EE 303H
09/15/11

Biasing of BJT, npn

P. 402 ⇒ Q

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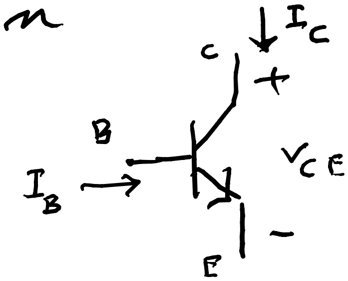
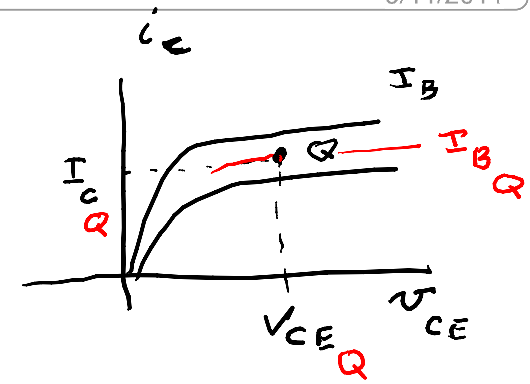
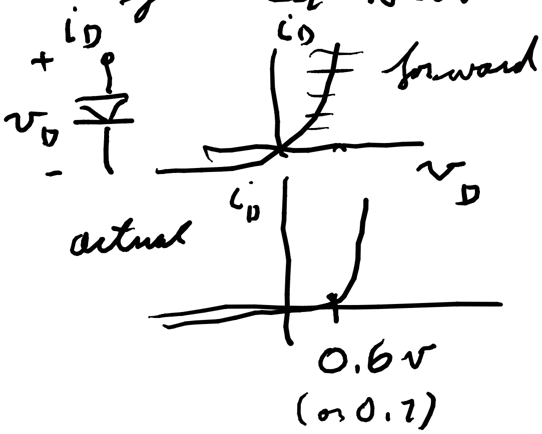
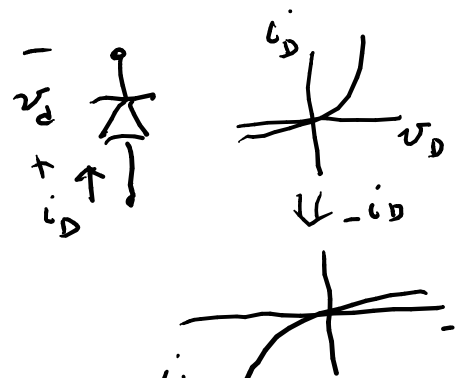


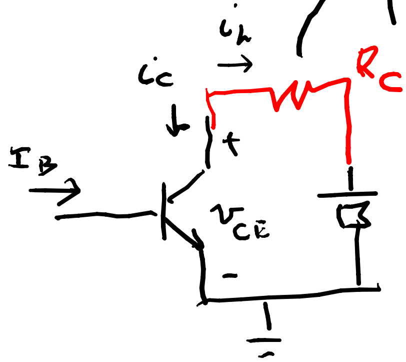


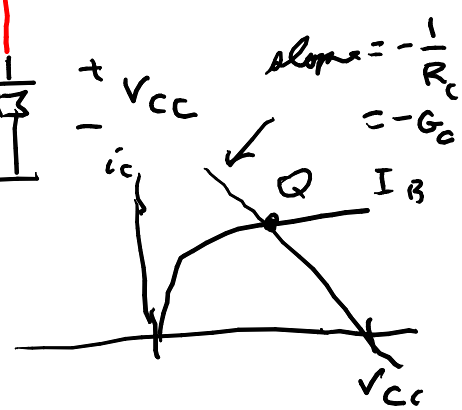
In forward active region

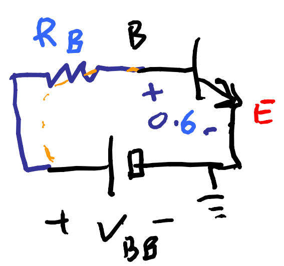
forward bias BE reverse bias CB











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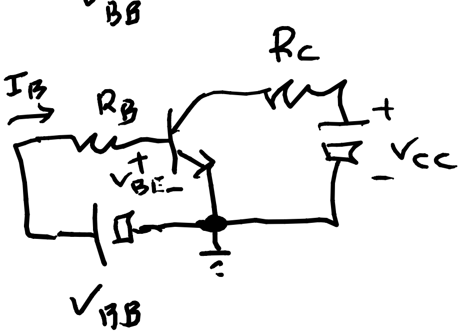


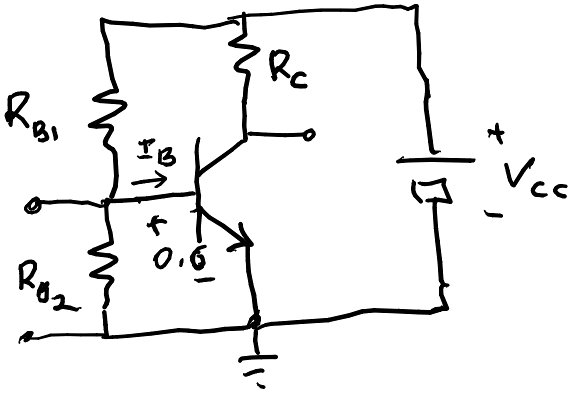
$$\Rightarrow \quad 0 = -V_{BB} + R_B I_B + \underset{\substack{\parallel \\ 0.6}}{V_{BE}} \quad \Rightarrow \quad 0 = -V_{CC} + R_C I_C + V_{CE}$$

$$\Rightarrow \quad R_C = \frac{V_{CC} - V_{CE_Q}}{I_C}$$

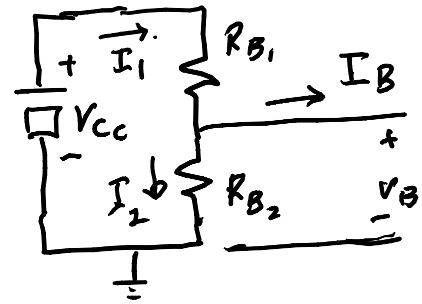
given V_{BB} & I_B at the Q point

gives $R_B = (V_{BB} - V_{BE})/I_B$

To do with only one battery, given Q point



look at the base bias



1,2) KCL: $I_1 = I_B + I_2$, $\quad V_{BE} = R_{B_2} I_2$, ohm's law

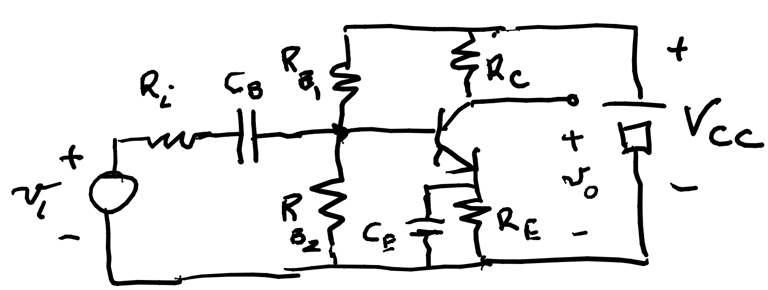
3) $\quad = I_B + \dfrac{V_{BE}}{R_{B_2}}$

4) KVL: $0 = -V_{CC} + R_{B_1} I_1 + V_{BE}$

5) $V_{CC} - V_{BE} = R_{B_1}(I_B + V_{BE}/R_{B_2}) = R_{B_1} I_B + V_{BE} \cdot \dfrac{R_{B_1}}{R_{B_2}}$

Here have 1 eq. in 2 unknowns R_{B_1} & R_{B_2} so since $V_{CC} - V_{BE}$ is limited, so have "constraints." nice for PSpice PARAM part use.

small signal equivalent comes from



C $\quad Z_c = \dfrac{1}{sC}$ if sinus.

$= \dfrac{1}{j\omega C}$

$|Z_c| = \dfrac{1}{\omega C}$

$\infty \uparrow$ if $\omega \downarrow 0$

for C_B & C_E choose large so they are shorts for signal frequencies

& R_{B_1} & R_{B_2} are large (10 Meg Ω or so)

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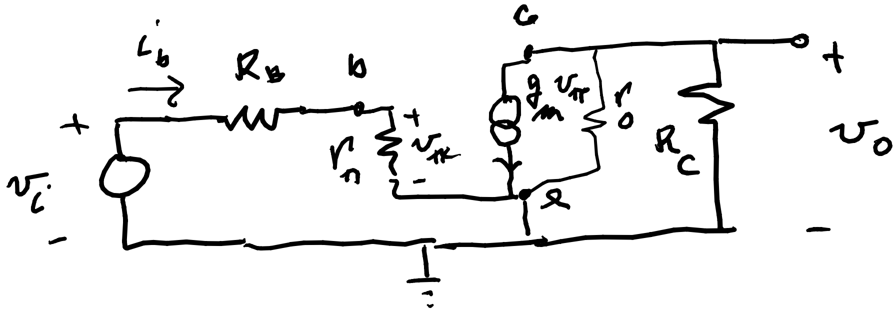

$g_m = \dfrac{I_C}{V_T}$, V_T = thermal voltage

$g_o = \dfrac{I_C}{V_A} = \dfrac{1}{r_o}$

$g_\pi = \dfrac{g_m}{\beta} = \dfrac{1}{r_\pi}$

gives gain $\dfrac{v_o}{v_i}$ for small signals

$$v_i = R_B i_b + r_\pi i_b = (R_B + r_\pi)\, i_b \Rightarrow i_b = \frac{v_i}{R_B + r_\pi}$$

$$v_\pi = r_\pi \cdot i_b = \frac{r_\pi}{R_B + r_\pi} \cdot v_i \Rightarrow g_m v_\pi = \frac{g_m r_\pi}{R_B + r_\pi} \cdot v_i$$

R_o = "output" $= \dfrac{r_o R_C}{r_o + R_C}$; $v_o = -(g_m v_\pi) \times \dfrac{r_o R_C}{r_o + R_C}$

$$\frac{v_o}{v_i} = -\frac{g_m r_\pi}{R_B + r_\pi} \cdot \frac{r_o R_C}{r_o + R_C} = A_v = \text{voltage gain}$$

if $r_o = \dfrac{V_A}{I_C}$ is large then $A_v \simeq -\dfrac{g_m}{1 + R_B/r_\pi} \cdot R_C \simeq -g_m R_C$

$|A_v|$ can be large