

# INA149EVM

This user's guide describes the characteristics, operation, and use of the evaluation module (EVM) for the INA149. The EVM is designed to evaluate the performance of the device in both single and dual-supply configurations. This document also includes the schematic, printed circuit board (PCB) layout, and a bill of materials (BOM). Throughout this document the terms *evaluation board*, *evaluation module*, and *EVM* are synonymous with the INA149EVM.

**WARNING**

**Danger: HIGH VOLTAGE! This evaluation board is intended for professional use only. It has exposed high voltages. Do not operate this board without proper high-voltage/high-current safety practices. Read [Section 1.3](#) before using the EVM.**

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## 1 Introduction and Warnings

### 1.1 INA149

The [INA149](#) is a precision unity-gain difference amplifier with a very high input common-mode voltage range ( $\pm 275$  V). It is composed of a precision operational amplifier and an integrated thin-film resistor network. The topology allows the device to buffer small differential signals in the presence of a large common-mode voltage. The device is pin-compatible with the [INA117](#) and other industry standard devices. It is available in an SO-8 package.

### 1.2 INA149EVM

The INA149EVM is intended to provide basic functional evaluation of the [INA149](#). It provides the following features:

- Easy access to pertinent nodes with test points and terminal blocks
- Convenient input and output filtering
- Versatile pad for evaluation in current/sensing applications
- Reverse supply and overvoltage protection
- Advanced evaluation with prototype areas and SMA/SMB connector footprints
- Footprints for providing a flexible reference voltage

A picture of the INA149EVM is shown in [Figure 1](#)

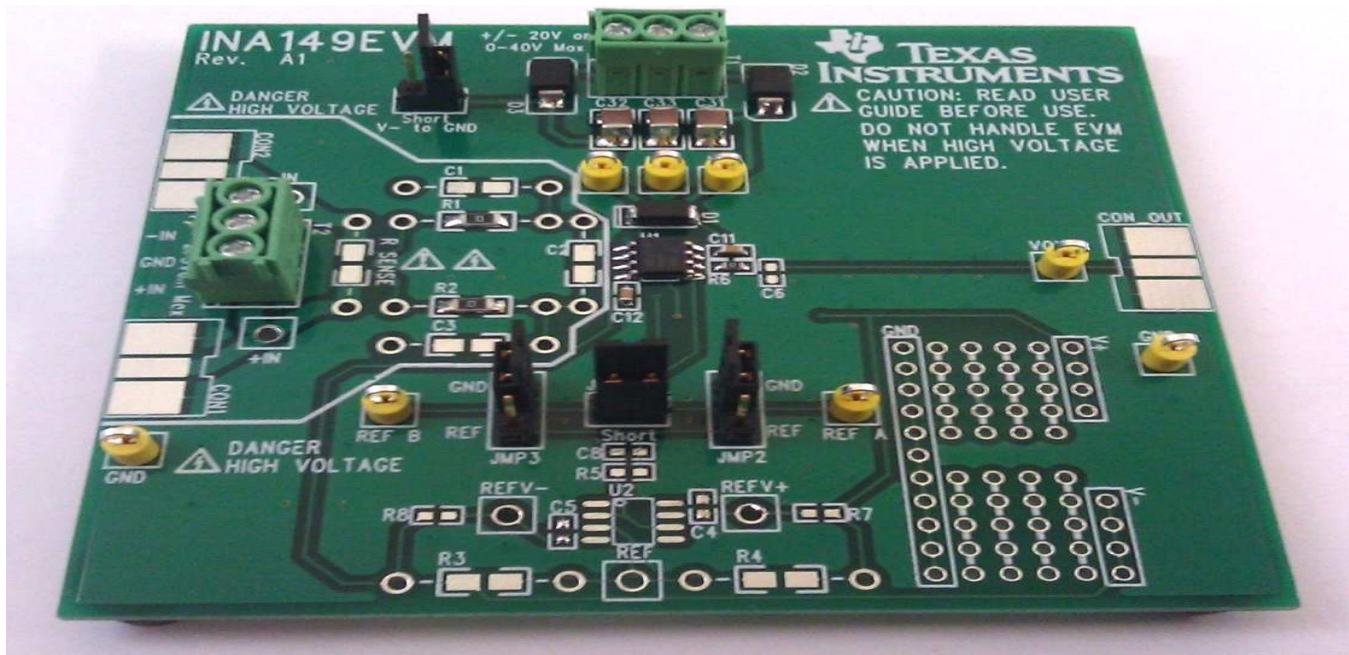


Figure 1. INA149EVM

### **1.3 Evaluation Module Limitations & Warnings**

As a result of the high common-mode input voltage rating of the INA149, evaluation of the device often involves high-voltage operation. As a difference amplifier, it may also be used in current-sensing applications. In addition to voltage and current limitations, proper electrostatic discharge precautions are recommended.

#### **1.3.1 High Voltage**

The common-mode input voltage rating of the INA149 is  $\pm 275$  V. When using the device and EVM under such circumstances, all proper safety practices must be followed. Do not apply more than  $\pm 275$  V common-mode.

#### **1.3.2 High Current**

For current-sensing applications, an unpopulated pad is provided for a sense resistor (RSENSE). The sense resistor trace has a maximum current rating of 5 A. Ensure that the power rating of the sense resistor is sufficient for the application.

#### **1.3.3 Electrostatic Discharge**

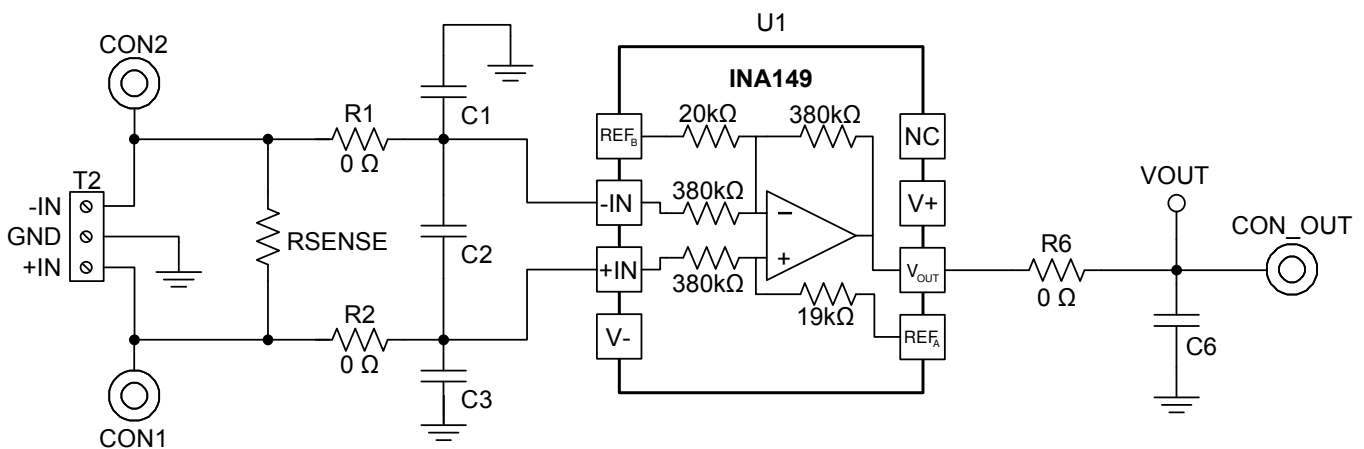
Many of the components on the INA149EVM are susceptible to damage by electrostatic discharge (ESD). Customers are advised to observe proper ESD handling precautions when unpacking and handling the EVM, including the use of a grounded wrist strap at an approved ESD workstation.

## 2 INA149EVM Hardware

This section discusses the INA149EVM hardware schematics, PCB layout, prototype area, and jumpers.

### 2.1 Input/Output Schematic

The input/output section of the schematic is shown in [Figure 2](#). The input signal is applied through terminal block T2 and the output can be measured with test point VOUT. Alternately, SMA or SMB connectors can be populated in the provided footprints: CON1, CON2, and CON\_OUT. Input filtering can be applied with R1, R2, and C1-3. The common-mode and differential-mode cutoff frequency equations are given in [Equation 1](#) and [Equation 2](#), respectively. It is recommended to make C2 approximately ten times larger than C1 and C3. The equations assume R1 is equivalent to R2 and C1 is equivalent to C3. Note that any of the capacitors and resistors selected must be rated for the inputs being applied. An output filter can also be implemented with R6 and C6. The corresponding cutoff frequency equation is given in [Equation 3](#). Finally, a versatile pad is provided for evaluation in current-sensing applications. RSENSE can accommodate through-hole resistors or a surface-mount sense resistor from 0603 to 1206 in size. The trace width provides for evaluation of load currents up to 5 A.



**Figure 2. INA149EVM Input/Output Schematic**

Common-mode cutoff frequency:

$$f_{c\text{-cm}} = \frac{1}{2\pi \cdot R1 \cdot C1} \quad (1)$$

Differential-mode cutoff frequency:

$$f_{c\text{-dm}} = \frac{1}{2\pi \cdot (R1+R2) \cdot \left(C2 + \frac{C1}{2}\right)} \quad (2)$$

Output filter cutoff frequency:

$$f_{c\text{-o}} = \frac{1}{2\pi \cdot R6 \cdot C6} \quad (3)$$

## 2.2 Reference Voltage Schematic

Figure 3 shows that the reference voltage can be applied to the INA149 in a variety of ways. The INA149 has two pins for reference voltages: REFA, REFB. Most applications require REFA and REFB to be shorted. This functionality is accomplished with JMP4. In dual-supply applications, the reference voltages are typically connected to ground. Connecting pins 2 and 3 of JMP2 and JMP3 accommodate this configuration. For single-supply applications, it is often required to connect the reference voltages to mid-supply. This can be accomplished by either applying a voltage directly to test point REFA (or test point REFB) and shorting JMP4, or using the resistive divider created by R3 and R4. If a matched precision resistor network is desired, a SOT-23 pad (R9) is located on the bottom of the board. When using a resistor divider, however, the voltage must be buffered to ensure good common-mode rejection (CMR). U2 is intended for a standard pinout operational amplifier in an SO-8 package. If U2 is to be powered by the V+ and V- supplies, R7 and R8 should be populated with 0-Ω resistors; otherwise, another supply can be connected to the REFV+ and REFV- test points. Recommendations for this operational amplifier include the [OPA376](#), [OPA330](#), and [OPA277](#).

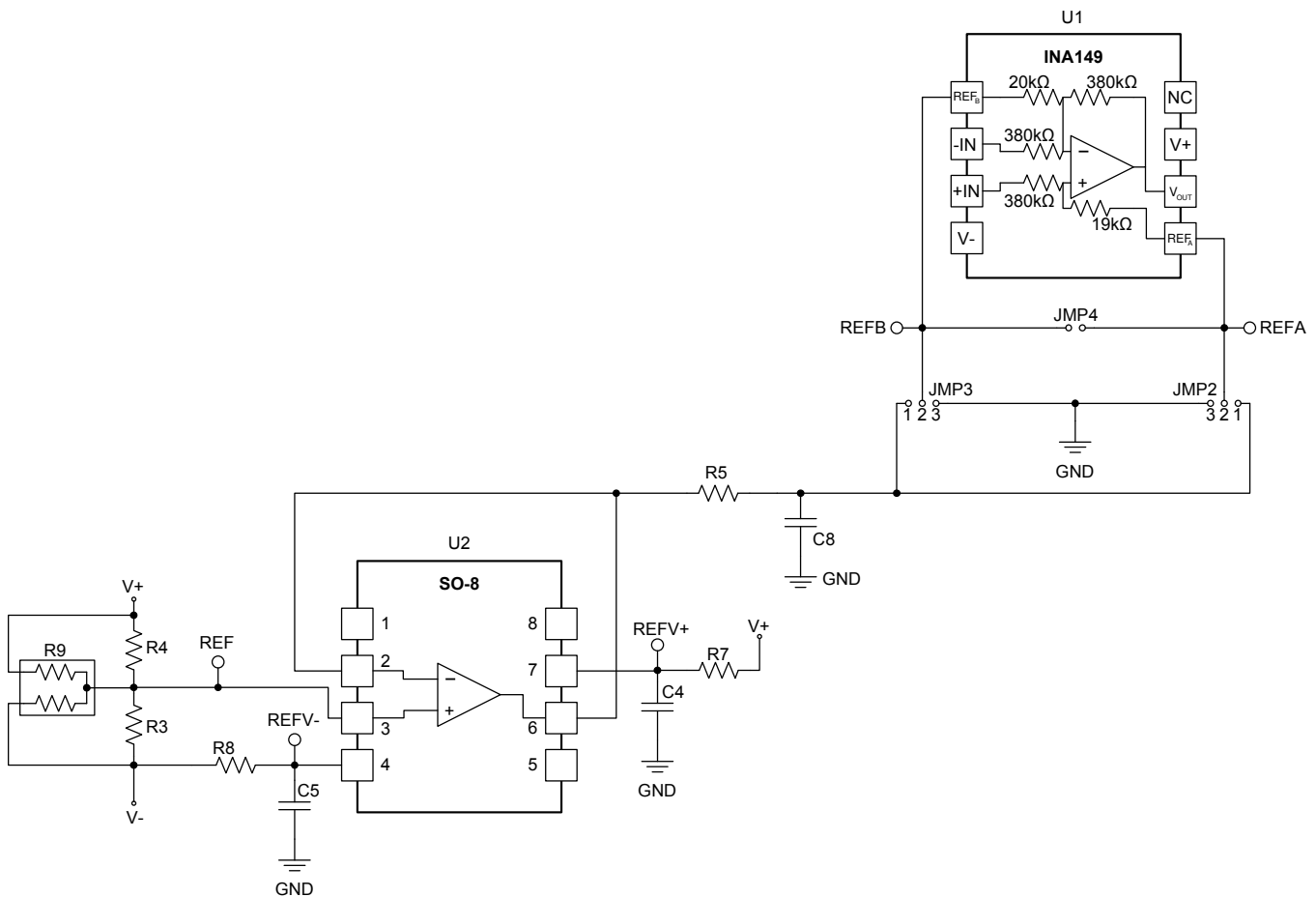
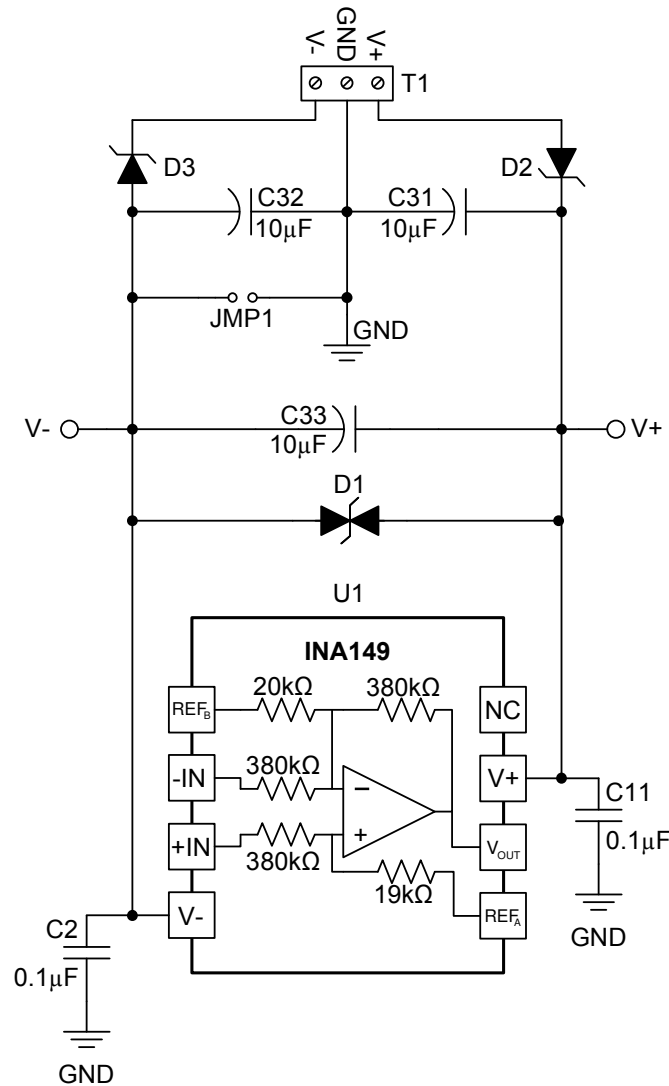


Figure 3. INA149EVM Reference Voltage Schematic

### 2.3 Power Schematic

The power schematic is depicted in [Figure 4](#). Power is applied to the INA149EVM through terminal block T1. Reverse supply protection diodes (D2, D3) protect the device from accidental switching of the positive and negative supply voltages. As a consequence, each supply voltage should be increased by one diode voltage drop. Test points V+ and V- have been provided to ensure the desired supply voltage is being applied to the device. D1 is a transient voltage suppressor (TVS) diode. D1 aids in protecting the INA149 from supply voltages in excess of 36 V ( $\pm 18$  V). JMP1 allows the user to short the negative supply voltage (V-) to ground, which provides a simple method for operating the device with a single supply. Do not shunt JMP1 during dual-supply operation because this action will short the negative supply to ground. Capacitors C2 and C11 are placed as close to the device as possible to provide power-supply decoupling.



**Figure 4. INA149EVM Power Schematic**

## 2.4 Complete Schematic

Figure 5 depicts the complete INA149EVM schematic.

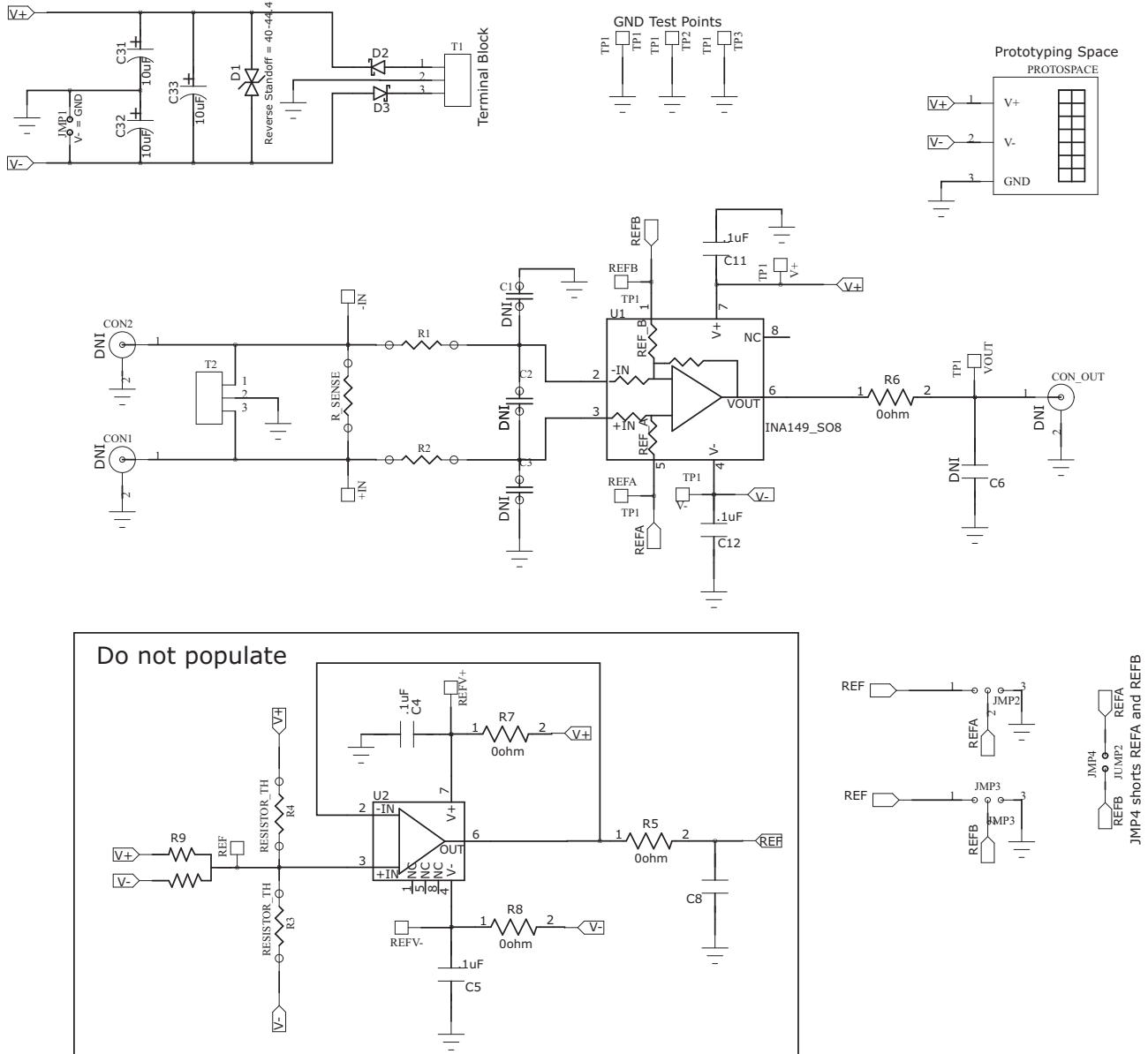


Figure 5. INA149EVM Complete Schematic

## 2.5 Prototype Area

For flexible evaluation, the INA149EVM has a small prototyping area. This area is intended to be used with devices mounted on 8-pin DIP adapter boards. Power can be readily applied using the nearby V+, V-, and GND rails.

## 2.6 Jumper Table

There are four jumpers located on the INA149EVM. Their functions are summarized in [Table 1](#).

**Table 1. Jumpers**

Jumper	Function
JMP1	This jumper shorts the V- power rail to ground. It allows a single supply to be used instead of a dual supply.
JMP2	This jumper allows the REFA pin on the INA149 to be connected to ground or the external reference op amp. The shunt on the jumper can be removed as well to allow an external reference to be attached to the REFA test point.
JMP3	This jumper allows the REFB pin on the INA149 to be connected to ground or the external reference op amp. The shunt on the jumper can be removed as well to allow an external reference to be attached to the REFB test point.
JMP4	This jumper shorts the REFA and REFB pins together. When shorting this jumper, make sure JMP2 and JMP3 are not in conflicting positions.



## 2.7 PCB Layout

Figure 6 depicts the PCB layout.

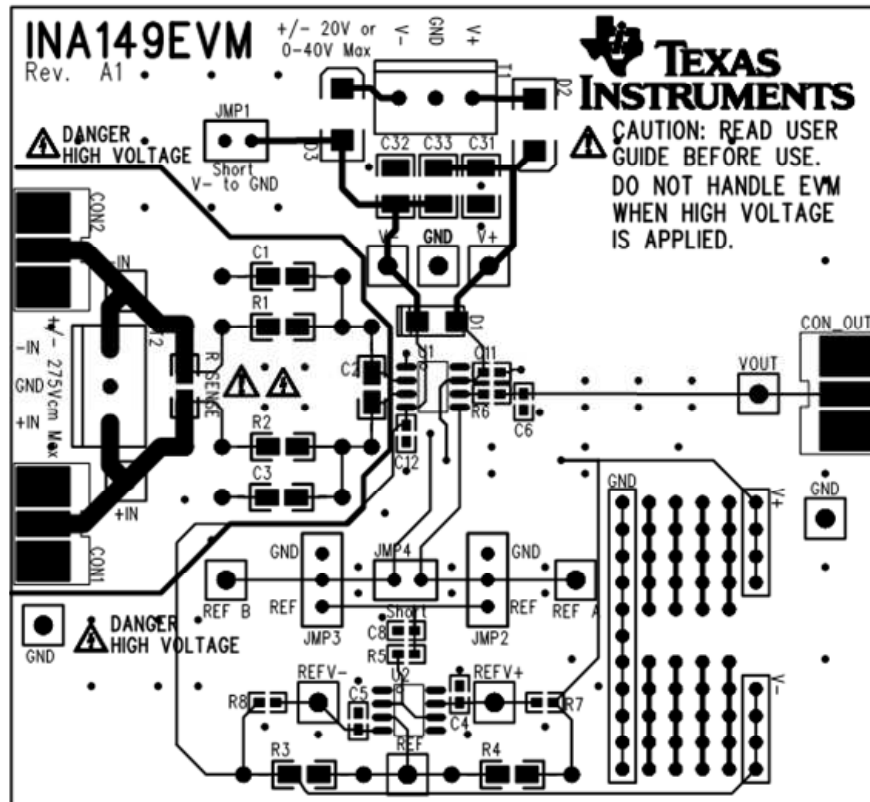


Figure 6. INA149EVM PCB Layout

**NOTE:** Board layout is not to scale. This figure is intended to show how the board is laid out; it is not intended to be used for manufacturing INA149EVM PCBs.

### 3 Bill of Materials

Table 2 the bill of materials used for the INA149EVM. It also lists examples of optional components.

**Table 2. INA149EVM Bill of Materials**

Count	RefDes	Value	Description	Part Number	MFR
1	U1	N/A	INA149, SO-8	INA149	Texas Instruments
2	C11-12	0.1µF	Capacitor, .10µF, 50V, X7R, 0603	06035C104JAT2A	AVX Corporation
3	C31-33	10µF	Capacitor, 4.7µF, 50V, X7S, 1210	C3225X7S1H106M	TDK Corporation
1	D1	N/A	Diode, TVS, 36V, 400W Bi-directional, SMD	SMAJ36CA	Bourns Inc.
2	D2-3	N/A	Diode, Schottky, 40V, SMB	MBRS2040LT3G	On Semiconductor
2	T1-2	N/A	Terminal Block, 3.5mm, 3 Position	1984620	Phoenix Contact
1	R6	0ohm	Resistor, 00hm, 0603	RC0603JR-070RL	Yageo
2	R1-2	0ohm	Resistor, 00hm, 1206	RC1206JR-070RL	Yageo
2	JMP2-3	3POS	3 Position Connection Header .100"	TSW-102-07-G-S	Samtec
2	JMP1,4	2POS	2 Position Connection Header .100"	TSW-102-07-G-S	Samtec
10	REFA, REFB, 3xGND, V+, V-, VOUT	N/A	Through-hole Test Points	5009	Keystone Electronics
4	N/A	N/A	Bumpon, .375X.135, Black	SJ61A8	3M
4	N/A	N/A	Shunt w/Handle, 2 Position	881545-2	TE Connectivity
Not Installed	C1-3	N/A	Capacitor, 0603-1206 or through-hole		
Not Installed	C4-6, C8	N/A	Capacitor, 0603		
Not Installed	RSENSE	N/A	Sense Resistor, 0603-1206 or through-hole		
Not Installed	R3-R4	N/A	Resistor, 0603-1206 or through-hole		
Not Installed	R5, R7-8	N/A	Resistor, 0603		
Not Installed	REF, REFV+, REFV-, +IN, -IN	N/A	Through-hole Test Point	5009	Keystone Electronics
Not Installed	U2	N/A	Op-Amp, SO-8		
Not Installed	CON1, CON2, CON_OUT	N/A	SMA/SMB Edge mounted connector		

### 4 Related Documentation from Texas Instruments

The following documents provide information regarding Texas Instruments' integrated circuits and support tools for the INA149EVM. This user's guide is available from the TI web site under literature number **SBOU119**. 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 may be available from the [TI web site](#), or call the Texas Instruments' Literature Response Center at (800) 477-8924 or the Product Information Center at (972) 644-5580. When ordering, identify the document by both title and literature number.

#### Related Documentation

Document	Literature Number
<a href="#">INA149</a> Product Data Sheet	<a href="#">SBOS579</a>
<a href="#">OPA376</a> Product Data Sheet	<a href="#">SBOS406</a>
<a href="#">OPA277</a> Product Data Sheet	<a href="#">SBOS079</a>
<a href="#">OPA330</a> Product Data Sheet	<a href="#">SBOS432</a>

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## EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of  $\pm 275$  V common-mode and  $\pm 13.5$  V differential and the output voltage range of  $-13.5$  V to  $+13.5$  V.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's 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, some circuit components may have case temperatures greater than  $+30^{\circ}\text{C}$ . The EVM is designed to operate properly with certain components above  $+30^{\circ}\text{C}$  as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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### General Statement for EVMs including a radio

*User Power/Frequency Use Obligations:* This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

### 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

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**

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.

### **For EVMs annotated as IC – INDUSTRY CANADA Compliant**

This Class A or B digital apparatus complies with Canadian ICES-003.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

### **Concerning EVMs including radio transmitters**

This device complies with Industry Canada licence-exempt RSS standard(s). 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.

### **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.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

### **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.

### **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.

## **【Important Notice for Users of this Product in Japan】**

**This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan**

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product 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 this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure 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.
3. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

**Certain Instructions.** It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

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