Experiment: 15

PHOTODIODE CHARACTERISTICS

AIM: To obtain reverse bias characteristics of the given photo-diode and hence to determine its photo responsivity.

APPARATUS: Photodiode, Light emitting diode(LED), DC regulated power supply, Ammeter, Voltmeter and connecting wires.

INTRODUCTION: A Photodiode is semiconductor diode (p-n junction) which converts light energy into electric current. When a photon of sufficient energy ($h\nu > E_g$) is incident on the diode, it generates an electron-hole pair. If electron hole-pairs are generated within the depletion region or one diffusion length away from it, these carriers are swept from the junction by the built-in electric field of the depletion region. This causes separation of charge carriers and generation of photo current.

If the photodiode is short circuited externally, current flows between p and n regions. It is known as **photoconductive mode** of operation. The diode is reverse biased for photoconductive operation. On the other hand, if the diode is left open (unbiased), an externally measurable voltage appears between p and n region. This is known as **photovoltaic mode**. This mode of operation is used in solar cells. A traditional solar cell is just a large area photodiode which works on the principle of photovoltaic effect.

A semiconductor photodiode is a reverse biased p-n junction. When the reverse bias is applied across the junction, depletion layer widens as mobile carriers are swept to their respective majority side. If the depletion region is wider, most of the incident photons are absorbed in this region and hence, efficiency of the device increases.

The Photodiode has a p-n junction or PIN structure. The P-N junction is made up of a light sensitive semiconductor. Silicon (190-1100 nm), Germanium (400-1700 nm), Indium Gallium Arsenide (800-2600 nm), Lead sulphide (1000-3500 nm) etc. are the semiconductors used for making different types of photodiodes. The photodiode is similar to an LED in construction but its p-n junction is highly sensitive to light.

The p-i-n diode has wide intrinsic semiconductor layer between p and n region. In this type of photo diode depletion region is very wide and extends throughout the intrinsic region and hence reverse bias applied is small, of the order of 5 V.

The photo responsivity of a photodiode is defined as the ratio of the output photocurrent measured in Ampere to its input optical specified in Lux.
The **lux** (symbol: lx) is the SI derived unit of illuminance and luminous emittance, measuring luminous flux per unit area. It is equal to one lumen per square meter. In photometry, this is used as a measure of the intensity, as perceived by the human eye, of light that hits or passes through a surface.

Photodiodes are used in consumer electronic devices such as compact disc players, smoke detectors and the receivers for infrared remote control devices used to control equipment from televisions to air conditioners. For many applications either photodiodes or photoconductors may be used. Either type of photo sensor may be used for light measurement, as in camera light meters, or to respond to light levels, as in switching on street lighting after dark.

p-i-n photo diode: To increase the sensitivity, the depletion region width should be made as large as possible. This can be achieved in p-i-n photodiode. The p-i-n photodiode consists of a p region and n region separated by intrinsic region.

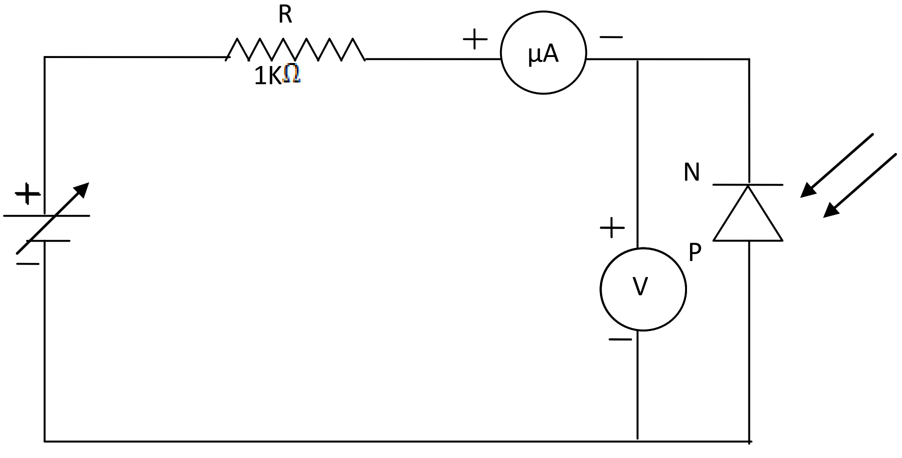
FORMULA:

1. $R = \frac{V}{I} = \frac{1}{slope}$

Where
I is the current through the photodiode in A
V is the voltage across the photodiode in V
R is the Resistance of the photodiode in reverse bias in Ω

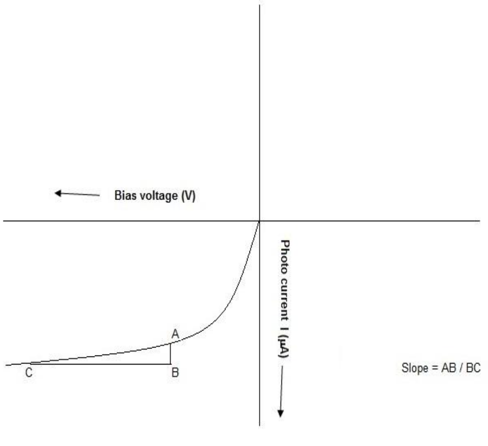
2. Photo responsivity $= \frac{Photocurrent\,(Ampere)}{Input\ optical\ power\,(Lux)}$

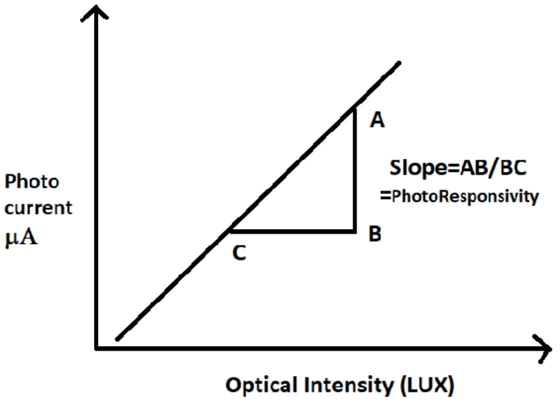
CIRCUIT DIAGRAM:



NATURE OF THE GRAPH:

1. Reverse bias characteristic of photo diode   2. Variation of photocurrent with intensity





PROCEDURE:

1. Connect the circuit as shown in the diagram.
2. Keep the light source at a distance of 2 cm from the photodiode.
3. Switch on the light source and vary the reverse bias voltage from 0 to 5V. Note the corresponding current through the photodiode for each voltage keeping the distance between the photodiode and the light source constant.
4. Plot current (I) v/s voltage (V) on a graph & determine reverse bias resistance of the photodiode from the plot.
5. Fix the reverse voltage to 5V and vary the distance between the light source & the photodiode.
6. For each distance (D) note down the current (I) through the photodiode.
7. Plot a graph of reverse current (I) versus input optical intensity in Lux.
8. Calculate the slope of the above graph to obtain photoresponsivity.

TABULAR COLUMN:

Reverse bias characteristics:

For fixed distance (D) =…..cm

Applied voltage (V)	**Reverse Current** (µA)	**Applied voltage** (V)	**Reverse current** (µA)	**Applied voltage** (V)	**Reverse current** (µA)
0		**0.5**		**3.0**	
0.1		**1.0**		**3.5**	
0.2		**1.5**		**4.0**	
0.3		**2.0**		**4.5**	
0.4		**2.5**		**5.0**	

Photo responsivity:

For fixed voltage (V) =…….V

Distance (cm)	**Reverse current** (µA)	Intensity of light(Lux)
1.0		
1.5		
2.0		
2.5		
3.0		
3.5		
4.0		

RESULT:

Resistance of the photodiode in reverse bias R = ……………………..Ω.

The photo responsivity of the given photodiode is =………………Ampere/Lux