T-41-51

PD150/PD151 TO-18 Type Color Sensor

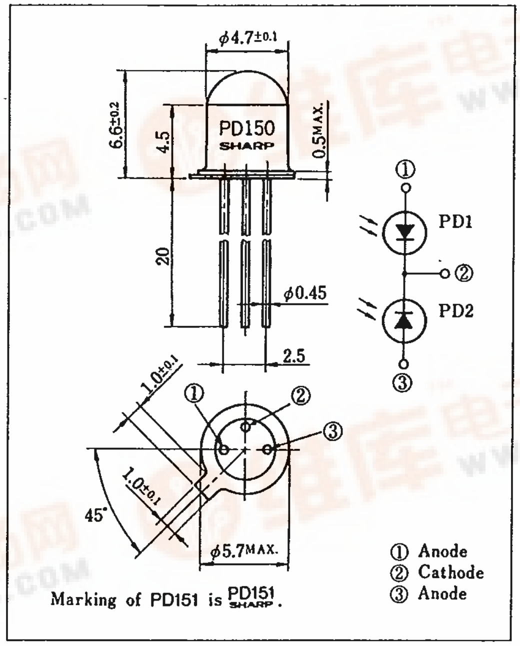
■ Features

1. Output corresponding to the wavelength of light
2. Compact 1-chip structure
3. Blue to near infrared light range
4. Infrared cut-off type : PD151

■ Applications

1. Color reading
   - Automatic white balancing for VCR cameras
   - Flame color meter for fan heaters
   - Color identification for color paper
   - Chromatic balance adjustment for TVs
2. Color temperature/wavelength reading
   - Measurement and control for color temperature/wavelength of light source

■ Outline Dimensions (Unit : mm)



■ Absolute Maximum Ratings (Ta=25°C)

Parameter	Symbol	Rating	Unit
Reverse voltage	V_R	5	V
Operating temperature	T_{opr}	0~+70	°C
Storage temperature	T_{stg}	−25~+100	°C
*1 Soldering temperature	T_{sol}	260	°C

*1 For 10 seconds at the position of 1.3mm from the bottom face of can package

■ Electro-optical Characteristics (Ta=25°C)

Parameter		Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Dark current		I_d	V_R=1V	—	—	10	nA
Terminal capacitance		C_{t1}	V_R=0, f=1MHz	—	200	—	pF
		C_{t2}	V_R=0, f=1MHz	—	100	—	pF
Short-circuit current	PD150	I_{SC1}	λ=600nm	—	0.75	—	μA
	PD151		E_e=50μW/cm²	—	0.65	—	μA
	PD150	I_{SC2}	λ=600nm	—	0.19	—	μA
	PD151		E_e=50μW/cm²	—	0.16	—	μA
Short-circuit current ratio		I_{SC2}/I_{SC1}	λ=600nm	—	0.25	—	—
			λ=900nm	—	4.5	—	—

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■ Theory of Operation

The semiconductor color sensor PD150 is an element of two PN-junctions (photodiode) vertically incorporated into one chip with its thickness of silicon acting as an optical filter.

This means, as shown in Fig. 2, that with the lights of short wavelength absorbed near the surface of silicon and those of long wavelength going deeper to be absorbed, the photodiode PD1 of the less deep PN-junction will have greater sensitivity to short wavelength lights while the photodiode PD2 of the deeper PN-junction will have greater sensitivity to long wavelength lights. These characteristics are shown in Fig. 3.

According to this spectral sensitivity, as a signal processing method for picking up a signal (color signal) corresponding to its wavelength of light, the short circuit current ratio between the two photodiodes above mentioned is used.

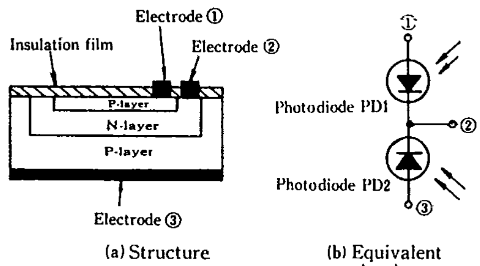
From Fig. 3, the relationship between the short circuit current ratio (I_{SC2}/I_{SC1}) and the wavelength of the incident light (λ) can be obtained as shown in Fig. 5. As it is obvious in this figure, there is the 1-to-1 correspondence between one wavelength and the short circuit current ratio to indicate that the reading of color of light (wavelength) is possible.

Thus, the wavelength of blue to near infrared color can be read by PD150,

Also taken into account to make the color signal reading capability as close to that of human eye as possible is the fact the human eye is insensitive to wavelength of over 700nm. Hence the PD151 which is a PD150 with built-in infrared cut-off filter. Its spectral sensitivity characteristics are shown in Fig. 4.

Next, concretely described in Fig. 3, Fig. 4 and Fig. 5 will be a case with a monochromatic light striking upon the semiconductor color sensor and a case with a composite light of various wavelength striking upon it.

Fig. 1 Structure of Semiconductor Color Sensor T-41-51



(a) Structure (b) Equivalent circuit

Fig. 2 Wavelength and Light Absorbtion Areas

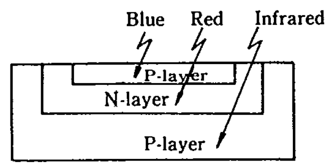
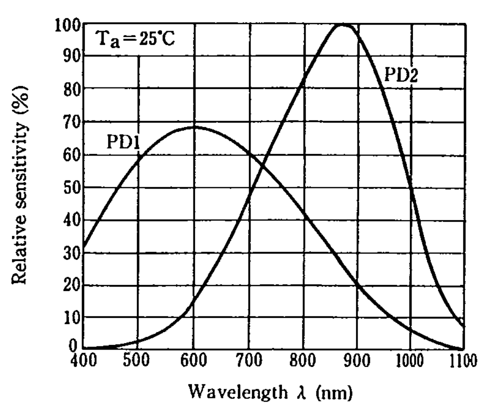


Fig. 3 Spectral Sensitivity (PD150)



(1) When a monochromatic light of wavelength (λ = 500nm) strikes upon it :

In the case with the PD150, the short circuit current ratio of PD1 to PD2 to be obtained from Fig. 3 :

$I_{sc2}/I_{sc1} = 0.020C_1/0.580C_1 = 0.034$
(C_1 : constant)

corresponds to the short circuit current ratio shown in Fig. 5.

The similar result can be obtained with PD151 from Fig. 4 and Fig. 5 . However, in the case of near infrared light striking upon it even though it is monochromatic as in the above case, the PD150 with no infrared light cut-off filter incorporated is more effective than the PD151 because of its greater sensitivity in the near infrared zone.

(2) When a composite light of various wavelengths (visible and near infrared) strikes upon it :

Suppose the incident light is made up of
a light (A) : wavelength $\lambda_A = 500nm$,
irradiance $E_{eA} = 5.0mW/cm^2$
and
a light (B) : wavelength $\lambda_B = 800nm$,
irradiance $E_{eB} = 3.0mW/cm^2$

The human eye will recognize this inciedent light as of about 500nm wavelength while this semiconductor color sensor will recognize the same light as follows.

i) With the PD151 :

The short circuit current for PD1 and PD2, from Fig. 4, is

$I_{sc1} = (5\times0.900+3\times0.010)C_2 = 4.530C_2$
(C_2 : constant) ······················①

$I_{sc2} = (5\times0.031+3\times0.020)C_2 = 0.215C_2$
(C_2 : constant) ························②

From the equations ① and ②, the short circuit current ratio can be obtained. Thus,

$I_{sc2}/I_{sc1} = 0.047.$

So the wavelength that corresponds to the short circuit ratio of 0.047, according to Fig. 5, is λ = 510nm, which the PD151 recognizes.

ii) With the PD150 :

In the same way as in i), from Fig. 3 and Fig. 5, λ = 680nm will be obtained. So the wavelength whci the PD150 recognizes is λ = 680nm.

Fig. 4 Spectral Sensitivity (PD151)

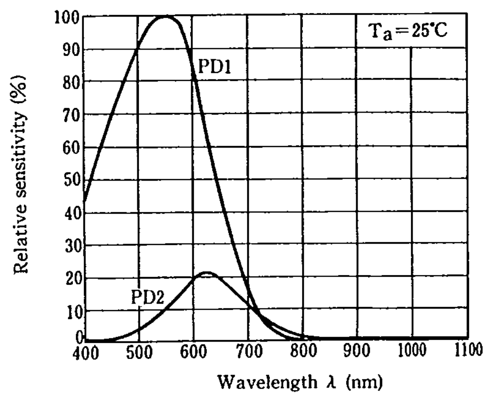


Fig. 5 Short Circuit Current Ratio vs. Wavelength (PD150, PD151)

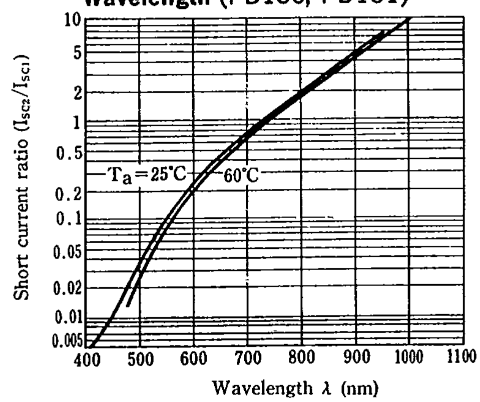
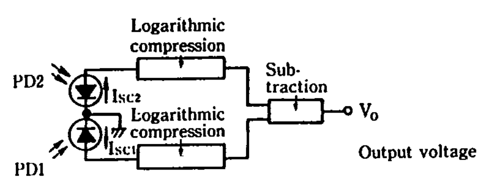


Fig. 6 Block Diagram of a Sample Signal Processing Circuit



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