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Elimination of Pulse Interference with Operation of the Device Ilsd-U

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ABSTRACT: The article is devoted to the actual problem of eliminating impulse noise caused by the shocks of the receiving coils of a locomotive during movement and the magnetization of rail lashes. For this purpose, the calculation of the EMF values, the induction arising in the receiving coils of the locomotive, is extended. The analysis of the field lines of force between the rails of the coils was carried out, the characteristics of the EMF from the distance of the coils to the rail lashes were constructed. Oscillograms of currents in rails in the presence of shaking coils on the locomotive are removed. Oscillograms made it possible to determine the minimum current in the track circuit in order to eliminate the noise caused by jogging of the coils when the locomotive is moving. The calculation and experimental characteristics made it possible to obtain field induction values in track circuits and insulated joints, as well as in elements of the turnouts for the sections of the track for the normal operation of the integrated locomotive safety device - Unified (ILSD-U). Found ways reliable operation of the automated device ILSD-U. Recommendations on the use of coded and uncoded track circuits, as well as on electrified sections of railways, are given.

KEYWORDS: ILSD-U, magnetization, EMF, impulse, induction, strength, core.

I. INTRODUCTION

Recently, the latest signaling, centralization and blocking systems have been introduced to the railway transport. The main elements of them are rail chains [1]. The correct arrangement of rail circuits is essential for the safety of the movement of trains and the uninterrupted operation of signaling systems, such as ILSD-U. The development of technology in recent years will significantly automate the process of controlling the movement of the train. This problem, in particular, is solved with the help of a complex of developed devices, called ILSD-U and other automatic control units [2].

In this connection, it is necessary to create stable systems of automatic blocking and continuous locomotive signaling of their good protection from interference from electric traction and power lines. The steady operation of ILSD-U is affected by the influence of impulse noise arising due to the magnetization of rail lashes. Elimination of impulse noise affecting the operation of ILSD-U devices is an urgent task.

In continuous locomotive signaling, the calculation of the transmission of electrical energy from the track circuit to the receiving devices of a locomotive is a difficulty due to the fact that the receiving devices of the locomotive, in the form of receiving coils, are located at a considerable distance from the rail head.

The air gap is 75% of the entire length of the magnetic circuit. Improving the conditions for the transfer of electrical energy from the rail circuit to the receiving locomotive coils will allow: to use amplifiers with lower gain, to reduce the current in the rail circuit under the receiving coils, which will reduce power consumption [3].

II. LITERATURE SURVEY

The shape of the core of the receiving coils and its location relative to the rail is shown in Figure.1.

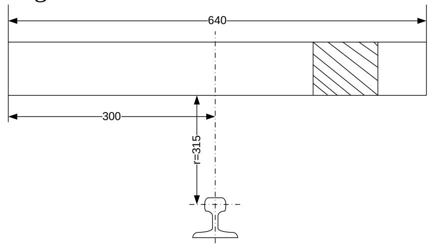

Fig.1. The shape of the core of the receiving coils and its location relative to the rail

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The values of EMF is calculated by the formula:

$$E_2=4{,}44\nu\omega\Phi_m, \quad (1)$$

where ν is the frequency of the current in hertz, ω is the number of turns in the secondary winding, Φ_m-amplitude value of the magnetic flux in Wb.

The magnetic flux is calculated by the formula:

$$\Phi_m=B\cdot S, \quad (2)$$

where B is the magnetic induction in T, S is the cross section of the core $м^2$.

The EMF value at the output of the receiving coils from the height of their suspension is shown in Table 1 and is shown in Figure.2.

Table 1

The EMF value of the receiving coil, depending on the height of the suspension above the rail head

Height h, mm	140	160	180	200	220	240	260	280	300	320
EMF, V	66,01	58,2	52,2	46,5	42,3	38,8	35,8	33,24	31,03	29,1

Signal transmission in continuous locomotive signaling systems from the track circuit to the locomotive is carried out using a magnetic field formed around the rails by the current passing through them. The magnetic field lines around the rail are shown in Figure 3, the configuration of which was obtained using iron filings.

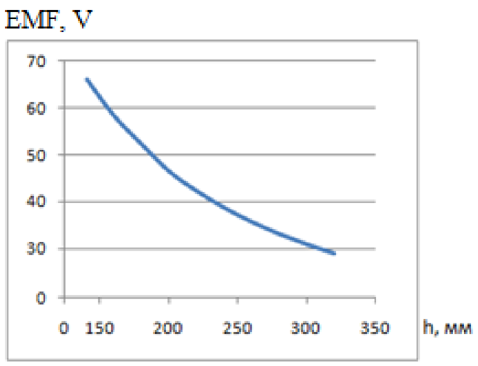

Fig.2. The value of the EMF of the receiving coil depending from the height of the suspension above the rail head

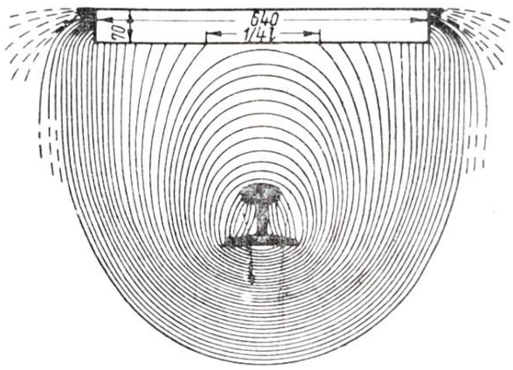

Fig.3. Magnetic lines of force around the rail in the presence of the core of the receiving coil

III. EXPERIMENTAL RESULTS

From fig.2. it is seen that with decreasing distance between the core and the rail, it increases the emf of the receiving coil of the locomotive, due to the increase in the number of field lines of the core. This is confirmed by rice. 3, since as the distance decreases, the number of magnetic field lines penetrating the core will increase. Formula 1 shows that the emf will increase rectilinearly and with a change in frequency, but it increases, according to a non-linear law, since there is a core [4]. This is shown in Figure.4.

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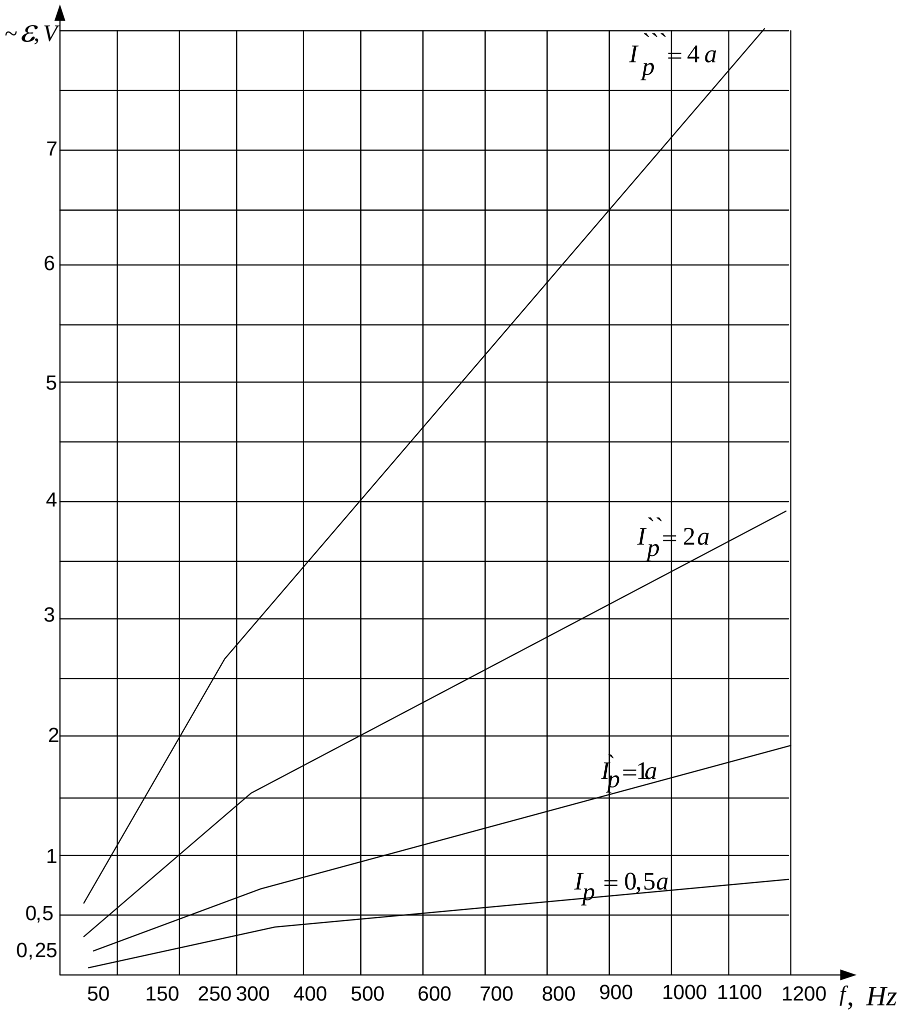

Fig.4. The dependence of the EMF on the frequency of the current in the track circuit

To determine the EMF, we use the equation of the magnetic field strength in the center of the core of the receiving coil, located above the rail:

$$H_m = \frac{0{,}2I\sqrt{2}}{r}, \quad (3)$$

where H_m is the magnetic field strength in oersteds (E), I is the effective current value in A, r is the distance from the current axis to the center of the core in cm.

In the SI system 1A/m=$4\pi \cdot 10^{-3}E$. The magnitude of the magnetic induction in the center of the coil [6]:

$$B = \mu_1 \cdot H, \quad (4)$$

where B is the magnetic induction in gf, E- is the magnetic field strength in, μ_1-is the magnetic permeability of the whole body.

In the SI system 1Tl = 104 gf [7]. Velichana μ_1 depends on the shape of the body "m" and the magnetic permeability of the substance of the body. Since the electromagnet is a cylindrical coil with a cylindrical core, the length of the coil must be within:

$$6d<l<37d, \quad (5)$$

where l-is the length of the coil; d-diameter of the coil.

The body shape "m" is calculated:

$$m = \frac{\left(\frac{l}{d}\right)^2}{2{,}72\ \lg\left(\frac{l}{d}\right) - 0.69}. \quad (6)$$

The magnitude of the magnetic permeability of the body:

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$$\mu_1 = \frac{m\mu}{m+\mu-1}. \quad (7)$$

Equivalent diameter of a circle, the area of which is equal to the cross section of the core is determined by the equation [8]:

$$d = \sqrt{\frac{4S}{\pi}}, \quad (8)$$

where S is the cross-sectional area of the core in cm^2[9].

In the calculations, it was assumed: l = 64cm S = 49cm^2, steel permeability μ = 500, I = 1.25A, r = 40.2cm. From formula 3, the magnetic field strength in the center of the core is H = 0.0088E = 0.7A/m, the values l /d = 8, μ = 500, μ_1 = 32. The magnitude of the magnetic induction (V = 0.282Gs = 0.282•10^{-4} = 0.0282 mT = 28.2 μT). This field is much weaker than the field of terrestrial magnetism B3 = 0.5E = 0.05mT = 50 μT [1]. The value of the electromotive force induced in two locomotive coils is determined by the formula (1) and was equal to E2 = 0.195V. Direct measurement of the EMF at the terminals of the receiving coils is somewhat less obtained in the calculations E2=0.185V. This is due to the fact that the distribution of magnetic induction along the core is uneven. The calculation results show that in order to increase the EMF in the receiving coils of the locomotive, it is necessary to increase the cross section of the core, or, with the same cross section, increase the width of the core and reduce its height. The values of currents in the rails should be at least 1.5A. A lower current value causes noticeable interference due to the fact that the track circuit field is much smaller than terrestrial magnetism. Therefore, the slightest shaking of the receiving coils when receiving causes significant interference, this is confirmed by the oscillograms shown in Figure.5.

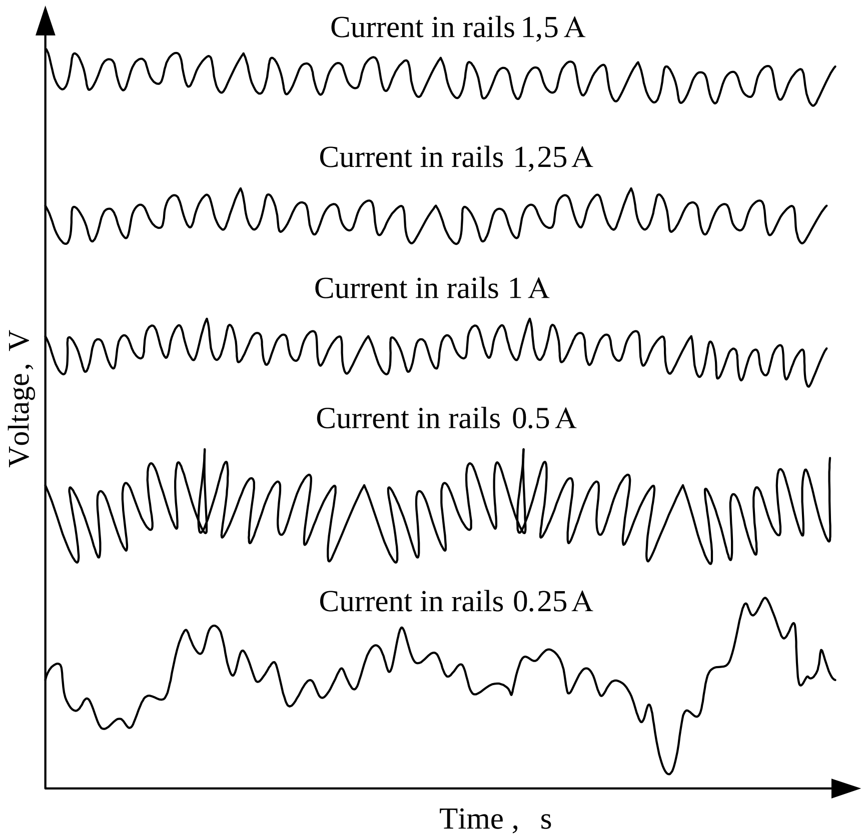

Fig. 5. Oscillograms of currents in rails in the presence of shake coils on locomotives

The magnetization of the track circuits due to the rotation of the wheel sets as well as the reverse current of the traction network has a negative effect on the work of the CLUB-U. The permissible values of magnetic induction for the normal functioning of CLUB-U are shown in Table 2, where its limits are shown for rail circuits and isolated joints, as well as on elements of switches of track sections with rails inside the track.

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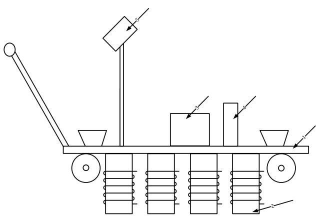
Table 2
Valid values of magnetic induction for the normal functioning of CLUB-U

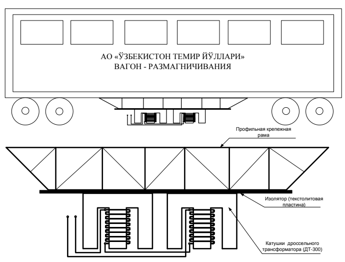
B, µT	Valid Values	B, µT	Valid Values
50	Normal value of induction in track circuits	50	Normal induction value in turnouts
100		100	
150		150	
200		200	
250		250	
300		300	
350		350	
400		400	
450		450	
500		500	
550		550	
600		600	
650		650	
700	Not valid values induction in rail circuits	700	
1000		1000	
1500		1500	
2000		2000	
2500		2500	
3000		3000	
3500		3500	
4000		4000	
4500		4500	
5000		5000	Not valid values induction in switches
5500		5500	
6000		6000	
6500		6500	
7000		7000	
7500		7500	
8000		8000	
8500		8500	
9000		9000	
9500		9500	
10000		10000	

From table 2 it can be seen that the permissible maximum value of induction, at which the track circuit will function normally, is B = 700µT, for switches, 4900µT, insulating joints 700µT. Degaussing devices have been developed, both stationary for degaussing rail lashes prior to welding, and movable demagnetizing devices: on a trolley at a speed of 5 km/h and on a platform at a speed of 80 km/h. In Figure.6. Degaussing devices are presented.



a) manual mobile degaussing device

b) stationary degaussing device



c) degaussing car

Fig.6. Degaussing devices

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The work of CLUB-U is also influenced by the geometry of the location of the receiving coils on the locomotives. Receiving coils must be rigidly fastened to the locomotive, in order to avoid harmful electromotive forces, and the core must be located horizontally to the rail. Incorrect installation of the receiving coils is shown in Figure.7.

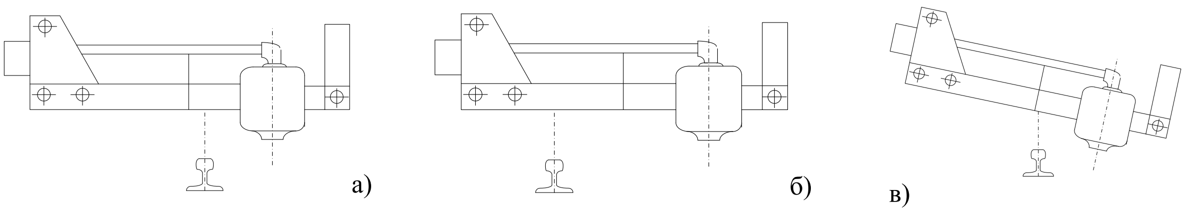

Fig.7. Incorrect installation of receiving coils ILSD-U:
a and b - in the transverse direction; in - height

Magnetic field lines enter the core approximately 3/4 the length of its lower and side faces. Approximately 1/4 of the core length against the rail head, the lines of force do not enter the core body. If you increase the area of the core, which is parallel to the rails, leaving the core section unchanged, then the magnetic flux through each area of the core surface will be:

$$d\Phi = \bar{B} d\bar{S}. \tag{9}$$

All flow coupled to the contour of the core:

$$\Phi = \oint_S \bar{B} dS. \tag{10}$$

Let's build on the contours limiting the platforms dS of the core of the power tubes. Since the lines of the vector $\bar{B}$ are always closed in a magnetic field, the power tubes are obtained to be closed. If we denote the axis of the tube L, then the circulation of the vector $\overline{H}$ along the axis of any tube will be equal to the current loop:

$$\oint_L \overline{H}\bar{\ell} = I. \tag{11}$$

Consequently, when the width of the core section changes, in the longitudinal direction and decreases in height, the magnetic flux penetrates the core area, which leads to an increase in the EMF in the receiving coils of the locomotive, without changing the current in the rail circuits.

In this regard, it is proposed to increase the width of the core, in the longitudinal direction up to 100mm, its height should be reduced to 50mm, while the area of the core remains unchanged and is equal to S = 〖50cm〗 ^2.

As a result of the proposed modernization, $H = 0{,}022787E = 1{,}8A/m$; $B = 0{,}771gf = 0{,}771 \cdot 10^{-4}T = 77{,}1\mu Тл$; $E_2 = 0{,}5V$. The values of the EMF induced in the two receiving coils of the locomotive when the core width varies from frequency ν are shown in Figure.8.

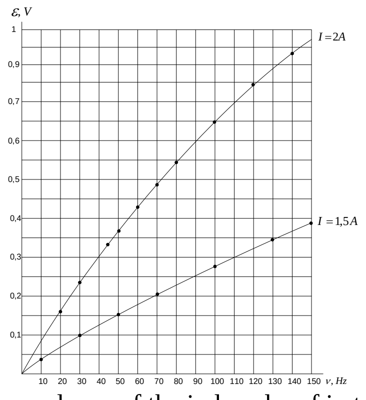

Fig.8. The dependence of the induced emf in two receivers
coil locomotive, when measuring the width of the core frequency

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IV. CONCLUSION AND FUTURE WORK

According to the results of the study, the following conclusion can be made.

1. Reliable functioning of the ILSD-U will be at installation of the core of the receiving coils of the locomotive at a distance of 300mm from the left end and horizontally above the rail head at a distance of 250mm.

2. You must have connecting jumpers from the body to the body of each traction motor.

3. Locomotive receiving coils must be removed from the running current-carrying parts of the locomotive.

4. The receiving coils of the locomotive must be rigidly fastened in order to avoid harmful EMF mechanical vibrations.

5. Rail lash connections should be fastened not by steel cables, but by copper terminals.

6. On non-coded non-electrified sections of railways, the zero rail lash should be grounded every 250 meters, the earthing switch is made of pipes driven to a depth of 1 meter from the surface of the Earth, to which a triangle with sides of 1.5 meters is welded.

7. On the electrified sections of railways, rail lashes must be connected with each other by a jumper every 300 meters.

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