Operational Amplifiers

Motivation:

In this lab, we will study operational amplifiers and explore some of their applications.

Related Lecture Content:

- Operational Amplifiers and Negative Feedback
- Op-Amp Circuits

Before You Start:

µA741 Operational Amplifier

For this lab, we will be using the µA741 general-purpose operational amplifier from Texas Instruments. The op-amp comes in an 8-pin dual inline package (DIP) shown in Figure 1.

Figure 1: µA741 Op-amp Image from Digikey

Dual inline packages have a notch at one end or a dot in one corner in order to provide visual identification of the orientation of the package. In case of a dot, it is located next to Pin 1 and in case of a notch, it is located between Pins 1 and 8. The rest of the pins are numbered counter-clockwise as shown in Figure 2. For this particular op-amp, Pin 8 is not connected (NC). Pins 1 and 5 are used to eliminate any offset voltage and will not be used in this lab. The remaining of the pin assignments are shown in Figure 2.

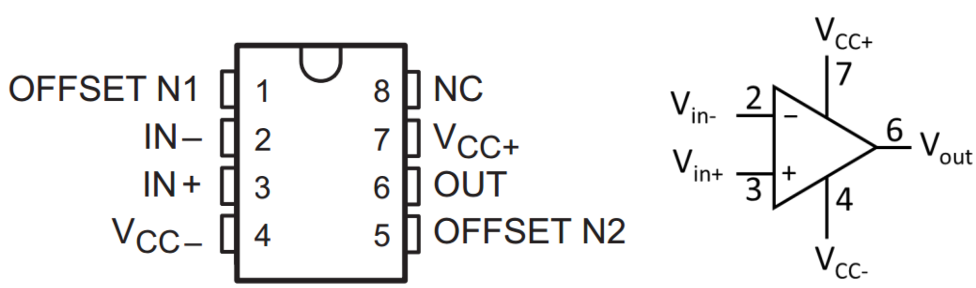

Figure 2: µA741 Op-amp Pin Numbering and Assignment

Experiment:

Please fill out the experimental report while going through the lab and submit it to the TA at the end of the lab for grading.

Part 1

In order to have a better control over the gain of an amplifier, minimize the clipping and stabilize the output, negative feedback loops are commonly used. Voltage followers are the most basic form of negative feedback circuit and have unity gain. They are very useful as a first stage in circuits and are often used as buffers for logic circuits.

1.1 Construct the voltage follower circuit shown in Figure 3, connect V_{CC-} and V_{CC+} pins to the power supply and set them to -15 V and 15 V respectively. To supply these voltages from a DC power supply, as shown in Figure 4, connect the negative terminal of the first channel to the positive terminal of the second channel <u>on the breadboard</u>; this will create a reference point of zero voltage. You can then use the positive terminal of the first channel to supply the 15 V and the negative terminal of the second channel to supply the -15 V. Make sure the channels of the power supply are set to independent mode.

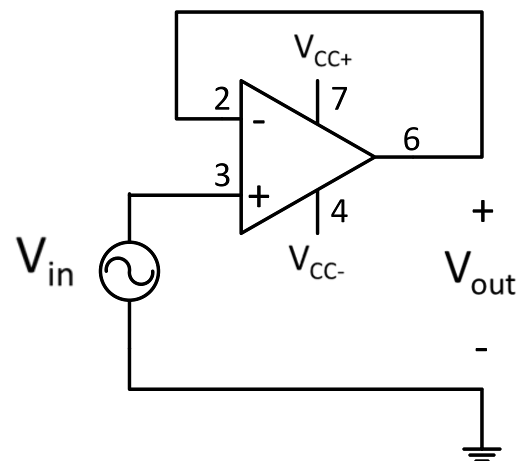

Figure 3: Voltage Follower Circuit

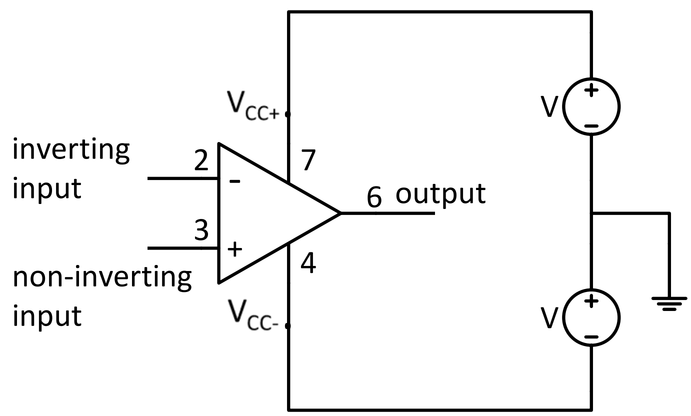

Figure 4: Op-amp V_{cc+} and V_{cc-} Connections

Connect the input V_{in} to a function generator and apply a sine wave of 8 V peak-to-peak voltage. Monitor both the input and output voltages, with respect to ground, using the oscilloscope. Make sure you are using the DC coupling. Overlay the input and output on the oscilloscope screen. Vary the frequency of the input signal. Over what approximate range of frequencies is the output essentially identical to the input? Plot the gain V_{out}/V_{in} from 1 Hz to 1 MHz.

1.2 While setting the frequency of the input signal to 15 kHz, vary its amplitude. Over what approximate range of amplitudes is the output essentially identical to the input? Observe different waveforms versus amplitude and frequency. Verify that they are buffered similarly.

1.3 Place a 10 kΩ resistor in the feedback loop. What happens to the output?

Part 2

In most cases, one requires the gain to be different from unity, and in this case, an inverting or non-inverting amplifier can be used. The non-inverting amplifier uses two resistors to provide a gain $V_{out}/V_{in} = (1+R_2/R_1)$.

2.1 Build the circuit in Figure 5 and choose R_1 and R_2 such that the circuit will provide you with a gain of 3. You may need to use series and parallel combinations of resistors for R_1 and R_2. Connect V_{CC-} and V_{CC+} to the power supply and set them at -15 V and 15 V, respectively. Apply a sine wave with 1 V peak-to-peak voltage and a frequency of 2 kHz, with a DC offset of 0.5 V. Monitor both the input and output voltages, with respect to ground, using the oscilloscope. Measure the gain of the circuit. Does the circuit amplify both AC peak-to-peak and DC offsets equally?

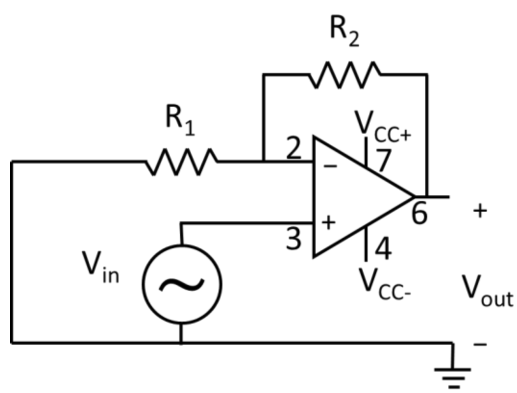

Figure 5: Non-Inverting Amplifier