CIRCUITS AND SYSTEMS LABORATORY

EXERCISE 5

VOLTAGE AND CURRENTS SYMMETRICAL COMPONENTS FILTERS

1. PROGRAM OF EXPERIMENTS

1.1. DEVICES AND PANELS USED IN EXERCISE

The following devices are to be used in this exercise:
- 3-phase power supply panel, signed “Zasilacz trójfazowy”,
- symmetrical components filter panel, signed “Filtr składowych symetrycznych”,
- phase sequence detection panel, signed “Badanie następstwa faz”,
- 3-phase resistance panel, signed “Odbiornik trójfazowy – R”,
- 3-phase inductance panel, signed “Odbiornik trójfazowy – L”,
- 3-phase capacitors panel, signed “Odbiornik trójfazowy – C”,
- moving iron ammeters and voltmeters.

1.2. ZERO-SEQUENCE CURRENT MEASUREMENT

Measurement without measuring transformers

Measuring should be made with use of 4-wire wye-configured circuit shown in figure 1 with equal resistance values of $R_A = R_B = R_C = 30\ \Omega$ and input voltage system of positive and negative phase sequence:
a: balanced input $U_A = U_B = U_C$, e.g. $U_A = U_B = U_C = 22$ V,
b: unbalanced input $U_A \neq U_B \neq U_C$, e.g. $U_A = 33$ V, $U_B = 22$ V, $U_C = 11$ V,
c: single phase break, e.g. $U_A = 33$ V, $U_B = 0$, $U_C = 22$ V.

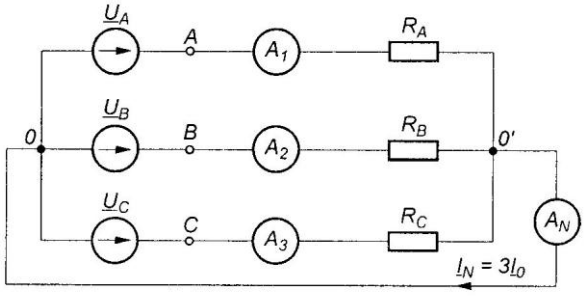

Fig. 1 Circuit diagram for measuring zero-sequence current in 4-wire configuration

The results of measurements should be written in table 1.

Table 1

Results table for measuring zero-sequence current in 4-wire circuit

No.	Measurements										Calculations	
	I_1	I_2	I_3	I_N	U_A	U_B	U_C	U_{AB}	U_{BC}	U_{CA}	$\underline{I}_N$	$\underline{I}_0$
	A	A	A	A	V	V	V	V	V	V	A	A
1a												
1b												
1c												
2a												
2b												
2c												

where: 1 – positive-sequence input voltage; 2 – negative-sequence input voltage

Measurement with measuring transformers

Measuring should be made with use of circuit shown in figure 2 for the following positive and negative sequence input voltage values:

a: $U_A = U_B = U_C = 22$ V, $R_A = R_B = R_C = 30\ \Omega$ (balanced input, balanced load),

b: $U_A = 22$ V, $U_B = U_C = 11$ V, $R_A = R_B = R_C = 30\ \Omega$ (unbalanced input, balanced load),

c: $U_A = U_B = U_C = 11$ V, $R_A = R_B = 15\ \Omega$, $R_C = 30\ \Omega$ (balanced input, unbalanced load).

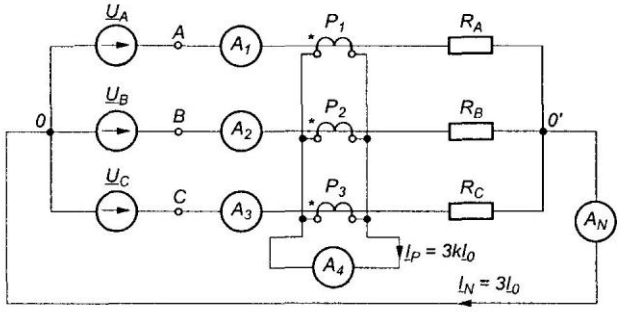

Fig. 2 Circuit diagram for measuring zero-sequence current in 4-wire configuration with current measuring transformers

The results of measurements should be written in table 2.

Table 2

Results table for measuring zero-sequence current in 4-wire circuit with measuring transformers

No.	Measurements											Calculations	
	I_1	I_2	I_3	I_N	I_P	U_A	U_B	U_C	U_{AB}	U_{BC}	U_{CA}	$\underline{I}_N$	$\underline{I}_P$
	A	A	A	A	A	V	V	V	V	V	V	A	A
1a													
1b													
1c													
2a													
2b													
2c													

where: 1 – positive-sequence input voltage; 2 – negative-sequence input voltage

1.3. ZERO-SEQUENCE PHASE VOLTAGE MEASUREMENT

Measuring should be made with use of 3-wire wye-configured circuit shown in figure 3 with equal resistance values of $R_A = R_B = R_C = 30\ \Omega$ and input voltage system of positive and negative phase sequence:

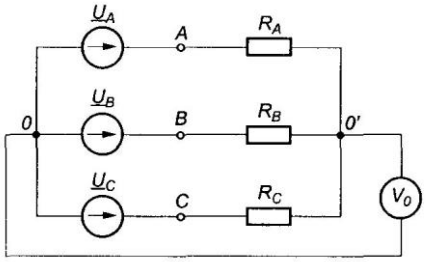

Fig. 3 Circuit diagram for measuring zero-sequence phase voltage in 3-wire configuration

a: balanced input $U_A = U_B = U_C$, e.g. $U_A = U_B = U_C = 22$ V,
b: unbalanced input $U_A \neq U_B \neq U_C$, e.g. $U_A = 33$ V, $U_B = 22$ V, $U_C = 11$ V,
c: single phase break, e.g. $U_A = 11$ V, $U_B = 22$ V, $U_C = 0$.
The results of measurements should be written in table 3.

Table 3

Results table for measuring zero-sequence phase voltage

No.	Measurements							Calculations	From graph
	U_A	U_B	U_C	U_{AB}	U_{BC}	U_{CA}	U_{V0}	$\underline{U_0}$	$\underline{U_0}$
	V	V	V	V	V	V	V	V	V
1a									
1b									
1c									
2a									
2b									
2c									

where: 1 – positive-sequence input voltage; 2 – negative-sequence input voltage

1.4. POSITIVE AND NEGATIVE SEQUENCE LINE VOLTAGE FILTER

Measuring should be made with use of circuit shown in figure 4 for the following filter elements values: $R = 15\ \Omega$, $L = 30$ mH, $C = 150\ \mu$F and input voltage system of positive and negative phase sequence:
a: balanced input $U_A = U_B = U_C$, e.g. $U_A = U_B = U_C = 11$ V,
b: unbalanced input $U_A \neq U_B \neq U_C$, e.g. $U_A = 11$ V, $U_B = 22$ V, $U_C = 33$ V,
c: single phase break, e.g. $U_A = 22$ V, $U_B = 0$, $U_C = 11$ V.

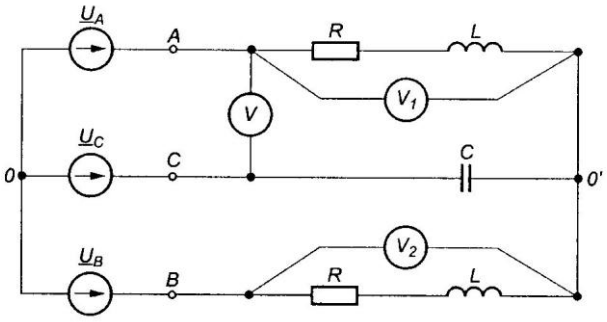

Fig. 4 Circuit diagram for measuring positive and negative sequence line voltage in 3-wire configuration

With balanced input, either positive or negative sequence voltage is present, depending on the direction of phase spin. However, with unbalanced input, both positive and negative sequence voltages are present. The results of measurements should be written in table 4.

Table 4

Results table for measuring positive and negative sequence line voltage

No.	Measurements					Calculations					From graph	
	U_{AB}	U_{BC}	U_{CA}	U_1	U_2	$\underline{U}_{AB}$	$\underline{U}_{BC}$	$\underline{U}_{CA}$	$\underline{U}_1$	$\underline{U}_2$	U_1	U_2
	V	V	V	V	V	V	V	V	V	V	V	V
1a												
1b												
1c												
2a												
2b												
2c												

2. DETERMINING THE PHASE SEQUENCE

The diagrams of three selected configurations for phase sequence determination are shown in figure 5. These three systems are available on the phase sequence detection panel. The detection is made by connecting a balanced input system (*A*, *B* and *C* phases) to the terminals (1, 2 and 3) in normal and inverse sequence. After a connection is made, one should measure the voltage on particular elements and observe the light bulbs brightness. The results should be written into tables 5, 6 and 7.

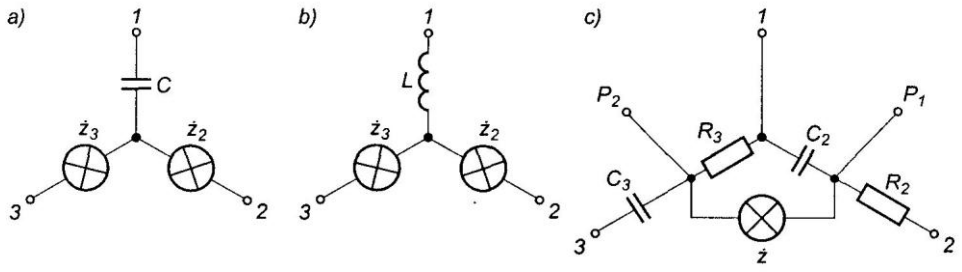

Fig. 5 Diagrams of phase sequence detection circuits

3. RESULTS PROCESSING

After running the experiments, one should:

1. Calculate each particular symmetrical components values.
2. Determine each particular symmetrical components values using graphical method.
3. Compare values gained by analytic method to those gained by graphical method.
4. Include example calculations for each case given in points 1.2, 1.3 and 1.4.
5. Make calculations and vector graphs for all measurement variants made in point 2. Include example calculations.
6. Include one's own conclusions.

Table .5

Experiment results for phase sequence detection with the following circuit parameters: U_{ph} = 22 V, C = 1,1 μF, $R_{Ż2} = R_{Ż3}$ = 3 kΩ

			Configuration as in fig. 5a	Measurements				Calculations							
				U_N	U_C	$U_{Ż2}$	$U_{Ż3}$	$\underline{U}_N$	$\underline{U}_C$	$\underline{U}_{Ż2}$	$\underline{U}_{Ż3}$	U_N	U_C	$U_{Ż2}$	$U_{Ż3}$
				V	V	V	V	V	V	V	V	V	V	V	V
			A – 1 B – 2 C – 3												
a)	A – 2 B – 1 C – 3	b) A – 1 B – 3 C – 2	c) A – 3 B – 2 C – 1												

(Choice a, b or c is to be given by the teacher)

Table 6

Experiment results for phase sequence detection with the following circuit parameters: U_{ph} = 22 V, L = 4 H, $R_{Ż2} = R_{Ż3}$ = 3 kΩ

			Configuration as in fig. 5b	Measurements				Calculations							
				U_N	U_L	$U_{Ż2}$	$U_{Ż3}$	$\underline{U}_N$	$\underline{U}_L$	$\underline{U}_{Ż2}$	$\underline{U}_{Ż3}$	U_N	U_L	$U_{Ż2}$	$U_{Ż3}$
				V	V	V	V	V	V	V	V	V	V	V	V
			A – 1 B – 2 C – 3												
a)	A – 2 B – 1 C – 3	b) A – 1 B – 3 C – 2	c) A – 3 B – 2 C – 1												

(Choice a, b or c is to be given by the teacher)

Table 7

Experiment results for phase sequence detection with the following circuit parameters: U_{ph} = 22 V, $C_2 = C_3$ = 1,1 μF, $R_{Ż2} = R_{Ż3}$ = 3 kΩ, Z_A = 0

Configuration as in fig. 5c	Measurements					Calculations									
	U_N	U_{R2}	U_{C2}	U_{R3}	U_{C3}	$\underline{U}_{Ż}$	$\underline{U}_{R2}$	$\underline{U}_{C2}$	$\underline{U}_{R3}$	$\underline{U}_{C3}$	$U_{Ż}$	U_{R2}	U_{C2}	U_{R3}	U_{C3}
	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
A – 1 B – 2 C – 3															
a) A – 2 B – 1 C – 3															
b) A – 1 B – 3 C – 2															
c) A – 3 B – 2 C – 1															

(Choice a, b or c is to be given by the teacher)