

**ABSTRACT**

This user's guide contains information for the TPS62932 as well as support documentation for the TPS62932 evaluation module. This document includes the following information for the TPS62932EVM:

- Performance specifications
- Board layout
- Schematic
- List of materials

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1 Introduction

The TPS62932 is a high efficiency, easy-to-use synchronous buck converter. With the wide input voltage range of 3.8 V to 30 V, it is ideally suited for systems powered from 5-V, 12-V, 19-V, 24-V power-bus rails. The device supports up to 2-A continuous output current, 0.8-V to 22-V output voltage, and maximum 98% duty cycle operation. The device employs fixed frequency peak current control mode for fast transient response and good line and load regulation. The optimized internal loop compensation eliminates the external compensation components over a wide range of output voltage and operation frequency. Pulse frequency modulation (PFM) mode maximizes the light load efficiency. The ULQ™ DC/DC converters (Ultra Low Quiescent) feature is extremely beneficial for long battery life time in low power operation. The switching frequency can be set by configuring the RT pin in the range of 200 kHz to 2.2 MHz, allowing the user to optimize system efficiency, filtering size, and bandwidth.

The TPS62932EVM evaluation module (EVM) is a single, synchronous buck converter providing 5 V at 2 A from a 5.1-V to 30-V input. This user's guide describes the TPS62932EVM performance. The following table provides the rated input voltage and output current ranges for the evaluation module.

Table 1-1. Input Voltage and Output Current Summary

EVM	Input Voltage Range	Output Current Range
TPS62932EVM	$V_{IN} = 5.1 \text{ V to } 30 \text{ V}$	0 A to 2 A

2 Performance Specification Summary

The following table provides a summary of the TPS62932EVM performance specifications. Specifications are given for an input voltage of $V_{IN} = 24 \text{ V}$ and an output voltage of 5 V, unless otherwise noted. The ambient temperature is 25°C for all measurement, unless otherwise noted.

Table 2-1. Performance Specifications Summary

Specifications	Test Conditions	Min	Typ	Max	Unit
Input voltage range		5.1	24	30	V
Output voltage set point			5		V
Operating frequency	$V_{IN} = 24 \text{ V}, I_O = 2 \text{ A}$		500		kHz
Output current range		0		2	A
Over current limit	$V_{IN} = 24 \text{ V}, L_O = 10 \mu\text{H}$		5		A
Output ripple voltage	$V_{IN} = 24 \text{ V}, I_O = 2 \text{ A}$		20		mV _{pp}

3 Modifications

These evaluation modules are designed to provide access to the features of the TPS62932. Some modifications can be made to this module.

3.1 Output Voltage Setpoint

To change the output voltage of the EVMs, change the value of resistor R_4 . Changing the value of R_4 can change the output voltage. The value of R_4 for a specific output voltage can be calculated using the following equation.

$$R_4 = \frac{R_5 \times (V_{out} - 0.8)}{0.8} \quad (1)$$

4 Test Setup and Results

This section describes how to properly connect, set up, and use the TPS62932EVM. The section also includes test results typical for the evaluation modules and the following:

- Efficiency
- Output load regulation
- Output line regulation
- Load transient response
- Output voltage ripple
- Input voltage ripple
- Start-up
- Shutdown

4.1 Input and Output Connections

The TPS62932EVM is provided with input and output connectors and test points as shown in [Table 4-1](#). [Figure 4-1](#) shows connectors and jumpers placement on TPS62932EVM board.

A power supply capable of supplying 2 A must be connected to J2 through a pair of 20-AWG wires. The load must be connected to J1 through a pair of 20-AWG wires. The maximum load current capability is 2 A. Wire lengths must be minimized to reduce losses in the wires. Test point TP3 provides a place to monitor the V_{IN} input voltages with TP7 providing a convenient ground reference. TP1 is used to monitor the output voltage with TP9 as the ground reference.

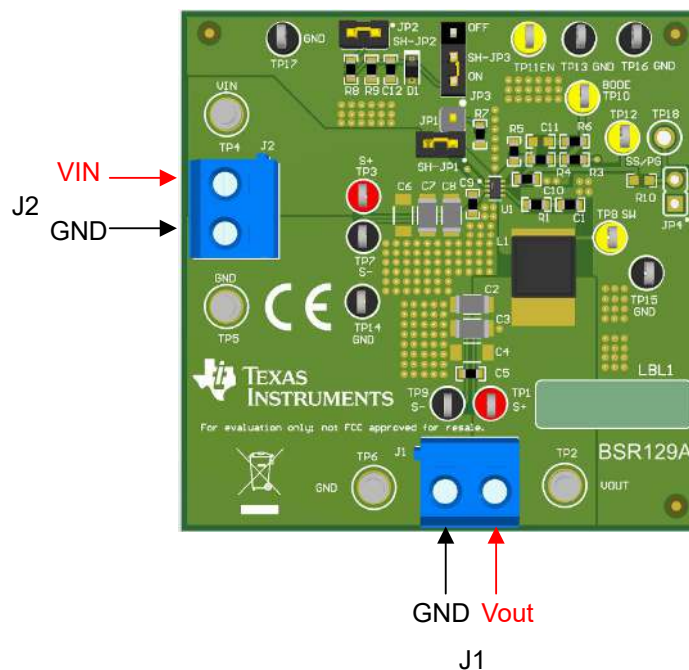


Figure 4-1. TPS62932EVM Connectors and Jumpers Placement

Table 4-1. Connection and Test Points

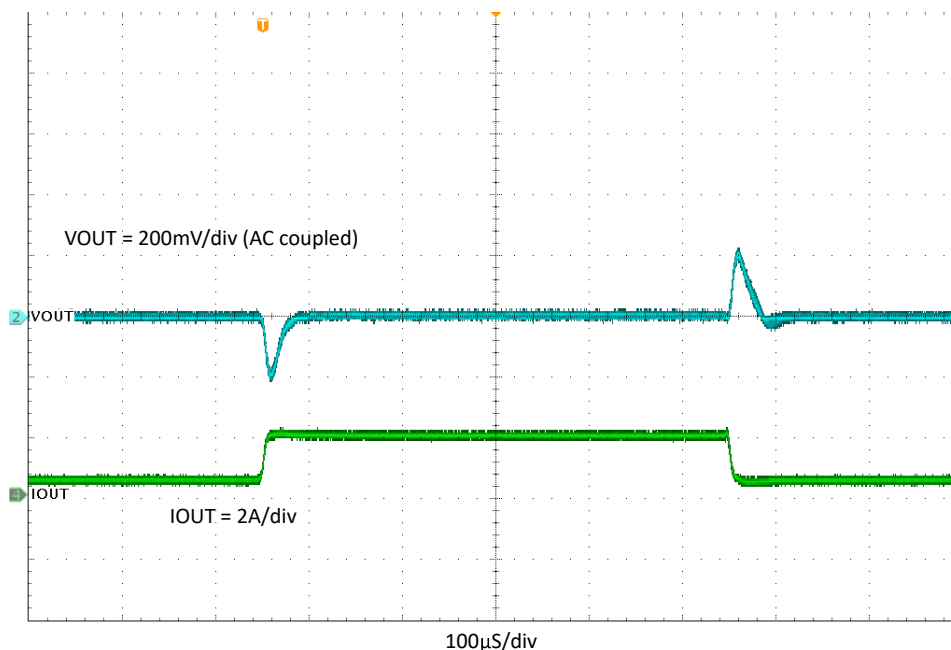
Reference Designator	Function
J1	V_{OUT} , 5 V at 2-A maximum
J2	V_{IN} (see Table 1-1 for V_{IN} range)
JP1	Different frequency choice by changing the state of the RT pin
JP2	V_{IN} divider
JP3	EN control. Shunt EN to GND to disable.
JP4	PG or SS version choice
TP1	V_{OUT} positive monitor point
TP2	V_{OUT} positive power point
TP3	V_{IN} positive monitor point
TP4	V_{IN} positive power point
TP5, TP6	GND power point
TP7, TP9, TP13, TP14, TP15, TP16, TP17	GND monitor point
TP8	Switch node test point
TP10	Test point for loop response measurements
TP11	EN test point
TP12	SS test point
TP18	PGOOD test point

4.2 Start-Up Procedure

1. Ensure that the jumper at JP3 (Enable control) pins 2 and 3 are covered to shunt EN to GND, disabling the output.
2. Apply appropriate V_{IN} voltage to VIN (J2-1) and GND (J2-2).
3. Move the jumper at JP3 (Enable control) pins 2 and 3 (EN and GND) to enable the output.

4.3 Load Transient Response

Figure 4-2 and Figure 4-3 show the TPS62932EVM response to load transient. The current steps and slew rates are indicated in the figures with 20-MHz scope bandwidth. Total peak-to-peak voltage variation is as shown in the figures.


Figure 4-2. TPS62932EVM Load Transient Response, 0.5-A to 2-A Load Step, 0.8 A/µs

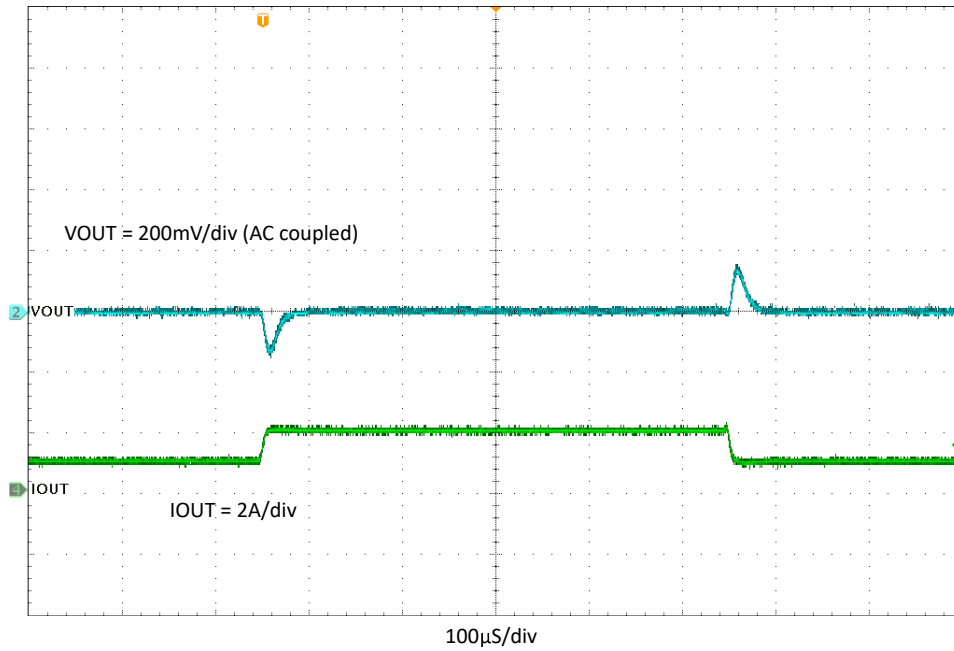


Figure 4-3. TPS62932EVM Load Transient Response, 1-A to 2-A Load Step, 0.8 A/µs

4.4 Output Voltage Ripple

Figure 4-4 through Figure 4-8 show the TPS62932EVM output voltage ripple. The output currents are as indicated and all waveforms are with 20-MHz scope bandwidth.

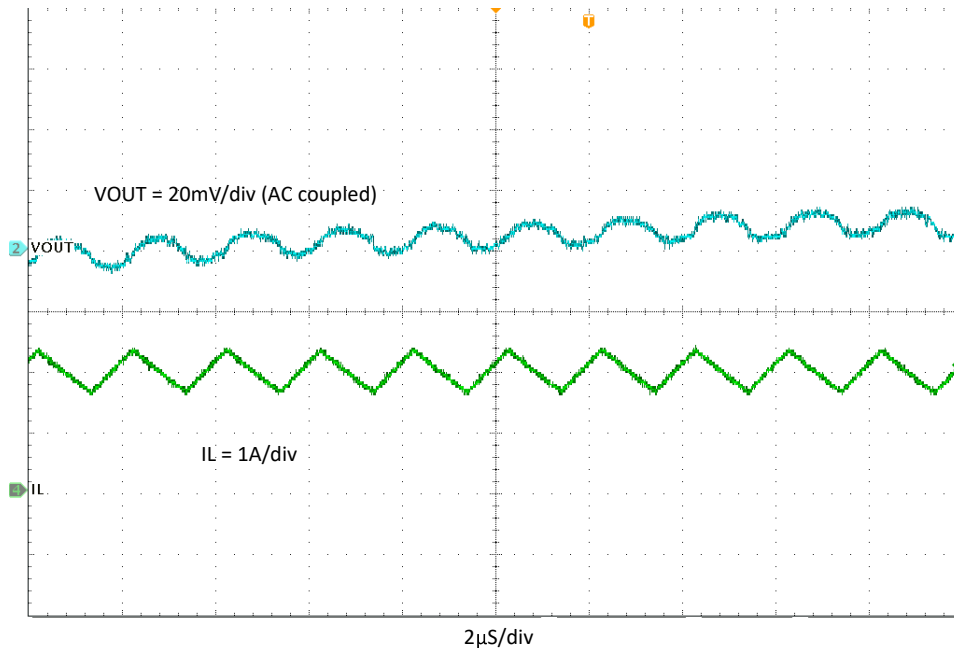


Figure 4-4. TPS62932EVM Output Voltage Ripple, $I_{OUT} = 2\text{ A}$

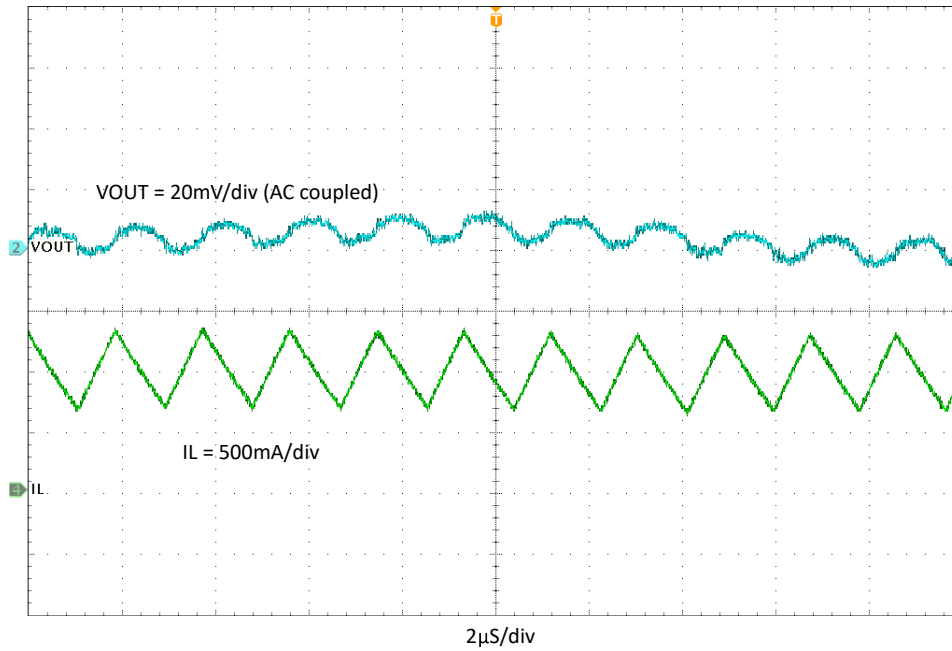


Figure 4-5. TPS62932EVM Output Voltage Ripple, $I_{OUT} = 1\text{ A}$

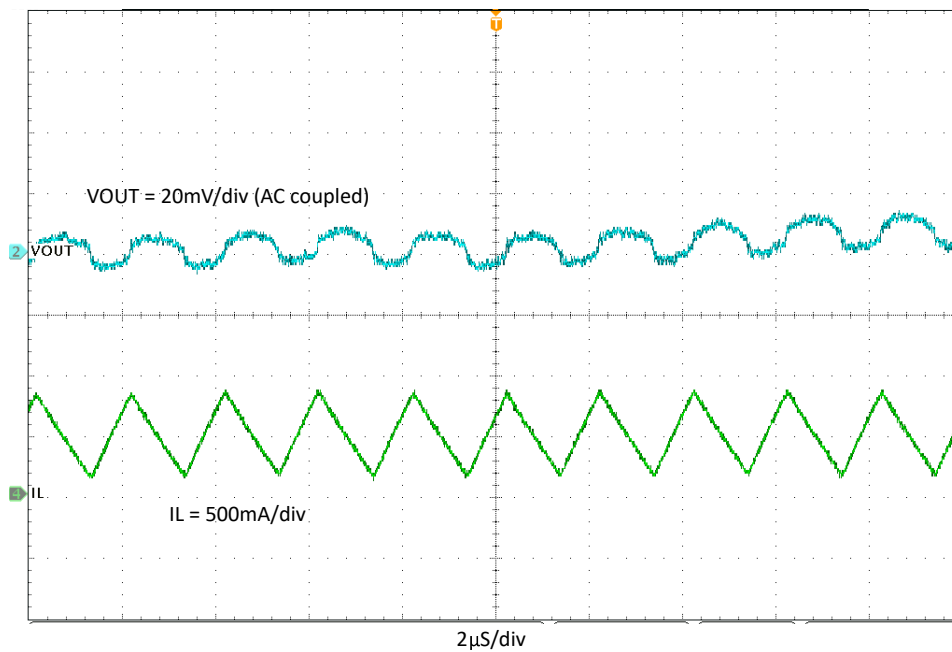


Figure 4-6. TPS62932EVM Output Voltage Ripple, $I_{OUT} = 500\text{ mA}$

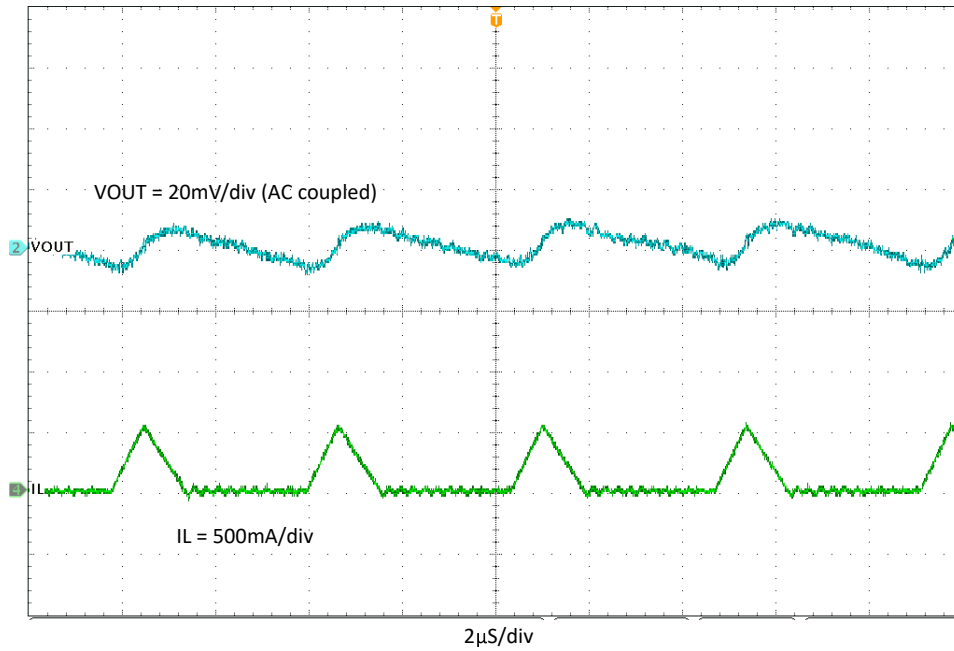


Figure 4-7. TPS62932EVM Output Voltage Ripple, $I_{OUT} = 100 \text{ mA}$

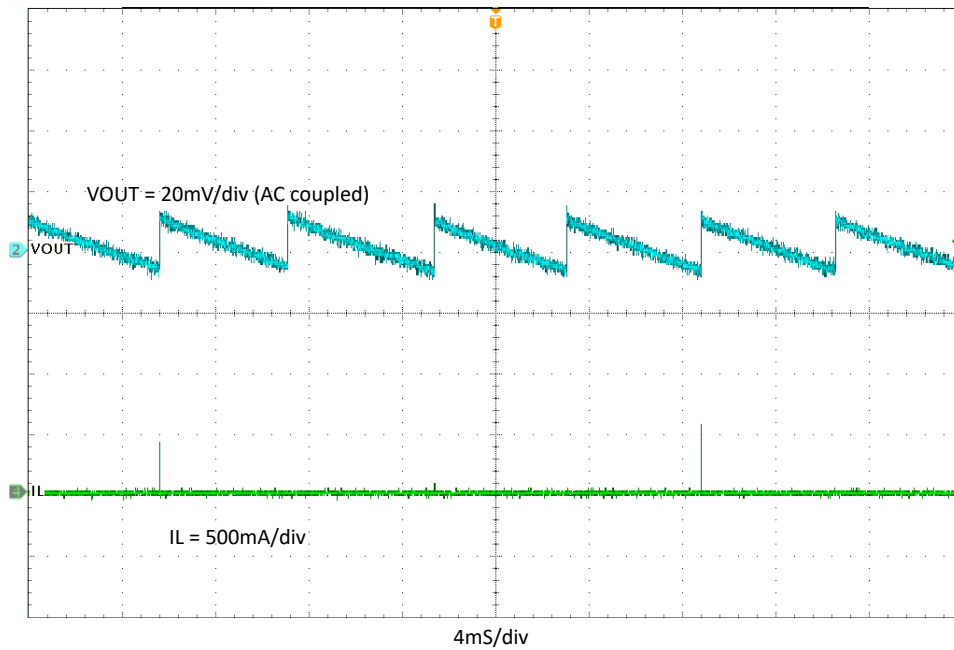


Figure 4-8. TPS62932EVM Output Voltage Ripple, $I_{OUT} = 0 \text{ A}$

4.5 Start-Up

Figure 4-9 shows the TPS62932EVM start-up waveform with 20-MHz scope bandwidth relative to V_{IN} . The load is 2 A.

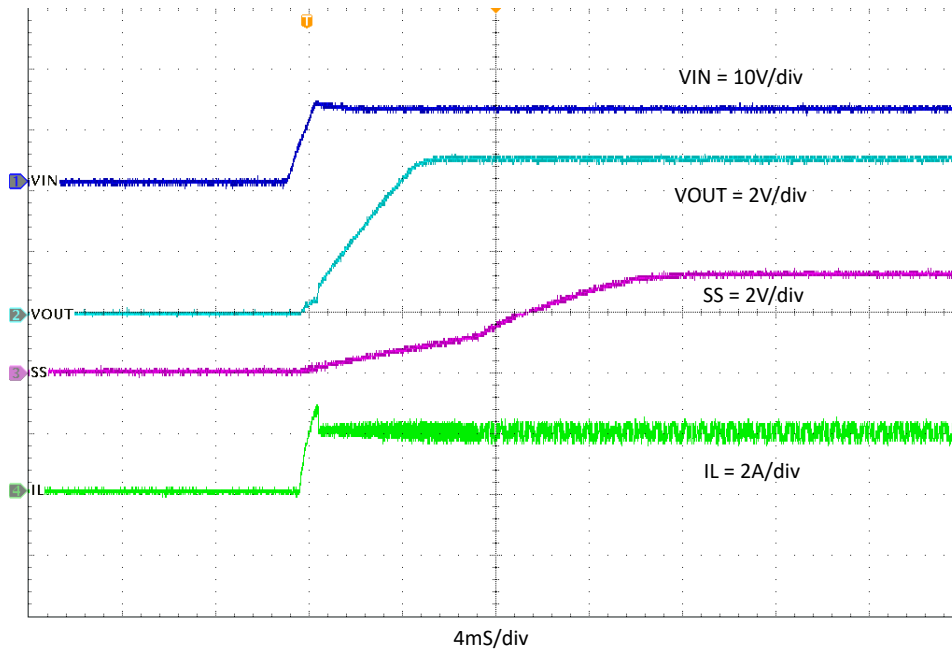


Figure 4-9. TPS62932EVM Start-Up Relative to V_{IN}

4.6 Shutdown

Figure 4-10 shows the TPS62932EVM shutdown waveform with 20-MHz scope bandwidth relative to V_{IN} . The load is 2 A.

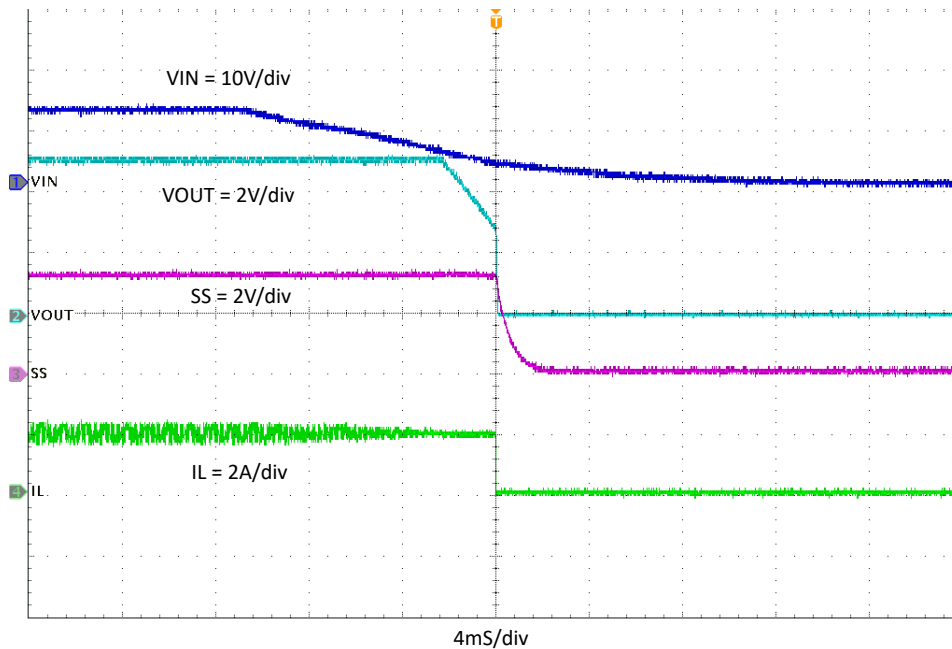


Figure 4-10. TPS62932EVM Shutdown Relative to V_{IN}

5 Board Layout

This section provides a description of the TPS62932EVM, board layout, and layer illustrations.

5.1 Layout

Figure 5-1, Figure 5-2, and Figure 5-3 show the board layout for the TPS62932EVM. The top layer contains the main power traces for VIN, VOUT, and ground. Connections for the pins of the TPS62932 and a large area filled with ground are also on the top layer. Most of the signal traces are also located on the top side. The input decoupling capacitors, C6, C7, C8, and C9 are located as close to 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 the switching node copper fill, signal ground copper fill, and the feedback trace from the point of regulation to the top of the resistor divider network. Both the top layer and bottom layer use 2-oz copper thickness.

Figure 5-4 and Figure 5-5 are the TPS62932EVM board top view and bottom view, respectively.

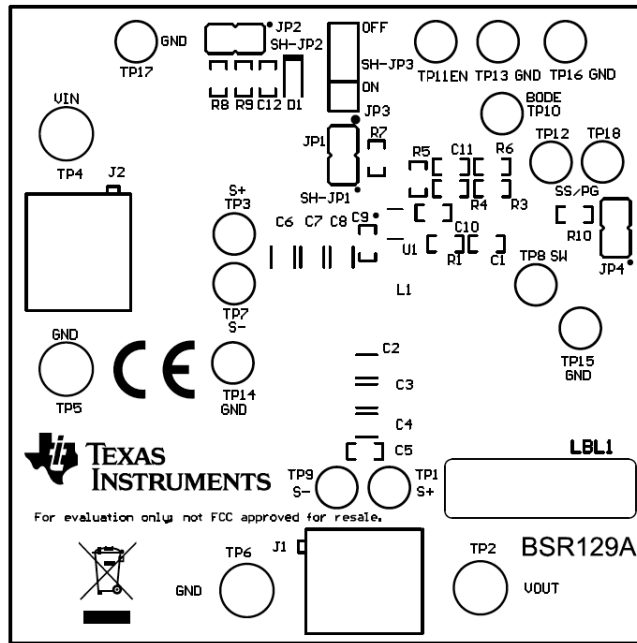


Figure 5-1. TPS62932EVM Top Assembly

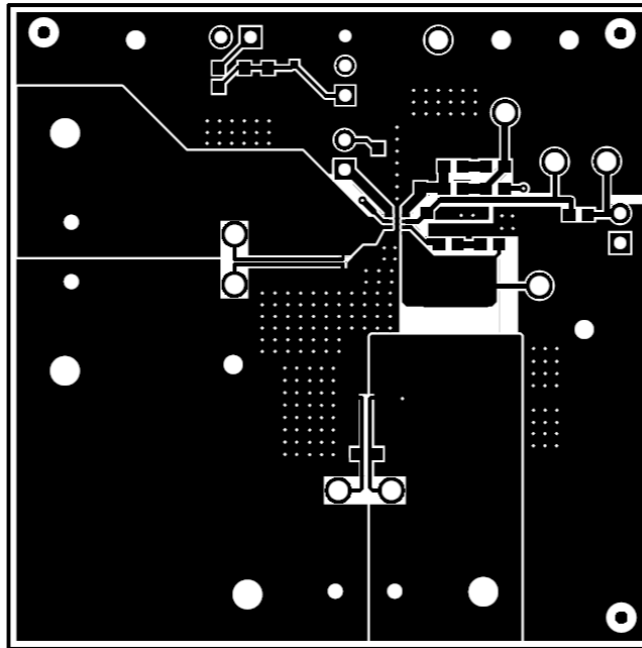


Figure 5-2. TPS62932EVM Top Layer

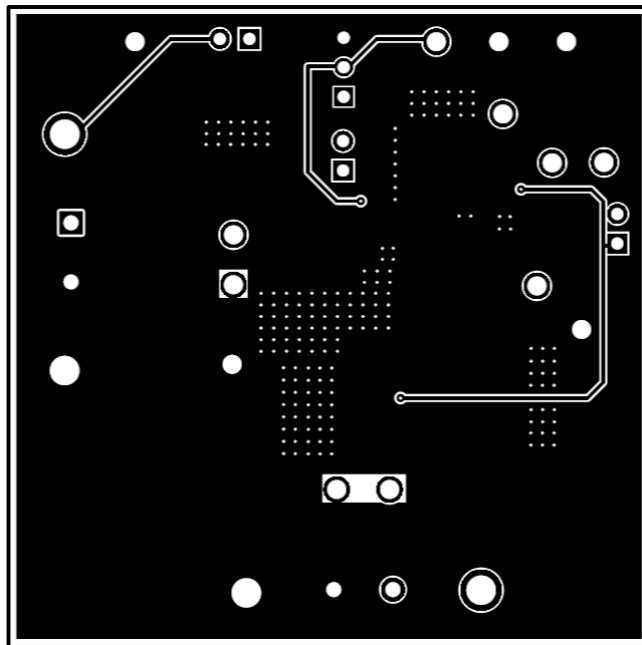


Figure 5-3. TPS62932EVM Bottom Layer



Figure 5-4. TPS62932EVM Board Top View



Figure 5-5. TPS62932EVM Board Bottom View

6 Schematic, List of Materials, and Reference

6.1 Schematic

Figure 6-1 is the schematic for the TPS62932EVM.

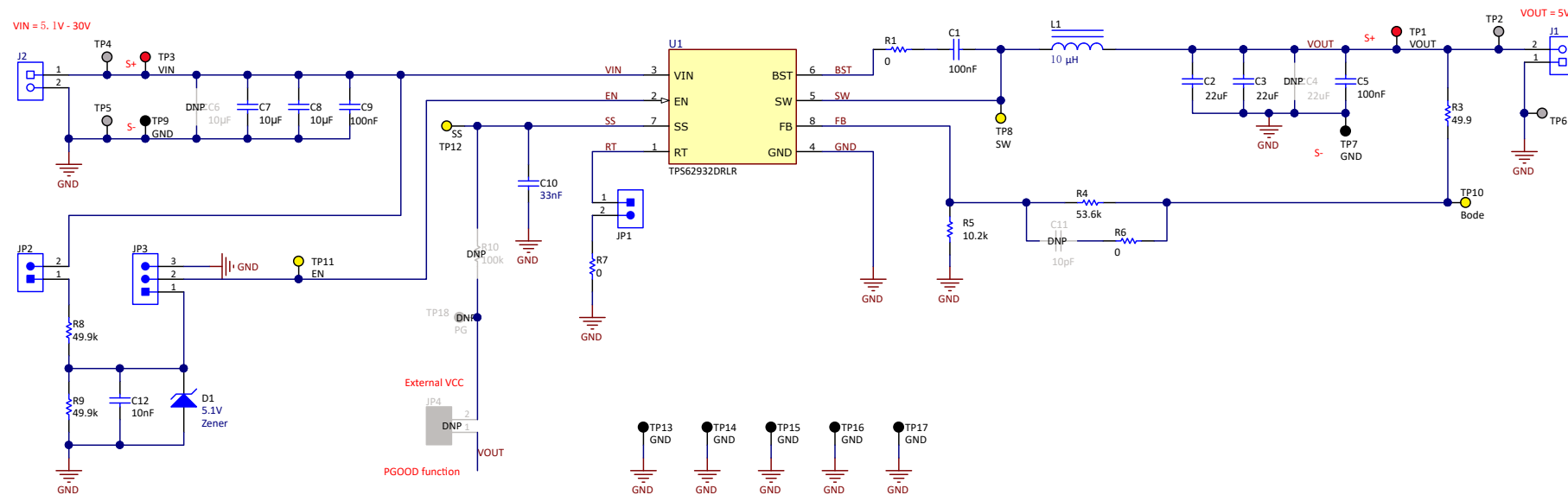


Figure 6-1. TPS62932EVM Schematic Diagram

6.2 List of Materials

Table 6-1. List of Materials

Description	Des	Part Number	Qty	Manufacturer
Printed Circuit Board	!PCB1	BSR129	1	Any
CAP, CERM, 0.1 μ F, 50 V, \pm 10%, X7R, 0603	C1, C5, C9	C0603C104K5RACAUTO	3	Kemet
CAP, CERM, 22 μ F, 35 V, \pm 20%, X5R, 1206	C2, C3	C3216X5R1V226M160AC	2	TDK
CAP, CERM, 10 μ F, 50 V, \pm 10%, X7R, 1206	C7, C8	CGA5L1X7R1H106K160AC	2	TDK
CAP, CERM, 6800 pF, 50 V, \pm 10%, X7R, 0603	C10	GRM188R71H682KA01D	1	MuRata
CAP, CERM, 0.01 μ F, 50 V, \pm 5%, X7R, 0603	C12	C0603C103J5RACTU	1	Kemet
Diode, Zener, 5.1 V, 200 mW, SOD-323	D1	MMSZ5231BS-7-F	1	Diodes Inc.
Terminal Block, 5.08 mm, 2 \times 1, Brass, TH	J1, J2	ED120/2DS	2	On-Shore Technology
Header, 100 mil, 2 \times 1, Gold, TH	JP1, JP2, JP4	PBC02SAAN	3	Sullins Connector Solutions
Header, 100 mil, 3 \times 1, Tin, TH	JP3	PEC03SAAN	1	Sullins Connector Solutions
Inductor, Shielded, Hyperflux, 10 μ H, 5 A, 0.02915 Ω , SMD	L1	74439346100	1	Würth Elektronik
Thermal Transfer Printable Labels, 0.650" W \times 0.200" H - 10,000 per roll	LBL1	THT-14-423-10	1	Brady
RES, 0, 5%, 0.1 W, 0603	R1, R6, R7	RC0603JR-070RL	3	Yageo
RES, 49.9, 1%, 0.1 W, 0603	R3	RC0603FR-0749R9L	1	Yageo
RES, 53.6 k, 1%, 0.1 W, 0603	R4	RC0603FR-0753K6L	1	Yageo
RES, 10.2 k, 1%, 0.1 W, 0603	R5	RC0603FR-0710K2L	1	Yageo
RES, 49.9 k, 1%, 0.1 W, 0603	R8, R9	RC0603FR-0749K9L	2	Yageo
RES, 100 k, 1%, 0.1 W, 0603	R10	RC0603FR-07100KL	1	Yageo
Shunt, 100 mil, Gold plated, Black	SH-JP1, SH-JP2, SH-JP3, SH-JP4, SH-JP5	SNT-100-BK-G	5	Samtec
Test Point, Multipurpose, Red, TH	TP1, TP3	5010	2	Keystone
Terminal, Turret, TH, Double	TP2, TP4, TP5, TP6	1502-2	4	Keystone
Test Point, Multipurpose, Black, TH	TP7, TP9, TP13, TP14, TP15, TP16, TP17	5011	7	Keystone
Test Point, Multipurpose, Yellow, TH	TP8, TP10, TP11, TP12, TP18	5014	5	Keystone
3.8-V to 30-V Input, 3-A and 2-A, 200-kHz to 2.2-MHz, Low I_Q Synchronous Buck Converter in SOT583 Package	U1	TPS62932DRLR	1	Texas Instruments
CAP, CERM, 22 μ F, 35 V, \pm 20%, X5R, 1206	C4	C3216X5R1V226M160AC	0	TDK
CAP, CERM, 10 μ F, 50 V, \pm 10%, X7R, AEC-Q200 Grade 1, 1206	C6	CGA5L1X7R1H106K160AC	0	TDK
CAP, CERM, 10 pF, 50 V, \pm 5%, C0G/NP0, 0603	C11	C0603C100J5GACTU	0	Kemet

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.
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 - 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。
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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2. 実験局の免許を取得後ご使用いただく。
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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
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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.

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