User's Guide

TRF37x73 and TRF37x75 EVM

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ABSTRACT

This document outlines the basic steps and functions that are required to ensure the proper operation and quick setup of the TRF37x73 and TRF37x75 EVM. This document also includes a schematic diagram, a bill of materials (BOM), printed-circuit board (PCB) layouts, board loss plots, and test block diagrams. Throughout this document, the abbreviations *EVM*, *TRF37x73/75 EVM*, and the term *evaluation module* are synonymous with the TRF37x73 and TRF37x75 EVM, unless otherwise noted.

Table of Contents

List of Figures

List of Tables

1 Contents

The TRF37x73/75 EVM consists of the following components:

- TRF37x73/75 EVM board

2 EVM Overview

This section includes the schematic diagram, a bill of materials (BOM), and general usage information.

2.1 Schematic and BOM

The TRF37x73/75 EVM for RF gain blocks comes in a 2 × 2 WSON package. The device type is visually identified in component U1 by the 0402 selection resistors TRF37A73, TRF37B73, TRF37C73, TRF37A75, TRF37B75, and TRF37C75.

The TRF37x73 are a family of 3.3-V, RF gain blocks that have 3 gain variants (A73 = 12 dB, B73 = 15 dB, and C73 = 18 dB). The TRF37x75 are a family of 5-V, RF gain blocks that have 3 gain variants (A75 = 12 dB, B75 = 15 dB, and C75 = 18 dB).

The TRF37x73/75 EVM schematic is shown in Figure 2-1.

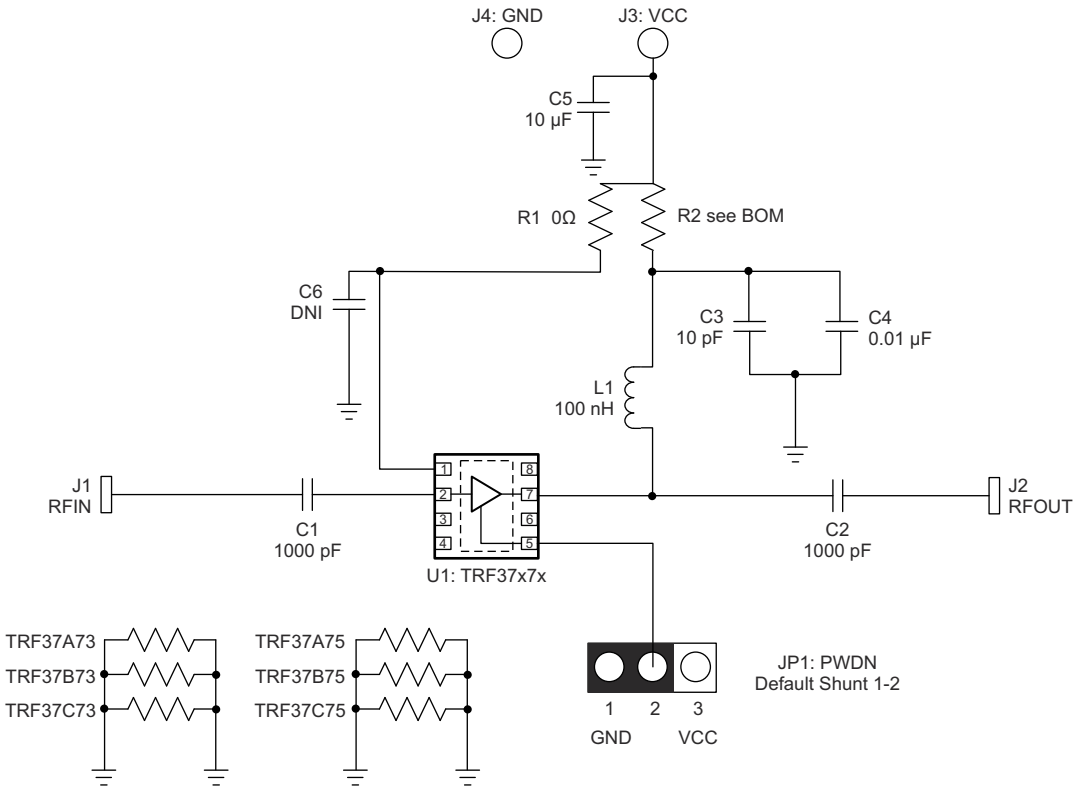


Figure 2-1. TRF37x73/75 EVM Schematic

2.2 TRF37x73/75 EVM Bill of Material

Table 2-1. TRF37x73/75 EVM BOM

Common BOM				
Component	**Description (Footprint)**	**Value**	**Manufacturer**	**Part Number**
C1, C2, C6	AC coupling capacitor (0402)	1000 pF	Murata	GRM1555C1H102JA01D
C3	Power Supply Decoupling (0402)	10 pF	Murata	GRM1555C1H100JZ01D
C4	Power Supply Decoupling (0603)	0.01 µF	Kemet	C0603C103K1RACTU
C5	Power Supply Decoupling (Tantalum)	10 µF	Kemet	T494A106M016AS
J1, J2	AC signal SMA connector		Emerson Connectivity (Johnson)	142-0701-851
J3	Terminals for VCC (Clip)	Red	Keystone	5005
J4	Terminal for GND (Clip)	Black	Keystone	5006
JP1	Terminals for PWDN		1:3 10 mil header	
L1	DC biasing inductor (0603)	100 nH	CoilCraft	0603HP-R10XJLW
R1	DC Biasing resistor (0603)	0 Ω		
TRF37A75-Specific BOM				
R2	DC biasing resistor (0603)	1.8 Ω	Panasonic	ERG-3GEYJ1R8V
U1	TRF37A75	5 V, 12 dB gain	TI	TRF37A75
TRF37A75	0402 BOM Identification resistor	0 Ω		
TRF37B75-Specific BOM				
R2	DC biasing resistor (0603)	3.9 Ω	Panasonic	ERG-3GEYJ3R9V
U1	TRF37B75	5 V, 15 dB gain	TI	TRF37B75
TRF37B75	0402 BOM Identification resistor	0 Ω		
TRF37C75-Specific BOM				
R2	DC biasing resistor (0603)	6.8 Ω	Panasonic	ERG-3GEYJ6R8V
U1	TRF37C75	5 V, 18 dB gain	TI	TRF37C75
TRF37C75	0402 BOM Identification resistor	0 Ω		
TRF37A73-Specific BOM				
R2	DC biasing resistor (0603)	0 Ω		
U1	TRF37A73	3.3 V, 12 dB gain	TI	TRF37A73
TRF37A73	0402 BOM Identification resistor	0 Ω		
TRF37B73-Specific BOM				
R2	DC biasing resistor (0603)	0 Ω		
U1	TRF37B73	3.3 V, 15 dB gain	TI	TRF37B73
TRF37B73	0402 BOM Identification resistor	0 Ω		
TRF37C73-Specific BOM				
R2	DC biasing resistor (0603)	0 Ω		
U1	TRF37C73	3.3 V, 18 dB gain	TI	TRF37C73
TRF37C73	0402 BOM Identification resistor	0 Ω		

2.3 General Usage Information

This section provides general usage information for the EVM.

1. Recommended power up sequence:
   a. Connect GND to J4 (black – GND)
   b. Connect Vcc to J3 (red – VCC)
   c. Connect RF input signal to J1 (RFIN)
   d. Connect measurement instrument to J2 (RFOUT)
   e. Ensure the device is not in power-down mode by shorting JP1 terminals 1 and 2 or simply remove JP1 to take advantage of the TRF37x73/75's internal pull-down resistor.
2. Power supply options:
   a. For TRF37x73 devices, set VCC to 3.3 V
   b. For TRF37x75 devices, set VCC to 5.0 V
3. PWDN option:
   a. Short terminals 2 and 3 on JP1 to put the TRF37x73/75 in its power down state.
4. Tuning options:
   a. Solder mask has been removed along the RF signal paths and VCC path allowing an easy method to slide surface mount components along these traces for optimal tuning.

3 EVM Layout

3.1 Description: Stack up and Material

The TRF37x73/75 EVM is a 62-mil, 4-layer board whose material type is Isola® 370HR. The top layer routes the power, ground, and signals to and from the device. The signal impedance is targeted at 49.9 Ω. The bottom 3 layers are ground layers.

3.2 PCB Layers

Figure 3-1 through Figure 3-3 illustrate the PCB layers for this EVM.

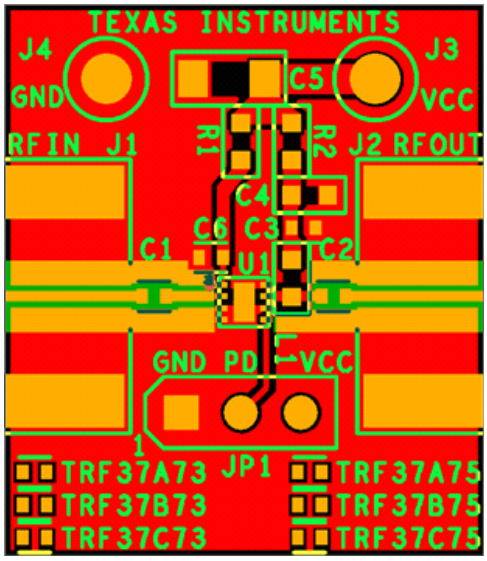


Figure 3-1. Top Layer

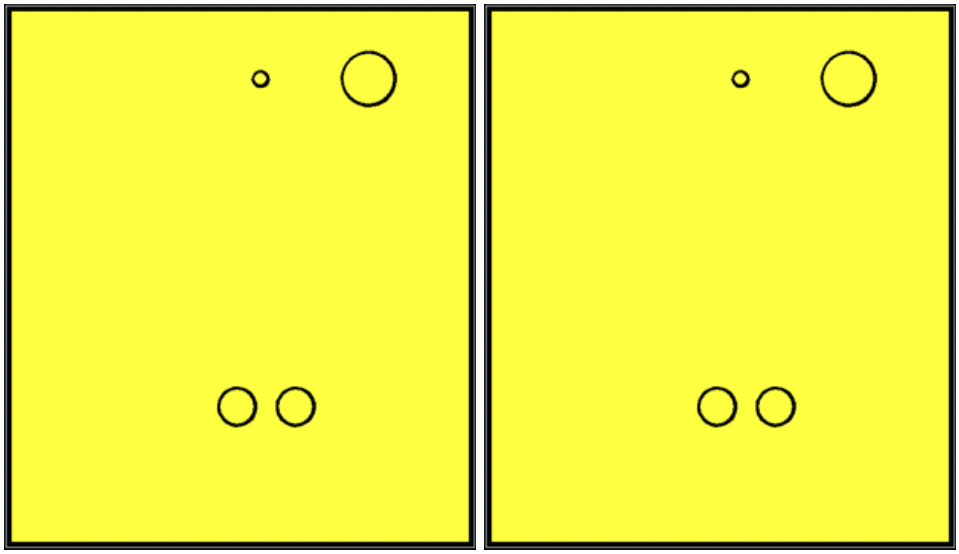


Figure 3-2. Layers 2 and 3

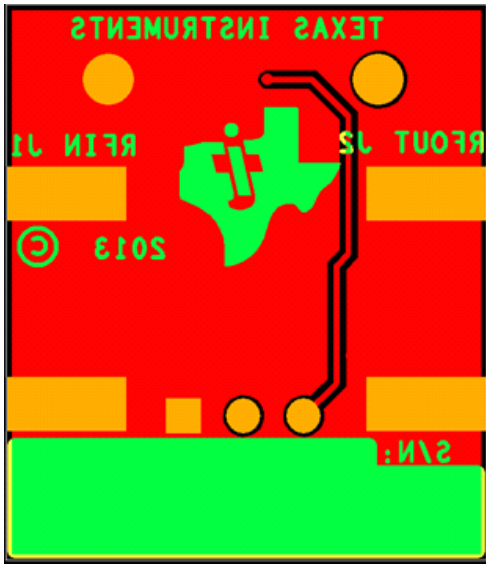


Figure 3-3. Bottom Layer (Through Top Side)

4 EVM Board Loss

Performance plots of the TRF37x73/75 EVM board are illustrated in Figure 4-1 and Figure 4-2, with the following modifications to the BOM:

- U1 gain block uninstalled
- C1 and C2 removed, terminals shorted with strip of copper whose width equaled the trace width.

Figure 4-1 and Figure 4-2 show the S11 and S22 log magnitude responses to a –10-dBm input signal. These measurements were taken with an Agilent E5071B vector network analyzer calibrated from 1 MHz to 6 GHz to the end of the coaxial cables. The coaxial cables were connected directly to J1 and J2 on the EVM board. Port 1 refers to J1 in the schematic and Port 2 refers to J2 in the schematic.

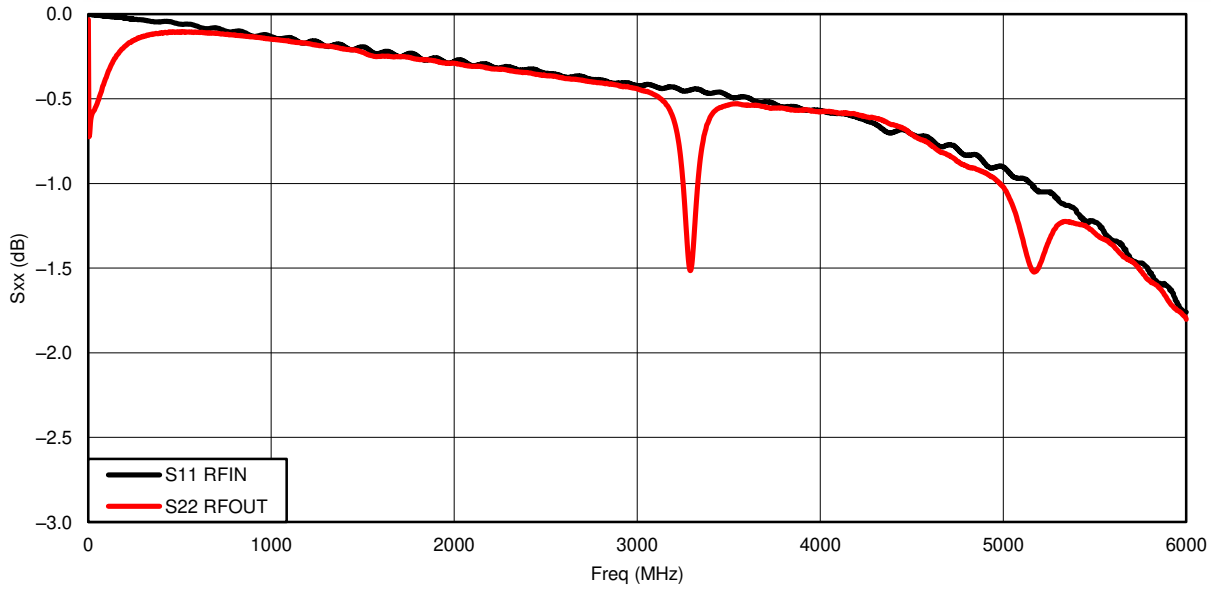


Figure 4-1. S11, S22 (Open), U1 Uninstalled

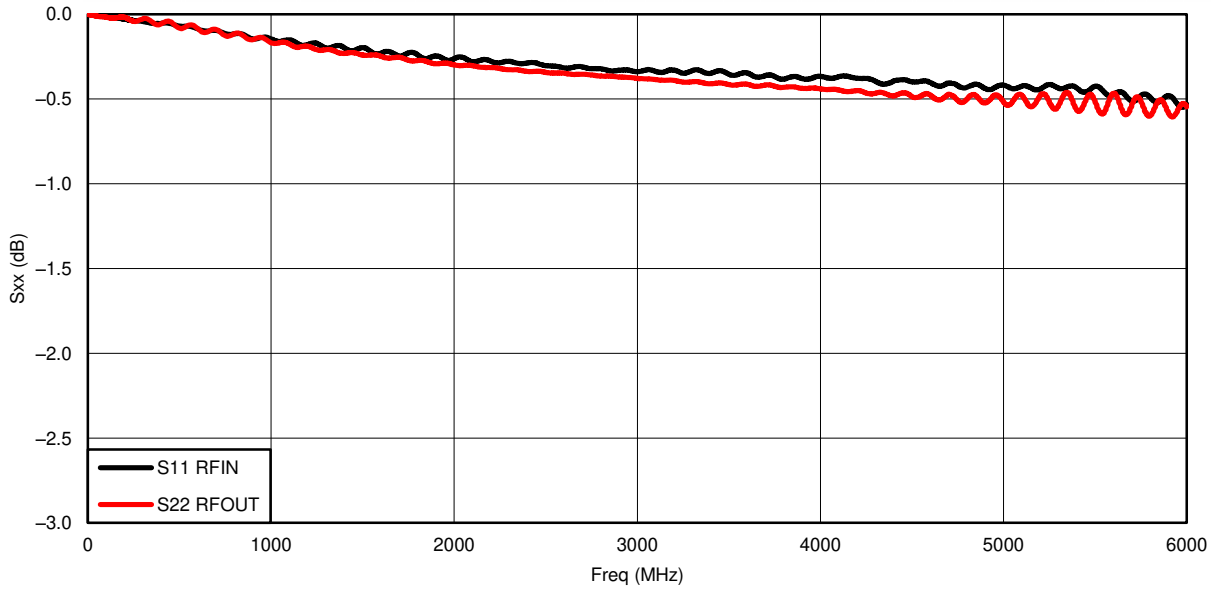


Figure 4-2. S11, S22 (Open), U1 and L1 Uninstalled, Copper Tape Replaced C1 and C2

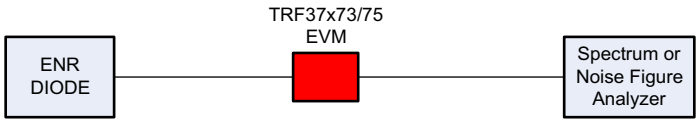
5 Test Block Diagrams

This section includes recommendations, comments, and test block diagrams for noise figure, gain and P1dB, and OIP3.

5.1 Noise Figure

Recommendations and comments:

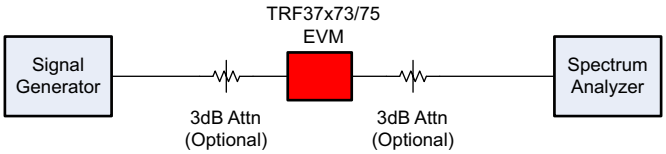
1. Use the traditional Y-factor method
2. Take into account losses of coax to the EVM board
3. Take into account losses of traces on the board up to the input pin of the device under test (DUT)



5.2 Gain and P1dB

Recommendations and comments:

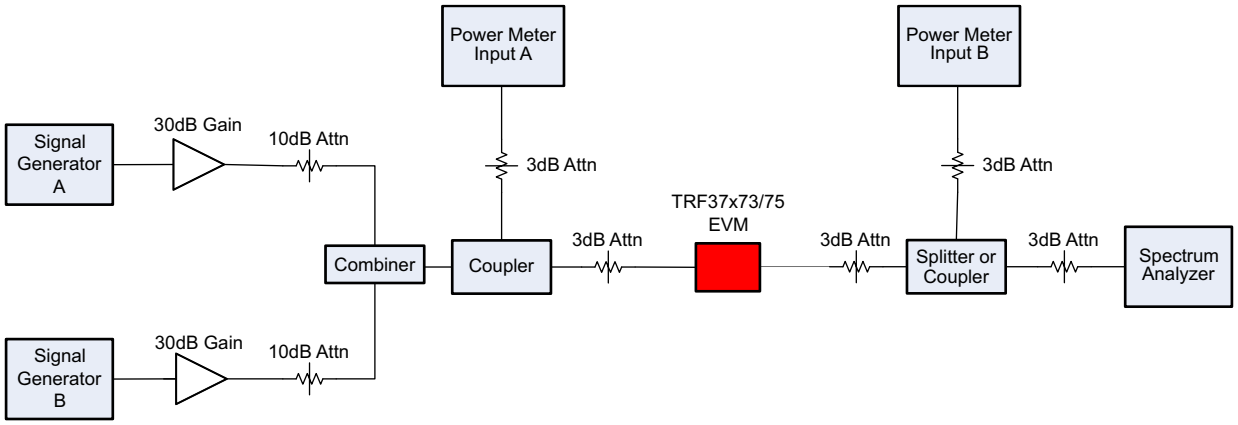
1. Take into account losses of coax and attenuators to and from the EVM board
2. Take into account losses of traces on the board up to the I/O pins of the DUT
3. Power meters are typically a few tenths of dB more accurate than a signal generator's level controls and spectrum analyzer measurement capability. For precise measurements, use a power meter to measure the output of the signal generator and output of the TRF37x73/75 EVM.



5.3 OIP3

Recommendations and comments:

1. This setup can also be used for gain and P1dB, if desired
2. For wideband measurements, the 30-dB gain stage and 10-dB attenuators are used to improve the input IP3 level that is created from the interaction of the 2 signal generators via the isolation of the combiner. For narrow band measurements, it maybe possible to create a setup with enough isolation using an isolator and/or combiner. In this case the 10-dB pads could be reduced or removed.
3. Power meter A is used to ensure the amplitude of the two tones at the input of the TRF37x73/75 EVM are within a certain tolerance. The gain stages will have unique gain characteristics and their gain can drift over time
4. Power meter B can be used for measuring the amplitude of individual tones for more accurate measurements.
5. Keep spectrum analyzer RBW and VBW settings identical for main tone and IM3 products
6. Take into account losses of coax and attenuators to and from the EVM board
7. Take into account losses of traces on the board up to the I/O pins of the DUT



6 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision * (March 2014) to Revision A (October 2021)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document	2
• Updated the L1 components part number from *-6-3HP-F10XJLU* to *0603HP-R10XJLW* in the *TRF37x73/75 EVM BOM* table	3

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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 DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

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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/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

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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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3.4.1 *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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4.1 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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