

## EVM User's Guide: REF54EVM-2

# REF54 陶瓷 LCCC 封装评估模块



### 说明

REF54EVM-2 是一款精密电压基准评估模块，可展示德州仪器 (TI) 高精度串联基准器件 (采用陶瓷 LCCC 封装的 REF54) 的性能。REF54 是一个低漂移、低噪声电压基准器件系列。REF54 具有低温漂、低闪烁噪声和低长期漂移特性。通过使用 REF54EVM-2 和适当的实验室设备，用户可以评估 REF54 的性能，包括其初始精度、静态电流、温漂、长期漂移、噪声以及强制/检测输出和接地功能。

### 开始使用

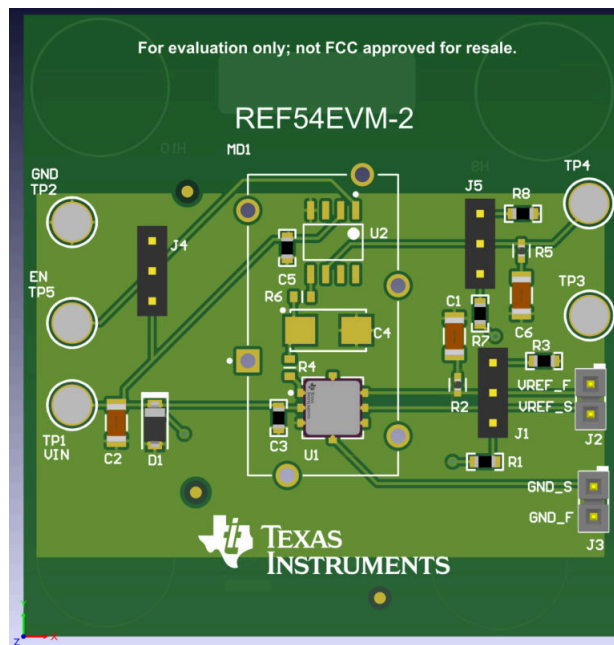
1. 从 [REF54EVM-2 工具页面](#) 订购 EVM。
2. 使用所需的输出强制和检测引脚为 EVM 配置开尔文连接。
3. 将 VIN 连接到电源。
4. 测试输出。

### 特性

- 通过强制和检测引脚进行开尔文连接。
- 用于评估负载调整率的电阻器。
- 用于安装降噪电容器和遮罩以进行低噪声测试的空间。
- 用于评估 REF54 的 SOIC 封装的空间。

### 应用

- 半导体测试和 ATE
- 数字万用表 (DMM)
- 信号发生器
- 电池测试
- 精密数据采集系统



REF54EVM-2 电路板

## 1 评估模块概述

### 1.1 简介

REF54EVM-2 是一款精密电压基准评估模块，可展示采用 LCCC 封装的 REF54 性能。REF54 具有低长期漂移和温漂，有助于满足高精度应用的严格性能要求。该器件还在输出端包含一个强制和检测引脚，以支持开尔文连接。

本用户指南介绍了 REF54EVM-2 的特性、操作和推荐用例。本文档提供了有关如何使用 REF54EVM-2 电路板的示例和说明。本文档中的评估板、评估模块和 EVM 等所有术语均指 REF54EVM-2。本文档还包含原理图、参考印刷电路板 (PCB) 布局和完整的物料清单 (BOM)。

### 1.2 套件内容

表 1-1 详细说明了 EVM 套件的内容。如果缺少任何元件，请通过 (972) 644-5580 联系 TI 产品信息中心。

表 1-1. 套件清单

条目	数量
REF54EVM-2	1

### 1.3 规格

REF54EVM-2 的主要功能是评估 REF54 精密电压基准的陶瓷封装版本。电路板上提供了用于安装电容的空间，以便配合降噪 (NR) 引脚使用。电路板上还有一个可用于评估 REF54 SOIC 封装版本的空间。该电路板使用 8.5 DMM 进行评估。

### 1.4 器件信息

采用陶瓷封装的 REF54 是一款精密电压基准。设计为具有极低的温度漂移和长期漂移，REF54 还是一款低噪声器件。因此，REF54 可与超高精度 ADC 和 DAC 搭配使用。REF54 的陶瓷封装版本在输出端包含一个强制和检测引脚，允许通过开尔文连接来补偿较长 PCB 走线的压降。它还包含一个降噪 (NR) 引脚。如果操作得当，谨慎利用该引脚连接一个最大 100 $\mu$ F 的电容器，可以降低噪声。

## 2 硬件

### 2.1 设置

图 2-1 所示的是 REF54EVM-2 原理图。

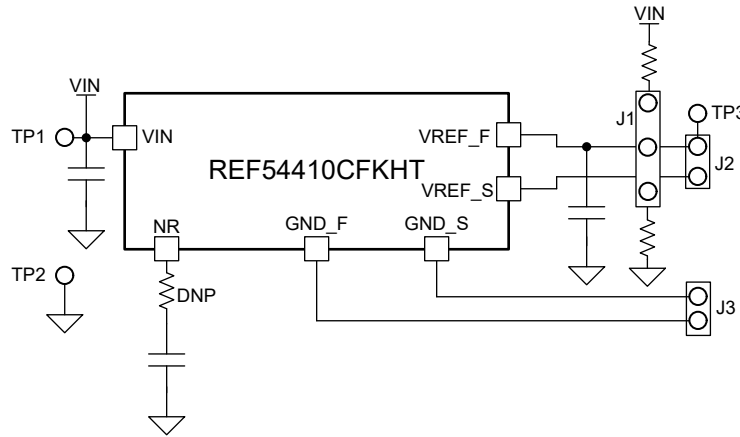


图 2-1. REF54EVM-2 设置

REF54EVM-2 旨在允许用户评估图 2-1 中所示的配置。提供了电路板可配置选项，允许用户评估负载调整率、降噪功能以及 VREF\_F、VREF\_S、GND\_F 和 GND\_S 引脚的开尔文连接。

### 2.2 EVM 连接

REF54EVM-2 提供了各种连接来评估 REF54。有关这些连接的信息，请参阅表 2-1。

表 2-1. REF54EVM-2 连接

EVM 连接功能	电路板标识符	REF54410CFKHT 引脚	建议使用条件
输入电压	TP1	VIN (引脚 2)	最小值：4.096V + V <sub>DO</sub>
			最大值：18V
输出电压强制连接	J2 (标签：VREF_F)	VREF_F (引脚 7)	连接到 VREF_S (引脚 6) 后，使用数字万用表测量
输出电压检测连接	J2 (标签：VREF_S)	VREF_S (引脚 6)	连接到 VREF_F (引脚 7) 后，使用数字万用表测量
额外输出电压连接	TP3	VREF_F (引脚 7)	提供一个额外的测试点，用于在 J2 的两条引线都短接时进行测量
接地强制连接	J3 (标签：GND_F)	GND_F (引脚 3)	短接至 GND_S (引脚 4) 后接地
接地检测连接	J3 (标签：GND_S)	GND_S (引脚 4)	短接至 GND_F (引脚 3) 后接地
额外接地连接	TP2	GND_F (引脚 3)	接地
电阻负载选择	J1	J1 顶部引脚：不适用	将 J1 的中间引脚连接到 J1 的顶部引脚，可将高达 10mA 的电流拉入短接在一起的 VREF_F 和 VREF_S 中。将 J1 的中间引脚连接到 J1 的底部引脚，可从短接在一起的 VREF_F 和 VREF_S 灌入高达 10mA 的电流。
		J1 中间引脚：VREF_F (引脚 7)	
		J1 底部引脚：不适用	

图 2-2 展示了默认 EVM 设置。

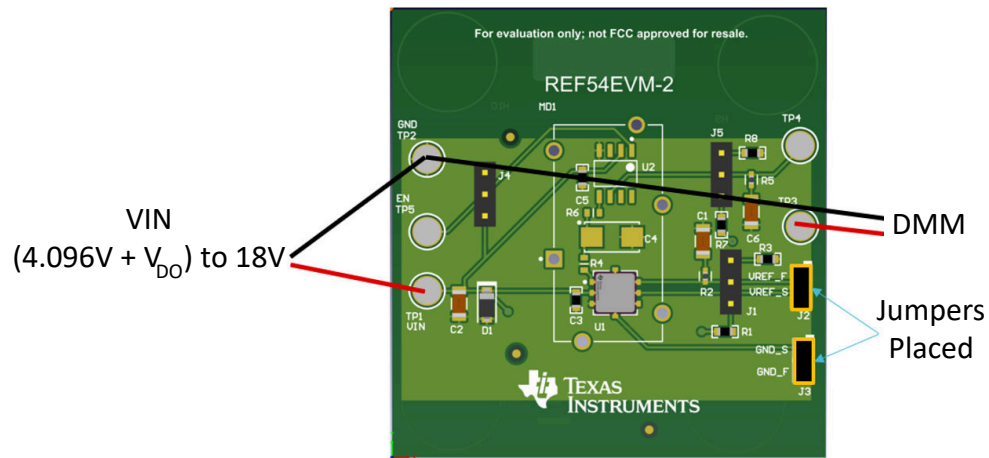


图 2-2. REF54EVM-2 默认设置

## 2.3 最佳实践

- 使用具有优秀 PSRR 的电源。
- 使用高分辨率仪器 ( DMM、示波器 ) 测量输出，以便获得出色性能。TI 建议使用 8.5 位 DMM。
- 遵循测量噪声和选择降噪电容器的最佳实践。有关更多详细信息，请参阅节 2.3.1。

### 2.3.1 降噪 (NR) 引脚最佳实践

电路板上留出了一个空间，用于根据需要安装降噪电容器 (C4)。如果向 C4 添加了降噪电容器，用户还必须组装或短接 R4 的焊盘，以将该电容器连接到 NR 引脚 ( REF54410CFKHT 的引脚 1 )。电容器选择和电路板设计是添加 NR 电容器后获得规定噪声性能的关键。如果不遵循谨慎电容器选择实践，不良的电容器特性可能导致 REF54 出现输出电压波动。

将电容器置于 NR 引脚上时，最佳实践是选择低泄漏铝电容器。REF54EVM-2 还支持在 REF54 和 NR 电容器上安装一个遮罩 (MD1)。默认情况下，遮罩已卸下。但是，如果用户希望安装低泄漏铝电容器来测试 REF54 的输出电压噪声，请盖住 REF54 和 NR 电容器以减少气流接触。有关 NR 电容器 (C4) 和遮罩 (MD1) 器件型号建议，请参阅节 4.3。由于 REF54 具有超低噪声，气流接触 NR 电容器所引发的压电效应会导致电容器振动，这可能会主导 REF54 的输出电压性能。在 REF54 和 NR 电容器周围放置一个遮罩，可以尽可能减少气流与 NR 电容器的接触。这样用户就仅能观察到 REF54 电压基准本身添加的噪声，消除外部电容器引入的噪声。

请注意，要使 REF54 成功运行，不需要在 NR 引脚与接地之间添加电容器，但通过谨慎的电路板设计和元件选择实践，这么做是降低低频噪声的实用选项。如果 NR 引脚保持悬空，则评估噪声时无需遮罩。有关如何表征低频闪烁噪声的更多信息，请参阅精密串联基准中的噪声测量技术。

## 3 实现结果

### 3.1 评估设置

使用下列条件对 EVM 进行测试。

- **VIN (TP1)** : 将 TP1 连接到一个 Keithley 2420 SMU，并将该 SMU 的接地端连接到 TP2。
- **VREF\_F 和 VREF\_S (J2)** : 使用提供的跳线短接 VREF\_F 和 VREF\_S。
- **GND\_F 和 GND\_S (J3)** : 使用提供的跳线短接 GND\_F 和 GND\_S。
- **VREF (TP3)** : 将 TP3 连接到一个 2458A DMM，并将该 DMM 的接地端连接到 TP2。
- **负载选择 (J1)** : 选择适当的负载来测试灌电流和拉电流负载调整率。

### 3.2 性能数据和结果

REF54EVM-2 的输出电压是在数据表规格允许的压降条件下测得的。它还符合初始精度、长期漂移和温度漂移规格限制。该器件满足相关测试的线路调整率规格和关断条件。

## 4 硬件设计文件

### 4.1 原理图

图 4-1 展示了 REF54EVM-2 的原理图。

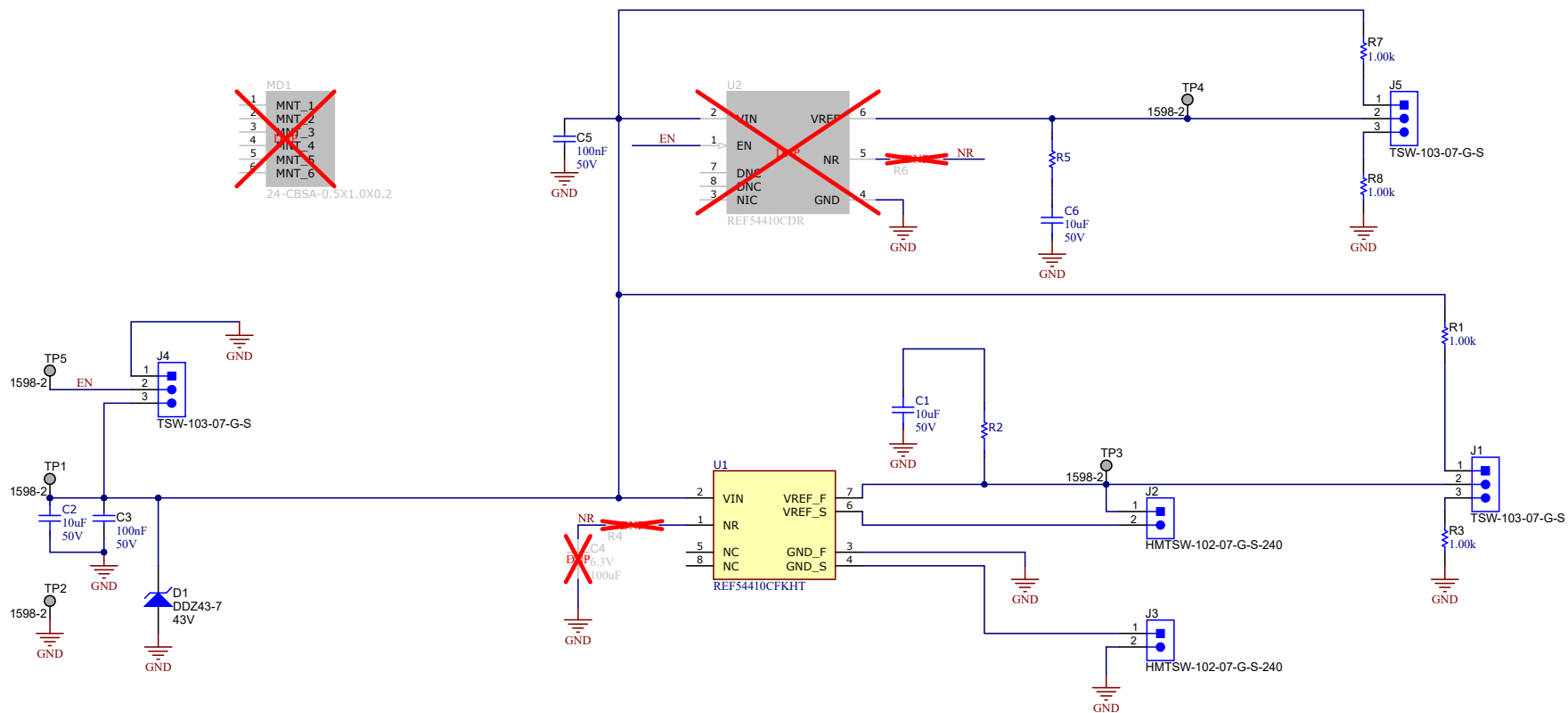


图 4-1. REF54EVM-2 原理图

## 4.2 PCB 布局

REF54EVM-2 是一种两层电路板。本节中说明了它的布局。

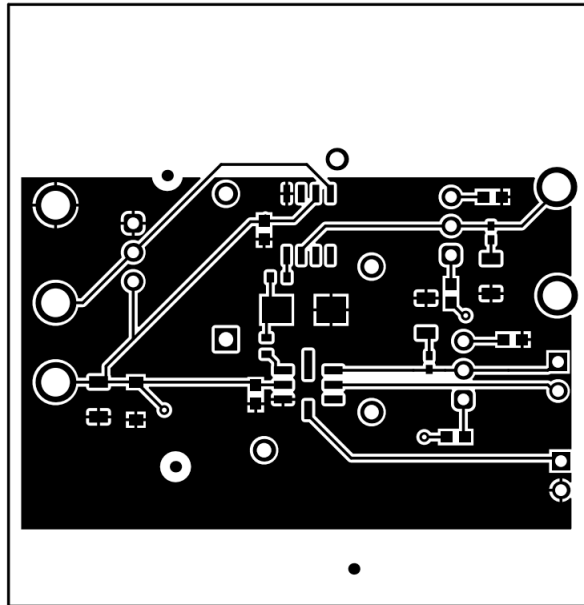


图 4-2. REF54EVM-2 顶层

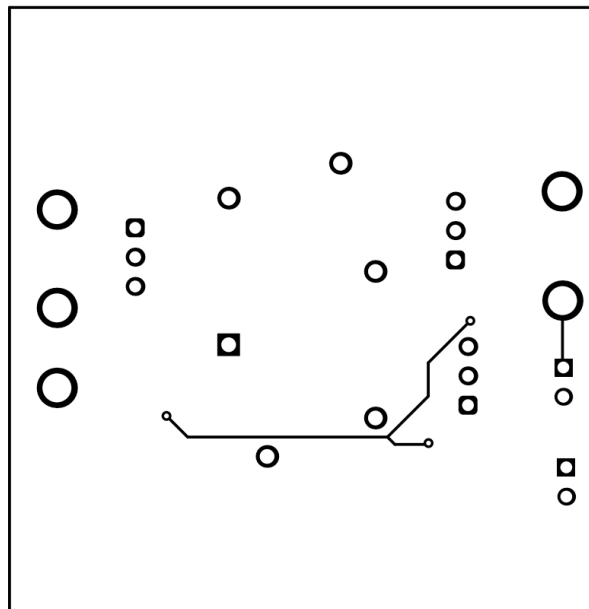


图 4-3. REF54EVM-2 底层

### 4.3 物料清单 (BOM)

表 4-1 列出了 REF54EVM-2 的物料清单。

表 4-1. 物料清单

位号	数量	说明	封装参考	器件型号	制造商
C1、C2、C6	3	10 $\mu$ F $\pm$ 10% 50V 陶瓷电容器 X7R 1206 ( 公制 3216 )	1206	GMC31X7R106K50NT	Cal-Chip Electronics
C3、C5	2	电容, 陶瓷, 1 $\mu$ F, 50V, +/-10%, X7R, AEC-Q200 0.1 级, 0603	0603	06035C104KAZ2A	AVX
D1	1	二极管, 齐纳, 43V, 500mW, AEC-Q101, SOD-123	SOD-123	DDZ43-7	Diodes Inc.
H9、H10、H11、H12	4	Bumpon, 半球形, 0.44 X 0.20, 透明	透明 Bumpon	SJ-5303 (CLEAR)	3M
J1、J4、J5	3	接头, 100mil, 3x1, 金, TH	3x1 接头	TSW-103-07-G-S	Samtec
J2、J3	2	接头, 100mil, 2x1, 金, TH	接头, 2.54mm, 2x1, TH	HMTSW-102-07-G-S-240	Samtec
LBL1	1	热转印打印标签, 0.650" ( 宽 ) x 0.200" ( 高 ) - 10,000/卷	PCB 标签, 0.650 x 0.200 英 寸	THT-14-423-10	Brady
R1、R3、R7、R8	4	电阻, 1.00k, 1%, 0.1W, AEC-Q200 0 级, 0603	0603	CRCW06031K00FKEA	Vishay-Dale
R2、R5	2	0 $\Omega$ 跳线 0.1W, 1/10W 片式 电阻器 0402 ( 公制 1005 ) - 厚膜	0402	CR0402-10W-000T	Venkel
SH-J1、SH-J2、SH-J3、SH- J4、SH-J5	5	连接器跳线 S2 (1 x 2) 位置分 流连接器黑色开孔顶部 0.100"(2.54mm) GoldHORTING .100" 金	跳线	QPC02SXGN-RC	Sullins
TP1、TP2、TP3、TP4、TP5	5	端子, 调整钮, TH, 三联	Keystone1598-2	1598-2	Keystone
U1	1	REF54410CFKHT	LCCC8	REF54410CFKHT	德州仪器 (TI)
C4	0	电容, 钽, 100 $\mu$ F, 6.3V, +/-10%, 0.075 $\Omega$ , SMD	6032-28	TPSC107K006R0075	AVX
MD1	0	射频屏蔽 0.5" X 1" 穿孔	PTH_RF_SHIELD	24-CBSA-0.5X1.0X0.2	Leader Tech
R4、R6	0	0 欧姆 $\pm$ 1% 片式电阻器 0603 ( 公制 1608 ) 厚膜	0603	CR160000F	Meritek Electronics
U2	0	0.8ppm/ $^{\circ}$ C 温漂 ( 最大值 )、 0.11ppmp-p 1/f 噪声、380 $\mu$ A 电流精密电压基准	SOIC8	REF54410CDR	德州仪器 (TI)

## 5 合规信息

### 5.1 合规性和认证

[REF54EVM-2 EU 符合性声明 \(RoHS\)](#)。

## 6 其他信息

### 6.1 商标

所有商标均为其各自所有者的财产。

## 7 相关文档

本用户指南可从 TI 网站上获得，文献编号为 **SLVUDJ6**。附加到文献编号的任何字母对应于撰写本文档时已有的最新文档修订版。较新的修订版可从 TI 网站 [www.ti.com](http://www.ti.com) 获得，也可以致电德州仪器 (TI) 文献响应中心 ( 电话为 (800) 477-8924 ) 或产品信息中心 ( 电话为 (972) 644-5580 ) 了解评估模块。订购时，可通过文档标题或文献编号识别文档。

## 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.
2. *Limited Warranty and Related Remedies/Disclaimers:*
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  - 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.
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**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.

【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】 開発キットの中には技術基準適合証明を受けていないものがあります。技術適合証明を受けていないもの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。日本テキサス・イ

ンスツルメンツ株式会社

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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.
  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.
  6. *Disclaimers:*
    - 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.
    - 6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.
  7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMNITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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