

TPS48110Q1EVM: Evaluation Module for Smart High-Side Driver TPS48110-Q1



ABSTRACT

This user's guide describes the evaluation module (EVM) for the TPS48110-Q1 smart high-side driver. The document provides EVM configuration information and test setup details for evaluating the TPS48110-Q1 device. The EVM schematic, board layout, and bill of materials (BOM) are also included.


	<p>Caution</p>	<p>Caution Hot surface. Contact may cause burns. Do not touch!</p>
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Trademarks

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1 Introduction

The TPS48110Q1EVM allows reference circuit evaluation of TI's smart high-side driver TPS48110-Q1. The TPS48110-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 device provides two-level adjustable overcurrent protection with adjustable circuit breaker timer, overvoltage protection, fast short-circuit protection, accurate analog current monitor output, and remote overtemperature protection.

1.1 EVM Features

General TPS48110Q1EVM 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
- 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:

- PTC heater
- Power distribution unit
- eCAT heater

2 Description

The TPS48110Q1EVM evaluation board enables evaluation of the TPS48110-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. TPS48110Q1EVM Evaluation Board Options and Setting

Part Number	EVM Function	Vin Range	Vin UVLO	Vin OVP	ENABLE (EN/UVLO)	Overcurrent Protection		Features
						Low Setting	Hi Setting	
TPS48110Q1EVM	Smart high-side driver with protection and diagnostics	24 V to 60 V	24 V	58 V	Active high	5 A	50 A	Overload protection with auto-retry and latch response Overvoltage protection

3 Schematic

Figure 3-1 illustrates the EVM schematic.

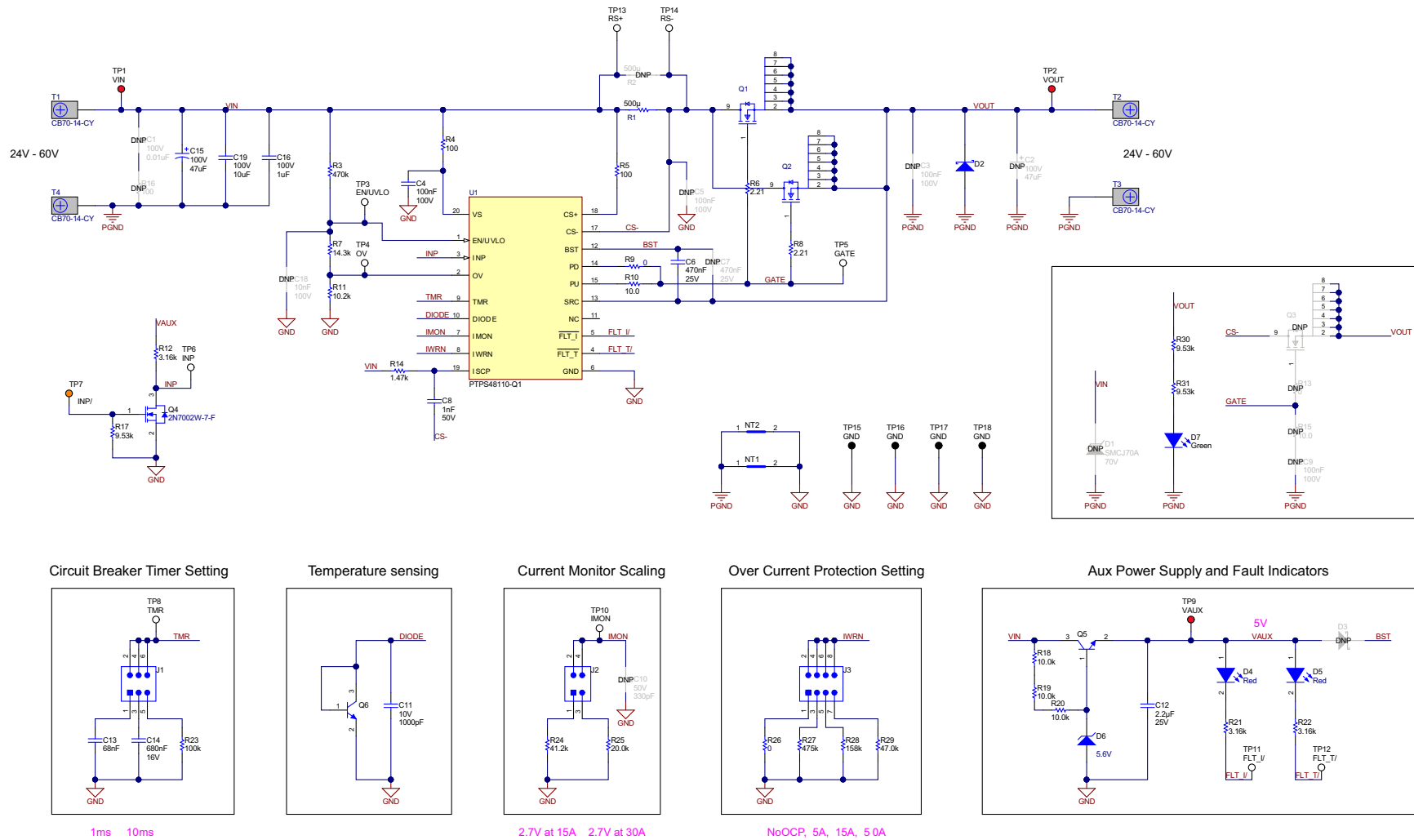


Figure 3-1. TPS48110Q1EVM Evaluation Module Schematic

4 General Configurations

4.1 Physical Access

Table 4-1 lists the TPS48110Q1EVM 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
TP4	OV	Overvoltage 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

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 60-V 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 TPS48110Q1EVM Evaluation Board

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

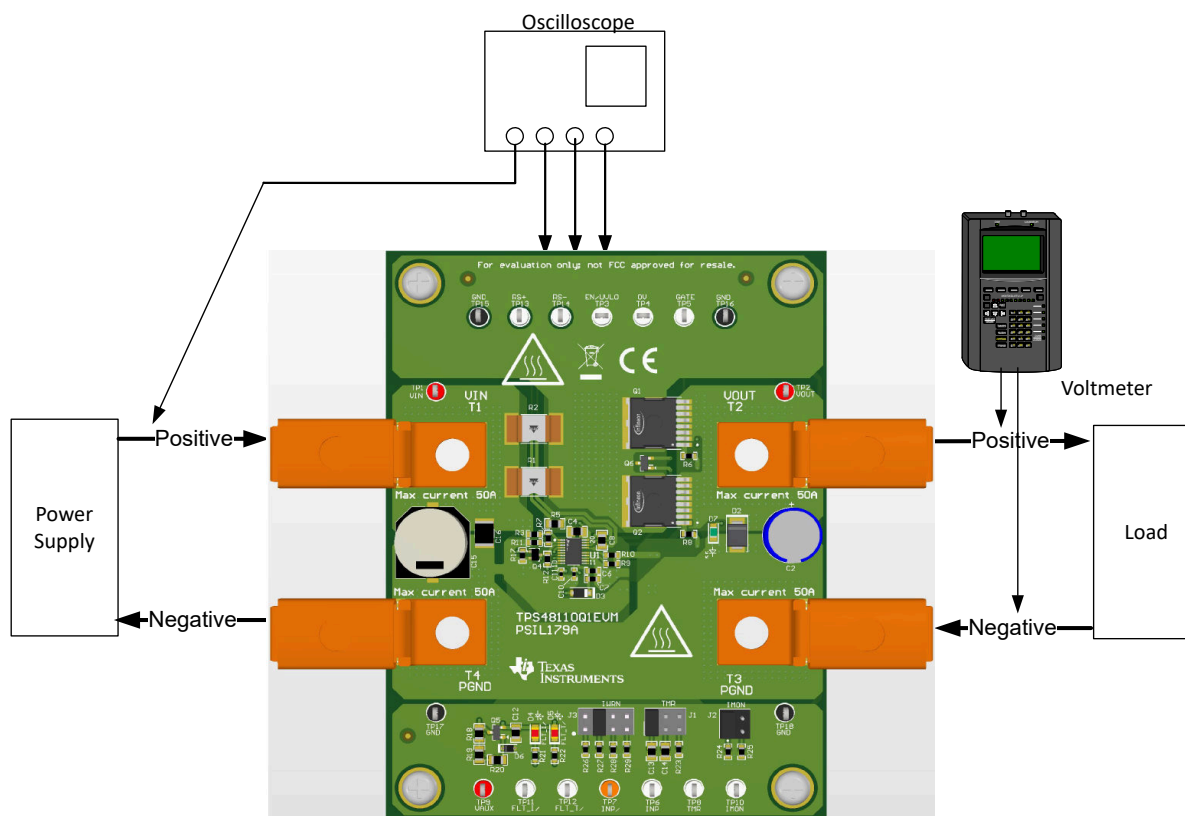


Figure 5-1. TPS48110Q1EVM Setup with Test Equipment

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.
- 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 Power Up with EN Control

Use the following instructions to verify the power-up profile of TPS48110-Q1:

1. Connect the EN/UVLO pin (TP3) to ground and INP (TP6) to ground.
2. Set the input supply voltage VIN to 48 V and current limit of 10 A.
3. Enable the power supply.
4. 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 5-2](#).
5. Now, disable the controller by making EN/UVLO = LOW.
6. Connect INP (TP6) to VAUX to set INP as HIGH.
7. 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 5-3](#).

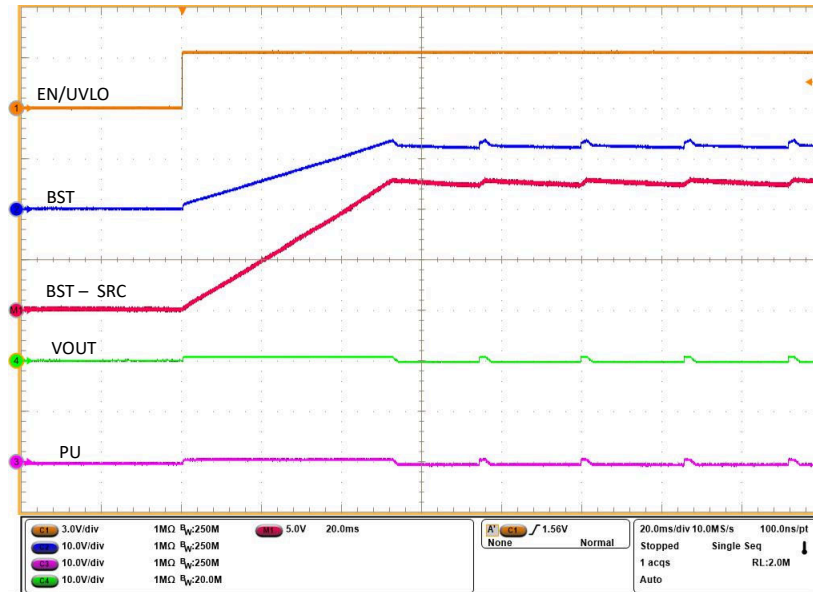


Figure 5-2. Start-Up Profile of Bootstrap Voltage for INP = GND

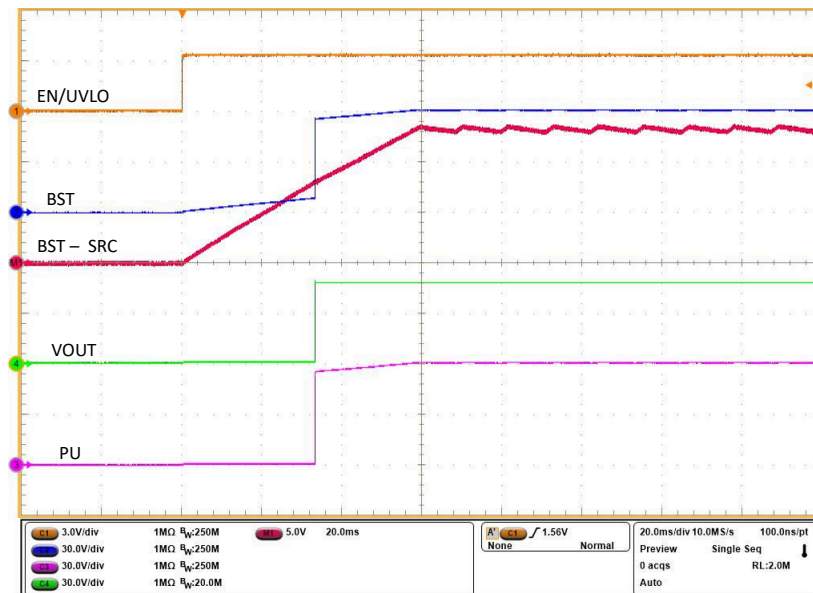


Figure 5-3. Start-Up Profile of Bootstrap Voltage for INP = HIGH

5.2 ON and OFF Control with INP Input

Use the following instructions to verify ON and OFF control of TPS48110-Q1:

1. Connect the INP (TP6) to ground.
2. Set the input supply voltage VIN to 48 V and current limit of 10 A.
3. Enable the power supply.
4. Now, toggle the INP to HIGH and then LOW to verify the turn-ON and turn-OFF response of PU/PD of TPS48110-Q1.

Figure 5-4 and Figure 5-5 show the turn-ON and turn-OFF responses on the TPS48110Q1EVM Evaluation Board.

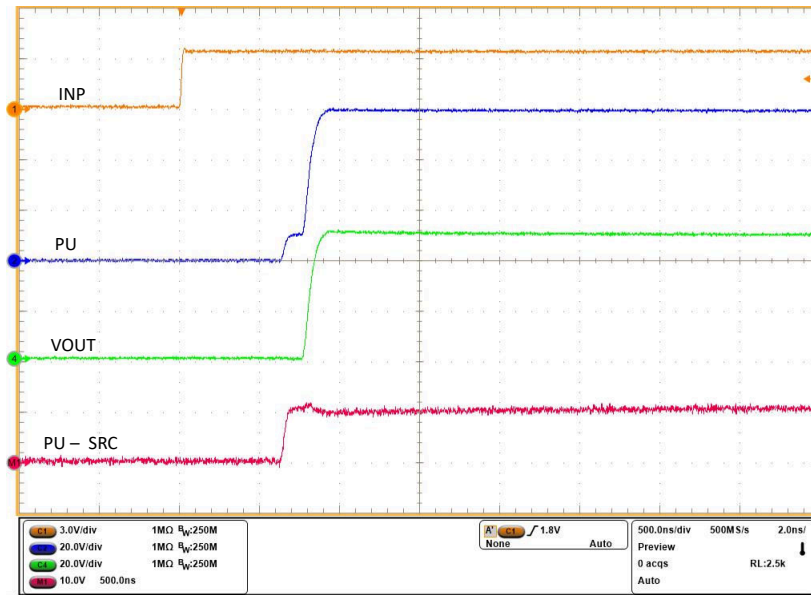


Figure 5-4. Turn-ON Response of TPS48110-Q1 for INP -> LOW to HIGH

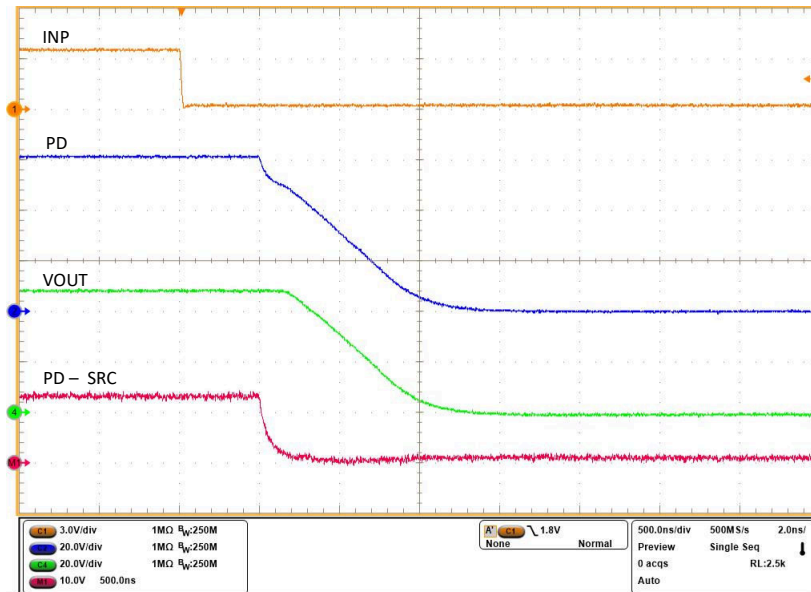


Figure 5-5. Turn-OFF Response of TPS48110-Q1 for INP -> HIGH to LOW

5.3 Overcurrent Protection Test

Use the following instructions to perform the overcurrent test on the TPS48110Q1EVM:

1. Enable the control input INP (TP6) of the main MOSFETS.
2. By default, the EVM is configured for 5-A overcurrent protection.
3. Now, load the output with rheostat or electronic load and gradually increase the load current to observe the overload behavior of TPS48110-Q1.
4. Place jumper J3 at other settings to test at various overcurrent limits.

Figure 5-6 and Figure 5-7 show test waveforms for an overcurrent fault.

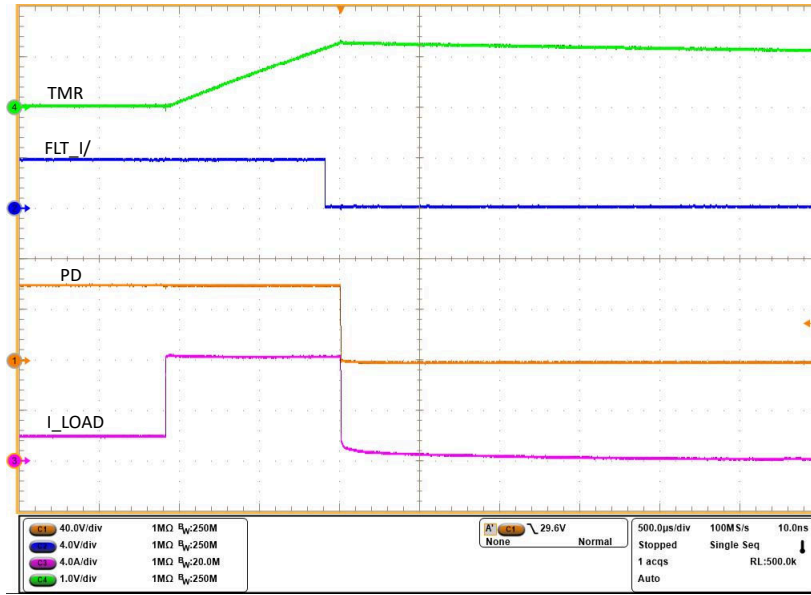


Figure 5-6. Overcurrent Response of TPS48110-Q1 for a Load Step from 2 A to 8 A with 5-A Overcurrent Protection Setting

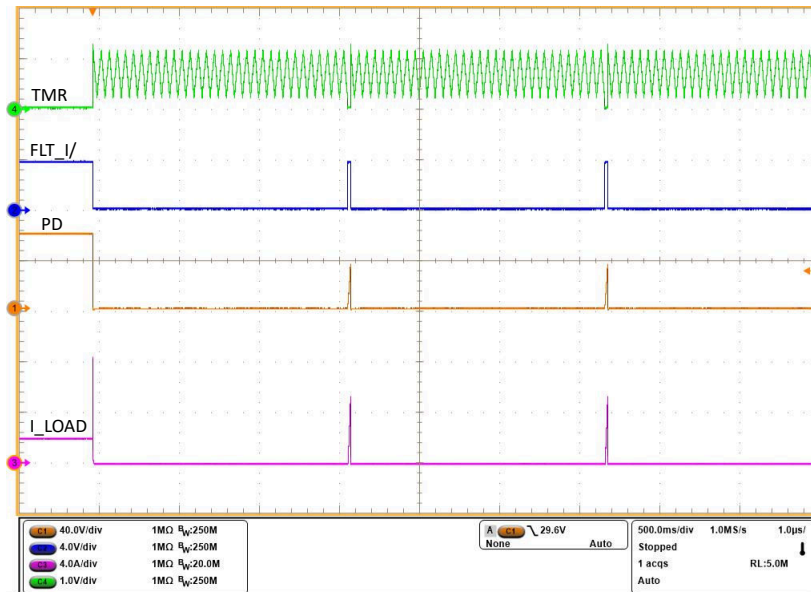


Figure 5-7. Auto-Retry Response of TPS48110-Q1 for an Overcurrent Fault

5.4 Overvoltage Protection Test

Use the following instructions to perform the overvoltage test:

1. Set the input supply voltage V_{IN} to 48 V and current limit of 10 A.
2. Enable the power supply.
3. Now, gradually increase the V_{IN} voltage to observe the overvoltage cutoff response of TPS48110-Q1 using an oscilloscope.

Figure 5-8 shows overvoltage cutoff response of TPS48110-Q1 on TPS48110Q1EVM Evaluation Board.

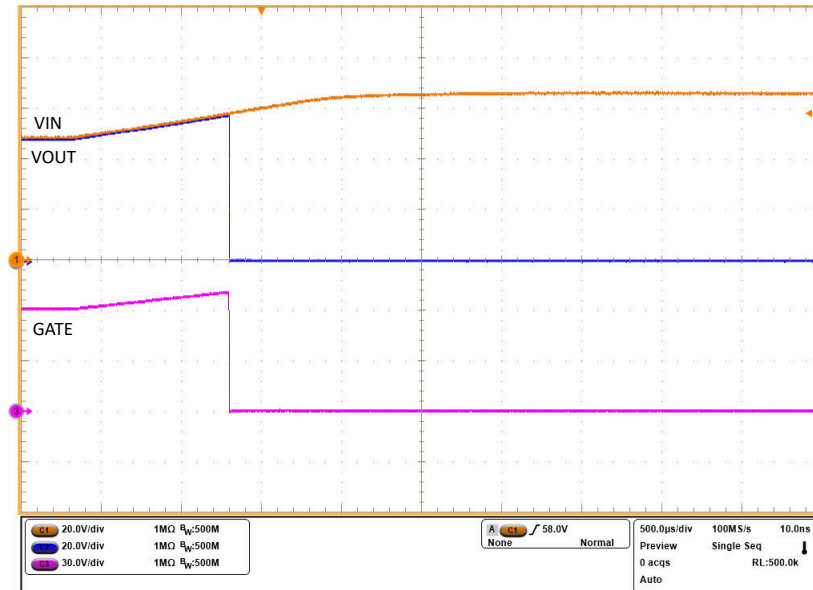


Figure 5-8. Overvoltage Cutoff Response at 58-V Level of TPS48110-Q1

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.

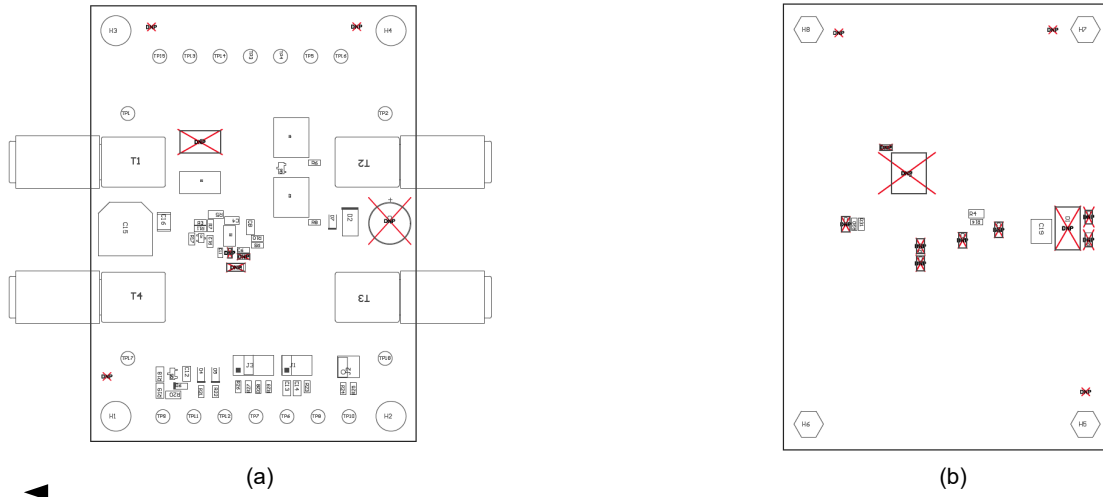


Figure 6-1. TPS48110Q1EVM Board (a) Top Assembly (b) Bottom Assembly

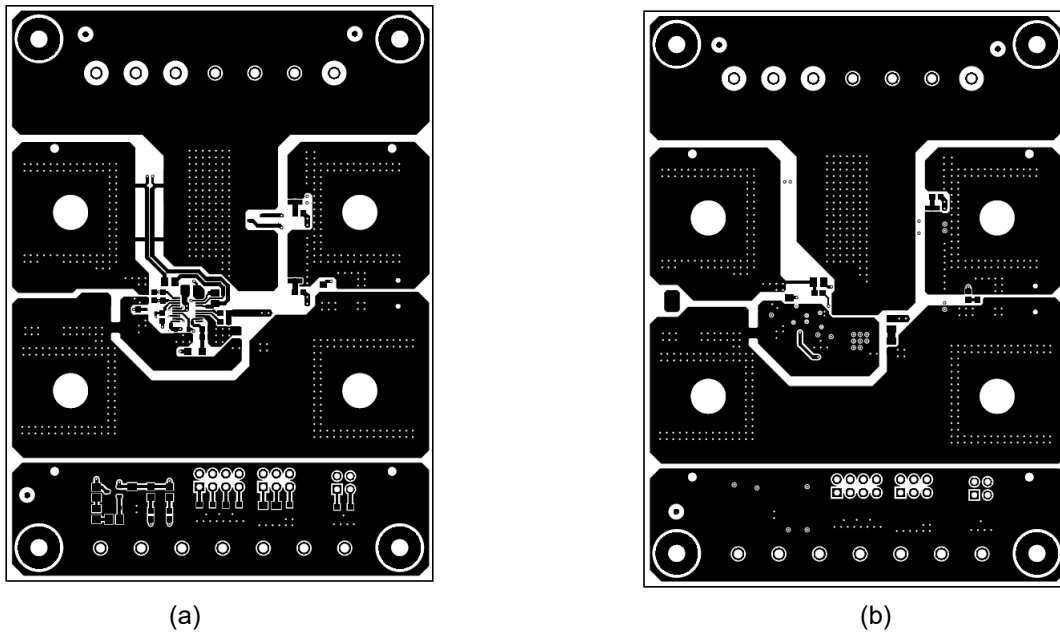


Figure 6-2. TPS48110Q1EVM Board (a) Top Layer (b) Bottom Layer

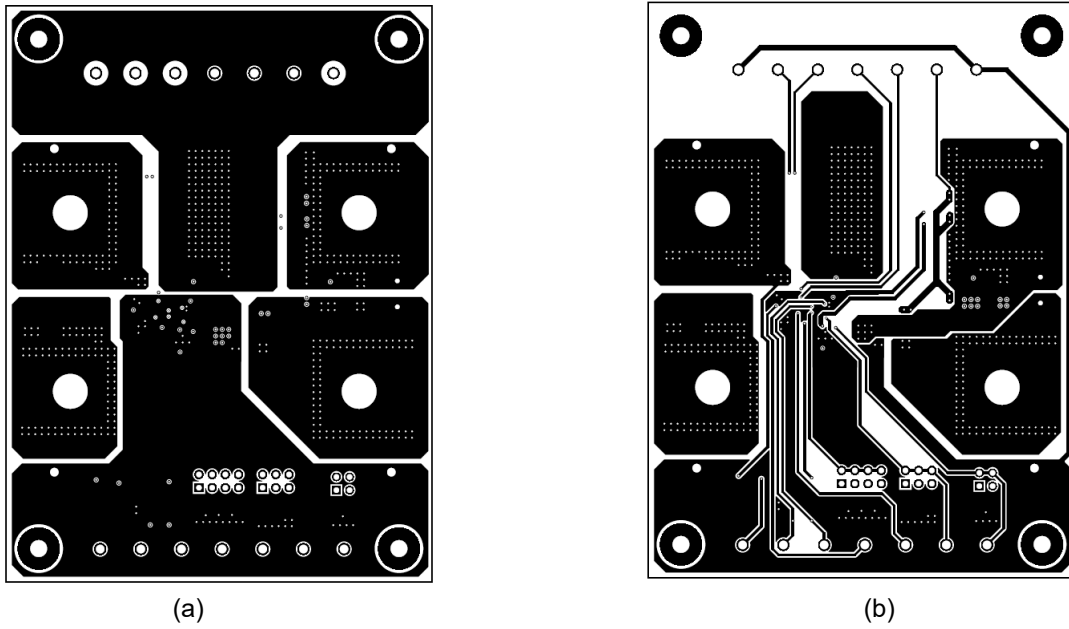


Figure 6-3. TPS48110Q1EVM Board (a) Inner Signal Layer (b) Inner Routing Layer

7 Bill of Materials (BoM)

Table 7-1 lists the EVM BoM.

Table 7-1. TPS48110Q1EVM Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
!PCB1	1		Printed Circuit Board		PSIL179	Any
C4	1	0.1 uF	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	0805	CGA4J2X7R2A104K125AA	TDK
C6	1	0.47 uF	CAP, CERM, 0.47 uF, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E3X7R1E474K080AB	TDK
C8	1	1000 pF	CAP, CERM, 1000 pF, 50 V, +/- 5%, X7R, 0805	0805	C0805C102J5RACTU	Kemet
C11	1	1000 pF	CAP, CERM, 1000 pF, 10 V, +/- 10%, X7R, 0402	0402	0402ZC102KAT2A	AVX
C12	1	2.2 uF	CAP, CERM, 2.2 uF, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	0805	GCM21BR71E225KA73L	MuRata
C13	1	0.068 uF	CAP, CERM, 0.068 uF, 100 V, +/- 10%, X7R, 0805	0805	C0805C683K1RACTU	Kemet
C14	1	0.68 uF	CAP, CERM, 0.68 uF, 50 V, +/- 10%, X7R, 0805	0805	C0805C684K5RACTU	Kemet
C15	1	47 uF	CAP, AL, 47 uF, 100 V, +/- 20%, 0.32 ohm, AEC-Q200 Grade 2, SMD	SMT Radial H13	EEV-FK2A470Q	Panasonic
C16	1	1 uF	CAP, CERM, 1 uF, 100 V, +/- 10%, X7R, 1812	1812	C4532X7R2A105K230KA	TDK
C19	1	10uF	CAP, CERM, 10 uF, 100 V, +/- 20%, X7R, 2220	2220	22201C106MAT2A	AVX
D2	1	100 V	Diode, Schottky, 100 V, 2 A, SMB	SMB	SS2H10-E3/5BT	Vishay-Semiconductor
D7	1	Green	LED, Green, SMD	LED_0805	LTST-C170KGKT	Lite-On
D4, D5	2	Red	LED, Red, SMD	Red 0805 LED	LTST-C170KRKT	Lite-On
D6	1	5.6 V	Diode, Zener, 5.6 V, 300 mW, AEC-Q101, SOD-323	SOD-323	SZMM3Z5V6ST1G	ON Semiconductor
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	1902C	Keystone
J1	1		Header, 100mil, 3x2, Tin, TH	3x2 Header	PEC03DAAN	Sullins Connector Solutions
J2	1		Header, 100mil, 2x2, Tin, TH	Header, 2x2, 2.54mm, TH	PEC02DAAN	Sullins Connector Solutions

Table 7-1. TPS48110Q1EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
J3	1		Header, 100mil, 4x2, Tin, TH	Header, 4x2, 100mil, Tin	PEC04DAAN	Sullins Connector Solutions
Q1, Q2	2		N-Channel 80V 300A (Tc) 375W (Tc) Surface Mount PG-HSOG-8-1	H SOG-8	IAUS300N08S5N012ATMA1	Infineon
Q4	1	60 V	MOSFET, N-CH, 60 V, 0.115 A, SOT-323	SOT-323	2N7002W-7-F	Diodes Inc.
Q5	1	160 V	Transistor, NPN, 160 V, 0.3 A, SOT-23	SOT-23	PMBT5551,215	Nexperia
Q6	1	40 V	Transistor, NPN, 40 V, 0.2 A, SOT-23	SOT-23	MMBT3904	Fairchild Semiconductor
R1	1	500 μ	Res Metal Strip 3921 0.0005 Ohm 1% 3W \pm 175ppm/ $^{\circ}$ C Molded SMD SMD Embossed Plastic T/R	3921	WSL3921L5000FEA	Vishay Dale
R3	1	470k	RES, 470 k, 1%, 0.1 W, 0603	0603	RC0603FR-07470KL	Yageo
R4, R5	2	100	RES, 100, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW0805100RFKEA	Vishay-Dale
R6, R8	2	2.21	RES, 2.21, 1%, 0.1 W, 0603	0603	RC0603FR-072R21L	Yageo
R7	1	14.3k	RES, 14.3 k, 1%, 0.1 W, 0603	0603	RC0603FR-0714K3L	Yageo
R9	1	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R10	1	10.0	RES, 10.0, 1%, 0.25 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310R0FKEAHP	Vishay-Dale
R11	1	10.2k	RES, 10.2 k, 1%, 0.1 W, 0603	0603	RC0603FR-0710K2L	Yageo
R17, R30, R31	3	9.53 k	RES, 9.53 k, 1%, 0.1 W, 0603	0603	RC0603FR-079K53L	Yageo
R12, R21, R22	3	3.16 k	RES, 3.16 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06033K16FKEA	Vishay-Dale
R14	1	1.47 k	RES, 1.47 k, 0.1%, 0.1 W, 0603	0603	RT0603BRD071K47L	Yageo America
R18, R19, R20	3	10.0 k	RES, 10.0 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	ERJ-6ENF1002V	Panasonic
R23	1	100 k	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100KFKEA	Vishay-Dale
R24	1	41.2 k	RES, 41.2 k, 1%, 0.1 W, 0603	0603	RC0603FR-0741K2L	Yageo
R25	1	20.0 k	RES, 20.0 k, 0.5%, 0.1 W, 0603	0603	RT0603DRE0720KL	Yageo America
R26	1	0	RES, 0, 5%, 0.1 W, 0603	0603	ERJ-3GEY0R00V	Panasonic
R27	1	475 k	RES, 475 k, 1%, 0.1 W, 0603	0603	RC0603FR-07475KL	Yageo

Table 7-1. TPS48110Q1EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R28	1	158 k	RES, 158 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603158KFKEA	Vishay-Dale
R29	1	47.0 k	RES, 47.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060347K0FKEA	Vishay-Dale
SH-J1, SH-J2, SH-J3	3	1x2	Shunt, 100mil, Flash Gold, Black	Closed Top 100mil Shunt	SPC02SYAN	Sullins Connector Solutions
T1, T2, T3, T4	4		Terminal 90A Lug	CB70-14-CY	CB70-14-CY	Panduit
TP1, TP2, TP9	3		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone
TP3, TP4, TP5, TP6, TP8, TP10, TP11, TP12, TP13, TP14	10		Test Point, Multipurpose, White, TH	White Multipurpose Testpoint	5012	Keystone
TP7	1		Test Point, Multipurpose, Orange, TH	Orange Multipurpose Testpoint	5013	Keystone
TP15, TP16, TP17, TP18	4		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone
U1	1		100V Smart High Side controller with Protection and Diagnostics	VSSOP20	PTPS48110-Q1	Texas Instruments
C1	0	0.01 uF	CAP, CERM, 0.01 uF, 100 V, +/- 10%, X7R, 1206	1206	12061C103KAT2A	AVX
C2	0	47uF	CAP, AL, 47 uF, 100 V, +/- 20%, 0.43 ohm, TH	10x12.5mm	UHE2A470MPD	Nichicon
C3, C5, C9	0	0.1 uF	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	0805	CGA4J2X7R2A104K125AA	TDK
C7	0	0.47 uF	CAP, CERM, 0.47 uF, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E3X7R1E474K080AB	TDK
C10	0	330 pF	CAP, CERM, 330 pF, 50 V, +/- 10%, X7R, 0402	0402	GRM155R71H331KA01D	MuRata
C18	0	0.01 uF	CAP, CERM, 0.01 uF, 100 V, +/- 5%, X7R, 0805	0805	08051C103JAT2A	AVX
D1	0	70 V	Diode, TVS, Uni, 70 V, 113 Vc, SMC	SMC	SMCJ70A	Littelfuse
D3	0	100 V	Diode, Schottky, 100 V, 0.25 A, SOD-123F	SOD-123F	BAT46WH,115	Nexperia
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A

Table 7-1. TPS48110Q1EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
Q3	0		N-Channel 80V 300A (Tc) 375W (Tc) Surface Mount PG-HSOG-8-1	H SOG-8	IAUS300N08S5N012ATMA1	Infineon
R2	0	500 μ	Res Metal Strip 3921 0.0005 Ohm 1% 3W \pm 175ppm/ $^{\circ}$ C Molded SMD SMD Embossed Plastic T/R	3921	WSL3921L5000FEA	Vishay Dale
R16	0	100	RES, 100, 1%, 0.5 W, AEC-Q200 Grade 0, 1206	1206	CRCW1206100RFKEAHP	Vishay-Dale
R13	0	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R15	0	10.0	RES, 10.0, 1%, 0.125 W, 0805	0805	RC0805FR-0710RL	Yageo America

8 Revision History

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

Changes from Revision * (May 2022) to Revision A (December 2022)	Page
• Updated TPS48110Q1EVM Evaluation Module Schematic.....	3
• Updated TPS48110Q1EVM Setup with Test Equipment.....	5

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 DEGRADATION 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/lstds/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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。日本テキサス・イ

ンスツルメンツ株式会社

東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。 <https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html>

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.

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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 MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS 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 EPIDEMIC FAILURE WARRANTY OR 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.
 - 6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.
 7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMNITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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