Bipolar Junction Transistor (BJT)

BASIC ELECTRONICS

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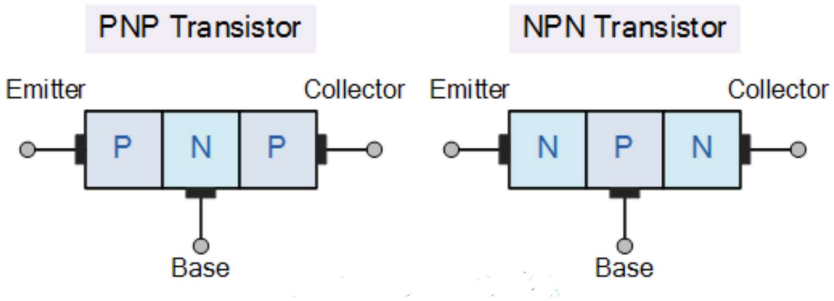
Bipolar Junction Transistor (BJT)

- The Bipolar Junction Transistor (BJT) is perhaps the most basic of three-terminal semiconductor devices.
- It can be found, for example, as a vital component in digital and analog integrated circuits, audio and other frequency range amplifiers, radio electronics, and electronic control devices with a wide range of applications.

Bipolar Transistor Construction

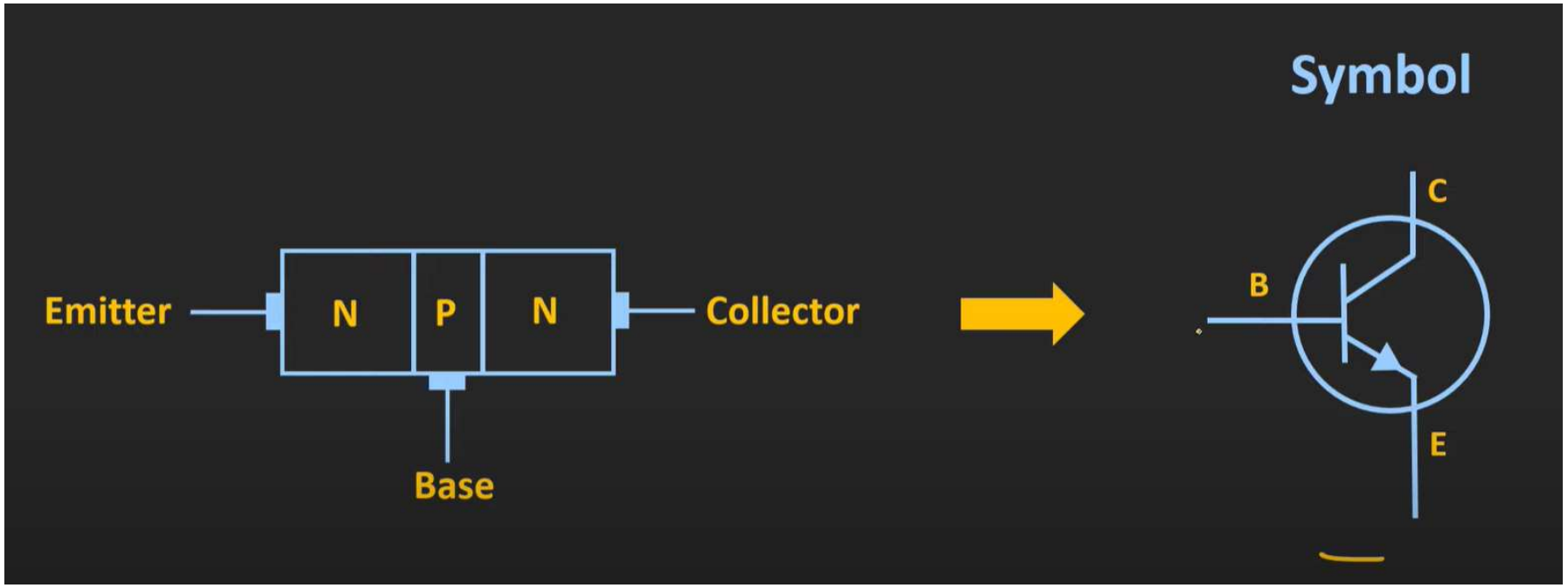
- BJTs are constructed with two p-n junctions sharing a common region, identified as the base region.
- This common region, lying between two regions of the complementary doping, causes the two diode-like p-n junctions to become coupled.
- The base region may be doped as either a p-region or an n-region: the two types of BJT formed are identified as *npn* or *pnp* respectively.



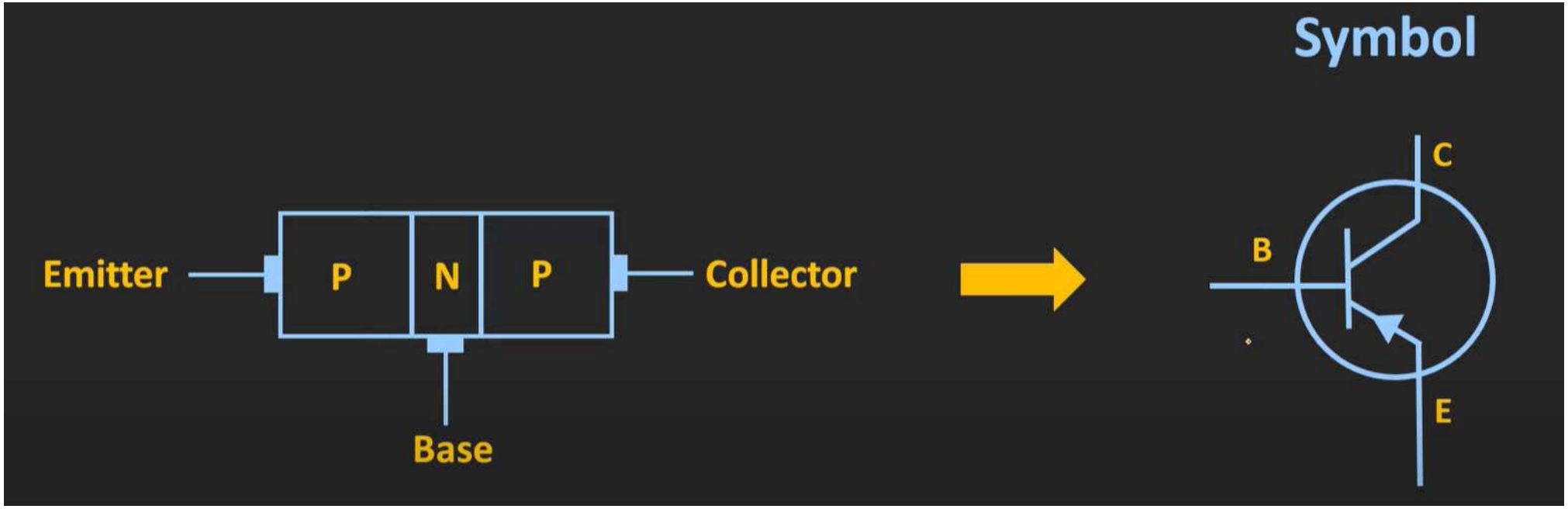
Bipolar Transistor Construction Cont.

- 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 Transistor Construction Cont.



NPN Transistor

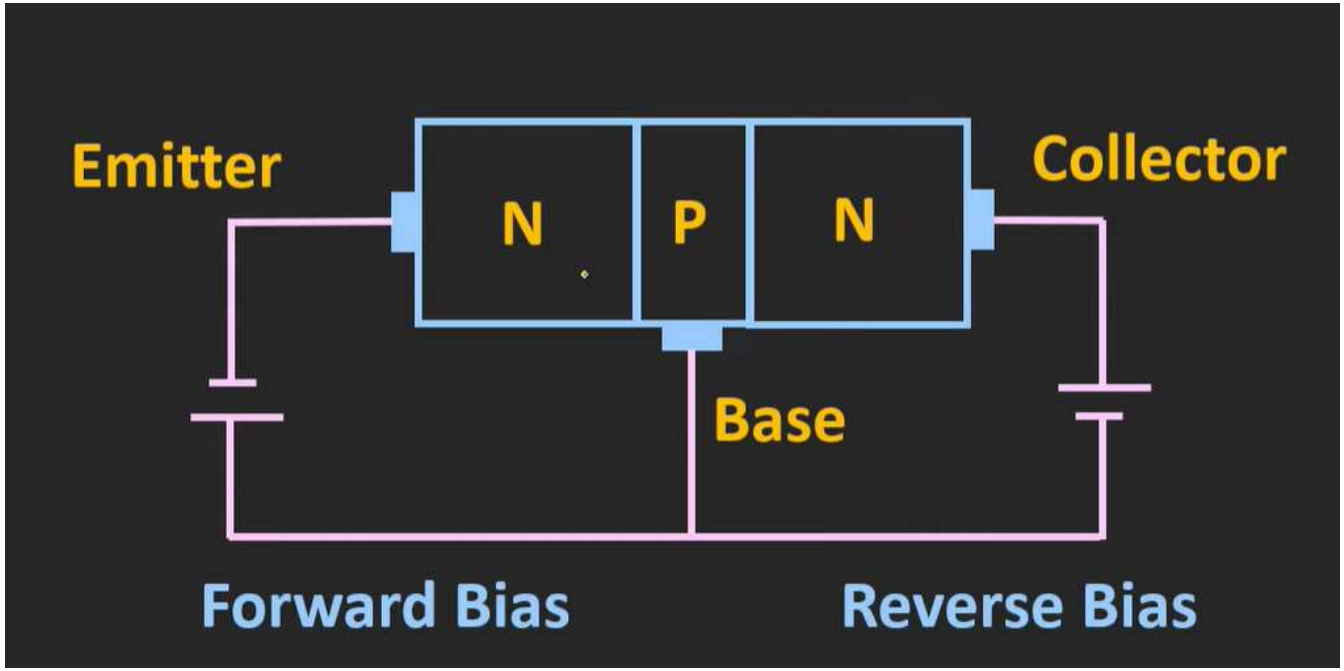


PNP Transistor

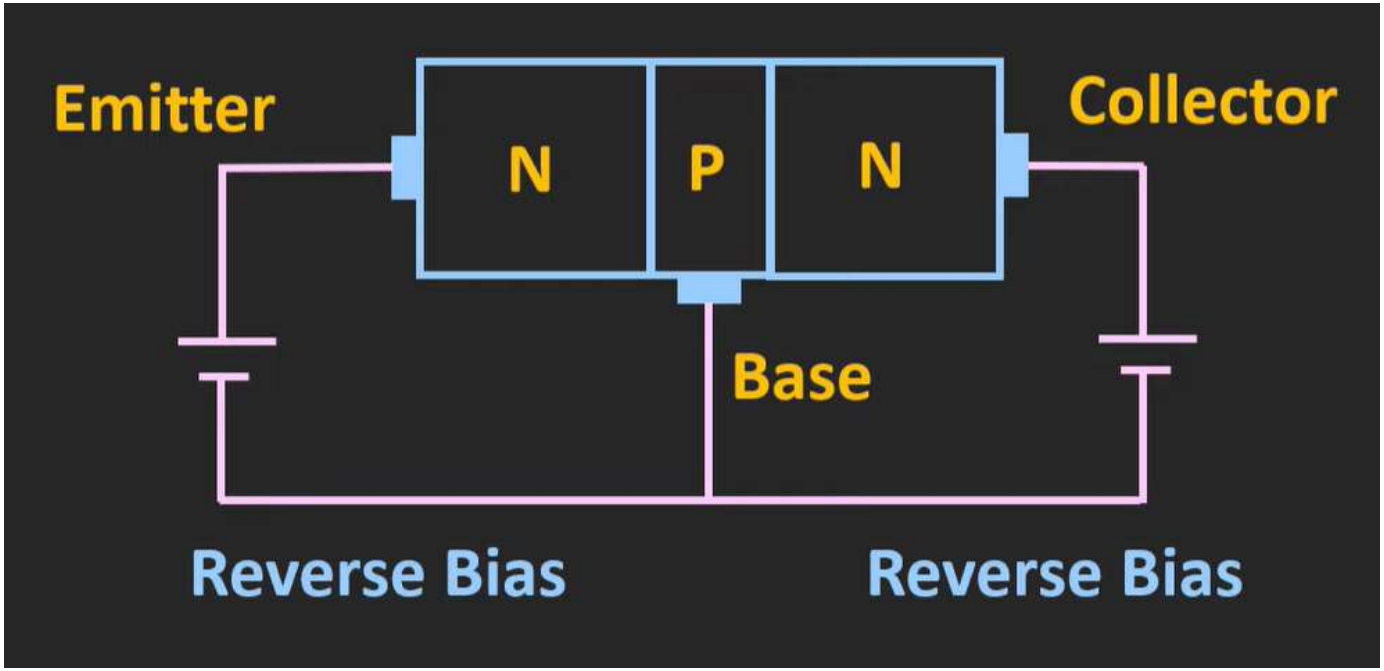
Different Regions of Operations

- There are two junctions. B-E junction and B-C junction.
- These junctions can be forward biased or reverse biased during the operation and hence three operating modes of the transistor are identified as follows.

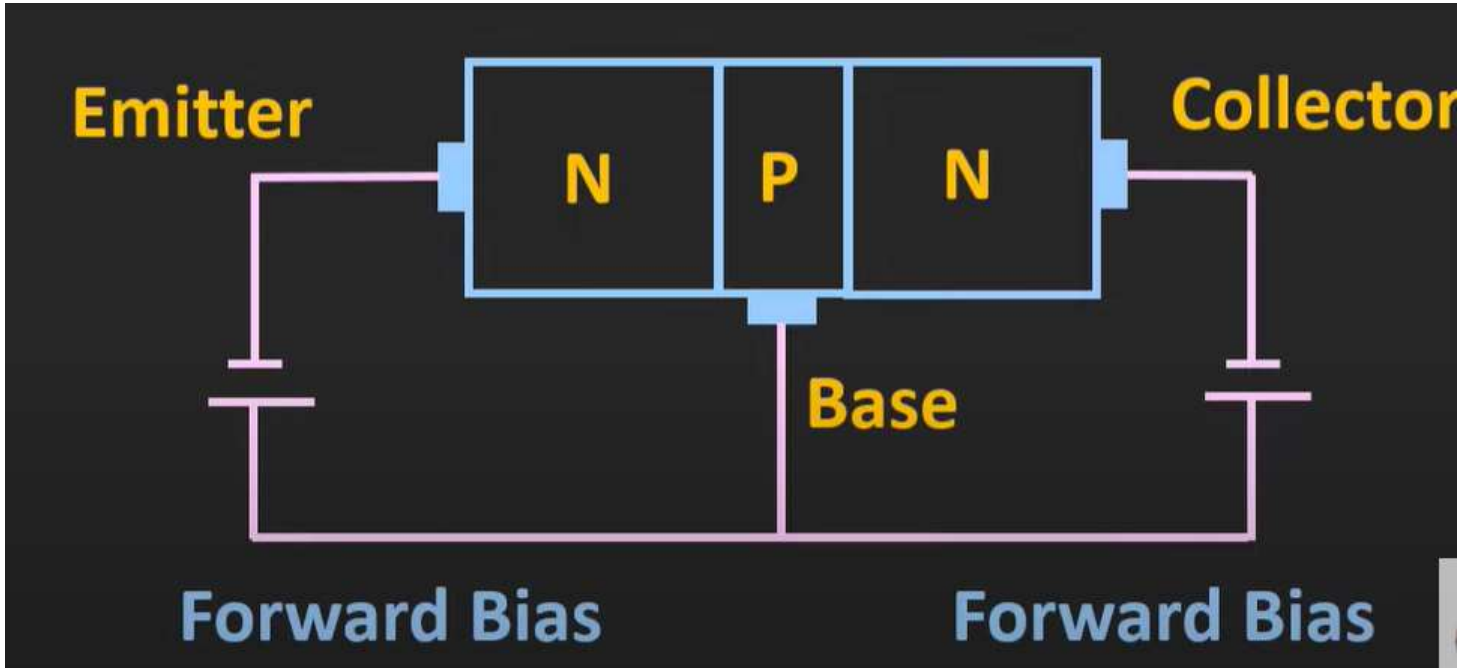
  - Active – B-E forward biased, B-C reverse biased
  - Cut OFF – Both the junctions reverse biased($I_B = 0$)
  - Saturation – Both the junctions forward biased ($V_{CE} = 0$)



Active Region

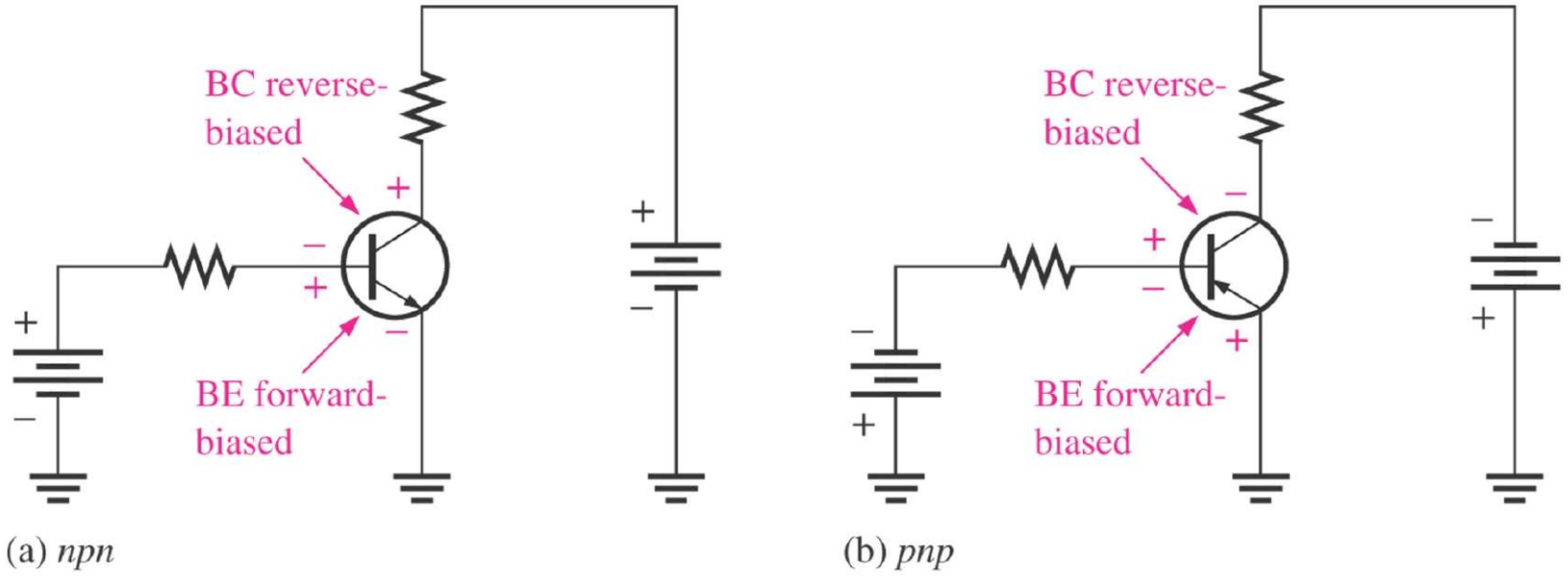


Cut-Off Region

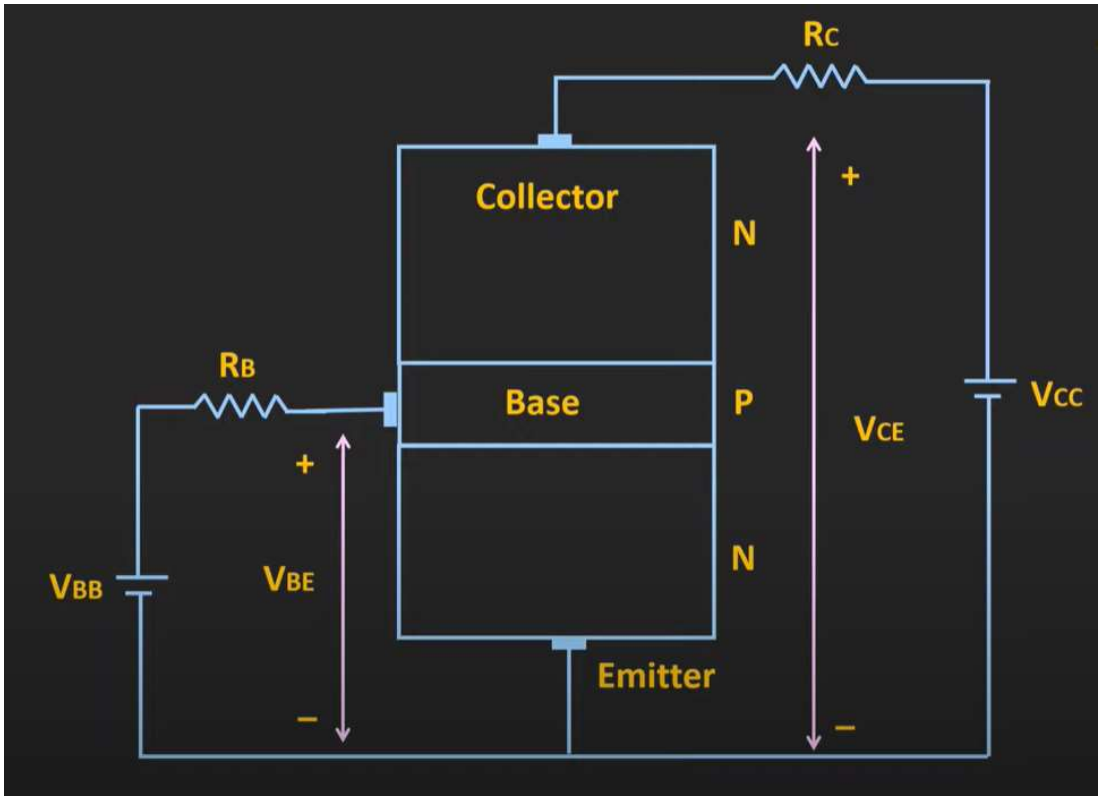


Saturation Region

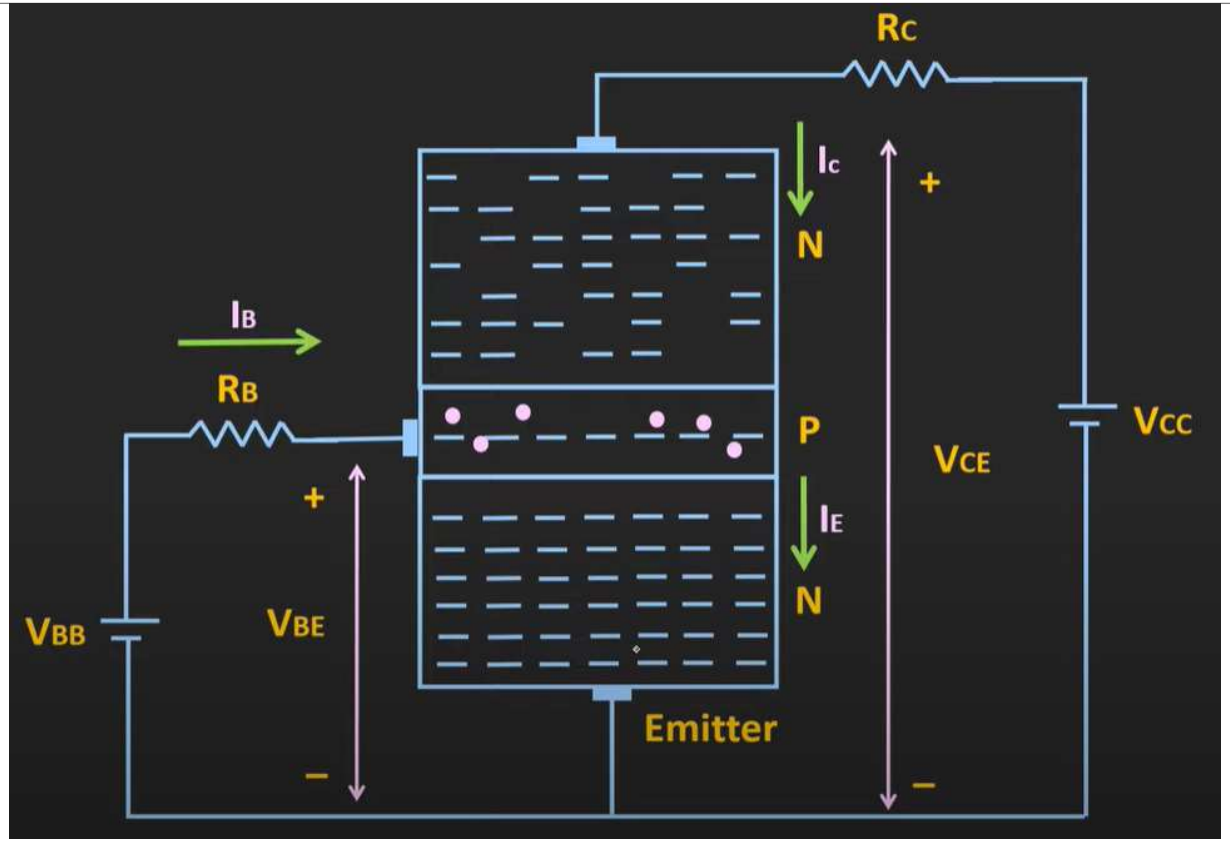
Forward-reverse bias of a BJT



Working of BJT



Working of BJT



Transistor Currents

- The emitter current is the sum of the collector and base currents, expressed as follows:

$$I_E = I_C + I_B$$

- I_B is very small compared to I_E or I_C. The capital-letter subscripts indicate dc values.
- These direct currents (emitter, base, and collector) are also related by two parameters:

the dc **alpha** (α_{DC}), which is the ratio I_C / I_E and the dc **beta** (β_{DC}), which is the ratio I_C / I_B.

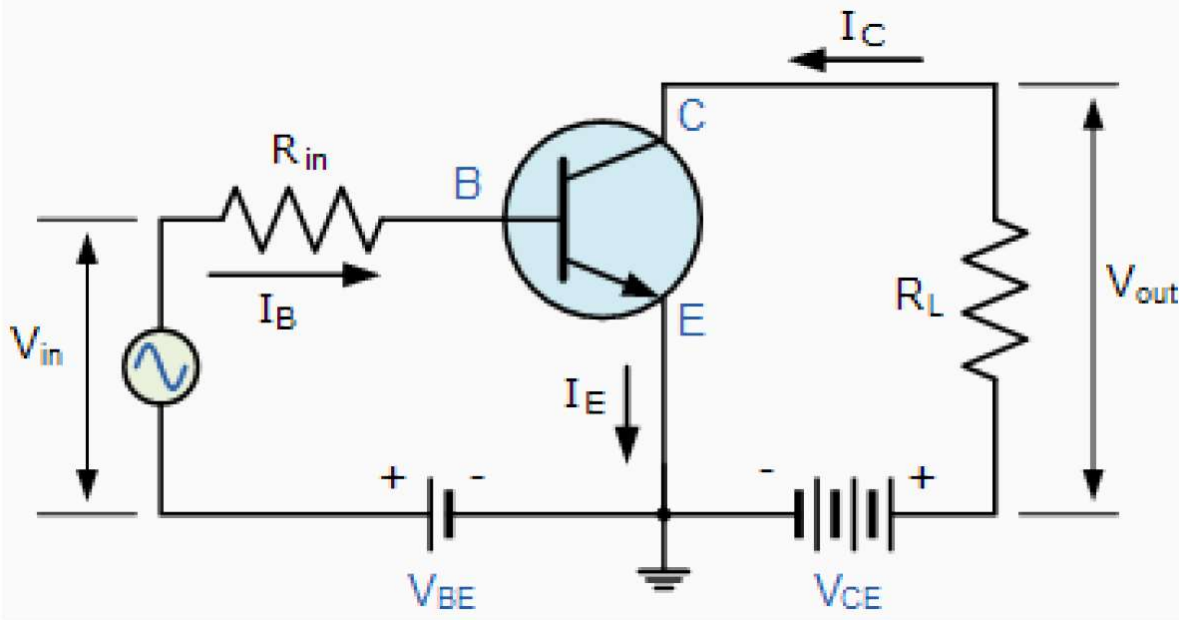
What good is all of this

- Transistor is used as a switch when it is in cut off and saturation modes. Fully On or Fully off
- Transistor is used as an amplifier when it is operating in active (amplifying) mode.
- Therefore, it is clear that we need to apply correct voltages to the three terminals in order to drive the transistor to the particular mode we want.
- This is called biasing the transistor.
- In the active mode of operation transistor acts as an active device because it can draw power from the DC circuits and deliver it to the signal that is being amplified.

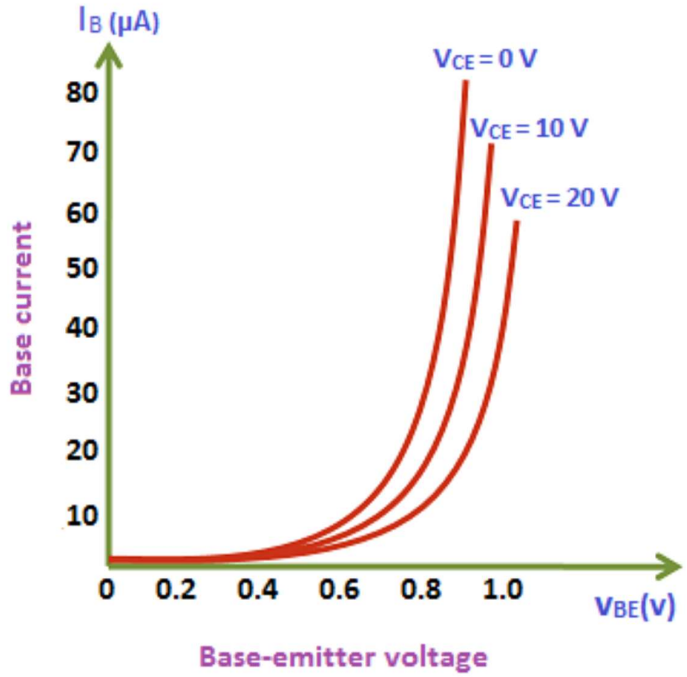
Possible Way to Connect a Transistor

1. Common Base Configuration - has Voltage Gain but no Current Gain.
2. Common Emitter Configuration - has both Current and Voltage Gain.
3. Common Collector Configuration - has Current Gain but no Voltage Gain.

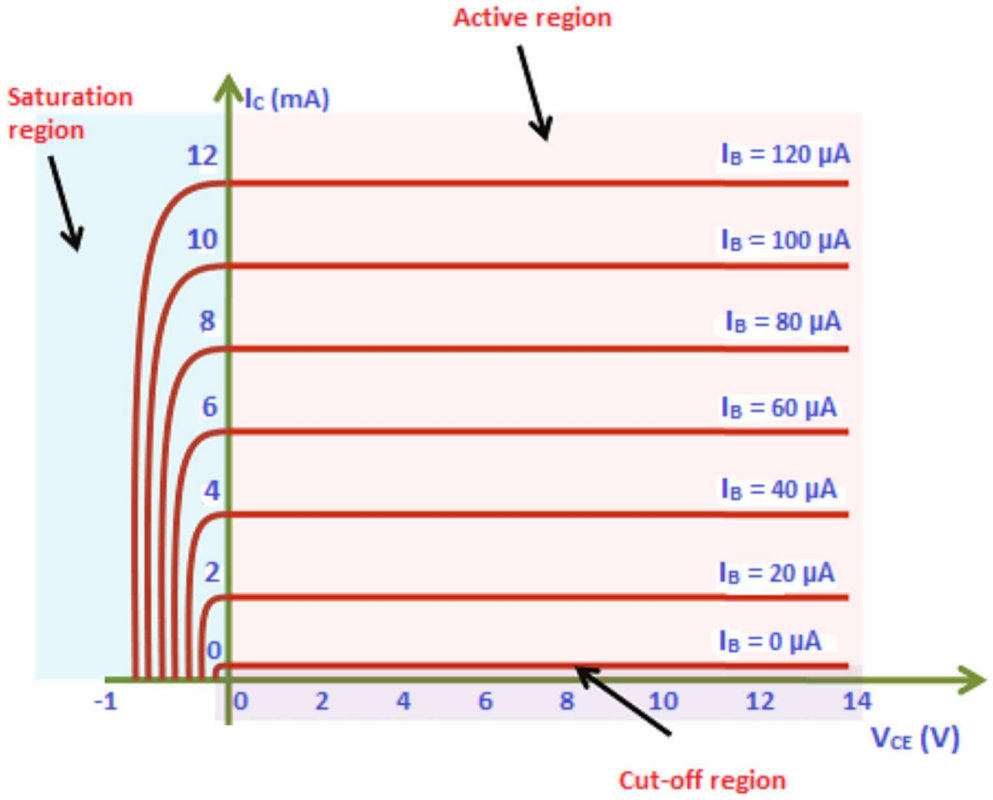
The Common Emitter (CE) Configuration



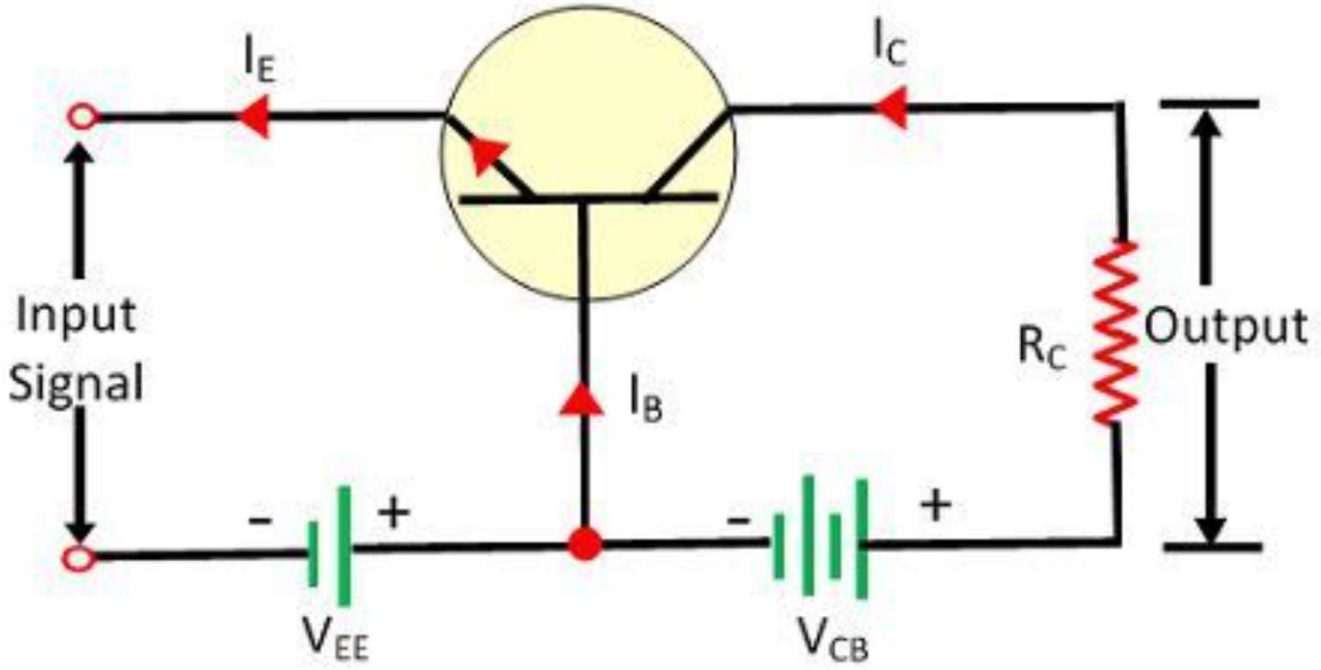
Common Emitter Configuration – Input Characteristic



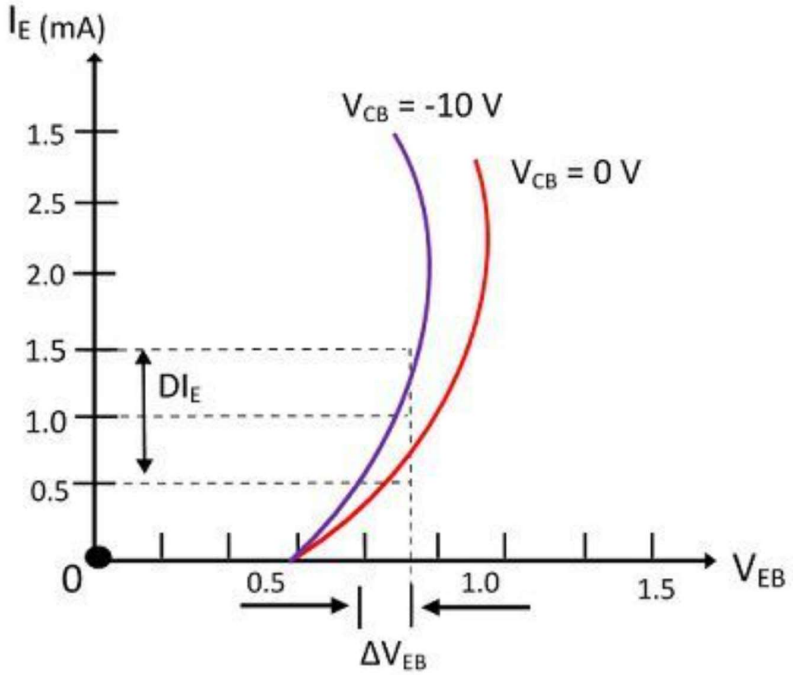
Common Emitter Configuration – Output Characteristic



The Common Base Transistor Circuit



Common Base Configuration – Input Characteristic

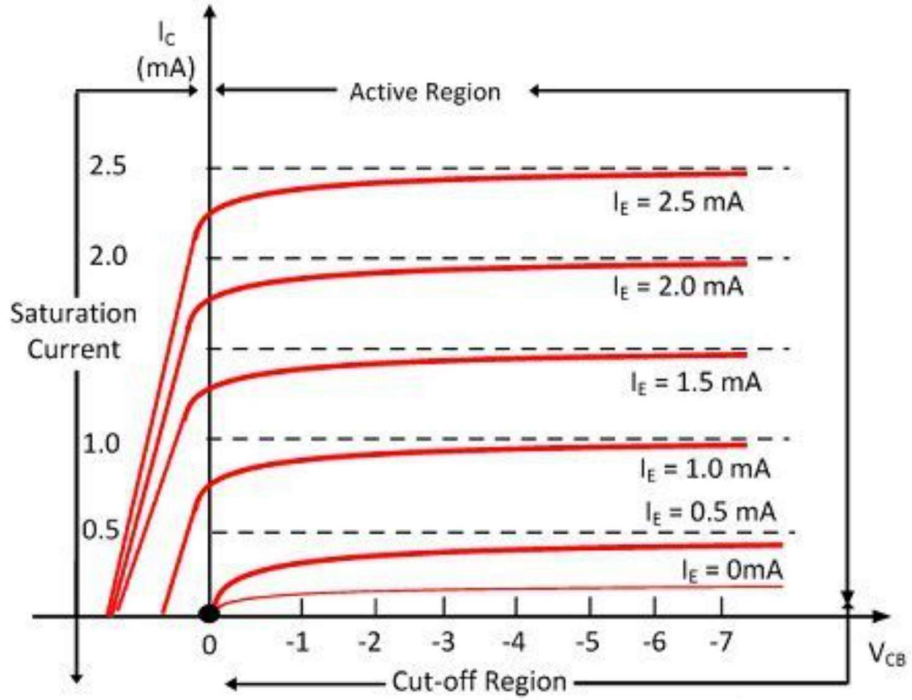


Input Resistance

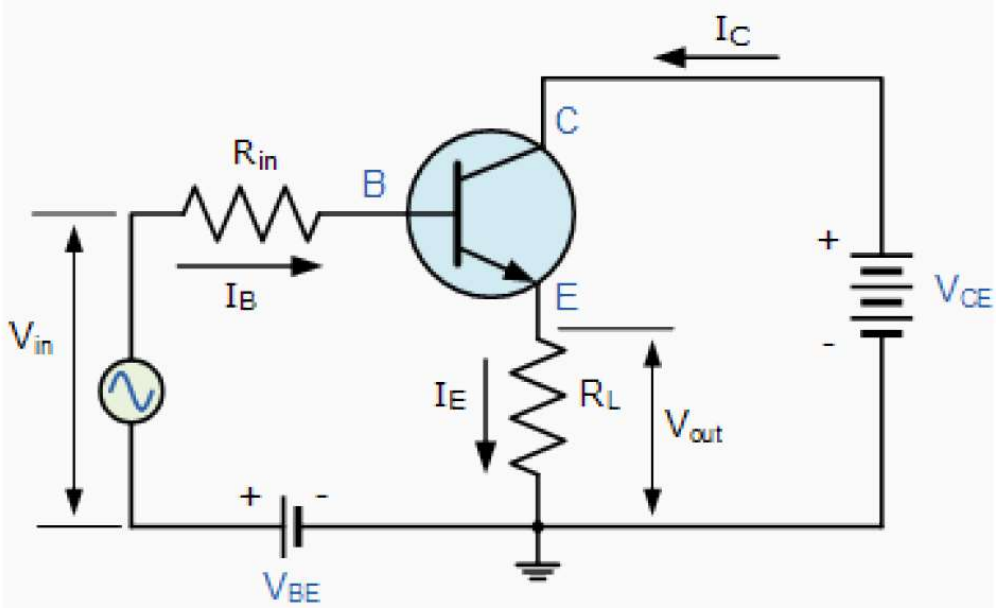
The ratio of change in emitter-base voltage to the resulting change in emitter current at constant collector base voltage V_{CB} is known as input resistance. The input resistance is expressed by the formula

$$r_i = \frac{\Delta V_{EB}}{\Delta I_E}$$

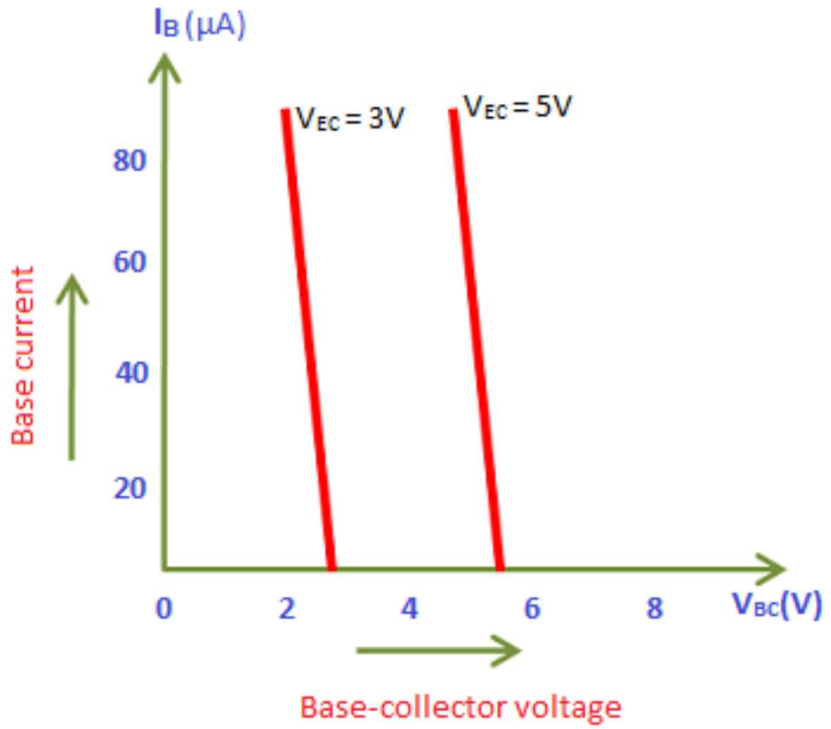
Common Base Configuration – Output Characteristic



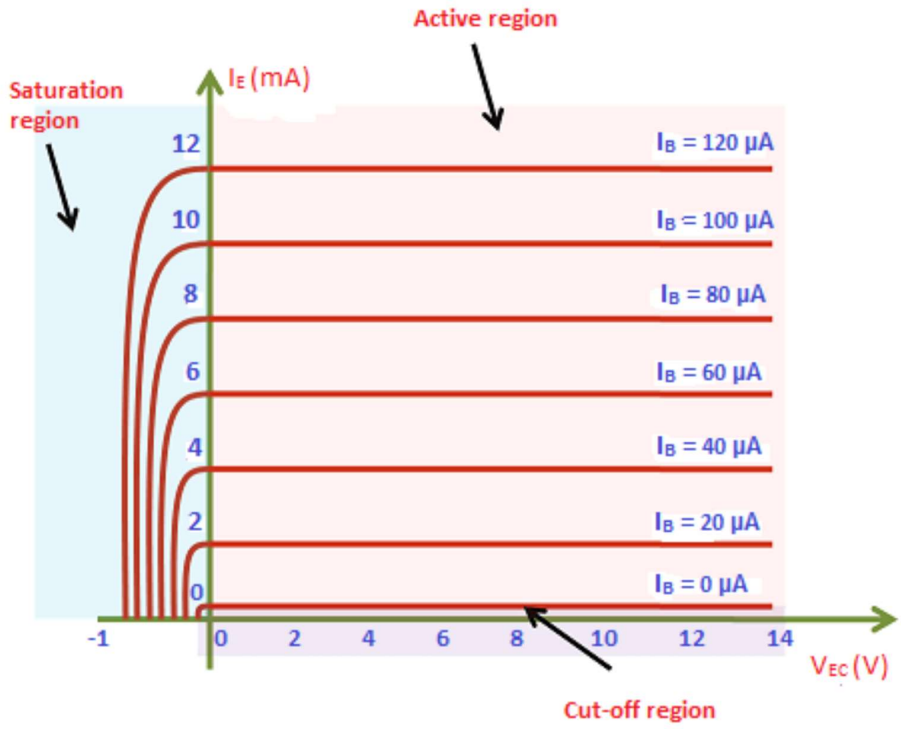
The Common Collector (CC) Configuration



Common Collector Configuration – Input Characteristic



Common Collector Configuration – Output Characteristic



Output characteristics

The Common Collector Current Gain

$$I_E = I_C + I_B$$

$$A_i = \frac{I_E}{I_B} = \frac{I_C + I_B}{I_B}$$

$$A_i = \frac{I_C}{I_B} + 1$$

$$A_i = \beta + 1$$

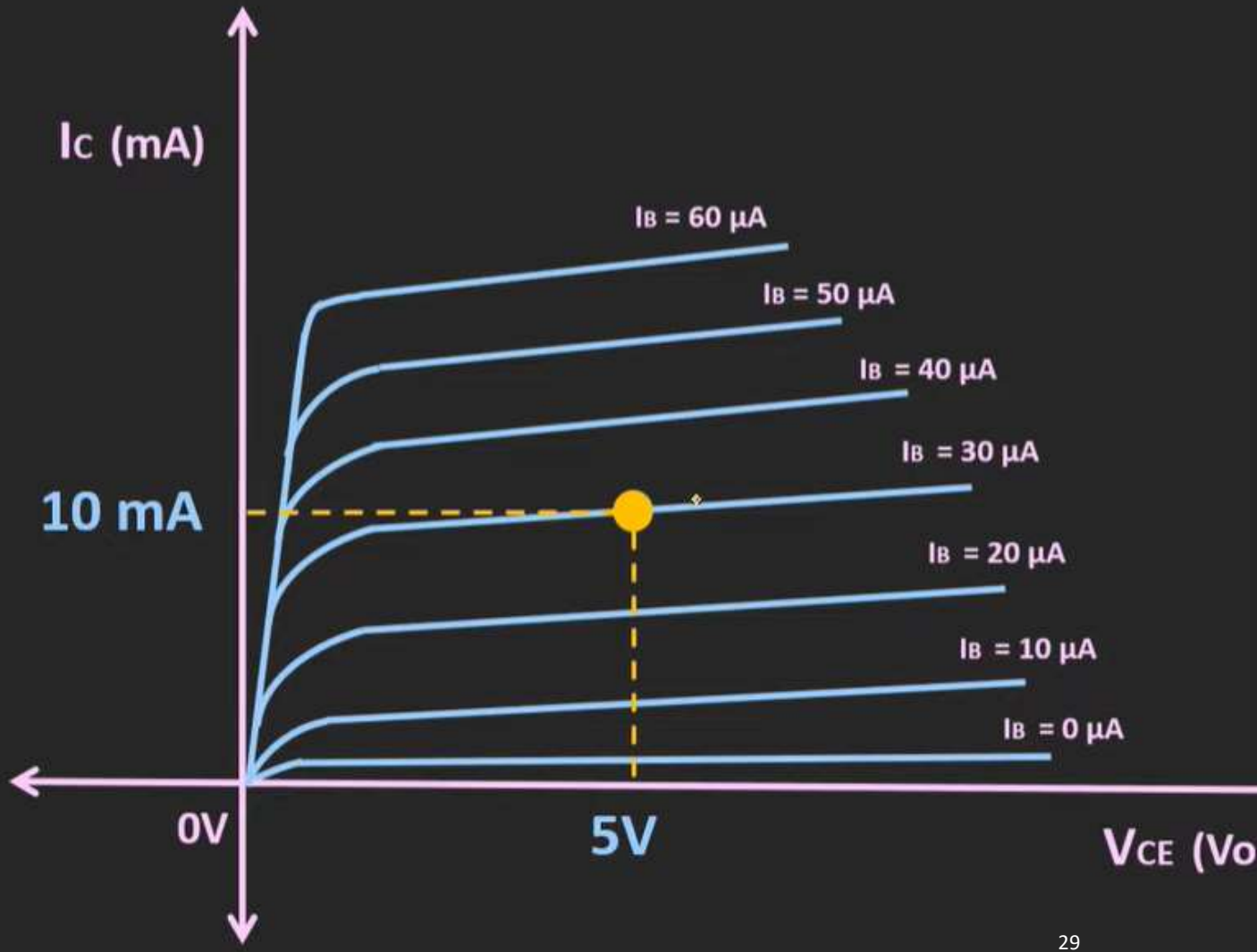
Transistor Biasing

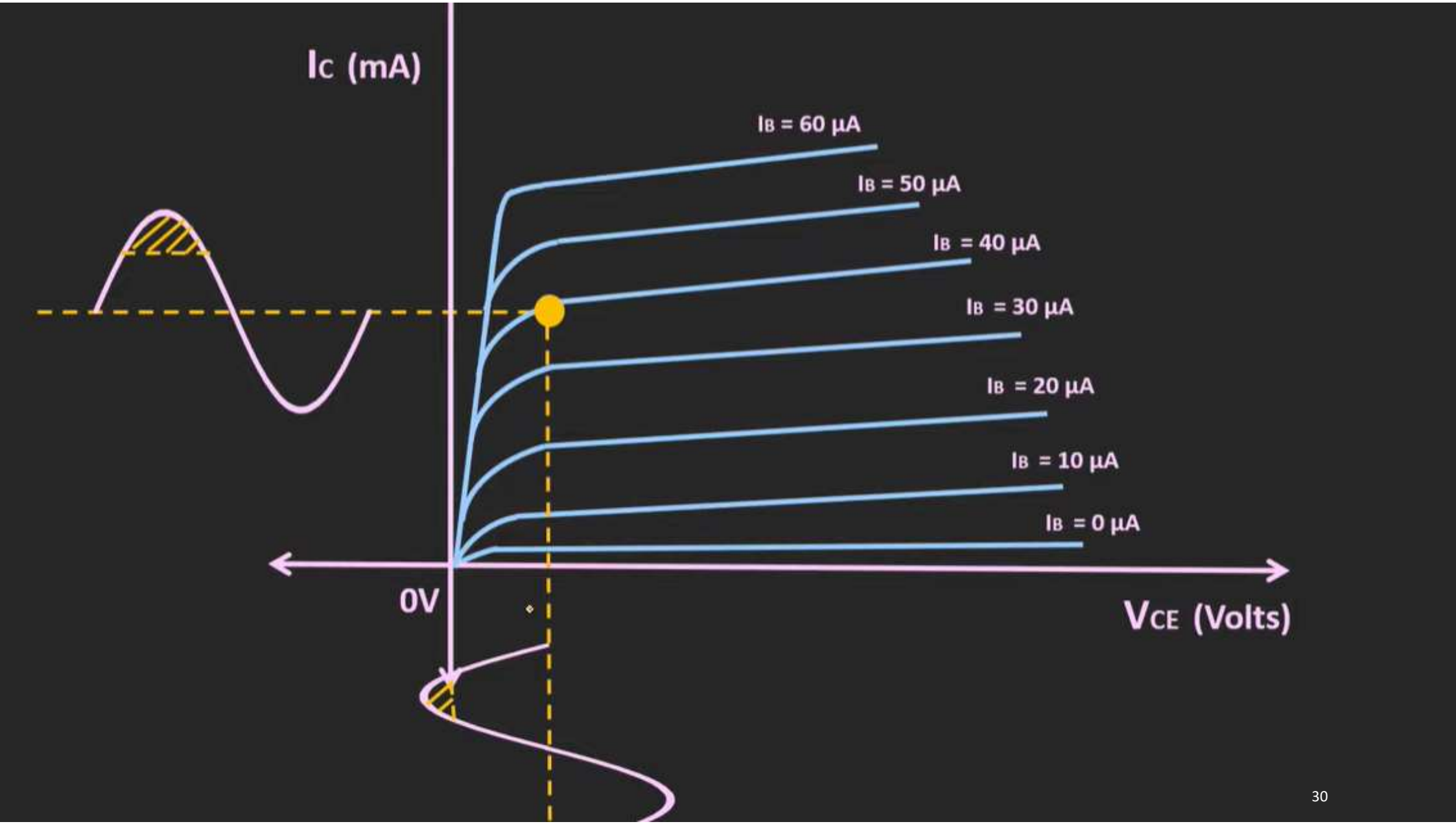
- Biasing is the process of providing DC voltage which helps in the functioning of the circuit.

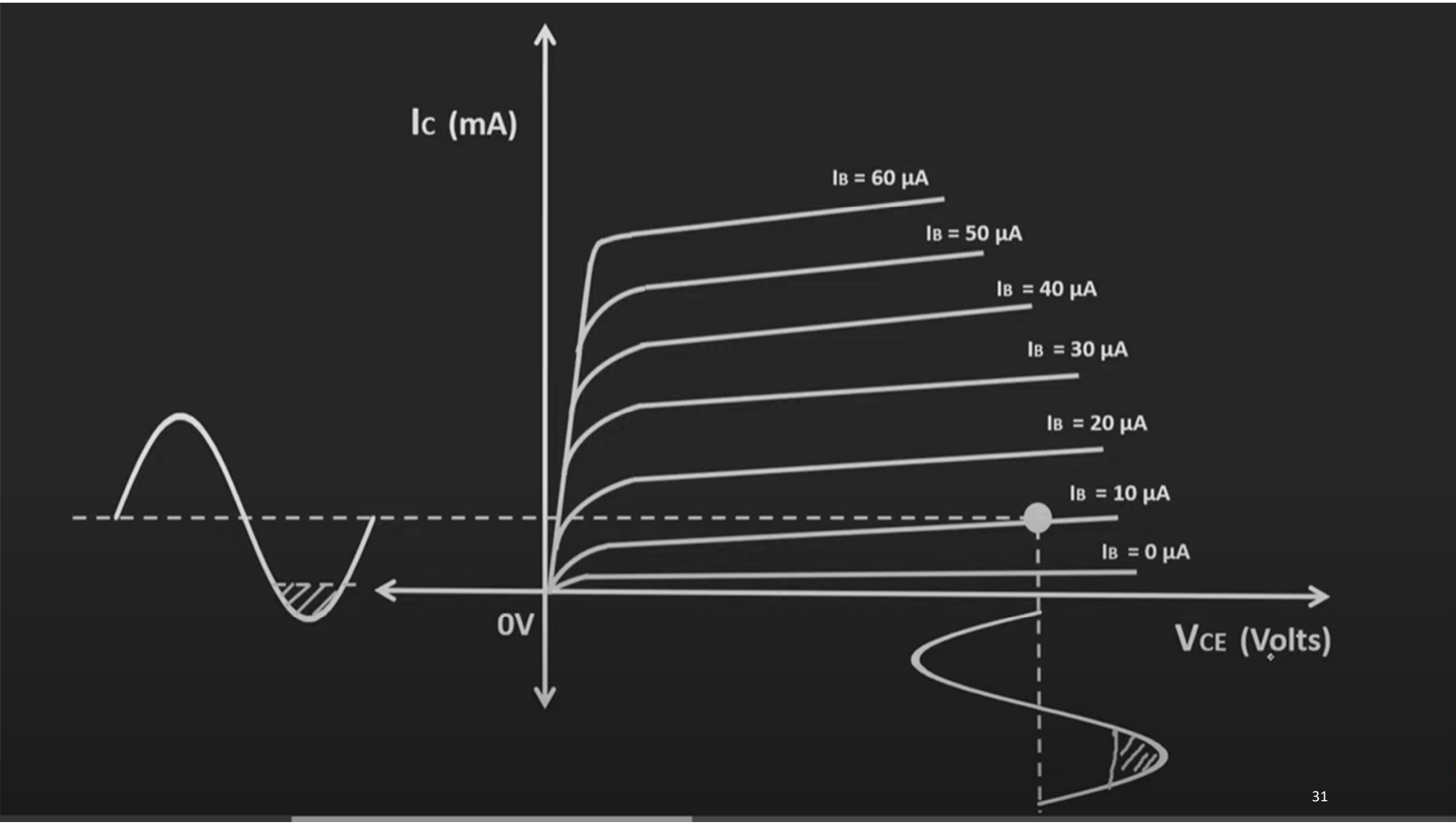
- A transistor is based in order to make the emitter base junction forward biased and collector base junction reverse biased, so that it maintains in active region, to work as an amplifier.

Output Characteristics

Operating Point or Q-Point




Ic (mA)
IB = 60 µA
IB = 50 µA
IB = 40 µA
IB = 30 µA
IB = 20 µA
IB = 10 µA
IB = 0 µA
0V
VCE (Volts)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IB = 60 µA
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IB = 20 µA
IB = 10 µA
IB = 0 µA
0V
VCE (Volts)

What is a Q point of a Diode?

- Q point or the operating point of a device, also known as a bias point, or quiescent point is the steady-state DC voltage or current at a specified terminal of an active device such as a diode or transistor with no input signal applied.
- Also, the Q Point is the relationship between the diode forward voltage and current defined by the device characteristic. Consequently, there is only one point on the dc load line where the diode voltage and current are compatible with the circuit conditions.
- In other words, this operating point (Q point) is the intersection where the optimum forward voltage and forward current converge, and it is also the point where the diode operates at its optimum.

THANK YOU