

ABSTRACT

This user's guide describes the characteristics, operation, and use of the INA190-EP evaluation module (EVM). This EVM is designed to evaluate the performance of the INA190-EP voltage-output, current shunt monitor in a variety of configurations. This document also includes a schematic, reference printed circuit board (PCB) layouts, and a complete bill of materials (BOM).

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1 Overview

The INA190-EP devices are voltage output, high- and low-side measurement, bidirectional, zero-drift current shunt monitors. This family of devices has gains that range from 25 V/V to 500 V/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 accurately sense voltage drops across shunts at common-mode voltages from -0.2 V to 40 V , independent of supply voltages. These devices operate with supply voltages between 1.7 V and 5.5 V and draw a maximum of $65\text{ }\mu\text{A}$ at room temperature. The low offset of the zero-drift architecture enables the sensing of very small differential input voltage which helps widen the usable input dynamic range. Additionally, the INA190-EP has a very low input bias current and thus, can easily measure microamps of current. Finally, the INA190-EP is an enhanced version, and is capable of an extended temperature range of -55°C through 150°C .

The INA190-EP devices are currently available in a DDF package. [Table 1-1](#) summarizes the available device gain options.

Table 1-1. INA190-EP Device Summary

Product	Gain
INA190A1-EP	25
INA190A2-EP	50
INA190A3-EP	100
INA190A4-EP	200
INA190A5-EP	500

1.1 INA190-EP Kit Contents

[Table 1-2](#) summarizes the contents of the INA190EPEVM kit. Contact the [Texas Instruments Product Information Center](#) nearest you if any component is missing. TI also recommends checking the [INA190-EP device product folder](#) at www.ti.com for any further information regarding this product.

Table 1-2. INA190EPEVM Kit Contents

Item	Item Part Number	Quantity
INA190EPEVM test board	SENS091	1
Quick Connect Receptacle 10-12AWG, 0.250"	4-520448-2	2

1.2 Related Documentation From Texas Instruments

This document provides information regarding Texas Instruments' integrated circuits used in the assembly of the INA190EPEVM.

Table 1-3. Related Documentation

Document	Literature Number
INA190-EP product data sheet	SBOSA74

2 INA190EPEVM Hardware

The INA190EPEVM is intended to provide basic functional evaluation of the INA190-EP 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 INA190EPEVM consists of one PCB with an option to cut out six individual PCBs, one for each of the five gain variants (INA190A1-EP, INA190A2-EP, INA190A3-EP, INA190A4-EP, and INA190A5-EP). Each of the PCB cutouts consists of one INA190AXNDDFREP device (where X is 1, 2, 3, 4, and 5) and test points for external hardware connections, as well as pads to solder down optional circuitry. A sixth board includes a guarding scheme to guard the input traces thus, preventing leakage current. This board has the INA190A5-EP as the installed test device.

2.1 Features

The INA190EPEVM PCB provides the following features:

- Evaluation of all gain options through provided device boards
- Ease of access to device pins with test points
- Pads for optional filtering at the input pins and output pin
- Multiple input signal options, including a method to solder a shunt resistor
- Low-current measurement panel with a voltage guarding plane to minimize leakage currents

Refer to [INA190-EP Bidirectional, Low-Power, Zero-Drift, Wide Dynamic Range Precision Current Sense Amp](#) for comprehensive information about the INA190-EP family of devices.

3 Quick Start Setup and Use

Follow these procedures to set up and use one of the panels of the INA190EPEVM. For the following instructions, X = 1, 2, 3, 4, 5, or is not present for the guarded input board.

1. Choose the desired gain option panel.
2. Ensure valid connections for the enable (EN) and reference (REF) pins for the section under test are set to the appropriate voltages.
 - a. For the device to amplify the input signal, it must be enabled by connecting the ENABLE input to a value between $0.7 \times V_s$ and 6 V as per the data sheet. The EN connection of each panel has an option to directly connect to the V_s through R1x, but this is depopulated by default. To create this connection, either place a voltage between $0.7 \times V_s$ and 6 V on the EN connection point, or solder a 0- Ω resistor at R1x to permanently enable the device under test.
 - b. For the device to have a ground reference, the REF input must be connected to the same connection as GND. If a custom reference voltage is desired, drive the REF input with an external voltage source set at the desired voltage.
3. Connect an external DC supply voltage between 1.7 V and 5.5 V to one of the VS inputs, and connect the ground reference of that supply to a GND test point on same panel.
4. Provide an input voltage signal (referenced to GND) to the IN+ and IN- pins by connecting signal leads to J0x and J1x quick-fit tabs. This is explained in [Section 3.1](#).

3.1 Measurements

The INA190EPEVM allows the user to either simulate the voltage developed across a sense resistor based on a given set of system conditions, or to connect it remotely to an existing shunt already included in an example application. Additionally, a surface-mount technology (SMT) shunt resistor can be soldered across the IN+ and IN- pads these inputs can be connected in-series with their system and load.

To configure a measurement evaluation without a shunt resistor, follow these procedures:

1. Connect a differential voltage to the IN+ (J0x) and IN- (J1x) tabs. With the reference voltage set at ground, ensure that the IN+ pin is the more positive of the two inputs.
2. Additionally, if the differential voltage supply is a floating supply, connect a common-mode voltage between -0.1 V to 40 V to the inputs by connecting the positive lead of the external voltage source to the IN- (J1x) tab and source ground to a GND test point. This effectively raises the absolute voltage of the input pins, while still retaining a positive input differential signal.
3. Measure the output voltage at the OUT connection point.

To configure a measurement evaluation with a shunt resistor, follow these procedures:

1. Solder down a resistor at the R4x pad that connects the IN+ (J0x) and IN- (J1x) inputs.
2. Connect the IN+ (J0x) and IN- (J1x) tabs in series with the load and bus voltage sources while powered off.

WARNING

If measuring current, please first ensure the equipment (shunt resistor, wires, connectors, and so forth) being used can support the amperage and power dissipation. Secondly, ensure the current flowing through J0x and J1x does not exceed 15 A. If using the "Guarded Inputs" panel, ensure current flowing between J0 and J1 does not exceed 10 A. Failure to do any of this could result in hot surfaces ($> 55^\circ\text{C}$), damage to the EVM, or personal injury.

3. Power on the system and measure the output voltage at the OUT connection point.

Note

The output voltage (if measured with respect to reference voltage) is equal to the gain of the device multiplied by the differential voltage measured directly at the device input pins.

4 INA190EPEVM Circuit and Components

This section summarizes the INA190EPEVM components. For the following instructions, x = 1 to 5 or is not present for the guarded input board.

4.1 R2x, R3x, R5x, C2x, C3x

R2x, R3x, and R5x are factory-installed, 0-Ω resistors, and C3x is a factory-installed input filter capacitor. C2x are not populated by default. Collectively, these pads allow for user-defined filters for the differential input voltage and output voltage. If a filter is desired, remove these resistors and replace them with > 0-Ω SMT resistors and populate the capacitor pads with capacitors corresponding to the desired cutoff frequency. Additional information regarding the use of input filtering, as well as calculation of desired cutoff frequencies is provided in [INA190-EP Bidirectional, Low-Power, Zero-Drift, Wide Dynamic Range Precision Current Sense Amp](#).

4.2 C1x

C1x are factory mounted 0.1-μF power supply bypass capacitors.

4.3 R1x

R1x 0-Ω resistors that provide the ability to test the device in a "constantly enabled" state. If the EN feature of the EVM does not require discrete control, populate R1x from the panel under test with a 0-Ω resistor prior to powering on the panel to remove this functionality. Ensure that the individual voltages provided to each pin do not violate voltage conditions.

4.4 R6

R6 is a connection resistor for the "Guarded Inputs" panel. This resistor provides an initial voltage to the guarding plane that is the same voltage as the input common-mode voltage. This may only be necessary if measuring very small currents at high common-mode voltages. This resistor is populated by default.

4.5 R4x

R4x is unpopulated, but allows a surface-mount shunt resistor to be soldered down in between the IN+ and IN- inputs. If used, ensure R4x has proper power dissipation for the user-set current load. This resistor chosen must at a minimum have a 0603 Imperial footprint.

4.6 U1x - INA190-EP

U1x is the location for the INA190Ax-EP test device. Six device boards are supplied with the INA190EPEVM board. Each board is populated with one of the available device gains. This option allows users to test the devices and determine the gain setting that is best suited for a given application.

The following list of factors are involved in selecting the appropriate device:

- The INA190-EP 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 not exceeding the supply voltage or going below GND.
- 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 within the swing limitations specified for the device for response in the linear range.
- 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.

4.7 J0x, J1x

J0x and J1x are 0.240 inch non-insulated, quick-fit terminals that are designed to insert into similarly-sized female receptacles. The kit provides two receptacles. Using insulated receptacles with J0x and J1x terminals allows the user to ensure a strong and safe connection between the current source and EVM when dealing with high currents.

WARNING

If using the EVM to measure currents, ensure a proper power resistor is soldered at the R4x pad and the receptacles (connecting to J0x and J1x) and their crimped wires can support the amperage of the current being measured and the necessary power dissipation. Do not exceed 15 A of current flowing between J0x and J1x. If using the "Guarded Inputs" panel, ensure current flowing from J0 to J1 does not exceed 10 A. Failure to do any of this could result in hot surfaces ($> 55^{\circ}\text{C}$), damage to the EVM, or personal injury.

Standard metal clips can electrically interface with these tabs for lower currents.

The IN+ (J0x) and IN- (J1x) inputs accept a differential voltage that is amplified by the selected device gain and is presented at the OUT connection point. 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.

5 Reference Voltage Setup

The INA190 devices allow for the use of an external reference through the REF pin. The INA190EPEVM provides a test point to drive the REF pin externally. The reference determines what offset the output will have when $V_{SENSE} = 0$ V, and allows these devices to be used in both unidirectional and bidirectional current-sensing applications.

5.1 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 5 V. 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 IN⁻ / Load. If the reference is set to 5 V, the output is set near 5 V with no input voltage, and responds to input voltages that are negative with respect to IN⁻ / Load.

5.2 Bidirectional Mode

Bidirectional refers to a load current that flows in both directions. For bidirectional applications, the reference voltage should be set anywhere within the GND to V_S range. 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 minus the specified output swing to V_S in the data sheet.

6 Guarding Voltage - Using the "Guarded Inputs" Panel

One panel on the INA190EPEVM is labeled as "Guarded Inputs" because it includes extra circuitry to help guard the input traces going into the IN+ and IN- pins of the INA190A5. When measuring a small current, it is desirable to minimize the input bias currents of the device, which is in the nanoamps. The input bias current could increase due to leakage currents sinking into a nearby ground plane and this is simply due to finite resistance of PCB material and a voltage potential. This voltage potential only grows as common-mode voltage increases. Guard the input traces with an isolated guarding plane and fence that is at the same potential and any leakage currents from the input traces will be significantly reduced. This technique is more practical when dealing with currents in the picoamps level, but it is included to help evaluate any extreme cases: low-current or high common-mode voltage or both.

The guarding plane can be driven by an external voltage source using the VG test point, or by populating R6 with a 0-Ω resistor, which will automatically tie common-mode voltage at the inputs to the guarding plane. If using the VG test point, ensure the external source has a common ground with the INA190-EP.

7 INA190EPEVM Schematics 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 INA190EPEVM PCBs.

7.1 Schematics

Figure 7-1 through Figure 7-3 show the schematics for the INA190EPEVM PCB.

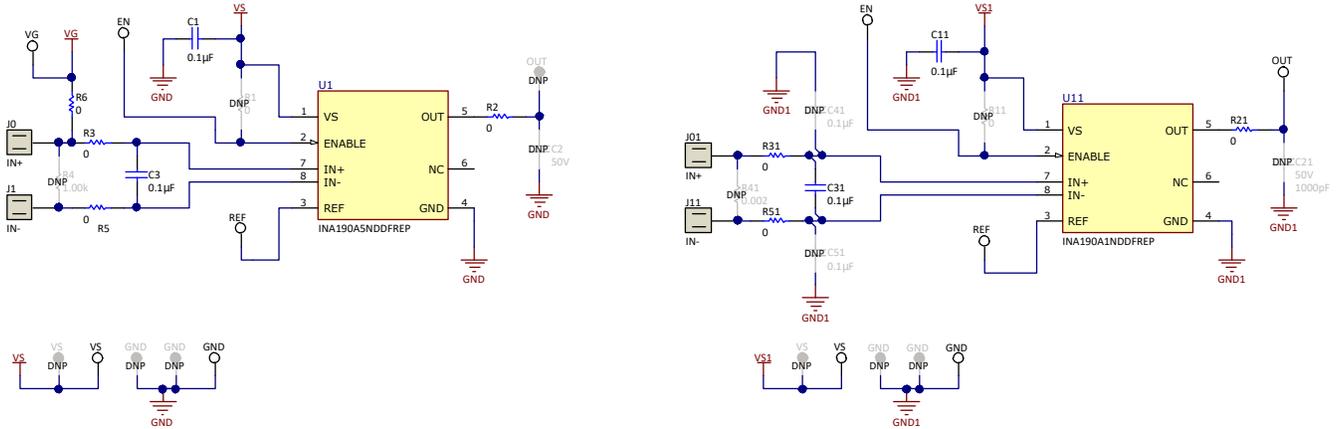


Figure 7-1. INA190EPEVM Schematic - Gain A1 and Guarding Panels

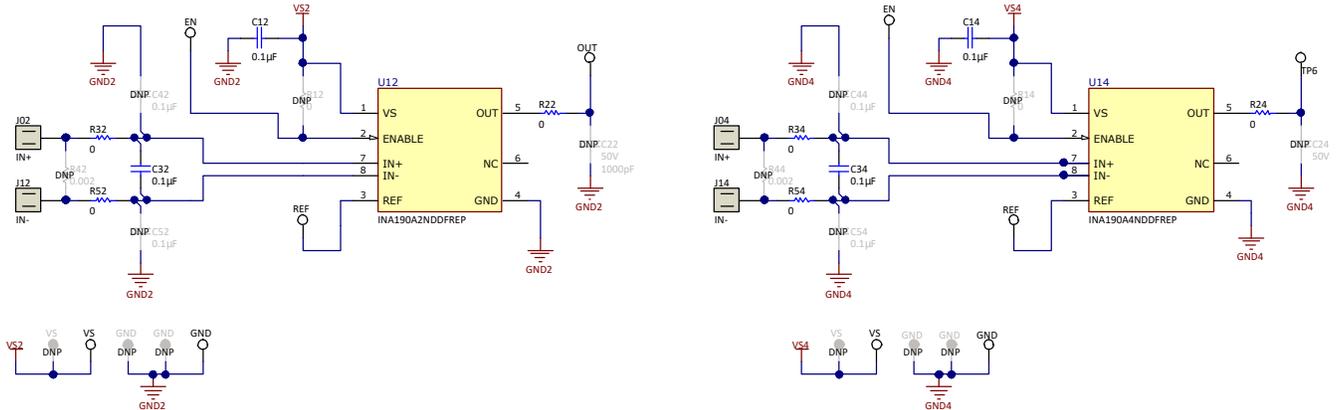


Figure 7-2. INA190EPEVM Schematic - Gain A2 and A4 Panels

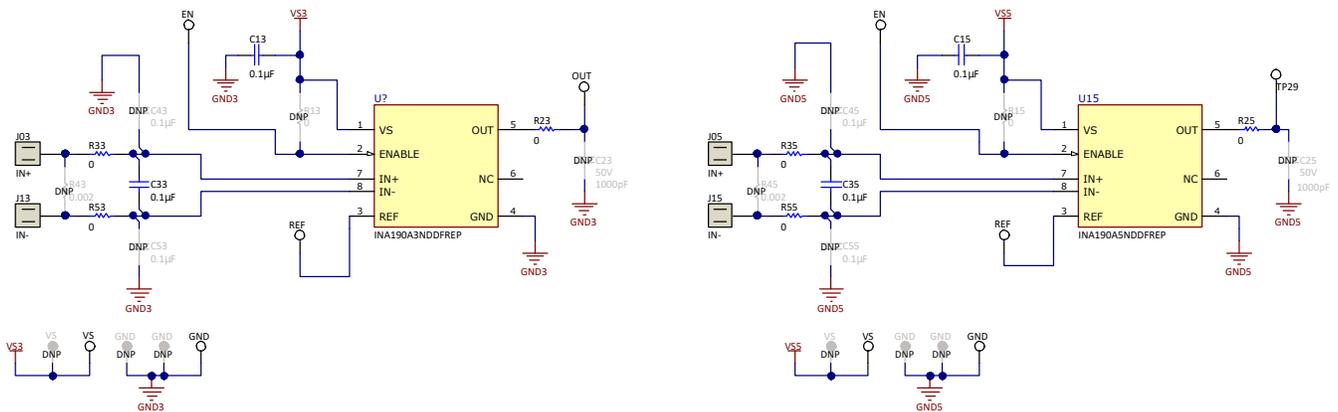


Figure 7-3. INA190EPEVM Schematic - Gain A3 and A5 Panels

7.2 PCB Layout

Figure 7-4 through INA190EPEVM Bottom Layer show the PCB layout for the INA190EPEVM.

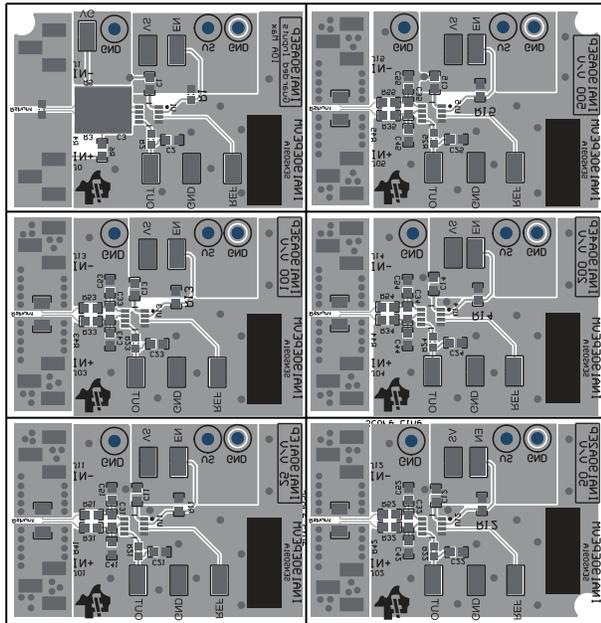


Figure 7-4. INA190EPEVM Top Overlay

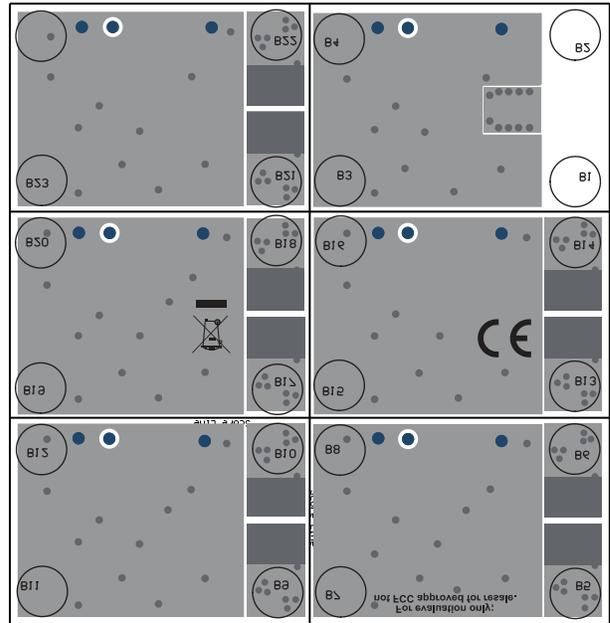


Figure 7-5. INA190EPEVM Bottom Overlay

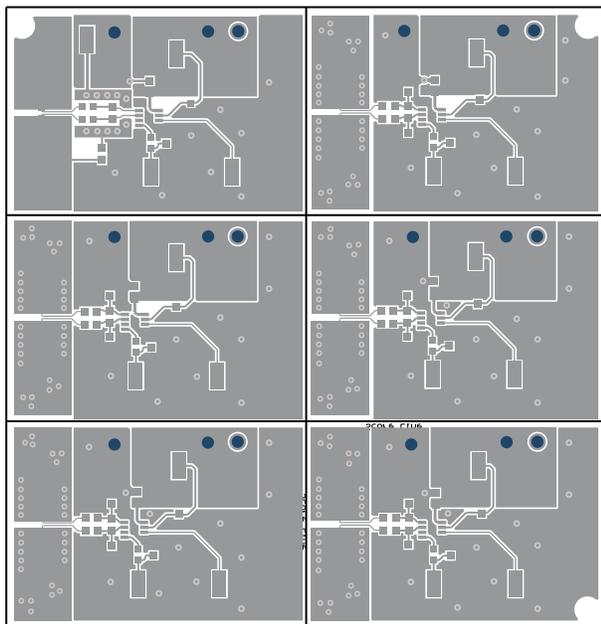


Figure 7-6. INA190EPEVM Top Layer

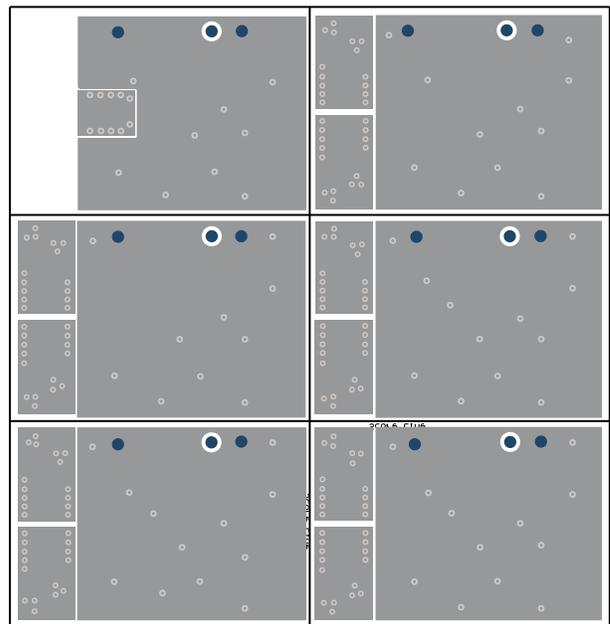


Figure 7-7. INA190EPEVM Bottom Layer

8 Bill of Materials

Table 8-1 provides the parts list for the INA190EPEVM.

Table 8-1. Bill of Materials

Designator	QTY	Value	Description	Package Reference	Part Number	MFR
B1, B2, B3, B4, B5, B6, B7, B8, B9, B10, B11, B12, B13, B14, B15, B16, B17, B18, B19, B20, B21, B22, B23, B24	24		Bumpon, Hemisphere, 0.25 X 0.075, Clear	3M_SJ5382	SJ5382	3M
C1, C3, C11, C12, C13, C14, C15, C31, C32, C33, C34, C35	12	0.1 μ F	CAP, CERM, 0.1 μ F, 50 V, +/- 10%, X8R, AEC-Q200 Grade 0, 0603	0603	CGA3E3X8R1H104K080A E	TDK
H13, H14	2		Quick-Fit Connector	N/A	4-520448-2	TE Connectivity AMP Connectors
J0, J01, J1, J02, J03, J04, J05, J11, J12, J13, J14, J15	12		Quick-Fit 0.240 Tab	Keystone_4928TR	4928TR	Keystone
R2, R3, R5, R6, R21, R22, R23, R24, R25, R31, R32, R33, R34, R35, R51, R52, R53, R54, R55	19	0 Ω	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ-3GEY0R00V	Panasonic
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP15, TP18, TP20, TP23, TP24, TP25, TP26, TP27, TP28, TP29, TP30, TP31, TP32, TP33, TP35, TP38, TP40, TP43, TP45, TP48	31		Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone
U1, U15	2	500 V/V	Bidirectional, Low-Power, Zero-Drift, Wide Dynamic Range Precision Current Sense Amp, SOT23-8	SOT23-8	INA190A5NDDFREP	Texas Instruments
U11	1	25 V/V	Bidirectional, Low-Power, Zero-Drift, Wide Dynamic Range Precision Current Sense Amp, SOT23-8	SOT23-8	INA190A1NDDFREP	Texas Instruments
U12	1	50 V/V	Bidirectional, Low-Power, Zero-Drift, Wide Dynamic Range Precision Current Sense Amp, SOT23-8	SOT23-8	INA190A2NDDFREP	Texas Instruments
U13	1	100 V/V	Bidirectional, Low-Power, Zero-Drift, Wide Dynamic Range Precision Current Sense Amp, SOT23-8	SOT23-8	INA190A3NDDFREP	Texas Instruments
U14	1	200 V/V	Bidirectional, Low-Power, Zero-Drift, Wide Dynamic Range Precision Current Sense Amp, SOT23-8	SOT23-8	INA190A4NDDFREP	Texas Instruments
C2, C21, C22, C23, C24, C25	0	1000 pF	CAP, CERM, 1000 pF, 50 V, +/- 10%, X8R, AEC-Q200 Grade 0, 0603	0603	C0603C102K5HACTU	Kemet
C41, C42, C43, C44, C45, C51, C52, C53, C54, C55	0	0.1 μ F	CAP, CERM, 0.1 μ F, 50 V, +/- 10%, X8R, AEC-Q200 Grade 0, 0603	0603	CGA3E3X8R1H104K080A E	TDK
R1, R11, R12, R13, R14, R15	0	0 Ω	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ-3GEY0R00V	Panasonic
R4	0	1.00 k Ω	RES, 1.00 k, 0.1%, 0.1 W, 0603	0603	RT0603BRD071KL	Yageo America
R41, R42, R43, R44, R45	0	0.002 Ω	RES, 0.002, 1%, 1 W, 1206	1206	CSNL1206FT2L00	Stackpole Electronics Inc

Table 8-1. Bill of Materials (continued)

Designator	QTY	Value	Description	Package Reference	Part Number	MFR
TP12, TP13, TP14, TP16, TP17, TP19, TP21, TP22, TP34, TP36, TP37, TP39, TP41, TP42, TP44, TP46, TP47, VS1	0		Test Point, Compact, White, TH	White Compact Testpoint	5007	Texas Instruments

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