TPS25944X635EVM: Evaluation Module for TPS25944X

This user's guide describes the evaluation module (EVM) for the Texas instruments TPS25944X devices. TPS25944X devices are circuit breaker with True Reverse Blocking for Power Mux that operates from 2.7 V to 18 V, device has integrated back-to-back FETs with programmable undervoltage, overvoltage, reverse-voltage, overcurrent and in-rush current protection features.

Important Note to TPS25944XEVM-635 Users

While ordering the TPS25944XEVM-635, customers may receive the EVM with TPS25940XEVM-635 or TPS25942XEVM-635 labels.

Make the following changes to configure the received EVM as TPS25944XEVM-635, to achieve the TPS25944X circuit breaker functionality:

1. Please order TPS25944ARVCR and TPS25944LRVCR samples from www.ti.com
2. Replace the U1, as the with TPS25944A
3. Replace the U2, as the with TPS25944L
4. Make sure the following parts are unpopulated:
   - R7, R8

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1 Introduction

The TPS25944X-EVM allows reference circuit evaluation of TI's TPS25944X devices. The TPS25944X devices are available with both latched and auto-retry operation.

1.1 EVM Features

- General TPS25944XEVM features are:
  - 2.7-V to 18.0-V (TYP) operation
    - CH1 rising input voltage turn-On threshold – 10.8 V (TYP)
    - CH1 falling input voltage turn-off threshold – 10 V (TYP)
    - CH2 rising input voltage turn-On threshold – 10.8 V (TYP)
    - CH2 falling input voltage turn-off threshold – 2.1 V (TYP)
  - 0.6 A to 5.0 A programmable current limit
  - Programmable undervoltage lockout/overvoltage
  - Programmable VOUT slew rate
  - Latched-off TPS25944LRUV (CH2)
  - Auto-retry TPS25944ARUV (CH2)
- Push button RESET signal
- On-board transorb is for overvoltage input protection
- Common diode at output prevents negative spike when load is removed

1.2 EVM Applications

- Solid state drives and hard disk drives
- PCIe, RAID, and NIC Cards
- USB power switch
- Industrial:
  - PLCs
  - Solid state relays and FAN control
- Power Path Management:
  - Active ORing
  - Priority power multiplexing

2 Description

The TPS25944XEVM-635 enables full evaluation of the TPS25944X devices. The EVM supports two versions (Auto-Retry and Latched) of the devices on two Channels (CH1 and CH2, respectively). Input power is applied at J3 (CH1) and J8 (CH2), while J2 (CH1)/J7 (CH2) provide the output connection to the load, refer to the schematic in Figure 1, and test setup in Figure 2.

D5/C1 (CH1), D9/C7 (CH2) provides input protection for TPS25944X (U1 and U2, respectively) while D4/C2/C3/C4 (CH1), D8/C8/C9/C10 (CH2) provides output protection.

S1 allows U1 and S2 allows U2 to be RESET or disabled. A power good (PG) indicator is provided by D2 and D6 for CH1 and CH2, respectively, and circuit faults can be observed with D2 and D6. Scaled channel current can be monitored at TP11 and T22 with a scale factor of 0.842 V/A.

Table 1. TPS25944X EVM Options and Default Setting

Part Number	EVM Function	Vin Range	UVLO		OVP	Current Limit			Fault Response	
			CH1	CH2		LO Setting	No Jumper	HI Setting	CH1	CH2
TPS25944XEVM-635	Circuit Breaker	2.7 V–18 V	10.8 V	Internal (2.3 V)	16.5 V	3.6 A	2.1 A	5.3 A	Auto-retry	Latched

3 Schematic

Figure 1 illustrates the TPS25944X EVM schematic.

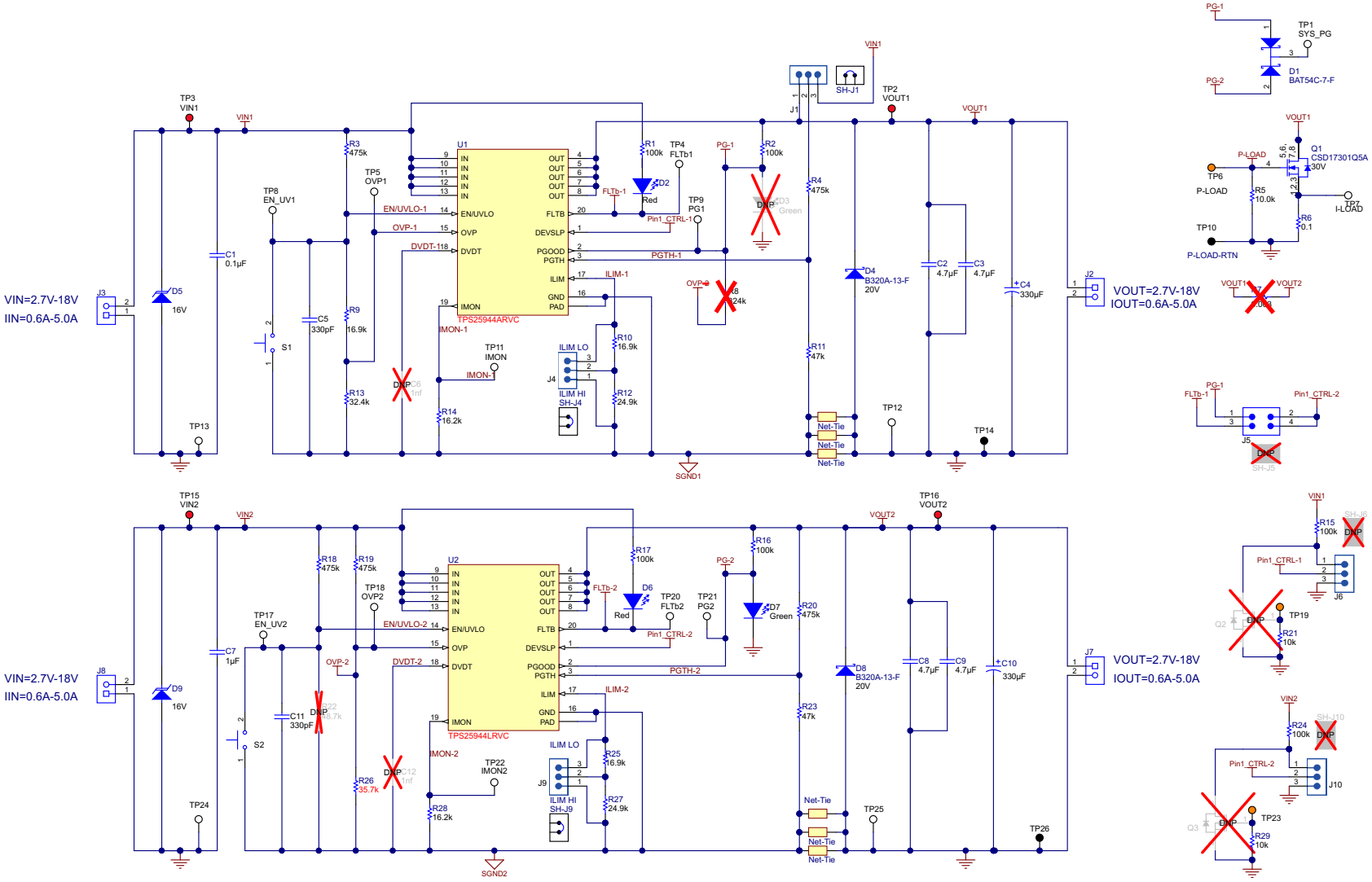

Figure 1. TPS25944XEVM Schematic

4 General Configurations

4.1 Physical Access

Table 2 lists the TPS25944XEVM-635 input and output connector functionality, Table 3 describes the test point availability, and Table 4 describes the jumper functionality.

Table 2. Input and Output Connector Functionality

Connector		Label	Description
J3	CH1	VIN1(+), GND(–)	CH1 Input power supply to the EVM
J2		VOUT1(+),GND(–)	CH1 Output power from the EVM
J8	CH2	VIN2(+), GND(–)	CH2 Input power supply to the EVM
J7		VOUT2(+),GND–)	CH2 Output power from the EVM

Table 3. Test Points Description

Channel	Test Points	Label	Description
CH1	TP3	VIN1	CH1 Input power supply to the EVM
	TP8	EN_UV1	CH1 Active high enable and undervoltage input
	TP5	OVP1	CH1 Active high overvoltage input (> 16.5 V)
	TP11	IMON1	CH1 Current monitor. Load current = 1.187 × voltage on TP11
	TP2	VOUT1	CH1 Output from the EVM
	TP9	PG1	CH1 Power good test point
	TP4	FLTb1	CH1 Fault test point
	TP12	GND	GND
	TP13	GND	GND
	TP14	GND	GND
CH2	TP15	VIN2	CH2 Input power supply to the EVM
	TP17	EN_UV2	CH2 Active high enable and under voltage input
	TP18	OVP2	CH2 Active high overvoltage input
	TP22	IMON2	CH2 Current monitor. Load current = 1.187 × voltage on TP22
	TP16	VOUT2	CH2 Output from the EVM
	TP21	PG2	CH2 Power good test point
	TP20	FLTb2	CH2 Fault test point
	TP24	GND	GND
	TP25	GND	GND
	TP26	GND	GND

Table 4. Jumper and LEDs Descriptions

Jumper	Label	Description
J4	LO - HI	CH2 Current Setting
J5	J5	PG1 and FLTb1 setting
J9	LO - HI	CH2 Current Setting
D2 (Red)	D2	CH1 circuit fault indicator. LED turns on when the internal MOSFET is disabled due to a fault condition such as over load , short circuit, under voltage etc.
D3 (Green)	D3	CH1 Power good indicator. LED turns on when the voltage at TP2(VOUT1) is more than 10.8V
D6 (Red)	D6	CH2 circuit fault indicator. LED turns on when the internal MOSFET is disabled due to a fault condition such as over load , short circuit, under voltage etc.
D7 (Green)	D7	CH2 Power good indicator. LED turns on when the voltage at TP2(VOUT1) is more than 10.8V

4.2 Test Equipment

4.2.1 Power Supplies

One adjustable power supply: 0-V to 20-V output, 0-A to 6-A output current limit.

4.2.2 Meters

One DMM minimum needed and may require more if simultaneous measurements are needed.

4.2.3 Oscilloscope

A DPO2024 or Lecroy 424 oscilloscope or equivalent, three 10X voltage probes, and a DC current probe.

4.2.4 Loads

One resistive load or equivalent which take up to 6 ADC load at 12 V and capable to do the output short.

4.3 Test Setup

Figure 2 shows a typical test setup for the TPS25944XEVM. Connect J3/J8 to the power supply and J2/J7 to the load.

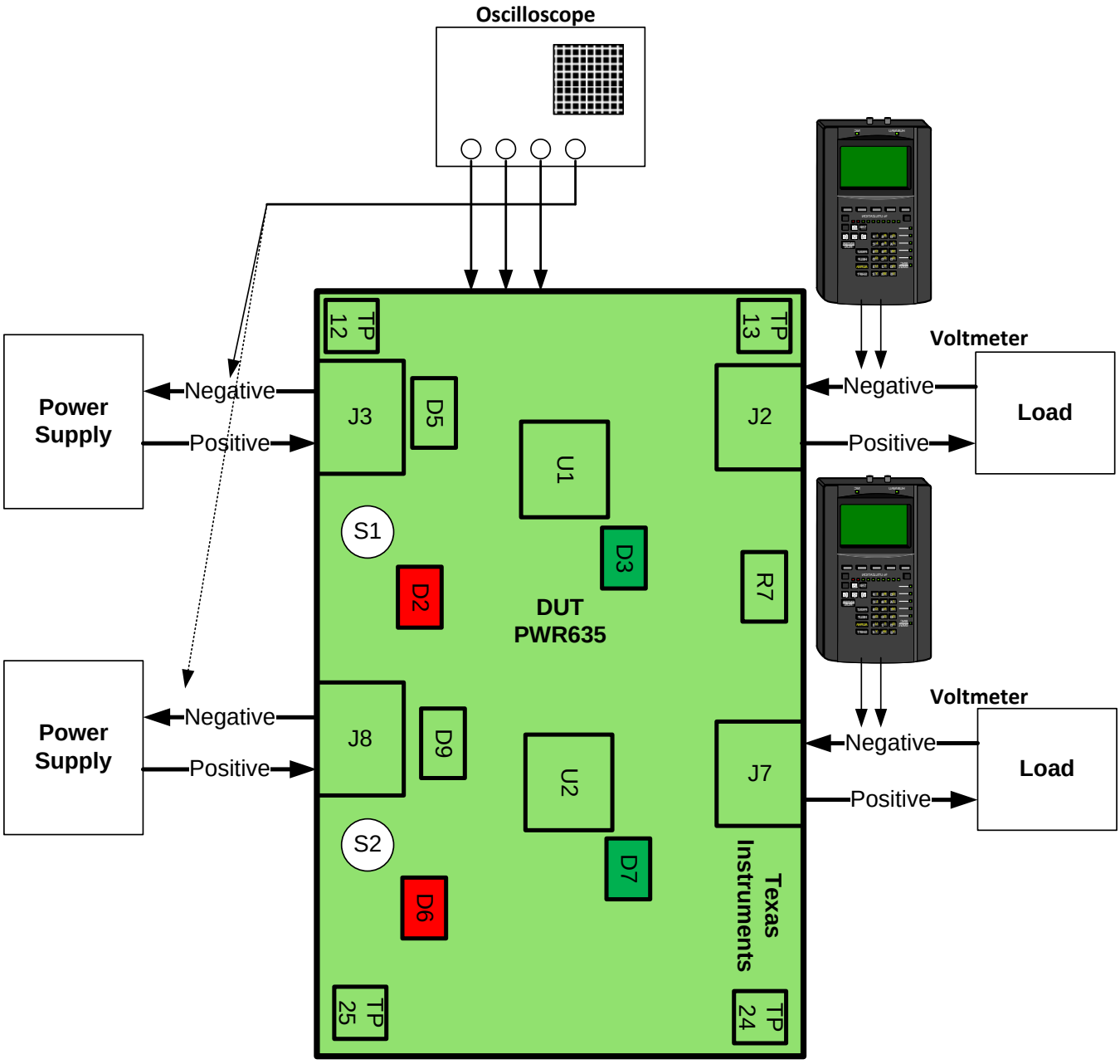

Figure 2. EVM Test Setup

4.4 Test Procedures

Use the following procedures for testing:

1. The operational voltage range of the two rails VIN1 and VIN2 can be adjusted by changing a few resistor settings, as listed in Table 5.

Table 5. Operational Range Setting for VIN1, VIN2 = 12 V, 5 V and 3.3 V

VIN Operational Range	Rail: VIN1 or VIN2	R9	R13	R11	R22	R8
12 V: 10.5 V to 16 V (Default)	VIN1	16.9 kΩ	32.4 kΩ	47 kΩ		
5 V: 4.6 V to 5.7 V	VIN1	23.2 kΩ	105 kΩ	137 kΩ		
3.3 V: 3 V to 3.8 V	VIN1	48.7 kΩ	187 kΩ	237 kΩ		
2.3 V to 15.5 V (Default)	VIN2				No PoP	32.4 kΩ
5 V: 4.6 V to 5.7 V	VIN2				130 kΩ	100 kΩ
3.3 V: 3 V to 3.8 V	VIN2				237 kΩ	169 kΩ

2. Turn on the power supply and set the power supply voltage to 12 V on CH1 and CH2.
3. Turn off the power supply. Hook up CH1 and CH2 of the PWR635 assembly as shown in Figure 3.
4. Ensure that the output load is disabled and the power supply is set properly for the DUT. Connect the negative probe of DMM to TP12 or TP25 (GND) to the test points in Table 6.
5. Turn on the power supply. Verify that the voltages shown in Table 6 are obtained. Use only one power supply at a time for this verification.

Table 6. PWR635 DMM Readings at Different Test Points

Voltage Test on (CH1)	Measured Voltage Reading	Voltage Tested on (CH2)	Measured Voltage Reading
VIN1 (TP3)	12 ±0.3 VDC	VIN2 (TP15)	12 ±0.3 VDC
EN_UV1 (TP8)	1.13 ±0.1 VDC	EN_UV2 (TP17)	12 ±0.3 VDC
OVP1 (TP5)	0.742 ±0.1 VDC	OVP2 (TP18)	0.742 ±0.1 VDC
IMON1 (TP11)	33.8 mV ±5 mVDC	IMON2 (TP22)	33.8 mV ±5 mVDC
VOUT1 (TP2)	12 ±0.3 VDC	VOUT2 (TP16)	12 ±0.3 VDC
PG1 (TP9)	2.40 ±0.1 VDC	PG2 (TP21)	2.4 ±0.1 VDC
FLTb1 (TP4)	10.51 ±0.5 VDC	FLTb2 (TP20)	10.5 ±0.5 VDC

4.4.1 Preliminary Test

Use the steps in the following sections for preliminary testing.

4.4.1.1 For CH1 (J3-J2)

1. With the power supply set to 12 V on CH1, verify that the red LED (D2) is off. Press the EVM RST switch (S1) and verify that the voltage at VOUT1 (TP2) starts falling slowly below 12 V and that the FLTb1 red LED (D2) turns ON. Release S1.
2. Reduce the input voltage on VIN1 and monitor VOUT1. Verify that VOUT1 (TP2) starts falling and is fully turned off when VIN1 (TP3) reaches 9.5 V (±0.5 V). Verify that the FLTb1 red LED (D2) turns ON.
3. Increase the input voltage on VIN1 and monitor VOUT1. Verify that VOUT1(TP2) starts increasing and is fully turned off when VIN1 (TP3) reaches 16.5 V (±1 V). Verify that the FLTb1 red LED (D2) turns ON.

4.4.1.2 For CH2 (J8-J7)

1. With the power supply set to 12 V on VIN2, press the EVM RST switch (S2) and verify that the voltage at VOUT2 (TP16) starts falling slowly below 12 V and that the green PG LED (D7) turns off and the RED FLTb2 LED (D6) turns on. Release S2.
2. Reduce the input voltage on VIN2 and monitor VOUT2. Verify that VOUT2 (TP16) starts falling and is

fully turned off when VIN2 (TP15) reaches 2.1 V (+0.3 V). Verify that the PG2 green LED (D7) turns off and the FLTb2 red LED (D6) turns ON.

3. Increase the input voltage on VIN2 and monitor VOUT2. Verify that VOUT2 (TP16) starts increasing and is fully turned off when VIN2 (TP15) reaches 15.5 V (±1 V). Verify that the PG2 green LED (D7) turns off and the FLTb2 red LED (D6) turns ON.
4. Turn off the power supply.

4.4.1.3 Ramp-Up Time Test (CH1 and CH2)

1. Verify ramp-up time (CH1 and CH2, with only 1 channel powered at a time). Set up the oscilloscope as shown in Table 7.

Table 7. PWR635 Oscilloscope Setting for Ramp-Up Voltage Test

Oscilloscope Setting	CH1 Probe Points	CH2 Probe Points
Channel 1 = 5 V/div	TP2 = VOUT1	TP16 = VOUT2
Channel 2 = 5 V/div	TP3 = VIN1	TP15 = VIN2
Channel 3 = 5 V/div	TP8 = EN/UVLO1	TP17 = EN/UVLO2
Channel 4 = 2 A/div	Current probe in input +Ve wire	Current probe in input +Ve wire
Trigger source = Channel 1		
Trigger level = 6.0 ±0.5 V		
Trigger polarity = Positive		
Trigger Mode = Single Sequence		
Time base = 1 ms/div		

2. Set the output load at 5 Ω on CH1 and then enable the load. Turn on the power supply, Press the EVM RST switch (S1) and release, verify that VOUT1 (TP2) ramps up as shown in Figure 3.

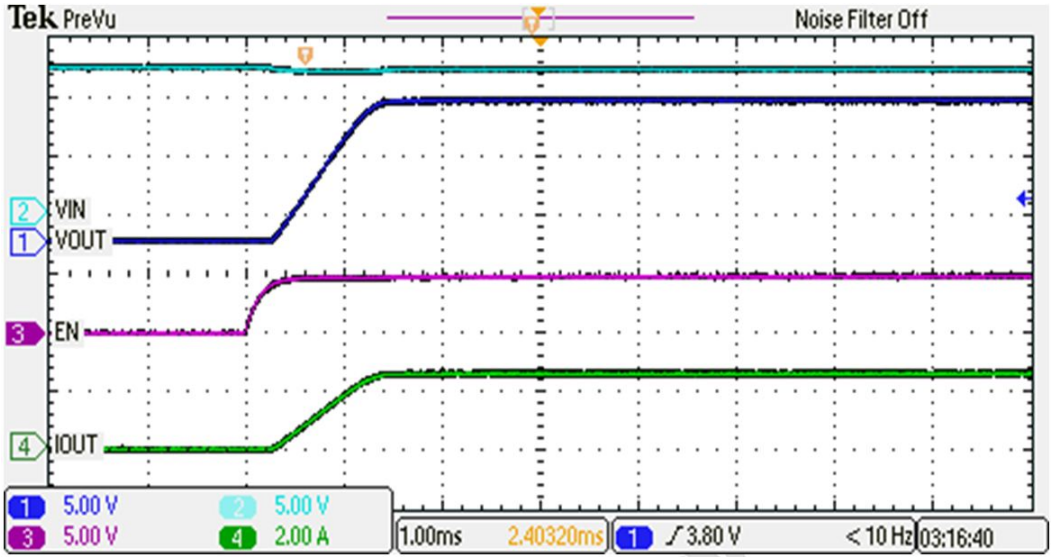

Figure 3. Vout Ramp-Up Time of Auto-Retry Circuit Breaker (CH1)

3. Set the output load at 5 Ω on CH2 and then enable the load. Turn on the power supply, Press the EVM RST switch (S2) and release, verify that VOUT2 (TP16) ramps up as shown in Figure 4.

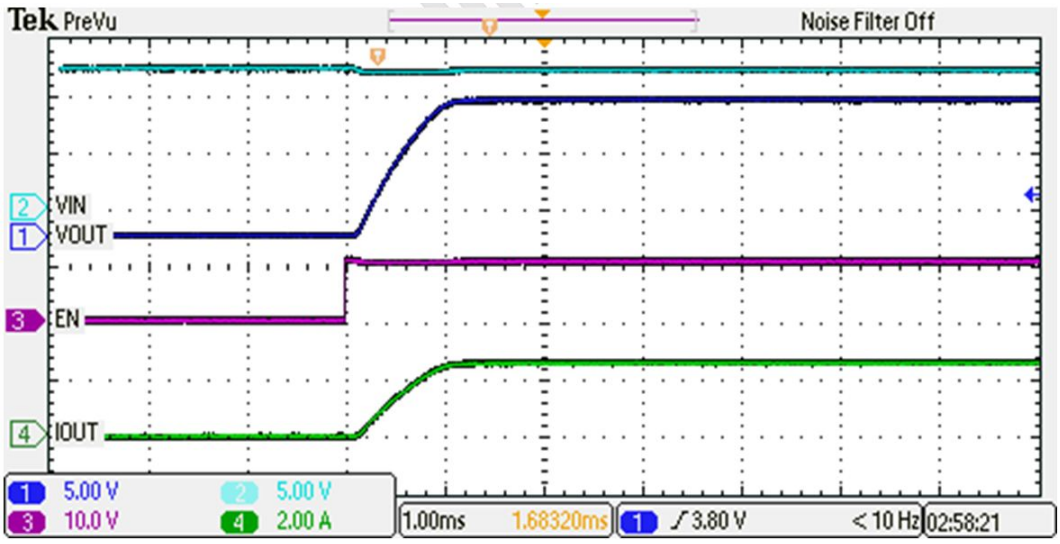

Figure 4. Vout Ramp-up Time of Latched Circuit Breaker (CH2)

4.4.1.4 Circuit Breaker Current Limit Test

1. Verify all three current limits (CH1 and CH2, with only 1 channel powered at a time) and verify the Latch and auto-retry feature. Setup the oscilloscope as shown in Table 8.

Table 8. PWR635 Oscilloscope Setting for Current Limit Test(1)

Oscilloscope Setting	CH1 Probe Points	CH2 Probe Points
Channel 1 = 5 V/div	TP2 = VOUT1	TP16 = VOUT2
Channel 2 = 5 V/div	TP3 = VIN1	TP15 = VIN2
Channel 4 = 5 A/div	Input current into J3 +Ve wire	Input current into J8 +Ve wire
Trigger source = Channel 4		
Trigger level = 1.0 ±0.2 A		
Trigger polarity = +Ve		
Trigger Mode = Single Sequence		
Time base	40 ms/div	

(1) If an electronic load is used, ensure that the output load is set to constant resistance mode and not constant current mode.

2. The jumper setting for the different current limit test is shown in Table 9.

Table 9. PWR635 Jumper Setting for Current Limits

Jumper Position		Load Current Limit
J4 (CH1)	J9 (CH2)	
HI	HI	5.3 A
LO	LO	3.6 A
No Jumper	No Jumper	2.1 A

3. Set the output load at 1.0 ±0.1 Ω on CH1 and current limit to 5.3 A, and then enable the load. Turn on the power supply, verify that input current is limited as per the setting in Table 9 and the device goes in auto retry mode and FLTb1, RED LED (D2) turns ON. Observe from Figure 7 that the circuit breaking time delay is 4.36 ms

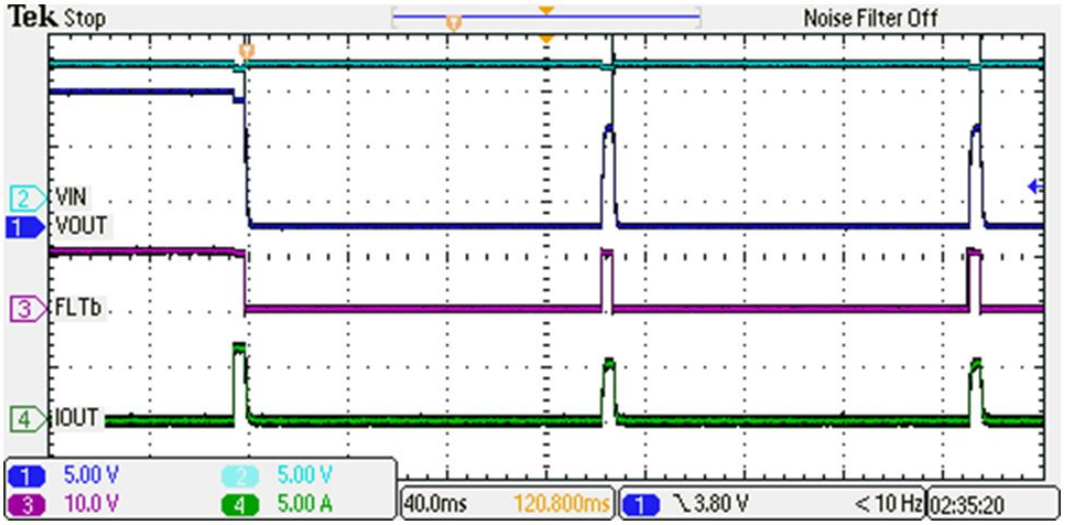

Figure 5. Output Short Circuit Behavior of Auto-Retry Circuit Breaker (CH1)

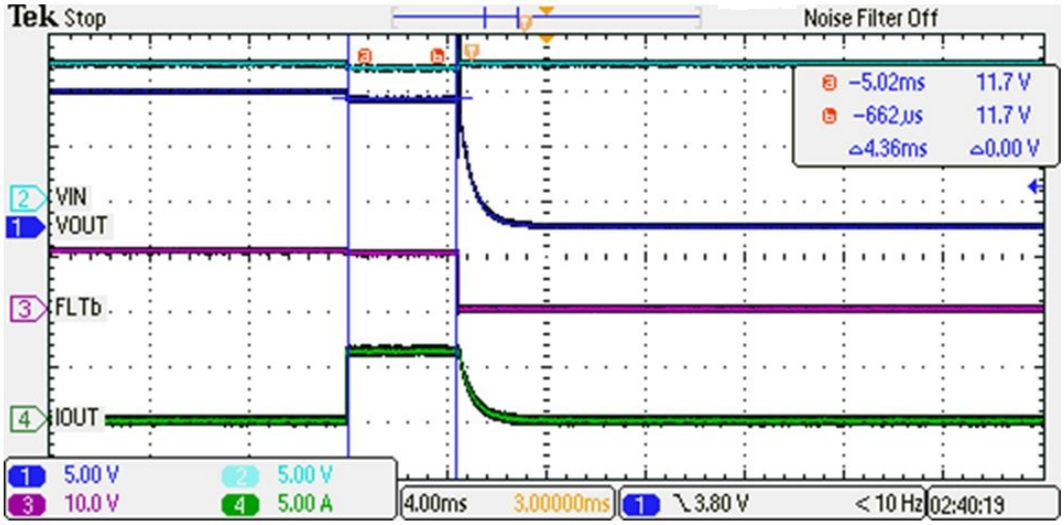

Figure 6. Circuit Breaking Time Delay (CH1)

4. Set the output load at 1.0 ±0.1 Ω on CH1 and current limit to 5.3 A and then enable the load. Turn on the VIN2 power supply and verify that the input current is limited as per the setting in Table 9 and the device is in latched-off mode and FLTb2 RED LED (D6) turns ON.

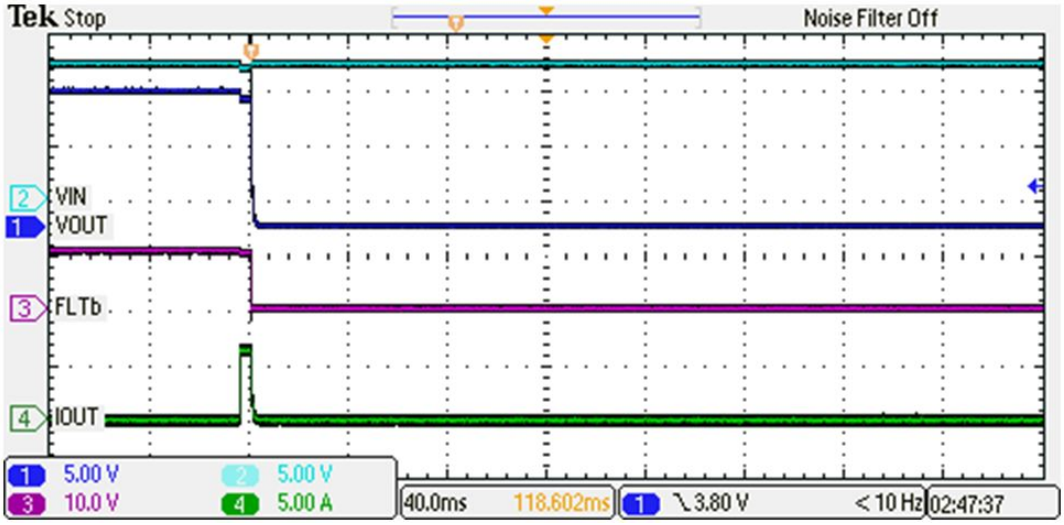

Figure 7. Output Short-Circuit Behavior of Latched Circuit Breaker (CH2)

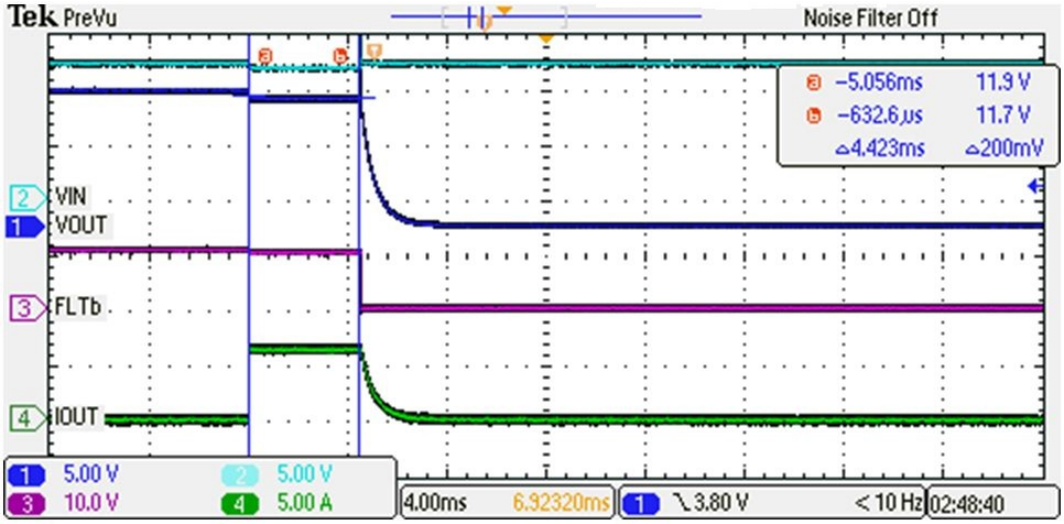

Figure 8. Circuit-Breaking Time Delay (CH2)

5. Set the input power supply to zero volts and disconnect all equipment from the DUT

5 EVM Assembly Drawings and Layout Guidelines

5.1 PCB Drawings

Figure 9 through Figure 11 show component placement and layout of the EVM.

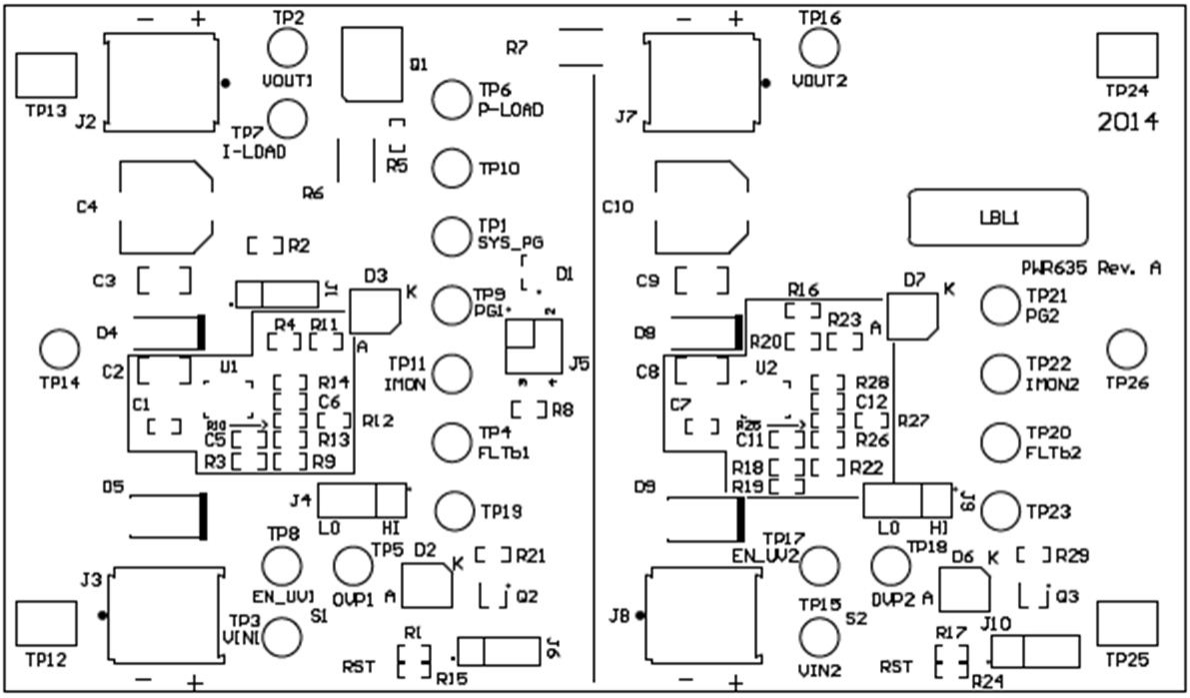

Figure 9. Top Side Placement

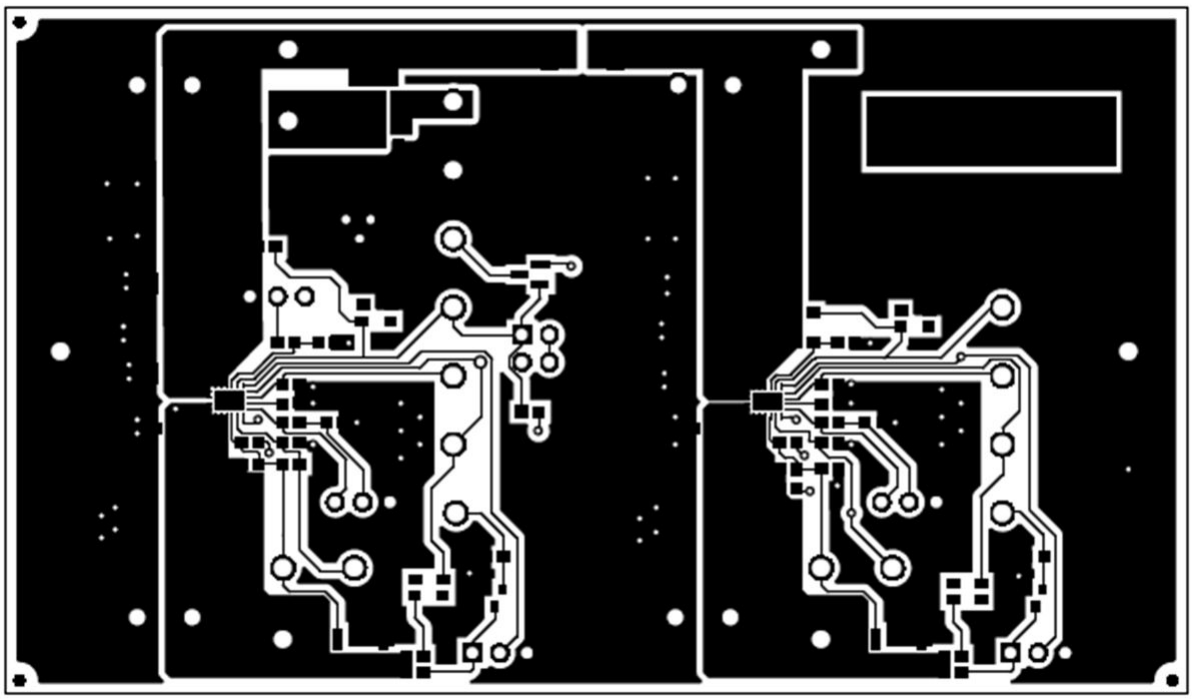

Figure 10. Top Side Routing Layer

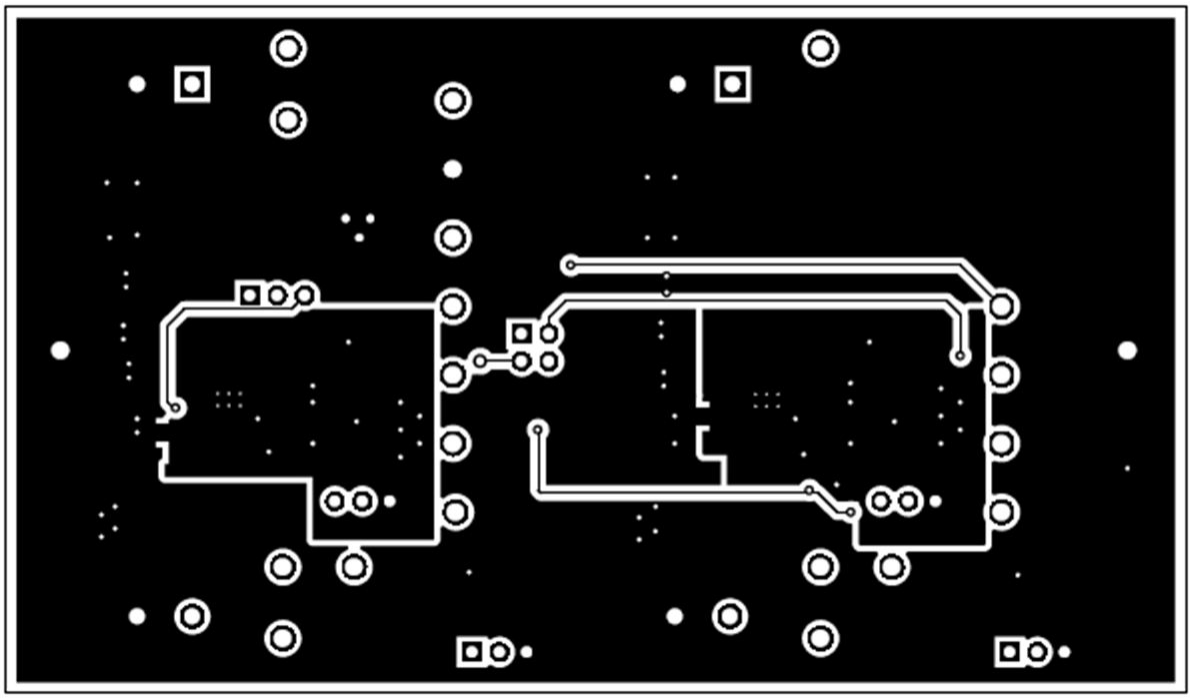

Figure 11. Bottom Side Routing Layer

6 Bill of Materials (BOM)

Table 10. TPS25944XEVM-635 Bill of Material(1)

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
!PCB	1		Printed Circuit Board		PWR635	Any	-	-
C1	1	0.1uF	CAP, CERM, 0.1uF, 25V, +/-10%, X7R, 0603	0603	06033C104KAT2A	AVX		
C2, C3, C8, C9	4	4.7uF	CAP, CERM, 4.7uF, 25V, +/-10%, X7R, 1206	1206	C3216X7R1E475K	TDK		
C4, C10	2	330uF	CAP, AL, 330uF, 25V, +/-20%, 0.16 ohm, SMD	HA0	EMZA250ADA331MHA0G	Nippon Chemi-Con		
C5, C11	2	330pF	CAP, CERM, 330pF, 100V, +/-5%, X7R, 0603	0603	06031C331JAT2A	AVX		
C7	1	1uF	CAP, CERM, 1uF, 25V, +/-10%, X5R, 0603	0603	C1608X5R1E105K080AC	TDK		
D1	1	30V	Diode, Schottky, 30V, 0.2A, SOT-23	SOT-23	BAT54C-7-F	Diodes Inc.		
D2, D6	2	Red	LED, Red, SMD	Power TOPLED w/lens	LS E63F-DBFA-1-Z	OSRAM	-	-
D4, D8	2	20V	Diode, Schottky, 20V, 3A, SMA	SMA	B320A-13-F	Diodes Inc.		
D5, D9	2	16V	Diode, TVS, Uni, 16V, 600W, SMB	SMB	SMBJ16A-13-F	Diodes Inc.		
D7	1	Green	LED, Green, SMD	Power TOPLED w/lens	LT E63C-CADB-35-L-Z	OSRAM	-	-
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A		
H1, H2, H3, H4	4		Bumpon, Cylindrical, 0.312 X 0.200, Black	Black Bumpon	SJ61A1	3M		
J1, J4, J6, J9, J10	5	1x3	Header, TH, 100mil, 1x3, Gold plated, 230 mil above insulator	PBC03SAAN	PBC03SAAN	Sullins Connector Solutions	Equivalent	Any
J2, J3, J7, J8	4		Terminal Block, 2x1, 5.08mm, TH	10.16x15.2x9mm	282841-2	TE Connectivity		
J5	1		Header, TH, 100mil, 2x2, Gold plated, 230 mil above insulator	TSW-102-07-G-D	TSW-102-07-G-D	Samtech Inc	Equivalent	Any
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650"H x 0.200"W	THT-14-423-10	Brady	-	-
Q1	1	30V	MOSFET, N-CH, 30V, 100A, SON 5x6mm	SON 5x6mm	CSD17301Q5A	Texas Instruments	None	None
R1, R2, R16, R17	4	100k	RES, 100k ohm, 5%, 0.1W, 0603	0603	CRCW0603100KJNEA	Vishay-Dale		
R3, R4, R18, R19, R20	5	475k	RES, 475k ohm, 1%, 0.1W, 0603	0603	CRCW0603475KFKEA	Vishay-Dale	Equivalent	Any
R5	1	10.0k	RES, 10.0k ohm, 1%, 0.1W, 0603	0603	CRCW060310K0FKEA	Vishay-Dale	Equivalent	Any
R6	1	0.1	RES, 0.1 ohm, 1%, 3W, 2512	2512	CRA2512-FZ-R100ELF	Bourns		
R9, R10, R25	3	16.9k	RES, 16.9k ohm, 1%, 0.1W, 0603	0603	CRCW060316K9FKEA	Vishay-Dale	[NoValue], [NoValue], Equivalent	[NoValue], [NoValue], Any
R11, R23	2	47k	RES, 47k ohm, 5%, 0.1W, 0603	0603	CRCW060347K0JNEA	Vishay-Dale		
R12, R27	2	24.9k	RES, 24.9k ohm, 1%, 0.1W, 0603	0603	CRCW060324K9FKEA	Vishay-Dale		
R13	1	32.4k	RES, 32.4k ohm, 1%, 0.1W, 0603	0603	CRCW060332K4FKEA	Vishay-Dale		
R14, R28	2	16.2k	RES, 16.2k ohm, 1%, 0.1W, 0603	0603	CRCW060316K2FKEA	Vishay-Dale		
R15, R24	2	100k	RES, 100k ohm, 1%, 0.1W, 0603	0603	CRCW0603100KFKEA	Vishay-Dale		
R21, R29	2	10k	RES, 10k ohm, 5%, 0.1W, 0603	0603	CRCW060310K0JNEA	Vishay-Dale		
R26	1	35.7k	RES, 35.7k ohm, 1%, 0.1W, 0603	0603	RC0603FR-0735K7L	Yageo America		
S1, S2	2		Switch, Push Button, SMD	2.9x2x3.9mm SMD	SKRKAEE010	Alps	Equivalent	Any
SH-J1, SH-J4, SH-J9	3	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M	SNT-100-BK-G	Samtec

(1) Unless otherwise noted in the Alternate Part Number and/or Alternate Manufacturer columns, all parts may be substituted with equivalents.

Table 10. TPS25944XEVM-635 Bill of Material[(1)] (continued)

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
TP1, TP4, TP5, TP8, TP9, TP11, TP17, TP18, TP20, TP21, TP22	11	White	Test Point, TH, Multipurpose, White	Keystone5012	5012	Keystone	Equivalent	Any
TP2, TP3, TP15, TP16	4	Red	Test Point, TH, Multipurpose, Red	Keystone5010	5010	Keystone	Equivalent	Any
TP6, TP19, TP23	3	Orange	Test Point, Multipurpose, Orange, TH	Orange Multipurpose Testpoint	5013	Keystone		
TP7	1	White	Test Point, Multipurpose, White, TH	White Multipurpose Testpoint	5012	Keystone		
TP10, TP14, TP26	3	Black	Test Point, TH, Multipurpose, Black	Keystone5011	5011	Keystone	Equivalent	Any
TP12, TP13, TP24, TP25	4	SMT	Test Point, SMT, Compact	Testpoint_Keystone_Compact	5016	Keystone	Equivalent	Any
U1	1		2.7V-18V eFuse with True Reverse Blocking for Power Mux, RVC0020A	RVC0020A	TPS25944ARVC	Texas Instruments		None
U2	1		2.7V-18V eFuse with True Reverse Blocking for Power Mux, RVC0020A	RVC0020A	TPS25944LRVC	Texas Instruments		None
C6, C12	0	1000pF	CAP, CERM, 1000pF, 100V, +/-20%, X7R, 0603	0603	06031C102MAT2A	AVX	-	-
D3	0	Green	LED, Green, SMD	Power TOPLED w/lens	LT E63C-CADB-35-L-Z	OSRAM	-	-
Q2, Q3	0	60V	MOSFET, N-CH, 60V, 0.31A, SOT-323	SOT-323	2N7002KW	Fairchild Semiconductor		None
R22	0	48.7k	RES, 48.7k ohm, 1%, 0.1W, 0603	0603	CRCW060348K7FKEA	Vishay-Dale		
SH-J5, SH-J6, SH-J10	0	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M	SNT-100-BK-G	Samtec

Revision History

Changes from Original (May 2015) to A Revision	Page
• Added *Important Note to TPS25944XEVM-635 Users*.	1

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

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.

   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 and conditions 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 and conditions 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 any defects that are 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. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

   2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, 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.

3 *Regulatory Notices:*

   3.1 *United States*

      3.1.1 *Notice applicable to EVMs not FCC-Approved:*

      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*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). 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 by Radio Law of Japan to follow the instructions below with respect to EVMs:

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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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 WRITTEN DESIGN MATERIALS PROVIDED WITH THE EVM (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 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.

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8. *Limitations on Damages and Liability:*

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