User's Guide
SLVUBI9A–October 2018–Revised March 2019

TPS16630-32EVM: Evaluation Module for TPS1663x

This user's guide describes the evaluation module (EVM) for the Texas instruments TPS1663 family of eFuse devices, TPS16630 and TPS16632. The document provides EVM configuration information and test setup details for evaluating TPS1663 eFuse devices with the EVM. The EVM schematic, board layout and bill of materials (BOM) are also included.

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1 Introduction

The TPS16630-32EVM allows reference circuit evaluation of TI's TPS1663x eFuse devices. The TPS1663x are 4.5-V to 60-V, 0.6-A to 6-A industrial eFuses with integrated 31-mΩ FET, programmable undervoltage, overvoltage, overcurrent, inrush current protection, and output current monitoring features.

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1.1 REACH Compliance

In compliance with the Article 33 provision of the EU REACH regulation, we are notifying you that this EVM includes a component containing at least one substance of very high concern (SVHC) above 0.1%. These uses from Texas Instruments do not exceed 1 ton per year. The SVHC summary is listed in Table 1

Table 1. SVHC Summary

Component Manufacturer	Component type	Component part number	SVHC Substance	SVHC CAS (when available)
Diodes Inc.	Diode	SMCJ33CA-13-F	Lead	7439-92-1

1.2 EVM Features

The TPS16630-32EVM features include:

- 4.5-V to 60-V input operating voltage range
- 0.6-A to 6-A programmable current limit
- Output Power Limiting Scheme (PLIM)
- Programmable input UVLO and OVP cut off – 18 V and 33 V respectively
- Fixed Overvoltage Clamp (Channel 2 only) – 35-V fixed
- Programmable V_{OUT} slew rate control
- Selectable Overcurrent fault response (Auto-Retry and Latch)
- Optional on-board transient protection devices like input TVS and output Schottky diodes
- 33-V SMC TVS for power rails up-to 33-V and 51-V SMB TVS for 48-V power rails
- On-board reset switch and fault indicators

1.3 Applications

- PLC, CNC
- Medical Equipment
- Control and Automation
- Industrial power systems
- Sensors Hubs

2 Description

The TPS16630-32EVM enables full evaluation of the TPS1663x devices. This EVM has two independent channels (CH1 and CH2) where two devices can be evaluated together. CH1 is configured to test OVP cut-off version TPS16630 and CH2 is configured to test OV clamp and power limit version TPS16632. Input power is applied at T1 (CH1) and T3 (CH2) while T2 (CH1) and T4 (CH2) provide the output connections to the load respectively. Refer to the schematic in Figure 7 and EVM test setup in Figure 1. S1 and S2 allow U1 and U2 to be reset or disabled and Jumper J4 and J10 allow current limit setting to be changed.

S1 and S2 allows U1 and U2 to RESET. A fault (FLTb) indicator is provided by D1 and D6 for CH1 and CH2, respectively. Scaled current for each channel can be monitored at TP8 and TP17 with a scaling factor of 0.83 V / A.

Table 2. TPS16630-32EVM Options and Setting

Part Number	EVM Function	V_{IN} Range	UVLO		OVP		Current Limit		Versions Available
			CH1	CH2	CH1	CH2	Minimum Setting	Maximum Setting	
TPS16630-32EVM	4.5-V to 60-V, 0.6-A to 6-A Industrial eFuse	4.5 V to 60 V	18 V	18 V	33-V OV Cutoff	35-V OV Clamp	0.6 A	6 A	Auto retry Latch off Current Limit Circuit Breaker Power Limit

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3 General Configurations

3.1 Physical Access

Table 3 lists the TPS16630-32EVM input and output connector functionality, Table 4 describes the test point availability, and Table 5 describes the jumper functionality.

Table 3. Input and Output Connector Functionality

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

NOTE: For testing with continuous input voltage greater than 33V, remove TVS diode D2 (for CH1) and D7 (for CH2) and install TVS diodes with appropriate voltage rating.

For testing with continuous input voltage greater than 50V, diodes D2 and D7 and capacitors C3 and C7 have to be replaced with diodes and capacitors of appropriate voltage rating.

Table 4. Test Points Description

Channel	Test Points	Label	Description
CH1	TP1	FLTb1	CH1 fault indicator
	TP2	SHDNb1	CH1 shutdown input
	TP3	VIN1	CH1 system power supply input
	TP4	VOUT1	CH1 output voltage
	TP5, TP6, TP7	GND	GND
	TP8	IMON1	CH1 output current monitor
	TP9	PGOOD1	CH1 output power good
CH2	TP10	FLTb2	CH2 fault indicator
	TP11	SHDNb2	CH2 shutdown input
	TP12	VIN2	CH2 system power supply input
	TP13	VOUT2	CH2 output voltage
	TP14, TP15, TP16	GND	GND
	TP17	IMON2	CH2 output current monitor
	TP18	PGOOD2	CH2 output power good

Table 5. Jumper and LED Descriptions

Jumper	Label	Description
J1	J1	CH1 fault LED pulled to VIN1, if installed
J2	J2	CH1 output power good indicator LED pulled to VOUT1, if installed
J4	J4	CH1 current limit setting 1-2 position sets 6 A 3-4 position sets 4.5 A 5-6 position sets 2 A 7-8 position sets 1 A 9-10 position sets 0.6 A
J5	J5	CH1 MODE selection Open position sets latch-off mode Closed position sets auto-retry mode
J6	J6	Not Used, Reserved
J7	J7	CH2 fault LED pulled to VIN1, if installed

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Table 5. Jumper and LED Descriptions (continued)

Jumper	Label	Description
J8	J8	CH2 output power good indicator LED pulled to VOUT1, if installed
J10	J10	CH2 current limit setting 1-2 position sets 6 A 3-4 position sets 4.5 A 5-6 position sets 2 A 7-8 position sets 1 A 9-10 position sets 0.6 A
J11	J11	CH2 MODE selection Open position sets latch-off mode Closed position sets auto-retry mode
J12	J12	CH2 PLIM setting Disables power limiting, if installed
D1, D6 (RED-LED)	Fault LED	CH1, CH2 fault indicators, respectively. LED turns on when the internal MOSFET is disabled due to any fault condition such as undervoltage, overvoltage, overload, short circuit, reverse current, and thermal shutdown.
D5, D10 (GREEN-LED)	Output power indicator	CH1, CH2 output power good indicators, respectively. LED turns on whenever the output voltage is above programmed power good threshold 12 V.

3.2 Test Equipment

3.2.1 Power Supplies

One adjustable power supply: 0-V to 60-V output, 0-A to 8-A output current limit.

3.2.2 Meters

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

3.2.3 Oscilloscope

A DPO2024, or equivalent. Three 10x voltage probes and one DC current probe.

3.2.4 Loads

One resistive load which can tolerate up to 8-A DC load at 24 V.

NOTE: A resistive load is recommended for testing. If an electronic load is used, ensure that the output load is set in the constant resistance (CR) mode, not in the constant current (CC) mode.

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3.3 Test Setup

Figure 1 shows the typical test setup for the TPS16630-32EVM. Connect T1/T3 to the power supply and T2/T4 to the load.

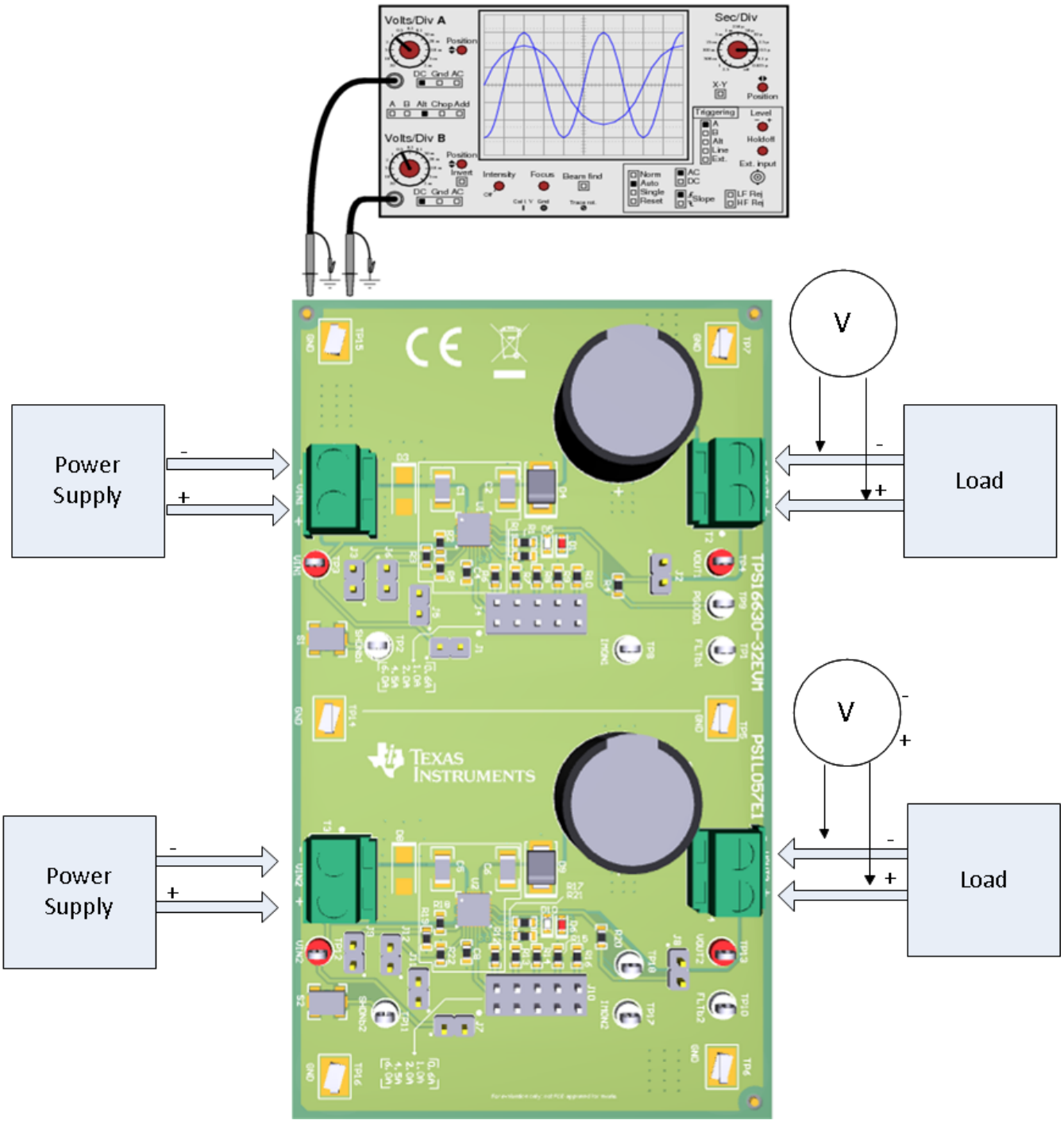


Figure 1. EVM Test Setup

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3.4 Test Procedure

NOTE: CH1 and CH2 can be tested one by one with a single power supply and the load.

3.4.1 Preliminary Tests

1. Turn on the power supply and set the output voltage and the current limit according to Table 6.

Table 6. Power Supply Setting for the TPS16630-32EVM

EVM	Channel	Voltage Set Point	Power Supply Current Limit
TPS16630-32EVM	CH1	24 V	8 A
	CH2	24 V	8 A

2. Turn on the load and set the load resistance to 24-Ω ±1 Ω.
3. Disable the power supply, load and hook up the TPS16630-32EVM assembly as shown in Figure 1
4. Make sure the default evaluation board jumper settings are as shown in Table 7.

Table 7. Default Jumper Setting for the TPS16630-32EVM

	J1	J2	J4	J5	J6
CH1	Install	Install	1-2	Do not Install	Do not Install
	J7	**J8**	**J10**	**J11**	**J12**
CH2	Install	Install	1-2	Do not Install	Do not Install

5. Enable the power supply and the load.
6. Connect the negative probe of the DMM to test point TP5 or TP14, the positive probe to the respective test points and verify that the voltages shown in Table 8 are obtained.

Table 8. TPS16630-32EVM DMM Readings at Different Test Points

Voltage test on (CH1)	Measured Voltage Reading	Voltage test on (CH2)	Measured Voltage Reading
VIN_SYS1 (TP3)	24 V ±1 V DC	VIN_SYS2 (TP12)	24 V ±1 V DC
VOUT1 (TP4)	24 V ±1 V DC	VOUT2 (TP13)	24 V ±1 V DC
IMON1 (TP8)	0.83 V ±0.2 V DC	IMON2 (TP17)	0.83 V ±0.2 V DC
FLTb1 (TP1)	22.6 V ±0.5 V DC	FLTb2 (TP10)	22.6 V ±0.5 V DC
SHDNb1 (TP2)	2.7 V ±0.5 V DC	SHDNb2 (TP11)	2.7 V ±0.5 V DC

7. Press the CH1/CH2 shutdown switch S1/S2 and verify the CH1/CH2 output voltage VOUT1/VOUT2 drops to zero. Release the S1/S2 switch and verify the output voltage resumes to nominal 24-V ±1 V.
8. Disable the power supply and the load.

3.4.2 UVLO, OVP Tests

Follow the instructions to verify undervoltage and overvoltage levels of the device:

1. Set the load resistance to 24-Ω ±1 Ω and the power supply voltage to 24 V. Enable the power supply and the load.
2. Increase the CH1 input voltage (VIN1) and monitor the output voltage (VOUT1). Verify that VOUT1 increases as VN1 increases and drops to zero when VIN1 exceeds 33-V ±1 V (CH1 OVP limit).
3. Reduce the CH1 input voltage and verify that the output turns on at 31-V ±1 V.
4. Further reduce the CH1 input voltage and verify that VOUT1 reduces as VN1 reduces and drops to zero when VIN1 falls below 18-V ±1 V (CH1 UVLO limit).
5. Increase the CH2 input voltage (VIN2) and monitor the output voltage (VOUT2). Verify that VOUT2 increases as VN2 increases and clamps to 35 V when VIN2 exceeds 35-V ±1 V (CH2 OV Clamp limit).

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6. Reduce the CH2 input voltage and verify that the output turns on at 33-V ±1 V.
7. Further reduce the CH2 input voltage and verify that VOUT2 reduces as VN2 reduces and drops to zero when VIN2 falls below 18-V ±1 V (CH2 UVLO limit).
8. Verify that CH1 and CH2 FLTb red LEDs (D1/D6) turn on whenever the supply voltage reaches either OVP or UVLO limits of the respective channels.
9. Disable the power supply and the load.

3.4.3 Output Voltage Start-Up Time Test

Follow the instructions to verify the individual channels output voltage start-up time:

1. Set up the oscilloscope as listed in Table 9.
2. Set the load resistance to 12-Ω ±1 Ω and the power supply voltage to 24 V.
3. Enable the load.
4. Enable the power supply and verify that the output voltage startup waveform is as shown in Figure 2.

Table 9. TPS16630-32EVM Oscilloscope Setting for the Output Voltage Start-Up Test

Oscilloscope Setting	CH1 Probe Points	CH2 Probe Points
Channel 1 = 10 V / div	VIN_SYS1 (TP3)	VIN_SYS2 (TP12)
Channel 2 = 10 V / div	VOUT1 (TP4)	VOUT2 (TP13)
Channel 3 = 20 V / div	PGOOD1 (TP19)	PGOOD2 (TP20)
Channel 4 = 1 A / div	Input current into T1 +Ve wire	Input current into T3 +Ve wire
Trigger source = Channel 1		
Trigger level = 12 V ±1 V		
Trigger polarity = Rising		
Trigger mode = Single		
Time base	5 ms / div	

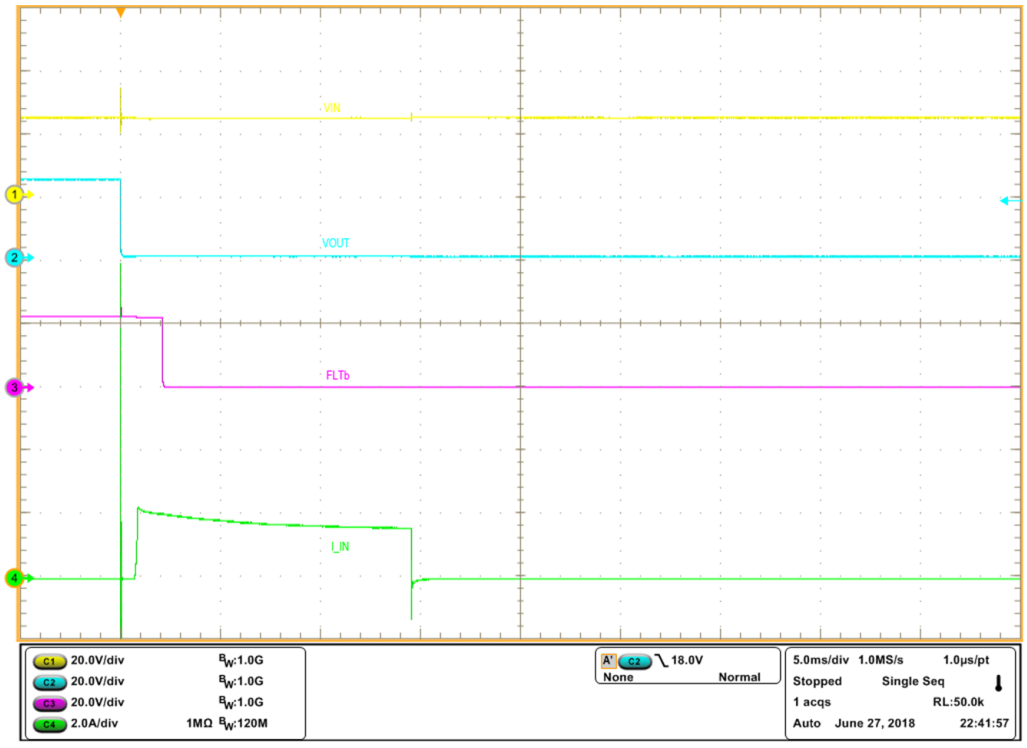


Figure 2. Output Voltage Start-Up Waveform

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3.4.4 Current Limit and Fault Responses Test

Follow the instructions to verify the current limit and various fault response modes like auto-retry and latch off:

NOTE: Measuring the current limit value on the oscilloscope can easily cause ±10% error from the typical expected values as listed in Table 10.

1. Set the current limit to 6 A by installing the J4/J10 jumper in position 1-2.
2. The jumper setting for different current limits is shown in Table 10.

Table 10. TPS16630-32EVM Jumper Setting for Current Limits

CH1, CH2 Jumper Positions (J4, J10)	Load Current Limit (A)
1-2	6
3-4	4.5
5-6	2
7-8	1
9-10	0.6

3. Set the load resistance to 24-Ω ±1 Ω and the power supply voltage to 24 V.
4. Enable the load and the power supply .
5. Change the load resistance to 3-Ω ±1 Ω and verify that the IC limits the current to 6 A and latches off after current limit
6. Change the load resistance to 24-Ω ±1 Ω and disable the power supply.
7. Set the current limit response mode to auto-retry by installing the J5/J11 jumper in the position 1-2.
8. Enable the power supply, change the load resistance to 24-Ω ±1 Ω and verify the current limit auto-retry behavior.
9. Disable the power supply and the load.

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3.4.5 Output Short-Circuit Protection Test

Follow the instructions to verify the output short-circuit protection feature of the device:

1. Set up the oscilloscope as listed in Table 11.

Table 11. TPS16630-32EVM Output Short-Circuit Protection Test

Oscilloscope Setting	CH1 Probe Points	CH2 Probe Points
Channel 1 = 10 V / div	VIN_SYS1 (TP3)	VIN_SYS2 (TP12)
Channel 2 = 10 V / div	VOUT1 (TP4)	VOUT (TP13)
Channel 3 = 20 V / div	FLTb1 (TP1)	FLTb2 (TP10)
Channel 4 = 2 A / div	Input current into T1 +Ve wire	Input current into T3 +Ve wire
Trigger source = Channel 1		
Trigger level = 12 V ±1 V		
Trigger polarity = Falling		
Trigger mode = Single		
Time base	5 ms / div	

2. Set the current limit 2 A by installing the J4/J10 jumper in position 5-6.
3. Set the load resistance to 24 Ω ±1 Ω and the power supply voltage to 24 V. Enable the load and the power supply.
4. Use either wire or FET to short the output to ground and verify the output short-circuit response waveform as shown in Figure 3.

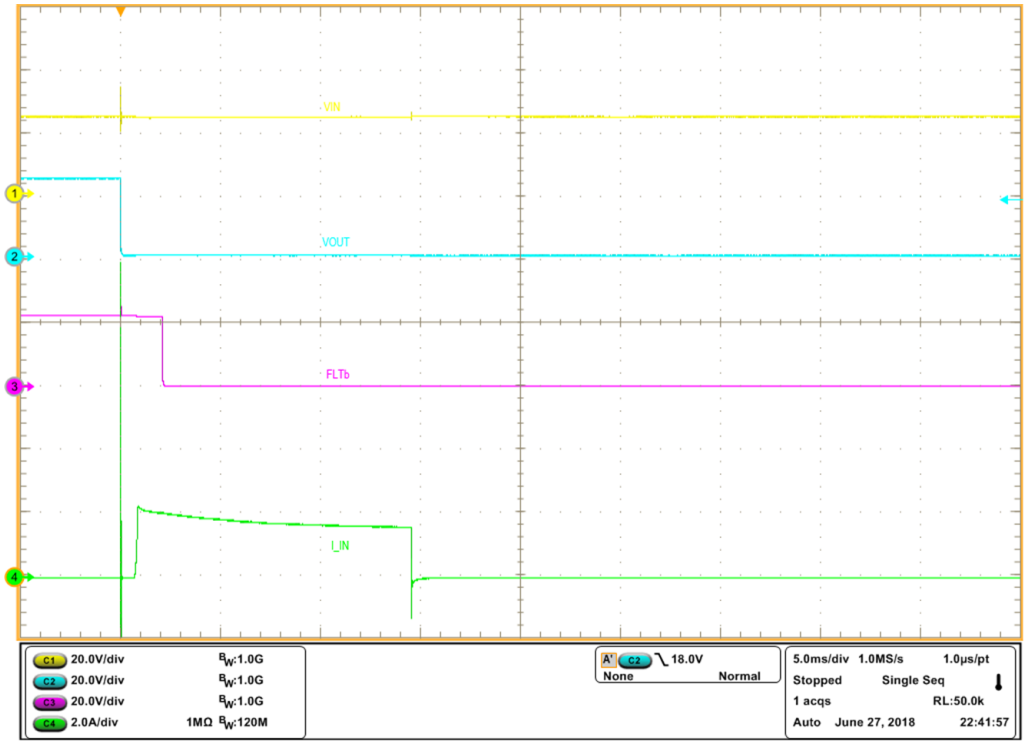


Figure 3. Output Short-Circuit Protection

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4 EVM Board Assembly Drawings and Layout

4.1 PCB Drawings

Figure 4 through Figure 6 show component placement and layout of the EVM.

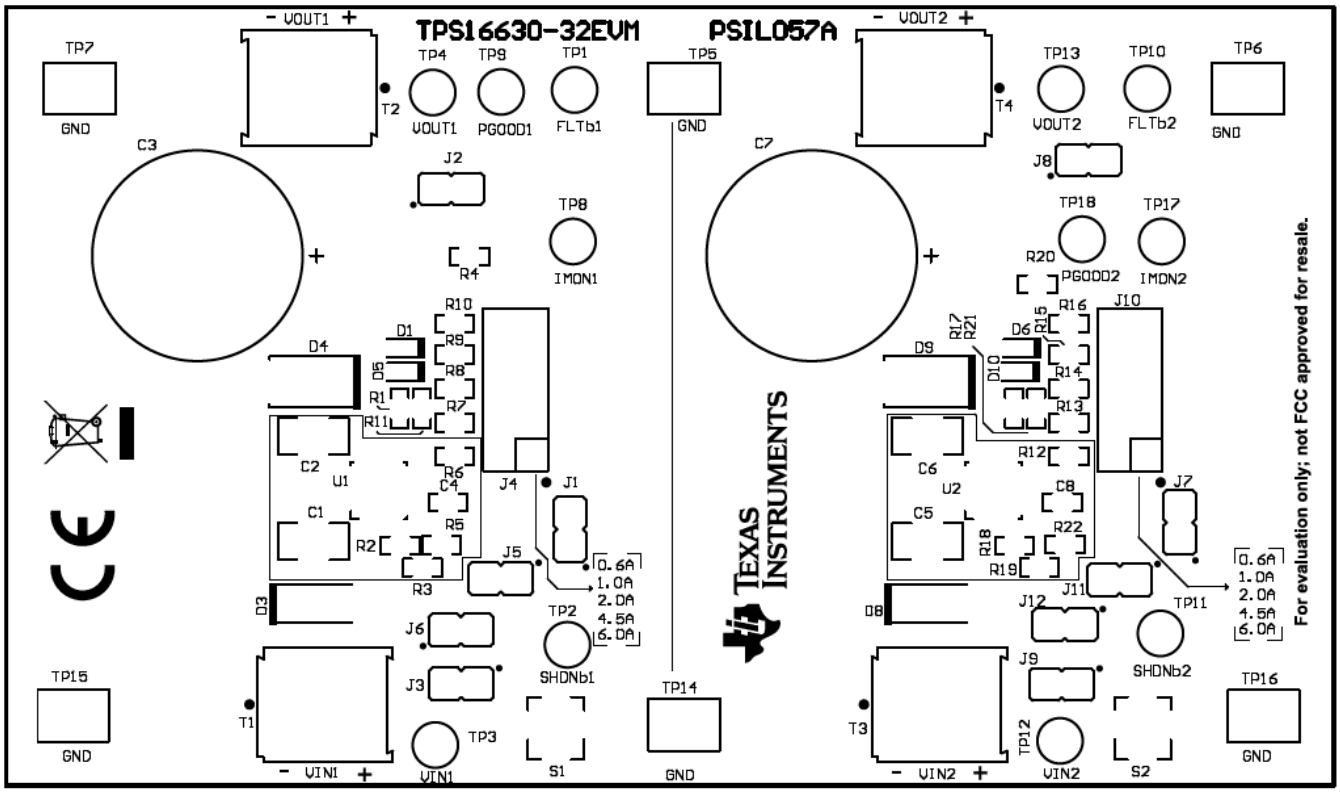


Figure 4. Top Side Placement

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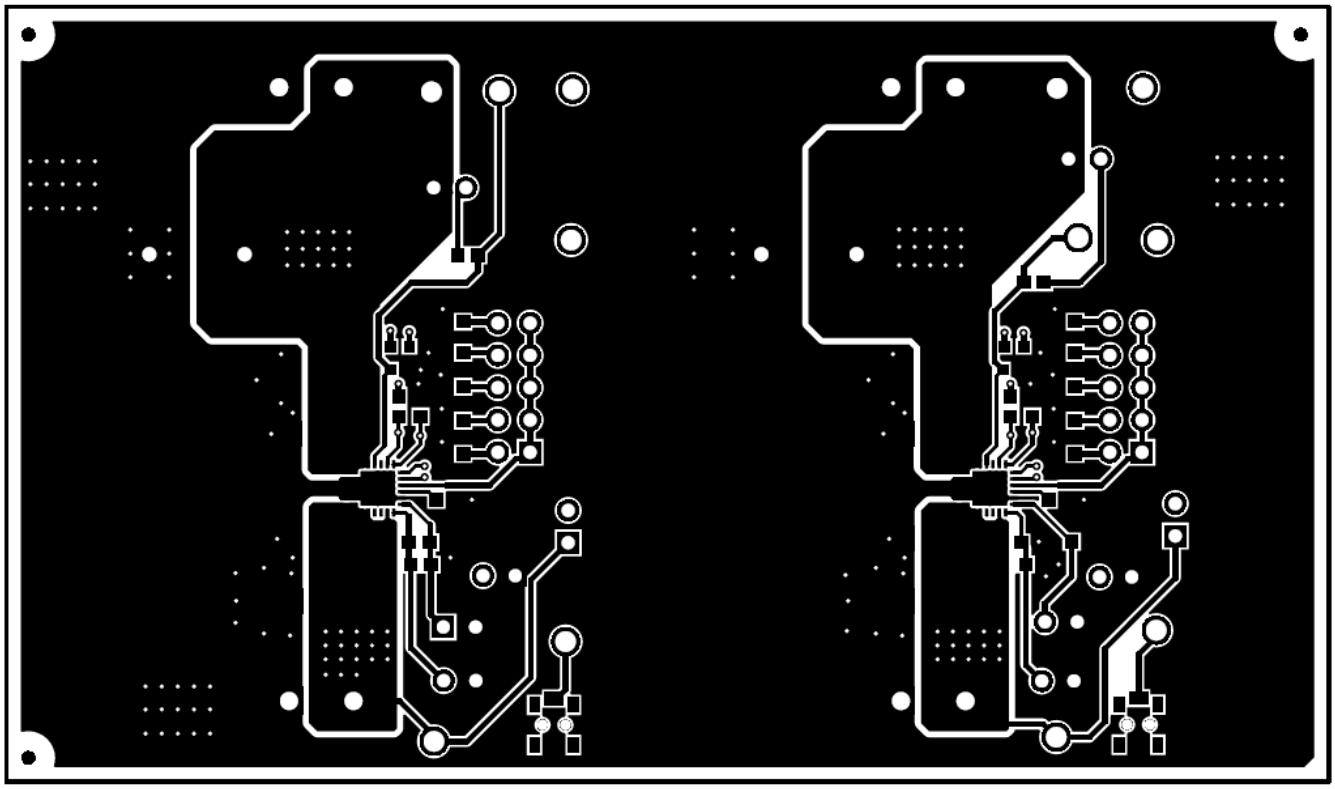


Figure 5. Top Layer

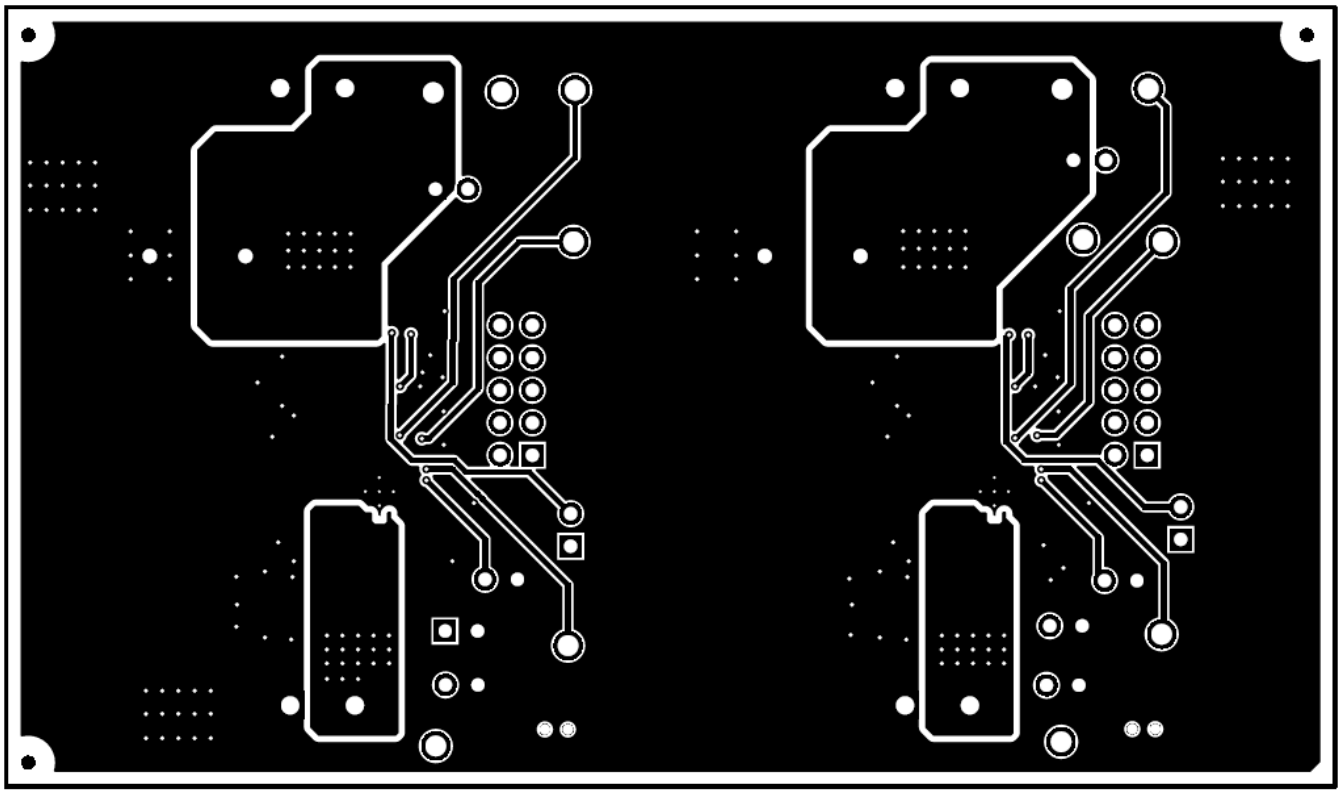


Figure 6. Bottom Layer

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5 Schematics

Figure 7 illustrates the TPS16630-32EVM schematic.

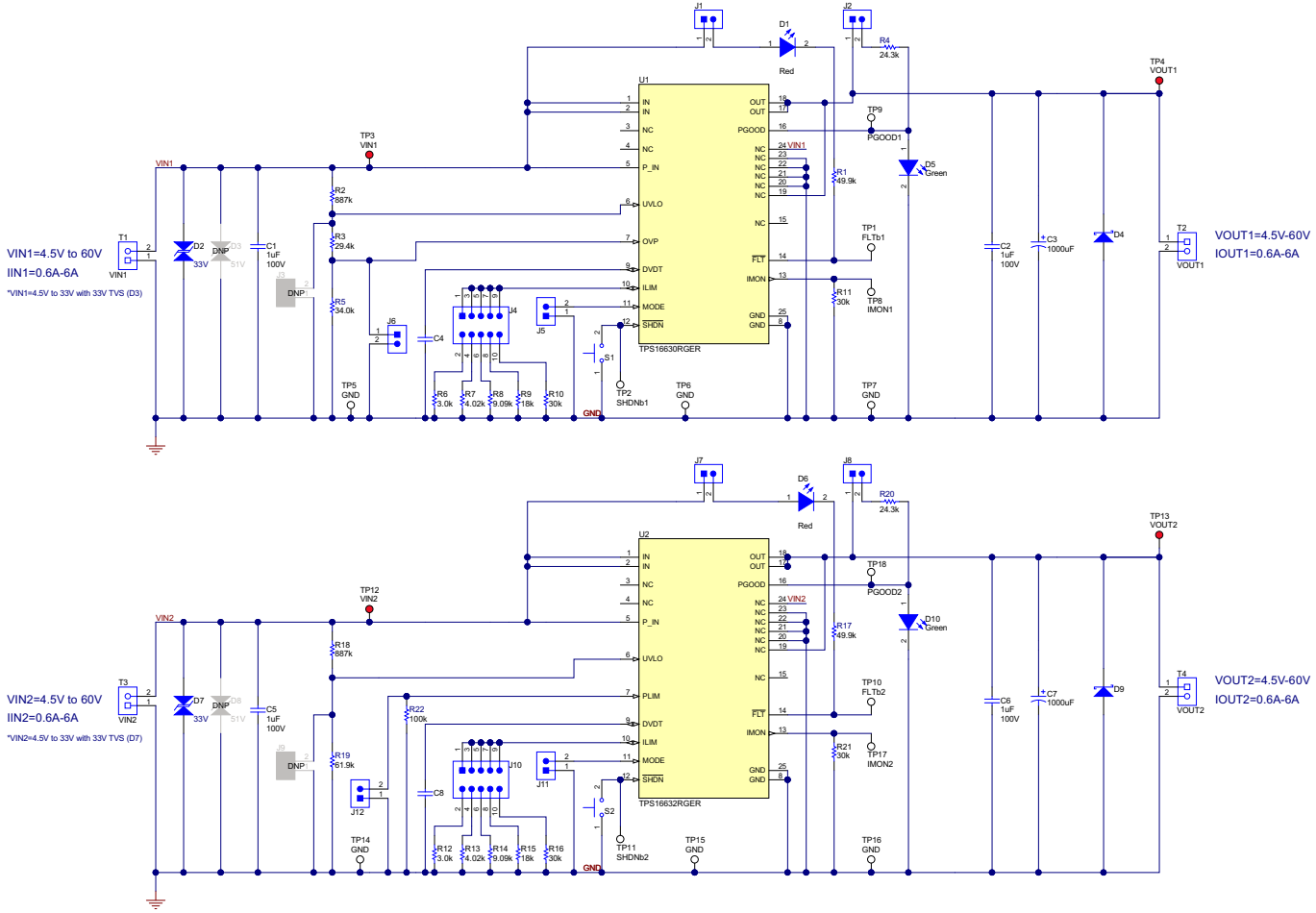


Figure 7. TPS16630-32EVM Schematic

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6 Bill of Materials

Table 12 lists the TPS16630-32EVM BOM.

Table 12. TPS16630-32EVM Bill of Materials

Item#	Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
1	PCB1	1		Printed Circuit Board		PSIL057	Any
2	C1, C2, C5, C6	4	1 uF	CAP, CERM, 1 uF, 100 V, +/- 10%, X7R, 1206	1206	C3216X7R2A105K160AA	TDK
3	C3, C7	2	1000 uF	CAP, AL, 1000 uF, 50 V, +/- 20%, 0.034 ohm, AEC-Q200 Grade 2, TH	D16xL25	EEU-FC1H102	Panasonic
4	C4, C8	2	0.022 uF	CAP, CERM, 0.022 uF, 16 V, +/- 10%, X7R, 0603	0603	C0603C223K4RACTU	Kemet
5	D1, D6	2	Red	LED, Red, SMD	Red LED, 1.6x0.8x0.8mm	LTST-C190CKT	Lite-On
6	D2, D7	2	33 V	Diode, TVS, Bi, 33 V, 53.3 Vc, 1500 W, 200 A, SMC	SMC	SMCJ33CA-13-F	Diodes Inc.
7	D4, D9	2	60 V	Diode, Schottky, 60 V, 2 A, SMB	SMB	B260-13-F	Diodes Inc.
8	D5, D10	2	Green	LED, Green, SMD	1.6x0.8x0.8mm	LTST-C190GKT	Lite-On
9	H1, H2, H3, H4	4		Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon	SJ-5303 (CLEAR)	3M
10	J1, J2, J5, J6, J7, J8, J11, J12	8		Header, 100mil, 2x1, Gold, TH	Sullins 100mil, 1x2, 230 mil above insulator	PBC02SAAN	Sullins Connector Solutions
11	J4, J10	2		Header, 100mil, 5x2, Tin, TH	Header, 5x2, 100mil, Tin	PEC05DAAN	Sullins Connector Solutions
12	R1, R17	2	49.9 k	RES, 49.9 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060349K9FKEA	Vishay-Dale
13	R2, R18	2	887 k	RES, 887 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603887KFKEA	Vishay-Dale
14	R3	1	29.4 k	RES, 29.4 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060329K4FKEA	Vishay-Dale
15	R4, R20	2	24.3 k	RES, 24.3 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060324K3FKEA	Vishay-Dale
16	R5	1	34.0 k	RES, 34.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060334K0FKEA	Vishay-Dale
17	R6, R12	2	3.0 k	RES, 3.0 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06033K00JNEA	Vishay-Dale

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Table 12. TPS16630-32EVM Bill of Materials (continued)

Item#	Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
18	R7, R13	2	4.02 k	RES, 4.02 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06034K02FKEA	Vishay-Dale
19	R8, R14	2	9.09 k	RES, 9.09 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06039K09FKEA	Vishay-Dale
20	R9, R15	2	18 k	RES, 18 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060318K0JNEA	Vishay-Dale
21	R10, R11, R16, R21	4	30 k	RES, 30 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060330K0JNEA	Vishay-Dale
22	R19	1	61.9 k	RES, 61.9 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060361K9FKEA	Vishay-Dale
23	R22	1	100 k	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100KFKEA	Vishay-Dale
24	S1, S2	2		Switch, SPST-NO, Off-Mom, 0.05A, 12VDC, SMD	3.9x2.9mm	PTS820 J20M SMTR LFS	CK Components
25	SH-J1, SH-J2, SH-J4, SH-J7, SH-J8, SH-J10	6	1x2	Shunt, 100mil, Flash Gold, Black	Closed Top 100mil Shunt	SPC02SYAN	Sullins Connector Solutions
26	T1, T2, T3, T4	4		Terminal Block, 2x1, 5.08mm, TH	10.16x15.2x9mm	282841-2	TE Connectivity
27	TP1, TP2, TP8, TP9, TP10, TP11, TP17, TP18	8		Test Point, Multipurpose, White, TH	White Multipurpose Testpoint	5012	Keystone
28	TP3, TP4, TP12, TP13	4		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone
29	TP5, TP6, TP7, TP14, TP15, TP16	6		Test Point, Compact, SMT	Testpoint_Keystone_Compact	5016	Keystone
30	U1	1		60-V, 6-A Power limiting eFuse, RGE0024H (VQFN-24)	RGE0024H	TPS16630RGER	Texas Instruments
31	U2	1		60-V, 6-A Power limiting eFuse, RGE0024H (VQFN-24)	RGE0024H	TPS16632RGER	Texas Instruments
32	D3, D8	0	51 V	Diode, TVS, Bi, 51 V, SMA	SMA	SMAJ51CA	Littelfuse
33	FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
24	J3, J9	0		Header, 100mil, 2x1, Gold, TH	Sullins 100mil, 1x2, 230 mil above insulator	PBC02SAAN	Sullins Connector Solutions

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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。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required 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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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。

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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/lsds/ti_ja/general/eStore/notice_02.page
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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:*

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, INDEMITY 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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