User's Guide
SLVU929–November 2013

TPS65301EVM User's Guide

1 Introduction

The Texas Instruments TPS65301EVM evaluation module (EVM) evaluates the operation and performance of the TPS65301 power-supply IC for safety applications. The EVM contains the TPS65301 device and some circuitry for basic operation.

Table 1. Device and Package Configurations

CONVERTER	IC	PACKAGE
IC1	TPS65301QPWPRQ1	PWP-24

2 Background

3 Setup

This section describes the jumpers and connectors on the EVM, and how to properly connect, set up, and use the TPS65301EVM.

3.1 Input and Output Connector Descriptions

Table 2. Connectors

Connector	IN/OUT	Name	Description
J1	Output	VREG	Output terminal for the TPS65301 switch-mode converter
J2	Input	VBAT	Power input terminal for the device
J3	Input	IGN	Input terminal to enable the TPS65301
J4	Output	3.3V	Output terminal for the TPS65301 3.3-V linear regulator
J5	Output	1.2V	Output terminal for the TPS65301 1.2-V linear regulator
JP6	Output	5VS	Output terminal for the TPS65301 5-V linear regulator

3.2 Supply

The input voltage range for the converter is VBAT = 5.6 to 40 V. VBAT is supplied to J2.

Table 3. EVM Voltages

Name	IN/OUT	Connector	Pin	GND	Min	Typ	Max	Unit
VBAT	Input	J2	2, 4	12	5.6	13.8	40	V
VREG	Output	J1	22	12	5.3	5.45	5.6	
3.3V	Output	J4	18	12	3.234	3.3	3.366	
1.2V	Output	J5	16	12	1.176	1.2	1.224	
5V	Output	5V	10	12	4.9	5	5.1	
5VS	Output	J6	7	12	4.9	5	5.1	

PowerPAD is a trademark of Texas Instruments.

3.3 Jumper Settings

For proper operation of the TPS65301 device, jumpers must be properly configured. Table 4 shows the recommended jumper settings.

Table 4. EVM Jumper

J	Description	Option	Standard
IGN	When IGN = High (jumper set), the device starts up.	Open shuts down the device	Set
EN	This jumper keeps the outputs of the devices active after ignition is turned off (IGN = low). However, a high level on IGN is required for initial start-up. Before initial start-up, the EN-jumper has no effect. Note that as opposed to IGN, the EN-pin is a logic-level-input, maximum input voltage must not exceed 5.25 V.	Open allows device shutdown with IGN	Set
3.3VPWR	This jumper supplies the 3.3-V regulator out of the buck regulator VREG.		Set
1.2VPWR	This jumper supplies the 1.2-V regulator out of the buck regulator VREG.		Set
J6	This jumper supplies 1.2-V regulator out of 3.3-V Regulator.		Open

3.4 Test Points

Test Points are placed to measure different nodes on the board.

Table 5. Test Points

Test Point	Description
VBAT	Power Input
VIN_D, VIN	Power Input after the reverse battery-protection diode
IGN	Ignition. This test point monitors if IGN-input is high, powering up the device.
IGN_EN	Ignition enable (IGN after series resistor)
BOOT_LDO	Voltage at the internal regulator, which supplies the power to charge the flying-boot capacitor.
VREG	Regulated output of the switch-mode converter, supplying 5.45 V
DELAY	Input for reset delay
SS	Input for soft start time
EN	Enable pin. When EN is high, the device remains active after IGN transitions to low.
GND (×7)	Ground
PH	Switch node, source of internal switching FET
nRST	Reset output for Switcher, which is asserted high after VREG and the 3.3-V and 1.2-V regulator outputs are regulating and after the delay timer expires.
3.3V	3.3-V linear-regulator output
3.3V DRIVE	DRIVE-Base drive for external 3.3-V-regulator bipolar transistor
1.2V	1.2-V linear-regulator output
1.2V DRIVE	DRIVE-Base drive for external 1.2-V-regulator bipolar transistor
VSENSE	Inverting node of the error amplifier for voltage-mode control of VREG
IGN_ST	Ignition input indicator which is asserted high while ignition input is high.
5V	Output of the 5-V linear regulator. Because no screw-terminal is provided for this output, use this test point to attach load.
5VS	Output of the 5-V-sensor linear regulator. Because no screw-terminal is provided for this output, use this test-point to attach load.

3.5 Switch Mode Output 5.45 V

The VREG voltage regulator is supplied by VBAT. Several blocking caps, C4 and C14, are connected from VBAT to GND and help stabilize the supply voltage. For long supply cables, additional bigger caps are helpful. The node PH is the switching node of the buck converter. L1 is the inductor connected to PH and VREG. The diode D1 is the freewheeling diode to allow current flow when the internal High-Side Transistor of the device is turned off. C1 and C2 are the output caps of the VREG regulator. The pin VREG is the feedback line used to close the control loop of the VREG regulator, and is also the supply node for internal use and for the 5-V and 5-VS regulator. The output voltage VREG is available at J1.

3.6 5V (5-V Linear Regulator)

5V is a fixed-regulated output of 5-V ±2% over temperature and input supply using the precision-voltage sense-resistor network. A low-ESR ceramic capacitor is required for loop stabilization; this capacitor must be placed close to the pin of the IC. This output is protected against shorts to ground by a fold-back current limit for safe operating conditions, and by a current limit for limiting in-rush current due to depleted charge on the output capacitance. On initial IGN_EN or EN power cycle the soft-start circuit on this regulator is initiated. The soft-start takes typically 13 ms. This output may require a larger output capacitor to ensure that during load transients the output does NOT drop below the required regulated specifications.

3.7 3.3V Linear-Regulator Controller (3.3-VSENSE)

The linear regulator controller requires an external NPN bipolar pass transistor of sufficient gain-stage to support the maximum load current required. The base-drive output current is protected by current-limiting both the source- and sink-drive circuitry. The 3.3VSENSE is the remote sense input of the output of REG3 supply and controls the 3.3VDRIVE output accordingly. This regulator is fixed at 3.3 V with ±2% tolerance using a precision-voltage sense-resistor network. A low-ESR ceramic output capacitor is used for loop compensation of the regulator. A voltage on this pin of less-than approximately 50% of the regulated value initiates a current limit on the 3.3VDRIVE output. This output may require larger output capacitors to support load transients, so the output does *not* drop below 90% of 3.3 V.

3.8 1.2V Linear-Regulator Controller (1.2-VSENSE)

The linear regulator controller requires an external NPN bipolar pass transistor of sufficient gain stage to support the maximum load current required. The 1.2VSENSE is the remote-sense input of the output of 1.2-V supply and controls the 1.2VDRIVE output accordingly. This regulator output is 1.2 V with ±2% tolerance using a precision-voltage sense-resistor network. A low-ESR ceramic-output capacitor is used for loop compensation of the regulator. A voltage on this pin of less-than approximately 50% of the regulated value initiates a current limit on the 1.2VDRIVE output. This output may require larger output capacitors to support load transients, so the output does *not* drop below 90% of 1.2 V.

3.9 5VS (Protected Sensor-Supply Linear Regulator)

5VS is a fixed-regulated output of 5-V ±2% over temperature and input supply using a precision-voltage sense-resistor network. A low-ESR ceramic capacitor is required for loop stabilization; this capacitor must be placed close to the pin of the IC. This output is protected against shorts to ground by a fold-back current limit for safe operating conditions, and by a current limit for limiting in-rush current due to depleted charge on the output capacitance. This output is also protected against shorts to battery voltage by limiting the reverse current, and because of this, this supply is used to power a sensor outside the electrical-control unit, ECU.

On initial IGN_EN or EN power cycle the soft-start circuit on this regulator is initiated. The soft-start takes typically 10 ms. This output may require a larger output capacitor to ensure that during load transients the output does *not* drop below the required regulated specifications.

4 EVM Schematic

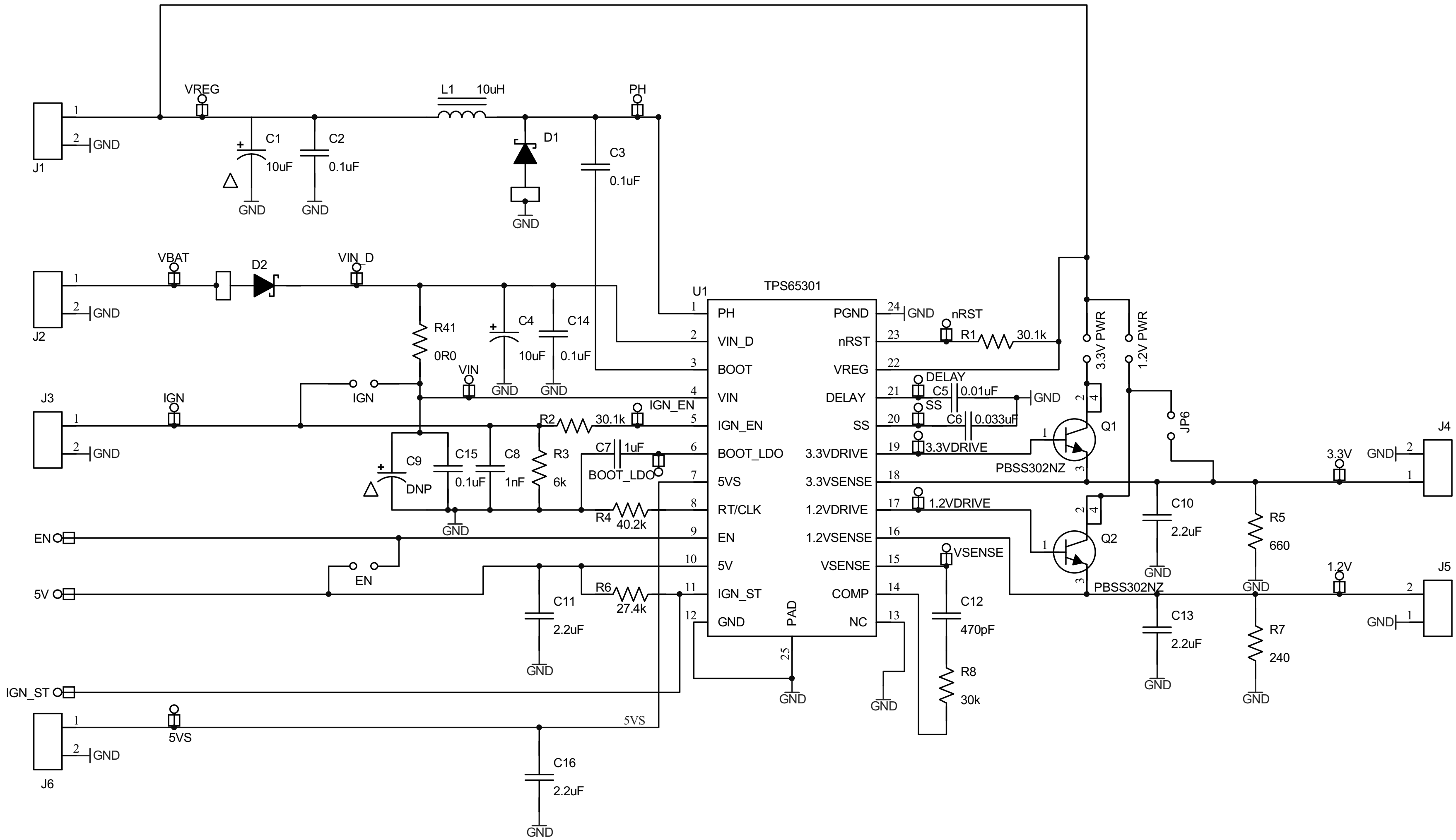

Figure 1. Schematic

5 Board Layout

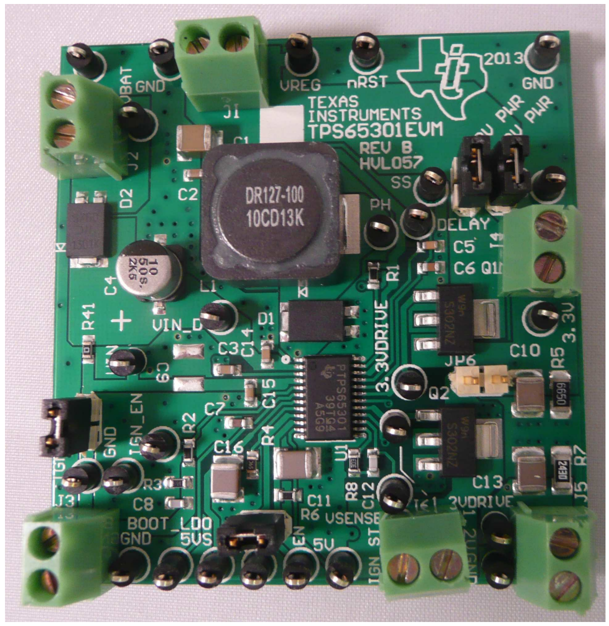

Figure 2. EVM Top Side

6 Board Assembly

Figure 3 shows the board assembly for the TPS65301EVM. The external components of the EVM operate the TPS65301 device.

Although the TPS65301 converter offers high efficiency, it dissipates power. The PowerPAD™ package offers an exposed thermal pad to enhance thermal performance. This pad must be soldered to the copper landing on the PCB for optimal performance. The PCB provides 2-oz copper planes on the top and bottom of the board to dissipate heat.

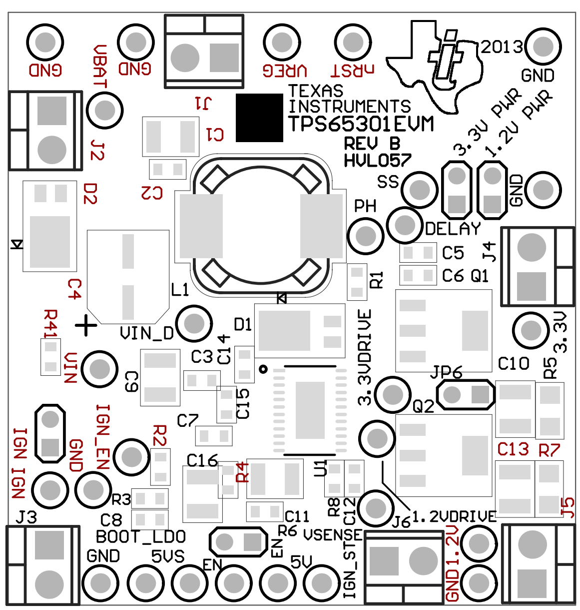

Figure 3. Top-Side Assembly Layer

7 Bill of Materials

Designator	Quantity	Description	Manufacturer	Part Number
PCB	1	Size 52.96 × 50.80 × 1,5 mm	Any	HVL057
C9	0	Uninstalled CAP1210	Uninstalled	CAP_0603 (UN)
C1	1	Capacitor, SMT, 1210, ceramic,100 µF,16V,20%,X5R	TAIYO YUDEN	EMK325ABJ107MM
C10, C11, C13, C16	4	Capacitor, SMT,1210, ceramic,2.2 µF,100V,10%,X7R	KEMET	C1210C225K1RAC
C2, C3, C14, C15	4	Capacitor, SMT,0603, ceramic,50V,10%,0.1 µF,X7R	PANASONIC	ECJ-1VB1H104K
C5	1	Capacitor, SMT,0603, ceramic,0.01 µF,100V,5%,X7R	KEMET	C0603C103J1RAC
C7	1	Capacitor, SMT,0603, ceramic,1.0 µF,16V,10%,X5R	KEMET	C0603C105K4PAC
C8	1	Capacitor, SMT,0603, ceramic,0.001 µF,50V,5%,X7R	KEMET	C0603C102J5RAC
C6	1	Capacitor, SMT,0603, ceramic,10%_25V_0.033 µF	MURATA	GRM39X7R333K025A
C12	1	Capacitor, SMT,0603, ceramic,470pF,5%,50V,C0G(NP0)	KEMET	C0603C472J5RAC
C4	1	Capacitor aluminum elec, 10 µF, 50 V, 20%, SMD	PANASONIC	EEE-1HA100WAR
D1, D2	2	Diode, Schottky, 7 A, 60 V	DIODES INC	PDS760-13
J1, J2, J3, J4, J5, J6	6	TBLK_6A_2x3.5mm_Terminal, 2 pin, 6 A, 3,5 mm	OnShore technology Inc.	ED555/2DS
JP2, JP3, JP4, JP5, JP6	5	Header, THU, 1 × 2, 2,54 mm	Sullins	PEC02SAAN
L1	1	Festinduktoren 10 µH 11.2 A 0.0172 Ω	Coiltronics	DR127-100-R
Q1, Q2	2	20 V, 5.8 A NPN low VCEsat (BISS) transistor	NXP	PBSS302NZ
R1, R2	2	Resistor, SMT, 0603, 1%, 1/10 W, 30.1K	VISHAY	CRCW06033012F
R4	1	Resistor, SMT, 0603, 1%, 1/10W, 40.2K	VISHAY	CRCW06034022F
R6	1	Resistor, SMT, 0603, 1%, 1/10 W, 27.4K	VISHAY	CRCW06032742F
R41	1	Resistor, SMT, 0603,1/10 W, 0 Ω	VISHAY	CRCW0603000Z
R8	1	Resistor, SMT, 0603, 5%, 1/10 W, 30K	PANASONIC	ERJ-3GSYJ303
R3	1	Resistor, SMT, 0603, 1%, 1/10 W, 6.04K	VISHAY	CRCW06036041F
R5	1	Resistor, SMT, 1206, 1%, ¼ W, 665 Ω	VISHAY	CRCW12066650F
R7	1	Resistor, SMT, 1206, 1%, ¼ W, 243 Ω	VISHAY	CRCW12062430F
TP1-TP27	27	Testpoint mini , 040'D black, Glass Beaded Test Point	Keystone	5001
U1	1	DUT,SMT,PWP,R-PDSO-G24, 0,65 mm LS, 7,9 × 6,6 × 1,2 mm, Thermal Pad	TI	TPS65301QPWPRQ1

EVALUATION BOARD/KIT/MODULE (EVM) ADDITIONAL TERMS

Texas Instruments (TI) provides the enclosed Evaluation Board/Kit/Module (EVM) under the following conditions:

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit www.ti.com/esh or contact TI.

No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which such TI products or services might be or are used. TI currently deals with a variety of customers for products, and therefore our arrangement with the user is not exclusive. TI assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein.

REGULATORY COMPLIANCE INFORMATION

As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

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

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

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.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-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.

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.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

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.

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.

【Important Notice for Users of EVMs for RF Products in Japan】

This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product 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 this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

Texas Instruments Japan Limited
(address) 24-1, Nishi-Shinjuku 6 chome, Shinjuku-ku, Tokyo, Japan

http://www.tij.co.jp

【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】

本開発キットは技術基準適合証明を受けておりません。

本製品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
http://www.tij.co.jp

EVALUATION BOARD/KIT/MODULE (EVM) WARNINGS, RESTRICTIONS AND DISCLAIMERS

For Feasibility Evaluation Only, in Laboratory/Development Environments. Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure 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.
3. Since the EVM is not a completed product, it may not meet all applicable regulatory and safety compliance standards (such as UL, CSA, VDE, CE, RoHS and WEEE) which may normally be associated with similar items. You assume full responsibility to determine and/or assure compliance with any such standards and related certifications as may be applicable. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM’s electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI’s recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to 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 use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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