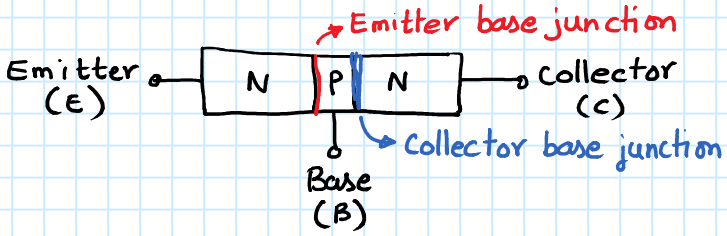
Lecture 18 [BJT]

Bipolar Junction Transistor (BJT):



⇒ NPN transistor

Regions of operation:

	Base - Emitter jn.	Base - Collector junction
Cut off	reverse-biased	reverse-biased
Amplifier ⇐ Active	forward-biased	reverse-biased
Saturation	forward-biased	forward-biased

Operation in active mode:

$V_{BE} > 0$ and $V_{BC} < 0$ $(\Rightarrow V_{CE} > V_{BE})$

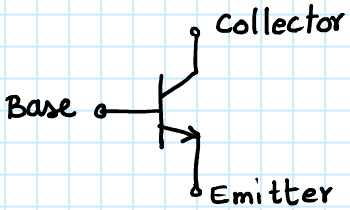
$I_C = \alpha I_E \quad \alpha < 1$

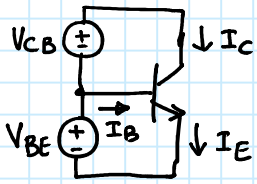
$I_C + I_B = I_E \Rightarrow I_B = (1-\alpha) I_B$

Current gain: $\frac{I_C}{I_B} = \beta = \frac{\alpha}{1-\alpha}$

$\alpha = 0.99 \Rightarrow \beta = 100$

NPN BJT Symbol





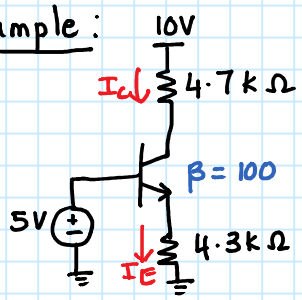
Active mode

$I_C = I_S \exp\left(\frac{V_{BE}}{V_T}\right)$; $V_T = \frac{kT}{q}$

$I_C = \beta I_B$

$I_E = (\beta+1) I_B$

Example:



$V_{BE} \approx 0.7 \Rightarrow I_E = \frac{4.3-0}{4.3k\Omega} = 1mA$

$\alpha = \frac{\beta}{\beta+1} = 0.99 \Rightarrow I_C = 0.99\,mA$

$I_B = 0.01\,mA$

$\Rightarrow V_C = 10V - 4.7k \times 0.99m \approx 5.3V$

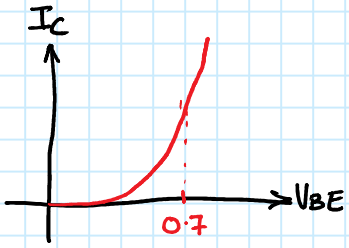
$V_{CB} = 0.3 > 0 \Rightarrow$ reverse biased

NPN BJT I-V Characteristics

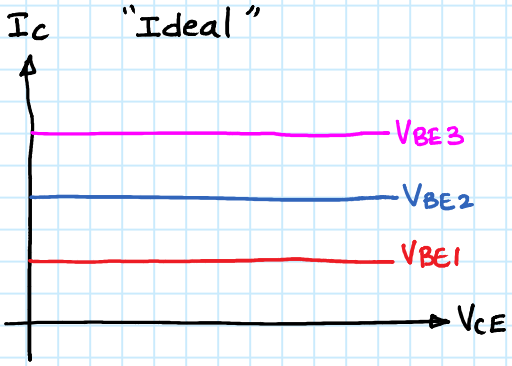
$$I_C = I_S \cdot \exp\left(V_{BE}/V_T\right)$$

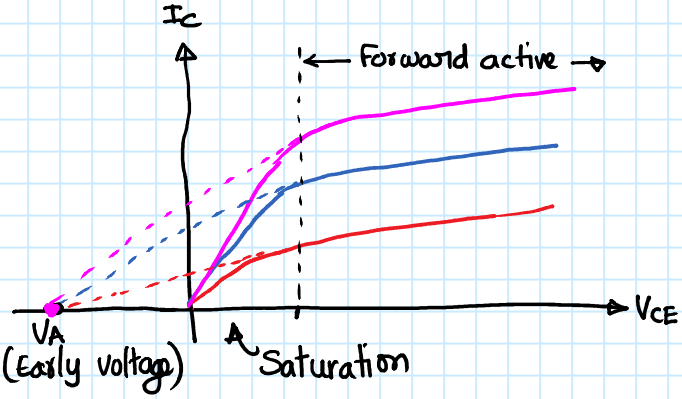
Typically $V_{BE} = 0.6 - 0.8\,V$

Assume $V_{BE} \approx 0.7\,V$

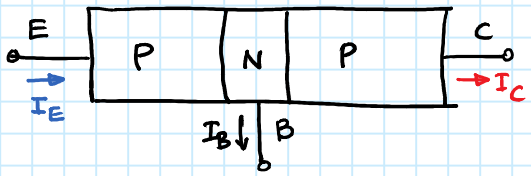


I_C Vs V_{CE}





PNP BJT:

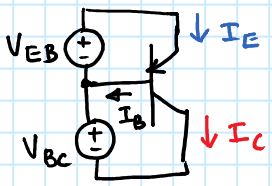


$$I_E = I_B + I_C$$

$$I_C = I_S \exp\left(V_{EB}/V_T\right) = \alpha I_E$$

$$I_B = I_C/\beta$$

Regions of operation:



Cut off : $V_{EB} < 0$ & $V_{BC} > 0$

Forward active : $V_{EB} \sim 0.7$ & $V_{BC} > 0$

Saturation : $V_{EB} \sim 0.7$ & $V_{BC} < 0$