

DEVELOPMENT OF A MICROELECTRONIC CODE TRANSMITTER FOR AUTOMATION AND TELEMECHANICS SYSTEMS IN RAILWAY TRANSPORT AND MODELING OF ITS PRINCIPLES OF OPERATION

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ANNOTATION

Nowadays, microprocessor and microelectronic elements are widely used in the development of systems and devices for railway automation and telemechanics. The use of microelectronics and microprocessor technology in systems and devices of railway automation and telemechanics not only expands the working functions of its elements in comparison with electromagnetic relay systems, but also improves the correct organization and operation technology of these systems and devices.

In this article, the modeling of TSH-65 and TSH-2000 transmitter relays designed to transmit the codes generated by the KPTSH transmitter to road traffic lights and locomotive traffic lights in rail chains equipped with self-locking systems and automatic locomotive signaling systems at the joint-stock company "Uzbekistan Railways" is considered.

Moreover, the article considers the process of modeling KJ codes based on the graphs of Petri nets of the newly developed unified microprocessor code transmitter for the transmission of codes formed in railway automation and telemechanics systems. Time descriptions of pulses of TSH-65 and TSH-2000 transmitter relays, as well as diagrams of time descriptions of pulses and intervals in code "RY" for transmitter relays. In addition, "RY" codes were studied.

Nowadays, microprocessor and microelectronic systems and devices are widely used in railway automation and remote control systems. The use of systems and devices for railway automation and remote control, developed on the basis of

microelectronics and microprocessor elements, ensures reliable operation in comparison with systems based on electromagnetic relays.

A functional diagram of a new developed integrated microprocessor code transmitter for transmitting codes generated in railway automation and telemechanics systems has been developed. Dimmed microelectronic code of the transmitting device, work as relays TSH-65 and TSH-2000, and they are modeled in the Proteus program.

Keywords: Auto- blocking, locomotive automatic signaling, electric centering systems, rail chains, code, processes, anchor, relay, Petri networks, graphs, transmitter, microelectronic device, software, relay, contact, unit, microprocessor.

Introduction

Sections equipped with auto-blocking and automatic locomotive signaling are considered to be the main devices for interval organization of train movement. Equipment and devices used in electrical and dispatcher centralizations are necessary equipment for receiving and sending trains to the station and controlling their movement. Furthermore, the control of trains is a special labor-intensive technological sequence.

When using automation and telemechanic devices on railways, it is necessary to take into account the peculiarities of the systems and devices themselves. The quality of operation of these devices is assessed through the degree of safety of movement [1-6]. Railways are designed with automation and telemechanic systems based on performance quality indicators. Taking into account these indicators, the intended purpose of the design is the invention and development of a vehicle that provides safety at the highest level of efficiency in the transportation of cargo and passengers [1-9].

Nowadays, in the development of railway automation and telemechanics, it is implemented through the widespread use of microprocessor and microelectronic devices. The use of microelectronics and microprocessor techniques in systems not only expands the element's work function compared to electromagnetic relay systems, but also requires new views on the proper organization of the use of these systems and the assessment of the quality of operating technology.

Modern code transmitters manufactured in foreign countries are facing problems of purchasing and bringing them for use in automation and telemechanics devices owned by "Uzbekistan Temir Yollari " Joint Stock Company [8-15]. The solution to these problems is the production of integrated microelectronic code transmitters (IMCT).

Pendulum transmitters of electrical circuits models and their research.

Among the most urgent scientific problems in the field of railway automation and telemechanics is to improve the directions of analysis and synthesis of their work, as well as ensuring the safety level and reliability coefficient of control systems and equipment [10-18].

In order to increase the level of safety in railway automation and telemechanics equipment and systems, multi-channel control methods have been introduced. The basis of these channels is equipment, software, and time backup, and the goal is to create security and stability reserves of elements, and to eliminate equipment failures in system operation [10-20].




However, in current days, when implementing the same methods of increasing safety on railways, the conditions for the operation of railway automatic and telemechanical devices and systems, the development of railways and the intensity of the movement of trains moving in them are not always considered necessary and urgent.

As a result, the use of only one technical solution to increase the level of security in most cases causes hardware and software systems to work more than necessary, which reduces the efficiency of work and complicates their structural structure.

Therefore, it is becoming important to develop and implement methods of increasing the level of safety in the operation of railway automatic and telemechanical equipment and systems, evaluating their impact on train traffic and taking into account economic factors.

Petri networks are a means of introducing automatic and telemechanical railway systems. The theory of Petri networks makes it possible to model systems in the form of Petri networks in a mathematical hypothesis. The theory of Petri networking was developed in order to model parallel processes in systems.

Petri networking are composed of R processes, T conditional transitions, I input and O output task elements. Input and output functions are interconnected through processes and conditional transitions. This ensures that the structure of the Petri network consists of the suitability of processes and conditional transitions. Petri is represented by graphs in order to simplify the appearance of the theory of networks. Graphs used in the construction of Petri networks are reflected in the simulator in the form of multigraphs.

Based on this,  – the processes and conditions of logical elements,  – logical element represents conditional transitions. In order to indicate which process is active in Petri networking, it is determined by placing a checkmark in the circle -  logical element [19,20].

Below we will consider the use of Petri networks to develop the optimal algorithm of microelectronic devices and their software at the expense of modeling the operation of TSH-65 and TSH-2000 transmitter relays.

To do this, we need the time parameters of the pulses at the outputs of the TSH-65 and TSH-2000 transmitter relay contacts for plotting Petri graphs (Fig. 1).

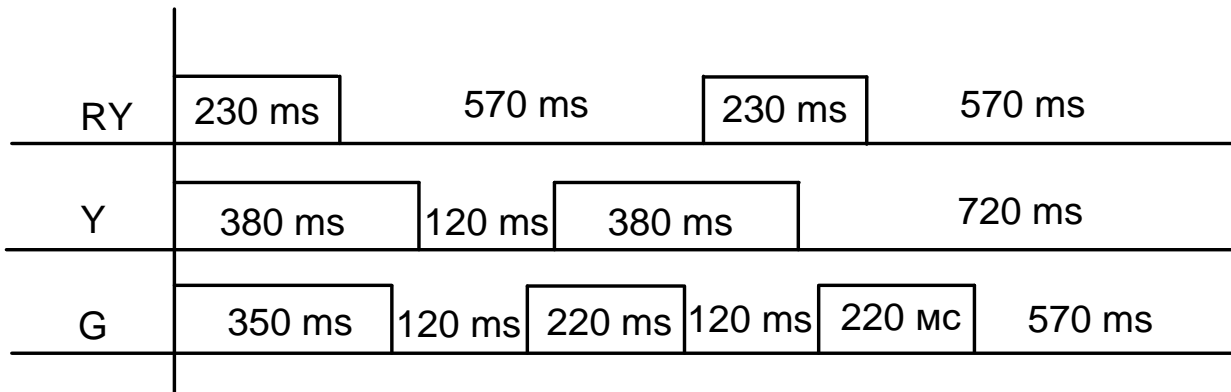


Figure 1. Diagram of time characteristics of pulses of transmitter relays TSH-65 and TSH-2000

It is clear from Figure 1 that the time diagrams of TSH-65 and TSH-2000 relay contacts are overlapped on one another. Therefore, the Petri plots of TSH-65 and TSH-2000 transmitter relays are also combined.

Below we will discuss Petri graphs for Red and Yellow codes.

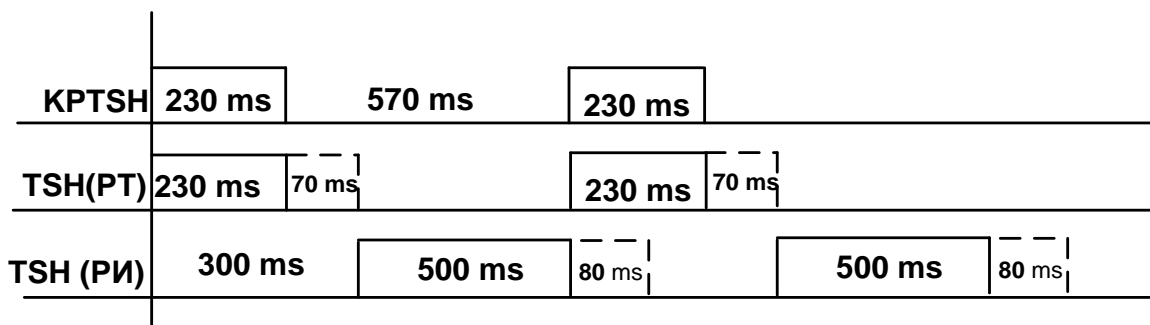


Figure 2. Diagram of time characteristics of pulses and intervals in the "Red and Yellow" codes for TSH-65 and TSH-2000 transmitter relays.

The following table provides the processes and process descriptions:

Table 1

Process procedure	The purpose of the process
P1	The supply was given and the impulse began to come.
P2	The process of raising the armature of the RT relay during the pulse.
P3	The process of checking the arrival of a first pulse for 230 milliseconds.
P4	Checking that the 70 milliseconds delay time to drop the RT relay armature during the first interval after the pulse ends.
P5	RT relay anchor drop.

P6	RI relay armature lift.
P7	Interval check for 500 milliseconds.
P8	80 milliseconds delay time for pulse arrival and release of RI relay armature at the end of the first interval
P9	RI relay anchor drop
P10	The process of checking the arrival of a second pulse for 230 milliseconds.
P11	Checking that the 70 milliseconds delay time to drop the RT relay armature during the second interval after the pulse ends.
P12	Interval check for 500 milliseconds.
P13	80 milliseconds delay time for pulse arrival and release of RI relay armature at the end of the second interval
Order of conditions	The purpose of the transition conditions
t1	Connecting to power and receiving a pulse.
t2	Transition from the first impulse to the first interval.
t3	After the 70 MS delay, the armature of the RT relay switches from the energized state to the de-energized state.
t4	Transition from the first interval to the second pulse.
t5	After the 80 ms delay, the RI relay switches to de-energized state.
t6	Transition from the second impulse to the second interval.
t7	After the 70 MS delay, the armature of the RT relay switches from the energized state to the de-energized state.
t8	Transition from the second interval to the first pulse of the second cycle.
t9	After the 80 ms delay, the RI relay switches to de-energized state.

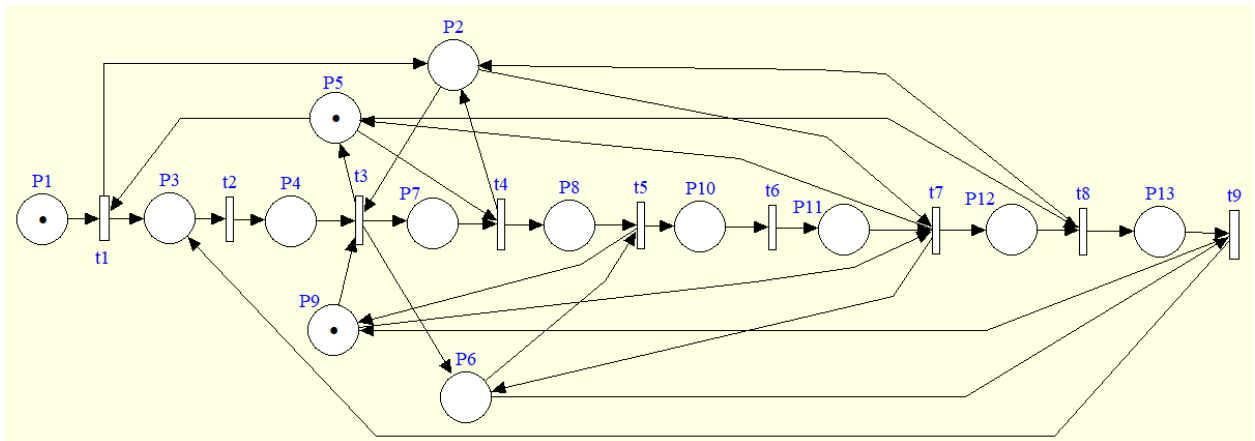


Figure 3. TSH-65 and TSH-2000 transmitter relays when the supply is connected
Petri networking graph

Condition transitions $t_1, t_2, t_3, t_4, t_5, t_6, t_7, t_8$ and t_9 are used in the graph.

In Figure 3, when the supply is connected and the pulse arrives, the chip is in the P1 position. At the same time, the timer t1 checks the condition of receiving a pulse during $0 \div 230$ ms, and when the condition is fulfilled, we have outputs $O(t_1) = \{P_2, P_3\}$.

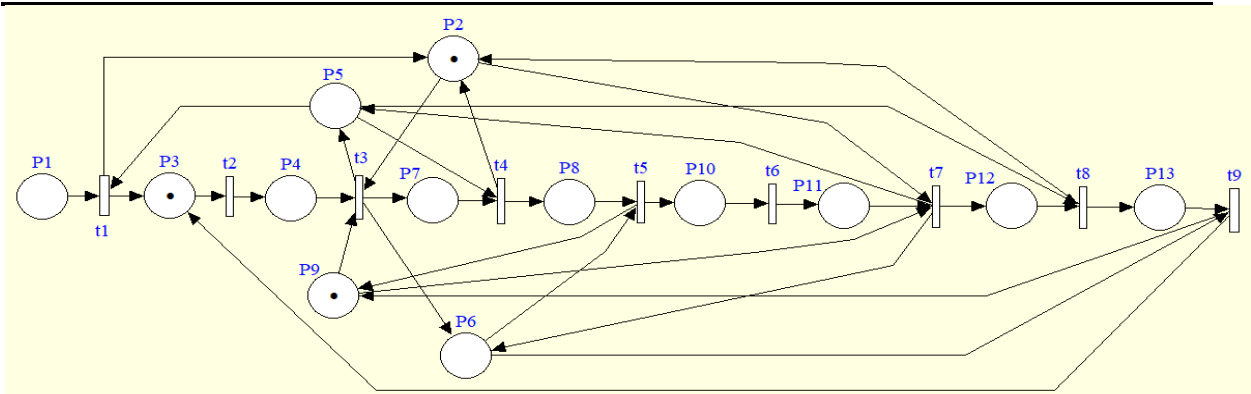


Figure 4. TSH-65 and TSH-2000 transmitter relays when the supply is connected 230 MS graph of the Petri network after the impulse arrives.

In Figure 4, when the supply is connected and a pulse arrives for 230 MS, the chips P2, P9 and P3 are activated. The RT anchor is raised and as a result of the P2 process being activated. And through P3, t2 is connected to the conditional transition. Thus we get the input $I(t2) = \{P3\}$.

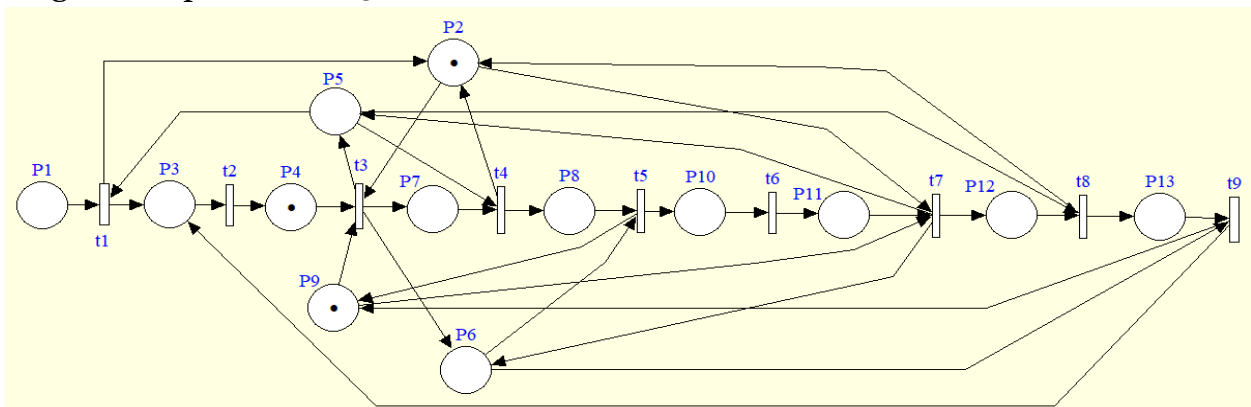


Figure 5. A plot of a Petri network at the end of the pulse and the start of the interval.

In Fig. 5, we can see that the P4 chip is activated after the t2 condition is fulfilled, that is, after the pulse time is over and the transition to the interval is fulfilled. From the above case, we get only $O(t2) = \{P4\}$. Position P2 is still active. That is, in order to fulfill the condition t3, inputs $I(t3) = \{P2, P4, P9\}$ must be implemented. As a result of the activation of the P4 position, the process of transition of the PT armature from the current state to the non-current state begins in the condition t3. Our output becomes $O(t3) = \{P5, P6, P7\}$, and the input to P4 becomes $I(t4) = \{P5, P7\}$.

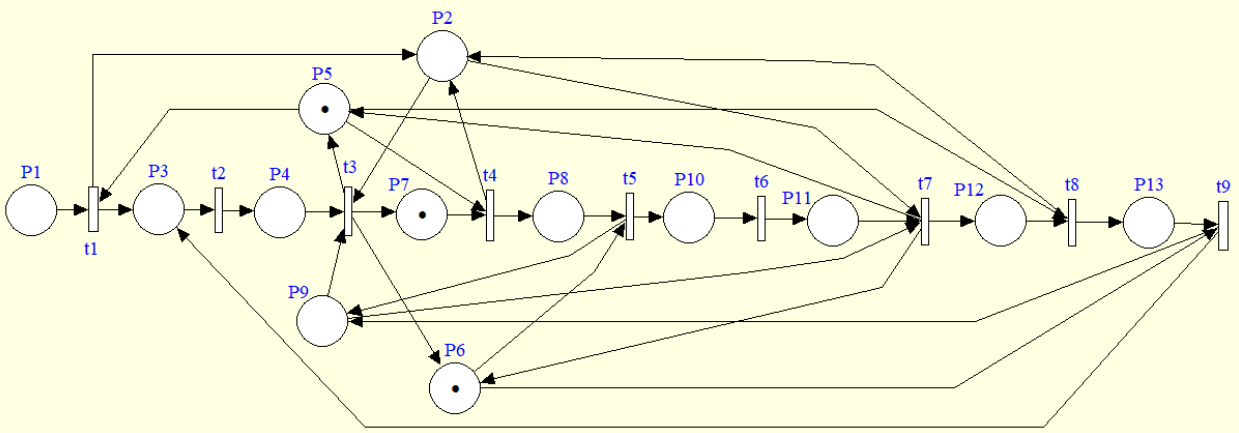


Figure 6. Petri network plot of RT relay armature transition from energized state to de-energized state.

As a result of the condition t_4 being fulfilled, an interval of 500 MS is created and we get the output $O(t_4)=\{P_2, P_8\}$. Checking the delay time of 70 MS to drop the PT relay armature at the end of the pulse and the start of the interval, it is shown that the P5 and P7 positions are activated after the condition is fulfilled (Fig. 6).

It turns out that the PT anchor has dropped due to the activation of the chip P5 position. Since t_5 is the input $I(t_5)=\{P_6, P_8\}$, PI anchor raising process is started.

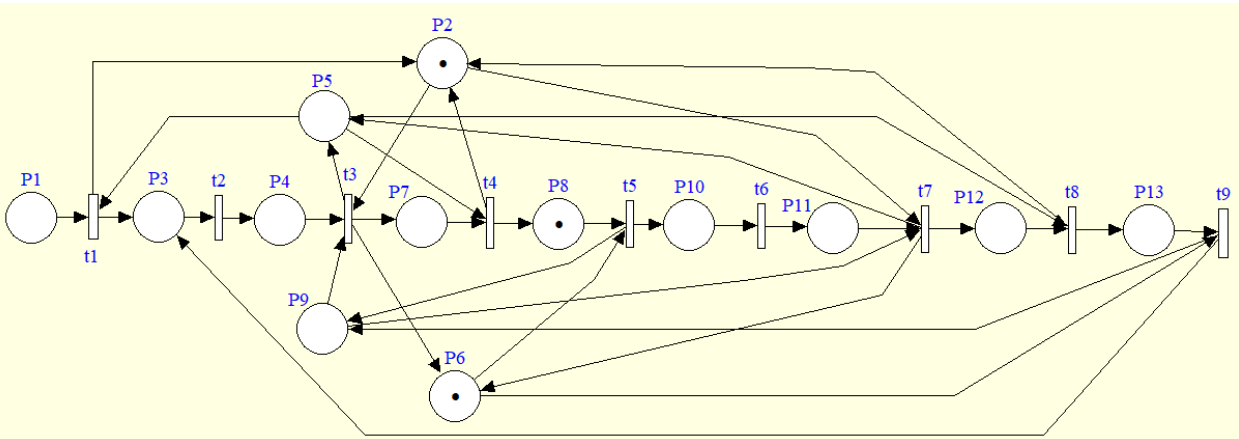


Figure 7. Petri network graph of relay armature RI switching from no current to live state.

Dropping the PT relay armature produces $O(t_5)=\{P_9, P_{10}\}$ at the output of t_5 . This, in turn, serves to raise the PI anchor. At the input of t_6 , $I(t_6)=\{P_{10}\}$ is generated. The activation of the P6 process means that the PI relay is energized for 500 MS. The output of t_6 is $O(t_6)=\{P_{11}\}$ P10 and the chip is falling, which means that after the interval, the pulse arrives and the 80 MS delay process for dropping the PI anchor is taking place. As a result, we have inputs $I(t_7)=\{P_2, P_9, P_{11}\}$ (Figure 7).

In the second pulse and the second interval and subsequent cycles, the Petri net will continue to operate in the same manner. (Figure 3).

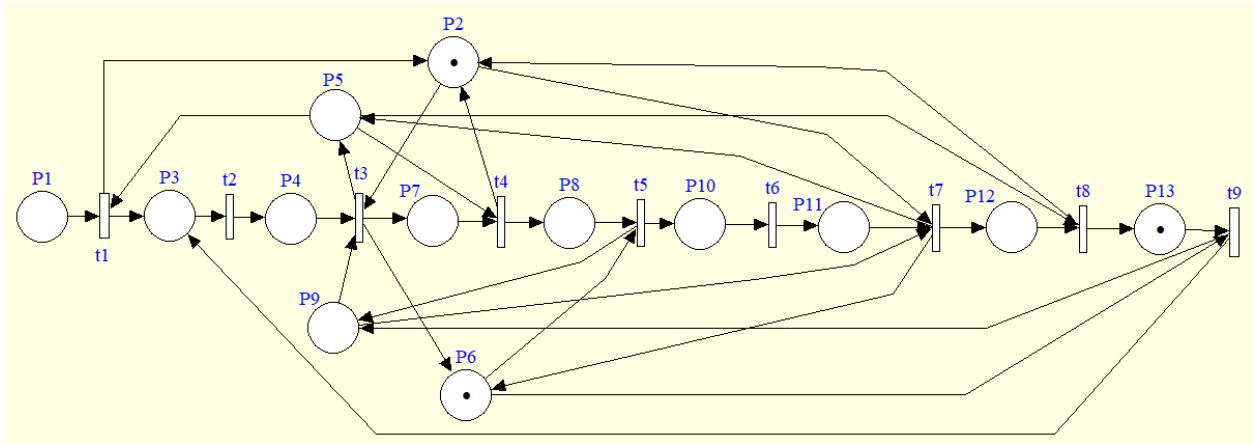


Figure 8. Petri network graph of relay armature RI transition from energized state to de-energized state.

In Fig. 8, it is known that the condition $O(t_9)=\{P_3,P_9\}$ at the output of t_9 is fulfilled during the delay of 80 MS, and the PI relay switches to the no-current state again. Extended input (I) and output (O) functions for the TSH-65 Petri network multigraph are presented in Table 2.

Extended input (I) and output (O) functions for the Petri graph in the "Red and Yellow" codes of the TSH-65 relay.

Table 2

$I(t_1)=\{P_1, P_5\}$	$O(t_1)=\{P_2,P_3\}$
$I(t_2)=\{P_3\}$	$O(t_2)=\{P_3\}$
$I(t_3)=\{P_2, P_4,P_9\}$	$O(t_3)=\{P_5,P_6,P_7\}$
$I(t_4)=\{P_5,P_7\}$	$O(t_4)=\{P_2,P_8\}$
$I(t_5)=\{P_6,P_8\}$	$O(t_5)=\{P_9,P_{10}\}$
$I(t_6)=\{P_{10}\}$	$O(t_6)=\{P_{11}\}$
$I(t_7)=\{P_2, P_9,P_{11}\}$	$O(t_7)=\{P_5,P_6,P_{12}\}$
$I(t_8)=\{P_5, P_{12}\}$	$O(t_8)=\{P_{13}\}$
$I(t_9)=\{P_6, P_{13}\}$	$O(t_9)=\{P_3\}$

Corresponding to the designation in Table 2, the expression forms a matrix of form 1 and 2.

Matrix 1

$$I = |t_{\tau\epsilon}| = \begin{matrix} & P1 & P2 & P3 & P4 & P5 & P6 & P7 & P8 & P9 & P10 & P11 & P12 & P13 \\ \begin{matrix} t1 \\ t2 \\ t3 \\ t4 \\ t5 \\ t6 \\ t7 \\ t8 \\ t9 \end{matrix} & \begin{matrix} 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{matrix} \end{matrix}$$

Matrix 2

$$O = |o_{\tau\epsilon}| = \begin{matrix} & P1 & P2 & P3 & P4 & P5 & P6 & P7 & P8 & P9 & P10 & P11 & P12 & P13 \\ \begin{matrix} t1 \\ t2 \\ t3 \\ t4 \\ t5 \\ t6 \\ t7 \\ t8 \\ t9 \end{matrix} & \begin{matrix} 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{matrix} \end{matrix}$$

Development of a functional diagram of a microelectronic code transmitter

The microelectronic code transmitter has the following advantages [16]:

- the possibility of self-control of these devices in case of errors during operation;
- small dimensions of the microelectronic pendulum device;
- no problem of contact erosion due to the use of non-contact elements;
- duration and ease of maintenance period;
- low cost;
- energy efficiency;

The functional diagram of the IMCT device is shown in fig. 9. Functional diagram of the IMCT. It consists of blocks : secure data entry module – SDEM, comparison block- CB, microcontroller 1,2- MC- 1 and MC- 2 , decoder- DC.

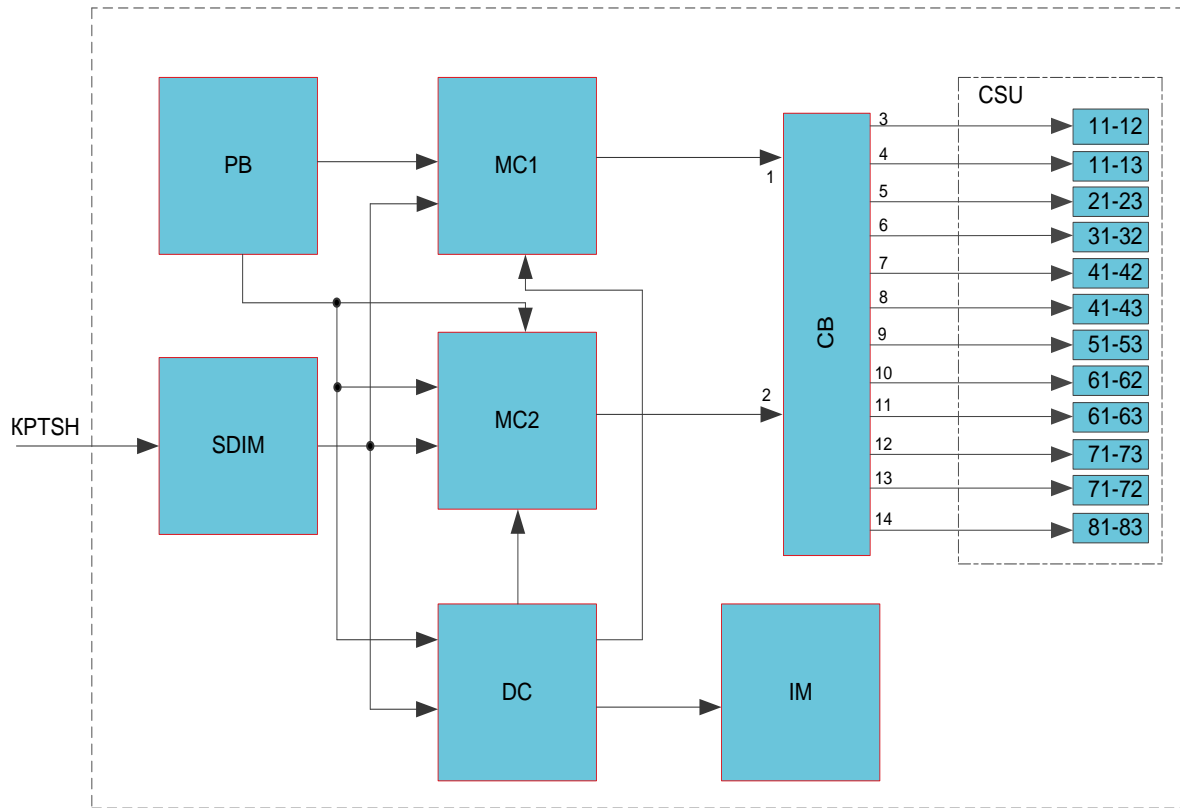


Figure 9. Functional diagram of a microelectronic code transmitter for a road transmitter.

SDIM - a secure data input module is required for the secure connection of the microcontroller with the KPTSH. PB- the power supply unit serves to provide the microcontroller with the necessary voltage . MC1 - the 1st microcontroller, MC2 - the 2nd microcontroller MC1 and MC2 are written by the power program and send data corresponding to the codes to the comparison unit. A DC - decoder is needed to check the correct operation of two MC1 and MC2. IM - indexing module is used to turn on the light indicators depending on the presence of the code in the decoder, for example, it turns on the “RY- Red and Yellow” indicator for the “RY” code, and the “B” indicator if the code is not received. CB - comparison unit compares the data coming from MC1 and MC2 , and after comparing the data coming from MC1 and MC2, it switches to proximity switches in accordance with the incoming pulses, and this code opens and closes them proportionally. CSU - contactless switch unit is oriented to open and close pulses and intervals according to these codes based on the information coming from the supply unit.

Development of a circuit for a microelectronic code transmitter

Microelectronic code transmitter based on the above functional diagram a circuit diagram was developed and its operation was verified using the Proteus program (fig. 10.)

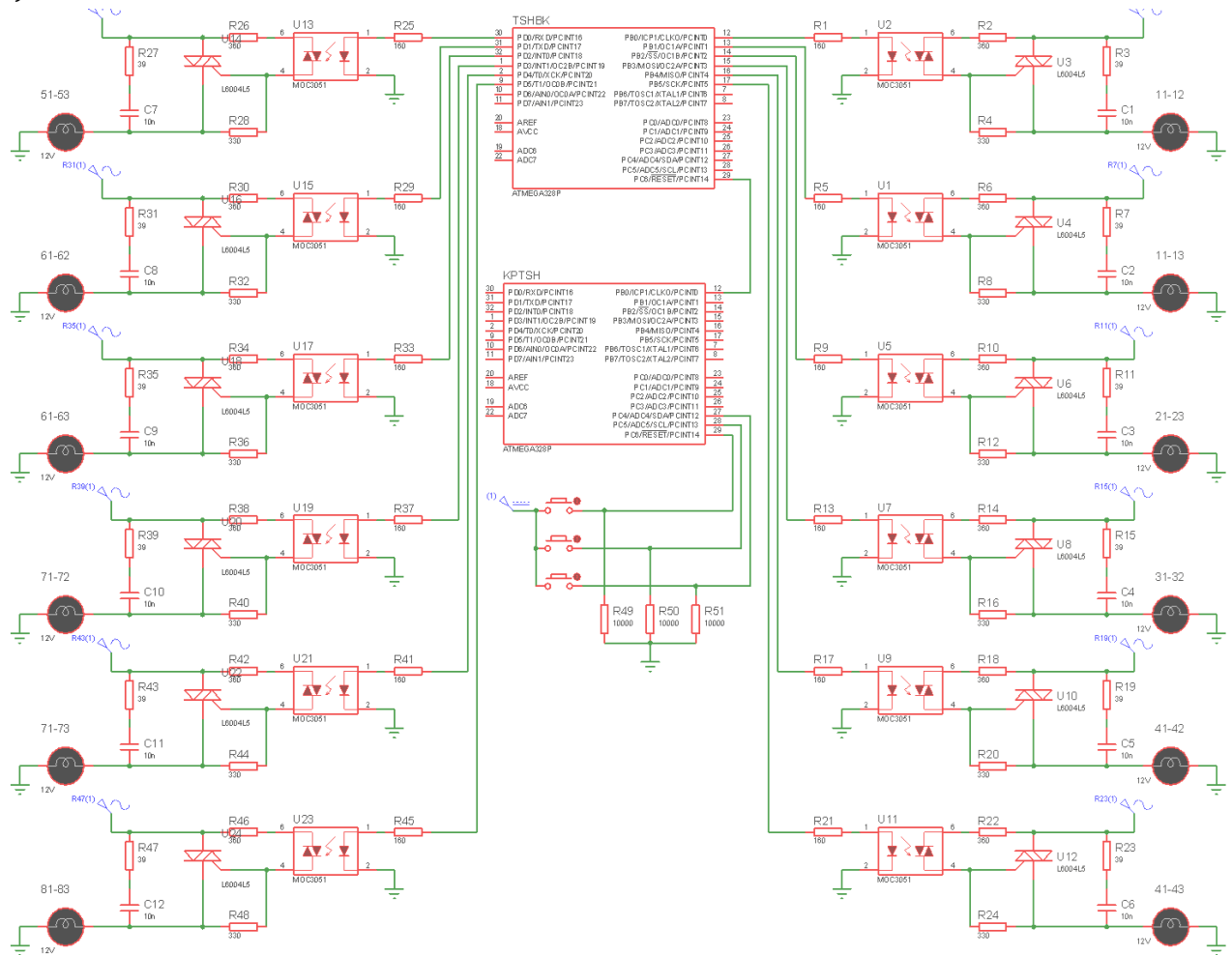


Figure 10 Diagram of a microelectronic code transmitter in the Proteus program.

In the Proteus program, the IMCT circuit diagram included the following several functional parts: 1. Microprocessor unit. 2. Indication circuit 3. Consists of KPTSH for checking the operation of proximity switches and TSH.

Proximity switches consist of optocouplers and triacs and have control and controlled signals, these two signals are provided by galvanic isolation.

Optocouplers are used as an element that performs the function of galvanic isolation. The voltage required to operate this device is simultaneously applied to the LED in the optocoupler.

Their burning is carried out by a photodiode, which serves to generate current. As a result, the circuit designed to control the switched-on device is activated

In addition, when developing a device, it allows the use of special optoelectronic devices, such as an opto- and photoresistor [12–16].

The device includes proximity switches 11-12, 11-13, 21-23, 31-32, 41-42, 41-43, 51-53, 61-62, 61-63, 71-72, 71-73 and 81-83 installed.

The basis of the microprocessor unit is the ATMEGA328P class microcontroller. The microcontroller performs the task of receiving pulses and codes generated in the KPTSH road code sensor and transmitting them to proximity switches.

To check the operation of the microelectronic code transmitter through the Proteus program, a code generator (KPTSH) is additionally installed. The KPTSH device is equipped with 3 separate buttons "RY -for Red and Yellow", "Y -for Yellow" and "G-for green" each code.

If the "RY" button is pressed, a voltage appears in block 27 of the KPTSH device, the RS6 input is activated, and the device develops the RY code, and through the RVo output, pulses in the form of the RY code arrive from the 12-29 network to the RS6 input of the IMCT device. In the normal state of the IMCT, there was a logical 1 (5V voltage) from the outputs PB1, PB2, PB5, PDo, PD2, PD4 and PD5. When the pulse arrives, the microelectronic device supplies its outputs RVo, RV3, RV4 and RD1. As a result, it passes through the limiting resistors R1, R13, R17 and R29 of the device and comes to the optocoupler.

The term "Control" is used for the signal to the optocoupler, because the control signal (5 V) from the microcontroller turns on the photodiode and opens the triac inside the optocoupler.

Now the controlled signal passes through the limiting resistors R2, R14, R18 and R30 and comes to the controlled element of the triac through the open optocoupler. As a result, the circuit breaker opens and switches 11-12, 31-32, 41-42 and 61-62. According to the time diagram "RY" (Fig. 11), contactless switches 11-12, 31-32, 41-42 and 61-62 remain connected for 230 MS for continuous pulse delivery.

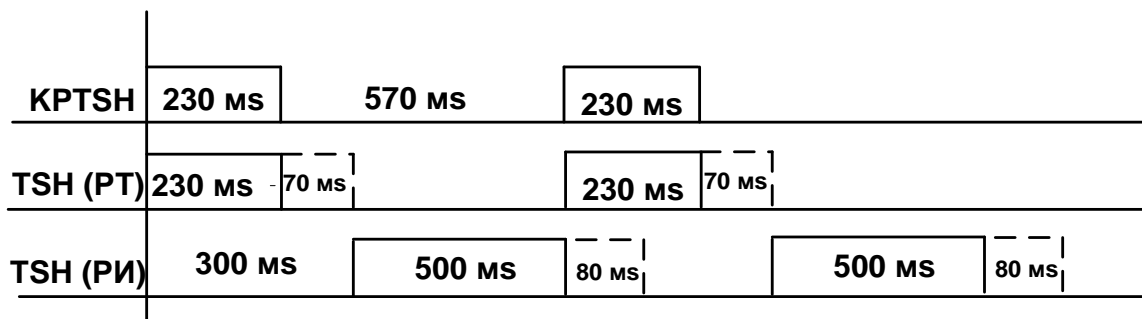


Figure 11. Diagram of temporal characteristics of impulses and intervals in the code "RY" for relay-transmitters TSh-65 and TSh-2000

After the 230MS timer has expired, the 70ms delay time will start to open proximity switches 11-12, 31-32, 41-42 and 61-62. After these delay times, the microelectronic code transmitter at the output of PD3 has a voltage of 5 V. Through block 2, it passes through the limiting resistors R37 and enters the optocoupler. The control signal to the optocoupler turns on the photodiode and the triac inside the optocoupler opens. And the controlled signal passes through the limiting resistor R37 and enters the triac control element through an open optocoupler, and the triac opens and closes proximity switches 71-73, this connection lasts 570 MS. After a delay of 80 MS, the 2nd pulse starts to flow and the proximity switches 11-12, 31-32, 41-42 and 61-62 are connected in the above order. Disabling these proximity switches will enable proximity switches 71-72. Switches 71-73 remain on for 570 MS, and after 570 MS the switches turn off.

Thus, the first cycle ends and the second cycle begins before the 80MS interval end delay expires, and the microcontroller starts the above processes again. A light is on on the display unit, indicating the arrival of the code "RY". This process continues until the code is exchanged in the rail circuits (until another button is pressed on the KPTSH device).

The principle of operation of the device is the same for all codes, but they differ from each other in the number and duration of pulses and intervals. Instead of the "RY" light bulb, the "Y" or "G" light bulbs on the display unit light up.

During the initial check, the clock generator, the timer, the enable and reset circuits of the indication, and the service program return to the following modes:

Initial Setup Steps:

- Set the type of microcontroller;
- Security bit off, wdt off;
- Standard xt - generator.
- Determination of the state of special-purpose registers;
- Configure port b for output;
- Configure port d for output;
- Configure port c for access;
- Determination of the state of special-purpose registers;
- Setting registers 1, 2 and 3 as a half cycle timer;
- Check pc6 for 1;
- If 0, set outputs pb1, pb2, pb5, pdo, pd2, pd3, pd4, pd5 to 1;
- If 1 setting outputs rv0, rv3, rv4 and rd1 to 1;
- Return to the beginning of the program;

The program then loops and stays that way until an interrupt occurs to change the signal potential of the port.

Conclusion

The article selects the method of Petri networks when modeling code-transmitting devices in the field of railway automation and telemechanics. To develop the most convenient software and collect concepts into one package, research was carried out on the mathematical models of the TSH code transmitter using the Petri networks mathematical device. From the results of the study, the graph of Petri networks for the “Red and Yellow” codes is represented by the depiction in the simulator, the sequence of execution of processes and conditions.

Above is shown the software operation algorithm when using the integrated microelectronic code transmitter device based on the Proteus software. In this algorithm, a pulse and an interval are specified, so the normal state of the ports is the same for all encoders. The operating time of the ports and the number of pulses and code matching intervals change only in proportion to the incoming code. For example, for the code «RY» there is one pulse and one interval, and for the code "Y" - two pulses and two intervals. In the software, all inputs and outputs work in the same order for the codes “RY”, “Y”, and “G”, but the pulse duration and intervals are different.

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