LM5150RUMEVM User's Guide

The LM5150RUMEVM evaluation module (EVM) is designed to supply a minimum voltage from a vehicle battery during cranking and provides the users with a fully functional boost converter to evaluate the LM5150 Wide VIN Automotive Low I_Q Boost Controller IC. The EVM requires minimum 5V at the output to start up properly. After the start-up, the input voltage can go down to 2.5V and can go up to 40V. The EVM produces minimum 8.5V at load current up to 2.94A. When the input/output voltage is high enough to guarantee minimum 8.5V at the output, external PMOS bypass switch turns on automatically to save power loss.

Contents

List of Figures

List of Tables

1 Features and Electrical Performance

- 2.5V to 40V input voltage range (5V is required at the output to start up. 6V input is sufficient to make the output voltage greater than 5V)
- 8.5V target output voltage when input voltage drops below the target.
- Up to 2.94A output current
- 440kHz typical switching frequency
- Automatic bypass switch control

Table 1. Electrical Performance Specifications

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
INPUT CHARACTERISTICS					
Input voltage		2.5 (6 V to start up)		40	V
Input current	I_{LOAD} = 2.94 A			12	A
OUTPUT CHARACTERISTICS					
Output regulation target	I_{LOAD} = 2.94 A	8.075	8.5	8.925	V
Output current				2.94	A
SYSTEM CHARACTERISTICS					
Switching frequency			440		kHz
Full load efficiency	V_{SUPPLY} = 2.5 V		82%		
	V_{SUPPLY} = 5 V		92%		

2 Test Points and Jumpers

2.1 Test Points

Table 2. Test Point Descriptions

TEST POINT NAME	DESCRIPTIONS
J6(+), J10(–)	Input voltage measure
J8(+), J9(–)	Output voltage measure
TP1	STATUS pin
TP2	Switching node (SW)
TP3	VOUT pin
TP4	COMP pin
TP5	PVCC pin
TP6	Analog ground (AGND)

2.2 Jumpers

Table 3. Jumper Description

JUMPER NAME	DESCRIPTIONS
J3(#1 – #2(GND))	Optional external dithering input (Default : OPEN)
J4(#1 – #2(GND))	SYNC input (Default : Short)
J5	(#1 – #2 short) Enable (#2 – #3 short) Disable

Table 4. VSET Setting

JUMPER 7	MODE	VOUT	ILOAD	MIN VIN	MAX VIN	
#1 - #2	Start-stop mode	10.5V	2.0A	2.5V	40V	
#3 - #4		8.5V	2.9A	2.5V	40V	Default setting
#5 - #6		7.5V	2.7A	2.5V	40V	
#7 - #8		6.8V	2.9A	2.5V	40V	
#9 - #10	Emergency-call mode	10.5V	2.0A	2.5V	40V	
#11 - #12		8.5V	2.9A	2.5V	40V	
#13 - #14		7.5V	2.7A	2.5V	40V	
#15 - #16		6.8V	2.9A	2.5V	40V	

3 Test Equipment

3.1 Power Supply

Power supply should be capable of 40V/20A, current monitoring and remote sensing.

3.2 Electronic Load

Electronic load should be capable of 40V/3A, Constant Current (CC) mode.

3.3 Meters

One current meter is required to measure input current accurately. Maximum current rating of the meter should be carefully considered. Input current can be as high as 17A at full load current and minimum input voltage. Input and output voltages are monitored by voltage meters which should be capable of monitoring up to 40V.

3.4 Oscilloscope

Oscilloscope and 10x probe with at least 20MHz bandwidth are recommended.

3.5 Cranking Simulator

Texas Instruments HVAL068A automotive cranking simulator or equivalent equipment.

4 Test Setup and Procedure

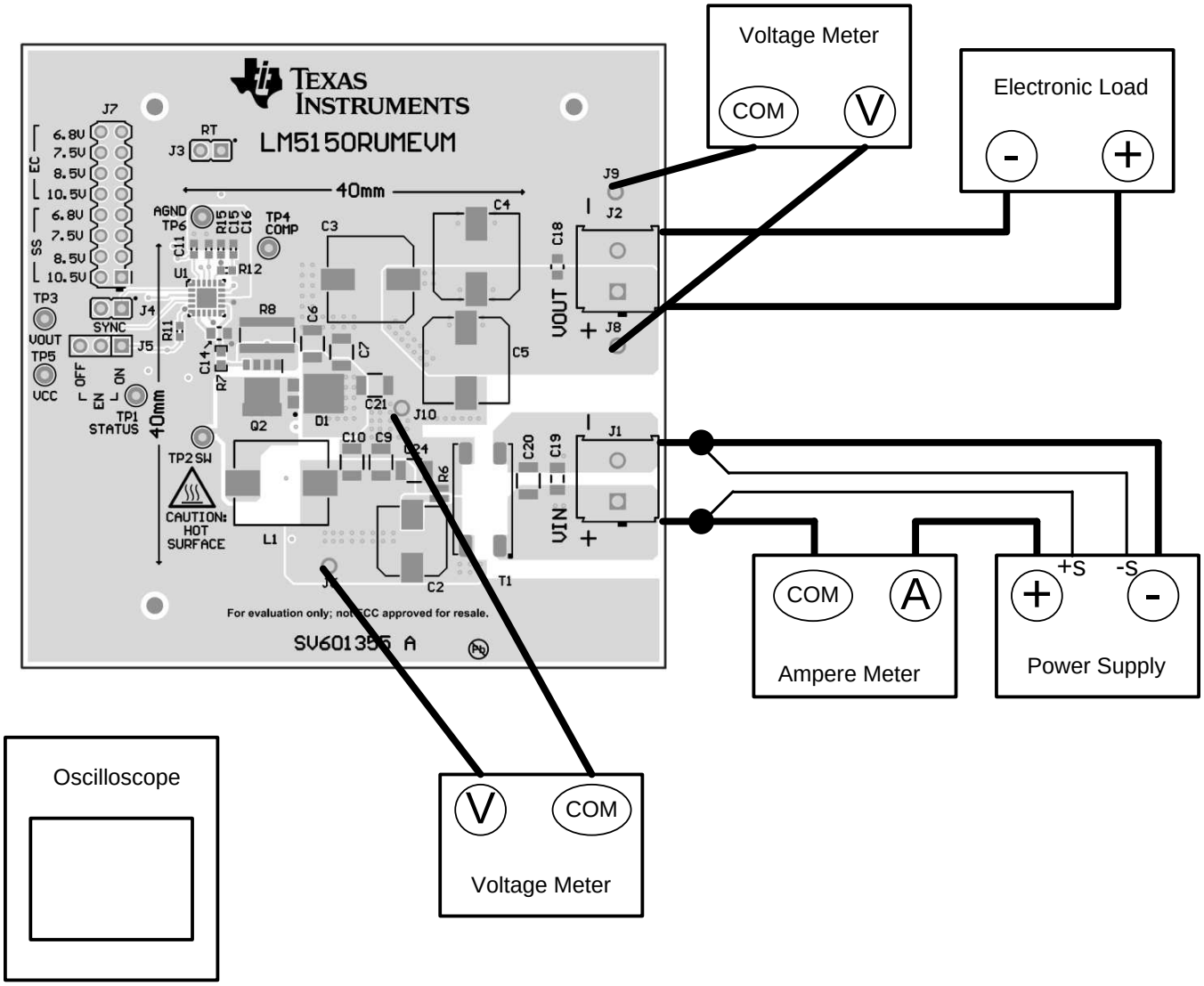

Figure 1. Standard Connection Diagram

4.1 Precaution & Wire Gauge

CAUTION:

Prolonged operation with low input at full power will cause heating of the MOSFET, the diode, the sense resistor and the inductor. It is recommended to use a fan with a minimum of 200LFM.

Board surface is hot. Do not touch. Contact may cause burns

Wire gauge for the input power supply should be 8 AWG minimum and no longer than 1 foot each for VIN and GND. Wire gauge for the output electronic load should be 14 AWG minimum and no longer than 1 foot each for VOUT and GND.

4.2 Test Setup

4.2.1 Power Supply

Connect the power supply's positive terminal (+) to 'A' terminal of ampere meter and negative terminal (-) to J1 negative terminal. Connect the power supply's positive remote sense terminal to J1 positive terminal and negative remote sense terminal to J1 negative terminal.

4.2.2 Meter

Connect 'COM' terminal of ampere meter to J1 positive terminal. Double check 'A' terminal is connected to the power supply's positive terminal. Voltage meter is used to measure input/output voltage. To measure input voltage, connect positive terminal (V) of the voltage meter to J6 and negative terminal (COM) of the voltage meter to J10. To measure output voltage, connect positive terminal (V) of the voltage meter to J8 and negative terminal (COM) of the voltage meter to J9.

4.2.3 Load

Connect electronic load's positive terminal (+) to J2 positive terminal and negative terminal (-) of the electronic load to J2 negative terminal.

4.2.4 Test Set-Up Using Cranking Simulator

The Texas Instruments HVAL068A automotive cranking simulator or the equivalent can be used to evaluate the performance during cranking. The simulator can generate three different types of cranking test pulses and supports up to 50W. For more detail information, refer to the *Automotive Cranking Simulator User's Guide* (SLVU984).

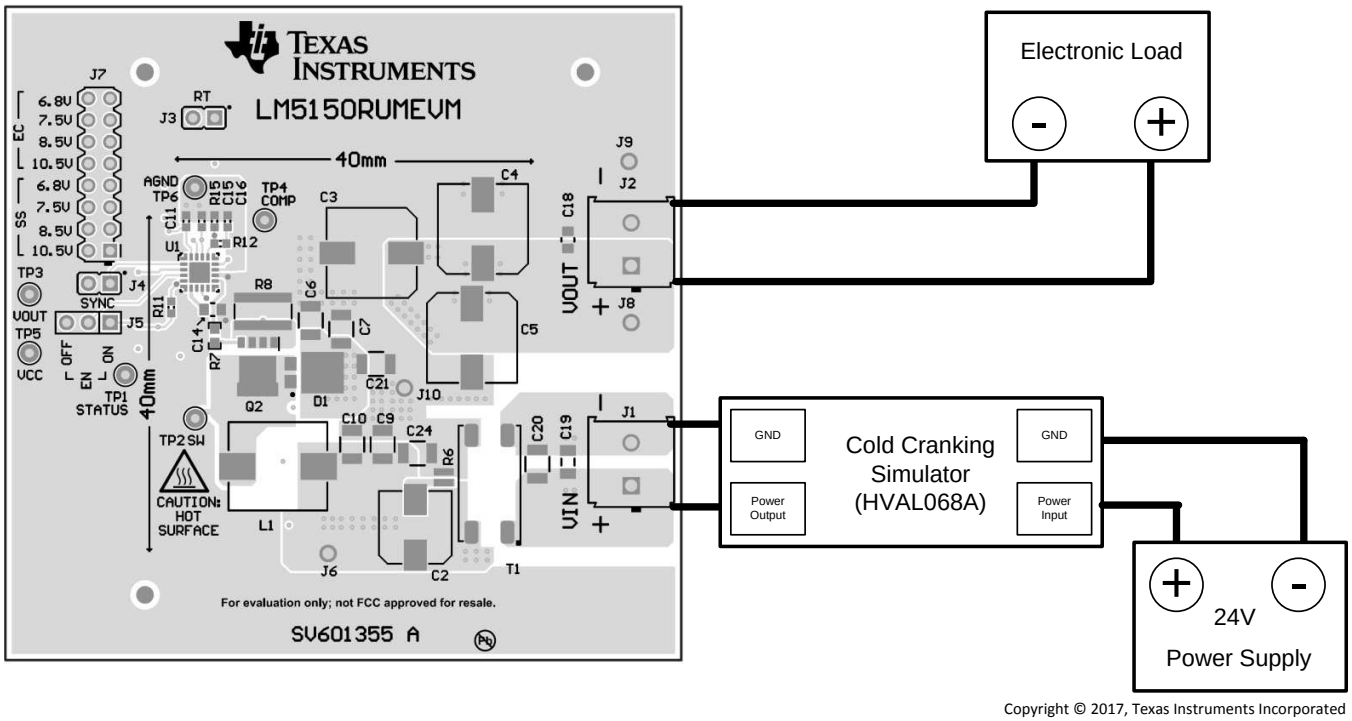

Figure 2. Cranking Simulator Connection Diagram

4.3 Quick Test Procedure

4.3.1 Start-Up

- Set load current to 0A in CC mode and turn on the electronic load
- Set power supply current limit to 20A
- Turn on the power supply and increase the supply voltage slowly up to 12V
- Increase the load current slowly up to 2.94A
- Decrease the power supply voltage down to 2.5V

4.3.2 Shutdown

- Turn off the load
- Decrease the input voltage down to 0V
- Turn on the electronic load and discharge output capacitor

5 Performance Curves

The following curves are presented for reference. The actual field data may differ from these curves. Actual performance data can be affected by measurement techniques, equipment setting and environmental variables.

5.1 Efficiency

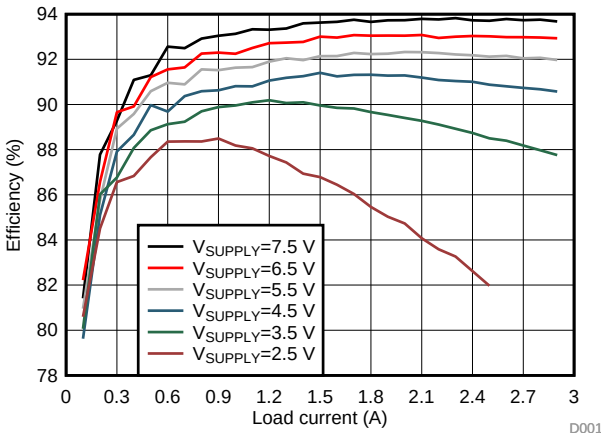

Figure 3. Efficiency

5.2 Clock Synchronization

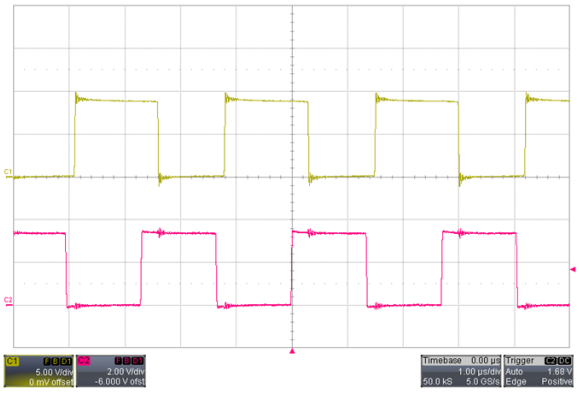

Figure 4. Clock Synchronization(C1:Switch node, C2:SYNC)

5.3 Performance During Cranking

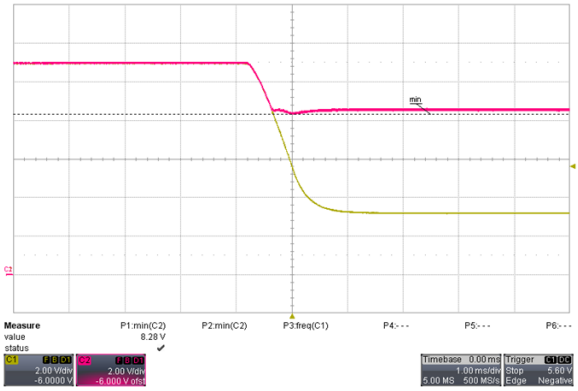

Figure 5. Cold-Cranking Using Cranking Simulator(C1:V_{SUPPLY}, C2: V_{LOAD})

5.4 Light Load Skip Cycle Operation

8V input, No load

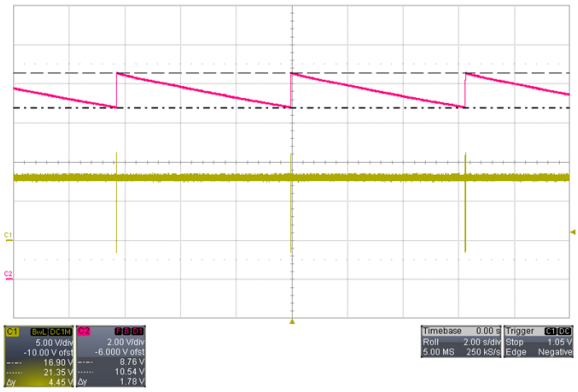

Figure 6. No Load Skip Cycle Operation(C1:Switch Node, C2: V_{LOAD})

5.5 Load Transient

5V input, full load to half load transition

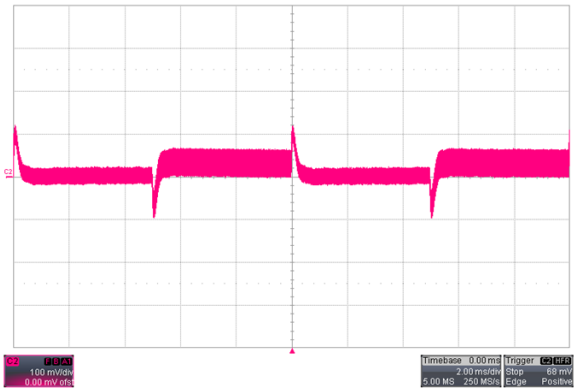

Figure 7. Load Transient(C2:V_{LOAD} AC-coupled)

5.6 Conducted EMI

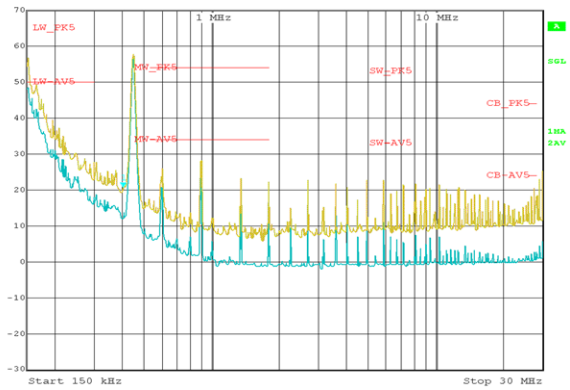

Figure 8. Conducted EMI Test Result 150kHz to 30MHz

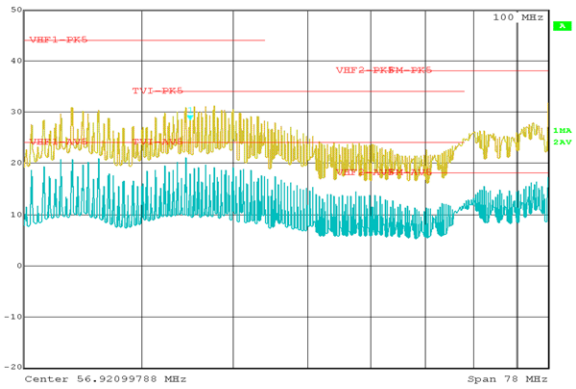

Figure 9. Conducted EMI Test Result 30MHz to 108MHz

6 EVM Schematic

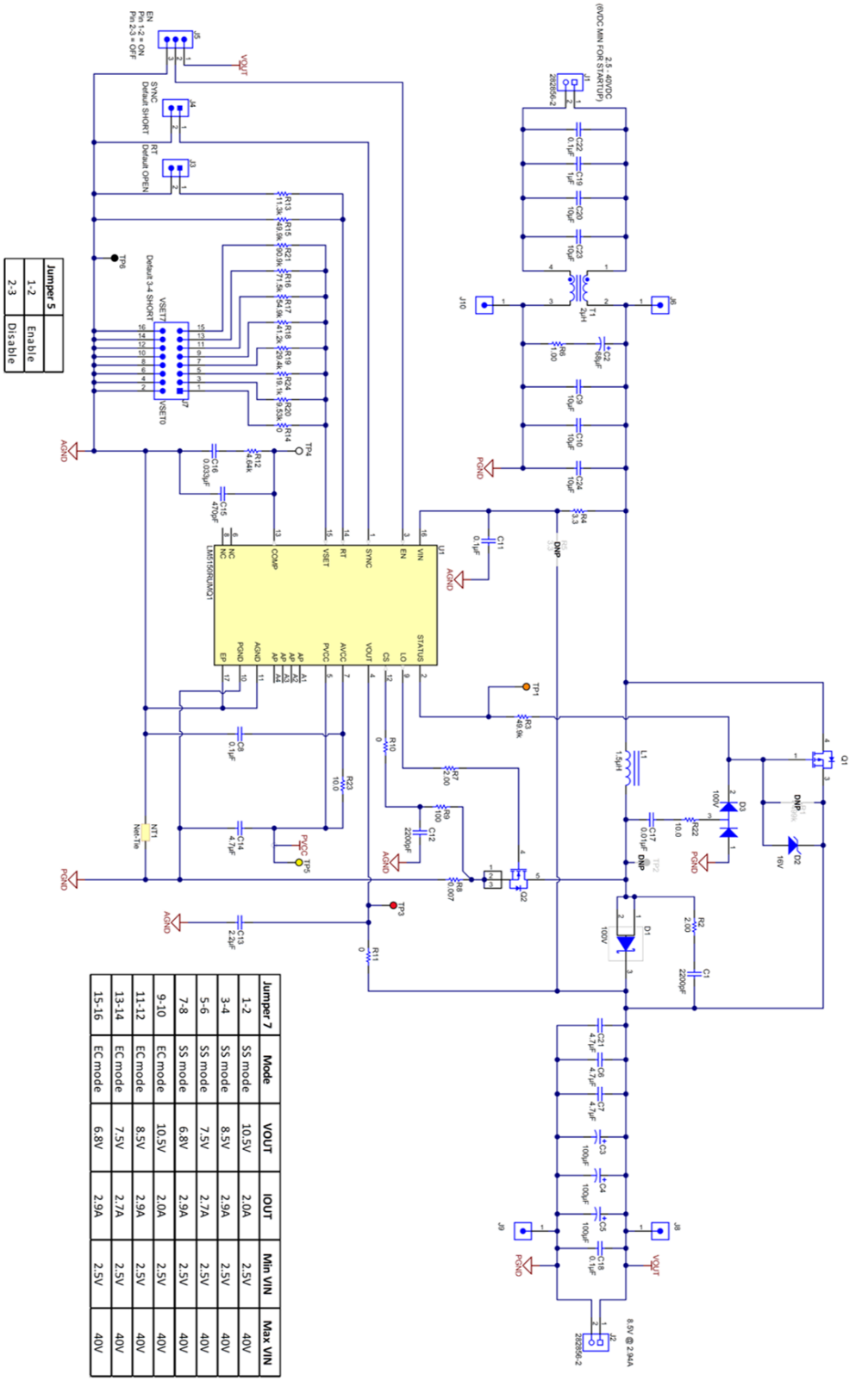

Figure 10. EVM Schematic

7 Layout

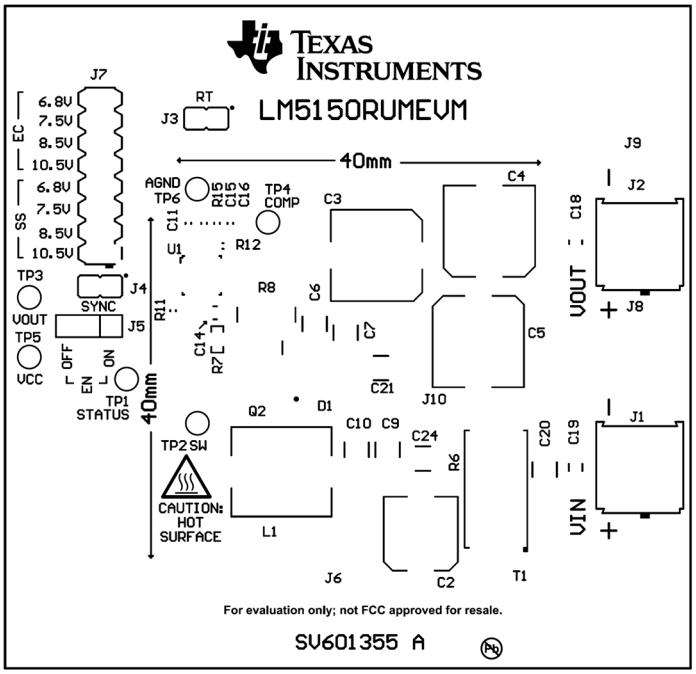

Figure 11. Top Silk (Top View)

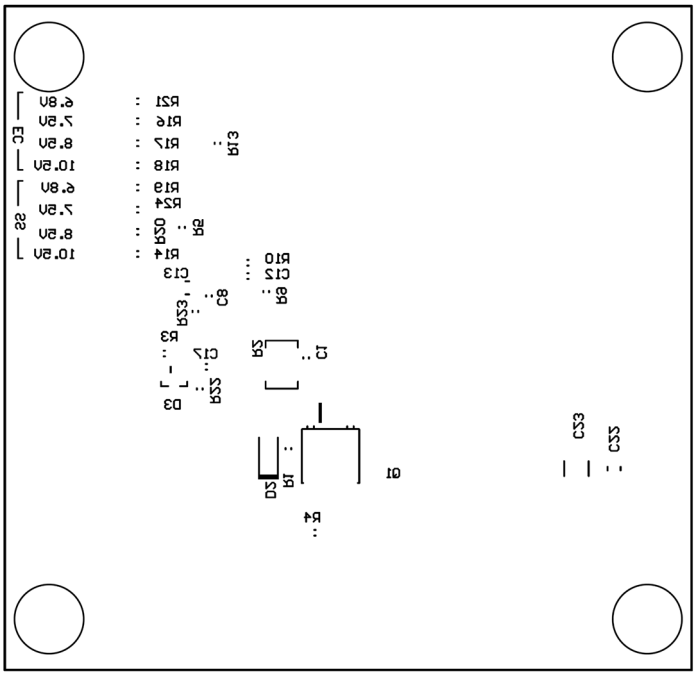

Figure 12. Bottom Silk (X-Ray View)

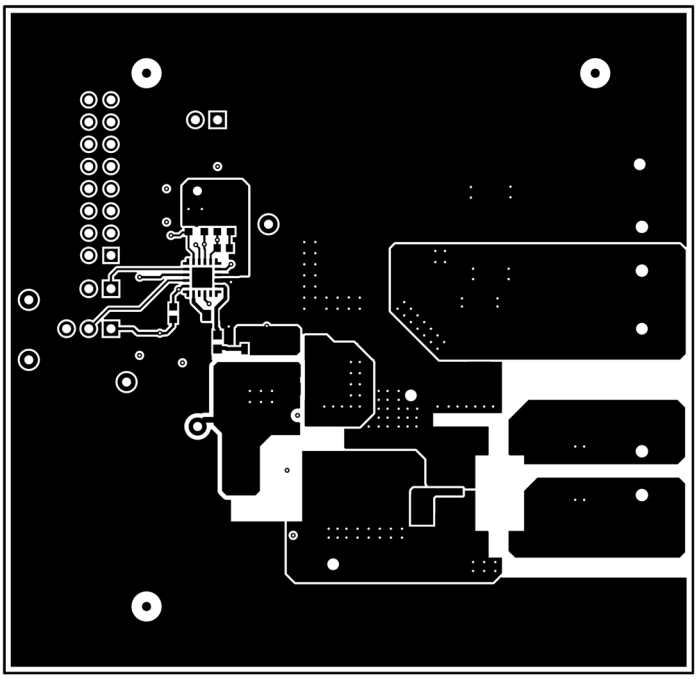

Figure 13. Top Copper (Top View)

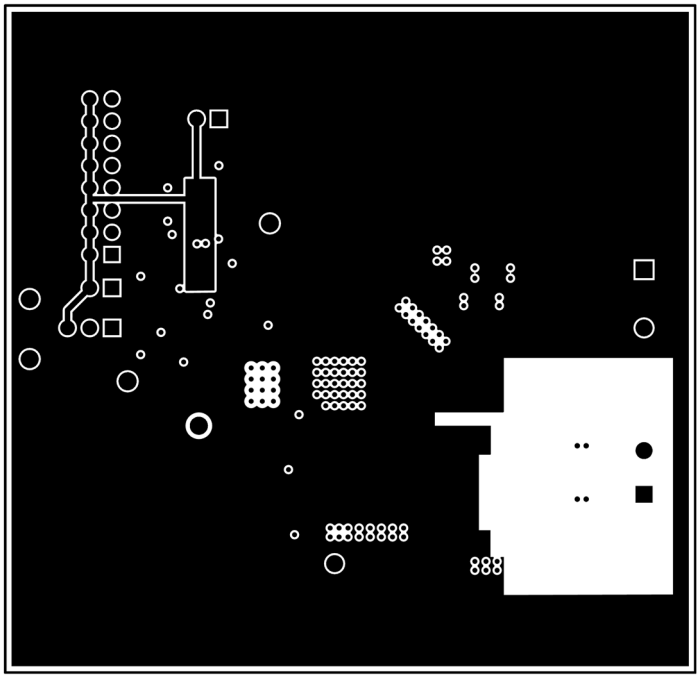

Figure 14. Mid1 Copper (X-Ray View)

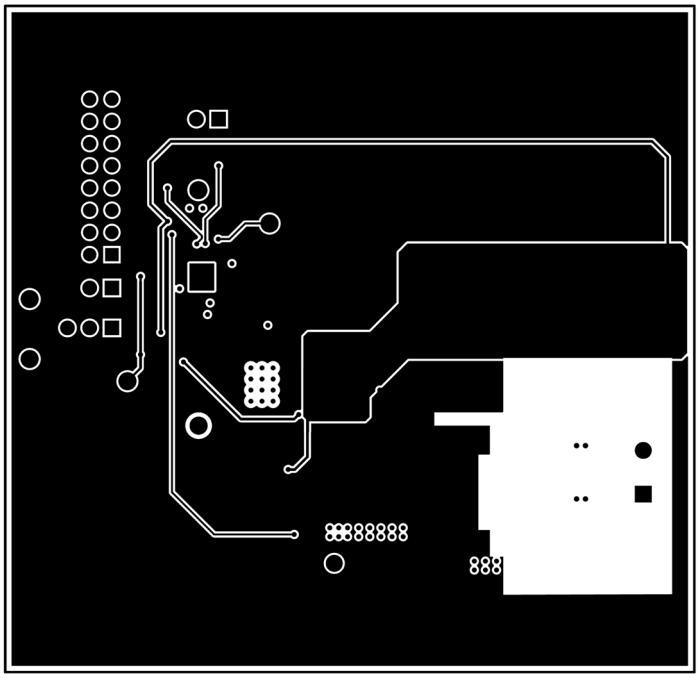

Figure 15. Mid2 Copper (X-Ray View)

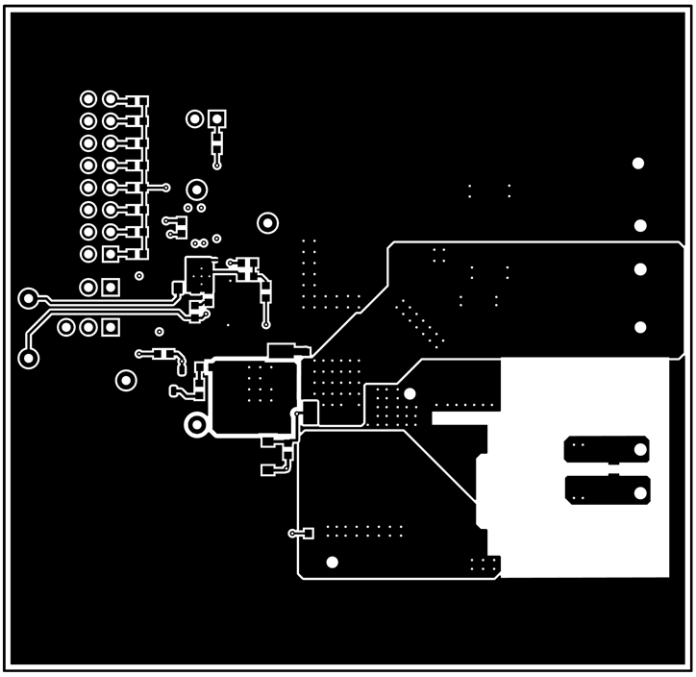

Figure 16. Bottom Copper (X-Ray View)

8 Bill of Materials

Table 5. Bill of Materials

DESIGNATOR	DESCRIPTION	PART NUMBER	MANUFACTURER
C1, C12	CAP, CERM, 2200 pF, 50 V, +/- 10%, X7R, 0603	GRM188R71H222KA01D	MuRata
C2	CAP ALUM POLY HYB 68UF 50V SMD	EEH-ZC1H680P	Panasonic
C3, C4, C5	CAP, Polymer Hybrid, 100 µF, 50 V, +/- 20%, 28 ohm, 10x10 SMD	EEHZC1H101P	Panasonic
C6, C7, C21	CAP, CERM, 4.7 µF, 50 V, +/- 10%, X7R, 1210	C3225X7R1H475K250AB	TDK
C8, C11	CAP, CERM, 0.1 µF, 100 V, +/- 10%, X7S, 0603	C1608X7S2A104K080AB	TDK
C9, C10, C20, C23, C24	CAP, CERM, 10 µF, 50 V, +/- 10%, X7R, 1210	GRM32ER71H106KA12L	MuRata
C13	CAP, CERM, 2.2 µF, 50 V, +/- 10%, X7R, 0805	C2012X7R1H225K125AC	TDK
C14	CAP, CERM, 4.7 µF, 16 V, +/- 10%, X7R, 0805	GRM21BR71C475KA73L	MuRata
C15	CAP, CERM, 470 pF, 50 V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0603	GCM1885C1H471JA16D	MuRata
C16	CAP, CERM, 0.033 µF, 25 V, +/- 10%, X7R, 0603	GRM188R71E333KA01D	MuRata
C17	CAP, CERM, 0.01 µF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	CGA3E2X7R2A103K080AA	TDK
C18, C22	CAP, CERM, 0.1 µF, 100 V, +/- 10%, X7R, 0805	C2012X7R2A104K125AA	TDK
C19	CAP, CERM, 1 µF, 50 V, +/- 10%, X7R, 1206	GRM31MR71H105KA88L	MuRata
D1	Diode, Schottky, 100 V, 20 A, AEC-Q101, TO-277A	FSV20100V	Fairchild
D2	Diode, Zener, 6.2 V, 500 mW, AEC-Q101, SOD-123	DDZ16Q-7	Diodes
D3	Diode, Standard Recovery Rectifier, 100 V, 0.715 A, AEC-Q101, SOT-23	SBAV99LT1G	ON
H1, H2, H3, H4	Bumpon, Cylindrical, 0.312 X 0.200, Black	SJ61A1	3M
J1, J2	Therminal Block, 5 mm, 2-pole, Tin, TH	282856-2	TE Connectivity
J3, J4	Header, 100mil, 2x1, Gold, TH	PBC02SAAN	Sullins Connector
J5	Header, 100mil, 3x1, Gold, TH	PBC03SAAN	Sullins Connector
J6, J8, J9, J10	TEST POINT SLOTTED .118", TH	1040	Keystone
J7	Header, 2.54mm, 8x2, Gold, TH	PRPC008DAAN-RC	Sullins Connector
L1	FIXED IND 1.5UH 16A 4.6 MOHM SMD	PA4342.152NLT	Pulse Electronics
Q1	MOSFET P-CH 40V 90A TO252-3	IPD90P04P405ATMA1	Infineon
Q2	MOSFET, N-CH, 60 V, 100 A, AEC-Q101, SOT669	BUK9Y7R2-60E,115	NXP
R2	RES, 2.00, 1%, 0.5 W, AEC-Q200 Grade 0, 1210	ERJ-14BQF2R0U	Panasonic
R3, R15	RES, 49.9 k, 1%, 0.1 W, 0603	CRCW060349K9FKEA	Vishay-Dale
R4	RES, 3.3, 5%, 0.1 W, 0603	CRCW06033R30JNEA	Vishay-Dale
R6	RES, 1.00, 1%, 0.5 W, 0805 Wide	LTR10EVHFL1R00	Rohm
R7	RES, 2.00, 1%, 0.1 W, 0603	CRCW06032R00FKEA	Vishay-Dale
R8	RES, 0.007, 1%, 3 W, 2512 WIDE	KRL6432E-M-R007-F-T1	Susumu

Table 5. Bill of Materials (continued)

DESIGNATOR	DESCRIPTION	PART NUMBER	MANUFACTURER
R9	RES, 100, 1%, 0.1 W, 0603	CRCW0603100RFKEA	Vishay-Dale
R10, R11, R14	RES, 0, 5%, 0.1 W, 0603	CRCW06030000Z0EA	Vishay-Dale
R12	RES, 4.64 k, 1%, 0.1 W, 0603	CRCW06034K64FKEA	Vishay-Dale
R13	RES, 11.3 k, 1%, 0.1 W, 0603	CRCW060311K3FKEA	Vishay-Dale
R16	RES, 71.5 k, 1%, 0.1 W, 0603	CRCW060371K5FKEA	Vishay-Dale
R17	RES, 54.9 k, 1%, 0.1 W, 0603	CRCW060354K9FKEA	Vishay-Dale
R18	RES, 41.2 k, 1%, 0.1 W, 0603	CRCW060341K2FKEA	Vishay-Dale
R19	RES, 29.4 k, 1%, 0.1 W, 0603	CRCW060329K4FKEA	Vishay-Dale
R20	RES, 9.53 k, 1%, 0.1 W, 0603	CRCW06039K53FKEA	Vishay-Dale
R21	RES, 90.9 k, 1%, 0.1 W, 0603	CRCW060390K9FKEA	Vishay-Dale
R22, R23	RES, 10.0, 1%, 0.1 W, 0603	CRCW060310R0FKEA	Vishay-Dale
R24	RES, 19.1 k, 1%, 0.1 W, 0603	CRCW060319K1FKEA	Vishay-Dale
SH-J1, SH-J2, SH-J3	Shunt, 100mil, Gold plated, Black, 1x2	382811-6	AMP
T1	Coupled inductor, 2 µH, A, 1.8 ohm, SMD	PLT10HH101150PNL	MuRata
TP1	Test Point, Miniature, Orange, TH	5003	Keystone
TP3	Test Point, Miniature, Red, TH	5000	Keystone
TP4	Test Point, Miniature, White, TH	5002	Keystone
TP5	Test Point, Miniature, Yellow, TH	5004	Keystone
TP6	Test Point, Miniature, Black, TH	5001	Keystone
U1	Wide VIN Automotive Low IQ Boost Controller	LM5150-Q1	Texas Instruments

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.

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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。
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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。

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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)*:

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.

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