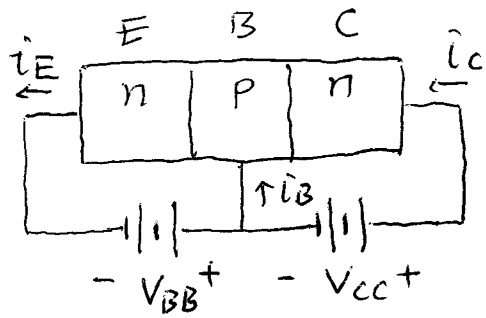
CMPE 314 Midterm Exam-2 Solutions

spring 2018

P1



Forward active mode

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

$V_{CC} > 0$

i_E: e^- from emitter injected into base

i_C: Same e^- swept to collector

i_B: h^+ from base move to emitter

P2

① $V_I < V_{BE}(on)$, in cutoff mode

$$V_o = V_{CC} = 5\,V$$

② $V_I > V_{BE}(on)$, in forward active mode

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

$$I_C = \beta I_B$$

$$V_o = V_{CC} - R_C I_C = V_{CC} - \beta \frac{R_C}{R_B}\left(V_I - V_{BE}(on)\right)$$

③ When $V_{CE} = V_{CE}(sat)$, in saturation mode

$$V_o = V_{CE} = V_{CE}(sat) = V_{CC} - \beta \frac{R_C}{R_B}\left(V_{I,sat} - V_{BE}(on)\right)$$

$$\rightarrow V_I \geq V_{I,sat} = \frac{R_B}{\beta R_C}\left(V_{CC} - V_{CE}(sat)\right) + V_{BE}(on)$$

P3

$$I_E = I_{EO} = 0.8\ mA$$

Assume in forward active mode

$$I_C = \frac{\beta}{1+\beta} I_E = \frac{80}{81} 0.8\ mA = 0.79\ mA$$

$$I_B = \frac{I_E}{1+\beta} = \frac{0.8\ mA}{81} = 9.88\ \mu A$$

$$V_C = -10 + R_C I_C = -10 + 5\ k\Omega \times 0.79\ mA = -6.05\ V$$

$$V_{EC} = V_E - V_C = 0.7 - (-6.05) = 6.75\ V$$

$V_{EC} > V_{EC}(sat)$, yes in forward active mode

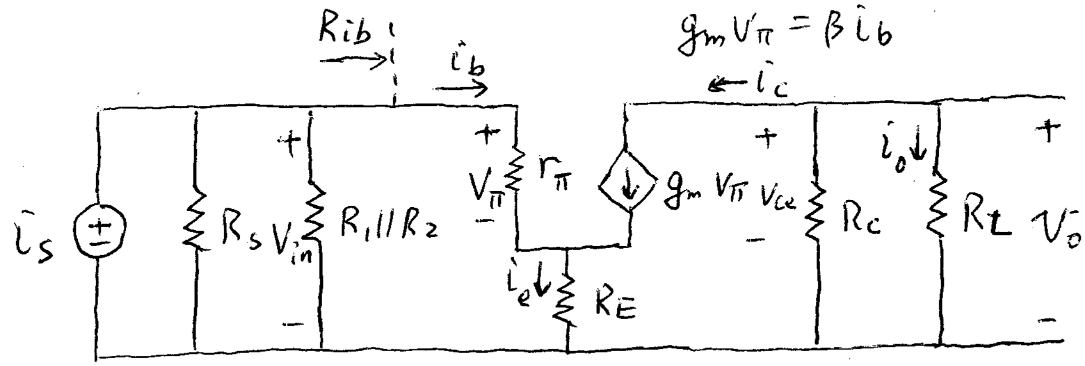
$$P_Q = V_{EB} I_B + V_{EC} I_C$$

$$= 0.7\ V \times 9.88\ \mu A + 6.75\ V \times 0.79\ mA$$

$$= 5.34\ mW$$

P4

(a)



(b)

$$v_{ce} = v_o - v_{RE}$$

$$= -i_c (R_C \| R_L) - i_e R_E \qquad i_e = \frac{1+\beta}{\beta} i_c$$

$$= -i_c \left(R_C \| R_L + \frac{1+\beta}{\beta} R_E \right)$$

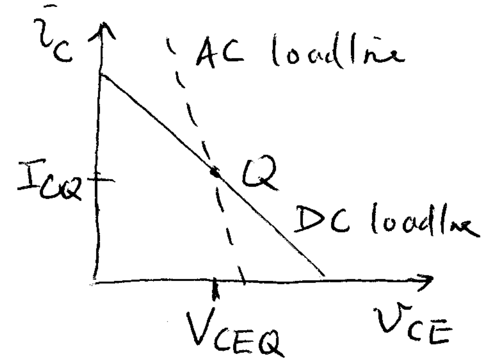
$$\text{AC loadline slope} = -\frac{1}{R_C \| R_L + \frac{1+\beta}{\beta} R_E}$$

Under symmetric swing

$$i_{c,max} = 2 I_{CQ}$$

$$|\Delta i_c| = 2 I_{CQ}$$

$$|\Delta v_{ce}| = |\Delta i_c| \left(R_C \| R_L + \frac{1+\beta}{\beta} R_E \right)$$



(c)

$$i_o = -i_c \frac{R_C}{R_C + R_L}$$

$$i_c = \beta i_b$$

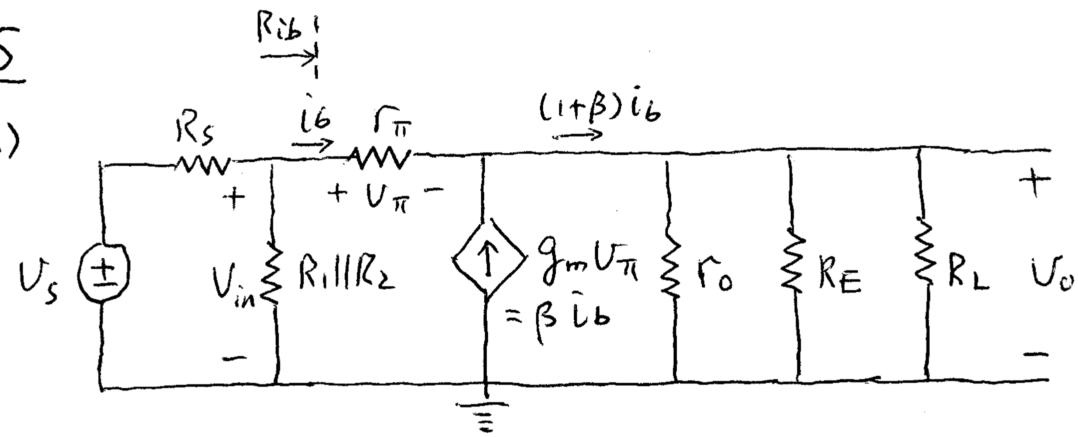
$$i_b = i_s \frac{R_S \| R_1 \| R_2}{R_S \| R_1 \| R_2 + R_{ib}}$$

$$A_o = \frac{i_o}{i_s} = -\frac{R_S \| R_1 \| R_2}{R_S \| R_1 \| R_2 + R_{ib}} \cdot \frac{R_C}{R_C + R_L}$$

$$R_{ib} = \frac{V_{in}}{i_b} = \frac{V_\pi + V_{RE}}{i_b} = \frac{r_\pi i_b + (1+\beta) i_b R_E}{i_b} = r_\pi + (1+\beta) R_E$$

P5

(a)



(b) $R_{ib} = \dfrac{v_{in}}{i_{in}}$ $\qquad\qquad i_{in} = i_b$

$v_{in} = v_\pi + v_o$ $\qquad\qquad v_\pi = r_\pi i_b$

$= r_\pi i_b + (1+\beta) i_b (r_o \| R_E \| R_L)$

$R_{ib} = r_\pi + (1+\beta) r_o \| R_E \| R_L$

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

$R_i = R_1 \| R_2 \| R_{ib}$

$v_{in} = v_s \dfrac{R_i}{R_s + R_i}$

$i_b = \dfrac{v_{in}}{R_{ib}} = \dfrac{v_s}{R_{ib}} \dfrac{R_i}{R_s + R_i}$

$A_v = \dfrac{v_o}{v_s} = \dfrac{(1+\beta) r_o \| R_E \| R_L}{r_\pi + (1+\beta) r_o \| R_E \| R_L} \cdot \dfrac{R_i}{R_s + R_i}$

(d) Emitter follower

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

R_i high $\quad R_o$ small