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Q. What is PIN diode? Explain its working and V-I characteristics.

⇒ PIN diode:

PIN diode is a short form of Positive - Intrinsic - Negative diode.

PIN diode has highly improved switching time in comparison with a PN diode. Here a high resistivity intrinsic layer is sandwiched between P^+ and N^+ regions as shown in fig. ⓐ. Due to increased seperation between P and N regions, capacitance decreases. So PIN diode has fast response time. Therefore, it is useful at high frequencies.

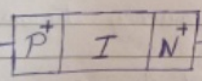

Fig ⓐ PIN diode

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Working:

With no bias applied, there will be diffusion of carriers because there is concentration gradient across the junction. The diffusion electrons and holes produce a depletion layer across PI and IN junctions as shown in fig ⓑ.

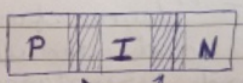

Fig ⓑ Depletion layer

The depletion layer penetrates to a little distance in P and N regions while a larger distance in I region. In this way device has a high value of resistance. As reverse biased is applied and gradually increased, the depletion region becomes more and more thick unfill the entire I region

is swept free of mobile carriers. The applied bias necessary for this to happen is termed as the 'Swept out voltage'.

At zero bias most of the I layer has mobile carriers and diode has high resistance. As increasing forward biased applied, carrier injection into I layer from P and N regions and reduces its forward resistance. Thus when PIN diode is forward biased, it acts like a variable resistance.

Applications:-

1) It can be used as alternator.
2) Used as constant impedance device.
3) PIN diode can be used in construction of phase modulator and amplitude modulator.
4) It can be used as a phase shifter.
5) It can be used as T-R switch in radar applications.

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Qu Give constructional details of photodiode. Draw its V-I characteristics and explain its working.

Qu Write the equation for the volt-ampere characteristics of a photodiode. Define each term in the equation

Qu List applications of photodiode.

⇒ A P-N photodiode is essentially a reverse biased junction diode with light permitted to fall on one surface of the device across the junction, keeping the remaining sides unilluminated. Fig. (a) shows the structure where P-N junction is embedded in a clear plastic capsule.

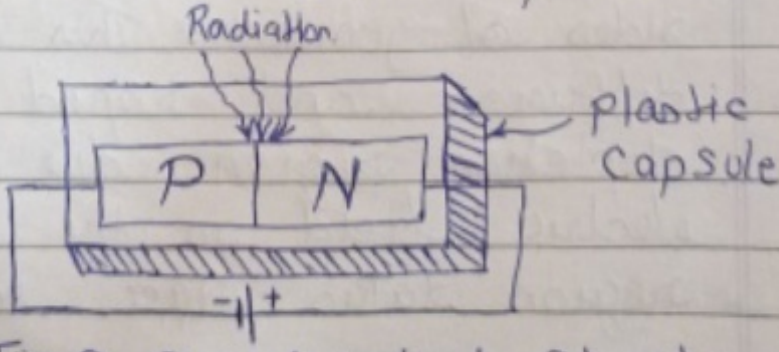

Fig (a) P-N photodiode Structure

The mechanism of current flow is shown in fig. (b)

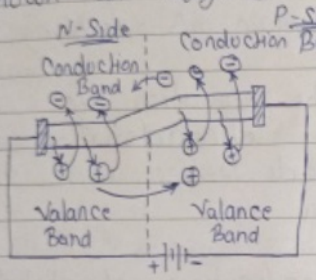

Fig (b) Mechanism of current flow

A reverse biased P-N junction has a small amount of reverse saturation current due to thermally generated electron – hole pairs i.e. minority carriers. When the radiation is incident, electron-hole pairs are created on both sides of junction. This process of diffusion and rapid crossing of depletion region due to strong electric field in the depletion region takes place so rapidly that there is a little possibility of recombination. The typical voltage-current characteristics of P-N photodiode is shown in fig (c). With zero illumination, the current equals the reverse current shown as a dark current.

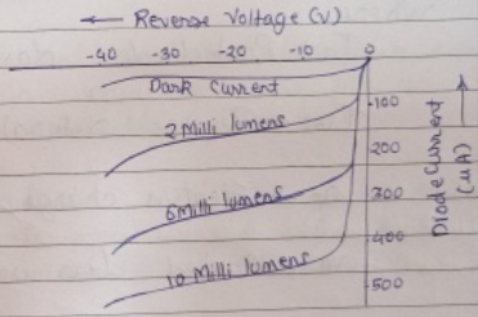

Fig (c) characteristics

It is obvious from the graph that curve do not pass through the origin and reverse current is almost dependent on the intensity of light.

The equation is given as follows

When reverse bias is applied, a small reverse saturation current appears. It is related to dark current as

$$I_D = I_{SAT}\left(e^{\frac{q \cdot V_A}{K_B T}} - 1\right)$$

Where,

$I_D \rightarrow$ Photodiode dark current

$I_{SAT} \rightarrow$ Reverse saturation current

$q \rightarrow$ Electron charge

$V_A \rightarrow$ Applied bias voltage

$K_B \rightarrow 1.38 \times 10^{-23}$ J/K (Boltzmann Constant)

$T \rightarrow$ Absolute temperature

Applications:-

1) P-N photodiodes are used in similar applications to other photodetectors, such as photoconductors, charge-coupled devices and photomultiplier tubes.

2) Used in consumer electronics devices such as compact disc players, smoke detectors.

3) Photodiodes are often used for accurate measurement of light intensity in science and industry.

4) They are also widely used in various medical applications, such as detector for computed tomography, instruments to analyze samples.