INA302 and INA303 Evaluation Module

This user's guide describes the characteristics, operation, and use of the INA30xEVM evaluation module. It discusses how to set up and configure the hardware and reviews various aspects of the hardware operation. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the INA30xEVM. This document also includes an electrical schematic, printed circuit board (PCB) layout drawings, and a parts list for the EVM.

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1 Overview

The INA302 and INA303 are voltage-output current-shunt monitors with integrated dual high-speed comparators that enable accurate current measurement in conjunction with fast over- and under-current detection capability. The dual comparators of the INA302 are configured to detect over-current events spanning two levels of severity, whereas the dual comparators of the INA303 function as a window comparator, enabling users to detect over- and under-current events. Each device has three variants corresponding to the available gain options for the internal amplifier. The variants of the INA302 are INA302A1 (Gain = 20V/V), INA302A2 (Gain = 50V/V) and INA302A3 (Gain = 100V/V), and similarly the variants of the INA303 are the INA303A1, INA303A2 and INA303A3.

The INA30xEVM is offered as two distinct orderable items, namely, the INA302EVM and the INA303EVM. Each EVM is a PCB consisting of three independent break-away sections. Each section contains a different variant of the corresponding device, along with its own set of input, output and power terminals, as well as signal and power conditioning circuitry to allow users to test each device variant independently.

1.1 INA30xEVM Kit Contents

Table 1 summarizes the contents of the INA30xEVM kit. Contact the Texas Instruments Product Information Center nearest you if any component is missing. It is highly recommended that you also check the INA302 and INA303 device product folders on the TI web site at www.ti.com for any further information regarding this product.

Table 1. INA30xEVM Kit Contents

Item	Quantity
INA30x test board	1

1.2 INA30xEVM Features

The INA30xEVM provides basic functional evaluation of the INA302 and INA303 family of devices. The fixture layout is not intended for electromagnetic compatibility (EMC) testing.

The INA30xEVM PCB provides the following features:

- Ease of access to device pins with test points
- Supports unipolar or bipolar input signals
- Includes options for amplifier input and output filtering
- Contains on-board reference source; also supports external reference source
- Includes resistors for setting comparator switching thresholds
- On-board LEDs for visually monitoring states of $\overline{\text{ALERT}}$ pins

Refer to the INA30x product data sheet, (SBOS775), for comprehensive information about this family of current sense amplifiers.

1.3 Related Documentation from Texas Instruments

The following document provides information regarding Texas Instruments' integrated circuits used in the assembly of the INA30xEVM. This user's guide is available from the TI web site under literature number SBOU185. 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 to be available from www.ti.com, or call 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 2. Related Documentation

Document	Literature Number
INA302 and INA303 product data sheets	SBOS775

2 Hardware

Each break-away section of the INA30xEVM PCB is intended to be tested independently. The power supply, inputs, and outputs of each break-away board are accessible through the clearly labeled surface-mount test points located along the periphery of the board. Only the most frequently used test points are populated for easy access using standard sprung hook probes. Multiple GND test points have been provided for convenience during testing. Figure 1 depicts a block diagram representing the individual break-away boards comprising the INA30xEVM.

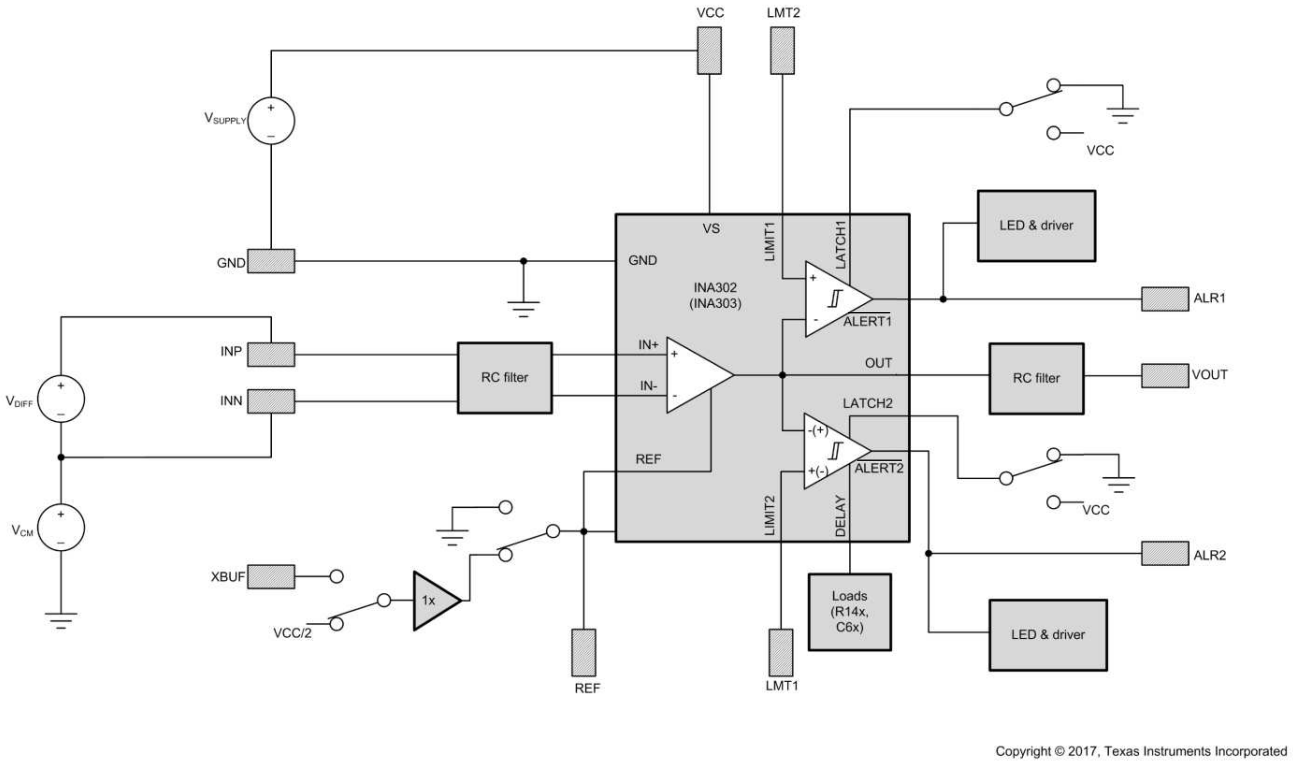

Figure 1. INA30xEVM Block Diagram and Default Test Setup

The following subsections describe the main PCB inputs and outputs.

2.1 Power Supply

To power the board, a 2.7-V to 5.5-V source must be connected between the test point labeled VCC and the adjacent GND terminal. The 10-µF capacitor, C7x, is located between these test points and decouples the VCC source from high-frequency loads on the board. In addition, each active device on the board also has a dedicated 0.1-µF bypass capacitor located in close proximity to its supply pin.

2.2 Signal Inputs

The test points INP and INN are connected to the INA30x input pins (that is, IN+ and IN-, respectively) through an on-board user-customizable differential RC network, populated with 0-Ω resistors, by default. Note that the input voltage signal must have valid differential (that is, INP – INN) and common-mode (that is, INP – GND or INN – GND) components as specified in the *Electrical Characteristics* section of product data sheet (SBOS775). Typically, the most convenient method of driving the input signal using common lab equipment is to connect two floating voltage sources in series, as per Figure 1, with the upper source (V_{DIFF}) connected between INP and INN to supply the differential voltage, and the lower source (V_{CM}) connected between the low-side of V_{DIFF} and device ground to supply the input common-mode voltage.

2.3 Reference Input

The REF terminal of the PCB is directly connected to the REF input pin of the INA30x device, and must not be left floating. With default jumper settings, the on-board op amp buffer U2x drives the REF signal to mid-supply and therefore no external input is necessary. Alternatively, the REF input can be shorted to GND (useful when making unipolar measurements) through J2x, or supplied by an external source, using one of the following methods.

- Set J2x to connect the output of U2x to REF and drive the XBUF test point from an external voltage source
- Leave J2x unpopulated and drive the REF test point directly with a low-impedance voltage source

2.4 LIMITx Inputs

The test points labeled LMTx are connected to the LIMITx pins of the INA30x device. The EVM includes on-board resistors that set the voltages at LIMIT1 and LIMIT2 to about 4 V and 400 mV, respectively. Alternatively, the LIMITx voltages can be set by driving the LMTx test points using low-impedance voltage sources. Note that for proper window comparator functionality on the INA303, the voltage at LIMIT1 must be greater than the voltage at LIMIT2.

2.5 LATCHx Inputs

There are no dedicated test points for the INA30x LATCHx inputs but they can be accessed through J1x. With J1x unpopulated, the INA30x is configured for transparent mode operation. Latched operation can be enabled by pulling LATCHx to VCC using the appropriate setting on J1x.

2.6 DELAY Input

The DELAY pin of the INA30x is a high-impedance node and highly susceptible to noise pickup. For this reason, all routing to the DELAY pin has been kept as short as possible and there are no test points associated with it. The PCB does include placeholders C6x and R14x to allow users to control the propagation delay of the $\overline{\text{ALERT2}}$ signal. C6x is intended for installing a load capacitor to GND. Note that the $\overline{\text{ALERT2}}$ delay increases with load capacitance on the DELAY pin, as explained in the product data sheet (SBOS775). R14x is a pull-up load resistor to VCC and helps minimize the $\overline{\text{ALERT2}}$ delay. Installing a 50-kΩ to 100-kΩ resistor at R14x is recommended for minimal delay. Using values below 50 kΩ increases the supply current without yielding any significant reduction in the $\overline{\text{ALERT2}}$ delay.

2.7 Amplifier Output

The output of the internal INA30x amplifier is accessible through the VOUT test point. The signal path from the INA30x to the VOUT test point includes an optional RC network for low-pass filtering.

VOUT may be referenced to REF or GND depending on whether the component being driven by the INA30x device requires a unipolar or bipolar input signal.

VOUT swing limitations specified in the *Electrical Characteristics* section of the product data sheet (SBOS775) must be considered in order to operate the amplifier in linear fashion.

2.8 $\overline{\text{ALERTx}}$ Outputs

The $\overline{\text{ALERT1}}$ and $\overline{\text{ALERT2}}$ pins of the INA30x are accessible through the test points labeled ALR1 and ALR2, respectively. For gross testing, users can also monitor the states of the $\overline{\text{ALERT}}$ pins using the corresponding LED indicators provided on the PCB.

2.9 Quick-Start Setup and Use

Use the following steps and the default jumper settings to setup and use the INA30xEVM. Details of the test setup are illustrated in Figure 1.

1. Connect the power supply between the VCC and GND test points
2. Connect the input signal between the INP and INN test points, strictly adhering to the input common-mode requirements
3. Measure the amplifier output voltage between the test points VOUT and GND or VOUT and REF, as necessary
4. Optionally, monitor the states of the LEDs D1x and D2x to discern the states of the $\overline{\text{ALERT1}}$ and $\overline{\text{ALERT2}}$, respectively

3 Schematic, PCB Layout, and Bill of Materials

3.1 Schematic

Figure 2 shows the complete schematic of the INA30x test board.

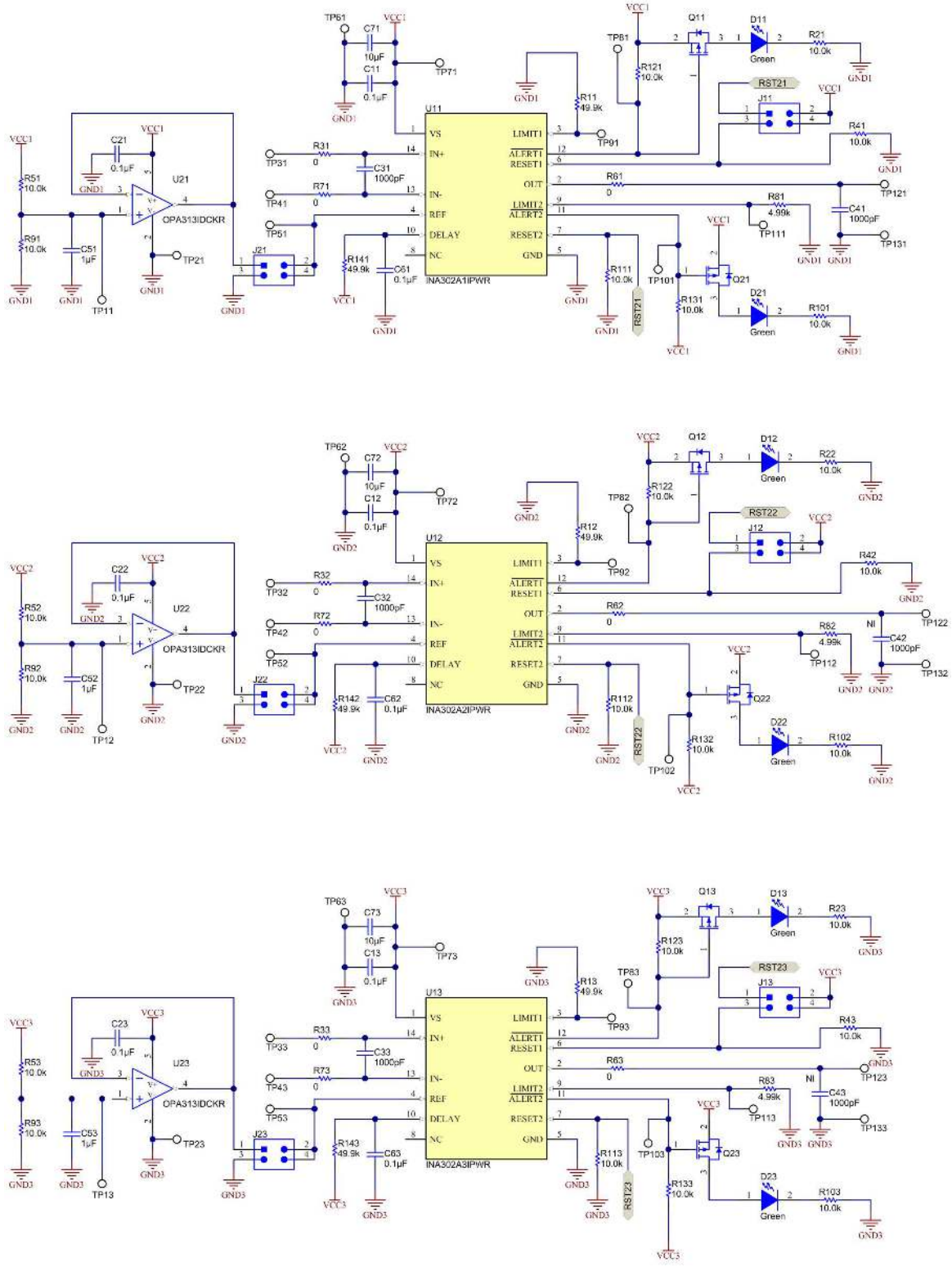

Figure 2. INA30x Test Board Schematic

3.2 PCB Layout

The two-layer EVM PCB measures 1.7 in × 5.3 in and is fabricated with a 1-oz copper pour. Figure 3 shows the component placement and Figure 4 depicts the layout of the top layer of the PCB. The top layer contains all of the components and signal routing. Solid copper tied to VCC fills the regions between traces as well as regions with no routing. This not only provides a low impedance path for VCC load currents but also helps shield high-impedance nets such as DELAY and LIMITx from the high-frequency noise associated with the fast switching comparator outputs. The bottom layer (not shown) has no components but contains a solid copper ground plane that provides a low-impedance path for return currents.

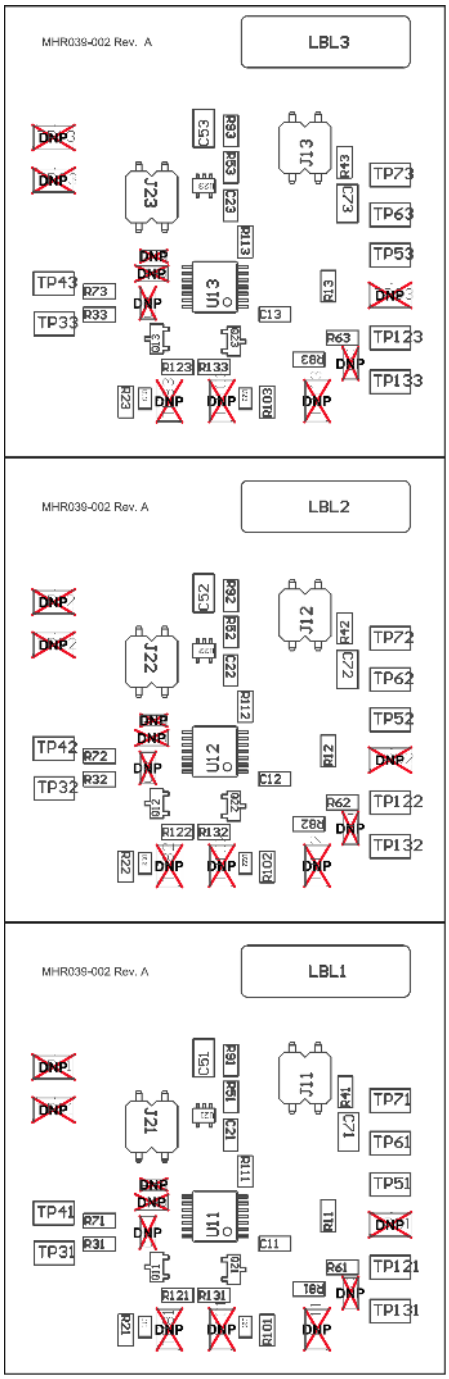

Figure 3. PCB Component Placement

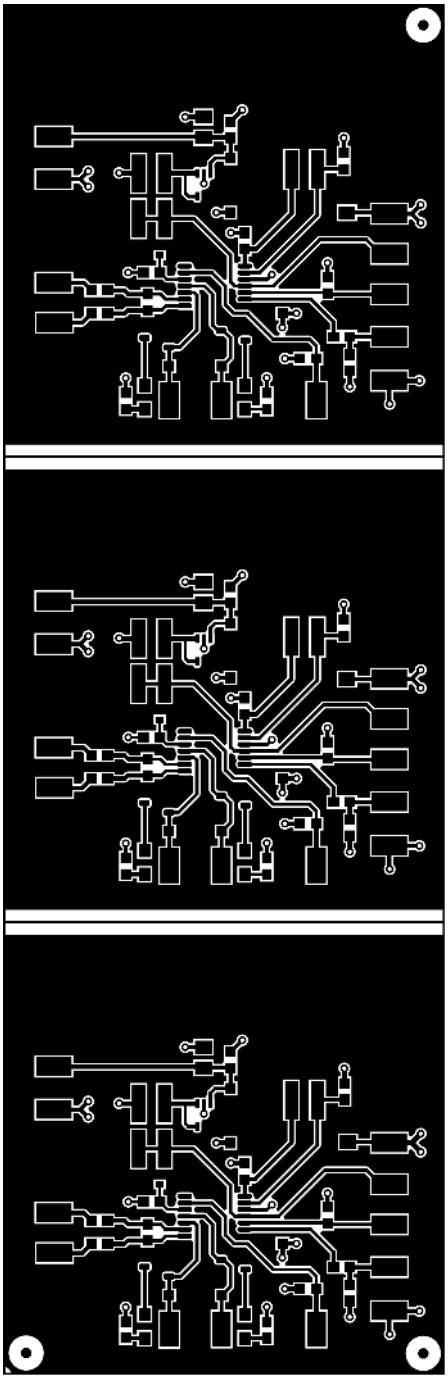

Figure 4. PCB Top Layer

3.3 Bill of Materials

Table 3 lists the bill of materials (BOM) for the INA30x test board.

Table 3. INA30x Test Board BOM

Part Number	Manufacturer	Description	Designator	Qty
0015912040	Molex	Header, 2.54mm, 2x2, Gold, SMT	J11, J12, J13, J21, J22, J23	6
06033C104KAT2A	AVX	CAP, CERM, 0.1 µF, 25 V, +/- 10%, X7R, 0603	C11, C12, C13, C21, C22, C23	6
APT2012LZGCK	Kingbright	LED, Green, SMD	D11, D12, D13, D21, D22, D23	6
BSS84-7-F	Diodes Inc.	MOSFET, P-CH, -50 V, -0.13 A, SOT-23	Q11, Q12, Q13, Q21, Q22, Q23	6
C0805C105K3RACTU	Kemet	CAP, CERM, 1 µF, 25 V, +/- 10%, X7R, 0805	C51, C52, C53	3
GRM21BR71A106KE51L	Murata	CAP, CERM, 10 µF, 10 V, +/- 10%, X7R, 0805	C71, C72, C73	3
INA303A1IPWR	Texas Instruments	36-V, High-Speed, Bi-Directional, Zero-Drift, Voltage-Output, Current-Shunt Monitor with Multi-Alert High-Speed, Overcurrent Comparator, PW0014A	U11	1
INA303A2IPWR	Texas Instruments	36-V, High-Speed, Bi-Directional, Zero-Drift, Voltage-Output, Current-Shunt Monitor with Multi-Alert High-Speed, Overcurrent Comparator, PW0014A	U12	1
INA303A3IPWR	Texas Instruments	36-V, High-Speed, Bi-Directional, Zero-Drift, Voltage-Output, Current-Shunt Monitor with Multi-Alert High-Speed, Overcurrent Comparator, PW0014A	U13	1
OPA313IDCKR	Texas Instruments	1-MHz, Micro-Power, Low-Noise, RRIO,1.8-V CMOS OPERATIONAL AMPLIFIER Precision Value Line Series, DCK0005A	U21, U22, U23	3
RC0603FR-0710KL	Yageo America	RES, 10.0 k, 1%, 0.1 W, 0603	R21, R22, R23, R41, R42, R43, R51, R52, R53, R91, R92, R93, R101, R102, R103, R111, R112, R113, R121, R122, R123, R131, R132, R133	24
RC0603JR-070RL	Yageo America	RES, 0, 5%, 0.1 W, 0603	R31, R32, R33, R61, R62, R63, R71, R72, R73	9
RG1608P-4991-B-T5	Susumu Co Ltd	RES, 4.99 k, 0.1%, 0.1 W, 0603	R81, R82, R83	3
RG1608P-4992-B-T5	Susumu Co Ltd	RES, 49.9 k, 0.1%, 0.1 W, 0603	R11, R12, R13	3
5015	Keystone	Test Point, Miniature, SMT	TP31, TP32, TP33, TP41, TP42, TP43, TP51, TP52, TP53, TP61, TP62, TP63, TP71, TP72, TP73, TP121, TP122, TP123, TP131, TP132, TP133	21

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   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*

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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

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http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

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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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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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