

# TPS51383 and TPS51384 Buck Converter Evaluation Module User's Guide



## ABSTRACT

This user's guide describes the characteristics, operation, and use of the Texas Instruments TPS51383 and TPS51384 evaluation modules (EVM). The TPS51383EVM and TPS51384EVM are designed to help user easily evaluate and test the operation and functionality of the TPS51383 and TPS51384. This user's guide includes the following:

- Setup instructions for the hardware
- Printed-circuit board layouts for the EVM
- Schematic diagram
- Bills of materials
- Test results for the EVM

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### Trademarks

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## 1 Introduction

The TPS51383 and TPS51384 are the single, D-CAP3™ mode, synchronous buck converters requiring a very low external component count. The TPS51383 provides a fixed 3.36-V 8-A maximum output along with a separate 3.3-V, 100-mA maximum LDO. The TPS51384 provides a fixed 1.82-V 8-A maximum output along with a separate 1.8-V, 100-mA maximum LDO. Both support switch-over functionality, specifically designed for a notebook power system. Their integrated low  $R_{DS(ON)}$  power MOSFETs enable high efficiency and offer ease-of-use with a minimal external component count for space-constrained power systems. Features include the following:

- Accurate reference voltage
- Fast load transient response
- Auto-skip mode operation for light load efficiency
- OOA light load operation with > 25-kHz switching frequency
- D-CAP3 control mode with good line, load regulation, and no requirement for external compensation

The TPS51383 and TPS51384 evaluation modules (EVM) are single, synchronous buck converter boards providing 3.36 V or 1.82 V at 8 A from a 4.5-V to 24-V input. This user's guide describes the TPS51383 and TPS51384 EVM performance.

**Table 1-1. Input Voltage and Output Current Summary**

EVM	Input Voltage ( $V_{IN}$ ) Range	Output Current ( $I_{OUT}$ ) Range
TPS51383EVM, TPS51384EVM	4.5 V to 24 V	0 A to 8 A

## 2 Performance Specification Summary

The following tables provide a summary of the TPS51383EVM and TPS51384EVM performance specifications. Specifications are given for an input voltage of 12 V, unless otherwise noted. The ambient temperature is 25°C for all measurement, unless otherwise noted.

**Table 2-1. TPS51383EVM Performance Specifications Summary**

Specifications		Test Conditions	MIN	TYP	MAX	Unit
$V_{IN}$	Input voltage		4.5	12	24	V
Buck	Output voltage			3.36		V
	Operating frequency	$V_{IN} = 12\text{ V}, I_{OUT} = 8\text{ A}$		600		kHz
	Output current range		0		8	A
	Over current limit (IL valley)	$V_{IN} = 12\text{ V}, L_{OUT} = 1.5\text{ }\mu\text{H}$		11		A
	Output ripple voltage	$V_{IN} = 12\text{ V}, I_{OUT} = 8\text{ A}$			20	mV <sub>PP</sub>
LDO	Output voltage			3.3		V

**Table 2-2. TPS51384EVM Performance Specifications Summary**

Specifications		Test Conditions	MIN	TYP	MAX	Unit
$V_{IN}$	Input voltage		4.5	12	24	V
Buck	Output voltage			1.82		V
	Operating frequency	$V_{IN} = 12\text{ V}, I_{OUT} = 8\text{ A}$		600		kHz
	Output current range		0		8	A
	Over current limit (IL Valley)	$V_{IN} = 12\text{ V}, L_{OUT} = 1\text{ }\mu\text{H}$		11		A
	Output ripple voltage	$V_{IN} = 12\text{ V}, I_{OUT} = 8\text{ A}$			20	mV <sub>PP</sub>
LDO	Output voltage			1.8		V

## 3 External Components

The TPS51383 and TPS51384 are fixed output devices. Users do not need to add feedback resistors, which saves the BOM costs and solution size. Regarding external components selection, users can refer to the following table for some recommendation values.

**Table 3-1. Recommended Component Values**

V <sub>OUT</sub> (V)	L <sub>OUT</sub> (μH)	C <sub>OUT</sub> (μF)		C <sub>FF</sub> (PF)
	TYP	MIN	MAX	
3.36 (TPS51383)	1.5	44	220	22
1.82 (TPS51384)	1	44	220	NA

## 4 Test Setup and Results

This section describes how to properly connect, set up, and use the TPS51383EVM and TPS51384EVM. The section also includes test results typical for the evaluation modules.

### 4.1 Input and Output Connections

The TPS51383EVM and TPS51384EVM are provided with input and output connectors and test points as shown in the following table. A power supply capable of supplying 8 A must be connected to J1 through a pair of 20AWG wires. The load must be connected to J2 through a pair of 20AWG wires. The maximum load current capability is 8 A. Wire lengths must be minimized to reduce losses in the wires. Test point TP2 provides a place to monitor the V<sub>IN</sub> input voltages with TP9 providing a convenient ground reference. TP5 is used to monitor the output voltage with TP12 as the ground reference.

**Table 4-1. Connection and Test Points**

Reference Designator	Function
J1	V <sub>IN</sub>
J2	V <sub>OUT</sub> , 3.36 V (TPS51383) or 1.82 V (TPS51384) at 8-A maximum
JP1	PG pullup control. Short pin 1 and pin 2 to pull PG up to VCC. Short pin 2 and pin 3 to pull PG up to VOUT.
JP2	EN high control. Short pin 1 and pin 2 to connect V <sub>IN</sub> to pin 1 of JP3.
JP3	EN control. Short pin 1 and pin 2 as well as short pin 1 and pin 2 of JP2 to make EN high.
JP4	Mode control. Float or short pin 2 and pin 3 to set PSM mode. Short pin 2 and pin 1 to set OOA mode.
TP1	V <sub>IN</sub> positive monitor point
TP2	V <sub>IN</sub> positive test point
TP3	Switch node test point
TP4	V <sub>OUT</sub> positive monitor point
TP5	V <sub>OUT</sub> positive test point
TP6	EN test point
TP7	PG test point
TP8	GND monitor point
TP9	GND test point
TP10	GND monitor point
TP11	Loop test point (need to disable LDO for loop measurement )
TP12	GND test point
TP13	LDO output monitor point
TP14	LDO output test point
TP15	VCC test point
TP16	GND test point
TP17	GND test point
TP18	GND test point
TP19	GND monitor point

## 4.2 Start-Up Procedure

1. Ensure that the jumper at JP2 (Enable High Control) is covered to connect  $V_{IN}$  to pin 1 of JP3. Also ensure JP3 (Enable Control) pin 2 and 3 are covered to shunt EN to GND to disable the output.
2. Apply appropriate input voltage to VIN (J1-1) or TP1 and GND (J1-2) or TP8. Note that the board cannot support hot plug-in. The input lines must be connected between J1 and external power source first before turning on the power source.
3. Move the jumper at JP3 (Enable Control) from pin 2 and 3 (EN and OFF) to pin 2 and 1 (EN and ON). Make sure JP3 pin 1 and pin 2 are covered, then the output can be enabled.
4. Apply the loading to VOUT (J2-2) or TP4 and GND (J2-1) or TP10.

### 4.3 Start-Up

The following images show the TPS51383EVM and TPS51384EVM start-up waveforms relative to EN.

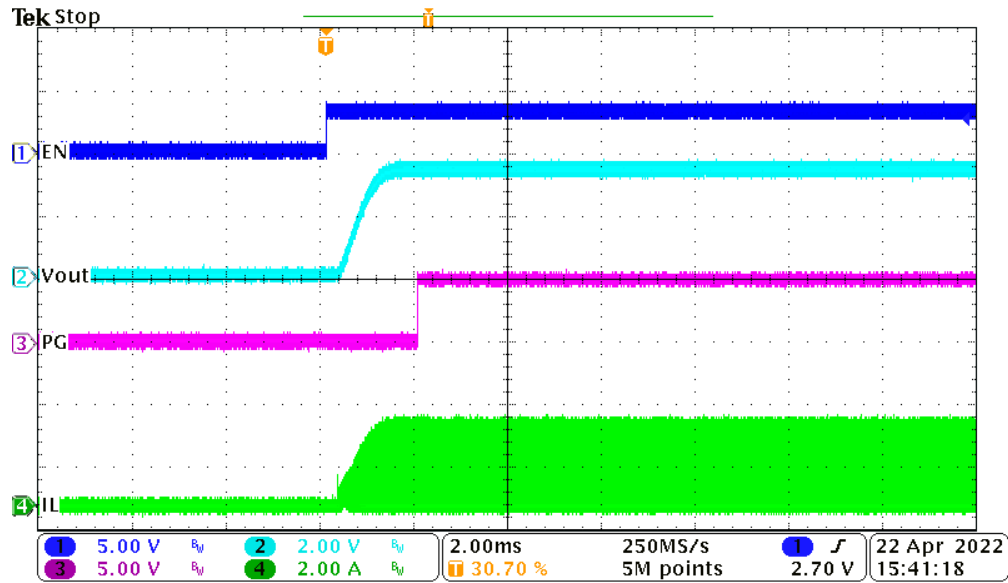


Figure 4-1. TPS51383EVM Start-Up Relative to EN,  $I_{OUT} = 0.1$  A

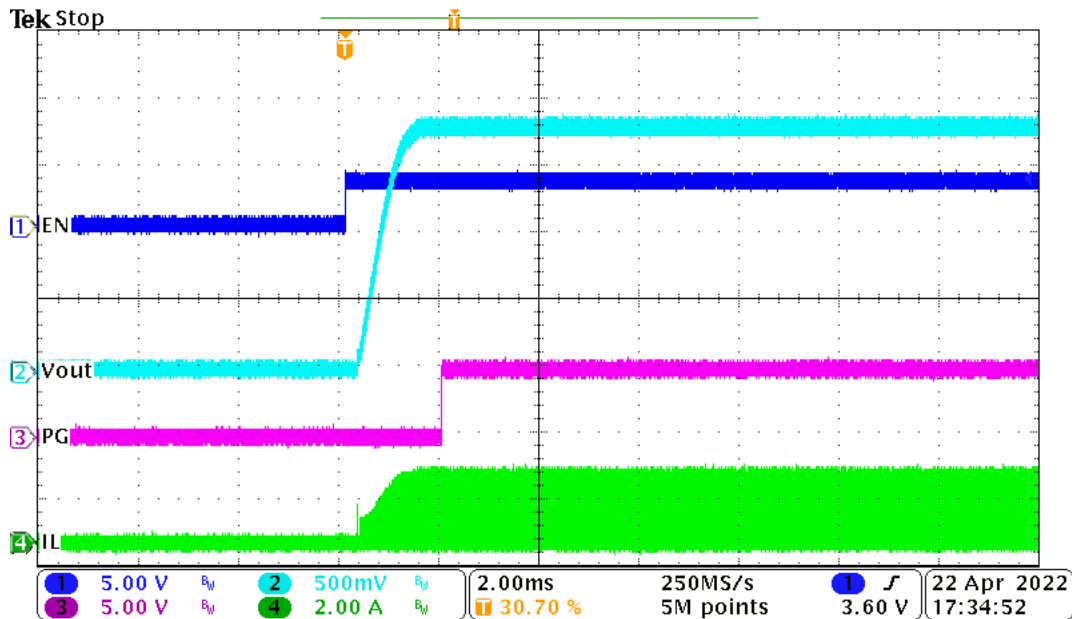


Figure 4-2. TPS51384EVM Start-Up Relative to EN,  $I_{OUT} = 0.1$  A

### 4.4 Shutdown

The following images show the TPS51383EVM and TPS51384EVM shutdown waveforms relative to EN.

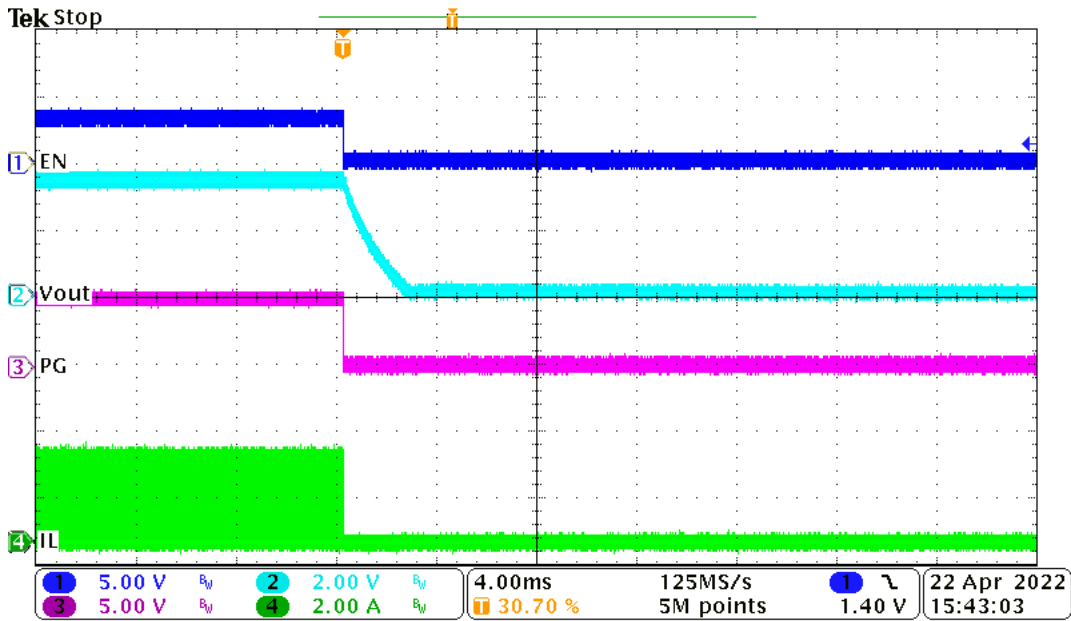


Figure 4-3. TPS51383EVM Shutdown Relative to EN,  $I_{OUT} = 0.1$  A

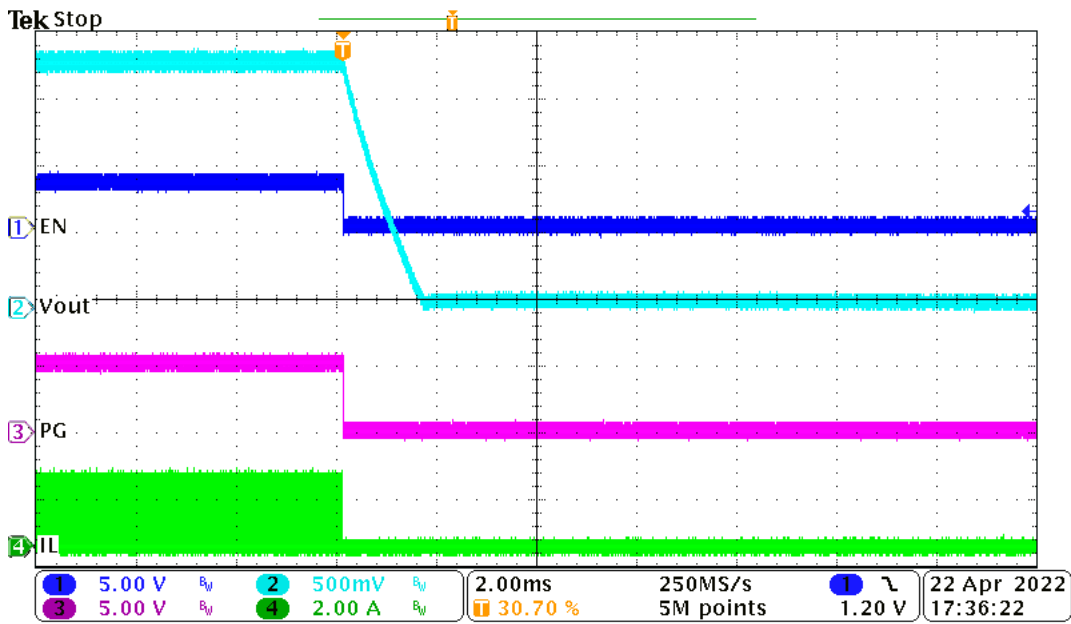


Figure 4-4. TPS51384EVM Shutdown Relative to EN,  $I_{OUT} = 0.1$  A

## 4.5 Output voltage ripple

The following images show the TPS51383EVM output voltage ripple.

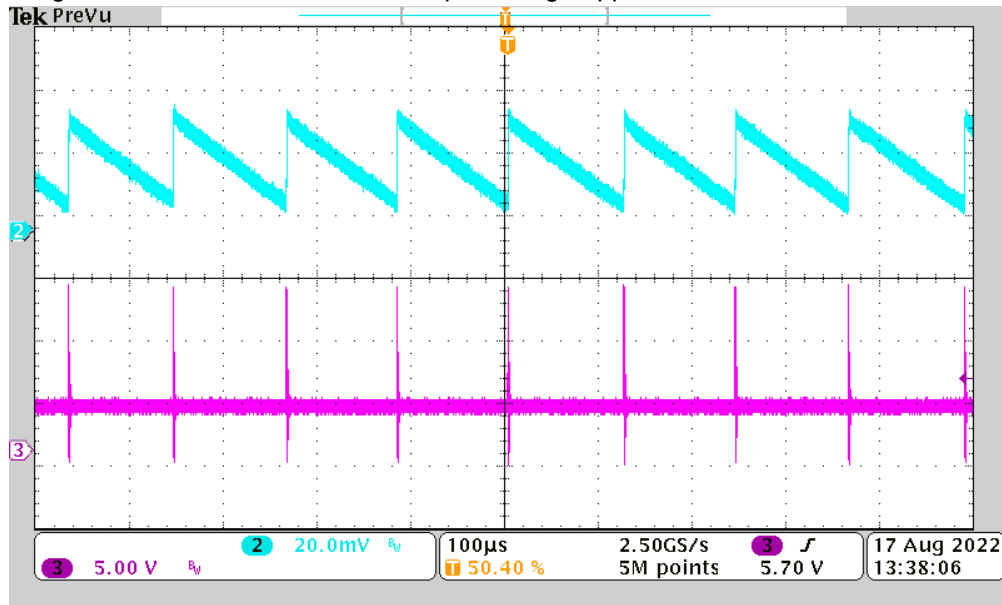


Figure 4-5. TPS51383EVM Output Voltage Ripple,  $I_{OUT} = 10\text{ mA}$ , PSM Mode

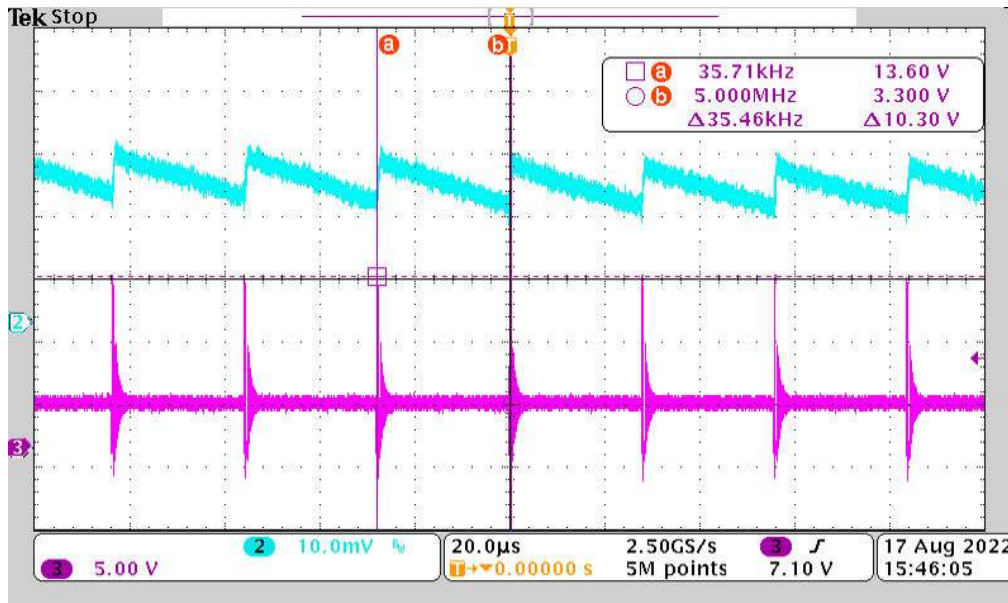


Figure 4-6. TPS51383EVM Output Voltage Ripple,  $I_{OUT} = 10\text{ mA}$ , OOA Mode



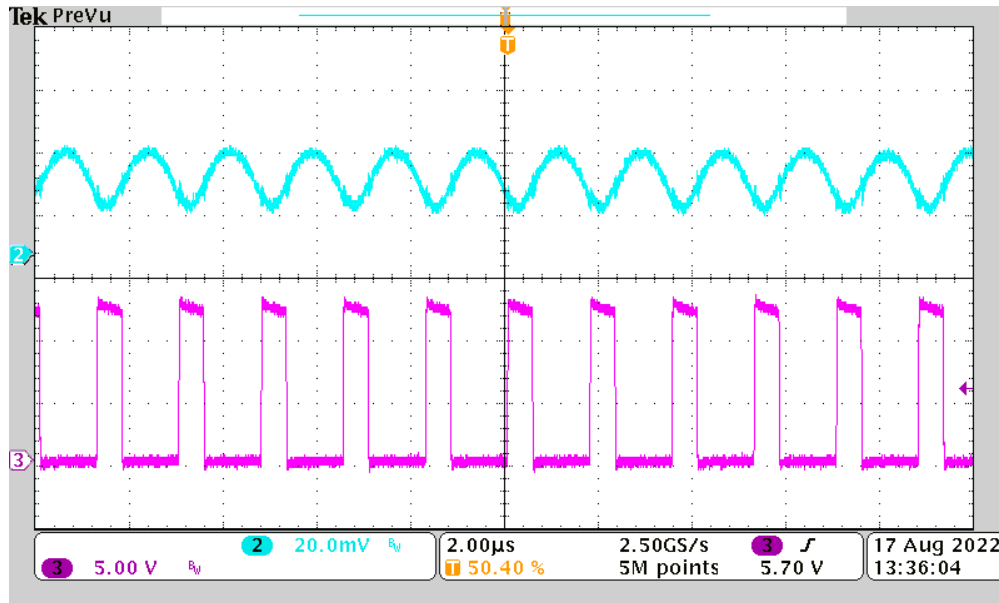


Figure 4-7. TPS51383EVM Output Voltage Ripple,  $I_{OUT} = 8 \text{ A}$

## 5 Board Layout

This section provides a description of the TPS51383 and TPS51384 EVM, board layout, and layer illustrations.

### 5.1 Layout

The following images show the board layout for the TPS51383EVM and TPS51384EVM. The TPS51383EVM and TPS51384EVM have four layers. The top layer contains the main power traces for VIN, VOUT, and GND. Also on the top layer are connections for the pins of the TPS51383EVM and TPS51384EVM and a large area filled with ground. Most of the signal traces are also located on the top side. The input decoupling capacitors, C3, C4, C5, and C6 are located as close to VIN pins and PGND pins of the IC as possible. The input and output connectors, test points, and all of the components are located on the top side. The bottom layer is a ground plane along with signal ground copper fill and the feedback trace from the point of regulation to the top of the resistor divider network. Two inner layers are ground plane.

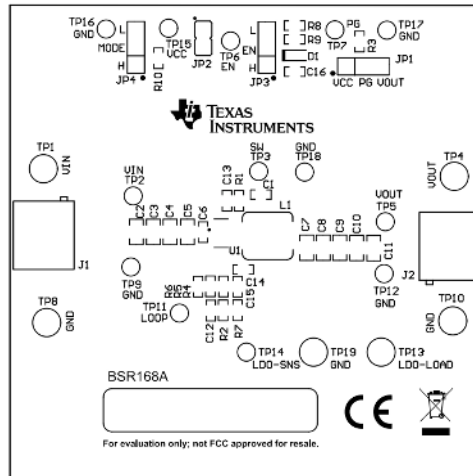


Figure 5-1. TPS51383 and TPS51384 EVM Top Assembly

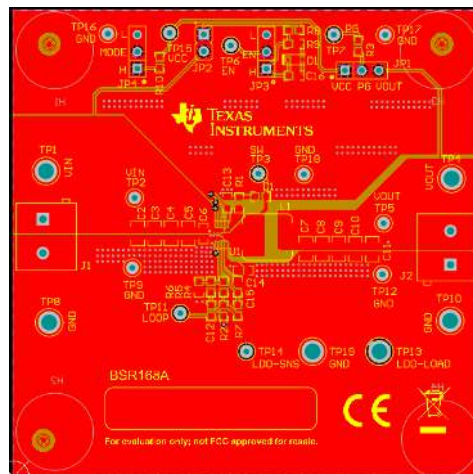
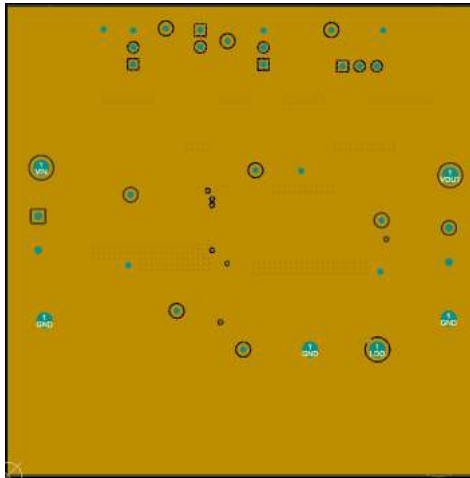
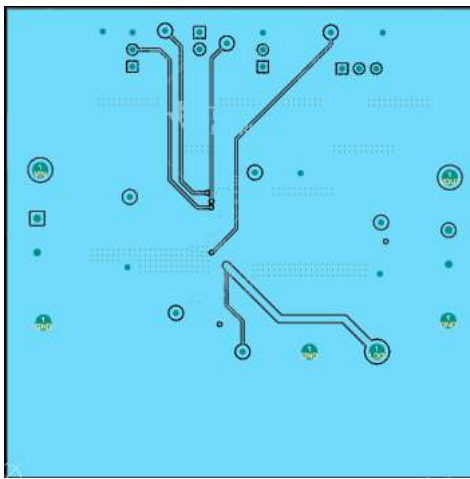


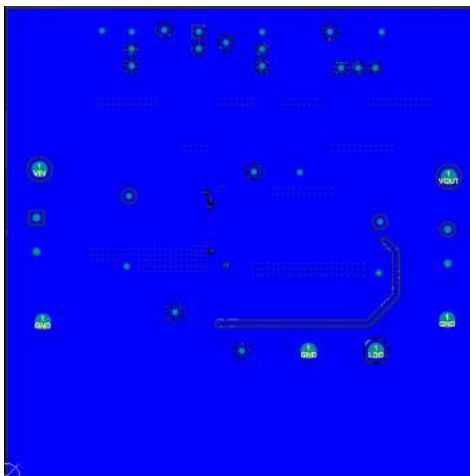
Figure 5-2. TPS51383 and TPS51384 EVM Top Layer



**Figure 5-3. TPS51383 and TPS51384 EVM Inner1 Layer**



**Figure 5-4. TPS51383 and TPS51384 EVM Inner2 Layer**

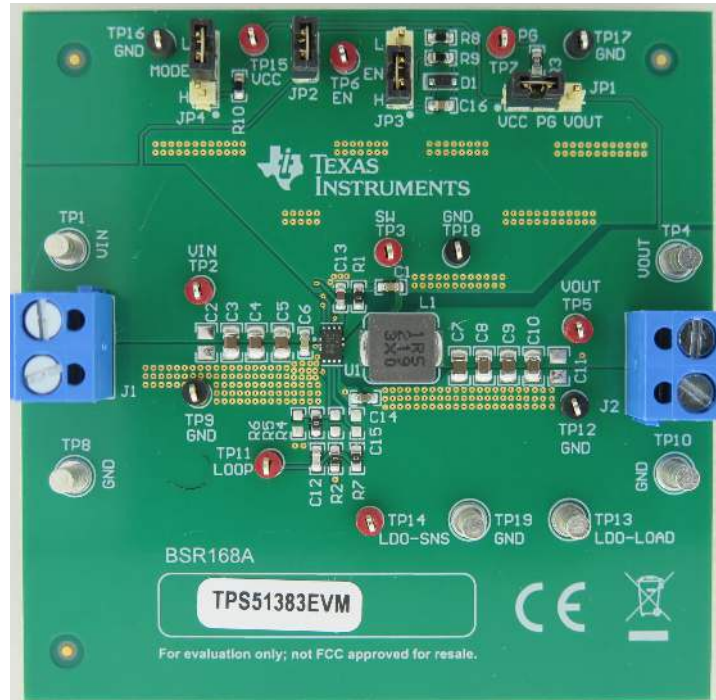


**Figure 5-5. TPS51383 and TPS51384 EVM Bottom Layer**

## 6 Board Profile, Schematic, List of Materials, and Reference

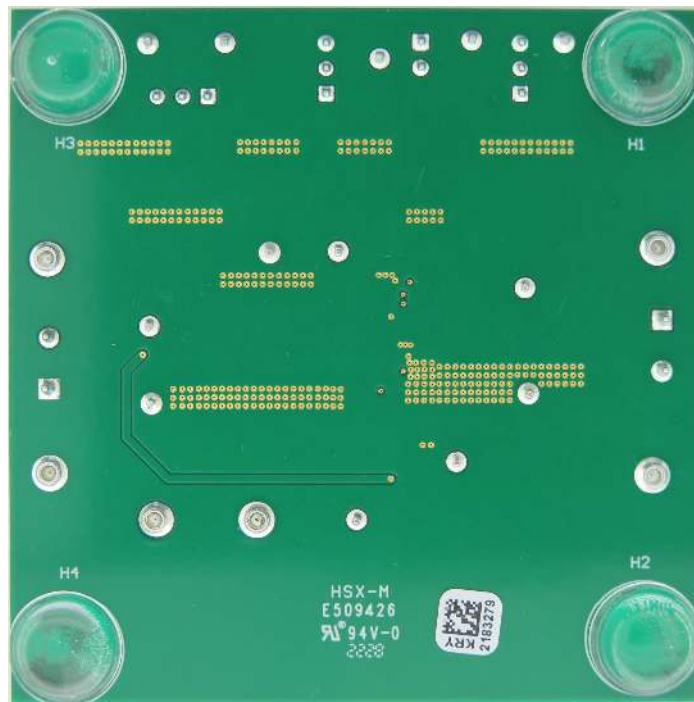
### 6.1 Board Profile

The following image shows the top view for the TPS51383EVM.



**Figure 6-1. Top View of TPS51383EVM**

The following image shows the bottom view for the TPS51383EVM.



**Figure 6-2. Bottom View of TPS51383EVM**

## 6.2 Schematic

Figure 6-3 and Figure 6-4 are the schematics for the TPS51383EVM and TPS51384EVM.

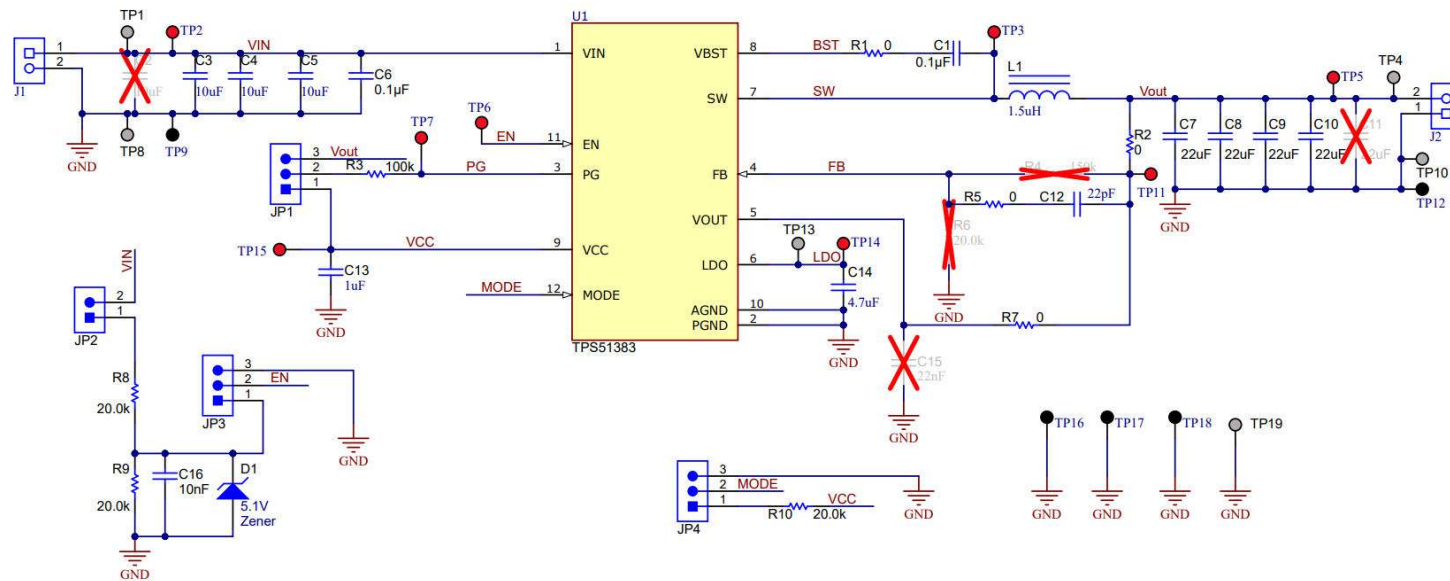


Figure 6-3. TPS51383EVM Schematic Diagram

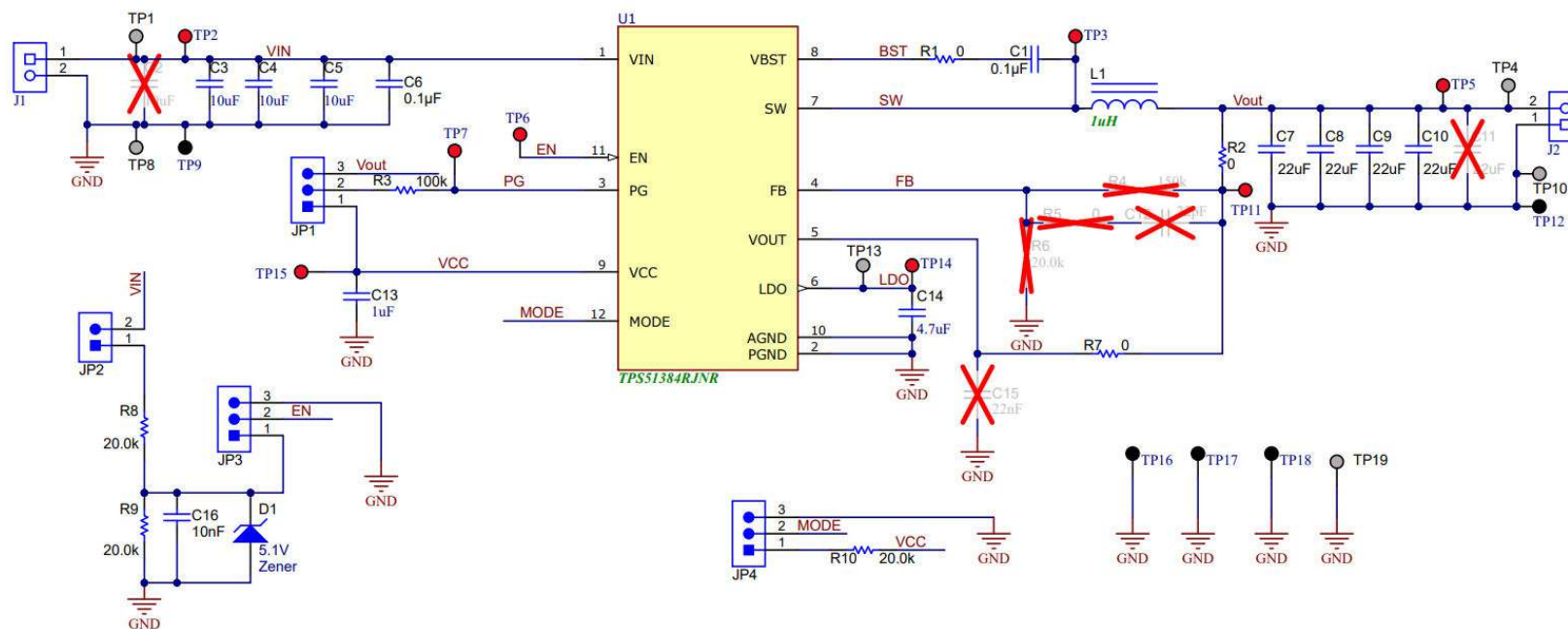


Figure 6-4. TPS51384EVM Schematic Diagram

## 6.3 List of Materials

The following tables display the TPS51383EVM and TPS51384EVM list of materials.

**Table 6-1. TPS51383EVM List of Materials**

Designator	Qty	Description	Part Number	Manufacturer
IPCB1	1	Printed Circuit Board	BSR168	Any
C1, C6	2	CAP, CERM, 0.1 $\mu$ F, 25 V, $\pm$ 10%, X5R, 0603	CL10A104KA8NUNC	Samsung Electro-Mechanics
C3, C4, C5	3	CAP, CERM, 10 $\mu$ F, 35 V, $\pm$ 10%, X5R, 0805	GRM21BR6YA106KE43L	MuRata
C7, C8, C9, C10	4	CAP, CERM, 22 $\mu$ F, 10 V, $\pm$ 20%, X5R, 0805	GRM21BR61A226ME44L	MuRata
C12	1	CAP, CERM, 22 $\mu$ F, 50 V, $\pm$ 5%, C0G/NP0, 0603	C0603C220J5GACTU	Kemet
C13	1	CAP, CERM, 1 $\mu$ F, 10 V, $\pm$ 10%, X5R, 0603	C0603C105K8PACTU	Kemet
C14	1	CAP, CERM, 4.7 $\mu$ F, 6.3 V, $\pm$ 10%, X5R, 0603	C0603C475K9PACTU	Kemet
C16	1	CAP, CERM, 0.01 $\mu$ F, 16 V, $\pm$ 10%, X7R, 0603	C0603C103K4RACTU	Kemet
D1	1	Diode, Zener, 5.1 V, 200 mW, SOD-323	MMS5231BS-7-F	Diodes Inc.
H1, H2, H3, H4	4	Bumpon, Hemisphere, 0.44 $\times$ 0.20, Clear	SJ-5303 (CLEAR)	3M
J1, J2	2	Terminal Block, 5.08 mm, 2 $\times$ 1, Brass, TH	ED120/2DS	On-Shore Technology
JP1, JP3, JP4	3	Header, 100 mil, 3 $\times$ 1, Tin, TH	PEC03SAAN	Sullins Connector Solutions
JP2	1	Header, 100mil, 2 $\times$ 1, Gold, TH	PBC02SAAN	Sullins Connector Solutions
L1	1	Inductor, 1.5 $\mu$ H, 11 A, 0.0089 $\Omega$ , SMD	CMLE063T-1R5MS	Cyntec
LBL1	1	Thermal Transfer Printable Labels, 1.250" W $\times$ 0.250" H – 10,000 per roll	THT-13-457-10	Brady
R1, R2, R5, R7	4	RES, 0, 5%, 0.1 W, 0603	RC0603JR-070RL	Yageo
R3	1	RES, 100 k, 5%, 0.1 W, 0603	CRCW0603100KJNEAC	Vishay-Dale
R8, R9, R10	3	RES, 20.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060320K0FKEA	Vishay-Dale
SH-JP1, SH-JP2, SH-JP3, SH-JP4	4	Shunt, 100 mil, Gold plated, Black	SNT-100-BK-G	Samtec
TP1, TP4, TP8, TP10, TP13, TP19	6	Terminal, Turret, TH, Triple	1598-2	Keystone
TP2, TP3, TP5, TP6, TP7, TP11, TP14, TP15	8	Test Point, Miniature, Red, TH	5000	Keystone
TP9, TP12, TP16, TP17, TP18	5	Test Point, Miniature, Black, TH	5001	Keystone
U1	1	4.5-V to 24-V Input, 3.36-V Output, 8-A Synchronous Buck Converters With 100-mA LDO	TPS51383	Texas Instruments
C2	0	CAP, CERM, 10 $\mu$ F, 35 V, $\pm$ 10%, X5R, 0805	GRM21BR6YA106KE43L	MuRata
C11	0	CAP, CERM, 22 $\mu$ F, 10 V, $\pm$ 20%, X5R, 0805	GRM21BR61A226ME44L	MuRata
C15	0	CAP, CERM, 0.022 $\mu$ F, 25 V, $\pm$ 10%, X7R, 0603	C0603C223K3RACTU	Kemet
R4	0	RES, 150 k, 1%, 0.1 W, 0603	RC0603FR-07150KL	Yageo
R6	0	RES, 20.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	ERJ-3EKF2002V	Panasonic

**Table 6-2. TPS51384EVM List of Materials**

Designator	Qty	Description	Part Number	Manufacturer
IPCB1	1	Printed Circuit Board	BSR168	Any
C1, C6	2	CAP, CERM, 0.1 $\mu$ F, 25 V, $\pm$ 10%, X5R, 0603	CL10A104KA8NUNC	Samsung Electro-Mechanics
C3, C4, C5	3	CAP, CERM, 10 $\mu$ F, 35 V, $\pm$ 10%, X5R, 0805	GRM21BR6YA106KE43L	MuRata
C7, C8, C9, C10	4	CAP, CERM, 22 $\mu$ F, 10 V, $\pm$ 20%, X5R, 0805	GRM21BR61A226ME44L	MuRata
C13	1	CAP, CERM, 1 $\mu$ F, 10 V, $\pm$ 10%, X5R, 0603	C0603C105K8PACTU	Kemet
C14	1	CAP, CERM, 4.7 $\mu$ F, 6.3 V, $\pm$ 10%, X5R, 0603	C0603C475K9PACTU	Kemet
C16	1	CAP, CERM, 0.01 $\mu$ F, 16 V, $\pm$ 10%, X7R, 0603	C0603C103K4RACTU	Kemet
D1	1	Diode, Zener, 5.1 V, 200 mW, SOD-323	MMS5231BS-7-F	Diodes Inc.
H1, H2, H3, H4	4	Bumpon, Hemisphere, 0.44 $\times$ 0.20, Clear	SJ-5303 (CLEAR)	3M
J1, J2	2	Terminal Block, 5.08 mm, 2 $\times$ 1, Brass, TH	ED120/2DS	On-Shore Technology
JP1, JP3, JP4	3	Header, 100 mil, 3 $\times$ 1, Tin, TH	PEC03SAAN	Sullins Connector Solutions
JP2	1	Header, 100 mil, 2 $\times$ 1, Gold, TH	PBC02SAAN	Sullins Connector Solutions
L1	1	Inductor, 1 $\mu$ H, 14.4 A, 0.0064 $\Omega$ , SMD	CMLE063T-1R0MS	Cyntec
LBL1	1	Thermal Transfer Printable Labels, 1.250" W $\times$ 0.250" H – 10,000 per roll	THT-13-457-10	Brady
R1, R2, R7	3	RES, 0, 5%, 0.1 W, 0603	RC0603JR-070RL	Yageo
R3	1	RES, 100 k, 5%, 0.1 W, 0603	CRCW0603100KJNEAC	Vishay-Dale
R8, R9, R10	3	RES, 20.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060320K0FKEA	Vishay-Dale
SH-JP1, SH-JP2, SH-JP3, SH-JP4	4	Shunt, 100 mil, Gold plated, Black	SNT-100-BK-G	Samtec

**Table 6-2. TPS51384EVM List of Materials (continued)**

Designator	Qty	Description	Part Number	Manufacturer
TP1, TP4, TP8, TP10, TP13, TP19	6	Terminal, Turret, TH, Triple	1598-2	Keystone
TP2, TP3, TP5, TP6, TP7, TP11, TP14, TP15	8	Test Point, Miniature, Red, TH	5000	Keystone
TP9, TP12, TP16, TP17, TP18	5	Test Point, Miniature, Black, TH	5001	Keystone
U1	1	4.5-V to 24-V Input, 1.82-V Output, 8-A Synchronous Buck Converters With 100-mA LDO	TPS51384RJNR	Texas Instruments
C2	0	CAP, CERM, 10 $\mu$ F, 35 V, $\pm$ 10%, X5R, 0805	GRM21BR6YA106KE43L	MuRata
C11	0	CAP, CERM, 22 $\mu$ F, 10 V, $\pm$ 20%, X5R, 0805	GRM21BR61A226ME44L	MuRata
C12	0	CAP, CERM, 22 pF, 50 V, $\pm$ 5%, C0G/NP0, 0603	C0603C220J5GACTU	Kemet
C15	0	CAP, CERM, 0.022 $\mu$ F, 25 V, $\pm$ 10%, X7R, 0603	C0603C223K3RACTU	Kemet
R4	0	RES, 150 k, 1%, 0.1 W, 0603	RC0603FR-07150KL	Yageo
R5	0	RES, 0, 5%, 0.1 W, 0603	RC0603JR-070RL	Yageo
R6	0	RES, 20.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	ERJ-3EKF2002V	Panasonic

## 6.4 Reference

- Texas Instruments, [TPS51383 and TPS51384 4.5-V to 24-V Input, 8-A Synchronous Buck Converter With 100-mA LDO](#) data sheet

## 7 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 (August 2022)	Page
• Changed output voltage ripple from 30 mV <sub>PP</sub> to 20 mV <sub>PP</sub> in <a href="#">Table 2-1</a> .....	3
• Added <a href="#">Section 4.5</a> .....	8
• Changed board labels from BSR168E1 to BSR168A in <a href="#">Figure 5-1</a> and <a href="#">Figure 5-2</a> .....	10
• Changed <a href="#">Figure 6-1</a> and <a href="#">Figure 6-2</a> from E1 version board images to A-version board images.....	12



## 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](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。  
[http://www.tij.co.jp/lstds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/lstds/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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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](http://www.tij.co.jp/lstds/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.

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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.

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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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