LM5150RUMHDEVM EVM User's Guide

The LM5150RUMHDEVM evaluation module (EVM) is designed to supply a minimum voltage from a vehicle battery during cranking and demonstrate a high density layout design example using 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 3.2V and can go up to 40V. The EVM produces minimum 6.8V at load current up to 1.1A (continuous) 2.2A (peak). When the input/output voltage is high enough to guarantee minimum 6.8V at the output, the device automatically goes into low I_Q standby mode.

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1 Features and Electrical Performance

- 3.2V 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)
- 6.8V target output voltage when input voltage drops below the target.

- Up to 2.2A output current (1.1A continuous, 2.2A peak(2sec))
- 2.2MHz typical switching frequency

Table 1. Electrical Performance Specifications

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
INPUT CHARACTERISTICS					
Input voltage		3.2 (6 V to start up)		40	V
Input current	I_{LOAD} = 2.2 A		7		A
OUTPUT CHARACTERISTICS					
Output regulation target	I_{LOAD} = 2.2 A	6.46	6.8	7.14	V
Output DC current	Peak, 2sec			2.2	A
	Continuous			1.1	A
SYSTEM CHARACTERISTICS					
Switching frequency			2.2		MHz
Full load efficiency (during switching)	V_{SUPPLY} = 3.2 V		81%		
	V_{SUPPLY} = 5 V		86%		

2 Test Points

2.1 Test Points

Table 2. Test Point Descriptions

TEST POINT NAME	DESCRIPTION
J1(+), J4(–)	Input voltage supply
J2(+), J3(–)	Load connection

3 Test Equipment

3.1 Power Supply

Power supply should be capable of 40V/14A, 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 10A at full load current and minimum input voltage.

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

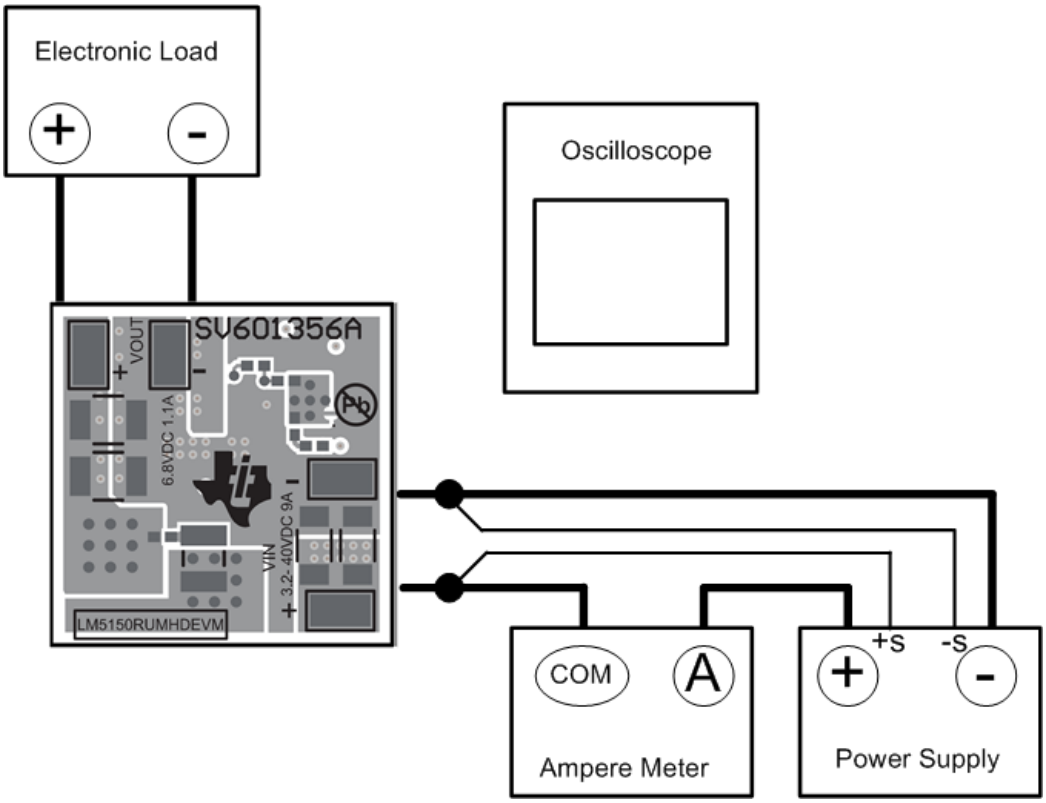

Figure 1. Standard Connection Diagram

4.1 Precaution and Wire Gauge

CAUTION:

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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, soldered to the EVM and no longer than 1 foot each for VIN and GND. Wire gauge for the output electronic load should be 14 AWG minimum, soldered to the EVM 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 J4. Connect the power supply's positive remote sense terminal to J1 and negative remote sense terminal to J4.

4.2.2 Meter

Connect 'COM' terminal of ampere meter to J1. Double check 'A' terminal is connected to the power supply's positive terminal.

4.2.3 Load

Connect electronic load's positive terminal (+) to J2 and negative terminal (-) of the electronic load to J3.

4.2.4 Test Setup 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, please refer Automotive Cranking Simulator User's Guide SLVU984.

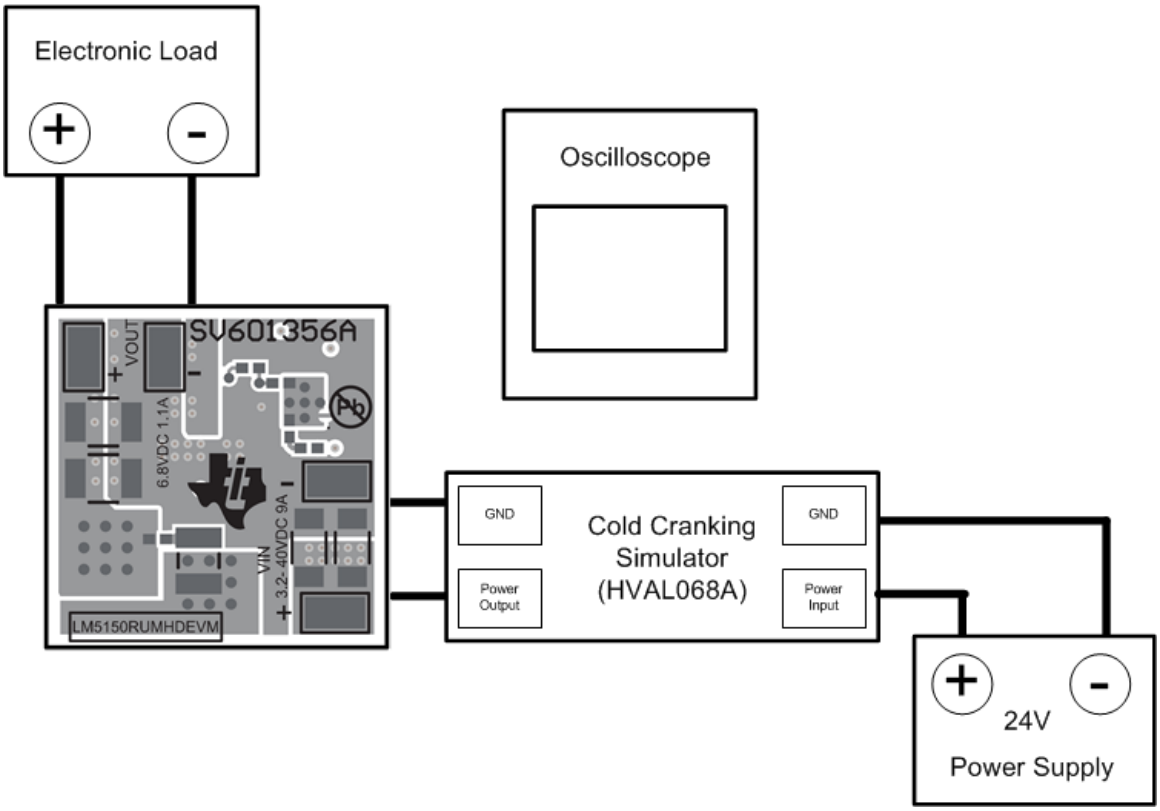

Figure 2. Cranking Simulator Connection Diagram

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 14A
- Turn on the power supply and increase the supply voltage slowly up to 12V
- Increase the load current slowly up to 1.1A
- Decrease the power supply voltage down to 3.2V

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

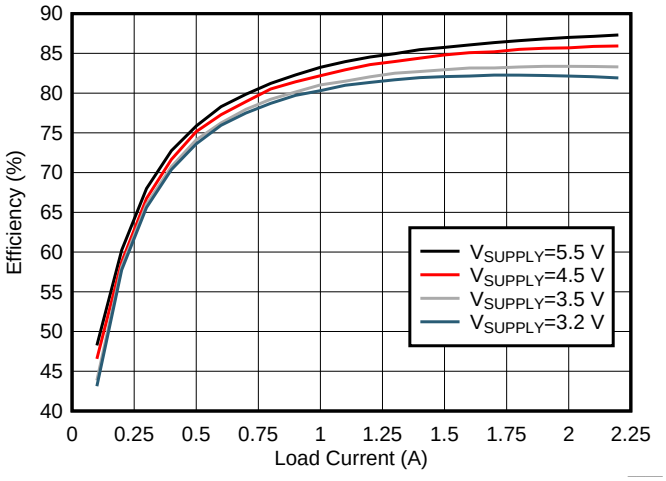

Figure 3. Efficiency

5.2 Performance During Cranking

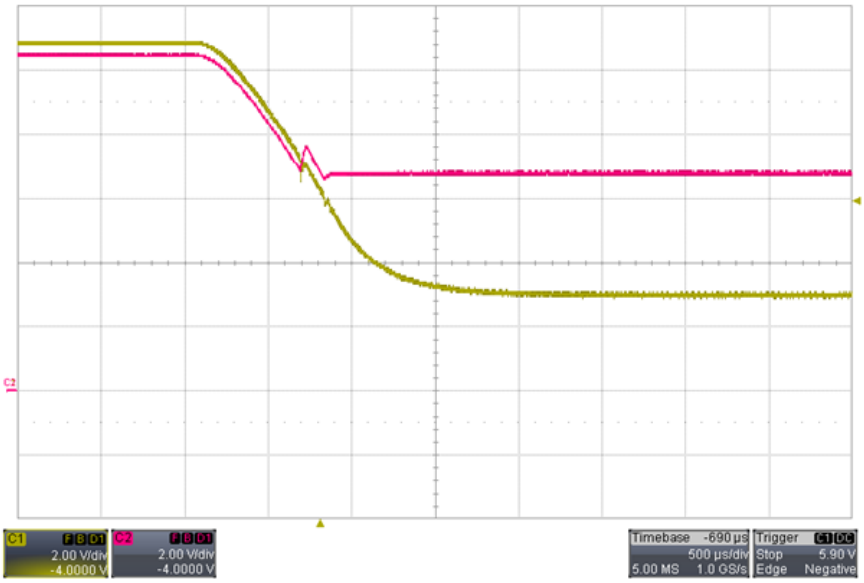

Figure 4. Cold-Cranking Using Cranking Simulator(C1:V_{SUPPLY}, C2:V_{LOAD})

5.3 Load Transient

5V input, full load to half load transition (2.2A to 1.1A)

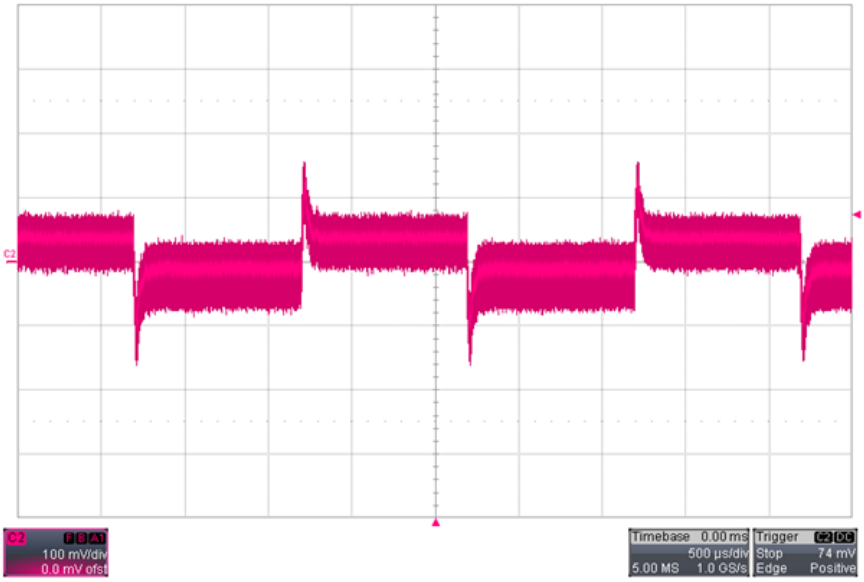

Figure 5. Load Transient(C2: V_{LOAD} AC-coupled)

6 EVM Schematic

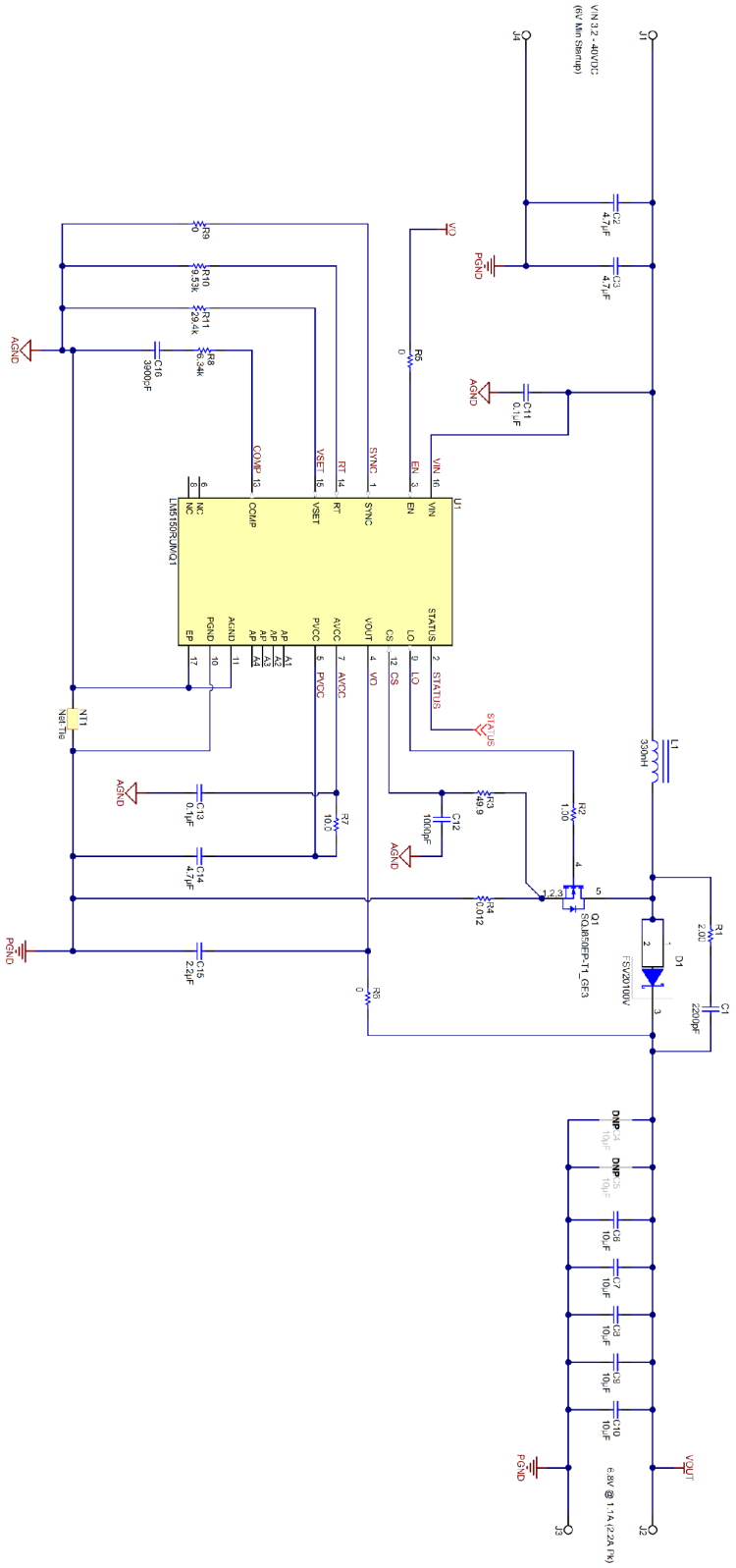

Figure 6. EVM Schematic

7 Layout

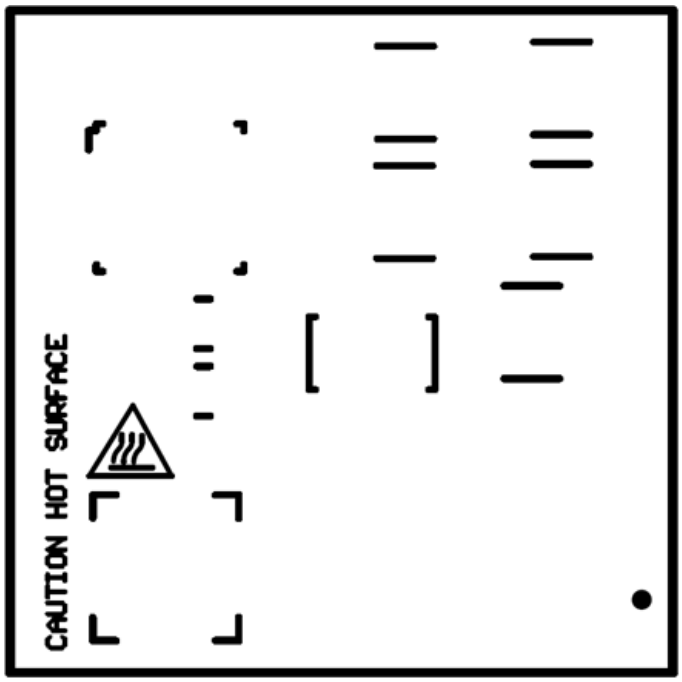

Figure 7. Top Silk (Top View)

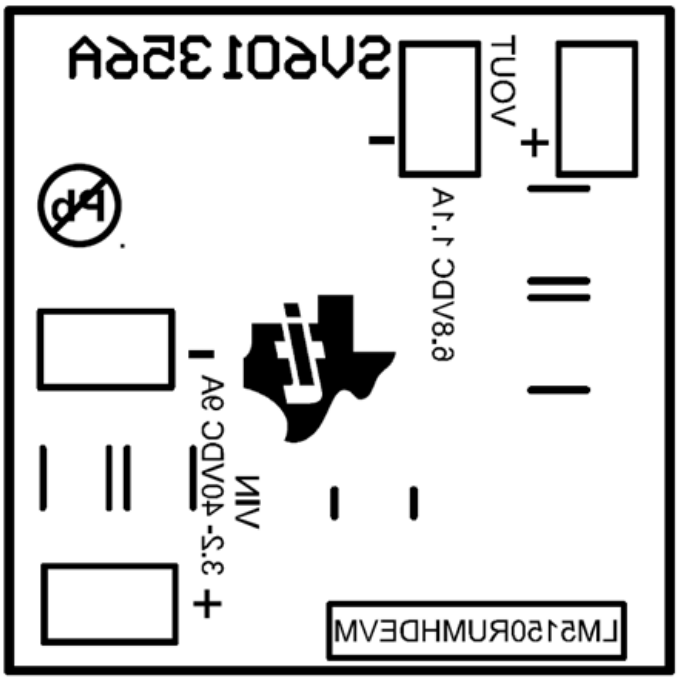

Figure 8. Bottom Silk (X-Ray View)

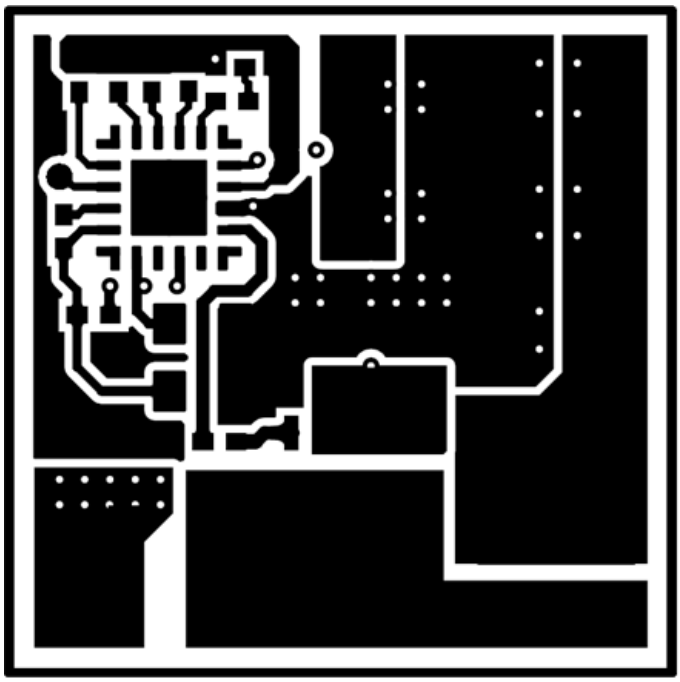

Figure 9. Top Copper (Top View)

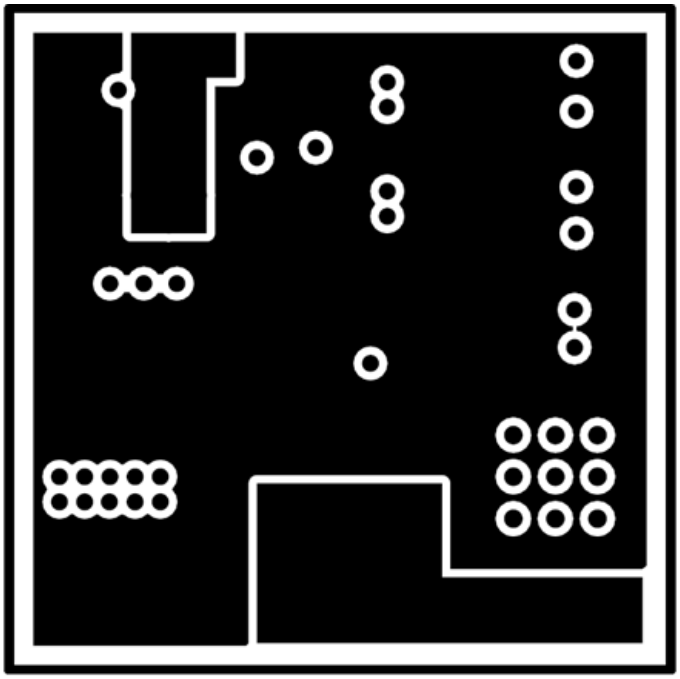

Figure 10. Mid1 Copper (X-Ray View)

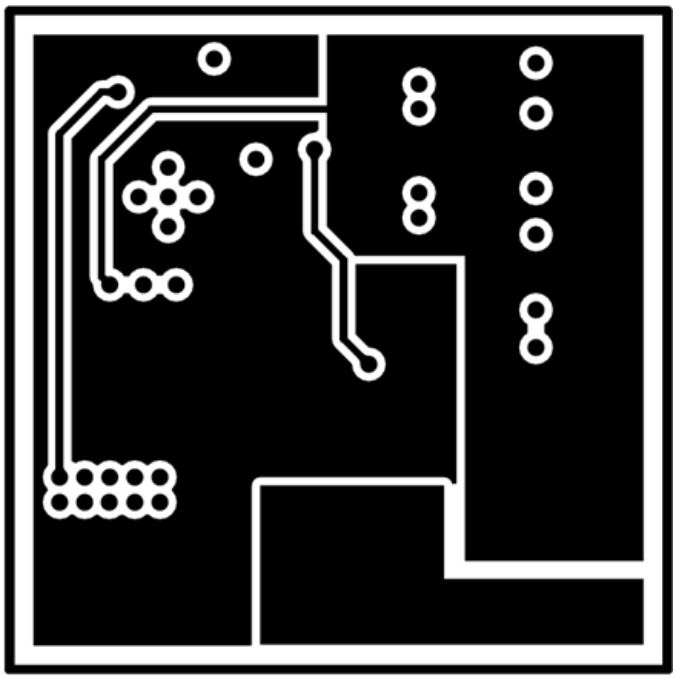

Figure 11. Mid2 Copper (X-Ray View)

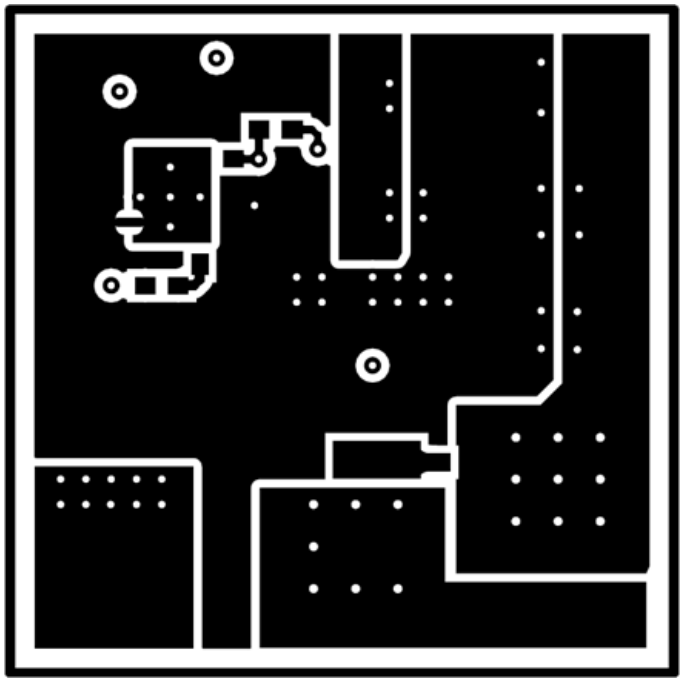

Figure 12. Bottom Copper (X-Ray View)

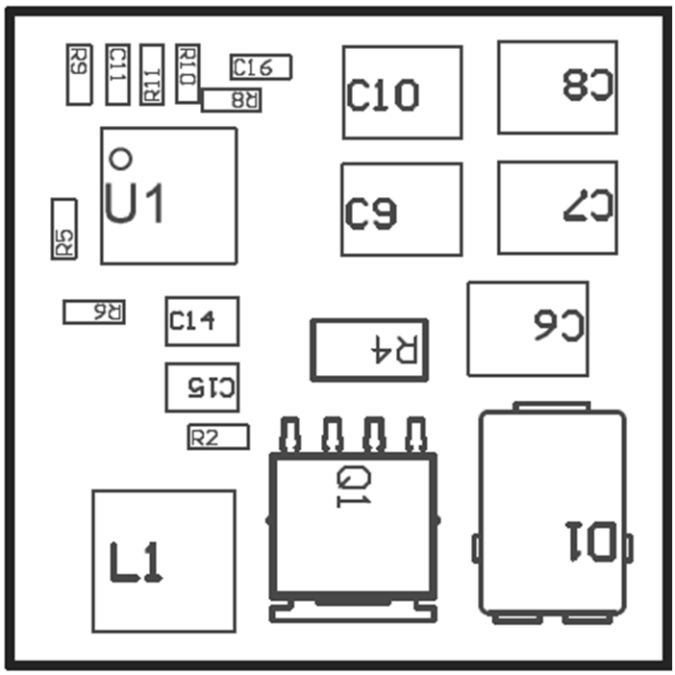

Figure 13. Top Assembly (Top View)

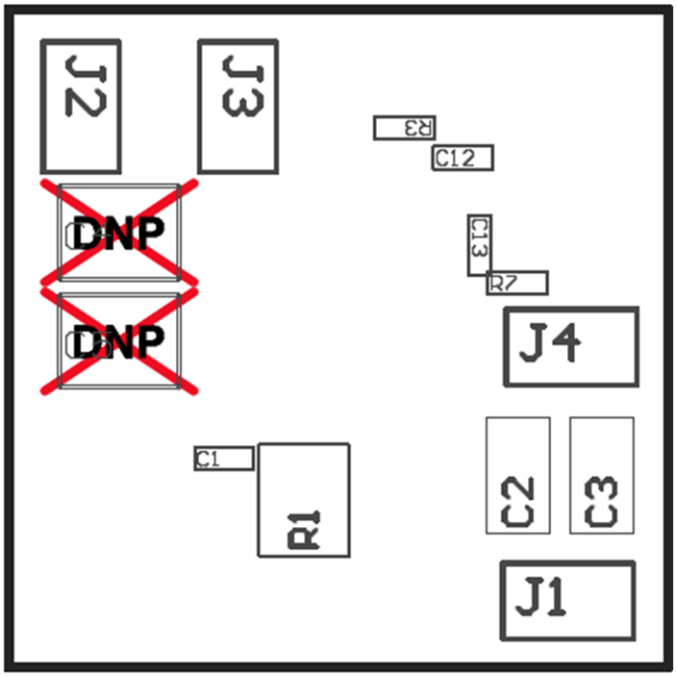

Figure 14. Bottom Assembly (Bottom View)

8 Bill of Materials

Table 3. Bill of Materials

DESIGNATOR	DESCRIPTION	PART NUMBER	MANUFACTURER
C1	CAP, CERM, 2200 pF, 100 V, +/- 10%, X7R, 0402	GRM155R72A222KA01D	MuRata
C2, C3	CAP, CERM, 4.7 µF, 50 V, +/- 10%, X6S, 1206	C3216X6S1H475K160AB	TDK
C6, C7, C8, C9, C10	CAP, CERM, 10 µF, 50 V, +/- 10%, X7S, AEC-Q200 Grade 1, 1210	CGA6P3X7S1H106K250AB	TDK
C11, C13	CAP, CERM, 0.1 µF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402	CGA2B3X7R1H104K050BB	TDK
C12	CAP, CERM, 1000 pF, 50 V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0402	CGA2B2C0G1H102J050BA	TDK
C14	CAP, CERM, 4.7 µF, 16 V, +/- 10%, X7R, 0805	GRM21BR71C475KA73L	MuRata
C15	CAP, CERM, 2.2 µF, 50 V, +/- 10%, X7R, 0805	C2012X7R1H225K125AC	TDK
C16	CAP, CERM, 3900 pF, 50 V, +/- 10%, X7R, 0402	GRM155R71H392KA01D	MuRata
D1	Diode, Schottky, 100 V, 20 A, AEC-Q101, TO-277A	FSV20100V	Fairchild
J1, J2, J3, J4	Test Point, Miniature, SMT	5015	Keystone
L1	Inductor, Shielded, 330 nH, 9.6 A, 0.0072 ohm, AEC-Q200 Grade 1, SMD	784383560033	Wurth
Q1	MOSFET N-CH 60V 24A	SQJ850EP-T1_GE3	Vishay
R1	RES, 2.00, 1%, 0.5 W, AEC-Q200 Grade 0, 1210	ERJ-14BQF2R0U	Panasonic
R2	RES, 1.00, 1%, 0.063 W, 0402	CRCW04021R00FKED	Vishay-Dale
R3	RES, 49.9, 1%, 0.063 W, 0402	CRCW040249R9FKED	Vishay-Dale
R4	RES, 0.012, 1%, 1 W, 0612	PRL1632-R012-F-T1	Susumu
R5, R6, R9	RES, 0, 5%, 0.063 W, 0402	CRCW04020000Z0ED	Vishay-Dale
R7	RES, 10.0, 1%, 0.063 W, 0402	MCR01MZPF10R0	Rohm
R8	RES, 6.34 k, 1%, 0.063 W, 0402	CRCW04026K34FKED	Vishay-Dale
R10	RES, 9.53 k, 1%, 0.063 W, 0402	CRCW04029K53FKED	Vishay-Dale
R11	RES, 29.4 k, 1%, 0.063 W, 0402	CRCW040229K4FKED	Vishay-Dale
U1	Wide VIN Automotive Low IQ Boost Controller	LM5150-Q1	Texas Instruments

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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.

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   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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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.

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