

LM34936EVM User's Guide

The LM34936EVM features a four switch buck-boost converter based on TI's LM34936 wide V_{IN} buck-boost controller.

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1 Description

The LM34936EVM features a four switch buck-boost converter based on TI's LM34936 wide V_{IN} buck-boost controller. This converter is designed to operate from input voltage from 6 V to 24 V (42-V transient) and provide a 12 V regulated output with a load current of up to 6 A. The board specifications are listed in [Table 1](#).

Table 1. Board Specifications

PARAMETER	VALUE
Input voltage (V_{IN})	6 V to 24 V (42-V transient)
Output voltage (V_{OUT})	12 V
Maximum output current (I_{OUT})	6 A
Default switching frequency (f_{sw})	300 kHz
Synchronizable frequency range	300 kHz to 600 kHz
Efficiency ($I_{OUT} = 5$ A, $V_{IN} = 6$ V to 36 V)	93.8% to 98.5%
Board size (4 layers)	96.4 mm × 91.5 mm (3.8 in × 3.6 in)

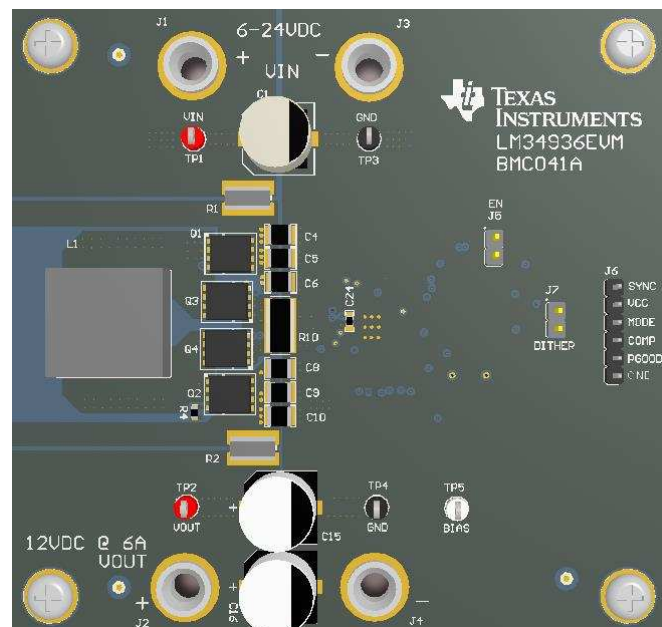


Figure 1. LM34936Evaluation Board

2 Setup

This section describes input and output connectors on the EVM and the step-by-step procedure for setting up and using the LM34936 Evaluation Board.

2.1 Input/Output Connector Description

REF	NAME	DESCRIPTION
TP1	VIN	VIN sense terminal
TP2	VOOUT	VOOUT sense terminal
J1	VIN	Positive input power terminal for the EVM
J2	VOOUT	Positive output from the converter
TP3	GND	Input ground sense terminal
TP4	GND	Output ground sense terminal
J3	GND	Return input power terminal for the EVM
J4	GND	Ground or return terminal for the output
J5	ENABLE	3 terminal ENABLE selections. Short pin 1 and 2 to disable the DC/DC converter. Removing the short allows the converter to start up depending on the EN pin voltage.
J6-6	GND	Unpopulated

2.2 Test Points

J6-2	VCC	Internal VCC regulator output
J6-3	MODE	MODE pin voltage. See LM34936 data sheet for details on this pin
J6-5	PGOOD	Power good indicator. There is a 10-k Ω pullup to VCC on the board.
J6-1	SYNC	External frequency synchronization input terminal (SYNC). This is connected to the RT/SYNC pin of the LM5175 controller IC through a 100-pF capacitor on the board.
J6-4	COMP	Output of the LM5175 GM error amplifier.

2.3 Test Bench Setup

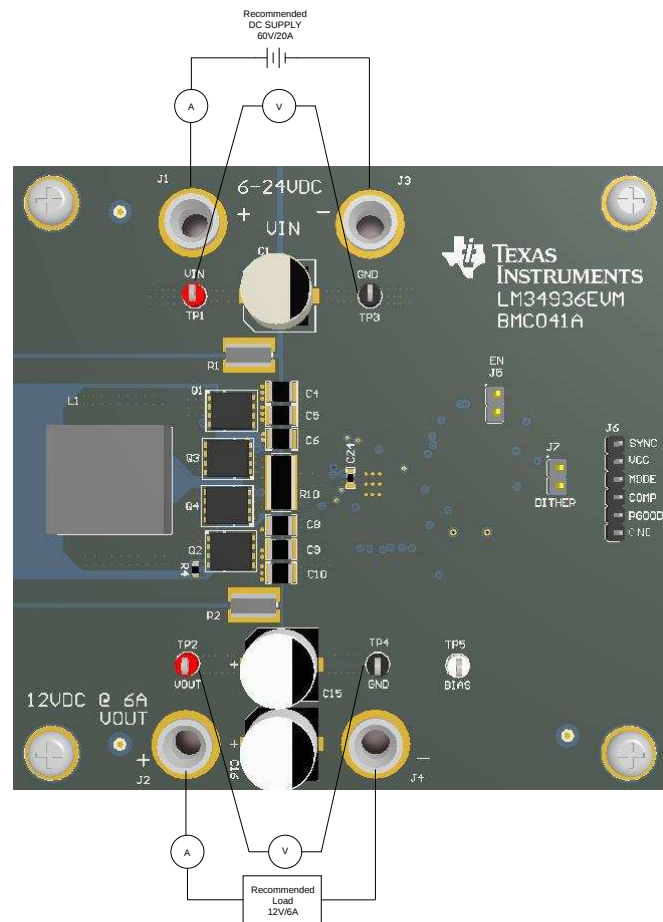


Figure 2. Test Bench Setup

A typical LM34936 test bench setup is shown in [Figure 2](#). The power supply and the load should be capable of handling the input and output voltage and current rating of the board. Follow these steps to get started with the LM34936EVM.

1. Connect the power and ground connectors VIN (J1) and GND (J3) to the power supply.
2. Connect an ammeter in series with the input if needed.
3. Connect a voltmeter across the input terminals (TP1, TP3).
4. Connect a resistive load or an electronic load across terminals VOUT (J2) and GND (J4).
5. An ammeter can be inserted in series with the load to observe the load current.
6. Connect a voltmeter across the output terminals (TP2, TP4) to observe the output voltage.
7. With the load initially set to no load, set the power supply between 6 V and 24 V and turn on the power supply. Check for 12 V at the output.
8. Once the output is at the expected target (12 V), increase the load gradually within the operating range.

3 Performance

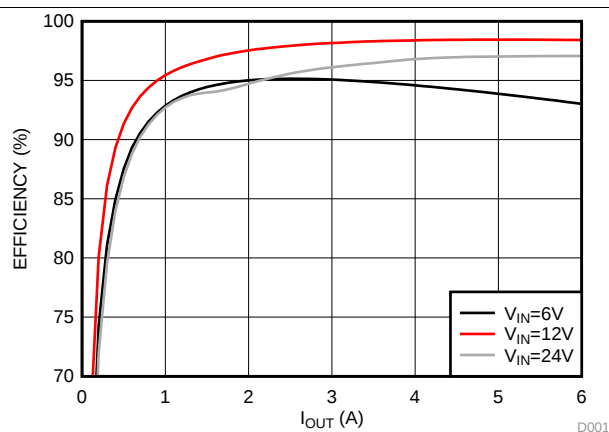


Figure 3. Efficiency vs Load Current

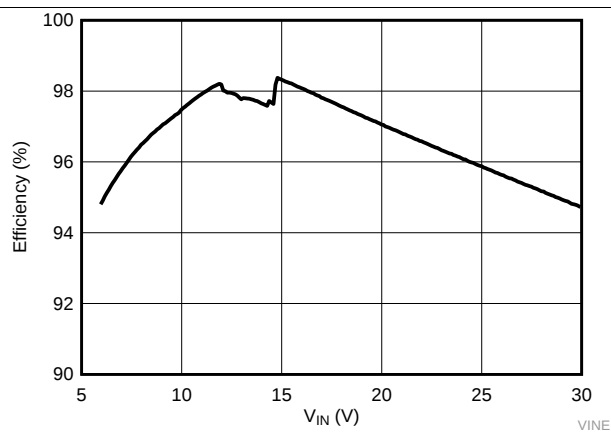


Figure 4. Efficiency vs Input Voltage

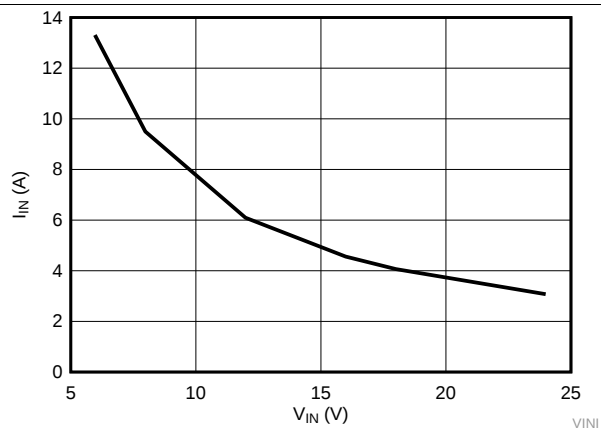


Figure 5. Input Current vs Input Voltage

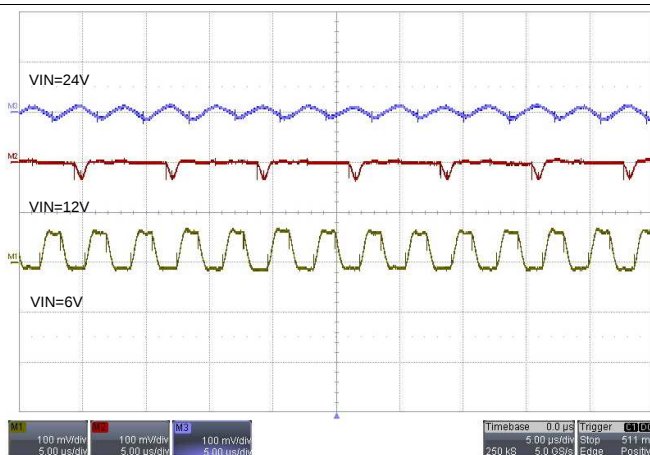
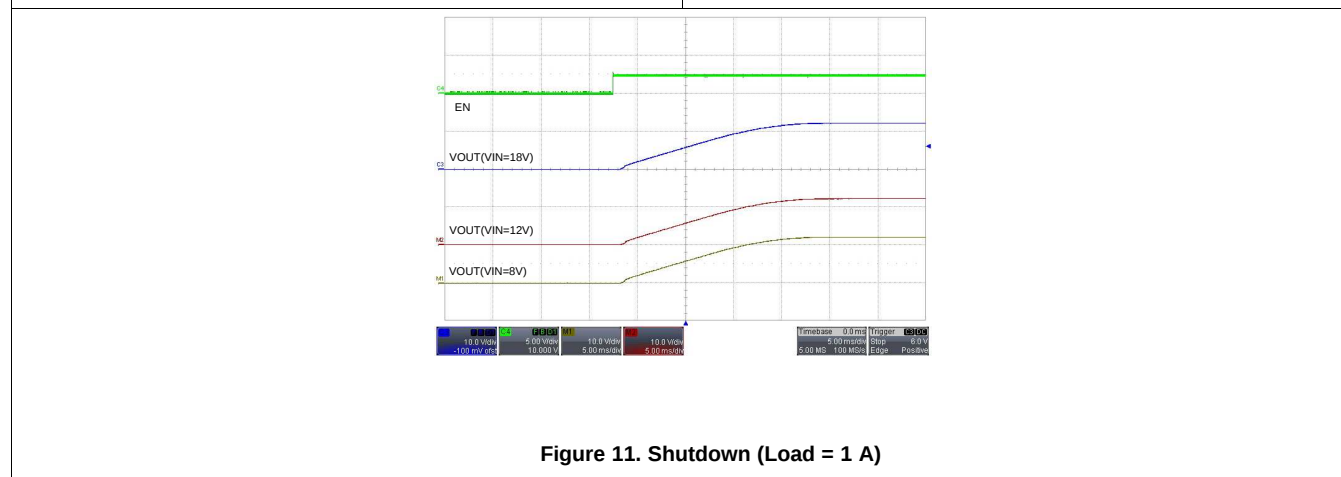
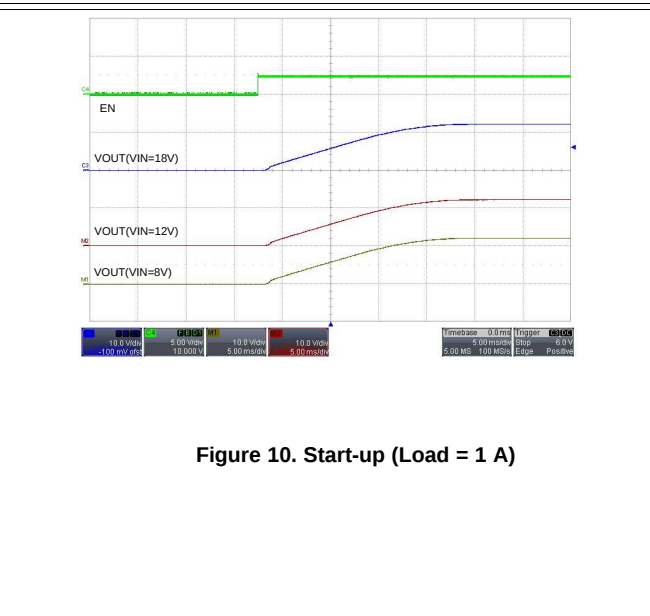
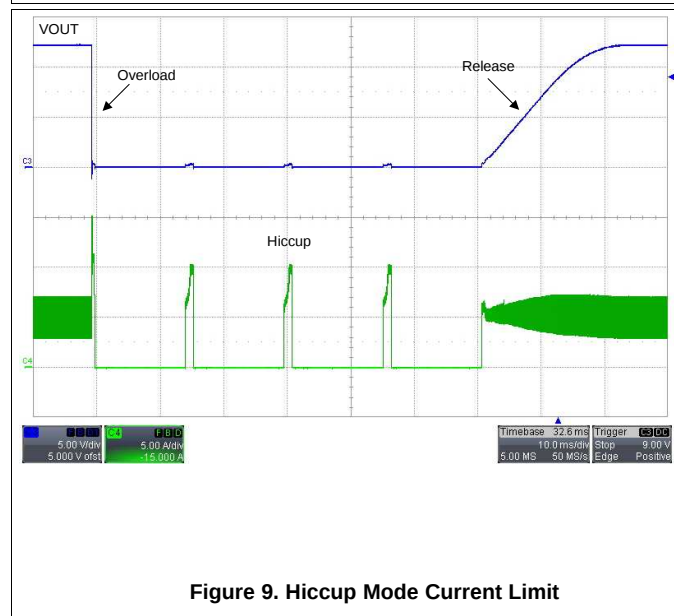
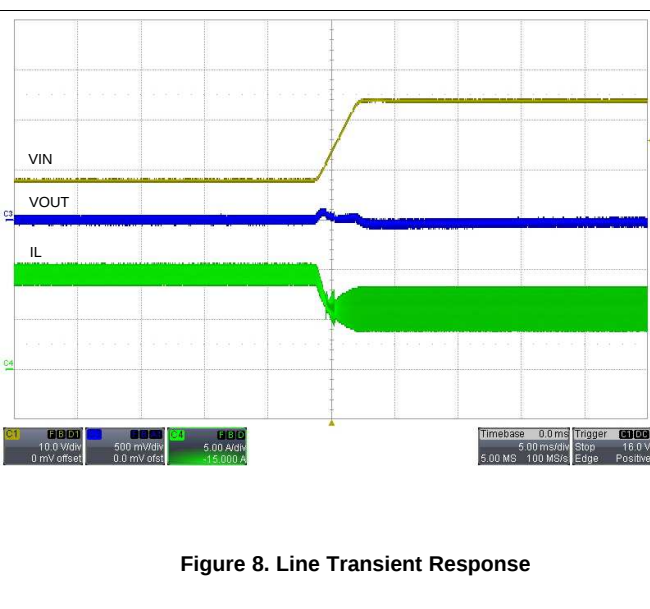
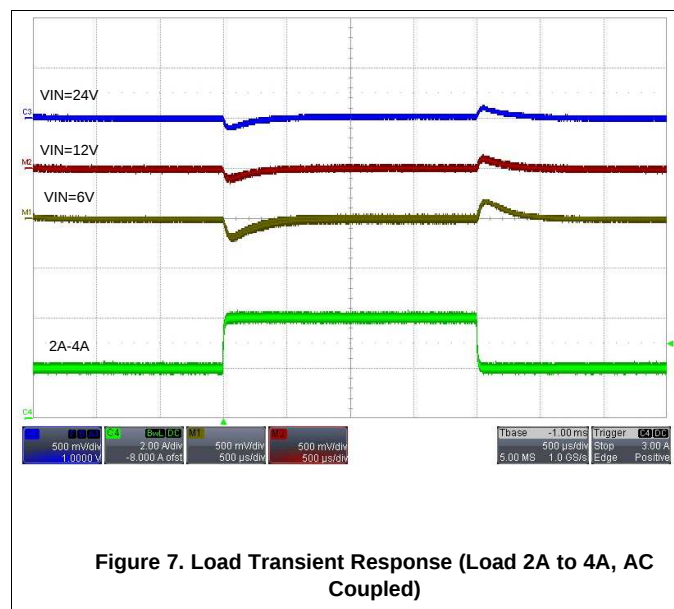


Figure 6. Output Voltage Ripple



4 Complete Schematic

The complete schematic of LM34936 evaluation board is shown in Figure 12.

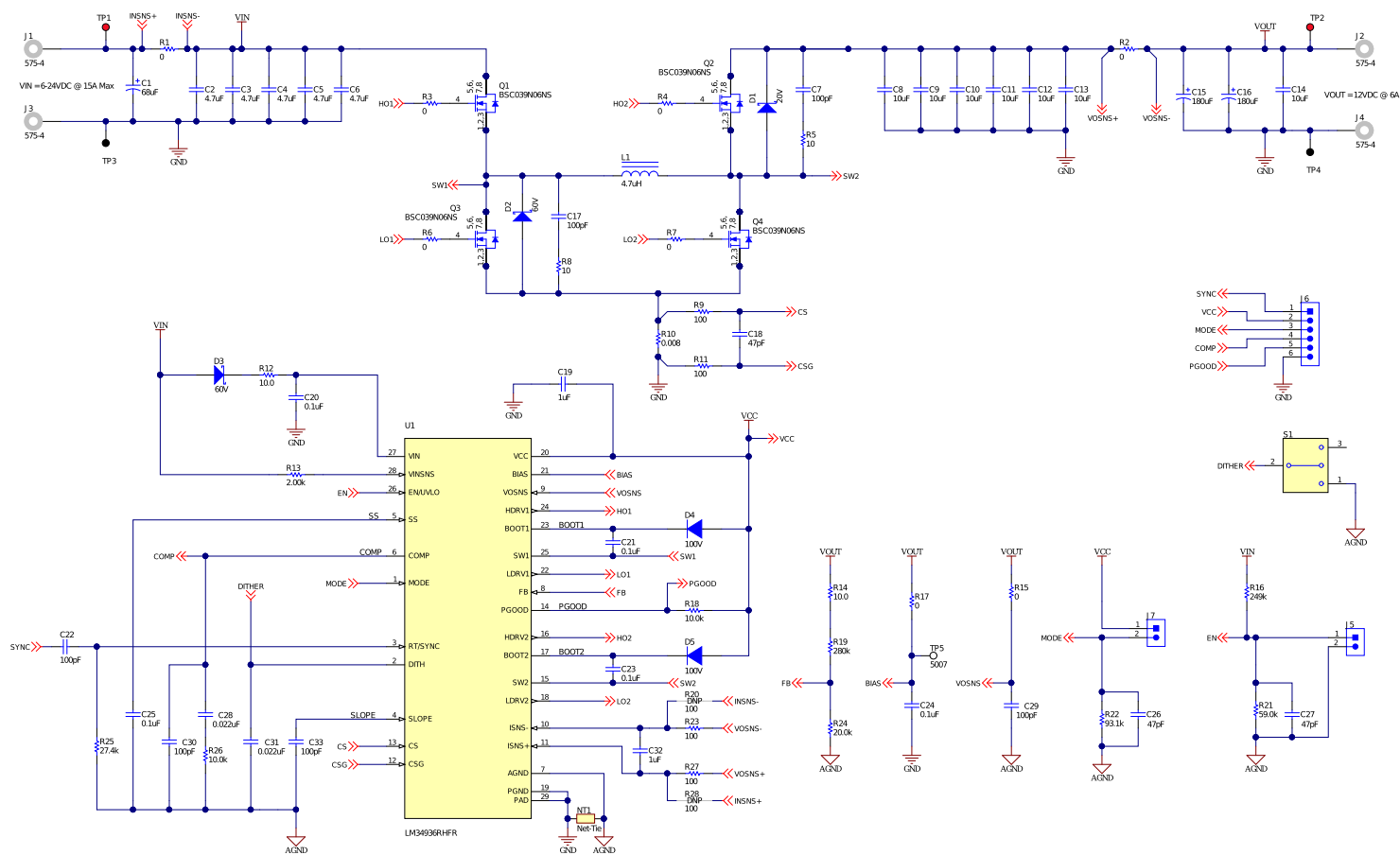


Figure 12. LM34936EVM Schematic

5 Bill of Materials (BOM)

Table 2. Bill of Materials (BOM)

DESIGNATOR	DESCRIPTION	MANUFACTURER	PART NUMBER	QTY
PCB	Printed Circuit Board	Any	SV601130	1
C1	CAP, Aluminum Polymer, 68 μ F, 63 V, $\pm$ 20%, 0.028 ohm, 2-Pin SMD, Body 10.3 x 10.3 mm, Height 10 mm SMD	Nichicon	PCR1J680MCL1GS	1
C2, C3, C4, C5, C6	CAP, CERM, 4.7 μ F, 100 V, $\pm$ 10%, X7S, 1210	TDK	C3225X7S2A475K200AB	5
C8, C9, C10, C11, C12, C13, C14	CAP, CERM, 10 μ F, 50 V, $\pm$ 10%, X7R, 1210	MuRata	GRM32ER71H106KA12L	7
C7, C17	CAP, CERM, 100 pF, 100 V, $\pm$ 5%, COG/NP0, 1206	AVX	12061A101JAT2A	2
C15, C16	CAP, Aluminum Polymer, 180 μ F, 50 V, $\pm$ 20%, 0.019 ohm, SMD, 2-Leads, Dia 10.5mm, Pin Spacing 8mm SMD	Nichicon	PCR1H181MCL1GS	2
C18	CAP, CERM, 47 pF, 50 V, $\pm$ 5%, C0G/NP0, 0603	MuRata	GRM1885C1H470JA01D	1
C19, C32	CAP, CERM, 1 μ F, 25 V, $\pm$ 10%, X7R, 0603	MuRata	GRM188R71E105KA12D	2
C20, C25	CAP, CERM, 0.1 μ F, 100 V, $\pm$ 10%, X7R, 0603	MuRata	GRM188R72A104KA35D	2
C21, C23, C24	CAP, CERM, 0.1 μ F, 100 V, $\pm$ 10%, X7R, 0603	MuRata	GRM188R72A104KA35D	3
C22, C29, C30, C33	CAP, CERM, 100 pF, 100 V, $\pm$ 5%, C0G/NP0, 0603	MuRata	GRM1885C2A101JA01D	4
C28, C31	CAP, CERM, 0.022 μ F, 50 V, $\pm$ 10%, X7R, 0603	Kemet	C0603C223K5RACTU	2
D3	Diode, Schottky, 60 V, 1 A, SOD-323F	NXP Semiconductor	PMEG6010CEJ,115	1
D4, D5	Diode, Ultrafast, 100V, 0.25A, SOD-323	NXP Semiconductor	BAS316,115	2
H1, H2, H3, H4	Machine Screw, Round, 4-40 x 1/4, Nylon, Philips Panhead	B and F Fastener Supply	NY PMS 440 0025 PH	4
H5, H6, H7, H8	Standoff, Hex, 0.5 inch Long 4-40 Nylon	Keystone	1902C	4
J1, J2, J3, J4	Standard Banana Jack, Uninsulated, 5.5mm	Keystone	575-4	4
J5, J17	Header, TH, 100mil, 2x1, Gold plated, 230 mil above insulator	Sullins Connector Solutions	PBC02SAAN	2
L1	Inductor, Shielded, Composite, 4.7 μ H, 29A, 0.00335 ohm, SMD	Coilcraft	XAL1510-472MEB	1
Q1, Q2, Q3, Q4	MOSFET, N-CH, 60 V, 19 A, PG-TDSON-8	Infineon Technologies	BSC039N06NS	4
R1, R2	RES, 0 Ω , 5%, 2 W, 2512 WIDE	Vishay Draloric	RCL12250000Z0EG	2
R3, R4, R6, R7, R15, R17	RES, 0 Ω , 5%, 0.1 W, 0603	Yageo America	RC0603JR-070RL	6
R5, R8	RES, 10.0 Ω , 1%, 0.25 W, 1206	Yageo America	RC1206FR-0710RL	2
R9, R11,	RES, 100 Ω , 1%, 0.1 W, 0603	Yageo America	RC0603FR-07100RL	2
R10	RES, 0.008 Ω , 1%, 4 W, 3015 WIDE	Susumu Co Ltd	KRL7638-C-R008-F-T1	1
R12, R14	RES, 10.0 Ω , 1%, 0.1 W, 0603	Yageo America	RC0603FR-0710RL	2
R13	RES, 2.0 k Ω , 1%, 0.1 W, 0603	Yageo America	RC0603FR-0702KL	1
R16	RES, 249 k Ω , 1%, 0.1 W, 0603	Yageo America	RC0603FR-07249KL	1
R18, R26	RES, 10.0 k Ω , 1%, 0.1 W, 0603	Yageo America	RC0603FR-0710KL	2
R19	RES, 280 k Ω , 1%, 0.1 W, 0603	Yageo America	RC0603FR-07280KL	1
R21	RES, 59.0 k Ω , 1%, 0.1 W, 0603	Yageo America	RC0603FR-0759KL	1
R22	RES, 93.1 k Ω , 1%, 0.1 W, 0603	Yageo America	RC0603FR-0793K1L	1
R23, R27	RES, 100, 1%, 0.1 W, 0603	Vishay Dale	CRCW0603100RFKEAL	2
R24	RES, 20.0 k Ω , 1%, 0.1 W, 0603	Yageo America	RC0603FR-0720KL	1
R25	RES, 27.4 k Ω , 1%, 0.1 W, 0603	Yageo America	RC0603FR-0727K4L	1
TP1, TP2	Test Point, Compact, Red, TH	Keystone	5005	2
TP3, TP4	Test Point, Compact, Black, TH	Keystone	5006	2

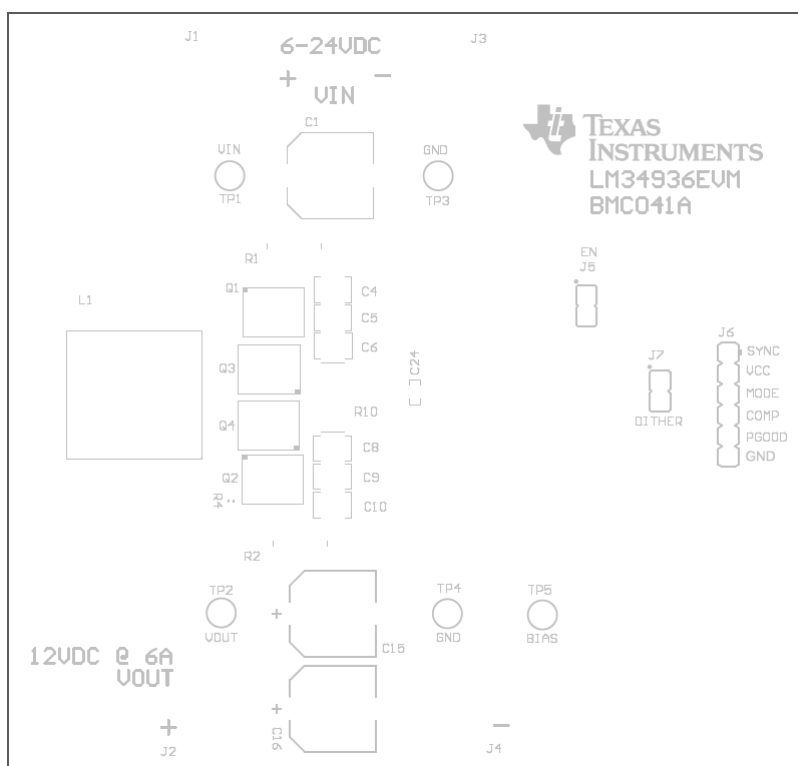
Table 2. Bill of Materials (BOM) (continued)

DESIGNATOR	DESCRIPTION	MANUFACTURER	PART NUMBER	QTY
TP5, TP6, TP7, TP8, TP9, TP10	Test Point, Compact, White, TH	Keystone	5007	6
U1	30V Wide VIN 4-Switch Synchronous Buck-Boost Controller, RHF (R-PVQFN-N28)	Texas Instruments	LM34936RHFT	1

6 Re-Configuring the Average Current Loop

PART	USE I_{OUT} LOOP	USE I_{IN} LOOP
R2	Populate (see data sheet for value)	0 Ω (default)
R23, R27	100 Ω (default)	De-populate
R1	0 Ω (default)	Populate (see datasheet for value)
R20, R28	De-populate	100 Ω
C32	Populate (see datasheet for value)	Populate (see datasheet for value)

7 Board PCB


Figure 13. Top Overlay

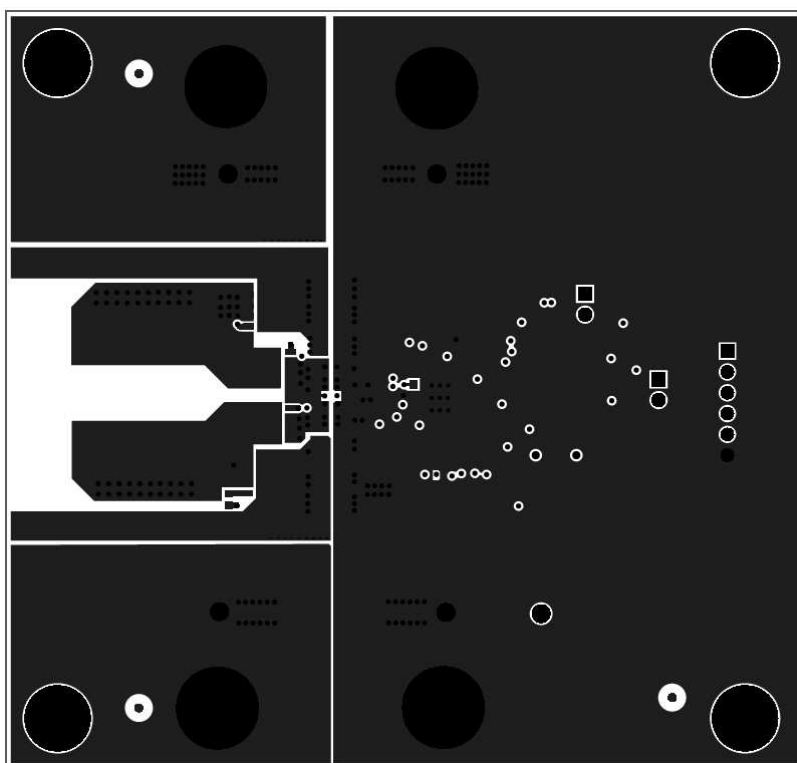


Figure 14. Top Layer

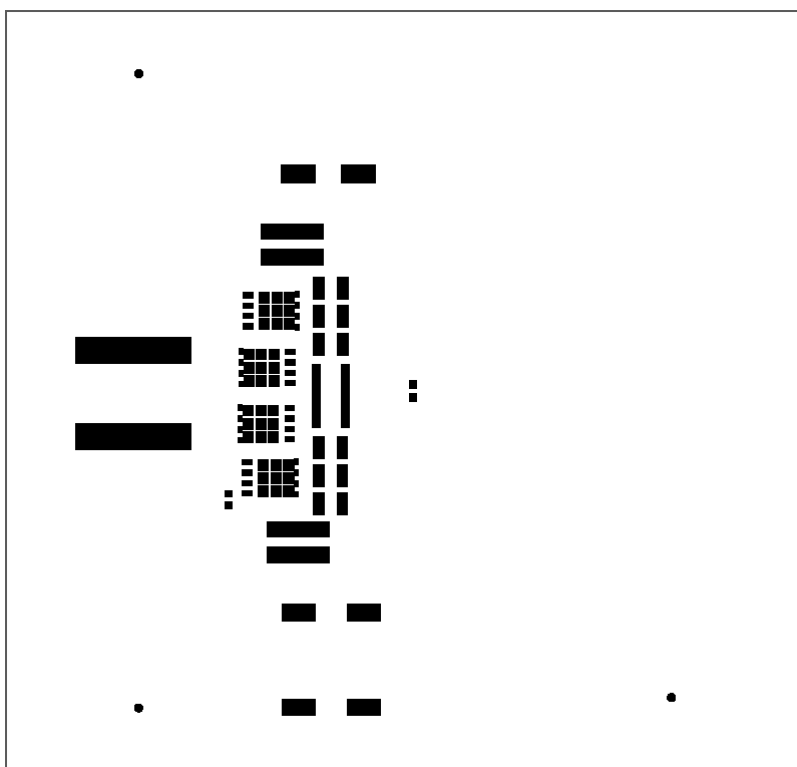


Figure 15. Top Solder

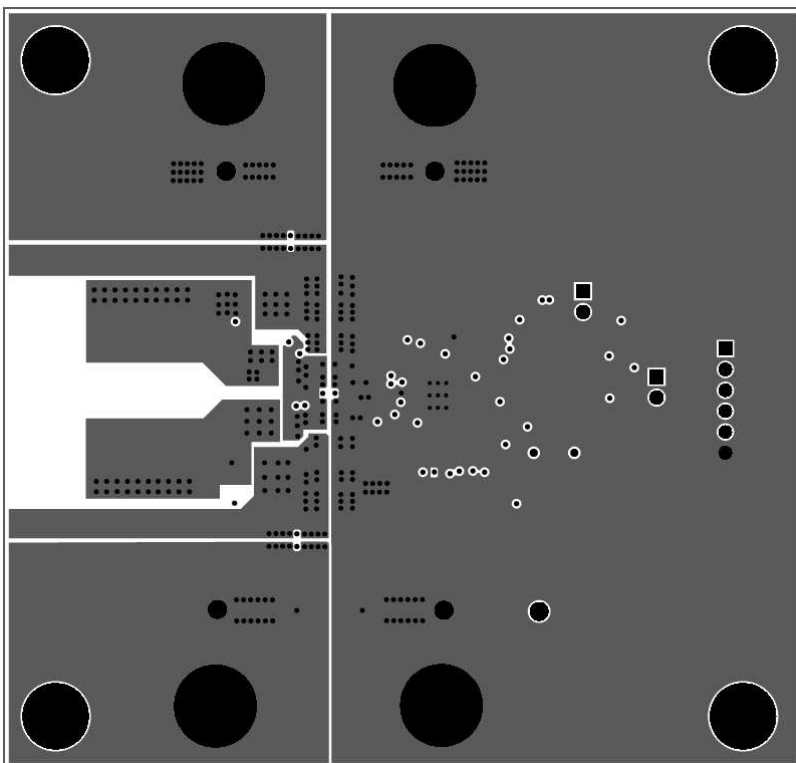


Figure 16. Mid Layer 2

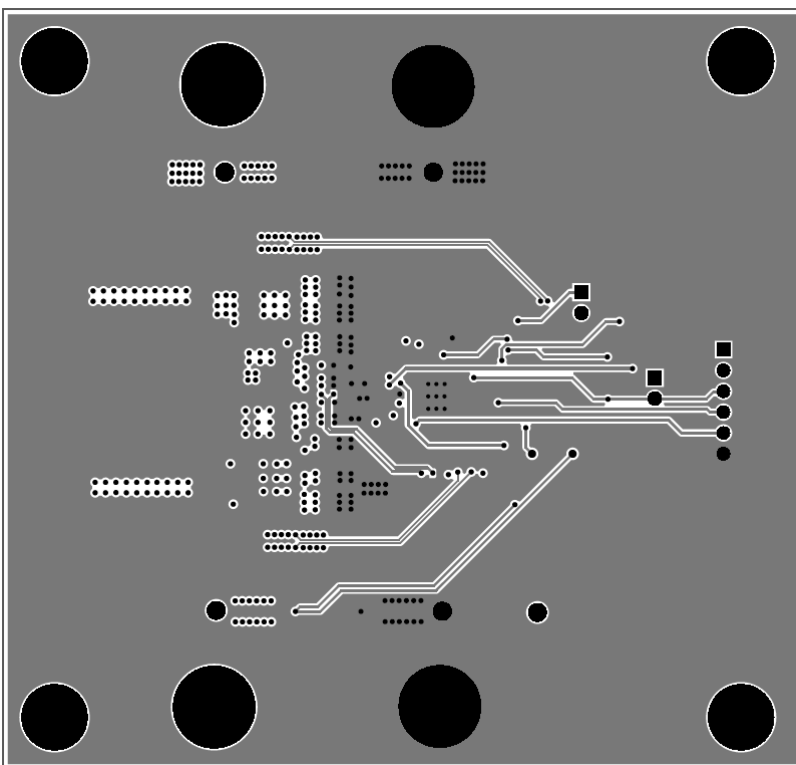


Figure 17. Mid Layer 3

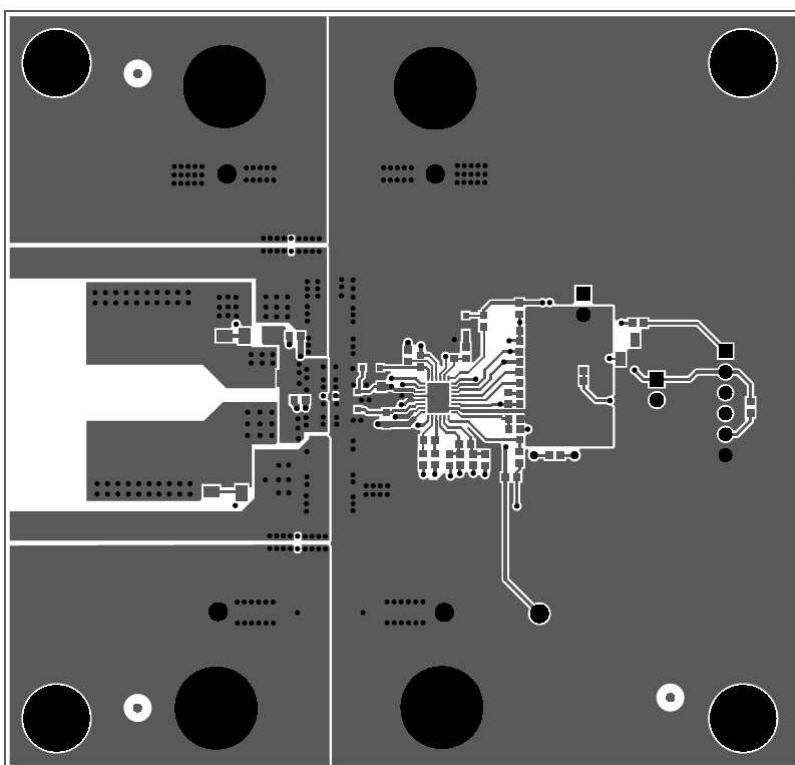


Figure 18. Bottom Layer

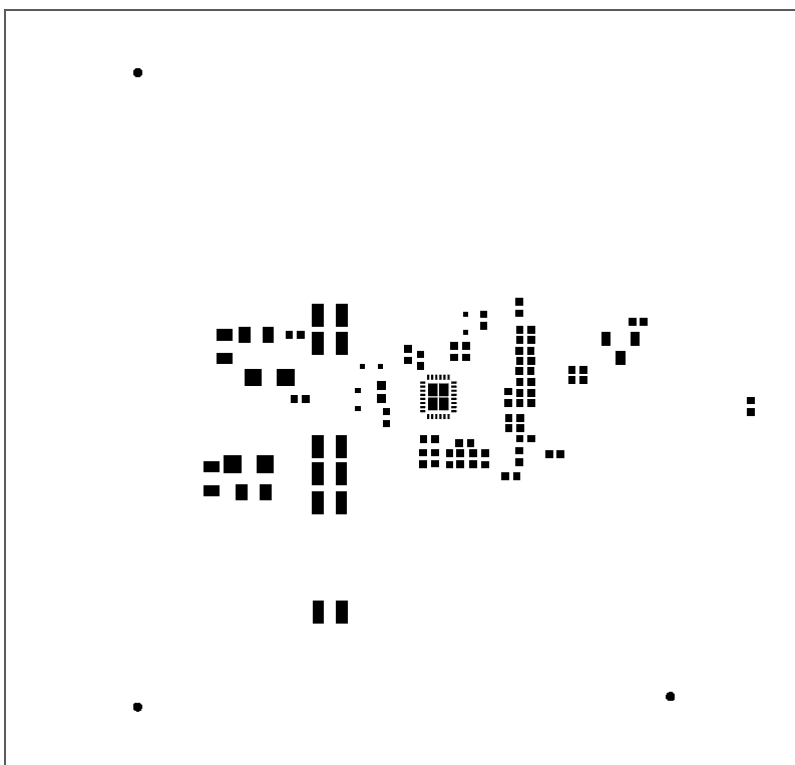


Figure 19. Bottom Solder

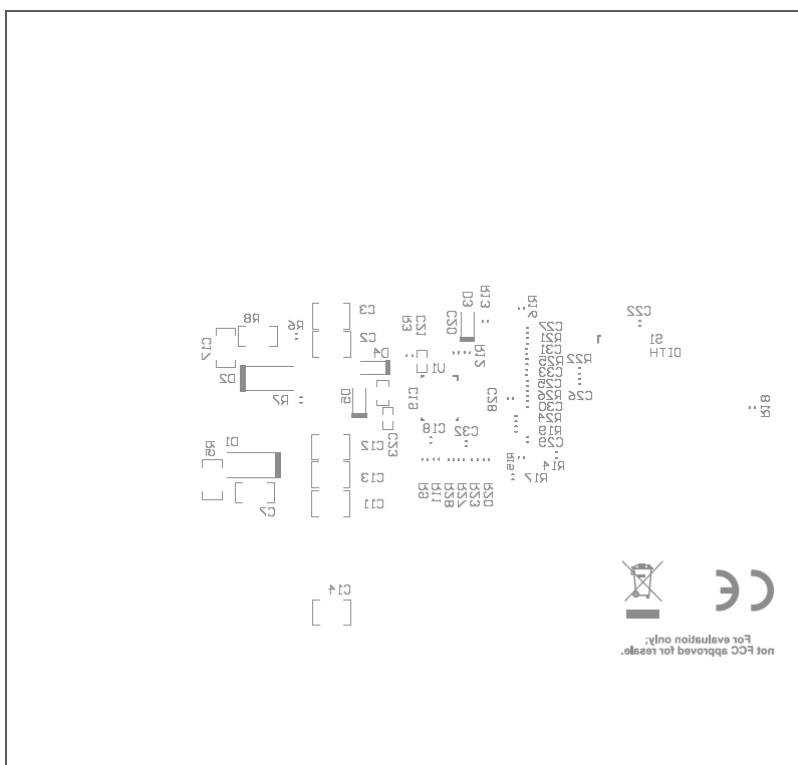


Figure 20. Bottom Overlay

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- 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/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 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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3.4 *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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