

EVM User's Guide: THS6232RHF EVM

THS6232RHF Evaluation Module



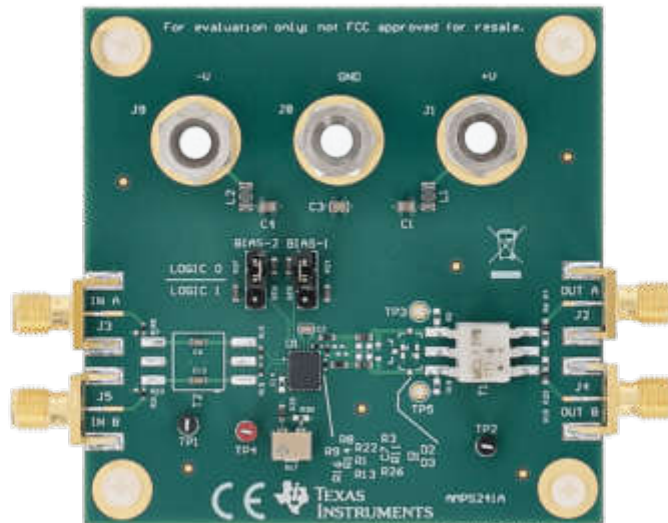
Description

This THS6232RHF evaluation module (EVM) is designed to quickly and easily demonstrate the functionality and versatility of the amplifier. The EVM is ready to connect to power, signal sources, and test instruments through the use of onboard connectors. The EVM comes configured for easy connection with common 50Ω laboratory equipment on the inputs and outputs. The amplifier is configured for a differential input with a gain of 10V/V to a differential output. The board includes jumpers to easily switch the device between different bias modes and a potentiometer to set the value of the IADJ pin. The EVM can be easily configured for other gains and for single- or split-supply operation. The output transformer and

resistors can be configured to present a 50Ω single-ended output.

Features

- Configured for split-supply operation and easily modified for single supply
- Default gain of 10V/V configuration can easily be reconfigured for other gains
- Designed for easy connection to standard 50Ω input and output impedance test equipment
- Quick setup board for THS6222 devices, with an optional pad for VCM pin capacitor
- Potentiometer and nearby resistors allow for precise setting of IADJ pin, including for ultra-low bias mode



THS6232RHF EVM

1 Evaluation Module Overview

1.1 Introduction

The THS6232RHFEVM is an evaluation module for the THS6232 line driver in the RHF package. This user's guide describes the characteristics, operation, and use of the THS6232RHFEVM. This evaluation module (EVM) is an evaluation and development kit for evaluating the THS6232RHFR, a differential line-driver amplifier with a current-feedback architecture that is targeted for use in broadband power line communications (PLC) line driver applications. A complete circuit description as well as schematic diagram and bill of materials are included in this document.

Throughout this document, the abbreviation *EVM* and the term *evaluation module* are synonymous with the THS6232RHFEVM.

1.2 Kit Contents

- THS6232RHFEVM Circuit Board
- EVM Disclaimer Read Me

1.3 Specification

The typical performance specifications for the THS6232RHFEVM are listed in [Table 1-1](#).

Table 1-1. THS6232RHFEVM Specifications

Specification	Typical Value Range
Split-supply voltage range	$\pm 3.5\text{V}$ to $\pm 20\text{V}$
Single-supply voltage range (VEE = ground)	7V to 40V
Quiescent current (no load, split supply, full-bias mode)	25mA
Output voltage swing (VCC = 12V, 100 Ω load)	21V _{PP}
Linear output current (VCC = 40V, 1 Ω load)	800mA

1.4 Device Information

The high-speed line driver EVM is setup for selecting bias modes using jumpers to either LOGIC 0 or LOGIC 1 voltage levels. These bias modes select the quiescent current of the THS6232RHFR. The option is available to use in either single or split-supply configuration, as well as to amend the output network of the amplifier for application-specific loading (pi-attenuator, etc). A potentiometer is available for fine adjustment of IADJ pin, as well as series & parallel zero-Ohm resistors for floating or bypassing the IADJ pin to GND. The THS6232RHFR is available in a 24-pin VQFN package with a 5mm x 4mm footprint. See the [THS6232 7V-to-40V, Differential HPLC Line Driver with Common-Mode Buffer Data Sheet](#) for more information.

2 Hardware

2.1 Power Connections

The THS6232RHFEVM is equipped with three banana jacks for easy connection of power to bench & lab instruments. The positive supply input is labeled V+, the negative supply input is labeled V-, and ground is labeled GND as the center jack of the power-supply area.

For split-supply operation, populating R12 is required and is the default configuration when the board is received.

For single-supply operation, removing R12 is required for correct operation. This configuration is not default and requires a board modification.

2.1.1 Split-Supply Operation

To operate as a split supply, apply the positive supply voltage to V+, the negative supply voltage to V-, and the ground reference from supply to GND.

When operating with equal (balanced) split-supplies, the input common mode is held to GND by R12 on the bottom of the THS6232RHFEVM PCB. This configuration is default and is present upon opening the EVM for the first time.

If operating with uneven supplies, then the input common mode must be referenced to mid-supply, $((V+)+(V-))/2$. For uneven supplies, this input common mode is not at GND potential. A board modification is required. Follow the steps in [Section 2.1.2](#) for implementing uneven supplies on the THS6232RHFEVM.

2.1.2 Single-Supply Operation

When operating the THS6232RHFEVM in a single-supply configuration, the input common mode must be referenced to mid-supply, $((V+)+(V-))/2$. For single-supply operation, the input common mode is not at GND potential.

The THS6232 has an internal common mode buffer (see section [Detailed Description: Overview](#) of THS6232 data sheet); this buffer drives the common mode voltage to mid-supply without external circuitry. The input common mode voltage is at the node between R10 and R15 in the THS6232RHFEVM schematic; this node is connected to TP1 as well as GND via R12 by default.

To enable a input common mode of $((V+)+(V-))/2$, a board modification is required. Please remove R12 from the bottom side of the PCB: R12 connects the input common mode node, between R10 and R15, to GND. Setting the input common mode to GND for a single supply configuration does not properly operate the amplifier; there is no device output on the THS6232RHFEVM if R12 is populated. The removal of R12 allows the internal common mode buffer circuit to work as intended during single-supply operation.

After removing R12 from the rear of the PCB, follow these steps for single-supply operation:

- Connect both the V- connector and the GND connector to ground; apply the positive supply voltage to V+.
- Optionally, use TP1 (red) to confirm the input common mode is at $((V+)+(V-))/2$.

2.2 Input and Output Connections

The THS6232RHFEVM is equipped with SMA connectors for easy connection of signal generators and analysis equipment. As shipped, the EVM is configured for a gain of 10V/V, split-supply, differential input and output with 50 Ω termination. By default, the inputs INA and INB are configured for a differential input connection. To use the device with a single-ended input, either use an external transformer or populate transformer T2 on the board, remove R21, populate R23 with a 0 Ω resistor, and use INA as the single-ended input. OUTA (J2) is the output connector for single-ended output signals. The output resistors R8 and R13 in combination with the transformer (T1) on the amplifier output provide a 2.5 Ω series resistance for PLC applications to the amplifier. There are several pads between the R8 and R13 resistors and the T1 output transformer. These pads are available for use as output attenuation, matching networks, and so forth. Users can change R8 and R13 to align with the desired application (for example DSL, PLC, solar rapid shutdown). For lab applications with bench instruments, R8 and R13 can be changed to provide a 25 Ω load to the amplifier when terminated in 50 Ω differentially (via T1 transformer). Resistors R8 and R13 must change to 24.9 Ω from 2.49 Ω to interface with lab instruments without additional loading or attenuation. To use the EVM with a single-ended output, remove resistor R18 and populate resistor R20 with 0 Ω , which gives a single-ended output on OUTA. The EVM contains provisions for additional output devices to change the loading of the amplifier and to add protection devices. A common implementation for PLC measurements is to utilize a pi-attenuator to load the amplifier for PLC measurements. See the applications section, schematics, and layouts for more detail and how to reconfigure the EVM in the [THS6232 7V-to-40V, Differential HPLC Line Driver With Common-Mode Buffer](#) data sheet.

2.2.1 Bias Mode Control Pins

The amplifier bias modes can be controlled through selecting between LOGIC 0 and LOGIC 1 positions on jumpers J6 (BIAS-1) and J7 (BIAS-2). By default, the jumper shorts are set to LOGIC 0, which pulls the input signals low, leaving the device in full-bias mode. Jumper J6 controls pin BIAS-1 and jumper J7 controls pin BIAS-2. In conjunction, the jumpers can be used to place the device in four bias modes or in shutdown.

Ultra-low bias mode requires an additional step to the other bias modes for use:

- Put the device into low bias mode, BIAS-1 (J6) open & BIAS-2 (J7) closed
- Use either method to raise the impedance on the IADJ pin:
 - R17 potentiometer, with default value zero-Ohms, and set to maximum 100kOhms
 - R29 zero-Ohm resistor, remove to float IADJ pin
- Measure quiescent current and confirm ultra-low bias mode

2.2.2 IADJ Pin Connection

The fine current adjustment (IADJ) pin of the device is controlled using the potentiometer R17 on the board. By default, the potentiometer is set to 0 Ω , which yields the maximum quiescent current for each bias mode. By increasing the resistance of the potentiometer, the quiescent current can be reduced to a desired lowered value at the cost of reduced performance.

Resistors R29 (series) and R30 (parallel) are included for additional control options of the IADJ pin. Both resistors can be used to set values for the potentiometer. R29 can be used to float the IADJ pin and R30 can be used to bypass the potentiometer.

2.2.3 Optional VCM Pin Connection

The EVM includes an optional connection on the VCM (pin 5) of the device for a capacitor. This inclusion is for support of THS6222 RHF devices, which can be evaluated on the THS6232RHFEVM board. For the THS6222, the optional VCM capacitor can be added to help filter common-mode noise if needed by the application. The THS6232 does not have a VCM pin, so VCM is not populated by default on the EVM.

3 Hardware Design Files

3.1 Schematic

The EVM schematic is shown in [Figure 3-1](#).

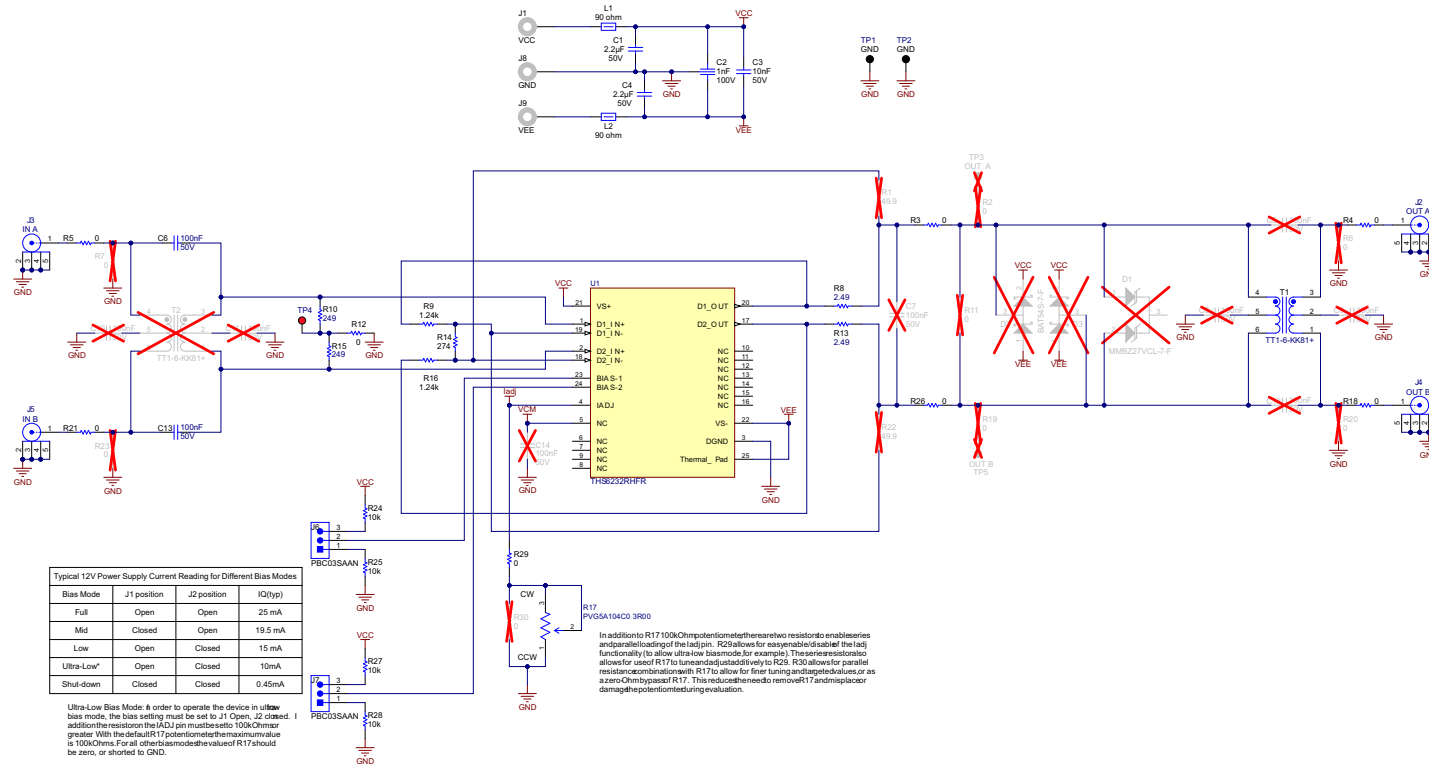


Figure 3-1. THS6232RHF EVM Schematic

3.2 Board Layout

The board layers, in top to bottom order, are illustrated in [Figure 3-2](#) through [Figure 3-5](#).

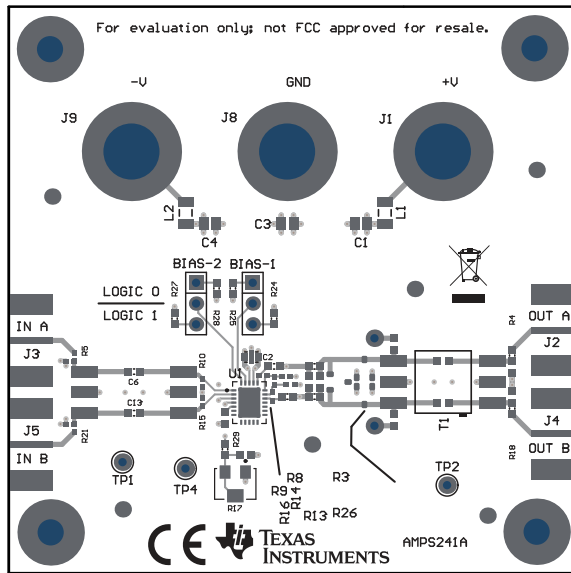


Figure 3-2. Top Layer

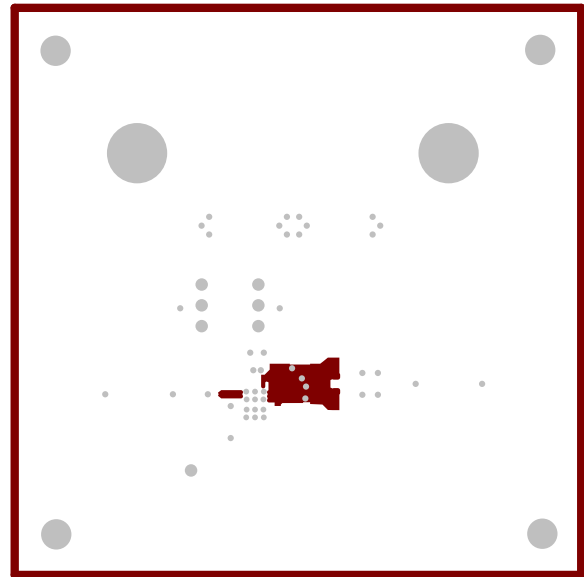


Figure 3-3. Ground Layer

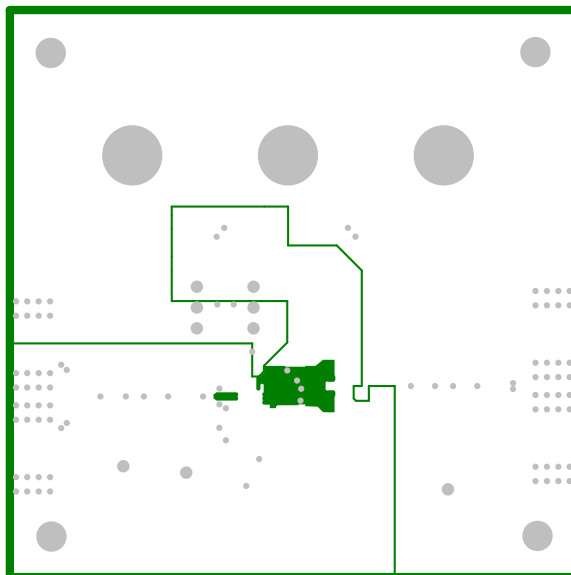


Figure 3-4. Power Layer

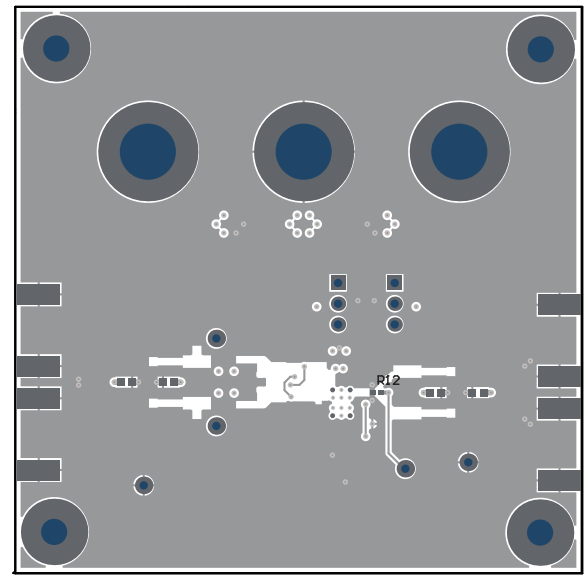


Figure 3-5. Bottom Layer

3.3 Bill of Materials

The EVM BOM is listed in [Table 3-1](#).

Table 3-1. Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
C1, C4	2	2.2uF	CAP, CERM, 2.2uF, 50V, +/- 10%, X7R, 0805	0805	C2012X7R1H225K125AC	TDK
C2	1	1000pF	CAP, CERM, 1000pF, 100V, +/- 20%, X7R, 0603	0603	CX0603MRX7R0BB102	Yageo America
C3	1	0.01uF	CAP, CERM, 0.01uF, 50V, +/- 10%, X7R, 0805	0805	08055C103KAT2A	AVX
C6, C13	2	0.1uF	CAP, CERM, 0.1uF, 50V, +/- 5%, X7R, 0603	0603	C0603C104J5RACTU	Kemet
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
J1, J8, J9	3		Standard Banana Jack, Uninsulated	Pomona_3267	3267	Pomona Electronics
J2, J3, J4, J5	4		Connector, End launch SMA, 50 ohm, SMT	SMA End Launch	142-0701-851	Cinch Connectivity
J6, J7	2		Header, 100mil, 3x1, Gold, TH	PBC03SAAN	PBC03SAAN	Sullins Connector Solutions
L1, L2	2	90 ohm	Ferrite Bead, 90 ohm at 100MHz, 1.5A, 1206	1206	MI1206K900R-10	Laird-Signal Integrity Products
R3, R4, R18, R26, R29	5	0	RES, 0, 5%, 0.1 W, 0603	0603	RC0603JR-070RL	Yageo
R5, R12, R21	3	0	RES, 0, 5%, 0.063 W, 0402	0402	RC0402JR-070RL	Yageo America
R8, R13	2	2.49	RES, 2.49, 1%, 0.1 W, 0603	0603	RC0603FR-072R49L	Yageo
R9, R16	2	1.24k	RES, 1.24 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04021K24FKED	Vishay-Dale
R10, R15	2	249	RES, 249, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2RKF2490X	Panasonic
R14	1	274	RES, 274, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402274RFKED	Vishay-Dale
R17	1	100k	100 kOhms 0.25W, 1/4W J Lead Surface Mount Trimmer Potentiometer Cermet 12.0 Turn Top Adjustment	SMT3	PVG5A104C03R00	Bourns
R24, R25, R27, R28	4	10k	RES, 10 k, 5%, 0.1 W, 0603	0603	RC1608J103CS	Samsung Electro-Mechanics
SH-J1, SH-J2	2		Shunt, 2.54mm, Gold, Black	Shunt, 2.54mm, Black	60900213421	Würth Elektronik
T1	1		RF Transformer, 50ohm, 0.004 to 300MHz, SMT	7.62x6.86mm	TT1-6-KK81+	Minicircuits
TP1, TP2	2		Test Point, Miniature, Black, TH	Black Miniature Test point	5001	Keystone
TP4	1		Test Point, Miniature, Red, TH	Red Miniature Test point	5000	Keystone
U1	1		7V to 40V, Differential HPLC Line Driver	VQFN24	THS6232RHFR	Texas Instruments
C5, C7, C8, C9, C10, C11, C12, C14	0	0.1uF	CAP, CERM, 0.1uF, 50V, +/- 5%, X7R, 0603	0603	C0603C104J5RACTU	Kemet
D1	0	27V	Diode, TVS, Uni, 27V, 38 Vc, SOT-23	SOT-23	MMBZ27VCL-7-F	Diodes Inc.
D2, D3	0	30V	Diode, Schottky, 30V, 0.2A, SOT-23	SOT-23	BAT54S-7-F	Diodes Inc.

Table 3-1. Bill of Materials (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
R1, R22	0	49.9	RES, 49.9, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040249R9FKED	Vishay-Dale
R2, R6, R11, R19, R20, R30	0	0	RES, 0, 5%, 0.1 W, 0603	0603	RC0603JR-070RL	Yageo
R7, R23	0	0	RES, 0, 5%, 0.063 W, 0402	0402	RC0402JR-070RL	Yageo America
T2	0		RF Transformer, 50ohm, 0.004 to 300MHz, SMT	7.62x6.86mm	TT1-6-KK81+	Minicircuits
TP3, TP5	0		Test Point, Miniature, Red, TH	Red Miniature Test point	5000	Keystone

4 Additional Information

4.1 Trademarks

All trademarks are the property of their respective owners.

5 Related Documentation

For related documentation, see the following:

- Texas Instruments, [THS6232 7V-to-40V, Differential HPLC Line Driver with Common-Mode Buffer](#), data sheet

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WARNING

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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/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.

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4. *EVM Use Restrictions and Warnings:*
 - 4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.
 - 4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.
 - 4.3 *Safety-Related Warnings and Restrictions:*
 - 4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.
 - 4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.
 - 4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.
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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
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