EVM User's Guide: TPS25751EVM

TPS25751 Evaluation Module

Description

The TPS25751 is a highly integrated stand-alone USB Type-C® and Power Delivery (PD) controller optimized for applications supporting USB-C PD Power. The TPS25751 integrates managed power paths with robust protection for a complete USB-C PD design. The TPS25751 also integrates control for external battery charger ICs for added ease of use and reduced time to market. The intuitive web based GUI asks the user a few simple questions on the application's needs using clear block diagrams and simple multiple-choice questions. The GUI creates the configuration image for the user's application, reducing much of the complexity associated with competitive USB-PD designs.

Get Started

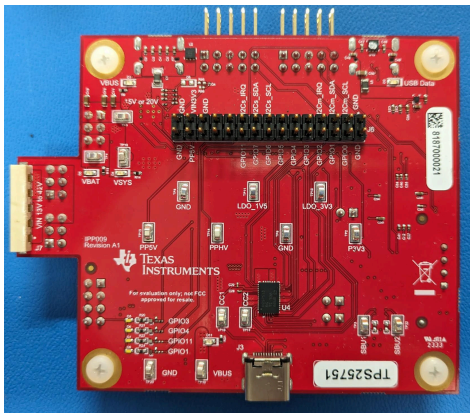
1. Order the TPS25751EVM, highly integrated USB Type-C and USB PD Controller evaluation module
2. Read the TPS25751EVM user's guide
3. Start development with the Application Customization Tool
4. Refer to the data sheet, technical reference manual, or E2E for questions and support

Features

- TPS25751 is certified by USB-IF for PD3.1 specification (TID# 10306)
- Up to 100W (20V/5A) source and sink applications with integrated I2C control for TI battery chargers
  - BQ25756, BQ25756E, BQ25792, BQ25798, and BQ25713
  - 100W (20V/5A) source and 100W (20V/5A) sink with BQ25756(E)EVM for 1S-14(7)S battery applications
  - 45W (20V/2.25A) source and 60W (20V/3A) sink with BQ25792/8EVM for 1S-4S battery applications
  - 60W (20V/3A) source and 60W (20V/3A) sink with BQ25713EVM for 1S-4S battery applications
- Easy-to-use GUI with pre-configured firmware to configure:
  - Programmable Power Supply (PPS) within 5V-21V range
  - Liquid Detection and Corrosion Mitigation measureable on SBU1 and SBU2
- Multiple test points and headers for quick and easy debug
  - Exposed VBUS and CCx test points to monitor PD traffic
  - PP5V and PPHV test points to measure voltage transitions

Applications

- Battery pack for cordless power tool, power bank, retail automation and payment
- Wireless speakers, cordless vacuum cleaner
- Personal/portable electronics, industrial applications
- Medical applications, personal care and fitness



TPS25751EVM

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1 Evaluation Module Overview

1.1 Introduction

This document is the user's guide for the TPS25751 Evaluation Module (TPS25751EVM). The TPS25751EVM allows for evaluation of the TPS25751 IC as part of a stand-alone testing kit and USB Type-C and Power Delivery (PD) products.

1.2 Kit Contents

- TPS25751EVM
- Ribbon Cable
- EVM Disclaimer Read Me

1.3 Specification

Figure 1-1 shows the block diagram.

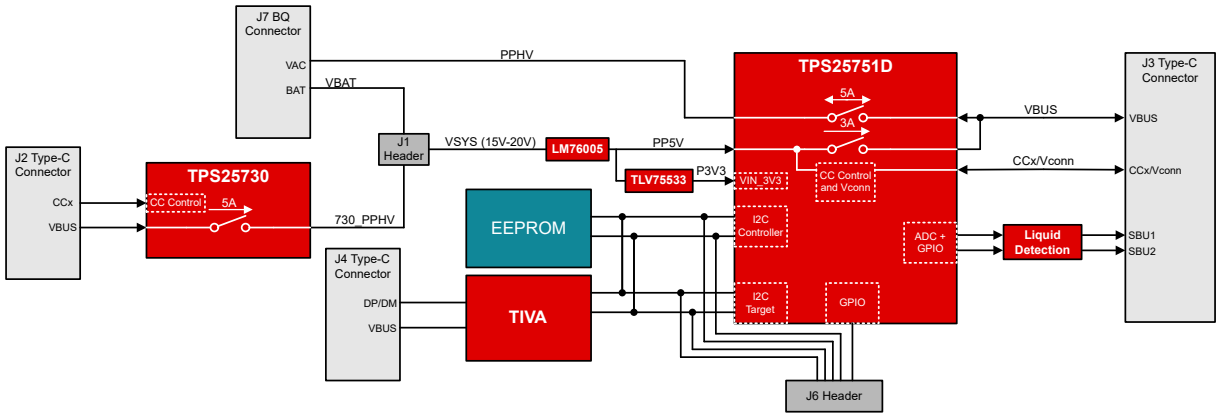


Figure 1-1. TPS25751EVM Block Level Diagram

1.4 Device Information

The TPS25751D is a single-port, USB Type-C PD controller with integrated bi-directional high voltage power paths for power-only applications. The TPS25751EVM is used to evaluate functionally equivalent TPS25751S (external high-voltage power path) version of the TPS25751 PD controller. The TPS25751 PD controller is an excellent choice for single port power applications operating in the Standard Power Range (SPR) for Dual Role Power (DRP) applications up to 100W (20V/5A).

The TPS25751EVM includes several devices for complete evaluation of voltage protection, power topology, and an additional TPS25730D PD controller for barrel-jack replacement. For more details on each device on the TPS25751EVM refer to Table 1-1.

The TPS25751 PD controller is configurable through the Web-based GUI for application specific requirements, architectures, and power/data roles. The GUI tool provides additional optional firmware configuration to integrate control for selected Battery Charger Products (BQ25756, BQ25756E, BQ25792, BQ25798, and BQ25713). For more information on BQ configuration, refer to Section 4.2.

Table 1-1. Devices on TPS25751EVM

Designator	Device Name	Description
U1	TPS25730	USB Type-C Sink-Only PD controller, DC barrel jack replacement
U2, U3	TVS2200	22V flat-clamp surge protection device
U4	TPS25751	USB Type-C PD controller
U5	TPD2S300	USB Type-C Short-to-VBUS and ESD protection for SBU lines Liquid Detection/Corrosion Mitigation
U6	CAT24C512	EEPROM Serial 512-Kb I2C
U7	TPD2E009	Dual ESD protection diode with 5A surge rating

Table 1-1. Devices on TPS25751EVM (continued)

Designator	Device Name	Description
U8	TM4C123GH6PM	TIVA MCU, used in conjunction with GUI to flash the EVM
U9, U11	TLV75533	Low-dropout voltage regulator for 3.3V (P3V3)
U10	LM76005	Synchronous step-down converter for 5V (PP5V)

2 Hardware

2.1 Power Requirements

For standalone PD evaluation, the main power supply for the TPS25751EVM is through the Type-C Sink only port (J2), which accepts 45W Type-C PD Source (15V to 20V). If the Type-C adapter is not capable of minimum 15V, then the TPS25751EVM does not power on properly. Alternatively, the EVM can also be powered on from an external bench supply connected to VSYS test point (TP19), with the bench supply providing 15V-20V range.

Note

VSYS (TP4) has an absolute maximum rating of 48V with recommended maximum of 42V. Applying more than the maximum voltage can cause damage to the EVM.

The TPS25751EVM can also be powered directly through Type-C Connector (J3) to simulate the TPS25751 in a dead battery scenario. When the TPS25751EVM is powered only through port J3, the EVM acts as sink only (unable to source unless VSYS is powered on).

For battery charging application, the selected BQ EVM can be used to power on the TPS25751EVM. The BQ25756EVM comes with a interfacing connector to connect to J7 connector on the TPS25751EVM. If a BQ Battery Charger is connected, the VBUS side of the BQ Battery Charger is connected to the internal high-voltage bidirectional power path (PPHV) of the TPS25751EVM. For more information on setting up and programming TPS25751 for battery charger application refer to Section 4.2.

2.2 Setup

Out of the box, the TPS25751EVM is configured for 15W (5V/3A) source and 100W (20V/5A) sink power. When different configurations are required, use the Application Customization Tool to create a configuration or load a different configuration template. Refer to Section 3 for detailed instructions on using the Application Customization Tool.

2.3 Header Information

J6 header contains numerous pinout from TPS25751 for testing, evaluation, and debugging purposes. The header pins are clearly labeled on the top layer of the TPS25751EVM for easy access, for details refer to Table 2-1. Pin 1 is indicated by a white circle, see the picture below for reference.

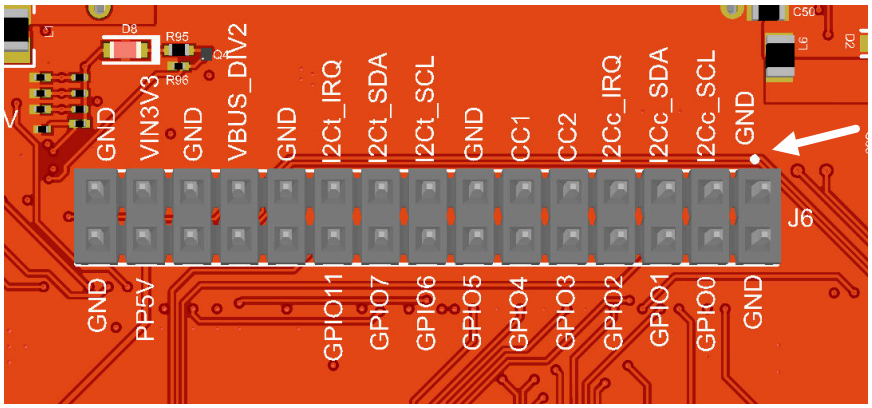


Figure 2-1. J6 Header

Table 2-1. J6 Header Pinout

Pin Number	Pin Label	Description
1	GND	Ground reference for EVM.
2	GND	Ground reference for EVM.
3	I2Cc_SCL	I2C controller clock line of TPS25751.
4	GPIO0	GPIO0 of TPS25751.
5	I2Cc_SDA	I2C controller data line of TPS25751.
6	GPIO1	GPIO1 of TPS25751.
7	I2Cc_IRQ	I2C controller interrupt line of TPS25751. This can also be reconfigured to GPIO12.
8	GPIO2	GPIO2 of TPS25751.
9	751_CC2	CC2 pin of J3 Type-C Port, used for PD negotiation. This can be VCONN or CC depending on the polarity flip of the USB Type-C cable.
10	GPIO3	GPIO3 of TPS25751.
11	751_CC1	CC1 pin of J3 Type-C Port, used for PD negotiation. This can be VCONN or CC depending on the polarity flip of the USB Type-C cable.
12	GPIO4	GPIO4 of TPS25751.
13	GND	Ground reference for EVM.
14	GPIO5	GPIO5 of TPS25751.
15	I2Ct_SCL	I2C target clock line of TPS25751.
16	GPIO6	GPIO6 of TPS25751.
17	I2Ct_SDA	I2C target data line of TPS25751.
18	GPIO7	GPIO11 of TPS25751.
19	I2Ct_IRQ	I2C target interrupt line of TPS25751. This can also be reconfigured to GPIO10.
20	GPIO11	GPIO11 of TPS25751.
21	GND	Ground reference for EVM.
22	DBG_UART	Connected to TIVA for internal testing purposes, do not use.
23	VBUS_DIV2	Resistor divider output of VBUS line between TPS25751 and J3 Type-C port. This output pin halves the value of VBUS, for example when VBUS is at 20V the pin reads 10V.
24	TEST1	Connected to TIVA for internal testing purposes, do not use.
25	GND	Ground reference for EVM.
26	TEST2	Connected to TIVA for internal testing purposes, do not use.
27	VIN3V3	3.3V supply connected to VIN_3V3 of TPS25751.
28	PP5V	5V supply connected to PP5V of TPS25751.
29	GND	Ground reference for EVM.
30	GND	Ground reference for EVM.

2.4 Jumper Information

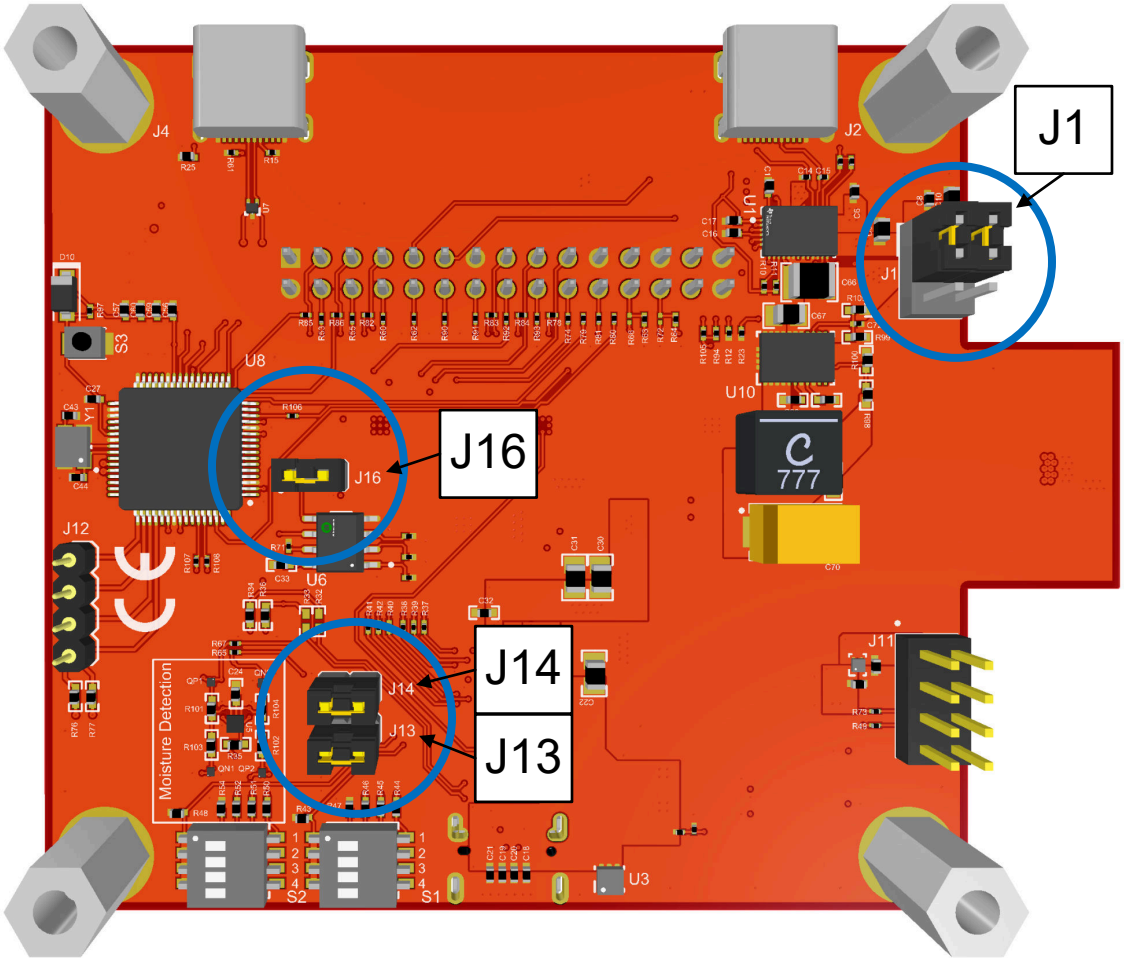


Figure 2-2. Jumper Locations

Table 2-2. Jumper Descriptions

Jumper Designator	Description
J1	Power selector between VBAT and 730_PPHV to board system power (VSYS), refer to Figure 4-1.
J13	3.3V input to VIN_3V3 on TPS25751. Remove jumper to disconnect 3.3V power to TPS25751 to simulate dead-battery mode.
J14	3.3V output from LDO_3V3 on TPS25751. Remove jumper to disconnect 3.3V power to the on-board EEPROM. This also disconnect 3.3V pull-up on the I2Cc and I2Ct lines.
J16	I2Cc data line between TPS25751 and EEPROM, remove jumper to disable I2C flash.

2.5 LED Information

Table 2-3. LEDs

Designator	Net Label	Description
D1	730_VBUS	Blue LED that shows when USB Type-C is connected to Sink Only Type-C Port (J2).
D2	USB_Data	Blue LED that shows when USB Type-C is connected to Data Type-C Port (J4).
D3	VBAT	Blue LED that shows when BQ battery is connected to VBAT.
D4	VSYS	Blue LED that shows when VBAT or 730_PPHV is supplying system power (VSYS).
D5	GPIO3	White LED that shows GPIO3 is high.
D6	GPIO2	White LED that shows GPIO2 is high.
D7	GPIO11	White LED that shows GPIO11 is high.
D8	730_CAP_MIS	Red LED that shows capability mismatch when an attached source is not providing enough power to the Sink Only Type-C Port (J2).
D9	GPIO1	White LED that shows GPIO1 is high.
D11	751_VBUS	Blue LED that shows when VBUS has a voltage of 5V through 20V

2.6 Test Points

Table 2-4. Test Points

Designator	Label	Description
TP2	P3V3	3.3V system supply to VIN_3V3 of TPS25751.
TP3	SBU2	SBU2 pin of J3 Type-C Port, used for liquid detection.
TP4	VSYS	System power of TPS25751EVM, feeds into 5V and 3.3V power rail.
TP5	730_PPHV	TPS25730 high-voltage sinking node in the system, can be connected to VSYS to provided system power through J1.
TP8, TP9, TP20	GND	Ground reference for EVM.
TP10	LDO_3V3	3.3V output of supply switched from VIN_3V3 or VBUS LDO.
TP11	LDO_1V5	1.5V output of the CORE LDO.
TP13	VBUS	TPS25751 VBUS voltage reference.
TP14	PPHV	TPS25751 high-voltage sinking node in the system.
TP15	PP5V	TPS25751 5V system supply to VBUS, supply for CCy pins as VCONN.
TP16	CC1	CC1 pin of J3 Type-C Port, used for PD negotiation. This can be VCONN or CC depending on the polarity flip of the USB Type-C cable.
TP17	CC2	CC2 pin of J3 Type-C Port, used for PD negotiation. This can be VCONN or CC depending on the polarity flip of the USB Type-C cable.
TP19	VBAT	Battery voltage reference, can be connected to VSYS to provide system power through J1.
TP22	SBU1	SBU1 pin of J3 Type-C Port, used for liquid detection.

2.7 Switches/Push Buttons

Table 2-5. Switches/Push Buttons

Designator	Label	Description
S1	ADCIN1	Switch used to set the resistor divider for ADCIN1. Refer to the TPS25751 data sheet (SLVSH93) on how to configure the pin-strapping.
S2	ADCIN2	Switch used to set the resistor divider for ADCIN2. Refer to the TPS25751 data sheet (SLVSH93) on how to configure the pin-strapping.
S3	T_RST	Push-button to pull the RST pin (38) of the TIVA device. When pressed, the RST pin goes high.

3 Software

3.1 Software Description

The required software is available at the TI Gallery, and is run from the web browser, provided that Google Chrome™, Firefox®, or Safari ®is used. If this is desired, then TI Cloud Agent needs to be installed as a browser extension as well as on the PC. When the application is launched, instructions appears for installing TI Cloud Agent. The software can also be run natively on the PC. If this is desired, then GUI Composer Runtime needs to be installed natively. 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.

3.1.1 Software Installation

The tool can be launched either through a web browser or as a native application.

3.1.2 Web Browser

1. Navigate to Developer Gallery.
2. Search for the USBCPD Application Customization Tool in the Gallery.
3. Once found, click on the card that has the correct tool.
4. A new tab opens with the application launched. If TI Cloud Agent is not already installed, then instructions appear for installing the required software.

3.1.3 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.

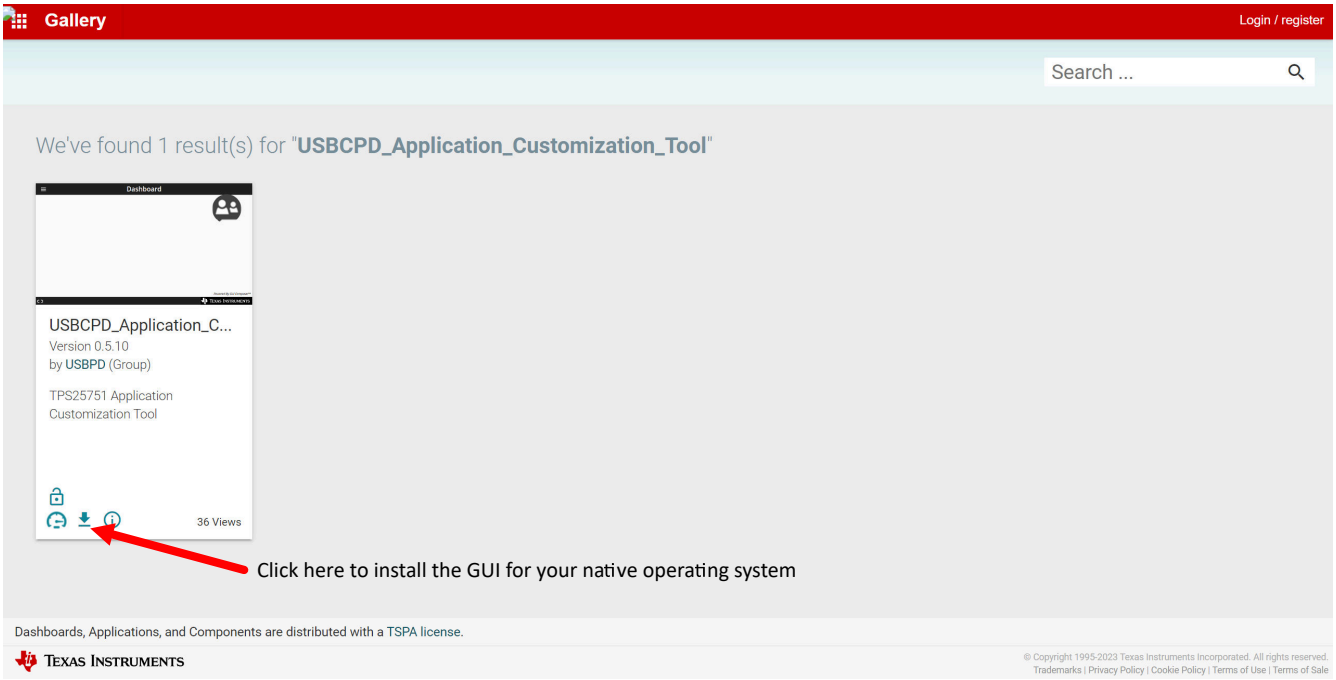


Figure 3-1. Application Customization Tool Download

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

3.2 Software Development

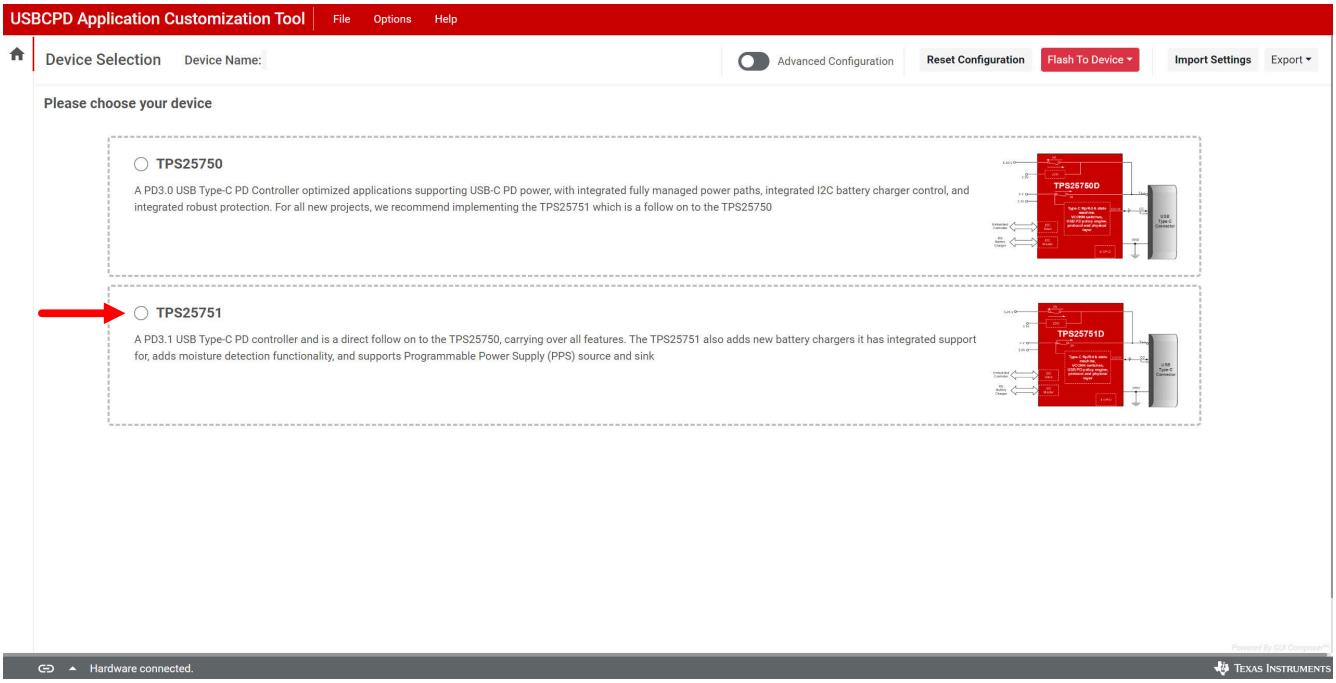
The TPS25751 Application Customization Tool provides users with the following capabilities:

- Generate new configuration settings.
- Load configuration settings to a device
- Save configuration settings in JSON format.
- Export configuration settings in Binary and C format.

3.3 Using the TPS25751 Application Customization Tool

3.3.1 Default View

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



3.3.2 Selecting a Configuration

The first question of the GUI asks to select a configuration the TPS25751 is used for. The ten configuration are separated into three main categories: Power Source (provider) and Power Sink (consumer), Power Sink (consumer) only, and Power Source (consumer) only. When choosing a configuration, check to make sure which variant is selected. Based on the configuration selected, certain questions are disabled. See the image and table below for a breakdown of each configuration.

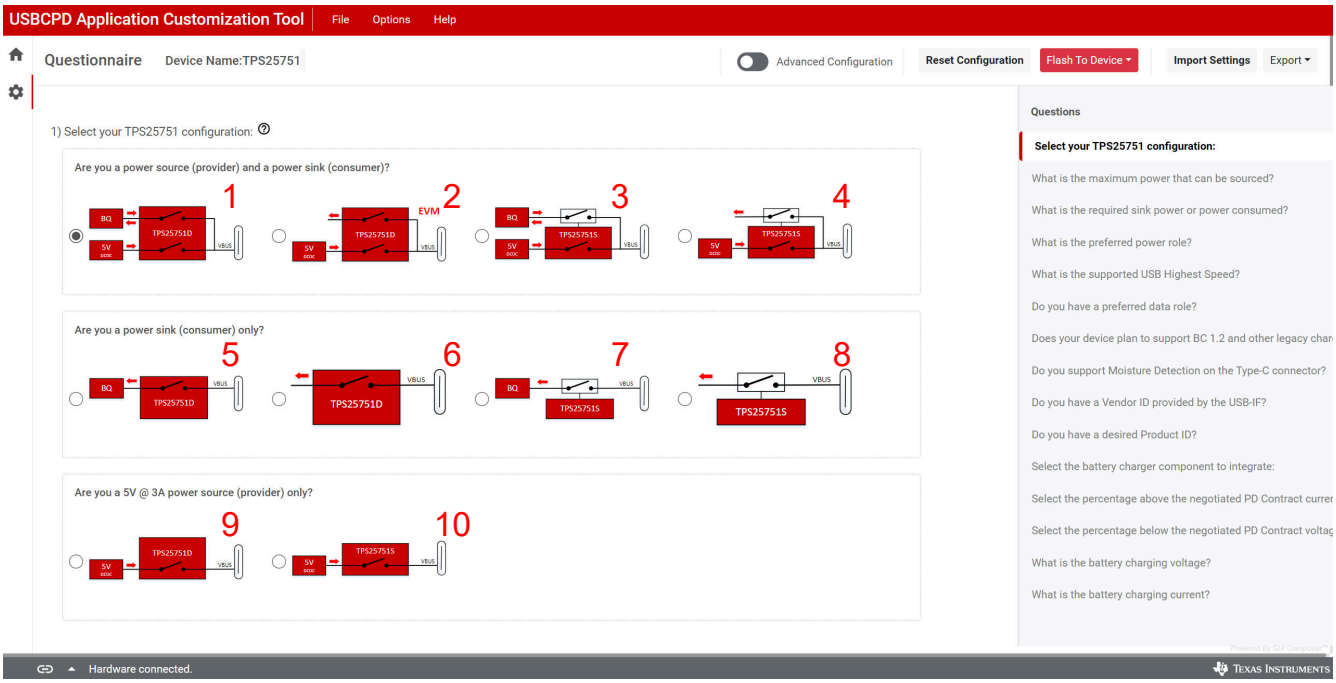


Figure 3-2. Application Customization Tool Configuration

Table 3-1. TPS25751 Configuration

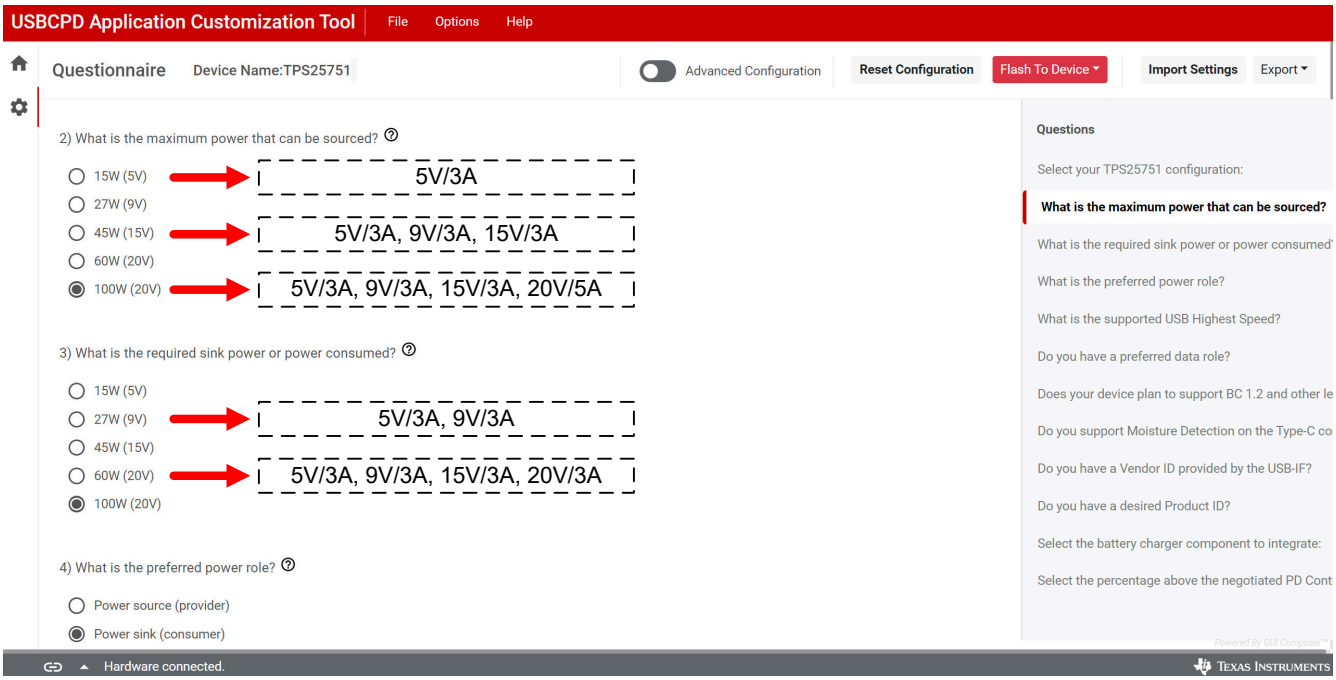
Configuration Index	Device Variation	Power Role	BQ Support
1	D	Source and Sink (DRP)	Yes
2	D	Source and Sink (DRP)	No
3	S	Source and Sink (DRP)	Yes
4	S	Source and Sink (DRP)	No
5	D	Sink Only	Yes
6	D	Sink Only	No
7	S	Sink Only	Yes
8	S	Sink Only	No
9	D	Source Only	No
10	S	Source Only	No

3.3.3 Filling Out the Questionnaire

After selecting the TPS25751 configuration, continue to fill out the remaining questions to flash or generate a full configuration. Based on the selection for Question 1, some of the remaining questions can be unavailable for selection.

Questions 2 through 4 asks for the maximum power that is sourced or sinked. If a source-only configuration was selected in Question 1, then Question 3 is not available to select. If a sink-only configuration was selected, then Question 2 is not available to select. Question 4 determines the power role preference of TPS25751, this question is only available if the system is DRP (Dual Role Power).

When selecting the maximum power that can be sourced or sink, this configures the Transmit Source Capabilities (0x32) and Transmit Sink Capabilities (0x33) register of TPS25751 by adding default Source/Sink PDOs. The voltage and current rating applies for both Source and Sink PDOs. See the figure below for the default configuration.



Question 5 asks for the supported USB speed. 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 asks for the preferred data role. Based on the selection, this determines the data role (UFP, DFP, or DRP) TPS25751 is configured for. If there is no preference, then select *No*.

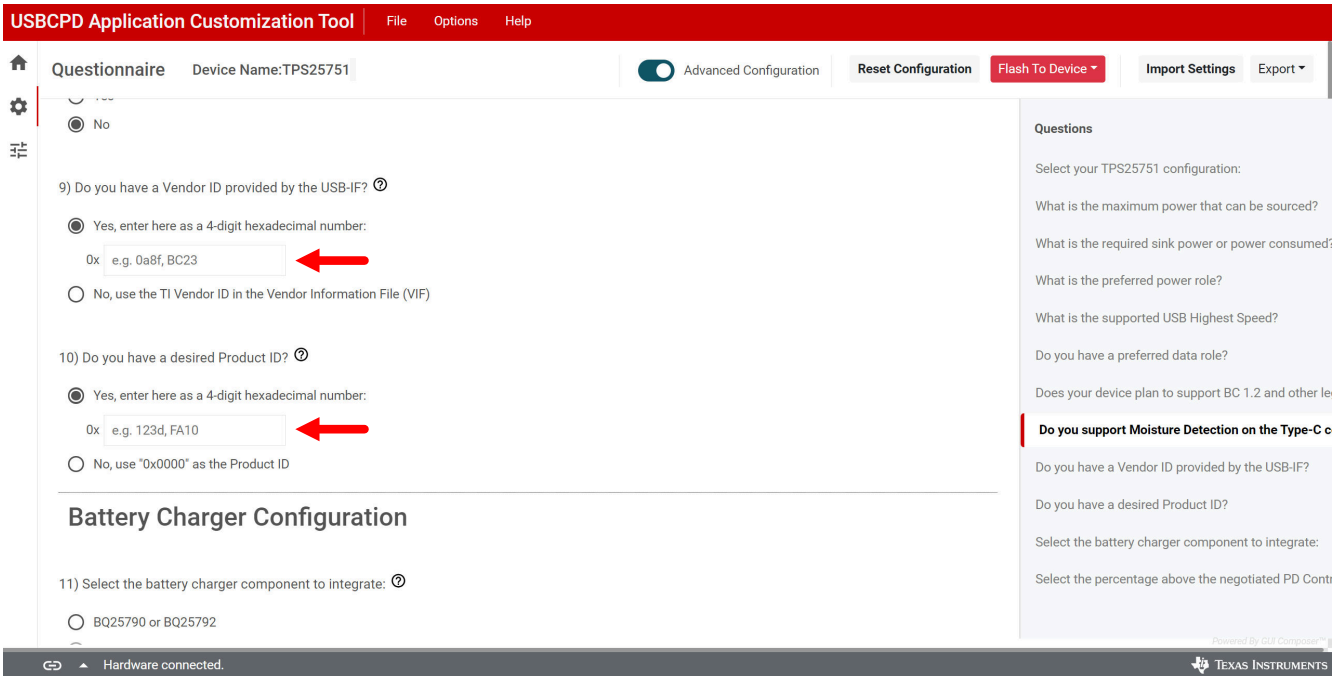
Question 7 asks for BC1.2 and legacy charging support. Based on the selection, TPS25751 can enumerate different BC1.2 charging schemes. Refer to the TPS25751 data sheet for more details.

Question 8 asks for Liquid Detection support. This is a new feature of TPS25751 based on the Type-C specifications for Liquid Detection and Corrosion Mitigation. Refer to Section 4.3 for more details.

Note

TPS25751 is not able to support BC1.2 and Liquid Detection simultaneously since both features utilize the same GPIO pins.

Questions 9 and 10 asks for the Vendor ID and the desired Product ID respectively. The Vendor ID is given by the USB-IF and the Product ID is simply a configuration identifier. Select *Yes* option to enter 4-digit hexadecimal number, otherwise select *No*.



Questions 11 through 18 corresponds to configuring the selected BQ (Battery Charger) device if applicable. These questions are only available for filling in if a BQ configuration was selected in the first question. For all other non-BQ configuration (TPS25751 only), these questions are disabled. Refer to Section 4.2 section for more details on each questionnaire and the applications.

3.3.4 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*.

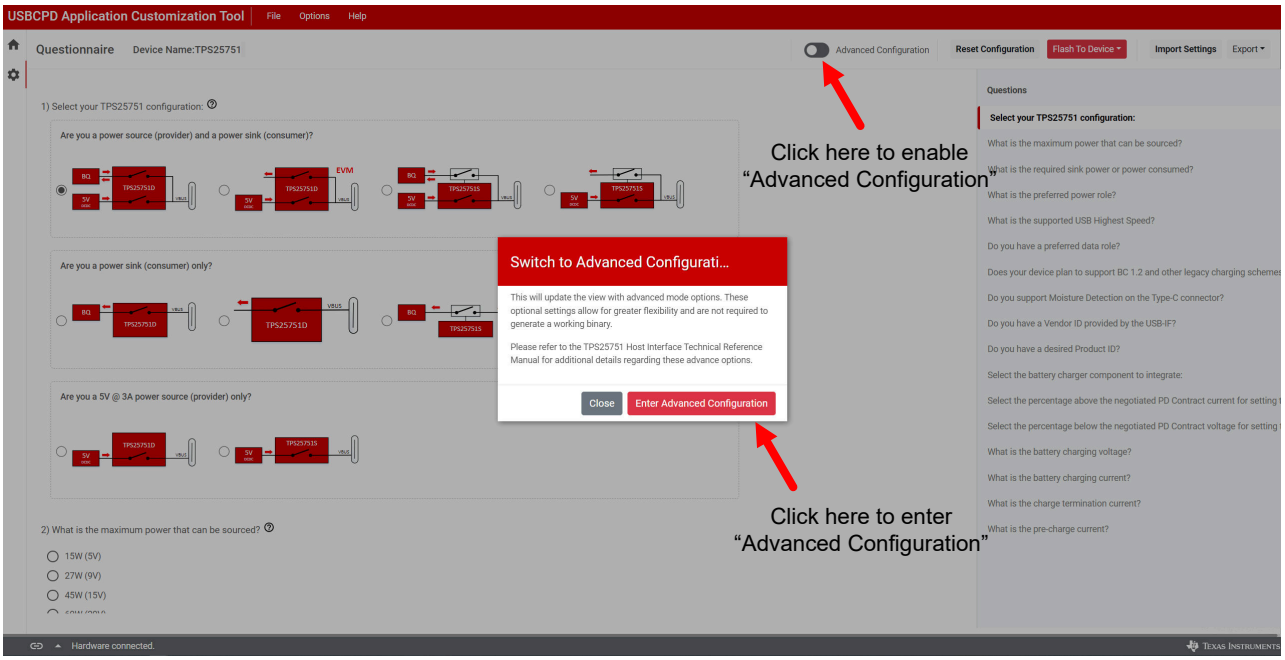


Figure 3-3. Enabling Advanced Configuration

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 most available registers on the TPS25751. For details on register fields and the description, refer to the TPS25751 Technical Reference Manual. See the example below of configuring the Source_PDO_4 under Transmit Source Capabilities (0x32).

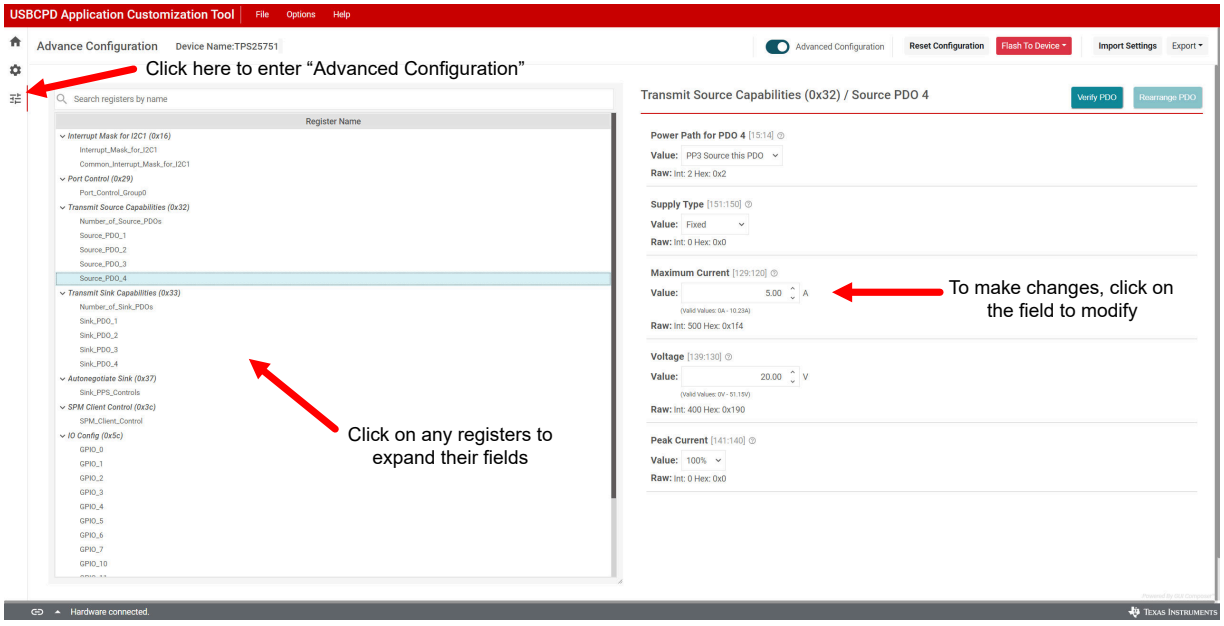


Figure 3-4. Using Advanced Configuration

3.3.5 Flashing Configuration onto EVM

The Application Customization Tool is used to directly load a configuration onto the TPS25751EVM. Connect J4 Type-C connector with a cable (both USB-A to USB-C or USB-C to USB-C® cables work) to a laptop or computer with the Application Customization Tool open. Make sure the TPS25751EVM is properly powered either through J2 Type-C connector to a 15V-20V Type-C adapter or with a bench power supply. See the figure below for reference.

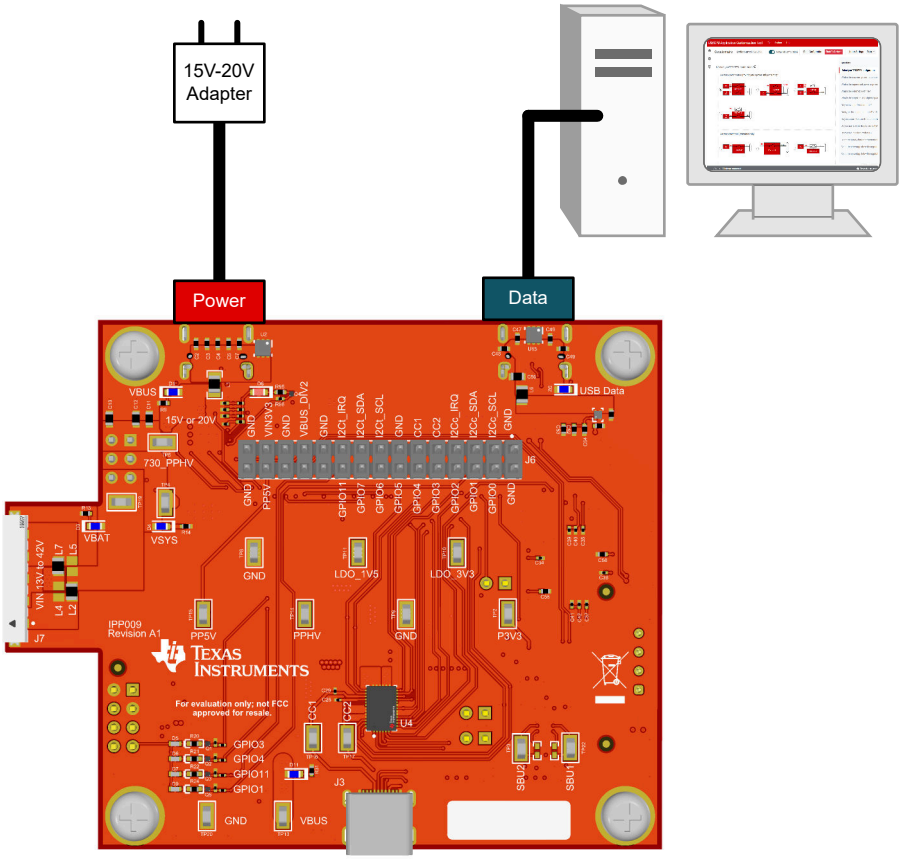


Figure 3-5. TPS25751EVM Connection with PC

Note

When flashing a configuration onto TPS25751EVM, connect the TPS25751EVM with a power source such as a PD adapter or bench power supply. For evaluation battery charging applications with the BQ257xxEVM, connect the BQ EVM after the TPS25751EVM has a proper configuration loaded.

Open the Application Customization Tool and complete the questionnaire, refer to Section 3.3.3 for details on each question. Once the questionnaire is complete and the TPS25751EVM is connected properly, click on Options → Serial Port Configuration to make sure the correct COM port is selected. See the figure below for reference.

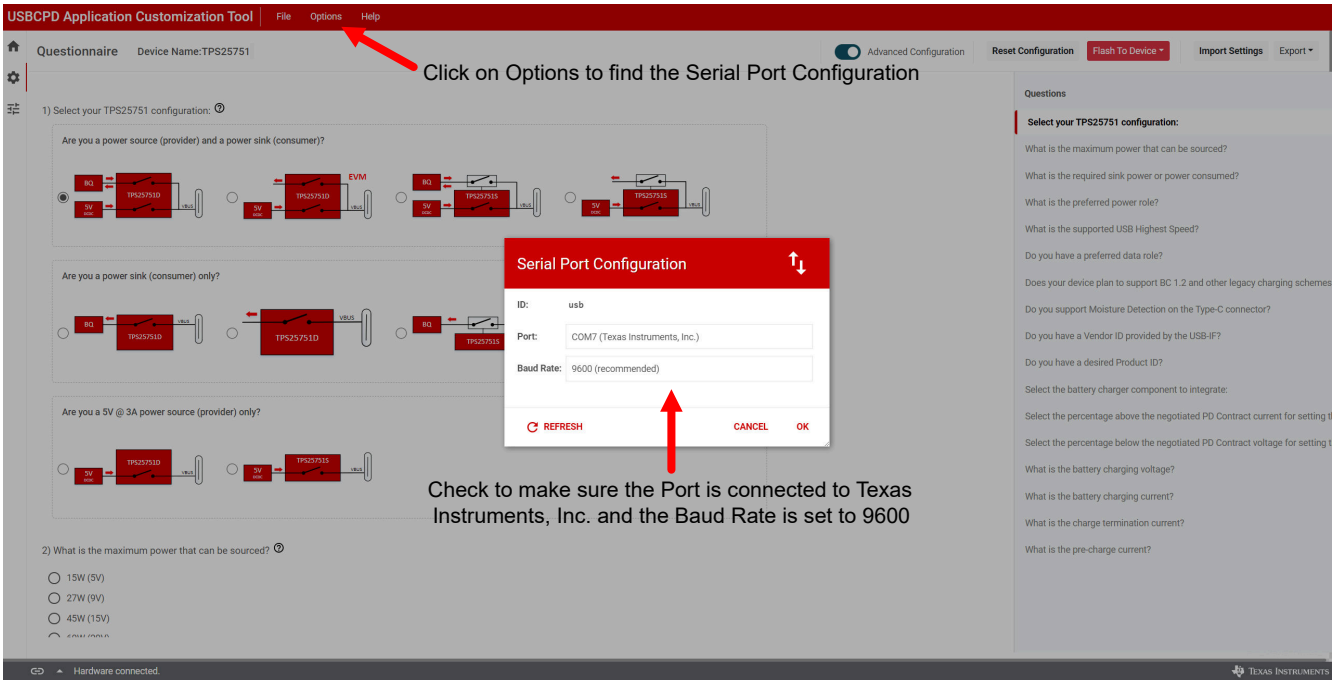


Figure 3-6. Serial Port Configuration Settings

If the TPS25751EVM 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 TPS25751EVM supports data.
2. Make sure the power source (whether it's from a Type-C adapter or bench power supply) is supplying 15V-20V. TPS25751EVM cannot power on properly if the power source is less than 15V.
3. Make sure only one tab 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 TPS25751EVM is connected to the Application Customization Tool, click on Flash To Device → Flash to device from current configuration.

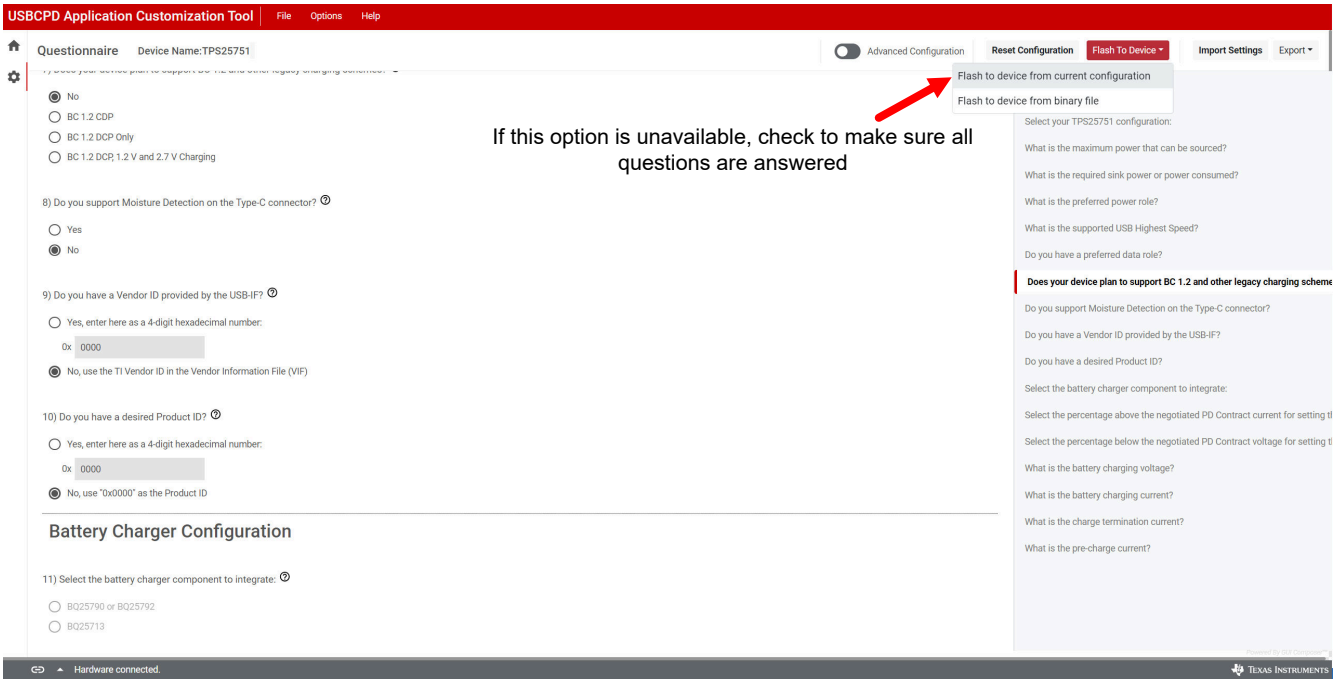


Figure 3-7. Flash to Device from Current Configuration

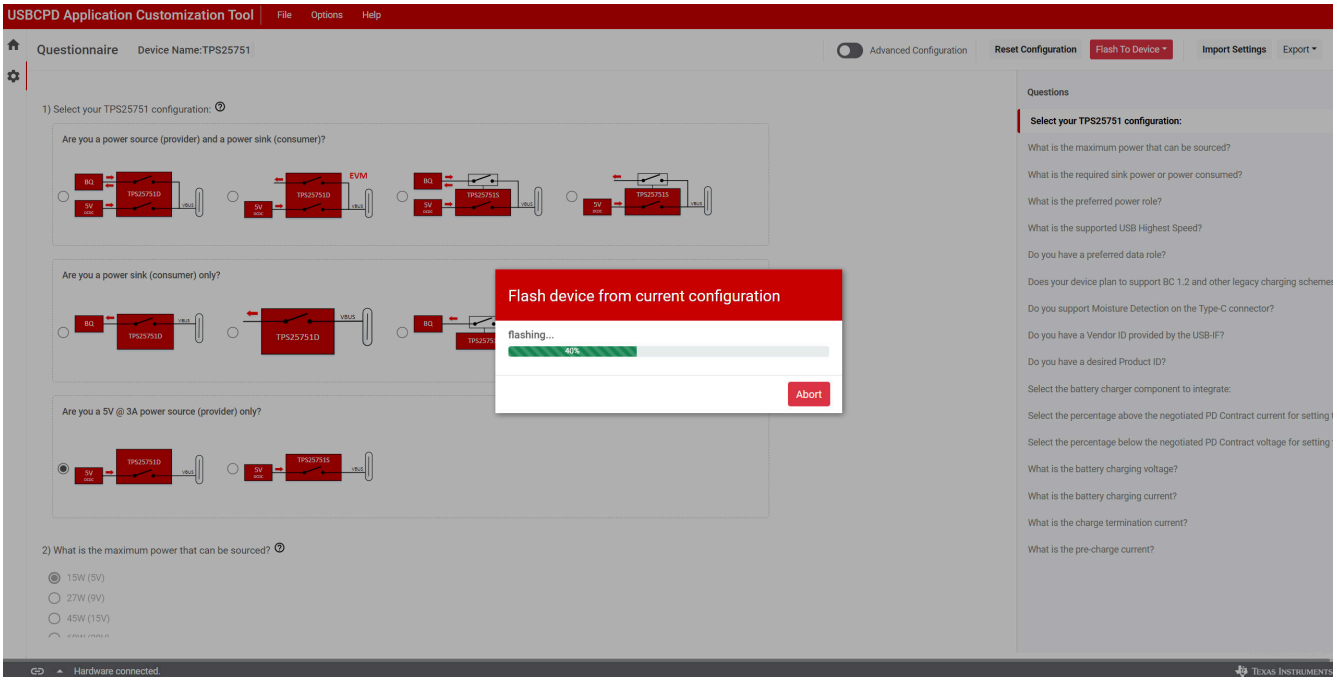


Figure 3-8. Flash to Device from Current Configuration

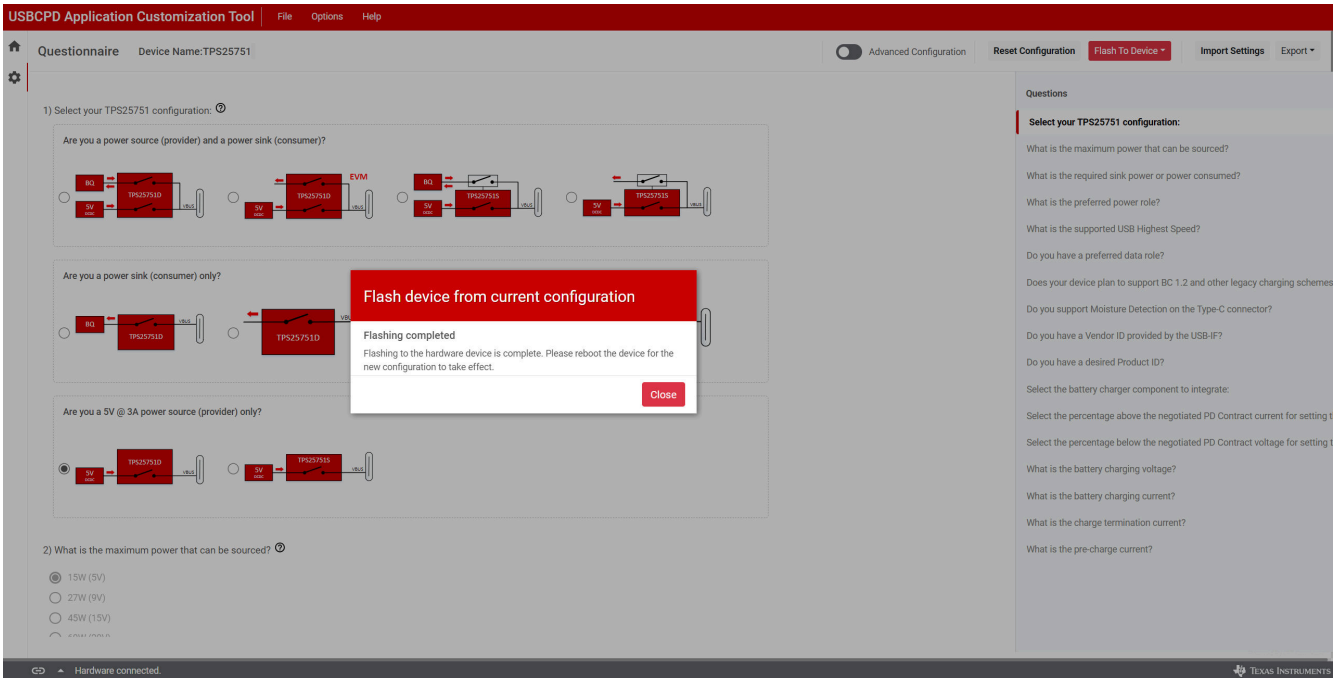


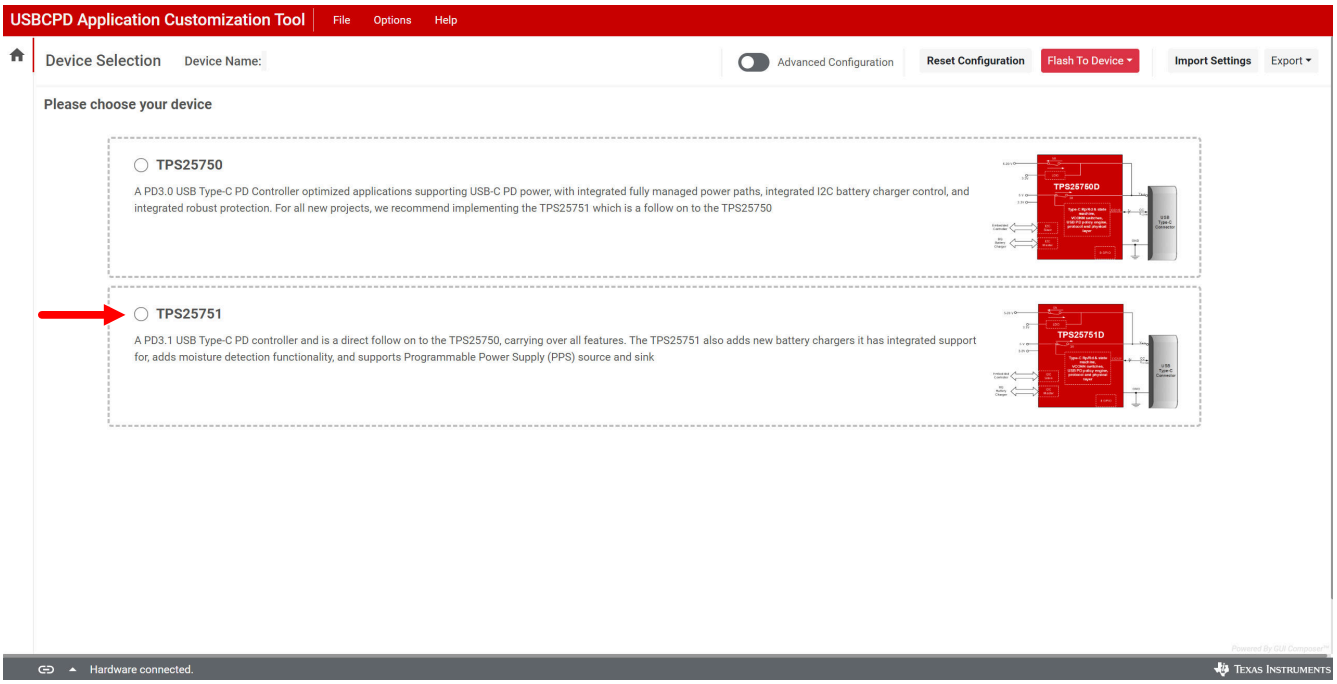
Figure 3-9. Flash to Device from Current Configuration

Note

When the tool is flashing the configuration, DO NOT connect or disconnect any cables on the TPS25751EVM. Connecting or disconnecting any cables can cause errors when flashing.

3.3.6 Additional Settings

The Application Customization Tool includes additional settings for creating new configurations, exporting and importing settings, generating binaries and VIF files. To start, select TPS25751 to start configuring, refer to Section 3.3.3.



3.3.6.1 Generating a New Configuration

To generate a new customization configuration for the TPS25751 device, 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 resetting the form back to the default settings. TI recommends to export the existing form first so that the existing configuration is not lost. Refer to Section 3.3.6.2 for details on how to save configurations.

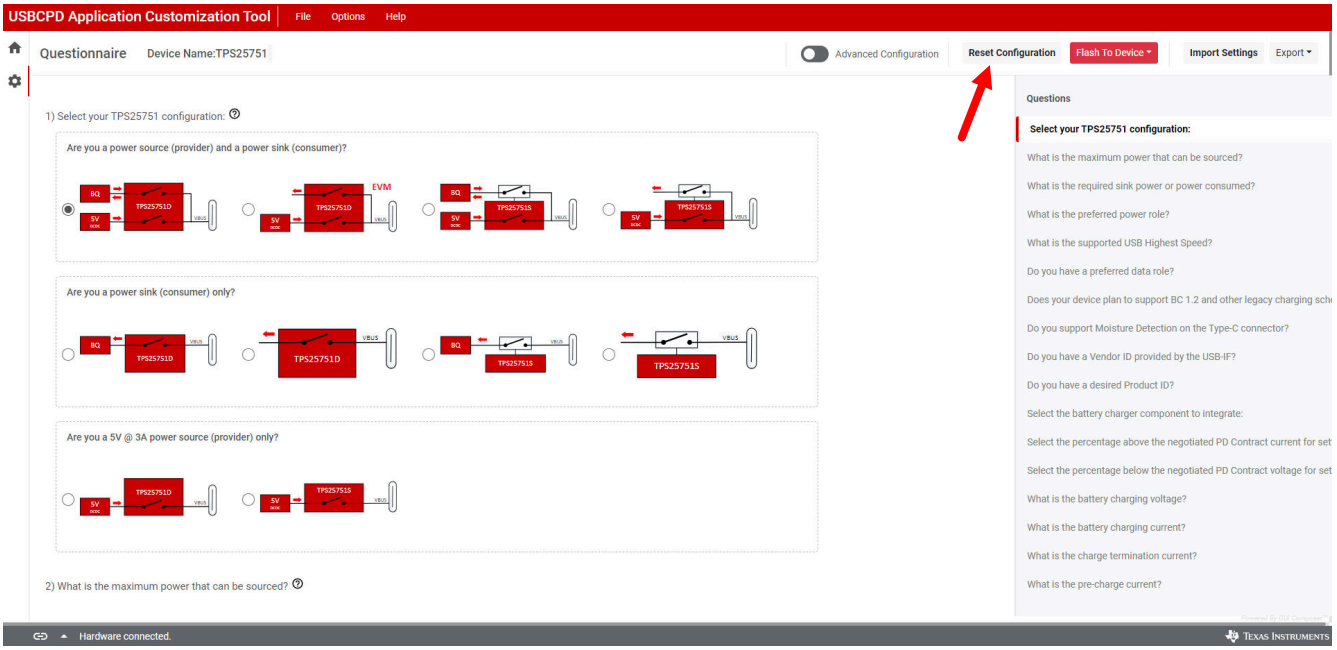


Figure 3-10. Resetting Configuration

3.3.6.2 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.

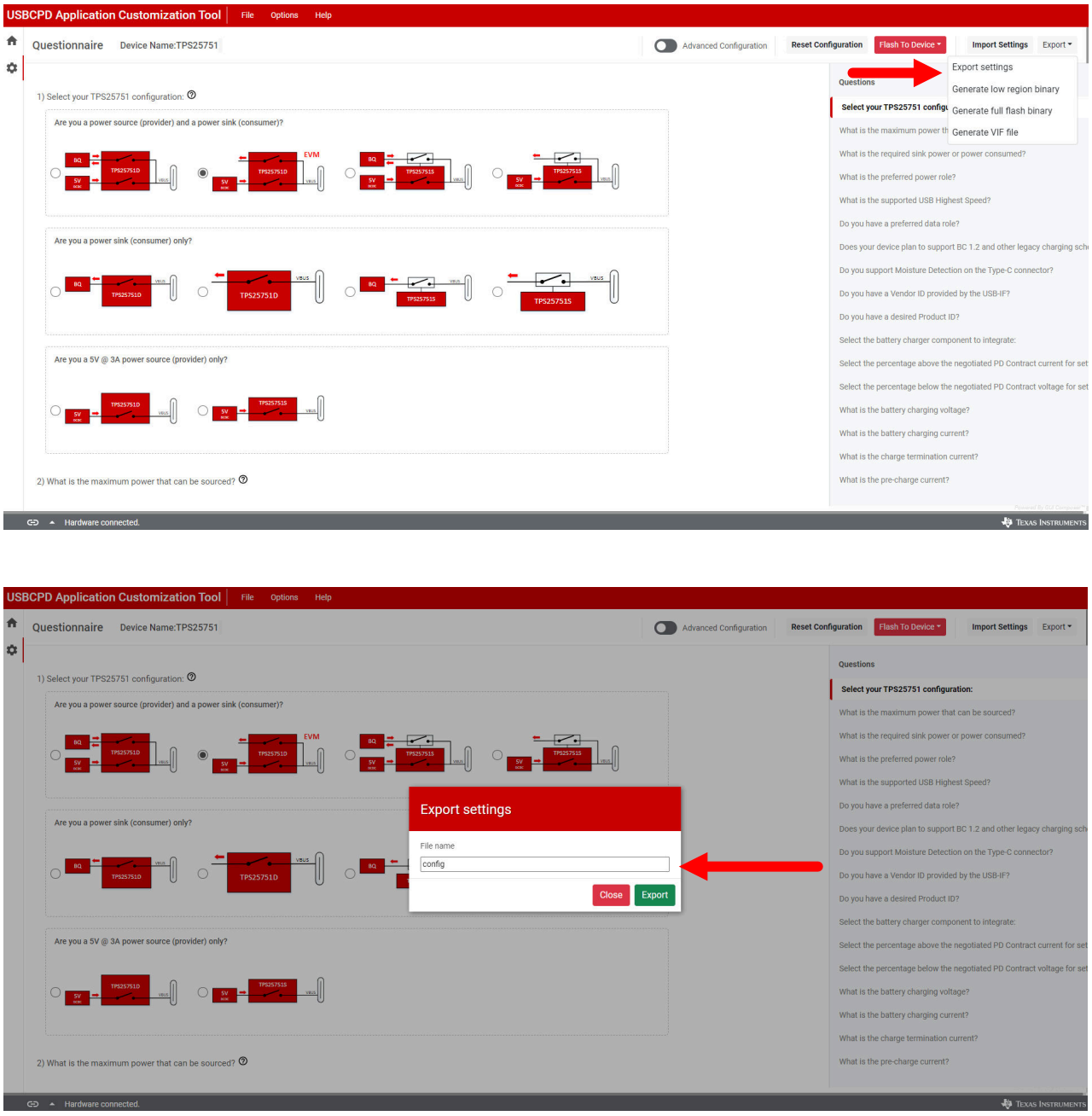


Figure 3-11. Export Settings in Application Customization Tool

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.

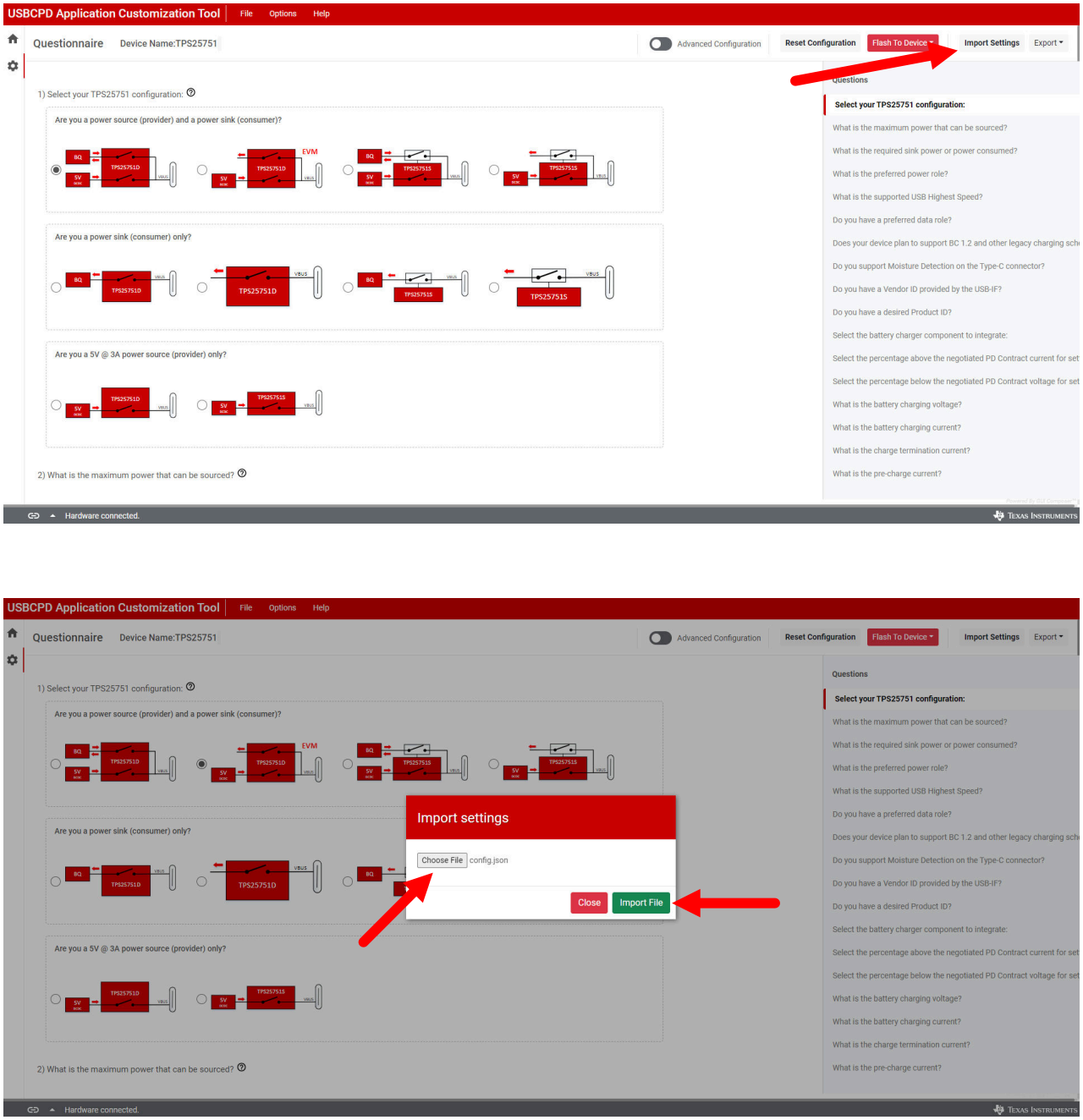


Figure 3-12. Import Settings in Application Customization Tool

3.3.6.3 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.

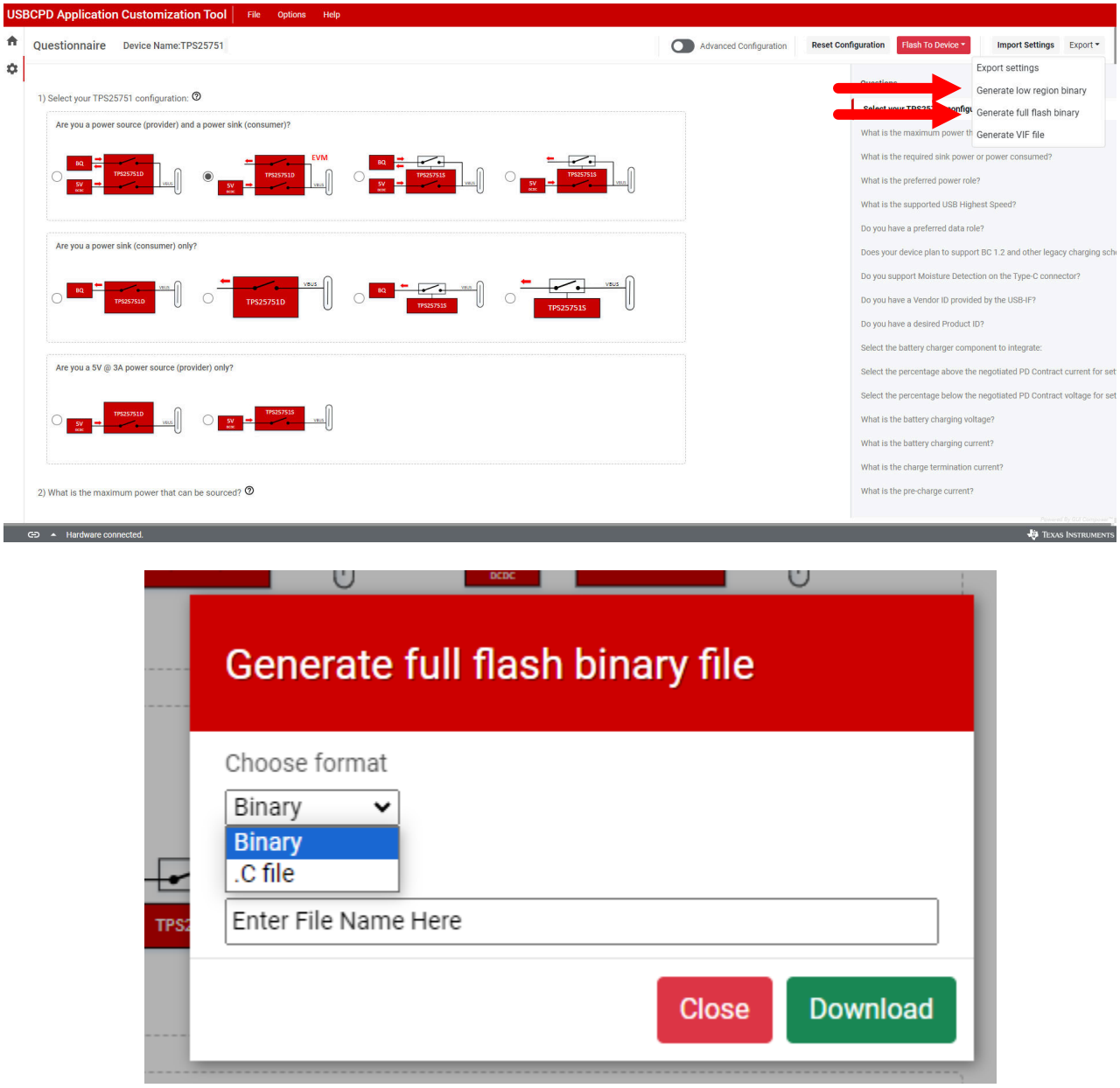


Figure 3-13. Generating Binary Configuration Using the Application Customization Tool

3.3.6.4 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 USB-IF to create or modify VIF files, refer to USB Vendor Info File Generator.

4 Application Specific Use Case

4.1 Application Specific General Overview

This section explains in more detail how to set up application specific use case for battery charging applications with BQ257xx devices and configuring Liquid Detection and Corrosion Mitigation.

4.2 TPS25751EVM and BQ257xxEVM Setup

The TPS25751EVM can be used in conjunction with the BQ25756(E)EVM, BQ25792/8EVM, and BQ25713EVM to simulate Type-C and battery charger applications. When using the BQ EVM, check to make sure the J1 jumper on the TPS25751EVM is set to select power from VBAT instead of 730_PPHV. See Figure 4-1 for reference.

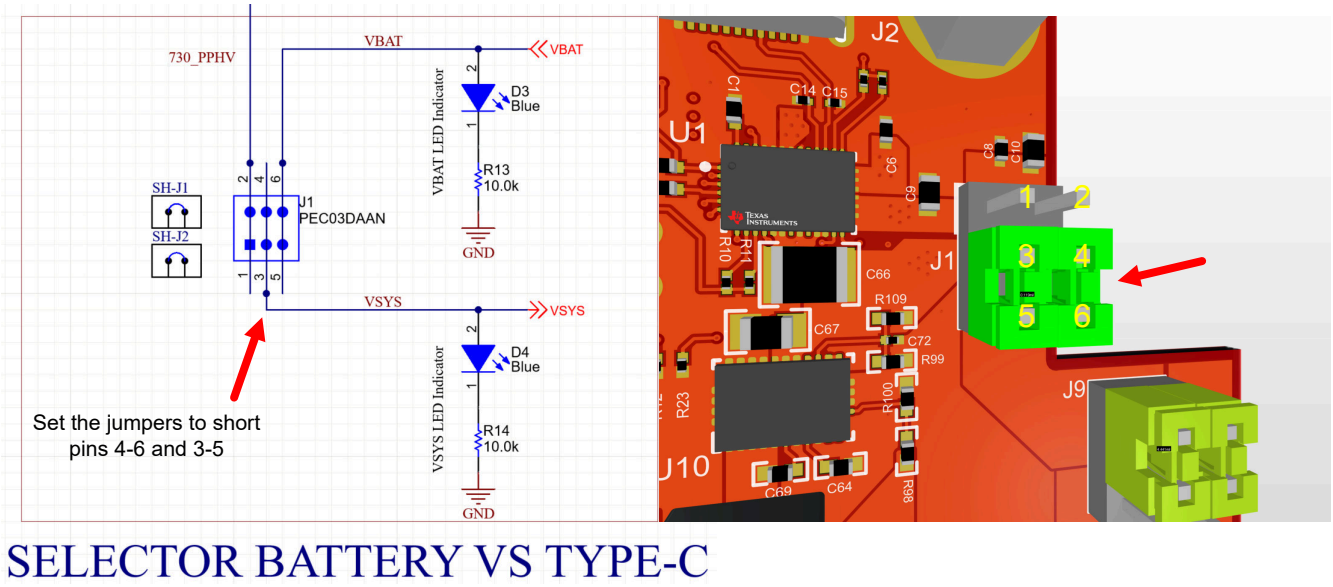


Figure 4-1. J1 Jumper for BQ Setups

When using the TPS25751EVM in conjunction with a BQ257xxEVM, plugging in the Type-C Power Adapter to J2 port is not a requirement. The BQ257xxEVM can supply power to the TPS25751EVM VSYS through VBAT.

Note

VBAT (TP19) and VSYS (TP4) has an absolute maximum rating of 48V. DO NOT apply more than 48V on VBAT or VSYS.

When using BQ257xxEVM with TPS25751EVM, refer to the specific BQ257xxEVM for jumper placements to configure battery cells. Incorrect settings of the BQ257xxEVM can result in a non-functioning setup, refer to the corresponding *Setting up with BQ257xxEVM* sections for further details.

4.2.1 Setting up with BQ25756(E)EVM

To use the TPS25751EVM and BQ25756EVM, the following items are needed:

1. TPS25751EVM
2. Ribbon cable (included with TPS25751EVM)
3. TPS25751EVM user's guide and application customization tool
4. BQ25756(E)EVM
5. BQ25756EVM user's guide and data sheet or BQ25756EEVM user's guide and data sheet
6. BQStudio with EV2400 [optional]
7. DC power supply or battery simulator

4.2.1.1 Hardware Setup with BQ25756(E)EVM

To setup the hardware, follow the instructions below:

1. Set the J1 jumper of TPS25751EVM to select VBAT for power, refer to Section 4.2 for details.
2. Connect the J7 mating connectors of the TPS25751EVM and the BQ25756(E)EVM together.
3. On the bottom side of the TPS25751EVM, attach the ribbon cable to J11 header as shown below.

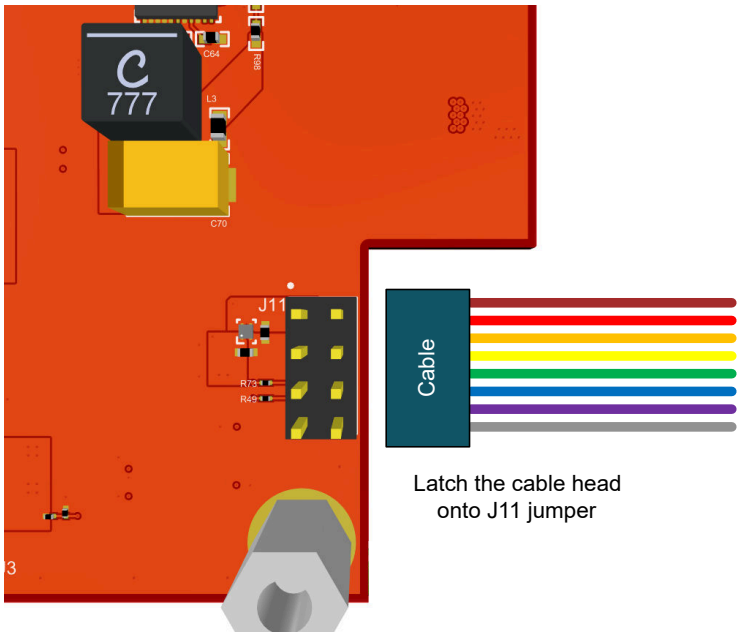


Figure 4-2. Ribbon Cable Connection to J11 header

4. Connect the other end of the ribbon cable to J8 header of the BQ25756(E)EVM. The complete setup is shown below.

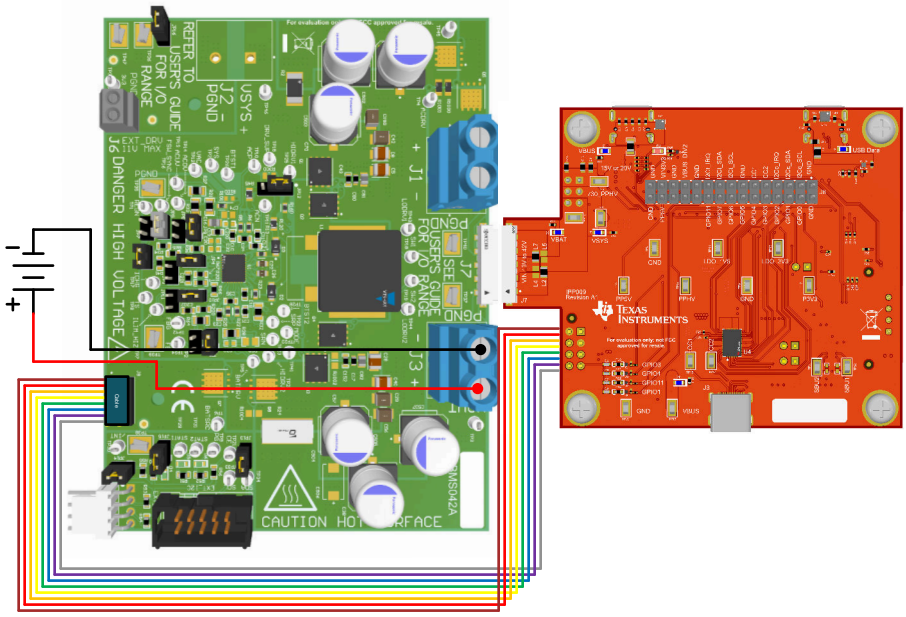


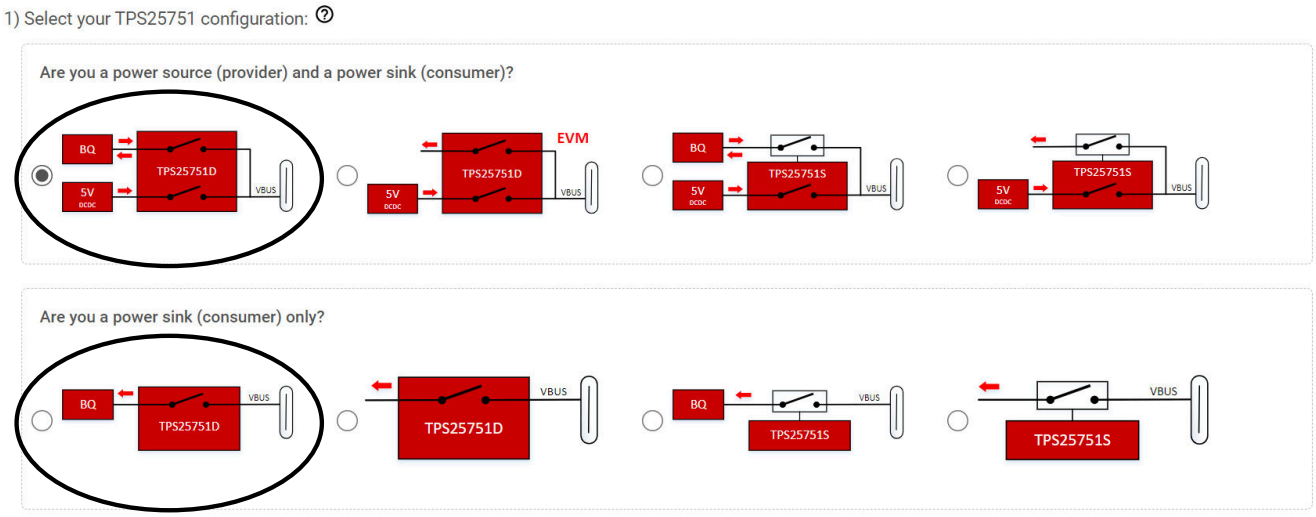
Figure 4-3. TPS25751EVM and BQ25756(E)EVM Hardware Setup

5. Refer to BQ25756EVM user's guide or BQ25756EEVM user's guide for setting the proper jumper for battery charging application. Incorrect jumper settings or insufficient input power can result in a faulty evaluation.

4.2.1.2 Software Setup with BQ25756(E)EVM

To setup the software configuration, follow the instructions below.

1. Open the Application Customization Tool and select one of the following TPS25751D + BQ configuration below.



2. Fill out the questionnaire from Q2 to Q10, refer to Section 3.3.3 for more details on each question configuration. All the questions must be filled out to flash/export.
3. Questions 11 through 18 are for Battery Charger (BQ) Configurations.
4. For Question 11, select BQ25756(E).
5. For Question 12, select the INDPM configuration for the BQ25756(E).
   a. For example, if the user selects "5% - INDPM is set to 5% above the negotiated PD Contract Current" and TPS25751 negotiates a PD contract at 3A, then the INDPM is set to 3.15A.
   b. This questionnaire configures register 0x06 - IAC_DPM of BQ25756(E).
6. For Question 13, select the VINDPM configuration for the BQ25756(E).
   a. For example, if the user selects "5% - VINDPM is set to 5% below the negotiated PD Contract Voltage" and TPS25751 negotiates a PD contract at 5V, the VINDPM is set to 4.75V.
   b. This questionnaire configures register 0x08 - VAC_DPM of BQ25756(E).
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 BQ25756(E).
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 BQ25756(E).
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 BQ25756(E).
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 BQ25756(E).
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 TPS25751 and set "Enable Dead Battery Clear [111]" to '1'.
    b. Upon boot-up from dead battery mode (TPS25751 receives power from VBUS first instead of VIN_3V3), TPS25751 reads register 0x33 - VBAT_ADC of BQ25756.
    c. If VBAT voltage is greater or higher than set threshold in Q18, then TPS25751 automatically clear the dead battery flag, otherwise the dead battery flag remains. Refer to the TPS25751 Technical Reference Manual for details.
12. Refer to Section 3.3.6 for flashing the configuration or exporting the binary.

4.2.2 Setting up with BQ25792/8EVM

To use the TPS25751EVM and BQ25792EVM, the following items are needed:

1. TPS25751EVM
2. Test hook clips jumper wires
3. TPS25751EVM User Guide and Application Customization Tool
4. BQ25792EVM or BQ25798EVM
5. BQ25792EVM user's guide and data sheet or BQ25798EVM user's guide and data sheet
6. BQStudio with EV2400 [optional]
7. DC Power Supply or Battery Simulator

4.2.2.1 Hardware Setup with BQ25792/8EVM

To setup the hardware, follow the instructions below:

1. Set the J1 jumper of TPS25751EVM to select VBAT for power. Refer to Section 4.2 for details.
2. Use the test hook clips/jumper wires to connect the two EVMs as shown below. See Table 4-1 for details.
3. Refer to BQ25792EVM user's guide or BQ25798EVM user's guide for setting the proper jumper for battery charging application. Incorrect jumper settings or insufficient input power can result in a faulty evaluation.

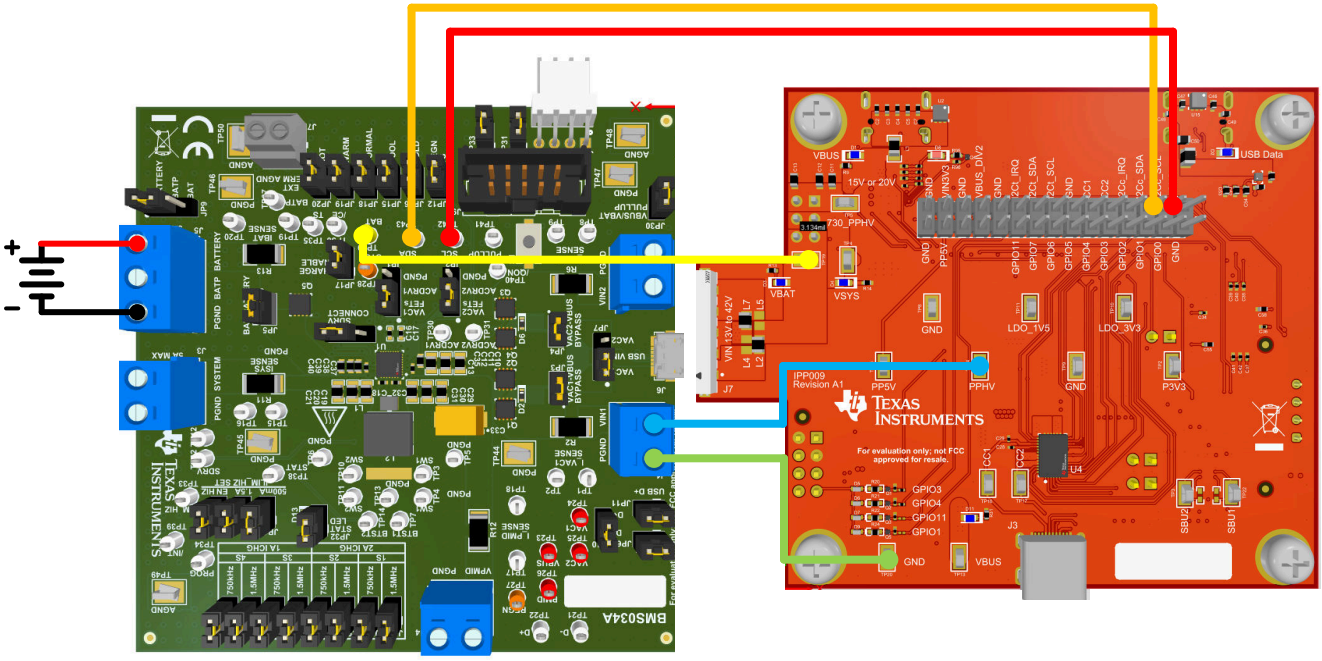


Figure 4-4. TPS25751EVM and BQ25792/8EVM Hardware Setup

Table 4-1. TPS25751EVM and BQ25792/8EVM Connections

Color Designator	TPS25751EVM Location	BQ25792/8EVM Locator
Red	I2Cc_SCL	TP42 - SCL
Orange	I2Cc_SDA	TP43 - SDA
Yellow	TP4 - VBAT	TP29 - BAT
Blue	TP14 - PPHV	J1 - VIN1
Green	GND	PGND

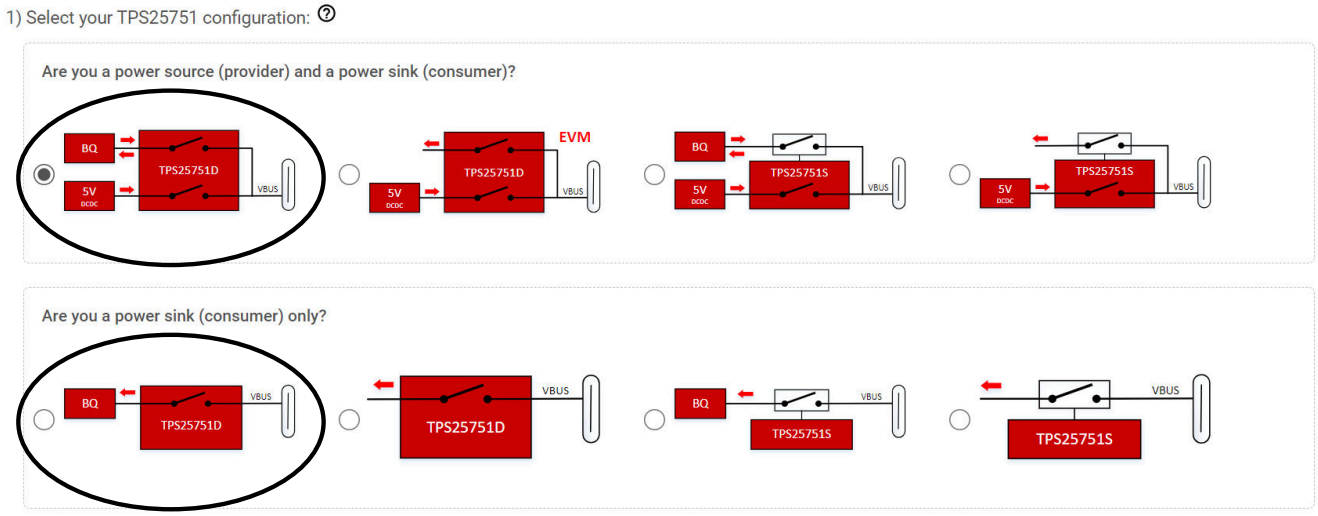
Note

VBAT, PPHV, and GND pins on TPS25751EVM draws significant current, so make sure the cables used to connect the EVMs are able to support high current (max 5A).

4.2.2.2 Software Setup with BQ25792/8EVM

To setup the software configuration, follow the instructions below.

1. Open the Application Customization Tool and select one of the following TPS25751D + BQ configurations below:



2. Fill out the questionnaire from Q2 to Q10, refer to Section 3.3.3 for more details on each question configuration. All the questions must be filled out to flash or export settings.
3. Questions 11 through 18 are for Battery Charger (BQ) Configurations.
4. For Question 11, select BQ25792/8.
5. For Question 12, select the INDPM configuration for the BQ25792/8EVM.
   a. For example, if the user selects "5% - INDPM is set to 5% above the negotiated PD Contract Current" and TPS25751 negotiates a PD contract at 3A, the INDPM is set to 3.15A.
   b. This questionnaire configures register 0x06 - IINDPM of BQ25792/8.
6. For Question 13, select the VINDPM configuration for the BQ25792/8EVM.
   a. For example, if the user selects "5% - VINDPM is set to 5% below the negotiated PD Contract Voltage" and TPS25751 negotiates a PD contract at 5V, the VINDPM is set to 4.75V.
   b. This questionnaire configures register 0x05 - VINDPM of BQ25792/8.
7. For question 14, enter the Charge Voltage in units of Voltage (3V through 18.8V, 10mV/bit).
   a. This questionnaire configures register 0x01 - VREG of BQ25792/8.
8. For question 15, enter the Charge Current in units of Ampere (0.05A through 5A, 10mA/bit)
   a. This questionnaire configures register 0x03 - ICHG of BQ25792/8.
9. For question 16, enter the Charge Termination Current Limit in units of Ampere (0.04A through 1A, 40mA/bit).
   a. This questionnaire configures register 0x09 - ITERM of BQ25792/8.
10. For question 17, enter the Precharge Current Limit in units of Ampere (0.04A through 2A, 40mA/bit)
    a. This questionnaire configures register 0x08 - IPRECHG of BQ25792/8.
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 TPS25751 and set "Enable Dead Battery Clear [111]" to '1'.
    b. Upon boot-up from dead battery mode (TPS25751 receives power from VBUS first instead of VIN_3V3), TPS25751 reads register 0x3B - ADC VBAT of BQ25792/8.
    c. If VBAT voltage is greater or higher than set threshold in Q18, TPS25751 automatically clear the dead battery flag, otherwise the dead battery flag remains. Refer to the TPS25751 Technical Reference Manual for details.
12. Refer to Section 3.3.6 for flashing the configuration or exporting the binary.

4.2.3 Setting up with BQ25713EVM

To use the TPS25751EVM and BQ25713EVM, the following items are needed:

1. TPS25751EVM
2. Test hook clips jumper wires
3. TPS25751EVM User Guide and Application Customization Tool
4. BQ25713EVM
5. BQ25713EVM user's guide and data sheet
6. BQStudio with EV2400 [optional]
7. DC Power Supply or Battery Simulator

4.2.3.1 Hardware Setup with BQ25713EVM

To setup the hardware, follow the instructions below.

1. Set the J1 jumper of TPS25751EVM to select VBAT for power. Refer to Section 4.2 for details.
2. Use the test hook clips/jumper wires to connect the two EVMs as shown below. See Figure 4-5 for details.
3. Refer to BQ25713EVM user's guide for setting the proper jumper for battery charging application. Incorrect jumper settings or insufficient power can result in a faulty evaluation.

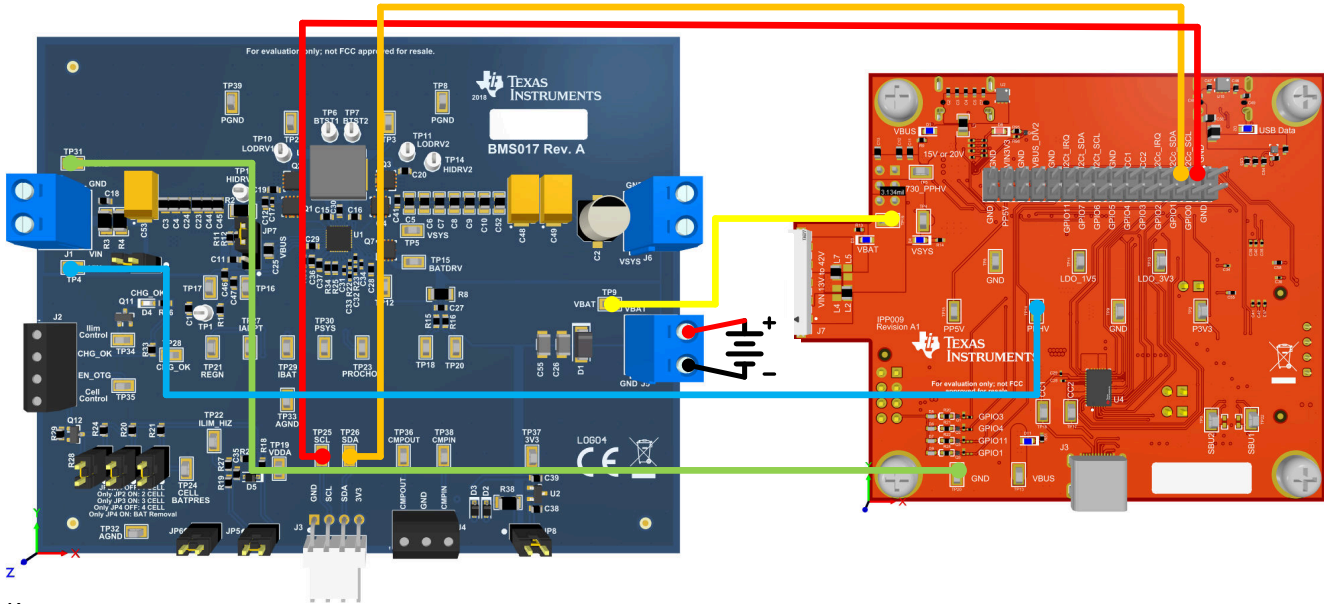


Figure 4-5. TPS25751EVM and BQ25713EVM Hardware Setup

Table 4-2. TPS25751EVM and BQ25713EVM Connections

Color Designator	TPS25751EVM Location	BQ25713EVM Locator
Red	I2Cc_SCL	TP25 - SCL
Orange	I2Cc_SDA	TP26 - SDA
Yellow	TP4 - VBAT	TP9 - BAT
Blue	TP14 - PPHV	J1 - VIN (TP4)
Green	GND	J1 - PGND (TP31)

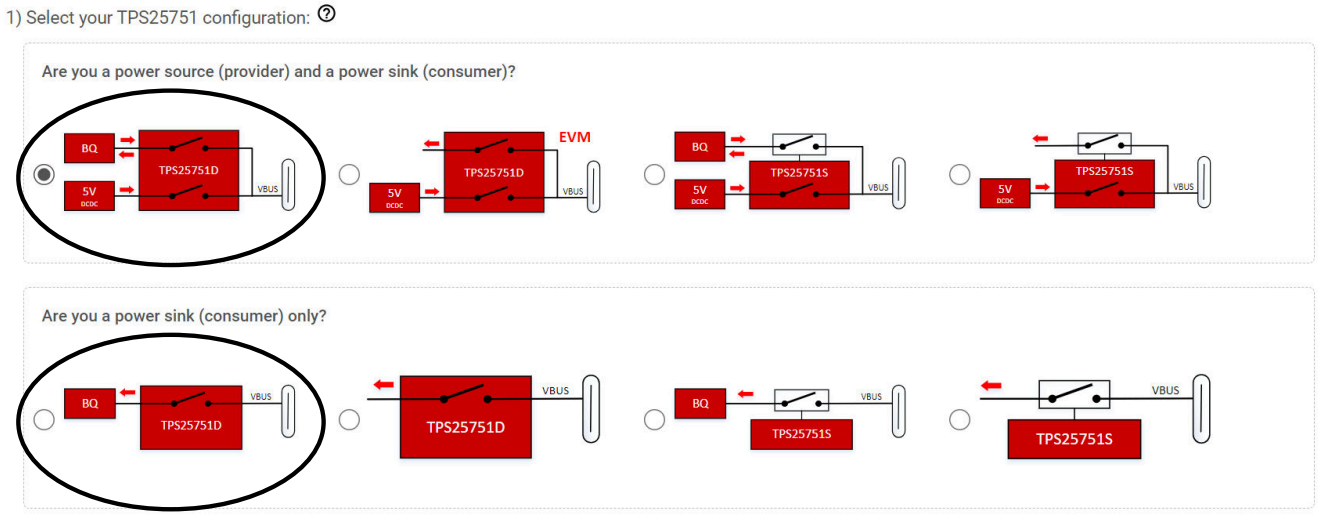
Note

VBAT, PPHV, and GND pins on TPS25751EVM draws significant current, so make sure the cables used to connect the EVMs are able to support high current (max 5A).

4.2.3.2 Software Setup with BQ25713EVM

To setup the software configuration, follow the instructions below:

1. Open the Application Customization Tool and select one of the following TPS25751D + BQ configurations below.



2. Fill out the questionnaire from Q2 to Q10, refer to Section 3.3.3 for more details on each question configuration. All the questions must be filled out to flash or export settings.
3. Questions 11 through 18 are for Battery Charger (BQ) Configurations.
4. For Question 11, select BQ25713.
5. For Question 12, select the INDPM configuration for the BQ25713.
   a. For example, if the user selects "5% - INDPM is set to 5% above the negotiated PD Contract Current" and TPS25751 negotiates a PD contract at 3A, the INDPM is set to 3.15A.
   b. This questionnaire configures register 0x0F - IIN_HOST of BQ25713.
6. For Question 13, select the VINDPM configuration for the BQ25713.
   a. For example, if the user selects "5% - VINDPM is set to 5% below the negotiated PD Contract Voltage" and TPS25751 negotiates a PD contract at 5V, the VINDPM is set to 4.75V.
   b. This questionnaire configures register 0x0B/0x0A - input voltage of BQ25713.
7. For question 14, enter the Charge Voltage in units of Voltage (1.024V through 19.2V, 8mV/bit).
   a. This questionnaire configures register 0x05/0x04 - Max Charge Voltage of BQ25713.
8. For question 15, enter the Charge Current in units of Ampere (0.05A through 5A, 10mA/bit)
   a. This questionnaire configures register 0x03/0x02 - Charge Current of BQ25713.
9. For question 16 and 17, BQ25713 does not have registers to configure the Charge Termination Current and Precharge Current. These fields are grayed out and do not accept any inputs.
10. 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 TPS25751 and set "Enable Dead Battery Clear [111]" to '1'.
    b. Upon boot-up from dead battery mode (TPS25751 receives power from VBUS first instead of VIN_3V3), TPS25751 reads register 0x2C - VBAT of BQ25713.
    c. If VBAT voltage is greater or higher than set threshold in Q18, then TPS25751 automatically clear the dead battery flag, otherwise the dead battery flag remains. Refer to the TPS25751 Technical Reference Manual for details.
11. Refer to Section 3.3.6 for flashing the configuration or exporting the binary.

4.3 Liquid Detection and Corrosion Mitigation Overview

TPS25751EVM supports Liquid Detection and Corrosion Mitigation to protect the system from unexpected shorts (liquid, moisture, debris) on the USB Type-C port. In the Liquid Detection state TPS25751 monitors the SBU lines for unexpected shorts to ground or high voltage (5V and above). TPS25751 supports Corrosion Mitigation by automatically disabling the Type-C port when a short is detected. When a short is no longer detected across the SBU pins, TPS25751 enters back into normal operation. Refer to the block diagram below of the hardware implementation, for hardware requirements refer to the TPS25751 data sheet.

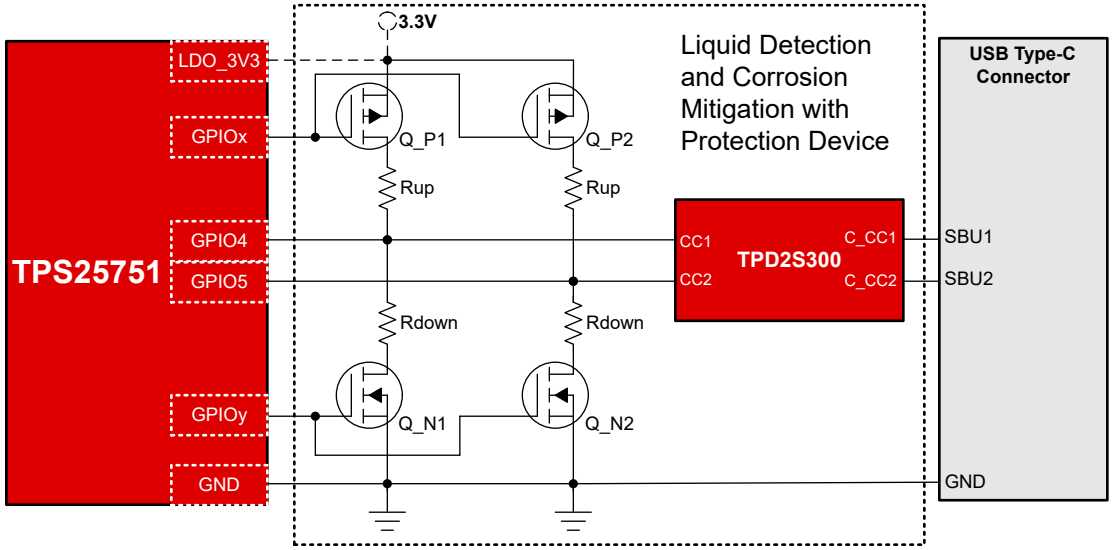


Figure 4-6. Liquid Detection/Corrosion Mitigation Setup

Note

Liquid Detection/Corrosion Mitigation and BC1.2 cannot be configured in the same system. Both applications utilizes GPIO4 and GPIO5 of TPS25751 for different functions.

4.3.1 Liquid Detection/Corrosion Mitigation Hardware Setup

Out of the box, the hardware on TPS25751EVM is set up for Liquid Detection/Corrosion Mitigation. R34 and R36 are populated to connect J3 Type-C SBU pins to TPS25751 GPIO4 and GPIO5 for liquid detection, R32 and R33 are not populated. TPD2S300 (U5) is in between TPS25751 and J3 Type-C port for protection in case of short to VBUS. Refer to Figure 4-7 and Figure 4-8 for location details.

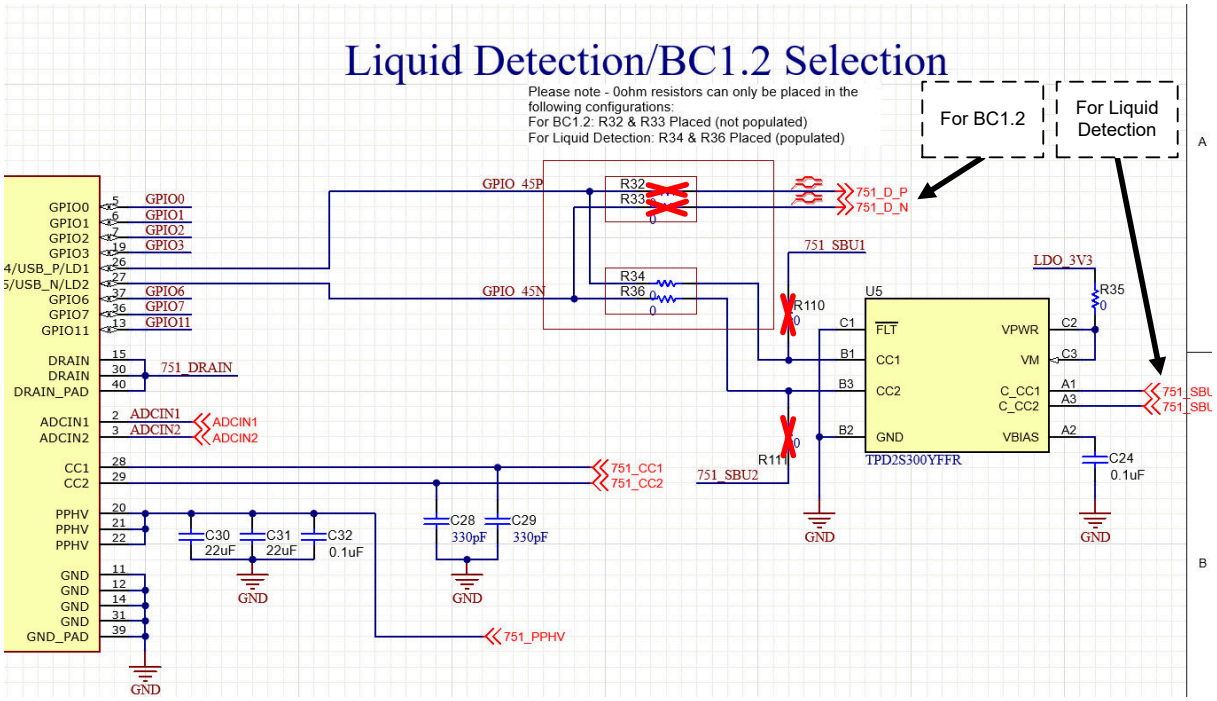


Figure 4-7. Liquid Detection Resistor Selection

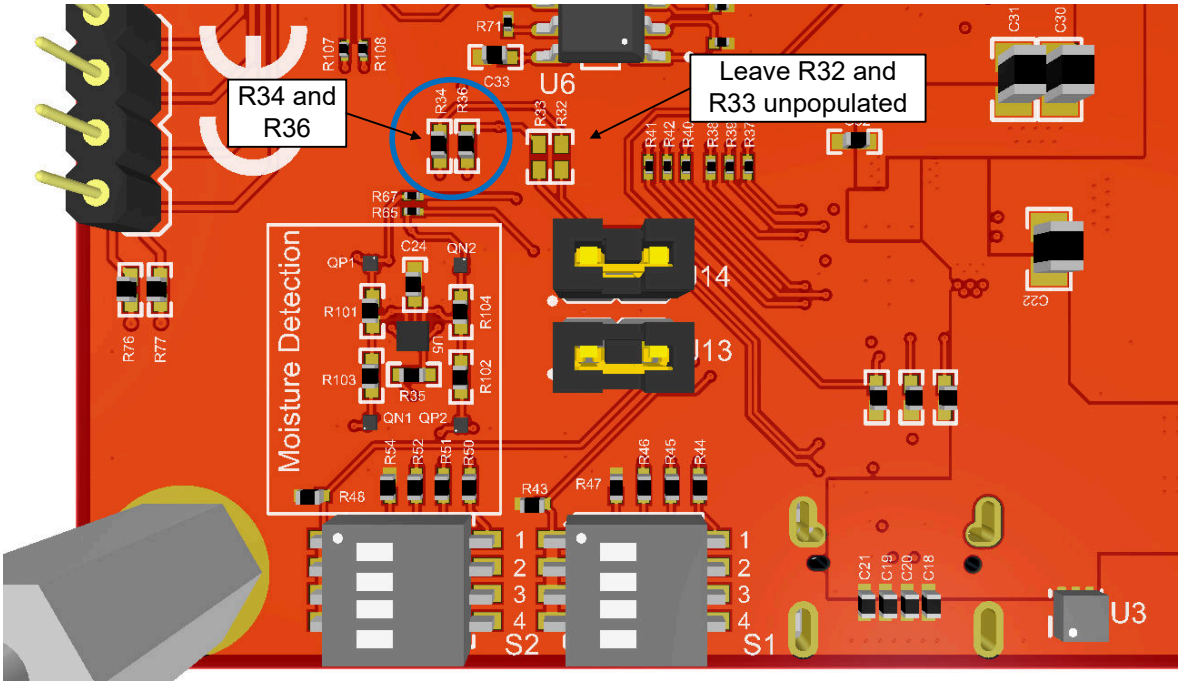


Figure 4-8. Liquid Detection Resistor Location

Note

Liquid Detection/Corrosion Mitigation and BC1.2 cannot be configured in the same system, so make sure R32/R33 and R34/R36 are not both populated at the same time.

On the TPS25751EVM 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, refer to Table 4-3 for details on specific test point and the configurability for custom designs. Refer to Section 4.3.2.

Table 4-3. 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 NFET (QN1 and QN2) to enable pull-down, when enabled PD is detecting short to VBUS/CC	Configurable for custom designs
GPIO7	Connected to PFET (QP1 and QP2) to enable pull-up, when enabled PD is detecting short to GND	Configurable for custom designs
GPIO1	Connected to D9 LED to indicate if liquid is detected at J3 Type-C port	Configurable for custom designs

4.3.2 Liquid Detection/Corrosion Mitigation Software Setup

To setup Liquid Detection/Corrosion Mitigation software, follow the instructions below:

1. Open the Application Customization Tool and fill out the questionnaire, refer to Section 3.3.3 for more details on each question configuration.
2. For Question 8, select *Yes*. Selecting *Yes* enables key registers and fields hidden in Advanced Configuration, the default Liquid Detection configuration is shown below:

Table 4-4. Liquid Detection/Corrosion Mitigation Default Configuration

Register	Field	Description
Interrupt Mask for I2C1 (0x16)	Liquid Detection [60]	Enable interrupt event for "Liquid Detection [60]"
IO Config (0x5c)	GPIO_1	Set to "LIQUID_DETECTED (157)". When liquid is detected at J3 Type-C port, GPIO1 toggles D9 LED high until liquid is no longer present
IO Config (0x5c)	GPIO_4	Set to "Pin multiplexed to ADC" for detecting liquid on SBU1
IO Config (0x5c)	GPIO_5	Set to "Pin multiplexed to ADC" for detecting liquid on SBU2
IO Config (0x5c)	GPIO_6	Set to "LIQUID_PMOS_CONTROL (155)". GPIO6 is used to toggle the PFET to enable pull-up to detect short to VBUS/CC
IO Config (0x5c)	GPIO_7	Set to "LIQUID_NMOS_CONTROL (156)". GPIO7 is used to toggle the NFET to enable pull-up to detect short to GND
Liquid Detection Config (0x98)	Enable Corrosion Mitigation [81]	Enable feature to automatically disable Type-C port if liquid is detected
Liquid Detection Config (0x98)	Enable Liquid Detection [82]	Enable feature to detect liquid at Type-C port

3. Refer to Section 3.3.4 to make additional configuration changed by enabling Advanced Configuration.
4. Refer to TPS25751data sheet and TPS25751 Technical Reference Manual for in-depth details of each registers and the fields.

5 Hardware Design Files

5.1 Schematics

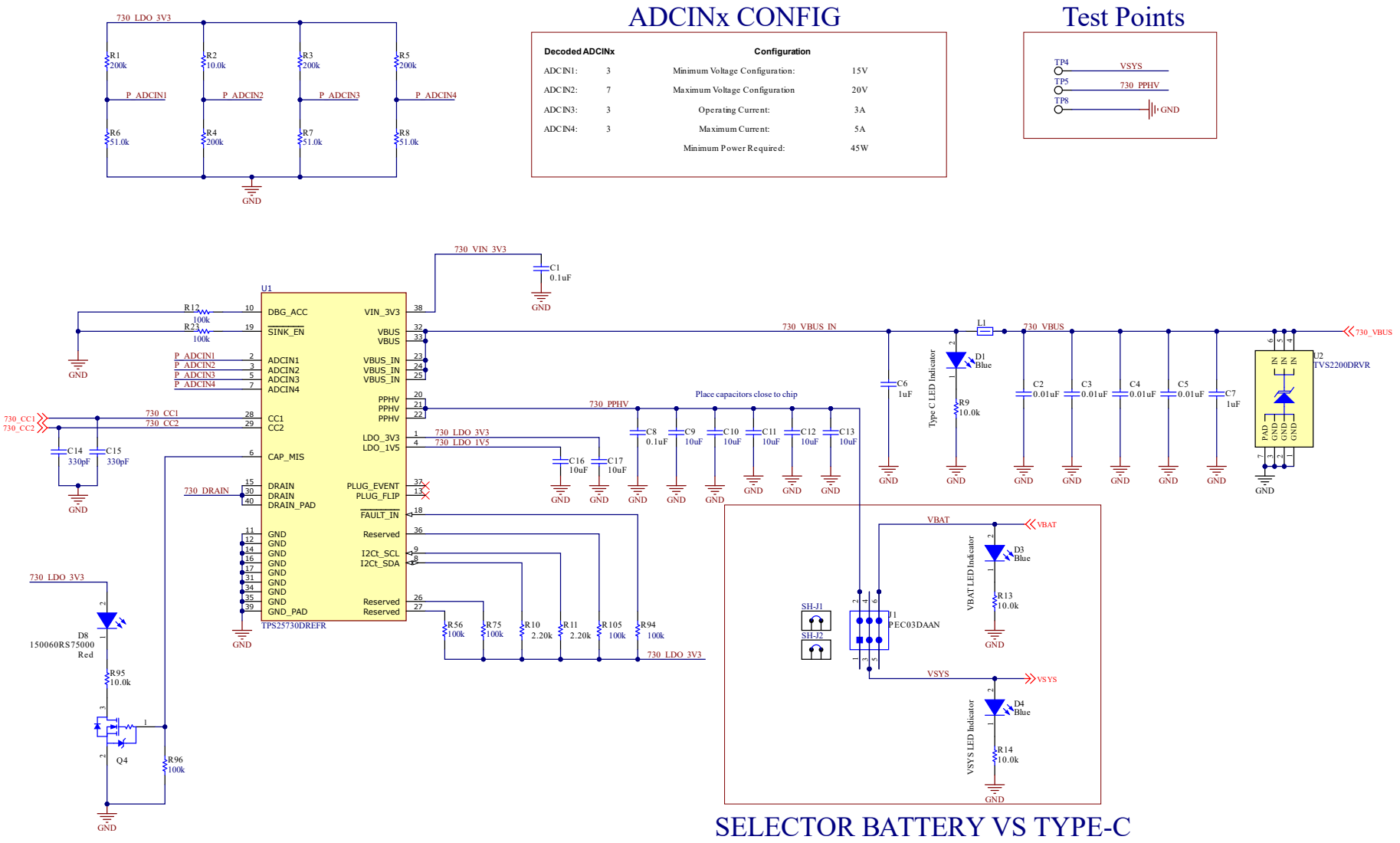


Figure 5-1. TPS25730 Power Input Schematic

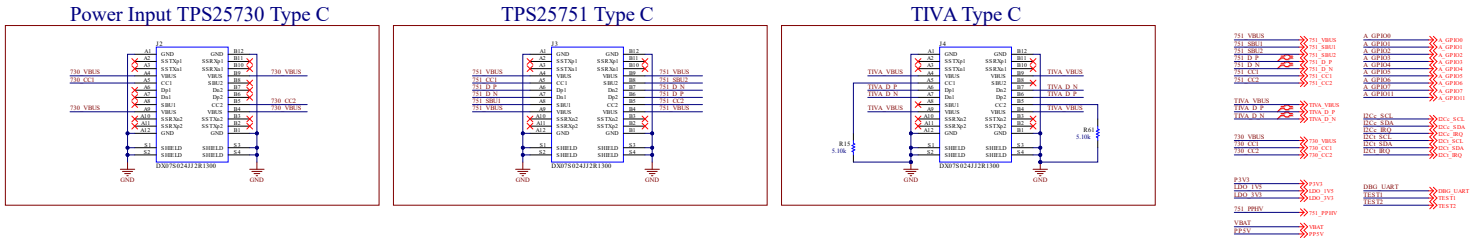


Figure 5-2. Type-C Connectors Schematic

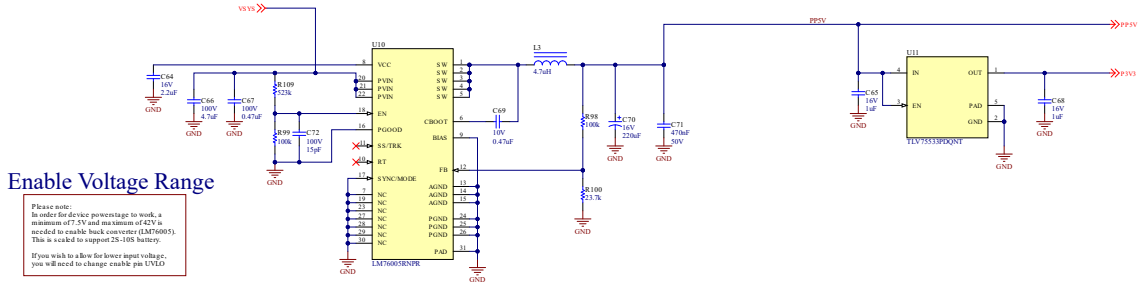


Figure 5-3. Power Stage Schematic

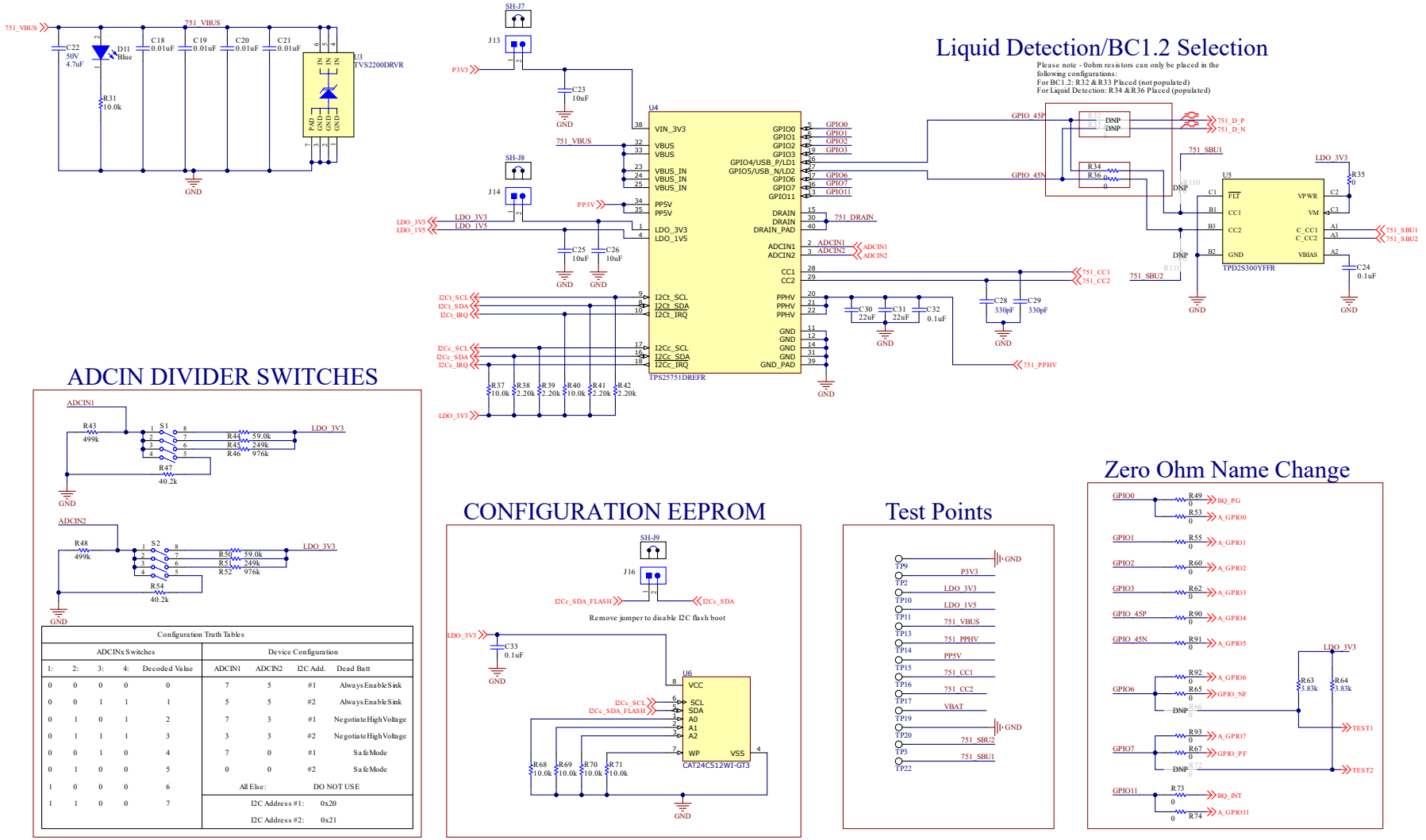


Figure 5-4. TPS25751 Schematic

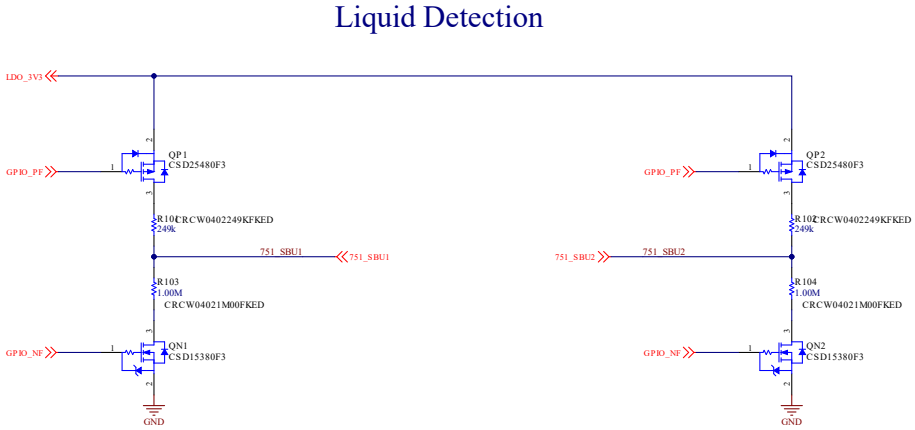


Figure 5-5. Liquid Detection Schematic

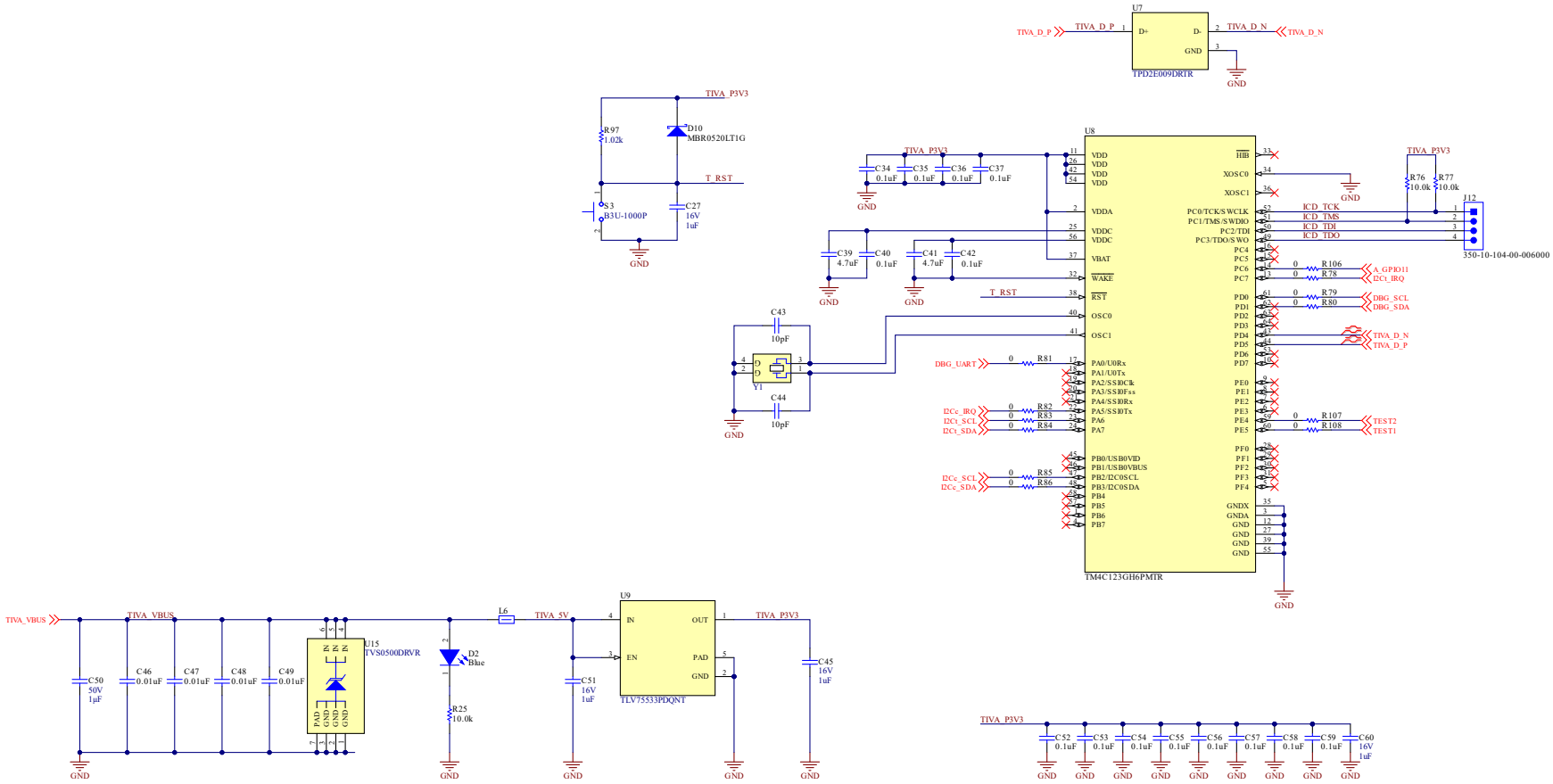


Figure 5-6. TIVA Schematic

5.2 PCB Layouts

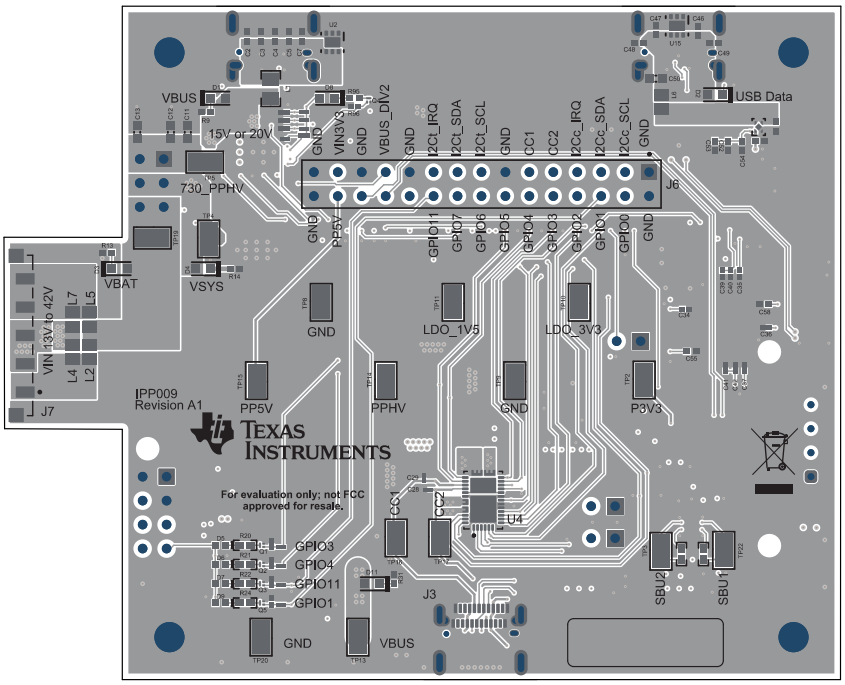


Figure 5-7. TPS25751EVM Top Layer Composite View

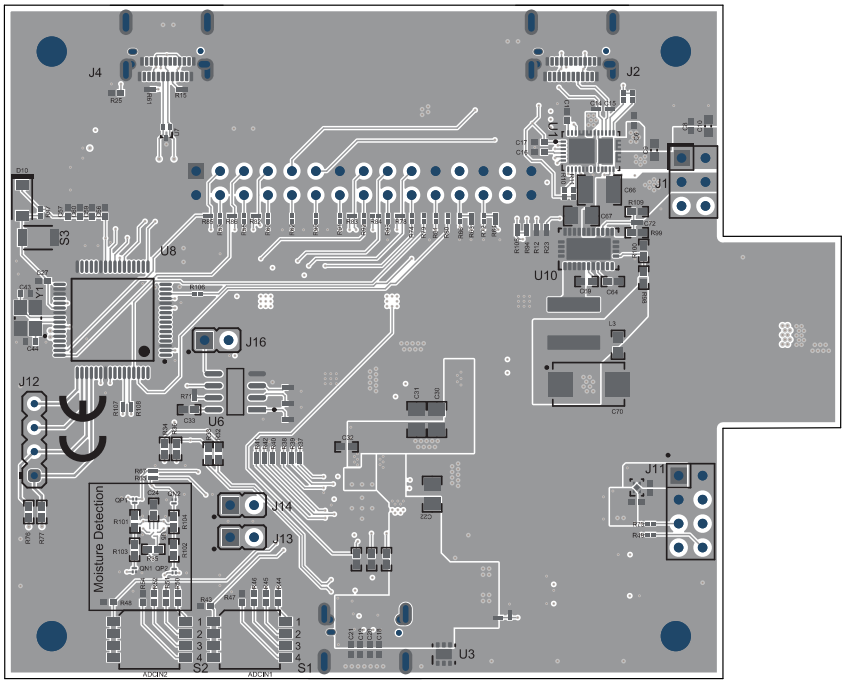


Figure 5-8. TPS25751EVM Bottom Layer Composite View

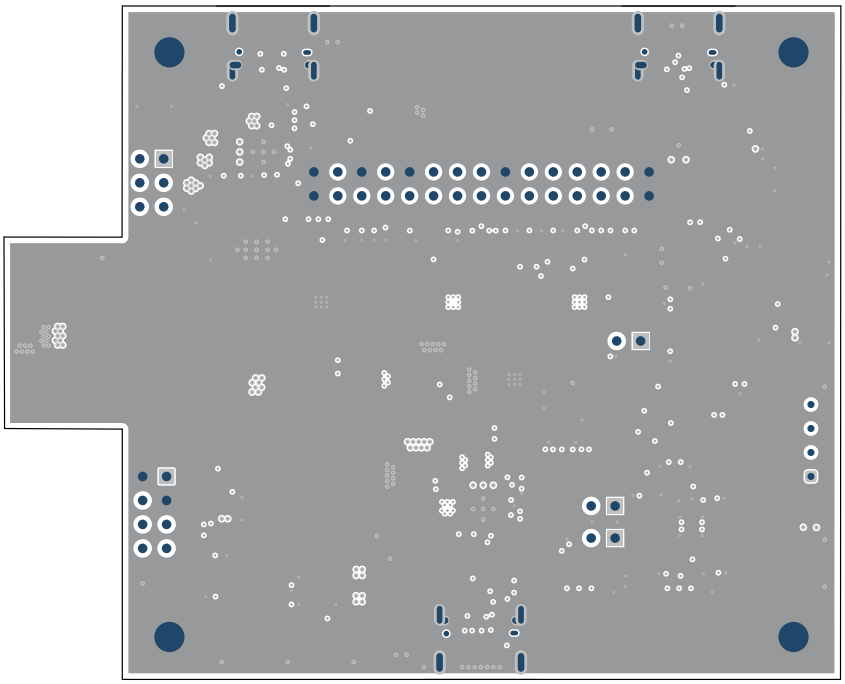


Figure 5-9. TPS25751EVM Ground Layer

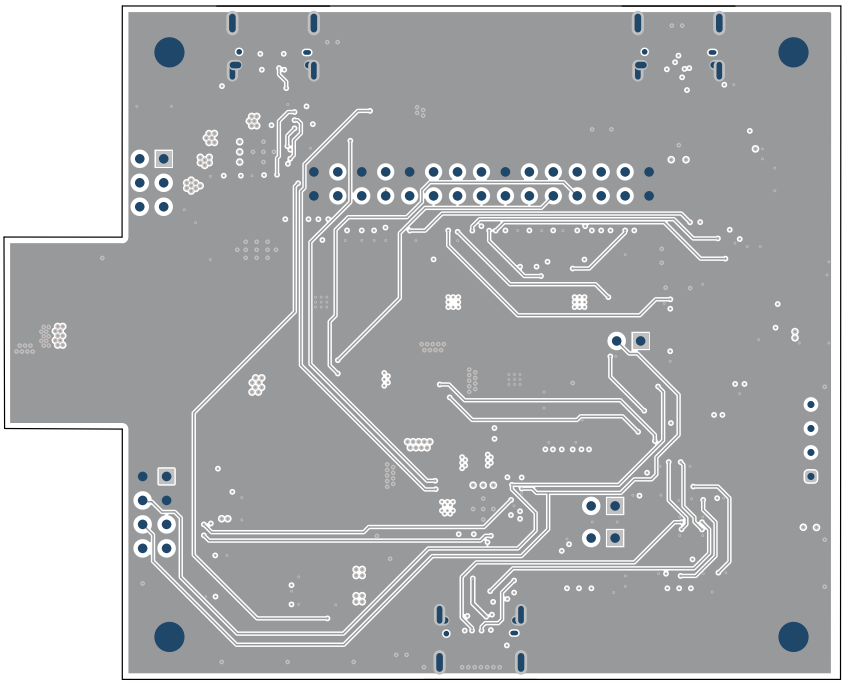


Figure 5-10. TPS25751EVM Signal Layer

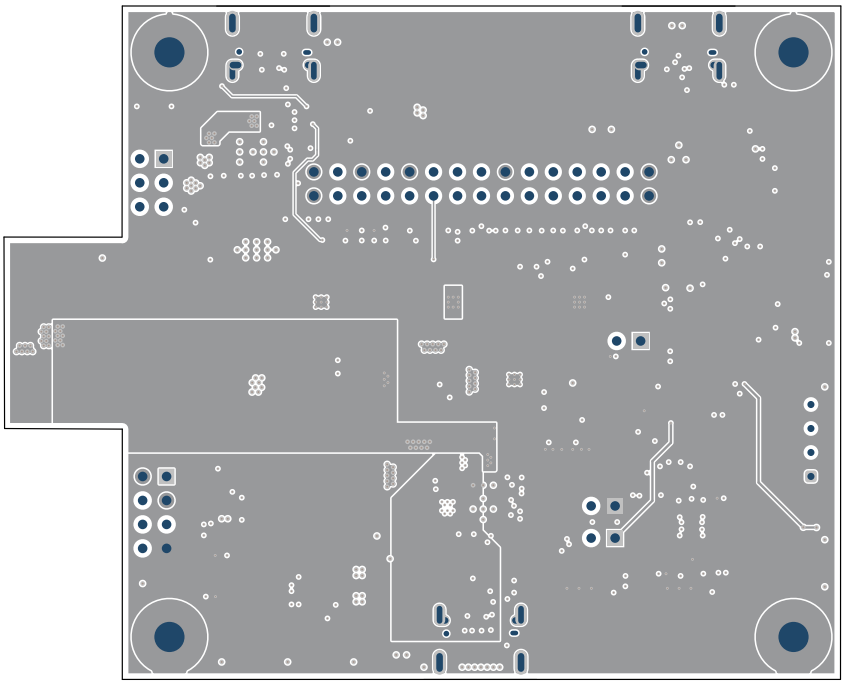


Figure 5-11. TPS25751EVM Power1 Layer

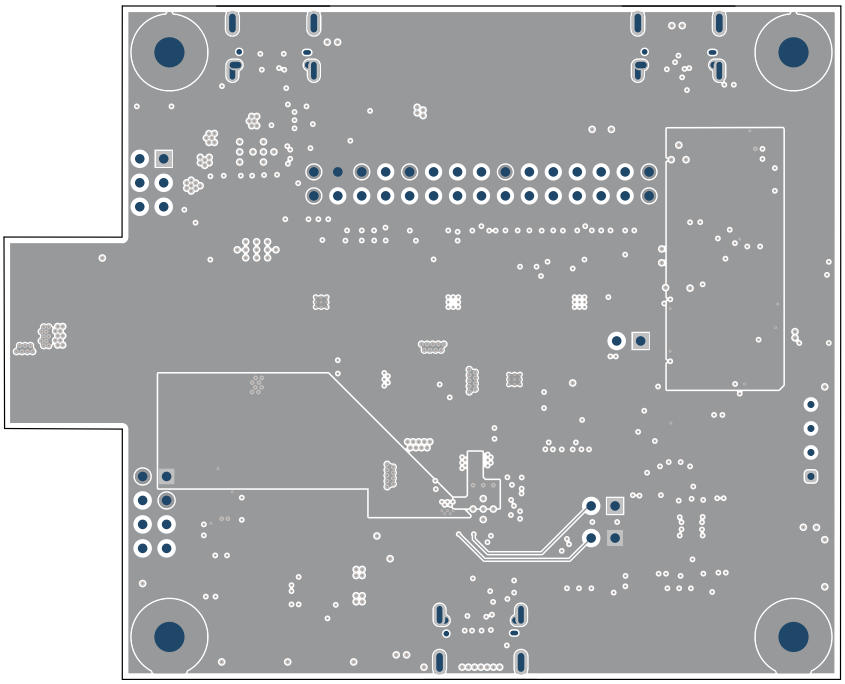


Figure 5-12. TPS25751EVM Power 2 Layer

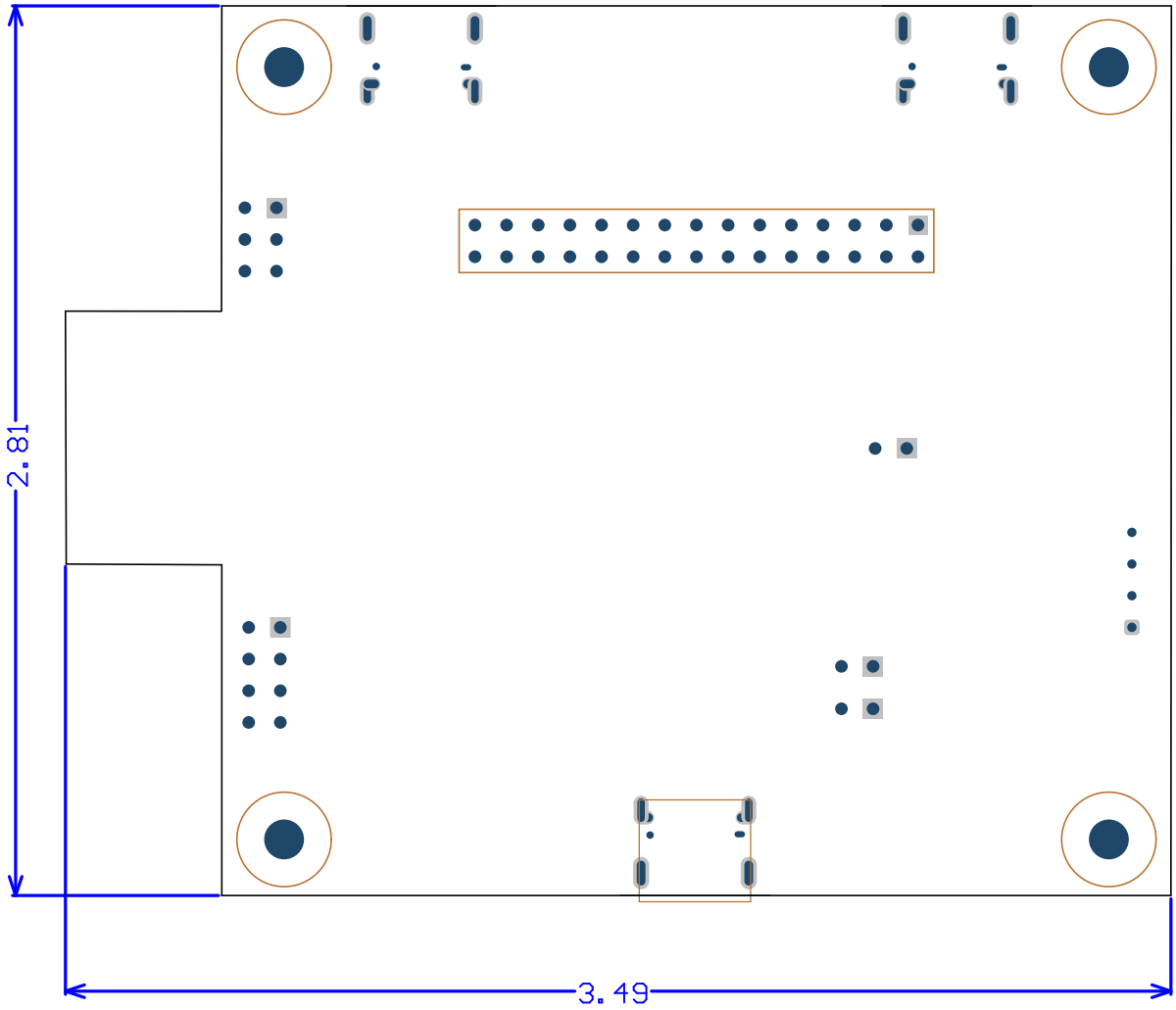


Figure 5-13. TPS25751EVM Board Dimensions

5.3 Bill of Materials (BOM)

Table 5-1 lists the bill of materials for TPS25751EVM.

Table 5-1. Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
!PCB1	1		Printed Circuit Board		IPP009	Any		
C1, C8, C24, C32, C33	5	0.1uF	CAP, CERM, 0.1uF, 35V, +/- 10%, X5R, 0402	0402	GMK105BJ104KV-F	Taiyo Yuden		
C2, C3, C4, C5, C18, C19, C20, C21, C46, C47, C48, C49	12	0.01uF	CAP, CERM, 0.01uF, 50V, +/- 5%, X7R, 0402	0402	C0402C103J5RACTU	Kemet		
C6, C7	2	1uF	CAP, CERM, 1uF, 35V, +/- 10%, X5R, 0402	0402	GRM155R6YA105KE11D	MuRata		
C9, C10, C11, C12, C13	5	10uF	CAP, CERM, 10uF, 35V, +/- 20%, X5R, 0603	0603	GRM188R6YA106MA73D	Murata		
C14, C15, C28, C29	4	330pF	CAP, CERM, 330pF, 50V, +/- 10%, X7R, AEC-Q200 Grade 1, 0201	0201	CGA1A2X7R1H331K030BA	TDK		
C16, C17, C23, C25, C26	5	10uF	CAP, CERM, 10uF, 10V, +/- 20%, X5R, 0402	0402	CL05A106MP5NUNC	Samsung Electro-Mechanics		
C22	1	4.7uF	CAP, CERM, 4.7uF, 50V, +/- 10%, X5R, 0805	0805	C2012X5R1H475K125AB	TDK		
C27, C45, C51, C60, C65, C68	6	1uF	CAP, CERM, 1uF, 16V, +/- 10%, X6S, 0402	0402	C1005X6S1C105K050BC	TDK		
C30, C31	2	22uF	CAP, CERM, 22uF, 35V, +/- 20%, X5R, 0805	0805	C2012X5R1V226M125AC	TDK		
C34, C35, C36, C37, C40, C42	6	0.1uF	CAP, CERM, 0.1uF, 10V, +/- 10%, X5R, 0201	0201	CL03A104KP3NNNC	Samsung Electro-Mechanics		
C39, C41	2	4.7uF	CAP, CERM, 4.7uF, 6.3V, +/- 20%, X5R, 0201	0201	GRM035R60J475ME15D	MuRata		
C43, C44	2	10pF	CAP, CERM, 10pF, 16V,+/- 10%, C0G, 0402	0402	C0402C100K4GACTU	Kemet		
C50	1	1uF	CAP, CERM, 1µF, 50V,+/- 20%, X5R, AEC-Q200 Grade 3, 0603	0603	CGA3E3X5R1H105M080AB	TDK		
C52, C53, C54, C55, C56, C57, C58, C59	8	0.1uF	CAP, CERM, 0.1uF, 50V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402	0402	CGA2B3X7R1H104K050BB	TDK		
C64	1	2.2uF	CAP, CERM, 2.2uF, 16V, +/- 10%, X6S, 0402	0402	C1005X6S1C225K050BC	TDK		

Table 5-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
C66	1	4.7uF	CAP, CERM, 4.7uF, 100V, +/- 10%, X7S, 1210	1210	C3225X7S2A475K200AE	TDK		
C67	1	0.47uF	CAP, CERM, 0.47uF, 100V, +/- 10%, X7S, 0805	0805	C2012X7S2A474K125AB	TDK		
C69	1	0.47uF	CAP, CERM, 0.47uF, 10V, +/- 10%, X5R, 0402	0402	GRM155R61A474KE15D	MuRata		
C70	1	220uF	CAP, TA, 220uF, 16V, +/- 20%, 0.1 ohm, SMD	7343-43	TPSE227M016R0100	AVX		
C71	1	0.47uF	CAP, CERM, 0.47uF, 50V, +/- 10%, X7R, 0603	0603	C1608X7R1H474K080AC	TDK		
C72	1	15pF	CAP, CERM, 15pF, 100V,+/- 5%, C0G/NP0, 0201	0201	GRM0335C2A150JA01D	MuRata		
D1, D2, D3, D4, D11	5	Blue	LED, Blue, SMD	LED_0603	150060BS75000	Wurth Elektronik		
D5, D6, D7, D9	4	White	LED, White, SMD	0402, White	LW QH8G-Q2S2-3K5L-1	OSRAM		
D8	1	Red	LED, Red, SMD	LED_0603	150060RS75000	Wurth Elektronik		
D10	1	20V	Diode, Schottky, 20V, 0.5A, SOD-123	SOD-123	MBR0520LT1G	ON Semiconductor		
H2, H3, H4, H5	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply		
H7, H8, H10, H11	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone		
J1	1		Header, 100mil, 3x2, Tin, TH	3x2 Header	PEC03DAAN	Sullins Connector Solutions		
J2, J3, J4	3		Receptacle, USB 3.1 Type C, R/A, Gold, SMT	Receptacle, USB 3.1 Type C, R/A, SMT	DX07S024JJ2R1300	JAE Electronics		
J6	1		Header, 100mil, 15x2, Gold, TH	TH, 30-Leads, Body 1500x200mil, Pitch 100mil	TSW-115-08-L-D	Samtec		
J7	1			CONN_SSL_SOCKET5	2.09159E+14	KYOCERA AVX		
J11	1		Header, 100mil, 4x2, Gold, TH	4x2 Header	TSW-104-07-G-D	Samtec		
J12	1		Header, 2.54mm, 4x1, Gold, TH	Header, 2.54mm, 4x1, TH	350-10-104-00-006000	Mill-Max		
J13, J14, J16	3		Header, 100mil, 2x1, Gold, TH	Sullins 100mil, 1x2, 230 mil above insulator	PBC02SAAN	Sullins Connector Solutions		

Table 5-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
L1, L6	2	22 ohm	Ferrite Bead, 22 ohm @ 100MHz, 6A, 0805	0805	742792021	Wurth Elektronik		
L3	1	4.7uH	Inductor, Shielded, Composite, 4.7µH, 10.5A, 0.0144 ohm, AEC-Q200 Grade 1, SMD	IND_6.4x6.1x6.6	XAL6060-472MEB	Coilcraft		
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady		
Q1, Q2, Q3, Q4, Q5, QN1, QN2	7	20V	MOSFET, N-CH, 20V, 0.5A, YJM0003A (PICOSTAR-3)	YJM0003A	CSD15380F3	Texas Instruments		None
QP1, QP2	2	-20V	MOSFET, P-CH, -20 V, -1.7 A, YJM0003A (PICOSTAR-3)	YJM0003A	CSD25480F3	Texas Instruments		None
R1, R3, R4, R5	4	200k	RES, 200 k, 1%, 0.05 W, 0201	0201	CRCW0201200KFKED	Vishay-Dale		
R2, R6, R7, R8	4	51.0k	RES, 51.0 k, 1%, 0.05 W, 0201	0201	RC0201FR-0751KL	Yageo America		
R9, R13, R14, R25, R31, R76, R77, R95	8	10.0k	RES, 10.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040210K0FKED	Vishay-Dale		
R10, R11, R38, R39, R41, R42	6	2.20k	RES, 2.20 k, 1%, 0.05 W, 0201	0201	CRCW02012K20FKED	Vishay-Dale		
R12, R23, R56, R75, R94, R96, R105	7	100k	RES, 100 k, 1%, 0.05 W, 0201	0201	RC0201FS-7D100KL	Yageo America		
R15, R61	2	5.10k	RES, 5.10 k, 1%, 0.05 W, 0201	0201	RC0201FR-075K1L	Yageo America		
R16, R17, R18, R19	4	100k	RES, 100 k, 1%, 0.05 W, 0201	0201	RC0201FR-7D100KL	Yageo America		
R20, R21, R22, R24	4	10.0k	RES, 10.0 k, 1%, 0.063 W, 0402	0402	RC0402FR-0710KL	Yageo America		
R26, R27, R28, R30	4	10.0k	RES, 10.0 k, 1%, 0.05 W, 0201	0201	RC0201FR-0710KL	Yageo America		
R29, R49, R55, R60, R62, R65, R67, R73, R78, R79, R80, R81, R82, R83, R84, R85, R86, R87, R106, R107, R108	21	0	RES, 0, 5%, 0.05 W, 0201	0201	CRCW02010000Z0ED	Vishay-Dale		
R34, R35, R36	3	0	RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04020000Z0ED	Vishay-Dale		

Table 5-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
R37, R40, R68, R69, R70, R71	6	10.0k	RES, 10.0 k, 1%, 0.05 W, 0201	0201	CRCW020110K0FKED	Vishay-Dale		
R43, R48	2	499k	RES, 499 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402499KFKED	Vishay-Dale		
R44, R50	2	59.0k	RES, 59.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040259K0FKED	Vishay-Dale		
R45, R51, R101, R102	4	249k	RES, 249 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402249KFKED	Vishay-Dale		
R46, R52	2	976k	RES, 976 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402976KFKED	Vishay-Dale		
R47, R54	2	40.2k	RES, 40.2 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040240K2FKED	Vishay-Dale		
R63, R64	2	3.83k	RES, 3.83 k, 1%, 0.05 W, 0201	0201	CRCW02013K83FKED	Vishay-Dale		
R97	1	1.02k	RES, 1.02 k, 1%, 0.05 W, 0201	0201	RC0201FR-071K02L	Yageo America		
R98, R99	2	100k	RES, 100 k, 1%, 0.063 W, 0402	0402	CRCW0402100KFKED	Vishay-Dale		
R100	1	23.7k	RES, 23.7 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2RKF2372X	Panasonic		
R103, R104	2	1.00Meg	RES, 1.00M, 1%, 0.063W, AEC-Q200 Grade 0, 0402	0402	CRCW04021M00FKED	Vishay-Dale		
R109	1	523k	RES, 523 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402523KFKED	Vishay-Dale		
S1, S2	2		DIP Switch, SPST 4Pos, Slide, SMT	6.2x2.0x6.2mm	TDA04H0SB1	C&K Components		
S3	1		SWITCH TACTILE SPST-NO 0.05A 12V	3x1.6x2.5mm	B3U-1000P	Omron Electronic Components		
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J9	9	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec	969102-0000-DA	3M
TP2, TP3, TP4, TP5, TP8, TP9, TP10, TP11, TP13, TP14, TP15, TP16, TP17, TP19, TP20, TP22	16		Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone		

Table 5-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
U1	1		USB Type-C and USB PD Controller with Integrated Power Switches Optimized for Power Applications	WQFN38	TPS25730DRJKR	Texas Instruments		
U2, U3	2		22V Precision Surge Protection Clamp, DRV0006A (WSON-6)	DRV0006A	TVS2200DRVR	Texas Instruments		Texas Instruments
U4	1		USB Type-C and USB PD Controller with Integrated Power Switches Optimized for Power Applications	WQFN38	TPS25751DREFR	Texas Instruments		
U5	1		USB Type C Short-to-VBus and IEC ESD Protector for CC, YFF0009AJAJ (DSBGA-9)	YFF0009AJAJ	TPD2S300YFFR	Texas Instruments		Texas Instruments
U6	1		EEPROM Memory IC 512Kb (64K x 8) I²C 1MHz 900ns 8-SOIC	SOIC8	CAT24C512WI-GT3	ON Semi		
U7	1		ESD Protection Array for High-Speed Data Interfaces, 2 Channels, -40 to +85 degC, 3-pin SOT (DRT), Green (RoHS & no Sb/Br)	DRT0003A	TPD2E009DRTR	Texas Instruments		
U8	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	PM0064A	TM4C123GH6PMTR	Texas Instruments		
U9, U11	2		500mA, Low IQ, Small Size, Low Dropout Regulator, DQN0004A (X2SON-4)	DQN0004A	TLV75533PDQNT	Texas Instruments	TLV75533PDQNR	Texas Instruments
U10	1		3.5V to 60V 5A Synchronous Step-Down Voltage Regulator, RNP0030A (WQFN-30)	RNP0030A	LM76005RNPR	Texas Instruments		Texas Instruments
U15	1		5V Precision Surge Protection Clamp, DRV0006A (WSON-6)	DRV0006A	TVS0500DRVR	Texas Instruments		Texas Instruments
Y1	1		Crystal, 16MHz, 8pF, SMD	3.2x0.75x2.5mm	NX3225GA-16.000M-STD-CRG-1	NDK		
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A		
R32, R33, R110, R111	0	0	RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04020000Z0ED	Vishay-Dale		

Table 5-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
R53, R66, R72, R74, R88, R89, R90, R91, R92, R93	0	0	RES, 0, 5%, 0.05 W, 0201	0201	CRCW02010000Z0ED	Vishay-Dale		
R57, R58, R59	0	10.0k	RES, 10.0 k, 1%, 0.05 W, 0201	0201	CRCW020110K0FKED	Vishay-Dale		

6 Additional Information

6.1 Trademarks

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USB Type-C® and USB-C® are registered trademarks of USB Implementers Forum.
Firefox® is a registered trademark of Mozilla Foundation.
Safari ® is a registered trademark of Apple Inc.
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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 y 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

6.5.1 Documentation Support

- USB Power Delivery Specification
- USB-PD Specifications
- USB Type-C Cable and Connector Specifications
- USB Document Library
- USB Power Delivery - Compliance Reports

6.6 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on 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.

7 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision * (November 2023) to Revision A (March 2024)	Page
• Added details for supported BQ devices, removed BQ25731, and changed *Moisture* to *Liquid* based on Type-C Specifications	1
• Changed *Moisture Detection* to *Liquid Detection* based on updated Type-C terminology	4
• Included links for each supported Battery Charger product. Removed BQ25731	4
• Added note for maximum rating on VSYS (TP4)	5
• Added J6 header picture and updated pinout definitions	5
• Added image for jumper locations	7
• Updated LED D6 from GPIO4 to GPIO2 to reflect EVM hardware design	8
• Updated the terminology *moisture detection* to *liquid detection* for SBU1/2 description	8
• Added *Application Specific Use Case* section	23
• Updated *Hardware Setup with BQ25756(E)EVM* image	24
• Added step 11 instructions	25
• Updated *Hardware Setup with BQ25792/8EVM* image and added a note	26
• Added step 11 instructions	27
• Added *Liquid Detection and Corrosion Mitigation Overview* section	30
• Updated schematic design	33
• Updated PCB design	39
• Updated *Bill of Materials* table to reflect RevA1 EVM	43

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 semiconductors 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 DEGREDATION 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/lsds/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.

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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。

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東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/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.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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