NANYANG TECHNOLOGICAL UNIVERSITY
SCHOOL OF ELECTRICAL & ELECTRONIC ENGINEERING
EE4341 ADVANCED ANALOG CIRCUITS
TUTORIAL 4

1. A signal source with v_s = 5 mV will be connected to the amplifier circuit designed with op amp. Assume an equivalent noise bandwidth of 20 kHz for the amplifier circuit (ideal LPF type). Boltzmann's constant k = 1.38 $\times$ 10^{-23} J/K and T = 300 K.

   (a) The μA741 op amp is chosen to design a non-inverting amplifier as shown in Fig. 1(i). The signal source V_s is connected to the non-inverting input through R_3 = 600 Ω. What is the total equivalent rms noise voltage present at the non-inverting input of the op amp? Determine the SNR. What is the SNR if the same μA741 op amp is used as an inverting amplifier as shown in Fig. 1(ii)? The required voltage gain of the inverting amplifier = 10. The equivalent input noise parameters of μA741 op amp are: $\overline{v_n^{\,2}} = 8\times10^{-16}\ \mathrm{V^2/Hz},\ \overline{i_n^{\,2}} = 9\times10^{-25}\ \mathrm{A^2/Hz}$.

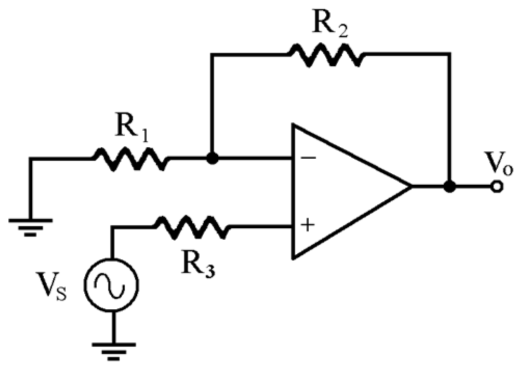

Fig. 1(i)

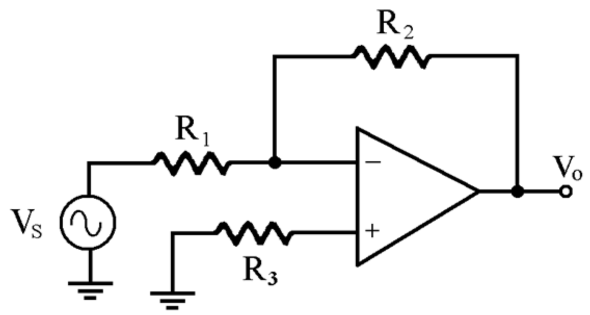

Fig. 1(ii)

   (b) Repeat part (a) if SE5534 op amp is used instead? Given that the input noise parameters of SE 5534: $\overline{v_n^{\,2}} = 16\times10^{-18}\ \mathrm{V^2/Hz},\ \overline{i_n^{\,2}} \approx 0\ \mathrm{A^2/Hz}$.

2. The circuit shown in Fig. 2 is designed to give an output $v_o = 2(v_1 - v_2 - v_3)$, where v_1, v_2 and v_3 are the inputs for the circuit. If $R_1 = R_3 = 10\ \text{k}\Omega$, determine the values of resistors R_2, R_4 and R_F. What are the rms output noise voltage and peak-to-peak output noise voltage of the amplifier above 1 Hz? The op amp has a gain-bandwidth (GBW) product of 10^6 (Note: GBW = -3dB bandwidth of the amplifier multiplies mid-band voltage gain of the amplifier). Boltzmann's constant k = 1.38 $\times$ 10^{-23} J/K and T = 300 K. The equivalent input voltage and current noise spectral densities for the op amp are:

$$\overline{v_n^2} = e_{nw}^2\left(\frac{f_{ce}}{f}+1\right)\ \text{V}^2/\text{Hz}$$, where e_{nw} = 20nV/√Hz and f_{ce} = 200 Hz

$$\overline{i_n^2} = i_{nw}^2\left(\frac{f_{ce}}{f}+1\right)\ \text{V}^2/\text{Hz}$$, where i_{nw} = 0.5pA/√Hz and f_{ci} = 2000 Hz

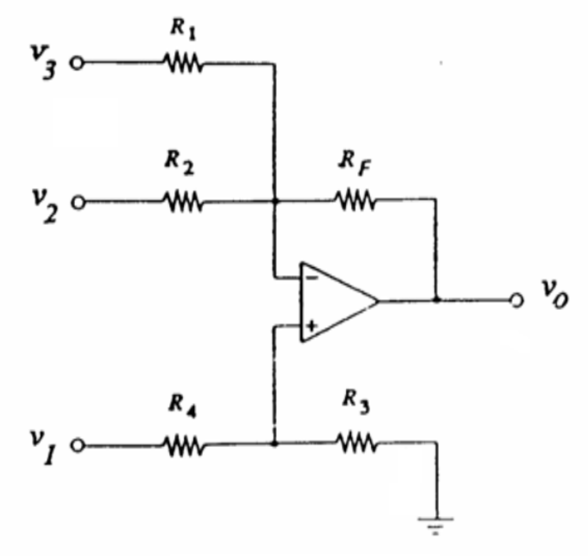

Fig. 2

Q1 Answer:

(a) Fig. 1(1) circuit: Eni = 4.05 µV, SNR = 61.8dB;
Fig. 1(2) circuit: Eni- = 4.46 µV, SNR = 61dB.
(b) Fig. 2(1) circuit: Eni = 0.85 µV, SNR = 75.4dB;
Fig. 2(2) circuit: Eni- = 0.94 µV, SNR= 74.5 dB.

Q2 Answer:

R2 = 10 Kohm, R4 = 15 Kohm, RF= 20 Kohm;
Eno = 67.64 µV; Eno, p-p = 0.45 mV.