CMPE 314 Midterm Exam 2

(April 19, 2011)

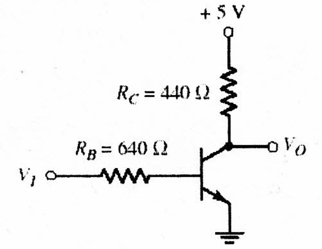
Problem 1. (15 points) - drawing & description

(a) What are the conditions for the cutoff, forward-active, and saturation modes for a pnp bipolar transistor? Show the structure, biasing connections.

(b) What are the charge carrier contributions to the emitter, collector and base currents (show directions)?

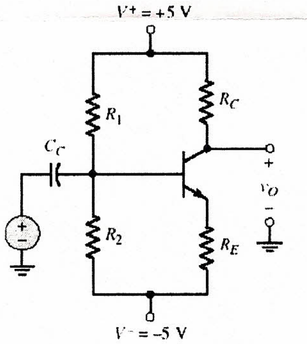
Problem 2. (20 points) - numerical answer

The transistor in the circuit has $\beta=50$, $V_{BE}(\text{on})=0.7$ V and $V_{CE}(\text{sat})=0.2$ V. Determine I_B, I_C, and the power dissipated in the transistor for $V_I=3.6$ V. Is the transistor in the forward-active mode?



Problem 3. (25 points) - equations

Derive the equations for I_{CQ} and V_{CEQ}. Comment on the role of R_E. What is the maximum collector current under symmetric swing.

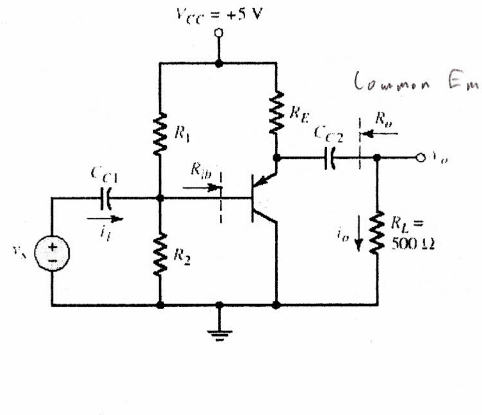


Problem 4. (40 points) - equations

(a) Assume finite V_A. Draw the AC equivalent circuit, including the hybrid-π model.

(b) Find the DC load-line lope and the AC load-line slope.

(c) Find the small-signal voltage gain and input resistance. Comment on the type of amplifier configuration and output resistance.



Common Emitter $A_v > 1$

$A_i > 1$

Input → Moderate

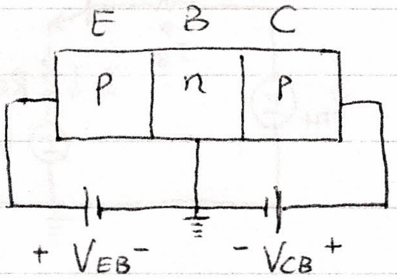
Output → Moderate → High

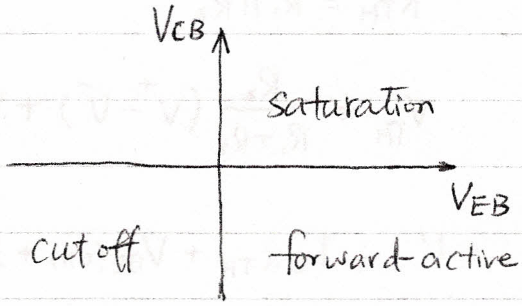
Solutions to Midterm Exam II

CMPE 314
Spring 2011

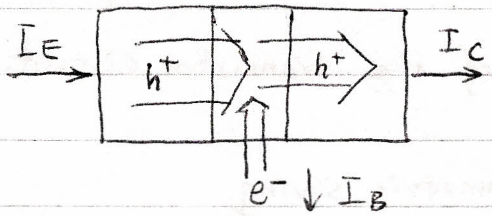
Problem 1

(a)





(b)



I_E, I_C : Holes contribute most.

I_B : Electrons contribute most.

Problem 2

$V_I = I_B R_B + V_{BE}(on)$ $\quad (V_I = 3.6V) \rightarrow \quad I_B = \frac{3.6-0.7}{640} = 4.53\,mA$

If $\quad I_c = \beta I_B = 50 \times 4.53\ \cancel{mA} = 226.56\ mA$

then

$V_{CE} = V^+ - I_c R_c = 5 - 99.66 = -94.66\ V$ $\qquad$ not possible.

Transistor is in saturation

$$I_c = \frac{V^+ - V_{CE}(sat)}{R_C} = \frac{5-0.2}{440} = 10.91\ mA$$

$P_D = I_B V_{BE}(on) + I_C V_{CE}(sat) = 3.171 + 2.182 = 5.353\ mW$

Solutions to Midterm Exam II

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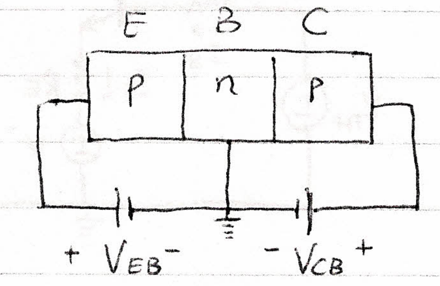
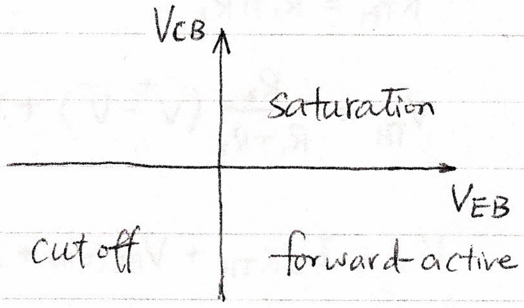
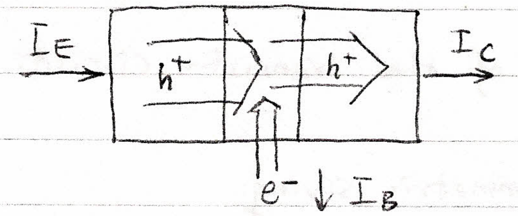
Problem 1

(a)





(b)



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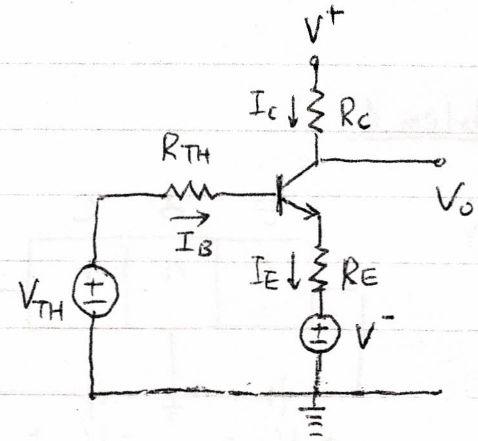
Transistor is in saturation

$$I_C = \frac{V^+ - V_{CE}(sat)}{R_C} = \frac{5-0.2}{440} = 10.91\,mA$$

$$P_Q = I_B V_{BE}(on) + I_C V_{CE}(sat) = 3.171 + 2.182 = 5.353\,mW$$

Problem 3



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

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

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

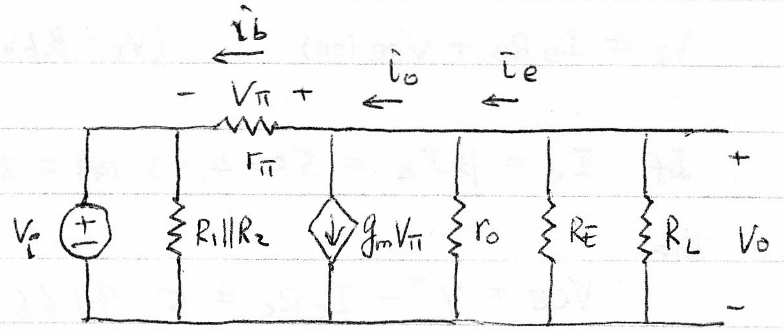
$$V^+ - V^- = I_C R_C + I_E R_E + V_{CE} \qquad I_C = \beta I_B = \frac{\beta}{1+\beta} I_E$$

R_E is to stablize the Q-pt of the transistor circuit.

$\hat{i}_{C,max} = 2 I_{CQ}$ under symmetric swing

Problem 4

(a)



(b)

$$DC: \quad V^+ = I_E R_E + V_{EC} = \frac{I_C}{\alpha} R_E + V_{EC}$$

$$\text{slope, DC} = -\frac{\alpha}{R_E}$$

$$AC: \quad \text{slope, AC} = -\frac{\alpha}{r_o \| R_E \| R_L}$$

(c) $v_o = -i_o(r_o \| R_E \| R_L) = -(1+\beta)(r_o \| R_E \| R_L)\, i_b$ $\quad\quad \beta i_b = g_m v_\pi$

$v_i = -v_\pi + v_o = -r_\pi i_b - (1+\beta)(r_o \| R_E \| R_L)\, i_b$

$$A_v = \frac{v_o}{v_i} = \frac{(1+\beta)(r_o \| R_E \| R_L)}{r_\pi + (1+\beta)(r_o \| R_E \| R_L)}$$

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

It is an emitter-follower circuit.

$A_v \lesssim +1$. $\quad$ R_o is small.