

LM5175 Wide VIN 4-Switch Buck-Boost Converter High Power Evaluation Module

User's Guide



Literature Number: SNVU465

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This user's guide describes the characteristics, operation, and use of the LM5175 high power evaluation module (EVM). The LM5175EVM-HP is a fully assembled and tested circuit for evaluating the performance of the LM5175 42 V wide VIN Synchronous 4-Switch Buck-Boost Controller. This user's guide contains the electrical specification, quick setup procedure, performance curves, application schematic, and bill of materials (BOM).

1 Introduction

The LM5175 is a synchronous 4-switch buck-boost controller capable of regulating the output voltage at, below, or above the input voltage. The wide input voltage of 3.5 V to 42 V supports a variety of applications. The output voltage is adjustable from 0.8 V to 55 V.

The LM5175EVM-HP high power EVM is fully assembled and tested platform for evaluating the operation and performance of the LM5175 buck-boost controller. The LM5175EVM-HP has an input voltage range from 6 V to 36 V, the output voltage is set as 12 V using an external feedback resistor divider.

1.1 Features

- Wide input voltage range from 6 V to 36 V
- 12 V nominal output voltage
- Up to 10 A output current capability (120W output power)
- 260kHz switching frequency
- Constant Output Voltage and Constant Output Current Options
- Optional frequency dithering
- Optional parallel FET sites provide flexibility to further extend output power capability

1.2 Applications

- Industrial PCs
- Point of Sale Terminals
- Automotive Start-Stop Systems
- Battery Backup Systems

2 Connector, Test Point and Selection Switch Descriptions

2.1 Connector and Test Point Descriptions

This EVM includes I/O connectors and test points as shown in [Table 1](#). The power supply must be connected to input connectors, J1 and J2. The load must be connected to output connectors, J3 and J4.

Table 1. Connectors and Test Points

Reference Designator	Description
J1	Input voltage positive connection
J2	Input voltage return connection
J3	Output voltage connection
J4	Output voltage return connection
TP1 (VIN)	Input voltage positive test point
TP2 (GND)	Input voltage return test point
TP3 (VOUT)	Output voltage positive test point
TP4 (GND)	Output voltage return test point
TP5 (PGOOD)	Power Good output
TP6 (BIAS)	BIAS voltage test point
TP7(SYNC)	SYNC input

2.2 Selection Switch Descriptions

2.2.1 S1 Mode

This switch provides selection of different operation modes detailed as following:

- Switch in position 1 (Mode pin tied to GND), Hiccup mode disabled and DCM.
- Switch in position 2 (Mode pin tied to 93.1kΩ resistor), Hiccup mode enabled and CCM.
- Switch in position 3 (Mode pin tied to VCC), Hiccup disabled and CCM.

Note 1: If Hiccup enabled and DCM combination is desired, change R19 to 49.9 kΩ and put switch in position 2.

2.2.2 S2 ENABLE

This switch enables/disables LM5175 on the EVM, or it can be used to set adjustable VIN UVLO.

- Switch in position 1 (EN pin tied GND), LM5175 disabled.
- Switch in position 2 (EN pin tied to resistor divider network consist of R13 and R18), EN pin along the resistor divider network to set LM5175 UVLO threshold.
- Switch in position 3 (EN pin tied VCC), LM5175 enabled.

2.2.3 S3 DITHER

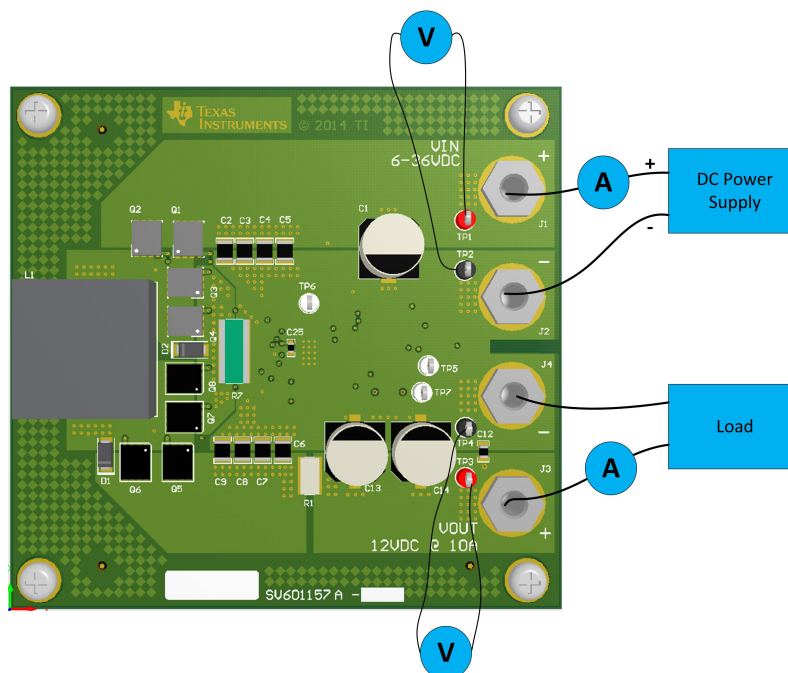
This switch enables/disables frequency dithering feature on the EVM.

- Switch in position 1 (EN pin tied GND), frequency dithering feature disabled.
- Switch in position 2 (EN pin tied to C27), frequency dithering feature enabled.
- No connection in position 3, do not apply switch to this position.

3 Test Setup and Procedure

3.1 Test Setup

Figure 1 shows a typical test setup to evaluate the LM5175EVM-HP



3.2 Test Procedure

Step 1: Set the power supply current limit to 1 A. Turn off the power supply. Connect the positive output of the power supply to J1 and the negative output to J2.

Step 2: Connect the load to J3 for the positive connection and J4 for the negative connection.

Step 3: Set the power supply voltage to 9V and the load to 0.1 A. The electronic load voltage should be in regulation with a nominal 12 V output.

Step 4: Slowly increase the load while monitoring the output voltage between TP3 and TP4. It should remain in regulation with a nominal 12 V output as the load is increased up to 10 A.

Step 5: Slowly sweep the input voltage from 6 V to 36 V. The output voltage should remain in regulation with a nominal 12 V output.

Step 6: Turn off the load, and decrease the input voltage down to 0 V to shut down the buck-boost converter, and then turn on the load to discharge the output capacitors.

4 Test Data and Performance Curve

4.1 Efficiency

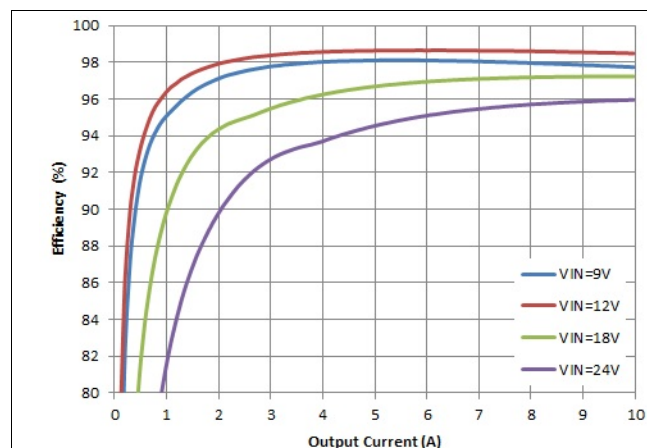


Figure 2. Efficiency vs. Output Current

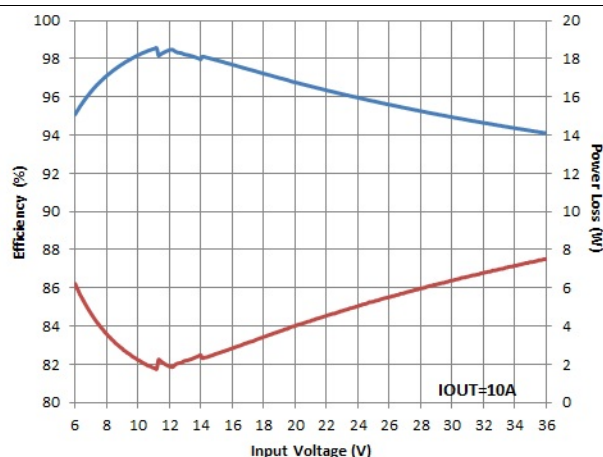


Figure 3. Efficiency and Power Loss vs. Input Voltage

4.2 Typical Operation Waveforms

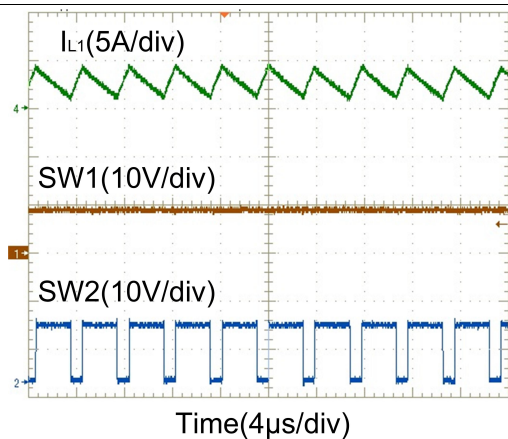


Figure 4. Typical Operation Waveforms (VIN=9 V, IOUT=2 A)

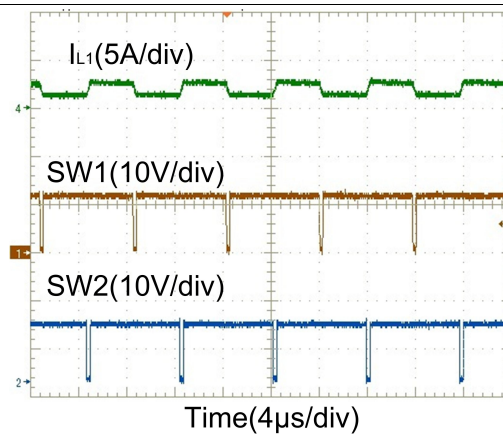


Figure 5. Typical Operation Waveforms (VIN=12 V, IOUT=2 A)

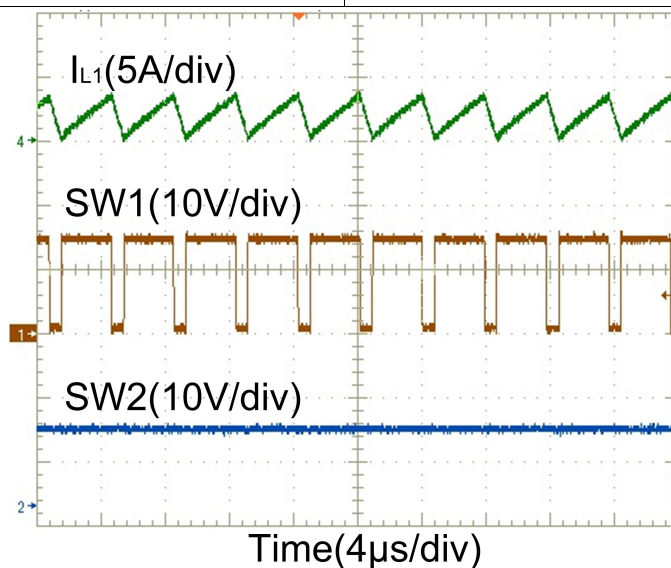


Figure 6. Typical Operation Waveforms (VIN=15 V, IOUT=2 A)

4.3 Soft Start

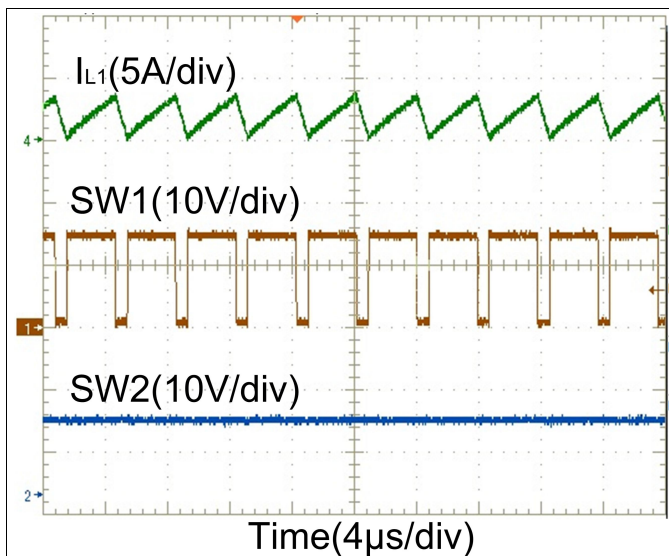


Figure 7. Turn-on Waveforms ($V_{IN}=24\text{ V}$, $I_{OUT}=0\text{ A}$)

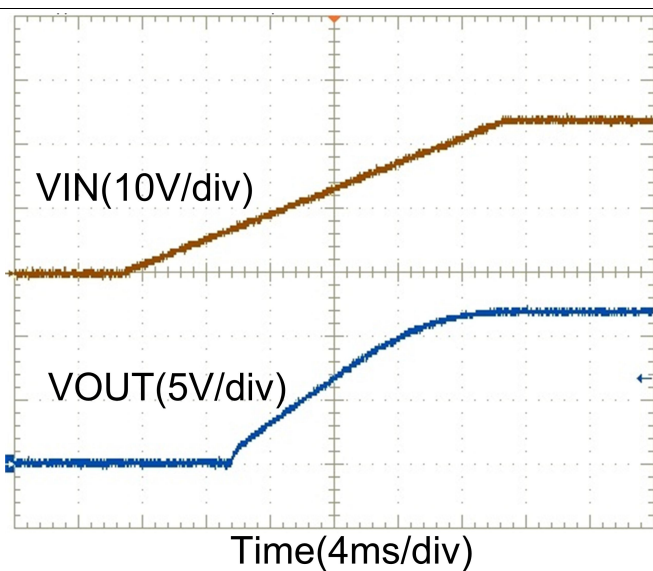


Figure 8. Turn-on Waveforms ($V_{IN}=24\text{ V}$, $I_{OUT}=10\text{ A}$)

5 LM5175EVM-HP Schematic

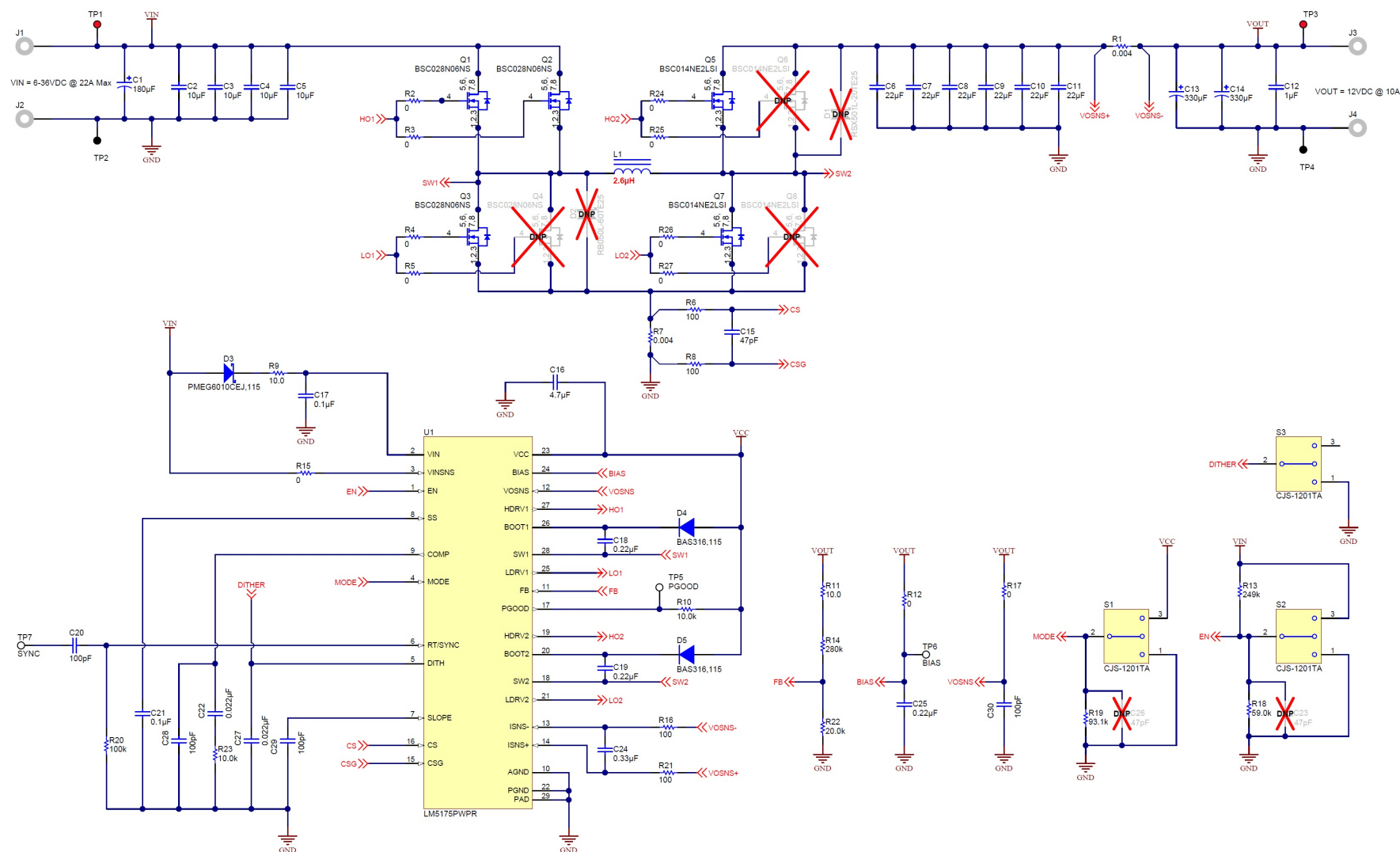
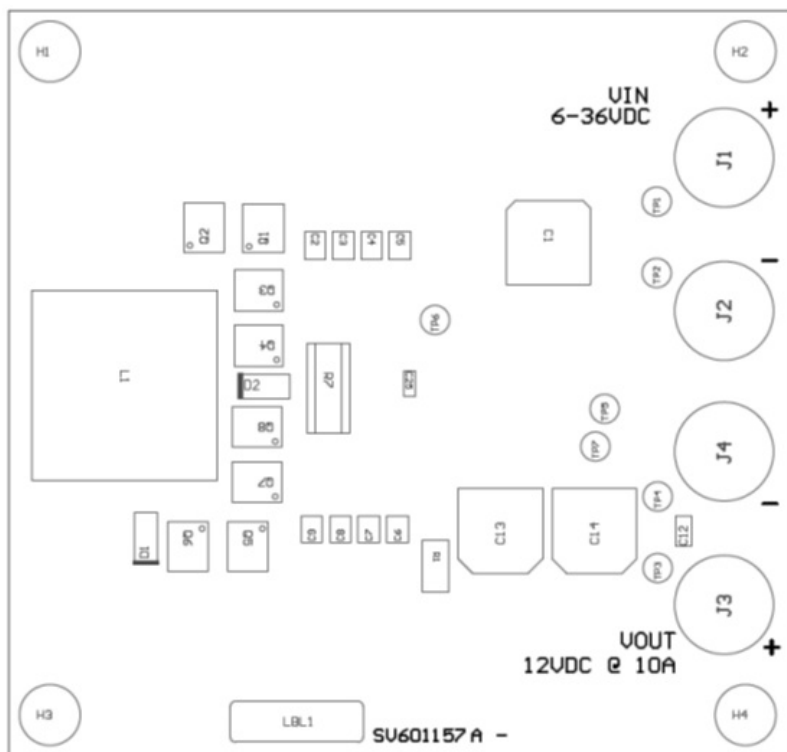


Figure 9. 4-Switch Buck-Boost Converter Schematic

6 Assembly Drawings and Layout

Figure 12 through Figure 17 show the design of the LM5175EVM-HP PCB.



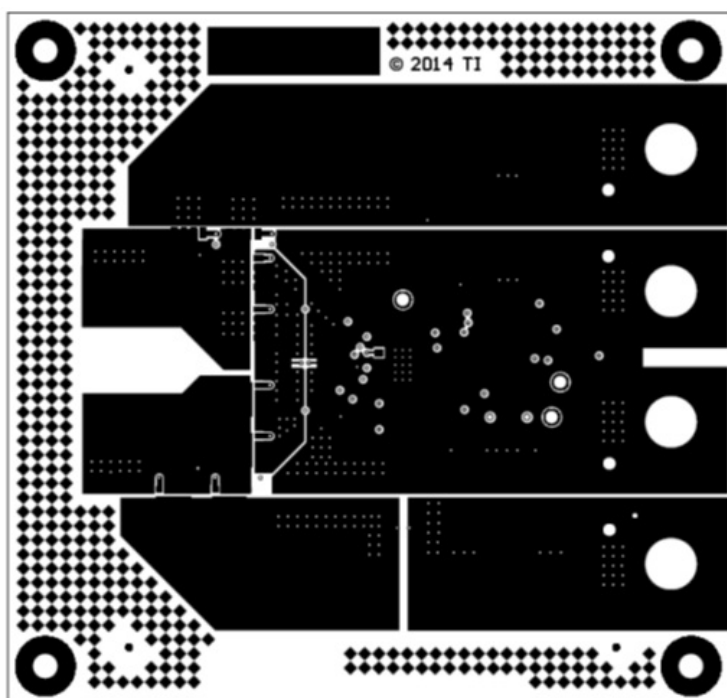


Figure 12. Top Layer

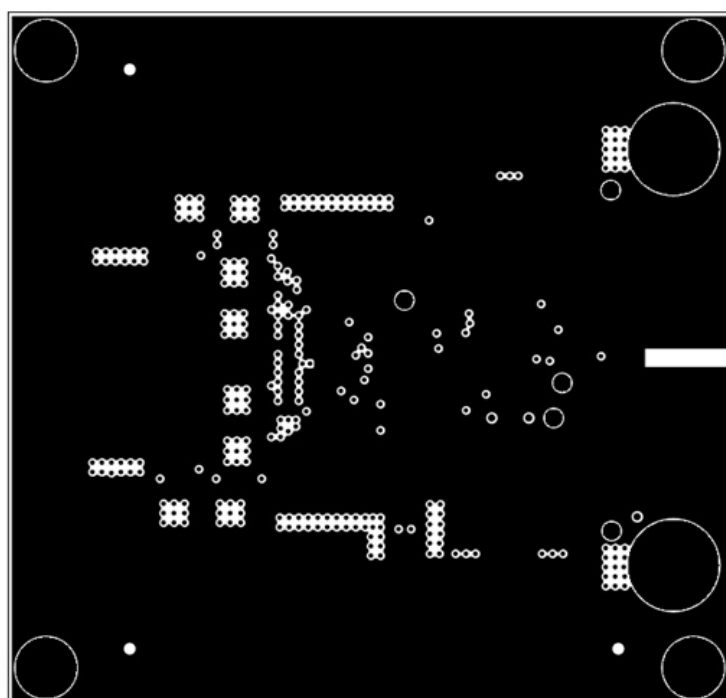


Figure 13. Mid-Layer 1

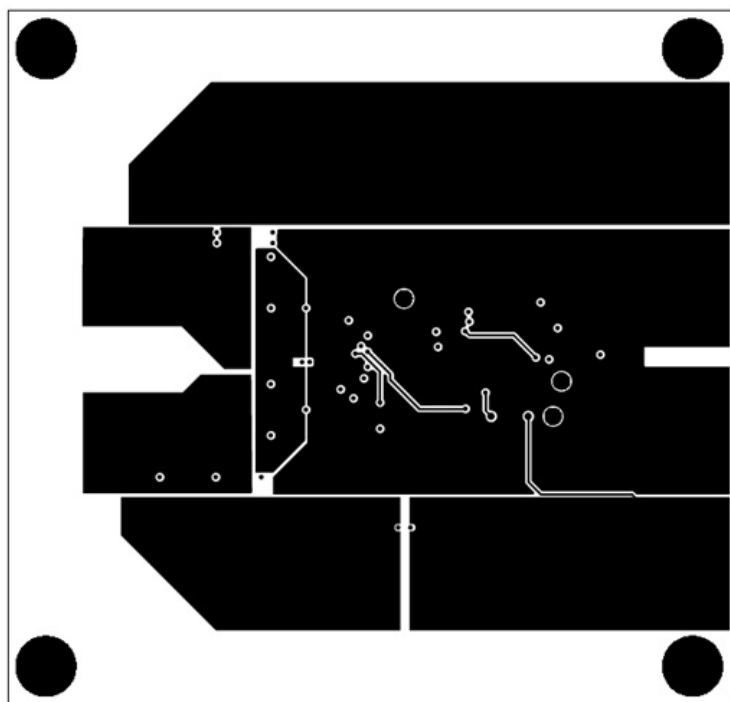


Figure 14. Mid-Layer 2

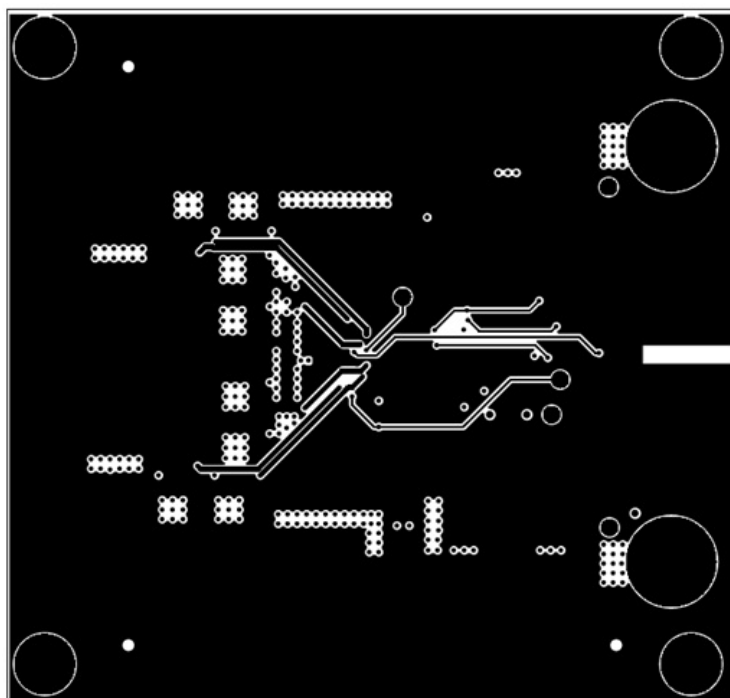


Figure 15. Mid-Layer 3

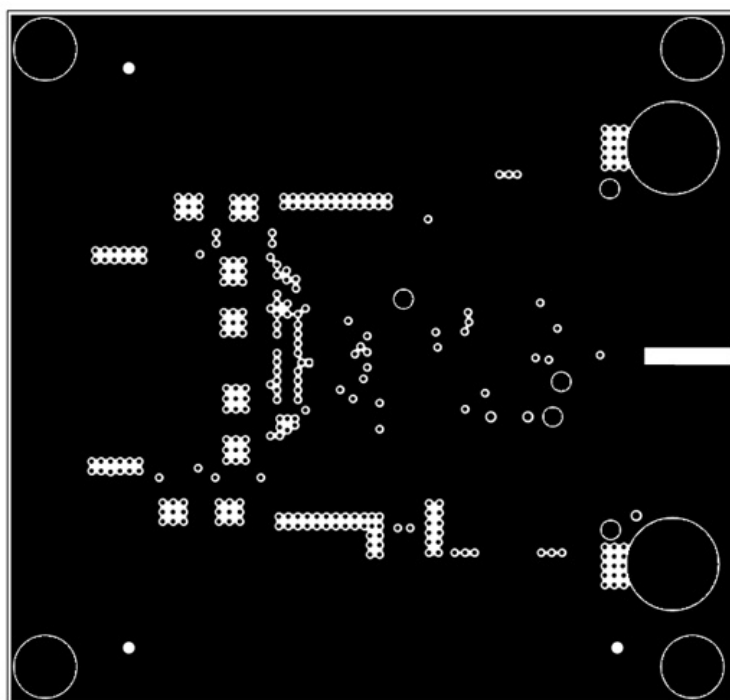


Figure 16. Mid-Layer 4

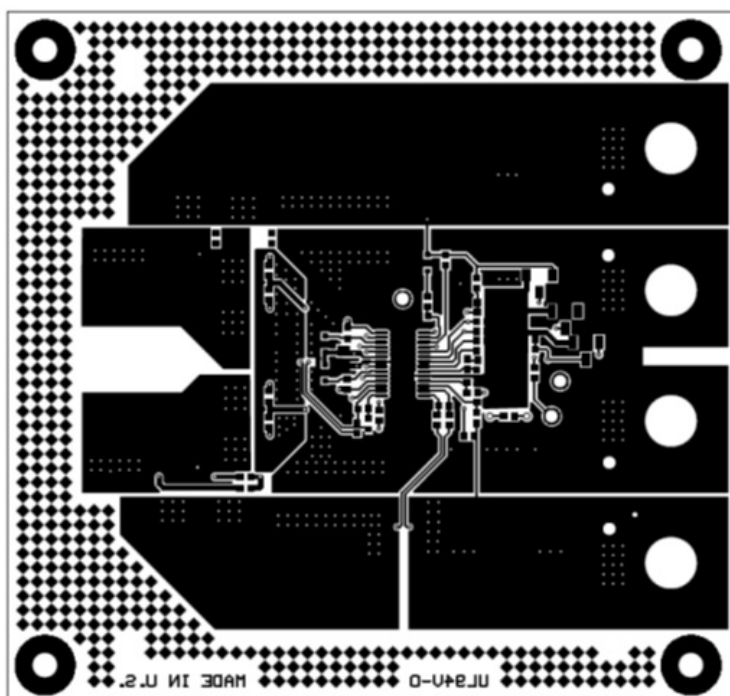


Figure 17. Bottom Layer

7 LM5175EVM-HP Bill of Materials

Table 2. LM5175EVM-HP Bill of Materials

Ref Des	Quantity	Description	Part Number	Manufacturer
PCB	1	Printed Circuit Board	SV601157	Any
C1	1	CAP, AL, 180 μ F, 50 V, +/- 20%, 0.019 ohm, SMD	PCR1H181MCL1GS	Nichicon
C2, C3, C4, C5	4	CAP, CERM, 10 μ F, 50 V, +/- 10%, X7R, 1210	GRM32ER71H106KA12L	MuRata
C6, C7, C8, C9, C10, C11	6	CAP, CERM, 22 μ F, 16 V, +/- 20%, X7R, 1210	GRM32ER71C226ME18L	MuRata
C12	1	CAP, CERM, 1 μ F, 25 V, +/- 10%, X7R, 0805	GRM219R71E105KA88D	MuRata
C13, C14	2	CAP, OS-CON, 330 μ F, 16 V, +/- 20%, 0.016 ohm, 10x10.3 SMD	16SVP330M	Sanyo
C15	1	CAP, CERM, 47pF, 50V, +/-5%, C0G/NP0, 0603	Std	Std
C16	1	CAP, CERM, 4.7 μ F, 16 V, +/- 10%, X7R, 0805	Std	Std
C17, C21	2	CAP, CERM, 0.1 μ F, 100V, +/-10%, X7R, 0603	Std	Std
C18, C19, C25	3	CAP, CERM, 0.22 μ F, 25 V, +/- 10%, X7R, 0603	Std	Std
C20, C28, C29, C30	4	CAP, CERM, 100pF, 100V, +/-5%, C0G/NP0, 0603	Std	Std
C22, C27	2	CAP, CERM, 0.022 μ F, 50V, +/-10%, X7R, 0603	Std	Std
C24	1	CAP, CERM, 0.33 μ F, 16 V, +/- 10%, X7R, 0603	Std	Std
D3	1	DIODE SCHOTTKY 60V 1A SOD323F	PMEG6010CEJ,115	NXP Semiconductors
D4, D5	2	Diode, Ultrafast, 100V, 0.25A, SOD-323	BAS316,115	NXP Semiconductors
H1, H2, H3, H4	4	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	NY PMS 440 0025 PH	B&F Fastner Supply
H5, H6, H7, H8	4	Standoff, Hex, 0.5"L #4-40 Nylon	1902C	Keystone
J1, J2, J3, J4	4	Standard Banana Jack, Uninsulated, 15A	108-0740-001	Emerson Network Power
L1	1	Inductor, Shielded Drum Core, WE-Superflux200, 2.6 μ H, 31.5 A, 0.0016 ohm, SMD	7443556260	Würth Elektronik eiSos
Q1, Q2, Q3	3	MOSFET, N-CH, 60 V, 100 A, TDSO-8	BSC028N06NS	Infineon Technologies
Q5, Q7	2	MOSFET, N-CH, 25 V, 100 A, TDSO-8	BSC014NELSI	Infineon Technologies
R1	1	RES 0.004 OHM 3W 1% 2512 WIDE	KRL6432E-M-R004-F-T1	Susumu
R2, R3, R4, R5, R12, R15, R17, R24, R25, R26, R27	11	RES, 0 ohm, 5%, 0.1W, 0603	Std	Std
R6, R8, R16, R21	4	RES, 100 ohm, 1%, 0.1W, 0603	Std	Std
R7	1	RES, 0.004, 1%, 6 W, 4320_WIDE	KRL11050-C-R004-F-T1	Susumu Co Ltd
R9, R11	2	RES, 10.0 ohm, 1%, 0.1W, 0603	Std	Std
R10, R23	2	RES, 10.0k ohm, 1%, 0.1W, 0603	Std	Std
R13	1	RES, 249k ohm, 1%, 0.1W, 0603	Std	Std
R14	1	RES, 280k ohm, 1%, 0.1W, 0603	Std	Std
R18	1	RES, 59.0k ohm, 1%, 0.1W, 0603	Std	Std

Table 2. LM5175EVM-HP Bill of Materials (continued)

Ref Des	Quantity	Description	Part Number	Manufacturer
R19	1	RES, 93.1 k, 1%, 0.1 W, 0603	Std	Std
R20	1	RES, 100 k, 1%, 0.1 W, 0603	Std	Std
R22	1	RES, 20.0k ohm, 1%, 0.1W, 0603	Std	Std
S1, S2, S3	3	Slide SW, SPDT 0.1A 50VDC	CJS-1201TA	Copal Electronics
TP1, TP3	2	Test Point, Compact, Red, TH	5005	Keystone
TP2, TP4	2	Test Point, Compact, Black, TH	5006	Keystone
TP5	1	Test Point, Compact, White, TH	5007	Keystone
TP6, TP7	2	Test Point, Compact, White, TH	5007	Keystone
U1	1	42V Wide VIN 4-Switch Synchronous Buck-Boost Controller, TSSOP-28	LM5175PWP	Texas Instruments
C23, C26	0	CAP, CERM, 47pF, 50V, +/-5%, C0G/NP0, 0603	Std	Std
D1	0	DIODE SCHOTTKY 20V 5A PMDS	RSX501L-20TE25	Rohm Semiconductor
D2	0	DIODE SCHOTTKY 60V 3A PMDS	RB050L-60TE25	Rohm Semiconductor
Q4	0	MOSFET, N-CH, 60 V, 100 A, TDSO-8	BSC028N06NS	Infineon Technologies
Q6, Q8	0	MOSFET, N-CH, 25 V, 100 A, TDSO-8	BSC014NELSI	Infineon Technologies

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.

- 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 and conditions 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 and conditions 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 any defects that are 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. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.
- 2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, 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:*

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

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

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/llds/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/llds/ti_ja/general/eStore/notice_01.page

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

If User uses EVMs in Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

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】

本開発キットは技術基準適合証明を受けておりません。

本製品のご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。

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西新宿三井ビル

3.3.3 Notice for EVMs for Power Line Communication: Please see http://www.tij.co.jp/llds/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/llds/ti_ja/general/eStore/notice_02.page

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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