User's Guide

TPS48111Q1EVM: Evaluation Module for Smart High-Side Driver TPS48111-Q1

TEXAS INSTRUMENTS

ABSTRACT

This user's guide describes the evaluation module (EVM) for the TPS48111-Q1 smart high-side driver. The document provides EVM configuration information and test setup details for evaluating the TPS48111-Q1 device. The EVM schematic, board layout, and bill of materials (BOM) are also included.

	Caution	Caution Hot surface. Contact may cause burns. Do not touch!

Table of Contents

List of Figures

List of Tables

Trademarks

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1 Introduction

The TPS48111Q1EVM allows reference circuit evaluation of TI's smart high-side driver TPS48111-Q1. The TPS48111-Q1 has an operating range of 3.5 V–80 V and has strong gate drive strength of 4 A to enable switching parallel MOSFETs in high current designs. The controller TPS48111-Q1 can drive back-to-back N-channel MOSFETs and also has a separate pre-charge driver (G) with independent control input (INP_G) to drive large capacitive loads. The device provides two-level adjustable overcurrent protection with adjustable circuit breaker timer, fast short-circuit protection, accurate analog current monitor output, and remote overtemperature protection.

1.1 EVM Features

General TPS48111Q1EVM features include:

- 24-V to 60-V (typical) operation
- 5-A to 50-A adjustable overcurrent protection using on-board jumpers
- Programmable circuit breaker timer
- Bi-directional current flow capability
- Load current monitoring output
- Programmable auto-retry and latch options
- LED status indication for overcurrent and overtemperature faults

1.2 EVM Applications

This EVM can be used for the following applications:

- Circuit breaker and safety disconnect switch
- Power distribution unit
- e-relay
- HVAC compressor module

2 Description

The TPS48111Q1EVM evaluation board enables evaluation of TPS48111-Q1 driver from TPS4811x-Q1 family. The input power is applied between connectors T1 and T4 while T2 and T3 provide an output connection to the load, Refer to the schematic in Figure 3-1 and EVM test setup in Figure 5-1.

D4 and D5 provide the fault indication output for the overcurrent and overtemperature faults respectively. Scaled current of the load can be monitored at TP10.

Table 2-1. TPS48111Q1EVM Evaluation Board Options and Setting

Part Number	EVM Function	Vin Range	Vin UVLO	ENABLE (EN/UVLO)	Overcurrent Protection		Features
					Low Setting	Hi Setting	
TPS48111Q1EVM	Smart high-side driver with protection and diagnostics	24 V to 60 V	24 V	Active high	5 A	50 A	Pre-charging the output overload protection with auto-retry and latch response

3 Schematic

Figure 3-1 illustrates the EVM schematic.

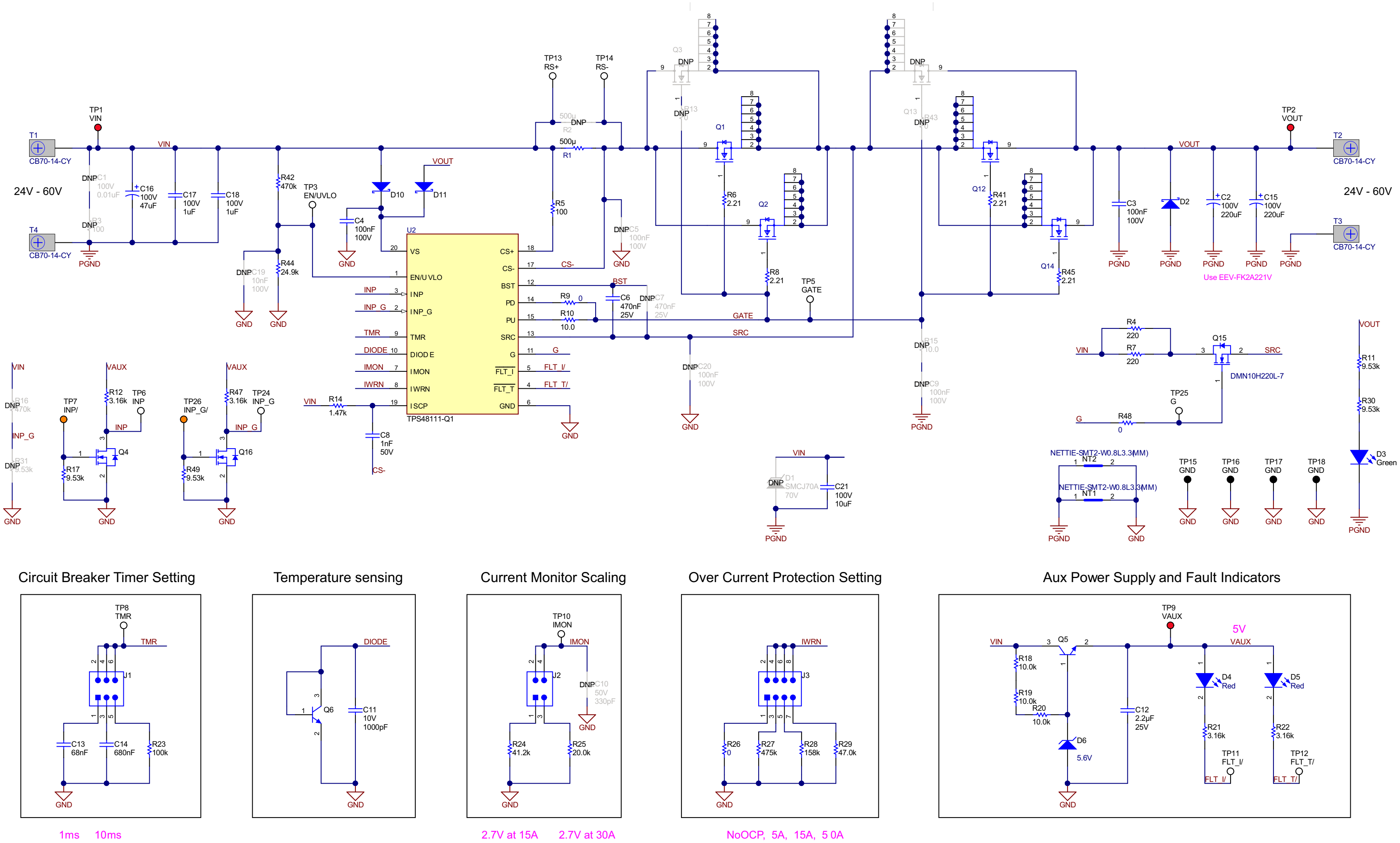


Figure 3-1. TPS48111Q1EVM: Evaluation Module Schematic

4 General Configurations

4.1 Physical Access

Table 4-1 lists the TPS48111Q1EVM 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	VIN	Power input connector to the positive rail of the input power supply
T4	PGND	Ground connection for the power supply
T2	VOUT	Power output connector to the positive side of the load
T3	PGND	Ground connection for the load

Table 4-2. Test Points Description

Test Points	Label	Description
TP1	VIN	Input power supply to the EVM
TP2	VOUT	Output from the EVM
TP3	EN/UVLO	Enable control (active high) and undervoltage input
TP5	GATE	GATE of the external main MOSFET
TP6	INP	Control input of main MOSFET
TP7	INP/	Inversion of control input for main MOSFET
TP8	TMR	Fault timer voltage
TP9	VAUX	Auxiliary supply to bias fault LEDs
TP10	IMON	Load current monitor
TP11	FLT_I/	Overcurrent fault output
TP12	FLT_T/	Overtemperature fault output
TP13	RS+	Positive terminal of current sense input
TP14	RS–	Negative terminal of current sense input
TP15, TP16, TP17, TP18	GND	GND
TP24	INP_G	Control input of pre-charge MOSFET
TP25	G	GATE of the pre-charge MOSFET
TP26	INP_G/	Inversion of control input for pre-charge MOSFET

Table 4-3. Jumper and LED Descriptions

Jumper	Label	Description
J1	TMR	Fault timer setting 1-2 position sets 15-ms delay 3-4 position sets 150-ms delay 5-6 position sets the controller in latch-off mode
J2	IMON	Current scale setting 1-2 position sets 0.09 V/A 3-4 position sets 0.034 V/A
J3	IWRN	Overcurrent protection threshold setting 1-2 position sets R_{IWRN} to short and disables the overcurrent protection 3-4 position sets 5 A 5-6 position sets 15 A 7-8 position sets 50 A
D4 (RED – LED)	D4	Fault indicator. LED turns on for overcurrent fault.
D5 (RED – LED)	D5	Fault indicator. LED turns on for overtemperature 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 50-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 50-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 TPS48111Q1EVM Evaluation Board

J1	J2	J3
1-2	1-2	3-4

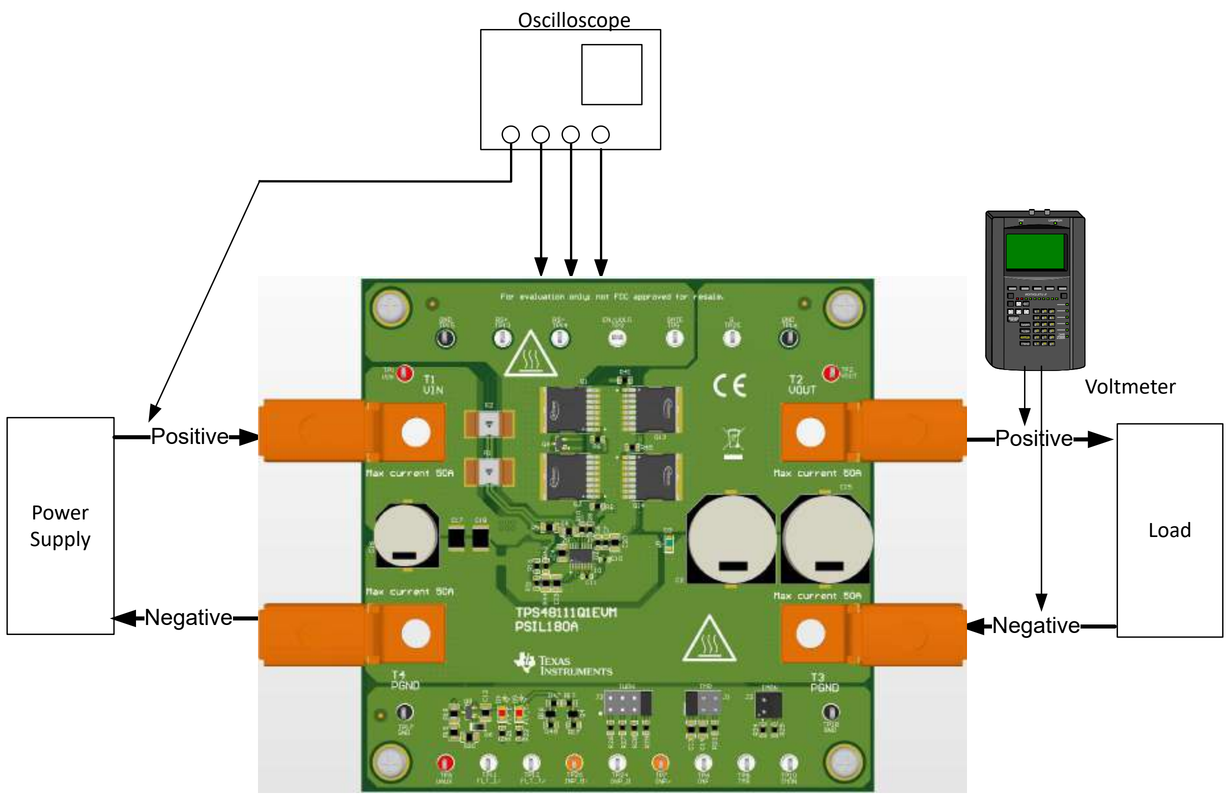


Figure 5-1. TPS48111Q1EVM Setup with Test Equipment

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

- Set the power supply output (VIN) to zero volts.
- Turn ON the power supply and set the power supply output (VIN) to 48 V, current limit = 50 A.
- Turn OFF the power supply.
- Set the jumper setting on EVM to default position as shown in Table 5-1.

5.1 Pre-charging Functional Test

Use the following instructions to capture the pre-charging current profile:

1. First, disable both the Main MOSFETs and pre-charge FET by connecting INP (TP6) and INP_G (TP24) to ground.
2. Set the jumper setting on EVM to default position as shown in Table 5-1.
3. Set the input supply voltage VIN to 48 V and current limit of 10 A.
4. Enable the power supply.
5. Enable the control input (INP_G at TP24) of the pre-charge MOSFET by releasing the ground connection.
6. Observe the waveform at SRC. That is, VOUT (TP2) with an oscilloscope.

Figure 5-2 shows an example of pre-charging current profile captured on the TPS48111Q1EVM Evaluation Board.

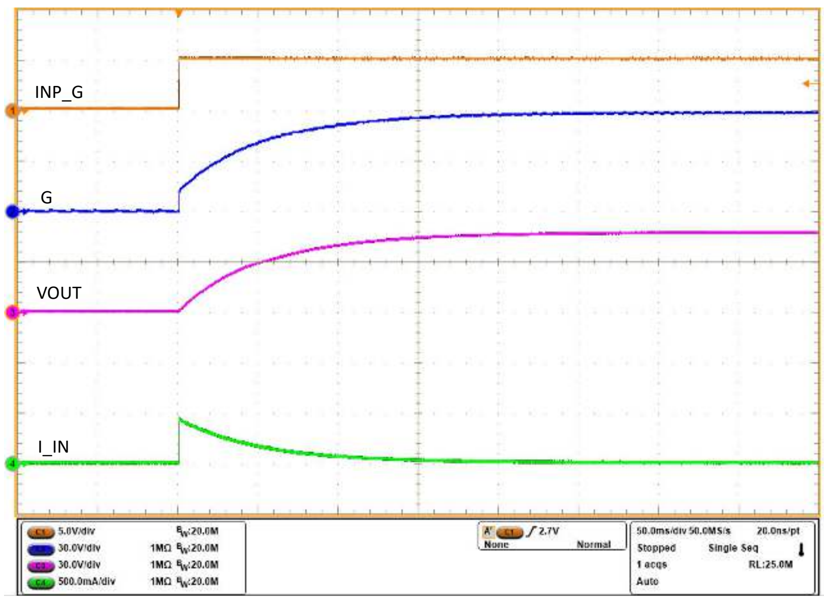


Figure 5-2. Pre-charge Profile of the Output Capacitance (VIN = 48 V, COUT = 440 µF, No-load)

5.2 Power-Up With EN Control

Use the following instructions to verify the power-up profile of TPS48111-Q1:

1. Remove the output capacitors of 440 µF from the board.
2. Disable the pre-charge path by connecting INP_G (TP24) to ground.
3. Connect the EN/UVLO pin (TP3) to ground and INP (TP6) to ground.
4. Set the input supply voltage VIN to 48 V and current limit of 10 A.
5. Enable the power supply.
6. Now, enable the EN/UVLO to HIGH to observe the start-up profile of BST, GATE and SRC when INP = GND as shown in Figure 5-3.
7. Now, disable the controller by making EN/UVLO = LOW.
8. Connect INP (TP6) to VAUX to set INP as HIGH.
9. Now again, enable the EN/UVLO to HIGH to observe the start-up profile of BST, GATE and SRC when INP = HIGH as shown in Figure 5-4.

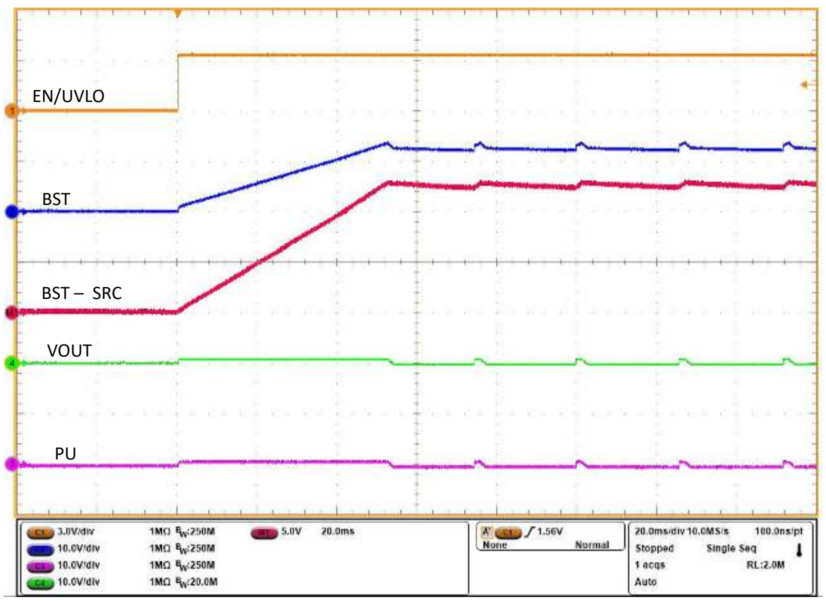


Figure 5-3. Start-Up Profile of Bootstrap Voltage for INP = GND

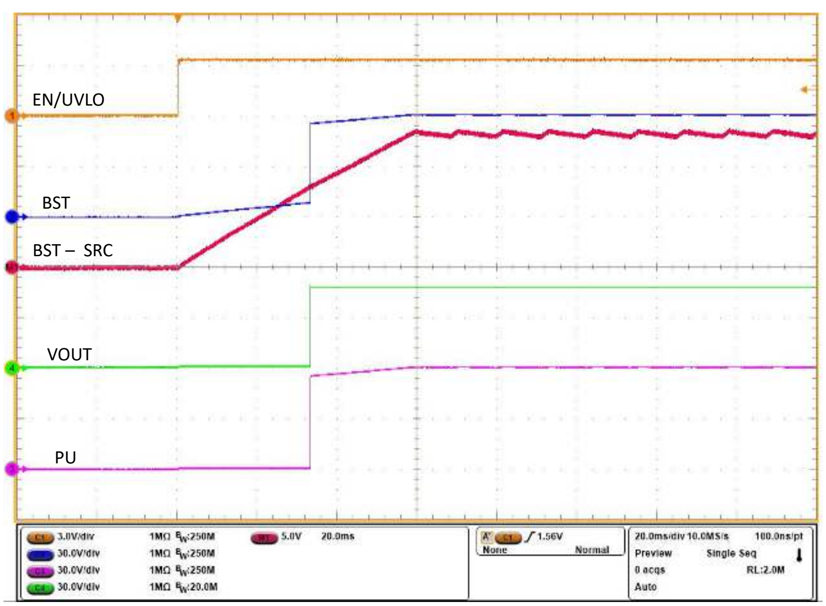


Figure 5-4. Start-Up Profile of Bootstrap Voltage for INP = HIGH

5.3 ON and OFF Control With INP Input

Use the following instructions to verify ON and OFF control of TPS48111-Q1:

1. Remove the output capacitors of 440 µF from the board.
2. Disable the pre-charge path by connecting INP_G (TP24) to ground.
3. Connect the INP (TP6) to ground.
4. Set the input supply voltage VIN to 48 V and current limit of 10 A.
5. Enable the power supply.
6. Now, toggle the INP to HIGH and then LOW to verify the turn-ON and turn-OFF response of PU/PD of TPS48111-Q1.

Figure 5-5 and Figure 5-6 show the turn-ON and turn-OFF responses on the TPS48111Q1EVM Evaluation Board.

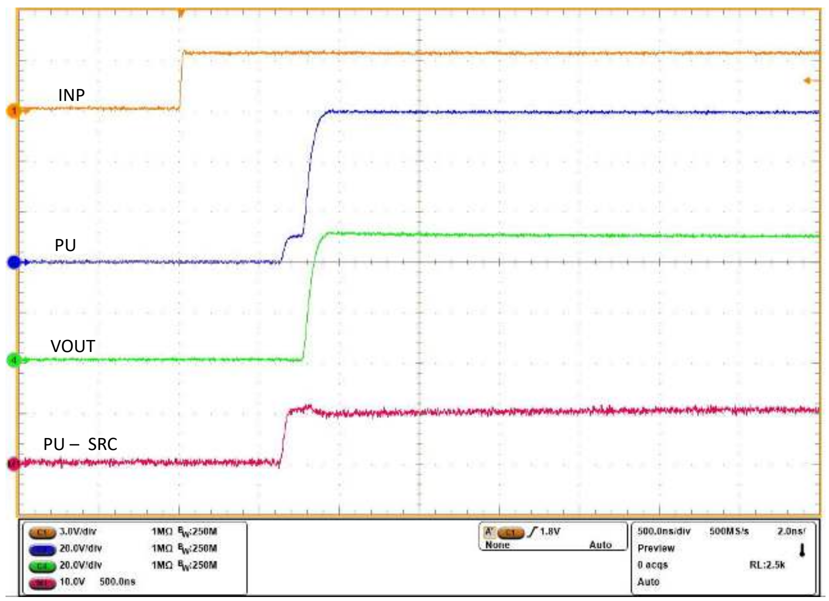


Figure 5-5. Turn-ON Response of TPS48111-Q1 for INP -> LOW to HIGH

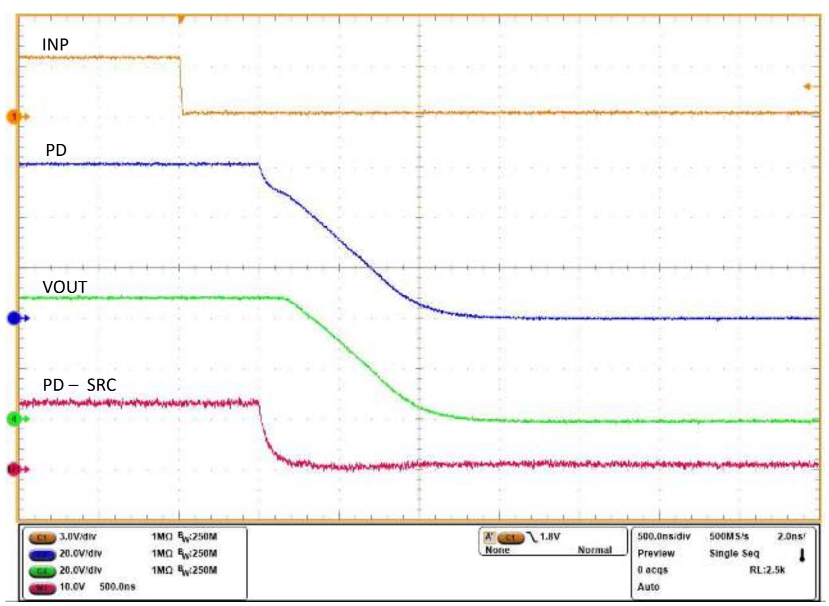


Figure 5-6. Turn-OFF Response of TPS48111-Q1 for INP -> HIGH to LOW

5.4 Overcurrent Protection Test

Use the following instructions to perform the overcurrent test on the TPS48111Q1EVM:

1. Pre-charge theoutput voltage by following the steps in *Pre-charging Functional Test*.
2. Now, enable the control input INP (TP6) of the main MOSFETS.
3. Disable the pre-charge FET by connecting INP_G (TP24) to ground.
4. By default, the EVM is configured for 5-A overcurrent protection.
5. Now, load the output with rheostat or electronic load and gradually increase the load current to observe the overload behavior of TPS48111-Q1.
6. Place jumper J3 at other settings to test at various overcurrent limits.

Figure 5-7 and Figure 5-8 show test waveforms for an overcurrent fault.

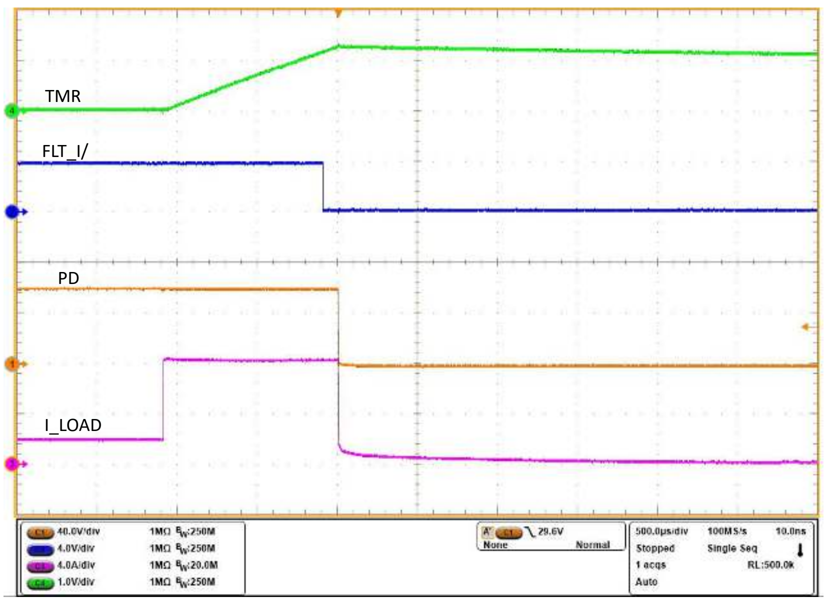


Figure 5-7. Overcurrent Response of TPS48111-Q1 for a Load Step from 2 A to 8 A With 5-A Overcurrent Protection Setting

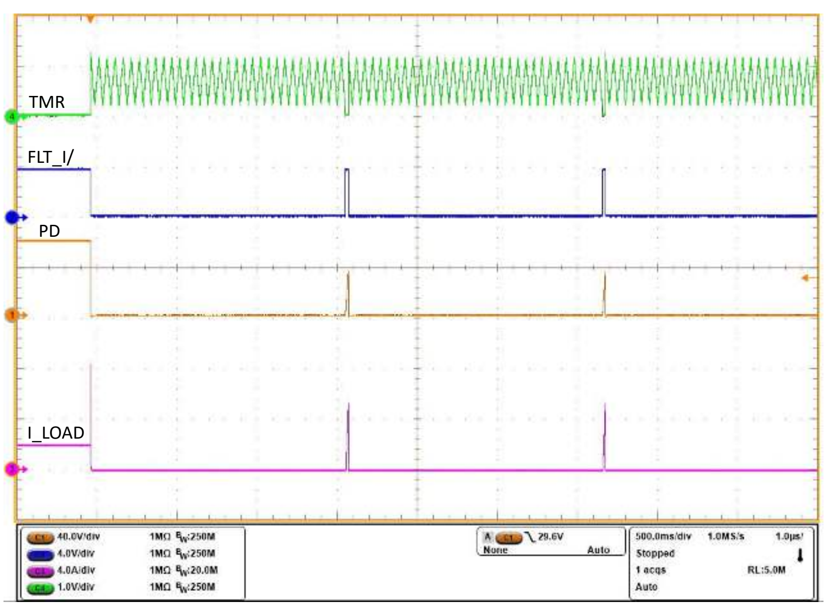


Figure 5-8. Auto-Retry Response of TPS48111-Q1 for an Overcurrent Fault

5.5 Output Hot-Short Test

Use the following instructions to perform output the hot-short test:

1. Pre-charge the output voltage by following the steps in *Pre-charging Functional Test*.
2. Now, enable the control input INP (TP6) of the main MOSFETS.
3. Disable the pre-charge FET by connecting INP_G (TP24) to ground.
4. Now, short the output, That is, VOUT to GND with a shorter cable and observe the short-circuit response of TPS48111-Q1 using an oscilloscope.

Figure 5-9 shows hot-short response of TPS48111-Q1 on TPS48111Q1EVM Evaluation Board.

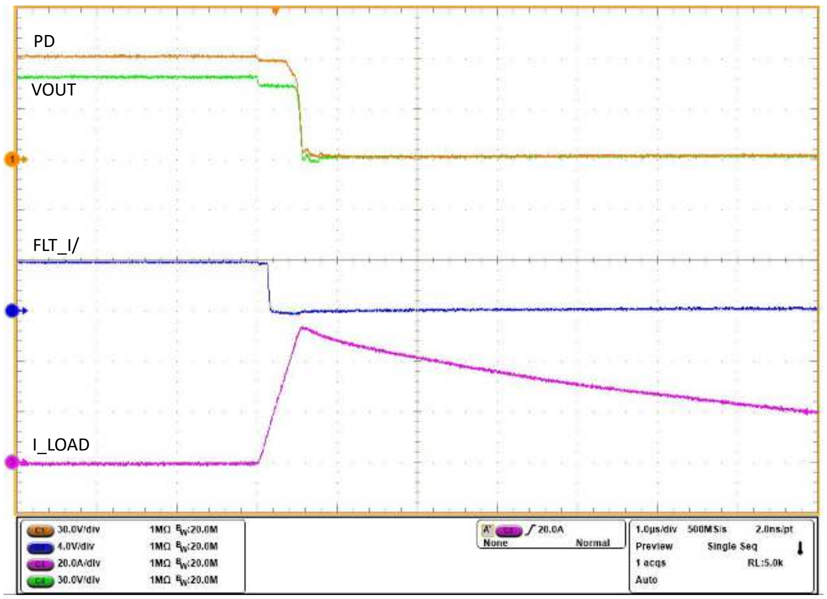
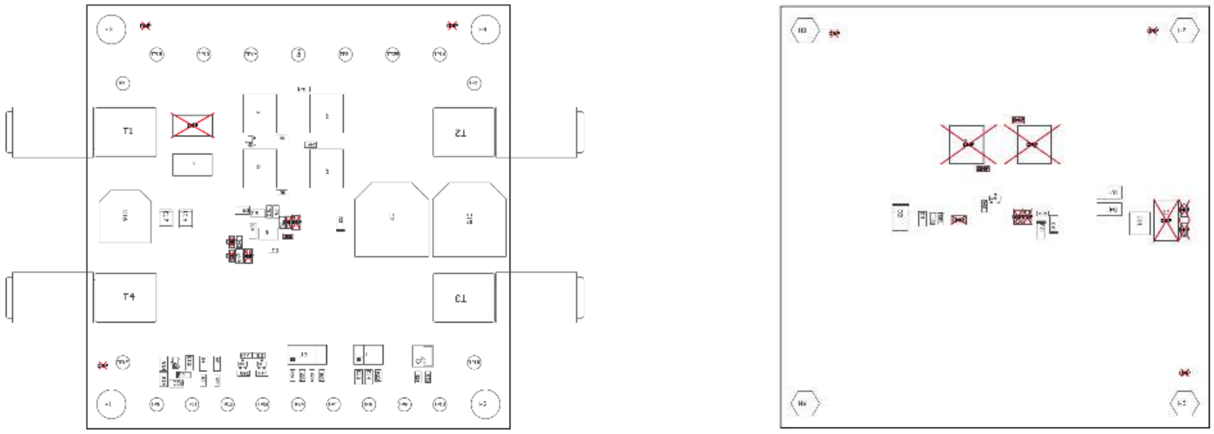


Figure 5-9. Output Hot-Short Response of TPS48111-Q1 Device

6 EVAL Board Assembly Drawings

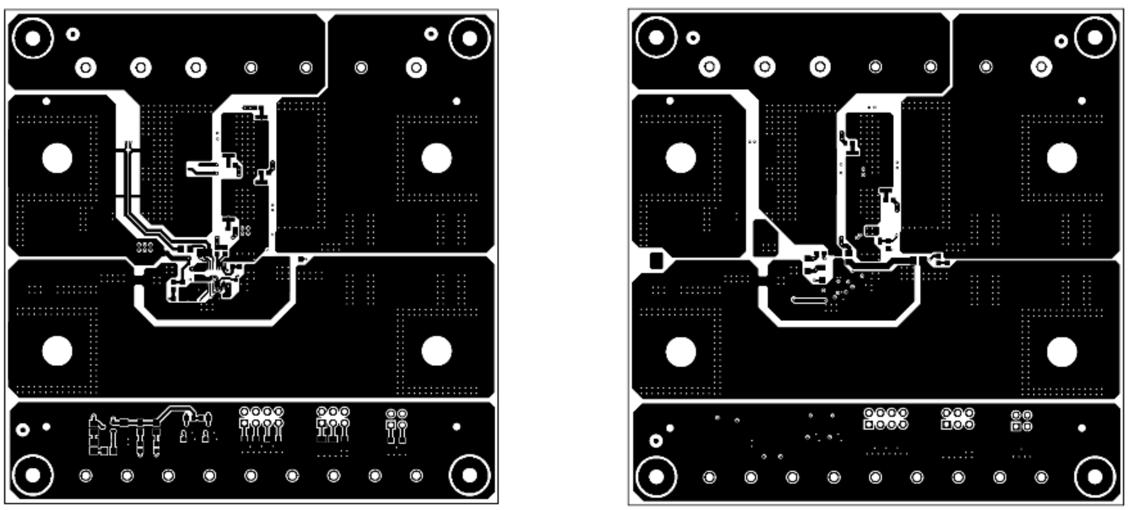
6.1 PCB Drawings

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



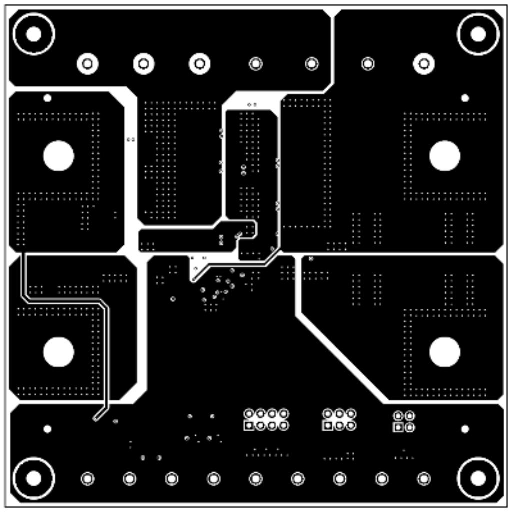
(a) (b)

Figure 6-1. TPS48111Q1EVM Board (a) Top Assembly (b) Bottom Assembly



(a) (b)

Figure 6-2. TPS48111Q1EVM Board (a) Top Layer (b) Bottom Layer


(a)

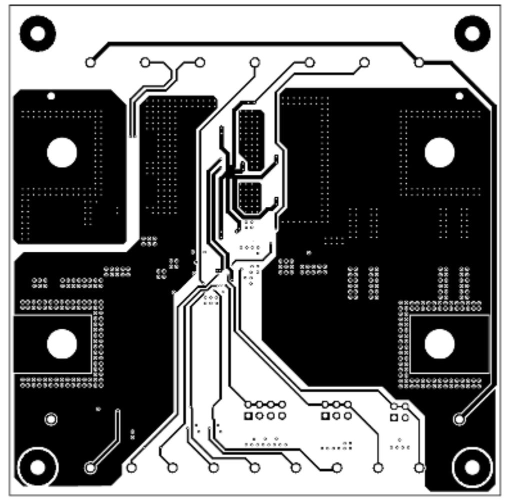

(b)

Figure 6-3. TPS48111Q1EVM Board (a) Inner Signal Layer (b) Inner Routing Layer

7 Bill Of Materials (BoM)

Table 7-1 lists the EVM BoM.

Table 7-1. TPS48111Q1EVM Bill Of Materials

Designator	Quantity	Description	Part Number	Manufacturer
!PCB1	1	Printed Circuit Board	PSIL180	Any
C2, C15	2	CAP, AL, 220 uF, 100 V, +/- 20%, 0.153 ohm, AEC-Q200 Grade 2, SMD	EEV-FK2A221M	Panasonic
C3, C4	2	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	CGA4J2X7R2A104K125AA	TDK
C6	1	CAP, CERM, 0.47 uF, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	CGA3E3X7R1E474K080AB	TDK
C8	1	CAP, CERM, 1000 pF, 50 V, +/- 5%, X7R, 0805	C0805C102J5RACTU	Kemet
C11	1	CAP, CERM, 1000 pF, 10 V,+/- 10%, X7R, 0402	0402ZC102KAT2A	AVX
C12	1	CAP, CERM, 2.2 µF, 25 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0805	GCM21BR71E225KA73L	MuRata
C13	1	CAP, CERM, 0.068 uF, 100 V, +/- 10%, X7R, 0805	C0805C683K1RACTU	Kemet
C14	1	CAP, CERM, 0.68 uF, 50 V, +/- 10%, X7R, 0805	C0805C684K5RACTU	Kemet
C16	1	CAP, AL, 47 uF, 100 V, +/- 20%, 0.32 ohm, AEC-Q200 Grade 2, SMD, SMT Radial H13	EEV-FK2A470Q	Panasonic
C17, C18	2	CAP, CERM, 1 uF, 100 V, +/- 10%, X7R, 1812	C4532X7R2A105K230KA	TDK
C21	1	CAP, CERM, 10 uF, 100 V, +/- 20%, X7R, 2220	22201C106MAT2A	AVX
D2	1	Diode, Schottky, 100 V, 2 A, SMB	SS2H10-E3/5BT	Vishay-Semiconductor
D3	1	LED, 0805, Green, SMD	LTST-C170KGKT	Lite-On
D4, D5	2	LED, Red, 0805, SMD	LTST-C170KRKT	Lite-On
D6	1	Diode, Zener, 5.6 V, 300 mW, AEC-Q101, SOD-323	SZMM3Z5V6ST1G	ON Semiconductor
D10, D11	2	Diode, Schottky, 100 V, 0.25 A, SOD-123F	BAT46WH,115	Nexperia
H1, H2, H3, H4	4	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4	Standoff	1902C	Keystone
J1	1	Header, 100mil, 3x2 3x2, Tin, TH	PEC03DAAN	Sullins Connector Solutions
J2	1	Header, 100mil, 2x2, Tin, TH	PEC02DAAN	Sullins Connector Solutions
J3	1	Header, 100mil, 4x2, Tin, TH	PEC04DAAN	Sullins Connector Solutions

Table 7-1. TPS48111Q1EVM Bill Of Materials (continued)

Designator	Quantity	Description	Part Number	Manufacturer
Q1, Q2, Q12, Q14	4	N-Channel 80V 300A (Tc) 375W (Tc) Surface Mount PG-HSOG-8-1	IAUS300N08S5N012ATMA1	Infineon
Q4, Q16	2	MOSFET, N-CH, 60 V, 0.115 A, SOT-323	2N7002W-7-F	Diodes Inc.
Q5	1	Transistor, NPN, 160 V, 0.3 A, SOT-23	PMBT5551,215	Nexperia
Q6	1	Transistor, NPN, 40 V, 0.2 A, SOT-23	MMBT3904	Fairchild Semiconductor
Q15	1	MOSFET, N-CH, 100 V, 1.4 A, SOT-23	DMN10H220L-7	Diodes Inc.
R1	1	Res Metal Strip 3921 0.0005 Ohm 1% 3W ±175ppm/°C Molded SMD SMD Embossed, 3921 Plastic T/R	WSL3921L5000FEA	Vishay Dale
R4, R7	2	RES, 220, 1%, 1 W, AEC-Q200 Grade 0, 2512	CRCW2512220RFKEG	Vishay-Dale
R5	1	RES, 100, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	CRCW0805100RFKEA	Vishay-Dale
R6, R8, R41, R45	4	RES, 2.21, 1%, 0.1 W, 0603	RC0603FR-072R21L	Yageo
R9	1	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06030000Z0EA	Vishay-Dale
R10	1	RES, 10.0, 1%, 0.25 W, AEC-Q200 Grade 0, 0603	CRCW060310R0FKEAHP	Vishay-Dale
R11, R17, R30, R49	4	RES, 9.53 k, 1%, 0.1 W, 0603	RC0603FR-079K53L	Yageo
R12, R21, R22, R47	4	RES, 3.16 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06033K16FKEA	Vishay-Dale
R14	1	RES, 1.47 k, 0.1%, 0.1 W, 0603	RT0603BRD071K47L	Yageo America
R18, R19, R20	3	RES, 10.0 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	ERJ-6ENF1002V	Panasonic
R23	1	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW0603100KFKEA	Vishay-Dale
R24	1	RES, 41.2 k, 1%, 0.1 W, 0603	RC0603FR-0741K2L	Yageo
R25	1	RES, 20.0 k, 0.5%, 0.1 W, 0603	RT0603DRE0720KL	Yageo America
R26, R48	2	RES, 0, 5%, 0.1 W, 0603	ERJ-3GEY0R00V	Panasonic
R27	1	RES, 475 k, 1%, 0.1 W, 0603	RC0603FR-07475KL	Yageo
R28	1	RES, 158 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW0603158KFKEA	Vishay-Dale
R29	1	RES, 47.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060347K0FKEA	Vishay-Dale
R42	1	RES, 470 k, 1%, 0.1 W, 0603	RC0603FR-07470KL	Yageo
R44	1	RES, 24.9 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	CRCW080524K9FKEA	Vishay-Dale
SH-J1, SH-J2, SH-J3	3	Shunt, 100mil, Flash Gold, Black	SPC02SYAN	Sullins Connector Solutions
T1, T2, T3, T4	4	Terminal 90A Lug	CB70-14-CY	Panduit

Table 7-1. TPS48111Q1EVM Bill Of Materials (continued)

Designator	Quantity	Description	Part Number	Manufacturer
TP1, TP2, TP9	3	Test Point, Multipurpose, Red, TH	5010	Keystone
TP3, TP5, TP6, TP8, TP10, TP11, TP12, TP13, TP14, TP24, TP25	11	Test Point, Multipurpose, White, TH	5012	Keystone
TP7, TP26	2	Test Point, Multipurpose, Orange, TH	5013	Keystone
TP15, TP16, TP17, TP18	4	Test Point, Multipurpose, Black, TH	5011	Keystone
U2	1	100V Smart High Side controller with Protection and Diagnostics	PTPS48111-Q1	Texas Instruments
C1	0	CAP, CERM, 0.01 uF, 100 V, +/- 10%, X7R, 1206	12061C103KAT2A	AVX
C5, C9, C20	0	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	CGA4J2X7R2A104K125AA	TDK
C7	0	CAP, CERM, 0.47 uF, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	CGA3E3X7R1E474K080AB	TDK
C10	0	CAP, CERM, 330 pF, 50 V, +/- 10%, X7R, 0402	GRM155R71H331KA01D	MuRata
C19	0	CAP, CERM, 0.01 uF, 100 V, +/- 5%, X7R, 0805	08051C103JAT2A	AVX
D1	0	Diode, TVS, Uni, 70 V, 113 Vc, SMC	SMCJ70A	Littelfuse
FID1, FID2, FID3, FID4, FID5, FID6	0	Fiducial mark. There is nothing to buy or mount.	N/A	N/A
Q3, Q13	0	N-Channel 80V 300A (Tc) 375W (Tc) Surface Mount PG-HSOG-8-1	IAUS300N08S5N012ATMA1	Infineon
R2	0	Res Metal Strip 3921 0.0005 Ohm 1% 3W ±175ppm/°C Molded SMD SMD Embossed Plastic T/R	WSL3921L5000FEA	Vishay Dale
R3	0	RES, 100, 1%, 0.5 W, AEC-Q200 Grade 0, 1206	CRCW1206100RFKEAHP	Vishay-Dale
R13, R43	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06030000Z0EA	Vishay-Dale
R15	0	RES, 10.0, 1%, 0.125 W, 0805	RC0805FR-0710RL	Yageo America
R16	0	RES, 470 k, 1%, 0.1 W, 0603	RC0603FR-07470KL	Yageo
R31	0	RES, 9.53 k, 1%, 0.1 W, 0603	RC0603FR-079K53L	Yageo

8 Revision History

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

Changes from Revision * (June 2022) to Revision A (December 2022) **Page**

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265