MULTICHANEL OPTOCOUPLER CIRCUITS

Elena Nedialkova Koleva

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

Multichannel optocouplers are used in the same areas as unichannel optocoupler. Multichannel optocouplers have identical parameters. They are used for galvanic separation in multichannel systems. The devices where multichannel optocouplers are used become more compact. Some more specific applications of different types of multichannel optocouplers will be given here. Photodiode optocouplers has the most universal application in analog and digital circuits of all multichannel optocouplers due to their high response time and linear transfer characteristic. With multichannel optocouplers there is a parameter which is missing in monochannel optocouplers – isolation voltage between the single optocouplers, which in most cases is lower in value than the input-output isolation voltage of the monochannel optocouplers.

Keywords: multichanel optocoupler, photodiode optocoupler, two-channel phototransistor optocouplers

1. CIRCUITS WITH MULTICHANEL OPTOCOUPLER

With multichannel optocouplers two, three or four identical optocouplers are positioned in one body. These are usually photodiode, phototransistor, Darlington phototransistor optocouplers, photothyristor and phototriac optocouplers, optocouplers with field and MOS phototransistors. Multichannel optocouplers are used in the same areas as unichannel optocoupler.

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1.1 Applicable circuits

A circuit for converting a continuous sinusoidal signal into a square pulse – fig. 1 a), realized by means of Darlington optocouplers. The optocoupler LEDs are connected in parallel for AC voltage operation.

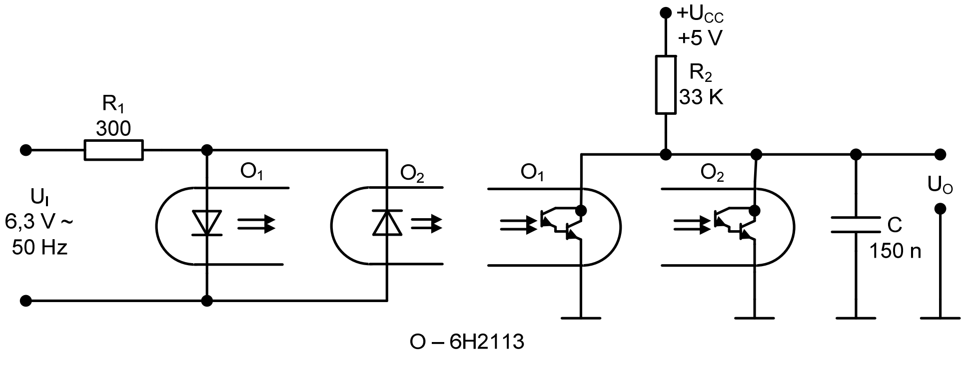

Fig. 1 a)

The optocoupler phototransistors are connected to a common collector circuit.

The capacitor C maintains a low output level at low input voltages. The circuit can be used as an indicator for the absence of input voltage or for its drop below a given minimum. The circuit operation is illustrated by the time chart shown in fig. 1 b).

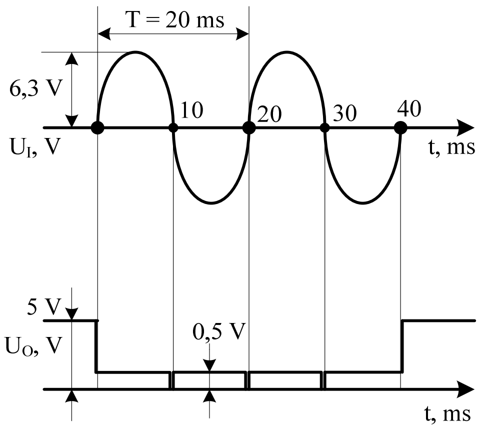

Fig. 1 b)

Two-channel Darlington optocouplers of PC825 or ILD – 30 types are suitable for this circuit.

1.2 Separation of even pulse sequence from odd pulse sequence – fig. 2 a).

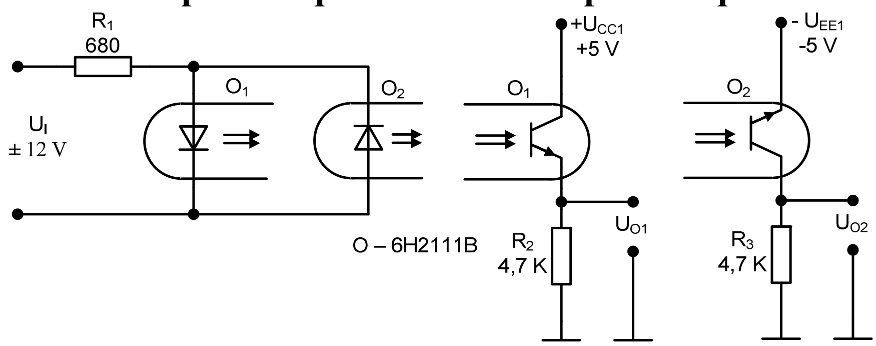

Fig. 2 a)

The circuit is realized by means of two-channel phototransistor optocouplers. Optocouplers of AOT 101 (Russia) ILD 2, ILD 74, MCT 6 types are suitable to be used. In this case the input voltage is a bipolar pulse. The circuit can be used for separating the positive pulses from the negative ones.

The circuit operation is illustrated by the time charts shown in fig. 2 b).

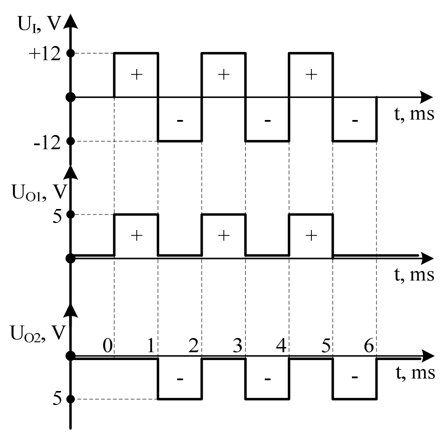

Fig. 2 b)

1.3 Current-frequency (period) coverter – fig. 3.

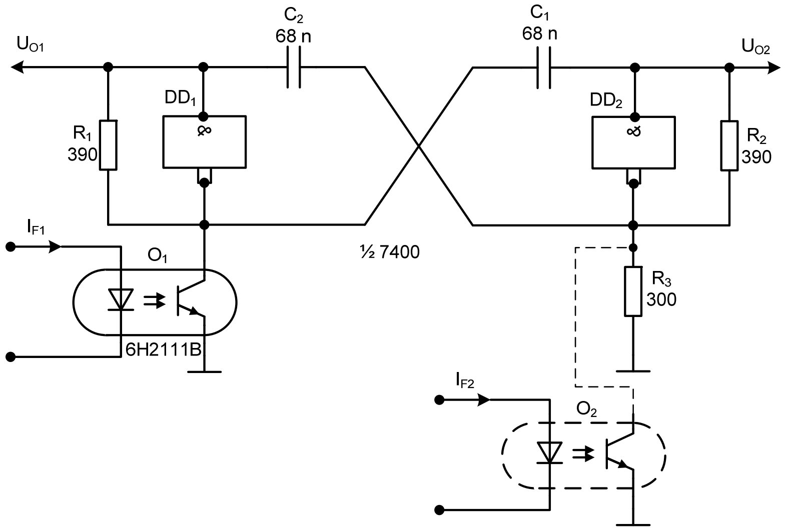

Fig. 3

An autofluctuating multivibrator with differentiating circuits and logic TTL IC is used. The resistors of the differentiating circuits are replaced by the optocoupler phototransistors.

The resistors R_1 and R_2 are connected so that the generator can be easily self-excited. If the optocoupler O_2 ($I_{F2} = 0$) is absent, the resistor R_3 is present and the change of $I_{F1} = 5 \div 0,5$ mA, the period T changes from $25 \div 45$ µs.

If the collector-emitter resistance of the phototransistor is marked by R_{CE}, then the period of the generated pulses is determined by the equation (1) and equation (2):

$$T \approx 0,7C_1\left[R_{CE1}(I_{F1}) + R_1\right] + 0,7C_2\left[R_{CE2}(I_{F2}) + R_2\right], R_3 = \infty \qquad (1)$$

At $C_1 = C_2 = C$ and $R_1 = R_2 = R$

$$T = 1,4CR + 0,7C\left[R_{CE1}(I_{F1}) + R_{CE2}(I_{F2})\right] \qquad (2)$$

1.4 Conversion of constant voltage into bipolar surge voltage – fig. 4.

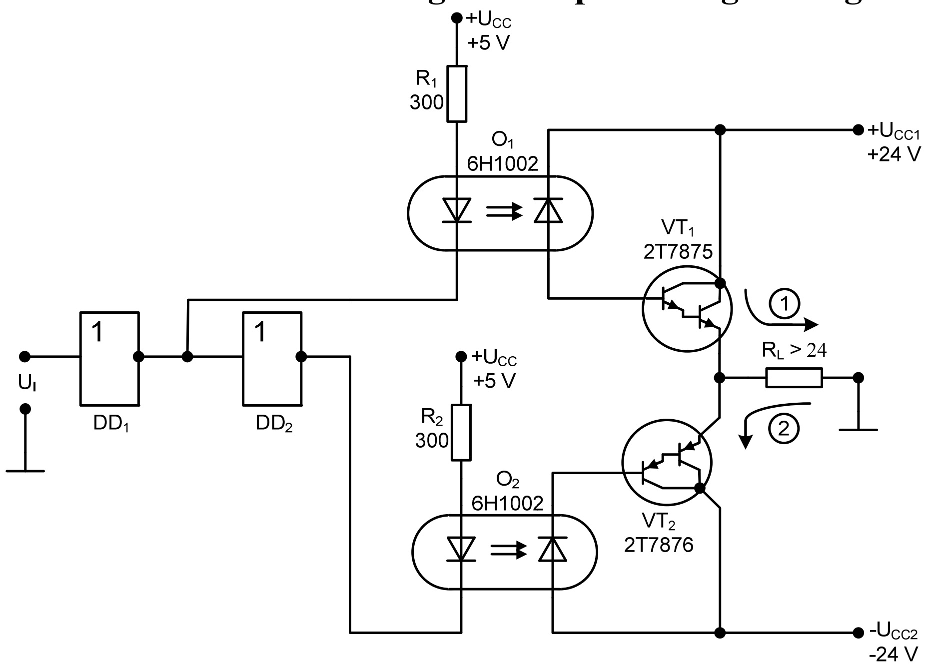

Fig. 4

At high input level the Darlington transistor VT_1 is ON and the current across the load R_L flows into the direction marked 1. At low input level the transistor VT_2 is ON and the current across the load flows into the direction marked 2.

Application – control of electromagnets and step motors for electromechanical clocks, positioning of solar batteries, etc. Two-channel optocouplers of АОД109В, АОД109Г, АОД109Д (Russia) types are suitable to be used. The optocouplers LEDs operate in a photogalvanic mode and control the two PNP and NPN transistors.

Methodology for circuit dimensioning.

Methodology for dimensioning the circuit in fig. 1 a):

The current across the optocoupler LED is equation (3):

$$I_F = \frac{U_I - U_F}{R_1} \tag{3}$$

Let's determine the minimum input voltage at which the current flows along the LED I_F, taking into consideration that the following conditions must be satisfied–
$I_F > 0,5$ mA, $U_I > U_F$, $U_F = 1,2$ V. When $U_I = 1,4$ V, the following is obtained – equation (4):

$$I_F = \frac{1,4 - 1,2}{300} = 0,66\, mA\ (0,66\, mA > 0,5\, mA)$$

$$U_I = U_{I\max}.\sin\alpha;\ U_I = 6,3\text{ V},\ U_{I\max} = 8,9\text{ V} \tag{4}$$

To determine the lag in switching ON the optocoupler phototransistor – equation (5):

$$\sin\alpha = \frac{U_I}{U_{I\max}} = \frac{1,4}{8,9} = 0,157 \tag{5}$$

The phase lag is equation (6):

$$\alpha = ar\sin 0,157 \approx 9^\circ \tag{6}$$

When the period T = 20 ms (f = 50 Hz), f/2 = 10 ms, the ratio is equation (7):

$$\gamma = \frac{\alpha}{2n} = \frac{9^\circ}{180^\circ} = 0,05 \tag{7}$$

The time lag in switching ON the Darlington phototransistor is equation (8):

$$t_d = \frac{T}{2}.\gamma = 10\, ms.0,05 = 0,5\, ms = 500\, \mu s \tag{8}$$

The time constant of charging the capacitor C is equation (9):

$$\tau = R_2 C \ge 5t_d \tag{9}$$

Condition (9) must be satisfied, $\tau = 33.10^3.150.10^{-9} = 4950\, \mu s$. Condition (9) is satisfied $\tau >> t_d$ (4950 μs > 500 μs).

Methodology for dimensioning the circuit in fig. 4:

Transistors with $U_{CE} = 45$ V, $I_C = 1$A, $h_{21E} \ge 200$ are used.

The base current is equation (10):

$$I_B \ge \frac{I_C}{h_{21E}} = \frac{1A}{2000} = 0,5\, mA \tag{10}$$

The photodiode photocurrent is equation (11):

$$I_{ph} = K_I . I_F \quad (11)$$

The LED current is equation (12):

$$I_F = \frac{U_{CC} - U_F - U_{OL}}{R} = \frac{5 - 1,2 - 0,3}{300} = 11,3\ mA \quad (12)$$

When $R_1 = R_2 = R$ от (4.53), the following is obtained:

$$I_{ph} = 0,05.11.10^{-3} = 0,55\ mA$$

The following condition must be satisfied – equation (13):

$$I_{ph} > I_B \ \ (0,55\ mA > 0,50\ mA) \quad (13)$$

Application– indicators for absence of a given phase, voltage or voltage drop below a particular value, pulse distributors, multichannel current-frequency and current voltage converters, measuring circuits, positioning of electromagnets, logic circuits, galvanic separation in multichannel systems, multiplication-division devices, amplifier circuits, interfaces in microprocessor equipment, etc.

2. References

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