DEVELOPMENT OF TWO – EMITTER OPTOCOUPLER CIRCUITS

Elena Nedialkova Koleva, Ivan Stanchev Kolev

Department of Eiectronics, Technical University – Gabrovo, Street "Hadji Dimiter" No. 4, 5300 Gabrovo , Bulgaria, phone: +359 223 433, e – mail: elena_ndpt@yahoo.com, ipk_kolev@yahoo.com

The optocouplers with two – emitter are designed for an operation of bipolar pulse voltage or sin – wave voltage. The proposed optocoupler using two light sources (infrared LEDs) and one photodetector significantly expands the functional capabilities of the optocouplers, mainly those used in the pulse and digital equipment, household electronics, diagnostics, etc. Optocouplers with two LEDs and a photodetector are used in logic circuits, time relays, bistable circuits (triggers), high reliability optoelectronic circuits. The optocouplers with two – emitter can be connected in parallel bidirectionally of the LEDs or between LEDs non connection. The last tape optocouplers have large possibility.

Keywords: two – emitter optocoupler, photodetector, light sources

1. CIRCUITS WITH TWO – EMITTER OPTOCOUPLERS

So far only batch production of FTO optocouplers with two emitters (infrared LEDs) connected in parallel bidirectionally has been common (fig. 1). The optocoupler input circuit is designed for an operation of bipolar pulse voltage or sine-wave voltage.

1.1 The optocoupler shown in fig. 1 can be realized by means of two optocouplers according to the circuit in fig. 2.

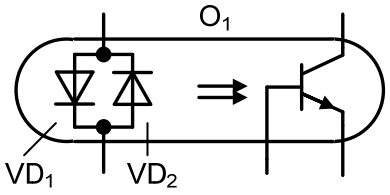

Fig. 1

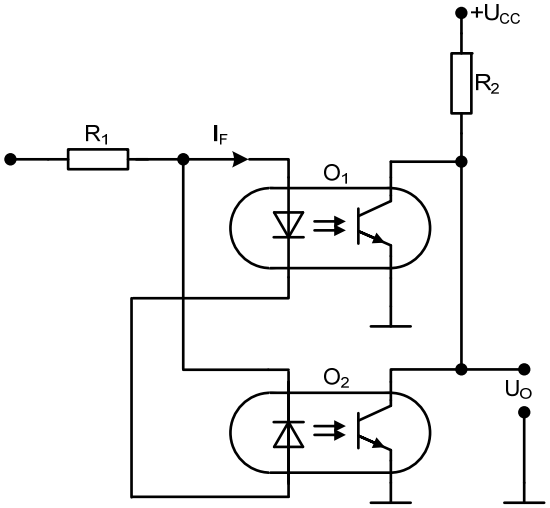

Fig. 2

The birectionsal connection of the LEDs in the optocoupler limits the application of these optocouplers.

1.2 Optocouplers with a photodetector and two independent LEDs – fig. 3. Applicable Circuits. OR logic circuit – fig. 4.

Therefore, the development of optocouplers with a photodetector and two independent LEDs – fig. 3, respectively a photoresistor optocoupler a), a photodiode optocoupler b), a phototransistor optocoupler c) and a photothyristor optocoupler d) is proposed.

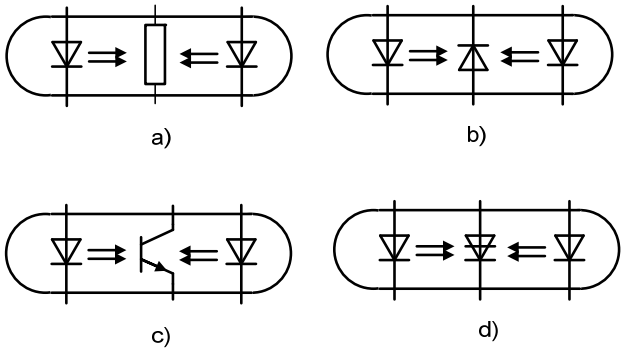

Fig. 3 a), b), c), d)

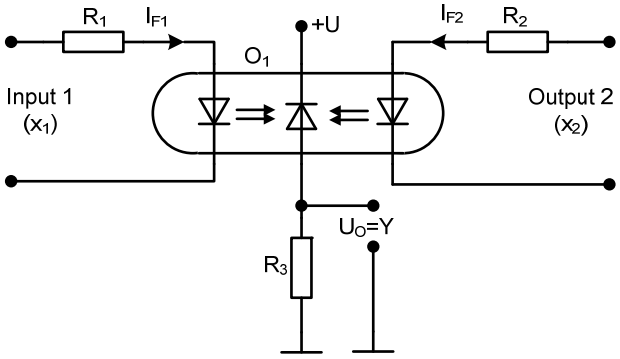

Fig. 4

The output voltage can be expressed as follows is equation (1):

$$U_O = I_{F1} + I_{F2} \text{ or } Y = X_1 + X_2 \quad (1)$$

1.3 Connection of the optocoupler input circuit to a bipolar surge or sine-wave voltage – fig. 5. To increase the circuit reliability, the photodetector can be controlled by means of several independent channels, in this case two channels – fig. 6.

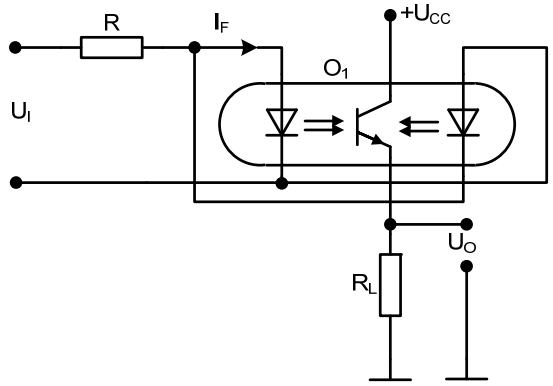

Fig. 5

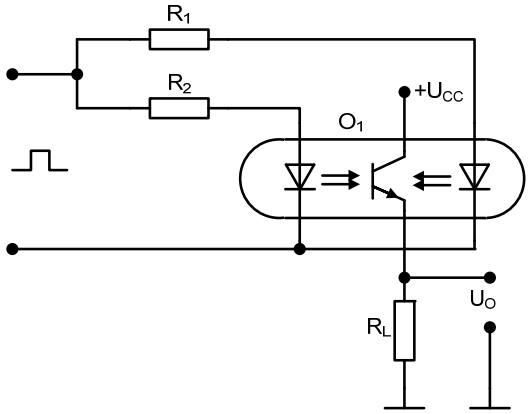

Fig. 6

The condition related to the saturation of the optocoupler phototransistor is equation (2):

$$I_F \geq \frac{U_{CC} - U_{CEsat}}{K_I . R_L} \quad (2)$$

where K_I is the current transmission coefficient of the optocoupler.

The calculation of the reliability of such a system is based on the equation (3):

$$P = 1 - (1 - p)^2 \quad (3)$$

where p – the reliability of one of the channels when p = 0,9; P = 0,99.

It can be seen that the no-failure operation probability increases from 0,9 (one channel) to 0,99 (two channels).

It can be seen that the no-failure operation probability increases from 0,9 (one channel) to 0,99 (two channels).

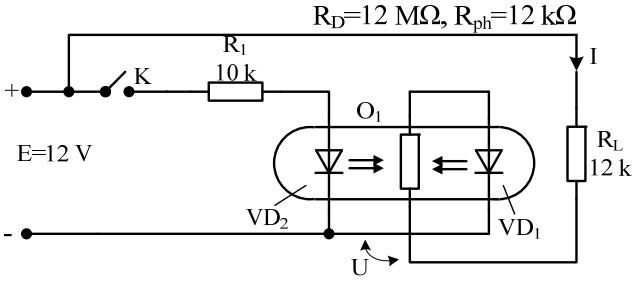

Fig. 7

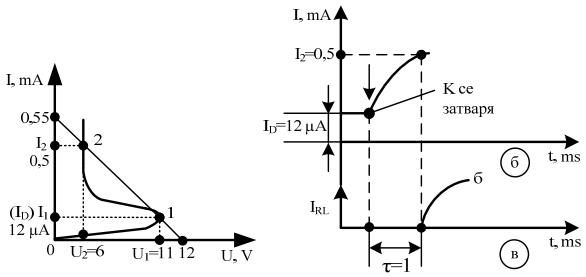

Fig. 8 а), б), в)

1.4 Time relay – fig. 7.

The time relay is realized by means of a photoresistor optocoupler connected to an optical positive feedback circuit.

The LED VD_1 and the photoresistor are connected in series. When the key K is open, a weak current I_1 (I_D) flows through the circuit +E, R_L, Photoresistor, LED, and no optical positive feedback is generated. The operating point is in the 0 – 1 range of the current-voltage characteristic – fig. 8 a). When the key K is closed, a current flow through the LED VD_2 and it illuminates the photoresistor. The photoresistor resistance decreases and an optical positive feedback is generated, which in turn results in the displacement of the operating point in p. 2.

1.5 The time delay τ is determined by the inertia of the photoresistor – fig. 8 b) and fig. 8 c).

The relay is switched off when the key K opens. The time relay can be realized by optocouplers where filament lamps are used as light sources.

1.6 The circuit delay is higher because the inertia of the lamps is also included – fig. 9. The optical positive feedback circuit is a bistable circuit. It has two stable states and can be used as a trigger – fig. 10.

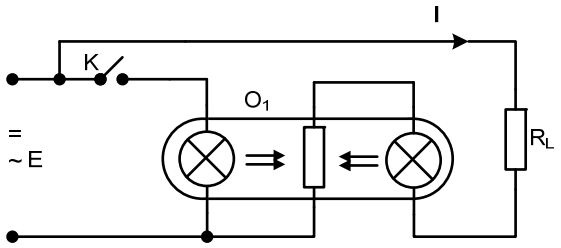

Fig. 9

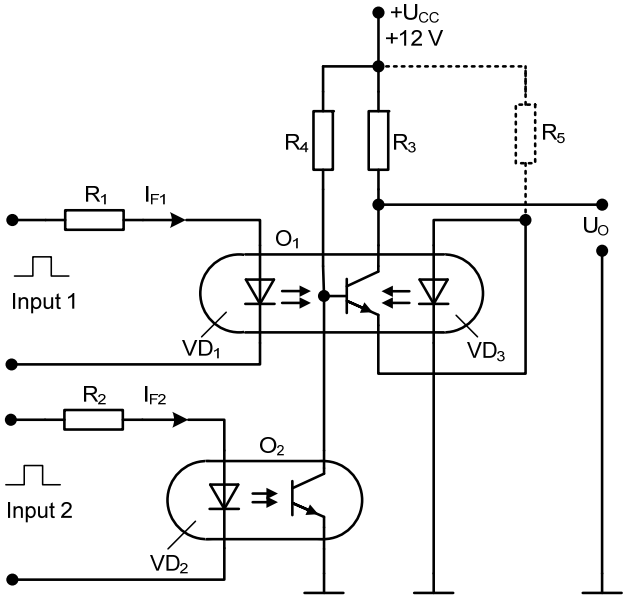

Fig. 10

When the currents across the LED are $I_{F1} = 0$; $I_{F2} = 0$, only dark current flows through the circuit and no optical positive feedback is generated. The phototransistor is OFF and the output voltage is high (U_{OH}).

When current flows along the LED VD_1 – I_{F1}, the phototransiostor is illuminated and an optical positive feedback is generated thus resulting in switching off the phototransistor. The output voltage is low (U_{OL}) is equation (4):

$$U_{OL} = U_{CEsat} + U_{F3} \tag{4}$$

where U_{CEsat} – the voltage between the collector and the emitter of the photoresistor of the optocoupler O_1 in a saturation mode, U_{F3} – the forward voltage of the LED VD_3.

The circuit remains in this stable state even when $I_{F1} = 0$. To convert the circuit, current must be supplied to the LED VD_2 – I_{F2} of the optocoupler O. The photoresistor of the optocoupler is OFF and the output voltage is again high.

The current across the LED in the circuits is calculated by using the equation (5):

$$I_F = \frac{E - U_F}{R} \tag{5}$$

where E – the control (input) напрежение, U_F – the forward voltage of the LED, R – the LED resistor connected in series.

1.7 Figure 11 shows a circuit of a RS trigger where the input signals are separated by the trigger in a galvanic way.

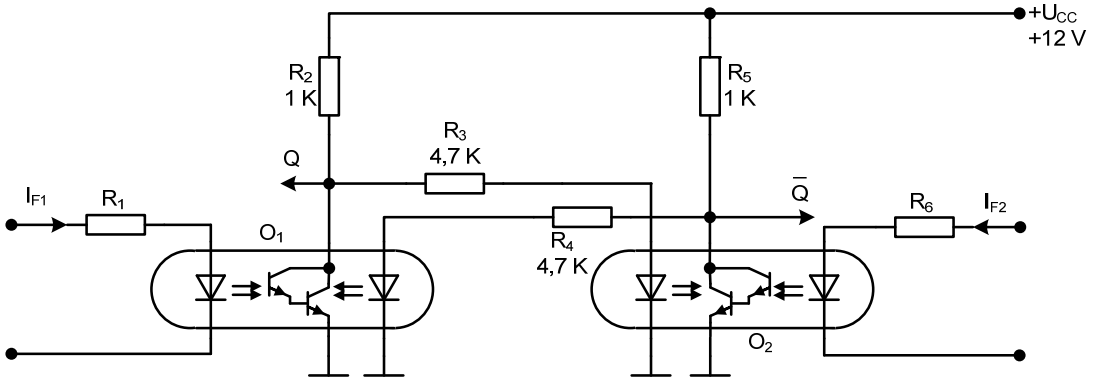

Fig. 11

The operation of the trigger is illustrated by a truth table – table 1.

Table 1

I_{F1}	I_{F2}	Q	$\overline{Q}$
0	0	0	1
0	1	1	0
1	0	0	1
1	1	0	0

To saturate the phototransistor, the following condition must be satisfied – equation (6):

$$I_{F1}(I_{F2}) \geq \frac{U_{CC} - U_{CEsat}}{R_C . K_I}, (R_2 = R_5 = R_C) \tag{6}$$

The amplitude of the output pulse is equation (7):

$$U_Q(U_{\bar{Q}}) = \frac{U_{CC} - U_F}{R_C + R}.R + U_F, (R_3 = R_4 = R) \quad (7)$$

$$U_Q = \frac{12 - 1{,}2}{1.10^3 + 4.7.10^3}.4.7.10^3 + 1{,}2 \approx 10V$$

1.8 Application

Optocouplers with two LEDs and a photodetector are used in logic circuits, time relays, bistable circuits (triggers), high reliability optoelectronic circuits. Control of the LED input circuit by unipolar, bipolar pulse and sinusoidal signals.

1.9 Conclusion

The proposed optocoupler using two light sources (infrared LEDs) and one photodetector significantly expands the functional capabilities of the optocouplers, mainly those used in the pulse and digital equipment, household electronics, diagnostics, etc.

2. REFERENCES

[1] Колев, И. С. и Е. Н. Колева. *Оптоелектроника. Прибори. Елементи. Приложения.* С., Техника, 2007/монография/, ISBN 978-954-03-0670-4.

[2] Колев, И. С. и Е. Н. Колева. *Некохерентна оптоелектроника.* Габрово, Унив. изд. „В. Априлов", 2007, ISBN 978-954-683-373-0 /монография/.

[2] Hewlett Packard. *Optoelectronics Designer's Catalog,* 1996.

[3] Siemens. *Optohalbleiter,* 1995.

[4] Toshiba. *Photocouplers,* 1999.