Measuring Method for Photo Detector Characteristics

This document describes the methods and units used in measuring the principal characteristics of a photo detector.

Dark current

Dark current is the current that flows through a photo detector in dark state. It is measured using a voltmeter while applying a voltage from a constant voltage power supply. Dark currents are in the order of several nA.

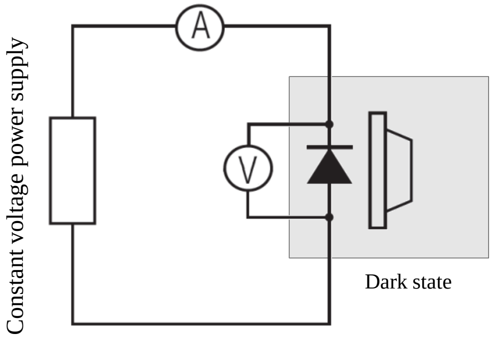


Fig.1 Dark current measuring method for a PIN photodiod

Photo current

Assuming its use mainly in combination with infrared LED, radiation luminance (W/cm^2) is used for measuring photo sensitivity. For this reason, a photo current is regulated by radiation luminance and applied voltage. For measurement purposes, a lamp with standard luminous intensity and a color temperature of 2,856K (JIS C7526) is used as the light source. Fig.2 shows the measuring method.

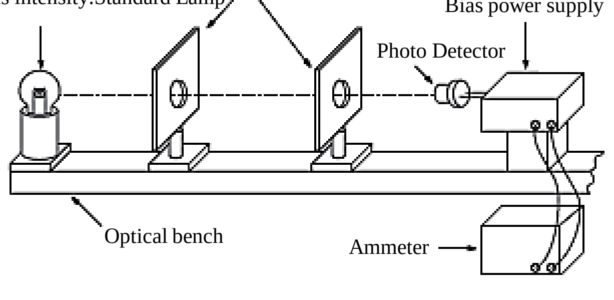


Fig.2 Photo current measuring method

Response speed

Response speed is the measure of the time that it takes generated carriers to move into an external circuit, and is generally expressed in terms of rise time or fall time. The rise time and fall time is defined as the time for a photo current to rise or fall from 10% to 90% or from 90% to 10% of its maximum value, respectively, with respect to a pulsed light input.

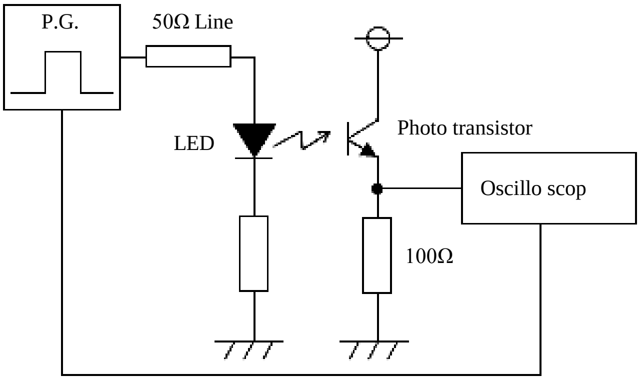


Fig. 3: Response speed measuring method for PIN photodiodes

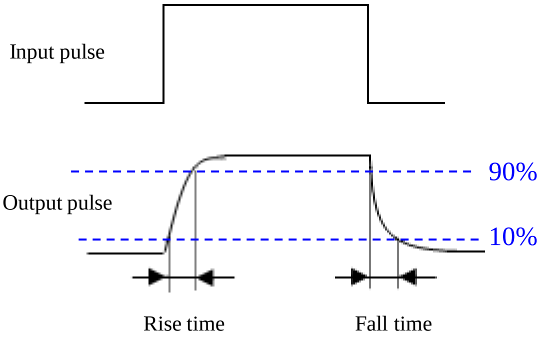


Fig.4 Definition of response speed

Directional characteristics

Directional characteristics are obtained by rotating the photo detector around the top of its lens, as shown in Fig.5. They are normally expressed relative to a value of 1 for the angle with the highest output intensity.

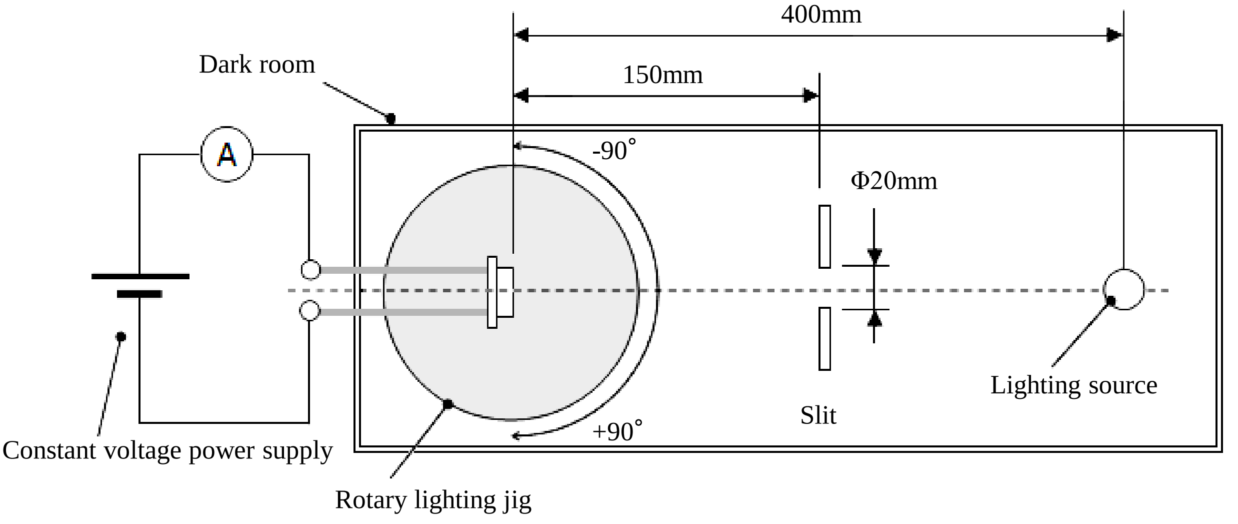


Fig.5 Measuring method of directional characteristics

The directional characteristics are generally defined by the lens shape. Fig.6 shows an example of narrow directional characteristics, and Fig.7 shows an example of wide directional characteristics.

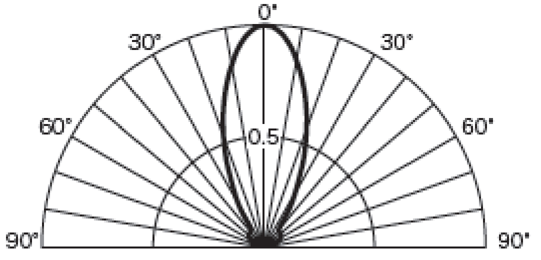


Fig.6 Narrow directional characteristics

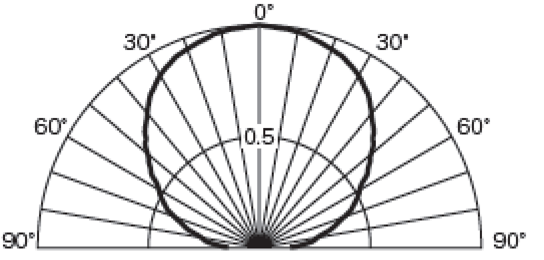


Fig.7 Wide directional characteristics

Characteristics and Usage Method

Spectral sensitivity characteristics

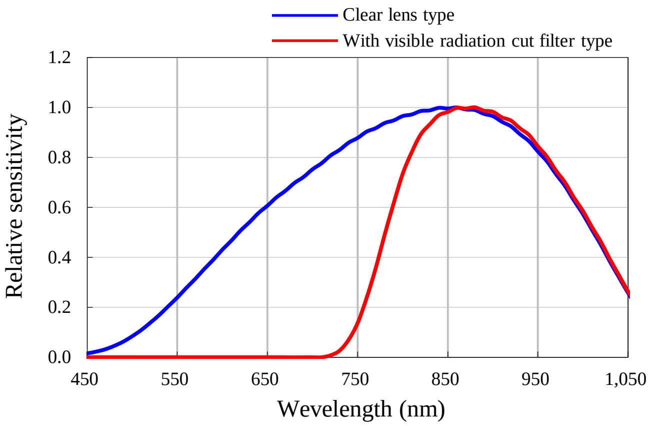


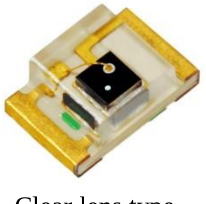
Fig.8 Spectral sensitivity characteristics

As shown in Fig.8, the sensitivity of a photo detector varies according to the wavelength of light. The shorter the wavelength, the more efficiently it is absorbed near the surface, and the longer the wavelength, the more efficiently it is absorbed away from the surface. The limiting wavelength of the absorbed light is defined by the band gap energy Eg of the photo detector material, and is expressed by Equ.1 shown below.
The band gap energy of silicon (Si) is 1.12eV, so silicon cannot absorb lights of wavelengths greater than 1100 nm.

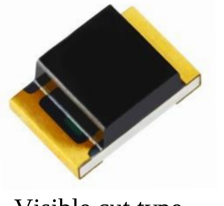
$$\lambda = \frac{1,240}{Eg} \text{ (nm)} \qquad \text{Equ.1}$$

When combined with an infrared LED, the sensitivity of a photo detector is influenced by ambient light (sunlight, fluorescent lamps, etc.), because it also responds to visible light. If this is a problem, a visible light cutting filter should be attached to the photo detector, as necessary. There is the type which gave sealing resin to use for the lens of the package a visible cut function to the Photo Detector device.. As for the Photo Detector device with the visible cut function, sensitivity properties of the visible wavelength domain are greatly controlled.(Fig.8)

Photo Detector device



Clear lens type



Visible cut type

Radiation luminance vs. relative photo current characteristics

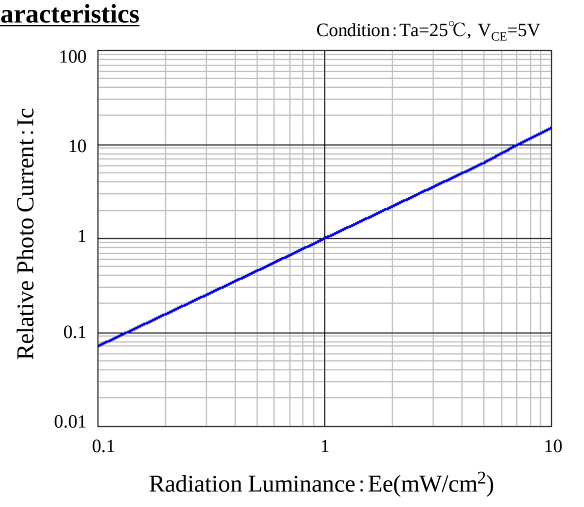


Fig.9 radiation luminance vs. relative photo current characteristics

As shown in Fig.9 the size of the photo current in a photo detector changes according to radiation luminance. The graph shows relative values based on radiation luminance as the defining factor.

Collector-emitter voltage vs. photo current characteristics

The graph below shows the characteristic relationship between the collector-emitter voltage and photo current in a phototransistor. Note that radiation luminance (Ee) is used in place of the base current of a regular transistor.

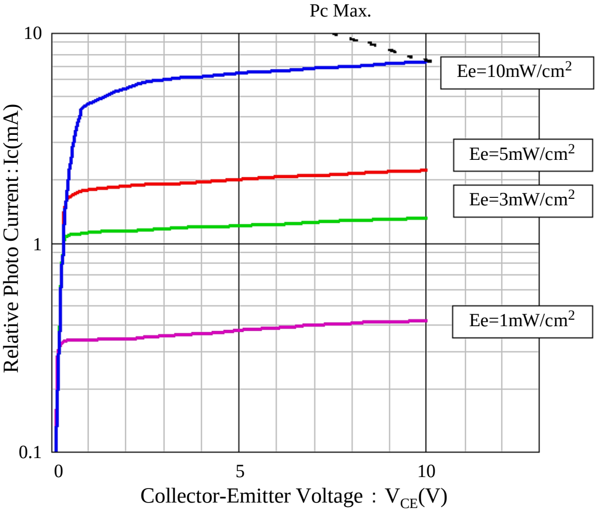


Fig.10 Collector-emitter voltage vs. photo current characteristics