TPS65320EVM

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.

Contents

List of Figures

List of Tables

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.

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.

Eco-mode is a trademark of Texas Instruments.

2 Schematic, BOM, and Layout

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

2.1 Schematic

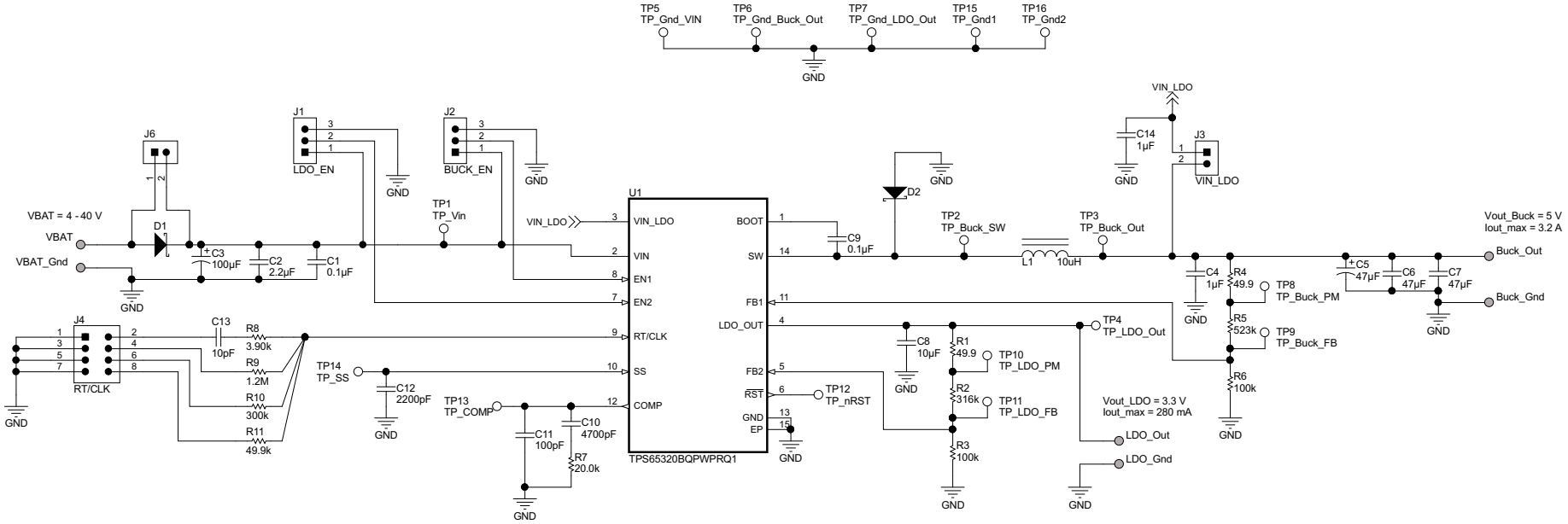

Figure 1. TPS65320EVM Schematic

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 µF, 100 V, ±10%, X7R, 0805	0805_HV	C0805C104K1RACTU	Kemet
C2	1	Capacitor, ceramic, 2.2 µF, 100 V, ±10%, X7R, 1210	1210	C1210C225K1RACTU	Kemet
C3	1	Capacitor, aluminum, 100 µF, 63 V, ±20%, 0.35 Ω, SMD	SM_RADIAL_G	EEE-FK1J101P	Panasonic
C4, C14	2	Capacitor, ceramic, 1 µF, 50 V, ±10%, X7R, 0805	0805_HV	GRM21BR71H105KA12L	MuRata
C5	1	Capacitor, aluminum, 47 µF, 80 V, ±20%, 0.7 Ω, 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 µF, 25 V, ±20%, X7S, 6x5x5mm	CKG57N	CKG57NX7S1E476M500JH	TDK
C8	1	Capacitor, ceramic, 10 µF, 16 V, ±10%, X5R, 0805	0805_HV	EMK212BJ106KG-T	Taiyo Yuden
C10	1	Capacitor, ceramic, 4700 pF, 50 V, ±5%, X7R, 0603	0603	C0603C472J5RACTU	Kemet
C11	1	Capacitor, ceramic, 100 pF, 50 V, ±5%, C0G/NP0, 0603	0603	C0603C101J5GAC	Kemet
C12	1	Capacitor, ceramic, 2200 pF, 100 V, ±5%, X7R, 0603	0603	06031C222JAT2A	AVX
C13	1	Capacitor, ceramic, 10 pF, 50 V, ±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 × 0.20, clear	Bumpon_SJ5003Transparent	SJ-5303 (CLEAR)	3M
J1, J2	2	Header, 2.54 mm, 3 × 1, gold, TH	Sullins_Gxx03SAAN	GBC03SAAN	Sullins Connector Solutions
J3, J6	2	Header, 2.54 mm, 2 × 1, gold, TH	WURTH_61300211121	61300211121	Wurth Elektronik eiSos
J4	1	Header, 100 mil, 4 × 2, gold, SMT	Molex_0015910080	0015910080	Molex
L1	1	Inductor, Shielded, Ferrite, 10 µH, 5.8 A, 0.019 Ω, SMD	B82477P4	B82477P4103M000	TDK
R1, R4	2	Resistor, 49.9 Ω, 1%, 0.1 W, 0603	0603	CRCW060349R9FKEA	Vishay-Dale
R2	1	Resistor, 316 kΩ, 1%, 0.1 W, 0603	0603	CRCW0603316KFKEA	Vishay-Dale
R3, R6	2	Resistor, 100 kΩ, 1%, 0.1 W, 0603	0603	CRCW0603100KFKEA	Vishay-Dale
R5	1	Resistor, 523 kΩ, 1%, 0.1 W, 0603	0603	CRCW0603523KFKEA	Vishay-Dale
R7	1	Resistor, 20 kΩ, 1%, 0.1 W, 0603	0603	CRCW060320K0FKEA	Vishay-Dale
R8	1	Resistor, 3.9 kΩ, 1%, 0.1 W, 0603	0603	CRCW06033K90FKEA	Vishay-Dale
R9	1	Resistor, 1.2 MΩ, 1%, 0.1 W, 0603	0603	CRCW06031M20FKEA	Vishay-Dale
R10	1	Resistor, 300 kΩ, 1%, 0.1 W, 0603	0603	CRCW0603300KFKEA	Vishay-Dale
R11	1	Resistor, 49.9 kΩ, 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 solider pads). Also C14 is used if additional capacitance is needed at VIN_LDO.

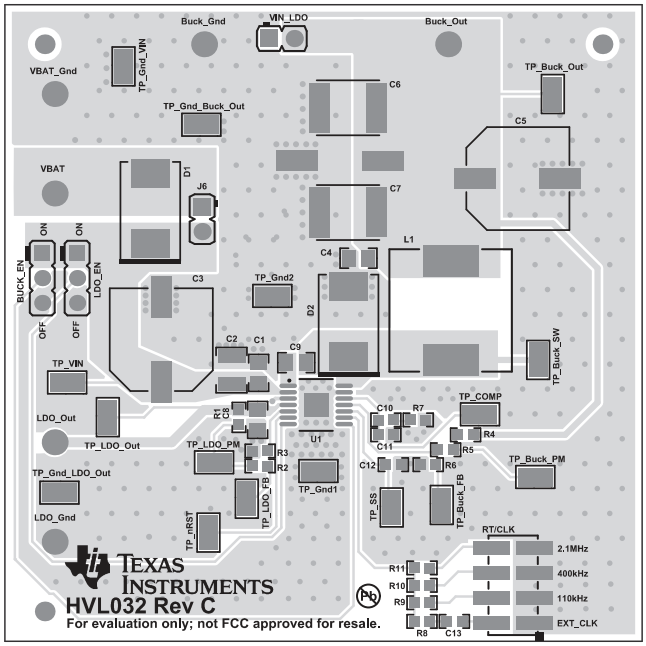

Figure 2. Component Placement, Top Overview

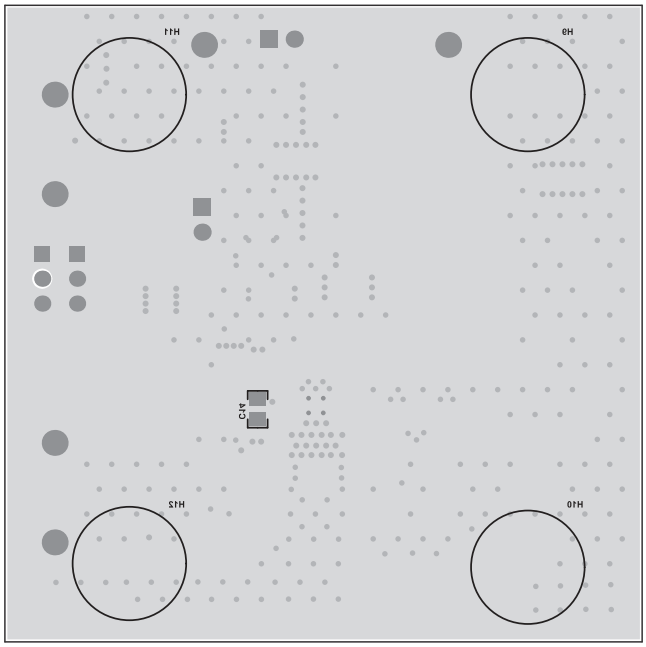

Figure 3. Component Placement, Bottom Overview

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.

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.

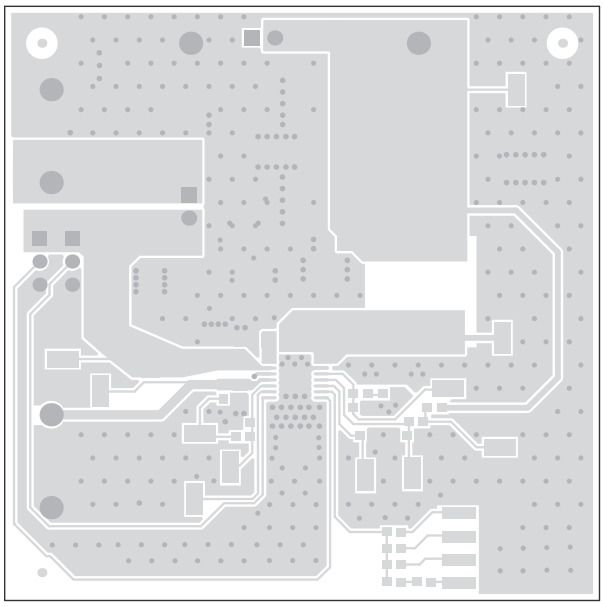

Figure 4. Top Layout

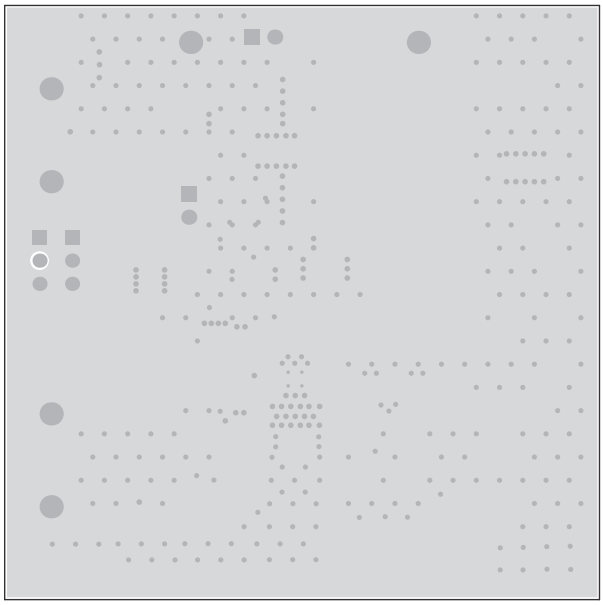

Figure 5. Bottom Layout

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.

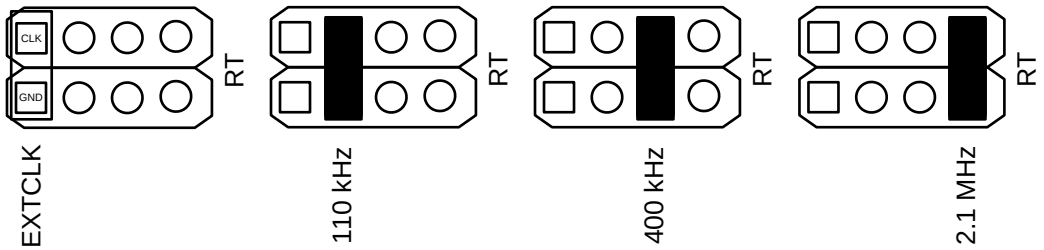

Figure 6. RT Jumper Settings

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.

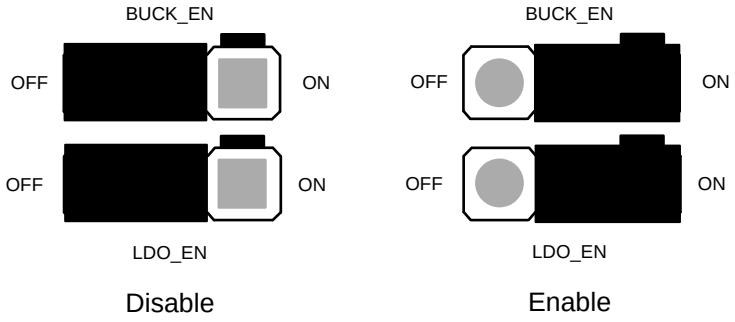

Figure 7. Enable Jumper Setting

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 µs. For other soft-start-times, the capacitor may be replaced.

Revision History

Changes from Original (February 2013) to A Revision	Page
• Changed TPS65320QPWPRQ1 to TPS65320BQPWPRQ1 and updated the schematic, PCB and BOM for revision C of the board	1

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.

   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 and conditions 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 and conditions 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 any defects that are 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. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

   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/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 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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社

東京都新宿区西新宿６丁目２４番１号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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 WRITTEN DESIGN MATERIALS PROVIDED WITH THE EVM (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 IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

   6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS AND CONDITIONS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT MADE, CONCEIVED OR ACQUIRED PRIOR TO OR AFTER DELIVERY OF THE EVM.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS AND CONDITIONS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS ANDCONDITIONS OR THE USE OF THE EVMS PROVIDED HEREUNDER, 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 ONE YEAR AFTER THE RELATED CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY WARRANTY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS AND CONDITIONS, OR ANY USE OF ANY TI EVM PROVIDED HEREUNDER, EXCEED THE TOTAL AMOUNT PAID TO TI FOR THE PARTICULAR UNITS SOLD UNDER THESE TERMS AND CONDITIONS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM AGAINST THE PARTICULAR UNITS SOLD TO USER UNDER THESE TERMS AND CONDITIONS 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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265