

## INA79xx Evaluation Module



### Description

The INA79xEVM features the INA790x –4V to 110V, bidirectional, ultra-precise, current-sense amplifier with 75A EZShunt™ technology. The INA790 also features enhanced PWM rejection. The EVM provides a platform that facilitates gain and reference voltage configuration.

### Get Started

1. Order the EVM from [ti.com](https://www.ti.com).
2. Read the EVM user's guide.
3. Start evaluating.

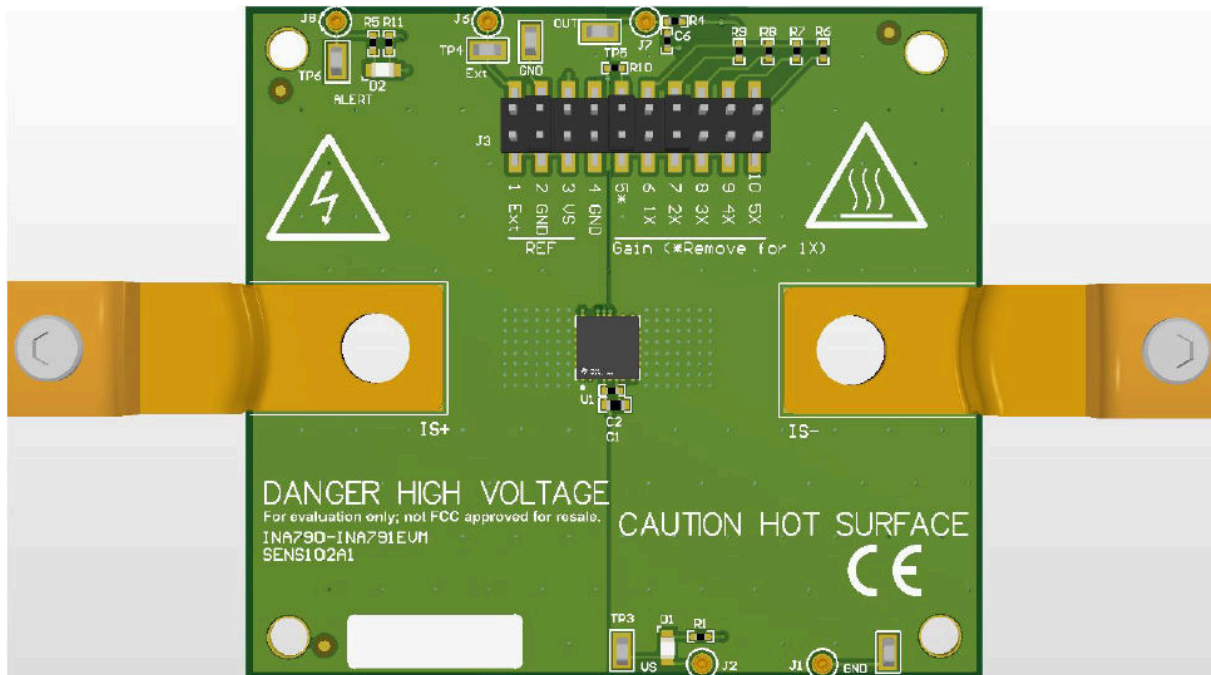
4. Refer to the product data sheet or [E2E](#) for questions and support.

### Features

- Evaluation of all sensitivity options for the [INA790 and INA791](#)
- Ease-of-access to device pins with test points
- Evaluation of high-side and low-side configurations

### Applications

- [Motor drives](#), solenoids, and actuators
- Injection molding machine, [cordless power tools](#)



# 1 Evaluation Module Overview

## 1.1 Introduction

This user's guide describes the characteristics, operation, and use of the [INA790 and INA791](#) evaluation module (EVM). This EVM is designed to evaluate the performance of the current-sense amplifiers in a variety of configurations. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the INA79xEVM. This document includes a schematic, reference printed circuit board (PCB) layouts, and a complete bill of materials (BOM).

See the corresponding product data sheet for comprehensive information about the [INA790 and INA791](#).

### Note

This EVM comes with either of four devices (INA790A/B and INA791A/B) populated. To evaluate, order the correct EVM from corresponding product folder.

## 1.2 Kit Contents

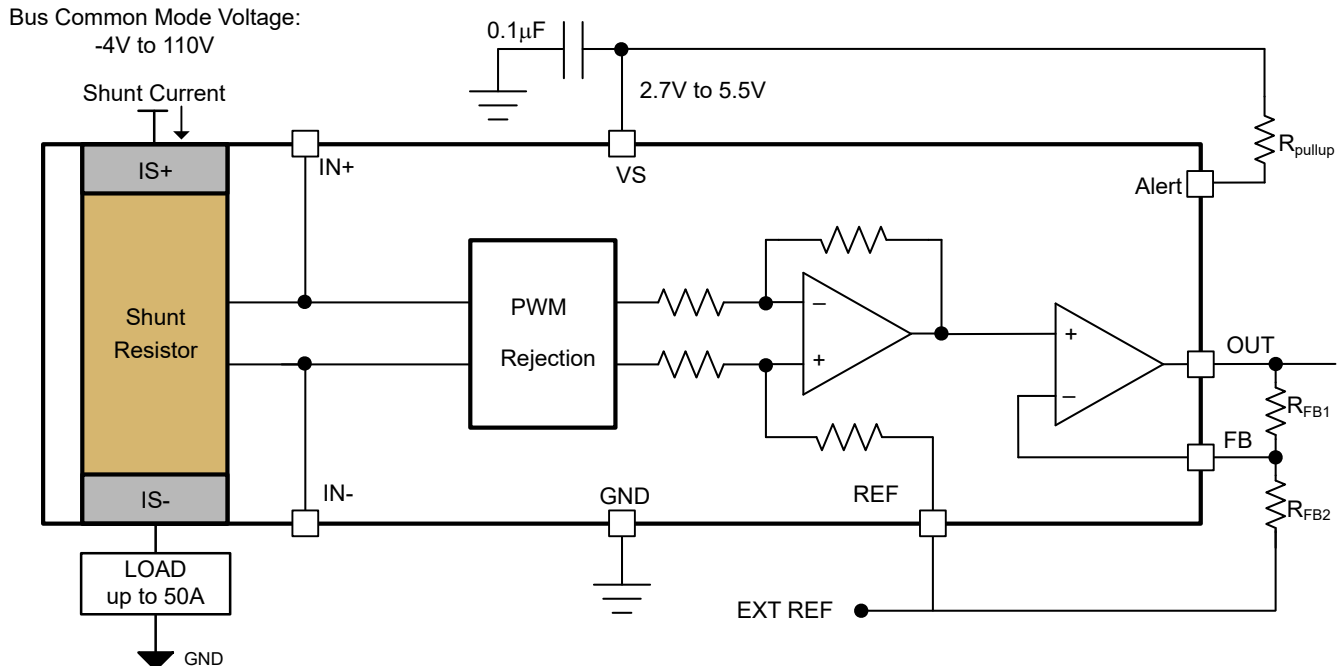
[Table 1-1](#) lists the contents of the INA79xEVM kit. Contact the [Texas Instruments Customer Support Center](#) if any component is missing. TI highly recommends checking the [INA79x](#) family product folder on the TI website at [www.ti.com](#) for further information regarding this product.

**Table 1-1. INA79xEVM Kit Contents**

ITEM	QUANTITY
INA790AEVM, INA790BEVM, INA791AEVM or INA791BEVM Test Board	1

## 1.3 Specification

[Figure 1-1](#) shows the device block diagram.



**Figure 1-1. INA790 Device Block Diagram**

## 1.4 Device Information

The [INA790x](#) current-sense amplifier comes with an integrated shunt resistor of  $400\mu\Omega$ . The INA790x is designed to monitor bidirectional current over a common-mode range of  $-4V$  to  $110V$ , independent of the supply voltage. Adjustable gain option assists in optimizing the system dynamic range.

This device operates from a single  $2.7V$  to  $5.5V$  power supply, drawing a maximum of  $3.75mA$  of supply current. All versions are specified over the extended operating temperature range ( $-40^{\circ}C$  to  $+125^{\circ}C$ ), and are available in a 15-pin VQFN package

[Table 1-2](#) lists the available sensitivity options.

**Table 1-2. INA79x Device Summary**

PRODUCT	Grade	PWM Rejection
INA790A	A	Yes
INA790B	B	Yes
INA791A	A	No
INA791B	B	No

## 1.5 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 the 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://ti.com/support> for further information.

**Save all warnings and instructions for future reference.**

### WARNING

Failure to follow warnings and instructions can 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 suitably qualified, then immediately stop from further use of the HV EVM.

#### 1. Work Area Safety

- a. Keep work area clean and orderly.
- b. Qualified observers must be present anytime circuits are energized.
- c. Effective barriers and signage must be present in the area where the TI HV EVM and the interface electronics are energized, indicating operation of accessible high voltages can 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, a good engineering practice to assume that the entire EVM can have fully accessible and active high voltages.

- a. De-energize the TI HV EVM and all the 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 the electrical circuits, as the EVM or the electrical circuits can 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 Hardware

The [INA79x](#) is a wide-common mode current-sense amplifier that provides ease-of-use and high performance. The INA79xEVM is a family of EVMs intended to provide basic, functional evaluation of all [INA79x](#) variants.

The INA79xEVM is populated with either of INA790A, INA790B, INA791A or INA791B device. Each of the variants is a unique orderable, and can be ordered from the corresponding product folder. The EVM allows testability of the adjustable gain and options for driving the reference pin.

Across all EVM variants, the parts that can be examined with the EVM are:

- INA790A
- INA790B
- INA791A
- INA791B

### 2.1 Circuitry

This section summarizes the INA79xEVM components.

#### 2.1.1 Bypass Capacitors

C1 and C2 are 1 $\mu$ F and 0.1 $\mu$ F supply bypass capacitors respectively. The capacitors are present to help smooth the supply voltage of the [INA79x](#). Typically only one 0.1 $\mu$ F bypass capacitor is required. The EVM can come with both capacitors populated.

#### 2.1.2 Output Filter

C6 and R4 are footprints for the optional output filter. Default values are 10nF and 0 $\Omega$ , but no capacitors are installed.

#### 2.1.3 Configurable Gain

The INA790x features default gain 20mV/A. With an external adjustable gain resistor network, total gain (G) can range up to 400mV/A. Position 5 through 10 of header J3 allows the user to customize the adjustable gain, with two shorting jumpers B and C as shown in [Figure 3-1](#). Configuration options provided by the EVM are shown in [Table 2-1](#):

**Table 2-1. Configurable Gain**

J3 Positions of Jumpers B and C	Output Amplifier Gain (V/V)	System Gain (mV/A)
B removed; C at #6	1	20
B installed; C at #7	2	40
B installed; C at #8	3	60
B installed; C at #9	4	80
B installed; C at #10	5	100

#### 2.1.4 Configurable Reference Voltage

The INA790x output is configurable to allow for unidirectional or bidirectional operation. The output voltage is set by applying a voltage from an external reference at REF pin. The voltage at REF pin can range between supply and GND. For symmetric bidirectional current sensing REF is set at mid-supply.

$$V_{OUT} = G \times (I_{SHUNT}) + V_{REF} \quad (1)$$

Positions 1 through 3 of header J3 allow the user to customize the REF pin voltage,  $V_{REF}$ , with shorting jumper A as shown in [Figure 3-1](#). When using external reference, the voltage source can be connected through J6 or TP4. Configuration options provided by the EVM are shown in [Table 2-2](#).

**Table 2-2. Configurable Reference**

J3 Position of Jumper A	V <sub>REF</sub> (V)
#1	User Provided
#2	0
#3	V <sub>S</sub>

### 2.1.5 Thermal Alert Function

The INA790x thermal alert is activated when internal shunt temperature reaches 160°C or above. The ALERT pin is open-drain and is equal to supply voltage when internal shunt temperature is below 60°C. When thermal alert function is activated, ALERT pin pulls to GND, and LED D2 on the EVM illuminates.

### 2.1.6 Load Connectors

The input connectors labeled IS+ (MP1) and IS– (MP2) correspond to the load connectors. These components are screwed to the board to make contact. The voltage developed over the integrated shunt is amplified by the device and is presented at the VOUT.

### 2.1.7 INA79x Current-Sense Amplifier

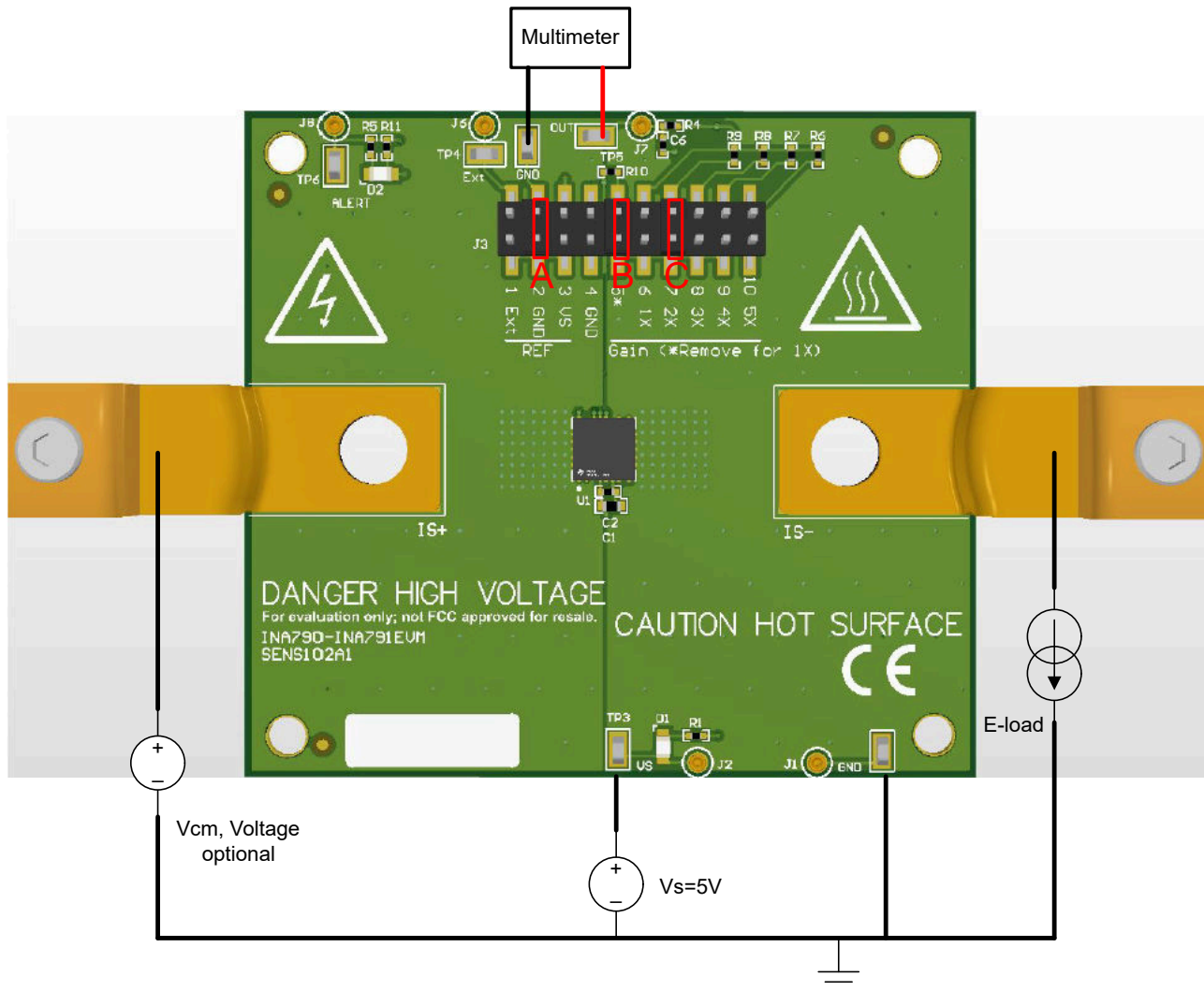
U1 is the INA79x current-sense amplifier. The INA79xEVM board comes with either of the four devices in the family (INA790A, INA790B, INA791A and INA791B ). Link to the correct orderable EVM is provided in individual product folders.

- A differential voltage is generated when the load current flows through the integrated shunt that is connected across the inputs IS+ and IS–.
- The INA79x can be configured to allow for unidirectional or bidirectional operation.
- The INA79x gain can be configured to optimize output voltage swing.

### 3 Implementation Results

#### 3.1 Operation

The following are instructions to set up and use the INA79xEVM. **Figure 3-1** shows an example of a simple, high-side setup. The high voltage source for load is noted as  $V_{CM}$ . The low voltage DUT supply is noted as  $V_S$ . The shorting jumpers A, B and C are installed such that  $V_{REF}$  equals to GND and the DUT gain is 40mV/A.



**Figure 3-1. High-side Forward Current Setup**

1. Attach the high-current lug connectors to IS+ and IS-.
2. Connect the terminals of an external  $V_S$  supply to the GND and  $V_S$  test points on the EVM.
3. Connect the input per [Section 3.1.1](#).

#### WARNING

When measuring current, first make sure that equipment (wires, connectors, and so forth) can support the amperage and power dissipation. Secondly, make sure that current flowing through the inputs of the device is kept within the safe operating area limits of the device found in the device data sheet. Failure to do so can result in damage to the EVM, or personal injury.

Do not touch the high voltage  $V_{CM}$  terminals.

Hot surface. Contact can cause burns. Do not touch.



### 3.1.1 Measurements

The following procedures are used to configure a measurement evaluation with an electronic load.

For low-side measurements:

1. Connect the electronic load positive input terminal to the positive terminal of a supply capable of sourcing the desired amount of maximum load current.
2. Connect the electronic load negative output terminal to the load sinking terminal of the EVM
3. Connect the load sourcing terminal of the EVM (IS+ or IS-) to the external supply GND
4. Turn on all the connected supplies
5. Apply load with electronic load or actual system load
6. Measure the output voltage at the OUT test point

For high-side measurements:

1. Connect the electronic load positive input terminal to the load sourcing terminal (IS+ or IS-) of the EVM.  
For high-side measurement of forward current, IS- sources to the electronic load; for reverse current, IS+ sources to the load.
2. Connect the electronic load negative output terminal to the external supply GND terminal
3. Connect the external supply to the load sinking terminal of the EVM
4. Turn on all the connected supplies
5. Apply load with electronic load or actual system load
6. Measure the output voltage at the OUT test point

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#### Note

Set  $V_{REF}$ , Gain and load current direction so that the output voltage is within the linear range between GND and  $V_S$ .

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### 3.1.2 Advanced Measurement Tips

To assess whether the expected load matches the measured load, use a precision shunt resistor rated for the maximum intended current in series with the DUT. The precision shunt needs to have a kelvin connection where the generated sense voltage can be measured by a precision multimeter, such as the 3458a multimeter. Sensing an external shunt voltage is preferred, as a typical multimeter can have a current limit far below the needed current measurement limits in question. Additionally, some meters have better voltage measurement precision than current measurement precision.

For evaluating performance when the DUT is subjected to quick current pulses, use short, large-gauge wire, or short bus bars, to reduce the inductance and resistance between the HV-supply, load, and EVM. By minimizing the inductance, the rate of load slew can be increased. If assessing the performance over large transient current spikes (>20A) is desired, then be sure to use a supply with sufficient voltage headroom to accommodate the series resistance of the wires or bus bars, the board planes, and the DUT lead frame resistance. Use a large capacitor bank between the supply terminals to make sure there is an adequate charge reservoir available to prevent the supply from drooping. A large capacitor bank can also help supply the large current inrush through the device.

To assess temperature performance, use wide, thin bus bars to reduce the thermal sinking ability of the system and minimize the inductance of the system. Board temperature are not an exact indicator of DUT temperature. More precise measurements can be obtained by placing a layer of thermally conductive grease on top of the DUT package and placing a thermal sensor directly on the thermal grease. See [Thermal Implementation Guide for In-Package Magnetic Current Sensors](#) for tips on thermal best practices.





## 4.2 PCB Layout

Figure 4-2 through Figure 4-5 illustrate the PCB layers of the EVM.

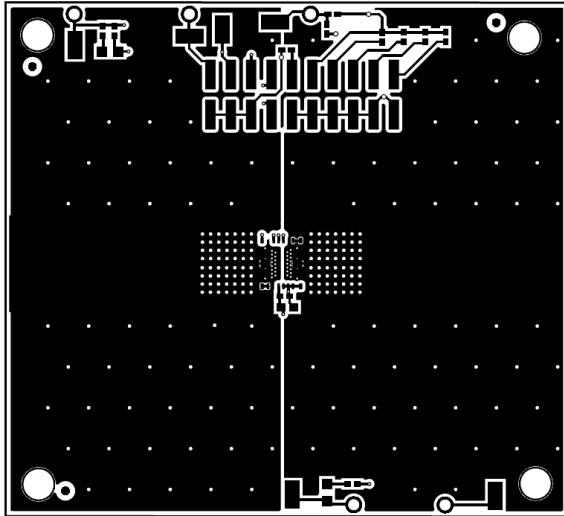


Figure 4-2. Top Layer

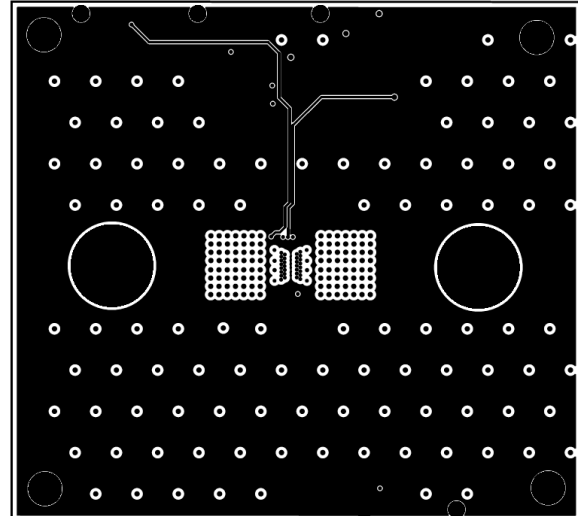


Figure 4-3. Signal Layer 1

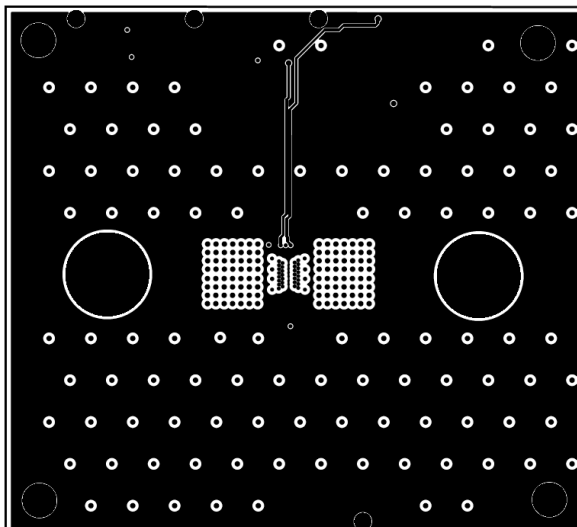


Figure 4-4. Signal Layer 2

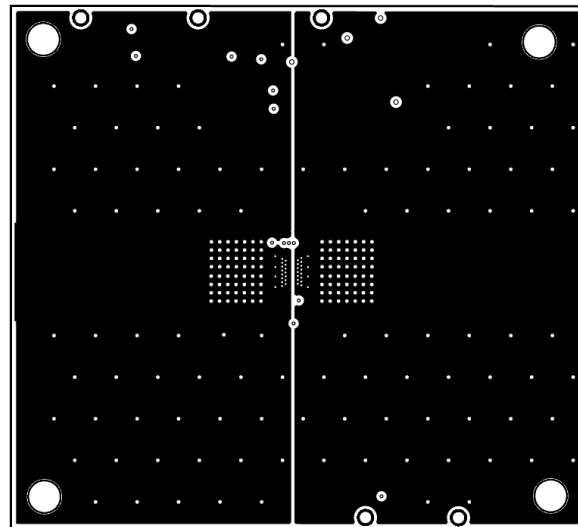


Figure 4-5. Bottom Layer

### 4.3 Bill of Materials

Table 4-1 shows the BOM of INA790AEVM. Only U1 is different for the rest of the INA79xEVM variants.

**Table 4-1. Bill of Materials**

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C1	1	1uF	CAP, CERM, 1uF, 50V, +/- 10%, X6S, 0603	0603	C1608X6S1H105K080AC	TDK
C2	1	0.1uF	CAP, CERM, 0.1uF, 50V, +/- 20%, X7R, 0402	0402	GRM155R71H104ME14D	MuRata
D1, D2	2		LED, White, SMD	0805	VAOL-S8WR4	Visual Communications Company, LLC
H1, H2, H3, H4	4		Bumpon, Hemisphere, 0.375 X 0.235, Black	Black Bumpon	SJ61A2	3M
J1, J2, J6, J7, J8	5		CONN PIN RCPT .018-.021 SOLDER	PIN_RCPT	3-331272-8	TE Connectivity
J3	1		Header, 2.54mm, 10x2, Gold, SMT	1000x180x290mil	TSM-110-01-L-DV-P	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
MP1, MP2	2		Terminal Connector Rectangular Lug, Grounding 1/4 Stud	TERMINAL_CONN	CB70-14-190	Panduit
R1, R5, R8, R11	4	10.0k	RES, 10.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040210K0FKED	Vishay-Dale
R4	1	0	RES, 0, 5%, 0.063 W, 0402	0402	CRC0402JR-070RL	Yageo America
R6	1	20.0k	RES, 20.0 k, 1%, 0.063 W, 0402	0402	CRCW040220K0FKED	Vishay-Dale
R7	1	15.0k	RES, 15.0 k, 1%, 0.063 W, 0402	0402	CRCW040215K0FKED	Vishay-Dale
R9, R10	2	4.99k	RES, 4.99 k, 1%, 0.063 W, 0402	0402	CRCW04024K99FKED	Vishay-Dale
SH-J1, SH-J2, SH-J3,	3	1x2	Shunt, 100mil, Flash Gold, Black	Closed Top 100mil Shunt	SPC02SYAN	Sullins Connector Solutions
TP1, TP2, TP3, TP4, TP5, TP6	6		Test Point, Miniature, SMT	Test point_Keystone_Miniature	5015	Keystone
U1	1		INA790AIDEKR	VQFN15	INA790AIDEKR	Texas Instruments

## 5 Additional Information

### 5.1 Trademarks

EZShunt™ is a trademark of Texas Instruments.  
 All trademarks are the property of their respective owners.

## 6 Related Documentation From Texas Instruments

[Table 6-1](#) provides literature references for TI's integrated circuits used in the assembly of the EVM. This user's guide is available from the TI website under literature number SBAU461. Any letter appended to the literature number corresponds to the document revision that is current at the time of the writing of this document. Newer revisions are available from [www.ti.com](http://www.ti.com) or the Texas Instruments' Literature Response Center at (800) 477-8924 or the Product Information Center at (972) 644-5580. When ordering, identify the document by both title and literature number.

**Table 6-1. Related Documentation**

DOCUMENT	LITERATURE NUMBER
<a href="#">INA790</a> product data sheet	<a href="#">SBOSAA6</a>
<a href="#">INA791</a> product data sheet	<a href="#">SBOSAD1</a>

## 7 Revision History

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

Changes from Revision * (May 2024) to Revision A (November 2024)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document.....	1
• Updated layout images throughout the document to reflect the updated layout.....	1

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