Photodiode as current source

Student Group

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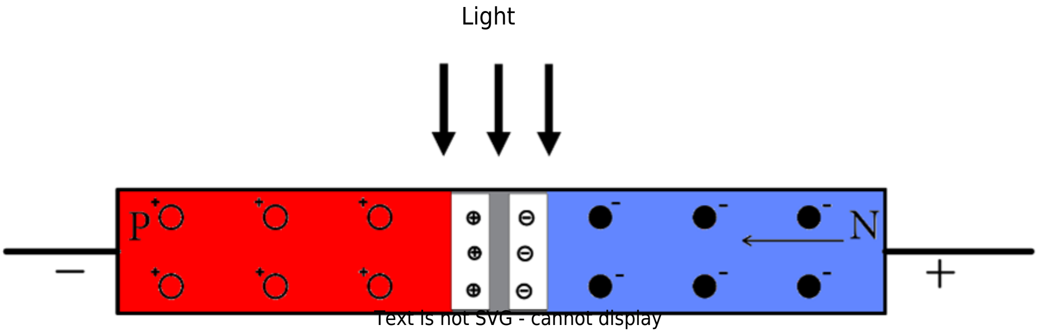
A photodiode is a special type of diode which, **in the absence of light**, exhibits a **current-voltage relationship** very similar to that of a standard diode (see the **dark current** characteristic in the **\(I-V\) diagram**).

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

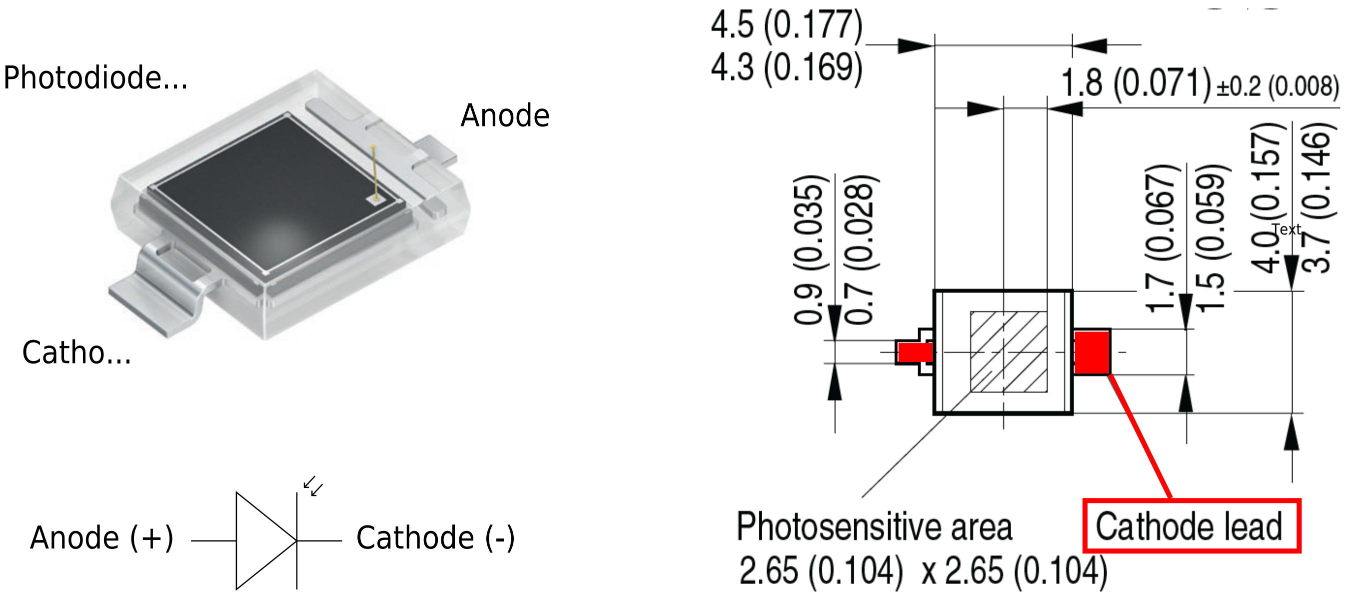


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Fig. 2: Inverting Op-Amp: Photodiode BPW 34 S

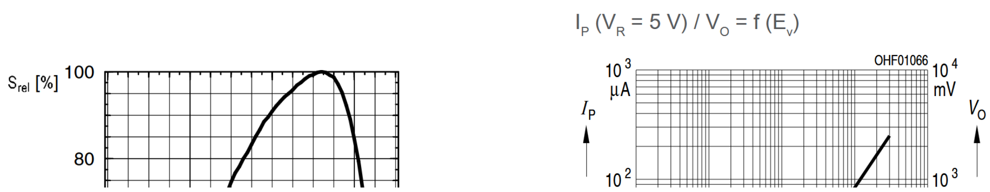

Fig. 3: Inverting Op-Amp: Diagramms of BPW 34 S

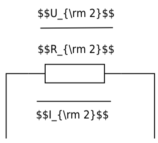

Fig. 4: Inverting Op-Amp: Photo Diode as current source

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

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 maximim current (100%) at 300 lx is 30 ${\rm\mu}$A.
We can now estimate the current we would expect from the photodiode at 300 lx:

$I_{\rm 1} = 30 {\rm~\mu A} * 0.3 = 9 {\rm~\mu A}$
$I_{\rm 1} \approx 10 {\rm~\mu A}$

30% of 30 ${\rm\mu A}$ is roughly 10 ${\rm\mu A}$.
We will assume a current of 10 ${\rm\mu A}$ at 300 lx for our calculations.

Complete the arrows in the circuit diagram in figure 4.

Calculate $R_{\rm 2}$ so that $U_{\rm OUT}$ = 5 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 $I_{\rm 1}$, $I_{\rm 2}$, $U_{\rm 2}$ and $U_{\rm OUT}$.

$I_{\rm 1}{\rm~=}$

$I_{\rm 2}{\rm~=}$

$U_{\rm 2}{\rm~=}$

$U_{\rm OUT}{\rm~=}$

$R_{\rm 2}{\rm~=}$

What value would you expect for $U_{\rm D}$ in figure 4 and why?

$U_{\rm D}{\rm~=}$

${\rm ....}$

${\rm ....}$

${\rm ....}$

${\rm ....}$

${\rm ....}$

${\rm ....}$

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

$U_{\rm D}{\rm~=}$

${\rm ....}$

${\rm ....}$

${\rm ....}$

${\rm ....}$

${\rm ....}$

${\rm ....}$

Measure or calculate the values given in the table below.

Illumination	\(U_{\rm OUT}\) [...	\(I_{\rm 1}\) [µA...	\(I_{\rm 2}\) [µA...	\(U_{\rm D}\) [mV...	\(U_{\rm D}\) [mV...
dark...					X
300 lx...		...			

Tab. 1: Photodiode measured and calculated values