User's Guide

TPS548B27EVM-162 20-A, Buck Converter Evaluation Module User Guide

ABSTRACT

This user's guide contains information for the TPS548B27EVM-162 evaluation module (EVM) as well as for the TPS548B27 DC/DC converter. Also included are the performance specifications, the schematic, and the list of materials for the TPS548B27EVM.

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Trademarks

D-CAP3™ is a trademark of TI.
All trademarks are the property of their respective owners.

1 Introduction

The TPS548B27 is a D-CAP3™ synchronous buck converter designed for 20-A output current, and the evaluation module is designed to demonstrate the small printed-circuit-board areas that may be achieved when designing with the device. The high-side and low-side switching MOSFETs are integrated in the device package along with their gate drive circuitry. Rated input voltage and output current ranges for the evaluation module are given in Table 3-1.

2 Safety Warnings

Figure 2-1. Hot Surface. Contact may cause burns. Do not touch.

3 Background

The EVM is setup to allow the user to evaluate the performance of the TPS548B27 IC, and easily make changes to multiple settings. The low drain-to-source on resistance of the MOSFETs allows the device to achieve high efficiencies and keep the junction temperature low at high output currents. There is no need for external compensation components since this device is designed with D-CAP3™ control topology. On the EVM, the switching frequency and the operation mode are externally selectable using a jumper to set the resistor from the MODE pin to AGND. An external resistor divider allows for an adjustable output voltage. Additionally, the device provides adjustable soft start, adjustable OC limit threshold, external reference input, and an open-drain power good indicator. Lastly the TPS548B27 device has a fixed internal VIN under voltage lockout and externally adjustable UVLO using a resistor divider at the EN pin.

Table 3-1. Input Voltage and Output Current Summary

EVM	Input Voltage Range	Output Current Range
TPS548B27	V_{IN} = 4 V to 16 V	0 A to 20 A

4 Performance Specification Summary

A summary of the TPS548B27EVM performance specifications is provided in Table 4-1. Specifications are given for an input voltage of V_{IN} = 12 V and an output voltage of 1.0 V, unless otherwise specified. The TPS548B27EVM is designed and tested for V_{IN} = 8 V to 14 V. The ambient temperature is 25°C for all measurements, unless otherwise noted. The design can be modified to perform over 4 V to 16 V.

Table 4-1. Performance Specification Summary

Specification	Test Conditions	MIN	TYP	MAX	Unit
V_{IN} voltage range (without internal Bias)		8	12	14	V
Output voltage setpoint			1.0		V
Output current range	V_{IN} = 8 V to 14 V	0	20	20	A
Internal LDO Voltage			3.0		V
Operating frequency			800		kHz

5 Modifications

These evaluation modules are designed to provide access to the features of the TPS548B27. Some modifications can be made to this module.

5.1 Output Voltage Setpoint

To change the output voltage of the EVM, it is necessary to change the value of resistor R8 and R9. R13 is fixed at 10 kΩ. Changing the total value of R8 plus R9 can change the output voltage above the 0.6-V reference voltage V_{INTREF}. A two resistor configuration of R8 + R9 is implemented to give the exact desired output voltage setting. The value of R8 and R9 for a specific output voltage can be calculated using Equation 1.

$$R_{FB\_HS} = \frac{V_O - V_{INTREF}}{V_{INTREF}} \times R_{FB\_LS} \quad (1)$$

where

- V_{INTREF} = 0.6 V
- $R_{FB\_HS} = R_8 + R_9$
- $R_{FB\_LS} = R_{13}$ = 10 kΩ

5.2 Frequency and Operation Mode Setting

To change the frequency and operation mode of the part, the MODE pin is used. J4 and the surrounding circuitry allows for an easy change to the frequency and operation mode setting. Table 5-1 shows all 6 options offered by J4.

Table 5-1. TPS548B27EVM Mode Pin Selection

Switching Frequency (F_{SW})	Operation Mode Under Light Load	Mode Pin Connections	
		Connection	Jumper Setting
600 kHz	Skip Mode	Short to VCC	Short Pins 1 and 2
800 kHz	Skip Mode	243 kΩ ±10% to AGND	Short Pins 3 and 4
1000 kHz	Skip Mode	121 kΩ ±10% to AGND	Short Pins 5 and 6
1000 kHz	Forced CCM	60.4 kΩ ±10% to AGND	Short Pins 7 and 8
800 kHz	Forced CCM	30.1 kΩ ±10% to AGND	Short Pins 9 and 10
600 kHz	Forced CCM	Short to AGND	Short Pins 11 and 12

5.3 Enable Pin Selection

The converter can be enabled and disabled by J3.

Default setting: EN pin connected to VIN.

Table 5-2. Enable Pin Selection

Set On Connection	Enable Selection
Pins 2-3 Shorted	EN pin connected to VIN pins through resistor divider
J3 Open	EN pin is left floating
Pins 1-2 Shorted	EN pin connected to PGND

5.4 Remote Sensing

The EVM is not set-up for remote sensing by default. To set up remote sensing follow these steps:

1. Replace R10 and R14 with 100-Ω resistors
2. Connect your sense points to the Vsns+ and Vsns- test points

5.5 Adjustable UVLO

The undervoltage lockout (UVLO) can be adjusted externally using R2 and R9. See the *TPS548B27 4-V to 16-V Input, 15-A/20-A Synchronous Step-Down Converter Data Sheet* for detailed instructions for setting the external UVLO.

6 Schematic

Figure 6-1 illustrates the TPS548B27EVM schematic.

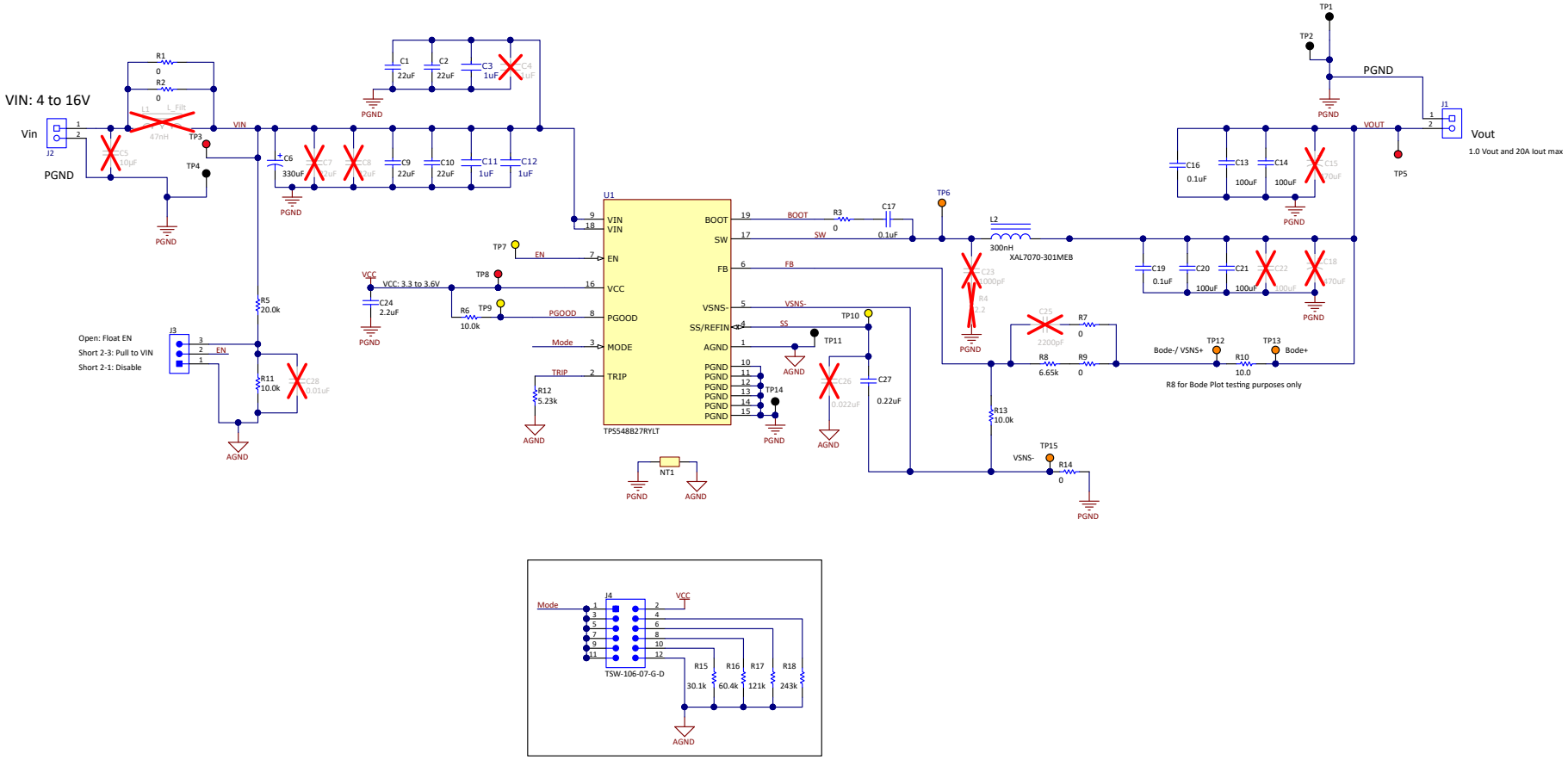

Figure 6-1. TPS548B27EVM Schematic

7 List of Materials

Table 7-1 presents the list of materials for the TPS548B27EVM.

Table 7-1. TPS548B27EVM List of Materials

Designator	QTY	Description	Part Number	Manufacturer
C1, C2, C9, C10	4	CAP, CERM, 22 uF, 25 V, +/- 20%, X6S, 1206_190	GRM31CC81E226ME11L	Murata
C3, C11, C12	3	CAP CER 1UF 25V X6S 0402	GRM155C81E105KE11D	Murata
C6	1	CAP, AL, 330 uF, 25 V, +/- 20%, 0.15 ohm, SMD	EEE-FC1E331P	Panasonic
C13, C14, C20, C21	4	CAP, CERM, 100 uF, 4 V, +/- 20%, X6S, 1206_190	C3216X6S0G107M160AC	TDK
C16, C19	2	CAP, CERM, 0.1 uF, 6.3 V, +/- 10%, X7R, 0402	GRM155R70J104KA01D	MuRata
C17	1	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402	CGA2B3X7R1H104K050BB	TDK
C24	1	CAP, CERM, 2.2 uF, 10 V, +/- 20%, X5R, 0402	GRM155R61A225ME95	Murata
C25	1	CAP, CERM, 2200 pF, 16 V, +/- 10%, X7R, 0402	GRM155R71C222KA01D	Murata
C26	1	CAP, CERM, 0.022 uF, 16 V, +/- 10%, X7R, 0402	GRM155R71C223KA01D	Murata
C27	1	CAP, CERM, 0.22 uF, 10 V, +/- 10%, X7R, 0402	GRM155R71A224KE01D	Murata
C28	1	CAP, CERM, 0.01 uF, 16 V, +/- 10%, X5R, 0402	GRM155R61C103KA01D	Murata
H1, H2, H3, H4	4	Bumpon, Hemisphere, 0.44 X 0.20, Clear	SJ-5303 (CLEAR)	3M
J1, J2	2	Therminal Block, 5 mm, 2-pole, Tin, TH	282856-2	TE Connectivity
J3	1	Header, 100mil, 3x1, Gold, TH	HTSW-103-07-G-S	Samtec
J4	1	Header, 100mil, 6x2, Gold, TH	TSW-106-07-G-D	Samtec
L2	1	Inductor, Shielded, Composite, 300 nH, 33.4 A, 0.00106 ohm, SMD	XAL7070-301MEB	Coilcraft
LBL1	1	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	THT-14-423-10	Brady
R1, R2	2	RES, 0, 1%, 0.5 W, 1206	5108	Keystone
R3, R7, R9, R14	4	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	ERJ-2GE0R00X	Panasonic
R5	1	RES, 20.0 k, 0.1%, 0.1 W, 0603	RT0603BRD0720KL	Yageo America
R6, R13	2	RES, 10.0 k, 1%, 0.1 W, 0402	ERJ-2RKF1002X	Panasonic
R8	1	RES, 6.65 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW04026K65FKED	Vishay-Dale
R10	1	RES, 10.0, 1%, 0.063 W, 0402	CRCW040210R0FKED	Vishay-Dale
R11	1	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060310K0FKEA	Vishay-Dale
R12	1	RES, 5.23 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW04025K23FKED	Vishay-Dale
R15	1	RES, 30.1 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060330K1FKEA	Vishay-Dale
R16	1	RES, 60.4 k, 1%, 0.1 W, 0603	RC0603FR-0760K4L	Yageo
R17	1	RES, 121 k, 1%, 0.1 W, 0603	RC0603FR-07121KL	Yageo
R18	1	RES, 243 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW0603243KFKEA	Vishay-Dale
SH-J1, SH-J2	2	Shunt, 100mil, Gold plated, Black	SNT-100-BK-G	Samtec
TP1, TP2, TP4, TP11, TP14	5	Test Point, Multipurpose, Black, TH	5011	Keystone
TP3, TP5, TP8	3	Test Point, Multipurpose, Red, TH	5010	Keystone
TP6	1	Test Point, Compact, Orange, TH	5008	Keystone
TP7, TP9, TP10	3	Test Point, Compact, Yellow, TH	5009	Keystone
TP12, TP13, TP15	3	Test Point, Multipurpose, Orange, TH	5013	Keystone
U1	1	2.7V - 16V, 20A Synchronous Step-Down Converter With Differential Remote Sense	TPS548B27RYLT	Texas Instruments
C4	0	CAP CER 1UF 25V X6S 0402	GRM155C81E105KE11D	Murata
C5	0	CAP, CERM, 10 uF, 25 V, +/- 10%, X7R, 0805	GRM21BZ71E106KE15L	Murata
C7, C8	0	CAP, CERM, 22 uF, 25 V, +/- 20%, X6S, 1206_190	GRM31CC81E226ME11L	Murata
C15, C18	0	CAP, Tantalum Polymer, 470 uF, 6.3 V, +/- 20%, 0.01 ohm, 7343-40 SMD	6TPF470MAH	Panasonic
C22	0	CAP, CERM, 100 uF, 4 V, +/- 20%, X6S, 1206_190	C3216X6S0G107M160AC	TDK
C23	0	CAP, CERM, 1000 pF, 50 V, +/- 5%, X7R, 0603	CL10C102JB8NNNC	Samsung Electro-Mechanics
'FID1, FID2, FID3, FID4, FID5, FID6	0	Fiducial mark. There is nothing to buy or mount.	N/A	N/A

Table 7-1. TPS548B27EVM List of Materials (continued)

Designator	QTY	Description	Part Number	Manufacturer
L1	0	Inductor, Wirewound, Ceramic, 47 nH, 0.5 A, 0.31 ohm, SMD	0805CS-470XJLB	Coilcraft
R4	0	RES, 2.2, 5%, 0.5 W, 1206	CRM1206-JW-2R2ELF	Bourns

8 Layout

The board layout for the TPS548B27EVM is shown in Figure 8-3 through Figure 8-6. The top-side layer of the EVM is laid out in a manner typical of a user application. The top, bottom, and internal layers are 2-oz. copper.

The top layer contains the main power traces for V_{IN}, V_{OUT}, and SW. Also on the top layer are connections for the remaining pins of the TPS548B27 and the majority of the signal traces. The top layer has a dedicated ground plane for quiet analog ground that is connected to the main power ground plane at a single point. The internal layer-1 is a large ground plane. The internal layer-2 contains an additional large ground copper area as well as an additional V_{OUT} copper fill. The bottom layer is another ground plane with two additional traces for the output voltage feedback and various signals routed to test points and headers. There are also additional V_{IN} and V_{OUT} planes on the bottom layer. The top-side ground traces are connected to the bottom and internal ground planes with multiple via groupings placed around the board.

The input decoupling capacitors and bootstrap capacitor are all located as close to the IC as possible. Additionally, the voltage set point resistor divider components are kept close to the IC. The voltage divider network ties to the output voltage at the point of regulation, the copper V_{OUT} trace at the TP4 test point. An additional input bulk capacitor is used to limit the noise entering the converter from the input supply. Critical analog circuits that are noise sensitive are terminated to the quiet analog ground island on the top layer.

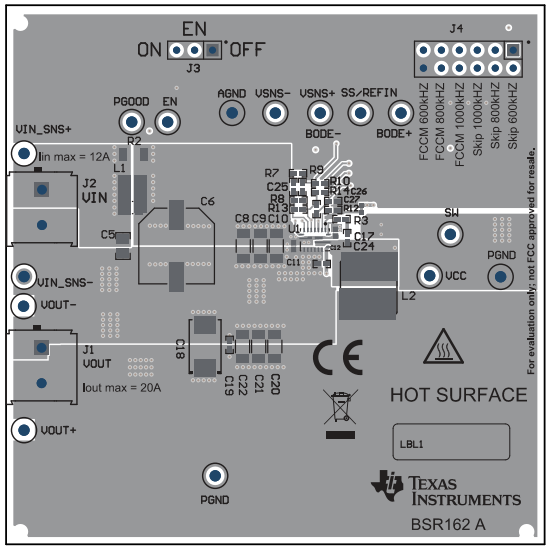

Figure 8-1. TPS548B27EVM Top-Side Composite View

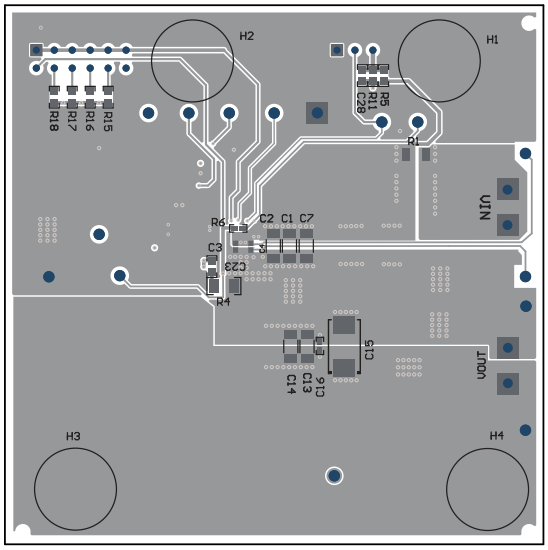

Figure 8-2. TPS548B27EVM Bottom-Side Composite View

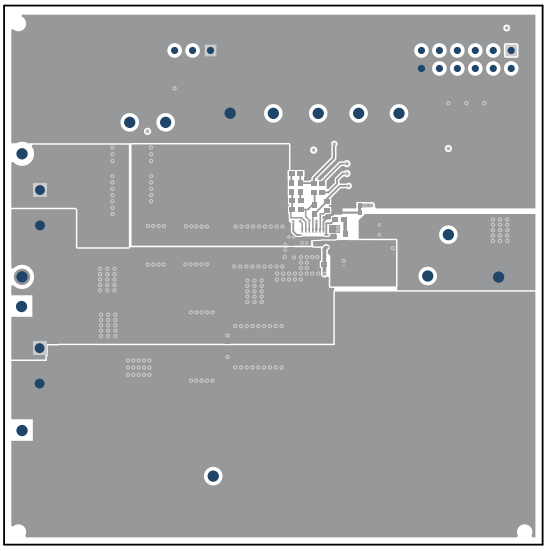

Figure 8-3. TPS548B27EVM Top-Side Layout

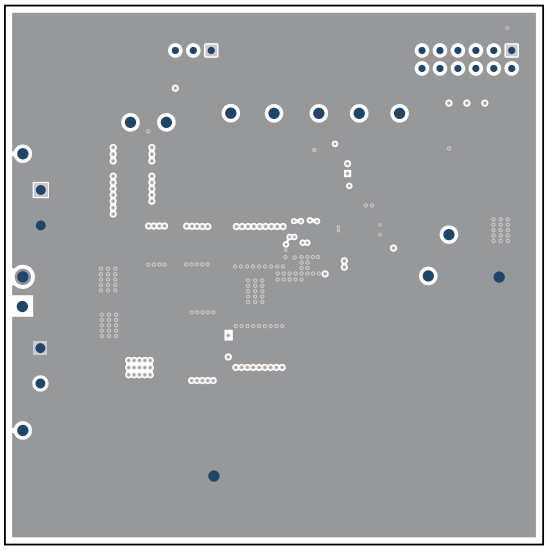

Figure 8-4. TPS548B27EVM Internal Layer-1 Layout

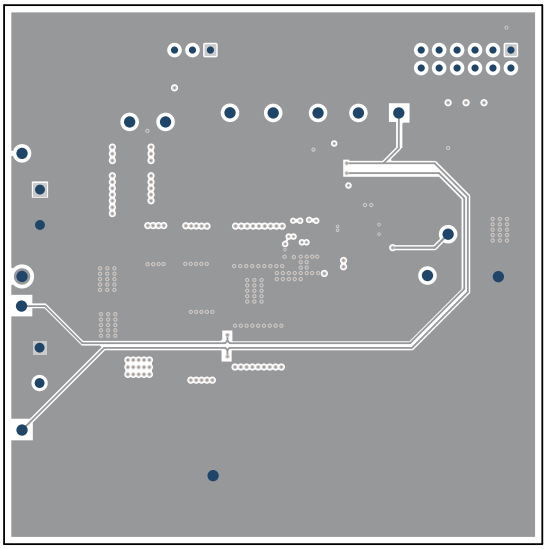

Figure 8-5. TPS548B28EVM Internal Layer-2 Layout

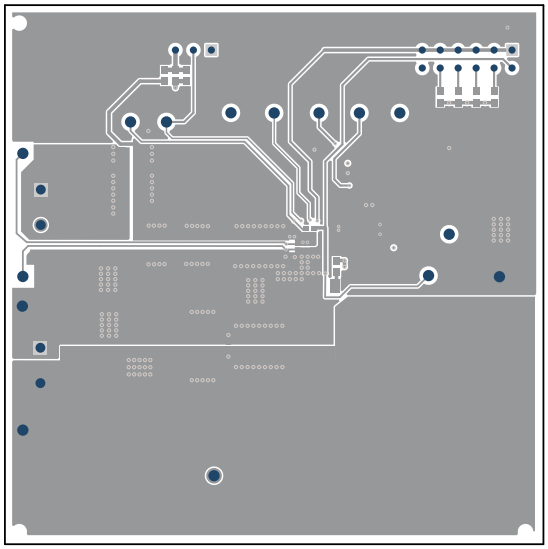

Figure 8-6. TPS548B27EVM Bottom-Side Layout

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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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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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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:*

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