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MICROPROCESSOR TECHNOLOGY IN THE DEVICES RAILWAY AUTOMATION AND TELEMECHANICS

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Abstract
This article presents the results of simulation using Petri networks, operation of nodes of microprocessor set block control arrows system of railway automation and telemechanics.
Keywords: electromagnetic relays, modeling, algorithms, electrical circuits, microprocessor, Petri multiplayers, positions and transitions, input and output functions.

Introduction The current state of science and technology has been marked by the widespread adoption of microelectronic technologies in control and monitoring systems. This trend is reflected in the number of innovative projects aimed at introducing microelectronic devices into existing systems. Innovative projects of railway automation and telemechanics are actively included in these processes. One of these projects includes research projects aimed at the application of modern technologies in railway automation and telemechanics systems.

Innovation ideas can be safely attributed to a project aimed at solving the innovation problem based on the use of microprocessors in the system of blocked electric centralization (BEC), which has been successfully used for decades on the CIS railways. One of the positive qualities of this system is the extensive operational experience and the availability of qualified specialists in the design and maintenance of this system. However, one of the elements of this system is electromagnetic relays of the second reliability class, which contain mechanical switching parts and a contact group. This makes it necessary to regularly check these relays at control points of signaling and communication distances; in addition, updating the fleet of these relays is currently becoming very problematic, because the cost of the relay is growing exponentially from year to year. The aim of this work is to study the possibility of replacing these electromagnetic relays used in the typesetting blocks of the BEC system.

The object of study is the electrical circuits of push-button, automatic push-button relays, as well as starting control relays. The studies, the results of which are presented in the materials [2], show the possibility of using an opto-relay of type PVG 612, instead of the rear and front contacts of the code relay. In electrical circuits, automatic push-button relays and starting control relays, low-resistance relays of the KDR-1M type are used in series with a coil winding resistance of 3.8

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Ohms. A technical problem arises, namely, which devices can replace these relays, which have an internal resistance commensurate with the resistance of the winding above the specified electromagnetic relay. This device should solve two problems, the first one is to determine the presence of current in the circuit, the second is to transmit information about this to the controller, which will accept this information as a fact of the relay operation. The first solution to this problem was to use an optocoupler type PS-817. However, the internal resistance of this device is quite large, about 150 Ohms, as well as the permissible current flowing through it should not exceed 150 mA. In the considered electrical circuits connected to a 24 V power supply, the maximum allowable current is 1.8 A. Therefore, this device, by its technical characteristics, cannot be used instead of the code relay. A better option is the ACS 712 current sensor, capable of detecting the presence of current in the circuit under study, namely in the electrical circuits of the plus and minus control relays. When specifying the route, the 24 V battery is supplied to the terminals of the arrow control blocks. For example, for the block of "single slip switch control", the sensor is connected in series between the terminals of the electric circuits of the positive starting control relays 2PU 2-13, 2-3 (Fig. 1) and 1PU between the terminals 1-3 and 1-13, for negative control relays 1MU between the terminals 1 -3, 1-17, for a 2MU relay between terminals 2-17 and 2-3. In the block of "double slip switch control"-Current sensors block, it is necessary to include instead of the windings of the relay PU1, PU2 and MU. The current sensor of the electric circuit of the starting control relay of the first arrow must be placed in the gap between the terminals 1-13 and 1-3, the current sensor of the second positive control relay is connected to the open circuit of the excitation circuit between the terminals 2-3 and 2-13. The presence of current in the excitation circuit of the MU relay is simulated by turning on the current sensor between terminals 2-3 and 1-3.

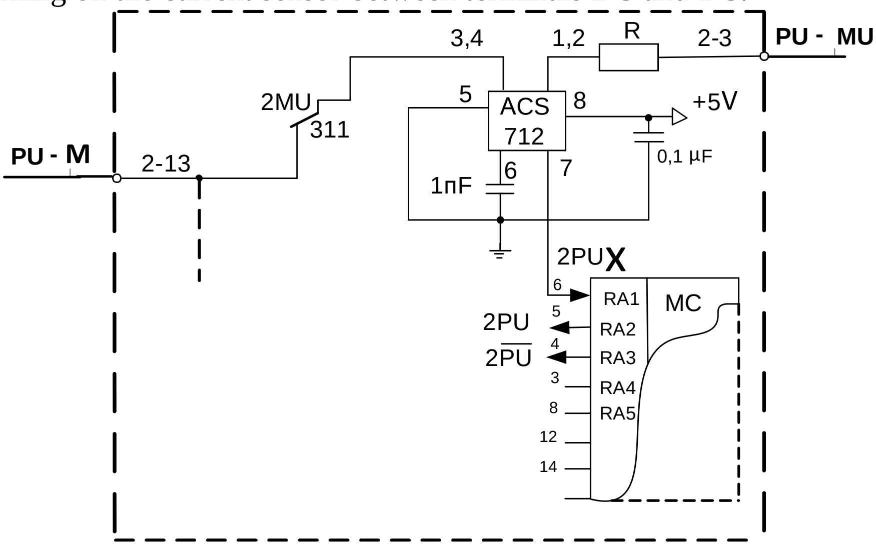

Fig. 1 Scheme of inclusion of current sensors in the circuit plus and minus control block of "single slip switch control"

The main functional purpose of the current sensor in these devices is to determine the presence of current in the above listed circuits. Information in the form of an analog signal is taken from the eighth leg of the sensor and fed to the microprocessor input in the form of a variable containing the symbol "x" The reference voltage of the sensor is supplied to the 8 leg of the sensor, in this case 5V. In Fig. 1, the variable is an analog signal supplied to the input of the ADC built into the microprocessor. If there is no power at the inputs of terminals 2-13 and 2-3, this voltage is 2.5V. The microprocessor software is configured in such a way that when an analog signal is received at the ADC input equal to 2.5V, the variable is assigned a logical zero value, and the variable is assigned a logical unit value. In the presence of voltages at terminals 2-13 and 2-3, current flows

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through the contacts 1,2 and 3,4 of the sensor, the value of which is reflected in the voltage value i.e. there is a deviation from the average value of the analog signal 2.5V in one direction or another . The microprocessor software perceives these changes as the presence of current in the circuit of the starting control relays, and assigns the signal "1" to the variable, and the signal "0" to the variable. A typical electrical circuit of the starting relays, to limit the current in the circuit of the control relays and create a uniform operation mode with a different number of them, is achieved by supplying power through two resistors of 10 Ohms. In this case, we mean the presence of a different number of arrows in the route from one or more. In order to maintain a balance of resistances, replacing the relay winding with a current sensor, the transition resistance, which between the terminals 1,2 and 3.4 is practically zero, you must include an additional resistance of at least R = 4 Ohms with a power of at least 5 watts. The analysis of relay block circuits like block of "single slip switch control" and block of "double slip switch control", showed that a number of relay contact connections can be implemented using a microprocessor software. In the block of "single slip switch control" block, these connections include the rear-connected rear contacts of the 2PU and 2MU relays between terminals 2-8 and 2-9 of the route accumulation elimination circuit. In the microprocessor block of "single slip switch control" block software, this function is determined by the expression in Fig. 2. In the block of "double slip switch control" relay block, the rear contacts of the relay PU2 and MU between terminals 2-8 and 2-9 are connected in series, the rear contacts of the relay PU1 and MU between terminals 18 and 19, and the front contacts PU1 and PU2 are also connected in parallel between the terminals 2-7 and 2-5 of the control circuit of the arrow electric drive of the paired arrows.

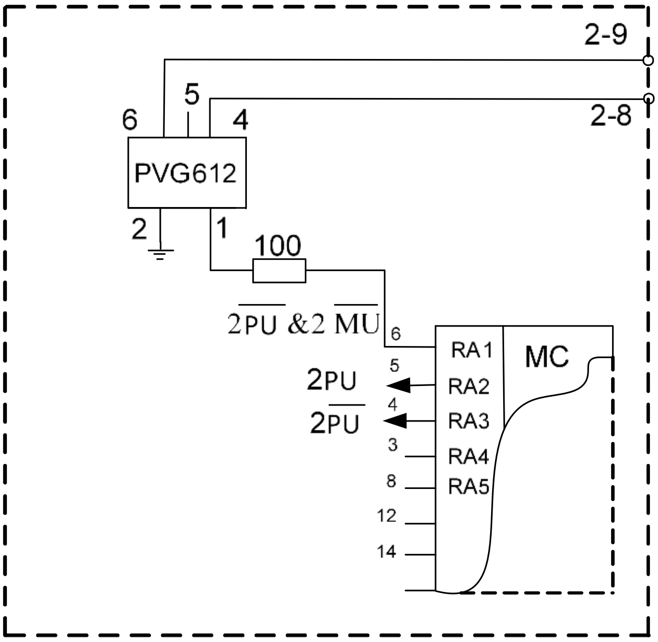

Fig. 2 Scheme of the implementation of the function $\overline{2PU}\&\overline{2MU}$of the microprocessor block of "single slip switch control"

In the microprocessor "double slip switch control", block microprocessor software, these connections are reflected by variables, and for the implementation of these functions, one optorelay of Fig. 3

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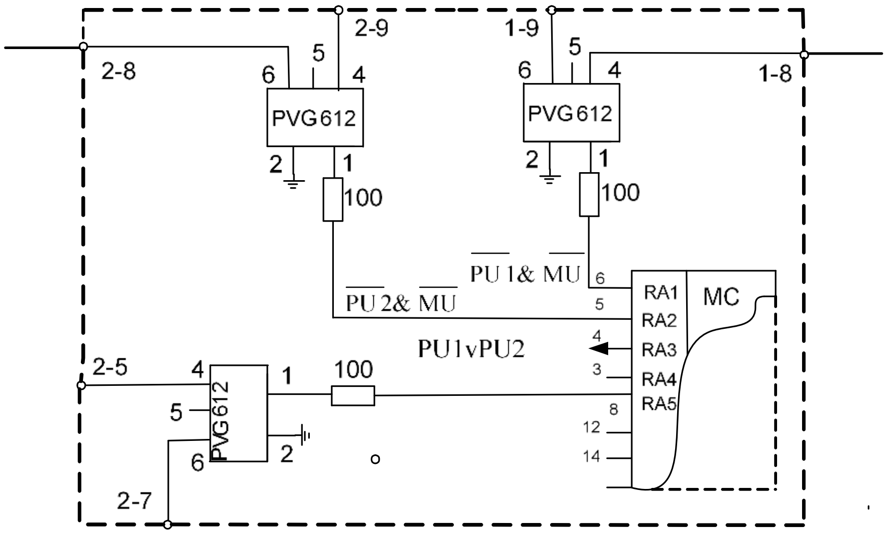

Fig. 3 Scheme of the implementation of the function of
$\overline{PU2}\&\overline{MU}, \overline{PU1}\&\overline{MU}, PU1 \cup PU2$ in the microprocessor block of “double slip switch control”

In [1], using Petri nets, models of electrical circuits of starting control relays, push-button relays and matching circuits were investigated. However, in these papers, a generalized model of the operation of the microprocessor block of “single slip switch control”, and microprocessor block of “double slip switch control”, are not considered.

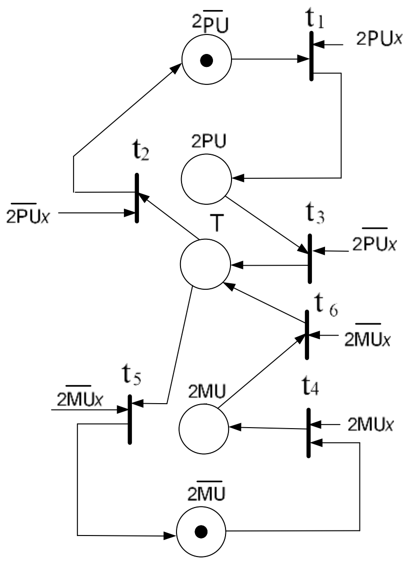

Fig. 4 Graph of the Petri net of the generalized block model microprocessor block of “double slip switch control”

Consider the work of the graph of a generalized model of the microprocessor block of “single slip switch control” fig. 4, where the position reflects the state of variables equal to $2PU = 1$, with $\overline{2PU} = 0$, the position reflects the value $\overline{2PU} = 1$ with 2PU = 0. In accordance with this, the positions are similar, and if 2MU = 1, then $\overline{2MU} = 0$ and vice versa. The variable reflects the state of the electrical circuit of the positive control relay, 2PUx in the presence of conditions for the closure of this circuit, this variable is 2PUx = 1, and the variable $\overline{2PUx} = 0$, and vice versa, in the absence of an electric circuit, this variable takes a value equal to $\overline{2PUx} = 1$, and the variable

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2PUx = 0,. Similar reasoning is also valid for variables and reflecting the state of the electric circuit of the negative control relay. The position reflects the state of the timer delay time of 500ms. For a Petri net graph, the extended input (I) and output (O) functions are:

Consider the work of a generalized model of the microprocessor block of "single slip switch control". In the initial state, when no routes are set, all switch control relays are without current, so the $2\overline{MU}$ and $2\overline{PU}$ variables are equal to 1, which is reflected by the presence of chips in these positions of the graph. Accordingly, the variables $2MU$ and $2PU$ are equal to zero and their positions do not have chips. Consider the option when the switch of the microprocessor block of "single slip switch control" block participates in a given route, which runs along its positive position. In this case, an electrical circuit of the positive control relay must be created, i.e. the variable is $2PUx$ not equal to zero. In this case, conditions are created for the execution of the output function $O(2\overline{PU}) = \{t_1\}$, because the transition has the following input function $I(t_1) = \{2\overline{PU}, 2PUx\}$ there are conditions for starting the transition, and the chip must move to the position, according to the input function $I(2PU) = \{t_1\}$. Then the graph will take the form of Fig. 5

$I(2PU) = \{t_1\}$;	$O(2PU) = \{t_3\}$;
$I(2\overline{PU} = \{t_2\}$;	$O(2\overline{PU} = \{t_1\}$;
2MU $= \{t_4\}$;	$O(2MU) = \{t_6\}$;
$I(2\overline{MU} = \{t_5\}$;	$O(2\overline{MU} = \{t_4\}$;
$I(T) = \{t_3, t_6\}$;	$O(T) = \{t_2, t_4\}$;
$I(t_1) = \{2\overline{PU}, 2PUx\}$;	$O(t_1) = \{2PU\}$;
$I(t_2) = \{2\overline{PU}x, T\}$;	$O(t_2) = \{2\overline{PU}\}$;
$I(t_3) = \{2PU, 2\overline{PU}x\}$;	$O(t_3) = \{T\}$;
$I(t_4) = \{2MU, 2\overline{MU}\}$;	$O(t_4) = \{2MU\}$;
$I(t_1) = \{2MU, 2\overline{MU}x, T\}$;	$O(t_5) = \{2\overline{MU}\}$;
$I(t_6) = \{2MU, 2\overline{MU}x\}$;	$O(t_6) = \{T\}$;

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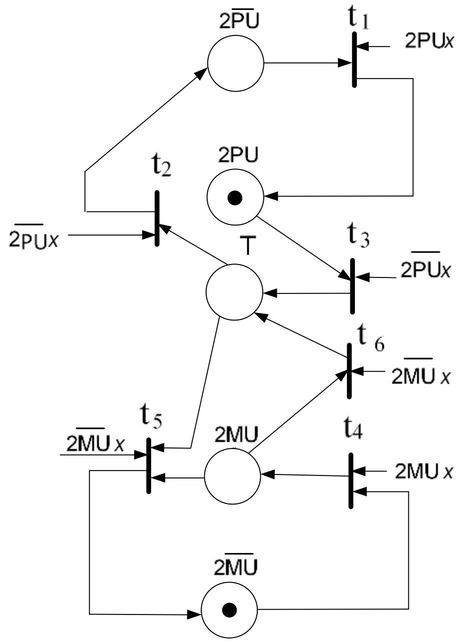

Fig. 5 Graph of the Petri net of the generalized model of the microprocessor block of “single slip switch control” when simulating the operation of the plus control relay.

The presence of chips in the position $2PU$ creates conditions to run the transitions and, according to the output functions $O(2PU) = (t_2, t_3)$. transition can be launched in the implementation of the conditions of functions $I(t_2) = \{2PU, 2\overline{PU}x, T\}$, that is when the relay 2PU is under current electric chain is broken and there is an excerpt time 500 msec. in this case the transition not start because there is electric chain response relay $2PUx = 1$ and timer exposure time not counts a given time. when breakage Circuit positive manager relay variables $2PUx$ and $2\overline{PU}x$ take respectively value of 0 and 1. Algorithm of the electric centralization at the same time can not be created two electric chain positive and negative manager relay, so for the time positive relay variable $2\overline{MU}x$ always equal to 1. the absence of Circuit creates conditions for the implementation of the input functions $I(t_3) = \{2PU, 2\overline{PU}x\}$, ie. electric chain open and variable is $2\overline{PU}x$ equal to 1 and chip is in the position. chip in the position will move after the end of reference timer exposure time 500ms. count in this case will take the form figure 6. exposure time 500ms. and the presence of chips in the position creates conditions for the implementation of the output functions $O(T) = \{t_2, t_4\}$ and input the transition functions $I(t_2) = \{2PU, 2\overline{PU}x, T\}$. consider options response and run the transition is t_5 not necessary because minus control relay in this case does not work. Launch of the transition t_2 provides the transfer of chips from the position in the position $2\overline{PU}$ and count becomes the original state of figure 1 similar arguments apply to the model power microprocessor block of “single slip switch control” when installing the route on the negative the status of switches.

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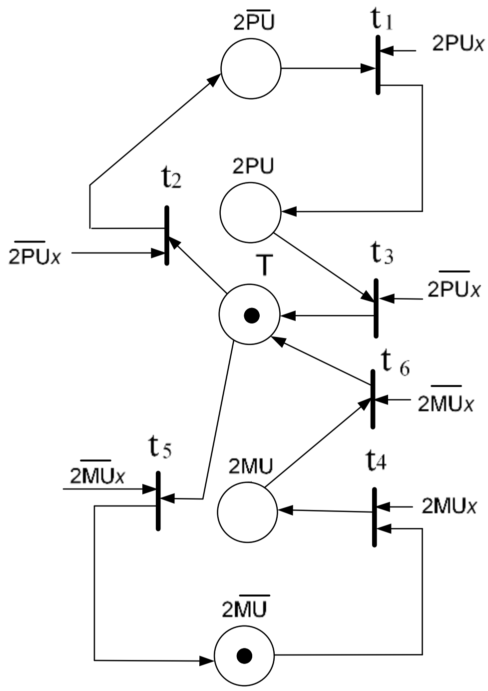

Fig. 6 Petri nets generalized the model power microprocessor block of “single slip switch control” modeling the end of the time of delay time in 500ms

Consider the work of a generalized model of the microprocessor block of “single slip switch control” block. The models of the positive control relays of this block are identical to the similar relays of the microprocessor block of “single slip switch control” block. The difference between the operation of these relays is that in the microprocessor block of “double slip switch control” block it is possible to simultaneously establish a route according to the plus positions of the arrow. This explains the need for two independent timers. The Petri net graphs of these relays are shown in Fig. 7.

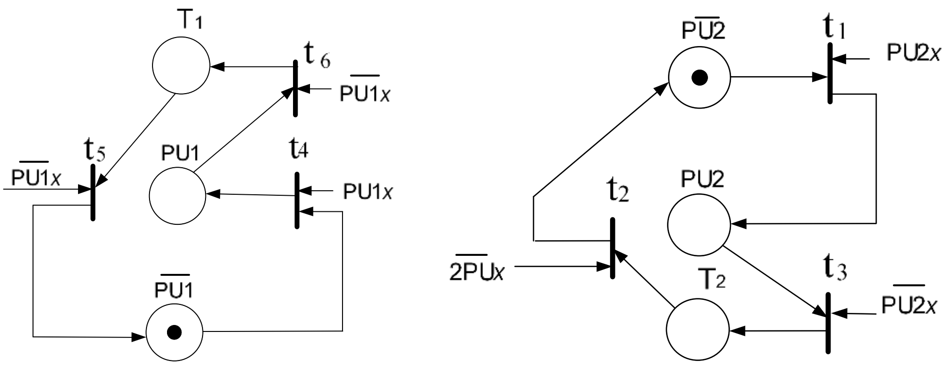

Fig. 7 Graph of the Petri net of the generalized model of the microprocessor block of “double slip switch control” for plus relay control relays

Relay graphs of the angular and negative control relays will have a similar appearance as shown in Fig. 7, with a corresponding change in position.

Consider the algorithm of the microprocessor block of “single slip switch control” shown in Fig. 8. It can be seen from the algorithm that, if there is power, the microprocessor sets to the block all the inverse variables of the plus and minus control relays, as well as the logic assembly variable $2PU\&2MU$. Then the processor analyzes the current value of the electric circuits of the positive

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start control relay, in the absence of the latter, the current of the negative control relay is analyzed, in the absence of such a program returns to the beginning. Consider the option of setting the route to the positive position of the arrow, i.e. there is an electric circuit, which is reflected by the non-fulfillment of the condition $2PUx = 2{,}5\ V$. block 2. The cycle is repeated until the conditions for breaking the electric circuit are created. In this case, the condition 2PUx = 2.5 V. is fulfilled, and the program from block 4 moves to block 5. where the state of the variable is determined, because this variable is equal to "1", then a time delay unit 10 is included in the work, which simulates the time delay for the 2PU relay to fall off. The algorithm works in a similar way when setting the route minus the arrow, then the work occurs according to the 2MU variable of the microprocessor block of “single slip switch control”.

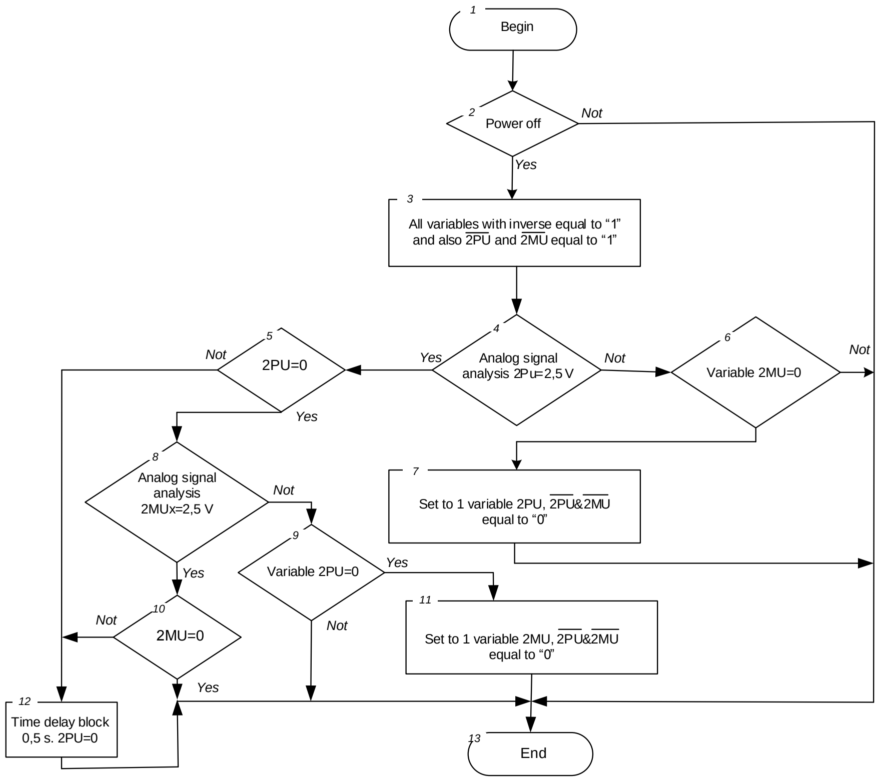

Fig. 8 Algorithm of work of microprocessor block of “single slip switch control”

Consider the operation algorithm of the microprocessor block of “double slip switch control”, the difference from which is the presence of the second positive control relay and an angular relay. A feature of the operation of the microprocessor block of “double slip switch control” is that two positive control relays can be simultaneously under current. Figure 9 shows the algorithm of the subroutine of the second positive control relay of the microprocessor block of “double slip switch control”. In addition to this, the software of the unit also has control subroutines for the first plus control relay, negative control relay and angular relay. In the algorithm of the subroutine of the negative control relay, the safety requirements are met, namely, when the MU relay is activated, the de-energized state of both positive relays must be checked, block 3 of the algorithm of the subroutine of the control negative relay Fig.10.

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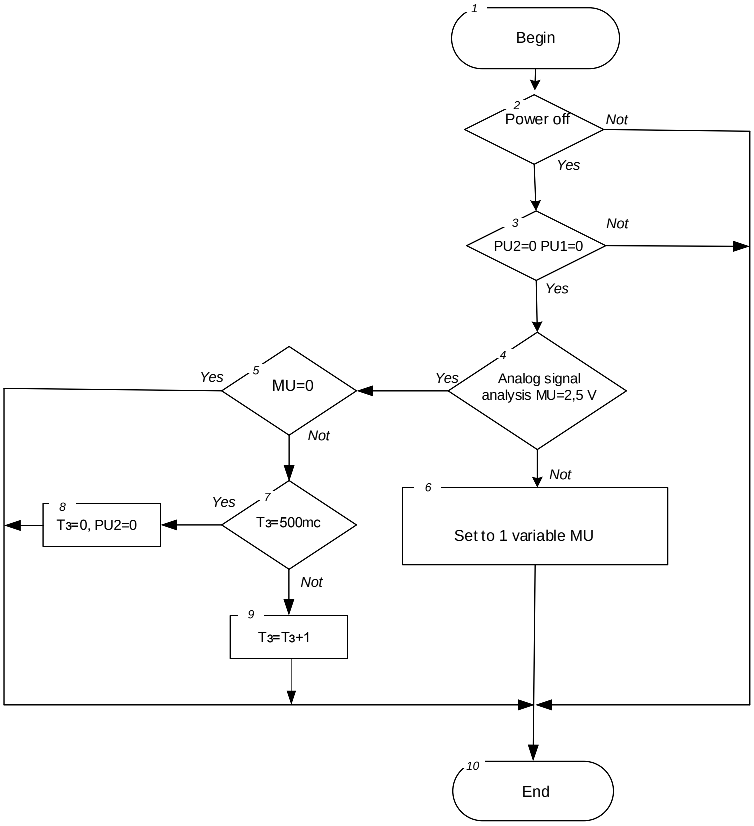

Fig. 9 Algorithm routines management plus managet relay second switchs block microprocessor block of"double slip switch control".

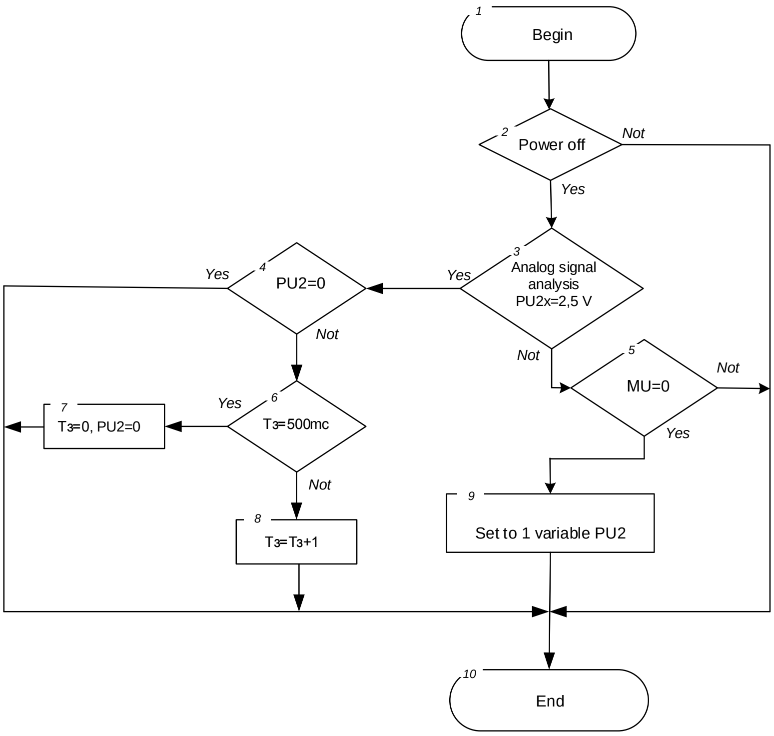

Fig. 10 Algorithm routines management minus manager relay microprocessor block of"double slip switch control"

The algorithm of the entire microprocessor block of "double slip switch control" is shown in Fig. 11. As a result of the application of microelectronic technologies in devices of railway

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automation and telemechanics of microprocessor devices, we can conclude that these devices are completely identical in their functionality to relay analogs. With their use, reliability will be improved, due to the rejection of mechanical contacts of the railway automation and telemechanics relay, electricity consumption will be reduced, and the country import independence from the supply of electromagnetic relays will be ensured.

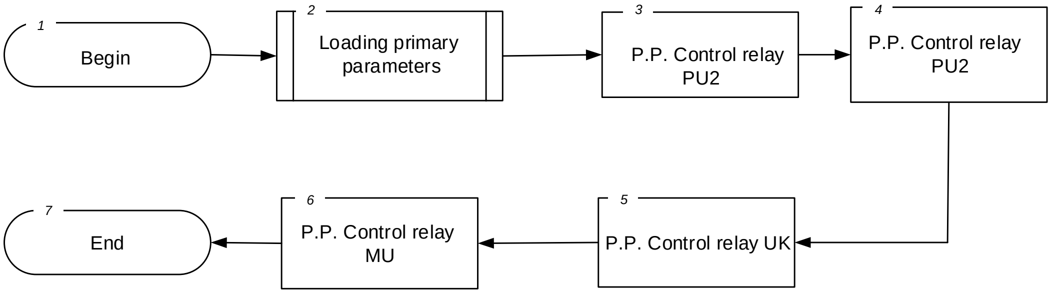

Fig. 11 Algorithm of work of microprocessor block of“double slip switch control”

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