29/11/24

CH :- OPTO Electronics

- ## Light Emitting Diode :- / A PN

Junction diode, which emits light when forward biased, is known as a light emitting diode. The emitted light may be visible or invisible.

The electrons from the N-type material crosses the PN Junction and recombine with holes in the p-type material.

When recombining takes place, these electrons release energy in the form of heat & light.

In Germanium & silicon diode, almost the entire energy is given up in the form of heat & emitted light is insignificant.

However, materials like Gallium, Arsenide, the number of photons of light energy is sufficient to produced in tance visible light.

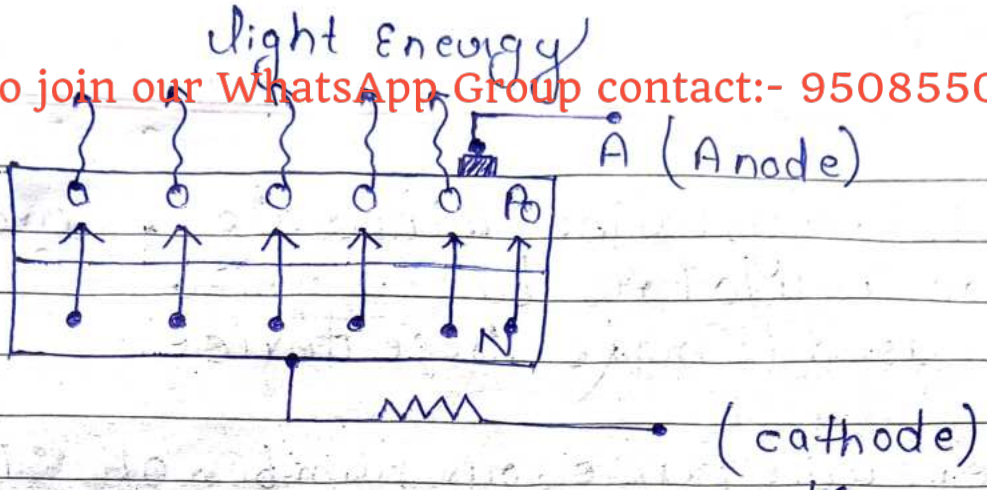


Fig :- Basic structure of LED

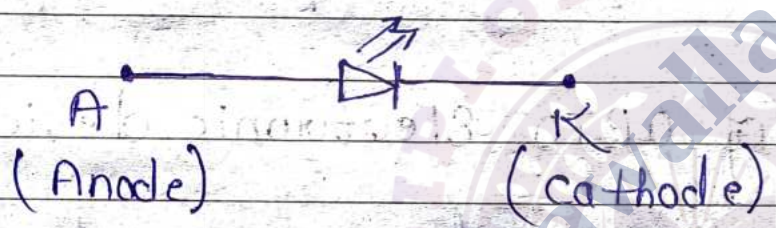


Fig :- Symbol of LED

13/12/24

→ ① OPTO electronic device is research, design and production of a hardware device. That transform electrical energy into light energy using semiconductors.

② It is the connection between optics and electronics. OPTO design electronic devices are special type of semiconductor devices that are able to convert light energy to electrical energy or electrical energy to light energy.

(3) Solid crystaline minerals, are heavier than insulator, but lighter than metals, are used to make these device.

(4) There are numerous number of OPTO electronic application like in millatary, telecommunication, automatic access control system, medical equipment etc.

* Properties of OPTO Electronic device :-

1. such devices have a longer wavelength.
2. They can be easily fabricated.
3. They are cost effected.
4. They have the size of a nanometer.
5. Such devices uses high power light sources.
6. OPTO electronic junction devicled are the P-N junction. in which the carriers are generated by Photos.

As per quantum theory, light consist of descipt packet of energy is called 'Photon'

The Energy (E) contain is a photon is given by

$E = hf$ Where h = Plank's constant
$= 6.625 \times 10^{-34}$ J/s

f = frequency of light.

$f = \frac{c}{\lambda}$

c = Velocity of light (3×10^8 m/s)

λ = Wave length of light (in m)

$\lambda = \frac{c}{f}$

$\lambda = \frac{ch}{E}$

$\lambda = \frac{6.625 \times 10^{-34} \times 3 \times 10^8}{E}$

If E is in (electron volt), 1 EV = 1.6×10^{-19} J

$= \frac{6.625 \times 10^{-34} \times 3 \times 10^8 \times 10}{16 \times 10^{-19}}$ Joule

$= \frac{6.625 \times 10^{-34} \times 3 \times 10^9}{16 \times 10^{-19} \times 10^3}$

$= \frac{6.625 \times 10^{-34} \times 10^9 \times 10^{19} \times 10^{-3}}{16}$

$= \frac{6625 \times 3 \times 10^{-9}}{16}$

$= \frac{19875 \times 10^{-9}}{16}$

$= \frac{12422.18}{E}$

$\lambda = \frac{12.42 \times 10^{-7}}{E}$ m

• LDR photo conducting Effect पर काम करता है।

in micrometer

$$\lambda = \frac{1.242}{E} \mu m$$

→ When the P-N Junction is forward biased, both the electrons and holes process the junction. During the process some electron recombine with holes. Consequantly some energy is losed by the electrons.

The amount of energy lost is equal to the difference in energy between conduction and valence band, these being known as the semiconductor energy gap.

Eg for Si = 1.1 eV
Eg for GaAS = 1.43 eV
Eg for InAs = 0.36 eV

16/12/24.

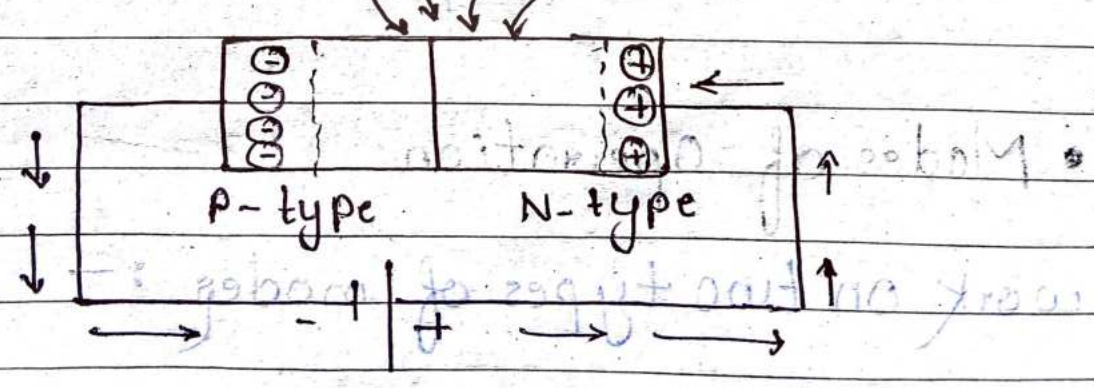
* P-N Junction Photo diode

→ It is a two terminal junction device which is operated first by reverse biasing the junction and then eluminating it. The active diameter of these about 2.5ml but they are mounted in standard packages with a window to allow maximum incident light.

A photo diode can be currents on and off nano seconds, hence it is One of the fastest photo detector

It is also called light sensor, light detector or Photo sensor.

Working



→ Through this process, which also known as photo electric effect, produce electron hole pair when light strike its [illegible] An electric field inside the diode moves these particles, sending holes to the anode and electron to the cathode, creating a photo current.

→ When the light is absorved closed to the diode electric field when this occur then

→ The photo current which comes from the light and the dark current which runs even in the absence of light make up the total current.

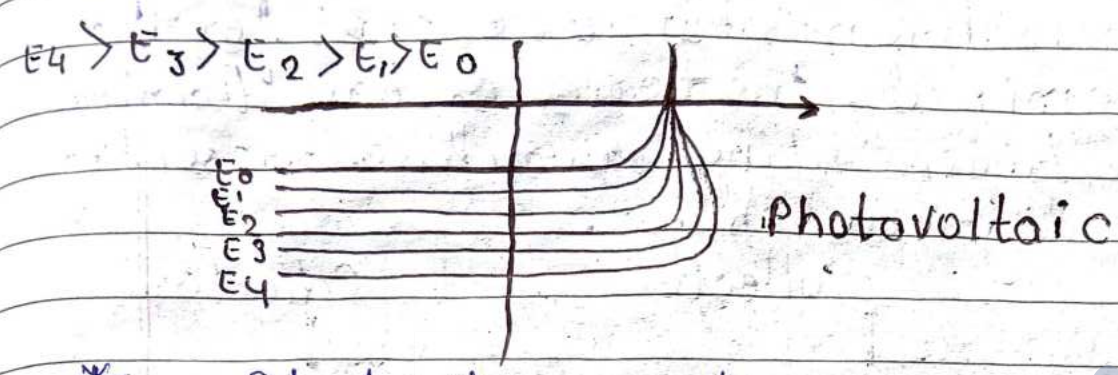
→ It is crucial to lower the dark current in order to increase the photo diode sensitivity

• Modes of Operation

* It work on two types of modes :-

① Photo voltaic Mode

② Photo conductive Mode



* Photo transistor :-

→ ① A semi conductor device like a phototransistor includes 3 layers with the light sensitive base region.

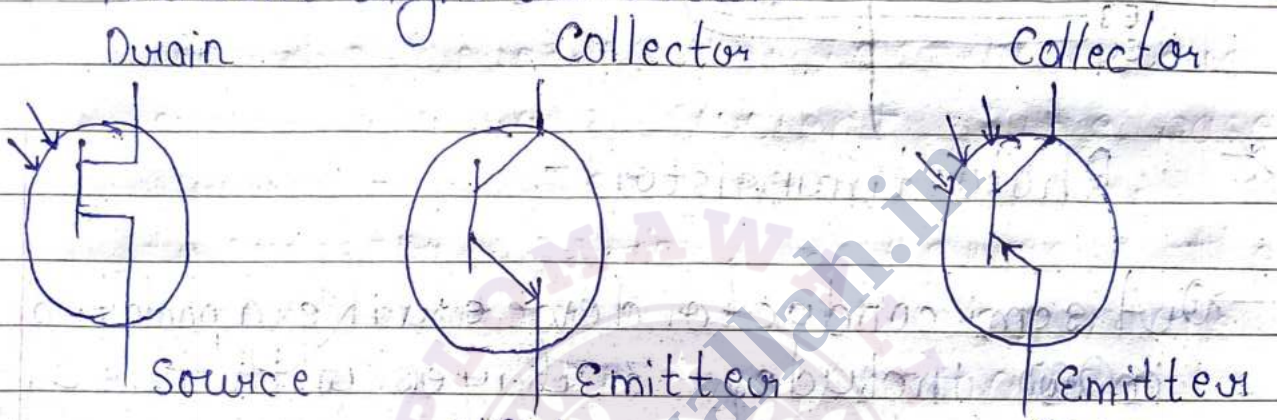
② The base region detact the light the change in into electrical current that supplies amount the two regiod & ammeter and collector.

③ These type of transistor changes directly from photons to charge similar to a photo diode and also efforts are current gain.

* Symbol of Photo transistor :-

Unlike a normal transistor, a photo

transistor has only two terminals and ammeter and collector. It is similar to the normal transistor except for the base terminal. Instead of base terminal there are two pointing arrows representing incident light as shown.



FET Photo transistor

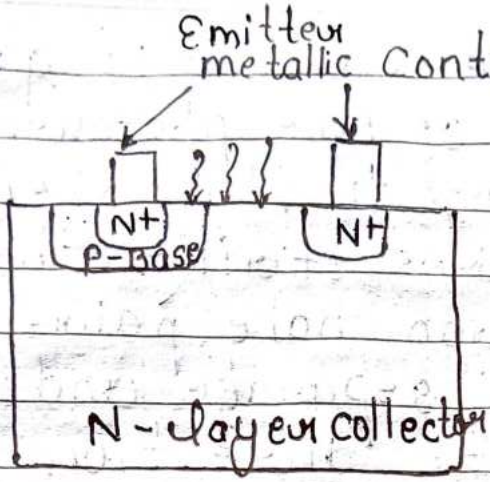
NPN Photo transistor

PNP Photo transistor

* Construction of Photo transistor :-

1. As compare to the normal transistor a photo transistor ~~is~~ has large area in collector and emitter terminal.

2. It was design with a single semi-conductor material such as germanium or silicon. For high efficiency we can also use arsenic and gallium for construction.



- It is similar design to the normal BJT except base and collector region is larger as compare to normal transistor.
- The base is covered with transparent epoxy resin and lens to prevent the base from focus of light.
- The emitter is heavily doped as compared to the collector is but very large.
- The physical area of base and collector region is escape large more light intensity.
- The larger area more base current that is amplified thus, making it more sensitive than photo-diode.

* Working Principle :—

→ Phototransistor operates just like any normal bipolar transistor except for the fact that the base current is generated by a light source instead of a voltage

source. The base current is generated on the principle of the photovoltaic effect. According to this phenomenon whene photons strike the PN Junction, electron hole pairs are generated that separate and move in the opposite direction. thus creating a base current. The base current is then amplified by the transistor action. Therefore the phototransistor is 100 times more sensitive than the photodiode.

When biasing the collector is Kept at a higher voltage with respect to the emitter in NPN phototransistor while in PNP, the collector is at a lower voltage with respect to the emitter. And the collector to the base junction is reverse biased, the base terminal is Kept open or not connected, otherwise, it will operate as a normal transistor.

Under no light conditions, there is a small reverse saturation current or leakage current called dark current

that is directly proportional to the temp as in photodiodes. When light shines on the phototransistor, the lens focuses the light onto the collector - base junction and generates a base current collector base function and generates a base current due to the photovoltaic effect. The base current is amplified hundred of times.

* Modes of operation :—

→ The phototransistor just like BJT can operate in two modes so that linear or active mode or switch mode.

(1) Linear or Active mode :— While operating in linear mode, the output current is directly proportional to the intensity of the incident light. However, practically the response is not very linear and forms a curve. Therefore, this mode is correctly known as active mode. This mode is used for its amplification factor. The base current generated is amplified depending on the gain of the transistor.

(ii) Switch mode :— In switch mode operation, the phototransistor has two states i.e 'off' state and 'on' state just like a switch. Thus the name switch mode. This mode is usually used due to the non-linear response of the phototransistor to the light.

When there is no light, there is no base current and the device is said to be in an 'off' state. With an increase in light intensity, the output current increases. Eventually, a point is reached where the increase in light intensity does not affect the output current and the device is saturated and the device is said to be in the 'on' state.

Just like a digital switch, it operates on two levels. Due to the non-linear nature of the active region this mode is used for decoding, sending, object detection, signal conversion, etc.

* Types of phototransistor :—

→ Phototransistors are classified into two types namely BJT and FET.

- BJT transistor :—

→ In the deficiency of light, BJT photo-transistor allows leakage among collectors as well as an emitter of 100nA otherwise low. Once this transistor is exposed to the beam, it performs upto 500mA. This distinguishes it from photodiode which cannot allow much current.

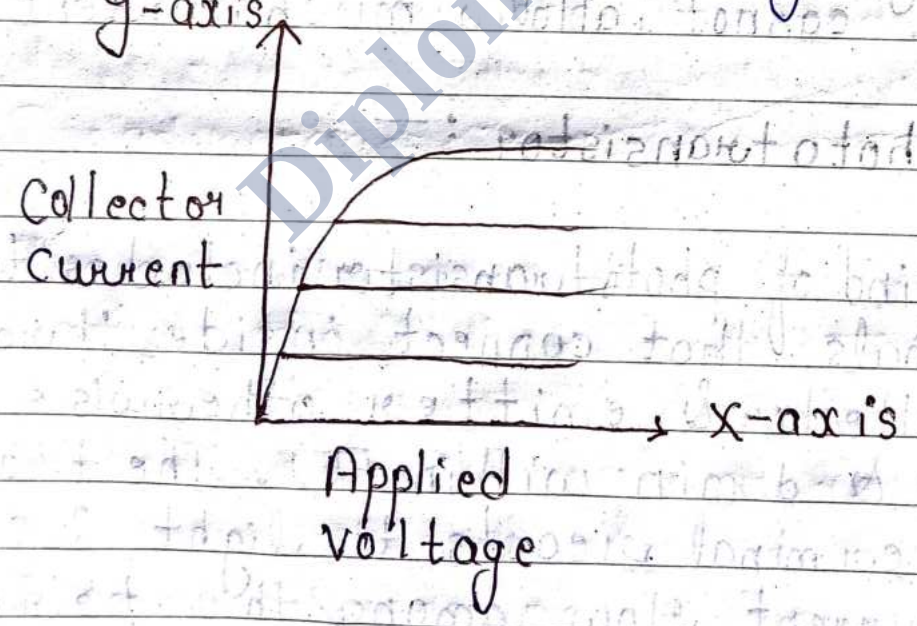
- FET Phototransistor :—

→ This Kind of phototransistor includes two terminals that connect inside through its collector & emitter otherwise source & drain within FET. The transistors base terminal reacts to light & controls the current flow among the terminals.

* Characteristics :- *

→ The characteristics of a phototransistor are discussed below.

In the following graph, the x-axis signifies the applied voltage at the collector emitter region of the transistor whereas the y-axis signifies the collector current supplies throughout the device in mA. From the following graph, we can notice how the current flow in the collector region changes with the incident light intensity.



The current within the collector terminal enhances through the intensity of light. The current within the collector region

changes through the wavelength as well as the light intensity. In the above graph, we can notice that the current increases through the light intensity. When falls on the base terminal And also signifies the difference within the base current through the difference within the intensity of light.

* Advantages :—

→ The advantages of phototransistors include the following :—

- High sensitive
- Not expensive
- Less complex
- It provides a high amount of current including high gain
- As compared with photodiodes, these transistor have high gain, current & quick response time.
- These are sensitive to wavelength which range from UV to IR through visible radiation.

- Sensitive to different light sources like fluorescent, incandescent, lasers, sunlight, neon bulbs, flames etc.
- Stable temporarily.
- Reliable highly.
- Less noisy as compared to avalanche type photodiodes.
- These are available in different packages like transfer - molded, epoxy-coated & surface mounted.

* Disadvantages :—

→ The disadvantages of phototransistor include the following :—

- It gives a less frequent response.
- Electric surges occur frequently.
- Phototransistors get affected by the difference within electromagnetic energy.

- When the illumination is ~~love~~ low then the circuit is not capable to notice it effectively.

* Applications :—

→ The applications of phototransistors are as follows :-

- For light detecting and controlling
- In counting systems and punch card readers
- In relays
- Alarm systems
- Level indicators
- Proximity detectors
- Encoders

* Difference between photodiode and Phototransistors.

→ The main difference betwe photodiode and phototransistor includes the following :-

	Photo diode	Photo transistor
(i)	It is responsive more to incident light.	It is not responsive more to incident light.
(ii)	The linear response is high, so used to measure the exact measurement of light.	The linear response is low.
(iii)	It is not sensitive.	It is more sensitive
(iv)	Dark current is low.	Dark current is high
(v)	It is not used as a solid state switch.	It is used as a solid state switch.
(vi)	Operational speed is high.	(vi) Operational speed is low.
(vii)	Noise interference is less immune.	(vii) Noise interference is more immune
(viii)	Output response is fast.	Output response is low.

* Photoemission cell :—

This cell is also known as photo tube. It is based on the emission of electrons from a metal cathode (or photo sensitive surface) when it is exposed to light or other radiation.

It consists of two metallic electrodes (i.e, cathode and and anode) supported in an evacuated glass bulb fitted with a base like a thermionic valve.

The cathode is either semi-cylindrical or V-shaped and is made of a metal coated with an emissive material. The anode is in the form of a thin wire facing the cathode.

When the light falls on the cathode photo electrons are emitted which are attracted by the positive anode. Subsequently current is produced whose magnitude (for a given cathode) depends on (i) intensity of incident radiation and (ii) Anode cathode voltage.

Photo - emissive cell finds use in *
(i) field of photometry and calorimetry
(ii) f sound reproduction from a motor - picture film on and off circuit and other circuits concerning the counting or sorting of the objects an a conveyor belt, automatic opening of a door etc.

* Photoconductivity :— The principle of photo - conductivity is that a material becomes more electrically conductive when it absorbs electromagnetic radiation, such as visible light, ultraviolet light, infrared light, or gamma radiation. This happens because the light excites electrons to higher energy levels, making them more mobile.

Photoconductivity refers to the phenomenon where the electrical conductivity of a material increases when it is exposed to light, such as infrared, visible, or ultraviolet light. This occurs due to the excitation of electrons to higher energy levels, making

them more mobile and leading to the generation of current carries within the material.

* Photoconductive cell :—

"Photoconductive cell" use a semi-conductor material whose resistance changes in accordance with the radiant energy received. The resistivity of semi-conductor materials like selenium, cadmium, sulphide, lead sulphide, lead sulphide and thalmium sulphide is decreased when irradiated.

The simplest form of such a cell using selenium. There are two electrodes provided with the semiconductor material attached to them.

As soon as the cell is illuminated its resistance decreases and current through the circuit becomes large. The shape of the semiconductor material is so made as to obtain a large ratio of dark to light resistance.

A cadmium sulphide cell has two electrodes which are extended in an inter-digital pattern in order to increase the contact area with the sensitive material. It has high dark to light ratio.

Photoconductive cells are generally used for detecting ships and aircrafts by the radiations given out by their exhausts or (funnels) and for telephony by modulated infrared lights.

* Photovoltaic effect :— The photo-voltaic effect is the process of converting light into electricity. It is a physical phenomenon that occurs when light, made up of photons, is absorbed by a material, causing the excitation of electrons or other charge carriers to a higher-energy state. The separation of these charges produces an electric potential, or voltage.

The PV effect is used in solar cells, which are electronic devices that directly convert sunlight into electricity. The process of the PV effect in a solar cell can be summarized as follows:-

- Absorption of light :- Photons are absorbed by the cell.
- Generation of charge carriers :- Electron-hole pairs are produced.
- Separation of charge carriers :- The charge carriers are separated under a built in electric field.

Photovoltaic Cell :-

(1) A photovoltaic cell is an altogether different device from all the devices discused upto now the photovoltaic cell generates voltage proportional to the intensity of incident light.

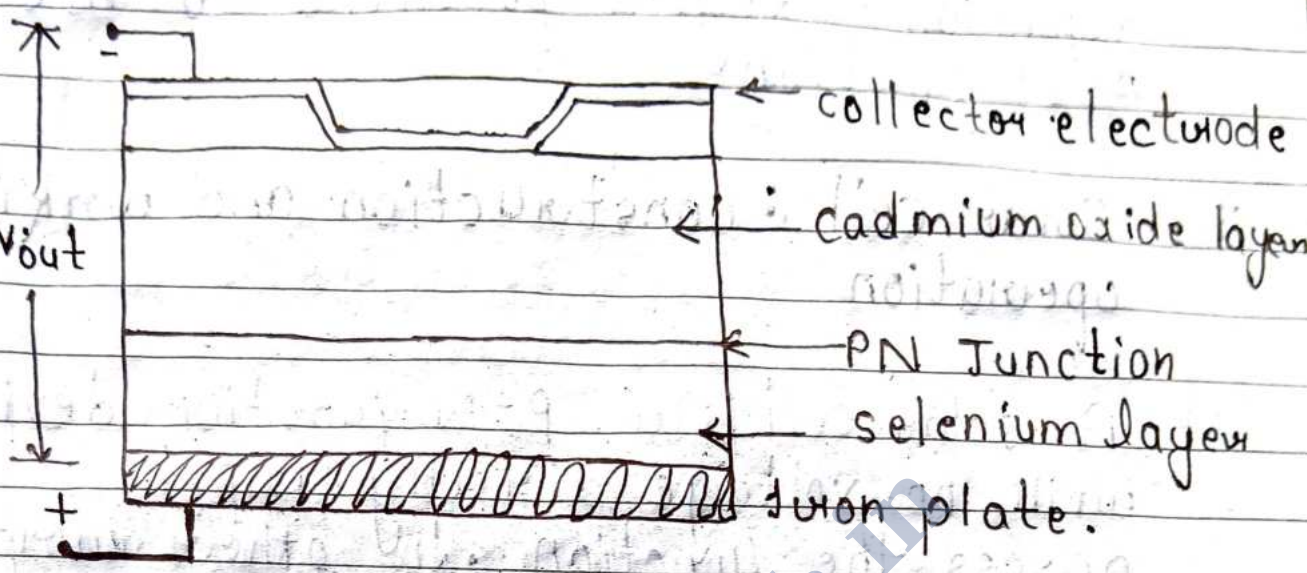
(ii) The photovoltaic cell operates on the principle of photovoltaic effect.

(iii) The construction of a selenium photovoltaic cell and their practical arrangement.

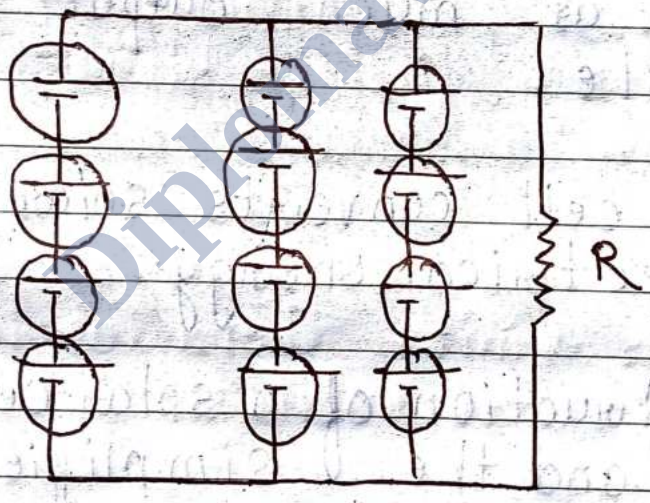
(iv) The selenium photovoltaic cell contain a base plate mode from steel, which acts as an positive electrode. A selenium layer is placed above the base plate. Selenium layer is sensitive to light.

(v) Above this, an electrically conducting cadmium oxide layer is deposited.

(vi) This layer is transparent to light, so the photons incident on the cell will reach the selenium layers. Absorption of photons takes place at the selenium layer and electron hole pairs are created.



(a) construction of selenium photovoltaic cell.



Array of Photovoltaic cell

(VII) The number of electron hole pairs is proportional to the intensity of incident light. The electrons and holes are seperated out by the

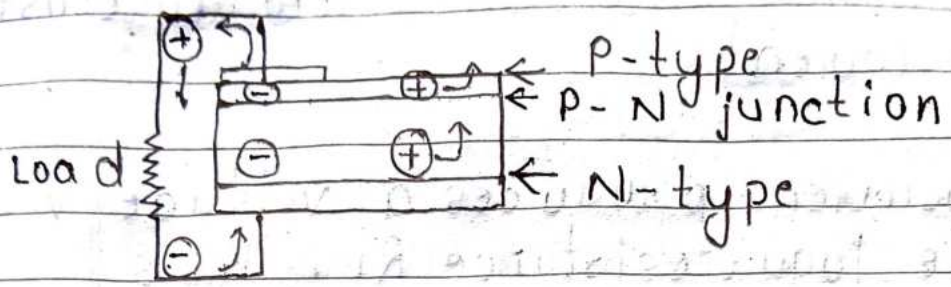
depletion - region potential to the P-N junction.

* Solar cell : construction and working operation

(i) A solar cell is a P-N junction device with no voltage directly applied across the junction. In other words we can say that it is essentially a large photodiode designed to operate solely as a photovoltaic device and give as much output power as possible.

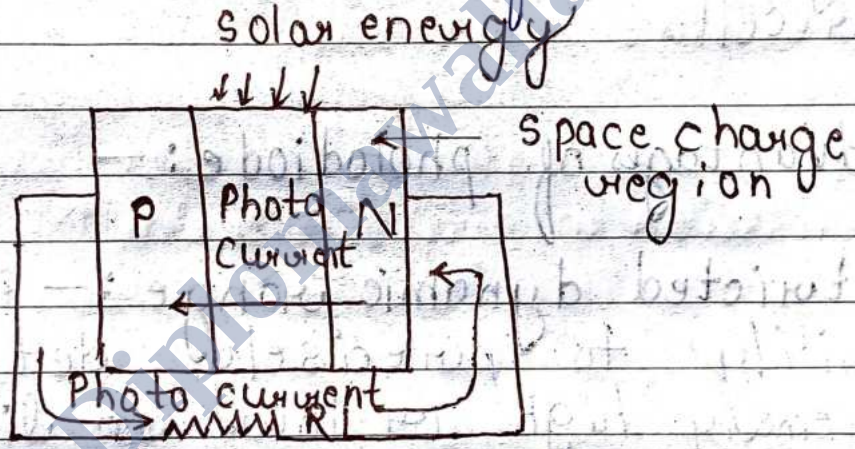
(ii) The solar cell converts solar energy into electrical energy.

(iii) The construction of a solar cell is depicted and the simplified depicted in canb be used to explain the operation of the solar cell.



⊖ direction of electron flow
⊕ direction of hole flow

(a) Construction of a solar cell



(b) Simplified diagram

(iv) When the light hits the space charge region, electrons and holes are generated due to the photons striking the valence electron and imparting energy to them. The optically generated electron - hole pairs are quickly seperated and swept outside the space charge region by the electric field.

(v) These electrons and holes flow to constitute the photocurrent.

(vi) This photocurrent produces a voltage V across the load resistance R_1. Thus solar cell supplies power. Solar cell are usually fabricated from silicon, but they can be made of GaAS or other trivalent or pentavalent materials. The symbol and construction of a solar cell.

* Disadvantages of photodiode :—

3. Restricted dynamic range :— Photodiodes inability to precisely detect extremely high or low light intensities limits their applicability in particular situations.

4. Noise :— Photodiode have the potential to produce additional electrical noise in reverse biased modes. This noise may impede the quality of the signal, especially in sensitive applications such as communications systems.

* Photodiode :—

- Features of Photodiode :—

→ Critical performance parameters of a photodiode consists of :—

1. Critical performance parameters
   - Spectral responsivity
   - Dark current
   - Response time
   - Noise - equivalent power
2. Spectral Responsivity
   - Ratio of generated photocurrent to incident light power.
   - Can also be expressed as quantum efficiency.
3. Dark current
   - Current through the photodiode in absence of light.

- Needs calibration for accurate optical power measurements and adds noise in optical communication systems.

4. Response time :-

- Time for the detector to respond to optical input.
- Affected by transmit time spread and RC time constant.
- Determines bandwidth for data transmission in optical system.

* Advantages of photodiode :-

1. High sensitivity :- These detectors are capable of detecting low light levels, particularly when they are built with reverse bias or avalache setups.

2. Compact size :- Photodiodes are light-weight, compact and simple to incorporate into a variety of systems.

3. Low cost :- In comparison to other light detecting technologies, such as photomultipliers, they are comparatively affordable.

4. Durability :- Photodiodes can function in a variety of environmental situations and have a lengthy lifespan.

5. Modest electricity consumption :- They usually use very little electricity and demand modest operating voltages.

* Disadvantages of photo diode :-

1. Dark current :- Even in the absence of light, photodiodes produce a tiny current known as 'dark current' which can introduce noise and lower the light detection accuracy.

2. Temp sensitivity :- Changes in temp can have an impact on photodiode performance with an increase in dark current at higher temperatures

* Sensor :— A sensor is a device that measures physical qantity and convert it into a signal which can be read by an observer or by an instrument.

*

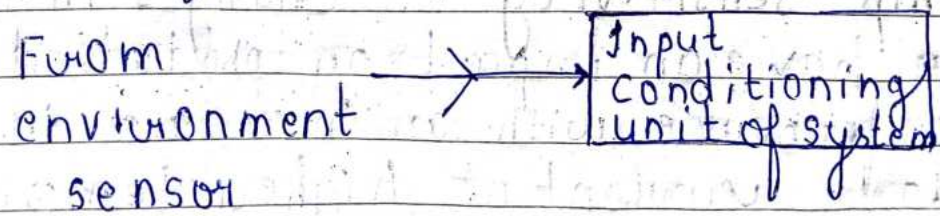
Sensor and Actuator :—

→ Sensors are the devices that we used to convert any physical characteristics or events into electrical signal.

In simple word, we can say that sensor is a hard ware device which is used to collect data inputs from its environment, convert it into electrical signals and then gives it to devices.

Sensors monitors environment condition such as fluid levels, voltage, temp vibration etc. After that it convert in electrical form.—:

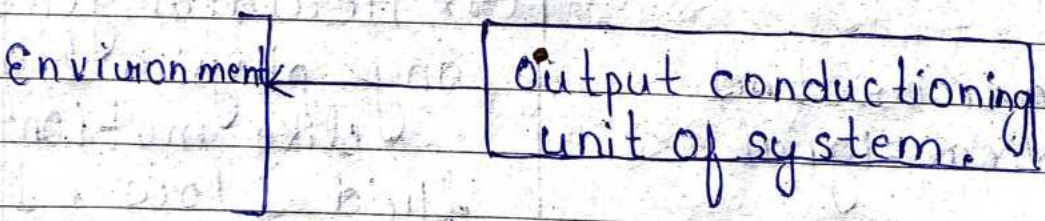
For example, a thermometer takes the temperature as the physical characteristics and them convert it into electrical signal for the other system.



Acctuator :— Accuator is a device that convert the electrical signal into the physical condition or characteristics. It takes the input from the system and gives output to the environment.

It is just opposite to the sensor. In simple word can say that, an accuator would receive input from any system in the form of electrical signal and generates the output from the environment.

Heaters, comb driver, Pneumatic cylinders, Hydraulic cylinders and electrical motors are some of the common accuator.

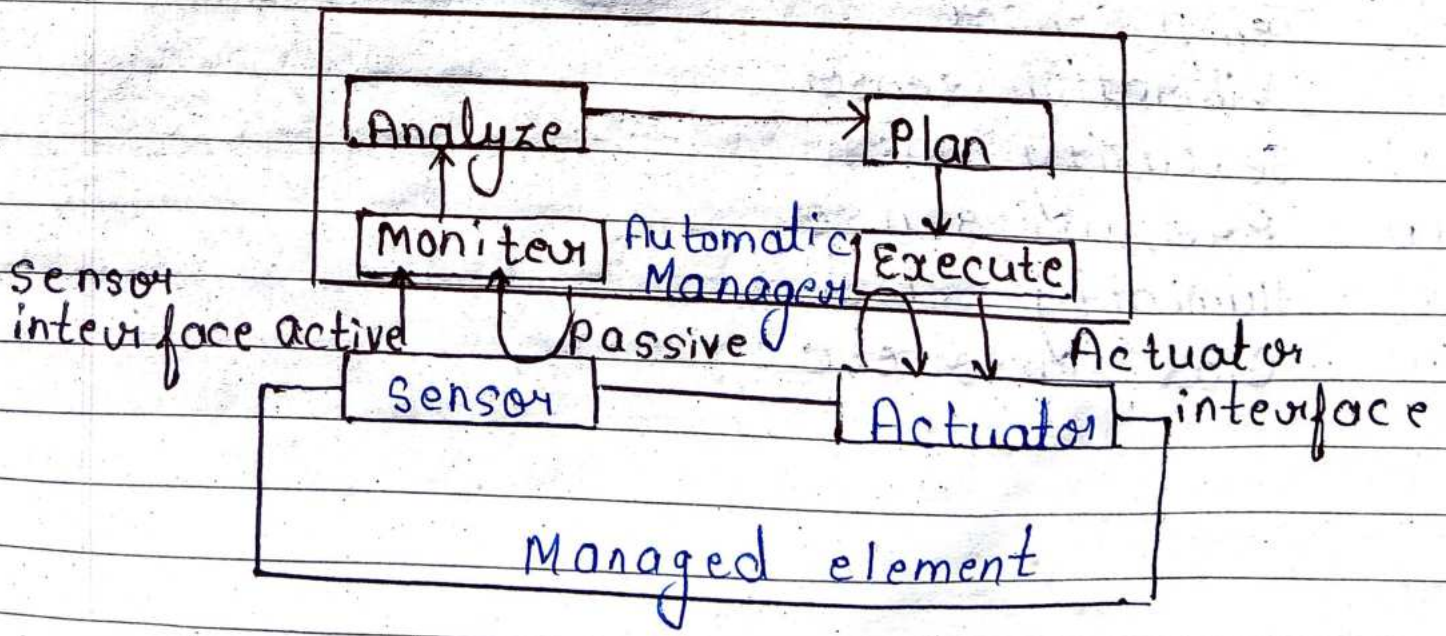


* Difference between SENSOR and ACTUATOR.

→

SENSOR	ACTUATOR
(1) It converts physical characteristics into electrical signal.	(1) It converts electri signal into physical characteristics.
(2) It takes input from environment.	(2) It takes input from output conditioning unit of system.
(3) It gives output to input conditioning unit of system.	(3) It gives output to the environment.
(4) Sensor generated electrical signal.	(4) Actuator generates any physical quantity like motion, heat fluid flow, light
(5) It is placed as the input port of the system.	(5) It is placed as the output port of the system.

SENSOR	ACTUATOR
(vi) It is used to measure the physical quantity.	(vii) It is used to measure the continuous and discrete process parameter.
(vii) It gives information to the system about environment.	(vii) It accepts command to perform a function.
(viii) Ex :- Photovoltaic cell which converts light energy into electrical energy.	(viii) Ex :- Stepper motor where electr energy derives the motor.



* Types of ACTUATOR :-

→ There are different types of actuator for various application :-

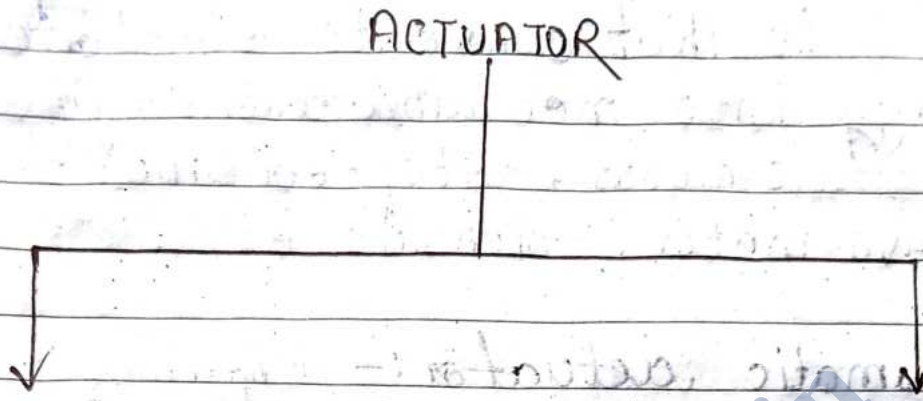
(i) Manual actuator
(ii) Pneumatic actuator
(iii) Hydraulic actuator
(iv) Electric actuator
(v) Spring actuator

* Types of Sensor :-

→ There are various types of SENSOR for different - different applications. some sensor are :-

(i) Temp sensor
(ii) Vibration sensor
(iii) Security sensor
(iv) Pressure sensor
(v) Humidity sensor
(vi) Gas sensor etc.

* Types of ACTUATOR :-



(i) Linear actuator :- The actuator that can provide motion in a straight line and their output can be classified under the category of linear actuators. Hydraulic and pneumatic actuators are most common linear actuator used in industry.

(ii) Rotatory Actuator :- The actuator that can provide a circular motion at their output can be classified under the category of rotatory actuators.

(iii) Electric actuator :- Electric actuator is an electro mechanical device which is that converts electrical energy into mechanical energy.
Ex :- AC motor, stepper motor Servo motor, solenoids etc.

(iv) Pneumatic actuator :- Pneumatic actuator is a device which is used to convert compress air into mechanical motion. There are some type of pneumatic actuator :-

(i) Linear Pneumatic actuator
(ii) Rotatory Pneumatic "
(iii) Rack and pinion pneumatic actuator.

(v) Hydraulic actuator :- A hydraulic actuator is a device that consists of a cylinder or fluid motors that uses hydraulic power to facilitate mechanical operation.

* Advantages of hydraulic actuator :-

- Hydraulic actuator can produce a large magnitude of force and high speed.
- Used in welding, clamping etc.
- Used for lowering or raising the vehicles in car transport carriers.

* Disadvantages :-

- Hydraulic fluid leaks can cause efficiency loss and issues of cleaning.
- It is expensive.
- It requires noise reduction equipment, heat enchangers and high maintenance systems.

5/1/25

Sensor ....

* Types of sensor :—

→ There are countless number of sensors, each with there own specification. There are some common types are following :—

(i) Active Sensor :— The active sensor is a sensing device that required an external power source to operate.

- It emits energy, transmit it to a target and measure the reflected energy.
- Some ex of active sensor are LBDT (Linear Variable differential Transformer) strain guage, LiDar (Light Detection and ranging) etc.

(ii) Passive Sensor :— A passive sensor is a device that does not require any external source or power to operate. It simply detected and respond to some types of input from the physical environment.

- It detecd energy that's naturally available light, heat, sound etc. Example of passive sensor are thermo-couple, Light sensors, infrared sensor, water level sensor etc.

Active and passive technologies are both used in remote sensing to make observation and measurement from a distance or on a scale beyond those observation to the nakedise sensors can also be used in harsh environment and places that are inaccessible to people.

* Types :—

(i) Analog
(ii) Digital
(iii) Voltage
(iv) Humidity
(v) Temp
(vi) Pressure.
(vii) Position
(viii) Level
(ix) Proximity
(x) Light
(xi) Chemical
(xii) Source
(xiii) Motion
(xiv) Sound
(xv) Contact
(xvi) Non-contact.

* Advantage of Pneumatic Actuators :-

- They are a low-cost option and are used at extreme temp where using air is a safer option than chemicals.
- They need low maintenance, are durable, and have a long operational life.
- It is very quick in starting and stopping the motion.

* Disadvantages :-

- Loss of pressure can make it less efficient.
- The air compressor should be running continuously.
- Air can be polluted and it needs maintenace.

* Advantages of electrical Actuators :—

- It has many applications in various industries as it can automate industrial valves.
- It produces less noise and is safe to use since there are no fluid leakages.
- It can be re-programmed and it provides the highest control precision positioning.

* Disadvantage :—

- It is expensive.
- It depends a lot on environmental conditions.

* Other actuators are :—

- Thermal / Magnetic actuators :— These are actuated by thermal or mechanical energy. Shape memory alloys or Magnetic shape memory alloys are used by these actuator. An example of a thermal

magnetic actuator can be a piezo motor using SMA.

- Mechanical actuator :- A mechanical actuator execute movement by converting rotary motion into linear motion. It involves chains, gears, rails and other devices to operate. Ex :- A crankshaft.
- Soft actuator
- Shape memory polymer
- Light activated polymer

* Application of actuators :-

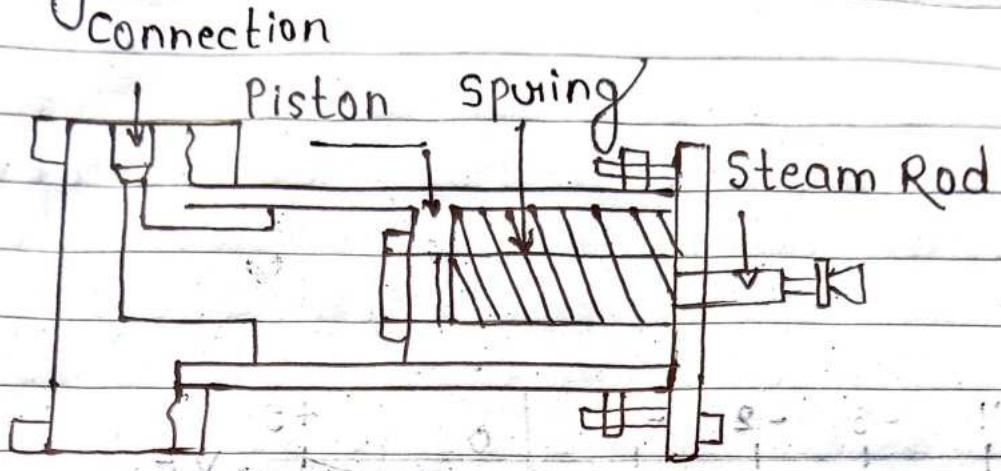
→ Actuator have a wide range of use in the modern world in machines, automobiles, and automation. The following table describes common applications, devices suitable for said applications, and actuator that provide power to the devices.

Table :- Applications, devices, and actuators.

Applications	Device	Actuator type
Automated control of fluid flow in pipelines and process systems.	control valve, flow Meter.	Linear, Rotary (Hydraulic electric)
Adjustment of industrial valves, positioning of machine component.	Ball Valve, solenoid valve, servo motor.	Rotary (Hydraulic electric)
Digging, grading and excavating in construction and mining operations.	excavator Backhoe	Linear, Rotary (Hydraulic)
Manufacturing of metal parts, plastic molding and forging operations.	Hydraulic press, CNC Machine, Forging Hammer.	Rotary (Hydraulic electric)
Powering machine tools, robots and conveyor systems	electric motor, Robot Arm, conveyor Belt	Linear, Rotary (Electric Hydraulic)

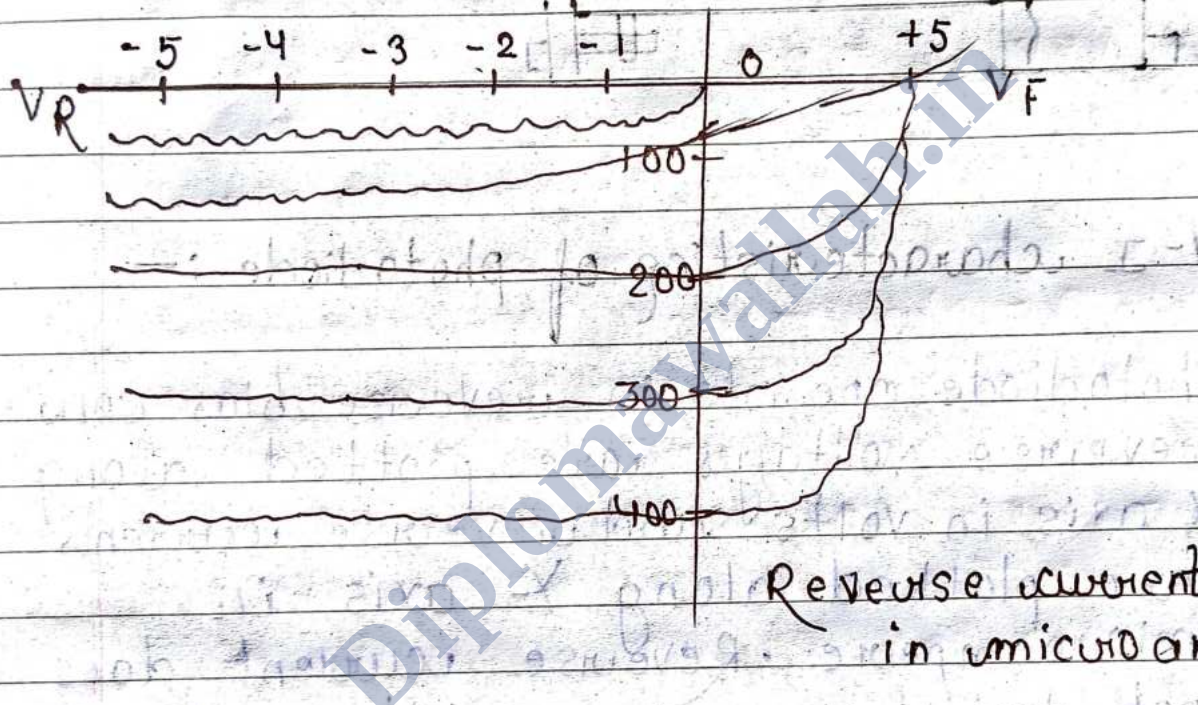
Positioning of machine components in automated production system	Linear actuator, servo Motor Gripper.	Linear, Rotary (Electric Hydraulic)
Regulating the flow of fuel and air into internal combustion engines	Throttle valve, fuel injector	Rotary (Mechanical electric)
Regulating the speed of steam or gas turbines in power plants	Turbine Governor, valve	Rotary (Electric, Hydraulic Thermal)
simple machine control in mechanical systems such as door openers	Mechanical Lever, electric switch	Linear rotary (Mechanical electric)
Transmission of power in machines such as conveyor systems and gear pumps	Gearbox, Gear pump Hydraulic Motor.	Linear, Rotary (Hydraulic, Mechanical, electric)

- Hydraulic actuators :—



* V-I characteristics of photodiode :—

Photodiode operate in reverse bias condition reverse voltages are plotted along X axis in volts and reverse current are plotted along Y- axis in microampere. Reverse current does not depend on reverse voltage. When there is no light illumination reverse current will be almost zero. The minimum amount of current present is called as Dark current. Once when the light illumination increases, reverse current also increases linearly.



* Types of Photo diode :—

1. PN Photodiode :— This photodiode can be useful in a number of circumstances. This is used in all minimum light conditions since it does not require reverse bias.

2. PIN Photodiode :— PIN Photodiodes have a larger surface area for both collecting and converting light photons which allows them to capture photons of light with a bigger effect than PN photodiodes.

3. Avalanche photodiode :— This type of photodiode can multiply both electrons and holes since it operates at a much higher reverse bias.

4. Schottky photodiode :— This type of photodiode combines several schottky diodes to provide both long and short wavelength identification.

* Application of photodiodes :—

1. Optical communication systems :— In fiber optic communication, photodiodes are utilized to transform light signal into electrical impulses that are then used to tranfer data.

2. Consumer electronics :- Includes in gadgets such as optical sensor in smartphones, remote controllers and cameras.

3. Medical devices :- used to identify the body absorption of light in devices like heart rate monitors and pulse oximeters.

4. Environmental Monitoring :- Photodiodes are used to measure light intensity in solar energy system, UV index detectors, and light meters.

5. safety systems :- Used in smoke detectors and other safety devices to perceive changes in light conditions.

- Temp sensor :—

→ A temp sensor measures heat and cold of an object or space. It's built into common items like thermometers and household appliances like water heaters refrigerator and microwaves. Temp sensors are a staple in climate control and industrial monitoring.

- Pressure sensor :—

→ A pressure sensor detect the force exerted by a fluid - liquid or gas - on a surface. This type of sensor is used for predictive maintenance to take care of industrial equipment, as well as monitoring automotive tire pressure in cars and Patient's blood pressure in medical care.

- Position sensor :—

→ A position sensor detects an object's position and movement. It comes in many forms - including linear, rotary, proximity, tilt and

incremental and is commonly used in robotics, automative systems and industrial machinery for accurate control and operation when tracking the position, orientation or displacement of components.

- Level sensor :—

→ A level sensor measures the level of liquids, solids or granular materials with in a container or system. It either reports when contents have passed a certain marker, known as point level measurement, or continuously gauges the materials rise and fall. A car's gas tank, for example, features a level sensor.

- Humidity sensor :—

→ A humidity sensor measures the moisture content in the air. It powers instrument like hygrostats, hygrometers and humistors,

which are commonly featured in HVAC systems, weather monitoring and industrial processes to relay humidity readings and prevent issues related to excessive moisture or dryness.

- Force sensor :—

→ A force sensor measures the amount of applied force on an object. It tracks different types of mechanical forces including weight, tension, compression, torque, strain, stress or pressure and is commonly used in robotics and quality control across automative testing and industrial machinery.

* Sound sensor :—

→ A sound sensor detects sound waves, then converts the acoustic signals to electrical ones for processing. Microphones voice command systems and security alarms use sound sensors that are designed to sense noise levels or identify specific sounds.

* Contact Sensor :—

→ A contact sensor detects physical contact or pressure between two surfaces and is triggered when that contact is broken. This security device is composed of two parts, a magnet and a sensor, and is typically installed to doors, windows or gets to alert homeowners of intruders.

* Non-contact sensor :—

→ A non-contact sensor monitors an object without requiring physical contact. It uses wear-free technologies such as infrared, ultrasonic or capacitive sensing and is widely used to operate automatic doors, X-rays and parking assistance systems that enable detection at a distance.

* Infrared sensor :—

An infrared sensor detets infrared

radiation emitted by objects. This means it can sense an object's presence or movement by heat fluctuations within range. Infrared sensors are commonly built into motion detection systems, thermal imaging and remote control devices.