

## **INA210-214EVM User's Guide**

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This user's guide describes the characteristics, operation, and use of the INA210-214EVM evaluation module (EVM). This EVM is designed to evaluate the performance of the [INA210-214](#) voltage output current shunt monitors in a variety of configurations. The EVM layout and design are flexible enough to allow evaluation of a wide range of applications. This document also includes a schematic, reference printed circuit board (PCB) layouts, and a complete bill of materials.

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## 1 Introduction and Overview

### 1.1 INA210-214

The INA210-214 devices are voltage output, high-side measurement, bi-directional, zero-drift current shunt monitors. This family of devices has gains that range from 50V/V to 1000V/V. The voltage developed across the device inputs is amplified by the corresponding gain of the specific device and is presented at the output pin. These devices can sense voltage drops across shunts at common-mode voltages from  $-0.3\text{V}$  to  $26\text{V}$ , independent of supply voltages. These devices operate with supply voltages between  $2.7\text{V}$  and  $26\text{V}$  and draw a maximum of  $100\mu\text{A}$ . The low offset of the zero-drift architecture enables current sensing with maximum drops across the shunt as low as  $10\text{mV}$  full-scale.

The INA210-214 devices are currently available in an SC70 surface-mount package. [Table 1](#) summarizes the available device options.

**Table 1. INA210-214 Device Summary**

Product	Gain
INA210	200
INA211	500
INA212	1000
INA213	50
INA214	100

### 1.2 INA210-214EVM

The INA210-214EVM is intended to provide basic functional evaluation of this device family. The fixture layout is not intended to be a model for the target circuit, nor is it laid out for electromagnetic compatibility (EMC) testing.

The layout of the INA210-214EVM printed circuit board (PCB) is designed to provide the following features:

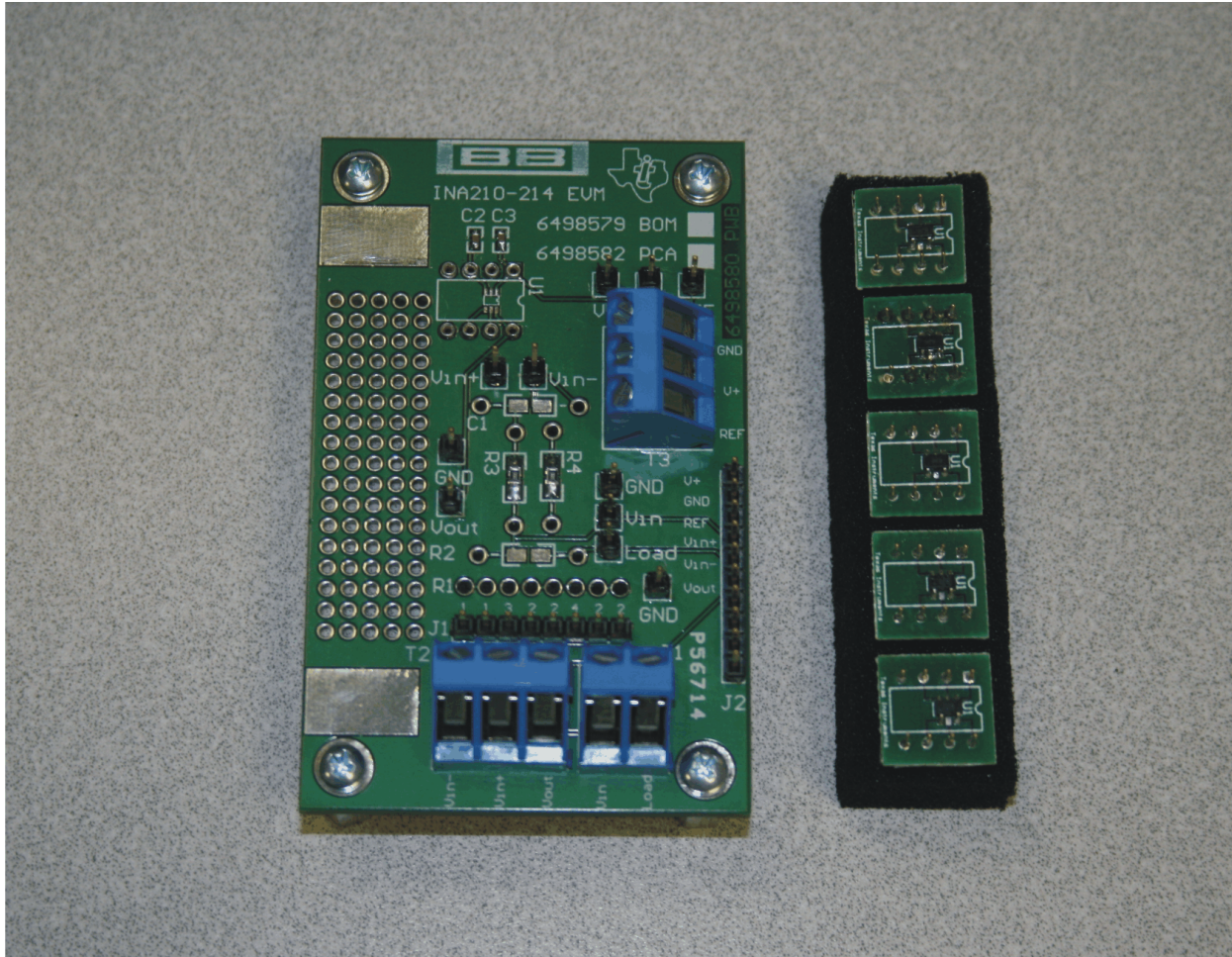
- Easy handling of the small package; a mechanical drawing of the recommended land pattern is found at the end of the [product data sheet](#).
- Easy access to all device pins
- Space for optional input filtering capacitors and resistors as well as a prototype area for additional user defined circuitry
- Space for shunt resistors of various footprints
- Multiple input signal options
- Evaluation of all gain options through provided device boards as well as a location to solder a test device directly onto the board

The INA210-214EVM allows the user to install a shunt resistor, and then connect both the common-mode voltage and load to develop the input voltage, or omit the shunt resistor and apply a differential voltage directly to the device input. This flexibility allows a user to test the device operation in a simulated manner as well as an actual application.

Refer to the [INA210-214 product data sheet](#) for comprehensive information about the INA210-214 family of devices.

### 1.3 Hardware Included

The initial release of this evaluation board and user's guide may precede the actual release of some members of the INA210-214 device family. As additional devices with the family are released, the INA210-214EVM evaluation board will be associated with them. A test fixture populated with an INA210 is provided in all INA210-214EVMS delivered, as [Figure 1](#) shows.



**Figure 1. Hardware Included with the INA210-214EVM**

The INA210-214EVM kit is shipped with the following items:

- INA210-214EVM PCB
- Five populated test boards (INA210, INA211, INA212, INA213, INA214)

If any of these items are missing or damaged, please contact the Texas Instruments Product Information Center nearest you to inquire about a replacement.

## 2 Quick Start Setup and Use

Follow these procedures to set up and use the INA210-214EVM.

- Step 1. Insert the device board to be evaluated into the U1 location. The U1 location allows the user to either evaluate one of the provided device boards or install the test device directly on the surface-mount pads in the U1 footprint.
- Step 2. Connect an external dc supply voltage between 2.7V and 26V to the V+ terminal referenced to the GND terminal of T3. The INA210-214 device output voltage is limited to 50mV above ground to 200mV below the supply level.
- Step 3. Connect the REF terminal of T3 to ground. The voltage applied at the reference input can vary depending on how the device is to be used. Further details regarding the use of the reference voltage are discussed later in this document.
- Step 4. Connect the input.

### 2.1 Measurement with Shunt

This connection method allows the user to install a shunt resistor on the EVM and connect the common-mode voltage and load to incorporate the test device directly into a sample application, as [Figure 2](#) shows. To configure a measurement evaluation with a shunt, follow these procedures.

1. Install a shunt resistor into the R2 location. If not using a surface-mount or through-hole shunt, please refer to [Section 3.1](#) for a summary of R1 component specifications.
2. Connect the common-mode voltage to the  $V_{IN}$  terminal of T1.
3. Connect load to the Load terminal of T1.

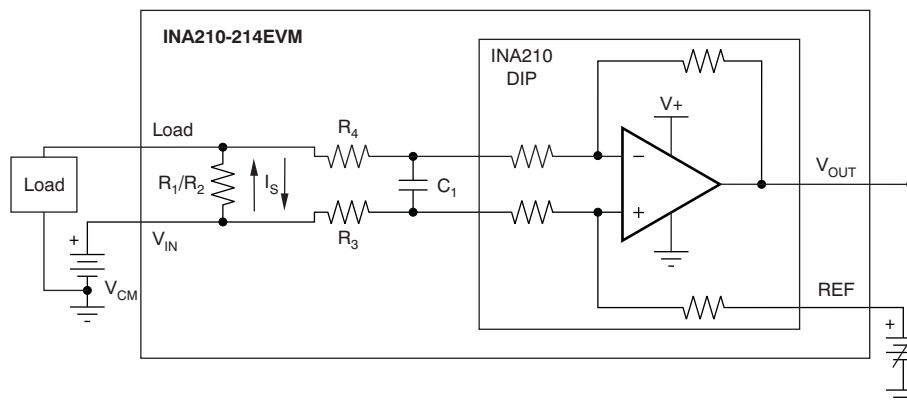


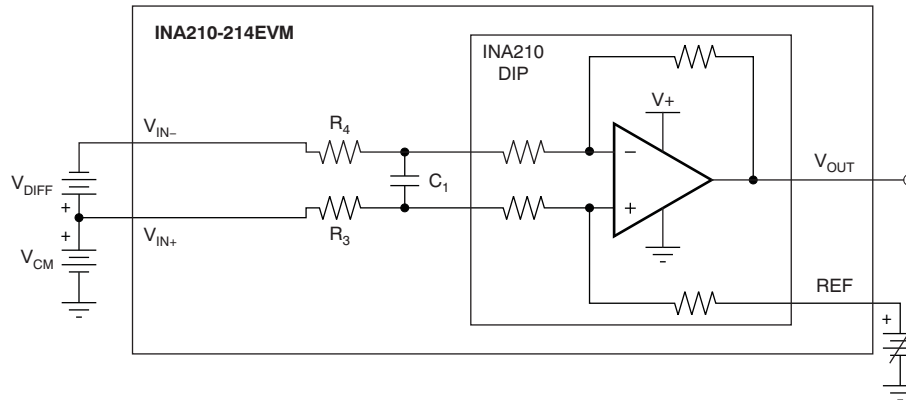
Figure 2. Measurement with Shunt

## 2.2 Measurement without Shunt

This connection method allows the user to either simulate the voltage developed across a sense resistor based on a given set of system conditions, or to connect the INA210-214EVM remotely to an existing shunt already included in an example application. Figure 3 illustrates a measurement configuration without a shunt.

To configure a measurement evaluation without a shunt, follow these procedures.

1. Connect a differential voltage to the  $V_{IN+}$  and  $V_{IN-}$  terminals of T2. With the reference voltage set at ground, ensure that the  $V_{IN+}$  terminal is the more positive of the two inputs.
2. Measure the output voltage at the  $V_{OUT}$  terminal of T2.



**Figure 3. Measurement without Shunt**

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**Note:** The output voltage is equal to the gain of the device multiplied by the differential voltage measured directly at the device input pins.

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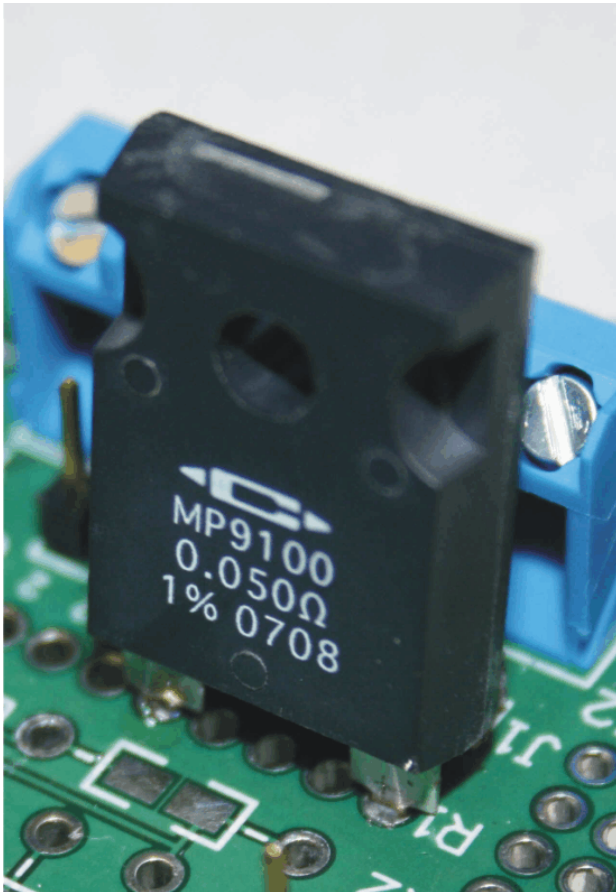
### 3 INA210-214EVM Circuit

This section summarizes the INA210-214EVM components.

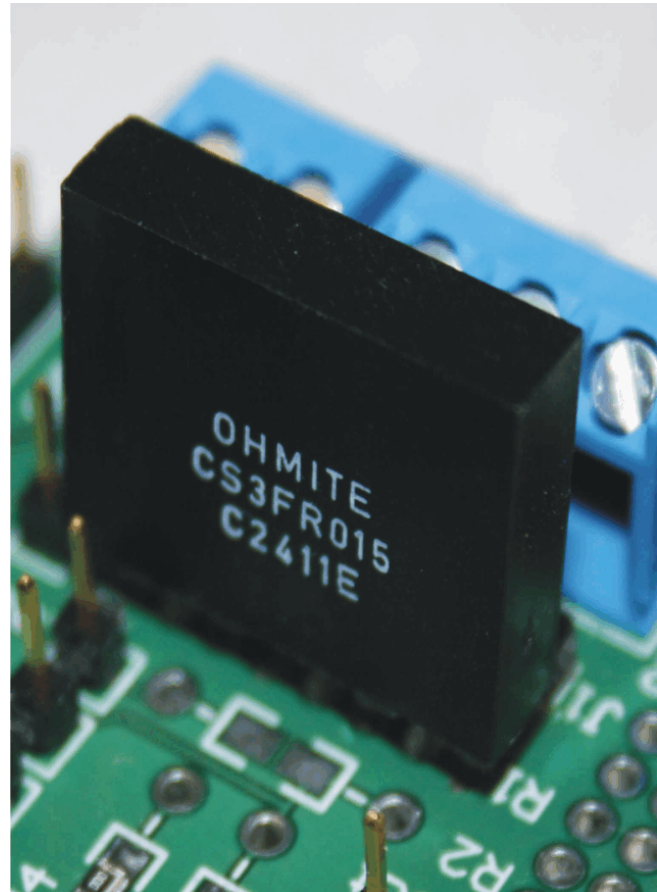
#### 3.1 R1

R1 can be used for shunt resistors that have a package that may not be easily adaptable to a standard, two-terminal, through-hole footprint or to a 0603 through 1206 surface-mount footprint. Specifically, this component location was added to allow the use of TO-126, TO-220, TO-247, and four terminal inline radial packages such as the CS3 series of shunts from Ohmite. The numbers located on the printed circuit board (PCB) between R1 and J1 correspond to each of the holes in the R1 footprint. Holes with the same number are connected together. The designation of 1 and 2 indicates that a particular hole is connected directly to the  $V_{IN+}$  and  $V_{IN-}$  inputs, respectively. The designation of 3 and 4 indicates that a particular hole is intended for the sense measurement of a four-wire shunt. Care must be taken to ensure that the shunt is placed in the correct position in the R1 location. This placement consideration is evident when using a two-connection shunt with a spacing of 200 mils (.200in or 5,080mm). As shown in [Figure 4](#) and [Figure 7](#), the shunt must be placed in the second 1-designated hole in order for the other leg to fit into the 2 position. If the shunt is placed in the first 1 position, the second leg is left floating; no differential voltage will be generated for the current monitor.

Additional packages can be tested by using the provided prototype area of the board.



**Figure 4. TO-247 Package In R1**



**Figure 5. CS3 Package in R1**



Figure 6. TO-126 Package in R1

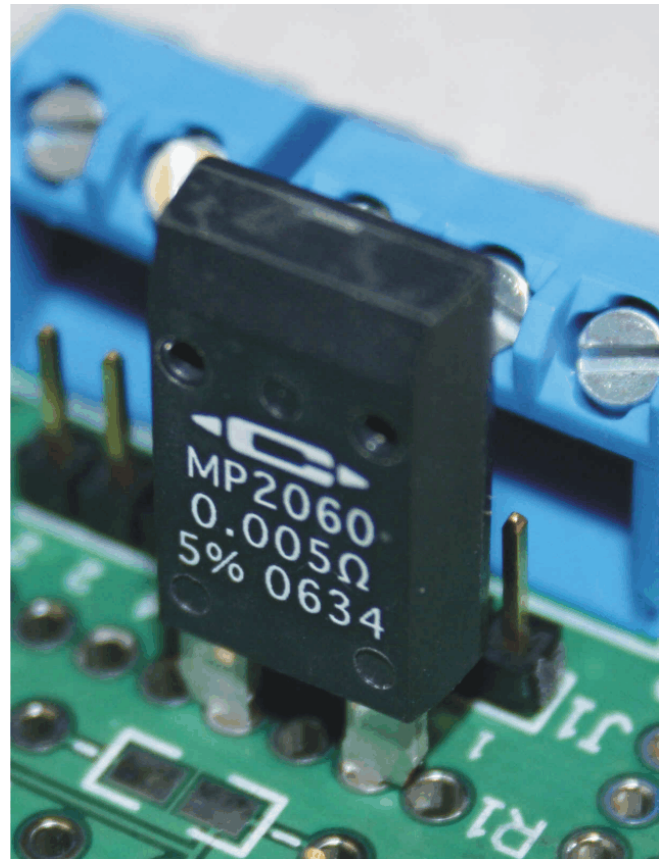
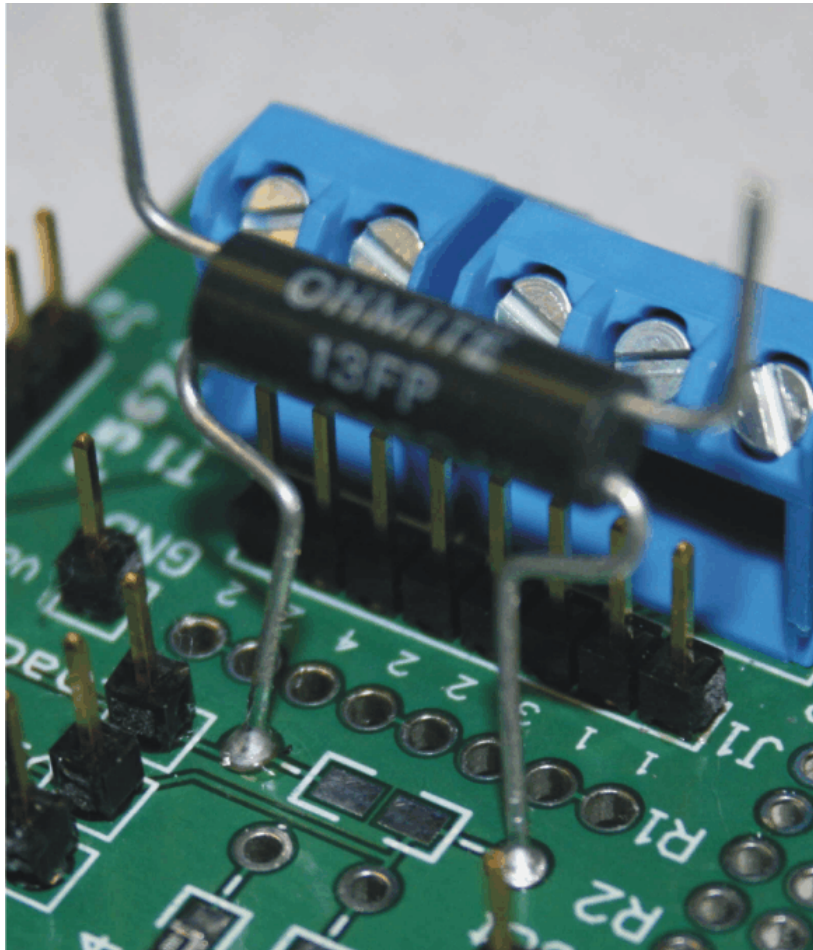


Figure 7. TO-220 Package in R1

### 3.2 R2

R2 is intended to handle two- and four-terminal radial packages (as [Figure 8](#) shows) as well as surface-mount packages that range in size from 0603 to 1206.



**Figure 8. Radial Package in R2**



### 3.3 R3, R4, C1

R3 and R4 are factory-installed 0Ω resistors. These resistors, in combination with C1, form an input filter. These locations allow for both through-hole and surface-mount packages that range in size from 0603 to 1206. Additional information regarding the use of input filtering is provided in the [INA210-214 product data sheet](#).

### 3.4 Bypass Capacitors and Jumpers

C2 and C3 are 0.1μF supply bypass capacitors.

J1 is intended to be used as measurements points of R1, if necessary.

J2 is used as a test port at the factory but can be used for the corresponding input and output pins, if desired.

### 3.5 U1

U1 is the location for the test device. Five device boards are supplied with the INA210-214EVM board. Each board is populated with one of the available device gains. This interchangeable option allows users to test the devices and determine the gain setting that is best suited for a given application.

Here is a list of the factors involved in selecting the appropriate device.

- The INA210-214 devices are identical with the exception of different gain settings.
- The differential input voltage is either applied across the inputs or developed based on the load current that flows through the shunt resistor.
- The limiting factor that requires attention to be given to device selection is the output voltage.
- The selected device must allow the output voltage to remain within the acceptable range after the developed input voltage is amplified by the respective device gain. The output voltage must remain with the range of 50mV above ground to 200mV below the supply voltage.
- An output below the minimum allowable output requires the selection of a device with a higher gain. Likewise, an output above the maximum allowable output requires the selection of a device with a lower gain.

In addition to being able to accommodate the device boards, a surface-mount footprint is also included so the user can install one of these devices directly onto the board, if desired. [Figure 9](#) illustrates the U1 footprint on the EVM. [Figure 10](#) shows the U1 slot populated with a DIP board device.

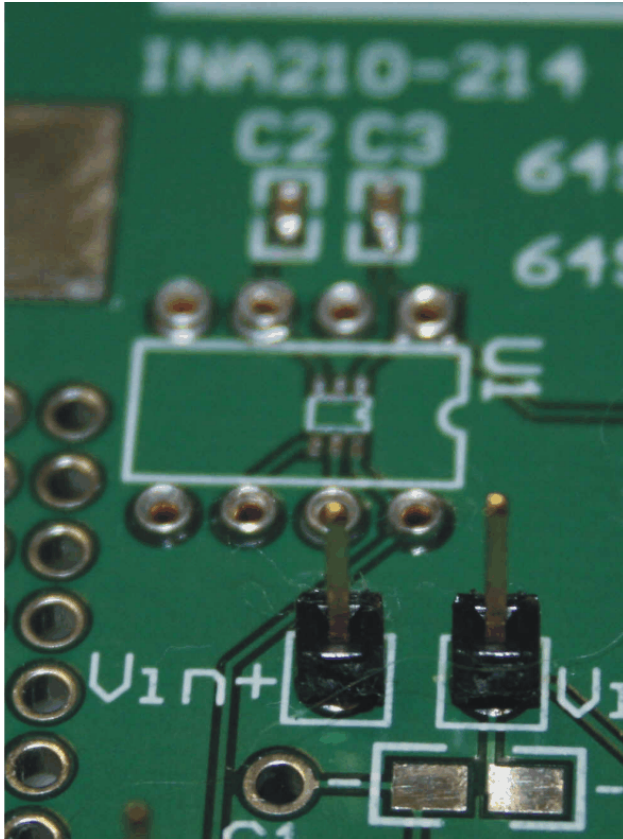


Figure 9. U1 Footprint

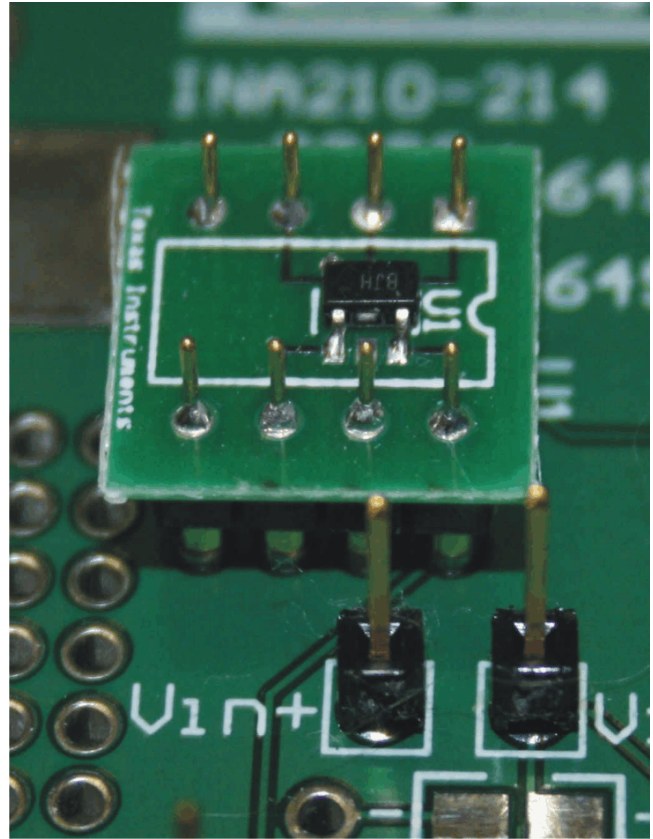


Figure 10. U1 Populated with DIP Board

### 3.6 Voltage Inputs

The  $V_{IN+}$  and  $V_{IN-}$  terminals of T2 are intended to be used if the designer is configuring the EVM for measurement without an onboard shunt resistor (see [Figure 3](#)). These inputs accept a differential voltage that is amplified by the selected device gain and is presented at the  $V_{OUT}$  terminal of T2. These inputs could also be used to connect the differential voltage developed across an external shunt in an existing circuit. The acceptable differential input voltage range and polarity are determined by the supply voltage, reference voltage, and gain of the selected device.

$V_{IN}$  and Load terminals of T1 are intended to be used if the user configures the EVM for measurement with a shunt resistor (see [Figure 2](#)). The common-mode voltage should be connected to the  $V_{IN}$  terminal and the load should be connected to the Load terminal. The shunt can be installed in R1, R2, or the prototype area, and wired to the R2 footprint. As in the setup for the measurement without a shunt resistor, the input voltage range and polarity are determined by the supply voltage, reference voltage, and the gain of the selected device.

### 3.7 Miscellaneous

The REF terminal of T3 allows the user to configure the INA210-214EVM for either unidirectional or bi-directional operation

Two easily accessible oscilloscope ground pads are located on the board to facilitate easier probing.

## 4 Reference Voltage Setup

The INA210-214 devices allow for the use of an external reference. This reference determines how the output responds to certain input conditions. The reference also allows these devices to be used in both unidirectional and bi-directional applications.

### 4.1 Unidirectional Mode

*Unidirectional* refers to a load current that flows in only one direction. For unidirectional applications, the reference voltage can be set to ground or to +5V. If the reference is set to ground, the output is set at near ground with no input voltage, and responds to input voltages that are positive with respect to  $V_{IN-}/\text{Load}$ . If the reference is set to +5V, the output is set near +5V with no input voltage, and responds to input voltages that are negative with respect to  $V_{IN-}/\text{Load}$ .

### 4.2 Bi-directional Mode

*Bi-directional* refers to a load current that flows in both directions. [Figure 2](#) shows  $I_S$  flowing in both directions. For bi-directional applications, the reference voltage can be set anywhere within the 0V to 5V range specified for the reference input. The voltage applied to the reference pin establishes the output voltage of the device with no input voltage. The output voltage is limited by the supply voltage, so there is a greater available range for positive input voltages than negative voltages because the reference voltage is limited to the range of 0V to 5V.

The maximum range for the output of this device to accommodate a bi-directional application involves applying 5V to the reference pin and a supply voltage of 18V. This configuration allows for a maximum output voltage range of  $-4.95\text{V}/+20.8\text{V}$  about the 5V reference.

## 5 INA210-214EVM Schematic and PCB Layout

**Note:** Board layouts are not to scale. These figures are intended to show how the board is laid out; they are not intended to be used for manufacturing INA210-214EVM PCBs.

### 5.1 Schematic

Figure 11 shows the schematic for the INA210-214EVM PCB.

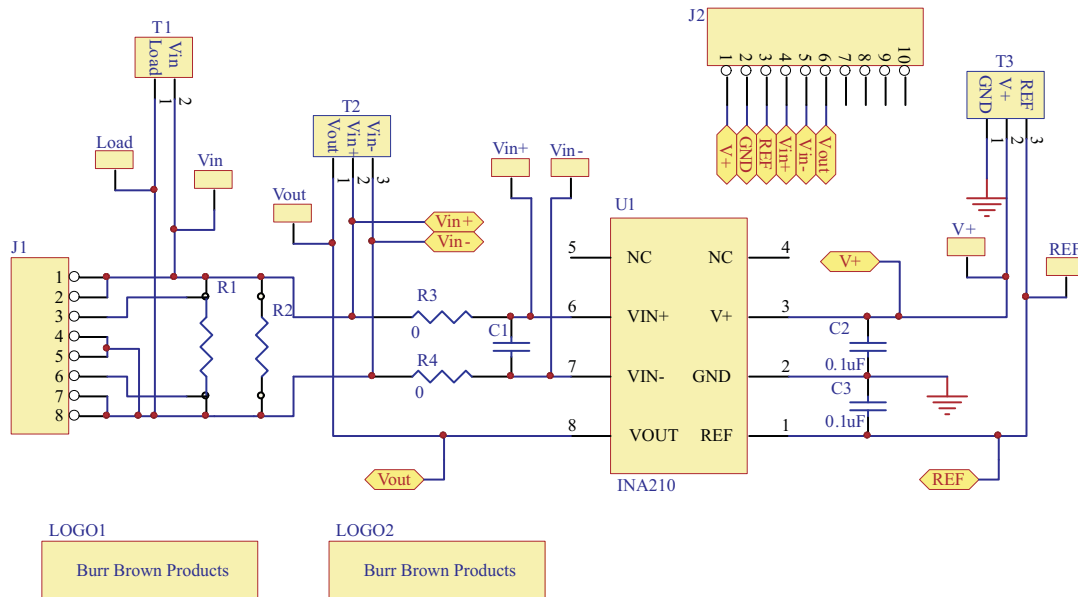


Figure 11. INA210-214EVM Schematic

## 5.2 PCB Layout

Figure 12 illustrates the PCB layout for the INA210-214EVM.

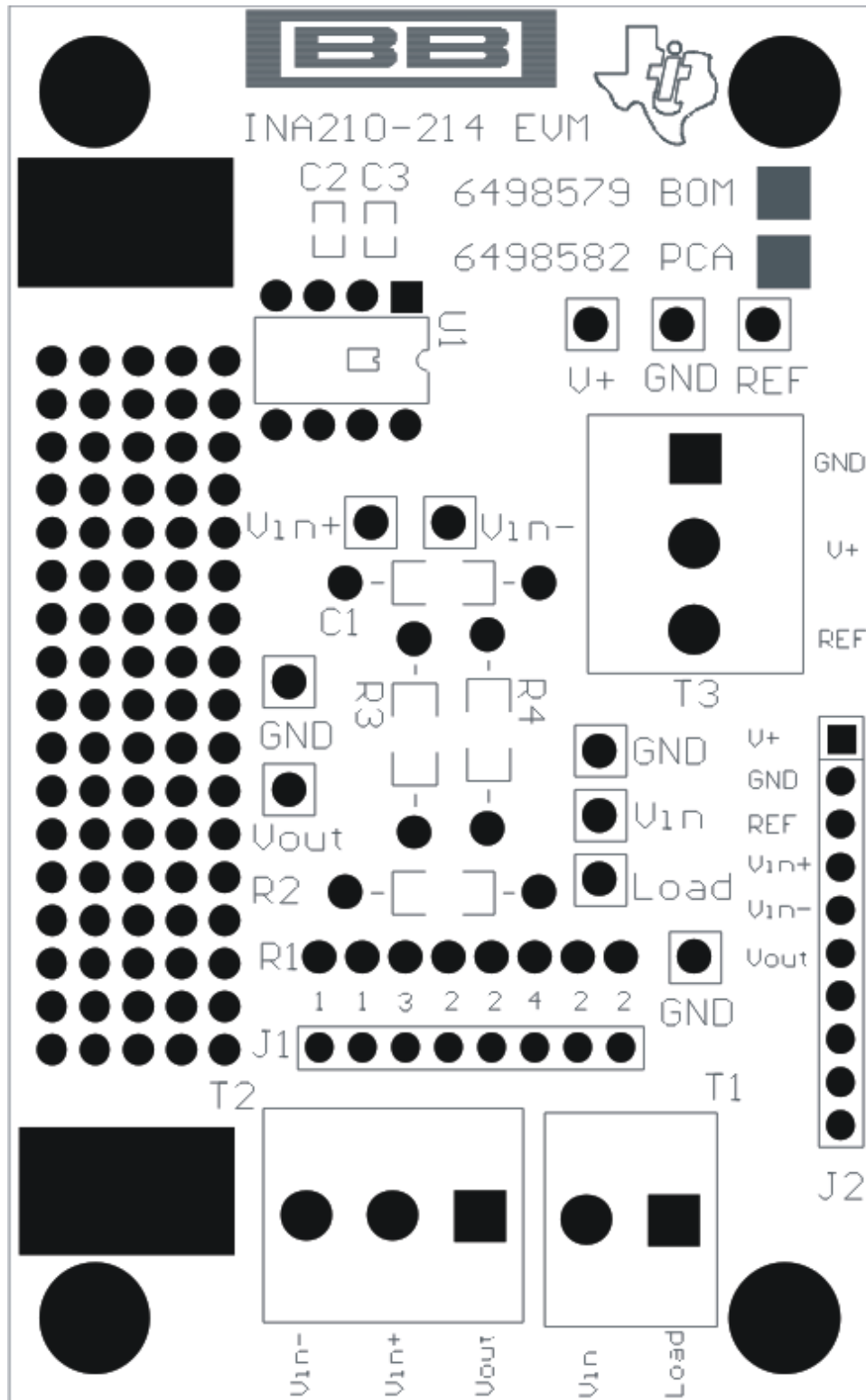


Figure 12. INA210-214EVM PCB

## 6 Bill of Materials

Section 7 provides the parts list for the INA210-214EVM.

**Table 7. Bill of Materials**

Count	RefDes	Value	Description	Part Number	MFR
Optional/Not Installed	R1	N/A	TO-126, TO-220, TO-247, C53		
Optional/Not Installed	R2	N/A	Resistor, 0603-1206/Through-hole		
2	R3, R4	0Ω	Resistor, 0Ω, 1/8W 5%, 0603-1206/Through-hole	ERJ-6GEY0R00V	Panasonic - ECG
Optional/Not Installed	C1	N/A	Capacitor, 0603-1206/Through-hole		
2	C2, C3	0.1uF	Capacitor, 0.1μF 50V X7R, 0603	ECJ-1VB1H104K	Panasonic - ECG
2	J1, J2	Strip cut to size	Conn Header 32-POS .100" SGL GOLD (4 per Strip)	TSW-132-07-G-S	Samtec
11	All test points	TP cut to size	Conn Header 32-POS .100" SGL GOLD	TSW-132-07-G-S	Samtec
8	None	N/A	Pin Socket Rcpt .014-.026 30AU (U1)	5050863-5	AMP
4	None	N/A	Screw, Machine, Phillips, Panhead 4-40 x 1/4 SS	PMSSS 440 0025 PH	Building Fasteners
4	None	N/A	Standoffs, Hex , 4-40 Threaded, 0.500" length, 0.250" OD	2203	Keystone Electronics
5	INA210DIP - INA214DIP	N/A	Populated DIP-Adapter Board		Texas Instruments
2	T2, T3	N/A	3-Position Terminal Strip, Cage Clamp, 45°, 15A, Dove-tailed	ED300/3	On Shore Technology
1	T1	N/A	2-Position Terminal Strip, Cage Clamp, 45°, 15A, Dove-tailed	ED300/2	On Shore Technology

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### EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of  $-0.3V$  to  $+26V$  and the output voltage range of  $-0.3V$  to  $+26V$ .

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  $+25^{\circ}C$ . The EVM is designed to operate properly with certain components above  $+25^{\circ}C$  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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