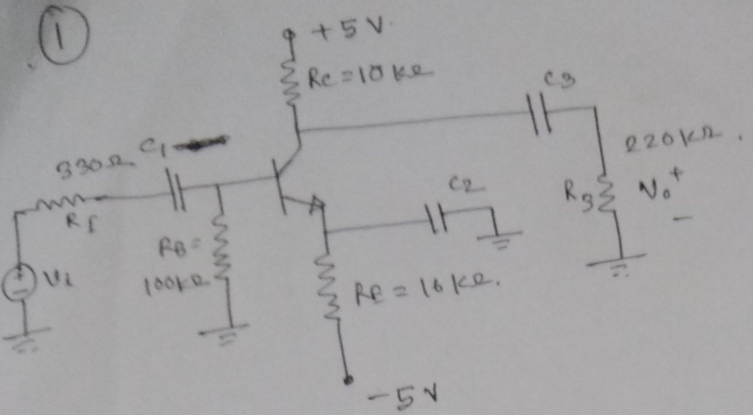
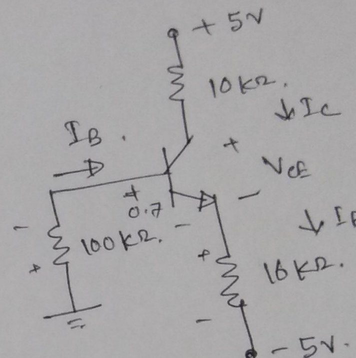
(1)



$\beta_F = 65$ V.

$V_A = 50$ V.

$V_{BE-ON} = 0.7$ V.



DC analysis

KVL base loop.

$100\times10^3 \times I_B + 0.7 + (1+\beta)\times 16\times 10^3 I_B = 5$.

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

$\therefore I_B = 3.71$ µA.

$\therefore I_C = 65 \times 3.71$ µA $= 241$ µA.

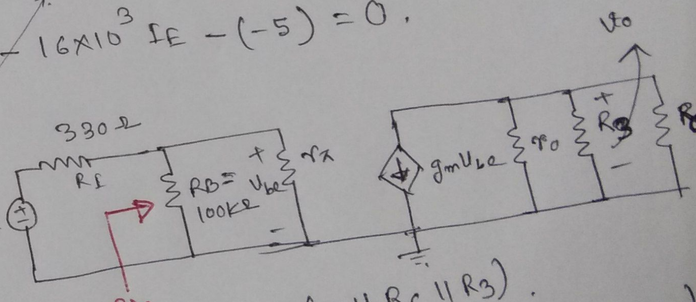
$I_E = 244.86$ µA.

Q-point.

KVL in outer loop:

$5 - 10\times10^3 I_C - V_{CE} - 16\times10^3 I_E - (-5) = 0$.

$V_{CE} = 3.67$ V.

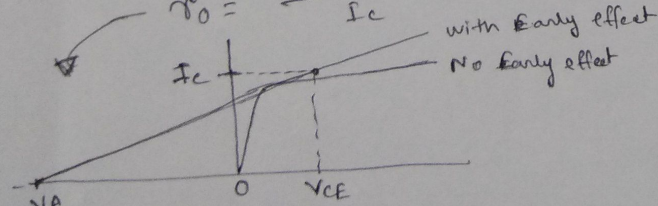


Ac analysis:

$g_m = \frac{I_C}{V_T} = 9.27\times10^{-3}$ S.

$r_\pi = \frac{\beta}{g_m} = 7.03\times10^3$ Ω.

$r_o = \frac{V_A + V_{CE}}{I_C} = 222.69$ kΩ.



$v_o = -g_m v_{be}\cdot(r_o \| R_C \| R_3)$.

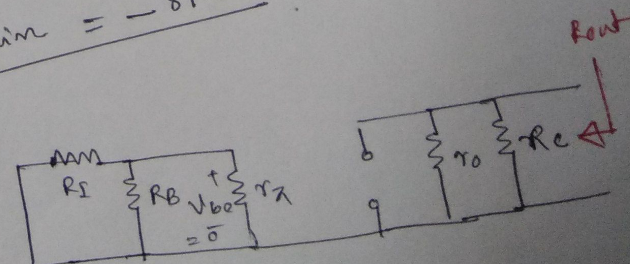
$\therefore v_o = -g_m \left(\frac{R_B\|r_\pi}{R_B\|r_\pi + R_I}\right)\cdot v_i\,(r_o\|R_C\|R_3)$

$\therefore \frac{v_o}{v_i} = -g_m\left(\frac{R_B\|r_\pi}{R_B\|r_\pi + R_I}\right)(r_o\|R_C\|R_3)$.

Gain $= -81.26$.

Input resistance

$R_{in} = R_B \| r_\pi = 6.54$ kΩ.



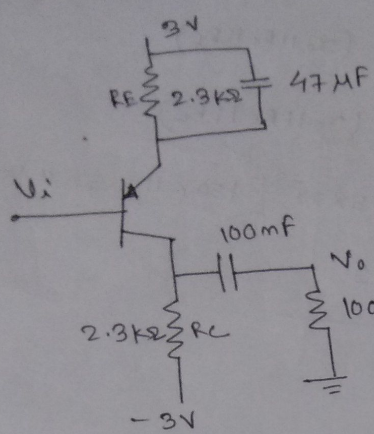
output resistance

$R_{out} = R_C \| r_o = 9.57$ kΩ.

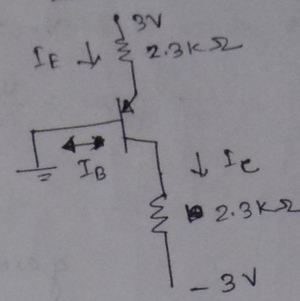
(2)

[redacted]

$\beta = 200$ and $V_A = 150\text{ V}$. (Early voltage)



In DC



p-n-p Common emitter amplifier

(a) Assuming the BJT is in active mode:

$V_{EB} = 0.7\text{ V}$, $I_C > 0$ and $V_{EC} > 0.7\text{ V}$.

Apply KVL in B-E Loop, $3 = 2.3 \times 10^3 \times I_E + V_{EB}$

$\therefore I_E = 1\text{ mA} \approx I_C$

[as $\beta = 200$]

$\therefore I_B = \frac{I_C}{\beta} = 5\ \mu A$.

Apply KVL in C-E loop, $3 = 2.3 \times 10^3 I_E + V_{EC} + 2.3 \times 10^3 I_C - 3$

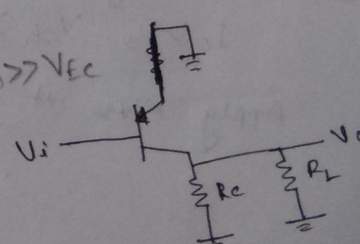
$\therefore V_{EC} = 1.4\text{ V}$ (> 0.7)

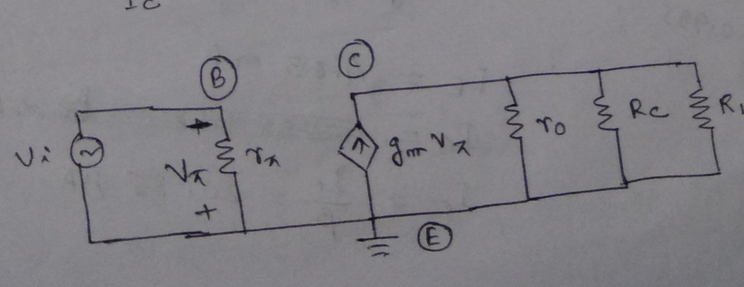
so, in active region as assumed.

(b) $g_m = \frac{I_C}{V_T} = \frac{10^{-3}}{26 \times 10^{-3}} = 38.5\text{ mS}$

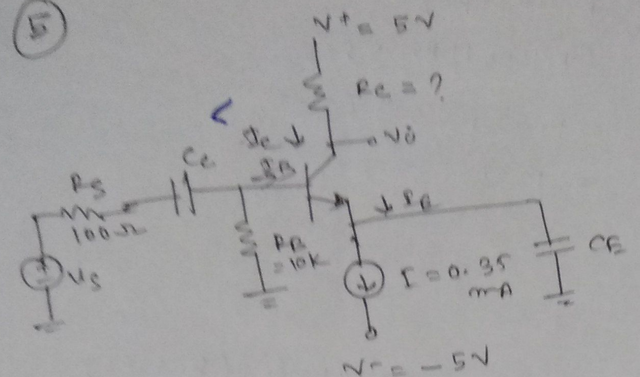
$r_o = \frac{V_A}{I_C} = \frac{150}{1\text{ mA}} = 150\text{ K}\Omega$; $V_A \gg V_{EC}$

$r_\pi = \frac{\beta V_T}{I_C} = 5.2\text{ K}\Omega$





(5)



$\beta = 100$

(a)

So, $I_E = 0.35\ mA$.

$\therefore I_B = \frac{0.35}{101} = 0.00347\ mA = 3.47\ \mu A$

$\therefore V_B = -I_B R_B = -(3.47\ \mu A) \times 10K$.

$V_B = -0.0347\ V$.

$V_{BE(ON)} = 0.7$.

$\therefore V_B - V_E = 0.7$.

$\therefore V_E = -0.7 + V_B = -0.7347\ V$.

~~(b) KVL in C~~

$V_{CEQ} = 3.5V$.

$\therefore V_O = V_{CEQ} + V_E$

$= 3.5 - 0.7347$

$\cong 2.77V$.

(b) $\frac{5 - V_O}{R_C} = I_C = \frac{\beta}{1+\beta} I_E$

$\therefore \frac{5 - 2.77}{R_C} = 0.347$.

$\therefore R_C = 6.43\ k\Omega$.

(c) $V_A = 100\ V$, $r_o = \frac{V_A}{I_C} = 288\ k\Omega$.

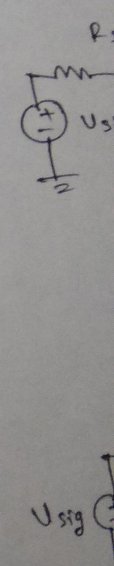
$g_m = \frac{I_C}{V_T} = 13.3\ mA/V$.

$r_\pi = \frac{100 \times V_T}{I_C} = 7.49\ k\Omega$

$$\text{gain}(A_v) = \frac{V_o}{V_s} = -g_m \cdot \left(\frac{R_B \| r_\pi}{R_S + R_B \| r_\pi} \right) (R_C \| r_o)$$

$= -81.7$.

(6)



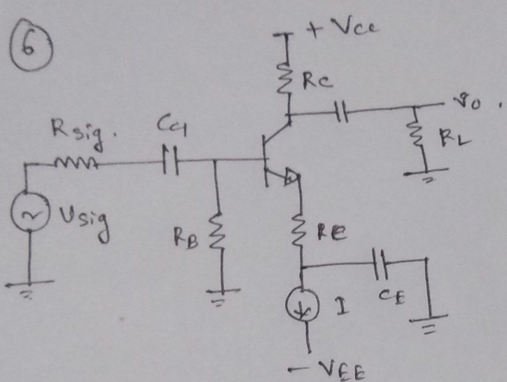
(d)

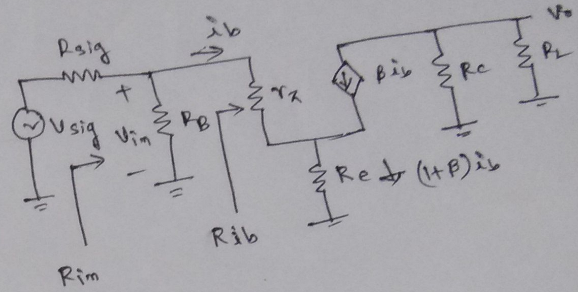
(d) if, $R_s = 500\Omega$

$$A_v = -g_m \times \frac{R_B \parallel r_\pi}{R_B \parallel r_\pi + R_s} \times (R_c \parallel r_o)$$

$$= -74.9$$ (Comment: gain reduces when R_s increases)

(6)





$$V_{in} = i_b r_\pi + (1+\beta) i_b R_e \quad \therefore \; R_{ib} = \frac{V_{in}}{i_b} = r_\pi + (1+\beta) R_e$$

$$R_{in} = R_B \parallel R_{ib}$$

$$\therefore \; V_{in} = \frac{R_{in}}{R_{in} + R_{sig}} V_{sig}$$

$$V_o = -\beta i_b (R_c \parallel R_L)$$

$$V_o = -\beta \cdot \frac{V_{in}}{R_{ib}} (R_c \parallel R_L)$$

$$V_o = -\frac{\beta (R_c \parallel R_L)}{r_\pi + (1+\beta) R_e} \cdot V_{in}$$

$$\therefore \; \frac{V_o}{V_{in}} = -\frac{\beta (R_c \parallel R_L)}{r_\pi + (1+\beta) R_e}$$

$$\therefore \; \frac{V_o}{V_{sig}} = -\frac{\beta R_{in} (R_c \parallel R_L)}{(R_{in} + R_{sig})\left[r_\pi + (1+\beta) R_e\right]} = A_v$$ (Small-signal voltage gain).