

## Evaluating the **AD8237** Micropower, Zero Drift, True Rail-to-Rail Instrumentation Amplifier and the **AD8420** Wide Supply Range, Micropower, Rail-to-Rail Instrumentation Amplifier

### FEATURES

- Simple evaluation of **AD8237** and **AD8420**
- SMA/SMB or vector test pin inputs and outputs
- Bandwidth mode selection switch for **AD8237**
- Shipped with **AD8420ARMZ** and **AD8237ARMZ**

### APPLICATIONS

- Quick, easy product evaluation and characterization
- Pads for common surrounding components
- Interface to other evaluation tools

### GENERAL DESCRIPTION

The EVAL-INAMP-ICF-RMZ allows users the option of evaluating the **AD8237** or the **AD8420** indirect current feedback (ICF) instrumentation amplifier individually or connected to an adjacent board in an application. This evaluation board ships with both instrumentation amplifiers in surface-mount MSOP packages. The evaluation board is arranged so that the user can easily adjust the gain resistors and common discrete components surrounding the part. A bandwidth mode switch for the **AD8237** and reference

jumpers are included for added convenience. The board also offers an SMA/SMB outline at the input and output for best signal integrity.

Users can add their own end-launch SMA/SMB connector to interface the evaluation board with complementary tools, such as an analog-to-digital converter (ADC) evaluation board, available from Analog Devices, Inc.

To get started with this evaluation board, see the Quick Start for the EVAL-INAMP-ICF-RMZ Board section.

### BASIC OPERATION

The **AD8237** and **AD8420** series in-amps convert a differential input signal to a gained single-ended output signal with respect to a reference voltage. The board connects the user-provided power supplies to pins of the integrated circuit and ground to the board. The differential signal is applied between the +IN and -IN pins of the in-amp, while the signal output appears between the V<sub>OUT</sub> pin and the REF pin of the in-amp.

Figure 2 shows the component layout and the location of the connections for the EVAL-INAMP-ICF-RMZ printed circuit board (PCB).

### DIGITAL PHOTOGRAPH OF THE EVAL-INAMP-ICF-RMZ

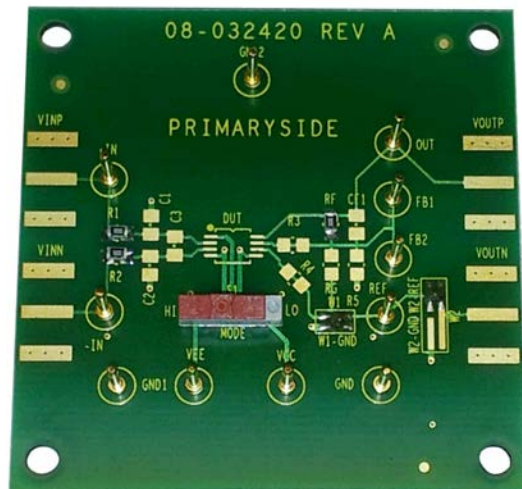


Figure 1. EVAL-INAMP-ICF-RMZ Evaluation Board, Primary Side

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**REVISION HISTORY**

2/13—Revision 0: Initial Version

## EVAL-INAMP-ICF-RMZ SCHEMATIC AND USER OPTIONS

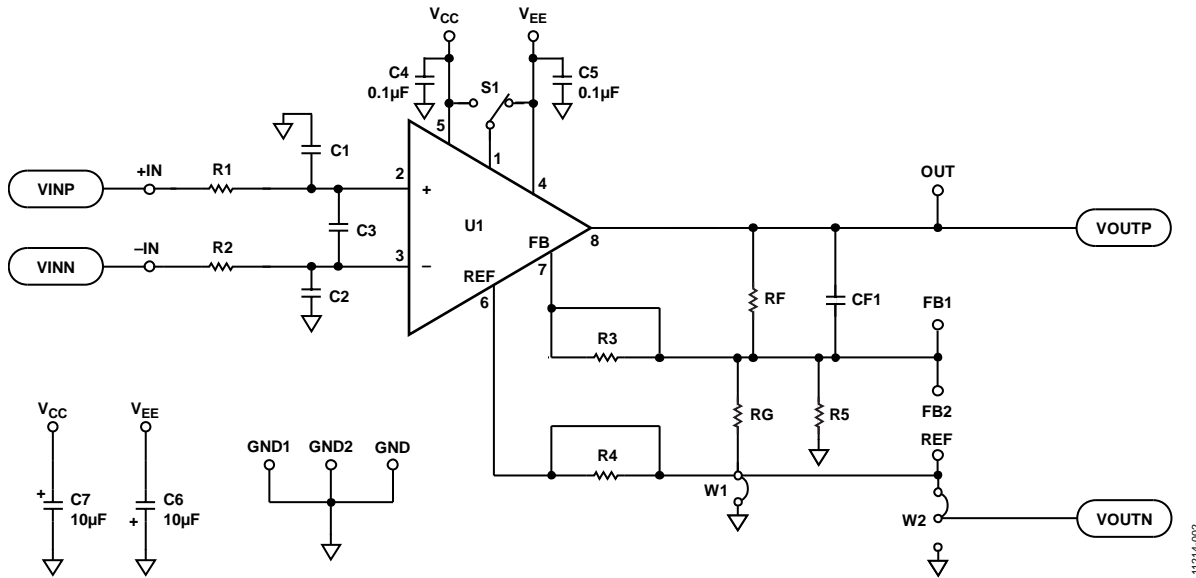


Figure 2. EVAL-INAMP-ICF-RMZ Schematic Diagram

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### USER OPTIONS

Table 1. Jumpers and Switches

Jumper	Function	Description	Factory Setting
W1	REF to GND	REF is shorted to ground through W1 solder jumper. Remove W1 to drive REF with a voltage other than ground.	Shorted
W2	VOUTN select	Determines what voltage is at VOUTN. If REF is being driven to level-shift the output but GND must be passed to an adjacent board through the SMA/SMB, remove the solder jumper and set W2 to GND. Otherwise, it can be left as-is.	REF
S1	Pin 1 select	Bandwidth mode setting for the AD8237. If the switch toggle is moved to the right (LO), Pin 1 is shorted to VEE (AD8237 low bandwidth mode). If the switch toggle is moved to the left position (HI), Pin 1 is shorted to VCC (AD8237 high bandwidth mode). For the AD8420, the best frequency response is obtained if S1 is set to LO (Pin 1 is shorted to VEE).	LO (-Vs)

Table 2. Input/Output

I/O	Function
V <sub>CC</sub>	Positive supply voltage rail of the in-amp.
V <sub>EE</sub>	Negative supply voltage rail of the in-amp.
GND	Ground connection for the board. Connect to power supply ground. GND1, GND2, and GND pins are all connected to board ground.
+IN/VINP	Positive input of the in-amp (vector pin/SMA).
-IN/VINN	Negative input of the in-amp (vector pin/SMA).
OUT/VOUTP	Output of the in-amp (vector pin/SMA).
FB1/FB2	Feedback input for the in-amp. Two pins are provided to simplify gain setting with leaded resistors on press mount sockets.
REF	External reference input for the in-amp. W1 must be removed before driving REF with a voltage source.
VOUTN	Selectable reference or ground SMA output (see W2 in Table 1).

Table 3. Suggested Accessories

Reference Designation	Part
SMA Jack	Side launch 0.062" board thickness, such as the EMERSON 142-0701-851 (Digi-Key J658-ND)
SMA Plug	Side launch 0.062" board thickness, such as the EMERSON 142-0801-811 (Digi-Key J10131-ND)
SMB Jack	Side launch 0.062" board thickness, such as the EMERSON 131-3701-801 (Digi-Key J10107-ND)
SMB Plug	Recommend above jack and adapter, such as the Amphenol Connex 142246 (Digi-Key ACX1479-ND)
Press mount socket	Plugs onto the vector test pin, such as the Cambion 450-4352-01-03-10 (Newark 40F6130). Can be used for inputs and outputs or through-hole gain setting resistors.

## QUICK START FOR THE EVAL-INAMP-ICF-RMZ BOARD

The quick start instructions in this section assume that the evaluation board is in its default condition as is shown in Table 4. The values provided are intended to simplify the process of getting started and of checking functionality. Consult the [AD8237](#) data sheet and the [AD8420](#) data sheet for more detailed and up-to-date information on these instrumentation amplifiers.

**Table 4. Factory Setting**

Connection	Purpose
W1 Soldered	REF tied to ground
S1 set to LO	Ensures proper setting for <a href="#">AD8237</a>

Follow Step 1 through Step 4 to get started using the EVAL-INAMP-ICF-RMZ evaluation board (see Figure 3).

1. Install the desired component in the MSOP footprint.
2. Connect the supply voltages within the ranges shown in Table 5 to  $V_{CC}$  and  $V_{EE}$ , and connect the power supply ground return to GND.
3. Drive the inputs with a signal within the listed input range shown in Table 6. Ensure that the expected output signal (default configuration:  $V_{OUT} = V_{+IN} - V_{-IN}$ ) is within the supplies.
4. Measure the output on a multimeter or oscilloscope. The output voltage is the voltage measured between  $V_{OUT}$  (OUT) and  $V_{REF}$  (REF). The default configuration is a gain of 1 with REF shorted to the board ground. The output can drive another device, such as another amplifier or an ADC.

**Table 5. Supply Voltage Range**

Part Number	Single-Supply Range	Dual-Supply Range
<a href="#">AD8237</a>	1.8 V to 5.5 V	$\pm 0.9$ V to $\pm 2.75$ V
<a href="#">AD8420</a>	2.7 V to 36 V	$\pm 2.7$ V <sup>1</sup> to $\pm 18$ V

<sup>1</sup> For  $V_{CM}$ ,  $V_{REF} = 0$  V. The  $\pm 1.35$  V supply may be used with  $V_{CM}$  and  $V_{REF}$  at  $V_{EE}$ .

**Table 6. Input Range**

Part Number	Input Range (+IN, -IN, FB, and REF)	Differential Input Limit <sup>1</sup>
<a href="#">AD8237</a>	$V_{EE} - 0.3$ V to $V_{CC} + 0.3$ V	$\pm(V_S - 1.2)^2$
<a href="#">AD8420</a>	$V_{EE} - 0.15$ V to $V_{CC} - 2.2$ V	$\pm 1$ V

<sup>1</sup> Defined as the maximum voltage between +IN and -IN for the valid output.

<sup>2</sup> For example, if  $V_{CC} = 2.5$  V and  $V_{EE} = -2.5$  V, the differential input limit is  $\pm 3.8$  V.

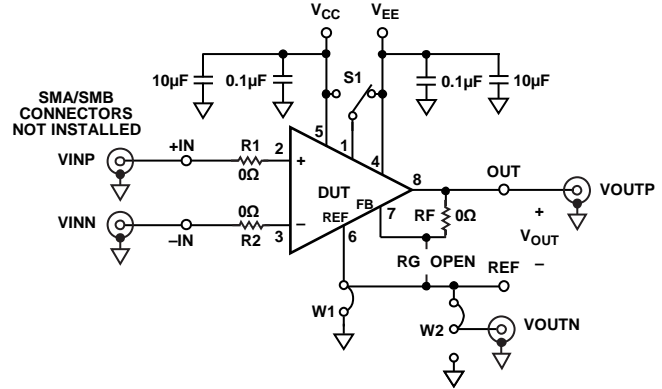


Figure 3. Default Connection Diagram

### CIRCUIT OPTIONS

#### Using a Single Supply

The EVAL-INAMP-ICF-RMZ can be used in single-supply mode by shorting the  $V_{EE}$  pin to ground and connecting the single power supply between  $V_{CC}$  and ground. Both the [AD8237](#) and the [AD8420](#) can operate with the inputs and the reference pin at ground on a single supply; however, because the output cannot swing all the way to ground, there must be a positive input signal. For this reason, in many single-supply circuits, it is necessary to remove W1 and drive the reference pin with a higher voltage, such as midsupply. See the Reference section for more details.

#### Changing the Gain

The EVAL-INAMP-ICF-RMZ board defaults to a gain of 1 because of the  $0\ \Omega$  resistor at  $R_F$ . Removing the  $0\ \Omega$  resistor and installing  $0805$ -sized resistors at  $R_F$  and  $R_G$  creates the following transfer function:

$$V_{OUT} = G(V_{+IN} - V_{-IN}) + V_{REF}$$

where  $G = 1 + (R_F/R_G)$ .

**Table 7. Suggested 1% Resistor Values for Various Gains**

$R_F$ (k $\Omega$ )	$R_G$ (k $\Omega$ )	Gain
Short	None	1.00
49.9	49.9	2.00
80.6	20	5.03
90.9	10	10.09
95.3	5	20.06
97.6	2	49.8
100	1	101
200	1	201
499	1	500
1000	1	1001

While the ratio of  $R_F$  to  $R_G$  sets the gain, the designer determines the absolute value of the resistors. Larger values reduce power consumption and output loading; smaller values limit the FB input bias current or offset current error. For best performance, keep  $(R_F + R_G) \parallel R_L \geq 20$  k $\Omega$ .

**Compensating Errors from the FB Pin Bias Current and Input Impedance**

Cutting the trace between the R4 pads and placing a resistor of  $RF \parallel RG$  in R4 limits errors from the FB pin bias current (see Figure 4). At higher gains, this resistor can be the same value as  $RG$ . Although the offset current of the AD8237 is the same as the bias current, this resistor still helps to compensate the error due to the common-mode input resistance and is therefore recommended.

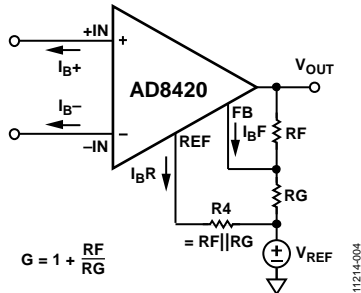


Figure 4. Cancelling Out Error from FB Input Bias Current

If the source resistance is well known, setting the parallel combination of  $RF$  and  $RG$  equal to  $R_S$  can be used to cancel differential input impedance errors. If practical resistor values force the parallel combination of  $RF$  and  $RG$  to be less than  $R_S$ , cut the trace between the R3 pads and insert a resistor to make up for the difference.

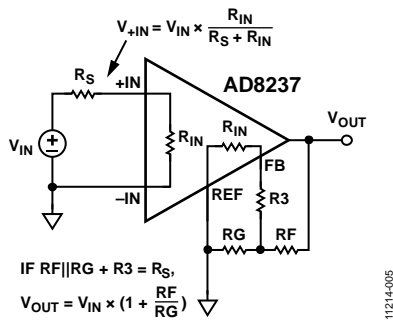


Figure 5. Canceling Input Impedance Errors

**Mode Switch**

By default, S1 is switched to the right (LO). For AD8237, this corresponds to low bandwidth mode. In low bandwidth mode, AD8237 is unity-gain stable and has a gain bandwidth product of 200 kHz. For gains greater than or equal to 10, S1 can be switched to the left (HI) to put the AD8237 in high bandwidth mode, which has a gain bandwidth product of 1 MHz. In high bandwidth mode, AD8237 is not stable for gains less than 10.

For the AD8420, Pin 1 is listed as a no connect pin; however, it is high impedance and may be shorted to either supply. Setting S1 to LO matches the parasitic capacitance at the inputs, allowing the best common-mode rejection ratio (CMRR) vs. frequency.

**RFI Filtering**

An RFI filter is formed by  $R1$  and  $R2$  with  $C1$ ,  $C2$ , and  $C3$ . RFI signals can be filtered with a low-pass RC network placed at the input of the instrumentation amplifier, such as the one shown in Figure 6, where  $C1 = C2 = C_C$ ,  $C3 = C_D$ , and  $R1 = R2 = R$ . The filter limits the input signal bandwidth according to the following relationship:

$$FilterFrequency_{DIFF} = \frac{1}{2\pi R(2C_D + C_C)}$$

$$FilterFrequency_{CM} = \frac{1}{2\pi RC_C}$$

where  $C_D \geq 10 C_C$ .

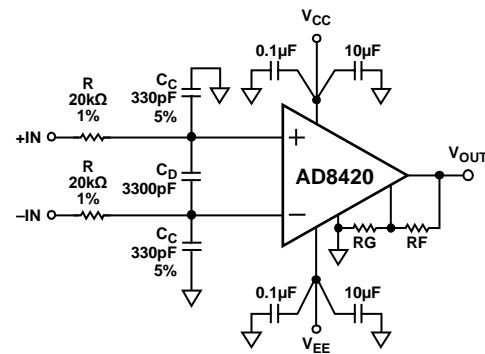


Figure 6. RFI Filtering

$C_D$  affects the differential signal, and  $C_C$  affects the common-mode signal. Values of  $R$  and  $C_C$  are chosen to minimize out of band RFI at the expense of reduced signal bandwidth. Mismatch between the  $R \times C_C$  at the positive input and the  $R \times C_C$  at the negative input degrades the CMRR of the in-amp. By using a value of  $C_D$  that is at least one magnitude larger than  $C_C$ , the effect of the mismatch is reduced and performance is improved.

The AD8237 has an internal RFI filter that is sufficient for most applications. Nonetheless, an external RFI filter can be added if additional immunity is necessary.

$R1$  and  $R2$  can also be used for input protection or to simulate the source resistance expected in an application. Alternatively, input attenuators can be formed with  $R1$  and a resistor in the place of  $C1$ , and/or  $R2$  and a resistor in the place of  $C2$ . A differential attenuator can be formed with  $R1$ , a resistor in the  $C3$  position, and  $R2$ .

**Other Board Options**

A capacitor in CF1, which is parallel with RF, can be used to reduce the gain at high frequencies and therefore reduce noise. If R5 is installed instead of RG, the following transfer function results:

$$V_{OUT} = G(V_{+IN} - V_{-IN} + V_{REF})$$

Where  $G = 1 + (RF/R5)$

In this case,  $V_{OUT}$  is measured with respect to ground. This transfer function can be useful in certain cases, such as electrocardio gram (ECG) circuits that require high gain and dc removal. This configuration on the evaluation board is generally most useful when a dual supply is used. See the Applications Information section for the AD8420 data sheet or the AD8237 data sheet for more information.

**REFERENCE**

The reference level of the instrumentation amplifier can be set by driving the REF pin with an amplifier or voltage reference, a dc source, or even a resistor divider (see the AD8420 data sheet or the AD8237 data sheet for further information). By default, W1 is in place and REF is shorted to ground. If a reference voltage other than ground is used, remove the solder from W1 before driving REF with the reference voltage, as shown in Figure 7.

**INPUT**

Do not leave the in-amp inputs floating, that is, without a dc return path for the bias current. This often occurs when the inputs are connected to a transformer, a thermocouple, or a pair of series capacitors. The inputs must have a dc path to ground, as shown in Figure 7 and Figure 8.

The circuit shown in Figure 8 has series capacitors, C, between the signal generator and the input. The series capacitors act as an open circuit at dc; therefore, they prevent a dc current from flowing into the input transistors of the in-amp. Two 10 kΩ resistors are used between the inputs of the in-amp and ground to provide the necessary current path. Closely match the resistors and capacitors in the positive and negative signal path to optimize CMRR.

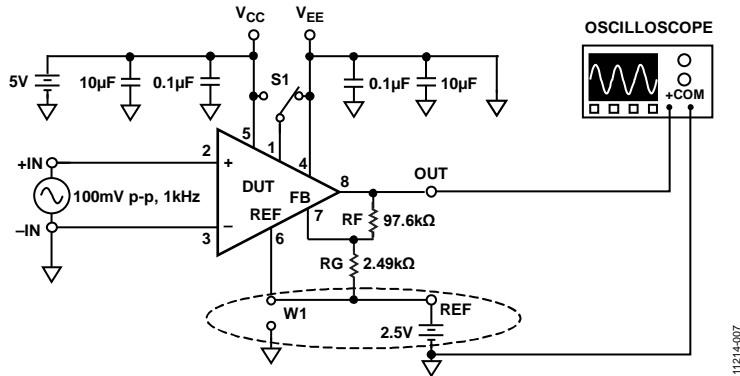


Figure 7. Using an External Voltage Source to Set the Reference Level (See Encircled)

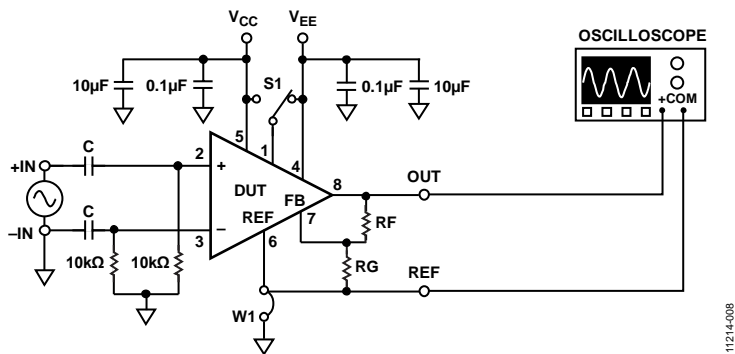


Figure 8. AC Input Coupling, Using a Resistive DC Return Path

**OUTPUT**

Measure the output voltage by monitoring the voltage between the OUT and REF tie points of the board, as shown in Figure 9. If an external voltage reference is used, the output can be measured, referred to ground, as shown in Figure 7. The evaluation board offers two SMA/SMB outlines at the output, VOUTP and VOUTN. The cable shields for VOUTP and VOUTN are both connected to ground. The voltage in the signal conductor of VOUTN is selectable by Solder Jumper W2. By default, the output voltage at VOUTN is  $V_{REF}$ . If the REF pin is being driven but ground must be passed to the next stage, such as a pseudo-differential ADC, the default solder jumper can be removed, and VOUTN can be shorted to ground. Take care that the voltage source driving REF does not become inadvertently shorted to ground during this process.

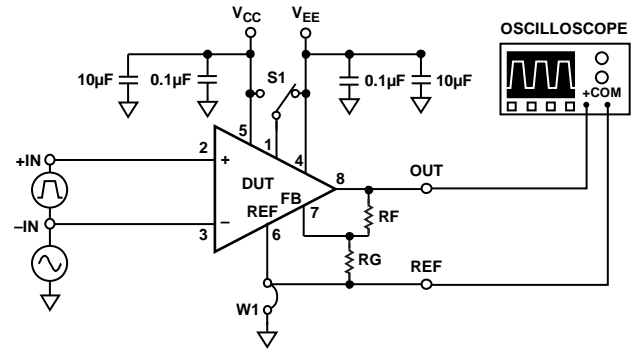


Figure 9. Correct Output Connection Using the REF Pin

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## NOTES

**ESD Caution**

**ESD (electrostatic discharge) sensitive device.** Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

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