User's Guide

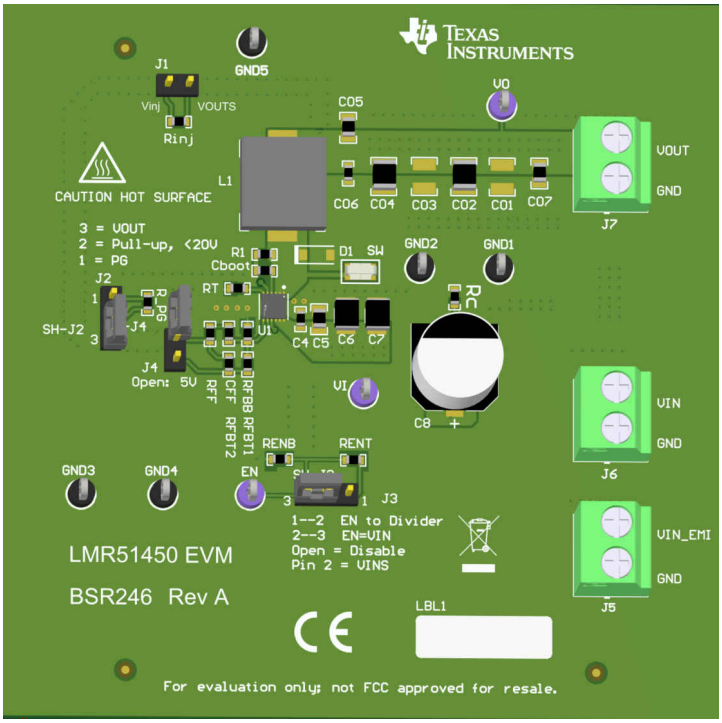
LMR51450 EVM

ABSTRACT

The LMR51450 evaluation module (EVM) is designed to help customers evaluate the performance of the LMR51450 synchronous step-down voltage converter. This EVM implements the LMR51450 in a 12-pin WSON package, as shown in Table 1-1. The EVM is capable of delivering 5 V or 3.3 V output voltage and up to 5 A load current with high efficiency and output accuracy in a very small solution size. The EVM provides multiple power connectors and test points. It also provides a good layout example, which is optimized for EMI and thermal performance.

Table 1-1. Device and Package Configurations

CONVERTER	IC	PACKAGE
U1	LMR51450	12-pin WSON package 3.0 mm × 3.0 mm × 0.75 mm



LMR51450EVM Front

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1 Introduction

1.1 LMR51450 Synchronous Step-Down Voltage Converter

The LMR51450 device is an easy-to-use synchronous step-down DC/DC converter capable of driving up to 5 A of load current from a supply voltage ranging from 4 V to 36 V. The LMR51450 provides very high efficiency and output accuracy in a very small solution size. The LMR51450 is capable of delivering 5 A of load current and is peak current mode controlled. The following are additional features that provide both flexible and easy-to-use solutions for a wide range of applications:

- Adjustable switching frequency
- FPWM variant (LMR51450FNDRRR)
- Power-good flag
- Precision enable

Automatic frequency foldback at light load improves efficiency over the entire load range. The device requires few external components and PFM variant integrates Spread Spectrum for optimal EMI. Protection features include the following:

- Thermal shutdown
- Input undervoltage lockout
- Cycle-by-cycle current limiting
- Hiccup short-circuit protection

The LMR51450 device is pin-to-pin compatible with the LMR51440 for easy output current scaling.

For a quick reference, Figure 1-1 shows the pin configuration of the LMR51450 and Figure 1-2 shows the simplified schematic. See the LMR51450 4-V to 36-V, 5-A, Synchronous Step-Down DC/DC Converter Data Sheet for more detailed feature descriptions and design guide.

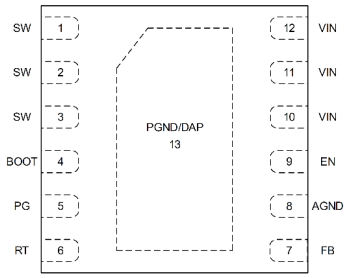

Figure 1-1. LMR51450 Pin Configuration (Top View)

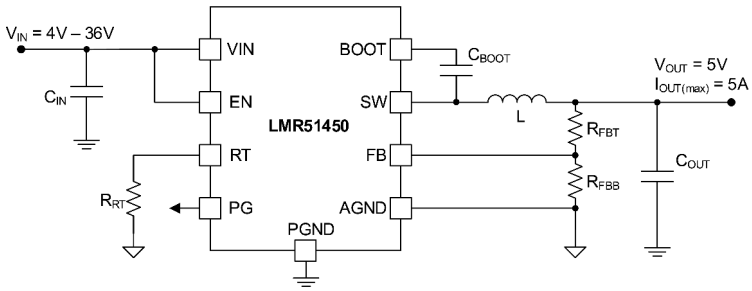

Figure 1-2. LMR51450 Schematic

1.2 LMR51450 Evaluation Module

The LMR51450 EVM has the board populated with the LMR51450SDRRR and limiting current to 5 A and comes with auto mode enabled.

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2 Quick Start

1. Connect the voltage supply between the VIN and GND connectors or between VIN_EMI and GND of J5 to include the on-board input filter in the input path. Use short and thick gauge wires to minimize inductance and IR drop. Note that sense points for V_{IN} and V_{OUT} are provided.
2. Connect the load of the converter between VOUT and GND connectors using short and thick wires.
3. Set the supply voltage at an appropriate level between 7 V to 36 V. The 7 V minimum ensures enough head room for V_{OUT} to equal 5 V at a 5-A load current. Set the current limit of the supply to an appropriate level to supply needed current and protection.
4. Turn on the power supply. With the default configuration, the EVM powers up and provides V_{OUT} = 5 V.
5. Monitor the output voltage with sense points. The maximum load current must be 5 A with the LMR51450. Note that the maximum output current need to derate if ambient temperature is high, especially if device is operated at higher frequency, for example, 1 MHz.

See Figure 2-1 for connector locations.

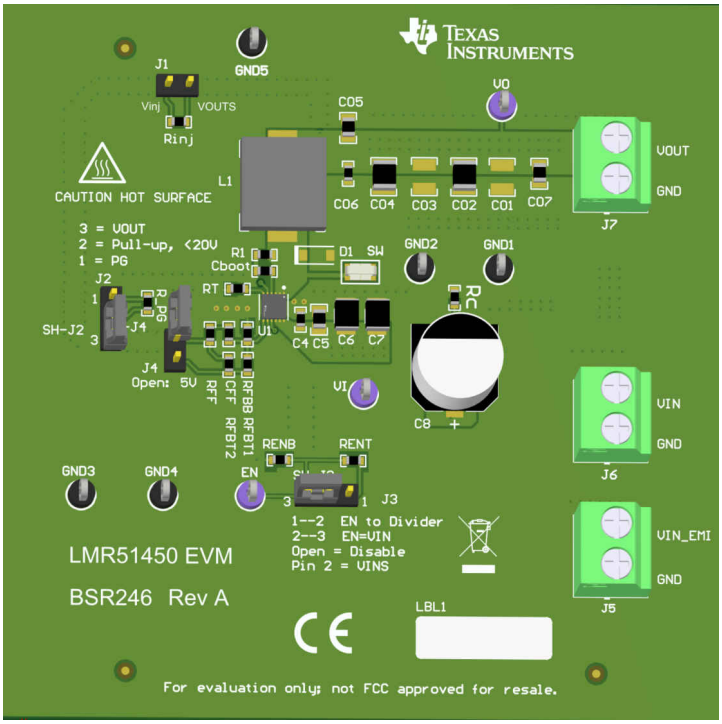

Figure 2-1. Top View of LMR51450 EVM

CAUTION

Caution Hot surface.
Contact may cause burns.
Do not touch.

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3 Detailed Descriptions

3.1 Connectors

This section describes the connectors on the EVM and how to properly connect, set up, and use the EVM. See Figure 2-1 for a top view of the EVM.

VOUT Output voltage of the converter

The VOUT connector connects to the power inductor and output capacitors. Connect the load between VOUT connector and the GND connector right next to it to provide load current. Connect the loading device to the board with short and thick wires to handle the large DC output current.

GND1-GND5 Ground of the converter

The GND is connected to the PGND and AGND pins of the device, as well as the ground of the input and output capacitors. The GND connections next to VIN, VIN_EMI, and VOUT connectors are meant for current return path for the supply voltage and load, respectively. Connectors are provided in pairs to allow easy and accurate sensing of voltages. Connect to supply and load grounds with short and thick wires. Other GND connectors are for signal measurement and probing.

VIN Input voltage to the converter

The VIN connector connects to the input capacitors and the VIN pins of the LMR51450. Connect the supply voltage from a power supply or a battery between VIN and GND connectors as power input to the device. The voltage range must be higher than 3.9 V for the device to start up. VIN higher than 6 V provides regulated 5-V output voltage. VIN must be no higher than 36 V to avoid damaging the device. After start-up, the device stays active until VIN drops below 3.4 V. The current limit on the supply must be high enough to provide the needed supply current. Otherwise, the supply voltage does not maintain the desired voltage. The supply voltage must be connected to the board with short and thick wires to handle the pulsing input current.

VIN_EMI Input voltage to input filter of the converter

LMR51450 EVM provides the option for the use of input filter. C1, C2 and L4 are placeholders for input filter networks to be populated. If the input filter is desired between the supply and the LMR51450, put C1, C2, and L4 on the board and connect the supply voltage between VIN_EMI and GND_EMI connectors. The supply voltage must be connected to the board with short and thick wires to handle pulsing input current. The output of the filter is connected to VIN, which is connected to the VIN pins of the LMR51450 and the input capacitors.

GND_EMI Ground return for the input filter

This connector is the current return path for the supply connected to VIN_EMI. This connector provides a short-loop connection to the input filter capacitors to best filter the conducted noise generated from the PCB. Use VIN_EMI and GND_EMI connection if input filter is used and conducted EMI test is desired.

EN To monitor the EN pin or input EN control signal

This test point is used to monitor the voltage on the device EN pin. By default, the EN pin is connected to Vin.

PG To monitor the PGOOD pin

The PGOOD flag indicates whether the output voltage is within the regulation band. The PGOOD pin of the device is an open-drain output and it is pulled up to V_{OUT} on this board through a pullup resistor. This flag is high impedance when the output voltage is in regulation.

VO This connector is provided to allow V_{OUT} to be measured more accurately.

VI This connector is provided to allow V_{IN} to be measured more accurately.

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3.2 Jumpers

This section describes the jumpers on the EVM. See Figure 2-1 for a top view of the EVM.

J2 This jumper allows the PG pin to be pulled up through 16k ohm resistor to Vout.

J3 This jumper allows the selection of an adjustable input UVLO.

J4 This jumper allows the selection of output voltage to be 5 V or 3.3 V.

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4 Schematic

The bill of materials of the EVM is tabulated in *Bill or Materials* . In addition, Figure 4-1 shows the corresponding schematic.

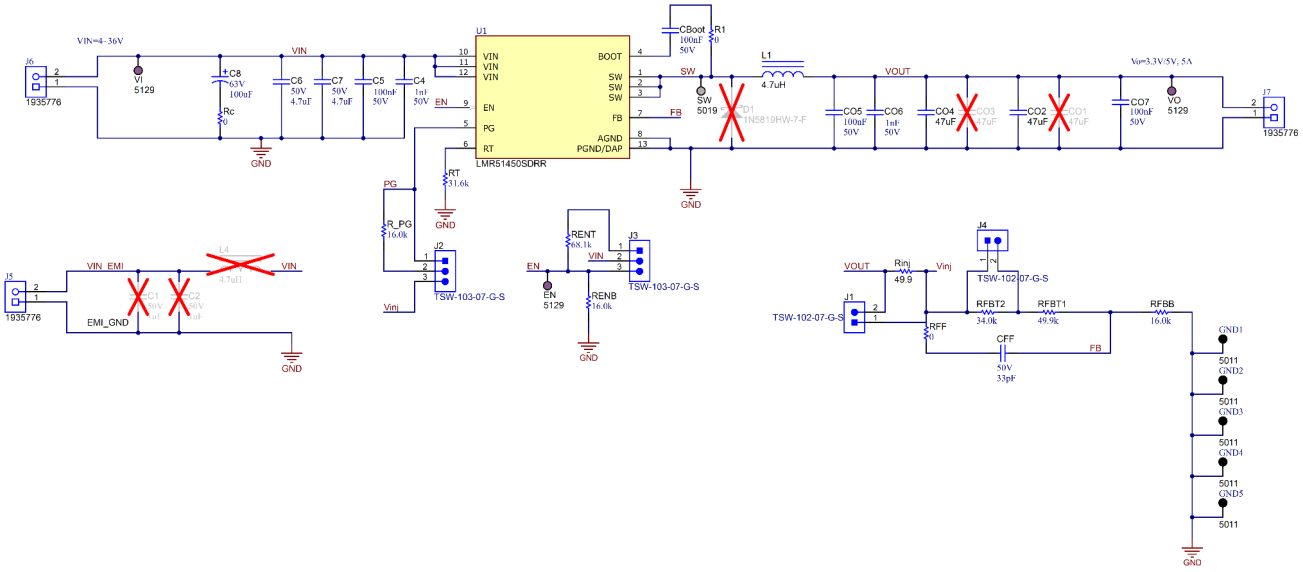

Figure 4-1. LMR51450 EVM Schematic

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5 Board Layout

Figure 5-1 through Figure 5-6 show the board layout for the LMR51450 EVM. The EVM offers resistors, capacitors, and test points to configure the following:

- Output voltage
- Precision enable
- Set frequency

The 12-pin WSON package offers a very small solution size. The PCB consists of a 4-layer design. There are 2-oz copper planes on the top and bottom and 1-oz copper mid-layer planes to dissipate heat with an array of thermal vias to connect to all four layers.

Test points have been provided for ease of use to connect the power supply and required load, and to monitor critical signals.

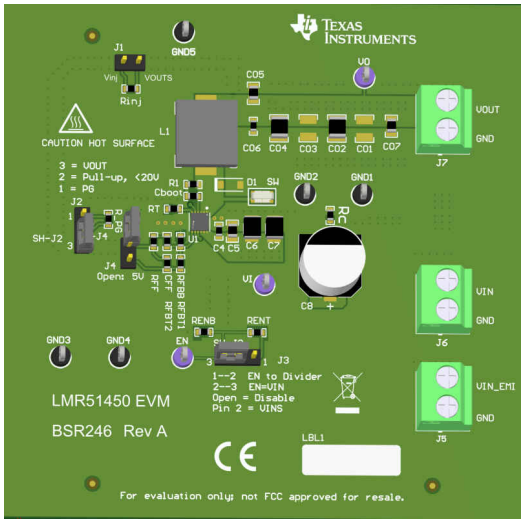

Figure 5-1. Top 3D View

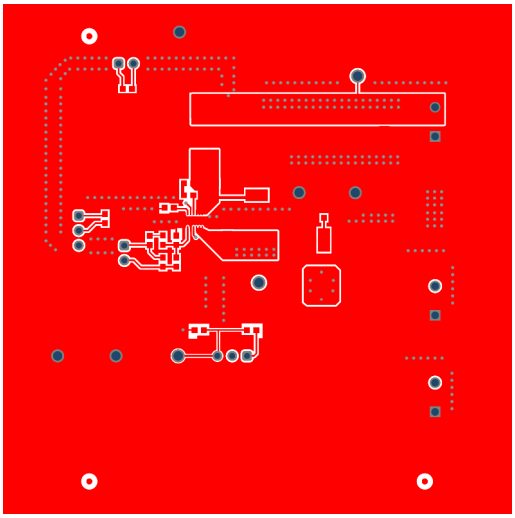

Figure 5-2. Top Layer

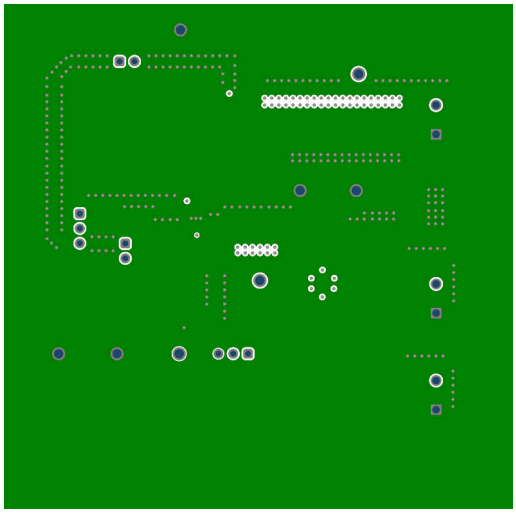

Figure 5-3. Signal Layer 1 - Ground Plane

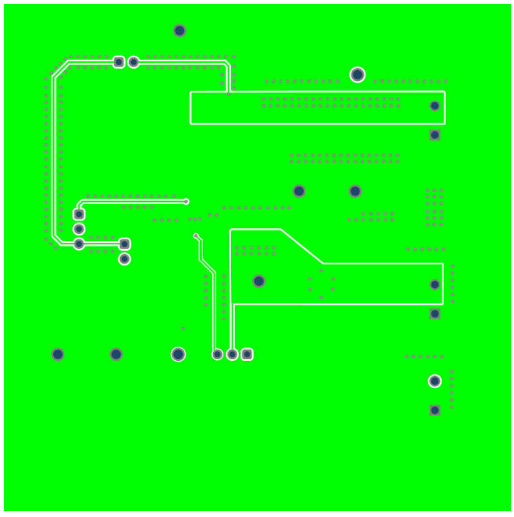

Figure 5-4. Signal Layer 2 - Routing

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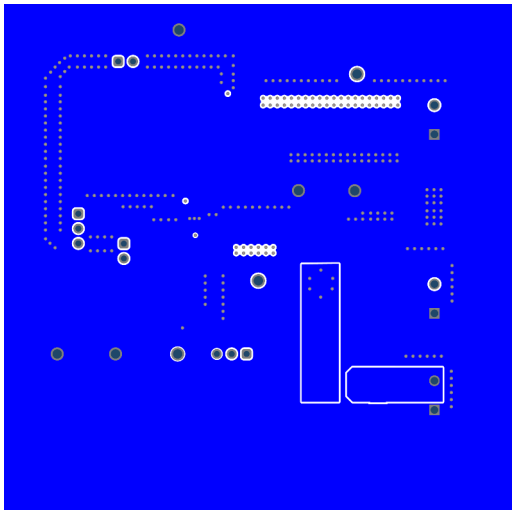

Figure 5-5. Bottom Layer

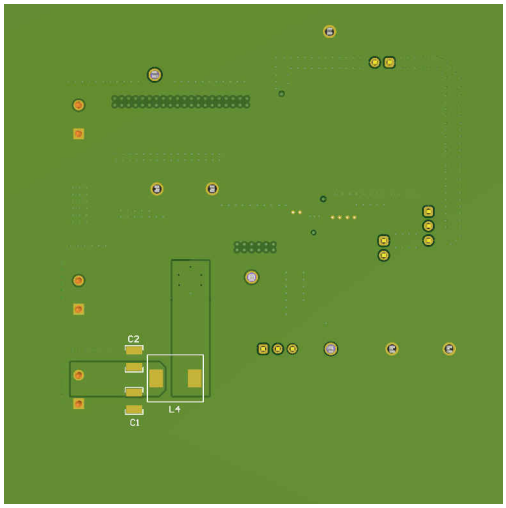

Figure 5-6. Bottom 3D view

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6 Bill of Materials

The bill of material is shown in Table 6-1 for the LMR51450 EVM.

Table 6-1. LMR51450 EVM Bill of Materials

DESIGNATOR	QTY	DESCRIPTION	PART NUMBER	MANUFACTURER
PCB	1	Printed Circuit Board	BSR246 Rev A	Any
C4, CO6	2	CAP, CERM, 1000 pF, 50 V,+/- 10%, X7R, 0603	885012206083	Wurth Elektronik
C5, CO5, CO7	3	CAP, CERM, 0.1 uF, 50 V, +/- 5%, X7R, 0805	08055C104JAT2A	AVX
C6, C7	2	CAP, CERM, 4.7 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1210	CGA6P3X7R1H475K250AB	TDK
C8	1	CAP, Aluminum Polymer, 100 uF, 63 V, +/- 20%, 0.024 ohm, SMD, 2-Leads, Dia 10.5 mm, Pin Spacing 8 mm SMD	PCR1J101MCL1GS	Nichicon
CBoot	1	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	06035C104KAT2A	AVX
CFF	1	CAP, CERM, 33 pF, 50 V, +/- 5%, C0G/NP0, 0603	06035A330JAT2A	AVX
CO2, CO4	2	CAP, CERM, 47 uF, 10 V, +/- 20%, X7R, 1210	GRM32ER71A476ME15L	MuRata
EN, VI, VO	3	Test Point, Multipurpose, Purple, TH	5129	Keystone Electronics
GND1, GND2, GND3, GND4, GND5	5	Test Point, Multipurpose, Black, TH	5011	Keystone Electronics
J1, J4	2	Header, 100mil, 2x1, Gold, TH	TSW-102-07-G-S	Samtec
J2, J3	2	Header, 100mil, 3x1, Gold, TH	TSW-103-07-G-S	Samtec
J5, J6, J7	3	Terminal Block, 2x1, 5 mm, Green, TH	1935776	Phoenix Contact
L1	1	Inductor, Shielded Drum Core, Powdered Iron, 4.7 uH, 7 A, 0.015 ohm, SMD	74437368047	Wurth Elektronik
LBL1	1	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	THT-14-423-10	Brady
R1, Rc, RFF	3	RES, 0, 5%, 0.1 W, 0603	RC0603JR-070RL	Yageo, Yageo America
R_PG, RENB, RFBB	3	RES, 16.0 k, 1%, 0.1 W, 0603	RC0603FR-0716KL	Yageo
RENT	1	RES, 68.1 k, 1%, 0.1 W, 0603	RC0603FR-0768K1L	Yageo
RFBT1	1	RES, 49.9 k, 1%, 0.1 W, 0603	RC0603FR-0749K9L	Yageo
RFBT2	1	RES, 34.0 k, 1%, 0.1 W, 0603	RC0603FR-0734KL	Yageo
Rinj	1	RES, 49.9, 1%, 0.1 W, 0603	RC0603FR-0749R9L	Yageo
RT	1	RES, 31.6 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060331K6FKEA	Vishay-Dale
SH-J2, SH-J3, SH-J4	3	Shunt, 100mil, Tin plated, Black	SNT-100-BK-T-H	Samtec
SW	1	Test Point, Miniature, SMT	5019	Keystone
U1	1	36-V, 5-A Synchronous Step-down Converter	LMR51450SDRR	Texas Instruments
C1, C2	0	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1210	CGA6L2X7R1H105K160AA	TDK
CO1, CO3	0	CAP, CERM, 47 uF, 10 V, +/- 20%, X7R, 1210	GRM32ER71A476ME15L	MuRata
D1	0	Diode, Schottky, 40 V, 1 A, SOD-123	1N5819HW-7-F	Diodes Inc.

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7 Revision History

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

Changes from Revision E (October 2022) to Revision A (November 2022)	Page
• Updated the EVM front image from Rev. E to Rev. A	1
• Updated the descriptions to match the Rev. A design	5
• Updated the schematic	7
• Updated the Top 3D view	8
• Updated the Bill of Materials	10

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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.

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   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

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   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.

WARNING

Evaluation Kits 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 shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

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

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

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

CAUTION

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

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

FCC Interference Statement for Class A EVM devices

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

FCC Interference Statement for Class B EVM devices

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

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

3.2 *Canada*

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

Concerning EVMs Including Radio Transmitters:

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

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

Concernant les EVMs avec appareils radio:

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

Concerning EVMs Including Detachable Antennas:

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

Concernant les EVMs avec antennes détachables

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

3.3 *Japan*

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

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

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

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

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

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

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4 *EVM Use Restrictions and Warnings:*

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

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

4.3 *Safety-Related Warnings and Restrictions:*

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

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.

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