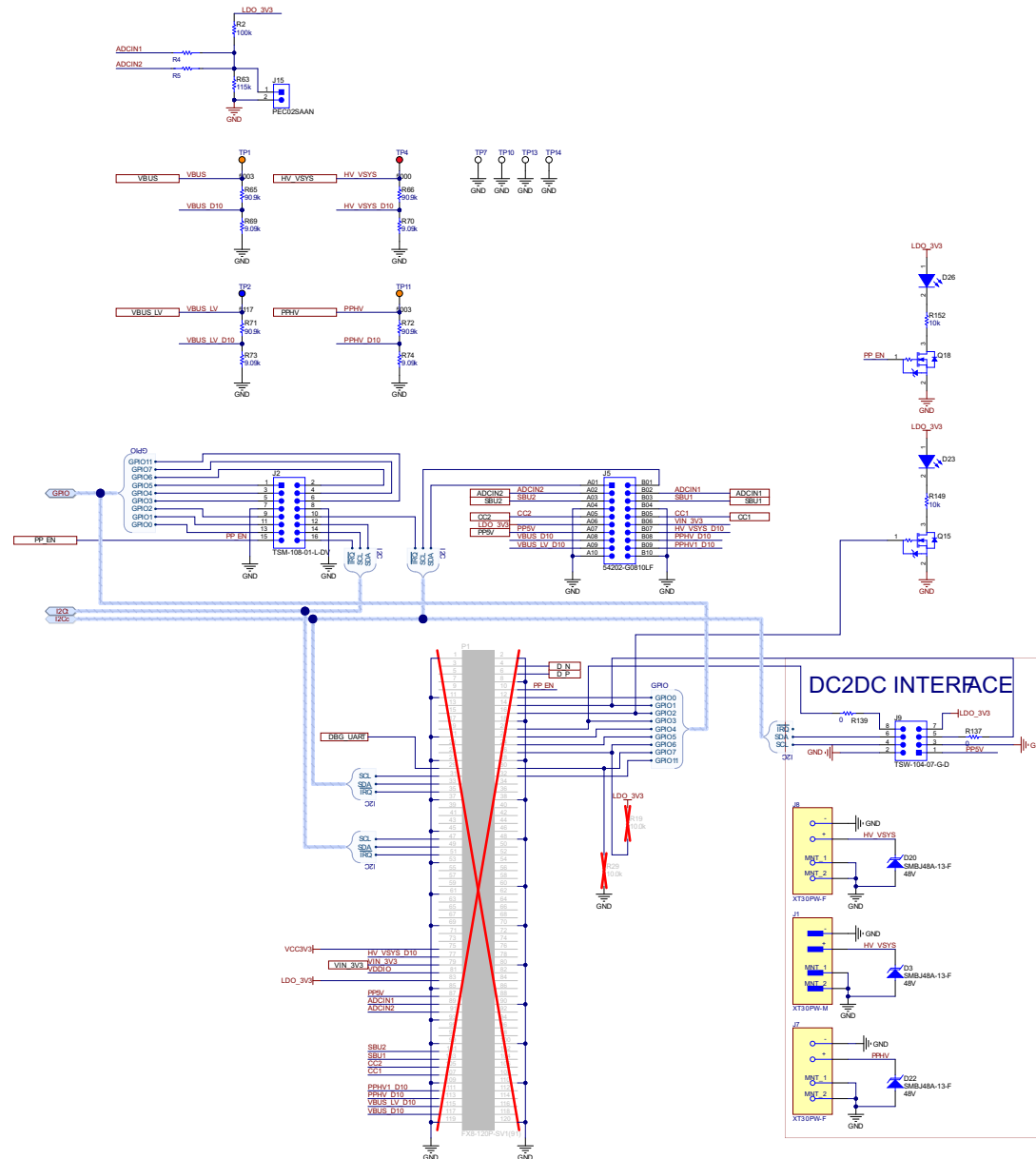


Figure 5-9. Connectors

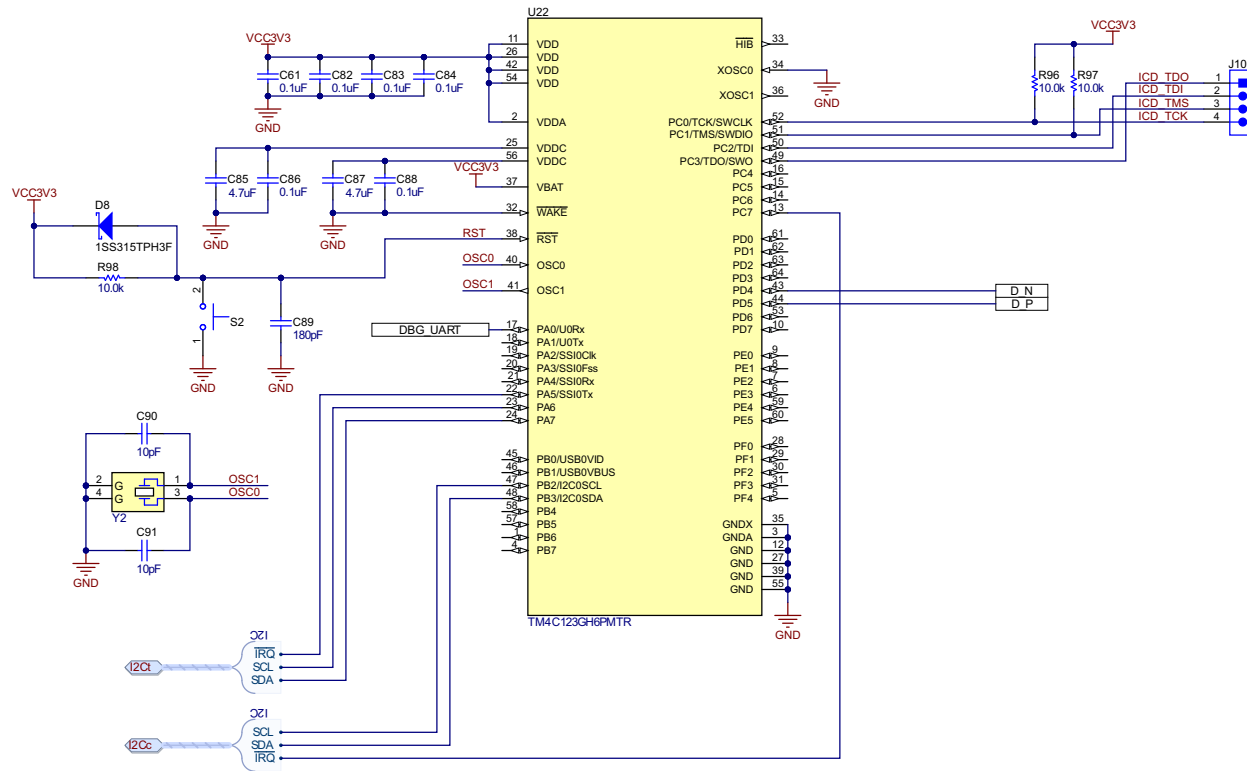


Figure 5-10. TIVA MCU

5.2 PCB Layouts

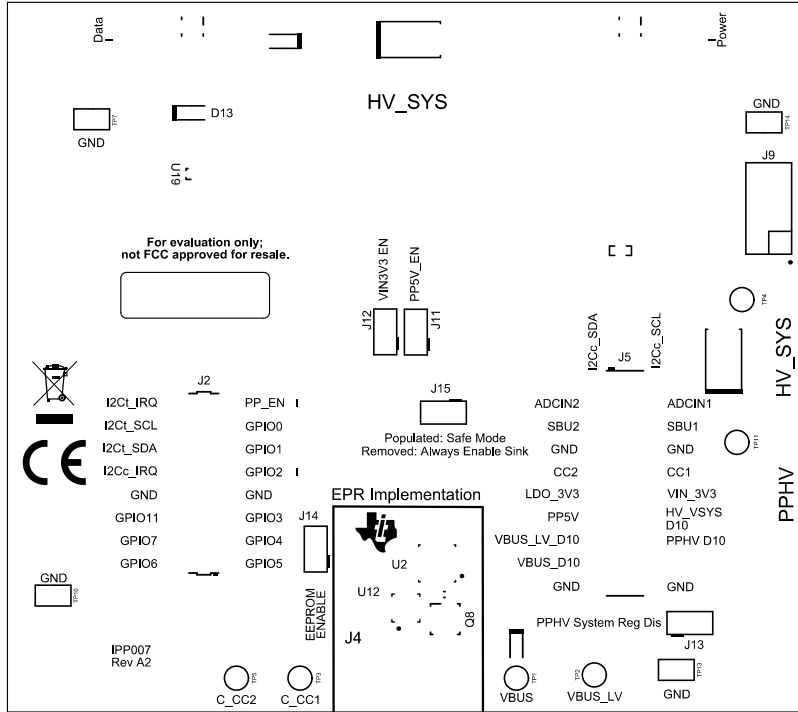


Figure 5-12. TPS26750EVM Top Layer (Composite View)

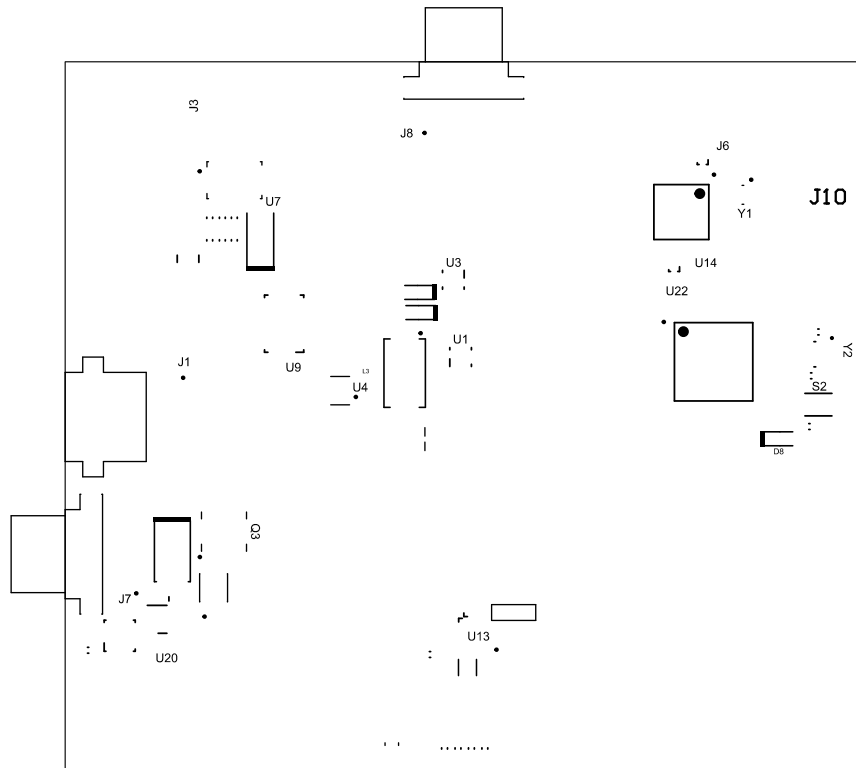


Figure 5-13. TPS26750EVM Bottom Layer (Composite View)

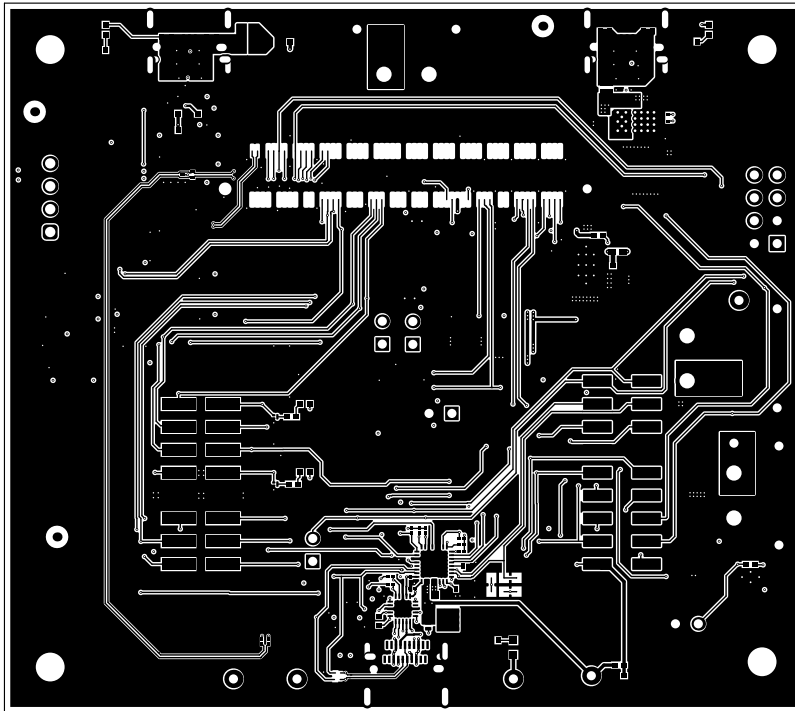


Figure 5-14. TPS26750EVM Top Layer

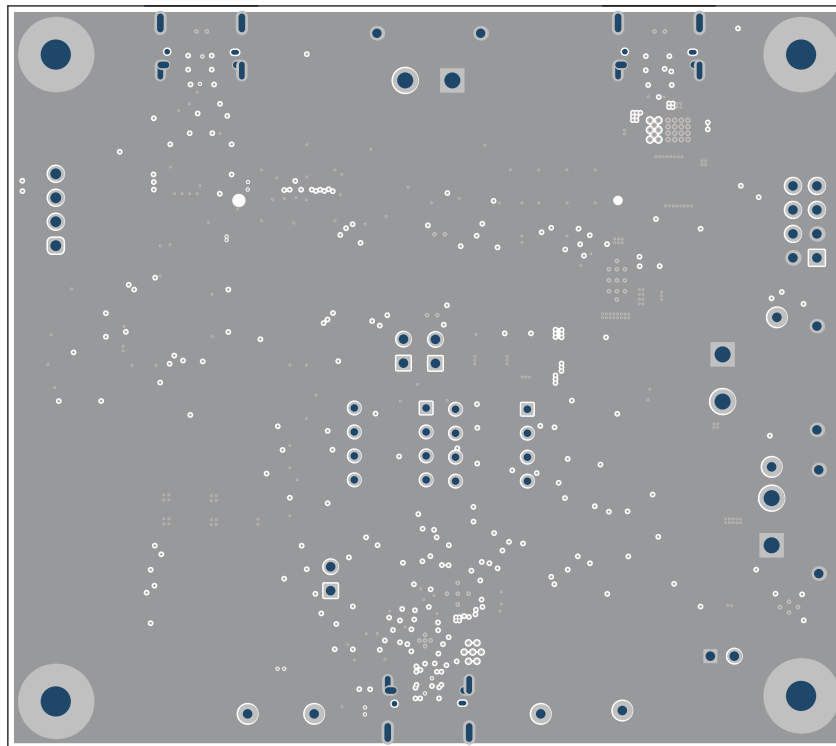


Figure 5-15. TPS26750EVM GND Layer

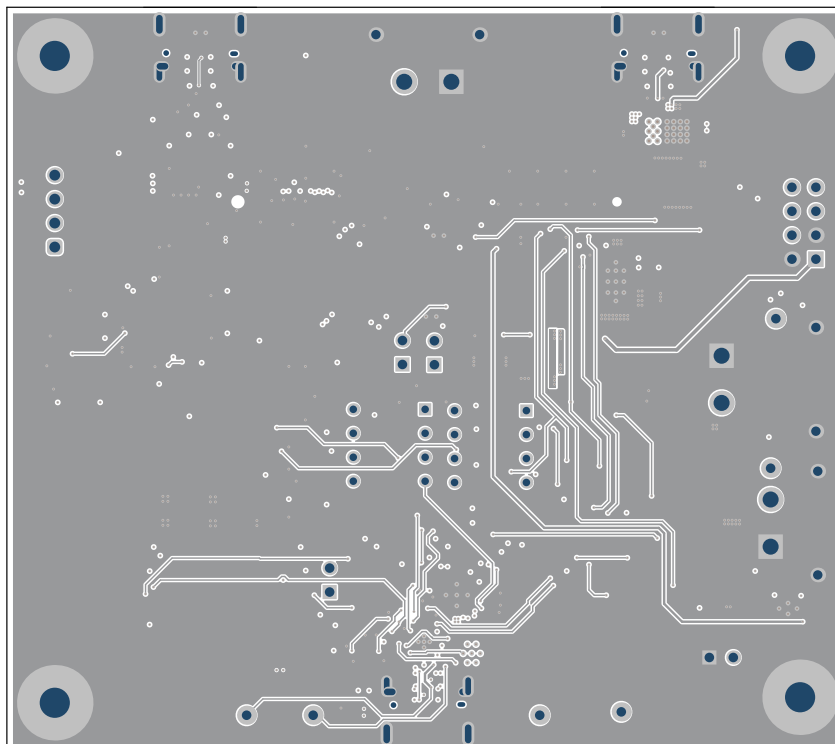


Figure 5-16. TPS26750EVM Internal Layer 1

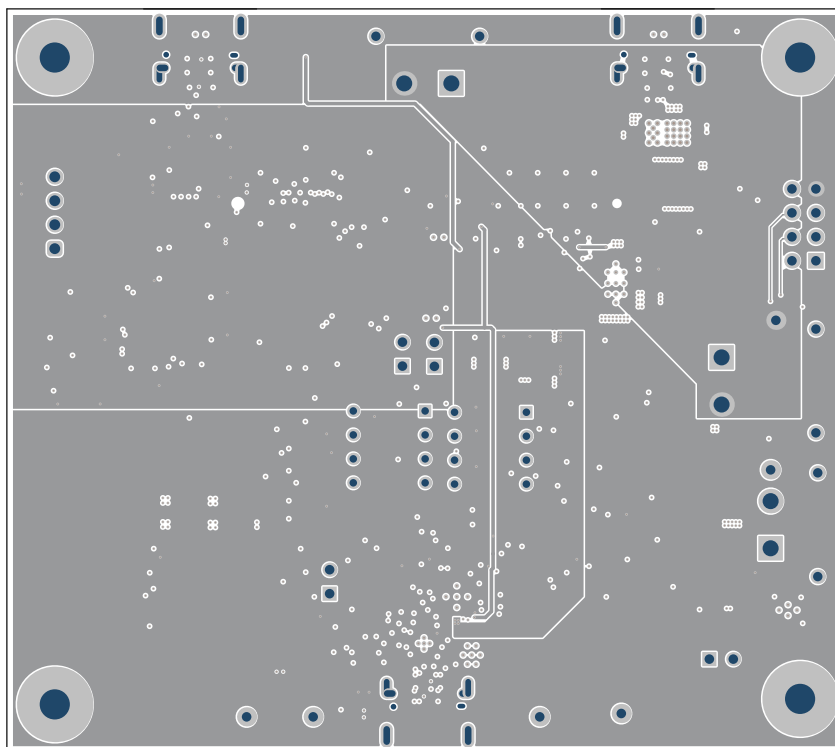


Figure 5-17. TPS26750EVM Internal Layer 2

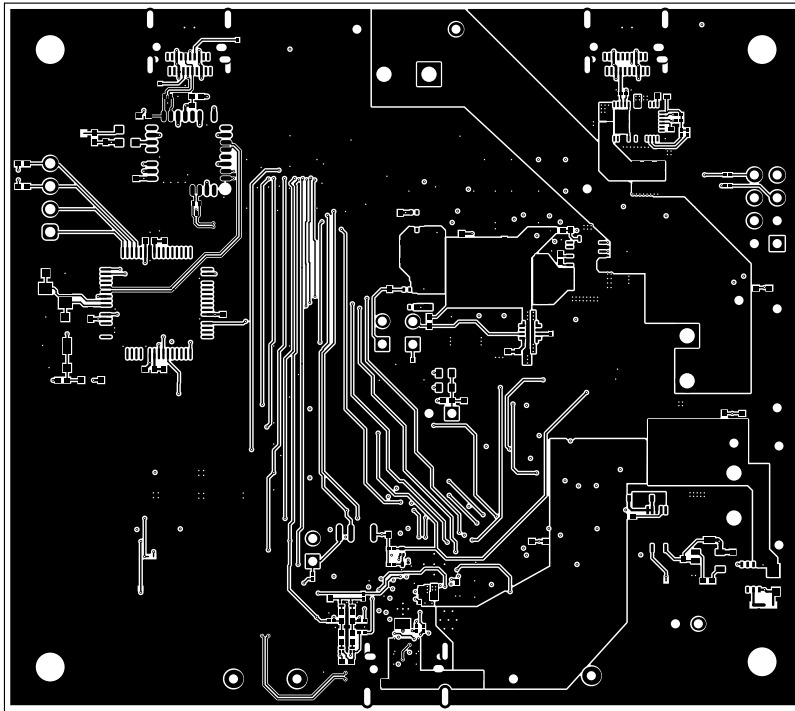


Figure 5-18. TPS26750EVM Bottom Layer

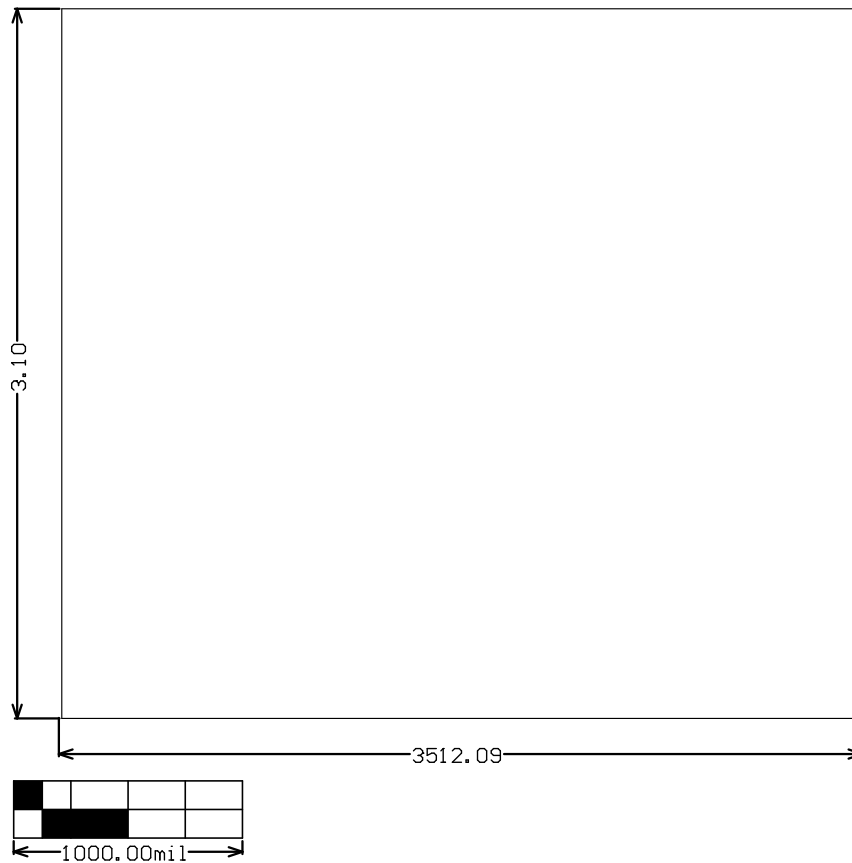


Figure 5-19. TPS26750EVM Board Dimensions

5.3 Bill of Materials (BOM)

Table 5-1. Bill of Materials

Designator	Quantity	Value	Description	Part Number	Manufacturer	Package Reference
!PCB1	1		Printed Circuit Board	IPP007	Any	
C1, C2, C5, C6, C35	5	1uF	CAP, CERM, 1uF, 16V, +/- 10%, X6S, 0402	C1005X6S1C105K050BC	TDK	0402
C3, C48	2	0.1uF	CAP, CERM, 0.1uF, 50V, +/- 10%, X5R, 0402	C1005X5R1H104K050BB	TDK	0402
C4, C7, C9	3	3.3uF	CAP, CERM, 3.3uF, 10V, +/- 10%, X5R, 0402	C1005X5R1A335K050BC	TDK	0402
C8	1	0.22uF	CAP, CERM, 0.22uF, 25V, +/- 20%, X5R, 0402	C1005X5R1E224M050BC	TDK	0402
C12	1	1uF	CAP, CERM, 1uF, 35V, +/- 10%, X5R, 0402	GRM155R6YA105KE11D	MuRata	0402
C13, C22	2	0.1uF	CAP, CERM, 0.1uF, 35V, +/- 10%, X5R, 0402	GMK105BJ104KV-F	Taiyo Yuden	0402
C14, C15, C16, C17, C62, C63, C64, C65	8	0.01uF	CAP, CERM, 0.01uF, 50V, +/- 5%, X7R, 0402	C0402C103J5RACTU	Kemet	0402
C18, C19, C42, C45, C46	5	10uF	CAP, CERM, 10uF, 10V, +/- 20%, X5R, 0402	CL05A106MP5NUNC	Samsung Electro-Mechanics	0402
C20, C21	2	330pF	CAP, CERM, 330pF, 50V, +/- 10%, X7R, AEC-Q200 Grade 1, 0201	CGA1A2X7R1H331K030BA	TDK	0201
C23, C24, C25, C26, C27, C28	6	10uF	CAP, CERM, 10uF, 35V, +/- 20%, X5R, 0603	GRM188R6YA106MA73D	Murata	0603
C30	1	4.7uF	CAP, CERM, 4.7uF, 100V, +/- 10%, X7S, 1210	C3225X7S2A475K200AE	TDK	1210
C31	1	0.47uF	CAP, CERM, 0.47uF, 100V, +/- 10%, X7S, 0805	C2012X7S2A474K125AB	TDK	0805
C33	1	0.47uF	CAP, CERM, 0.47uF, 10V, +/- 10%, X5R, 0402	GRM155R61A474KE15D	MuRata	0402
C34	1	220uF	CAP, TA, 220uF, 16V, +/- 20%, 0.1 ohm, SMD	TPSE227M016R0100	AVX	7343-43
C36	1	2.2uF	CAP, CERM, 2.2uF, 16V, +/- 10%, X6S, 0402	C1005X6S1C225K050BC	TDK	0402
C37	1	4.7µF	4.7µF ±10% 100V Ceramic Capacitor X5R 0805 (2012 Metric)	C2012X5R2A475K125AC	TDK	0805
C38, C39, C40, C41	4	0.01uF	CAP, CERM, 0.01uF, 100V, +/- 10%, X7R, 0603	C0603X103K1RACTU	Kemet	0603
C43, C44	2	10uF	CAP, CERM, 10uF, 25V, +/- 20%, X5R, 0603	GRM188R61E106MA73D	MuRata	0603
C47	1	0.1uF	CAP, CERM, 0.1uF, 100V, +/- 10%, X5R, 0402	GRM155R62A104KE14D	MuRata	0402
C49	1	0.1uF	CAP, CERM, 0.1uF, 25V, +/- 10%, X5R, 0201	GRM033R61E104KE14J	MuRata	0201
C50	1	0.47uF	CAP, CERM, 0.47uF, 100V, +/- 10%, X7R, 1206	C3216X7R2A474K160AA	TDK	1206
C51, C52	2	220pF	CAP, CERM, 220pF, 50V, +/- 10%, X7R, AEC-Q200 Grade 1, 0201	CGA1A2X7R1H221K030BA	TDK	0201
C53, C61, C82, C83, C84, C86, C88	7	0.1uF	CAP, CERM, 0.1uF, 50V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402	CGA2B3X7R1H104K050BB	TDK	0402
C54, C55, C56, C57	4	0.1uF	CAP, CERM, 0.1uF, 6.3V, +/- 10%, X5R, 0402	GRM155R60J104KA01D	MuRata	0402
C58	1	10uF	CAP, CERM, 10µF, 10V,+/- 20%, X5R, 0402	0402ZD106MAT2A	AVX	0402

Table 5-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer	Package Reference
C59	1	1uF	CAP, CERM, 1μF, 100V,+/- 10%, X7S, 0805	C2012X7S2A105K125AE	TDK	0805
C60	1	2.2uF	CAP, CERM, 2.2uF, 16V, +/- 10%, X7R, 0603	GRM188Z71C225KE43	MuRata	0603
C66	1	1uF	CAP, CERM, 1μF, 10V,+/- 20%, X5R, 0402	CC0402MRX5R6BB105	Yageo America	0402
C85, C87	2	4.7uF	CAP, CERM, 4.7uF, 10V, +/- 20%, X5R, 0402	C1005X5R1A475M050BC	TDK	0402
C89	1	180pF	CAP, CERM, 180pF, 50V, +/- 5%, C0G/NP0, 0603	06035A181JAT2A	AVX	0603
C90, C91	2	10pF	CAP, CERM, 10pF, 50V, +/- 5%, C0G/NP0, 0603	06035A100JAT2A	AVX	0603
D1	1	60V	Diode, Schottky, 60V, 5A, SMA	SK56A-LTP	Micro Commercial Components	SMA
D2, D5, D10	3	30V	Diode, Schottky, 30V, 0.2A, SOD-323	BAT42WS-7-F	Diodes Inc.	SOD-323
D3, D20, D22	3	48V	Diode, TVS, Uni, 48V, 77.4 Vc, SMB	SMBJ48A-13-F	Diodes Inc.	SMB
D4, D6, D23, D26	4	White	LED, White, SMD	LW QH8G-Q200-3K5L-1	OSRAM	0402, White
D7	1	Blue	LED, Blue, SMD	150060BS75000	Würth Elektronik	LED_0603
D8	1	5V	Diode, Schottky, 5V, 0.03A, SOD-323	1SS315TPH3F	Toshiba	SOD-323
D12	1	30V	Diode, Schottky, 30V, 0.5A, 0402 Diode	NSR05F30NXT5G	ON Semiconductor	0402 Diode
D13	1	10V	Diode, Schottky, 10V, 3A, SOD-323F	PMEG1030EJ,115	Nexperia	SOD-323F
FID1, FID2, FID3	3		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	NY PMS 440 0025 PH	B&F Fastener Supply	Screw
H5, H6, H7, H8	4		Standoff, Hex, 0.5	1902C	Keystone	Standoff
J1	1		Socket, DC supply, XT30, male, PIN: 2, on PCBs, THT, yellow, 15A, 500V	XT30PW-M	Amass	CONN_PLUG2
J2	1		Header, 2.54mm, 8x2, Gold, SMT	TSM-108-01-L-DV	Samtec	Header, 2.54mm, 8x2, SMT
J3, J4, J6	3		Receptacle, USB 3.1 Type C, R/A, Gold, SMT	DX07S024JJ2R1300	JAE Electronics	Receptacle, USB 3.1 Type C, R/A, SMT
J5	1		Header, 2.54mm, 10x2, Tin, SMT	54202-G0810LF	FCI	Header, 2.54mm, 10x2, SMT
J7, J8	2		Socket, DC supply, XT30, female, PIN: 2, on PCBs, THT, yellow, 15A	XT30PW-F	Amass	CONN_SOCKET_DC2
J9	1		Header, 100mil, 4x2, Gold, TH	TSW-104-07-G-D	Samtec	4x2 Header
J10	1		Header, 2.54mm, 4x1, Gold, TH	61300411121	Würth Elektronik	Header, 2.54mm, 4x1, TH
J11, J12, J13, J14, J15	5		Header, 100mil, 2x1, Tin, TH	PEC02SAAN	Sullins Connector Solutions	Header, 2 PIN, 100mil, Tin
L2, L4, L5	3	22 ohm	Ferrite Bead, 22 ohm at 100MHz, 6A, 0805	742792021	Würth Elektronik	0805

Table 5-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer	Package Reference
L3	1	4.7uH	Inductor, Shielded, Composite, 4.7uH, 10.5A, 0.0144 ohm, AEC-Q200 Grade 1, SMD	XAL6060-472MEC	Coilcraft	IND_6.4x6.1x6.6
LBL1	1		Thermal Transfer Printable Labels, 0.650	THT-14-423-10	Brady	PCB Label 0.650 x 0.200 inch
Q3	1		Mosfet Array 80V 30A (Tc) 48W Surface Mount PowerPAK® SO-8 Dual	SQJB80EP-T1_GE3	Vishay	SO-8L-DUAL
Q6, Q7	2	30V	MOSFET, N-CH, 30V, 3A, YJJ0003A (PICOSTAR-3)	CSD17484F4T	Texas Instruments	YJJ0003A
Q8	1	30V	MOSFET, N-CH, 30V, 60A, DNH0008A (VSONP-8)	CSD17581Q3A	Texas Instruments	DNH0008A
Q15, Q18, QN1, QN2	4	20V	MOSFET, N-CH, 20V, 0.5A, YJM0003A (PICOSTAR-3)	CSD15380F3	Texas Instruments	YJM0003A
QP1, QP2	2	-20V	MOSFET, P-CH, -20 V, -1.7 A, YJM0003A (PICOSTAR-3)	CSD25480F3	Texas Instruments	YJM0003A
R1, R18, R21, R22, R58, R79, R80	7	100k	RES, 100 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW0402100KFKED	Vishay-Dale	0402
R2	1	100k	RES, 100 k, 1%, 0.1 W, 0402	ERJ-2RKF1003X	Panasonic	0402
R3, R15, R56, R60, R93, R149, R152	7	10k	RES, 10 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040210K0JNED	Vishay-Dale	0402
R4, R5	2	0	0 Ohms Jumper 0.125W, 1/8W Chip Resistor 0603 (1608 Metric) Automotive AEC-Q200 Thick Film	ERJ-H3G0R00V	Panasonic	0603
R11, R12	2	200k	RES, 200 k, 1%, 0.05 W, 0201	CRCW0201200KFKED	Vishay-Dale	0201
R13, R14	2	51.0k	RES, 51.0 k, 1%, 0.05 W, 0201	RC0201FR-0751KL	Yageo America	0201
R16, R17, R36, R37, R42, R43	6	2.20k	RES, 2.20 k, 1%, 0.05 W, 0201	CRCW02012K20FKED	Vishay-Dale	0201
R20	1	412k	RES, 412 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW0402412KFKED	Vishay-Dale	0402
R23	1	23.7k	RES, 23.7 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	ERJ-2RKF2372X	Panasonic	0402
R24, R25, R26, R27, R28, R30, R45, R46, R89, R90, R137, R139	12	0	RES, 0, 5%, 0.05 W, 0201	CRCW02010000Z0ED	Vishay-Dale	0201
R32, R96, R97, R98	4	10.0k	RES, 10.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040210K0FKED	Vishay-Dale	0402
R34, R35	2	100k	RES, 100 k, 1%, 0.05 W, 0201	RC0201FR-07100KL	Yageo America	0201
R38, R44, R59	3	10.0k	RES, 10.0 k, 1%, 0.05 W, 0201	CRCW020110K0FKED	Vishay-Dale	0201
R47, R52	2	100k	RES, 100 k, 1%, 0.063 W, 0402	RC1005F104CS	Samsung Electro-Mechanics	0402

Table 5-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer	Package Reference
R48, R49, R50, R51	4	1.00Meg	RES, 1.00M, 1%, 0.1W, 0402	ERJ-2RKF1004X	Panasonic	0402
R53	1	1.50k	RES, 1.50 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	RMCF0402FT1K50	Stackpole Electronics Inc	0402
R54, R55	2	5.10k	RES, 5.10 k, 1%, 0.05 W, 0201	RC0201FR-075K1L	Yageo America	0201
R63	1	115k	RES, 115 k, 1%, 0.063 W, 0402	RC0402FR-07115KL	Yageo America	0402
R65, R66, R71, R72	4	90.9k	RES, 90.9 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040290K9FKED	Vishay-Dale	0402
R69, R70, R73, R74	4	9.09k	RES, 9.09 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW04029K09FKED	Vishay-Dale	0402
R81	1	750	RES, 750, 1%, 0.05 W, 0201	RC0201FR-07750RL	Yageo America	0201
R91	1	100k	RES, 100 k, 1%, 0.05 W, 0201	RC0201FS-7D100KL	Yageo America	0201
S2	1		SWITCH TACTILE SPST-NO 0.05A 12V	B3U-1000P	Omron Electronic Components	3x1.6x2.5mm
SH-J11, SH-J12, SH-J13, SH-J14, SH-J15	5	1x2	Shunt, 100mil, Gold plated, Black	SNT-100-BK-G	Samtec	Shunt
TP1, TP11	2		Test Point, Miniature, Orange, TH	5003	Keystone Electronics	Orange Miniature Test point
TP2	1		Test Point, Miniature, Blue, TH	5117	Keystone	Blue Miniature Test point
TP3, TP5	2		Test Point, Miniature, White, TH	5002	Keystone Electronics	White Miniature Test point
TP4	1		Test Point, Miniature, Red, TH	5000	Keystone Electronics	Red Miniature Test point
TP7, TP10, TP13, TP14	4		Test Point, Miniature, SMT	5015	Keystone Electronics	Test point_Keystone_Miniature
U1, U3	2		1A Low-Quiescent-Current Low-Dropout (LDO) Regulator, DRV0006A (WSON-6)	TLV75733PDRVR	Texas Instruments	DRV0006A
U2	1		USB Type-C® and USB PD Controller with Integrated Power Switches Optimized for Power Applications	TPS26750RSMR	Texas Instruments	VQFN32
U4	1		2.7-16V, 10A, 7m? eFuse with transient overcurrent blanking timer	TPS259814ARPWR	Texas Instruments	QFN10
U6	1		Switched Capacitor Voltage Converter, 6-pin SOT-23, Pb-Free		Texas Instruments	DBV0006A
U7	1		USB Type-C and USB PD Controller with Integrated Power Switches Optimized for Power Applications	TPS25750DRJK	Texas Instruments	VQFN32
U8	1		22V Precision Surge Protection Clamp, DRV0006A (WSON-6)	TVS2200DRVR	Texas Instruments	DRV0006A
U9	1		3.5V to 60V 5A Synchronous Step-Down Voltage Regulator, RNP0030A (WQFN-30)	LM76005RNPR	Texas Instruments	RNP0030A

Table 5-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer	Package Reference
U10	1		High-Side Gate Driver IC Non-Inverting 10-MSOP-EP	LTC7004IMSE#TRPBF	Analog Devices	MSOP10
U12	1		USB Type-C® 48V EPR Port Protector: Short-to-VBUS Overvoltage and IEC ESD Protection	TPD4S480RUKR	Texas Instruments	WQFN20
U13	1		EEPROM Memory IC 512Kb (64K x 8) I ² C 1MHz 900ns 8-SOIC	CAT24C512WI-GT3	ON Semi	SOIC8
U14	1		2 / 3-Port Hub for USB with Optional Serial EEPROM Interface, 3.3V, 0 to 70 degC, 32-Pin LQFP (VF), Green (RoHS & no Sb/Br)	TUSB2036VFR	Texas Instruments	VF0032A
U15, U18, U19	3		ESD Solution for Super-Speed (6Gbps) USB 3.0 Interface, 2 Channels, -40 to +85 degC, 3-pin SOT (DRT), Green (Rohs & No Sb/Br)	TPD2EUSB30DRTR	Texas Instruments	DRT0003A
U17	1		5V Precision Surge Protection Clamp, DRV0006A (WSON-6)	TVS0500DRVR	Texas Instruments	DRV0006A
U20	1		60V, 5uA Iq, 100mA Low-Dropout (LDO) Voltage Regulator With Enable and Power Good, DRB0008B (VSON-8)	TPS7A1650DRBR	Texas Instruments	DRB0008B
U22	1		Tiva C Series Microcontroller, 256 KB Flash, 32 KB SRAM, 12 Bit, 12 Channels, -40 to 105 degC, 64-Pin LQFP (PM), Green (RoHS & no Sb/Br), Tape and Reel	TM4C123GH6PMTR	Texas Instruments	PM0064A
Y1	1		Oscillator XO 48MHz ±50ppm 15pF HCMOS 55% 1.8V/2.5V/3.3V 4-Pin Mini-CSMD T/R	ECS-2520MV-480-BN-TR	ECS International	SMT_OSC_2MM5_2MM0
Y2	1		Crystal, 16MHz, 8pF, SMD	NX3225GA-16.000M-STD-CRG-1	NDK	3.2x0.75x2.5mm

6 Additional Information

6.1 Trademarks

USB Type-C® is a registered trademark of USB Implementers Forum.

Google Chrome® is a registered trademark of Google LLC.

Firefox® is a registered trademark of Mozilla Foundation.

Safari® is a registered trademark of Apple Inc.

All trademarks are the property of their respective owners.

6.2 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits can be more susceptible to damage because very small parametric changes can cause the device not to meet the published specifications.

6.3 Terminology

[TI Glossary](#) lists and explains generic terms, acronyms, and definitions.

[A Primer on USB Type-C® and USB Power Delivery Applications and Requirements](#) lists and explains USB Type-C and USB Power Delivery terms, acronyms and definitions.

6.4 Device Support

6.4.1 Third-Party Products Disclaimer

TI's publication of information regarding third-party products or services does not constitute an endorsement regarding the ability of such products or services or a warranty, representation or endorsement of such products or services, either alone or in combination with any TI product or service.

6.4.2 Supplemental Content

For the device to function in accordance with the relevant specifications, the user needs to download the latest version of the firmware for the device (see section on receiving notification of documentation and firmware updates). If the latest version of the firmware is not downloaded and incorporated into the device, then the device is provided “as is” and TI makes no warranty or representation whatsoever in respect of such device, and disclaims any and all warranties and representations with respect to such device. Further, if the latest version of the firmware is not downloaded and incorporated into the device, TI is not be liable for and specifically disclaims any damages, including direct damages, however caused, whether arising under contract, tort, negligence, or other theory of liability relating to the device, even if TI is advised of the possibility of such damages.

6.5 Documentation Support

- [USB Power Delivery Specification](#)
- [USB-PD Specifications](#)
- [USB Type-C Cable and Connector Specifications](#)
- [USB Document Library](#)
- [USB Power Delivery - Compliance Reports](#)
- [Designing a Battery Charging System for Diversifying Applications](#), application note
- [USB Type-C PD3.1 extended power range, and the benefits of Type-C + BQ solution](#), seminar
- [Designing an application to support a wide input voltage and battery voltage](#), technical article

6.6 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](https://www.ti.com). Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

6.7 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask questions to get the quick design help you need. Linked content is provided "AS IS" by the respective contributors. The content does not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.
 - 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductor products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software
 - 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.
2. *Limited Warranty and Related Remedies/Disclaimers:*
 - 2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
 - 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.
 - 2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI's recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI's recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI's instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGRADATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 Regulatory Notices:

3.1 United States

3.1.1 Notice applicable to EVMs not FCC-Approved:

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html>

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。技術適合証明を受けていないものご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。日本テキサス・イ

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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。 <https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html>

3.4 European Union

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive):*

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

-
- 4 *EVM Use Restrictions and Warnings:*
 - 4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.
 - 4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.
 - 4.3 *Safety-Related Warnings and Restrictions:*
 - 4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.
 - 4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.
 - 4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.
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