Bipolar Junction Transistor

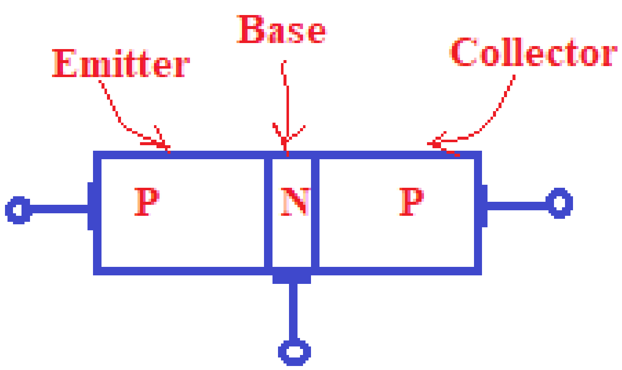
Dipanwita Das
Assistant Professor
Department of Physics

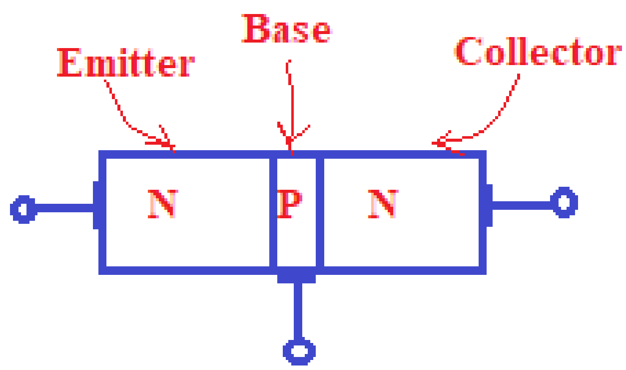
Bipolar because both electrons and holes contributes to the conduction

The device includes two pn junctions

Transistor comes from transfer resistance

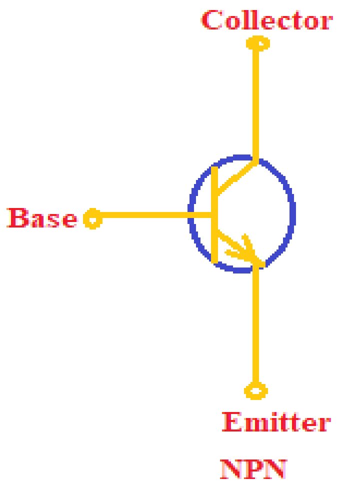
The point contact transistor was invented in 1948 by John Bardeen and Walter Brattain. But these transistors had many limitations.
To overcome some of problems William Shockley proposed the junction form of transistor and was invented in 1951.

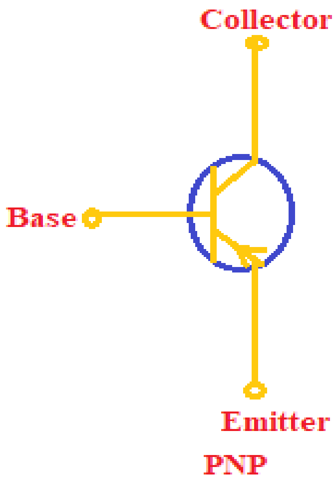


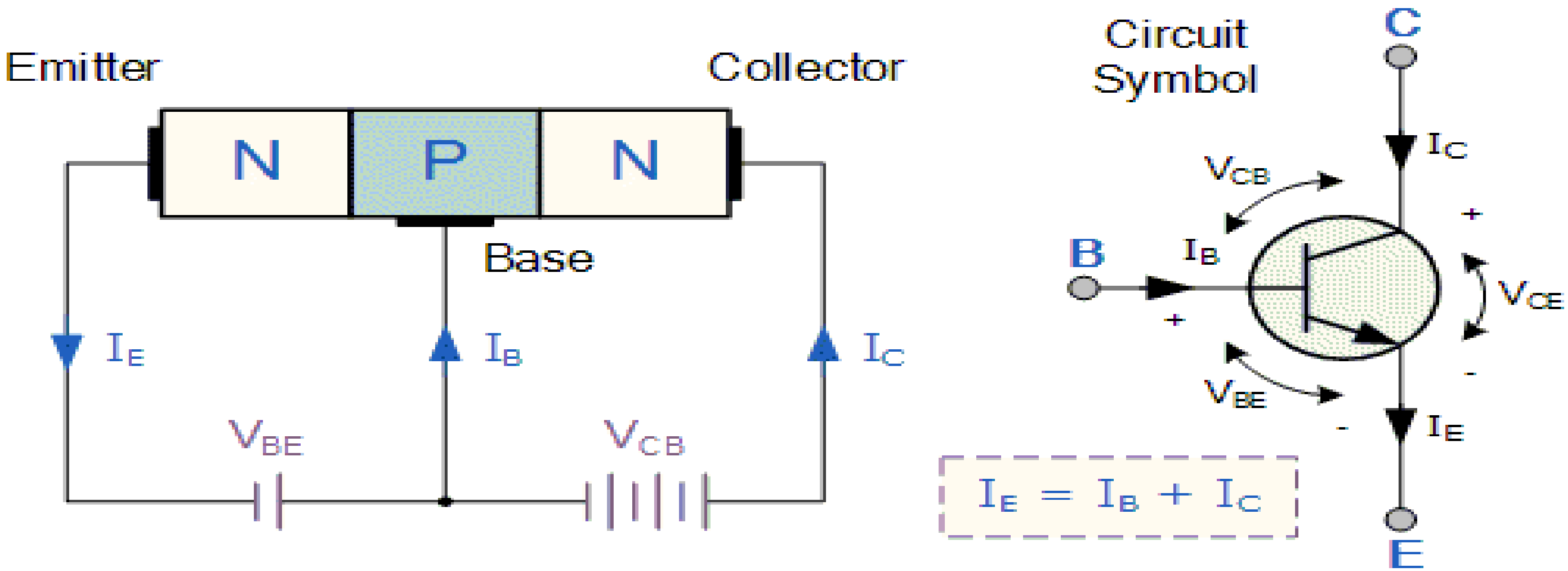


It consists of a silicon or germanium single crystal containing two pn junctions
In beginning, junction transistors were manufactured by the two classical methods
(i)Grown junction
(ii)Alloy junction techniques

For normal operation of a transistor
(i)The emitter -base junction is forward biased so that the junction offers a low resistance to the flow of current
(ii)The collector- base junction is reverse biased so that the junction offers a high resistance to the flow of current







The emitter current I_E is due to

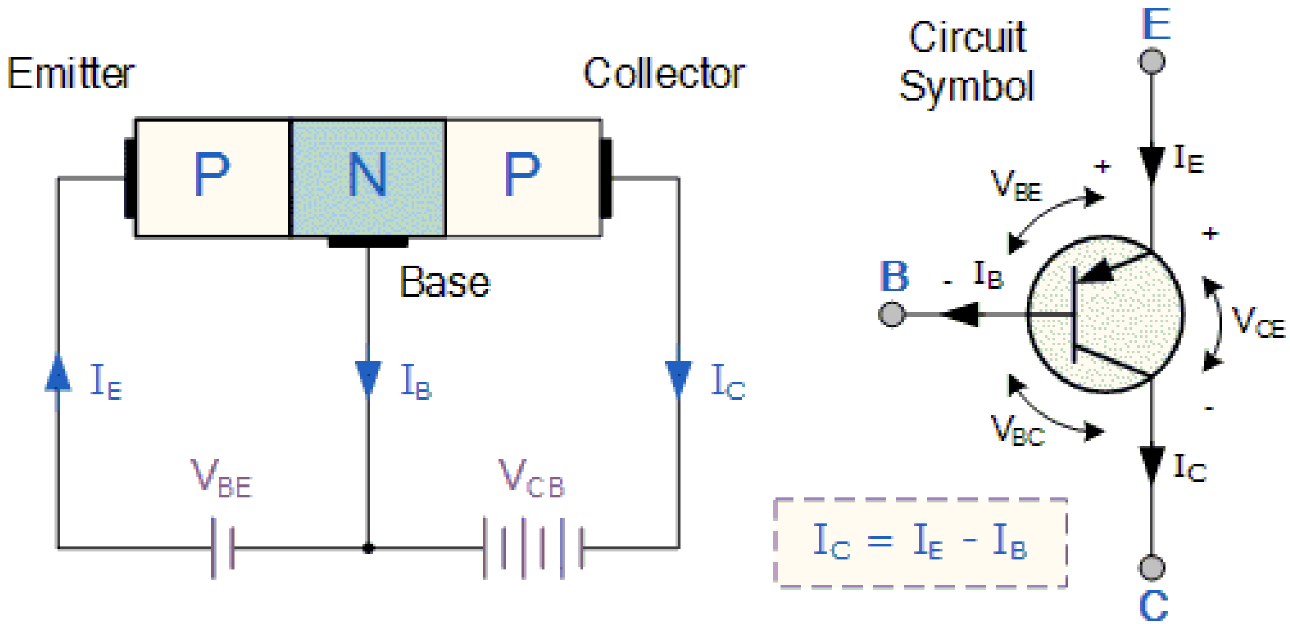
(i)The majority carriers in the emitter flowing from the emitter to the base and

(ii)The majority carriers of the opposite sign in the base flowing from the base to the emitter

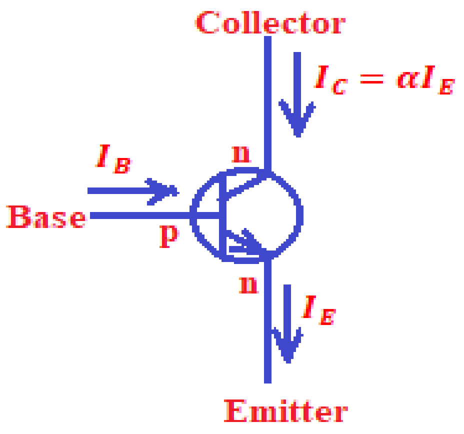
For efficient working of a transistor I_c should be as large a fraction of I_E as possible

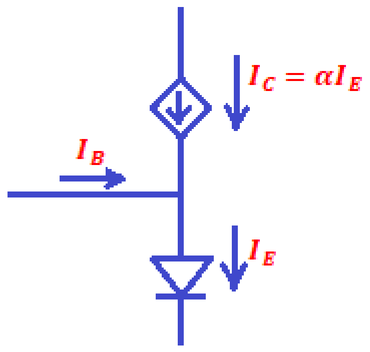
(i)I_E is almost entirely due to the flow of the majority carriers from the emitter region and

(ii)During the flow of majority carriers through the base region their decrease in number due to the recombination process is minimum.


Emitter
Collector
P
N
P
Base
I_E
I_B
I_C
V_{BE}
V_{CB}
Circuit Symbol
E
B
C
V_{BE}
V_{BC}
V_{CE}
I_E
I_B
I_C
+
-
+
-
$I_C = I_E - I_B$

Equivalent circuit of NPN transistor



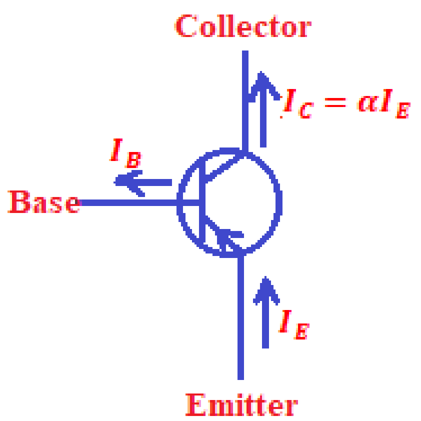


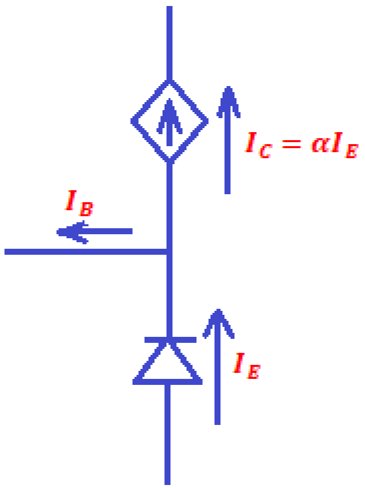
In active region

Emitter-Base junction is forward biased i.e. $V_{BE} > 0$ i.e. $V_B - V_E > 0$

Collector-Base junction is reverse biased i.e. $V_{BC} < 0$ i.e. $V_B - V_C < 0$

Equivalent circuit of PNP transistor





In active region

Emitter-Base junction is forward biased i.e. $V_{EB} > 0$ i.e. $V_E - V_B > 0$

Collector-Base junction is reverse biased i.e. $V_{CB} < 0$ i.e. $V_C - V_B < 0$

Since the Base-Emitter junction is forward biased, the voltage is typically 0.6 to 0.75 V

The Base -Collector junction is reverse biased and the reverse biase voltage can be several volts to hundred of volts

$$I_C = \alpha I_E$$

Where α has value very nearly to 1

$$\begin{aligned} I_E &= I_B + I_C \\ I_B &= I_E - I_C \\ &= I_E - \alpha I_E \\ &= I_E(1-\alpha) \end{aligned}$$

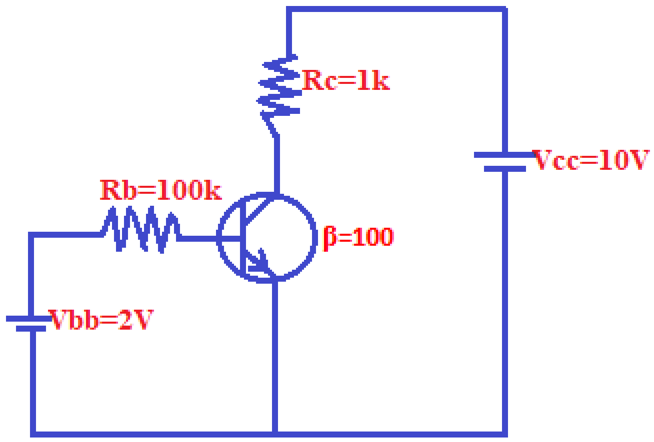
The current gain of the transistor, $\beta = \frac{I_C}{I_B}$

$$= \frac{\alpha I_E}{I_E(1-\alpha)} = \frac{\alpha}{1-\alpha}$$

β is a function of I_C and temperature

Usually transistors are designed to have high value of β of the order of 100 to 250

If β is large $I_B \ll I_C$ i.e. the transistor is operating in active region.



Is the transistor operating in active region?