EVM User's Guide: INA790AEVM, INA790BEVM, INA791AEVM, INA791BEVM

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

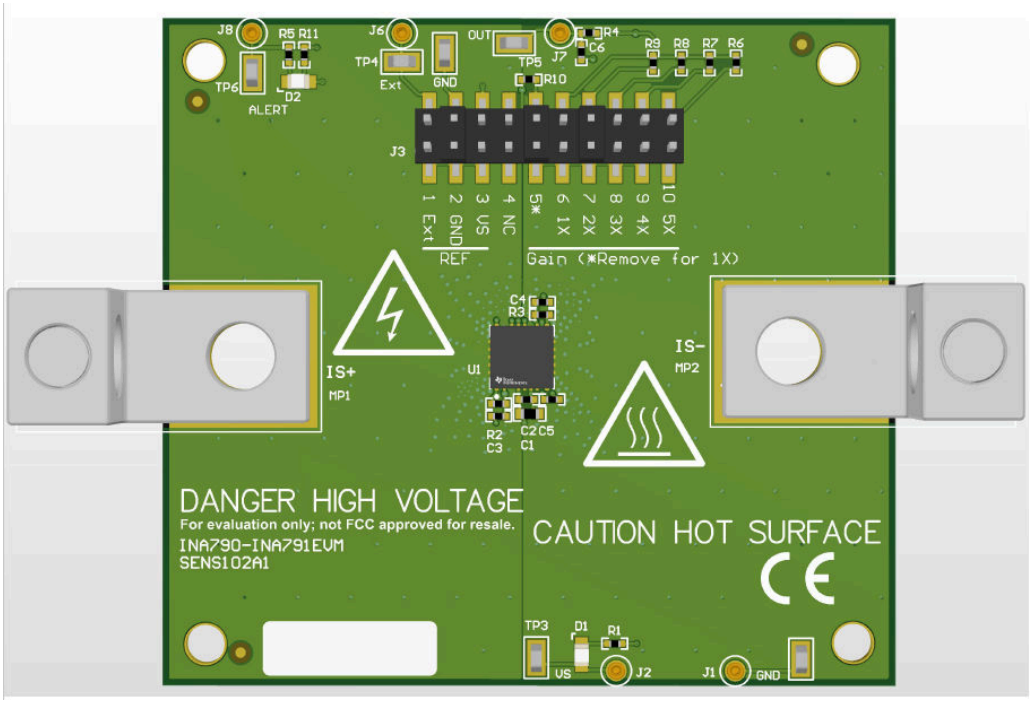
1. Order the EVM from ti.com.
2. Read the EVM user's guide.
3. Start evaluating.
4. Refer to the product data sheet or E2E for questions and support.

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 79xEVM 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.

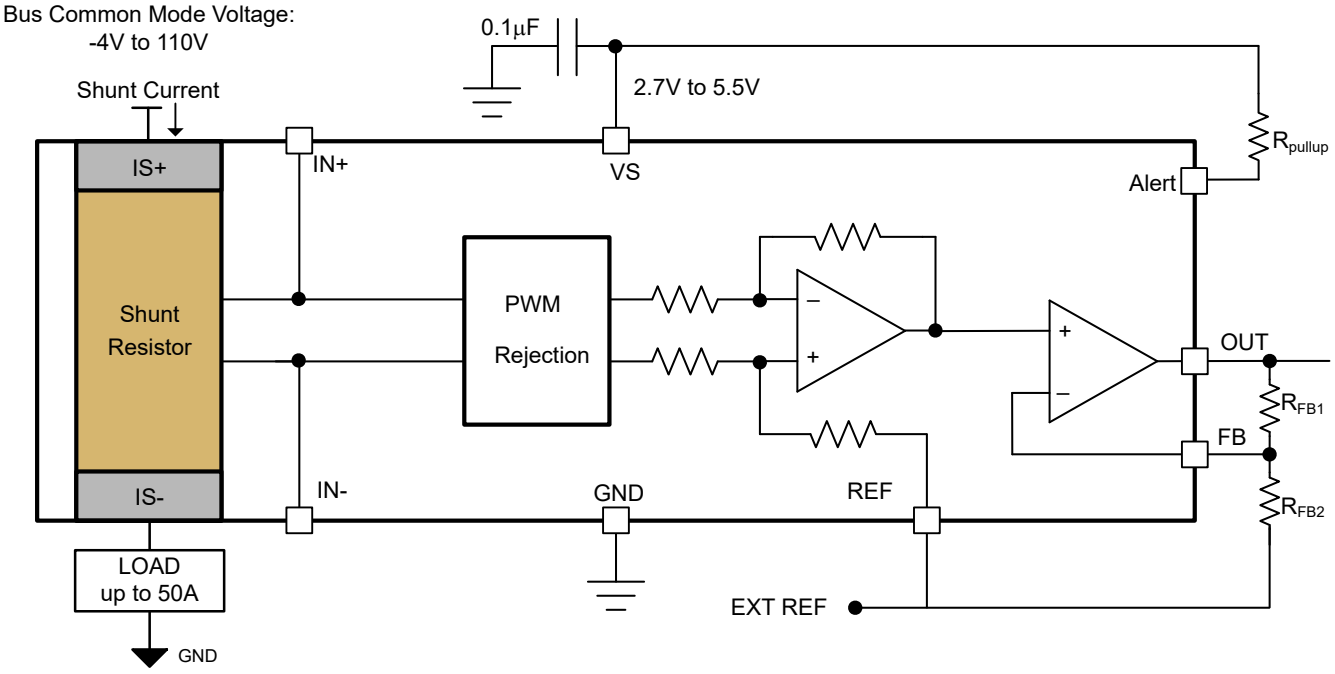


Figure 1-1. INA790 Device Block Diagram

1.4 Device Information

The INA790x current-sense amplifier comes with an integrated shunt resistor of 400µΩ. 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°C to +125°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 1µF and 0.1µF supply bypass capacitors respectively. The capacitors are present to help smooth the supply voltage of the INA79x. Typically only one 0.1µF 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 0Ω, 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 though 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 though 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_{REF} (V)
#1	User Provided
#2	0
#3	V_S

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.

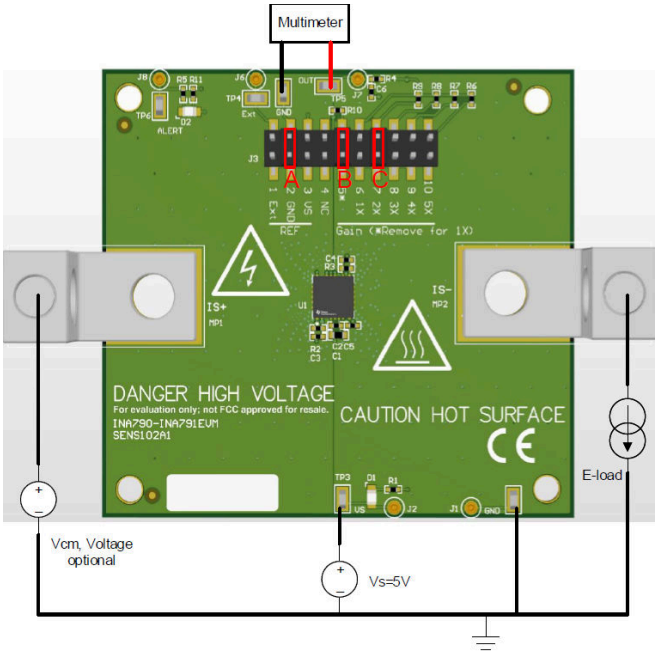


Figure 3-1. High-side Forward Current Setup

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

Note

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

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 (>20 A) 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 Hardware Design Files

4.1 Schematics

Figure 4-1 shows the schematic of the A1 sub board on the INA790AEVM PCB. All INA790xEVM orderables use the same circuit and same PCB layout. Only U1 is unique among the orderables.

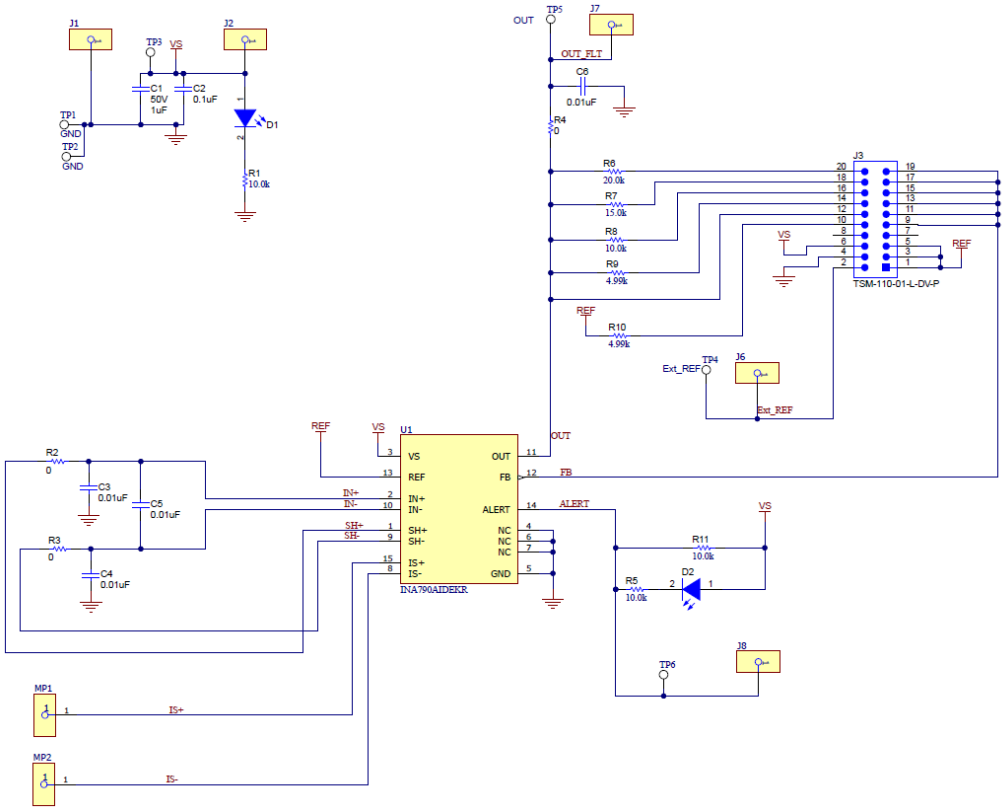


Figure 4-1. Schematic

4.2 PCB Layout

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

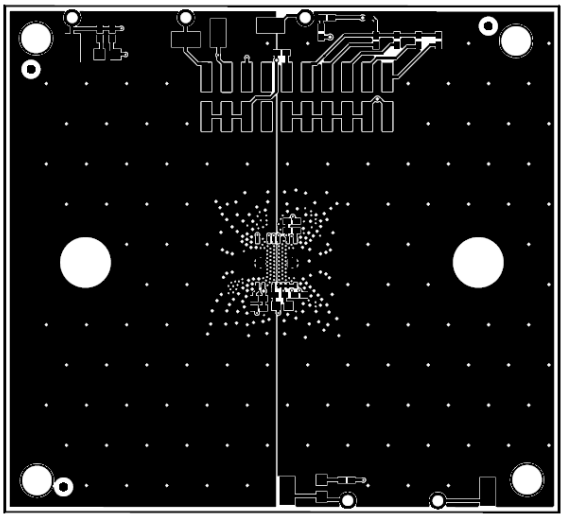


Figure 4-2. Top Layer

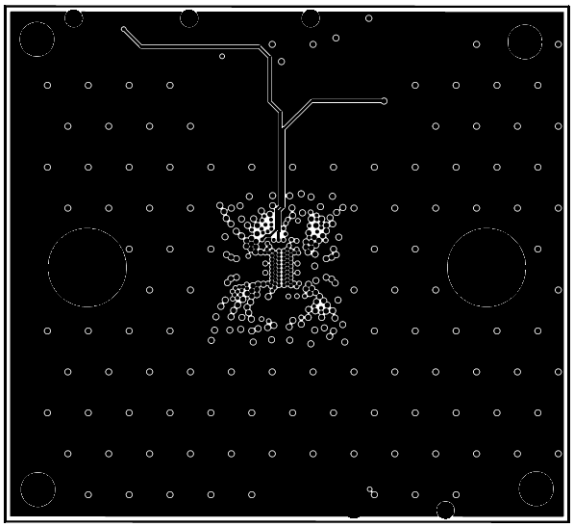


Figure 4-3. Signal Layer 1

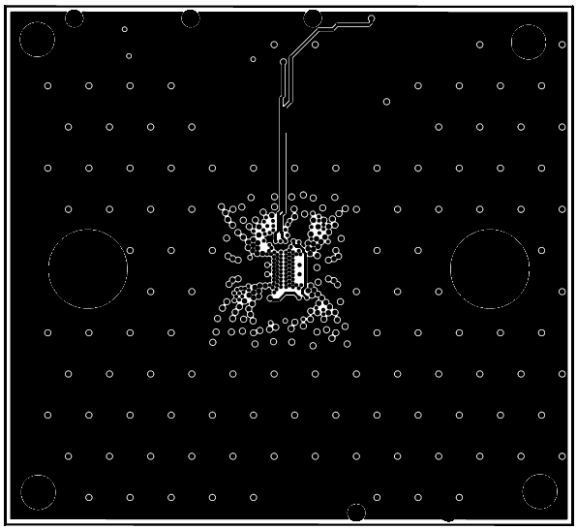


Figure 4-4. Signal Layer 2

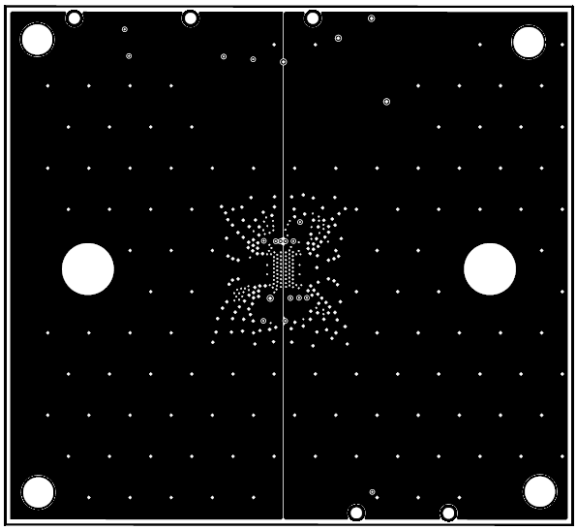


Figure 4-5. Bottom Layer

4.3 Bill of Materials

Table 4-1shows 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 6-14 AWG 1/4 Stud	TERMINAL_CONN	LAMA6-14-QY	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
R2, R3, R4	3	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 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
INA790 product data sheet	SBOSAA6
INA791 product data sheet	SBOSAD1

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社

東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user 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, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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