Assignment - 4

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Section: 01

Course: CSE251

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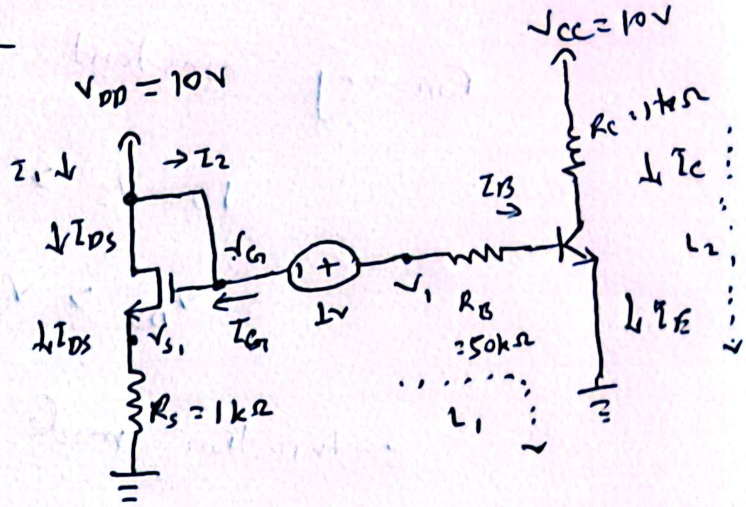
Ans to the Ques. No.-1

a

$V_G = V_{DD} = 10V$



b

$V_1 - V_G = 1$

$\Rightarrow V_1 = 1 + V_G$

$= 1 + 10$

$= 11V$

c

$V_{GS} = V_G - V_S = 10 - V_S$

$V_{DS} = V_D - V_S = 10 - V_S$; $[V_D = V_{DD}]$

~~$V_{OV} = V_G - V_T = 10 - 0.9$; $[V_T = 0.9V]$~~

~~$= 9.1V$~~

$V_{OV} = V_{GS} - V_T = 10 - V_S - 0.9$; $[V_T = 0.9V]$

$= 9.1 - V_S$

d

For any constant value of V_s,

$$10 - V_s > 9.1 - V_s$$

$$\therefore V_{DS} > V_{ov}$$

$\therefore$ saturation mode

e

From d,
$m \rightarrow$ saturation

$$I_{DS} = \frac{1}{2} k (V_{ov})^2 = \frac{1}{2} \times 4 \times (9.1 - V_s)^2.$$

$$= 2(9.1 - V_s)^2$$

$$= 2(82.81) - 18.2 V_s + V_s^2).$$

$$= 165.62 - 36.4 V_s + 2V_s^2 \quad ..(i)$$

Ohm's law on R_s,

$$\frac{V_s - 0}{2} = I_{DS}$$

$$\therefore I_{DS} = V_s \quad ..(ii)$$

(i), (ii),

$$V_s = 165.62 - 36.4 V_s + 2V_s^2$$

$\cancel{\Rightarrow 2V_S^2 - 35.4 V_S + 165.62 = 0}$

$\cancel{\therefore V_S =}$

$\Rightarrow 2V_S^2 - 37.4 V_S + 165.62 = 0$

$\therefore V_S = 11.5$ or $V_S = 7.2$

$\therefore V_{DS} = 10 - 11.5$

$= -1.5V$

$\therefore V_{DS} = 10 - 7.2$

$= 2.8V$

$V_S = 7.2$ makes more accurate for saturation

$\therefore I_{DS} = \frac{7.2 - 0}{1} = 7.2$ mA

$\therefore V_{DS} = 2.8V$

f

Assumption-I,

bjt in saturation

$V_{BE} = 0.8V$

$V_{CE} = 0.2V$

KVL along L_1,

$11 - 0 = 50 I_B + V_{BE}$

$\Rightarrow 11 = 50 I_B + 0.8$

$\therefore I_B = 0.216$ mA

KVL along l_2,

$$10 - 0 = I_C + V_{CE}$$

$$\Rightarrow 10 - 0.2 = I_C$$

$$\therefore I_C = 9.8 \text{ mA}$$

$$I_E = I_B + I_C = 0.216 + 9.8 = 10.016 \text{ mA}$$

<u>Verification:</u>

$$I_B, I_C, I_E > 0$$

$$\frac{I_C}{I_B} = \frac{9.8}{0.216} = 45.37 < \beta = 100$$

$\therefore$ Assumption-1 connect

$$I_B = 0.216 \text{ mA}$$

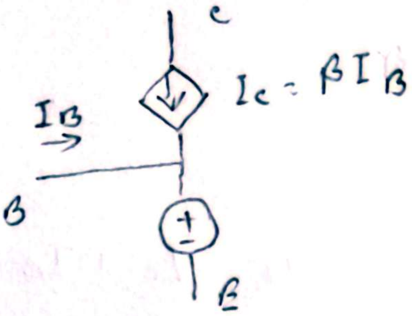
$$I_C = 9.8 \text{ mA}$$

$$I_E = 10.016 \text{ mA}$$

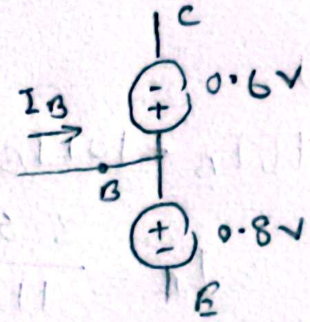
Ans. to the Ques. No.- 2

a

BJT during active –



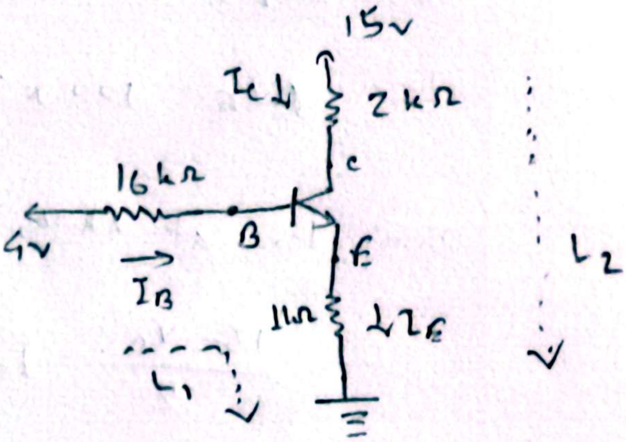
BJT during saturation –



b

Assumption-1,

BJT is active



$V_{BE} = 0.7$

$\frac{I_c}{I_B} = \beta = 100$

$I_c = \alpha I_E$

$I_E = I_c + I_B$

$R_{th} = \frac{20 \times 80}{20+80} = 16k\Omega$

$V_{th} = 5 \times \frac{80}{20+80} = 4V$

KVL along L_1,

$$4 - 0 = 16 I_B + V_{BE} + I_E$$

$$\therefore 16 I_B + I_E - 3.3 = 0 \quad \text{--- (i)}$$

KVL along L_2,

$$15 - 0 = 2I_C + V_{CE} + I_E$$

$$\therefore 2I_C + I_E + V_{CE} - 15 = 0 \quad ..(ii)$$

$$I_E = I_C + I_B = \beta I_B + I_B = I_B(\beta + 1) = (100+1)I_B$$
$$= 101 I_B \quad ..(iii)$$

(i), (iii),

$$16I_B + 101I_B = 3.3$$

$$\therefore I_B = \frac{3.3}{117} = 0.028 \text{ mA}$$

$$I_E = 101 \times 0.028 \text{ mA} = 2.828 \text{ mA}$$

$$I_C = \beta I_B = 100 \times 0.028 = 2.82 \text{ mA}$$

Ohm's law at $2k\Omega$,

$$\frac{15 - V_C}{2} = I_C$$

$$\Rightarrow 15 - V_C = 2I_C$$

$$\Rightarrow 15 - V_C = 2 \times 2.82$$

$$\therefore V_C = 9.36 \text{ V}$$

Ohm's law at $1k\Omega$,

$$\frac{V_E - 0}{2} = I_E$$

$$\therefore V_E = I_E = 2.828 \text{ mA}$$

$\therefore V_{CE} = V_C - V_E = 9.36 - 2.828 = 6.532\ V$

<u>Verification</u>

$I_C, I_B, I_E > 0$

$V_{CE} = 6.5 > 0.2$

$\therefore$ Assumption correct

c

$V_{BB} = 5.1\ V$

$$V_{th} = 5.1 \times \frac{80}{20+80} = 4.08\ V$$

$R_{th} = 16\ k\Omega$ ~~units~~

~~Assump~~

<u>Assumption-1:</u> ~~Active~~

BJT is active

KVL along L_1,

$$4.08 - 0 = 16 I_B + V_{BE} + I_E$$

$$\Rightarrow 16 I_B + I_E - 3.38 = 0 \ldots (i)$$

KVL along L_2,

$$15 - 0 = 2I_C + V_{CE} + I_E$$

$$\Rightarrow 2I_C + I_E + V_{CE} = 15$$

$$\therefore 2I_C + I_E + V_{CE} - 15 = 0 \ldots (ii)$$

$I_E = I_C + I_B = \beta I_B + I_B = (1+\beta) I_B = 101 I_B$

(i),

$16 I_B + 1001 I_B = 3.38$

$\therefore I_B = \dfrac{3.38}{117} = 0.028\ mA$

$I_C = \beta I_B = 2.89\ mA$

$I_E = 101 I_B = 1001 \times 0.028 \doteq 2.828\ mA$

(ii),

$2 \times 2.8 + 2.828 + V_{CE} = 15$

$\therefore V_{CE} = 6.572$

<u>Verification</u>

$I_C, I_B, I_E > 0$

$V_{CE} > 0.2$

Assumption-1 correct.

Ohm's law at 2kΩ,

$$\frac{15-V_C}{2} = I_C$$

$$\Rightarrow 15 - V_C = 2.89 \times 2$$

$$\therefore V_C = 9.22 \text{ V}$$

$\Delta I_C = I_{C_{new}} - I_{C_{old}} = 2.89 - 2.82 = 0.07$ mA

d

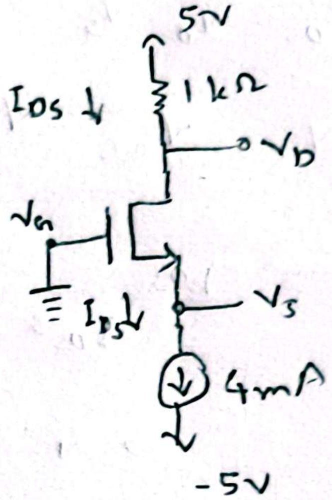
Due to a small change in the input, it produces a small amount of change in base current. Multiplying it by gain (β) makes it big. This can be used in order to amplify. with small amount of sesing, driving huge loads signals.

Ans. to the Ques. No.- 3

a

$V_G = 0V$

$I_{DS} = 4mA$



b

Ohm's law on 1kΩ,

$$\frac{5 - V_D}{1} = I_{DS}$$

$$\Rightarrow 5 - V_D = 4$$

$$\therefore V_D = 1\ V$$

c

Assuming,

(1)

m → saturation

$V_{GS} \geq V_T$

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

$V_{GS} = V_G - V_S = 0 - V_S = -V_S$

$V_T = 1V$

$V_{DS} = V_D - V_S = 1 - V_S$

$V_{ov} = V_{GS} - V_T = \cancel{0} - V_S - 1$

From eqn,

$$I_{DS} = \frac{1}{2} \times k \times (V_{ov})^2$$

$$\Rightarrow 4 = \frac{1}{2} \times 4 \times (-V_S - 1)^2$$

$$\Rightarrow 4 = 2(-V_S - 1)^2$$

$$\Rightarrow 4 = 2V_S^2 + 4V_S + 2$$

$$\Rightarrow V_S^2 + 2V_S + 1 = 2$$

$$\Rightarrow V_S^2 + 2V_S - 1 = 0$$

$$\therefore V_S = 0.414 \quad \text{or} \quad V_S = -2.414$$

considering $V_S = -2.414\,V$,

$V_{GS} = -V_S = 2.414 \geq V_T = 1V$

$V_{DS} = 1 - V_S = 1 - (-2.414) = 3.414$

$V_{ov} = -V_S - \cancel{0}\, 1 = -(-2.414) - 1 = 1.414$

$\therefore V_{DS} \geq V_{ov}$

$\therefore$ Assumption ~~corrects~~ correct.

$\therefore V_S = x = -2.414\,V$

Ans. to the Ques. No: 4

a

$i_{g_1} = I_{G_1} = 0 mA$; [no current flow in the gate]

$i_{g_2} = I_{G_2} = 0 mA$; [no current flow in the gate]

b

i. S model is asymmetric. SR model is symmetric.

ii. S model has poor bidirectional current but SR model has excellent bidirectional current

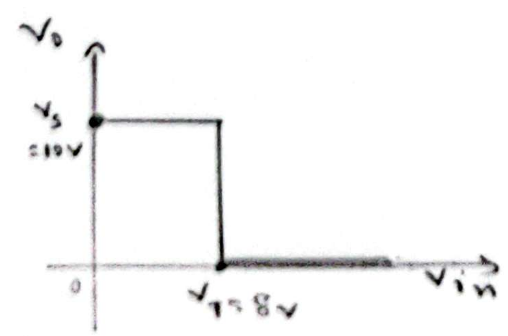
iii. S model has low (static) body effect accuracy but SR model has high (dynamic) body effect accuracy

iv. S model has inaccurate analog. switch use but SR has accurate.

v. S model has poor simulation convergence but SR model has better.

vi.

e



<u>c</u>

~~Assumptions~~,

B_1, B_2 in saturation

$\beta = 100$

$V_{BE} = 0.8\,V$

~~$I_C = \beta I_B$~~

$V_{CE} = 0.2\,V$

~~Have to start~~

<u>B_1,</u>

$V_{E_1} = V_{B_1} - V_{BE}$

$= 5 - 0.8$

$= 4.2\,V$

$$I_{E_1} = \frac{V_{E_1}}{1\,k\Omega} = \frac{4.2}{2} = 4.2\,mA$$

~~$I_{E_1} = I_{C_1} + I_{B_1} = \beta I_{B_1} + I_{B_1}$; [$I_C = \beta I_B$]~~

~~$= (101) I_{B_1}$~~

$$I_{E_1} = I_{C_1} + I_{B_1} = I_{C_1} + \frac{I_{C_1}}{\beta} \; ; [\, I_C = \beta I_B \,]$$

$$\Rightarrow 4.2 = I_{C_1}\left(1 + \frac{1}{100}\right)$$

$$\therefore I_{C_1} = 4.16\,mA$$

$\therefore I_{B_1} = \frac{I_{C_1}}{\beta} = \frac{4.16}{100} = 0.0416 \ mA$

B_2,

$V_{E_2} = V_{C_2} - 0.2 = 8 - 0.2 = 7.8 V$

$I_{E_2} = \frac{V_{E_2}}{\cancel{R_E}\ 1k\Omega} = \frac{7.8}{1} = 7.8 mA$

again,

$I_{E_2} = I_{C_2}\left(1 + \frac{1}{100}\right) ; [\beta = 100]$

$\therefore I_{C_2} = \frac{7.8}{1.01} = 7.72 mA$

$\cancel{d}$

B_1 in ~~B_1 act~~ Forward active.

$V_{BE} = 0.7V$

$V_{B_1} = 5V$

$V_{E_1} = V_{B_1} - V_{BE} = 5 - 0.7 = 4.3 V$

$I_{E_1} = \frac{V_{E_1}}{1k\Omega} = \frac{4.3}{1} = 4.3 mA$

$I_{E_1} = I_{C_1} + I_{B_1}$

again,

$I_{E_1} = I_{C_1}\left(1 + \frac{1}{\beta}\right)$

$\Rightarrow I_{C_1} = \frac{4.3}{\left(1 + \frac{1}{100}\right)} = 4.257 \ mA$

$$I_{B_1} = \frac{I_{C_1}}{\beta} = \frac{4.257}{100} = 0.0426 \text{ mA}$$

$$V_{C_1} = 10V - (I_{C_1} \times 1 k\Omega)$$

$$= 10 - 4.257$$

$$= 5.743 \text{ V}$$

$$V_{in} = V_{C_1} = 5.74 \text{ V}$$