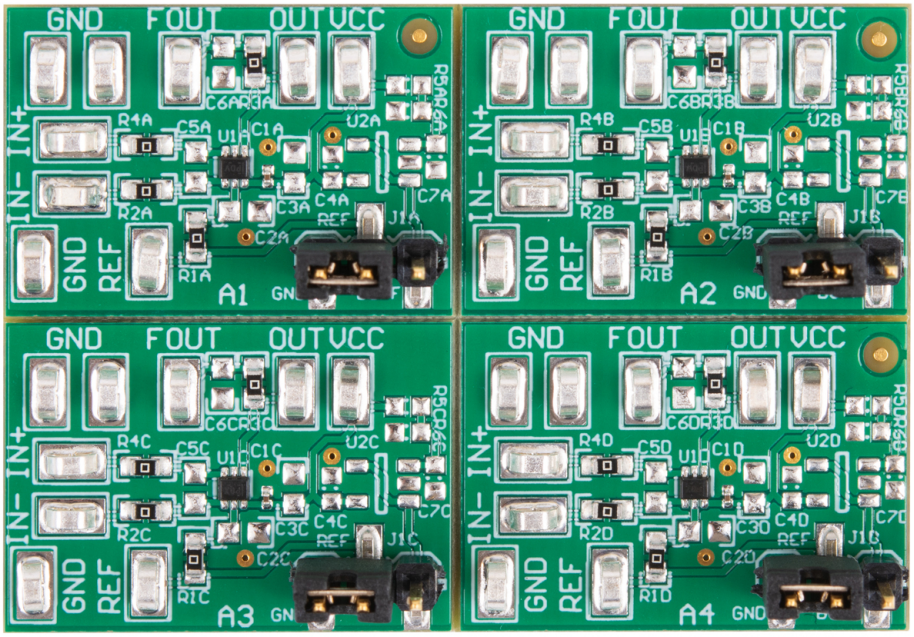
INA185EVM



This user's guide describes the characteristics, operation, and use of the INA185 evaluation module (EVM). This EVM is designed to evaluate the performance of the INA185A1, INA185A2, INA185A3, and INA185A4 voltage output current-shunt monitors in a variety of configurations. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the INA185EVM. This document includes a schematic, reference printed-circuit board (PCB) layouts, and a complete bill of materials.

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1 Overview

The INA185 current-shunt monitor (also called current-sense amplifier) can sense voltage drops across shunts at common-mode voltages from –0.2 V to +26 V, independent of the supply voltage. Four fixed gain options are available: 20 V/V, 50 V/V, 100 V/V, and 200 V/V. The INA185 has a reference pin that enables bidirectional current measurements. The device operates 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 INA185 devices are currently available in a SOT-563 surface-mount package. Table 1 lists the available gain options.

Table 1. INA185Ax Gain Option Summary

PRODUCT	GAIN (V/V)
INA185A1	20
INA185A2	50
INA185A3	100
INA185A4	200

1.1 Kit Contents

Table 2 lists the contents of the INA185EVM kit. Contact the nearest Texas Instruments Product Information Center if any components are missing. TI highly recommends checking the INA185 family product folder on the TI website at www.ti.com for further information regarding this product.

Table 2. INA185EVM Kit Contents

ITEM	QUANTITY
INA185EVM 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 INA185EVM. This user's guide is available from the TI website under literature number (SBOU167). 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
INA185 Product data sheet	SBOS378

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2 Hardware

The INA185 is an integrated, op amp-based current sense circuit that provides ease of use and high performance. The INA185EVM is intended to provide basic functional evaluation of this device family. The board layout is neither intended to be a model for the target circuit, nor is it laid out for electromagnetic compatibility (EMC) testing. The INA185EVM consists of one PCB that can be cut into four individual PCBs segments, one for each of the four device gain options.

2.1 Features

The layout of the INA185EVM printed-circuit board (PCB) is designed to provide the following features:

- Evaluation of all gain options for the INA185
- Ease of access to device pins with test points
- Capability to evaluate high-side and low-side configurations
- Capability to provide a buffered reference through a user defined voltage divider

See the INA185 data sheet (SBOS378) for comprehensive information about the INA185 family of devices.

3 Quick Start Setup and Use

The following instructions show how to set up and use the INA185 devices with the INA185EVM. For the circuits in the following instructions, x = A to D.

Step 1. Connect an external dc supply voltage between 2.7-V and 5.5-V to the VCC test point TP2x, and connect the ground reference of that supply to one of the GND test points: TP7x, TP8x, or TP9x.

Step 2. The REF pin is connected to the GND pin 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 as described in Section 3.1.

3.1 Measurements

The INA185EVM can either simulate the voltage developed across a sense resistor based on a given set of system conditions, or connect remotely to an existing shunt already included in a user application.

The following procedures are used to configure a measurement evaluation without a shunt. For the circuits in the following instructions, x = A to D.

Step 1. Connect a differential voltage to the IN+ (TP6x) and IN– (TP3x) test points. With the reference voltage set at ground, make sure that the IN+ pin is the more positive of the two inputs.

Step 2. Measure the output voltage at the OUT test point (TP4x or TP5x).

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

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4 Circuitry

This section summarizes the INA185EVM components. For the following circuits, x = A to D.

4.1 C1x, J1x, R1x, and TP1x

C1x and R1x form a low-pass RC filter to the source that supplies the INA185 REF pin. By default, no filter is installed, with R1x shorted by a 0-Ω resistor, and C1x not populated. J1x is a jumper that conveniently allows the user to short the INA185 reference to ground, connect directly to an external power supply, or short to a voltage set by a buffered voltage divider.

4.2 C2x and C3x, and TP2x

C2x is a 0.1-µF supply bypass capacitor for the INA185, U1x. The C2x footprint size, 0201, was chosen in order to reduce overall layout size. A 0.1-µF capacitor is required for proper operation of the INA185, and the user typically will not need to replace or adjust C2x. C3x is a footprint for an additional supply bypass capacitor that the user can populate to further stabilize the supply. TP2x allows the user to connect an external supply to the INA185 VS pin.

4.3 C4x

C4x is a 0.1-µF supply bypass capacitor for the optional INA185 reference pin buffer, U2x.

4.4 C5x, R2x, and R4x

C4x, R2x, and R4x form a differential mode filter to the input of the INA185, U1x. By default, this filter is not installed, with R2x and R4x shorted by a 0-Ω resistor, and C4x not populated. If this filter is installed, R2x and R4x must be less than 10 Ω with low tolerance (≤1%) in order to minimize measurement error.

4.5 C6x, R3x, TP4x, and TP5x

C3x and R3x form a low-pass filter on the output of the INA185, U1x. By default, no filter is installed with R3x shorted by a 0-Ω resistor, and C6x not populated. TP4x shows unfiltered output. By default, TP5x also shows unfiltered output, but with R3 and C6 populated, TP5x shows filtered output.

4.6 C7x, R5x, and R6x

C7x and R5x form a low-pass filter to the input of the optional reference buffer. R5x and R6x form a voltage divider that sets a desired reference voltage.

4.7 U1x

U1x is the INA185 current shunt monitor. Four gain-option segments are supplied within the INA185EVM board. Each segment is populated with one of the available device gains. This configuration enables users to test the devices and determine the best gain setting for a given application. For x = A to D, the gain is 20 V/V, 50 V/V, 100 V/V, and 200 V/V, respectively.

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

- 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 greater than ground to 100 mV less than the supply voltage.
- An output less than the minimum allowable output requires a device with a higher gain. Likewise, an output greater than the maximum allowable output requires a device with a lower gain.

4.8 U2x

U2x is a SOT-23 footprint for a buffer amplifier. By default, this part is not populated.

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5 Reference Voltage Setup

The INA185 allows for 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.

By default, each EVM board segment (one segment for each gain option) has the INA185 REF pin connected to GND through a 0-Ω resistor and a jumper. This connection sets the INA185 for unidirectional measurements. If bidirectional measurements are required, the EVM board segments can be modified to add external voltages to the REF pins.

5.2 Bidirectional Mode

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

The INA185 is able to measure bidirectional currents. The ability to measure 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 to greater than REF for positive differential signals (relative to the IN– pin), and by decreasing to less than 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 midscale for an equal signal range in both current directions. However, REF is set at a voltage other than midscale when the bidirectional current and corresponding output signal do not have to be symmetrical.

5.3 REF Pin Configuration

Jumper connection J1x configures the respective EVM board segment for either unidirectional or bidirectional operation. Shorting the left and middle pins of J1x sets the board for unidirectional measurements. Removing the jumper and applying a voltage between 0 V to V+ to the middle pin of J1x sets the board to a bidirectional measurement with the zero current output centered at the applied voltage. Alternatively, install C4x, R5x, R6x, and U2x to provide a buffered voltage divider input from the supply to set the reference voltage. For the buffered divider, install the jumper on the middle and right pins of J1x.

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6 Schematic, PCB Layout, and Bill of Materials

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 INA185EVM PCBs.

6.1 Schematic

Figure 1 shows the schematic for the INA185EVM PCB. Only the schematic for the 20-V/V gain variant is included because all other variants use the same exact circuit with the same layout. All components associated with the 20-V/V INA185 A1 gain variant have the letter *A* appended at the end. The 50-V/V A2 gain variant has *B* appended, the 100-V/V A3 gain variant has *C* appended, and the 200-V/V A4 gain variant has a *D* appended.

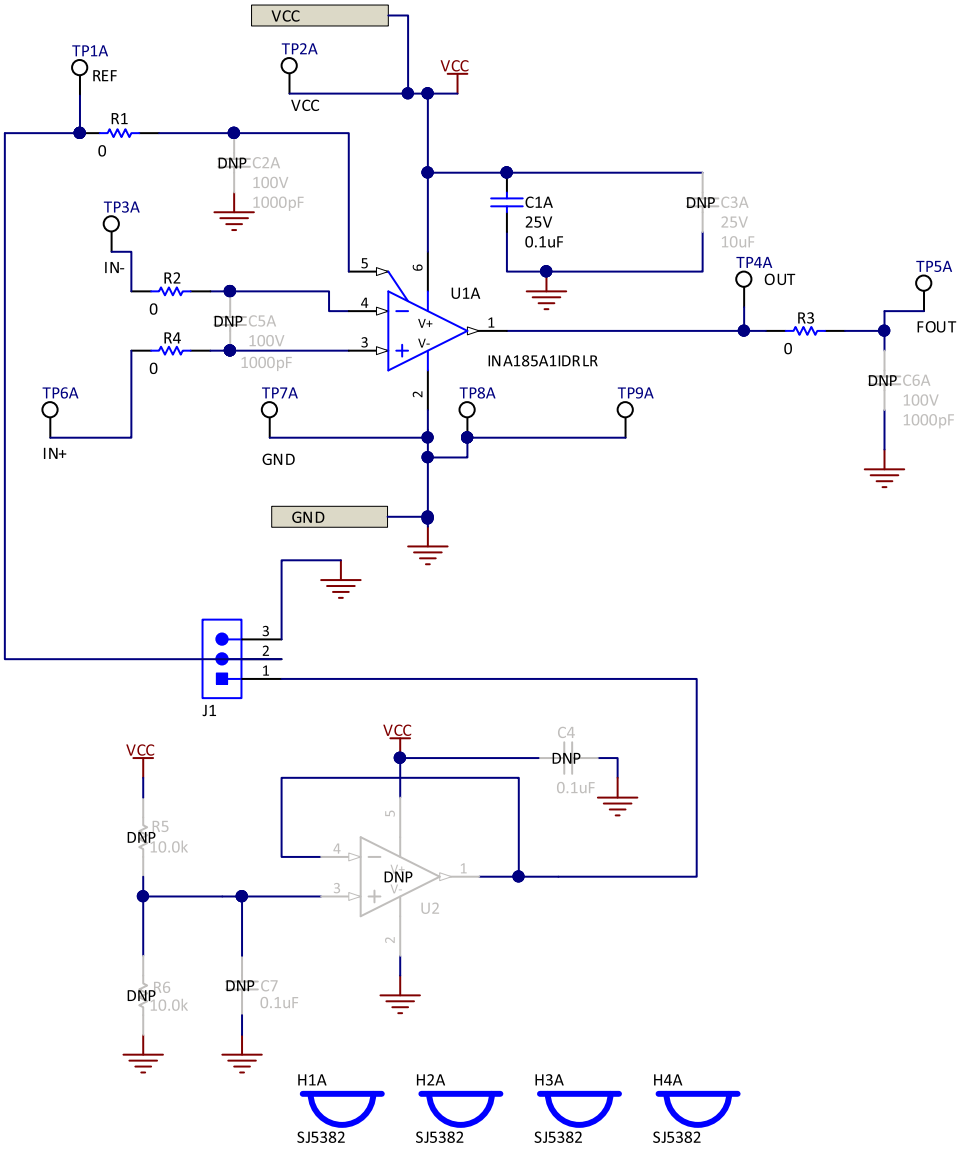


Figure 1. INA185EVM Schematic

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6.2 PCB Layout

Figure 2 through Figure 8 illustrate the PCB layout for the INA185EVM.

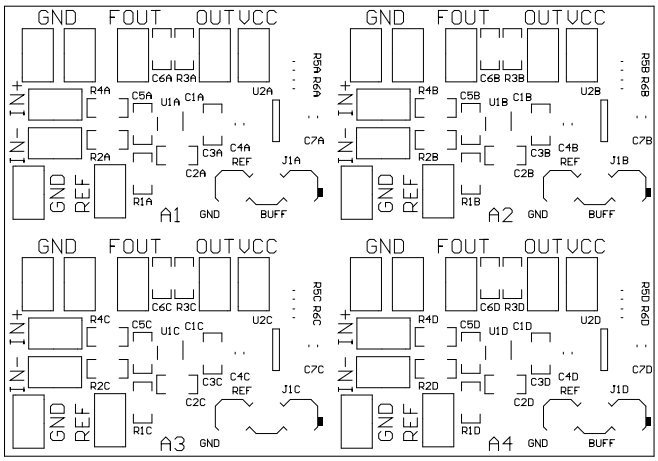


Figure 2. INA185EVM Top Overlay

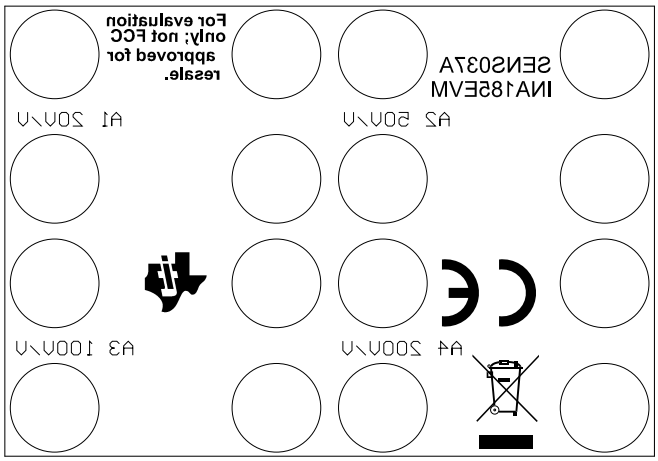


Figure 3. INA185EVM Bottom Overlay

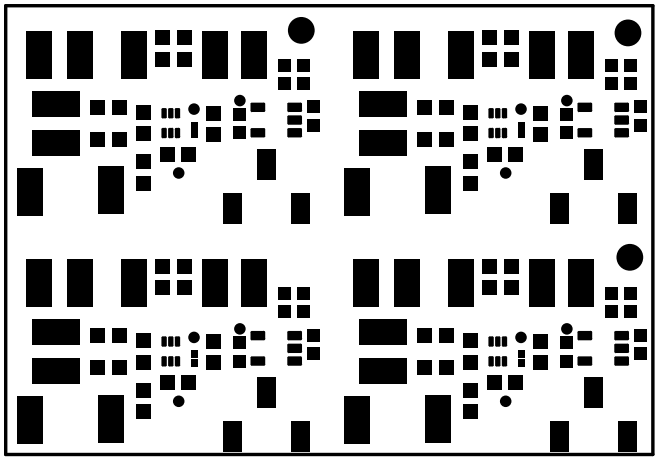


Figure 4. INA185EVM Top Solder Mask

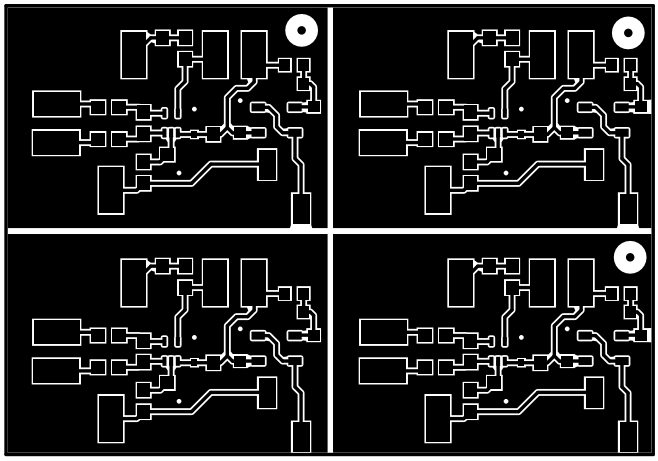


Figure 5. INA185EVM Top Layer

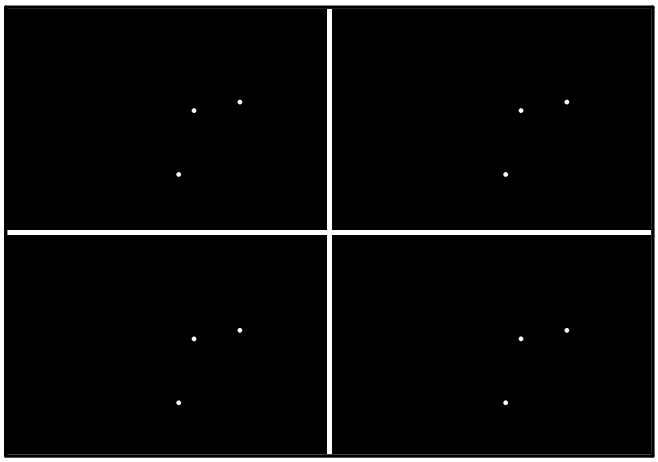


Figure 6. INA185EVM Bottom Layer

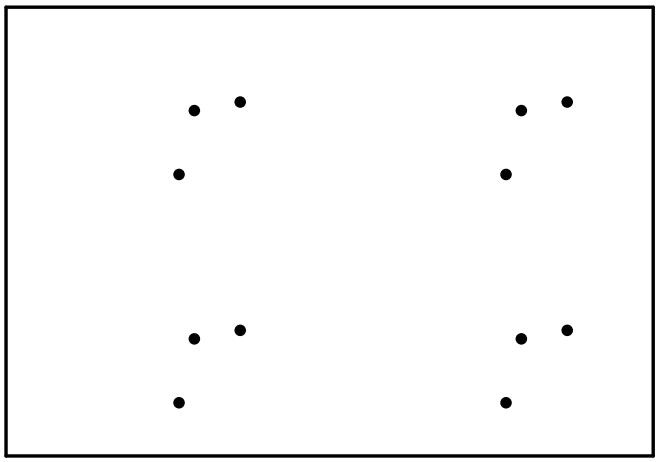


Figure 7. INA185EVM Bottom Solder Mask

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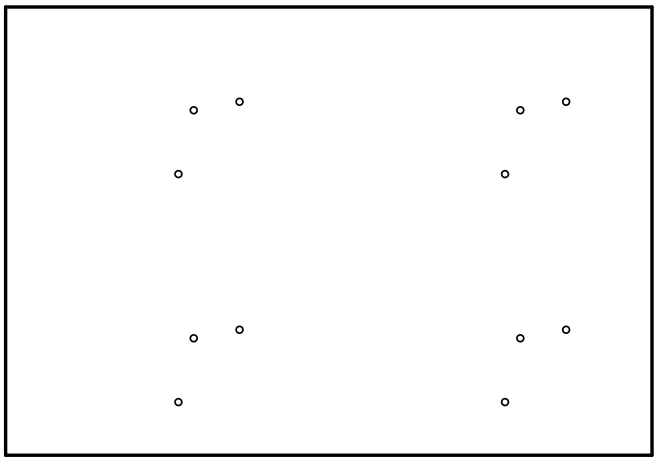


Figure 8. INA185EVM Drill Drawing

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6.3 Bill of Materials

Table 4 provides the parts list for the INA185EVM.

Table 4. Bill of Materials

DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
!PCB	1		Printed-Circuit Board		SENS037	Any
C1A, C1B, C1C, C1D	4	0.1uF	CAP, CERM, 0.1 uF, 25 V, +/- 10%, X6S, 0201	0201	GRM033C81E104KE14D	MuRata
H1A, H1B, H1C, H1D, H2A, H2B, H2C, H2D, H3A, H3B, H3C, H3D, H4A, H4B, H4C, H4D	16	0	Bumpon, Hemisphere, 0.25 X 0.075, Clear	75x250 mil	SJ5382000Z0EA	3M
J1A, J1B, J1C, J1D	4	SMT	Header, 2.54mm, 3x1, Gold, SMT	Header, 2.54mm, 3x1, SMT	M20-8770342	Harwin
R1A, R1B, R1C, R1D, R2A, R2B, R2C, R2D, R3A, R3B, R3C, R3D, R4A, R4B, R4C, R4D	16	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603ZT0R00	Stackpole Electronics Inc
SH-J1, SH-J2, SH-J3, SH-J4	4		Shunt, 100mil, Gold plated, Black	Shunt 2 pos. 100 mil	881545-2	TE Connectivity
TP1A, TP1B, TP1C, TP1D, TP2A, TP2B, TP2C, TP2D, TP3A, TP3B, TP3C, TP3D, TP4A, TP4B, TP4C, TP4D, TP5A, TP5B, TP5C, TP5D, TP6A, TP6B, TP6C, TP6D, TP7A, TP7B, TP7C, TP7D, TP8A, TP8B, TP8C, TP8D, TP9A, TP9B, TP9C, TP9D	36		Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone
U1A	1		Bidirectional, Precision Low- and High-Side Voltage Output, Current-Sense Amplifier, DRL0006A (SOT-5X3-6)	DRL0006A	INA185A1IDRLR	Texas Instruments
U1B	1		Bidirectional, Precision Low- and High-Side Voltage Output, Current-Sense Amplifier, DRL0006A (SOT-5X3-6)	DRL0006A	INA185A2IDRLR	Texas Instruments
U1C	1		Bidirectional, Precision Low- and High-Side Voltage Output, Current-Sense Amplifier, DRL0006A (SOT-5X3-6)	DRL0006A	INA185A3IDRLR	Texas Instruments
U1D	1		Bidirectional, Precision Low- and High-Side Voltage Output, Current-Sense Amplifier, DRL0006A (SOT-5X3-6)	DRL0006A	INA185A4IDRLR	Texas Instruments
C2A, C2B, C2C, C2D, C5A, C5B, C5C, C5D, C6A, C6B, C6C, C6D	0	1000pF	CAP, CERM, 1000 pF, 100 V, +/- 10%, X7R, 0603	0603	C1608X7R2A102K080AA	TDK
C3A, C3B, C3C, C3D	0	10uF	CAP, CERM, 1000 pF, 100 V, +/- 10%, X7R, 0603	0603	GRT188R61E106ME13D	MuRata
C4A, C4B, C4C, C4D, C7A, C7B, C7C, C7D	0	0.1uF	CAP, CERM, 10 uF, 25 V, +/- 20%, X5R, 0603	0603	06035C104KAT2A	AVX
R5A, R5B, R5C, R5D, R6A, R6B, R6C, R6D	0	10.0k	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	0603	RC0603FR-0710KL	Yageo
U2A, U2B, U2C, U2D	0		1-MHz, Low-Power Operational Amplifier for Cost-Sensitive Systems, DBV0005A (SOT-23-5)	DBV0005A	TLV6001IDBVR	Texas Instruments

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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.

WARNING

Evaluation Kits 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 shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

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。
上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社
東京都新宿区西新宿 6 丁目 2 4 番 1 号
西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page
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/lsds/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.

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, INDEMITY 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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