

***Universal  
Operational Amplifier  
Evaluation Module***

*User's Guide*

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# Preface

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## ***Related Documentation From Texas Instruments***

- ***Amplifiers, Comparators, and Special Functions Data Book*** (literature number SLYD011). This data book contains data sheets and other information on the TI operational amplifiers that can be used with this evaluation module.
- ***Power Supply Circuits Data Book*** (literature number SLVD002). This data book contains data sheets and other information on the TI shunt regulators that can be used with this evaluation module.

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# Contents

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<b>1</b>	<b>Introduction</b> .....	<b>1-1</b>
1.1	Design Features .....	1-2
1.2	Power Requirements .....	1-2
<b>2</b>	<b>Board Layout</b> .....	<b>2-1</b>
2.1	Physical Considerations .....	2-2
2.2	Area 100 – SOIC .....	2-3
2.3	Area 200 – TSSOP or MSOP .....	2-4
2.4	Area 300 – SOT23-5A .....	2-5
2.5	Area 400 – SOT23-5B .....	2-6
2.6	Component Placement .....	2-7
2.7	Board Layout .....	2-8
<b>3</b>	<b>Example Circuits</b> .....	<b>3-1</b>
3.1	Schematic Conventions .....	3-1
3.2	Sallen-Key Low-Pass Filter .....	3-2
3.3	Sallen-Key High-Pass Filter .....	3-3
3.4	Inverting Amplifier .....	3-5
3.5	Noninverting Amplifier .....	3-6
3.6	Two Operational Amplifier Instrumentation Amplifier .....	3-7
3.7	Differential Amplifier .....	3-9

# Figures

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2-1	Area 100 Schematic – SOIC .....	2-3
2-2	Area 200 Schematic – TSSOP and MSOP .....	2-4
2-3	TLV22X1 Device Pinout .....	2-5
2-4	Area 300 Schematic – SOT23–5A .....	2-5
2-5	TLV2771 and TLV2461 Device Pinout .....	2-6
2-6	Area 400 Schematic – SOT23–5B .....	2-6
2-7	Universal Operational Amplifier EVM Board Component Placement .....	2-7
2-8	Universal Operational Amplifier EVM Board Layout Top .....	2-8
2-9	Universal Operational Amplifier EVM Board Layout Bottom .....	2-9
3-1	Sallen-Key Low-Pass Filter with Dual Supply Using Area 100 .....	3-2
3-2	Sallen-Key High-Pass Filter with Single Supply Using Area 200 .....	3-4
3-3	Inverting Amplifier with Dual Supply Using Area 300 .....	3-5
3-4	Noninverting Amplifier with Single Supply Using Area 400 .....	3-6
3-5	Two Operational Amplifier Instrumentation Amplifier with Single Supply .....	3-8
3-6	Single Operational Amplifier Differential Amplifier with Single Supply .....	3-9

# Introduction

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This User's Guide describes a universal operational amplifier (op amp) evaluation module (EVM) that simplifies evaluation of surface-mount op amp.

<b>Topic</b>	<b>Page</b>
1.1 Design Features .....	1-2
1.2 Power Requirements .....	1-2

## 1.1 Design Features

The evaluation module board design allows many different circuits to be constructed easily and quickly. The board has four separate circuit development areas that can be snapped apart and separated. Areas 100 and 200 are for dual op amps in the SOIC and TSSOP/MSOP packages. Areas 300 and 400 are for SOT23–5 single operational amplifier packages. A few possible circuits are listed below:

- Voltage Follower
- Noninverting Amplifier
- Inverting Amplifier
- Simple or Algebraic Summing Amplifier
- Difference Amplifier
- Current-to-Voltage Converter
- Voltage-to-Current Converter
- Integrator/Low-Pass Filter
- Differentiator/High-Pass Filter
- Instrumentation Amplifier
- Sallen-Key Filter

The EVM PCB is of two-layer construction, with a ground plane on the solder side. Circuit performance should be comparable to final production designs.

## 1.2 Power Requirements

The devices and designs that are used dictate the input power requirements. Three input terminals are provided for each area of the board:

Vx+	Positive input power for area x00	i.e., V1+ ⇒ area 100
GNDx	Ground reference for area x00	i.e., GND2 ⇒ area 200
Vx–	Negative input power for area x00	i.e., V4– ⇒ area 400

Each area has four bypass capacitors, two for the positive supply, and two for the negative supply. Each supply should have a 1- $\mu$ F to 10- $\mu$ F capacitor for low frequency bypassing and a 0.01- $\mu$ F to 0.1- $\mu$ F capacitor for high frequency bypassing.

When using single supply circuits, the negative supply is shorted to ground by bridging Cx02 or Cx06, and power input is between Vx+ and GNDx. The voltage reference circuitry is provided for single supply applications that require a reference voltage to be generated.



# Evaluation Module Layout

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This chapter describes and shows the universal op amp EVM board layout and the relationships between the four areas.

<b>Topic</b>	<b>Page</b>
2.1 Physical Consideration .....	2-2
2.2 Area 100 – SOIC .....	2-3
2.3 Area 200 – TSSOP or MSOP .....	2-4
2.4 Area 300 – SOT23-5A .....	2-5
2.5 Area 400 – SOT23-5B .....	2-6
2.6 Component Placement .....	2-7
2.7 Board Layout .....	2-8

## 2.1 Physical Considerations

The EVM board has four circuit development areas. If a specific area is desired, it can be separated from the others by breaking along the score lines. The circuit layout in each area supports an op amp package, voltage reference, and ancillary devices. The op amp package is unique to each area as described in the following paragraphs. The voltage reference and supporting devices are the same for all areas. Surface-mount or through-hole devices can be used for all capacitors and resistors on the board.

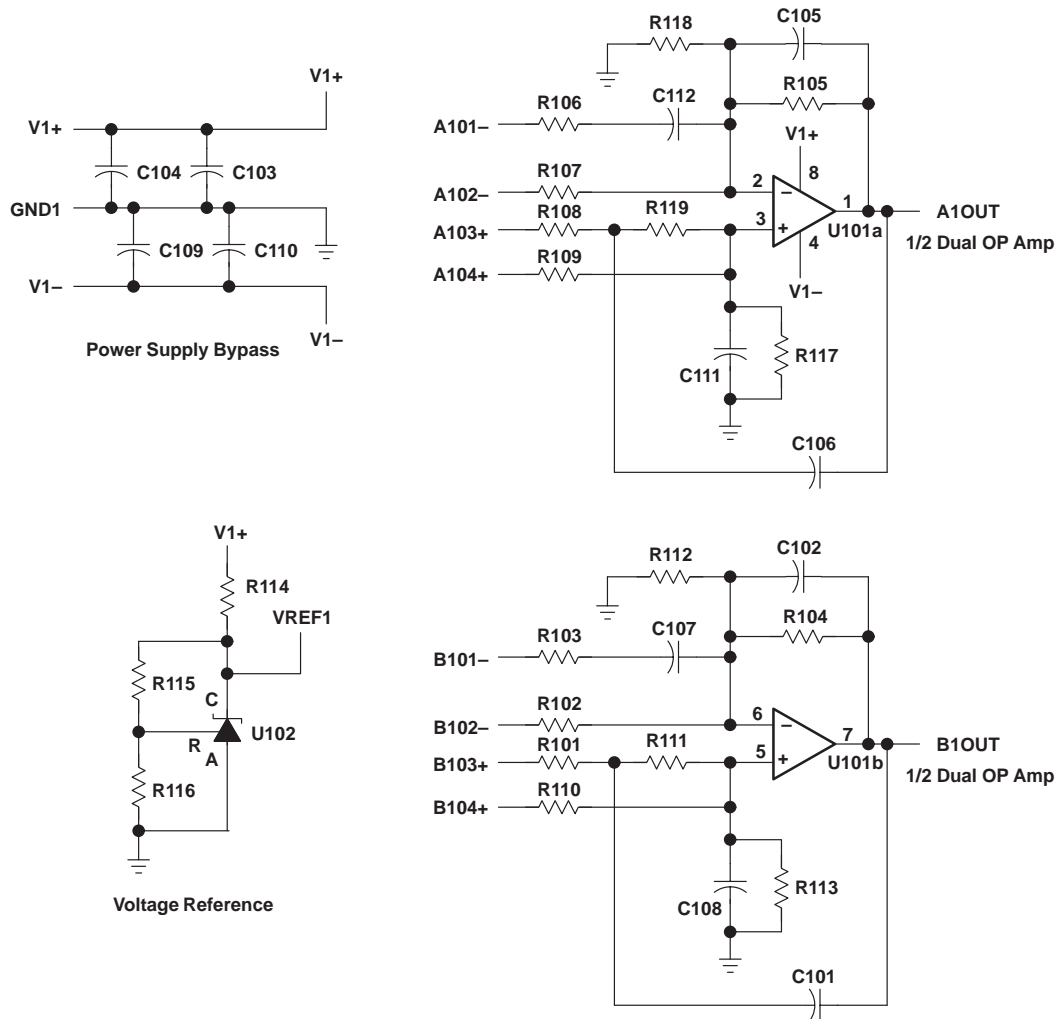
The voltage reference can be either surface mount or through hole. If surface-mount is desired, the TLV431ACDBV5 or TLV431AIDBV5 adjustable shunt regulators can be used. If through hole is desired, then the TLV431ACLP, TLV431AILP, TL431CLP, TL431ACLP, TL431ILP or TL431AILP adjustable shunt regulators can be used. Refer to Texas Instruments' *Power Supply Circuits Data Book* (literature number SLVD002) for details on usage of these shunt regulators.

Each passive component, resistor and capacitor, has a surface-mount 1206 foot print with through holes at 0.2" spacing on the outside of the 1206 pads. Therefore, either surface-mount or through-hole parts can be used.

## 2.2 Area 100 – SOIC

Area 100 uses 1xx reference designators, and is compatible with dual op amps in 8-pin SOIC packages. Most dual op amps are available in this package. This surface-mount package is designated by a D suffix in TI part numbers as in TLV2422CD, TLV2342ID, TLV2252ID, etc. Refer to Figure 2–1 for a schematic.

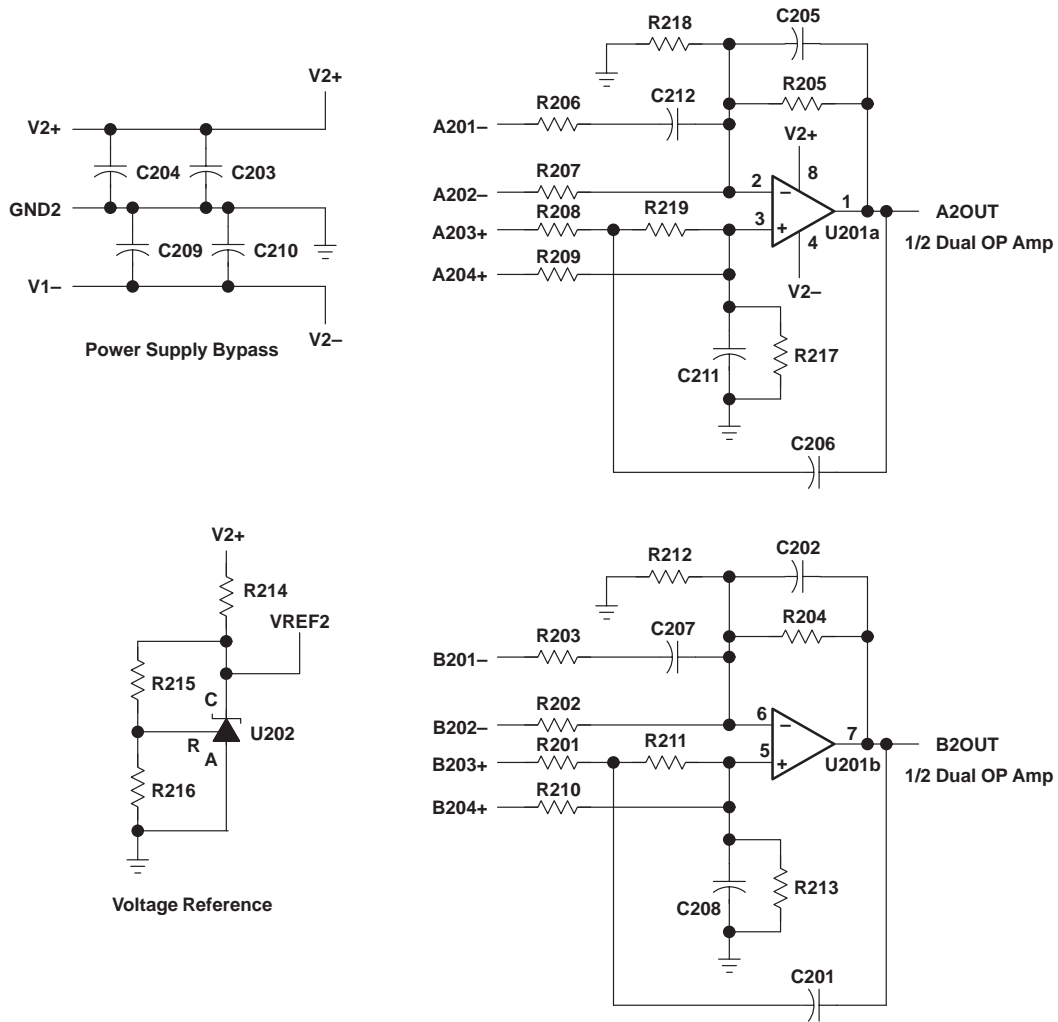
Figure 2–1. Area 100 Schematic – SOIC



### 2.3 Area 200 – TSSOP or MSOP

Area 200 uses 2x reference designators, and is compatible with dual op amps in an 8-pin TSSOP or MSOP package. The TSSOP package is designated by a PW suffix in TI part numbers as in TLV2422CPWLE, TLV2342IPWLE, TLV2252AIPWLE, etc. The MSOP package is designated by a DGK suffix in TI part numbers as in TLV2462CDGK. Refer to Figure 2–2 for a schematic.

Figure 2–2. Area 200 Schematic – TSSOP and MSOP



## 2.4 Area 300 – SOT23-5A

Area 300 uses 3xx reference designators, and is compatible with single op amps in the 5-pin SOT-23 package with the pinout used for the TLV22X1 as shown in Figure 2–3. This surface-mount package is designated by a DBV suffix in TI part numbers as in TLV2211CDBV, TLV2221CDBV, TLV2361CDBV, TLV2231IDBV, etc. Note: other parts like TLV2771CDBV, TLV2711CDBV, TLV2461CDBV, etc., follow different pin-out schemes, which are not compatible with this layout. See Figure 2–4 for a schematic.

Figure 2–3. TLV22X1 Device Pinout

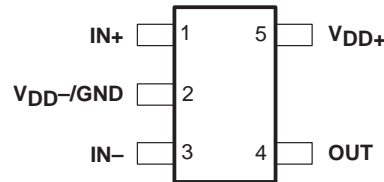
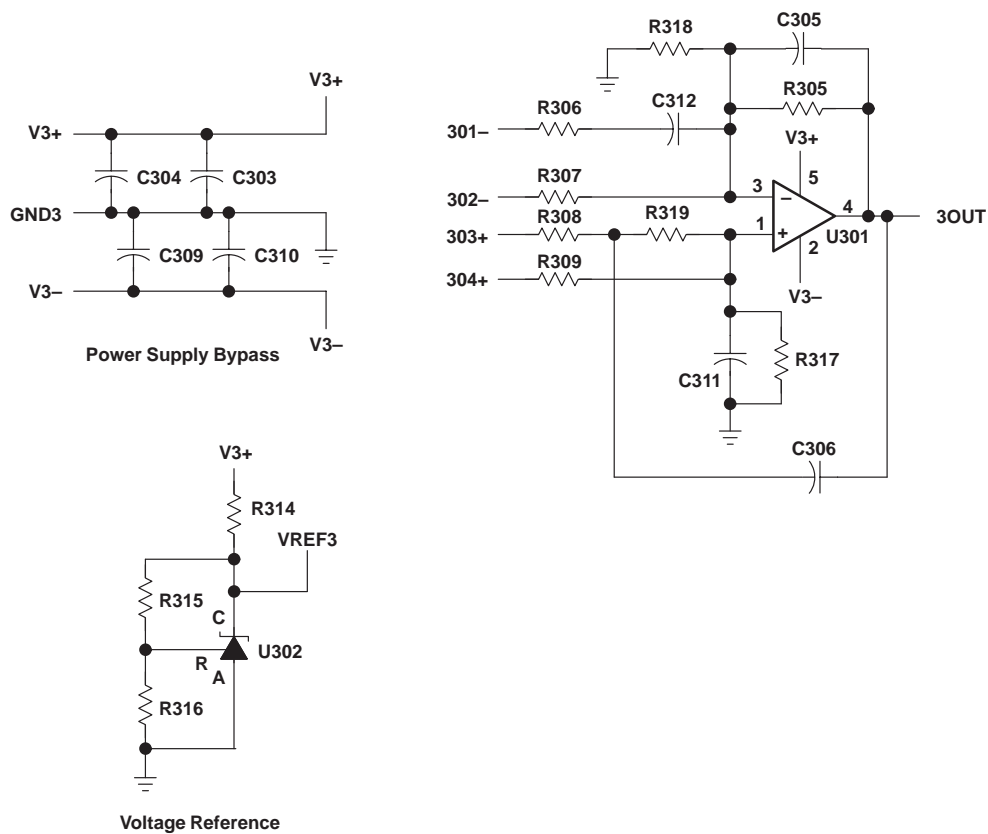


Figure 2–4. Area 300 Schematic – SOT23-5A



## 2.5 Area 400 – SOT23-5B

Area 400 uses 4xx reference designators, and is compatible with single op amps in the 5-pin SOT-23 package with the pinout used for the TLV2271CDBV and TLV2461CDBV as shown in Figure 2–5. This surface-mount package is designated by a DBV suffix in TI part numbers as in TLV2771CDBV and TLV2461CDBV. Note: earlier parts like TLV2221CDBV, TLV2231IDBV, TLV2361CDB, and TLV2711CDBV, etc., follow a different pin-out scheme, which is not compatible with this layout. Refer to Figure 2–6 for a schematic.

Figure 2–5. TLV2771 and TLV2461 Device Pinout

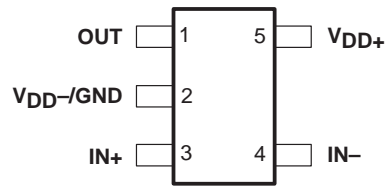
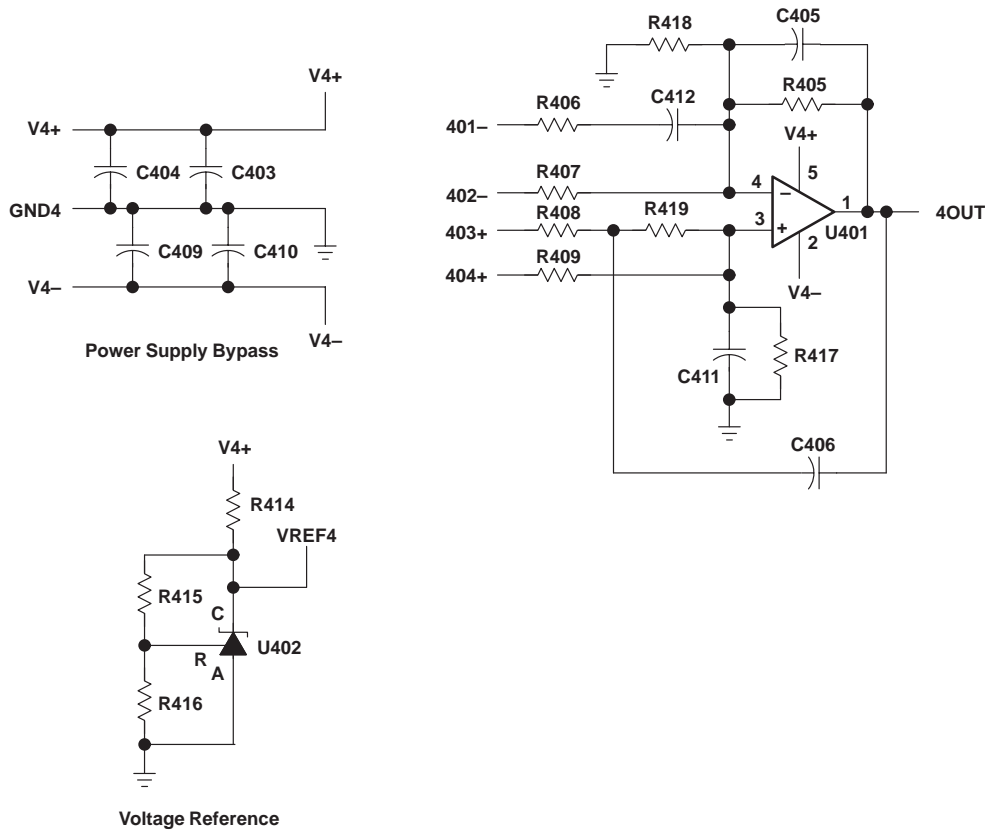


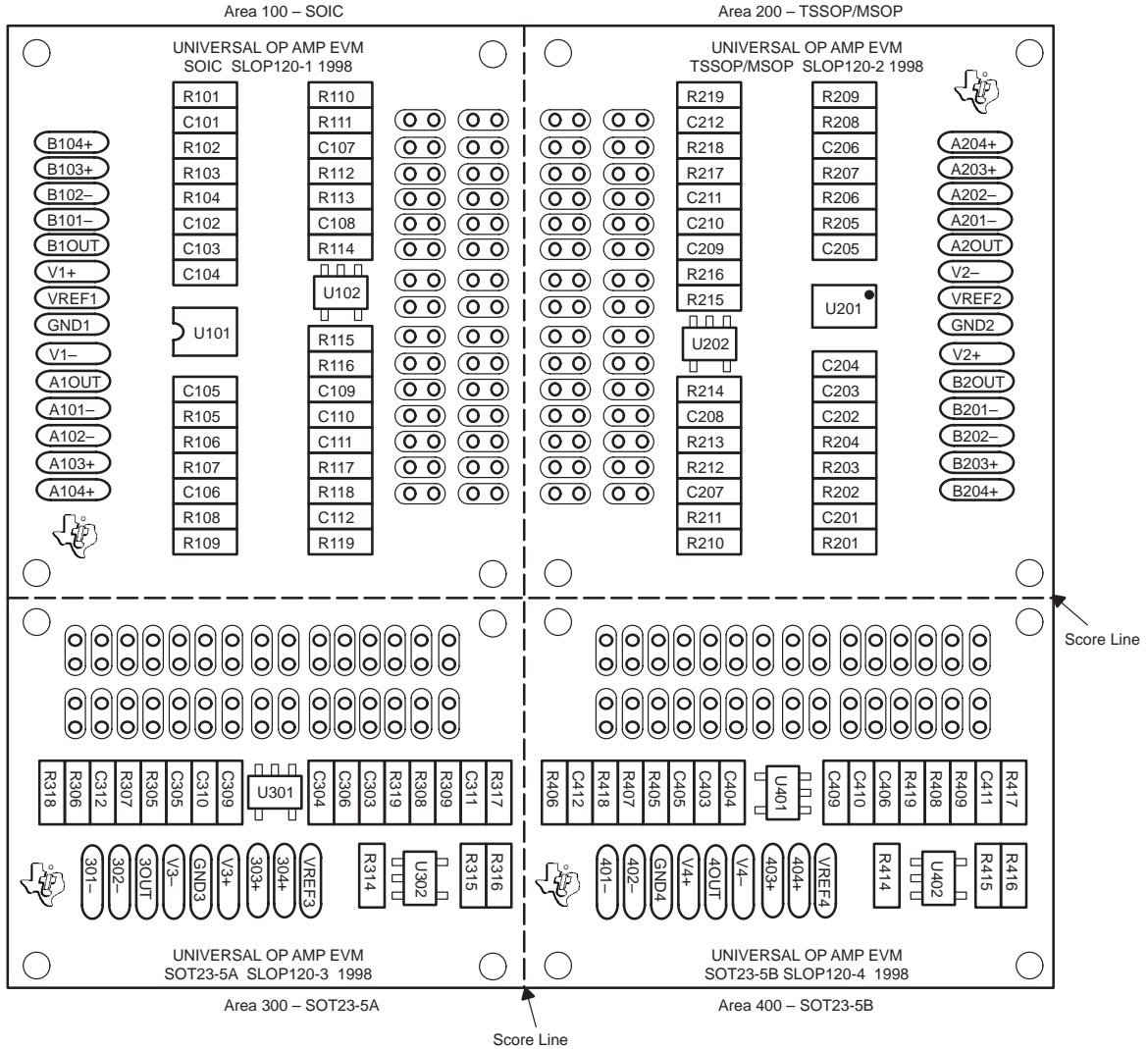
Figure 2–6. Area 400 Schematic – SOT23-5B



## 2.6 Component Placement

Figure 2-7 shows component placement for the EVM board.

Figure 2-7. Universal Operational Amplifier EVM Board Component Placement



## 2.7 Board Layout

Figures 2–8 and 2–9 show the EVM top and bottom board layouts, respectively.

Figure 2–8. Universal Operational Amplifier EVM Board Layout Top

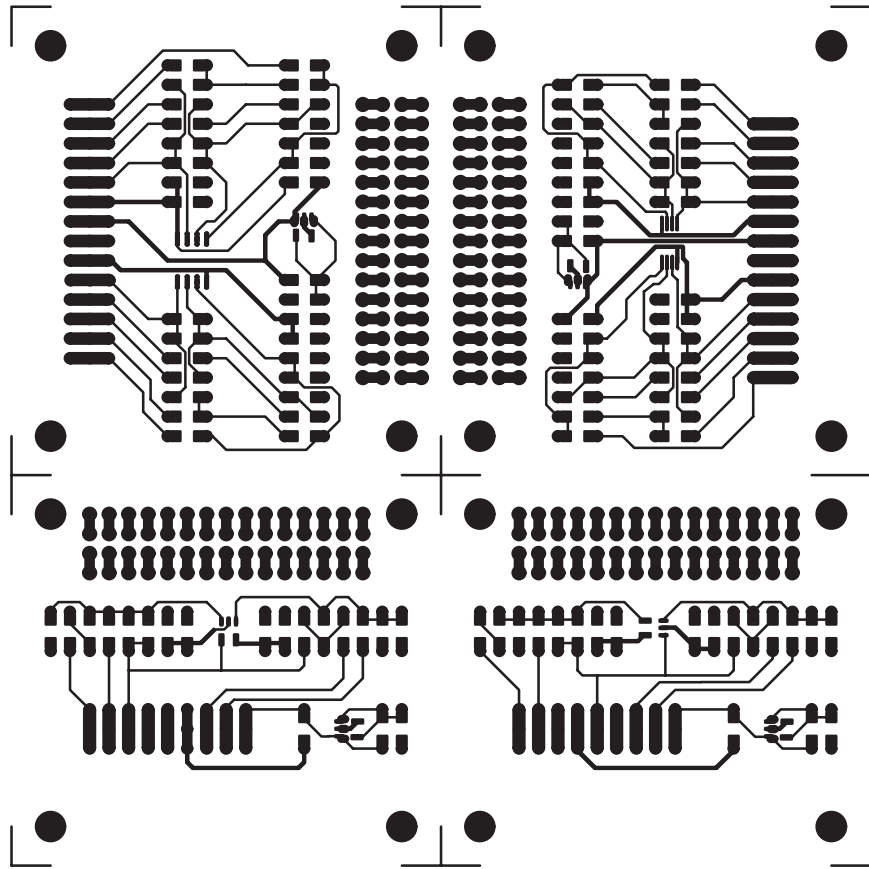
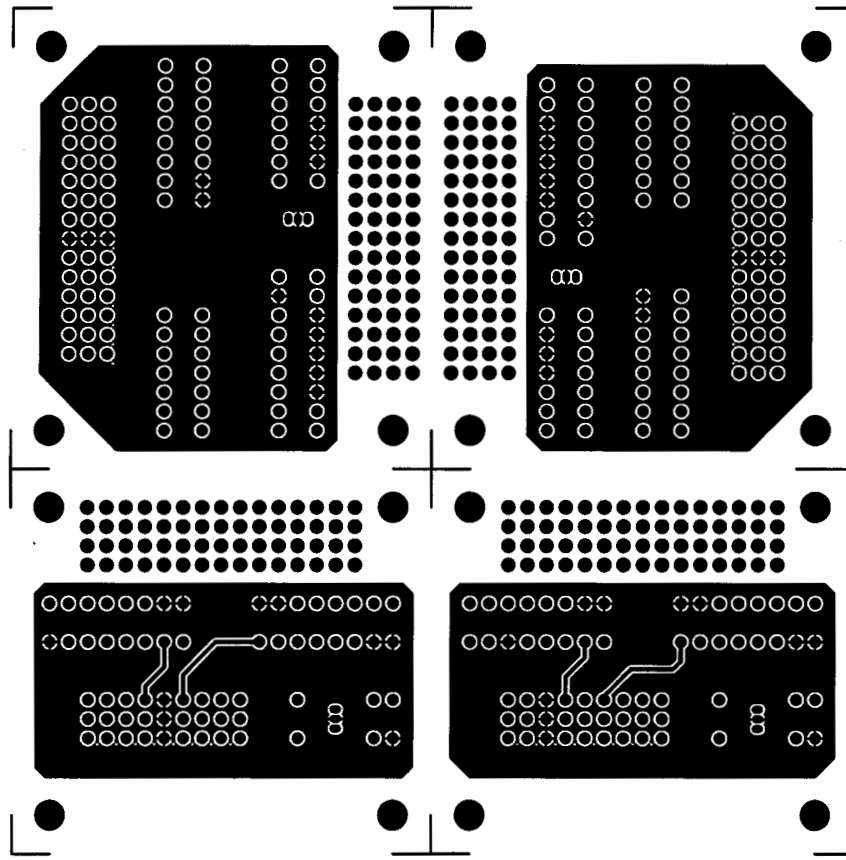




Figure 2–9. Universal Operational Amplifier EVM Board Layout Bottom





# Example Circuits

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This chapter shows and discusses several example circuits that can be constructed using the universal operational amplifier EVM. The circuits are all classic designs that can be found in most operational amplifier design books.

Topic	Page
<b>3.1 Schematic Conventions</b> .....	3-1
<b>3.2 Sallen-Key Low-Pass Filter</b> .....	3-2
<b>3.3 Sallen-Key High-Pass Filter</b> .....	3-3
<b>3.4 Inverting Amplifier</b> .....	3-5
<b>3.5 Noninverting Amplifier</b> .....	3-6
<b>3.6 Two Operational Amplifier Instrumentation Amplifiers</b> .....	3-7
<b>3.7 Differential Amplifier</b> .....	3-9

## 3.1 Schematic Conventions

Figures 3-1 through 3-6 show schematics for a sampling of circuits that can be constructed on the Universal Operational Amplifier EVM. The components that are placed on the board are shown in bold and unused components are blanked out. Jumpers and other changes are noted. These examples are only a few of the many circuits that can be built on the EVM.

### 3.2 Sallen-Key Low-Pass Filter

Figure 3–1 shows area 100 equipped with a dual operational amplifier configured as a second-order Sallen-Key low-pass filter using dual-power supplies.

Basic set up is done by proper choice of resistors R and mR, and capacitors C and nC. The transfer function is:

$$\frac{V_{OUT}}{V_{IN}} = \frac{1}{1 - (f/f_o)^2 + (j/Q)(f/f_o)}$$

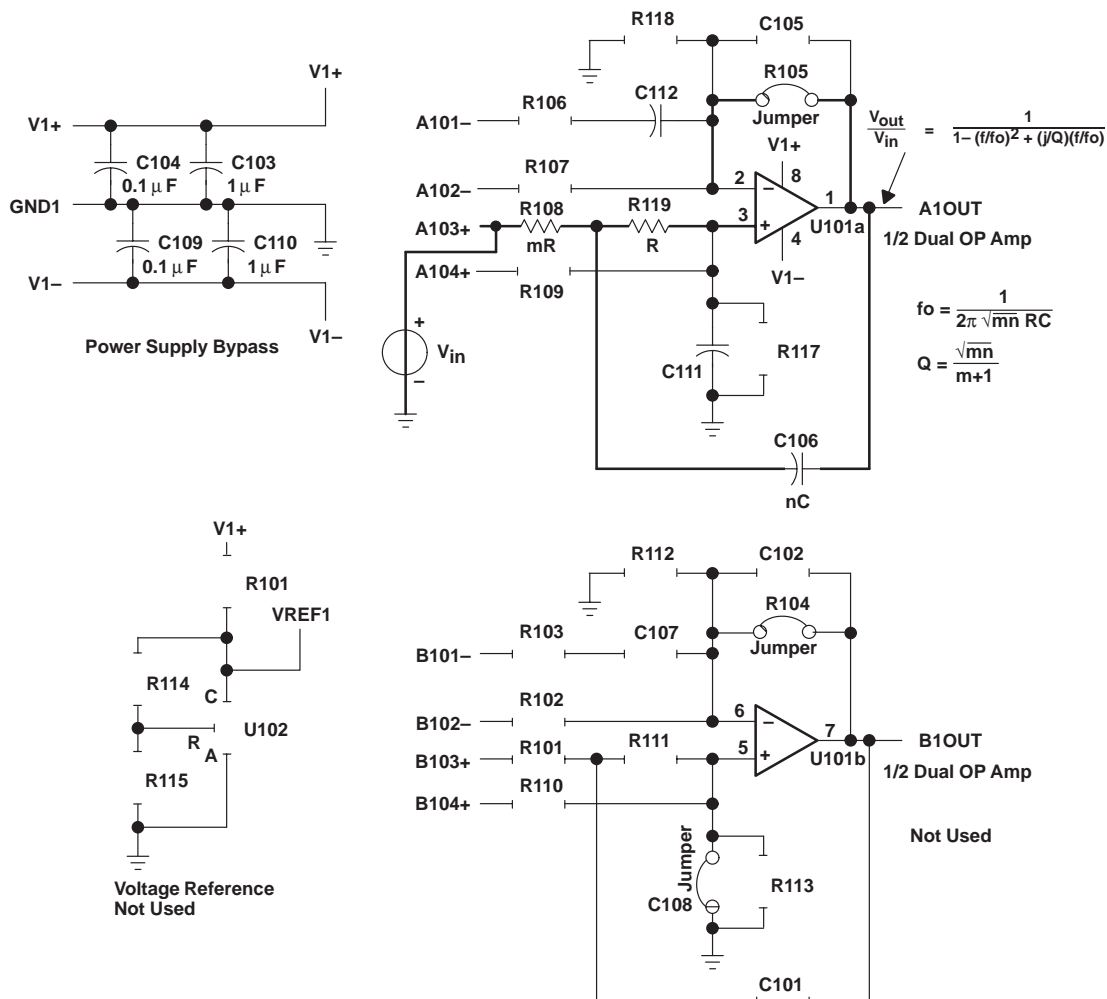
Where:

$$f_o = \frac{1}{2\pi \sqrt{m n} RC}$$

And

$$Q = \frac{\sqrt{m n}}{m + 1}$$

Figure 3–1. Sallen-Key Low-Pass Filter with Dual Supply Using Area 100



### 3.3 Sallen-Key High-Pass Filter

Figure 3–2 shows area 200 equipped with a dual operational amplifier configured as a second-order Sallen-Key high-pass filter using single-supply power input.

Basic setup is done by proper choice of resistors R and mR, and capacitors C and nC. Note that capacitors should be used for components R210 and R211, and a resistor for C201. The transfer function for the circuit as shown is:

$$V_{OUT} = V_{IN} \times \left[ \frac{-(f/f_0)^2}{1 + (j/Q)(f/f_0) - (f/f_0)^2} \right] + VREF2$$

Where:

$$f_0 = \frac{1}{2\pi \sqrt{m n} RC}$$

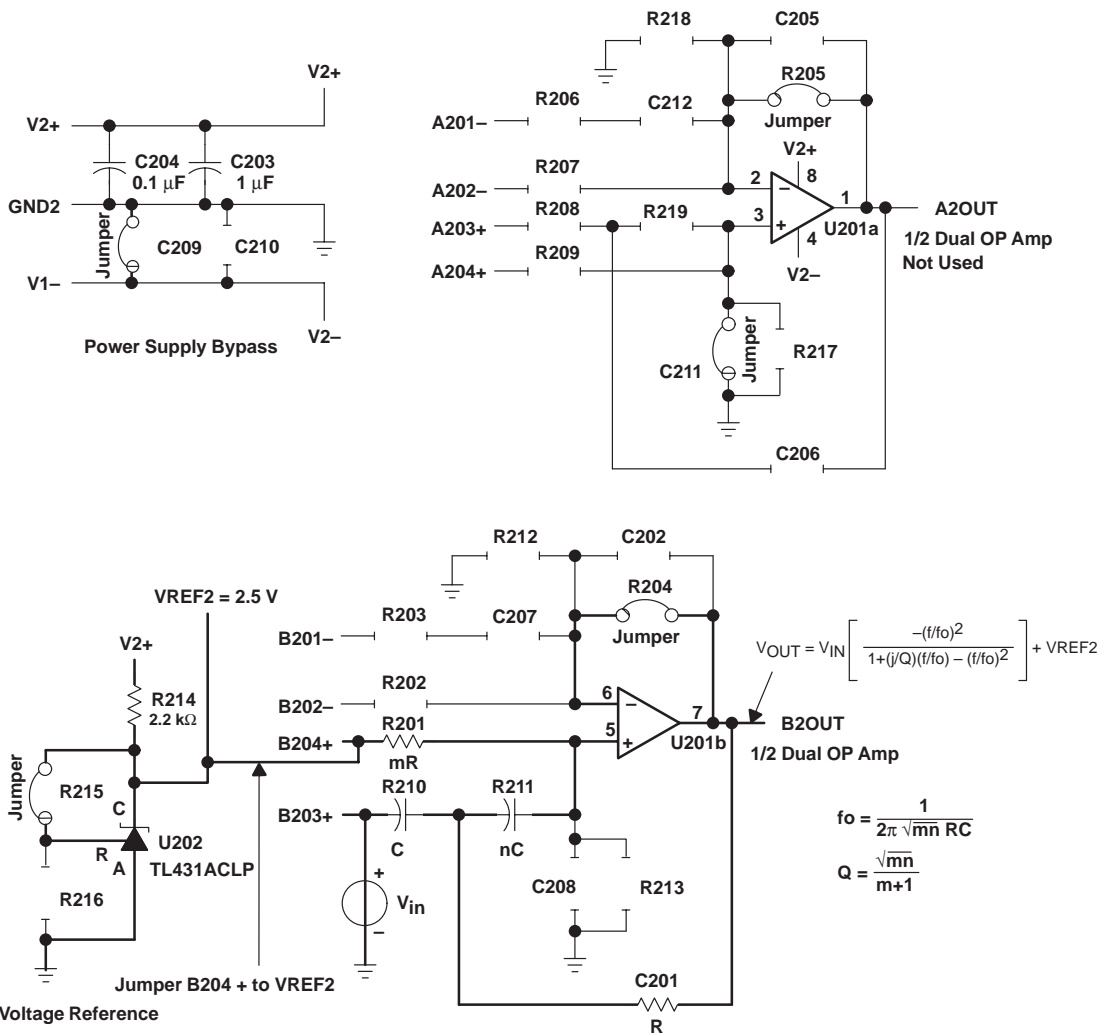
And

$$Q = \frac{\sqrt{m n}}{n + 1}$$

The TL431 adjustable precision shunt regulator, configured as shown, provides a low impedance reference for the circuit at about 1/2 V2+ in a 5 V system. Another option is to adjust resistors R215 and R216 for the desired VREF2 voltage. The formula for calculating VREF2 is:

$$VREF2 = 2.50 \text{ V} \left( \frac{R215 + R216}{R216} \right)$$

Figure 3–2. Sallen-Key High-Pass Filter with Single Supply Using Area 200



### 3.4 Inverting Amplifier

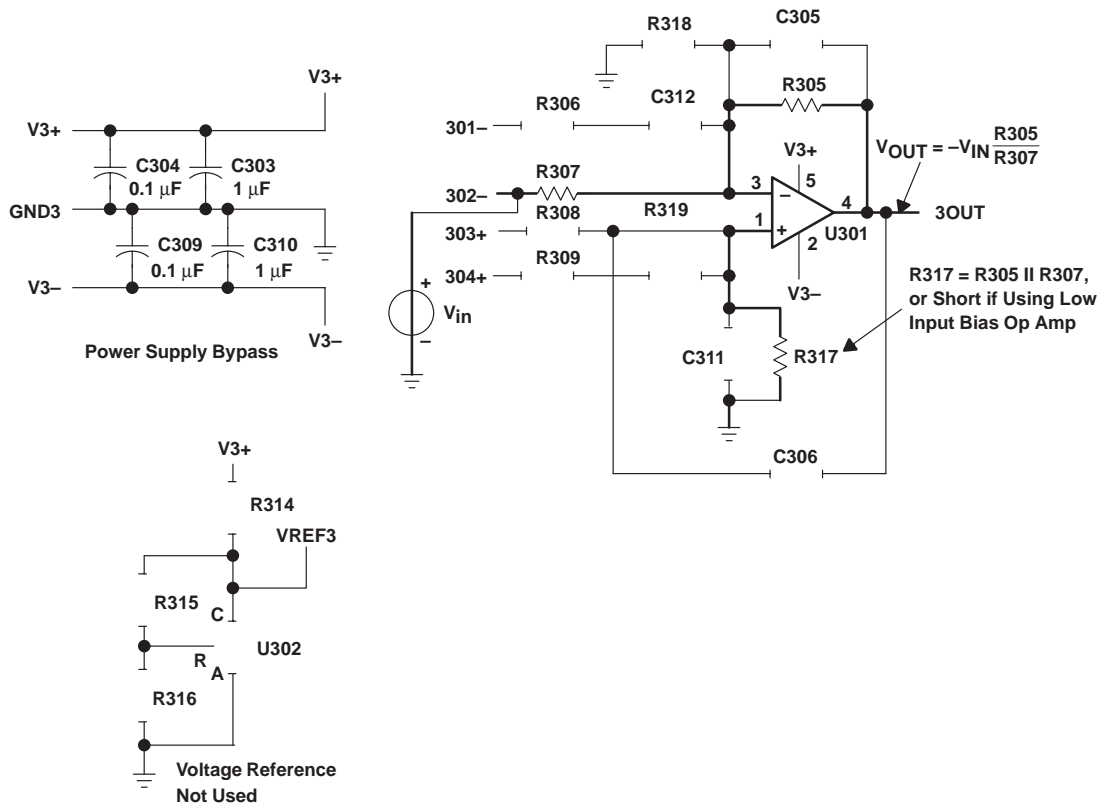
Figure 3–3 shows area 300 equipped with a single operational amplifier configured as an inverting amplifier using dual power supplies. Note the pinout for the operational amplifier in area 300 follows the TLV2211 type pinout.

Basic setup is done by choice of input and feedback resistors. The transfer function for the circuit as shown is:

$$V_{OUT} = -V_{IN} \frac{R_{305}}{R_{307}}$$

To cancel the effects of input bias current, set  $R_{317} = R_{305} \parallel R_{307$ , or use a  $0 \Omega$  jumper for  $R_{317}$  if the operational amplifier is a low input bias operational amplifier.

Figure 3–3. Inverting Amplifier with Dual Supply Using Area 300



### 3.5 Noninverting Amplifier

Figure 3–4 shows area 400 equipped with a single operational amplifier configured as a noninverting amplifier with single supply power input. Note the pinout for the operational amplifier in area 400 follows the TLV2771 type pinout.

Basic setup is done by choice of input and feedback resistors. The transfer function for the circuit as shown is:

$$V_{OUT} = V_{IN} \left( 1 + \frac{R_{405}}{R_{407}} \right) + VREF4$$

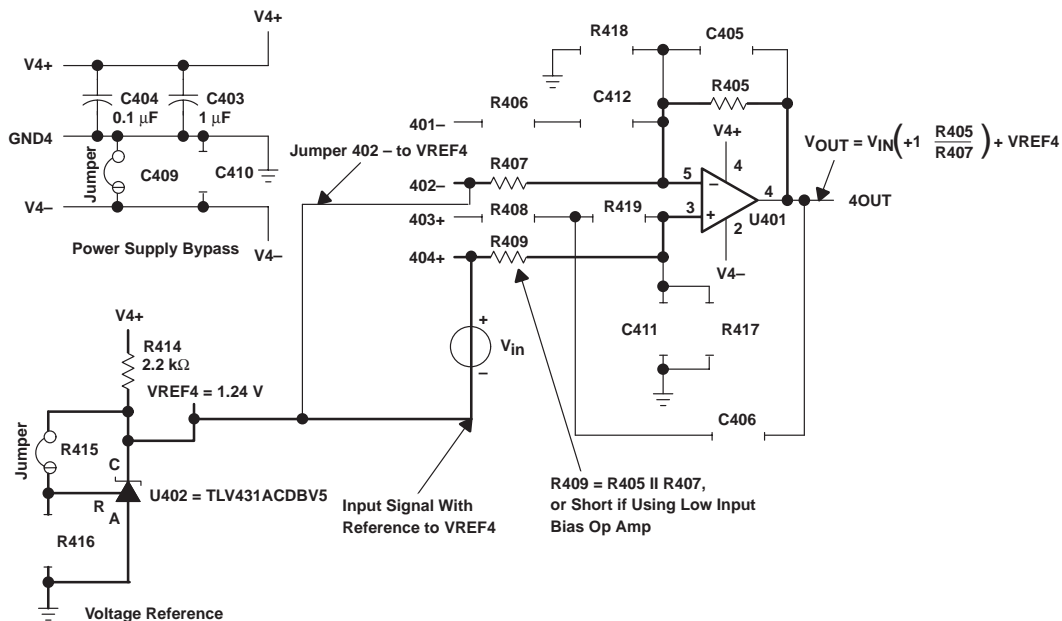
Note that the input signal must be referenced to VREF4.

To cancel the effects of input bias current, set  $R_{409} = R_{405} \parallel R_{407}$ , or use a  $0 \Omega$  jumper for R409 if the operational amplifier is a low input bias operational amplifier.

The TL431 adjustable precision shunt regulator, configured as shown, provides a low impedance reference for the circuit at about 1/2 V4+ in a 3 V system. Another option is to adjust resistors R415 and R416 for the desired VREF4 voltage. The formula for calculating VREF4 is:

$$VREF4 = 1.24 V \left( \frac{R_{415} + R_{416}}{R_{416}} \right)$$

Figure 3–4. Non-Inverting Amplifier with Single Supply Using Area 400





### 3.6 Two Operational Amplifier Instrumentation Amplifier

Figure 3–5 shows area 200 equipped with a dual operational amplifier configured as a two-operational-amplifier instrumentation amplifier using a voltage reference and single power supply.

Basic setup is done by choice of input and feedback resistors. The transfer function for the circuit as shown is:

$$V_{\text{OUT}} = V_{\text{IN}} \left( 1 + \frac{2R_{205}}{R_{207}} + \frac{R_{205}}{R_{206}} \right) + V_{\text{REF2}}$$

Where

$$R_{205} = R_{202}$$

and

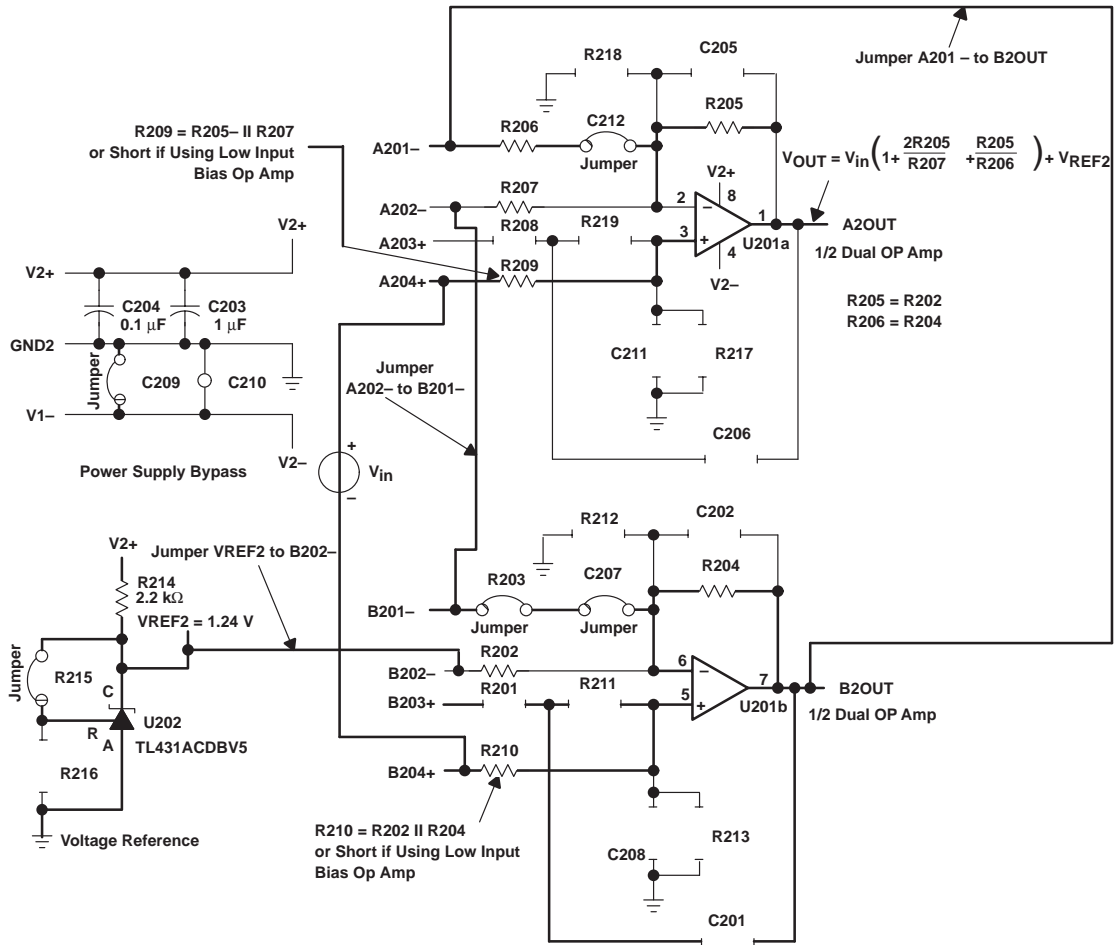
$$R_{206} = R_{204}$$

To cancel the effects of input bias current, set  $R_{209} = R_{205} \parallel R_{207}$  and set  $R_{210} = R_{202} \parallel R_{204}$ , or use a  $0 \Omega$  jumper for  $R_{209}$  and  $R_{210}$  if the operational amplifier is a low input bias operational amplifier.

The TLV431 adjustable precision shunt regulator, configured as shown, provides a low impedance reference for the circuit at about  $1/2 V_{2+}$  in a 3 V system. Another option is to adjust resistors  $R_{215}$  and  $R_{216}$  for the desired  $V_{\text{REF2}}$  voltage. The formula for calculating  $V_{\text{REF2}}$  is:

$$V_{\text{REF2}} = 1.24 \text{ V} \left( \frac{R_{215} + R_{216}}{R_{216}} \right)$$

Figure 3–5. Two Operational Amplifier Instrumentation Amplifier with Single Supply Using Area 200



### 3.7 Differential Amplifier

Figure 3–6 shows area 300 equipped with a single operational amplifier configured as a differential amplifier using a voltage reference and single power supply.

Basic setup is done by choice of input and feedback resistors. The transfer function for the circuit as shown is:

$$V_{OUT} = V_{IN} \left( \frac{R_{305}}{R_{307}} \right) + V_{REF3}$$

Where

$$\frac{R_{305}}{R_{307}} = \frac{R_{309}}{R_{308}}$$

The TLV431 adjustable precision shunt regulator, configured as shown, provides a low impedance reference for the circuit at about 1/2 V3+ in a 3 V system. Another option is to adjust resistors R315 and R316 for the desired VREF3 voltage. The formula for calculating VREF3 is:

$$V_{REF3} = 1.24 \text{ V} \left( \frac{R_{315} + R_{316}}{R_{316}} \right)$$

Figure 3–6. Single Operational Amplifier Differential Amplifier with Single Supply Using Area 300

