Basic Electronics

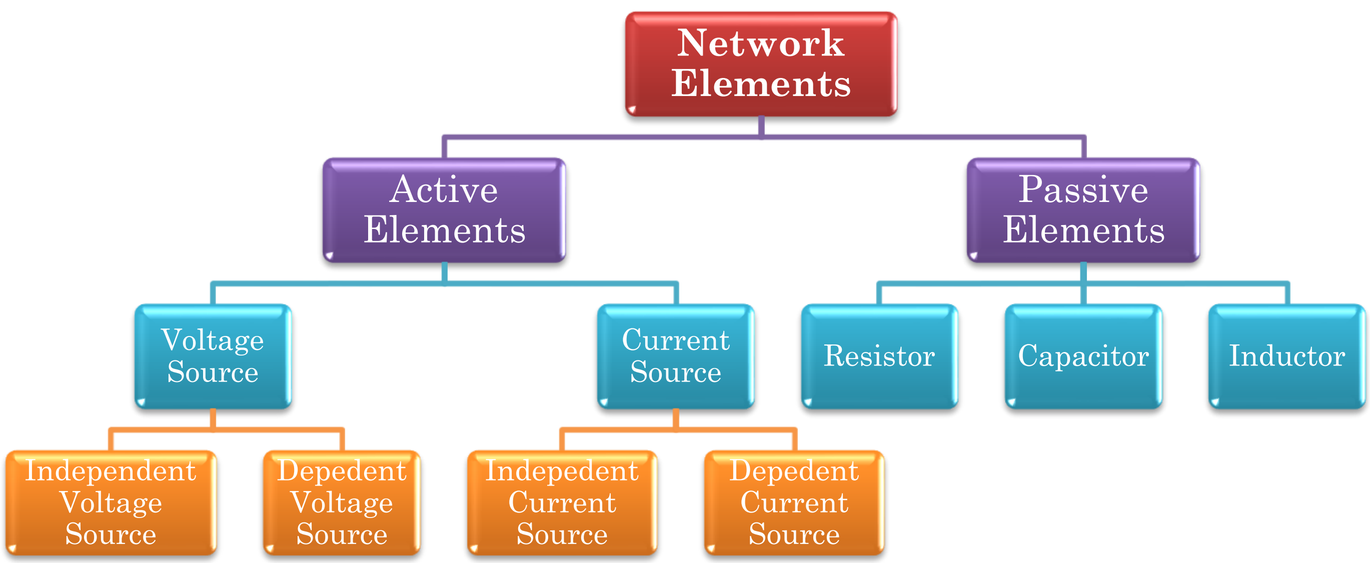
Unit I:

Basic Circuits analysis:

Network elements classification

Network: - It is an arrangement of various electrical energy sources along with different circuit elements.

Network elements: - Any individual circuit element with two terminals which can be connected to other circuit elements is called network elements.



- So, network elements can be either active or passive elements.
  - ⇒ **Active Elements** are the elements which supply power or energy to the network.
    - o **Example: -** Voltage Source & Current Source
  - ⇒ **Passive Elements** are the elements which either store or dissipate energy in the form of heat.
    - o **Example: -** Resistor, Inductor & Capacitor. (Inductor & Capacitor can store energy and resistor dissipates energy in the form of heat.)

- Network elements are classified into different types depending on the behavior & characteristics of its elements.

Classification of Network elements: -

- **i.** Linear Network *(or)* Non-Linear Network
- **ii.** Unilateral Network *(or)* Bilateral Network
- **iii.** Time Variant Network *(or)* Time Invariant Network
- **iv.** Lumped Network *(or)* Distributed Network

i. **Linear Network: -** A network whose parameters (resistance, inductance & capacitance) are always constant irrespective of the change in time, voltage, temperature etc. is known as *Linear Network.*
Non-linear Network: - A network whose parameters change their values with change in time, voltage, temperature etc. is known as *Non-linear Network.*

ii. **Unilateral Network: -** A network whose behavior is dependent on the direction of the current flow through various elements is called *Unilateral Network.*
Example: Network consists of diodes, which allows flow of current in only one direction.
Bilateral Network: - A network whose behavior is irrespective of the direction of the current flow through various elements is called B*ilateral Network.*
Example: Network consists of only resistors.

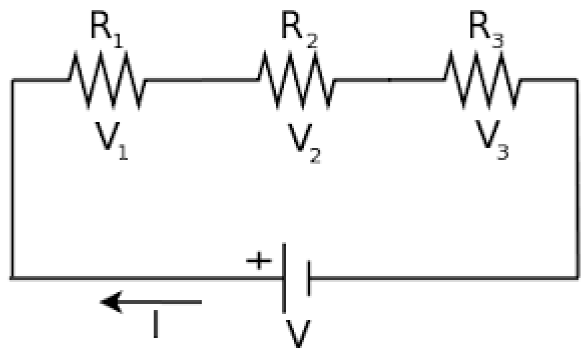
iii. **Time Variant network: -** A network whose parameters vary with time.
Time Invariant network: - A network whose parameters don't vary with time.

iv. **Lumped Network: -** A network in which all elements is physically separable.
Distributed Network: - A network in which circuit elements (resistance, capacitance & inductance) cannot be physically separable.

Kirchhoff's Voltage Law

Loop Rule

In any closed loop of electrical circuit, the algebraic sum of emfs of cell and the product of currents and resistance is always equal to zero. *(or)* The algebraic sum of the potential differences around any closed loop is equals to zero.



i.e. $\sum \Delta V = 0$ or $\sum E = \sum IR$

Consider the following diagram,

$V_1 + V_2 + V_3 - V_s = 0$

We know that,

$V_1 = IR_1 \;\; V_2 = IR_2 \;\; V_3 = IR_3$

So,

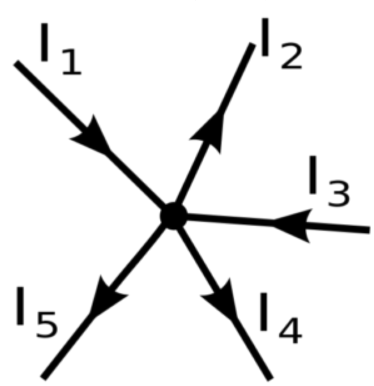
$V_s = IR_1 + IR_2 + IR_3 = I(R_1 + R_2 + R_3)$

$$\Rightarrow \boxed{I = \frac{V_S}{R_1+R_2+R_3}}$$

Kirchhoff's Current Law

Junction Rule

The algebraic sum of electric currents at any junction of electric circuit is equals to zero. *(or)* The sum of current entering into a junction is equal to the sum of current leaving the junction.



i.e. $\sum I = 0$

Consider the following diagram,

$I_1 + I_3 = I_2 + I_4 + I_5$

$I_1 + I_3 - I_2 - I_4 - I_5 = 0$

$$\Rightarrow \boxed{\sum I = 0}$$

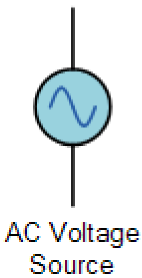
Series and Parallel Connected Independent sources

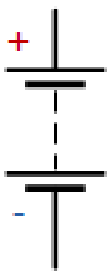
Independent Sources: They are of two types: -

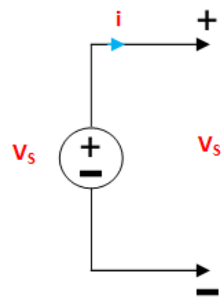
i) Independent Voltage Source
ii) Independent Current Source

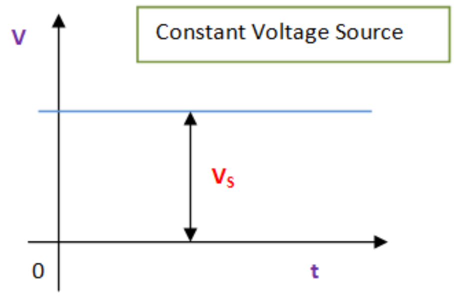
I) **Independent Voltage Source :** It is the property of source that voltage across its terminals is:

a) Independent of current passing through it.
b) It can be specified independently of any other variable in circuit.
c) Symbolic representation.









II) **Independent Current Source: -** It delivers constant current which is independent of the voltage across its terminals.
It can be specified independently of any other variables.

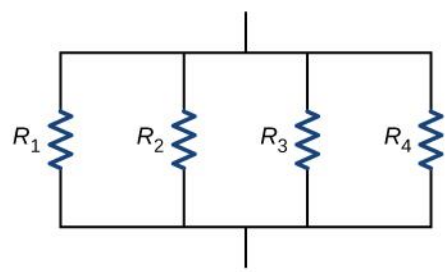
Resistor in series and parallel

a) Resistors in Series

⇒ In this combination, different resistors are connected end to end.
⇒ Equivalent resistance can be obtained by the formula,

$$\boxed{R_{eq} = R_1 + R_2 + \cdots + R_n}$$

(a) Resistors connected in series



(b) Resistors connected in parallel

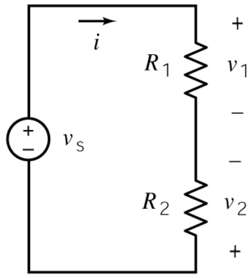
b) Resistors in Parallel

⇒ In this combination, first end of all the resistors are connected to one point and last end of the resistors are connected to other point.
⇒ Equivalent resistance can be obtained by the formula,

$$\boxed{\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}}$$

Voltage Division

Here are two drawings of the same circuit. The bottom circuit is a mirror image of the top circuit.

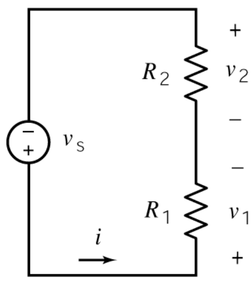


In both circuits:

$$i = \frac{v_s}{R_1 + R_2}$$

$$v_1 = \left(\frac{R_1}{R_1 + R_2}\right) v_s$$

$$v_2 = -\left(\frac{R_2}{R_1 + R_2}\right) v_s$$



There are two possible reference directions for source voltage: + on top or + on bottom. Similarly, there are two possible reference directions for the resistor voltage: + on top or + on bottom. Taken together, there are four possibilities for the source and resistor voltage reference directions. All four are illustrated by these two circuits.

Current Division

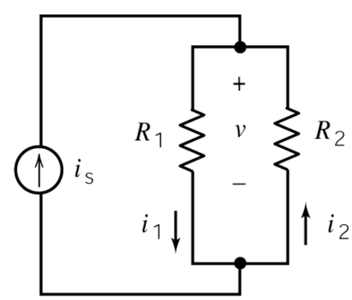
Here are two drawings of the same circuit. The bottom circuit is a mirror image of the top circuit.

In both circuits:

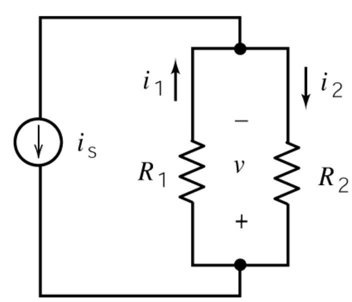
$$v = (\frac{R_1 R_2}{R_1 + R_2}) i_s$$

$$i_1 = \left(\frac{R_2}{R_1 + R_2}\right) i_s$$

$$i_2 = -\left(\frac{R_1}{R_1 + R_2}\right) i_s$$



There are two possible reference directions for the source current: downward or upward. Similarly, there are two possible reference directions for the resistor current: downward or upward. Taken together, there are four possibilities for the source and resistor current reference directions. All four are illustrated by these two circuits.



Unit II:

Semiconductor devices:

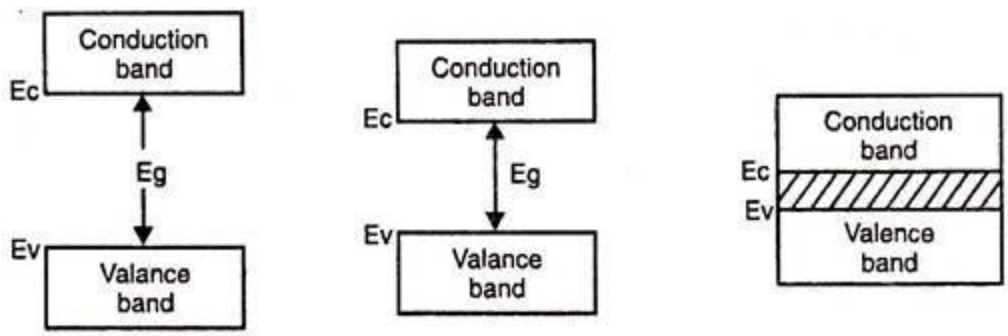
Introduction to semiconductor materials

Classification of Materials:

On the basis of the relative value of electrical conductivity (σ) or resistivity ($\rho = 1/\sigma$) the solids are broadly classified as:

1) **Metals:** They possess very low resistivity or high conductivity.
   $\rho \sim 10^{-2}–10^{-8}\Omega m, \boldsymbol{\sigma} \sim 10^{-2}–10^{-8}Sm^{-1}$
2) **Semiconductors:** They have resistivity or conductivity intermediate to metals and insulators.
   $\rho \sim 10^{-5}–10^{-6}\Omega m, \boldsymbol{\sigma} \sim 10^{-5}–10^{0}Sm^{-1}$
3) **Insulators:** They have high resistivity or low conductivity.
   $\rho \sim 10^{11}–10^{19}\Omega m, \boldsymbol{\sigma} \sim 10^{-11}–10^{-19}Sm^{-1}$

The electrical conductivity of a material is understood with the help of energy band diagrams:



(*a*) Insulator (*b*) Semiconductor (*c*) Conductor

Semiconductors

Semiconductors are the materials whose conductivity is lies between metals and insulators. They are characterized by narrow energy gap (~1eV) between the valence band and conduction band.

On the basis of purity semiconductor can be classified as

Intrinsic Semiconductors

It is a pure semiconductor without any significant dopant species present.

$$n_e = n_h = n_i$$

where, $n_e and\, n_h$ are number densities of electrons and holes respectively and n_i is called intrinsic carries concentration. An intrinsic semiconductor is also called an **undoped semiconductor** or **i-type semiconductor.**

The total current I is the sum of the electron current $I_e$and hole currentI_h.

$$I = I_e + I_h$$

Extrinsic Semiconductors

Apure semiconductor when doped with the impurity, it is known as extrinsic semiconductor.

Extrinsic semiconductors are basically of two types:

i) **n-type Semiconductor**

In this type of extrinsic semiconductor, majority charge carriers are electrons and minority charge carriers are holes, i.e. $n_e > n_h$.

Here, we dope a tetravalent element like Si or Ge with a pentavalent element, such as As, P or Sb of group V, then four of its electrons bond with the four silicon neighbors, while fifth remains very weakly bound to its parent atom.

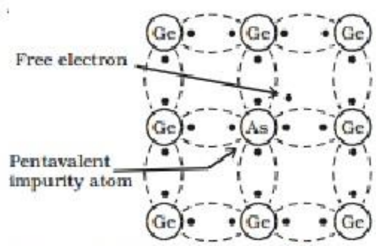


Fig a N-type semiconductor

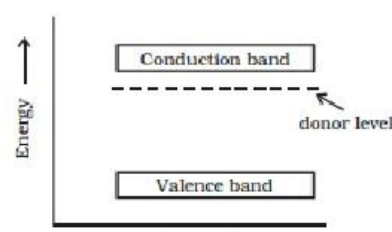
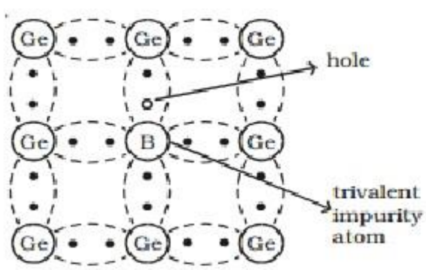


Fig b Energy band diagram of N-type semiconductor



a P-type semiconductor

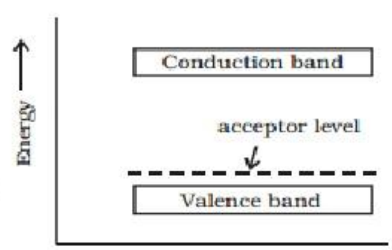


Fig b Energy band diagram of a P-type semiconductor

ii) **p-type Semiconductor**

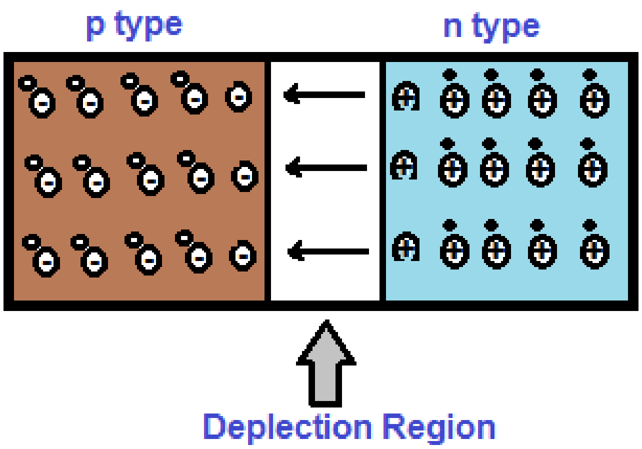
In this semiconductor, majority charge carriers are holes and minority charge carriers are electrons i.e. $n_h > n_e$.

In a p-type semiconductor, doping of tetravalent atoms is done with trivalent impurity atoms such as Al, B, i.e. those atoms which have three valence electrons in their valence shell.

Operation and characteristics of p-n junction diode

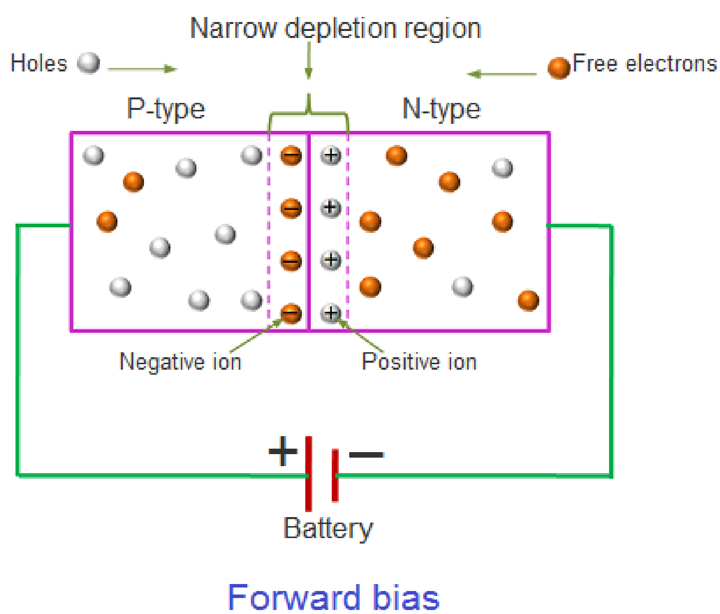
p-n Junction

A p-n junction is an arrangement made by a close contact of n-type semiconductor with p-type semiconductor.



Forward Bias P-N Junction Diode

Junction diode is said to be forward biased when the positive terminal of the external battery is connected to the p-side and negative terminal to the n-side of the diode. When an external voltage is applied to it in such a direction that it cancels the potential barrier and permits the current flow.



Here, the current flows across the junction, the holes from P-type semiconductor are repelled form positive terminal of battery towards the junction & simultaneously, the electrons in N-type semiconductor are repelled by negative battery terminal toward junction.

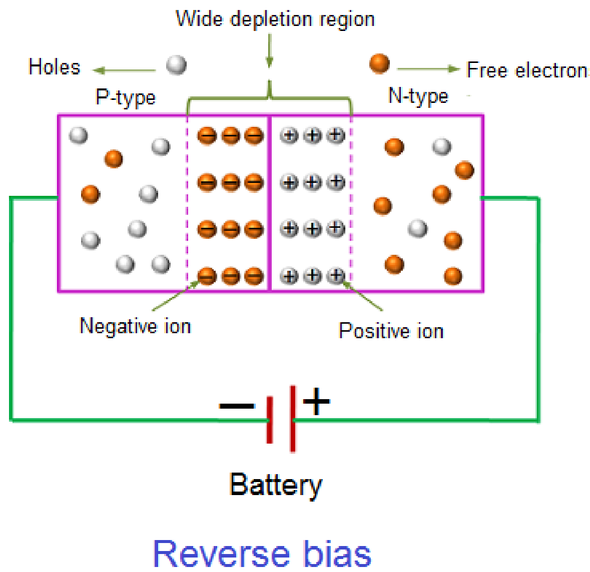
When an electron-hole combination takes place near the junction, a covalent bond near positive terminal of battery breaks down. This causes the liberation of an electron which enters the positive terminal and new hole is moved towards the junction.

This constant movement of electrons towards the positive terminal and the holes towards the negative terminal produces a high forward current.

Reverse Bias P-N Junction Diode

If the positive terminal of a battery is connected to n-side and negative terminal to the p-side, then the p-n junction is said to be reverse biased. When an external voltage is applied to it in such a direction that it increases the potential barrier.

Here, the applied reverse voltage establishes an electric field which acts in the same direction of potential barrier. Therefore, the resultant field at the junction is strengthened and the barrier height is increased and it prevents the flow of charge carriers across the junction. In this way a high resistance path is established.



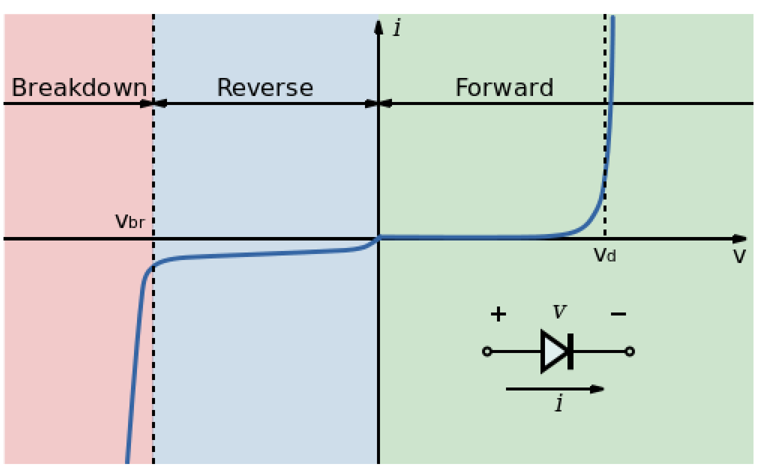
When the junction is reversed biased the electrons in N-type and holes in P-type semiconductor are attracted away from the junction. Since there is no recombination of electron-hole pairs, no current flows in the circuit.

Forward Biased Characteristic

- In forward biasing width of depletion layer decreases.
- In forward biasing resistance offered $R_{forward} \approx 10\Omega - 25\Omega$

Reverse Biased Characteristic

- In reverse biased, the applied voltage supports the flow of minority charge carriers across the junction. So, very small current flows across the junction due to minority charge carriers.



Diode resistance (Static and Dynamic)

A p-n junction diode allows electric current in one direction and blocks electric current in another direction. It allows electric current when it is forward biased and blocks electric current when it is reverse biased. However, no diode allows electric current completely even in forward biased condition.

The depletion region present in a diode acts like barrier to electric current. Hence, it offers resistance to the electric current. Also, the atoms present in the diode provide some resistance to the electric current.

When charge carriers (free electrons and holes) flowing through the diode collides with atoms, they lose energy in the form of heat. Thus, depletion region and atoms offer resistance to the electric current.

When forward biased voltage is applied to the p-n junction diode, the width of depletion region decreases. However, the depletion region cannot be completely vanished. There exists a thin depletion region or depletion layer in the forward biased diode. Therefore, a thin depletion region and atoms in the diode offer some resistance to electric current. This resistance is called forward resistance.

When the diode is reversed biased the width of depletion region increases. As a result, a large number of charge carriers (free electrons and holes) flowing through the diode will be blocked by the depletion region.

In a reverse biased diode, only a small amount of electric current flows. The minority carriers present in the diode carry this electric current. Thus, reverse biased diode offer large resistance to the electric current. This resistance is called reverse resistance.

The two types of resistance takes place in the p-n junction diode are:

- Forward resistance
- Reverse resistance

Forward resistance

Forward resistance is a resistance offered by the p-n junction diode when it is forward biased.

In a forward biased p-n junction diode, two type of resistance takes place based on the voltage applied.

The two types of resistance takes place in forward biased diode are

- Static resistance or DC resistance
- Dynamic resistance or AC resistance

Static resistance or DC resistance

When forward biased voltage is applied to a diode that is connected to a DC circuit, a DC or direct current flows through the diode. Direct current or electric current is nothing but the flow of charge carriers (free electrons or holes) through a conductor. In DC circuit, the charge carriers flow steadily in single direction or forward direction.

The resistance offered by a p-n junction diode when it is connected to a DC circuit is called static resistance.

Static resistance is also defined as the ratio of DC voltage applied across diode to the DC current or direct current flowing through the diode.

The resistance offered by the p-n junction diode under forward biased condition is denoted as R_f.

$$R_f = \frac{\text{DC voltage}}{\text{DC current}}$$

Dynamic resistance or AC resistance

The dynamic resistance is the resistance offered by the p-n junction diode when AC voltage is applied.

When forward biased voltage is applied to a diode that is connected to AC circuit, an AC or alternating current flows though the diode.

In AC circuit, charge carriers or electric current does not flow in single direction. It flows in both forward and reverse direction.

Dynamic resistance is also defined as the ratio of change in voltage to the change in current. It is denoted as r_f.

$$r_f = \frac{\text{Change in voltage}}{\text{Change in current}}$$

Reverse resistance

Reverse resistance is the resistance offered by the p-n junction diode when it is reverse biased.

When reverse biased voltage is applied to the p-n junction diode, the width of depletion region increases. This depletion region acts as barrier to the electric current. Hence, a large amount of electric current is blocked by the depletion region. Thus, reverse biased diode offer large resistance to the electric current.

The resistance offered by the reverse biased p-n junction diode is very large compared to the forward biased diode. The reverse resistance is in the range of mega ohms (MΩ).

Diode junction capacitance

In a *p-n junction diode,* two types of capacitance take place. They are,

- Transition capacitance (C_T)
- Diffusion capacitance (C_D)

Transition capacitance (C_T)

When a P-N junction is reverse-biased, the depletion region acts like an insulator or dielectric material while a P and N-type region acts as the plate. In this way P-N junction may be regarded as parallel plate capacitor. The junction capacitance is called the transition capacitance and denoted by C_T.

$$C_T = dQ / dV$$

Where,

CT = Transition capacitance

dQ = Change in electric charge dV = Change in voltage

The transition capacitance can be mathematically written as,

$$C_T = \varepsilon A / W$$

Where,

ε = Permittivity of the semiconductor

A = Area of plates or p-type and n-type regions

W = Width of depletion region

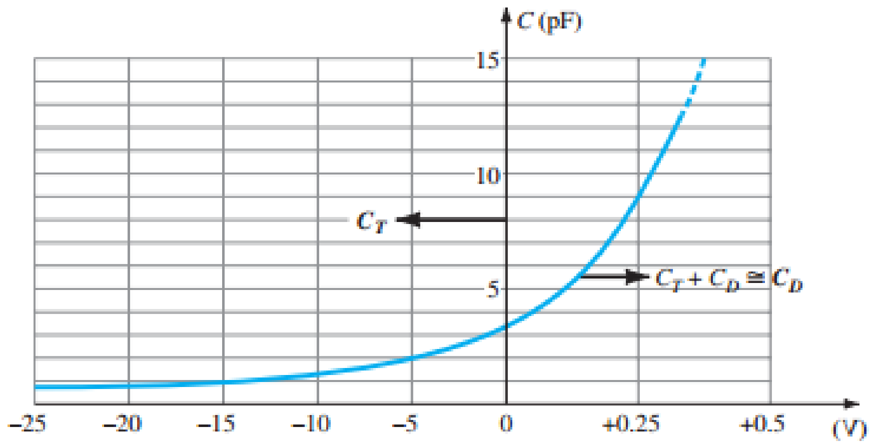


FIG. 1.33

Transition and diffusion capacitance versus applied bias for a silicon diode.

Diffusion capacitance (C_D)

When the diode is forward biased the width of the depletion region depletes and holes from P-side get diffused into N-side while the electrons from N-side move into the P-side. As the applied voltage increases diffused charge carriers also increases.

The rate of change of diffused charge with applied voltage is known as diffusion capacitance.

$$C_D = dQ / dV$$

$$C_D = \boldsymbol{\tau I}/\eta \boldsymbol{V_f}$$

Where,

C_D = Diffusion capacitance

dQ = Change in number of minority carriers stored outside the depletion region

dV = Change in voltage applied across diode

$\boldsymbol{\tau}$ = mean life time of carrier

η = constant (1 for Ge & 2 for Si)

$\boldsymbol{V_f}$ = volt quivalent of temperature

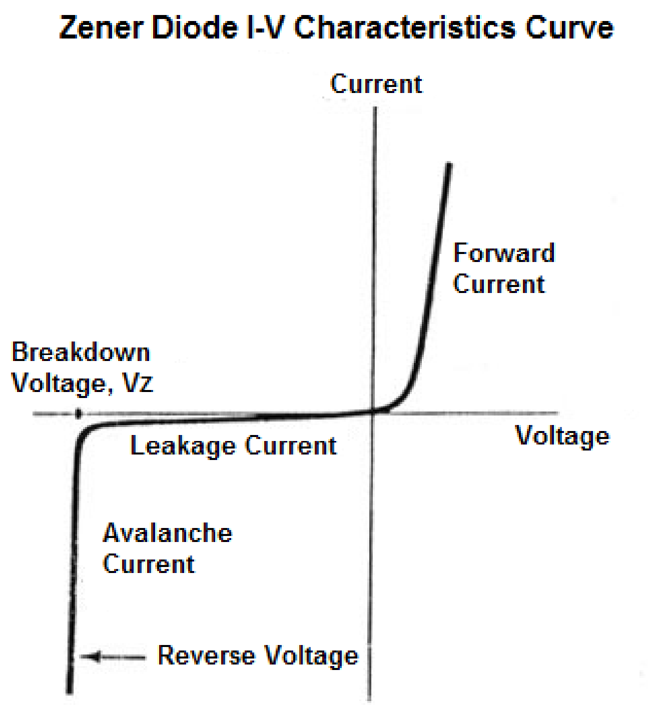
I = forward current

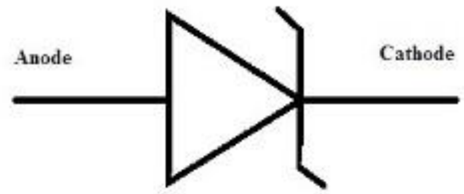
Special Diodes

Zener diode

Zener diode is a reverse biased heavily doped p-n junction diode. It is operated in breakdown region.

V-I characteristics of Zener Diode are shown below:





i) **Zener Diode as a Voltage Regulator**
When the applied reverse voltage *(V)* reaches the breakdown voltage *(V_z)* of the Zener diode there is a large change in the current. So, after the breakdown voltageV_z, produced by almost insignificant change in the reverse bias voltage i.e. Zener voltage remains constant even though the current through the Zener diode varies over a wide range.

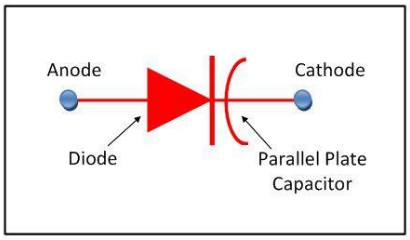
ii) This breakdown in a diode due to the band to band tunneling is called **Zener breakdown.**

Applications:

- **Zener diodes** are used for:
  - **i)** Voltage regulation,
  - **ii)** Surge suppressors
  - **iii)** Switching **applications** and clipper circuits

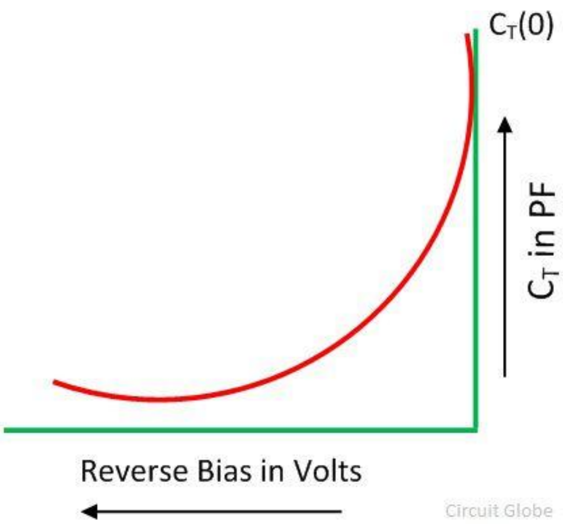
Varactor diode

The diode whose internal capacitance varies with the variation of the reverse voltage such type of diode is known as the **Varactor diode**. It is used for storing the charge. The Varactor diode always works in reverse bias, and it is a voltage-dependent semiconductor device.



Characteristic of Varactor Diode

The characteristic curve of the Varactor diode is shown in the figure below. The graph shows that when the reverse bias voltage increases the depletion region increases, and the capacitance of the diode reduces.



Applications of Varactor Current:

Owing to the special property of varying capacitance with varying voltage, Varactor diodes are mostly used in frequency modulation or tuning circuits where the value of capacitance determines the output modulation frequency. Some of the other applications include:

i. Automatic Frequency Controllers (AFCs)
ii. Ultra-High Frequency Television sets
iii. High frequency Radios
iv. Frequency Multipliers
v. Band Pass Filters
vi. Harmonic Generator

Light Emitting Diode (LED)

It is a heavily doped forward biased p-n junction diode which spontaneously converts electrical energy into light energy.

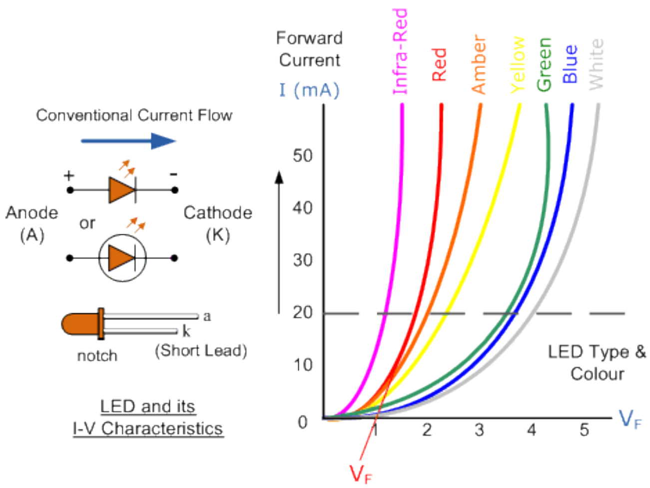
Advantages of LED:

a) Fast action and no warm up time required
b) It is nearly monochromatic
c) Low operational voltage and less power consumed, long life, ruggedness
d) Fast ON-OFF switching capability in nanoseconds

Disadvantages of LED:

a) High up-front costs
b) Potential color shift over lamp life
c) Performance standardization has not yet been streamlined.

V-I characteristics of LED are shown below:

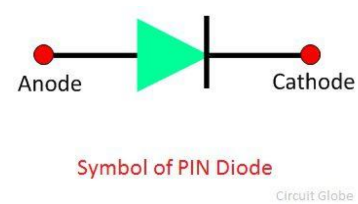


Liquid Crystal Display (LCD)

Liquid crystal display technology **works** by blocking light. Specifically, an **LCD** is made of two pieces of polarized glass (also called substrate) that contain a **liquid crystal** material between them. A backlight creates light that passes through the first substrate.

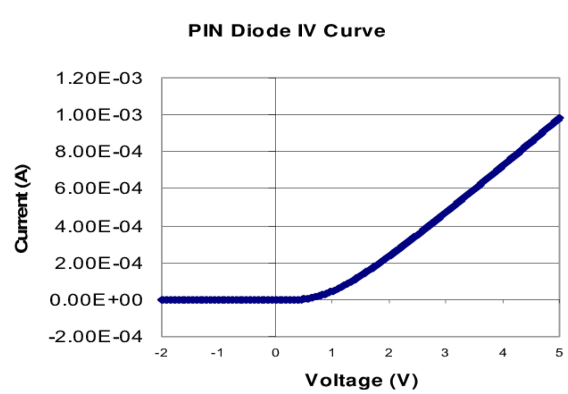
Applications of LCD:

a. The liquid crystal displays (LCDs) are used in **aircraft cockpit displays**.
b. It is used as a display screen in **calculators**.
c. For displaying images used in digital cameras.
d. The television is **main applications** of LCD.
e. Mostly the **computer monitor** is made up of LCDs.



PIN Diode

A **PIN diode** is a **diode** with a wide, undoped intrinsic semiconductor region between a p-type semiconductor and an n-type semiconductor region. The p-type and n-type regions are typically heavily doped because they are used for ohmic contacts.



Applications of **PIN Diodes**

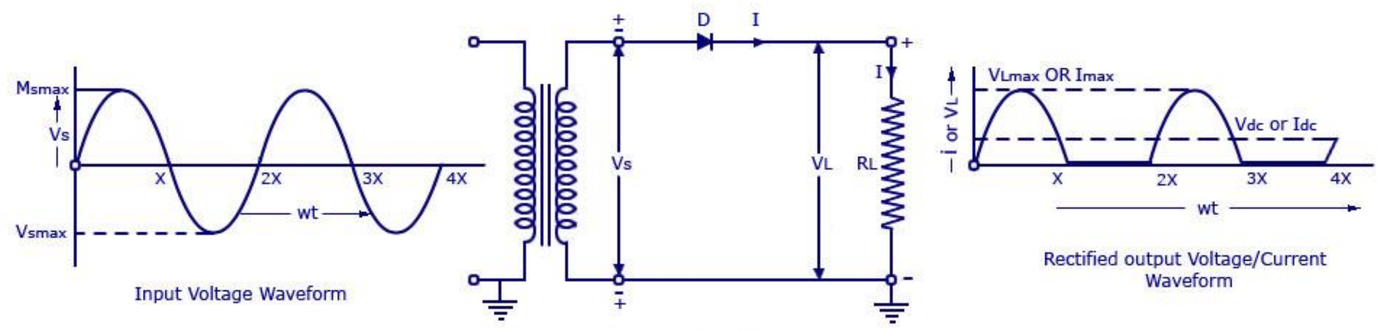
a) It is used as a **Photo Detector.**
b) Used in **electronic pre-amplifier.**
c) Used as a **variable resistor.**
d) Widely used in **RF modulator circuit**

Diode application: Rectifier

The process of converting alternating voltage/current into direct voltage/current is called **rectification.** Diode is used as a rectifier for converting alternating current/voltage into direct current/voltage. There are two ways of using diode as a rectifier.

I. Diode as a Half-Wave Rectifier

Diode conducts corresponding to positive half cycle and does not conduct during negative half cycle. Hence, AC is converted by diode into unidirectional pulsating DC. This action is known as **half-wave rectification.**

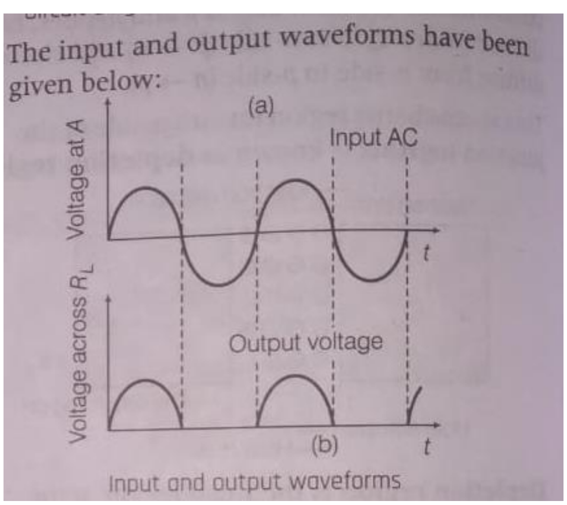


Half-Wave Rectifier

Ac voltage to be rectified is connected to the primary coil of a step-down transformer. Secondary coil is connected to the diode through resistors R_L, across which output is obtained.

Working:

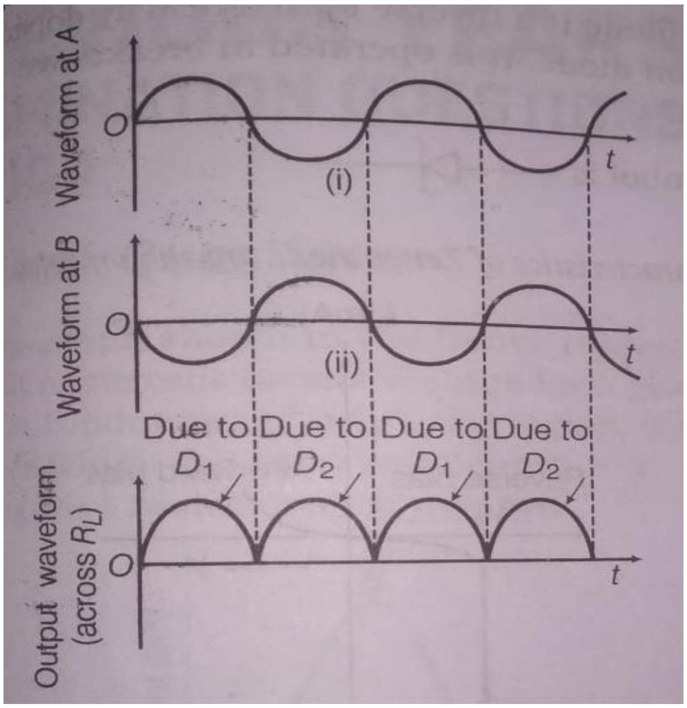
During positive half cycle of the input AC, the p-n junction is forward biased. Thus, the resistance in p-n junction becomes low and current flows. Hence, we get output in the load. During negative half cycle of the input AC, the p-n junction is high and current does not flow. Hence, no output in the load. So, for complete cycle of AC, current flows through the load resistance in the same direction.

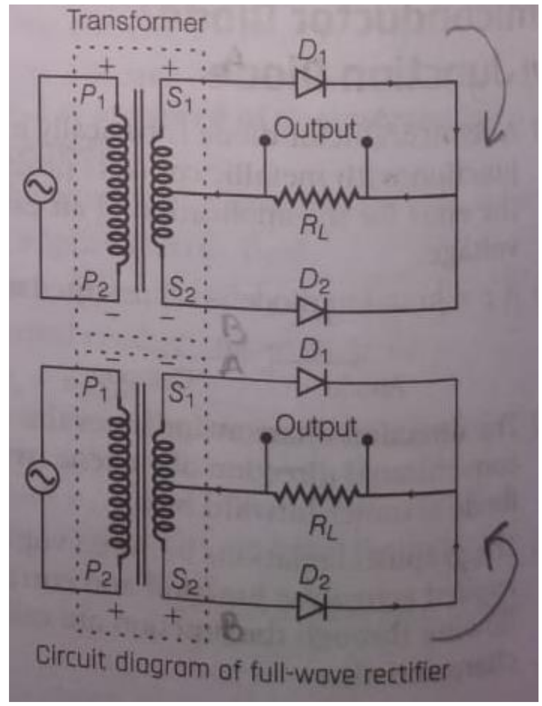


II. Diode as a Full-Wave Rectifier

In the full-wave rectifier, two p-n junction diodes, D_1 and D_2 are used. Its working is based on the principle that junction diode offer very low resistance in forward bias and very high resistance in reverse bias.

The input and output waveforms have been given below:





Circuit diagram of full-wave rectifier

Working:

During the first half cycle, the upper end of the coil is at positive potential and lower end at negative potential. The function diode D_1 is forward biased and D_2 in reverse biased. Current flows in output load in the direction shown in figure. During the second half of input cycle, D_2 is forward biased. In this way, current flows in the load in the single direction as shown in figure.

Key Points:

i) The average value or DC value obtained from a half-wave rectifier,

$$I_{DC} = I_0/\pi$$

ii) The average value or DC value obtained from a full-wave rectifier,

$$I_{DC} = 2I_0/\pi$$

iii) The pulse frequency of a half-wave rectifier is equal to frequency of AC.

iv) The pulse frequency of a full-wave rectifier is double to that of AC.

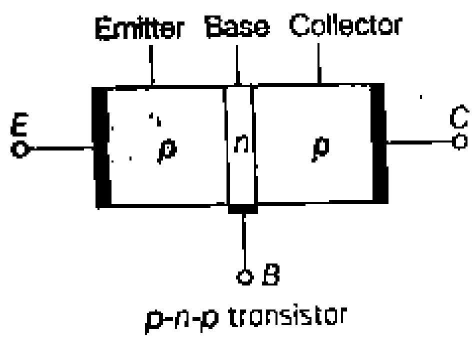
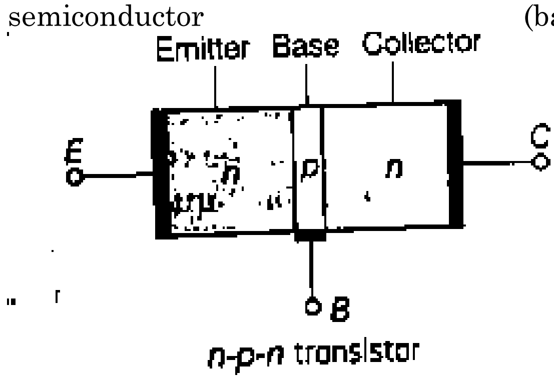
Unit III:

Transistors (BJT and FET):

Junction transistor

A junction transistor is three terminal semiconductor devices consisting of two p-n junctions formed by placing a thin layer of doped semiconductor (p-type or n-type) between two thick similar layers of opposite type.

There are two types of transistor:

<table>
<tr>
<td>p-n-p transistor
Here, two thicker segments of p-type (termed as emitter and collector) are separated by a segment of n-type semiconductor (base).
</td>
<td>n-p-n transistor
Here, two thicker segments of n-type semiconductor (emitter and collector) are separated by a segment of p-type semiconductor (base).
</td>
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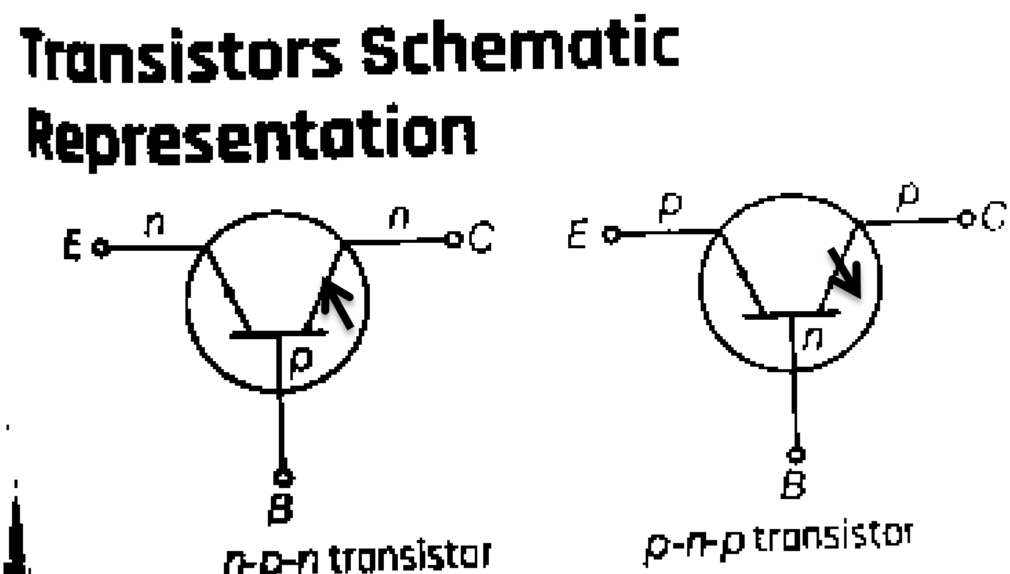
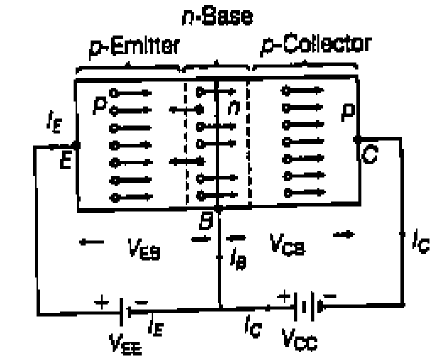


Transistor Action or Working of Transistor

p-n-p Transistor

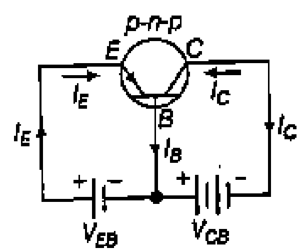
From given figure, we can see that, the emitter-base junction is forward biased. Collector-base junction is reversed biased.



Flow of charge carriers in *p-n-p* transistor

The resistance of emitter-base junction is very low. So, the voltage of $V_{EE}(V_{EB})$ is quite small (i.e., 1.5 V). The current in p-n-p transistor is carried by holes and at the same time their concentration is maintained.

But in external circuit, the current is due to the flow of electrons.



Action of *p-n-p* transistor and its biasing

In this case,

$I_E = I_B + I_C$ [Using Kirchhoff's law]

Where, I_E= emitter current

I_B= base current

I_C= collector current

n-p-n Transistor

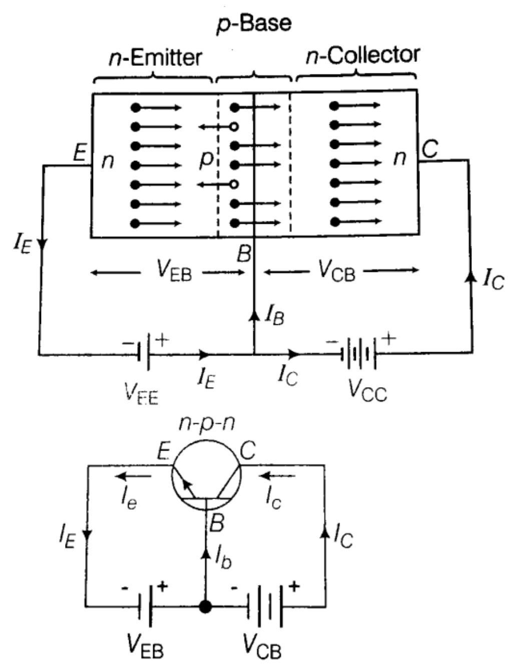
In the base, I_E and I_C flow in opposite directions. In this transistor, the emitter-base junction is forward biased and its resistance is very low.

So, the voltage of $V_{EE}$is quite small.

The collector base junction is reverse biased. The resistance of this junction is very high. So, the voltage of $V_{CC}(V_{CB})$ is quite large (45 V). In *n-p-n* transistor, the current is carried inside as well as in external circuit by the electrons. Thus, in this [$I_B \ll I_C$] case also,

$I_E = I_B + I_C$ [Using Kirchhoff's law]

In the base, I_E and I_C flows in opposite direction.



Action of *n-p-n* transistor and its biasing

Transistor Current Components

➢ The directions of actual currents in both NPN and PNP transistors are shown in the figure : **(Conventional currents direction always is taken outward to node)**

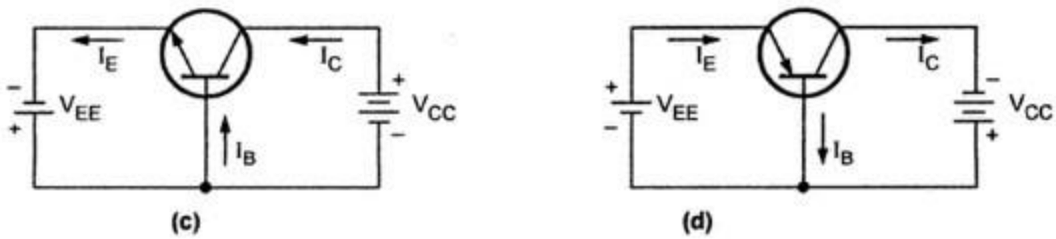


Fig. 6.16 Transistor conventional current directions

Transistor current Components

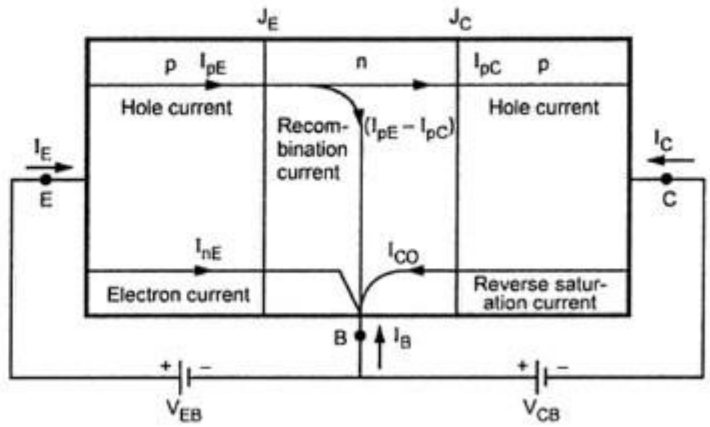


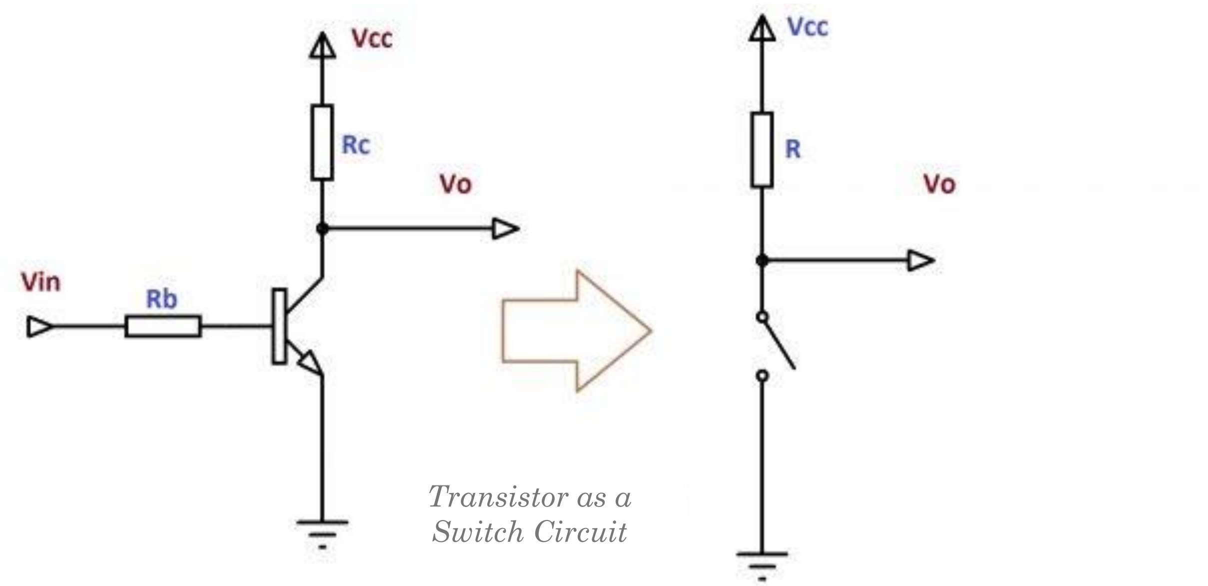
Fig. 6.17 Transistor current components for a forward biased emitter junction and a reversed biased collector junction

➢ I_{pE}, I_{nE}, I_{pC}: The emitter current I_E consists of hole current I_{pE} (holes crossing from the emitter into the base) and electron current I_{nE} (electrons crossing from base into emitter).

Transistor as a Switch

➢ We all know that a transistor has 4 regions of operation, in which Active, Cutoff and Saturation are commonly used.
➢ A transistor works in active region when worked as an Amplifier. When a transistor works as a Switch it works in Cutoff and Saturation Regions.
➢ In the Cutoff State both Emitter Base Junction and Collector Base junctions are reverse biased. But in saturation region both junctions are forward biased.
➢ Switch is a very useful and important application of transistors. In most digital IC's transistors will work as a switch to make power consumption very low.

Circuit Diagram – Transistor as a Switch

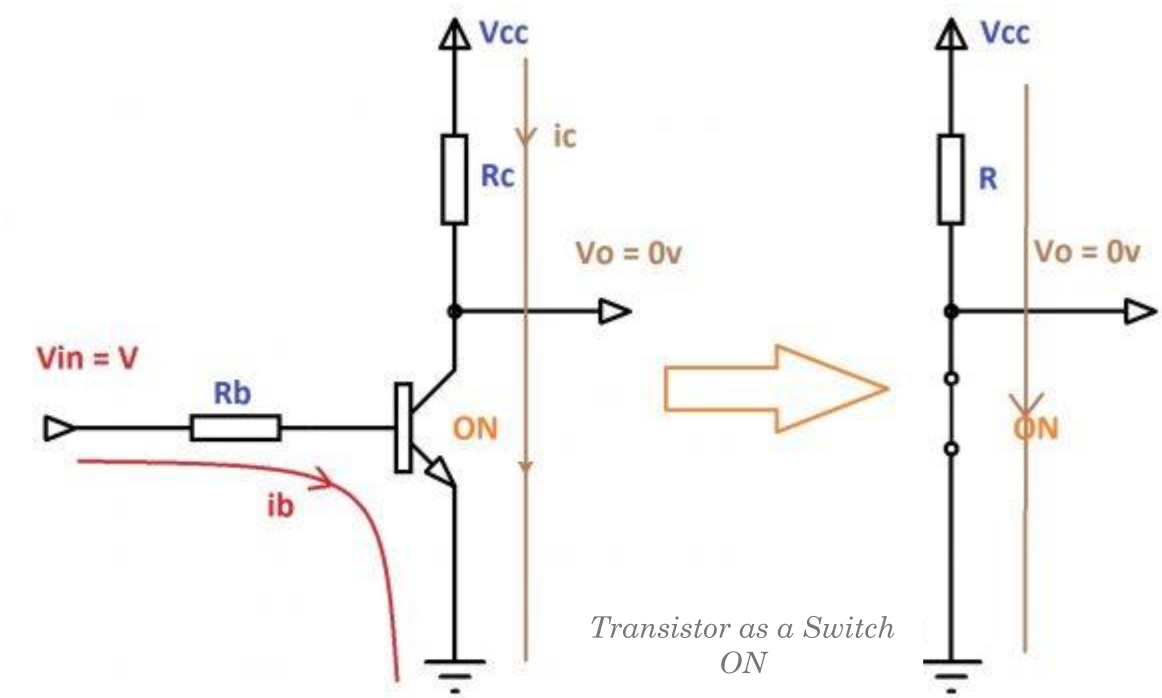


Transistor as a Switch Circuit

From the above circuit we can see that the control input V_{IN} is given to base through a current limiting resistor R_B and R_C is the collector resistor which limits the current through the transistor. In most cases output is taken from collector but in some cases load is connected in the place of R_C.

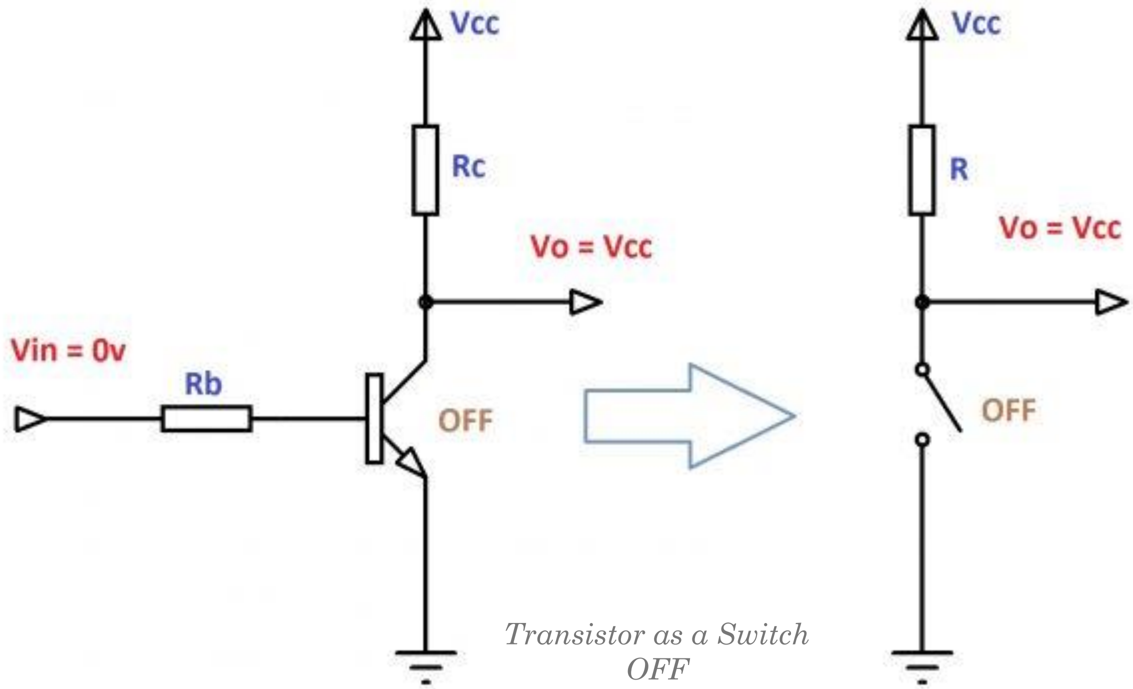
- ON = Saturation
- OFF = Cutoff

Transistor as a Switch – ON



Transistor will become ON (saturation) when a sufficient voltage V is given to input. During this condition the Collector Emitter voltage V_{CE} will be approximately equal to zero, i.e. the transistor acts as a short circuit. For a silicon transistor it is equal to 0.3v. Thus collector current $I_C = V_{CC}/R_C$ will flow.

Transistor as a Switch – OFF

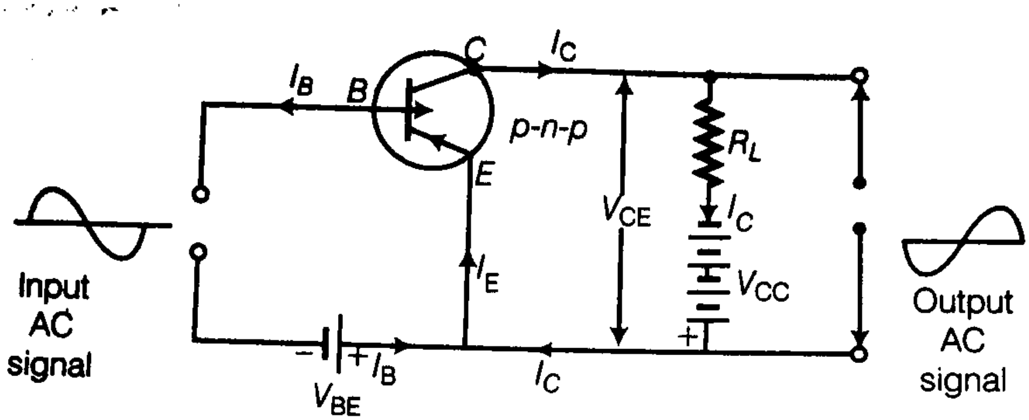


Transistor as a Switch OFF

Transistor will be in OFF (cutoff) when the input V_{IN} equal to zero. During this state transistor acts as an open circuit and thus the entire voltage V_{CC} will be available at collector.

Transistor as an amplifier

An amplifier is a device which is used for increasing the amplitude of input signal. The circuit diagram for *p-n-p* transistor as an amplifier is shown in the figure given below:



Circuit diagram of transistor as an amplifier

Working:

The emitter-base circuit is forward biased by a low voltage batteryV_{BE} that means the resistance of input circuit is small. The collector-emitter circuit is reversed biased by a high voltage batteryV_{CC} that means the resistance of the output circuit is high.

R_L is a load resistance connected in collector-emitter circuit.

The weak input AC signal is applied across the base-emitter circuit and the amplified output is obtained across the collector emitter circuit.

When no AC voltage is supplied to the input circuit, we have

$$I_E = I_B + I_C \qquad \dots \text{(i)}$$

Due to collector current I_C, the voltage drop across the lode resistance (R_L) is $I_C R_L$.

Therefore, the collector emitter voltage $V_{CE}$is given by

$$V_{CE} = V_{CC} - I_c R_L \qquad \dots \text{(ii)}$$

When the input AC voltage signal is applied across the base-emitter circuit, it changes base-emitter voltage and hence, emitter-current I_E changes which in turn changes the collector currentI_C. So, the collector-emitter voltage V_{CE} varies in the accordance with Eq. (ii). This variation in V_{CE} appears as an amplified output.