VINNITSA NATIONAL AGRARIAN UNIVERSITY

Department of Electric Power Engineering, Electrical Engineering and Electromechanics

CALCULATION OF COMPLEX SINUSOIDAL CIRCLES (the method of equivalent transformations and the method of nodal potentials)

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UNITY OF METHODS OF CALCULATING ALTERNATING AND DIRECT CURRENT CIRCUITS

For alternating current circuits, in general, the same calculation methods can be applied as for direct current circuits, provided that the currents, voltages and parameters of the electric circuit are represented as provided by the complex symbolic method of calculation. So, based on what has been said, let's consider examples of the application of methods for calculating sinusoidal current circles in more detail.

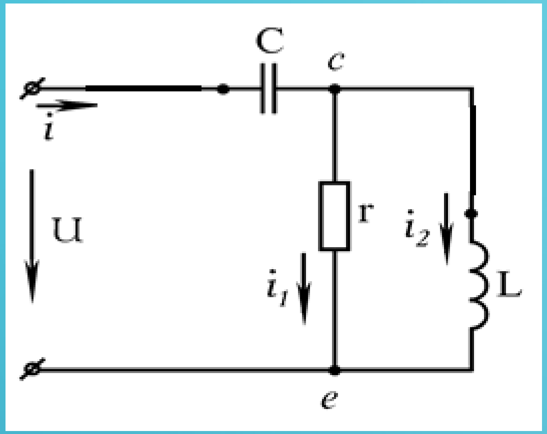
EQUIVALENT TRANSFORMATIONS OF ALTERNATING CURRENT CIRCUITS

This method is useful when the circuit contains only one power source. The essence of this method is that the entire passive part of the circuit is reduced to one equivalent resistance, which is connected to the poles of the power source. After that, according to Ohm's rule, the input current of the circuit is found, which is further distributed between the branches.

Let us consider various possible variants of equivalent transformations.

EXAMPLE

Calculate the input current in the electrical circuit:



u(t) = 180 sin (wt+30⁰) (V)
R = 20 (Ohm)
L = 100 (mH)
C = 190 (μF)
f = 50 (Hz)

CALCULATION

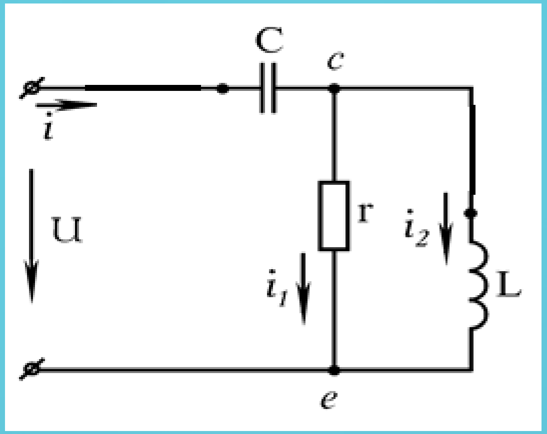
$$\omega = 2\cdot\pi\cdot f = 2\cdot 3{,}14\cdot 50 = 314\ (rad/s)$$

$$X_L = \omega\cdot L = 314\cdot 100\cdot 10^{-3} = 31{,}4\ (Ohm) \qquad \underline{X_L} = 31{,}4\cdot j\ (Ohm)$$

$$X_C = \frac{1}{\omega\cdot C} = \frac{1}{314\cdot 190\cdot 10^{-6}} = 16{,}76\ (Ohm) \qquad \underline{X_C} = -16{,}76\cdot j\ (Ohm)$$

$$\underline{Z}_{екв} = \underline{X_C} + \frac{R\cdot \underline{X_L}}{R+\underline{X_L}} = -16{,}76\cdot j + \frac{20\cdot 31{,}4\cdot j}{20+31{,}4\cdot j} = -16{,}76\cdot j + \frac{20\cdot e^{0^0 j}\cdot 31{,}4\cdot e^{90^0 j}}{37{,}23\cdot e^{57{,}51^0 j}} =$$

$$= -16{,}76\cdot j + 16{,}87\cdot e^{32{,}49^0 j} = -16{,}76\cdot j + 14{,}23 + 9{,}06\cdot j = 14{,}23 - 7{,}7\cdot j = 16{,}18\cdot e^{-28{,}42^0 j}\ (Ohm)$$



$$\underline{U} = \frac{180}{\sqrt{2}} \cdot e^{30^0 j} = 127{,}66 \cdot e^{30^0 j}\ (V)$$

$$\underline{I} = \frac{\underline{U}}{\underline{Z}_{екв}} = \frac{127{,}66 \cdot e^{30^0 j}}{16{,}18 \cdot e^{-28{,}42^0 j}} = 7{,}89 \cdot e^{58{,}42^0 j}\ (A)$$

$$i(t) = 7{,}89 \cdot \sqrt{2} \cdot \sin(314 \cdot t + 58{,}42^0) = 11{,}12 \cdot \sin(314 \cdot t + 58{,}42^0)\ (A)$$

INDIVIDUAL WORK

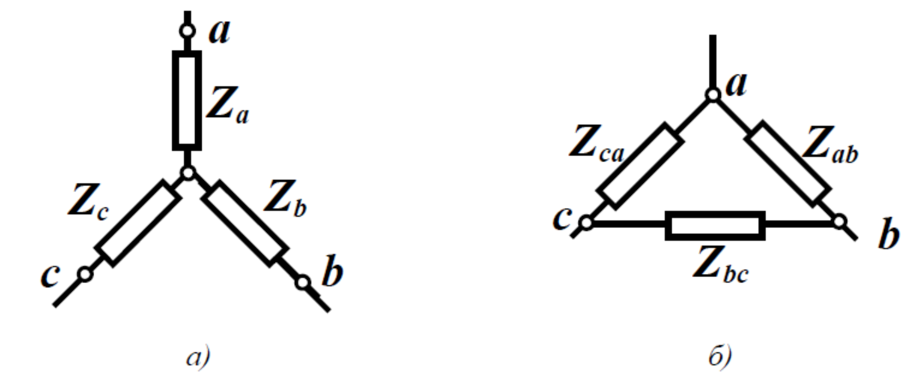
Calculate the currents $i_1(t)$ and $i_2(t)$

THE TRANSFORMATION FROM A TRIANGLE TO A STAR

$$\underline{Z}_a = \frac{\underline{Z}_{ab}\underline{Z}_{ac}}{\underline{Z}_{ab} + \underline{Z}_{ac} + \underline{Z}_{bc}},$$

$$\underline{Z}_b = \frac{\underline{Z}_{ab}\underline{Z}_{bc}}{\underline{Z}_{ab} + \underline{Z}_{ac} + \underline{Z}_{bc}},$$

$$\underline{Z}_c = \frac{\underline{Z}_{bc}\underline{Z}_{ac}}{\underline{Z}_{ab} + \underline{Z}_{ac} + \underline{Z}_{bc}},$$

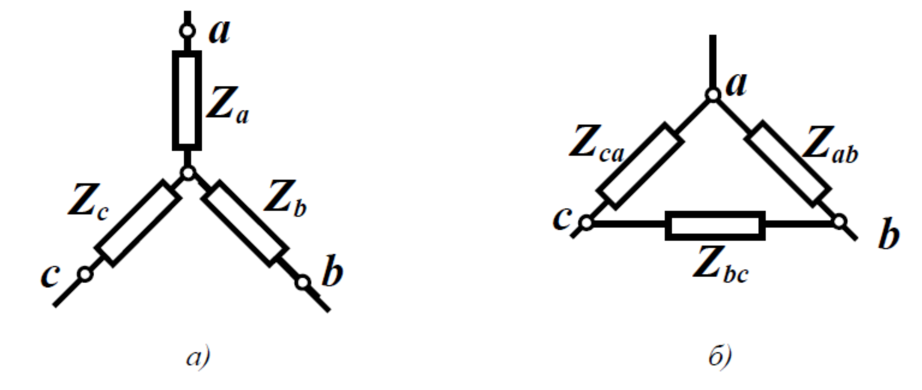


THE TRANSFORMATION FROM A STAR TO A TRIANGLE

$$\underline{Z}_{ab} = \underline{Z}_a + \underline{Z}_b + \frac{\underline{Z}_a \underline{Z}_b}{\underline{Z}_c},$$

$$\underline{Z}_{bc} = \underline{Z}_b + \underline{Z}_c + \frac{\underline{Z}_b \underline{Z}_c}{\underline{Z}_a},$$

$$\underline{Z}_{ca} = \underline{Z}_a + \underline{Z}_c + \frac{\underline{Z}_a \underline{Z}_c}{\underline{Z}_b}.$$



METHOD OF NODAL POTENTIALS

It is advisable to use the nodal potential method if the number of equations according to Kirchhoff's first rule is less than the number of equations according to the second rule.

In addition, circles in which the number of nodes and branches reaches hundreds or even thousands cannot be calculated using standard mathematical software packages. In such cases, special computer programs are developed, and it is the method of nodal potentials that is algorithmized better than others and provides effective software implementation.The essence of the method is that, first, the complex potentials of all nodes of the circle except for one, which is called the basic one, and whose potential is assumed to be zero, are plotted.

According to this method, the system of equations also has a unified form for any circle scheme.

In the general case, the system of equations for m-1 nodals has the form:

$$\underline{Y}_{11}\underline{\varphi}_1 - \underline{Y}_{12}\underline{\varphi}_2 - \underline{Y}_{13}\underline{\varphi}_3 - \ldots - \underline{Y}_{1m}\underline{\varphi}_m = \underline{I}_{11}$$

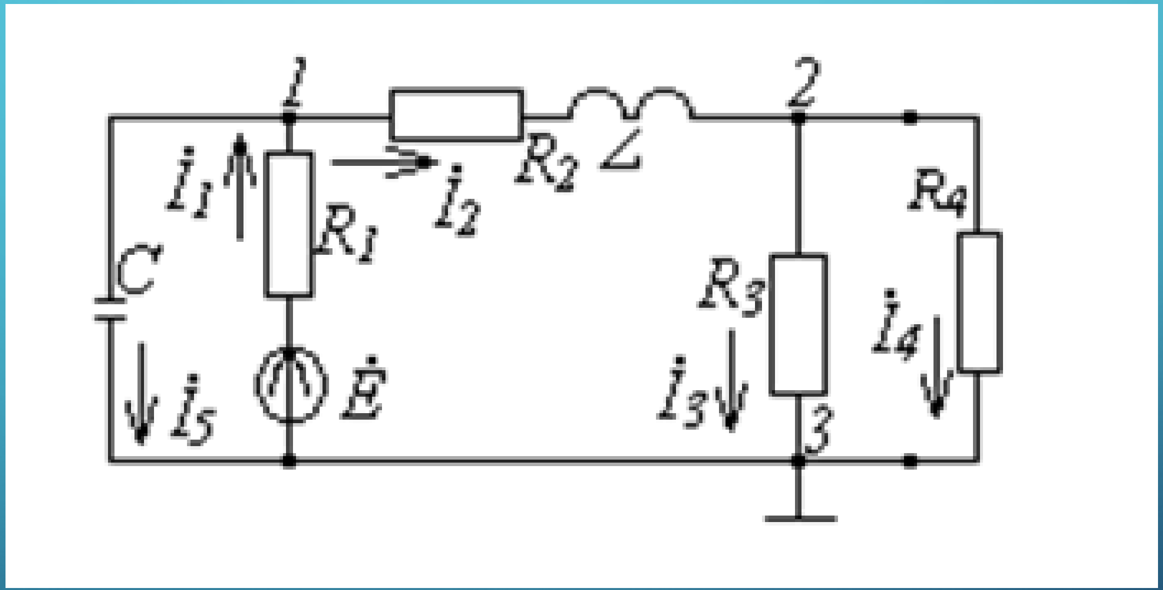
$$-\underline{Y}_{21}\underline{\varphi}_1 + \underline{Y}_{22}\underline{\varphi}_2 - \underline{Y}_{23}\underline{\varphi}_3 - \ldots - \underline{Y}_{2m}\underline{\varphi}_m = \underline{I}_{22}$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$-\underline{Y}_{m1}\underline{\varphi}_1 - \underline{Y}_{m2}\underline{\varphi}_2 - \underline{Y}_{m3}\underline{\varphi}_3 - \ldots + \underline{Y}_{mm}\underline{\varphi}_m = \underline{I}_{mm}$$

INDIVIDUAL WORK

For the circle shown in the figure, complete a system of equations using the method of nodal potentials.



THANK FOR YOUR ATTENTION!