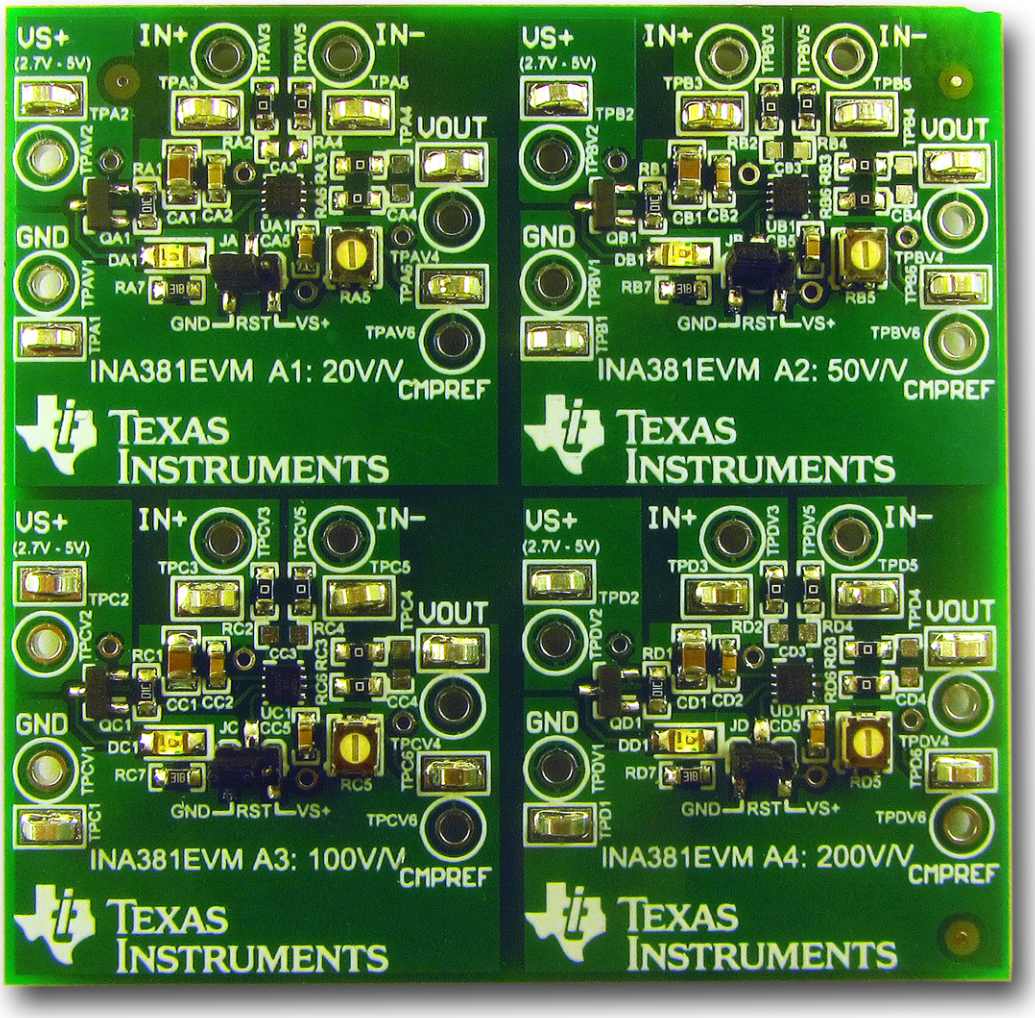
User's Guide

SBOU196–December 2017

INA381EVM



This user's guide describes the characteristics, operation, and use of the INA381 evaluation module (EVM). This EVM is designed to evaluate the performance of the INA381A1, INA381A2, INA381A3, and INA381A4 voltage output current-shunt monitors in a variety of configurations. The EVM also provides an internal comparator with each of the above devices, and allows the user to define reference voltages for each device's alert function. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the INA381EVM. This document includes a schematic, reference printed-circuit board (PCB) layouts, and a complete bill of materials (BOM).

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Contents

1 Overview 3
2 Hardware 4
3 Quick Start Setup and Use 4
4 Circuitry 5
5 Schematics, PCB Layout, and Bill of Materials 6

List of Figures

1 Schematic for A1 Device 6
2 Schematic for A2 Device 6
3 Schematic for A3 Device 7
4 Schematic for A4 Device 7
5 Top Overlay 8
6 Top Layer 8
7 Bottom Overlay 8
8 Bottom Layer 8

List of Tables

1 INA381Ax Device Summary 3
2 INA381EVM Kit Contents 3
3 Related Documentation 3
4 Bill of Materials 9

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1 Overview

The INA381 family of current-shunt monitors (also called current-sense amplifiers) can sense voltage drops across shunts at common-mode voltages from –0.3 V to +26 V, independent of the supply voltage. Four fixed gains are available: 20 V/V, 50 V/V, 100 V/V, and 200 V/V. These devices operate from a single 2.7-V to 5.5-V power supply, drawing a maximum of 1000 μA of supply current per amplifier channel. A comparator is included to provide an active low alert signal when the output exceeds a user defined voltage. The alert function operates in either continuous mode or latch mode to respectively indicate whether a certain overvoltage or overcurrent event is occurring or has occurred. The INA381 devices are currently available in a 8-pin WSON surface-mount package with a thermal pad as the device ground connection. Table 1 lists the available gain options.

Table 1. INA381Ax Device Summary

Product	Gain
INA381A1	20 V/V
INA381A2	50 V/V
INA381A3	100 V/V
INA381A4	200 V/V

1.1 Kit Contents

Table 2 lists the contents of the INA381EVM kit. Contact the nearest Texas Instruments Product Information Center if any component is missing. TI highly recommends checking the INA381 family product folder on the TI website at www.ti.com for further information regarding this product.

Table 2. INA381EVM Kit Contents

Item	Quantity
INA381EVM Test Board	1

1.2 Related Documentation From Texas Instruments

The following document provides information regarding TI's integrated circuits used in the assembly of the INA381EVM. This user's guide is available from the TI website under literature number SBOU196. 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 3. Related Documentation

document	Literature Number
INA381 product data sheet	SBOS848

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2 Hardware

The INA381 is an op amp current-sense solution that provides ease of use and high performance. The INA381EVM is intended to provide basic functional evaluation of this device family. 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 INA381EVM consists of one PCB with an option to snap apart into four individual PCBs; one for each of the four devices (INA381A1, INA381A2, INA381A3, and INA381A4).

2.1 Features

The layout of the INA381EVM printed-circuit board (PCB) is designed to provide the following features:

- Evaluation of all gain options for the INA381Ax
- Ease of access to device pins with test points
- Capability to evaluate high-side and low-side configurations
- Ability to set the comparator trip voltage.

See the INA381 data sheet for comprehensive information about the INA381 family of devices.

3 Quick Start Setup and Use

The following are instructions to set up and use the INA381 devices of the INA381EVM. For the following instructions, x = A to D.

Step 1. Connect ground reference of that supply to the GND test point TPx1 or TPxV1 and connect an external dc supply voltage between 2.7 V and 5.5 V to the Vs test point TPx2 or TPxV2.

Step 2. Connect the input per Section 3.1.

3.1 Measurements

The INA381EVM enables the user to either simulate the voltage developed across a sense resistor based on a given set of system conditions or to connect remotely to an existing shunt already included in an example application.

The following procedures are used to configure a measurement evaluation without a shunt. For the following instructions, x = A to D.

Step 1. Stack a floating differential voltage supply on top of a common mode voltage by connecting the ground of the floating differential voltage supply to the positive voltage output of the common mode voltage supply. Adjust common mode voltage to any value between –0.2 V and +26 V; the data sheet condition is 12 V.

Step 2. Connect the positive polarity of the differential voltage to IN+ (TPx3 or TPxV3) and the negative polarity to IN– (TPx5 or TPxV5) test points. (IN+ pin must be the more positive of the two inputs.)

Step 3. Measure the output voltage at the VOUT test point (TPx4 or TPxV4).

NOTE: The output voltage is equal to the gain of the device multiplied by the differential voltage measured directly at the device input pins.

3.2 Alert Function

The INA381EVM provides an alert pin that will pull low when the output exceeds a user-defined voltage. With the alert function, there are two different modes: latch mode and continuous mode. The device enters latch mode when RESET (pin 4) is pulled to VS+ (pin 2). When reset is pulled to GND (bottom pad) the device enters continuous mode and resets the device if it is latched and the output voltage is below CMPREF (pin 5). CMPREF determines at what voltage the ALERT pin goes low. This value is conveniently adjustable to any voltage between GND and VS+ with the onboard potentiometer. When the voltage on VOUT exceeds the voltage of CMPREF, the onboard LED turns on.

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4 Circuitry

This section summarizes the INA381EVM components. For the following instructions, x = A to D.

4.1 Cx1, Cx2

Cx1 and Cx2 are 10-μF and 0.1-μF supply bypass capacitors respectively.

4.2 Cx3, Rx2, Rx4

Cx3, Rx2, and Rx4 footprints are for customizing the input pi-filter to the INA381 device. Default values are 0 Ω and 1000 pF. However, no capacitor is installed.

4.3 Cx4, Rx3

Cx4 and Rx3 are footprints for a customizable output filter. Default values are 0 Ω and 1000 pF. However, no capacitor is installed.

4.4 Ux1

Ux1 is the test-device location. Four device boards are supplied with the INA381EVM. Each board is populated with one of the available device gains: 20 V/V, 50 V/V, 100 V/V, or 200 V/V. This option enables users to test the devices and determine the gain setting best suited for a given application. The following list of factors is involved in selecting the appropriate device:

- Select INA381 for unidirectional applications only.
- The differential input voltage is applied across the inputs, or developed based on the load current that flows through the shunt resistor connected across the inputs.
- The most limiting factor that requires attention to be given to device selection is the output voltage.
- The selected device must allow the output voltage to remain within the acceptable range after the Vsense voltage (IN+ – IN–) is amplified by the respective device gain. The max output voltage must remain within the range of 10 mV above ground to 100 mV below the supply voltage.
- Choose an appropriate gain and sense resistor to create the largest appropriate output swing possible and to minimize error.

4.5 Rx5, Cx5

Rx5 is a 50-kΩ trimming potentiometer that allows the user to set the CMPREF voltage without having to use an additional power supply. Cx5 is a bypass capacitor that is meant to absorb any transients that would otherwise feed into the CMPREF pin.

4.6 Rx1, Rx7, Qx1, Dx1

Rx1 serves as a pull-up resistor that keeps the ALERT pin voltage around VS+ when the ALERT pin is open drain (inactive) and as an impedance path that prevents VS+ from shorting to GND when the ALERT pin goes low (active). Qx1 serves as a switch controlled by the ALERT pin. When Qx1 switches on (ALERT goes active low), Dx1 turns on, which notifies the user that voltage at VOUT exceeded the voltage at CMPREF. Rx7 limits the current through Dx1.

4.7 Jx

Jx controls whether the device uses continuous mode or latch mode. RST shorted to VS+ puts the device in latch mode. RST shorted to GND puts the device in continuous mode.

4.8 Voltages Inputs

The IN+ (TPx3 or TPxV3) and IN– (TPx5 or TPxV5) inputs accept a differential voltage that is amplified by the selected device gain and is presented at the VOUT test point (TPx04 or TPx14). 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 and polarity are determined by the supply voltage and gain of the selected device.

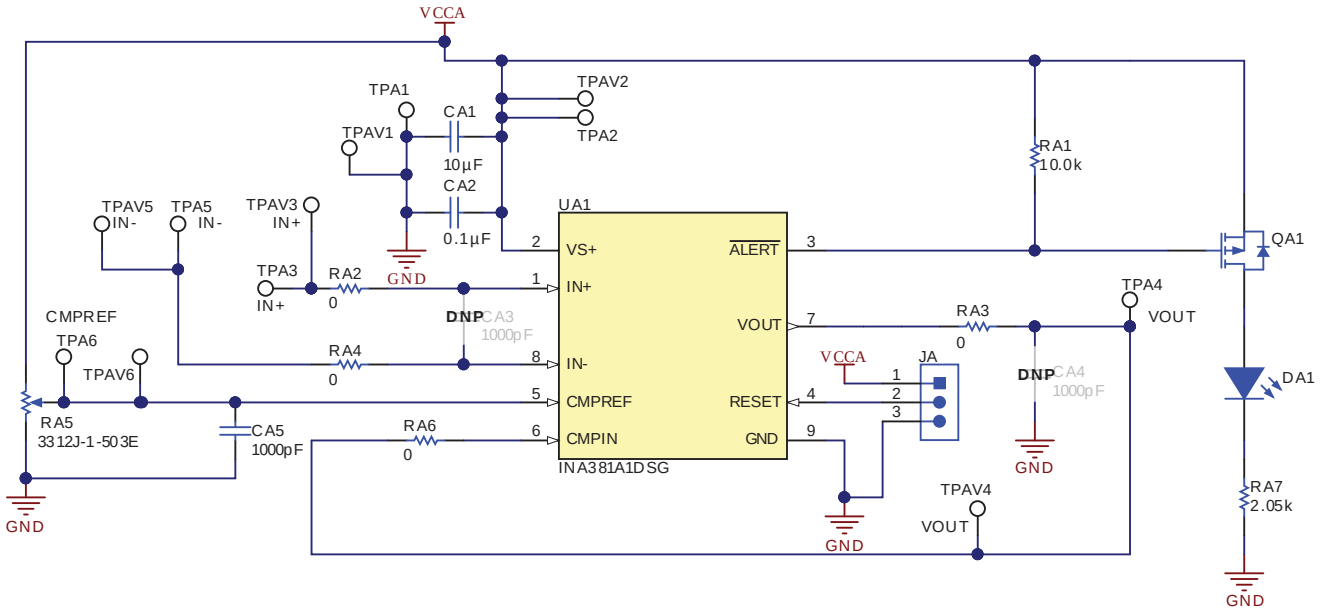
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5 Schematics, PCB Layout, and Bill of Materials

NOTE: Board layouts are not to scale. These figures are intended to show how the board is laid out. The figures are not intended to be used for manufacturing INA381EVM PCBs.

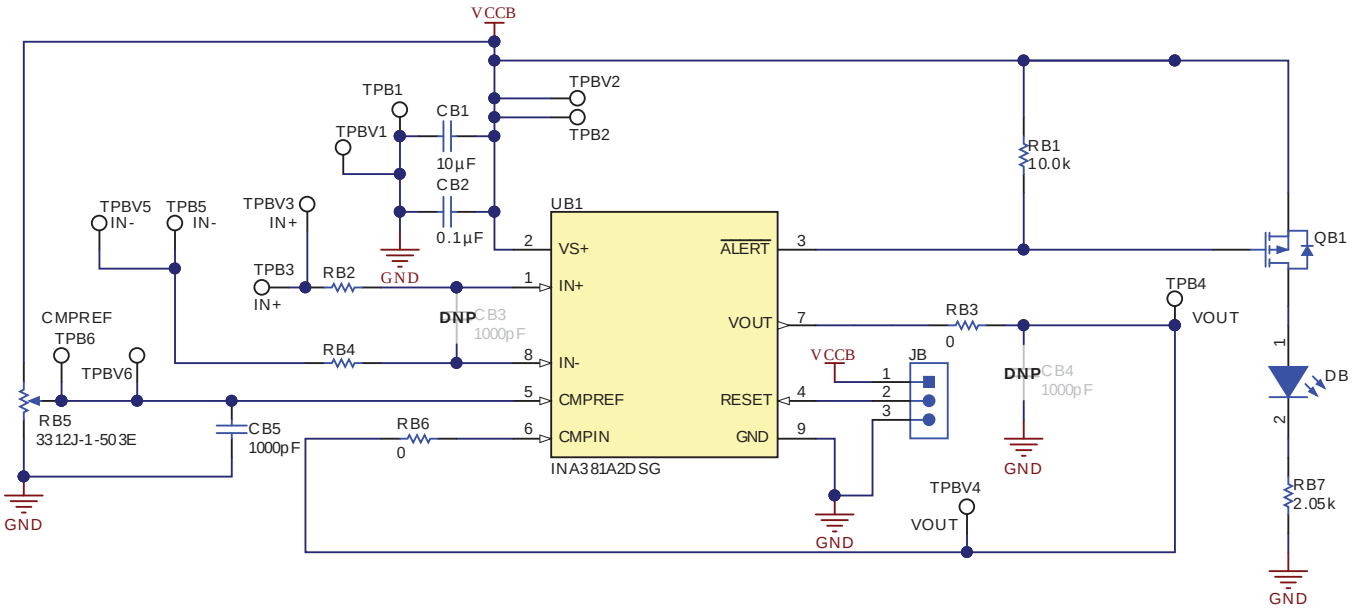
5.1 Schematics

Figure 1 through Figure 4 shows the schematics for the INA381EVM A1, A2, A3, and A4 devices, respectively.



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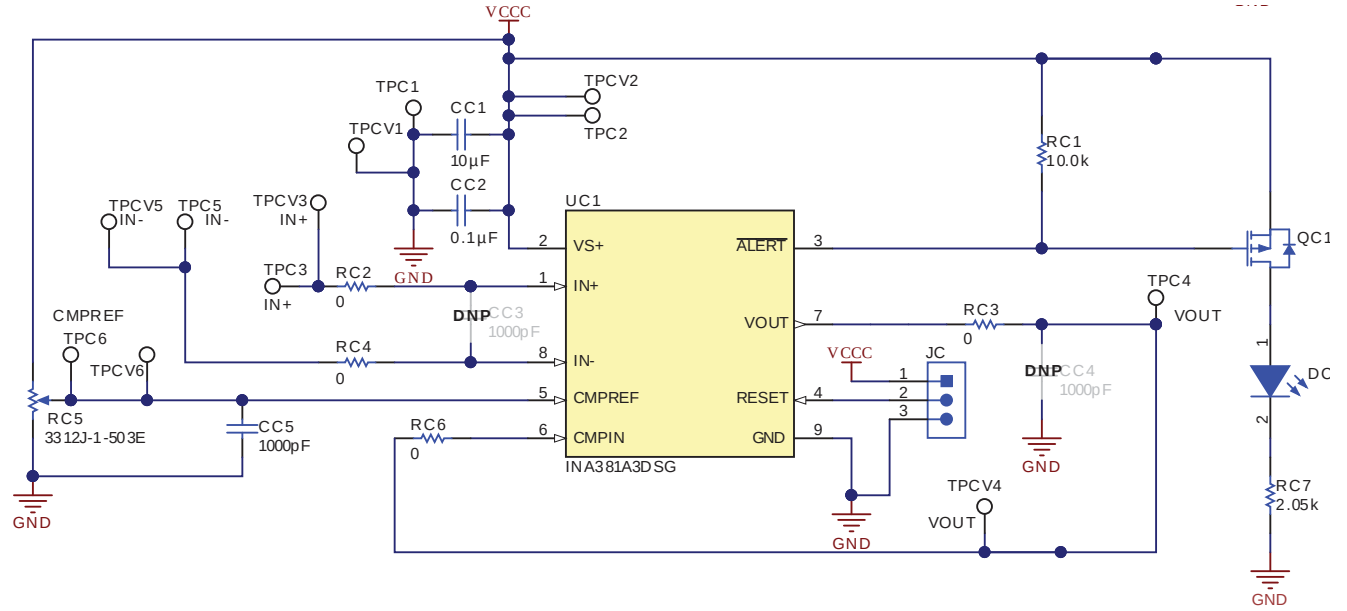
Figure 1. Schematic for A1 Device



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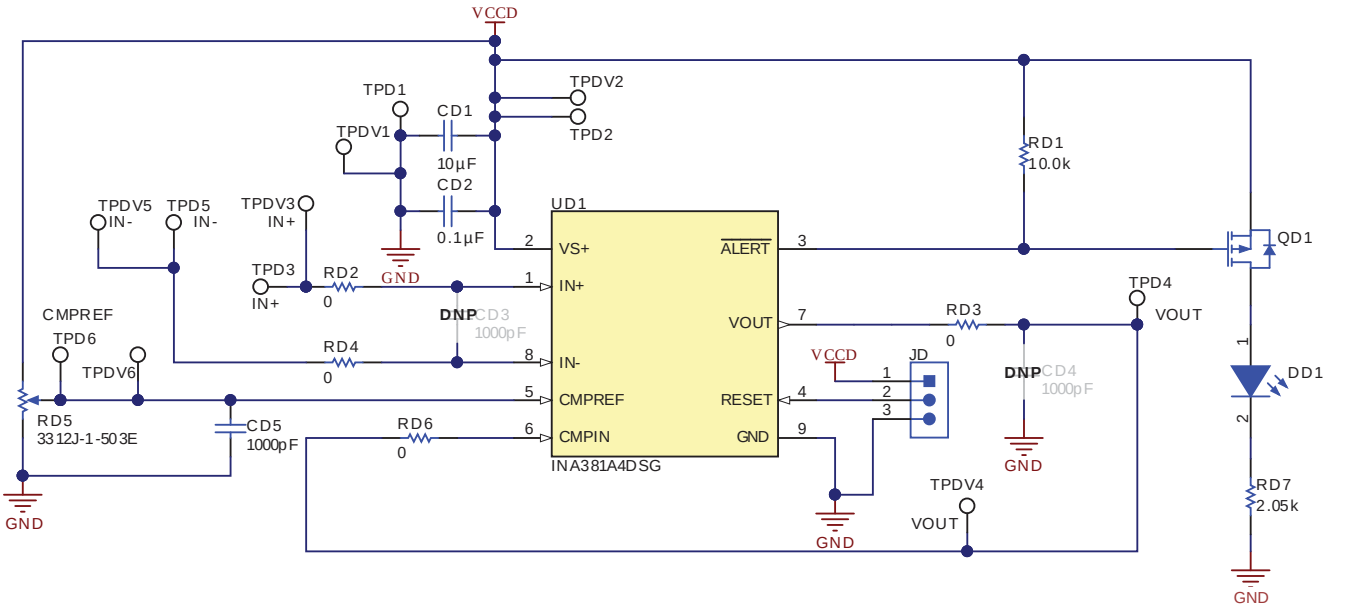
Figure 2. Schematic for A2 Device

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Figure 3. Schematic for A3 Device



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Figure 4. Schematic for A4 Device

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5.2 PCB Layout

Figure 5 through Figure 8 illustrate the PCB layers of the INA381EVM.

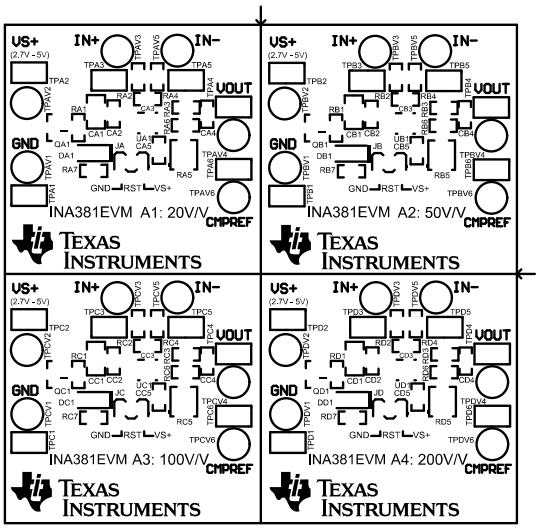


Figure 5. Top Overlay

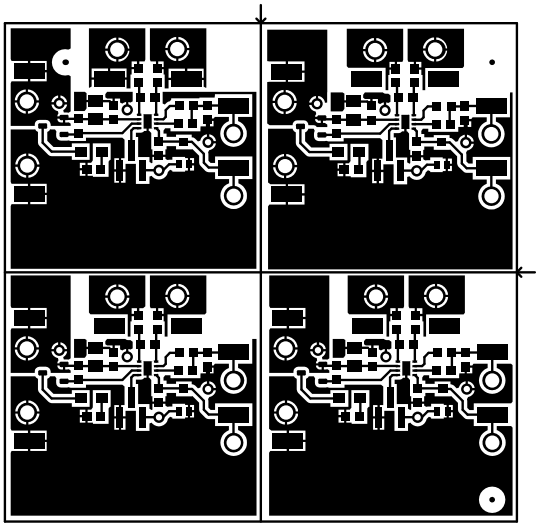


Figure 6. Top Layer

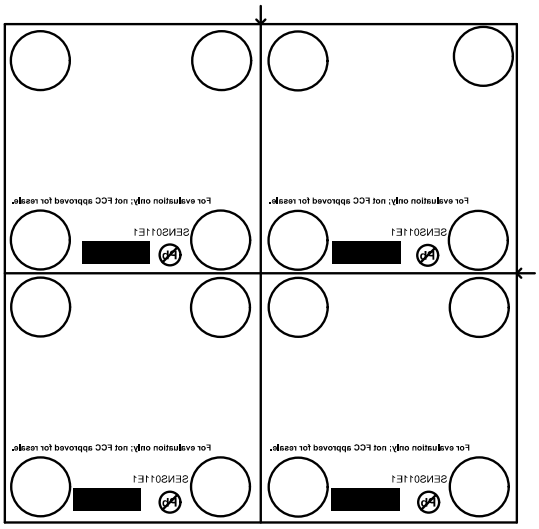


Figure 7. Bottom Overlay

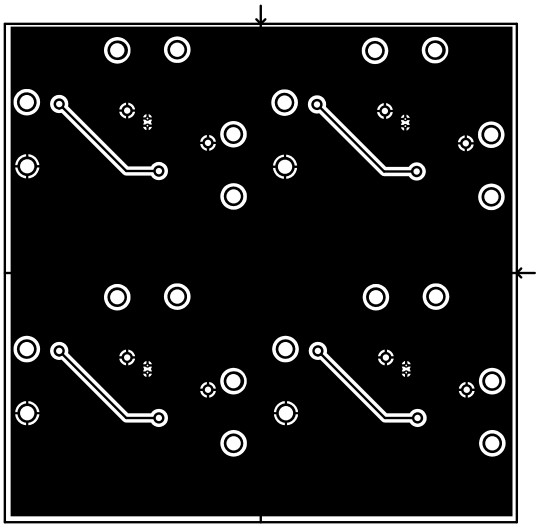


Figure 8. Bottom Layer

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5.3 Bill of Materials

Table 4 provides the parts list for the INA381EVM.

Table 4. Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
CA1, CB1, CC1, CD1	4	10uF	CAP, CERM, 10 µF, 16 V,+/- 20%, X7R, 0805	0805	EMK212BB7106MG-T	Taiyo Yuden
CA2, CB2, CC2, CD2	4	0.1uF	CAP, CERM, 0.1 µF, 16 V,+/- 10%, X7R, 0603	0603	C0603C104K4RACTU	Kemet
CA5, CB5, CC5, CD5	4	1000pF	CAP, CERM, 1000 pF, 50 V, +/- 10%, X7R, 0603	0603	C0603C102K5RACTU	Kemet
DA1, DB1, DC1, DD1	4	Green	LED, Green, SMD	LED_0805	APT2012LZGCK	Kingbright
H1, H2, H3, H4, H5, H6, H7, H8, H9, H10, H11, H12, H13, H14, H15, H16	16		Bumpon, Hemisphere, 0.25 X 0.075, Clear	75x250 mil	SJ5382	3M
JA, JB, JC, JD	4		Header, 1.27mm, 3x1, Gold, SMT	Header, 1.27mm, 3x1, SMT	GRPB031VWTC-RC	Sullins Connector Solutions
QA1, QB1, QC1, QD1	4	-50V	MOSFET, P-CH, -50 V, -0.13 A, SOT-23	SOT-23	BSS84-7-F	Diodes Inc.
RA1, RB1, RC1, RD1	4	10.0k	RES, 10.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0710KL	Yageo America
RA2, RA3, RA4, RA6, RB2, RB3, RB4, RB6, RC2, RC3, RC4, RC6, RD2, RD3, RD4, RD6	16	0	RES, 0, 5%, 0.1 W, 0603	0603	RC0603JR-070RL	Yageo America
RA5, RB5, RC5, RD5	4	50k	TRIMMER, 50k ohm, 0.1 W, SMD	2.5x2.8mm	3312J-1-503E	Bourns
RA7, RB7, RC7, RD7	4	2.05k	RES, 2.05 k, 1%, 0.1 W, 0603	0603	RC0603FR-072K05L	Yageo America
SH-J1, SH-J2, SH-J3, SH-J4	4		Mini Shunt, Closed Top, 650 V AC, -45 to 85 degC, Pitch 1.27 mm, Height 3 mm, RoHS	Mini Shunt, Body 2.5x1.27mm, Height 3mm	NPB02SVAN-RC	Sullins Connector Solutions
TPA1, TPA2, TPA3, TPA4, TPA5, TPA6, TPB1, TPB2, TPB3, TPB4, TPB5, TPB6, TPC1, TPC2, TPC3, TPC4, TPC5, TPC6, TPD1, TPD2, TPD3, TPD4, TPD5, TPD6	24		Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone
UA1	1	20V/V	26-V, Low Cost, Zero-Drift, Voltage-Output, Current-Shunt Monitor With Integrated Comparator, DSG0008A (WSON-8)	DSG0008A	INA381A1DSG	Texas Instuments
UB1	1	50V/V	26-V, Low Cost, Zero-Drift, Voltage-Output, Current-Shunt Monitor With Integrated Comparator, DSG0008A (WSON-8)	DSG0008A	INA381A2DSG	Texas Instuments
UC1	1	100V/V	26-V, Low Cost, Zero-Drift, Voltage-Output, Current-Shunt Monitor With Integrated Comparator, DSG0008A (WSON-8)	DSG0008A	INA381A3DSG	Texas Instuments
UD1	1	200V/V	26-V, Low Cost, Zero-Drift, Voltage-Output, Current-Shunt Monitor With Integrated Comparator, DSG0008A (WSON-8)	DSG0008A	INA381A4DSG	Texas Instuments

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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.

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   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.

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   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.

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。
http://www.tij.co.jp/lsds/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.

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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.

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