9. I-V relationships in active region: (Low to medium freq.)

$$i_E = i_c + i_B = (1+\beta)\, i_B$$

$$i_c = \beta \cdot i_B = \alpha \cdot i_E = \left(\frac{\beta}{1+\beta}\right) i_E$$

$$\alpha = \frac{\beta}{1+\beta}$$

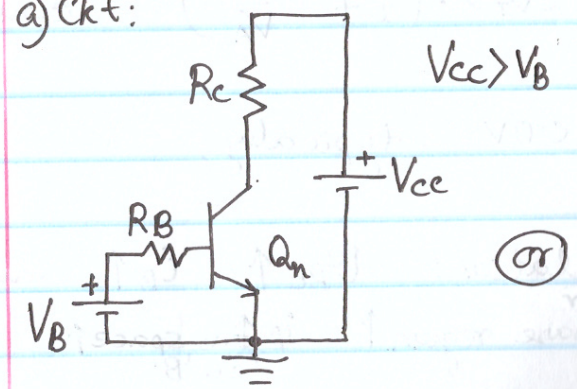
$$\beta = \frac{\alpha}{1-\alpha}$$

npn	pnp
$i_c = I_S \cdot e^{\frac{v_{BE}}{V_T}}$	$i_c = I_S \cdot e^{\frac{v_{EB}}{V_T}}$
$i_E = \frac{i_c}{\alpha} = \frac{I_S \cdot e^{\frac{v_{BE}}{V_T}}}{\alpha}$	$i_E = \frac{i_c}{\alpha} = \frac{I_S \cdot e^{\frac{v_{EB}}{V_T}}}{\alpha}$
$i_B = \frac{i_c}{\beta} = \frac{I_S \cdot e^{\frac{v_{BE}}{V_T}}}{\beta}$	$i_B = \frac{i_c}{\beta} = \frac{I_S \cdot e^{\frac{v_{EB}}{V_T}}}{\beta}$

(without early effect).

10. Active region in common-emitter configuration: CE

a) Ckt:

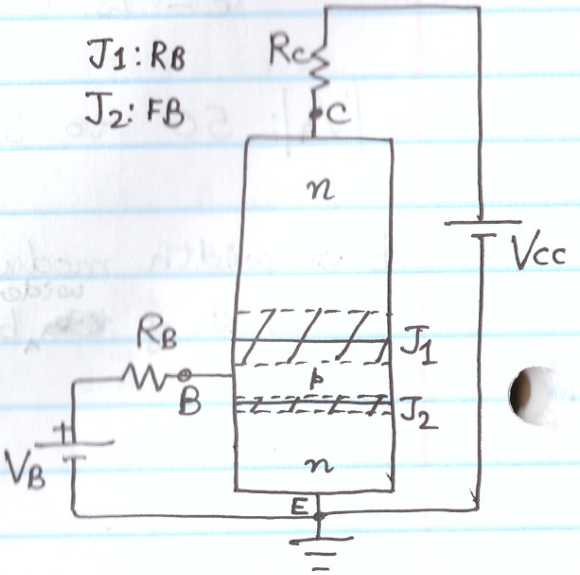


$V_{CC} > V_B$

J_1: RB

J_2: FB

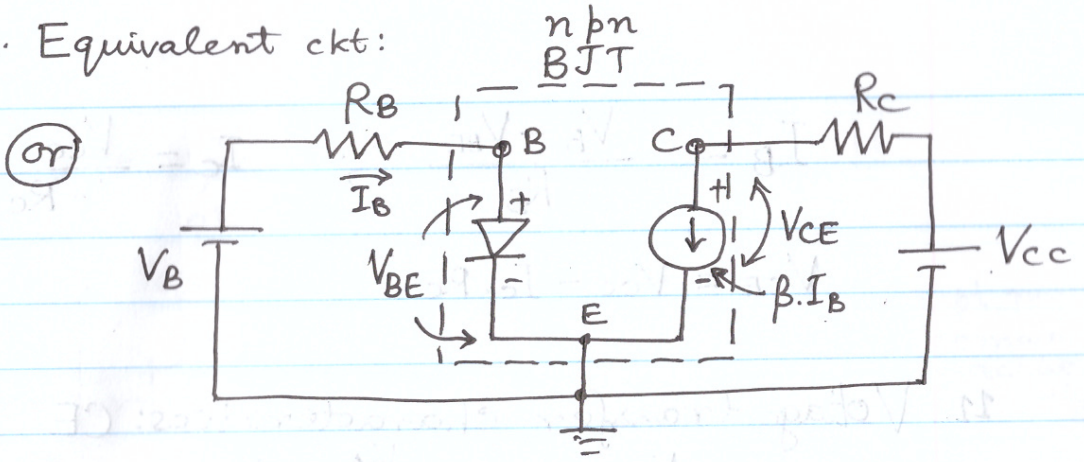
(or)



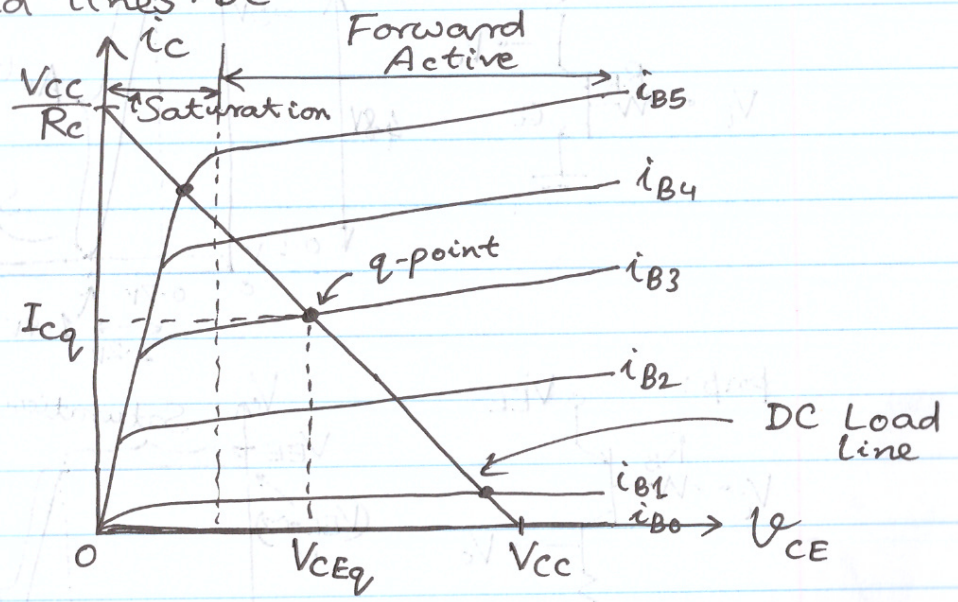
$J_1 \Rightarrow$ Reverse biased junction

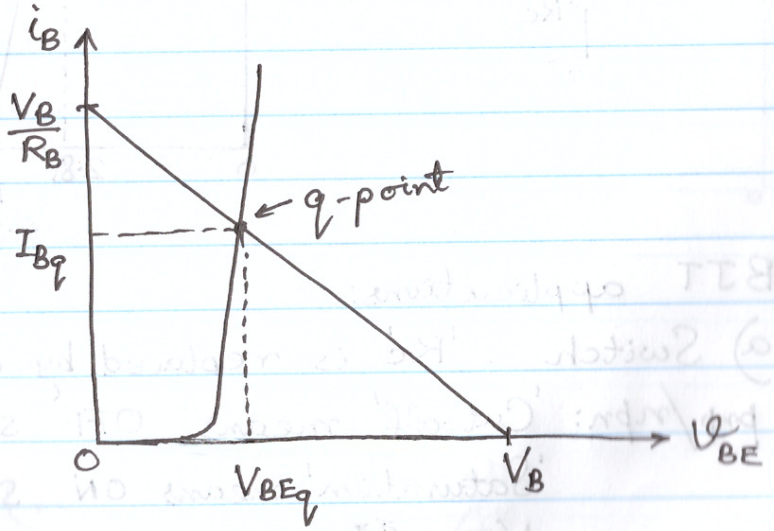
$J_2 \Rightarrow$ Forward biased junction

b. Equivalent ckt:



c. Load lines: DC





$$I_B = \frac{V_B - V_{BE}}{R_B} \quad ; \quad I_C = \frac{V_{CC} - V_{CE}}{R_C}$$

$$V_{CE} = V_{CC} - I_C \cdot R_C$$

11. Voltage transfer characteristics: CE

npn: