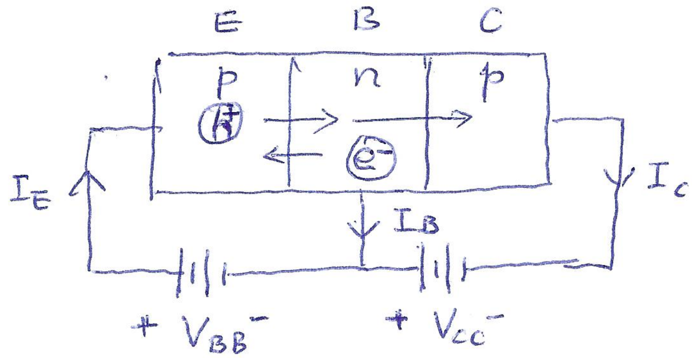
CMPE 314 Midterm Exam-II Solutions Fall 2016

P1



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

$V_{CC} > 0$

P2

① $V_I < V_{BE}(on)$, in cutoff

$i_B = \frac{i_C}{\beta} = 0$

$V_o = V^+$

② $V_I \geq V_{BE}(on)$, enters forward-active mode

$I_B = \frac{V_I - V_{BE}(on)}{R_B}$, $I_C = \beta I_B$

$V_o = V^+ - R_C I_C = V^+ - \frac{R_C}{R_B}\beta\left[V_I - V_{BE}(on)\right]$

③ $V_I \geq V_I'$ too high, in saturation mode

$V_o = V^+ - \frac{R_C}{R_B}\beta\left[V_I' - V_{BE}(on)\right] = V_{CE}(sat)$

so $V_o = V_{CE}(sat)$ when $V_I \geq V_I'$

$V_I' = V_{BE}(on) + \frac{R_B}{\beta R_C}\left[V^+ - V_{CE}(sat)\right]$

P3

$I_E = 1.2 \text{ mA}$

If in forward-active mode

$$I_C = \frac{\beta}{1+\beta} I_E = \frac{80}{81} \times 1.2 \text{ mA} = 1.185 \text{ mA}$$

$$I_B = \frac{I_E}{1+\beta} = 0.0148 \text{ mA}$$

$$V_C = V^+ - R_C I_C = 5 - 2.37 = 2.63 \text{ V}$$

$$V_E = -V_{BE} = -0.7 \text{ V}$$

$$V_{CEQ} = V_C - V_E = 3.3 \text{ V}$$

$V_{CE} > V_{CE(sat)}$ OK, in forward-active mode

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

$$= 0.0148 \times 0.7 + 1.185 \times 3.3$$

$$= 3.956 \text{ mW}$$

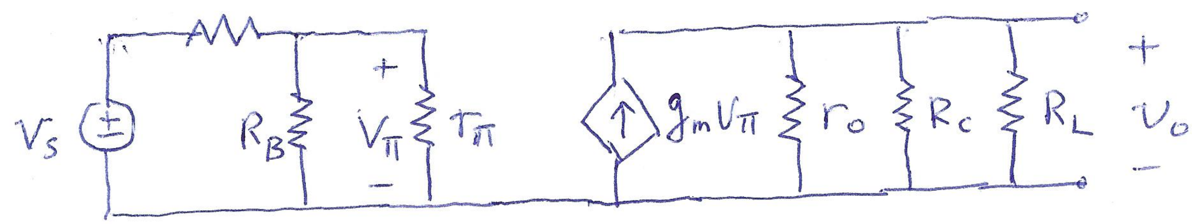
P4

(a) DC loadline

$$V^+ - V^- = I_E R_E + I_C R_C + V_{EC}$$

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

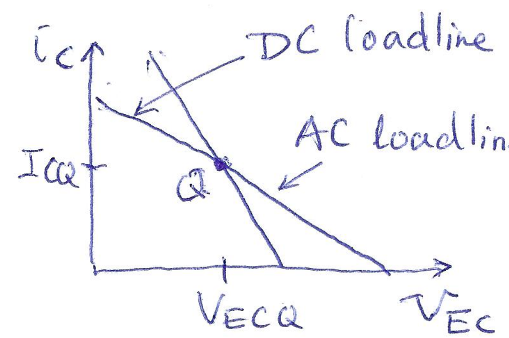
(b)



(c) AC loadline

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

$$\text{AC loadline slope} = \frac{-1}{R_C \| R_L}$$



(d) For symmetric swing

$$\begin{cases} i_{C,min} = 0 \\ i_{C,max} = 2 I_{CQ} \end{cases} \qquad \begin{cases} i_{c,min} = i_{C,min} - I_{CQ} = -I_{CQ} \\ i_{c,max} = i_{C,max} - I_{CQ} = I_{CQ} \end{cases}$$

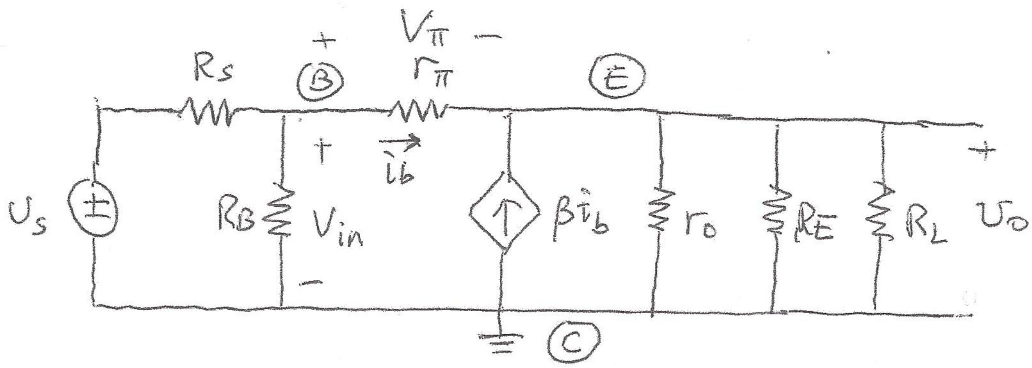
$$v_{EC} = V_{ECQ} + v_{ec} = V_{ECQ} - i_c (R_C \| R_L)$$

$$v_{EC,max} = V_{ECQ} - i_{c,min} (R_C \| R_L) = V_{ECQ} + I_{CQ} (R_C \| R_L)$$

$$v_{EC,min} = V_{ECQ} - i_{c,max} (R_C \| R_L) = V_{ECQ} - I_{CQ} (R_C \| R_L)$$

P5

(a)



$$r_\pi = \frac{V_T}{I_{BQ}}, \quad g_m = \frac{I_{CQ}}{V_T}, \quad r_o = \frac{V_A}{I_{CQ}} \qquad \beta i_b \equiv g_m V_\pi$$

(b) $V_{in} = i_b r_\pi + (1+\beta) i_b (r_o \| R_E \| R_L)$

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

(c) $U_o = (1+\beta) i_b (r_o \| R_E \| R_L)$

$$i_b = \frac{U_{in}}{R_{ib}}$$

$$R_i = R_B \| R_{ib}$$

$$U_{in} = V_s \frac{R_i}{R_s + R_i}$$

$$A_v = \frac{U_o}{U_s} = \frac{(1+\beta)(r_o \| R_E \| R_L) R_i}{R_{ib}(R_s + R_i)}$$

(d) emitter-follower

$A_v \simeq 1$ $\qquad$ $A_i > 1$

R_o small $\qquad$ R_i moderate