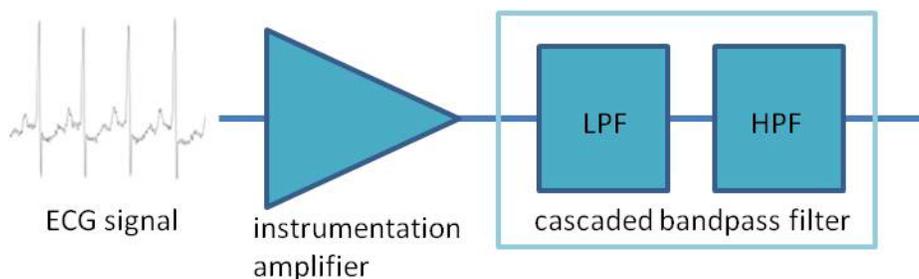


Lab 8 Prelab

The prelab is required in order to perform the lab. Complete this prelab before attending the lab and show the completed materials to the TA at the beginning of your lab.

For Lab 8, we will be designing filters using a different opamp chip, the UA747. This chip contains two identical UA741 opamps, allowing you to build a simple cascade bandpass filter with a single chip. A datasheet for the UA741 is posted on the class website. To perform SPICE simulations for the UA741, you should use the .subcircuit definition provided on the next page rather than the previous .subcircuit for the OP467. This subcircuit is also posted on the website as a .txt file.

Following the steps below, use the examples and information provided in the background section of Lab 8 to design your own low pass, high pass, and cascaded bandpass filters suitable for your Lab 6-7 instrumentation amplifier. The bandpass filter will be connected as shown below and used in this lab to record ECG signals. You should design for an input ECG signal with a maximum amplitude of about **30mV** and information content in the **0.5 – 180Hz** frequency range.



1. Considering your instrumentation amplifier has been designed to provide a gain of 30 V/V, determine what gain your passband filter should provide so that they do not saturate the output when the input ECG signal is at its maximum value. Assume the filters are connected to a 0-10V power supply and that your output should remain within 1 – 9 V (because most amplifiers cannot function correctly all the way to the supply voltage). Use the equation below to calculate filter gain.

$$\text{max_output_swing} = \text{max_input_amplitude} * \text{amplifier_gain} * \text{filter_gain}$$

Next, consider that the filter gain will be split between the low pass and high pass filters. Round the filter gain *down* to an even integer value and assign $\frac{1}{2}$ of this gain to low pass and $\frac{1}{2}$ to high pass filter circuits. Record your calculated (max) filter gain and the rounded gain values assigned to each of the two filter circuits. Turn these in with your circuit sketch and SPICE plots below.

2. Using the low and high pass filter circuits shown in the Lab 8 Background, calculate all the R and C values to provide the gain and bandwidth needed for recording ECG signals. Sketch a circuit diagram for both high and low pass filters and label component values to match your hand calculations. Remember to choose reasonable R and C values that can be implemented with components in the lab: $R = \{100\Omega - 10M\Omega\}$, $C = \{1pF - 1\mu F\}$.
2. Implement your low and high pass filter designs in SPICE and test the frequency response to see if your gain and cutoff frequencies are correct. Adjust your circuit as necessary to achieve desired performance. Print the frequency response plots for the final low and high pass filters.
3. In SPICE, combine the low and high pass filters to form a cascade bandpass filter (see figure above). Test the frequency response to see if your gain and cutoff frequencies are correct, and adjust your circuit as necessary to achieve desired performance. Print the frequency response plot for the bandpass filter, adding labels for passband gain and upper and lower -3dB frequencies.
4. In SPICE, combine the bandpass filter with your instrumentation amplifier from Lab 6 prelab, with the filter following the output of the instrumentation amplifier. Note, you will have two different opamp models in your SPICE netlist, but that should not be a problem. Simulate the frequency response and measure the passband gain and upper and lower -3dB frequencies. Once everything is working correctly, print the frequency response plot and label the measured characteristics.

```

* UA741 OPERATIONAL AMPLIFIER "MACROMODEL" SUBCIRCUIT
* CONNECTIONS: NON-INVERTING INPUT
*      | INVERTING INPUT
*      || POSITIVE POWER SUPPLY
*      ||| NEGATIVE POWER SUPPLY
*      |||| OUTPUT
*      |||||
.SUBCKT UA741 1 2 3 4 5
*
C1 11 12 4.664E-12
C2 6 7 20.00E-12
DC 5 53 DX
DE 54 5 DX
DLP 90 91 DX
DLN 92 90 DX
DP 4 3 DX
EGND 99 0 POLY(2) (3,0) (4,0) 0 .5 .5
FB 7 99 POLY(5) VB VC VE VLP VLN 0 10.61E6 -10E6 10E6 10E6 -10E6
GA 6 0 11 12 137.7E-6
GCM 0 6 10 99 2.574E-9
IEE 10 4 DC 10.16E-6
HLIM 90 0 VLIM 1K
Q1 11 2 13 QX
Q2 12 1 14 QX
R2 6 9 100.0E3
RC1 3 11 7.957E3
RC2 3 12 7.957E3
RE1 13 10 2.740E3
RE2 14 10 2.740E3
REE 10 99 19.69E6
RO1 8 5 150
RO2 7 99 150
RP 3 4 18.11E3
VB 9 0 DC 0
VC 3 53 DC 2.600
VE 54 4 DC 2.600
VLIM 7 8 DC 0
VLP 91 0 DC 25
VLN 0 92 DC 25
.MODEL DX D(IS=800.0E-18)
.MODEL QX NPN(IS=800.0E-18 BF=62.50)
.ENDS

```

Lab 8 Grading Sheet

PARTNER NAMES: _____

Exercise 1**Low Pass Filter**Step 7

Output voltage: _____, Gain (pass band): _____, Frequency: _____

Step 8

Output voltage @ -3dB: _____, -3dB frequency: _____

Step 9

Unity gain bandwidth: _____

High Pass FilterStep 10

Output voltage: _____, Gain (pass band): _____, Frequency: _____

Output voltage @ -3dB: _____, -3dB frequency: _____

Unity gain bandwidth: _____

Band Pass FilterStep 11

Passband Gain: _____, upper -3dB freq.: _____, lower -3dB freq.: _____

Bandwidth: _____, Q-factor: _____, Damping factor: _____,

Exercise 1: TA Check off: _____

Exercise 2

ECG Signal from Function Generator

LabVIEW SetupStep 9

Exercise 2a: TA Check off: _____

Step 12

Exercise 2b: TA Check off: _____