# Bipolar Junction Transistor (BJT)

Operation Theory

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# Transistors

- Transistors are used for amplification or gain in a circuit.
- When a small variation in voltage or current is used to create a large variation. Like small valve in large water system.
- Two important kinds of transistors are

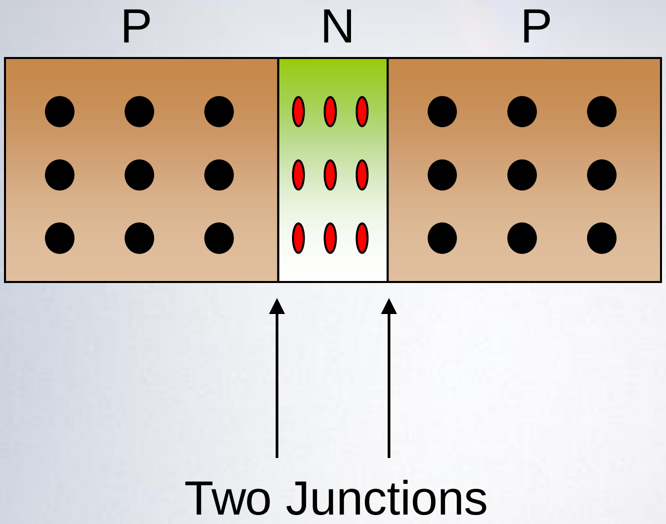
I. BJT----bipolar junction transistor(Bi polar-two polarities)

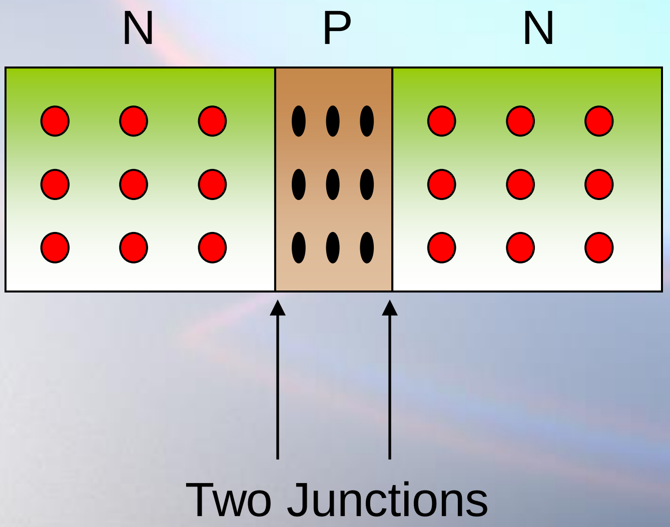
II. FET----Field Effect transistor (Mostly using in I.C)

# BJT, Bipolar Junction Transistor

- Three terminal semiconductor device containing two PN junctions
- Formed from a bar of material that has been doped in such a way that it changes from N to P & back to N.
- When transistor is formed by sandwiching a single P region between two N regions, it is called an NPN type.
- Middle region of each transistor is called base, other two regions are emitter & collector.

# Formation of BJT

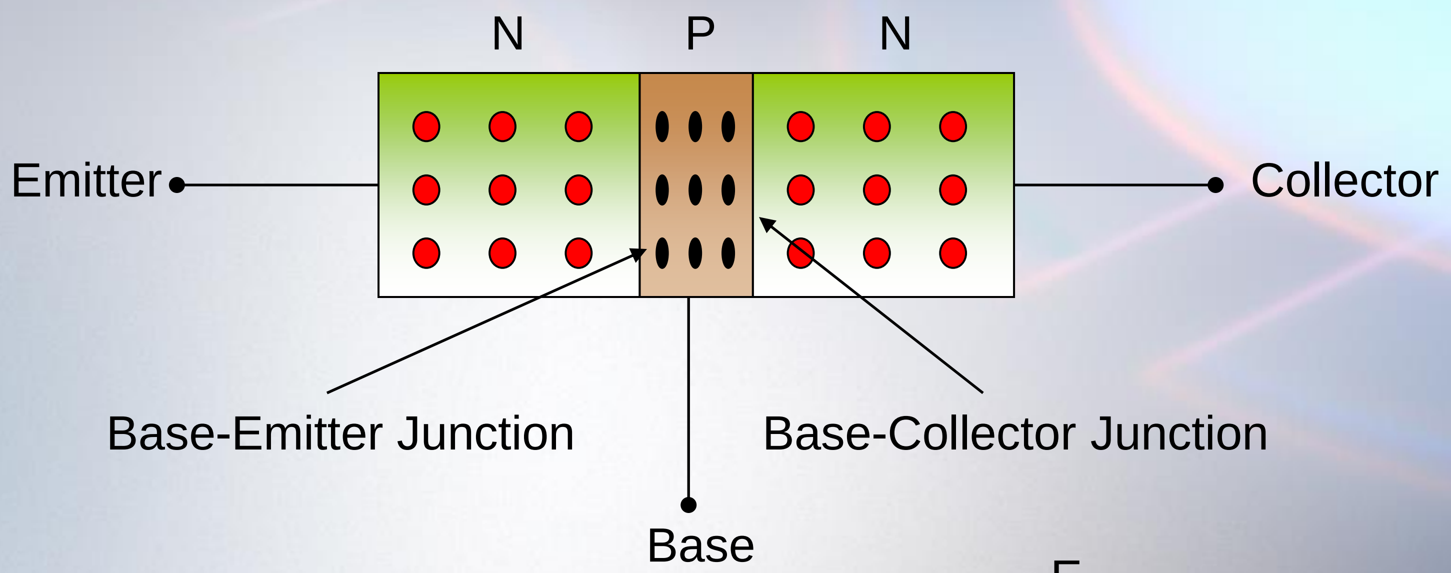


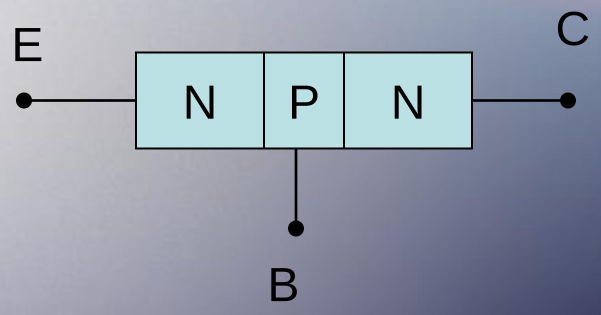




N-Type material has excessive free electrons and P-Type material has excessive holes

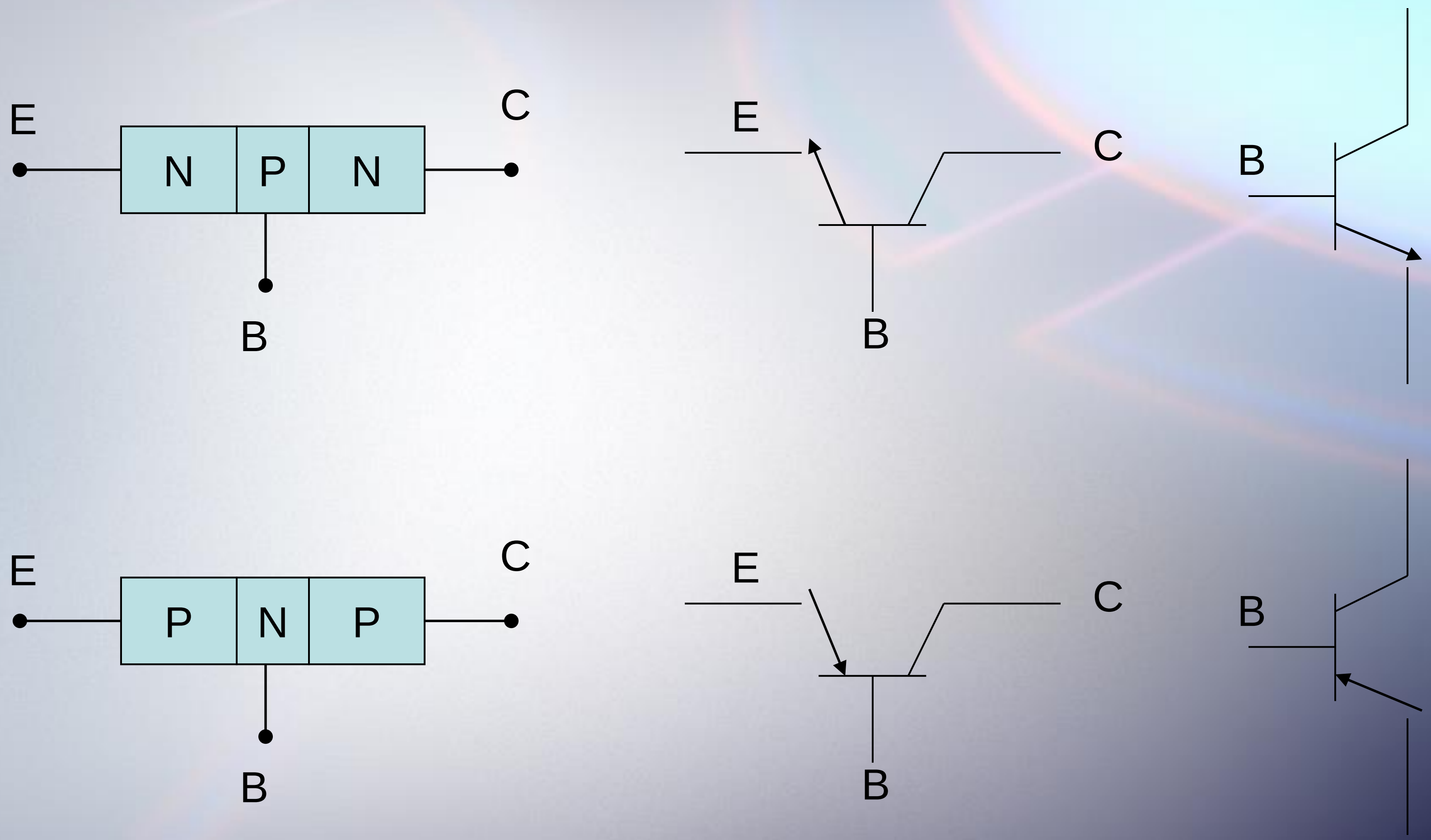
NPN and PNP BJTs have same characteristics. The only difference is in their polarities of applied voltages. The polarities are reversed for the two types of transistor.

# BJT Terminals



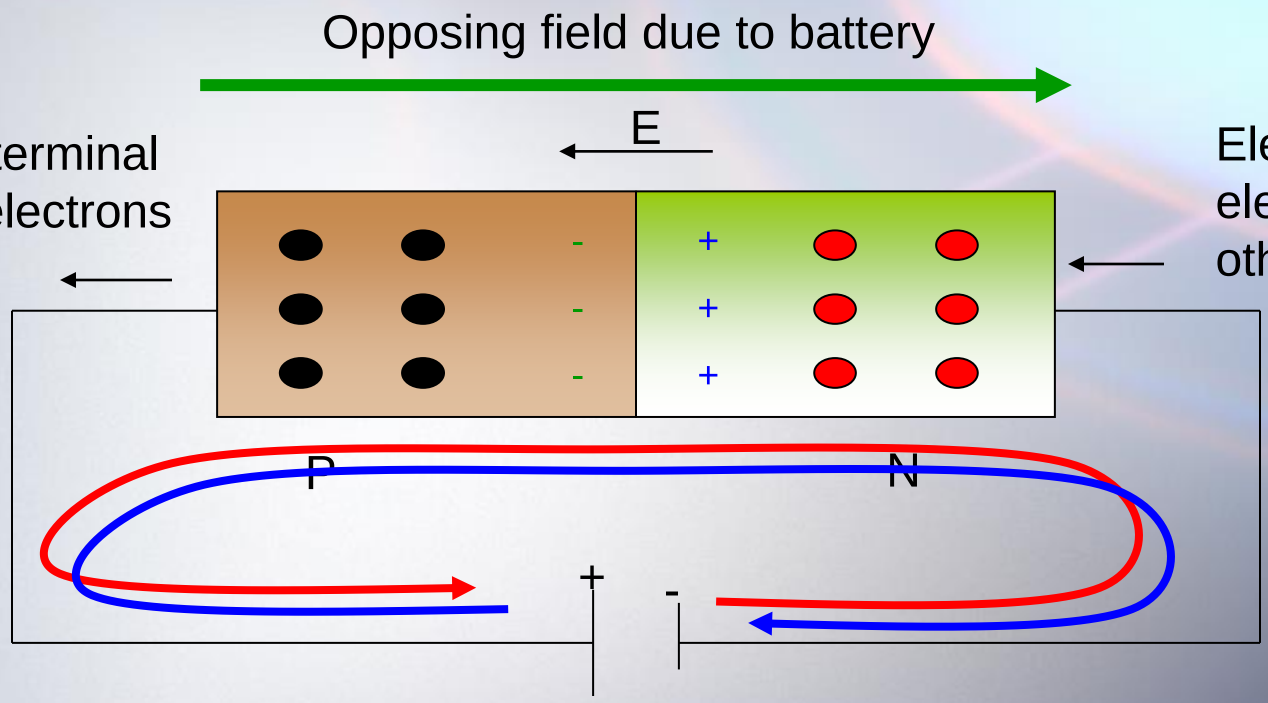
# BJT Circuit Symbols



# BJT

- Base region is much more lightly doped and thinner than E & C.
- Emitter is usually heavily doped.
- Biasing is necessary for both PN junctions to obtain normal transistor action.

# Forward Biased Junction Operation




Positive terminal attracts electrons

Electrons Push electrons to the other side

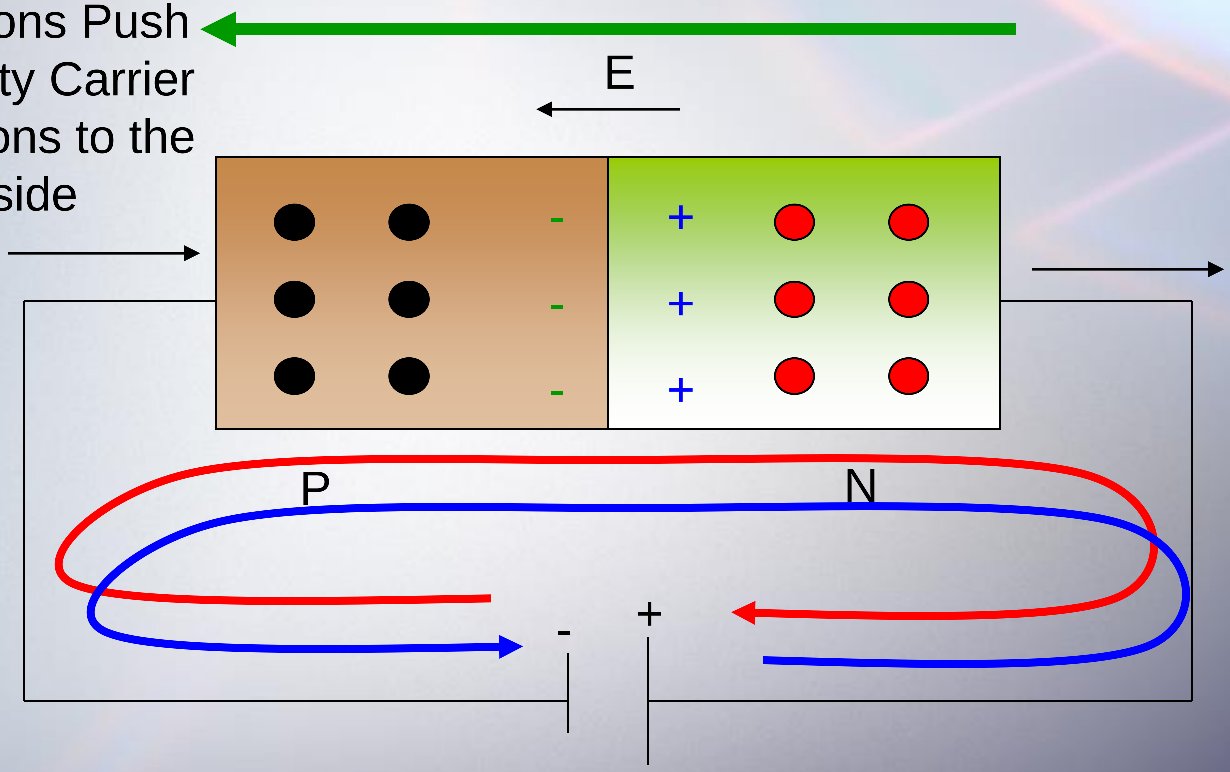
Depletion region become narrow. Diffusion current flow across junction.

Flow of electron current (diffusion current); but in semiconductor electronics the flow of positive or conventional current is considered

# Reverse Biased Junction Operation

Supporting field due to battery

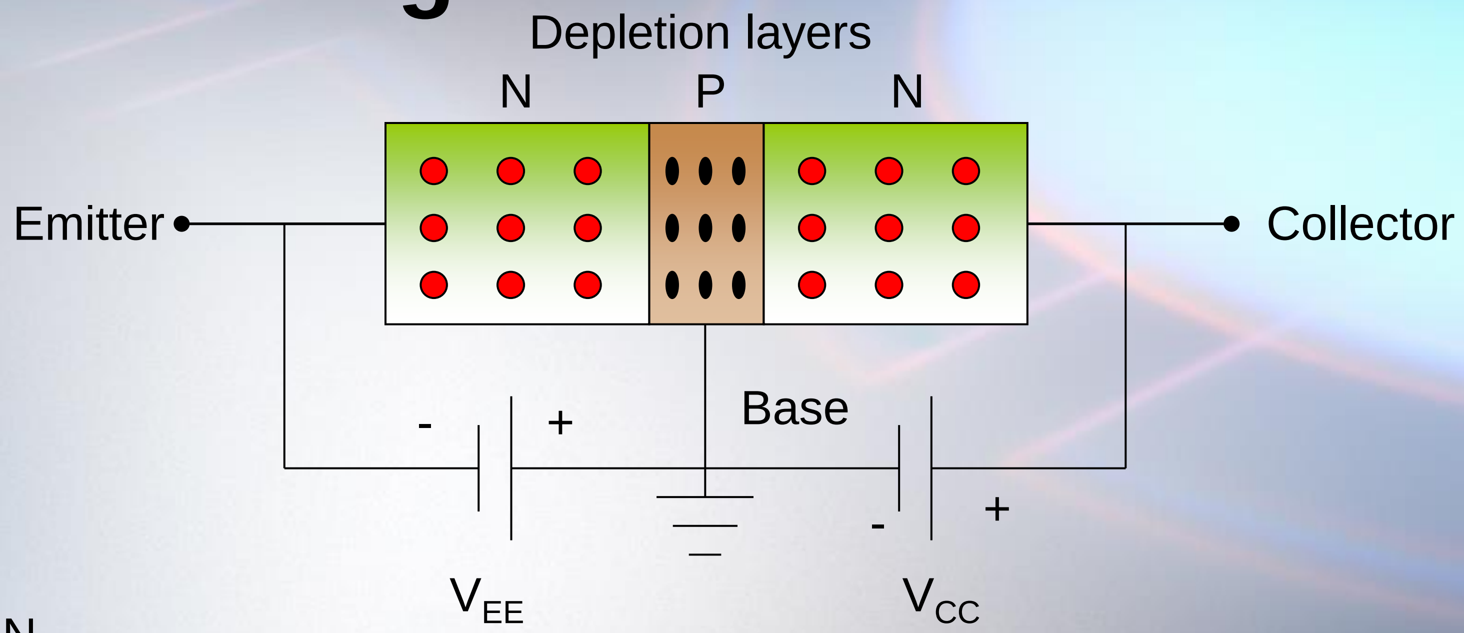
Electrons Push Minority Carrier electrons to the other side

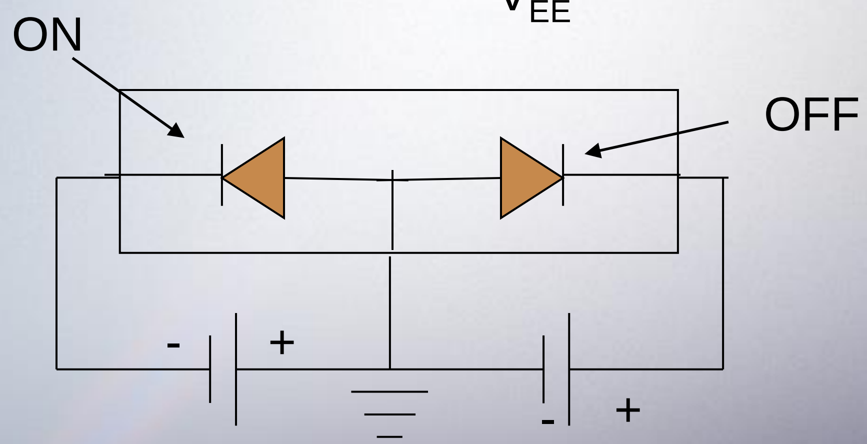



Positive terminal attracts Minority Carrier electrons

Depletion region is widened, Current flows due to minority carriers

# BJT Biasing



# BJT

- Base is very thin & lightly doped, very few of the electrons injected into the base from the emitter recombines with holes, they diffuse to the reverse-biased base-collector junction.
- Electrons injected into the base become minority carriers in that P-type region.
- Depletion region widens at BC junction. Only current flow due to minority carriers. i.e due to electrons
- Electron flow constitute the dominant current type in an NPN transistor, for PNP hole is the dominant type.
- Most of the electrons injected into the base cross into the collector, a few of them do combine with holes in the base.
- Each electron that combines with the hole, an electron leaves the base region via the base terminal known as base current, about 2% or less of the electron current from emitter to collector.
- Universal rule for biasing transistors for normal operation (ACTIVE MODE); The base emitter junction must be forward biased & the

# BJT

- For both NPN & PNP

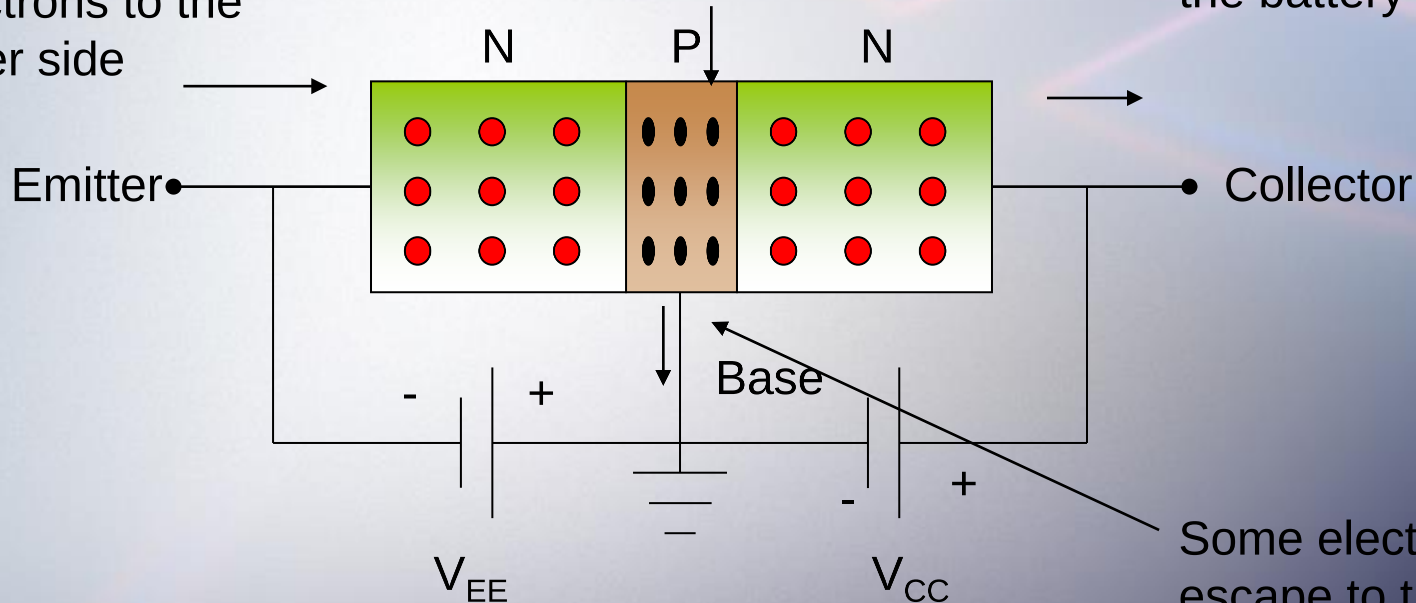
$$I_E = I_C + I_B$$

# BJT Currents

Negative Terminal pushes electrons to the other side

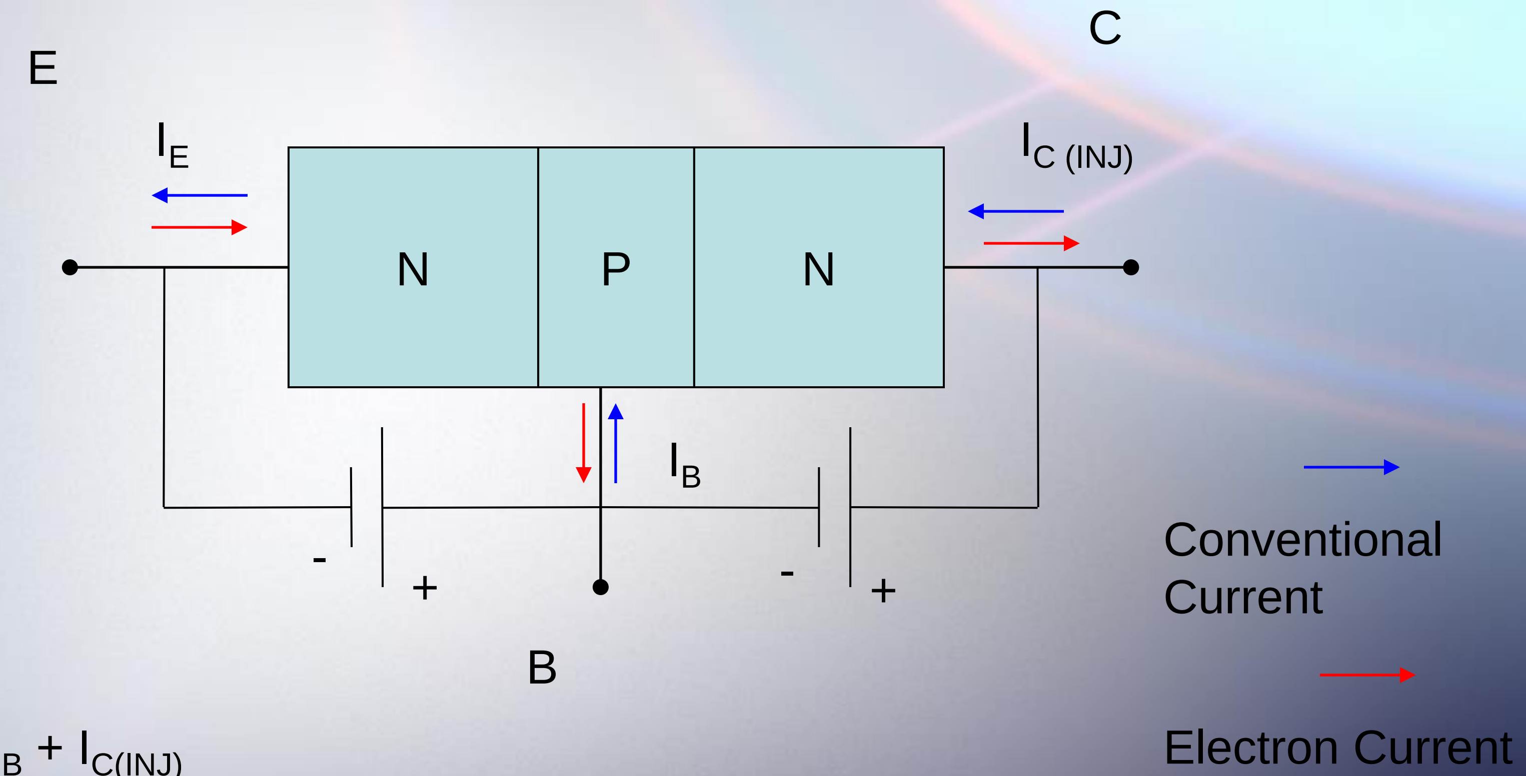
When electrons come to Base, they become minority carriers

Minority carriers are attracted to the positive terminal of the battery



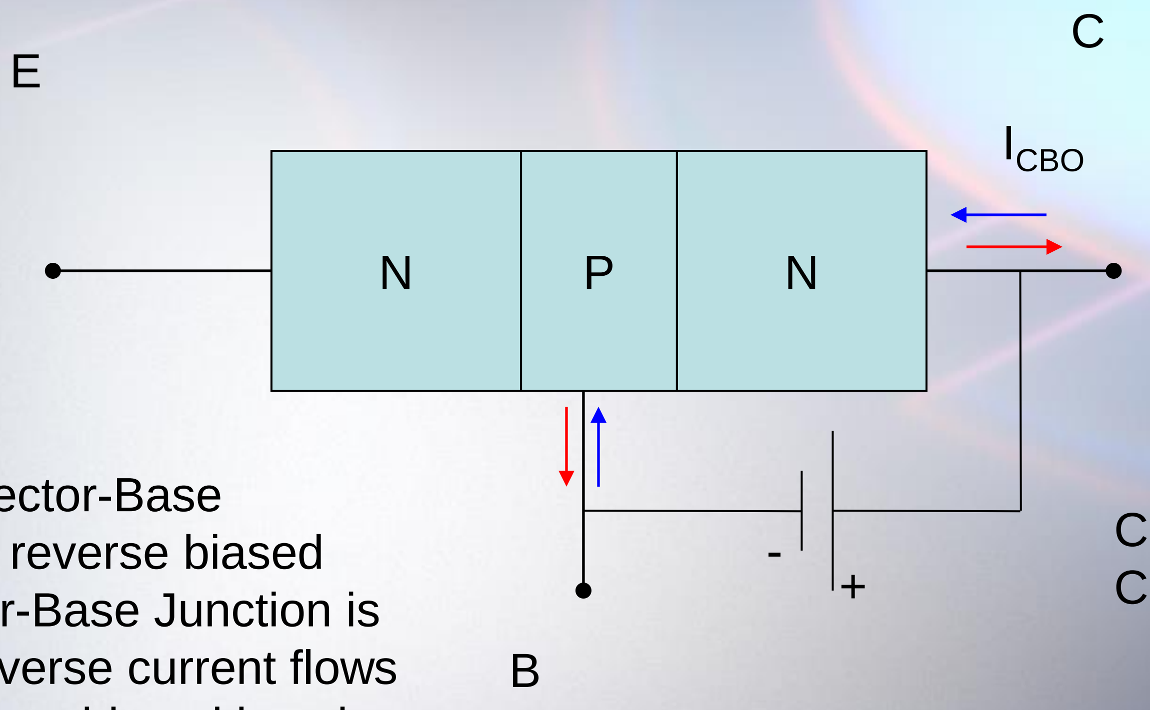

Some electrons escape to the ground

# BJT Currents




$I_E = I_B + I_{C(INJ)}$

# Collector-Base Reverse Current




When Collector-Base Junction is reverse biased and Emitter-Base Junction is Open, a reverse current flows in this reverse biased junction which is called $I_{CBO}$

Conventional Current

Electron Current

Total Collector current is = $I_C = I_{C(INJ)} + I_{CBO}$

# $I_{CBO}$ Reverse Current

- Collector current is the sum of two components, the injected minority carriers & the thermally generated minority carriers.
- If the base & emitter are left open & the Collector-Base junction is reverse bias, the only current that flow must be “reverse” component due to thermally generated carriers. This current is called Icbo (The collector to base current with the emitter open)

  $I_C = I_{C(INJ)} + I_{CBO}$
- Transistor parameter, Alpha, is defined as “The ratio of the collector current resulting from carrier injection to the total emitter current”

  $\alpha = I_{C(INJ)}/I_E$
- Alpha measures the portion of the emitter current that survives after passage through base.
- Alpha is always less than “1”

# $I_{CBO}$ Reverse Current

- The greater the value of Alpha, the better the transistor.
- Typical transistor have values of Alpha range from 0.95 to 0.995

  $I_C = \boldsymbol{\alpha} I_E + I_{CBO}$
- $I_{CBO}$ in modern transistors is so small that it can be neglected. $I_{CBO}$ is exactly the same as the reverse diode current (Is)
- $I_{CBO}$ is negligible small in most practical situations, we can set it equal to 0.

  $I_C = \boldsymbol{\alpha} I_E$

  $\boldsymbol{\alpha} = I_C/I_E$

# α of BJT

$\alpha = I_{C(INJ)}/I_E$

$I_C = I_{C(INJ)} + I_{CBO}$ $\quad$ $I_{CBO} << I_{C(INJ)}$

$I_C = I_{C(INJ)}$

$\alpha = I_C/I_E$

# Any Questions?