Two-channel Circuits for Generation of Control Signals with Programmable Duration and Frequency

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Abstract – **In this paper digital circuits forming two-channel control signals with programmable duration are described. A simulation and experimental study and comparative analysis of two circuits are made. The circuits can be used as a base in building of precise microprocessor devices intended for test and control of transistor converting devices.**

Keywords – **control signals, programmable duration, generation, simulation, hexadecimal counter**

I. Introduction

Through the recent years the number of applications requiring more precise and stable forming of signals with various duration and frequency defined from controlled object and it's modes of operation increases. The technical decisions in that area are the following:

1. Analogue methods. Disadvantages of such circuits are poor stability of formed signals parameters, depending on ambient temperature, supplying power, variations of the parameter characteristics in serial production. They require measures for temperature stability, hardware and software corrections of the formed signal parameters.

2. Digital-analogue methods. Some of disadvantages of the analogue methods are eliminated here, but it is difficult to form signals with precise step of the signal changes and requirements for hardware and software corrections of the formed signal parameters exist.

3. Digital methods [1]. They remove most of the disadvantages of the analogue and digital-analogue methods. Also there are possibilities for microprocessor control of the signal parameters, thus allowing programmability, parameters measuring and so on.

II. Aim and Tasks of the Project

The major aim is to develop and analyze digital circuit variants forming two-channel control signals with programmable duration.

The tasks in developing the circuits are as follows:

- development of two-channel circuits forming control signals with programmable duration;
- circuits simulation in a distinct range of parameters values (frequency, pulse duration);
- experimental study of the circuits;
- comparative analysis based on the simulations and experiments.

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III. Circuits and Operation

Variant 1 of circuit forming control signals

- *Circuits and operation*

The first variant of circuit is shown in Fig.1. It consist of two generators: G1 (low frequency) and G2 (high frequency), four D-triggers (U1A, U1B, U7A, U7B), an inverter (U2A), four hexadecimal counters (U3, U4, U5, U6), connected in series and two 3-input AND gates (U8A, U8B).

G2 generates square waves with fixed frequency and period shown in Eq. (1):

$$T_{G2} = \frac{1}{f_{G2}}, \qquad (1)$$

determining the step of pause change between the two channels output signals. G1 generates square waves which frequency f_{G1} can be changed with a step of Δf_{G1} in a defined working range and respectively period T_{G1}. The triggers U1B and U1A synchronize the frequencies of G1 and G2 and form two-channel output signals dephased on π (rad).

The counters U4 and U6 and the trigger U7A form programmable pause on the output Q of the trigger U7A in the form of logical "0" and duration set by the pins a, b, c and d of the counters U4 and U6. The Eq. (2) gives the duration of the pause:

$$t_П = T_{G2}.k_Д, \qquad (2)$$

$k_Д$ is a scaling formed from 8-digit divider realized by the connected in series counters U4 and U6.

The gates U8A and U8B generate two-channel control signals with duration, given in the Eq. (3):

$$T_{УB} = T_{УA} = T_{G1} - t_П \qquad (3)$$

- *Simulation of the 1 variant working*

The software Protel 99 SE [2] in simulation mode is used for the analysis. The circuit shown in Fig. 1 is used for that purpose. The simulation is made using the following data-in:

- output frequencies $\frac{f_{G1}}{2}$ in the range of 10 kHz to 1 MHz;
- fixed generator frequency of G2 $f_{G2}=20\ MHz$ setting up the change step for the programmable duration;
- setting proper values for the scaling $k_Д$ varying in the range from 0 to 255.

For the parameters of integrated circuits (counters, triggers, gates) the typical values from their technical data at normal conditions are set.

Fig. 2 and Table I show the results from the simulation of output signals, where *a* is the first channel output signal and *b* is the second channel output signal.

- *Experimental study of the circuit working*

The results form the experiments with the first circuit variant using the oscilloscope TDS 1002 and generator FG-8102 are shown in Table II, where:

F_y is the output signal frequency

T_y – output signal period

$t_П$ – pause duration

$k_Д$ - scaling

$t_П^{E/C}$ - pause duration from the experiment /simulation

$t_И^1$ - channel 1 pause duration

$t_И^2$ - channel 2 pause duration

The comparison of the experimental and simulation results shows that there are slight differences which proves the correct working of the circuit.

Variant 2 of circuits forming control signals

The second variant of a circuit is shown in Fig. 3. In contrast to the first variant it is without two hexadecimal counters and a D-trigger.

The Eqs. (1), (2) and (3) are valid here too. The difference in functioning of this variant in comparison to the first one is that during one period T_{G1} the scaling is load to the frequency dividers U3 and U4 twice at the beginning of each one-half period.

Table III and Table IV show respectively the results of simulation and experiments. It is evident that they are nearly the same.

IV. CONCLUSION

It is seen from the comparing of the experimental results and two circuits analyses that the parameters of the programmable pauses and output pulses are closer to the ideal ones at the second circuit. Also the number of elements is less, thus determining less expenses in production.

The developed circuits forming programmable pause may be implemented in building two-channel devices for test, control and regulating resonant inverters work.

REFERENCES

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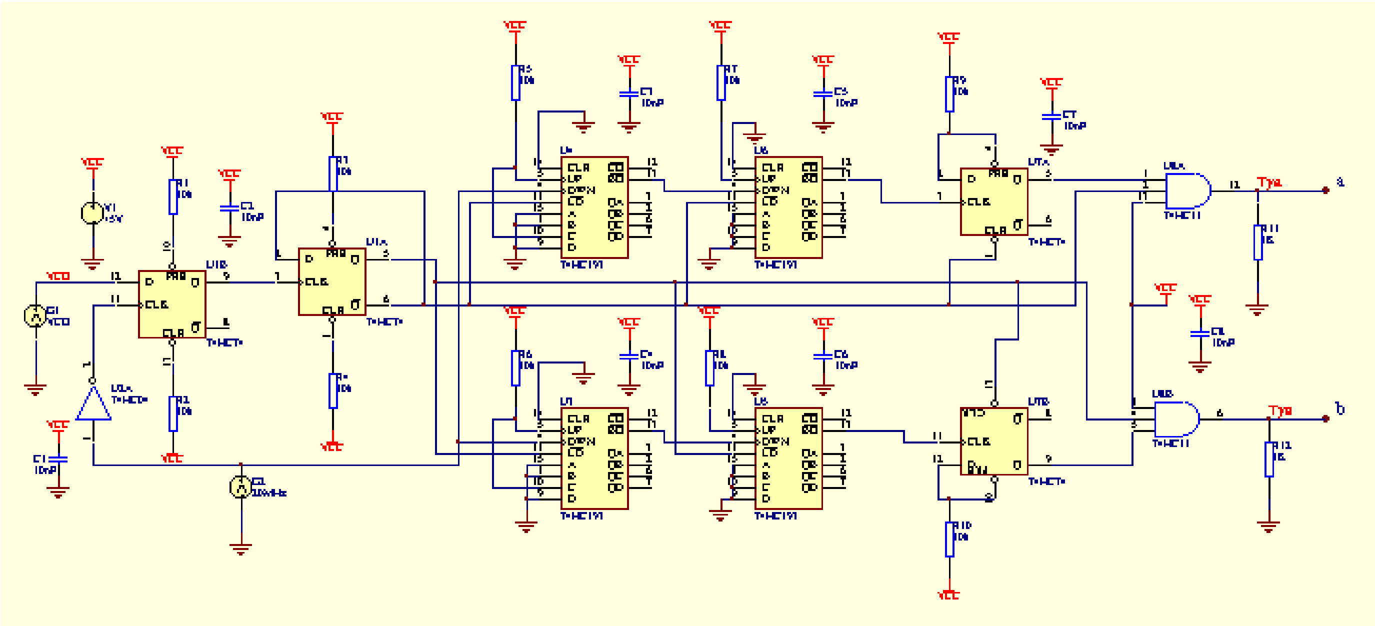

Fig 1 Control signal generating circuit – variant 1

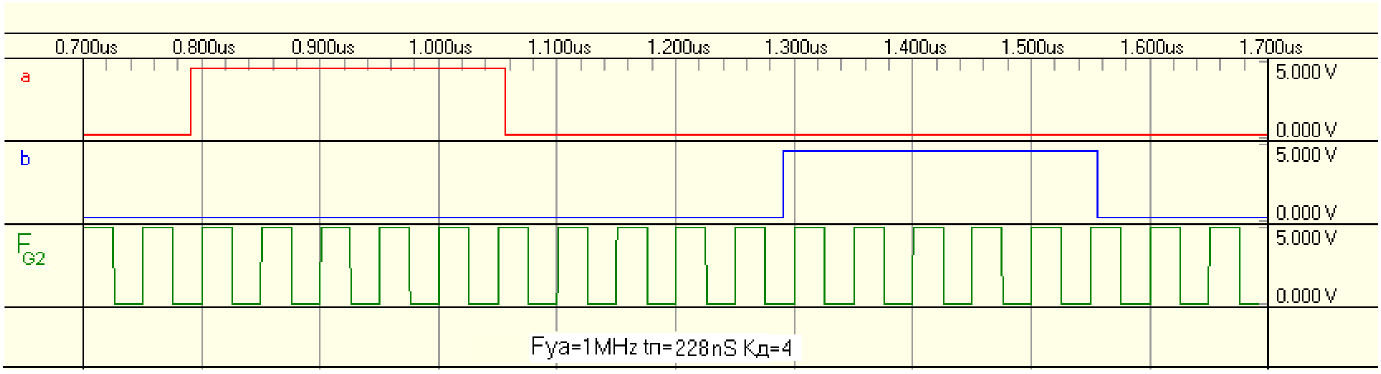

Fig 2 Output signal timing diagram for the circuit 1

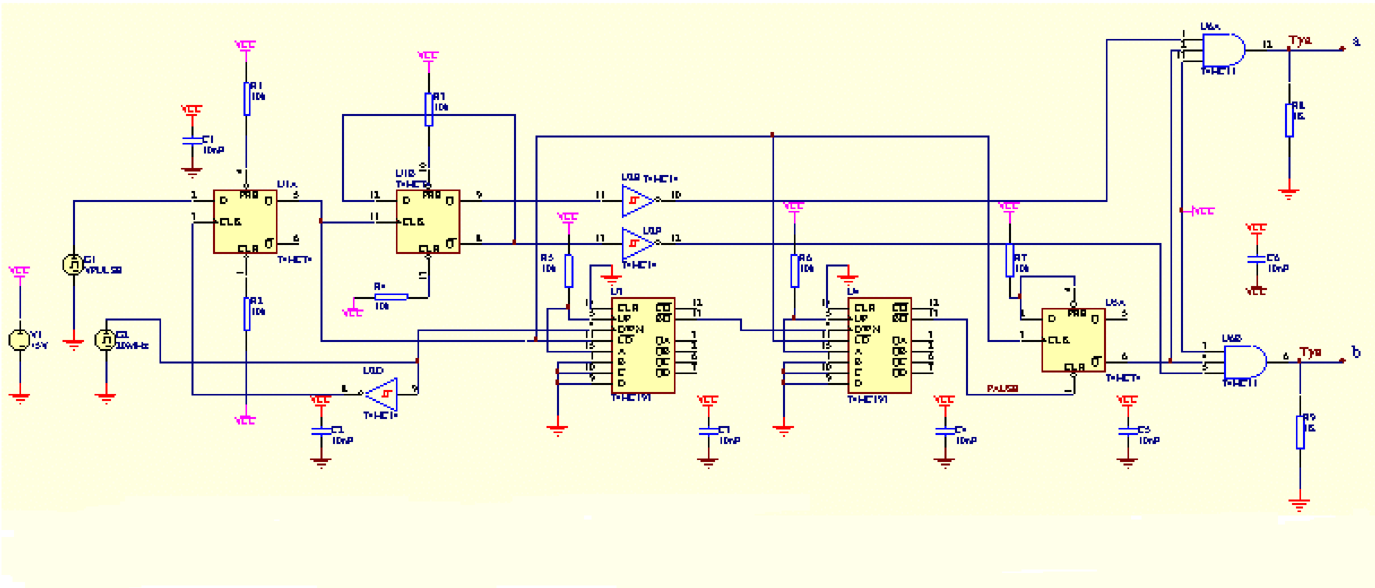

Fig 3 Control signal generating circuit – variant 2

TABLE I

SIMULATION RESULTS FOR CIRCUIT DIAGRAM 1

$F_у$	$T_у$	$t_п=К_д.Т_п$ [nS]						$К_д$						$t_п^C$ [nS]						$t_и^1$ [µS], $t_и^2$ [µS]					
KHz	µS	t_0	t_1	t_2	t_3	t_4	t_5	t_0	t_1	t_2	t_3	t_4	t_5	t_0	t_1	t_2	t_3	t_4	t_5	t_0	t_1	t_2	t_3	t_4	t_5
10	100	0	50	100	150	200	250	0	1	2	3	4	5	29	78	128	179	230	279	49,95	49,85	49,8	49,75	49,7	49,65
50	20	0	50	100	150	200	250	0	1	2	3	4	5	29	78	128	179	230	278	9,95	9,9	9,85	9,8	9,75	9,7
100	10	0	50	100	150	200	250	0	1	2	3	4	5	29,2	79	129	179	230	278	4,95	4,9	4,85	4,8	4,75	4,7
200	5	0	50	100	150	200	250	0	1	2	3	4	5	29,4	79	130	180	229	278	2,46	2,42	2,36	2,32	2,26	2,21
400	2,5	0	50	100	150	200	250	0	1	2	3	4	5	28,7	78,8	130	179	228	279	1,21	1,17	1,12	1,07	1,02	0,97
500	2	0	50	100	150	200	250	0	1	2	3	4	5	29	79	129	180	230	278	0,97	0,92	0,87	0,82	0,77	0,72
1000	1	0	50	100	150	200	250	0	1	2	3	4	5	30	79	129	180	228	279	0,465	0,418	0,37	0,318	0,27	0,22

TABLE II

EXPERIMENTAL RESULTS FOR CIRCUIT DIAGRAM 1

$F_у$	$T_у$	$t_п=К_д.Т_п$ [nS]						$К_д$						$t_п^E$ [nS]						$t_и^1$ [µS], $t_и^2$ [µS]					
KHz	µS	t_0	t_1	t_2	t_3	t_4	t_5	t_0	t_1	t_2	t_3	t_4	t_5	t_0	t_1	t_2	t_3	t_4	t_5	t_0	t_1	t_2	t_3	t_4	t_5
10	100	0	50	100	150	200	250	0	1	2	3	4	5	32	82	133	183	233	283	49,991	49,987	49,981	49,978	49,976	49,973
50	20	0	50	100	150	200	250	0	1	2	3	4	5	31	82	132	183	232	282	9,94	9,89	9,84	9,79	9,74	9,68
100	10	0	50	100	150	200	250	0	1	2	3	4	5	32	83	134	182	233	282	4,94	4,89	4,84	4,79	4,74	4,68
200	5	0	50	100	150	200	250	0	1	2	3	4	5	32	83	133	184	233	281	2,44	2,40	2,34	2,30	2,24	2,19
400	2,5	0	50	100	150	200	250	0	1	2	3	4	5	31	81	134	183	234	281	1,19	1,13	1,10	1,05	1,00	0,968
500	2	0	50	100	150	200	250	0	1	2	3	4	5	32	82	132	182	232	283	0,968	0,918	0,868	0,818	0,768	0,718
1000	1	0	50	100	150	200	250	0	1	2	3	4	5	32	81	134	184	233	282	0,463	0,416	0,368	0,316	0,268	0,217

TABLE III

SIMULATION RESULTS FOR CIRCUIT DIAGRAM 2

$F_у$	$T_у$	$t_п=К_д.Т_п$ [nS]							$К_д$							$t_п^C$ [nS]							$t_и^1$ [µS], $t_и^2$ [µS]						
KHz	µS	t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_0	t_1	t_2	t_3	t_4	t_5	t_6
10	100	0	50	100	150	200	250	300	0	1	2	3	4	5	6	1,02	43	94	143	193	242	294	49,99	49,98	49,84	49,81	49,8	49,77	49,69
50	20	0	50	100	150	200	250	300	0	1	2	3	4	5	6	1,02	43	94	144	192	243	294	9,998	9,957	9,906	9,857	9,808	9,755	9,703
100	10	0	50	100	150	200	250	300	0	1	2	3	4	5	6	1,02	42	94	143	193	243	293	4,992	4,952	4,903	4,852	4,803	4,753	4,701
200	5	0	50	100	150	200	250	300	0	1	2	3	4	5	6	1,03	43	95	143	193	243	292	2,492	2,452	2,402	2,352	2,313	2,253	2,202
400	2,5	0	50	100	150	200	250	300	0	1	2	3	4	5	6	1,02	44	94	142	192	244	293	1,242	1,202	1,152	1,102	1,052	1,003	0,957
500	2	0	50	100	150	200	250	300	0	1	2	3	4	5	6	1,02	44	95	144	194	243	293	0,991	0,953	0,902	0,852	0,804	0,754	0,704
1000	1	0	50	100	150	200	250	300	0	1	2	3	4	5	6	1,03	43	94	143	194	244	294	0,499	0,457	0,415	0,352	0,303	0,255	0,204

TABLE IV

EXPERIMENTAL RESULTS FOR CIRCUIT DIAGRAM 2

$F_у$	$T_у$	$t_п=К_д.Т_п$ [nS]							$К_д$							$t_п^E$ [nS]							$t_и^1$ [µS], $t_и^2$ [µS]						
KHz	µS	t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_0	t_1	t_2	t_3	t_4	t_5	t_6
10	100	0	50	100	150	200	250	300	0	1	2	3	4	5	6	2,4	47	98	147	197	247	297	49,99	49,98	49,81	49,8	49,79	49,76	49,68
50	20	0	50	100	150	200	250	300	0	1	2	3	4	5	6	2,2	48	97	147	197	247	297	9,99	9,95	9,9	9,85	9,8	9,75	9,7
100	10	0	50	100	150	200	250	300	0	1	2	3	4	5	6	2,1	48	97	147	198	247	298	4,99	4,95	4,9	4,85	4,8	4,75	4,7
200	5	0	50	100	150	200	250	300	0	1	2	3	4	5	6	2,3	47	97	147	198	248	298	2,49	2,45	2,4	2,35	2,31	2,25	2,2
400	2,5	0	50	100	150	200	250	300	0	1	2	3	4	5	6	2,1	48	97	147	198	248	298	1,24	1,2	1,15	1,1	1,05	1	0,955
500	2	0	50	100	150	200	250	300	0	1	2	3	4	5	6	2,2	48	98	147	198	248	298	0,99	0,952	0,9	0,85	0,802	0,752	0,702
1000	1	0	50	100	150	200	250	300	0	1	2	3	4	5	6	2,2	48	98	147	198	248	298	0,49	0,452	0,4	0,353	0,302	0,252	0,202