zener diode → used for voltage/current regulation

BJT

case : 1 → ACTIVE [amplifier]

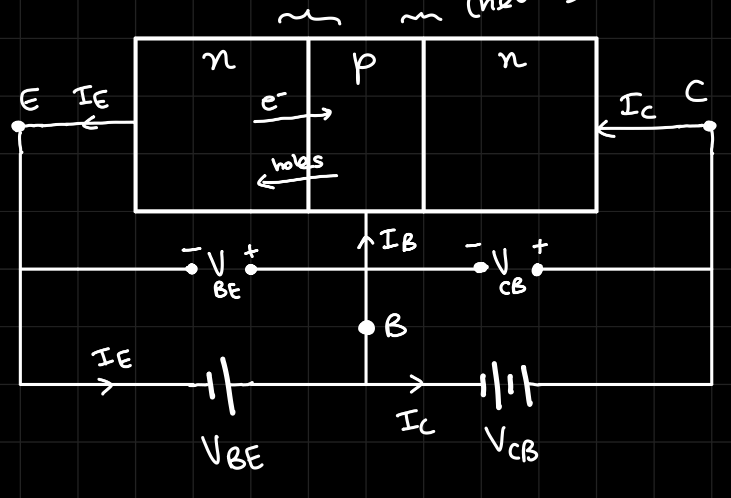
$V_{BE} = 0.7V$ Forward bias
$V_{CB} = 0V$ Reverse bias

case : 2 → saturation [switch]

$V_{BE} = 0.8V$ Forward bias
$V_{CB} = 0.7V$ Forward bias

NPN TRANSISTOR

EBJ → emitter base junction (forward biased)
CBJ → collector base junction (heavily reverse biased)



$I_E = I_B + I_C$

e^- from E → B much more desirable than holes from B → E^-

E: highly doped with n type semiconductor
→ so less # of holes
B: lightly doped with p type semiconductor

→ for forward bias EBJ, the concentration

$$n_p(0) \propto e^{\frac{V_{BE}}{V_T}}$$

→ e^- concentration : $n_p(0)$ is highest at the E side and lowest (~zero) at the C side

$$n_p(0) = n_{po} e^{\frac{V_{BE}}{V_T}}$$

note: V_T ⇒ thermal voltage
$V_T = 25mV$ at room temperature

V_{BE}: forward BE voltage

Electron diffusion current

$$I_n = \underbrace{A_E}_{\text{cross sectional area of the BEJ}} \underbrace{q}_{e^- \text{charge}} \overbrace{D_n}^{e^- \text{diffusivity in the base}} \frac{dn_p(x)}{dx}$$

$$I_n = A_E q D_n \overbrace{\left(-\frac{n_p(0)}{\underbrace{W}_{\text{width of the base region}}}\right)}^{\text{current flows opposite to the flow of } e^-} \rightarrow \text{C/second}$$

* base region is lightly doped as compared to the emmitor region
→ So concentration of holes as compared to e^- from E is less
→ I_B is very less (~negligible)
→ So, $I_C \simeq I_E$

What if we remove the base region? Since E is highly doped, there will be some diffusion current flowing but can it function properly?

$$I_C = I_S e^{V_{BE}/V_T}$$

$$I_S = \frac{A_E q D_n n_{po}}{W} = \frac{A_E q D_n n_i^2}{W N_A}$$

$$n_{po} = \frac{n_i^2}{N_A}$$

n_i = intrinsic carrier density
N_A = doping concentration of base

[SOCKETS
bind listen accept
htons
↳ used to convert port "number" to the format used by the internet

β = common emmitor current gain
↳ influenced by
→ W
→ relative doping of base emitter regions (N_A/N_D)

High value of β ⇒
thin base (W ~ nm)
lightly doped base
heavily doped emmiter
(small N_A/N_D)

$$\beta = \frac{I_C}{I_B} \quad \text{and} \quad i_E = i_C + i_B$$

$$i_B = \frac{I_C}{\beta}$$

$$\beta i_E = \beta i_C + i_C$$

$$i_E = \left(\frac{\beta + 1}{\beta}\right) i_C$$

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

$$i_E = \frac{i_C}{\alpha}$$

common base → $\alpha = \frac{i_C}{i_E}$

let $\beta = 0.99$
$\alpha \simeq 1$
$i_C = i_E$

eg) $I_B = 10\mu A$
$I_C = 600\mu A$

$\alpha, \beta = ?$

$\beta = 60$

$\alpha = \frac{60}{61} = 0.9836$

eg) $V_{BE} = 0.76V$
$I_C = 10mA$

npn

$I_C = ?$ at $V_{BE} = 0.7V$

$$I_C = I_S e^{V_{BE}/V_T}$$

$$10^{-2} = I_S e^{30.4}$$

$$I_S = \frac{10^{-2}}{e^{30.4}}$$

$$I_C = \frac{10^{-2}}{e^{30.4}} e^{0.7/0.025} = 10^{-2} \cdot e^{28-30.4}$$

$$= 10^{-2} \cdot e^{-2.4}$$
$$= 9 \times 10^{-4} A$$
$$= \underline{0.9mA}$$

$$10 \times 10^{-4} = e^{-30.4} e^{V_{BE}/0.025}$$

$$\log_e 10^{-3} = -30.4 + \frac{V_{BE}}{0.025}$$

$$V_{BE} = (-6.9 + 30.4)\, 0.025$$

$$V_{BE} = \underline{0.5875}\ V$$

formula used → $I_C = I_S e^{\frac{V_{BE}}{V_T}}$

SOMETHING