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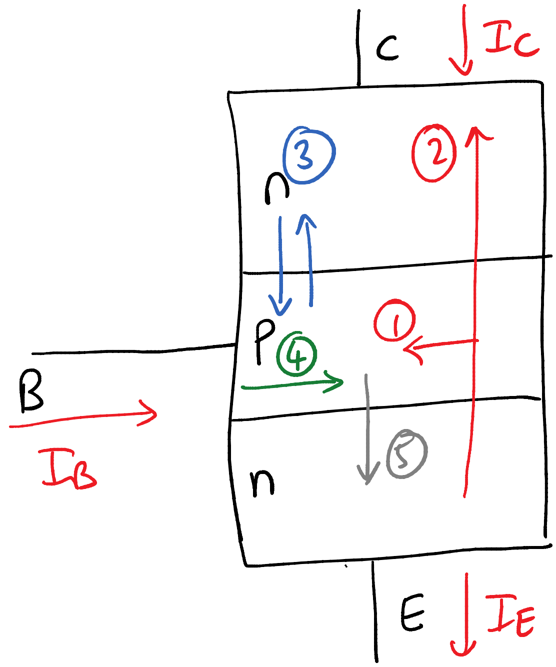
LECTURE - 23

BJT CURRENTS

npn TRANSISTOR



① INJECTED ELECTRONS LOST TO RECOMBINATION IN BASE

② INJECTED ELECTRONS REACHING THE RB COLLECTOR JUNCTION

③ THERMALLY GENERATED EHP → REVERSE SAT. CURRENT → RB COLLECTOR CURRENT AT RB COLLECTOR JUNCTION

④ HOLES SUPPLIED BY BASE FOR RECOMBINING WITH ELECTRONS

⑤ HOLES INJECTED ACROSS FB BE JUNCTION

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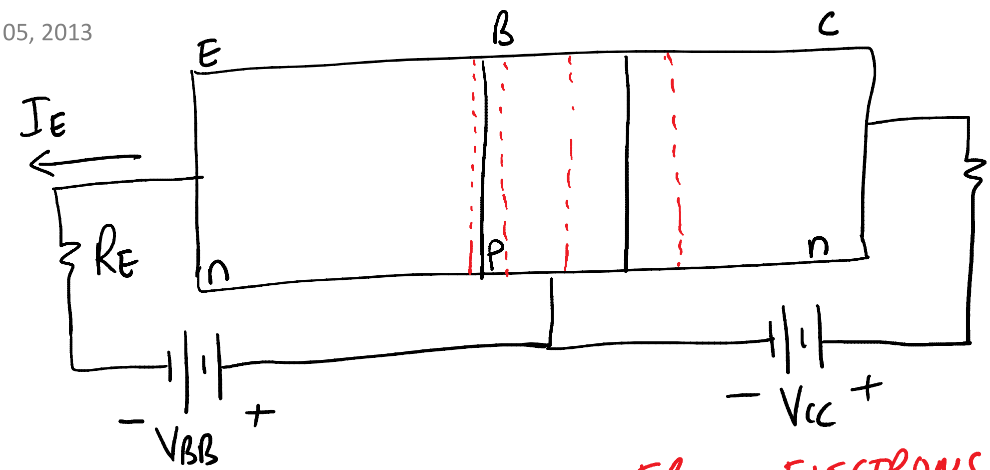
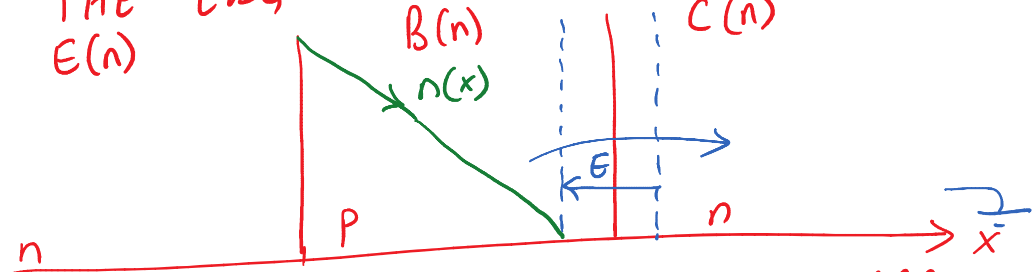


* SINCE BE JUNCTION IS FB, ELECTRONS FROM EMITTER MOVE INTO BASE ∴ EXCESS MINORITY CONCENTRATION IN BASE. SINCE BC JUNCTION IS RB, ELECTRON CONCENTRATION AT THE EDGE OF BASE IS 0



* BASE REGION IS DESIGNED TO BE NARROW SO THAT ELECTRONS DON'T RECOMBINE WITH ANY MAJORITY CARRIERS IN BASE

$\tau_n \rightarrow$ ELECTRON LIFE TIME

$\tau_t \rightarrow$ ELECTRON TRANSIT TIME THROUGH BASE

$$\tau_t <<< \tau_n$$

$$\boxed{\frac{\tau_n}{\tau_t} = \beta}$$ ← GAIN EQ.

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* ELECTRONS DIFFUSE TO THE EDGE OF THE BC JUNCTION AND ARE SWEPT ACROSS THE BC JUNCTION BY THE E FIELD TO FORM I_C

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EMITTER CURRENT → ELECTRON CURRENT

I_E IS OPPOSITE, COMING OUT OF THE EMITTER TERMINAL

"ELECTRONS GO FROM n TO p"

COLLECTOR CURRENT

OF ELECTRONS REACHING THE COLLECTOR, DEPENDS ON THE # OF ELECTRONS INJECTED INTO THE BASE, WHICH INTURN DEPENDS ON THE BE VOLTAGE

$$I_C \propto e^{V_{BE}}$$

$$I_C < I_E$$

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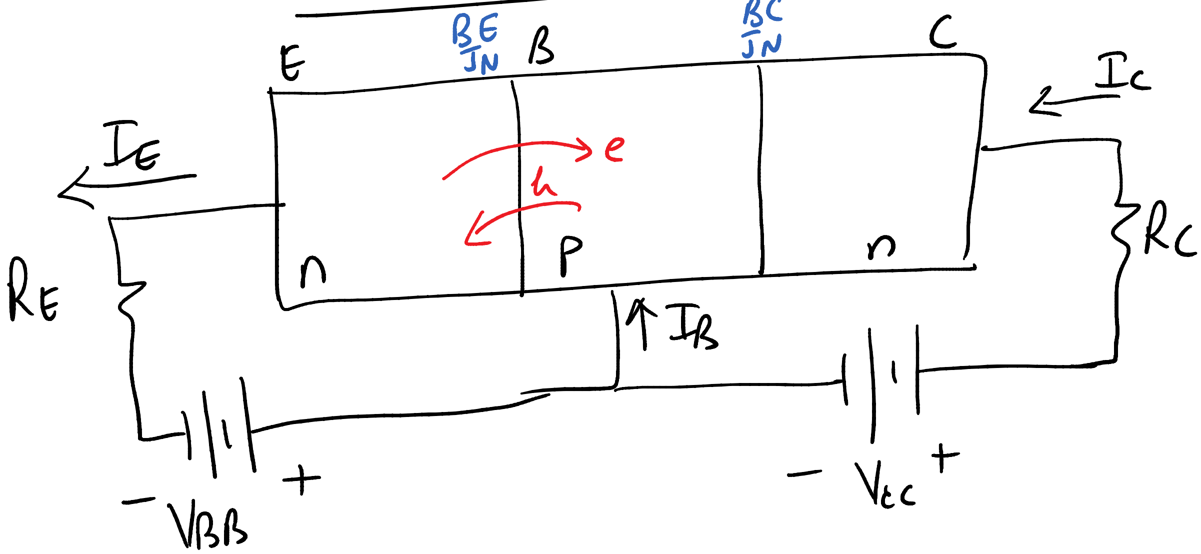
npn TRANSISTOR

BASE IS NARROW!



EMITTER CURRENT

I_E ELECTRON CURRENT

COLLECTOR CURRENT

$I_C \longrightarrow$ MOST OF I_E

$I_C \propto e^{V_{be}}$

$I_C < I_E$

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BASE CURRENT

SINCE BE JUNCTION IS FB, HOLES FROM BASE FLOW INTO THE EMITTER

$$I_{B_1} \propto e^{V_{be}}$$

A FEW ELECTRONS COMBINE WITH HOLES IN BASE. THIS SHOULD BE REPLACED BY THE BASE

$$I_{B_2} \propto e^{V_{be}}$$

$$I_B = I_{B_1} + I_{B_2}$$

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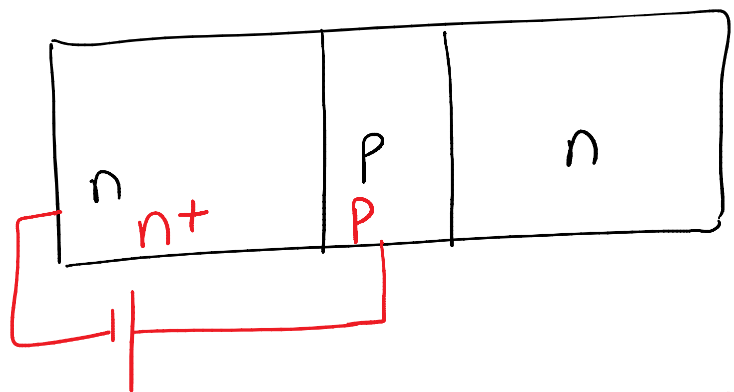
* MAJORITY CURRENT TO BE ELECTRON CURRENT
* ? MINIMIZE THE HOLE CURRENT ??



① TO MAXIMIZE ELECTRON DIFFUSION AND MINIMIZE HOLE DIFFUSION, n SIDE IS MORE HEAVILY DOPED THAN THE p SIDE

② BASE IS VERY NARROW

$$I_{B_2} <<< I_c$$

EMITTER ELECTRON CURRENT i_{En} I_{En}

EMITTER HOLE CURRENT i_{Ep} I_{Ep}

COLLECTOR CURRENT $i_c \approx i_{cn}$ I_{cn}

BASE CURRENT $i_B \approx i_{Bp}$ I_{Bp}

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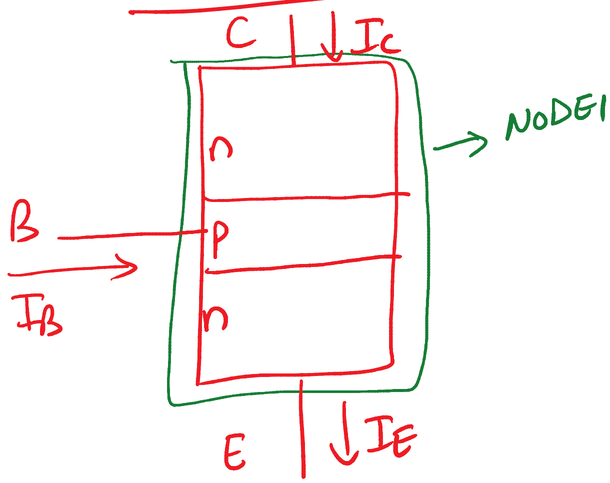
npn TRANSISTOR



① EMITTER INJECTION EFFICIENCY

$$\gamma = \frac{I_{En}}{I_{En} + I_{Ep}}$$

② BASE TRANSPORT FACTOR

$$\alpha_F = \frac{I_{Cn}}{I_{En}}$$

③ CURRENT TRANSFER RATIO

$$\alpha = \alpha_0 = \frac{I_C}{I_E} = \frac{I_{Cn}}{I_E}$$

$$= \frac{I_{Cn}}{I_{En}} \cdot \frac{I_{En}}{(I_{En} + I_{Ep})}$$

$$\alpha = \alpha_F \gamma$$

KCL NODE 1

$$-I_C - I_B + I_E = 0$$

$$I_B = I_E - I_C \Rightarrow I_C + I_B = I_E$$

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GAIN $\beta = \frac{I_C}{I_B} = \frac{I_C}{I_E - I_C}$

h_{FE}

$$= \frac{I_C / I_E}{1 - \frac{I_C}{I_E}} = \frac{\alpha}{1-\alpha}$$

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

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

IF $\alpha = 0.99$ $\quad \beta = \frac{0.99}{0.01} = 99$

$\alpha < 1$ $\quad \therefore \beta > 1$

IF $\alpha = 0.01$ $\quad \beta = \frac{0.01}{1-0.01} = \frac{0.01}{0.99}$

$\beta = \frac{1}{99}$ → VERY SMALL UNDESIRABLE!

$\therefore$ * DESIRE β ↑↑↑

* α SHOULD BE LESS THAN 1 BUT CLOSE TO 1 FOR HIGH $\underline{\beta}$

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

$$\beta - \beta\alpha = \alpha$$

$$\beta = \beta\alpha + \alpha$$

$$= \alpha(1+\beta)$$

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