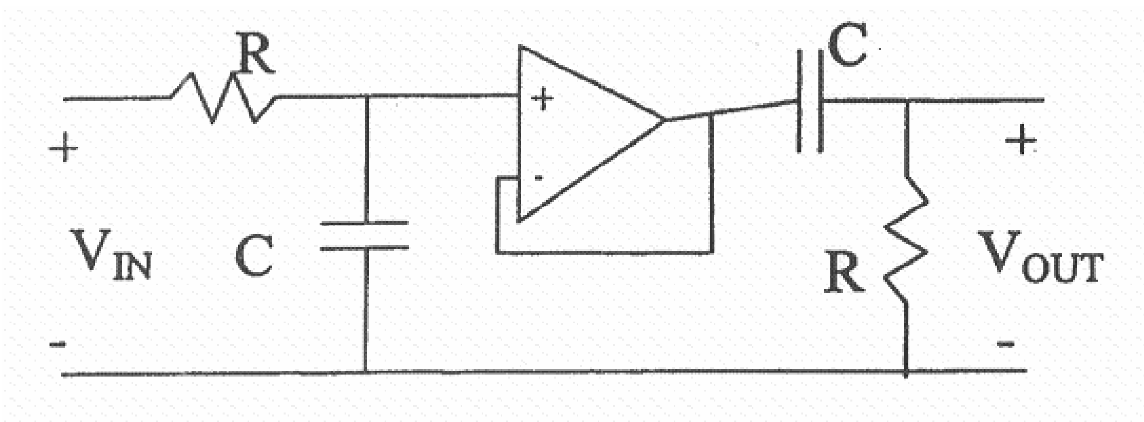
ENG 100 Lab 5 - The Operational Amplifier in Filters

In this lab, the 741 op amp will be used again. Common applications of op amps are in filters and as buffers between circuits, as you will see in this lab.

NOTE: Make sure that you finish your Pre-Lab work before coming to the lab.

Circuit I:

The circuit shown below uses one op amp as a unity-gain buffer to isolate two RC sections. The first section is a low-pass filter and the second section is a high-pass filter.



Procedure:

1. Using your prototype board, construct this RC bandpass circuit. Use R = 1500 Ω and C = 0.01 μF.

2. Drive the input of your circuit with the function generator, and also connect the input to channel 1 on the oscilloscope (this will be your reference).

3. Set the function generator to generate a sinusoid and display it on channel 1 of the oscilloscope. Adjust the frequency to 1 kHz, and the amplitude to 1 Vpp.

4. To measure the output amplitude, connect the output voltage of the circuit to channel 2 of the oscilloscope.

5. To measure phase, adjust the oscilloscope to display both channel 1 and channel 2 simultaneously.

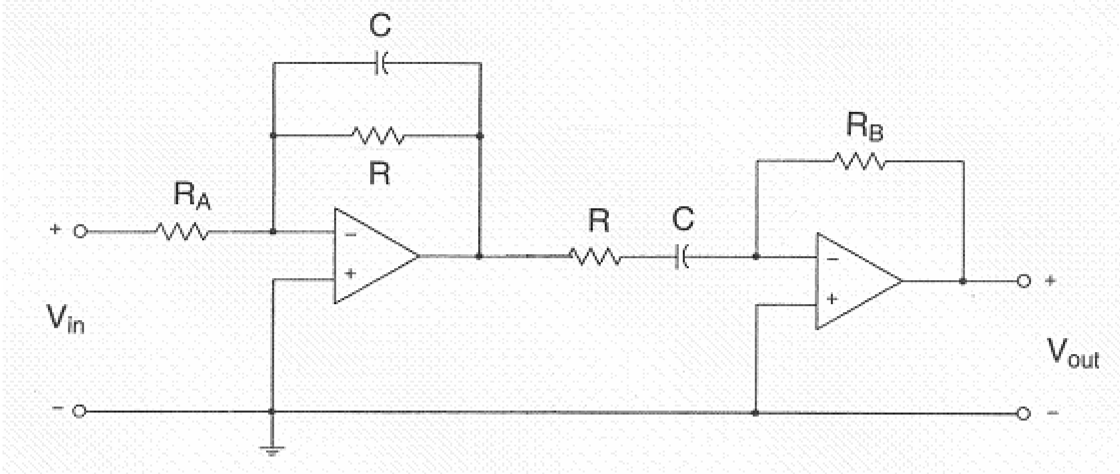
6. To measure phase, measure the time delay between the input signal and output signal. From the time delay, you can calculate: Phase = $-360^o t_d/T$, where T is the period of the sinusoid and t_d is the time delay. The time delay t_d can be measured as the time from a positively-sloped zero crossing of the input to the nearest positively-sloped zero closing of the output. (Note: t_d can be positive or negative).

7. Repeat the above procedure for all the frequencies in the table in the Prelab. Fill in the table with your measured data. Make sure the input amplitude remains at 1 Vpp for all input frequencies.

8. Plot your measured magnitude (in dB) and phase (in degrees) versus frequency (in Hz on a log scale) of the transfer function H = Vout/Vin. (This plot can be done after the lab period ends). Do each plot on the same graph as the calculated plot of the prelab data.

<u>Circuit II:</u>

The circuit below is also a band-pass filter, but it uses two op amps.



Procedure:

1. Using your prototype board, construct the RC bandpass circuit. Use R = 1500 Ω and C = 0.01 μF. Use the resistor value R_A = 1kΩ and R_B based on the resistor ratio R_B / R_A that you found in the prelab (or use the closest value for R_B that you can find in the lab).

2. Drive the input of your circuit with the function generator, and also connect the input to channel 1 on the oscilloscope (this will be your reference).

3. Set the function generator to generate a sinusoid and display it on channel 1 of the oscilloscope. Adjust the frequency to 1 kHz, and the amplitude to 1 Vpp.

4. To measure the output amplitude, connect the output voltage of the circuit to channel 2 of the oscilloscope.

5. To measure phase, adjust the oscilloscope to display both channel 1 and channel 2 simultaneously

6. To measure phase, measure the time delay between the input signal and output signal. From the time delay, you can calculate: Phase = $-360^{o}t_d/T$, where T is the period of the sinusoid and t_d is the time delay. The time delay t_d can be measured as the time from a positively-sloped zero crossing of the input to the nearest positively-sloped zero closing of the output. (Note: t_d can be positive or negative).

7. Repeat the above procedure for all the frequencies in the table in the Prelab. Fill in the table with your measured data. Make sure the input amplitude remains at 1 Vpp for all input frequencies.

8. Plot your measured magnitude (in dB) and phase (in degrees) versus frequency (in Hz on a log scale) of the transfer function $H = V_{out}/V_{in}$. (This plot can be done after the lab period ends). Do each plot on the same graph as the calculated plot of the prelab data.

Questions:

Q1- How do the measured and calculated plots compare?

Q2- How do the magnitude and phase plots for the first and second circuit compare?

Q3- How do the frequency ω_o and the quality factor Q of Circuit 1 above differ from the frequency ω_o and Q calculated for the passive RC band-pass filter in Lab #3? Why are they different?

III. Report

Make Bode plots of the magnitude (dB) and phase (degrees) for versus frequency (Hz) for the transfer function of both circuits (use a log scale for the frequency axis or semi-log paper). For each circuit, plot both calculated and measured values on the same graph, so you can compare the expected and measured amplitude and phase plots. Include the completed Tables 1 and 2 in your report.

Turn in a Prelab report along with your lab report. The prelab should include:
the transfer function derivations, calculation of R_B/R_A, calculated data (in the tables), and Bode plots for the each circuit.

Also, include answers to any questions above in your report.

Updated: 5/3/07