JOURNAL OF TRANSPORT

ISSUE 1, 2025 vol. 2
E-ISSN: 2181-2438
ISSN: 3060-5164

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VOLUME 2, ISSUE 1
MARCH, 2025

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TASHKENT STATE TRANSPORT UNIVERSITY

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SCIENTIFIC-TECHNICAL AND SCIENTIFIC INNOVATION JOURNAL

VOLUME 2, ISSUE 1 MARCH, 2025

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Analysis of the algorithm for the operation of anti-repetition, auxiliary final and intermediate relays in the dialing group blocks NM2P and NM2AP, which control two combined shunting traffic lights of the railway automation and telemechanics system

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Abstract: The article analyzes automation and telemechanics systems, as well as signaling, centralization and communication devices at railway stations. The question of improvement of group dialing blocks (NM2P and NM2AP) controlling two combined shunting traffic lights of the "BMRM" system, which is considered to be one of the systems of railway automation and telemechanics, i.e. creation of their microprocessor variant, is considered. At the same time algorithms are being developed and software is being created for each working circuit of anti-repeat, auxiliary final and intermediate relays. It is planned to create a prototype of the above-mentioned NM2P and NM2AP units based on the developed software and industrial controllers.

Keywords: relay, relay system, route, shunting traffic light, electromechanical, microprocessor system, microelectronic, microcontroller, PLC industrial controllers

1. Introduction

Today the introduction of modern and energy-efficient technologies and devices in all industries is one of the urgent tasks.[4] In this regard, it is also worth noting that the introduction of new and modern centralization systems based on microprocessors does not always increase economic efficiency, because of the high cost of such systems requires a long time for their payback.[11] However, when creating modern centralization systems, one of the most alternative solutions is to use the existing architecture and algorithm of BMRM system operation, proven in production for years. In addition, it is much easier and more cost-effective to modernize an existing system piecemeal than to upgrade it completely[6].

2. Methodology and empirical analysis

In the BMRM system, the anti-repetition relays OP, PP and MP, the auxiliary intermediate relay VP, the final VK and VKM are considered second-stage relays and are energized from the direction circuits through the contacts of the push-button relay. The power is supplied from the end of the circuit depending on the type and direction of the route, which is determined by pressing the start button.[8] These relays remain energized until the route is fully established. They, in turn, energize the automatic push-button relay (second circuit), which turns off the push-button relay (first circuit), and the relay controlling the arrow relay (third circuit).[1]

The anti-repetition relay determines the start of the route and its type in route dialing schemes.

These include:

- PP -train route anti-repetition relay;
- OP -general anti-repetition relay;
- MP – shunting route anti-repetition relay.

The shunting route anti-repetition relay MP is installed in the blocks of the shunting traffic lights NMI, NM2P, NM2AP.[9] In the block of the NPM train traffic lights, two anti-repetition relays OP and PP are installed. The general anti-repetition relay OP operates on train and shunting routes, while the PP relay operates only on train routes.

The anti-repetition relay contacts are involved in switching on the starting (compliance scheme - the fourth chain of the route set), the control section (the first chain of the execution schemes) and the signal relay (the second chain of the execution schemes).

In order to develop a modern microprocessor version of the dialing group block НМ2П, which controls two combined shunting traffic lights, we analyze the scheme and operation algorithm of the auxiliary final and intermediate relays in the block.[5] When setting a route from an optional M signal controlled by the NM2P block, power is supplied to the NM or CHM bus and the MP relay in the NM2P block switches to the energized state. This is the first condition for the MP relay to switch to the energized state, which is expressed as follows:

1 condition: [(2-14) ∧ KN ∧ MG=1] [MP=1]

After the push-button relay is de-energized, the MP is connected to the supply via a self-locking circuit through its own contact and the back contact of the signal relay, which is expressed as follows:

2 condition: [(1-9) ∧ MP ∧ KN ∧ MG=1] [MG=1]

Based on the above two conditions, the MP relay operation algorithm is as follows:

[a] https://orcid.org/0009-0007-7852-6554
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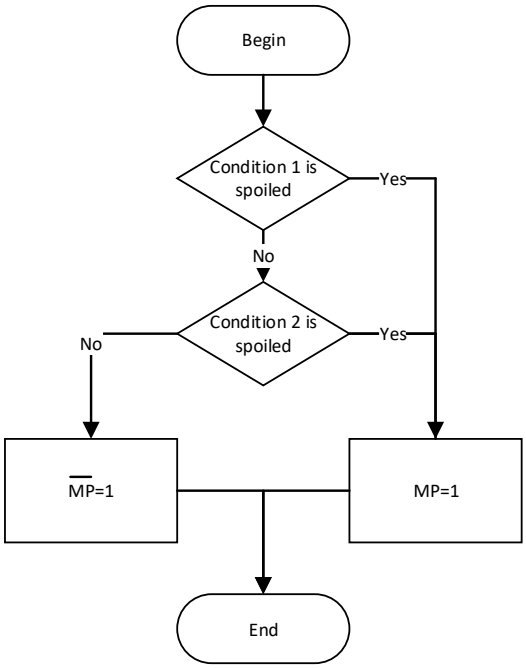

Fig. 1. MP relay operation algorithm

When the permitting signal opens at the traffic light on the selected route, the MP relay is de-energized through the signal relay contact.

Auxiliary final relays determine:

− VK - the end of the train route.

− VKM - the end of the shunting route

The VKM relay is installed in the NMI, NM2P and NM2AP shunting traffic light blocks. In the NPM block, the VK and VKM relays are installed.[2]

This relay is turned on when the traffic light button on the control device is pressed as a final and serves to turn on the automatic push-button relay (AKN) and the turn signal control relay (PU and MU) circuits, and in the executive group, the final shunting relay is turned on by the VKM relay contacts.

The conditions for switching the VKM relay to the energized state in the NM2P and NM2AP blocks are as follows:

1 condition: [(2-16) ∧ KN ∧ MG=1] [VKM=1]

When the push-button relay switches to the de-energized state, the terminating relay locks itself through its contacts and maintains its energized state.

2 condition: [(2-12) ∧ VKM ∧ KN ∧ MG=1] [VKM=1]

The auxiliary final relay VKM is de-energized through the locking relay contact after the route is fully installed and electrically locked.

Based on the above conditions, the algorithm for the operation of the VKM relay, which completes the shunting route, can be expressed as follows:

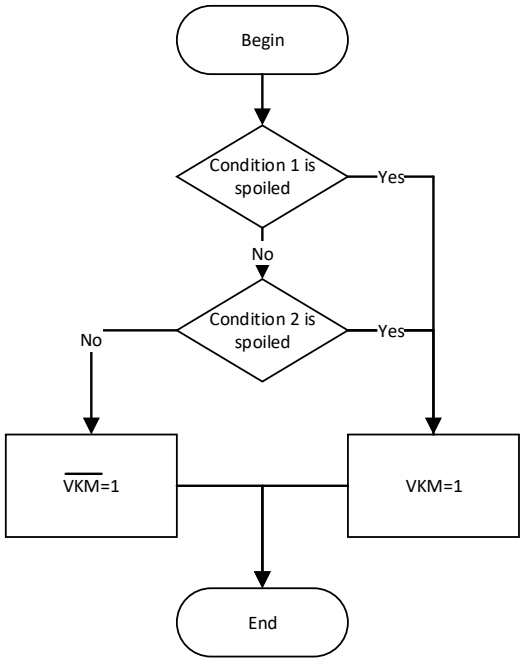

Fig. 2. VKM relay operation algorithm

If the train route does not include shunting traffic lights or the shunting route is formed in the opposite direction, the auxiliary intermediate relay VP is turned on in the blocks controlling these traffic lights (the MP and VKM relays do not work in the blocks).[3]The activation of the push-button relays of both elementary routes is checked through the VP relay circuit. The circuit for switching the VP relay to the energized state is as follows:

1 condition: [(1-16) ∧ KN ∧ MG=1] [VP=1]

2 condition: [(2-12) ∧ VP ∧ KN ∧ MG=1] [VP=1]

Based on the above conditions, the operation algorithm of the VP auxiliary intermediate relay can be expressed as follows:

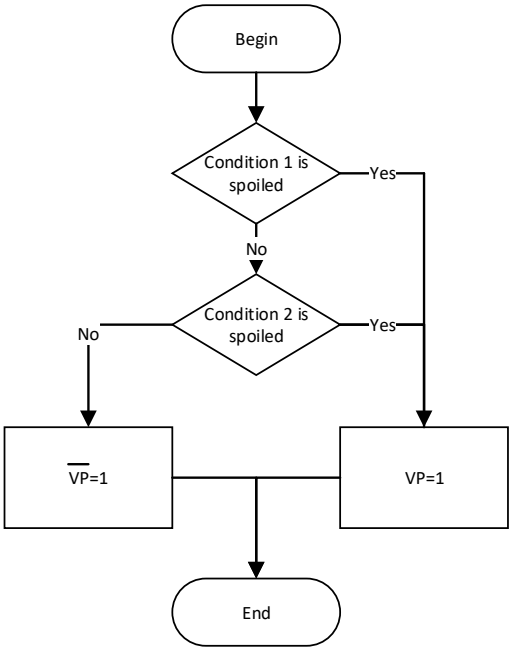

Fig. 3. Algorithm of operation of the VP relay

It is possible to upgrade VKM, VP, and MP relays based on electromagnetic relays by introducing a logical sequence of operations into modern industrial controllers based on the above-mentioned operating algorithm.

To do this, the MP relay operating circuit (Figure 4) must be expressed in the ladder programming language used in programming many industrial controllers.

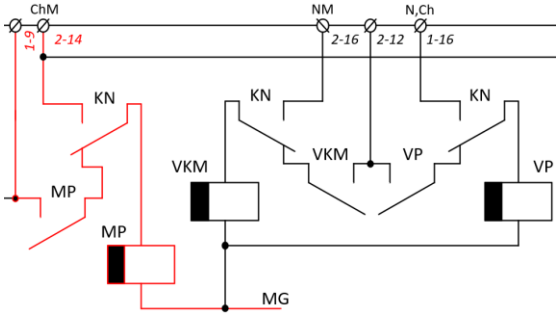

Fig. 4. MP relay operating circuit

3. Results and Discussion

According to the working circuit of the MP relay, for the relay to switch to the energized state, there must be a positive supply at inputs 2-14, the KN relay must be energized, and there must be a negative supply to MG. This sequence is as follows in the ladder programming language. Figure 5.

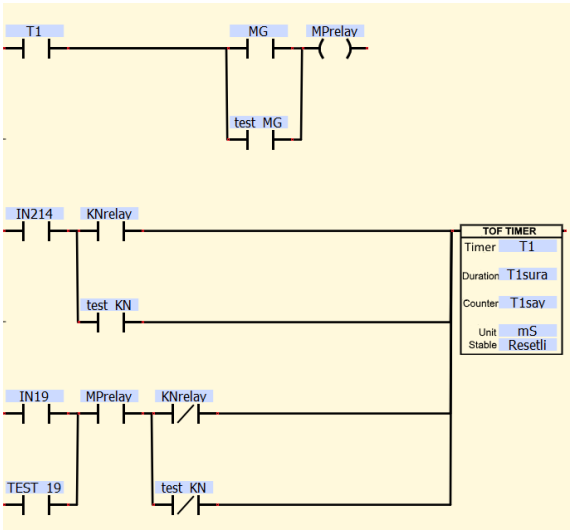

Fig. 5. MP relay software in ladder programming language

The working circuit of the VKM and VP relays (Figure 6) in the ladder programming language is similar to the MP relay program, but there are differences in the inputs and outputs.[7] According to the working circuit and algorithm of the VKM relay, two conditions must be met for the relay to switch to the energized state.[10]

Condition 1: There must be a positive supply at inputs 2-16, the KN relay must be energized and a negative MG supply must be available;

Condition 2: There must be a positive supply at inputs 2-12, the KN relay must be de-energized, the VKM relay must pass through its contact and a negative MG supply must be available;

These sequences are written in ladder programming language as follows. Figure 7.

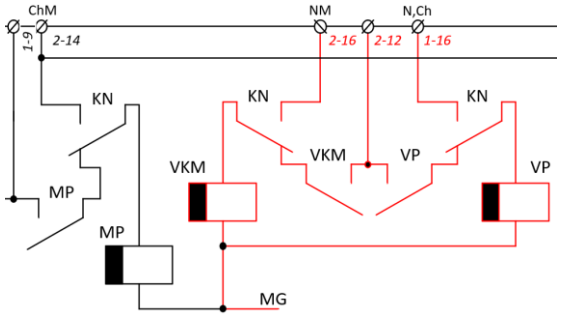

Fig. 6. The working circuit of the VKM and VP relays

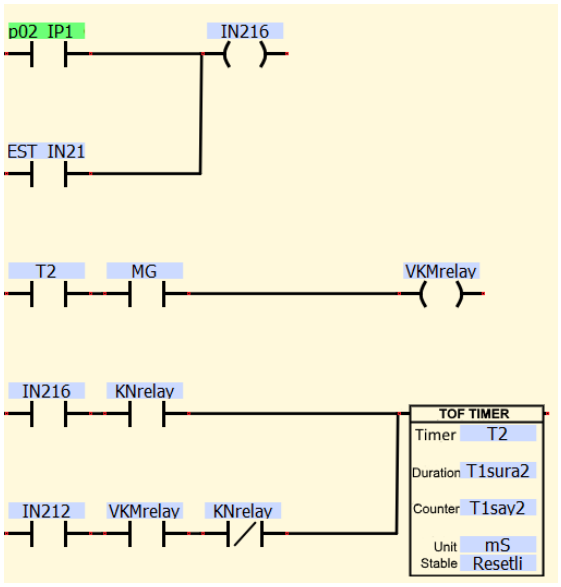

Fig. 7. VKM relay software in ladder programming language

According to the working circuit and algorithm of the VP relay, two conditions must be met for the relay to switch to the energized state. [12]

Condition 1: There must be a positive supply at inputs 1-16, the KN relay must be energized, and the minus MG supply must be available;

Condition 2: There must be a positive supply at inputs 2-12, the KN relay must be de-energized, the VP relay must pass through its contact, and the minus MG supply must be available;

These sequences are as follows in the ladder programming language (Figure 8).

Since the VKM, VP, and MP electromagnetic relays have a delay in de-energizing during de-energizing, a TOF timer is used in the software.

This ensures that the relay remains energized for three seconds when the relay power is disconnected, and during this time it begins to receive power through a self-locking circuit.

https://doi.org/10.56143/2181-2438-2025-1-201-204 Research, Innovation, Results

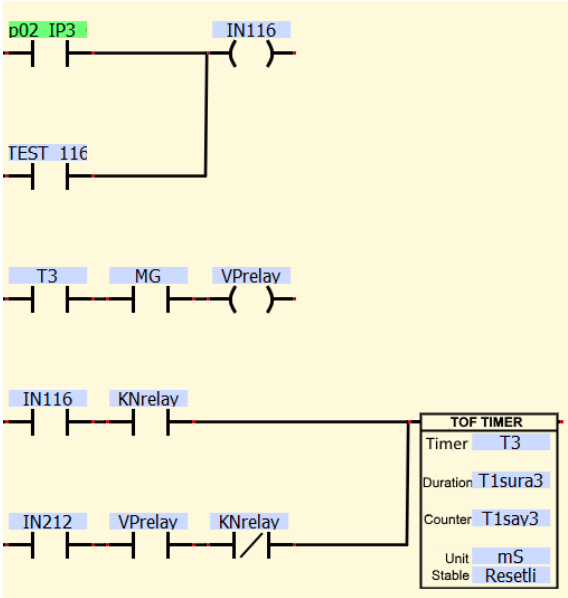

Fig. 8. VKM relay software in ladder programming language

4. Conclusion

The development of the control unit of the two combined shunting traffic lights of the railway automation and telemechanics system, that is, the development of modern industrial controllers, has advantages over existing electromagnetic relay units in terms of energy efficiency, compactness, and the presence of additional functions to expand capabilities. In addition, the development of new technical solutions and the use of modern innovative devices to increase safety and speed of transportation in the railway transport sector are relevant.

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