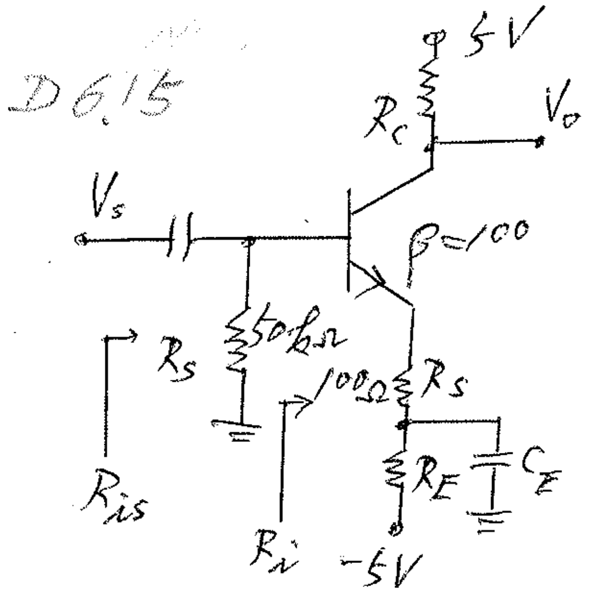
EECE 315 Exercise # 4

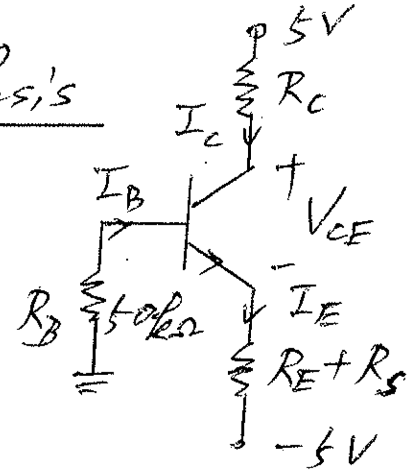
D6.15



$I_{CQ} = 0.25\ mA$, $V_{CEQ} = 3V$

dc analysis

$I_C = \beta I_B$



$$I_B \times R_B + 0.7 + I_E(R_E + R_S) - 5 = 0$$

$$\underline{\underline{R_E = 16.4\ k\Omega}}$$

$$-5 + I_C R_C + V_{CE} + I_E(R_E + R_S) - 5 = 0$$

$$\underline{\underline{R_C = 11.3\ k\Omega}}$$

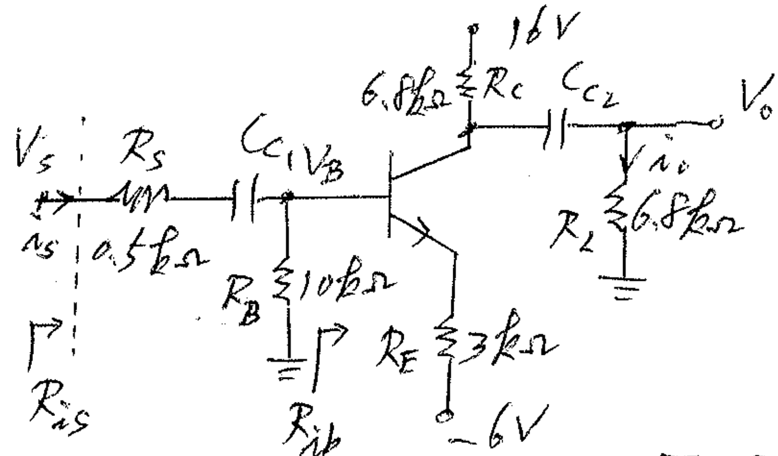
$$g_m = \frac{I_{CQ}}{0.025} = 0.01\ A/V, \quad r_\pi = \frac{\beta}{g_m} = 10\ k\Omega$$

$$R_i = r_\pi + (1+\beta) \times R_s = 20.1\ k\Omega$$

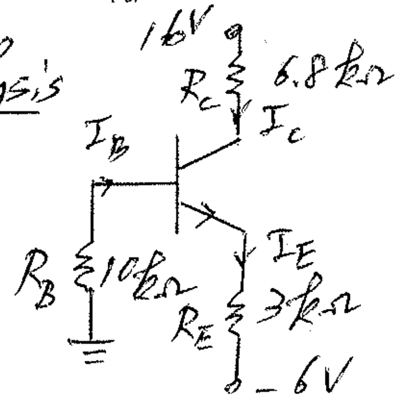
$$R_{is} = R_B \parallel R_i = \underline{\underline{14.3\ k\Omega}}$$

$$A_V = -\frac{\beta R_C}{(\beta+1)R_S + r_\pi} = \underline{\underline{-56.2}}$$

6.26



dc analysis



$$I_B \times R_B + 0.7 + I_E R_E - 6 = 0$$

$$\frac{I_{CQ}}{\beta} \times R_B + 0.7 + \left(\frac{I_{CQ}}{\beta} + I_{CQ}\right) R_E - 6 = 0$$

$$\underline{\underline{I_{CQ} = 1.69 \text{ mA}}}$$

$$V_{CEQ} = 16 - I_{CQ} R_C - I_{EQ} \times 3 + 6$$

$$\underline{\underline{V_{CEQ} = 5.39 \text{ V}}}$$

$$g_m = \frac{I_{CQ}}{0.025} = \underline{\underline{67.6 \text{ mA/V}}}$$

$$r_\pi = \frac{\beta}{g_m} = \underline{\underline{1.479 \text{ k}\Omega}}, \quad \underline{\underline{r_o = \infty}}$$

$$R_{ib} = r_\pi + (\beta+1) \times R_E = \underline{\underline{304.5 \text{ k}\Omega}}$$

$$R_{is} = R_s + (R_{ib} \parallel R_B) = \underline{\underline{10.18 \text{ k}\Omega}}$$

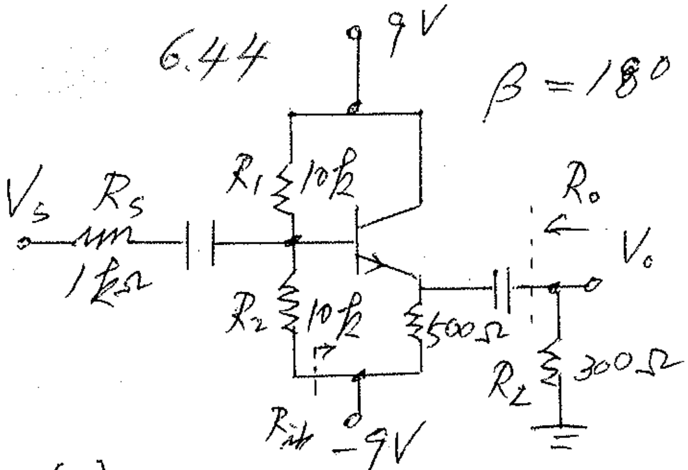
$$\frac{V_o}{V_B} = -\frac{\beta (R_C \parallel R_L)}{(\beta+1) R_E + r_\pi} = -1.117$$

$$\frac{V_o}{V_s} = \frac{V_o}{V_B} \times \frac{V_B}{V_s}; \quad \frac{V_B}{V_s} = \frac{R_{ib} \parallel R_B}{R_{ib} \parallel R_B + R_s} = 0.951$$

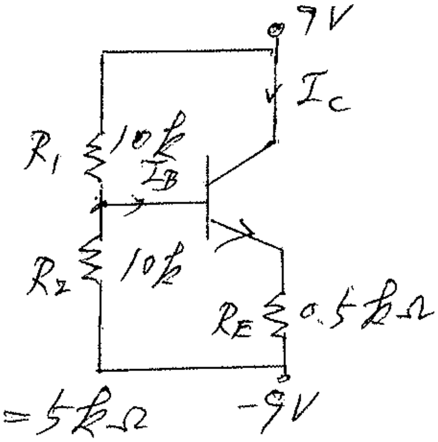
$$\frac{V_o}{V_s} = -1.117 \times 0.951 = \underline{\underline{-1.062}}$$

$$i_o = \frac{V_o}{R_L}, \quad i_s = \frac{V_s}{R_{is}}, \quad \frac{i_o}{i_s} = \frac{V_o}{V_s} \times \frac{R_{is}}{R_L} = \underline{\underline{-1.59}}$$

6.44 $\beta = 180$



dc analysis



(a)

$V_{TH} = 0$ (why), $R_{TH} = R_1 // R_2 = 5k\Omega$

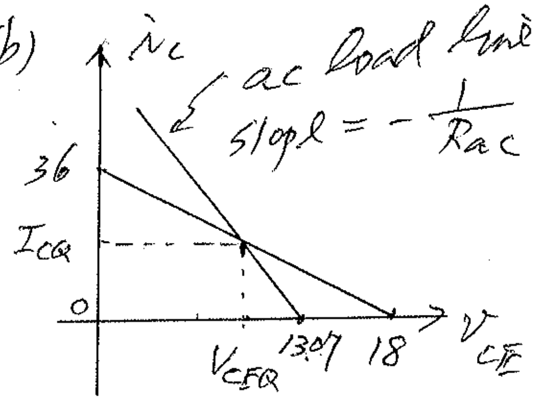
$$-V_{TH} + \frac{I_{CQ}}{\beta} \times R_{TH} + 0.7 + \left(\frac{I_{CQ}}{\beta} + I_{CQ}\right) \times 0.5 - 9 = 0$$

$$g_m = \frac{I_{CQ}}{0.025} = 0.6256 \text{ A/V}$$

$\therefore$ $\underline{I_{CQ} = 15.64 \text{ mA}}$,

$$V_{CEQ} = 9 - (-9) - \left(I_{CQ} + \frac{I_{CQ}}{\beta}\right) \times 0.5 = \underline{10.136 \text{ V}}$$

(b)



dc load line eq

$$18 \simeq V_{CE} + I_C R_E$$

$$R_{ac} = 500 // 300 = 187.5\Omega$$

ac load line eq

$$v_{CE} + R_{ac} i_C = b$$

where $b = V_{CEQ} + R_{ac} I_{CQ}$

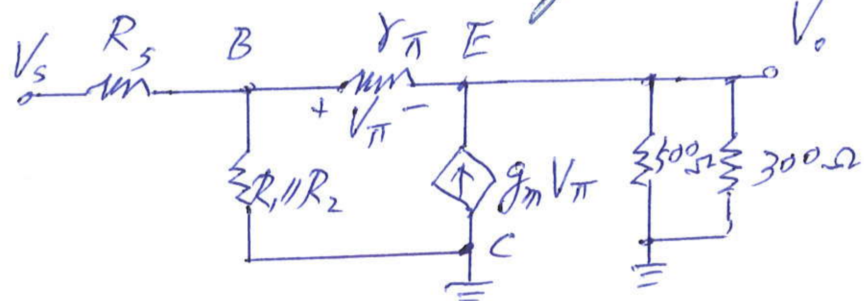
ac load line eq. $v_{CE} + R_{ac} i_C = V_{CEQ} + R_{ac} I_{CQ}$

(c) $R_{ib} = r_\pi + (\beta + 1)(500 // 300)$, $r_\pi = \frac{180}{g_m} = 287.7\Omega$

$\underline{R_{ib} = 34.2 \text{ k}\Omega}$

6.44

ac analysis



$$\frac{V_o}{500 \parallel 300} - g_m V_\pi + \frac{V_o - V_B}{r_\pi} \simeq 0 \quad ; \quad V_o - V_B = -V_\pi$$

$$\frac{V_o}{187.5} - 0.6256 V_\pi - \frac{V_\pi}{287.7} = 0 \quad , \quad \underline{V_o = 117.95 V_\pi}$$

$$\frac{V_B}{R_1 \parallel R_2} + \frac{V_\pi}{r_\pi} + \frac{V_B - V_s}{R_s} = 0 \quad ; \quad V_B = V_o + V_\pi$$

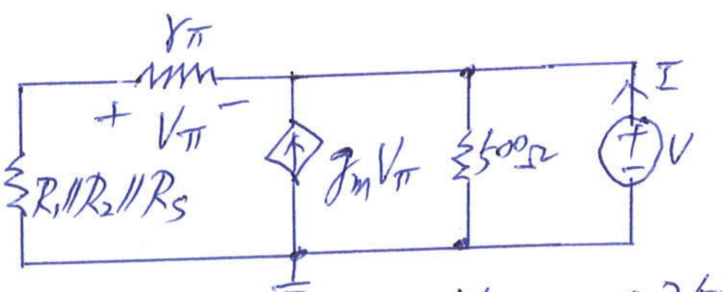
$$\left(\frac{1}{5000} + \frac{1}{1000}\right)(V_o + V_\pi) + \frac{V_\pi}{287.7} - \frac{V_s}{1000} = 0$$

$$0.0012(V_o + 0.00848 V_o) + 0.0000295 V_o = \frac{V_s}{1000}$$

$$\therefore A_v = \frac{V_o}{V_s} = \underline{\underline{0.806}}$$

(d)

Eq. circuit to determine R_o



$$I = \frac{V}{500} - g_m V_\pi - \frac{V_\pi}{r_\pi}$$

$$V_\pi = -V \times \frac{r_\pi}{r_\pi + (R_1 \parallel R_2 \parallel R_s)}$$

$R_1 \parallel R_2 \parallel R_s = 833.3\Omega$, $V_\pi = -0.257V$, $I = \frac{V}{500} - \left(g_m + \frac{1}{r_\pi}\right) V_\pi$

$$I = \frac{V}{500} - \left(0.6256 + \frac{1}{287.7}\right) \times (-0.257)\, V$$

$$\therefore R_o = \frac{V}{I} = \underline{\underline{6.11\ \Omega}}$$

6.67 dc analysis

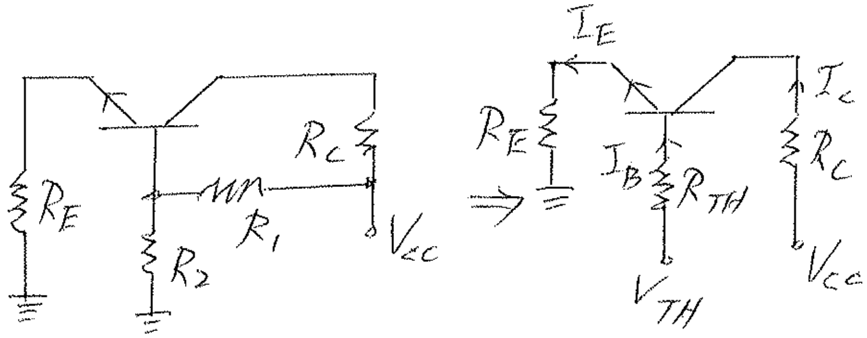
(a)

$V_{CC} = 9V$, $R_C = 6\ k\Omega$

$R_E = 3\ k\Omega$, $R_1 = 150\ k\Omega$

$R_2 = 50\ k\Omega$, $\beta = 125$

$V_{BE} = 0.7\ V$, $V_A = \infty$



$R_{TH} = R_1 \| R_2 = 37.5\ k\Omega$

$V_{TH} = V_{CC} \times \frac{R_2}{R_1 + R_2} = 2.25\ V$

$-V_{TH} + I_B \times R_{TH} + V_{BE} + I_E \times R_E = 0$, $I_E = I_B + I_C = (\beta+1) I_B$

$-2.25 + 37.5 \times I_B + 0.7 + 126 \times 3 \times I_B = 0$, $I_B = 3.73\ \mu A > 0$

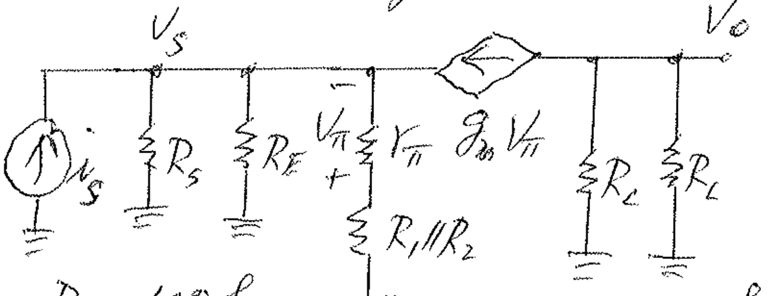
$\therefore\ I_{CQ} = \underline{0.466\ mA}$, $V_{CEQ} = V_{CC} - I_C R_C - I_E R_E = \underline{4.79\ V}$

$V_{BC} = V_{BE} - V_{CE} = 0.7 - 4.79 = -4.09\ V < 0$

(b) ac analysis $R_L = 4\ k\Omega$

$g_m = \frac{I_{CQ}}{0.025} = 18.64\ mA/V$

$r_\pi = \frac{\beta}{g_m} = 6.706\ k\Omega$



$V_o = -g_m V_\pi \times (R_L \| R_C) = -44.736\ V_\pi$

$V_\pi = -V_S \times \frac{r_\pi}{r_\pi + (R_1 \| R_2)} = -0.1517\ V_S$

$R_S = 100\ k\Omega$

$R_C \| R_L = 2.4\ k\Omega$

$\therefore\ A_v = \frac{V_o}{V_S} = \underline{6.786}$ (c)

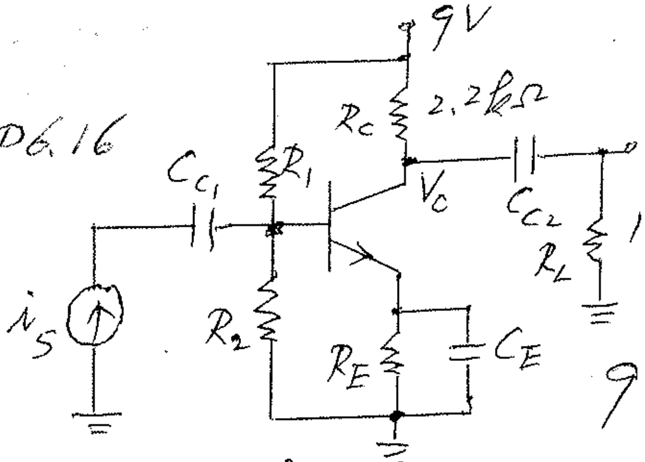
$i_S = \frac{V_S}{R_S} + \frac{V_S}{R_E} - g_m V_\pi - \frac{V_\pi}{r_\pi}$

$i_S = (\frac{1}{R_S} + \frac{1}{R_E}) V_S - g_m(-0.1517 V_S) - \frac{1}{r_\pi} \times (-0.1517 V_S)$

$i_S = [\frac{1}{R_S} + \frac{1}{R_E} + 0.1517 g_m + 0.1517 \times \frac{1}{r_\pi}] V_S = 3.194\ V_S$

$\frac{V_o}{i_S} = \frac{6.786\ V_S}{3.194\ V_S} = \underline{2.125\ k\Omega}$

Fig. P6.16



$R_E = 2\,k\Omega$

$\beta = 150$

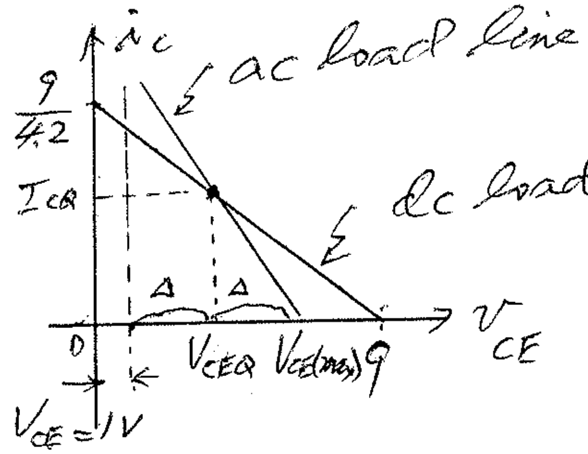
dc load line eq.

$$9 = I_C \times R_C + I_E \times R_E + V_{CE}$$

$$9 \simeq I_C(R_C + R_E) + V_{CE}$$

$$9 \simeq 4.2\, I_C + V_{CE} \quad \cdots\cdots (1)$$

$$R_{ac} = 2.2 \,//\, R_L = 0.6875\ k\Omega$$



$$\Delta = V_{CEQ} - 1$$

$$\therefore\ R_{ac} = \frac{\Delta}{I_{CQ}} = \frac{V_{CEQ} - 1}{I_{CQ}}$$

$$V_{CEQ} = I_{CQ} R_{ac} + 1 \quad \cdots (2)$$

Sub. V_{CEQ} from (2) into (1), we obtain

$$I_{CQ} = 1.64\ mA \text{ and } V_{CEQ} = 2.12\ V$$

$$V_{CE(max)} = V_{CEQ} + \Delta = 2V_{CEQ} - 1 = 3.24\ V < 8\ V$$

Now, choose R_1 and R_2 to give the Q-point.

$$-9 \times \frac{R_2}{R_1 + R_2} + 0.7 + I_{BQ} \times \frac{R_1 R_2}{R_1 + R_2} + I_{EQ} R_E = 0$$

Let $R_{TH} = \dfrac{R_1 R_2}{R_1 + R_2} = \dfrac{(1+\beta) R_E}{10}$ or $R_E = 10 \times \dfrac{R_{TH}}{\beta + 1}$

$$R_1 = 62.9\ k\Omega, \quad R_2 = 58.1\ k\Omega$$