

LMR33630xRNXEVM User's Guide

The Texas Instruments LMR33630ARNXEVM and LMR33630CRNXEVM evaluation modules help designers to evaluate the operation and performance of the LMR33630A and LMR33630C buck regulators. The LMR33630 is a family of easy-to-use synchronous step-down DC-DC converters capable of driving up to 3 A of load current from an input voltage of 3.8 V to 36 V. The LMR33630xRNXEVMs feature a selectable output voltage of 3.3 V or 5 V and a switching frequency of either 400 kHz or 2.1 MHz. See the [LMR33630 data sheet](#) for additional features, detailed description, and available options. The EVM options are found in [Table 1](#).

Table 1. Device and Package Configurations

EVM	DEVICE	FREQUENCY / Output Current
LMR33630ARNXEVM	LMR33630ARNX	400 kHz / 3A
LMR33630CRNXEVM	LMR33630CRNX	2100 kHz / 3A

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Trademarks

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1 Setup

This section describes the test points and connectors on the EVM and how to properly connect, set up and use the LMR33630xEVM. Either the banana jacks and test points on the top of the board can be used for connections, or the card edge connector can be used. See [Figure 1](#) for the top of board connections, and [Figure 2](#) and [Figure 3](#) for the card edge connections. The following lists the functions of the connections:

- **VIN** - Input supply to EVM. Connect to a suitable input supply. See the [LMR33630 data sheet](#) for input supply requirements.
- **GND** - System ground
- **VOUT** - Output of EVM. Connect to desired load.
- **VOS** - Output voltage sense connection.
- **VIS** - Input voltage sense connection.
- **GNDS** - Ground sense point for analog measurements.

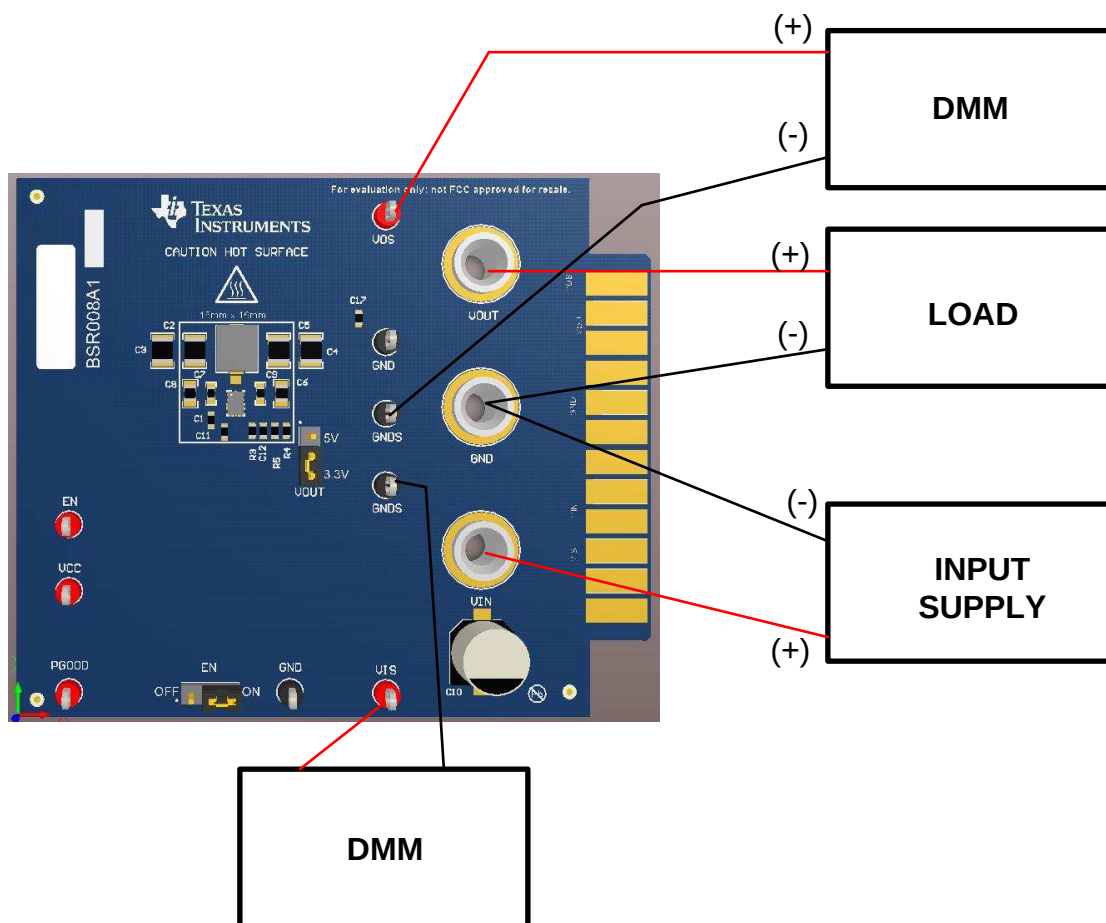


Figure 1. EVM Board Connections

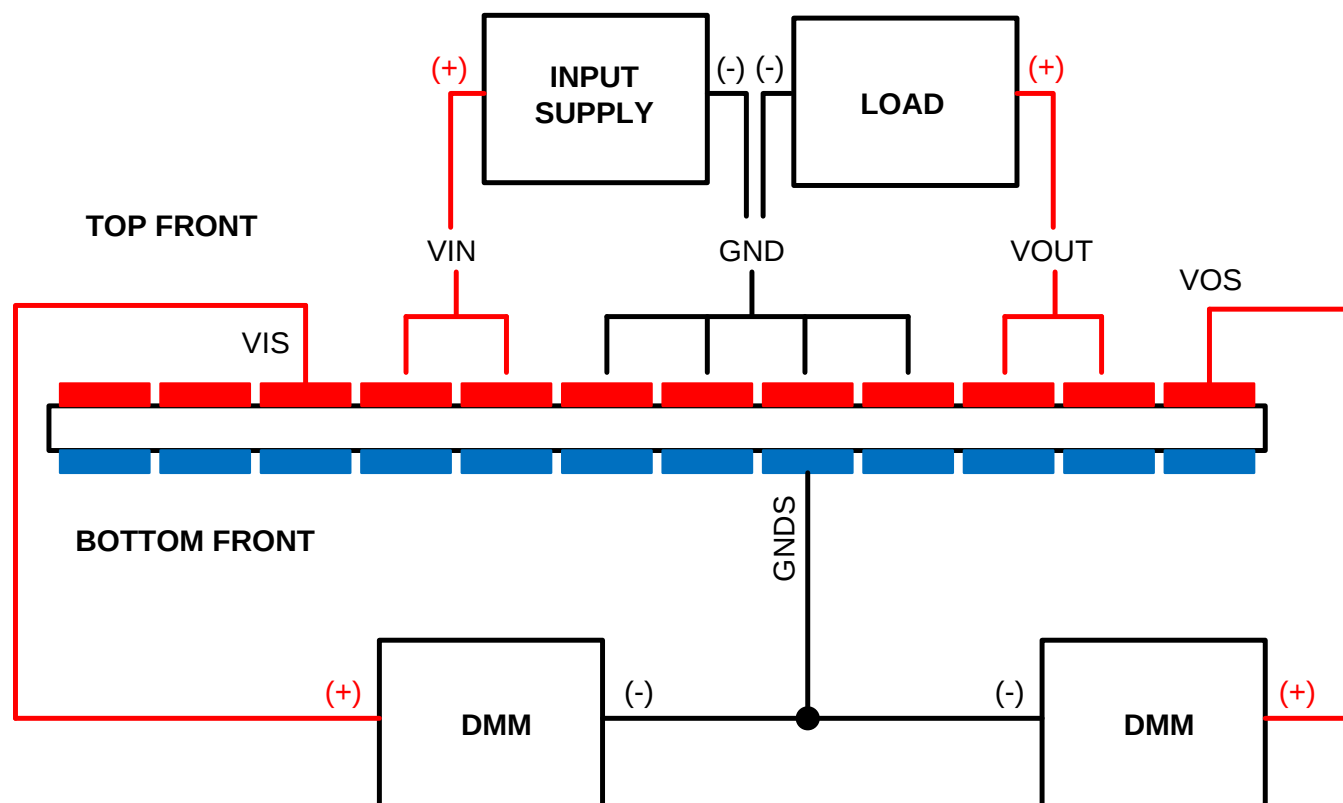


Figure 2. EVM Card Edge Connections

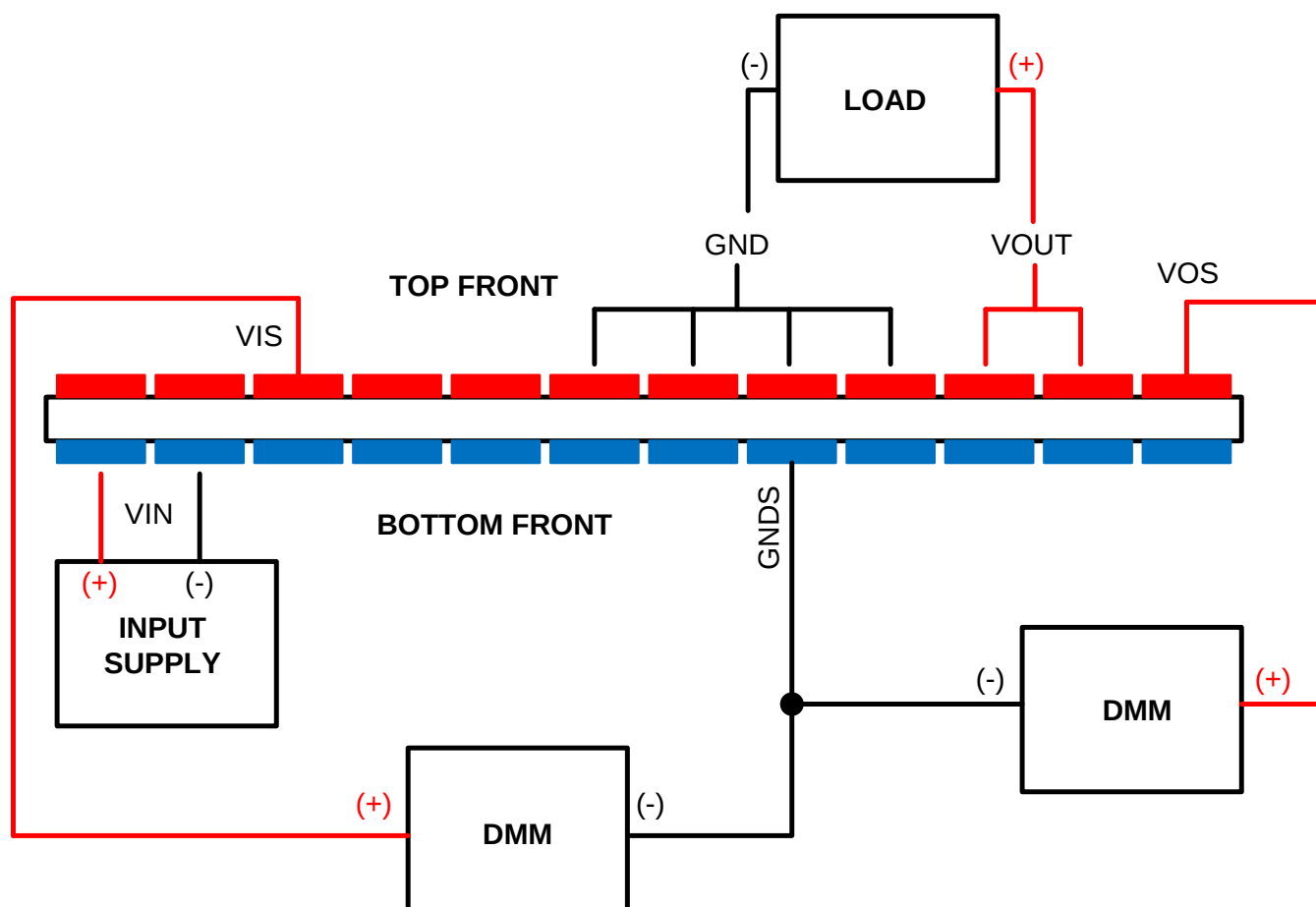


Figure 3. EVM Card Edge Connections for EMI Filter

1.1 Jumpers

See [Figure 4](#) for jumper locations.

- **EN** - This jumper allows the EN input to be connected to either ground (OFF) or VIN (ON). Remove this jumper to allow an external logic signal to control the EN function.
- **VOUT** - This jumper is used to select one of the two pre-defined output voltages. The "3.3V" position provides a 3.3-V output; while the "5V" position provides a 5-V output.

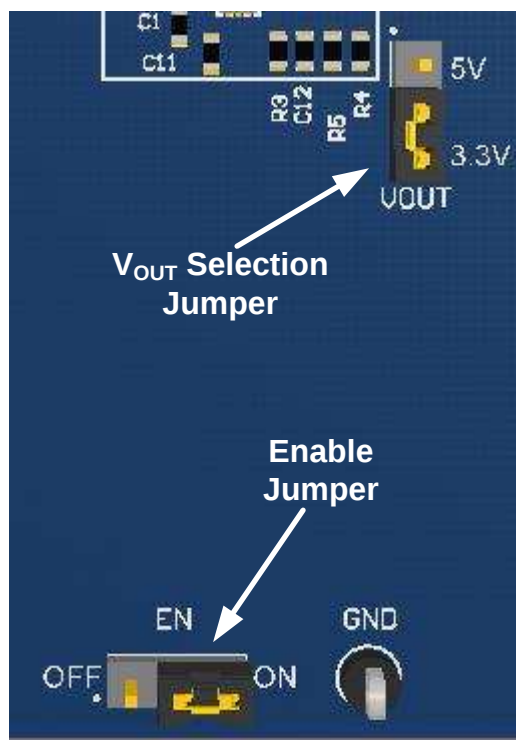


Figure 4. Jumper Locations

1.2 Test Points

- **VIN** - Input supply to EVM. Connect to a suitable input supply. See the [LMR33630 data sheet](#) for input supply requirements.
- **GND** - System power ground
- **VOUT** - Power output of EVM. Connect to desired load.
- **VOS** - Output voltage sense connection; connect to DMM. Also, used for frequency response analyzer connection.
- **VIS** - Input voltage sense connection; connect to DMM.
- **GNDS** - Ground sense point for analog measurements; connect to DMM.
- **VCC** - Test point to measure internal VCC of device; approximately 5 V. On-board PGOOD pullup resistor is connected to VCC.
- **EN** - Connection for external EN logic input. Remove EN jumper and connect controlling logic to EN test point for external enable control.
- **PGOOD** - Power good flag output. This test point is connected to VCC through a 20-kΩ resistor. The power-good function can be monitored at this test point.
- **A** - Connection for frequency response analyzer (on bottom of board) - see [Figure 5](#).

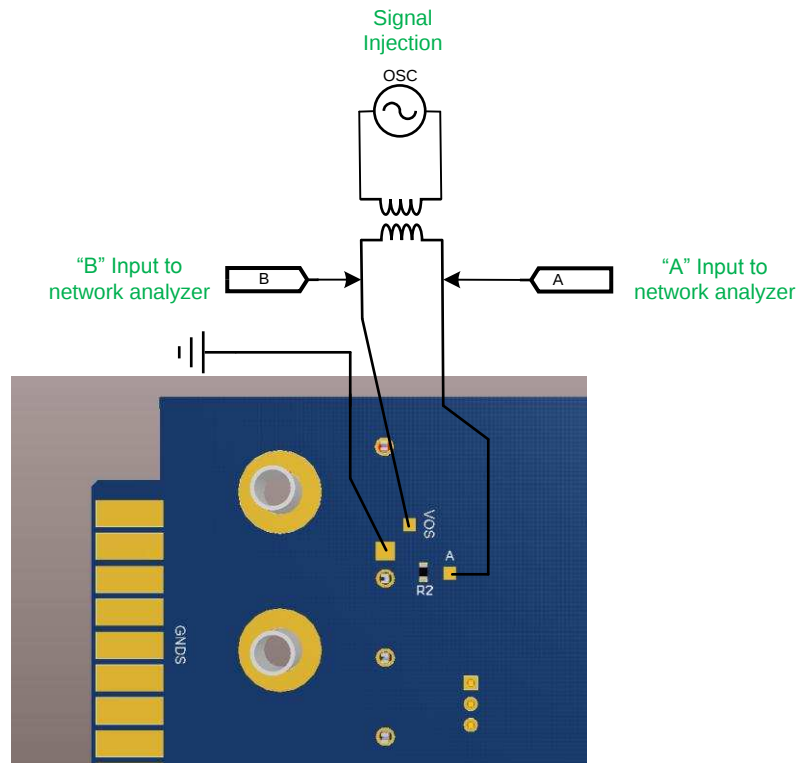


Figure 5. FRA Setup

2 Operation

Once the above connections are made and the appropriate jumpers are set, the EVM is ready for use. If external control of the EN input is desired, remove the EN jumper, and apply the external signal to the EN test point and GND. The PGOOD output is pulled up to VCC through a 20-k Ω resistor. In this way the PGOOD signal swings from 0 V to about 5 V to indicate when the output voltage is either outside or inside of the PGOOD window, respectively. If an external pullup and supply is desired for the PGOOD function, remove the 20-k Ω resistor, and pull the PGOOD test point up to the desired voltage through an appropriate resistance. See the [LMR33630 data sheet](#) for more details.

The output voltage of the EVM can be selected, by the VOUT jumper, to either 3.3 V or 5 V. Other values of output voltage can be programmed by changing the value of R_{FBB} on the EVM. In addition the values of the inductor and the output capacitance may also need to be changed. See the [LMR33630 data sheet](#) for more information.

The EVM has been designed for maximum flexibility regarding component selection. This allows the user to place preferred components, such as the inductor and/or capacitors, on the board and test the performance of the regulator. In this way the power supply system can be tested before committing the design to production.

The EVM also has locations for the components of an EMI filter. Note that these components are not included with the EVM. Suggested component values are found in [Table 2](#). To use the EMI filter, the input voltage to the EVM should be routed as shown in [Figure 3](#). Note that if a common-mode choke is used, then the input and output grounds are not at the same potential.

3 Performance Curves

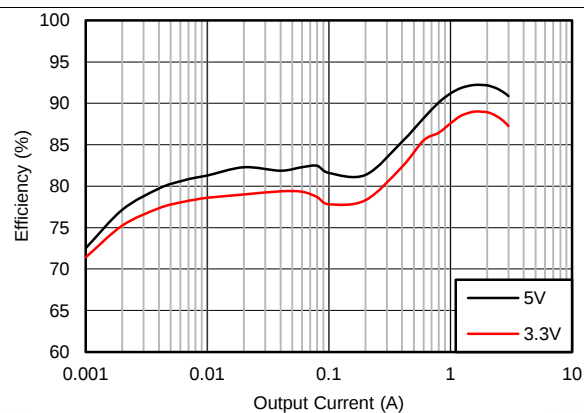


Figure 6. Efficiency: $V_{IN} = 12\text{ V}$, $f_{sw} = 2.1\text{ MHz}$

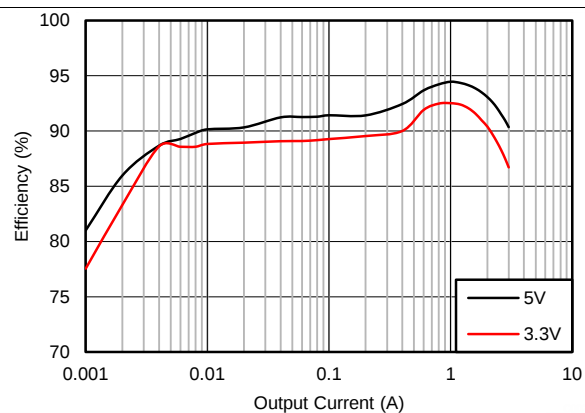


Figure 7. Efficiency: $V_{IN} = 12\text{ V}$, $f_{sw} = 400\text{ kHz}$

4 Schematic

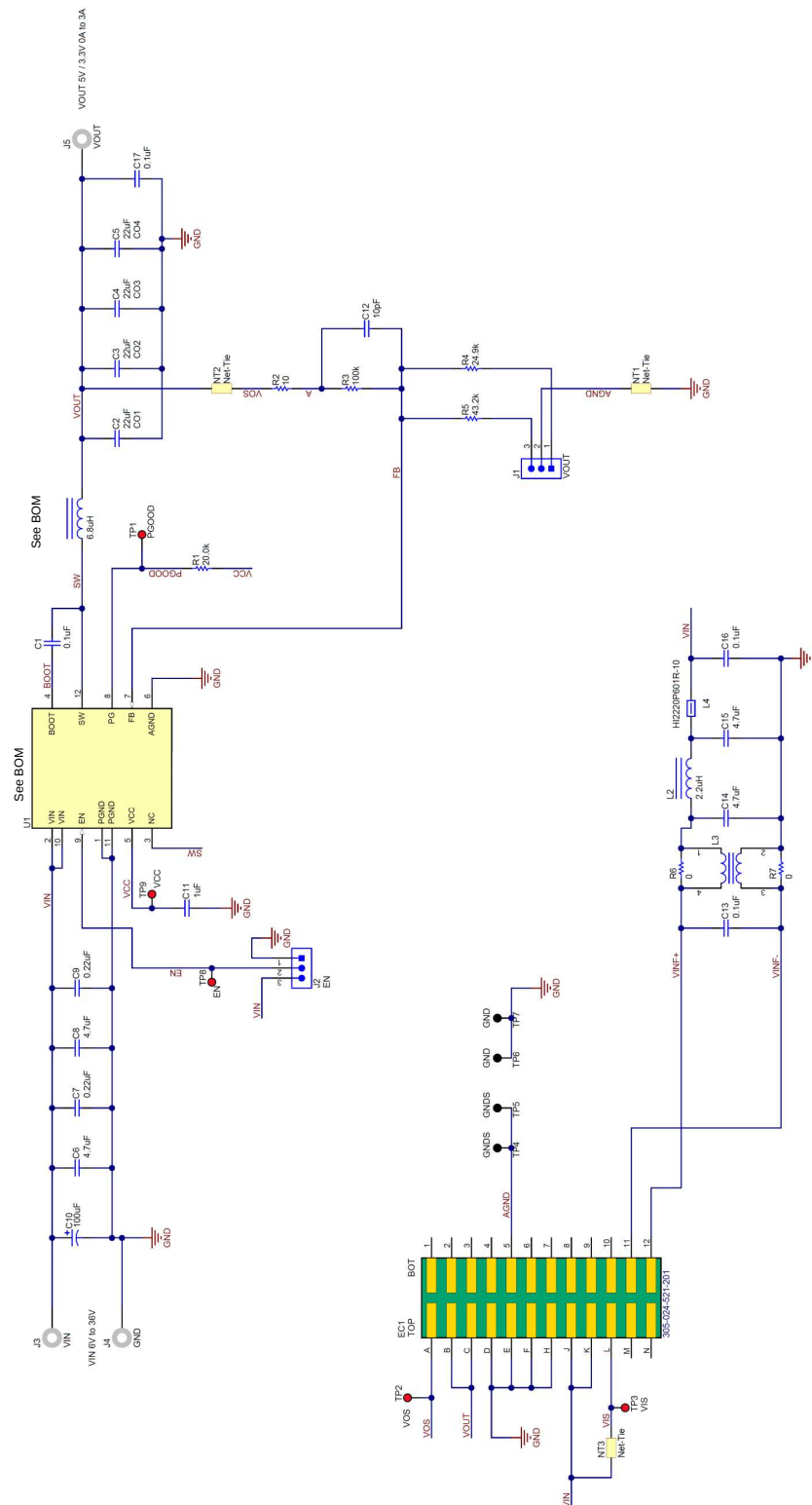


Figure 8. LMR33630EVM Schematic

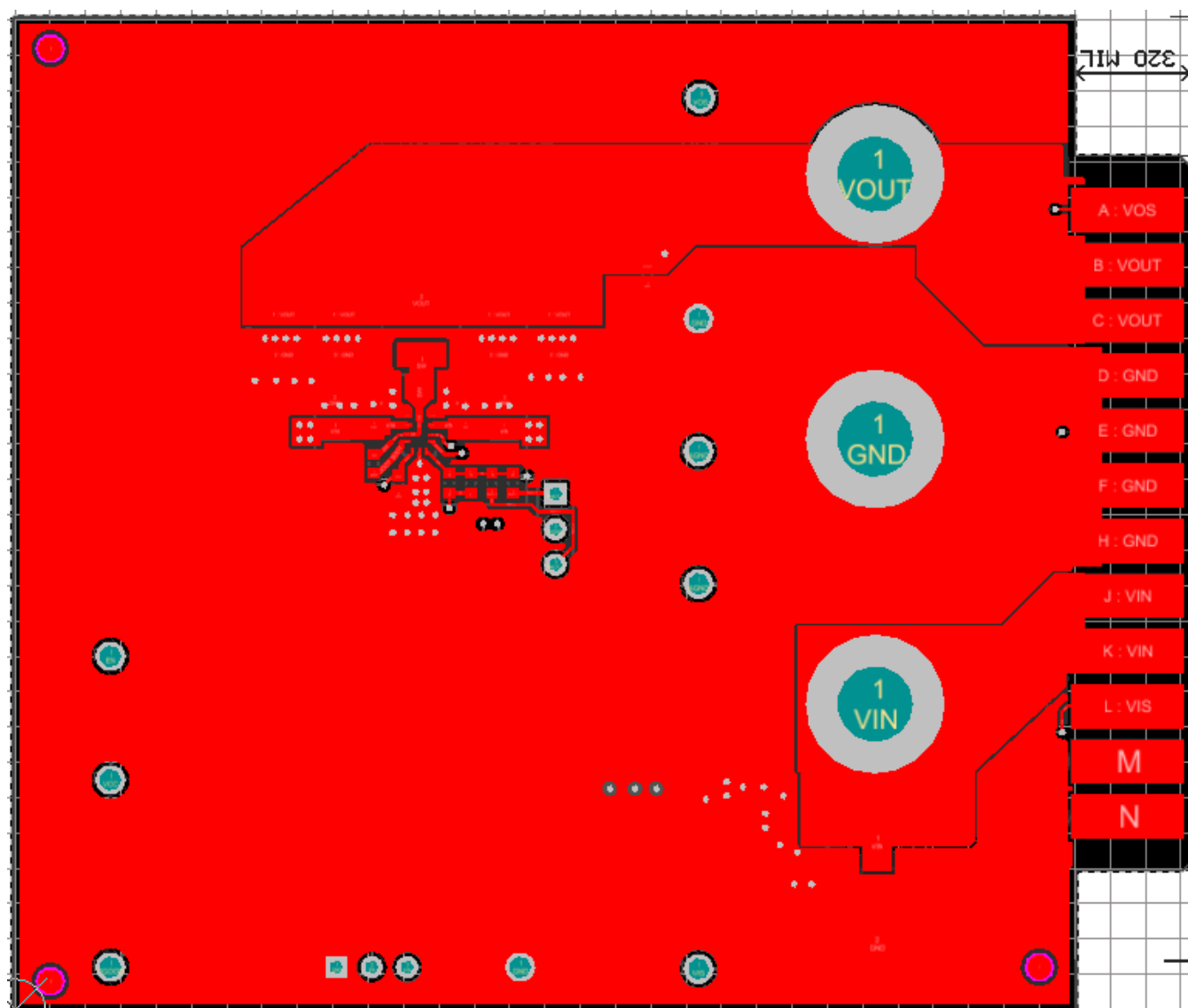


Figure 10. EVM Top Copper Layer

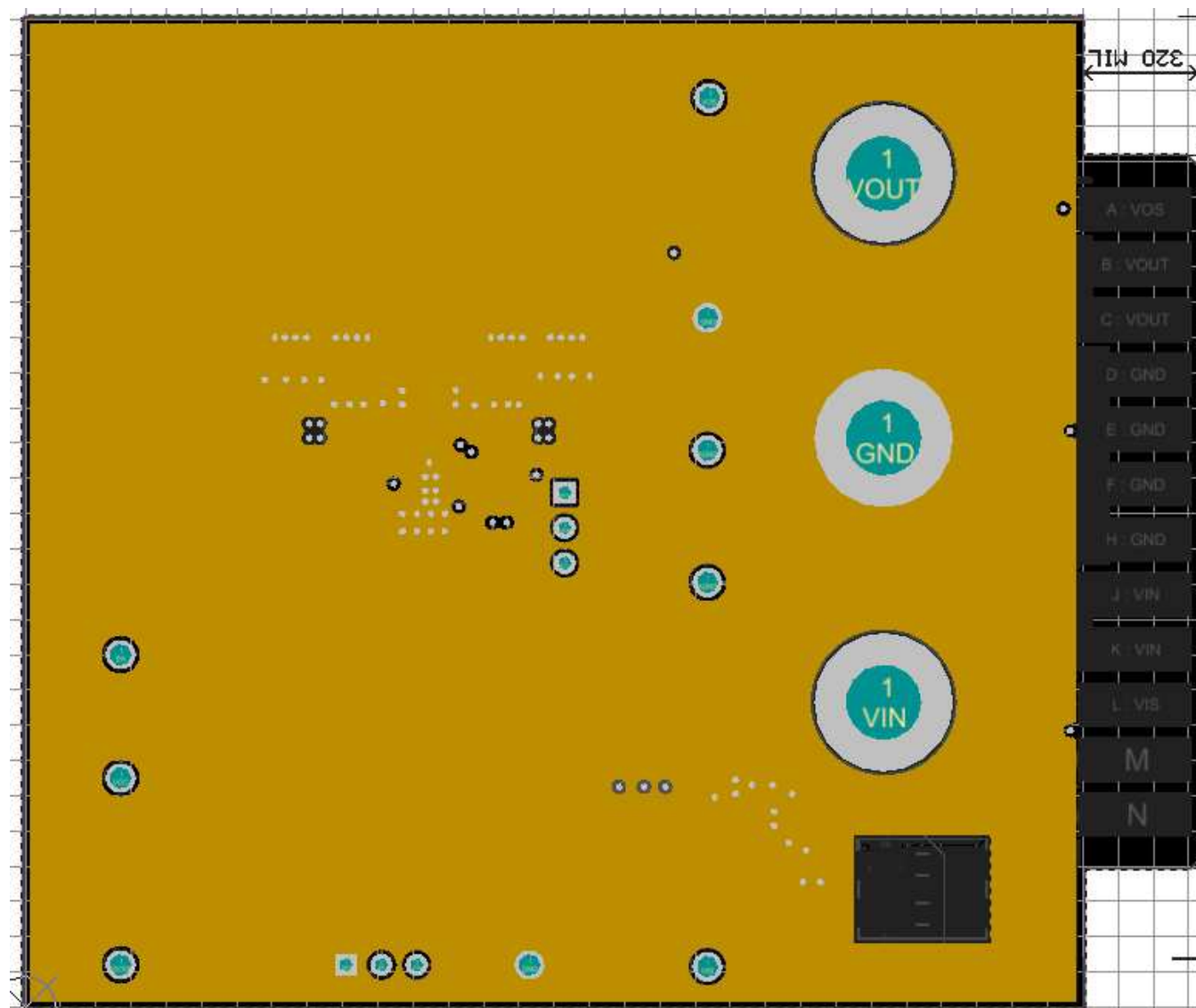


Figure 11. EVM Mid-Layer One

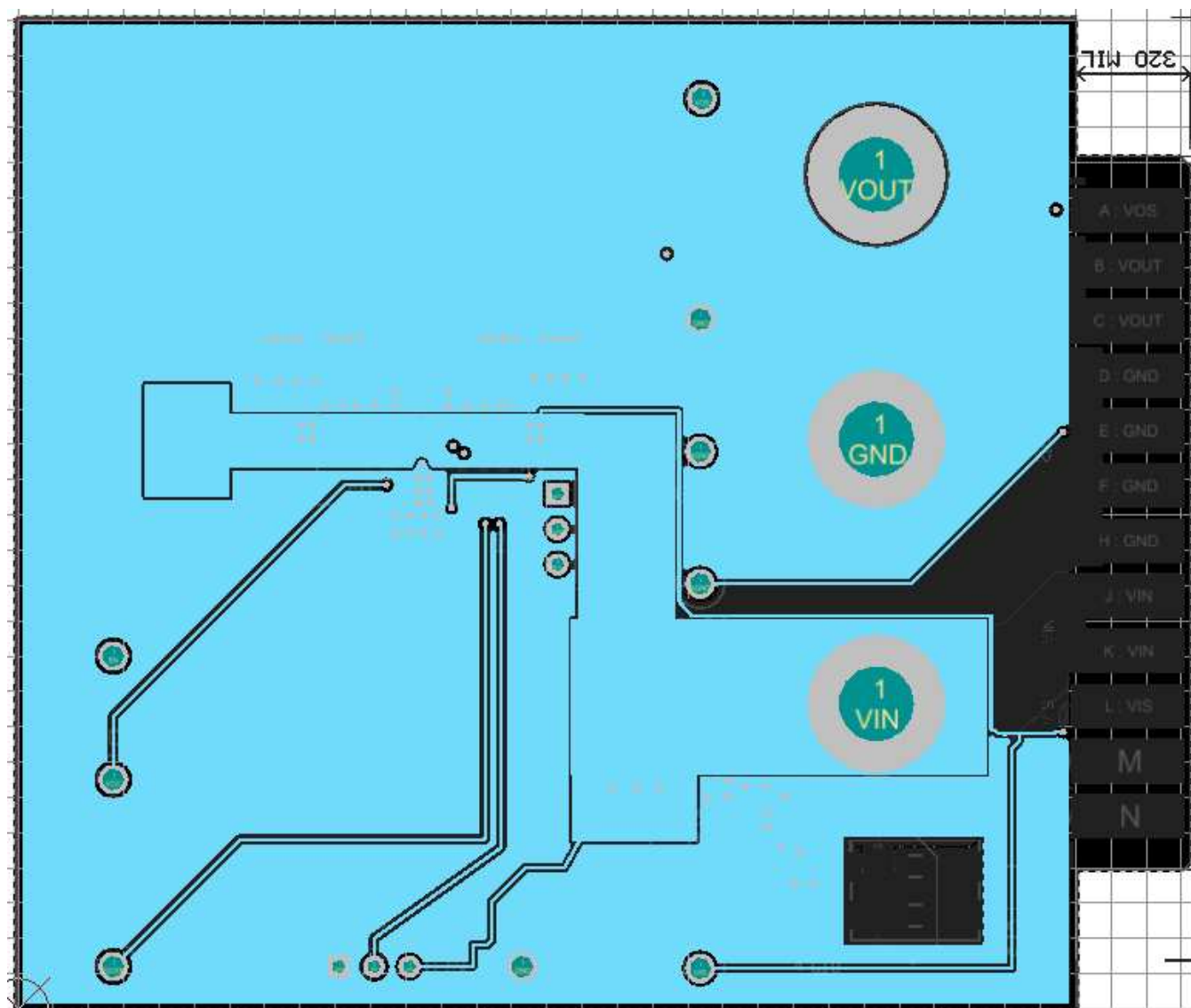


Figure 12. EVM Mid-Layer Two

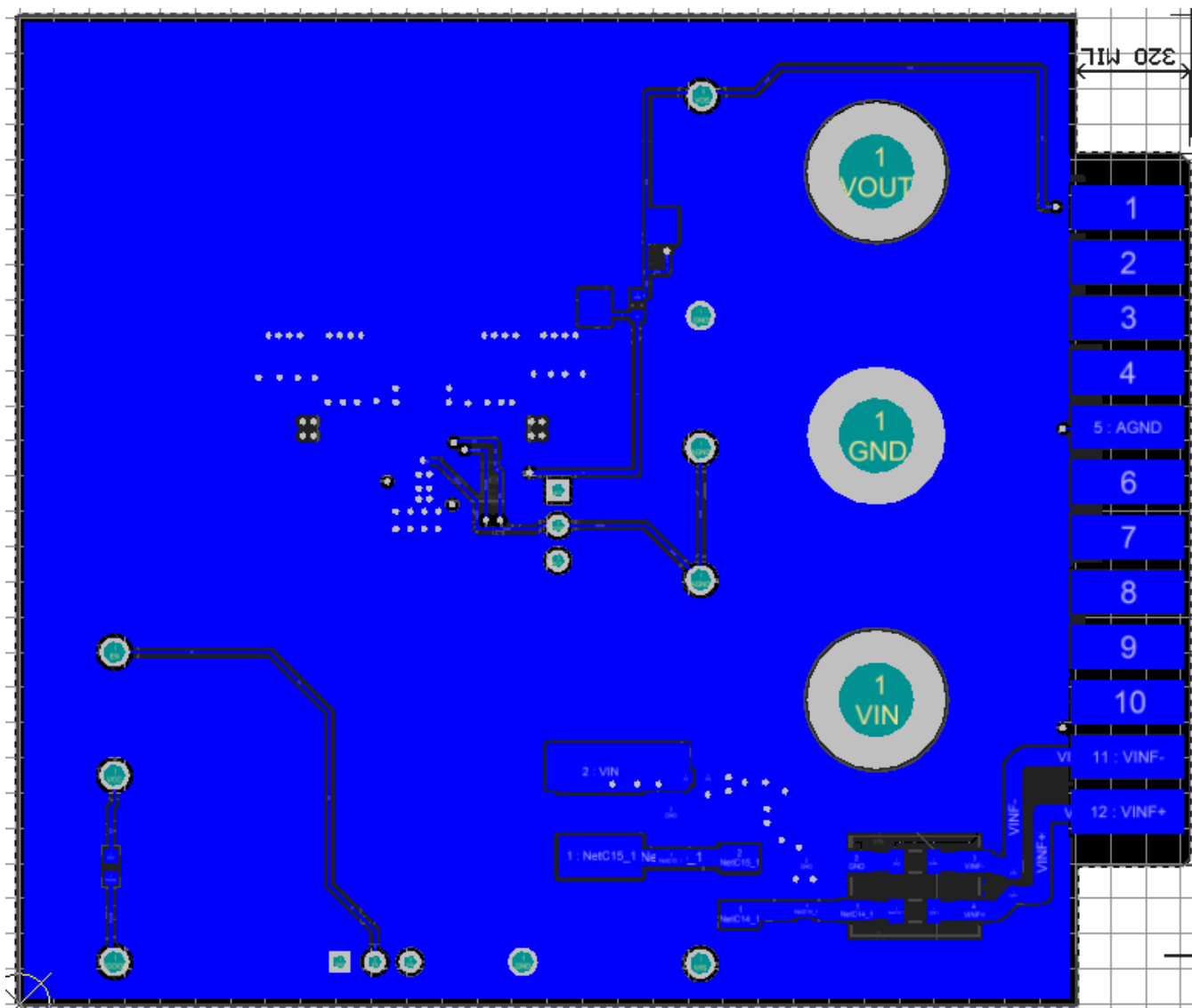


Figure 13. EVM Bottom Copper Layer

6 Bill of Materials

Table 2. BOM for LMR33630ARNXEVM

DESIGNATOR	DESCRIPTION	MANUFACTURER	PART NUMBER	QUANTITY
C1, C17	CAP, CERM, 0.1 μ F, 25 V, +/- 10%, X7R, 0603	AVX	06033C104KAT2A	2
C2, C3, C4, C5	CAP, CERM, 22 μ F, 25 V, +/- 10%, X5R, 1210	Samsung Electro-Mechanics	CL32A226KAJNNNE	4
C6, C8	CAP, CERM, 4.7 μ F, 50 V, +/- 10%, X5R, 0805	TDK	C2012X5R1H475K125AB	2
C7, C9	CAP, CERM, 0.22 μ F, 50 V, +/- 10%, X7R, 0603	TDK	C1608X7R1H224K080AB	2
C10	CAP, AL, 100 μ F, 50 V, +/- 20%, SMD	Chemi-Con	EMVA500ADA101MHA0G	1
C11	CAP, CERM, 1 μ F, 25 V, +/- 10%, X7R, 0603	Würth Elektronik	885012206076	1
J3, J4, J5	Standard Banana Jack, Uninsulated, 8.9mm	Keystone	575-8	3
J1, J2	Header, 100mil, 3x1, Gold, TH	Samtec	HTSW-103-07-G-S	2
L1	Inductor, Shielded, Ferrite, 6.8 μ H, 4 A, 0.0762 ohm,	Bourns	SRP5030T-6R8M	1
R1	RES, 20.0 k, 1%, 0.1 W, 0603	Yageo America	RC0603FR-0720KL	1
R2	RES, 10, 5%, 0.1 W, 0603	Vishay-Dale	CRCW060310R0JNEA	1
R3	RES, 100 k, 1%, 0.1 W, 0603	Yageo America	RC0603FR-07100KL	1
R4	RES, 24.9 k, 1%, 0.1 W, 0603	Yageo America	RC0603FR-0724K9L	1
R5	RES, 43.2 k, 1%, 0.1 W, 0603	Yageo America	RC0603FR-0743K2L	1
SH-J1, SH-J2	Shunt, 100mil, Gold plated, Black	Samtec	SNT-100-BK-G	2
TP1, TP2, TP3, TP8, TP9	Test Point, Multipurpose, Red, TH	Keystone	5010	5
TP4, TP5, TP6, TP7	Test Point, Multipurpose, Black, TH	Keystone	5011	4
U1	SIMPLE SWITCHER 3.8V to 36V 3A/2A Synchronous Step-Down Voltage Regulator, RNX0012A (VQFN-HR-12)	Texas Instruments	LMR33630ARNX	1
C12	CAP, CERM, 10 pF, 50 V, +/- 5%, C0G/NP0, 0603	MuRata	GRM1885C1H100JA01D	0
C13, C16	CAP, CERM, 0.1 μ F, 16 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	TDK	CGJ3E2X7R1C104K080AA	0
C14, C15	CAP, CERM, 4.7 μ F, 50 V, +/- 20%, X7R, AEC-Q200 Grade 1, 1210	TDK	CGA6P3X7R1H475M250AB	0
L2	Inductor, Shielded Drum Core, Powdered Iron, 2.2 μ H, 5.5 A, 0.025 ohm, SMD	Vishay-Dale	IHLP2020CZER2R2M11	0
L3	Coupled inductor, 5 A, 0.01 ohm, SMD	TDK	ACM9070-701-2PL-TL01	0
R6, R7	RES, 0, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	Vishay-Dale	RCA12060000ZSEA	0
L4	Ferrite Bead, 600 ohm @ 100 MHz, 4 A, 2220	Laird-Signal Integrity Products	HI2220P601R-10	0

Table 3. BOM for LMR33630CRNXEVM

DESIGNATOR	DESCRIPTION	MANUFACTURER	PART NUMBER	QUANTITY
C1, C17	CAP, CERM, 0.1 μ F, 25 V, +/- 10%, X7R, 0603	AVX	06033C104KAT2A	2
C2, C5	CAP, CERM, 22 μ F, 25 V, +/- 10%, X5R, 1210	Samsung Electro-Mechanics	CL32A226KAJNNNE	2
C6, C8	CAP, CERM, 4.7 μ F, 50 V, +/- 10%, X5R, 0805	TDK	C2012X5R1H475K125AB	2
C7, C9	CAP, CERM, 0.22 μ F, 50 V, +/- 10%, X7R, 0603	TDK	C1608X7R1H224K080AB	2
C10	CAP, AL, 100 μ F, 50 V, +/- 20%, SMD	Chemi-Con	EMVA500ADA101MHA0G	1
C11	CAP, CERM, 1 μ F, 25 V, +/- 10%, X7R, 0603	Würth Elektronik	885012206076	1
J3, J4, J5	Standard Banana Jack, Uninsulated, 8.9mm	Keystone	575-8	3
J1, J2	Header, 100mil, 3x1, Gold, TH	Samtec	HTSW-103-07-G-S	2
L1	Inductor, Shielded, Ferrite, 2.2 μ H, 5.5 A, 0.035 ohm, SMD	Bourns	SRP5030T-2R2M	1
R1	RES, 20.0 k, 1%, 0.1 W, 0603	Yageo America	RC0603FR-0720KL	1
R2	RES, 10, 5%, 0.1 W, 0603	Vishay-Dale	CRCW060310R0JNEA	1
R3	RES, 100 k, 1%, 0.1 W, 0603	Yageo America	RC0603FR-07100KL	1
R4	RES, 24.9 k, 1%, 0.1 W, 0603	Yageo America	RC0603FR-0724K9L	1
R5	RES, 43.2 k, 1%, 0.1 W, 0603	Yageo America	RC0603FR-0743K2L	1
SH-J1, SH-J2	Shunt, 100mil, Gold plated, Black	Samtec	SNT-100-BK-G	2
TP1, TP2, TP3, TP8, TP9	Test Point, Multipurpose, Red, TH	Keystone	5010	5
TP4, TP5, TP6, TP7	Test Point, Multipurpose, Black, TH	Keystone	5011	4
U1	SIMPLE SWITCHER 3.8V to 36V 3A/2A Synchronous Step-Down Voltage Regulator, RNX0012A (VQFN-HR-12)	Texas Instruments	LMR33630CRNX	1
C12	CAP, CERM, 10 pF, 50 V, +/- 5%, C0G/NP0, 0603	MuRata	GRM1885C1H100JA01D	0
C13, C16	CAP, CERM, 0.1 μ F, 16 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	TDK	CGJ3E2X7R1C104K080AA	0
C14, C15	CAP, CERM, 4.7 μ F, 50 V, +/- 20%, X7R, AEC-Q200 Grade 1, 1210	TDK	CGA6P3X7R1H475M250AB	0
L2	Inductor, Shielded Drum Core, Powdered Iron, 2.2 μ H, 5.5 A, 0.025 ohm, SMD	Vishay-Dale	IHLP2020CZER2R2M11	0
L3	Coupled inductor, 5 A, 0.01 ohm, SMD	TDK	ACM9070-701-2PL-TL01	0
R6, R7	RES, 0, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	Vishay-Dale	RCA12060000ZSEA	0
L4	Ferrite Bead, 600 ohm @ 100 MHz, 4 A, 2220	Laird-Signal Integrity Products	HI2220P601R-10	0

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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- 2.1 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/lstds/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/lstds/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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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。

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

3.4 *European Union*

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

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

4 *EVM Use Restrictions and Warnings:*

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

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

4.3 *Safety-Related Warnings and Restrictions:*

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

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

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

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

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