

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL TECHNICAL UNIVERSITY OF UKRAINE
“IGOR SIKORSKY KYIV POLYTECHNIC INSTITUTE”

INFORMATION TECHNOLOGIES LABORATORY GUIDE

Tutorial

Recommended by Methodical council of “Igor Sikorsky Kyiv Polytechnic Institute”
as a tutorial for bachelors
according to the educational program “Electronic components and systems”
specialty 171 Electronics

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The discipline «Information Technologies» is an integral part of the disciplines that are included in the list of required disciplines of bachelor's degree in electronic engineering. The purpose of the discipline «Information Technologies» is to provide students with basic in-depth knowledge of methods, methods and algorithms for using the MATLAB software package to solve applied problems in mathematics, electronics, circuitry, analysis and synthesis of electronic circuits and systems. The manual is intended for students majoring in 171 “Electronics”, educational program “Electronic Components and Systems”.

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CONTENT

Introduction.....	4
1. Laboratory work 1	5
2. Laboratory work 2	6
3. Laboratory work 3	14
4. Laboratory work 4	16
5. Laboratory work 5	21
6. Laboratory work 6	27
7. Laboratory work 7	35
8. Laboratory work 8	42
Recommended Books	53

INTRODUCTION

The course "Information Technologies" is an integral part of the disciplines that are included in the list of required disciplines of bachelor's degree in the educational program "Electronic components and systems" specialty 171 Electronics.

The study of the discipline is based on the knowledge gained by students in the study of such courses as "Analytical Geometry", "Probabilistic Fundamentals of Data Processing", "Personal Computers and Fundamentals of Programming", "Programming and Algorithmic Languages".

Assimilation of the material of the discipline "Information Technologies" creates a basis for studying the courses "Theory of Electrical Circuits", "Modeling in Electronics", "Power Electronics", "Devices of Conversion Technology".

The main purpose of the laboratory guide is to help students learn the course "Information Technologies" when working independently on the course and in the process of performing tests. The purpose of the course "Information Technologies" is to provide students with basic in-depth knowledge of methods, methods and algorithms for using the MATLAB software package to solve applied problems in mathematics, electronics, circuitry, analysis and synthesis of electronic circuits and systems.

The laboratory workshop consists of eight laboratory works that provide an opportunity to gain practical skills in applying the theoretical provisions of the course "Information Technologies".

Laboratory work № 1

ELEMENTARY OPERATIONS WITH MATRIXES

The goal of the work

Get acquainted with the menu system, command window, workspace, command history window, ways to edit and execute programs in MATLAB, learn to perform basic operations with matrices.

Task

1. Create and enter a matrix in MATLAB:

№ record book = abcd

$$A = \begin{bmatrix} a & b & c & d \\ a+b & c & a+c & d \\ b & a+d & a & c+b \\ d & c & b+d & c+d \end{bmatrix}$$

2. Calculate the sum of the columns of the matrix A.
3. Calculate the sum in the rows of the matrix A.
4. Calculate the sum of the elements on the main diagonal of the matrix A.
5. Calculate the sum of the elements on the antidiagonal of the matrix A.
6. Perform operations on matrix elements: $A(a+d) * A(c+b) / A(c+d)$, where $a+d$, $c+b$, $c+d$ - single indices obtained from the record book number.
7. Assign matrix B the value of the Dürer matrix and perform the operation of multiplying matrices $A * B$.
8. Create a magic square (matrix) using the built-in function in 4x4 MATLAB.
9. Convert the created matrix B into a Dürer matrix A (you need to change the location of the columns).
10. Generate a 4x4 matrix C with a uniform distribution of random elements.
11. Generate a 4x4 matrix D with normal distribution of random elements.
12. Save the 4x4 matrix (for example, the Dürer matrix) in a text file (file name ldata.dat) and upload it to MATLAB.
13. Combine the ldata matrix with the B, C and D matrices into an 8x8 matrix S.
14. Remove the column from the resulting matrix $(c+1)$.

15. Delete the string from the resulting matrix $(c + 1)$.
16. Create and save in m -file the above operations (save the file in the same directory with the file ldata.dat) and perform recalculations from it. Show the teacher and run the created and saved m-file.
17. Write the program to the m-file

Control questions

1. What windows does the MATLAB interface have and what is their purpose?
2. What is the structure of the Windows Command window?
3. How are commands entered and executed in MATLAB?
4. Name the areas of the Command Windows window.
5. How to increase the length of the Command Windows command line by extending them to several physical command window lines?
6. What is a MATLAB workspace?
7. How do I view and edit variable values in the Workspace window?
8. How to display the list of variables created in this session in the command window?
9. How do I delete an unused variable from the MATLAB workspace?
10. How to get help on the selected MATLAB command?
11. In what format are real numbers published in MATLAB?
12. What real number formats are used in MATLAB?
13. How are operations with complex numbers performed in MATLAB?
14. How are operations with matrices of numbers performed in MATLAB?
15. How is MATLAB computing elementary functions from vectors and matrices?
16. Methods of entering matrices in MATLAB
17. What conditions must be observed when introducing matrices
18. Calculating the sum of matrix columns

19. Calculating the sum in the rows of the matrix
20. Calculate the sum of the elements on the main diagonal of the matrix
21. Calculating the sum of elements on the antidiagonal of the matrix
22. Create a magic square (matrix) using the built-in function in MATLAB
23. How to load matlab from text matrix file
24. Combining several matrices into one
25. Remove from the matrix of the n-th column
26. Delete nth row from matrix
27. Methods of indexing matrix elements in MATLAB
28. List the main functions for generating matrices

Laboratory work № 2

GRAPHICS

The goal of the work

Get acquainted and master the basics of graphical visualization of calculations in MATLAB.

Task

- Using the normal and uniform distribution of random elements, create 2 vector columns (A and B) with the number of elements $n = 20 + d$.

№ record book = abcd

- Create a third column vector $C = \sqrt{B^2 - A^2}$.
- Construct a graph on the x-axis of which the ordinal number of the element of the column vector will be plotted, and on the y-axis - the value of the element of the column vector. For each of the three column vectors, choose a different color, line style, and graph marker.
- In another window, plot the function according to the option in the table:

№ z.k.	function	The boundaries of the graph	interval between points	color lines	line style	marker	axis, grid
01	$\sin(t)$	$0 \leq t \leq 2\pi$	$\pi/20$	blue	solid	+	axis of equal length
02	$\cos(t)$	$0 \leq t \leq 2\pi$	$\pi/20$	crimson	dashed	o	marks of increments of the same length
03	$\sqrt{t}$	$0 \leq t \leq 10$	0.2	yellow	dotted	*	with a grid of coordinates
04	$\arctan(t)$	$-2\pi \leq t \leq 2\pi$	$\pi/20$	red	dash-dotted	x	without grid
05	$\frac{t^2}{45}$	$0 \leq t \leq 10$	0.2	green	without line (only with markers)	+	enter construction boundaries manually
06	$\frac{t^2}{50} + \frac{t}{10} - 1$	$0 \leq t \leq 10$	0.2	blue	solid	o	axis of equal length
07	$\sin(t)$	$0 \leq t \leq 3\pi$	$\pi/30$	black	dashed	*	marks of increments of the same length

08	$\cos(t)$	$0 \leq t \leq 3\pi$	$\pi/30$	blue	dotted	x	with a grid of coordinates
09	$\sqrt{t}$	$0 \leq t \leq 30$	0.3	crimson	dash-dotted	+	without grid
10	$\arctan(t)$	$-3\pi \leq t \leq 3\pi$	$\pi/30$	yellow	without line (only with markers)	o	enter construction boundaries manually
11	$\frac{t^2}{45}$	$0 \leq t \leq 30$	0.3	red	solid	*	axis of equal length
12	$\frac{t^2}{50} + \frac{t}{10} - 1$	$0 \leq t \leq 30$	0.3	green	dashed	x	marks of increments of the same length
13	$\sin(t)$	$0 \leq t \leq 4\pi$	$\pi/10$	blue	dotted	+	with a grid of coordinates
14	$\cos(t)$	$0 \leq t \leq 4\pi$	$\pi/10$	black	dash-dotted	o	without grid
15	$\sqrt{t}$	$0 \leq t \leq 20$	0.1	blue	without line (only with markers)	*	enter construction boundaries manually
16	$\arctan(t)$	$-4\pi \leq t \leq 4\pi$	$\pi/10$	crimson	solid	x	axis of equal length
17	$\frac{t^2}{45}$	$0 \leq t \leq 20$	0.1	yellow	dashed	+	marks of increments of the same length
18	$\frac{t^2}{50} + \frac{t}{10} - 1$	$0 \leq t \leq 20$	0.1	red	dotted	o	with a grid of coordinates
19	$\sin(t)$	$0 \leq t \leq 2\pi$	$\pi/25$	green	dash-dotted	*	without grid
20	$\cos(t)$	$0 \leq t \leq 2\pi$	$\pi/25$	blue	without line (only with markers)	x	enter construction boundaries manually
21	$\sqrt{t}$	$0 \leq t \leq 15$	0.25	black	solid	+	axis of equal length
22	$\arctan(t)$	$-2\pi \leq t \leq 2\pi$	$\pi/25$	blue	dashed	o	marks of increments of the same length
23	$\frac{t^2}{45}$	$0 \leq t \leq 15$	0.25	crimson	dotted	*	with a grid of coordinates
24	$\frac{t^2}{50} + \frac{t}{10} - 1$	$0 \leq t \leq 15$	0.25	yellow	dash-dotted	x	without grid
25	$\sin(t)$	$0 \leq t \leq 4\pi$	$\pi/15$	red	without line (only with markers)	+	enter construction boundaries manually
26	$\cos(t)$	$0 \leq t \leq 4\pi$	$\pi/15$	green	solid	o	axis of equal length

27	$\sqrt{t}$	$0 \leq t \leq 25$	0.15	blue	dashed	*	marks of increments of the same length
28	$\arctan(t)$	$-4\pi \leq t \leq 4\pi$	$\pi/15$	black	dotted	x	with a grid of coordinates
29	$\frac{t^2}{45}$	$0 \leq t \leq 25$	0.15	blue	dash-dotted	+	without grid
30	$\frac{t^2}{50} + \frac{t}{10} - 1$	$0 \leq t \leq 25$	0.15	crimson	without line (only with markers)	o	enter construction boundaries manually

- Sign axes, add a title, and insert text with the option number anywhere on the chart.
- Create and save to m-file the above operations. Check the m-file by recalculating it.
Show the teacher and run the created and saved m-file.
- Construct a three-dimensional graph of the function of two variables $z(x, y)$ according to the option in the table (write and debug the program in m -file):

P var.	function $z(x, y)$	the boundaries of the graph in areas x and y	interval between points	colormap	chart type
01	$\frac{x^2}{c+1} + \frac{y^2}{b}$	$-(b+d+1) \leq x, y \leq (b+d+1)$	$\frac{b+d+1}{10}$	hsv	grid 3D graphic with color
02	$x \cdot \exp(-\frac{x^2}{b} - \frac{y^2}{c+1})$			hot	3D grid graph with projections
03	$\frac{\sin(x)}{\frac{x^2}{d+1} + \frac{y^2}{c+1} + 0,1 \cdot (d+1)}$			gray	3D graphics with color
04	$\frac{\sin(r)}{r}, r = \sqrt{\frac{x^2}{d+1} + \frac{y^2}{b}}$			bone	3D graphic with color and projection
05	$x^2 + y^2$			copper	construction of the illuminated surface
06	$x \cdot \exp(-x^2 - y^2)$			pink	grid 3D graphic with color
07	$\frac{\sin(x \cdot (d+1))}{x^2 + y^2 + 0,1 \cdot (d+1)}$			flag	3D grid graph with projections
08	$\frac{\sin(\frac{r}{d+1})}{r}, r = \sqrt{x^2 + y^2}$			lines	3D graphics with color
09	$\frac{x^2}{c+1} + \frac{y^2}{b}$			colorcube	3D graphic with color and projection

10	$x \cdot \exp(-\frac{x^2}{b} - \frac{y^2}{c+1})$		vga	construction of the illuminated surface
11	$\frac{\sin(x)}{\frac{x^2}{d+1} + \frac{y^2}{c+1} + 0,1 \cdot (d+1)}$		jet	grid 3D graphic with color
12	$\frac{\sin(r)}{r}, r = \sqrt{\frac{x^2}{d+1} + \frac{y^2}{b}}$		prism	3D grid graph with projections
13	$x^2 + y^2$		cool	3D graphics with color
14	$x \cdot \exp(-x^2 - y^2)$		autumn	3D graphic with color and projection
15	$\frac{\sin(x \cdot (d+1))}{x^2 + y^2 + 0,1 \cdot (d+1)}$		spring	construction of the illuminated surface
16	$\frac{\sin(\frac{r}{d+1})}{r}, r = \sqrt{x^2 + y^2}$		winter	grid 3D graphic with color
17	$\frac{x^2}{c+1} + \frac{y^2}{b}$		summer	3D grid graph with projections
18	$x \cdot \exp(-\frac{x^2}{b} - \frac{y^2}{c+1})$		hsv	3D graphics with color
19	$\frac{\sin(x)}{\frac{x^2}{d+1} + \frac{y^2}{c+1} + 0,1 \cdot (d+1)}$		hot	3D graphic with color and projection
20	$\frac{\sin(r)}{r}, r = \sqrt{\frac{x^2}{d+1} + \frac{y^2}{b}}$		gray	construction of the illuminated surface
21	$x^2 + y^2$		bone	grid 3D graphic with color
22	$x \cdot \exp(-x^2 - y^2)$		copper	3D grid graph with projections
23	$\frac{\sin(x \cdot (d+1))}{x^2 + y^2 + 0,1 \cdot (d+1)}$		pink	3D graphics with color
24	$\frac{\sin(\frac{r}{d+1})}{r}, r = \sqrt{x^2 + y^2}$		prism	3D graphic with color and projection
25	$\frac{x^2}{c+1} + \frac{y^2}{b}$		winter	construction of the illuminated surface

8. Sign axes, add a title and legend, and insert text with the option number anywhere in the chart.
9. In the new window, build a three-dimensional graph of the function of two variables $z(x, y)$ according to the option in the previous table, remove the grid image on the

three-dimensional surface of the image and set the interpolation for color shades of the three-dimensional surface.

10. Show the teacher and run the created and saved m-file. Write m-file commands

Control questions

1. What is the sequence of actions in MATLAB to construct spatial curves?
2. For what purposes is the meshgrid function used?
3. How do surfaces built with mesh, surf and surfl differ from each other?
4. How to get information about the properties of a graphic object that contains a surface image?
5. Which command activates the display mode of edges that are closed by the surface?
6. Which command sets the angular position of the surface viewpoint?
7. How are graphic images stored and read in binary format?
8. How are graphic images exported to known graphic formats?
9. Graphs on a logarithmic scale
10. Graphs in semi-logarithmic scale
11. Graphs in the polar coordinate system
12. Graphs of vectors
13. Add a new curve to an existing graph
14. How to remove the grid image on the three-dimensional surface of the image and at the same time set the interpolation for the color shades of the three-dimensional surface for the graph of the function of two variables
15. Construction of histograms
16. Create a function graph in MATLAB
17. Creating a new image window in MATLAB
18. Angular histograms

19. Line color, line style and markers in MATLAB graphics
20. Enter text anywhere in the graphic
21. Derivation of explanations and legends
22. Output of color scale (color shades)
23. Quiver gradient field graphs
24. Contour graphs
25. Overlapping graphs on each other
26. Plotting surfaces
27. Construction of the illuminated surface
28. Construction of the surface and its projection
29. Construction of a surface with coloring
30. Creating data arrays for 3D graphics
31. Three-dimensional contour graphs
32. Manage the properties of graph axes
33. Installation of axial inscriptions
34. Setting the color palette (color scheme)
35. Installation of the title inscription

Laboratory work № 3

POLYNOMS

The goal of the work

Get acquainted and learn the basics of working with polynomials in MATLAB.

Task

1. Convert the polynomial represented by the vector of coefficients $y = [-abc -d]$ into a symbolic expression.
2. Convert polynomial is represented by a symbolic expression $y = -A \cdot x^d + b \cdot x^c + c \cdot x^b - d \cdot x^a$ in the vector of coefficients.
3. Calculate the value of the polynomial y provided that:
 - vector of coefficients $p = [d, -c]$ (coefficients are arranged in descending order of degree x);
 - value of arguments $x = [d, -c; b, -a]$.
4. Add and subtract polynomials $p = [-a, -b, c, 0, d]$ and $q = [c, -d, a]$.

note: create a function m-file polysum.m:

```
function s = polysum (p, q)
% POLYSUM Addition and subtraction of two polynomials
% C = polysum (A, B) calculates the sum of C = A + B
% C = polysum (A, -B) calculates the difference C = A - B
% length (C) = max (length (A), length (B)).
maxlen = max (length (p), length (q));
p1 = zeros (1, maxlen);
q1 = zeros (1, maxlen);
p1 (maxlen-length (p) + 1: maxlen) = p;
q1 (maxlen-length (q) + 1: maxlen) = q;
s = p1 + q1;
```

select the working directory with the polysum.m function file and compile it in the command window: `mcc -m polysum.m` (for MATLAB select compiler - select Lcc).

5. Multiply the polynomials p and q .

6. Divide the polynomials: obtained by the polynomial in the previous problem (polynomial y) by the polynomial p.
7. Calculate the derivative of the polynomial represented by the vector of coefficients p, the derivative of the product of the polynomials $p * q$, and the derivative of the fractional-rational function p / q .
8. Integrate polynomial p (integration constant (free primitive) **WITH** $-C$).
9. Find the roots of x polynomial p.
10. Restore the vector p from the roots of the polynomial found in the previous problem.
11. Create an m-file in which to write all the commands needed to perform the above tasks (the created m-file must be in the same directory with the function file polysum.m).
12. Write commands to the created m-file

Control questions

1. Transforming the representation of polynomials
2. Using the sym function
3. Calculating the value of a polynomial
4. Calculation of a polynomial from a matrix operand
5. Addition and subtraction of polynomials
6. Multiplication and division of polynomials
7. Differentiation of polynomials
8. Integration of polynomials
9. Finding the roots of a polynomial
10. Calculating the value of a symbolic polynomial
11. Calculation of a polynomial with symbolic coefficients
12. Substitution of several character parameters

Laboratory work № 4

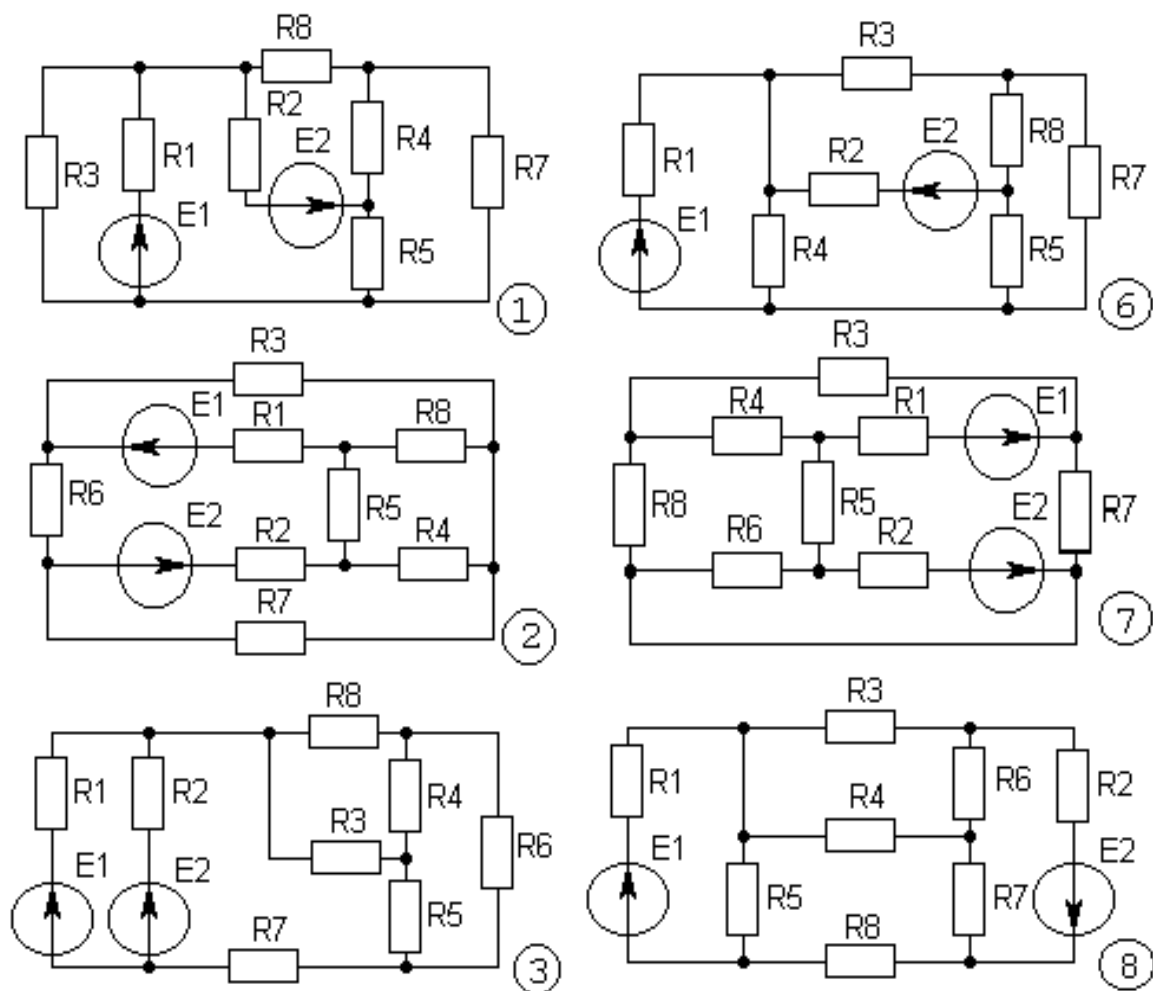
PROGRAMMING COMPUTER PROCESSES IN MATLAB

The goal of the work

Developing skills in using the MATLAB software package for programming computational processes and consolidating knowledge of Ohm's and Kirchhoff's laws.

Procedure and methods of work

1. Display in the protocol of laboratory work in Fig. 4.2 the studied scheme according to the variant (Fig. 4.1 and Table 4.1). Indicate in the diagram the nominal values of resistors and voltage sources.



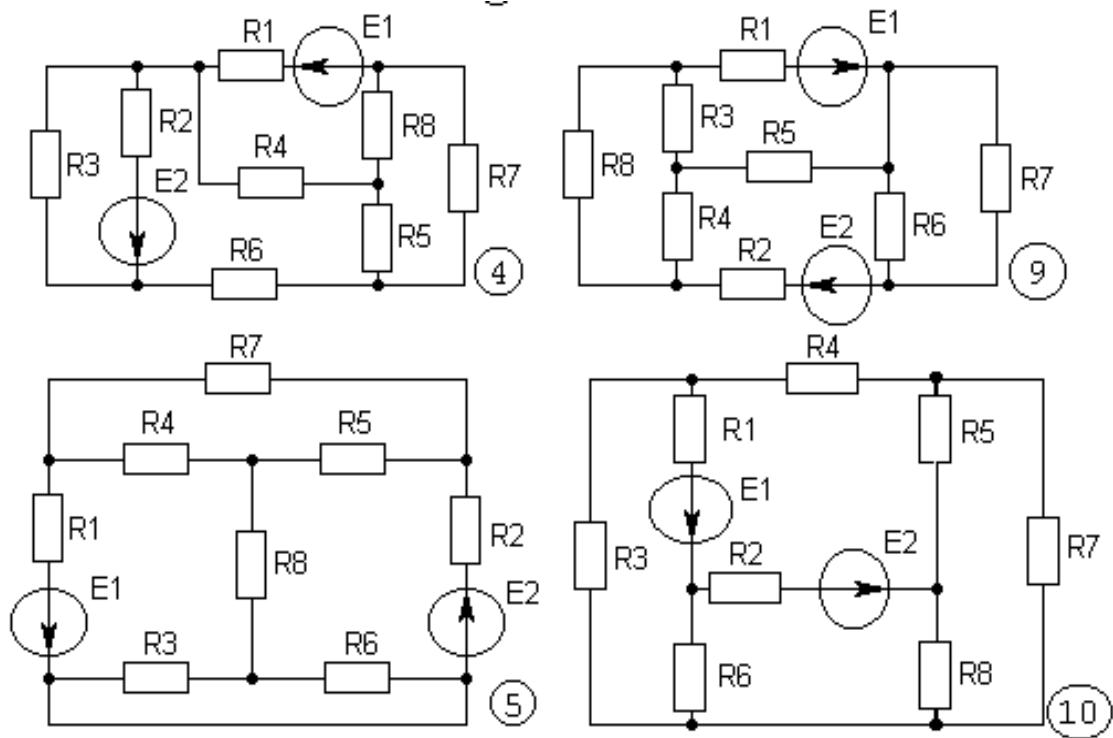


Fig. 4.1. Variants of schemes.

Table 4.1.

Version	The number of the scheme in Fig.1	Elements of schemes according to fig.1									
		R1, Oh m	R2, Oh m	R3, Oh m	R4, Oh m	R5, Oh m	R6, Oh m	R7, Oh m	R8, Oh m	E1, B	E2, B
1	1	10	20	30	40	50	60	70	80	25	18
2	2	20	30	40	50	60	70	80	90	26	22
3	3	30	40	50	60	70	80	90	100	27	20
4	4	40	50	60	70	80	90	100	110	28	18
5	5	50	60	70	80	90	100	110	120	29	20
6	6	60	70	80	90	100	110	120	130	30	22
7	7	70	80	90	100	110	120	130	140	25	22
8	8	80	90	100	110	120	130	140	150	26	20
9	9	90	100	110	120	130	140	150	160	27	22
10	10	100	110	120	130	140	150	160	170	28	20
11	2	110	120	130	140	150	160	170	180	29	18

12	4	120	130	140	150	160	170	180	190	30	24
13	6	130	140	150	160	170	180	190	200	25	20
14	8	140	150	160	170	180	190	200	210	26	23
15	10	150	160	170	180	190	200	210	220	27	21
16	5	160	170	180	190	200	210	220	230	28	19
17	3	170	180	190	200	210	220	230	240	29	21
18	1	130	140	150	160	170	180	190	200	25	20
19	7	140	150	160	170	180	190	200	210	26	23
20	8	150	160	170	180	190	200	210	220	27	21

2. Compose a system of linear equations by the method of contour currents and write it in the protocol.

3. Write a program for calculating currents in all branches. When writing a program to check the compatibility and certainty of the system of linear equations. Find the general solution of the system for the case when it is uncertain. All coefficients must be present in the text of the program, as well as provide for the input of all coefficients from the command window. Select and record the coefficients at which the system will be uncertain. List the program in Appendix A in the laboratory work report.

4. Using the found currents to calculate in the program the voltage on the circuit elements and record the results in the protocol of laboratory work in the table:

	R1	R2	R3	R4	R5	R6	R7	R8	E1	E2
U, B										
I, A									X	X
R, Ohm									X	X

Control questions

1. Operator formats in MATLAB
2. Input and output of calculation results

3. Eval and feval functions
4. M-file editor toolbar
5. How to control the input and output values of m-functions
6. Which commands include the Text menu
7. Which commands include the Debug menu
8. Which commands include the Edit menu
9. List of subfunctions of the call.m file
10. Debug commands (Debug menu)
11. Search for a normal pseudo-solution of a system of linear equations
12. Operations of linear algebra on matrices
13. Existence and unity of the solution of the system of linear equations
14. Inverse and pseudo-inverse matrix. Solution of a common system of linear equations: Kramer's system
15. Solution of a common system of linear equations: indefinite system
16. Solution of a common system of linear equations: search for a private solution of an inhomogeneous system of equations
17. Solution of a common system of linear equations: search for a normal private solution of an inhomogeneous system of equations
18. Solutions of a common system of linear equations: search for the basis of the solution space
19. Solution of a common system of linear equations: general solution of a homogeneous system
20. Pseudo-solutions of an incompatible system of linear equations
21. Search for a normal pseudo-solution of a system of linear equations
22. How do the results returned by the functions exp and expm, log and logm, sqrt and sqrtm differ, respectively?

23. Which MATLAB function finds the solution of the system of linear equations, reflecting the results obtained at each step of the transformations of the extended matrix of the system?
24. What functions do you return: the number of conditionality of the matrix, the determinant of the matrix, the rank of the matrix, the orthonormal basis?
25. What functions are used when working with sparse matrices? How do they make more efficient use of your computer's RAM?
26. Which MATLAB function returns solutions of nonlinear equations that include functions that depend on one variable? What is the call syntax of this function?
27. Which MATLAB function returns the value of a definite integral calculated by the trapezoid method?
28. How is the calculation of a certain integral different from the calculation of an integral with a variable upper bound?
29. Which MATLAB function returns the value of the double integral?
30. Which MATLAB functions return numerical solutions of ordinary differential equations? What determines the choice of specific functions?

Laboratory work № 5

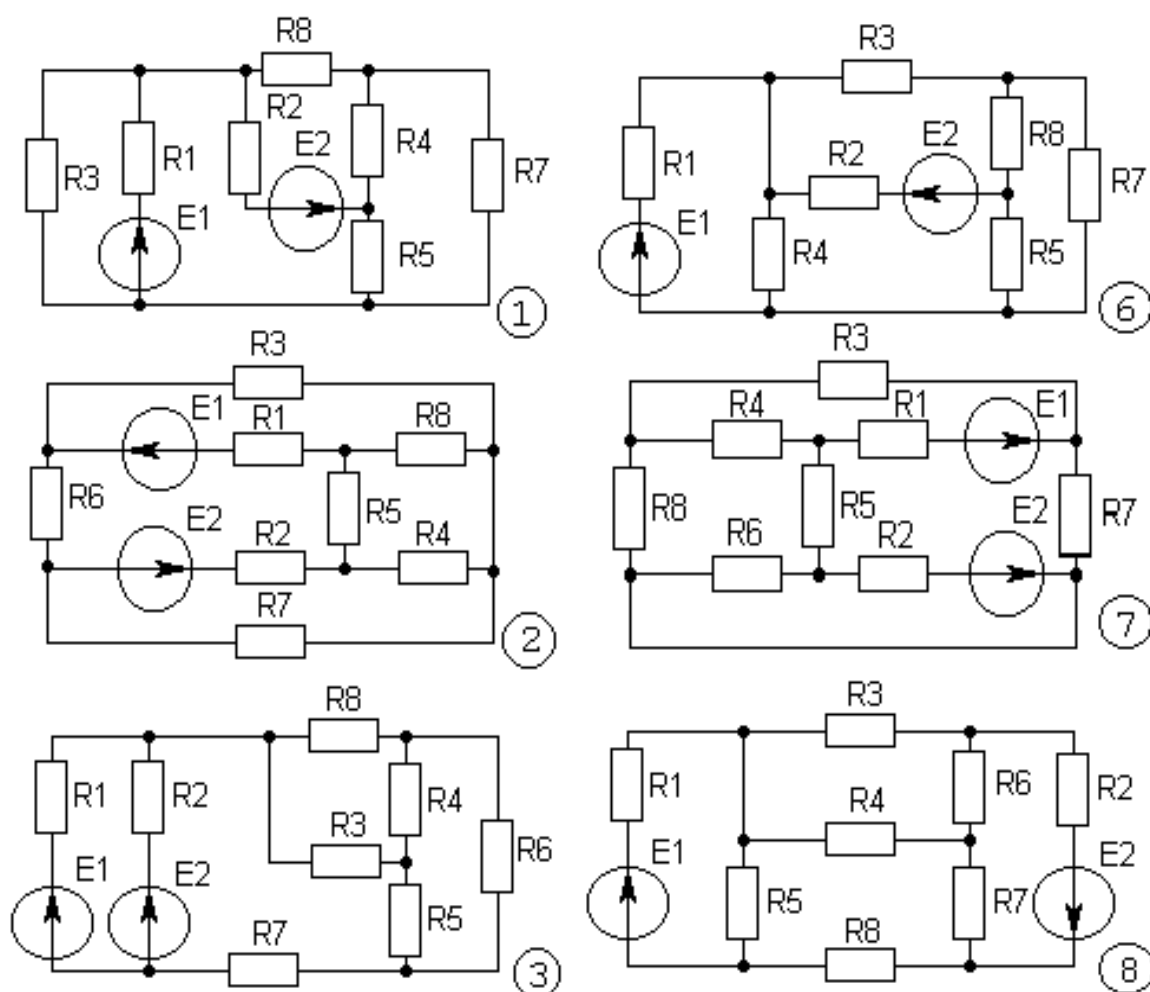
RESEARCH OF OMA AND KIRHHOF'S LAWS WITH THE SIMULINK SIMULINK MODELING SOFTWARE PACKAGE (MATLAB)

The goal of the work

Developing skills in using the Simulink simulation software package to study electrical circuit diagrams and consolidate knowledge of Ohm's and Kirchhoff's laws.

Procedure and methods of work

1. Display in the protocol of laboratory work in Fig. 5.2 the studied scheme according to the variant (Fig. 5.1 and Table 5.1). Indicate in the diagram the nominal values of resistors and voltage sources. Set positive directions of currents in the branches and indicate them in the diagram.



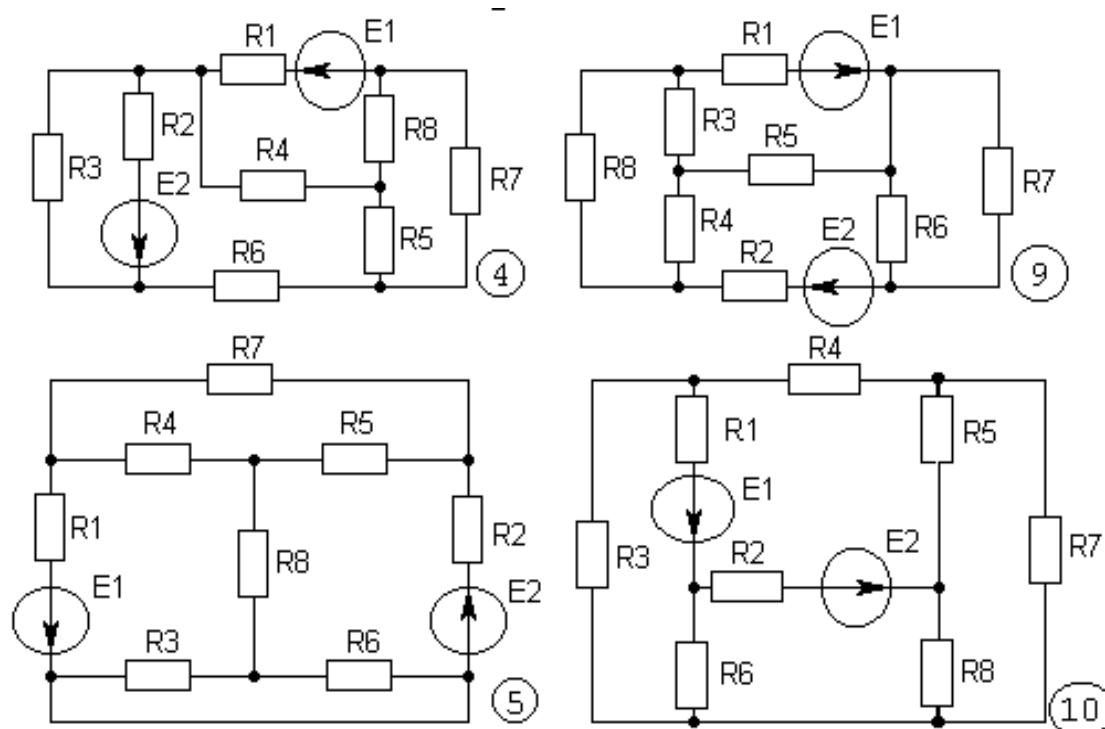


Fig. 5.1. Variants of schemes.

Table 5.1.

Version	The number of the scheme in Fig.1	Schematic elements in Fig.1									
		R1, Oh m	R2, Oh m	R3, Oh m	R4, Oh m	R5, Oh m	R6, Oh m	R7, Oh m	R8, Oh m	E1, B	E2, B
1	1	10	20	30	40	50	60	70	80	25	18
2	2	20	30	40	50	60	70	80	90	26	22
3	3	30	40	50	60	70	80	90	100	27	20
4	4	40	50	60	70	80	90	100	110	28	18
5	5	50	60	70	80	90	100	110	120	29	20
6	6	60	70	80	90	100	110	120	130	30	22
7	7	70	80	90	100	110	120	130	140	25	22
8	8	80	90	100	110	120	130	140	150	26	20
9	9	90	100	110	120	130	140	150	160	27	22
10	10	100	110	120	130	140	150	160	170	28	20
11	2	110	120	130	140	150	160	170	180	29	18

12	4	120	130	140	150	160	170	180	190	30	24
13	6	130	140	150	160	170	180	190	200	25	20
14	8	140	150	160	170	180	190	200	210	26	23
15	10	150	160	170	180	190	200	210	220	27	21
16	5	160	170	180	190	200	210	220	230	28	19
17	3	170	180	190	200	210	220	230	240	29	21
18	1	130	140	150	160	170	180	190	200	25	20
19	7	140	150	160	170	180	190	200	210	26	23
20	8	150	160	170	180	190	200	210	220	27	21

2. In the section viewer of the Simulink library, first create a new model field, and then select the necessary elements and transfer them to the model field (Fig. 5.3):

- Simulink Library Browser \ Simulink \ Sinks \ Display
- Simulink Library Browser \ Power System Blockset \ Measurements \ Multimeter
- Simulink Library Browser \ Power System Blockset \ powergui
- Simulink Library Browser \ Power System Blockset \ Connectors \ Ground (output)
- Simulink Library Browser \ Power System Blockset \ Connectors \ T connector
- Simulink Library Browser \ Power System Blockset \ Connectors \ L connector
- Simulink Library Browser \ Power System Blockset \ Electrical Sources \ DC Voltage Source
- Simulink Library Browser \ Power System Blockset \ Elements \ Series RLC Branch

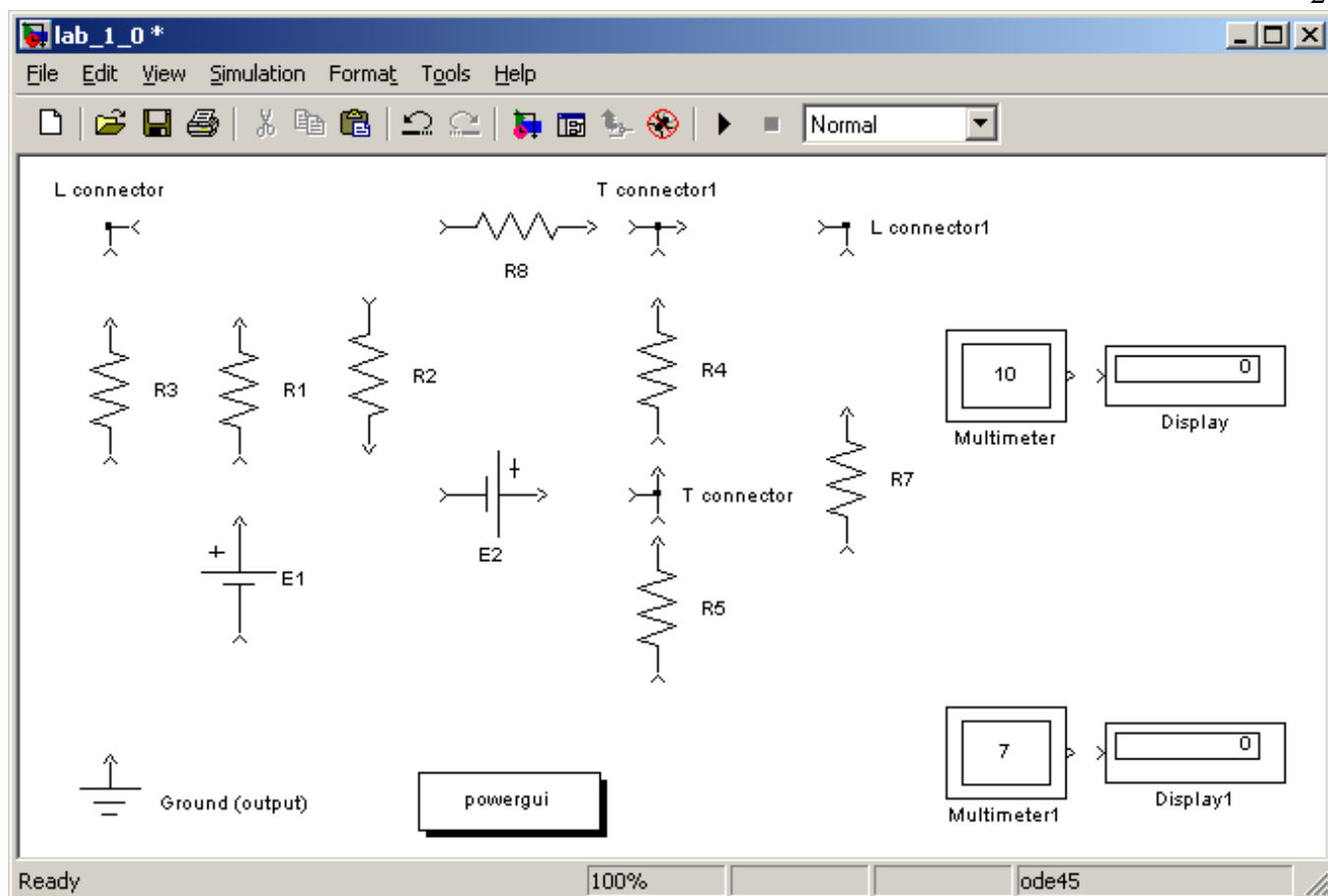


Fig. 5.3. Simulink model field

3. In the parameters of the block "Series RLC Branch" set the following parameters (Fig.5.4):

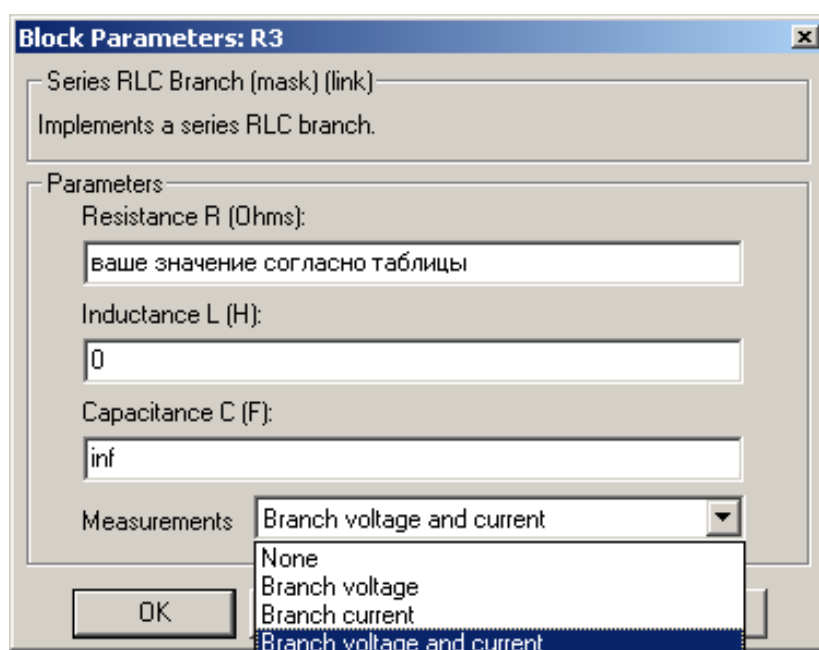


Fig. 5.4. Series RLC Branch parameters

4. Connect the blocks with connecting lines and rename all the elements according to the task (Fig. 5.5)

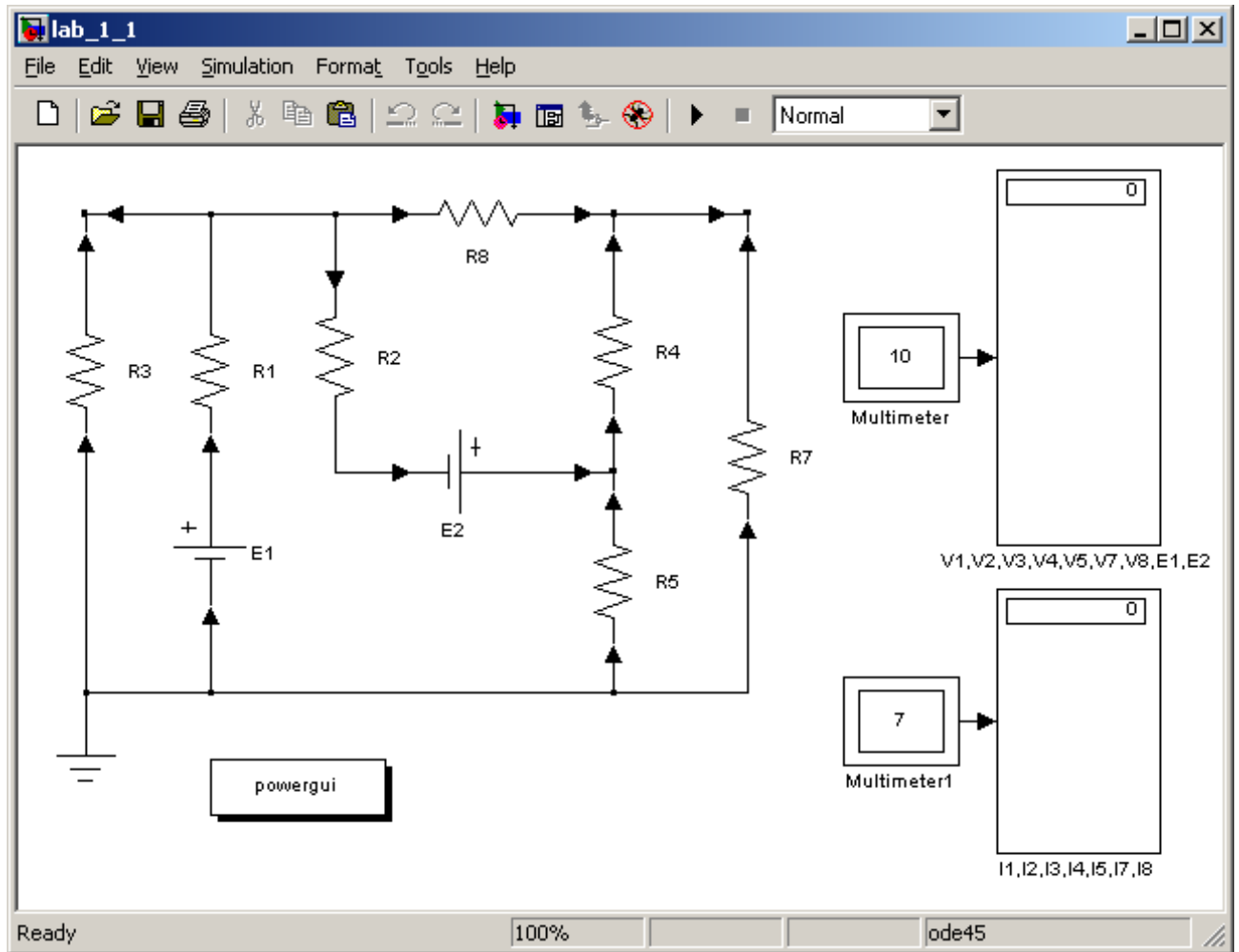


Fig. 5.5. Scheme model

5. Model a composite model of the scheme, record the results of modeling in a table and check whether Ohm's law and Kirchhoff's laws are followed.

	R1	R2	R3	R4	R5	R6	R7	R8	E1	E2
U, B										
I, A									X	X
R, Ohm									X	X

control questions

1. Simulink Library Section Browser
2. Creating a model in Simulink

3. Setting model calculation parameters: Simulation time (Simulation time or calculation time)
4. Setting model calculation parameters: Solver options
5. Setting model calculation parameters: Output options
6. Setting exchange options with the workspace
7. List the main sections of the Simulink library
8. Sources - signal sources (list blocks)
9. Ground Zero Signal Unit - Purpose and Parameters
10. Digital Display Display - purpose and parameters of the unit
11. Sinks - signal receivers (list blocks)
12. Parallel RLC Branch - purpose and parameters of the block
13. Series RLC Branch - purpose and parameters of the block
14. Electrical Sources - list power sources (list blocks)
15. AC Current Source - purpose and parameters of the unit
16. AC Voltage Source - purpose and parameters of the unit
17. DC Voltage Source - purpose and parameters of the unit
18. Block Multimeter - purpose and parameters
19. Library Power Elements - passive library (list blocks)
20. Power Electronics - library of power elements (list blocks)

Laboratory work № 6

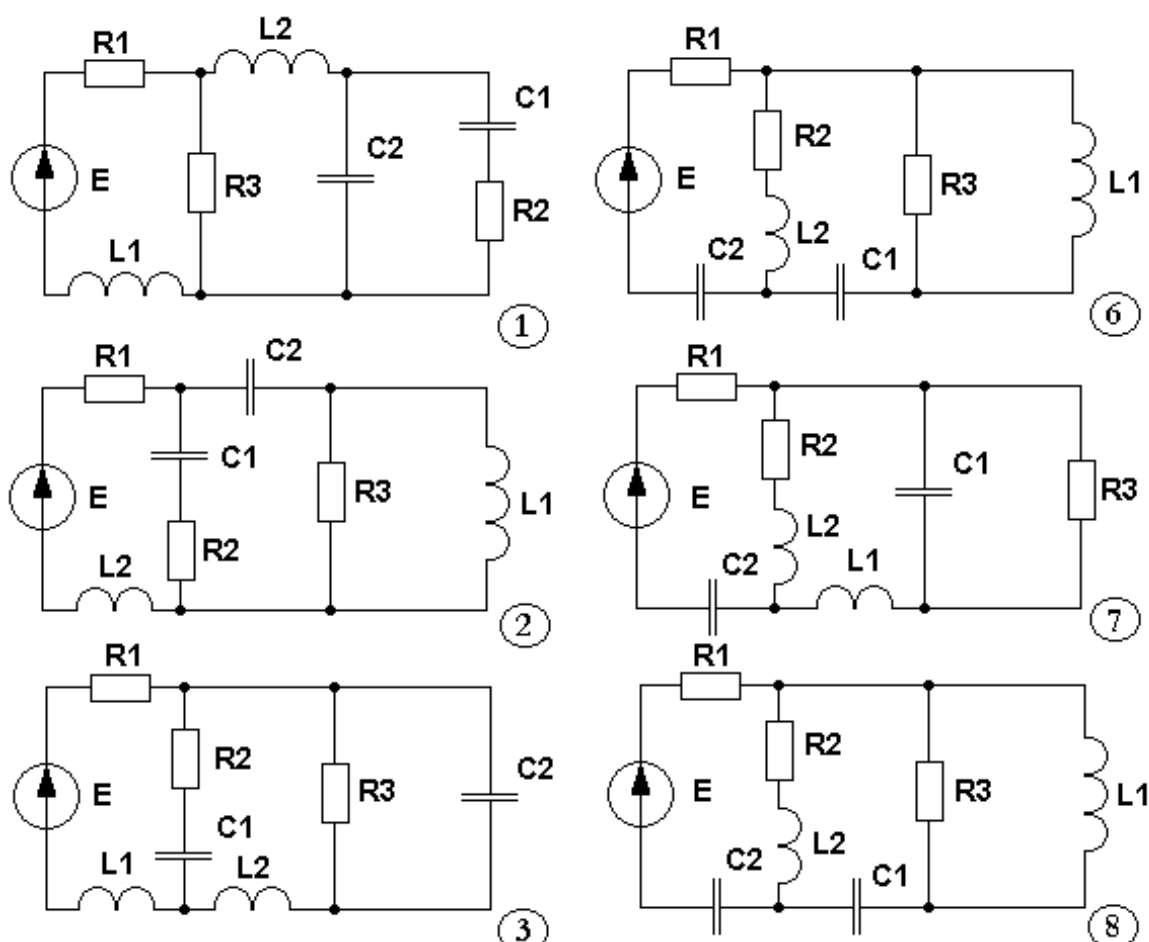
ANALYSIS OF ELECTRIC CHAIN CIRCUIT CIRCUITS USING SIMULINK SIMULATION SOFTWARE PACKAGE

The goal of the work

Developing skills in using the Simulink simulation software package and using Kirchhoff's laws to analyze schematic electrical sinusoidal current circuits.

Procedure and methods of work

1. Create a circuit model in Simulink and enter the parameters of the elements in accordance with the option in table 6.1.



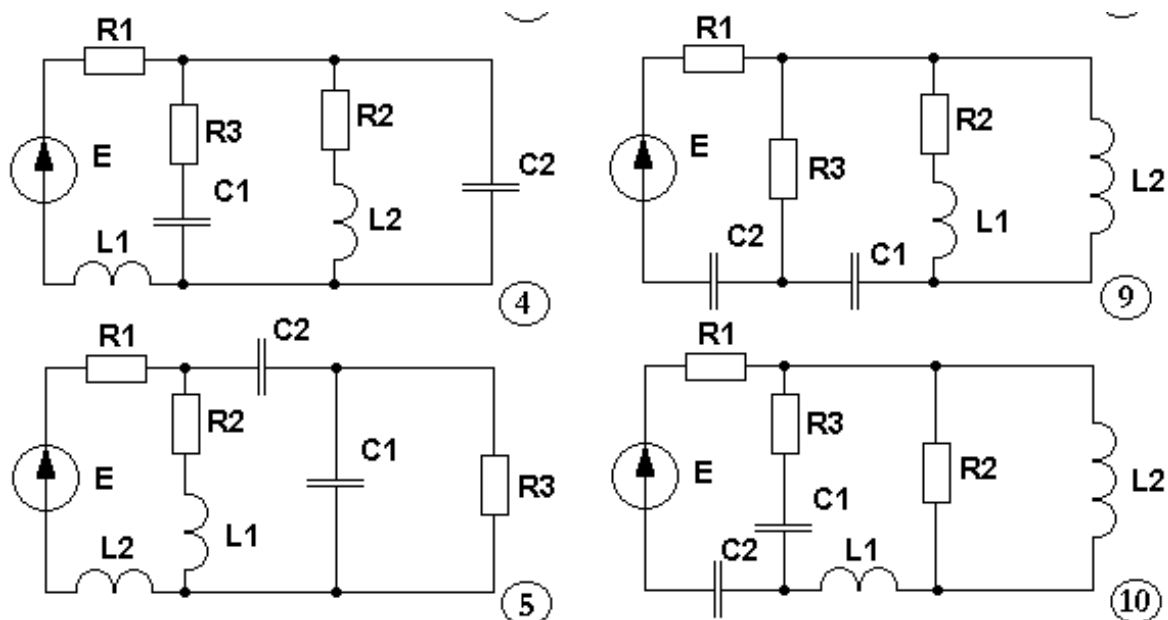


Fig. 6.1. Variants of schemes.

Table 6.1

Variant	Scheme number in Fig.1	Schematic elements in Fig.1							Source parameters		
		$R1$, Ohm	$R2$, Ohm	$R3$, Ohm	$L1$, mH	$L2$, mH	$C1$, uF	$C2$, uF	E , B	f, kHz	$\psi, ^\circ$
1	1	10	20	30	10	20	20	33	25	3.0	30
2	2	10	30	20	15	25	22	47	20	2.0	45
3	3	20	10	30	10	25	15	30	30	1.0	-90
4	4	20	10	30	20	10	47	56	40	3.5	90
5	5	10	20	30	25	10	9	33	50	2.5	-30
6	6	10	30	20	15	20	56	22	25	1.5	60
7	7	10	20	30	20	15	33	47	20	3.2	-60
8	8	10	30	20	10	15	47	20	30	2.2	120
9	9	20	10	30	20	25	56	9	40	1.2	-45
10	10	10	20	30	25	15	22	56	50	4.0	30
11	1	10	30	20	10	20	20	22	25	3.0	30
12	2	20	10	30	15	25	22	47	20	2.0	45
13	3	20	10	30	10	25	15	20	30	1.0	-90
14	4	10	20	30	20	10	47	9	40	3.5	90
15	5	10	30	20	25	10	9	56	50	2.5	-30
16	6	10	20	30	15	20	56	33	25	1.5	60

17	7	10	30	20	20	15	33	47	20	3.2	−60
18	8	20	10	30	10	15	47	30	30	2.2	120
19	9	20	10	30	20	25	56	56	40	1.2	−45
20	10	10	30	20	25	15	22	33	50	4.0	30

2. Draw in the protocol of laboratory work in Fig. 6.2 the studied scheme in accordance with the option (Fig. 6.1 and Table 6.1). Indicate in the diagram the nominal values of resistors and voltage sources.

3. In the Simulink library section browser, first create a new model field, then select the required elements and transfer them to the model field:

- Simulink Library Browser \ Simulink \ Sinks \ Scope
- Simulink Library Browser \ Power System Blockset \ Measurements \ Multimeter
- Simulink Library Browser \ Power System Blockset \ powergui
- Simulink Library Browser \ Power System Blockset \ Connectors \ T connector
- Simulink Library Browser \ Power System Blockset \ Connectors \ L connector
- Simulink Library Browser \ Power System Blockset \ Electrical Sources \ AC Voltage Source
- Simulink Library Browser \ Power System Blockset \ Elements \ Series RLC Branch
- Simulink Library Browser \ Simulink \ Comonly Used Blocks \ Demux
- Simulink Library Browser \ Simulink \ Comonly Used Blocks \ Mux

4. In the properties of the block "Series RLC Branch" set the following parameters:

Table 6.2

Separate R, L or C element	Resistance R (Ohm)	Inductance L (Gn)	Capacity C (F)
Series RLC Branch parameters			
Resistance R (Ohms)	Enter your value in this field	This field must have a ZERO value (0)	
Inductance L (H)	This field must have a ZERO value (0)	Enter your value in this field	This field must have a ZERO value (0)
Capacitance C (F)	This block must have a value of INFINITY (Inf)		Enter your value in this field

5. Connect the blocks with connecting lines and rename all the elements according to the task. Calculate the simulation time according to the equation and change it (Simulation → Simulation Parameters)

$$t \approx \frac{1}{f} \cdot 10^6$$

Change the ZSU solver from "ode 45 (Domain - Prince)" to "ode 23s (stiff / Mod.Rosenblock)" (Simulation → Simulation Parameters → Solver option).

Using the example shown in Figure 4, create your model according to the option in Table 6.1.

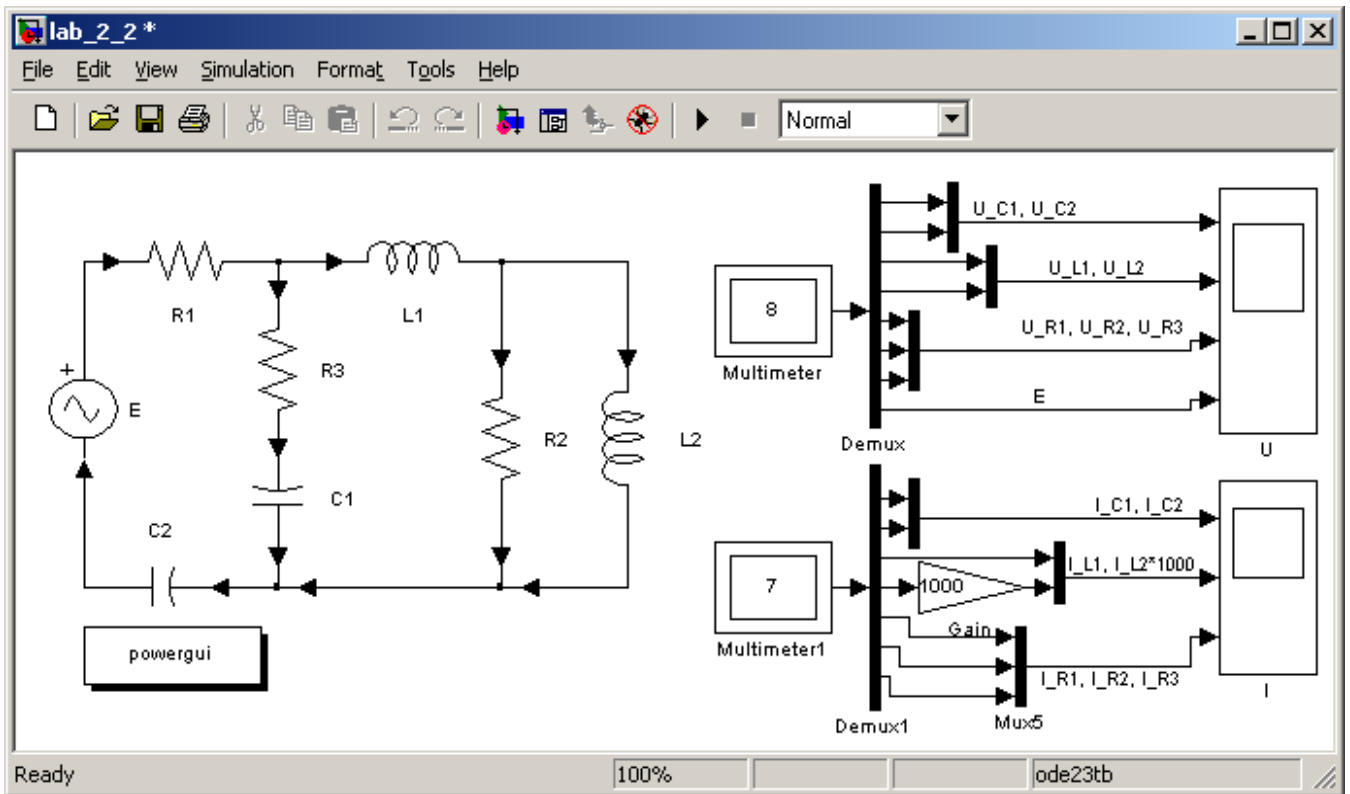


Fig. 6.4. An example of a circuit model created in Simulink

6. Model the composite circuit model and record the simulation results from the "powergui" block in tables 6.3 and 6.4:

Table 6.3

	$C1$	$C2$	$L1$	$L2$	$R1$	$R2$	$R3$	E
U, B								
$\psi U, ^\circ$								

Table 6.4

	$C1$	$C2$	$L1$	$L2$	$R1$	$R2$	$R3$
I, A							
$\psi I, ^\circ$							

7. Translate, taking into account the angles of displacement of the phases of voltage and current in the complex. On the complexes of currents and voltages calculate the complexes of total power, active and reactive power of each of the passive elements in the circuit. The results of the calculations are entered in table 6.5.

Table 6.5

Circuit elements	Voltage complex $\dot{U}$, B	Connected current complexes $\hat{I}$, A	Full power complex $\dot{S}$, BA	Active power P, W.	Reactive power Q, BAp
<i>WITH1</i>					
<i>WITH2</i>					
<i>L1</i>					
<i>L2</i>					
<i>R1</i>					
<i>R2</i>					
<i>R3</i>					
Σ	—	—			

8. Assess the performance of the power balance for active and reactive components. The total value of the corresponding capacities, as well as the power generated by the source, enter in table 6.6.

Table 6.6

Source of EMF					Passive part of the chain	
$\dot{E}$, B	$\hat{I}$, A	$\dot{S}$, BA	P , Tue.	Q , BAr	P , Tue.	Q , BAr

9. Check whether Kirchhoff's laws for sinusoidal current circuits are observed.

Control questions

1. Simulink Library Section Browser
2. Creating a model in Simulink
3. Setting model calculation parameters: Simulation time (Simulation time or calculation time)

4. Setting model calculation parameters: Solver options
5. Setting model calculation parameters: Output options
6. Setting exchange options with the workspace
7. List the main sections of the Simulink library
8. Sources - signal sources (list blocks)
9. Ground Zero Signal Unit - Purpose and Parameters
10. Digital Display Display - purpose and parameters of the unit
11. Sinks - signal receivers (list blocks)
12. Parallel RLC Branch - purpose and parameters of the block
13. Series RLC Branch - purpose and parameters of the block
14. Parallel RLC Load - purpose and parameters of the block
15. Series RLC Load - purpose and parameters of the block
16. Electrical Sources - list power sources (list blocks)
17. AC Current Source - purpose and parameters of the unit
18. AC Voltage Source - purpose and parameters of the unit
19. Controlled Current Source - purpose and parameters of the block
20. Controlled Voltage Source - purpose and parameters of the unit
21. Block Multimeter - purpose and parameters
22. Library Power Elements - passive library (list blocks)
23. Power Electronics - library of power elements (list blocks)
24. Oscilloscope Scope - purpose and parameters of the unit
25. Oscilloscope Floating Scope - purpose and parameters of the unit
26. Graphic device HU Graph - purpose and parameters of the unit
27. Block for reading data from the file From File - purpose and parameters
28. Unit for reading data from the workspace From Workspace - purpose and parameters
29. Data storage unit in the file To File - purpose and parameters

30. Data storage unit in the workspace To Workspace - purpose and parameters
31. Stop Simulation stop unit - purpose and parameters
32. The calculation unit of the module Abs - purpose and parameters
33. Sum calculation unit Sum - purpose and parameters
34. Product multiplication unit - purpose and parameters
35. Sign signal sign detection unit - purpose and parameters
36. POWERGUI unit - purpose and parameters

Laboratory work № 7

STUDY OF RESONANCE PHENOMENA AT CONNECTIVE CONNECTION
OF INDUCTIVE COIL AND CAPACITOR USING SIMULINING
SIMULATION SOFTWARE PACKAGE

Goal

Developing skills in using the Simulink simulation software package to study resonant phenomena when connecting an inductor and a capacitor in series.

Procedure and methods of work

1. Calculate the resonant frequency of the series circuit (Fig. 7.1) according to the option in table 7.1.

$$f = \frac{1}{2 \cdot \pi \cdot \sqrt{L \cdot C}}$$

(1)

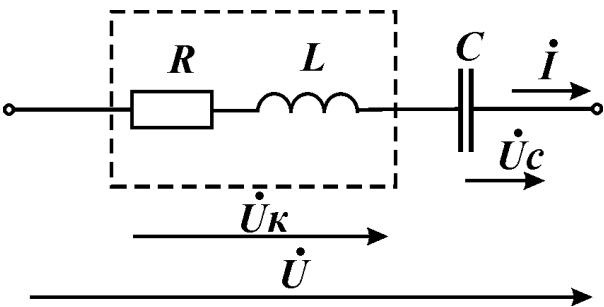


Fig. 1. Sequential resonant circuit

Table 7.1

Version		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Coil	R, Ohm	20																			
	L, mGn	30	30	30	40	40	50	50	60	60	60	70	70	80	80	90	90	100	100	70	50
Capacitor	C, uF	0.25	0.1	0.13	0.1	0.2	0.15	0.06	0.11	0.06	0.05	0.1	0.05	0.25	0.1	0.13	0.1	0.2	0.25	0.33	0.13
Source	E, B	10	5	7	6	10	8	6	7	6	5	7	5	12	14	10	8	7	5	8	7
	f, Hz	$f = \frac{1}{2 \cdot \pi \cdot \sqrt{L \cdot C}}$																			

2. Draw a diagram of the resonant circuit in Simulink. In the Simulink library section browser, first create a new model field, then select the required elements and move

them to the model field:

- Simulink Library Browser \ Simulink \ Sinks \ Scope
- Simulink Library Browser \ Power System Blockset \ Measurements \ Multimeter
- Simulink Library Browser \ Power System Blockset \ powergui
- Simulink Library Browser \ Power System Blockset \ Connectors \ T-connector
- Simulink Library Browser \ Power System Blockset \ Connectors \ L-connector
- Simulink Library Browser \ Power System Blockset \ Electrical Sources \ AC Voltage Source
- Simulink Library Browser \ Power System Blockset \ Elements \ Series RLC Branch
- Simulink Library Browser \ Power System Blockset \ Elements \ Series RLC Branch
- Simulink Library Browser \ Simulink \ Commonly Used Blocks \ Demux
- Simulink Library Browser \ Simulink \ Math Operations \ Add

3. Connect the blocks with connecting lines and rename all the elements according to the task. Calculate the Simulation Time according to the equation and change it (Simulation → Simulation Parameters):

$$t = \frac{1}{f} \cdot (3 \dots 4) \text{ c}$$

Replace the ODE solver with "ode 45 (Domain - Prince)" to "ode 23s (stiff / Mod.Rosenblock)" (Simulation → Simulation Parameters → Solver option).

Using the example shown in Figure 7.2, create your model according to the option in Table 7.1.

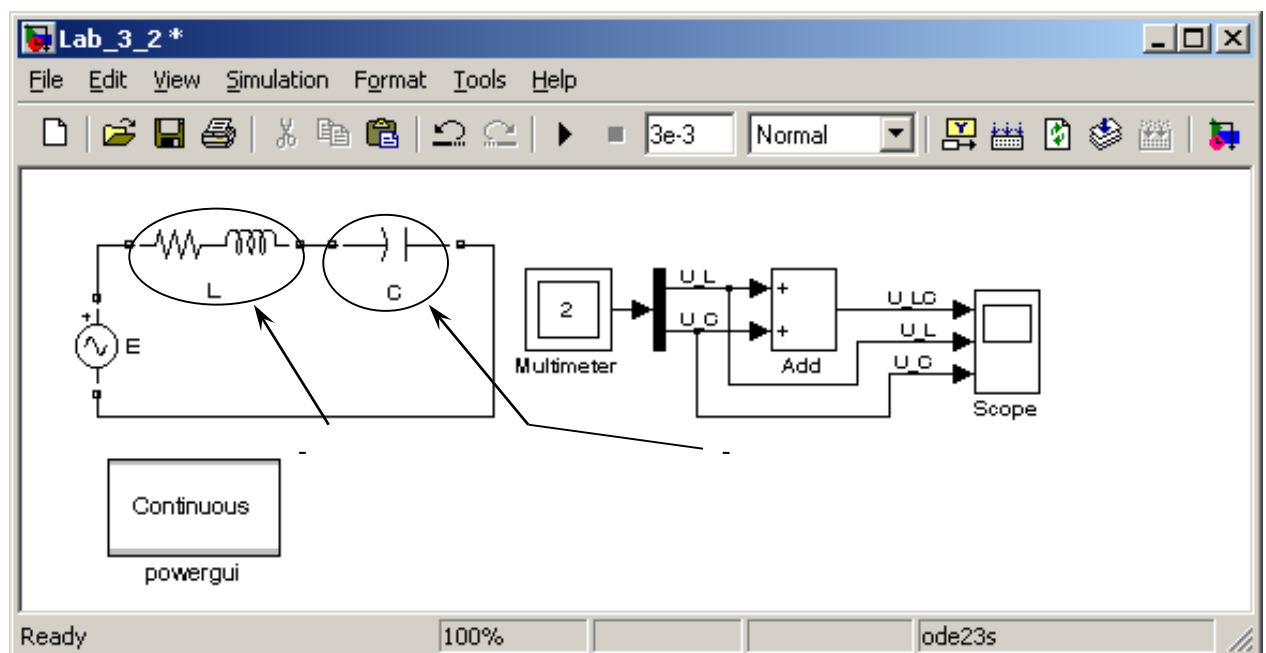


Fig. 7.2. An example of a circuit model created in Simulink

4. Simulate the composite circuit model and record the simulation results (values of voltage on the coil and capacitor and phase shifts on them) from the "powergui" block in table 7.2 (in Powergui Steady - State Tool you need to select units (Units) - RMS values (current values)) :

Chain resistance:

$$z = \sqrt{R^2 + x^2} = \sqrt{R^2 + (x_L - x_C)^2} = \sqrt{R^2 + (\omega L - 1/\omega C)^2} \quad (2)$$

Table 7.2 - Frequency characteristics

N_2 $p /$ p	$f /$ f_0	$f, \text{ kHz}$	I, A (current values - RMS value)	$\psi I,$ $\square$	U_s, B (current values - RMS value)	ψU_c , $\square$	U_k, B (current values - RMS value)	$\psi U_k,$ $\square$	$\varphi = \frac{\pi}{2} - \psi_{U_k}$	$z,$ Ohm
1	0.5									
2	0.6									
3	0.7									
4	0.8									
5	0.9									
6	1.0									
7	1.1									
8	1.2									
9	1.3									
10	1.4									
11	1.5									

5. According to Table 2, plot the frequency characteristics: $I (f / f_0)$, $U_s (f / f_0)$, $U_k (f / f_0)$, $\square (f / f_0)$, $z (f / f_0)$.

6. Calculate the quality factor of the circuit according to formula (3)

$$Q = \omega_0 \frac{L}{R} = 2\pi f \frac{L}{R} = 2\pi \cdot \frac{1}{2\pi \cdot \sqrt{L \cdot C}} \cdot \frac{L}{R} = \sqrt{\frac{L}{C}} \cdot \frac{1}{R} \quad (3)$$

7. Calculate the value of the internal resistance R of the inductor according to formula (4) for cases where the quality factor of the circuit is equal to: $Q = 2.5$, $Q = 5$, $Q =$

10. When changing the relative frequency f / f_0 in the range 0.5 ... 1.5 measure the value of current in the circuit. Enter the results in table 7.3.

$$R = \sqrt{\frac{L}{C}} \cdot \frac{1}{Q} \quad (4)$$

Table 7.3

N_0 p / p	f / f_0	f, Hz	I, A from the table. 2 (current values - RMS value)	I / I_0 I_0 - circuit current at resonanc e (f / f_0 = 1.0)	$Q = 2.5$		$Q = 5$		$Q = 10$	
					I, A (current values - RMS value)	I / I_0	I, A (current values - RMS value)	I / I_0	I, A (current values - RMS value)	I / I_0
1	0.5									
2	0.6									
3	0.7									
4	0.8									
5	0.9									
6	1.0									
7	1.1									
8	1.2									
9	1.3									
10	1.4									
11	1.5									

8. According to table.2 and table.3 to construct a number of characteristics $I / I_0 (f / f_0)$ at different values of quality factor Q . From the graphs to determine the bandwidth. Summarize the data in table.4. In the last term of table 4 enter the results of data processing according to claim 4 for the circuit with the primary quality factor (at $R = 20 \text{ Ohms}$). Compare the results obtained.

Table 7.4 - Bandwidth

Q	$f_1,$	$f_2,$	$(f_1 - f_2),$ according to p.7	$(f_1 - f_2)$ by the formula: $f_1 - f_2 =$ f_0 / Q
2.5				

5				
10				
...				

9. Draw conclusions from the work, paying attention to the influence of the quality factor of the circuit on the frequency response and bandwidth.

Control questions

1. Simulink Library Section Browser
2. Creating a model in Simulink
3. Setting model calculation parameters: Simulation time (Simulation time or calculation time)
4. Setting model calculation parameters: Solver options
5. Setting model calculation parameters: Output options
6. Setting exchange options with the workspace
7. List the main sections of the Simulink library
8. Digital Display Display - purpose and parameters of the unit
9. Parallel RLC Branch - purpose and parameters of the block
10. Series RLC Branch - purpose and parameters of the block
11. Parallel RLC Load - purpose and parameters of the block
12. Series RLC Load - purpose and parameters of the block
13. Electrical Sources - list power sources (list blocks)
14. AC Current Source - purpose and parameters of the unit
15. AC Voltage Source - purpose and parameters of the unit
16. Block Multimeter - purpose and parameters
17. Library Power Elements - passive library (list blocks)
18. Power Electronics - library of power elements (list blocks)
19. Oscilloscope Scope - purpose and parameters of the unit

20. Block for reading data from the file From File - purpose and parameters
21. Unit for reading data from the workspace From Workspace - purpose and parameters
22. Data storage unit in the file To File - purpose and parameters
23. Data storage unit in the workspace To Workspace - purpose and parameters
24. Stop Simulation stop unit - purpose and parameters
25. Sum calculation unit Sum - purpose and parameters
26. Product multiplication unit - purpose and parameters
27. Multiplexer (mixer) Mux - purpose and parameters of the unit
28. Demux demultiplexer (separator) - purpose and parameters of the unit
29. Bus Creator bus unit - purpose and parameters
30. Bus Selector unit - purpose and parameters
31. Selector block Selector - purpose and parameters
32. Block for assigning new values to elements of the Assignment array - purpose and parameters
33. Merge signal integration unit - purpose and parameters
34. Block combining signals into a matrix Matrix Concatenation - purpose and parameter
35. Goto signal transmission unit - purpose and parameters
36. From signal reception unit - purpose and parameters
37. Width signal dimensioning unit - purpose and parameters
38. The unit for determining the moment of intersection of the threshold value of Hit Crossing - purpose and parameters
39. Information block Model Info - purpose and parameters

Laboratory work № 8

ANALYSIS OF THREE-PHASE CHAINS USING SIMULINK SIMULATION SOFTWARE PACKAGE

The goal of the work

Development of skills of using Simulink simulation software package for analysis of three-phase circuits.

Task

To the symmetrical three-phase generator with phase voltage U_f through a three-wire power line connected by a star or triangle two consumers (linear voltage in $\sqrt{3}$ times more phase: $U_{AB} = \sqrt{3} \cdot U_A$). As a result of the accident there was a break at the point M or N (three-phase circuit became asymmetric)

1. Calculate currents and voltages in all branches, determine the readings of measuring instruments before the accident.
2. Calculate currents and voltages in all branches, determine the readings of measuring instruments in emergency mode.

The option number is determined by the last two digits of the record book number. In all variants of the task, the calculation coefficient is used, which is one more than the sum of the digits of the record book number:

$$K = a + b + c + d + 1$$

For example, for the record book number 1 2 2 4 the coefficient $K = 1 + 2 + 2 + 4 + 1 = 10$

Table 8.1

P var	U_f, B	f, Hz	R_l, Ohm	X_l, Ohm	R, Ohm	X_L, Ohm	X_C, Ohm	Break at the point
01	127	50	–	5.3	5K	–	10K	M
02	220	50	K	2	40	3K	–	M
03	110	60	3K	–	80	4K	2	M
04	200	50	$K/2$	4	ZK	–	10K	M

05	150	50	-	<i>K</i>	5K	-	20K	M
06	300	60	10	-	10K	<i>K</i>	-	M
07	240	50	2K	-	60	-	25K	M
08	180	50	15	-	4K	2K	-	M
09	135	60	-	<i>K/ 2</i>	3K	-	15K	M
10	210	50	18	-	15K	-	40K	M
11	380	50	-	<i>K</i>	48	-	10K	M
12	127	60	9	<i>K</i>	80	-	50K	M
13	220	50	13	2K	10K	-	210	M
14	110	50	<i>K</i>	3	27	-	7K	M
15	200	60	2K	-	45	2	30K	M
16	150	50	3K	<i>K</i>	75	-	180	<i>N</i>
17	300	50	<i>K/ 2</i>	-	-	15	5K	M
18	240	60	10	-	-	<i>K</i>	10K	<i>N</i>
19	180	50	15	-	-	3K	25K	<i>M</i>
20	135	50	18	-	-	10K	50K	<i>N</i>
21	210	60	13	-	10K	27	-	M
22	380	50	16	-	20K	10	-	<i>N</i>
23	127	50	5K	-	50	<i>K</i>	-	<i>M</i>
24	220	60	<i>K</i>	-	27	5K	-	<i>N</i>
25	110	50	2K	15	5K	20	-	M

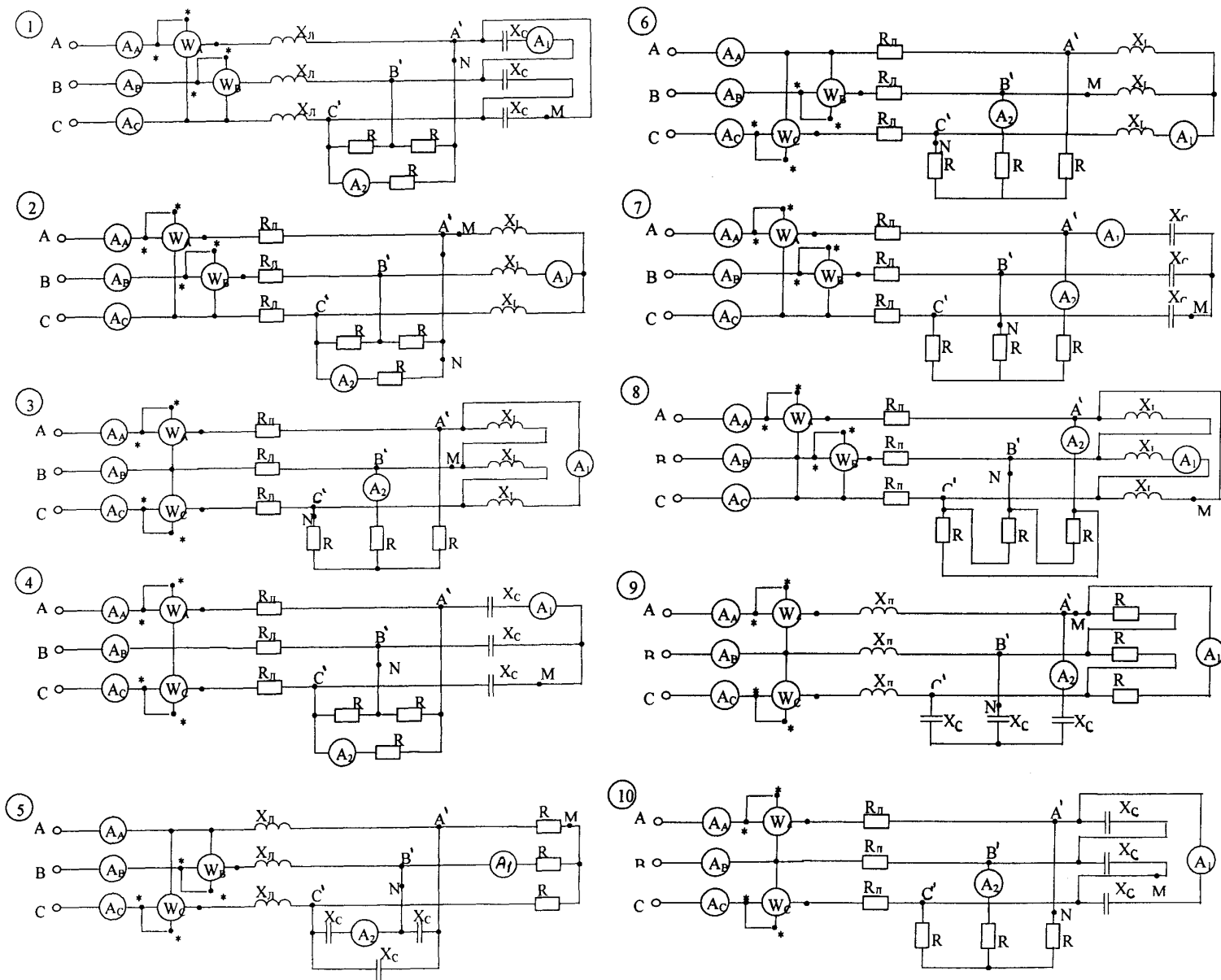


Fig. 8.1. Variants of schemes.

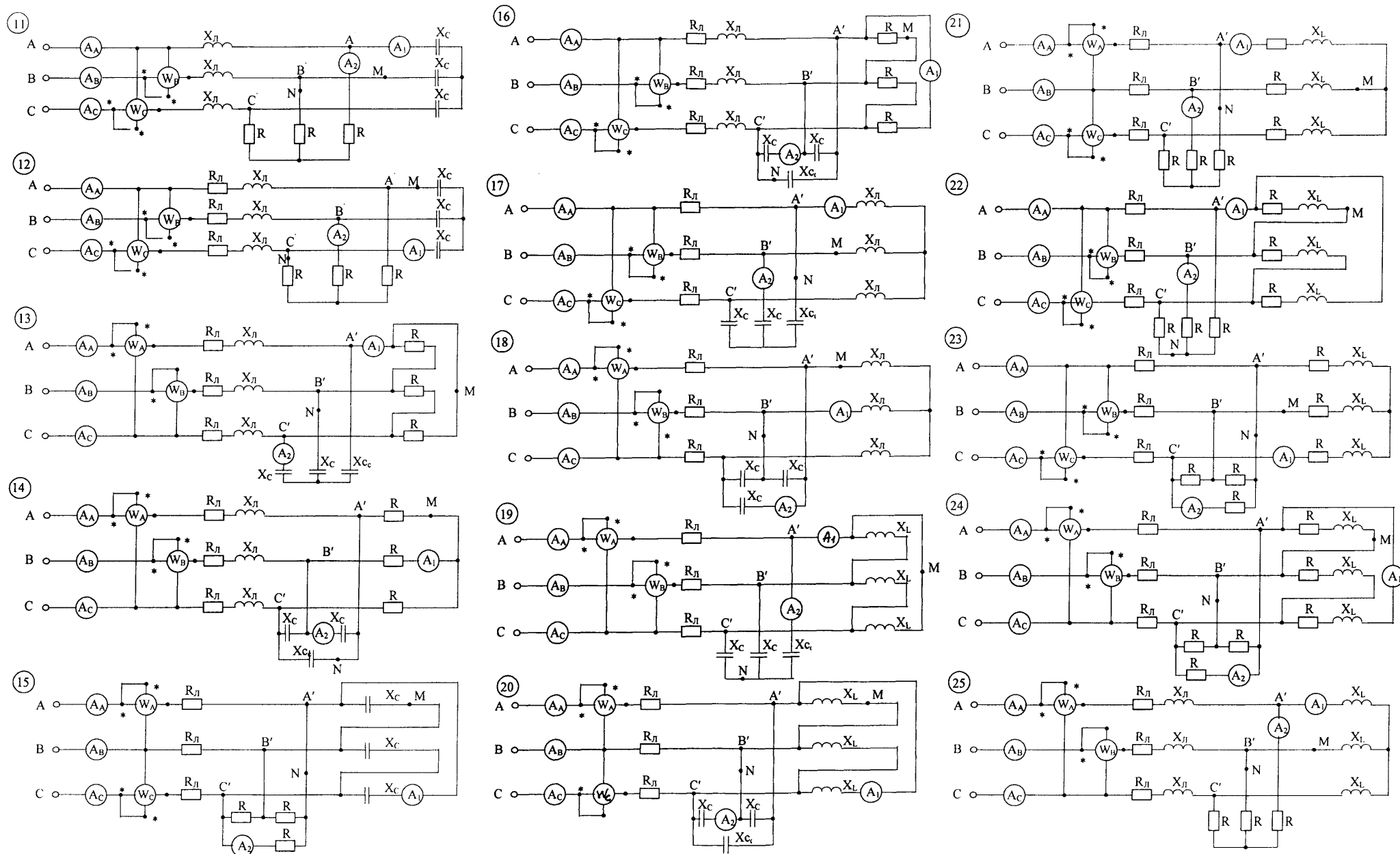


Fig. 8.2. Variants of schemes.

Procedure and methods of work

1. Create a model of the circuit in Simulink according to the option in Fig.8.1 - 8.2 and enter the parameters of the elements according to the option in table 1. The parameters of the three-phase circuit elements are calculated by formulas (8.1) - (8.3):

$$X_L = \omega L \quad \rightarrow \quad L = \frac{X_L}{\omega} = \frac{X_L}{2\pi f} \quad (8.1)$$

$$X_C = \frac{1}{\omega C} \quad \rightarrow \quad C = \frac{1}{\omega X_C} = \frac{1}{2\pi f \cdot X_C} \quad (8.2)$$

$$X_{\bar{E}} = \omega L \quad \rightarrow \quad L = \frac{X_{\bar{E}}}{\omega} = \frac{X_{\bar{E}}}{2\pi f} \quad (8.3)$$

2. Draw a diagram of a three-phase circuit in Simulink. In the Simulink library section browser, first create a new model field, then select the required elements and move them to the model field:

- Simulink Library Browser \ Power System Blockset \ Electrical Sources \ AC Voltage Source
- Simulink Library Browser \ Power System Blockset \ Extra Library \ Three-Phase Library \ 3-Phase Series RLC
- Simulink Library Browser \ Power System Blockset \ Elements \ Series RLC Branch
- Simulink Library Browser \ Power System Blockset \ powergui
- Simulink Library Browser \ Power System Blockset \ Measurements \ Multimeter
- Simulink Library Browser \ Power System Blockset \ Measurements \ Voltage Measurement
- Simulink Library Browser \ Simulink \ Commonly Used Blocks \ Demux
- Simulink Library Browser \ Simulink \ Commonly Used Blocks \ Mux
- Simulink Library Browser \ Simulink \ Sinks \ Scope
- Simulink Library Browser \ Simulink \ Sinks \ Display
- Simulink Library Browser \ Simulink \ Sinks \ To Workspace
- Simulink Library Browser \ Power System Blockset \ Extra Library \ Measurements \ Active & Reactive Powek
- Simulink Library Browser \ Power System Blockset \ Connectors \ T connector
- Simulink Library Browser \ Power System Blockset \ Connectors \ L connector

3. Using the example shown in Fig.8.2, create your model according to the option in table 8.1. Connect the blocks with connecting lines and rename all the elements according to the task. Calculate the Simulation Time according to the equation and change it (Simulation → Simulation Parameters):

$$t = \frac{1}{f} \cdot (3 \dots 4) \text{ c}$$

4. Change the ODE solver from "ode 45 (Domain - Prince)" to "ode 23s (stiff / Mod.Rosenblock)" (Simulation → Simulation Parameters → Solver option).

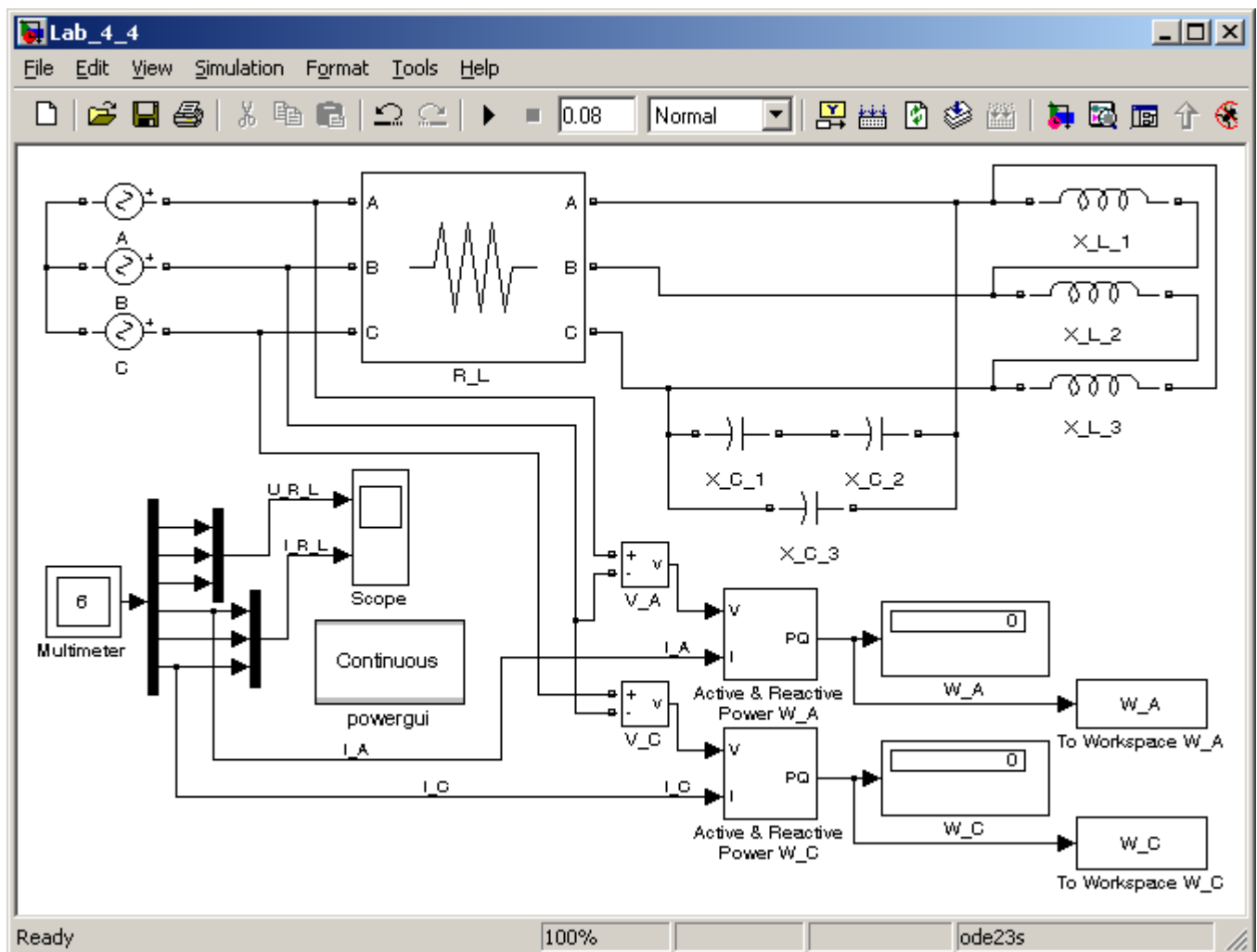


Fig. 8.2. An example of a circuit model created in Simulink

5. Simulate the composite model of the circuit before the accident and record the simulation results (values of voltage on the circuit elements and currents in their three-phase circuit and phase shift on them, as well as evidence of active and reactive power between phases) from the block "powergui" (Fig. 8.3) in table 8.2 - 8.4.

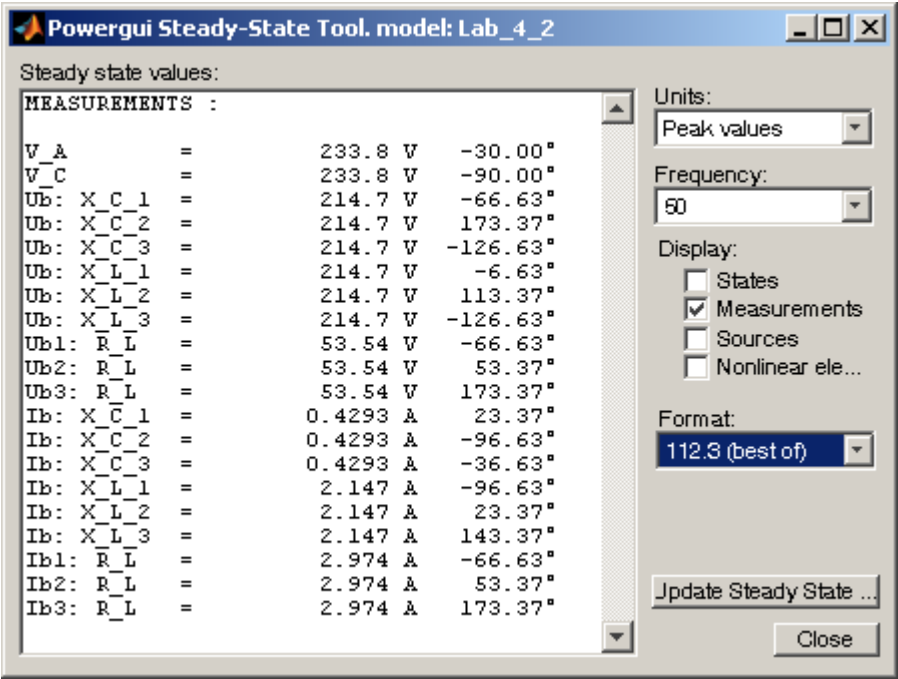


Fig. 8.3. POWERGUI window with voltage values on circuit elements and currents in their three-phase circuit and phase shift on them

Table 8.2

Element diagram							
U, B							
$\psi U, ^\circ$							

Element diagram							
U, B							
$\psi U, ^\circ$							

Table 8.3

Element diagram					
I, A					
$\psi I, ^\circ$					

Element diagram					
I, A					
$\psi I, ^\circ$					

Table 8.4

Wattmeter	Active power P, W.	Reactive power Q, BAp
$W_{\text{—}}$		
$W_{\text{—}}$		

5. Model the composite circuit model in emergency mode and record the simulation results (voltage values on the circuit elements of the three-phase circuit and phase shift on them) from the block "powergui" in table 8.5 - 8.7:

Table 8.5

Element diagram							
U, B							
$\psi U, ^\circ$							

Element diagram							
$U, \text{ B}$							
$\psi U, ^\circ$							

Table 8.6

Element diagram					
$I, \text{ A}$					
$\psi I, ^\circ$					

Element diagram					
$I, \text{ A}$					
$\psi I, ^\circ$					

Table 8.7

Wattmeter	Active power $P, \text{ W.}$	Reactive power $Q, \text{ BAp}$
$W_{\text{---}}$		
$W_{\text{---}}$		

6. Show the teacher the oscillogram of voltage and current in the Scope window before the accident and in emergency mode (Fig.8.4 example of the oscillogram of voltage and current in the Scope window in emergency mode):

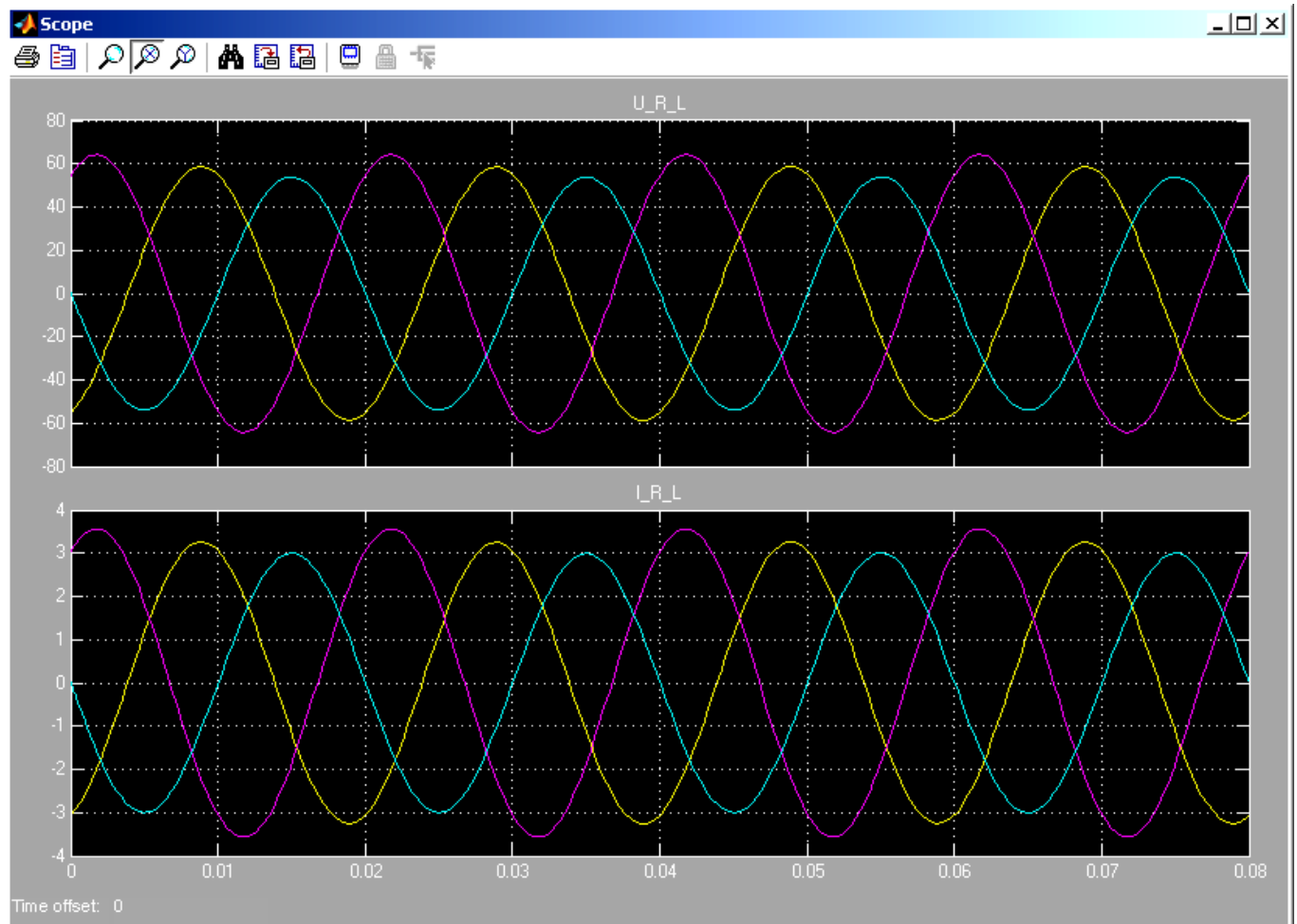


Fig.8.4. An example of an oscillogram of voltages and currents in the Scope window in emergency mode

Control questions

1. Simulink Library Section Browser
2. Creating a model in Simulink
3. Setting model calculation parameters: Simulation time (Simulation time or calculation time)
4. Setting model calculation parameters: Solver options
5. Setting exchange options with the workspace
6. List the main sections of the Simulink library
7. Digital Display Display - purpose and parameters of the unit

8. AC Current Source - purpose and parameters of the unit
9. AC Voltage Source - purpose and parameters of the unit
10. Block Multimeter - purpose and parameters
11. Library Power Elements - passive library (list blocks)
12. Power Electronics - library of power elements (list blocks)
13. Oscilloscope Scope - purpose and parameters of the unit
14. Block for reading data from the file From File - purpose and parameters
15. Unit for reading data from the workspace From Workspace - purpose and parameters
16. Data storage unit in the file To File - purpose and parameters
17. Data storage unit in the workspace To Workspace - purpose and parameters
18. Stop Simulation stop unit - purpose and parameters
19. Sum calculation unit Sum - purpose and parameters
20. Product multiplication unit - purpose and parameters
21. Multiplexer (mixer) Mux - purpose and parameters of the unit
22. Demux demultiplexer (separator) - purpose and parameters of the unit
23. Bus Creator bus unit - purpose and parameters
24. Bus Selector unit - purpose and parameters
25. Selector block Selector - purpose and parameters
26. Merge signal integration unit - purpose and parameters
27. Goto signal transmission unit - purpose and parameters
28. From signal reception unit - purpose and parameters
29. Width signal dimensioning unit - purpose and parameters
30. The unit for determining the moment of intersection of the threshold value of Hit Crossing - purpose and parameters
31. Three - Phase VI - purpose and parameters of the unit

32. 3 - Phase Sequence Analyzer - purpose and parameters of the block
33. Fourier block - purpose and parameters
34. Active & Reactive Power unit - purpose and parameters
35. Impedance Measurement block - purpose and parameters
36. Voltage Measurement block - purpose and parameters
37. Current Measurement block - purpose and parameters
38. Universal Bridge - purpose and parameters of the unit
39. Linear Transformer - purpose and parameters of the block
40. Mutual Inductance - purpose and parameters of the unit
41. Three - Phase Transformer (Two Windings) - purpose and parameters of the unit
42. Three - Phase Transformer (Three Windings) - purpose and parameters of the unit
43. PI Section Line - purpose and parameters of the block
44. Distributed Parameter Line - purpose and parameters of the block
45. Ideal Switch - purpose and parameters of the unit
46. MOSFET - purpose and parameters of the block
47. GTO - purpose and parameters of the block
48. Diode - purpose and parameters of the block
49. Thyristor - purpose and parameters of the block
50. Total Harmonic Distortion block - purpose and parameters

Recommended Books

1. Anufriev IE, Smirnov AB, Smirnova EN MATLAB 7. - SPb .: BHV-Petersburg, 2005. - 1104 p.
2. Herman-Galkin SG Power electronics: Laboratory work on a PC. - SPb .: Uchitel i uchenik, KORONA print, 2002. - 304 s., Il.
3. Dyakonov VP MATLAB 6 / 6.1 / 6.5 + Simulink 4/5. Basics of application. Complete user manual - M .: SOLON-Press. - 2002.— 768 p.
4. Dyakonov VP Simulink 4. Special reference. - СПб .: ПИТЕР, 2002. - 528с .: ил.
5. Ketkov Yu.L., Ketkov A.Yu., Schultz MM MATLAB 7: programming, numerical methods. - СПб .: БХВ-Петербург, 2005. - 752 с .: ил.
6. Getting started with MATLAB (Getting Started with MATLAB) / Перевод с англ. Konyushenko VV (konushenko@afrodita.phys.msu.su) - <http://www.exponenta.ru/educat/free/matlab/gs.pdf>
7. Matlab and Simulink Community -<http://matlab.exponenta.ru/>
8. Chen K., Giblin P., Irving A. Matlab in Mathematical Research: Per. with English - M .: Mir, 2001. 346 s, il.
9. Chernykh IV Simulink: Dynamic systems modeling tool. - <http://matlab.exponenta.ru/simulink/book1/index.php>
10. Chernykh IV SIMULINK: the environment for creating engineering applications / Under common. ed. Ph.D. V.G. Potemkin. - M .: DIALOGUE-MYTHS, 2003. - 496 p.
11. Chernykh IV Modeling of electrical devices in MATLAB, SimPowerSystems and Simulink. - M .: DMK Press; SPb .: Piter, 2008. - 288 s .: il.