User's Guide
SLVUBO9A–April 2019–Revised March 2020

TPS65987 Evaluation Module

This document is the user guide for the TPS65987 Evaluation Module (TPS65987EVM). The TPS65987EVM allows for evaluation of the TPS65987 IC as part of a stand-alone testing kit for development and testing of USB Type-C and Power Delivery (PD) end products. Out of the box, the TPS65987EVM is configured to emulate a single port laptop computer. The TP65987EVM also contains a TPD6S300A device for protection.

Contents

1 Introduction 2
2 Setup 4
3 Using the TPS65987EVM 7
4 Schematic and Bill of Materials 8

List of Figures

1 TPS65987EVM Board 2
2 TPS65987EVM Block Level Diagram 3
3 Power Path Jumper Configuration for Source or Sink 4
4 USB Type-C™ and External Module Connectors 8
5 FTDI Device and Connector 9
6 USB PD Controller and Memory 10
7 USB PD Power Paths 11
8 Variable DC/DC Controller 12
9 Buck and Boost DC/DC Convertors 13

List of Tables

1 Jumper Configuration 4
2 Connector Functionality 5
3 Test Points 5
4 LEDs 5
5 S1 Switch Bank 6
6 S4 Switch Bank 6
7 Push Buttons 6
8 TPS65987EVM Bill of Materials 14

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1 Introduction

Texas Instrument's (TI's) TPS65987 evaluation module helps designers evaluate the operation and performance of the TPS65987 device.

The TPS65987 device is a USB Type-C and Power Delivery (PD) controller providing cable plug and orientation detection at the USB Type-C connector. Upon cable detection, the TPS65987 communicates on the CC wire using the USB PD protocol. When cable detection and USB PD negotiation are complete, the TPS65987 device enables the appropriate power path and configures Alternate Mode settings for external multiplexers. The TPS65987D device has two internal power paths that can be source or sink with current rating up to 5 A. The EVM is customizable through the TPS65987 Application Customization Tool. Additionally, the EVM is equipped with an FTDI chip for flashing a new project through SPI or I2C for debugging and development.

Figure 1 shows the TPS65987EVM board and Figure 2 shows a block level diagram.

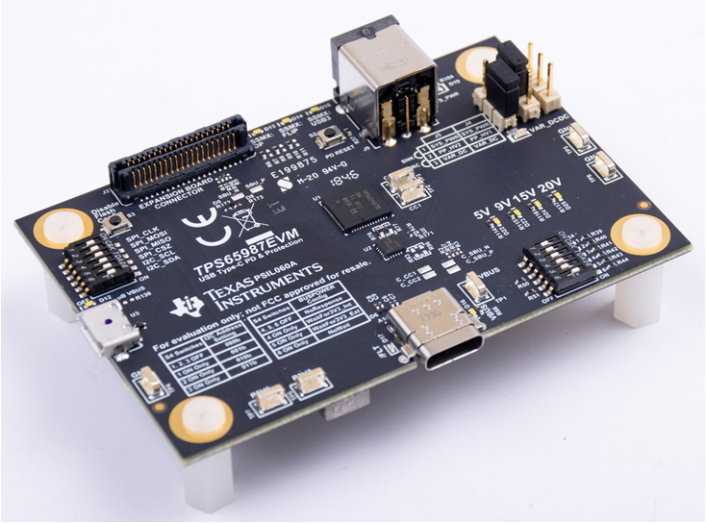


Figure 1. TPS65987EVM Board

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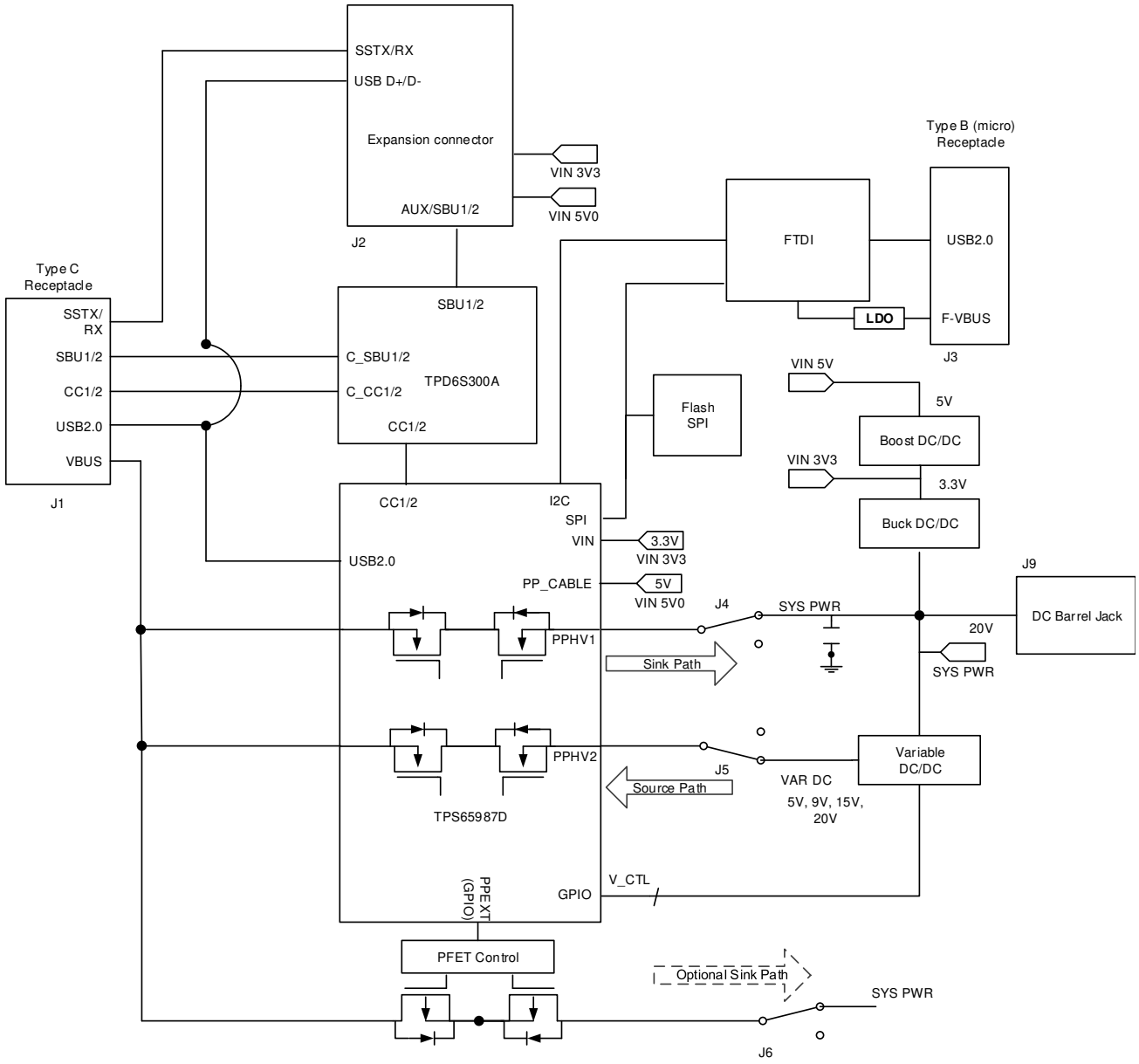


Figure 2. TPS65987EVM Block Level Diagram

1.1 Items Required for Operation

The following is required to operate the EVM:

- TPS65987EVM
- 20-V barrel jack adapter or dc power supply
- Active or e-marked USB Type-C cables
- USB Type-A to USB Micro-B cable (for configuration customization, debugging and updating FW flash)
- *TPS65987D USB Type-C and USB PD Controller with Integrated Power Switches* data sheet
- *TPS6598x configuration tool*
- *TPS6598x Application Customization Tool* user's guide
- *How to evaluate and configure TI's USB type-C PD Controllers* training videos

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2 Setup

This section describes the header and jumper connections on the EVM and getting started using the TPS65987EVM.

2.1 Jumper Configuration

Out of the box, the TPS65987EVM is configured to use TPS65987's PPHV1 as sink path (J4) and PPHV2 as source path (J5), which matches the configuration of firmware already programmed in the device. Recovery FW can be programmed using the Application customization tool. In order to do that open the Application customization tool, go to File menu Device/Re Flash EVM Firmware (recovery), and select EVM Recovery File tps65987_evm_flash_image.bin.

Remember, the jumper configuration in the hardware must match the source and sink paths in the software, *Application Customization Tool (GUI)*. See Figure 3 and Table 1 for the jumper configuration.

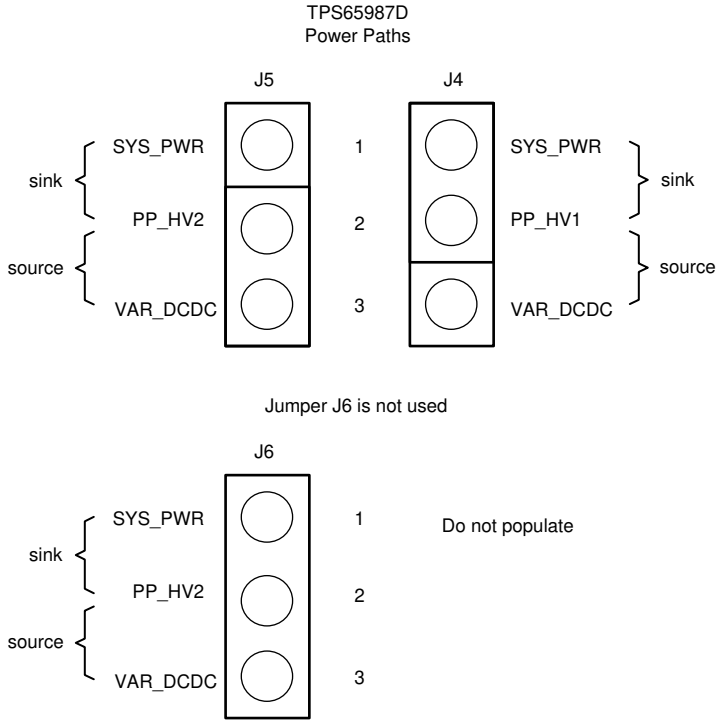


Figure 3. Power Path Jumper Configuration for Source or Sink

Table 1. Jumper Configuration

Jumper	Description
J4	TPS65987D power path: Jump pins 1-2 to sink on PP_HV1 (default)
J5	TPS65987D power path: Jump pins 2-3 to source on PP_HV2 (default)

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2.2 Connector Functionality

Table 2 lists the TPS65987EVM connector and functionality.

Table 2. Connector Functionality

Designator	Description
J1	USB Type-C connector: TI recommends using an active or e-marked USB Type-c cable
J2	Expansion board connector: Option to connect to external module.
J3	Micro-B connector: Connect to a PC to flash a project on the PD controller. You must download the *TPS6598x configuration tool (GUI)* to flash a project properly.
J9	Barrel jack connector: Use a 19-V to 20-V DC supply. A standard Dell or HP notebook adapter (or similar) will provide the required power.

2.3 Test Points

Table 3 lists the TPS65987EVM test points.

Table 3. Test Points

Test Point	Label	Description
TP1	VBUS	V_{BUS} voltage on the USB Type-C connector. Sourcing and sinking is always in reference to V_{BUS} (Source to V_{BUS} or sink from V_{BUS}).
TP2	CC1	System side CC1. This could be VCONN or CC depending on polarity flip of the USB Type-C cable.
TP3	CC2	System side CC2. This could be VCONN or CC depending on polarity flip of the USB Type-C cable.
TP4, TP5, TP8	GND	Ground reference for entire board
TP6	P3V3	Output of 3.3-V DC/DC convertor to power up all ICs on the EVM
TP7	P5V0	Output of 5-V DC/DC convertor used for PP_CABLE (VCONN)

2.4 LEDs

Table 4 lists the TPS65987EVM LEDs.

Table 4. LEDs

Designator	Label	Description
D12	µB VBUS	White LED that shows when the µB port is connected (FTDI for GUI).
D13	SSMX: DP	White LED that shows when the TPS65987D device has enabled this signal for external module super-speed MUX (depending on version of EVM the silkscreen may appear to show this signal swapped with SSMX: USB3)
D14	SSMX: FLIP	White LED that shows when the TPS65987D device has enabled this signal for external module super-speed MUX
D15	SSMX: USB3	White LED that shows when the TPS65987D device has enabled this signal for external module super-speed MUX
D16	VBUS	White LED that shows when V_{BUS} has a voltage of 5 V, 9 V, 15 V, or 20 V
D19	SYS_PWR	Blue LED that shows when the barrel jack is connected
D20	VAR_DCDC	Green LED that shows when there is a voltage on the variable DC/DC controller (U9). When the EVM acts as a source, D20 lights up.
D22	PDO_0	White LED that shows when there is a 5-V PD contract (only shown when sourcing)
D22	PDO_1	White LED that shows when there is a 9-V PD contract (only shown when sourcing)
D24	PDO_2	White LED that shows when there is a 15-V PD contract (only shown when sourcing)
D25	PDO_3	White LED that shows when there is a 20-V PD contract (only shown when sourcing)
D17	/FLT	Red LED that shows when there is an fault occurred TPD6S300A device

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2.5 Switches

Table 5, Table 6, and Table 7 lists the TPS65987EVM switches. For S1, make sure to leave all six switches in the ON position (to the right) for flashing a project and debugging. For S4 Switch: EVM out of th box should have S4->4 (BP_WaitFor3V3_Internal) as on(right). This ensures that PD controller enables internal paths in dead battery mode. This switch can be turned off(left) if EVM is used as source only. Note, S4[1, 2, 3] only one switch should be in "ON" position at a time, same way for S4[4, 5, 6].

Table 5. S1 Switch Bank

Switch (S1)	Description
1: SPI_CLK	Connects SPI_CLK node from FTDI to TPS65987D, EEPROM when the switch is in the ON position (to the right), and disconnects when in the OFF position (to the left)
2: SPI_MOSI	Connects SPI_MOSI node from FTDI to TPS65987D, EEPROM when the switch is in the ON position (to the right), and disconnects when in the OFF position (to the left)
3: SPI_MISO	Connects SPI_MISO node from FTDI to TPS65987D, EEPROM when the switch is in the ON position (to the right), and disconnects when in the OFF position (to the left)
4: SPI_CSZ	Connects SPI_CSZ node from FTDI to TPS65987D, EEPROM when the switch is in the ON position (to the right), and disconnects when in the OFF position (to the left)
5: I2C_SCL	Connects I2C_SCL node from FTDI to TPS65987D, EEPROM when the switch is in the ON position (to the right), and disconnects when in the OFF position (to the left)
6: I2C_SDA	Connects I2C_SDA node from FTDI to TPS65987D, EEPROM when the switch is in the ON position (to the right), and disconnects when in the OFF position (to the left)

Table 6. S4 Switch Bank

Switch (S4)	Description
1, 2, 3 OFF	I2C address selection: 000b
1 ON Only	I2C address selection: 001b
2 ON Only	I2C address selection: 010b
3 ON Only	I2C address selection: 011b
4, 5, 6 OFF	Dead battery mode: BP_NoResponse
4 ON Only	Dead battery mode: BP_WaitFor3V3_Internal
5 ON Only	Dead battery mode: BP_WaitFor3V3_External
6 ON Only	Dead battery mode: BP_NoWait

Table 7. Push Buttons

Designator	Label	Description
S2	PD Reset	This switch is a push-button that pulls the HRESET pin (44) of the TPS65987D device high when pressed. Releasing the push-button pulsl HRESET low again, and the TPS65987D device goes through a soft reset, which consists of reloading firmware from RAM. If a valid configuration is present in RAM, the TPS65987D device will not reload configuration from the external flash.
S3	Disable Flash Config	This push button switch will hold the SPI Miso line to GND. Use this button when booting the device. If this button is pressed when the device is booting, the TPS65987D device does not load its configuration from the SPI Flash and instead boots into a default ROM configuration.

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3 Using the TPS65987EVM

This section discusses how to power the EVM, configure the firmware, and how to debug.

3.1 Powering the TPS65987EVM

The main power supply for the EVM is the barrel jack (J9), which accepts 19 V to 20 V via a barrel jack adapter. The EVM can also be powered with an external power supply on SYS_PWR (pin 1 of J4, J5, or J6). The input voltage can range from 5 V to 20 V, but configure the appropriate power profile for PP_HV in the firmware using the configuration tool. The EVM can also be powered as a sink through a USB Type-C cable from a source adaptor, EVM, or device.

3.2 Firmware Configurations

Out of the box, the TPS65987EVM is configured to emulate a single port laptop computer. This configuration can be used to source or sink power known as (DRP), and this configuration sets DFP_D (Downward Facing Port). If different configurations are required to test your system, use the *TPS6598x configuration tool(GUI)* to create a configuration or load a different configuration template.

3.3 Debugging the EVM

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

Make sure that a firmware image is loaded on the TPS65987EVM, using the *TPS6598x configuration tool(GUI)*.

- Make sure the CC lines are toggling for dual-role port functionality.
- Make sure the following system supplies:
  - P3V3 = 3.3 V
  - P5V0 = 5 V
  - Barrel jack / SYS_PWR = 20 V (when plugged in)
  - VAR_DCDC = 5 V (when barrel jack is plugged in without a USB Type-C attached cable or device)
  - V_{BUS} = 5 V, 9 V, 15 V, or 20 V (when USB Type-C port is attached to another EVM or device)

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4 Schematic and Bill of Materials

4.1 Schematic

Figure 4 to Figure 9 illustrate the TPS65987EVM schematics.

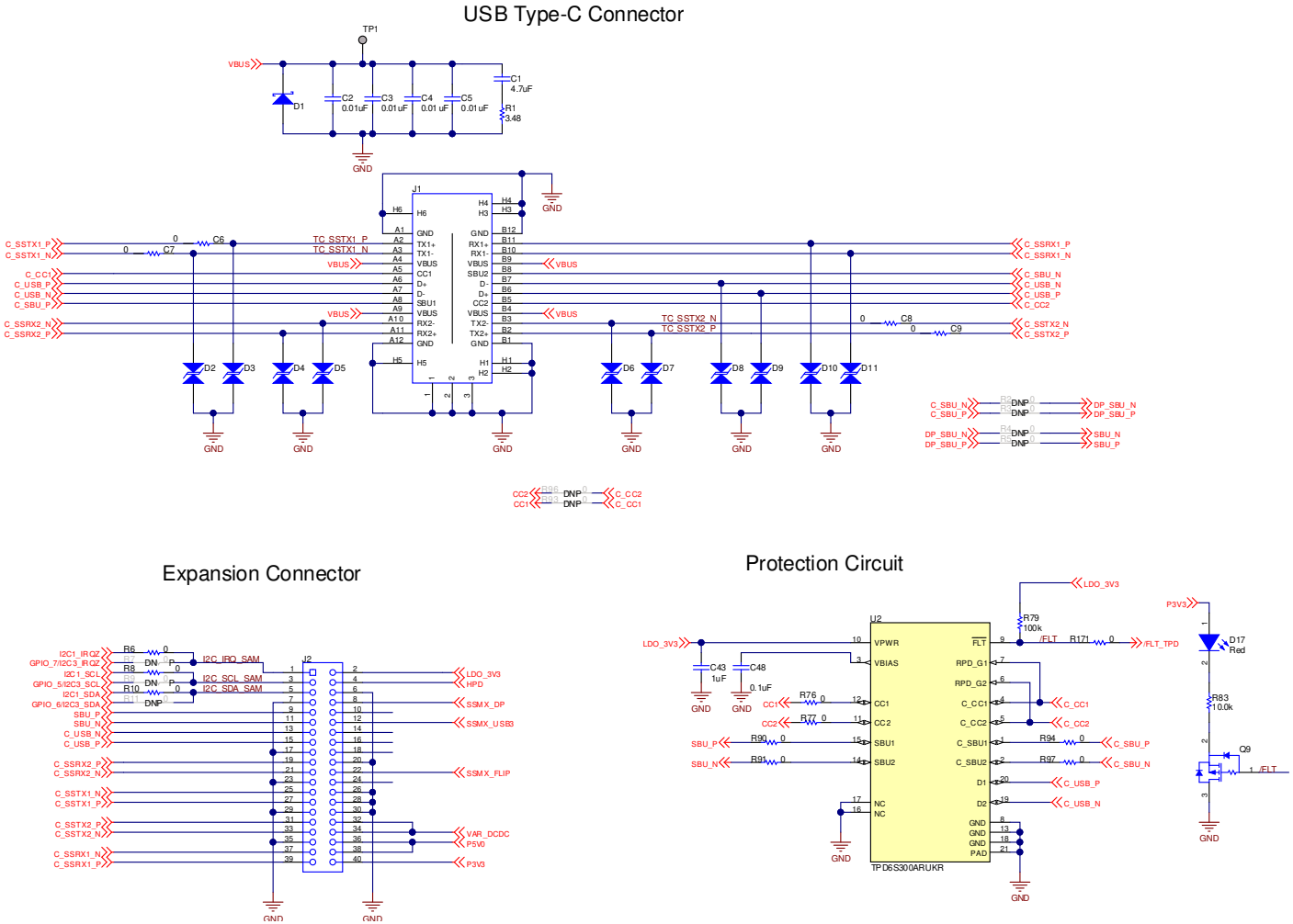


Figure 4. USB Type-C™ and External Module Connectors

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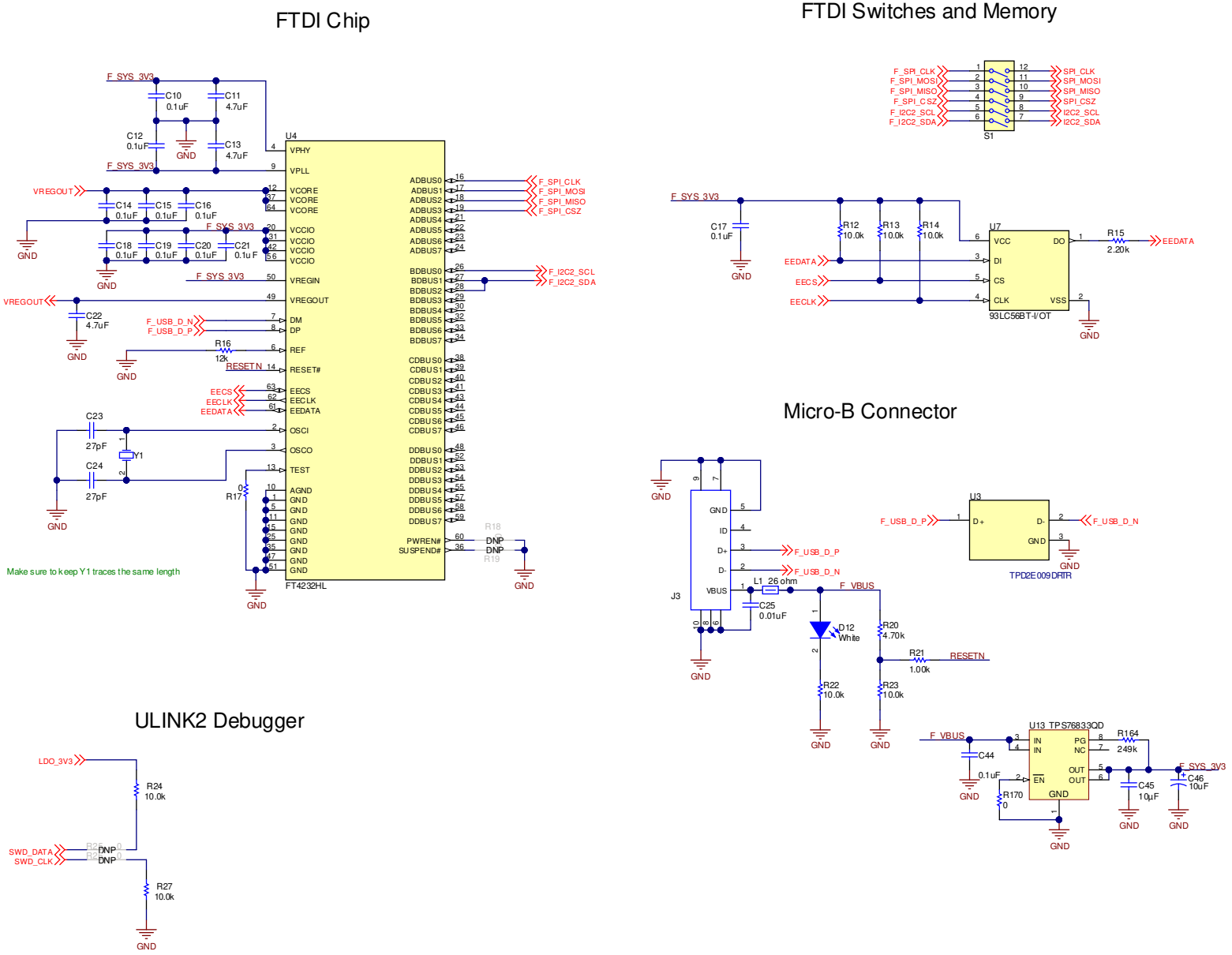


Figure 5. FTDI Device and Connector

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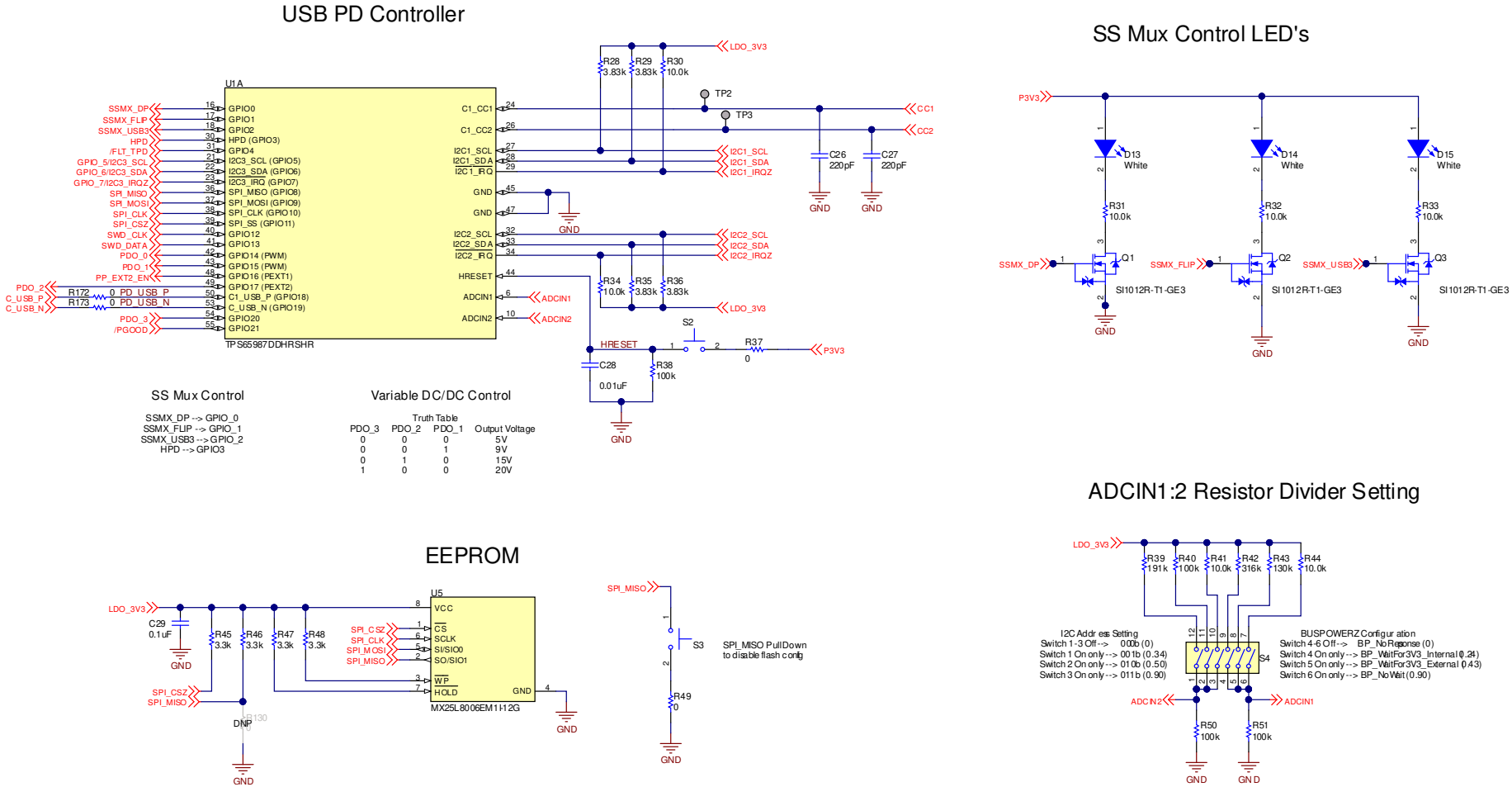


Figure 6. USB PD Controller and Memory

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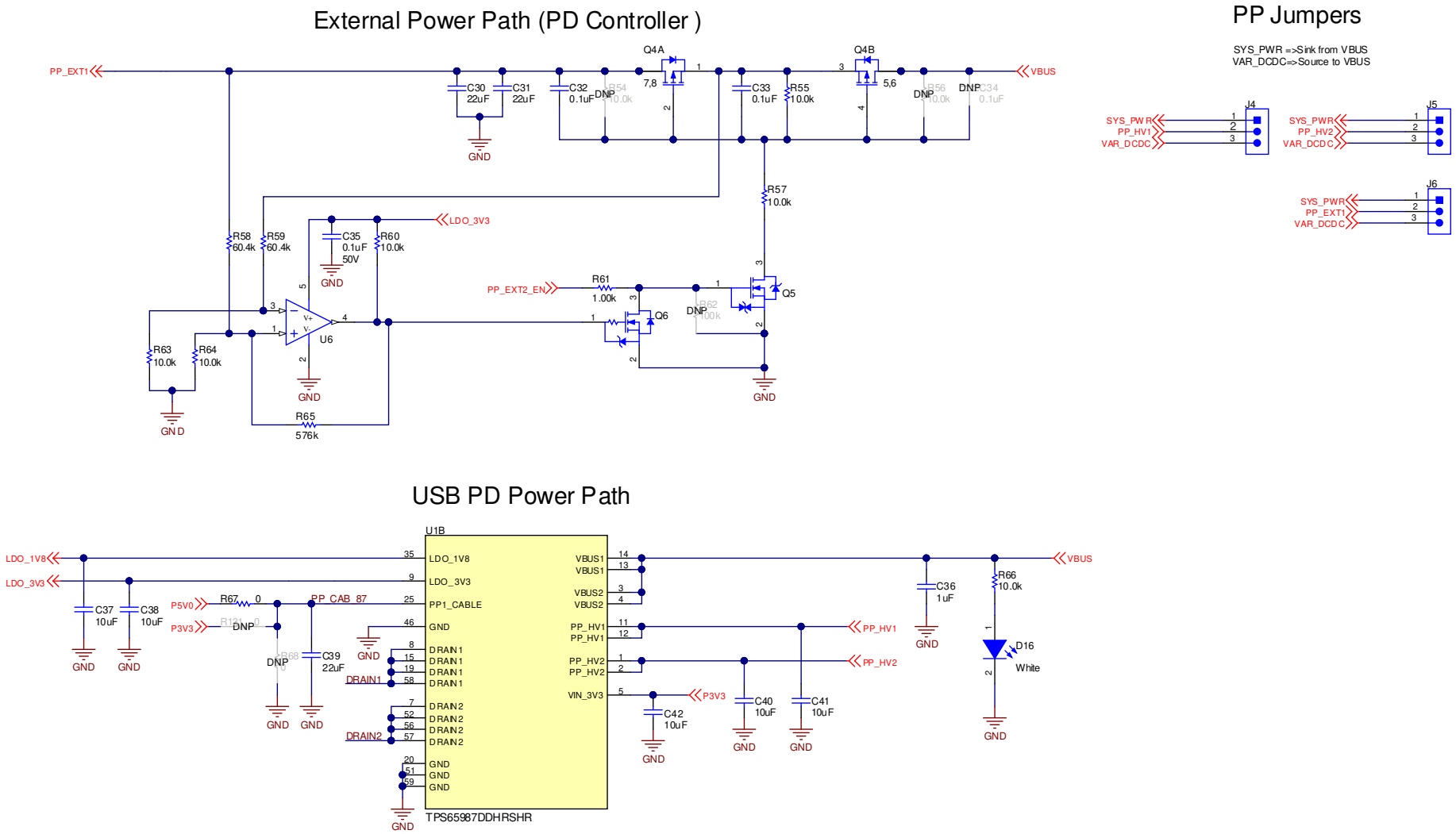


Figure 7. USB PD Power Paths

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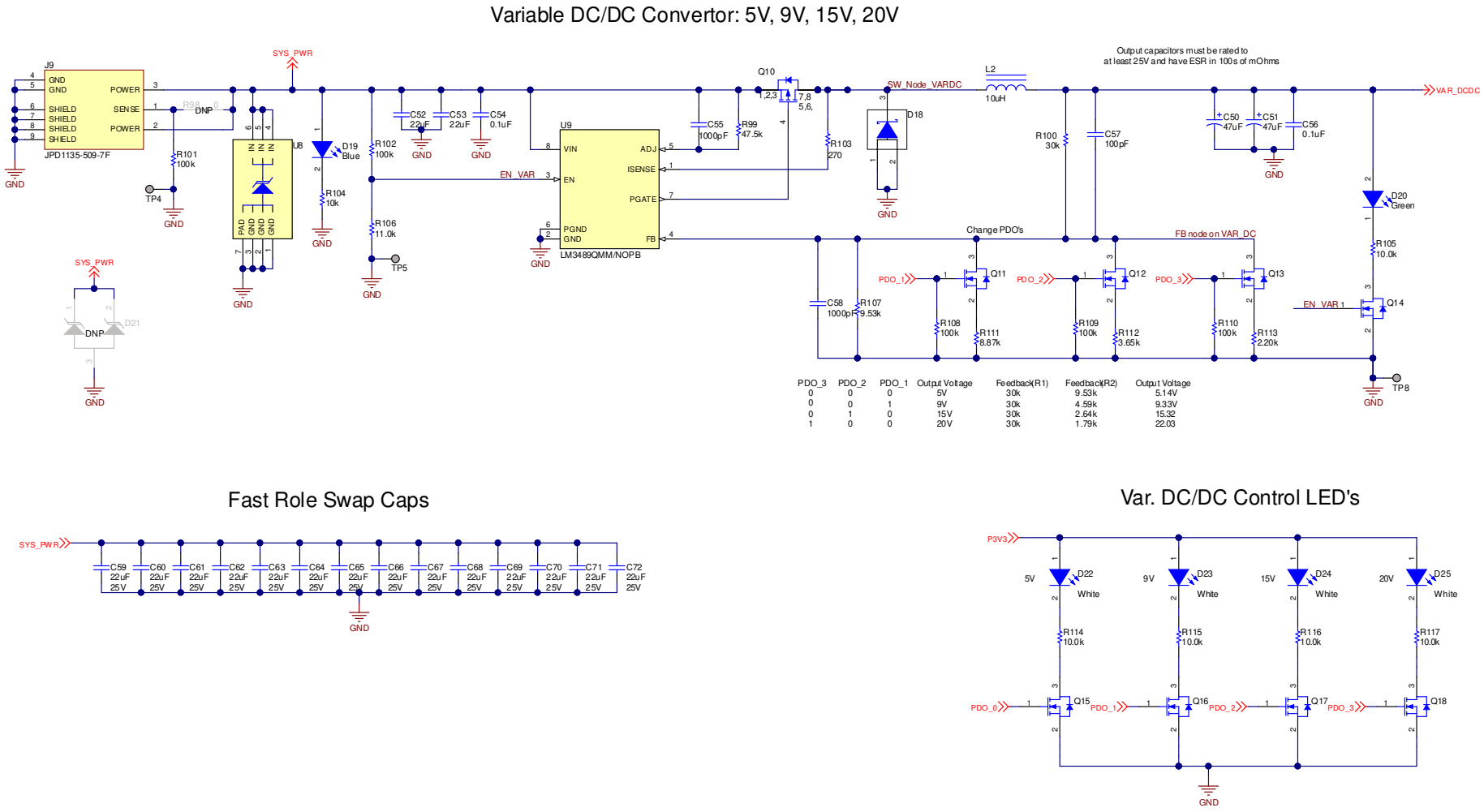


Figure 8. Variable DC/DC Controller

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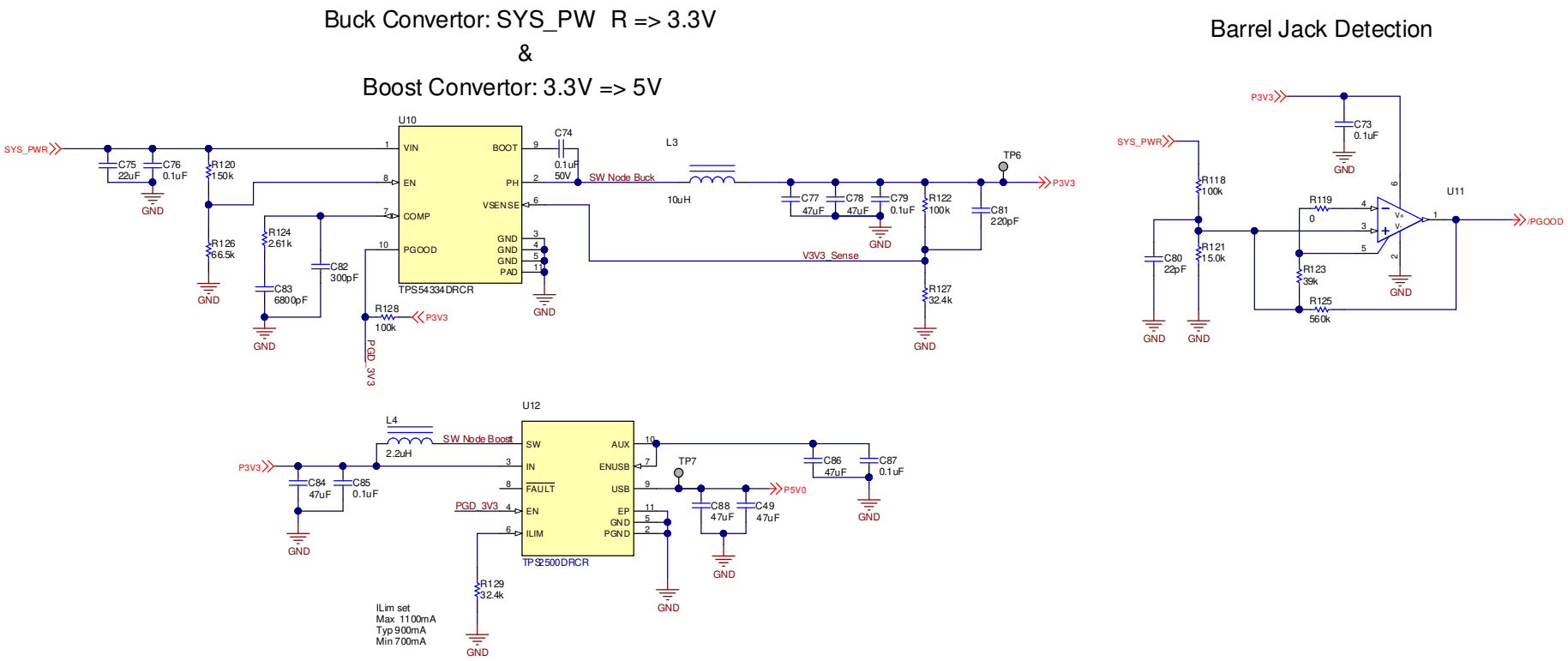


Figure 9. Buck and Boost DC/DC Convertors

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4.2 Bill of Materials

Table 8 lists the TPS65987EVM BOM.

Table 8. TPS65987EVM Bill of Materials

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
!PCB1	1		Printed Circuit Board		PSIL060	Any	-	-
C1	1	4.7 uF	CAP, CERM, 4.7 µF, 35 V, +/- 10%, X5R, 0603	0603	GRM188R6YA475KE15D	MuRata		
C2, C3, C4, C5, C28	5	0.01 uF	CAP, CERM, 0.01 µF, 50 V, +/- 10%, C0G/NP0, 0402	0402	GCM155R71H103KA55D	MuRata		
C6, C7, C8, C9, R170	5	0	RES, 0, 5%, .05 W, AEC-Q200 Grade 0, 0201	0201	'ERJ-1GN0R00C	Panasonic		
C10, C12, C35, C44, C48, C74, C76, C79, C85, C87	10	0.1 uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402	0402	GCM155R71H104KE02D	MuRata		
C11, C13, C22	3	4.7 uF	CAP, CERM, 4.7 uF, 10 V, +/- 20%, X5R, 0402	0402	C1005X5R1A475M050BC	TDK		
C14, C15, C16, C17, C18, C19, C20, C21	8	0.1 uF	CAP, CERM, 0.1 µF, 50 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0402	0402	CGA2B3X7R1H104K050BD	TDK		
C23, C24	2	27 pF	CAP, CERM, 27 pF, 50 V, +/- 1%, C0G/NP0, 0603	0603	CL10C270FB8NNNC	Samsung Electro-Mechanics		
C25	1	0.01 uF	CAP, CERM, 0.01 µF, 50 V, +/- 5%, X7R, 0402	0402	C0402C103J5RACTU	Kemet		
C26, C27	2	220 pF	CAP, CERM, 220 pF, 25 V, +/- 10%, X7R, 0201	0201	GRM033R71E221KA01D	MuRata		
C29	1	0.1 uF	CAP, CERM, 0.1 µF, 16 V,+/- 10%, X7R, 0402	0402	885012205037	Wurth Elektronik		
C30, C31, C52, C53, C59, C60, C61, C62, C63, C64, C65, C66, C67, C68, C69, C70, C71, C72, C75	19	22 uF	CAP, CERM, 22 µF, 25 V, +/- 20%, X5R, 0805	0805	GRM21BR61E226ME44L	MuRata	C2012X5R1V226M125AC, [NoValue]	
C32, C33, C56, C73	4	0.1 uF	CAP, CERM, 0.1 µF, 35 V,+/- 10%, X5R, 0402	0402	GMK105BJ104KV-F	Taiyo Yuden		
C36	1	1 uF	CAP, CERM, 1 µF, 50 V,+/- 10%, X7R, 0603	0603	UMK107AB7105KA-T	Taiyo Yuden		
C37, C38, C42	3	10 uF	CAP, CERM, 10 µF, 10 V, +/- 20%, X5R, 0402	0402	CL05A106MP5NUNC	Samsung Electro-Mechanics		

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Table 8. TPS65987EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
C39	1	22 uF	CAP, CERM, 22 µF, 10 V, +/- 20%, X5R, 0603	0603	C1608X5R1A226M080AC	TDK		
C40, C41	2	10 uF	CAP, CERM, 10 µF, 25 V, +/- 20%, X5R, 0603	0603	GRM188R61E106MA73D	MuRata		
C43	1	1 uF	CAP, CERM, 1 µF, 16 V,+/- 10%, X5R, 0402	0402	EMK105BJ105KVHF	Taiyo Yuden		
C45	1	10 uF	CAP, CERM, 10 µF, 10 V,+/- 20%, X5R, 0402	0402	0402ZD106MAT2A	AVX		
C46	1	10 uF	CAP, TA, 10 uF, 10 V, +/- 10%, 2.5 ohm, SMD	3528-21	293D106X9010B2TE3	Vishay-Sprague		
C49, C84, C86, C88	4	47 uF	CAP, CERM, 47 µF, 6.3 V, +/- 20%, X5R, 0603	0603	GRM188R60J476ME15D	MuRata		
C50, C51	2	47 uF	CAP, TA, 47 µF, 35 V, +/- 20%, 0.9 ohm, AEC-Q200 Grade 1, SMD	7343-43	TAJE476M035RNJ	AVX		
C54	1	0.1 uF	CAP, CERM, 0.1 µF, 50 V, +/- 10%, X6S, 0402	0402	C1005X7R1H104K050BB	TDK		
C55, C58	2	1000 pF	CAP, CERM, 1000 pF, 50 V,+/- 20%, X7R, 0402	0402	C1005X7R1H102M050BE	TDK		
C57	1	100 pF	CAP, CERM, 100 pF, 50 V,+/- 10%, X7R, 0402	0402	CC0402KRX7R9BB101	Yageo America		
C77, C78	2	47 uF	CAP, CERM, 47 µF, 6.3 V, +/- 20%, X5R, 0805	0805	GRM21BR60J476ME15L	MuRata		
C80	1	22 pF	CAP, CERM, 22 pF, 50 V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0402	0402	GCM1555C1H220JA16D	MuRata		
C81	1	220 pF	CAP, CERM, 220 pF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0201	0201	CGA1A2X7R1H221K030BA	TDK		
C82	1	300 pF	CAP, CERM, 300 pF, 25 V, +/- 5%, C0G/NP0, 0402	0402	C0402C301J3GAC7867	Kemet	GCM1555C1H301JA16D	
C83	1	6800 pF	CAP, CERM, 6800 pF, 50 V, +/- 10%, X7R, 0402	0402	GRM155R71H682KA88D	MuRata		
D1	1	30 V	Diode, Schottky, 30 V, 2 A, 2-XFDFN	2-XFDFN	NSR20F30NXT5G	ON Semiconductor		
D2, D3, D4, D5, D6, D7, D8, D9, D10, D11	10		1-Channel ESD Protection Diode for USB Type-C and Thunderbolt 3, DPL0002A (X2SON-2)	DPL0002A	TPD1E01B04DPLR	Texas Instruments	TPD1E01B04DPLT	Texas Instruments
D12, D13, D14, D15, D16, D22, D23, D24, D25	9	White	LED, White, SMD	0402, White	LW QH8G-Q2S2-3K5L-1	OSRAM	LW QH8G-Q2OO-3K5L-1	
D17	1	Red	LED, Red, SMD	0402	APHHS1005SURCK	Kingbright		
D18	1	40 V	Diode, Schottky, 40 V, 10 A, PowerDI5	PowerDI5	PDS1040L-13	Diodes Inc.		
D19	1	Blue	LED, Blue, SMD	1.6x0.8mm	LTST-C193TBKT-5A	Lite-On		
D20	1	Green	LED, Green, SMD	LED_0603	150060GS75000	Wurth Elektronik		

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Table 8. TPS65987EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply		
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone		
J1	1		Connector, Receptacle, USB Type C, R/A, SMT	Connector, Receptacle, USB Type C, SMT	20-0000016-01	Lintes Technology		
J2	1		Socket, 0.8mm, 20x2, Gold, SMT	Socket, 0.8mm, 20x2, Gold, SMT	LSEM-120-03.0-F-DV-A-N-K-TR	Samtec		
J3	1		Connector, Receptacle, Micro-USB Type AB, R/A, Bottom Mount SMT	Connector, Receptacle, Micro-USB Type AB, R/A, Bottom Mount SMT	ZX62RD-AB-5P8(30)	Hirose Electric Co. Ltd.	ZX62RD-AB-5P8	
J4, J5, J6	3		Header, 100mil, 3x1, Gold, TH	3x1 Header	TSW-103-07-G-S	Samtec		
J9	1		Connector, DC Power Jack, R/A, 3 Pos, TH	Power connector	JPD1135-509-7F	Foxconn		
L1	1	26 ohm	Ferrite Bead, 26 ohm at 100 MHz, 6 A, 0603	0603	BLM18SG260TN1D	MuRata		
L2	1	10 uH	Inductor, Shielded, Powdered Iron, 10 µH, 7.5 A, 0.03 ohm, AEC-Q200 Grade 1, SMD	11x10mm	SRP1038A-100M	Bourns		
L3	1	10 uH	Inductor, Shielded, 10 µH, 4 A, 0.068 ohm, SMD	7.2 mm x 6.65 mm	ASPI-0630LR-100M-T15	Abracon Corporation	-	-
L4	1	2.2 uH	Inductor, Shielded, Powdered Iron, 2.2 uH, 4.7 A, 0.035 ohm, AEC-Q200 Grade 1, SMD	4.1x4.1mm	78438356022	Wurth Elektronik		
Q1, Q2, Q3	3	20 V	MOSFET, N-CH, 20 V, 0.6 A, SOT-416	SOT-416	SI1012R-T1-GE3	Vishay-Siliconix		None
Q4	1	-30 V	MOSFET, 2-CH, P-CH, -30 V, -60 A, 610x604x515mm	610x604x515mm	SI7997DP-T1-GE3	Vishay-Siliconix		None
Q5	1	30 V	MOSFET, N-CH, 30 V, 0.35 A, AEC-Q101, SOT-323	SOT-323	NX3008NBKW,115	Nexperia		None
Q6	1	20 V	MOSFET, N-CH, 20 V, 0.5 A, YJM0003A (PICOSTAR-3)	YJM0003A	CSD15380F3	Texas Instruments		None
Q9	1	–20 V	MOSFET, P-CH, -20 V, -0.76 A, SOT-416	SOT-416	NTA4151PT1G	ON Semiconductor		None
Q10	1	–30V	MOSFET, P-CH, -30 V, -11 A, FET, 3x0.8x3mm	FET, 3x0.8x3mm	AON7403	AOS		None
Q11, Q12, Q13	3	20 V	MOSFET, N-CH, 20 V, 1.05 A, SOT-23	SOT-23	BSH105,215	Nexperia		None
Q14, Q15, Q16, Q17, Q18	5	30 V	MOSFET, N-CH, 30 V, 0.18 A, SOT-323	SOT-323	NX3020NAKW,115	Nexperia		None
R1	1	3.48	RES, 3.48, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04023R48FKED	Vishay-Dale		

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Table 8. TPS65987EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
R6, R8, R10	3	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2GE0R00X	Panasonic		
R12, R13, R14, R22, R23, R30, R32, R33, R34, R41, R44, R55, R57, R60, R63, R64, R66, R105, R114, R115, R116, R117	23	10.0 k	RES, 10.0 k, 1%, 0.1 W, 0402	0402	ERJ-2RKF1002X	Panasonic		
R15	1	2.20 k	RES, 2.20 k, 1%, 0.063 W, 0402	0402	RC0402FR-072K2L	Yageo America		
R16	1	12 k	RES, 12 k, 5%, 0.063 W, 0402	0402	CRCW040212K0JNED	Vishay-Dale		
R17, R119	2	0	RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04020000Z0ED	Vishay-Dale		
R20	1	4.70 k	RES, 4.70 k, 1%, 0.1 W, 0402	0402	ERJ-2RKF4701X	Panasonic		
R21, R61	2	1.00 k	RES, 1.00 k, 1%, 0.1 W, 0402	0402	ERJ-2RKF1001X	Panasonic		
R24, R27	2	10.0 k	RES, 10.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0710KL	Yageo		
R28, R29, R35, R36	4	3.83 k	RES, 3.83 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04023K83FKED	Vishay-Dale		
R31	1	10.0 k	RES, 10.0 k, 0.5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040210K0DHEDP	Vishay-Dale		
R37, R49, R67, R76, R77	5	0	RES, 0, 5%, 0.063 W, 0402	0402	RC0402JR-070RL	Yageo America		
R38, R40, R50, R51, R101, R102, R108, R109, R110, R118, R122, R128	12	100 k	RES, 100 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402100KFKED	Vishay-Dale		
R39	1	191 k	RES, 191 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402191KFKED	Vishay-Dale		
R42	1	316 k	RES, 316 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402316KFKED	Vishay-Dale		
R43	1	130 k	RES, 130 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402130KFKED	Vishay-Dale		
R45, R46, R47, R48	4	3.3 k	RES, 3.3 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04023K30JNED	Vishay-Dale		
R58, R59	2	60.4 k	RES, 60.4 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040260K4FKED	Vishay-Dale		
R65	1	576 k	RES, 576 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402576KFKED	Vishay-Dale		
R79	1	100 k	RES, 100 k, 5%, 0.05 W, 0201	0201	RC0201JR-7D100KL	Yageo America		

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Table 8. TPS65987EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
R83	1	10.0 k	RES, 10.0 k, 1%, 0.063 W, 0402	0402	RC0402FR-0710KL	Yageo America		
R90, R91, R94, R97, R171, R172, R173	7	0	RES, 0, 5%, 0.05 W, 0201	0201	CRCW02010000Z0ED	Vishay-Dale		
R99	1	47.5 k	RES, 47.5 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040247K5FKED	Vishay-Dale		
R100	1	30 k	RES, 30 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040230K0JNED	Vishay-Dale		
R103	1	270	RES, 270, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402270RJNED	Vishay-Dale		
R104	1	10 k	RES, 10 k, 5%, 0.1 W, 0603	0603	RC0603JR-0710KL	Yageo		
R106	1	11.0 k	RES, 11.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040211K0FKED	Vishay-Dale		
R107	1	9.53 k	RES, 9.53 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04029K53FKED	Vishay-Dale		
R111	1	8.87 k	RES, 8.87 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04028K87FKED	Vishay-Dale		
R112	1	3.65 k	RES, 3.65 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04023K65FKED	Vishay-Dale		
R113	1	2.20 k	RES, 2.20 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04022K20FKED	Vishay-Dale		
R120	1	150 k	RES, 150 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402150KFKED	Vishay-Dale		
R121	1	15.0 k	RES, 15.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040215K0FKED	Vishay-Dale		
R123	1	39 k	RES, 39 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040239K0JNED	Vishay-Dale		
R124	1	2.61 k	RES, 2.61 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04022K61FKED	Vishay-Dale		
R125	1	560 k	RES, 560 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402560KJNED	Vishay-Dale		
R126	1	66.5 k	RES, 66.5 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040266K5FKED	Vishay-Dale		
R127, R129	2	32.4 k	RES, 32.4 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040232K4FKED	Vishay-Dale		
R164	1	249 k	RES, 249 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603249KFKEA	Vishay-Dale		
S1, S4	2		DIP Switch, SPST, 6Pos, Slide, SMT	8.75x6.2mm	TDA06H0SB1	C&K Components		
S2, S3	2		SWITCH TACTILE SPST-NO 0.05-A ,12 V	3x1.6x2.5mm	B3U-1000P	Omron Electronic Components		
SH-J1, SH-J2	2	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec	969102-0000-DA	3M

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Table 8. TPS65987EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8	7		Test Point, Miniature, SMT	Test Point, Miniature, SMT	5019	Keystone		
U1	1		USB Type-C and USB PD Controller with Integrated Power Switches, RSH0056E (VQFN-56)	RSH0056E	TPS65987DDHRSHR	Texas Instruments	TPS65987DDHRSHT	Texas Instruments
U2	1		USB Type-C Port Protector: Short-to-VBUS Overvoltage and IEC ESD Protection, RUK0020B (WQFN-20)	RUK0020B	TPD6S300ARUKR	Texas Instruments		Texas Instruments
U3	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		
U4	1		Quad High Speed USB to Multipurpose UART/MPSSE IC	LQFP_10x10mm	FT4232HL	FTDI		
U5	1		8Mb, 86MHz, NOR Flash, SOP-8	8-SOP	MX25L8006EM1I-12G	Macronix International Co., LTD		
U6	1		2.2-V to 36-V, microPower Comparator, DBV0005A (SOT-23-5)	DBV0005A	TLV1701AIDBVR	Texas Instruments	TLV1701AIDBVT	Texas Instruments
U7	1		2K Microwire Compatible Serial EEPROM, SOT-23-6	SOT-23-6	93LC56B-I/OT	Microchip	93LC56BT-I/OT	
U8	1		22-V Precision Surge Protection Clamp, DRV0006A (WSON-6)	DRV0006A	TVS2200DRVR	Texas Instruments		Texas Instruments
U9	1		Automotive Grade 4.5-35 V, Hysteretic Non-Synchronous PFET Buck Controller with Enable Pin, DGK0008A (VSSOP-8)	DGK0008A	LM3489QMM/NOPB	Texas Instruments		Texas Instruments
U10	1		4.2-V to 28-V Input voltage, 3-A Output current Synchronous buck Converter with 570kHz fixed frequency, DRC0010J (VSON-10)	DRC0010J	TPS54334DRCR	Texas Instruments	TPS54334DRCT	Texas Instruments
U11	1		Nanopower, 1.8 V, SOT23 Push-Pull Comparator with Voltage Reference, DCK0006A (SOT-SC70-6)	DCK0006A	TLV3012AIDCKR	Texas Instruments	TLV3012AIDCKT	Texas Instruments
U12	1		Integrated USB Power Switch with Boost Converter, DRC0010J (VSON-10)	DRC0010J	TPS2500DRCR	Texas Instruments		
U13	1		Single Output Fast Transient Response LDO, 1 A, Fixed 3.3 V Output, 2.7 to 10 V Input, with Low IQ, 8-pin SOIC (D), -40 to 125 degC, Green (RoHS & no Sb/Br)	D0008A	TPS76833QD	'Texas Instruments		
Y1	1		CRYSTAL, 12 MHz, 20 pF, SMD	7x2.3x4.1mm	ECS-120-20-3X-TR	ECS Inc.		
C34	0	0.1 uF	CAP, CERM, 0.1 µF, 35 V,+/- 10%, X5R, 0402	0402	GMK105BJ104KV-F	Taiyo Yuden		
D21	0	24 V	Diode, TVS, Uni, 24 V, 70 Vc, SOT-23	SOT-23	PESD24VS2UT,215	Nexperia		

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Table 8. TPS65987EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A		
R2, R3, R4, R5	0	0	RES, 0, 5%, 0.05 W, 0201	0201	CRCW02010000Z0ED	Vishay-Dale		
R7, R9, R11	0	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2GE0R00X	Panasonic		
R18, R19	0	0	RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04020000Z0ED	Vishay-Dale		
R25, R26	0	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06030000Z0EA	Vishay-Dale		
R54, R56	0	10.0 k	RES, 100 k, 1%, 0.063 W, 0402	0402	ERJ-2RKF1002X	Panasonic		
R62	0	100 k	RES, 100 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402100KFKED	Vishay-Dale		
R68, R93, R96, R130, R131	0	0	RES, 0, 5%, 0.063 W, 0402	0402	RC0402JR-070RL	Yageo America		
R98	0	0	RES, 0, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	ERJ-6GEY0R00V	Panasonic		

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Revision History

Changes from Original (April 2019) to A Revision	Page
• Updated Section 1.1.	3
• Updated Table 1.	4
• Updated Table 2.	5
• Updated Table 4.	5
• Updated Section 3.2.	7
• Updated Figure 4 title.	8

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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。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

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・インスツルメンツ株式会社
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。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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.

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