

How to Wire an Inverting Amplifier Circuit

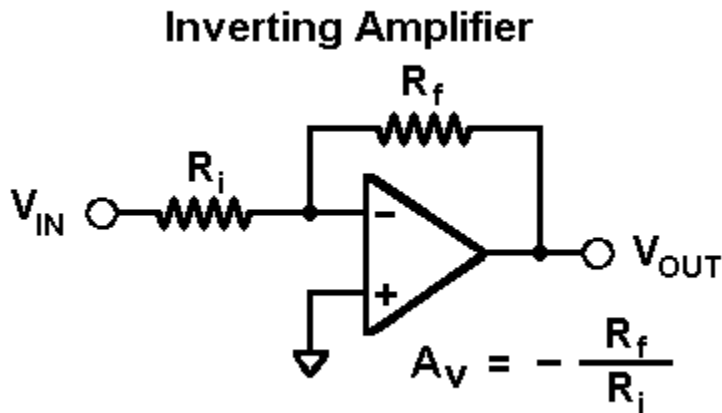


Figure 1: Inverting Amplifier Schematic

Introduction

The purpose of this instruction set is to provide you with the ability to wire a simple inverting amplifier circuit. An inverting amplifier is an extremely important circuit to understand in the world of electrical engineering. This circuit consists of an input voltage in series connection with a resistor. This resistor is then fed to a node containing the negative voltage signal input of an operational amplifier (op amp). The operational amplifier outputs its voltage into a node that also contains a resistor "feeding back" to the input node. The positive terminal of the op amp is grounded. The gain (ratio of output voltage to input voltage) of this particular system, will be the negative proportion of the value of the resistor in the feedback loop to the value of the resistor in series with the input voltage.

The equation for the gain is:

$$Gain = - \frac{R_2}{R_1}$$

R_2 being the resistor in the feedback loop.

For use of example in this document, $R_2 = 80 \Omega$ and $R_1 = 40 \Omega$, giving us a gain of negative 2.

Op Amp Layout

All basic op amps have the same general functions, although they may be laid out in differing ways. For this document, an LF.412 op-amp will be used. Take a look at Figure 2, on the right, the schematic for this op amp. Frequently, throughout this document this picture will be referred to. Nodes 4-8 will be used for this project, although nodes 1-4 and 8, are identical to nodes 4-8.

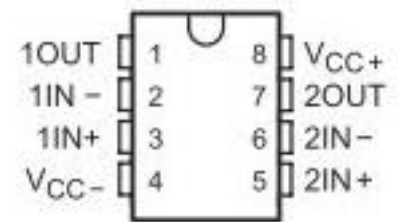


Figure 2: LF .412 Pin Layout

Materials Needed:

- A breadboard
- a spool of wire
- wire strippers
- two different resistors
- LF.412 op amp (May be changed, although this instruction set will use this model as example)
- 3-5 (depending upon your breadboard) Banana-Banana clips
- 2-5 (depending upon your breadboard) Banana -Alligator clips
- Oscilloscope
- Function generator
- 15 Volt Power Supply

Before you start:

- Clear your breadboard of all previous components to start with a blank slate.
- Double check that you have all required materials in front of you before you begin; it is difficult to keep your train of thought if you are interrupted in the middle of wiring because you need to find a circuit component.
- Turn on your power supply to check what voltage it is currently outputting. If the interface reads anything but 0 V adjust it so that it does. This is important because a potential of more than 15 volts can destroy your op amp. Once you check this, turn the power supply off.

Step 1: Attach power supply positive, negative, and ground terminals to breadboard

- Find three terminal inputs (tiny colored cylinders) installed across the top of the breadboard
- Take three banana to banana plugs and connect them to the power supply (one in +V port, -V port, and ground port) (see Figure)

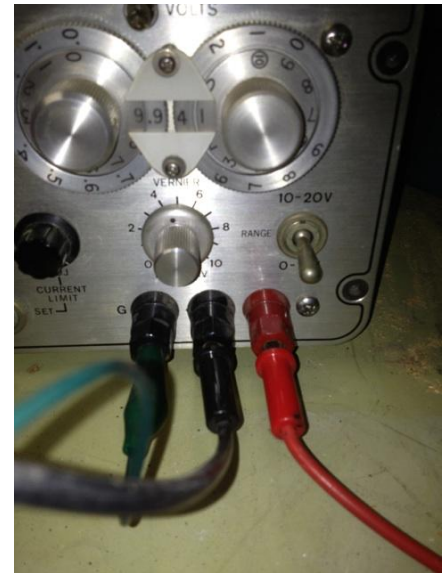


Figure 3: Plugging into Power Supply

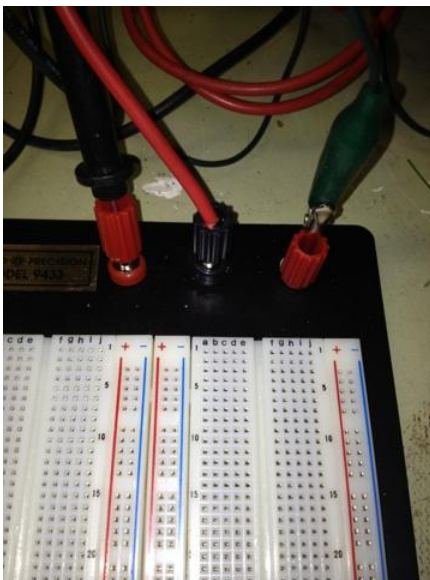


Figure 4: Connecting power to breadboard

- Next connect the other ends of the banana plugs to the terminals inputs on your breadboard (see Figure). It is entirely your choice which input you are using for each plug, but remember to take note which one is which.

Step 2: Connect terminals to breadboard nodes

- Cut and strip three pieces of wire, approximately the length of your index finger
- Take one of the wires and connect one end to one of the terminals you just hooked to the power supply
- Do this same thing for the remaining two wires and terminals
- Next, locate the narrow vertical strips on your breadboard that are usually denoted with positive and negative signs. Each of those represents a node that carries the input voltage along the entirety of the of that vertical strip.
- Plug each of the three wires into its own vertical node.
- You now have successfully powered your breadboard. Refer to Figure to double check your work.

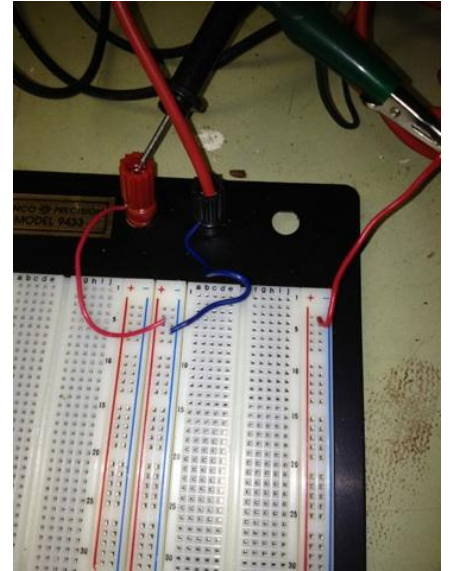


Figure 5: Powering vertical breadboard nodes

Step 3: Install Op Amp

- Find your op amp and examine it to locate the semi-circular notch (see Figure 6a) that is cut into the face of it. The notch denotes the top of the op amp, giving you an orientation point
- Straddle the center of the op amp across one of the vertical breaks in your breadboard with the notch pointing up (away from you, see Figure 6b)
- Gently press down to ensure that all legs are fully inserted

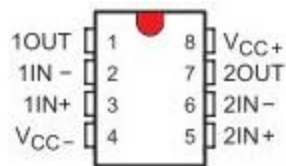


Figure 6a: Correct orientation of op amp

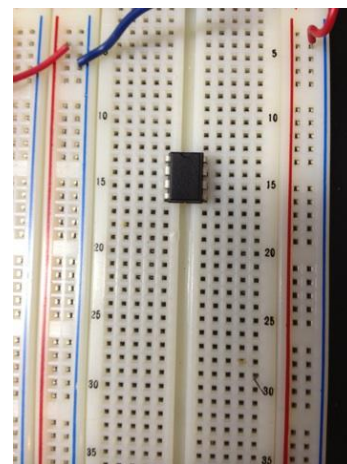


Figure 6b: Your installed op amp should look like this

Step 4: Attach Power to Op Amp

- Cut and strip three pieces of wire, once again approximately the size of your index finger (roughly 3 in.)
- Insert one wire into one of the vertical nodes that currently is wired to the power supply
- Repeat procedure for the remaining 2 wires and nodes
- Find your positively charged node (If you can't remember which is which physically follow the wire back to the power supply)
- Take the wire that is plugged into the positively charged node and attach it to port 8 of the op-amp. The top right port denoted in red in Figure 7a.

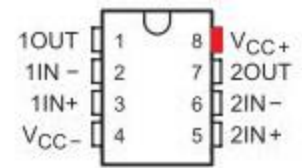


Figure 7a: Port 8 - attach your positive voltage supply here

- Take the wire that is plugged into the negatively powered vertical node and attach it to port 4 of the op-amp. The bottom left port denoted in red in Figure 7b.

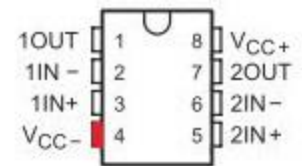


Figure 7b: Port 4 - attach your negative voltage supply here

- Take the wire that plugged into the grounded node and attach it to port 5, the positive signal input terminal of the op-amp. The bottom right port denoted in red in Figure 7c.

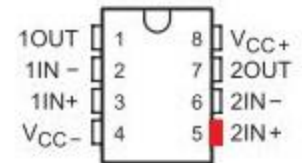


Figure 7c: Port 5 - ground this node

- Your powered op amp should now look like Figure 7d.

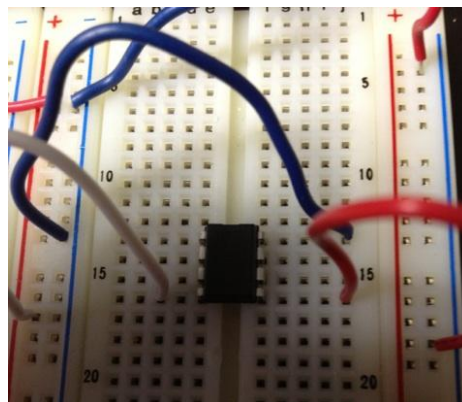


Figure 7d: Successfully powered op amp

Step 5: Wire Input Signal from Function Generator

- Locate a banana to alligator clip and strip two pieces of different length wire (3-4 in, 1-2 in)
- Insert one end of the 3-4 inch wire into the port 6 node, denoted in Figure 8.
- Insert the other end of the same wire into a *free* node (a node with nothing else connected to it), we will call this **Node A** above the op amp
- Find *another free node*. We will call this **Node B**
- Insert the 1-2 inch wire into the second free node
- Take the alligator end of the alligator banana clip and attach it to other end of the 1-2 inch wire
- Plug the banana end into the function generator's output

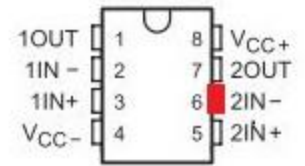


Figure 8: Port 6 - insert input from function generator

Step 6: Inserting Resistors

- Take one resistor and insert one end (direction of resistor changes nothing) into **Node A** and the second lead of the resistor into **Node B**.
- Take your second resistor and attach one lead to port 7's node
- Attach the other lead of the same resistor to port 6's node
- Examine Figure 9 to ensure you correctly configured your resistors

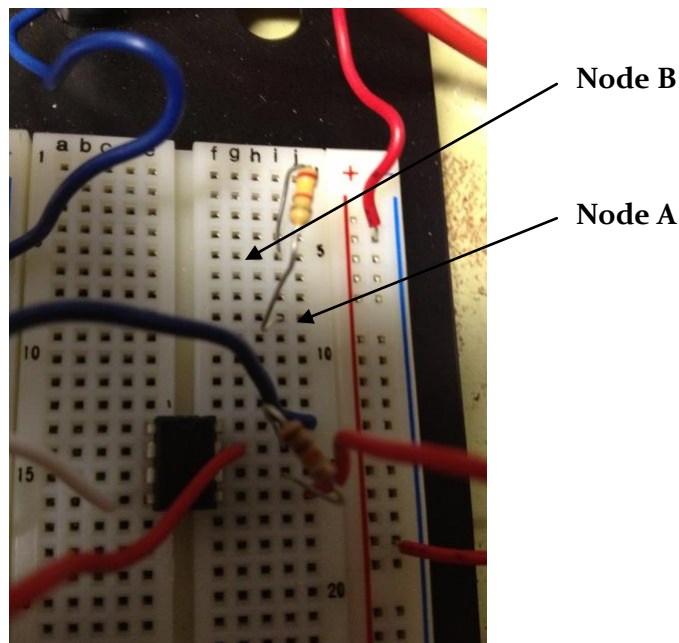


Figure 9: Resistors properly installed, note Node A and Node B

Step 7: Wire Oscilloscope to Circuit

- Strip a 1-2 inch piece of wire and locate another alligator to banana wire
- Insert one lead of the wire into port 7
- Clip the alligator end onto the other end of the wire
- Plug the banana end into the input port of the oscilloscope

Step 8: Powering on the circuit and setting up a testing experiment

- Turn on the power supply and turn the input voltage to 15
- Turn on the function generator and set to a DC amplitude of 4 V, see Figure 10a . (4 V is an arbitrary value used for this experiment)
- Turn on the oscilloscope to read a value for the output of the circuit, in the experiment conducted for example purposes in this document the output should read -8 V see Figure .



Figure 10a: Oscilloscope is reading 4 V

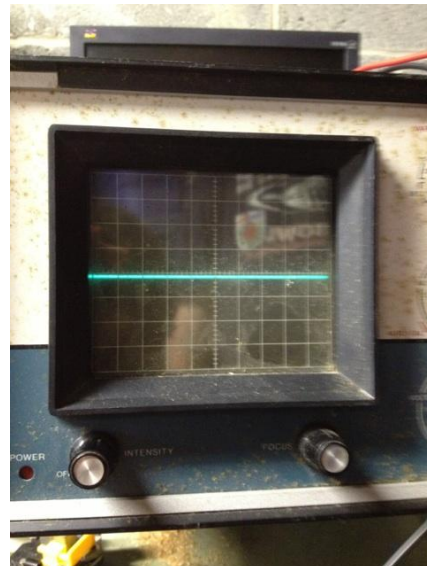


Figure 10b: Oscilloscope is now reading -8 V. (Vertical partitions are set to 6V)

Conclusion:

If you failed to get these exact results you either used different size resistors or your circuit is wired improperly. Troubleshooting consists merely of retracing your steps and determining which node is wired incorrectly. For electrical engineers, understanding the design behind how an inverting amplifier is wired is vitally important. It is widely applicable in designing a large variety of circuits. After having mastered the inverting amplifier, move on to the non-inverting amplifier, the summing amplifier, and the inverting integrator