**The University of Sheffield**

**Department of Electronic and Electrical Engineering**

## EEE118 Problem Sheet

# Operational Amplifiers

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

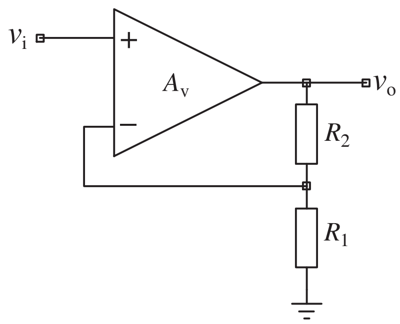


**Figure 1**

**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?

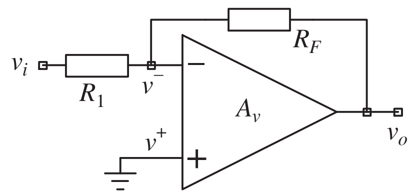


**Figure 3**

**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)*

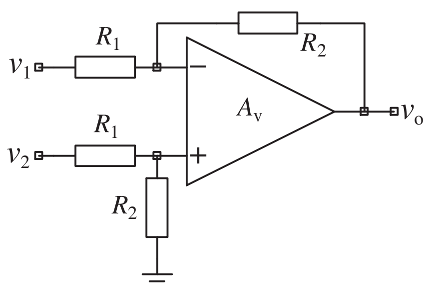


**Figure 4**

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

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

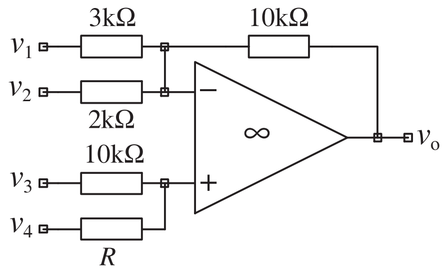


**Figure 5**

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

**AND FOR EXPERTS**

**(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 $v_4$.)*

*(The experts can fathom out part (ii) for themselves!)*