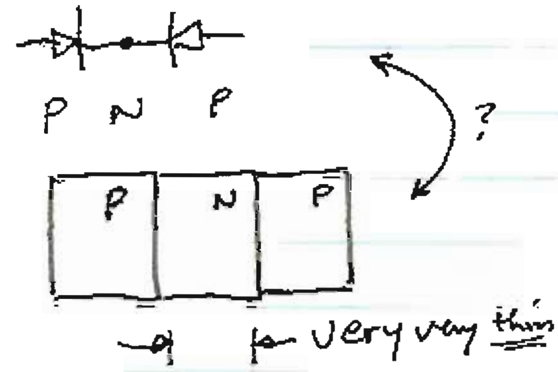
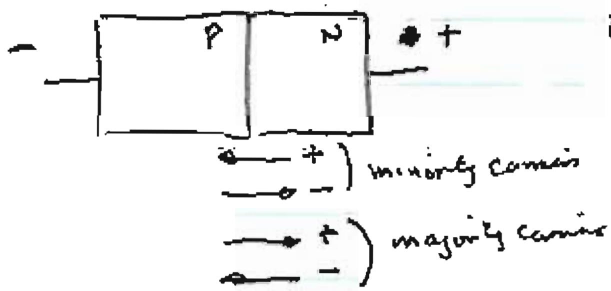




~~[illegible]~~

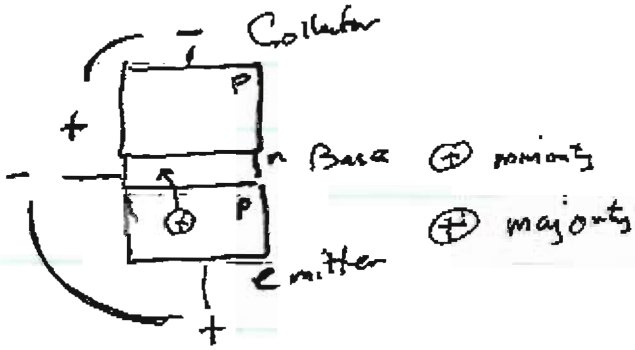
N-type
n majority
p minority

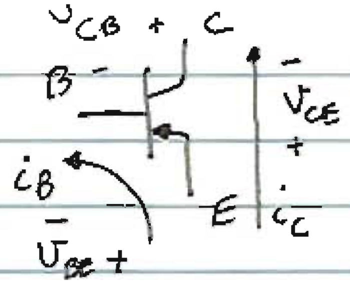
P-type
p majority
n minority

now revere-biased
minority carrier current
small

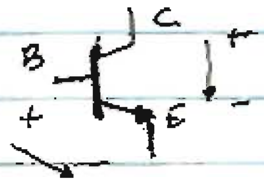
Suppose we inject minority carriers into either type material.

"Controlled breakdown"

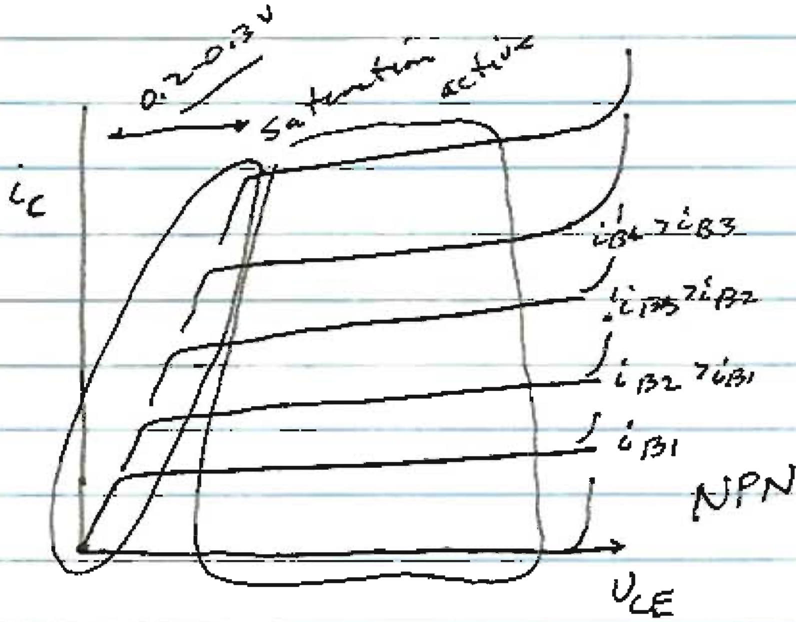




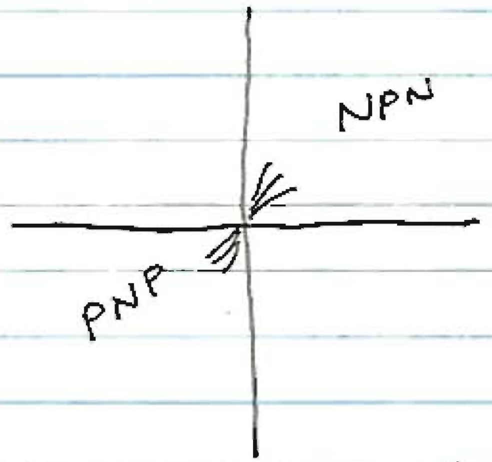
v_{CB} + C
B −
V_{CE}
+
−
i_B
−
v_{BE} +
E
i_C



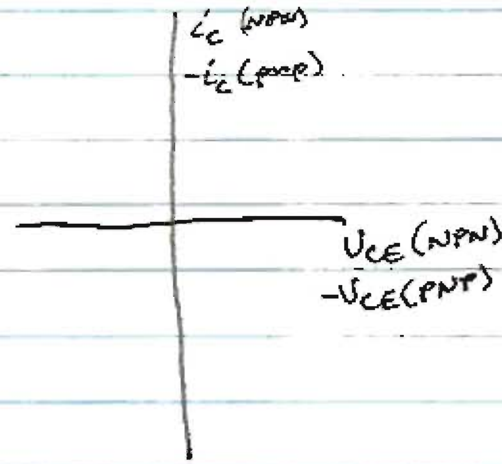
C
B
+
−
E
+



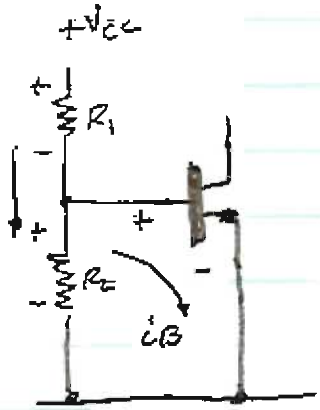
0.2–0.3V
saturation
active
i_C
$i_{B4} > i_{B3}$
$i_{B3} > i_{B2}$
$i_{B2} > i_{B1}$
i_{B1}
NPN
v_{CE}



NPN
PNP



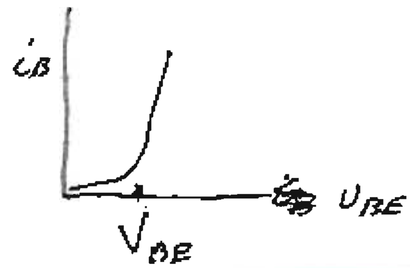
i_C (NPN)
$-i_C$ (PNP)
v_{CE} (NPN)
$-v_{CE}$ (PNP)



$V_{R2} \simeq V_{BE}$

Problem

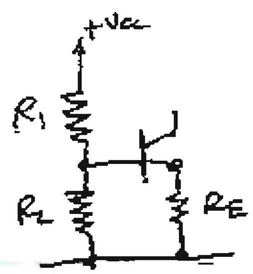
1. knee of exponential curve



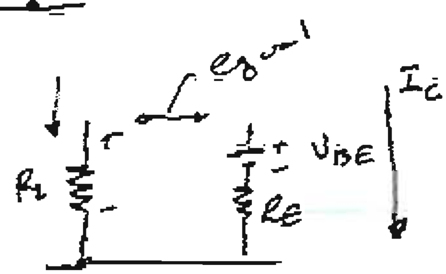
2. $I_C/I_B = \beta_{DC}$ varies widely

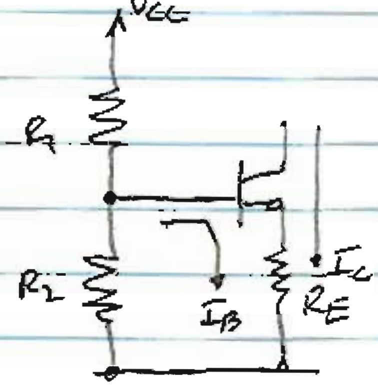
$20 \le \beta_{DC} \le 400$

Fixed-bias unworkable unless "tuned".
Self-bias or combination of fixed & self req'd



$V_{R2} = V_{BE} + (I_C + I_B) R_E$





V_B (open)

$$\left(\frac{R_2}{R_1+R_2}\right) V_{CC} = V_{BB}$$

$$\frac{R_1 R_2}{R_1+R_2} = R_{BB}$$

$$I_C = \beta_{DC} I_B$$

loop equation

$$-V_{BB} + R_{BB} I_B + V_{BE} + \underbrace{(I_B + I_C)}_{(1+\beta_{DC})I_B} R_E = 0$$

$$\left[R_{BB} + (1+\beta_{DC}) R_E\right] I_B = V_{BB} - V_{BE}$$

$$I_B = \frac{V_{BB} - V_{BE}}{R_{BB} + (1+\beta_{DC}) R_E}$$

observe that if $R_{BB} \ll (1+\beta_{DC}) R_E$

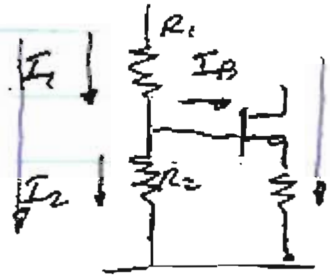
$$I_B \simeq \frac{V_{BB} - V_{BE}}{(1+\beta_{DC}) R_E}$$

In practice make $R_{BB} \simeq R_E$

$$I_C = \beta_{DC} I_B = \frac{(V_{BB} - V_{BE})\beta_{DC}}{R_{BB} + (1+\beta_{DC}) R_E}$$

If β_{DC} is large

$$I_C = \frac{V_{BB} - V_{BE}}{R_E} = \frac{V_E}{R_E} \text{ (ohm's law)}$$



$I_1 = I_2 + I_B$

If $I_B \ll I_2$

$I_1 \doteq I_2$ simple voltage divider

β_{DC} is large

$I_1 \doteq I_2 = I_C = \beta_{DC} I_B$

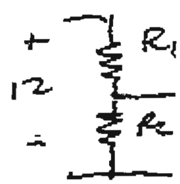
$I_B = \frac{I_1}{\beta_{DC}}$

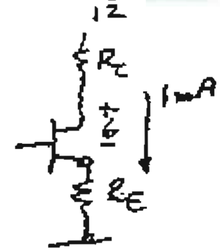
$\therefore$ I_B is negligible if

$I_1 = I_2 = I \simeq I_C$

"Gordon Rule"

Example: $I_C = 1mA$, $V_{CE} = 6V$, $V_{CC} = 12V$





Drop across $(R_E + R_C)$ is $12 - 6 = 6$

Assume $V_E = 2 \Rightarrow V_{RC} = 4V$

$I_C R_E = 2 \Rightarrow R_E = \frac{2}{10^{-3}} = \underline{\underline{2K}}$

$V_B = \underset{2}{V_{RE}} + \underset{0.7}{V_{BE}} = 2.7$

$\left(\frac{R_2}{R_1 + R_2}\right) 12 = 2.7$

$\frac{R_1 R_2}{R_1 + R_2} = 2K$

$\frac{12}{R_1} = \frac{2.7}{2K}$

$R_1 = \frac{24K}{2.7} = \underline{\underline{8 \sim 10K}}$

10/15/07 6/6

$\underline{V_C} = V_{CC} - R_C I_C$

$8 = 12 - R_C \cdot 10^{-3}$

$\cancel{8K} = R_C$

$R_C = 4K$

$V_C = 12 - (6+2)$

$= 4$