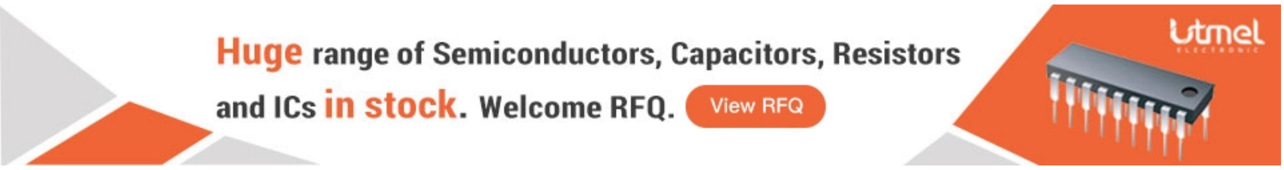
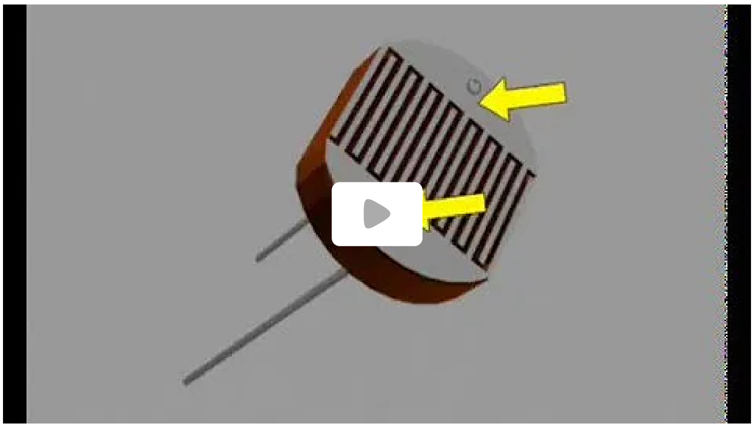


Photoresistor Basics: Types, Principles and Applications

Alan 03 January 2020 11084

The article introduces the photoresistor's main characteristics and principles including the working principle and structural principle. There are three types of photoresistor: ultraviolet photoresistors, infrared photoresistors, visible light photoresistors. Dimming circuit and light switch are the two applications of the photoresistor.



Light Dependent Resistors (LDR): Working Principle

Abstracts

There are three types of photoresistor: ultraviolet photoresistors, infrared photoresistors, visible light photoresistors. Commonly used materials are cadmium sulfide, selenium, aluminum sulfide, lead sulfide, and bismuth sulfide. The working principle of the photoresistor is based on the internal photoelectric effect. Photosensitive resistors are formed by mounting electrode leads at both ends of the semiconductor photosensitive material and encapsulating them in a tube case with a transparent window. Dimming circuit and light switch are the two applications of the photoresistor.

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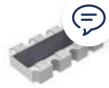

I. Introduction

Figure 1. Photoresistor

The photoresistor is also known as the light-dependent resistor (abbreviated as LDR) or photoconductor. Commonly used materials are cadmium sulfide, selenium, aluminum sulfide, lead sulfide, and bismuth sulfide. These manufacturing materials have the characteristic that the resistance value decreases rapidly under the irradiation of light of a specific wavelength. This is because the carriers generated by the light all participate in the conduction and make a drift movement under the action of an external electric field. The electrons move to the positive pole of the power supply, and the holes move to the negative pole of the power supply so that the resistance of the photoresistor decreases rapidly.

The photoresistor is the special resistor made of semiconductor materials such as sulfurized or selenized spacers, and its working principle is based on the internal photoelectric effect. The stronger the light, the lower the resistance value. As the light intensity increases, the resistance value decreases rapidly, and the bright resistance value can be as small as 1KΩ or less. The photoresistor is very sensitive to light. When there is no light, the photoresistor is in a high resistance state, and the dark resistance is generally up to 1.5MΩ.

The photoresistor is a type of resistor made by using the photoconductive effect of a semiconductor to change its resistance value according to the intensity of incident light. It is also called a photoconductive detector; the intensity of the incident light is reduced, then the resistance is reduced; the incident light is weak, and the resistance increase. There is another kind of photoresistor. When the incident light is weak, the resistance is reduced; the incident light is strong, the resistance is increased.

Photoresistors are generally used for light measurement, light control, and photoelectric conversion (converting changes in light to changes in electricity). A commonly used photoresistor is a cadmium sulfide photoresistor, which is made of semiconductor material. The photoresistor's sensitivity to light (that is, its spectral characteristics) is very close to the human eye's response to visible light (0.4 ~ 0.76) μm. When designing the light control circuit, the light of incandescent bulbs (small electric beads) or natural light is used as the control light source, which greatly simplifies the design.

II. Specifications

Generally, the photoresistor is made into a sheet structure to absorb more light energy. When it is irradiated with light, an electron-hole pair is excited in the semiconductor wafer (photosensitive layer) to participate in conduction and increase the current in the circuit. In order to obtain high sensitivity, the electrode of the photoresistor often uses a comb-like pattern, which is formed by vapor-depositing a metal such as gold or indium on a photoconductive film under a certain mask. The structure of a general photoresistor is shown below.

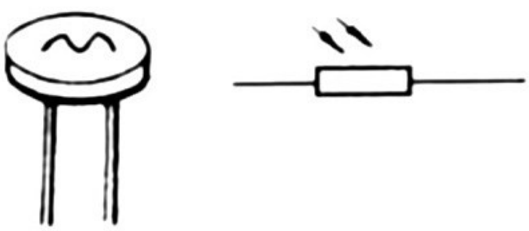

Figure 2. Structure of a general photoresistor

Photoresistor usually consists of a photosensitive layer, a glass substrate (or a resin moisture-proof film), and electrodes. Photoresistors are represented by the letters "R" or "RL", "RG" in the circuit.

A photoresistor is made of cadmium sulfide (CdS). It is divided into epoxy resin package and metal package, both of which are wire type (DIP type). Epoxy packaged photoresistors are divided into Ø3mm, Ø4mm, Ø5mm, Ø7mm, Ø11mm, Ø12mm, Ø20mm, Ø25mm according to the ceramic substrate diameter.

III. Parameter & Characteristics

According to the spectral characteristics of the photoresistor, it can be divided into three types of photoresistors: ultraviolet photoresistors, infrared photoresistors, and visible light photoresistors.

1. The main parameters

(1) Photocurrent and bright resistance. Under a certain applied voltage, the current flowing is called photocurrent when light is irradiated, and the ratio of the applied voltage to the photocurrent is called bright resistance, which is usually expressed by "100LX".

(2) Dark current and dark resistance. Under a certain applied voltage, the photoresistor is called dark current when there is no light. The ratio of the applied voltage to the dark current is called the dark resistance, and it is usually expressed as "0LX" (the light intensity is measured with an illuminance meter, and its unit is lax lx).

(3) Sensitivity. Sensitivity refers to the relative change in the resistance value (dark resistance) when the photoresistor is not illuminated by light and the resistance value (bright resistance) when illuminated by light.

(4) Spectral response. The spectral response is also called spectral sensitivity, which refers to the sensitivity of the photoresistor under the irradiation of monochromatic light with different wavelengths. If you plot the sensitivity at different wavelengths, you can get a curve of the spectral response.

(5) Illumination characteristics. Illumination characteristics refer to the characteristics of the electrical signal output by the photoresistor as a function of illumination. It can be seen from the light characteristic curve of the photoresistor that as the light intensity increases, the resistance value of the photoresistor starts to decrease rapidly. If the light intensity is further increased, the change in resistance value decreases, and then gradually becomes gentle. In most cases, this characteristic is non-linear.

(6) Volt-ampere characteristic curve. Under a certain illumination, the relationship between the voltage and current applied across the photoresistor is called the volt-ampere characteristic. At a given bias, the greater the light intensity, the larger the photocurrent. Under a certain light intensity, the larger the voltage applied, the larger the photocurrent. However, the voltage cannot be increased indefinitely, because any photoresistor is limited by the rated power, the maximum operating voltage, and the rated current. Exceeding the maximum operating voltage and maximum rated current may cause permanent damage to the photoresistor.

(7) Temperature coefficient. The photoelectric effect of the photoresistor is greatly affected by temperature. Some photoresistors have higher photoelectric sensitivity at low temperatures, but lower sensitivity at high temperatures.

(8) Rated power. Rated power refers to the power that the photoresistor can consume in a certain line. When the temperature increases, the power it consumes decreases.

2. Frequency characteristics

When the photoresistor is irradiated with pulsed light, the photocurrent takes a period of time to reach a stable value. After the light is stopped, the photocurrent is not immediately zero, which is the time delay characteristic of the photoresistor. Due to the different photosensitivity and resistance delay characteristics of different materials, their frequency characteristics are also different. The use frequency of lead sulfide is much higher than that of cadmium sulfide, but the delay of most photoresistors is relatively large, so it cannot be used in applications that require fast response.

IV. How does the photoresistor work?

1. Working principle

The working principle of the photoresistor is based on the internal photoelectric effect. Photosensitive resistors are formed by mounting electrode leads at both ends of the semiconductor photosensitive material and encapsulating them in a tube case with a transparent window. In order to increase the sensitivity, the two electrodes are often made into a comb shape. The materials used to make photoresistors are mainly semiconductors such as metal sulfides, selenides, and tellurides. Coating, spraying, sintering, and other methods are used to make a very thin photoresistor and a comb-shaped ohmic electrode on an insulating substrate. The leads are connected and sealed in a sealed housing with a light-transmitting mirror to prevent its sensitivity from being affected by moisture. After the incident light disappears, the electron-hole pairs generated by the photon excitation will recombine, and the resistance of the photoresistor will return to its original value. When a voltage is applied to the metal electrodes at both ends of the photoresistor, a current passes through it. When the photoresistor is irradiated by the light with a certain wavelength, the current will increase with the light intensity, thereby achieving photoelectric conversion. The photoresistor has no polarity and is purely a resistive device. It can be used with both DC voltage and AC voltage. The conductivity of a semiconductor depends on the number of carriers in the semiconductor's conduction band.

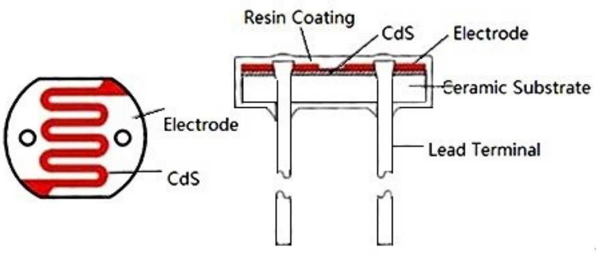

Figure 3. Photoresistor schematic

2. Structural principle

Photoresistors are special resistors made of vulcanized or selenized semiconductor materials. The surface is also coated with a moisture-proof resin, which has a photoconductive effect. The working principle of the photoresistor is based on the internal photoelectric effect, that is, the electrode leads are mounted at both ends of the semiconductor photosensitive material, and the photoresistor is formed by packaging it in a tube case with a transparent window. To increase sensitivity, the two electrodes are often comb-shaped.

The conductivity of a semiconductor depends on the number of carriers in the semiconductor's conduction band. When the photoresistor is illuminated, the electrons in the valence band absorb the photon energy and then jump to the conduction band and become free electrons. At the same time, holes are generated. The appearance of the electron-hole pair makes the resistivity smaller. The stronger the light, the more photo-generated electron-hole pairs and the lower the resistance value. When a voltage is applied across the photoresistor, the current flowing through the photoresistor increases with increasing light. The incident light disappears, the electron-hole pair gradually recombines, the resistance gradually returns to its original value, and the current gradually decreases.

The photoresistor is very sensitive to light. When there is no light, the photoresistor is in a high resistance state, and the dark resistance is generally up to 1.5MΩ. When there is light, free electrons and holes are excited in the material, and its resistance value decreases. As the light intensity increases, the resistance value decreases rapidly, and the bright resistance value can be as small as 1KΩ or less.

The lighting characteristics of the photoresistor are non-linear in most cases, only linear in a small range, and the resistance value of the photoresistor has a large dispersion (resistance change, large range irregularity).

The sensitivity of the photoresistor refers to the relative change in the resistance value (dark resistance) of the photoresistor when it is not exposed to light and the resistance value (bright resistance) when it is exposed to light. The ratio of the dark resistance to the light resistance of the photoresistor is about 1500: 1. The larger the dark resistance, the better. Apply DC or AC bias voltage to the photoresistor. The MG photoresistor is suitable for visible light. It is mainly used in various automatic control circuits, photoelectric counting, photoelectric tracking, light control electric lamps, automatic exposure of cameras, and automatic brightness control circuits of color televisions.

V. Classification

Divided by semiconductor material: intrinsic photoresistor, doped photoresistor. The latter has stable performance and good characteristics, so it is mostly used.

According to the spectral characteristics of the photoresistor, it can be divided into three types of photoresistors:

1. Ultraviolet photoresistor: more sensitive to ultraviolet light, including cadmium sulfide, cadmium selenide photoresistors, etc.

2. Infrared photoresistor: mainly lead sulfide, lead telluride, lead selenide. Photosensitive resistors such as indium antimonide are widely used in missile guidance, astronomical detection, non-contact measurement, human lesion detection, infrared spectroscopy, infrared communications and other defense, scientific research, and industrial and agricultural production.

3. Visible light photoresistor: including selenium, cadmium sulfide, cadmium selenide, cadmium telluride, gallium arsenide, silicon, germanium, and zinc sulfide photoresistors. It is mainly used in various photoelectric control systems, such as photoelectric automatic opening and closing of portals, automatic turning on and off of navigation lights, street lights and other lighting systems, automatic water supply and automatic water stopping devices, mechanical automatic protection devices, and "position detectors", camera automatic exposure device, photoelectric counter, smoke alarm, photoelectric tracking system, etc.

VI. Application

The photoresistor is a semiconductor light-sensitive device. In addition to its high sensitivity, fast response speed, good spectral characteristics, and good r-value consistency, it can maintain high stability and reliability in harsh environments with high temperature and humidity, which can be widely used in cameras, solar garden lights, lawn lights, currency detectors, quartz clocks, music cups, gift boxes, mini night lights, photoacoustic control switches, street light automatic switches and various light control toys, light control lighting, lamps and other light automatic switches Control field. A few typical application circuits are given below.

1. Dimming circuit

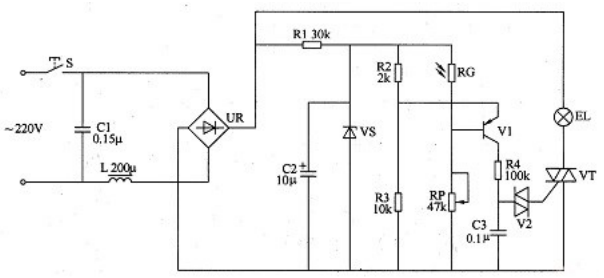

Figure 4. typical light-control dimming circuit

Figure 4 is a typical light-control dimming circuit. Its working principle is: when the surrounding light becomes weak, the resistance of the photoresistor increases, so that the divided voltage applied to the capacitor C rises, and then achieving the purpose of increasing the voltage across the lamp. Conversely, if the surrounding light becomes brighter, the resistance value of RG will decrease, which will cause the conduction angle of the **thyristor** to decrease, and the voltage across the lamp will also decrease at the same time.

The rectifier bridge given in the above circuit must be a DC pulsating voltage, which cannot be filtered by a capacitor into a smooth DC voltage.

2. Light switch

There are many forms of light-controlled switch circuits with relay-controlled output that use photoresistors as core components, such as self-locking bright excitation, dark excitation, precision light excitation, and dark excitation. Several typical circuits are given below.

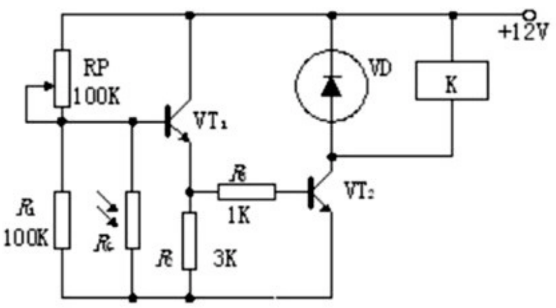

Figure 5. simple dark-excitation relay switching circuit

Figure 5 is a simple dark-excitation relay switching circuit. Its working principle is: when the illuminance drops to the set value, VT1 is turned on due to the rise of the resistance of the photoresistor, the VT2 excitation current makes the relay work, the normally open contact is closed, and the normally closed contact is opened to achieve external circuit control.

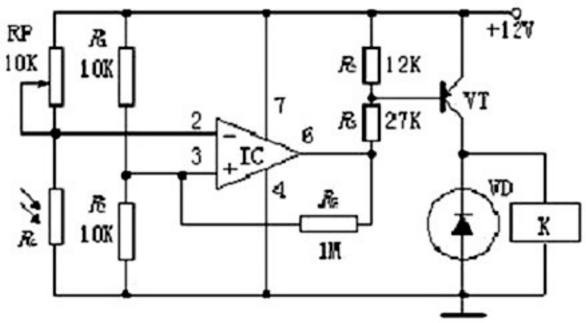

Figure 6. precision dark-excitation time delay relay switch circuit

Figure 6 is a precision dark-excitation time delay relay switch circuit. Its working principle is: when the illuminance drops to the set value, the potential of the inverting terminal of the op-amp IC increases due to the rise of the resistance of the photoresistor, and its output excites VT to turn on. The VT excitation current makes the relay work, and the normally open contact is closed. The normally closed contact is opened to realize the control of the external circuit.

VII. Advantage and Disadvantage

1. Advantage

(1) The internal photoelectric effect has nothing to do with the electrode (only the photodiode is related), that is, a DC power supply can be used;

(2) Sensitivity is related to the semiconductor material and the wavelength of the incident light;

(3) Coated with epoxy, Good reliability, Small volume, Small sensitivity, Quick response, Good spectrum characteristic.

2. Disadvantage

(1) Poor linearity of photoelectric conversion under strong light;

(2) The photoelectric relaxation process is longer. That is to say, after light irradiation, the photoconductance of semiconductors gradually rises with the illumination time, and reaches a steady-state value after a period of time. After the light stops, the photoconductivity gradually decreases;

(2) The frequency response (the ability of the device to detect light signals that change rapidly) is very low;

(2) It is greatly affected by temperature, and the response speed is not fast. Between ms and s, the delay time is affected by the light intensity of the incident light (the photodiode does not have this disadvantage, the photodiode has higher sensitivity than the photoresistor).

VIII. Conclusion

The photoresistor is an important photoelectric conversion element. With the rapid development of electronic information technology and the continuous enhancement of the performance requirements of electronic components, the automation of photoresistor production will greatly improve the development of industrialization.

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Frequently Asked Questions

1 Who invented the Photoresistor?

Willoughby Smith 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.

2 Is Photoresistor analog or digital?

A photo-resistor is fundamentally an analog component. They are usually used with a series fixed resistor to make a variable voltage source.

3 Is LDR active or passive?

A photoresistor (LDR for Light Decreasing Resistance, or light-dependent resistor, or photo-conductive cell) is a passive component that decreases resistance with respect to receiving luminosity (light) on the component's sensitive surface.

4 Is photodiode and LDR the same?

LDR is a light-dependent resistance, the photoresistor is identical to LDR, but the photodiode is a diode connected in inverse polarization whose conduction varies according to the light. a photodiode can measure very small changes in light intensity. it can even be used to detect different light colors.

5 What devices use LDRs?

These resistors are used as light sensors and the applications of LDR mainly include alarm clocks, street lights, light intensity meters, burglar alarm circuits.

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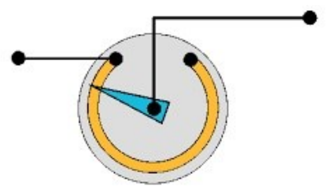

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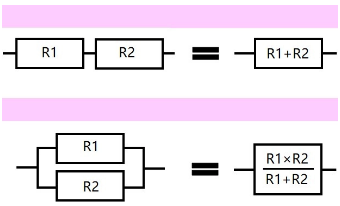

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