Experiment: To study the intensity response of photo cell /solar cell and verify inverse square law of radiations using a photoelectric cell.

Apparatus: Photo cell (Selenium) mounted in the metal box with connections brought out at terminals, Lamp holder with 60W bulb, two moving coil analog meters (500µA & 1000mV) mounted on the front panel and connections brought out at terminals, wooden bench fitted with scale and connecting wires.

Theory:

A device used to convert light energy into electrical energy is called Photo Electric Cell. Photocell is based on the phenomenon of Photoelectric effect. Photo cell are of three types.

1. Photo-Emissive Cell.
2. Photo-Voltaic Cell.
3. Photo-Conductive Cell.

Photo-Emissive Cell: There are two types of photo-emissive cells; Vacuum type or gas filled type cells. Generally, it consists of two electrodes i.e. cathode (K) and anode (A). The cathode is in the form of semi-cylindrical plate coated with photo-sensitive material like sodium potassium or cesium i.e. alkali metals. To have large current, it is usually coated with antimony cesium alloy or combination of bismuth, silver, oxygen and cesium. The anode (A) is in the form of a straight wire made of nickel or platinum. The anode (A) faces the cathode (K). These electrodes are sealed in an evacuated glass or quartz bulb according to weather it is to be used with visible or ultra-violet light. As the current due to vacuum is small, so to increase the current, the bulb of the cells is filled with an inert gas like helium, neon, argon etc. at pressure of 1mm of mercury.

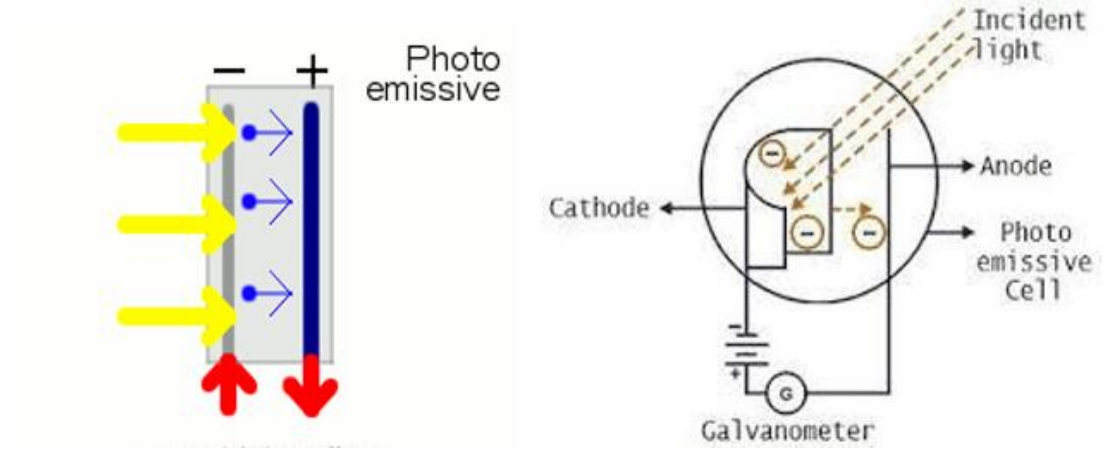


Fig. 1. Schematic and working of photo emissive cell

When photo-electrons flow from cathode to anode, they ionize the gas filled and hence the current gets modified. The main drawback of this type of cell (i.e., gas filled cell) is that the photo-electric current does not vary linearly with the intensity of the light.

Since there is no time lag between the incident light and the flow of electrons and hence current, therefore such a cell is used in television, photometry, fire alarm etc.

Photo-Voltaic Cell:

Photo-Voltaic Cell is based on the principle of inner photo electric cell. It is called true cell since it generates e.m.f. without applying any external potential difference but by only the light incident on it. It consists of a semiconductor layer formed on the surface of the metal plate by either heat treatment or cathode sputtering. A film of semi-transparent metal is coated over the semi-conductor. This film maintains the electrical contact with the semi- conductor and simultaneously allows the incident light to fall on the semi-conductor.

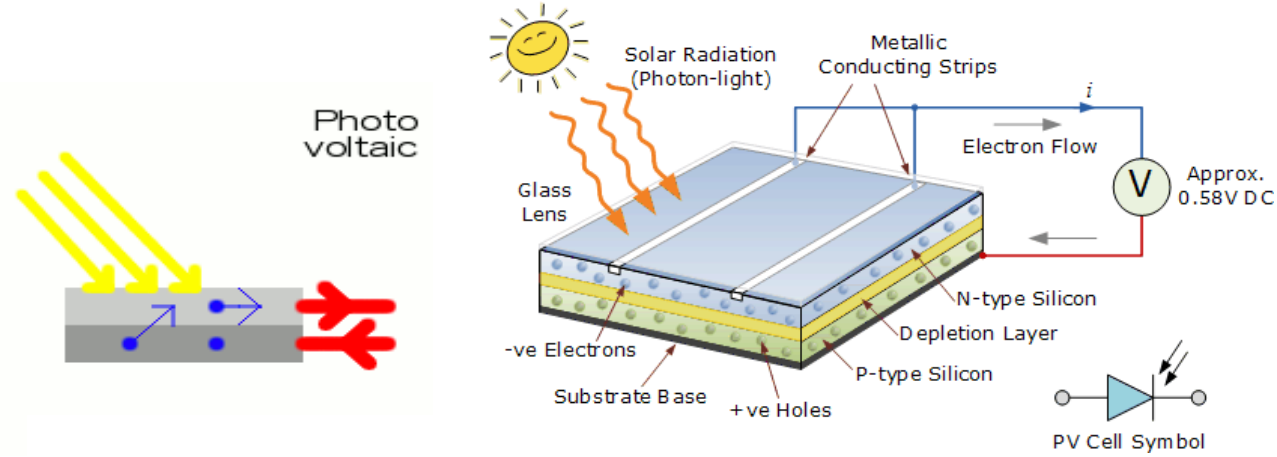


Fig. 2. Schematic and working of photovoltaic cell (Solar cell)

When light is incident on the semi-conductor, electrons are emitted which flow in a direction opposite to the light rays. If the circuit is completed between the surface transparent film and metal base through a low resistance galvanometer (G), the current can be measured. If the resistance of the circuit is very small, the current is proportional to the intensity of incident light. The main advantage of this cell is that it requires no external voltage for its operation. This type of cell is widely used in photographic exposure meters, photometers and illumination meters etc.

Photo-Conductive Cell:

Photo-Conductive Cell is also based on the principle of inner photoelectric effect. It consists of a thin film of semi-conductor like Selenium or Thallium sulphide placed below a thin film of semi-transparent metal. The combination is placed over the block of iron. The iron base and the transparent metal film is connected through battery and resistance. When light falls on the cell, its resistance decrease and hence the current starts flowing in the external circuit.

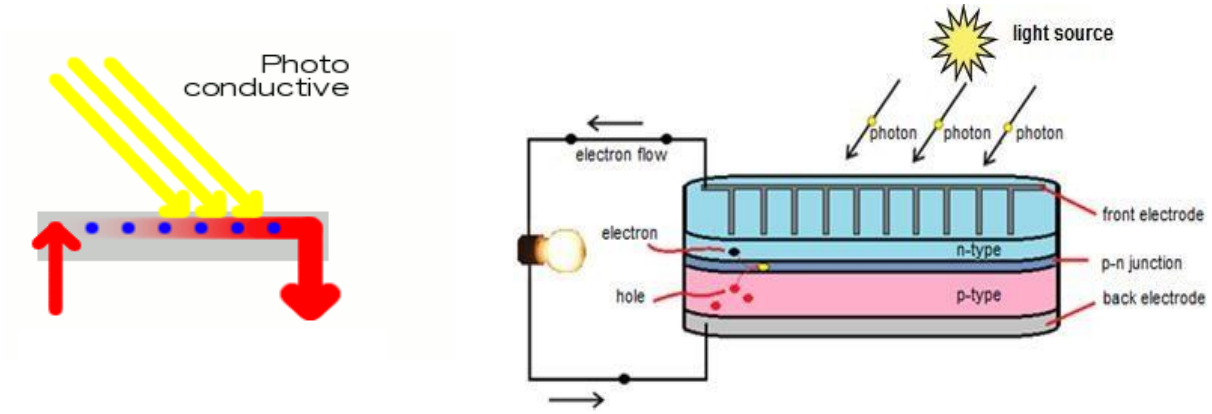


Fig. 3. Schematic and working of Photo conductive cell.

However here the change in current is not proportional to change in intensity of light. Further there also sufficient time lag between the change in light intensity and change in photo current so generated i.e. response time is large.

Selenium Cell: In this cell the base is Ni plated iron on which a thin layer of semiconducting

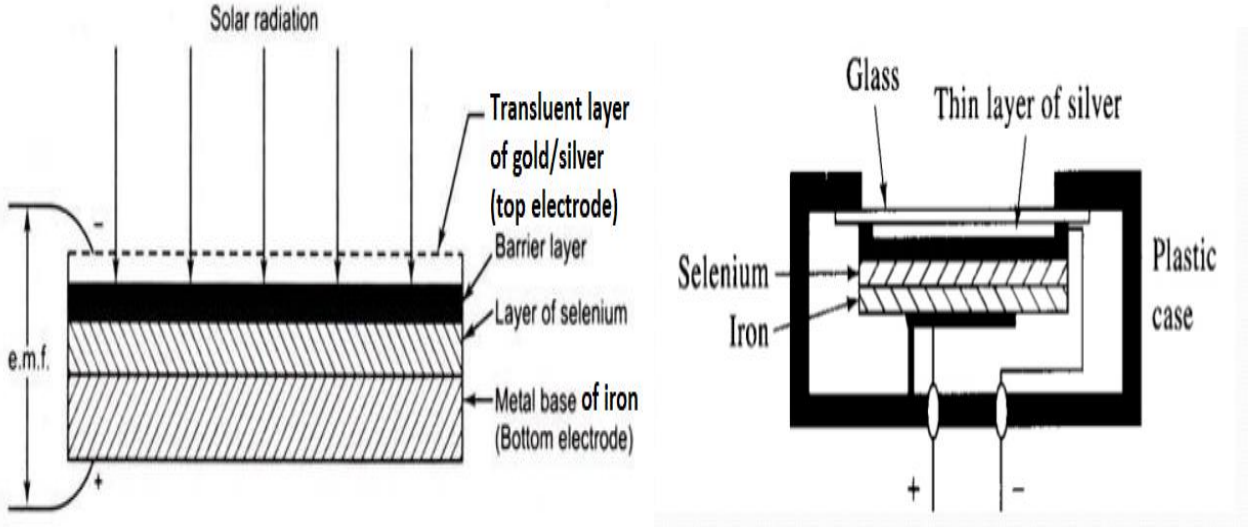


Fig.4. Selenium photovoltaic cell

material (e.g. Se) is spread. The surface is a translucent layer of Ag or Pt . The barrier layer is formed

when silver is deposited by electrical sputtering process. A Cu ring is in contact with the iron bases serving as one electrode and other Cu ring in contact with silver film acting as second electrode. The cell is enclosed in a case fitted with a protective window.

When light falls on the cell it passes through the window and incident on translucent surface film of silver and transparent barrier layer. On hitting the selenium layer it ejects electrons which move across the barrier. Under the influence of light a negative charge builds up on the silver electrode and positive charge on the bottom electrode producing an emf.

Let 'I' be the luminous intensity of an electric lamp and 'E' be the illuminance at a point distance'd' from it. According to the inverse square law;

$$E = \frac{I}{d^2}$$

If light from the lamp be incident on the photovoltaic cell placed at a distance'd' from it, then the photo-current given out is proportional to E and if θ be the corresponding deflection shown by the microammeter then,

$$\theta \propto E$$

or $$\theta \propto \frac{I}{d^2}$$

or $$\theta \times d^2 = \text{constant}$$

Circuit diagram:

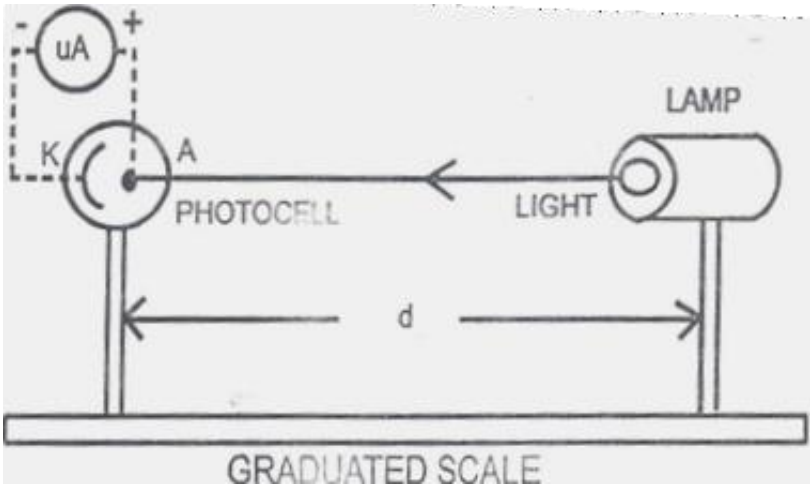


Fig. 4 Experimental Board

Procedure:

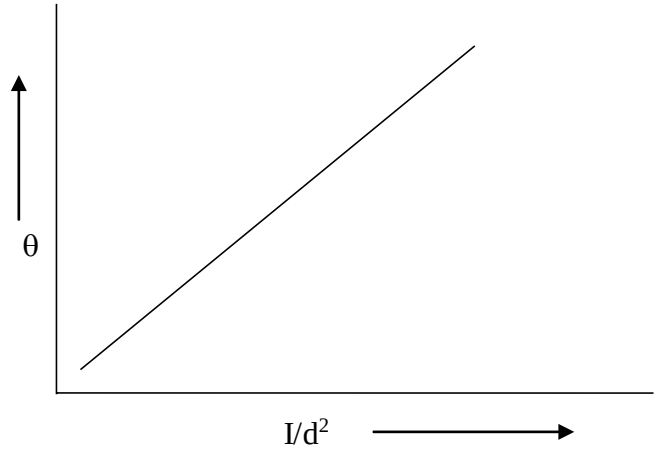
1. Perform the experiment in dark room, for this mount the various parts of the apparatus on the wooden plank provided with a ½ meter scale. Make the other connections as shown in the Fig. 4.
2. Switch on the lamp and adjust it at a suitable distance from the photocell so that the micro ammeter and mill-voltmeter indicate a reasonable deflection.
3. Change the distance of lamp from the voltaic cell and take a series of observations for the corresponding values of distance (d) and deflection (θ).

Observations:

	Position of the lamp d_1 (cm)	Position of the photocell d_2 (cm)	Deflection (θ) (μA)	Distance from Photo cell and lamp ($d=d_2- d_1$) (cm)	$E=I/d^2$	$d^2\times\theta$
1.						
2.						
3.						
4.						

Graph:

Plot a graph between $1/d^2$ and θ, taking $1/d^2$ along X-axis and θ along Y-axis. It should be a straight line.



Precautions:

1. Stray light should be avoided.
2. The effect of the reflected light from the bench surface should be minimized.
3. Very sensitive micro ammeter should be used.h

Some questions for viva voce examination:

Q.1 What is photoelectric effect?

Q.2 What is a photo cell?

Q.3 Define the illuminating power and intensity of illumination.

Q.4 Which type of the cell is a solar cell?

Q.5. Give two applications of solar cell in daily life.

Q6. Is there any difference between photodiode and photocell?

Q7. What is dark current in photodiode?

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