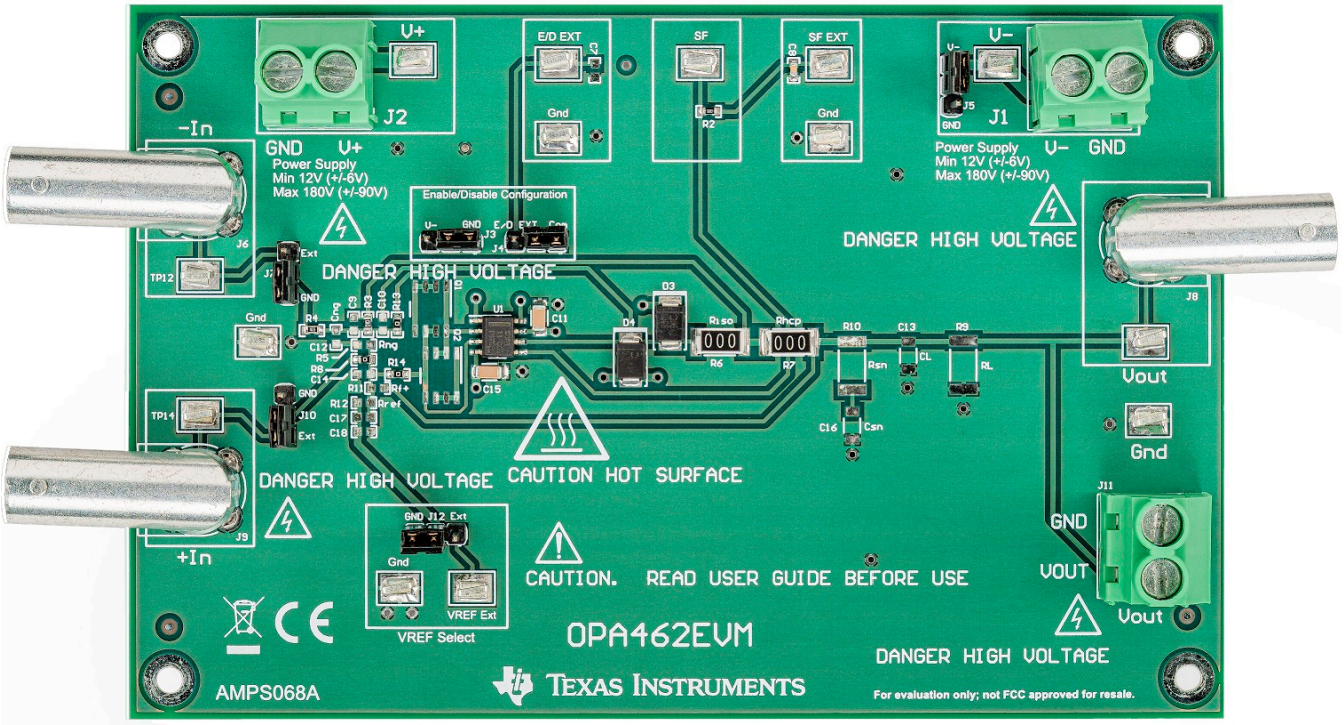
OPA462EVM



This user's guide describes the characteristics, operation, and use of the evaluation module (EVM) for the OPA462. The EVM is designed to evaluate the performance of the devices in both single and dual-supply configurations. This document also includes the schematic, printed circuit board (PCB) layout, and a bill of materials (BOM). Throughout this document the terms *evaluation board*, *evaluation module*, and *EVM* are synonymous with OPA462EVM.

WARNING

Danger: HIGH VOLTAGE! This evaluation board is intended for professional use only. It has exposed high voltages. Do not operate this board without proper high-voltage/high-current safety practices. Read Section 1.4 before using the EVM.

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Trademarks

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1 Overview

1.1 OPA462

The OPA462 is a precision power amplifier capable of operating over a very wide supply range of ±6 V to ±90 V, with an input common-mode range that extends to within a few volts from each rail. This amplifier is composed of an internal differential input amplifier stage, followed by a voltage amplifier, and finally, a high-current output stage. This device is designed to avoid phase inversion problems that are typically found in similar op amps. The OPA462 is unity-gain stable, and comes in an SO PowerPAD™ package.

1.2 OPA462EVM

The OPA462EVM is intended to provide basic functional evaluation of the OPA462. The EVM provides the following features:

- Easy access to pertinent nodes with test points and terminal blocks
- Convenient input and output filtering
- Access to multiple nodes and footprints for compensation
- Protection against power supply sequencing and inductive load kickback
- Configurable for any common amplifier topology, including the improved Howland current pump
- Footprints for providing a flexible reference voltage

1.3 Related Documentation

The following documents listed in Table 1 provide information about TI's integrated circuits and support tools for the OPA462EVM.

Table 1. Related Documentation

Document	Literature Number
OPA462 Product Data Sheet	SBOS803
OPA445 Product Data Sheet	SBOS156

1.4 Evaluation Module Limitations and Cautions

As a result of the high common-mode input voltage rating of the OPA462, evaluation of the device often involves high-voltage operation. As a difference amplifier, it may also be used in current-sensing applications. In addition to voltage and current limitations, proper electrostatic discharge precautions are recommended.

1.4.1 High Voltage Warning

The OPA462 is rated for supply voltages up to ±90 V (180 V for single supply), and common-mode input voltages up to ±85 V. When using the device and EVM under such circumstances, all proper safety practices must be followed. Do not apply more than rated voltages. See the OPA462 data sheet for additional information.

1.4.2 Electrostatic Discharge Caution

Many of the components on the OPA462EVM are susceptible to damage by electrostatic discharge (ESD). Customers are advised to observe proper ESD handling precautions when unpacking and handling the EVM, including the use of a grounded wrist strap at an approved ESD workstation.

CAUTION

A wrist strap may only be used with circuit voltages less than 100 V. For circuit voltages equal to or greater than 100 V, use an ionizer.

2 Getting Started

This section explains the connectors and jumpers, and details the basic EVM functionality.

2.1 Power Supplies

The OPA462EVM can be configured from ±6 V to ±90 V for dual supply operation, or from 12 V to 180 V for single-supply operation. Shorting pins 2 and 3 of J5 sets the EVM to single supply, and shorting pins 1 and 2 of J5 sets up the EVM for dual supplies. The OPA462 is capable of sourcing or sinking up to 30 mA of current. Power is provided to the EVM through J2 (V+) and J1 (V–). Take care to select supplies capable of providing the required power for the application. Use a supply capable of supplying at least twice the anticipated current at the intended operating voltage.

2.2 Jumpers

There are six jumpers located on the OPA462EVM. The jumper functions are summarized in Table 2.

Table 2. Jumper Table

Jumper	Function
J3	Enable or disable (E/D) common configuration
J4	Enable or disable (internal or external)
J5	Sets the negative supply to GND for single-supply operation.
J7	Selects inverting input (external or GND)
J10	Selects noninverting input (external or GND)
J12	Sets the reference voltage at the noninverting pin

2.3 Inputs

The inputs to the EVM can be any signal within the common-mode voltage range. BNC connectors are available at both inputs to allow for easy interfacing with signal generators or other equipment. Additionally, signals can be input using test points TP12 (IN–) and TP14 (IN+).

Jumpers J7 and J10 set the voltages seen at IN– and IN+, respectively. Short pins 2 and 3 of these jumpers to set the inputs to GND. Short pins 1 and 2 to allow whatever voltages present at the input BNCs to be passed to the op amp.

2.4 Outputs

The output of the EVM can be monitored from TP13. A BNC connector, J8, and terminal block, J11, are also provided to interface with other equipment or circuits. The EVM includes footprints for a load resistor, load capacitor, and an RC snubber network. If significant power is going to be driven into the load, use external loads.

2.5 Enable or Disable (E/D)

The OPA462 incorporates a disable feature that can be set using jumpers J3 and J4 on the EVM. The disable is accomplished without disturbing the input signal path, which helps save power in addition to protecting the load. Jumper J3 sets the voltage of the E/D Com pin, which can be set to either the negative rail or GND. The voltage at the E/D Com pin serves as the reference voltage for the E/D pin. J4 sets the voltage at the E/D pin. The device is enabled by floating the E/D pin, or by forcing the E/D pin high using an external voltage. If forcing the E/D pin high, the pin must be pulled at least 2.5 V greater than the E/D Com pin, but should not be pulled any more than 5 V greater than the E/D Com pin. Shorting the E/D pin to the E/D Com pin disables the device.

2.6 Status Flag

The OPA462 incorporates a status flag pin to indicate overcurrent or overtemperature conditions. This pin is an open-drain, active-low output that allows the pin to be easily interfaced with standard low-voltage logic. The pin goes active if the junction temperature of the device rises to greater than 150°C, and resets after the device cools to 130°C. Additionally, the pin goes active if the device attempts to source more than the maximum continuous current of 30 mA. The status flag can be monitored from TP2, and an external pullup voltage can be input on TP11.

2.6.1 Circuit Protection

The OPA462EVM is protected from inductive surges and power supply transients with the use of Schottkey diodes on the amplifier output and transient voltage suppressors on the power supply inputs. See D1, D2, D3 and D4 on the schematic shown in Figure 4, and in the BOM shown in Table 3 at the end of this document.

In addition, footprints have been provided for optional components Q1 and Q2. These may be used to protect the amplifier inputs from voltage transients that briefly exceed the maximum input voltage. See the BOM at the end of this document for the recommended part number.

3 Application Circuits

The OPA462EVM may be configured in most standard op amp circuits. See the OPA462 data sheet for typical applications.

3.1 Improved Howland Current Pump

The OPA462EVM can be configured as an improved Howland current pump that provides an output current proportional to a single- or differential-input voltage. The improved Howland current pump is described and analyzed in section 3 of the *A Comprehensive Study of the Howland Current Pump* application report. Information about how the current-pump resistor values are determined for a particular input voltage and a corresponding output current is provided in the application report. The report information is applied here in this section as a practical use for the OPA462EVM.

The OPA462EVM, as configured in Figure 1, sources on an output current of –20 mA when a single-ended input voltage of 2.5 V is applied to the VP input. If the input voltage sign is reversed, the output reverses direction and sinks 20 mA. The circuit in Figure 1 provides the resistance values required to obtain the correct 20-mA output current. The resistor and capacitor labels correspond to those screened on the OPA462EVM printed circuit board. As shown in Figure 1, when RL is equal to 500 Ω, the sourced output current level is –20 mA, and Vout is 10 V, as Ohm's law dictates.

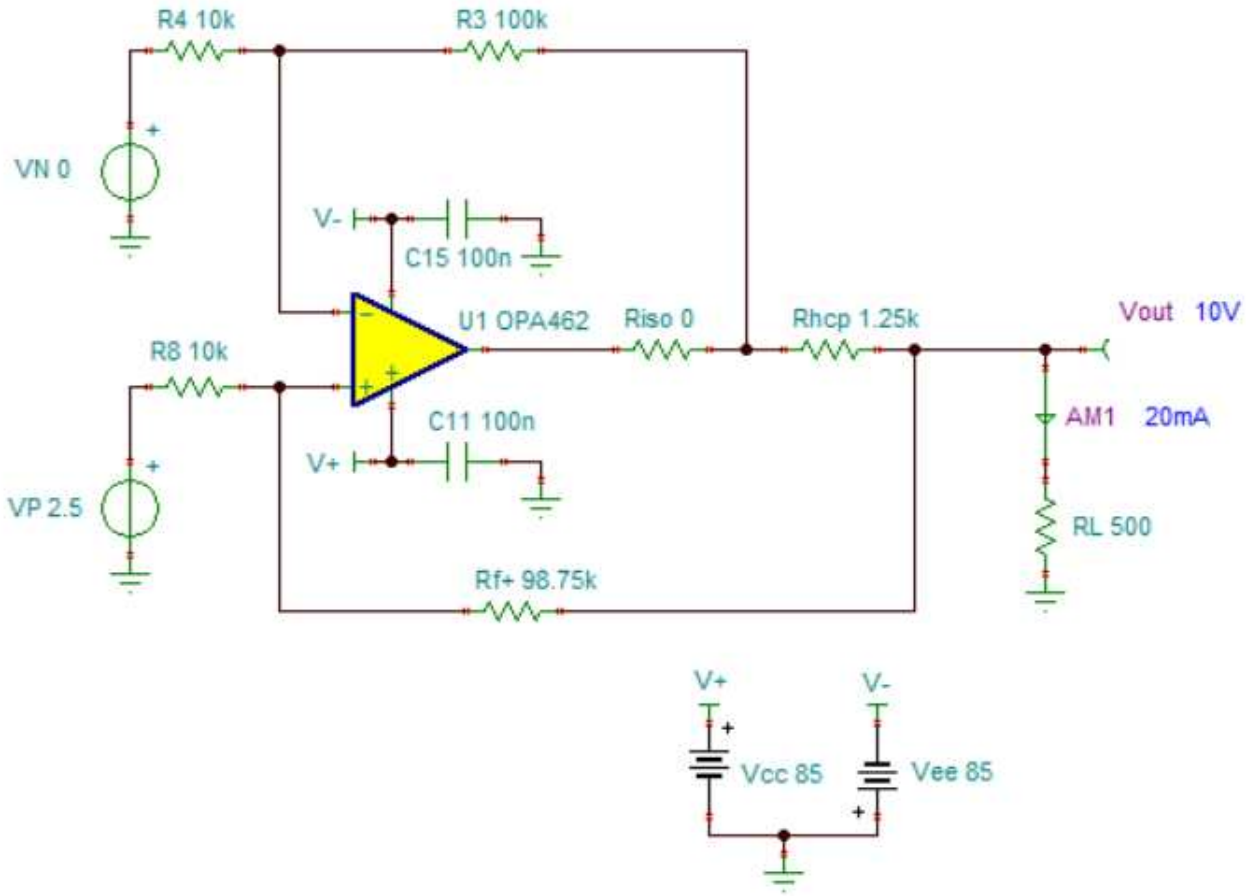

Figure 1. Practical, 20-mA, Improved Howland Current-Pump Circuit

Practical current sources have a limited output voltage range that can be covered. The OPA462 op amp has a wide output voltage range because of the high-voltage supplies used. The OPA462 data sheet provides information about the linear output voltage range that should always be observed.

For the improved Howland current pump application, the output voltage (Vout) that is attainable at the load is further constrained by the voltage drop developed across Rhcp. The 20-mA load current flows through the resistor, and causes a voltage drop. Therefore, with a fixed 20-mA output current flowing through RL, there is a limit as to how far Vout can swing. For this example, the limit occurs when Vout reaches approximately 57.4 V, and RL is 2.87 kΩ. This limit can be seen in Figure 2. Resistor RL can be any value from 0 Ω to 2.87 kΩ, and the output will remain within the circuit linear compliance range. However, if the value of RL is increased further, the current pump operation is forced outside the compliance range, and the output current will no longer remain constant. Thus, increasing the value of RL to greater than 2.87 kΩ defeats the goal of providing a constant current.

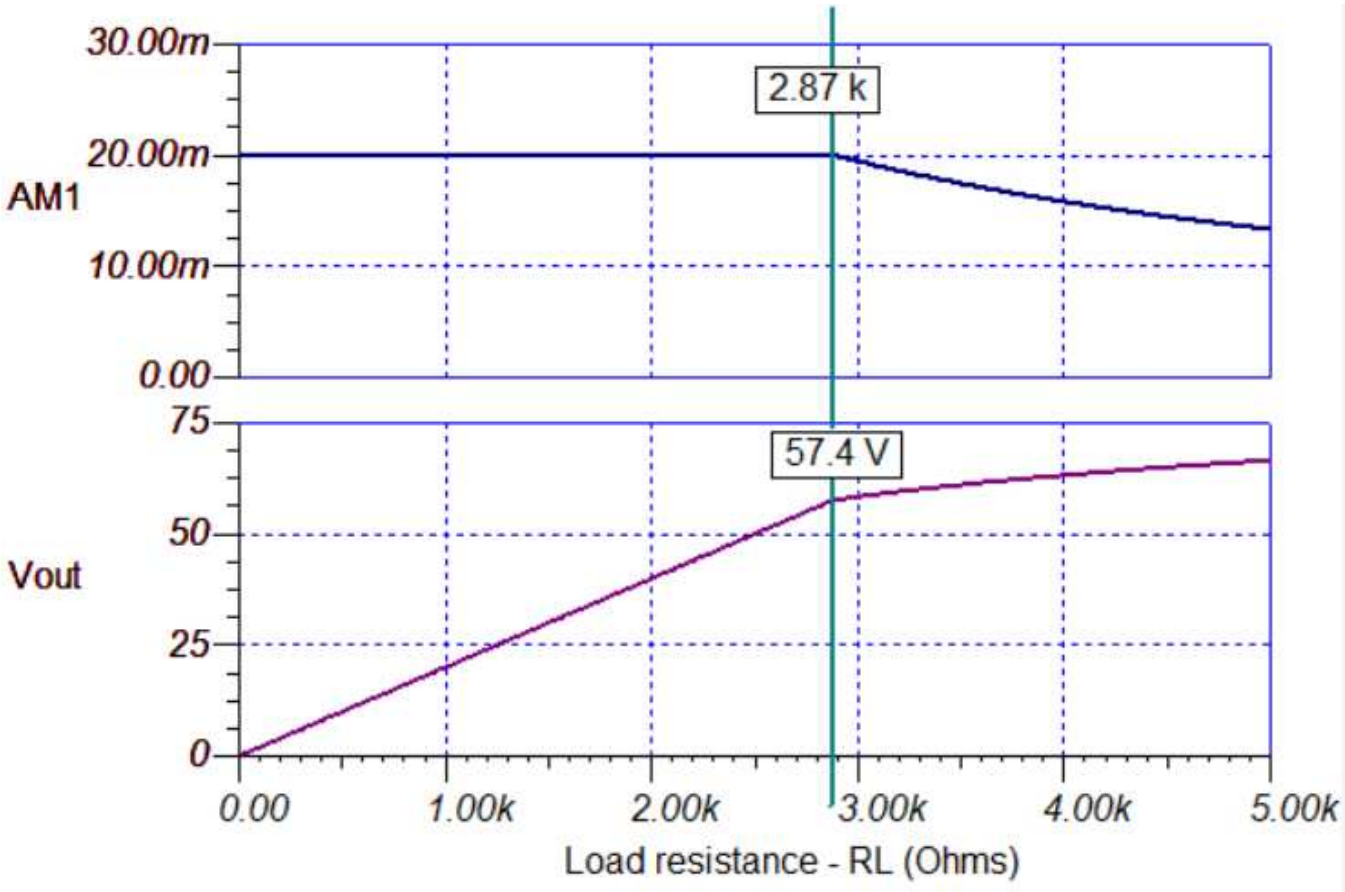

Figure 2. Improved Howland Current Pump Output-Voltage Compliance Range

The improved Howland current pump can be used to generate an ac waveform with a peak current that corresponds to a maximum specified dc value. A 20-mA dc current source using the OPA462 has been demonstrated, and will now be used to show how a 20-mA peak ac-current waveform can be realized.

The same circuit shown in Figure 1 is applied, except the 2.5-VDC VP voltage source in Figure 1 is replaced by an 100-Hz ac source having a peak voltage of 2.5 V. The peak output current depends on the peak voltage level applied at the VP input. A triangle wave is used in the example; however, a sine wave, square wave, or other waveform could be applied instead. Figure 3 shows that a 2.5-V peak input triangle wave applied to the current pump input, VP, results in a 20-mA peak triangle wave at the output, Vout.

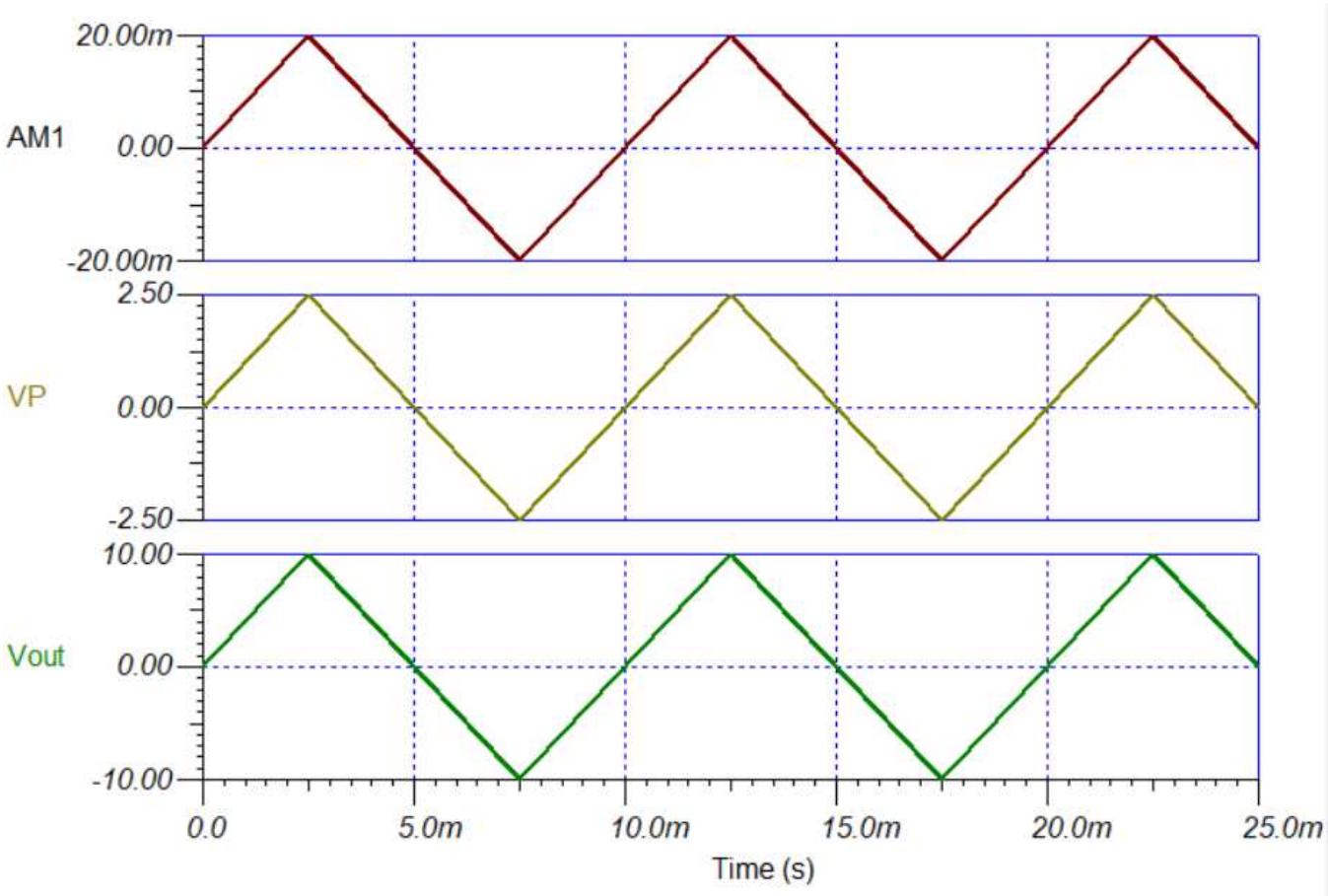

Figure 3. Improved Howland Current Pump Applied as a Peak AC-Current Generator

The improved Howland current pump op amp circuit relies on both negative and positive feedback for operation; more negative feedback than positive feedback, but that feedback does not always provide stability. When unity-gain-stable op amps, such as the OPA462, are employed and they drive a resistive load, the op amp phase margin should be sufficient such that the circuit is stable. However, if the output load is complex, containing both resistive and reactive components (R±jX), there can be combinations that degrade the phase margin, and instability results. Degradation of the phase margin often occurs when the current pump is used to drive loads that are predominantly inductive.

The OPA462EVM has a number of positions where component may be added to stabilize the various OPA462 amplifier and improved Howland current pump configurations that are supported by the EVM. Some of the component locations that are used for this purpose are R6 (ISO), R5 (Rng), C12 (Cng, noise gain), R10 (Rsn), C16 (Csn, snubber), and C9 and C10 in the feedback loop. Compensation, when required, is determined based on the particular circuit to which the OPA462 is being applied. Op amp stability and compensation is a vast subject covered in numerous TI documents, and TI training programs such as *TI Precision Labs – Op Amps*.

4 Schematic, PCB Layout, and Bill of Materials

This section discusses the OPA462EVM hardware schematics, PCB layout and jumper configurations.

4.1 EVM Schematic

Figure 4 depicts the complete OPA46xEVM schematic.

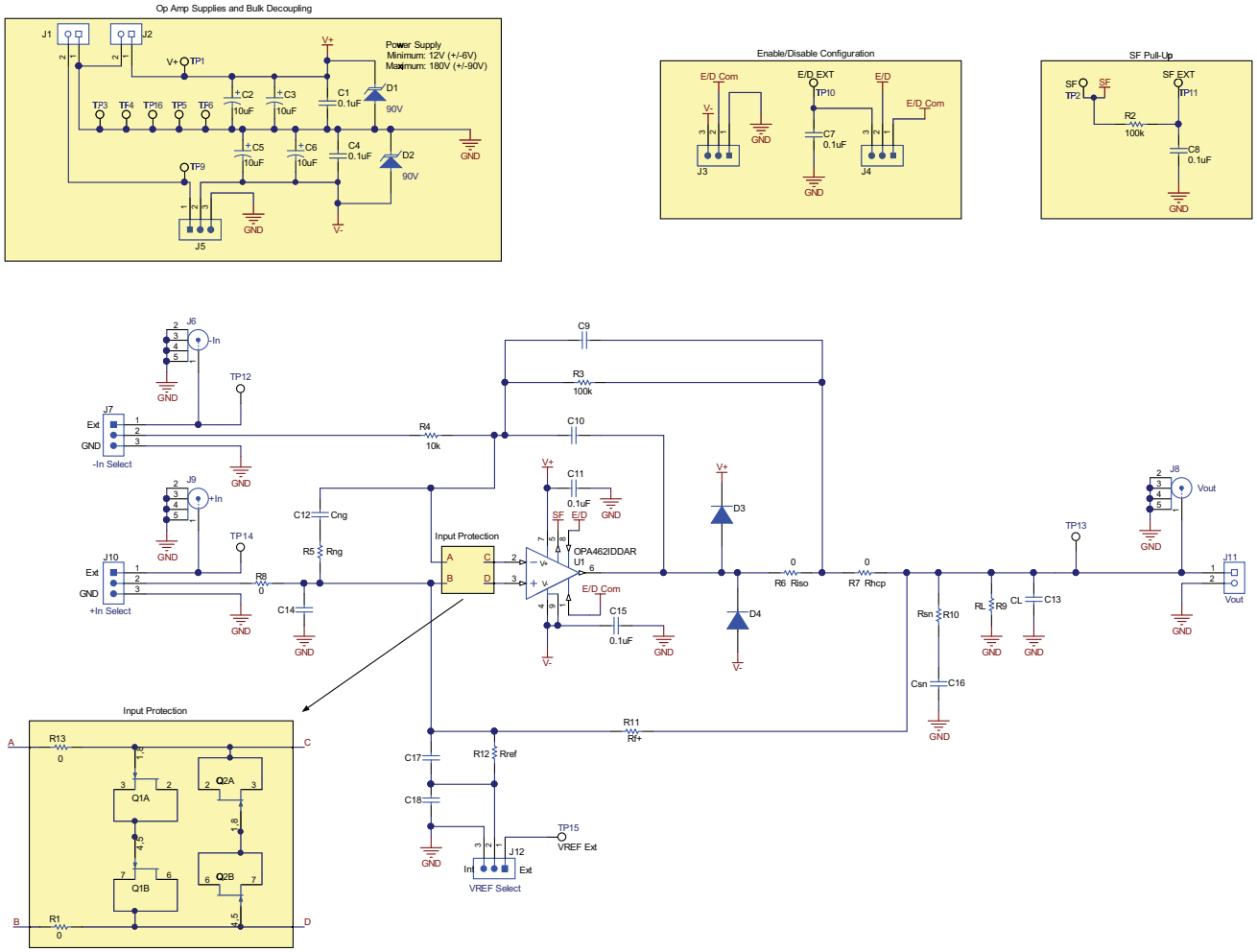

Figure 4. OPA462EVM Schematic

4.2 EVM Default Configuration

The OPA462EVM ships in a standard amplifier configuration with a noninverting gain of 11. Figure 5 shows the schematic for the default configuration. Any components shown on the complete schematic but not on this schematic are optional and not installed.

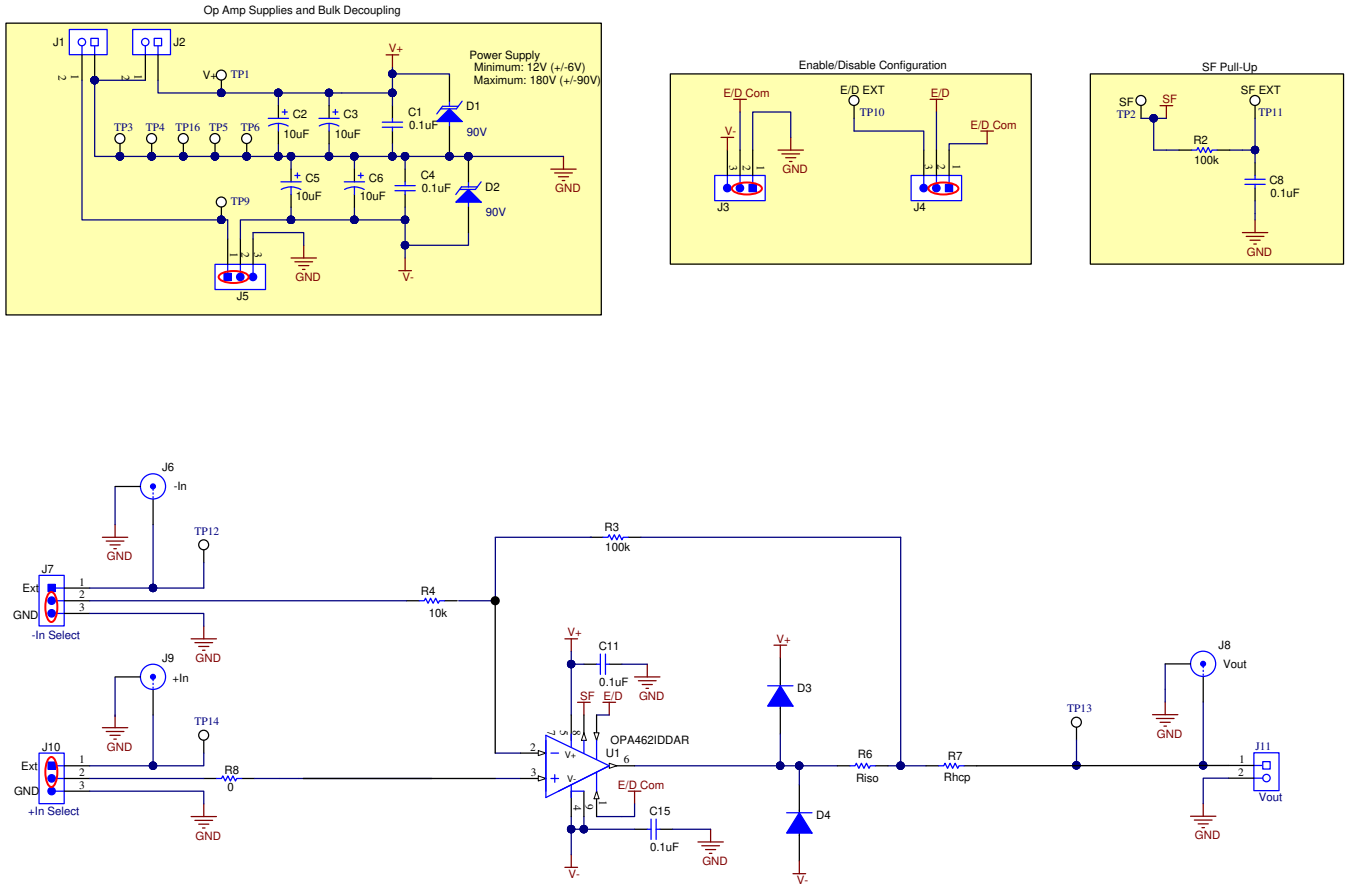

Figure 5. OPA462EVM Default Configuration

4.3 PCB Layout

Figure 6 depicts the PCB layout.

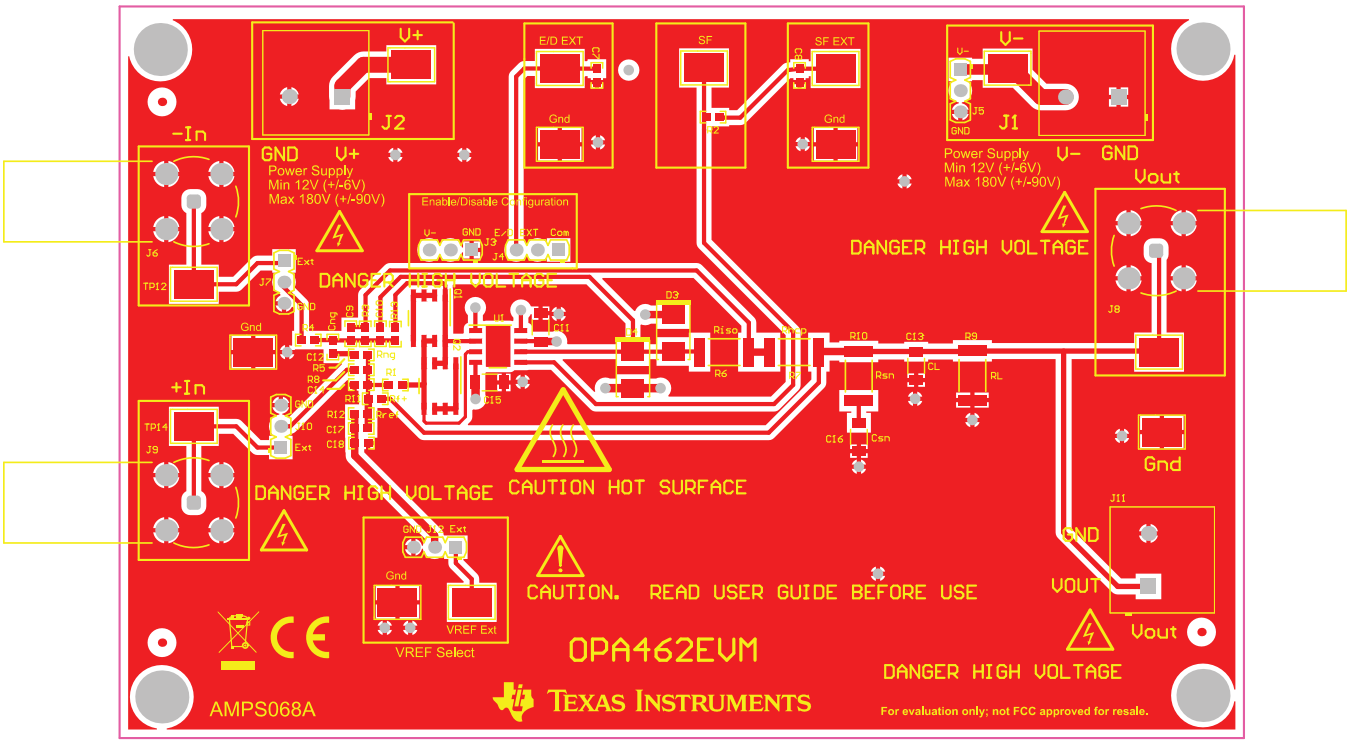

Figure 6. OPA462EVM PCB Layout

NOTE: Board layout is not to scale. This figure is intended to show how the board is laid out, and is not intended to be used for manufacturing OPA462EVM PCBs.

4.4 Bill of Materials

Table 3 lists the bill of materials (BOM) used for the OPA46xEVM.

Table 3. OPA462EVM BOM

Designator	Quantity	Description	Part Number	Manufacturer	Notes
C1, C4, C11, C15	4	CAP, CERM, 0.1 uF, 450 V, +/- 10%, X7T, 1206_190	C3216X7T2W104K160AA	TDK	
C2, C3, C5, C6	4	CAP, AL, 10 uF, 250 V, +/- 20%, SMD	ULR2E100MNL1GS	Nichicon	
C8	1	CAP, CERM, 0.1 uF, 25 V, +/- 10%, X7R, 0603	06033C104KAT2A	AVX	
D1, D2	2	Diode, TVS, Uni, 90 V, 146 Vc, SMC	5.0SMDJ90A	Littelfuse	
D3, D4	2	Diode, Ultrafast, 400 V, 1 A, SMB	MURS140-13-F	Diodes Inc.	
H1, H2, H3, H4	4	MACHINE SCREW PAN PHILLIPS 4-40	9900	Keystone	
H5, H6, H7, H8	4		2203	Keystone	
J1, J2, J11	3	Terminal Block, 2x1, 6.35mm, Green, TH	1714955	Phoenix Contact	
J3, J4, J5, J7, J10, J12	6	Header, 2.54mm, 3x1, Tin, TH	68001-403HLF	FCI	
J6, J8, J9	3	BNC Low Profile Elbow Jack, Gold, R/A, TH	5-1634513-1	TE Connectivity	
R1, R8, R13	3	RES, 0, 5%, 0.1 W, 0603	RC0603JR-070RL	Yageo	
R2, R3	2	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW0603100KFKEA	Vishay-Dale	
R4	1	RES, 10.0 k, 0.1%, 0.1 W, 0603	RG1608P-103-B-T5	Susumu Co Ltd	
R6, R7	2	RES, 0, 5%, 1 W, 2512	RC6432J000CS	Samsung	
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6	6	Shunt, 100mil, Gold plated, Black	881545-2	TE Connectivity	
TP1, TP2, TP3, TP4, TP5, TP6, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16	14	Test Point, Compact, SMT	5016	Keystone	
U1	1	High-Voltage (180-V), High-Current (30-mA) Operational Amplifier, G = 1 Stable, DDA0008J (SOIC-8)	OPA462IDDAR	Texas Instruments	OPA462IDDA
C7	0		06033C104KAT2A	AVX	Optional-Not installed
C9, C10, C12, C14, C17, C18	0				Optional-Not installed
C13, C16	0				Optional-Not installed
FID1, FID2, FID3	0				Optional-Not installed
Q1, Q2	0	JFET, 2-CH, N-CH, V, A, SOIC-8	IF1322A	InterFET	Optional-Not installed
R5, R11, R12	0				Optional-Not installed
R9, R10	0				Optional-Not installed

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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:

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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

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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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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page
電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。http://www.tij.co.jp/lsds/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.

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