OSCILLATORS

Oscillator

- An **oscillator** is a circuit which produces a continuous, repeated, alternating waveform without any input. Oscillators basically convert unidirectional current flow from a DC source into an alternating waveform which is of the desired frequency, as decided by its circuit components.
- An **electronic oscillator** is an electronic circuit that produces a periodic, oscillating electronic signal, often a sine wave or a square wave.
- Oscillators convert direct current (DC) from a power supply to an alternating current (AC) signal.
- They are widely used in many electronic devices ranging from simplest clock generators to digital instruments (like calculators) and complex computers and peripherals etc.
- Common examples of signals generated by oscillators include signals broadcast by radio and television transmitters, clock signals that regulate computers and quartz clocks, and the sounds produced by electronic beepers and video game

BIPOLAR JUNCTION TRANSISTOR (BJT)

- Transistors are three terminal active devices made from different semiconductor materials that can act as either an insulator or a conductor by the application of a small signal voltage.
- The transistor’s ability to change between these two states enables it to have two basic functions: “switching” (digital electronics) or “amplification” (analogue electronics)

- The **Bipolar Transistor** basic construction consists of two PN-junctions producing three connecting terminals with each terminal being given a name to identify it from the other two. These three terminals are known and labelled as the Emitter (E), the Base (B) and the Collector (C) respectively

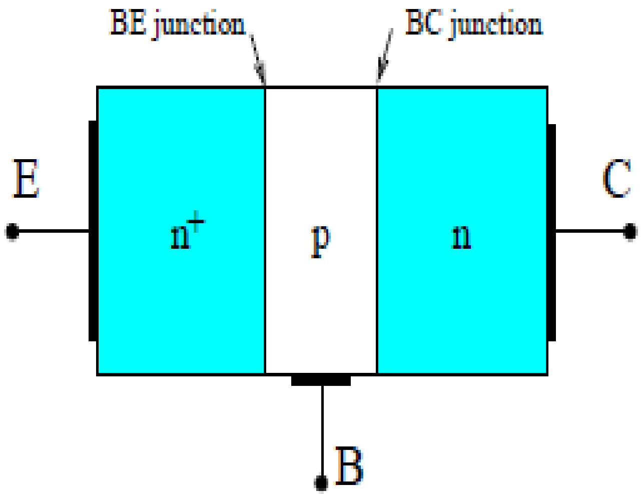
- Bipolar Transistors are current regulating devices that control the amount of current flowing through them from the Emitter to the Collector terminals in proportion to the amount of biasing voltage applied to their base terminal, thus acting like a current-controlled switch. As a small current flowing into the base terminal controls a much larger collector current forming the basis of transistor action.

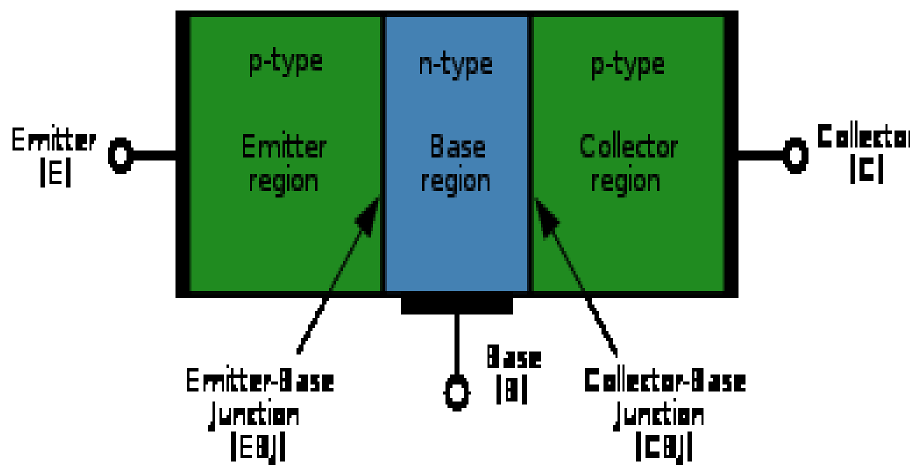
- The principle of operation of the two transistor types PNP and NPN, is exactly the same the only difference being in their biasing and the polarity of the power supply for each type

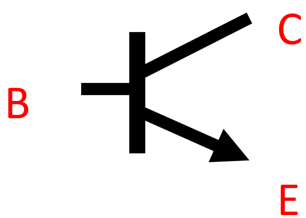
CONSTRUCTION

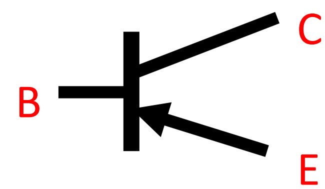
- Formed by joining 3 sections of semiconductors with alternative doping.
- There are 3 regions ***base***, ***collector*** and ***emitter.***
- Base region is narrow and lightly doped.
- Emitter is heavily doped.
- Collector is moderately doped ,physically largest among three region.

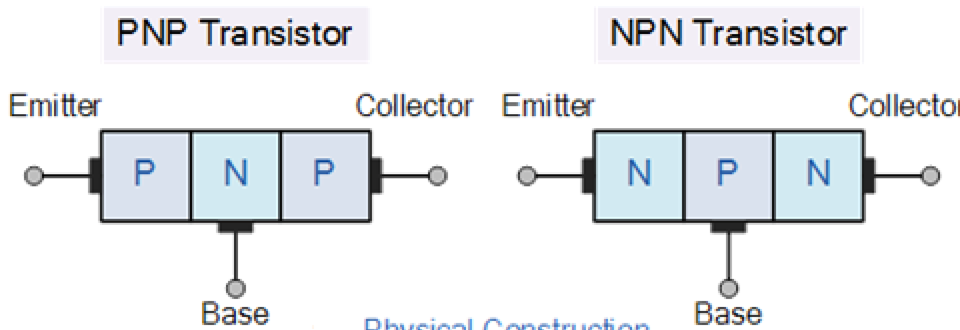
- Two variants are available : *npn* and *pnp.*



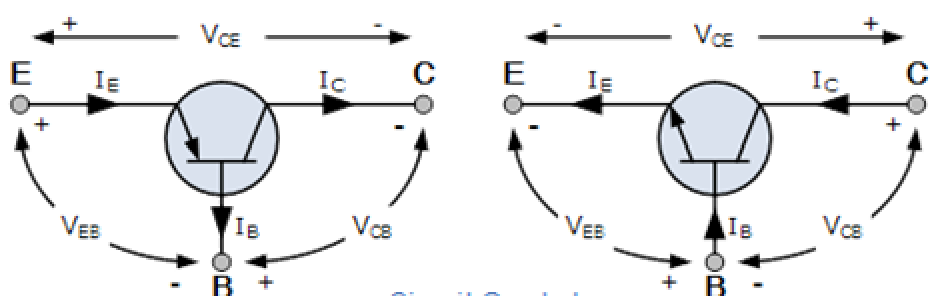








Physical Construction

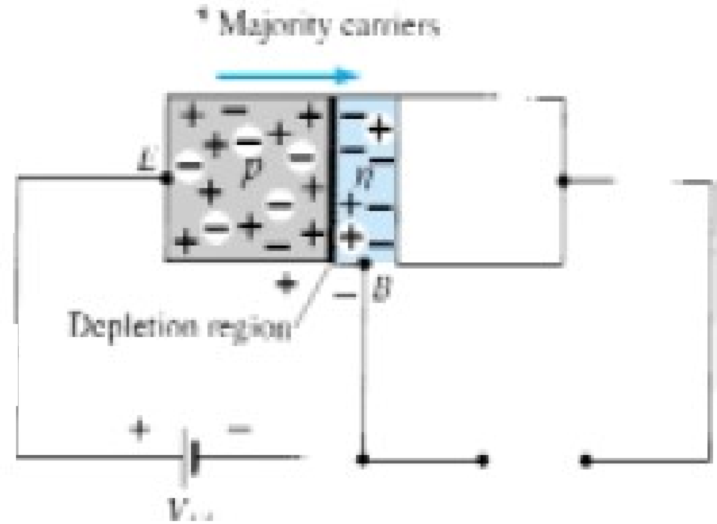


Circuit Symbols

- The arrow in the circuit symbol always showing the direction of “conventional current flow” between the base terminal and its emitter terminal.
- The direction of the arrow always points from the positive p-type region to the negative n-type region for both transistor types, exactly the same as for the standard diode symbol.

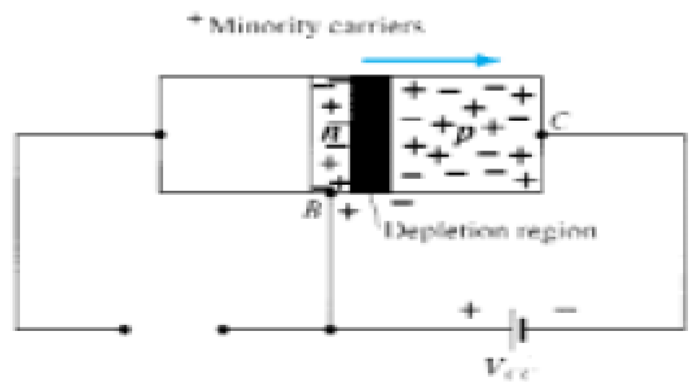
Operation

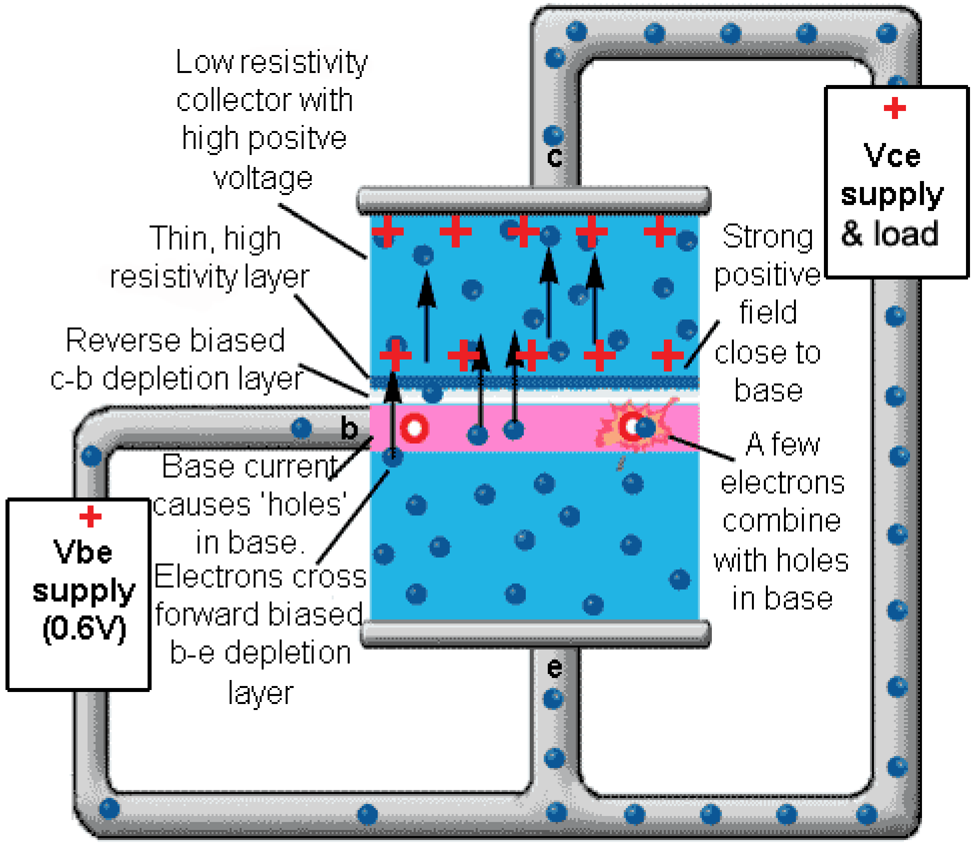
Pnp transistor without any base to collector bias.
Forward bias the emitter base junction.
It acts like a diode now, the depletion region gets reduced due to bias voltage. Thus heavy flow of majority carriers from p side to n side.



Remove the B-E bias and reverse bias the base – collector junction. Here flow of majority charge carriers is zero.
But there will be some minority charge carrier flow.

A large number of majority carriers will diffuse across the forward biased pn junction into n region.
This flow of a charge carriers constitute the *Emitter Current* .
A small amount of these diffused carriers pass to the base and form the *Base current*.
Rest of the carrier diffuse to p region to the collector terminal and constitute the *Collector Current.*





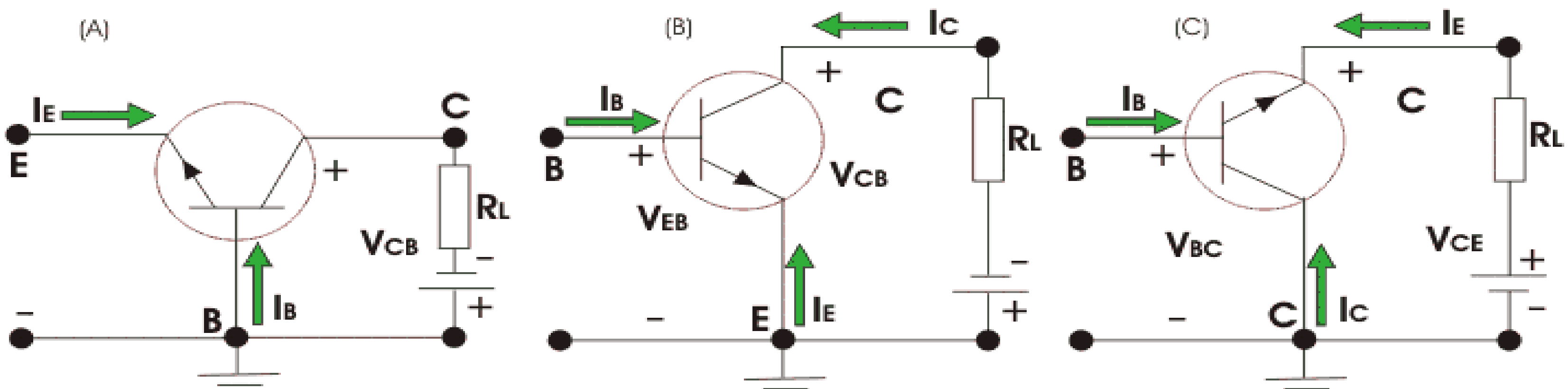
Few electrons flow in b-e circuit - Many flow in c-e circuit

- During normal operation, a potential is applied across the base/emitter junction so that the base is approximately 0.6v more positive than the emitter, this makes the base/emitter junction forward biased.
- A much higher potential is applied across the base/collector junction with a relatively high positive voltage applied to the collector, so that the base/collector junction is heavily reverse biased. This makes the depletion layer between base and collector quite wide once power is applied.
- The collector is made up of mainly heavily doped, low resistivity material with a thin layer of lightly doped, high resistivity material next to the base/collector junction. This means that most of the voltage between collector and base is developed across this thin high resistivity layer, creating a high voltage gradient near the collector base junction.

- When the base emitter junction is forward biased, a small current will flow into the base. Therefore holes are injected into the P type material. These holes attract electrons across the forward biased base/emitter junction to combine with the holes.
- However, because the emitter region is very heavily doped, many more electrons cross into the P type base region than are able to combine with the available holes.
- This means there is a large concentration of electrons in the base region and most of these electrons are swept straight through the very thin base, and into the base/collector depletion layer. Once here, they come under the influence of the strong electric field across the base/collector junction.
- This field is so strong due to the large potential gradient in the collector material mentioned earlier, that the electrons are swept across the depletion layer and into the collector material, and so towards the collector terminal.

Bipolar Transistor Configurations

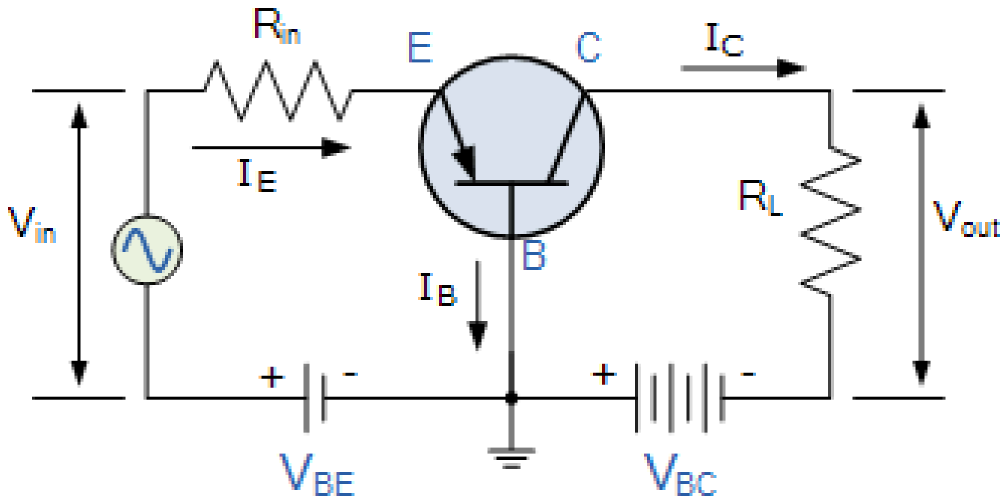
- As the **Bipolar Transistor** is a three terminal device, there are basically three possible ways to connect it within an electronic circuit with one terminal being common to both the input and output.
- Common base
- Common emitter
- Common collector.



The Common Base (CB) Configuration

- In the **common base** or grounded base configuration, the BASE connection is common to both the input signal AND the output signal. The input signal is applied between the transistors base and the emitter terminals, while the corresponding output signal is taken from between the base and the collector terminals as shown. The base terminal is grounded or can be connected to some fixed reference voltage point.
- The input current flowing into the emitter is quite large as its the sum of both the base current and collector current respectively therefore, the collector current output is less than the emitter current input resulting in a current gain for this type of circuit of “1” (unity) or less, in other words the common base configuration “attenuates” the input signal.

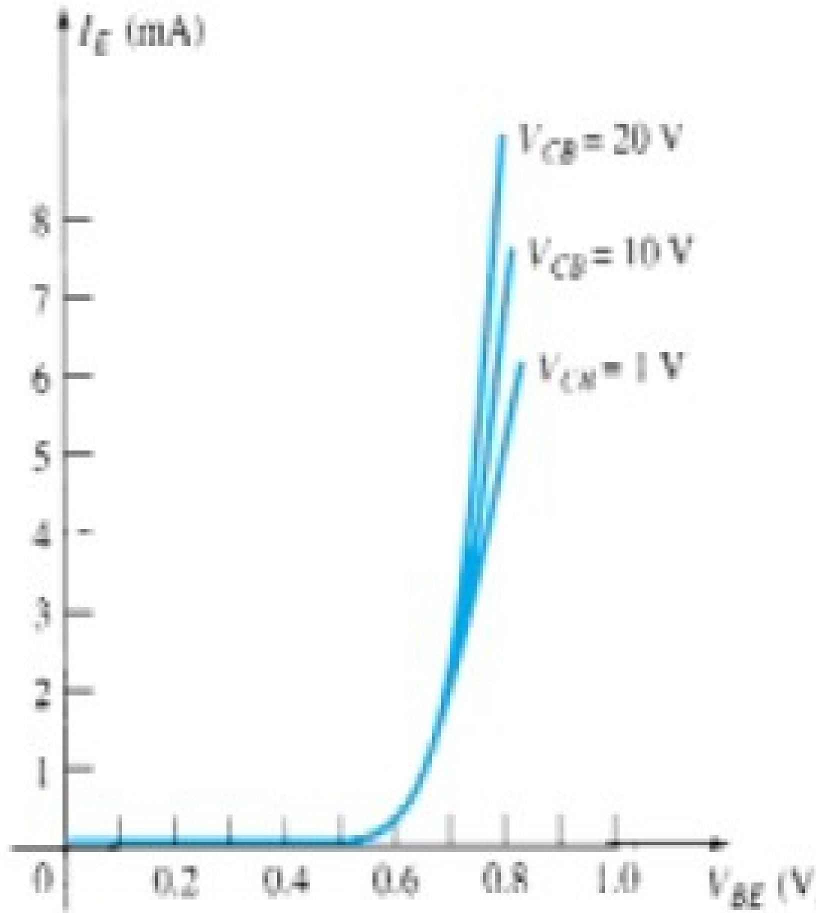
Common Base



- Here base terminal is common for both input and output side.
- There are two sets of characteristic .
  - Input characteristics
  - Output characteristics

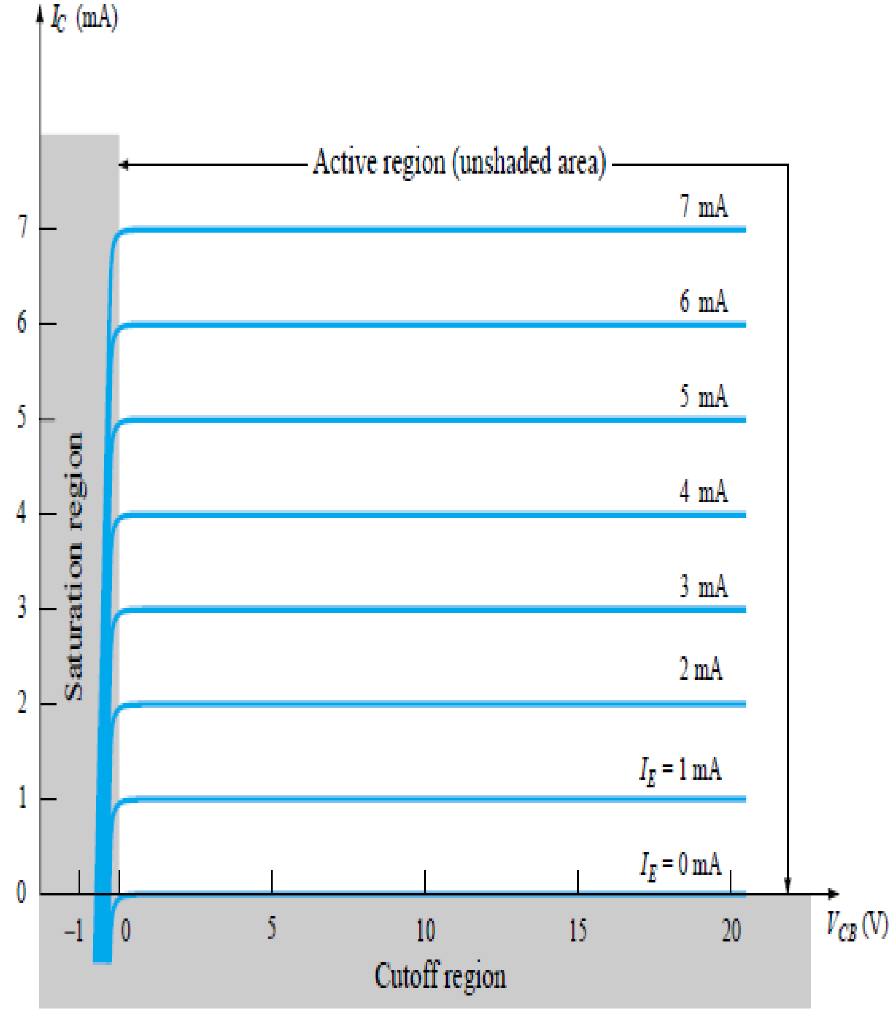
Input characteristics

- Relation between input current and input voltage for various values of output voltage.
- I_e Vs V_{be} for various V_{CB}.



Output characteristics.

- Relation between output current and output voltage for various values of input current.
- I_C vs V_{CB} for various I_E



- Output characteristics has 3 regions
  - Active
  - Cut-off
  - Saturation.
- In active region the collector base junction is reverse biased and base emitter junction is forward biased.
- as the emitter current increase the collector current also increase.

$$\boxed{I_C \cong I_E}$$

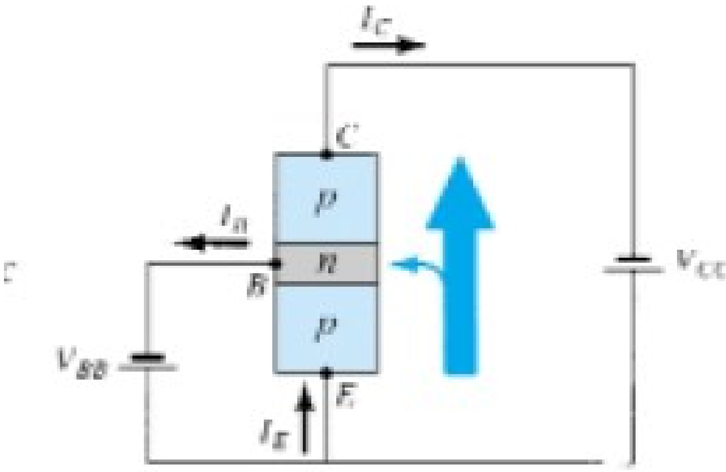
- In the cut off region, both the junctions are reverse biased. Hence the current in output side(collector current) remains zero.

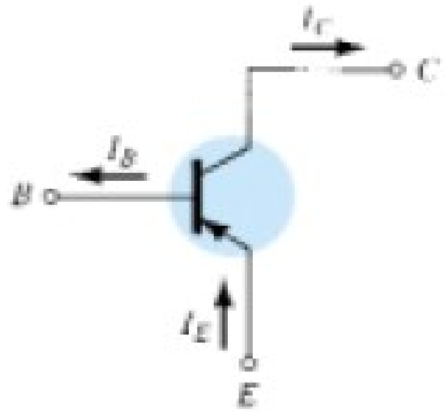
- Saturation region. Here both the junctions are forward biased. Due to which output current rises exponentially.

COMMON-EMITTER CONFIGURATION

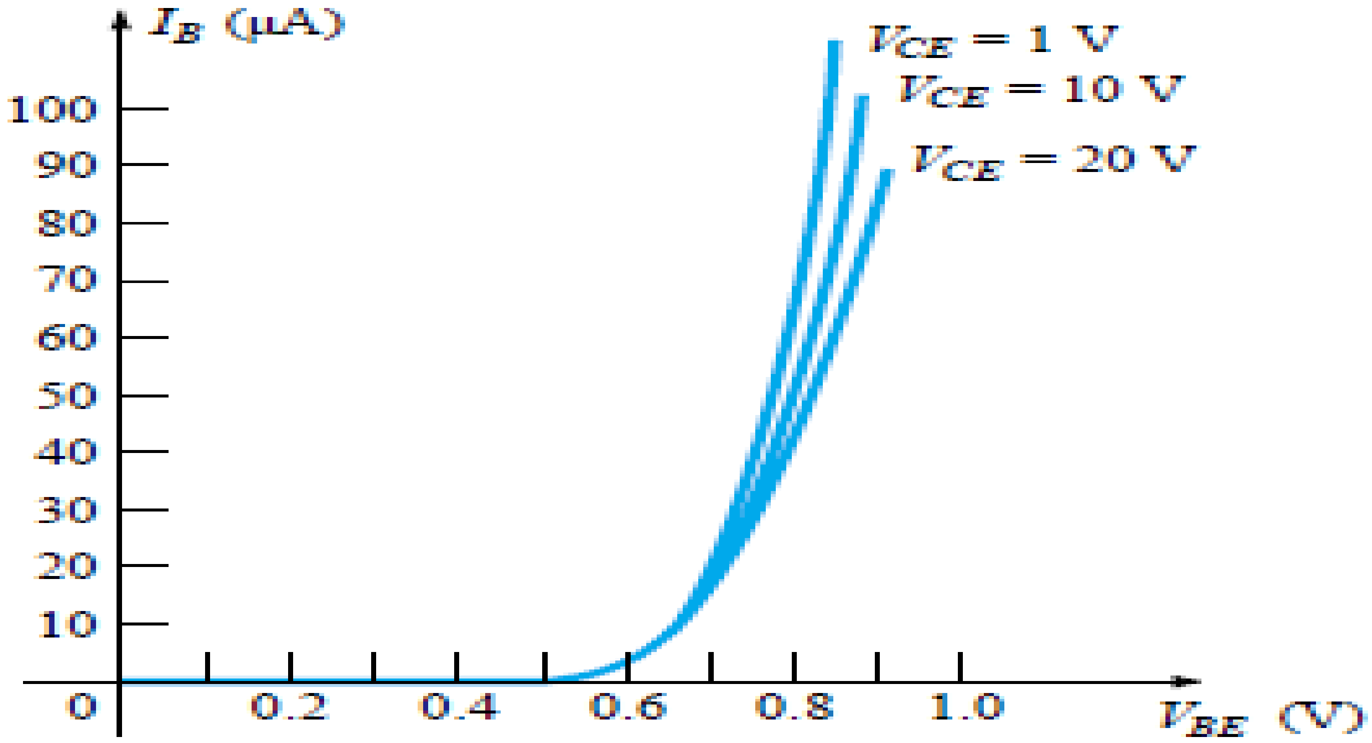
- Emitter is common for both the input and output side.
- In CE configuration ,ratio of I_c to I_B is dc gain denoted by beta

$$\boxed{\beta_{dc} = \frac{I_C}{I_B}}$$

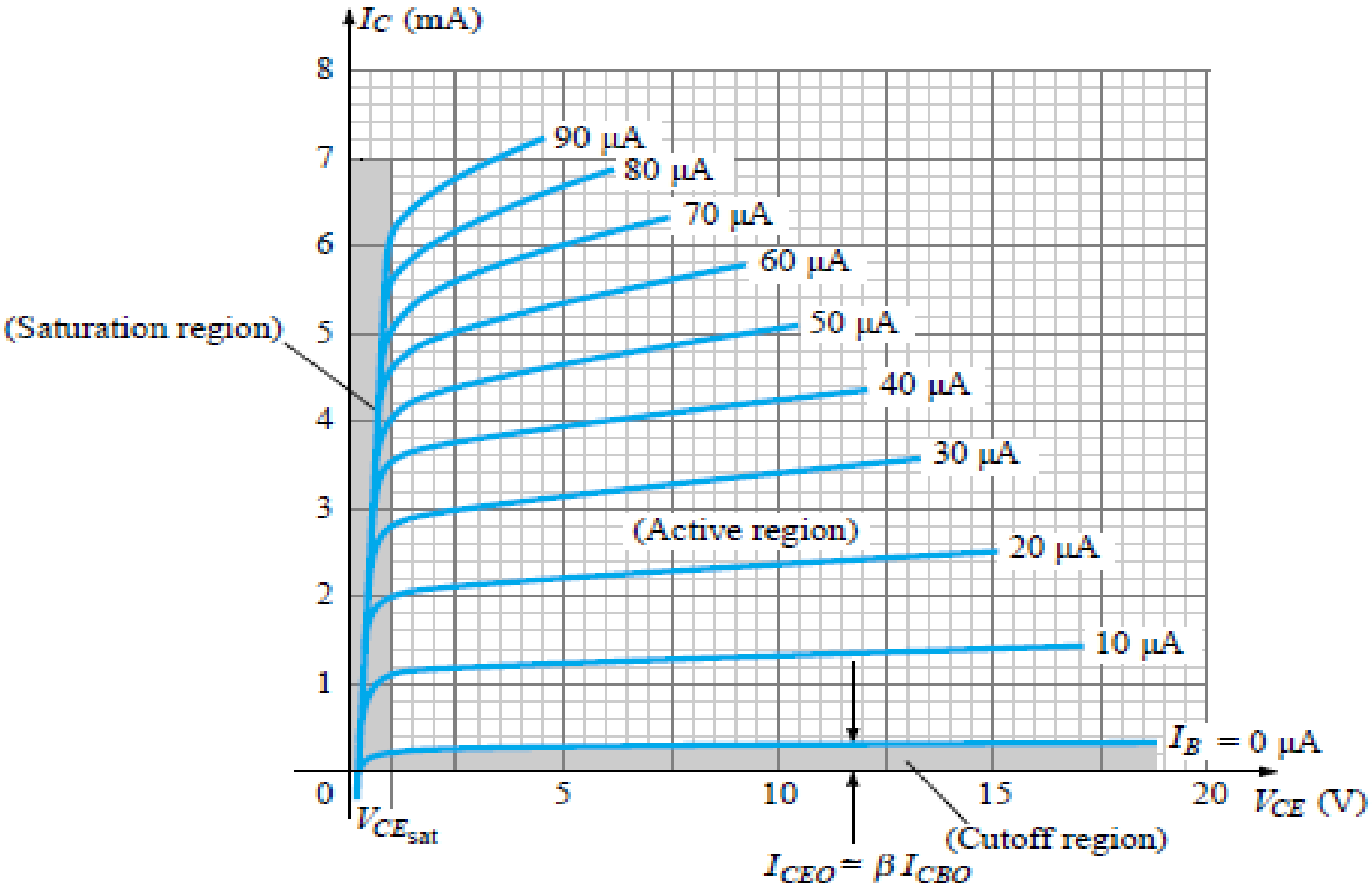




Input characteristics



Output characteristics



Biasing

- Application of Dc voltages to establish a fixed level of current and voltage.
- Resulting dc current and voltage establish an operating point on the output characteristics.
- operating point is also called the quiescent point (Q-point).
- Biasing is done is such a way that the Q-point remains in the active region.

Biasing condition

- For the BJT to be biased active operating region the following must be true:

  1. The base–emitter junction *must be forward-biased*
  2. The base–collector junction *must be reverse-biased* .

- *2.Cutoff-region operation*:
- Base–emitter junction reverse biased
- 3. *Saturation-region operation*:
- Base–emitter junction forward biased
- Base–collector junction forward biased