ESC201A EndSem Part 2

SHIV NARAYAN

TOTAL POINTS

12.5 / 19

QUESTION 1

Q1 9 pts

1.1 1(a) **3 / 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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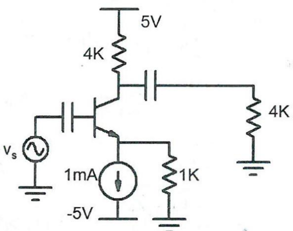
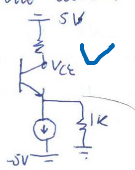
1 (a). Carry out dc analysis to determine collector voltage for the circuit shown below. Assume that current gain β_F =100. [3]



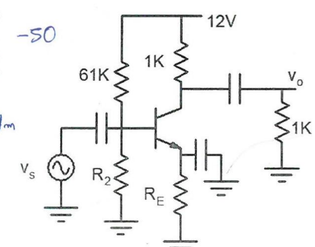
DC Analysis Battery ≡ short circuit
capacitor ≡ open circuit

Clearly there is no current in the Base terminal of BJT ⇒ BJT is in cutoff mode. Hence no current flows.



Hence $V_{collector} = 5V$

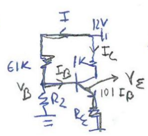
1 (b). Determine suitable values for resistances R_E and R_2 so as to obtain a voltage gain of -50 for the amplifier shown. Assume that dc value of base voltage is 5.9V , transistor is in forward active mode, thermal voltage V_T = 0.026V and β_F =100. [6]



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

$r_\pi = \frac{\beta}{g_m} = \frac{V_T}{I_B}$

Doing DC Analysis



$I_C = 100 I_B$

$I = \frac{12-V_B}{61K} = I_B + \frac{V_B}{R_2}$

$V_E = 101 I_B R_E$

KVL (through by pencil path)

$-12 + I \times 61K + 0.7 + 101 I_B R_E = 0$

$I_C = 50 \times V_T = 50 \times 0.026 = 1.3$

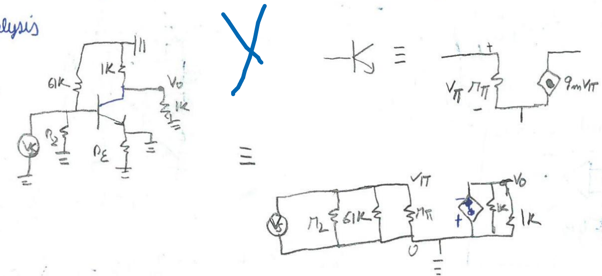
$0.7 + 101 I_B R_E = V_B$

$I_B = \frac{1.3}{100} A$

$V_B = 5.9V$ (Given)

$5.9 = 0.7 + 101 \times \frac{1.3}{100} R_E \Rightarrow R_E = 3.96\Omega$

AC Analysis



$V_o = -g_m V_\pi \Rightarrow -g_m V_s$

$-\frac{V_s}{V_o} = +g_m$

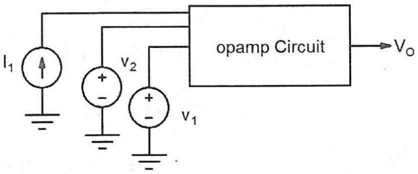
$g_m = +50 \Rightarrow g_m = -50$

$I_B + \frac{V_B}{R_2} = I \Rightarrow \frac{1.3}{100} + \frac{5.9}{R_2} = I$

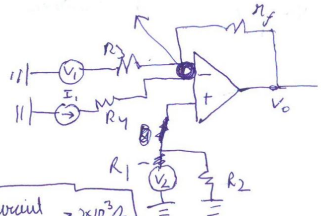
$I = \frac{12-V_B}{61K} \Rightarrow \frac{12-5.9}{61K} = \frac{1.3}{100} + \frac{5.9}{R_2}$

$R_2 = 453.84\Omega$

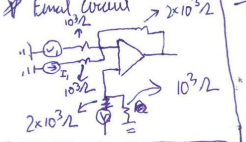
2(a). Design an opamp circuit that would produce the output voltage $V_O = -2 \times 10^3 I_1 - 2v_1 + v_2$, where I_1, v_1 and v_2 are input current and input voltages respectively as shown below. Assume ideal opamp characteristics and use only one opamp. [6]



same point

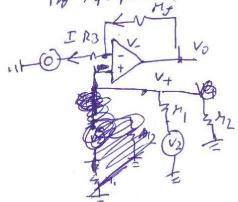


Final circuit



$\Rightarrow V_0 = \frac{V_2 R_2}{R_1+R_2}\left(1+\frac{R_f}{R_3}\right)$

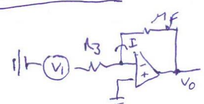
By superposition



$V_+ = V_- = \frac{V_2 R_2}{R_1+R_2}$

$I \Rightarrow \frac{V_-}{R_3} = I \Rightarrow I = \frac{V_2 R_2}{R_1+R_2} \Rightarrow V_0 = V_-\left(1+ R_f\right)$

Next superposition

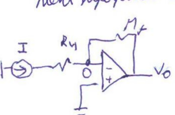


$V_0 \Rightarrow -V_1\left(\frac{R_f}{R_3}\right)$

as $V_- = V_+ = 0$

so $I = \frac{V_1}{R_3}$ & $V_0 = -\frac{V_1 \times R_f}{R_3}$

Next superposition



$V_- = V_+ = 0$

so $V_0 = -I R_f$

summing All V_0's

$V_{net} = \frac{V_2 R_2}{R_1+R_2}\left(1+\frac{R_f}{R_3}\right) - V_1\frac{R_f}{R_3} - IR_F$

Comparing coefficients we get

$-IR_F = -2\times10^3 I$

$\Rightarrow \boxed{R_f = 2\times10^3\,\Omega}$

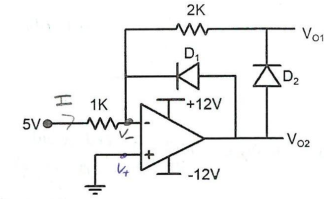
$\frac{R_f}{R_3} = 2 \Rightarrow \boxed{R_3 = 10^3\,\Omega}$

$\frac{R_2}{R_1+R_2}\left(1+\frac{R_f}{R_3}\right) = 1 \Rightarrow \frac{3R_2}{R_1+R_2} = 1$

$\boxed{2R_2 = R_1}$ Only ratio important

R_2 ... can be any value $\boxed{R_2 = 10^3\,\Omega}$ $\boxed{R_1 = 2\times10^3\,\Omega}$

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



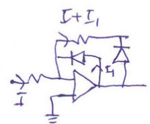
Assuming Virtual ground property

$V_- = V_+ = 0$

So the value of I is $\frac{5}{10^3}$ A

Case I

assume D_1 is forward biased



$\Rightarrow$ $I+I_1 > 0$

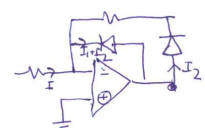
$V_{O2} = V_- = 0$

but this makes D_2 reverse biased hence no current can flow through D_2 hence D_1 forward biased

∴ Not possible

Case II

assume D_2 is forward



$V_{O1} = V_{O2}$ but $I_1+I_2 > 0$ hence D_1 is reverse biased so not possible

So Both diodes are reverse biased and no current flows $\Rightarrow$ $V_{O1} = V_- = 5V$

$V_{O2} = -12V$ (since opamp will be inversely saturated)