Semiconductor 2

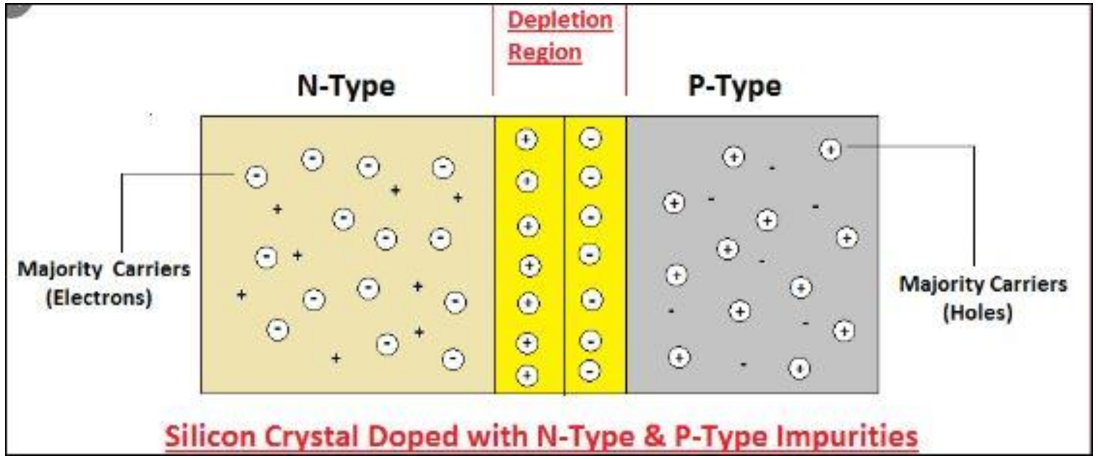
PH-122

PN JUNCTION

- If a piece of silicon is partially doped with p type and partially with n type semiconductor, pn junction formed
- P region has large number of holes than n type and n region has large number of electrons than p type.

Formation of depletion region:

- Free electrons near the junction begin to diffuse across the junction into p type and combine with holes and create a layer of –ve charges (ions) near junction
- When electrons diffuse across the junction ,creates a layer of +ve charges(ions) near the junction
- At one point , the migratory action is stopped because an additional electrons from the N region are repelled by the net negative charge of the p region. Similarly, an additional holes from the P region are repelled by the net positive charge of the n region. Net result a creation of a thin layer of each side of the junction which is depleted (emptied) of mobile charge carrier. This is known as DEPLETION LAYER.
- Depletion region acts as a barrier to the further movement of electrons across the junction
- Thickness is of the order of 10-6meter



Potential Barrier:

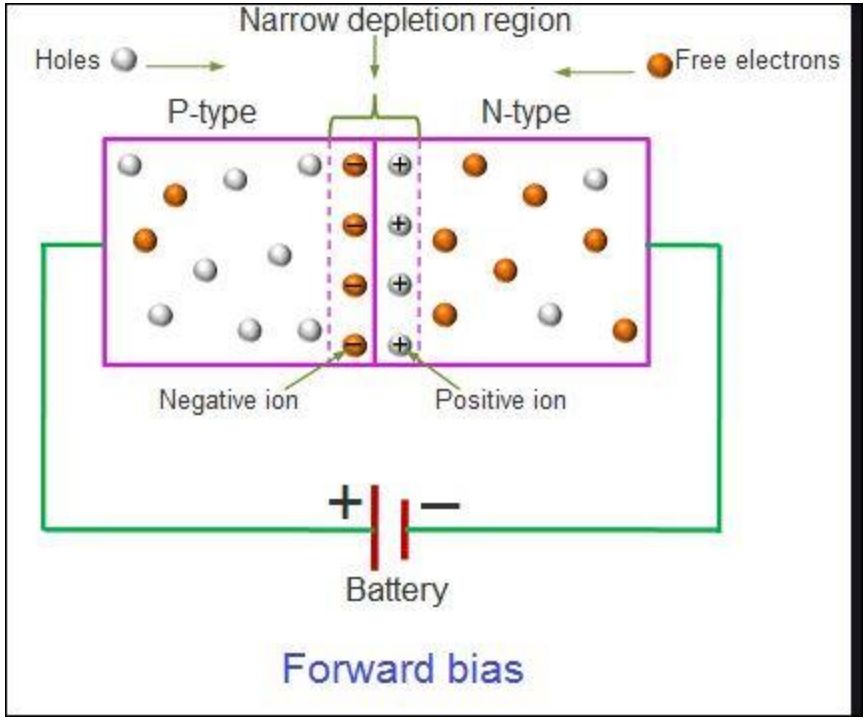
- In depletion region many positive and negative charges on opposite side of the pn junction. Therefore Electric field is created inside the depletion region.
- Potential thus produced are called ..potential barrier.The amount of energy required to produce full conduction across the pn junction
- The electrons in the N region have to climb the potential hill in order to reach the P region
- Factors: type of semi-conductive material , the amount of doping and temperature.
- Barrier potential for silicon ---- 0.7 V and for Germanium ---0.3 V at 25^{o}C.

Biasing

Bias is the application of a voltage across a pn junction.

- Forward biased PN junction
- Reverse biased PN junction

- **<u>Forward Bias:</u>** is the condition that's allows current through pn junction,
- External voltage decreases width of potential barrier.
- **Requirements:**
- i) n-region connected to –ve terminal of the battery and p-region connected to +ve terminal of the battery.
- ii)Bias voltage must be greater than the barrier potential.



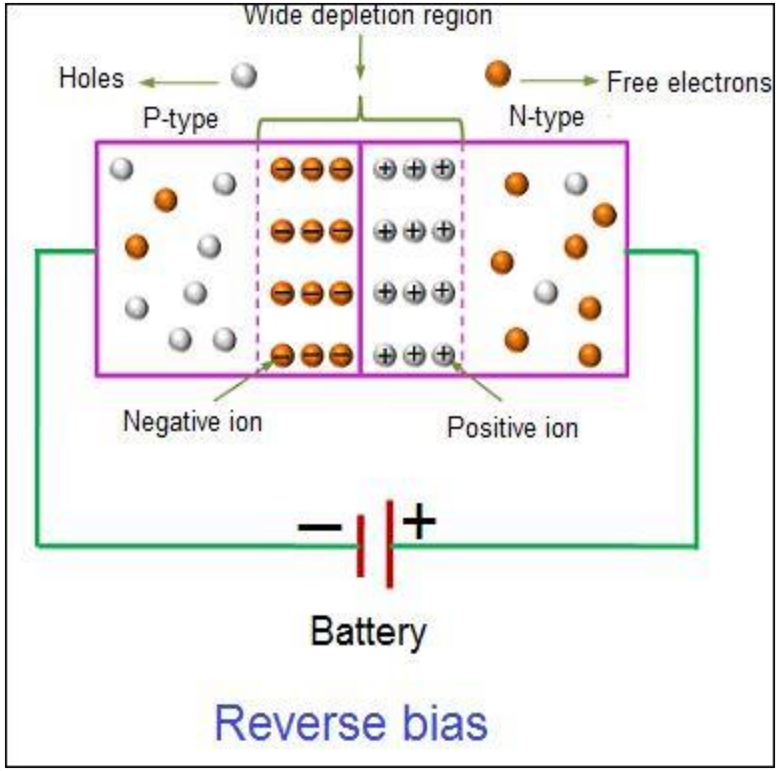
Reverse Bias:

pn junction blocks current in reverse bais

External voltage increases the built-in potential barrier.

p-region connected to +ve terminal of the battery and p- region connected to -ve terminal of the battery.

Depletion region is wider in reverse biasing.



Bipolar Junction Transistors

- The transistor is a three-layer semiconductor device consisting of either two n- and one p- type layers of material or two p- and one n-type layers of material.
- The former is called an npn transistor, while the latter is called a pnp transistor
- So, there are two types of BJT

i) pnp transistor

ii) ii) npn transistor

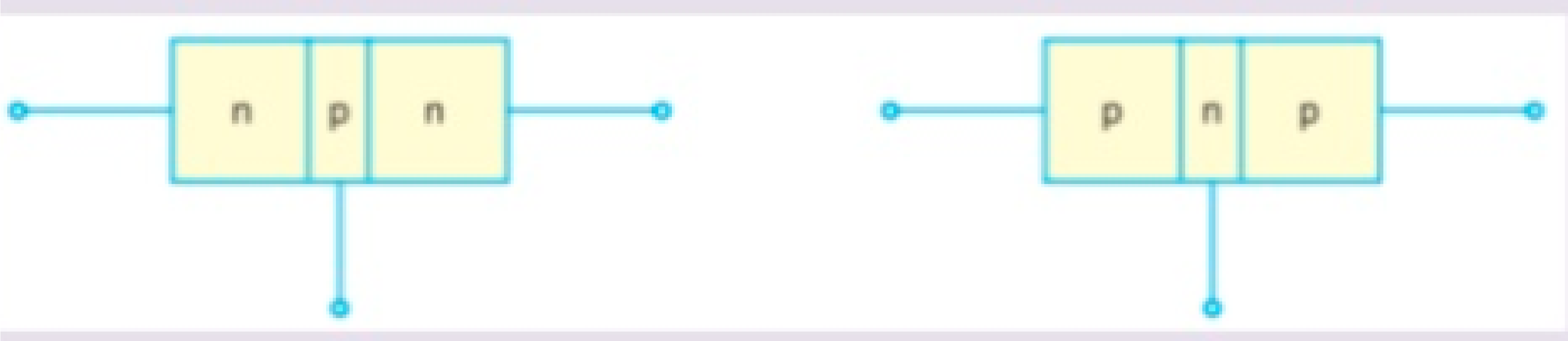
Bipolar Junction Transistors

In each transistor following points to be noted

i) There are two junction, so transistor can be considered as two diode connected back to back.

ii) There are three terminals.

iii)The middle section is thin than other.



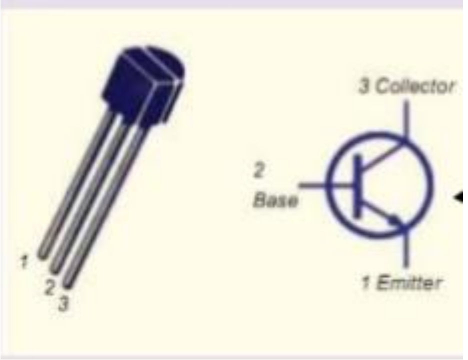
Some important factors to be remembered

- Emitter is heavily doped so it can inject large amount of carriers into the base.
- Base is lightly doped so it can pass most of the carrier to the collector.
- Collector is moderately doped.
- The junction between emitter and base is called emitter-base junction(emitter diode)
- The junction between base and collector is called collector-base junction(collector diode).
- The emitter diode is always forward biased and collector diode is reverse biased.

Naming of Transistor Terminals

• Transistor has three section of doped semiconductor.

• The section one side is called “emitter” and the opposite side is called “collector”. The middle section is called “base”.



Transistor symbol

Emitter:

- The section of one side that supplies carriers is called emitter.
- Emitter is always forward biased w.r.t base so it can supply carrier.
- For “npn transistor” emitter supply holes to its junction. For “pnp transistor” emitter supply electrons to its junction.

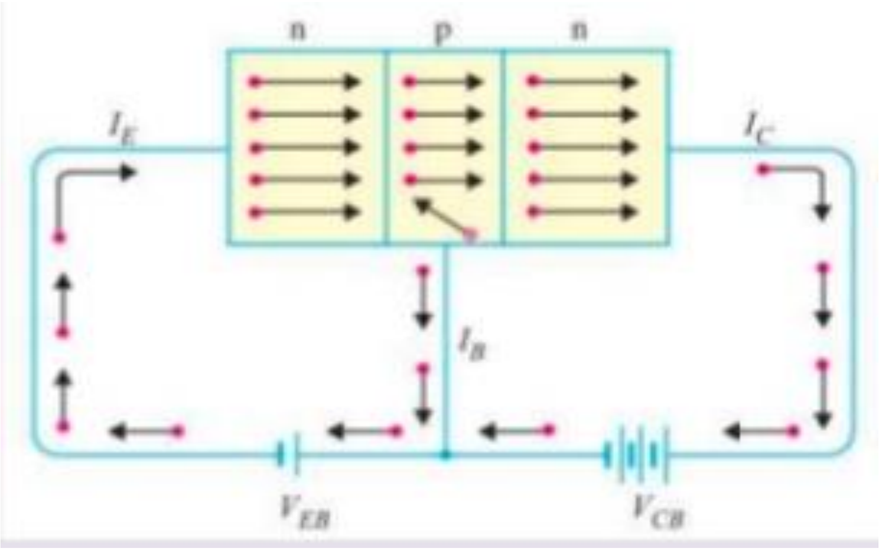
Collector:

- The section on the other side that collects carrier is called collector.
- The collector is always reversed biased wr to base.
- For “npn transistor” collector receives holes to its junction. For “pnp transistor” collector receives electrons to its junction.

Base: The middle section which forms two pn junction between emitter and collector is called Base.

Transistor Operation

- Working of npn transistor: Forward bias Is applied to emitter- base junction and reverse bias is applied to collector- base junction. The forward bias in the emitter-base junction causes electrons to move toward base. This constitute emitter current, I_E
- As this electrons flow toward p-type base, they try to recombine with holes. As base is lightly doped only few electrons recombine with holes within the base. These recombined electrons constitute small base current I_B. The remainder electrons crosses base and constitute collector current I_C.
- $I_E = I_C + I_B$



transistor Connection

Transistor can be connected in a circuit in following three ways

1) Common Base

2) Common Emitter

3) Common Collector

Common emitter configuration

$$I_E = I_C + I_B$$

$$\beta_{DC} = \frac{I_c}{I_B}, \alpha_{DC} = \frac{I_c}{I_E}$$

$$V_{in} = I_B R_1 + V_{BE}$$

$$V_{CC} = I_C R_2 + V_{CE}$$

Figure 1

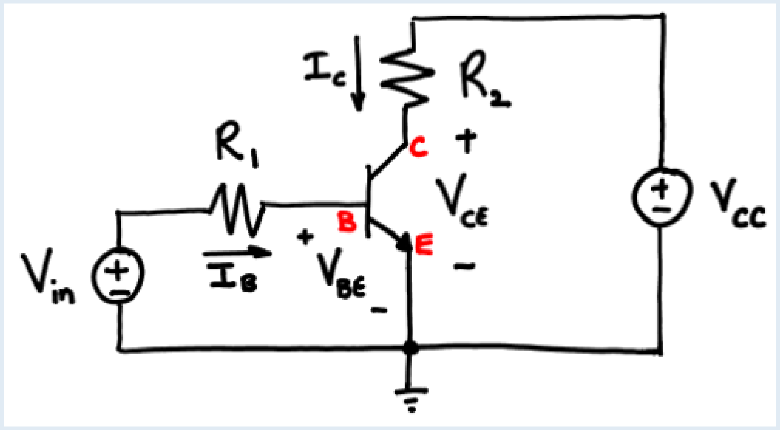
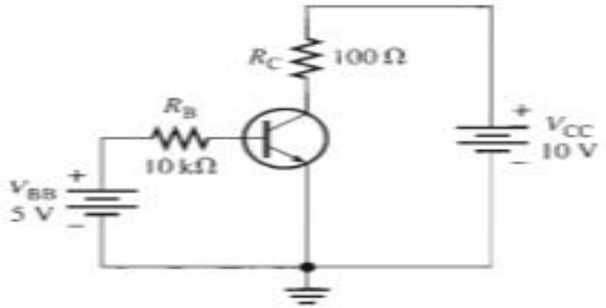


Fig. 1: Common emitter circuit. The emitter of the BJT is wired directly to ground. The input voltage source V_{in} is connected through resistor R_1 to the base. A constant voltage source V_{CC} is connected through resistor R_2 to the collector.

Problem

Determine I_B, I_C, I_E, V_{BE}, V_{CE}, and V_{CB} in the circuit of Figure 4–8. The transistor has a $\beta_{DC} = 150$.

▶ FIGURE 4–8



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}.

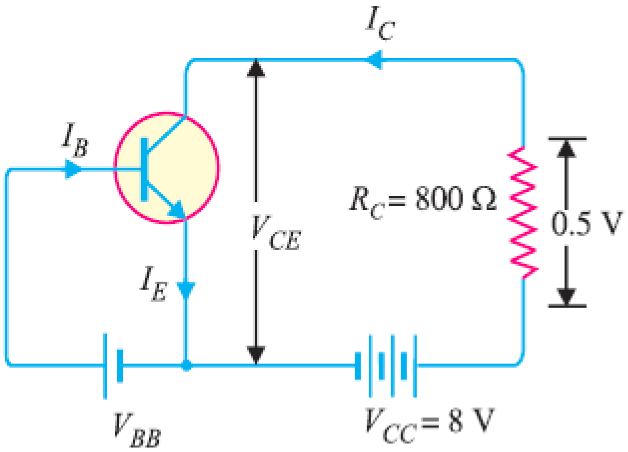
$$V_{CE} = V_{CC} - I_C R_C = 10\text{ V} - (64.5\text{ mA})(100\ \Omega) = 10\text{ V} - 6.45\text{ V} = \mathbf{3.55\ V}$$

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

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

problem

A transistor is connected in common emitter configuration in which collector supply is 8 V and the voltage drop across resistance R_C connected in the collector circuit is 0.5 V. The value of R_C = 800 Ω. If α = 0.96, determine : (i) collector-emitter voltage (ii) base curren



Collector-emitter voltage, (i)

$$V_{CE} = V_{CC} - 0.5 = 8 - 0.5 = 7.5 \text{ V}$$

(ii)

The voltage drop across R_C (= 800 Ω) is 0.5 V.

$$I_C = \frac{0.5 \text{ V}}{800 \ \Omega} = \frac{5}{8} \text{ mA} = 0.625 \text{ mA}$$

Now $$\beta = \frac{\alpha}{1-\alpha} = \frac{0.96}{1-0.96} = 24$$

∴ Base current, $$I_B = \frac{I_C}{\beta} = \frac{0.625}{24} = 0.026 \text{ mA}$$