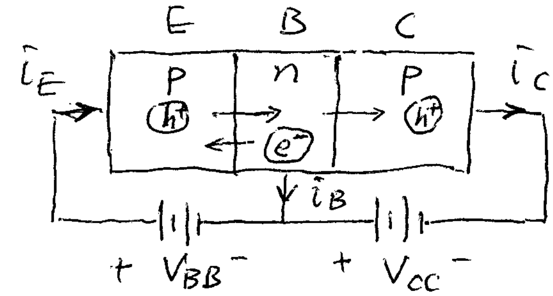
CMPE 314 Midterm Exam-2 Solutions

Fall 201

P1



In forward active mode

$V_{BB} > V_{EB}(on)$

$V_{CC} > 0$

i_E : holes moving from emitter to base

i_C : holes swept from base to collector

i_e : electrons moving from base to emitter.

P2

$\frac{I_C}{I_B} = 2 < \beta$ transistor in saturation region

$V_{CE} = V_{CE}(sat)$

$V_{CC} = R_C I_C + V_{CE}$

$\rightarrow I_R = \frac{V_{CC} - V_{CE}(sat)}{R_C} = \frac{5 - 0.2}{10\ k\Omega} = 0.48\ mA$

$I_B = \frac{I_C}{2} = 0.24\ mA$

$V_I = R_B I_B + V_{BE}(on)$

$= 20\,k\Omega \times 0.24\,mA + 0.7\ V$

$= 5.5\ V$

$P_Q = I_B V_{BE}(on) + I_C V_{CE}(sat)$

$= 0.24\ mA \times 0.7\ V + 0.48\ mA \times 0.2\ V$

$= 0.264\ W$

P3

$$I_E = I_{EO} = 0.5\ mA$$

Assume in forward active mode

$$I_B = \frac{I_E}{1+\beta} = \frac{0.5\ mA}{1+80} = 6.2\ \mu A$$

KVL: $V^- + V_{EC} = V_{EB}(on) + R_B I_B$

$$\rightarrow \quad V_{ECQ} = -V^- + V_{EB}(on) + R_B I_{BQ}$$

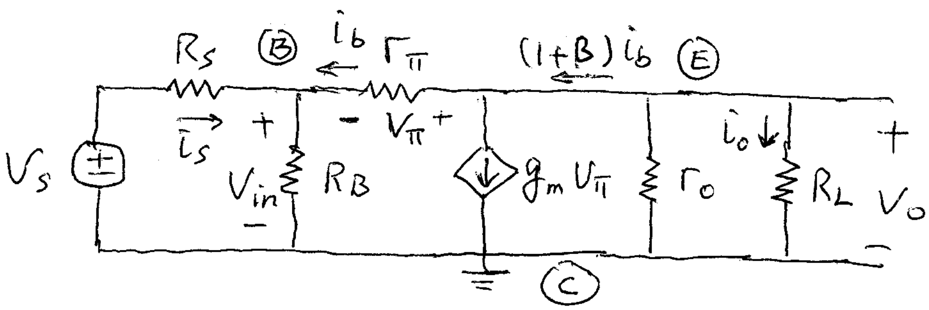
$$= -(-5) + 0.7 + 10\ k\Omega \times 6.2\ \mu A$$

$$= 5.762\ V$$

$V_{ECQ} > V_{EC}(sat)$. Yes, in forward active mode

P4

(a)



$$g_m V_\pi = \beta i_b$$

(b)

$$V_{in} = -V_\pi + V_o$$

$$V_\pi = r_\pi i_b$$

$$V_o = -(1+\beta) i_b (r_o // R_L)$$

$$V_{in} = -[r_\pi + (1+\beta) r_o // R_L] i_b$$

$$R_{ib} \equiv \frac{V_{in}}{-i_b} = r_\pi + (1+\beta) r_o // R_L$$

(c)

$$i_o = i_L = \frac{V_o}{R_L} = -(1+\beta) i_b \frac{r_o}{r_o + R_L}$$

$$i_b = -i_s \frac{R_B}{R_B + R_{ib}}$$

$$A_i = \frac{i_o}{i_s} = (1+\beta) \frac{R_B}{R_B + R_{ib}} \cdot \frac{r_o}{r_o + R_L}$$

(d) Emitter follower

$A_v \lessapprox 1$ $\quad A_i > 1$

R_i moderate to high $\quad R_o$ small

P5

(a)

$$V_{TH} = V^- + (V^+ - V^-)\frac{R_2}{R_1+R_2}$$

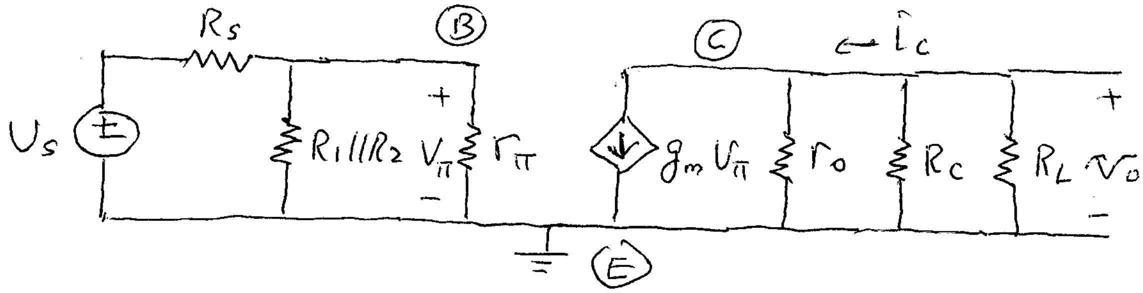
$$R_{TH} = R_1 \| R_2$$

$$V_{TH} = R_{TH} I_B + V_{BE(on)} + R_E I_E \qquad I_E = (1+\beta) I_B$$

$$V^+ - V^- = R_C I_C + R_E I_E + V_{CE} \qquad I_C = \beta I_B$$

$$\text{DC loadline slope} = -\frac{1}{R_C + \frac{(1+\beta)}{\beta} R_E}$$

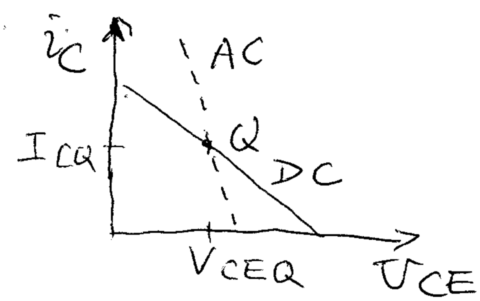
(b)



$$r_\pi = \frac{V_T}{I_{BQ}} \qquad g_m = \frac{I_{CQ}}{V_T} \qquad r_o = \frac{V_A}{I_{CQ}}$$

(c)

$$v_o = v_{ce} = -i_c (R_C \| R_L)$$



(d) $i_C(min)$ specified

Symmetric swing $\rightarrow$ $i_c(max) = I_{CQ} - i_C(min)$

$$i_C(max) = I_{CQ} + i_c(max)$$
$$= 2I_{CQ} - i_C(min)$$

$$v_{CE} = V_{CEQ} + v_{ce} = V_{CEQ} - i_c(R_C \| R_L)$$

$$v_{CE}(min) = V_{CEQ} - i_c(max)(R_C \| R_L)$$
$$= V_{CEQ} - [I_{CQ} - i_C(min)](R_C \| R_L)$$