3. Theory

A. V-I characteristics of photosensitive sensor

Under a certain incident illuminance, the relationship between the current I and the applied voltage U of the photosensitive element is called the V-I (volt-ampere) characteristic of the photosensitive device. By changing the illuminance, a group of V-I characteristic curves can be obtained. It is an important basis for selecting electrical parameters when designing sensor applications. Typical curves of V-I characteristics of photoresistors, silicon photocells, photodiodes, and phototransistors under certain illuminance E_C conditions are shown in Fig. 3.

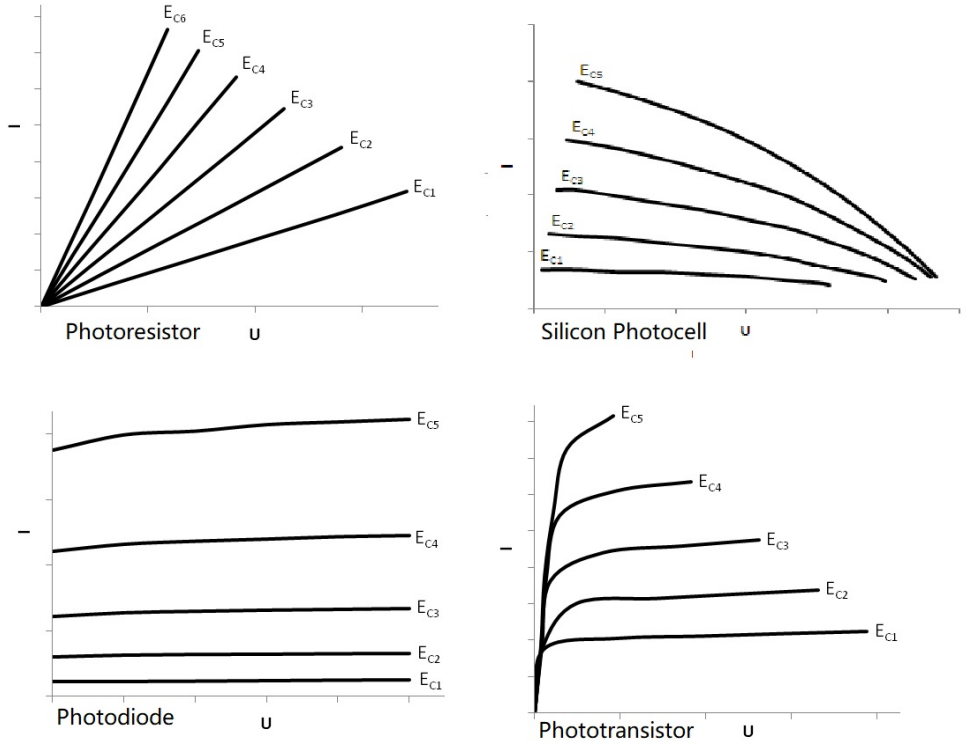

Figure 3 V-I characteristic curves of photoresistor, silicon photocell, photodiode and phototransistor

From the V-I characteristics of the above four photosensitive devices, it can be seen that the photoresistor is similar to a pure resistor, and its V-I characteristic is linear. Under a certain illuminance, the greater the voltage, the greater the photocurrent, but the maximum dissipation of the photoresistor must be considered. Power exceeding the rated voltage or the maximum current may cause permanent damage to the photoresistor.

The V-I characteristics of the photodiode are similar to those of the phototransistor, but the photocurrent of the phototransistor is many times larger than the photodiode of the same type. At zero bias, the photodiode has a photocurrent output, while the phototransistor has no photocurrent output.

When the silicon photocell is at zero bias, the current $I = I_P$ (reverse photocurrent) flows through the PN junction, so when the silicon photocell is at zero bias and no light, its output voltage is not zero ($\neq 0$). Only when the silicon photovoltaic cell is applied a negative bias, the current flowing through the PN junction $I = I_P - I_S$ (reverse saturation current) = 0, the output

voltage of the silicon photocell can be made zero. Under a certain illuminance, the V-I characteristics of silicon photovoltaic cells are nonlinear.

B. Illumination characteristics of photosensitive sensor

The relationship between the spectral sensitivity and the incident light intensity of the photosensitive sensor is called the illumination characteristic. Sometimes the relationship between the output voltage or current and the incident light intensity of the photosensitive sensor is also called the illumination characteristic. It is also an important parameter for the design of the photosensitive sensor applications. The typical curves of the illumination characteristics of photoresistors, silicon photocells, photodiodes, and phototransistors under certain operating voltage U are shown in Figure 4.

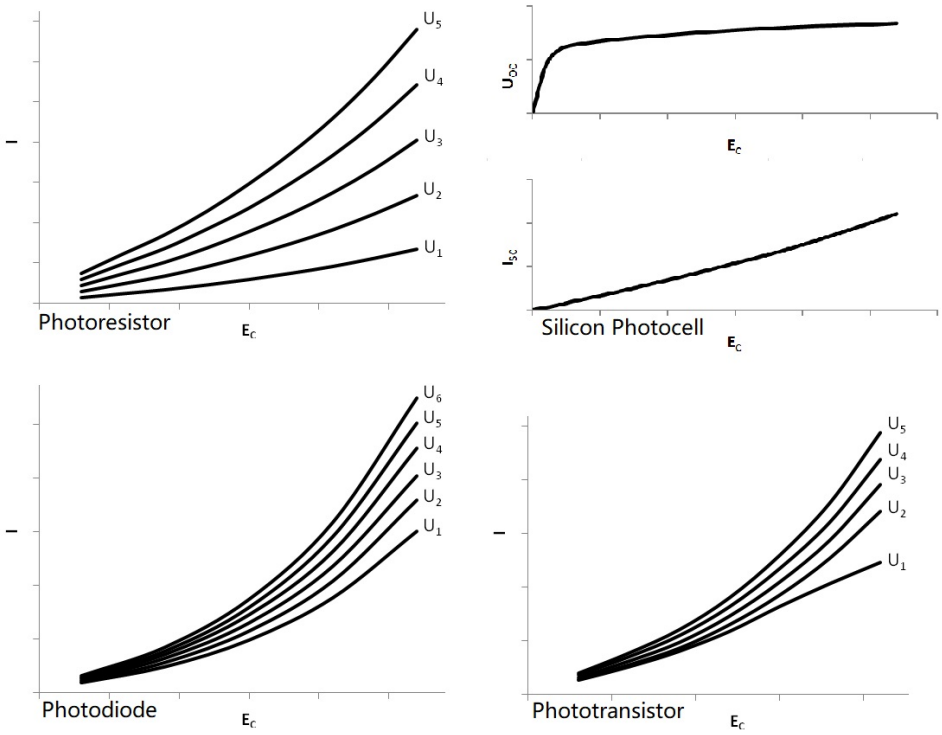

Figure 4 Illumination characteristic curves of photoresistor, silicon photocell, photodiode, and phototransistor

From the illumination characteristics of the above four photosensitive devices, it can be seen that the illumination characteristics of the photoresistor and the phototransistor are non-linear, and generally are not suitable for linear detection. The open circuit voltage of the silicon photocell is also nonlinear and saturated. The short circuit current of the silicon photocell shows good linearity, this characteristic can be used in applications. The so-called short-circuit current refers to the current when the external load resistance is much smaller than the internal resistance of the silicon photocell. Generally, when the load is below 50 ohm, the short-circuit current and the illuminance are well linear, and the smaller the load, the better the linear relationship and the wider the linear range.