CMPE 314 Midterm Exam II Solutions

Fall 2014

P1

$$V^+ = V_{EB(on)} + I_B R_B + V_I$$

$$I_B = \frac{V^+ - V_I - V_{EB(on)}}{R_B} = \frac{5 - 2 - 0.7}{200\ k\Omega} = 0.0115\ mA$$

If $I_C = \beta I_B = 0.92\ mA$

$\rightarrow$ $V_{EC} = V^+ - I_C R_C = -2.36\ V$ $\times$

$\rightarrow$ In saturation $V_{EC} = V_{EC(sat)}$

$$I_C = \frac{V^+ - V_{EC(sat)}}{R_C} = \frac{5 - 0.2}{8\ k\Omega} = 0.6\ mA$$

$$P_Q = I_B V_{EB(on)} + I_C V_{EC(sat)}$$

$$= 0.0115\ mA \times 0.7\ V + 0.6\ mA \times 0.2\ V = 0.128\ mW$$

P2

$I_E = 1.2\ mA$

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

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

$V_E = -0.7\ V$

$V_{CEQ} = V_C - V_E = 2.63 - (-0.7) = 3.33\ V$

$V_{CE} > V_{CE(sat)}$ Yes, transistor is in forward-active mode.

P3

(a)

$$V^+ = I_E R_E + V_{EB(on)} + I_B R_B$$

$$I_C = \beta I_B, \quad I_E = (1+\beta) I_B$$

$\rightarrow I_{BQ}, I_{CQ}, I_{EQ}$

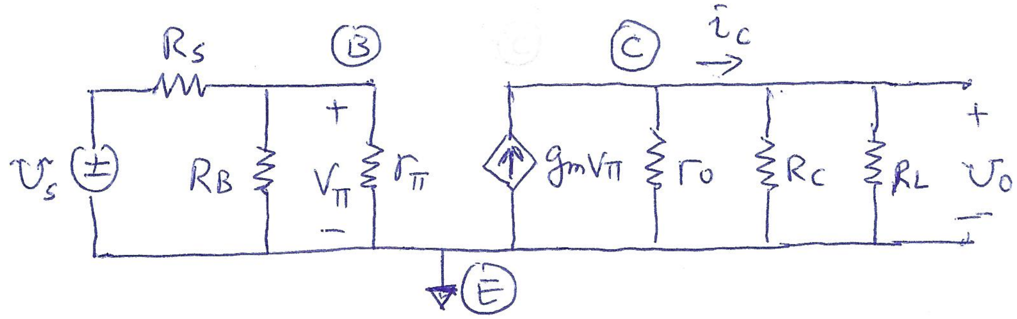
$$V^+ - V^- = I_E R_E + I_C R_C + V_{EC} \quad \rightarrow \quad V_{ECQ}$$

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

R_E — stabilize Q-pt.

C_E — short R_E to increase AC loadline slope.

(b)



(c)

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

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

For symmetric swing

$$i_{C,min} = 0 \qquad i_{c,min} = i_{C,min} - I_{CQ} = -I_{CQ}$$

$$i_{C,max} = 2I_{CQ} \qquad i_{c,max} = i_{C,max} - I_{CQ} = I_{CQ}$$

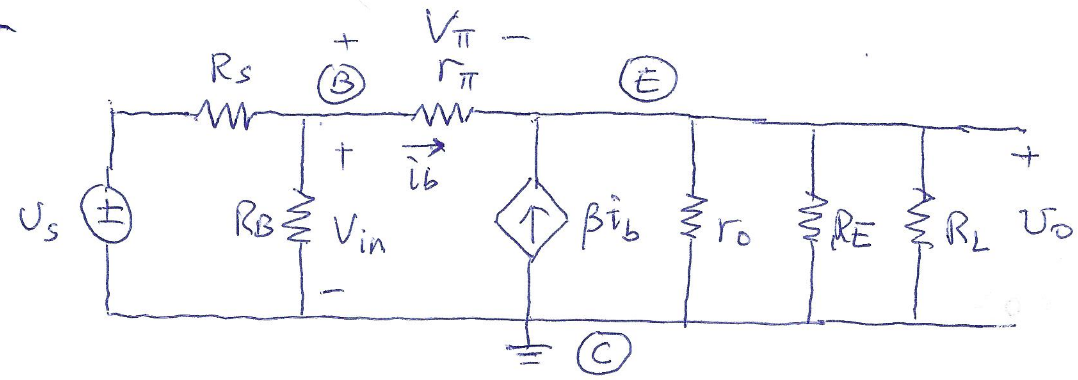
$$v_{EC} = V_{ECQ} + v_{ec} = V_{ECQ} - i_c (R_C \| R_L)$$

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

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

P4

(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)

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

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

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

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

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

(d) emitter-follower

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

R_o small $\qquad$ R_i moderate