

Universal Difference Amplifier Evaluation Module

This user's guide describes the characteristics and operation of the universal difference amplifier evaluation module (EVM) that is compatible with all standard pinout difference amplifiers. The EVM is designed to evaluate the performance of these devices in a variety of common configurations and supports both single and dual-supply operation. The amplifier interfaces with the board through a DIP socket, allowing evaluation of any amplifier package with a DIP adapter board. A breakaway DIP adapter section is included to accommodate both SOIC-8 and VSSOP-8 style packages. This document includes the schematic, printed circuit board (PCB) layouts, and BOM. Throughout this document the terms *evaluation board*, *evaluation module*, and *EVM* are synonymous with the Universal Diff-Amp EVM. Note this EVM is not compatible with fully differential amplifiers.

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1 Overview

1.1 Features

This EVM is intended to provide basic functional evaluation of the amplifiers shown in [Table 1](#) with the pinout shown in [Figure 1](#). The EVM provides the following features:

- Breakaway DIP adapter boards for evaluation of multiple packages and easy comparison of devices
- Intuitive layout for setting jumpers
- Easy access to nodes with surface-mount test points
- Reference voltage source flexibility
- Support for a variety of configurations as a diff amp, current source, or precision inverting/non-inverting amplifier

1.2 Diff-amp Pinout

This EVM is intended to evaluate diff-amps that have the pinout shown in [Figure 1](#). Pin 8 is normally a no connect pin, but some devices provide an additional reference input at this pin. Pin 8 is tied to ground on the EVM, so these devices may also be tested but an additional reference is not supported. If it is desired to evaluate an amplifier with a pinout different than that in [Figure 1](#) than a custom DIP adapter board will be required.

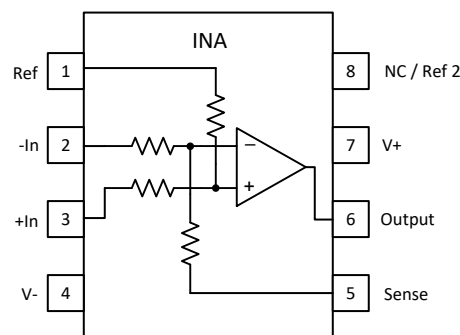


Figure 1. Supported Difference Amplifier Pinout

1.3 Compatible Devices

Devices that are compatible with this EVMs are shown in [Table 1](#).

Table 1. Compatible Devices

Device	Description
INA105	Precision Unity Gain Differential Amplifier
INA106	Precision Gain = 10 Differential Amplifier
INA132	Low Power, Single-Supply Difference Amplifier
INA133	High-Speed, Precision Difference Amplifier
INA134	Audio Differential Line Receivers, 0dB (G=1)
INA137	Audio Differential Line Receivers, +-6dB (G=1/2 or 2)
INA143	High-Speed, Precision, G = 10 or G = 0.1 Difference Amplifier
INA152	Single-Supply Difference Amplifier
INA154	High-Speed, Precision Difference Amplifier (G = 1)
INA157	High-Speed, Precision Difference Amplifier
INA159	High-Speed, Precision Gain of 0.2 Level Translation Difference Amplifier
INA592	Wide Bandwidth, e-Trim Difference Amplifiers

2 PCB Layout

The top and bottom sides of the EVM are shown in [Figure 2](#) and [Figure 3](#), respectively.

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 PCBs.

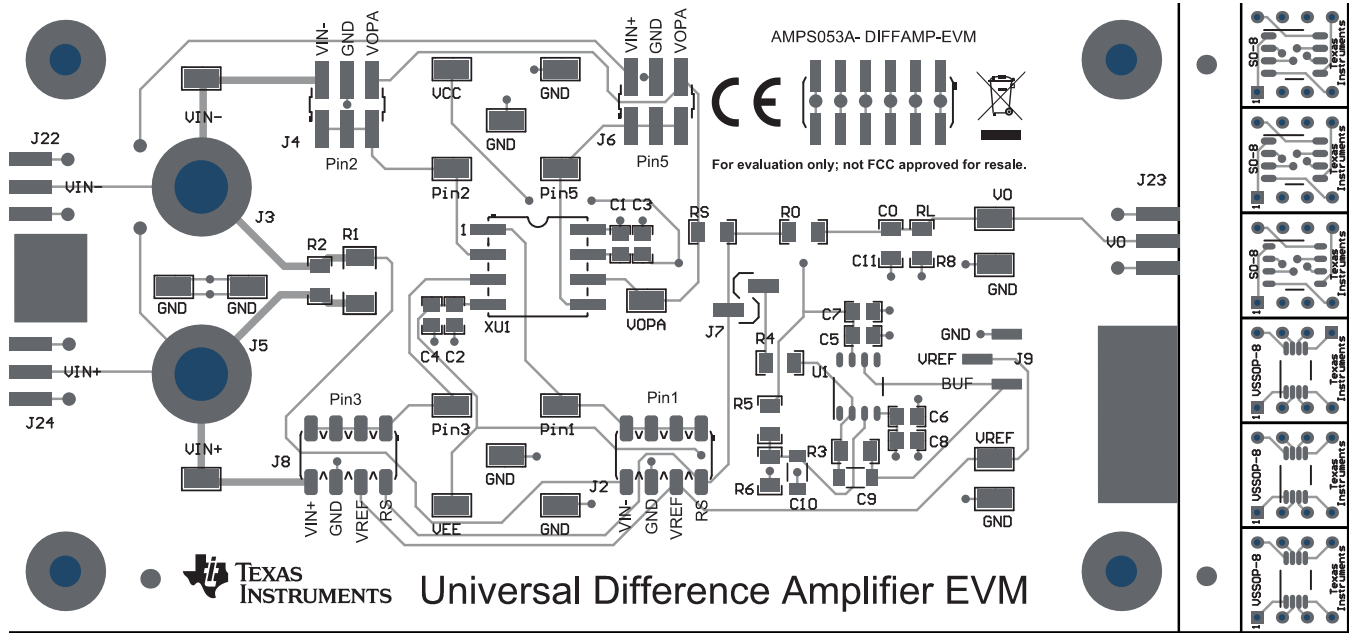


Figure 2. DIFFAMP-EVM Top Side

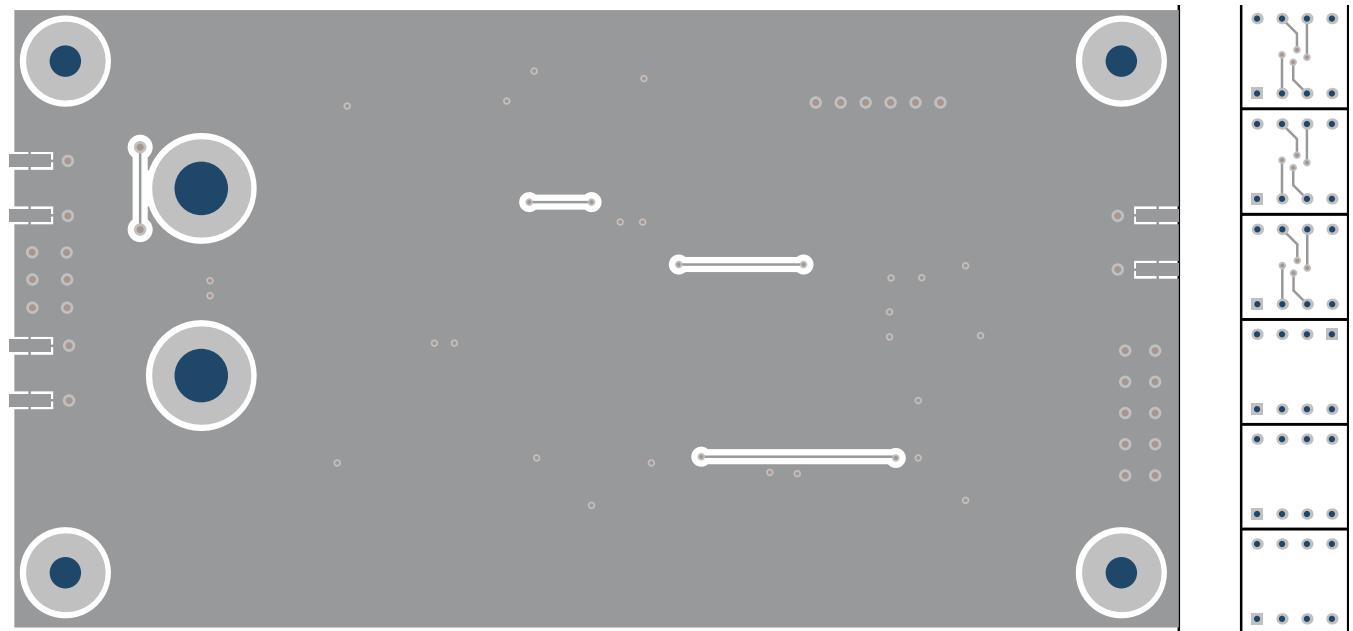
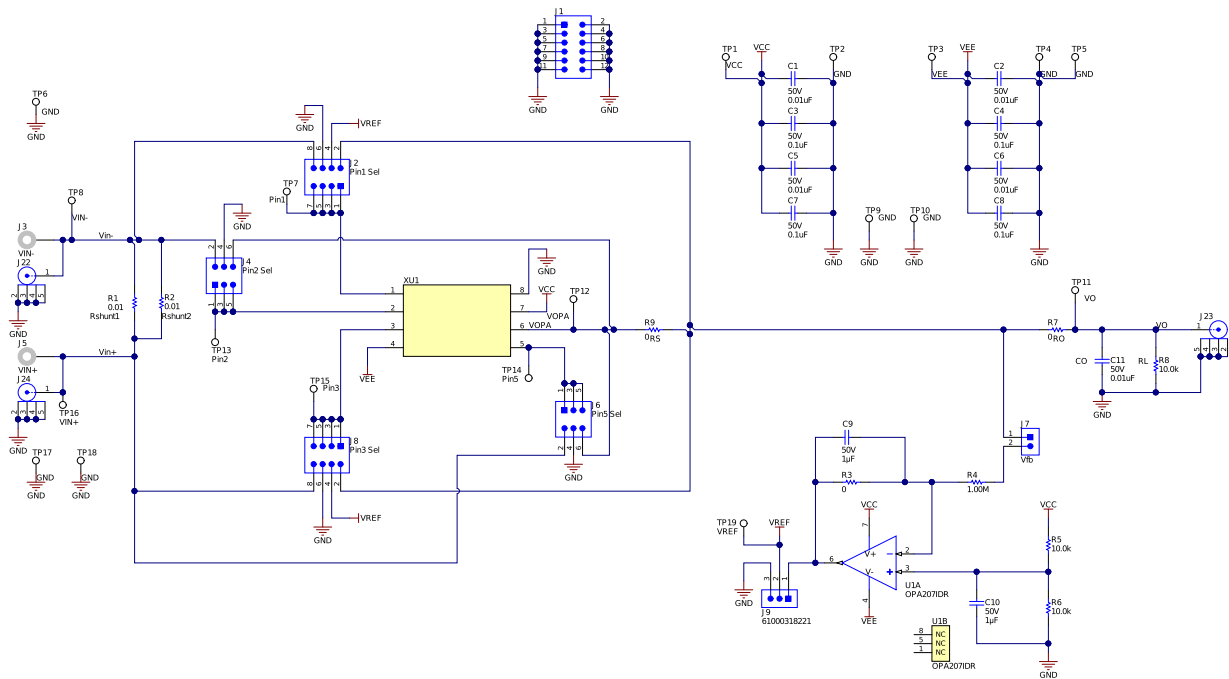


Figure 3. DIFFAMP-EVM Bottom Side

3 Schematic

Figure 4 shows the schematic for the PCB.



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Figure 4. DIFFAMP-EVM Schematic

4 EVM Components

4.1 Power

Power is applied to the device with test points VCC and VEE at TP1 and TP3, respectively. These test points power both the socketed diff-amp and the onboard reference amplifier. The board is initially populated with an OPA207 as the reference amplifier, but if a different device is used then take care that the new device can operate with the same supply as the diff-amp.

4.2 Inputs

Inputs are applied to the device using test points VIN+ and VIN-. Alternately, they can be applied at banana jacks J3 and J5. This is recommended if high currents will flow through the input. The jacks are spaced a 1/4 inch apart to interface with standard connectors. Two footprints are provided at the input for shunt resistors if it is desired to test an amplifier for a current sense application. Additionally, footprints are provided for edge mount SMA connectors for easily interfacing with other EVMs or test equipment.

4.3 Output

The output of the circuit may be accessed through test point VO or by adding an SMA connector at J23.

4.3.1 Output Filtering

RO and CO provide the ability to apply a single-pole RC output filter. Care must be taken not to overload the output with excess capacitance, as this could lead to stability issues. The cutoff frequency of the output filter is calculated as shown in [Equation 1](#):

$$f_{c-o} = \frac{1}{2\pi \times RO \times CO} \quad (1)$$

4.4 Reference

There are multiple methods of applying a reference voltage to the device. The reference voltage is set by J9, which either connects the reference to ground or ties it to the output of the reference buffer. The reference buffer is initially configured to generate a rail at mid-supply for single supply operation. Alternatively, this jumper can be left unconnected and the desired voltage can be applied directly to the VREF test point. It is also possible to connect J7 and configure the reference buffer as an integrator to ac couple the output as shown in [Figure 6](#).

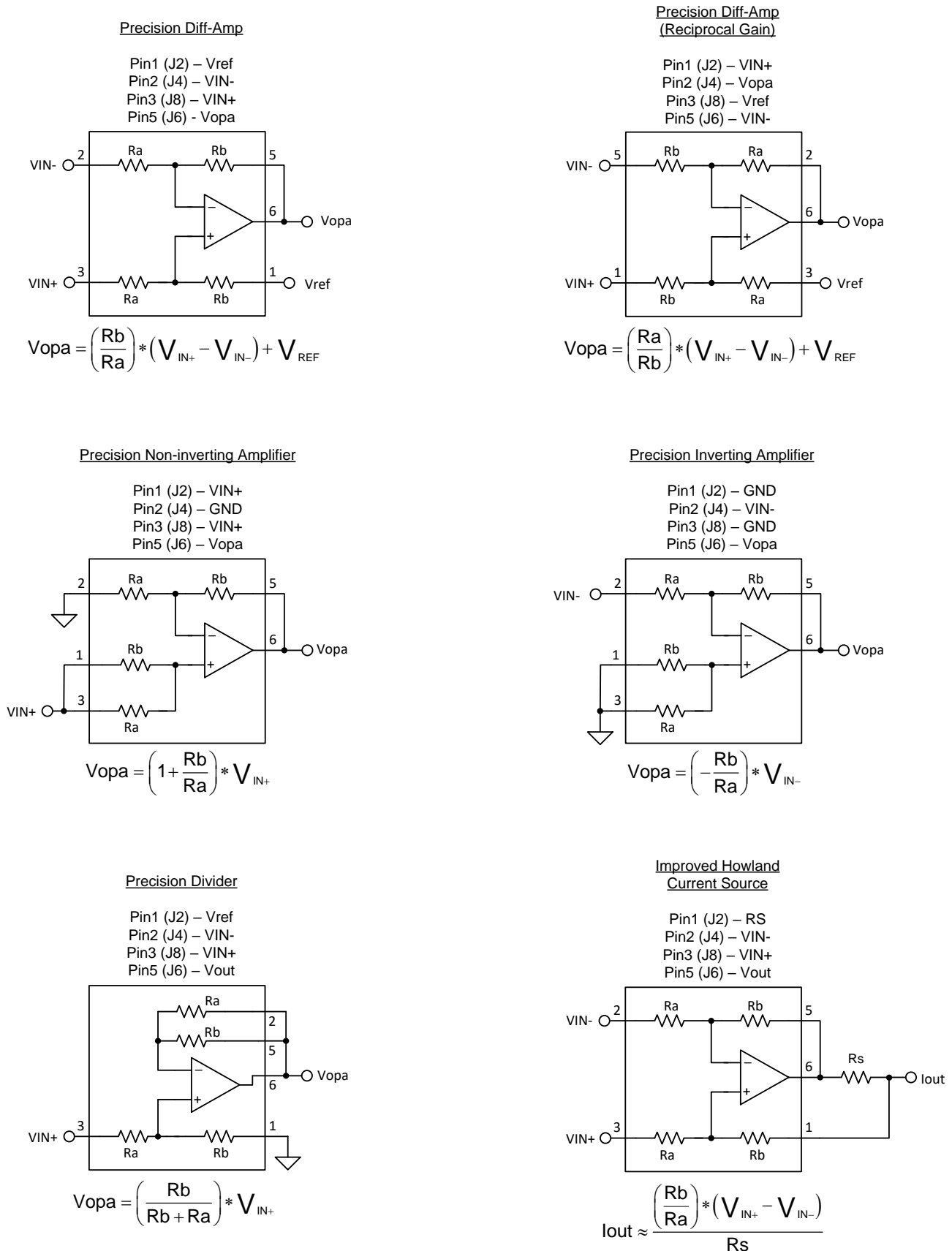
4.5 Miscellaneous

C1, C2, C3, and C4 are the supply bypass capacitors for the device and are pre-populated with 0.1 μ F and 0.01 μ F capacitors that usually provide adequate power supply bypassing for U1. Refer to the difference amplifier data sheet for further information. Similarly, C5, C6, C7, and C8 provide supply bypassing for U2. Refer to the buffer amplifier data sheet for further information.

5 Configurations

5.1 Difference Amplifier

This EVM allows for many jumper-selectable configurations. Pins 1, 2, 3, and 5 of the amplifier are routed to headers that allow the user to define what connections are made to the internal resistors. Note it is always necessary for either pin 2 or pin 5 to route to the output to ensure closed loop operation with negative feedback. [Figure 5](#) shows several ways to configure the jumpers and the associated transfer function. The exact gain depends on the ratio of resistors used in the selected difference amplifier. If the resistors in the difference amplifier are not all equal, then reciprocal gains can be achieved in each configuration as shown in the top two figures.


Figure 5. Common Difference Amplifier Configurations

5.2 Reference Amplifier

An onboard amplifier provides flexibility in reference configuration. In the default configuration the amplifier operates as a supply splitter, dividing the positive supply voltage in half and buffering it for single supply operation.

5.2.1 Buffered Reference Voltage Connection

A buffered-reference configuration is useful when the source impedance is high (for example, a voltage divider). Buffering a high-impedance source with an operational amplifier provides a low-impedance source and preserves common-mode rejection. The reference amplifier voltage is derived from the positive power supply and can be adjusted by changing the R5 and R6.

5.2.2 AC Coupled Output

It is possible to generate an ac coupled output by feeding the output of the diff-amp through an integrator and back to the reference pin. The output of the integrator will drive the reference such that the dc voltage at the output of the diff-amp matches the voltage applied to the non-inverting terminal of the reference amplifier. R5 can be removed if it is desired to ground the input of the amplifier in dual supply operation. The cutoff frequency will be set by the RC time constant of the integrator. This is sometimes preferable to using ac coupling capacitors at the input because capacitors tend to have wide tolerance ranges and mismatch in these capacitors can degrade the common-mode rejection of the amplifier. This can be implemented by placing a jumper on J7, removing R3, and populating R4 and C9 as shown in [Figure 6](#).

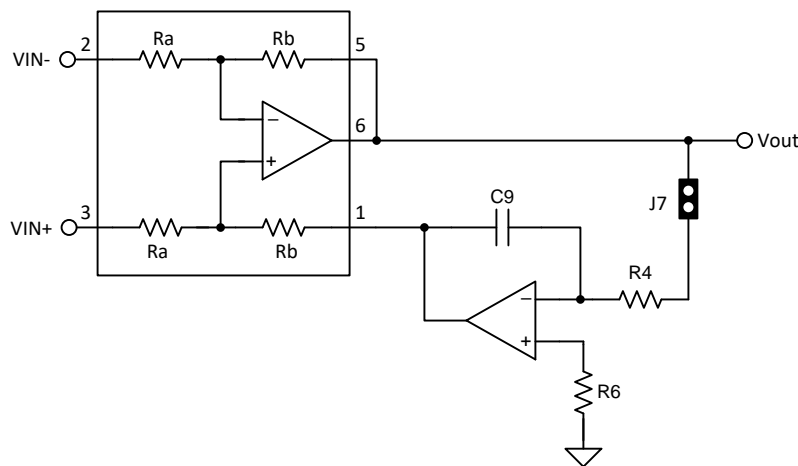


Figure 6. AC Coupling with Output Integrator

6 Bill of Materials

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
C1, C2, C5, C6	4	0.01uF	CAP, CERM, 0.01 uF, 50 V, +/- 10%, X7R, 0805	0805	C0805C103K5R ACTU	Kemet
C3, C4, C7, C8	4	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0805	0805	C0805C104K5R ACTU	Kemet
C10	1	1uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206	UMK316B7105K LHT	Taiyo Yuden
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4			Standoff	1902C	Keystone
J1	1		Header, 2.54mm, 6x2, Gold, SMT	Header, 2.54mm, 6x2, Gold, TH	61031221121	Wurth Elektronik
J2, J8	2		Header, 2.54mm, 4x2, Gold, SMT	Header, 2.54mm, 4x2, SMT	95278-801A08LF	FCI
J3, J5	2		Standard Banana Jack, Uninsulated, 5.5mm	Keystone_575-4	575-4	Keystone
J4, J6	2		Header, 2.54mm, 3x2, Gold, SMT	Header, 2.54mm, 3x2, SMT	TSM-103-01-L-DV	Samtec
J7	1		Header, 2.54 mm, 2x1, Gold, R/A, SMT	Header, 2.54 mm, 2x1, R/A, SMT	878980204	Molex
J9	1		Header, 2.54mm, 3x1, Gold, SMT	Header, 2.54mm, 3x1, SMT	TSM-103-02-L-SV	Samtek
R3, R7, R9	3	0	RES, 0, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW12060000 Z0EA	Vishay-Dale
R5, R6	2	10.0k	RES, 10.0 k, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	ERJ-8ENF1002V	Panasonic
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J9, SH-J10	10		Shunt, 100mil, Gold plated, Black	Shunt 2 pos. 100 mil	881545-2	TE Connectivity
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17, TP18, TP19	19		Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone

U1	1		High Precision, Low Noise, Low Power Operational Amplifier, D0008A (SOIC-8)	D0008A	OPA207IDR	Texas Instruments
XU1	1		Socket, DIP-8, 2.54 mm Pitch, SMT	Socket, DIP-8, 2.54 mm Pitch	110-87-308-41-105191	Preci-Dip
C9	0	1uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206	UMK316B7105K LHT	Taiyo Yuden
C11	0	0.01uF	CAP, CERM, 0.01 uF, 50 V, +/- 10%, X7R, 1206	1206	C1206C103K5R ACTU	Kemet
J10, J11, J12, J13, J14, J15, J16, J17, J18, J19, J20, J21	0		Header, 2.54mm, 4x1, Gold, Black, TH	Header, 2.54mm, 4x1, TH	TS-104-G-AA	Samtec
J22, J23, J24	0		SMA(F) Jack, 50 Ohm, SMT	SMA(F) Jack, SMT	EMPCB.SMAFS T.J.B.HT	Taoglas Antenna Solutions
R1	0	0.01	RES, 0.01, 1%, 1 W, 2010	2010	PMR50HZPFU1 0L0	Rohm
R2	0	0.01	RES, 0.01, 1%, 0.5 W, 1206	1206	CSR1206FK10L 0	Stackpole Electronics Inc
R4	0	1.00Meg	RES, 1.00 M, 1%, 0.25 W, 1206	1206	MCR18EZH100 4	Rohm
R8	0	10.0k	RES, 10.0 k, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	ERJ-8ENF1002V	Panasonic

7 Related Documentation from Texas Instruments

The following documents provide information regarding Texas Instruments' integrated circuits and support tools for the EVM. This user's guide is available from the TI web site under literature number [SBOU211](#). 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 may be available from the [TI web site](#), or call 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 2. Related Documentation

Document	Literature Number
OPA207 Product Data Sheet	SBOS826

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 semiconductor 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.
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.

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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.

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.

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