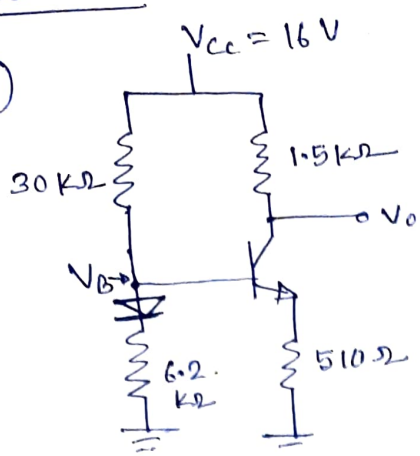
Test-2

(1)



Find Q-point (V_{CEQ} and I_{CQ})

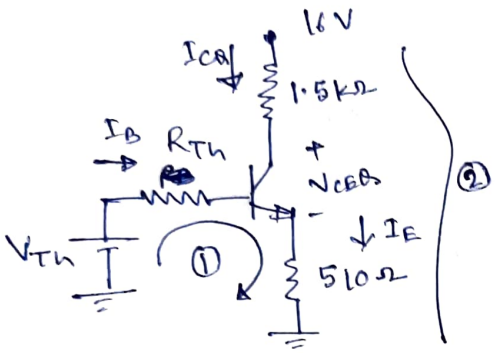
$\beta = 200$, $V_\gamma = 0.7\,V$ (given)

$$V_B = \frac{6.2}{6.2+30}(16-0.7) + 0.7 = V_{Th}.$$

$$= 2.62 + 0.7 = 3.32\,V. = V_{Th}.$$

$$R_{Th} = 30\,K\Omega \,||\, 6.2\,K\Omega$$

$$= 5.138\,K\Omega$$



Equivalent ckt.

KVL along the loop as shown, —①

$$V_{Th} = I_B R_{Th} + V_{BE-ON} + I_E \cdot (510\,\Omega)$$

$$3.32 = I_B \times (5.138\,K\Omega) + 0.7 + (1+\beta) I_B \times (0.51\,K\Omega)$$

(Currents in mA).

$$I_B = 0.0244\,mA.$$

Assuming, BJT is in saturation. $\therefore$ $I_{CQ} = \beta I_B = 200 \times 0.0244 = 4.89\,mA.$ ②

$$I_E = (1+\beta) I_B = 4.90\,mA.$$

* Units are very important.

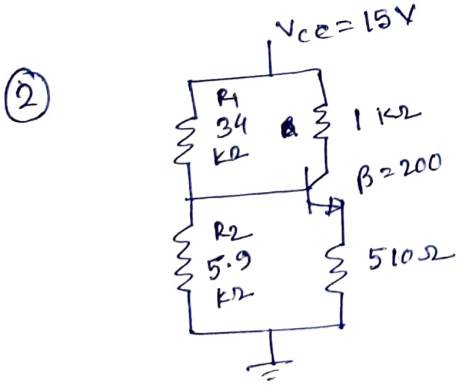
KVL along ②,

$$V_{CEQ} = 16 - I_C \times 1.5 - I_E \times 0.51$$

$V_{CEQ} = 6.166\,V.$ ②

$V_{CE} > 0.2V$, BJT is in saturation as assumed.

(2)



[DC Part]

$$V_{Th} = 15 \times \frac{5.9}{5.9+34} = 2.21\,V.$$

$$R_{Th} = 5.9 \,||\, 34 = 5.02\,K\Omega$$

KVL at B-E loop as indicated,

$$V_{Th} = I_B R_{Th} + V_{BE-ON} + R_E \cdot I_E$$

$$[I_E = (1+\beta) I_B.]$$

$$2.21 = I_B \times 5.02 + 0.7 + 0.51 \times (1+\beta) I_B$$

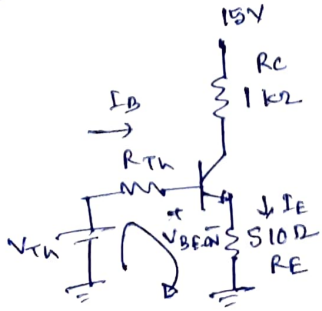
$$I_B = 0.0143\,mA.$$

$$I_C \approx I_E = V_{CC} - I_C R_C - I_E R_E$$

$I_C = 2.87\,mA.$ ①

$$V_E = I_E \times 0.510 = 2.87 \times 0.510$$

$V_E = 1.4637\,V$ ①



Small-signal parameters:

$$g_m = \frac{I_C}{V_T} = \frac{2.87\ mA}{26\ mV} = 0.110\ S.$$

$V_T = 26\ mV$ at $T = 300K$

$g_m = 0.110\ A/V$ or 0.110 mho

$$r_\pi = \frac{V_T}{I_B} = \frac{0.026\ V}{0.0143\ mA} = 1.81\ K\Omega$$

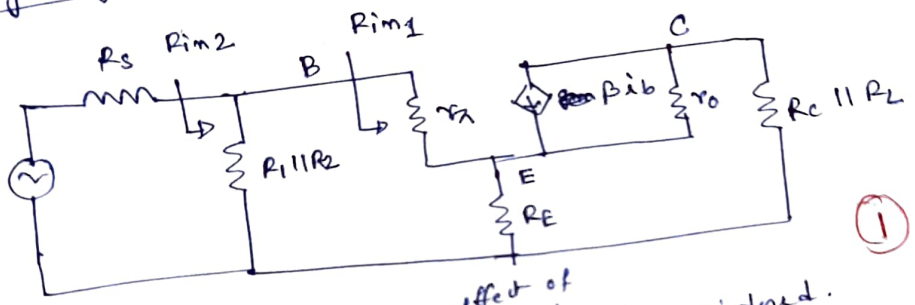
$$r_o = \frac{V_A}{I_C} = \frac{150\ V}{2.87\ mA} = 52.26\ K\Omega$$

Small-signal gain.

$R_C \| R_L = 1K\Omega \| 100\ K\Omega$

$R_S = 100\ \Omega$

$R_C \| R_L = 0.99\ K\Omega$



As, $r_o >> (R_C \| R_L)$, for simplicity effect of 'r_o' not considered.

$$R_{in1} = r_\pi + (1+\beta)R_E = 1.81\ K\Omega + 201 \times 0.51\ K\Omega = 104.32\ K\Omega$$

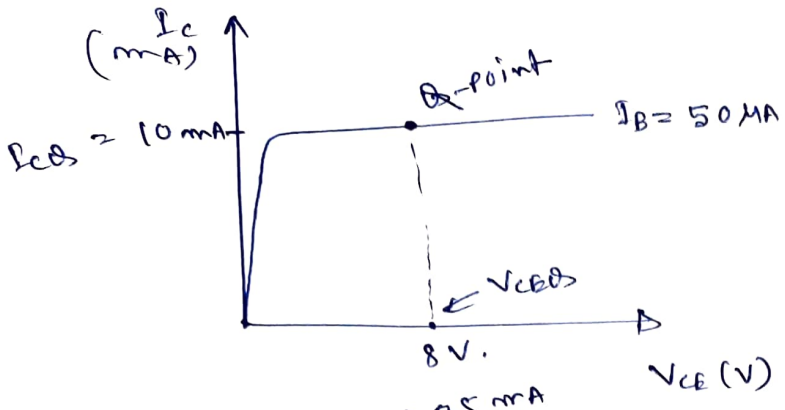
$$R_{in2} = r(R_1 \| R_2 \| R_{in1}) = 4.77\ K\Omega$$

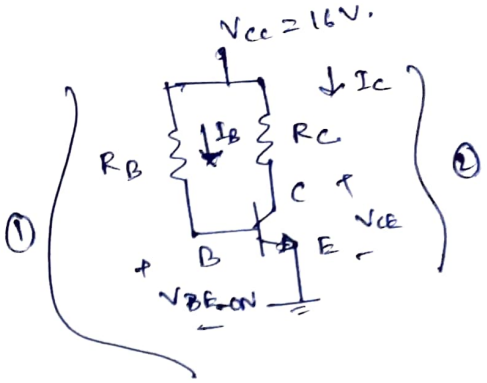
$$\text{gain} = -\frac{\beta(R_C \| R_L)}{r_\pi + (1+\beta)R_E} \cdot \frac{R_{in2}}{R_{in2} + R_S} \quad ; \text{ as, } R_{in2} >> R_S.$$

$$\text{gain} = -\frac{\beta(R_C \| R_L)}{r_\pi + (1+\beta)R_E} = \frac{-200 \times 0.99}{1.81 + (201)0.51} = -1.89$$

Ans

(3) Find the value of R_B and R_C to establish the Q-point.





I_B = 50 MA = 0.05 mA

I_C = 10 mA

$\beta = \frac{I_C}{I_B}$ = 200 (1)

Along loop ①, $V_{CC} = I_B \cdot R_B + V_{BE-ON}$

$16 - 0.7 = R_B \times 0.050$

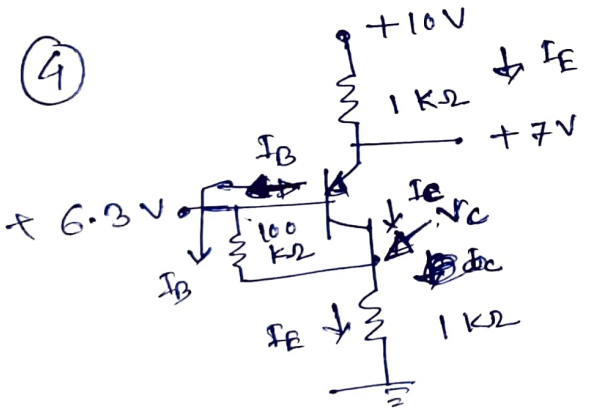
R_B = 306 KΩ — (1.5)

Along loop ②, $V_{CC} = I_C R_C + V_{CE\,Q}$

$16 - 8 = 10 \times R_C$

$\therefore R_C = \frac{8}{10} = 0.8$ KΩ. — (1.5)

(4)



$I_E = \frac{10-7}{1\,K\Omega}$ = 3 mA. — (1)

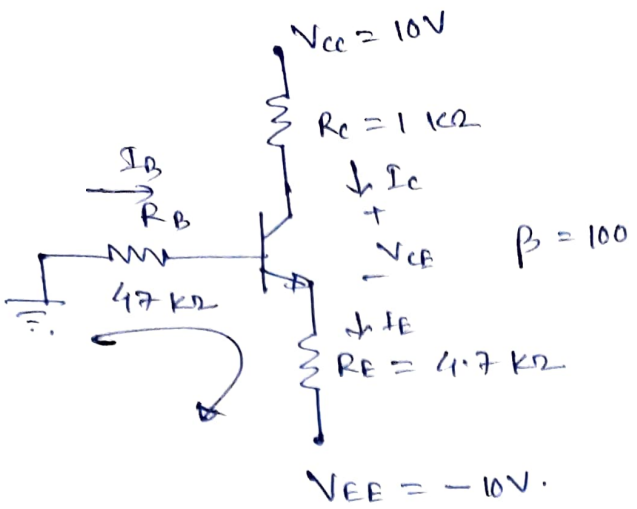
$V_C = I_E \times 1\,K\Omega$ = 3V

$I_B = \frac{(6.3-3)V}{100\,K\Omega}$ = 0.033 mA — (1)

$\frac{I_E}{I_B} = 1+\beta$; $\beta = \frac{3\,mA}{0.033\,mA} - 1$

β = 89.9 — (1)

(5)



Along CE loop

$$V_{CE} = V_{CC} + V_{EE} - I_C(R_C + R_E)$$

When, $I_C = 0$

$$V_{CE} = V_{CC} + V_{EE} = 20V.$$

When, $V_{CE} = 0$, $I_C = \frac{20}{R_C + R_E}$

$= 3.51\ mA.$

Along BE loop

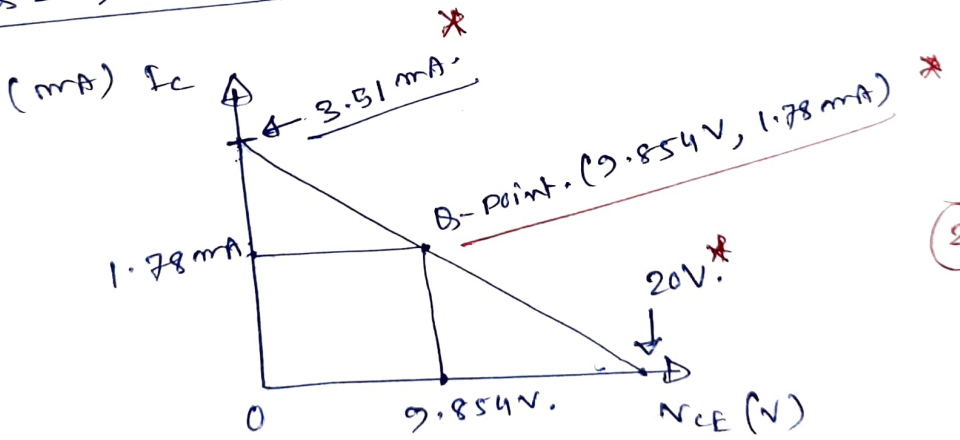
$$0 = I_B \cdot R_B + V_{BE-ON} + I_E \cdot R_E - 10 \quad ; I_E = (\beta+1) I_B.$$

$$9.3 = I_B [R_B + 101 R_E]$$

$\therefore I_B = 0.0178\ mA.$

$I_{CQ} = 1.78\ mA.$

$V_{CEQ} = 9.854\ V.$ } —— (1)



(2)