Azmani Sultana

Id: 22201949

CSE251

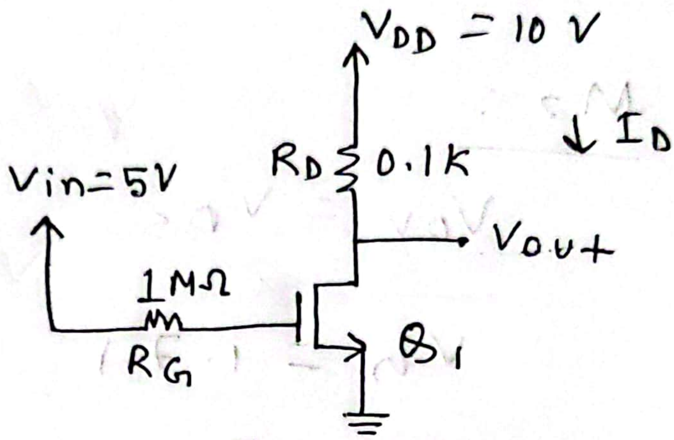
Section: 09

CamScanner

①

a) $V_{DS} > V_{OV}$
$V_{GS} > V_t$ } for saturation

b)



$V_T = 1V$

$k = 4\,mA/V^2$

$V_S = 0$

$V_G = 5V$

$V_{GS} = 5\,V$

$V_D = x$

$V_{DS} = x$

$$I_D = \frac{10 - x}{0.1}$$

$V_{OV} = 5 - 1 = 4V$

Saturation:

$$I_D = \frac{1}{2} k (V_{OV})^2$$

$$\Rightarrow \frac{10 - x}{0.1} = \frac{1}{2} \times 4 \times (4)^2$$

$\Rightarrow x = 6.8$

$I_D = 32mA$

$V_{DS} = 6.8 > V_{OV}$

$V_{GS} > V_T$

$V_{out} > 5$

∴ Nirmol correct

c)

$V_T = 1V$

$K = 4\ mA/V^2$

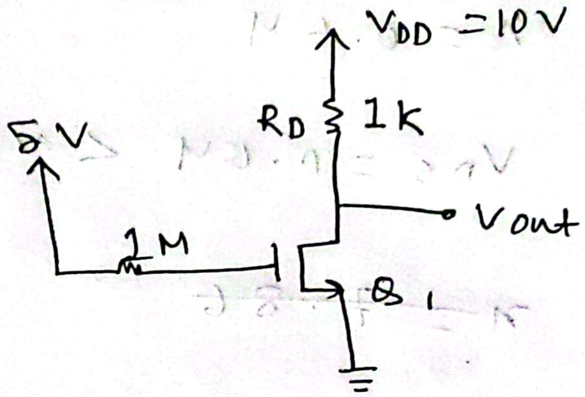
$V_S = 0$

$V_G = 5V$

$V_{GS} = 5$

$V_D = x$

$V_{DS} = x$



$I_D = \frac{10 - x}{1}$

$V_{ov} = 4V$

Saturation:

$I_D = \frac{1}{2} K (V_{ov})^2$

$\Rightarrow 10 - x = \frac{1}{2} \times 4 \times 4^2$

$\Rightarrow x = -22$

$V_{DS} < V_{ov}$ ✗

Triode:

$I_D = K \left[V_{ov} V_{DS} - \frac{1}{2} V_{DS}^2 \right]$

$\Rightarrow 10 - x = 4 \left[4 \times x - \frac{1}{2} x^2 \right]$

$\Rightarrow 10 - x = 16x - 2x^2$

$\Rightarrow -2x^2 + 17x - 10 = 0$ $\therefore x = 7.86, 0.64$

$x = 0.64$

$V_{DS} = 0.64 < V_{ov}$ ✓

~~$x = 7.86$~~

~~$V_{DS} = 7.86 > V_{ov}$~~

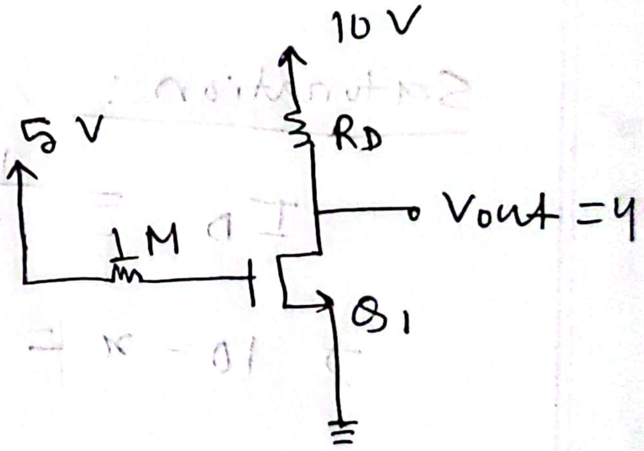
$V_{GS} = 5 > 1\,V$

working properly.

d) $V_{DS} = V_{ov}$

$\Rightarrow x = 4 = V_D$

~~$I_D = \frac{10-4}{R_D}$~~



$V_{ov} = 4\,V$

Active ~~$\Rightarrow 0.64 =$~~

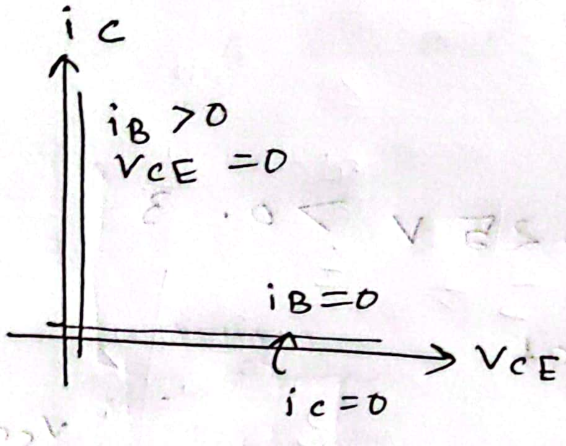
$I_D = \frac{4}{2} \times (4)^2 = 32\ mA$

$\frac{10-4}{R_D} = 32$

$R_D = 0.1875\ k\Omega$

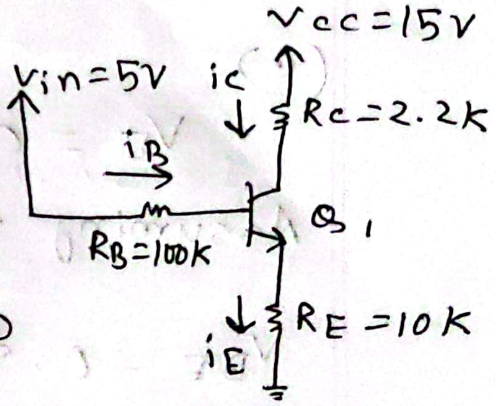
(2)

a) The s-model of BJT focuses on how BJT behaves under small variations of input signals around a specific operating point, typically in the active region.



Here, bjt simply works like a switch.

b) Active:



$-5 + R_B i_B + 0.7 + i_E R_E = 0$

$\Rightarrow -5 + 100 i_B + 0.7 + i_E \times 10 = 0$

$\Rightarrow 100 i_B + 10 i_E = 4.3$

$\beta i_B = i_C$

$\Rightarrow 100 i_B = i_E - i_B$

$\Rightarrow 101 i_B - i_E = 0$

$\therefore i_B = 3.87 \times 10^{-3}$ mA

$i_E = 0.39$ mA

$i_C = \beta i_B = 100 \times i_B = 0.387$

$$\frac{15 - V_C}{2.2} = i_C = 0.387$$

$\Rightarrow V_C = 14.15\ V$

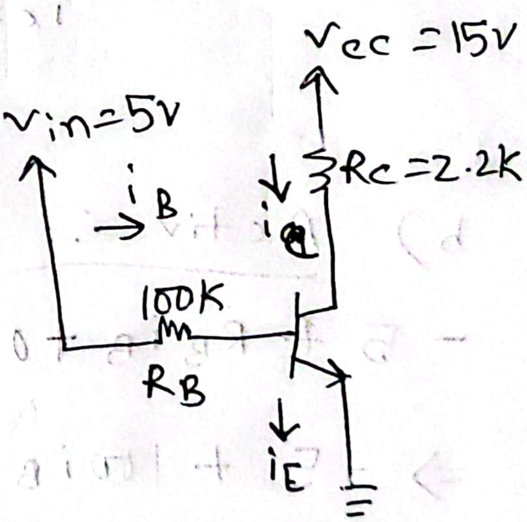
$$i_E = \frac{V_E}{R_E}$$

$\therefore V_E = 3.9$

$V_{CE} = 14.15 - 3.9 = 10.25\ V > 0.3$

Rahim was correct

(c)



$V_E = 0$

Assuming saturation:

$V_{BE} = 0.8\ V$

$V_{CE} = 0.2\ V$

$\therefore V_C = 0.2\ V$

$\therefore V_B = 0.8\ V$

$$\frac{5 - 0.8}{100} = i_B$$

$\Rightarrow i_B = 0.042\ mA$

$\cancel{-5 + i_B R_B + 0.8 = 0}$

$\Rightarrow \cancel{-15 + i_C R_C + V_{CE}}$

$$\frac{15 - 0.2}{2.2} = i_C$$

$\Rightarrow i_C = 6.73 \text{ mA}$

$$\frac{i_C}{i_B} = \frac{6.73}{0.042} = 160.17 > \beta$$

Assuming Active :

$V_{BE} = 0.7 \text{ V}$

$V_B = 0.7 \text{ V}$

$$\frac{5 - 0.7}{100} = i_B$$

$\Rightarrow i_B = 0.043 \text{ mA}$

$i_C = \beta i_B = 100 \times 0.043 = 4.3 \text{ mA}$

$$\frac{15 - V_C}{2.2} = 4.3$$

$V_E = 0$

$i_E = 0.043 + 4.3$

$= 4.343 \text{ mA}$

$\therefore V_C = 5.54$

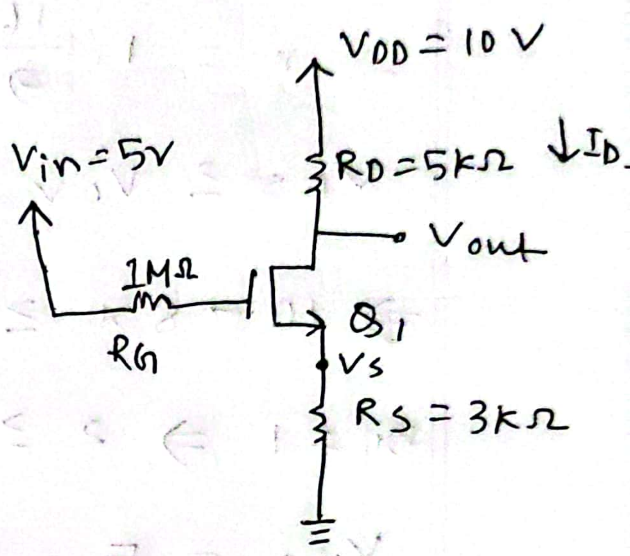
$\therefore V_{CE} = 5.54 - 0 = 5.54 > 0.3$ $\quad \therefore$ Active state

③ a)

$$f = \overline{DE + A(B+C)}$$

b) $V_T = 1V$

$K = 2 mA/V^2$



$V_G = 5V$

$I_D = x$

① $\dfrac{10 - V_D}{5K} = I_D$

$\Rightarrow 10 - V_D = 5 I_D$

$\Rightarrow V_D = 10 - 5 I_D = 10 - 5x$

$V_S = 3 I_D = 3x$

$V_{GS} = 5 - 3x$

$V_{OV} = V_{GS} - V_T = 5 - 3x - 1 = 4 - 3x$

$V_{DS} = V_D - V_S = 10 - 8x$

Saturation: $I_D = \dfrac{K}{2} V_{OV}^2$

$\Rightarrow x = \dfrac{2}{2} (4 - 3x)^2$

$\Rightarrow x = 16 - 24x + 9x^2$

$\Rightarrow 9x^2 - 9x - 16x + 16 = 0$

$\Rightarrow 9x(x-1) - 16(x-1) = 0$

$\therefore x = 1, \frac{16}{9}$

$V_{DS} \geq V_{OV}$

$\Rightarrow 10 - 8x \geq 4 - 3x$

$x = 1 \Rightarrow 2 \geq 1$

$V_{GS} = 5 - 3 = 2 > 1$

$x = 1$

$\boxed{I_{DS} = 1\ mA}$

$V_{out} = 10 - 5x = \boxed{5V}$

Assumption correct.

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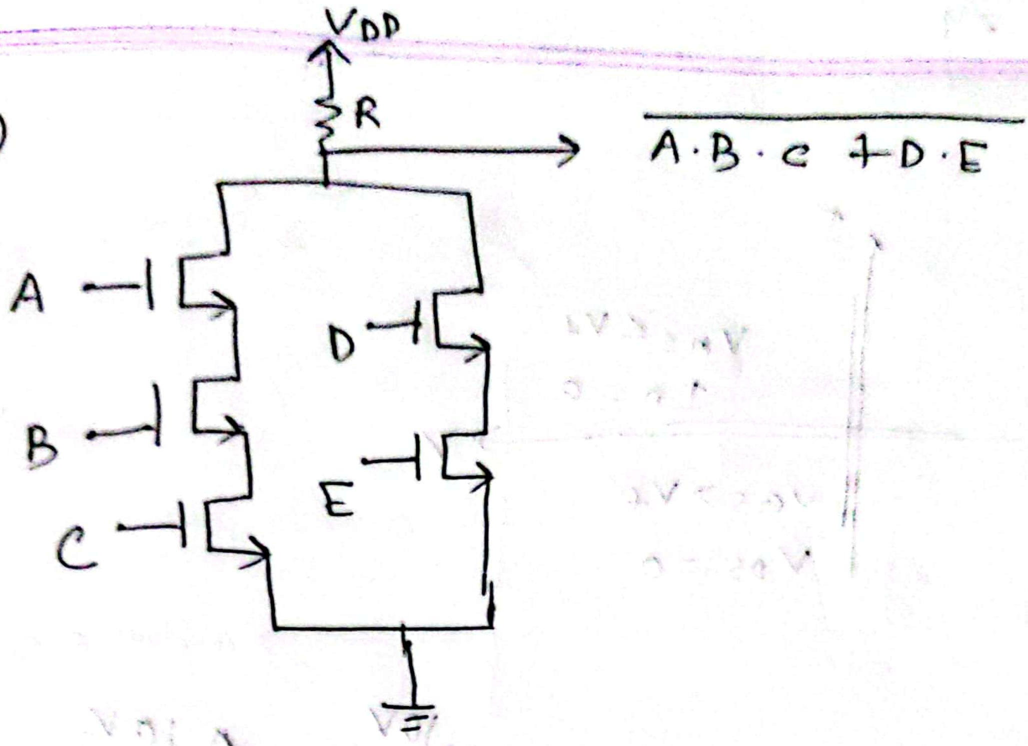
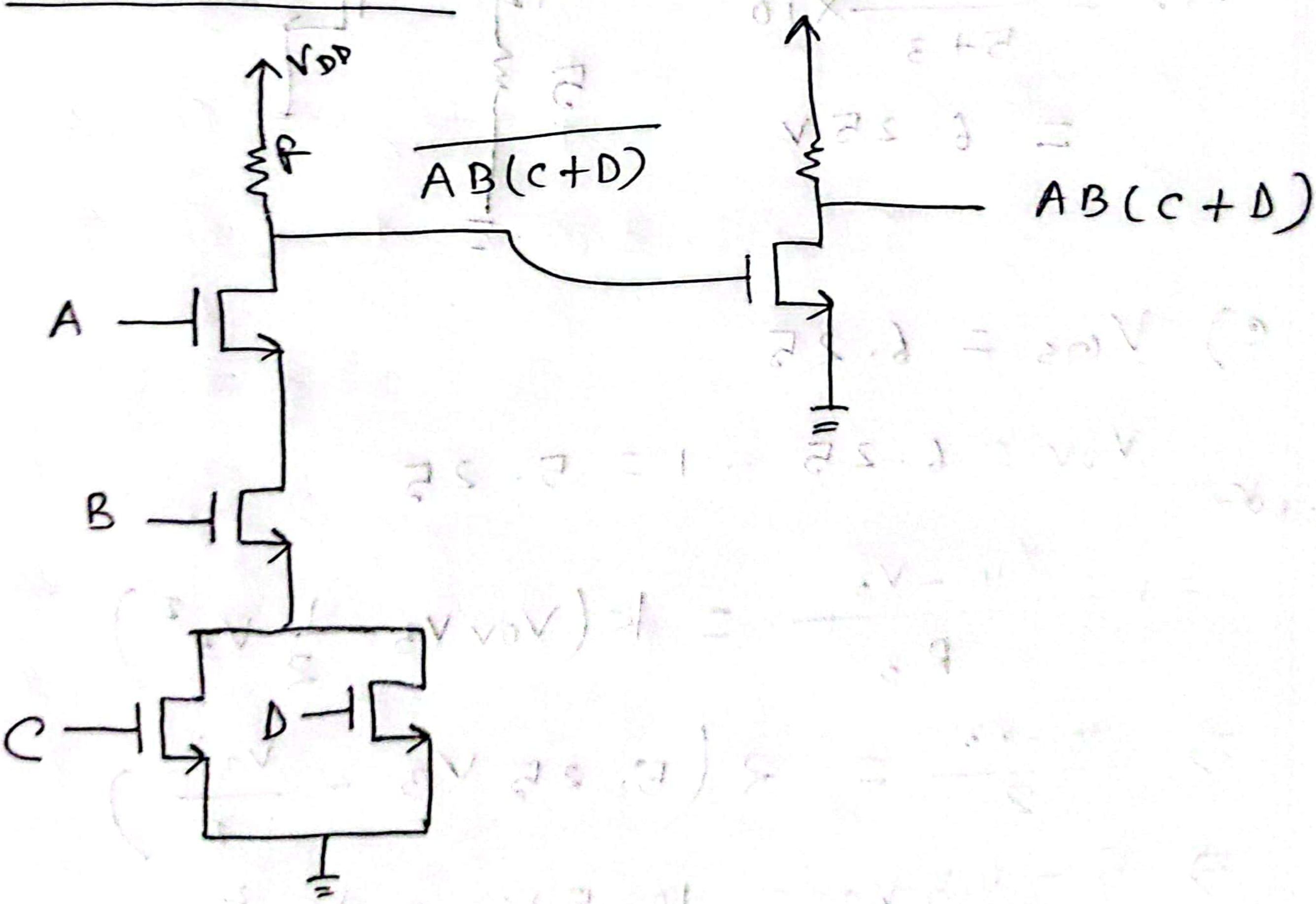
c)



V_{DD}
R
$\overline{A \cdot B \cdot C + D \cdot E}$
A
B
C
D
E

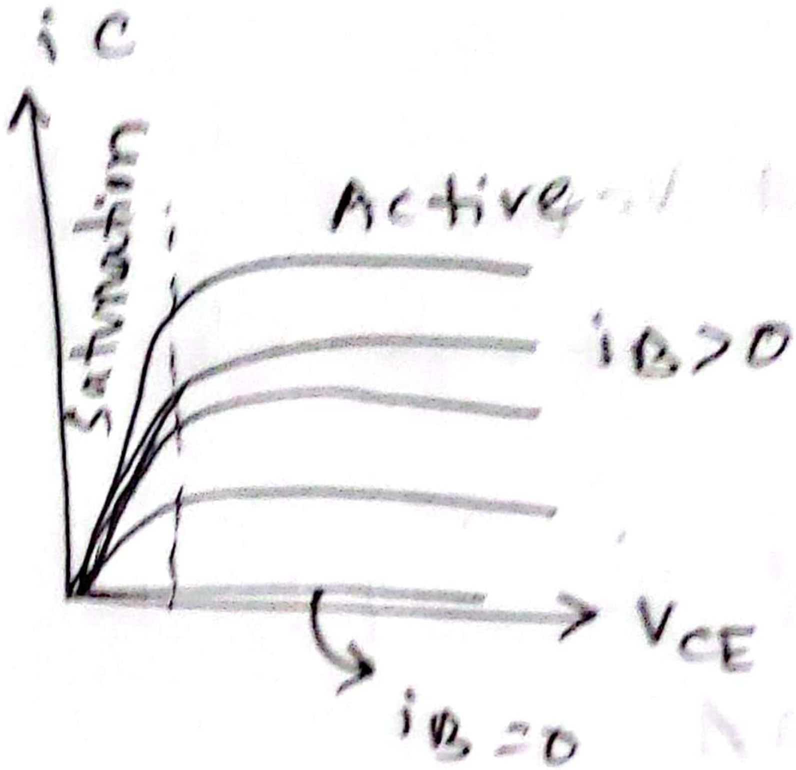
$AB(C+D)$



V_{DD}
R
$\overline{AB(C+D)}$
$AB(C+D)$
A
B
C
D

(4)

a)

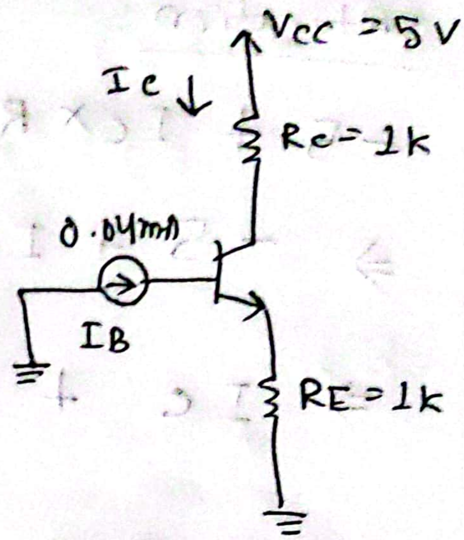


b) Active:

$I_E = (1+\beta) I_B$

$= (1+90) \times 0.04$

$= 3.64 \text{ mA}$



$I_C = \beta I_B$

$= 90 \times 0.04$

$= 3.6 \text{ mA}$

$$\frac{5 - V_C}{1} = I_C$$

$\Rightarrow V_C = 1.4 \text{ V}$

$$I_E = \frac{V_E}{R_E} = \frac{V_E}{1}$$

$\Rightarrow 3.64 = V_E$

$V_{CE} = 1.4 - 3.64 = -2.24 \text{ V} < 0.3$

Saturation:

$$-5 + I_C \times R_C + 0.2 + I_E R_E = 0$$

$$\Rightarrow -5 + I_C + 0.2 + I_E = 0$$

$$\Rightarrow I_C + I_E = 4.8$$

$$I_E = I_C + I_B$$

$$\Rightarrow -I_C + I_E = 0.04$$

$$I_C = 2.38 \text{ mA}$$

$$I_E = 2.42 \text{ mA}$$

$$I_B = 0.04 \text{ mA}$$

$$\frac{I_C}{I_B} = \frac{2.38}{0.04} = 59.5 < \beta$$

$$\frac{5 - V_C}{1} = 2.38$$

$$\Rightarrow V_C = 2.62 \text{ V}$$

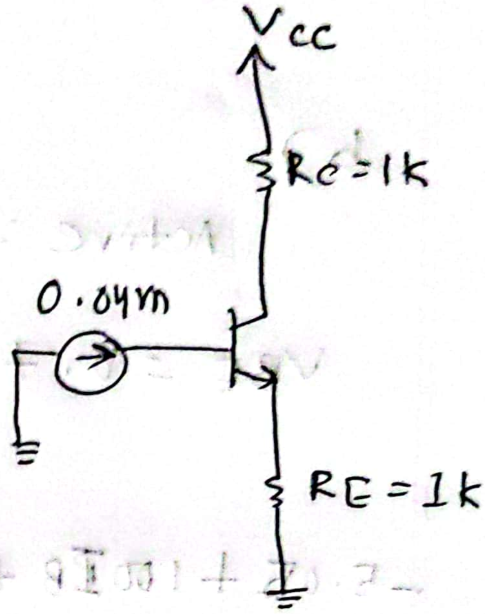
$$I_E = \frac{V_E}{R_E} = \frac{V_E}{1}$$

$$\therefore V_E = 2.42 \text{ V}$$

$V_{CE} = 0.2 \text{ V}$ $\therefore$ Saturation

c) Part B, we found saturation state.

Now, we need to calculate for Active.



$I_E = 3.64\ mA$

$I_C = 3.6\ mA$

$V_C = 5 - 1 \times 3.6 = 1.4\ V$

$V_E = 3.64\ V$

$V_{CE} = -2.24$

but

$V_{CE} > 0.3$

$V_{CC} = 5 + 2.24 + 0.3 + 0.01$

$= 7.55\ V$

d)