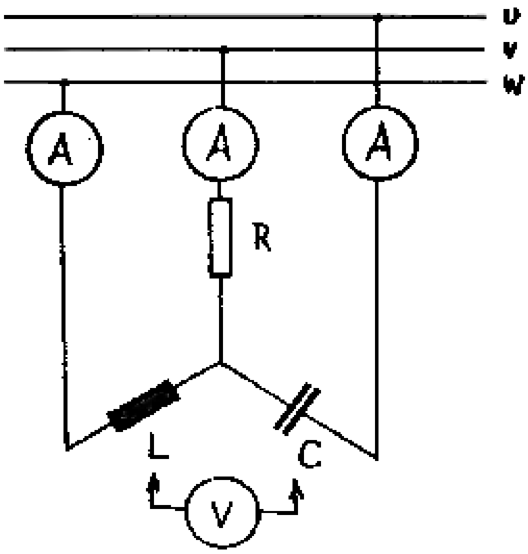
Symmetrization of a single-phase loads in three-phase network

Task:

1. For the given value of the substitute load resistance calculate the inductance and capacitance required for the symmetrisation in the star connection.
2. On the symmetrisation device connected into the star measure all the voltage values and currents and write the values into the table.
3. Draw vector diagram for the measured values.

Circuit diagram:



Used devices:

- Variable resistor that simulates alternative load resistance
- The ohmmeter
- Set of inductances
- Set of capacities
- The symmetrisation panel with a regulated voltage source
- Voltmeter
- Ammeter
- Connection conductors

Theoretical analysis:

Induction furnaces are causing with their single phase loads asymmetry in the three-phase network. To remove this asymmetry, there is the inductance and the capacitance inserted into other phases either in the star or delta connection. Right inductance and capacitance causes that the phase currents are equal and current is in a phase with relevant phase voltage. The required value of capacitance and inductance can be derived as follows:

Symmetrisation connection into the star

For two indicated loops using the second Kirchhoff's law can be written following formula:

$$\overline{U}_{UV} = \frac{1}{jwC}\overline{I}_C - R\overline{I}_R \qquad (1)$$

$$\overline{U}_{VW} = R\overline{I}_R - jwL\overline{I}_L \qquad (2)$$

In symmetrical three-phase circuit applies:

$$\overline{U}_{VW} = \overline{U}_{UV} \cdot e^{-j\frac{2p}{3}} \qquad (3)$$

Substituting for U_{VW} into the second formula from the formula (3) and multiplying both sides this way adjusted formula with the $e^{j(2\pi/3)}$ we get an formula with an equal left side as the formula (1).

From the equality of the right sides we get:

$$\frac{1}{jwC}\overline{I}_C - R\overline{I}_R = R\overline{I}_R e^{j\frac{2p}{3}} - jwL\overline{I}_L e^{j\frac{2p}{3}} \qquad (4)$$

From the fact that this is a symmetric system result equalities:

$$\overline{I}_C = \overline{I}_R e^{j\frac{2p}{3}} \qquad (5)$$

$$\overline{I}_L = \overline{I}_R e^{-j\frac{2p}{3}} \qquad (6)$$

Substituting into (4) from formulas (5) and (6) and dividing exponents we get:

$$-j\frac{1}{wC}\left(-\frac{1}{2} + j\frac{\sqrt{3}}{2}\right) - R = R\left(-\frac{1}{2} + j\frac{\sqrt{3}}{2}\right) - jwL \qquad (7)$$

From the equality of the real parts from left and right side of the formula (7) we calculate the capacitance value:

$$C = \frac{\sqrt{3}}{wR}$$

By substituting this capacity into the equality imaginary parts of the left and right side of the formula (7) we calculate the inductance value:

$$L = \frac{R}{\sqrt{3} \cdot w}$$

Calculated elements of the symmetrisation device is necessary to connect in the correct phase order, if no, phase currents are different.

The measurement procedure:

1. From the given value of the substitute load resistor we calculate the necessary capacitance and inductance for connection of the symmetrization device into the star.
2. We involve the role for measurement of symmetrization connection into the star.
3. We measure out all the necessary voltage values and currents and we insert them into tables.
4. From the measured values construct a vector diagram.

Substitute load resistance: R = 170 Ω