Electronic Circuits-1(CNET-112)
Level 4^{th}
Department of CNET

College of CS & IS
Jazan University
KSA

CHAPTER -5

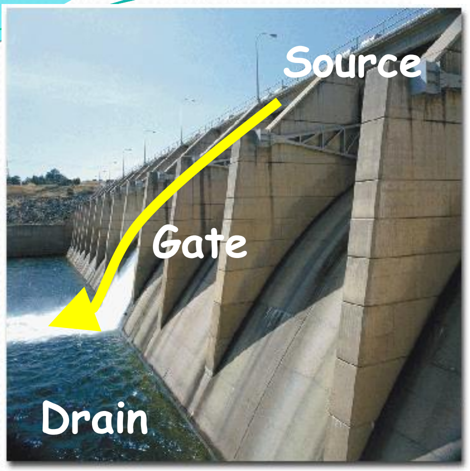
TRANSISTORS

Objectives

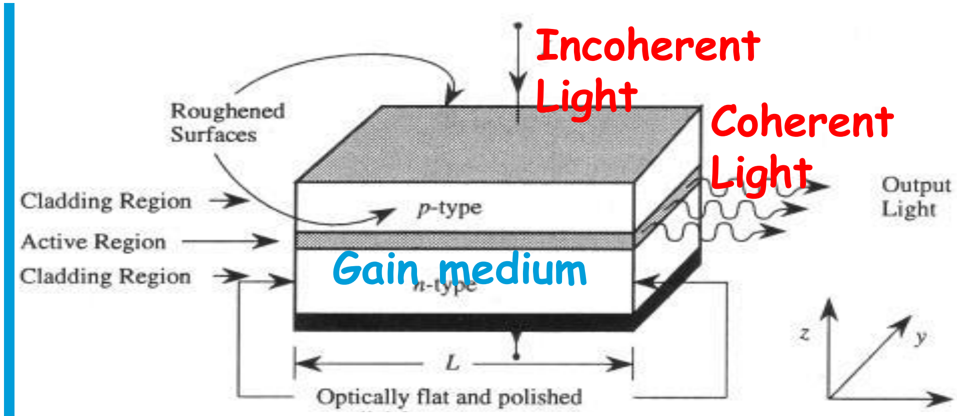
In this Chapter, student will learn the following topics:-

- Introduction of Bipolar Junction Transistor(BJT)
- Construction and Working of BJT
- BJT Configuration
- Regions of operation, Active, Cutoff, Saturation.
- Amplifier
- Voltage, Current and Power Amplifiers

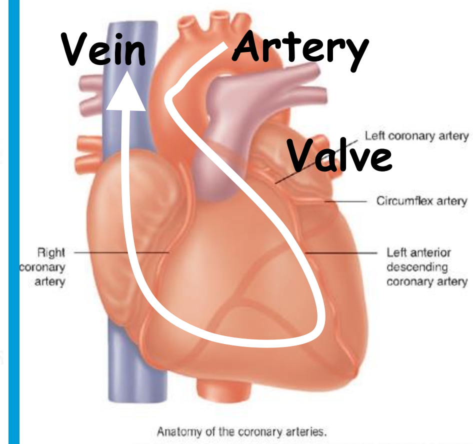
Transistor/switch/amplifier – a 3 terminal device



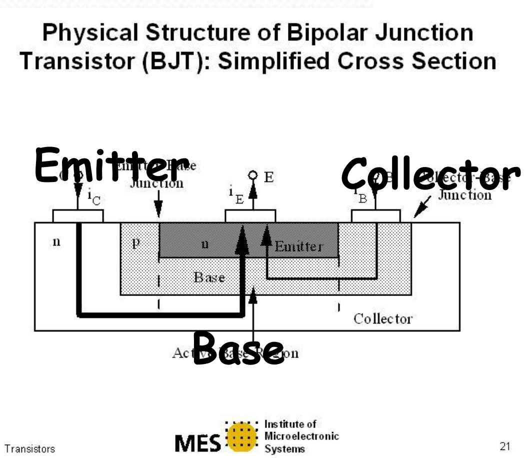
Dam



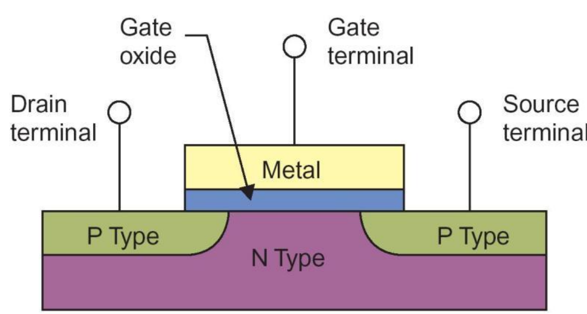
Laser



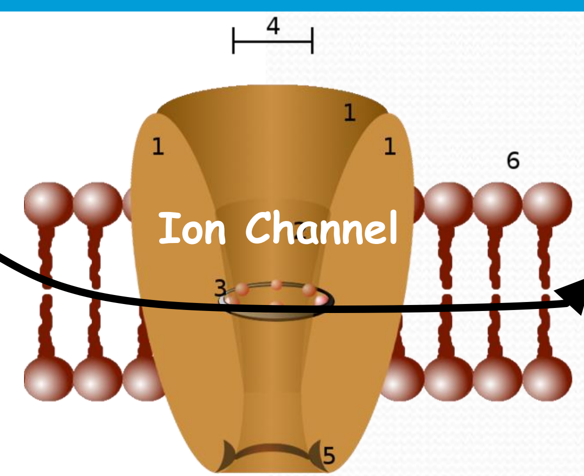
Heart



BJT



MOSFET

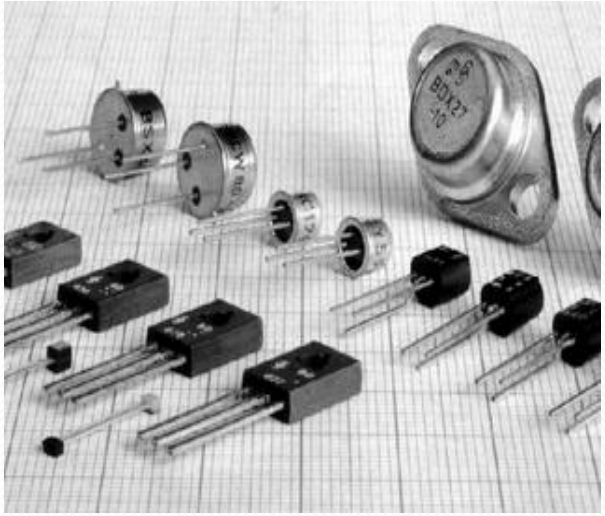


Axonal conduction

(c)

Bipolar junction transistor(BJT)

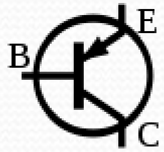
- A bipolar junction transistor (bipolar transistor or BJT) is a type of transistor that uses both electron and hole charge carriers.
- BJTs are manufactured in two types, NPN and PNP, and are available as individual components, or fabricated in integrated circuits, often in large numbers.
- The basic function of a BJT is to amplify current. This allows BJTs to be used as amplifiers or switches, giving them wide applicability in electronic equipment, including computers, televisions, mobile phones, audio amplifiers, industrial control, and radio transmitters.



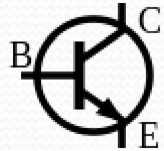
BJT Construction

There are two types of transistors:

1. **PNP**

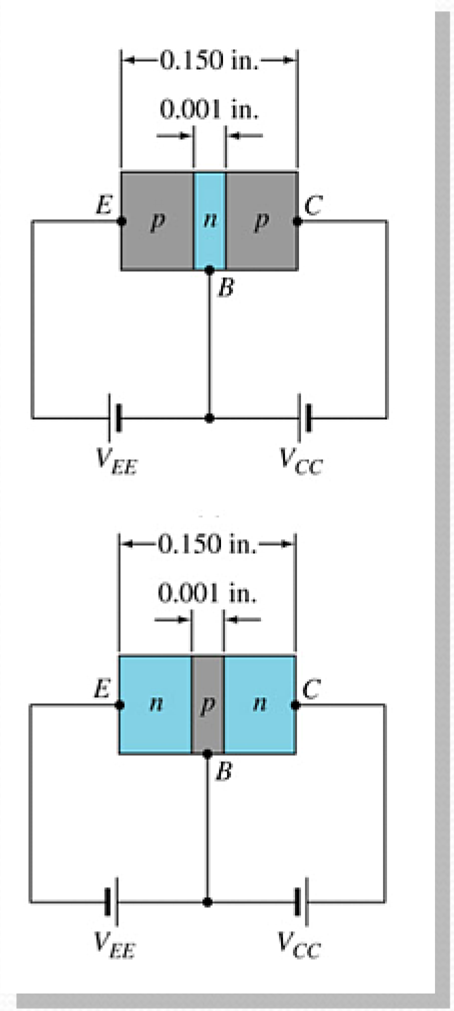


2. **NPN**

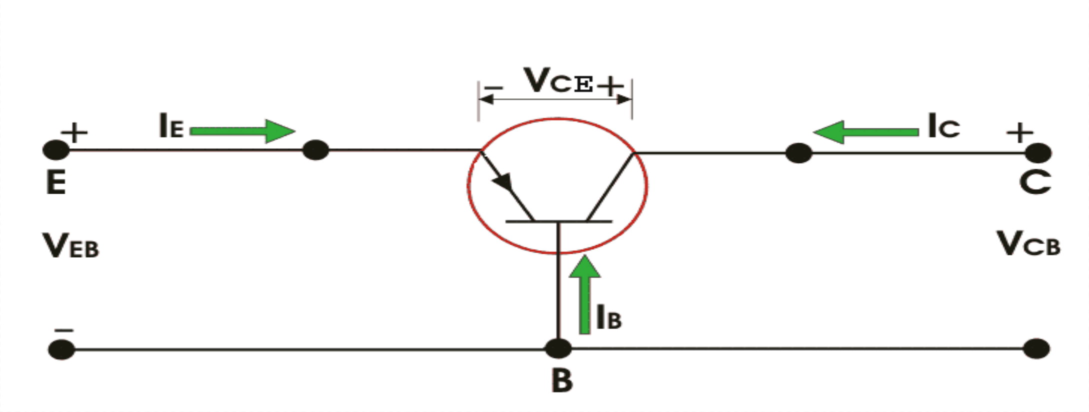


The terminals are labeled:

- **E - Emitter**
- **B - Base**
- **C - Collector**



Working of BJT



- Figure shows an n-p-n transistor biased in the active region. the BE junction is forward biased whereas the CB junction is reversed biased. The width of the depletion region of the BE junction is small as compared to that of the CB junction.
- The forward bias at the BE junction reduces the barrier potential and causes the electrons to flow from the emitter to base.

- As the base is thin and lightly doped it consists of very few holes so some of the electrons from the emitter (about 2%) recombine with the holes present in the base region and flow out of the base terminal.
- This constitutes the base current, it flows due to recombination of electrons and holes.
- The remaining large number of electrons will cross the reverse biased collector junction to constitute the collector current. Thus by KCL,

$$I_E = I_B + I_C$$

- The base current is very small as compared to emitter and collector current.

Therefore $I_E \sim I_C$

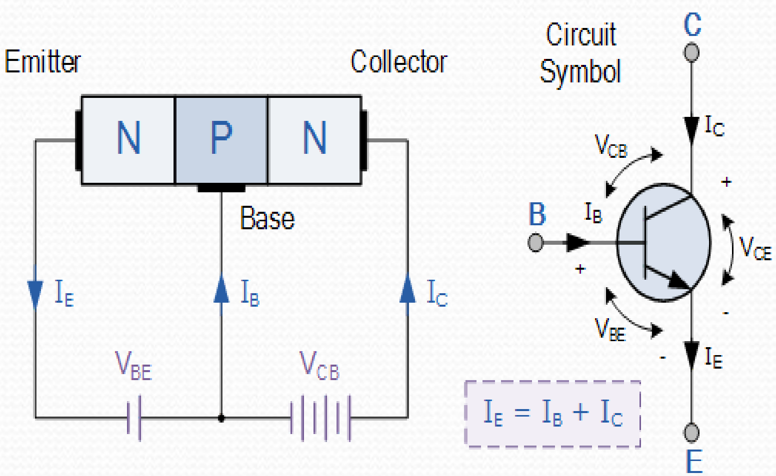
Configuration of BJT

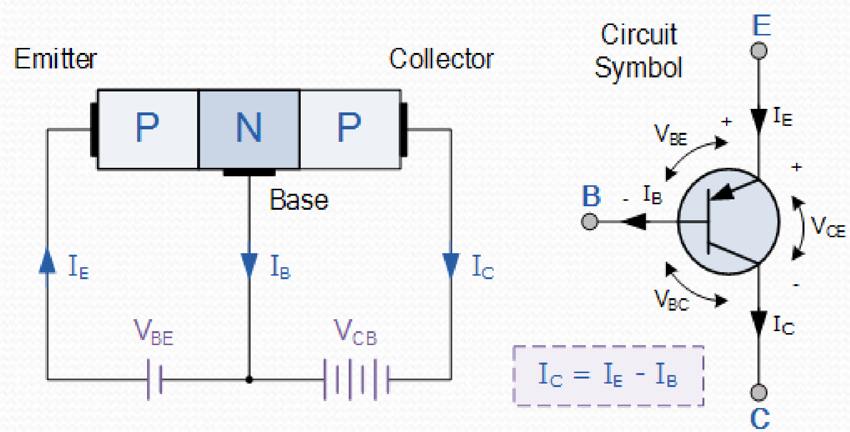
There are three types of BJT Configuration on the basis of biasing.

1. Common Base (CB) Configuration
2. Common Emitter (CE) Configuration
3. Common Collector (CC) Configuration

Common Base (CB) Configuration

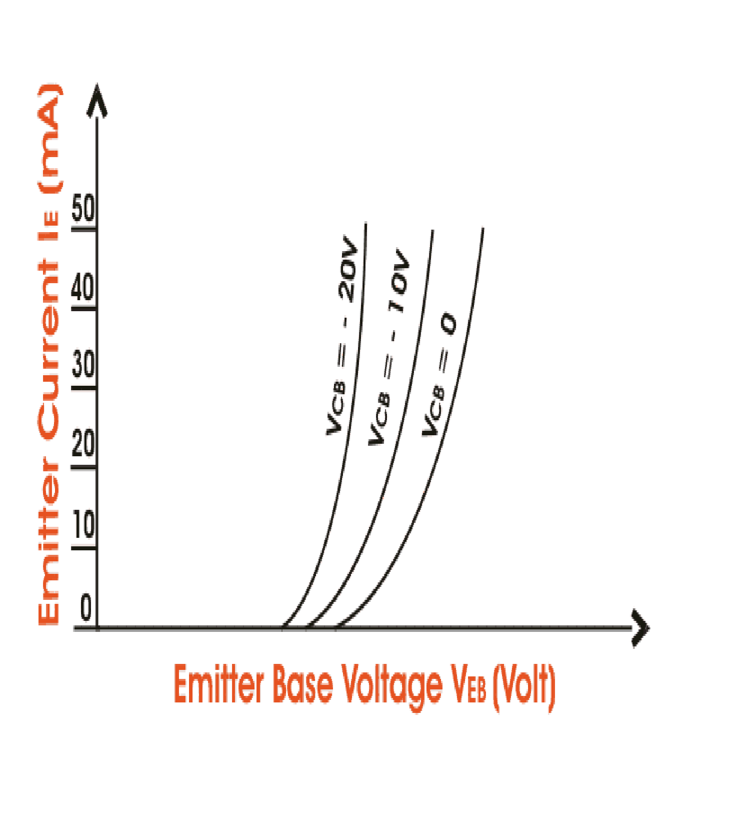
- In this configuration we use base as common terminal for both input and output signals. The configuration name itself indicates the common terminal. Here the input is applied between the base and emitter terminals and the corresponding output signal is taken between the base and collector terminals with the base terminal grounded. Here the input parameters are V_{EB} and I_E and the output parameters are V_{CB} and I_C.



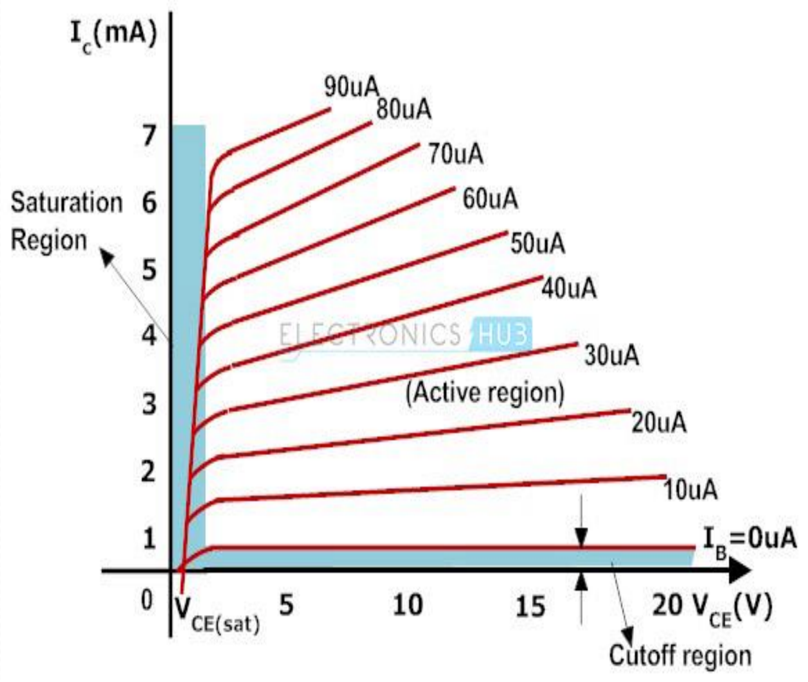


Input And Output Characteristics

Input Characteristic



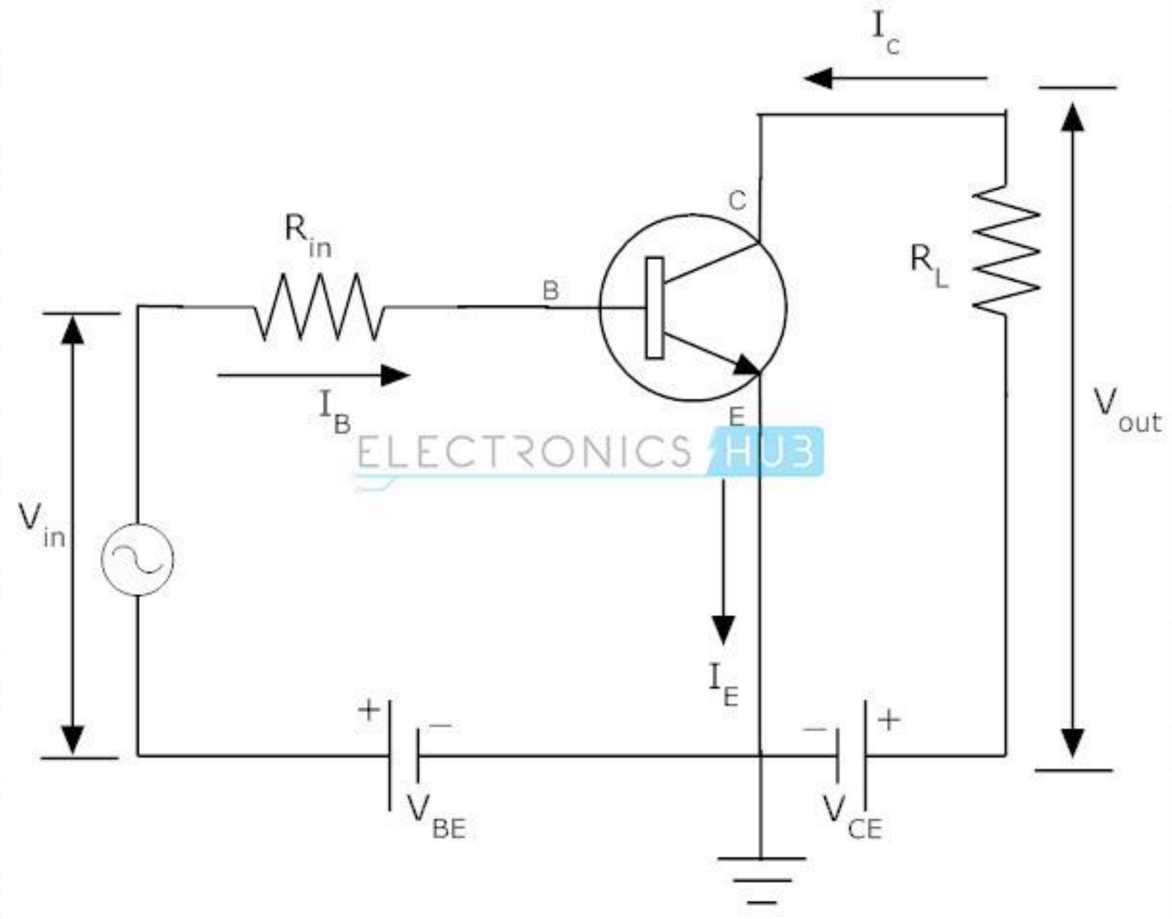
Output Characteristic



Common Emitter(CE) Configuration

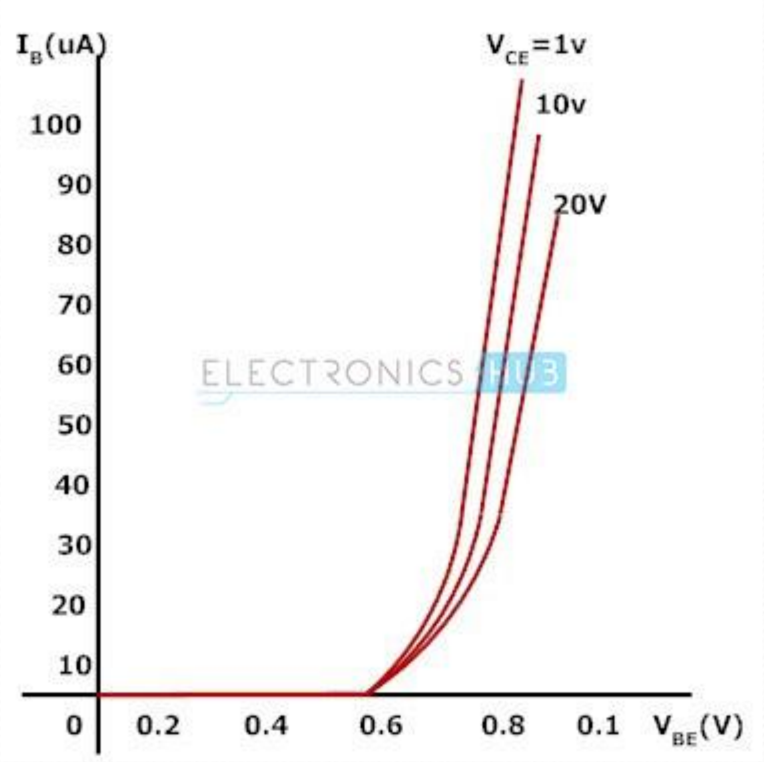
- In this configuration we use emitter as common terminal for both input and output. Here the input is applied between base-emitter region and the output is taken between collector and emitter terminals. In this configuration the input parameters are V_{BE} and I_B and the output parameters are V_{CE} and I_C.

Circuit for CE Configuration

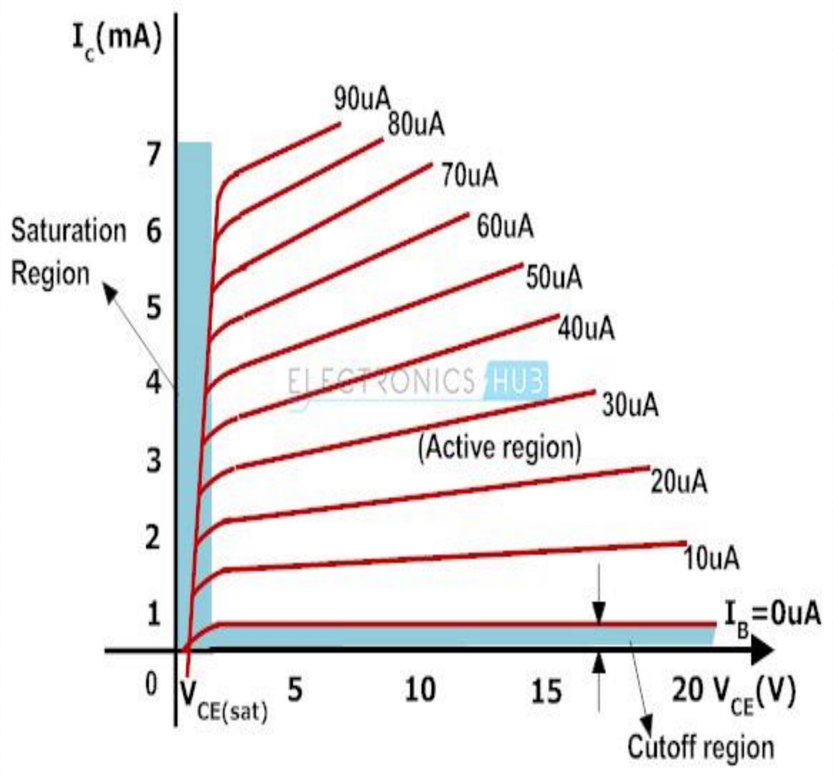


Input And Output Characteristics

Input Characteristics

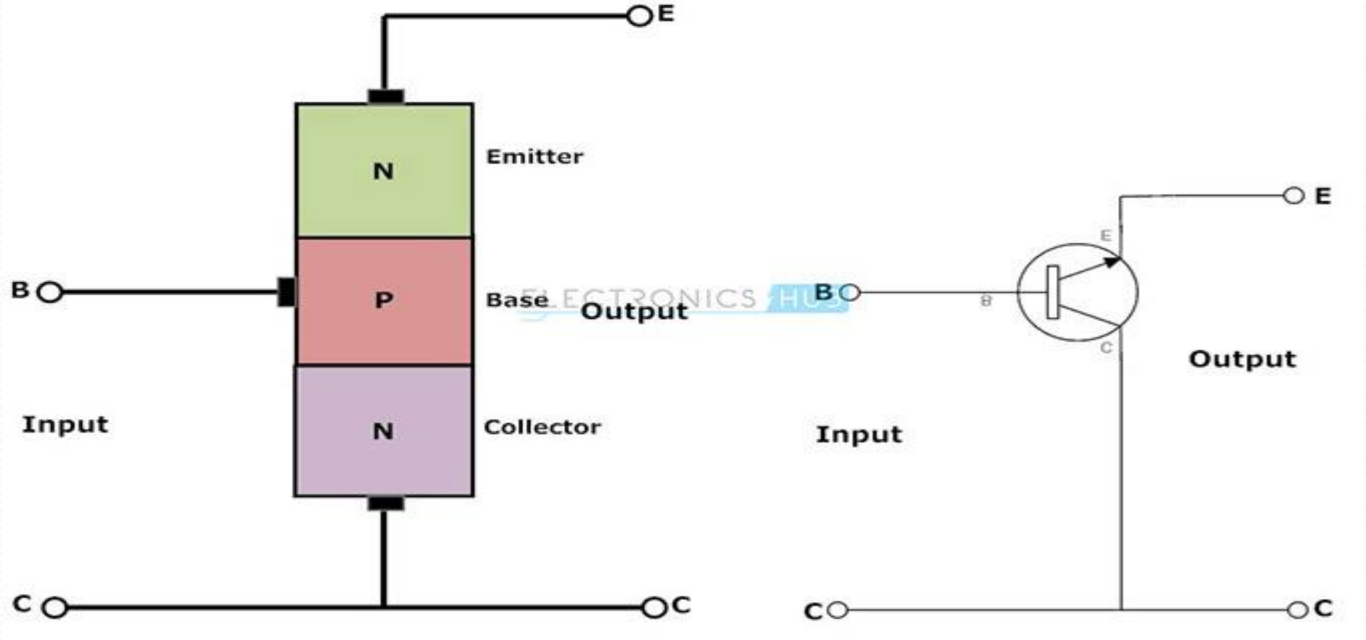


Output Characteristics

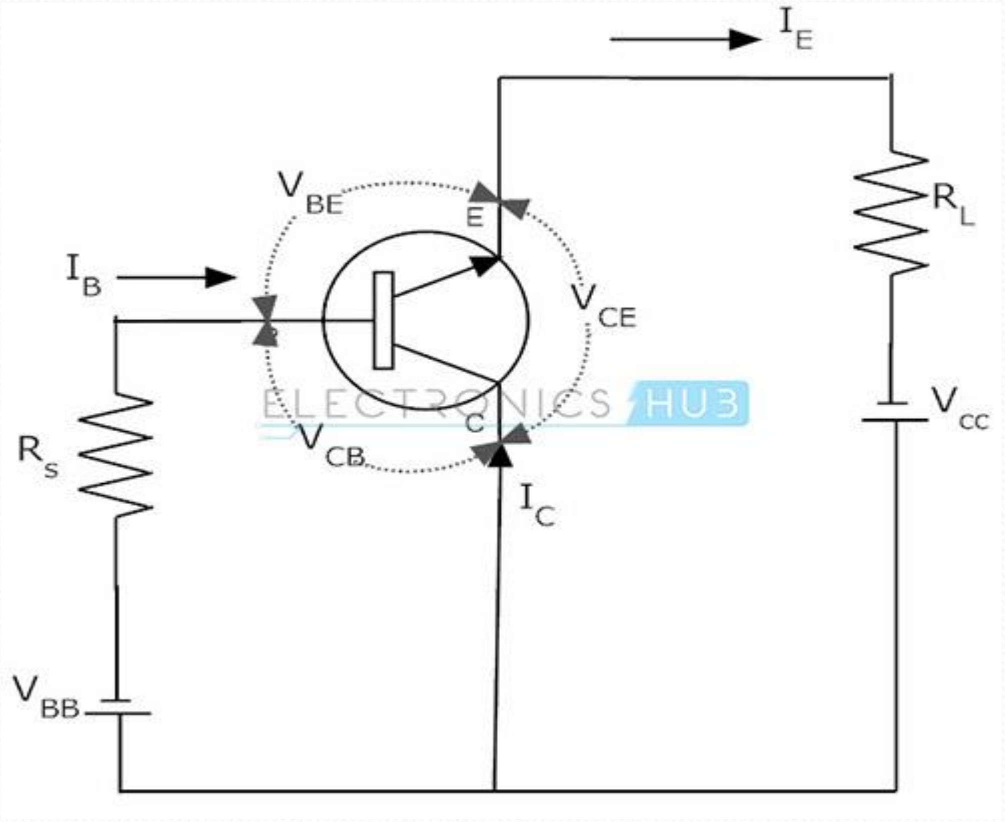


Common Collector[CC] Configuration

- In this configuration the input signal is applied between the base-collector region and the output is taken from the emitter-collector region. Here the input parameters are V_{BC} and I_B and the output parameters are V_{EC} and I_E. The common collector configuration has high input impedance and low output impedance.



Circuit for CC Configuration



Operating Regions

- **Active** – **Operating range of the amplifier.**
- **Cutoff** – **The amplifier is basically off. There is voltage, but little current.**
- **Saturation** – **The amplifier is full on. There is current, but little voltage.**

Emitter and collector currents: $I_C \cong I_E$

Base-emitter voltage: $V_{BE} = 0.7\ V$ **(for Silicon)**

Relationship between amplification factors α(Alfa) β(Beta)

1. Emitter Current in Transistor

$I_E = I_C + I_B$

2. Amplification Gain for CB

$\alpha = I_C / I_E$

3. Amplification Gain for CE

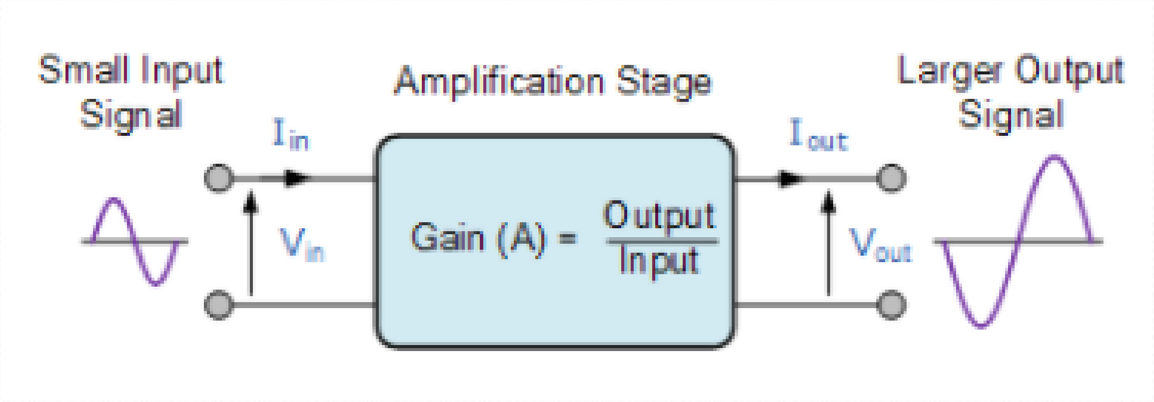
$\beta = I_C / I_B$

$$\alpha = \frac{\beta}{\beta + 1} \qquad \beta = \frac{\alpha}{\alpha - 1}$$

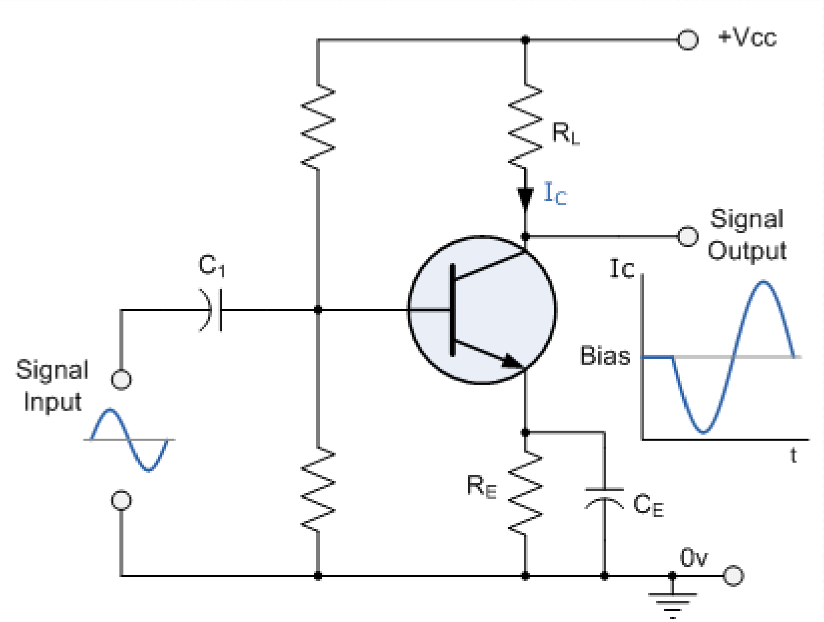
Transistor Characteristics

Amplifier (Definition)

An amplifier is an electronic device that increases the voltage, current, or power level of a signal. Amplifiers are commonly used in electronic devices, wireless communications and broadcasting.



Voltage Amplifier

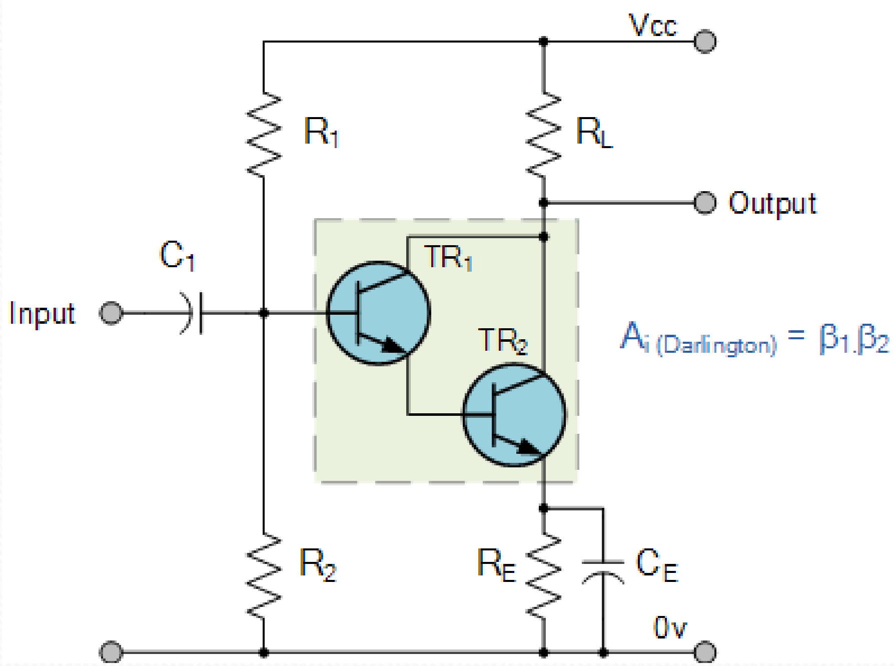


$$V_i = V_{be}$$

$$V_{out} = V_c = V_{cc} - I_c R_c$$

$$\text{Gain} = A_v = V_{out}/V_{in} = V_c/V_b$$

Current Amplifier (Darlington Transistor Configuration)

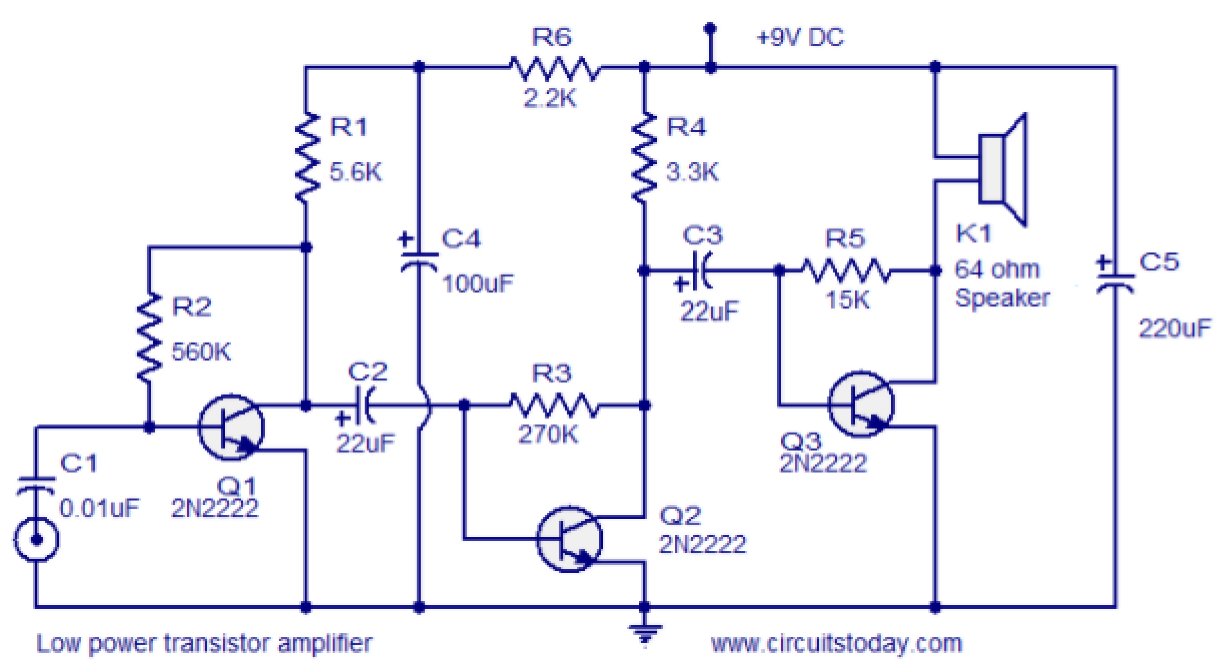


$$I_{e1} \cong \beta_{ac1} I_{b1}$$

$$I_{e2} \cong \beta_{ac2} I_{e1} = \beta_{ac1}\beta_{ac2} I_{b1}$$

$$\beta_{ac} = \beta_{ac1}\beta_{ac2}$$

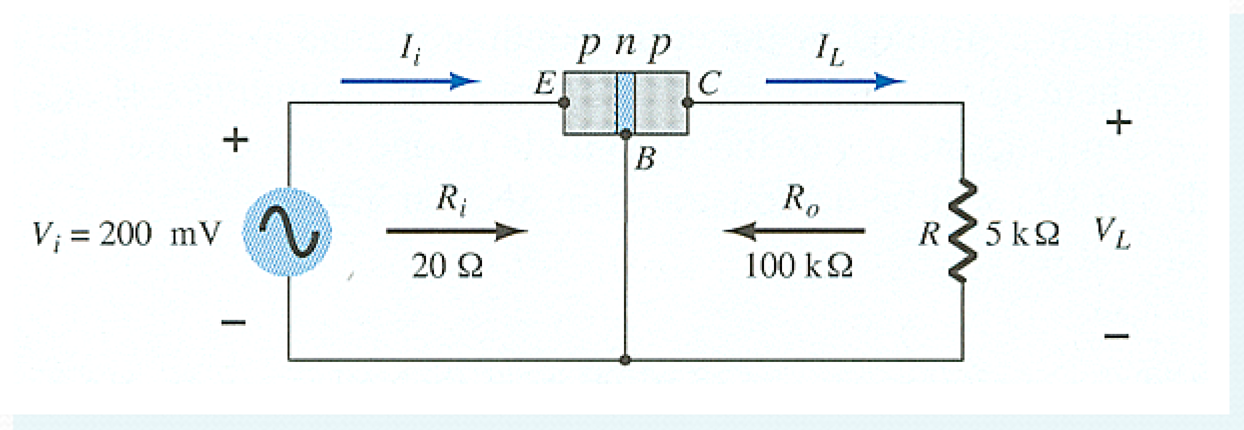
Power Amplifier



$$A_p = A_v A_i$$

Power Gain = Voltage Gain * Current Gain

Numerical Example



Currents and Voltages:

$$I_E = I_i = \frac{V_i}{R_i} = \frac{200\text{mV}}{20\Omega} = 10\text{mA}$$

$$I_C \cong I_E$$

$$I_L \cong I_i = 10\text{ mA}$$

$$V_L = I_L R = (10\text{ ma})(5\text{ k}\Omega) = 50\text{ V}$$

Voltage Gain:

$$A_v = \frac{V_L}{V_i} = \frac{50\text{V}}{200\text{mV}} = 250$$

Query