Transistor
Lecture 6

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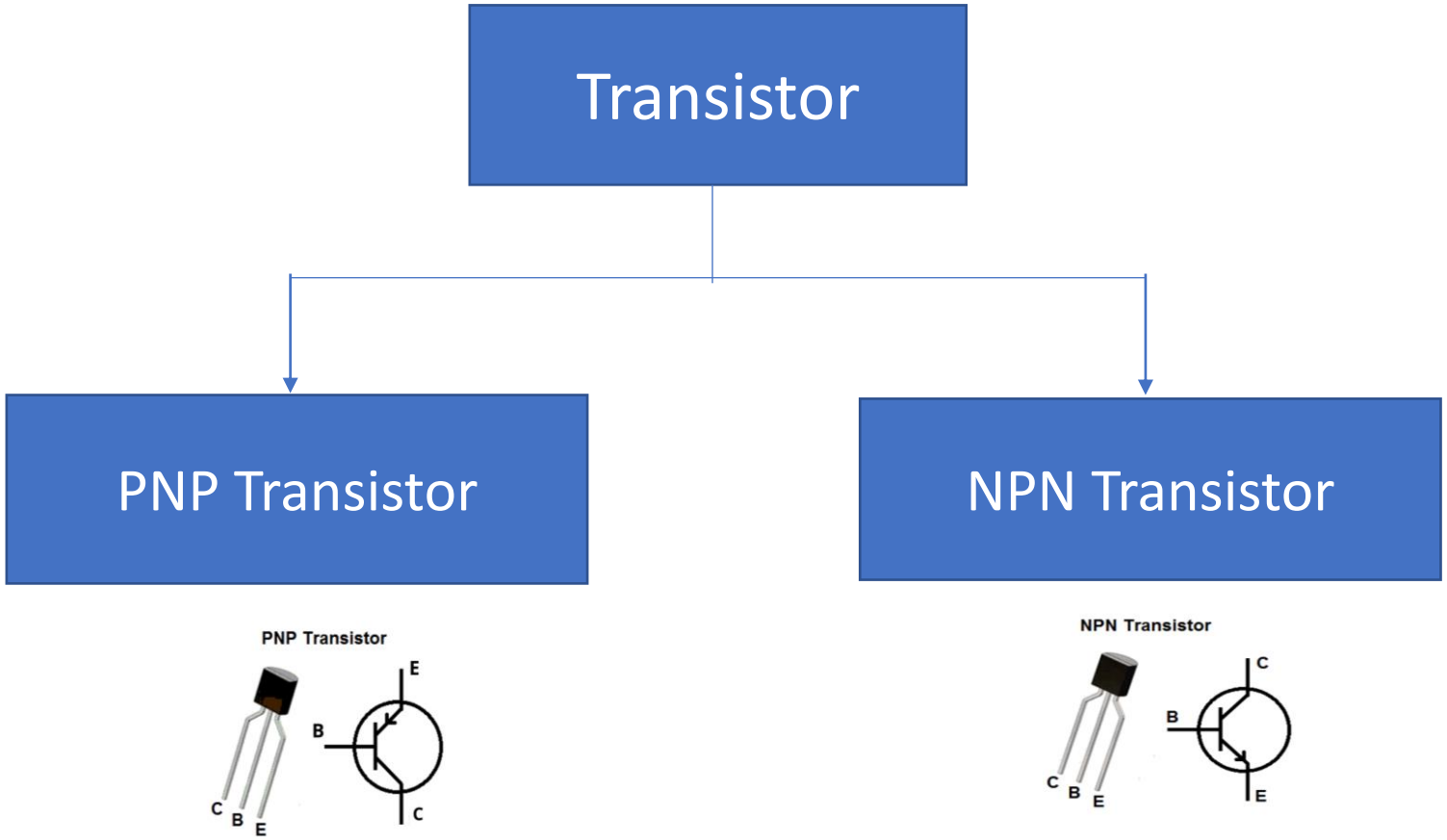
Definition of Transistor :

Transistor is a three electrode device capable of amplification in addition of rectification. It is the basic building block in modern electronics



A junction transistor is made up of a semiconductor such as Ge or Si in which a P$-type$ thin layer is sandwiched between two $N-type$ layers. The transistor so formed is called $N-P-N$ transistor. Alternately a transistor can also have an $N-type$ layer between two $P-type$ layers. The transistor is then termed a $P-N-P$ transistor. $P-N-P$ and $N-P-N$ transistor are systematically shown in $Fig\ 1\ and\ Fig\ 2$. The middle portion of the transistor is called the $\boldsymbol{Base}$ and the two end portions are known as $\boldsymbol{Emitter}$ and $\boldsymbol{Collector}$. The emitter-base junction is usually referred as emitter junction $\boldsymbol{J_E}$ and the collector-base junction as the collector junction $\boldsymbol{J_C}$. The size of the transistor is quite small.

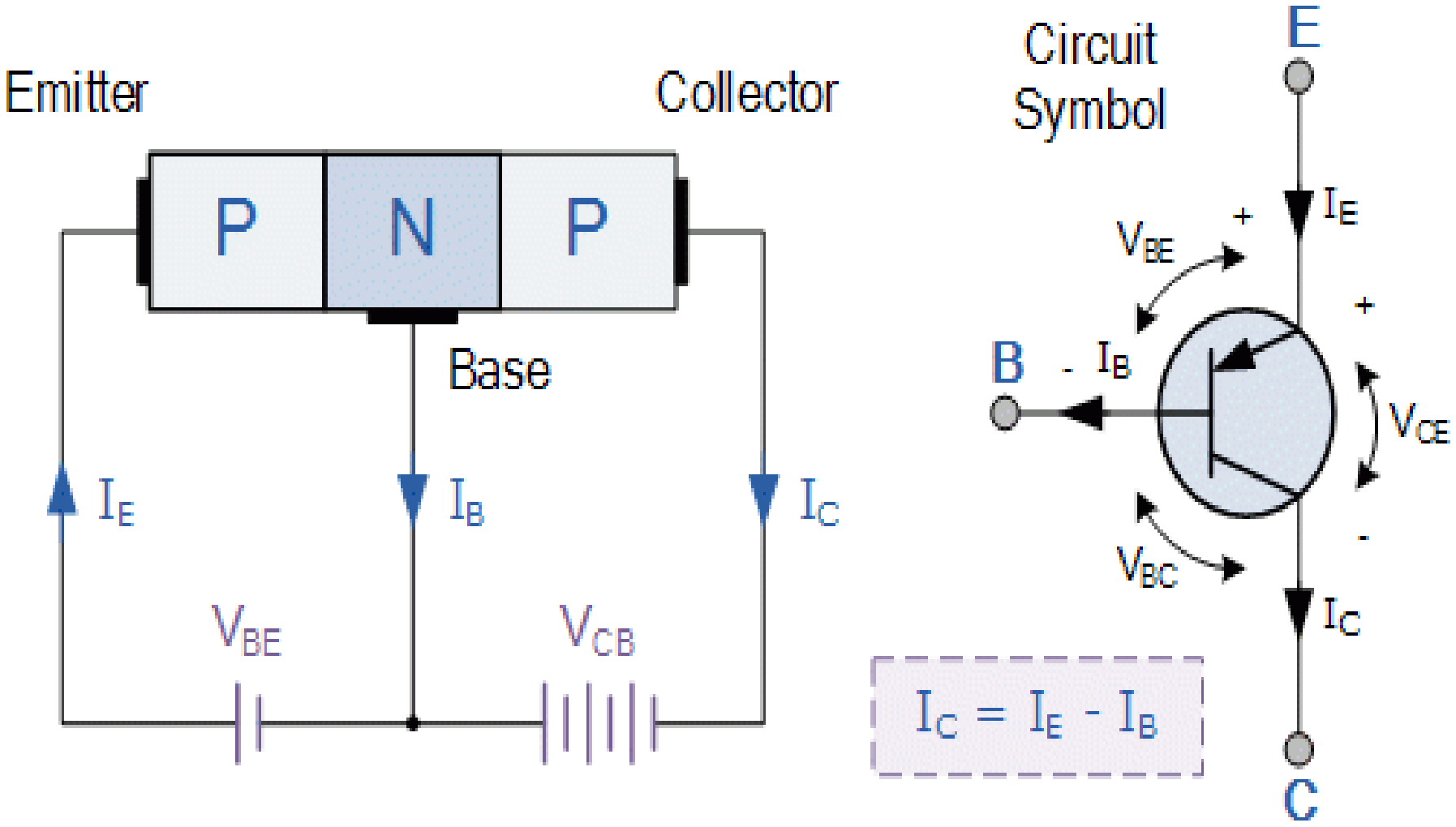

Emitter
Collector
P
N
P
Base
I_E
I_B
I_C
V_{BE}
V_{CB}
Circuit Symbol
E
B
C
I_E
I_B
I_C
V_{BE}
V_{BC}
V_{CE}
+
-
+
-
$I_C = I_E - I_B$

Fig 1

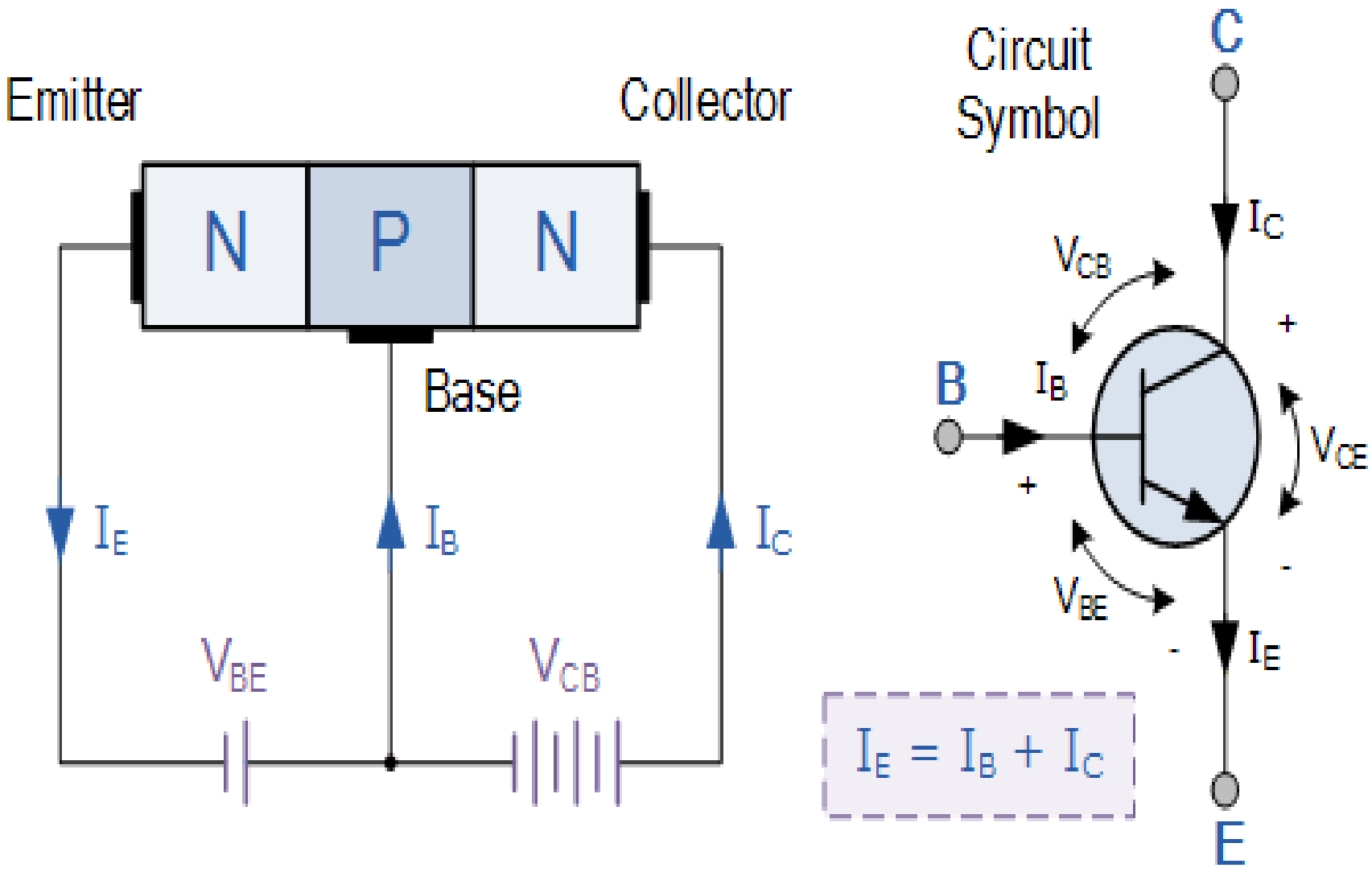

Emitter
Collector
N
P
N
Base
I_E
I_B
I_C
V_{BE}
V_{CB}
Circuit Symbol
C
B
E
I_C
I_B
I_E
V_{CB}
V_{BE}
V_{CE}
+
+
-
-
$I_E = I_B + I_C$

Fig 2

The structure is sealed inside a metal or plastic case to protect it from moisture. Metal leads $E, B\ and\ C$ come out of the package for connection to the $emitter$, the $base$ and the $collector$ respectively. Since both the majority and minority carriers are involved in a junction transistor the device is termed as *bipolar junction transistor(BJT) , bipolar transistor or bipolar device*.

In the normal transistor operation $emitter - base$ junction is forward biased and the $collector - base$ junction is reversed biased. The current enters the transistor through the emitter terminal for a $P - N - P$ transistor. On the other hand current leaves the transistor through the for an $N - P - N$ transistor.

In both case the $emitter, base\ and\ collector$ currents $I_E, I_B\ and\ I_C$ respectively are taken positive when the currents go into the transistor. The symbols $V_{EB}, V_{CB}\ and\ V_{CE}$ represent respectively the $emitter - base, collector - base$ and $collector - emitter$ voltages.

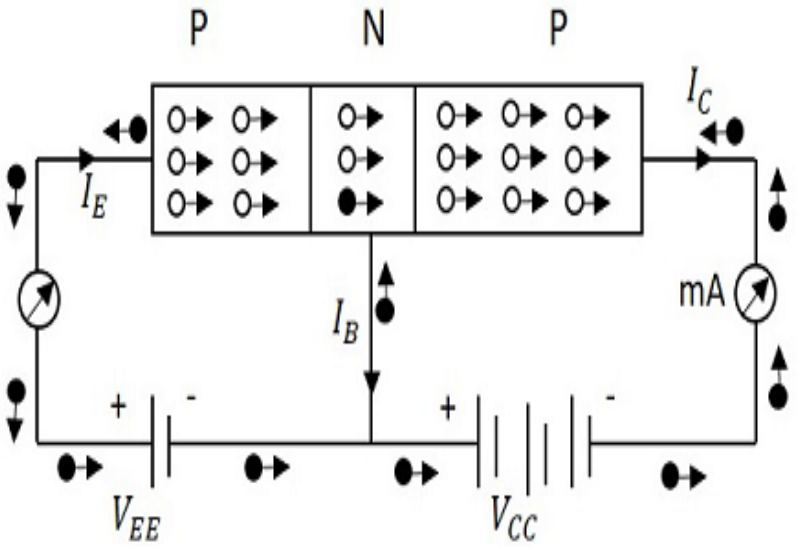


Fig 3

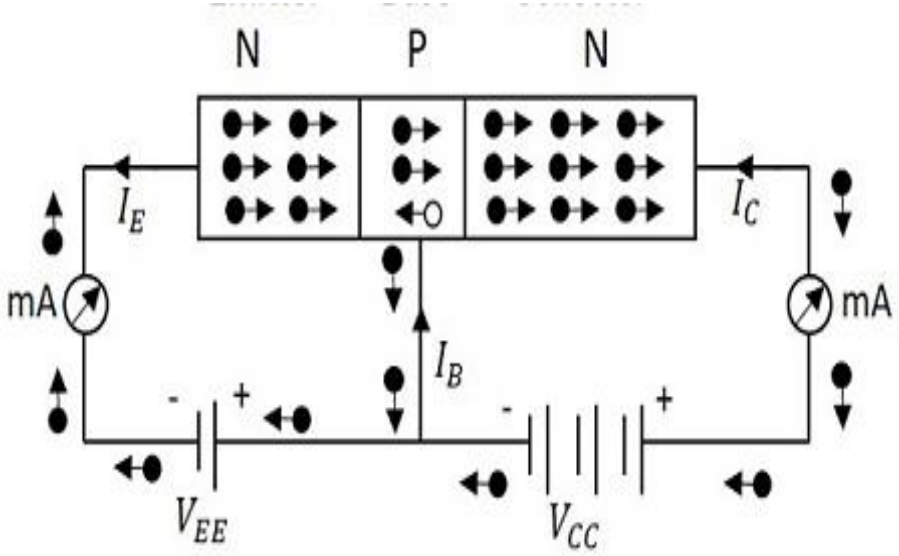


Fig 4

Three points are important for $P-N-P$ transistor

a)The conduction in $P-N-P$ transistor takes place through holes.

b)The collector current is slightly less than the emitter current

c)The increase or decrease in $emitter\ current$ affects the $collector\ current$.

Similarly the operation of $N-P-N$ transistor can be explained by $Fig\ 4$, in which $emitter-base$ junction forward biased and $collector-base$ junction is revered biased. The V_{EE} provides negative potential at the emitter which repels the electrons in the $N-type$ material and these electrons cross the emitter-base junction to reach the base region. This flow slowly increases and the electron current flows through the transistor.

The points are important for $N-P-N$ transistor

The conduction in a $N-P-N$ transistor takes place through electrons.

The collector current is higher than the emitter current.

The increase or decrease in the emitter current affects the collector current.

The amplification factor $\alpha\ and\ \beta$ may be defined as

$$\alpha = \left(\frac{\partial I_C}{\partial I_E}\right) \rightarrow (i), when\ V_{CB}\ \ is\ constant$$

$$\beta = \left(\frac{\partial I_C}{\partial I_B}\right) \rightarrow (ii), when\ V_{CE}\ is\ constant$$

By definition $\Delta I_C = \alpha . \Delta I_E$

The magnitude of emitter current is equal to sum of collector and base current. Thus

$$|\Delta I_E| = |\Delta I_C| + |\Delta I_B| = |\alpha I_E| + |\Delta I_B|$$

$$\Longrightarrow \Delta I_B = \Delta I_E(1-\alpha)$$

$$\Longrightarrow \frac{\Delta I_B}{\Delta I_C} = \frac{\Delta I_E}{\Delta I_C}(1-\alpha)$$

$$\Longrightarrow \frac{1}{\beta} = \frac{1}{\alpha}(1-\alpha)$$

$$\Longrightarrow \beta = \frac{\alpha}{1-\alpha} \rightarrow (iii)$$