

Syllabus

- 16.1 Introduction
- 16.2 p-n Junction Diode as a Rectifier
- 16.3 Special Purpose Junction Diodes
- 16.4 Bipolar Junction Transistor (BJT)
- 16.5 Logic gates

16.2 Pn junction Diode

Q.1 What is a rectifier? What is the principle of a rectifier?

Ans:

i. Rectifier:

The process of converting alternating current into direct current is called rectification and the device used for this process is called rectifier.

ii. Principle of a rectifier :

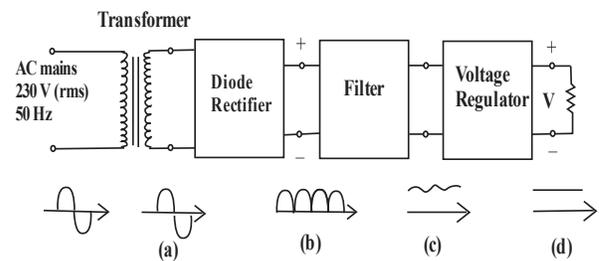
- a. When a p-n junction diode is forward biased, it offers less resistance and a current flows through it; but when it is reverse biased, it offers high resistance and almost no current flows through it.
- b. This unidirectional property of a diode enables it to be used as a rectifier.
- c. When a.c. signal is fed to a diode, the diode is forward biased during the positive half cycle and a current flows through it.
- d. During the negative half cycle, the diode is reverse biased and it does not conduct. Thus the signal is rectified.
- e. The p-n junctions can be used as
 - i. a half-wave rectifier, and
 - ii. a full-wave rectifier.

Q.2 What is ripple?

Ans: The output of the rectifier contains some AC component. This AC component in the DC output of a rectifier is called ripple.

Q.3 Explain rectification using block diagram

Ans:



i. Transformer :

The AC main supply is connected to the primary of a transformer and its secondary is connected to a rectifier circuit.

ii. Diode Rectifier:

The AC voltage shown as a sinusoidal wave from the secondary of the transformer, shown as wave (a), is converted into a DC voltage by a diode rectifier. This is shown as a pulsating wave (b).

The output of the rectifier contains some AC component called ripple. It is shown at the output of the rectifier as waveform (c).

iii. Filter :

It is removed by using a filter circuit. The output of the filter circuit is almost a pure DC.

vi. Voltage regulator:

The voltage regular circuit is connected after filter which produces a waveform as shown by wave (d).

Q.4 State the advantage of using transformer in a rectifier circuit.

Ans: Advantage of transformer in rectifier circuit:

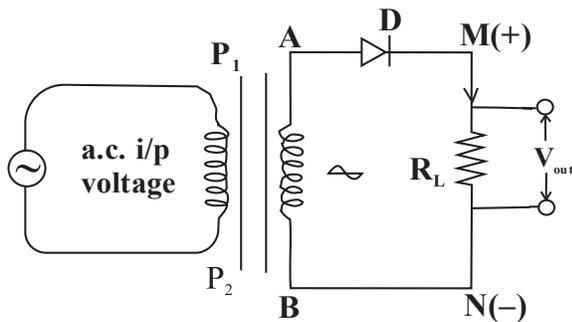
- i. It allows us to step up or step down the AC input voltage as per the requirement of the circuit.
- ii. It isolates the rectifier circuit from the mains supply to reduce the risk of electric shock.

Q.5 Draw a neat labelled circuit diagram for junction diodes as a half wave rectifier.

OR

★ **With the help of a neat circuit diagram, explain the use of p-n junction diode as a half wave rectifier.**

Ans : Circuit arrangement :



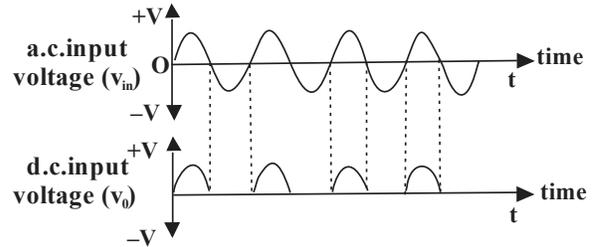
- i. The AC voltage which is to be rectified is applied between the primary terminals P_1 and P_2 of a transformer.
- ii. The secondary of the transformer is connected in series with a junction diode D and a load resistance R_L .
- iii. The output d.c. voltage is taken across R_L .

Working :

- a. The AC voltage developed between the terminals A and B of the secondary.
- b. During each positive half cycle, when A is at a positive potential with respect to B , the junction diode is forward biased and allows the current to pass through it. This current flows through the resistance R_L from M to N .
- c. During the next half cycle the terminal A is at a negative potential with respect to B and hence the diode is reverse biased; acts as open circuit. So no current flows

through the resistance R_L and no D.C. voltage developed across it.

- d. Thus, the current flows through R_L only for half cycle of the applied A.C. Hence, it is called half wave rectifier.
- e. The variation of the AC input voltage and output voltage (across R_L) with time is as shown in the graphs.



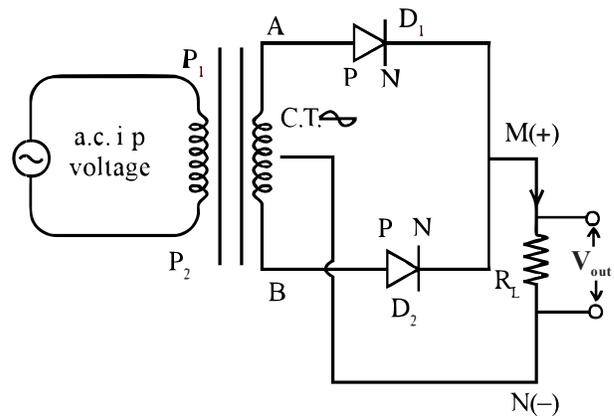
Q.6 Draw a neat labelled circuit diagram for junction diodes as a full wave rectifier.

OR

★ **With the help of a neat circuit diagram explain the use of a p-n junction diode as a full wave rectifier.**

Ans: Circuit arrangement :

- i. The AC input voltage to be rectified is applied to the terminals P_1 and P_2 of a transformer. The secondary terminals S_1 and S_2 are connected to the p-sides of diodes D_1 and D_2 .
- ii. The n-sides of the diodes are connected together. Their common point is connected to the centre-tap S through a load resistance R_L .
- iii. The output d.c. voltage is taken across R_L .

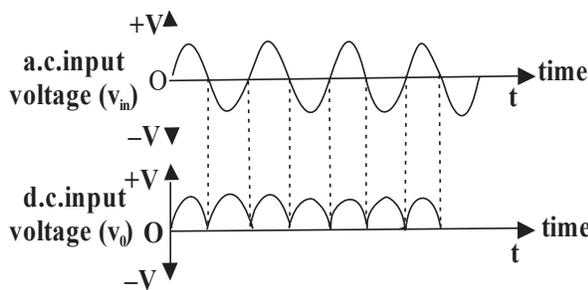


Working :

- a. The AC voltage developed between the terminals A and B of the secondary.
- b. During each positive half cycle when A

is at positive potential, diode D_1 is forward biased and it conducts current which flows through the load resistance R_L from M to N. During the same cycle, B is at a negative potential, diode D_2 is reverse biased and does not conduct current.

- c. During each negative half cycle, B is at a positive potential, diode D_2 is forward biased and it conducts current which flows through the load resistance R_L from M to N. During the same cycle, A is at negative potential, diode D_1 is reverse biased and does not conduct current.
- d. Thus, the current flows through R_L in each half cycle of the applied a.c. Hence, it is called full wave rectifier.
- e. The variation of the AC input voltage and output voltage (across R_L) with time is as shown in the graphs.



Q.7 Write some advantages of a full wave rectifier over half wave rectifier.

Ans:

- i. Rectification takes place in both the cycles of the AC input.
- ii. Efficiency of a full wave rectifier is higher than that of a half wave rectifier.
- iii. The ripple in a full wave rectifier is less than that in a half wave rectifier.

INTEXT QUESTION

If the frequency of the input voltage 50 Hz is applied to a (i) half wave rectifier and (ii) full wave rectifier, what is the out put frequency in both cases?

Ans:

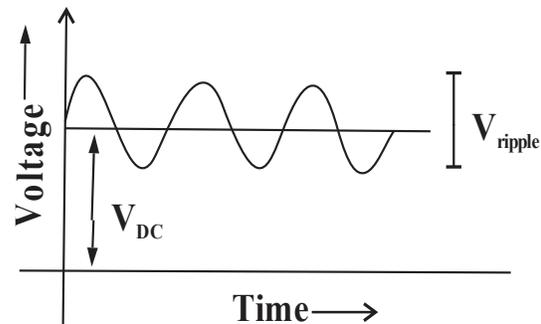
- i. In case of a half wave rectifier, for one pulsating AC input we get one cycle of DC. Thus, the output frequency will be 50 Hz.
- ii. In case of full wave rectifier, for one pulsating AC input, we get two cycles of DC. Thus, the output frequency will be 100 Hz.

Q.8 Write a short note on a ripple factor.

Ans:

- i. The output of a rectifier consists of a small fraction of an AC component along with DC called the ripple.
- ii. This ripple is undesirable and is responsible for the fluctuations in the rectifier output.
- iii. The effectiveness of a rectifier depends on the magnitude of the ripple component in its output. A smaller ripple means that the rectifier is more effective.
- iv. The ratio of root mean square (r.m.s) value of the AC component to the value of the DC component in the rectifier output is known as

$$\text{Ripple factor} = \frac{\text{r.m.s value of AC component}}{\text{value of DC component}}$$



★ Q.9 Why do we need filters in a power supply?

Ans:

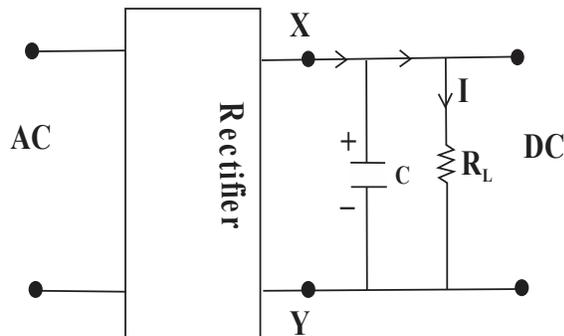
- i. For any rectifier, the output is unidirectional but the output does not have a steady value.
- ii. It keeps fluctuating due to the ripple component present in it.
- iii. A filter circuit is used to remove the ripple from the output of a rectifier. Hence, to get a steady output from a power supply, we need filters.

Q.10 What is a filter circuit? Explain working of a capacitor filter with neat and labelled diagrams. Also write the uses of capacitor filter.

Ans: A filter circuit is a circuit which removes the AC component or the ripple from a rectifier output and allows only the DC component.

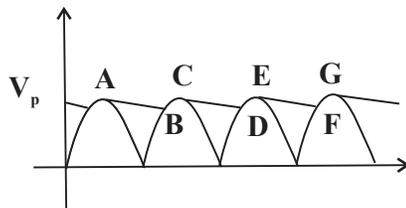
Working of a capacitor filter:

i. In a capacitor filter, the pulsating DC voltage of a rectifier output is applied across the capacitor as shown in the fig. (a).



ii. As the voltage across the capacitor rises, capacitor gets charged to point A shown in fig. (b) and supplies current to the load resistance. SA

iii. At the end of quarter cycle, the capacitor gets charged to the peak voltage of the rectified output voltage.



iv. Now, the rectifier voltage begins to decrease, so that the capacitor starts discharging through the load resistance and the voltage across it begins to drop. Voltage across the load decrease only slightly, up to the point B in the fig. (b), because the next voltage peak recharges the capacitor immediately.

v. This process is repeated again and again and the output voltage waveform takes the form shown in fig. (b).

- i. The capacitor filter circuit is widely used because of its low cost, small size and light weight.
- ii. This type of filter is preferred for small load currents.
- iii. It is commonly used in battery eliminators.

Q.11 Define

- i. Unregulated power supply
- ii. Regulated power supply

Ans:

i. **Unregulated power supply:**

A power supply whose output changes when a load is connected across it is called unregulated power supply.

ii. **Regulated power supply:**

When the output of a power supply remains steady even after connecting a load across it, it is called a regulated power supply.

16.3 Special Purpose Junction Diode.

Q.12 What is a Zener diode? Give its symbol.

Ans: Zener diode. A junction diode specially designed to operate only in the reverse breakdown region continuously (without getting damaged) is called a Zener diode. Zener diodes with different breakdown voltages can be obtained by changing the doping concentrations of p- and n- sides which, in turn, change the width of depletion layer and also the barrier field across the junction. The symbol of a Zener diode is shown in figure



Symbol for Zener diode.

Q.13 Explain the concept of Zener breakdown in detail

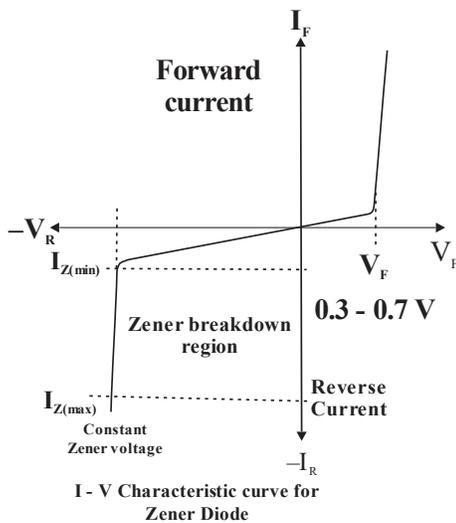
Ans: **Mechanism of Zener breakdown:**

- i. When the reverse voltage across a p-n junction diode is increased, the electric field across the junction increases. This results in a force of attraction on the negatively charged electrons at the junction

- ii. Covalent bonds which hold the semiconductor together are broken due to this force and electrons are removed from the bonds.
- iii. These free electrons are then available for electrical conduction and result in a large current.
- iv. When the applied voltage is increased, the electric field across the junction also increases and more and more electrons are removed from their covalent bonds. Thus, a net current is developed which increases rapidly with increase in the applied voltage. This process is known as Zener breakdown.

Q.14 Explain the forward and the reverse characteristic of a Zener diode.

Ans: **Forward bias:** Forward characteristic of a Zener diode are same as that of the normal diode as shown in the figure. i.e., a Zener diode behaves like a normal diode when forward biased.



Reverse bias:

- a. When a Zener diode is reverse biased, it shows a breakdown at reverse voltage called as Zener voltage (V_Z).
- b. The current suddenly increases if the applied voltage is increased beyond the Zener voltage.
- c. After the breakdown voltage V_Z , a large change in the current can be produced by almost insignificant change in the reverse bias voltage. Zener voltage remains constant,

even though current through the Zener diode varies over wide range.

Q.15 Explain how Zener diode maintains constant voltage across a load

Ans:

Q.16 How is a Zener diode different than an ordinary diode?

Ans:

- i. Zener diode is a heavily doped p-n junction diode. It has very thin depletion layer because of its heavy doping.
- ii. Generally moderately doped ordinary diode gets damaged when reverse voltage is increased beyond its breakdown value.
- iii. Whereas, Zener diode is designed to operate in reverse region.
- iv. Also, ordinary diode is majority used for rectification and Zener diode is used for voltage regulation.

Q.17 Give applications of Zener Diode.

Ans: **Applications of Zener diode:**

- i. Voltage regulator,
- ii. Fixed reference voltage provider in transistor biasing circuits,
- iii. Peak clipper or limiter in a wave shaping circuit,
- iv. Protector against meter damage from accidental fluctuation, etc.

INTEXT QUESTION

A 5.0 V stabilized power supply is required to be designed using a 12 V DC power supply as input source. The maximum power rating P_Z of the Zener diode is 2.0 W. Calculate,

- i. The maximum current flowing through the Zener diode.
- ii. The minimum value of the series resistor, R_s
- iii. The load current I_L if a load resistor of 1k is connected across the Zener diode.
- iv. The Zener current I_Z at full load.

Data: $V_Z = 5.0 \text{ V}$, $V_S = 12 \text{ V}$,
 $P_Z = 2.0 \text{ W}$, $R_L = 1 \text{ k}\Omega$

To find: i. Maximum current ($I_{Z_{\max}}$)
ii. Minimum series resistance (R_S)
iii. Load current (I_L)
iv. Full load current ($I_{Z_{\min}}$)

Formulae: i. $(I_{Z_{\max}}) = \frac{\text{Power } P_Z}{\text{Voltage } V_Z}$

ii. $R_S = \frac{(V_S - V_Z)}{I_{Z_{\max}}}$

iii. $I_L = \frac{V_Z}{R_L}$

iv. $(I_{Z_{\min}}) = (I_{Z_{\max}}) - I_L$

Solution:

$$(I_{Z_{\max}}) = \frac{\text{Power } P_Z}{\text{Voltage } V_Z} = \frac{2.0}{5.0} = 0.4 \text{ A} = 400 \text{ mA}$$

$$R_S = \frac{(V_S - V_Z)}{I_{Z_{\max}}} = \frac{(12 - 5)}{0.4} = 17.5 \Omega$$

$$I_L = \frac{V_Z}{R_L} = \frac{5}{1 \times 10^3} = 5 \times 10^{-3} \text{ A} = 5 \text{ mA}$$

$$(I_{Z_{\min}}) = (I_{Z_{\max}}) - I_L = 400 - 5 = 395 \text{ mA}$$

Ans : i. Maximum current through the Zener diode is 400mA
ii. Maximum resistance connected in series is 17.5Ω.
iii. The load current is 5 mA.
iv. The current through Zener diode in full load condition is 395 mA

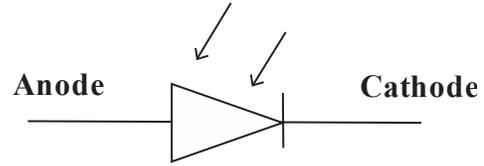
Q.18 What is photo diode?

★ **Explain the principle of operation of photo diode**

Ans:

i. A photodiode is a special type of a p-n junction diode which converts light energy into electrical energy.

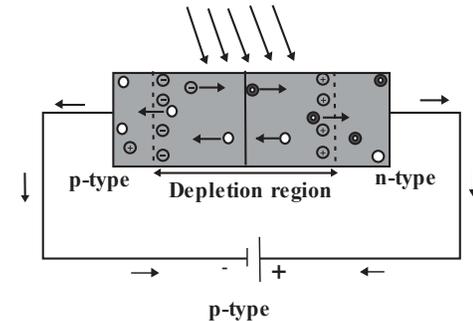
ii. It generates current when exposed to light. Hence, it is also called as photo detector or a photo sensor. Fig. represents the circuit symbol of the photodiode.



iii. It operates in reverse biased mode and only minority current flows through a photodiode.

Working principle of photodiode:

- i. When a p-n junction diode is reverse biased, a reverse saturation current flows through the junction.
- ii. The magnitude of this current is constant for a certain range of reverse bias voltages. This current is due to the minority carries on either side of the junction. The fig. shows a schematic representation of working of a photodiode.



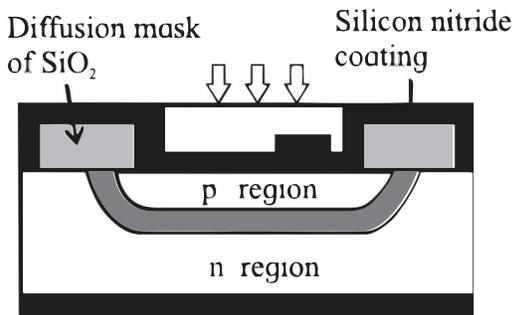
- iii. The reverse current depends only on the concentration of the minority carriers and not on the applied voltage. This reverse current is called dark current because it flows even when the photodiode is not illuminated.
- iv. When the p-n junction in illuminated with photons of energy greater than the band gap energy of semiconductor electron-hole pairs are generated in the depletion region.
- v. The electrons and the holes are separated due to the intrinsic electric field present in the depletion region. The electrons are attracted towards the anode and the holes are attracted towards the cathode. More carriers are

available for conduction and the reverse current is increased.

- vi. The reverse current of a photodiode depends on the intensity of the incident light. Thus, the reverse current can be controlled by controlling the concentration of the minority carriers in the junction.

Q.19 Draw a neat labelled schematic diagram for structure of photo diode.

Ans :



Q.20 Why should a photo diode be operated in reverse biased mode?

Ans: A photodiode is preferably operated in reverse bias condition. Consider an n-type semiconductor. Its majority carrier (electron) density is much larger than the minority hole density i.e., $n \gg p$. When illuminated with light, both types of carries increase equally in number.

$$n' = n + \Delta n$$

$$\therefore \frac{\Delta n}{n} \ll \frac{\Delta p}{p}$$

That is, the fractional increase in majority carries is much less than the fractional increase in minority carriers. Consequently, the fractional change due to the photo-effects on the minority carrier dominated reverse bias current is more easily measurable than the fractional change in the majority carrier dominated reverse bias current is more easily measurable than the fractional change in the majority carrier dominated forward bias current. Hence, photodiodes are preferable used in the reverse bias condition for measuring light intensity.

Q.21 What are some advantage and disadvantage of photodiode?

Ans: Advantage of photodiode:-

- i. Quick response when exposed to light.
- ii. The reverse current is linearly proportional to intensity of incident light. (Linear response)
- iii. High speed of operations.
- iv. Light weight and compact size.
- v. Wide spectral response. E.g., photodiode made from silicon respond to radiation of wavelengths from 190 nm (UV) to 1100 nm (IR).
- vi. Relatively low cost.

Disadvantage of photodiode:-

- i. Its properties are temperature dependent, similar to many other semiconductor devices.
- ii. Low reverse current for low illumination levels.

Q.22 Write a note on applications of a photodiode.

Ans: Application of photodiode: A photodiode has many applications in a number of fields ranging from domestic applications to industrial applications due to its linear response.

- i. Counters and switches.
- ii. Burglar alarm systems.
- iii. Detection of visible and invisible radiations.
- iv. Circuits in which fast switching and high speed operations are required.
- v. Fiber optics communication system.
- vi. Optocouplers, used to provide an electric isolation between two electronic circuits.
- vii. Photo sensors/detectors, for accurate measurement of light intensity.
- viii. Safety electronics like fire and smoke detectors.

★ Q.23 State the principle and uses of a solar cell.

Ans: Solar cell uses solar energy and converts it into electric energy. Hence, it is also called as a photovoltaic cell.

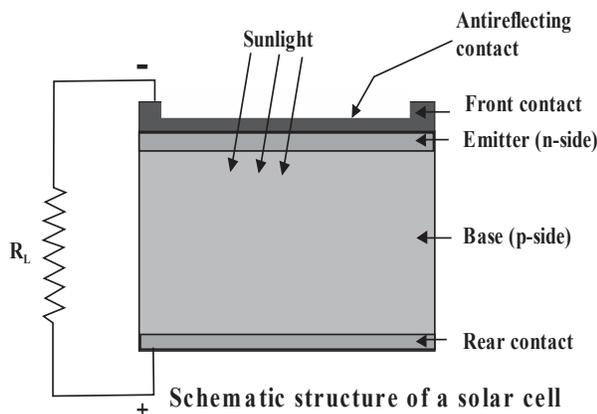
Uses of solar cell:

- i. Solar cells are used for charging batteries during day time so that batteries can supply power during night.
- ii. They are useful at remote places, for supplying power to various electronic equipments from calculators to satellites and space stations.
- iii. They are used to supply power to traffic signals, in communication stations, and in lux meter to measure intensity of light.

★ Q.24 Explain the construction and working of solar cell.

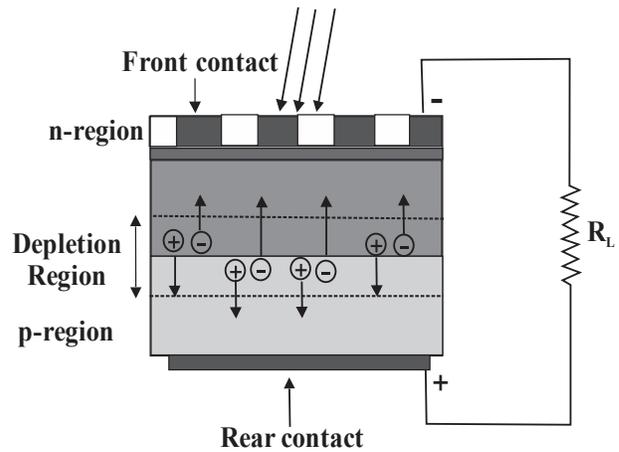
Ans: Constructions:

- i. It consists of a p-n junction. The n-side of the junction faces the solar radiation. The p-side is relatively thick and is at the back of the solar cell.
- ii. Both the p-side and the n-side are coated with a conducting material. The n-side is coated with antireflection coating which allows visible light to pass through it. The main function of this coating is to reflect the IR (heat) radiations and protect the solar cell from heat.
- iii. This coating works as the electrical contact of the solar cell. The contact on the n-side is called the front contact and that at the p-side is called the back contact or the rear contact.
- iv. The n-side of a solar cell is thin so that the light incident on it reaches the depletion region where the electron-hole pairs are generated.



Working:

- i. When a light with photon energy greater than the band gap energy is incident on a solar cell, electron-hole pairs are formed in the depletion region of the diode.
- ii. The electrons and holes thus formed get recombined and are not available for conduction.
- iii. However, the photo-generated electrons in the p-type material, and the photo-generated holes in the n-type material are spatially separated and prevented from recombination in a solar cell.
- iv. This separation of carriers is possible due to the intrinsic electric field of the depletion region. Fig. (b) Shows this schematically.

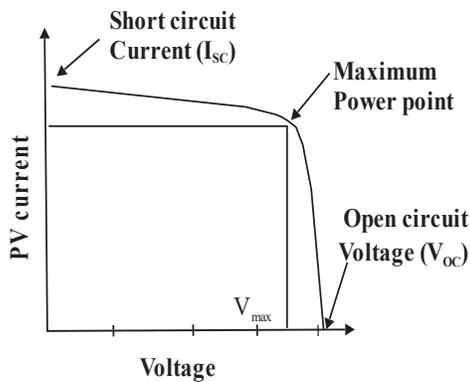


- v. When the light-generated electron in the p-type region reaches the junction it crosses the junction due to the electric field at the junction. It reaches the n-type region where it is now a majority carrier.
- vi. Similarly, the light generated hole reaches the p-type region and becomes a majority carrier in it.
- vii. The positive and negative charges are thus accumulated on the p-region and the n-region of the solar cell which can be used as a voltage source.
- viii. When the solar cell is connected to an external circuit, the light-generated carriers flow through the external circuit.

Q.25 Describe V-I characteristics of a solar cell.

Ans: V-I characteristics of a solar cell when illuminated:

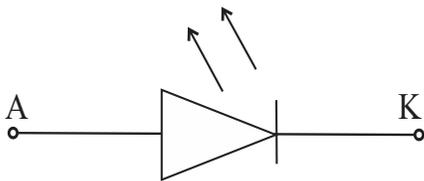
- i. I-V characteristics of solar cell is drawn in fourth quadrant because a solar cell supplies current to the load.
- ii. The power delivered to the load is zero when the load is short-circuited.
- iii. The intersection of the curve with the I-axis is the short-circuit current I_{sc} corresponding to a given light intensity. The intersection of the curve with V-axis is the open circuit voltage V_{oc} corresponding to given light intensity.
- iv. Power delivered to the load is also zero when the load is open. However, there is a point on the curve where power delivered $PL = V_{OL} \times I_{sc}$ is maximum.



V-I Characteristic of solar cell or photovoltaic cell

Q.26 What is LED. Give its Symbol

Ans: The Light Emitting Diode or LED is called as a diode which emits light when large forward current passes through it.



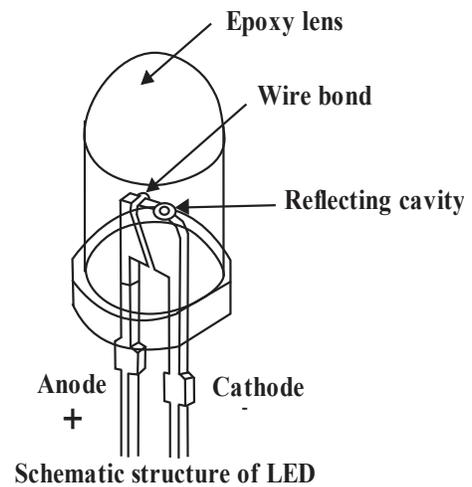
Q.27 Explain the construction and

★ Working of LED

Ans: Construction of LED:

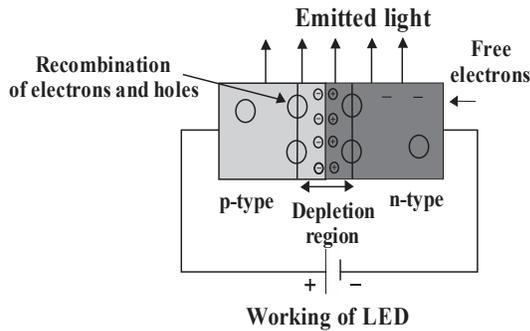
- i. In an LED, the n-region is heavily doped than the p-region of the p-n junction.

- ii. The LED p-n junction is encased in a dome-shaped transparent case so that light is emitted uniformly in all directions and internal reflections are minimized.
- iii. Metal electrodes attached on either side of the p-n junction serve as contacts for external electrical connection. The larger leg of a LED is the positive electrode or anode.
- iv. LED is fabricated in such a way that light emitted is not reabsorbed into the material.
- v. It is ensured that the electron-hole recombination takes place on the surface for maximum light output.



Working of LED:

- i. When the LED is forward biased, electrons from the semiconductor's conduction band recombine with holes from the valence band releasing sufficient energy to produce photons which emit a monochromatic light.
- ii. Because of the thin layer, a reasonable number of these photons can leave the junction and emit coloured light.
- iii. The amount of light output is directly proportional to the forward current. Thus, higher the forward current, higher is the light output.
- iv. The given fig. schematically shows the emission of light when electrons-hole pair combines.

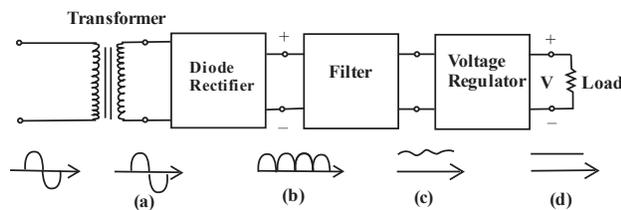


Working of LED

Q.28 Describe the waveforms obtained in a rectifier using a block diagram.

Ans:

i. Working of simple rectifier circuit is shown in fig.



Block diagram of a simple rectifier circuit

- ii. The AC main supply is connected to the primary of a transformer and its secondary is connected to a rectifier circuit.
- iii. The AC voltage shown as a sinusoidal wave from the secondary of the transformer, shown as wave (a), is converted into a DC voltage by a diode rectifier. This is shown as a pulsating wave (b).
- iv. The output of the rectifier contains some AC component called ripple. It is shown at the output of the rectifier as waveform (c).
- v. It is removed by using a filter circuit. The output of the filter circuit is almost a pure DC.
- vi. The voltage regular circuit is connected after filter which produces a waveform as shown by wave (d).

Q.29 Give advantages and disadvantages of LED.

Ans: Advantage of LED:

- i. LEDs are energy efficient i.e., more light output can be obtained for lesser electrical power.

- ii. They have long lifetime. If properly manufactured, they can sustain for 50,000 hours or more.
- iii. LEDs are also called Solid State Lights (SSL) as they are made of solid material with no filament or tube of bulb to break. i.e., they are rugged.
- iv. LEDs start emitting light in nanoseconds. Thus, there is almost no warm up period.
- v. Excellent colour rendering: Colours produced by LED do not fade out making them perfect for displays and retail applications.
- vi. LED do not contain mercury or other hazardous substances. Thus, they are environment friendly.
- vii. Brightness and colour of light emitted by LEDs can be controlled.

Disadvantage of LED:

- i. Hazardous blue light quality
- ii. Temperature dependence
- iii. Voltage sensitive
- iv. High initial cost

16.4 Bipolar Junction Transistor (BJT)

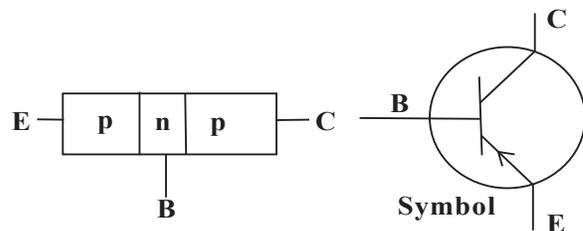
Q.30 What is a transistor? Explain the types of transistor with neat diagrams.

Ans: Transistor :

A semiconductor device having three doped regions and two junction is called a transistor. The three doped regions are emitter, base and collector.

Types of transistors

i. PNP transistor :

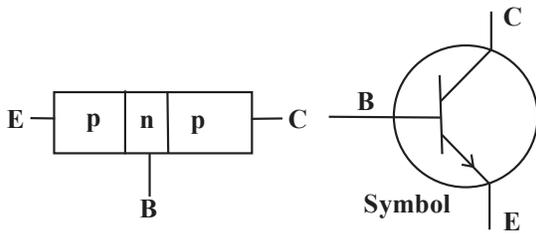


A thin layer of the n-type material is sandwiched between two regions of the p-type material. The device is called PNP transistor.

ii. NPN transistor :

A thin layer of the p-type material is

sandwiched between the two regions of n-type material. This device is called as NPN transistor.



Explanation:

- In both the type of transistors, base is thin and lightly doped, emitter is heavily doped and collector is largest of the three regions and moderately doped.
- In the symbol arrowhead indicates the emitter and it points the direction of conventional current.

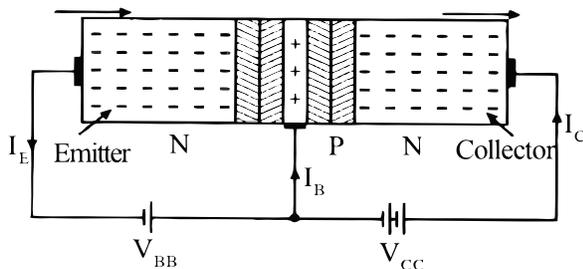
Q.31 Describe the construction of npn transistor and explain transistor action.

OR

Explain the action of a junction transistor with a neat labelled circuit diagram.

Ans: Construction:

- For normal operation of a transistor, the E-B junction is always forward biased and C-B junction is always reverse biased.
- The biasing of npn transistor is as shown in figure.



- The E-B junction is forward biased by the battery V_{BB} while the C-B junction is reverse biased by the battery V_{CC} .

Working:

- As E-B junction is forward biased and $V_{BE} > 0.6V$, large number of electrons

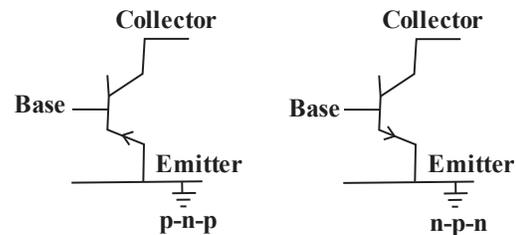
enter the base but few electrons (5%) from emitter, recombine with holes in base region and come out as small base current (mA).

- As C-B junction is reverse biased, most of the emitter-injected electrons (95%) enters collector, then they move into positive terminal of source V_{CC} that produces large collector current (mA).
- Slight variation in I_B produces large change in I_C .
- The transistor is also called as bipolar transistor because both the carriers (electron and holes) are involved in its conduction.
- For transistor,
 $I_E = I_B + I_C$ (with $I_C @ I_E$)

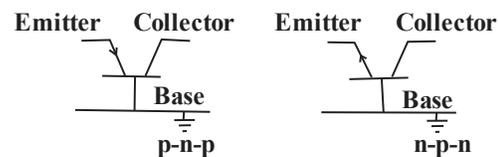
Q.32 What are the possible configurations of transistor in a circuit? Explain each in brief.

Ans: The possible configurations of transistor in a circuit are,

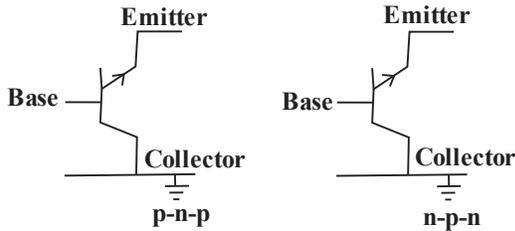
- Common Emitter (CE):** The emitter of the transistor is common to both the input and the output.



- Common Base (CB):** The base of the transistor is common to both the input and the output.



- Common Collector (CC):** The collector of the transistor is common to both the input and the output.



Q.33 Define current ratio α and β for transistor. Obtain the relation between them.

Ans:

i. **Common- Base current or Current gain (α_{dc}):** It is defined as the ratio of collector current to emitter current.

$$\alpha_{dc} = \frac{I_C}{I_E} \quad \dots(1)$$

ii. **Common- Emitter current or Current gain (β_{dc}):** It is defined as the ratio of collector current to base current.

$$\beta_{dc} = \frac{I_C}{I_B} \quad \dots(2)$$

iii. For a transistor,

$$I_E = I_B + I_C$$

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

From eq. (i) and (ii)

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

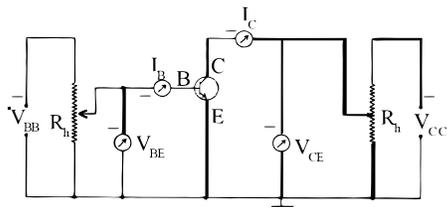
$$\alpha_{dc} = \frac{\beta_{dc}}{1 + \beta_{dc}} \quad \dots(3)$$

or
$$\beta_{dc} = \frac{\alpha_{dc}}{1 - \alpha_{dc}} \quad \dots(4)$$

Note: For a transistor
 a. $\alpha_{dc} \approx 1$ (0.92 to 0.98)
 b. $\beta_{dc} = 50$ to 900

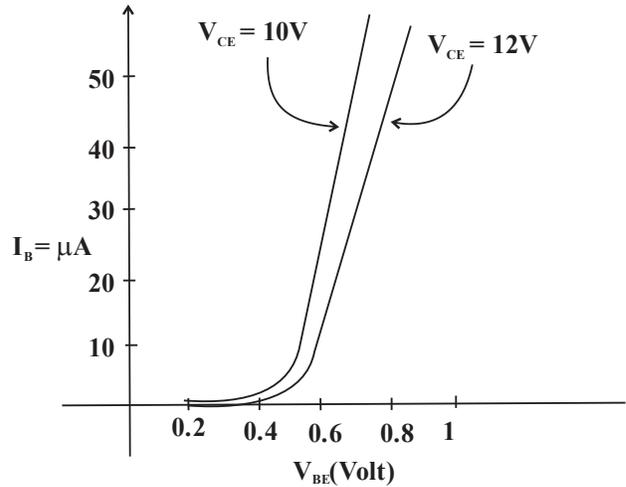
Q.34 Draw a neat circuit diagram to study C-E transistor characteristic. Explain the input and output characteristics.

Ans: C-E transistor circuit:



Input Characteristics

i. For C-E mode, it is graph of base current (I_B) versus base voltage (V_{BE}), at constant output voltage (V_{CE}) as shown in fig.

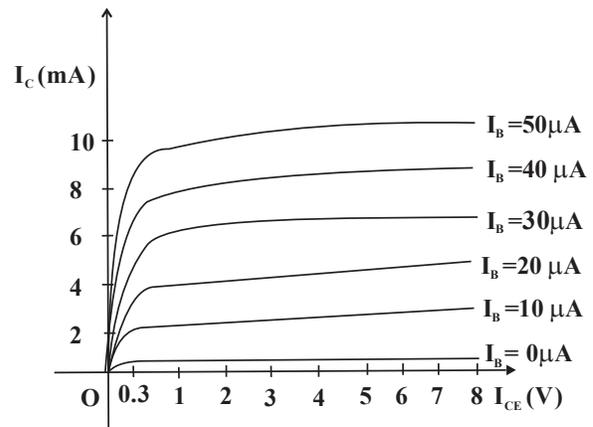


- ii. As V_{BE} is increased in small steps and corresponding I_B is recorded.
- iii. For V_{BE} less than barrier potential (0.6V), I_B is nearly zero and increases rapidly after crossing barrier potential.
- iv. Dynamic input resistance is given by

$$r_i = \left(\frac{\Delta V_{BE}}{\Delta I_B} \right)_{V_{CE} = \text{constant}}$$

Output Characteristics :

i. For C-E mode, it is graph of collector current (I_C) versus collector voltage (V_{CE}), at the fixed value of I_B as show in fig.



- ii. As $I_B = \text{const}$, V_{CE} is increased in small steps and corresponding I_C is recorded.
- iii. From output characteristics it is clear that

- a. **Cut off region :**
When $I_B = 0$, then $I_C \simeq 0$.
- b. **Saturation region:**
When $V_{CE} < 0.2$ V, both the junctions gets forward biased and I_C no longer can be controlled by I_B
- c. For $V_{CE} < 0.3$ V, I_C increases with V_{CE} and can be controlled by V_{CE}
- d. **Active region:**
When $V_{CE} > V_{BE}$ (0.7), C-E junction gets reverse biased and I_C gets saturated and can be controlled by I_B .

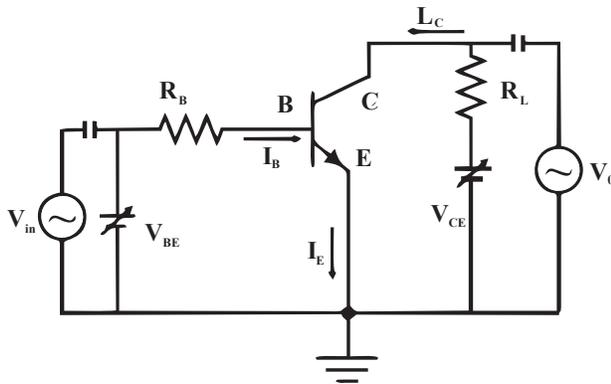
vi. The dynamic output resistance is given by,

$$r_o = \left(\frac{\Delta V_{CE}}{\Delta I_C} \right)_{I_B = \text{CONST}}$$

Q.35 Explain working of a transistor as an amplifier in detail with the help of proper diagram.

Ans: Working of an amplifier:

i. The circuit of an amplifier using a n-p-n transistor in CE configuration is shown in the fig.



- ii. When the input voltage V_{in} is not applied, applying the Kirchoff's law to the output loop, we can write,
 $V_{CC} = V_{CE} + I_C R_L$
- iii. Similarly, for input loop,
 $V_{BB} = V_{BE} + I_B R_B$
- iv. When input AC signal is applied, is not zero. Thus, the voltage drop across the input loop will now be (1)
- v. The AC signal applied adds the current of to the original current flowing through the circuit. Therefore, the additional voltage drop in the

input loop will be across resistor and across the input dynamics resistance of the transistor.

- vi. From equation (1),
As, is very small, we can consider,
- vii. The changes in the base current cause changes in the collector current. This changes the voltage drop across the load resistance because is constant. We can write,
- viii. The change in the output voltage is the output voltage hence we can write,

Q.36 Define following terms and explain them.

- i. **AC current gain (β_{AC})**
- ii. **Voltage gain of amplifier**
- iii. **Power gain of the amplifier**

Ans:

i. **AC current gain (β_{AC})** Ratio of change in collector current to change in base current is AC current gain of the amplifier.

$$\beta_{AC} = \frac{\Delta I_C}{\Delta I_B} = \frac{i_C}{i_B}$$

ii. **Voltage gain of amplifier:** Ratio of output voltage to the input voltage of the amplifier is the voltage gain of the amplifier.

$$A_V = \frac{V_o}{V_{in}} = \frac{\Delta V_{CE}}{r_i \Delta I_B}$$

$$\text{But, } \Delta V_{CE} = \beta_{AC} R_L \Delta I_B$$

$$A_V = - \frac{\beta_{AC} R_L \Delta I_B}{r_i \Delta I_B} = - \frac{\beta_{AC} R_L}{r_i}$$

The negative sign indicates that the output voltage and the input voltage are out of phase.

iii. **Power gain of the amplifier:** The power gain of the amplifier is the ratio of output power to the input power. Magnitude of the power gain can also be written as,

$$A_p = \beta_{AC} A_V$$

Type - I

Numerical based current gain

- ★ 1) **In a common-base connection, a certain transistor has an emitter current of 10 mA and collector current of 9.8 mA. Calculate the value of the base current.**

Data: $I_E = 10 \text{ mA}$, $I_C = 9.8 \text{ mA}$

To find: Base current (I_B)

Formula: $I_E = I_B + I_C$

Solution:

$$I_E = I_B + I_C = 10 - 9.8 = 0.2 \text{ mA}$$

Ans: The value of base current is 0.2mA.

★ 2) In a common-base connection, the emitter current is 6.28 mA and collector current is 6.20 mA. Determine the common base DC current gain.

Data: $I_E = 6.28 \text{ mA}$, $I_C = 6.20 \text{ mA}$

To find: DC current gain (α_{DC})

Formula: $\alpha_{DC} = \frac{I_C}{I_E}$

Solution: $\alpha_{DC} = \frac{I_C}{I_E} = \frac{6.20}{6.28} = 0.987$

Ans: The value of DC current gain is 0.987.

★ 3) The common-base DC current gain of a transistor is 0.967. If the emitter current is 10 mA, what is the value of base current?

Data: $\alpha_{DC} = 0.967$, $I_E = 10 \text{ mA}$

To find: Base current (I_B)

Formulae: i. $\alpha_{DC} = \frac{I_C}{I_E}$ ii. $I_E = I_B + I_C$

Solution: $\alpha_{DC} = \frac{I_C}{I_E}$

$$I_C = \alpha_{DC} I_E = 0.967 \times 10 = 9.67 \text{ mA}$$

$$I_B = I_E - I_C = 10 - 9.67 = 0.33 \text{ mA}$$

Ans: The value of base current is 0.33mA.

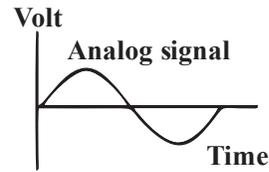
16.5 Logic gates

Q.37 What are analog and digital signals?

Ans:

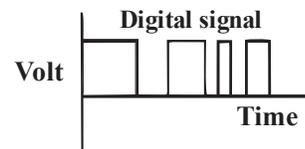
- i. Continuously varying signals are called analog signals. For example, a sinusoidal voltage is an analog signal as shown in figure (a).

- ii. In an analog electronic circuit, the output signal varies continuously according to the input signal.



- iii. A signal which can have only two discrete values is called a digital signal. For example, a square wave is a digital signal as shown in figure(b).

- iv. In digital circuit, the output voltage can have only two states (i.e. values), either low (0 V) or high (+5 V) value.



Q.38 What do you mean by a logic gate, a truth table and a Boolean expression?

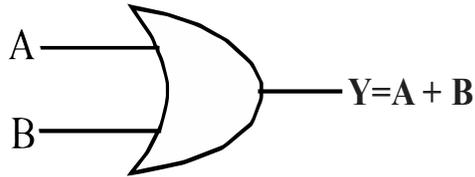
Ans:

- i. **Logic gate:** A digital circuit with one or more input signals but only one output signal is called a logic gate. It is a switching circuit that follows certain logical relationship between the input and output voltages.
- ii. **Truth table:** A truth table shows all possible combinations of the input and corresponding outputs. It defines the function of a logic gate and helps understand the behaviour of a logic gate.
- iii. **Boolean Expression:** The mathematical statement that provides the relationship between the input and the output of a logic gate is called a Boolean expression.

Q.39 Draw the schematic symbol for OR gate. Explain its working with the help of its truth table.

Ans: 'OR' gate :

- i. It is an electronic circuit, which has two or more inputs and only one output.
- ii. Symbol for OR gate



- iii. It produces (generates) HIGH output when any or all of its inputs are HIGH.
- iv. Truth table

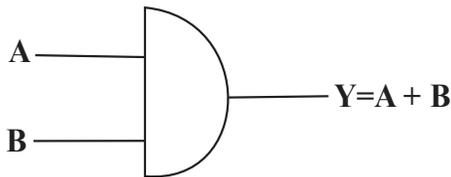
Inputs		Output
A	B	$Y = A + B$
0	0	0
1	0	1
0	1	1
1	1	1

- v. OR operation is indicated by '+' sign.
- vii. Boolean expression for OR gate is,
 $Y = A + B$

Q.40 Draw the schematic symbol for AND gate. Explain its working with the help of its truth table.

Ans: 'AND' gate :

- i. It is an electronic circuit, which has two or more inputs and only one output.
- ii. Symbol for AND gate



- iii. It produces (generates) HIGH output when any or all of its inputs are HIGH.
- iv. Truth table

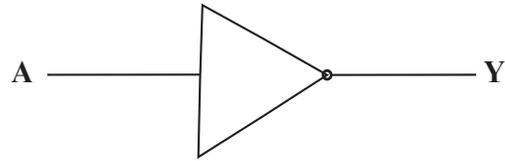
Inputs		Output
A	B	$Y = A \cdot B$
0	0	0
1	0	0
0	1	0
1	1	1

- v. AND operation is denoted by '×' or '·' sign.
- vi. Boolean expression for AND gate is,
 $Y = A \cdot B$

Q.41 Draw the schematic symbol for NOT gate. Explain its working with the help of its truth table.

Ans: 'NOT' gate :

- i. It is an electronic circuit, which has only one input and only one output.
- ii. Symbol for NOT gate



- iii. It produces (generates) HIGH output when any or all of its inputs are LOW and vice-versa i.e. its output is NOT of input or complement of input.
- iv. Truth table

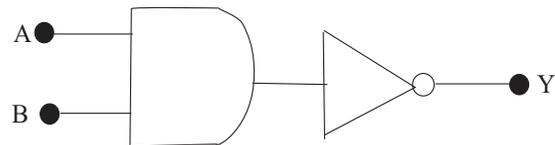
Inputs	Output
A	y
0	1
1	0

- v. NOT operation is indicated by 'drawing bar over the variable' sign.
- vi. Boolean expression for NOT gate is,
 $Y = \bar{A}$

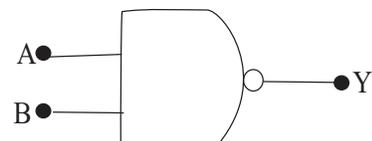
Q.42 Draw the schematic symbol for NAND gate. Explain its working with the help of its truth table.

Ans: 'NAND' gate :

- i. It is an electronic circuit, which has two or more inputs and only one output.
- ii. NAND gate is AND gate followed by NOT gate.
i.e. NOT + AND = NAND



- iii. Symbol for NAND gate



- iv. It produces (generates) HIGH output when any of the input is LOW.
- v. Truth table

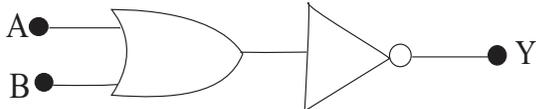
Inputs		Output
A	B	$Y = \overline{A \cdot B}$
0	0	1
1	0	1
0	1	1
1	1	0

- vi. NAND operation is indicated by '•' sign.
- vii. Boolean expression for NAND gate is,
 $Y = \overline{A \cdot B}$

Q.43 Draw the schematic symbol for NOR gate. Explain its working with the help of its truth table.

Ans: 'NOR' gate :

- i. It is an electronic circuit, which has two or more inputs and only one output.
- ii. NOR gate is OR gate followed by NOT gate. i.e. NOT + OR = NOR



- iii. Symbol for NOR gate



- iv. It produces (generates) HIGH output when all the inputs are LOW.
- v. Truth table

Inputs		Output
A	B	$Y = \overline{A + B}$
0	0	1
1	0	0
0	1	0
1	1	0

- vi. NAND operation is indicated by '•' sign.
- vii. Boolean expression for NAND gate is,
 $Y = \overline{A + B}$

Q.44 State the uses logic gates.

- Ans:**
- i. Every digital circuit or instrument or system is made up of logic gates.
 - ii. They are used in automatic control system in industry, where certain operation is performed after checking status of sensors.
 - iii. Arithmetic and logic unit of computers and calculators uses logic gates.

□□□