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Improvement of control devices for road sections of railway automation and telemechanics

Aziz Saitov*, *Janibek* Kurbanov, *Zohid* Toshboyev, and *Sunnatillo* Boltayev

Tashkent State Transport University, Tashkent, Uzbekistan

Abstract. In this scientific article, control sensors and control devices have been improved based on the method of counting arrows of the rolling stock of railway transport. The microprocessor-controlled control unit and control system have been simplified to manage traffic between two stations, and a self-monitoring, reliable and risky scheme has been developed. Wiring diagrams of existing transport relays have been updated for uninterruptible power supplies, microprocessor devices, and sensors. An automated schematic diagram with a microprocessor for signaling a collision of a railway with wagons has been created, and the order in which the speed of train movement approaches the crossing has been maintained. The complex functional control of rolling stock was improved based on the method of counting bullets, electronic archiving of the movement of orders of the train attendant and dispatcher, as well as the operation of devices for monitoring the technical condition of the station.

1 Introduction

Railway automation devices play an important role in organizing the technological process of railway transport enterprises. These devices ensure the safety of train traffic, always be in working order, and determine the train's location with the required accuracy. The main means of locating a train are track circuits (TC). However, there are sections where it is not possible to use the vehicle. The low reliability of the rail circuits in several cases casts doubt on the effectiveness of their use. As an alternative to TC, rolling stock axle counting devices can be used. In the general case, the principle of determining the train's location using the axle counters of the rolling stock is as follows (Fig. 1). The monitored section of the track is fenced on both sides by track sensors for counting axes S1 and S2. The number of axles passed over the track sensors is equal in the initial state, and the track section control relay (CT) is energized. Suppose there are axles of the rolling stock between the track sensors of the axle counting. In that case, the fixed number of axles passed over one

*Corresponding author: jonik_piter@mail.ru

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sensor will differ from the number of axles of the other sensor, and the deciding device (DD) will turn off the gearbox relay [1, 3, 9].

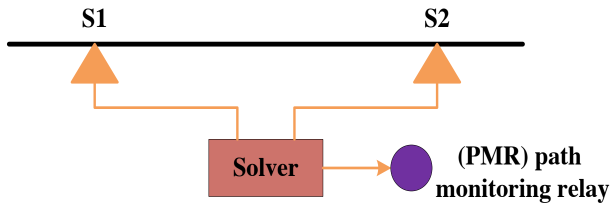

Fig.1. Block diagram of the track section vacancy control device

This scientific work proposes a complex of automation and telemechanics devices, using a device for monitoring the free track of rolling stock. These include microprocessor-based semi-automatic blocking (MBSAB), automatic block post (ABP MBSAB), microprocessor-based automatic crossing signaling (MBACS), a system of devices for monitoring the state of vacancy of station track sections (MVSTS).

2 Materials and Methods

2.1 Microprocessor-based semi-automatic blocking (MBSAB)

The MBSAB system can be used on single-track or multi-track tracks with any type of train traction and can be linked to any type of train control systems at stations that limit the track. The block diagram of the MBSAB system is shown in Fig. 2.

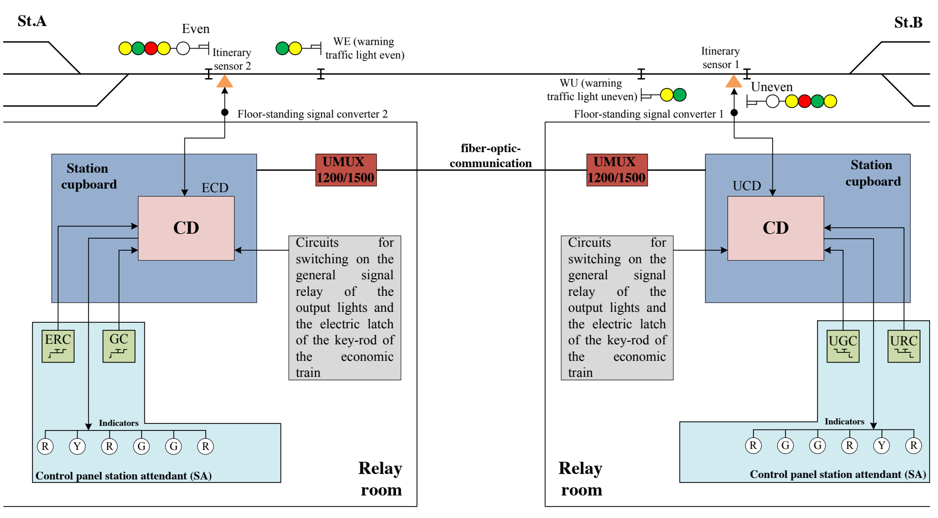

Fig.2. Block diagram of the MBSAB system

The MBSAB system includes floor and post equipment.

Floor-standing equipment includes the equipment of rolling stock axle counting points (CP), consisting of a track axle sensor (TS), an outdoor sensor signal converter (OSC), and two universal multiplexers (UMUX1, 2) for receiving and sending data over fiber-optic lines communication. Subsidiaries are located at the borders of the controlled haul at the places where the entrance traffic lights of the stations are installed that limit the haul. TS is installed on the rail base without drilling holes in it - using a specialized fastener and electrically connected to the pump station located in the cable box [2, 8, 14].

The station equipment includes the calculating device (CD), which ensures the implementation of the SAB logical dependencies, the counting of the axles of the rolling stock that followed the track sensor of this station, followed by comparison with the number of axles received from the neighboring station via the communication line (at the opposite end of the stretch), determination of the freedom of the haul, the chain of linking with the train control system at the station, control elements (buttons "Giving consent," "Canceling consent"), elements of indication of the state of the haul (indicators "Obtaining consent" OC, "Giving consent to departure" GCD, "Track departure" software, "Track arrival" TA, "Run control" of the control panel CP), uninterruptible power supply devices (not shown in the figure).

The algorithm of operation of the MBSAB system is similar to the algorithm of operation of semi-automatic blocking relay systems, with the exception of the implementation of the functions of automatic control of the freedom of the run and automatic recording of the arrival of the train at the station in full. The function of automatic recording of the arrival of a train at the station in its entirety allows remote control of the station operation. Classic examples of remote control of station operation are supervisory control when the station is controlled by a train dispatcher and the transfer of the station to the automatic mode of input and output signals along the main track. In the second case, the work of traffic lights at the station is actually controlled by the attendants at the adjacent stations, and the station itself operates in the automatic block post mode [7, 16].

2.2 Automatic block post (ABP)

Devices of a microprocessor-based automatic blocking post (MBABP) are intended for use as part of a microprocessor-based semi-automatic blocking MBABP to increase the throughput of the haul. The block diagram of the automatic block post is shown in figure 3.

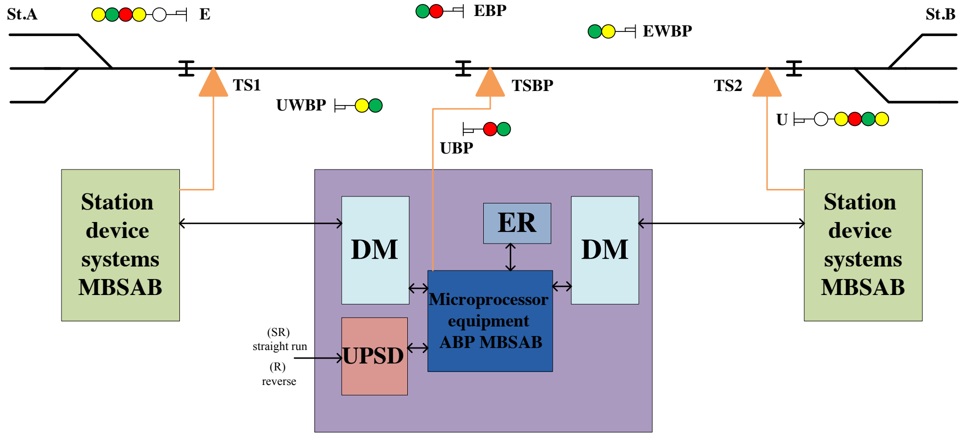

Fig.3. Block diagram of an automatic block post

MBABP devices (see Fig. 3) are located on the stretch and, in general, divide into two parts. Depending on the requirements for throughput, several block posts can be installed on the stretch. At the location of the block post, traffic lights are installed, enclosing the inter-block posts. Also, at the installation site of automatic block post devices, a rolling stock axle counting point is installed, similar to the MBSAB system.

In addition to the above, the devices of a microprocessor-based automatic block post include executive control elements located in a transportable module or relay cabinets, even warning block post (EWBP), uneven warning block post (UWBP) airbag traffic lights of the block post, rail circuits intended for coding areas of approach to traffic lights (not shown in the figure conventionally).

Executive control elements include microprocessor equipment MBABP, executive relays (ER) designed to link microprocessor equipment with executive elements (traffic lights, rail circuits, etc.), devices for matching with a communication line (DM), uninterruptible power supply devices (UPSD).

Let's consider the principle of operation of an automatic block post using the example of the passage of two even trains. For the departure of the first even train, the person on duty at station A asks the person on duty at station B to agree to the departure of the even train. The person on duty at station B confirms consent in an established manner, and the person on duty at station A makes the necessary manipulations to send an even train [6, 11, 14].

After the first train passes over the TS1 sensor (see Fig. 3), the system detects the occupancy of the first in the course of the inter-post haul, the even block post's traffic lights (EBP), and the warning EWBP light up green. These traffic lights allow the train to proceed through the block post without stopping and retain the indicated readings until the first axles of the train pass over the TSBP sensor, after which the system records the busyness of the second inter-post haul, the EBP traffic light takes a prohibiting indication, and the EWBP traffic light turns yellow. After the first train has completely traveled over the TSBP sensor, the system detects the freedom of the first in the course of the inter-post haul, and the automatic block post generates a blocking signal of the track. The MBSAB devices at station A return to their initial state, and the automatic block post automatically generates a blocking signal "Giving consent" to station A. The duty officer at station A sends the second even train to the track, which, when passing over the sensor TS1, takes over the first interpost track.

As soon as the first even train in its entirety is tracked over the TS2 sensor and the actual arrival scheme is completed, the MBSAB equipment of station B sends a blocking signal of the actual arrival to the block post and returns to its original state. At the same time, the traffic light of the block post EBP retains the prohibiting indication.

To receive the second even-numbered train, the person on duty at station B agrees to the train following the block post, after which the EBP traffic light takes a permissive indication, and a green light comes on at the EWBP traffic light. The passage of the second train to the automatic block post is similar to the passage of the first, and after complete passage to station A, it becomes possible to send the next even train. If there is no need for this, the person on duty at station A does not take any action.

After the second train in full arrives at station B, the system will return to its original state and will be ready to handle trains of any direction.

2.3 Microprocessor-based automatic crossing signaling (MBACS)

The block diagram of the MBACS system is shown in figure 4.

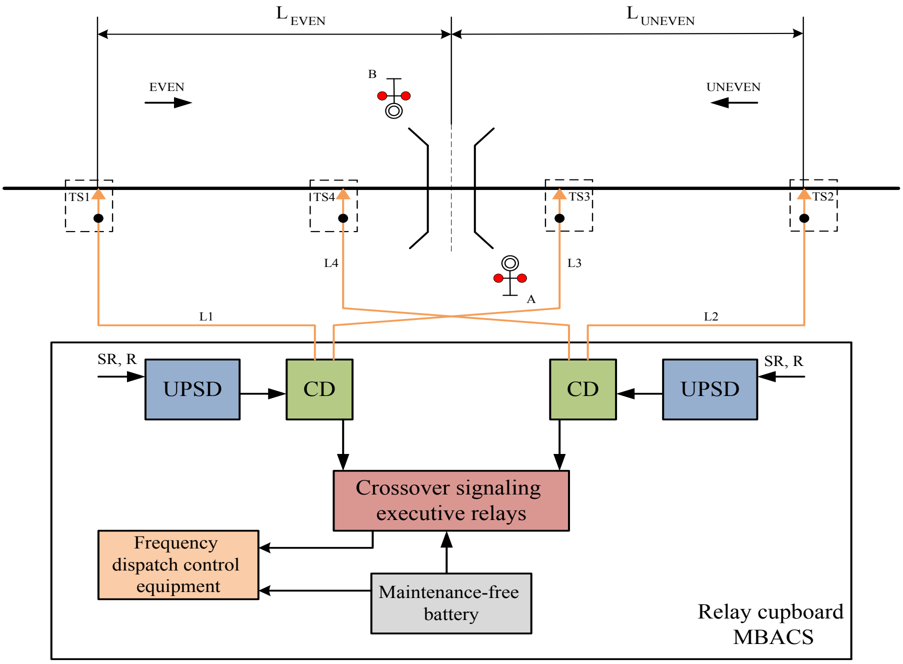

Fig.4. Block diagram of the MBACS system

The system consists of floor and post equipment. Floor-standing equipment includes axle counting points CP1 - CP4, similar to the MBACS system, crossing traffic lights; - car barriers (if any), devices for barriers of crossings (DBC) (if any).

The axes counting points are located along the boundaries of the approach (removal) sections. L_E, L_U are areas of approach from odd and even sides, respectively. The lengths of the approach sections are calculated based on the established train speed and the length of the carriageway of the crossing [10, 12].

The station equipment includes CD devices, which programmatically ensure the execution of algorithms for the operation of the MBACS system, executive level crossing signaling relays that enable the corresponding readings at crossing traffic lights and control the operation of auto barriers and DBCs (if any), uninterruptible power supply units PSU, which provide uninterrupted operation of the CD, a maintenance-free battery that ensures the operation of the operating relays of the crossing automation in the absence of an external supply voltage, the EWBP equipment, which provides information about the state of the transfer to the station in charge of the crossing, which switches on relay (SR), relay of flashing indications (F), relay control of flashing devices (CFD), which link the electronic equipment of the SF with the executive level crossing signaling relays, the AR relay, which is designed to artificially restore (AR) the initial state of the MBACS equipment in the event of a failure and after production maintenance work.

The principle of operation of the MBACS system is similar to the operation of level crossing signaling relay systems. The control of the sections approaching the crossing and the crossing section itself is carried out by the axle counting method, and the CD devices carry out the implementation of the crossing signaling algorithms and control the operation of the switching relay B. sensors and the time the train takes the removal section. If the specified sequence is violated or the train is delayed at the removal section for more than the estimated time of re-blocking, the crossing will be closed to traffic. The opening of the crossing, in this case, will occur after the train has completely cleared all controlled sections of the track by the MBACS system [13, 20, 21, 22,].

Instead of the EWBP equipment, a microprocessor control circuit can be used to transmit information about the state of the crossing to the station, which allows the signaling control electromechanics to receive more detailed information about the state of the crossing at the station.

2.4 System of devices for monitoring the state of vacancy of station track sections (DMVS)

The system for monitoring the state of vacancy of station track sections based on rolling stock axle counters (DMVS) is intended for use at stations of mainline and industrial railway transport to continuously monitor the state of vacancy of track sections. The block diagram of the DMVS system is shown in figure 5 [5, 15].

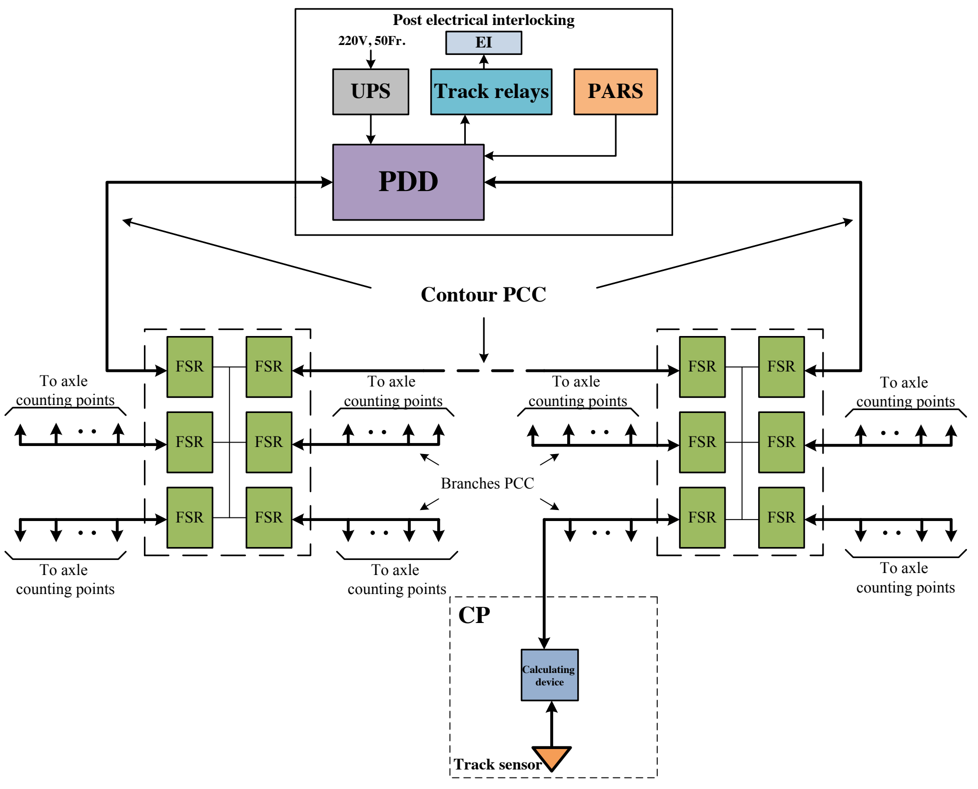

Fig.5. Block diagram of the DMVS system

The DMSS system includes axle counting points (CP), a contour and branches of a power and communication cable (PCC), floor signal repeaters (FSR), a post deciding device (PDD), travel relays (T), a panel for artificial restoration of the initial state of control devices free path (PARS), uninterruptible power supply device (UPS).

The axle counting points used in the DMVS system differ from the previous systems counting points in that the number of axles traced over the path sensor is counted directly at the counting point, and the counting result is transmitted to the station via the RS-485 interface. The post deciding device (PDD) receives information about the number of axes traced over each sensor and, according to a predetermined algorithm, determines the state of the track sections. If the track section is free, the field distributor energizes the corresponding track relay. The states of the trip relays are transferred to existing electrical interlocking systems [17-19].

3 Results and Discussion

The main advantages of the MBSAB system over relay systems are the implementation of the function of automatic transmission of the "Arrival dacha" signal, control of the logic of the train following the section, an intelligent algorithm for self-checking of counting points after malfunctions, logging and archiving of events in real time, the ability to organize remote monitoring with archiving and logging, the possibility of expanding the functionality of the system, the possibility of using these devices on sections with dispatch control of train traffic, continuous monitoring of the freedom of the haul, the ability to work via a voice frequency communication channel, including fiber-optic communication lines, a significant reduction in the amount of equipment and work on maintenance of devices, increasing the reliability of the system due to redundancy of the main elements (in the MBSAB -R version), the ability to switch stations to the automatic action mode of input and output traffic lights according to in clear ways (in the MBSAB -A version).

The advantages of the uneven block ABP system include the use of the MBSAB system as a cutting point, which allows, without changing the station devices, to organize one or several block posts on the stretch, located one after another, and, therefore, increase the throughput of the haul by several times, bringing it closer to the throughput of automatic blocking, continuous control of the freeness of inter-station passes and control of the logic of the train's progress along the haul, which makes it possible to implement the function of automatic sending of the blocking signal "giving arrival", an intelligent algorithm for self-checking of counting points after malfunctions, low-maintenance axle counting equipment is used, which reduces the cost of maintaining the system, as an inter-post communication line, cable-line-connection (CLC), fiber-optic-communication (FOC) or a dedicated voice-frequency communication channel can be used, which makes it possible to use in sections with fiber-optic communication lines, increase the reliability of the devices due to the redundancy of the main elements (in version of ABP MPAB-R), system diagnostics and control of ongoing events with logging and archiving, the ability to transfer this information to the diagnostic systems or to our own automated workplaces (AWP).

The main advantages of the MBACS system include the absence of track circuits and their elements (devices, diesel fuel, choke transformerб insulating joints, rail connectors, etc.), a decrease in the amount of equipment used (by 3.7 times for a single-track haul), a decrease (up to 40%) the volume of work performed on the maintenance of the alarm system, increasing the vandal resistance of the alarm system due to the absence of copper-containing elements, maintaining the system operability when the power feeders are disconnected due to the use of uninterruptible power supplies, the possibility of remote monitoring, reducing operating costs in track and signaling farms.

4 Conclusions

The main advantages of the system are the absence of track circuits, logging and archiving of events in real time, the ability to organize remote monitoring with archiving and logging, the ability to expand the functionality of the system, continuous monitoring of the vacancy of track sections, a significant reduction in the amount of work on the maintenance of devices. All considered systems have passed the necessary tests and are approved for use in railway transport. The experience of operating these systems has shown high reliability and protection from external factors.

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