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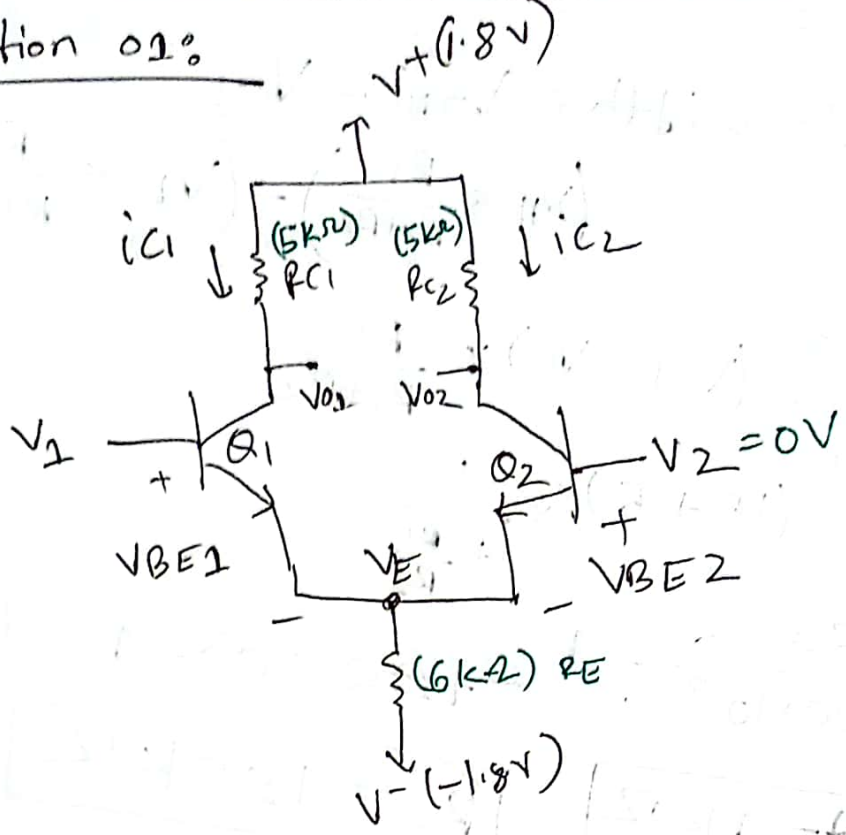
CSE 350
HW5

Question 01:



(Q1, Q2 circuit symmetrical)

if $V_1 = 0V$,

$Q_1, Q_2 \rightarrow$ FA (current flow same as $V_1 = 0$, $V_2 = 0$)

So, $V_{BE1} = 0.7V$, So, $V_E = -0.7V$

$$\therefore i_E = \frac{-0.7 - (-1.8)}{6K} = 0.1833\ mA$$

$$\rightarrow i_{C1} = i_{C2} = \frac{i_E}{2} = 0.091667$$

Here, $i_{C1} = \frac{V_+ - V_{O1}}{R_{C1}}$

$$\therefore V_{O1} = V_+ - i_{C1} \times R_{C1}$$

$$= (1.8 - 5 \times 0.091667)$$

$$= 1.341665\ V$$

$V_{O2} = (1.8 - 5 \times 0.091667) = 1.341665\ V$

$V_2 - V_1 > 120mV$, $Q_1 \to C$, $Q_2 \to FA$

if $V_1 = -0.5V$

Here, we know,

if $V_2 - V_1 > 120mV$ then $Q_1 \to$ cutoff, $Q_2 \to FA$

$= 0 + 0.5 \Rightarrow 500mV > 120mV$, so, $Q_1 \to C$, $Q_2 \to FA$

$i_{C1} = 0$, $V_{BE2} = 0.7V$, $V_E = -0.7V$

$\therefore i_E = \frac{-0.7 - (-1.8)}{6K} = 0.1833mA.$

So, $i_{C1} + i_{C2} = i_E$

0

$i_E = i_{C2} = 0.1833mA.$

$V_{O1} = V^+ - i_{C1} \times R_{C1}$

$= 1.8V$

$V_{O2} = 1.8 - (0.1833 \times 5)$

$= 0.8835V.$

if $V_1 = +0.5V$, $Q_1 \to FA$, $Q_2 =$ cutoff.

$i_{C2} = 0$, $V_E = 0.5 - 0.7 = -0.2V$

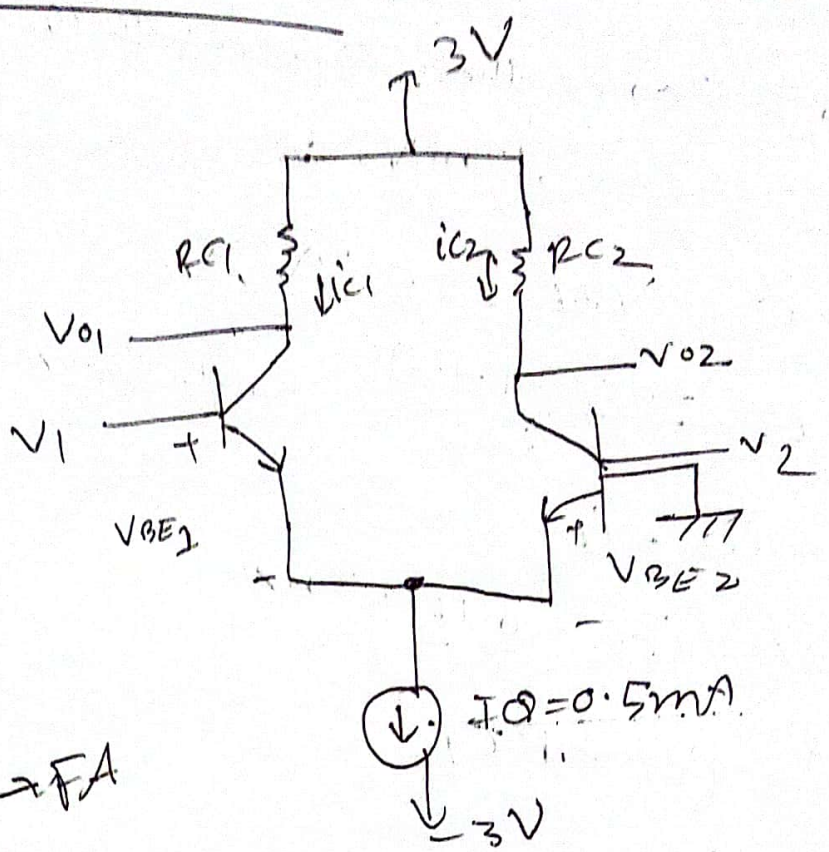
$i_E = \frac{-0.2 - (-1.8)}{6K} = 0.2667$

$i_{C1} = i_E = 0.2667$, $i_{C2} = 0$

$V_{O1} = V^+ - i_{C1} \times R_{C1} = 0.4665V$

$V_{O2} = V^+ - i_{C1} \times R_{C1} = 1.8V$ (Ans)

Question 02:



Q1 → Q_1 cut, Q_2 → FA

Here, V_1 must be $< -120mV$, as $V_{o2} = -1$.

So, obtain $i_{C1} = 0mA$. $I_Q = i_{C1} + i_{C2}$.

$\therefore I_Q = i_{C2} = 0.5mA$

So, $i_{C2} = \frac{3 - V_{O2}}{R_{C2}}$

$\Rightarrow 0.5 \times R_{C2} = (3 + 1)$

$\therefore R_{C2} = 8k\Omega$

For scenario 2,

$V_{o1} = 0V$, when $V_i = 1V$ so, $Q_1 = FA$, $Q_2 \rightarrow Cut$

so, $i_{C2} = 0mA$, $i_{C1} = 0.5mA = IQ$.

$$\therefore \frac{3 - V_{o1}}{R_{C1}} = i_{C1}$$

$$\therefore R_{C1} = 6k\Omega$$

Scenario 3 →

$i_{C1} = 0.3mA$, $i_{C2} = 0.2mA$

$$i_{E1} \propto e^{\frac{V_{BE}}{V_T}}, \quad i_{E2} \propto e^{\frac{V_{BE2}}{V_T}}$$

$$\text{So, } \frac{i_{E1}}{i_{E2}} = \frac{e^{V_{BE1}/V_T}}{e^{V_{BE2}/V_T}} = e^{\frac{V_{BE1} - V_{BE2}}{V_T}}$$

$$\text{So, } V_{BE1} - V_{BE2} = V_{B1} - V_{E1} - V_{BE2} + V_{E2}$$

$$= V_{B1} - V_{B2}$$

$$= V_{B1} - 0 \quad (\text{Given } V_{B2} = GND)$$

$$\frac{0.2}{0.3} = e^{V_{B1}/V_T}$$

$$\Rightarrow \frac{V_{B1}}{V_T} = \ln\left(\frac{0.2}{0.3}\right)$$

$$\therefore V_{B1} = V_T \ln\left(\frac{0.2}{0.3}\right) \quad (V_T = 25.9mV)$$

$$= 25.9 \times \ln\left(\frac{0.2}{0.3}\right)$$

$$= -10.5015463\,mV \quad (\text{Ans:})$$

Question 03:

$Q_5 \rightarrow FA$, $i_1 = 0.5mA$

$$i_1 = \frac{0-(-0.2)}{R_1}$$

$\therefore R_1 = 0.6\,k\Omega$

(1.6V) so, $i_2 = \frac{-1.6-(-3.3)}{R_2}$ $[i_2 = 0.5mA]$.

$\therefore R_2 = 3.2\,k\Omega$

$$i_5 = \frac{(+1)-(-3.3)}{R_5} \quad [i_5 = 0.5mA]$$

$\therefore R_5 = 5.6\,k\Omega$.

Did rough in other way as time sheet for final

Question 4

~~R3 = 1.5~~

in R_3 (I_{R3}) = 1.5 mA

V_R = 2.695 V

when logic '1' value of $V_{O2} = 3$

$V_H = 3$

$V_Y = 3$

I_{RE} = 2.875 mA

I_{RC} = 2.875 mA

V_{B3} = 3.09 V

$P = \Delta V I$ = 27.39 mW

Assume $V_H = V_Y$ - logic 0.

when logic 1 $V_{O1} = 3$,

$V_H = 2.39$, $V_Y = 2.39$

I_{RE} = 2.49, $I_{RC1} = 0$, I_{R2} = 2.49

$V_{B4} = 3.1015$, $P = \Delta V I$ = 26.55

Question 5

$\overline{(AB+CD)}$