VINNITSA NATIONAL AGRARIAN UNIVERSITY

Department of Electric Power Engineering, Electrical Engineering and Electromechanics

METHOD OF EQUIVALENT GENERATOR

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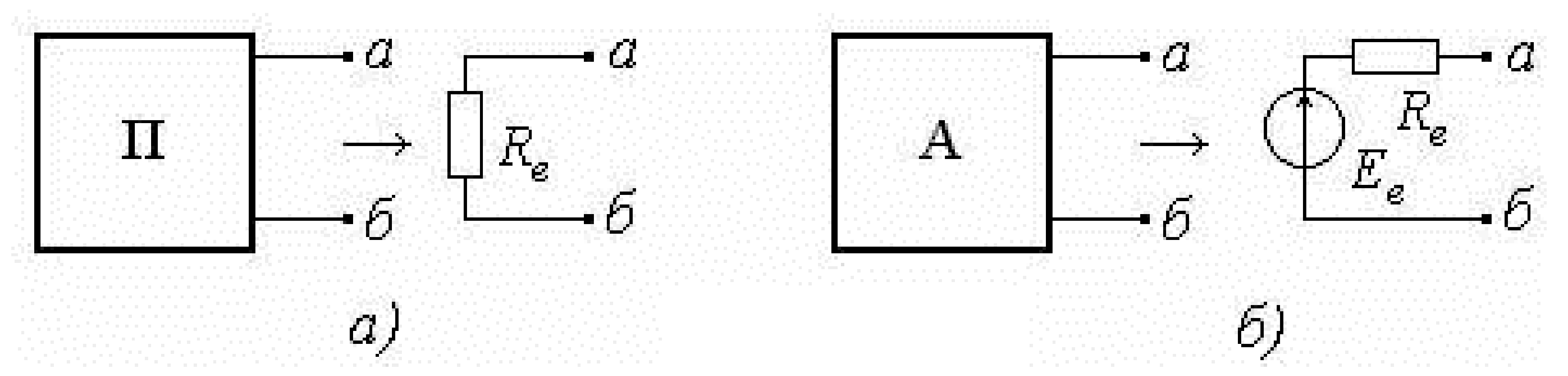
THE ESSENCE AND MAIN APPROACHES

A two-pole circuit (dipole) is a circuit that has two terminals to which a source or consumer of electrical energy can be connected.

Passive dipole, in which there are no energy sources, can be replaced by one equivalent resistance (Fig. a).

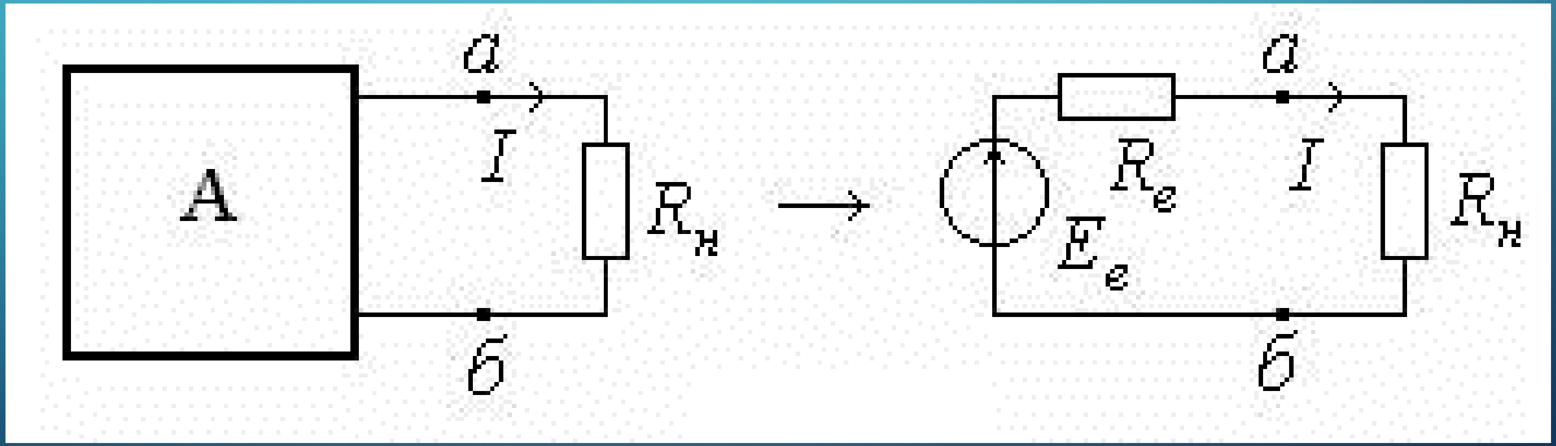
Active dipole - contains sources of electrical energy. It manifests itself in the presence of voltage on the open terminals, which is called no-load voltage

The active dipole can be replaced by an equivalent generator (Fig. b).



THEOREM ABOUT AN ACTIVE DIPOLE

The current in branches a, b of the electric circuit will not change if the active dipole (Fig. a) to which this branch is connected is replaced by an equivalent voltage source (equivalent generator), the EMF of which is equal to the breakdown voltage at the poles of the active dipole, and the internal resistance is equal to the input resistance relative to the poles a, b of the passive dipole, obtained from this active dipole when energy sources are removed from it (Fig. b).



ALGORITHM FOR CALCULATING AN ELECTRIC CIRCUIT USING THE METHOD OF EQUIVALENT GENERATOR

1. Disconnect the line in which the current is determined, marking the disconnection points with points a, b.
2. Use any of the known methods to calculate the remaining circuit (mode of breaking the active two-pole) and determine the voltage Uab between points a, b, to which the line was connected.
3. Remove the energy sources from the scheme, replacing them with internal resistances, determine the input resistance Rvx relative to points a, b.
4. Determine the current in the line according to the formula:

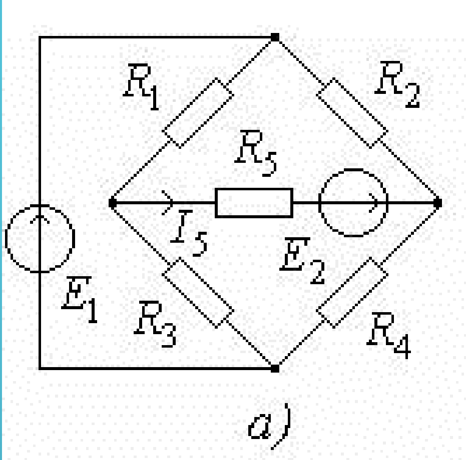
$$I = \frac{U_{аб}}{R_{вх} + R_{н}} = \frac{E_{e}}{R_{e} + R_{н}}.$$

5. If there is an EMF source in the line whose current is calculated, then the calculation is carried out according to the formula:

$$I = \frac{U_{аб} \pm E}{R_{вх} + R_{н}} = \frac{E_{e} \pm E}{R_{e} + R_{н}}.$$

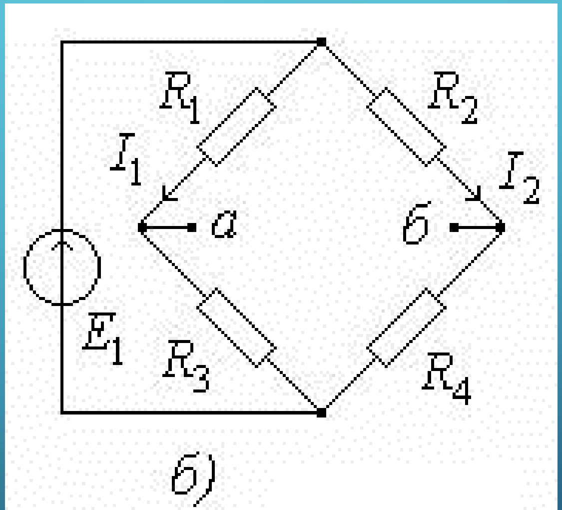
EXAMPLE

Determine the current I5 in the circuit in the figure



Solution

1. The line with current I5 is disconnected (Fig. b).
2. The remaining scheme is calculated (mode of breaking of the active dipole) and the voltage Uab between points a, b, to which the line was connected, is determined.

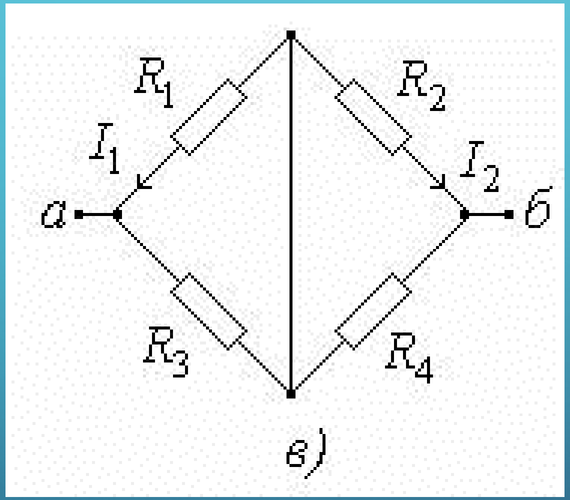


$$U_{аб} = E_e = -I_1R_1 + I_2R_2 = -\frac{E_1R_1}{R_1+R_3} + \frac{E_1R_2}{R_2+R_4} = \frac{E_1(R_2(R_1+R_3) - R_1(R_2+R_4))}{(R_1+R_3)(R_2+R_4)}.$$

After simplifying the expression, we get:

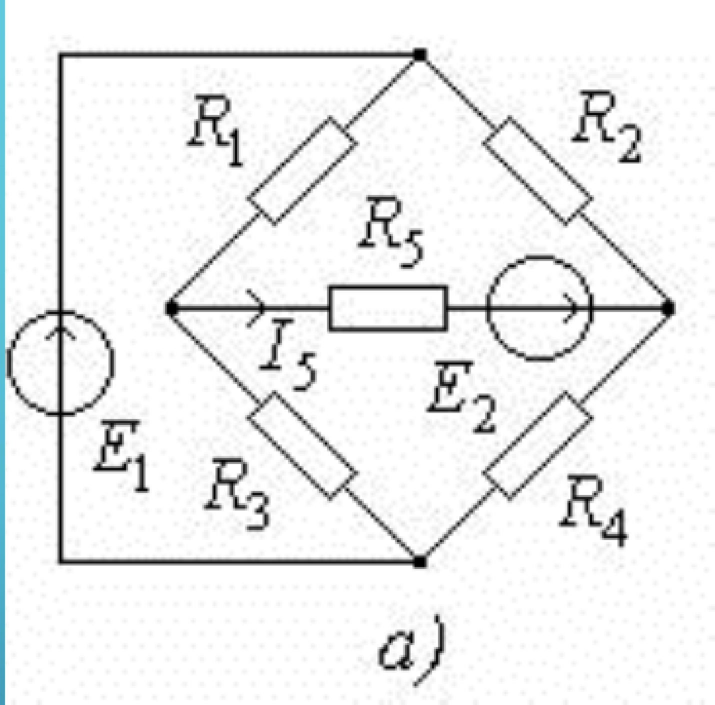
$$U_{аб} = E_e = \frac{E_1(R_2R_3 - R_1R_4)}{(R_1 + R_3)(R_2 + R_4)}.$$

3. E2 is removed from the circuit, replacing it with an internal resistance (short circuit), the input resistance Rвх is determined relative to points a, b, (Fig. c). The supports R1 and R3, R2 and R4 are connected in parallel, and in series with each other.



$$R_{вх} = \frac{R_1R_3}{R_1 + R_3} + \frac{R_2R_4}{R_2 + R_4}.$$

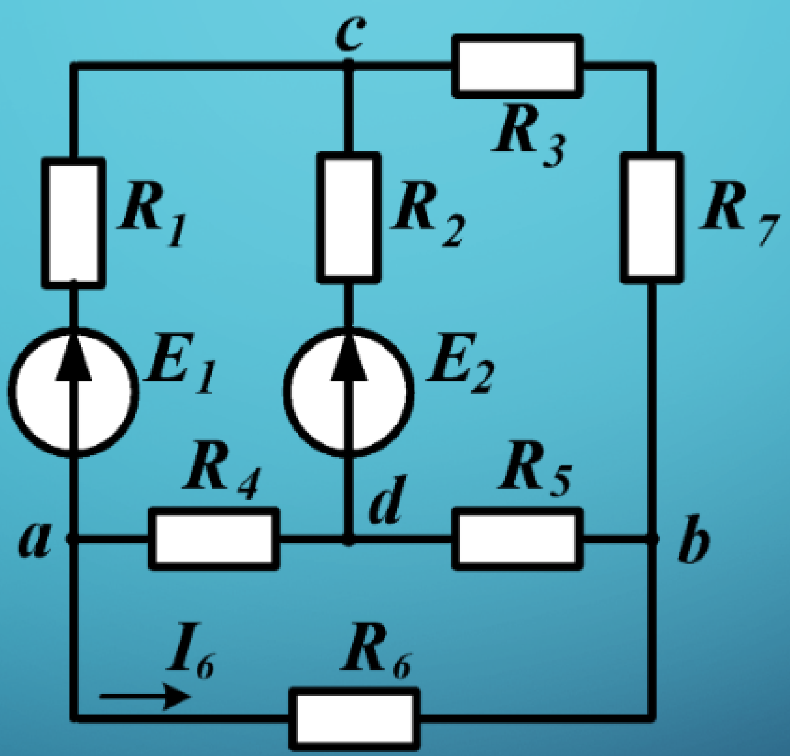
4. The current I5 is determined by the formula:



$$I_5 = \frac{U_{аб} + E_2}{R_{вх} + R_5} = \frac{E_e + E_2}{R_e + R_5}.$$

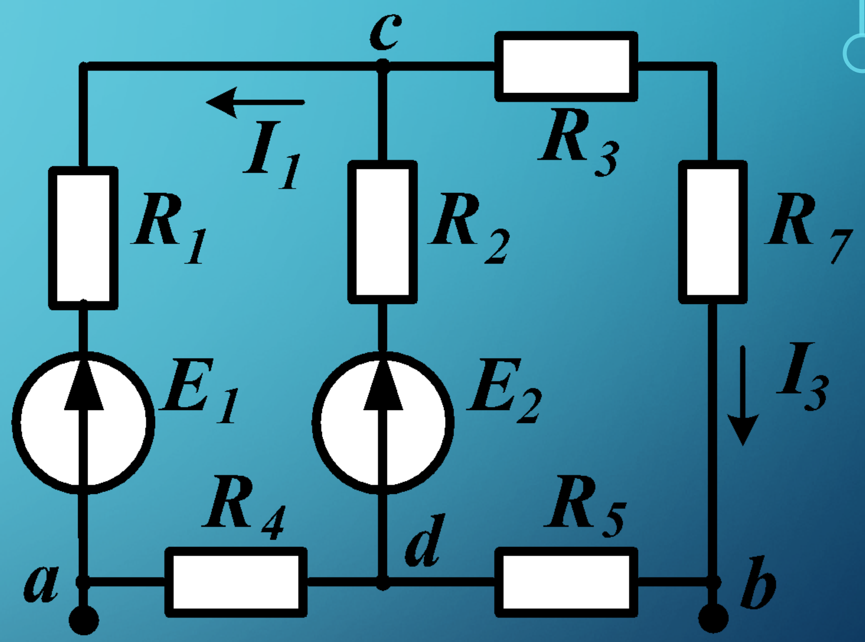
EXAMPLE

Calculate the current I6 using the equivalent generator method



Let's calculate the EMF of the equivalent generator

$$U_{cd} = \frac{\dfrac{E_1}{R_1 + R_4} + \dfrac{E_2}{R_2}}{\dfrac{1}{R_1 + R_4} + \dfrac{1}{R_2} + \dfrac{1}{R_3 + R_5 + R_7}}$$

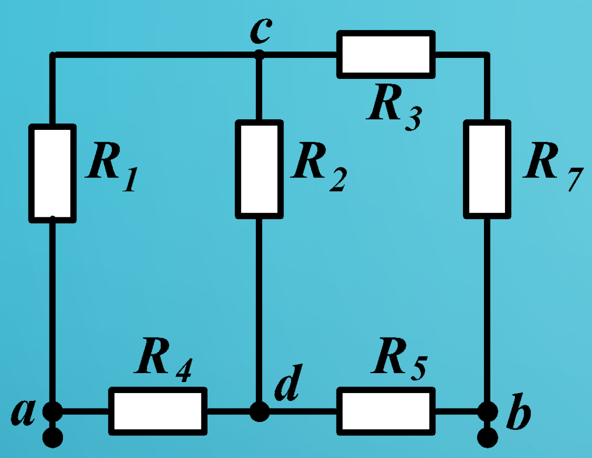


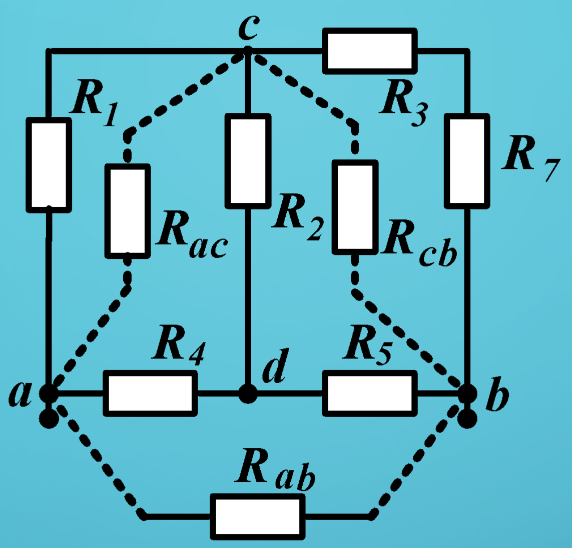
$$I_1 = \frac{U_{cd} - E_1}{R_1 + R_4} \qquad I_3 = \frac{U_{cd}}{R_3 + R_5 + R_7}$$

$$\varphi_a = \varphi_d + I_1 R_4 \qquad \varphi_b = \varphi_d + I_3 R_5$$

$$U_{ab} = \varphi_a - \varphi_b$$

Let's calculate the resistance of the equivalent generator

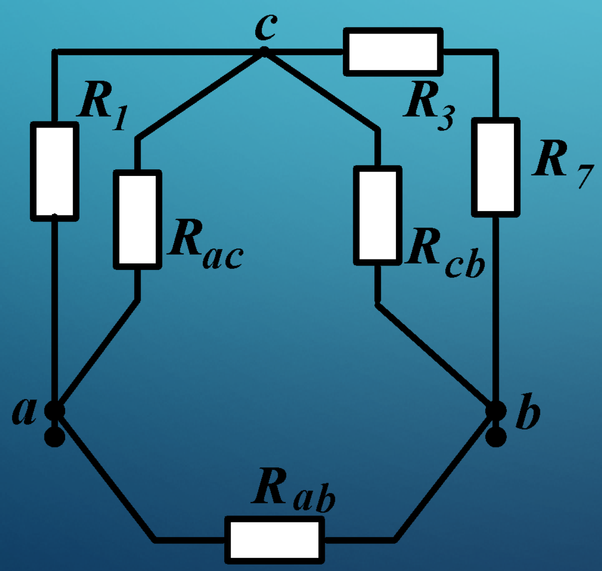




$$R_{ab} = R_5 + R_4 + \frac{R_5 R_4}{R_2}$$

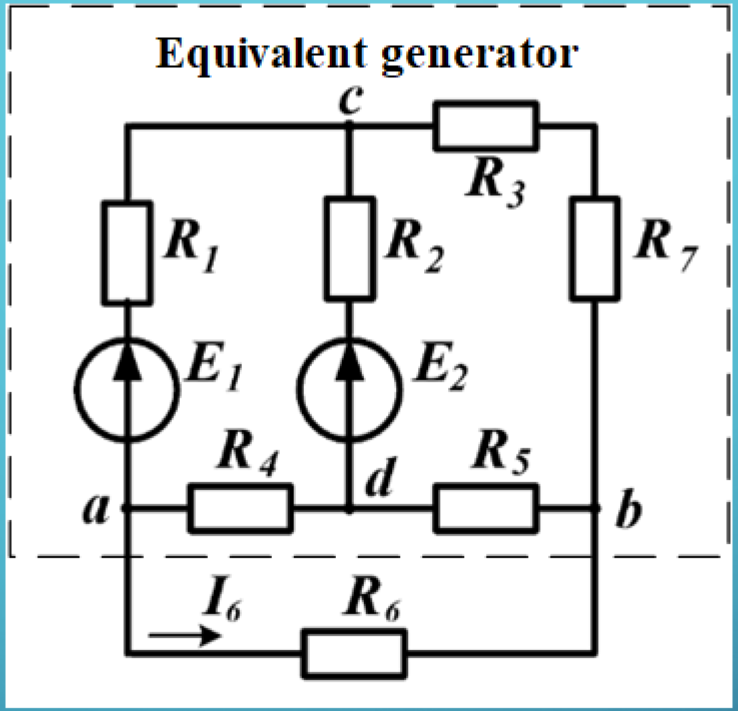
$$R_{cb} = R_2 + R_5 + \frac{R_2 R_5}{R_4}$$

$$R_{ac} = R_2 + R_4 + \frac{R_2 R_4}{R_5}$$



$$R_{ab.bx} = \frac{R_{ab}\left(\frac{R_1 R_{ac}}{R_1 + R_{ac}} + \frac{(R_3 + R_7)R_{cb}}{R_3 + R_7 + R_{cb}}\right)}{R_{ab} + \frac{R_1 R_{ac}}{R_1 + R_{ac}} + \frac{(R_3 + R_7)R_{cb}}{R_3 + R_7 + R_{cb}}}$$

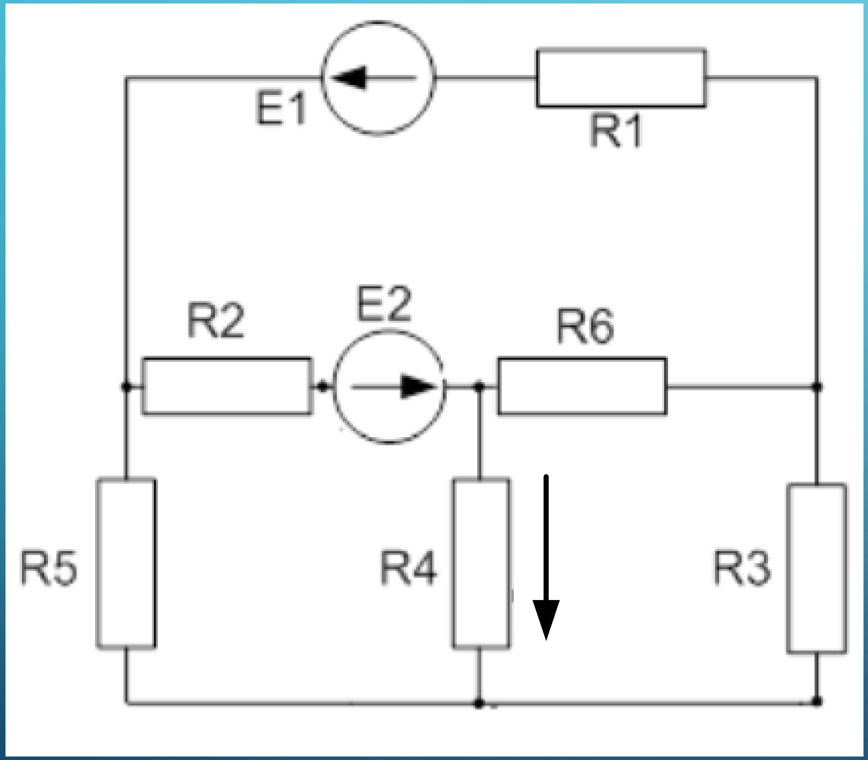
Let's calculate the current



$$I_6 = \frac{U_{ab}}{R_6 + R_{ab.bx}}$$

EXAMPLE OF CALCULATION (individual work)

Calculate the current I4 using the method of equivalent generator



R1 = 15 Ohm
R2 = 20 Ohm
R3 = 10 Ohm
R4 = 25 Ohm
R5 = 25 Ohm
R6 = 15 Ohm
E1 = 150 V
E2 = 120 V

THANK FOR YOUR ATTENTION!