How to Assemble Inverting Amplifier Circuits

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Introduction

This document will instruct Electrical Engineering students with some knowledge of circuit analysis how to assemble inverting amplifier circuits, using the MC1458 opamp and resistors as discrete components. It assumes the student knows how to use a voltmeter to take voltage measurements, the basics of circuit assembly with a breadboard, the terminal characteristics of ideal operational amplifiers, and how to use a power supply. This document will ***not*** discuss the inner workings of an opamp.

Equipment Needed

MC1458P1 opamp by Texas Instruments

2 Power Supplies (one dual)

1 1kΩ resistor

2 10kΩ resistors

1 100kΩ resistor

Voltmeter

Wires, 16 gauge with bare ends, unferruled

Steps

Notice: If available, use an ESD strap and a suitable ESD workbench to avoid damaging components with electrostatic discharge (ESD).

1. Place the MC1458 IC chip on the breadboard, pressing firmly. Note the following connections coming from the MC1458 IC chip as shown in figure 1.

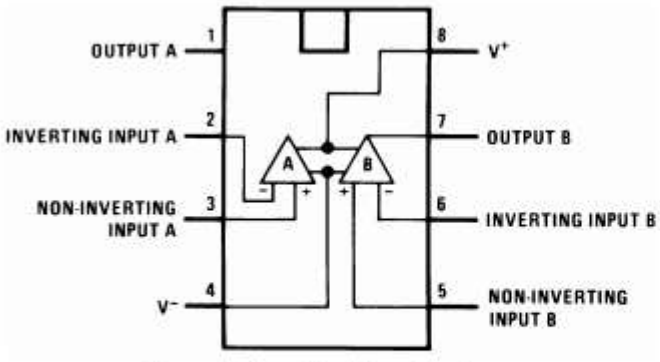

Figure 2. Dual-In-Line Package (Top View) See Package Number D (R-PDSO-G8) or P (R-PDIP-T8)

Figure 1 MC1458P1 by TI (a) pin layout (b) external view

Source: http://www.ti.com/lit/ds/symlink/lm1458.pdf

Refer to figure 2 for reference connections for the inverting amplifier you will construct.

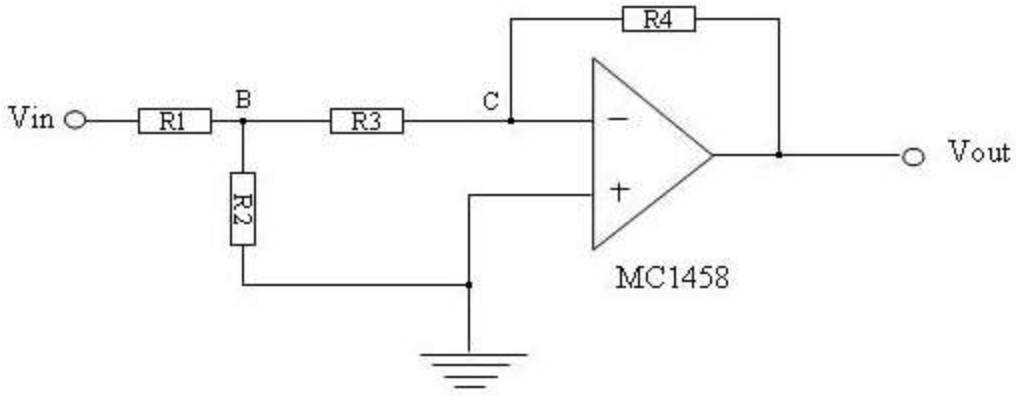

Figure 2 Circuit Diagram: R1 = 10 kΩ, R2 = 100 Ω, R3 = 1k Ω, R4 = 10 kΩ

2. Place a wire from the inverting input (pin 2) of the op amp to the R3 (1 kΩ) resistor.
3. Place a wire from the R3 resistor to the R1 (10 kΩ) resistor, leaving a space to connect-in the R2 resistor.

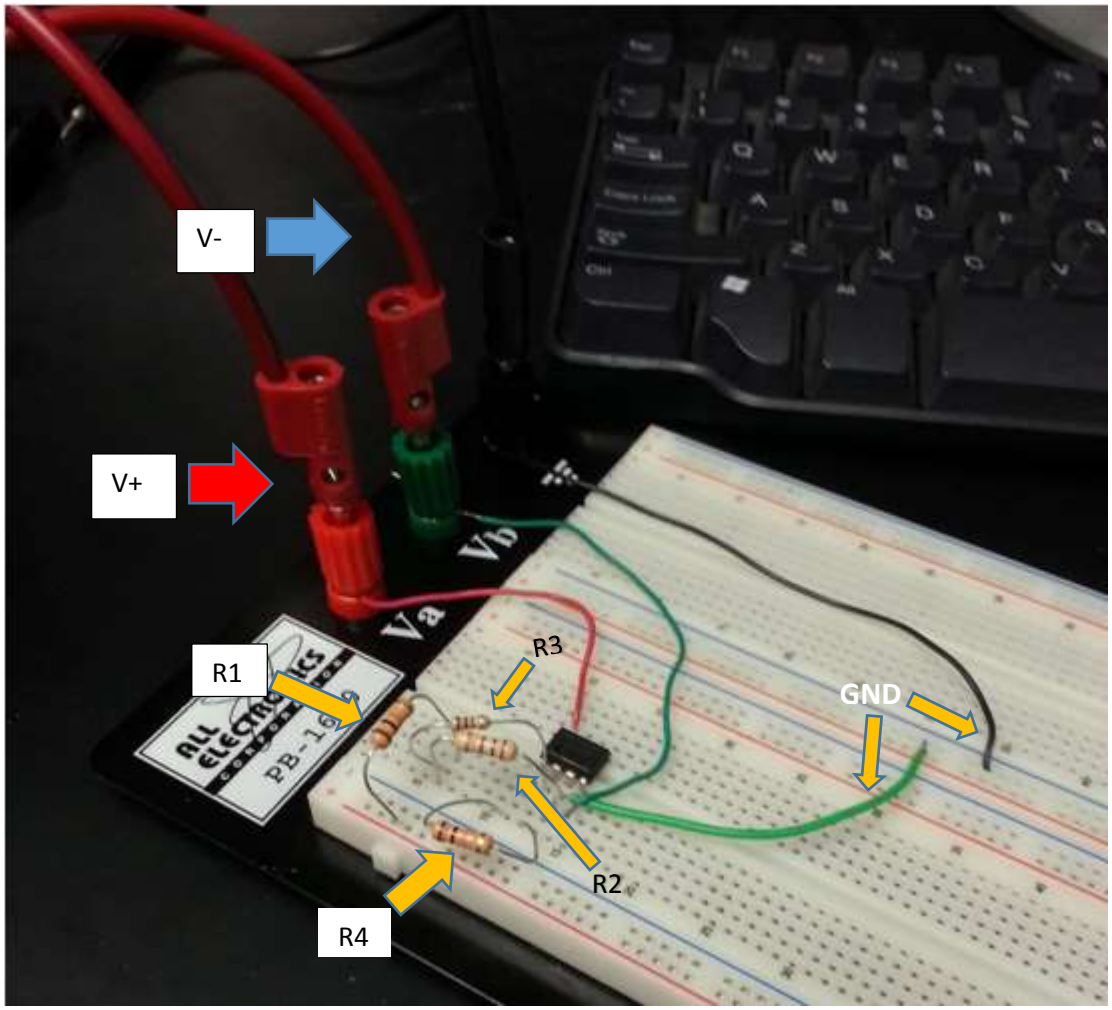

Figure 3 Example build of circuit

4. Connect the R2 (100 Ω) resistor to the node (B) shared by the R1 and R3 resistors.
5. Connect a wire from the free end of the R2 resistor to a ground.
6. Connect a wire from the noninverting input of the op amp (+, pin 3) to the same ground as the resistor R2 from the previous step.
7. Bridge the inverting input and output of the opamp with a 10 kΩ resistor (R4). Use wires if necessary.
8. Connect a wire to the input (free end of R1) for connection to a power supply.

Depending on the style of voltmeter probes you have, you may skip Step 9.

9. Connect a wire to the output (pin 1 of the opamp IC). Leave the other end free for an alligator clip style attachment to the voltmeter.
10. Set your dual power supply to + 10 V and – 10 V. Make sure output is OFF before doing so. See Figure 4.

    Warning. If you are not certain how to use your power supply, refer to the power supply's manual.

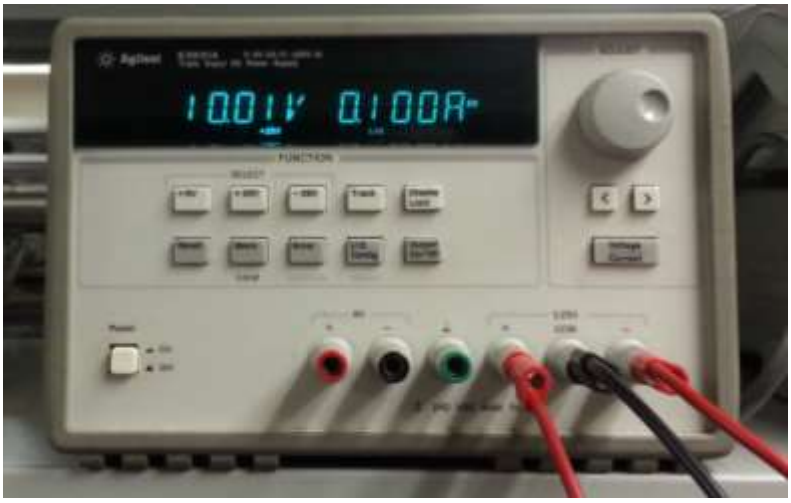

Figure 4 Power Supply. Red cable on the left is +10 V and the red cable on the far right is -10 V. The black cable in between the two red cables is common ground.

11. Create a connection from the +10 V output to pin 8 of the opamp IC.
12. Connect -10 V to pin 4 of the opamp IC.
13. Turn the power supply's output to ON.

If you don't have a dual power supply, you may use two power supplies to generate the negative voltage. It is also possible to use one positive power supply with a voltage divider circuit. Steps 14 to 17 describe how to use two power supplies to acquire the +/- 10 voltage signals. You may skip steps 14 to 17 if you have a power supply capable of producing +/- 10 V for the opamp, such as the one shown in figure 4.

14. Connect the negative of one supply to the positive of the other.
15. Connect a ground wire to one of these shared connections to the common ground shared by the circuit.
16. Connect the negative terminal of the 2nd power supply to the -10 V input of the circuit, and the positive terminal of the 1st supply to the +10 V of the circuit.
17. Turn the supply output to ON.
18. Provide +10 V as the input voltage to the circuit as a test input. You may share the +10 V connection to the opamp or use another power supply.

19. Use the common ground for the ground of this power supply.
20. Measure the voltage at the output (V_o in figure 2) using a voltmeter.

    Your reading should be approximately -0.9 Volts. If it is not, refer to the troubleshooting section.
21. Change the input supply voltage to -10 V. You may share the -10 V supply to pin 4 of the opamp.

    You should observe 0.9 Volts at the output if the circuit was built successfully. If it is not, refer to the troubleshooting section.

Congratulations, you've just built an inverting amplifier!

22. For varied inputs, use a Function Generator and experiment a little.

The circuit in these instructions observes the mathematical relationship shown in Figure 3 between the input and output.

$$\mathbf{Vout} = -(\mathbf{R4/R3}) * \frac{(R2 \parallel R3)}{(R2 \parallel R3) + R1} * Vin$$

Figure 5 Mathematical relationship between Input and Output Voltage

The Gain, denoted G_V, is an important quantity in amplifier design. It is mathematically equivalent to V_{out}/ V_{in}. For further hands-on experience, experiment with different R values to achieve different Gains.

Troubleshooting

- If you don't get approximately similar voltage readings, first check your connections to the various components. Fix any improper connections. If the connections are correct, make sure the power supplies share the same ground as the circuit.
- If the power supply stops displaying the correct voltages, try replacing the opamp as this may have become damaged. Make sure to turn off the power supply first before doing so!
- If you find yourself shorting the circuit or damaging components due to excess current, use the current limiting feature of your power supply. Refer to the user's manual if you don't know how to use this feature.