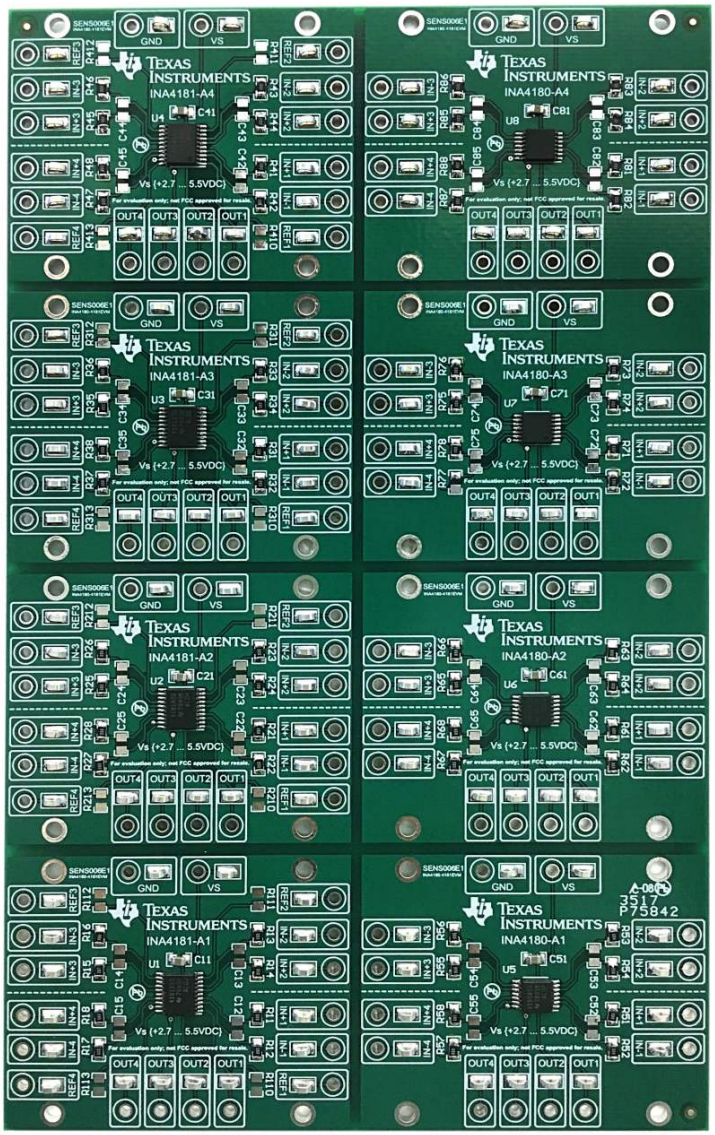
INA4180-INA4181 Evaluation Module User's Guide

This user's guide describes the characteristics, operation, and use of the INA4180-4181EVM (evaluation module). This EVM is designed to evaluate the performance of the INA4180A1, INA4180A2, INA4180A3, INA4180A4, INA4181A1, INA4181A2, INA4181A3, INA4181A4 voltage output current-shunt monitors in a variety of configurations. This document includes a schematic, reference printed-circuit board (PCB) layouts, and a complete bill of materials.



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1 Overview

The INA4180 family of current-shunt monitors (also called current-sense amplifiers) can sense drops across shunts at common-mode voltages from –0.2 V to +26 V, independent of the supply voltage. Four fixed gains are available: 20 V/V, 50 V/V, 100 V/V, and 200 V/V. The INA4181 family has the same capabilities as the INA4180 family but with the addition of reference pins on each channel that enables bidirectional current measurements. These devices operate from a single 2.7-V to 5.5-V power supply, drawing a maximum of 260 μA of supply current per amplifier channel.

The INA4180 devices are currently available in a TSSOP(14) and the INA4181 devices are available in a TSSOP(20) surface-mount packages. Table 1 lists the available gain options.

Table 1. INA418x Device Summary

PRODUCT	GAIN
INA4180A1, INA4181A1	20
INA4180A2, INA4181A2	50
INA4180A3, INA4181A3	100
INA4180A4, INA4181A4	200

1.1 INA4180-4181EVM Kit Contents

Table 2 lists the contents of the INA4180-4181EVM kit. Contact the nearest Texas Instruments Product Information Center if any component is missing. TI highly recommends checking the INA4180 family product folders on the TI website at www.ti.com for further information regarding these products.

Table 2. INA4180-4181EVM Kit Contents

ITEM	QUANTITY
INA4180-4181EVM Test Board	1

1.2 Related Documentation From Texas Instruments

This user guide provides information regarding TI's integrated circuits used in the assembly of the INA4180-4181EVM. See also the device data sheets:

Table 3. Related Documentation

DOCUMENT	LITERATURE NUMBER
INA4180 Product data sheet	SBOS741
INA4181 Product data sheet	SBOS793

2 INA4180-4181EVM Hardware

The INA4180 is a current sense integration solution that provides ease of use and high performance. The INA4181 has the same capabilities as the INA4180 but with the addition of reference pins that enable bidirectional current measurements. The INA4180-4181EVM 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 INA4180-4181EVM consists of one PCB with an option to snap apart eight individual PCBs — one for each of the eight devices (INA4180A1, INA4180A2, INA4180A3, INA4180A4, INA4181A1, INA4181A2, INA4181A3 and INA4181A4).

2.1 Features

The layout of the INA4180-4181EVM printed-circuit board (PCB) is designed to provide the following features:

- Evaluation of all gain options for the INA4180Ax and INA4181Ax
- Ease of access to device pins with test points
- Capability to evaluate high-side and low-side configurations

See the INA4180 and INA4181 data sheets for comprehensive information about the INA4180 and INA4181 family of devices.

3 Quick Start Setup and Use

The following are instructions to set up and use the INA4180Ax devices of the INA4180-4181EVM.

Step 1. Connect an external dc supply voltage between 2.7 V and 5.5 V to the VS test point, and connect ground reference of that supply to the GND test point.

Step 2. Connect the input per Section 3.1.

The following are instructions to set up and use the INA4181Ax devices of the INA4180-4181EVM.

Step 1. Connect an external dc supply voltage between 2.7 V and 5.5 V to the VS test point, and connect ground reference of that supply to the GND test point.

Step 2. Connect an external supply to the REF1, REF2, REF3 or REF4 test point (depends on which channel are you using). This reference voltage can be set anywhere from 0 V to VS. Further details regarding the use of the reference voltage are discussed later in Section 4.6.

Step 3. Connect the input per Section 3.1.

3.1 Measurements

The INA4180-4181EVM enables the user to either simulate the voltage developed across a sense resistor based on a given set of system conditions or to connect remotely to an existing shunt already included in an example application.

The following procedures are used to configure a measurement evaluation without a shunt.

- **Channel 1:**

  Step 1. Connect a differential voltage to the IN+1 and IN–1 test points.

  Step 2. Measure the output voltage at the OUT1 test point.

- **Channel 2:**

  Step 1. Connect a differential voltage to the IN+2 and IN–2 test points.

  Step 2. Measure the output voltage at the OUT2 test point.

- **Channel 3:**

  Step 1. Connect a differential voltage to the IN+3 and IN–3 test points.

  Step 2. Measure the output voltage at the OUT3 test point.

- **Channel 4:**

  Step 1. Connect a differential voltage to the IN+4 and IN–4 test points.

  Step 2. Measure the output voltage at the OUT4 test point.

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

4 INA4180-4181EVM Circuit

This section summarizes the INA4180-4181EVM components. For the following instructions, x = 1 to 8. These section refers primarily to channel 1 test points of each board. Refer to Table 4 for test points equivalence for other three channels.

Table 4. Components designators by channel

COMPONENT	CHANNEL 1	CHANNEL 2	CHANNEL 3	CHANNEL 4
Input filter resistors	Rx1 and Rx2	Rx3 and Rx4	Rx5 and Rx6	Rx7 and Rx8
Input filter capacitor	Cx2	Cx3	Cx4	Cx5
Voltage inputs	IN+1, IN-1	IN+2, IN-2	IN+3, IN-3	IN+4, IN-4
Reference Voltage	REF1	REF2	REF3	REF4
0-Ω resistors to connect REF pins to GND	Rx10	Rx11	Rx12	Rx13

4.1 Input Filters: Rx1, Rx2, Rx3, Rx4, Rx5, Rx6, Rx7, Rx8,Cx2, Cx3, Cx4, Cx5

Rx1 and Rx2 are factory-installed 0-Ω resistors. These resistors, in combination with Cx2, form an input filter. These locations allow for 0805 surface-mount package size. Additional information regarding the use of input filtering is provided in the INA4180 and INA4181 product data sheets.

4.2 Bypass Capacitors: Cx1

Cx1 are 0.1-μF supply bypass capacitors.

4.3 Ux

Ux is the location for the test device. Eight device boards are supplied with the INA4180-4181EVM board. Each board is populated with one of the available device gains. This option enables users to test the devices and determine the gain setting that is best suited for a given application.

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

- The INA4180A1-A4 devices are identical with the exception of different gain settings. The INA4181A1-A4 devices have the same device gain options of the INA4180 but with the addition of the reference pin that enables bidirectional current measurements.
- Select INA4180 for unidirectional applications only, and select INA4181 for unidirectional or bidirectional applications.
- The differential input voltage is applied across the inputs, or developed based on the load current that flows through the shunt resistor.
- A significant 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 input voltage is amplified by the device gain. The output voltage must remain within the range of 10 mV above ground to 100 mV 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.

4.4 Voltages Inputs(IN+1, IN–1, IN+2, IN–2, IN+3, IN-3, IN+4, IN-4)

The IN+1 and IN–1 inputs accept a differential voltage that is amplified by the selected device gain and is presented at the OUT1 test point. These inputs can 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.

4.5 Reference Voltage pins (REF1, REF2, REF3, REF4)

REF1 test points enables the user to configure the INA4181A1-A4 device boards for either unidirectional or bidirectional operation. Refer to Section 4.6 for more information.

4.6 Reference Voltage Setup

The INA4181A1-A4 devices enable the use of an external reference, REF1. This reference determines how the output responds to certain input conditions. The reference also enables these devices to be used in unidirectional and bidirectional applications. The REF1 pin can also be connected to supply (VS) to enable unidirectional measurement in the negative direction.

4.6.1 Rx10, Rx11, Rx12 and Rx13

Rx10 resistors locations are not populated. If a 0-Ω resistor is populated, the REF1 pin will be connected to GND, and the INA4181 can be used for unidirectional measurements. These locations allow for 0805 surface-mount package size.

4.6.2 Unidirectional Mode

Unidirectional refers to a load current that flows in only one direction.

The INA4180A1-A4 devices are able to measure unidirectional currents only. The INA4181A1-A4 devices measure unidirectional and bidirectional currents. For unidirectional measurements, connect the REF1 pin to GND. You can connect the REF1 pin to GND through a 0-Ω resistor (Rx10) or ground it directly with the test point.

4.6.3 Bidirectional Mode

Bidirectional refers to a load current that flows in both directions.

The INA4181A1-A4 are able to measure bidirectional currents. The ability to measure this current flowing in both directions is enabled by applying a voltage to the REF1 pin. The voltage applied to REF1 sets the output state that corresponds to the zero-input level state. The output then responds by increasing above REF1 for positive differential signals (relative to the IN–1 pin) and responds by decreasing below REF1 for negative differential signals. This reference voltage applied to the REF1 pin can be set anywhere from 0 V to VS. For bidirectional applications, REF1 is typically set at mid-scale for equal signal range in both current directions. In some cases, however, REF1 is set at a voltage other than mid-scale when it is unnecessary that the bidirectional current and corresponding output signal be symmetrical.

5 INA4180-4181EVM Schematic and PCB Layout

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 INA4180-181EVM PCBs.

5.1 Schematics

Figure 1 shows the schematic for the INA4180Ax section of the INA4180-4181EVM PCB, and Figure 2 shows the schematic for the INA4181Ax section of the INA4180-4181EVM PCB.

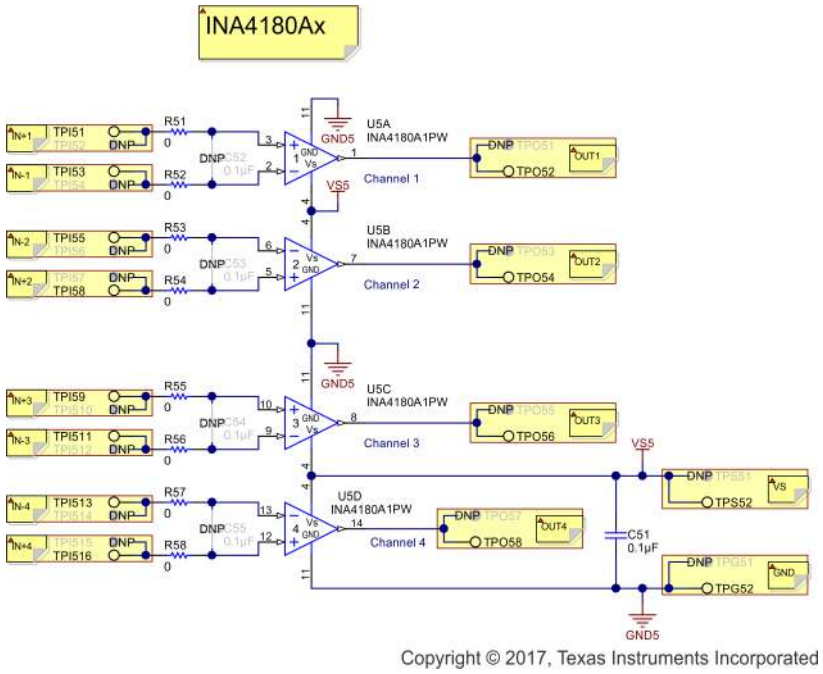

Figure 1. INA4180Ax Schematic

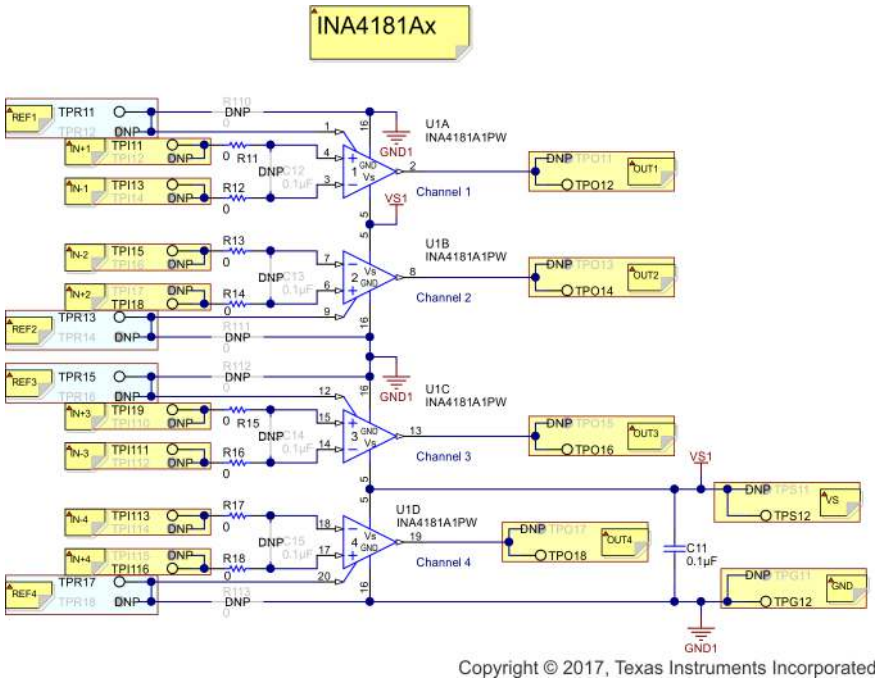

Figure 2. INA4181Ax Schematic

5.2 PCB Layout

Figure 3 through Figure 8 illustrate the PCB layout for the INA4180-4181EVM.

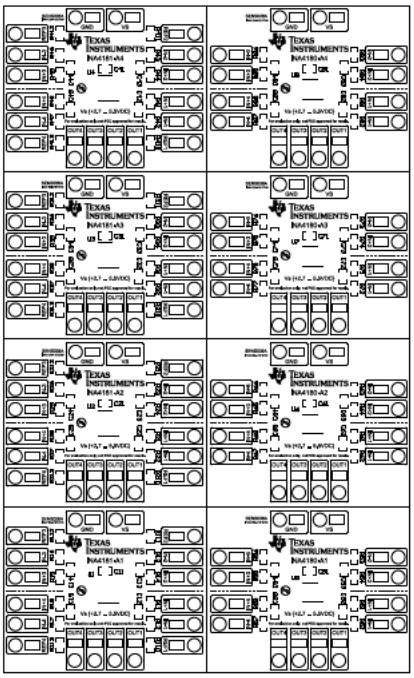

Figure 3. INA4180-4181EVM Top Overlay

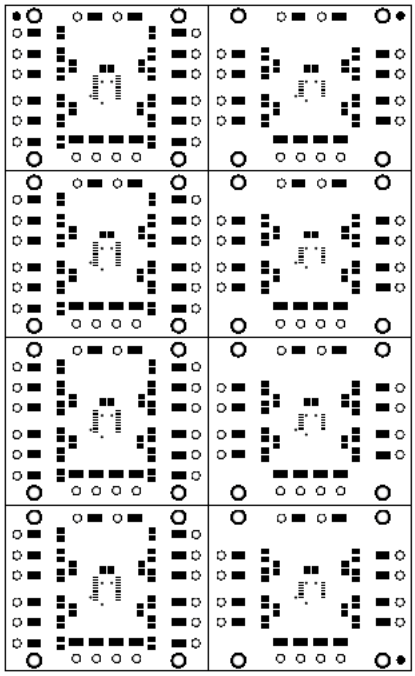

Figure 4. INA4180-4181EVM Top Solder Mask

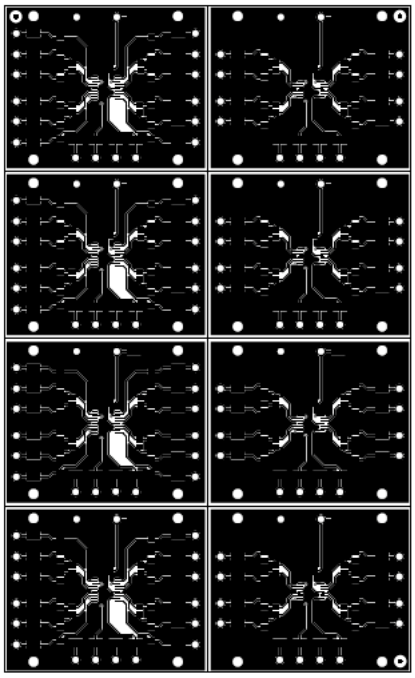

Figure 5. INA4180-4181EVM Top Layer

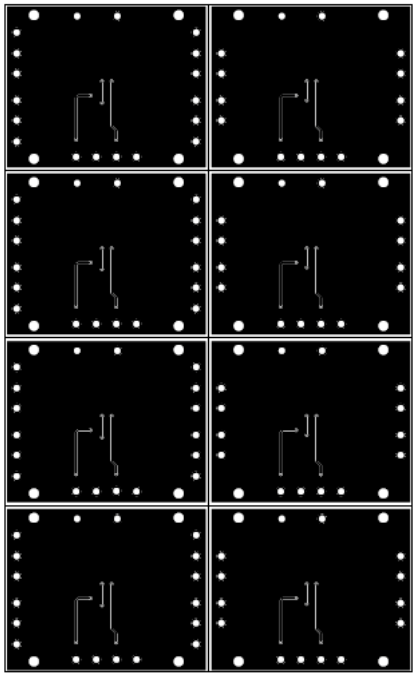

Figure 6. INA4180-4181EVM Bottom Layer

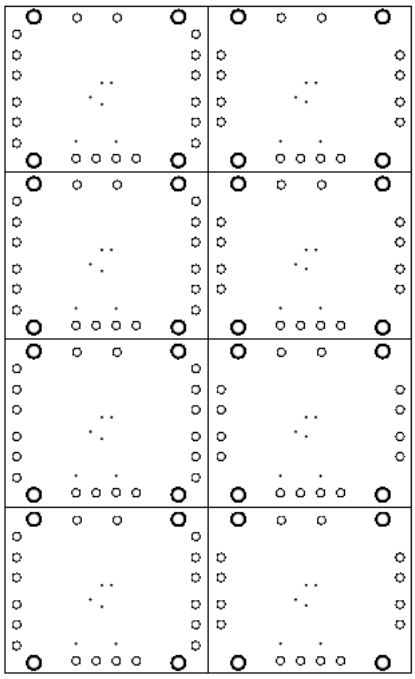

Figure 7. INA4180-4181EVM Bottom Solder Mask

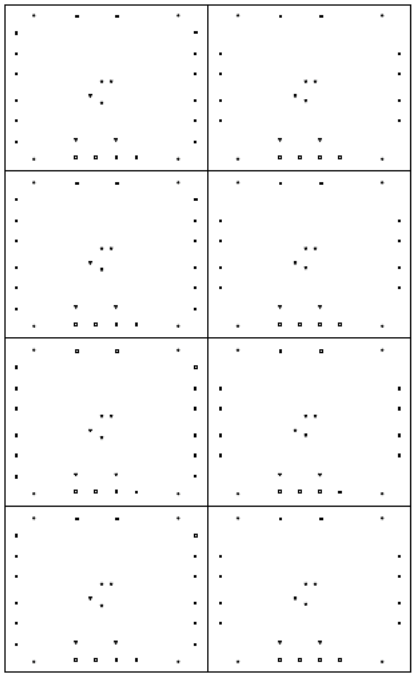

Figure 8. INA4180-4181EVM Drill Drawing

6 Bill of Materials

Table 5 provides the parts list for the INA4180-4181EVM.

Table 5. Bill of Materials

Designator	Qty	Value	Description	PackageReference	PartNumber	Manufacturer
C11, C21, C31, C41, C51, C61, C71, C81	8	0.1uF	CAP, CERM, 0.1 µF, 50 V, +/- 5%, X7R, 0805	0805	08055C104JAT2A	AVX
R11, R12, R13, R14, R15, R16, R17, R18, R21, R22, R23, R24, R25, R26, R27, R28, R31, R32, R33, R34, R35, R36, R37, R38, R41, R42, R43, R44, R45, R46, R47, R48, R51, R52, R53, R54, R55, R56, R57, R58, R61, R62, R63, R64, R65, R66, R67, R68, R71, R72, R73, R74, R75, R76, R77, R78, R81, R82, R83, R84, R85, R86, R87, R88	64	0	RES, 0, 5%, 0.125 W, 0805	0805	CRCW08050000Z0EA	Vishay-Dale
TPG12, TPG22, TPG32, TPG42, TPG52, TPG62, TPG72, TPG82, TPI11, TPI13, TPI15, TPI18, TPI19, TPI21, TPI23, TPI25, TPI28, TPI29, TPI31, TPI33, TPI35, TPI38, TPI39, TPI41, TPI43, TPI45, TPI48, TPI49, TPI51, TPI53, TPI55, TPI58, TPI59, TPI61, TPI63, TPI65, TPI68, TPI69, TPI71, TPI73, TPI75, TPI78, TPI79, TPI81, TPI83, TPI85, TPI88, TPI89, TPI111, TPI113, TPI116, TPI211, TPI213, TPI216, TPI311, TPI313, TPI316, TPI411, TPI413, TPI416, TPI511, TPI513, TPI516, TPI611, TPI613, TPI616, TPI711, TPI713, TPI716, TPI811, TPI813, TPI816, TPO12, TPO14, TPO16, TPO18, TPO22, TPO24, TPO26, TPO28, TPO32, TPO34, TPO36, TPO38, TPO42, TPO44, TPO46, TPO48, TPO52, TPO54, TPO56, TPO58, TPO62, TPO64, TPO66, TPO68, TPO72, TPO74, TPO76, TPO78, TPO82, TPO84, TPO86, TPO88, TPR11, TPR13, TPR15, TPR17, TPR21, TPR23, TPR25, TPR27, TPR31, TPR33, TPR35, TPR37, TPR41, TPR43, TPR45, TPR47, TPS12, TPS22, TPS32, TPS42, TPS52, TPS62, TPS72, TPS82	128	SMT	Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone
U1	1		Bidirectional, Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifiers, PW0020A (TSSOP-20)	PW0020A	INA4181A1PW	Texas Instruments

Table 5. Bill of Materials (continued)

U2	1		Bidirectional, Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifiers, PW0020A (TSSOP-20)	PW0020A	INA4181A2PW	Texas Instruments
U3	1		Bidirectional, Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifiers, PW0020A (TSSOP-20)	PW0020A	INA4181A3PW	Texas Instruments
U4	1		Bidirectional, Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifiers, PW0020A (TSSOP-20)	PW0020A	INA4181A4PW	Texas Instruments
U5	1		Bidirectional, Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifiers, PW0014A (TSSOP-14)	PW0014A	INA4180A1PW	Texas Instruments
U6	1		Bidirectional, Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifiers, PW0014A (TSSOP-14)	PW0014A	INA4180A2PW	Texas Instruments
U7	1		Bidirectional, Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifiers, PW0014A (TSSOP-14)	PW0014A	INA4180A3PW	Texas Instruments
U8	1		Bidirectional, Low- and High-Side Measurement, Multichannel, Voltage Output, Current-Sense Amplifiers, PW0014A (TSSOP-14)	PW0014A	INA4180A4PW	Texas Instruments

Revision History

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

Changes from Original (November 2017) to A Revision	Page
• Changed links in abstract to point to correct locations	1

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