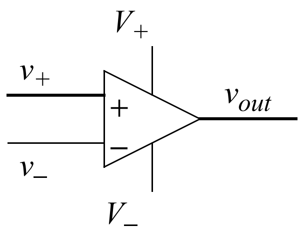
Physics 475, Laboratory 15
Active Rectifiers

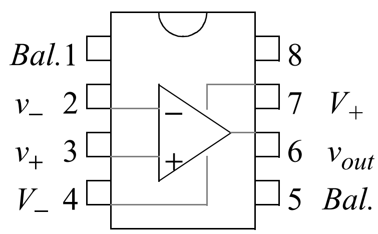
Overview

The purpose of these experiments is to use op-amps in circuits with diodes to improve the ability to rectify signals and select the peak signal generated.

Background

An operational amplifier (op-amp) is a differential amplifier with very high gain, very high input impdance, and very low output impedance. The 741 op-amp is an integrated circuit thaat comes in an 8-pin dual in-line package (DIP). The connections for the chip looking down with the notch facing up is:

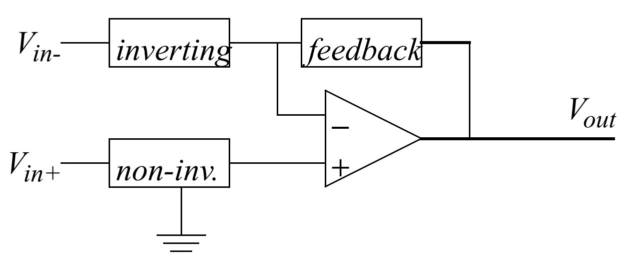




For large gain, low input current amplifiers used with feedback to the negative input there are two rules to follow:

1. **$I_+ = I_- = 0$.** *The input currents are 0.*
2. **$v_+ - v_- = 0$.** *The input voltage difference is 0.*

For feedback to the negative input, the general steps for analysis are to find the voltage at the non-inverting input and use rule two to assign that same voltage to the inverting input. The next step is to find the current flowing at the inverting input from any voltage source. Based on rule one all tis current is assumed to flow into the feedback network, and generate a voltage drop at the output voltage.



1. Ideal Diode

Connect a 741 op-amp and 1N914 diode to make the circuit in figure 1.

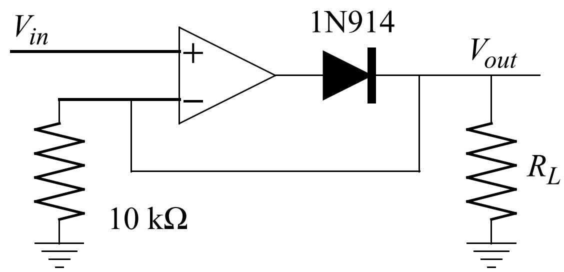


Figure 1: Ideal Diode

Use the variable power supply to provide V_{in}, and use a 100 Ω resistor for R_L. Measure V_{out} with the DMM for V_{in} = 0.1 V, 0.2 V, 0.5 V, 1.0 V, 2.0V and 5.0 V. Reverse the polarity of the power supply by swiching the ground connection to positive and using the negative input for V_{in}. Use a 1 MΩ resistor for R_L and measure V_{out} with the DMM for V_{in} = 0.1 V, 0.2 V, 0.5 V, 1.0 V, 2.0V and 5.0 V. How close is this circuit to a perfect diode?

2. Half-Wave Rectifier

Connect the op-amp as in figure 2 with v_{in} from a sine wave of the function generator.

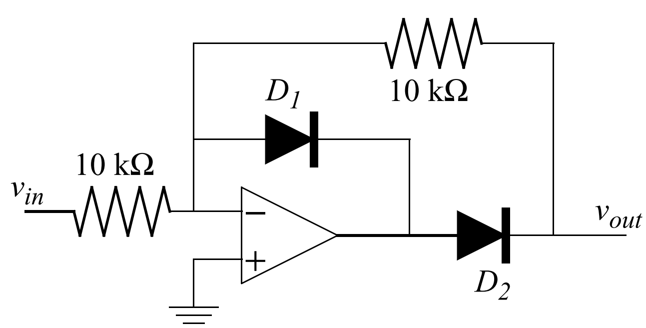


Figure 2: Half-Wave Rectifier

Measure v_{out} with a scope and find the gain for frequencies of 300 Hz, 30 kHz and 3 MHz. Observe any non-linear effects. The slew rate limit will cause the output to rise less rapidly than the input for very high frequency. Is there a slew rate limitation, and if so what is the slew rate for the circuit? It may help to make measurements at the output of the op-amp.

3. Full-Wave Rectifier

Add a summing op-amp amplifier to the circuit of figure 2 to make the circuit in figure 3.

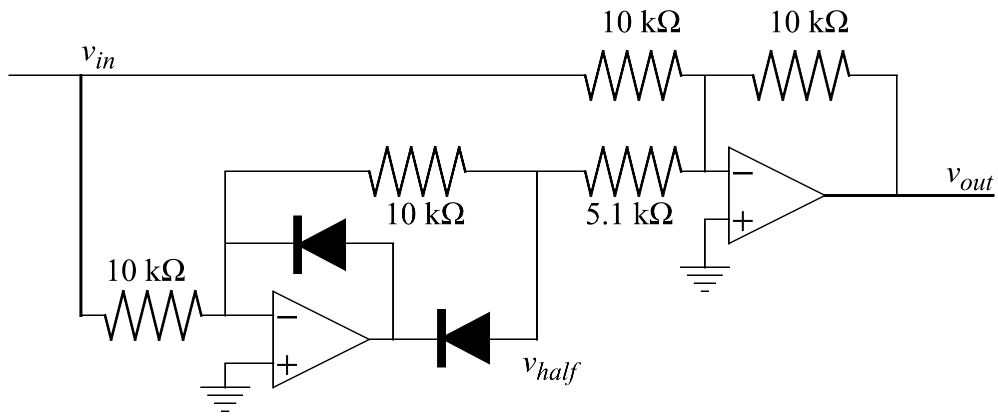


Figure 3: Full-Wave Rectifier

Repeat the measurements of part 2. Is there any switching effect at $v_{out} = 0$?

4. Peak Detector

Build the circuit in figure 4 with two 741 op-amps and use sine waves for v_{in}.

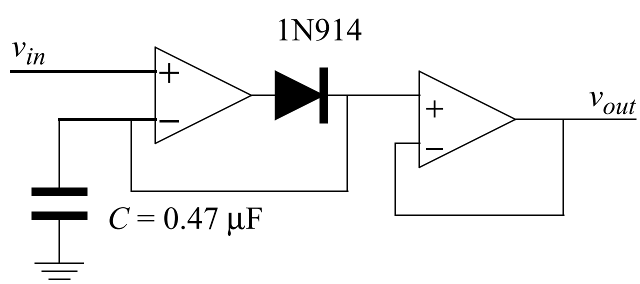


Figure 4: Peak Detector

Measure v_{in} and v_{out} with oscilloscope and look at the output for an input amplitude of 0.5 V. Increase the amplitude to 1.0 V and measure v_{out} again. Lower the amplitude back to 0.5 V and measure v_{out}. How long does it take for v_{out} to "forget" the old peak value?