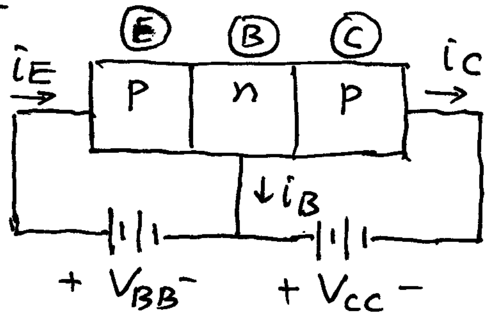
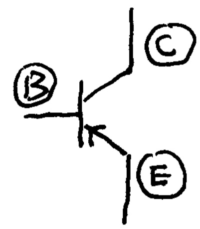
CMPE 314 Midterm Exam-2 Solutions

2018 Summer

P1





Forward-active mode

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

$V_{CC} > 0$

i_E : h^+ from emitter injected into base

i_C : Injected h^+ swept from base to collector

i_B : e^- injected from base to emitter

P2

(1) Assume in forward-active mode

$I_B = 15\ \mu A$

$I_C = \beta I_B = 120 \times 15\ \mu A = 1.8\ mA$

$I_E = (1+\beta) I_B = 121 \times 15\ \mu A = 1.815\ mA$

$V_{EC} = V^+ - R_E I_E = 2 - 1.5\,k\Omega \times 1.815\ mA = -0.7225\ V$ ×

(2) In saturation mode

$V_{EC} = V_{EC}(sat) = 0.2\ V$

$$I_E = \frac{V^+ - V_{EC}(sat)}{R_E} = \frac{2-0.2}{1.5\,k\Omega} = 1.2\ mA$$

$I_C = I_E - I_B = 1.2 - 0.015 = 1.185\ mA$

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

$= 0.7 \times 0.015 + 0.2 \times 1.185 = 0.2475\ mW$

P3

(1) Thevenin equivalent circuit at base

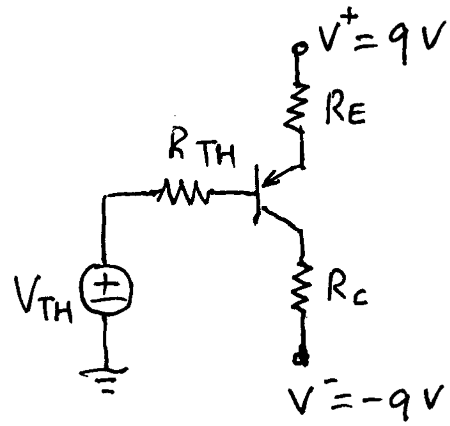
$$V_{TH} = V^- + \frac{R_1}{R_1+R_2}(V^+ - V^-)$$

$$= -9 + \frac{162}{18+162}(9-(-9)) = 7.2\ V$$

$$R_{TH} = R_1 \| R_2 = \frac{18 \times 162}{18+162} = 16.2\ k\Omega$$

(2)

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



$$I_E = (1+\beta) I_B$$

$$I_{BQ} = \frac{V^+ - V_{EB}(on) - V_{TH}}{R_{TH} + (1+\beta)R_E}$$

$$= \frac{9-0.7-7.2}{16.2+81\times 2} = 0.0062\ mA$$

$$I_{CQ} = \beta I_{BQ} = 80 \times 0.0062 = 0.494\ mA$$

$$I_{EQ} = (1+\beta) I_{BQ} = 81 \times 0.0062 = 0.5\ mA$$

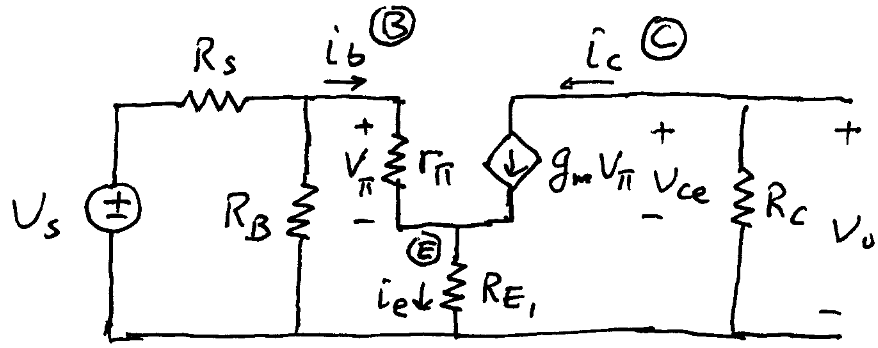
$$V_{ECQ} = V^+ - V^- - R_E I_E - R_C I_C$$

$$= 9-(-9) - 2k\Omega \times 0.5\,mA - 20k\Omega \times 0.494\,mA$$

$$= 18 - 1 - 9.88 = 7.12\ V$$

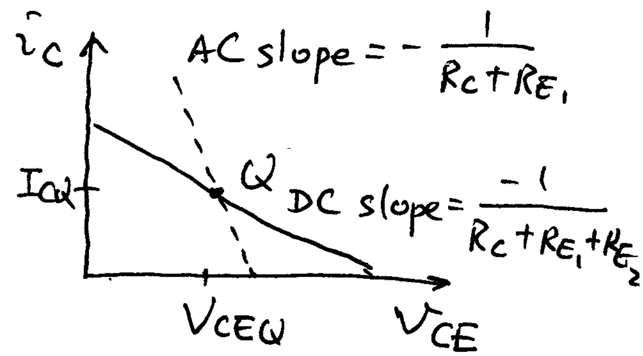
P4

(a)



(b)

$$v_{ce} = v_o - v_{RE_1}$$
$$= -R_c i_c - R_{E_1} i_e$$
$$= -\left(R_c + \frac{1+\beta}{\beta} R_{E_1}\right) i_c$$



(c) Under symmetric swing

$$i_c(\min) = -I_{CQ}, \quad i_c(\max) = I_{CQ}$$

$$i_{C,full}(\min) = 0, \quad i_{C,full}(\max) = 2I_{CQ}$$

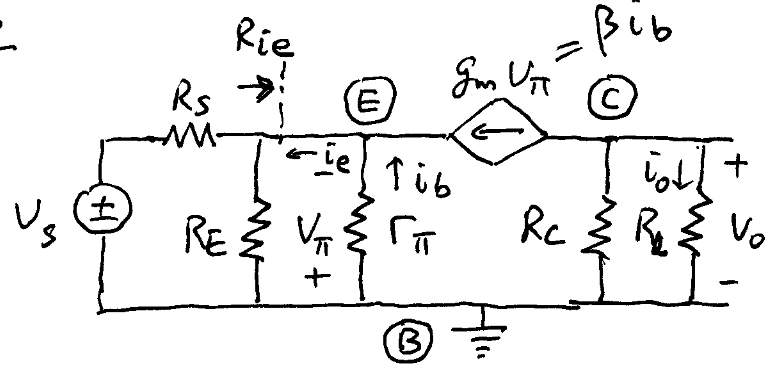
$$v_{o,full} = V^+ - i_{C,full} R_C$$

$$v_{o,full}(\max) = V^+ - i_{C,full}(\min) R_C = V^+$$

$$v_{o,full}(\min) = V^+ - i_{C,full}(\max) R_C = V^+ - 2 I_{CQ} R_C$$

P5

(a)



Common-base amplifier

$A_i \simeq 1$

$A_v > 1$

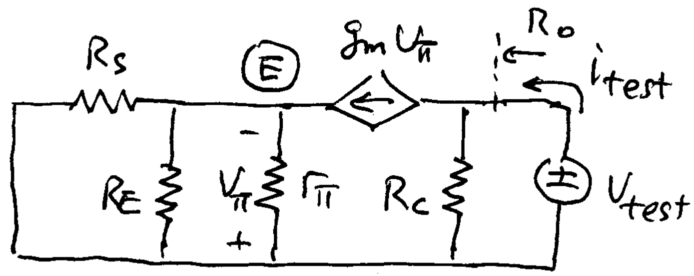
R_i small

R_o moderate to high

(b) $R_{ie} = \dfrac{V_{in}}{i_{in}} = \dfrac{-V_\pi}{-i_e} = \dfrac{V_\pi}{(1+\beta)i_b} = \dfrac{r_\pi}{1+\beta}$

$R_i = R_E // R_{ie}$

(c) KCL at E



$$g_m V_\pi + \frac{V_\pi}{r_\pi} + \frac{V_\pi}{R_E} + \frac{V_\pi}{R_s} = 0$$

$\rightarrow V_\pi = 0 \quad \rightarrow g_m V_\pi = 0 \quad \rightarrow R_o = R_C$

(d) KCL at E

$$g_m V_\pi + \frac{V_\pi}{r_\pi} + \frac{V_\pi}{R_E} + \frac{V_s - (-V_\pi)}{R_s} = 0$$

$$V_\pi \left(\frac{1+\beta}{r_\pi} + \frac{1}{R_E} + \frac{1}{R_s} \right) = -\frac{V_s}{R_s}$$

$g_m r_\pi = \beta$

$$\rightarrow V_\pi = -\frac{V_s}{R_s}\left[\left(\frac{r_\pi}{1+\beta}\right) // R_E // R_s\right]$$

$$i_o = -g_m V_\pi \frac{R_C}{R_C + R_L}$$

$$G_f = \frac{i_o}{V_s} = \frac{g_m}{R_s}\left[\left(\frac{r_\pi}{1+\beta}\right) // R_E // R_s\right]\frac{R_C}{R_C + R_L}$$