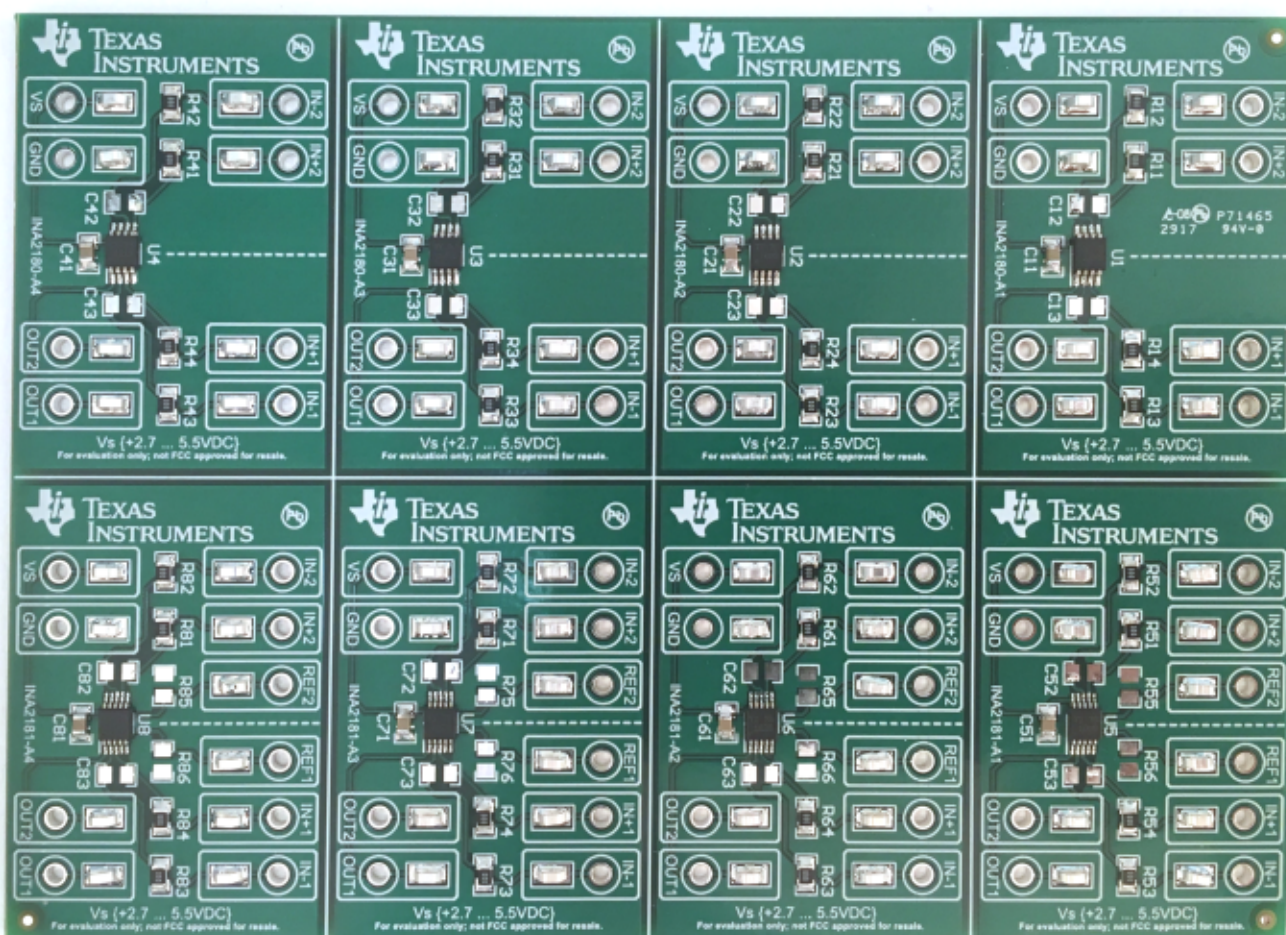


INA2180-2181 Evaluation Module User's Guide

This user's guide describes the characteristics, operation, and use of the INA2180-2181 evaluation module (EVM). This EVM is designed to evaluate the performance of the [INA2180A1](#), [INA2180A2](#), [INA2180A3](#), [INA2180A4](#), [INA2181A1](#), [INA2181A2](#), [INA2181A3](#), [INA2181A4](#) voltage output current-shunt monitors in a variety of configurations. This document includes a schematic, reference printed-circuit board (PCB) layouts, and a complete bill of materials.



Contents

1	Overview	3
2	INA2180-2181EVM Hardware.....	3
3	Quick Start Setup and Use	4
4	INA2180-2181EVM Circuit.....	4
5	Reference Voltage Setup	5
6	INA2180-2181EVM Schematic and PCB Layout	6
7	Bill of Materials	10

List of Figures

1	INA2180-2181EVM Schematic.....	6
2	INA2180-2181EVM Top Overlay	7
3	INA2180-2181EVM Top Solder Mask.....	7
4	INA2180-2181EVM Top Layer	7
5	INA2180-2181EVM Bottom Layer	7
6	INA2180-2181EVM Drill Drawing	8

List of Tables

1	INA218x Device Summary	3
2	INA2180-2181EVM Kit Contents	3
3	Related Documentation	3
4	Bill of Materials	10

Trademarks

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1 Overview

The INA2180 family of current-shunt monitors (also called current-sense amplifiers) can sense drops across shunts at common-mode voltages from -0.2 V to $+26\text{ V}$, independent of the supply voltage. Four fixed gains are available: 20 V/V , 50 V/V , 100 V/V , and 200 V/V . The INA2181 family has the same capabilities as the INA2180 family but with the addition of the reference pin that enables bidirectional current measurements. These devices operate from a single 2.7-V to 5.5-V power supply, drawing a maximum of $260\text{ }\mu\text{A}$ of supply current per amplifier channel.

The INA2180 devices are currently available in a VSSOP(8) and the INA2181 devices are available in a TSSOP(14) surface-mount packages. [Table 1](#) lists the available gain options.

Table 1. INA218x Device Summary

PRODUCT	GAIN
INA2180A1, INA2181A1	20
INA2180A2, INA2181A2	50
INA2180A3, INA2181A3	100
INA2180A4, INA2181A4	200

1.1 INA2180-2181EVM Kit Contents

[Table 2](#) lists the contents of the INA2180-2181EVM kit. Contact the nearest [Texas Instruments Product Information Center](#) if any component is missing. TI highly recommends checking the INA2180 family product folder on the TI website at www.ti.com for further information regarding this product.

Table 2. INA2180-2181EVM Kit Contents

ITEM	QUANTITY
INA2180-2181EVM Test Board	1

1.2 Related Documentation From Texas Instruments

This user guide provides information regarding TI's integrated circuits used in the assembly of the INA2180-2181EVM. See also the device data sheets:

Table 3. Related Documentation

DOCUMENT	LITERATURE NUMBER
INA2180 Product data sheet	SBOS741
INA2181 Product data sheet	SBOS793

2 INA2180-2181EVM Hardware

The INA2180 is a current sense integration solution that provides ease of use and high performance. The INA2181 has the same capabilities as the INA2180 but with the addition of the reference pin that enables bidirectional current measurements. The INA2180-2181EVM provides basic functional evaluation of this device family. The fixture layout is not intended to be a model for the target circuit, nor is it laid out for electromagnetic compatibility (EMC) testing. The INA2180-2181EVM consists of one PCB with an option to cut out eight individual PCBs - one for each of the eight devices (INA2180A1, INA2180A2, INA2180A3, INA2180A4, INA2181A1, INA2181A2, INA2181A3 and INA2181A4).

2.1 Features

The layout of the INA2180-2181EVM printed-circuit board (PCB) is designed to provide the following features:

- Evaluation of all gain options for the INA2180Ax and INA2181Ax
- Ease of access to device pins with test points
- Capability to evaluate high-side and low-side configurations

See the [INA2180](#) and [INA2181](#) data sheets for comprehensive information about the INA2180 and INA2181 family of devices.

3 Quick Start Setup and Use

The following are instructions to set up and use the INA2180Ax devices of the INA2180-2181EVM.

- Step 1. Connect an external dc supply voltage between 2.7 V and 5.5 V to the VS test point, and connect ground reference of that supply to the GND test point.
- Step 2. Connect the input per [Section 3.1](#).

The following are instructions to set up and use the INA2181Ax devices of the INA2180-2181EVM.

- Step 1. Connect an external dc supply voltage between 2.7 V and 5.5 V to the VS test point, and connect ground reference of that supply to the GND test point.
- Step 2. Connect an external supply to the REF1 and REF2 test points. This reference voltage can be set anywhere from 0 V to VS. Further details regarding the use of the reference voltage are discussed later in [Section 5](#).
- Step 3. Connect the input per [Section 3.1](#).

3.1 Measurements

The INA2180-2181EVM enables the user to either simulate the voltage developed across a sense resistor based on a given set of system conditions or to connect remotely to an existing shunt already included in an example application.

The following procedures are used to configure a measurement evaluation without a shunt.

- Channel 1:
 - Step 1. Connect a differential voltage to the IN+1 and IN–1 test points.
 - Step 2. Measure the output voltage at the OUT1 test point.
- Channel 2:
 - Step 1. Connect a differential voltage to the IN+2 and IN–2 test points.
 - Step 2. Measure the output voltage at the OUT2 test point.

NOTE: The output voltage is equal to the gain of the device multiplied by the differential voltage measured directly at the device input pins.

4 INA2180-2181EVM Circuit

This section summarizes the INA2180-2181EVM components. For the following instructions, x = 1 to 8.

4.1 Rx1, Rx2, Rx3, Rx4, Cx2, Cx3

Rx1 and Rx2 (Rx3 and Rx4 for Channel 2) are factory-installed 0-Ω resistors. These resistors, in combination with Cx2 (Cx3 for Channel 2), form an input filter. These locations allow for 0805 surface-mount package size. Additional information regarding the use of input filtering is provided in the [INA2180](#) and [INA2181](#) product data sheets.

4.2 Cx1

Cx1 are 0.1- μ F supply bypass capacitors.

4.3 Ux

Ux is the location for the test device. Eight device boards are supplied with the INA2180-2181EVM board. Each board is populated with one of the available device gains. This option enables users to test the devices and determine the gain setting that is best suited for a given application.

The following is a list of the factors involved in selecting the appropriate device:

- The INA2180A1-A4 devices are identical with the exception of different gain settings. The INA2181A1-A4 devices have the same device gain options of the INA2180 but with the addition of the reference pin that enables bidirectional current measurements.
- Select INA2180 for unidirectional applications only, and select INA2181 for unidirectional or bidirectional applications.
- The differential input voltage is applied across the inputs, or developed based on the load current that flows through the shunt resistor.
- The limiting factor that requires attention to be given to device selection is the output voltage.
- The selected device must allow the output voltage to remain within the acceptable range after the developed input voltage is amplified by the respective device gain. The output voltage must remain within the range of 10 mV above ground to 100 mV below the supply voltage.
- An output below the minimum allowable output requires the selection of a device with a higher gain. Likewise, an output above the maximum allowable output requires the selection of a device with a lower gain.

4.4 Voltages Inputs (IN+1, IN–1, IN+2, IN–2)

The IN+1 (IN+2 for Channel 2) and IN–1 (IN–2 for Channel 2) inputs accept a differential voltage that is amplified by the selected device gain and is presented at the OUT1 (OUT2 for Channel 2) test point. These inputs can also be used to connect the differential voltage developed across an external shunt in an existing circuit. The acceptable differential input voltage range and polarity are determined by the supply voltage, reference voltage, and gain of the selected device.

4.5 Reference Voltage (REF1, REF2)

REF1 and REF2 test points enables the user to configure the INA2181A1-A4 device boards for either unidirectional or bidirectional operation. Refer to [Section 5](#) for more information.

4.6 Rx5 and Rx6

Rx5 and Rx6 resistors locations are not populated. If a 0- Ω resistor is populated, the REF1 (REF2 for Channel 2) pin will be connected to GND, and the INA2181 can be used for unidirectional measurements. These locations allow for 0805 surface-mount package size.

5 Reference Voltage Setup

The INA2181A1-A4 devices enable the use of an external reference. This reference determines how the output responds to certain input conditions. The reference also enables these devices to be used in unidirectional and bidirectional applications. The REF pin can also be connected to supply (VS) to enable unidirectional measurement in the negative direction.

5.1 Unidirectional Mode

Unidirectional refers to a load current that flows in only one direction.

The INA2180A1-A4 devices are able to measure unidirectional currents only. The INA2181A1-A4 devices measure unidirectional and bidirectional currents. For unidirectional measurements the REF pins (REF1 and REF2) needs to be connected to GND. You can connect the REF1 pin (REF2 for Channel 2) to GND through a 0-ohm resistor (Rx5 and Rx6) or ground it directly.

5.2 Bidirectional Mode

Bidirectional refers to a load current that flows in both directions.

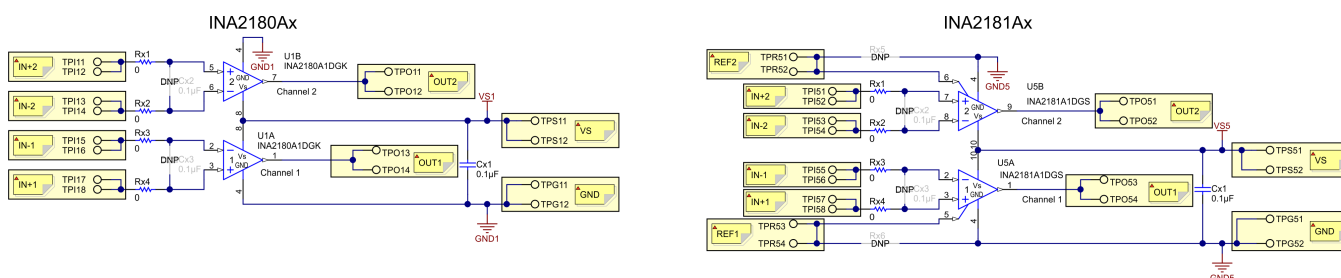
The INA2181A1-A4 devices are able to measure bidirectional currents. The ability to measure this current flowing in both directions is enabled by applying a voltage to the REF pin (REF1 and REF2). The voltage applied to REF1 (REF2 for Channel 2) sets the output state that corresponds to the zero-input level state. The output then responds by increasing above REF1 for positive differential signals (relative to the IN–1 pin) and responds by decreasing below REF1 for negative differential signals. This reference voltage applied to the REF1 pin can be set anywhere from 0 V to VS. For bidirectional applications, REF1 is typically set at mid-scale for equal signal range in both current directions. In some cases, however, REF1 is set at a voltage other than mid-scale when it is unnecessary that the bidirectional current and corresponding output signal be symmetrical.

6 INA2180-2181EVM Schematic and PCB Layout

NOTE: Board layouts are not to scale. These figures are intended to show how the board is laid out. The figures are not intended to be used for manufacturing INA2180-2181EVM PCBs.

6.1 Schematic

Figure 1 shows the schematic for the INA2180-2181EVM PCB.



6.2 PCB Layout

Figure 2 through Figure 6 illustrate the PCB layout for the INA2180-2181EVM.

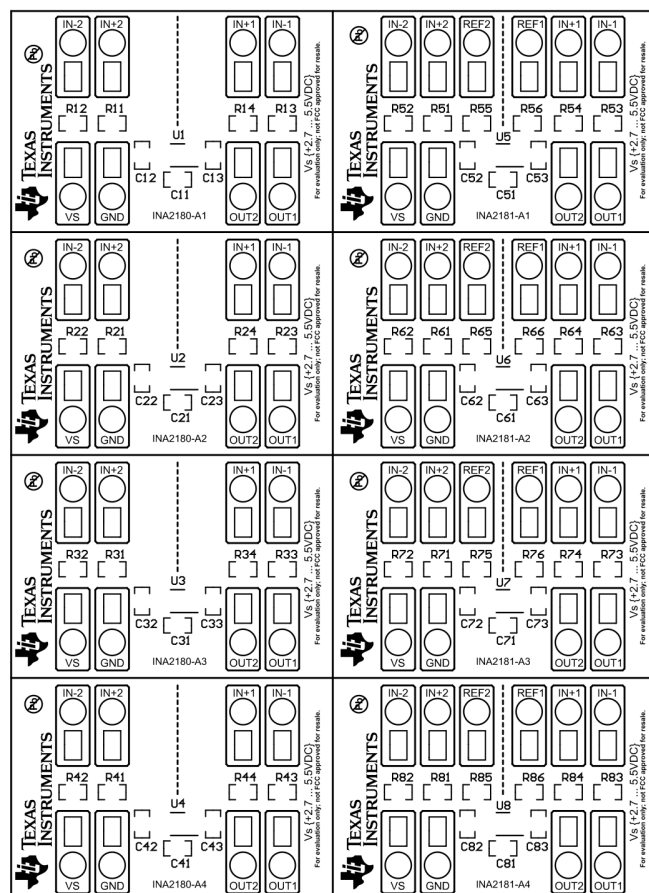


Figure 2. INA2180-2181EVM Top Overlay

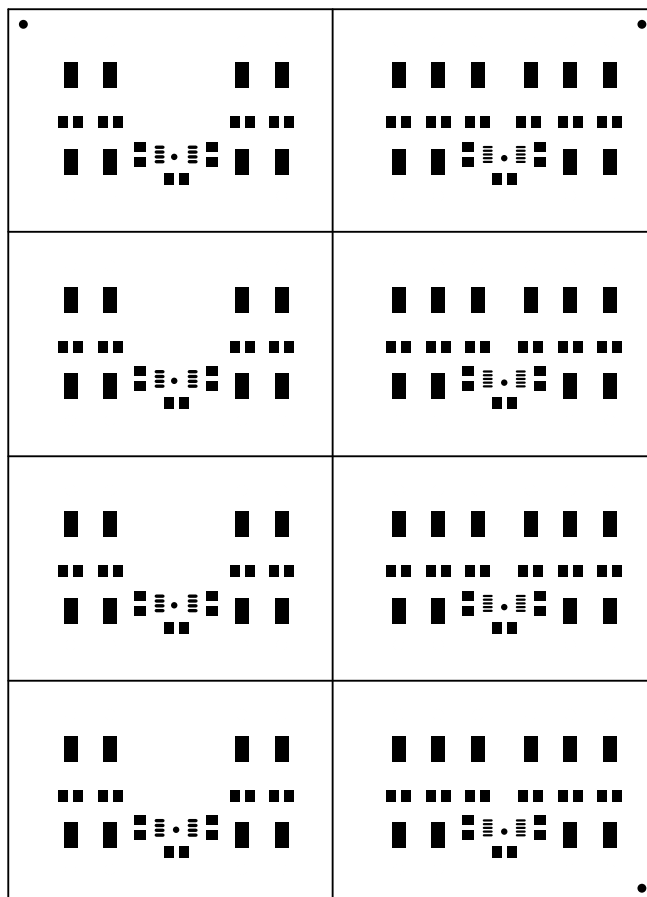


Figure 3. INA2180-2181EVM Top Solder Mask

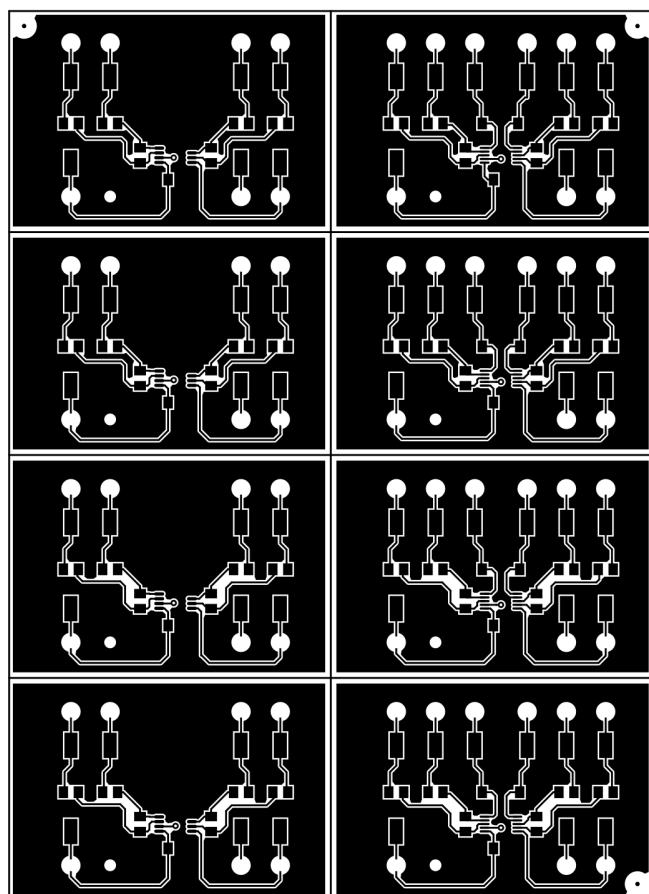


Figure 4. INA2180-2181EVM Top Layer

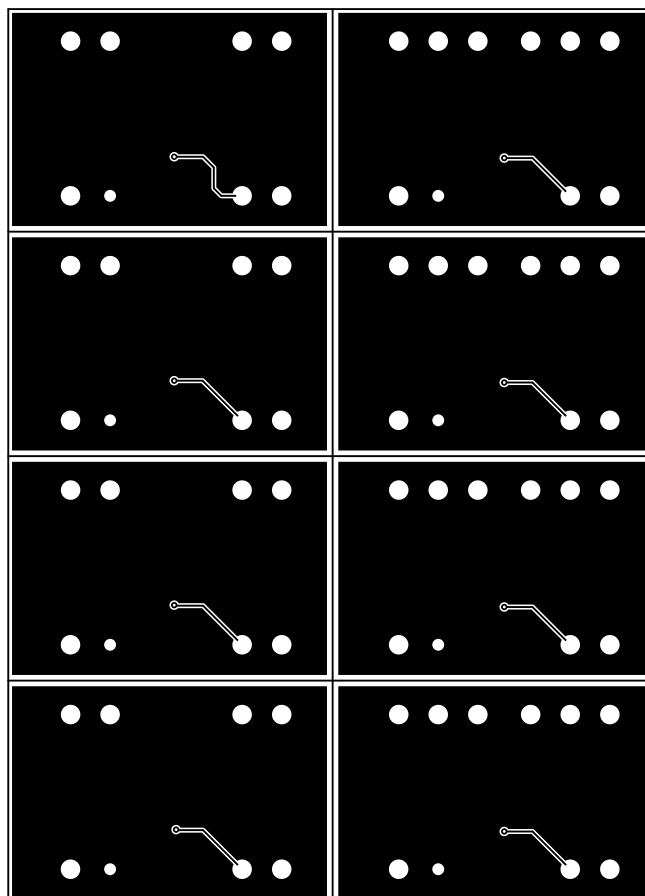
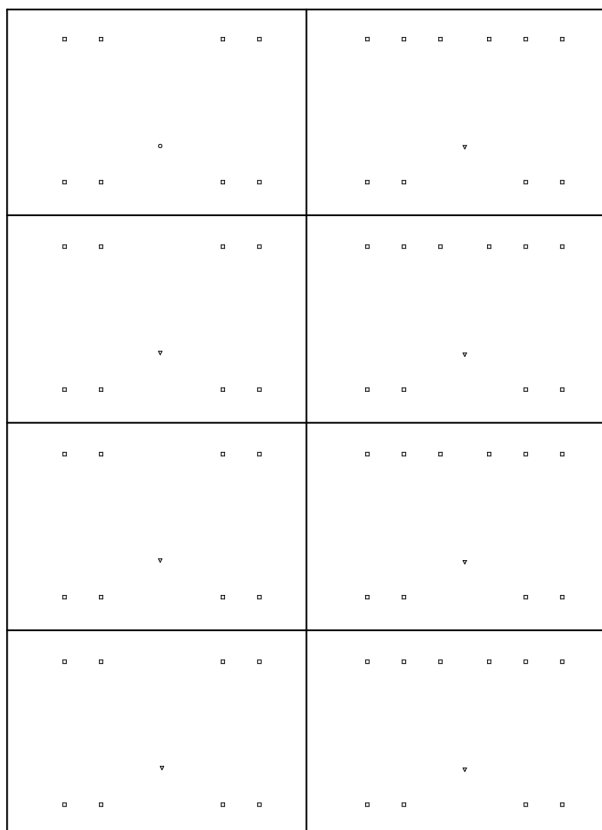


Figure 5. INA2180-2181EVM Bottom Layer



Symbol	Quantity	Finished Hole Size	Plated	Hole Type	Drill Layer Pair	Hole Tolerance
▽	7	15.00mil (0.381mm)	PTH	Round	Top Layer - Bottom Layer	
○	1	16.00mil (0.406mm)	PTH	Round	Top Layer - Bottom Layer	
□	72	63.00mil (1.600mm)	PTH	Round	Top Layer - Bottom Layer	
	80 Total					

Figure 6. INA2180-2181EVM Drill Drawing

7 Bill of Materials

Table 4 provides the parts list for the INA2180-2181EVM.

Table 4. Bill of Materials

Designator	Qty.	Value	Description	Package Reference	PartNumber	Manufacturer
C11, C21, C31, C41, C51, C61, C71, C81	8	0.1 μ F	CAP, CERM, 0.1 μ F, 50 V, +/- 5%, X7R, 0805	0805	08055C104JAT2A	AVX
R11, R12, R13, R14, R21, R22, R23, R24, R31, R32, R33, R34, R41, R42, R43, R44, R51, R52, R53, R54, R61, R62, R63, R64, R71, R72, R73, R74, R81, R82, R83, R84	32	0	RES, 0, 5%, 0.125 W, 0805	0805	CRCW08050000Z0EA	Vishay-Dale
TPG12, TPG22, TPG32, TPG42, TPG52, TPG62, TPG72, TPG82, TPI11, TPI13, TPI15, TPI18, TPI21, TPI23, TPI25, TPI28, TPI31, TPI33, TPI35, TPI38, TPI41, TPI43, TPI45, TPI48, TPI51, TPI53, TPI55, TPI58, TPI61, TPI63, TPI65, TPI68, TPI71, TPI73, TPI75, TPI78, TPI81, TPI83, TPI85, TPI88, TPO12, TPO14, TPO22, TPO24, TPO32, TPO34, TPO42, TPO44, TPO52, TPO54, TPO62, TPO64, TPO72, TPO74, TPO82, TPO84, TPR51, TPR53, TPR61, TPR63, TPR71, TPR73, TPR81, TPR83, TPS12, TPS22, TPS32, TPS42, TPS52, TPS62, TPS72, TPS82	72	SMT	Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone
U1	1		Bidirectional, Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifiers, DGK0008A (VSSOP-8)	DGK0008A	INA2180A1DGK	Texas Instruments
U2	1		Bidirectional, Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifiers, DGK0008A (VSSOP-8)	DGK0008A	INA2180A2DGK	Texas Instruments

Table 4. Bill of Materials (continued)

U3	1		Bidirectional, Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifiers, DGK0008A (VSSOP-8)	DGK0008A	INA2180A3DGK	Texas Instruments
U4	1		Bidirectional, Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifiers, DGK0008A (VSSOP-8)	DGK0008A	INA2180A4DGK	Texas Instruments
U5	1		Bidirectional, Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifiers, DGS0010A (VSSOP-10)	DGS0010A	INA2181A1DGS	Texas Instruments
U6	1		Bidirectional, Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifiers, DGS0010A (VSSOP-10)	DGS0010A	INA2181A2DGS	Texas Instruments
U7	1		Bidirectional, Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifiers, DGS0010A (VSSOP-10)	DGS0010A	INA2181A3DGS	Texas Instruments
U8	1		Bidirectional, Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifiers, DGS0010A (VSSOP-10)	DGS0010A	INA2181A4DGS	Texas Instruments
C12, C13, C22, C23, C32, C33, C42, C43, C52, C53, C62, C63, C72, C73, C82, C83	0	0.1 μ F	CAP, CERM, 0.1 μ F, 50 V, +/- 5%, X7R, 0805	0805	08055C104JAT2A	AVX

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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.

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- 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.
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- 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/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

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.

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.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS, REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMNITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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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 semiconductor 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.

- 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/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

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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2. 実験局の免許を取得後ご使用いただく。
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なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

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西新宿三井ビル

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電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。 http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page

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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