LP2951EVM

Contents

List of Figures

List of Tables

1 Introduction

The Texas Instruments LP2951EVM helps evaluate the operation and performance of the LP2951 family of LDOs. The LP2951 family can accommodate a wide input supply-voltage range of up to 30 V.

2 HW Description

This section describes the hardware of the LP2951EVM.

2.1 LP2951 Device

The LP2951EVM comes populated with LP2951-50-Q1 in the SON package. However, this EVM can be used to evaluate the SOIC package LP2951 device as well. Figure 1 shows the EVM populated with the SON package and the pads for the SOIC package on the board. Table 1 shows all LP2951 part numbers and packages that are compatible with the LP2951EVM.

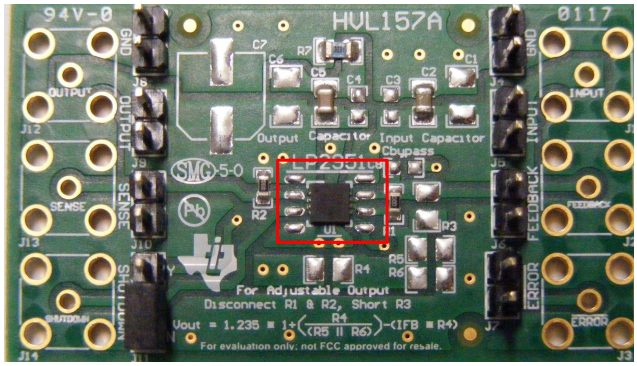

Figure 1. EVM With SON Package and SOIC Pads

Table 1. Compatible Parts and Packages for LP2951EVM

Part Number	Packages
LP2951	SOIC (D)
LP2951-30	SOIC (D)
LP2951-33	SOIC (D), SON (DRG)
LP2951-33-Q1	SON (DRG)
LP2951-50	SOIC (D), SON (DRG)
LP2951-50-Q1	SOIC (D), SON (DRG)
LP2951-N	SOIC (D)

2.2 Input Capacitors

Capacitors C_1-C_3 are all capacitors routed to the input of the LP2951 device to ground. C_2 comes populated on the board, and has a value of 1 µF. C_1 and C_3 are pads that allow for additional input capacitors to be put on the board and can accommodate different capacitor sizes.

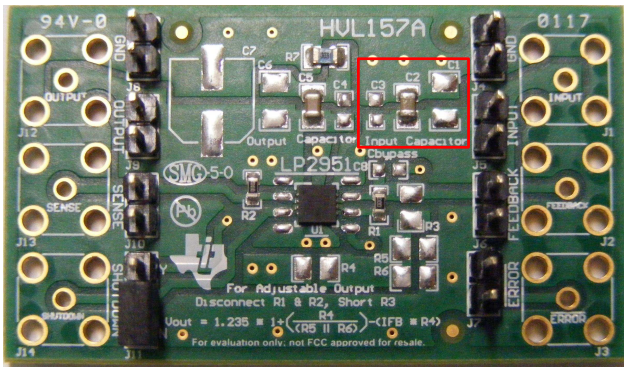

Figure 2. Input Capacitors C_1-C_3

2.3 Output Capacitors

Capacitors C_4-C_7 are all capacitors routed to the Output pin. C_4-C_6 are ceramic caps routed in series with a 1-Ω resistor, R_7, from the output to ground. This series resistance helps stabilize the internal amplifier of the LP2951 device. See the LP2951 or LP2951-N data sheet for the recommended series resistance when using a ceramic output capacitor. C_5 comes populated on the board and has a value of 2.2 µF. C_4 and C_6 are pads that allow for additional output capacitors to be put on the board and can accommodate different capacitor sizes. C_7 is meant for an electrolytic capacitor. It is routed directly from the output to ground with no series resistance, but still functionally the same as C_4-C_6. Electrolytic Capacitors do not require an external series resistance as the internal ESR of an electrolytic is typically enough to keep the device stable.

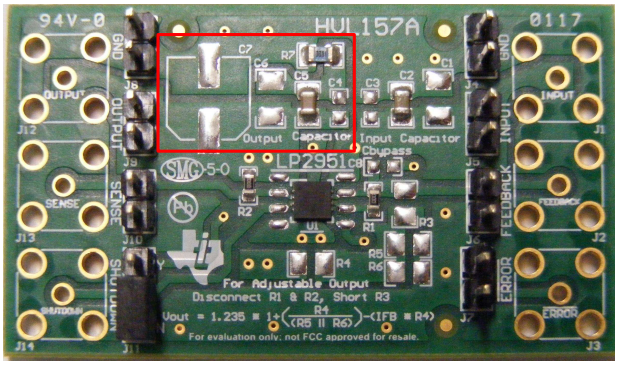

Figure 3. Output Capacitors C_4-C_7

2.4 Bypass Capacitor

Capacitor C_8 is meant to give additional stability to the internal amplifier of the LP2951 device by placing additional capacitance between the Output and the Feedback pins. Stray capacitance to the LP2951 Feedback pin can cause instability. This may especially be a problem when using high value external resistors to set the output voltage. To fix this problem, populate C_8 with a 100-pF capacitor and increase the output capacitor to at least 3.3 µF. See the LP2951 and LP2951-N data sheets for more information regarding the Cbypass.

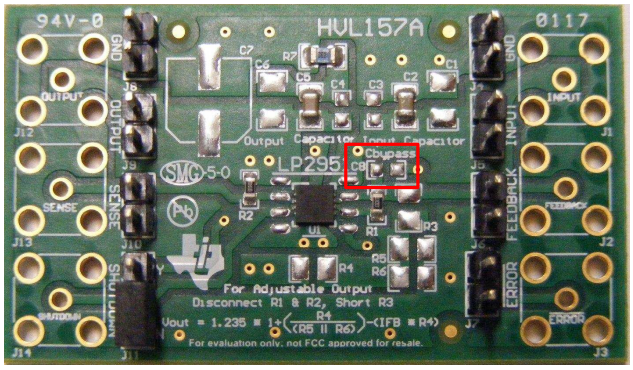

Figure 4. Location for Bypass Capacitor C_8

2.5 Fixed Output Voltage Resistors

Resistors R_1 and R_2 are 0-Ω resistors that keep the output in the fixed output voltage mode when populated. R_1 connects the Feedback pin to the V_{TAP} pin, while R_2 connects the Sense pin and the Output pin.

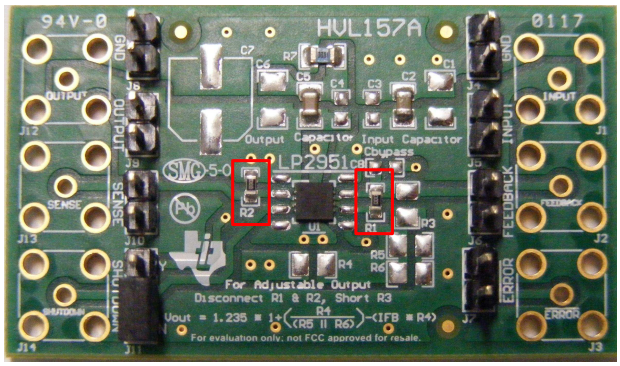

Figure 5. R_1 and R_2 Used to Set Fixed Voltage Mode on EVM

2.6 Adjustable Output Voltage Resistors

Resistors R_3-R_6 can be populated to set a desired output voltage. To do so, resistors R_1 and R_2 must first be removed. Resistors R_4-R_6 form a voltage divider and can be populated with values based on the desired output voltage by following the equation on the EVM. R_3 must be populated with a 0-Ω resistor to short the Feedback pin of the device to the voltage divider of R_4-R_6. See Section 3.2.2 for additional information regarding setting an adjustable output voltage.

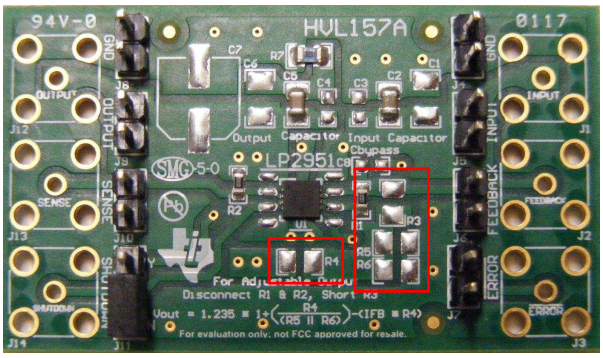

Figure 6. Resistors R_3-R_6 Used to Set Output Voltage in Adjustable Voltage Mode

3 Setup

These sections describe the jumpers and connectors on the EVM as well as how to properly connect, setup, and use the LP2951EVM.

3.1 Input/Output Connectors and Jumper Description

NOTE: Connectors J1-J3 and J12-J14 are blank SMB connectors. These can be populated, or wires can be soldered directly to them. The middle connection of the connector is the signal, while the four edge connections are all ground.

3.1.1 J5 - Input

Input for power. Connect supply to this connector.

3.1.2 J6- Feedback

Determines the output voltage. Connected to V_{TAP} through R_1 with standard setup.

3.1.3 J7 - ERROR

Error output connector. This active low output determines if the output voltage is within 6% of its expected value.

3.1.4 J4/J8 - GND

Return path connectors.

3.1.5 J9 - Output

Regulated output voltage connectors.

3.1.6 J10 - Sense

Output voltage sensing connectors.

3.1.7 J11 - Shutdown

Device shutdown connectors. By shorting the middle pin of J11 to the pin labeled as N, the device remains active. If the middle pin of J11 is shorted to the pin labeled Y, the device will shutdown. See Table 2 for shutdown jumper position connection.

Table 2. Shutdown Jumper Position Versus Output

Jumper Position	Output
N	Enabled
Y	Disabled

3.2 Operating Modes

There are two operating modes of the LP2951EVM. Either fixed voltage operation mode, which is what the EVM is set to out of the packaging, or adjustable voltage mode which the designer can enable.

3.2.1 Fixed Output Voltage Mode

This is the standard way the EVM is populated out of the packaging. For this operation mode the 0-Ω resistors R_1 and R_2 must be populated. Resistor R_1 shorts the Feedback pin to the Shutdown pin, while R_2 shorts the Sense pin to the Output pin. This mode utilizes an internal resistor divider which sets the voltage of the output to a fixed level. The LP2951 device populated on the EVM has an output of 5 V.

3.2.2 Adjustable Output Voltage Mode

To enable the adjustable voltage mode, the resistors R_1 and R_2 must be removed. Resistors R_4-R_6 must be populated with specific values based on the desired output voltage, while R3 is populated with a 0-Ω resistor.

The complete equation for the output voltage is:

$$V_{out} = V_{REF} * 1 + \left(\frac{R_4}{R_5 || R_6}\right) + I_{FB} R_4 \quad (1)$$

where

- V_{REF} is the nominal 1.235-V reference voltage and I_{FB} is the Feedback pin bias current, nominally –20 nA

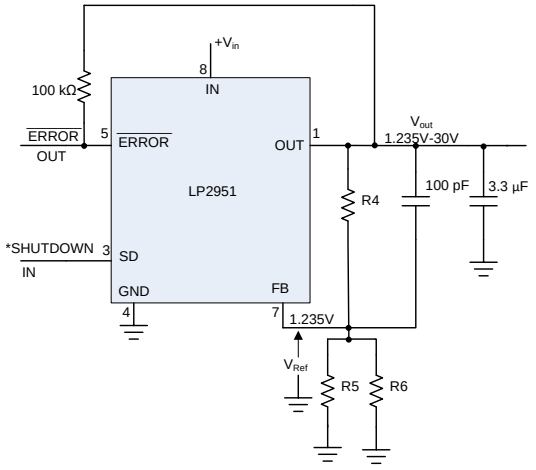

Figure 7. LP2951 Adjustable Output Voltage Block Diagram

Figure 7 shows the LP2951 device setup in adjustable output voltage mode. The minimum recommended load current of 1 µA forces an upper limit of 1.2 MΩ on the value of R_5 in parallel with R_6, if the regulator must work with no load (a condition often found in CMOS in standby). I_{FB} produces a 2% typical error in V_{OUT} which may be eliminated at room temperature by trimming R_4. For better accuracy, choosing a parallel combination of R_5 with R_6 = 100 kΩ reduces this error to 0.17% while increasing the resistor program current to 12 µA. Because the LP2951 typically draws 60 µA at no load with pin 2 open-circuited, this is a small price to pay. Figure 8 shows how the LP2951EVM looks set up in adjustable voltage mode.

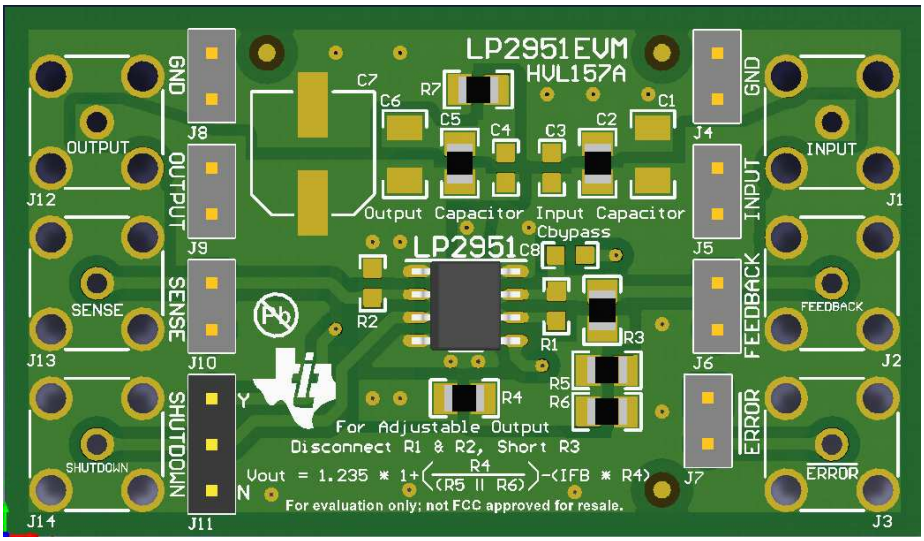

Figure 8. EVM With Adjustable Mode Resistors Populated

3.3 Equipment Connection

- Set power supply to desired input voltage. Verify that the supply is off. Connect positive voltage lead from supply to the input J5 header. Connect the ground lead from the power supply to GND J4/J8 header.
- Connect desired loading device from Output J9 header to GND J4/J8 header.
- Verify that J11 has the Shutdown pin shorted to the pin labeled N.

3.4 Operation

- Turn on the power supply.
- Vary respective load and input voltage, as necessary, for test purposes.

4 Thermal Guidelines and Layout Recommendations

Thermal management is a key component in the design of any power converter and is especially important when the power dissipation in the LDO is high. Use Equation 2 to approximate the maximum power dissipation for the particular ambient temperature:

$$T_J = T_A + P_D * \theta_{JA} \quad (2)$$

where

- Where T_J is the junction temperature, T_A is the ambient temperature
- P_D is the power dissipation in the device (Watts)
- θ_{JA} is the thermal resistance from junction to ambient

All temperatures are in degrees Celsius. The maximum operating junction temperature, T_J, must not be allowed to exceed 125 °C. The layout design must be copper trace. Plane areas smartly, as thermal sinks, to prevent T_J to exceed the absolute maximum rating under all temperature conditions and voltage conditions across the part.

5 Board Layout

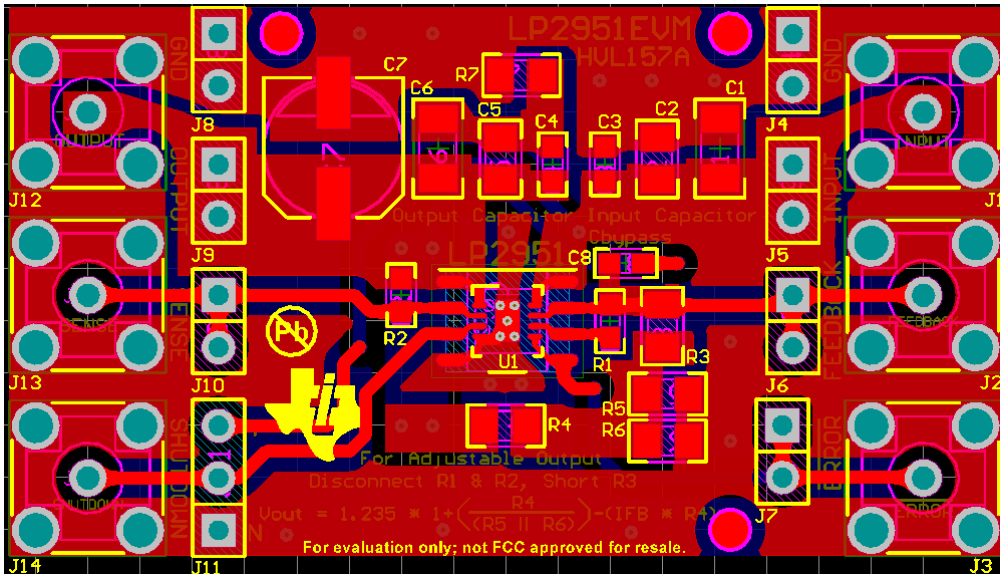

Figure 9. LP2951EVM Board Layout

6 EVM Schematic

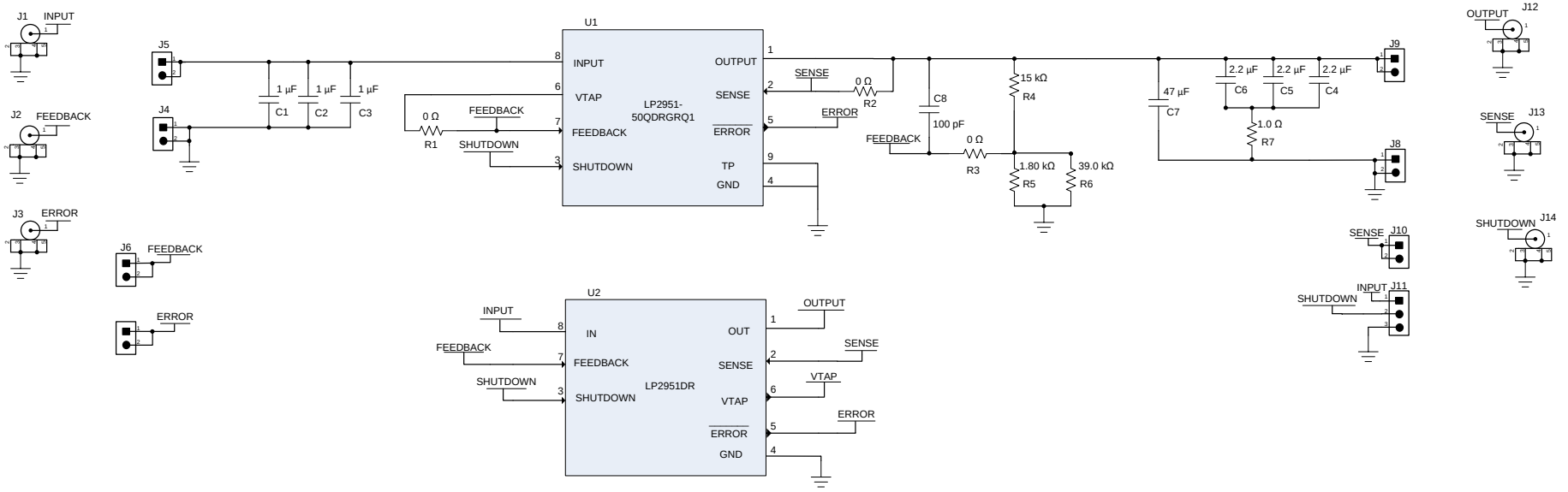

Figure 10. LP2951EVM Schematic

7 Bill of Materials

Table 3. Bill of Materials

Designator	Quantity	Value	Description	Package reference	Part Number	Manufacturer
!PCB1	1		Printed Circuit Board		HVL157	Any
C2	1	1 µF	CAP, CERM, 1 µF, 50 V, +/- 10%, X7R, 0805	0805	GRM21BR71H105KA12L	MuRata
C5	1	2.2 µF	CAP, CERM, 2.2 µF, 50 V, +/- 10%, X5R, 0805	0805	C2012X5R1H225K125AB	TDK
J4, J5, J6, J7, J8, J9, J10	7		Header, 100mil, 2x1, Gold, TH	Header, 100mil, 2x1, TH	HTSW-102-07-G-S	Samtec
J11	1		Header, 100mil, 3x1, Gold, TH	PBC03SAAN	PBC03SAAN	Sullins Connector Solutions
R1,R2	2	0	RES, 0, 5%, 0.1 W, 0603	0603	ERJ-3GEY0R00V	Panasonic
R7	1	1.0	RES, 1.0, 5%, 0.125 W, 0805	0805	ERJ-6GEYJ1R0V	Panasonic
U1	1		Fixed Regulator with 1 to 30 V Input and 1.2 to 30 V Output, -40 to 125 degC, 8-Pin SON (DRG), Green (RoHS & no Sb/Br)	DRG0008A	LP2951-50QDRGRQ1	Texas Instruments
C1	0	1 µF	CAP, CERM, 1 µF, 50 V, +/- 10%, X7R, 1206	1206	C3216X7R1H105K	TDK
C3	0	1 µF	CAP, CERM, 1 µF, 35 V, +/- 10%, X7R, 0603	0603	C1608X7R1V105K080AC	TDK
C4	0	2.2 µF	CAP, CERM, 2.2 µF, 35 V, +/- 10%, X5R, 0603	0603	GRM188R6YA225KA12D	MuRata
C6	0	2.2 µF	CAP, CERM, 2.2 µF, 50 V, +/- 10%, X7R, 1206	1206	GRM31CR71H225KA88L	MuRata
C7	0	47 µF	CAP, AL, 47 µF, 35 V, +/- 20%, 1 ohm, SMD	F55	EMVY350ADA470MF55G	Chemi-Con
C8	0	100 pF	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	GRM1885C1H101JA01D	MuRata
J1, J2, J3, J12, J13, J14	0		Connector, SMB,Vertical RCP 0-4GHz, 50 ohm, TH	236x293x236mil	131-3701-261	Emerson Network Power
R3	0	0	RES, 0, 5%, 0.125 W, 0805	0805	ERJ-6GEY0R00V	Panasonic
R4	0	15.0 k	RES, 15.0 k, 0.1%, 0.125 W, 0805	0805	RG2012P-153-B-T5	Susumu Co Ltd
R5	0	1.80 k	RES, 1.80 k, 0.1%, 0.125 W, 0805	0805	RG2012P-182-B-T5	Susumu Co Ltd
R6	0	39.0 k	RES, 39.0 k, 0.1%, 0.125 W, 0805	0805	RG2012P-393-B-T5	Susumu Co Ltd
U2	0		Adjustable Micropower Voltage Regulator with Shutdown, D0008A (SOIC-8)	D0008A	LP2951DR	Texas Instruments

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (March 2017) to A Revision	Page
• Changed C7 value from 4.7 µF to 47 µF in Bill of Materials table	11

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   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 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 do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

3 *Regulatory Notices:*

   3.1 *United States*

      3.1.1 *Notice applicable to EVMs not FCC-Approved:*

      FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

      3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

      CAUTION

      This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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

      FCC Interference Statement for Class A EVM devices

      NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【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

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

   6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS 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 EPIDEMIC FAILURE WARRANTY OR 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 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, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

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. 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 OR THE USE OF THE EVMS , 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 TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM 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 FOR TI DESIGN INFORMATION AND RESOURCES

Texas Instruments Incorporated ('TI") technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources 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.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your non-compliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include; without limitation, TI's standard terms for semiconductor products http://www.ti.com/sc/docs/stdterms.htm), evaluation modules, and samples (http://www.ti.com/sc/docs/sampterms.htm).

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