ECE 3254 **Name** ________________________
Operational Amplifier III **Date** __________________
Laboratory #10 Fall 2009 **Bench** ________
PRELAB **Bench:**

Read over entire laboratory #10.

Questions:

1. For the circuit of Figure 10-1 with C1=0.1μF, R1=R3=1k Ω, R2=10kΩ, find V_{out}/V_{in}. (10 points)

Is the circuit a high or low pass filter? (5 points)

Determine the cutoff frequency of this amplifier. (10 points)

Determine the amplifier's maximum (passband) output voltage for a $0.071V_{rms}$ input. (10 points)
Enter the passband output voltage and the cutoff frequency in Part I-3 on the data sheet.

2. For the circuit of Figure 10-2 with C2=0.1μF, R5=1k Ω, R4=R6=10kΩ, find V_{out}/V_{in}. (10 points)

Is the circuit a high or low pass filter? (5 points)

Determine the cutoff frequency of this amplifier. (10 points)

Determine the amplifier's maximum (passband) output voltage for a $0.071V_{rms}$ input. (10 points) Enter the passband output voltage and the cutoff frequency in Part II-3 on the data sheet.

3. Use Pspice to build the Bandpass circuit in Figure 10-3. Perform a decade AC Sweep simulation from 100Hz to 100kHz, using an Vin = 0.2Vpp = 0.0707 Vrms [set AC amplitude = 0.0707] and take at least 160 data points. On your schematic drawing information box at the bottom, place at least your name, the date, ECE3254 Prelab 10, and AC Sweep.

   On your AC sweep plot: Add a dB trace for Vout referenced to Vin. Use cursors to identify and label Vmax and dBmax in the passband, flow, and fhigh. Add a label with your name, and ECE 3254 Prelab 10.

   Print your schematic (8 points) and AC sweep plot (14 points).

   Vmax = ______________, dBmax = ____________, f_{low} = ____________, f_{high} =______________
   (each value worth 2 points) Enter these values on the Data Sheet in Part III-3.

ECE 3254
Operational Amplifier III – Active Filters
Laboratory #10
Last Revised: 10-29-2009

OBJECTIVES:

The purpose of this project is to give an introduction to the active filter. A single-pole low-pass and high-pass filter is presented for analysis. A band-pass filter is then developed by connecting the low-pass and high-pass filter in cascade.

Lab Techniques: Measuring the voltage output to input amplitude and phase differences over a range of frequencies.

EXERCISES:

This laboratory is broken into three parts:
- Part I: Inverting Op-Amp Filters
- Part II: Non-Inverting Op-Amp Filters
- Part III: Cascaded Op-Amp Filters

Part I: <u>INVERTING OP-AMP FILTER</u>

1. Build the circuit of Figure 10-1 **on the left hand side** of the breadboard.

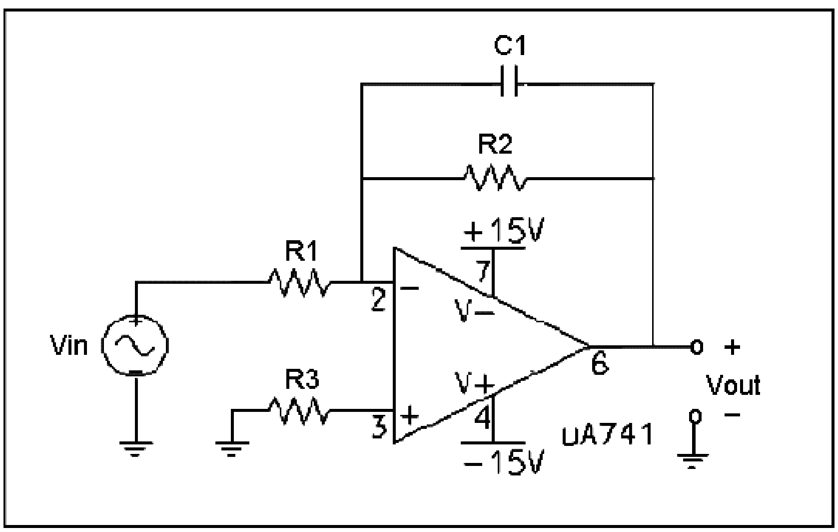

Figure 10-1: C1=0.1µF, R1=R3=1k Ω, R2=10kΩ

2. Connect the output voltage to channel 1 of the oscilloscope and the input voltage to channel 2. Connect the function generator Sync output to the external trigger input on the scope. Set the input signal to a sine wave with an amplitude of 0.2 V_{PP} and manually vary the frequency of the signal from 10Hz to 10kHz. Use the external trigger to stabilize the scope display. Record the peak to peak voltage values of the input and output signals, the phase difference between V_{in} and V_{out}, and the calculated gain in Data Table 10-1 on the data sheet. ***For correct phase, V_{in} should be connected to channel 2 and V_{out} should be connected to channel 1.***

3. Perform an AC Sweep using a sine wave with a 0.2 Vpp input amplitude, frequency limits of 10Hz and 10kHz, and 20 steps per decade. Save the sweep as a jpeg. Set the x scale mapping to log. Set the y scale mapping to dB and use 0.2Vpp for the reference. Use the **red cursor** to indicate the maximum gain and the **blue cursor** to indicate the cutoff frequency.

   * **Print the jpeg** - title the print; label the maximum gain, cutoff frequencies, and passband; clearly indicate where C_1 is an open circuit and where C_1 is a short circuit; write all names on the print; attach the print to the data sheet.

5. ***Keep this circuit intact*** and build the circuit for Part 2 on the right hand side of the breadboard, it will be used to construct the circuit of Part 3.

PART II: THE NON-INVERTING OP-AMP FILTER

1. Build the circuit of Figure 10-2 on the right hand side of the protoboard.

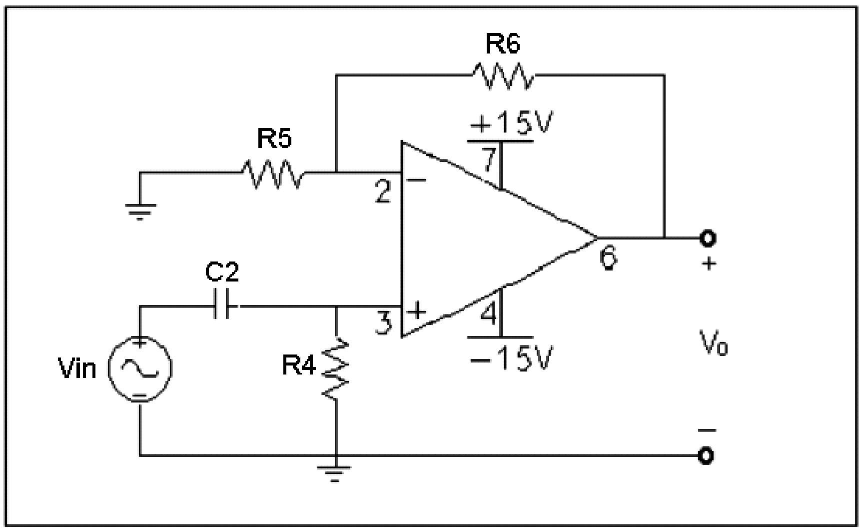

Figure 10-2: C2=0.1μF, R5=1k Ω, R4=R6=10kΩ

2. Connect the output voltage to channel 1 of the oscilloscope and the input voltage to channel 2. Set the input signal to a sine wave with a 0.2 V_{pp} amplitude and manually vary the frequency of the signal from 10Hz to 10kHz. Use the external trigger to stabilize the scope display. Record the peak to peak voltage values of the input and output signals, the phase difference, and the calculated gain in Data Table 10-2 on the data sheet.

3. Perform an AC Sweep using a sine wave with a 0.2 Vpp input amplitude, frequency limits of 10Hz and 10kHz, and 20 steps per decade. Save the sweep as a jpeg. Set the x scale mapping to log. Set the y scale mapping to dB and use 0.2Vpp for the reference. Use the **red cursor** to indicate the maximum gain and the **blue cursor** to indicate the cutoff frequency.

   * **Print the jpeg** - title the print; label the maximum gain, cutoff frequencies, and passband; clearly indicate where C_2 is an open circuit and where C_2 is a short circuit; write your name(s) on the print; attach the print to the data sheet.

PART III: CASCADED OP-AMP FILTER

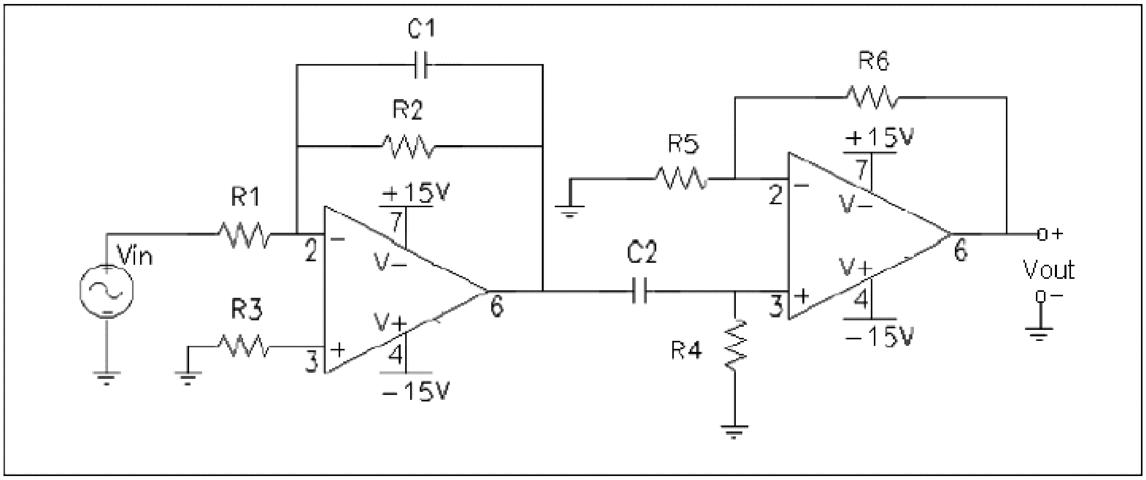

Figure 10-4: C1=C2=0.1μF, R1=R3=R5=1kΩ, R2=R4=R6=10kΩ

1. Build the circuit of Figure 10-4 by using the circuits from the previous sections. You should only need to connect the output of Part 1 to the input of Part II.

2. Connect the output voltage to channel 1 of the oscilloscope and the input voltage to channel 2. Set the input signal to a sine wave with an amplitude of 0.2 Vpp and vary the frequency of the signal from 10Hz to 10kHz. Use the external trigger to stabilize the scope display. Record the peak to peak voltage values of the input and output signals, the phase difference, and the calculated gain in Data Table 10-3 on the data sheet.

3. Perform an AC Sweep using a sine wave with a 0.2 Vpp input amplitude, frequency limits of 10Hz and 10kHz, and 20 steps per decade. Save the sweep as a jpeg. Set the x scale mapping to log. Set the y scale mapping to dB and use 0.2Vpp for the reference. Use the **red cursor** to indicate the cutoff frequency F_{low} and the **blue cursor** to indicate the cutoff frequency F_{high}.

   * **Print the jpeg** - title the print; label the maximum gain, cutoff frequencies, and passband; clearly indicate where C_1 and C_2 are open circuits and where C_1 and C_2 are short circuits; write yuor name(s) on the print; attach the print to the data sheet.

5. (5 points) Shut down Windows, return cables to racks, return parts to bins, return adapters to container, turn off power, clear bench, and place seat under bench.

ECE 3254 Lab 8 Data Sheet **Date______________** **Bench_________**
100 points total
Names: __________________________ ________________________ ________________________
by first name: 3^{rd} alphabetically – wiring 1^{st} alphabetically – Labview 2^{nd} alphabetically– data sheet

PART I: **INVERTING OP-AMP FILTER**

2. **Data Table 10-1** (Lowpass Filter)

Frequency (Hz)	V_{in} (V_{pp})	V_{out} (V_{pp})	Gain (dB)	V_{out} Phase (°)
10				
20				
100				
200				
1,000				
2,000				
10,000				

3. **Output V_{max} = ________Vrms, Max Gain = __________dB, Cutoff Freq = _____________**

From the Prelab: V_{Out} max (passband) = ____________ Cutoff Freq = _____________

***How well does your filter compare to the expected results?**

PART II: **THE NON-INVERTING OP-AMP FILTER**

2. **Data Table 10-2** (Highpass Filter)

Frequency (Hz)	V_{in} (V_{pp})	V_{out} (V_{pp})	Gain (dB)	V_{out} Phase (°)
10				
20				
100				
200				
1,000				
2,000				
10,000				

PART II: (cont)

3. **Output V_{max} = ________Vrms, Max Gain = _________dB, Cutoff Freq = ______________**

From the Prelab: V_{Out} max (passband) = ____________ Cutoff Freq = _____________

How well does your filter compare to the expected results?

PART III: CASCADED OP-AMP FILTER

2. **Data Table 10-3** (Passband Filter)

Frequency (Hz)	V_{in} (V_{pp})	V_{out} (V_{pp})	Gain (dB)	V_{out} Phase (°)
10				
20				
100				
200				
1,000				
2,000				
10,000				

3. ***From Pspice:*** V_{max} = _______________Vrms, Max Gain = ______________dB

Low Cutoff Freq = _______________, High Cutoff Freq = _______________

Measured : Output V_{max} = _____________Vrms, Max Gain = ____________dB

Low Cutoff Freq = _______________, High Cutoff Freq = _______________

How do the measurements compare to the Pspice simulation?

How do the measurements for dB_{max}, f_{low}, and f_{high} compare to [High Pass dB_{max} + Low pass dB_{max}], f_{low} and f_{high} from Parts I and II?

Why are these values (flow, fhigh and the gain sum) different?