

EVM User's Guide: INA1H94EVM

INA1H94-SP Evaluation Module



Description

The INA1H94EVM is an evaluation module (EVM) to test the INA1H94-SP. The EVM is designed with populated circuits to quickly evaluate the functionality of the INA1H94 in 8-pin CFP package (HKX). The board offers flexibility with input and output connections through banana connectors, SMA/SMB connector footprint, test points, and footprints to evaluate with a flexible reference voltage.

Get Started

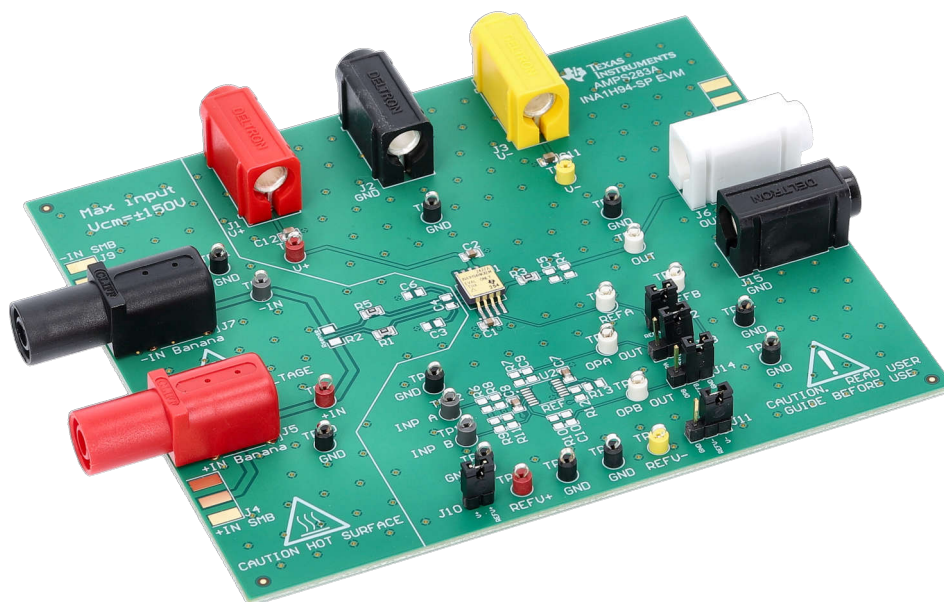
1. Order the INA1H94EVM board from the tool page
2. Download the [INA1H94-SP data sheet](#) for detailed device specification
3. Download the EVM user's guide for instructions

Features

- Populated with INA1H94HKX/EM device for ease of use
- Flexible input and output connections with banana connectors, test points, and SMB/SMA footprints
- Ease of access to device pins with test points
- Footprints available to populate sense resistor, input filtering, and external reference buffer

Applications

- [High-voltage current sensing](#)
- [Satellite electrical power system \(EPS\)](#)
- [Communications payload](#)



1 Evaluation Module Overview

1.1 Introduction

This user's guide contains support documentation for the INA1H94EVM. The EVM is designed to evaluate an INA1H94-SP and is populated with the INA1H94HKX/EM device.

This document includes description of how to use the EVM, high voltage precautions, contents, schematics, printed circuit board (PCB) layouts, and bill of materials (BOM). Throughout the document, the terms *evaluation board*, *evaluation module*, and *EVM* are synonymous with the INA1H94EVM.

1.2 Kit Contents

This EVM kit includes:

- INA1H94EVM evaluation module
- EVM Disclaimer Read Me
- High Voltage Read Me

This kit does not include:

- Capacitors and resistors for R_{SENSE} , input filtering, and output load
- Components for external reference circuit
- SMB/SMA connectors

1.3 Specification

The INA1H94EVM is an evaluation module that provides a method to evaluate the INA1H94-SP. The EVM is populated with the engineering sample version (INA1H94HKX/EM) and is not radiation-tested. The printed circuit board (PCB) is 4.20in by 5in in size and uses FR4 material.

The EVM offers the following features:

- High voltage input terminals up to $\pm 150\text{V}$. See the [Section General Texas Instruments High Voltage Evaluation \(TI HV EVM\) User Safety Guidelines](#) on high voltage guidelines.
- Optional reference buffer footprint (quad op amp in TSSOP-14 package)
- Optional sense resistor footprint (0805 components)
- Footprints for input filtering capacitors and output loads (0805 components)
- Footprints for SMA/SMB connectors on input and output of PCB
- Option to bias REFA and REFB to separate voltages

1.4 Device Information

The INA1H94-SP is a radiation-hardened precision unity-gain difference amplifier with very high input common-mode voltage range. The device is a single, monolithic device that consists of a precision op amp and an integrated thin-film resistor network. The INA1H94 can accurately measure small differential voltages in the presence of common-mode signals up to $\pm 150\text{V}$.

The INA1H94-SP is offered in HKX-8 package and available in QML Class V (QMLV) or engineering sample (EM) version. [Figure 1-1](#) shows a simplified block diagram. More device information can be found in the [INA1H94-SP Radiation-Hardened, High Common-Mode Voltage Difference Amplifier data sheet](#).

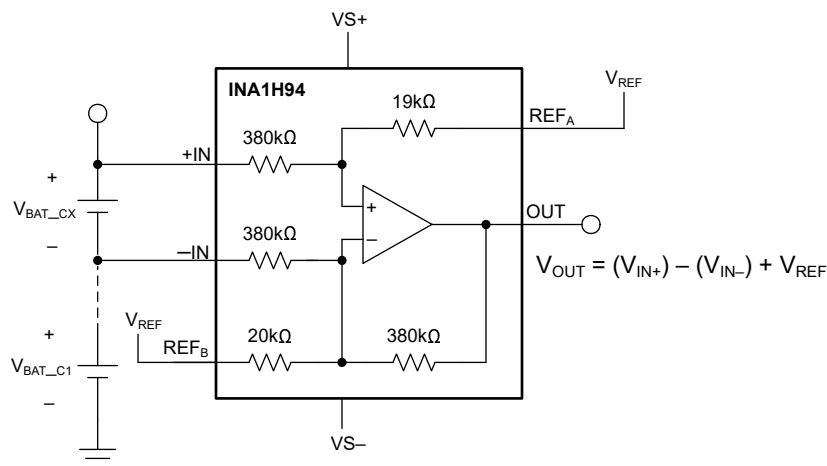


Figure 1-1. INA1H94 Simplified Application

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



Always follow TI's set-up 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/customer-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, you should immediately stop from further use of the HV EVM.

1. Work Area Safety:

- Keep work area clean and orderly.
- Qualified observers must be present anytime circuits are energized.
- 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.
- 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.
- Use stable and non-conductive work surface.
- 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 is to assume that the entire EVM can have fully accessible and active high voltages.
- 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.
- With the EVM confirmed de-energized, proceed with required electrical circuit configurations, wiring, measurement equipment hook-ups and other application needs, while still assuming the EVM circuit and measuring instruments are electrically live.
- Once 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

- Wear personal protective equipment e.g. latex gloves or safety glasses with side shields or protect EVM in an adequate lucent plastic box with interlocks from accidental touch.

Limitation for safe use:

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

2 Hardware

2.1 Power Requirements

The INA1H94 operates on a power supply voltage range from $\pm 2\text{V}$ to $\pm 9\text{V}$ dual supply or 4V to 18V single supply. The device can be operated in dual or single supply. The EVM has connections for positive supply ($V+$), negative supply ($V-$), and ground (GND) as shown in Figure 2-1. Bypass capacitors are populated on the board ($C1$, $C2$, $C11$, $C12$) for the device supply. The supply connection can be done either using a standard 4mm banana jack or using the power supply test points, both are not required for operation. If using in single supply, connect both ($V-$) and GND to ground.

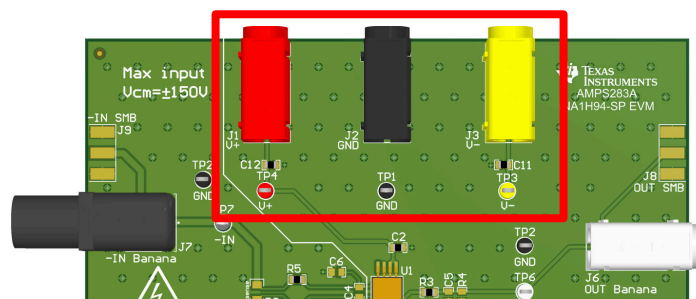


Figure 2-1. Power Connectors and Test Points

Figure 2-2 shows the high voltage section on the board is denoted by the silkscreen and the high voltage-rated banana jack connectors ($J5$, $J7$). The silkscreen portion is to show where the PCB traces have been optimized for high voltage clearance and design rules to withstand the max voltage rating of $\pm 150\text{V}$ per device rating. All other banana jack connectors are rated for less than 50V .

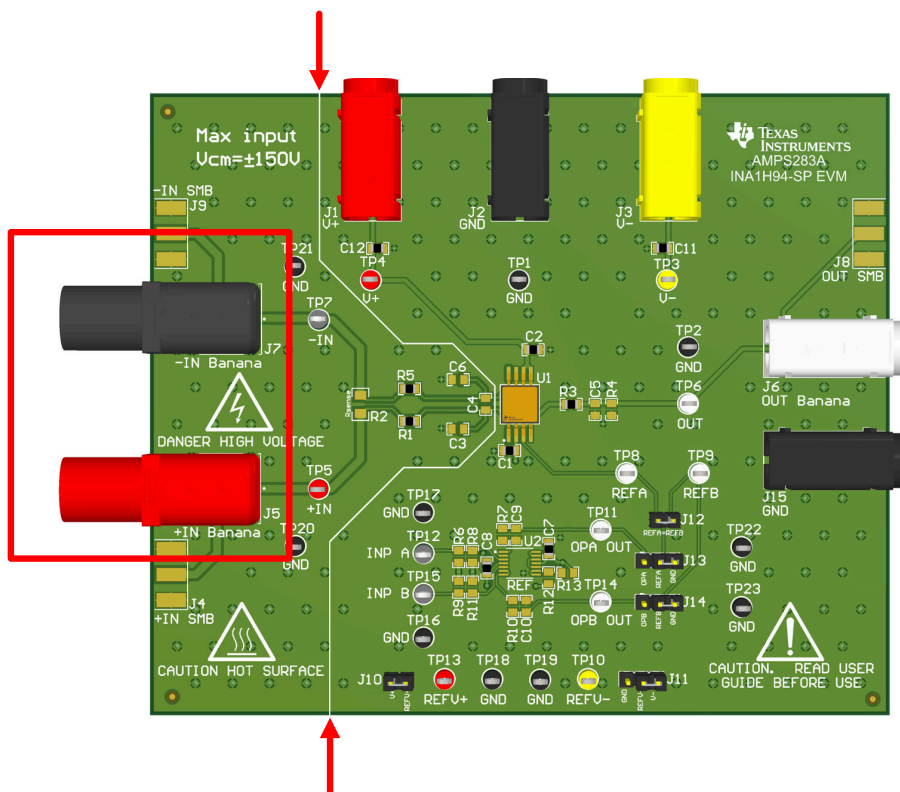


Figure 2-2. High Voltage Section of Evaluation Board

When using an external reference buffer, the supply voltage for the reference buffer ($REFV+$ and $REFV-$) can be either tied to the board supply ($V+$ and $V-$ or GND) via $J10$ and $J11$ or connected externally by the test points $TP13$ and $TP10$, both are not required for operation. Location of the test points and headers are indicated in

Figure 2-3. If REFV+ and REFV– are driven externally, remove shunts from J10 and J11. Do not connect the board supplies (V+ and V–) and REF supplies (REFV+ and REFV–) together if driving externally. See [Table 2-1](#) for more information.

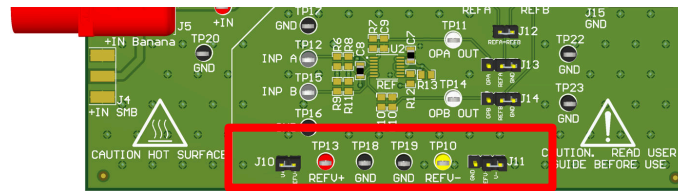


Figure 2-3. Reference Power Pin Headers and Test Points

Table 2-1. Reference Buffer Supply Voltage Headers

HEADER NAME	FUNCTION	SETTING	DESCRIPTION
J10	REFV+	Closed	REFV+ is shorted to V+. Do not apply an external voltage to TP13
		Open	REFV+ is floating and must be biased externally with TP13
J11	REFV-	Closed (REFV– to V–)	REFV– is shorted to V–. Do not apply an external voltage to TP10
		Closed (REFV– to GND)	REFV– is shorted to GND. Do not apply an external voltage to TP13
		Open	REFV– is floating and must be biased externally with TP10

2.2 Test Points

Test points, denoted on the board as "TP", are located throughout the board to access across the signal path and supplies. Test points can also be used to bias voltages directly on the inputs, reference voltages, or supply voltages. GND points are also included for ease of use. See [Section 3.1](#) for all test point locations.

2.3 Setup

The default configuration of the EVM can test the INA1H94 without any modifications and following the connections shown in [Figure 2-4](#) to test basic device characteristics with standard lab equipment. Modifications that can be made to circuit are shown from [Section 2.3.1](#) to [Section 2.3.2](#).

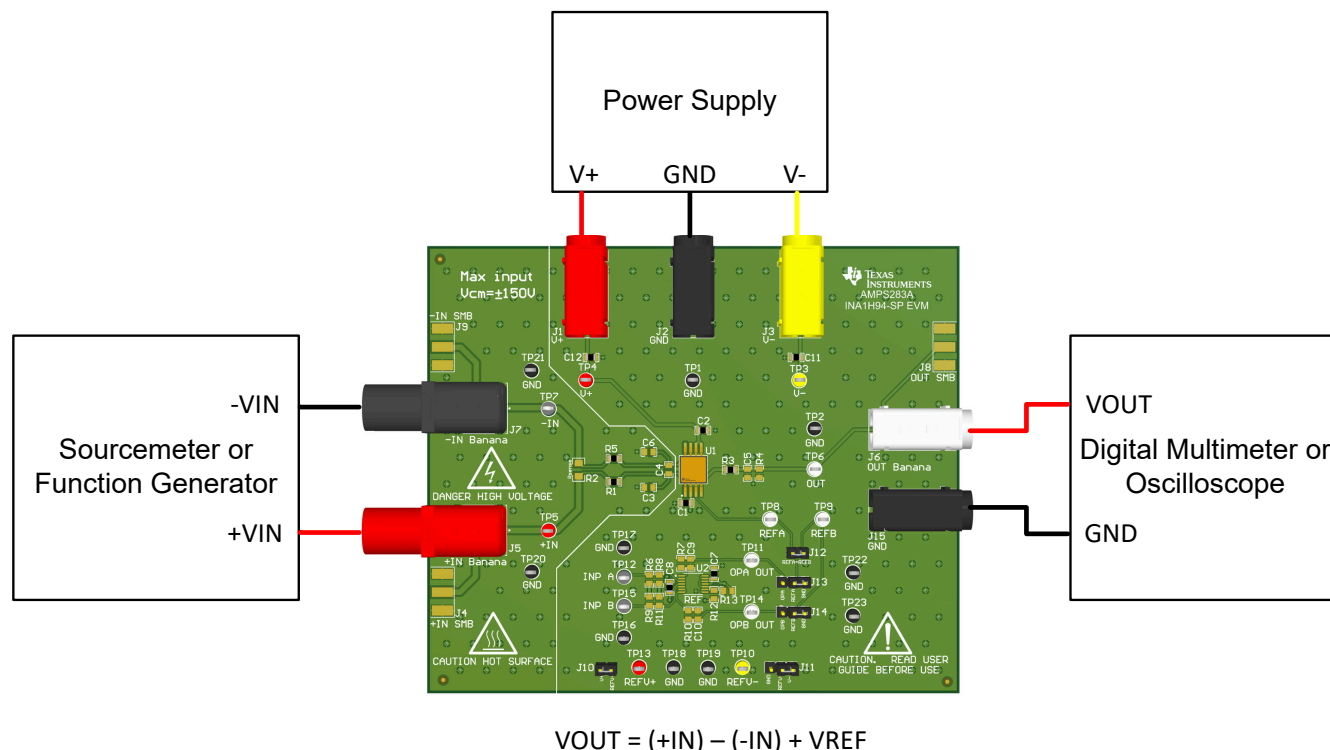


Figure 2-4. Simplified Bench Configuration using Default Setup

Table 2-2. Default Header Settings

HEADER NAME	SETTING
J10	Closed
J11	Closed (REFV- to V-)
J12	Closed
J13	Closed (REFA to GND)
J14	Closed (REFB to GND)

2.3.1 Reference Voltage

The EVM has an optional reference buffer footprint to allow the reference pin to be biased to different voltage potentials. Headers J12, J13, and J14 allow flexibility for the reference circuitry to drive the reference pins (REFA and REFB) together or independently with the external reference buffer circuitry. Information on the different configuration options are shown in [Table 2-3](#). By default, this circuit is left unpopulated and the headers set up the device for both REF pins to be grounded (see [Section 2.3.1.1](#)).

For options on how to supply power to the reference buffer circuit, see [Section 2.1](#).

The OPA4H014-SEP was selected for the reference buffer (U2) in the schematic because of compatibility with space applications. Most quad channel operational amplifier in TSSOP-14 package can be used as an alternative when using the reference circuit. Space-grade operational amplifier recommendations can be found through this [link on TI.com](#).

The reference voltage can be biased in multiple configurations, modifying the transfer function. Common configurations and examples with setup required are outlined from [Section 2.3.1.1](#) to [Section 2.3.1.3](#).

Table 2-3. Header Configurations for Reference Pins (REFA and REFB)

HEADER NAME	SETTING	DESCRIPTION
J12	Closed	Short REFA and REFB pin together
	Open	REFA and REFB pin connect separately
J13	Closed (REFA to OPA)	REFA is connected to output of reference buffer Ch A
	Closed (REFA to GND)	REFA is connected to GND
	Open	REFA is left floating. Pin can be driven externally through TP8.
J14	Closed (REFB to OPB)	REFB is connected to output of reference buffer Ch B
	Closed (REFB to GND)	REFB is connected to GND
	Open	REFB is left floating. Pin can be driven externally through TP9.

2.3.1.1 Configuration 1: REFA and REFB = GND

Figure 2-5 shows circuit for Configuration 1 and Table 2-4 outlines the header pin settings. The most common use case is to set both reference pins (REFA and REFB) to GND and the reference pins are connected together. By grounding the reference voltage, the transfer function simplifies to Equation 1.

$$V_{OUT} = (+IN) - (-IN) \quad (1)$$

Table 2-4. Header Pins for Configuration 1

HEADER NAME	SETTING
J12	Closed
J13	Closed (REFA to GND)
J14	Closed (REFB to GND)

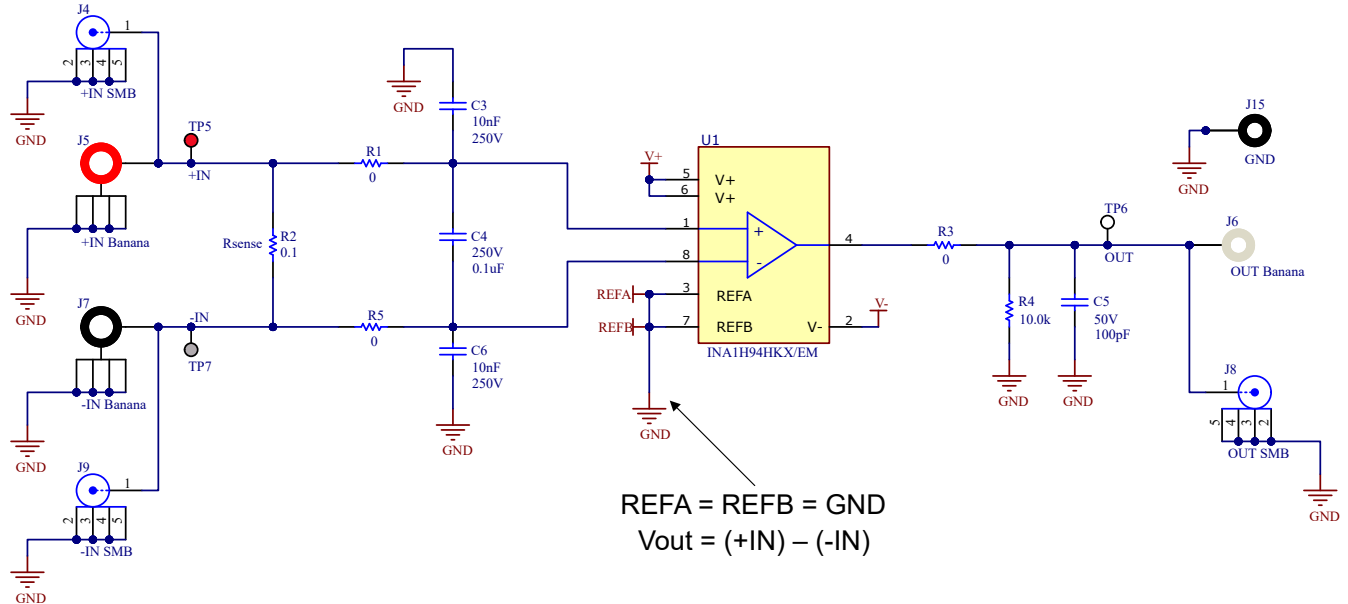


Figure 2-5. Reference Pins Grounded

2.3.1.2 Configuration 2: OPA CH A Bias REFA and REFB

Figure 2-6 shows circuit for Configuration 2 and Table 2-5 outlines the header pin settings.

This use case sets the reference voltage to mid-supply for REFA and REFB. The voltage is set by channel A of the external reference buffer (U2). The buffer circuitry must be populated and at a minimum, the following components must be added: U2, R6, R7, R8, R9, R10, R11, R12, R13. In this circuit, both REFA and REFB are biased by the same voltage by shorting J12. The corresponding transfer function becomes Equation 2, where the output of the reference buffer is V_{REF} .

$$V_{OUT} = (+IN) - (-IN) + V_{REF} \quad (2)$$

Table 2-5. Header Pins for Configuration 2

HEADER NAME	SETTING
J12	Open
J13	Closed (REFA to OPA)
J14	Open

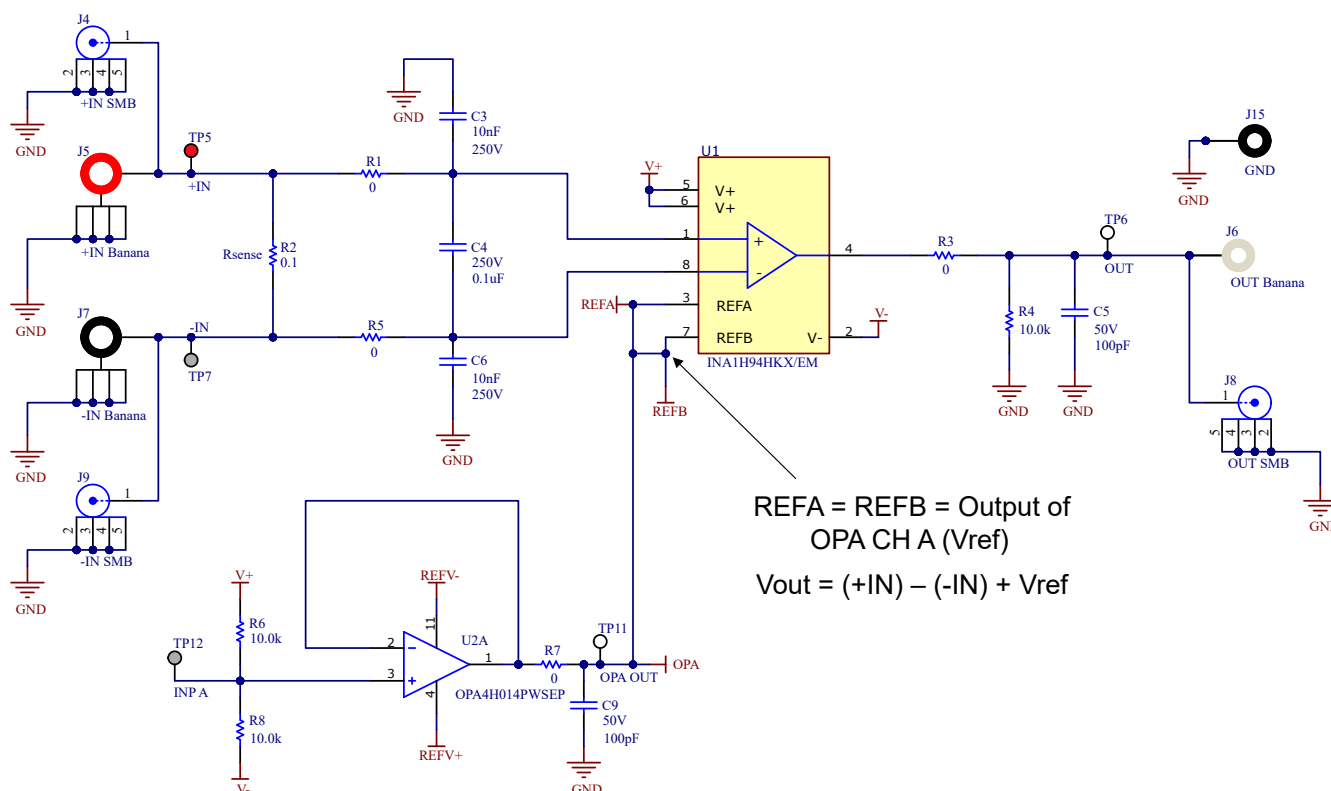


Figure 2-6. OPA Ch A Bias REFA and REFB

2.3.1.3 Configuration 3: REFA and REFB Bias Independently

Figure 2-7 shows circuit for Configuration 3 and Table 2-6 outlines the header pin settings.

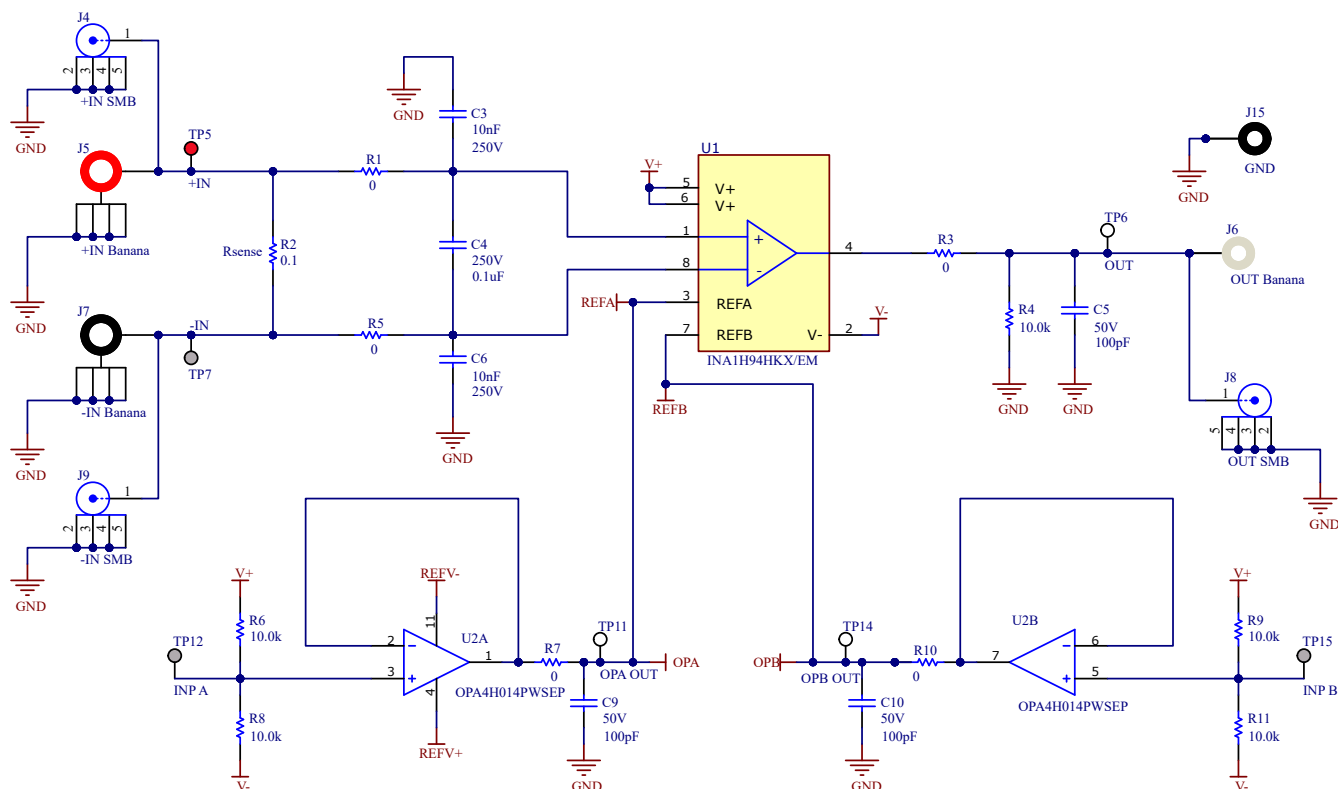
This use case sets the reference voltage for REFA and REFB independently. REFA is set by channel A of the external reference buffer (U2) and REFB is set by channel B. The corresponding transfer function becomes Equation 3. The buffer circuitry must be populated and at a minimum, the following components needs to be added: U2, R7, R10, R12, R13.

Two separate reference voltages can be biased to REFA and REFB by either applying a voltage to TP12 and TP15 or changing the resistor ratio on the input voltage divider ($R6/R8$ and $R9/R11$). Do not connect both an external voltage source and populate the resistor divider network.

$$V_{OUT} = (+IN) - (-IN) + 20 \times REF_A - 19 \times REF_B \quad (3)$$

Table 2-6. Header Pins for Configuration 3

HEADER NAME	SETTING
J12	Closed
J13	Closed (REFA to OPA)
J14	Closed (REFB to OPB)



REFA = Output of OPA CH A
REFB = Output of OPA CH B

$$V_{out} = (+IN) - (-IN) + 20 \times REFA - 19 \times REFB$$

Figure 2-7. REFA and REFB Bias Independently

2.3.2 Current Sensing

A R_{SENSE} resistor footprint (R2) is designed in the EVM layout to evaluate current-sensing applications. If using R_{SENSE} , this resistor must be rated for the inputs being selected and range from 0603 to 1206 in size. The trace width provides for evaluation of load currents up to 5A. See [Section General Texas Instruments High Voltage Evaluation \(TI HV EVM\) User Safety Guidelines](#) for all precautions on high-voltage safety use.

2.3.3 Input Filtering

Common-mode and differential input filtering can be applied to the circuit using C3, C4, C6. These components are unpopulated by default. When selecting component values for the capacitors, the recommendation is to make C4 approximately ten times larger than C3 and C6. Note that any capacitor and resistors selected must be rated for the inputs being applied.

2.3.4 Output Load

An output load can be applied to the circuit using R4 and C5, for resistive load and capacitive load respectively. R3 can be used with C5 for an output filter. By default, R3 is populated with 0Ω while R4 and R5 are left unpopulated.

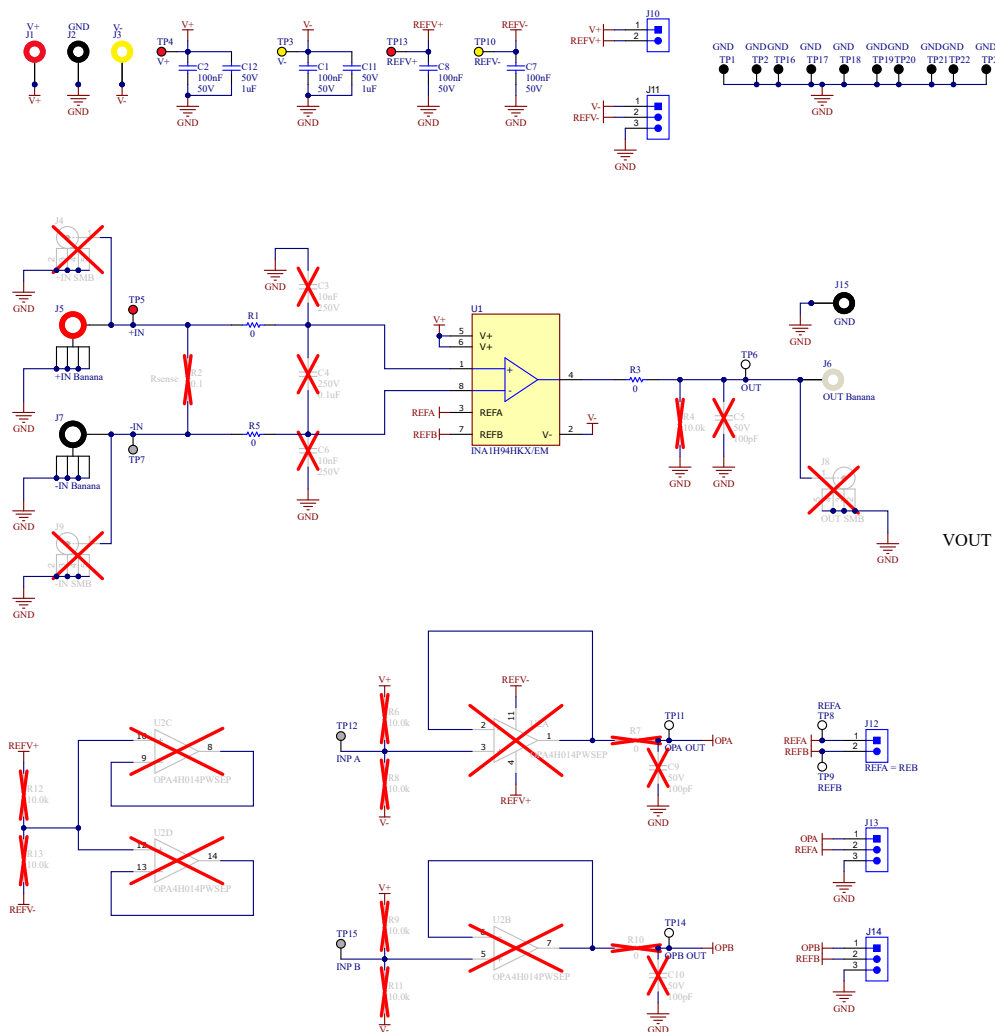
2.4 Best Practices

For best practices:

- Reference the [INA1H94-SP Radiation-Hardened, High Common-Mode Voltage Difference Amplifier data sheet](#) for device specification and information.
- Review [Section General Texas Instruments High Voltage Evaluation \(TI HV EVM\) User Safety Guidelines](#) for high voltage EVM safety guidelines before using EVM.
- The EVM and all components on board are intended for evaluation only and not for flight.

3 Hardware Design Files

3.1 Schematic



3.2 PCB Layouts

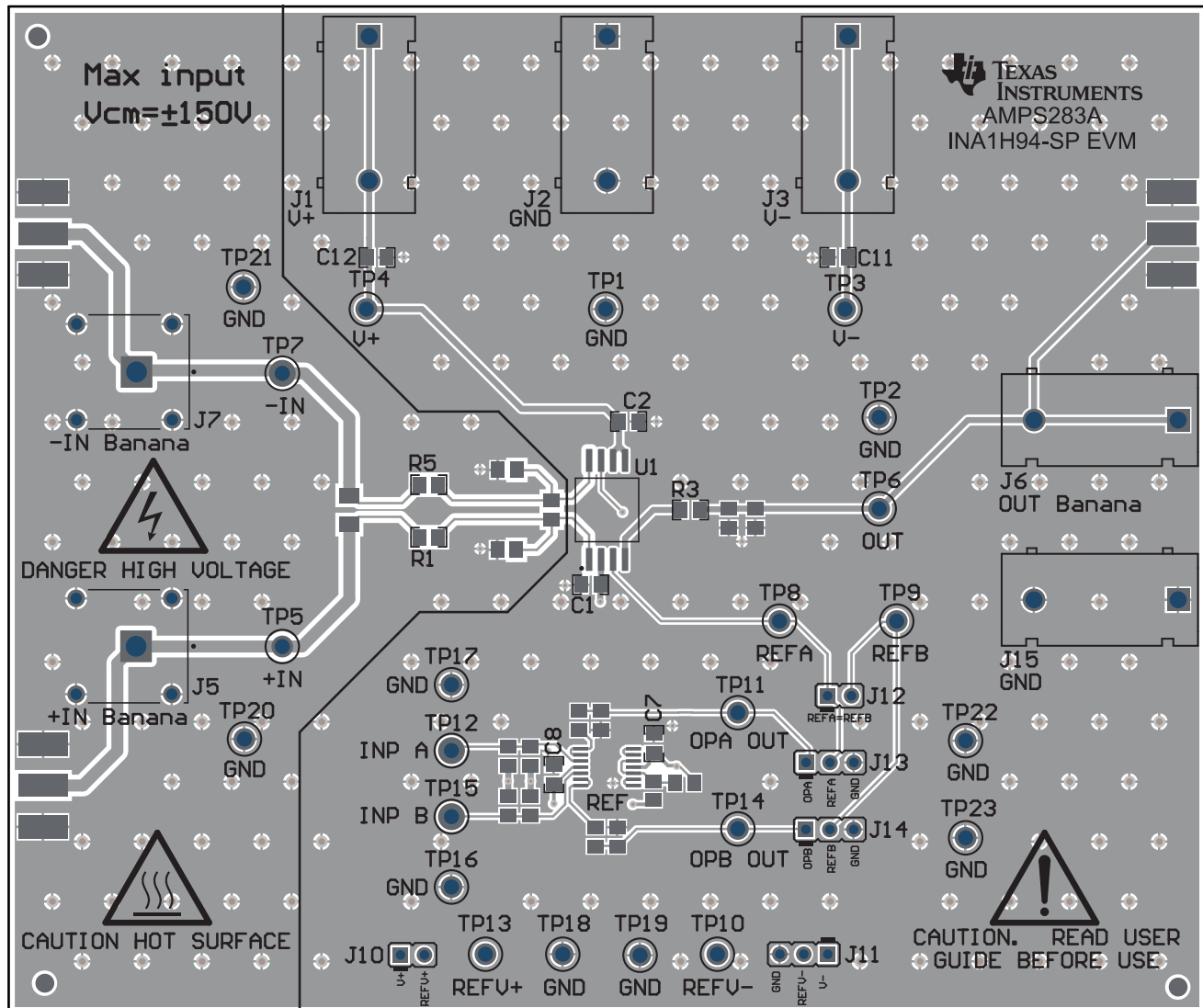


Figure 3-1. Top Layer Silkscreen

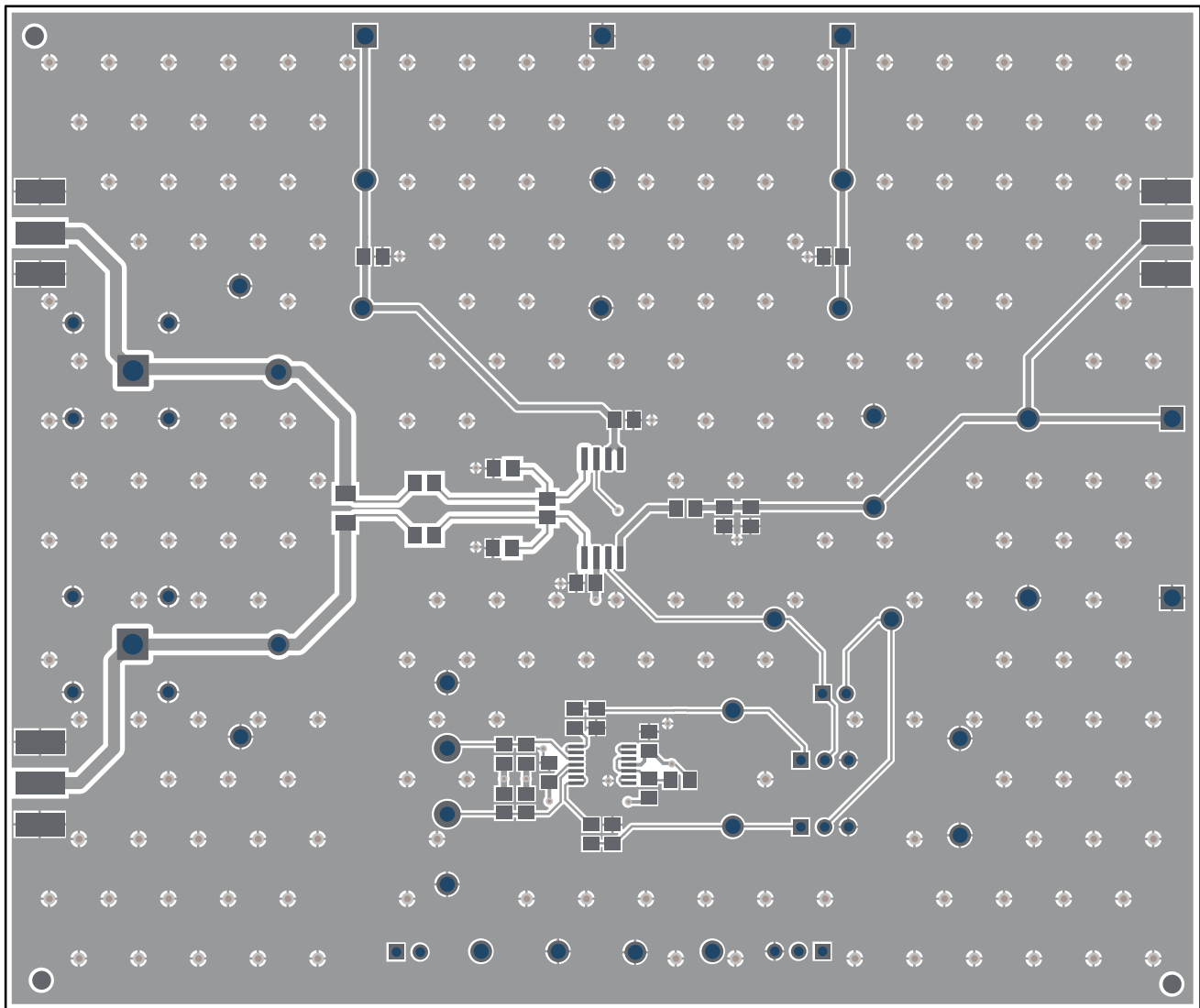


Figure 3-2. Top Layer Mask

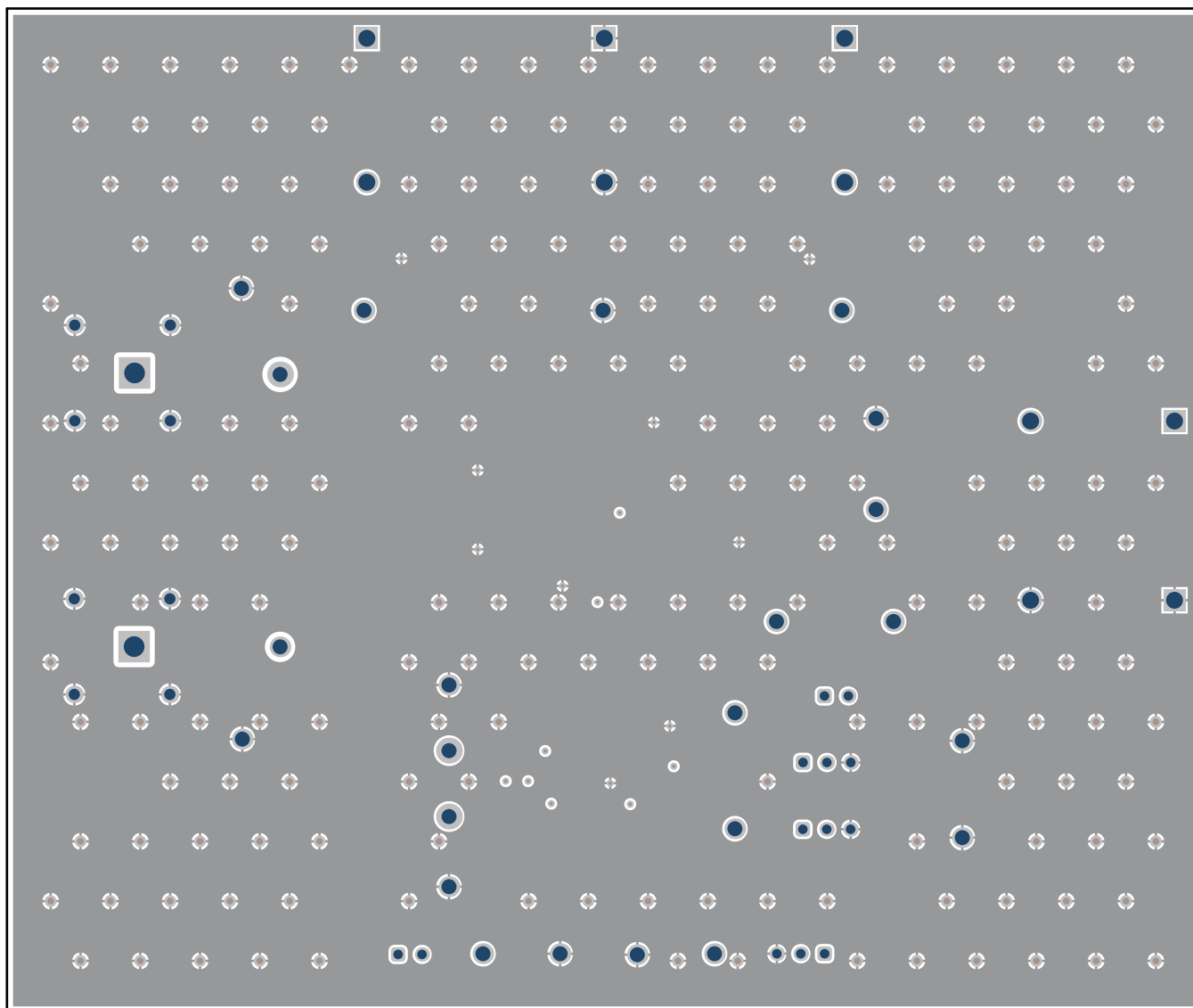


Figure 3-3. GND Layer Mask

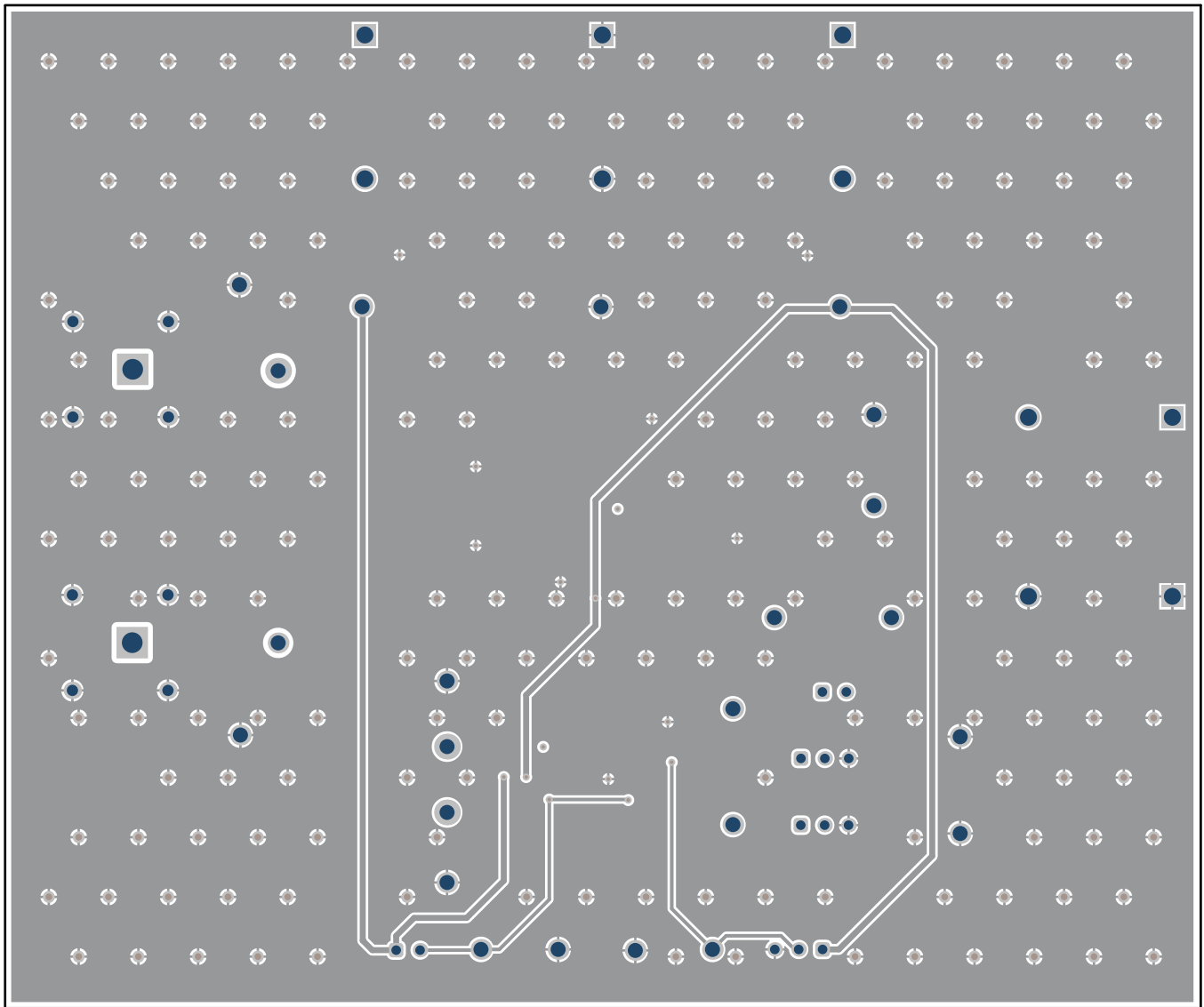
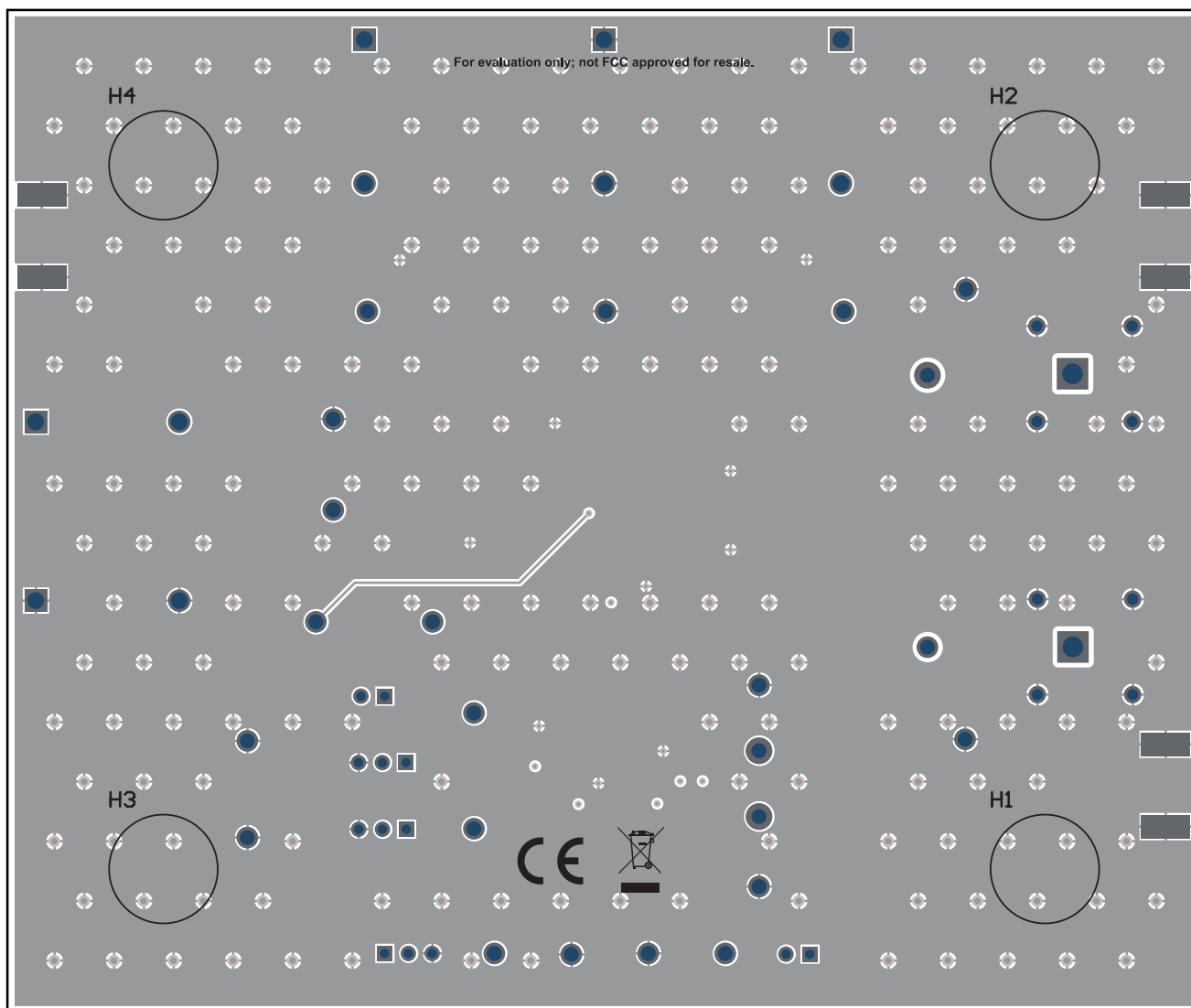


Figure 3-4. Power Layer Mask

**Figure 3-5. Bottom Layer Silkscreen**

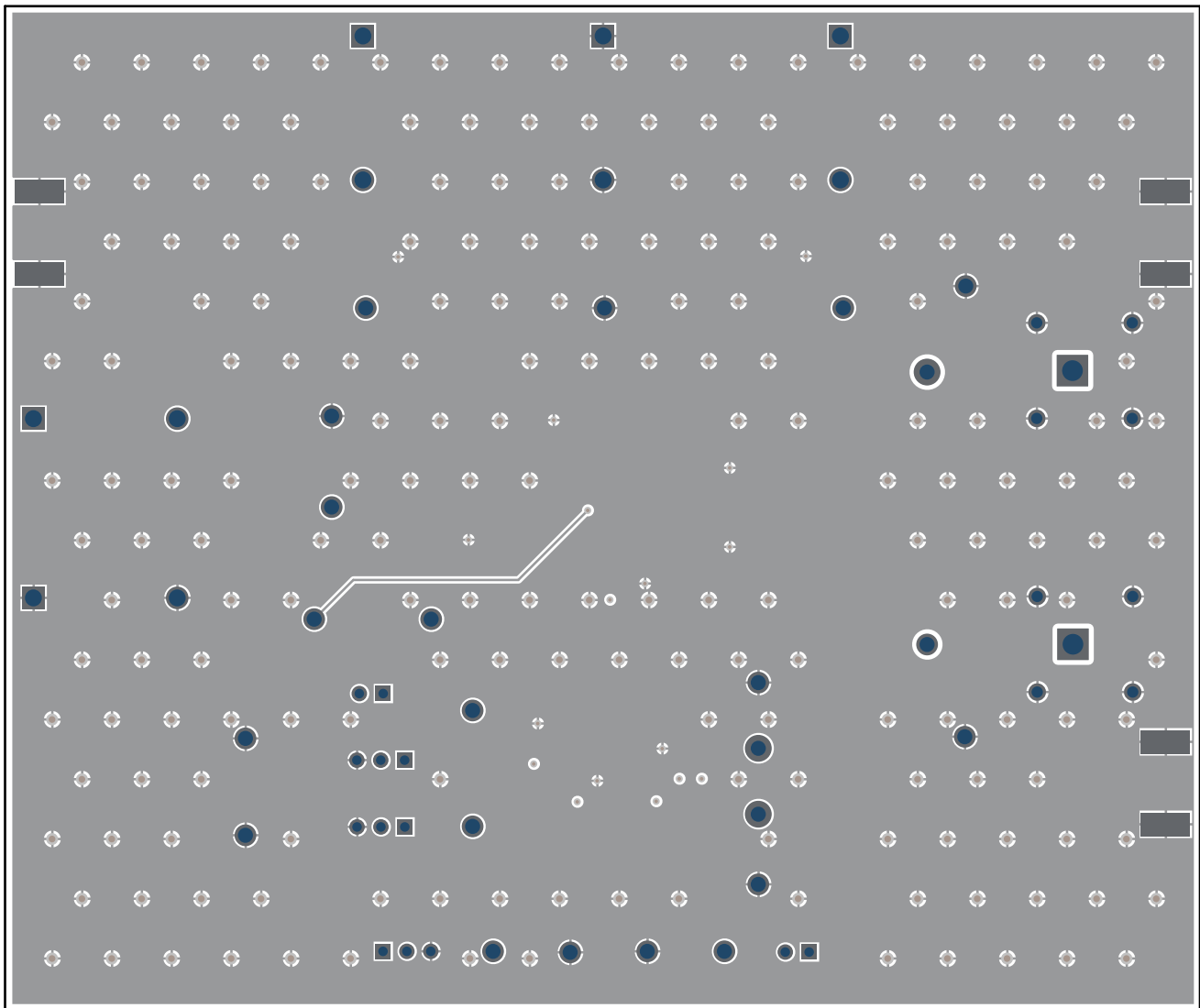


Figure 3-6. Bottom Layer Mask

3.3 Bill of Materials (BOM)

DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
C1, C2, C7, C8	4	0.1uF	CAP, CERM, 0.1μF, 50V, +/- 20%, X7R, 0805	0805	CL21B104MBCNNNC	Samsung
C11, C12	2	1uF	CAP, CERM, 1μF, 50V, +/- 20%, X7R, AEC-Q200 Grade 1, 0805	0805	GCJ21BR71H105MA01L	MuRata
H1, H2, H3, H4	4		Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon	SJ-5303 (CLEAR)	3M
J1	1		Standard Banana Jack, insulated, 10A, red	571-0500	571-0500	DEM Manufacturing
J2, J15	2		Standard Banana Jack, insulated, 10A, black	571-0100	571-0100	DEM Manufacturing
J3	1		Standard Banana Jack, insulated, 10A, yellow	571-0700	571-0700	DEM Manufacturing
J5	1		Banana Jack Connector Standard Banana Solder Red	CONN_BANANA_JACK	FCR7350R	CLIFF Electronic Components
J6	1		Standard Banana Jack, insulated, 10A, white	571-0600	571-0600	DEM Manufacturing
J7	1		Banana Jack Connector Standard Banana Solder Black	CONN_BANANA_JACK	FCR7350B	CLIFF Electronic Components
J10, J12	2		Header, 2.54mm, 2x1, Tin, TH	Header, 2.54mm, 2x1, TH	TSW-102-23-T-S	Samtec
J11, J13, J14	3		Header, 2.54mm, 3x1, Gold, TH	Header, 2.54mm, 3x1, TH	HMTSW-103-07-G-S-240	Samtec
R1, R3, R5	3	0	RES, 0, 5%, 0.125W, AEC-Q200 Grade 0, 0805	0805	ERJ-6GEY0R00V	Panasonic
SH-J10, SH-J11, SH-J12, SH-J13, SH-J14	5		Shunt, 2.54mm, Gold, Black	Shunt, 2.54mm, Black	60900213421	Wurth Elektronik
TP1, TP2, TP16, TP17, TP18, TP19, TP20, TP21, TP22, TP23	10		Test Point, Compact, Black, TH	Black Compact Testpoint	5006	Keystone Electronics
TP3, TP10	2		Test Point, Compact, Yellow, TH	Yellow Compact Testpoint	5009	Keystone Electronics
TP4, TP5, TP13	3		Test Point, Compact, Red, TH	Red Compact Testpoint	5005	Keystone Electronics
TP6, TP8, TP9, TP11, TP14	5		Test Point, Compact, White, TH	White Compact Testpoint	5007	Keystone Electronics
TP7, TP12, TP15	3		Test Point, Compact, Grey, TH	TestPoint, Grey, 220mil, TH	5123	Keystone Electronics
U1	1		Radiation-Hardened, High Common-Mode Voltage Difference Amplifier	CFP8	INA1H94HKX/EM	Texas Instruments
C3, C6	0	0.01uF	CAP, CERM, 0.01uF, 250V, +/- 10%, X7R, 0805	0805	GRM21BR72E103KW03 L	MuRata
C4	0	0.1uF	CAP, CERM, 0.1uF, 250V, +/- 10%, X7T, 0805	0805	C2012X7T2E104K125AA	TDK

DESIGNATOR	QUANTITY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
C5, C9, C10	0	100pF	CAP, CERM, 100pF, 50V,+/- 5%, C0G/NP0, 0805	0805	8.85012E+11	Würth Elektronik
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
J4, J8, J9	0		Connector, End launch SMA, 50 ohm, SMT	SMA End Launch	142-0701-851	Cinch Connectivity
R2	0	0.1	RES, 0.1, 1%, 0.5W, AEC-Q200 Grade 1, 1206	1206	UR73V2BTTDR100F	KOA Speer
R4, R6, R8, R9, R11, R12, R13	0	10.0k	RES, 10.0k, 0.1%, 0.125W, 0805	0805	RT0805BRD0710KL	Yageo America
R7, R10	0	0	RES, 0, 5%, 0.125W, AEC-Q200 Grade 0, 0805	0805	ERJ-6GEY0R00V	Panasonic
U2	0		11MHz, Precision, Low-Noise, RRO, JFET Op Amp in Space-Enhanced Plastic	TSSOP14	OPA4H014PWSEP	Texas Instruments

4 Additional Information

4.1 Trademarks

All trademarks are the property of their respective owners.

4.2 Related Documentation

For related documentation, see the following:

- Texas Instruments, [INA1H94-SP Radiation-Hardened, High Common-Mode Voltage Difference Amplifier data sheet](#)

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 DEGRADATION 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/sds/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。

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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/sds/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, INDEMNITY 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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