Equivalents of Optocouplers with a Photodynistor Photodetector

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Abstract – **Along with common optocouplers, such as photothyristor and phototriac, a circuit equivalent of a photodynistor optocoupler has been developed. Basic ratios have been derived, and application areas and circuits have been given. In this way the circuit element base of optoelectronics is enriched.**

Keywords – **Equivalents of optocouplers, photodynistor photodetector, photodynistor optocoupler**

I. INTRODUCTION

In scientific literature optocouplers with a photodynistor photodetector are not described. The photodynistor (photodiac) differs from the photothyristor since it can switch on when the anode voltage rises above the switch-on voltage. In addition, as it is with photothyristor, the photodynistor can be turned on in an optical way, by illuminating the LED. The photodynistor is turned off by decreasing the anode current below the hold current (I_H). As we are not able to offer a development of a photodynistor and a photodynistor optocoupler, we will present the circuit equivalent of such an optocoupler.

II. CIRCUIT EQUIVALENTS OF AN OPTOCOUPLER WITH A PHOTODYNISTOR PHOTODETECTOR

A. The simplest circuit equivalent of an optocoupler with a photodynistor photodetector is shown in fig. 1.

A photothyristor optocoupler O_1, where the control electrode of the photothyristor is external, is used. Other suitable optocouplers are 4N39, H11C1. When the current across the LED is $I_F = 0$, the photodynistor turns on when the anode voltage U_A increases. In this case the switch-on voltage (U_{on}) is about 6 V and the voltage between the anode and the cathode of the photodynistor in a saturation mode is $U_{AKsat} \approx$ 0,75 V. To increase the switch-on voltage, the value of the resistor R_2 must be increased. When the voltage $U_A < U_{on}$, the photodynistor can be switched on by the LED current I_F.

The photodynistor can be switched off by decreasing the anode current below the hold current (I_H).

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The photodynistor control current is Eq. 1:

$$I_G = \frac{U_A - U_{GK}}{R_1 + R_2} \tag{1}$$

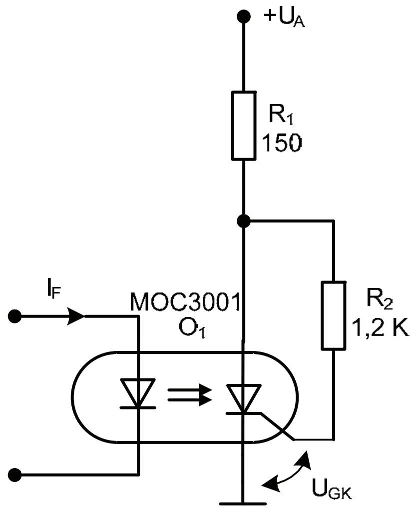

Fig. 1

Then the switch-on voltage is Eq. 2:

$$U_{on} = I_G(R_1 + R_2) + U_{GK} = 4.10^{-3}(150 + 1200) + 0,7 = 6,1V \tag{2}$$

The disadvantage of the circuit in fig. 1 is that unless the photodynistor is not turned on, some current passes along the photodynistor control circuit.

B. The circuit in fig. 2 does not have this disadvantage since a Zener diode VD_1 is used as a threshold element.

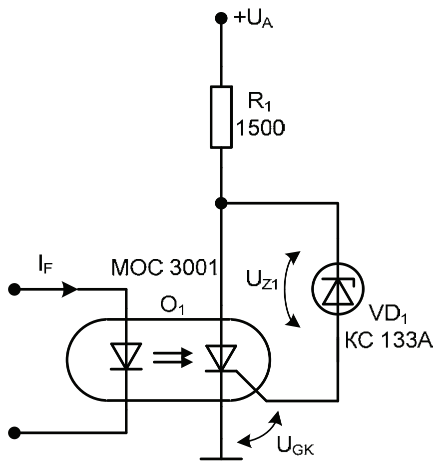

Fig. 2

The switch-on voltage of the photodynstor, when $I_F = 0$, is Eq. 3:

$$U_{on} = U_{Z1} + U_{GK} = 3{,}3 + 0{,}7 = 4\,V \qquad (3)$$

The voltage in a saturation mode is $U_{AKsat} \approx 0{,}75$ V.

The control current for the photodynistor, when $I_F = 0$ and $U_A = 12$ V, is Eq. 4:

$$I_G = \frac{U_A - U_{Z1} - U_{GK}}{R_1} = \frac{12 - 3{,}3 - 0{,}7}{150} = 5{,}3\,mA \qquad (4)$$

The circuits in fig. 1 and fig. 2 have unregulatable threshold switch-on voltage.

The control current of the photodynistor is Eq. 5:

$$I_G = \frac{U_A - U_{GK}}{R_{ph2}(I_{F2}) + R_A} \qquad (5)$$

Where R_{ph2} (I_{F2}) is the resistance of the photoresistor of the O_2 optocoupler.

C. Figure 3 presents an optocoupler with a photodynistor with controllable switch-on voltage, by means of the LED current I_{F2} of the O_2 optocoupler.

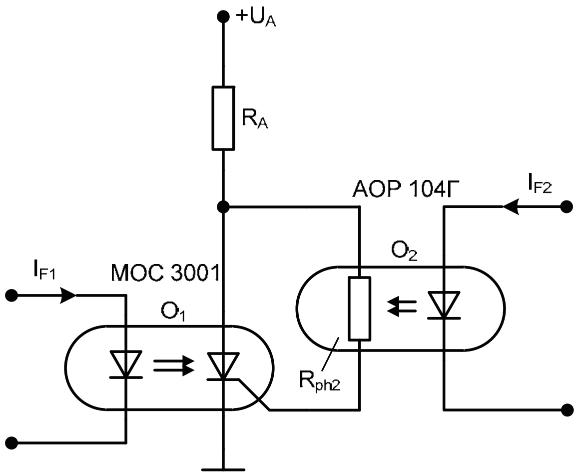

Fig. 3

The switch-on voltage can be determined by the expression – Eq. 6:

$$U_{on} = I_G[R_{ph2}(I_{F2}) + R_A] + U_{GK} \qquad (6)$$

When the current across the LED I_{F2} increases, the switch-on voltage decreases because the resistance of the R_{ph2} photoresistor falls down.

D. Figure 4 shows a circuit for the application of the optocoupler developed.

This is a circuit of a controllable generator of exponential voltage pulses of about 4V amplitude. The threshold voltage of the photodynistor is 4V (the voltage to which the capacitor C is charged).

The pulse-repetition rate from the generator is Eq. 7:

$$T \approx 0{,}5.R.C.\frac{U_{on}}{U_A} = 0{,}5.2.10^3.47.10^{-6}.\frac{4}{9} = 21\,ms \qquad (7)$$

By means of the LED current I_F the generations can be interrupted after turning on the photodynistor.

In practice there are not only dynistors but also symmetric dynistors (triacs) operating with AC voltage (bidirectional switch-on elements). An optocoupler with a triac as a photodetector is not presented but it could be built on the basis of the circuits in fig. 2 and fig. 3.

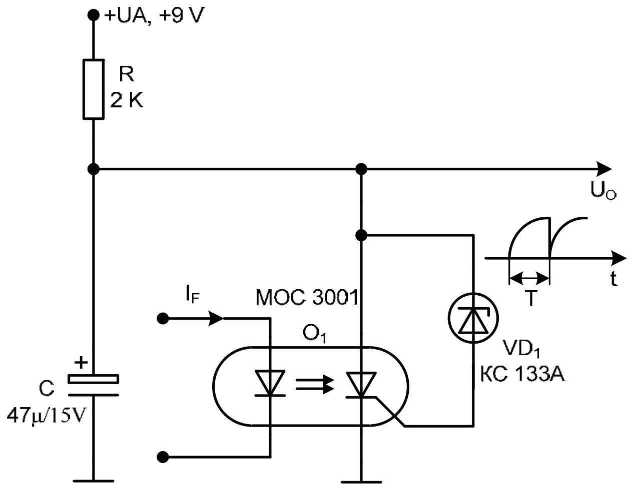

Fig. 4

E. The circuit in fig. 5 is a "mirror" circuit. The photodynistor optocoupler in fig. 2 has been used as a base.

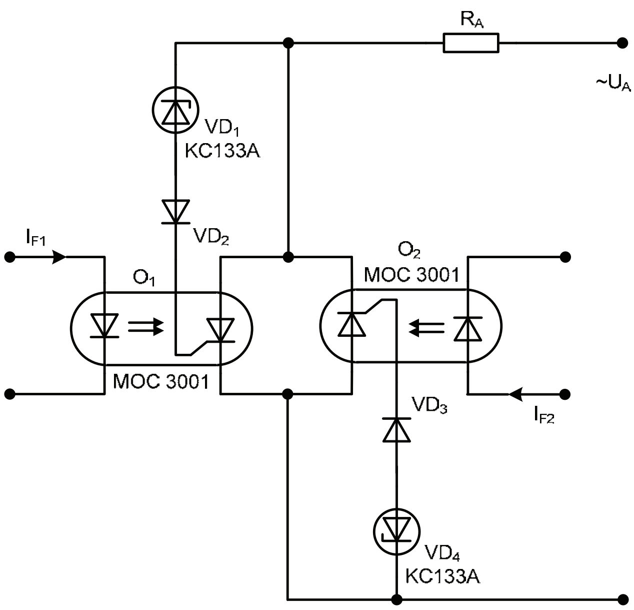

Fig. 5

Each photodynistor switches on during the respective half-period – during the positive half-period the photodynistor of the O_1 optocoupler switches on, whereas during the negative half-period the photodynistor of the O_2 optocoupler switches on.

F. The circuit in fig. 6 has a symmetric photodynistor built on the basis of the photodynistor optocoupler in fig. 3 and a phototriac optocoupler O_1.

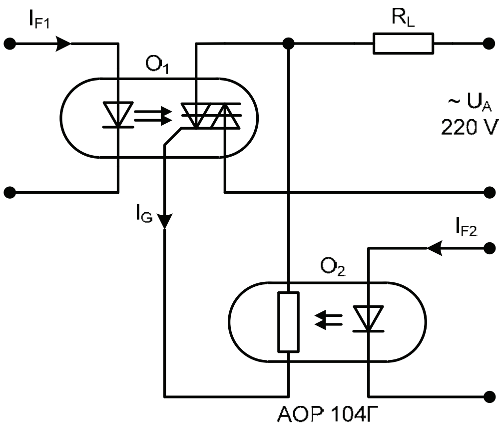

Fig. 6

G. The symmetric photodynstor optocoupler in fig. 7 is analogous to that in fig. 6; however, the O_2 optocoupler is not photoresistor but a FET optocoupler.

In the latter two circuits the symmetric photodynistor optocoupler is built on the basis of a phototriac optocoupler.

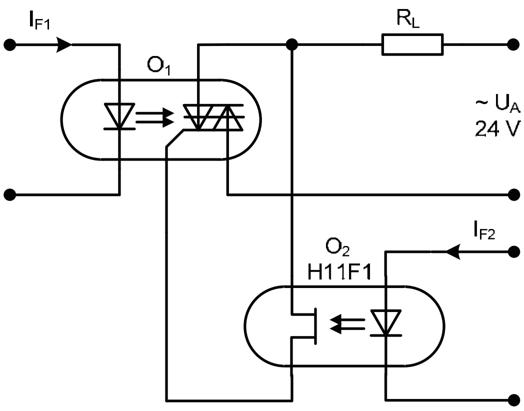

Fig. 7

The control current for the circuits in fig. 6 and fig. 7 is Eq. 8 end Eq. 9:

$$I_G = \frac{U_A - U_{GK}}{R_L + R_{ph}(I_{F2})} \qquad (8)$$

$$I_G = \frac{U_A - U_{GK}}{R_L + R_{DS}(I_{F2})} \qquad (9)$$

In the circuits in fig. 6 and fig. 7 photodetectors for AC voltage operation – a photoresistor and a field phototransistor, are used in the O_2 optocouplers.

Application for bidirectional independently controllable optocouplers switched on by an optical input (by the LED current) or by increasing the anode voltage over the switch-on voltage. Furthermore, the switch-on voltage can be regulated remotely by the LED current of the second optocoupler.

Development of generator, logic and control circuits, AC and DC relays, voltage relays.

III. Conclusion

Along with common optocouplers, such as photothyristor and phototriac, a circuit equivalent of a photodynistor optocoupler has been developed. Basic ratios have been derived, and application areas and circuits have been given. In this way the circuit element base of optoelectronics is enriched.

References

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