

# TPS65320EVM

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The Texas Instruments TPS65320EVM evaluation module (EVM) helps designers evaluate the operation and performance of the TPS65320-Q1 device, a switch-mode DC-DC step-down converter with an integrated low-dropout voltage regulator (LDO). This document describes how to setup and configure the EVM for operation. The document also includes the board layout, schematic, and bill of materials (BOM) for the EVM.

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## 1 Introduction

The TPS65320EVM is a fully assembled PCB design for evaluation the TPS65320-Q1 device (revision C, TPS65320BQPWPRQ1) which contains a DC-DC step-down converter and a low-dropout voltage regulator.

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**NOTE:** This document is the user's guide for revision C of the TPS65320EVM. The user's guides for revision B (TPS65320QPWPRQ1) and revision C (TPS65320BQPWPRQ1) has some minor differences. For access to the revision B user's guide, review the following forum to find the user's guide for revision B or request the PDF:  
<https://e2e.ti.com/support/applications/automotive>.

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## 2 Schematic, BOM, and Layout

This section provides a more detailed description of the Schematic, BOM, and Layout.

### 2.1 Schematic

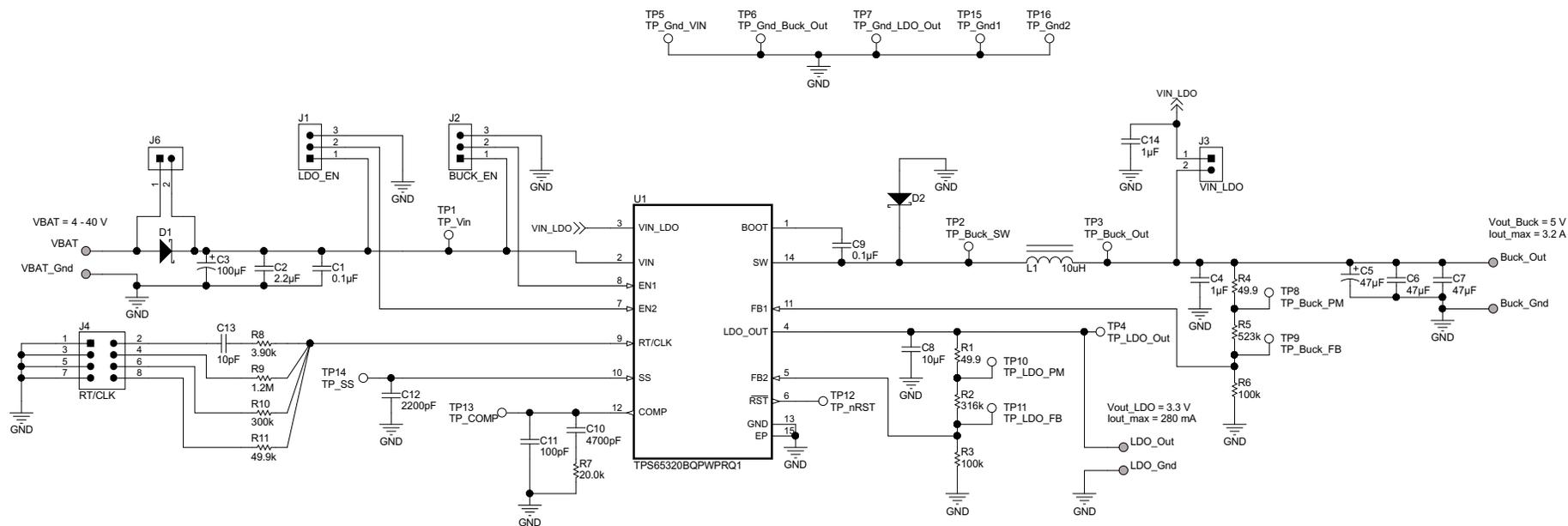


Figure 1. TPS65320EVM Schematic

### 2.2 Bill of Materials

Table 1. TPS65320EVM Bill of Materials

Designator	Quantity	Description	Footprint	PartNumber	Manufacturer
!PCB	1	Printed circuit board		HVL032	Any
Buck_Gnd, Buck_Out, LDO_Gnd, LDO_Out, VBAT, VBAT_Gnd	6	PCB pin, swage mount, TH	Mill-Max_2505-2	2505-2-00-44-00-00-07-0	Mill-Max
C1, C9	2	Capacitor, ceramic, 0.1 $\mu$ F, 100 V, $\pm$ 10%, X7R, 0805	0805_HV	C0805C104K1RACTU	Kemet
C2	1	Capacitor, ceramic, 2.2 $\mu$ F, 100 V, $\pm$ 10%, X7R, 1210	1210	C1210C225K1RACTU	Kemet
C3	1	Capacitor, aluminum, 100 $\mu$ F, 63 V, $\pm$ 20%, 0.35 $\Omega$ , SMD	SM_RADIAL_G	EEE-FK1J101P	Panasonic
C4, C14	2	Capacitor, ceramic, 1 $\mu$ F, 50 V, $\pm$ 10%, X7R, 0805	0805_HV	GRM21BR71H105KA12L	MuRata
C5	1	Capacitor, aluminum, 47 $\mu$ F, 80 V, $\pm$ 20%, 0.7 $\Omega$ , SMD	SM_RADIAL_G	EEE-FK1K470P	Panasonic

**Table 1. TPS65320EVM Bill of Materials (continued)**

Designator	Quantity	Description	Footprint	PartNumber	Manufacturer
C6, C7	2	Capacitor, ceramic, 47 $\mu$ F, 25 V, $\pm$ 20%, X7S, 6x5x5mm	CKG57N	CKG57NX7S1E476M500JH	TDK
C8	1	Capacitor, ceramic, 10 $\mu$ F, 16 V, $\pm$ 10%, X5R, 0805	0805_HV	EMK212BJ106KG-T	Taiyo Yuden
C10	1	Capacitor, ceramic, 4700 pF, 50 V, $\pm$ 5%, X7R, 0603	0603	C0603C472J5RACTU	Kemet
C11	1	Capacitor, ceramic, 100 pF, 50 V, $\pm$ 5%, C0G/NP0, 0603	0603	C0603C101J5GAC	Kemet
C12	1	Capacitor, ceramic, 2200 pF, 100 V, $\pm$ 5%, X7R, 0603	0603	06031C222JAT2A	AVX
C13	1	Capacitor, ceramic, 10 pF, 50 V, $\pm$ 5%, C0G/NP0, 0603	0603	C0603C100J5GACTU	Kemet
D1, D2	2	Diode, Schottky, 40 V, 4 A, SMC	SMC	SL44-E3/57T	Vishay-Semiconductor
FID1, FID2, FID3	3	Fiducial mark. There is nothing to buy or mount.	Fiducial10-20	N/A	N/A
H9, H10, H11, H12	4	Bumpon, Hemisphere, 0.44 x 0.20, clear	Bumpon_SJ5003Transparent	SJ-5303 (CLEAR)	3M
J1, J2	2	Header, 2.54 mm, 3 x 1, gold, TH	Sullins_Gxx03SAAN	GBC03SAAN	Sullins Connector Solutions
J3, J6	2	Header, 2.54 mm, 2 x 1, gold, TH	WURTH_61300211121	61300211121	Wurth Elektronik eiSos
J4	1	Header, 100 mil, 4 x 2, gold, SMT	Molex_0015910080	0015910080	Molex
L1	1	Inductor, Shielded, Ferrite, 10 $\mu$ H, 5.8 A, 0.019 $\Omega$ , SMD	B82477P4	B82477P4103M000	TDK
R1, R4	2	Resistor, 49.9 $\Omega$ , 1%, 0.1 W, 0603	0603	CRCW060349R9FKEA	Vishay-Dale
R2	1	Resistor, 316 k $\Omega$ , 1%, 0.1 W, 0603	0603	CRCW0603316KFKEA	Vishay-Dale
R3, R6	2	Resistor, 100 k $\Omega$ , 1%, 0.1 W, 0603	0603	CRCW0603100KFKEA	Vishay-Dale
R5	1	Resistor, 523 k $\Omega$ , 1%, 0.1 W, 0603	0603	CRCW0603523KFKEA	Vishay-Dale
R7	1	Resistor, 20 k $\Omega$ , 1%, 0.1 W, 0603	0603	CRCW060320K0FKEA	Vishay-Dale
R8	1	Resistor, 3.9 k $\Omega$ , 1%, 0.1 W, 0603	0603	CRCW06033K90FKEA	Vishay-Dale
R9	1	Resistor, 1.2 M $\Omega$ , 1%, 0.1 W, 0603	0603	CRCW06031M20FKEA	Vishay-Dale
R10	1	Resistor, 300 k $\Omega$ , 1%, 0.1 W, 0603	0603	CRCW0603300KFKEA	Vishay-Dale
R11	1	Resistor, 49.9 k $\Omega$ , 1%, 0.1 W, 0603	0603	CRCW060349K9FKEA	Vishay-Dale
SH-BUCK, SH-J6, SH-J8, SH-LDO, SH-VIN	5	Shunt, 2 mm, gold plated, black	2SN-BK-G	2SN-BK-G	Samtec
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16	16	Test point, miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone
U1	1	40-V step-down converter with Eco-mode™ and LDO regulator, PWP0014E	PWP0014E_N	TPS65320BQPWPRQ1	Texas Instruments

### 2.3 Layout and Component Placement

Figure 2 shows the top and Figure 3 shows the bottom component placement for the EVM. Two additional solder pads are added to Buck\_Out, between C6 and C7. Those pads allow the user to change the output capacitor configuration from the original setup with two ceramic capacitors (C6 and C7) to two electrolytic capacitors (C5 and solder pads). Also C14 is used if additional capacitance is needed at VIN\_LDO.

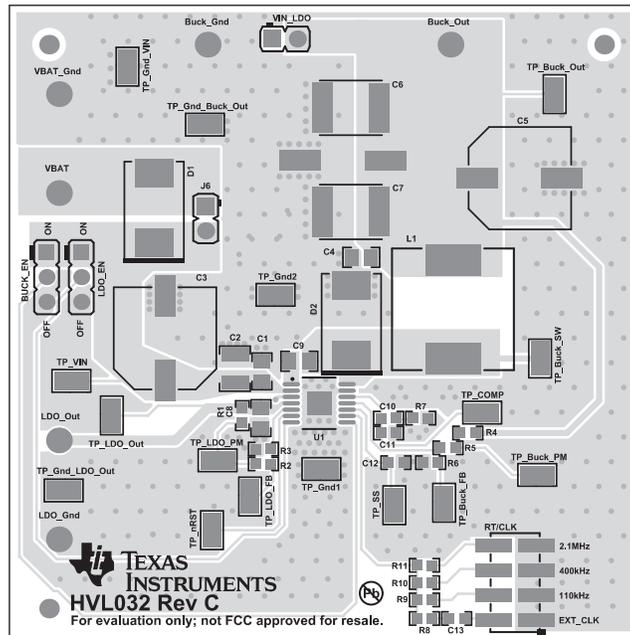


Figure 2. Component Placement, Top Overview

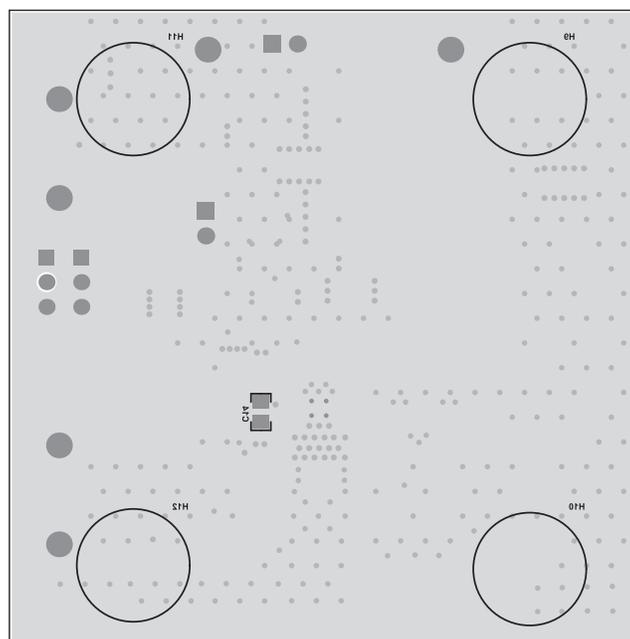


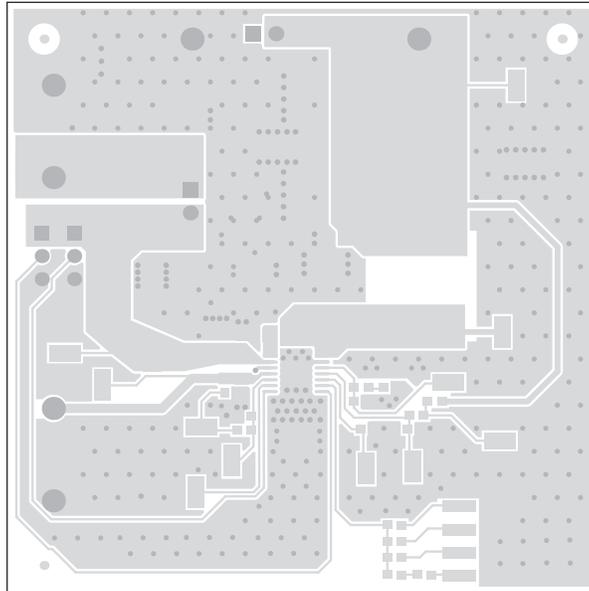
Figure 3. Component Placement, Bottom Overview

Figure 4 and Figure 5 show the top and bottom layout of the EVM. Although the TPS65320-Q1 device is a highly efficient converter a good connection between the heat sink and ground plane is important. Therefore ensuring that the thermal pad has a good connection to the copper landing is important. To improve the thermal performance of the board the thermal pad in this case is connected to ground with multiple vias to the bottom ground plane.

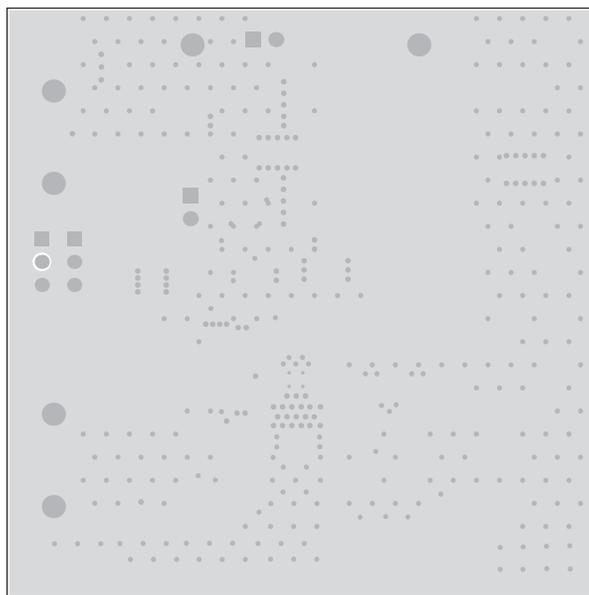
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**NOTE:** The feedback trace from Buck\_out to the feedback of the device is shielded with a ground plane which minimizes noise on the feedback node.

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**Figure 4. Top Layout**



**Figure 5. Bottom Layout**

### 3 Setup and Operation

This section describes the connectors, jumpers, and test points on the EVM as well as how to connect, set up, and properly use the EVM. An example of the EVM operation is also included.

#### 3.1 Input and Output Connectors

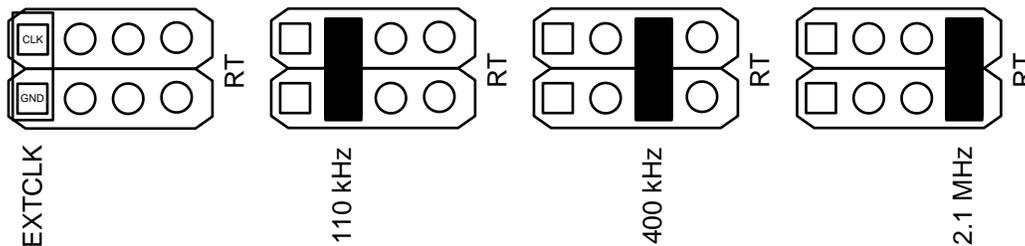
The EVM has three pairs of connectors: 1 input and 2 outputs. [Table 2](#) lists the connectors along with a function description. The description also includes the electrical specifications.

**Table 2. Terminal Description**

Terminal	Direction	Description
VBAT and VBAT_GND	Input	This terminal is the supply voltage for the device, the device and the design is capable of handling a input voltage between 4 to 40 V.
BUCK_Out and BUCK_Out_GND	Output	Buck is the output voltage of the buck regulator and are designed to deliver 5 V and capable to deliver a maximum output current of 3.2 A. This output is also the supply for the LDO.
LDO_Out and LDO_Out_GND	Output	LDO is the output voltage of the LDO and are able to deliver 0.28 A. In this design the output voltage set to 3.3 V.

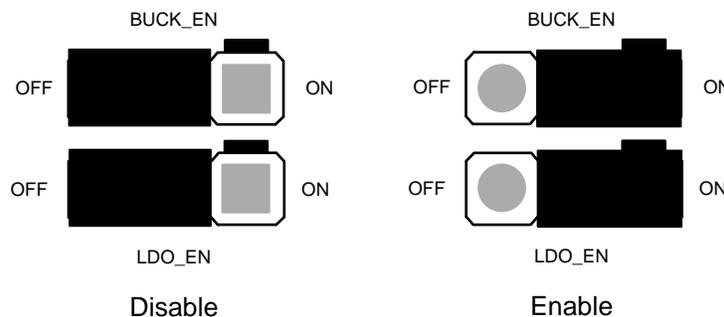
#### 3.2 Jumper Settings and Configuration

**J8 = RT/CLK**—This jumper is used to select the switching frequency for the switch-mode regulator. The jumper places a pulldown resistor to set the frequency to approximately 110 kHz, 400 kHz, or 2.1 MHz. If applying an external clock, use the pin closest to the label EXT\_CKL.



**Figure 6. RT Jumper Settings**

**BUCK\_EN and LDO\_EN** —These jumpers are used to enable or disable the buck converter and the LDO. Setting either jumper high enables respective rail; a low setting or a floating disables respective rail. Manual installation of the jumper may cause ringing, potentially asserting nRST low.



**Figure 7. Enable Jumper Setting**

**VIN\_LDO** —This jumper should always be installed to supply the LDO for Buck\_Out. The jumper can also be used for current measurements from Buck\_Out to VIN\_LDO.

**J6** — This jumper can be used to short the protection diode D1 and avoid the diode voltage drop at the input of the device.

### 3.3 Test Point Description

The test points and descriptions are as follows:

**TP\_Vin and TP\_Vin\_Gnd** — Used to measure the voltage on the Vin pin of the device .

**TP\_Buck\_Out and TP\_Gnd\_Buck\_Out** — Used to measure the output voltage of the buck regulator .

**TP\_LDO\_Out and TP\_Gnd\_LDO\_Out** — Used to measure the output voltage of the LDO.

**TP\_Buck\_SW** — Used to measure the switching of the buck converter.

**TP\_Buck\_PM** — Allows easy access for gain and phase analysis of the buck regulator .

**TP\_Buck\_FB** — Used to measure the feedback of the buck.

**TP\_LDO\_PM** — Allows easy access for gain and phase analysis of the LDO.

**TP\_LDO\_FB** — Used to measure the feedback of the LDO.

**TP\_COMP** — Compensation network for the feedback of the buck regulator.

**TP\_SS** — Used to measure the voltage drop over the soft start capacitor of the buck regulator.

**TP\_nRST** — Used to measure when the LDO begins to regulate.

**TP\_Gnd1 and 2** — Additional ground points close to the device

### 3.4 Basic Operation

The input voltage range for the converter is 4 to 40 V.

For proper operation of the TPS65320EVM, configure BUCK\_EN, LDO\_EN, and RT properly, using the jumper terminals as follows:

- BUCK\_EN — enabled
- LDO\_EN — enabled
- RT — 400 kHz

In this configuration, both regulators turn on when power is applied. Disable the regulators using the enable jumpers.

With the BUCK disabled, the LDO supply comes from VIN. Consider the power dissipation at high VIN. TP\_VIN\_LDO is at GND level in this condition.

To change the switching frequency, power down the device before moving the jumper. If an external clock is applied, remove any jumper installed on RT; however, if the external clock is missing without a jumper installed, the buck does not regulate.

**Table 3. Regulator Configuration**

Regulator	Output Voltage	Maximum Output Current
BUCK	5 V	3.2 A
LDO	3.3 V	0.28 A

The output capacitors of the BUCK regulator are 25-V types, supporting up to 18 V of the output voltage,  $V_O$ . In case of higher output voltage, TI recommends replacing these with capacitors having higher voltage ratings.

Low switching frequencies, high load transients, or limited allowed deviation of  $V_O$ , may require larger capacitance values. If needed, use the footprints of the unassembled electrolytic capacitor C5. Low-ESR capacitors also further reduce the coupled noise from the buck to the LDO.

On the EVM, a soft-start capacitor (C12) of 2.2 nF is installed, setting the time to approximately 700  $\mu$ s. For other soft-start-times, the capacitor may be replaced.

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## Revision History

**Changes from Original (February 2013) to A Revision****Page**

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- Changed TPS65320QPWPRQ1 to TPS65320BQPWPRQ1 and updated the schematic, PCB and BOM for revision C of the board ..... 1
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## STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.
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  - 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 and conditions do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
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  - 2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, 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.
3. *Regulatory Notices:*
  - 3.1 *United States*
    - 3.1.1 *Notice applicable to EVMs not FCC-Approved:*

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

#### Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). 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 by Radio Law of Japan to follow the instructions below with respect to EVMs:

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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#### 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:*

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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.

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