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Analysis of the operating algorithm of switches in local control mode

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Abstract: This article provides a theoretical and practical analysis of the issues related to local control of railway switches at stations operating under electric interlocking (EI) systems. The main objective of the research is to analyze and improve local control schemes that ensure the safe and reliable execution of shunting operations at railway stations. The study compares existing control methods, particularly those performed through central control panels and maneuvering posts, and highlights their operational contexts.

Within the research, the structure and operating principles of local switch control based on the four-wire control scheme commonly used in electric interlocking systems are examined. The article investigates how commands issued by the station operator are executed through electromagnetic relays, providing a detailed analysis of relay sequences and their respective functions based on schematic diagrams. The interconnection of control current sources, switch motors, track conditions, and relays within the local control scheme is clearly explained. As a result of the analysis, it is demonstrated that existing control schemes provide a high level of safety and operational reliability at stations. The technical solutions presented by the author can play a significant role in the modernization of electric interlocking systems.

Keywords: Switch, local control, shunting column, electric interlocking, station, route, relay, algorithm

1. Introduction

In the conditions of electric interlocking, shunting operations are carried out in two ways:

1. **From the control panel** — In this case, shunting operations are performed along routes that are locked in the same manner as train routes. The difference is that a shunting signal can open towards an occupied track or a section at the head of the station without a turnout (i.e., without changing tracks). However, it is closed after the train passes or after the first turnout section beyond it is vacated (i.e., the extinguishing of the signal differs from a regular train signal).

2. **From shunting columns, posts, and towers** — This method is used in cases where not only routed movements are required, but also when shunting is performed by pushing or along short shunting routes where traversing the entire route is not possible or not advisable [1-3].

At stations where large volumes of shunting operations are carried out, electric interlocking devices allow switching the turnouts in shunting areas to local control — this is done through control panels or shunting columns. The appearance of a shunting column is shown in Figure 1 [4].

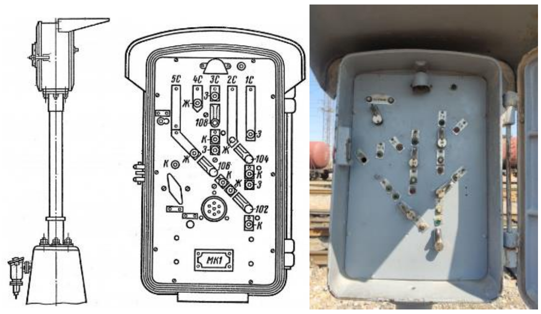

Figure 1. View of the maneuvering box

2. Research methodology

There are two types of local control schemes for turnouts, and they are used in the following systems:

- Centralized interlocking systems for intermediate stations with relay-based interlocking and a local power supply.
- Route-relay interlocking with blocking routes.

In this article, we will examine and analyze the operation algorithm of the local control scheme for turnouts in the first system

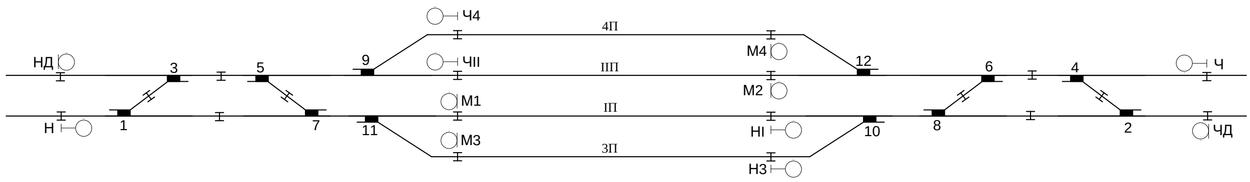

Figure 2. Single-track station layout

To control the turnout using a four-wire scheme (Figure 3.), four wires are laid from the ДСП post to the relay cabinet: P3 and P4 are used to operate the turnout relay (12ПС), while K1 and K2 are used to create the control circuit. From the relay cabinet to the electric drive, nine wires are laid.

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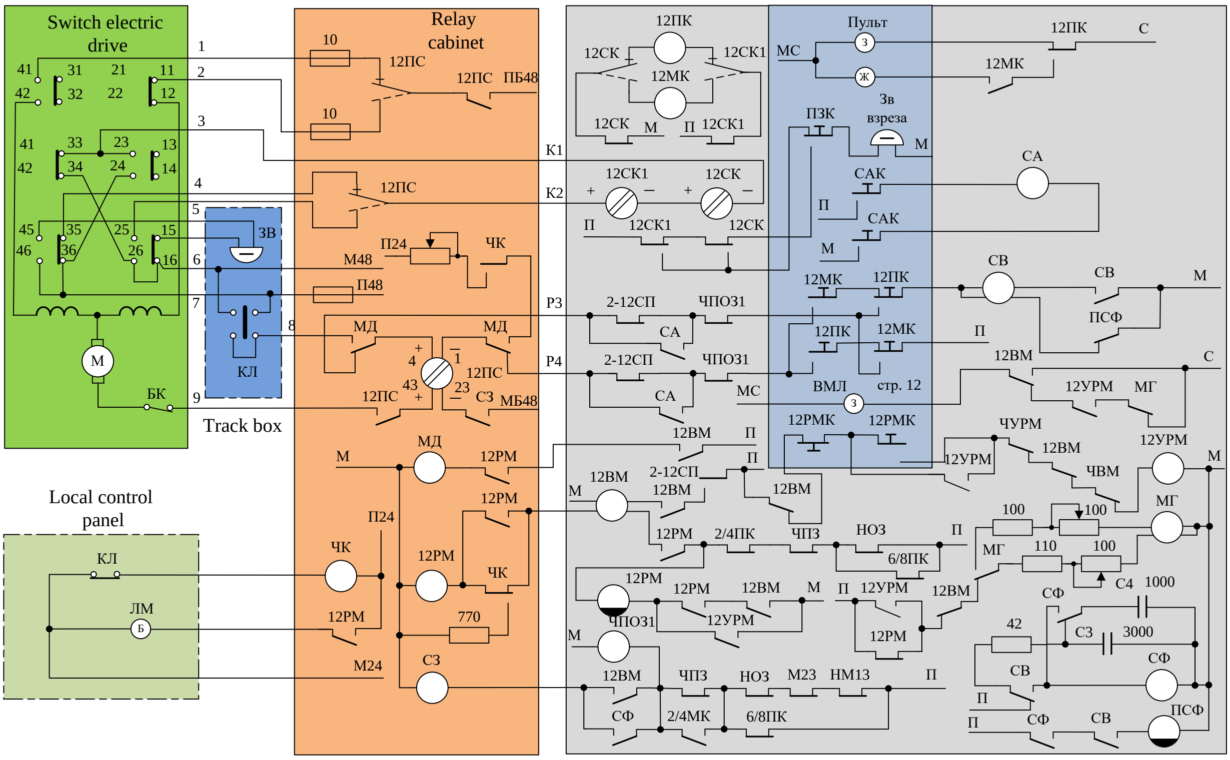

Figure 3. Four-wire turnout control circuit

At each thrown position of the switch, a control circuit is formed, and its elements are used to display the switch position on the control panel. In the given diagram, the state of the control circuit elements corresponds to the switch's physical (plunger) position. The switch control relays 12CK1 and 12CK are powered with properly polarized current along the network.

Figure 4 shows the algorithm of how the station dispatcher manages and monitors the switch. In order to operate the switch from the control panel, the following steps are performed:

1 – The "+" or "–" switch button is pressed.

2 – It is checked that no route is set in the station's paired throat.

3 – The switch section is checked for availability (it must be unoccupied).

4 – It is confirmed that the switch is not under local control.

5 – Based on the button pressed, the polarity of the PS relay is changed.

6 – It is checked that the block contact in the electric drive has not been broken.

7, 14 – A bell rings while the switch is changing position.

8, 15 – The electric motor operates for 7–9 seconds. This will be discussed in detail later.

10, 17 – The switch position indication lights up.

18 – If a cut or interruption occurs in the switch circuit, a bell rings.

13 – If the above conditions are not met, the switch cannot be operated.

11, 12 – If false occupancy is detected in the switch section, the station dispatcher presses the CAK button.

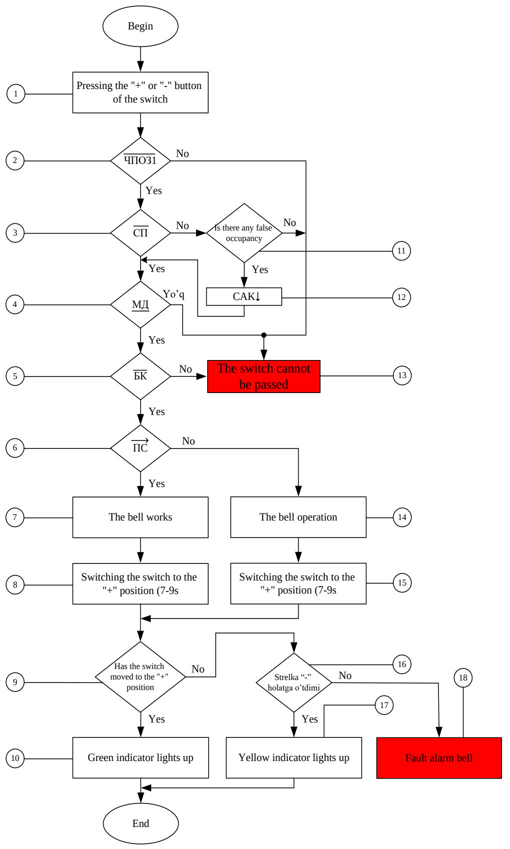

Figure 4. Algorithm of switch control and monitoring by the station dispatcher

П48 – (35-36)АП - ПС(Н) – К2 – 12СК1

– 12СК – К1 – (33-34) АП – М48

When the СК relay is activated, the neutral and energized anchor contacts connect, thereby creating the switching circuit of the pilus control relay 12ПК. The green light on the control panel lights up through the previous contact of the 12ПК relay. During the switch operation or in the incorrect position (vzrez), the control relays at the АП contacts are turned off, and the green light on the control panel goes out. The incorrect position buzzer is activated through the rear contacts of the СК relay. This buzzer is turned off by pressing the П3К button on the ДСП. When the П3К button is pressed, the control remains until recovery. After the switch position is monitored, the control relays turn on again, and the buzzer sounds. To turn it off, the ДСП removes the П3К button and leaves it in this state [5].

The following measures are implemented to prevent improper operation of the control circuit:

• Two switch control relays, 12СК and 12СК1, are connected in series to the control circuit, so that the ПК or МК relay only operates when the neutral and energized anchor states match in these relays. If only one СК relay is used, and its energized anchor sticks after the switch is operated, the ДСП would incorrectly control the switch position.

• The energized anchor contact of the 12ПС relay is connected to the control circuit, which is necessary for automatically checking the alignment of the switching contacts after the switch is operated and for turning off the СК relay when the 12ПС relay is triggered with a reverse polarity current.

• The supply to the 12СК relay comes from the electric drive's auto coupling, which is implemented when the line wires are connected to prevent incorrect operation.

• The control circuit of the 12СК relay has the ability to break the two-pole contacts through the auto coupling when the switch is operated or during the switch's cut-off.

• The 12СК relay circuit opens when the line wires are disconnected or connected.

To switch the switch to the "minus" position, the ДСП presses the 12МК button. Switch operation is only possible when the switch section is clear (in this case, the 2-12СП relay is on) and the switch is not linked to the route (in this case, the ЧПО31 relay is on). The ЧПО31 relay is a general recurring connection relay for the routes containing the 12th switch. These routes include:

• reception route (ЧП3),

• sending route (НО3),

• maneuver routes (М23 and НМ13).

Since the 12th switch (see Figure 1) does not enter the reception route of the 3П path, nor does it connect to the sending or maneuver routes on the 1П and 3П paths, these routes are short-circuited through the front contacts of the НО3, М23, and НМ13 relays (6/8ПК). When these conditions are met, the supply circuit with reverse polarity current is formed through the 12ПС relay (СКПШ5 type).

П – 12ПК – 12МК – ЧПО31 – 2-12СП – Р4 –

– МД – 12ПС – МД – Р3 – 2-12СП – ЧП31 – 12МК -

– СВ – ПСФ - М

He control coil of the 12ПС relay is connected in series with the СВ relay. The СВ relay, together with the СФ and ПСФ relays, forms a group of relays to protect the electric motor from overheating during prolonged operation. Upon activation, the СВ relay connects the activation circuit of the С3 relay located in the relay cabinet. After activation, the С3 relay closes the front contact in the working circuit of the electric drive and prepares this circuit for the switching of the converter.

The 12ПС relay closes the working circuit of the switch through its energized anchor and pulled neutral contacts. This circuit passes through the 43-23 current coil of the 12СП starting relay, the motor coils, and the 11-12 contacts of the АП auto coupling.

ПБ48 – 12ПС – 12ПС(П) – 2 – (11-12)АП –

– Д – БК – 9 – 12ПС – (43-23) 12ПС – С3 – МБ48

While the motor is operating and until the switch transfer is fully completed, the neutral armature of the start switch relay is held in a pulled state due to the low-resistance current coil. The relay power is cut off through the 1-4 coil once the 12МК button is released.

From the moment the 12МК button is pressed and the energized anchor of the 12ПС relay changes, the switch control relay is deactivated, the switch position monitoring is lost, and the buzzing of the switching process in the apparatus is activated.

Once the switch transfer is fully completed, the working circuit is interrupted through the 11-12АП contacts. Since the 12ПС relay is no longer powered through the current coil, it releases the neutral anchor and initiates a two-pole break of the working battery. After that, a reverse-polarity current closes the control circuit to activate the control relay.

П48 – (36-24-23)АП – К1 – 12СК1 – 12СК –

– К2 – 12ПС(П) - (25-26) АП – М48

When the 12СК and 12СК1 relays are activated, they close their neutral and polarized contacts, thereby forming the "minus" control circuit for activating the 12МК monitoring relay. Through the front contact of the 12МК relay, the yellow Ж lamp lights up on the control panel, and the buzzing for switch transfer monitoring is turned off.

From the moment the 12МК (12ПК) button is pressed, the protective circuit elements of the electric motor are activated. After the СВ relay in the start-up circuit is activated, it connects a 3000 μF capacitor—previously charged through the back contact of the СВ relay—to the СФ relay via its front contact. The СФ relay is activated by the discharge of this capacitor, pulls in the armature, and energizes both the С3 relay and the ПСФ repeater relay in the relay cabinet. The С3 relay closes the working circuit, which causes the switch to move to the "minus" position.

Once the 12МК button is released and the СВ relay is deactivated, the timing process of the protective circuit begins. This timing is carried out by the СФ relay. Even though it is disconnected from the 3000 μF capacitor via the СВ relay contact, the СФ relay remains energized and keeps its armature pulled in for 7–9 seconds due to the discharge of a 1000 μF capacitor. If the circuit operates normally and there are no obstructions, the switch will be fully transferred within this time. After the switch transfer is completed, the motor circuit is turned off through the 11-12АП contacts.

If the switch transfer is delayed or the electric motor runs too long, after 7–9 seconds the СФ relay releases its armature and deactivates the С3 relay, which results in disconnection of the motor circuit. Restarting the switch is

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only possible after this time interval ends and the armature of the ПСФ relay is released.

If false occupancy is detected in the switch section and the 2-12СП relay contacts are open, the duty operator (DСП) must verify that the section is truly unoccupied and that the rail circuits are intact. After verification, they press the САК button, which activates the СА emergency switch relay.

The contacts of the activated СА relay shunt the open 2-12СП contacts, forming a startup circuit for energizing the ПС relay.

The control scheme for paired switches is designed so that both switches are operated using a single pair of start buttons, and their transfer occurs sequentially. In this case, the switch located closer to the relay cabinet is always transferred first, followed by the one located farther away [6-7].

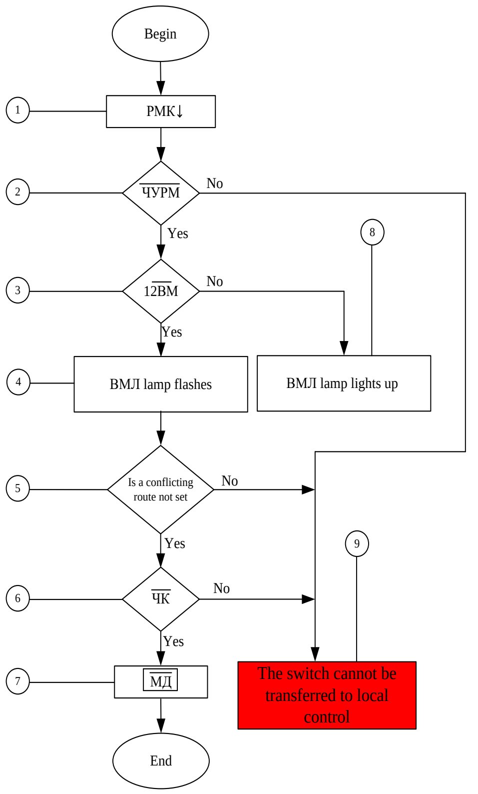

Figure 5. Algorithm for switching the turnout to local control

In Figure 5, the algorithm for switching the turnout to local control is shown. To switch to local control, the following operations and conditions must be met:

To switch turnout No. 12 to local control, the station duty officer (DShP) presses the 12РМК button on the control panel (see Figure 3), which activates the 12УРМ maneuver permission relay. This relay, through its front contacts, activates the following:

- МГ blinking relay
- ВМЛ lamp (located above the 12РМК button, blinking light)
- The self-holding circuit of the 12УРМ relay

In the activation circuit of the 12УРМ relay, the absence of other local control actions in this turnout group is verified through the back contacts of:

- ЧВМ relay
- 12ВМ relay
- ЧУРМ relay

The 12УРМ relay also prepares the activation circuit of the 12РМ maneuver permission relay. This relay is activated only when the following conditions are met:

- No route is set that would interfere with movement through turnout 12, verified by the front contacts of ЧПЗ and НОЗ relays
- The 2/4 protective turnouts are in a position guarding the local control zone, verified by the front contact of the 2/4ПК relay

If turnouts 6/8 are in the "+" position, the interference monitored by the НОЗ relay is bypassed by shunting the НОЗ contact through the 6/8РК contact.

The 12РМ relay then activates the following series-connected relays:

- 12ВМ (100 Ohm) – located at the post
- 12РМ repeater relay (4000 Ohm) – located in the relay cabinet

Due to the large resistance difference, only the 12РМ relay is activated and pulls in the armature.

In the 12РМ relay circuit, the presence of the КЛ switch inside the local control panel is verified through the front contact of the ЧК relay.

When the 12РМ relay pulls in, it lights up the ЛМ lamp on the local control panel, indicating to the maneuver agent that local control is permitted. The agent unlocks the КЛ switch, which deactivates the ЧК relay. A 770 Ohm resistor is connected in parallel to the 12РМ relay via the back contact of the ЧК relay. This reduces total resistance and increases the current enough to activate the 12ВМ relay at the post.

Upon activation, 12ВМ confirms that local control has been accepted by the maneuver agent and triggers the following:

- Deactivates the МГ blinking relay
- Switches the ВМЛ lamp from blinking to constant light, notifying the DShP that the key has been removed from the local control panel
- Deactivates the 12УРМ relay

Through the front contacts of 12ВМ and 12РМ, the МД maneuver decentralization relay in the relay cabinet is activated. This switches the 12ПС relay from centralized control to local control. From this point on, the maneuver agent can operate the turnout from the trackside box.

By inserting and turning the key in the lock of the trackside box, the agent closes a polarized circuit (either normal or reverse polarity) to activate the 12ПС relay and switch the turnout to the "+" or "–" position.

To monitor turnout switching in local control, a buzzer is installed in the trackside box, which is activated via the 15–16 and 45–46АП contacts. In local control, turnout switching is performed without checking if the turnout section is clear, which reduces false checks and speeds up maneuvering operations. However, it also requires the maneuver agent to exercise special caution with each turnout operation to avoid switching the turnout under a moving train.

After the maneuver is completed, the turnout is returned to central control. The maneuver agent inserts the local control key back into the lock on the local control panel, activating the ЧК relay. Through the front contact of the ЧК relay, the 770 Ohm resistor is disconnected from the 12ВМ relay's main circuit. As a result, total resistance increases and the current decreases to a level where the 12BM relay deactivates.

However, if the 2–12СП turnout section has not yet been cleared by the maneuvering train, the 12BM relay remains energized via the local circuit.

3. Conclusion

According to the analysis of the article, reliable and effective operation of local and central control of switches in electric interlocking systems requires complex yet precise relay-based systems built on specific algorithms. The study emphasizes that each component involved in the control, monitoring, and protection mechanisms of switch management must accurately perform its designated function. The local control mode enables maneuvering operations to be carried out quickly and efficiently, while also demanding the reinforcement of safety measures. As a result, the schemes and algorithms presented in the article play a crucial role in ensuring the safety of train movements at modern railway stations.

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