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Features of Construction of Systems of Railway Automatics and Telemechanics at the Organization of High-Speed Traffic in the Republic of Uzbekistan

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Abstract

The most effective way to intensify the work of railway transport, improve the use of its main complex and costly technical means of transportation process management automation is using complex systems of interval control of train traffic and ensure its security. In the Republic of Uzbekistan decided to modernize its railways, where the priority is to increase the speed of passenger trains. A number of activities were undertaken to ensure the safety of high-speed trains such as the strengthening of railway tracks, update the dimensions of buildings, changing the configuration of the switches. In some areas, replaced antiquated systems of interval train traffic management with focus on devices automatic locomotive signaling.

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Keywords: systems of railway automatics; high-speed traffic; safety; interval regulation on the stretch; the mathematical model of a rail line; an algorithm; optimal parameters.

1. Introduction

The most effective means of intensification of rail transport, improving its main complex and expensive technical means is the automation of the management of transportation process using complex systems of interval railway traffic control and security. Features high-speed movements affecting safety require special approach to the design of railway automatics such as: natural phenomena (storms, earthquakes, floods, mudflows, landslides),

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comprehensive, verified the concept of “resiliency” systems taking into account the entire life cycle: application of special processes engineering critical systems, coordination with other security systems, automated diagnosis systems and devices, automatic control and accounting of the planned work, a high degree of automation Manager, operator, system decision support, training, human factors, dangerous equipment failures. From the reliability of these systems especially for high-speed lines depend largely on the rhythm of the traffic and traffic safety of trains.

As shown by Teeg & Vlasenko (2010) system of train control in its composition must have sensors to control the state of the track sections and the satisfactory condition of rail lines.

Control function busy or free condition of the track sections, depending on the specific conditions of use of the sensors in the systems of railway automatics and telemechanics, can perform device based on a different technical principles: using counters axes; radio sensors; satellite navigation and track circuits. Innovative principles alarms, such as sending permission via radio and the movable block sections, can significantly increase the line capacity where it is needed.

2. Status and problems of introduction of high-speed traffic in the Republic of Uzbekistan

In the Republic of Uzbekistan embarked on the modernization of its Railways, where the main priority is to increase the speed of passenger trains. In this direction have already been put into operation high-speed line on the plot Tashkent-Samarkand with a train speed of 150–250 km/h. Conducted a number of measures to ensure the safety of high-speed trains such as the strengthening of railway tracks, updating the dimensions of buildings, change of configuration switches. In some areas replaced legacy systems with interval control of traffic, the main attention was paid to the automatic locomotive signaling.

Characteristics of high-speed traffic, affecting the security industry require a special approach to solutions of railway automatics such as the:

1. Natural phenomena (rain, earthquakes, floods, mudflows, landslides);
2. The integrated concept of “fault tolerance” verified systems taking into account the entire life cycle: the use of special processes engineering of critical systems; integration with other security systems; automated diagnostic systems and devices, automatic control and accounting of planned works; high degree of automation, the driver manager, decision support systems; training of personnel; the human factor; the dangerous failures of equipment;
3. High speed, limited response time to a dangerous situation;
4. Performance of baud rate, electromechanics, electronics;
5. Outdoor equipment of railway automatics for high speed lines: traffic lights (for shunting at stations; optional depending on the use: for extraordinary events (for example, to produce a signal of invitation); monitoring device availability (tonal rail circuits do not require insulation joints, additionally provide rail integrity monitoring; electronic axle counting more flexibility of application, high reliability and low maintenance cost); device transfer switches.

On one of the runs it was decided to use to monitor the status of the driving instead of track circuits, axle counters, and for transmission to the locomotive of the state of the input light automatic locomotive signaling. To justify the choice of this interval control system on the stretch was developed mathematical model of a rail line on the locomotive receiver.

3. A mathematical model of a rail line on the locomotive receiver ragged when one of the threads

According to Polevoy & Aliyev (2011) the equivalent circuit rail line at the precipice of one of the rail lines is presented in the form of the overall circuit shown in Fig. 1.

The input resistance of a rail line Rl_3 is determined by the following dependencies.

$$Z_{vx1} = \frac{A_3 Z_{vxk} + B_3}{C_3 Z_{vxk} + D_3}, \quad (1)$$

where $A_3 = \cosh\gamma l_3$; $B_3 = Z_v \sinh\gamma l_3$; $C_3 = \frac{1}{Z_v}\sinh\gamma l_3$; $D_3 = \cosh\gamma l_3$ – the coefficients of the quadrupole Rl_3.

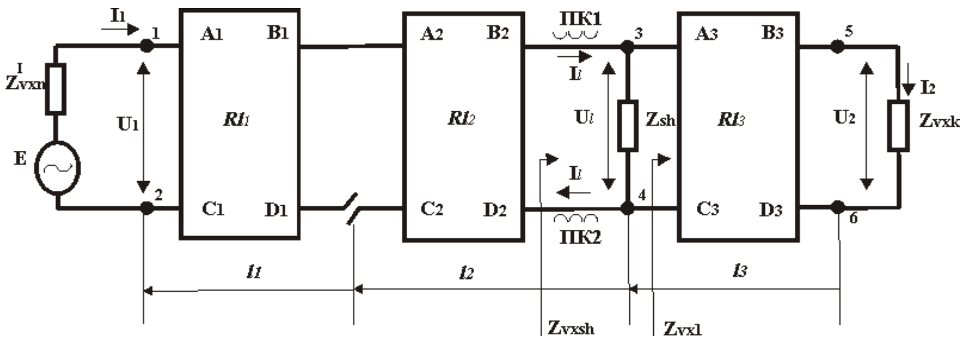

Fig. 1. General scheme of the replacement rail line locomotive receiver at the precipice of one of the rail lines: l_1 – is the distance from the beginning of a rail line to the place of breakage of rails; l_2 – is the distance from the train shunt to open rails; l_3 – is the distance from the end of a rail line to overlay the train shunt; Rl_1, Rl_2, Rl_3 – respectively track four from the precipice before a rail line, from imposing a train shunt to the point of breakage and affixing the train shunt to the end of a rail line with coefficients A,B,C and D; U_1, I_1, U_l, I_l, U_2, I_2 – respectively, the voltage and current at the beginning of the rail line, at the point of overlap of the train shunt and at the end of the rail line; Z^I_{vxn} – reverse input impedance of the apparatus of the beginning of the rail line; Z_{vxk} – direct input impedance of the instrument end of the rail line; Z_{sh} – train shunt; Z_{vx1} – input impedance rail line Rl_3 ; Z_{vxsh} – input impedance of a rail line at the point of overlap of the train shunt; ПК1 and ПК2 – locomotive receiving coil.

Then for this resistance have

$$Z_{vx1} = \frac{\cosh\gamma l_3 Z_{vxk} + Z_v \sinh\gamma l_3}{\frac{1}{Z_v}\sinh\gamma l_3 Z_{vxk} + \cosh\gamma l_3} . \quad (2)$$

The input impedance of a rail line at the point of imposition of the train shunt

$$Z_{vxsh} = \frac{Z_{vxsh} \times Z_{vxk}}{Z_{sh} + Z_{vxk}} . \quad (3)$$

Taking into account formulas (2), have

$$Z_{vxsh} = \frac{Z_{sh}\dfrac{\cosh\gamma l_3 Z_{vxk} + Z_v \sinh\gamma l_3}{\frac{1}{Z_v}\sinh\gamma l_3 Z_{vxk} + \cosh\gamma l_3}}{Z_{sh} + \dfrac{\cosh\gamma l_3 Z_{vxk} + Z_v \sinh\gamma l_3}{\frac{1}{Z_v}\sinh\gamma l_3 Z_{vxk} + \cosh\gamma l_3}} = \frac{Z_{sh} \times (\cosh\gamma l_3 Z_{vxk} + Z_v \sinh\gamma l_3)}{Z_{sh} \times (\frac{1}{Z_v}\sinh\gamma l_3 Z_{vxk} + \cosh\gamma l) + \cosh\gamma l_3 Z_{vxk} + Z_v \sinh\gamma l_3} . \quad (4)$$

Convert the diagram in Fig.1 in the main circuit of a rail line on the locomotive receiver with a torn one of the rail lines (Fig. 2).

For a quadrupole Rl_k valid coefficients:

$$A_k = \cosh\gamma(l_1 + l_2) + 2E\sqrt{1+2p}\cosh\gamma l_1 \sinh\gamma l_2 , \quad (5)$$

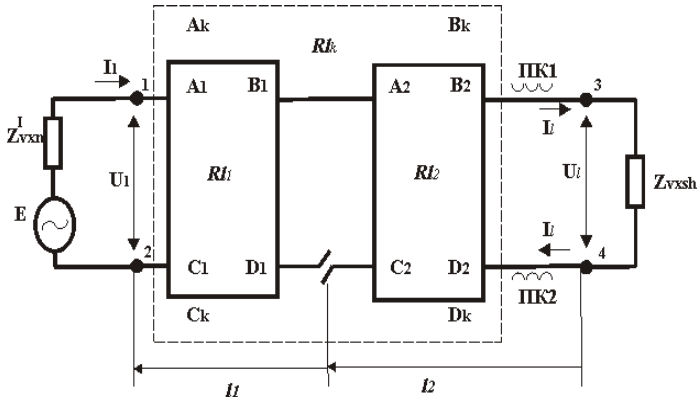

Fig. 2. The main circuit of a rail line on the locomotive receiver with a torn one of the rail lines.

$$B_k = Z_v \sinh \gamma (l_1 + l_2) + 2E\sqrt{1+2p} \cosh \gamma l_1 \cosh \gamma l_2 \ , \tag{6}$$

$$C_k = \frac{1}{Z_v} \sinh \gamma (l_1 + l_2) + 2E\sqrt{1+2p} \sinh \gamma l_1 \sinh \gamma l_2 \ , \tag{7}$$

$$D_k = \cosh \gamma (l_1 + l_2) + 2E\sqrt{1+2p} \sinh \gamma l_1 \cosh \gamma l_2 \ . \tag{8}$$

The voltage and current at the beginning of a rail line can be defined by the expressions:

$$U_1 = A_k U_l + B_k I_l \ , \tag{9}$$

$$I_1 = C_k U_l + D_k I_l \ , \tag{10}$$

where

$$U_1 = I_l Z_{vxsh} \ . \tag{11}$$

In the formula (11) we substitute the value U_l and we bring the current I_l of the brackets, we obtain:

$$U_1 = I_l (A_k \times Z_{vxsh} + B_k) \ , \tag{12}$$

$$I_1 = I_l (C_k \times Z_{vxsh} + D_k) \ . \tag{13}$$

EMF equivalent of the generator can be determined by the following equation:

$$E_e = U_1 + I_1 * Z^I_{vxn} \tag{14}$$

or

$$E_e = I_l ((A_k Z_{vxsh} + B_k) + (C_k Z_{vxsh} + D_k) Z^I_{vxn}) \ . \tag{15}$$

The transfer resistance of a rail line on the locomotive receiver is expressed by the equation:

$$Z_{pl} = \frac{E_e}{I_l}. \tag{16}$$

Substituting in the expression (16) is E_e from equation (15) and the values of the coefficients of the quadrupole Rl_k, will receive:

$$Z_{pl} = \frac{I_l((A_k Z_{vxsh} + B_k) + (C_k Z_{vxsh} + D_k) Z^1_{Ixn})}{I_l} =$$

$$= \frac{Z_{sh}(\cosh \gamma l_3 Z_{vxk} + Z_v \sinh \gamma l_3) \cdot (\cosh \gamma(l_1 + l_2) + 2E\sqrt{1+2p} \cosh \gamma l_1 \sinh \gamma l_2)}{Z_{sh}(\frac{1}{Z_v} \sinh \gamma l_3 Z_{vxk} + \cosh \gamma l_3) + \cosh \gamma l_3 Z_{vxk} + Z_v \sinh \gamma l_3} +$$

$$+ Z_v \sinh \gamma(l_1 + l_2) + 2E\sqrt{1+2p} \cos \gamma l_1 \cosh \gamma l_2 + Z^I_{vxn}[\frac{1}{Z_v} \sinh \gamma(l_1 + l_2) + 2E\sqrt{1+2p} \sinh \gamma l_1 \sinh \gamma l_2 \times$$

$$\times \frac{Z_{sh}(\cosh \gamma l_3 Z_{vxk} + Z_v \sinh \gamma l_3}{Z_{sh} \frac{1}{Z_v \sinh \gamma l_3 Z_{vxk} + \cosh \gamma l_3} + \cosh \gamma l_3 Z_{vxk} + Z_v \sinh \gamma l_3} + \cosh \gamma(l_1 + l_2) + 2E\sqrt{1+2p} \sinh \gamma l_1 \cosh \gamma l_2]. \tag{17}$$

If we assume that the resistance of the train shunt $Z_{sh} = 0$,

$$Z_{pl} = Z_v[\sinh \gamma(l_1 + l_2) + 2E\sqrt{1+2p} \cosh \gamma l_1 \cosh \gamma l_2 + Z^I_{vxn}[\frac{1}{Z_v} \sinh \gamma(l_1 + l_2) + 2E\sqrt{1+2p} \sinh \gamma l_1 \sinh \gamma l_2]. \tag{18}$$

On the obtained resistance value of the transfer rail line locomotive receiver can conduct research to determine the optimal parameters of the length of rail lines and equipment supply end, satisfying the flow of current automatic locomotive signalization under the receiving coils of the locomotive.

To determine the optimal parameters of the length of rail lines and equipment supply end was developed algorithm and drafted the program of calculation for different values of the resistance of the ballast. Calculations were performed for site-specific driving showed that at steady state, the resistance of the ballast at this stage you can use the above device.

4. Conclusions

1. An integrated approach to the implementation of motion control systems and railway automatics and telemechanics for high-speed traffic.
2. International experience and all the necessary components of railway automatics for the implementation of train speed on the Uzbek HSR up to 400 km/h with safety, reliability and comfort of transportation.
3. In one of the high-speed sections instead of track circuits for monitoring the status of driving a used axle counters, and for transmission to the locomotive of the state of the input lights – automatic locomotive signaling. To justify the choice of this interval control system on the stretch was developed mathematical model of a rail line on the locomotive receiver.

4. Calculations on the basis of the developed model for a specific area of the driving showed that at steady state, the resistance of the ballast on this stretch can be used in conjunction with the axle counting system and automatic locomotive signaling.

References

Полевой, Ю. И.; Алиев, Р. М. 2011. Схема замещения неограниченной рельсовой линии при наличии на ней подвижной единицы. *Научные труды Республиканской научно-технической конференции «Ресурсосберегающие технологии и на железнодорожном транспорте»* [Polevoy, Y. I.; Aliyev, R. M. The equivalent circuit of unlimited rail line in the presence of the mobile unit. Scientific proceedings of the Republican scientific-technical conference "Resource-Saving technologies on railway transport"]. Ташкент, с. 153–156.

Теег, Г.; Власенко, С. 2010. *Системы автоматики и телемеханики на железных дорогах мира* [Teeg, G; Vlasenko, S. Systems of automation and telemechanics on the Railways of the world]. Москва: Интекст. 496 с.