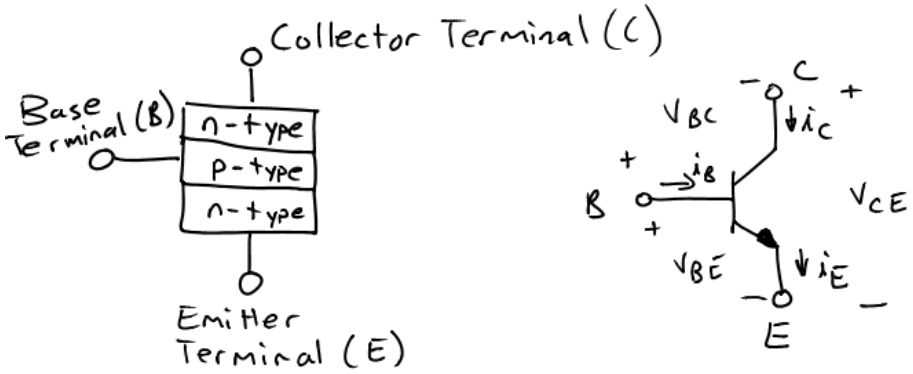
Bipolar Junction Transistors

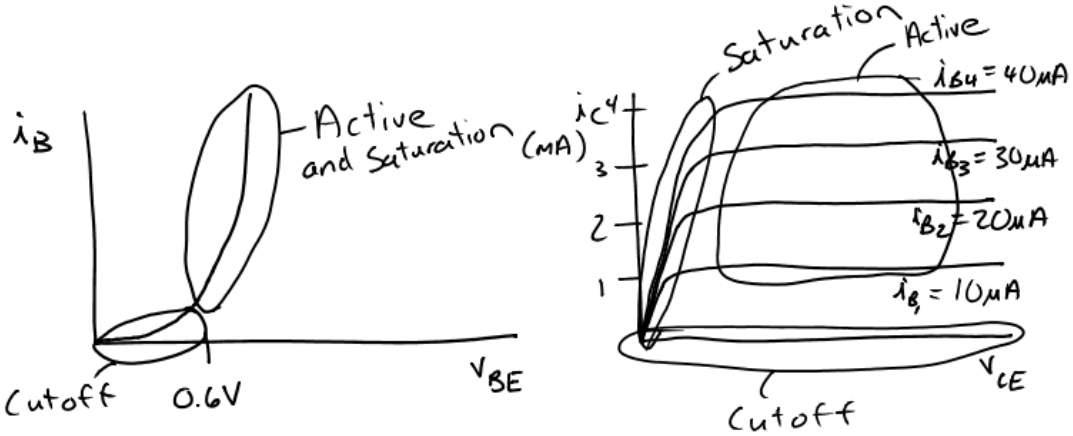
- Used for amplifiers and switches
- Consists of three layers (two n-type layers and one p-type layer (npn transistor) or two p-type layers and one n-type layer (pnp transistor)
- Has three terminals (base, collector, and emitter)

<u>npn BJT</u>



- Two pn-junctions (Base-Emitter and Base-Collector)

- Characteristic Curves



- Four possibilities for the states of the pn-junctions, but only three are used

	Base-Emitter	Base-Collector	Region
①	ON	OFF	Active
②	ON	ON	Saturation
③	OFF	OFF	Cutoff

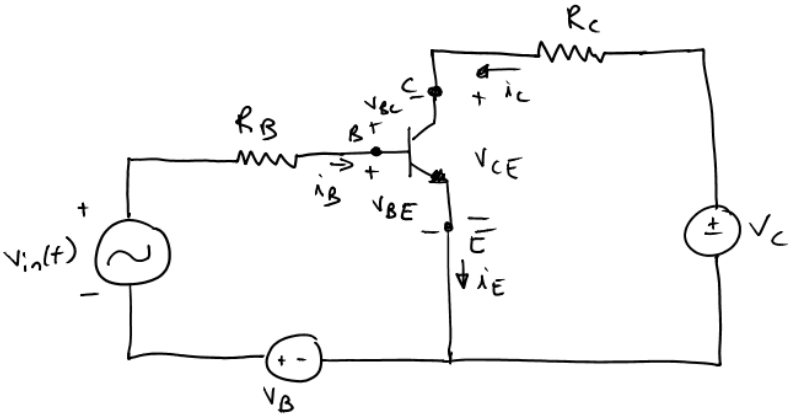
- For a pn-junction in the OFF state, the current is typically zero, but this not the case for the Active Region of a BJT due to the coupling effect of the shared p-type layer

- Amplification in the Active Region

$i_C = \beta i_B$ Want β to be large

$\alpha = \frac{i_C}{i_E}$ $0.9 < \alpha < 0.999$

- Load Line Analysis

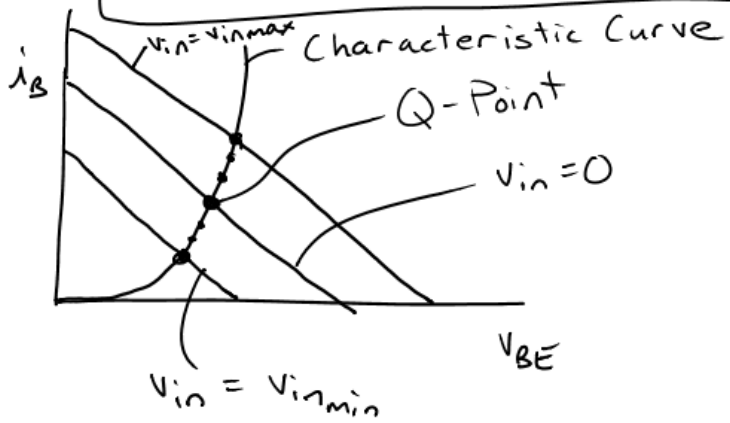


Input Circuit

KVL (Left, cw)

$$-V_B - V_{in} + i_B R_B + V_{BE} = 0$$

$$i_B = \frac{V_B + V_{in}}{R_B} - \frac{1}{R_B} V_{BE}$$

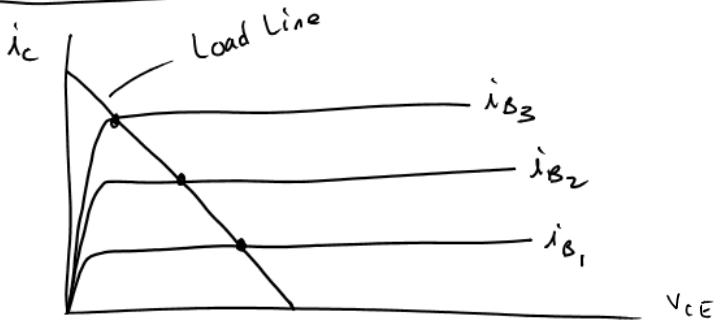


Output Circuit

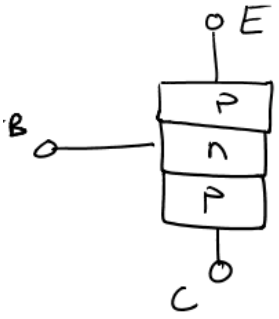
KVL (Right, cw)

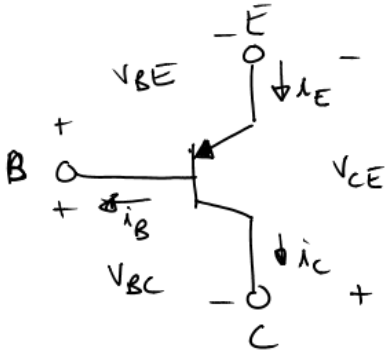
$$-v_{CE} - i_C R_c + V_c = 0$$

$$i_C = -\frac{1}{R} v_{CE} + \frac{V_c}{R}$$

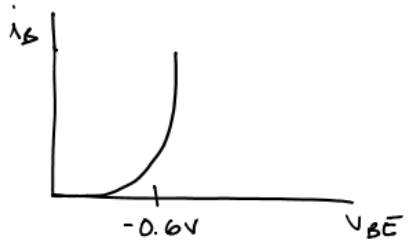


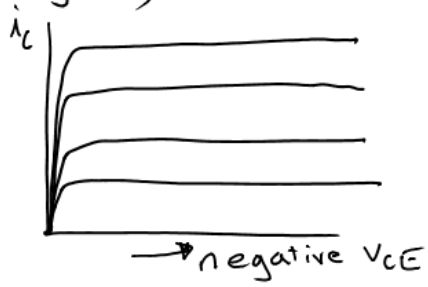
pnp BJT





$$i_C = \beta i_B \quad \text{(Active Region)}$$

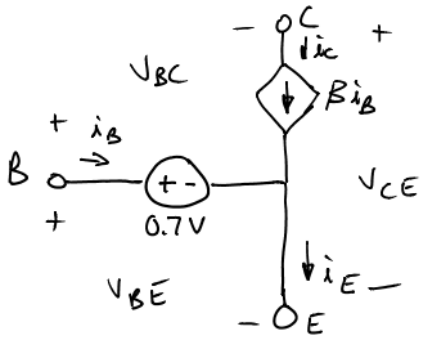




Large Signal DC Analysis of BJT's

- Replace the BJT with circuit elements that can be more readily analyzed
- Three regions: Active, Saturation, and Cutoff
- The ON/OFF voltages are modified versus a diode
  - Forward Bias: 0.7 V
  - Reverse Bias: 0.5 V

- Active Region (npn)



Check

$i_B > 0$

$V_{CE} > 0.2V$

KVL (BJT) — 0.7V

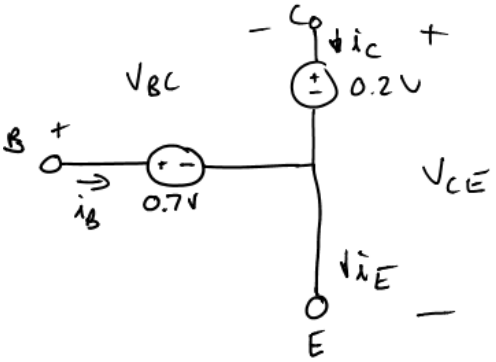
$V_{BC} + V_{CE} - V_{BE} = 0$

$V_{BC} = 0.7V - V_{CE}$

For $V_{BC} < 0.5V$

$\Rightarrow V_{CE} > 0.2V$

- Saturation Region (npn)

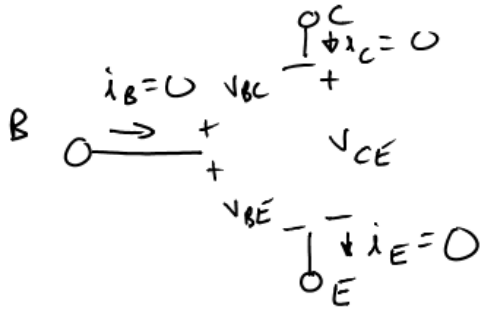


Checks

$i_B > 0$

$0 < i_C < \beta i_B$

- Cutoff Region (npn)

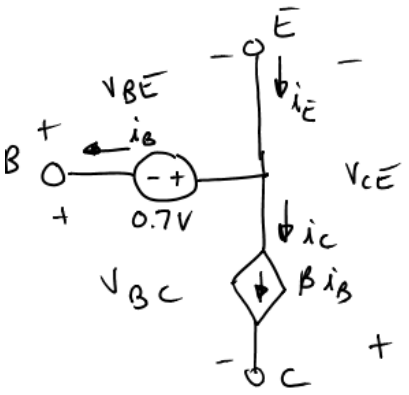


Checks

$V_{BE} < 0.5V$

$V_{BC} < 0.5V$

- Active Region (pnp)

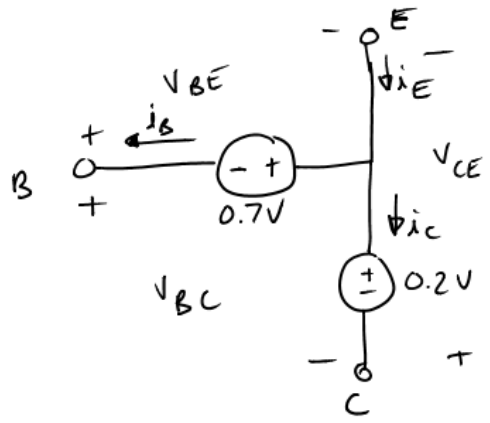


Checks

$i_B > 0$

$v_{CE} < -0.2V$

- Saturation Region (pnp)

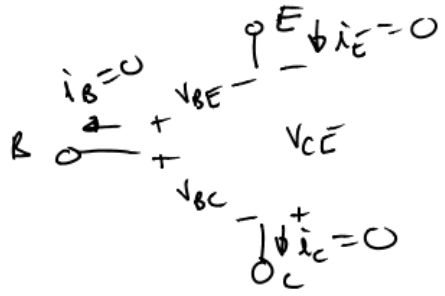


Checks

$i_B > 0$

$0 < i_c < \beta i_B$

- Cutoff Region (pnp)



Checks

$v_{BE} > -0.5\,V$

$v_{BC} > -0.5\,V$