TFEE-1

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

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Guidelines to laboratory works on discipline
THEORETICAL FUNDAMENTALS OF ELECTRICAL ENGINEERING
For full-time students' education in academic discipline 141"Electric Power, Electrical Engineering and Electromechanics"

Part 1
THEORY FUNDAMENTALS OF DC CIRCUITS
and
THEORY FUNDAMENTALS OF SINGLE-PHASE HARMONIC AC CIRCUITS

Dnipro
2021

Рекомендовано до видання навчально-методичним відділом (протокол № від за поданням науково-методичної комісії зі спеціальності 141 – Електроенергетика, електротехніка та електромеханіка (протокол № 21/22-01 від 30.08.2021 р.)

Методичні вказівки англійською мовою до лабораторних робіт з дисципліни «Теоретичні основи електротехніки», частина 1 (розділи: «Основи теорії кіл постійного струму» та «Основи теорії кіл гармонійного однофазного струму») для студентів спеціальності 141 – Електроенергетика, електротехніка та електромеханіка / В.С. Хілов; Нац. техн. ун-т. «Дніпровська політехніка» – Д.: НТУ "ДП", 2021. – 35 с.

Методичні вказівки англійською мовою призначено для виконання лабораторних робіт з дисципліни «Теоретичні основи електротехніки», частина 1 (розділи: «Основи теорії кіл постійного струму» та «Основи теорії кіл гармонійного однофазного струму»). В інструкціях до виконання лабораторних робіт наведено основний матеріал, який викладається на протязі двох чвертей семестру та відповідає затвердженій програмі. Кожна лабораторна робота складається з назви, мети, програми та етапів виконання, методичних вказівок, контрольних запитань.

Друкується в редакції автора.

Introduction

One of the most important types of classes in the course "Theoretical fundamentals of electrical engineering" is the performance of laboratory work. To increase the efficiency of the laboratory practicum, these methodical instructions have been developed.

Methodical instructions are intended for laboratory work in the discipline "Theoretical fundamentals of electrical engineering" (part 1, sections 1, 2 "Theory fundamentals of DC circuits" and "Theory fundamentals of single-phase harmonic AC circuits") for full-time students education in academic discipline: 141"Electric Power, Electrical Engineering and Electromechanics".

These laboratory works contain all the basic material, which is taught during two quarters of the semester and corresponds to the approved program.

Each laboratory work consists of the name, objective, program and stages of work execution, guidelines, control questions.

Duration of laboratory work is two academic hours; independent preparation for work - one hour; report - one hour.

The objective of laboratory classes is to consolidate the theoretical knowledge gained in lectures, and the acquisition of skills in experimental research of electrical circuits.

The process of laboratory work is designed for four stages: independent preparation for laboratory classes; experimental research on the stand; registration of research results; obtain the credit for laboratory work.

Independent preparation for the laboratory lesson is carried out in accordance with the topic and objective of the work. This is an in-depth study of the relevant sections of the TFEE course, the selection of individual parameters of the schemes, recording the necessary analytical relationships, drawings of schematic diagrams and tables for experimental results, answers to questions posed in the task.

The report is compiled by each student independently and is the main document in the performance and defense of laboratory work, which is drawn up in a separate notebook (18 sheets). Graphs and vector diagrams are built at scale. The report on each laboratory work should contain the main items: 1. Number and title of the work; 2. Objective of work; 3. Program of work c; 4. Analysis of results; 5. Conclusions on the performed calculations and their experimental verification. In addition to the main points, the report should contain additional points that are listed in each paper.

Experimental research is conducted at the training and research stand by teams of 2-3 students. The team receives permission to draw up an electrical circuit only after an interview with the tutor.

The student during the laboratory work must:

• follow the rules of electrical safety, which are given in the guidelines for laboratory work;

• perform laboratory work according to the appropriate method;

• make a report on the performance of laboratory work;

• protect the results of previous laboratory work;

• to receive an assessment for a laboratory module through a certain form of modular control (protection of reports on laboratory work).

BASIC SAFETY RULES
WHEN PERFORMED A LABORATORY PRACTICUM

1. Only students who are acquainted with the rules of safety in the electrical laboratories of the university are allowed to take the laboratory practicum.
2. Before passing the next cycle of the laboratory practicum in the electrical laboratories of the university, students must study the safety instructions and receive additional instruction before starting work in each subsequent laboratory. Students, after getting acquainted with the rules of safety and instructed, must sign the logbook for compliance with safety rules and liability for violation.
3. During work in electric laboratories it is forbidden to switch on laboratory stands under voltage, to make any switching on or switching in the main distribution cabinet, to change safety locks, and after automatic switching off by the protective equipment to do switching on again without the permission of the tutor conducting laboratory practicum.
4. Drawing up of electric schemes and all changes in electric schemes should be carried out at the switched-off voltage. It is impossible to switch in the scheme in work before check of its serviceability.
5. It is forbidden to leave current conductors with or without voltage in the passages between workplaces. It is forbidden to make any switches in the power supply circuits of the research stands.
6. It is possible to use conductors for drawing up schemes only on condition of sufficient area of their section by the provided value of currents. Conductors must be intact insulation and lugs. Particular care should be taken when studying circuits with series connections of inductors and capacitors, as resonant overvoltage’s are possible in such circuits.
7. Keep in mind that a disconnected capacitor can retain a dangerous residual charge, so it must be discharged before connecting to the circuit. Do not touch uninsulated current-carrying parts of electrical circuits that are or may be with voltage.
8. If during the laboratory work on the stand there is a characteristic smell of burnt plastic, strong buzzing of electrical equipment, smoke, or a sudden movement of the arrows off-scale of measuring instruments, you must immediately turn off the voltage and notify of the tutor.
9. In the event of an emergency (may be a person under voltage, a short circuit on the lab stand, breakage of current-carrying wires, fire etc.) first of all with the switch turns off the lab stand from the power supply, and if necessary, the button "Off 95 "the power supply of the classroom is disconnected. Button "Off. 95 "is in the distribution cabinet.
10. The fire is extinguished by a carbon dioxide fire extinguisher located at the workplace of the duty laboratory assistant. There is also a first aid kit with medicines for first aid.

Laboratory Work TFEE – 1/1

FAMILIARIZATION WITH THE STUDY-RESEARCH LABORATORY STEND AND EXPERIMENTAL CHECK OF THE CALCULATION OF ELECTRICAL CIRCUIT BY THE METHOD OF EQUIVALENT TRANSFORMATION

Objective

Familiarization with the study-research laboratory stand (УИЛС),
schemes of switching on of electric measuring devices,
experimental verification of performed calculations.

Program of Work

1. Familiarization with the conventional notation of the elements of circuits and electrical measuring devices.
2. Familiarization with schemes of switching on of electric measuring devices.
3. Familiarization with the technical data of the laboratory stand.
4. Calculation of power supply current according to a given electrical circuit.
5. Measurement of parameters of a source of electric power and values of resistances.
6. Experimental verification of the calculated current.
7. Analysis of results. Conclusions.

Work Stages

Stage 1. Familiarization with the conventional notation of the elements of circuits and electrical measuring devices.

Familiarizing yourself with table of conventions notation elements of electric circuits make singly before classroom lesson in accordance with these Methodical Instructions (Table 1.2).

Stage 2. Familiarization with switching on schemes of electric measuring devices.

Become familiarized takes place according to Methodical Instructions independently, before classroom lesson.

Stage 3. Familiarization with technical data of the study-research laboratory stand (УИЛС).

It takes place according to the Methodical Instructions independently, before the classroom lesson.

Stage 4. Calculation of power supply current for a given electrical circuit.

Performed independently, before class.

The individual variant of calculation of an electric circuit is given out by the tutor (according to Table 1.3 or 1.4).

In the tables, the rating values of the resistances $R_1 ... R_{12}$ for the every one of 25 variants are given in Ohms (Ω). If the resistor is absent then its value is equal to infinity (open circuit) or zero (instead of resistance, a jumper is installed).

According to table. 1.3, 1.4 and fig.1 draw a diagram of the circle under study. For the drawn scheme by the method of equivalent transformation of resistances to calculate resistance R_E as to the clams *a–b*.

Calculate the source current by the formula

$$I_L = E / R_E ,$$

where $E = 20\text{V}$ is rating value of the electromotive force (EMF) of the unregulated energy source; R_E – calculated value of the rating value of equivalent resistance.

Stage 5. Electric power source parameters and resistance values measurement.

Measurement of an unregulated DC voltage source EMF when open circuit is performed with a multimeter or electronic voltmeter.

Enter the obtained values in Table 1.1.

Table 1.1.

Rated and measured values of energy source and resistance parameters.

Parameter	E	R_{01}	R_{02}	R_{03}	R_{04}	R_{05}	R_{06}	R_{07}	R_{08}	R_{09}	R_{10}
Units of measurement	V	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω
Rated value	20	51	75	100	150	200	300	510	750	820	1000
Measured value											

Note. The resistance number in tab. 1.1 corresponds to the number of the box where the resistor is soldered.

Stage 6. Experimental verification of the calculated current.

Assemble an electric circuit according to the number of your variant. After checking the circuit, a voltage of 20 V is applied to the clamps of the assembled circuit, measure the input current, voltage and power consumption (Fig. 1.6, 1.7). Record the data in the report.

Compare the experimentally obtained values of current I with its calculated one I_L. If there are discrepancies between these values, explain them.

The Report must contain the following items:

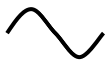
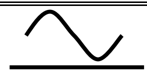
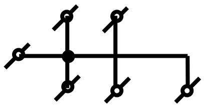
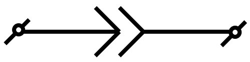
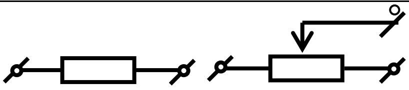
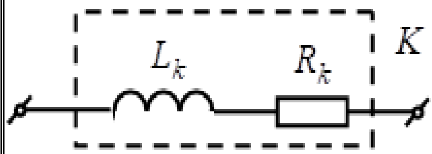
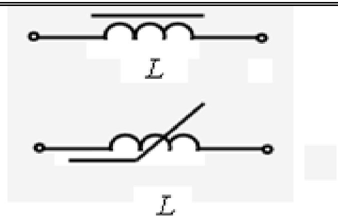
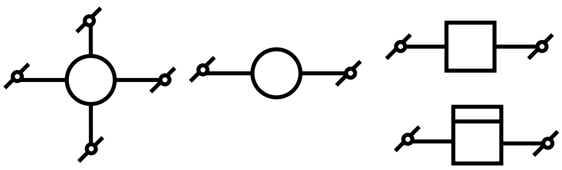
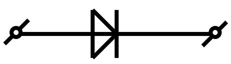
1. The number and title of the laboratory work.
2. The work program.
3. The table of notation conventions.
4. Scheme of under study circuit in accordance with variant number.
5. Calculation of the equivalent resistor.
6. Table 1.
7. The conclusions of the laboratory work.

Methodical instruction

To the Stage 1. Familiarization with the conventional notation of the elements of circuits and electrical measuring devices.

Table 1.1.

Symbols Denoted (DSTU 2.721 - 74)

Description	Symbol
Directed current (DC)	
Alternative current (AC)	
Directed and alternative current	
Wye and delta connection	**Y** Δ
Electrical connection (three conductors joined together), intersection (two conductors crossing but not joined) and bending wires	
Earthing (ground, GND)	
Plug-type connection contact (plug and socket joint)	
Unregulated (constant) and regulated (potentiometers) resistors	
Nonpolar capacitor and electrolytic capacitor	
Equivalent circuit linear inductance (series equivalent circuit)	
Steel core inductance (non-linear inductance)	
Electro measuring devices: indicating, recording, integrating ones. For the identification instrument in its device are inserted notation conventions (W – wattmeter, A – ammeter, V – voltmeter, mA – milliammeter, mV – millivoltmeter).	
Diode semi-conductor	

To the Stage 2. Familiarization with schemes of switching on of electric measuring devices.

To the main indicating electrical measuring instruments used in laboratory work include: ammeter, voltmeter, wattmeter, multimeter.

The connection schemes of the main electrical measuring instruments is shown in Fig. 1.7.

Ammeter is a device for measuring the value of electric current, which is connecting in series between the source and load of electric current.

Voltmeter is a device for measuring electrical different potentials (voltage) between two points of the electrical circuit. The voltmeter is connecting in parallel with the part of the circuit where the voltage is measured.

Wattmeter is a device for measuring electrical power. Relative to the load, the current circuit of this device is connecting in series, and the voltage circuit is connecting in parallel. Wattmeter generator terminals (marked with asterisks (*) on the device) are switching on at the side of the power source. Generator terminals are connecting by a jumper.

Determining the scale division value of the device. Multyranges measuring instruments are not calibrated in units of measurement, but in divisions. The scale division value is determined as follows:

– for the ammeter: $C_A = I_{\lim} / N$;

– for the voltmeter: $C_V = U_{\lim} / N$;

– for the wattmeter: $C_P = U_{\lim} \cdot I_{\lim} / N$,

where $U_{\lim}, I_{\lim}$ – upper limits of device measurement; N – the number of divisions of the scale; C_V, C_A, C_P – scale division value.

Each laboratory stand is equipped with an electric measuring device - a multimeter, which can be used to measure DC voltages in range $10^{-3} \ldots 10^{3}$ V, AC voltages ($10^{-3} \ldots 300$ V), voltage frequency (45 Hz …1кHz), DC resistance ($10^{-3} \ldots 2 \cdot 10^{3}$ кΩ), current frequency ($0{,}01 \ldots 10^{4}$кHz).

When DC voltage, the multimeter measures the voltage taking into account its polarity. The socket of the multimeter, relative to which the positive potential of the measured voltage is applied, is marked “+”. If the polarity of the measured signal does not correspond to the polarity of the input sockets of the multimeter, the image of zeros appears on the indicator of the device, and in the highest digit the flashing sign "-" flashes. To avoid error, it is necessary to change the polarity of the probes on the measuring element or device.

To the Stage 3. Familiarization with the technical data of the laboratory stand.

Universal study-research stand (УИЛС) is designed for laboratory classes and research work. General view of the stand is shown in Fig. 1.1.

The stand has three active units (left part), which are energy sources, three passive units (right part), which contain regulated and unregulated passive elements and assembling field (middle part).

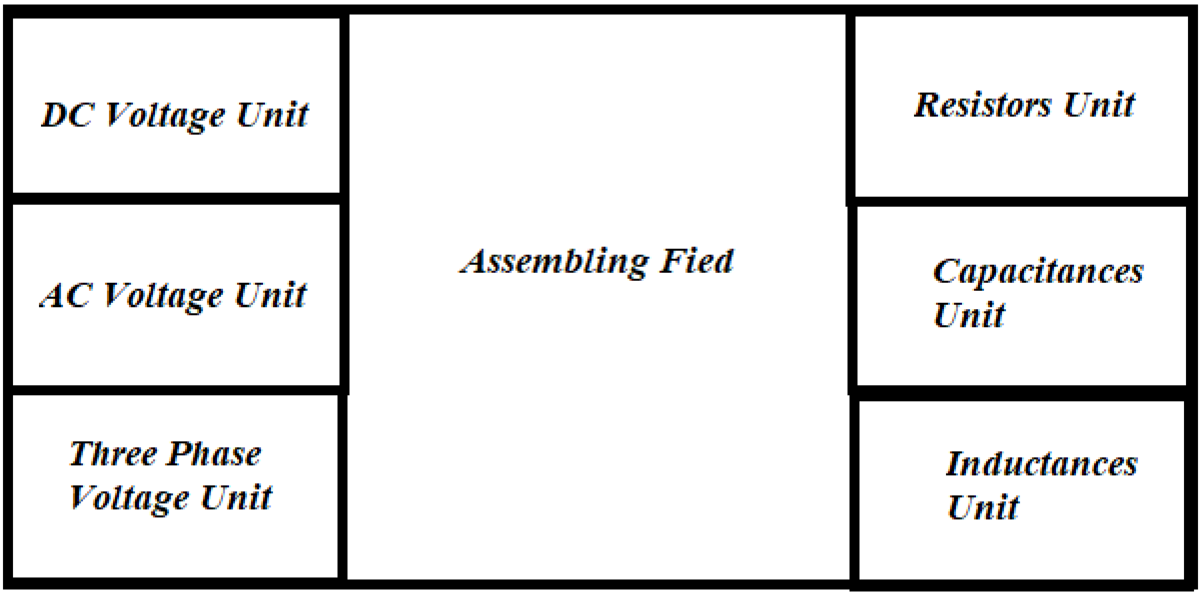


Figure 1.1. – General view of the stand УИЛС

DC Voltage Unit has regulated source of DC stabilized voltage (regulated range 2… 30 V); unregulated DC voltage source - 20 V.

The AC Voltage Unit has an AC single-phase voltage source with an regulated frequency of 0.5… 98 kHz of sinusoidal, triangular and rectangular shapes. The frequency can be measured with a multimeter. The voltage is adjustable in range 5…20 V.

The Three-Phase Voltage Unit has an industrial frequency of 50 Hz and stepwise control 0… 40 V with a resolution of 1 V. The phases of the source are electrically non-connected.

All power supplies have a short circuit and overload protection circuit. Protection tripping current - 1 A.

The Resistors Unit has three constant resistors and one regulated within R_4 =1…999 Ω (step regulation with discreteness in 1Ω). Permissible scattering power - 5 Wt.

The Capacitances Unit has three constant capacitors C_1, C_2, C_3 and a regulated capacitor C_4=0.01… 9.99 μF (stepwise control with a discreteness of 0.01 μF). The allowable voltage is 160 V.

The Inductances Unit has three unregulated inductors L_1, L_2, L_3 (inductively coupled coils L_1 and L_2) and regulated inductance L_4=0.1… 99.9 mH (stepwise control with a discreteness of 0.2 mH). The allowable limiting current is 0.2 A.

The Assembling Field is a panel with slots. The slots are connected in groups of three and four. Slots connection diagrams are drawn on the panel. Circuit elements are placed in transparent plastic boxes, inside which are standard radio elements.

The electrical circuit proposed for study is assembled on the Assembling Field by connecting wires using circuit elements.

For apply the voltage to the Lab Stand, it is necessary to switch on the “network” («Сеть») in position “ВКЛ”. This switch is on the surface panel of the Three-Phase Voltage Unit. After that one can switch on anyone of active block.

To the Stage 4. Calculation of power supply current according to a given electrical circuit.

In any complex electric circuit with one energy source, it is possible to define circuit parts that are connected in parallel, in series, by delta, by wye.

After replacing the whole circuit with one equivalent resistance (equivalent reduced circuit), the current of the electrical energy source is determined. After that, the circuit is deployed in the opposite direction with the simultaneous determination of voltages and currents of individual circuit elements.

Series connection of resistors (connection in series):

$$R_e = R_1 + R_2 + ... = \sum_{k=1}^{n} R_k,$$

where R_k – the value of the *k-th* series-connected resistors; *n* – the number of all resistors in the branch; R_e – value of equivalent resistor.

Parallel connection of resistors (connection in parallel):

$$G_e = G_1 + G_2 + ... = \sum_{k=1}^{n} G_k,$$

where G_k – the conductance of *k-th* parallel connected element; *n* – the number of all conductances in the branch; G_e – value of equivalent conductance.

Transformation of delta (Fig. 2) to wye-connection (Fig. 3):

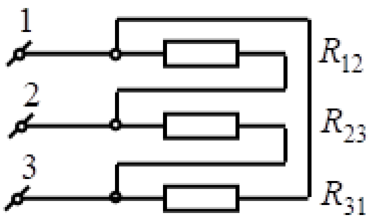


Figure 1.2. – Delta connection circuit

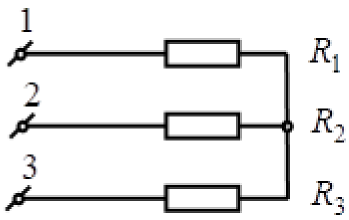


Figure 1.3. – Wye connection circuit

$$R_1 = \frac{R_{12} \cdot R_{31}}{R_{12} + R_{23} + R_{31}}; \ R_2 = \frac{R_{23} \cdot R_{12}}{R_{12} + R_{23} + R_{31}}; \ R_3 = \frac{R_{31} \cdot R_{23}}{R_{12} + R_{23} + R_{31}}.$$

Transformation of wye (Fig. 4) to delta-cnnection (Fig. 5):

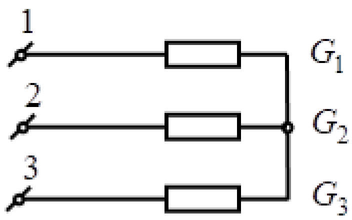


Figure 1.4. – Wye connection circuit

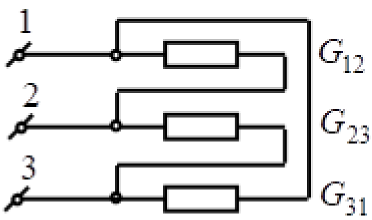


Figure 1.2. – Delta connection circuit

$$G_{12} = \frac{G_1 \cdot G_2}{G_1 + G_2 + G_3}; \quad R_{12} = 1/G_{12}; \ G_{23} = \frac{G_2 \cdot G_3}{G_1 + G_2 + G_3}; \ R_{23} = 1/G_{23};$$

$$G_{31} = \frac{G_3 \cdot G_1}{G_1 + G_2 + G_3}; \ R_{31} = 1/G_{31}.$$

Table 1.3.

Initial values of the resistances

№ variant	R_1, Ω	R_2, Ω	R_3, Ω	R_4, Ω	R_5, Ω	R_6, Ω	R_7, Ω	R_8, Ω	R_9, Ω	R_{10}, Ω	R_{11}, Ω	R_{12}, Ω
1	0	∞	100	150	∞	0	0	∞	750	510	51	0
2	100	0	∞	150	820	∞	0	∞	510	∞	51	∞
3	0	750	∞	150	220	∞	75	∞	∞	0	51	0
4	200	0	510	∞	820	75	0	∞	0	∞	51	∞
5	0	750	510	∞	820	75	0	200	∞	∞	∞	∞
6	0	150	200	∞	0	0	51	∞	∞	100	300	0
7	75	0	∞	∞	0	0	51	750	510	∞	300	∞
8	0	0	∞	150	100	0	0	750	510	∞	75	∞
9	∞	∞	51	∞	∞	100	150	750	∞	0	0	510
10	51	∞	∞	0	∞	100	150	750	∞	75	0	0
11	51	510	∞	∞	300	0	0	750	∞	0	100	0
12	0	510	∞	0	300	∞	∞	∞	75	0	100	200
13	∞	150	0	51	100	510	∞	∞	0	0	75	0
14	150	0	∞	51	0	0	∞	510	100	0	∞	75
15	75	0	∞	51	300	200	0	150	∞	∞	∞	∞
16	0	75	∞	∞	51	∞	0	∞	150	200	0	100
17	100	∞	∞	0	∞	∞	75	∞	150	200	51	0
18	∞	∞	100	∞	∞	0	75	∞	150	0	51	200
19	100	∞	∞	150	∞	510	∞	75	0	∞	51	∞
20	∞	∞	100	∞	∞	510	∞	75	150	∞	51	∞
21	100	∞	200	300	∞	0	0	∞	∞	75	0	51
22	100	∞	0	300	∞	200	∞	∞	150	∞	51	∞
23	100	∞	510	300	∞	200	∞	75	∞	∞	∞	∞
24	100	∞	∞	300	∞	∞	200	∞	75	0	51	0
25	100	150	∞	300	0	∞	0	∞	75	∞	51	∞

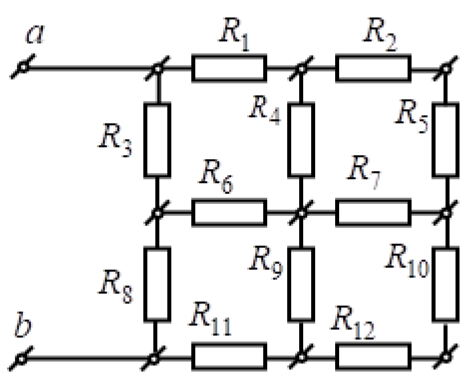


Figure 1.6 - Initial circuit

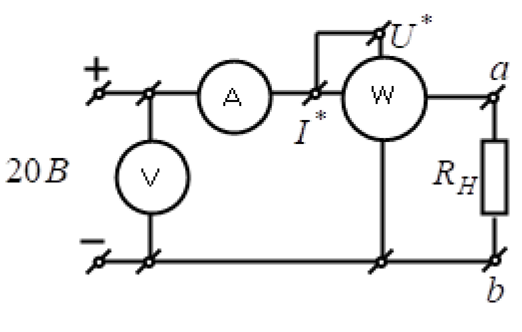


Figure 1.7 - Converted equivalent circuit

Table 1.4.

Initial values of the resistances

№ variant	R_1, Ω	R_2, Ω	R_3, Ω	R_4, Ω	R_5, Ω	R_6, Ω	R_7, Ω	R_8, Ω	R_9, Ω	R_{10}, Ω	R_{11}, Ω	R_{12}, Ω
1	0	∞	100	300	∞	200	∞	510	75	∞	0	∞
2	150	∞	100	300	∞	200	∞	510	75	∞	0	∞
3	0	∞	100	300	∞	200	∞	510	75	∞	51	∞
4	150	∞	100	∞	820	75	0	∞	0	∞	51	∞
5	150	∞	100	0	∞	200	∞	510	0	∞	51	∞
6	150	∞	100	75	∞	200	∞	510	0	∞	51	∞
7	150	∞	100	0	∞	200	∞	510	300	∞	51	∞
8	∞	0	0	100	150	0	200	∞	300	510	0	0
9	∞	0	0	100	150	0	200	∞	300	510	0	75
10	∞	51	0	100	150	0	200	∞	300	510	0	0
11	∞	51	0	100	150	0	200	∞	300	510	0	75
12	∞	51	0	100	0	0	200	∞	300	0	0	75
13	∞	51	0	100	510	0	200	∞	300	0	0	75
14	∞	51	0	100	0	0	200	∞	300	510	0	75
15	∞	0	51	100	750	0	200	∞	300	510	0	0
16	∞	0	51	100	150	0	200	∞	300	510	0	75
17	∞	75	51	100	150	0	200	∞	300	510	0	0
18	∞	75	51	100	150	0	200	∞	300	0	0	510
19	∞	75	51	100	0	0	150	∞	200	0	0	510
20	∞	75	51	100	300	0	150	∞	200	0	0	510
21	∞	75	51	100	0	0	150	∞	200	0	0	300
22	∞	0	0	100	75	75	150	∞	200	51	0	300
23	∞	0	0	100	510	75	150	∞	200	51	0	300
24	∞	51	0	100	510	75	150	∞	200	300	0	0
25	∞	51	0	100	510	75	150	∞	300	0	0	200

To the Stage 5. Measurement of parameters of a source of electric power and values of resistances.

The output voltage on clamps of energy supply source is determined by equation

$$U = E - R_i \cdot I ,$$

where E – electromotive force of the energy source; R_i – internal resistor of the energy source.

When the open circuit the current $I=0$ through energy supply source and we get

$$U=E.$$

So to determine the electromotive force of the energy source it is necessary to measure the output voltage in the open circuit mode when the current load is zero.

Questions for check knowledge

1. Draw an electrical circuit with has an ammeter, voltmeter, wattmeter.
2. How is the scale division value of the multirange voltmeter, ammeter determined?
3. Why it is impossible to connect a DC meter to an AC circuit and vice versa?
4. Write an expression for define of equivalent resistor when resistors connected in series, in parallel and when transformation of delta into wye and vice versa - wye into delta.
5. What is the difference between the values of the EMF of the source and the voltage at the output terminals of the energy source?
6. Give the definition for operating mode of open circuit.
7. Determine the mode of operation of the short circuit.
8. Give the definition for the ideal source of electromotive force.
9. Determine the ideal current source.
10. How is the scale division value of a wattmeter determined?

Laboratory Work TFEE – 1/2

EXPERIMENTAL STUDY OF POWER TRANSFER FROM ACTIVE TO PASSIVE ONE-PORT CIRCUITS BY METHOD OF EQUIVALENT GENERATOR

Objective

Determination of energy dependencies
in a circuit with active and passive one-port circuits

Program of Work

1. Assembly of the researched circuit.
2. Determination of open circuit EMF and short-circuit current of an active one-port circuit.
3. Calculation of the internal resistance of the equivalent generator.
4. Calculation of five characteristic values of the passive one-port circuit internal resistance.
5. Experimental determination of currents and voltage drops at the passive one-port circuit at five characteristic values of load resistance.
6. Calculation of the power consumed at the passive one-port circuit and its efficiency.
7. Plotting the found dependencies.
8. Analysis of the results. Conclusions.

Work Stages

Stage 1. Assembly of the researched electrical circuit.

1.1. Assemble the electric circuit shown in Fig.2.1.

As the main elements of the circuit are used:

power supplies: unregulated constant voltage source E1 = 20 V; regulated source of constant stabilized voltage E2 = 15 V;

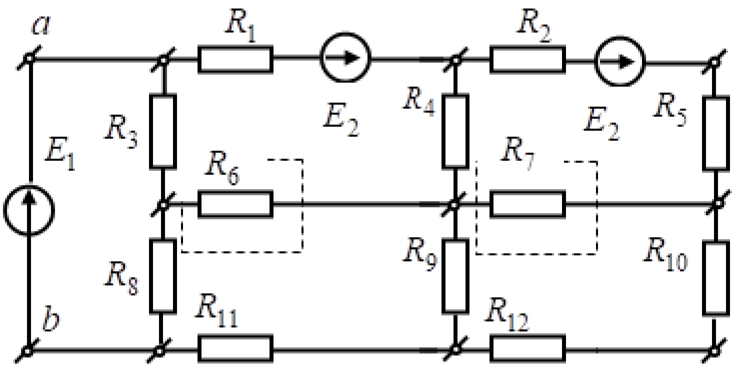


Figure 2.1. – Research circuit

– rated resistance $R_1 \ldots R_{12}$ are selected from table 2.4 of Lab work 1-TFEE for your own individual variant; rated resistance R is selected in the range of 75…150 Ω.

1.2. After check the assembled circuit, one can switch on the power supplies.

Stage 2. Determination of open circuit EMF and short-circuit current of an active one-port circuit by experimental measurement.

2.1. The resistor R_6 (for variants 1…7, 22…25) or R_7 (for variants 8…21) is select as a passive one-port circuit.

2.2. The passive one-port circuit (R_6 or R_7) is turned off from the circuit under study

2.3. In place of the turned off passive one-port circuit, connect a multimeter and measure the open circuit EMF of the active one-port circuit. Write down the measured values U_{oc} in Table 2.1.

2.4. Disconnect the multimeter and connect an ammeter (milliam-permeter) in its place and measure the short-circuit current of the activeone-port circuitl. Record the measured value I_{sc} in Table 2.1.

Table 2.1.

Measured and calculated values of the studied circle parameters

Measured value			Calculated value					
Parameter	U_{oc}	I_{sc}	R_{in}	$R_{60}(R_{70})$	$R_{61}(R_{71})$	$R_{62}(R_{72})$	$R_{63}(R_{73})$	$R_{64}(R_{74})$
Unit	V	mA	Ω	Ω	Ω	Ω	Ω	Ω
Value								

2.5 Switch off power supplies.

Stage 3. Calculation of the internal resistance of the equivalent generator.

3.1. According to the measured values of the open and short circuits, calculate the internal resistance R_{in} of the equivalent generator. Write down the calculated value R_{in} in the Table 1.

Stage 4. Calculation of five characteristic values of the passive one-port circuit internal resistance.

4.1. Calculate the rated value of resistors $R_{60}..R_{64}$ (or $R_{70}..R_{74}$) at with:

– the equivalent generator is loaded with current $I_{sc}/4$ (R_{61} or R_{71});
– the equivalent generator is loaded with current $I_{sc}/2$ (R_{62} or R_{72}) – matched mode of active and passive one-port circuits work;
– the equivalent generator is loaded with current $3I_{sc}/4$ (R_{63} or R_{73});
– the equivalent generator work at short circuit mode (R_{64} or R_{74}).

4.2. Write down the calculated values $R_{60}..R_{64}$ (or $R_{70}..R_{74}$) in the Table 2.1.

Stage 5. Experimental determination of currents and voltage drops at the passive one-port circuit at five characteristic values of load resistance.

5.1. As resistors $R_{60}..R_{64}$ (or $R_{70}..R_{74}$) use regulated resistor R_4 from the resistors block.

5.2. Switch on power sources E_1, E_2.

5.3. Set the value of the regulated resistor from the block of active resistances $R_{60}\dots R_{64}$ ($R_{70}\dots R_{74}$) in accordance with the characteristic values defined in paragraph 4.

For each characteristic value of resistance $R_{60}\dots R_{64}$ ($R_{70}\dots R_{74}$), measure the current and voltage of the passive one-port circuit and enter the measured data in Table 2.

Table 2.2.

Measured and calculated values of the studied circle parameters

	Parameter	Demention	I_{oc}	$0{,}25\cdot I_{sc}$	$0{,}5\cdot I_{sc}$	$0{,}75\cdot I_{sc}$	I_{sc}
Measured value	I	mA					
	$R_6(R_7)$	Ω					
	$U_6(U_7)$	V					
Calculated value	$P_6(P_7)$	Wt					
	η	Per unit					
	P_L	Wt					
	P_G	Wt					
	ΔU_{in}	V					

Stage 6. Calculation of the power consumed at the passive one-port circuit and its efficiency.

6.1. Calculation of the power consumed at the passive one-port circuit and its efficiency.

Calculate the power developed by the generator, losses on the internal resistance of the generator, the power consumed to the passive one-port circuit, the efficiency of the system. The calculated values write in Table 2.2.

Stage 7. Plotting the found dependencies.

Plot Energy Dependencies in convenient Scale.

The Report must contain

1. The number and title of the laboratory work.
2. The work goal.
3. The work program.
4. Fig.1 in accordance with personal variant.
5. Tables 2.1, 2.2.
6. Calculation of:
   – generator output power;
   – power loss on the internal resistor of the equivalent generator;
   – a power consumed in passive one-port circuit;
   – electric circuit coefficient of efficiency.
7. The diagrams are plotted in scale.
8. The conclusions of the laboratory work.

Methodical instruction

To the Stage 2. Determination of open circuit EMF and short-circuit current of an active one-port circuit.

Resistor (R_6 or R_7) is considered as a passive one-port circuit (Fig. 2.1), and the rest of the circuit relative to a passive one-port circuit is assumed to be an active one-port circuit.

To determine the parameters of the active one-port circuit, we are doing open-circuit and short-circuit experiments at the output terminals.

To the Stage 3. Calculation of the internal resistance of the equivalent generator

Calculate the internal resistor of the equivalent generator in accordance with Ohm's law:

$$R_{in} = U_{oc} / I_{sc},$$

where R_{in} – internal resistor of equivalent generator, Ω; U_{oc} – open circuit EMF (open circuit experiment), V; I_{sc} – short circuit current of equivalent generator, A.

To the Stage 4. Calculation of five characteristic values of the passive one-port circuit internal resistance.

Calculate the five characteristic resistors of the passive one-port circuit in accordance with next equation:

$$R_{60...64}(R_{70...74}) = U_{oc} / I_{sc} / n - R_{in},$$

where $R_{60...64}(R_{70...74})$ – passive one-port circuit internal resistors values, Ω; n – short circuit current submultiple factor of equivalent generator.

If submultiple factor of the short circuit current is:

– $n=0$ – equivalent generator work at open circuit mode;

– $n=0.25$ – equivalent generator loaded by current, with equal one quarter of short circuit current;

– $n=0.5$ – matched mode work of equivalent generator;

– $n=0.75$ – equivalent generator loaded by current, with equal three quarter of short circuit current;

– $n=1.0$ – short circuit mode of equivalent generator.

<u>To the Stage 6.</u> Calculation of the power consumed at the passive one-port circuit and its efficiency

According to experimental established magnitudes of currents and voltages are calculated a power consumed in passive one-port circuit and efficiency.

The power dissipated in passive one-port circuit:

$$P_{6,7} = R_{6,7}I^2 = U_{6,7}I \text{, Wt}$$

where currents I and voltages U_6 or U_7 values are taken from data Table 2.2.

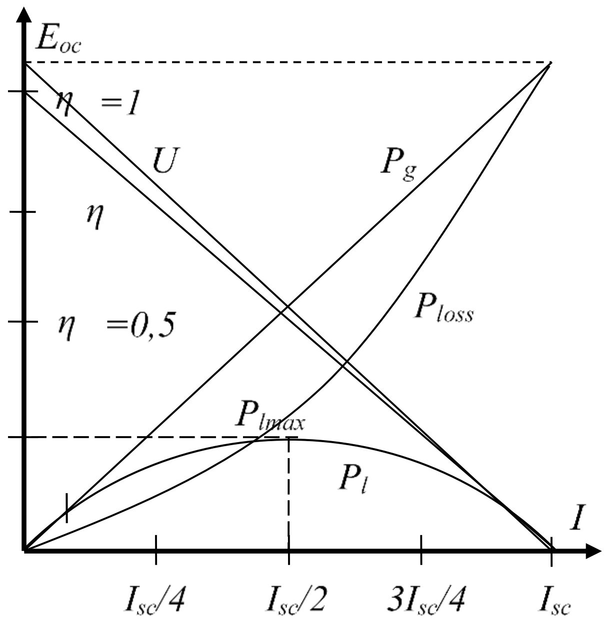


Fig. 2.2. — The circuit energy parameters

Efficiency:

$$\eta = 1/(1 + R_{in} / R_{6,7}) \text{, p.}$$

Equivalent generator delivers power:

$$P_G = U_{oc}I \text{, Wt}$$

The power that is allocated on the internal resistance of the source (heat losses in the source):

$$P_L = R_{in}I^2 \text{, Wt}$$

Voltage losses in the internal resistor of equivalent generator:

$$\Delta U_{in} = R_{in} I \text{ , V}$$

<u>To the Stage 7.</u> Plotting the found dependencies.

Plot in scale the diagrams $P_{6,7}, \eta, P_G, P_L, \Delta U_{in} = f(I)$. An approximate view of the graphs is shown in Fig. 2.

Questions for check knowledge

1. Formulate the main idea of the equivalent generator method.
2. How to determine experimental the open circuit EMF of an equivalent generator?
3.How to determine experimental the short circuit current of the generator?
4.How to determine the internal resistance of an equivalent generator?
5. Draw a diagram of an equivalent generator with an ideal current source and internal resistance, determined from the results of laboratory work.
6.What is the matched mode of operation of active and passive two-pole devices?
7. Why are powerful energy systems operating in an unmatched mode?
8. For which electrical devices does the matched mode of work apply?
9.How to determine the internal voltage drop and power losses in the equivalent generator?
10. How is the power of an equivalent generator and its efficiency determined?

Laboratory Work TFEE – 1/3

EXPERIMENTAL STUDY OF SERIES, PARALLEL AND MIXED CONNECTIONS OF ACTIVE AND REACTIVE RESISTANCES

Objective

Quantitative assessment of electrical parameters in a single-phase AC circuit

Program of Work

1. Assembly of the electrical circuit with a series connection of resistive, inductive and capacitive elements.
2. Measurement of current and drop voltages in circuit when the elements $R-L-C$ are connected in series.
3. Assembly of the electrical circuit when the elements $R-L-C$ are connected in parallel.
4. Measurement of currents and drop voltage in parallel connection $R-L-C$ elements.
5. Assembly of an electrical circuit with a mixed connection $R-L-C$ elements.
6. Measurement of currents and drop voltage when $R-L-C$ elements are connected in mixed.
7. Calculation of the electrical parameter values and plotting of phasor diagrams.
8. Analysis of results. Conclusions.

Work Stages

Stage 1. <u>Assembly of the electrical circuit with a series connection of resistive, inductive and capacitive elements.</u>

Assemble the electrical circuit shown in Fig. 3.1.

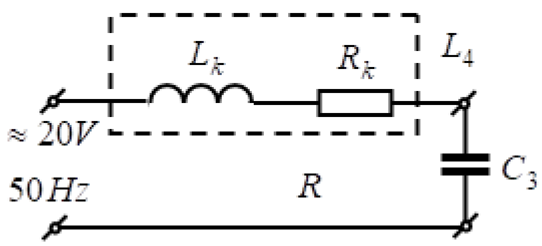


Figure 3.1. – R-L-C circuit connection in series

As circuit elements are used:

- power supply - voltage of the one phase from the three-phase voltage unit (20 V, 50 Hz);
- regulated inductance L_4 from inductivities unit. Values of the parameter L_4 is selected according to the team number, Table 3.1.

Before connecting the inductance coil to the circuit, the internal resistance of the coil is measured with a multimeter. The parameters of the inductance coil are given in Table 3.2.

- Capacitor C_3 - unregulated capacitance 20 μF from a the capacitors unit.

Table 3.1.

Initial parameters of the series R-L-C circuit

№ team	1	2	3	4	5	6
$L_4 / L_k, mH$	100	95	90	85	70	75

1.2. After checking the electrical circuit, the power supply is switched on.

Stage 2. Measurement of current and drop voltages in circuit when the elements $R-L-C$ are connected in series.

Using a multimeter, measure the voltage at the terminals of the source, inductance coil U_K, and capacitor U_C. Enter the data obtained in Table 3.2.

Measure current I with a milliammeter, enter the value in Table 3.2.

Table 3.2.

Measured and calculated parameters of the series R-L-C circuit

Measured							Calculated		
C_3	R_k	L_k	I	U	U_k	U_c	φ_k	U_L	U_{Rk}
μF	Ohm	mH	mA	B	B	B	grad	V	V

After finishing measurements, the power supply is switched off.

Stage 3. Assembly of the electrical circuit when the elements L-C are connected in parallel.

3.1. Assemble the electrical circuit shown in Fig. 3.2. Power supply, inductance coil and capacitance are taken as in the Stage 2.

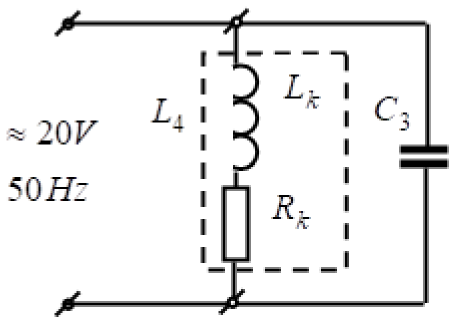


Figure 3.2. – R-L circuit connection in parallel

Stage 4. Measurement of currents and drop voltage in parallel connection L-C elements.

4.1. Using a milliammeter, measure the current in an unbranched section *I*, in the branches with the coil I_K and with capacitor I_C, and record the data in Table 3.3.

4.2. Using a multimeter measures the voltage across the parallel branches. Enter the measurement result in the Table 3.3.

Table 3.3.

Measured and calculated parameters of the parallel L-C circuit

Measured							Calculated		
L_k	R_k	C_3	I	I_C	I_k	U	φ_k	U_L	U_{Rk}
mH	ohm	μF	mA	mA	mA	V	grad	V	V

<u>**Stage 5.** Assembly of an electrical circuit with a mixed connection $R-L-C$ elements.</u>

5.1. Assemble the electrical circuit shown in Fig. 3.3. The effective value of the power supply voltage increase to 30 V.

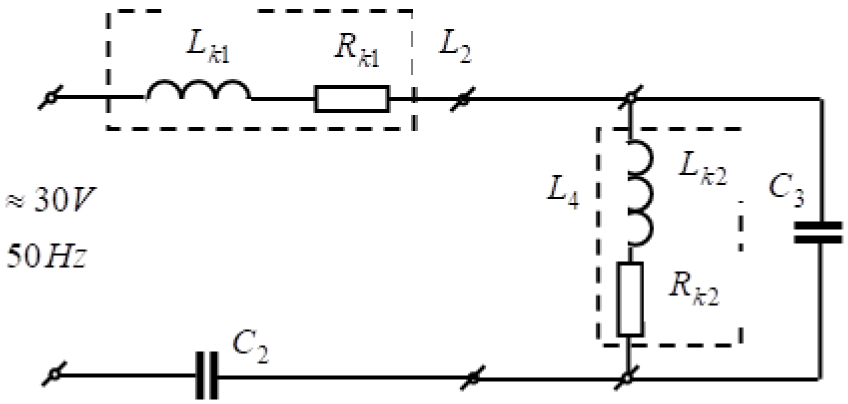


Figure 3.3. – The mixed connection of R-L-C circuit elements

Inductance coil L_4 and capacitor C_3 are taken as in the Stage 3. The coil L_2 is taken from unregulated inductors unit. Before connecting the inductance coil to the circuit, measure the resistance R_{K1} of the coil L_2, enter the resulting value in Table 3.4.

<u>**Stage 6.** Measurement of currents and drop voltage when $R-L-C$ elements are connected in mixed.</u>

6.1. Switch on the power source and measure the circuit *I* in branched section of the circuit, in the branches with the coil I_{K2} and with capacitance I_{C3}, measure the voltage drops across the source, coil L_2 (U_{K1}), coil L_4 (U_{K2}), and capacitance C_2 (U_{C2}). Enter the obtained numerical values of the parameters in Table 3.4.

Table 3.4.

Measured parameters of the mixed connection of R-L-C circuit elements

Measured												
R_{k1}	L_{k1}	C_2	R_{k2}	L_{k2}	C_3	U	I	U_{k1}	U_{C2}	U_{k2}	I_{k2}	I_{C3}
Ohm	mH	μF	Ohm	mH	μF	V	mA	V	V	V	mA	mA

6.2. After the measurements have been made, the power supply unit is switched off.

Stage 7. Calculation of the electrical parameter values and plotting of phasor diagrams.

7.1. Calculate the components of voltage drops across inductive elements. Enter the calculation results in Table 3.5.

Table 3.5.

Calculated parameters of the inductive coil

Calculated					
φ_{k1}	U_{Lk1}	U_{Rk1}	φ_{k2}	U_{Lk2}	U_{Rk2}
grad	V	V	grad	V	V

7.2. Plot in scale the combined phasor diagram of currents and voltages when the elements are connected in series.

7.3. Plot in scale the combined phasor diagram of currents and voltages when the elements are connected in parallel.

7.4. Plot in scale a combined phasor diagram when a mixed connection of elements.

The Report must contain

1. Number and title of work.
2. The purpose of the work.
3. Program of work.
4. Fig. 3.1, 3.2, 3.3, Tab. 3.1, 3.2, 3.2, 3.3, 3.4, 3.5.
5. Calculation of electrical parameters.
6.Three combined phasor diagrams.
7. Analysis of the results. Brief conclusions.

Methodical instruction

To the Stage 1. Assembly of the electrical circuit with a series connection of resistive, inductive and capacitive elements.

A real (practical) inductor coil differs from an ideal one in the presence of an active internal resistance, which is due to the resistance of the winding wire.

The electrical equivalent circuit of a real coil can be represented by a series connection of an ideal inductance and an ohmic resistance.

The capacitor has only capacitive resistance, and the resistor has only active one.

To the Stage 7. Calculation of the electrical parameter values and plotting of phasor diagrams.

7.1. Determining the parameters of the circuit at the industrial cyclic frequency f = 50 Hz (angular frequency $\omega = 2 \cdot \pi \cdot f = 314 rad/s$) it is assumed that the ohmic resistance does not depend on the frequency of the supply voltage, and the inductive X_L and capacitive X_C resistances are depended and determined by

$$X_L = X_k = \omega \cdot L; \; X_C = 1/(\omega \cdot C),$$

where L – the coil inductance in Henry, and C – capacitor capacitance in Farad.

Knowing the internal ohmic resistance R_K and inductive reactance X_L the impedance modulus of the coil Z_K and angle of sheft φ_K are defined as

$$U_{Rk} = U_K \cdot \cos\varphi_K; \; U_L = U_K \cdot \sin\varphi_K .$$

When plotting a phasor diagram for series connected elements, it is convenient to take the current vector as the base vector, coinsided it with the axis of positive real numbers. The phasor voltage diagram is oriented relative to the adopted base vector and is plotted on the basis that the total applied voltage is equal to the vector sum of the voltage drops across the circuit elements. It is more convenient to plot the voltage across the coil by the components U_{Rk} and U_L.

The active component U_{Rk} of the voltage drop across the coil coincides in phase with circuit current, the inductive component U_L – is leaded of the initial (current) vector by angle 90^0, but the capacitive one U_C – lags by angle 90^0.

The total applied voltage U is balanced by the vector sum of drops in voltage across the circuit elements

$$\underline{U} = \underline{U}_{Rk} + \underline{U}_L + \underline{U}_C .$$

Based on this vector equation, a vector diagram is plotted, where the beginning of each subsequent vector is added to the end of the previous one, as shown in the example of a simple circuit in Fig. 3.4.

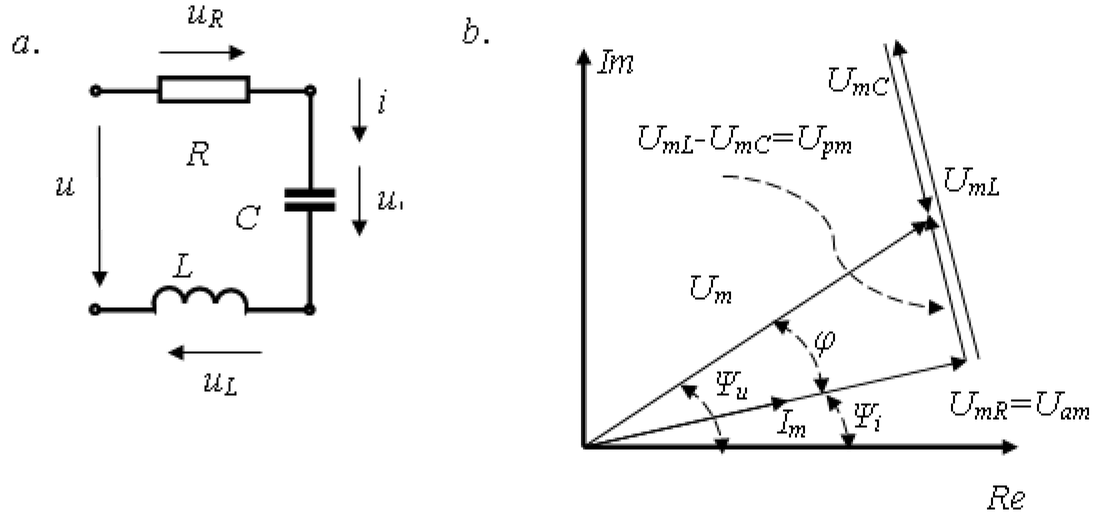


Figure 3.4. – The Phasor Diagram of the R-L-C circuit connection in series

7.2. When the elements are connected in parallel, it is convenient to take the voltage drop across the parallel branches $\underline{U}$ as the base vector.

The current vector in the resistive-inductive branch lags behind the base vector by an angle φ_K , and in the branch with a capacitance current vector leads the base voltage vector by an angle 90^0.

The voltage drop across the reactance x_L of the coil $\underline{U}_L$ leads the coil current by an angle $\pi/2$, and the voltage drop vector across the resistor R_K coincides with coil current in phase $\underline{I}_K$. The sum of the vectors of voltage drops across the coil elements is equal to the voltage vector across the capacitor. The vector diagram of currents is plotted in accordance with the Kirchhoff current law in a complex form, as shown in the example of a simple circuit in Fig. 3.4.

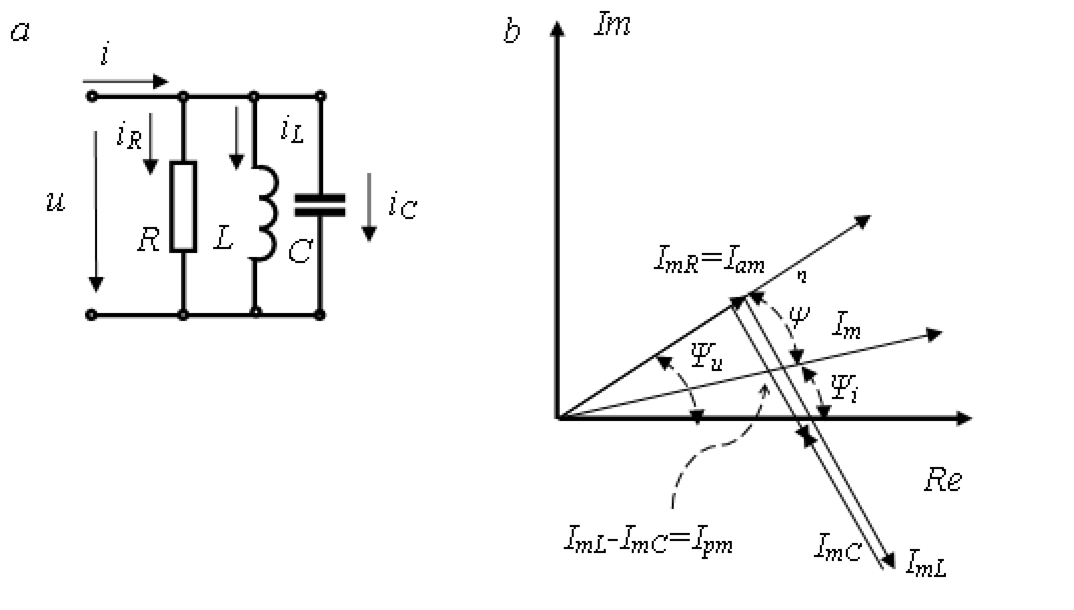


Figure 3.5. – The Phasor Diagram of the R-L-C circuit connection in parallel

7.3. It is more convenient to begin to start the plot vector diagram when the mixed connection elements with the voltage vector applied to the parallel branches with the coil L_4 and the capacitor C_3 . The coil L_4 and capacitor C_3 currents, as well as the voltage drop across the resistive and inductive resistance, are plotted as in section 7.

The input current is found as vector sum of the parallel branch currents. The voltage drop vectors across coil L_2 and capacitor C_2 are oriented with respect to the found input vector current.

The vector sum of the voltage drops across the capacitor C_3 (or the coil L_4), coil L_2 and capacitor C_2 is equal to the voltage vector mains supply.

Questions for check knowledge

1. Which vectors convenient are taken as basic when series, parallel and mixed connection when plotted vector diagrams?
2. How are the current and voltage vectors shifted in phase for resistive-inductive and resistive-capacitive loads?
3. What is the difference between a real inductor coil and an ideal one?
4. When knowing the complex value of the current, presented in the exponential form of the record, determine the instantaneous value of the current.
5. Plot a power triangle when connecting elements in series. connection.
6. With a mixed connection of elements, determine the currents of the branches by the method of mesh currents.
7. With parallel connection of the branches, determine the currents by the method of nodal potentials
8. Draw up a balance of electrical power with a mixed connection of element.
9. What are the dimensions of average, reactive and apparent powers?
10. How to determine the complex of the input resistance with a mixed connection of elements?

Laboratory Work TFEE – 1/4

EXPERIMENTAL STUDY OF RESONANCE PHENOMENA IN ELECTRIC CIRCUITS

Objective

Frequency characteristics study of harmonic current electric circuits with series and parallel connection of inductor coil and capacitor

Program of Work

1. Assembly of an electrical circuit containing a series connection of a coil and a capacitor.
2. Experimental determination of the circuit current and voltage drops on the elements dependences as a function of the supplied voltage frequency when coil and capacitor are connected in series.
3. Assembly the electrical circuit with parallel connection of the coil and capacitor.
4. Experimental determination of the dependences of currents in the branches of the values of the frequency of the supplied voltage when coil and capacitor are connected in parallel.
5. Frequency characteristics and phasor diagrams plotting for resonances of voltages and currents.
6. Analysis of the results. Brief conclusions.

Work Stages

Stage 1. Assembly of an electrical circuit containing a series connection of a coil and a capacitor.

1.1. Assemble the electric circuit shown in the Fig.4.1.

The main elements are:

- Power Source - single-phase AC unit working in a sinusoidal output signal mode; resistor R is taken in about $100\,\Omega$;
- in according with number of team the parameter of elements L_4 and C_4 are selected;
- regulated inductance L_4 is taken from inductances unit and value set by decade switches;
- regulated capacitance C_4 is taken from inductances unit and value is set by decade switches.

Before the element L_4 is connected in the circuit, the internal active resistance R_4 is measured by a multimeter. Record measured value in laboratory report.

After checking the electrical circuit, switch on the power supply unit.

Table 4.1.

Initial values of serial resonant circuit parameters

№ team	1	2	3	4	5	6
L_4, mH	27	31	63	39	49	48
C_4, μF	0,25	0,1	0,13	0,1	0,15	0,06

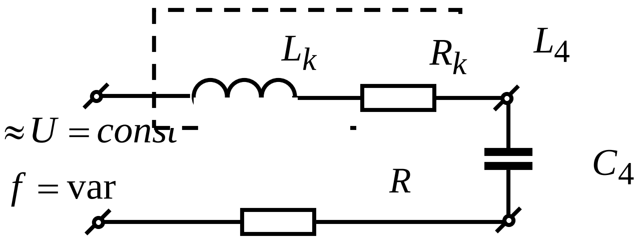


Figure 4.1. – Series oscillating circuit

Stage 2. Experimental determination of the circuit current and voltage drops on the elements dependences as a function of the supplied voltage frequency when coil and capacitor are connected in series.

2.1. Maintaining the output voltage of the power supply at a constant level of 5 V, changing the frequency, make sure there is a voltages resonance.

2.2. When voltages resonance, measure the voltage drops across the resistor, coil and capacitor with a multimeter. Enter the data obtained in the fourth line of Table 4.2.

Table 4.2.

The measured values of the series resonant circuit parameters

№	f, Hz	U_R, V	U_k, V	U_C, V
1				
2				
3				
4. VR				
5				
6				
7				

Turn switch the multimeter to frequency measurement and measure frequency when voltage resonance. Enter the frequency numerical value in Table 4.2 in the fourth line.

2.3. By decreasing and increasing the frequency of the supply voltage from the resonant one, obtain additional points of characteristics. Enter the data in Table 4.2.

Stage 3. Assembly the electrical circuit with parallel connection of the coil and capacitor.

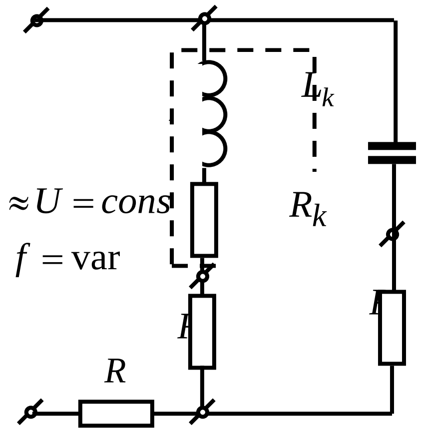


Figure 4.2. – Parallel oscillating circuit

Assemble the electrical circuit shown in Fig. 4.2. The parameters of the coil L_4 and the capacitor C_4 are selected according to the team number according to the data in Table 4.1.

Additional resistors are taken R about $10\,\Omega$, and R_4=$1\ldots2\,\Omega$.

The power supply is taken from a single-phase AC voltage unit, working in the voltage sinusoidal mode.

Stage 4. Experimental determination of the dependences of currents in the branches of the values of the frequency of the supplied voltage when coil and capacitor are connected in parallel.

4.1. Maintaining the output voltage of the power supply at a constant level of 5 V, changing the frequency, make sure there is a currents resonance.

4.2. When current resonance, measure drop voltages across the resistors in each branch with the multimeter and according to the Ohm's law calculate branch currents. Enter the data obtained in the fourth line of Table 4.3.

Table 4.3.

The measured values of the parallel resonant circuit parameters

№	f, Hz	I, mA	I_k, mA	I_C, mA
1				
2				
3				
4. CR				
5				
6				
7				

Turn switch the multimeter to frequency measurement and measure frequency when voltage resonance. Enter the frequency numerical value in Table 4.3 in the fourth line.

4.3. By decreasing and increasing the frequency of the supply voltage from the resonant one, obtain additional points of characteristics. Enter the data in Table 4.3.

Stage 5. Frequency characteristics and phasor diagrams plotting for resonances of voltages and currents.

5.1 According to data in Table 4.2 (fourth line), plot on a scale the combined phasor diagrams of currents and voltages.

5.2. Based on the data of the 4th line of Table 4.3, plot the combined phasor diagrams of currents and voltages on a scale.

5.3. According to data in the Table 4.2 plot frequency characteristics $U_C, U_K, U_R = f(\omega)$.

5.4. According to data in Table 4.3 plot frequency characteristics $I, I_K, I_C = f(\omega)$.

The Report must contain

1. The number and title of the laboratory work.
2. The work objective.
3. The work program.
4. Fig.4.1, 4.2.
5. Tables 4.1, 4.2, 4.3.
6. Frequency characteristics for voltages resonance $U_C, U_K, U_R = f(\omega)$ and for currents resonance $I, I_K, I_C = f(\omega)$.
7. The combined phasor diagrams of currents and voltages when voltages and currents resonance.
8. Analysis of the results. Brief conclusions.

Methodical instruction

To the Stage 2. Experimental determination of the circuit current and voltage drops on the elements dependences as a function of the supplied voltage frequency when coil and capacitor are connected in series.

When measuring the frequency characteristics, the current should be measured by the voltage drop across the resistance resistance with a multimeter. Direct current measurement with a milliammeter gives significant errors, since it has a comparable internal inductance with inductance L_4.

The voltage resonance is determined by the maximum current value when a linear increase (decrease) in the frequency of the supplied voltage.

To the Stage 4. Experimental determination of the dependences of currents in the branches of the values of the frequency of the supplied voltage when coil and capacitor are connected in parallel.

The current resonance is determined by minimum value of input current when a linear increase (decrease) in the frequency of the supplied voltage.

<u>To the Stage 5</u>. Frequency characteristics and phasor diagrams plotting for resonances of voltages and currents.

While drawing vector diagram for series connected elements it is convenient to take the vector of current for the initial one, having superposed it with an axis of positive real number. The voltage vector diagram is oriented with regard to the taken initial vector and is designed based on a common applied voltage that is equal to a vector sum of the voltages on the elements of the scheme. It is convient to draw the coil voltage by components U_{Rk} and U_L.

The active component U_{Rk} of the voltage drop across the coil coincides in phase with circuit current, the inductive component U_L – is leaded of the initial (current) vector by angle 90^0, but the capacitive one U_C – lags by angle 90^0.

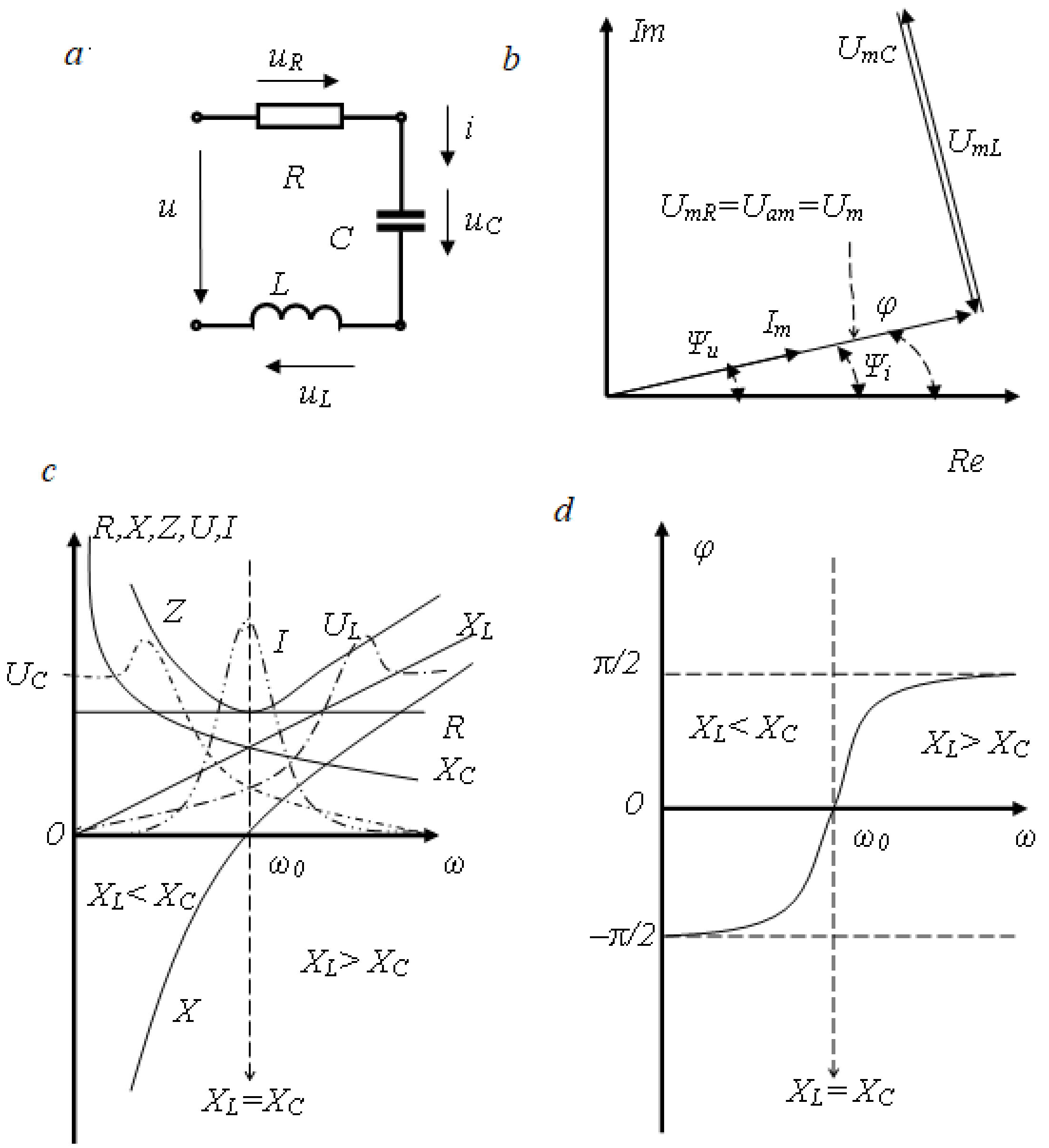


Figure 4.3. – Series oscillating circuit

The total applied voltage U is balanced by the vector sum of drops in voltage across the circuit elements

$$\underline{U} = \underline{U}_{Rk} + \underline{U}_L + \underline{U}_C .$$

Based on this vector equation, a vector diagram is plotted, where the beginning of each subsequent vector is added to the end of the previous one.

An approximate view of the vector diagram (Fig. 4.3,b) and frequency characteristics (Fig. 4.3,c,d) for voltages resonance is shown in Fig. 4.3.

5.2. It is convenient to take a drop in voltage on parallel branches (Fig. 4.4,a) as initial vector at parallel connection.

Current vector in resistive-inductive branch lags from initial vector on angle φ_K , but in the capacitive branch – lags on angle 90^0 from the voltage vector .

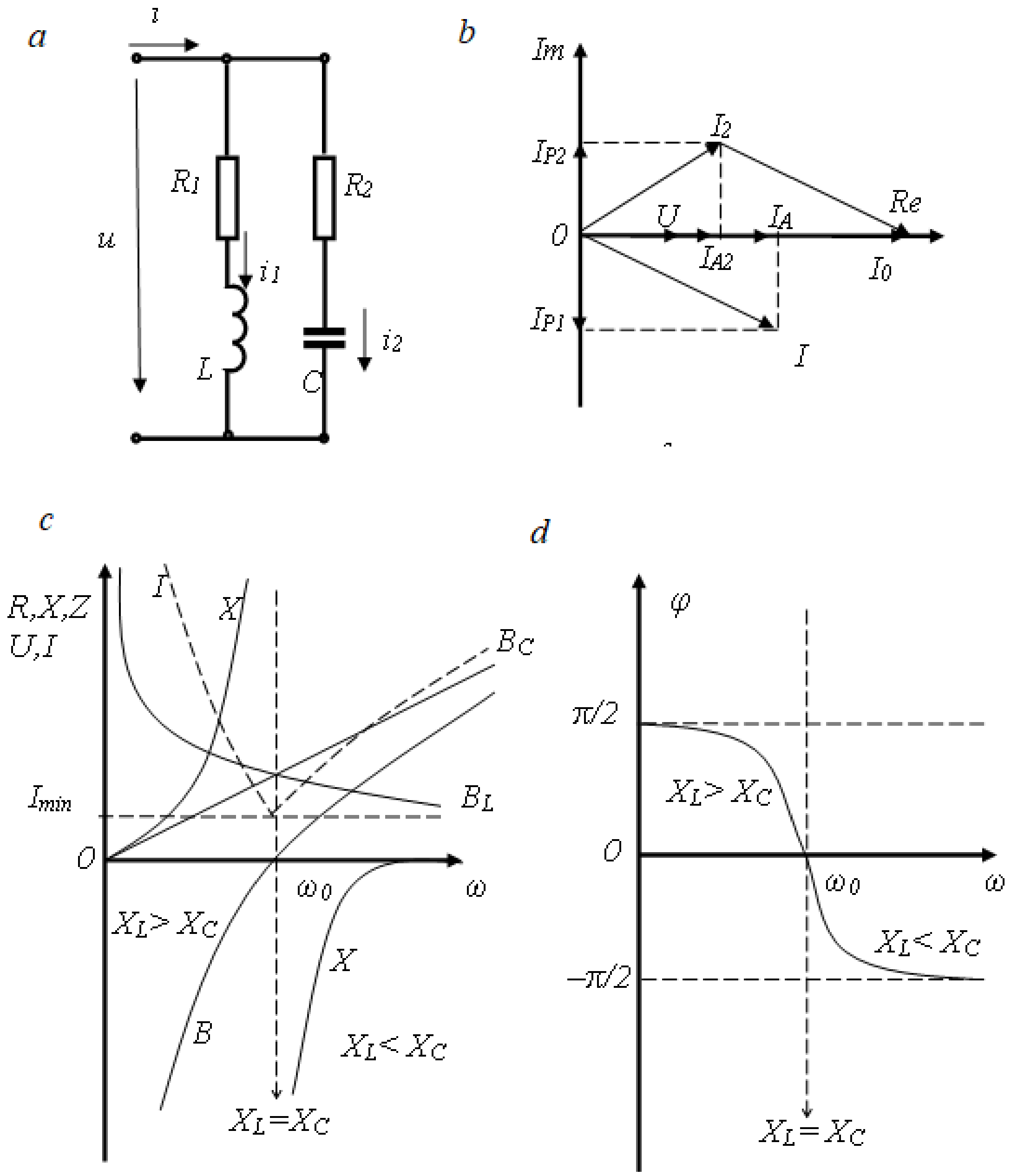


Figure 4.3. – Parallel oscillating circuit

The drop in voltage on the reactive coil resistance $\underline{U}_L$ takes the lead of the coil current in phase on angle $\pi/2$, but vector of drop in voltage on resistor R_K coincides with coil current in phase $\dot{I}_K$. The sum of drop voltages vectors on the coil elements is equal to the voltage vector on the capacitance.

An approximate view of the vector diagram (Fig. 4.4,b) and frequency characteristics (Fig. 4,c,d) for the currents resonance is shown in Fig. 4.4.

Questions for check knowledge

1. What are the conditions for voltage and current resonances arises?
2. What is the Q-factor of a circuit and how does its value affect the resonance curves?
3. How does the average power change in the studied circuits with a change in capacitance?
4. How to calculate the frequency of voltages and currents resonances using the given values C and L assuming that the resistive resistances of the circuits are zero?
5. How does the ohmic resistance affect the frequency of the supply voltage, at which the resonance of currents occurs?
6. Why does the input current curve when resonance currents not fall to zero?
7. How do capacitance and inductive reactance change when the frequency changes?
8. What energy processes occur in the circuit when resonance?
9. Plot a frequency response $Z = f(\omega)$ in series connection R, L, C elements.
10. Plot a frequency response $Z = f(\omega)$ in parallel connection R, L, C elements.

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CONTENT

Автор

Хілов Віктор Сергійович

Методичні вказівки англійскою мовою до лабораторних робіт з дисципліни
ТЕОРЕТИЧНІ ОСНОВИ ЕЛЕКТРОТЕХНІКИ, ЧАСТИНА 1
(розділи: «Основи теорії кіл постійного струму» та
«Основи теорії кіл гармонійного однофазного струму»
для студентів спеціальності
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