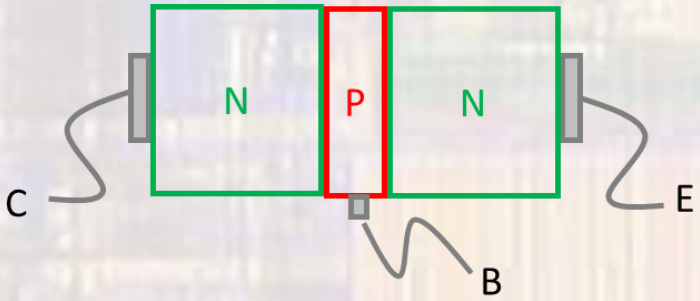
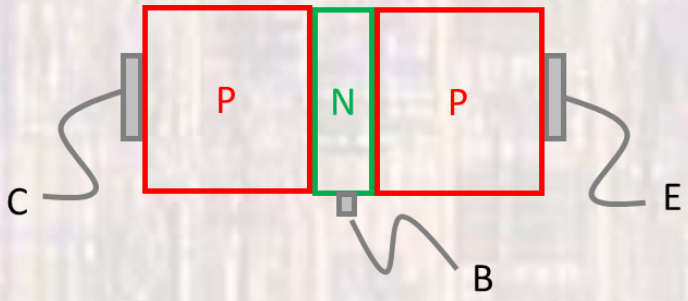
BJT Forward Active

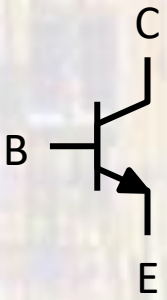
Last updated 2/18/22

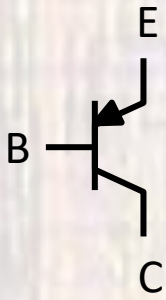
BJT Forward Active

- Review





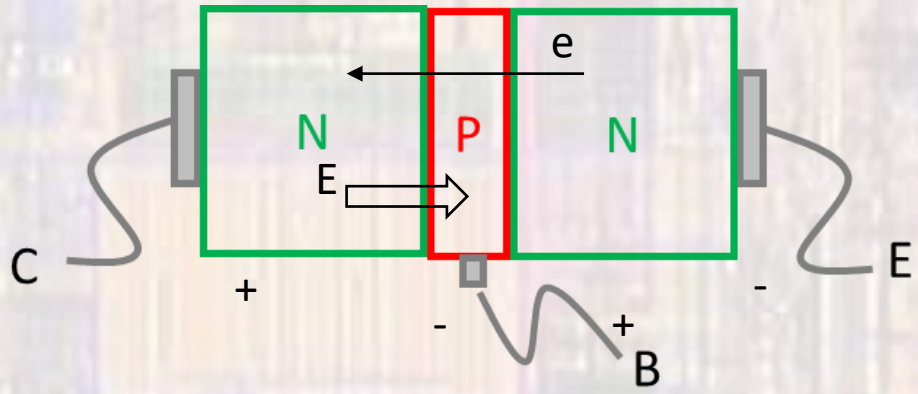




arrow points in direction of the P-N junction of the B/E diode

BJT Forward Active

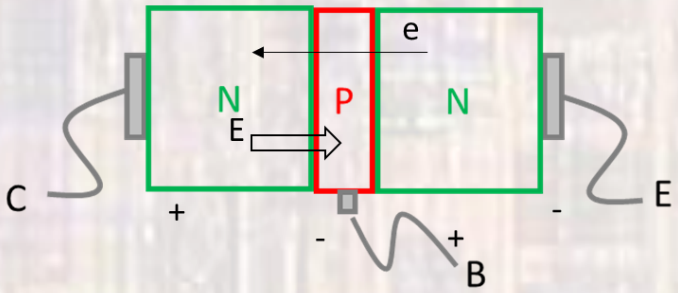
- Forward Active Mode - NPN
  - B-E junction forward biased, C-B junction reverse biased



  - With a short base – the electrons injected into the base get swept into the collector by the electric field
  - In the ideal case all of the electrons would be swept into the collector, leaving only a small hole current in the base
  - In the real case – additional factors lead to a small (relative to emitter) base current

BJT Forward Active

- Forward Active Mode - NPN
  - B-E junction forward biased, C-B junction reverse biased
  - Emitter Current



$$I_D = I_S\left[e^{\left(\frac{V_A}{nV_T}\right)} - 1\right]$$

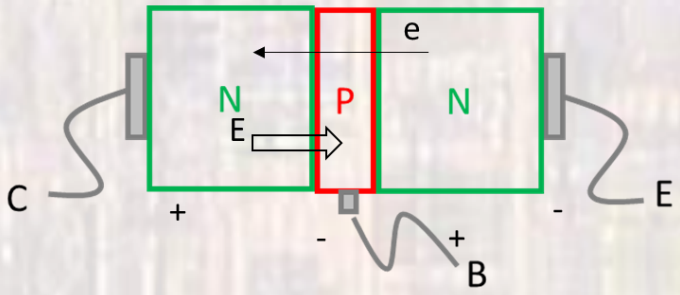
$$I_E = I_{E0}\left[e^{\left(\frac{V_{BE}}{nV_T}\right)} - 1\right]$$

$$I_E = I_{E0}\left[e^{\left(\frac{V_{BE}}{nV_T}\right)}\right]$$

for V_{BE} > few V_T

BJT Forward Active

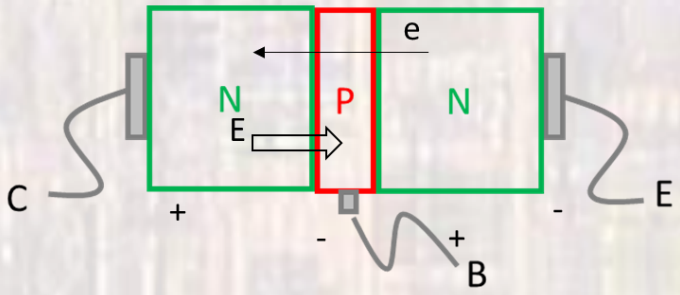
- Forward Active Mode - NPN
  - B-E junction forward biased, C-B junction reverse biased
  - Base Current
    - Some of the electrons do not make it to the collector
    - There are some holes naturally diffusing from the base to emitter



    - This current is relatively small compared to I_E
    - This current is transistor specific parameter

BJT Forward Active

- Forward Active Mode - NPN
  - B-E junction forward biased, C-B junction reverse biased
  - Collector Current
    - The collector current is the difference between the emitter current and the base current
    - $I_C = I_E - I_B$



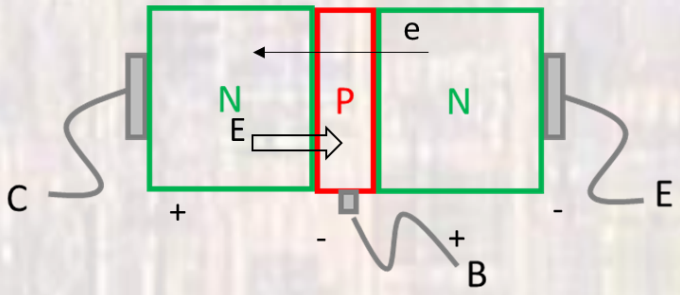
  - The ratio of the difference I_C/I_E is called the common-base current gain α
  - The ratio of the difference I_C/I_B is called the common-emitter current gain β
  - α and β are transistor dependent, and related

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

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

BJT Forward Active

- Forward Active Mode - NPN
  - B-E junction forward biased, C-B junction reverse biased
  - Collector Current
    - By convention we reference all the the currents to the collector



$$I_C = I_S\left[e^{\left(\frac{V_{BE}}{nV_T}\right)}\right]$$

for V_{BE} > few V_T, n and I_S device dependent

$$I_B = \frac{I_C}{\beta} = \frac{1}{\beta} I_S\left[e^{\left(\frac{V_{BE}}{nV_T}\right)}\right]$$

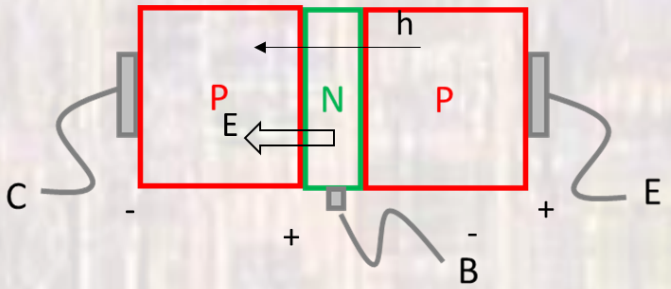
$$I_E = \frac{1}{\alpha} I_C = \frac{1}{\alpha} I_S\left[e^{\left(\frac{V_{BE}}{nV_T}\right)}\right]$$

$$I_C = \beta I_B$$

$$I_E = I_C + I_B$$

BJT Forward Active

- Forward Active Mode - PNP
  - B-E junction forward biased, C-B junction reverse biased
  - Collector Current
    - By convention we reference all the the currents to the collector



$$I_C = I_S\left[e^{\left(\frac{V_{EB}}{nV_T}\right)}\right]$$

for V_{BE} > few V_T, n and I_S device dependent

$$I_B = \frac{I_C}{\beta} = \frac{1}{\beta} I_S\left[e^{\left(\frac{V_{EB}}{nV_T}\right)}\right]$$

$$I_E = \frac{1}{\alpha} I_C = \frac{1}{\alpha} I_S\left[e^{\left(\frac{V_{EB}}{nV_T}\right)}\right]$$

$$I_C = \beta I_B$$

$$I_E = I_C + I_B$$