

**Evaluating the AD8411A, -2 V to 70 V Wide Input Voltage Range, 2.7 MHz High Bandwidth,  
Current-Sense Amplifier with PWM Rejection and Gain 50 V/V**

## FEATURES

- ▶ Enables quick breadboarding and prototyping
- ▶ Easily configurable for unidirectional or bidirectional operation
- ▶ Includes provision for current-sense shunt resistor
- ▶ Easy connection to test equipment
- ▶ Includes provisions for an input filter and an output filter
- ▶ Decoupled supply line

## EVALUATION KIT CONTENTS

- ▶ AD8411ARM-EVALZ evaluation board

## DOCUMENTS NEEDED

- ▶ [AD8411A](#) data sheet

## GENERAL DESCRIPTION

The AD8411ARM-EVALZ is designed to aid in the evaluation of the AD8411A current-sense amplifier. These boards are designed for easy configuration of different modes of operation and allow flexibility with loads. A shunt resistor (R1), with a maximum standard size of 2818, can be soldered to the board.

The AD8411ARM-EVALZ accommodates the AD8411A in a mini small outline package (MSOP).

Full specifications on the [AD8411A](#) are available in the AD8411A data sheet available from Analog Devices, Inc., and must be consulted with this user guide when using the AD8411ARM-EVALZ evaluation board.

**TABLE OF CONTENTS**

Features.....	1	Power Supplies.....	4
Evaluation Kit Contents.....	1	Components.....	4
Documents Needed.....	1	Setting the Reference Voltage.....	4
General Description.....	1	Input Filter.....	5
AD8411ARM-EVALZ Evaluation Board		Evaluation Board Schematic.....	6
Photographs.....	3	Ordering Information.....	7
Quick Start.....	4	Bill of Materials.....	7

**REVISION HISTORY****4/2023—Revision 0: Initial Version**

AD8411ARM-EVALZ EVALUATION BOARD PHOTOGRAPHS

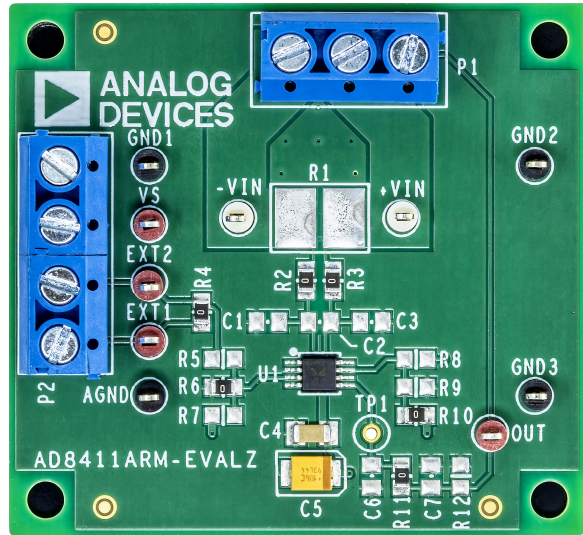


Figure 1. AD8411ARM-EVALZ Top View

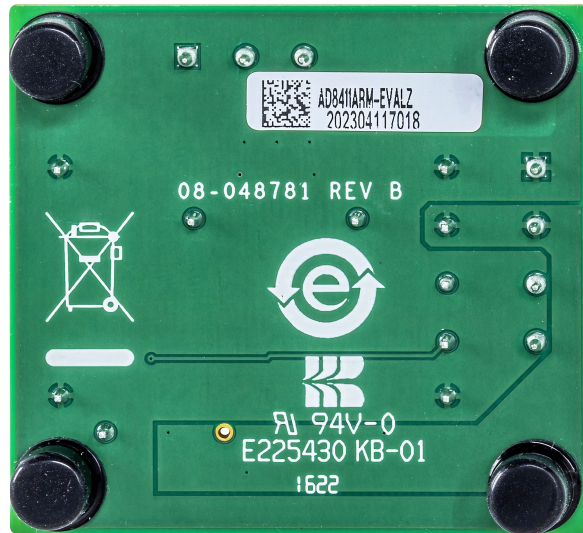


Figure 2. AD8411ARM-EVALZ Bottom View

**QUICK START**

By default,  $V_{REF1}$  is connected to  $V_S$ , and  $V_{REF2}$  is connected to the GND pin. This split supply configuration sets the output to midsupply and allows bidirectional current sensing. Connect 5 V to the  $V_S$  test point on the evaluation board, connect the ground of the supply to the AGND test point on the evaluation board, and place a 0.04 V differential voltage between the +VIN test point and the -VIN test point on the evaluation board. This small 0.04 V differential input voltage represents the voltage drop across the shunt resistor that is used in the application.

$$V_{OUT} = (2.5V + (V_{DIFF} \times GAIN)) \tag{1}$$

After the evaluation board is powered, the output reads as:

$$4.5V = (2.5V + (0.04V \times 50V/V)) \tag{2}$$

Then swap the input differential voltage leads (move the lead on the +VIN test point to the -VIN test point and move the lead that was on the -VIN test point to the +VIN test point). The output then reads as:

$$0.5V = (2.5V - (0.04V \times 50V/V)) \tag{3}$$

**POWER SUPPLIES**

The AD8411A has a power-supply operating range from 2.9 V to 5.5 V. Power is applied to the  $V_S$  test point. Decoupling capacitors of 10  $\mu$ F and 0.1  $\mu$ F are preinstalled on the evaluation board.

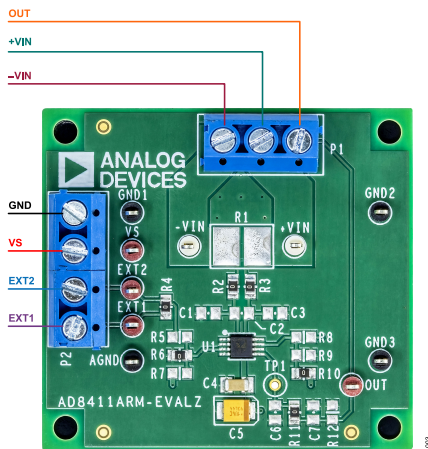


Figure 3. Connections to Terminal Blocks

**COMPONENTS**

The AD8411A can be used for a variety of current monitoring applications. The AD8411ARM-EVALZ has a provision for a current-sense shunt resistor with a maximum standard size of 2818. There are also provisions with 0805 footprints for a capacitive-load, a resistive load, an input electromagnetic interference (EMI) filter, an output filter, and provisions to set the reference voltage. Terminal blocks (P1 and P2) are provided to allow easy wiring and evaluation.

**SETTING THE REFERENCE VOLTAGE**

Three resistor spaces (R5, R6, and R7) are on the left side of the AD8411A on the AD8411ARM-EVALZ. These three resistors are used to set  $V_{REF2}$ . Fill only one of these resistor spaces at a time with a 0  $\Omega$ , 0805 resistor. See Table 2 for the resistors that must be filled with 0  $\Omega$  resistor to set  $V_{REF2}$ .

Three resistor spaces (R8, R9, and R10) are on the right side of the AD8411A on the AD8411ARM-EVALZ. These three resistors are used to set  $V_{REF1}$ . Fill only one of these resistor spaces at a time with a 0  $\Omega$ , 0805 resistor. See Table 1 for the resistors that must be filled with 0  $\Omega$  resistor to set  $V_{REF1}$ .

Table 1.  $V_{REF1}$  Pin Connections

Pin	R8	R9	R10
$V_S$	X	X	✓
GND	X	✓	X
EXT1	✓	X	X

Table 2.  $V_{REF2}$  Pin Connections

Pin	R5	R6	R7
$V_S$	X	X	✓
GND	X	✓	X
EXT2	✓	X	X

**Unidirectional Operation**

For unidirectional operation, the output can be set at the negative rail (near ground) or at the positive rail (near the supply voltage) when the differential voltage is 0 V. To set the AD8411ARM-EVALZ for a ground-referenced output, solder the 0  $\Omega$  resistor on the left side of the AD8411A in the R6 space and the 0  $\Omega$  resistor on the right side of the AD8411A in the R9 space.

To set the AD8411ARM-EVALZ for a supply voltage referenced output, solder the 0  $\Omega$  resistor on the left side of the AD8411A in the R7 space and the 0  $\Omega$  resistor on the right side of the AD8411A in the R10 space.

**Bidirectional Operation**

For a bidirectional operation, the output is typically set at half-scale for an equal range in both directions. To configure the output to be at midsupply in the presence of 0 A of current through the shunt resistor on the AD8411ARM-EVALZ, solder the 0  $\Omega$  resistor on the left side of the AD8411A in the R6 space and the 0  $\Omega$  resistor on the right side of the AD8411A in the R10 space.

By default, the output of the AD8411ARM-EVALZ is biased at midsupply.

Table 3 shows which resistor must be filled with 0  $\Omega$  resistor to set the AD8411ARM-EVALZ for different operations. In unidirectional operation, it can be ground-referenced output and supply

## QUICK START

voltage-referenced output, whereas, in the bidirectional operation, the output can be set to midsupply.

**Table 3. Operation Connection**

Mode	R6	R7	R9	R10
UNIDIRECTIONAL				
Ground Referenced	✓	×	✓	×
Supply Voltage Referenced	×	✓	×	✓
BIDIRECTIONAL				
Midsupply	✓	×	×	✓

### External Referenced Output

An external supply can also be used to set the reference voltage. To bias the output to a single external supply, solder a 0 Ω, 0805 resistor in the R4 space. Then, solder the 0 Ω resistor on the left side of the AD8411A in the R5 space and solder the 0 Ω resistor on the right side of the AD8411A in the R8 space. The external supply voltage can then be applied to any one of the EXT<sub>x</sub> test points on the evaluation board, and this configuration biases the output to the external supply.

The external supply can also be divided by 2 and used as a reference level. For this reference level, solder the 0 Ω resistor on the left side of the AD8411A in the R6 space, desolder the resistor in the R4 space, and solder the 0 Ω resistor on the right side of the AD8411A in the R8 space. Apply the external supply to the EXT1 test point or EXT1 terminal block input, and the output of the AD8411A is referenced to half of the external supply.

Two separate external supplies can also be used to set the reference for the output. Desolder the 0 Ω resistor from the R4 space. Solder the 0 Ω resistor on the left side of the AD8411A in the R5 space and solder the 0 Ω resistor on the right side of the AD8411A in the R8 space. Apply the first external supply, V<sub>EXT1</sub>, to the EXT1 test point or EXT1 terminal block input. Apply the second external supply, V<sub>EXT2</sub>, to the EXT2 test point or EXT2 terminal block input. This configuration references the output to:

$$\frac{(V_{EXT1} + V_{EXT2})}{2} \quad (4)$$

### INPUT FILTER

The AD8411ARM-EVALZ includes provisions for the components necessary for an input filter. By default, R2 and R3 are 0 Ω, 0805 resistors and C1, C2, and C3 are left unpopulated. It is required to filter at the input of the device to reduce EMI. The EMI specifications vary depending on the application. Filtering at the input must be preferred if the output cannot be filtered because filtering at the output changes the low output impedance seen by the components attached to the output of the AD8411A. The +IN and –IN inputs of the AD8411A has balanced input bias currents. This means that the input series resistors, R2 and R3, must be the same measured value not to have a large offset voltage added to the output of the

device as a result of R2 and R3. It is recommended to keep R2 and R3 below 100 Ω.

The EMI filter has two different bandwidths, common-mode ( $BW_{CM}$ ) and differential ( $BW_{DIFF}$ ). The differential bandwidth defines the frequency response of the filter with a differential input signal applied between the two inputs of the amplifier, which are +IN and –IN. C1 and C3 must be the same value for the following equations.

The –3 dB differential bandwidth for the filter is:

$$BW_{DIFF} = \frac{1}{2\pi \times R2 \times ((2 \times C2) + C1)} \quad (5)$$

The common-mode bandwidth defines what a common-mode RF signal experiences between ground and the +IN and –IN inputs of the amplifier tied together.

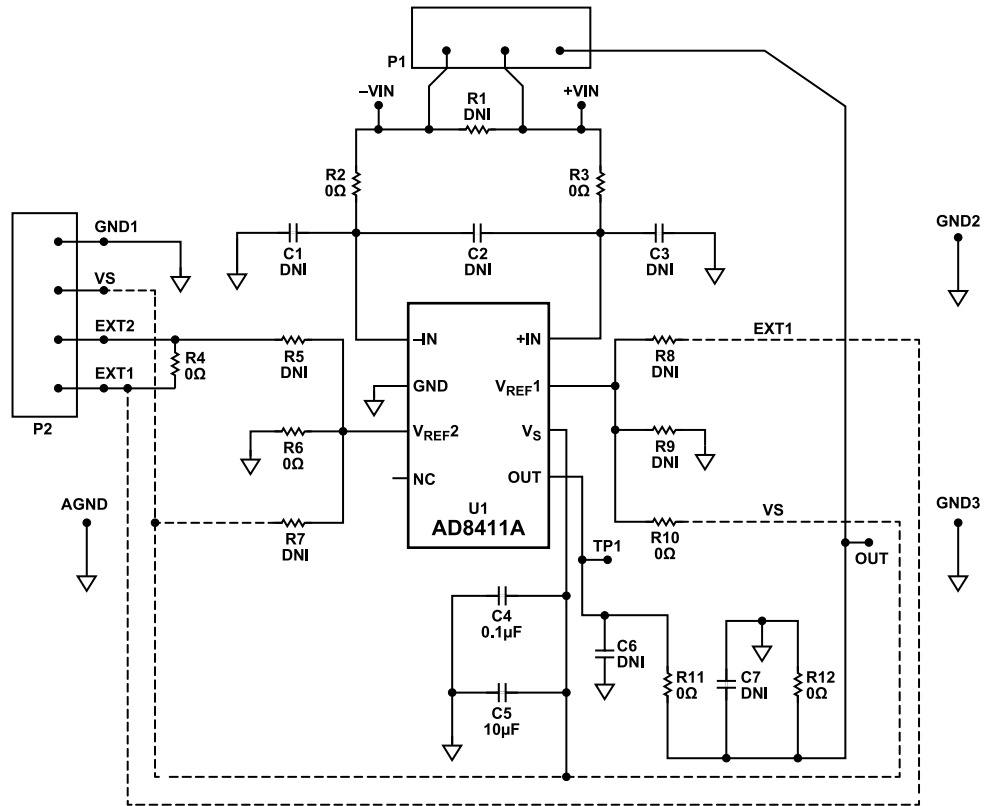
The –3 dB common-mode bandwidth for the filter is:

$$BW_{CM} = \frac{1}{2\pi \times R2 \times C1} \quad (6)$$

Keep the resistor values to a 1% tolerance and the filter capacitors to a 5% tolerance to assist with reducing AC common-mode rejection (CMR) errors. Choose C2 to be at least 10× larger than C1 or C3 to reduce AC CMR errors, which are caused by component mismatching.

Figure 1 shows the top view and Figure 2 shows the bottom view of the AD8411ARM-EVALZ. Figure 4 shows the default schematic of the AD8411ARM-EVALZ. The dotted lines in the AD8411ARM-EVALZ schematic are routed under the printed circuit board (PCB).

EVALUATION BOARD SCHEMATIC



NOTES  
 1. DOTTED LINES ARE ROUTED UNDER THE BOARD.

001

Figure 4. AD8411ARM-EVALZ Schematic

## ORDERING INFORMATION

## BILL OF MATERIALS

Table 4. Bill of Materials

Item	Quantity	Reference Designator	Part Description	Manufacturer, Part Number
1	1	U1	IC, High voltage, high bandwidth, current-sense amplifier, automotive	Analog Devices Inc., AD8411AWBRMZ
2	2	+VIN, -VIN	Connectors-PCB, test point white	Keystone Electronics, 5002
3	4	AGND, GND1, GND2, GND3	Connectors-PCB, test point black	Keystone Electronics, 5001
4	1	C4	Capacitor, CER, 0.1 $\mu$ F, 50 V, 10%, X7R, 1206	Yageo, CC1206KRX7R9BB104
5	1	C5	Capacitor, TANT, 10 $\mu$ F, 16 V, 10%, 3528-20	AVX Corporation, TAJB106K016RNJ
6	4	EXT1, EXT2, OUT, VS	Connectors-PCB, test point red	Keystone Electronics, 5000
7	1	P1	Connector-PCB, terminal block VERT, 5 mm pitch	On Shore Technology, OSTTC030162
8	1	P2	Connector-PCB, terminal block, 5 mm pitch, 3.5 mm solder tail	On shore Technology, OSTTC040162
9	6	R2, R3, R4, R6, R10, R11	Resistors, SMD, 0 $\Omega$ , 1/10 W, 0805	Multicomp (SPC), MC 0.1 W 0805 0R
10	4	Standard Grip	Miscellaneous, Bumper cylindrical, size 0.312" Dia (7.92 mm), thickness 0.215" (5.46 mm), black with adhesive	3M, SJ61A6
11	5	C1, C2, C3, C6, C7	Not installed, Capacitors, C0805	Not Applicable
12	1	R1	Not installed, Resistor, 2818	Vishay, WSHM2818R0500FEA
13	5	R5, R7, R8, R9, R12	Not installed, Resistors, R0805	Not Applicable
14	1	TP1	Connector-PCB, test point black	Keystone Electronics, 5001

**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.

**Legal Terms and Conditions**

By using the evaluation board discussed herein (together with any tools, components documentation or support materials, the "Evaluation Board"), you are agreeing to be bound by the terms and conditions set forth below ("Agreement") unless you have purchased the Evaluation Board, in which case the Analog Devices Standard Terms and Conditions of Sale shall govern. Do not use the Evaluation Board until you have read and agreed to the Agreement. Your use of the Evaluation Board shall signify your acceptance of the Agreement. This Agreement is made by and between you ("Customer") and Analog Devices, Inc. ("ADI"), with its principal place of business at Subject to the terms and conditions of the Agreement, ADI hereby grants to Customer a free, limited, personal, temporary, non-exclusive, non-sublicensable, non-transferable license to use the Evaluation Board FOR EVALUATION PURPOSES ONLY. Customer understands and agrees that the Evaluation Board is provided for the sole and exclusive purpose referenced above, and agrees not to use the Evaluation Board for any other purpose. Furthermore, the license granted is expressly made subject to the following additional limitations: Customer shall not (i) rent, lease, display, sell, transfer, assign, sublicense, or distribute the Evaluation Board; and (ii) permit any Third Party to access the Evaluation Board. As used herein, the term "Third Party" includes any entity other than ADI, Customer, their employees, affiliates and in-house consultants. The Evaluation Board is NOT sold to Customer; all rights not expressly granted herein, including ownership of the Evaluation Board, are reserved by ADI. CONFIDENTIALITY. This Agreement and the Evaluation Board shall all be considered the confidential and proprietary information of ADI. Customer may not disclose or transfer any portion of the Evaluation Board to any other party for any reason. Upon discontinuation of use of the Evaluation Board or termination of this Agreement, Customer agrees to promptly return the Evaluation Board to ADI. ADDITIONAL RESTRICTIONS. Customer may not disassemble, decompile or reverse engineer chips on the Evaluation Board. Customer shall inform ADI of any occurred damages or any modifications or alterations it makes to the Evaluation Board, including but not limited to soldering or any other activity that affects the material content of the Evaluation Board. Modifications to the Evaluation Board must comply with applicable law, including but not limited to the RoHS Directive. TERMINATION. ADI may terminate this Agreement at any time upon giving written notice to Customer. Customer agrees to return to ADI the Evaluation Board at that time. LIMITATION OF LIABILITY. THE EVALUATION BOARD PROVIDED HEREUNDER IS PROVIDED "AS IS" AND ADI MAKES NO WARRANTIES OR REPRESENTATIONS OF ANY KIND WITH RESPECT TO IT. ADI SPECIFICALLY DISCLAIMS ANY REPRESENTATIONS, ENDORSEMENTS, GUARANTEES, OR WARRANTIES, EXPRESS OR IMPLIED, RELATED TO THE EVALUATION BOARD INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, TITLE, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. IN NO EVENT WILL ADI AND ITS LICENSORS BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES RESULTING FROM CUSTOMER'S POSSESSION OR USE OF THE EVALUATION BOARD, INCLUDING BUT NOT LIMITED TO LOST PROFITS, DELAY COSTS, LABOR COSTS OR LOSS OF GOODWILL. ADI'S TOTAL LIABILITY FROM ANY AND ALL CAUSES SHALL BE LIMITED TO THE AMOUNT OF ONE HUNDRED US DOLLARS (\$100.00). EXPORT. Customer agrees that it will not directly or indirectly export the Evaluation Board to another country, and that it will comply with all applicable United States federal laws and regulations relating to exports. GOVERNING LAW. This Agreement shall be governed by and construed in accordance with the substantive laws of the Commonwealth of Massachusetts (excluding conflict of law rules). Any legal action regarding this Agreement will be heard in the state or federal courts having jurisdiction in Suffolk County, Massachusetts, and Customer hereby submits to the personal jurisdiction and venue of such courts. The United Nations Convention on Contracts for the International Sale of Goods shall not apply to this Agreement and is expressly disclaimed.

