

# Photodiode as current source

## Student Group

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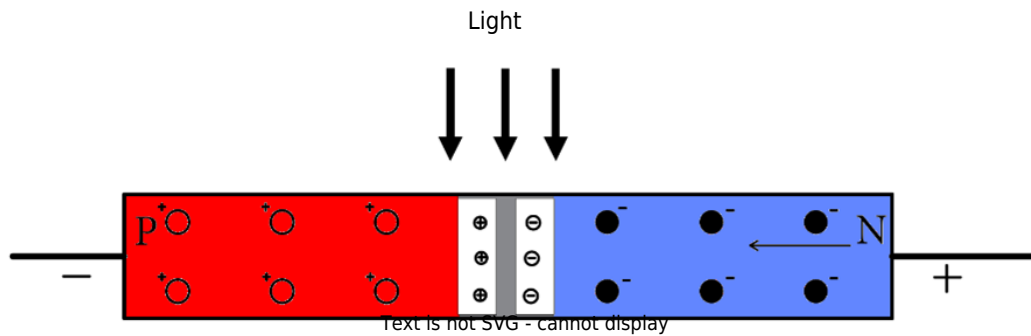
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## Photodiode as current source

A photodiode is a special type of diode which, **in the absence of light**, exhibits a **current-voltage relationship** very similar to that of a standard diode (see the **dark current** characteristic in the **(I-V) diagram**).

**When illuminated**, it generates additional electron-hole pairs within the crystal.



Photodiodes are often operated **in reverse bias**, where the charge carriers (electrons and holes) generated by the incident light cause an increased **reverse** current flow (**third quadrant** of the I-V diagram). The higher the light intensity, the greater the reverse current. **Forward bias operation** is also possible, where the photodiode behaves like a solar cell (**first quadrant** of the I-V diagram).

**Applications include** remote controls (IR range), galvanic isolation (optocouplers), light measurement, positioning, and light barriers.

Fig. 1: Inverting Op-Amp: Operating principle of a photodiode

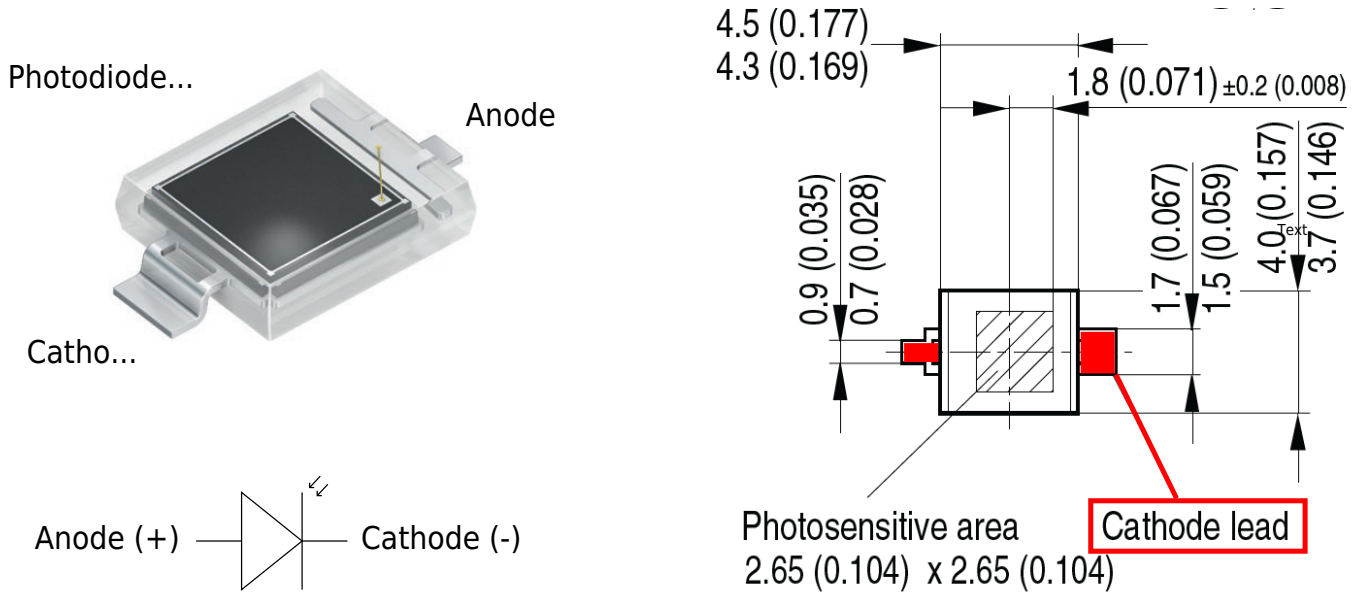


Fig. 2: Inverting Op-Amp: Photodiode BPW 34 S

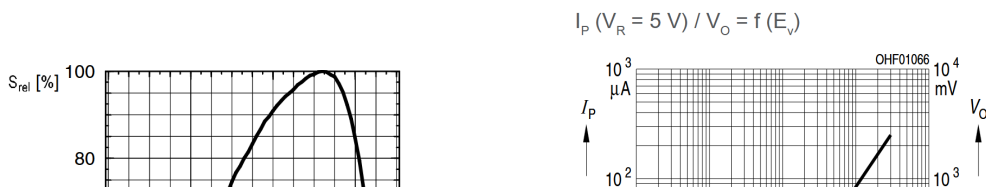


Fig. 3: Inverting Op-Amp: Diagramms of BPW 34 S

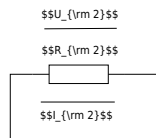


Fig. 4: Inverting Op-Amp: Photo Diode as current source

$$U_{DD} = 10\text{ V}, U_{SS} = -10\text{ V}$$

We are assuming a well-lit room with an illuminance of 300 lx, lit by a white LED. White light is a mixture of many wavelengths across the visible spectrum, roughly 380 to 780 nm. For a typical white LED, the spectrum usually comes from a blue LED chip with a peak around 450 nm, plus a broader phosphor emission that spreads across green, yellow, and red wavelengths. For an easier calculation, we take a mean value of 500 nm which is close to the peak value of the blue LED and 300 lx for the illumination. (500 nm is in reality a greenish light and not blue)

The graph in [figure 3](#) shows that the photodiode sensitivity at 500 nm is only 30%. The maximum current (100%) at 300 lx is 30  $\mu\text{A}$ .

We can now estimate the current we would expect from the photodiode at 300 lx:

$$I_1 = 30\ \mu\text{A} * 0.3 = 9\ \mu\text{A}$$

$$I_1 \approx 10\ \mu\text{A}$$

30% of 30  $\mu\text{A}$  is roughly 10  $\mu\text{A}$ .

**We will assume a current of 10  $\mu\text{A}$  at 300 lx for our calculations.**

Complete the arrows in the circuit diagram in [figure 4](#).

Calculate  $R_2$  so that  $U_{OUT} = 5\text{ V}$  at 300 lx. Take a resistor from the E6 series that is as close as possible to the calculated value.

Also enter the values for  $I_1$ ,  $I_2$ ,  $U_2$  and  $U_{OUT}$ .

$$I_{1}$$

$$I_{2}$$

$$U_{2}$$

$$U_{OUT}$$

$$R_{2}$$

What value would you expect for  $U_D$  in figure 4 and why?

$$U_D$$

.....

.....

.....

.....

.....

.....

What value would you expect for  $U_{\text{D}}$  at 300 lx when the photodiode is not connected to the Op-Amp or any other electronic component (open-circuit voltage) and why?

$U_{\text{D}} \approx$

$\text{V}$  .....

$\text{V}$  .....

$\text{V}$  .....

$\text{V}$  .....

$\text{V}$  .....

$\text{V}$  .....

Measure or calculate the values given in the table below.

| Illumination | $U_{\text{OUT}}$ [V] | $I_{\text{1}}$ [ $\mu\text{A}$ ] | $I_{\text{2}}$ [ $\mu\text{A}$ ] | $U_{\text{D}}$ [mV] | $U_{\text{D}}$ [mV] |
|--------------|----------------------|----------------------------------|----------------------------------|---------------------|---------------------|
| dark...      |                      |                                  |                                  |                     | X                   |
| 300 lx...    |                      | ...                              |                                  |                     |                     |

Tab. 1: Photodiode measured and calculated values

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