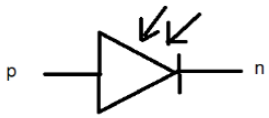
Photo Diode: Photodiodes are a class of diodes that converts light energy to electricity. Their working is exactly the opposite of LEDs which are also diodes but they convert electricity to light energy. Photodiodes can also be used in detecting the brightness of the light.

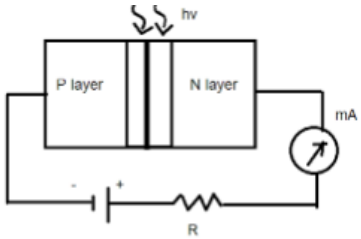
A photodiode is a PN-junction diode that consumes light energy to produce an electric current. They are also called a photo-detector, a light detector, and a photo-sensor. Photodiodes are designed to work in reverse bias condition. Typical photodiode materials are Silicon, Germanium and Indium gallium arsenide.

Symbol of Photo diode:



Construction of Photo diode:

The PN junction of the photodiode is placed inside a glass. This transparent glass allows sunlight to pass through the diode. The other side of the glass is insulated.



Working Principle: When the photodiode is not exposed to light or radiation, the electrons in the p side flow through the junction. As the minority carriers are flowing through the junction, there will be a flow of reverse current. This current is called dark current.

When the photodiode is exposed to light, the temperature of the junction will increase. The electrons and holes will get separated from each other. The electrons, which are on the n side will get attracted towards the positive terminal of the battery and the holes, which are on the p side will get attracted to the (-) terminal of the battery.

As a result of this, a high amount of reverse current gets generated through the junction. When the light intensity increases, more carriers are generated and flow through the photodiodes. Hence, a large current is produced.

The light intensity is directly proportional to the electric current

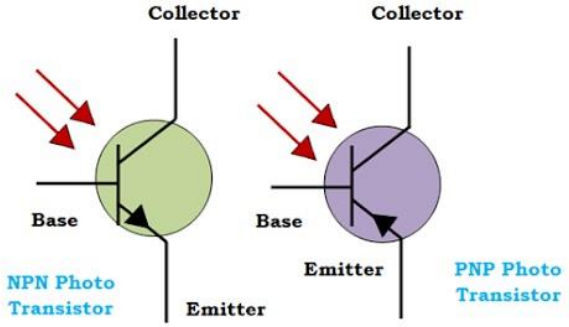
Applications:

- Photodiodes are used in burglar alarms.
- Photodiodes are used in counters and switching circuits.
- It helps to communicate in the optical system.

- It is used in logic circuits and encoders.

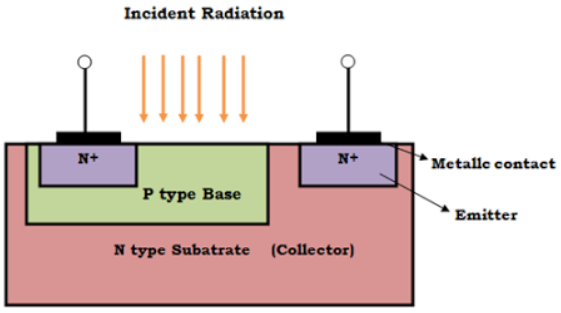
Photo Transistor: Photo Transistor is a three terminal semiconductor device which converts the incident light into photocurrent. Light is incident on the base terminal and it is converted into current which flows through emitter and collector. It is the combination of photo diode and transistor an amplifier. The current produced by the photo diode is low, so it is sent through the transistor and amplified.

Symbol:



The symbol of Photo Transistor is similar to the transistor. The arrows shows the light incident on the base terminal.

Construction:

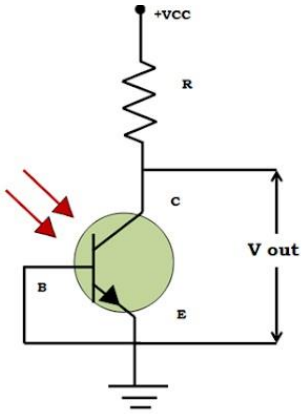


When compared to normal transistor, in photo transistor the base and collector area is large. The base area is increased to increase the amount of current generated. Because more the light falls more the current is generated.

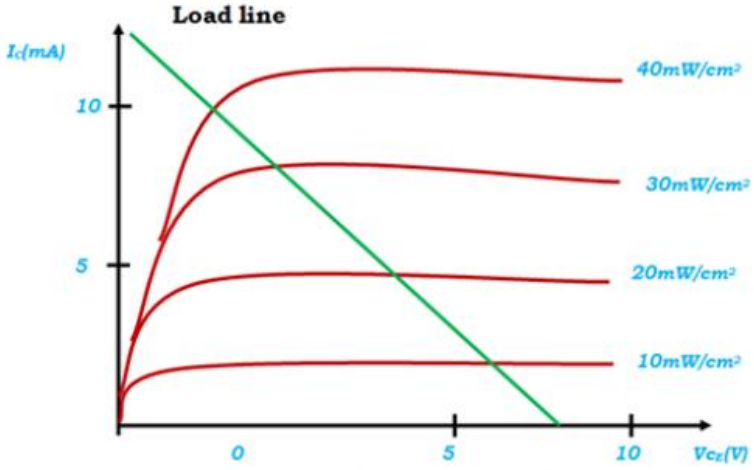
Earlier it was made up of single semiconductor material like silicon or germanium. Recently photo transistors are made up of Gallium and Arsenic to obtain higher efficiency. Finally photo transistor is placed inside a metallic case and a lens is kept at the top of the case to absorb the incident radiation.

Working of a transistor: we can know that base is not connected to any external bias and only light is incident on the base terminal. Collector terminal is connected to the positive side of external supply and output is taken from the emitter terminal.

When no light is incident on the base terminal only some leakage current flows and it is called as dark current. When light is incident on the lens at the base collector junction, base current is generated which is proportional to the intensity of the incident light.



Characteristics: we can observe how the collector current varies with the intensity of the incident light. The collector current increases with the intensity of the incident light. Collector current differs with the wavelength and the intensity of the light.



Advantages:

1. Efficiency is high
2. Faster response
3. Less noise interference
4. Low cost
5. Small in size

Disadvantages:

1. Poor performance at high frequency
2. Slower than photodiode

Applications:

1. Used in Counting systems

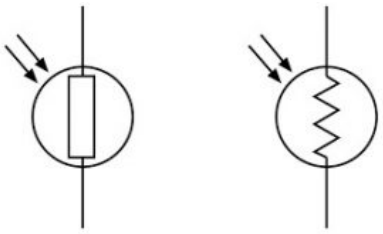
2. Used in Optical tape reader
3. Used to detect Object
4. Used in printers

Light Dependent Resistor: The controlling of lights and home appliances is generally operated and maintained manually on several occasions. But the process of appliances controlling may cause wastage of power due to the carelessness of human beings or unusual circumstances. To overcome this problem we can use the light-dependent resistor circuit for controlling the loads based on the intensity of light. An LDR or a photoresistor is a device that is made up of high resistance semiconductor material.

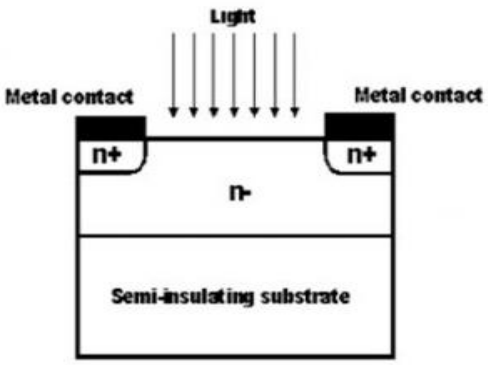
An electronic component like LDR or light-dependent resistor is responsive to light. Once light rays drop on it, then immediately the resistance will be changed. The resistance values of an LDR may change over several orders of magnitude. The resistance value will be dropped when the light level increases.

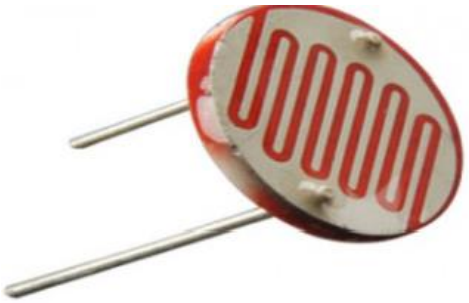
The designing of LDRs can be done by using semiconductor materials to allow their light-sensitive properties. The famous material used in this resistor is CdS (cadmium sulfide).

Symbol:



Construction: The construction of an LDR includes a light-sensitive material that is placed on an insulating substrate like ceramic. The material is placed in a zigzag shape in order to get the required power rating and resistance. The area of zigzag separates the metal-placed areas into two regions.



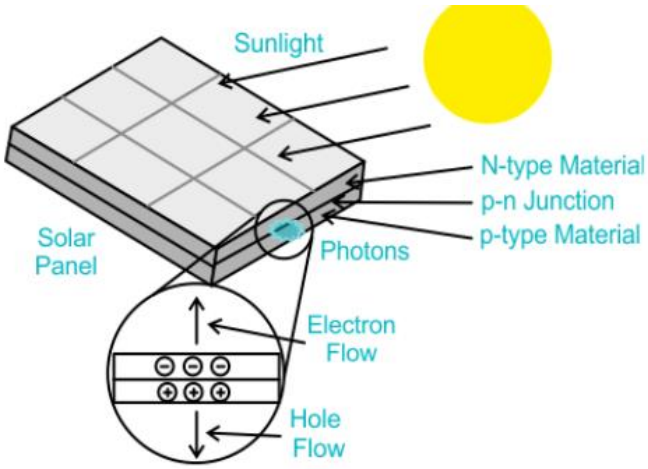


Working: The working principle of an LDR is photoconductivity, which is nothing but an optical phenomenon. When the light is absorbed by the material then the conductivity of the material enhances. When the light falls on the LDR, then the electrons in the valence band of the material are eager to the conduction band. But, the photons in the incident light must have energy superior to the bandgap of the material to make the electrons jump from one band to another band (valance to conduction).

Hence, when light having ample energy, more electrons are excited to the conduction band which grades in a large number of charge carriers. When the effect of this process and the flow of the current starts flowing more, the resistance of the device decreases.

Photovoltaic Cell: A photovoltaic cell is a type of PN junction diode which harnesses light energy into electricity. They generally work in a reverse bias condition. It is analogous to a solar cell since they belong to similar working principles but have distinct differences.

Construction:

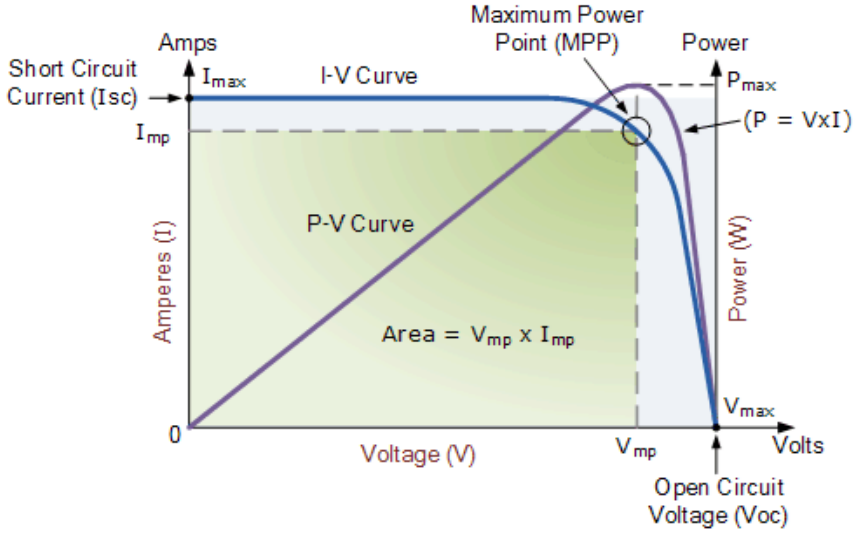


The cell consists of each a P-type and an N-type material and a PN junction diode sandwiched in between. This layer is responsible for trapping solar energy which converts into electricity. The N-type layer is also known as the first layer or the emitter layer. The P-type layer is the base layer and the intermediate layer between the two is the PN junction diode. The surface of the cell is covered by an anti-reflective material which traps the light energy and avoids any loss of energy. The bottom layer, the last one may completely be covered by the material in which the conductor is made up of.

Working: A photovoltaic cell works on the same principle as that of the diode, which is to allow the flow of electric current to flow in a single direction and resist the reversal of the same current, i.e, causing only forward bias current.

- When light is incident on the surface of a cell, it consists of photons which are absorbed by the semiconductor and electron-hole pairs are liberated to produce an external DC supply.
- In a solar cell, the junction area is much bigger than the photovoltaic cell because its main interest is the generation of power but for a photovoltaic cell the main purpose is the generation of electricity.
- If the incident energy (hv) is greater than the energy gap of that semiconductor material, these electron-hole pairs are generated at the depletion region of a diode.
- When this photon from external radiation hits the diode, these electron-hole pairs disrupt the neutrality of the conductor. If an external current path has been provided then the electrons flowing through the P-side travel towards the N-side,eventually generating a DC current and the magnitude of this electromotive force generated is directly proportional to the intensity of the incident radiation.

Characteristics:



The above graph shows the current-voltage (I-V) characteristics of a typical silicon PV cell operating under normal conditions. The power delivered by a single solar cell or panel is the product of its output current and voltage (I x V). If the multiplication is done, point for point, for all voltages from short-circuit to open-circuit conditions, the power curve above is obtained for a given radiation level.

With the solar cell open-circuited, that is not connected to any load, the current will be at its minimum (zero) and the voltage across the cell is at its maximum, known as the solar cells open circuit voltage, or Voc. At the other extreme, when the solar cell is short circuited, that is the positive and negative leads connected together, the voltage across the cell is at its minimum (zero) but the current flowing out of the cell reaches its maximum, known as the solar cells short circuit current, or Isc.

Advantages:

1. They generate clean energy and are sustainable for the environment
2. Low maintenance costs.
3. It is a renewable energy source and easily available.
4. They have a lower risk for the loss of efficiency and can be used for a longer time period.
5. Cancels noise pollution.

Disadvantages:

1. The infrastructure for photovoltaic cells are not readily available on a larger scale.
2. Though maintenance costs are low, the installation is much more expensive.
3. Currently photovoltaic cells cannot produce electricity at a commercial level, they operate on devices which require less electricity and power.
4. Long-range transmission is difficult when it comes to photovoltaics

Applications:

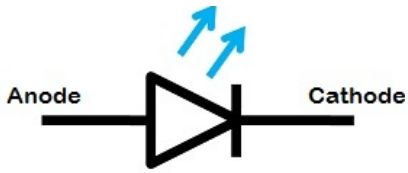
1. Can be used in making solar farms, which would generate gigawatts of electricity.

2. In difficult topographical conditions photovoltaic cells would efficiently deliver electricity than the conventional source.
3. Can be used in standalone devices and meters.
4. Primary power source for space explorations and experiments, due to its lightweight.
5. Navigation aids.

Light Emitting Diode (LED): The LED is a special type of diode and they have similar electrical characteristics to a PN junction diode. Hence the LED allows the flow of current in the forward direction and blocks the current in the reverse direction. The LED occupies a small area which is less than 1 mm^2.

The lighting emitting diode is a p-n junction diode. It is a specially doped diode and made up of a special type of semiconductors. When the light emits in the forward biased, then it is called a light-emitting diode.

LED Symbol: The LED symbol is similar to a diode symbol except for two small arrows that specify the emission of light, thus it is called LED (light-emitting diode). The LED includes two terminals namely anode (+) and the cathode (-).



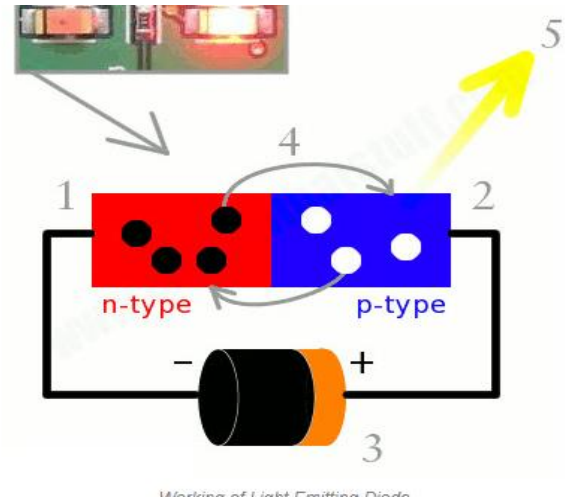
Construction: The construction of LED is very simple because it is designed through the deposition of three semiconductor material layers over a substrate. These three layers are arranged one by one where the top region is a P-type region, the middle region is active and finally, the bottom region is N-type. The three regions of semiconductor material can be observed in the construction. In the construction, the P-type region includes the holes; the N-type region includes elections whereas the active region includes both holes and electrons.

When the voltage is not applied to the LED, then there is no flow of electrons and holes so they are stable. Once the voltage is applied then the LED will forward biased, so the electrons in the N-region and holes from P-region will move to the active region. This region is also known as the depletion region. Because the charge carriers like holes include a positive charge whereas electrons have a negative charge so the light can be generated through the recombination of polarity charges.

Working:

1. From the above diagram, we can observe that the N-type silicon is in red color including the electrons which are indicated by the black circles.
2. The P-type silicon is in the blue color and it contains holes, they are indicated by the white circles.

3. The power supply across the p-n junction makes the diode forward biased and pushing the electrons from n-type to p-type. Pushing the holes in the opposite direction.
4. Electron and holes at the junction are combined.
5. The photons are given off as the electrons and holes are recombined.

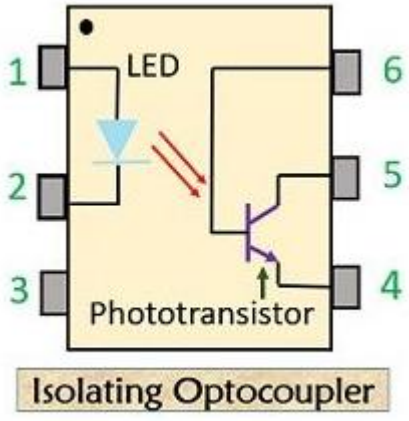


Opto Coupler: An optocoupler or optoelectronic coupler is an electronic component that basically acts as an **interface** between the two separate circuits with **different voltage levels**. Optocouplers are common component by which electrical isolation can be supplied between the input and output source. It is a **6 pin device** and can have any number of photodetectors.

Here, a beam of light emitted by a light source exists as an only contact between input and output. Due to this, we can have an **insulation resistance** of megaohms between the two circuits. In high voltage applications where the voltage difference between the two circuits differs by several thousand volts, such isolation is favourable. The use of all such electronic isolators lies in all that conditions where the signal is to pass between two isolated circuits.

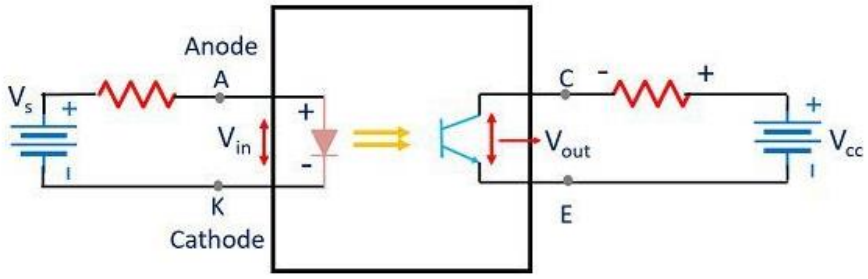
Construction: An optocoupler mainly consists of an infrared LED and a photosensitive device that detects the emitted infrared beam. The semiconductor photosensitive device can be a photodiode, phototransistor, SCR or TRIAC.

The infrared LED and the device that are light sensitive is packed in a single package. The LED is kept on the input side and the light-sensitive material is placed on the output side. A resistance is connected at the beginning of the circuit which is used to limit the current and the other resistance is connected between the supply voltage and the collector terminal.



Working: An Optocoupler is a combination of LED and a Photo-diode packed in a single package. As we can see in the below-shown circuit diagram, when a high voltage appears across the input side of the Optocoupler, a current start to flow through the LED.

Due to this current LED will emit light. This emitted light when falls on a phototransistor cause a current to flow through the same. The current flowing through the phototransistor is directly proportional to the supplied input voltage. An input resistance placed at the beginning of the circuit will decrease the amount of current flowing through the LED if its value is increased. As the LED glows due to this current, hence, when current will be low so as the light intensity of LED.



LED Driving a Phototransistor

As we have already discussed earlier the intensity of emitted light by the LED will be equal to the corresponding current flowing through the phototransistor. This means that the low-intensity light emitted by the LED will cause a low-level current to flow through the phototransistor. Thus a changing voltage is generated across the collector-emitter terminal of the transistor.

Advantages:

1. Optocouplers allow easy interfacing with logic circuits.
2. Electrical isolation provides circuit protection.
3. It allows wideband signal transmission.
4. It is small in size and lightweight device.

Disadvantages:

1. The operational speed of Optocouplers is low.
2. In case of a very high power signal, the possibility of signal coupling may arise.

Applications:

1. It is used in high power inverters.
2. It is used in high power choppers.
3. In AC to DC converters optocouplers are widely used.