

# 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 <u>INA149</u> 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 <u>INA117</u> 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 <u>INA149</u>. 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.





Common-mode cutoff frequency:

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

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(1)

Differential-mode cutoff frequency:

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

Output filter cutoff frequency:

$$f_{c-o} = \frac{I}{2\pi \cdot R6 \cdot C6}$$
(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 JPM3 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- $\Omega$  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.







#### 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 (±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.





### 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
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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.



Bill of Materials

#### 3 Bill of Materials

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

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		

#### Table 2. INA149EVM Bill of Materials

#### 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 <u>TI web site</u>, 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
INA149 Product Data Sheet	SBOS579
OPA376 Product Data Sheet	SBOS406
OPA277 Product Data Sheet	SBOS079
OPA330 Product Data Sheet	SBOS432

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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°C. The EVM is designed to operate properly with certain components above +30°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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