User's Guide

TPS25948EVM Evaluation Module for TPS25948 eFuse

ABSTRACT

This user's guide describes the evaluation module (EVM) for the TPS25948 eFuse. The TPS25948 device is a 3.5-V to 23-V, 8-A eFuse with integrated 13-mΩ FET with reverse current protection, overcurrent protection, inrush current protection, adjustable overcurrent transient blanking timer, and programmable undervoltage and overvoltage protection.

	**Caution**	**Hot surface.** **Contact can cause burns.** **Do not touch!**

Note

TP1(VIN1), TP14(VIN2), TP2(VOUT1), TP15(VOUT2) are Kelvin-sense test points and not a good choice for carrying high current. Do not apply power to these test points. Use connectors present on EVM for applying power.

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Trademarks

All trademarks are the property of their respective owners.

1 Introduction

The TPS25948EVM eFuse evaluation board allows reference circuit evaluation of the Texas Instruments TPS25948 eFuse. The TPS25948 device is a 3.5-V to 23-V, 8-A eFuse with integrated 13-mΩ FET with reverse current protection, overcurrent protection, inrush current protection, adjustable over current transient blanking timer, and programmable undervoltage and overvoltage protection.

1.1 EVM Features

General TPS25948EVM eFuse evaluation board features include:

- 3.5-V to 23-V (typical) operation
- 1-A to 9-A programmable current limit using onboard jumpers
- Programmable output voltage slew rate control
- Programmable transient current blanking timer
- Programmable current limit
- Power mux configuration
- TVS diode for input transient protection
- Onboard Schottky diode at output prevents negative spike during overcurrent faults
- LED status for Power Good and fault indication

1.2 EVM Applications

This EVM can be used for the following applications:

- Smartphone and tablet
- PC and notebook
- USB port protection
- Power MUXing/ORing
- Adapter and charger input protection

2 Description

The TPS25948EVM eFuse evaluation board has two channels and enables evaluation of TPS259480A and TPS259482L eFuses from TPS25948 family. Channels 1 and 2 share a common ground plane and provide option to evaluate power muxing and paralleling capabilities of TPS25948 eFuse. The channels provide programmable OVLO, ITIMER, dVdt, and ILM settings. The input power is applied at connectors J2 and J12, while J1 and J11 provide the output connection for channels 1 and 2 respectively. Refer to the schematic in Figure 3-1 and the EVM test setup in Figure 5-1.

TVS diodes U2 and U5 provide input protection from transient overvoltages, while Schottky diode D2 and D8 provide output protection for the TPS25948 eFuses in channels 1 and 2 respectively. S1 and S2 allows U1 and U2 to be RESET or disabled. A supply good (SPLYGD) indicator is provided by D1 and D7.

Table 2-1. TPS25948EVM eFuse Evaluation Board Options and Setting

EVM Function	Channel	Vin UVLO Threshold	Vin OVLO Threshold	ITimer	Output Slew Rate, dVdt	Current Limit	
						Low Setting	Hi Setting
3.5-V to 23-V, 8-A eFuse	CH1	10.84 V	Selectable OVLO – 13.8 V, 16.4 V, 21.5 V Note: Adjust UVLO resistor divider to keep UVLO threshold below OVLO	Selectable – 170 us, 1.7 ms, 17 ms	Selectable – 1.5 mV/us, 0.5 mV/us, 0.23 mV/us	1 A	9 A
	CH2	10.84V	Selectable OVLO – 13.8 V, 16.4 V, 21.5 V Note: Adjust UVLO resistor divider to keep UVLO threshold below OVLO	Selectable – 170 us, 1.7 ms, 17 ms	Selectable – 1.5 mV/us, 0.5 mV/us, 0.23 mV/us	1 A	9 A

3 Schematic

Figure 3-1 illustrates the EVM schematic.

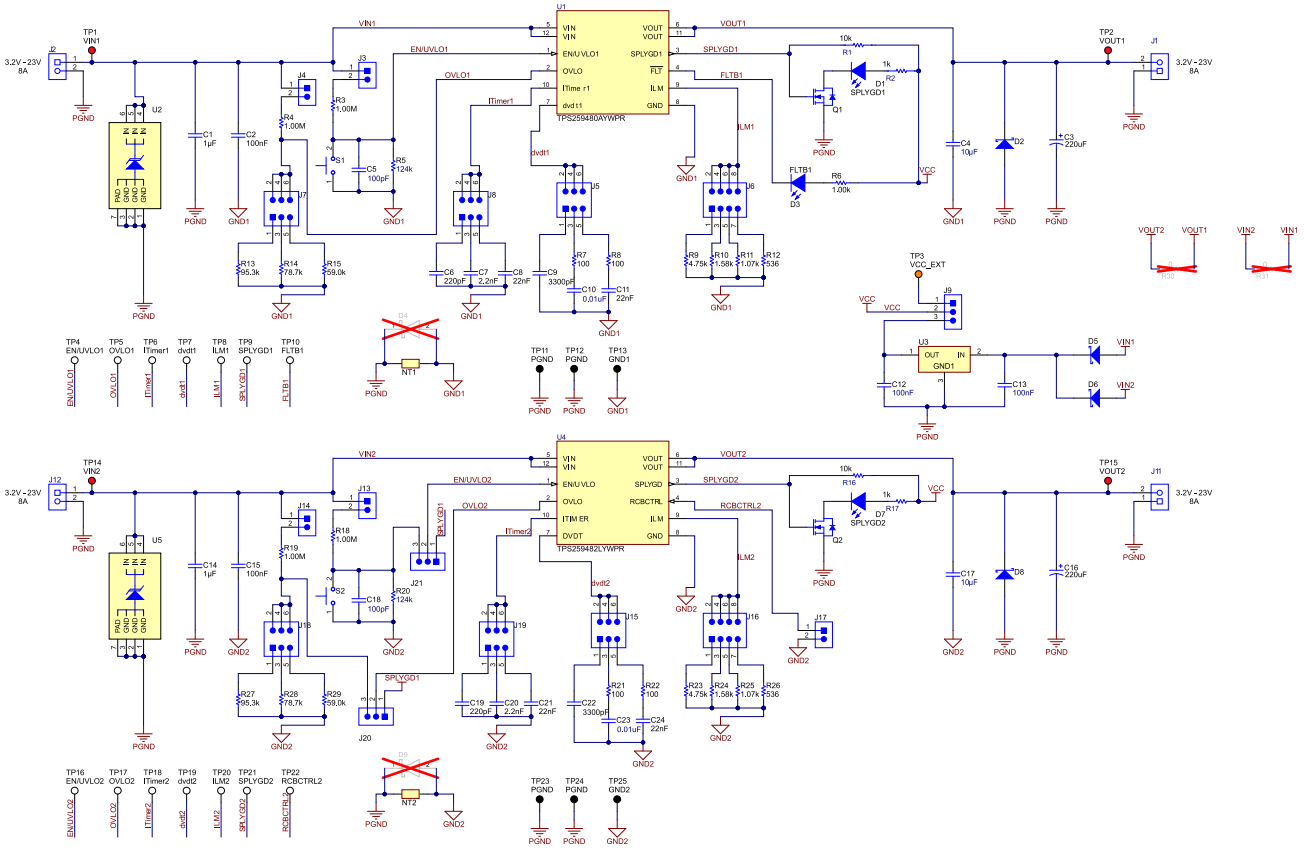

Figure 3-1. TPS25948EVM eFuse Evaluation Board Schematic

4 General Configurations

4.1 Physical Access

Table 4-1 lists the TPS25948EVM eFuse evaluation board input and output connector functionality. Table 4-2 and Table 4-3 describe the test point availability and the jumper functionality. Table 4-4 describes the function of signal LEDs.

Table 4-1. Input and Output Connector Functionality

Channel	Connector	Label	Description
CH1	J2	VIN1(+), PGND(–)	Input of CH1
	J1	VOUT1(+), PGND(–)	Output of CH1
CH2	J12	VIN2(+), PGND(–)	Input of CH2
	J11	VOUT2(+), PGND(–)	Output of CH2

Table 4-2. Test Points Description

Channel	Test Points	Label	Description
CH1	TP1	VIN1	CH1 input voltage
	TP2	VOUT1	CH1 output voltage
	TP4	EN/UVLO1	CH1 EN/UVLO signal
	TP5	OVLO1	CH1 OVLO signal
	TP6	ITIMER1	CH1 ITIMER signal
	TP7	dVdt1	CH1 output voltage ramp control
	TP8	ILM1	CH1 current limit and monitor signal
	TP10	FLTb1	CH1 fault signal
	TP9	SPLYGD1	CH1 supply good signal
	TP13	GND1	CH1 IC GND signal
CH2	TP14	VIN2	CH2 input voltage
	TP15	VOUT2	CH2 output voltage
	TP16	EN/UVLO2	CH2 EN/UVLO signal
	TP17	OVLO2	CH2 OVLO signal
	TP18	ITIMER2	CH2 ITIMER signal
	TP19	dVdt2	CH2 output voltage ramp control
	TP20	ILM2	CH2 current limit and monitor signal
	TP22	RCBCTRL2	CH2 reverse current blocking control signal
	TP21	SPLYGD2	CH2 supply good signal
	TP25	GND2	CH2 IC GND signal
CH1 & CH2	TP3	VCC_EXT	External VCC voltage point for CH1 and CH2
	TP11,TP12,TP23, TP24	PGND	Common Power GND for CH1 and CH1

Table 4-3. Jumper Descriptions and Default Positions

Channel	Jumper	Label	Description	Default Jumper Position
CH1	J5	dVdt1	1-2 position sets the output slew rate to 1.5 mV/us	3-4
			3-4 position sets the output slew rate to 0.5 mV/us	
			5-6 position sets the output slew rate to 0.23 mV/us	
	J6	ILM1	1-2 position sets the current limit to 1 A	7-8
			3-4 position sets the current limit to 3 A	
			5-6 position sets the current limit to 4.5 A	
			7-8 position sets the current limit to 9 A	
	J8	ITIMER1	1-2 position sets the transient current blanking period to 170 us	3-4
			3-4 position sets the transient current blanking period to 1.7 ms	
			5-6 position sets the transient current blanking period to 17 ms	
	J7	OVLO1	1-2 position sets input OVLO threshold at 13.8 V	3-4
			3-4 position sets input OVLO threshold at 16.4 V	
			5-6 position sets input OVLO threshold at 21.5 V	
	J4	OVLO1_VIN1	Connects OVLO pin to VIN resistor ladder	1-2
	J3	UVLO1_VIN1	Connects UVLO pin to VIN resistor ladder	1-2
	J15	dVdt2	1-2 position sets the output slew rate to 1.5 mV/us	3-4
			3-4 position sets the output slew rate to 0.5 mV/us	
			5-6 position sets the output slew rate to 0.23 mV/us	
	J16	ILM2	1-2 position sets the current limit to 1 A	7-8
			3-4 position sets the current limit to 3 A	
			5-6 position sets the current limit to 4.5 A	
CH2			7-8 position sets the current limit to 9 A	
	J19	ITIMER2	1-2 position sets the transient current blanking period to 170 us	3-4
			3-4 position sets the transient current blanking period to 1.7 ms	
			5-6 position sets the transient current blanking period to 17 ms	
	J18	OVLO2	1-2 position sets input OVLO threshold at 13.8 V	3-4
			3-4 position sets input OVLO threshold at 16.4 V	
			5-6 position sets input OVLO threshold at 21.5 V	
	J20	OVLO2_SPLYGD1	1-2 Position connects the SPLYGD1 with OVLO2. Use this setting for Power Muxing operation of U1 and U2	2-3
			2-3 position connects OVLO2 to VIN resistor ladder	
	J21	UVLO2_SPLYGD1	1-2 Position connects the SPLYGD1 with EN/UVLO2. Use this setting for parallel operation of U1 and U2	2-3
			2-3 position connects EN/UVLO2 to VIN resistor ladder	
	J14	OVLO2_VIN2	Connects OVLO pin to VIN resistor ladder	1-2
	J13	UVLO2_VIN2	Connects UVLO pin to VIN resistor ladder	1-2
	J17	RCBCTRL2	Connects RCBCTRL to GND to disable reverse current blocking	Open
CH1 & CH2	J9	VCC connection CH-1,2	2-3 position connects onboard generated voltage, VCC as reference for digital signals of U1 and U2	2-3

Table 4-4. LED Descriptions

LED	Description
D1	When ON, indicates that SPLYGD is asserted for channel 1
D3	When ON, indicates that FLTb is asserted for channel 1
D7	When ON, indicates that SPLYGD is asserted for channel 2

4.2 Test Equipment and Setup

4.2.1 Power Supplies

One adjustable power supply with 0-V to 23-V output and current limit greater than 9 A.

4.2.2 Meters

One DMM minimum needed.

4.2.3 Oscilloscope

A DPO2024 or equivalent, three 10x voltage probes, and a DC current probe.

4.2.4 Loads

One resistive load or equivalent that can tolerate up to 8-A DC load at 23 V and capable of the output short.

5 Test Setup and Procedures

In this user's guide section, the test procedure is described for TPS25948EVM testing.

Make sure the evaluation board has default jumper settings as shown in Table 5-1.

Table 5-1. Default Jumper Setting for TPS25948EVM eFuse Evaluation Board

J7	J4	J3	J8	J5	J6	J9	J14	J18	J20	J19	J15	J16	J17
3-4	1-2	1-2	3-4	3-4	7-8	2-3	1-2	3-4	2-3	3-4	3-4	7-8	open

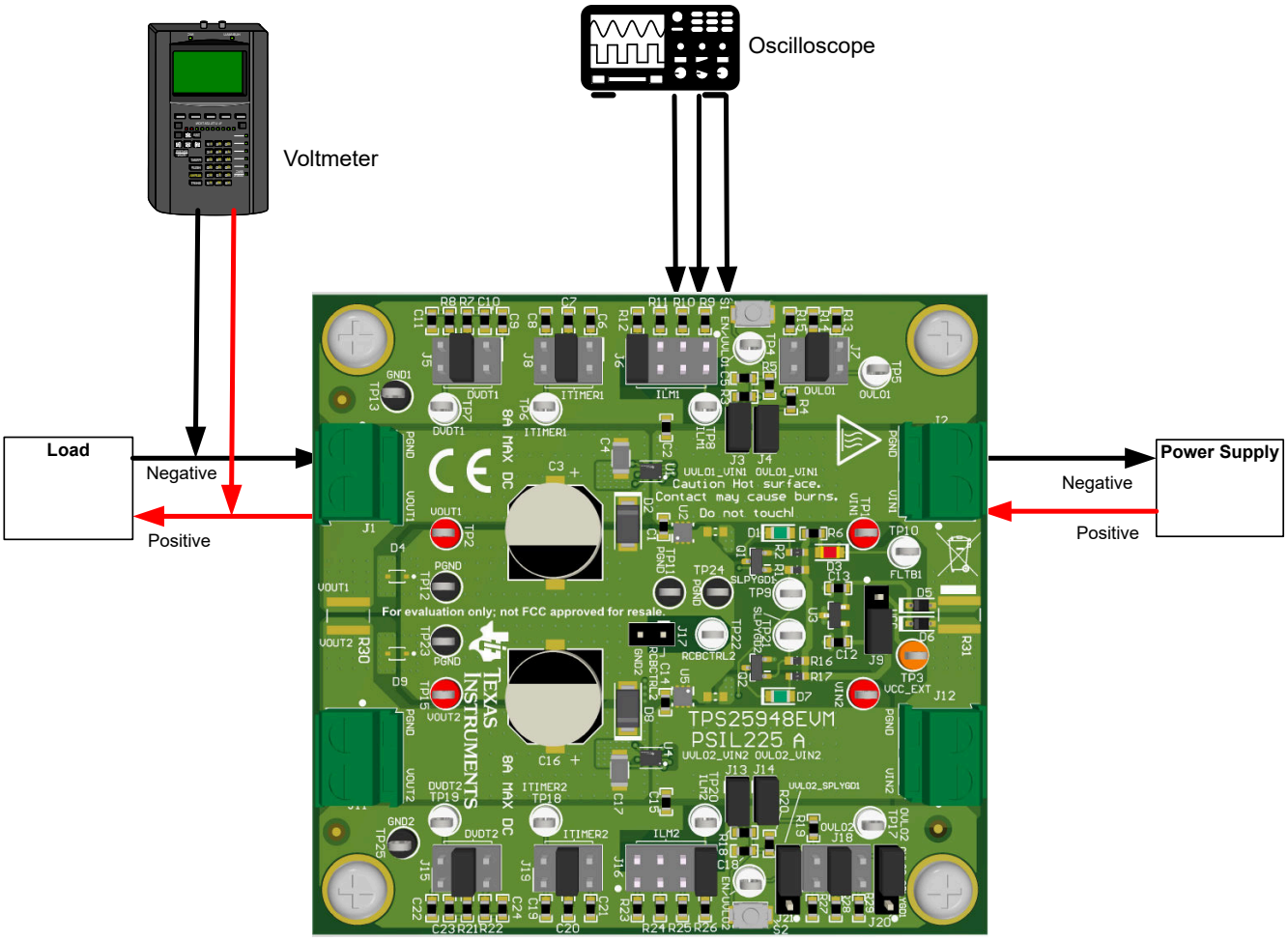

Figure 5-1. TPS25948EVM Setup with Test Equipment

Follow these instructions before starting any test and repeat again before moving to the next test:

1. Set the power supply output (VIN) to zero volts.
2. Turn ON the power supply and set the power supply output (VIN) to 12 V, current limit = 9 A.
3. Turn OFF the power supply.
4. Set the jumper setting on EVM to default position as shown in Table 5-1.

5.1 Hot-Plug Test

Use the following instructions to measure the inrush current during the Hot-Plug event on channel 1:

1. Set jumper J5 position to the desired slew rate as mentioned in Table 4-3.
2. Set the input supply voltage VIN to 12 V and current limit of 9 A. Enable the power supply.
3. Hot-plug the supply between VIN1 and PGND1 points of connector J2.
4. Observe the waveform at VOUT1 (TP2) and input current with an oscilloscope to measure the slew rate and rise time of the eFuse with a given input voltage of 12 V.

Figure 5-2 shows an example of inrush current captured on the TPS25948EVM eFuse evaluation board.

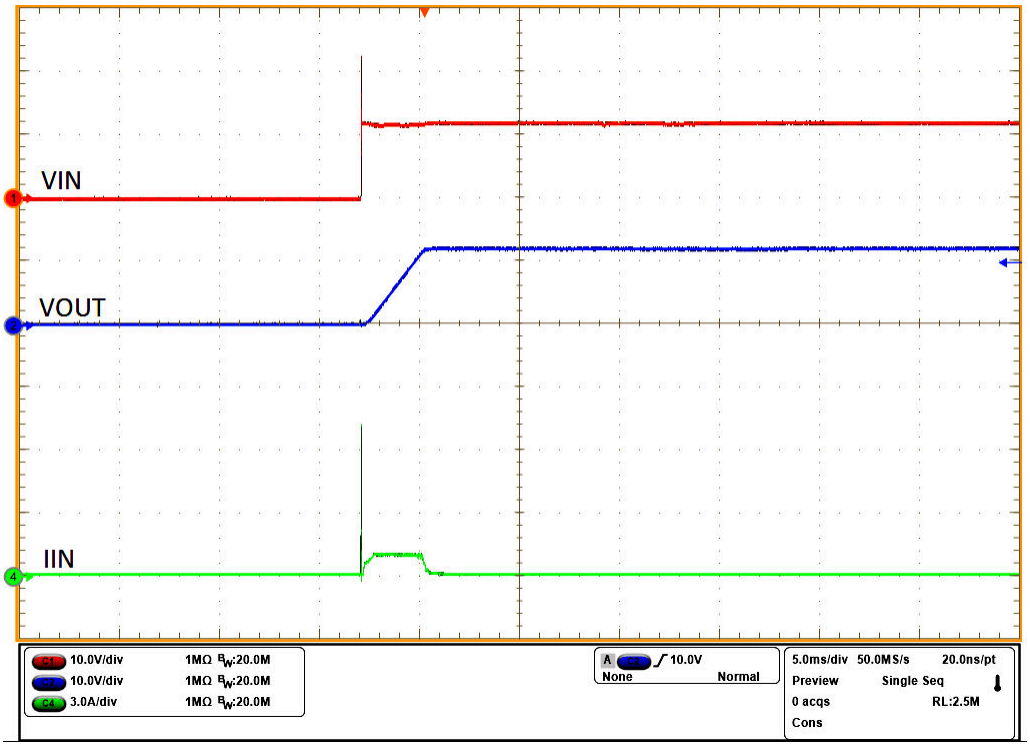

Figure 5-2. TPS25948 Output Rise Profile (VIN = 12 V, Cout = 220 µF, CdVdT = OPEN, R_{ILM} = 536 Ω, No Load)

5.2 Overcurrent Test

Use the following instructions to perform the overcurrent test on the current limit TPS25948 eFuse on channel 1:

1. Place jumper J8 to the appropriate position to obtain required blanking period as per Table 4-3.
2. Set the input supply voltage VIN to 12 V and current limit of 9 A and enable the power supply.
3. Place jumper J6 in good position to set the required current limit as per Table 4-3.
4. Apply an overload greater than the set current limit between VOUT1 and GND.
5. The device allows the overload current for the programmed ITIMER period and then starts limiting current.

Figure 5-3 shows an example of the circuit breaker test on the TPS25948EVM.

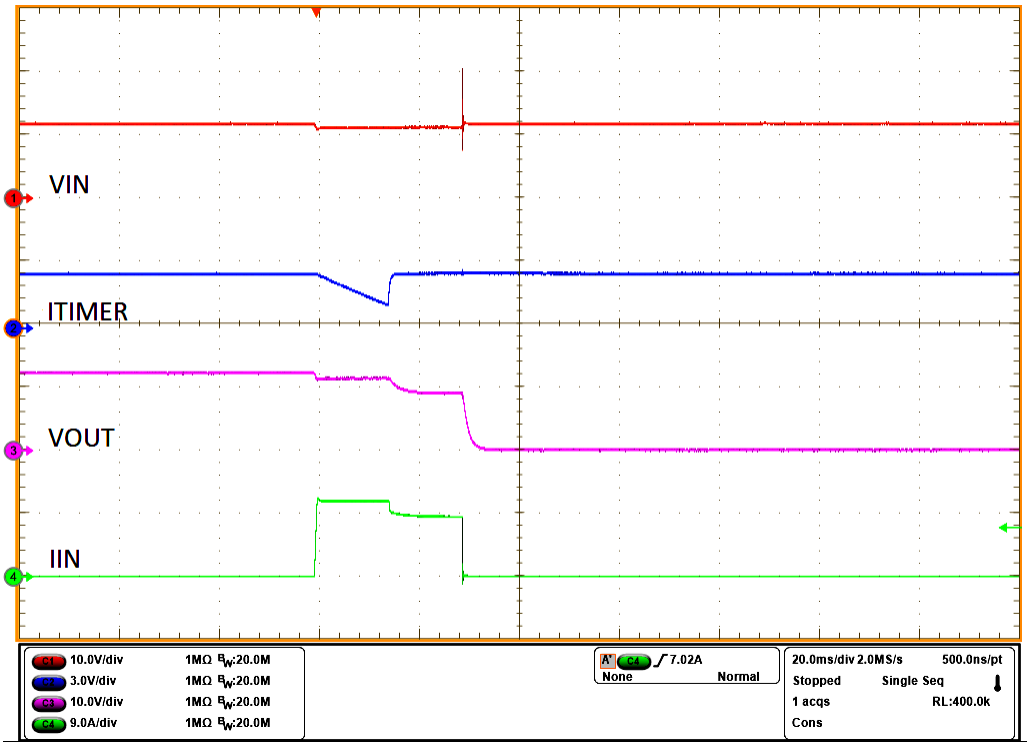

Figure 5-3. Overcurrent Response of TPS25948 for 9-A Current Limit Setting

5.3 Output Hot-Short Test

Use the following instructions to perform the output Hot-Short test:

1. Set the input supply voltage VIN to 12 V and current limit of 9 A. Turn ON the power supply.
2. Short the output of the device, VOUT1 to GND with a short cable.
3. Observe the waveforms using an oscilloscope.

Figure 5-4 shows test waveform of output Hot-short on the TPS25948EVM eFuse evaluation board.

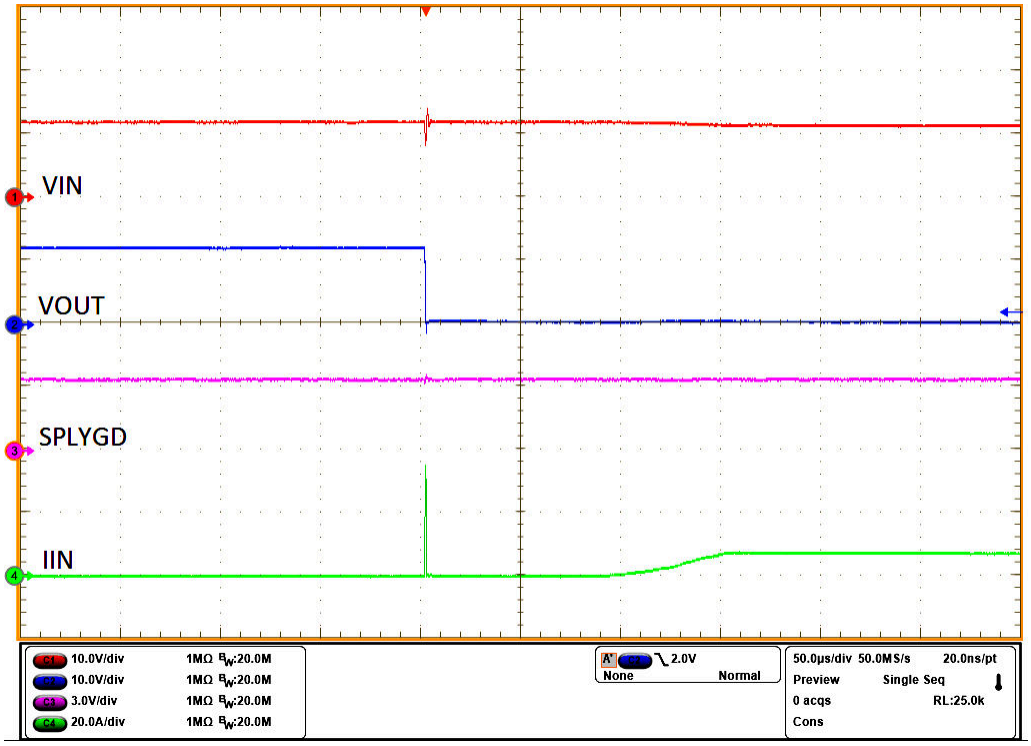

Figure 5-4. Output Hot-Short Response of the TPS25948 Device at Vin = 12 V, Cout = Open, R_{ILM} = 536 Ω

5.4 Wakeup into Short Test

Use the following instructions to perform the wakeup into short test:

1. Set the input supply voltage VIN to 12 V and current limit of 9 A. Turn OFF the power supply.
2. Short the output of the device, VOUT1 to GND with a short cable.
3. Turn ON the power supply.

Figure 5-5 shows test waveform of wakeup into output short on the TPS25948EVM eFuse evaluation board.

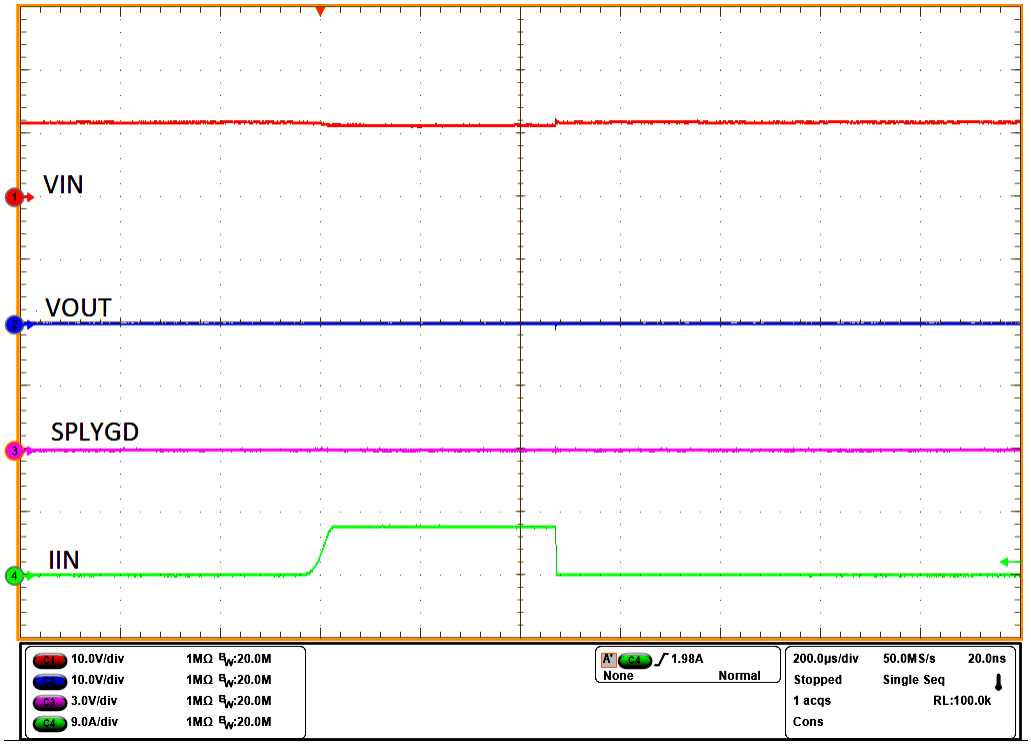

Figure 5-5. Test Waveform of Wakeup Into Output Short for the TPS25948 Device at Vin = 12 V, Cout = Open, R_{ILM} = 536 Ω

5.5 Overvoltage Test

Use the following instructions to perform the overvoltage protection test on channel 1:

1. Remove the input TVS diodes.
2. Place jumper J4 in position 1-2 and J7 in a good position to set the required OVLO threshold as per Table 4-3. For example, consider setting 1-2 to set threshold as 13.8 V.
3. Set the input supply voltage VIN to 12 V and current limit of 9 A. Apply the supply between VIN1 and PGND1 at connector J2 and enable the power supply.
4. Increase the input supply VIN from 12 V to 15 V and observe the waveforms using an oscilloscope.

Figure 5-6 shows overvoltage response of TPS25948 on the TPS25948EVM eFuse evaluation board.

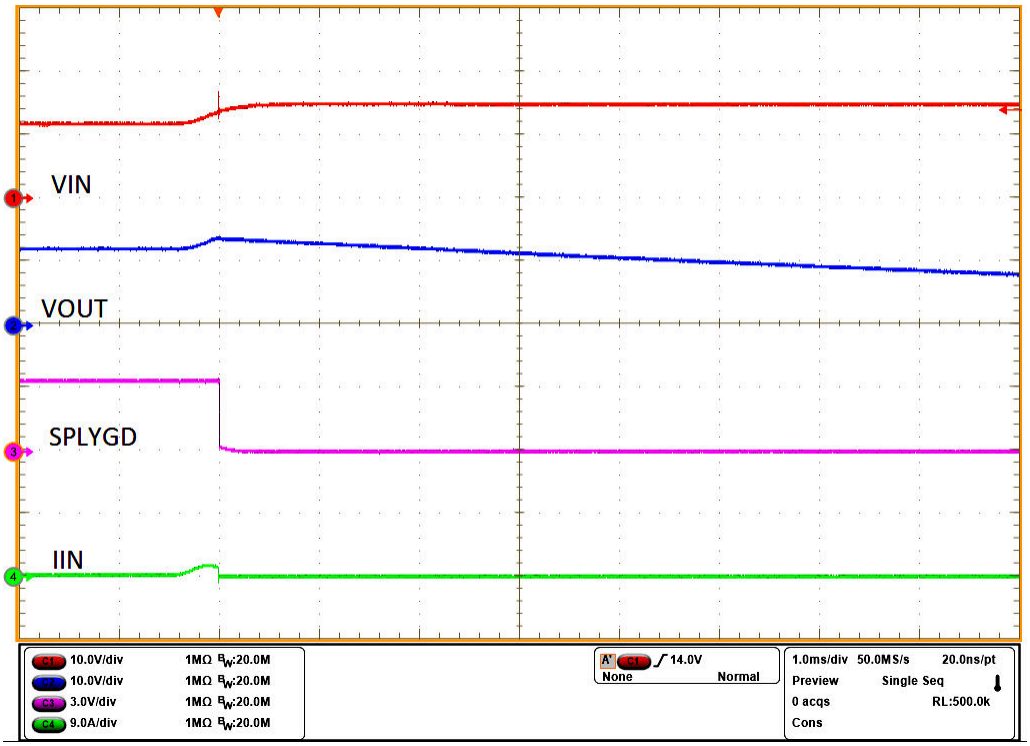

Figure 5-6. Overvoltage Protection Response of the TPS25948 Device

5.6 Priority Power Mux Test

Use the following instructions to perform Power Mux test:

1. Use Channel 1 and Channel 2 to test PowerMuxing capability of TPS25948.
2. Populate R30 with 0-Ω resistor to connect VOUT1 and VOUT2.
3. Connect J20 jumper setting to 1-2 to connect SPLYGD signal of Channel 1 to OVLO signal of Channel 2. This setting makes Channel 1 as primary and Channel 2 as secondary channels. Keep J17 open to keep reverse current blocking enabled on TPS259482.
4. Change the UVLO threshold setting for each channel as per the voltage intended to be applied.
5. Apply primary voltage on Channel 1 and secondary voltage on Channel 2.
6. Test various conditions.
   a. Turn off primary channel to see output being powered from secondary channel.
   b. Turn back on primary channel to see output connected back to primary from secondary channel.

Test Waveform of PowerMux configuration when primary voltage = 12 V, secondary voltage = 20 V, and output transitioning from primary to secondary voltage as primary loses power.

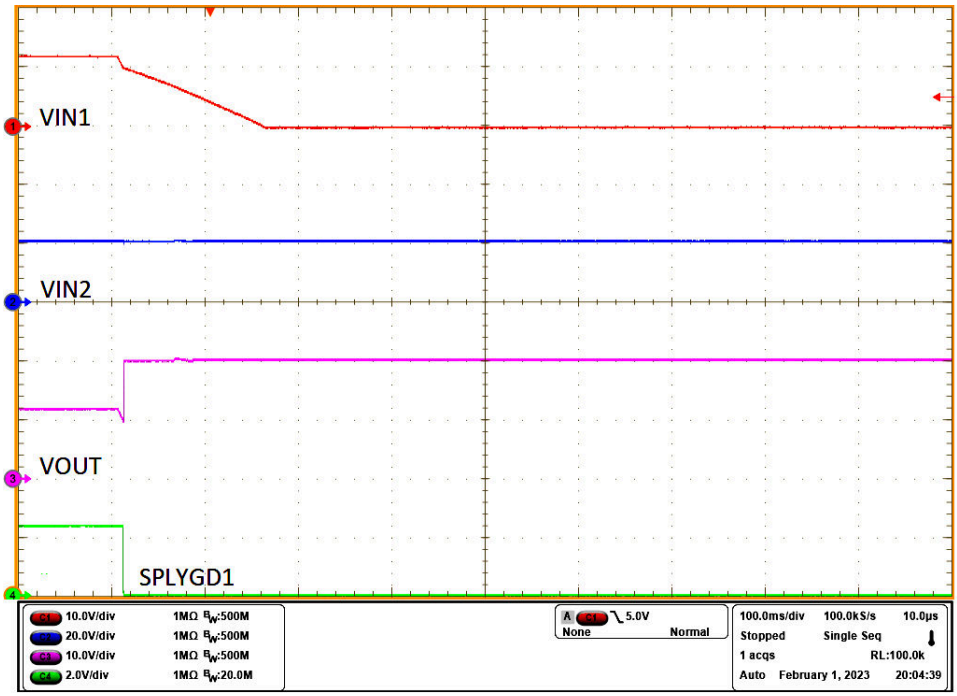

Figure 5-7. Priority PowerMux Test on TPS25948

6 EVAL Board Assembly Drawings and Layout Guidelines

6.1 PCB Drawings

Figure 6-1 shows component placement of the EVAL Board. Figure 6-2 shows PCB layout images.

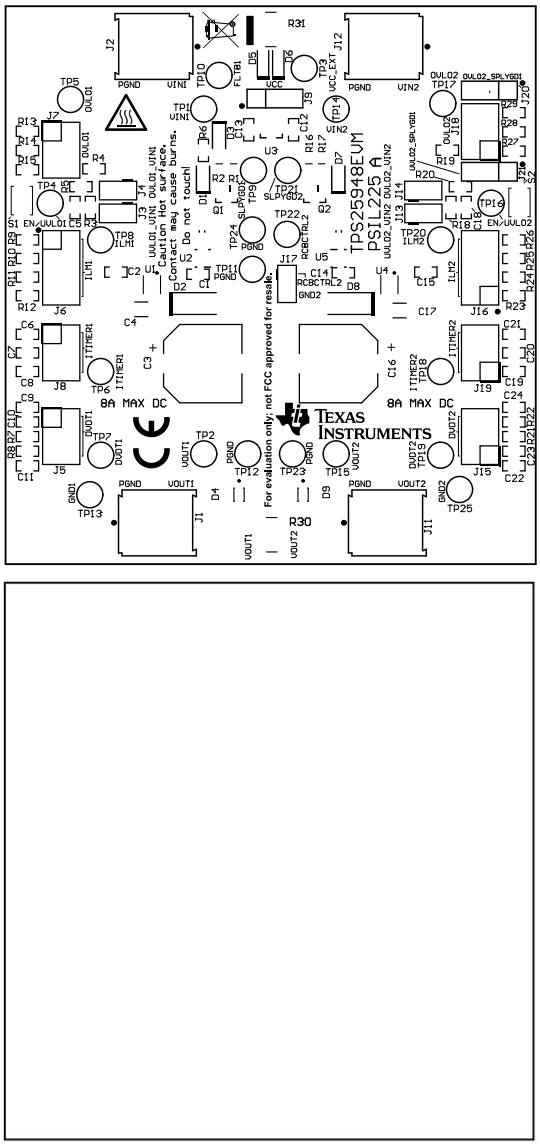

Figure 6-1. TPS25948EVM Board (a) Top Assembly (b) Bottom Assembly

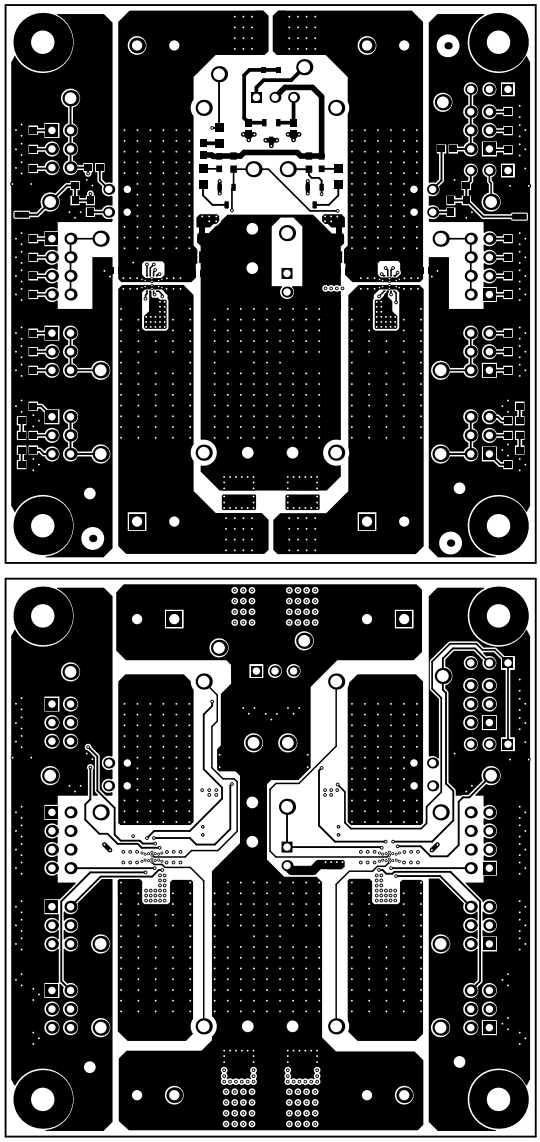

Figure 6-2. TPS25948EVM Board (a) Top Layer (b) Bottom Layer

7 Bill Of Materials (BOM)

Table 7-1 lists the EVM BOM.

Table 7-1. Bill of Materials

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
!PCB1	1		Printed Circuit Board		PSIL225	Any
C1, C14	2	1uF	CAP, CERM, 1 uF, 35 V, +/- 10%, X7R, 0603	603	C1608X7R1V105K080AC	TDK
C2, C15	2	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	603	C1608X7R1H104K080AA	TDK
C3, C16	2	220uF	CAP, AL, 220 uF, 35 V, +/- 20%, 0.15 ohm, SMD	SMT Radial G	EEE-FC1V221P	Panasonic
C4, C17	2	10uF	CAP, CERM, 10 µF, 50 V,+/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206	CGA5L1X7R1H106K160AC	TDK
C5, C18	2	100 pF	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0603	603	8.85012E+11	Wurth Elektronik
C6, C19	2	220 pF	CAP, CERM, 220 pF, 50 V, +/- 10%, X7R, 0603	603	C0603C221K5RACTU	Kemet
C7, C20	2	2200 pF	CAP, CERM, 2200 pF, 50 V, +/- 10%, X7R, 0603	603	C0603C222K5RAC	Kemet
C8, C11, C21, C24	4	0.022uF	CAP, CERM, 0.022 uF, 50 V, +/- 10%, X7R, 0603	603	C0603X223K5RACTU	Kemet
C9, C22	2	3300 pF	CAP, CERM, 3300 pF, 50 V, +/- 10%, X7R, 0603	603	C0603X332K5RACTU	Kemet
C10, C23	2	0.01uF	CAP, CERM, 0.01 uF, 50 V, +/- 5%, C0G/NP0, 0603	603	GRM1885C1H103JA01D	MuRata
C12, C13	2	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	603	06035C104KAT2A	AVX
D1	1	SPLYGD1	LED, Green, SMD	LED_0805	LTST-C170KGKT	Lite-On
D2, D8	2	30 V	Diode, Schottky, 30 V, 3 A, SMA	SMA	B330A-13-F	Diodes Inc.
D3	1	FLTB1	LED, Red, SMD	Red 0805 LED	LTST-C170KRKT	Lite-On
D5, D6	2	30 V	Diode, Schottky, 30 V, 0.2 A, SOD-323	SOD-323	BAT54WS-7-F	Diodes Inc.
D7	1	SPLYGD2	LED, Green, SMD	LED_0805	LTST-C170KGKT	Lite-On
FID1, FID3, FID5	3		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	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, J2, J11, J12	4		Terminal Block, 2x1, 5.08mm, TH	10.16x15.2x9mm	282841-2	TE Connectivity

Table 7-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
J3, J4, J13, J14, J17	5		Header, 100mil, 2x1, Tin, TH	Header, 2 PIN, 100mil, Tin	PEC02SAAN	Sullins Connector Solutions
J5, J7, J8, J15, J18, J19	6		Header, 100mil, 3x2, Tin, TH	3x2 Header	PEC03DAAN	Sullins Connector Solutions
J6, J16	2		Header, 100mil, 4x2, Tin, TH	Header, 4x2, 100mil, Tin	PEC04DAAN	Sullins Connector Solutions
J9, J20, J21	3		Header, 100mil, 3x1, Tin, TH	Header, 3 PIN, 100mil, Tin	PEC03SAAN	Sullins Connector Solutions
Q1, Q2	2	60 V	MOSFET, N-CH, 60 V, 115 A, SOT-23	SOT-23	2N7002	Fairchild Semiconductor
R1, R16	2	10k	10 kOhms ±0.1% 0.1W, 1/10W Chip Resistor 0603 (1608 Metric) Current Sense Thin Film	603	CRT0603-BY-1002ELF	Bourns Inc.
R2, R17	2	1k	1 kOhms ±1% 0.1W, 1/10W Chip Resistor 0603 (1608 Metric) Automotive AEC-Q200, Moisture Resistant Thick Film	603	AC0603FR-071KL	Yageo
R3, R4, R18, R19	4	1.00Meg	RES, 1.00 M, 1%, 0.1 W, 0603	603	RC0603FR-071ML	Yageo America
R5, R20	2	124k	RES, 124 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW0603124KFKEA	Vishay-Dale
R6	1	1.00k	RES, 1.00 k, 1%, 0.1 W, 0603	603	RC0603FR-071KL	Yageo
R7, R8, R21, R22	4	100	RES, 100, 1%, 0.1 W, 0603	603	RC0603FR-07100RL	Yageo
R9, R23	2	4.75k	RES, 4.75 k, 1%, 0.1 W, 0603	603	RC0603FR-074K75L	Yageo
R10, R24	2	1.58k	RES, 1.58 k, 1%, 0.1 W, 0603	603	RC0603FR-071K58L	Yageo America
R11, R25	2	1.07k	RES, 1.07 k, 1%, 0.1 W, 0603	603	RC0603FR-071K07L	Yageo America
R12, R26	2	536	RES, 536, 1%, 0.1 W, 0603	603	RC0603FR-07536RL	Yageo
R13, R27	2	95.3k	RES, 95.3 k, 1%, 0.1 W, 0603	603	RC0603FR-0795K3L	Yageo
R14, R28	2	78.7k	RES, 78.7 k, 1%, 0.1 W, 0603	603	RC0603FR-0778K7L	Yageo
R15, R29	2	59.0k	RES, 59.0 k, 1%, 0.1 W, 0603	603	RC0603FR-0759KL	Yageo
S1, S2	2		Switch, SPST-NO, 0.05 A, 12 VDC, SMT	3.9x2.9mm	SKRKAEE020	Alps
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J8, SH-J9, SH-J10, SH-J11, SH-J12, SH-J13, SH-J14, SH-J15, SH-J16	15	1x2	Shunt, 100mil, Flash Gold, Black	Closed Top 100mil Shunt	SPC02SYAN	Sullins Connector Solutions

Table 7-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
TP1, TP2, TP14, TP15	4		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone
TP3	1		Test Point, Multipurpose, Orange, TH	Orange Multipurpose Testpoint	5013	Keystone
TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP16, TP17, TP18, TP19, TP20, TP21, TP22	14		Test Point, Multipurpose, White, TH	White Multipurpose Testpoint	5012	Keystone
TP11, TP12, TP13, TP23, TP24, TP25	6		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone
U1	1		23 V, 12 mΩ, 8 A eFuse with True Reverse Current Blocking	PowerWCSP12	TPS259480AYWPR	Texas Instruments
U2, U5	2		22-V Precision Surge Protection Clamp, DRV0006A (WSON-6)	DRV0006A	TVS2200DRVR	Texas Instruments
U3	1		100 mA, Quasi Low-Dropout Linear Voltage Regulator, 3-pin SOT-23, Pb-Free	DBZ0003A	LM3480IM3-3.3/NOPB	Texas Instruments
U4	1		3.2 - 23 V, 12 mΩ, 8 A eFuse with True Reverse Current Blocking	PowerWCSP12	TPS259482LYWPR	Texas Instruments
D4, D9	0		DIODE SCHOTTKY 30 V 500 MA SOD323	SOD323	B0530WS-7-F	Diodes Inc.
R30, R31	0	0	0 Ohms Jumper Chip Resistor Wide 1812 (4532 Metric), 1218 Moisture Resistant Thick Film	1218	RC1218JK-070RL	Yageo

8 Revision History

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

Changes from Revision * (March 2023) to Revision A (July 2023)	Page
• Changed schematic	4
• Changed *TPS25948EVM Setup with Test Equipment* image	8
• Changed Figure 6-1 and Figure 6-2	15
• Changed *Bill of Materials* table	17

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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2. 実験局の免許を取得後ご使用いただく。
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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:*

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