

REF54 Ceramic LCCC Package Evaluation Module



Description

The REF54EVM-2 is a precision voltage reference evaluation module that demonstrates the performance of a high precision series reference device (REF54 in the ceramic LCCC package) from Texas Instruments. The REF54 is a family of low drift, and low noise voltage reference devices. REF54 offers low temperature drift, low flicker noise, and low long-term drift. Using REF54EVM-2 and the appropriate lab equipment, the user can evaluate the performance of REF54, including its initial accuracy, quiescent current, temperature drift, long-term drift, noise, and force/sense output and ground capabilities.

Features

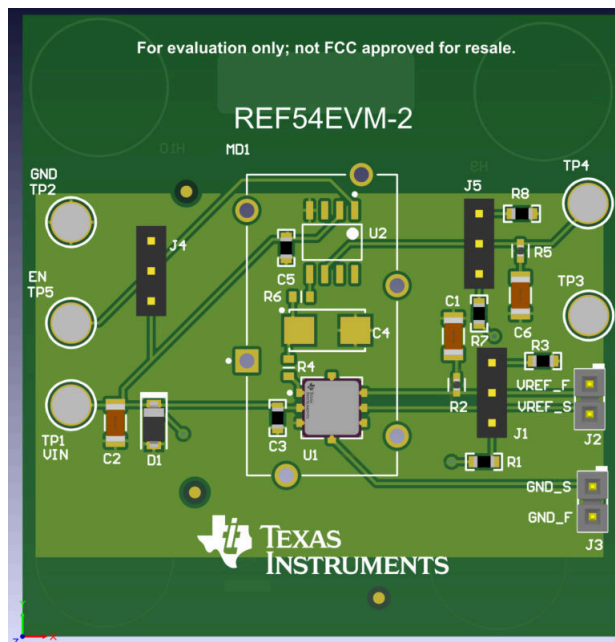
- Kelvin connection by force and sense pins.
- Resistors to evaluate load regulation.
- Footprint to install noise reduction capacitor and cover for low-noise testing.
- Footprint to evaluate SOIC package of REF54.

Applications

- [Semiconductor test and ATE](#)
- [Digital multimeter \(DMM\)](#)
- [Signal generator](#)
- [Battery test](#)
- [Precision data acquisition systems](#)

Get Started

1. Order the EVM from the [REF54EVM-2 tool page](#).
2. Configure EVM with the desired the output force and sense Kelvin connection configuration.
3. Connect VIN to power supplies.
4. Test the output.



REF54EVM-2 Board

1 Evaluation Module Overview

1.1 Introduction

The REF54EVM-2 is a precision voltage reference evaluation module that demonstrates the REF54 performance in a ceramic LCCC package. The REF54, with low long-term drift and temperature drift, helps meet strict performance requirements of high precision applications. This device also includes a force and sense pin on the output to support a Kelvin connection.

This user's guide describes the characteristics, operation, and recommended use cases of the REF54EVM-2. This document provides examples and instructions on how to use the REF54EVM-2 board. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the REF54EVM-2. This document also includes a schematic, reference printed circuit board (PCB) layouts, and a complete bill of materials (BOM).

1.2 Kit Contents

[Table 1-1](#) details the content of the EVM kit. Contact the TI Product Information Center at (972) 644-5580 if any component is missing.

Table 1-1. Kit List

| Item | Quantity |
|------------|----------|
| REF54EVM-2 | 1 |

1.3 Specification

REF54EVM-2 primary function is to evaluate the ceramic package version of the REF54 precision voltage reference. Footprints are available on the board to install a capacitor to use with the noise reduction (NR) pin. There is also a footprint on the board that can be used to evaluate the SOIC package version of REF54. The board is evaluated with an 8.5 digit DMM.

1.4 Device Information

The REF54 in a ceramic package is a precision voltage reference. The device is designed with an extremely low temperature drift and long-term drift. REF54 is also a low noise device. This allows REF54 to be used with the highest precision of ADCs and DACs. The ceramic package version of REF54 includes a force and sense pin on the output to allow for a Kelvin connection to compensate for long PCB trace voltage drop. It also include a noise reduction (NR) pin. Careful application of this pin with a capacitor up to 100 μ F can lower the noise if done correctly.

2 Hardware

2.1 Setup

Schematic shown in [Figure 2-1](#) is representative of the REF54EVM-2.

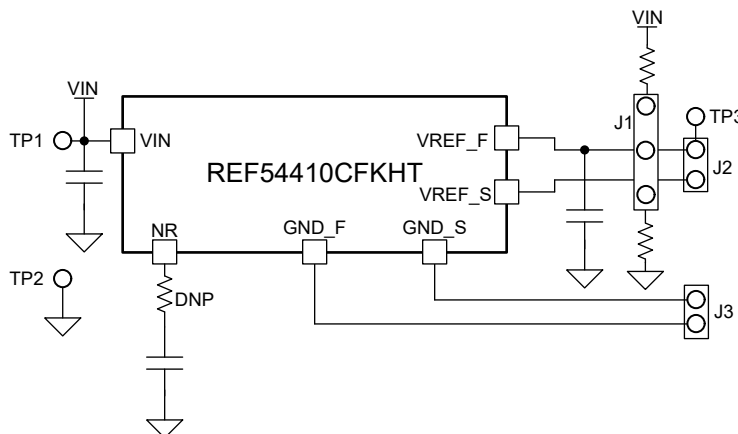


Figure 2-1. REF54EVM-2 Setup

The REF54EVM-2 is designed to allow users to evaluate the configuration shown in [Figure 2-1](#). Board configurable options are provided to allow the user to evaluate the load regulation, the noise reduction features, and the Kelvin connection for VREF_F, VREF_S, GND_F, and GND_S pins.

2.2 EVM Connections

The REF54EVM-2 provides various connections to evaluate REF54. See [Table 2-1](#) for information on these connections.

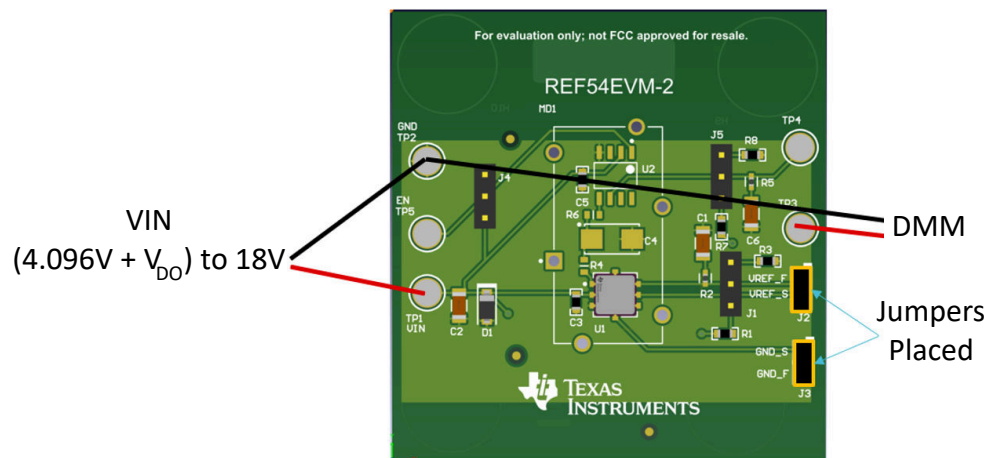
Table 2-1. REF54EVM-2 Connections

| EVM Connection Function | Board Designator | REF54410CFKHT Pin | Recommended Usage Conditions |
|--------------------------------------|--------------------|-------------------|---|
| Input Voltage | TP1 | VIN (Pin 2) | MIN: 4.096V + V _{DO} |
| | | | MAX: 18V |
| Output Voltage Force Connection | J2 (Label: VREF_F) | VREF_F (Pin 7) | Measured by digital multimeter after being connected to VREF_S (Pin 6) |
| Output Voltage Sense Connection | J2 (Label: VREF_S) | VREF_S (Pin 6) | Measured by digital multimeter after being connected to VREF_F (Pin 7) |
| Additional Output Voltage Connection | TP3 | VREF_F (Pin 7) | Offers an additional test point to measure from when both leads of J2 are shorted |
| Ground Force Connection | J3 (Label: GND_F) | GND_F (Pin 3) | Connect to ground after shorting to GND_S (Pin 4) |
| Ground Sense Connection | J3 (Label: GND_S) | GND_S (Pin 4) | Connect to ground after shorting to GND_F (Pin 3) |
| Additional Ground Connection | TP2 | GND_F (Pin 3) | Connect to ground |

Table 2-1. REF54EVM-2 Connections (continued)

| EVM Connection Function | Board Designator | REF54410CFKHT Pin | Recommended Usage Conditions |
|--------------------------|------------------|-------------------------------|--|
| Resistive Load Selection | J1 | J1 Top Pin: NA | Connect the middle pin of J1 to the top pin of J1 to source up to 10mA into VREF_F and VREF_S which are shorted together. Connect the middle pin of J1 to the bottom pin of J1 to sink up to 10mA current from VREF_F and VREF_S which are shorted together. |
| | | J1 Middle Pin: VREF_F (Pin 7) | |
| | | J1 Bottom Pin: NA | |

Default EVM setup is shown in [Figure 2-2](#).

**Figure 2-2. REF54EVM-2 Default Setup**

2.3 Best Practices

- Use a power supply which has a very good PSRR.
- Measure the output with high resolution instrument (DMM, oscilloscope) for best performance. TI recommends an 8.5 digit DMM.
- Follow best practices for noise measurement and noise reduction capacitor selection. See [Section 2.3.1](#) for more details.

2.3.1 Noise Reduction (NR) Pin Best Practices

A footprint is included on the board to install a noise reduction capacitor (C4), if desired. If a noise reduction capacitor is added to C4, the user must also populate or short the pads of R4 to connect the capacitor to the NR pin (Pin 1 of the REF54410CFKHT). Capacitor selection and board design are key to obtain the specified noise performance when the NR capacitor is added. If careful capacitor selection practices are not followed, undesirable capacitor characteristics may cause output voltage fluctuations on the REF54.

Selection of low-leakage tantalum capacitors is the best practice when placing a capacitor on the NR pin. The REF54EVM-2 also provides the option to install a cover (MD1) over the REF54 and NR capacitor. By default the cover is uninstalled. However, if the user desires to test the output voltage noise of the REF54 with a low-leakage tantalum capacitor installed, please cover REF54 and the NR capacitor to reduce air flow contact. Please see [Section 4.3](#) for NR capacitor (C4) and cover (MD1) part number recommendations. Since the REF54 has ultra-low noise, capacitor vibrations due to the piezoelectric effect caused by airflow contact with the NR capacitor could dominate the output voltage performance of the REF54. Placing a cover around the REF54 and the NR capacitor will reduce air flow contact with the NR capacitor as much as possible. This allows the user

to only observe the noise that is added by the REF54 voltage reference and removes noise introduced by the external capacitor.

Please note that adding a capacitor from the NR pin to ground is not required for successful operation of REF54, but it is a helpful option to decrease low frequency noise with careful board design and component selection practices. If the NR pin is left floating, there is no need for a cover to evaluate the noise. For more information on how low frequency flicker noise is characterized, please refer to [Techniques for Noise Measurements in Precision Series References](#).

3 Implementation Results

3.1 Evaluation Setup

EVM is tested with the conditions listed below.

- **VIN (TP1)** : Connect TP1 to one Keithley 2420 SMU and connect the ground from that SMU to TP2.
- **VREF_F and VREF_S (J2)** :Short VREF_F and VREF_S using the provided jumper.
- **GND_F and GND_S (J3)**: Short GND_F and GND_S using the provided jumper.
- **VREF (TP3)** : Connect TP3 to one 2458A DMM and connect the ground from that DMM to TP2.
- **Load Selection (J1)** : Appropriate load selected for testing sink and source current load regulation.

3.2 Performance Data and Results

Output voltage of REF54EVM-2 is measured with dropout conditions allowed per the datasheet specifications. It also meets the initial accuracy, long-term drift, and temperature drift specification limits. The device meets line regulation specifications and shutdown conditions for relevant tests.

4.2 PCB Layouts

REF54EVM-2 is a two layer board. The layout is included in this section.

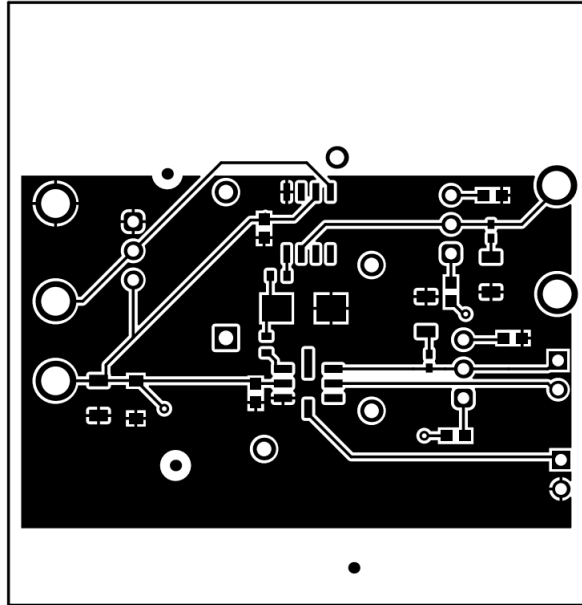


Figure 4-2. REF54EVM-2 Top Layer

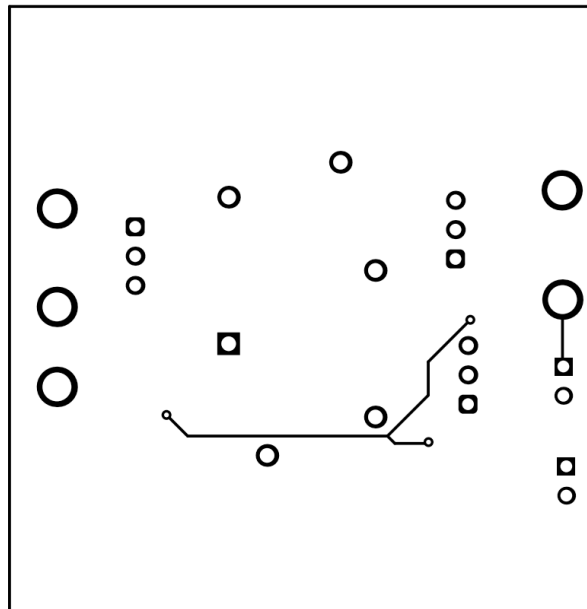


Figure 4-3. REF54EVM-2 Bottom Layer

4.3 Bill of Materials (BOM)

Table 4-1 lists the bill of materials for REF54EVM-2.

Table 4-1. Bill of Materials

| Designator | Quantity | Description | Package Reference | Part Number | Manufacturer |
|-----------------------------------|----------|---|------------------------------|----------------------|----------------------|
| C1, C2, C6 | 3 | 10 μ F \pm 10% 50V Ceramic Capacitor X7R 1206 (3216 Metric) | 1206 | GMC31X7R106K50NT | Cal-Chip Electronics |
| C3, C5 | 2 | CAP, CERM, 0.1 μ F, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603 | 0603 | 06035C104KAZ2A | AVX |
| D1 | 1 | Diode, Zener, 43 V, 500 mW, AEC-Q101, SOD-123 | SOD-123 | DDZ43-7 | Diodes Inc. |
| H9, H10, H11, H12 | 4 | Bumpon, Hemisphere, 0.44 X 0.20, Clear | Transparent Bumpon | SJ-5303 (CLEAR) | 3M |
| J1, J4, J5 | 3 | Header, 100mil, 3x1, Gold, TH | 3x1 Header | TSW-103-07-G-S | Samtec |
| J2, J3 | 2 | Header, 100mil, 2x1, Gold, TH | Header, 2.54mm, 2x1, TH | HMTSW-102-07-G-S-240 | Samtec |
| LBL1 | 1 | Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll | PCB Label 0.650 x 0.200 inch | THT-14-423-10 | Brady |
| R1, R3, R7, R8 | 4 | RES, 1.00 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603 | 0603 | CRCW06031K00FKEA | Vishay-Dale |
| R2, R5 | 2 | 0 Ohms Jumper 0.1W, 1/10W Chip Resistor 0402 (1005 Metric) - Thick Film | 0402 | CR0402-10W-000T | Venkel |
| SH-J1, SH-J2, SH-J3, SH-J4, SH-J5 | 5 | CONN JUMPER S2 (1 x 2) Position Shunt Connector Black Open Top 0.100" (2.54mm) GoldHORTING .100" GOLD | JUMPER | QPC02SXGN-RC | Sullins |
| TP1, TP2, TP3, TP4, TP5 | 5 | Terminal, Turret, TH, Triple | Keystone1598-2 | 1598-2 | Keystone |
| U1 | 1 | REF54410CFKHT | LCCC8 | REF54410CFKHT | Texas Instruments |
| C4 | 0 | CAP, TA, 100 uF, 6.3 V, +/- 10%, 0.075 ohm, SMD | 6032-28 | TPSC107K006R0075 | AVX |
| MD1 | 0 | Rf Shield 0.5" X 1" Through Hole | PTH_RF_SHIELD | 24-CBSA-0.5X1.0X0.2 | Leader Tech |
| R4, R6 | 0 | 0 Ohms \pm 1% Chip Resistor 0603 (1608 Metric) Thick Film | 0603 | CR160000F | Meritek Electronics |
| U2 | 0 | 0.8ppm/ $^{\circ}$ C drift (max), 0.11ppmp-p 1/f noise, 380 μ A current precision voltage reference | SOIC8 | REF54410CDR | Texas Instruments |

5 Compliance Information

5.1 Compliance and Certifications

[REF54EVM-2 EU Declaration of Conformity \(RoHS\)](#).

6 Additional Information

6.1 Trademarks

All trademarks are the property of their respective owners.

7 Related Documentation

This user's guide is available from the TI web site under literature number SLVUDJ6. Any letter appended to the literature number corresponds to the document revision that is current at the time of the writing of this document. Newer revisions are available from the TI web site at www.ti.com, or call Evaluation Module the Texas Instruments Literature Response Center at (800) 477-8924 or the Product Information Center at (972) 644-5580. When ordering, identify the document by both title and literature number.

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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/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。

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

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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.
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