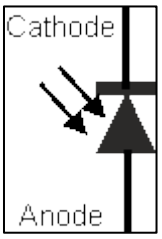
Optoelectronic Devices

Photodiode : A **photodiode** is a semiconductor device that converts light into current. The current is generated when photons are absorbed in the photodiode. A small amount of current is also produced when no light is present.



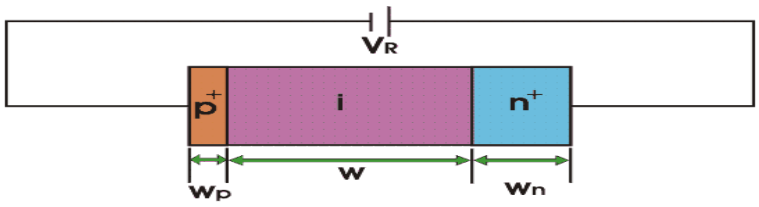
A photodiode is a p–n junction or PIN structure. When a photon of sufficient energy strikes the diode, it creates an electron-hole pair. This mechanism is also known as the inner photoelectric effect. If the absorption occurs in the junction's depletion region, or one diffusion length away from it, these carriers are swept from the junction by the built-in electric field of the depletion region. Thus holes move toward the anode, and electrons toward the cathode, and a photocurrent is produced. The total current through the photodiode is the sum of the dark current (current that is generated in the absence of light) and the photocurrent, so the dark current must be minimized to maximize the sensitivity of the device.

PIN/PN photodiode: PIN/PN photodiode is a kind of photo detector, it can convert optical signals into electrical signals.

There are three regions in this type of diode. There is a p-region an intrinsic region and an n-region. The p-region and n-region are comparatively heavily doped than the p-region and n-region of usual p-n diodes. The width of the intrinsic region should be larger than the space charge width of a normal p-n junction.

The PIN photo diode operates with an applied reverse bias voltage and when the reverse bias is applied, the space charge region must cover the intrinsic region completely. A PN photodiode does not require a reverse bias and as a result is more suitable for low light applications as a result of the improved noise performance. While reverse bias required by the PIN photodiode introduces a noise current which reduces signal to noise ratio Electron hole pairs are generated in the space charge region by photon absorption. The switching speed of frequency response of photo diode is inversely proportional to the life time. The switching speed can be enhanced by a small minority carrier lifetime. If the depletion region width should be made as large as possible for small minority carrier lifetime as a result the switch speed also increases.

This can be achieved PIN photo diode as the insertion of intrinsic region the space charge width larger. The diagram of a normal PIN photodiode is given below.

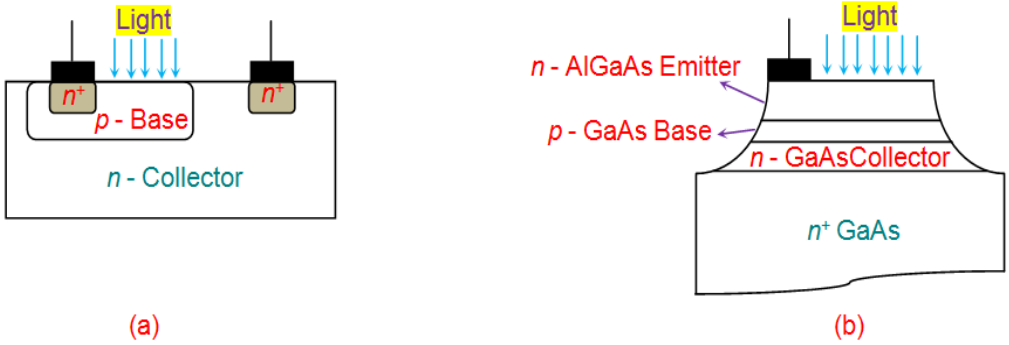


Applications

The PIN photo-diode does not have any gain, and for some applications this may be a disadvantage. Despite this it is still the most widely used form of diode, finding applications in audio CD players, and DVD drives, etc. In addition to this they are used in optical communication systems.PIN photodiode are also used as nuclear radiation detectors.

Phototransistors: Phototransistors are either tri-terminal (emitter, base and collector) or bi-terminal (emitter and collector) semiconductor devices which have a light-sensitive base region. Although all transistors exhibit light-sensitive nature, these are specially designed and optimized for photo applications.

These are made of diffusion or ion-implantation and have much larger collector and base regions in comparison with the ordinary transistors. These devices can be either homojunction structured or heterojunction structured, as shown by Figure a and b, respectively. In the case of homojunction phototransistors, the entire device will be made of a single material-type; either silicon or germanium. However to increase their efficiency, the phototransistors can be made of non-identical materials (Group III-V materials like GaAs) on either side of the pn junction leading to heterojunction devices. Nevertheless, homojunction devices are more often used in comparison with the hetero junction devices as they are economical.



Advantages of Phototransistor

1. Simple, compact and less expensive.
2. Higher current, higher gain and faster response times in comparison with photodiodes.
3. Results in output voltage unlike photo resistors.
4. Sensitive to a wide range of wavelengths ranging from ultraviolet (UV) to infrared (IR) through visible radiation.
5. Sensitive to large number of sources including incandescent bulbs, fluorescent bulbs, neon bulbs, lasers, flames and sunlight.
6. Highly reliable and temporally stable.
7. Less noisy when compared to avalanche photodiodes.
8. Available in wide variety of package types including epoxy-coated, transfer-molded and surface mounted.

Disadvantages of Phototransistor

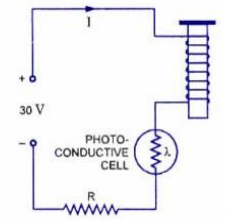
1. Cannot handle high voltages if made of silicon.
2. Prone to electric spikes and surges.
3. Affected by electromagnetic energy.
4. Do not permit the easy flow of electrons unlike electron tubes.
5. Poor high frequency response due to a large base-collector capacitance.
6. Cannot detect low levels of light better than photodiodes.

Applications of Phototransistor

1. Object detection, Encoder sensing
2. Automatic electric control systems such as in light detectors
3. Computer logic circuitry and Counting systems etc.

Photoconductive cell : The photoconductive cell is a two terminal semiconductor device whose terminal resistance will vary (linearly) with the intensity of the incident light. For obvious reasons, it is frequently called a *photoresistive device.*

The essential elements of a photoconductive cell are the ceramic substrate, a layer of photoconductive material, metallic electrodes to connect the device into a circuit and a moisture resistant enclosure. The photoconductive materials most frequently used include cadmium sulphide (CdS) and cadmium selenide (CdSe). When light of suitable frequency falls on the transparent film, the electrical resistance of selenium layer decreases. This changes the current flowing in the circuit. are often used include camera light meters, street lights, clock radios, and infrared detectors.

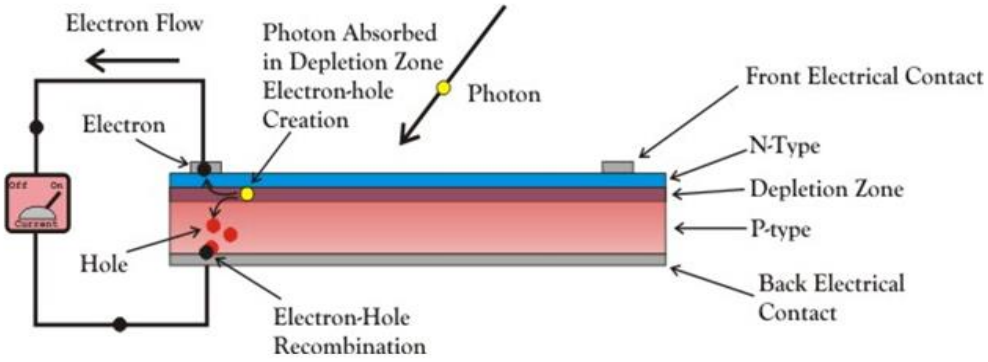


Photovoltaic Cell : A photovoltaic cell (PV cell) is a specialized semiconductor diode that converts visible light into direct current (DC). Some PV cells can also convert infrared (IR) or ultraviolet (UV) radiation into DC electricity. Photovoltaic cells are an integral part of solar-electric energy systems, which are becoming increasingly important as alternative sources of utility power. One of the major advantages of photovoltaics is the fact that it is non-polluting, requiring only real estate (and a reasonably sunny climate) in order to function. Another advantage is the fact that solar energy is unlimited. Once a photovoltaic system has been installed, it can provide energy at essentially no cost for years, and with minimal maintenance.

Solar Cell : A solar cell is a solid-state electrical device (p-n junction) that converts the energy of light directly into electricity (DC) using the photovoltaic effect. The process of conversion first requires a material which absorbs the solar energy (photon), and then raises an electron to a higher energy state, and then the flow of this high-energy electron to an external circuit. Silicon is one such material that such process.

Solar cell is basically a junction diode, but constructionally it is littlebit different form conventyional p - n junction diode. A very thin layer of p - type semiconductor is grown on a relatively thicker n - type semiconductor. We provide few finer electrodes on the top of the p - type semiconductor layer. These

electrodes do not obstruct light to reach the thin p - type layer.



When light reaches the p-n junction, the light photons can easily enter in the junction, through very thin p-type layer. The light energy, in the form of photons, supplies sufficient energy to the junction to create a number of electron-hole pairs. The incident light, breaks the thermal equilibrium condition of the junction. The free electrons in the depletion region can quickly come to the n-type side of the junction. Similarly, the holes in the depletion can quickly come to the p-type side of the junction. Once, the newly created free electrons come to the n-type side, cannot further cross the junction because of barrier potential of the junction. Similarly, the newly created holes once come to the p-type side cannot further cross the junction became of same barrier potential of the junction. As the concentration of electrons becomes higher in one side i.e. n-type side of the junction and concentration of holes becomes more in another side i.e. the p-type side of the junction, the p-n junction will behave like a small battery cell. A voltage is set up which is known as photo voltage. If a small load is connected across the junction, there will be a tiny current flowing throgh it.

LED : 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 as a light emitting diode.

There are many applications of the LED and some of them are explained below.

- LED is used as a bulb in the homes and industries
- The light emitting diodes are used in the motorcycles and cars
- These are used in the mobile phones to display the message
- At the traffic light signals led's are used

Advantages of LED's are**-**

- The cost of LED's is less and they are tiny.
- By using the LED's the electricity is controlled.
- The intensity of the LED differs with the help of the microcontroller.

LCD : A liquid crystal display or LCD draws its definition from its name itself. It is combination of two states of matter, the solid and the liquid. LCD uses a liquid crystal to produce a visible image. Liquid crystal displays are super-thin technology display screen that are generally used in laptop computer screen, TVs, cell phones and portable video games. LCD's technologies allow displays to be much thinner when compared to cathode ray tube (CRT) technology.

Advantages of an LCD's:

- LCD's consumes less amount of power compared to CRT and LED
- LCD's are consist of some microwatts for display in comparison to some mill watts for LED's
- LCDs are of low cost
- Provides excellent contrast
- LCD's are thinner and lighter when compared to cathode ray tube and LED

Disadvantages of an LCD's:

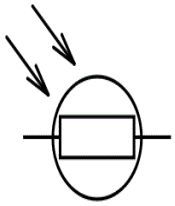
- Require additional light sources
- Range of temperature is limited for operation
- Low reliability
- Speed is very low
- LCD's need an AC drive

Applications of Liquid Crystal Display

Liquid crystal technology has major applications in the field of science and engineering as well on electronic devices.

- Liquid crystal thermometer
- Optical imaging
- The liquid crystal display technique is also applicable in visualization of the radio frequency waves in the waveguide
- Used in the medical applications

LDR : A **Light Dependent Resistor** (LDR) or a photo resistor is a device whose resistivity is a function of the incident electromagnetic radiation. Hence, they are light sensitive devices. They are also called as photo conductors, photo conductive cells or simply photocells. They are made up of semiconductor materials having high resistance. There are many different symbols used to indicate a **LDR**, one of the most commonly used symbol is shown in the figure below. The arrow indicates light falling on it.



ave low cost and simple structure. They are often used as light sensors. They are used when there is a need to detect absences or presences of light like in a camera light meter. Used in street lamps, alarm clock, burglar alarm circuits, light intensity meters, for counting the packages moving on a conveyor belt, etc.

Photocouplers : Photo Coupler is that which ensures total electronic isolation, including potential isolation (as in the case of transformer) in an electrical circuit. Devices of the Photo Coupler family include Photo Transistor, Photo Darlington Transistor High speed Photo coupler. These devices have the characteristics of excellent isolation, high CTR, compact package, high-speed operation, low decay and unit control function not being influenced by field effects. They are most suitable to be used for microelectronics, data processing and telecommunication system. Due to their high safety features, they are particularly suitable for use in switching mode power supply units.