Photovoltaic Optocouplers

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Abstract – **The circuit possibilities of photovoltaic optocouplers will be considered. The circuits proposed can be used for increasing the generated photoelectromotive force, the generated photocurrent, the generated power, as well as for selecting the photovoltaic optocouplers in couples or fours.**

Keywords – **Photovoltaic optocoupler, photoelectromotive force, photocell, photodiode**

I. INTRODUCTION

The circuit possibilities of photovoltaic optocouplers will be considered.

Photodiode optocouplers can operate in two modes – photodiode and photovoltaic. Within the photovoltaic mode the phodiode generate voltage, when it is illuminated by the LED.

II. CIRCUIT WITH PHOTOVOLTAIC OPTOCOUPLERS

When the photodiode is illuminated, the generated photoelectromotive force at idle running is Eq. 1:

$$E_{ph} \approx \varphi_T . \ln \frac{I_{ph}}{I_D} \qquad (1)$$

where φ_T – temperature potential, φ_T = κT/q = 25 mV (25°C), I_{ph} – the photocurrent of the photodiode, I_D – the dark current of the photodiode.

The generated photoelectromotive force at the Si photodiode is about 0,5 V and the photocurrent depends on the area of the photodiode PN junction.

A. To increase the generated photoelectromotive force, the photodiode and the photovoltaic optocoupler are connected in series – fig. 1.

The total photocurrent in the circuit is equal to the photocurrent of the element of the lowest photocurrent, and the generated photoelectromotive force is Eq. 2:

$$E_{ph\Sigma} = n.E_{ph} \qquad (2)$$

where n – the number of the photodiodes of the photovoltaic optocoupler, connected in series.

The power generated at the output is Eq. 3:

$$P_\Sigma = n.E_{ph}.I_{ph} = n.P \qquad (3)$$

where P – the power of one photocell.

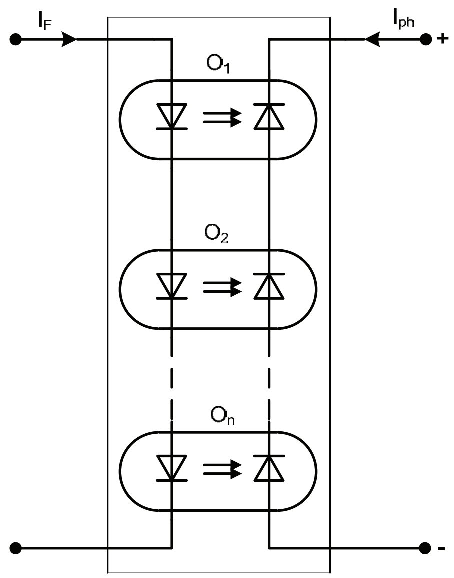

Fig. 1

The consumed input power is Eq. 4:

$$P_F = n.U_F.I_F \qquad (4)$$

The efficiency is Eq. 5:

$$\eta = \frac{n.E_{ph}.I_{ph}}{n.U_F.I_F} = \frac{0,5.1.10^{-3}}{1,2.10.10^{-3}} = 0,04 = 4\% \qquad (5)$$

B. To increase the photocurrent generated, the photocells of the photovoltaic optocoupler are connected in parallel – fig. 2.

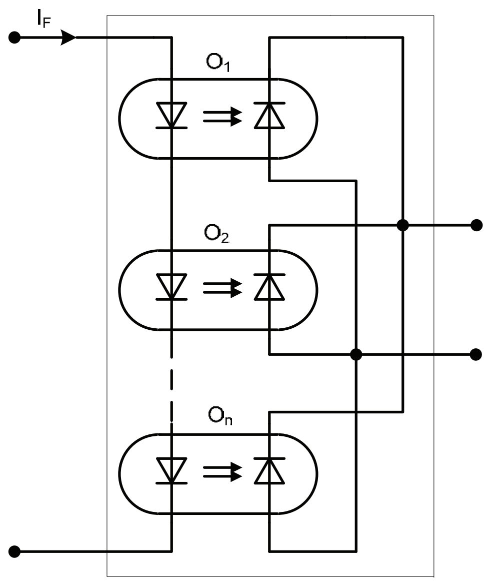

Fig. 2

The total generated photocurrent is Eq. 6:

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$$I_{ph\Sigma} = n.I_{ph} \quad (6)$$

where n is the number of the photocells of the photovoltaic optocoupler, connected in parallel. The overall generated output power is Eq.7:

$$P_{\Sigma} = n.I_{ph}.E_{ph} \quad (7)$$

C. The circuit in fig. 3 presents a mixed (series-parallel connection) connection of the photocells.

If n_1 is the number of the photocells connected in series in one module and n_2 is the number of the modules connected in parallel, then the overall generated output power is Eq. 8 and Eq. 9:

$$P_{\Sigma} = n_1.E_{ph}.n_2.I_{ph} = n_1.n_2.E_{ph}.I_{ph} \quad (8)$$

at $n_1 = n_2$

$$P_{\Sigma} = n^2.E_{ph}.I_{ph} \quad (9)$$

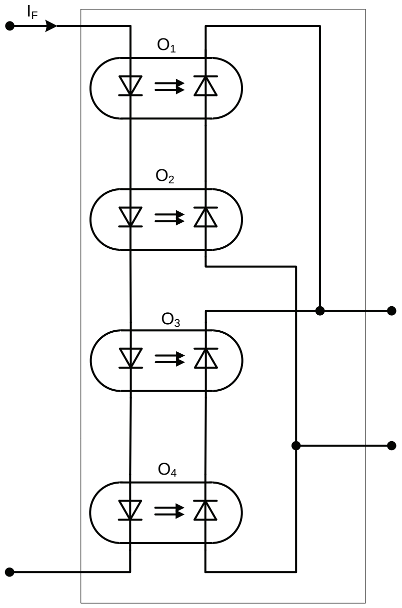

Fig. 3

D. The antidirectional connection in series of the optocoupler photocells is of particular interest – fig. 4.

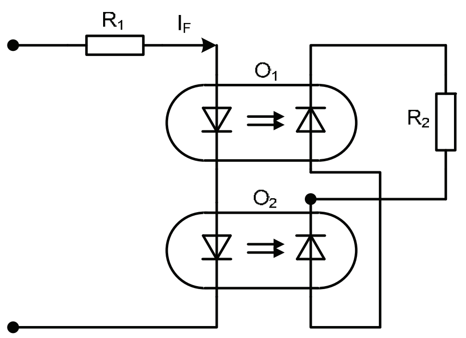

Fig. 4

The photoelectromotive force and the photocurrents are subtracted – Eq. 10, Eq. 11, Eq. 12:

$$E_{ph\Sigma} = E_{ph1} - E_{ph2} \quad (10)$$

$$I_{ph\Sigma} = I_{ph1} - I_{ph2} \quad (11)$$

$$P_{\Sigma} = E_{ph\Sigma}.I_{ph\Sigma} = (E_{ph1} - E_{ph2}).(I_{ph1} - I_{ph2}) \quad (12)$$

The asymmetry of two photovoltaic optocouplers is investigated by this circuit.

E. The antidirectional connection in parallel of the photocells of the ptotovoltaic optocouplers is shown in fig. 5.

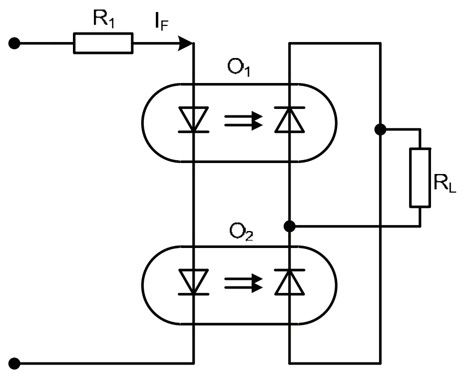

Fig. 5

It can be written for the circuit – Eq.13, Eq. 14, Eq. 15:

$$E_{ph\Sigma} = E_{ph1} - E_{ph2} \quad (13)$$

$$I_{ph\Sigma} = I_{ph1} - I_{ph2} \quad (14)$$

$$P_{\Sigma} = (E_{ph1} - E_{ph2}).(I_{ph1} - I_{ph2}) \quad (15)$$

The circuit can be used to investigate the asymmetry of the photovoltaic optocouplers. By using a bridge circuit for connecting four photocells, the photovoltaic optocouplers can be selected in couples.

These selected couples can be used for realizing differential phodiode optocouplers.

F. In the circuit in fig 6 the couples $O_1 – O_3$, $O_2 – O_4$ are selected.

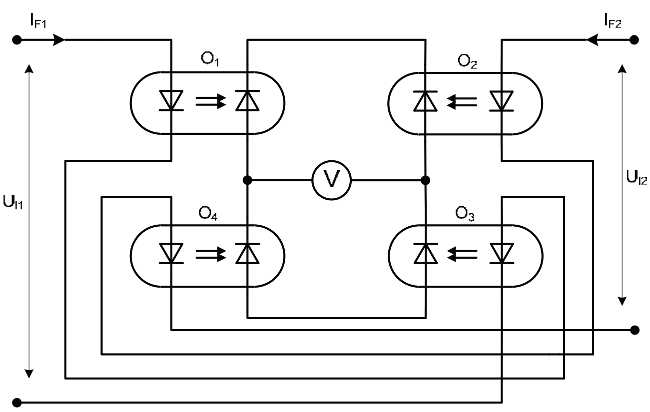

Fig. 6

G. To select the photocells in fours, the proposed bridge circuit can be used as well – fig. 7.

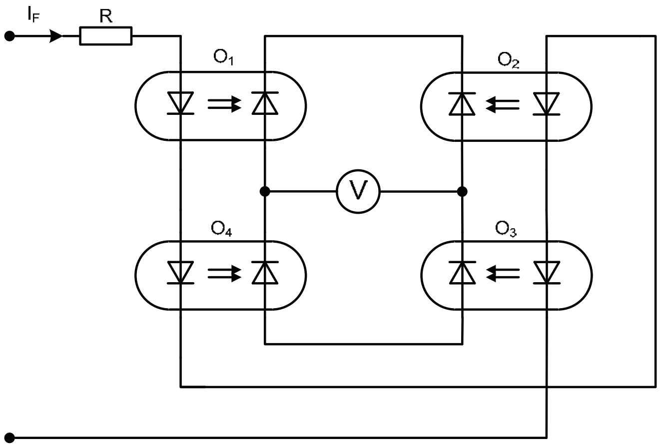

Fig. 7

Application of photovoltaic optocouplers:
- Control of bipolar transistors (ON, OFF);
- Control of field and MOS transistors;
- Control of operational amplifiers;
- Mains transformers;
- Matching transformers and broadband transformers;
- Current-voltage converters and current-current converters;
- Power supply.

III. CONCLUSION

The circuits proposed can be used for increasing the generated photoelectromotive force, the generated photocurrent, the generated power, as well as for selecting the photovoltaic optocouplers in couples or fours.

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