EMERGENT: JOURNAL OF EDUCATIONAL DISCOVERIES AND LIFELONG LEARNING (EJEDL)
ISSN: 2776-0995 Volume 3, Issue 5, May, 2022

INFLUENCES OF A CONTACT NETWORK ON ADJACENT LINES AND DIFFERENTIAL EQUATIONS OF ADJACENT LINES

Boltaev Otabek Tashmuxammatovich
Toshkent State Transport University, PhD, Uzbekistan, Tashkent
E-mail:otash be@mail.ru

Axmedova Firuza Anvarovna
Toshkent State Transport University, Asistent, Uzbekistan, Tashkent
Email:firuza.axmedova.83@mail.ru

Nurxonov Bahrom Shavkatovich
Toshkent State Transport University, Student, Uzbekistan, Tashkent
Email:nurxonovbahrom2000@gmail.com

Annotation

The article provides general information on the effect of the gravitational system on adjacent lines and develops differential equations of adjacent lines, based on which it is possible to reduce the degree of curvature between adjacent line conductors and the length of their parallel positions by reducing the value of the distribution coefficient.

Keywords: contact network, impact line, adjacent line, induced voltage, electric and magnetic field effects, differential equations.

Introduction

Adjacent lines located in the contact network stations and hauls have a voltage that is dangerous to human life even when they are disconnected from the voltage, and this voltage is the voltage of the contact network in the operating mode acting on the disconnected adjacent lines. Occasional electric shock injuries to service personnel from voltages generated by the action of a live contact network on a live contact network or adjacent lines. The main reason for this is that the concepts of the impact voltage of a non-disconnected line relative to a disconnected line are incomplete. Even on lines that are grounded in accordance with full legal regulations, a person can be injured under the influence of exposure voltage. Any mutually parallel lines will have an inductive effect on adjacent lines.

The effect of a live contact network on adjacent lines occurs and varies depending on the voltage across it, the load current, the length of the contact line and the parallel location of the adjacent line, and the distance between them.

An electromagnetic effect is the effect of one chain or device on another chain or device. The process of formation of an additional current or voltage in an electrical device used in different modes that occurs in a part of another adjacent electrical circuit is explained as an electromagnetic effect. In this process, an external electromagnetic effect is understood as a high-voltage line (s) acting on low-voltage lines. The electromagnetic effect is understood to be the electromagnetic effect of one type of power transmission line on another.

According to the available literature, an electromagnetic field is a special form of matter in which the electrical and magnetic properties of all points are determined by two vector quantities, respectively, the change of one generating the other and affecting the charged particles with their speed and charge magnitude. If the electromagnetic field does not change with time, then it is called a stationary field. In such a field, it will be possible to study the electric and magnetic fields separately.

An electric field is one of the two sides of an electromagnetic field that is generated around an electric charge and due to a change in the magnetic field, acting on a charged particle and body, and is determined by the force acting on the charged stationary particle and body.

A magnetic field is one of the two sides of an electromagnetic field created by the motion of a charged particle or body and a change in electric field, acting on a moving charged particle or body and determined by the force acting on a moving charged body perpendicular to its direction of motion.

An electric charge is a property of matter or matter that describes its interaction with itself and with an external electromagnetic field. The electric charge consists of positive charges (protons, positrons and other particles) and negative charges (electrons and other particles). The electric charge is numerically equal to the charged particle and is determined by the interaction force of the bodies.

An electromagnetic field appears around any charged particle, and this field forms an integral whole with the particle. The electromagnetic field can also be outside the particle. As the amount of charge changes, a correspondingly changing electromagnetic field is created.

The electromagnetic field carries a certain amount of energy and its energy can be converted into chemical, thermal, mechanical and other types of energy.

The electromagnetic field has the following specific properties:

- the electromagnetic field is an objective being, a special view of matter, which is an interconnected and a set of electric and magnetic fields that represent one another.
- the electromagnetic field has the same mass, energy, momentum and momentum as matter, is formed at the expense of other matter and can become another type of matter, and according to the basic law of nature, it does not exist and does not exist.

Alternatively, the electromagnetic field propagates in space in the form of a continuous wave, discrete or quantum. This property is unique to the electromagnetic field and is not observed in other types of matter.

- The force exerted by an electromagnetic field on charged particles is a special electromagnetic property of the field. Such a feature is not observed at all in mechanics.
- Under certain conditions, the electromagnetic field can become a substance, and the substance in turn can become a field. For example, an electron and a positron are converted into two quantum electromagnetic radiation, and in the absence of a photon, two pairs of electrons and a positron are formed.

The study of electromagnetic field theory provides an opportunity to learn the basics of operation of various electrical and electromagnetic devices and, most importantly, to calculate and design new devices at the required level.

Electric and magnetic fields are formed around any impact line depending on its voltage and current, and the characteristics of the acting current and voltage change over time.

Electromagnetic effects are mainly manifested as electric field, magnetic field and galvanic effects.

The electric field effect occurs as a result of the formation of capacitance between the contact network and the adjacent line. The contact network and the adjacent conductor can be thought of as a capacitor shell with a $C_1 \cdot l$ capacitance, where C_1 - 1 km the capacitance between the contact network and the adjacent line, which is 1 km long - the length of the system. It should also be taken into account that a capacitive divider is formed between the adjacent conductor $C_0 \cdot l$ and the ground. If the adjacent line is located in the region of the magnetic field generated by the impact line, the capacitance occurs independently of the length of the electrical system and is determined as follows.

$$U_e = U_k \cdot \frac{C_1 \cdot l}{C_1 \cdot l + C_0 \cdot l} = U_k \cdot \frac{C_1}{C_1 + C_0}.$$

The effect of the magnetic field occurs as a result of the residual EYUK intersecting with the alternating magnetic field. Under the influence of a current flowing through the contact network, a magnetic field is created around it. The alternating magnetic field in the contour of the ground and adjacent lines forms a residual EMF, and this EMF is determined according to the law of electromagnetic induction as follows: $e_2 = -\frac{dF}{dt}$,

where F is the magnetic flux acting on the ground and the adjacent line.

For a sinusoidal current, this value is defined as $\underline{E}_2 = -j\omega\underline{F}$

The galvanic effect occurs under the influence of a current flowing from the existing objects to the ground.

In addition to the above, there are also dangerous and interfering electromagnetic effects depending on the strength of the impact. Hazardous exposure may result in electric shock and damage to electrical equipment or fire. The interference effect is

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smaller in value but affects the normal operation of communication and telemechanics lines.

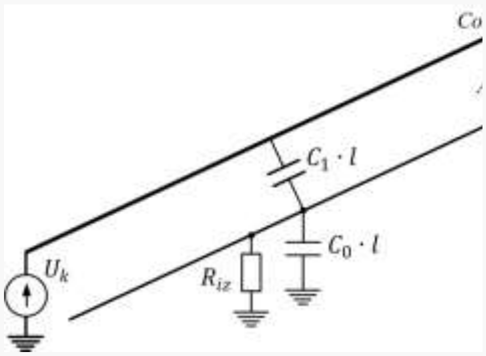

Figure 1. The effect of the electric field of an impact line on an adjacent line.

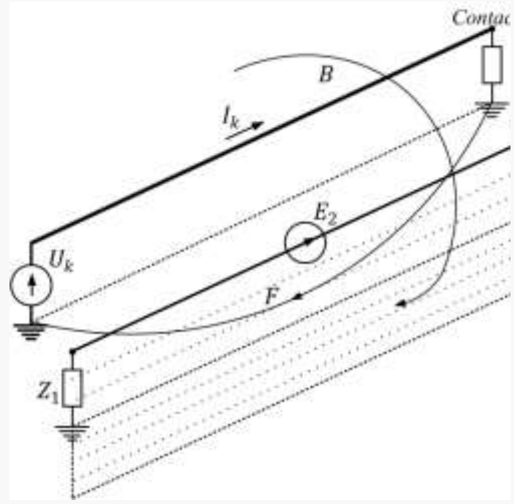

Figure 2. The effect of a magnetic field of an impact line on an adjacent line.

Strong electromagnetic processes occur between the conductor of the traction system, ie the contact network and the lines installed at the base of the contact network. The contact network of the traction system has a significant impact on the overhead line DPR (two wire - rails) and BE (longitudinal power supply) systems installed on its base or near a separate traction network. Although the voltages of these lines are the same as the voltage of the contact network, the magnetic effect of the line is also small because the value of the current flowing through them is small. As the voltage of the autoblocking supply and longitudinal power supply lines is 6-10 kV, the effect of the traction system on them will be stronger.

The three-phase external power supply also has a significant electromagnetic effect on adjacent lines in accordance with the value of voltage and current. In practice, it has been found that electromagnetic effects are rarely observed due to the distance and partial symmetry of this line with other adjacent lines.

An electromagnetic effect can be observed on distant adjacent lines due to the occurrence of pulse voltage and current in power transmission lines under the influence of lightning discharge.

Gravity system Gravity system is the main chain of influence for power supply devices. It includes a traction substation, an electric locomotive and a traction network. The traction system includes supply and suction conductors, contact line conductors, rails and ground. Because the traction system is symmetrical, it has a very high electromagnetic effect relative to adjacent lines.

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When considering the electromagnetic effect of a traction system on adjacent lines, it is advisable to look at it as a scattered parametric system. In order to simplify the calculations in scattered parameter chains, it is necessary to accept the following boundary conditions:
- When analyzing the impact of the traction system, it is necessary to consider only the closed contour between the contact network and the ground (the effect of the rails can be taken into account later);
- The approximation of the contact network to the adjacent line is considered parallel;
- The voltage and current of the contact network and the adjacent line are considered to be sinusoidal.

Common methods (contour currents, node potentials, two nodes), Om's law and Kirchhoff's laws are used in the analysis of processes in electrical circuits. The effects of electromagnetic field distribution are not taken into account in the analysis of circuits using these methods, and it is advisable to use these methods only in the calculation of short electric circuits.

In order to study the effect of the contact network on adjacent lines, it is expedient to develop differential equations of adjacent lines. To do this, we show that the EYuK at the beginning of the line ensures the separation of charges using references in the adjacent line exchange scheme. According to him, one conductor + q and the second conductor -q, the values of the currents in them are the same, but in opposite directions.

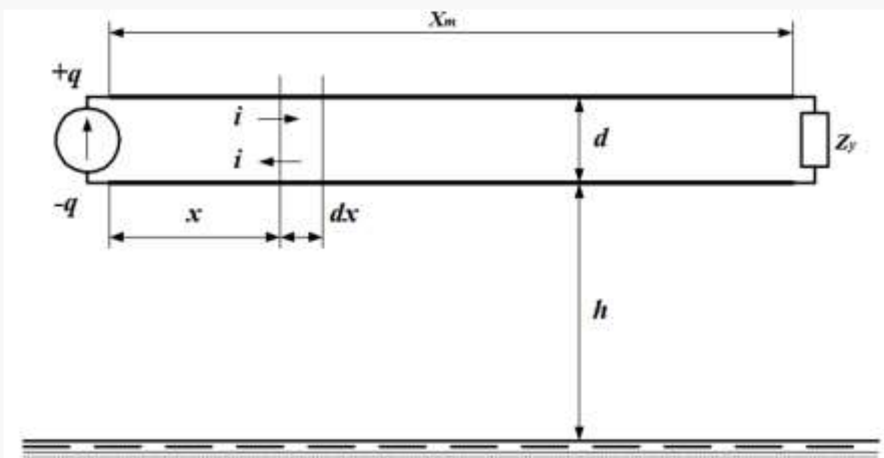

Figure 3. The mutual arrangement of two-wire adjacent lines.

Since the values of the currents in the lower and upper wires are the same, we connect the elements below with the elements above and leave the common wire below. In this case the potentials of the conductors will be different but the voltage between the wires will remain unchanged.

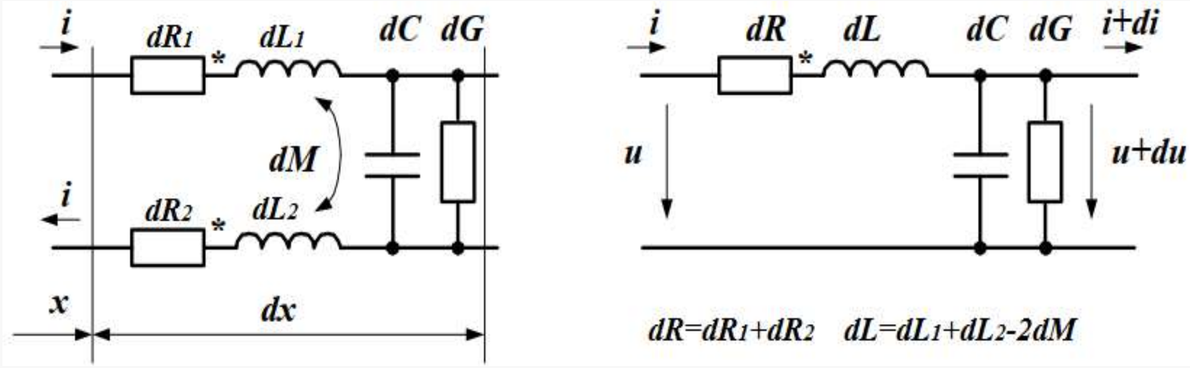

Figure 4. dx plot exchange scheme.

The parameters of the calculated line exchange scheme shown in the figure are directly proportional to the distance dx,

$$dR = R_0 \cdot dx;\ \ dL = L_0 \cdot dx;$$
$$dC = C_0 \cdot dx;\ \ dG = G_0 \cdot dx,$$

where R_0 (Om / km), L_0 (Gn / km), C_0 (F / km), G_0 (Sm / km) are called the primary parameters of the line, and these parameters are time-independent quantities. R_0, L_0 - 1 km of resistance and inductance, C_0, G_0 - 1 km of capacitance and conductivity. According to Kirchhoff's law, the equation constructed for the dx part of the above exchange scheme is as follows:

$$u = i \cdot dR + dL\frac{\partial i}{dt} + u + du;$$
$$i = i \cdot dG + dC\frac{\partial u}{dt} + i + di.$$

After some modifications, we create the following equation:

$$-\frac{\partial u}{dx} = R_0 i + L_0\frac{\partial i}{dt};$$
$$-\frac{\partial i}{dx} = G_0 u + C_0\frac{\partial u}{dt};$$

Given that the source voltage and current $u = U_m\, e^{\,j(\omega t + \Psi)}$; $i = I_m\, e^{\,j(\omega t + \Psi)}$ are equal to, the last expressions look like this:

$$-\frac{dU(x)}{dx} = Z_0 I(x);$$
$$-\frac{dI(x)}{dx} = Y_0 U(x).$$

From the expression for the voltage x we obtain the following second-order differential equation:

$$\frac{d^2U(x)}{dx^2} = \gamma^2 U(x);$$

where $Z_0 = R_0 + j\omega L_0$; $Y_0 = G_0 + j\omega C_0$; $\gamma^2 = Z_0 Y_0$; γ is the distribution coefficient. The solution of the second-order differential equation is:

$$U(x) = A_1 e^{\gamma x} + A_2 e^{-\gamma x}.$$

Accordingly, the current is determined as follows:

$$I(x) = \frac{\gamma}{Z_0}(-A_1 e^{\gamma x} + A_2 e^{-\gamma x})$$

We use the following boundary conditions to determine the constants A_1 and A_2

$$U(x)\Big|_{x=0} = U_m; \quad U(x)\Big|_{x=X_m} = I(x)\Big|_{x=X_m} \cdot Z_y;$$

where Z_y is the complex resistance of the load.

Using boundary conditions for voltage and current expressions, we define constants and generate the following expressions for chain sizes:

$$U(x) = \frac{U_m}{\Delta}\left[(Z_0 - \gamma Z_y) \cdot e^{\gamma x} - (Z_0 + \gamma Z_y) \cdot e^{\gamma(2X_m - x)}\right];$$

$$I(x) = -\frac{\gamma U_m}{\Delta \cdot Z_0}\left[(Z_0 - \gamma Z_y) \cdot e^{\gamma x} + (Z_0 + \gamma Z_y) \cdot e^{\gamma(2X_m - x)}\right].$$

Where $\Delta = Z_0(1 - e^{2\gamma X_m}) - \gamma Z_y(1 + e^{2\gamma X_m})$.

In order to fully analyze the area under study using the developed expression, we construct a graph of the relationship between the voltage between adjacent line conductors and the distance between parallel lines of adjacent lines at different values of the distribution coefficient using MathCad software.

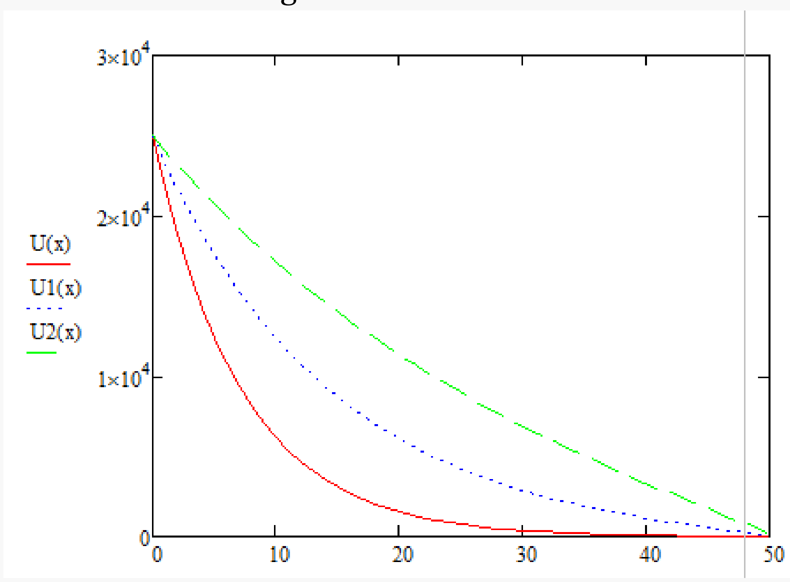

Figure 5. Curves between the voltage between adjacent line conductors and the length of their parallel position at different values of the distribution coefficient, $\gamma_1 > \gamma_2 > \gamma_3$

From the generated graphs, it can be concluded that by reducing the value of the propagation coefficient, it is possible to reduce the degree of curvature of the curves between the voltage between adjacent line conductors and the length of their parallel placement. It is also possible to maximize the linearity of the curves by coating the conductors with special insulation.

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