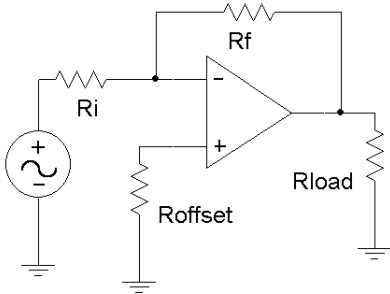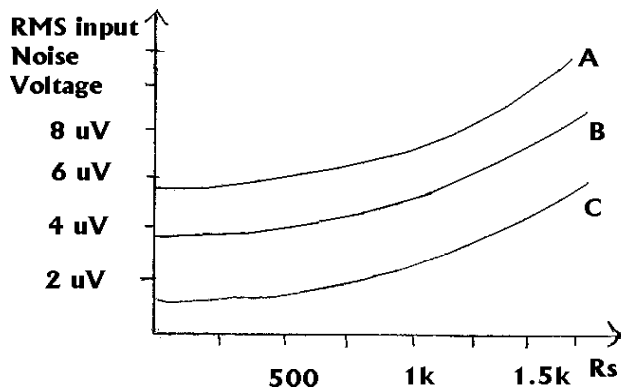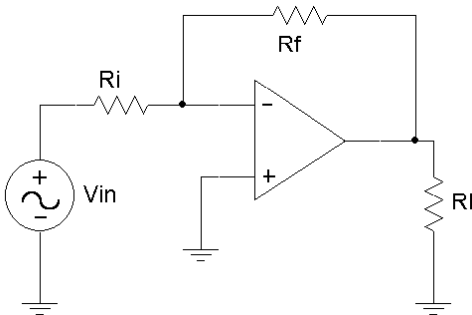# Op Amp Circuits Practice 2

1. For the circuit below determine an optimum value for R_{offset} to minimize offset and drift. Determine the output offset voltage if V_{os}=3mV and I_{os}=100nA. R_i=2k, R_f=40k, R_{load}=20k.

2. For the circuit below, determine the approximate input noise voltage and output noise voltage. If the nominal signal output is 1 lt RMS, determine the signal-to-noise ratio in dB. Ri=1k, Rf=10k, Rl=20k, F_{unity}=1.5MHz. Bandwidths: Curve A = 20Hz-150kHz, curve B = 50Hz-50kHz, curve C = 100Hz-10kHz

3. Determine the input impedance and gain of each channel of the circuit below. R1=10k, R2=2k, R3=5k, Rf=20k.
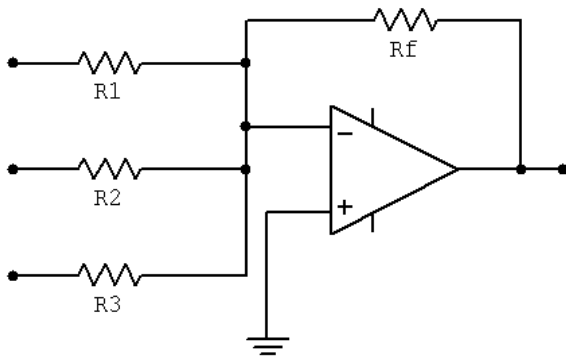

4. Design a unity gain 5 kHz 4th order Butterworth low pass filter.

Op Amp Circuits Practice 2   **Answers**

1. Roffset = Ri||Rf = 2k||40k = 1.9k
Anoise = 1+Rf/Ri = 1+40k/2k = 21
Vout-offset = Vos*An + Ios*Rf
Vout-offset = 3mv*21 + 100nA*40k = 63mV + 4mV = 67mV

2. Anoise = 1+Rf/Ri = 1+10k/1k = 11
f2 = funity/Anoise = 1.5MHz/11 = 136kHz
Rs is Ri for this circuit, 1k. Curve A is the closest to the desired
136kHz (this curve would be just below A so you might wish to imagine
this curve). The corresponding input noise would be around 6.5uV.
Vout-noise = Anoise*Vin-noise = 11*6.5uV = 71.5uV
S/N = Vout/Vout-noise = 1V/71.5uV = 13.99E3 = 82.9 dB

3. The input impedance of each channel is set by the associated input
resistor. The gain of each channel is set by Rf/inputR. Thus,
Channel 1: A = -20k/10k = -2, Zin = 10k
Channel 2: A = -20k/2k = -10, Zin = 2k
Channel 3: A = -20k/5k = -4, Zin = 5k

More channels may be added in a similar fashion. Non-inverting summers
are also possible. One way is to simply add inverting stages to the
inputs (i.e, invert the inversion). Gain is best adjusted via separate
pots (such as an output volume control) rather than replacing Rf or
the input resistors directly with pots.

4. For Butterworth, f_c=f_{3dB}(i.e., 5kHz). 4th order unity gain LP will
require two second order sections of the type found on page 433 (Fig
11.14). From the table on page 445, the damping factor for the first
section is 1.848, and for the second section .765. Therefore for the
first section, C1=1.082F and C2=.924F. For the second section,
C1=2.614F and C2=.3825F. The frequency scaling factor is 2pi5000 =
31,416. To raise f, decrease R or C. Therefore, C1=34.4uF, C2=29.4uF
for the first section and for the second, C1=83.2uF and C2=12.2uF. For
practical impedances, scale R up and C down by the same factor. 10k
would be convenient and reasonable. Therefore, all Rs are 10k (except
the feedback resistors which would be 20k, if used). The caps are
C1=3.44nF, C2=2.94nF and for stage two C1=8.32nF and C2=1.22nF. Of
course, in order to use standard values, the R and C values may need
to be adjusted slightly (R and C are adjusted by inverse factors, i.e.
if C is increased by 10% then R is decreased by 10%).