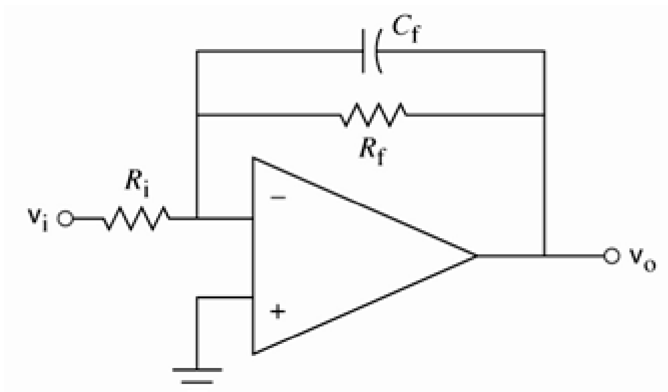
Homework 4 **ECE 445 Biomedical Instrumentation, Fall 2012**

Due: Monday Oct 22

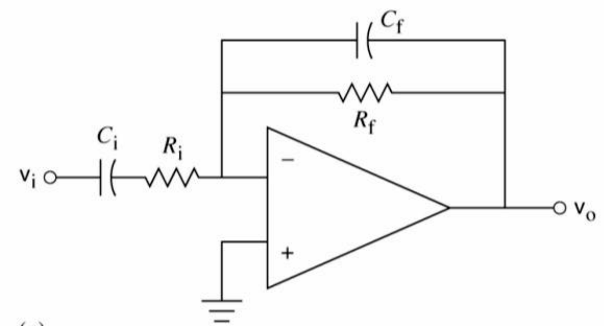
1. Using the amplifier circuit shown below, determine the values of Cf, Rf, and Ri for a low pass filter with a cutoff (-3dB) frequency of 50kHz and a DC gain of 50 (~34dB). Choose values of R and C that are "reasonable" for practical use, that is R = {100Ω – 10MΩ}, C = {1pF – 1μF}



2. Use a SPICE simulator to simulate your circuit from Problem 1. Plot the frequency response (v_o/v_i) for a 1mV sinusoidal input ranging from 1Hz and 100kHz with the amplitude (y-axis) in dB scale. Measure the passband gain and the -3dB frequency and comment on how well they compare to your goals from Problem 1. What is the unity gain (0dB) frequency of your final design? Print a plot of the frequency response.
   For the opamp, use the subcircuit model below for the OP467. You may want to start with the example netlist .txt file from Lab 6 that includes the subcircuit model. Use a power supply of 10V (either ±5V or 0 to 10V), but be sure to set your analog ground –the "ground" point in the schematic above- to the middle of the supply voltages. The example netlist below creates a 10V single supply system with a 5V analog ground.

   Turn in a copy of the final netlist and frequency response plot with all important data labeled.

3. Using the bandpass amplifier circuit shown below, calculate the values of C_i, C_f and R_f that will give a low pass cutoff at 80kHz, a high pass cutoff at 60Hz, and a DC gain of 40 (~32dB). For hand calculations, assume the high and low cutoffs are determined entirely by R_fC_f and R_iC_i, respectively and that the gain is determined by R_f/R_i. To begin, use the value $\mathbf{R_i = 500\Omega}$.
   Like in Problem 1, choose values of R and C that are reasonable for practical use



$$\frac{V_o(j\omega)}{V_i(j\omega)} = -\frac{R_f}{R_i}\frac{j\omega R_f C_i}{(1+j\omega R_f C_f)(1+j\omega R_i C_i)}$$

4. Using the subcircuit and power supply setup described in Problem 2, construct a SPICE simulation of the bandpass filter in Problem 3. Simulate and plot the frequency response using the circuit values you calculated in Problem 3. Measure the passband gain and the high and low -3dB frequencies and comment on how well they compare to your goals from Problem 3. Turn in your simulation plot, but you do not need to turn in the netlist.

FYI: You can get a free SPICE simulator at:
PSpice (same as installed in DECS labs): http://www.engr.uky.edu/~cathey/pspice061301.html or http://www.electronics-lab.com/downloads/schematic/013/
LTSpice: http://www.linear.com/designtools/software/#Spice
Good SPICE information at: http://www.ecircuitcenter.com/basics.htm

Subcircuit for OP467.

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****** COPY THIS SUBCIRCUIT MODEL INTO YOUR SPICE NETLIST ***
* OP467 SPICE Macro-model
* Copyright 1993 by Analog Devices
*
* Node assignments
*                 non-inverting input
*                 |  inverting input
*                 |  |  positive supply
*                 |  |  |  negative supply
*                 |  |  |  |  output
*                 |  |  |  |  |
.SUBCKT OP467     1  2  99 50 27
*
* INPUT STAGE
I1    4    50    10E-3
CIN   1    2     1E-12
IOS   1    2     5E-9
Q1    5    2     8     QN
Q2    6    7     9     QN
R3    99   5     185.681
R4    99   6     185.681
R5    8    4     180.508
R6    9    4     180.508
EOS   7    1     POLY(1)  (14,20)  0.2E-3 1
EREF 98    0     (20,0)  1
*
* GAIN STAGE AND DOMINANT POLE AT 1.5KHZ
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R7   10   0    3.714E6
C2   10   0    28.571E-12
G1   0    10   (5,6) 5.386E-3
V1   99   11   1.525
V2   12   50   1.525
D1   10   11   DX
D2   12   10   DX
RC   10   28   1.4E3
CC   28   27   12E-12
*
* COMMON MODE STAGE WITH ZERO AT 1.26KHZ
ECM  13   98   POLY(2) (1,20) (2,20) 0 0.5 0.5
R8   13   14   1E6
R9   14   98   25.119
C3   13   14   126.721E-12
*
* POLE AT 400E6
R10  15   98   1E6
C4   15   98   0.398E-15
G2   98   15   (10,20) 1E-6
*
* OUTPUT STAGE
ISY  99   50   -8.156E-3
RMP1 99   20   96.429E3
RMP2 20   50   96.429E3
RO1  99   26   200
RO2  26   50   200
L1   26   27   1E-7
GO1  26   99   (99,15) 5E-3
GO2  50   26   (15,50) 5E-3
G4   23   50   (15,26) 5E-3
G5   24   50   (26,15) 5E-3
D5   99   23   DX
D6   99   24   DX
D7   50   23   DY
D8   50   24   DY
*
* MODELS USED
.MODEL QN NPN(BF=33.333E3)
.MODEL DX D
.MODEL DY D(BV=50)
.ENDS
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