Bipolar Junction Transistors

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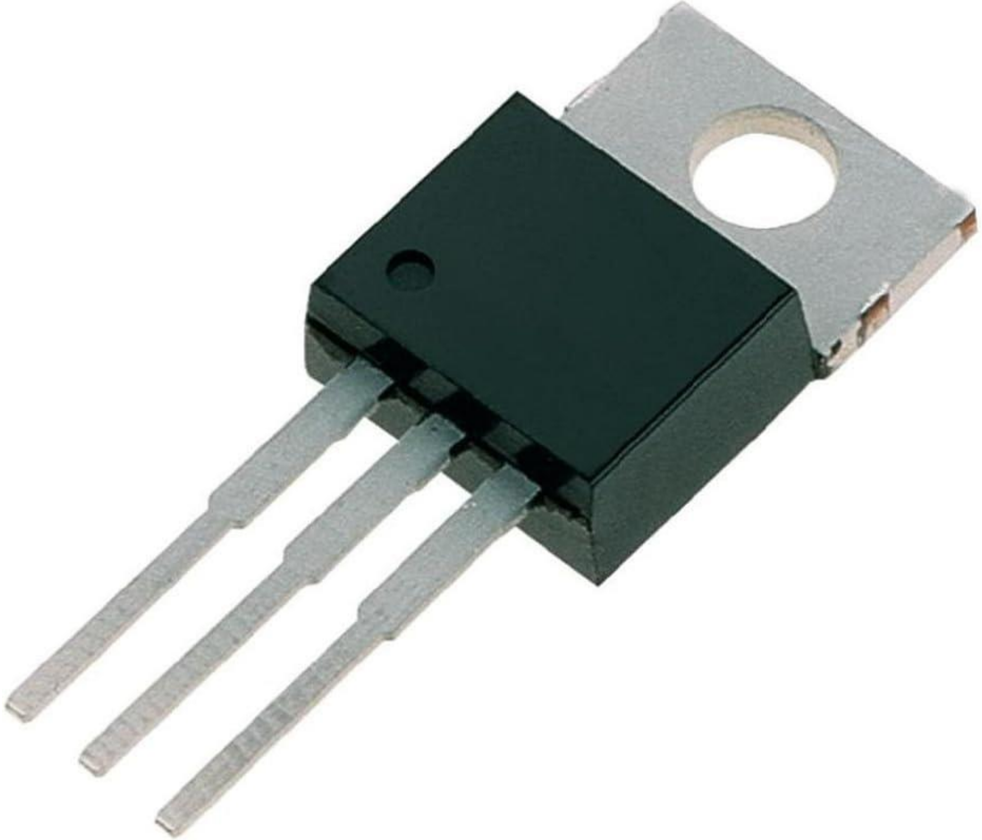
TRANSISTORS:



Transistors are used in almost all electronic circuits.

A transistor can be used as current amplification or a voltage amplification device.

The word transistor is the short form of the word “transfer resistor”.

The signal amplification in a transistor is achieved by transferring the signal from a region of low resistance to a region of high resistance.

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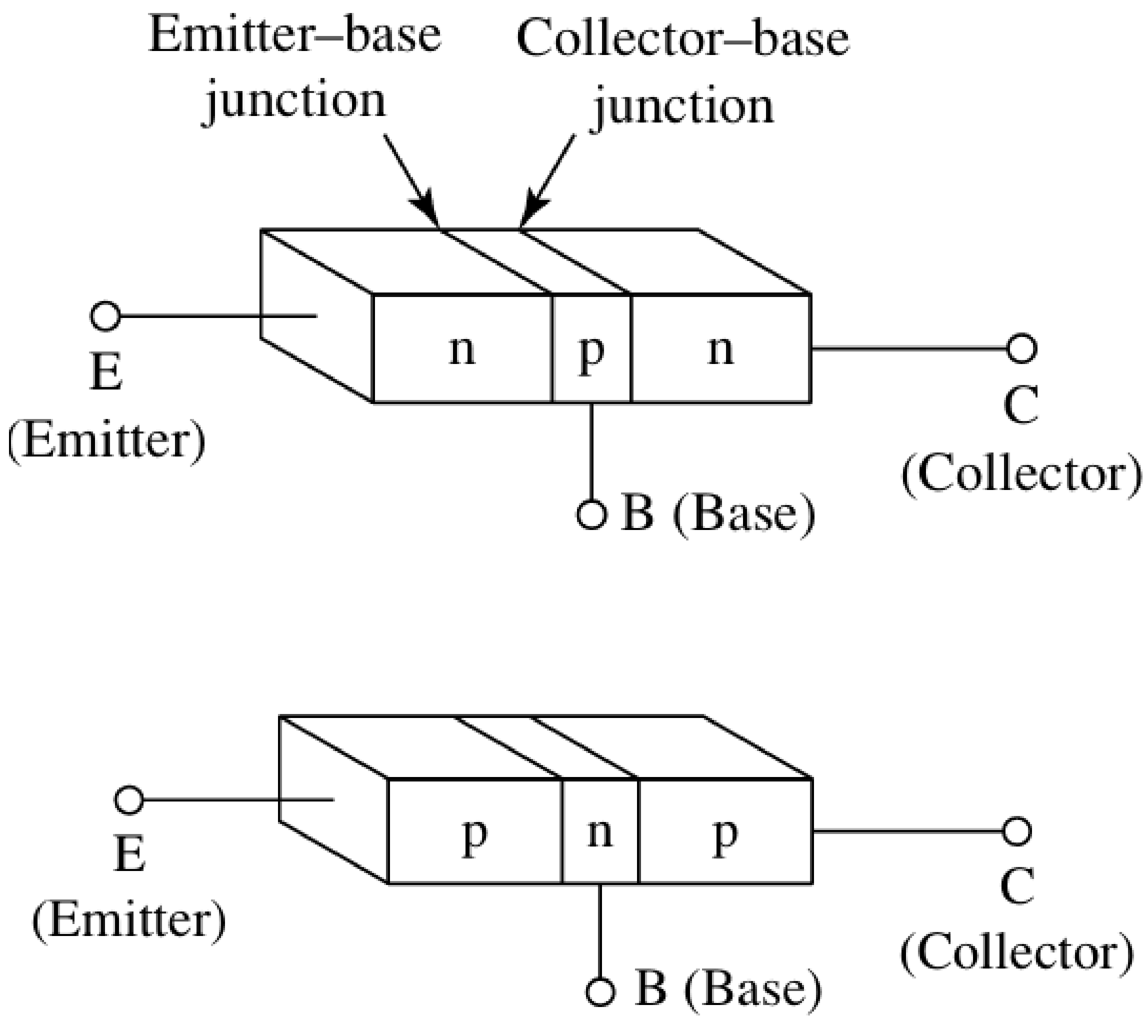

A bipolar junction transistor has three layers of semiconductor material.

These layers are arranged either in an n–p–n sequence or in a p–n–p sequence.

In an n–p–n transistor, a p-type semiconductor material is sandwiched between two n-type materials.

In a p–n–p transistor, an n-type semiconductor material is sandwiched between two p-type materials.

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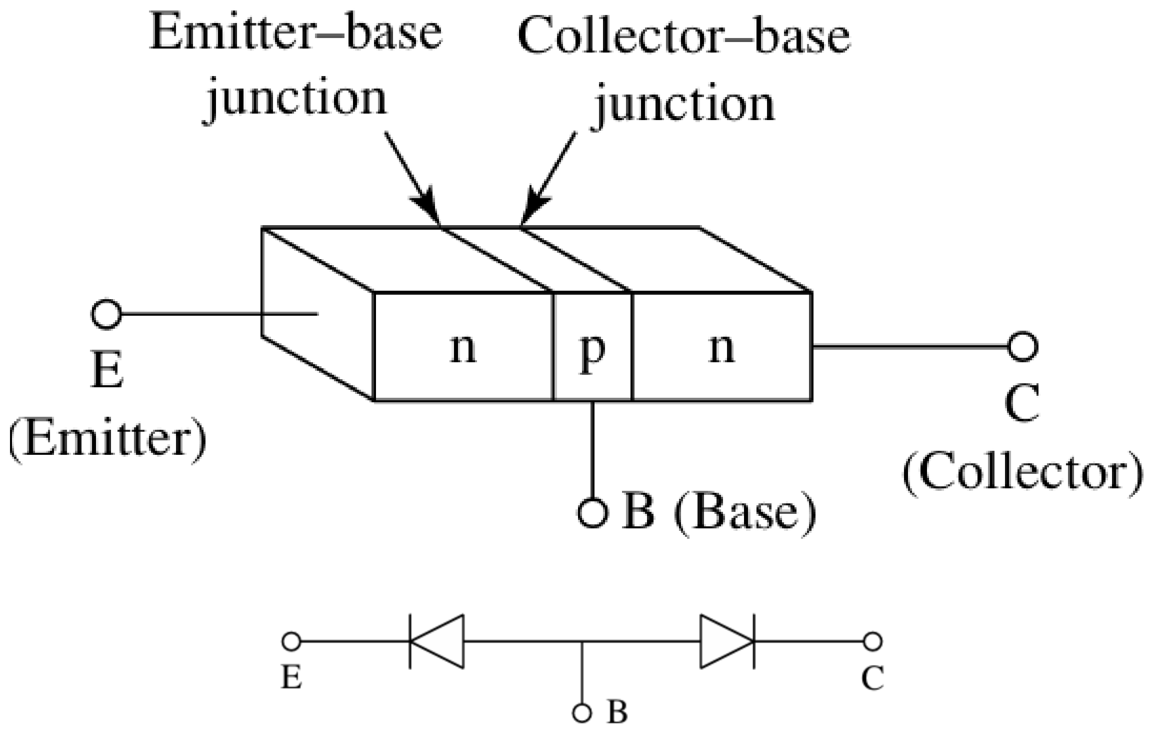

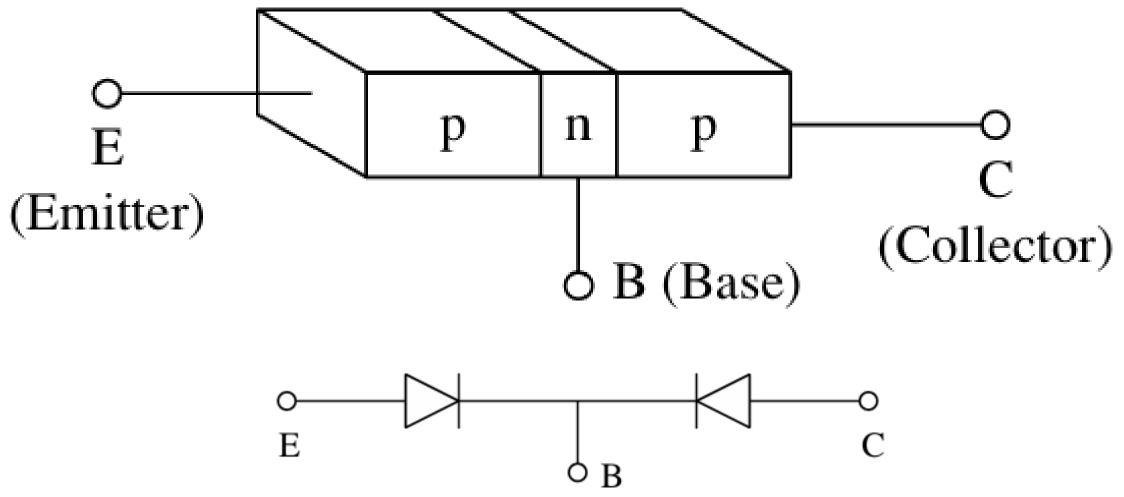

A transistor has two p–n junctions connected back-to-back.

The central layer is called the base, one of the outer layers is called the emitter, and the other is called the collector.

The emitter of a transistor is heavily doped. The base is lightly doped while the collector is less heavily doped than the emitter.

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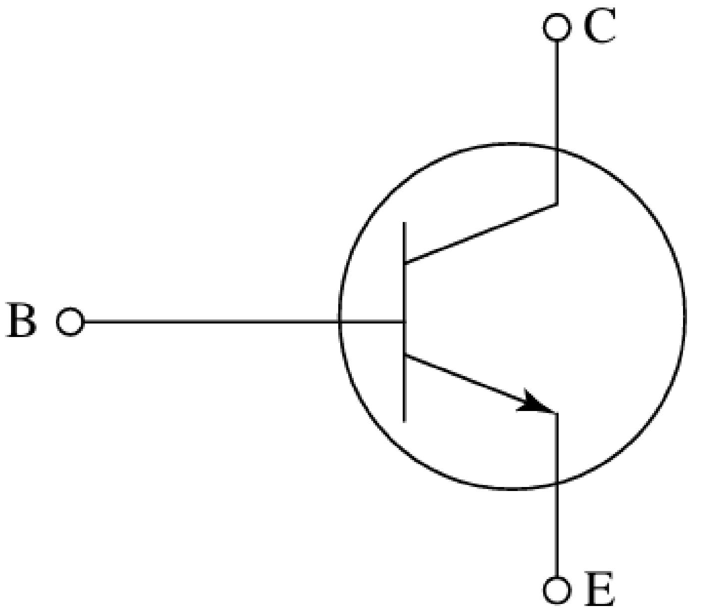
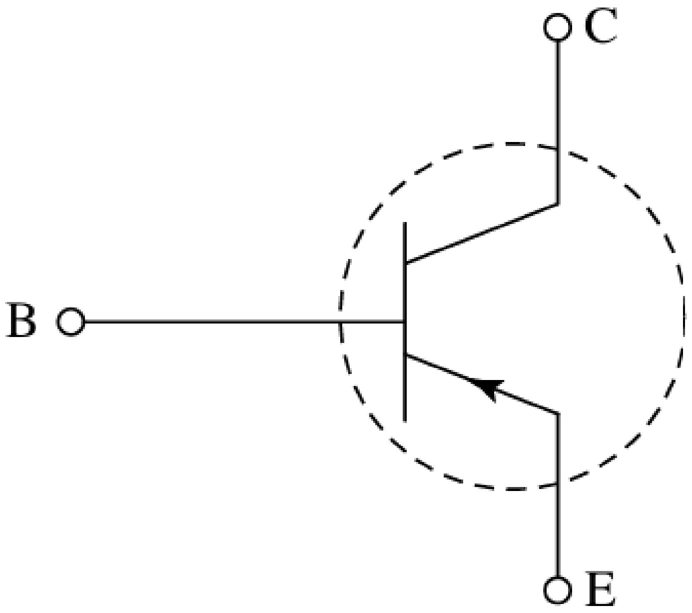


Symbol of NPN transistor

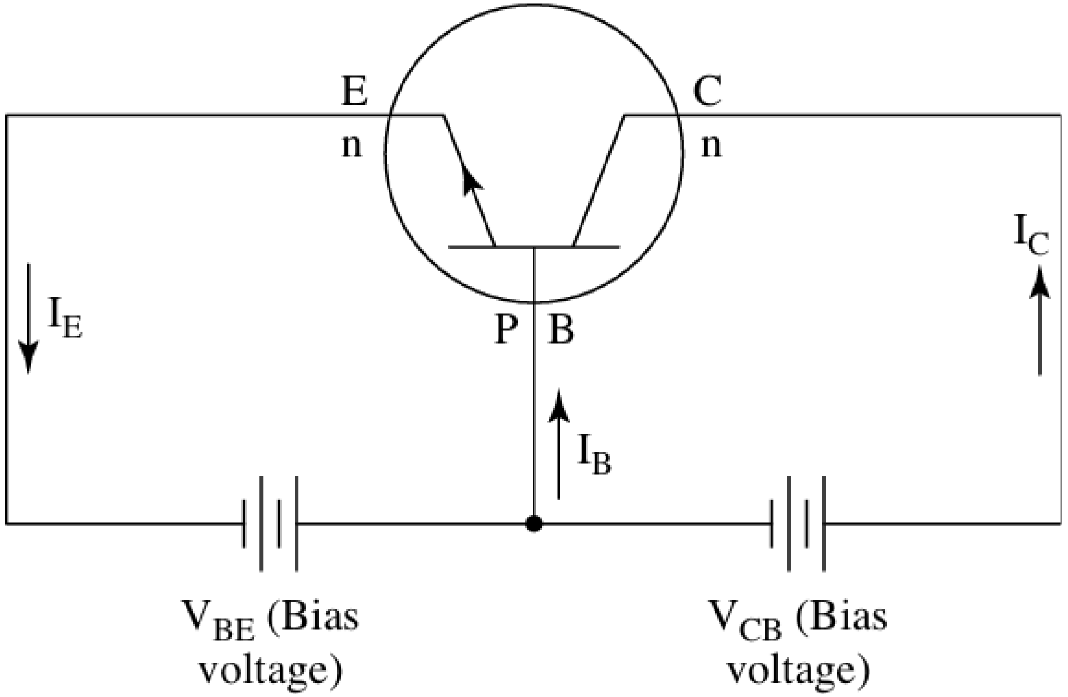


Symbol of PNP transistor

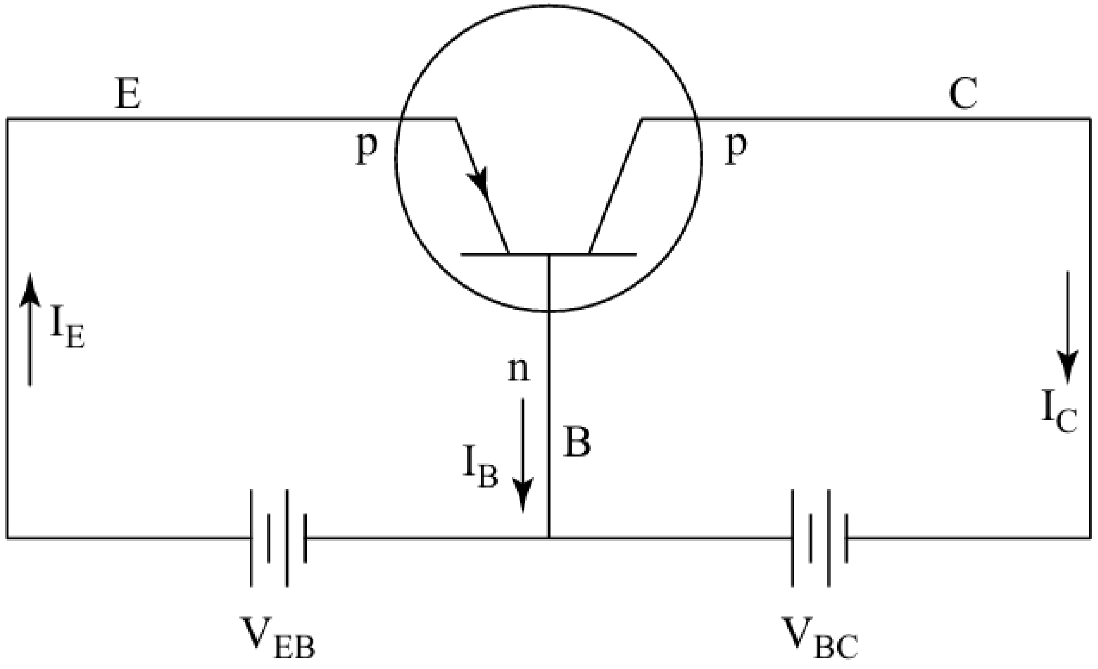
The symbol for an n–p–n or a p–n–p transistor is the same except for the direction of the arrowhead.

The arrowhead has to be shown from p terminal to n terminal between the emitter and the base.

BIASING TRANSISTORS:



Biasing of NPN transistor

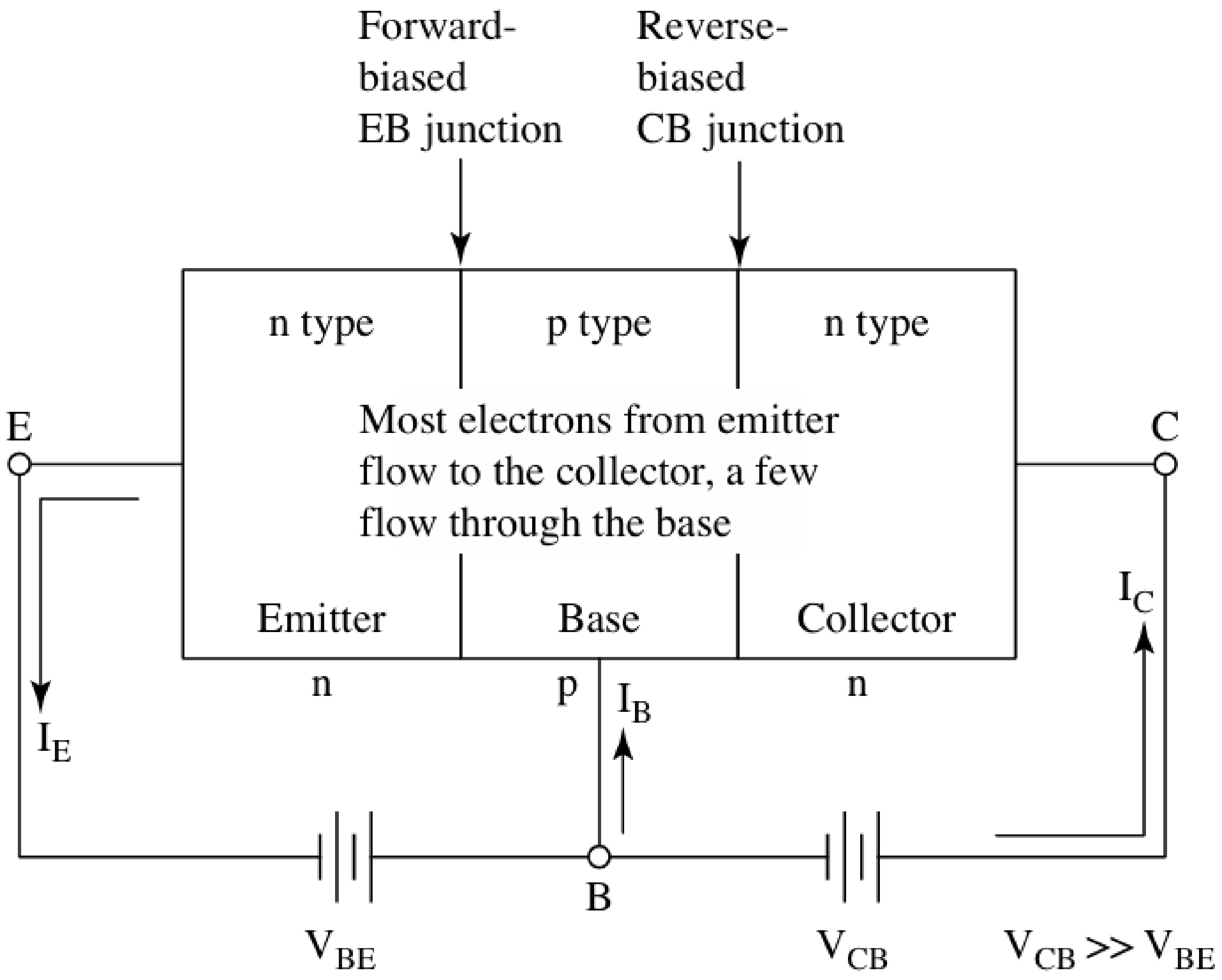


Biasing of PNP transistor

For proper working of a transistor, it must be biased by applying external voltage supply with proper polarity.

Its emitter–base junction must be forward biased, and its collector base junction must be reverse biased.

WORKING OF NPN TRANSISTORS:



The EB junction is forward biased.

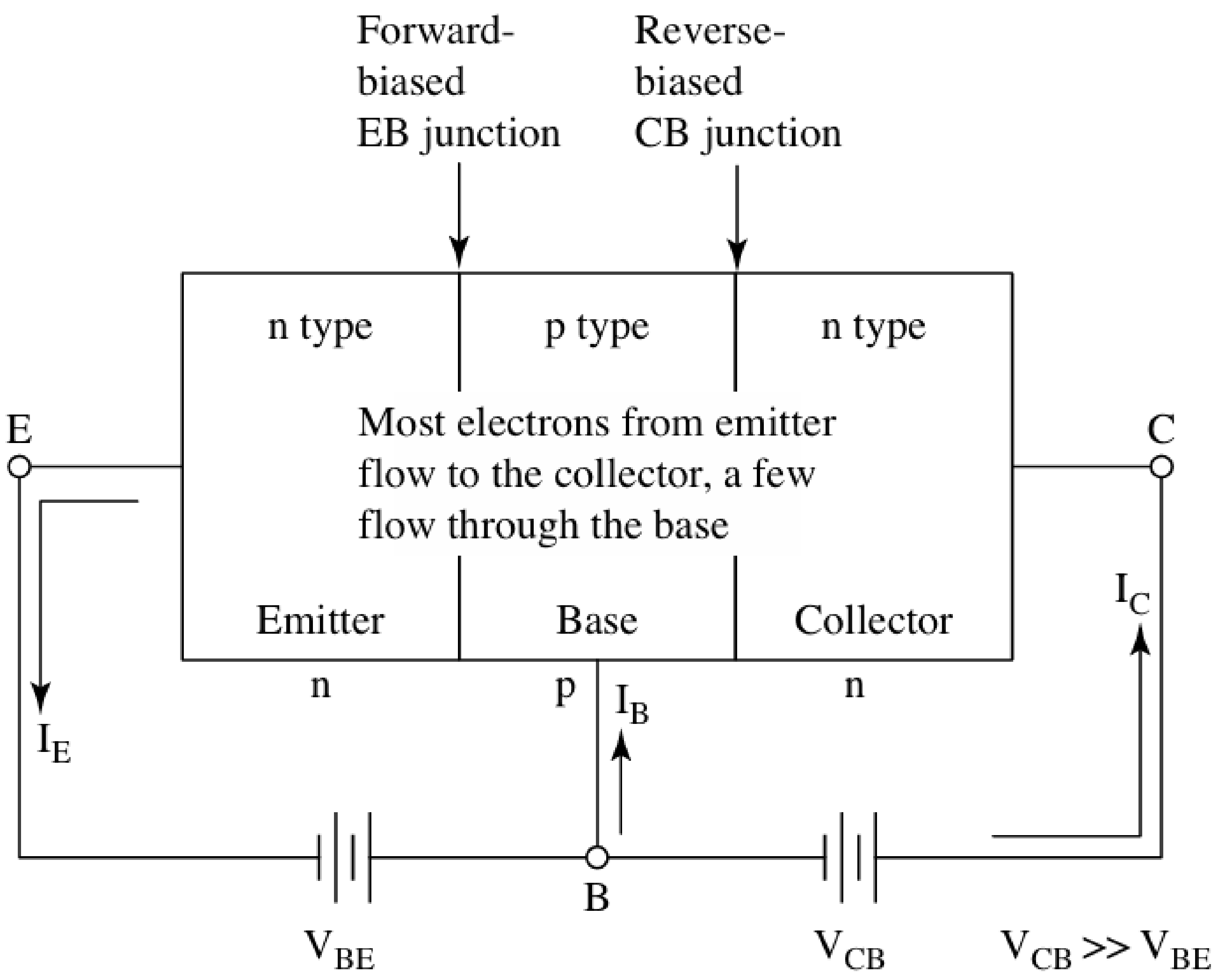
Therefore, the majority charge carriers from the N-type emitter flow from the emitter to the base region.

Only about two percent electrons from the emitter will recombine with holes in the base region because the base is lightly doped.

Due to large CB bias voltage, electrons will be pulled across the CB junction by the positive terminal of the collector.

The collector thus collects the 98 per cent of the electrons emitted by the emitter.

WORKING OF NPN TRANSISTORS:



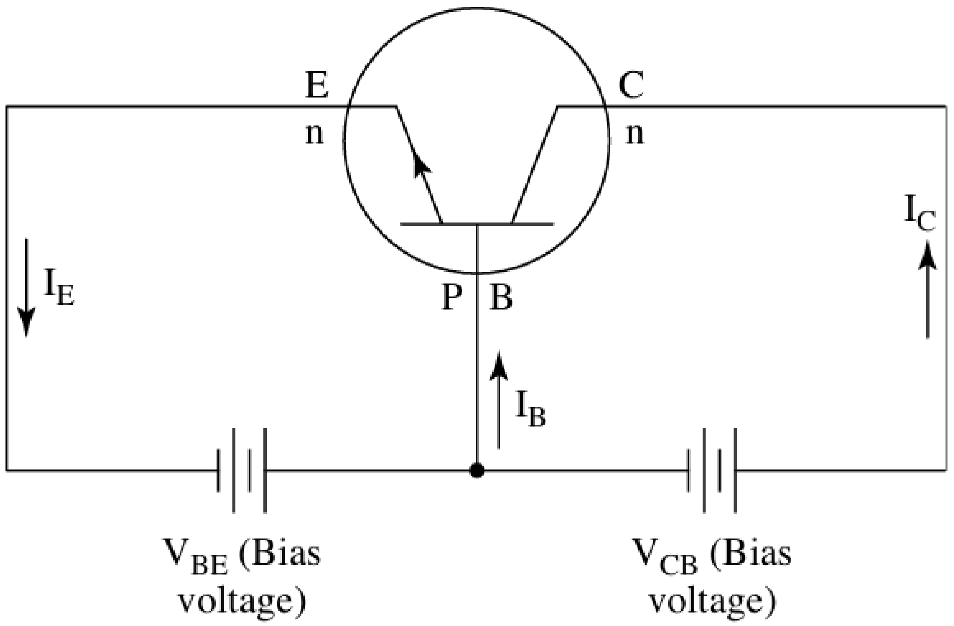
The quantity of charge carriers crossing the emitter to the base is controlled by the base–emitter bias voltage.

The emitter and collector current levels can be controlled by the base–emitter bias voltage.

Note: For a silicon transistor, the minimum bias voltage $V_{BE} = 0.7\,V$ and for a germanium transistor $V_{BE} = 0.3\,V$.

A small variation of V_{BE} (or I_B) can control I_E and I_C.

CURRENT GAIN OF A TRANSISTOR:



As the CB junction is reverse biased, a small reverse saturation current flows across the junction due to minority charge carriers.

If this reverse saturation current is neglected,
$I_E = I_C + I_B$

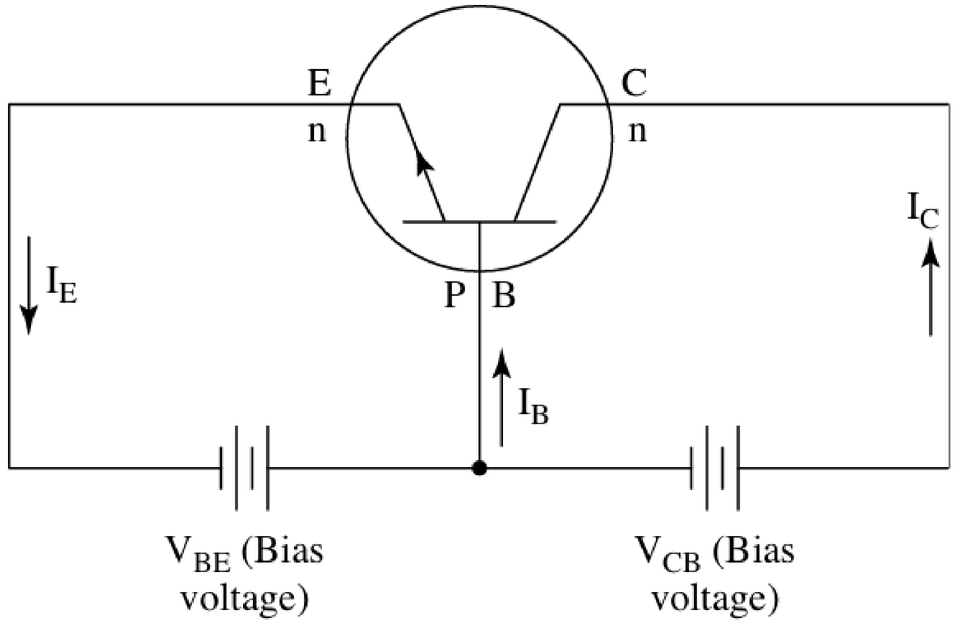
The ratio of the collector current to the emitter current of a transistor is called the emitter to collector current gain α_{dc}.

$$\alpha_{dc} = \frac{I_C}{I_E}$$

$$\therefore I_C = \alpha_{dc} \times I_E$$

The value of α_{dc} is normally 0.95 to 0.99.

CURRENT GAIN OF A TRANSISTOR:



β_{dc} is called the base to collector current gain.

It is the ratio of I_C to I_B.

The value of β_{dc} varies from 25 to over 200.

$$I_E = I_C + I_B \quad \cdots (1)$$

$$I_C = \alpha_{dc}\, I_E \quad \cdots (2)$$

$$\therefore I_C = \alpha_{dc}\,(I_C + I_B) \quad \cdots (3)$$

$$\therefore I_C\,(1 - \alpha_{dc}) = \alpha_{dc} I_B \quad \cdots (4)$$

$$\therefore I_C = \frac{\alpha_{dc}}{1 - \alpha_{dc}} I_B \quad \cdots (5)$$

Or

$$I_C = \beta_{dc} I_B \quad \cdots (6)$$

Where

$$\beta_{dc} = \frac{\alpha_{dc}}{1 - \alpha_{dc}} \quad \cdots (7)$$

EXAMPLE:

An NPN transistor has been provided with proper biasing voltages V_{BE} and V_{CB}. Calculate the values of I_C and I_E if $\alpha_{dc} = 0.96$ and I_B is 80 μA. Also calculate the value of β_{dc}.

Given: $\alpha_{dc} = 0.96$, $I_B = 80\, \mu A = 80 \times 10^{-6}\ A$

$$\beta_{dc} = \frac{\alpha_{dc}}{1 - \alpha_{dc}} = \frac{0.96}{1 - 0.96} = 24$$

$$I_C = \beta_{dc} I_B = 24 \times 80 \times 10^{-6} = 0.00192\, A = 1.92\, mA$$

$$\alpha_{dc} = \frac{I_C}{I_E}$$

$$\therefore I_E = \frac{I_C}{\alpha_{dc}} = \frac{0.00192}{0.96} = 0.002\, A = 2\, mA$$

Thank You