PSPICE Simulation of Optoelectronic Pulse Circuits

Elena N. Koleva[1] and Ivan S. Kolev[2]

***Abstract* – The pulse circuits simulated are own developments of the team. They present an autofluctuation multivibrator with photodiode optocouplers and a controllable combined generator of line altering voltage and square pulses (of fantastron type) with a phototransistor optocoupler. The circuits have been simulated by means of a PSPICE package. The circuits have been developed in practice.**

***Keywords* – multivibrator, photodiode optocouplers, fantastron generator, phototransistor optocoupler**

I. Introduction

The pulse circuits simulated are own developments of the team. They present an autofluctuation multivibrator with photodiode optocouplers and a controllable combined generator of line altering voltage and square pulses (of fantastron type) with a phototransistor optocoupler. The circuits have been simulated by means of a PSPICE package. Time diagrams of set points, as well as transfer characteristics are given. Equations for determining the basic parameters of generators such as frequency (period) and pulse duration have been worked out. The circuits have been realized in practice; the modeling results have been compared and the practical experiments have been theoretically calculated (the error does not exceed 5 %).

II. Controllable Autofluctuation Multivibrator with Photodiode Optocouplers

A. A traditional circuit of a transistor autofluctuation multivibrator has been used, where the transistors have been replaced with phototransistor optocouplers in a photodiode mode, and the base time-setting resistors with optocoupler photodiodes – fig.1.

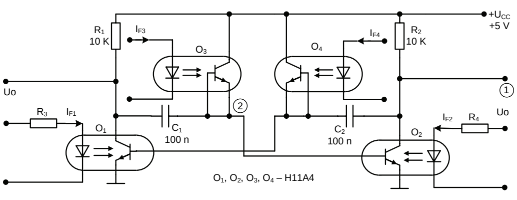

Fig. 1

B. The simulated time diagrams of the output voltage U_O (p. 1) and the voltage of one of the time-setting capacitor C_1 (p. 2) are shown in fig. 2.

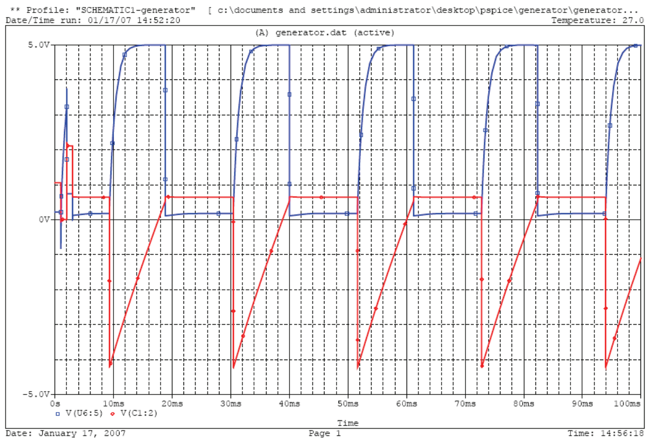

Fig. 2

The simulation refers to the following case:
$I_{F3} = I_{F4} = 30$ mA, $I_{F1} = I_{F2} = 0$ mA.

The reported simulated period of the generated pulses shown in fig. 2 is $T_C \approx 21$ms.

The equation for the period of the generated pulses, which has been theoretically worked out, is Eq. 1:

$$T \approx 0{,}7.C\left[R_{PD3}(I_{F3}).n_1(I_{F2}) + R_{PD4}(I_{F4}).n_2(I_{F1})\right] \quad (1)$$

$C = C_1 = C_2$, $I_{F3} = I_{F4} = I_F$, R_{PD} – resistance of optocouple phodiodes; n_1, n_2 – constants depending on the saturation degree of the phototransistors $n_1, n_2 = 1 \div 1{,}5$

When $I_{F3} = I_{F4} = 30$ mA, $I_{F1} = I_{F2} = 0$ mA, $n_1, n_2 = 1$, $T = 20$ ms, $f = 50$ Hz from equation (1).

The error is Eq. 2:

$$\varepsilon = \frac{T_C - T_И}{T_C}.100\% = \frac{21-20}{20}.100\% = 5\% \quad (2)$$

When $I_{F3} = I_{F4} = 0{,}2$ mA, $T_И = 0{,}98$ ms, $f \approx 1$ Hz from equation (1), i.e. the frequency changes over approximately 50.

C. Using table I, a transfer characteristic of the controllable multivibrator has been worked out (see fig. 3).

It can be seen that the transfer characteristic is linear within the range $I_F = 5 \div 30$ mA.

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TABLE I

I_F, mA	0,2	1	3	5	10
T, ms	960	185	87	64	42
F, Hz	1,04	5,41	11,5	15,6	23,8

I_F, mA	15	20	25	30
T, ms	31	25	21	18
F, Hz	32,3	40	48	55,6

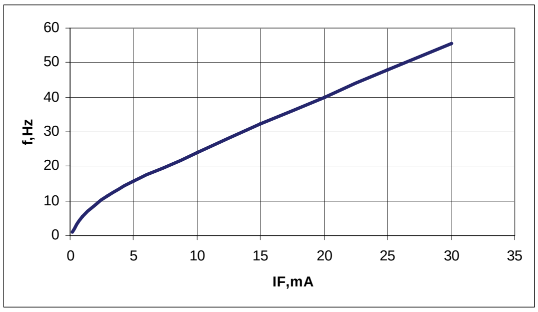

Fig. 3

II. Optoelectronic Fantastron Generator – Fig. 4

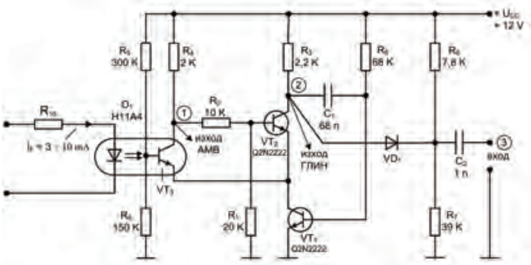

Fig. 4

It operates in a stand-by mode. The transistor fantastron generator has a collector coupling. The generator has an amplifier tracking coupling and contains a generator of line altering negative feedback voltage – Miller integrator with transistors VT_1 and VT_2. The transistors VT_2 and VT_3 form a trigger with an emitter coupling where the emitter resistor is replaced with the transistor VT_1 of the optocoupler O_1.

D. The circuit simulation is shown in fig. 5.

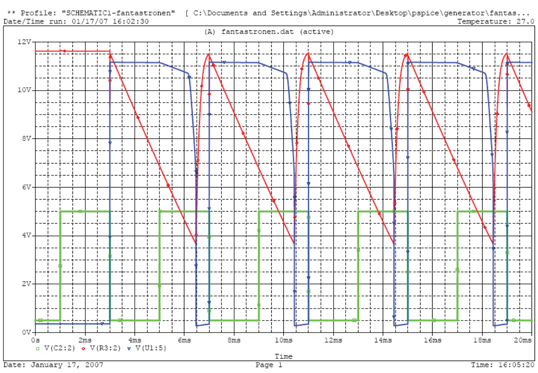

Fig. 5

Square pulses are taken at the output p.1 and line altering voltage at the output p.2. The circuit is set into motion at input p.3 by symmetric square pulses of 5 V amplitude and T = 4 ms (f = 250 Hz) period , where the T period of the generator of line altering voltage can be regulated within the range from 3,4 to 2,8 ms by changing the LED current from 3 ÷ 10 mA. The period of simulations is T_C = 4 ms when I_F = 3 mA (fig. 5).

Circuit application:

- Generator of line altering voltage
- Square pulse generator
- Pulse-width modulator
- Time-to-current (voltage) converter

The equations for the pulse duration ($t_И$), the pause between pulses (t_P), the non-linearity (K_H) and the period T of the generator are:

$$t_И = R_5.C_1 \frac{U_{CC} - U_{OL\,ГЛИН}}{U_{on\,ГЛИН}} = 68.10^3.68.10^{-9}\frac{12-3}{11,5} = 3,62\,ms \qquad (3)$$

$$t_P = R_3.C_1.\ln\frac{U_{CC}}{U_{CC} - U_Y} 2,2.10^3.68.10^{-9}\ln\frac{12}{12-10} = 0,268\,ms \qquad (4)$$

$$U_Y = \frac{U_{CC}}{R_6 + R_7}.R_7 = \frac{12}{7,8+39}.39 \approx 10V \qquad (5)$$

$$T = t_P + t_И = 3,62\,ms + 0,268\,ms = 0,388\,ms \qquad (6)$$

$$K_H = \frac{U_Y - U_{OL}}{U_{CC}}.\frac{R_5}{R_3.h_{21E}} = \frac{10-3}{12}.\frac{68}{2,2.180} = 0,1 \qquad (7)$$

The non-linearity of the generator of line altering voltage is K_H = 10 %.

The error, when T = 4 ms, is Eq. 8:

$$\varepsilon = \frac{T_C - T_И}{T_C}.100\,\% = \frac{4-3,88}{4}.100\,\% = 3\% \qquad (8)$$

III. Conclusions

Two types of optoelectronic pulse circuits have been developed. They have been simulated by means of a PSPICE package. Methods for calculating the basic parameters have been elaborated. The circuits have been developed in practice. The simulation and calculation error has been determined – it does not exceed 5 %.

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