

# EVM User's Guide: REF53EVM

## REF53-Q1 Evaluation Module



### Description

The REF53EVM is a precision voltage reference evaluation module (EVM) that demonstrates the performance of the REF53 high-precision reference device from Texas Instruments. REF53 is a family of low power, low noise, and low drift series voltage reference devices. The REF53 family offers low temperature drift coefficient, low noise, and high accuracy while consuming low current.

### Get Started

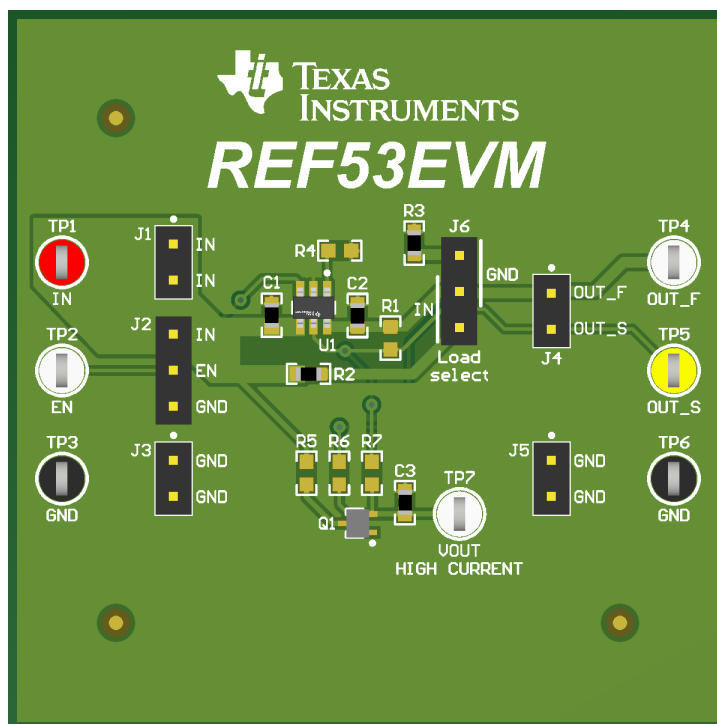
1. Order the EVM from the [REF53 tool page](#).
2. Configure jumpers on EVM to select a load.
3. Connect IN to a power supply.
4. Test the output voltage.

### Features

- Jumpers to select a load to GND or a load to IN to evaluate load regulation when sourcing and sinking current.
- Footprints for adding a transistor to provide higher current output

### Applications

- [Field transmitters](#)
- [PLC analog I/O modules](#)
- [Power monitoring](#)
- [Medical imaging](#)
- [Single and multiaxis servo drives](#)
- [Hospital patient care](#)
- [Electricity meter](#)
- [Battery management system](#)
- [LIDAR](#)
- [HEV/EV OBC and DC/DC converter](#)



REF53EVM Board

# 1 Evaluation Module Overview

## 1.1 Introduction

The REF53EVM is a series voltage reference evaluation module that demonstrates the performance of [REF53](#) in the 6-pin SOT-23 package. With low power, low noise, and low temperature drift, REF53 helps meet strict performance requirements of high precision applications. The device also comes with an enable pin (EN) that allows the device to be set in shutdown mode to improve power efficiency.

This EVM user's guide describes the characteristics, operation, and recommended use cases of the REF53EVM. This document provides examples and instructions on how to use the REF53EVM board. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the REF53EVM. 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 contents 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 |
|----------|----------|
| REF53EVM | 1        |

## 1.3 Specification

The primary function of REF53EVM is to evaluate the REF53 precision series voltage reference. Test points are installed to provide connection to a power supply and multimeter. Jumpers and resistors are included to test the load regulation of REF53. REF53EVM also includes an additional transistor to provide higher output currents.

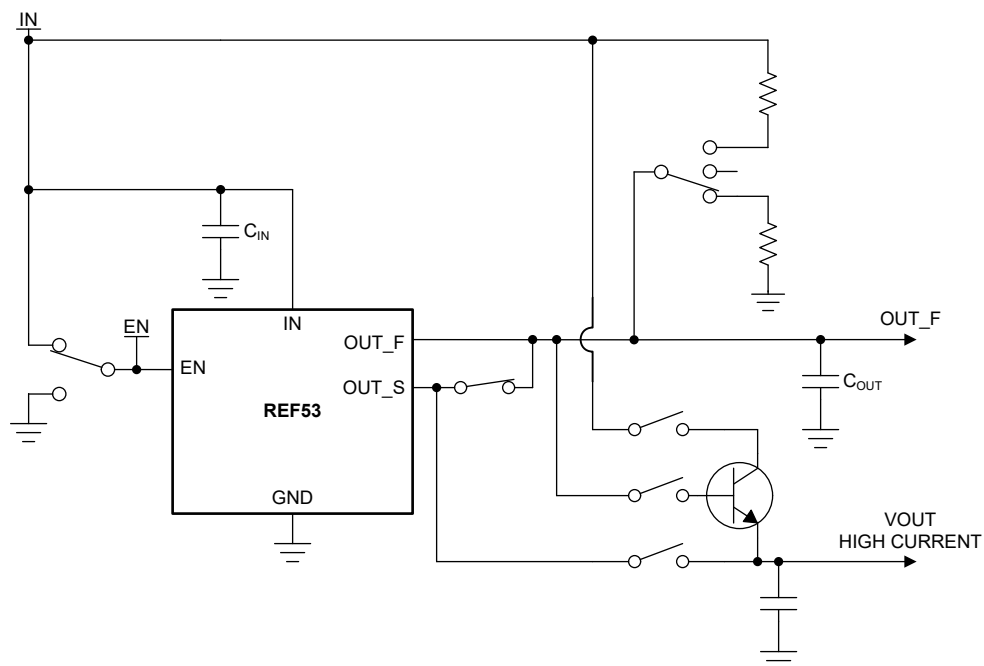
## 1.4 Device Information

REF53 is a precision series voltage reference. The device is designed with low power, low noise, low temperature drift, and high accuracy. This allows REF53 to be used with high-resolution data converters and analog front ends (AFEs). REF53 has an enable pin (EN) that allows the device to be set in shutdown mode to improve power efficiency.

## 2 Hardware

### 2.1 Setup

The schematic shown in [REF53EVM Setup](#) is representative of the REF53EVM.



**Figure 2-1. REF53EVM Setup**

The REF53EVM is designed to allow users to evaluate the configuration shown in [REF53EVM Setup](#). Resistors and jumpers are provided to evaluate the load regulation of REF53. An additional transistor is provided for a high-current output evaluation.

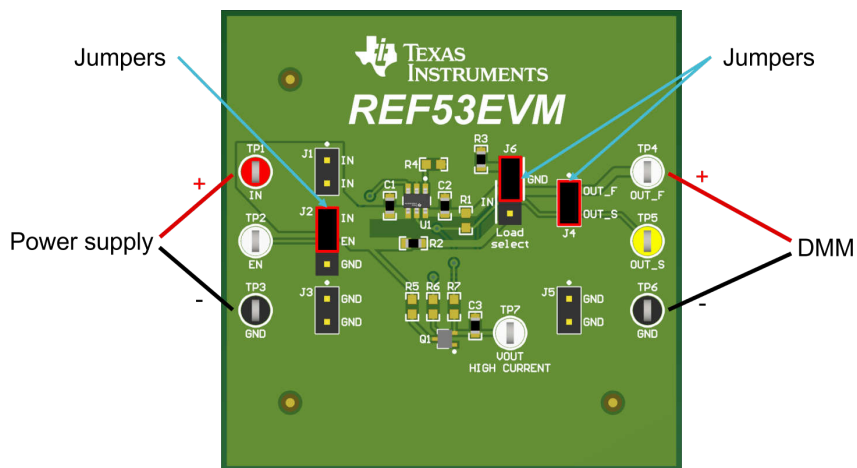
## 2.2 EVM Connection

To power REF53EVM, an external power supply must be used. For best performance, use a low noise power supply. The input voltage range is shown in [Table 2-1](#).

**Table 2-1. Input Voltage Range for REF53EVM**

| EVM input | Device connection         | EVM minimum input voltage | EVM maximum input voltage |
|-----------|---------------------------|---------------------------|---------------------------|
| IN        | REF53125AQDDCRQ1 (IN Pin) | 1.71V                     | 18V                       |

The default EVM setup is shown in [Figure 2-2](#). In the default EVM setup, a jumper on J6 connects the EVM output to GND through resistor R3, simulating a load on the reference. To test the output of REF53 with no load, remove the jumper from J6. The output reference voltage can be measured using the OUT\_F and GND test points provided on the board. For best temperature drift performance, use low thermal EMF probes to measure the output.



**Figure 2-2. REF53EVM Default Setup**

Additionally, there is an option to use a transistor to increase the output current of REF53. By removing C2, removing the jumpers on J4 and J6, and installing R5, R6, and R7, the output voltage can be measured using the test point labeled VOUT HIGH CURRENT. When using this configuration, the device only regulates the voltage while sourcing current and cannot sink current in this configuration.

## 2.3 Jumper Information

REF53EVM provides jumpers to configure the EVM to test functionality of REF53 under different conditions. The function of these jumpers is described in [Table 2-2](#).

**Table 2-2. REF53EVM Jumper Information**

| Jumper Designator | Name              | Jumper Function                                                                                                                                                                                                                                                                                                                                                   |
|-------------------|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| J2                | EN select         | Jumper J2 can be used to enable or disable REF53. Connect jumper to IN to enable REF53. Connect jumper to GND to put REF53 in shutdown mode. Remove jumper to provide an external EN signal                                                                                                                                                                       |
| J4                | OUT_F/OUT_S short | Jumper J4 can be used to connect OUT_F and OUT_S of REF53 together. The default configuration for REF53 is to connect these two pins.                                                                                                                                                                                                                             |
| J6                | Load select       | Jumper J6 can be used to test the load regulation of REF53. Connect jumper to IN to connect OUT_F of REF53 to IN through resistor R2 to test REF53 load regulation when sinking current. Connect jumper to GND to connect OUT_F of REF53 to GND through resistor R3 to test REF53 load regulation when sourcing current. Remove jumper to remove load from REF53. |

## 2.4 Best Practices

- Use a power supply with very good PSRR.
- Measure the output voltage with a high resolution instrument (DMM, oscilloscope) for best performance.

## 3 Implementation Results

### 3.1 Evaluation Setup

The REF53EVM is tested with the conditions listed below.

|                                                                                                                                                                            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>IN:</b> Connect the positive output of a Kiethley 2420 SMU to the IN test point on the EVM and the negative output of the SMU to the closest GND test point on the EVM. |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                                                                                                                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>OUT_F:</b> Connect the positive input of a 3458A DMM to the OUT_F test point on the EVM and the negative input of the DMM to the closest GND test point on the EVM. |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

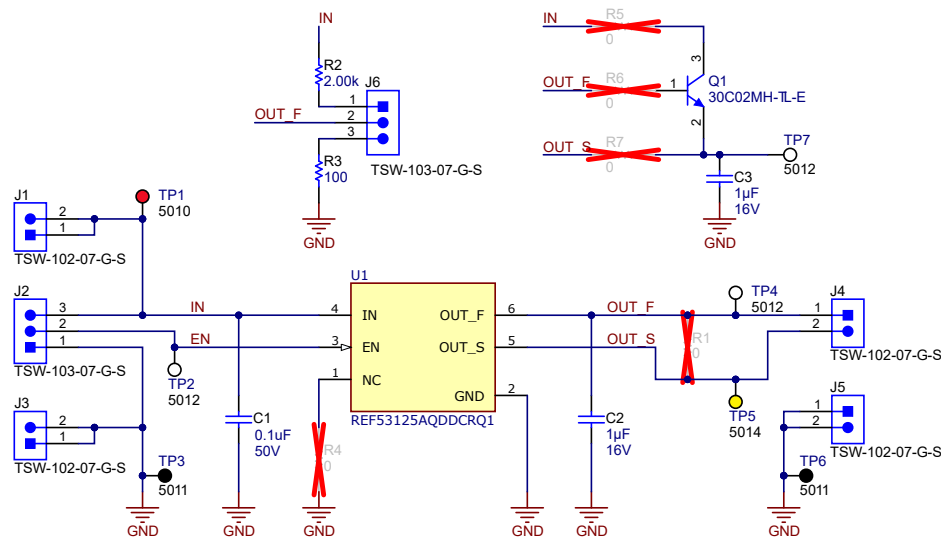
### 3.2 Performance Data and Results

The output voltage of REF53EVM is measured with dropout conditions and meets the initial accuracy, long-term drift, and temperature drift specification limit given in the REF53 datasheet. The device meets line regulation, load regulation, and shutdown condition specifications for relevant tests.

## 4 Hardware Design Files

### 4.1 Schematics

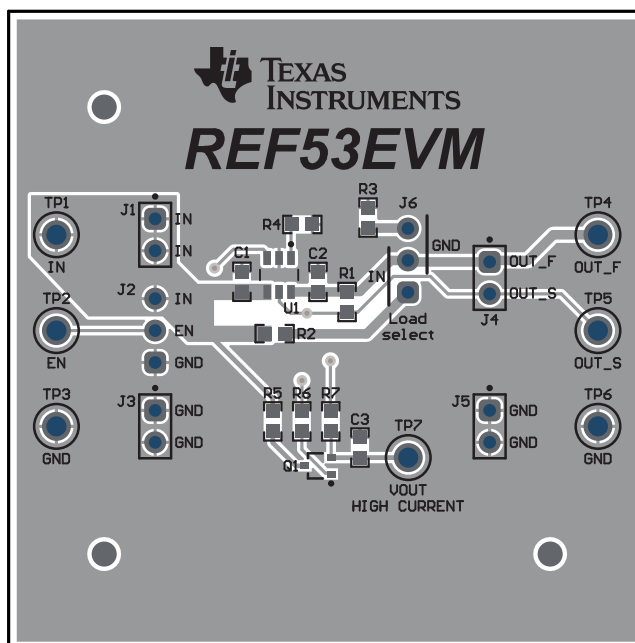
The schematic for the REF53EVM is illustrated in [Figure 4-1](#).



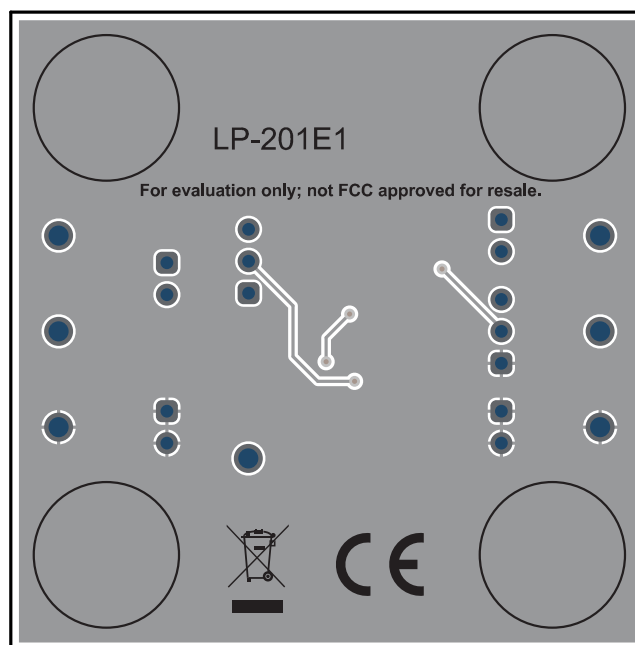
**Figure 4-1. REF53EVM Schematic**

## 4.2 PCB Layouts

REF53EVM is a two-layer board. The layout is illustrated in [Figure 4-2](#) and [Figure 4-3](#).



**Figure 4-2. REF53EVM Top Layer**



**Figure 4-3. REF53EVM Bottom Layer**

## 4.3 Bill of Materials (BOM)

Table 4-1 lists the bill of materials for REF53EVM.

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

| Designator          | Qty | Description                                                                                  | Package Reference             | Part Number          | Manufacturer         |
|---------------------|-----|----------------------------------------------------------------------------------------------|-------------------------------|----------------------|----------------------|
| C1                  | 1   | CAP, CERM, 0.1 uF, 50 V, +/- 10%, X8R, AEC-Q200 Grade 0, 0603                                | 0603                          | CGA3E3X8R1H104K080AB | TDK                  |
| C2, C3              | 2   | CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603                                  | 0603                          | CGA3E1X7R1C105K080AC | TDK                  |
| H9, H10, H11, H12   | 4   | Bump, Hemisphere, 0.44 X 0.20, Clear                                                         | Transparent Bump              | SJ-5303 (CLEAR)      | 3M                   |
| J1, J3, J4, J5      | 4   | Header, 100mil, 2x1, Gold, TH                                                                | 2x1 Header                    | TSW-102-07-G-S       | Samtec               |
| J2, J6              | 2   | Header, 100mil, 3x1, Gold, TH                                                                | 3x1 Header                    | TSW-103-07-G-S       | Samtec               |
| Q1                  | 1   | Bipolar Transistor, 30 V, 0.7 A, Low VCE(sat) NPN Single, 3-Pin SC70, Pb-Free, Tape and Reel | MCPH-3                        | 30C02MH-TL-E         | On Semiconductor     |
| R2                  | 1   | RES, 2.00 k, 0.1%, 0.1 W, 0603                                                               | 0603                          | RT0603BRD072KL       | Yageo America        |
| R3                  | 1   | RES, 100, 1%, 0.25 W, AEC-Q200 Grade 0, 0603                                                 | 0603                          | CRCW0603100RFKEAHP   | Vishay-Dale          |
| TP1                 | 1   | Test Point, Multipurpose, Red, TH                                                            | Red Multipurpose Testpoint    | 5010                 | Keystone Electronics |
| TP2, TP4, TP7       | 3   | Test Point, Multipurpose, White, TH                                                          | White Multipurpose Testpoint  | 5012                 | Keystone Electronics |
| TP3, TP6            | 2   | Test Point, Multipurpose, Black, TH                                                          | Black Multipurpose Testpoint  | 5011                 | Keystone Electronics |
| TP5                 | 1   | Test Point, Multipurpose, Yellow, TH                                                         | Yellow Multipurpose Testpoint | 5014                 | Keystone Electronics |
| U1                  | 1   | REF53125AQDDCRQ1                                                                             | SOT-23-THIN-6                 | REF53125AQDDCRQ1     | Texas Instruments    |
| SH-J1, SH-J2, SH-J3 | 3   | CONN JUMPER S2 (1 x 2) Position Shunt Connector Black Open Top 0.100                         | JUMPER                        | QPC02SXGN-RC         | Sullins              |
| R1, R4, R5, R6, R7  | 0   | RES, 0, 0%, 0.25 W, AEC-Q200 Grade 0, 0603                                                   | 0603                          | PMR03EZPJ000         | Rohm                 |

## 5 Compliance Information

### 5.1 Compliance and Certifications

[REF53EVM EU Declaration of Conformity](#) (RoHS).

## 6 Additional Information

### 6.1 Trademarks

All trademarks are the property of their respective owners.

## 7 Related Documentation

The documents in [Table 7-1](#) provide information regarding Texas Instruments integrated circuits used in the assembly of the REF53EVM. This user's guide is available from the TI web site under literature number SLVUDQ7. 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](http://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.

**Table 7-1. Related Device Documentation**

| Item                               | Literature Number |
|------------------------------------|-------------------|
| REF53125AQDDCRQ1 product datasheet | SNVSCU8           |

## 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.
  - 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 semiconductors 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.
2. **Limited Warranty and Related Remedies/Disclaimers:**
  - 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 instructions, 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/sds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/sds/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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#### 3.4 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.

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