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EXPRESSIONS TO DETERMINE THE VOLTAGE GENERATED IN ADJACENT LINES AS A RESULT OF ELECTRIC AND MAGNETIC FIELD EFFECTS OF THE CONTACT NETWORK AND THEIR NORMATIVE VALUES

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ANNOTATION

In the article, the expressions for determining the voltages occurring in adjacent (communication) lines from the electrical and magnetic effects of the contact network are studied and analyzed in a certain sequence. It is also based on the fact that it is possible to fully estimate the normative values by calculating the noise caused by the interference of the traction system to the adjacent lines from 7 harmonics to 41 harmonics.

Keywords: *electrical and magnetic effects, adjacent line, interference effect, communication line, normative values*

When no current flows from the contact network, there will be no magnetic effect on adjacent lines, but there will be an electrical effect due to the operating voltage. The electrical effect of the traction system occurs only at alternating voltage due to the lack of conductivity and capacitive current between the contact network and the ground at constant current. The current and voltage generated by electrical and magnetic influences on the adjacent line will depend on whether the adjacent line is insulated or grounded. We consider the currents and voltages that occur in adjacent lines in three different modes.

1)- the adjacent line is grounded, the current at the beginning and end of the wire is zero (Figures 1 and 2),

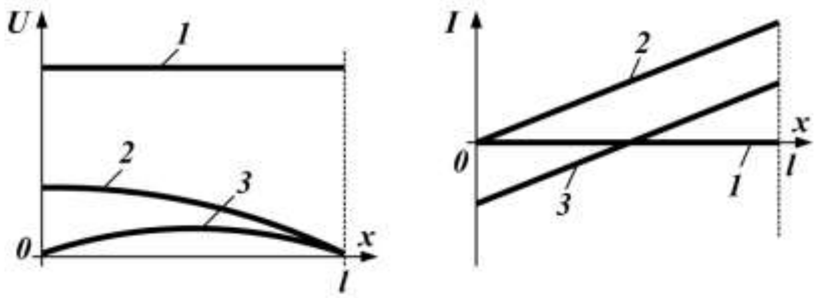


Figure 1. Currents and voltages occurring in adjacent lines under the influence of the electric field of the traction system

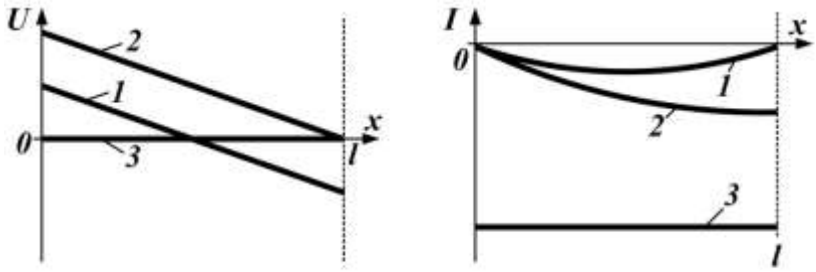


Figure 2. Currents and voltages occurring in adjacent lines under the influence of the magnetic field of the traction system.

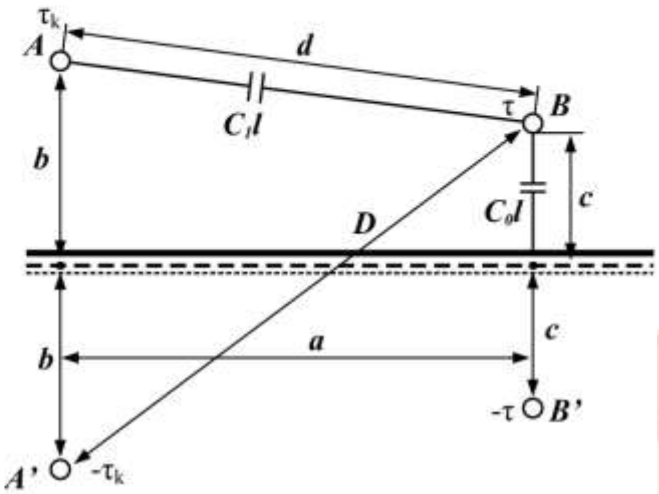
2) the head of the conductor is insulated, the end is grounded using a very small resistive fuse; the current at the beginning of the wire is zero, and the voltage at the end of the wire relative to ground is zero (Figures 1 and 2, 2);

3) the head and end of the wire are grounded, the voltage at the end and beginning of the wire relative to ground is zero (Figures 1 and 2, 3).

The maximum voltage under the influence of electricity occurs when the adjacent line is insulated from the ground. In this case, the current in the wire is zero, and the resulting voltage can be determined using a capacitive divider. If we consider that the adjacent line is partially outside the zone of electromagnetic action, the voltage across it is determined as follows:

$$U = U_0 \frac{C_1 l_e}{C_1 l_e + C_0 l} \approx U_0 \frac{C_1 l_e}{C_0 l}.$$

The voltage generated on adjacent lines as a result of the electric field effect of the contact network is determined using the Maxwell equation. Given that the conductors of the systems are parallel to each other, it is possible to assume that the contact network is a single wire.



3- picture. Perpendicular wire cross-section calculation system.

Here A is the contact line and B is the adjacent line. The potential at any point of wires of the same length is determined by Gauss's theorem as follows:

$$\varphi = -\frac{\tau}{2\pi\varepsilon_0} \ln r + C,$$

In this place τ - charge per unit length of wire, r - the distance from the wire axis to the observation point, ε_0 – absolute dielectric constant of air, C – integration constant.

When the potentials of the four wires are connected to each other, the potential at an arbitrary point M is determined as follows:

$$\varphi = \frac{\tau_K}{2\pi\varepsilon_0} \ln \frac{r_{A'M}}{r_{AM}} + \frac{\tau}{2\pi\varepsilon_0} \ln \frac{r_{B'M}}{r_{BM}}.$$

On the surface $\varphi = 0$ since the integration constant is assumed to be zero. From this formula we can write the following two equations for the potentials of the contact network and the adjacent line:

$$\left.\begin{aligned} U_K &= \tau_k \alpha_{11} + \tau \alpha_{12} \\ U &= \tau_k \alpha_{21} + \tau \alpha_{22} \end{aligned}\right\},$$

In this place

$$\alpha_{11} = \frac{1}{2\pi\varepsilon_0} \ln \frac{r_{A'A}}{r_k};\ \alpha_{12} = \frac{1}{2\pi\varepsilon_0} \ln \frac{r_{B'A}}{r_{BA}};\ \alpha_{21} = \frac{1}{2\pi\varepsilon_0} \ln \frac{r_{A'B}}{r_{AB}};\ \alpha_{22} = \frac{1}{2\pi\varepsilon_0} \ln \frac{r_{B'B}}{r};$$

r and $r_к$ - radius of wires (equivalent resistance for contact network)).

Solving the above equation, we obtain the following equation between the contact network and the adjacent line voltages:

$$U = U_k \cdot \frac{ln\left(\frac{D}{d}\right)}{ln\left(\frac{2b}{r_k}\right)};$$

$$ln\frac{D}{d} = \frac{1}{2}ln \cdot \frac{1+\frac{2bc}{a^2+b^2+c^2}}{1-\frac{2bc}{a^2+b^2+c^2}} \approx \frac{2bc}{a^2+b^2+c^2};$$

$$\dot{U} = k\dot{U}_k \cdot \frac{bc}{a^2+b^2+c^2}.$$

Also, the voltage drop for n sections is determined as follows:

$$\dot{U} = \frac{k\dot{U}_k}{l} \cdot \sum_{i=1}^{n} \frac{bc}{a_i^2+b^2+c^2} \cdot l_{эi}.$$

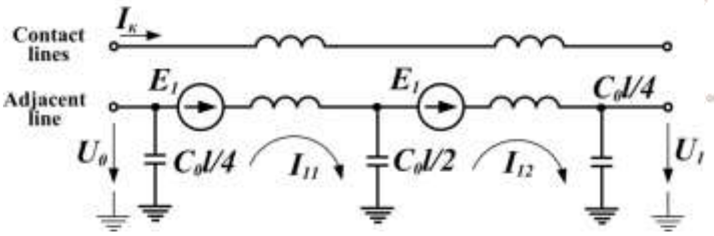
25 кВ on a one-way plot for a voltage contact network k=0.4, on a two-lane plot k=0.6 гa it would be expedient to assume that equal. It should be noted that since the grounded sheath of the cable line acts as a screen, there will be no electrical impact on it. The risk of voltage from electrical exposure is mainly significant when the adjacent line is installed on the contact network supports.

Approximately in a contact network that is not under voltage when a line is switched off in two-way sections 8-10 кВ voltage will occur.

In order to leave only the magnetic effect of the contact network, the operating mode of the contact network must be close to the short-circuit mode, ie $U_k = 0$. In this case, the capacity between the ground and the contact network can be ignored. Also, two identical EYuKs are formed in the ground-insulated wire (Fig. 4)).

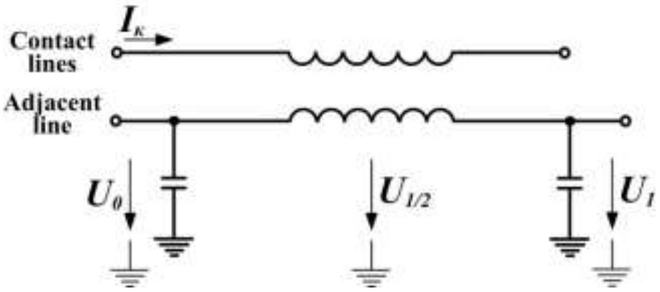
$\dot{E}_1 = -j\omega M\dot{I}_k l/2.$

These two voltage sources generate two contour currents, respectively. The sum of the currents in the middle capacitive element is zero, and the voltage between the insulated wire is zero with respect to ground..



4- picture. Switching schemes of contact network and adjacent lines.

The contact network and adjacent line wires are connected to each other by a magnetic field and can be considered as a cordless transformer.



5- picture. Contact network and switching schemes of adjacent lines.

In the short circuit and forced operation modes of the traction network, a dangerous impact voltage is generated on the adjacent lines. The voltage generated in the short-circuit mode is determined using the following expression:

$$U_m = \omega \cdot M \cdot I_{kz} \cdot l_e \cdot s_p, V$$

for the mandatory mode, it is defined as follows:

$$U_{mv} = k_f \cdot \omega \cdot M \cdot I_{ekv} \cdot l_e \cdot s_p, V$$

In this place: ω=314 рад/с – the angular frequency of the acting current;

M – mutual inductance between the communication line and the contact network, Гн/км;

$I_{кz}$ – maximum current in short circuit, A;

l_e – the shortest distance between adjacent lines, км;

s_p– the shielding effect coefficient of the rail, the specific conductivity of the ground 0,05..0,1 См/м when the coefficient is 0.55..0.60 equal.

The mutual inductance between the communication line and the contact network is determined by the following expression:

$$M = 10^{-4} \cdot \ln\left(1 + \frac{6 \cdot 10^5}{a^2 \cdot \sigma \cdot f}\right), H/km$$

In this place: a – the approximation width of the adjacent line, м;

σ– specific conductivity of the earth, См/м;

f– the frequency of the acting current, Гц;

k_f=1,15 – the coefficient characterizing the nosinusoidal current of the traction network.

When the wires of the communication line are insulated from the ground, an additional voltage is generated due to the electric effect, and it is determined as follows:

$$\dot{U} = k \cdot \dot{U}_k \cdot \frac{b \cdot c}{a^2 + b^2 + c^2} \cdot \frac{l_e}{l}, \ V$$

In this place: k=0,4 – the coefficient, taking into account the number of affected wires, is 0.4 for single-track sections, for wires located on the supports of the traction network;

The distance to which the communication line should be installed is determined by the following expression:

$$a = \sqrt{\frac{6 \cdot 10^5}{(e^{m \cdot 10^4} - 1) \cdot \sigma \cdot f}}.$$

b=6,8 m, c – the hanging height of the wire, i.e. the ground height of the contact line and the communication line, m.

The resulting electromagnetic effect voltage is determined in the form of the sum of electric and magnetic field effects as follows:

$$U_{me0} = \sqrt{(\frac{U_m \cdot l_c}{l})^2 + U_e^2}, V$$

In this palce: U_m – voltage generated by the action of a magnetic field, V;

l_C and l – determined in accordance with the calculation scheme, km;

U_e - voltage generated by the action of an electric field, B.

In addition, it will be possible to fully evaluate the normative values by calculating the noise caused by the interference of the traction system to the adjacent lines up to 41 harmonics. The voltage due to the interference from the 7th harmonica to the 41st harmonica is determined by the following expression:

$$U_{sh} = \sqrt{\sum_{k=7}^{41} (U_{shk})^2}\, , mV$$

where, the interfering voltage of the k-harmonics is determined using the following formula:

$$U_{shk} = 2\omega_k M_k I_k p_k \eta_k s_p \left| \frac{sh(\gamma_k l_c) \cdot sh(\frac{\gamma_k l_e}{2})}{\gamma_k sh(\gamma_k l)} \right| \cdot 10^3, mV$$

In this pace: ω_k=314 k рад/с – the angular frequency of the traction network current k-harmonics;

M_k – modulus of mutual inductance between the contact network and the communication lines for k-harmonics, Гн/км;

I_k – the equivalent current of the k-harmonics of the traction network, A;

p_k – coefficient of sound effect for k-harmonics;

η_k – the coefficient of sensitivity to interference for k-harmonics of a two-wire communication line;

s_p – the resulting shielding coefficient for the k-harmonics of the traction network;

γ_k – the coefficient of propagation between the communication line wire and the ground for k-harmonics,

$\gamma_k=\alpha_k+j\beta_k$– complex number, extinction and phase coefficients, respectively;

l_C ,l_e, l_k – lengths, km in accordance with the layout of the objects to calculate the interference effects.

It is necessary to pay special attention to the change in the distance between the contact lines in reducing the dangerous electromagnetic effects of the contact network as a result of studying the voltages generated in adjacent lines as a result of electric and magnetic field effects and determining their normative values. It was found that a partial increase in the distance between the contact line and the communication line leads to a sharp decrease in electrical exposure, and in these cases the development of measures to reduce magnetic exposure should take into account the length of the communication line and nosinusoidal electromagnetic current.

LIST OF USED REFERENCES:

[1] Boltayev Otabek Tashmuhammatovich and Akhmedova Firuza Anvarovna 2021. Induced Voltage From Traction Networks and Methods of Reducing its Influence on Adjacent Communication Lines. International Journal on Integrated Education. 4, 4 (Apr. 2021), 265-271.

[2] Boltayev O.T., Bayanov I.N., Akhmedova F.A. Galvanic effects of the gravitational network and measures to protect against it. International journal of trends in computer science ISSN:2348-5205. Volume 2 Issue 1 2021. pp. 3-11.

[3] Amirov S.F., Boltayev O.T., Akhmedova F.A. Calculation of Magnetic Chains with Mobile Screens // International Journal of Advanced Research in Science Engineering and Technology. India. - №6, Issue 5, May 2019 - pp. 9243-9245.

[4] A. Sulton, B. Otabek, A. Firuza. New created mathematical models of movable screens and a scatter parameter converters //(Scopus) Jour of Adv Research in Dynamical & Control Systems, Vol. 12, Special Issue-02, 2020. pp. 122-126.

[5] Болтаев О.Т., Ахмедова Ф.А. и др. Закономерности отказов и вопросы диагностики контактной сети // Universum: технические науки. 2020. №7-3 (76). URL: https://cyberleninka.ru/article/n/zakonomernosti-otkazov-i-voprosy-diagnostiki-kontaktnoy-seti.

[6] Otabek Boltayev, Firuza Akhmedova, Bakhrom Nurxonov. Improving the reliability of the power supply system // Science and Education. 2021. №5. URL: https://cyberleninka.ru/article/n/improving-the-reliability-of-the-power-supply-system.

[7] Амиров С.Ф., Атауллаев А.О., Болтаев О.Т. Исследование двухконтурных магнитных цепей датчиков с распределенными параметрами. Материалы II Международной научно - технической конференции «Проблемы получения, обработки и передачи измерительной информации», посвященной 90-летию со дня рождения профессора Зарипова М.Ф./Уфимск. Гос. Техн. Ун-т: РИК УГАТУ, 2019. -С.127-131.

[8] Amirov S.F., Boltayev O.T. Mathematical models of differential magnetic circuits of converters with movable screens and distributed parameters. Journal of Tashkent Institute of Railway Engineers 15 (3), 2019. pp. 75-81.

[9] Болтаев О.Т. Структурные методы расчета магнитных цепей с подвижными электромагнитными экранами// X Международный молодежный конкурс научных работ «Молодежь в науке: новые аргументы». 1 март 2019. – Липецк, Россия, 2019. – С. 20-24.

[10] Bader M.P. Elektromagnitnaya sovmestimost. Uchebnik dlya vuzov. - M.: Transport, 2002 g., 640 s.