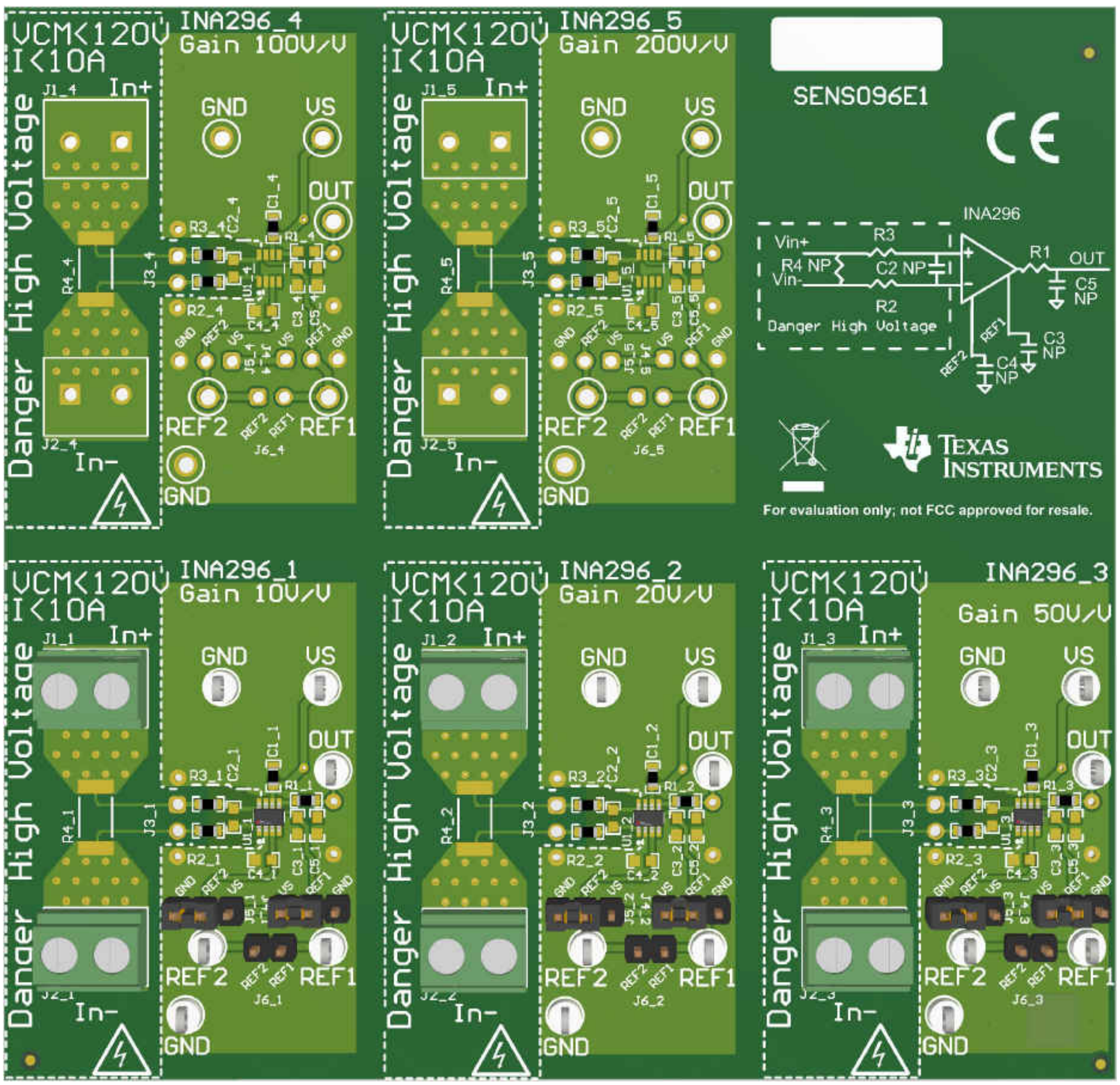
User's Guide

INA296EVM

ABSTRACT

This user's guide describes the characteristics, operation, and use of the INA296EVM evaluation module (EVM). This EVM is designed to evaluate the performance of the INA296A or INA296B voltage-output, current shunt monitor in a variety of configurations. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the INA296EVM. This document also includes a schematic, reference printed circuit board (PCB) layouts, and a complete bill of materials (BOM).



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Trademarks

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1 General Texas Instruments High Voltage Evaluation (TI HV EVM) User Safety Guidelines

Always follow TI's setup and application instructions, including use of all interface components within their recommended electrical rated voltage and power limits. Always use electrical safety precautions to help ensure your personal safety and those working around you. Contact TI's Product Information Center http://support/ti./com for further information.

Save all warnings and instructions for future reference.

> **WARNING**
>
> Failure to follow warnings and instructions may result in personal injury, property damage or death due to electrical shock and burn hazards.

The term TI HV EVM refers to an electronic device typically provided as an open framed, unenclosed printed circuit board assembly. It is *intended strictly for use in development laboratory environments, solely for qualified professional users having training, expertise and knowledge of electrical safety risks in development and application of high voltage electrical circuits. Any other use and/or application are strictly prohibited by Texas Instruments.* If you are not suitable qualified, you should immediately stop from further use of the HV EVM.

1. Work Area Safety
   a. Keep work area clean and orderly.
   b. Qualified observer(s) must be present anytime circuits are energized.
   c. Effective barriers and signage must be present in the area where the TI HV EVM and its interface electronics are energized, indicating operation of accessible high voltages may be present, for the purpose of protecting inadvertent access.
   d. All interface circuits, power supplies, evaluation modules, instruments, meters, scopes and other related apparatus used in a development environment exceeding 50Vrms/75VDC must be electrically located within a protected Emergency Power Off EPO protected power strip.
   e. Use stable and nonconductive work surface.
   f. Use adequately insulated clamps and wires to attach measurement probes and instruments. No freehand testing whenever possible.
2. Electrical Safety
   As a precautionary measure, it is always a good engineering practice to assume that the entire EVM may have fully accessible and active high voltages.
   a. De-energize the TI HV EVM and all its inputs, outputs and electrical loads before performing any electrical or other diagnostic measurements. Revalidate that TI HV EVM power has been safely de-energized.
   b. With the EVM confirmed de-energized, proceed with required electrical circuit configurations, wiring, measurement equipment connection, and other application needs, while still assuming the EVM circuit and measuring instruments are electrically live.
   c. After EVM readiness is complete, energize the EVM as intended.

   > **WARNING**
   >
   > While the EVM is energized, never touch the EVM or its electrical circuits, as they could be at high voltages capable of causing electrical shock hazard.
3. Personal Safety
   a. Wear personal protective equipment (for example, latex gloves or safety glasses with side shields) or protect EVM in an adequate lucent plastic box with interlocks to protect from accidental touch.

Limitation for safe use:

EVMs are not to be used as all or part of a production unit.

2 Overview

The INA296EVM device is a voltage-output, high-side current sense amplifier in a small SOT-23 (8) package with high small signal bandwidth of 1 MHz for all gain options. As shown in Table 2-1, the INA296x has gains that range from 10 V/V to 200 V/V, depending on the gain option that is selected. The device is in preview mode and only the following options of INA296A1, INA296A2 and INA296A3 are populated on this EVM at this time. The voltage developed across the device inputs is amplified by the corresponding gain of the specific device, and is presented at the output pin. The device can accurately sense voltage drops across shunts at –4-V to +110-V common-mode voltages. The device survives common-mode voltages from –20 V to +120 V. The device operates with supply voltages between 2.7 V and 20 V, and draws a typical of 2.5 mA at room temperature.

Table 2-1. INA296EVM Gain Option Summary

Product(1)	Gain (V/V)
INA296A1	10
INA296A2	20
INA296A3	50
INA296A4 (Not Installed)	100
INA296A5 (Not Installed)	200

(1) INA296x is a preview device

2.1 EVM Kit Contents

Table 2-2 summarizes the contents of the INA296EVM kit. Contact the nearest Texas Instruments Product Information Center if any component is missing. TI also recommends to check the device product folders at www.ti.com for any further information regarding this product.

Table 2-2. INA296EVM Kit Contents

Item	Item Part Number	Quantity
INA296EVM test board	INA296EVM	1

2.2 Related Documentation From Texas Instruments

This document provides information regarding Texas Instruments' integrated circuits used in the assembly of the INA296EVM.

Table 2-3. Related Documentation

Document	Literature Number
INA296A and INA296B product data sheet	SBOSA04

3 Hardware

The INA296EVM provides a basic functional evaluation of the INA296x. 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 INA296EVM is one PCB with five optional PCB cutouts the engineer can use to test each of the five gain options (1 to 5) listed in Table 2-1. Each PCB cutout has one INA296*n* device (where *n* is 1, 2, 3, 4, or 5), test points and sockets for external hardware connections, and pads to solder down optional circuitry. Only gain options A1, A2, and A3 are populated.

3.1 Features

The INA296EVM PCB provides the following features:

- Evaluation of all gain options through provided device boards
- Ease of access to device pins with test points
- Pads and sockets for optional filtering at the input pins and output pin
- Multiple input signal options, including a method to solder a shunt resistor (2512) and safely measure current up to 10A.

See the device data sheets for comprehensive information about the INA296EVM and the available gain options.

4 Operation

4.1 Quick Start Setup

Follow these procedures to set up and use one of the INA296EVM panels. For these instructions, n is gain option 1, 2, 3, 4, or 5.

1. Choose the desired gain option panel variation.
2. Connect an external DC supply voltage (between 2.7 V and 20 V) to a VS test point. Connect the ground reference of that supply to a GND test point on the same panel.
3. Provide a differential input voltage signal to the Vin+ and Vin– nodes by connecting the signal leads to the J1_n and J2_n on the EVM, as explained in Section 4.2. The IN296x is a bidirectional current-sensing device that has a reference pin. With this reference pin, the device can measure current in both directions. To use 1/2 of the supply voltage (VS) as the reference, place shorting bars on jumper J4, connect REF1 to VS and J5, and connect REF2 to GND. If you only want to measure unidirectional current, be careful not to short VS to GND. Remove the jumpers from J4 and J5 before placing a jumper on J6. After J6 shorts Ref1 to Ref2, place one jumper on J4 or J5 or drive the Ref1 and Ref2 pins to create your own reference voltage.

4.2 Measurements

The user can either emulate the voltage developed across a sense resistor based on a given set of system conditions with the INA296EVM, or connect the device inputs to an external shunt. The user can also solder a surface-mount technology (SMT) shunt resistor across the In+ and In– pads, and these inputs can be connected in series with the external system and load.

To configure a measurement evaluation without a shunt resistor, follow this procedure:

1. Connect a differential voltage across the In+ (J1_n) and In– (J2_n) tabs.
2. Connect a 2.7-V to 110-V common-mode voltage to the inputs if the differential voltage supply is a floating supply. Connect the positive lead of the external voltage source to the In– (J1_n) tab and source ground to a GND test point. The minimum common-mode voltage should be > –4 V. This action effectively raises the absolute common-mode voltage of the input pins.
3. Measure the output voltage at the Vout test point with respect to GND.

To configure a measurement evaluation with a shunt resistor, follow this procedure:

1. Solder a 2512 resistor at the R1_n pads that connects the In+ (J1_n) and In– (J1_n) inputs.
2. Connect the In+ (J1_n) and In– (J2_n) tabs in series with the load and bus voltage sources while powered off.

> **WARNING**
>
> Make sure that the equipment (shunt resistor, wires, connectors, and so on) can support the amperage and power dissipation first before you measure the current. Also make sure that the current flowing through J1 does not exceed 10 A. Failure to do so can result in hot surfaces (> 55°C), damage to the EVM, or personal injury.

3. Power on the system and measure the output voltage at the Vout test point. Vout is equal to the gain of the device multiplied by the differential voltage measured directly at the device input pins. If bidirectional, use voltage is referenced to VS/2. If unidirectional, the ouput is refrenced to voltage applied at Ref1 and Ref2.

5 EVM Components

This section summarizes the INA296EVM components. For these instructions, n is gain option 1, 2, 3, 4, or 5.

5.1 R1_n, R2_n, R3_n, C2_n, C5_n

R1_n, R2_n, and R3_n are factory-installed 0-Ω 0603 resistors.

C2_n and C5_n, are not populated.

Collectively, these pads allow user-defined filters for the input pins (IN+ and IN–) and the output pin (OUT) of the INA241. If a filter is desired, remove these resistors and replace them with > 0-Ω SMT resistors and populate the capacitor pads with capacitors. Consider the input bias current of the device when using input filtering.

5.2 C1_n

C1_n is a 0.1-µF, power-supply bypass capacitor.

5.3 R4_n

R4_n is unpopulated, but allows the user to solder down a surface-mount shunt resistor between the In+ and In– pads sensed by IN+ and IN– input pins. If used, make sure R4_n has proper power dissipation for the selected current load. The chosen resistor must have a 2512 footprint.

5.4 U1_n (INA296x)

U1_n is the location for the INA296An test device.

Consider these factors when selecting the appropriate device gain:

- The differential input voltage is either applied across the inputs or developed based on the load current that flows through the shunt resistor.
- Make sure that the output voltage does not exceed the supply voltage. This limiting factor requires attention to device selection.
- 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 device-specified swing limitations for response in the linear range.
- An output below the minimum allowable output requires a device with a higher gain. Likewise, an output above the maximum allowable output requires a device with a lower gain.

6 Schematic, PCB Layout, and Bill of Materials

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 INA296EVM PCB manufacturing.

6.1 Schematics

Figure 6-1 shows the schematic for one of the gain panels on the INA296EVM PCB. All other panels will have reference designators as subscript "_x" where "x" is the gain option.

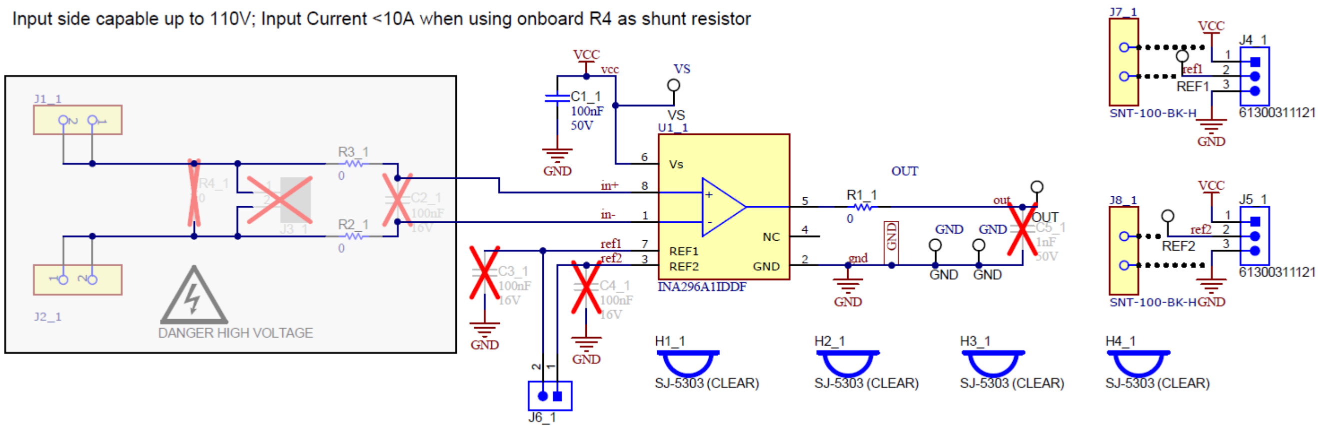


Figure 6-1. INA296EVMEVM Schematic: Gain Option 1 Panel

6.2 PCB Layout

Figure 6-2 through Figure 6-8 show the PCB layout for the INA296EVM.

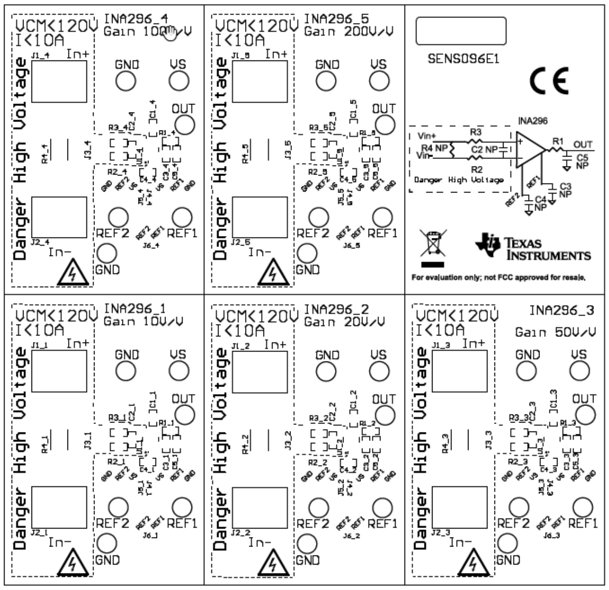


Figure 6-2. INA296EVM Top Overlay

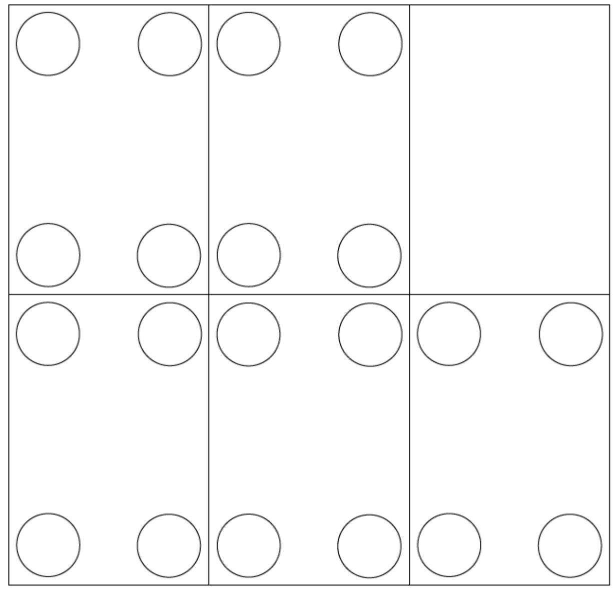


Figure 6-3. INA296EVM Bottom Overlay

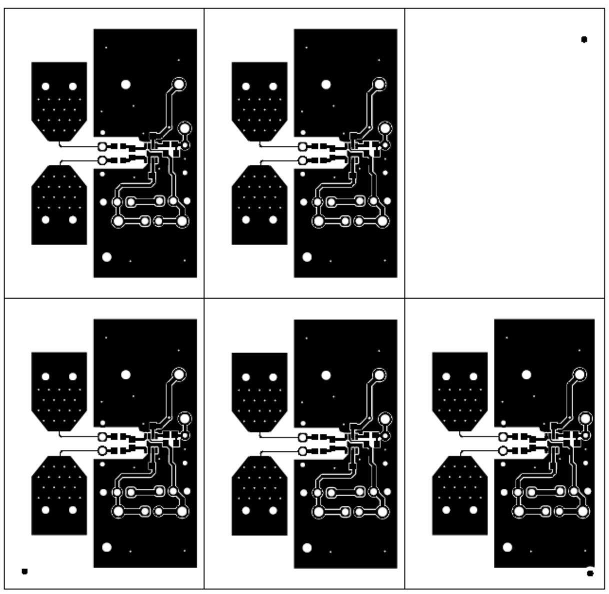


Figure 6-4. INA296EVM Top Layer

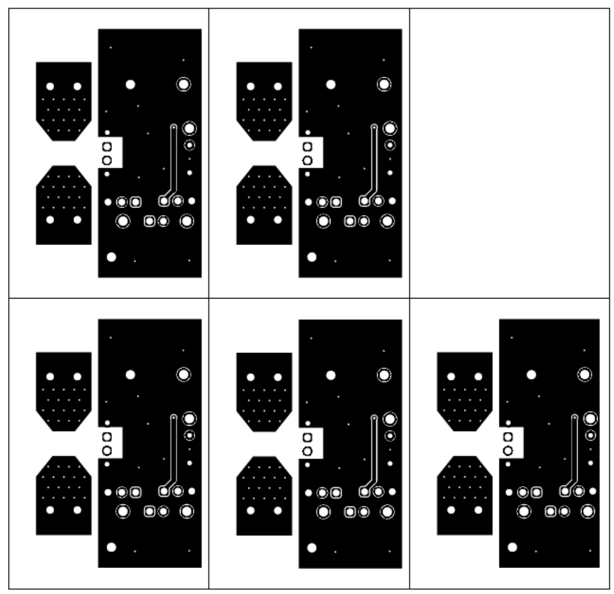


Figure 6-5. INA296EVM Bottom Layer

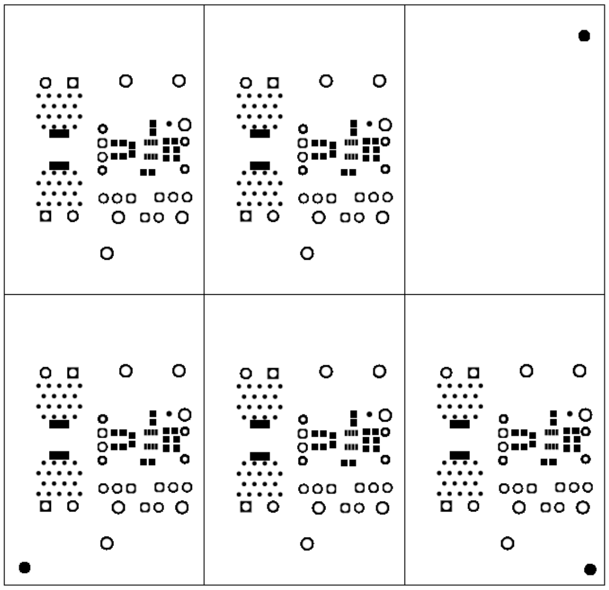


Figure 6-6. INA296EVM Top Solder

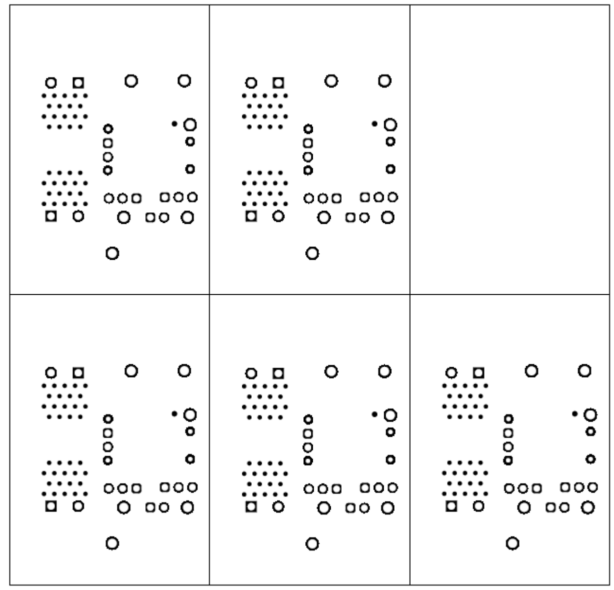
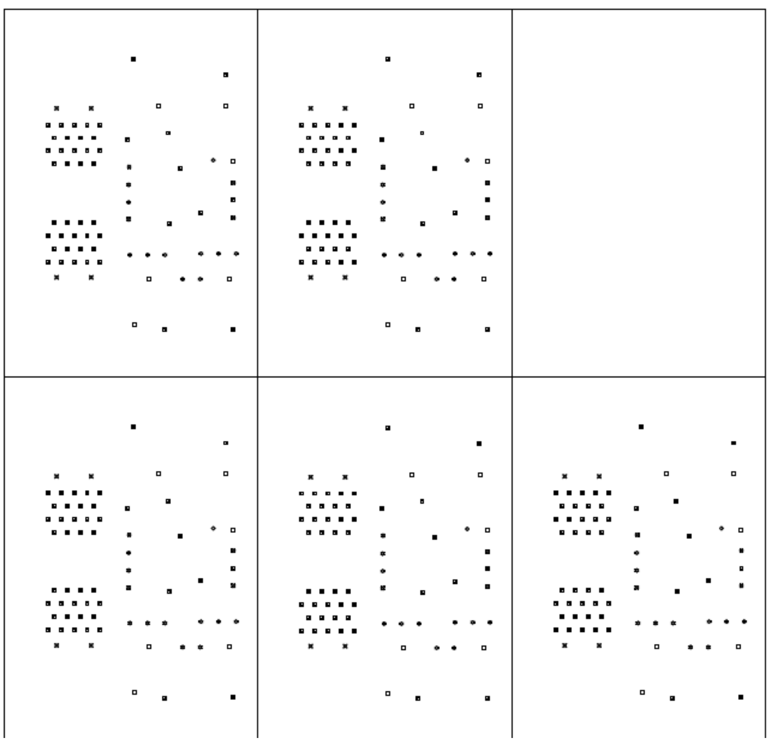


Figure 6-7. INA296EVM Bottom Solder



Symbol	Quantity	Finished Hole Size	Plated	Hole Type	Drill Layer Pair	Hole Tolerance
	230	10.00mil (0.254mm)	PTH	Round	Top Layer - Bottom Layer	
	5	16.00mil (0.406mm)	PTH	Round	Top Layer - Bottom Layer	
	20	30.00mil (0.762mm)	PTH	Round	Top Layer - Bottom Layer	
	50	45.28mil (1.150mm)	PTH	Round	Top Layer - Bottom Layer	
	20	51.18mil (1.300mm)	PTH	Round	Top Layer - Bottom Layer	
	30	63.00mil (1.600mm)	PTH	Round	Top Layer - Bottom Layer	
	355 Total					

Figure 6-8. INA296EVM Drill Drawing

6.3 Bill of Materials

Table 6-1 provides the parts list for the INA296EVM.

Table 6-1. Bill of Materials

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer
C1_1, C1_2, C1_3, C1_4, C1_5	5	0.1uF	CAP, CERM, 0.1 µF, 50 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	603	C0603C104K5RACAUTO	Kemet
FID1, FID2, FID3	3		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
H1_1, H1_2, H1_3, H2_1, H2_2, H2_3, H3_1, H3_2, H3_3, H4_1, H4_2, H4_3	12		Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon	SJ-5303 (CLEAR)	3M
J1_1, J1_2, J1_3, J2_1, J2_2, J2_3	6		TERM BLK 2POS SIDE ENTRY 5MM PCB	HDR2	6.91138E+11	Würth Elektronik
J4_1, J4_2, J4_3, J5_1, J5_2, J5_3	6		Header, 2.54 mm, 3x1, Gold, TH	Header, 2.54mm, 3x1, TH	61300311121	Wurth Elektronik
J6_1, J6_2, J6_3	3		Header, 2.54 mm, 2x1, Gold, TH	Header, 2.54mm, 2x1, TH	61300211121	Wurth Elektronik
J7_1, J7_2, J7_3, J8_1, J8_2, J8_3	6			CONN_JUMPER	SNT-100-BK-H	Samtec
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady
R1_1, R1_2, R1_3, R2_1, R2_2, R2_3, R2_4, R2_5, R3_1, R3_2, R3_3, R3_4, R3_5	13	0	RES, 0, 5%, 0.1 W, 0603	603	RC0603JR-070RL	Yageo
TP1_1, TP1_2, TP1_3, TP2_1, TP2_2, TP2_3, TP3_1, TP3_2, TP3_3, TP4_1, TP4_2, TP4_3, TP5_1, TP5_2, TP5_3, TP6_1, TP6_2, TP6_3	18		Test Point, Multipurpose, White, TH	White Multipurpose Testpoint	5012	Keystone Electronics
U1_1	1		-4-V to 110V, Bidirectional, 1-MHz, 5V/µs, Ultra-Precise Current Sense Amplifier	SOT-23-8	INA296A1IDDF	Texas Instruments
U1_2	1		-4-V to 110V, Bidirectional, 1-MHz, 5V/µs, Ultra-Precise Current Sense Amplifier	SOT-23-8	INA296A2IDDF	Texas Instruments
U1_3	1		-4-V to 110-V, Bidirectional, 1-MHz, 5V/µs, Ultra-Precise Current Sense Amplifier, SOT23-8	SOT23-8	INA296A3IDDF	Texas Instruments

Table 6-1. Bill of Materials (continued)

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer
C2_1, C2_2, C2_3, C2_4, C2_5, C3_1, C3_2, C3_3, C3_4, C3_5, C4_1, C4_2, C4_3, C4_4, C4_5	0	0.1uF	CAP, CERM, 0.1 uF, 16 V, +/- 5%, X7R, 0603	603	0603YC104JAT2A	AVX
C5_1, C5_2, C5_3, C5_4, C5_5	0	1000pF	CAP, CERM, 1000 pF, 50 V, +/- 10%, X7R, 0603	603	C0603X102K5RACTU	Kemet
H1_4, H1_5, H2_4, H2_5, H3_4, H3_5, H4_4, H4_5	0		Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon	SJ-5303 (CLEAR)	3M
J1_4, J1_5, J2_4, J2_5	0		TERM BLK 2POS SIDE ENTRY 5MM PCB	HDR2	6.91138E+11	Würth Elektronik
J3_1, J3_2, J3_3, J3_4, J3_5, J6_4, J6_5	0		Header, 2.54 mm, 2x1, Gold, TH	Header, 2.54mm, 2x1, TH	61300211121	Wurth Elektronik
J4_4, J4_5, J5_4, J5_5	0		Header, 2.54 mm, 3x1, Gold, TH	Header, 2.54mm, 3x1, TH	61300311121	Wurth Elektronik
J7_4, J7_5, J8_4, J8_5	0			CONN_JUMPER	SNT-100-BK-H	Samtec
R1_4, R1_5	0	0	RES, 0, 5%, 0.1 W, 0603	603	RC0603JR-070RL	Yageo
R4_1, R4_2, R4_3, R4_4, R4_5	0	0	RES, 0, 0.05%, 2 W, AEC-Q200 Grade 0, 2512	2512	HCJ2512ZT0R00	Stackpole Electronics Inc
TP1_4, TP1_5, TP2_4, TP2_5, TP3_4, TP3_5, TP4_4, TP4_5, TP5_4, TP5_5, TP6_4, TP6_5	0		Test Point, Multipurpose, White, TH	White Multipurpose Testpoint	5012	Keystone Electronics
U1_4, U1_5	0		-4-V to 110V, Bidirectional, 1-MHz, 5V/µs, Ultra-Precise Current Sense Amplifier	SOT-23-8	INA296A1IDDF	Texas Instruments