Name: SADAF M. ANIS
ID: 20101537
Sec: 11

CSE 350
HW2

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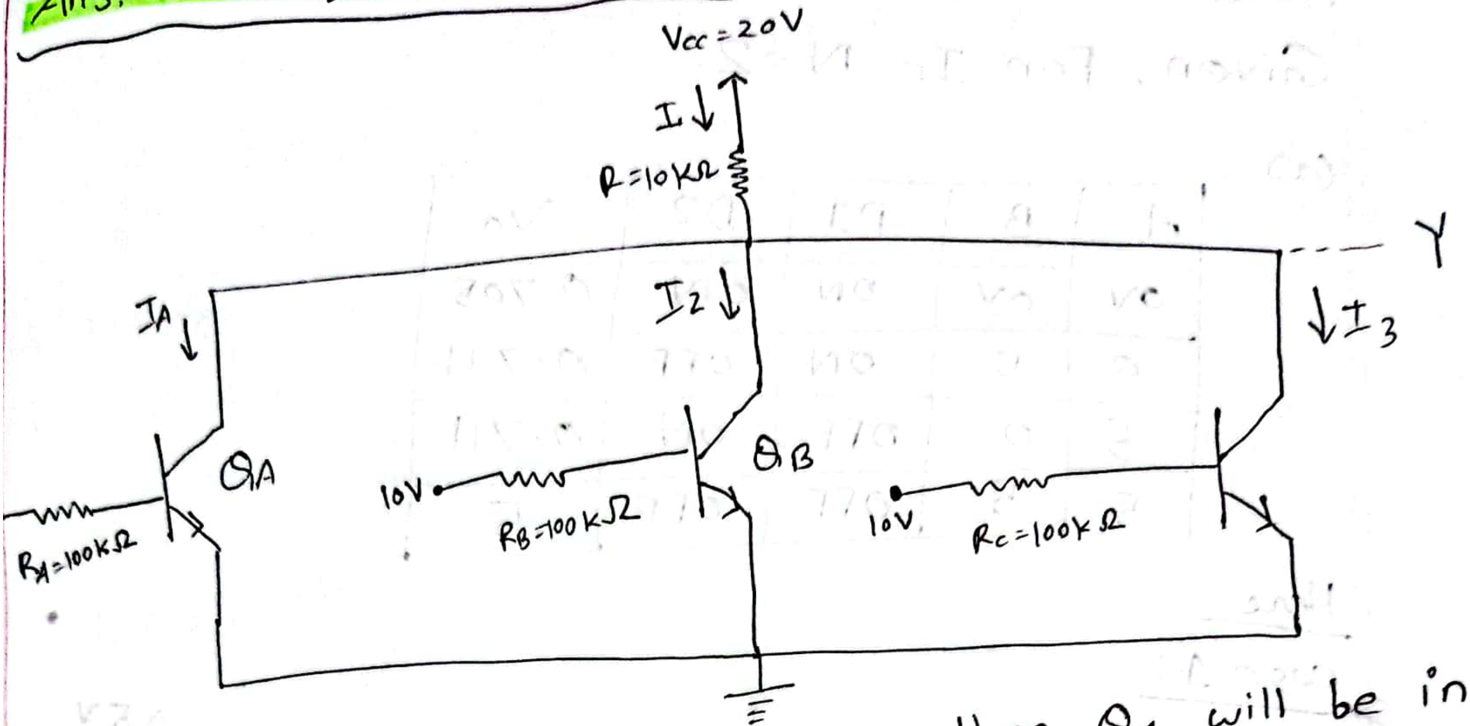
Ans. to the question no. 01:




Since input voltage of $Q_A$ is low then $Q_A$ will be in cutoff. while on the other hand $Q_B$ and $Q_C$ will be in saturation. as of high input voltage. So, $V = 0.2V$

$$\text{So, } I = \frac{20 - 0.2}{10K} = 1.98\,mA$$

As $Q_A$ is off then $I_A = 0mA$. Again other branches are identical. Therefore $I_B = I_C$

$$\therefore I_B = I_C = \frac{I}{2} = 0.99\,mA$$

Therefore,
$V = 0.2V$, $I = 1.98mA$, $I_A = 0$, $I_B = I_C = 0.99mA$.

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**Ans. to the question no. 02:**

Given, Fan In N = 2.

(a)

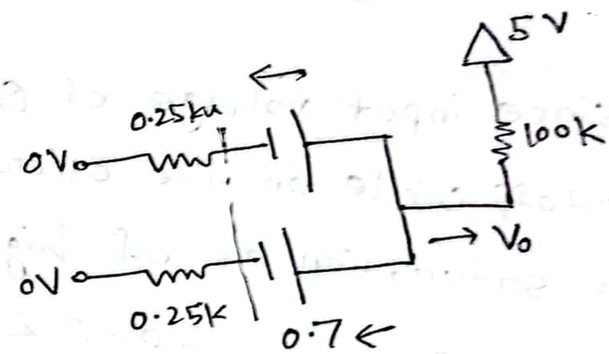
| A | B | D1 | D2 | Vo |
|---|---|---|---|---|
| 0V | 0V | ON | ON | 0.705 |
| 0 | 5 | ON | OFF | 0.711 |
| 5 | 0 | OFF | ON | 0.711 |
| 5 | 5 | OFF | OFF | 5 |

Here

Case 1:

$$\frac{V_o - 5}{100k} + \frac{V_o - 0.7 - 0}{0.25k} \times 2 = 0$$

$\therefore \boxed{V_o = 0.705\,V}$



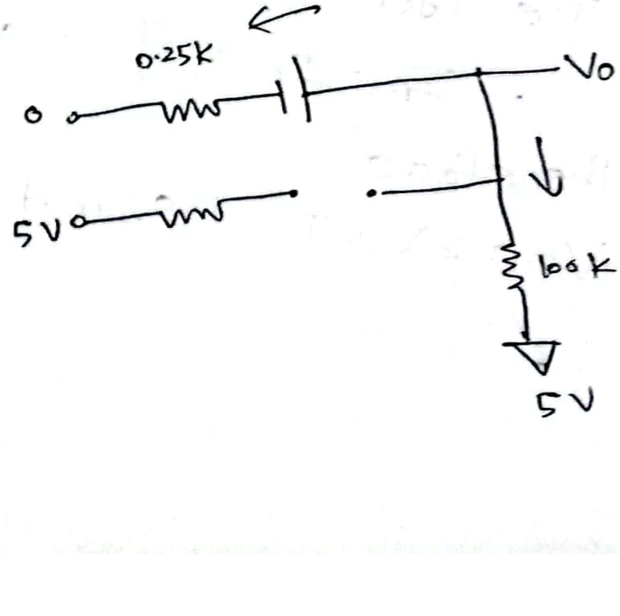

$0.7 = V_o - u$

$\therefore u = V_o - 0.7$

Case 2+3:

$$\frac{V_o - 5}{100k} + \frac{V_o - 0.7}{0.25k} = 0$$

$\therefore \boxed{V_o = 0.711V}$



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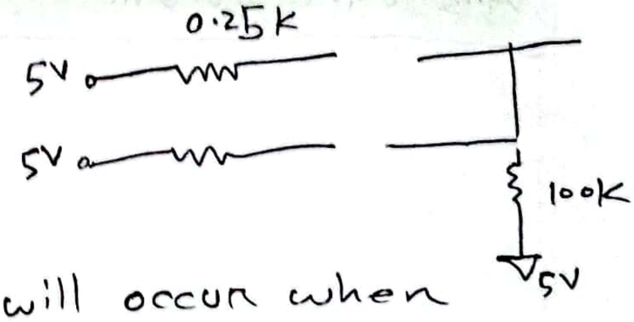
case 04:

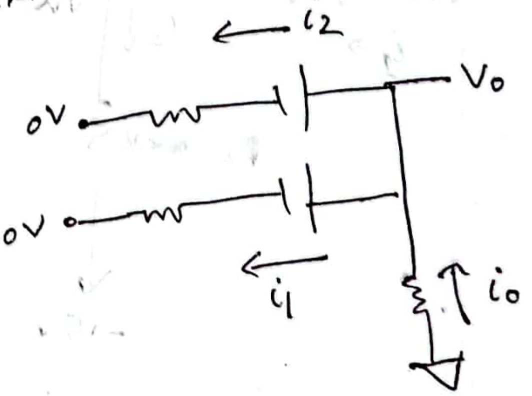
$$\frac{V_0 - 5}{100k} = 0$$

$\therefore \boxed{V_0 = 5V}$




(b) Maximum power dissipation will occur when both of the diodes are on. $V_0 = 0.705V$

$$\therefore i_0 = \frac{5 - 0.705}{100k} = 0.04295 \, mA$$




$$i_1 = i_2 = \frac{i_0}{2} = 0.021475 \, mA$$

$\therefore P_1 = i_1 \times (5-0)$

$P_2 = i_2 \times (5-0)$

$\therefore P = P_1 + P_2 = 5(i_1 + i_2)$

$= 5 \times 0.04295$

$= 0.21475 \, mW$

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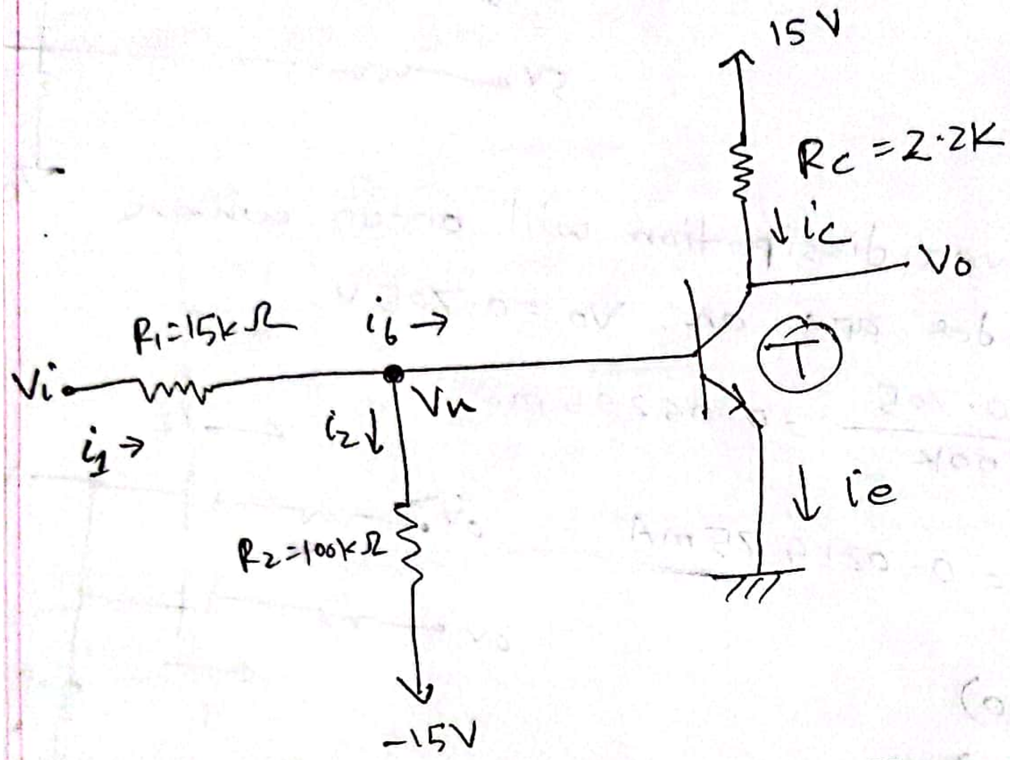
## Ans. to the question no. 03:




circuit will be in saturation. Therefore,

$V_{BE} = 0.8V$ and $V_{CE} = 0.2V$ | $\therefore V_o = 0.2V$,

$\therefore V_B = 0.8V$ and $V_C = 0.2V$

$$I_C = \frac{15 - 0.2}{2.2K} = 6.73 mA$$

$$I_1 = \frac{15 - 0.8}{15K} = 0.95 mA$$

$$I_2 = \frac{0.8 - (-15)}{100K} = 0.16 mA$$

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KCL at $V_n$,

$$I_1 = I_2 + I_B$$

$$\Rightarrow I_B = I_1 - I_2 = (0.95 - 0.16) = 0.79\,mA$$

We know,

$$I_E = I_B + I_C$$

$$\therefore I_E = (0.79 + 6.73)$$
$$= 7.52\,mA$$

So, $V_o = 0.2V$, $I_1 = 0.95\,mA$, $I_2 = 0.16\,mA$ and $I_E = 7.52\,mA$.

$I_C = 6.73\,mA$ ; $I_B = 0.79\,mA$

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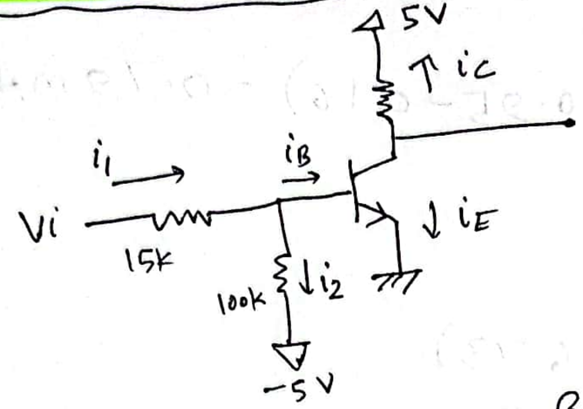
Ans. to the question no. 04:

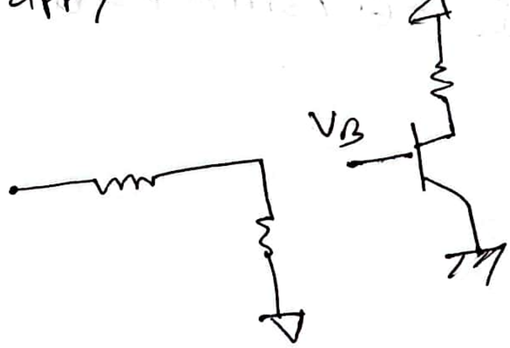
(a)




Given, $V_{OH} = 5V$, $V_{OL} = 0.2V$, $\beta_F = 30$ cutin Voltage $= 0.5V$

Finding $V_{IL}$:

Maximum voltage we can apply without turning on the transistor.




$V_{BE} = V_B = 0.5V$

$$\therefore i_2 = \frac{V_B - (-5)}{100K}$$

$$= \frac{0.5+5}{100K} = 0.055mA$$

Since, $i_1 = i_2$ (here)

$$\therefore \frac{V_i - V_B}{15K} = 0.055$$

$$\therefore V_i = (0.055 \times 15) + 0.5 = 1.33V$$

$$\therefore \boxed{V_{IL} = 1.33V}$$

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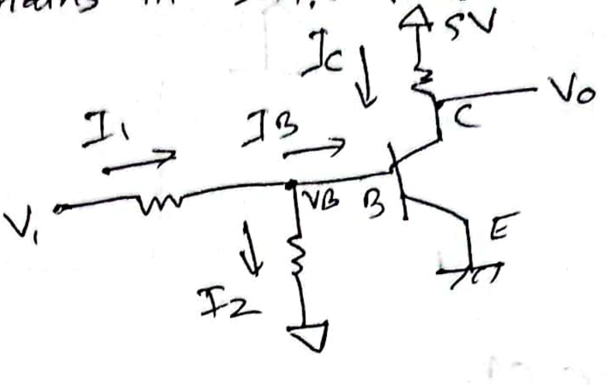
<u>Finding $V_{IH}$:</u> Minimum voltage we can apply so that the transistor remains in saturation.




So, $V_{CE} = V_o = 0.2V$

$V_{BE} = V_B = 0.8V$

$\therefore I_C = \frac{5-0.2}{2.2K}$

$= 2.182\,mA$

we can write,

$$\frac{I_C}{I_B} = \beta_F$$

$\therefore I_B = \frac{2.182}{30} = 0.073\,mA$

$\therefore I_2 = \frac{V_B - (-5)}{100K} = 0.058\,mA$

KCL at VB node—

$I_1 = I_2 + I_B$

$\frac{V_i - V_B}{15K} = (0.058 + 0.073)$

$V_i = (0.131 \times 15) + 0.8 = 2.765\,V$

$\therefore V_{IH} = 2.765\,V$

$\therefore NM_H = V_{OH} - V_{IH} = (4 - 2.765) = 1.235\,V$

$\therefore NM_L = V_{IL} - V_{OL} = (1.33 - 0.2) = 1.13\,V$

$NM = \text{Min of } (NM_H, NM_L)$

$= 1.13\,V$

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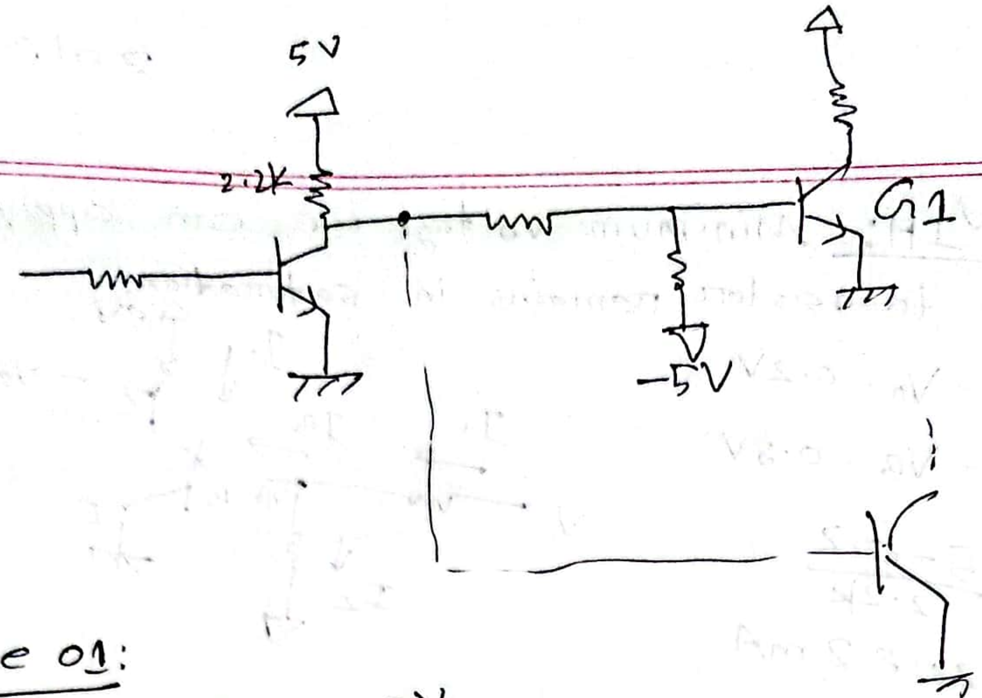
(b)




Case 01:

Let, $V_o = V_{OL} = 0.2V$

G1 will be in cutoff

$\therefore i_1 = i_2 = \dfrac{V_o - (-5)}{115K} = 0.045\ mA$

Here, supply current, $I_S = \dfrac{5 - 0.2}{2.2K} = 2.182 mA$

Fanout $= \left\lfloor \dfrac{2.182}{0.045} \right\rfloor = \lfloor 48.48 \rfloor = 48$

case 02:

Let, $V_o = V_{OH} = 4V$. So, G1 will be saturation.

$V_{BE} = V_B = 0.8V$

$I_1 = \dfrac{V_o - V_B}{15K} = \dfrac{4 - 0.8}{15K} = 0.213 mA$

supply current, $I_S = \dfrac{5-4}{2.2K} = 0.455 mA$

Fanout $= \left\lfloor \dfrac{0.455}{0.213} \right\rfloor = \lfloor 2.136 \rfloor = 2$

$\therefore$ maximum fanout $= 2$

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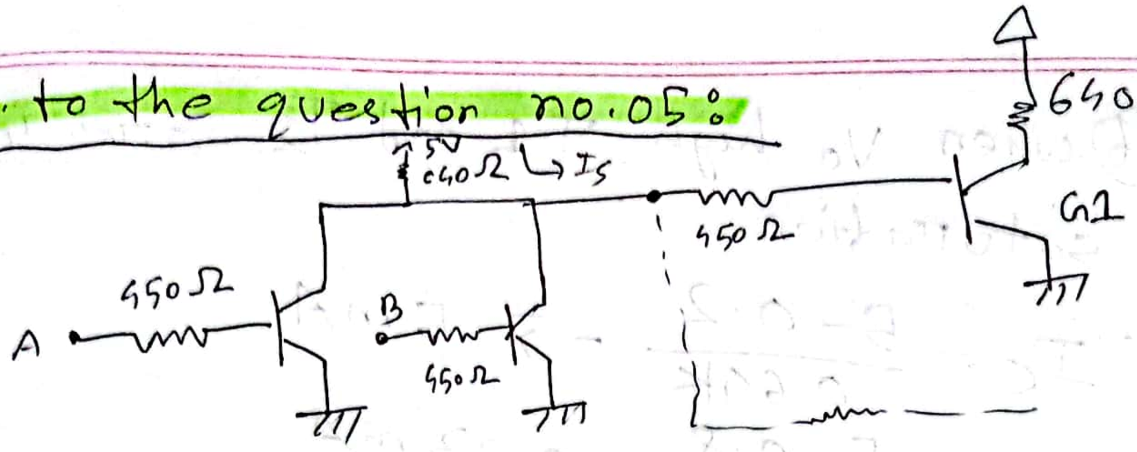
## Ans. to the question no. 05:

(a)




**case 01:** A and B high $V_o = V_{OL} = 0.2V$

Therefore, G1 will be in cutoff means $I_i = 0$

$\therefore$ fan out $= \left\lfloor \frac{I_s}{I_i} \right\rfloor = \left\lfloor \frac{I_s}{0} \right\rfloor = \infty$

**case 02:** A and B Low. $V_o = V_{OH} = 2.5V$

Therefore, G1 will be in saturation.

$$I_i = \frac{2.5 - 0.8}{0.45k} = 3.78mA$$

$$I_s = \frac{5 - 2.5}{0.64} = 3.91mA$$

$\therefore$ fanout $= \left\lfloor \frac{3.91}{3.78} \right\rfloor = 1$

maximum fanout $= \min(\infty, 1)$

$= 1.$

(b) when, $V_o$ = high T1 and T2 are in saturation.

$$\therefore I_C = \frac{5-0.2}{0.64K} = 7.5\,mA$$

$$I_B = \frac{5-0.8}{0.45K} = 9.33\,mA$$

$$\therefore \frac{I_C}{I_B} = \frac{7.5}{9.33} = 0.804 < \beta_{forced}$$

$$\therefore \beta_{min} = 0.804$$