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*signal current parameters control,
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THE TELEMETRIC SYSTEM FOR THE CONTROL OF SIGNAL CURRENT PARAMETERS IN VOICE-FREQUENCY TRACK CIRCUITS

In present work the improved mathematical model for signal current in voice-frequency track circuits of cab signal system with automatically regulation of locomotive speed has been developed. On its base the telemetric system for the control of the signal current parameters has been proposed.

TELEMETRYCZNY SYSTEM KONTROLI PARAMETRÓW SYGNAŁU PRĄDOWEGO W TONOWYCH OBWODACH TOROWYCH

W pracy został opracowany matematyczny model zmian prądu sygnałowego w obwodach torowych dla systemu sygnalizacji kabinowej z automatyczną regulacją prędkości lokomotywy. Zaproponowano system telemetryczny dla sterowania parametrami prądu sygnałowego.

1. INTRODUCTION

The automatic block systems with the centralized accommodation of the equipment and voice-frequency track circuits are widely used in many countries [1, 2]. These systems are used usually with the voice-frequency cab signal system with automatically regulation of locomotive speed in which code of cab-signal is transferred onto locomotive as a combination of two frequencies from six one (75, 125, 175, 225, 275, 325 Hz) [1]. First signal is from track circuit on which there is a train, and other - from following circuit.

The safety of railways equipped by cab signal system with automatically regulation of the locomotive speed that based on using voice-frequency track circuits is determined not only on non-failure operation of the equipment, but so by reliability of signaling transfer from rail circuits into the locomotive. In this connection cab signal system equipment is exposed to the periodic control during which will carry out the measurements of the basic electric parameters. But the control of cab signals only at station can't guarantee reliability, so it is

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necessary to supervise values of code signals directly in rail circuits that measured by periodical inspection or with using of mobile measuring laboratory.

But such methods of control track circuit's parameters don't provide the continuous control but the signal parameters can considerably changed within day under influence of different external destabilizing factors.

The existing mathematical models [1, 2] don't provide reliable results for the analysis of the voice-frequency track circuits operated with two-frequency code signal during locomotive movement.

So in this work the improved mathematical model for the signal current in voice-frequency cab signal system was developed with the aim to propose on its base the telemetric system for control the code signal parameters.

2. MATHEMATICAL MODEL

The equivalent circuit of a voice-frequency cab signal system is given in Fig.1. It is used the following symbolic denotation: E_G - electromotive force of the power supply generator, R_G. - **its** internal resistance; four-pole circuit N_k denote cable line, N_T - transformer, $N_{RL1}(l)$ **(for** $0<l<L_{SH}$) and $N_{RL2}(l)$ **(for** $0<l<L_{RL}$) - the block sites of track lines at the additional shunting zone (with length L_{SH}) and an examined rail line (with length L_{RL}). By two-poles are designated: Z_3 - full resistance following track lines, Z_4 - full entrance resistance of the rail transformer.

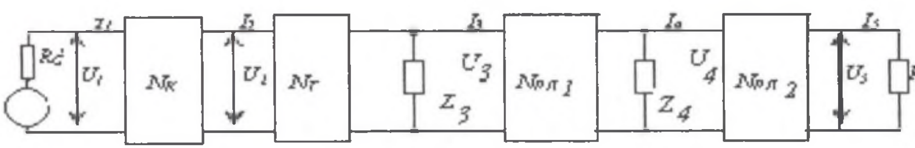

Fig.1. The equivalent circuit of a voice-frequency cab signal system

The currents and the voltages on generator (I_1, U_1) and on locomotive shunt (I_5, U_5) are connected by the equations for the four-pole circuits [1, 2]

$$\begin{aligned} U_1 &= AU_5 + BI_5 \\ I_1 &= CU_5 + DI_5 \end{aligned} \qquad (1)$$

Where ***A, B, C, D*** - coefficients of the four-pole circuits. The matrix of the coefficients (1) is determined as product of matrixes of coefficients of four-pole circuit's components (fig.1).

Nejnman formulas [1, 2] for active $\boldsymbol{R}$ and reactive $\boldsymbol{X_l}$ resistance of a ferromagnetic conductor are chosen for a determination of four-pole circuits coefficients $\boldsymbol{N_{RL}}$

$$
\begin{aligned}
R &= \frac{l}{u}\sqrt{\mu_e \rho \omega} \\
X_l &= 0.6\frac{l}{u}\sqrt{\mu_e \rho \omega}
\end{aligned}
\tag{2}
$$

in which $\boldsymbol{l}$ - length of a conductor, $\boldsymbol{u}$ – its perimeter, $\boldsymbol{\rho}$ - specific resistance of rail steel, $\boldsymbol{\mu_e}$ – magnetic permeability of rail steel determined on a curve of magnetization, $\boldsymbol{\omega = 2\pi f}$ - angular frequency. The values determined by these formulas are in convenience coincidence with measured data. After mathematical transformation the expression for relative current value $\boldsymbol{I_R(l)=I_l(l)/I_M}$ as a function of relative distance $\boldsymbol{l=l_l/L_{max}}$ during the train movements is obtained

$$
I_{omn}(l) = \frac{(A_M R_{SN} + B_M)(C(l)R_{SN} + D(l))}{(C_M R_{SN} + D_M)(A(l)R_{SN} + B(L))} \tag{3}
$$

3. RESULTS OF MODELING

The results of numerical calculations on the basis of the obtained mathematical description are presented in Fig.2. The dependence of relative value of signal current from distance at three frequencies – 75, 225 and 375 Hz for resistance of track rails ballast equal 1 Ohm/km is presented in Fig.2a. At $0.1 < L_R < 0.8$ the relative values of a signal current are decreased with frequency but at $0 < L_R < 0.1$ relative value of a current are increased with frequency, that is in accordance with frequency dependence of distribution coefficient of a rail line.

Dependence of relative values of signal current from distance at frequency 225 Hz at three values of ballast resistance – 1, 0.5 and 5 Ohms/km is presented in Fig.2b. It is visible, that at values of ballast resistance higher or equal to 1 Ohm/km, (value accepted for normative boundary ballast resistor) the relative values of signal current practically independent on distance in an interval $0.2 < L_R < 1.0$. Distinctions in values of a current appear at reduction of relative distance less than 0.2, i.e. at an entrance of the locomotive on block of the track line. For ballast resistance lower 1 Ohm/km the relative values of a signal current are decreased.

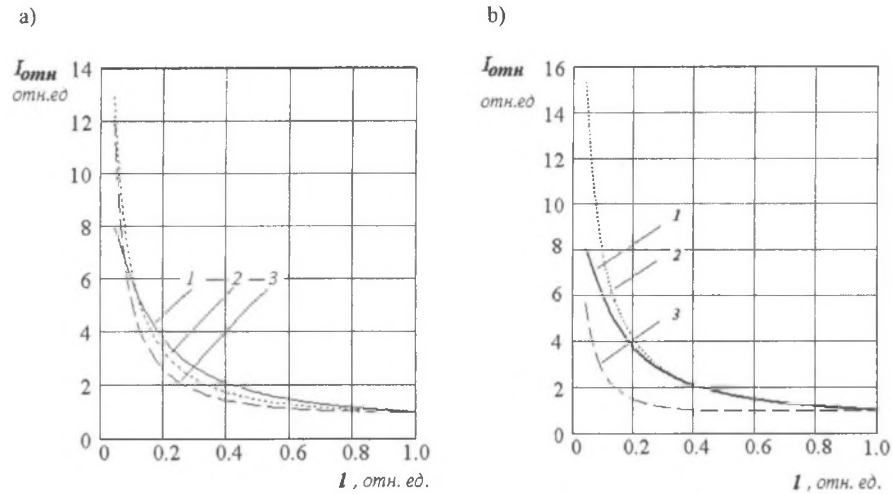

Fig.2. The dependence of relative values of a signal current on distance
a) at the frequencies (in Hz): 75 (1), 225 (2), 375 (3);
b) at values of ballast resistance (in Ohms/km): 1 (1), 0.5 (2), 5 (3)

4. TELEMETRIC CONTROL SYSTEM

As a result of investigation the telemetric system for control of the code signal parameters was developed. The signals proportional to a signal current were removed from additional resistors placed after filters The multiplexer and the analog-digital converter (with frequency of digitization 44 kHz) are used for transfer of the control signals into computer for the subsequent registration, processing and the analysis. The discrete signals from contacts of track circuits relays were carried out synchronously. Time parameters track circuits relays were estimated with accuracy not worse 0,01 s. The position of a train on a block sites was determined and carried out into computer simultaneously that allowed to obtained the dependence of signal current on distance during the train movements.

The measured dependences of signal current on distance are given on Fig.3. Comparison of experimental data with results of calculations under the given specified mathematical description has shown their satisfactory coincides.

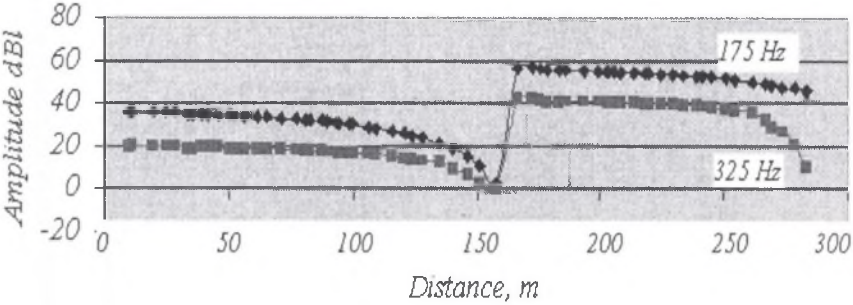

Fig.3. The dependence of a signal current on distance

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BIBLIOGRAPHY

[1] DMITRIEV V.S., MININ V., Developed automatic block systems. – Moscow, Transport -1987. 143 p.

[2] ARKATOV V.A., KRAVTSOV J.A., STEPENSKY V.M. Rail circuits. The analysis of operations and maintenance service. - Moscow, Transport, 1990. 295 p.

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