AN-1606 551012875, 551012922 Universal Op Amp Evaluation Boards (SOT-23 and SC-70)

1 Overview

The 551012875 and 551012922 Universal Evaluation Boards are designed to aid in the evaluation and testing of Texas Instruments low voltage/low power and some precision operational amplifiers. These boards will accommodate op amps that are assembled in a 6-Pin or 5-Pin SOT-23 and SC-70 package, regardless of the pin orientation.

This board is designed to use one or two amplifiers. Many different circuits can be made such as inverting, non-inverting, and differential-IN-differential-OUT amplifiers and low-pass, high-pass, band-pass, band-reject, or notch second-order filters. The amplifiers can be powered with single or dual supplies. These circuits can be configured without any modifications to the board; all that is necessary is to select the correct resistors and capacitors. The other optional components can be left open or shorted depending on the configuration desired.

These universal evaluation boards are designed as two-layer boards; the top side of each is designed for op amps with a pinout as shown in Figure 1.

The bottom side of each board is designed for op amps with the pinout shown in Figure 2. The board has been manufactured with vias connecting the equivalent pins of the top and bottom amplifiers. For example, Pin 1 of IC_{1A} is connected to Pin 3 of IC_{2A}. Similarly all other equivalent pins of the top and bottom amplifiers are connected. This allows for an efficient use of one board to test two amplifiers of different package types while keeping the same components on the board; just make sure that only one amplifier is soldered to the same pads.

Circuit performance of this evaluation board will be comparable to final production designs. Use this evaluation board as a guide for general layout and a tool to aid in device testing and characterization.

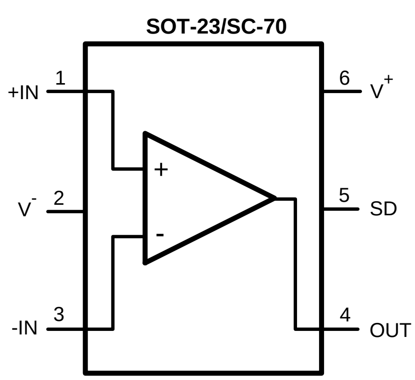


Figure 1. Connection Diagram for IC_{1A} and IC_{1B}

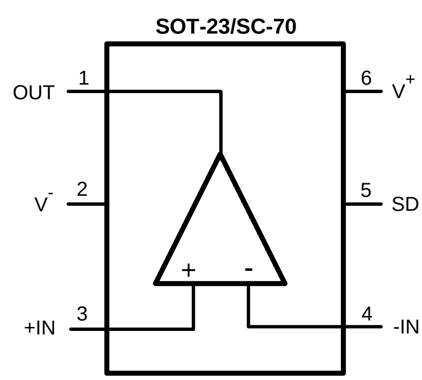


Figure 2. Connection Diagram for IC_{2A} and IC_{2B}

2 Hardware Setup

2.1 Component Notation

The pins of the footprint for IC_{1A} are connected to the equivalent pins for the footprint of IC_{2A} and the same is true for IC_{1B} and IC_{2B} Therefore, this application report will refer to the amplifier in IC_{1A} or IC_{2A} as Amp A and the amplifier in IC_{1B} or IC_{2B} as Amp B. The subscript of the PCB component refers to the specific amplifier; for example, R_{4A} is used for Amp A and R_{4B} for Amp B. In this document, components will be referred to, as an example, C_3. If using Amp A this refers to component C_{3A}, if using Amp B this refers to component C_{3B}.

In some circuits, a resistor will be installed where the PCB is labeled for a capacitor or a capacitor will be installed where a resistor is labeled. For example, C_{R6} indicates that a capacitor should be in the R_6 position. R_{C5} means that a resistor will be installed in the C_5 position.

2.2 Power

Power is applied to the points labeled V^-, GND, and V^+. If a single supply is used, then V^- should be connected to GND. A virtual ground, halfway between the positive supply voltage and ground, is the reference point for the input and output voltages. The output voltage swings above and below this virtual ground. Single-supply operation requires the generation of this virtual ground, usually at a voltage equal to $V^+/2$. The circuit in Figure 3 can be used to generate $V^+/2$; R_1 and R_2 should be of equal values. This junction along with capacitor C_1 will form a low-pass filter used to eliminate conducted noise or transients on the positive supply rail.

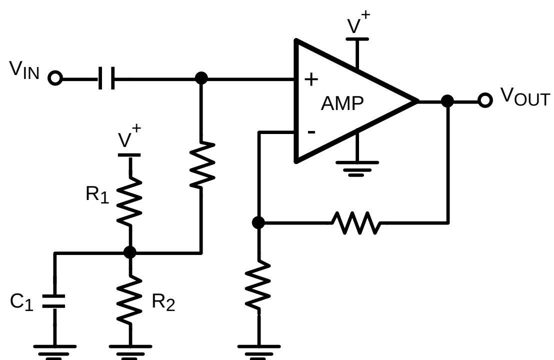


Figure 3. Single Supply Virtual Ground

2.3 Op Amp

Solder an op amp to either the IC_{1A} or IC_{2A} position. If building a circuit requiring two op amps, solder an additional op amp to either IC_{1B} or IC_{2B}. The corresponding pinout is shown on each side of the PCB.

2.4 Bypassing

Install the following capacitors:

C_{6A}, C_{9A}, C_{6B}, C_{9B}: 0.1 µF

C_{7A}, C_{8A}, C_{7B}, C_{8B}: 1 µF

2.5 Shutdown

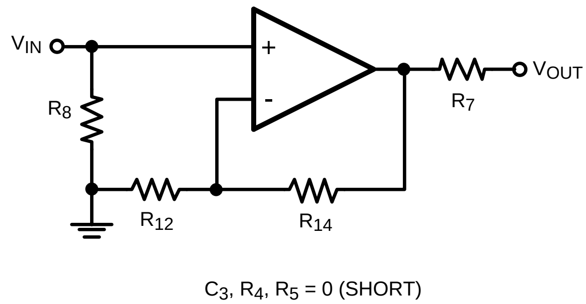
To use the shutdown feature of the amplifier in either the SOT-23 or the SC-70 package, install a resistor at R_{15} and an optional capacitor at C_{11}. The shutdown voltage is applied at S/D-A or S/D-B depending on the package of the amplifier being used.

2.6 Input and Output

SMA connectors are used for the input and output of signals. They are located on the edges of the PCB.

3 Circuit Configurations

3.1 Non-Inverting Amplifier



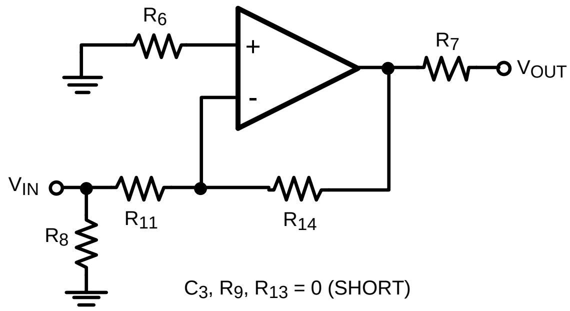
C_3	Short
R_4	Short
R_5	Short
R_8	Input Termination
R_7	Output series resistance (used for matching transmission lines or isolation)
R_{14}	Gain Resistor
R_{12}	Gain Resistor

Figure 4. Non-Inverting Amplifier

Where:

$$\frac{V_{OUT}}{V_{IN}} = 1 + \frac{R_{14}}{R_{12}} \tag{1}$$

3.2 Inverting Amplifier



C_3	Short
R_9	Short
R_{13}	Short
R_8	Input Termination
R_7	Output series resistance (used for matching transmission lines or isolation)
R_{14}	Gain Resistor
R_{11}	Gain Resistor

Figure 5. Inverting Amplifier

Where:

$$\frac{V_{OUT}}{V_{IN}} = -\frac{R_{14}}{R_{11}} \quad (2)$$

3.3 Register Calculations

Input Impedance: Set R_T to the desired input impedance. Calculate R_8 where:

$$R_8 = \frac{R_{11} \times R_T}{R_{11} - R_T} \quad (3)$$

To cancel the input bias current set R_6 to the value calculated with the following formula:

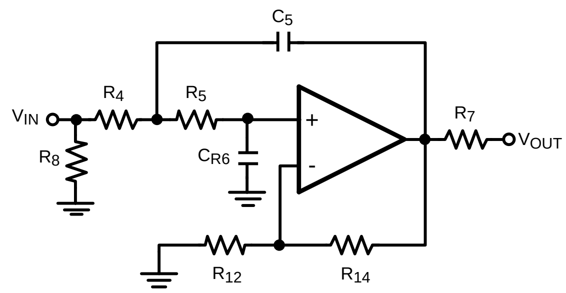
$$R_6 = \frac{R_{11} \times R_{14}}{R_{11} - R_{14}} \quad (4)$$

3.4 Active Filter Applications

Both Sallen-Key and Multiple Feedback filters can be built on this PCB. To design a filter, use the WEBENCH™ tool at www.ti.com. Performance at high frequencies is limited to the gain bandwidth product of the amplifier, but within this frequency range, these active filters can achieve very good accuracy, if low-tolerance resistors and capacitor are used.

3.5 Sallen-Key Low-Pass Filter

C_3	Short
R_{13}	Short
R_7	Output series resistance (used for matching transmission lines or isolation)
R_8	Input Termination
Set the following as determined using WEBENCH: R_4, R_5, C_{R6}, R_{14}, R_{12}	



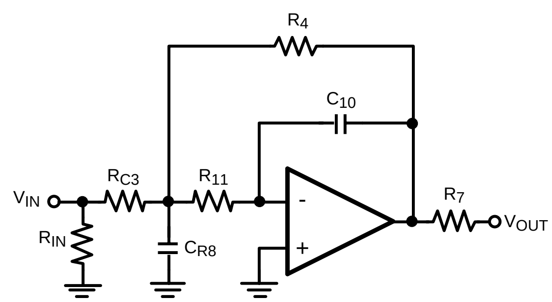
C_3, R_{13} = 0 (SHORT)

Figure 6. Sallen-Key Low-Pass Filter

3.6 Multiple Feedback Low-Pass Filter

Note: If needed, an input termination resistor will need to be soldered on to the SMA connector between the signal pin and the ground pin.

R_6	Short
R_{13}	Short
R_9	Short
C_5	Short
R_7	Output series resistance (used for matching transmission lines or isolation)
Set the following as determined using WEBENCH: R_{C3}, C_{R8}, R_4, R_{11}, C_{10}	



R_6, R_{13}, R_9, C_5 = 0 (SHORT)

Figure 7. Multiple Feedback Low-Pass Filter

3.7 Sallen-Key High-Pass Filter

C_3	Short
R_{13}	Short
R_{14}	Short
R_7	Output series resistance (used for matching transmission lines or isolation)
R_8	Input Termination
Set as determined using WEBENCH: C_{R4}, C_{R5}, R_{C5}, R_6	

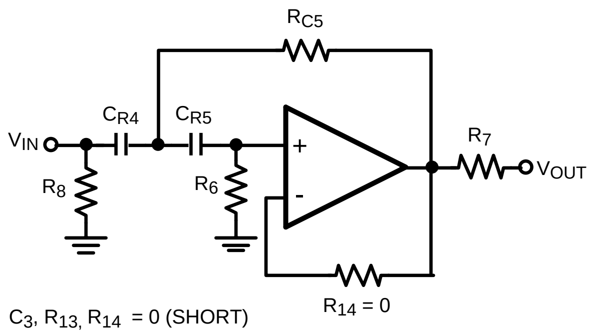


Figure 8. Sallen-Key High-Pass Filter

3.8 Multiple Feedback High-Pass Filter

Note: If needed, an input termination resistor will need to be soldered on to the SMA connector between the signal pin and the ground pin.

R_9	Short
R_4	Short
R_7	Output series resistance (used for matching transmission lines or isolation)
Set the following as determined using WEBENCH: C_3, R_8, C_5, C_{R11}, R_{14}	

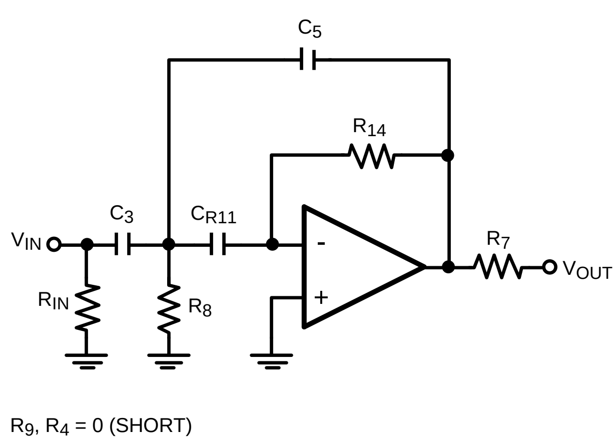


Figure 9. Multiple Feedback High-Pass Filter

3.9 *Sallen-Key Band-Pass Filter*

C_3	Short
R_{13}	Short
R_7	Output series resistance (used for matching transmission lines or isolation)
R_8	Input Termination
Set as determined using WEBENCH: R_4, C_4, C_{R5}, R_6, R_{C5}, R_{14}, R_{12}	

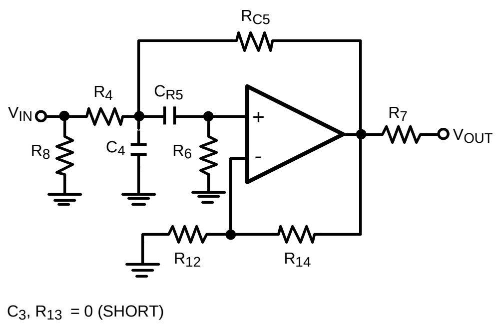


Figure 10. Sallen-Key Band-Pass Filter

3.10 *Multiple Feedback Band-Pass Filter*

Note: If needed, an input termination resistor will need to be soldered on to the SMA connector between the signal pin and the ground pin.

R_6	Short
R_{13}	Short
R_9	Short
R_4	Short
R_7	Output series resistance (used for matching transmission lines or isolation)
Set the following as determined using WEBENCH: R_{C3}, R_8, C_5, C_{R11}, R_{14}	

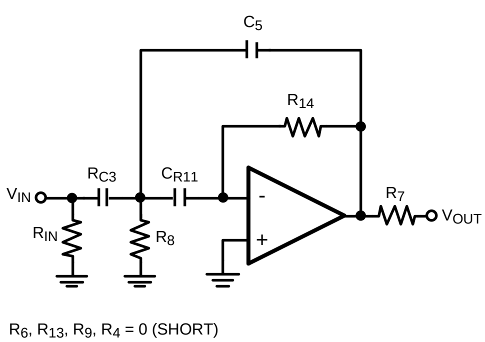


Figure 11. Multiple Feedback Band-Pass Filter

4 Applications Using Two Amplifiers

4.1 Two-Amplifier Filters

Filters using two amplifiers can be built by connecting the output of Amp A to the input of Amp B.

4.2 Single-Ended to Differential Conversion

The circuit in Figure 12 will convert a single-ended signal to a differential signal. This is done by using the combination of an inverting amplifier and a non-inverting amplifier. Each amplifier generates output signals of equal magnitude but of opposite polarity. This topology is useful in applications where the signal source is single-ended, but the ADC requires a differential input. The board will need to be modified by connecting Input A to Input B with a jumper wire.

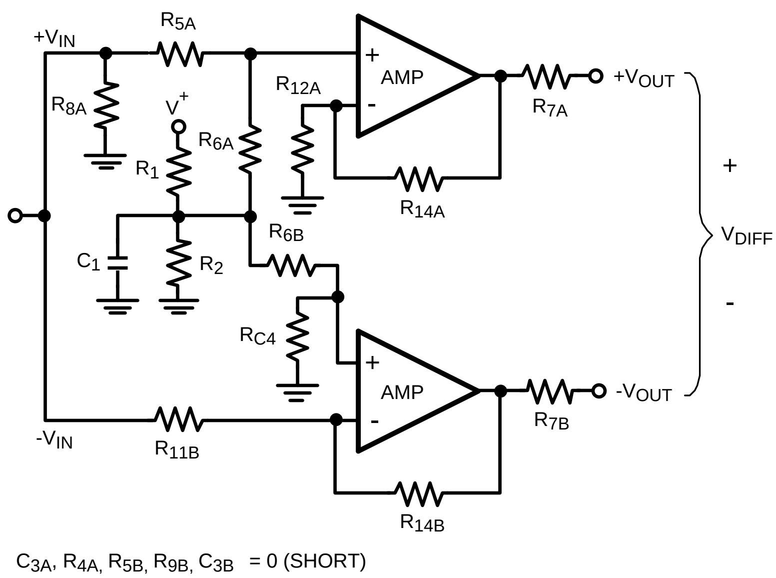


Figure 12. Single-Ended to Differential Conversion

4.3 Differential Input, Differential Output, Non-Inverting

Combining two non-inverting amplifiers with a common feedback network, as shown in Figure 13, forms a non-inverting amplifier with a differential input and a differential output. Through the inherent cancellation of the two op amp common-mode error signals this configuration fully exploits the noise reduction benefits of CMRR. In addition the output voltage swing is doubled and depending on the op amp used, the bandwidth and slew rate may also be increased, while maintaining the original gain bandwidth specification.

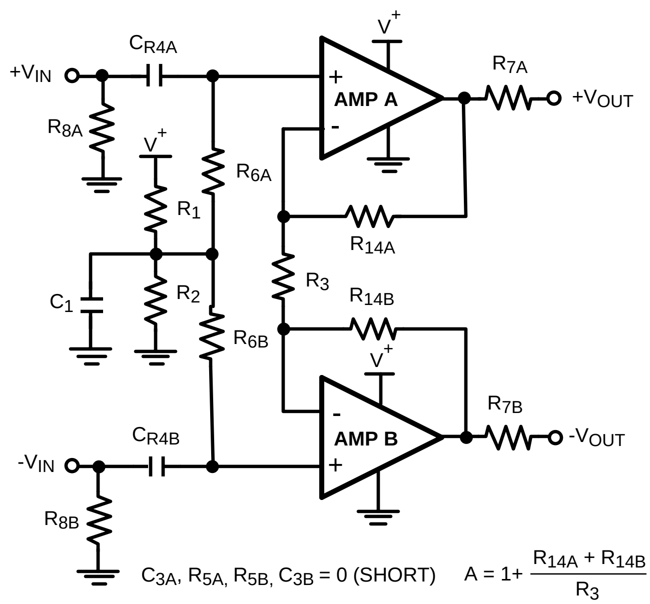
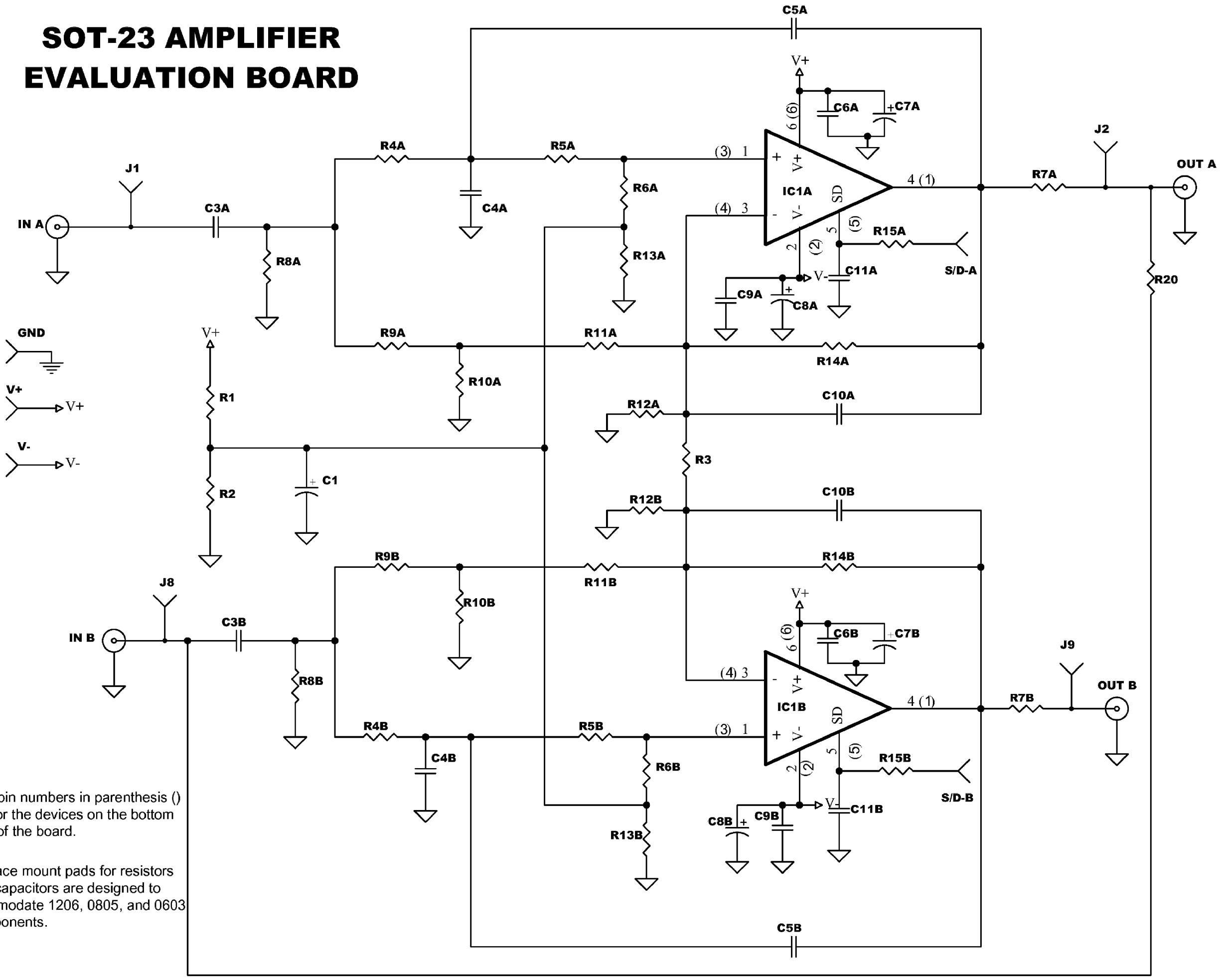


Figure 13. Differential Input, Differential Output, Non-Inverting

5 551012875-001 Schematic



Note: The pin numbers in parenthesis () are for the devices on the bottom side of the board.

Note: Surface mount pads for resistors and capacitors are designed to accomodate 1206, 0805, and 0603 components.

Figure 14. 551012875-001 Schematic

6 551012875-001 Layouts

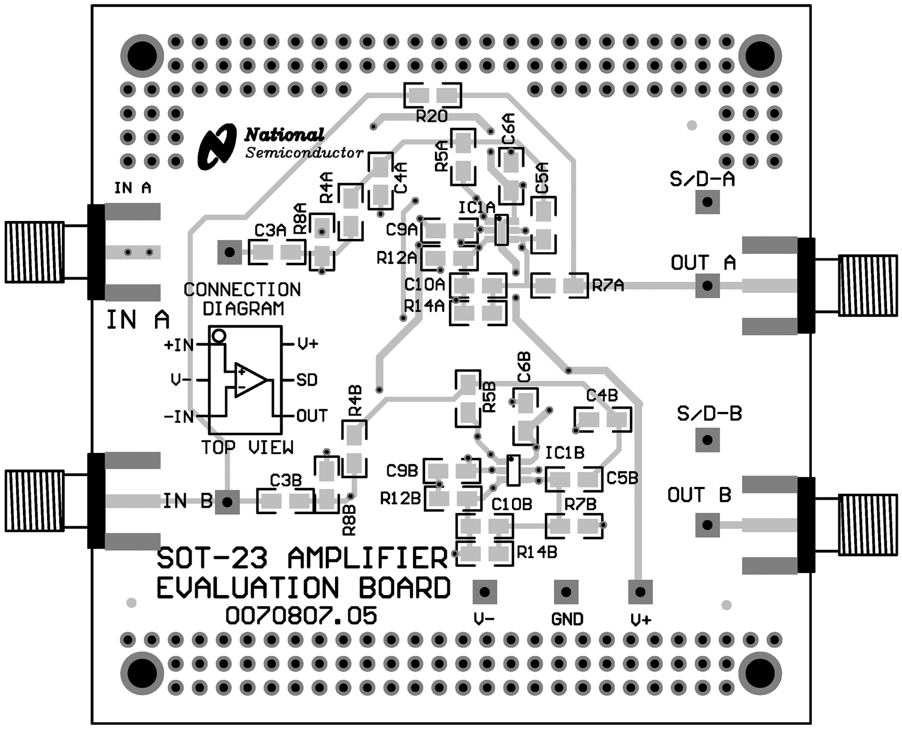


Figure 15. 551012875-001 Top Layout

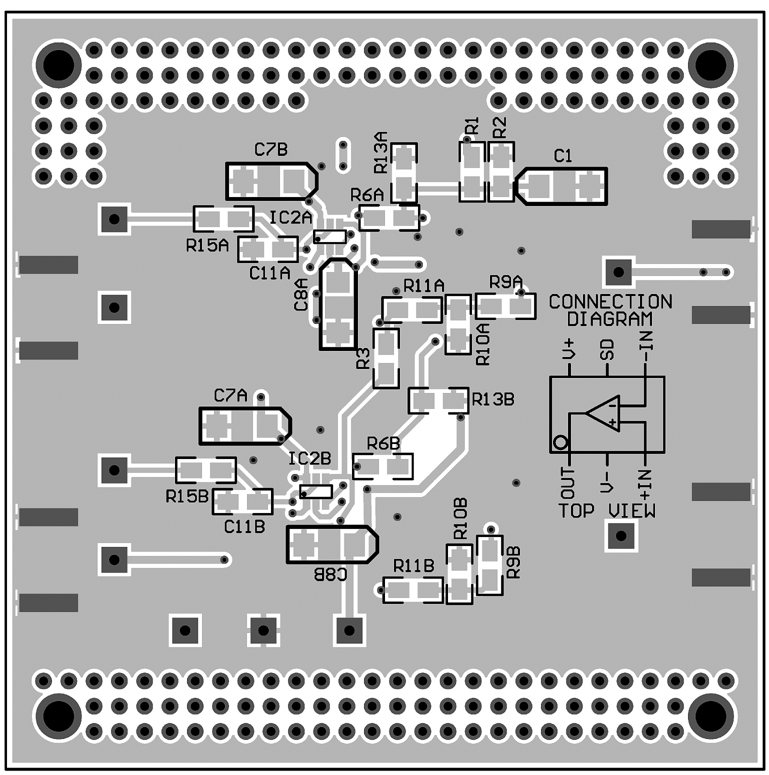


Figure 16. 551012875-001 Bottom Layout

7 551012922-001 Schematic

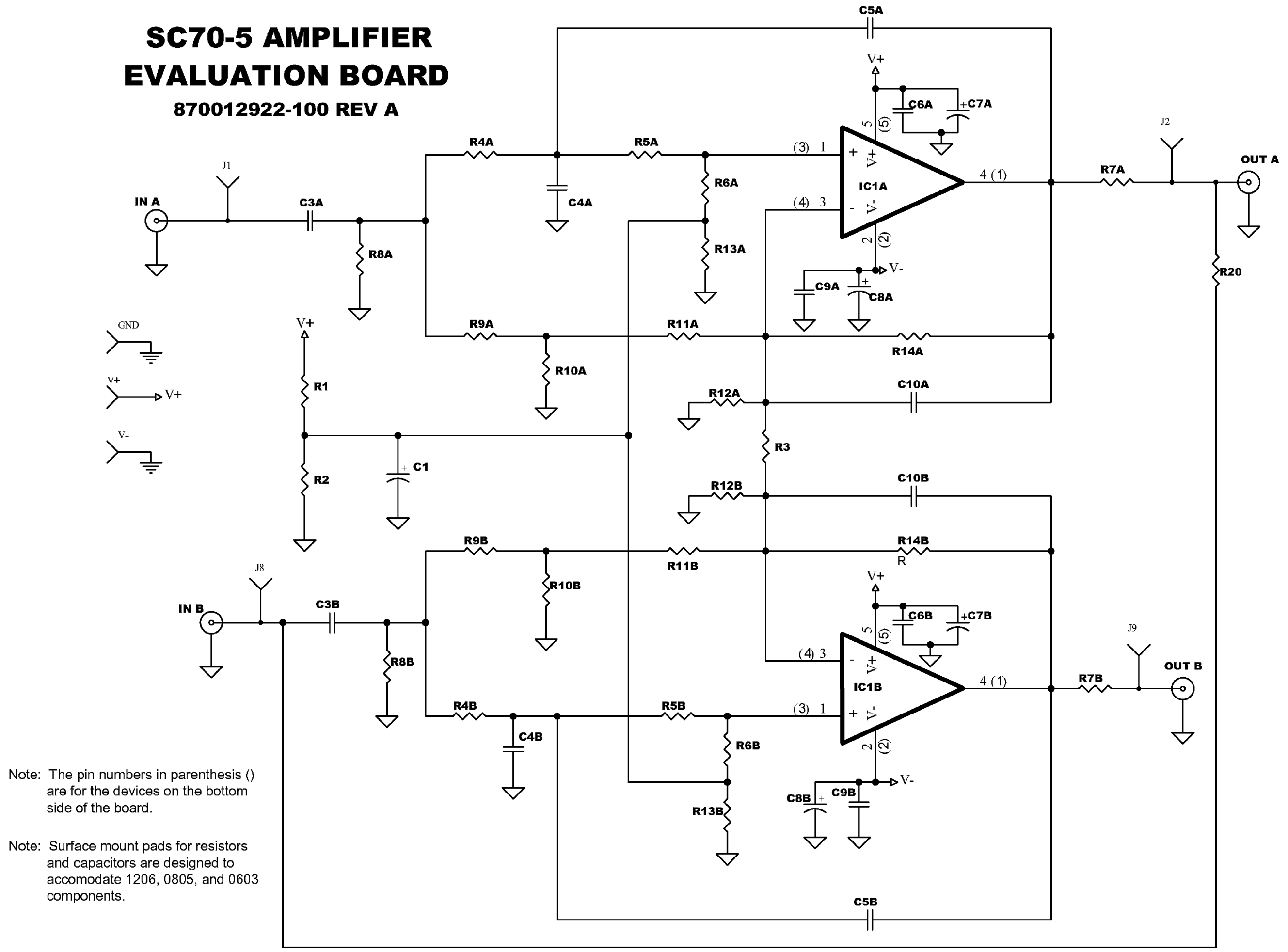


Figure 17. 551012922-001 Schematic

8 551012922-001 Layouts

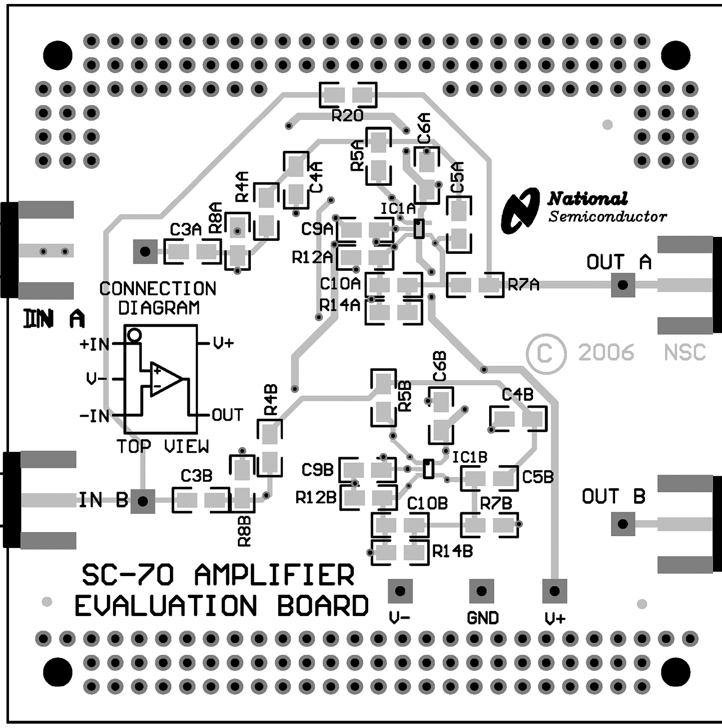


Figure 18. 551012922-001 Top Layout

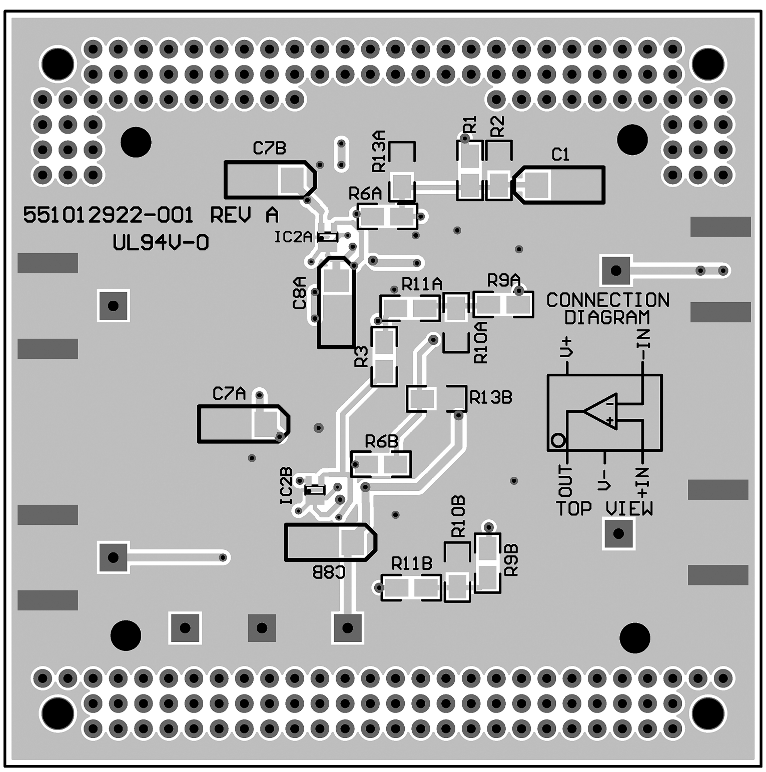


Figure 19. 551012922-001 Bottom Layout

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