# ESC201A EndSem Part 2

RAGHAV SHUKLA

TOTAL POINTS

**10.5 / 19**

QUESTION 1

## Q1 9 pts

### *1.1* 1(a) **1 / 3**

+ **+ 3 pts** Completely Correct
+ **+ 0 pts** Completely Incorrect
+ **+ 0 pts** Not Attempted
+ **+ 0 pts** Copied

✓ **+ 1 pts** *DC Equivalent circuit correctly found*

+ **+ 1 pts** Transistor currents correctly found
+ **+ 1 pts** Collector voltage correctly found

### *1.2* 1(b) **0.5 / 6**

+ **+ 6 pts** Completely Correct
+ **+ 0 pts** Completely Incorrect
+ **+ 0 pts** Not Attempted
+ **+ 0 pts** Copied
+ **+ 3 pts** Transistor currents correctly found
+ **+ 1.5 pts** RE correctly calculated
+ **+ 1.5 pts** R2 correctly calculated

**+ 0.5** *Point adjustment*

QUESTION 2

## Q2 10 pts

### *2.1* 2(a) **5 / 6**

+ **+ 6 pts** Completely Correct
+ **+ 0 pts** Completely Incorrect
+ **+ 0 pts** Not Attempted
+ **+ 0 pts** Copied
+ **+ 2 pts** Desirable circuit schematic correctly drawn

✓ **+ 1 pts** *Feedback resistance correctly found*

✓ **+ 1.5 pts** *Resistors corresponding to source v1 correctly found*

✓ **+ 1.5 pts** *Resistors corresponding to source v2 correctly found*

**+ 1** *Point adjustment*

### *2.2* 2(b) **4 / 4**

✓ **+ 4 pts** *Completely Correct*

+ **+ 0 pts** Completely Incorrect
+ **+ 0 pts** Not Attempted
+ **+ 0 pts** Copied
+ **+ 1 pts** Bias state of diodes correctly found
+ **+ 1.5 pts** Vo1 correctly found
+ **+ 1.5 pts** Vo2 correctly found

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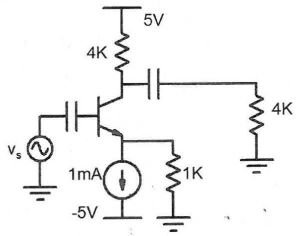
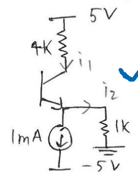
**1 (a). Carry out dc analysis to determine collector voltage for the circuit shown below. Assume that current gain $\beta_F$ =100. [3]**



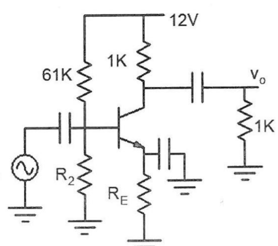

In DC analysis, we turn off all AC sources and treat capacitors as opens. We obtain the following circuit -




$5 - (4\times10^3) i_1 - V_{CE} - 10^3 i_2 = 0$

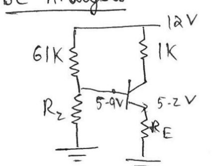
$i_2 + 10^{-3} = i_1$

**1 (b). Determine suitable values for resistances $R_E$ and $R_2$ so as to obtain a voltage gain of for the amplifier shown. Assume that dc value of base voltage is 5.9V , transistor is in forward active mode, thermal voltage $V_T$ = 0.026V and $\beta_F$ =100. [6]**




$A_v = -50$

DC Analysis




$I_E = \frac{5.2V}{R_E}$

$I_B = \left(\frac{12-5.9}{61K}\right) - \left(\frac{5.9}{R_2}\right)$

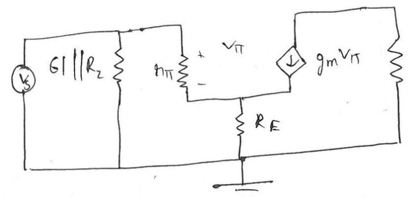
$I_C = 100\left(\left(\frac{6.1}{61K}\right) - \frac{5.9}{R_2}\right)$

We get $I_C + I_B = I_E \Rightarrow 101\left(0.1 - \frac{5.9}{R_2}\right) = \frac{5.2}{R_E}$

$R_2$ & $R_E \to k\Omega$

In AC analysis, we use small signal model, $r_\pi = \frac{\beta}{g_m}$

$g_m = \frac{I_C}{V_T}$




$R_C = 1||1 = \frac{1}{2}$

We find $A_v = \frac{+g_m R_C}{1+g_m\left(1+\frac{1}{\beta}\right)R_E} = +50$

$\Rightarrow g_m = 100\left(1+g_m\left(1+\frac{1}{100}\right)R_E\right)$

$\Rightarrow \boxed{g_m = 100 + 101\, g_m R_E}$

$g_m = \frac{I_C}{V_T} = 100\left(0.1 - \frac{5.9}{R_2}\right)\times\frac{1}{0.026}$

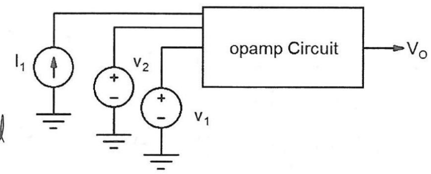
$\Rightarrow \cancel{100}\left(0.1-\frac{5.9}{R_2}\right)\times\frac{1}{0.026} = \cancel{100}\,1 + 101 \times \cancel{100}\left(0.1-\frac{5.9}{R_2}\right)\times\frac{R_E}{0.026}$

$\Rightarrow \left(\cancel{R_E}\right)\left(\frac{5.2}{R_E}\right)\times\frac{1}{0.026}\times\frac{1}{101} = 1 + \cancel{101}\times\left(\frac{5.2}{\cancel{R_E}}\times\frac{1}{\cancel{101}}\right)\frac{\cancel{R_E}}{0.026}$

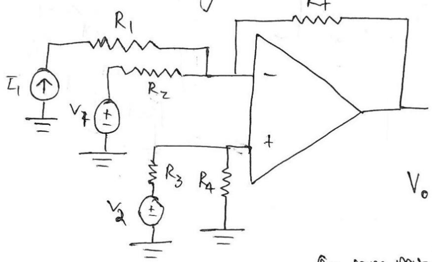
$\Rightarrow \cancel{\frac{5.2}{R_E}\times 1}\ \frac{200}{101 R_E} = 1 + 200 \Rightarrow R_E = \frac{200}{101\times2001}$

$= 9.8517\times10^{-3}\ k\Omega$

2(a). Design an opamp circuit that would produce the output voltage $V_O = -2 \times 10^3 I_1 - 2v_1 + v_2$, where $I_1$, $v_1$ and $v_2$ are input current and input voltages respectively as shown below. Assume ideal opamp characteristics and use only one opamp. [6]




Since coefficients of $I_1$ and $v_1$ are negative, they will be connected to inverting terminal. $v_2$ will be connected to non-inverting terminal.




$V_o$ can be found by superposition.

$$V_o = -R_f I_1 - \left(\frac{R_f}{R_2}\right)v_1 + \left(1+\frac{R_f}{R_2}\right)\left(\frac{R_4}{R_3+R_4}\right)v_2$$

On comparing with the expression given,

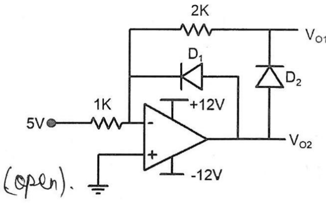
$R_f = +2\times10^3\ \Omega = \boxed{2k\Omega}$

$\frac{R_f}{R_2} = 2 \Rightarrow R_2 = 10^3\ \Omega = \boxed{1k\Omega}$

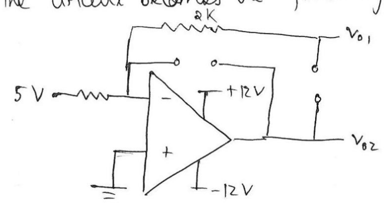
$\left(1+\frac{R_f}{R_2}\right)\left(\frac{R_4}{R_3+R_4}\right) = 1 \Rightarrow \frac{R_4}{R_3+R_4} = \frac{1}{3}$

Set $\boxed{R_4 = 1k\Omega}$, $\boxed{R_3 = 2k\Omega}$

2(b). Assuming ideal opamp and ideal diodes, determine output voltage $V_{O1}$ and $V_{O2}$. Note that opamp supply voltages are ±12V. [4]




Here, the 5V will attempt to force current into circuit.
However, the current encounters 2 diodes in reverse bias.
No current will flow through them (open).
The circuit becomes the following




$\Rightarrow V_{o1} = 5\text{ V}$ (Directly connected)

$\Rightarrow V_{o2} = -12\text{V}$

The opamp is in open loop mode and goes into saturation (comparator)