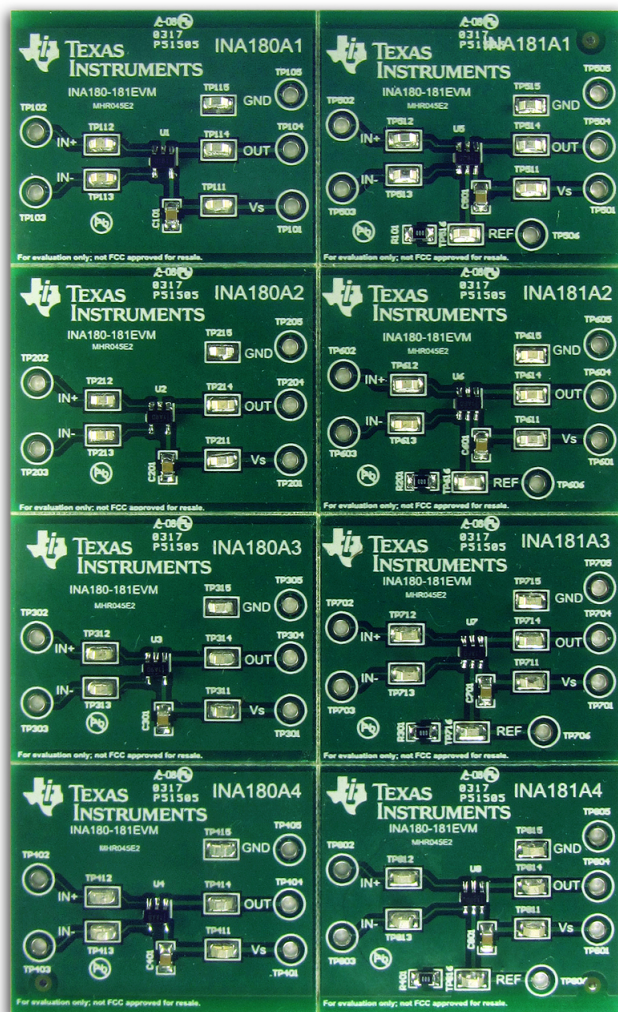


INA180-INA181EVM



This user's guide describes the characteristics, operation, and use of the INA180-181 evaluation module (EVM). This EVM is designed to evaluate the performance of the [INA180A1](#), [INA180A2](#), [INA180A3](#), [INA180A4](#), [INA181A1](#), [INA181A2](#), [INA181A3](#), [INA181A4](#) 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.

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1 Overview

The INA180 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 INA181 family has the same capabilities as the INA180 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 μA of supply current per amplifier channel.

The INA180 devices are currently available in a SOT23(5) and SC70(5) surface-mount packages in two common used Op-Amp pinouts and the INA181 devices are available in a SOT23(6) and SC70(6) surface-mount packages. [Table 1](#) lists the available gain options.

Table 1. INA18x Device Summary

PRODUCT	GAIN
INA180A1, INA181A1	20
INA180A2, INA181A2	50
INA180A3, INA181A3	100
INA180A4, INA181A4	200

1.1 INA180-181EVM Kit Contents

[Table 2](#) lists the contents of the INA180-181EVM kit. Contact the nearest [Texas Instruments Product Information Center](#) if any component is missing. TI highly recommends checking the INA180 family product folder on the TI website at www.ti.com for further information regarding this product.

Table 2. INA180-181EVM Kit Contents

ITEM	QUANTITY
INA180-181EVM Test Board	1

1.2 Related Documentation From Texas Instruments

The following document provides information regarding TI's integrated circuits used in the assembly of the INA180-181EVM. This user's guide is available from the TI website under literature number (SBOU183). Any letter appended to the literature number corresponds to the document revision that is current at the time of the writing of this document. Newer revisions are available from www.ti.com or 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 3. Related Documentation

DOCUMENT	LITERATURE NUMBER
INA180 Product data sheet	SBOS741
INA181 Product data sheet	SBOS793

2 INA180-181EVM Hardware

The INA180 is an Op-Amp current sense integration solution that provides ease of use and high performance. The INA181 has the same capabilities as the INA180 but with the addition of the reference pin that enables bidirectional current measurements. The INA180-181EVM is intended to provide 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 INA180-181EVM consists of one PCB with an option to cut out eight individual PCBs - one for each of the eight devices (INA180A1, INA180A2, INA180A3, INA180A4, INA181A1, INA181A2, INA181A3 and INA181A4).

2.1 Features

The layout of the INA180-181EVM printed-circuit board (PCB) is designed to provide the following features:

- Evaluation of all gain options for the INA180Ax and INA181Ax
- Ease of access to device pins with test points
- Capability to evaluate high-side and low-side configurations

See the INA180 and INA181 data sheets ([SBOS741](#), [SBOS793](#)) for comprehensive information about the INA180 and INA181 family of devices.

3 Quick Start Setup and Use

The following are instructions to set up and use the INA180Ax devices of the INA180-181EVM. For the following instructions, x = 1 to 4.

- Step 1. Connect an external dc supply voltage between 2.7-V and 5.5-V to the Vs test point TPx01 or TPx11, and connect ground reference of that supply to the GND test point TPx05 or TPx15.
- Step 2. Connect the input per [Section 3.1](#).

The following are instructions to set up and use the INA181Ax devices of the INA180-181EVM. For the following instructions, x = 5 to 8.

- Step 1. Connect an external dc supply voltage between 2.7-V and 5.5-V to the Vs test point TPx01 or TPx11, and connect ground reference of that supply to the GND test point TPx05 or TPx15.
- Step 2. The REF pin is connected to GND in the default board. The voltage applied at the reference input varies depending on how the device is going to be used. Further details regarding the use of the reference voltage are discussed later in this document.
- Step 3. Connect the input per [Section 3.1](#).

3.1 Measurements

The INA180-181EVM 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. For the following instructions, x = 1 to 8.

- Step 1. Connect a differential voltage to the IN+ (TPx02 or TPx12) and IN– (TPx03 or TPx13) test points. With the reference voltage set at ground, ensure that the IN+ pin is the more positive of the two inputs.
- Step 2. Measure the output voltage at the OUT test point (TPx04 or TPx14).

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 INA180-181EVM Circuit

This section summarizes the INA180-181EVM components. For the following instructions, x = 1 to 8.

4.1 Cx01

Cx01 are 0.1- μ F supply bypass capacitors.

4.2 Ux

Ux is the location for the test device. Eight device boards are supplied with the INA180-181EVM 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 INA180A1-A4 devices are identical with the exception of different gain settings. The INA181A1-A4 devices have the same device gain options of the INA180 but with the addition of the reference pin that enables bidirectional current measurements.
- Select INA180 for unidirectional applications only, and select INA181 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.

4.3 Voltages Inputs

The IN+ (TPx02 or TPx12) and IN– (TPx03 or TPx13) inputs accept a differential voltage that is amplified by the selected device gain and is presented at the OUT test point (TPx04 or TPx14). 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.

5 Reference Voltage Setup

The INA181A1-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.

5.1 Unidirectional Mode

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

The INA180A1-A4 devices are able to measure unidirectional currents only. The INA181A1-A4 devices measure unidirectional and bidirectional currents. The INA181A1-A4 boards in the EVM have the REF pin connected to GND through a 0-ohm resistor. This connection enables unidirectional measurements. If bidirectional measurements are needed, the INA181A1-A4 boards can be modified to add external voltages to the REF pin.

5.2 Bidirectional Mode

The INA181A1-A4 devices are able to measure bidirectional currents. *Bidirectional* refers to a load current that flows in both directions. The ability to measure this current flowing in both directions is enabled by applying a voltage to the REF pin. The voltage applied to REF sets the output state that corresponds to the zero-input level state. The output then responds by increasing above REF for positive differential signals (relative to the IN– pin) and responds by decreasing below REF for negative differential signals. This reference voltage applied to the REF pin can be set anywhere from 0 V to V+. For bidirectional applications, REF is typically set at mid-scale for equal signal range in both current directions. In some cases, however, REF is set at a voltage other than mid-scale when it is unnecessary that the bidirectional current and corresponding output signal be symmetrical.

5.3 REF Pin Configuration (INA181A1-INA181A4 Devices Only)

The REF test point (Tx06 or TPx16) enables the user to configure the INA181A1-A4 device boards for either unidirectional or bidirectional operation. INA181A1-A4 boards have a 0-ohm resistor that enables the user to use the boards for unidirectional or bidirectional measurements. If the 0-ohm resistor (Rx01) is populated, the REF pin will be connected to GND, and the INA181 can be used for unidirectional measurements. If bidirectional measurements are needed, the user must desolder the 0-ohm resistor (Rx01) and connect an external supply to the REF test point (TPx06 or TPx16).

6 INA180-181EVM 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 INA180-181EVM PCBs.

6.1 Schematic

Figure 1 shows the schematic for the INA180-181EVM PCB.

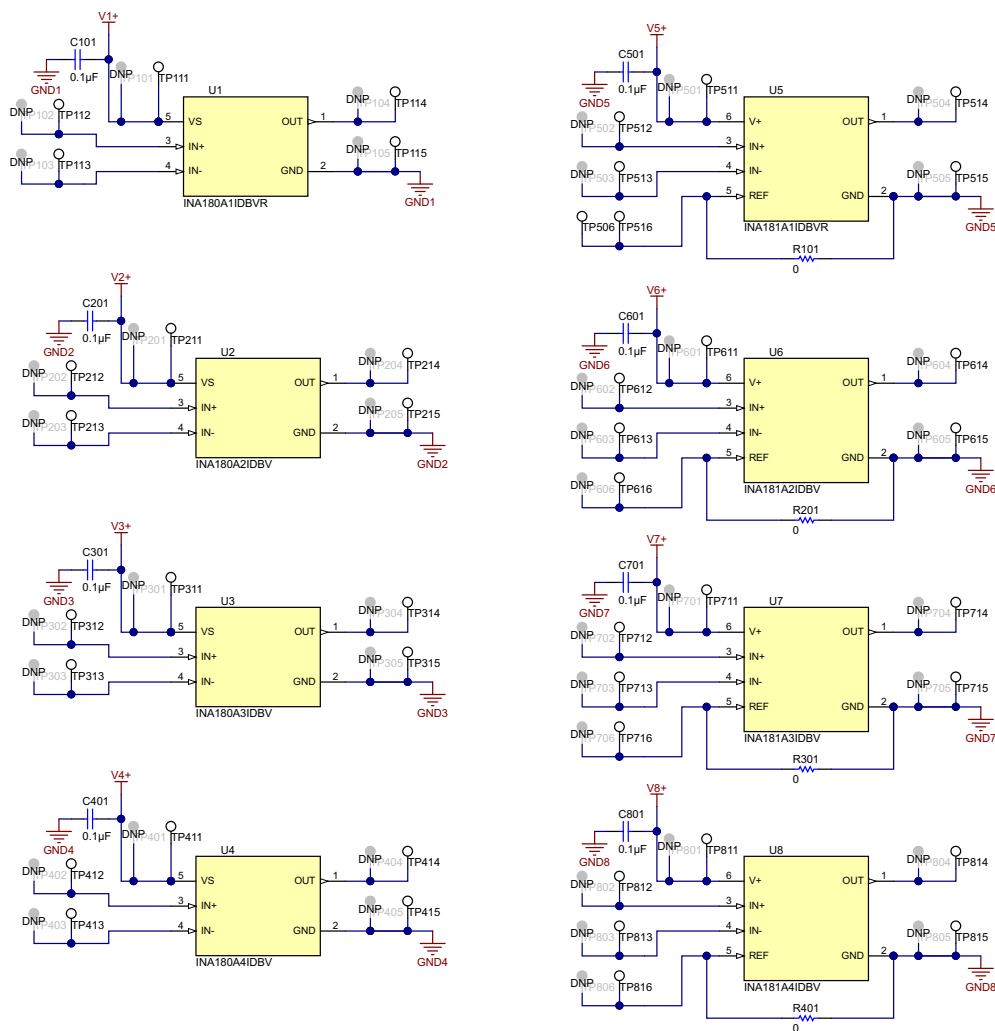


Figure 1. INA180-181EVM Schematic

6.2 PCB Layout

Figure 2 through illustrate the PCB layout for the INA180-181EVM.

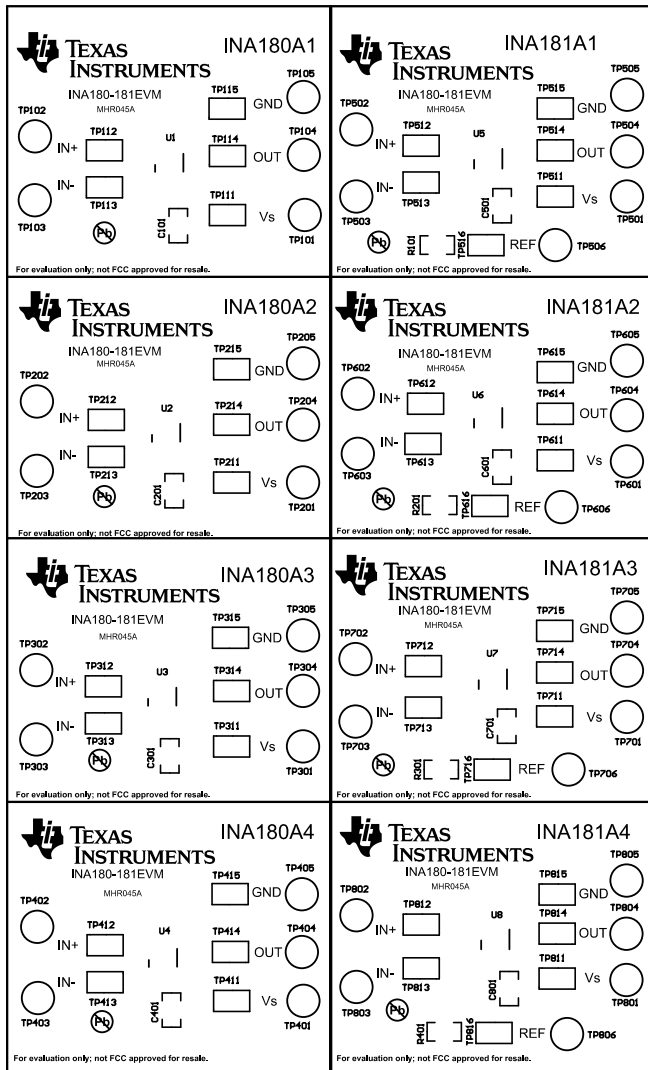


Figure 2. INA180-181EVM Top Overlay

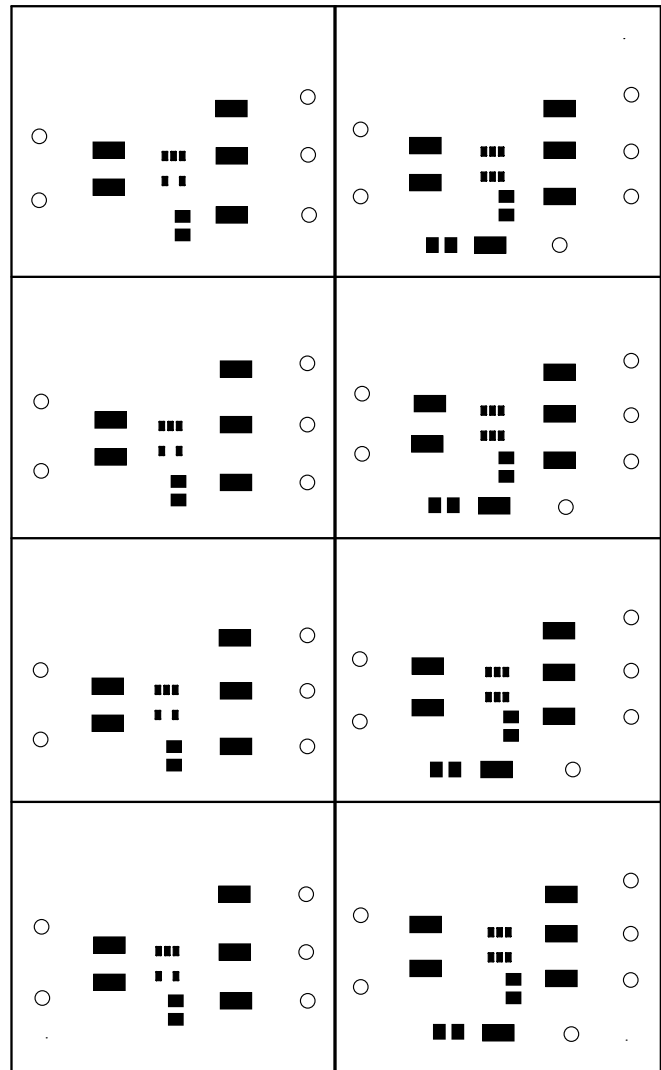


Figure 3. INA180-181EVM Top Solder Mask

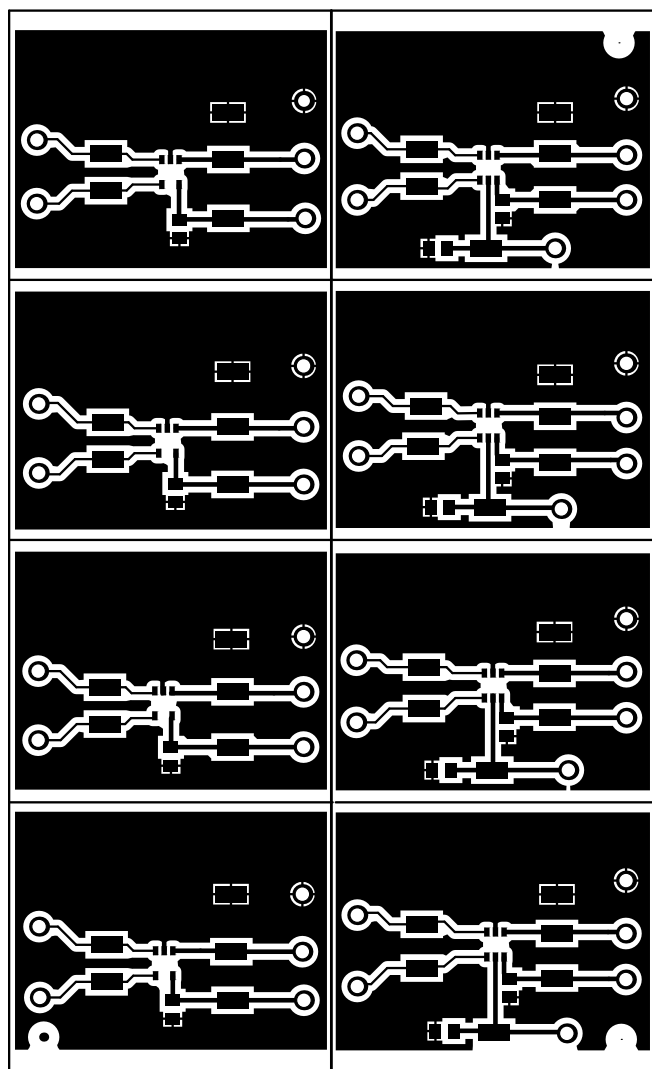


Figure 4. INA180-181EVM Top Layer

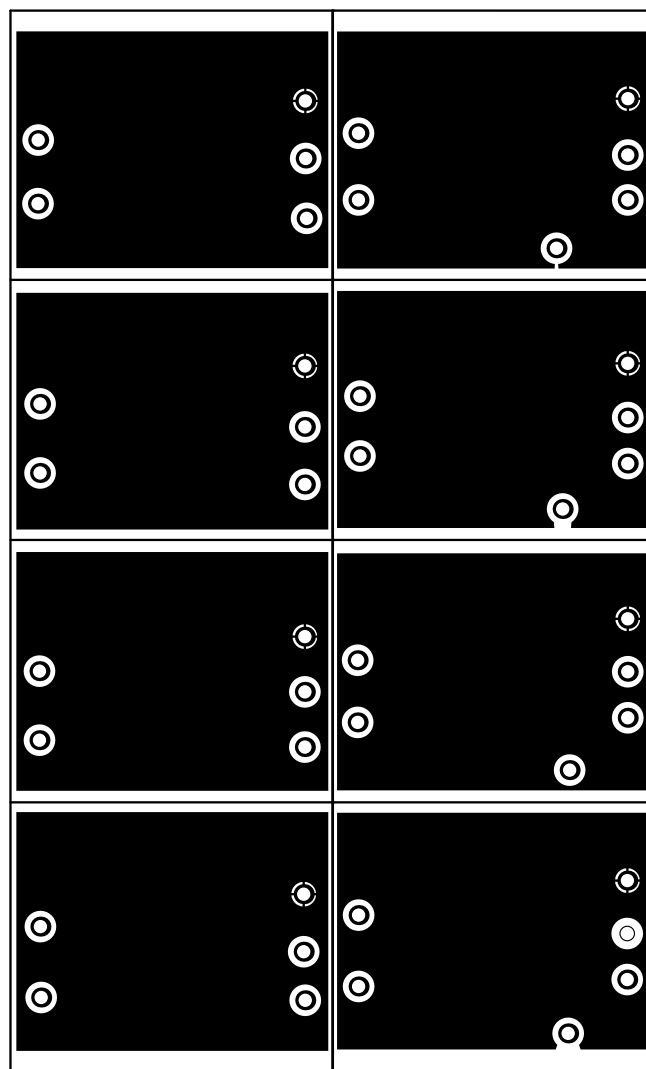


Figure 5. INA180-181EVM Bottom Layer

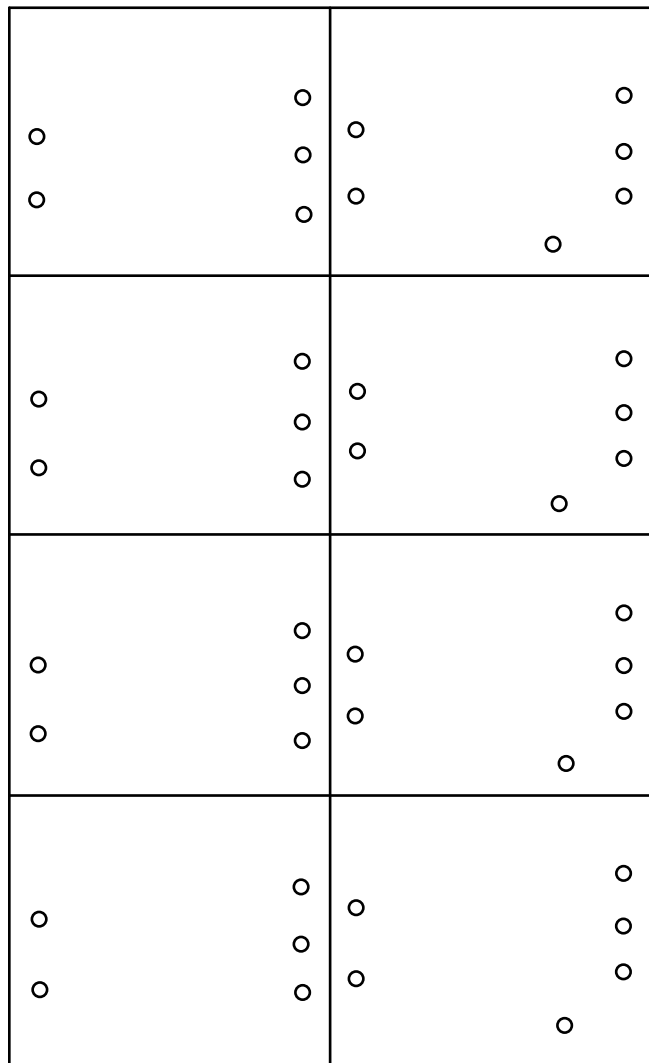


Figure 6. INA180-181EVM Bottom Solder Mask

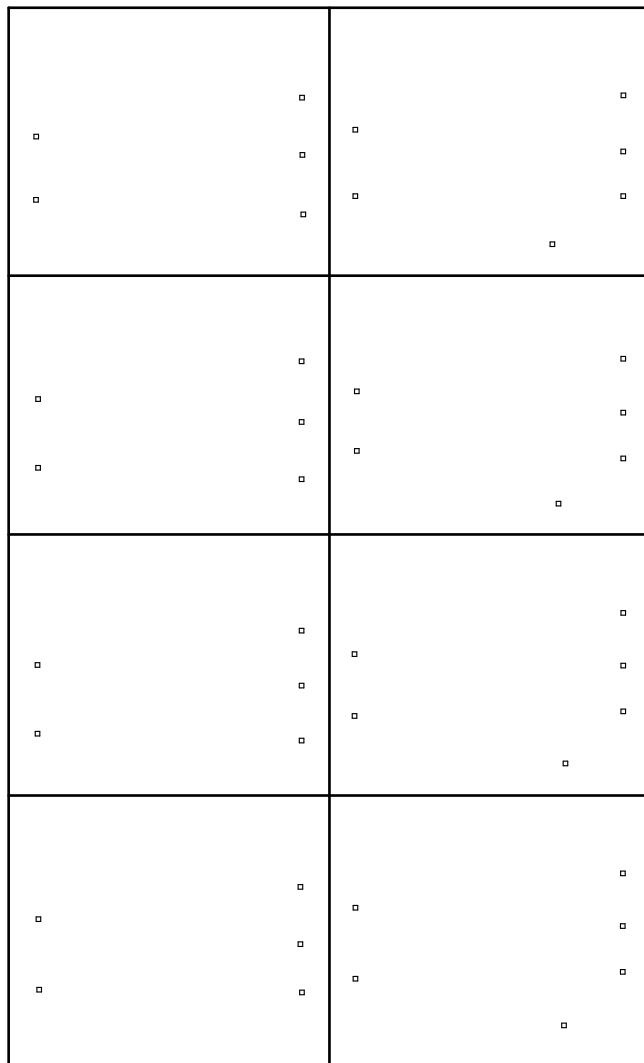


Figure 7. INA180-181EVM Drill Drawing

7 Bill of Materials

Table 4 provides the parts list for the INA180-181EVM.

Table 4. Bill of Materials

DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER	ALTERNATE PART NUMBER	ALTERNATE MANUFACTURER
!PCB	1		Printed-Circuit Board		MHR045	Any	-	-
C101, C201, C301, C401, C501, C601, C701, C801	8	0.1uF	CAP, CERM, 0.1 μ F, 50 V, $\pm$ 5%, X7R, 0805	0805	08055C104JAT2A	AVX		
R101, R201, R301, R401	4	0	RES, 0, 5%, 0.125 W, 0805	0805	CRCW08050000Z0EA	Vishay-Dale		
TP111, TP112, TP113, TP114, TP115, TP211, TP212, TP213, TP214, TP215, TP311, TP312, TP313, TP314, TP315, TP411, TP412, TP413, TP414, TP415, TP511, TP512, TP513, TP514, TP515, TP516, TP611, TP612, TP613, TP614, TP615, TP616, TP711, TP712, TP713, TP714, TP715, TP716, TP811, TP812, TP813, TP814, TP815, TP816	44	SMT	Test Point, Miniature, SMT	Testpoint_Keystone_Min ature	5015	Keystone		
U1	1		Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifier, DBV0005A	DBV0005A	INA180A1IDBVR	Texas Instruments	INA180A1IDBVT	Texas Instruments
U2	1		Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifier, DBV0005A	DBV0005A	INA180A2IDBV	Texas Instruments		Texas Instruments
U3	1		Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifier, DBV0005A	DBV0005A	INA180A3IDBV	Texas Instruments		Texas Instruments
U4	1		Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifier, DBV0005A	DBV0005A	INA180A4IDBV	Texas Instruments		Texas Instruments
U5	1		Bidirectional, Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifier, DBV0006A	DBV0006A	INA181A1IDBVR	Texas Instruments	INA181A1IDBVT	Texas Instruments
U6	1		Bidirectional, Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifier, DBV0006A	DBV0006A	INA181A2IDBV	Texas Instruments		Texas Instruments
U7	1		Bidirectional, Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifier, DBV0006A	DBV0006A	INA181A3IDBV	Texas Instruments		Texas Instruments
U8	1		Bidirectional, Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifier, DBV0006A	DBV0006A	INA181A4IDBV	Texas Instruments		Texas Instruments

STANDARD TERMS FOR EVALUATION MODULES

1. **Delivery:** TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

- 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software
- 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

- 2 **Limited Warranty and Related Remedies/Disclaimers:**

- 2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
- 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.
- 2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

- 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/lstds/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/lstds/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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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lstds/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.

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.

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