The University of Sheffield
Department of Electronic and Electrical Engineering

EEE123 - Problem Sheet

Operational Amplifiers

Q1 If R_2 = 75kΩ and R_1 = 15kΩ and $A_v \Rightarrow \infty$, evaluate the gain of the non-inverting amplifier circuit of figure 1. (6)

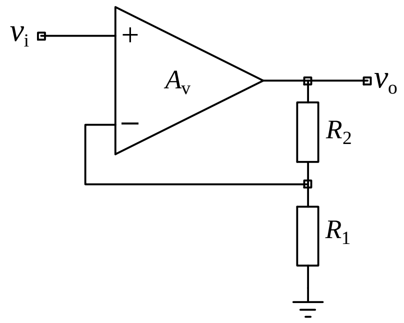

Figure 1

Q2 Show that for the circuit of figure 1, the effect of A_v on gain is given by:

$$\frac{v_o}{v_i} = \frac{1}{\left[\dfrac{1}{A_v} + \dfrac{R_1}{R_1 + R_2}\right]} = K$$

Under normal circumstances, one would assume that since the op-amp gain, A_v, is very large, the circuit gain, K, is controlled only by the resistors R_1 and R_2. If $A_v = 10^5$V/V, estimate the percentage error in gain caused by using the above assumption for:

a) $R_2 = 9R_1$ (ie. a nominal gain of 10V/V). (0.01%)

b) $R_2 = 299R_1$ (ie. a nominal gain of 300V/V). (0.3%)

Q3 Show that providing $A_v \Rightarrow\infty$ can be assumed, the gain of the inverting amplifier circuit of figure 3 is $\dfrac{v_o}{v_i} = -\dfrac{R_F}{R_1}$.

What is a virtual earth point and why does it exist? At which node is the virtual earth point in figure 3?

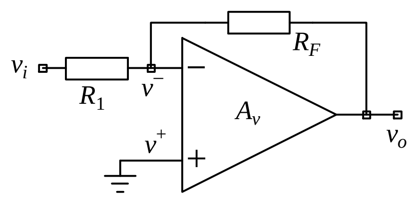

Figure 3

Q4 For the subtractor circuit of figure 4 show that:

$$v_o = \frac{R_2}{R_1}(v_2 - v_1) \qquad \text{for } A_v \Rightarrow\infty$$

(Use superposition to work out first v_o due to v_1, then v_o due to v_2, then add the two to get total v_o and rearrange to get the form given)

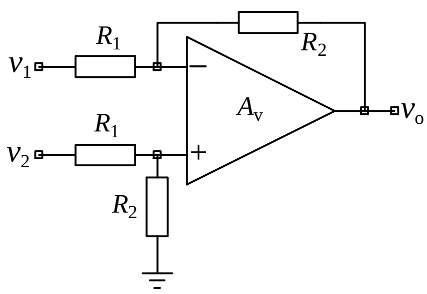

Figure 4

Q5 The three input voltages for the circuit of figure 5 are:

$v_1 = 0\text{V}$
$v_2 = 5\text{V}$
$v_3 = (15 \sin \omega t + 10)\text{V}$

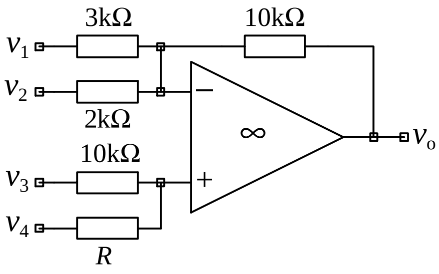

Figure 5

(i) Find values for R and the d.c. voltage v_4 that will give $v_o = (5 \sin \omega t + 0)\text{V}$. ($R = 370\Omega$, $v_4 = +2.4\text{V}$)

and for those who fancy a challenge . . .

(ii) If v_2 and v_3 have the values specified and v_4 and R are as calculated in part **(i)**, what are the upper and lower limits to the range of voltage allowed for v_1 if $|v_o| \leq 10\text{V}$ must be satisfied at all times? ($v_1 = \pm 1.5\text{V}$)

(Once again, superpostion is a useful tool here for part (i). You can also consider the ac and dc parts of the problem separately. It is easier to start by considering the ac part of the problem since this is affected by R but not by the dc voltage v_4. The dc behaviour, on the other hand, is affected by both R and v_4.)

(fathoming out part (ii) for yourselves is part of the challenge!)