User's Guide

INA-DDF-EVM

ABSTRACT

This user's guide describes the characteristics, operation, and use of the evaluation module (EVM) that is compatible with a variety of instrumentation amplifiers (IAs) in the DDF package. It is designed to evaluate the performance of the devices in both single- and dual-supply configurations. This document includes the schematic, printed circuit board (PCB) layouts, and BOM. Throughout this document the terms *evaluation board*, *evaluation module*, and *EVM* are synonymous with the INA-DDF-EVM.

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1 Overview

1.1 Features

This EVM is intended to provide basic functional evaluation of the amplifiers shown in Table 1-1 with the pinout shown in Figure 1-1. The EVM provides the following features:

- Easy access to nodes with surface-mount test points
- Reference voltage source flexibility
- Convenient input and output filtering

1.2 Instrumentation Amplifier Pinout

The EVM is intended to evaluate IAs that have the pinout shown in Figure 1-1.

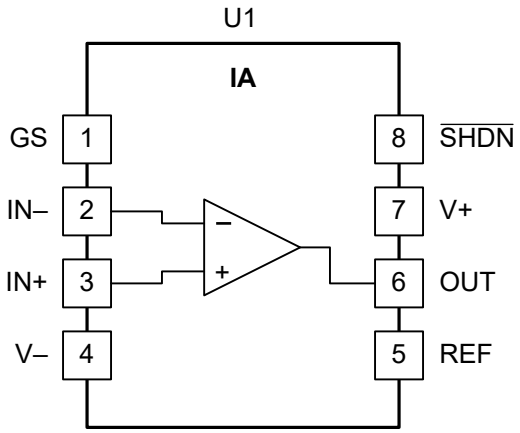


Figure 1-1. IA Pinout

1.3 Compatible Devices

Devices that are compatible with the EVM are shown in Table 1-1.

Table 1-1. Compatible Devices

Device	Description
INA350AB	Low-power selectable gain INA (G10/20)
INA350CD	Low-power selectable gain INA (G30/G50)
INA351AB	Low-power selectable gain INA (G10/20) with integrated voltage reference
INA351CD	Low-power selectable gain INA (G30/50) with integrated voltage reference

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2 PCB Layout

The front and back of the INA-DDF-EVM are shown in Figure 2-1 and Figure 2-2, respectively.

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 PCBs.

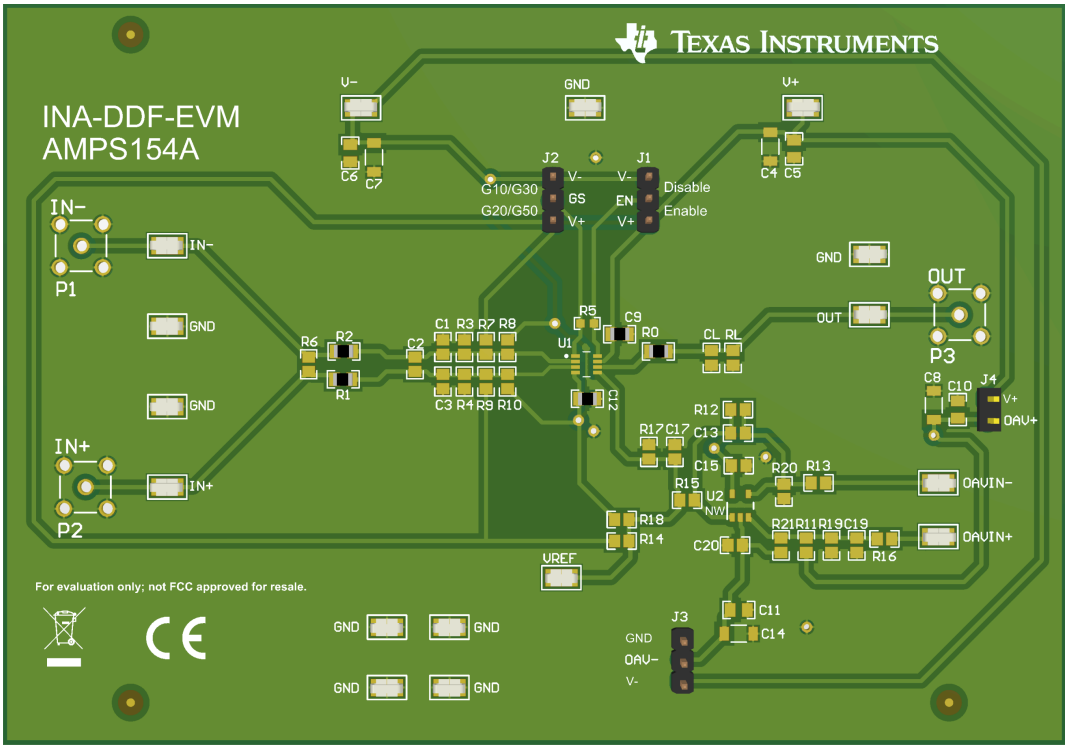


Figure 2-1. INA-DDF-EVM Component Side

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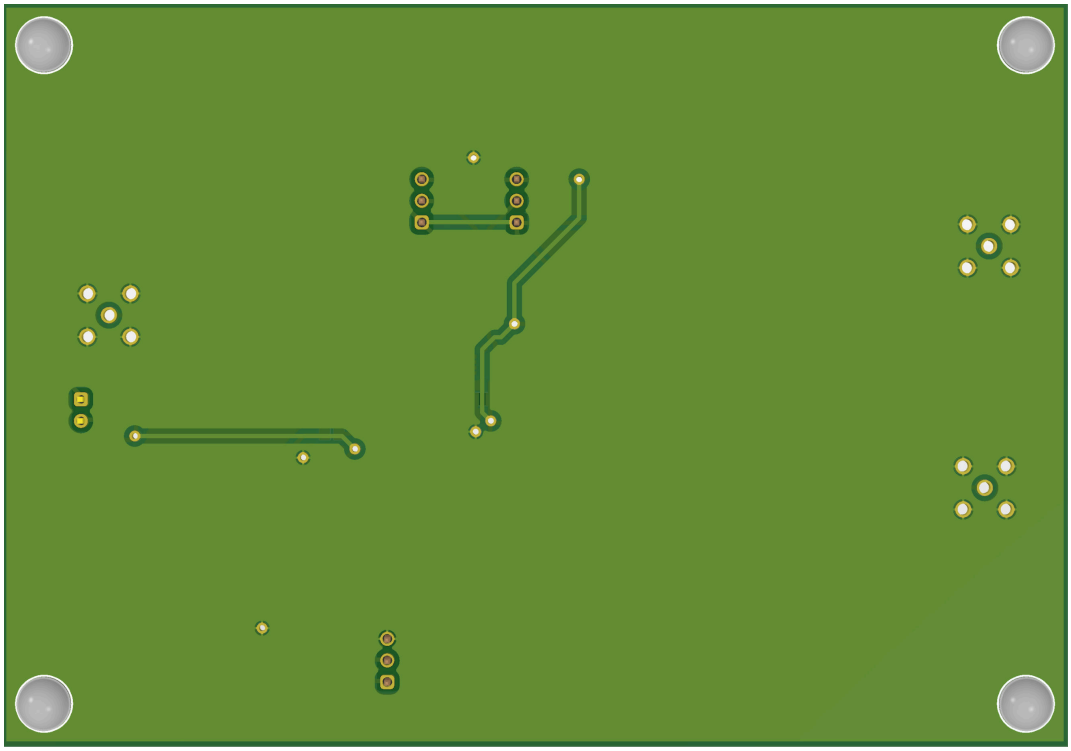


Figure 2-2. INA-DDF-EVM Bottom Side

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3 Schematic

Figure 3-1 and Figure 3-2 shows the schematic for the PCB.

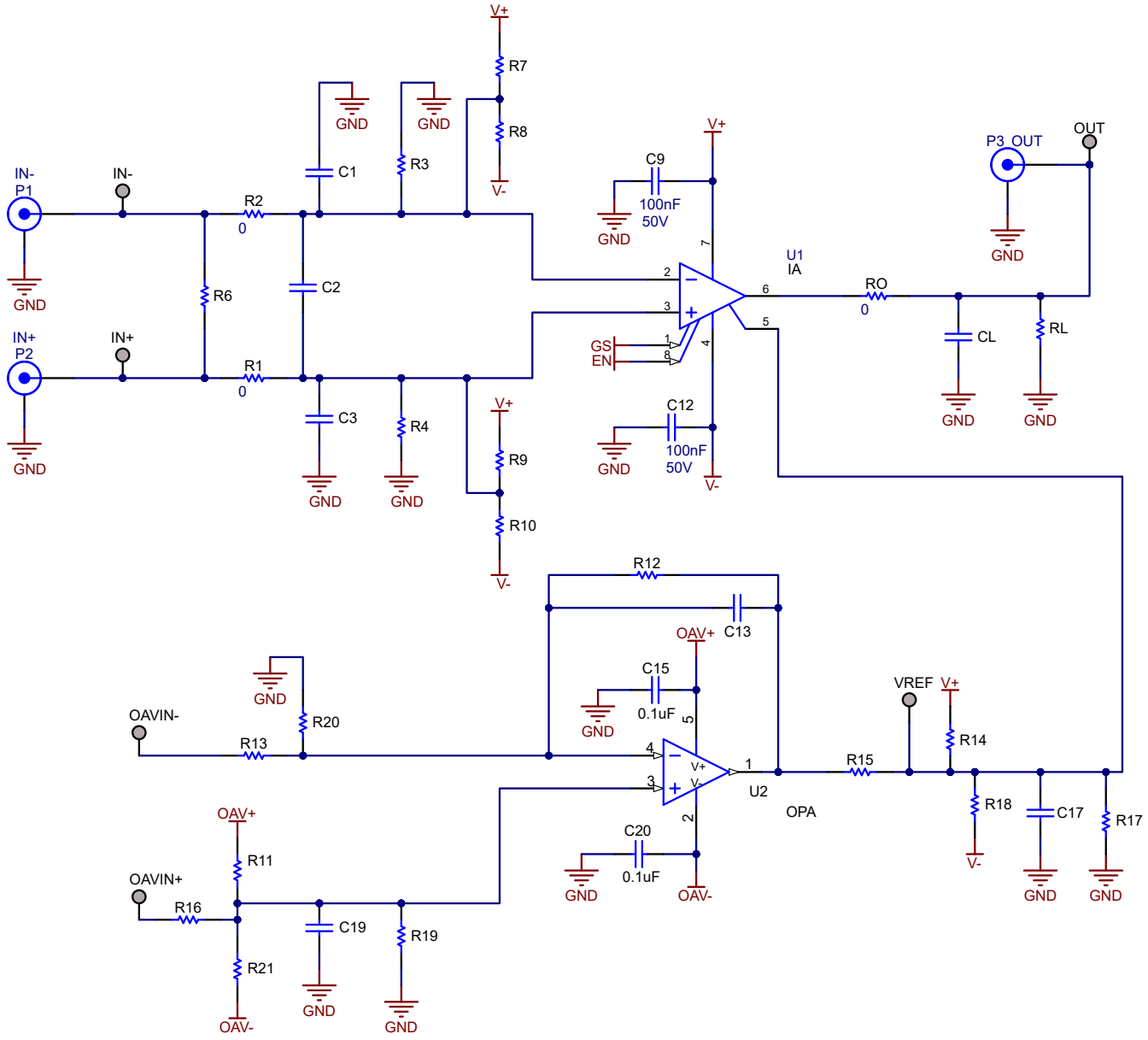


Figure 3-1. INA-DDF-EVM Schematic

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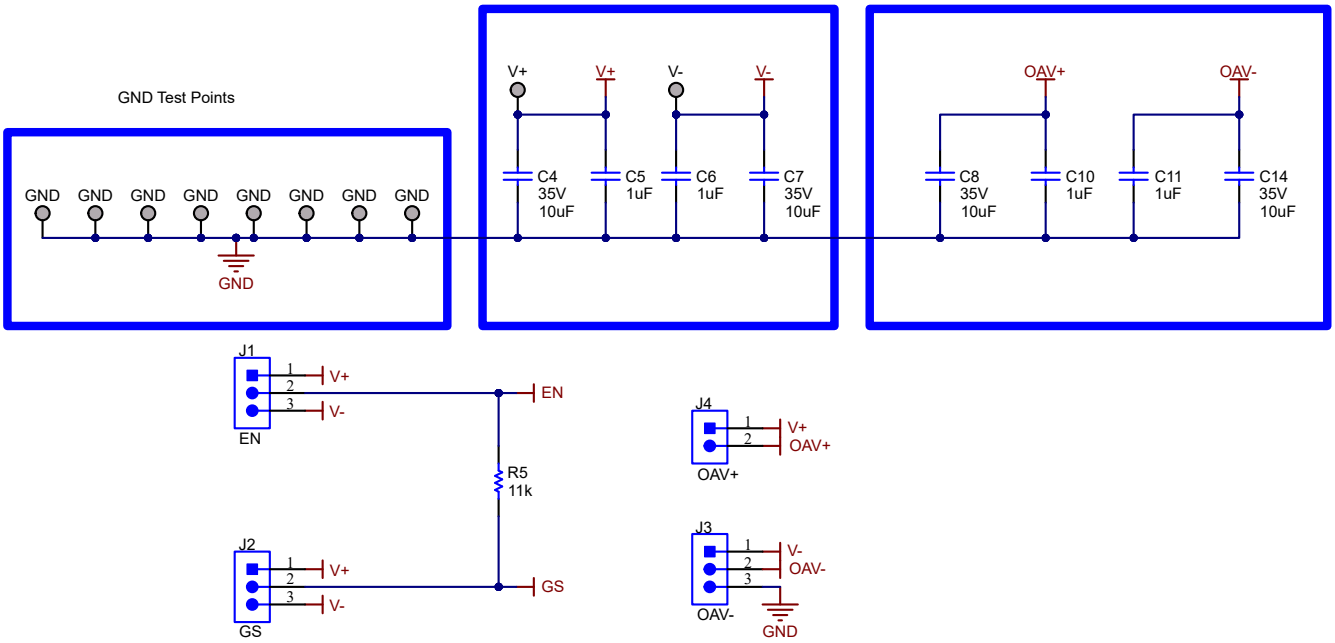


Figure 3-2. INA-DDF-EVM Schematic: Power and Jumpers

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4 EVM Components

4.1 Power

Power is applied to the IA (U1) with test points V+, GND, and V– located at the top of the board. For the voltage reference buffer (U2), power is applied using test points OAV+ and OAV–. Additionally, you can tie V+ and V– to OAV+ and OAV– using jumpers J3 and J4 to power U2 and U1 from the same connection.

4.2 Inputs

Inputs are applied to U1 using test points IN+ and IN–. Alternately, the inputs can be applied by populating the input SMB connectors (P1 and P2). The inputs for U2 are applied through test points OAVIN+ and OAVIN–.

4.2.1 Input Filtering

R1, R2, and C1 through C3 provide the ability to apply common-mode and differential-mode filtering to the inputs. The cutoff frequencies for the filters are shown in Equation 1 and Equation 2. For best performance, make C2 approximately ten times larger than C1 and C3. These calculations presume R1 = R2 and C1 = C3.

Common-mode cutoff frequency: (1)

$$f_{o-cm} = \frac{1}{2\pi \times \mathrm{R1} \times \mathrm{C1}}$$

Differential-mode cutoff frequency: (2)

$$f_{o-dm} = \frac{1}{2\pi\left(\mathrm{R1}+\mathrm{R2}\right)\left(\mathrm{C2}+\frac{\mathrm{C1}}{2}\right)}$$

4.3 Output

The output of U1 can be accessed with test point OUT or by populating the output SMB connector (P3).

4.3.1 Output Filtering

RO and CL provide the ability to apply a single-pole RC output filter. The cutoff frequency of the output filter is calculated as shown in Equation 3:

$$f_{o-o} = \frac{1}{2\pi \times \mathrm{RO} \times \mathrm{CL}} \quad (3)$$

4.4 Reference

There are multiple methods of applying a reference voltage to the device. A straightforward approach is to apply a voltage to the VREF test point with U2 unpopulated. If a buffered voltage is desired, then U2 can be populated with an operational amplifier in an appropriate DBV package with the OUT pin on pin 1. Ensure the series resistor R15, as well as any accompanying passive components, are populated before using the reference buffer.

If the reference voltage is GND, then either R17 can be populated with a 0-Ohm resistor or the VREF test point can be connected to GND. When grounding the reference pin, ensure R15 is not populated.

4.5 Other Passives

R6 is able to be populated with a 0 ohm resistor for testing purposes to easily allow testing of the common mode voltage range vs supply. R7/R8 and R9/R10 are voltage dividers between V+ and V- to allow a simple fixed voltage input to the IA. R3 and R4 allow either input to be easily connected to ground. CL and RL allow for testing to data sheet load conditions, or CL and RO can be used to apply an output low pass filter.

4.6 Miscellaneous

C6, C7, C4, and C5 are the supply decoupling capacitors for the device. C9 and C12 are prepopulated with 0.1 µF capacitors that usually provide adequate power-supply bypassing for U1. Refer to the instrumentation amplifier data sheet for further information (Table 1-1). Similarly, C8, C10, C11, and C14 can be populated to provide supply bypassing for U2. Additionally, for power-supply bypassing near the device, populate C15

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and C20. Refer to the buffer amplifier data sheet for further information on recommended decoupling capacitor values.

5 Quick Start

The procedures presented in this section describe how to quickly set up and use the INA-DDF-EVM for evaluation in dual-supply and single-supply configurations. Please note that GS and SD have internal pull-up resistors, and may be left floating or configured using jumpers J1 and J2.

5.1 Dual-Supply Configuration

Figure 5-1 shows an example of how to set up the EVM for dual-supply operation.

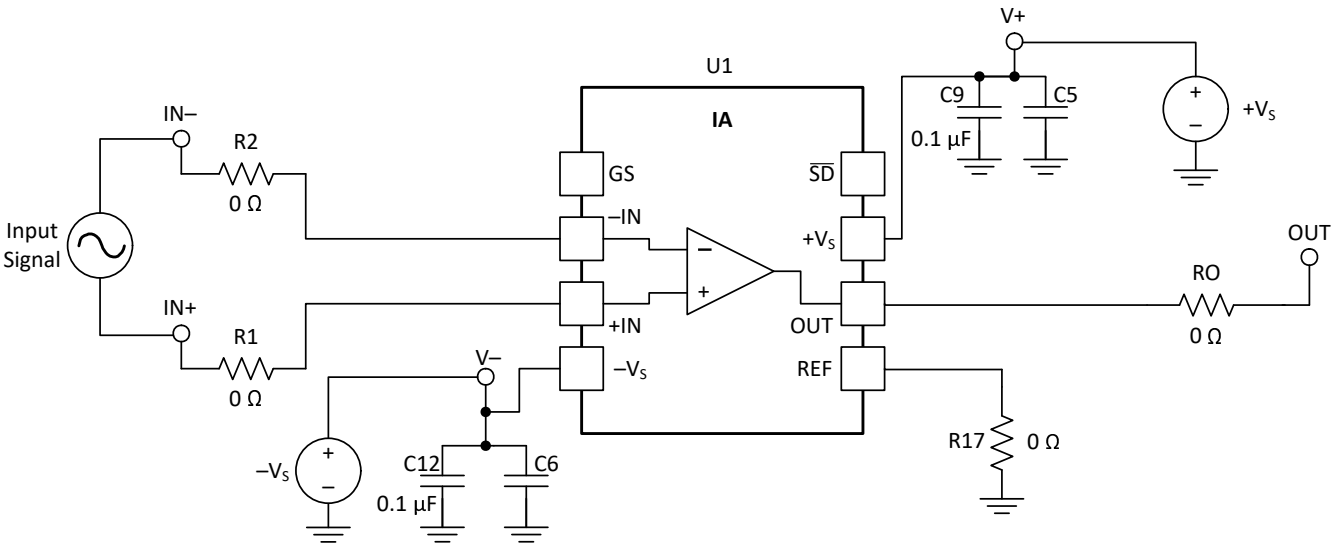


Figure 5-1. Dual-Supply Configuration

The following connections were made:

1. $+V_S$ to V+ test point
2. $-V_S$ to V– test point
3. Install 0-Ω resistor as R17 (or connect REF test point to GND)
4. Differential input signal connect to IN– and IN+ test points
5. Observe output at OUT test point

Note

1. C9 and C12 are prepopulated with 0.1-µF power-supply decoupling capacitors. Refer to the device data sheet for additional power-supply decoupling information (Table 1-1).

2. A valid input common mode must be present on both inputs of the IA for proper operation.

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5.2 Single-Supply Configuration

5.2.1 Direct-Reference Connection

Figure 5-2 shows an example of how to set up the EVM for single-supply operation with a direct voltage connection to the reference (REF pin).

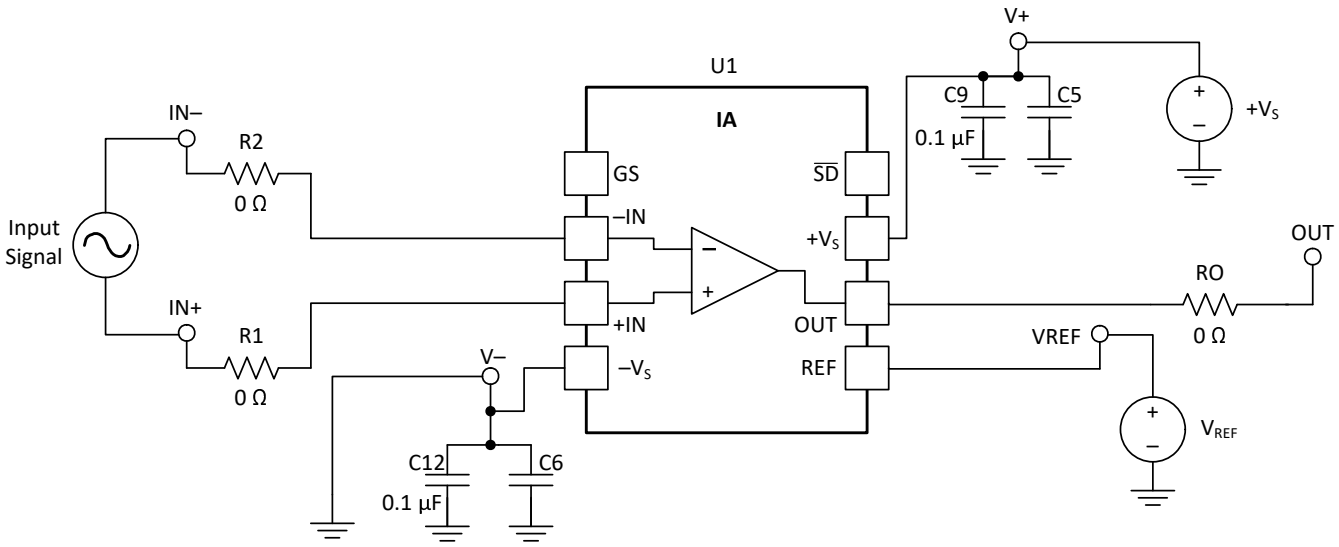


Figure 5-2. Single-Supply Configuration, Direct REF Connection

The following connections were made:

1. $+V_S$ to V+ test point
2. GND to V– test point
3. Reference voltage to VREF test point
4. Differential input signal to IN– and IN+ test points
5. Observe output at OUT test point

Note

1. C9 and C10 are prepopulated with 0.1-µF power-supply decoupling capacitors. It is not required to remove C9 for proper single-supply operation. Refer to the device data sheet for additional power-supply decoupling information (Table 1-1).

2. A valid input common mode must be present on both inputs of the IA for proper operation.

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5.2.2 Buffered-Reference Voltage Connection

A buffered-reference configuration is useful when the source impedance is high (for example, a voltage divider). Buffering a high-impedance source with an operational amplifier provides a low-impedance source and preserves common-mode rejection. Figure 5-3 shows an example of how to set up the EVM for single-supply operation with a buffered-reference voltage connection. Depending on the application, desirable single-supply buffer operational amplifiers include the TLV9001, TLV9041, TLV9051, and TLV9061.

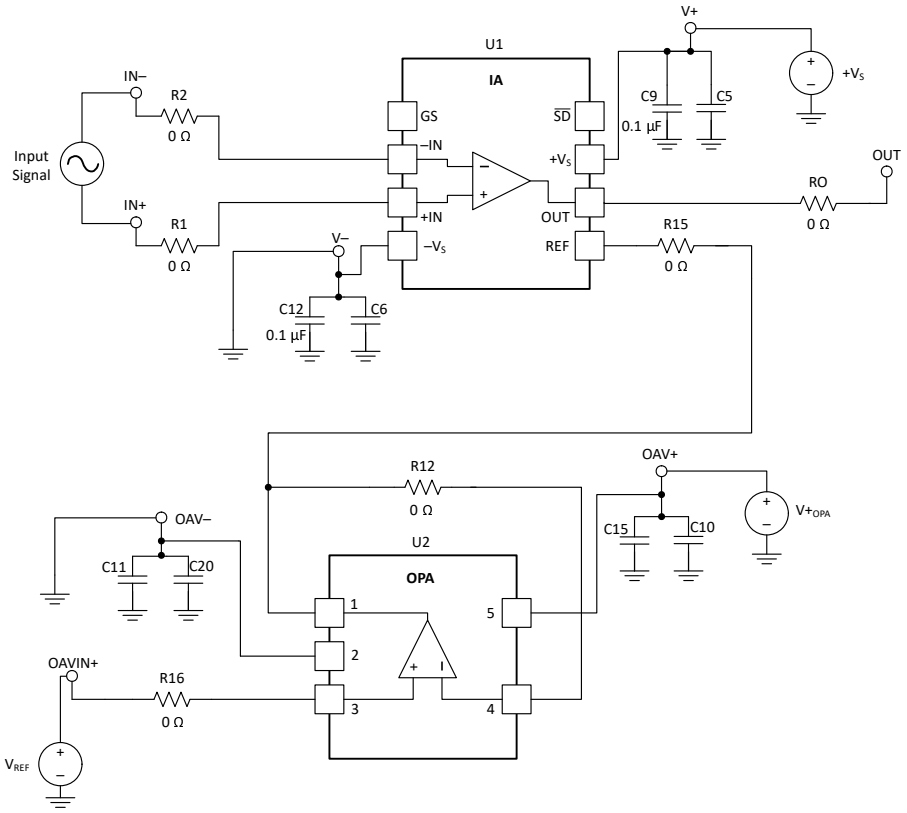


Figure 5-3. Single-Supply Configuration, Buffered REF Connection

The following connections were made:

1. $+V_S$ to V+ test point
2. $V+_{OPA}$ to OAV+ test point
3. GND to V– and OAV– test points
4. V_{REF} to OAVIN+ test point
5. Ensure that R17 is not populated
6. Populate R12, R15, and R16 with a 0-Ω resistor
7. Populate C10, C11, C15, and C20 with appropriate decoupling capacitors for buffer amplifier
8. Differential input signal to IN– and IN+ test points
9. Observe output at OUT test point

Note

1. C9 and C10 are prepopulated with 0.1-µF power-supply decoupling capacitors. It is not required to remove C9 for proper single-supply operation. Refer to the device data sheet for additional power-supply decoupling information (Table 1-1).

2. A valid input common mode must be present on both inputs of the IA for proper operation.

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6 Bill of Materials

Table 6-1 provides the parts list for the EVM.

Table 6-1. Universal IA EVM Bill of Materials

Count	RefDes	Value	Description	Part Number	Manufacturer
2	C9, C12	0.1 µF	CAP, CERM, 0.1 uF, 50 V, +/- 20%, X7R, 0805	08055C104MAT2A	AVX Corporation
4	H1, H2, H3, H4	N/A	Bumpon, Hemisphere, 0.25 X 0.075, Clear	SJ5382	3M
3	J1, J2, J3	N/A	Header, 2.54 mm, 3x1, Gold, TH	61300311121	Wurth Elektronik
1	J4	N/A	Header, 100mil, 2x1, Gold, TH	TSW-102-07-G-S	Samtec
3	R1, R2, RO	0	RES, SMD, 0, 0.125 W, 0805	ERJ-6GEY0R00V	Panasonic
4	SH-J1, SH-J2, SH-J3, SH-J4	N/A	Shunt, 100mil, Gold plated, Black	382811-6	AMP
16	Various	N/A	Test Point, Miniature, SMT	5019	Keystone

7 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision * (October 2022) to Revision A (December 2022)	Page
• Added INA188 device to Table 1	2

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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.

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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

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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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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:*

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