

# VINNITSA NATIONAL AGRARIAN UNIVERSITY

Department of Electric Power Engineering, Electrical Engineering and Electromechanics



## METHOD OF LOOP CURRENTS

by Associate Professor V. Hraniak



# ALGORITHM FOR SOLVING AN ELECTRIC CIRCUIT BY THE METHOD OF LOOP CURRENTS.

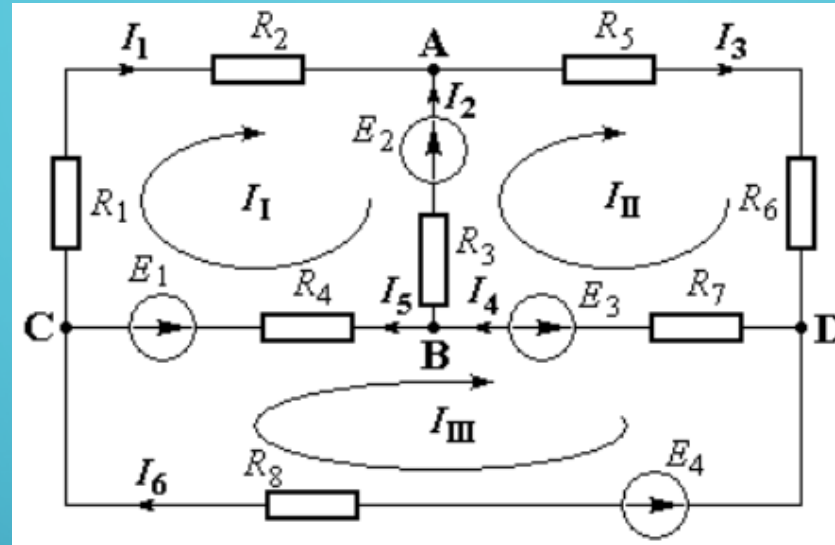
1. Determine the number of independent loops. Compile equations using according to method of loop currents. The number of equations composed by the method of loop currents should be equal to the number of independent loops.
2. Determine the own and joint resistances of loops and their EMF.
3. Use any calculation method to solve the system of equations and determine the loop currents.
4. Based on the found loop currents, determine the currents in the branches of the circuit.





# EXAMPLE

For the circuit shown in the figure, make a system of equations using the method of loop currents.



Let's select three independent loops in the circuit and write the system of equations according to the method of loop currents in the general form:

$$\begin{cases} I_{11}R_{11} + I_{22}R_{12} + I_{33}R_{13} = E_{11}, \\ I_{11}R_{21} + I_{22}R_{22} + I_{33}R_{23} = E_{22}, \\ I_{11}R_{31} + I_{22}R_{32} + I_{33}R_{33} = E_{33}. \end{cases}$$

Let's determine the own and joint resistances of the circuits and the loop own EMF.

$$R_{11} = R_1 + R_2 + R_3 + R_4,$$

$$R_{22} = R_3 + R_5 + R_6 + R_7,$$

$$R_{33} = R_4 + R_7 + R_8,$$

$$R_{12} = R_{21} = -R_3,$$

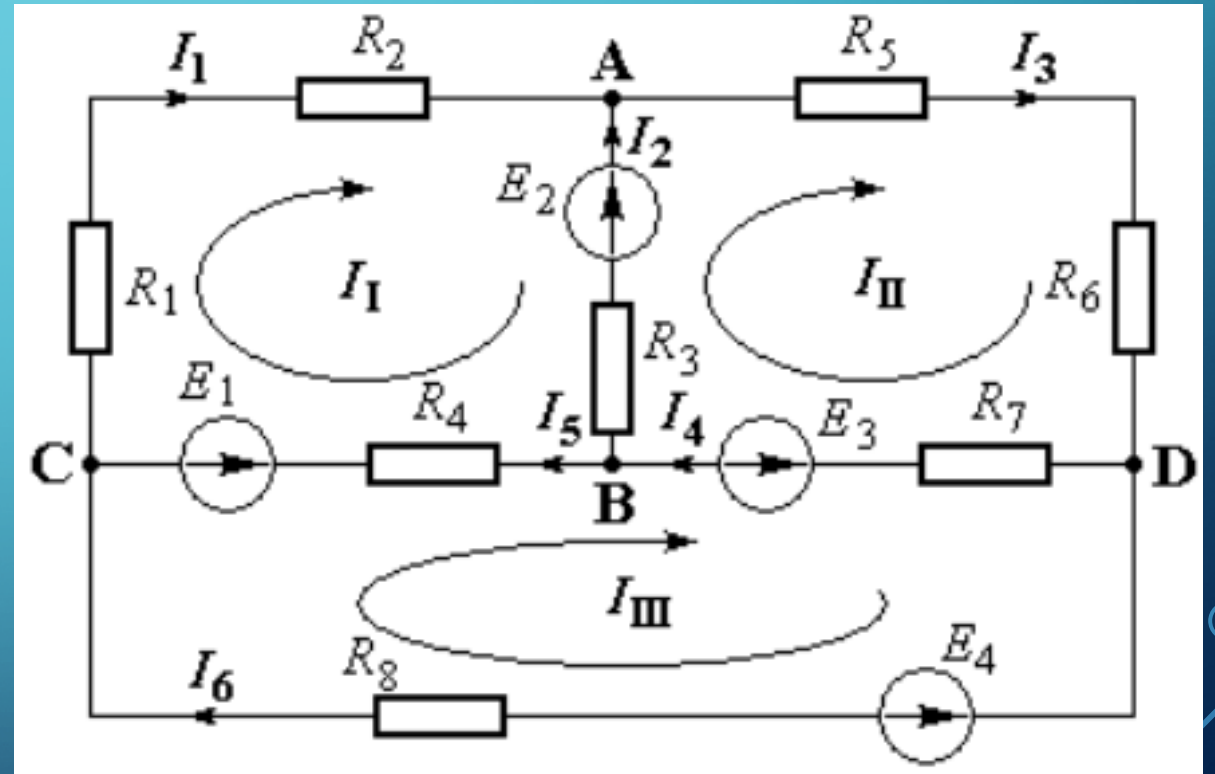
$$R_{13} = R_{31} = -R_4,$$

$$R_{23} = R_{32} = -R_7,$$

$$E_{11} = -E_1 - E_2,$$

$$E_{22} = E_2 - E_3,$$

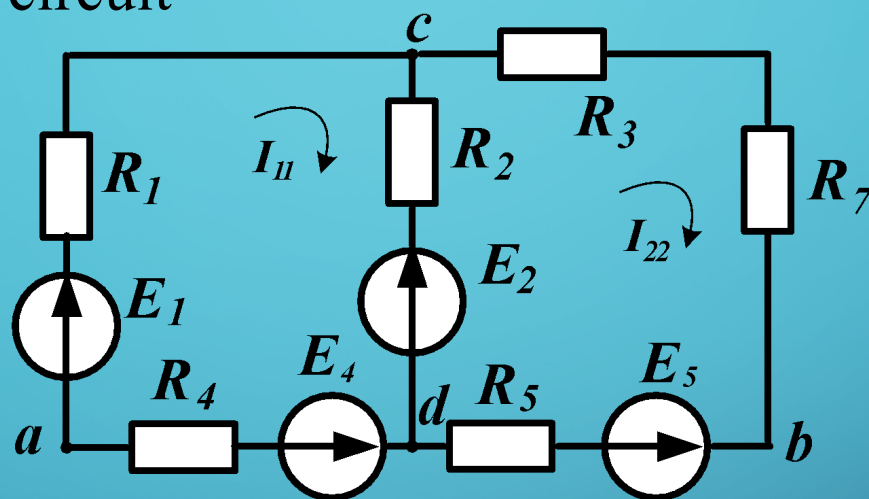
$$E_{33} = E_1 + E_3 - E_4.$$





# EXAMPLE OF CALCULATION

Complete the system of equations by the method of loop currents and write its coefficients for the next circuit



$$I_{11}R_{11} + I_{22}R_{12} = E_{11}$$

$$I_{11}R_{21} + I_{22}R_{22} = E_{22}$$

$$R_{11} = R_1 + R_4 + R_2$$

$$E_{11} = E_1 - E_2 - E_4$$

$$R_{22} = R_3 + R_2 + R_5 + R_7$$

$$E_{22} = E_2 - E_5$$

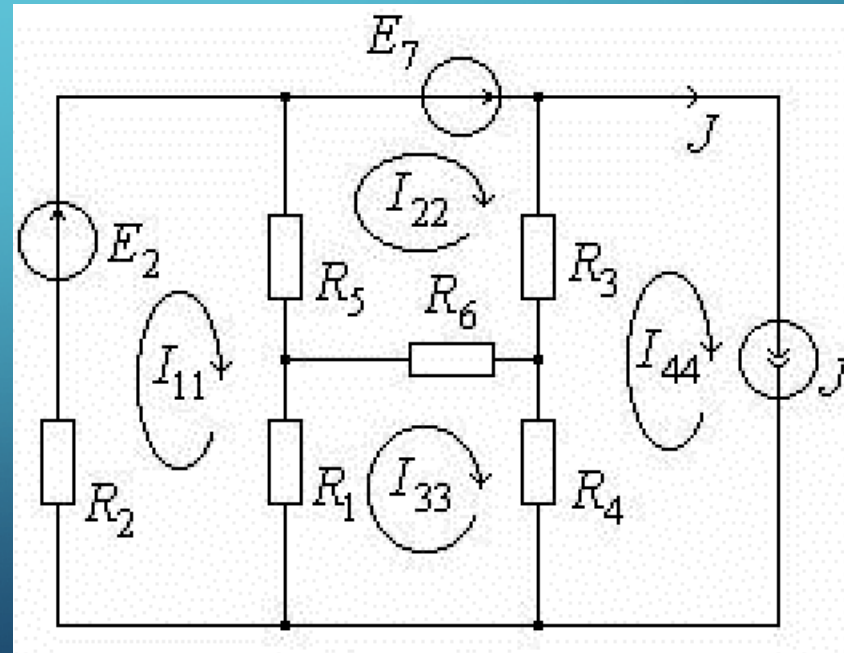
# PECULIARITIES OF THE LOOP CURRENT METHOD IF THERE ARE CURRENT SOURCES IN THE CIRCUIT

If the circuit has branches containing ideal current sources, it is convenient to choose the loops so that such a branch with current sources is included in only one loop. In this case, the loop current of this loop is already known - it is equal to the current of the current source, and the number of unknown loop currents decreases.

## Example

Calculate all currents in the circuit in the figure by the method of loop currents with the following set parameters:

$R_1=26(\text{Ohm})$ ,  $R_2=10(\text{Ohm})$ ,  
 $R_3=18(\text{Ohm})$ ,  $R_4=14(\text{Ohm})$ ,  
 $R_5=20(\text{Ohm})$ ,  $R_6=8(\text{Ohm})$ ,  
 $E_2=20(\text{V})$ ,  $E_7=24(\text{V})$ ,  
 $J=2(\text{A})$ .



The circuit has four independent loops. According to the method of loop currents, three equations need to be compiled, since the loop current  $I_{44}=J$  is known. Let's write the system of equations according to the method of loop currents in general form:

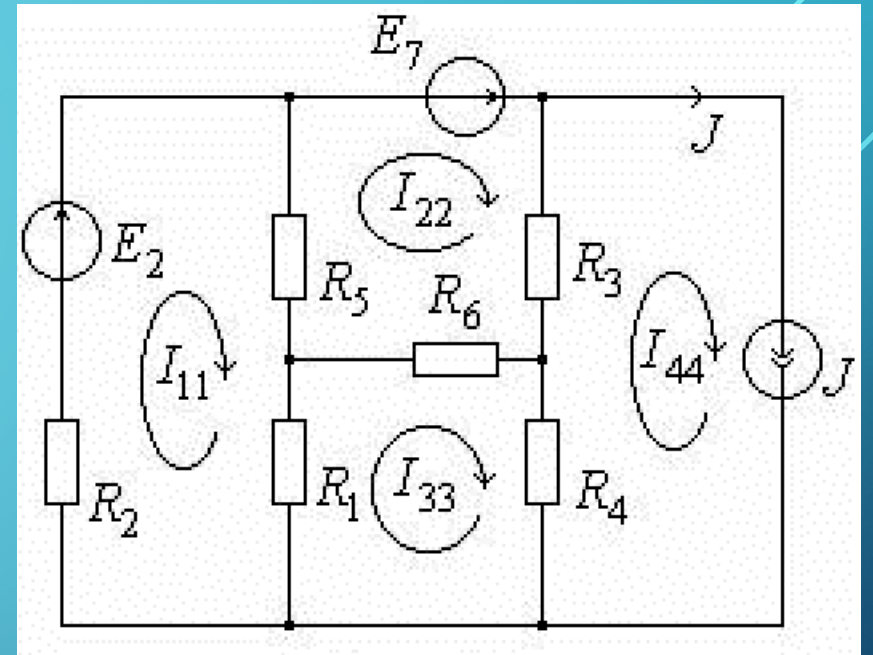
$$\begin{cases} I_{11}R_{11} + I_{22}R_{12} + I_{33}R_{13} + I_{44}R_{14} = E_{11}, \\ I_{11}R_{21} + I_{22}R_{22} + I_{33}R_{23} + I_{44}R_{24} = E_{22}, \\ I_{11}R_{31} + I_{22}R_{32} + I_{33}R_{33} + I_{44}R_{34} = E_{33}. \end{cases}$$

Own resistances:

$$R_{11} = R_1 + R_2 + R_5 = 26 + 10 + 20 = 56 \text{ (Ohm)},$$

$$R_{22} = R_5 + R_3 + R_6 = 20 + 18 + 8 = 46 \text{ (Ohm)},$$

$$R_{33} = R_1 + R_6 + R_4 = 8 + 14 + 26 = 48 \text{ (Ohm)}.$$





## Joint resistances

$$R_{12} = R_{21} = -R_5 = -20 \text{ (Ohm)},$$

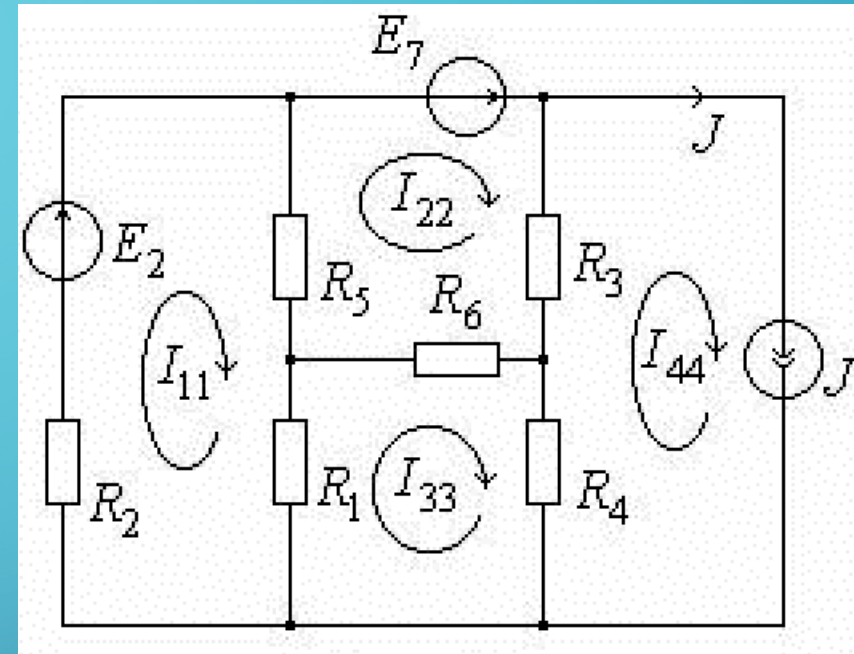
$$R_{13} = R_{31} = -R_1 = -26 \text{ (Ohm)},$$

$$R_{14} = R_{41} = 0 \text{ (Ohm)},$$

$$R_{23} = R_{32} = -R_6 = -8 \text{ (Ohm)},$$

$$R_{24} = R_{42} = -R_3 = -18 \text{ (Ohm)},$$

$$R_{34} = R_{43} = -R_4 = -14 \text{ (Ohm)}.$$



Own EMF:

$$E_{11} = E_2 = 20 \text{ (V)},$$

$$E_{22} = E_7 = 24 \text{ (V)},$$

$$E_{33} = 0 \text{ (V)}.$$

Let's substitute the values into the system of equations:

$$\begin{cases} 56I_{11} - 20I_{22} - 26I_{33} = 20, \\ -20I_{11} + 46I_{22} - 8I_{33} - 18 \cdot 2 = 24, \\ -26I_{11} - 8I_{22} + 48I_{33} - 14 \cdot 2 = 0. \end{cases}$$

or after simplification:

$$\begin{cases} 56I_{11} - 20I_{22} - 26I_{33} = 20, \\ -20I_{11} + 46I_{22} - 8I_{33} = 60, \\ -26I_{11} - 8I_{22} + 48I_{33} = 28. \end{cases}$$

Let's solve the system of equations using Kramer's method:

$$\Delta = \begin{bmatrix} 56 & -20 & -26 \\ -20 & 46 & -8 \\ -26 & -8 & 48 \end{bmatrix} = 61448,$$

$$\Delta_1 = \begin{bmatrix} 20 & -20 & -26 \\ 60 & 46 & -8 \\ 28 & -8 & 48 \end{bmatrix} = 150998,$$

$$\Delta_2 = \begin{bmatrix} 56 & 20 & -26 \\ -20 & 60 & -8 \\ -26 & 28 & 48 \end{bmatrix} = 171184,$$

$$\Delta_3 = \begin{bmatrix} 56 & -20 & 20 \\ -20 & 46 & 60 \\ -26 & -8 & 28 \end{bmatrix} = 146128.$$



Let's find the loop currents:

$$I_{11} = \frac{\Delta_1}{\Delta} = \frac{150928}{61448} = 2,456 \text{ (A)},$$

$$I_{22} = \frac{\Delta_2}{\Delta} = \frac{171184}{61448} = 2,785 \text{ (A)},$$

$$I_{33} = \frac{\Delta_3}{\Delta} = \frac{146128}{61448} = 2,378 \text{ (A)}.$$

All loop currents are positive, and therefore their actual directions coincide with the selected ones. Let's find the branch currents as the algebraic sum of the loop currents flowing in the branch.

$$I_1 = I_{11} - I_{33} = 2,456 - 2,378 = 0,078 \text{ (A)},$$

$$I_2 = I_{11} = 2,456 \text{ (A)},$$

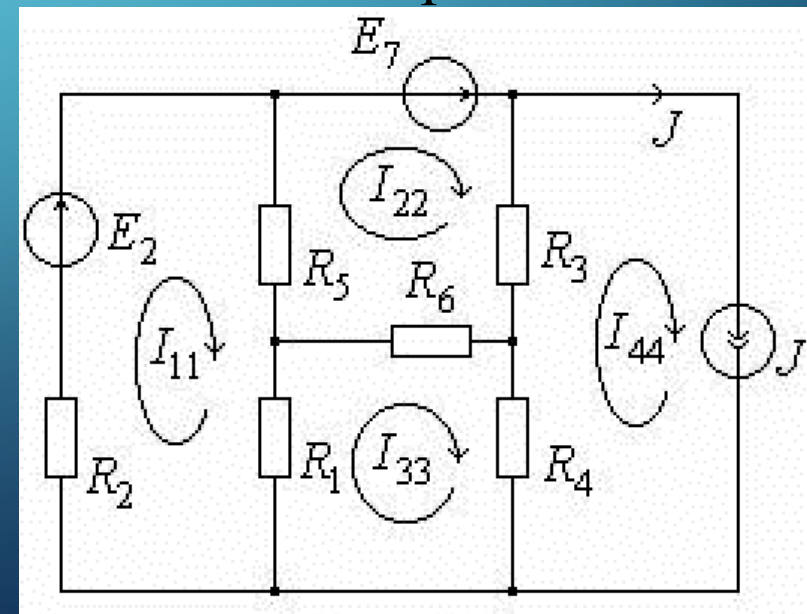
$$I_3 = I_{22} - I_{44} = 2,786 - 2 = 0,786 \text{ (A)},$$

$$I_4 = I_{33} - I_{44} = 2,378 - 2 = 0,378 \text{ (A)},$$

$$I_5 = I_{22} - I_{11} = 2,786 - 2,456 = 0,33 \text{ (A)},$$

$$I_6 = I_{22} - I_{33} = 2,786 - 2,378 = 0,408 \text{ (A)},$$

$$I_7 = I_{22} = 2,786 \text{ (A)}.$$



# EXAMPLE OF CALCULATION (individual work)

Complete the system of equations by the method of loop currents and write its coefficients for the next circuit

