COMBINATION OF THE PRINCIPLES OF SUPERPOSITION AND RECIPROCITY AS A METHOD FOR ANALYSIS OF ELECTRIC CIRCUITS

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Abstract. *The principles of superposition and reciprocity are well known basic principles, which are often used in the analysis of linear electric circuits. In this paper we use a new approach and offer a new efficient method for the analysis of electrical DC or AC circuit.*

With combination of the both principles, any complex electric circuit containing several sources shall be analyzed only once, as in the principle of superposition, under the action of one of the sources. From the obtained results with applying the principle of proportionality are calculated directly unknown branch currents (voltage).

Keywords: *superposition, reciprocity, analysis of electric circuits*

1. THE PRINCIPLE OF SUPERPOSITION

According to the method of superposition, the branch currents and the voltages between arbitrary pairs of points in a complex linear circuit can be defined as the algebraic sum of the corresponding branch currents and voltages, generated by the independent action of the individual sources [1, 2].

Sources which do not participate in the analysis are replaced by their internal resistances:

1) The voltage sources are replaced by a perfect conductor (short circuit);

2) Branches with current sources are disconnected (open circuit).

For the determination of the individual components of the branch currents and voltages can be used all methods of analysis. Because in practice it is necessary to analyze the circuits with a single source, so the most commonly used method to convert equivalent passive sections - series and parallel resistances, and using Ohm's and Kirchhoff's law.

The superposition helps reduce complex circuits to simpler circuits but has one disadvantage - require more work.

2. THE PRINCIPLE OF RECIPROCITY

2.1. In action of a voltage source

If a voltage source, only one for complex linear circuit, acting in the branch k of the circuit, produces the current i_m' in another branch m (Fig.1.a), the same source acting in the second branch m, it will produce the same current i_k'' in the first branch k (Fig.1.b) and it is satisfied

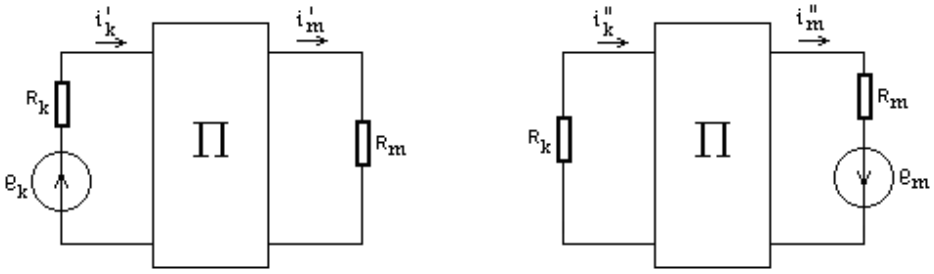
$$i_k'' = i_m'. \tag{1}$$

If in the branches acting different voltage sources, is valid the following equation

$$\frac{e_k}{e_m} = \frac{i_m'}{i_k''} \tag{2}$$

or

$$i_k'' = i_m' \frac{e_m}{e_k}. \tag{3}$$



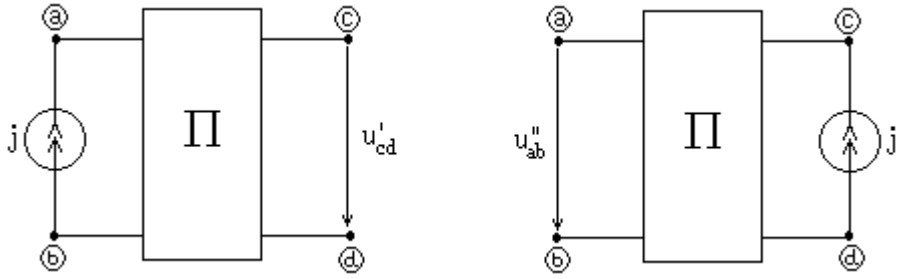
a) b)

Fig. 1

2.2. In action of a current source

If a current source, only one for complex linear circuit, acting between points *a* and *b* of the circuit, produces the voltage u_{cd}' between another points *c* and *d* (Fig.2a), the same source acting between points *c* and *d*, it will produce the same voltage u_{ab}'' between *a* and *b* (Fig.2b) and it is satisfied

$$u_{ab}'' = u_{cd}'. \tag{4}$$



a) b)

Fig. 2

If in the branches acting different current sources, is valid the following equation

$$\frac{j_k}{j_m} = \frac{u_{cd}'}{u_{ab}''} \tag{5}$$

or

$$u_{ab}'' = u_{cd}' \frac{j_m}{j_k}. \tag{6}$$

The principle of proportionality is convenient for the analysis of circuits to find a single branch current or voltage. With success can also be used in the analysis of bridge circuits.

3. THE COMBINATION OF THE BOTH PRINCIPLES – AS A METHOD FOR ANALYSIS OF ELECTRIC CIRCUITS

The combination of the two both above-mentioned principles - the principle of superposition and the principle of reciprocity - can be used as an efficient method for determining the current and voltage in a complex electric circuit.

Below is an example to illustrate the proposed method. For the circuit shown in Fig.3 find current i_2.

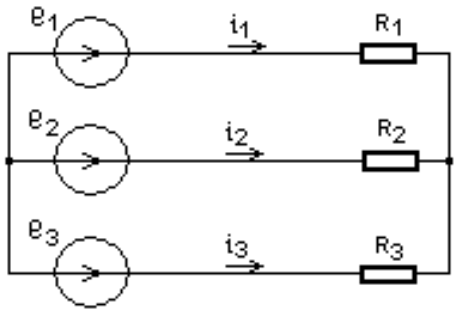


Fig. 3

Consider the circuit in Fig.4. When acting only voltage source e_2, like method of superposition, and determine the branch currents i_1', i_2' and i_3'.

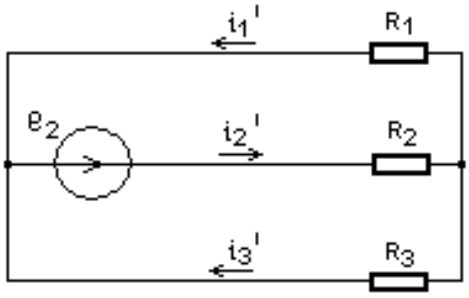


Fig. 4

Applying the principle of reciprocity for different voltage sources (2), (3), expression for the current i_2 obtain

$$i_2 = i_2' - i_1' \frac{e_1}{e_2} - i_3' \frac{e_3}{e_2}. \qquad (7)$$

Thus by a single analysis of the circuit obtain the value of the desired unknown current. The procedure can be repeated for the other branch currents.

References

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