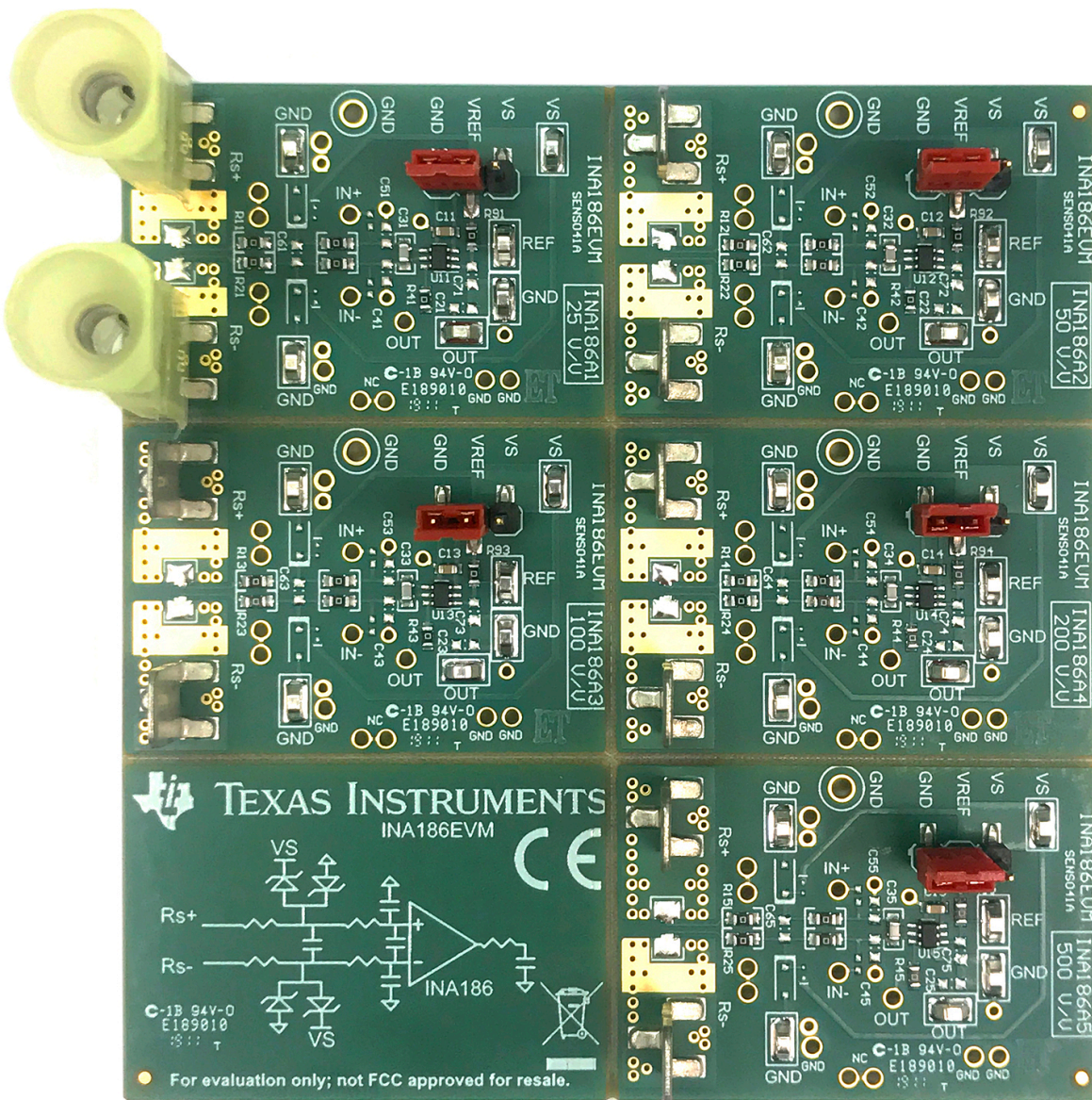


INA186EVM



This user's guide describes the characteristics, operation, and use of the INA186 evaluation module (EVM). This EVM is designed to evaluate the performance of the INA186 voltage-output, current shunt monitor in a variety of configurations. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the INA186EVM. This document also includes a schematic, reference printed-circuit board (PCB) layouts, and a complete bill of materials (BOM).

Contents

1	Overview	3
1.1	EVM Kit Contents	3
1.2	Related Documentation From Texas Instruments	3
2	Hardware	4
2.1	Features	4
3	Operation	4
3.1	Quick Start Setup	4
3.2	Measurements	5
4	EVM Components	6
4.1	R1x, R2x, R4x, R7x, R8x, R9x, C2x, C3x, C4x, C5x, C6x, and C7x	6
4.2	C1x	6
4.3	R3x	6
4.4	R5x, R6x	6
4.5	D1x, D2x, D3x, D4x	6
4.6	S0x, S1x, S2x, S3x, S4x, S5x, S5x, S7x, S8x, S9x, S10x, S11x, S12x	6
4.7	U1x - INA186	7
4.8	J0x, J1x	7
5	Schematic, PCB Layout, and Bill of Materials	8
5.1	Schematics	8
5.2	PCB Layout	13
5.3	Bill of Materials	15

List of Figures

1	INA186EVM Schematic: Gain A1 Panel	8
2	INA186EVM Schematic: Gain A2 Panel	9
3	INA186EVM Schematic: Gain A3 Panel	10
4	INA186EVM Schematic: Gain A4 Panel	11
5	INA186EVM Schematic: Gain A5 Panel	12
6	INA186EVM Top Overlay	13
7	INA186EVM Bottom Overlay	13
8	INA186EVM Top Layer	13
9	INA186EVM Bottom Layer	13
10	INA186EVM Top Solder	13
11	INA186EVM Bottom Solder	13
12	INA186EVM Drill Drawing	14

List of Tables

1	Gain Option Summary	3
2	EVM Kit Contents	3
3	Related Documentation	3
4	Bill of Materials	15

Trademarks

All trademarks are the property of their respective owners.

1 Overview

The INA186 device is a voltage-output, high- and low-side, bidirectional measurement current sense amplifier with a reference pin in an SC70-6 (DCK) package. As shown in [Table 1](#), the INA186 has gains that range from 25 V/V to 500 V/V, depending on the gain option that is selected. The voltage developed across the device inputs is amplified by the corresponding gain of the specific device, and is presented at the output pin. The device accurately senses voltage drops across shunts at common-mode voltages from -0.1 V to $+40\text{ V}$, independent of supply voltages. The device operates and survives common-mode voltages from -0.3 V to $+42\text{ V}$. The device operates with supply voltages between 1.7 V and 5.5 V , and draws a maximum of $65\text{ }\mu\text{A}$ at room temperature. The low offset of the zero-drift architecture enables sensing of very-small differential input voltages, which helps widen the usable input dynamic range and minimize power dissipation in the shunt resistor. Unlike many current sense amplifiers, the INA186 has a very low input bias current, and thus, can easily measure microamps of current.

Table 1. Gain Option Summary

Product	Gain (V/V)
INA186A1	25
INA186A2	50
INA186A3	100
INA186A4	200
INA186A5	500

1.1 EVM Kit Contents

[Table 2](#) summarizes the contents of the INA186EVM kit. Contact the [Texas Instruments Product Information Center](#) nearest you if any component is missing. TI also recommends checking the [INA186 device product folder](#) at www.ti.com for any further information regarding this product.

Table 2. EVM Kit Contents

Item	Item Part Number	Quantity
INA186EVM test board	INA186EVM	1
Quick Connect Receptacle 10-12AWG, 0.250"	4-520448-2	2
Jumper (Shunt Connector) 2POS	2-881545-2	5

1.2 Related Documentation From Texas Instruments

This document provides information regarding Texas Instruments' integrated circuits used in the assembly of the INA186EVM.

Table 3. Related Documentation

Document	Literature Number
INA186 product data sheet	SBOS318

2 Hardware

The INA186EVM is intended to provide basic functional evaluation of the INA186. The fixture layout is not intended to be a model for the target circuit, nor is it laid out for electromagnetic compatibility (EMC) testing. The INA186EVM consists of one PCB with an option to cut out five individual PCBs, one for each of the five gain options (A1 to A5) listed in [Table 1](#). Each of the PCB cutouts consists of one INA186Ax device (where x is 1, 2, 3, 4, or 5), and test points and sockets for external hardware connections, as well as pads to solder down optional circuitry.

2.1 Features

The INA186EVM PCB provides the following features:

- Evaluation of all gain options through provided device boards
- Ease of access to device pins with test points
- Pads and sockets for optional filtering at the input pins and output pin
- Pads for optional input protection devices (TVS or Zener diodes)
- Multiple input signal options, including a method to solder the shunt resistor (0603, 0805, 1206) and safely measure current up to 15 A.

See the device data sheet listed in [Table 3](#) for comprehensive information about the INA186 and the available gain options.

3 Operation

3.1 Quick Start Setup

Follow these procedures to set up and use one of the panels of the INA186EVM. For the following instructions, x = 1, 2, 3, 4, or 5, depending on the selected gain option.

- Step 1. Choose the desired gain option panel.
- Step 2. Make sure the J3x header for the reference (REF) pin is set to the appropriate voltage. Use the included two-position jumper to short header pins 1 (GND) and 2 (REF) for unidirectional current sensing. REF can be connected to VS for unidirectional applications only if the input differential voltage is negative. If bidirectional current sensing is required, then connect the REF pin to an external dc voltage source that is set to a voltage between GND and supply voltage V_S .
- Step 3. Connect an external dc supply voltage (between 1.7 V and 5.5 V) to one of the VS test points (TP3x), and connect the ground reference of that supply to a GND test point (TP4x, TP6x, or TP7x) on the same gain variant panel.
- Step 4. Provide a differential input voltage signal to Rs+ and Rs- by connecting the signal leads to the J0x and J1x quick-fit tabs on the EVM. This connection is explained in [Section 3.2](#).

3.2 Measurements

The INA186EVM allows the user to either emulate the voltage developed across a sense resistor based on a given set of system conditions, or to connect the device inputs to an external shunt. Optionally, a surface-mount technology (SMT) shunt resistor can be soldered across the Rs+ and Rs– pads, and these inputs can be connected in series with the external system and load. Onboard sockets allow for a through-hole shunt resistor to be inserted between S0x and S1x, given that the following socket pairs are shorted with wire jumper: S4x-S5x and S1x-S2x, where x = 1, 2, 3, 4, or 5.

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

1. Connect a positive differential voltage across the Rs+ (J0x) and Rs– (J1x) tabs. If REF is shorted to GND, then make sure that the Rs+ voltage is the more positive of the two inputs. The input sense voltage must be less than V_s / Gain , or else the amplifier output saturates.
2. Additionally, if the differential voltage supply is a floating supply, connect a –0.1-V to +40-V common-mode voltage to the inputs by connecting the positive lead of the external voltage source to the Rs– (J1x) tab, and source ground to a GND test point. This action effectively raises the absolute common-mode voltage of the input pins, while still retaining a positive input differential signal.
3. Measure the output voltage at the OUT test point (TP5x) with respect to GND. If using the EVM in a bidirectional application, then measure the gained-up shunt voltage at the OUT pin with respect to the REF pin.

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

1. Solder a 0603 to 1206 resistor at the R3x pads that connect the Rs+ (J0x) and Rs– (J1x) tabs.
2. Connect the Rs+ (J0x) and Rs– (J1x) tabs in series with the load and bus voltage sources while powered off.

WARNING

If measuring current, first make sure that the equipment (shunt resistor, wires, connectors, and so on) can support the amperage and power dissipation. Second, make sure that the current flowing through J0x and J1x does not exceed 15 A. Failure to do so can result in hot surfaces (> 55°C), damage to the EVM, or personal injury.

3. Set the REF pin to GND for unidirectional use, or to a voltage between GND and VS for bidirectional use.
4. Power on the system and measure the output voltage at the OUT test point (TP5x). The output voltage (VOUT) with respect to REF pin is equal to the gain of the device multiplied by the differential voltage measured directly at the device input pins. VOUT measured with respect to GND is equal to the REF voltage plus the gained up differential sense voltage.

4 EVM Components

This section summarizes the INA186EVM components. For the following components, x = 1, 2, 3, 4, or 5, depending on the selected gain option.

4.1 R1x, R2x, R4x, R7x, R8x, R9x, C2x, C3x, C4x, C5x, C6x, and C7x

R1x, R2x, R4x, R7x, R8x, and R9x are factory-installed 0- Ω 0603 resistors.

C2x, C3x, C4x, C5x, C6x, and C7x are not populated except for C3x.

Collectively, these pads allow for user-defined filters for the input pins (IN+ and IN–), the reference pin (REF), and the output pin (OUT) of INA186. If a filter is desired, remove these resistors, replace them with > 0- Ω SMT resistors, and populate the capacitor pads with capacitors. Additionally, these resistors can limit current for clamping diodes D4x, D3x, D2x, and D1x during overvoltage events. Additional information regarding the use of input filtering and input protection is provided in the [INA186data sheet](#).

4.2 C1x

C1x is a 0.1- μ F, power-supply bypass capacitor.

4.3 R3x

R3x is unpopulated, but allows a surface-mount shunt resistor to be soldered down in between the Rs+ and Rs– pads, which are sensed by the IN+ and IN– input pins. If used, make sure R3x has proper power dissipation for the user-set current load. The chosen resistor must at a minimum have a 0603 Imperial footprint.

4.4 R5x, R6x

R5x and R6x are unpopulated resistors and are meant for 0402 shunting 0- Ω resistors that connect the IN+ and IN– pins of INA186 directly to S2x and S5x sockets. These resistors are useful when an input filter is implemented, and the voltages must be measured directly at the INA186 input pins.

4.5 D1x, D2x, D3x, D4x

These diodes are unpopulated, and are meant for the onboard implementation and experimentation of input protection circuitry when the input common-mode voltage exceeds the absolute maximum rating of the INA186 during a transient event. Using diodes in SOD-323 package for D4x and D2x ties the input traces to ground, and protects from overvoltage events. Using diodes in SOD-923 package for D3x and D1x connects the inputs to the supply plane, and protects from undervoltage events.

4.6 S0x, S1x, S2x, S3x, S4x, S5x, S6x, S7x, S8x, S9x, S10x, S11x, S12x

These pin sockets are not populated, and are for inserted wires and through-hole components, or to provide a test point. The pin sockets are used to test the INA186 with input/output filters, a through-hole shunt resistor, test points, or a combination of any three.

4.7 U1x - INA186

U1x is the location for the INA186Ax test device. Five device boards are supplied with the INA186EVM board. Each board is populated with one of the available device gains. This option allows users to test the devices and determine the gain setting that is best for a given application.

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

- The INA186 devices are identical with the exception of the different gain settings.
- The differential input voltage is either applied across the inputs or developed based on the load current that flows through the shunt resistor.
- Make sure that the output voltage does not exceed the supply voltage. This limiting factor requires attention to device selection.
- The selected device must allow the output voltage to remain within the acceptable range after the developed input voltage is amplified by the respective device gain. The output voltage must remain within the device-specified swing limitations for response in the linear range.
- An output below the minimum allowable output requires the selection of a device with a higher gain. Likewise, an output above the maximum allowable output requires the selection of a device with a lower gain.

4.8 J0x, J1x

J0x and J1x are 0.240-inch, noninsulated, quick-fit terminals that are designed to insert into similarly-sized female receptacles. The kit provides two receptacles. Use insulated receptacles with J0x and J1x terminals to make sure that there is a strong and safe connection between the current source and EVM when dealing with high currents.

WARNING

If using the EVM to measure currents, make sure a proper power resistor is soldered at the R3x pads. Also make sure that the receptacles (connecting to J0x and J1x) and the respective crimped wires can support the amperage of the current being measured, and the necessary power dissipation. Do not exceed 15 A of current flowing between J0x and J1x. Failure to follow this requirement can result in hot surfaces (> 55°C), damage to the EVM, or personal injury.

Standard metal clips can electrically interface with these terminals when measuring lower currents.

The Rs+ (J0x) and Rs- (J1x) inputs accept a differential voltage that is amplified by the selected device gain, and is presented at the OUT test points (TP5x and S7x if populated). These inputs can also be used to connect the differential voltage developed across an external shunt in an existing circuit. The acceptable differential input voltage range is determined by the supply voltage and gain of the selected device.

5 Schematic, PCB Layout, and Bill of Materials

NOTE: Board layouts are not to scale. These figures are intended to show how the board is laid out; they are not intended to be used for manufacturing INA186EVM PCBs.

5.1 Schematics

Figure 1 through Figure 5 show the schematics for the INA186EVM PCB.

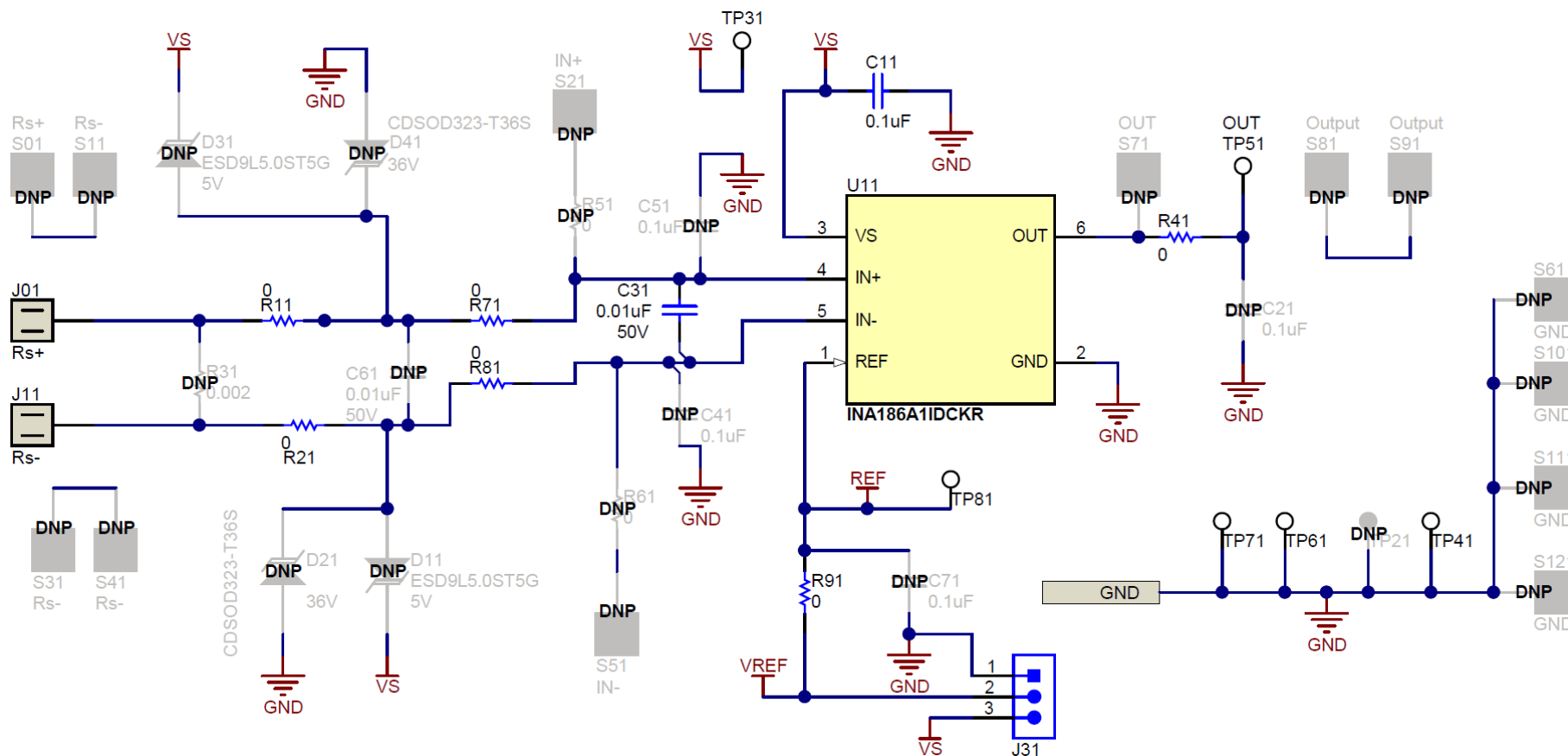


Figure 1. INA186EVM Schematic: Gain A1 Panel

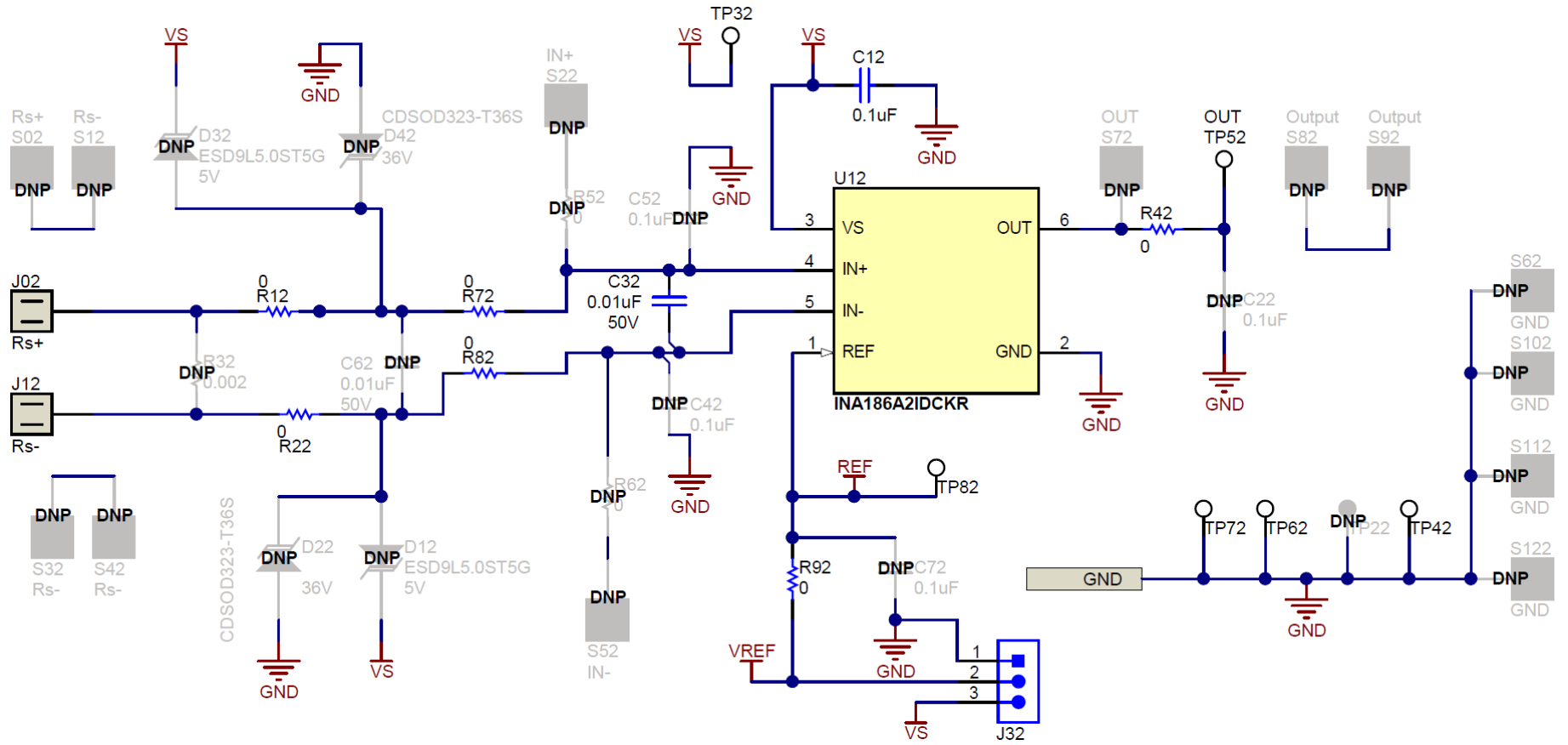


Figure 2. INA186EVM Schematic: Gain A2 Panel

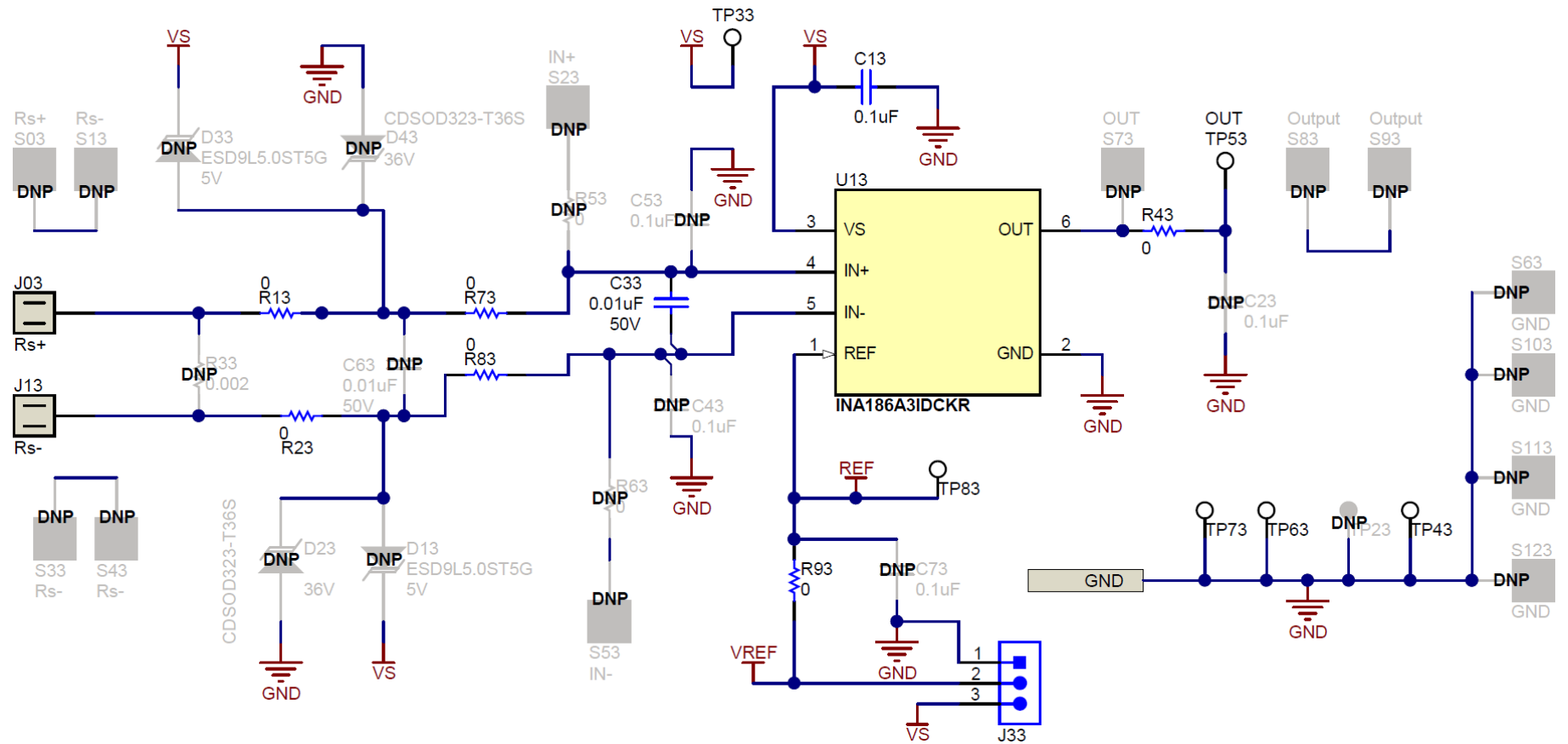


Figure 3. INA186EVM Schematic: Gain A3 Panel

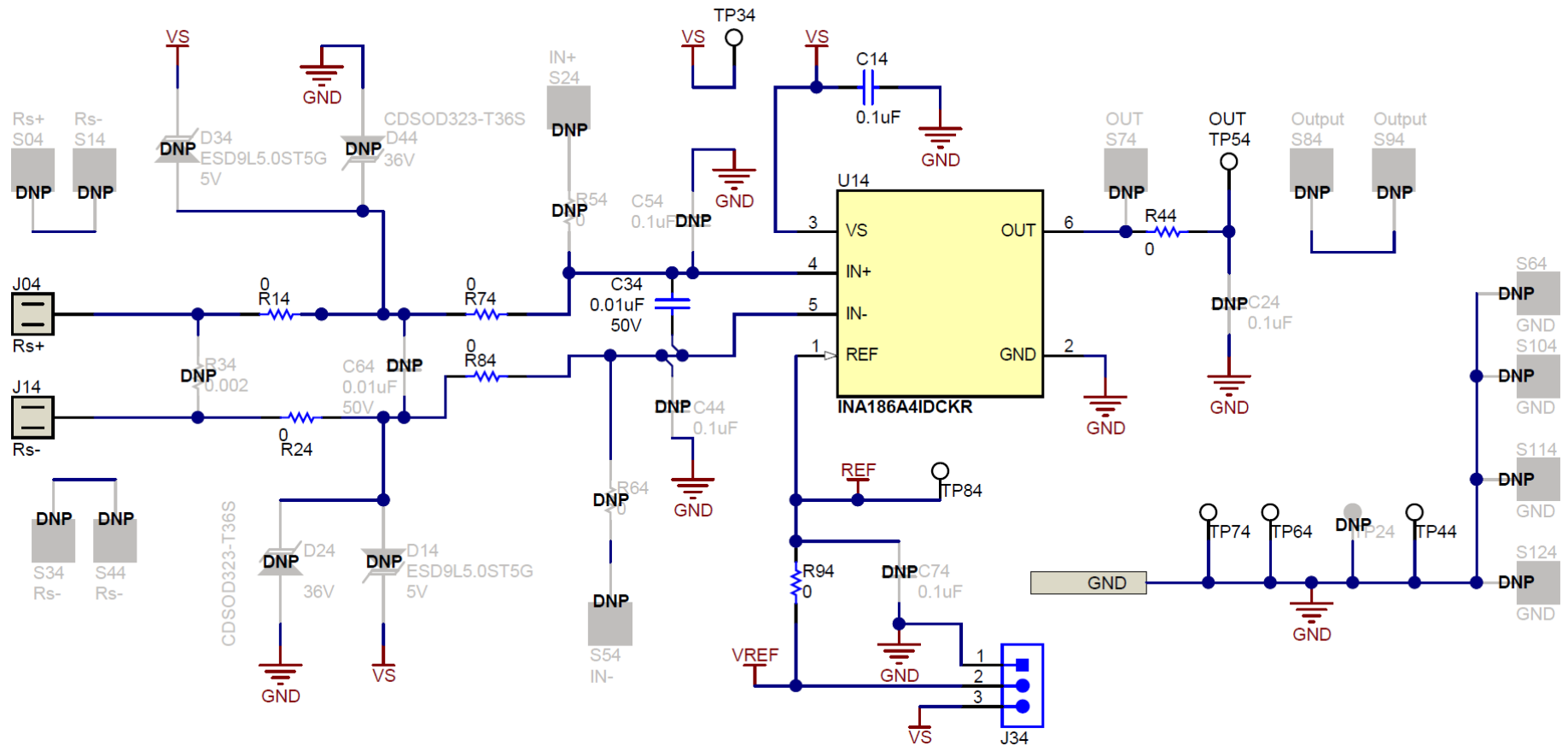


Figure 4. INA186EVM Schematic: Gain A4 Panel

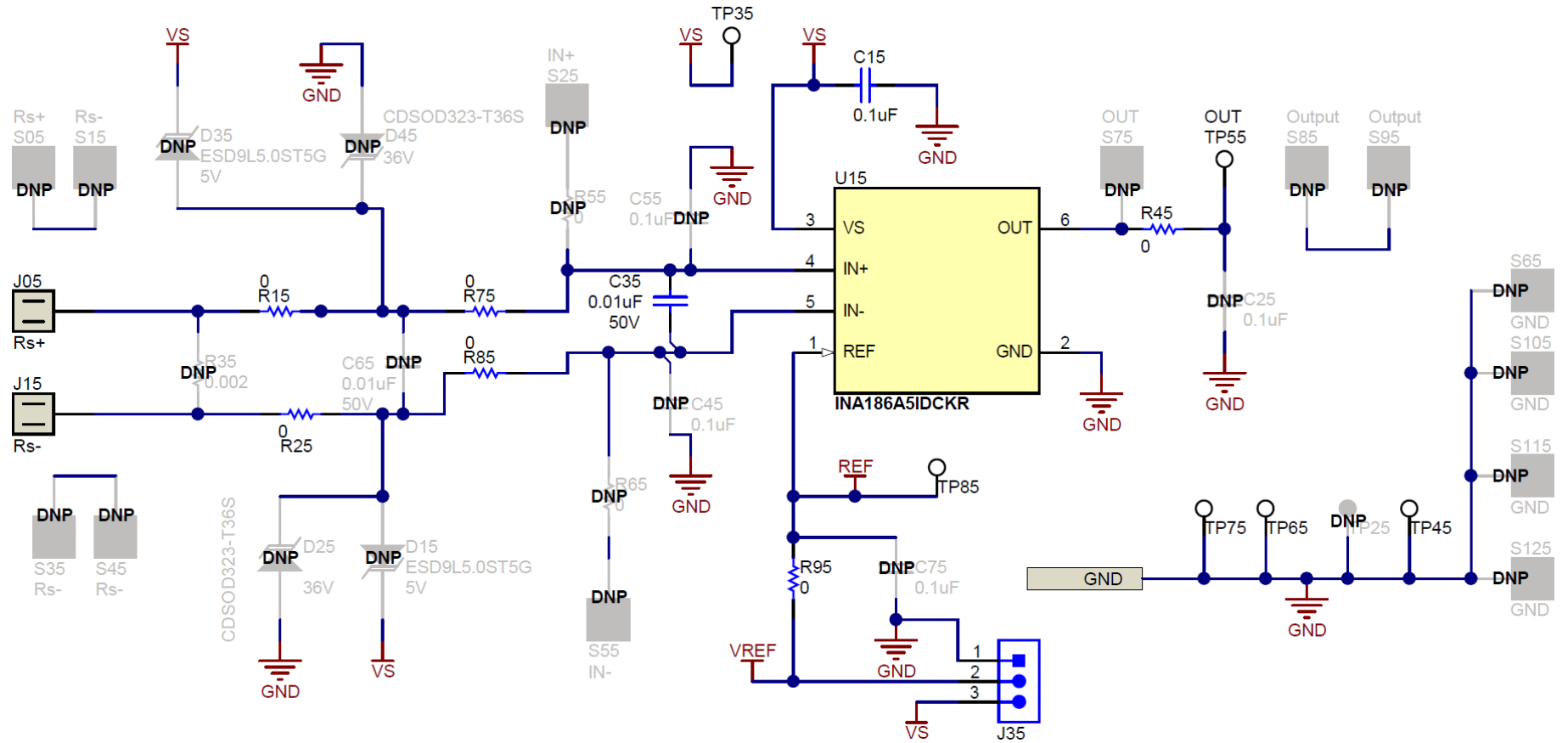


Figure 5. INA186EVM Schematic: Gain A5 Panel

5.2 PCB Layout

Figure 6 through Figure 12 illustrate the PCB layout for the INA186EVM.

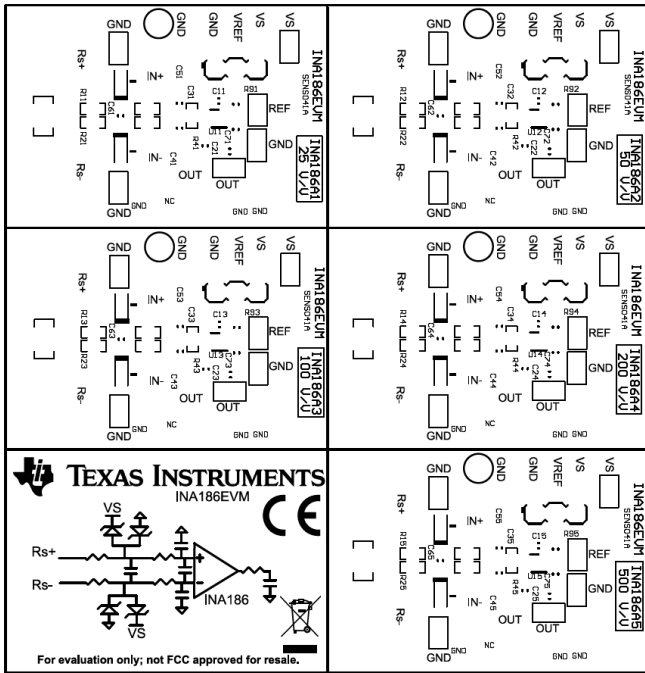


Figure 6. INA186EVM Top Overlay

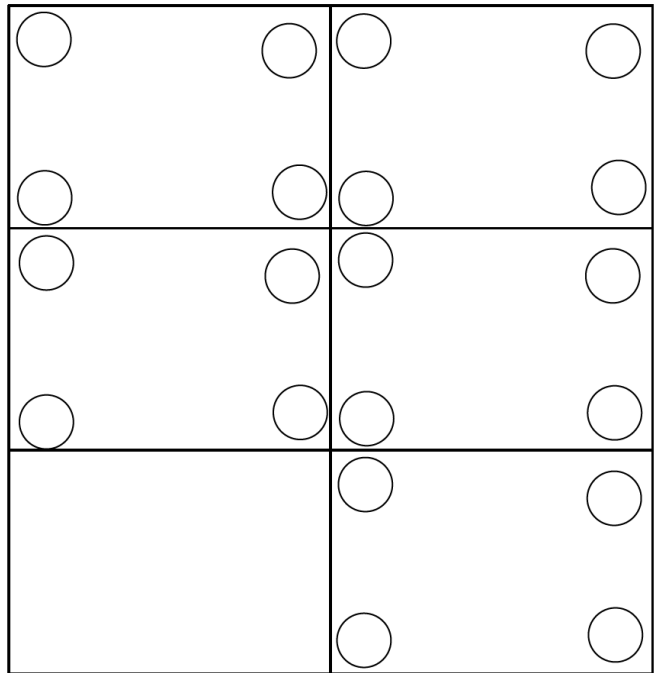


Figure 7. INA186EVM Bottom Overlay

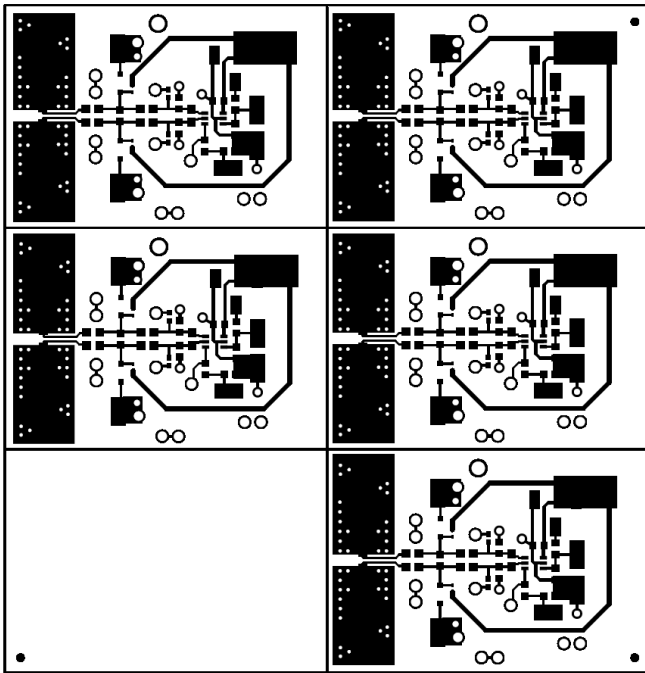


Figure 8. INA186EVM Top Layer

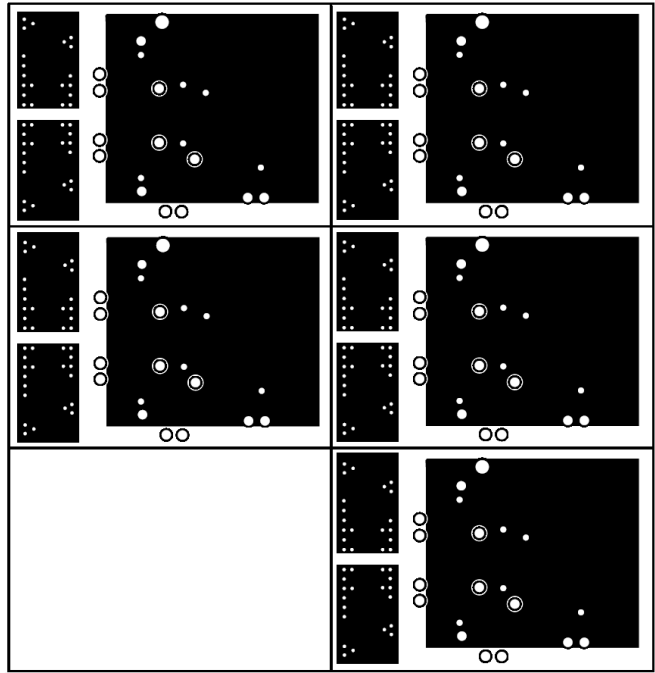


Figure 9. INA186EVM Bottom Layer

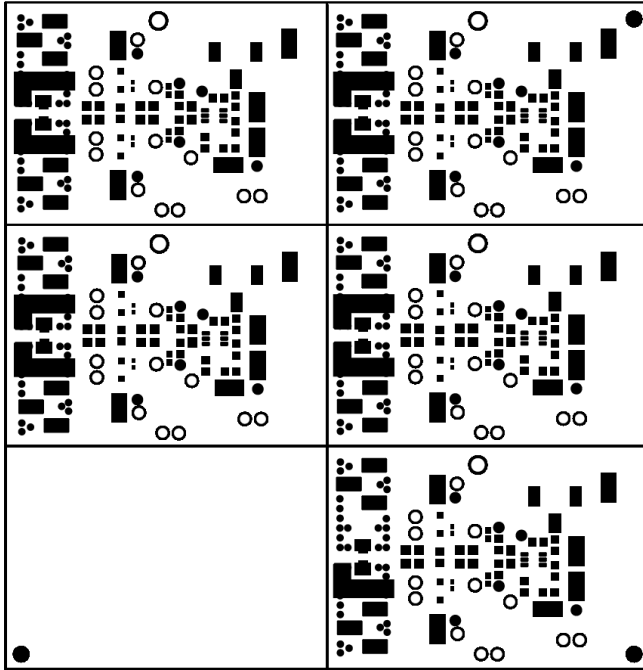


Figure 10. INA186EVM Top Solder

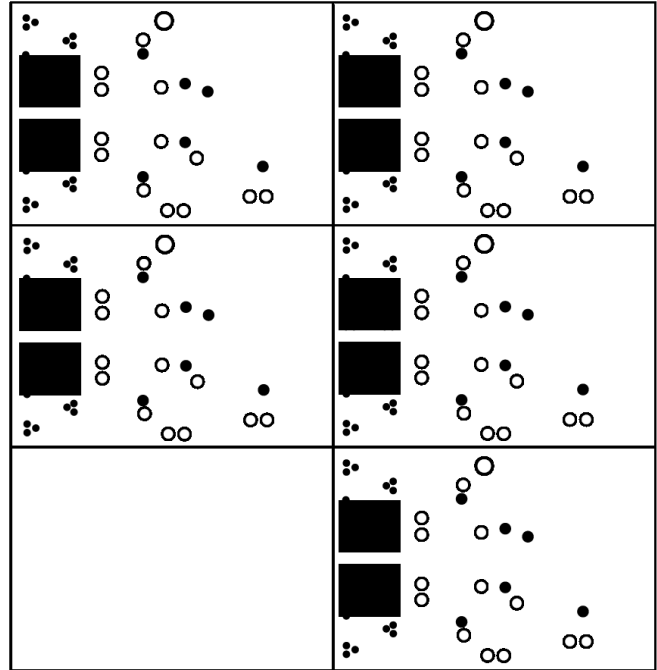


Figure 11. INA186EVM Bottom Solder

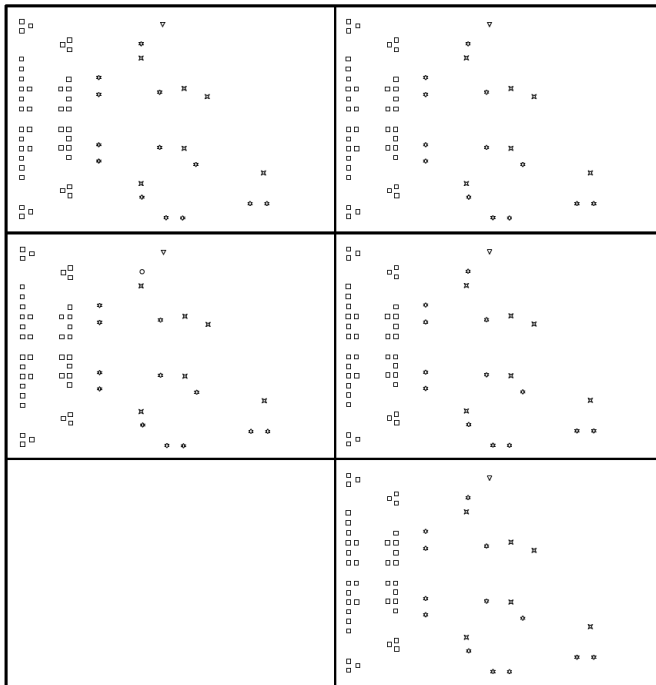


Figure 12. INA186EVM Drill Drawing

Symbol	Quantity	Finished Hole Size	Plated	Hole Type
□	200	15.00mil (0.381mm)	PTH	Round
⊠	30	28.00mil (0.711mm)	PTH	Round
○	1	41.00mil (1.041mm)	PTH	Round
☆	64	44.00mil (1.118mm)	PTH	Round
▽	5	83.00mil (1.600mm)	PTH	Round
	300 Total			

5.3 Bill of Materials

Table 4 provides the parts list for the INA186EVM.

Table 4. Bill of Materials

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer
B1, B2, B3, B4, B5, B6, B7, B8, B9, B10, B11, B12, B13, B14, B15, B16, B17, B18, B19, B20	20		Bumpon, Hemisphere, 0.25 X 0.075, Clear	75x250 mil	SJ5382	3M
C11, C12, C13, C14, C15	5	0.1 uF	CAP, CERM, 0.1 µF, 50 V, ±10%, X7R, 0603	0603	06035C104KAT2A	AVX
C31, C32, C33, C34, C35	5	0.01uF	CAP, CERM, 0.01 uF, 50 V, +/- 5%, C0G/NP0, 0603	0603	GRM1885C1H103JA01 D	MuRata
H1, H2, H3, H4, H5	5		CONN POST SHUNT NOVO 2POS (Kitting Item)	N/A	2-881545-2	TE Connectivity AMP Connectors
H6, H7	2		CONN QC RCPT 10-12AWG 0.250 (Kitting Item)	N/A	4-520448-2	TE Connectivity AMP Connectors
J01, J02, J03, J04, J05, J11, J12, J13, J14, J15	10		Quick-Fit 0.240 Tab	Keystone_4928TR	4928TR	Keystone
J31, J32, J33, J34, J35	5		Header, 2.54mm, 3x1, Gold, SMT	Harwin_M20-87703	M20-8770342	Harwin
R11, R12, R13, R14, R15, R21, R22, R23, R24, R25, R41, R42, R43, R44, R45, R71, R72, R73, R74, R75, R81, R82, R83, R84, R85 R91, R92, R93, R94, R95	30	0 Ω	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ-3GEY0R00V	Panasonic
TP31, TP32, TP33, TP34, TP35, TP41, TP42, TP43, TP44, TP45, TP51, TP52, TP53, TP54, TP55, TP61, TP62, TP63, TP64, TP65, TP71, TP72, TP73, TP74, TP75, TP81, TP82, TP83, TP84, TP85	30		Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone
U1	1	25 V/V	Low Supply, Voltage Output, Low- or High-Side Measurement, Bidirectional, Zero-Drift Series, Current- Shunt Monitor, DCK0006A (SOT-SC70-6)	DCK0006A	INA186A1DCKR	Texas Instruments
U2	1	50 V/V	Low Supply, Voltage Output, Low- or High-Side Measurement, Bidirectional, Zero-Drift Series, Current- Shunt Monitor, DCK0006A (SOT-SC70-6)	DCK0006A	INA186A2IDCKR	Texas Instruments
U3	1	100 V/V	Low Supply, Voltage Output, Low- or High-Side Measurement, Bidirectional, Zero-Drift Series, Current- Shunt Monitor, DCK0006A (SOT-SC70-6)	DCK0006A	INA186A3IDCKR	Texas Instruments
U4	1	200 V/V	Low Supply, Voltage Output, Low- or High-Side Measurement, Bidirectional, Zero-Drift Series, Current- Shunt Monitor, DCK0006A (SOT-SC70-6)	DCK0006A	INA186A4IDCKR	Texas Instruments
U5	1	500 V/V	Low Supply, Voltage Output, Low- or High-Side Measurement, Bidirectional, Zero-Drift Series, Current- Shunt Monitor, DCK0006A (SOT-SC70-6)	DCK0006A	INA186A5IDCKR	Texas Instruments
C21, C22, C23, C24, C25, C41, C42, C43, C44, C45, C51, C52, C53, C54, C55, C71, C72, C73, C74, C75	0	0.1 uF	CAP, CERM, 0.1 µF, 50 V, ±10%, X7R, 0603	0603	06035C104KAT2A	AVX
C61, C62, C63, C64, C65	0	0.01uF	CAP, CERM, 0.01 uF, 50 V, +/- 5%, C0G/NP0, 0603	0603	GRM1885C1H103JA01 D	MuRata

Table 4. Bill of Materials (continued)

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer
D11, D12, D13, D14, D15, D31, D32, D33, D34, D35	0	5V	Diode, TVS, Uni, 5 V, 9.8 Vc, AEC-Q101, SOD-923	SOD-923	ESD9L5.0ST5G	ON Semiconductor
D21, D22, D23, D24, D25, D41, D42, D43, D44, D45	0	36V	Diode, TVS, Uni, 36 V, 75 Vc, SOD-323	SOD-323	CDSOD323-T36S	Bourns
R31, R32, R33, R34, R35	0	0.002 Ω	RES, 0.002, 1%, 1 W, 1206	1206	CSNL1206FT2L00	Stackpole Electronics Inc
R51, R52, R53, R54, R55, R61, R62, R63, R64, R65	0	0 Ω	RES, 0, 5%, 0.063 W, 0402	0402	MCR01MZPJ000	Rohm
S01, S02, S03, S04, S05, S11, S12, S13, S14, S15, S21, S22, S23, S24, S25, S31, S32, S33, S34, S35, S41, S42, S43, S44, S45, S51, S52, S53, S54, S55, S61, S62, S63, S64, S65, S71, S72, S73, S74, S75, S81, S82, S83, S84, S85, S91, S92, S93, S94, S95, S101, S102, S103, S104, S105, S111, S112, S113, S114, S115, S121, S122, S123, S124, S125	0		Socket, 1 Pos, TH	Pin receptacle	147444-1	TE Connectivity
TP21, TP22, TP23, TP24, TP25	0		Test Point, Compact, White, TH	Keystone5007	5007	Keystone

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/lstds/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。
http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page

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/lstds/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。
http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page

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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2019, Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to TI's Terms of Sale (www.ti.com/legal/termsofsale.html) or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2019, Texas Instruments Incorporated