

# EVM User's Guide: LMR60440RBMQEVM

## LMR60440RBM-Q1 Evaluation Module



### Description

The LMR60440-Q1 evaluation module (EVM) operates over a wide input voltage range of 8V to 36V to provide a regulated 3.3V output up to 4A load at 2.2MHz switching frequency. The LMR60440RBMQEVM can support output voltage regulation accuracy greater than 1% and the output voltage setpoint is adjustable using an external resistor divider.

### Get Started

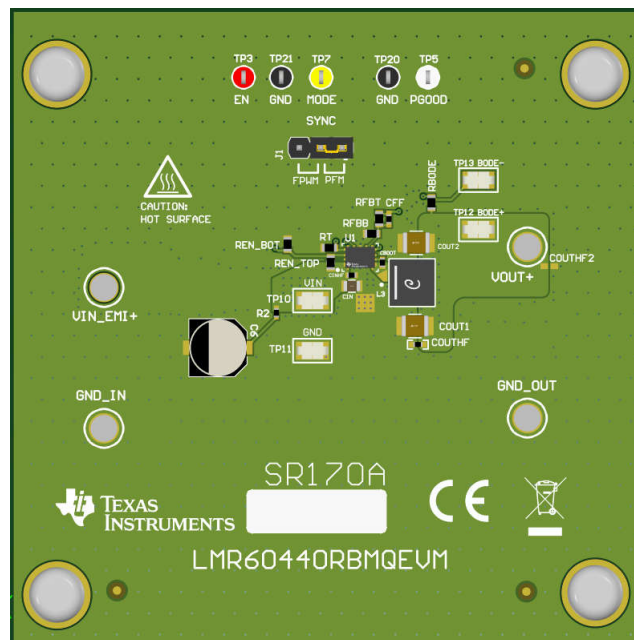
1. Order the EVM [here](#).
2. Prepare the bench setup per the user's guide instructions.
3. Power up the EVM by following the recommended steps.
4. Run tests and measurements. Beware of possible high component temperatures.

### Features

- Input voltage range: 8V to 36V
- Output voltage: 3.3V
- Load current: 0A to 4A
- Switching frequency: 2.2MHz
- Adjustable output voltage
- External synchronization capability
- Internal spread spectrum capability
- Selectable pulse-frequency modulation or forced pulse-width modulation at light load
- Supports other variants of the IC by replacing some components

### Applications

- [Advanced driver assistance systems \(ADAS\)](#)
- [Body electronics and lighting](#)
- [Infotainment and cluster](#)



LMR60440RBMQEVM

# 1 Evaluation Module Overview

## 1.1 Introduction

The Texas Instruments LMR60440RBMQEVM helps designers evaluate the operation and performance of the LMR604x0-Q1 wide-input buck converters. The LMR60440-Q1 is an easy-to-use synchronous step-down DC/DC converter capable of delivering up to 4A of load current from an input voltage of 3V up to 36V. The LMR60440RBMQEVM features an output voltage of 3.3V and a switching frequency of 2.2MHz that can support a load up to 4A.

The LMR60440-Q1 or LMR60430-Q1 in the RBM package is an 11-pin RBM WQFN package with preprogrammed settings to reduce component count and achieve high density designs. The LMR60440RBMQEVM comes with the RBM package variant of the LMR60440 and LMR60430, which allows for adjustable output voltage, external synchronization, and spread spectrum options at a fixed 2.2MHz switching frequency. See the LMR604x0-Q1 datasheet for the detailed information of all four variants of the device. The EVM uses the LMR60440-Q1 with the following features:

- Wide input voltage range
- Wide duty-cycle range
- Integrated high-side and low-side power MOSFETs
- Cycle-by-cycle overcurrent protection
- Internal loop compensation
- Designed for low electromagnetic interference (EMI) requirements

## 1.2 Kit Contents

The package includes:

1. LMR60440-Q1 evaluation module (LMR60440RBMQEVM) that includes the LMR604403SRBMRQ1
2. EVM Disclaimer Read-Me

## 1.3 Specification

A summary of the LMR60440RBMQEVM performance is provided in the table below. Due to variations in test setup, deviations from the measurements listed below can be expected.

SPECIFICATIONS		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{IN}$	Input voltage		8	12	36	V
$V_{OUT}$	Output voltage	$V_{IN} = 13.5V$		3.3	3.32	V
$F_{SW}$	Switching frequency			2.0		MHz
$I_{OUT}$	Output current range		0		4	A
Peak efficiency		$I_{OUT} = 2.2A, V_{IN} = 13.5V$		89.4		%

## 1.4 Device Information

**Table 1-1. Device and Package Configurations**

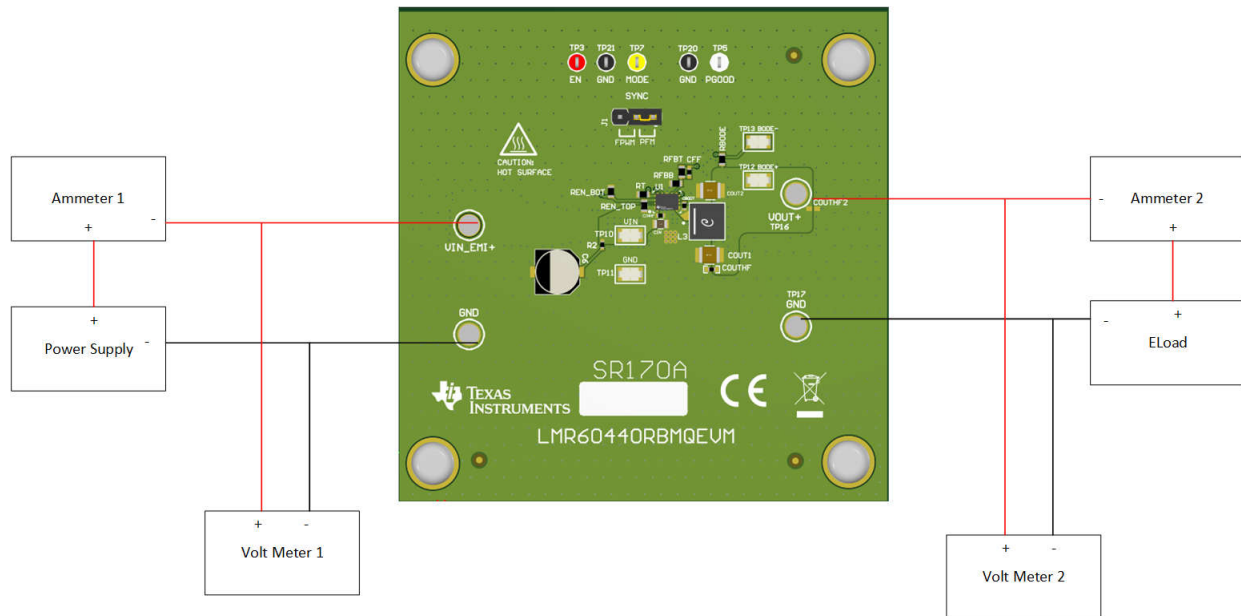
EVM	U1	FREQUENCY	SPREAD SPECTRUM	CURRENT	PIN 1 TRIM
LMR60440RBMQEVM	LMR604403SRBMRQ1	2.2MHz	Enabled	4A	Adjustable output voltage and MODE select

## 2 Hardware

### 2.1 EVM Setup

This section describes the test points and connectors on the EVM and how to properly connect, set up, and use the LMR60440RBMQEVM.

The EVM uses the LMR60440-Q1 converter which includes MODE/SYNC capability. This means that the device can operate in pulse frequency modulation (PFM) light-load mode when this pin is tied to GND. TI has observed additional output voltage ripple at input voltages close to the output voltage when the device is operating in PFM light-load mode. To see improved performance, TI recommends to configure the EVM to operate in forced pulse width modulation (FPWM) mode. To access the FPWM light-load operating mode, depopulate resistor R8 and populate resistor R6.



**Figure 2-1. EVM Board Connections**

The test setup consists of the following instruments in addition to the EVM board.

- **Power supply:** The input DC voltage source must be capable of supplying 36V and 4A.
- **Load:** The load must be an electronic, constant-current (CC) or constant-resistance (CR) mode load, capable of supporting 4A of load current at 3.3V. Disconnect the electronic load when performing no-load input current tests.
- **Multimeters:**
  - **Voltmeter 1:** Measures input voltage at VIN+ (TP14) and VIN- (TP15)
  - **Voltmeter 2:** Measures output voltage at VOUT (TP16) and VOUT- (TP17)
  - **Ammeter 1:** Measures input current
  - **Ammeter 2:** Measures output current
- **Oscilloscope:** With the scope set to 20MHz bandwidth and AC coupling, measure the output voltage ripple directly across an output capacitor with a short ground lead. Place the oscilloscope probe tip on the positive terminal of the output capacitor, and the ground lead on the negative terminal of the output capacitor. TI does not recommend using a long-leaded ground connection because the connection can induce additional noise due to a large ground loop. To measure other waveforms, adjust the oscilloscope as necessary.

### 2.1.1 Quick Start

1. Connect the voltage supply between the VIN+ and VIN- test points.
2. Connect the load between the VOUT and GND test points.
3. Set the supply voltage at an appropriate level between 8V to 36V. Set the current limit of the supply to an appropriate level.
4. Turn on the power supply. With the default configuration, the EVM powers up and provides  $V_{OUT} = 3.3V$ .
5. Monitor the output voltage. The load current must be 4A or less with the LMR60440-Q1 device.

### 2.1.2 Test Points

The test points on the top of the board are used for connecting to the input and output of the EVM. See for a description of the test points.

**Table 2-1. EVM Test Points**

Test Point	Signal	Description
VIN _EMI+	VIN	Input supply to EVM including an EMI filter. Connect to a good input supply. Connect at this point for conducted EMI test.
GND_IN	GND	Ground connection for the input supply
VOUT+	VOUT	Output voltage to EVM.
GND_OUT	GND	Ground connection for load.
TP3	EN	This test point is connected to the EN pin from the IC.
TP5	PGOOD	This test point is connected to the PGOOD pin from the IC. The test point is an open-drain output of the PGOOD pin. Using the resistor R3, the PGOOD pin can be tied to VOUT through a pullup resistor or left open.
TP7	MODE/SYNC	This test point is connected to the MODE/SYNC pin from the IC. This test point is connected to GND through R8
TP12 BODE+	VOUT	Top test point above 47.5Ω for Frequency Responce measurement.
TP13 BODE-	BODE	Bottom test point below 47.5Ω for Frequency Responce measurement.
TP10, TP11, TP20	GND	This test point is connected to GND.

### 3 Implementation Results

#### 3.1 Performance Data and Results

Actual performance data can be affected by measurement techniques and environmental variables. These curves are presented for reference and can differ from actual field measurements. Unless otherwise stated,  $V_{in} = 13.5V$ ,  $V_{out} = 3.3V$ , and  $F_{sw} = 2.2MHz$ .

##### 3.1.1 Efficiency, Load Regulation, and Dropout

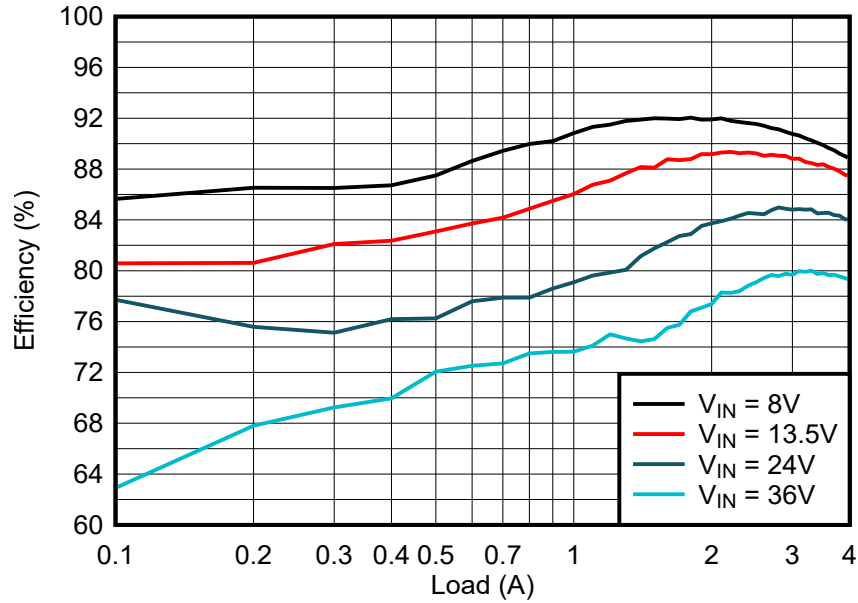


Figure 3-1. Conversion Efficiency (2.1MHz)

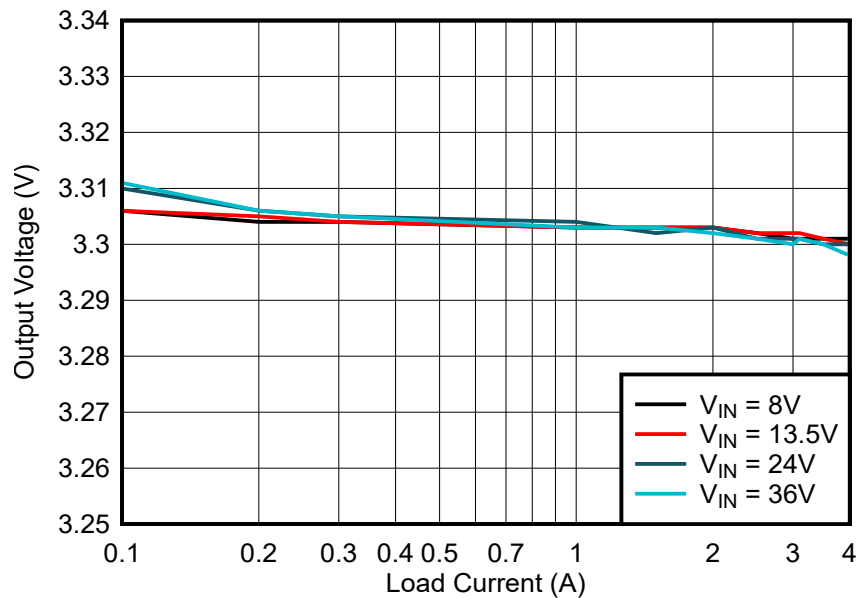


Figure 3-2. Output Voltage Regulation

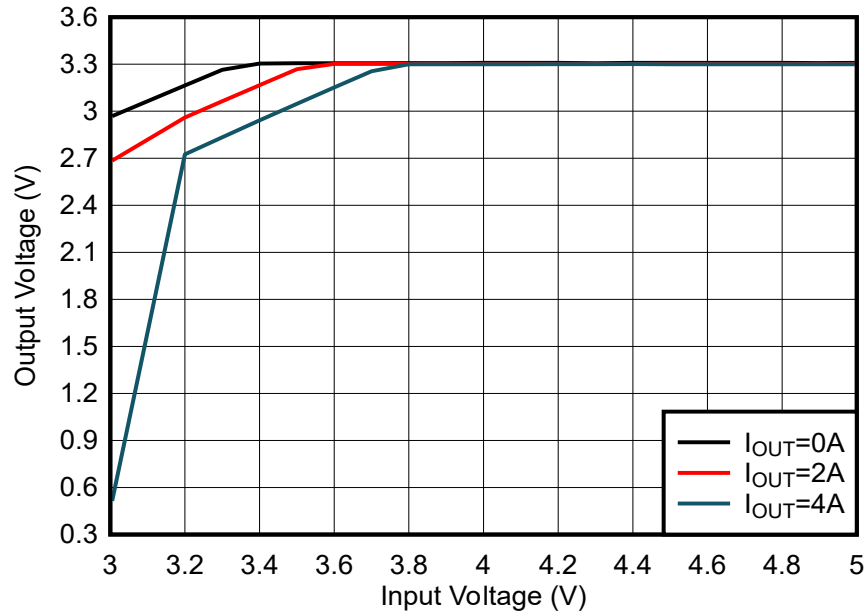


Figure 3-3. Dropout Performance Curves

### 3.1.2 Load Transients

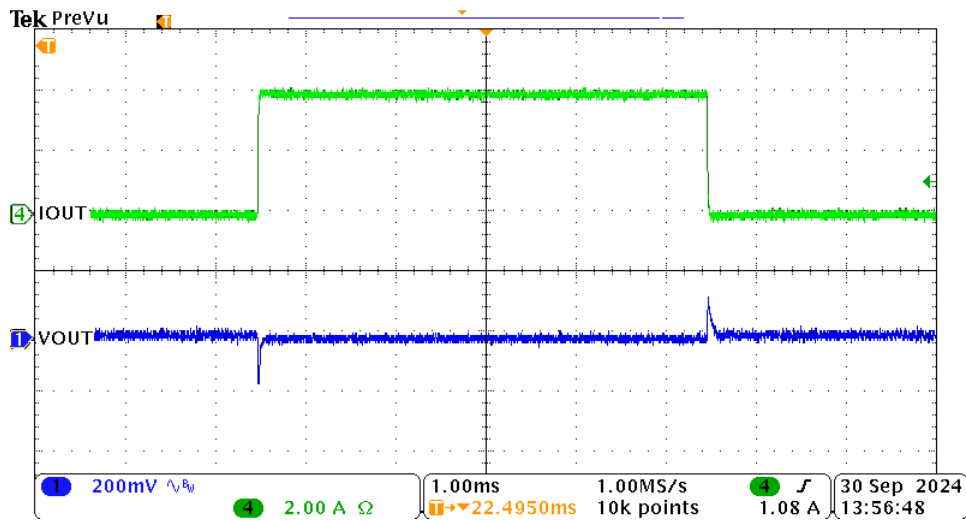


Figure 3-4. Load Transient, I<sub>OUT</sub> = 20mA to 4A

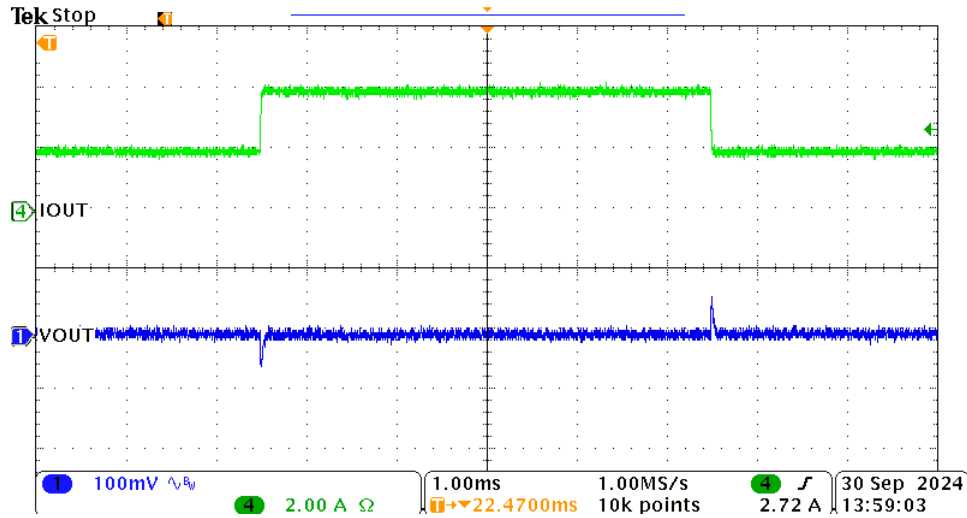


Figure 3-5. Load Transient,  $I_{OUT} = 2A$  to  $4A$

### 3.1.3 Start-Up and Shutdown

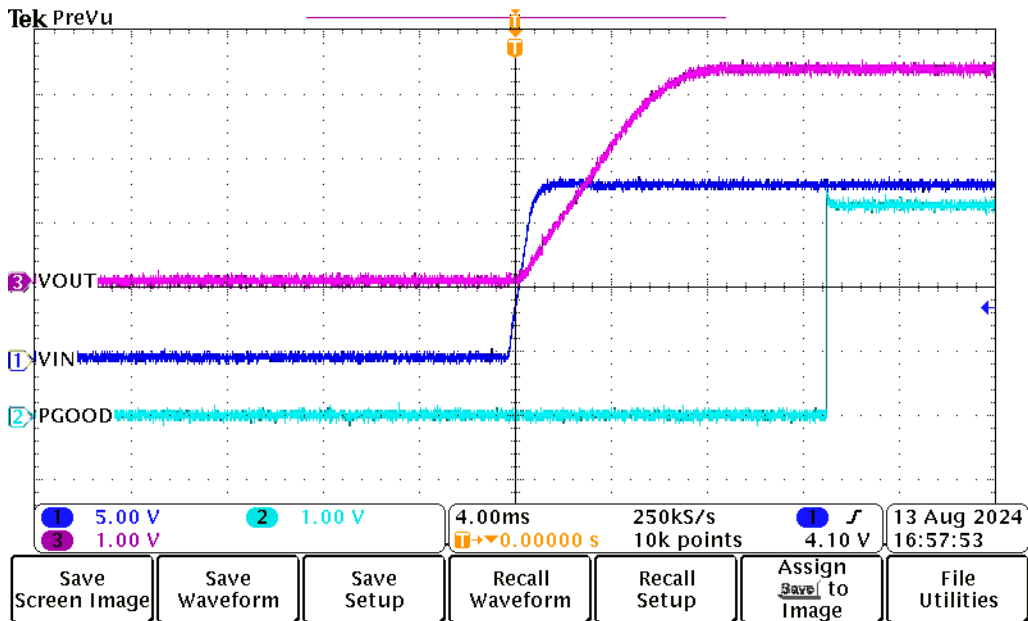


Figure 3-6. Start-Up,  $I_{OUT} = 4A$

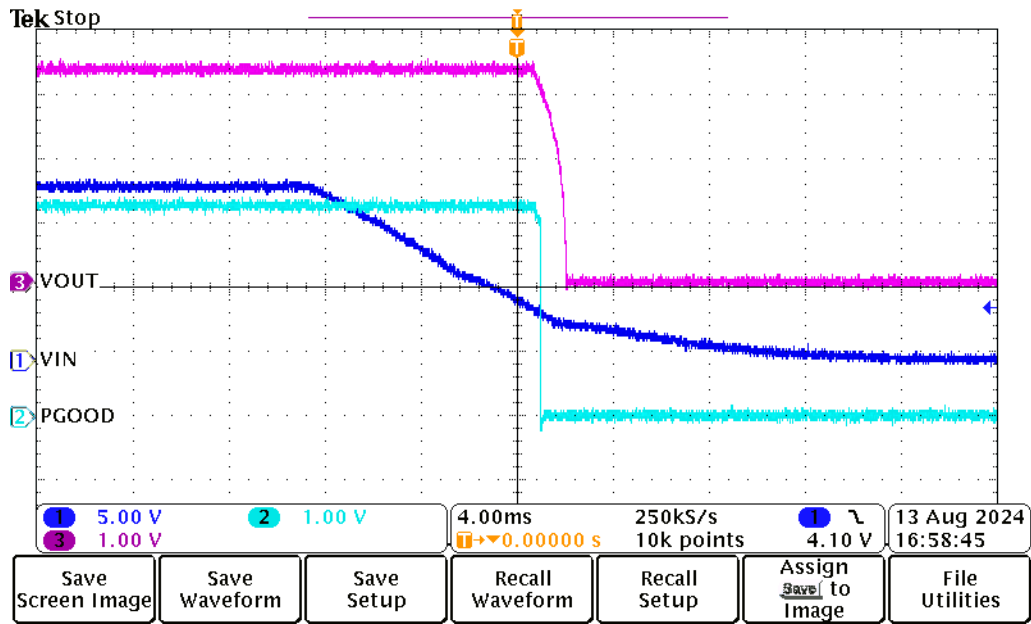


Figure 3-7. Shutdown,  $I_{OUT} = 4A$

## 4 Hardware Design Files

### 4.1 Schematic

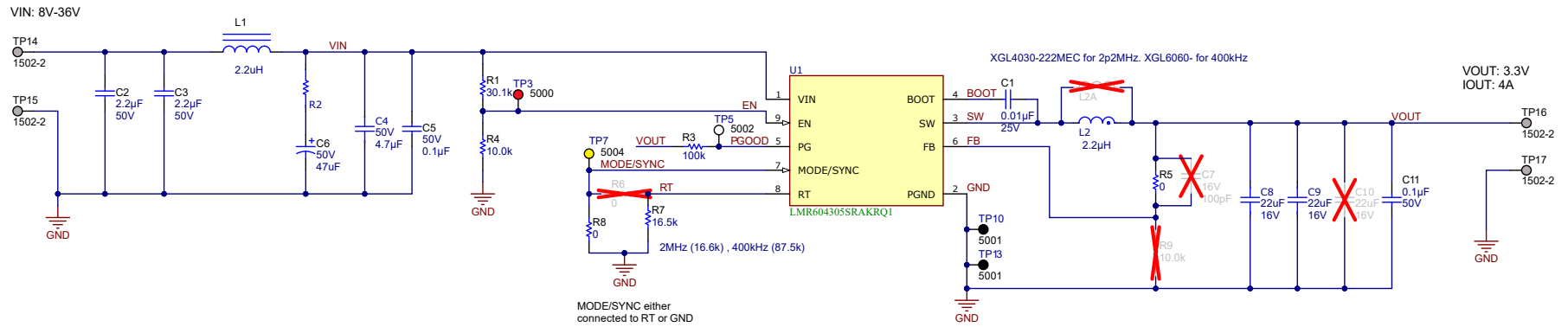


Figure 4-1. LMR60440RBMQEVM Schematic

## 4.2 Board Layout

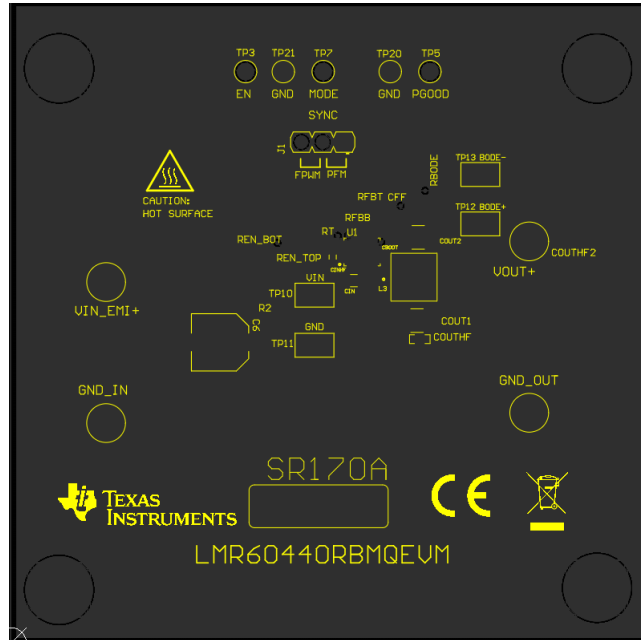


Figure 4-2. EVM Top Overlay

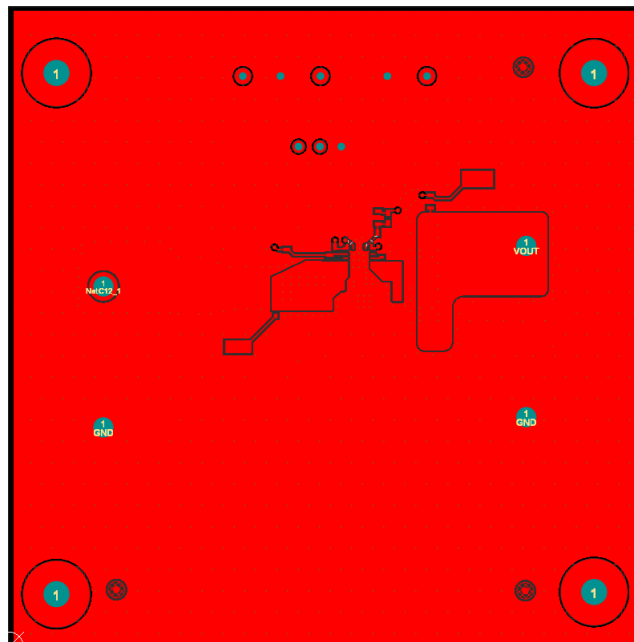


Figure 4-3. EVM Top Copper Layer

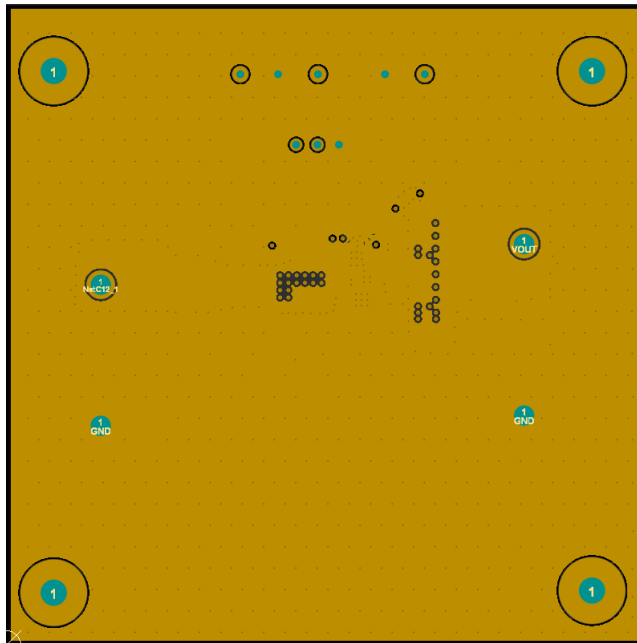


Figure 4-4. EVM Mid Layer One

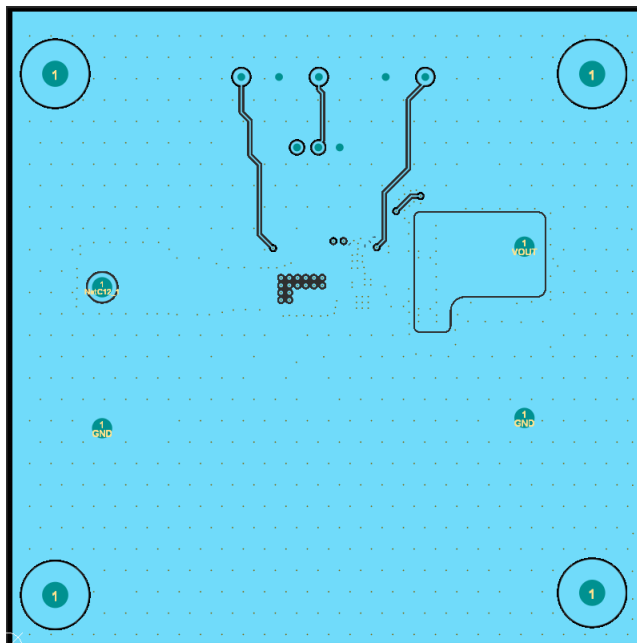


Figure 4-5. EVM Mid Layer Two



### 4.3 Bill of Materials

**Table 4-1. Bill Of Materials**

Designator	Quantity	Value	PartNumber	Description	Manufacturer
C2, C3, C12, C13, C14, C15	6	2.2uF	CGA4J3X7R1H225K125AB	CAP, CERM, 2.2 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	TDK
C6	1	47uF	EEEF1H470AP	CAP, AL, 47 uF, 50 V, +/- 20%, 0.68 ohm, AEC-Q200 Grade 2, SMD	Panasonic
CBOOT	1	0.1uF	CGA2B3X7R1E104K050BB	CAP, CERM, 0.1 uF, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402	TDK
CFF	1	22pF	CGA2B2C0G1H220J050BA	CAP, CERM, 22 pF, 50 V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0402	TDK
CIN	1	4.7µF	CGA4J1X7R1H475K125AC	Cap Ceramic 4.7uF 50V X7R 10% Pad SMD 0805 +125°C Automotive T/R	TDK Corporation
CINHF, COUTHF	2	0.1uF	CGA2B3X7R1H104K050BB	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402	TDK
COUT1, COUT2	2	22µF	CGA6P3X7R1E226M250AB	Cap Ceramic 22uF 25V X7R 20% Pad SMD 1210 +125°C Automotive T/R	TDK
J1	1		68001-403HLF	Header, 2.54mm, 3x1, Tin, TH	FCI
L1	1		XGL4020-222MEC	Shielded Power Inductor 2.2uH 20% 8.9A 21.5mOhm Max DCR AEC-Q200 4.0x4.0x2.1mm	Coilcraft
L3	1	2.2uH	XGL5020-222MEC	Shielded Power Inductors 1.5uH 20% 13.2mOhm 12.8A	Coilcraft
LBL1	1		THT-14-423-10	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	Brady
R2	1	0	RC0402JR-070RL	RES, 0, 5%, 0.063 W, 0402	Yageo America
R11	1	0	5108	0 Ohms Jumper 0.5W, 1/2W Chip Resistor 1206 (3216 Metric) - Metal Element	Keystone
RBODE	1	47.5	CRCW060347R5FKEA	RES, 47.5, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	Vishay-Dale
REN_BOT	1	10.2k	CRCW060310K2FKEA	RES, 10.2 k, 1%, 0.1 W, 0603	Vishay-Dale
REN_TOP	1	29.4k	CRCW060329K4FKEA	RES, 29.4 k, 1%, 0.1 W, 0603	Vishay-Dale
RFBB	1	24.9k	CRCW060324K9FKEA	RES, 24.9 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	Vishay-Dale
RFBT, RPG	2	100k	ERJ-3GEYJ104V	RES, 100 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Panasonic
RT	1	15.4k	CRCW060315K4FKEA	RES, 15.4 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	Vishay-Dale
TP3	1		5000	Test Point, Miniature, Red, TH	Keystone Electronics

**Table 4-1. Bill Of Materials (continued)**

TP5	1		5002	Test Point, Miniature, White, TH	Keystone Electronics
TP7	1		5004	Test Point, Miniature, Yellow, TH	Keystone Electronics
TP10, TP11, TP12, TP13	4		5019	Test Point, Miniature, SMT	Keystone
TP14, TP15, TP16, TP17	4		1502-2	Terminal, Turret, TH, Double	Keystone
TP20, TP21	2		5001	Test Point, Miniature, Black, TH	Keystone Electronics
U1	1		LMR604403SRBMRQ1	LMR604401	Texas Instruments
COU3, COU4	0	22 $\mu$ F	CGA6P3X7R1E226M250AB	Cap Ceramic 22uF 25V X7R 20% Pad SMD 1210 +125°C Automotive T/R	TDK
COUHF2	0	0.1uF	CGA2B3X7R1H104K050BB	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402	TDK
R_FPWM, R_PFM	0	0	RMCF0603ZT0R00	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	Stackpole Electronics Inc

## **5 Additional Information**

### **5.1 Trademarks**

All trademarks are the property of their respective owners.

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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 semiconductor 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.

### **WARNING**

**Evaluation Kits 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 shall operate the Evaluation Kit within TI's recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI's recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI's instructions for electrical ratings of interface circuits such as input, output and electrical loads.**

**NOTE:**

**EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGRADATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.**

### 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](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。

<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html>

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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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。日本テキサス・イ

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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/lstds/ti\\_ja/general/eStore/notice\\_02.page](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。 <https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html>

#### 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.

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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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    - 6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.
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