APPLICATIONS OF OPERATIONAL AMPLIFIERS

Charles O'Neill

Oklahoma State University

Stillwater, OK 74078

Lab Exercise No. 5

Section 406

Oct 19, 1999

1. Inverting Amplifier.

A 741 op-amp was connected as an inverting amplifier. The gain of an op-amp is $\frac{Z_f}{Z_i}$ which with a 51k and a 5.1 k Ohm resistor yields a gain of 10 and a dB gain of 20 as shown in Figure 1. At higher frequencies, the op-amp is unable to switch rapidly enough and the result is a decrease in the gain after 20000 Hz. A plot of the phase response, Figure 2, also shows the inability of the 741 to amplify at frequencies over 20000 Hz. Until approximately 20000 Hz, the op-amp shows a constant 180 degree phase shift.

2. Low Pass Filter.

A 741 op-amp was connected as shown above. The break frequency is $\frac{1}{R_2C} = 99.8Hz$ with a static gain of $\frac{R_2}{R_1} = 2.1$. From theory, the transfer function is $\frac{R_2}{R_1} \cdot \frac{1}{(R_2C\omega)^2+1}$ and the phase shift is $\Theta = -ATAN(R_2C\omega)$. However, the op-amp also shifts the phase 180 degrees (inverts). Figures 3 and 4 give the Frequency and Phase response of the low pass filter. The slope of the measured data is less than theory perhaps due to wire and connector influences to decrease the effective capacitance. The Phase response was very fuzzy; however, the theory line seems to go mostly through the middle of the range of data points.

3. High Pass Filter.

A 741 op-amp was connected as shown above into a high pass filter. The break frequency is $\frac{1}{R_1 C}$ with a static gain of $\frac{R_2}{R_1}$. The theoretical transfer function is $\frac{R_2}{\sqrt{(R_1^2+(\frac{1}{\omega C})^2)}}$ and the phase shift is $\Theta = -atan(\frac{1}{\omega C R_1})$. The op amp also inverts the output, which is identical to shifting by 180 degrees. The Phase diagram, Figure 6, matches nearly exactly both the measured and the theorectical responses. However, on the Frequency response plot, Figure 5, the measured and theory curves do not match. The high frequency magnitude is exact, but at low frequencies the op-amp tested was giving many magnitudes greater of a signal than should be expected. This may be due to inductance of the wiring allowing more than the theoretical to be amplified.

1: LabView

The circuit shown above was created in LabView and input a signal through an external signal generator. This circuit is an inverting op-amp with a gain of $\frac{R_2}{R_1}$. because LabView simulates the function of the op-amp, the output is nearly constant regardless of the frequency. The small differences are probably due to the function generator and not the computer (Figure 7). Figure 12 shows a typical inverted signal as shown in LabView.

2: LabView

This circuit shown above was created in LabView and input a signal through an external signal generator. The transfer function is $\frac{1}{R_1 C\omega}$. Figure 8 gives a Frequency Response plot of the LabView output. The theory and measured curves correspond nearly exactly.

3: LabView

The circuit shown above was created in LabView and input a signal through an external signal generator. The transfer function is $\frac{\sqrt{((\frac{1}{\omega C})^2+R_2^2)}}{R_1}$. A Frequency response plot in given in figure 9. Large difficulties were encountered trying to measure the amplitude in LabView. While the output was steady state, large variations in the magnitude were encountered with a period of 2 to 3 seconds. We measured the maximum magnitude which accounts for the closely matched slope but different magnitude in Figure 9 below 1000 Hz. Since the only energy storage element in the circuit is a capacitor, the capacitor must be storing and releasing energy perhaps due to a DC bias in the signal generator. At higher frequencies, the measured curve finally approached the magnitude and slope of the theoretical curve.

4: LabView

The circuit shown above was created in LabView and input a signal through an external signal generator. The transfer function is $\frac{R_2}{R_1}\frac{1}{\sqrt{(R_2 C\omega)^2+1^2}}$. A Frequency response plot is given in Figure 10. The measured and theoretical curves are similar at lower frequencies just as Figure 3. Since the function generator and the wires are the only remaining physical parts from the figure 3 experiment, the decrease in capacitance must be due to the inductance of the function generator and the connecting wires. Further experimentation into the location and geometry of the wires and function generator would be useful. Figure 11 shows how cirucit 4 integrated the square wave input signal into a triangle wave.