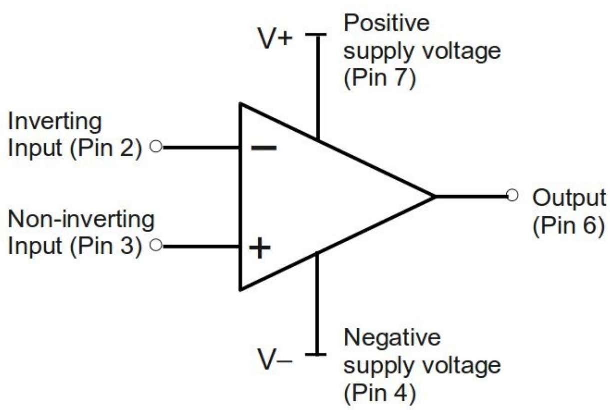
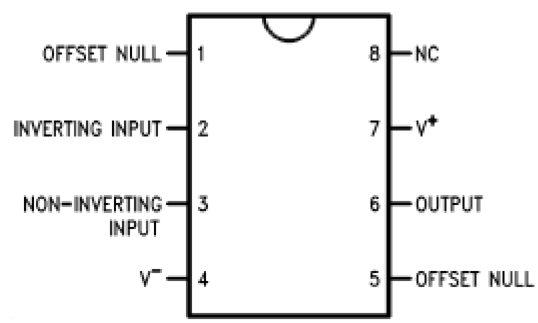
Lab 8: Operational amplifiers (version 1.2)

WARNING: Use electrical test equipment with care! Always double-check connections before applying power. Look for short circuits, which can quickly destroy expensive equipment.

LF411 integrated circuit

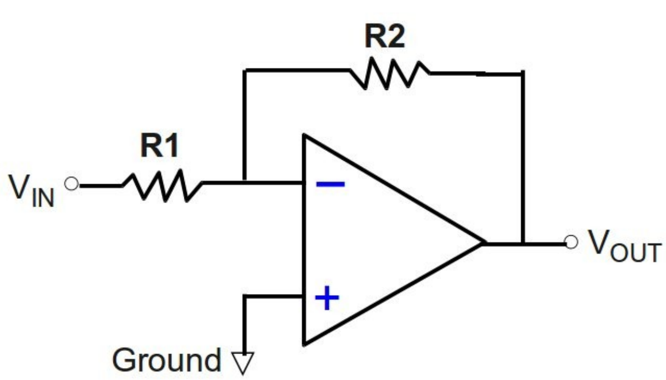
The LF411 is a general purpose operational amplifier. It comes in a variety of packages, including the dual inline pin (DIP) arrangement with two rows of four connectors. The package is oriented with a semi-circle notch located between pins 1 and 8. Pins 1, 5, and 8 are not used.





Inverting amplifier

Place the LF411 IC on the Elvis board so that it straddles a row divider, which allows independent connection of all 8 pins. With the Elvis board powered off, connect pin 7 to the +15V and pin 4 to –15V voltage sources on the lower left. Build the following circuit:

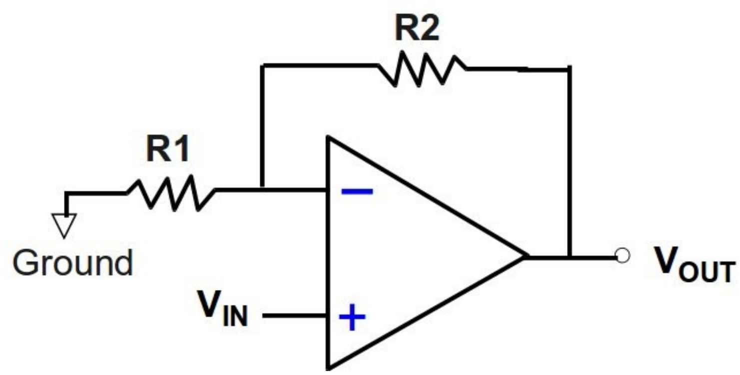


Use R1 = 10 kΩ and R2 = 50 kΩ ; neither value is very critical, but always measure components before placing them in the circuit. Be sure to connect the non-inverting opamp input to the power supply ground on the Elvis board (adjacent to the ±15V DC supply pins). V_{IN} is supplied by the function generator. Select the high impedance (High Z) mode using Utility: Output Setup: High Z. Then press Done. Setup the function generator to produce a 1 kHz sine wave with 300 mV p-p amplitude and zero offset. Make sure the negative lead of the EZ-hook input cable clips to circuit ground. Monitor the input signal on CH 1 of the oscilloscope (use BNC T-connector if desired) and display V_{OUT} on CH 2 using a scope probe.

After double-checking the connections, power on the Elvis board. Measure and record the gain of this amplifier, which is the ratio V_{OUT}/V_{IN}. Also measure and record the phase of the two signals. Replace R2 with a value close to 30 kΩ and repeat the measurement. Do the same for R1=R2. List the results in a table showing R1, R2, gain, and phase for the three circuit configurations and show to instructor.

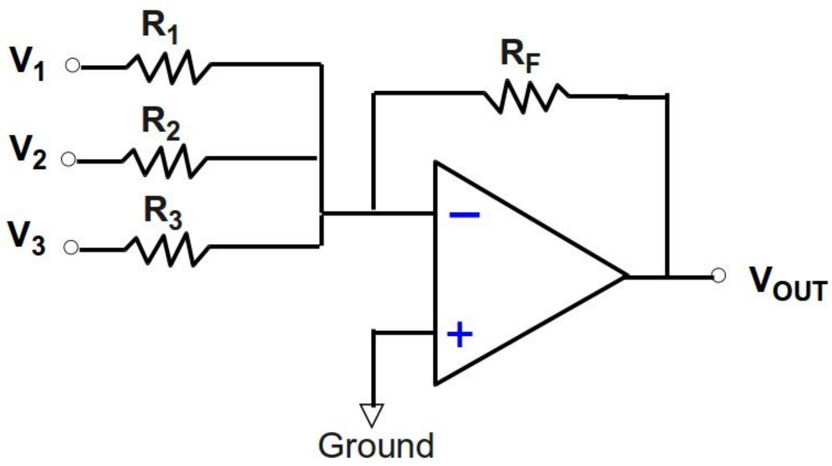
Non-inverting amplifier

Build the following circuit, repeat the above three measurements for the same resistor values, and show the table to the instructor.



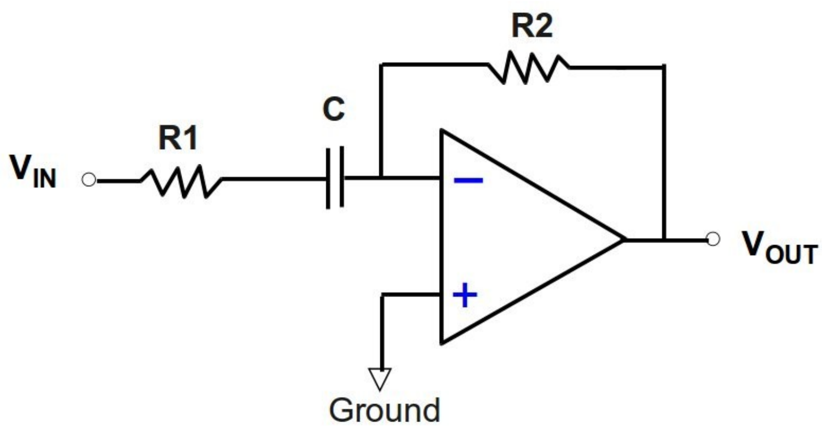
Summing amplifier

Configure the summing amplifier shown in the sketch below by selecting $R_1 = R_2 = R_3 = R_F = 10$ kΩ. Connect the function generator with the same output configuration as above to V_1 but leave the other inputs open. Record the gain and phase at V_{OUT}. Next connect the second input with a jumper wire between V_1 and V_2, leaving V_3 open. Record the output. Finally connect all 3 inputs to the function generator and record the output. Show the results table to the instructor.



Differentiating amplifier

Adding a capacitor to the input of the inverting amplifier converts it to a differentiating amplifier. To see this effect, construct the following circuit with R1 = 100 Ω, R2 = 10 kΩ, and C = 10 nF.



With the same sinusoidal input at frequency 1 kHz, the circuit will differentiate it to produce a 1 kHz cosine wave at V_{OUT}, i.e. a waveform that is phase shifted from the input by about 90°.

This circuit can also be thought of as a high-pass filter, i.e. it will tend to block frequencies close to DC (ω=0), while higher frequencies pass through and get amplified. This is because of the frequency-dependent impedance of the capacitor $Z_C = 1/j\omega C$. High-pass operation can be seen by choosing R1 = R2 = 10 kΩ and C = 10 nF (values not critical). Setup the Bode analyzer and demonstrate high-pass operation. Show results to instructor.

No writeup is required.