University of Calcutta
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PHYSICS
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BIPOLAR JUNCTION TRANSISTOR

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WHAT DO YOU MEAN BY THE *BIPOLAR JUNCTION TRANSISTOR (BJT)*

p-n-p and *n-p-n* transistors are schematically shown in Fig. 7.1. The middle portion of the transistor is called the *base*, and the two end portions are known as the *emitter* and the *collector*. The emitter-base junction is usually referred to as the *emitter junction* (J_E), and the collector-base junction as the *collector junction* (J_C). The size of the transistor is quite small. The structure is sealed inside a metal or a 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 the minority carriers are involved in junction transistors, these devices are termed *bipolar junction transistor* (BJT), *bipolar transistors* or *bipolar devices*.

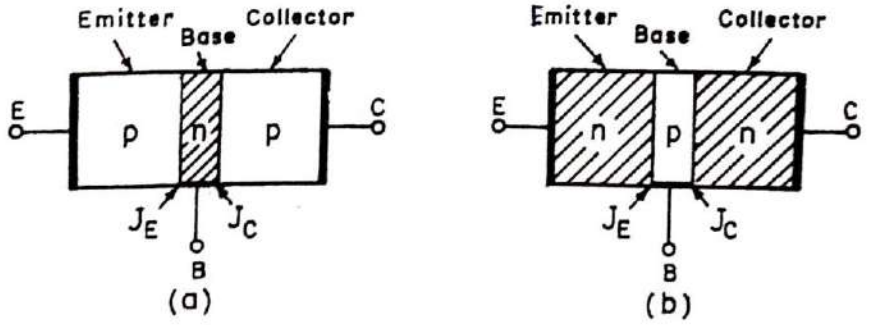
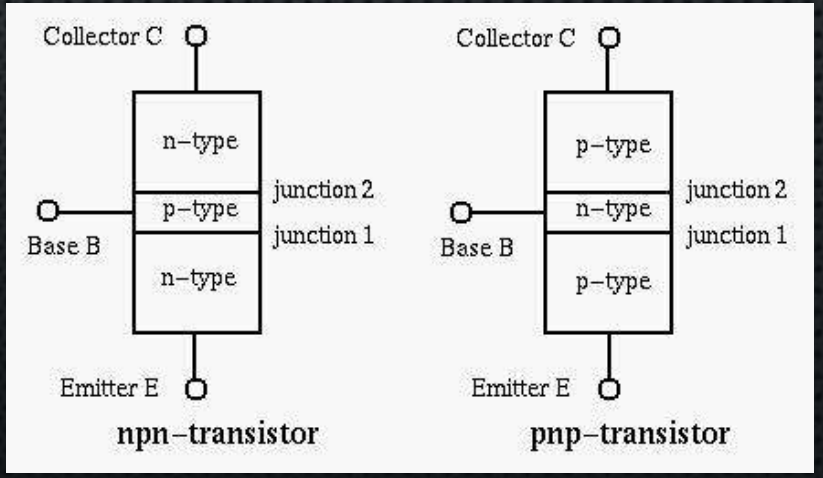


Fig. 7.1 Bipolar junction transistors (a) *p-n-p*, (b) *n-p-n*

A bipolar transistor is a semiconductor device commonly used for amplification. The device can amplify analog or digital signals. It can also switch DC or function as an oscillator. Physically, a bipolar transistor amplifies current, but it can be connected in circuits designed to amplify voltage or power.



HOW YOU WILL CONSTRUCT??

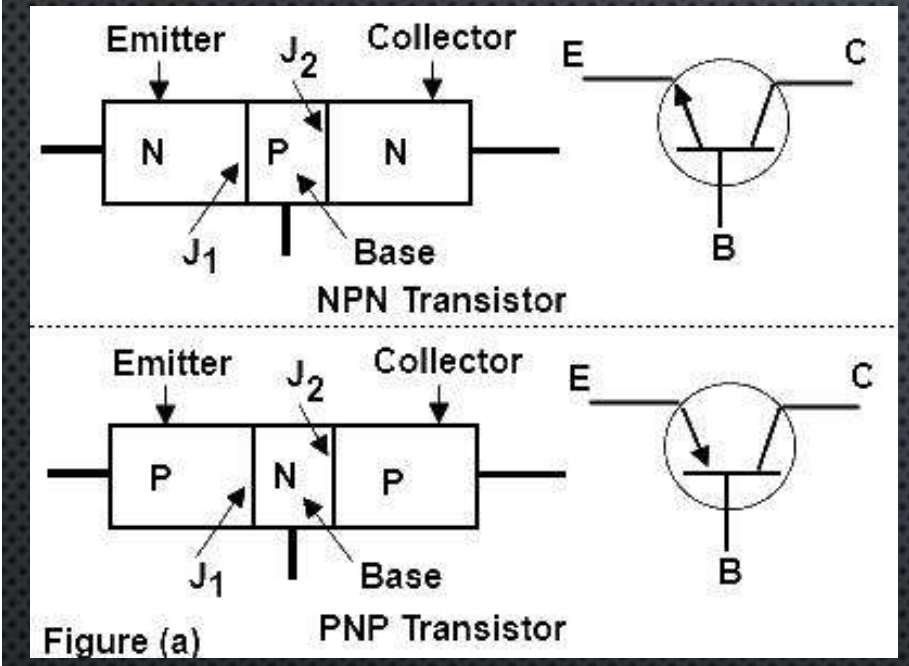
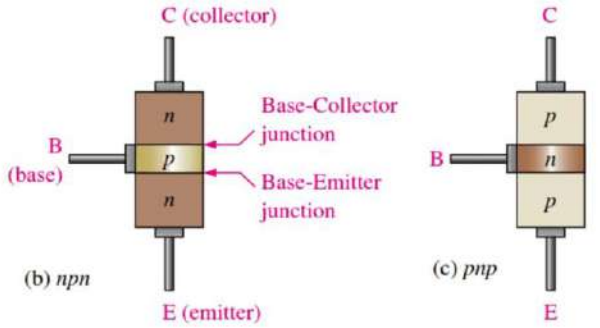


Figure (a)

The three regions are called emitter, base, and collector. Physical representations of the two types of BJTs are shown in Figure (b) and (c). One type consists of two n regions separated by a p region (npn), and the other type consists of two p regions separated by an n region (pnp). The term bipolar refers to the use of both holes and electrons as current carriers in the transistor structure.

The pn junction joining the base region and the emitter region is called the base-emitter junction. The pn junction joining the base region and the collector region is called the base-collector junction, as indicated in Above Figure (b). A wire lead connects to each of the three regions, as shown. These leads are labeled E, B, and C for emitter, base, and collector, respectively.



https://youtu.be/TJcQ5MovoR4

WHY BASE REGION IS LIGHTLY DOPED THAN EMIITER AND COLLECTOR??

The base region is lightly doped and very thin compared to the heavily doped emitter and the moderately doped collector regions.

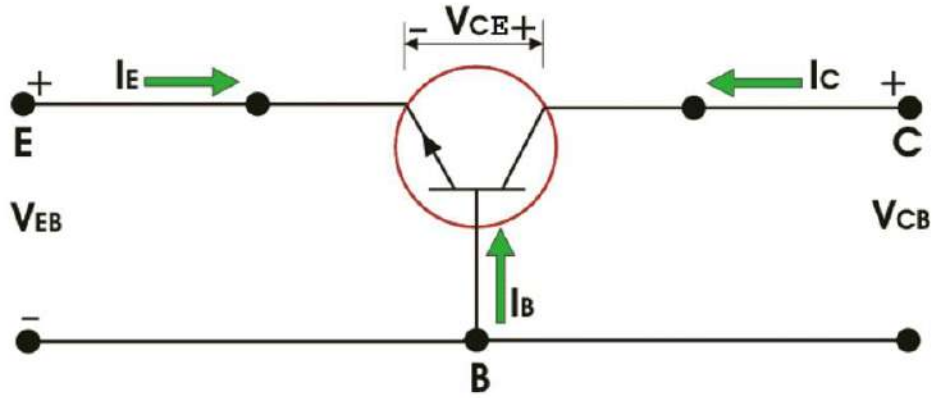
The base region is meant for “only the control” of the strong flow of charge carriers from the Emitter towards the Collector. It is not supposed to absorb/emit any carriers on its own ideally. That can be done by making the base extremely thin to see that the carriers won’t get enough time to recombine and also won’t get a chance to recombine, weakening the flow.

CURRENT COMPONENTS OF BJT

https://youtu.be/dTx9VKV0hjo

N-P-N Bipolar Junction Transistor

As started before in **n-p-n bipolar transistor** one p-type semiconductor resides between two n-type semiconductors the diagram below a n-p-n transistor is shown

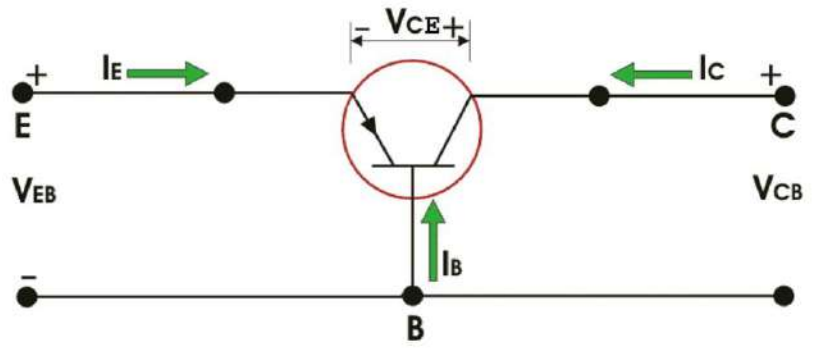


Now I_E, I_C is emitter current and collect current respectively and V_{EB} and V_{CB} are emitter base voltage and collector base voltage respectively. According to convention if for the emitter, base and collector current I_E, I_B and I_C current goes into the transistor the sign of the current is taken as positive and if current goes out from the transistor then the sign is taken as negative. We can tabulate the different currents and voltages inside the n-p-n transistor.

Transistor type	I_E	I_B	I_C	V_{EB}	V_{CB}	V_{CE}
n-p-n	–	+	+	–	+	+

P-N-P Bipolar Junction Transistor

Similarly for **p-n-p bipolar junction transistor** a n-type semiconductors is sandwiched between two p-type semiconductors. The diagram of a p-n-p transistor is shown below



For p-n-p transistors, current enters into the transistor through the emitter terminal. Like any bipolar junction transistor, the emitter-base junction is forward biased and the collector-base junction is reverse biased. We can tabulate the emitter, base and collector current, as well as the emitter base, collector base and collector emitter voltage for p-n-p transistors also.

Transistor type	I_E	I_B	I_C	V_{EB}	V_{CB}	V_{CE}
p – n – p	+	–	–	+	–	–

CURRENT DIRECTIONS AND VOLTAGE POLARITIES

In the normal transistor operation, emitter-base junction is forward-biased and the collector-base junction is reverse-biased. The circuit symbols for the *p-n-p* and *n-p-n* transistors are shown in Fig. 7.2(a) and (b), respectively. The arrow on the emitter specifies the direction of the current when the emitter-base junction is forward-biased. Therefore, the current *enters* the transistor through the emitter terminal for a *p-n-p* transistor and *leaves* the transistor through the emitter terminal for an *n-p-n* transistor. In both the cases, 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. These are assumed positive when the terminal marked by the first subscript is positive with respect to the terminal marked by the second subscript. These chosen reference current directions and voltage polarities are depicted in Fig 7.2.

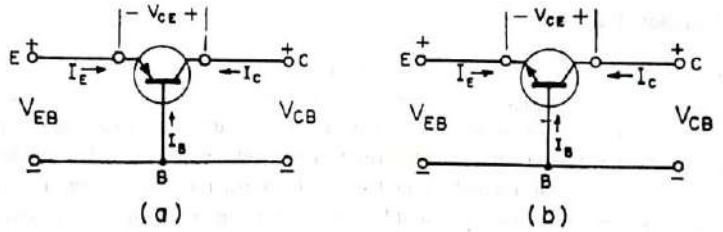


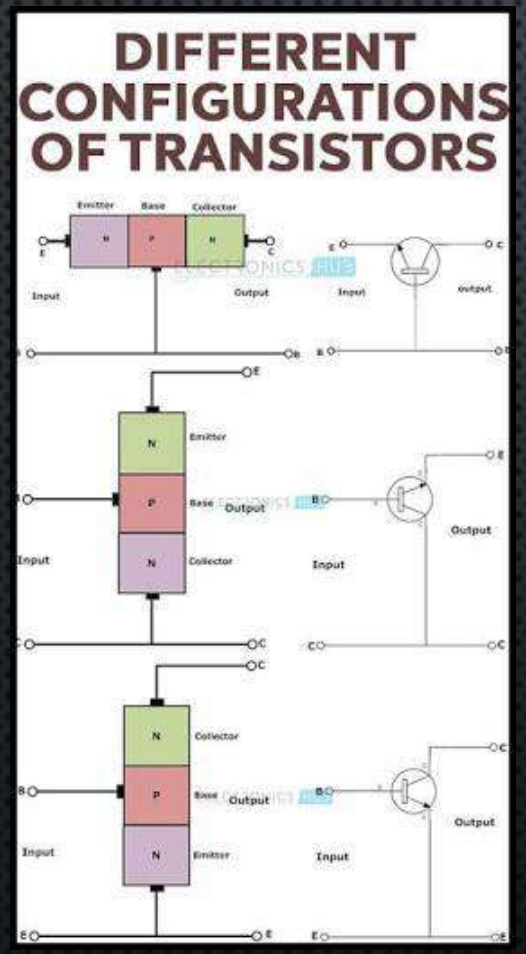
Fig. 7.2 Circuit symbols with reference current directions and voltage polarities for (a) a *p-n-p* and (b) an *n-p-n* transistor.

As the emitter junction is usually forward-biased, I_E is negative in the case of an *n-p-n* transistor and positive for a *p-n-p* transistor. Since the collector junction is reverse-biased, the voltage V_{CB} is negative for a *p-n-p* transistor and positive for an *n-p-n* transistor. Table 7.1 contains the signs of the different voltages and currents for the *p-n-p* and the *n-p-n* transistors. Note that the signs are opposite for the two types of transistors.

Table 7.1. Signs of currents and voltages for normal transistor operation

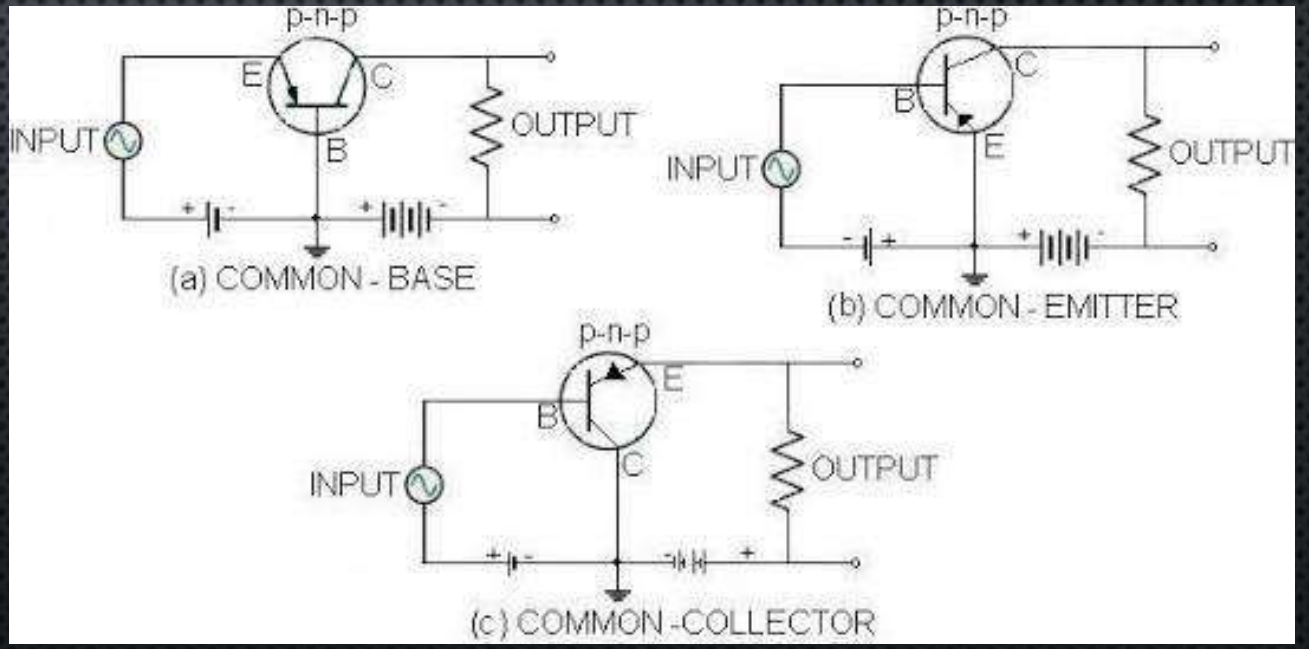
transistor type	I_E	I_B	I_C	V_{EB}	V_{CB}	V_{CE}
p-n-p	+	−	−	+	−	−
n-p-n	−	+	+	−	+	+

DIFFERENT CONFIGURATION OF TRANSISTOR



A Transistor has 3 terminals, the emitter, the base and the collector. Using these 3 terminals the transistor can be connected in a circuit with one terminal common to both input and output in a 3 different possible configurations.

The three types of configurations are **Common Base, Common Emitter** and **Common Collector** configurations. In every configuration, the emitter junction is forward biased and the collector junction is reverse biased.



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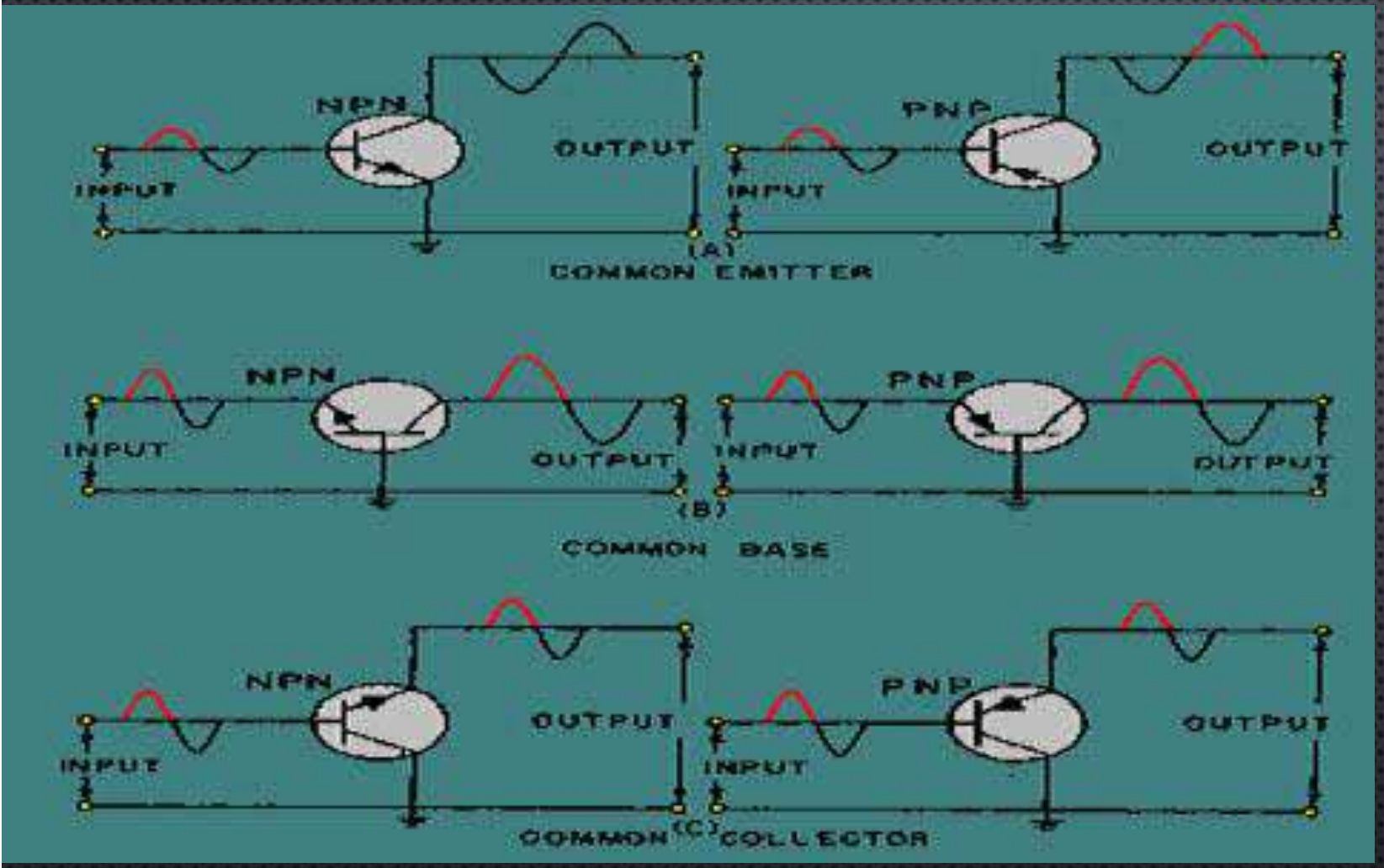

Ref: electronics-notes.com

TRANSISTOR CONFIGURATION SUMMARY TABLE

TRANSISTOR CONFIGURATION	COMMON BASE	COMMON COLLECTOR (EMITTER FOLLOWER)	COMMON EMITTER
Voltage gain	High	Low	Medium
Current gain	Low	High	Medium
Power gain	Low	Medium	High
Input / output phase relationship	0°	0°	180°
Input resistance	Low	High	Medium
Output resistance	High	Low	Medium

Assignments

2. (a) Indicate the reference current directions and voltage polarities of a transistor. Give the signs of the actual current directions and voltage polarities for an *n-p-n* and a *p-n-p* transistor operating normally.

   (b) Whey are junction transistors called bipolar devices?

   (c) Why is the emitter region of a transistor more heavily doped than the base region?

4. Show the doping profile in the emitter, base, and collector regions of a transistor. Why is the width of the base region very thin?

7. *Discuss how a transistor can be used as a current amplifier.*

(C.U. 1993)

Acknowledgement

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rgcetpdy.ac.in

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