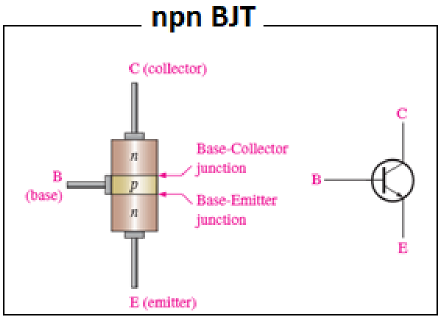
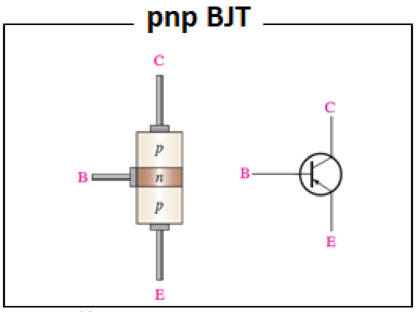
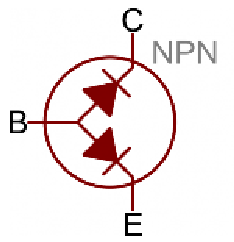
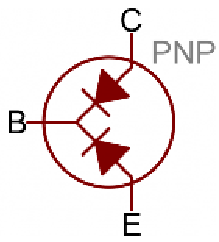
4–1: BJT structure









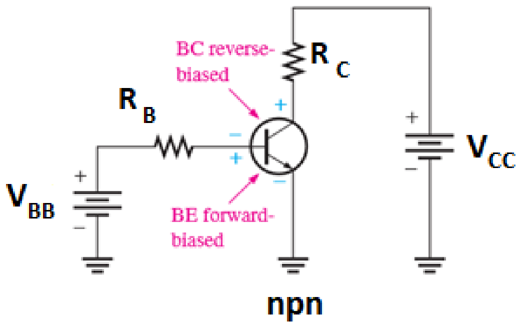
- **Constrcution of BJT**: three doped semiconductor regions separated by two pn junctions
- **Bipolar:** refers to the use of both holes and electrons as current carriers in the transistor structure.
- **Doping in BJT:**
  - The emitter region: heavily doped
  - The collector region: moderately doped
  - The base region: lightly doped (very thin)

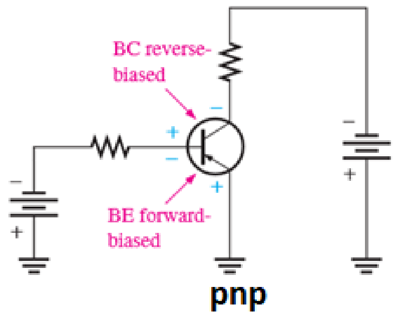
4-2: Basic BJT Operation

- **Two basic appliations** for BJT: **Amplifier** & **Switch**
- For the BJT to operate properly as an amplifier, the two pn junctions must be correctly biased with external dc voltages.

Biasing arrangement for npn/pnp BJTs for amplifier operation:

Forward-reverse bias of BJT





Notes:

- In both cases the base-emitter (BE) junction is forward-biased and the base-collector (BC) junction is reverse-biased. This condition is called **forward-reverse bias**.
- The operation of the pnp is the same as for the npn except that the roles of the electrons and holes, the bias voltage polarities, and the current directions are all reversed.

BJT Operation of npn BJT:

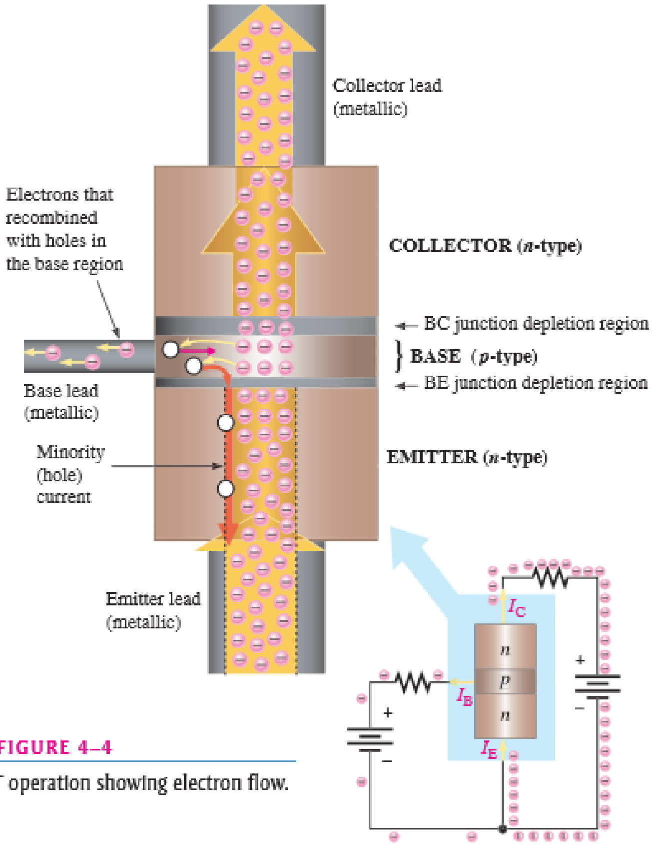
- The emiiter free electrons diffuse through the forward- biased BE junction base region.

- A small percentage of the free electrons injected into the base recombine with holes and move as valence electrons through the base region and into the emitter region as hole current(red arrow)

- When the electrons that have recombined with holes as valence electrons leave the crystalline structure of the base, they become free electrons in the metallic base lead and produce the external base current.

- As the free electrons move toward the reverse-biased BC junction, they are swept across into the collector region by the attraction of the positive collector supply voltage. The free electrons move through the collector region, into the external circuit, and then return into the emitter region along with the base current.

- The emitter current is slightly greater than the collector current because of the small base current that splits off from the total current injected into the base region from the emitter.



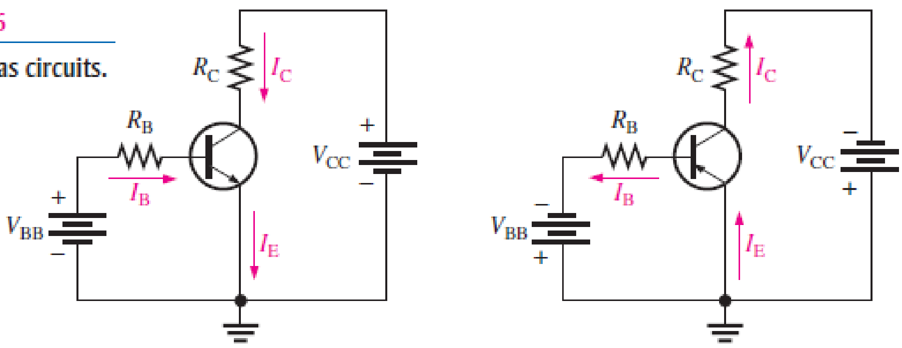
▲ FIGURE 4–4

BJT operation showing electron flow.

4-3: BJT Characteristics and Parameters

▶ FIGURE 4–6

Transistor dc bias circuits.



(a) *npn* (b) *pnp*

DC beta (β_{DC}) or dc current gain	$\beta_{DC} = \frac{I_C}{I_B}$ $h_{FE} = \beta_{DC}$ (Typical: 20 → 200)
DC alfa (α_{DC})	$\alpha_{DC} = \frac{I_C}{I_E}$ (Typical: 0.95 → 0.99)

Transistor DC model:

You can view the unsaturated BJT as a device with a current input and a dependent current source in the output circuit.

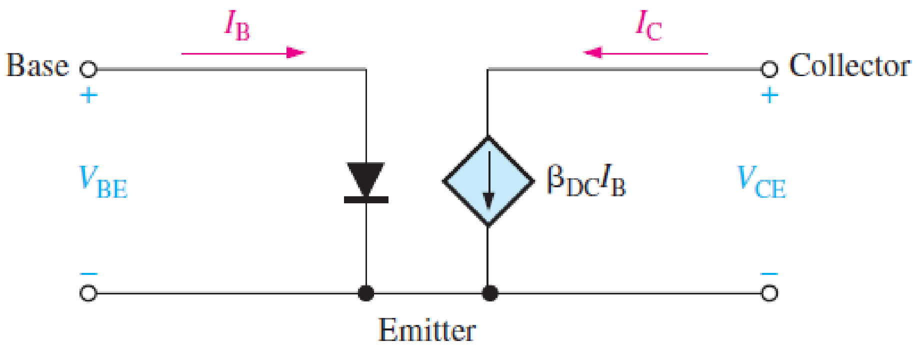


FIGURE 4–7

Ideal dc model of an *npn* transistor.

BJT circuit analysis:

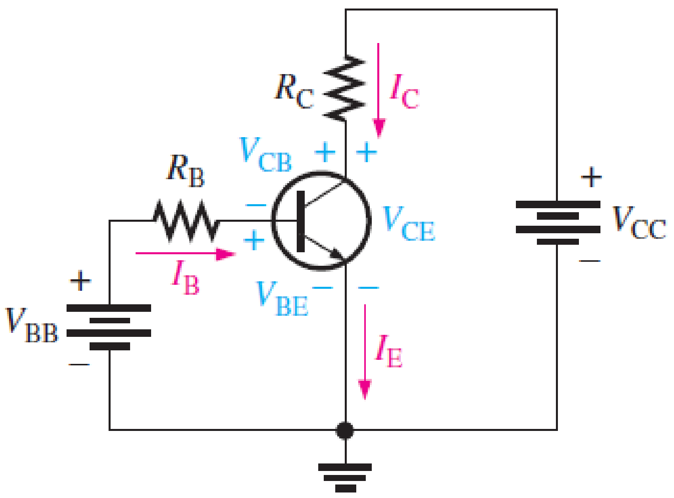


FIGURE 4–8

Transistor currents and voltages.

Note:

- V_{BB}, forward-biases the base-emitter (BE) junction, and the collector-bias voltage source V_{CC} reverse-biases the base-collector (BC) junction.

$$I_B = \frac{V_{BB} - V_{BE}}{R_B}$$

$$I_C = \beta_{DC} \times I_B$$

$$I_E = I_C + I_B$$

$$V_{BE} \sim 0.7\text{ V}$$

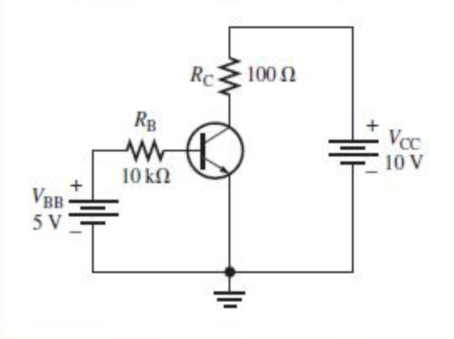
$$V_{CE} = V_{CC} - I_C R_C$$

$$V_{CB} = V_{CE} - V_{BE}$$

EXAMPLE 4–2

Determine I_B, I_C, I_E, V_{BE}, V_{CE}, and V_{CB} in the circuit of Figure 4–9. The transistor has a $\beta_{DC} = 150$.

► FIGURE 4–9



Solution From Equation 4–3, $V_{BE} \cong$ **0.7 V**. Calculate the base, collector, and emitter currents as follows:

$$I_B = \frac{V_{BB} - V_{BE}}{R_B} = \frac{5\text{ V} - 0.7\text{ V}}{10\text{ k}\Omega} = \mathbf{430\ \mu A}$$

$$I_C = \beta_{DC} I_B = (150)(430\ \mu\text{A}) = \mathbf{64.5\ mA}$$

$$I_E = I_C + I_B = 64.5\text{ mA} + 430\ \mu\text{A} = \mathbf{64.9\ mA}$$

Solve for V_{CE} and V_{CB}.

$$V_{CE} = V_{CC} - I_C R_C = 10\text{ V} - (64.5\text{ mA})(100\ \Omega) = 10\text{ V} - 6.45\text{ V} = \mathbf{3.55\ V}$$

$$V_{CB} = V_{CE} - V_{BE} = 3.55\text{ V} - 0.7\text{ V} = \mathbf{2.85\ V}$$

Since the collector is at a higher voltage than the base, the collector-base junction is reverse-biased.