TRANSISTOR

TRANSISTOR STRUCTURE

BJT is bipolar because both holes (+) and electrons (-) will take part in the current flow through the device

– N-type regions contains free electrons (negative carriers)

– P-type regions contains free holes (positive carriers)

• 2 types of BJT

– NPN transistor

– PNP transistor

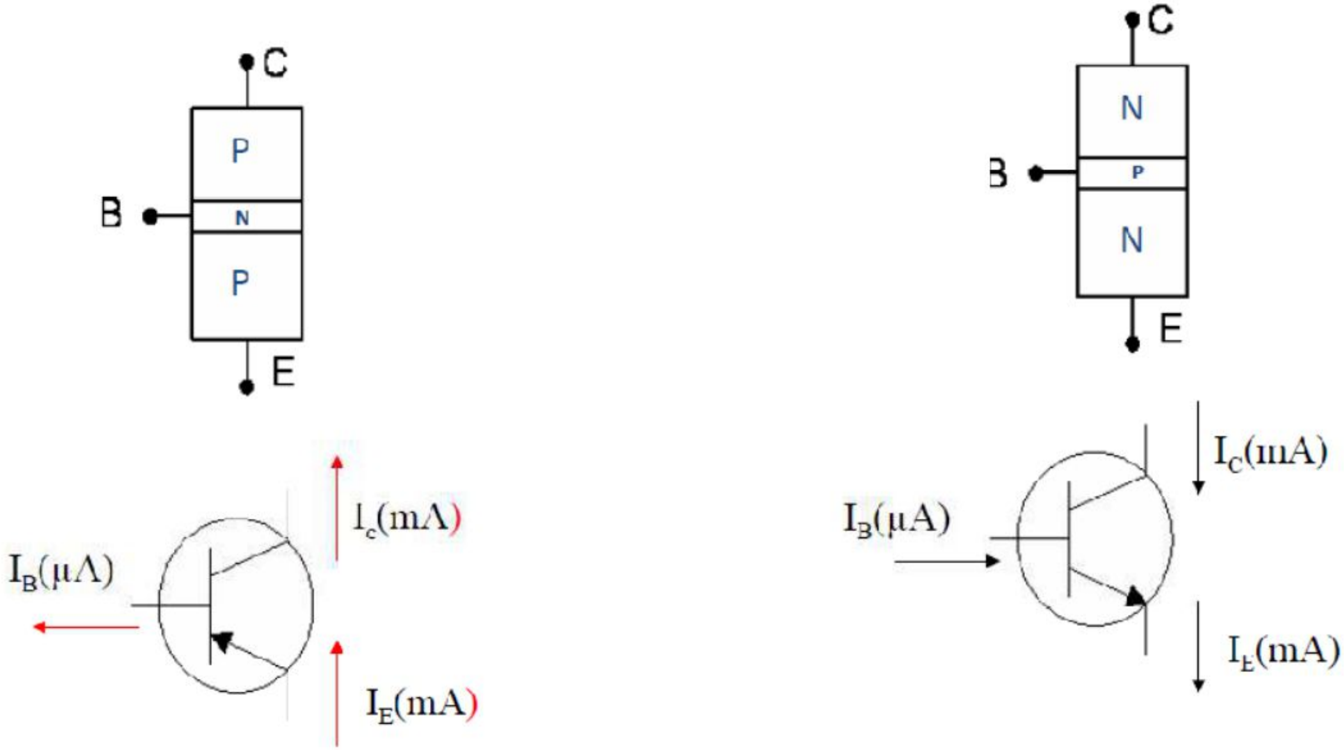
• The transistor regions are:

– Emitter (E) – send the carriers into the base region and then on to the collector

– Base (B) – acts as control region. It can allow none,some or many carriers to flow

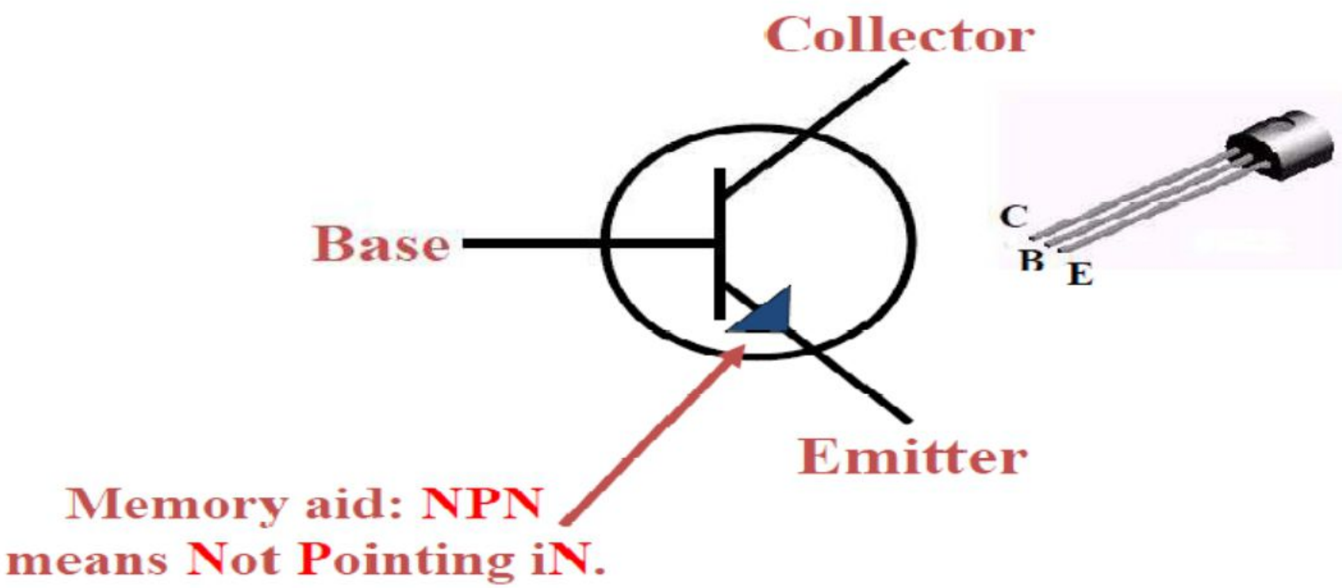
– Collector (C) – collects the carriers

PNP AND NPN TRANSISTOR STRUCTURE

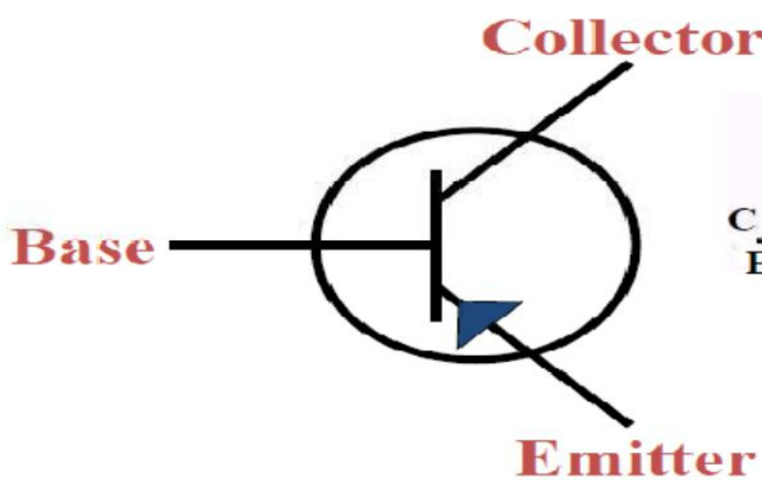


Arrow shows the current flows

NPN Schematic Symbol



PNP Schematic Symbol

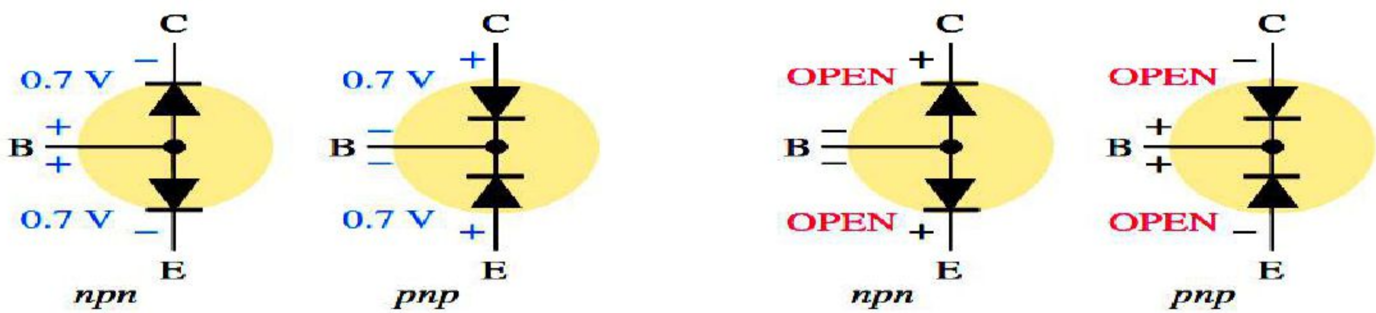


Memory aid: NPN
means Pointing iN Properly.

Testing of Transistor

- A digital Multimeter can be used as a fast and simple way to check a transistor for open or shorted junctions. For this test, you can view the transistor as two diodes connected as shown in Below Figure for both npn and pnp transistors. The base-collector junction is one diode and the base-emitter junction is the other.

Examples of faults and symptoms in the basic transistor bias circuit.



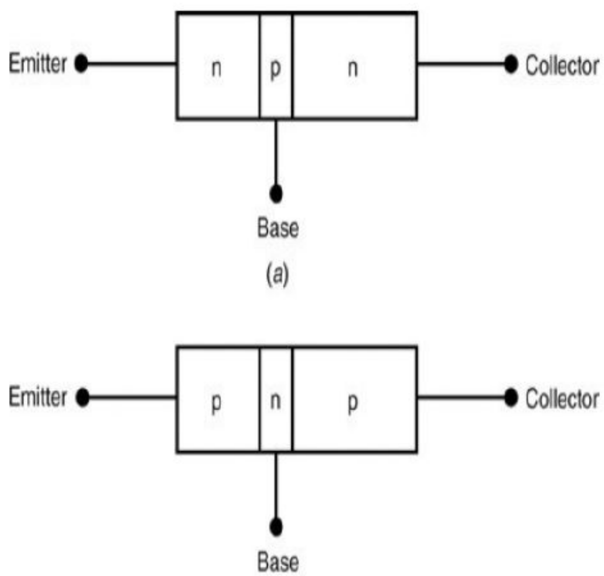
(a) Both junctions should typically read 0.7 V when forward-biased.

(b) Both junctions should ideally read OPEN when reverse-biased.

- A good diode will show an extremely high resistance (or open) with reverse bias and a very low resistance with forward bias. A defective open diode will show an extremely high resistance (or open) for both forward and reverse bias. A defective shorted or resistive diode will show zero or a very low resistance for both forward and reverse bias. An open diode is the most common type of failure. Since the transistor pn junctions are, in effect diodes, the same basic characteristics apply.
- Many digital Multimeter (DMMs) have a diode test position that provides a convenient way to test a transistor. A typical DMM, as shown in Below Figure, has a small diode symbol to mark the position of the function switch. When set to diode test, the meter provides an internal voltage sufficient to forward-bias and reverse-bias a transistor junction.

TRANSISTOR CONSTRUCTION

- A transistor has three doped regions.
- For both types, the base is a narrow region sandwiched between the larger collector and emitter regions.



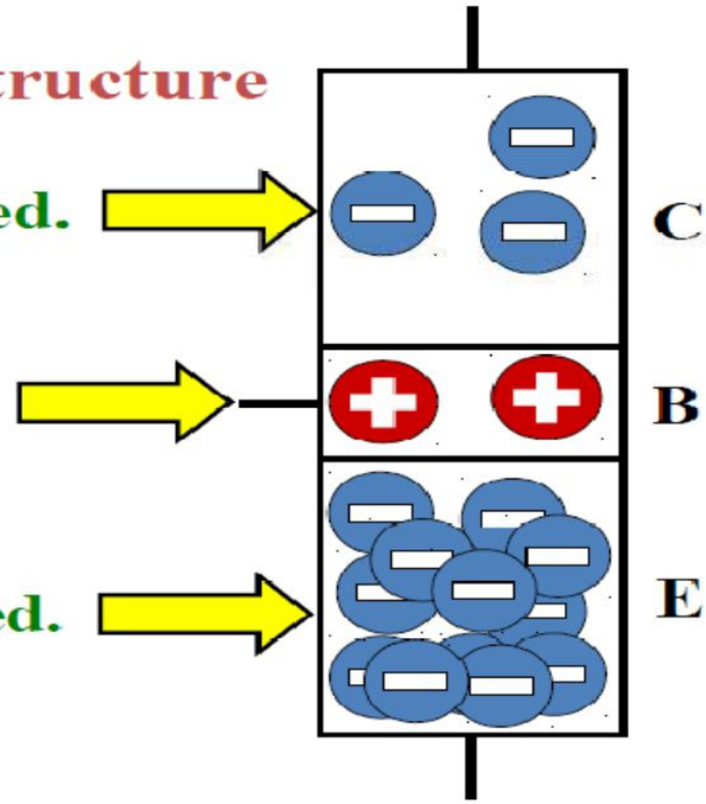
- The **emitter region is heavily doped** and its job is to emit carriers into the base.
- The **base region is very thin and lightly doped.**
- Most of the current carriers injected into the base pass on to the collector.
- The **collector region is moderately doped** and is the largest of all three regions.

NPN Transistor Structure

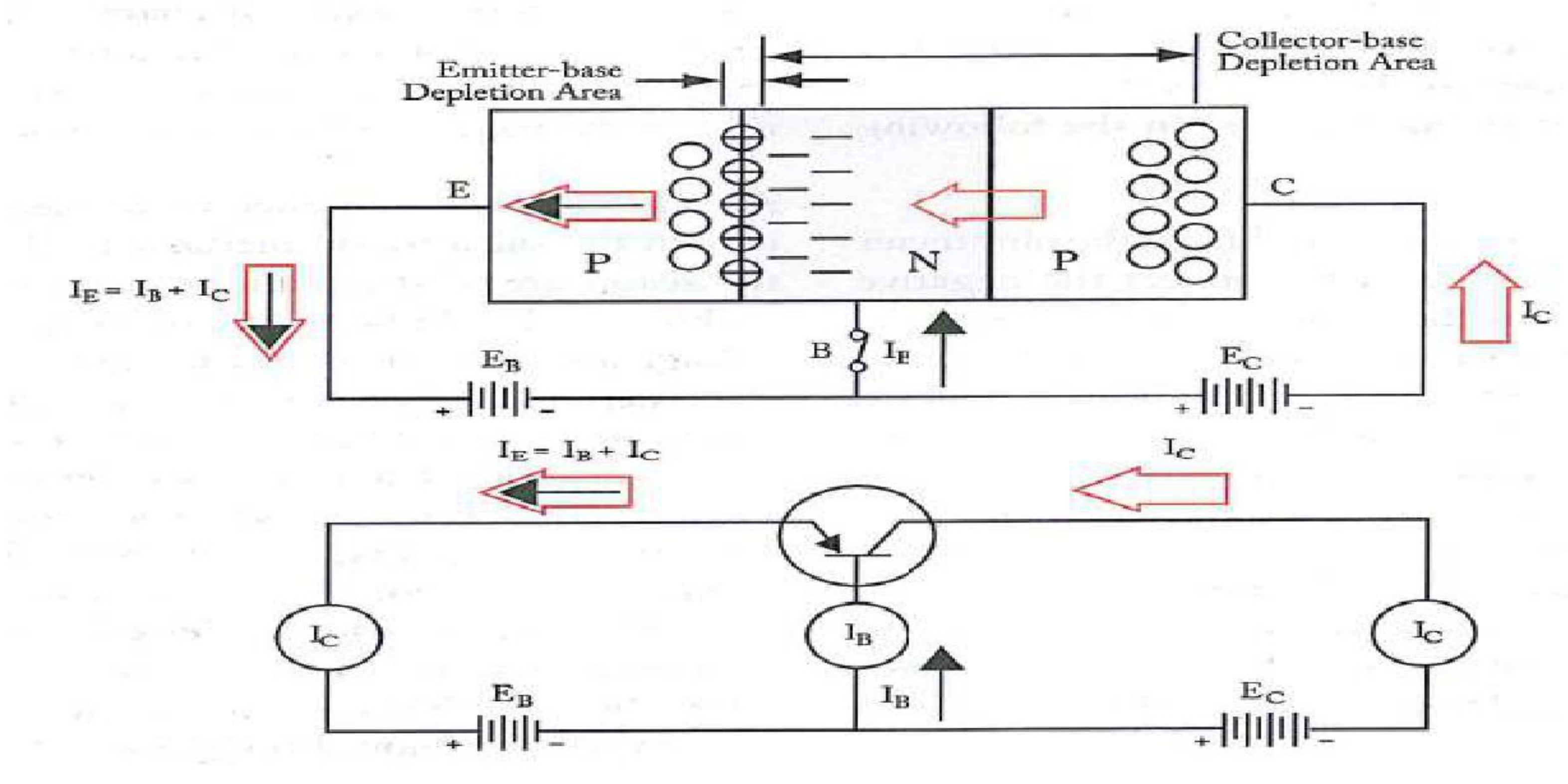
The collector is lightly doped.

The base is thin and is lightly doped.

The emitter is heavily doped.



TRANSISTOR OPERATION



TRANSISTOR CONFIGURATION

- Transistor configuration –is a connection of transistor to get variety operation.
- 3 types of configuration:
  – *Common Collector*.
  – *Common Base*.
  – *Common Emitter*

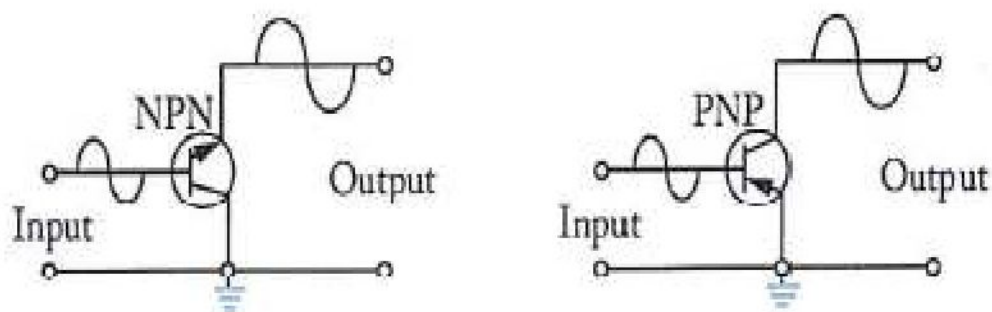
COMMON-COLLECTOR CONFIGURATION

- The input signal is applied to the base terminal and the output is taken from the emitter terminal.

• Collector terminal is common to the input and output of the circuit

Input – BC

Output – EC



Common-collector

- CC Configuration used for **impedance matching.**
- **High current gain** and very useful in switching circuit.
- **Input resistance is high while output resistance resistance is low**.
- Current gain is higher than that in the common emitter but lower power gain than CE or CB configuration.
- CC is typically referred to as an **emitter-follower** because the output developed on the emitter follows the input signal that is applied to the base.

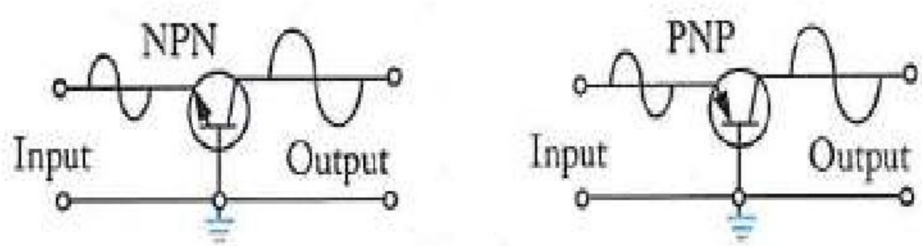
COMMON-BASE CONFIGURATION

Base terminal is a common point for input and output.

• Input – EB

• Output – CB

• Not applicable as an amplifier because the relation between input current gain (IE) and output current gain (IC) is approximately 1

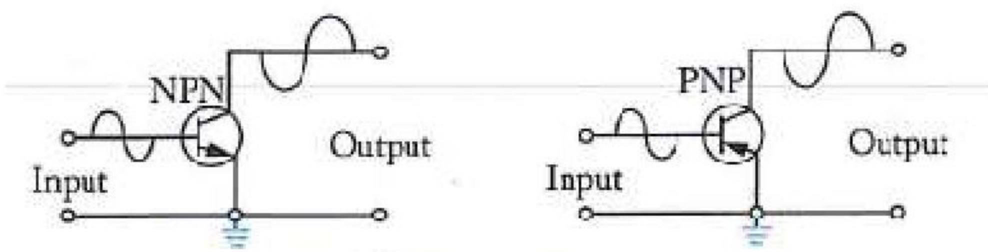


Common-base

- **Impedance matching** because it has **a low input impedance and high output resistance**.
- **Low input resistance** and its lack of current which is always below 1.
- Applicable for **voltage amplification**, such as microphone amplifiers.

COMMON-EMITTER CONFIGURATION

- Emitter terminal is common for input and output circuit
- Input – BE
- Output – CE
- Mostly applied in practical amplifier circuits, since it provides good voltage, current and power gain

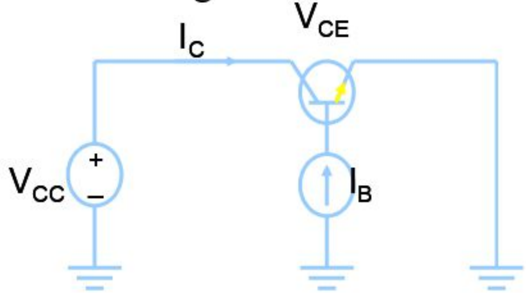


Common-emitter

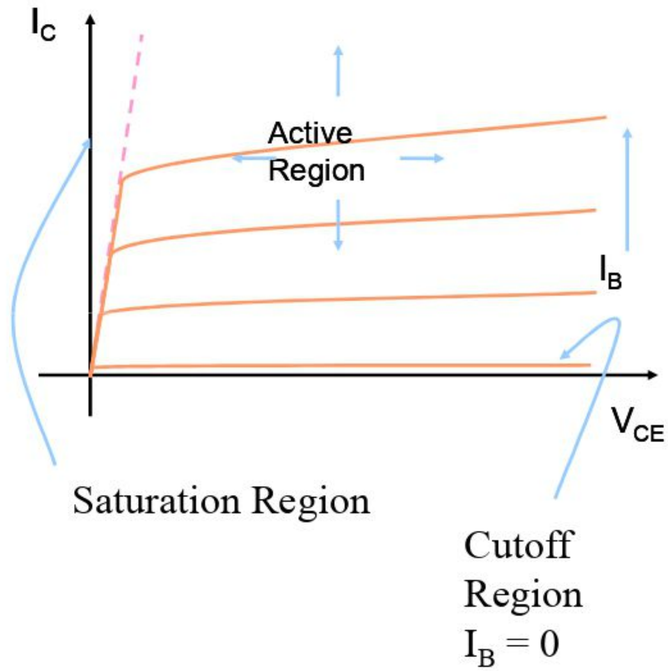
- CE Configuration is most Commonly used in **amplifier circuit** because it provides **high gain in voltage , current and power.**
- Input signal at BE (Low Resistance)
- Output signal at CE (High resistance)
- Two signal(I/O) are **180 degree out of phase.**
- CE Configuration that provides a **phase reversal.**
- Most popular of three configuration because it has the **best combination of current and voltage gain.**
- Each transistor Configuration has its unique gain characteristic even through the same transistor are used.

Common-Emitter

Circuit Diagram

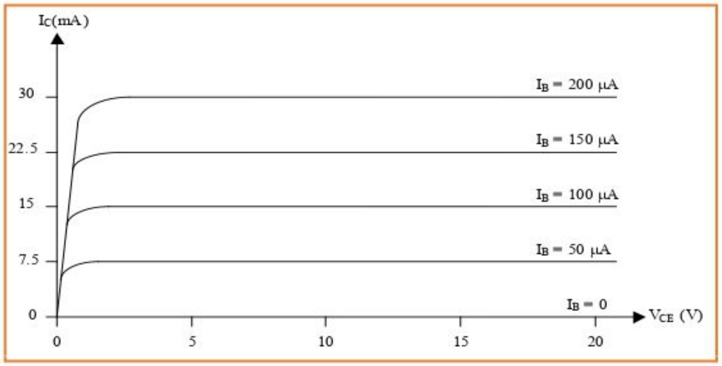


Collector-Current Curves



Region of Operation	Description
Active	**Small base current controls a large collector current**
Saturation	**$V_{CE(sat)}$ ~ 0.2V, V_{CE} increases with I_C**
Cutoff	**Achieved by reducing I_B to 0, Ideally, I_C will also be equal to 0.**

Output characteristics: npn BJT (typical)



$$\beta_{dc} = \frac{I_C}{I_B} = h_{FE}$$

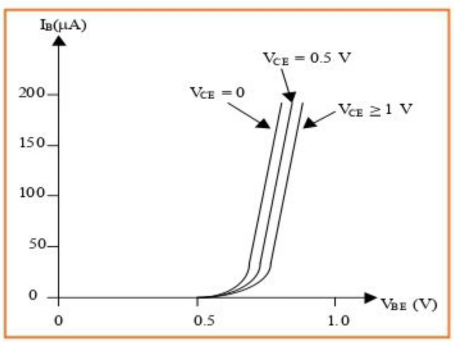
Note: The PE review text sometimes uses α_{dc} instead of β_{dc}. They are related as follows:

$$\alpha_{dc} = \frac{\beta_{dc}}{\beta_{dc} + 1}$$

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

- Find the approximate values of b_{dc} and a_{dc} from the graph.

Input characteristics: npn BJT (typical)



The input characteristics look like the characteristics of a forward-biased diode. Note that V_{BE} varies only slightly, so we often ignore these characteristics and assume:

Common approximation: $V_{BE} = V_o = 0.65$ to $0.7V$

Note: Two key specifications for the BJT are B_{dc} and V_o (or assume V_o is about 0.7 V)

Various Regions (Modes) of Operation of BJT

Active:

- Most important mode of operation
- Central to amplifier operation
- The region where current curves are practically flat

Saturation:

- Barrier potential of the junctions cancel each other out causing a virtual short (behaves as on state Switch)

Cutoff:

- Current reduced to zero
- Ideal transistor behaves like an open switch