Photoresistor – A Detailed Guide

While walking through the streets in the evening, have you ever noticed how the street lights turn on automatically as it starts getting darker? This automatic switching ON of the street lights are due to the presence of a special type of variable resistor on its circuit. The resistance of this variable resistor depends on the amount of light that falls on it.

Such a resistor is called the photo-resistor, and in this article we shall discuss about some aspects of the same.

So let's start!

What is a Photoresistor?

Photoresistor is the combination of words "photon" (meaning light particles) and "resistor". True to its name, a photo-resistor is a device or we can say a resistor dependent on the light intensity. For this reason, they are also known as light dependent a.k.a. LDRs.

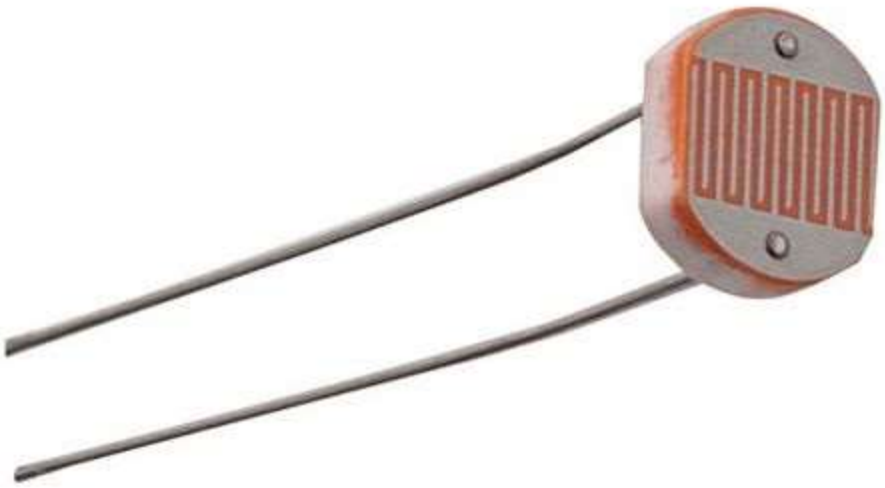
So to define a photo-resistor in a single line we can write it as:

"Photoresistor is a variable resistor whose resistance varies inversely with the intensity of light"

From our basic knowledge about the relationship between resistivity (ability to resist the flow of electrons) and conductivity (ability to allow the flow of electrons), we know that both are polar opposites of each other. Thus when we say that the resistance decreases when intensity of light increases, it simply implies that the conductance increases with increase in intensity of light falling on the photo-resistor or the LDR, owing to a property called photo-conductivity of the material.

Hence these Photoresistors are also known as photoconductive cells or just photocell.

The idea of Photoresistor developed when photoconductivity in Selenium was discovered by Willoughby Smith in 1873. Many variants of the photoconductive devices were then made.

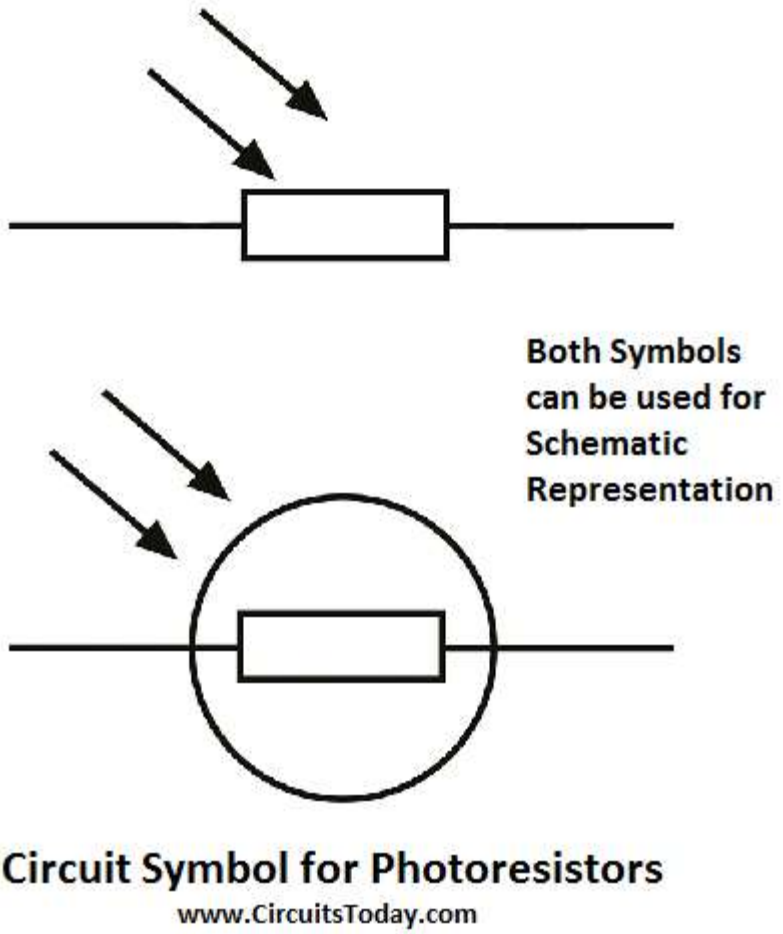


Photoresistor

Photoresistor Symbol

In order to represent a Photoresistor in a circuit diagram, the symbol chosen was that would indicate it to be a light dependent device along with the fact that it is a resistor.

While mostly the symbol used is shown in figure 2a (two arrows pointing to a resistor), some prefer to encase the resistor in a circle like that shown in figure 2b.



Photoresistors Circuit Symbol

Working principle of a Photoresistor

In order to understand the working principle of a Photoresistor, let's brush up a little about the valence electrons and the free electrons.

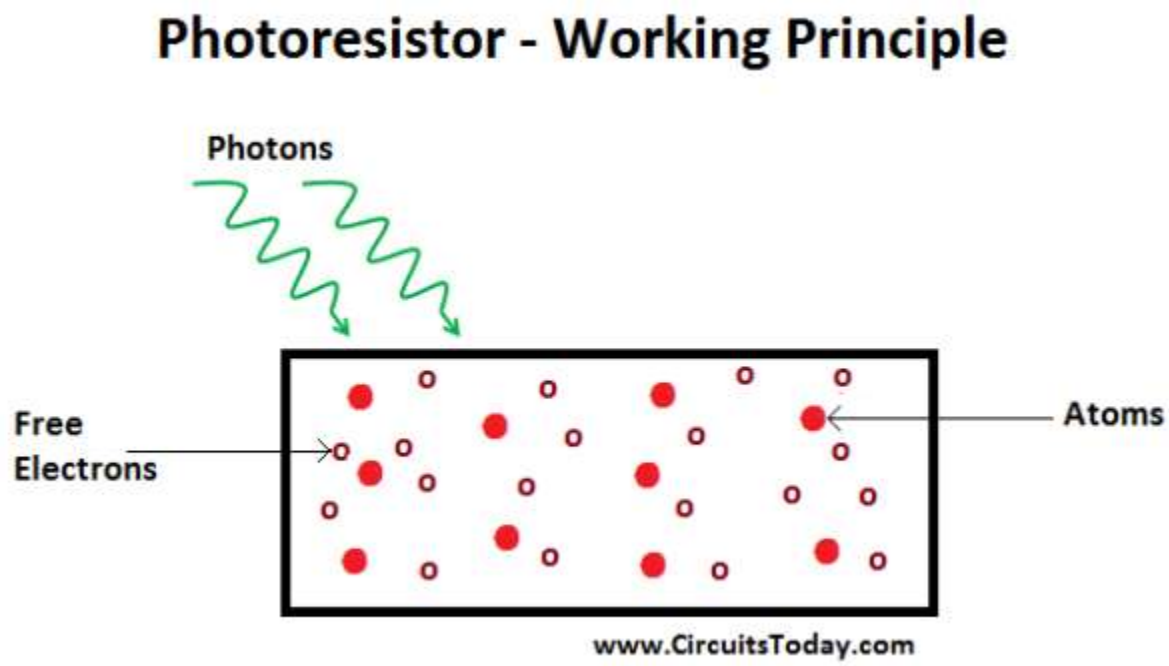
As we know valence electrons are those found in the outermost shell of an atom. Hence, these are loosely attached to the nucleus of the atom. This means that only some small amount of energy is needed to pull it out from the outer orbit.

Free electrons on the other hand are those which are not attached to the nucleus and hence free to move when an external energy like an electric field is applied. Thus when some energy makes the valence electron pull out from the outer orbit,

it acts as a free electron; ready to move whenever an electric field is applied. The light energy is used to make valence electron a free electron.

This very basic principle is used in the Photoresistor. The light that falls on a photoconductive material is absorbed by it which in turn makes lots of free electrons from the valence electrons.

The figure below shows a pictorial representation of the same:



Photoresistor Working Priciple

As the light energy falling on the photoconductive material increases, number of valence electrons that gain energy and leave the bonding with the nucleus increases. This leads to a large number of valence electrons jump to the conduction band, ready to move with an application of any external force like an electric field.

Thus, as the light intensity increases, the number of free electrons increases. This means the photoconductivity increases that imply a decrease in photo resistivity of the material.

Now that we have covered the working mechanism, we got an idea that a photoconductive material is used for the construction of a Photoresistor. According to the type of photoconductive material the Photoresistors are of two types. A brief introduction is given in the next section

Types of Photoresistor

A Photoresistor is generally made of a semiconductor material that is used as resistive element without any PN junction. This essentially makes Photoresistor a passive device. The two types of Photoresistors are:

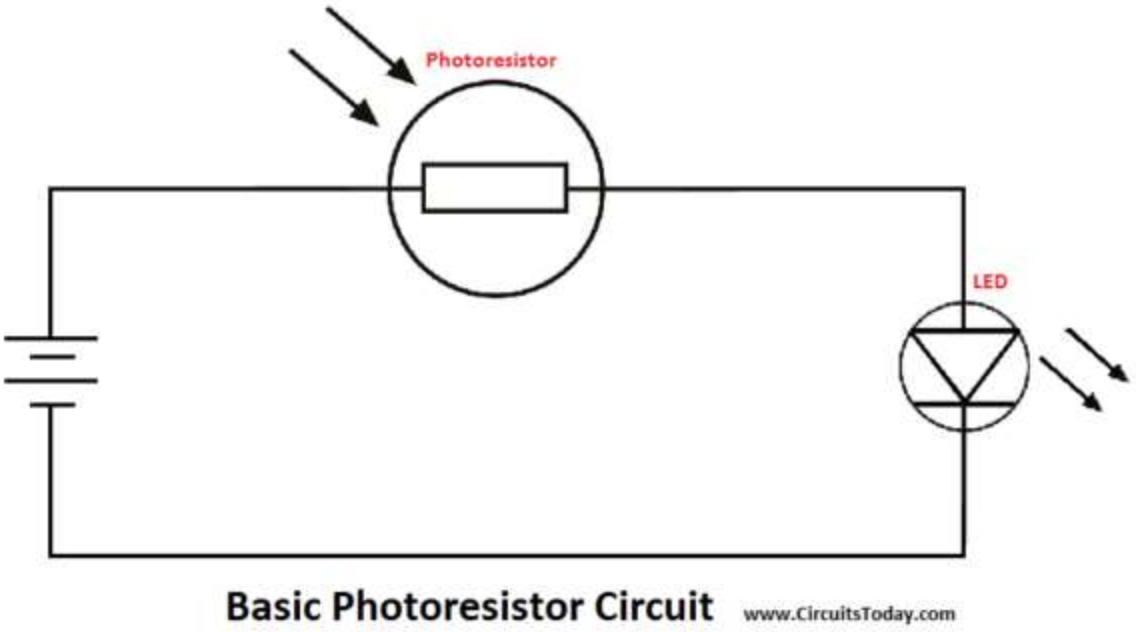
1. ***Intrinsic Photoresistor***: As we know, intrinsic is often referred for a semiconductor(in this case a photoconductive material) that is devoid of any doping. This means that the photoconductive material, used to build this Photoresistor involves excitation of charge carriers from the valence bands to the conduction band.
2. ***Extrinsic Photoresistor:*** Extrinsic Photoresistors have semiconductor material with some impurity or we can say they are doped, for better efficiency. The impurity dopants should be shallow and should not get ionised in the presence of light. The photoconductive material used for this Photoresistor involves excitation of charge carriers between an impurity and the valence band or conduction band.

Now that we have covered the mechanism and the types, you must have got an idea how a Photoresistor works. However, a question may arise: How to connect Photoresistor in simple circuit?

Let's see an example below that has a very basic Photoresistor circuit.

Basic Photoresistor Circuit

The figure below shows a basic circuit diagram of a Photoresistor ciruit. It has a battery, a Photoresistor and a led. This setup helps understand the behaviour of Photoresistor when subjected to an electric field.



Basic Photoresistor Circuit

CASE 1: No light is present on the Photoresistor (say, you covered the Photoresistor completely)
Can you guess what happens?

There is no light energy for the Photoresistor to absorb; therefore no free electrons are generated. This means even if the Photoresistor is subjected to an electric field, there is no free electrons that would move and start the flow of current.

What does it mean? Yes, it means the opposition to the flow of current is high or we can say its resistance is very high.

Will the LED bulb get lit? Obviously NO, since no current is flowing through the circuit.

CASE 2: Light falls on the Photoresistor

This is an easy one for you to guess now right?

Here there are photons falling on the Photoresistor, therefore light energy needed to create free electrons is absorbed by it. Now, as the Photoresistor is

connected to the battery, the free electrons start moving as they are now subjected to an electric field. Hence, we can say current starts flowing in the circuit.

So what does this imply about the resistance of the Photoresistor?

Yes you guessed it right; this implies that the resistance has decreased significantly allowing the flow of current in the circuit.

Thus the LED in this case would light up.

Next section lets you understand the common uses and applications of a Photoresistor.

Photoresistor – Uses & Applications

Automatic Street Lights: One of the prominent uses of Photoresistor that we experience in daily life is in the circuits of automatic street lights, as already hinted in the introductory paragraph. Here they are so used in a circuit that the street lights turn on as it starts getting dark and turns off in the morning.
Some of the Photoresistors are used in some of the consumer items like ***light meters in camera, light sensors*** like in robotic projects***, clock radios etc.***
They are also used ***to control the reduction in gain*** of dynamic compressors.
They are also considered as a ***good infra-red detector*** and hence find application in infrared astronomy.
With this we come to the conclusion of the article, let's rewind what we learnt in this short tutorial.

Photoresistor In a Nutshell

- "***Photons***" + "***Resistor***" = ***Photoresistor***: A special type of variable resistor whose resistance depends on the intensity of light falling on it.
- ***Other Names:*** Photoconductor, Photocell , Light dependent resistor(LDR)
- ***Willoughby Smith :*** First scientist to discover the photoconductivity in Selenium(a semiconductor)
- ***Construction:*** Made of semiconductor material that is photosensitive. *They do not have any PN junction.*
- ***Working Principle:*** When light falls on the photosensitive material (or on the Photoresistor), the valence electrons absorb the light energy and break free

from the nucleus to become free electrons. These electrons lead to flow of current when an external force like an electric field is applied.

Applications

Most common application in the circuits of automatic street lights, and other consumer items like light meter, light sensor etc