



## ABSTRACT

This user's guide describes the evaluation module (EVM) for the TPS1641 eFuse. The document provides EVM configuration information and test setup details for evaluating the TPS1641 device. This document includes the EVM schematic, board layout, and bill of materials (BOM).

## Table of Contents

1 Introduction.....	2
2 Description.....	3
3 Schematic.....	4
4 General Configurations.....	5
5 Test Setup and Procedures.....	7
6 EVAL Board Assembly Drawings.....	14
7 Bill of Materials (BOM).....	15
8 Revision History.....	18

## List of Figures

Figure 3-1. TPS1641EVM: Evaluation Module Schematic.....	4
Figure 5-1. TPS1641EVM Setup with Test Equipment.....	7
Figure 5-2. CH1 Output Rise Profile (VIN = 12 V, CdVdT = 150 nF, COUT = 470 uF, No Load).....	8
Figure 5-3. Power Limit Response of TPS16410 for 13.7-W Power Limit Setting.....	9
Figure 5-4. Current Limit Response of TPS16412 for 1-A Current Limit Setting.....	10
Figure 5-5. Overvoltage Protection Response for IN Voltage from 24 V to 40 V.....	11
Figure 5-6. Overvoltage Protection Response with External PFET for IN Voltage from 24 V to 60 V.....	11
Figure 5-7. Output Hot-Short Response of the TPS1641 Device.....	12
Figure 5-8. IN to OUT Short Response of the TPS1641 Device without External PFET.....	13
Figure 5-9. IN to OUT Short Response of the TPS1641 Device with External PFET.....	13
Figure 6-1. TPS1641EVM Board Assembly.....	14
Figure 6-2. Top Layer of TPS1641EVM Board.....	14
Figure 6-3. Bottom Layer of TPS1641EVM Board.....	14

## List of Tables

Table 2-1. TPS1641EVM Evaluation Board Options and Setting.....	3
Table 4-1. Input and Output Connector Functionality.....	5
Table 4-2. Test Points Description.....	5
Table 4-3. Jumper and LED Descriptions.....	5
Table 5-1. Default Jumper Setting for TPS1641EVM Evaluation Board.....	7
Table 7-1. TPS1641EVM Bill of Materials.....	15

## Trademarks

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## 1 Introduction

The TPS1641EVM allows reference circuit evaluation of TI's TPS1641x family of eFuse devices. The TPS1641x is an integrated eFuse with accurate power limit or current limit. The TPS1641x device provides overcurrent protection with adjustable blanking timer, output power limiting with adjustable blanking timer, short-circuit protection, overvoltage protection, IN to OUT short detection, and overtemperature protection.

### 1.1 EVM Features

General TPS1641EVM features include:

- 12-V (typical) operation for CH1 and 24-V (typical) operation for CH2
- 30-mA to 1.8-A adjustable overcurrent protection
- 4-W to 38-W programmable power limit
- Configurable blanking time for transient currents
- LED status indication for faults

### 1.2 EVM Applications

This EVM can be used for the following applications:

- Low power circuit for appliances
- Back-plane power protection in PLC and DCS modules
- HVAC actuators and valve control
- Medical equipment

## 2 Description

The TPS1641EVM evaluation board enables evaluation of TPS16410 and TPS16412 devices from TPS1641 eFuse family. Input power is applied at T1 (CH1) and T3 (CH2) while T2 (CH1) and T4 (CH2) provide an output connection to the load; refer to the schematic in [Figure 3-1](#) and EVM test setup in [Figure 5-1](#).

S1 and S2 allow U1 and U2 to RESET. D1 and D4 provide input protection for CH1 and CH2 respectively.

**Table 2-1. TPS1641EVM Evaluation Board Options and Setting**

Part Number EVM Function	Channel	Vin Range	Features	Protection		Fault Response
				Low Setting	Hi Setting	
TPS1641EVM TPS1641 evaluation module for 40-V, 1.8-A eFuse	CH1 - TPS16410	10.8 V to 28 V	Power limit	4 W	38 W	Auto-retry
	CH2 - TPS16412	18 V to 32 V	Current limit	30 mA	1.8 A	Auto-retry

### 3 Schematic

Figure 3-1 illustrates the EVM schematic.

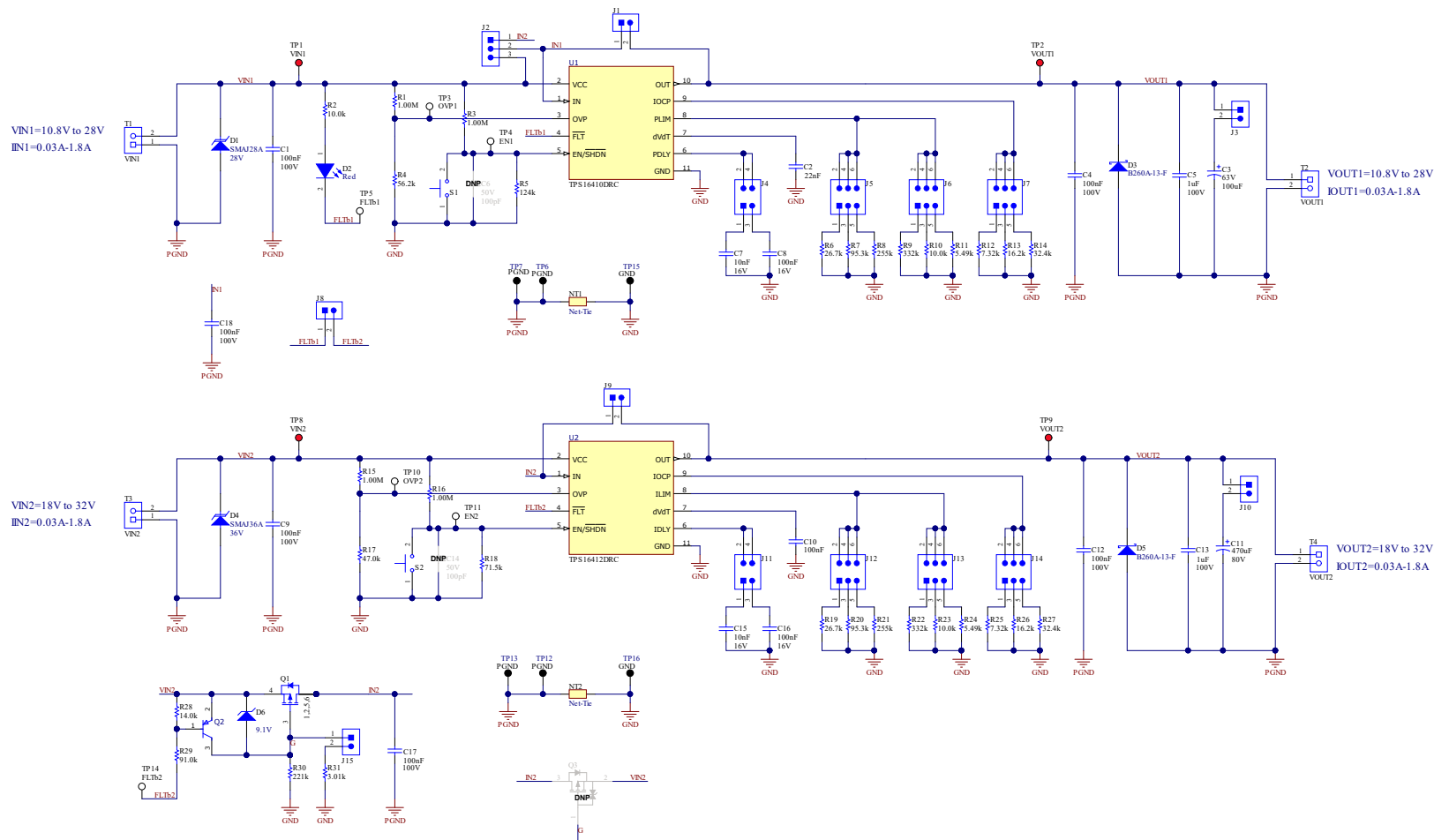


Figure 3-1. TPS1641EVM: Evaluation Module Schematic

## 4 General Configurations

### 4.1 Physical Access

Table 4-1 lists the TPS1641EVM Evaluation Board input and output connector functionality. Table 4-2 and Table 4-3 describe the test point availability and the jumper functionality.

**Table 4-1. Input and Output Connector Functionality**

Connector	Label	Description
T1	VIN1(+), PGND(-)	CH1 input power supply to the EVM
T2	VOUT1(+), PGND(-)	CH1 output from the EVM
T3	VIN2(+), PGND(-)	CH2 input power supply to the EVM
T4	VOUT2(+), PGND(-)	CH2 output from the EVM

**Table 4-2. Test Points Description**

Test Points	Label	Description
TP1	VIN1	Input power supply of CH1 to the EVM
TP2	VOUT1	Output from the EVM of CH1
TP3	OVP1	OVP of CH1
TP4	EN1	Enable control (active high) and undervoltage input of CH1
TP5	FLTb1	Fault output of CH1
TP6, TP7, TP12, TP13	PGND	System ground
TP8	VIN2	Input power supply of CH2 to the EVM
TP9	VOUT2	Output from the EVM of CH2
TP10	OVP2	OVP of CH2
TP11	EN2	Enable control (active high) and undervoltage input of CH2
TP14	FLTb2	Fault output of CH2
TP15, TP16	GND	Device ground

**Table 4-3. Jumper and LED Descriptions**

Jumper	Label	Description
J1	FET Short	Default position: OPEN. Install to emulate FET short.
J2	Vin Select	Jumper to select the source; Default position: 2-3 1-2 position selects Vin2 2-3 position selects Vin1
J3	J3	CH1 bulk output capacitor connects to VOUT1, if installed.
J4	PDLY	Sets blanking time for power limiting 1-2 position sets 5 ms delay 3-4 position sets 50 ms delay
J5	J5	Power limit setting 1-2 position sets 4 W 3-4 position sets 13.7 W 5-6 position sets 38 W
J6	J6	Not used
J7, J14	J7, J14	Overcurrent protection setting 1-2 position sets 2.23 A 3-4 position sets 1.01 A 5-6 position sets 0.5 A
J8	J8	Shorts FLTb1 and FLTb2 if installed
J9	FET Short	Default position: OPEN. Install to emulate FET short.

**Table 4-3. Jumper and LED Descriptions (continued)**

Jumper	Label	Description
J10	J10	CH2 bulk output capacitor connects to VOUT2, if installed.
J11	IDLY	Sets blanking time for current limiting 1-2 position sets 5-ms delay 3-4 position sets 50-ms delay
J12	J12	Not used
J13	J13	Current limit setting 1-2 position sets 30 mA 3-4 position sets 1 A 5-6 position sets 1.8 A
J15	J15	Jumper to set fast turn-ON for Q1
D2 (RED – LED)	D2	Fault indicator. LED turns on for fault.

## 4.2 Test Equipment and Setup

### 4.2.1 Power Supplies

One adjustable power supply with 0-V to 60V- output and 0-A to 2-A output current limit.

### 4.2.2 Meters

One DMM minimum needed.

### 4.2.3 Oscilloscope

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

### 4.2.4 Loads

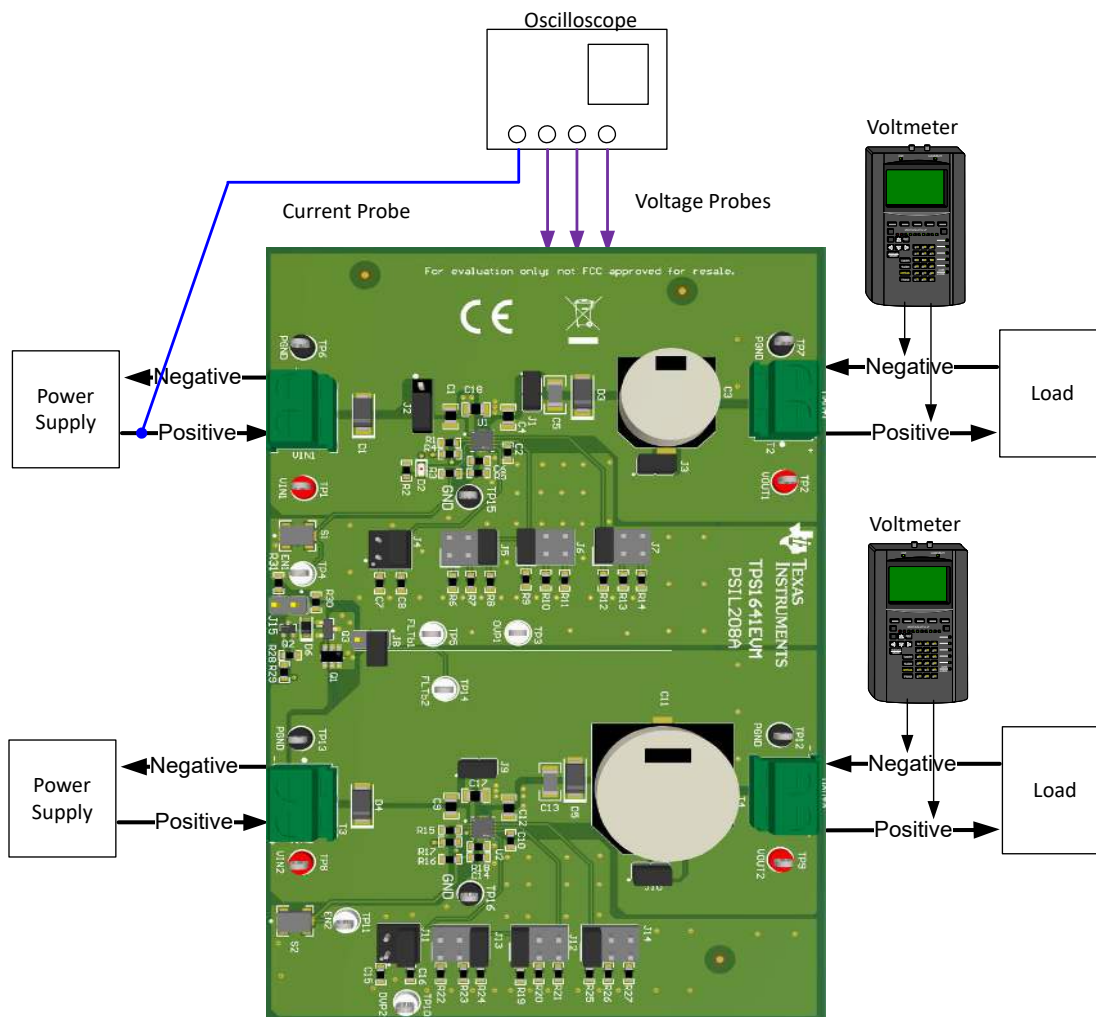
One resistive load or equivalent that can tolerate up to 2-A DC load at 60 V and capable of the output short.

## 5 Test Setup and Procedures

Make sure the evaluation board has default jumper settings as shown in [Table 5-1](#).

**Table 5-1. Default Jumper Setting for TPS1641EVM Evaluation Board**

CH1	J1	J2	J3	J4	J5	J6	J7	J8
		Open	2-3	Install	3-4	5-6	Open	1-2
CH2	J9	J10	J11	J12	J13	J14	J15	
	Open	Install	3-4	Open	5-6	1-2	Open	



**Figure 5-1. TPS1641EVM Setup with Test Equipment**

Follow the below instructions before starting any test and repeat again before moving to the next test.

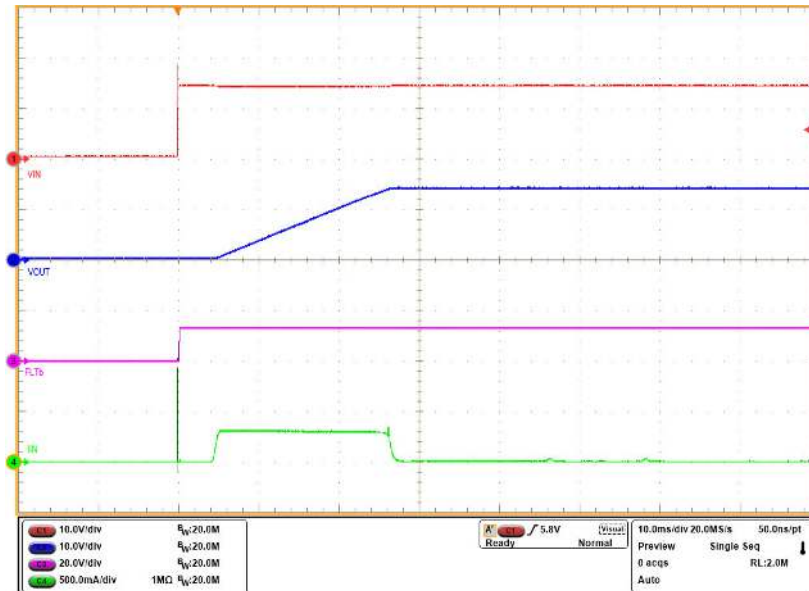
- Set the power supply output (VIN) to zero volts.
- Set the jumper setting on EVM to default position as shown in [Table 5-1](#).

## 5.1 Hot-Plug Test

Use the following instructions to measure the inrush current on CH1 during Hot-Plug event:

1. For checking inrush current control capability, insert load capacitance of 470 uF at output terminal T2
2. Make J3 OPEN.
3. Change Cdvdt capacitor C2 to 150 nF.
4. Set the input supply voltage VIN to 12 V and current limit of 2 A. Enable the power supply.
5. Hot-plug the supply at input terminal T1.
6. Observe the waveform at VOUT1 (TP2) 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 profile captured on the TPS1641EVM Evaluation Board.



**Figure 5-2. CH1 Output Rise Profile (VIN = 12 V, CdVdT = 150 nF, COUT = 470 uF, No Load)**



## 5.2 Power Limit Test

Use the following instructions to verify power limit response of TPS16410 on CH1:

1. Make J3 OPEN.
2. Set J4 in 1-2 position to set transient blanking time of 5 ms
3. Set J5 in 3-4 position to set 13.7-W power limit.
4. Set the input supply voltage VIN to 12 V and current limit of 3 A. Enable the power supply.
5. Apply load of 1-A at the output.
6. Now, apply overload to verify the power limiting behavior of TPS16410.

Figure 5-3 shows power limit response of TPS16410 on the TPS1641EVM Evaluation Board.

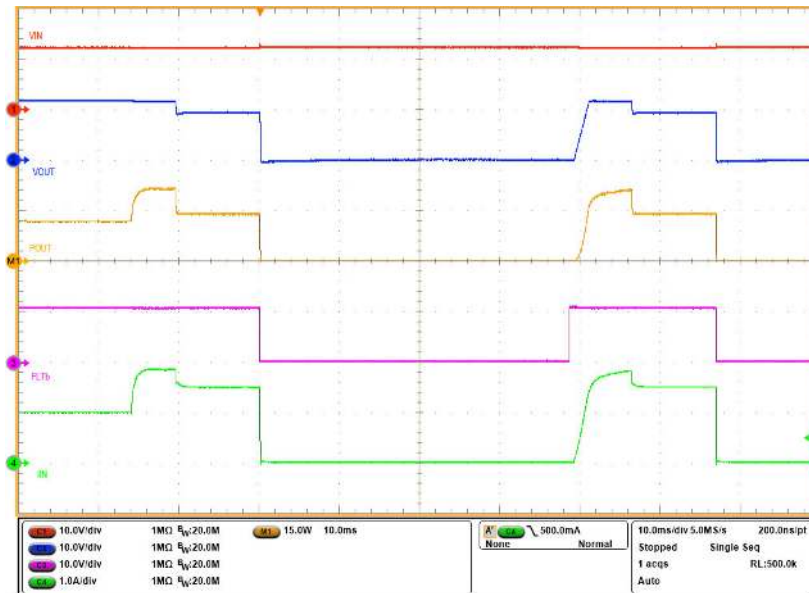


Figure 5-3. Power Limit Response of TPS16410 for 13.7-W Power Limit Setting

### 5.3 Current Limit Test

Use the following instructions to verify current limit response of TPS16412 on CH2:

1. Make J10 OPEN.
2. Set J11 in 1-2 position to set transient blanking time of 5 ms
3. Set J13 in 3-4 position to set 1-A current limit.
4. Set the input supply voltage VIN to 24 V and current limit of 2 A. Enable the power supply.
5. Apply load of 1A at the output.
6. Now, apply overload to verify the current limiting behavior of TPS16412.

Figure 5-4 shows current limit response of TPS16412 on the TPS1641EVM Evaluation Board.

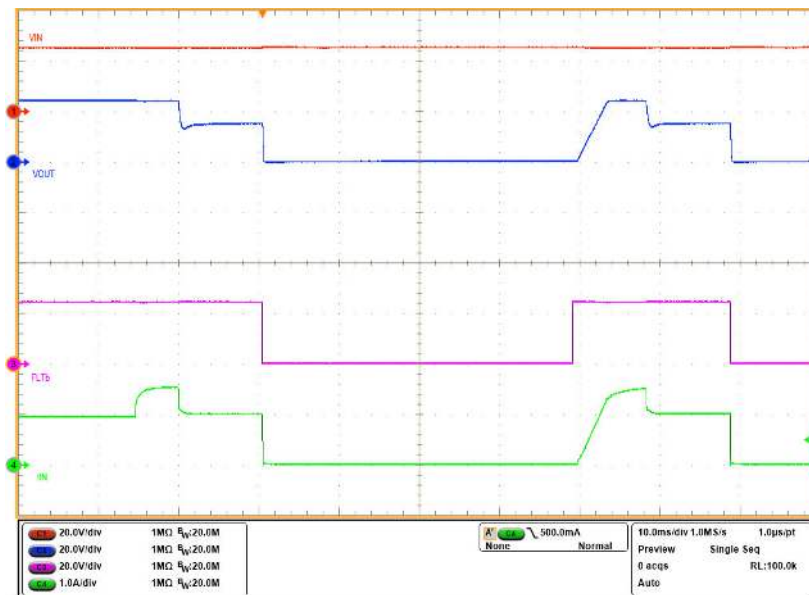


Figure 5-4. Current Limit Response of TPS16412 for 1-A Current Limit Setting

## 5.4 Overvoltage Protection Test

Use the following instructions to verify overvoltage response of TPS16412 on CH2:

1. Make J10 OPEN.
2. Short Q1 with a cable to bypass the external PFET.
3. Set the input supply voltage VIN to 24 V and current limit of 2 A. Apply the supply at input terminal T3 and enable the power supply.
4. Increase the input supply VIN from 24 V to 40 V and observe the response as shown in [Figure 5-5](#).
5. Now, disable the supply.
6. Remove the short across Q1 to engage external PFET in the circuit.
7. Enable the power supply.
8. Increase the input supply VIN from 24 V to 60 V and observe the response as shown in [Figure 5-6](#).

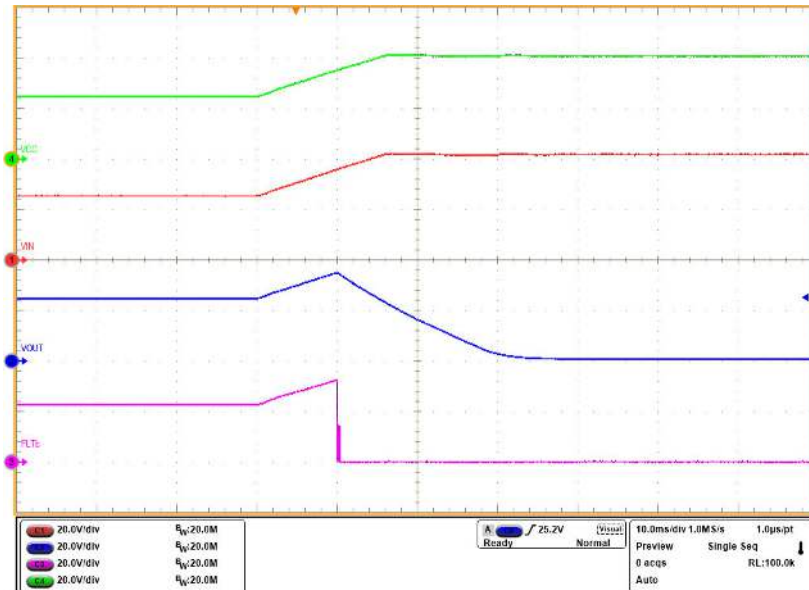


Figure 5-5. Overvoltage Protection Response for IN Voltage from 24 V to 40 V

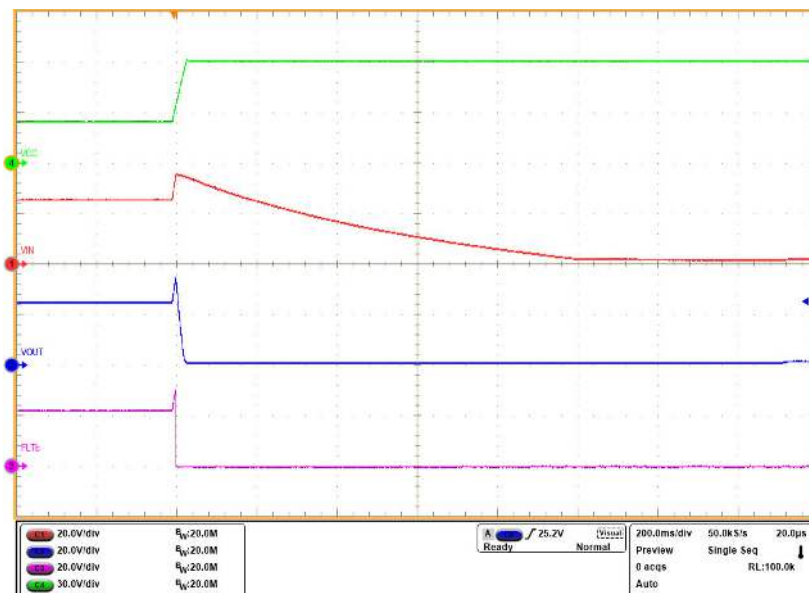


Figure 5-6. Overvoltage Protection Response with External PFET for IN Voltage from 24 V to 60 V

## 5.5 Output Hot-Short Test

Use the following instructions to perform output Hot-Short test on CH1:

1. Set the input supply voltage  $V_{IN}$  to 12 V and current limit of 2 A. Turn ON the power supply.
2. Short the output of the device for example,  $V_{OUT1}$  to GND with a shorter cable.
3. Observe the waveforms using an oscilloscope.

Figure 5-7 shows hot-short response of TPS1641 on the TPS1641EVM eFuse Evaluation Board.

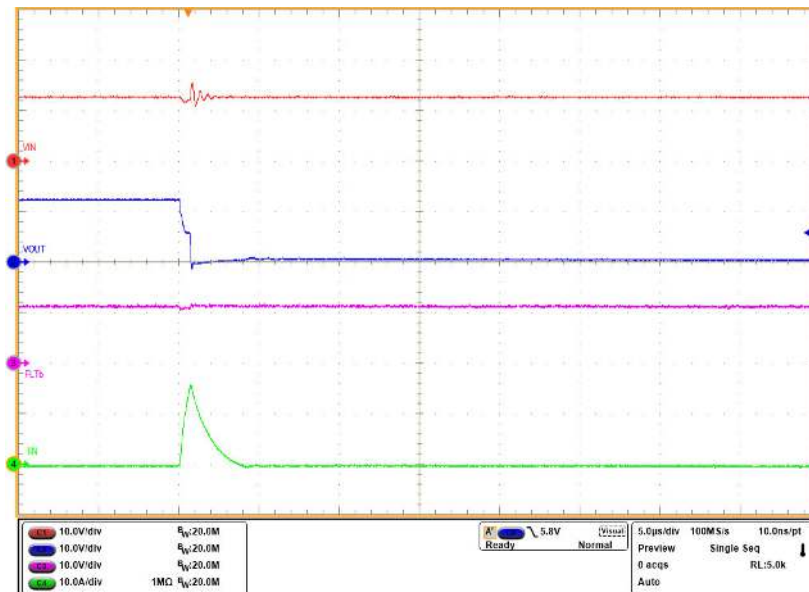


Figure 5-7. Output Hot-Short Response of the TPS1641 Device

## 5.6 IN to OUT Short Detection Test

Use the following instructions to perform IN-OUT short detection test on CH2:

1. Make J10 OPEN.
2. Short Q1 with a cable to bypass the external PFET.
3. Set the input supply voltage  $V_{IN}$  to 24 V and current limit of 2 A. Apply the supply at input terminal T3 and enable the power supply.
4. Apply a load of 1 A at the output.
5. Short the IN-OUT of TPS16412 by placing shunt on J9.
6. Observe the TPS16412 response. As seen in Figure 5-8, the FLTb asserts after 150 ms (typical) after IN-OUT short is detected. Note that the  $V_{OUT}$  is probed in AC coupling mode to observe the jump in the voltage for IN-OUT short.
7. Now, disable the supply and the load.
8. Remove the short across Q1 to engage external PFET in the circuit.
9. Enable the power supply.
10. Apply a load of 1 A at the output.
11. Short the IN-OUT of TPS16412 by placing shunt on J9.
12. The TPS16412 detects the IN-OUT short and asserts the FLTb, which in turn disables the external PFET to isolate the load from the supply. Figure 5-9 shows the IN-OUT short response with external PFET in the circuit.

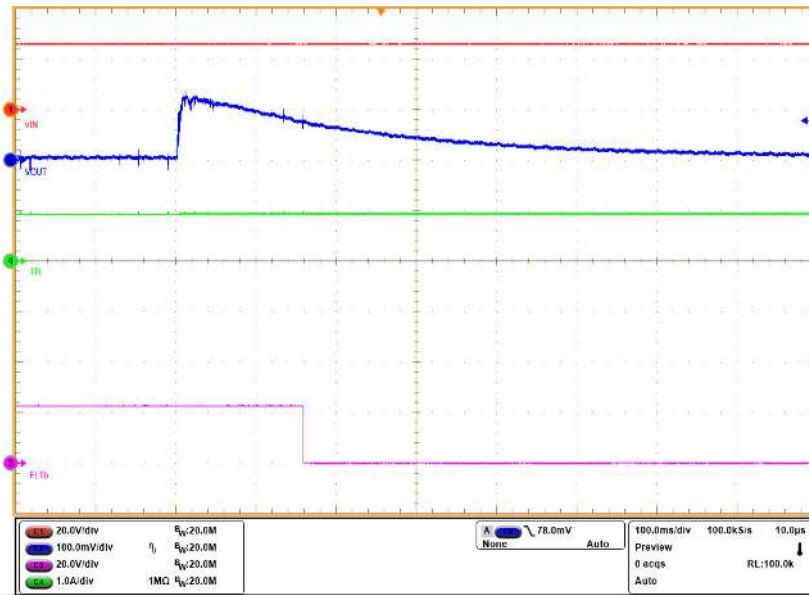


Figure 5-8. IN to OUT Short Response of the TPS1641 Device without External PFET

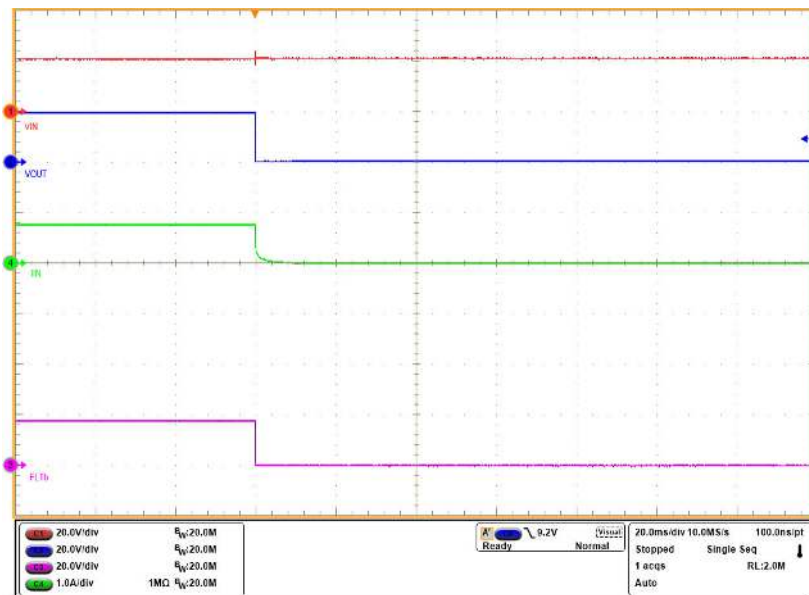


Figure 5-9. IN to OUT Short Response of the TPS1641 Device with External PFET

## 6 EVAL Board Assembly Drawings

### 6.1 PCB Drawings

Figure 6-1 shows component placement of the EVAL Board. Figure 6-2 and Figure 6-3 show PCB layout images.

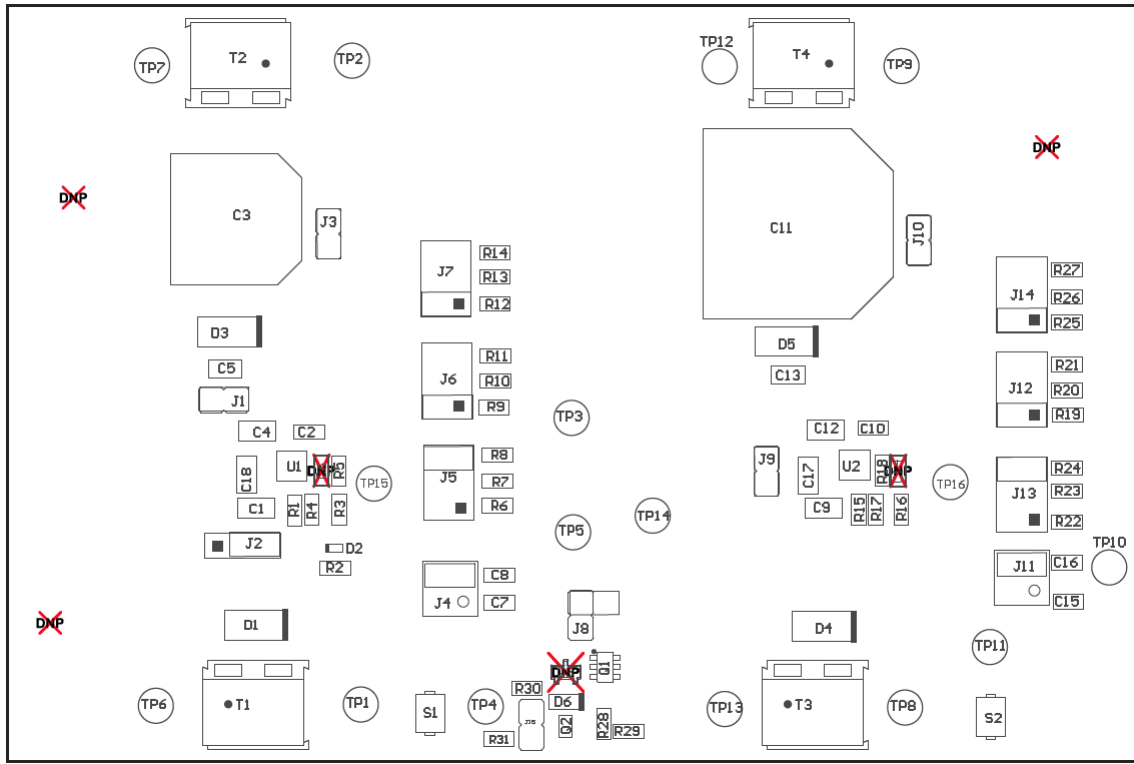


Figure 6-1. TPS1641EVM Board Assembly

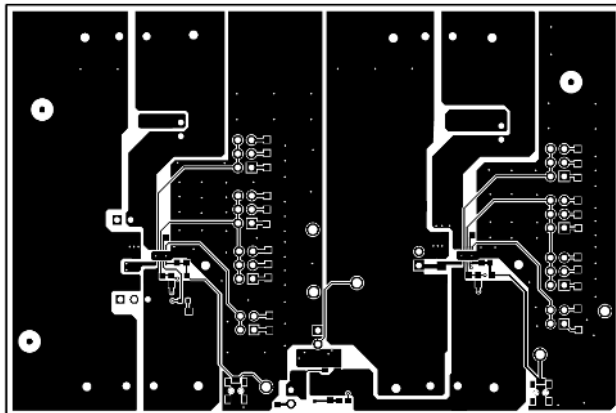


Figure 6-2. Top Layer of TPS1641EVM Board

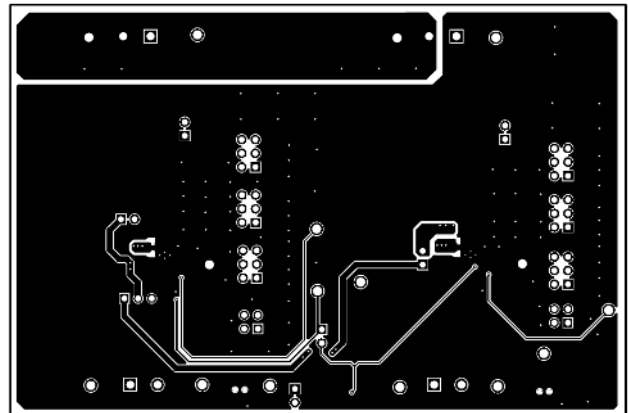


Figure 6-3. Bottom Layer of TPS1641EVM Board

## 7 Bill of Materials (BOM)

Table 7-1 lists the EVM BOM.

**Table 7-1. TPS1641EVM Bill of Materials**

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
!PCB1	1		Printed Circuit Board		PSIL208	Any
C1, C4, C9, C12, C17, C18	6	0.1 uF	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	0805	CGA4J2X7R2A104K125AA	TDK
C2	1	0.022 uF	CAP, CERM, 0.022 uF, 16 V, +/- 10%, X7R, 0603	0603	C0603C223K4RACTU	Kemet
C3	1	100 uF	CAP, AL, 100 uF, 63 V, +/- 20%, 0.25 ohm, SMD	KE0	EMVH630ARA101MKE0S	Chemi-Con
C5, C13	2	1 uF	CAP, CERM, 1 uF, 100 V, +/- 10%, X7R, 1206	1206	C3216X7R2A105K160AA	TDK
C7, C15	2	0.01 uF	CAP, CERM, 0.01 uF, 16 V, +/- 10%, X7R, 0603	0603	C0603C103K4RACTU	Kemet
C8, C16	2	0.1 uF	CAP, CERM, 0.1 uF, 16 V, +/- 10%, X7R, 0603	0603	C0603C104K4RACTU	Kemet
C10	1	0.1 uF	CAP, CERM, 0.1 uF, 25 V, +/- 5%, X7R, 0603	0603	06033C104JAT2A	AVX
C11	1	470 uF	CAP, AL, 470 uF, 80 V, +/- 20%, 0.153 ohm, AEC-Q200 Grade 2, SMD	SMT Radial K16	EEV-FK1K471M	Panasonic
D1	1	28V	Diode, TVS, Uni, 28 V, 45.4 Vc, 400 W, 8.8 A, SMA	SMA	SMAJ28A	Littelfuse
D2	1	Red	LED, Red, SMD	1.6x0.8mm	TLMS1000-GS08	Vishay-Semiconductor
D3, D5	2	60 V	Diode, Schottky, 60 V, 2 A, SMA	SMA	B260A-13-F	Diodes Inc.
D4	1	36 V	Diode, TVS, Uni, 36 V, 58.1 Vc, 400 W, 6.9 A, SMA	SMA	SMAJ36A	Littelfuse
D6	1	9.1 V	Diode, Zener, 9.1 V, 300 mW, AEC-Q101, SOD-323	SOD-323	SZMM3Z9V1ST1G	ON Semiconductor
H1, H2, H3, H4	4		Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon	SJ-5303 (CLEAR)	3M
J1, J3, J8, J9, J10, J15	6		Header, 100mil, 2x1, Gold, TH	Sullins 100mil, 1x2, 230 mil above insulator	PBC02SAAN	Sullins Connector Solutions
J2	1		Header, 100mil, 3x1, Tin, TH	Header, 3 PIN, 100mil, Tin	PEC03SAAN	Sullins Connector Solutions

**Table 7-1. TPS1641EVM Bill of Materials (continued)**

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
J4, J11	2		Header, 100mil, 2x2, Tin, TH	Header, 2x2, 2.54mm, TH	PEC02DAAN	Sullins Connector Solutions
J5, J6, J7, J12, J13, J14	6		Header, 100mil, 3x2, Tin, TH	3x2 Header	PEC03DAAN	Sullins Connector Solutions
Q1	1	-60 V	MOSFET, P-CH, -60 V, -3 A, SOT-23-6	SOT-23-6	FDC5614P	Fairchild Semiconductor
Q2	1	-65 V	Bipolar (BJT) Transistor PNP 65 V 100 mA 100MHz 200 mW Surface Mount SOT-323	SOT323	BC856W,115	Nexperia
R1, R3, R15, R16	4	1.00 Meg	RES, 1.00 M, 1%, 0.1 W, 0603	0603	RC0603FR-071ML	Yageo
R2, R10, R23	3	10.0 k	RES, 10.0 k, 0.1%, 0.1 W, 0603	0603	RG1608P-103-B-T5	Susumu Co Ltd
R4	1	56.2 k	RES, 56.2 k, 1%, 0.1 W, 0603	0603	RC0603FR-0756K2L	Yageo
R5	1	124 k	RES, 124 k, 1%, 0.1 W, 0603	0603	CRCW0603124KFKEA	Vishay-Dale
R6, R19	2	26.7 k	RES, 26.7 k, 1%, 0.1 W, 0603	0603	RC0603FR-0726K7L	Yageo
R7, R20	2	95.3 k	RES, 95.3 k, 1%, 0.1 W, 0603	0603	RC0603FR-0795K3L	Yageo
R8, R21	2	255 k	RES, 255 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ-3EKF2553V	Panasonic
R9, R22	2	332 k	RES, 332 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603332KFKEA	Vishay-Dale
R11, R24	2	5.49 k	RES, 5.49 k, 1%, 0.1 W, 0603	0603	RC0603FR-075K49L	Yageo
R12, R25	2	7.32 k	RES, 7.32 k, 1%, 0.1 W, 0603	0603	RC0603FR-077K32L	Yageo
R13, R26	2	16.2 k	RES, 16.2 k, 1%, 0.1 W, 0603	0603	RC0603FR-0716K2L	Yageo
R14, R27	2	32.4 k	RES, 32.4 k, 1%, 0.1 W, 0603	0603	RC0603FR-0732K4L	Yageo
R17	1	47.0 k	RES, 47.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0747KL	Yageo
R18	1	71.5 k	RES, 71.5 k, 1%, 0.1 W, 0603	0603	RC0603FR-0771K5L	Yageo
R28	1	14 k	RES, 14.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060314K0FKEA	Vishay-Dale
R29	1	91.0 k	RES, 91.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0791KL	Yageo
R30	1	221 k	RES, 221 k, 1%, 0.1 W, 0603	0603	RC0603FR-07221KL	Yageo
R31	1	3.01k	RES, 3.01 k, 1%, 0.1 W, 0603	0603	RC0603FR-073K01L	Yageo
S1, S2	2		Switch, SPST-NO, Off-Mom, 0.05A, 12VDC, SMD	3.9x2.9mm	PTS820 J20M SMTR LFS	C&K Components



**Table 7-1. TPS1641EVM Bill of Materials (continued)**

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J9, SH-J10, SH-J11, SH-J12, SH-J13, SH-J14	14	1x2	Shunt, 100mil, Flash Gold, Black	Closed Top 100mil Shunt	SPC02SYAN	Sullins Connector Solutions
T1, T2, T3, T4	4		Terminal Block, 2x1, 5.08mm, TH	10.16x15.2x9mm	282841-2	TE Connectivity
TP1, TP2, TP8, TP9	4		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone
TP3, TP4, TP5, TP10, TP11, TP14	6		Test Point, Multipurpose, White, TH	White Multipurpose Testpoint	5012	Keystone
TP6, TP7, TP12, TP13, TP15, TP16	6		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone
U1	1		TPS16410DRC	VSON10	TPS16410DRC	Texas Instruments
U2	1		TPS16412DRC	VSON10	TPS16412DRC	Texas Instruments
C6, C14	0	100 pF	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	885012006057	Würth Elektronik
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
Q3	0	-20 V	MOSFET, P-CH, -20 V, -2.8 A, SOT-23	SOT-23	PMV65XPER	Nexperia

## 8 Revision History

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

<b>Changes from Revision * (June 2022) to Revision A (December 2022)</b>	<b>Page</b>
• Updated Schematic section.....	<a href="#">4</a>
• Replaced Figure 5-1 TPS1641EVM Setup with Test Equipment as per the revised EVM.....	<a href="#">7</a>
• Updated TPS1641EVM board assembly and layer images.....	<a href="#">14</a>

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