UNIT-3

Hall Effect Transducer

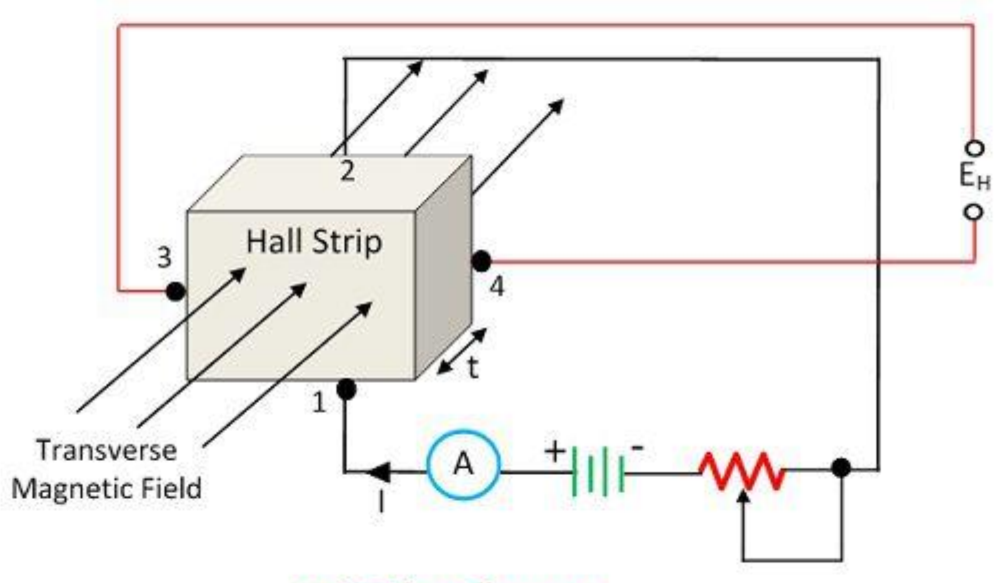
Definition: **The** hall effect **element is a type of transducer used for** measuring **the** magnetic field **by** converting **it into an** emf**. The direct measurement of the magnetic field is not possible. Thus the Hall Effect Transducer is used. The** transducer converts **the** magnetic field **into an** electric quantity **which is easily** measured **by the** analogue **and** digital meters.

Principle of Hall Effect Transducer

The principle of hall effect transducer is that if the current carrying strip of the conductor is placed in a transverse magnetic field, then the EMF develops on the edge of the conductor. The magnitude of the develop voltage depends on the density of flux, and this property of a conductor is called the Hall effect. The Hall effect element is mainly used for magnetic measurement and for sensing the current.

The metal and the semiconductor has the property of hall effect which depends on the densities and the mobility of the electrons.

Consider the hall effect element shown in the figure below. The current supply through the lead 1 and 2 and the output is obtained from the strip 3 and 4. The lead 3 and 4 are at same potential when no field is applied across the strip.



Hall Effect Element

When the magnetic field is applied to the strip, the output voltage develops across the output leads 3 and 4. The develops voltage is directly proportional to the strength of the material.

The output voltage is, $E_H = K_H I B / t$

$$K_H - Hall\ effect\ coefficient\ ;\ \frac{V - m}{A - Wbm^{-2}}$$

$$t - thickness\ of\ Strip\ ; m$$

where,

The I is the current in ampere and the B is the flux densities in Wb/m^2

The current and magnetic field strength both can be measured with the help of the output voltages. The hall effect EMF is very small in conductors because of which it is difficult to measure. But semiconductors like germanium produces large EMF which is easily measured by the moving coil instrument.

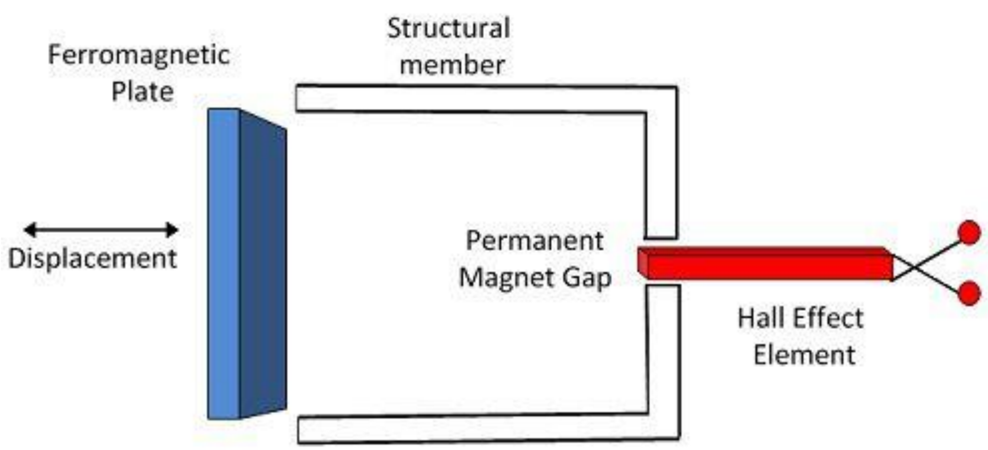
Applications of Hall Effect Transducer

The following are the application of the Hall effect Transducers.

1. Magnetic to Electric Transducer – The Hall effect element is used for converting the magnetic flux into an electric transducer. The magnetic fields are measured by placing the semiconductor material in the measurand magnetic field. The voltage develops at the end of the semiconductor strips, and this voltage is directly proportional to the magnetic field density.

The Hall Effect transducer requires small space and also gives the continuous signal concerning the magnetic field strength. The only disadvantage of the transducer is that it is highly sensitive to temperature and thus calibration requires in each case.

2. Measurement of Displacement – The Hall effect element measures the displacement of the structural element. **For example –** Consider the ferromagnetic structure which has a



Measurement of Displacement Using Hall Efect Transducer

permanent magnet.

The hall effect transducer placed between the poles of the permanent magnet. The magnetic field strength across the hall effect element changes by changing the position of the ferromagnetic field.

3. Measurement of Current – The hall effect transducer is also used for measuring the current without any physical connection between the conductor circuit and meter.

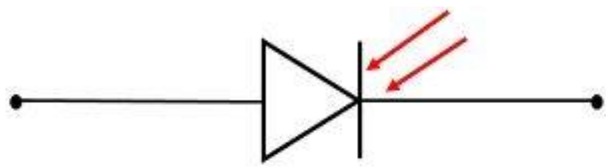
The AC or DC is applied across the conductor for developing the magnetic field. The strength of the magnetic field is directly proportional to the applied current. The magnetic field develops the emf across the strips. And this EMF depends on the strength of the conductor.

4. Measurement of Power – The hall effect transducer is used for measuring the power of the conductor. The current is applied across the conductor, which develops the magnetic field. The intensity of the field depends on the current. The magnetic field induces the voltage across the strip. The output voltage of the multiplier is proportional to the power of the transducer.

Photodiode

Definition: A special type of PN junction device that generates current when exposed to light is known as Photodiode. It is also known as photodetector or photosensor. It operates in reverse biased mode and **converts light energy into electrical energy**.

The figure below shows the symbolic representation of a photodiode:



Symbolic representation of Photodiode

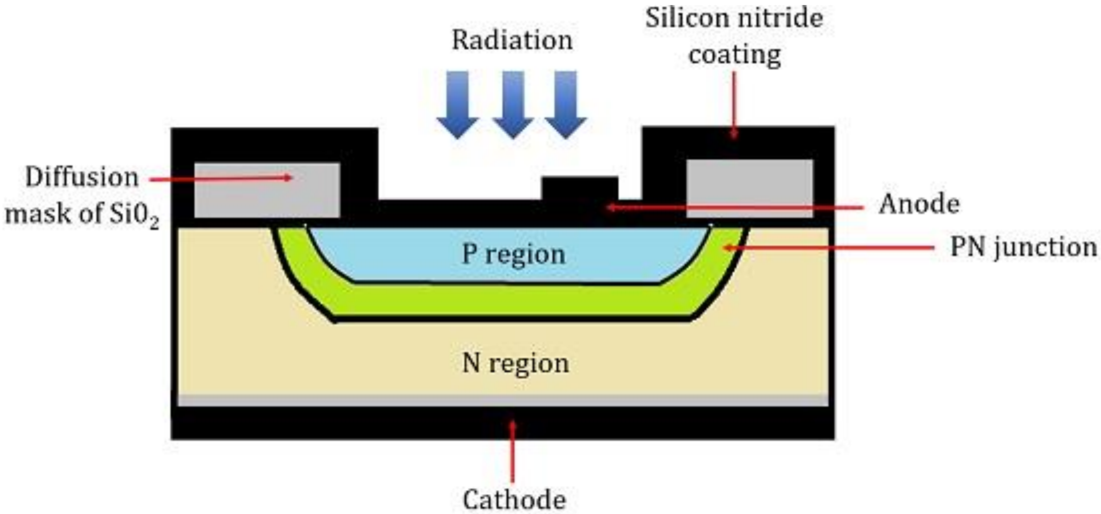
Principle of Photodiode

It works on the principle of **Photoelectric effect**.

The operating principle of the photodiode is such that when the junction of this two-terminal semiconductor device is illuminated then the electric current starts flowing through it. Only minority current flows through the device when the certain reverse potential is applied to it.

Construction of Photodiode

The figure below shows the constructional detail of a photodiode:



Structure of Photodiode

The PN junction of the device placed inside a glass material. This is done to order to allow the light energy to pass through it. As only the junction is exposed to radiation, thus, the other portion of the glass material is painted black or is metallised.

The overall unit is of very small dimension nearly about **2.5 mm**.

It is noteworthy that the current flowing through the device is in **micro-ampere** and is measured through an ammeter.

Operational Modes of Photodiode

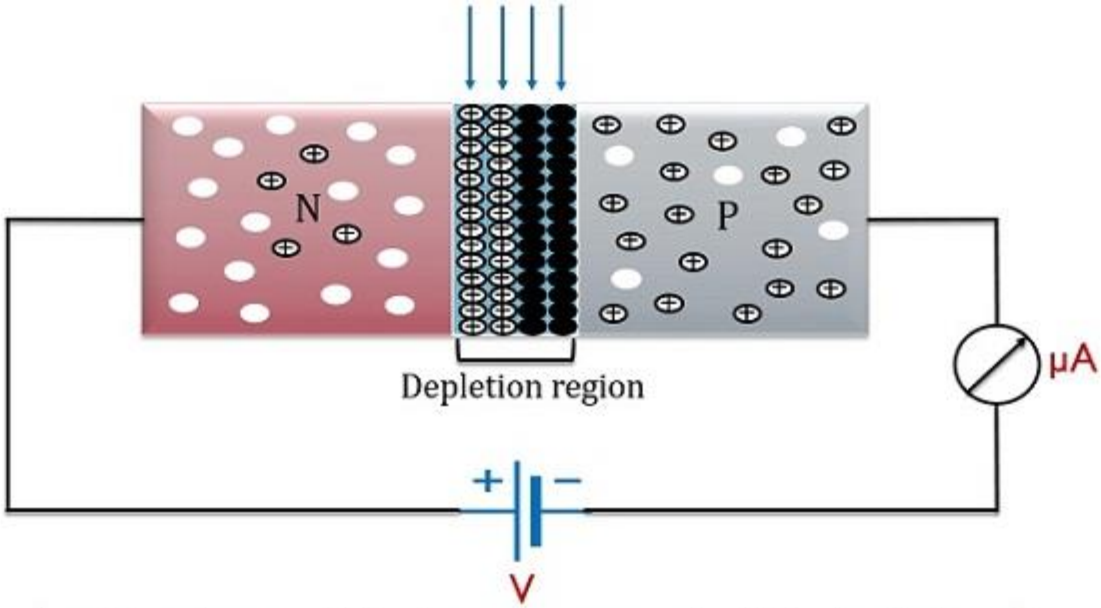
Photodiode basically operates in two modes:

Photovoltaic mode: It is also known as zero-bias mode because no external reverse potential is provided to the device. However, the flow of minority carrier will take place when the device is exposed to light.

Photoconductive mode: When a certain reverse potential is applied to the device then it behaves as a photoconductive device. Here, an increase in depletion width is seen with the corresponding change in reverse voltage.

Working of Photodiode

In the photodiode, a very small reverse current flows through the device that is termed as **dark current**. It is called so because this current is totally the result of the flow of minority carriers and is thus flows when the device is not exposed to radiation.



Structure and biasing arrangement of Photodiode

The electrons present in the p side and holes present in n side are the minority carriers. When a certain reverse-biased voltage is applied then minority carrier, holes from n-side experiences repulsive force from the positive potential of the battery.

Similarly, the electrons present in the p side experience repulsion from the negative potential of the battery. Due to this movement electron and hole recombine at the junction resultantly generating depletion region at the junction.

Due to this movement, a very small reverse current flows through the device known as dark current.

The combination of electron and hole at the junction generates neutral atom at the depletion. Due to which any further flow of current is restricted.

Now, the junction of the device is illuminated with light. As the light falls on the surface of the junction, then the temperature of the junction gets increased. This causes the electron and hole to get separated from each other.

At the two gets separated then electrons from n side gets attracted towards the positive potential of the battery. Similarly, holes present in the p side get attracted to the negative potential of the battery.

This movement then generates high reverse current through the device.

With the rise in the light intensity, more charge carriers are generated and flow through the device. Thereby, producing a large electric current through the device.

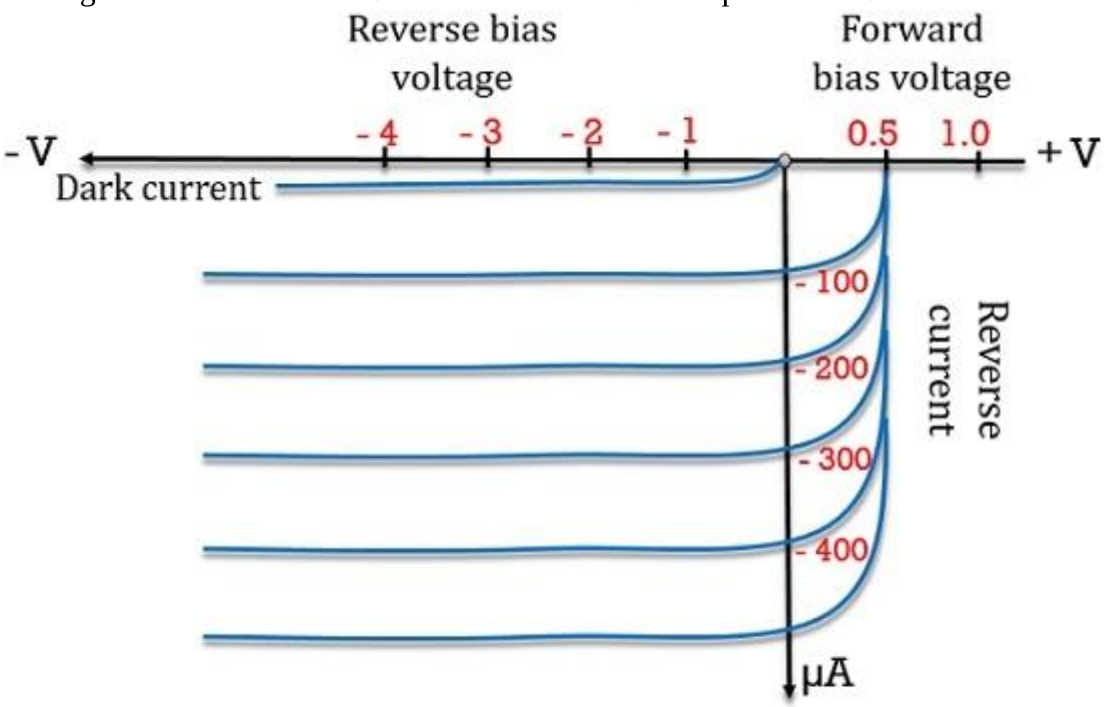
This current is then used to drive other circuits of the system.

So, we can say the intensity of light energy is directly proportional to the current through the device.

Only positive biased potential can put the device in no current condition in case of the photodiode.

CHARACTERISTICS OF PHOTODIODE

The figure below shows the VI characteristic curve of a photodiode:



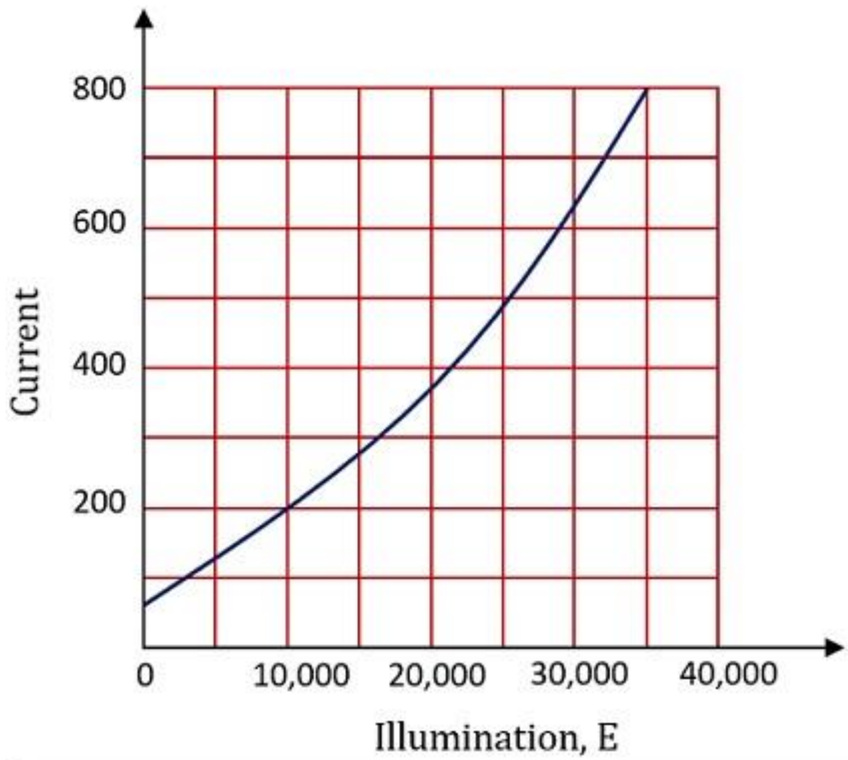
Characteristics curve of Photodiode

Here, the vertical line represents the reverse current flowing through the device and the horizontal line represents the reverse-biased potential.

The first curve represents the dark current that generates due to minority carriers in the absence of light.

As we can see in the above figure that all the curve shows almost equal spacing in between them. This is so because current proportionally increases with the luminous flux.

The figure below shows the curve for current versus illumination:



Illumination versus current curve

It is noteworthy here that, the reverse current does not show a significant increase with the increase in the reverse potential.

<u>Advantages of Photodiode</u>

It shows a quick response when exposed to light.

Photodiode offers high operational speed.

It provides a linear response.

It is a low-cost device.

<u>Disadvantages of Photodiode</u>

It is a temperature-dependent device. And shows poor temperature stability.

When low illumination is provided, then amplification is necessary.

<u>Applications of Photodiode</u>

Photodiodes majorly find its use in counters and switching circuits.

Photodiodes are extensively used in an optical communication system.

Logic circuits and encoders also make use of photodiode.

It is widely used in burglar alarm systems. In such alarm systems, until exposure to radiation is not interrupted, the current flows. As the light energy fails to fall on the device, it sounds the alarm.

In case of a typical photodiode, the normal reverse current is in tens of microampere range.

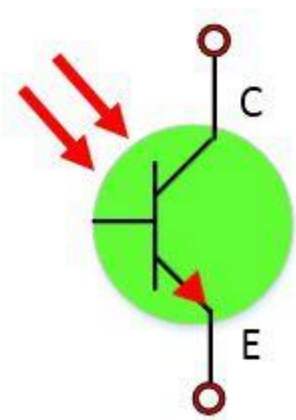
Phototransistor

Definition: The phototransistor is a three-layer semiconductor device which has a light-sensitive base region. The base senses the light and converts it into the current which flows between the collector and the emitter region.

The construction of phototransistor is similar to the ordinary transistor, except the base terminal. In phototransistor, the base terminal is not provided, and instead of the base current, the light energy is taken as the input.

Symbol of Phototransistor

The symbol of the phototransistor is similar to that of the ordinary transistor. The only difference is that of the two arrows which show the light incident on the base of the phototransistor.



Principle of Phototransistor

Consider the conventional transistor is having open terminal base circuited. The collector base leakage current acts as a base current I_{CBO}.

$$I_C = \beta I_B + (1+B)\, I_{CBO}$$

As the base current $I_B = 0$, It acts as an open circuited. And the collector current becomes.

$$I_C = (1+B)\, I_{CBO}$$

The above equations shown that the collector current is directly proportional to the current base leakage current, i.e., the I_C increases with the increases of the collector base region.

Phototransistor Operation

The phototransistor is made up of semiconductor material. When the light was striking on the material, the free electrons/holes of the semiconductor material causes the current which flows in the base region. The base of the phototransistor would only be used for biasing the transistor. In case of NPN transistor, the collector is made positive concerning emitter, and in PNP, the collector is kept negative.

The light enters into the base region of phototransistor generates the electron-hole pairs. The generation of electron-hole pairs mainly occurs into the reverse biasing. The movement of electrons under the influence of electric field causes the current in the base region. The base current injected the electrons in the emitter region. The major drawback of the phototransistor is that they have low-frequency response.

Phototransistor Construction

The construction of the phototransistor is quite similar to the ordinary transistor. Earlier, the germanium and silicon are used for fabricating the phototransistor. The small hole is made on the surface of the collector-base junction for placing the lens. The lens focuses the light on the surface.

Advantages of Phototransistors:

Phototransistors have several important advantages that separate them from another optical sensor some of them are mentioned below

- Phototransistors produce higher current than photodiodes.
- Phototransistors are relatively inexpensive, simple, and small enough to fit several of them onto a single integrated computer chip.
- Phototransistors are very fast and are capable of providing nearly instantaneous output.
- Phototransistors produce a voltage, that photo-resistors cannot do so.

Disadvantages of Phototransistors:

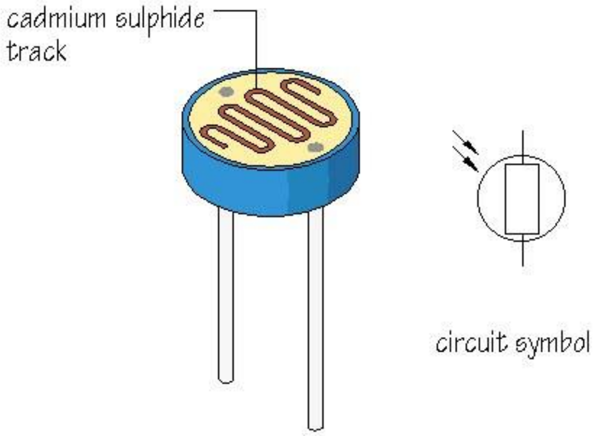
- Phototransistors that are made of silicon are not capable of handling voltages over 1,000 Volts.
- Phototransistors are also more vulnerable to surges and spikes of electricity as well as electromagnetic energy.
- Phototransistors also do not allow electrons to move as freely as other devices do, such as electron tubes.

Applications of Phototransistors

- The Areas of application for the Phototransistor include:
- Punch-card readers.
- Security systems
- Encoders – measure speed and direction
- IR detectors photo
- electric controls
- Computer logic circuitry.
- Relays

- Lighting control (highways etc)
- Level indication
- Counting systems

Light Dependent Resistor (LDR)

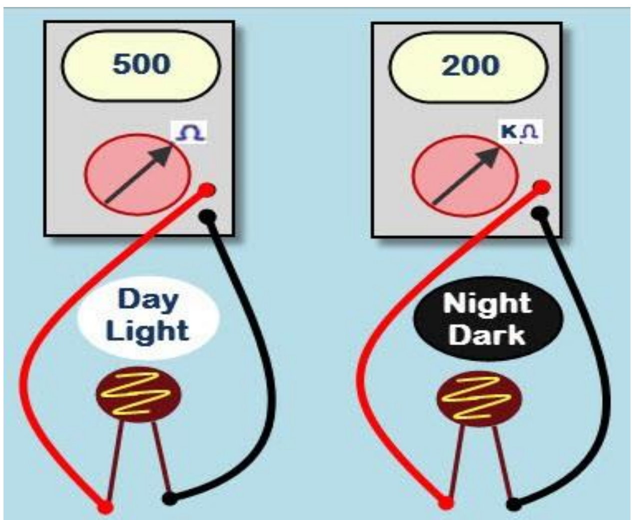


An LDR or light dependent resistor is also known as photo resistor, photocell, photoconductor. It is a one type of resistor whose resistance varies depending on the amount of light falling on its surface. When the light falls on the resistor, then the resistance changes. These resistors are often used in many circuits where it is required to sense the presence of light. These resistors have a variety of functions and resistance. For instance, when the LDR is in darkness, then it can be used to turn ON a light or to turn OFF a light when it is in the light. A typical light dependent resistor has a resistance in the darkness of 1MOhm, and in the brightness a resistance of a couple of KOhm

Working Principle of LDR

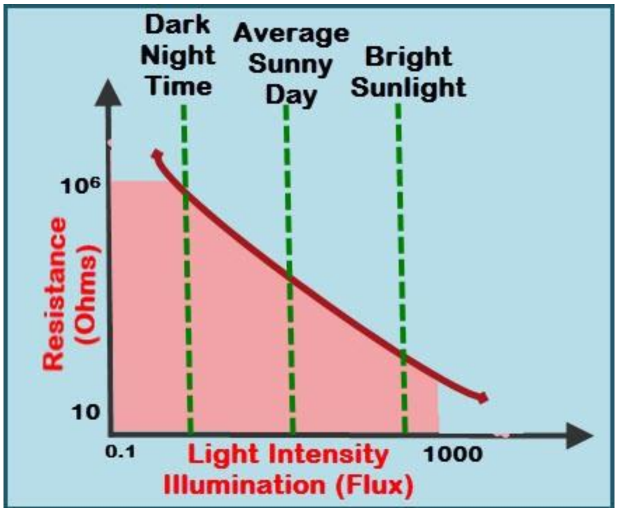
This resistor works on the principle of photo conductivity. It is nothing but, when the light falls on its surface, then the material conductivity reduces and also the electrons in the valence band of the device are excited to the conduction band. These photons in the incident light must have energy greater than the band gap of the semiconductor material.This makes the electrons to jump from the valence band to conduction.

These devices depend on the light, when light falls on the LDR then the resistance decreases, and increases in the dark.When a LDR is kept in the dark place, its resistance is high and, when the LDR is kept in the light its resistance will decrease.



Variation of LDR Resistance with Variation in Light Intensity

If a constant "V' is applied to the LDR, the intensity of the light increased and current increases. The figure below shows the curve between resistance Vs illumination curve for a particular light dependent resistor.



Light Intensity vs LDR Resistance

<u>Types of light Dependent Resistors</u>

Light dependent resistors are classified based on the materials used.

Intrinsic Photo Resistors

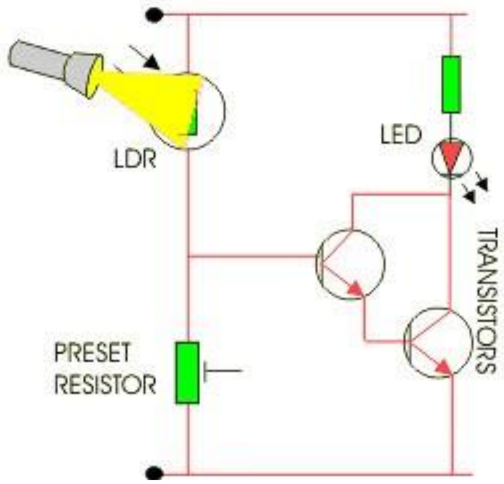
These resistors are pure semiconductor devices like silicon or germanium. When the light falls on the LDR, then the electrons get excited from the valence band to the conduction band and number of charge carriers increases.

Extrinsic Photo Resistors

These devices are doped with impurities and these impurities creates a new energy bands above the valence band. These bands are filled with electrons. Hence this decrease the band gap and small amount of energy is required in moving them. These resistors are mainly used for long wavelengths.

<u>Circuit Diagram of a Light Dependent Resistor</u>

The circuit diagram of a LDR is shown below. When the light intensity is low, then the resistance of the LDR is high. This stops the current flow to the base terminal of the transistor. So, the LED does not light. However, when the light intensity onto the LDR is high, then the resistance of the LDR is low.So current flows onto the base of the first transistor and then the second transistor.Consequently the LED lights.Here, a preset resistor is used to turn up or down to increase or decrease the resistance.

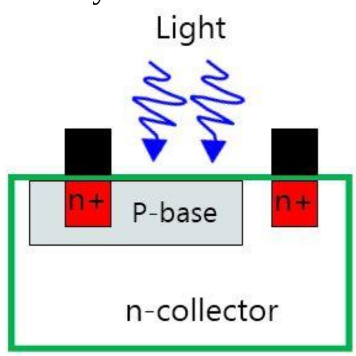


Light Dependent Resistor Circuit

Light Dependent Resistor Applications

Light dependent resistors have a low cost and simple structure. These resistors are frequently used as light sensors. These resistors are mainly used when there is a need to sense the absence and presence of the light such as burglar alarm circuits, alarm clock, light intensity meters, etc. LDR resistors mainly involves in various electrical and electronic projects. For better understanding of this concept, here we are explaining some real time projects where the LDR resistors are used.

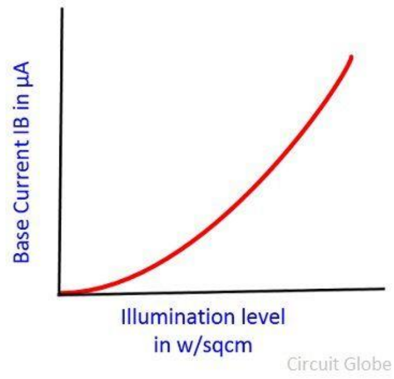
Nowadays the transistor is made of a highly light effective material (like gallium and arsenides



Phototransistor

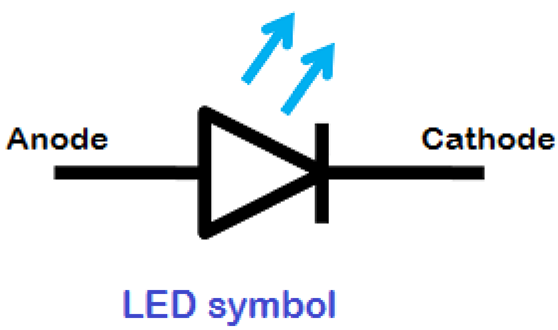
Circuit Globe). The emitter-base junction is kept at forward biased, and the collector-base junction is at the reverse biased.

When no light falls on the surface of the transistor, the small reverse saturation current induces on the transistor. The reverse saturation current induces because of the few minority charge carriers. The light energy falls on the collector-base junction and generates the more majority charge carrier which adds the current to the reverse saturation current. The graph below shows the magnitude of current increases along with the intensity of light.



Light emitting diode (LED)

The symbol of LED is similar to the normal p-n junction diode except that it contains arrows pointing away from the diode indicating that light is being emitted by the diode.



LEDs are available in different colors. The most common colors of LEDs are orange, yellow, green and red.

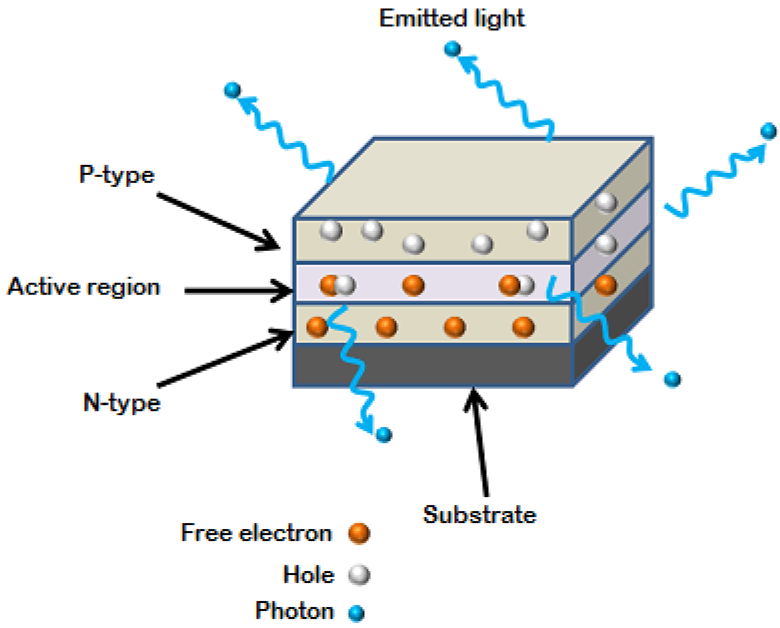
The schematic symbol of LED does not represent the color of light. The schematic symbol is same for all colors of LEDs. Hence, it is not possible to identify the color of LED by seeing its symbol.

Definition: The LED is a PN-junction diode which emits light when an electric current passes through it in the forward direction. In the LED, the recombination of charge carrier takes place. The electron from the N-side and the hole from the P-side are combined and gives the energy in the form of heat and light. The LED is made of semiconductor material which is colourless, and the light is radiated through the junction of the diode.

The LEDs are extensively used in segmental and dot matrix displays of numeric and alphanumeric character. The several LEDs are used for making the single line segment while for making the decimal point single LED is used.

LED construction

One of the methods used to construct LED is to deposit three semiconductor layers on the substrate. The three semiconductor layers deposited on the substrate are n-type semiconductor, p-type semiconductor and active region. Active region is present in between the n-type and p-type semiconductor layers.



Construction of LED

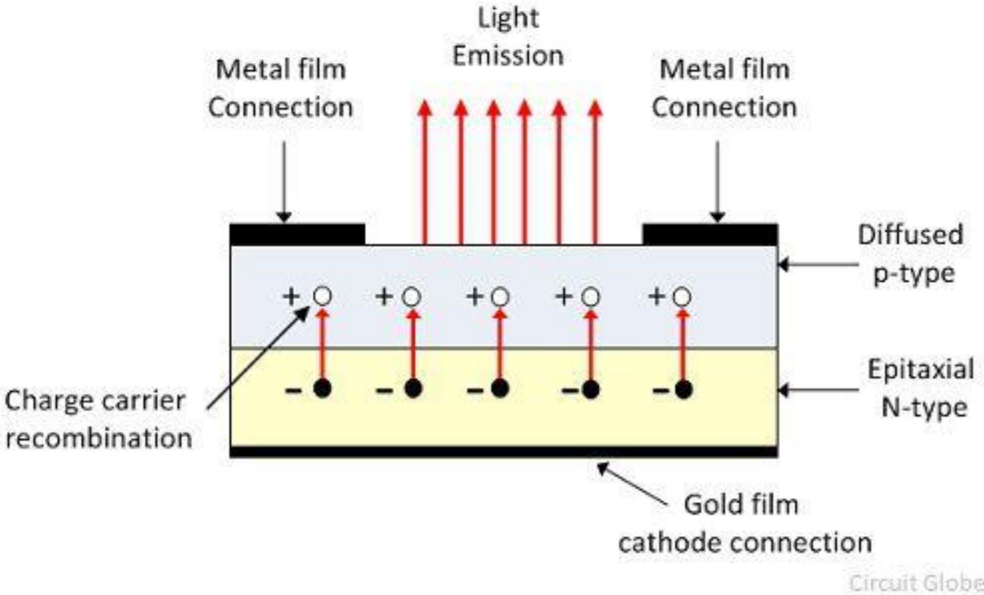
Physics and Radio-Electronics

When LED is forward biased, free electrons from n-type semiconductor and holes from p-type semiconductor are pushed towards the active region.

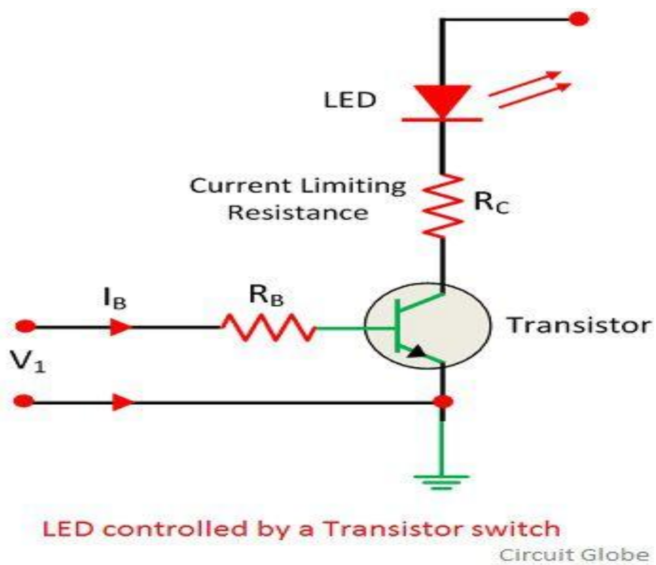
When free electrons from n-side and holes from p-side recombine with the opposite charge carriers (free electrons with holes or holes with free electrons) in active region, an invisible or visible light is emitted.

In LED, most of the charge carriers recombine at active region. Therefore, most of the light is emitted by the active region. The active region is also called as depletion region.

The recombination of the charge carrier occurs in the P-type material, and hence P-material is the surface of the LED. For the maximum emission of light, the anode is deposited at the edge of the P-type material. The cathode is made of gold film, and it is usually placed at the bottom of the N-region. This gold layer of cathode helps in reflecting the light to the surface.



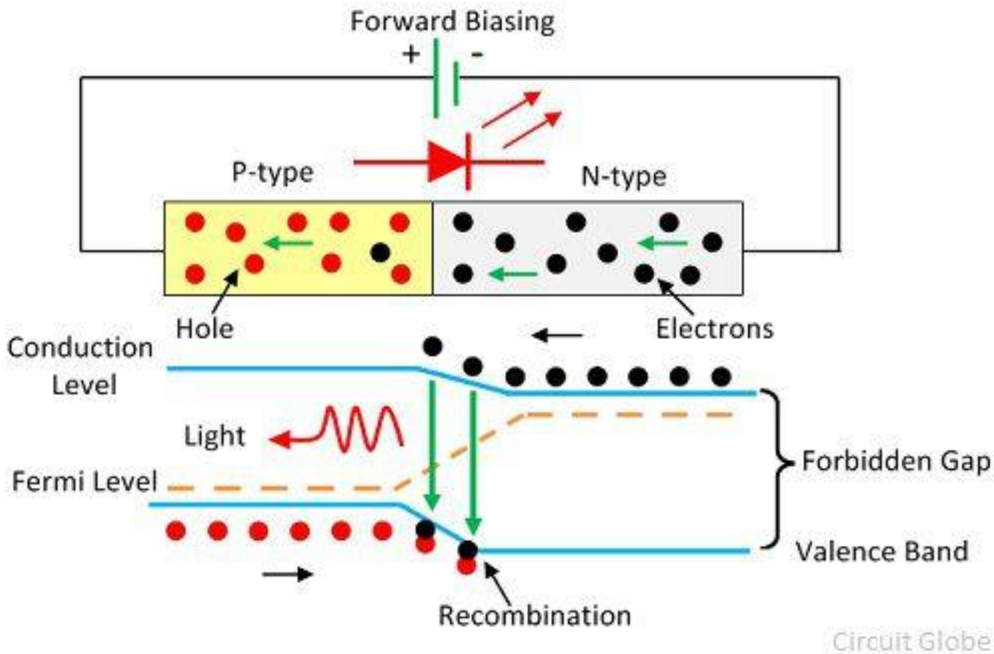
The gallium arsenide phosphide is used for the manufacturing of LED which emits red or yellow light for emission. The LED are also available in green, yellow amber and red in colour.



The simple transistor can be used for off/on of a LED as shown in the figure above. The base current I_B conducts the transistor, and the transistor conducts heavily. The resistance R_C limits the current of the LED.

Working of LED

The working of the LED depends on the quantum theory. The quantum theory states that when the energy of electrons decreases from the higher level to lower level, it emits energy in the form of photons. The energy of the photons is equal to the gap between the higher and lower level.



The LED is connected in the forward biased, which allows the current to flows in the forward direction. The flow of current is because of the movement of electrons in the opposite direction. The recombination shows that the electrons move from the conduction band to valence band and they emits electromagnetic energy in the form of photons. The energy of photons is equal to the gap between the valence and the conduction band.

Advantages of LED in electronic displays

The followings are the major advantages of the LED in an electronics displays.

- The LED are smaller in sizes, and they can be stacked together to form numeric and alphanumeric display in the high-density matrix.
- The intensity of the light output of the LED depends on the current flows through it. The intensity of their light can be controlled smoothly.
- The LED are available which emits light in the different colours like red, yellow, green and amber.
- The on and off time or switching time of the LED is less than of 1 nanoseconds. Because of this, the LED are used for the dynamic operation.
- The LEDs are very economical and giving the high degree of reliability because they are manufactured with the same technology as that of the transistor.
- The LED are operated over a wide range of temperature say 0° – 70°. Also, it is very durable and can withstand shock and variation.
- The LED have a high efficiency, but they require moderate power for operation. Typically, the voltage of 1.2V and the current of 20mA is required for full brightness. Therefore, it is used in a place where less power are available.

Disadvantages of LED

The LED consume more power as compared to LCD, and their cost is high. Also, it is not used for making the large display.

The current flowing through the LED is mathematically written as

$$I_F = \frac{V_s - V_D}{R_s}$$

Where,

I_F = Forward current

V_S = Source voltage or supply voltage

V_D = Voltage drop across LED

R_S = Resistor or current limiting resistor

Voltage drop is the amount of voltage wasted to overcome the depletion region barrier (which leads to electric current flow).

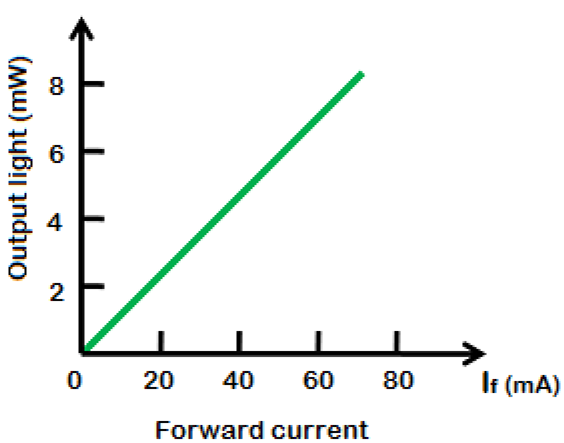
The voltage drop of LED is 2 to 3V whereas silicon or germanium diode is 0.3 or 0.7 V.

Therefore, to operate LED we need to apply greater voltage than silicon or germanium diodes.

Light emitting diodes consume more energy than silicon or germanium diodes to operate.

Output characteristics of LED

The amount of output light emitted by the LED is directly proportional to the amount of forward current flowing through the LED. More the forward current, the greater is the emitted output light. The graph of forward current vs output light is shown in the figure.



Visible LEDs and invisible LEDs

LEDs are mainly classified into two types: visible LEDs and invisible LEDs.

Visible LED is a type of LED that emits visible light. These LEDs are mainly used for display or illumination where LEDs are used individually without photosensors.

Invisible LED is a type of LED that emits invisible light (infrared light). These LEDs are mainly used with photosensors such as photodiodes.

What determines the color of an LED?

The material used for constructing LED determines its color. In other words, the wavelength or color of the emitted light depends on the forbidden gap or energy gap of the material.

Different materials emit different colors of light.

Gallium arsenide LEDs emit red and infrared light.

Gallium nitride LEDs emit bright blue light.

Yttrium aluminium garnet LEDs emit white light.

Gallium phosphide LEDs emit red, yellow and green light.

Aluminium gallium nitride LEDs emit ultraviolet light.

Aluminum gallium phosphide LEDs emit green light.

Advantages of LED

The brightness of light emitted by LED is depends on the current flowing through the LED. Hence, the brightness of LED can be easily controlled by varying the current. This makes possible to operate LED displays under different ambient lighting conditions.

- Light emitting diodes consume low energy.
- LEDs are very cheap and readily available.
- LEDs are light in weight.
- Smaller size.
- LEDs have longer lifetime.
- LEDs operates very fast. They can be turned on and off in very less time.
- LEDs do not contain toxic material like mercury which is used in fluorescent lamps.
- LEDs can emit different colors of light.

Disadvantages of LED

- LEDs need more power to operate than normal p-n junction diodes.
- Luminous efficiency of LEDs is low.

Applications of LED

- The various applications of LEDs are as follows
- Burglar alarms systems

- Calculators
- Picture phones
- Traffic signals
- Digital computers
- Multimeters
- Microprocessors
- Digital watches
- Automotive heat lamps
- Camera flashes
- Aviation lighting

Digital Transducers

A transducer measures physical quantities and transmits the information as coded digital signals rather than as continuously varying currents or voltages. Any transducer that presents information as discrete samples and that does not introduce a quantization error when the reading is represented in the digital form may be classified as a digital transducer. Most transducers used in digital systems are primarily analogue in nature and incorporate some form of conversion to provide the digital output. Many special techniques have been developed to avoid the necessity to use a conventional analogue - to-digital conversion technique to produce the digital signal. This article describes some of the direct methods which are in current use of producing digital outputs from transducers.

Some of the techniques used in transducers which are particularly adaptable for use in digital systems are introduced. The uses of encoder discs for absolute and incremental position measurement and to provide measurement of angul ar speed are outlined. The application of linear gratings for measurement of translational displacement is compared with the use of Moire fringe techniques used for similar purposes. Synchro devices are briefly explained and the various techniques used to produce a digital output from synchro resolvers are described. Brief descriptions of devices which develop a digital output from the natural frequency of vibration of some part of the transducer are presented. Digital techniques including vortex flowmeters and instruments using laser beams are also briefly dealt with. Some of them are as follows:

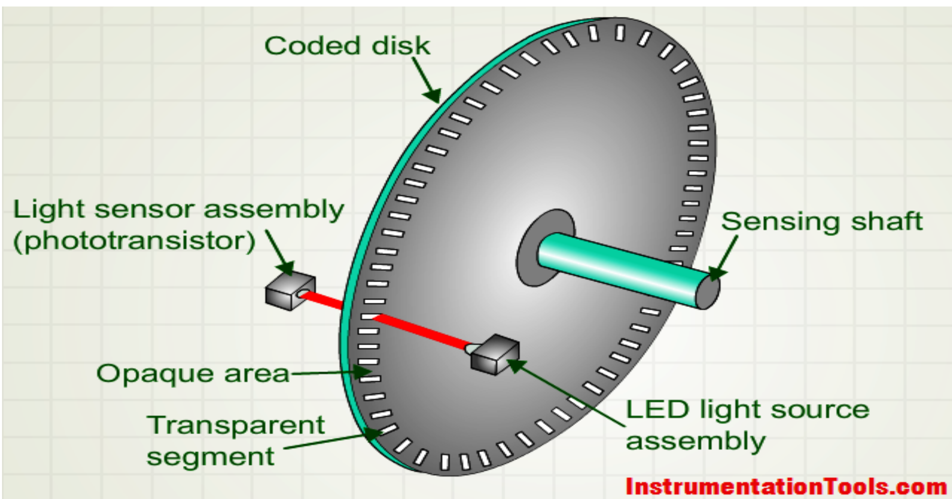
- Shaft Encoders
- Digital Resolvers
- Digital Tachometers
- Hall Effect Sensor
- Limit Switches

Shaft Encoders:

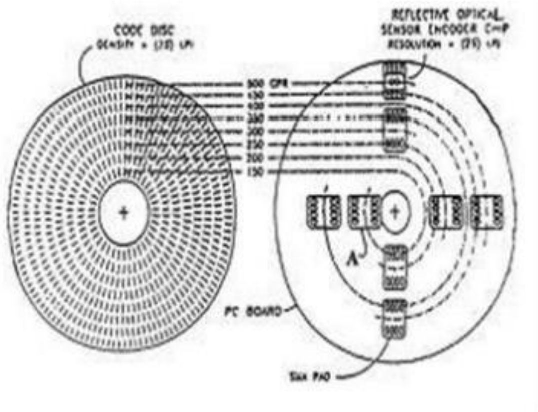
An encoder is a device that provides a coded reading of a measurement. A Shaft encoders can be one of the encoder that provide digital output measurements of angular position and velocity.

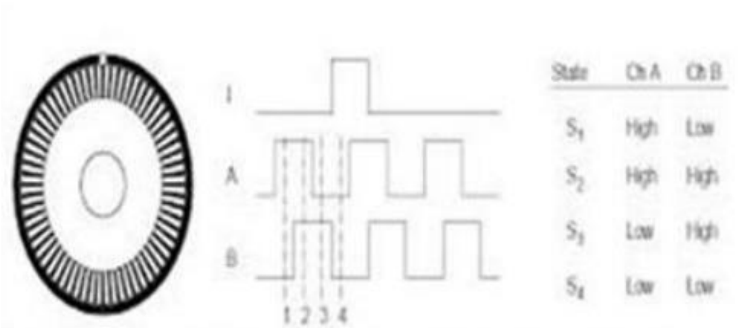
This shaft encoders are excessively applicable in robotics, machine tools, mirror positioning systems, rotating machinery controls (fluid and electric), etc. Shaft encoders are basically of two types-Absolute and Incremental encoders.

An "absolute" encoder maintains position information when power is removed from the system. The position of the encoder is available immediately on applying power. The relationship between the encoder value and the physical position of the controlled machinery is set at assembly; the system does not need to return to a calibration point to maintain position accuracy. An "incremental" encoder accurately records changes in position, but does not power up with a fixed relation between encoder state and physical position. Devices controlled by incremental encoders may have to "go home" to a fixed reference point to initialize the position measurement. A multi-turn absolute rotary encoder includes additional code wheels and gears. A high-resolution wheel measures the fractional rotation, and lower-resolution geared code wheels record the number of whole revolutions of the shaft.



An absolute encoder has multiple code rings with various binary weightings which provide a data word representing the absolute position of the encoder within one revolution. This type of encoder is often referred to as a parallel absolute encoder.



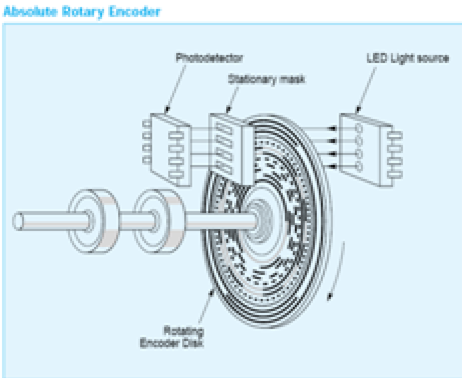


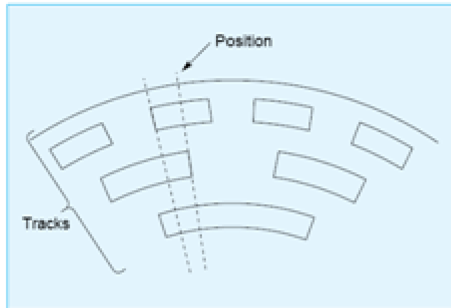
An incremental encoder works differently by providing an A and a B pulse output that provide no usable count information in their own right. Rather, the counting is done in the external electronics. The point where the counting begins depends on the counter in the external electronics and not on the position of the encoder. To provide useful position information, the encoder position must be referenced to the device to which it is attached, generally using an index pulse. The distinguishing feature of the incremental encoder is that it reports an incremental change in position of the encoder to the counting electronics.

Types of Rotary Encoder:

Absolute Encoder:

An absolute encoder maintains position information when power is removed from the encoder. The position of the encoder is available immediately on applying power. The relationship between the encoder value and the physical position of the controlled machinery is set at assembly; the system does not need to return to a calibration point to maintain position accuracy.





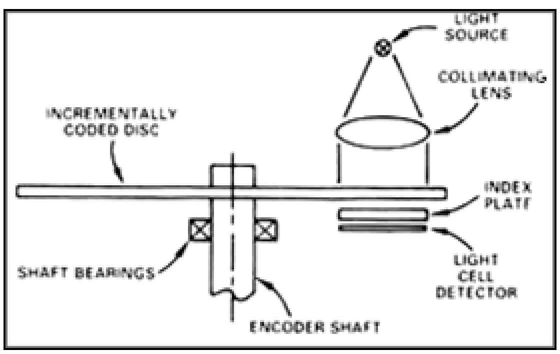
Typical disk pattern showing radial scanning method used to read position.

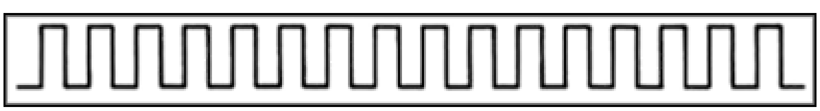
Components of Absolute Encoder

An absolute encoder has multiple code rings with various binary weightings which provide a data word representing the absolute position of the encoder within one revolution. This type of encoder is often referred to as a parallel absolute encoder.

A multi-turn absolute rotary encoder includes additional code wheels and gears. A high-resolution wheel measures the fractional rotation, and lower-resolution geared code wheels record the number of whole revolutions of the shaft.

Incremental Encoder:



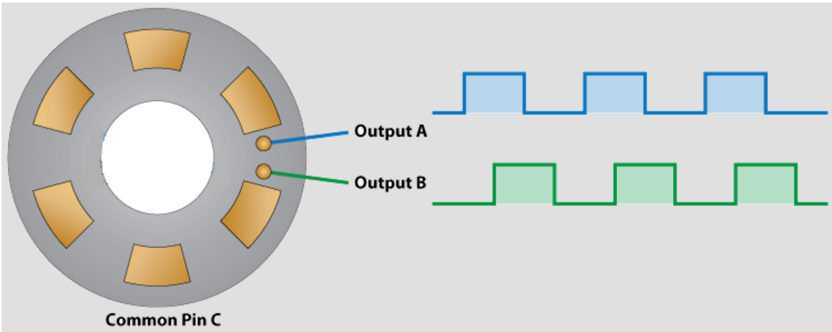


Pulse Train Produced from Incremental Encoder

An incremental encoder will immediately report changes in position, which is an essential capability in some applications. However, it does not report or keep track of absolute position. As a result, the mechanical system monitored by an incremental encoder may have to be moved to a fixed reference point to initialize the position measurement.

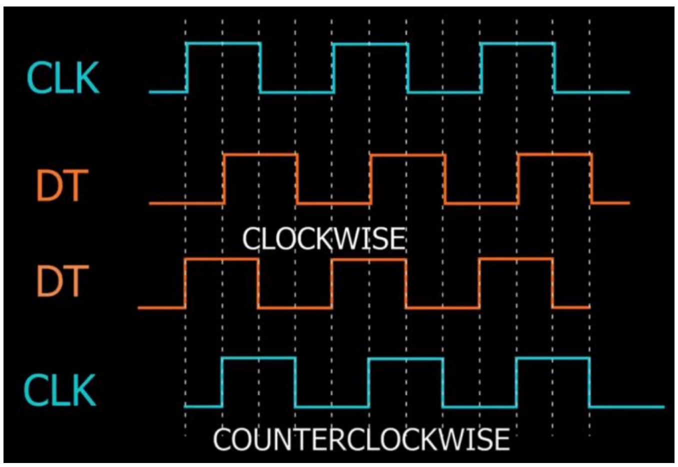
How Rotary Encoder Works?

The encoder has a disk with evenly spaced contact zones that are connected to the common pin C and two other separate contact pins A and B, as illustrated below.



When the disk will start rotating step by step, the pins A and B will start making contact with the common pin and the two square wave output signals will be generated accordingly.

Any of the two outputs can be used for determining the rotated position if we just count the pulses of the signal. However, if we want to determine the rotation direction as well, we need to consider both signals at the same time.



We can notice that the two output signals are displaced at 90 degrees out of phase from each other. If the encoder is rotating clockwise the output A will be ahead of output B.

So if we count the steps each time the signal changes, from High to Low or from Low to High, we can notice at that time the two output signals have opposite values. Vice versa, if the encoder is rotating counter clockwise, the output signals have equal values. So considering this, we can easily program our controller to read the encoder position and the rotation direction.

Advantages & Disadvantages of Rotary Encoders:

Advantages of an Encoder

1. Highly reliable and accurate
2. Low-cost feedback

3. High resolution
4. Integrated electronics
5. Fuses optical and digital technology
6. Can be incorporated into existing applications
7. Compact size

Disadvantages of an Encoder

1. Subject to magnetic or radio interference (Magnetic Encoders)
2. Direct light source interference (Optical Encoders)
3. Susceptible to dirt, oil and dust contaminates

Applications of Rotary Encoders:

An encoder can be used in applications requiring feedback of position, velocity, distance, etc. The examples listed below illustrate the vast capabilities and implementations of an encoder:

1. Assembly Machines
2. Packaging
3. X and Y Indication Systems
4. Printers
5. Testing Machines
6. CNC Machines
7. Robotics
8. Labeling Machines
9. Medical Equipment
10. Textiles
11. Drilling Machines
12. Motor Feedback

Electrical Tachometer

Definition: The tachometer use for measuring the rotational speed or angular velocity of the machine which is coupled to it. It works on the principle of relative motion between the magnetic field and shaft of the coupled device. The relative motion induces the EMF in the coil which is placed between the constant magnetic field of the permanent magnet. The develops EMF is directly proportional to the speed of the shaft.

Mechanical and electrical are the two types of the tachometer. The mechanical tachometer measures the speed of shaft regarding revolution per minutes.

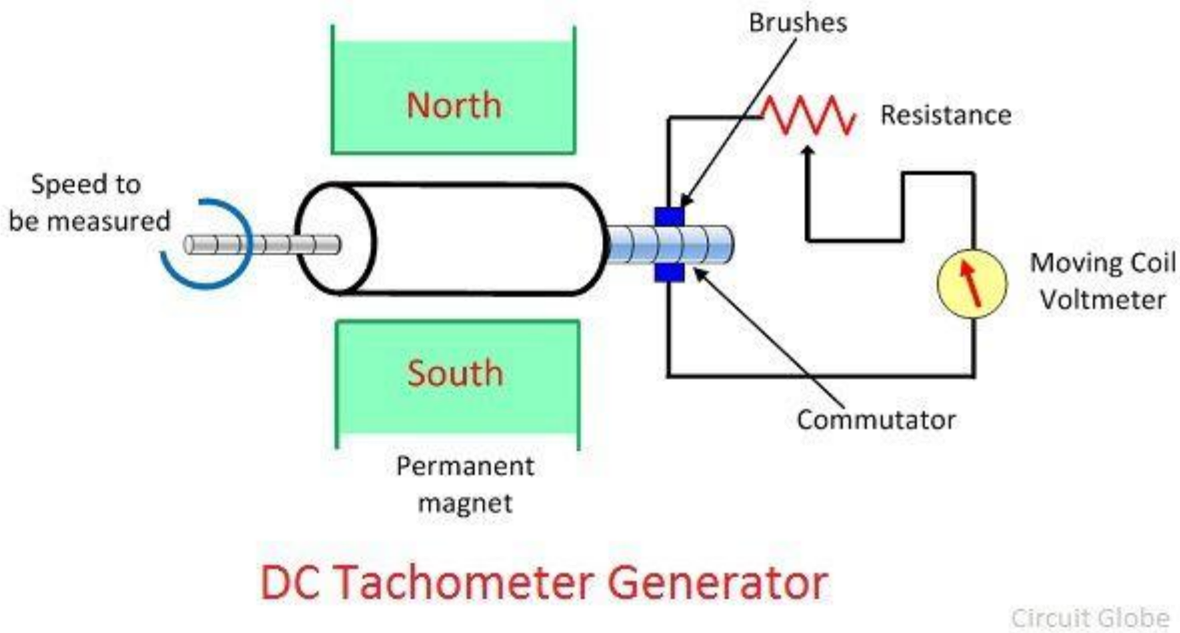
The electrical tachometer converts the angular velocity into an electrical voltage. The electrical tachometer has more advantages over the mechanical tachometer. Thus it is mostly used for measuring the rotational speed of the shaft. Depends on the natures of the induced voltage the electrical tachometer is categorized into two types.

- AC Tachometer Generator
- DC Tachometer Generator

DC Tachometer Generator

Permanent magnet, armature, commutator, brushes, variable resistor, and the moving coil voltmeter are the main parts of the DC tachometer generator. The machine whose speed is to be measured is coupled with the shaft of the DC tachometer generator.

The DC tachometer works on the principle that when the closed conductor moves in the magnetic field, EMF induces in the conductor. The magnitude of the induces emf depends on the flux link with the conductor and the speed of the shaft.



The armature of the DC generator revolves between the constant field of the permanent magnet. The rotation induces the emf in the coil. The magnitude of the induced emf is proportional to the shaft speed.

The commutator converts the alternating current of the armature coil to the direct current with the help of the brushes. The moving coil voltmeter measures the induced emf. The polarity of the induces voltage determines the direction of motion of the shaft. The resistance is connected in series with the voltmeter for controlling the heavy current of the armature.

The emf induces in the dc tachometer generator is given as

$$E = \frac{\emptyset PN}{60} \times \frac{z}{a}$$

Where, E – generated voltage

Φ – flux per poles in Weber

P- number of poles

N – speed in revolution per minutes
Z – the number of the conductor in armature windings.
a – number of the parallel path in the armature windings.

$$E \alpha N$$

$$E = KN$$

$$K = Constant = \frac{\emptyset P}{60} \times \frac{z}{a}$$

Advantages of the DC Tachometer.

The polarity of the induces voltages indicates the direction of rotation of the shaft.

The conventional DC type voltmeter is used for measuring the induces voltage.

Disadvantages of DC Generator

The commutator and brushes require the periodic maintenance.

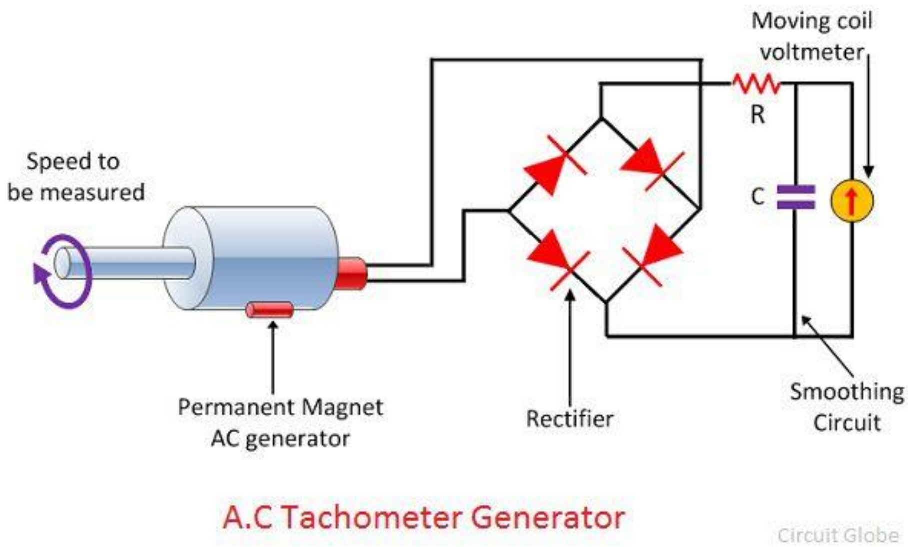
The output resistance of the DC tachometer is kept high as compared to the input resistance. If the large current is induced in the armature conductor, the constant field of the permanent magnet will be distorted.

AC Tachometer Generator

The DC tachometer generator uses the commutator and brushes which have many disadvantages. The AC tachometer generator designs for reducing the problems. The AC tachometer has stationary armature and rotating magnetic field. Thus, the commutator and brushes are absent in AC tachometer generator.

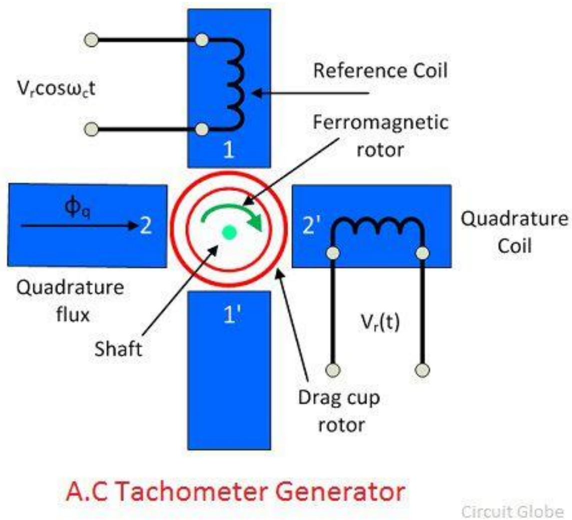
The rotating magnetic field induces the EMF in the stationary coil of the stator. The amplitude and frequency of the induced emf are equivalent to the speed of the shaft. Thus, either amplitude or frequency is used for measuring the angular velocity.

The below mention circuit is used for measuring the speed of the rotor by considering the amplitude of the induced voltage. The induces voltages are rectified and then passes to the capacitor filter for smoothening the ripples of rectified voltages.



Drag Cup Rotor AC Generator

The drag cup type A.C tachometer is shown in the figure below.



The stator of the generator consists two windings, i.e., the reference and quadrature winding. Both the windings are mounted 90° apart from each other. The rotor of the tachometer is made with thin aluminum cup, and it is placed between the field structure.

The rotor is made of the highly inductive material which has low inertia. The input is provided to the reference winding, and the output is obtained from the quadrature winding. The rotation of rotor between the magnetic field induces the voltage in the sensing winding. The induces voltage is proportional to the speed of the rotation.

Advantages

The drag cup Tachogenerator generates the ripple free output voltage.

The cost of the generator is also very less.

Disadvantage

The nonlinear relationship obtains between the output voltage and input speed when the rotor rotates at high speed.