ALMATY UNIVERSITY OF POWER ENGINEERING AND TELECOMMUNICATIONS

Department
of Electrical Engineering

THEORY OF ELECTRICAL CIRCUITS

Methodological guidelines and assignments
for performing calculation-graphical works № 1, 2, 3
for the 5B071600 – Instrumentation specialty

Almaty 2019

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The methodological guidelines and assignments for performing calculation-graphical works №1, 2, 3 for the Theory of electrical circuits (TEC) discipline contain three calculation-graphical works on the following topics: Calculation of transients in a linear electric circuit using classical calculation method, Calculation of transients in a linear electric circuit using the Laplace transform (operator calculation method) and Calculation of two-port networks.

The manual also includes requirements for the content and design of calculation-graphical works and guidelines.

The methodological guidelines and assignments for performing calculation-graphical works correspond to the working curricula and the working program of the TEC elective discipline for students of the 5B071600 – Instrumentation specialty.

20 illustrations, 8 tables, 8 items of references.

Reviewer: B. I. Tuzelbayev, Ph.D.

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Contents

Introduction

The discipline “Theory of Electrical Circuits” is intended to students of higher educational institutions in the specialty 5B071600 – Instrumentation, belongs to the module MPS08 “Theory of electrical circuits” and is included in the working curriculum as an elective discipline.

The purpose of the discipline is to study the methods of analysis and calculation of transients and steady-state modes in linear electrical circuits with lumped parameters, two-port networks and electrical filters, steady-state modes in linear electrical circuits with distributed parameters, and in nonlinear DC circuits.

The task of the discipline is the development by students of methods for calculating transients and steady-state modes in linear electrical circuits with lumped parameters, methods for calculating two-port networks and electrical filters, methods for calculating steady state modes in linear electrical circuits with distributed parameters and in non-linear DC circuits.

Preparing students on this basis for a successful and competent problem solving, which put special disciplines in the specialty “Instrumentation”.

The methodological guidelines and assignments for performing calculation-graphical works №1, 2, 3 for the Theory of electrical circuits (TEC) discipline contain three calculation-graphical works on the following topics: Calculation of transients in a linear electric circuit using classical calculation method, Calculation of transients in a linear electric circuit using the Laplace transform (operator calculation method) and Calculation of two-port networks.

In the process of performing calculation-graphical works, the student must master the classical and operator methods for calculating transients in linear electrical circuits and methods for calculating two-port networks.

The solution of calculation-graphical works helps students to check the degree of their learning the course, develops the skill to clearly and briefly express their thoughts.

1 Calculation-graphical work №1. Calculation of transients in linear electric circuits by the classical method

Purpose is to acquire the skills of transient calculation using the classical method in second-order linear electrical circuits.

1.1 Assignment

A second order linear circuit (figures 1.1-1.10) containing resistors, inductor and capacitor is connected to a DC EMF E source and is in steady state. At the moment of time $t = 0$, the circuit is switched by locking or opening the key and the transient process begins.

The following is required:

1) Write introduction: specify in which circuits and under what condition transient processes arise, what are the causes of transient processes, define the transient, steady state and free modes, specify the essence of the classical calculation method of transients.

2) Determine the current or voltage in one of the branches of the electrical circuit after switching by the classical method, according to a given variant (table 1.3).

3) Plot a graph of dependence of the desired function versus time (current or voltage), plot a graph over the time interval from 0 to $5\tau_{max}$ (if the characteristic equation roots are real) and from 0 to $5\tau = 5/\alpha$ (if the roots of the characteristic equation are complex-conjugate).

4) Make conclusion: in a conclusion write about the character of the free process depending on the type of roots of the characteristic equation and specify what is the duration of the transient process actually.

The number of circuit's scheme is determined by table 1.1, the numerical values of the circuit's parameters are given in tables 1.1, 1.2 and 1.3.

Table 1.1

Enrollment year	First letter of the surname									
even	АБВ	ГДЕ	ЖЗИ	КЛЫ	МН	ОПР	СТУ	ФЧЦ	ХШЩ	ЭЮЯ
odd	КЛЫ	ОПР	СТУ	ФЧЦ	АБВ	ГДЕ	ЖЗИ	МН	ЭЮЯ	ХШЩ
№ scheme	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10
E, V	60	70	40	35	50	55	35	65	45	30
R_1, Ω	50	65	45	55	40	75	55	60	40	70
R_2, Ω	30	50	68	60	55	45	75	58	45	60

Table 1.2

Enrollment year	Last digit of the credit book number									
even	0	9	8	7	6	5	4	3	2	1
odd	1	2	3	4	5	6	7	8	9	0
L, mH	25	15	30	10	20	18	25	10	20	28
R_3, Ω	40	60	56	70	65	60	55	70	45	50
R_4, Ω	60	45	55	60	50	50	55	70	60	55

Table 1.3

Enrollment year	Penultimate digit of the credit book number									
even	1	2	3	4	5	6	7	8	9	0
odd	0	9	8	7	6	5	4	3	2	1
C, μF	2,0	3,0	2,8	2,5	3,5	4,0	2,5	1,5	3,5	4,5
Find	u_C	i_L	i_C	u_L	u_C	i_L	i_C	u_L	i_C	u_L

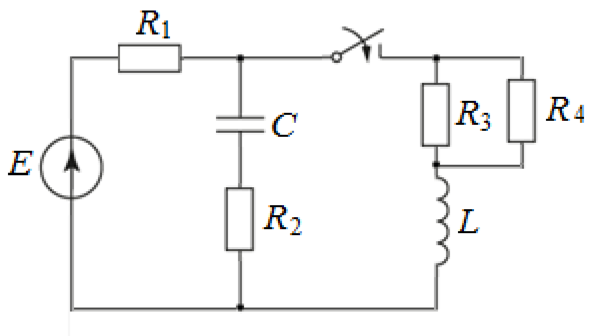
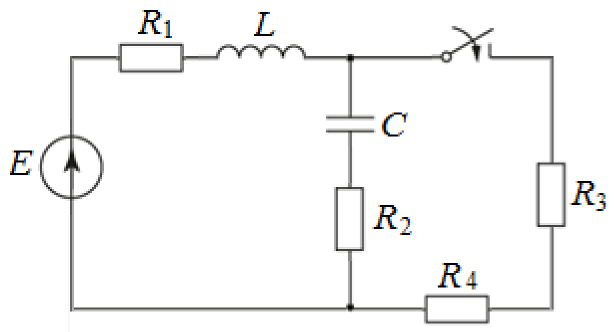


Figure 1.1



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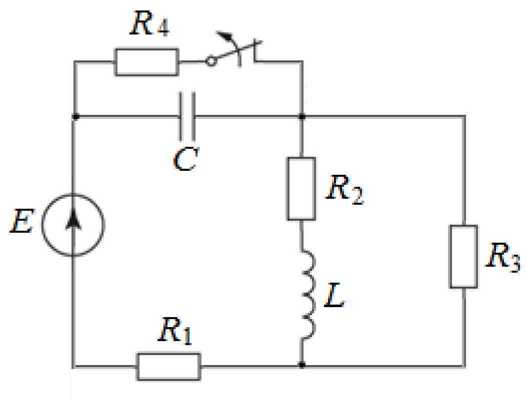

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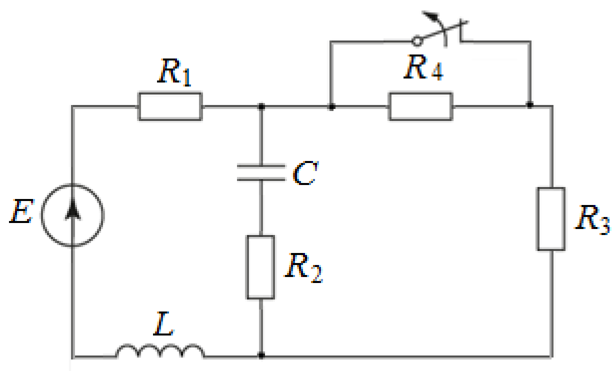

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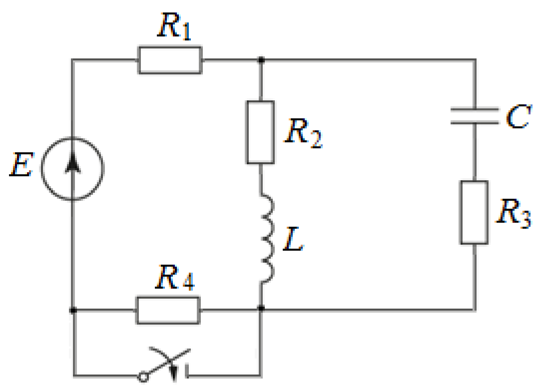


Figure 1.7

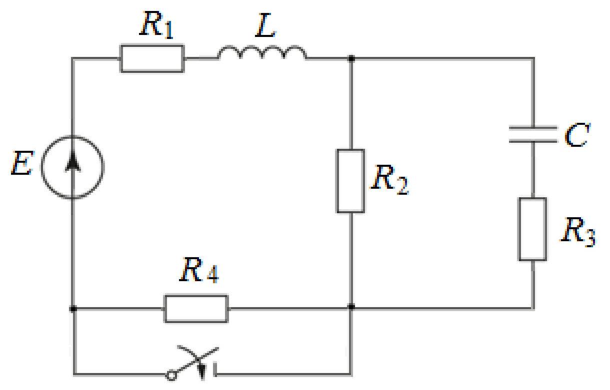


Figure 1.8

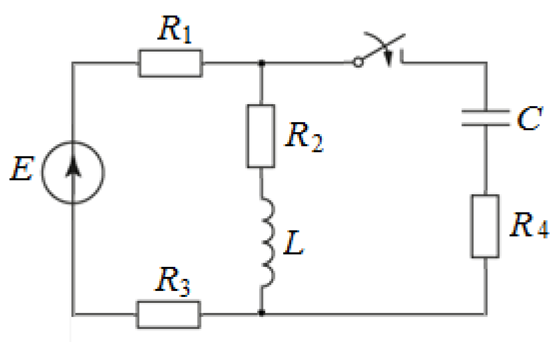


Figure 1.9

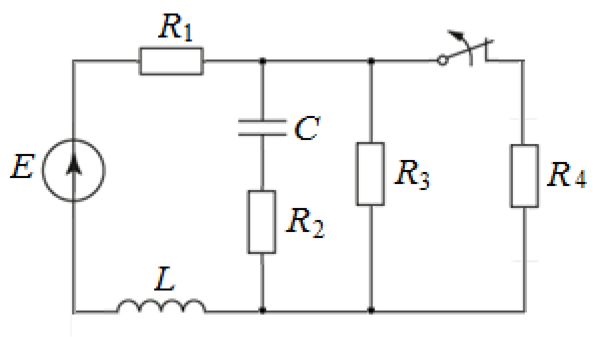


Figure 1.10

1.2 Methodological guidelines for performing of calculation-graphical work № 1

The classical calculation method of transients includes the following steps:

– before switching the steady state in the circuit is calculated: the current through the inductor $i_L(0–)$ and the voltage across the capacitor $u_C(0–)$ should be determined;

– independent initial conditions are determined by the commutation laws: $i_L(0)$, $u_C(0)$:

$$i_L(0) = i_L(0-); \quad u_C(0) = u_C(0);$$

– differential equations are written according to Kirchhoff's laws for a circuit after commutation;

– desired transient current or the desired transient voltage is determined in the form:

$$i(t) = i_{ss} + i_f(t); \quad u(t) = u_{ss} + u_f(t);$$

– steady state current i_{ss} or steady state voltage u_{ss} is found by calculating the steady state in the circuit after commutation;

– to determine i_f or u_f, make the characteristic equation, find the roots of the characteristic equation and write down the corresponding expressions for the free current i_f or free voltage u_f;

– the integration constants are determined using the initial values of the desired value itself and its first derivative.

The characteristic equation can be obtained using different ways: by a homogeneous differential equation, by the method of the main determinant or by the method of input impedance. The essence of the input impedance method is as follows:

a) write the input impedance $\underline{Z}(j\omega)$ for the circuit after commutation relative to any branch except the branch with an ideal current source;

b) in the expression $\underline{Z}(j\omega)$, replace $j\omega$ with p;

c) the resulting expression Z(p) equates to zero and get the characteristic equation Z(p) = 0.

The expression of the free component of current i_f or free component of voltage u_f is determined by the type of roots of the characteristic equation, which depends on discriminant of equation. There are three cases:

– discriminant D > 0, the roots are negative, real and different ($p_1 < 0$, $p_2 < 0$):

$$i_f(t) = A_1 e^{p_1 t} + A_2 e^{p_2 t}; \quad u_f(t) = A_1 e^{p_1 t} + A_2 e^{p_2 t};$$

– discriminant D = 0, the roots are negative, real and the same ($p_1 = p_2 = p$ <0):

$$i_f(t) = (A_1 + A_2 t)e^{pt}; \quad u_f(t) = (A_1 + A_2 t)e^{pt};$$

– discriminant D < 0, the roots are complex-conjugate $p_{1,2} = -\alpha \pm j\omega_f$:

$$i_f(t) = Ae^{-\alpha t}\sin(\omega_f t + \psi); \quad u_f(t) = Ae^{-\alpha t}\sin(\omega_f t + \psi),$$

where A, ψ and A_1, A_2 are constant of integrations.

2 Calculation-graphical work № 2. Calculation of transients in a linear electric circuit using Laplace transform

Purpose is obtaining the skills of transient calculation using the operator method (Laplace transform) in second-order linear electric circuits.

2.1 Assignment

A second order linear circuit (figures 1.1-1.10) containing resistors, inductor and capacitor is connected to a DC EMF E source and is in steady state. At the time moment of $t = 0$, the circuit is switched by locking or opening the key and the transient process begins.

The following is required:

1) Write introduction: write the essence of the operator method (Laplace transform) of calculating transients.

2) Determine the current or voltage in one of the branches of the electrical circuit after commutation by the operator method (Laplace transform) according to a given variant (table 1.3).

3) Plot a graph of the dependence value to be searched (current or voltage) on time, plot a graph over the time interval from 0 to $5\tau_{max}$ (if the characteristic equation roots are real) and from 0 to $5\tau = 5/\alpha$ (if the roots of the characteristic equation are complex-conjugate).

4) Make conclusion: compare the result of the transient process calculation by the both classical method (calculation-graphical work № 2) and operator method (Laplace transform), specify the advantages of the transients calculation using of the operator method.

The number of the circuit's scheme is determined by table 1.1, the numerical values of the circuit's parameters are given in tables 1.1, 1.2 and 1.3.

2.2 Methodological guidelines for performing of calculation-graphical work № 2

The method of calculating transients by the operator method includes the following steps:

− the steady state in the circuit before commutation is calculated and the current in the inductor $i_L(0–)$ and the voltage on the capacitor $u_C(0–)$ are determined;

− independent initial conditions are determined: $i_L(0)$, $u_C(0)$, which are found by the commutation laws:

$$i_L(0+) = i_L(0–) \text{ and } u_C(0+) = u_C(0–);$$

− an equivalent operator circuit is formed (the circuit is formed for the circuit after commutation);

− for an equivalent operator scheme, equations are written to determine the image of the desired quantity using any of the calculation methods: Kirchhoff's laws in operator form, the mesh current analysis, the nodal analysis, the Thevenin's theorem and the image of the desired quantity is determined;

− the desired value is determined by the original of the found image of the desired value.

When forming equivalent operator schemes, the sources of emf $e(t)$ are replaced by images $E(p)$, the image of the source of DC emf is equal to E/p.

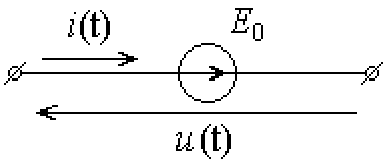
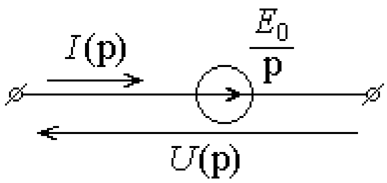
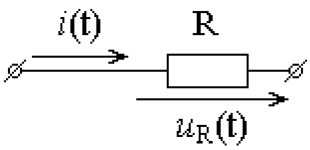
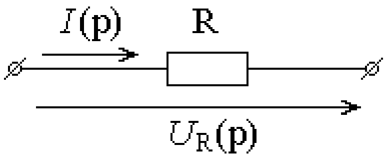
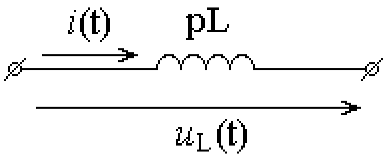
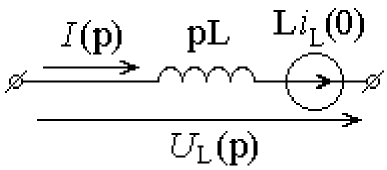
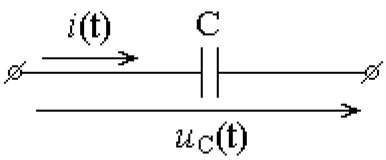
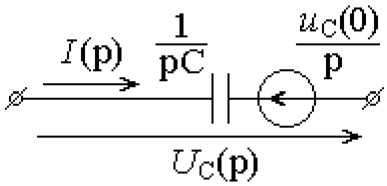
The currents $i(t)$ and voltages $u(t)$ are replaced by the corresponding images $I(p)$ and $U(p)$.

Under zero initial conditions $i_L(0) = 0$ and $u_C(0) = 0$, the inductance L is replaced by pL, the capacitance C is replaced by $1/pC$.

With non-zero initial conditions, the source of the calculated EMF $Li_L(0)$is added in series with the inductance pL, and the source of the calculated EMF $u_C(0)/p$ is added in series with the capacity $1/pC$.

Operator schemes of electrical circuit elements are shown in table 2.1.

Table 2.1

Originals and corresponding images of the linear electric circuit's elements	
Original	Image
 $u(t) = E_0 = constant$	
 $u_R(t) = R \cdot i(t)$	 $U_R(p) = R \cdot I(p)$
 $u_L(t) = \frac{d\psi(t)}{dt} = \frac{dLi(t)}{dt} = L\frac{di(t)}{dt}.$	 $U_L(p) = pL \cdot I(p) - L \cdot i_L(0)$
 $u_C(t) = \frac{q(t)}{C} = \frac{1}{C}\int i(t)\,dt.$	 $U_C(p) = \frac{1}{pC} \cdot I(p) + \frac{u_C(0)}{p}.$

To determine the original of the desired function of current or voltage according to its image the decomposition theorem is used (table 2.2).

Table 2.2

<table>
<tr><th colspan="2">Decomposition theorem</th></tr>
<tr><td colspan="2">An expression of the image of the desired function should be reduced to the form of rational algebraic fraction:
$$\frac{F_1(p)}{F_2(p)} = \frac{a_m p^m + a_{m-1}p^{m-1} + \cdots + a_1 p + a_0}{b_n p^n + b_{n-1}p^{n-1} + \cdots + b_1 p + b_0}$$, where $m < n$
$F_2(p) = 0$ – Analogue of the characteristic equation in a classical calculation method
The original is determined using decomposition theorem</td></tr>
<tr><td>Kind of the roots of a characteristic equation $F_2(p) = 0$ at $n = 2$</td><td>Decomposition theorem</td></tr>
<tr><td>The roots is real, different and negative: p_1 and p_2</td><td>$$\frac{F_1(p)}{F_2(p)} \doteqdot f(t) = \frac{F_1(p_1)}{F_2'(p_1)} e^{p_1 t} + \frac{F_1(p_2)}{F_2'(p_2)} e^{p_2 t},$$ where $F_2'(p) = dF(p)/dp$.</td></tr>
<tr><td>The roots is complex conjugate: $p_{1,2} = -\alpha \pm j\omega_0$</td><td>$$\frac{F_1(p)}{F_2(p)} \doteqdot f(t) = 2\,\mathrm{Re}\left[\frac{F_1(p_1)}{F_2'(p_1)} e^{p_1 t}\right]$$</td></tr>
<tr><td>The denominator has a zero root: $F_2(p) = pF_3(p)$.
The roots of $F_3(p) = 0$ is real, different and negative: p_1 и p_2</td><td>$$F(p) \doteqdot \frac{F_1(p)}{F_2(p)} = \frac{F_1(p)}{pF_3(p)}$$ $$f(t) = \frac{F_1(0)}{F_3(0)} + \frac{F_1(p_1)}{p_1 F_3'(p_1)} e^{p_1 t} + \frac{F_1(p_2)}{p_2 F_3'(p_2)} e^{p_2 t}$$</td></tr>
<tr><td>The denominator has a zero root: $F_2(p) = pF_3(p)$.
The roots of F_3(p) = 0 is complex conjugate: $p_{1,2} = -\alpha \pm j\omega_0$</td><td>$$\frac{F_1(p)}{pF_3(p)} \doteqdot f(t) = \frac{F_1(0)}{F_3(0)} + 2\,\mathrm{Re}\left[\frac{F_1(p_1)}{p_1 F_3'(p_1)} e^{p_1 t}\right]$$</td></tr>
</table>

3 Calculation-graphical work № 3. Calculation of two-port networks

Purpose is obtaining skills for calculating the parameters of the two-port networks.

3.1 Assignment

A passive symmetrical T-or π-shaped two-port network is set (figures 3.1-3.10).

The following is required:

1) Make an introduction: give an explanation which electric circuit is called a two-port network, give examples of a two-port network, what is the essence of the theory of a two-port network, to write down the transmission equations of a two-port network.

2) Determine the complex impedances of the branches of the two-port network.

3) Determine the A-parameters of the two-port network, using equations compiled by the of Kirchhoff's laws.

4) Determine the A-parameters of the two-port network, using currents and voltages in the modes of idling and short circuit.

5) Express Z-, Y-, H-parameters (according to a given variant, table 3.2) through A-parameters.

6) Determine the characteristic impedance of the two-port network $\underline{Z}_C$, using A-parameters.

7) Determine the characteristic impedance of the two-port network $\underline{Z}_C$ using the parameters of idling and short circuit.

8) Determine the characteristic constant of the transmission of the $\underline{\Gamma}_C$, the characteristic attenuation of the A_C, the phase constant of the B_C, using A-parameters.

9) Make conclusion: analyze the results obtained and check the fulfillment of the conditions, which are the A-, Z-, Y-, H-parameters of the passive symmetric two-port network satisfied (according to the given variant).

The number of the circuit's scheme, as well as numeric values of active, inductive and capacitive impedances are given in tables 3.1-3.3.

Table 3.1

Enrollment year	First letter of the surname									
even	АБВ	ГДЕ	ЖЗИ	КЛЫ	МН	ОПР	СТУ	ФЧЦ	ХШЩ	ЭЮЯ
odd	КЛЫ	ОПР	СТУ	ФЧЦ	АБВ	ГДЕ	ЖЗИ	МН	ЭЮЯ	ХШЩ
№ scheme	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.10
R_1, Ω	45	60	40	60	50	64	58	65	48	70
R_2, Ω	30	55	68	65	55	45	75	58	65	60

Table 3.2

Enrollment year	Last digit of the credit book number									
even	0	9	8	7	6	5	4	3	2	1
odd	1	2	3	4	5	6	7	8	9	0
X_{L1}, Ω	64	55	46	58	68	56	60	75	70	64
X_{C1}, Ω	60	75	85	60	50	40	75	40	50	68
Determine parameters	Z	Y	H	Z	Y	H	Z	Y	H	Y

Table 3.3

Enrollment year	Penultimate digit of the credit book number									
even	1	2	3	4	5	6	7	8	9	0
odd	0	9	8	7	6	5	4	3	2	1
X_{L2}, Ω	48	50	45	62	70	40	64	56	50	70
X_{C2}, Ω	55	46	65	35	40	56	58	60	60	50

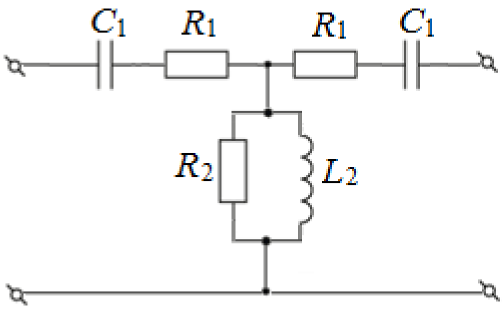


Figure 3.1

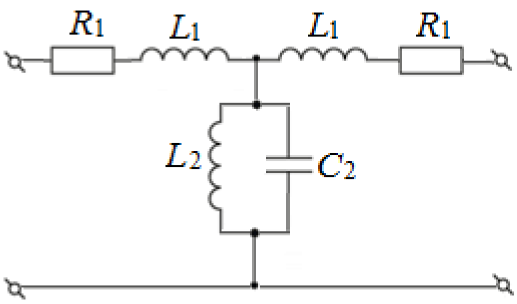


Figure 3.2

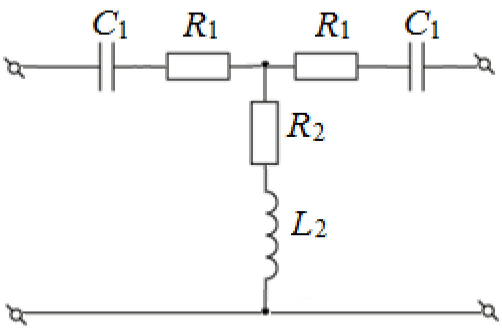


Figure 3.3

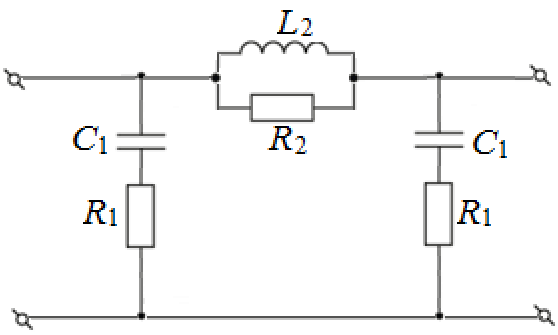


Figure 3.4

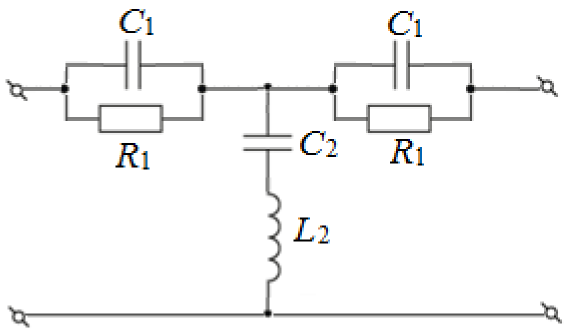


Figure 3.5

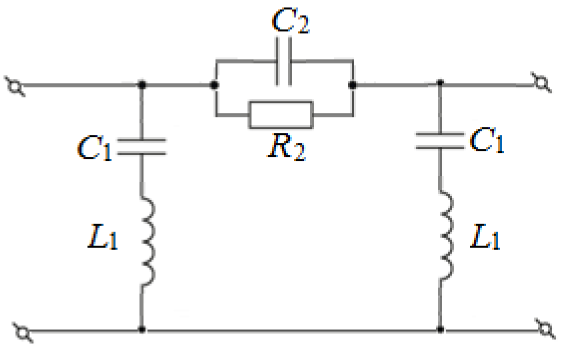


Figure 3.6

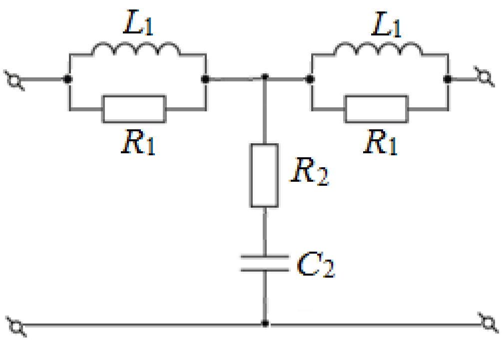


Figure 3.7

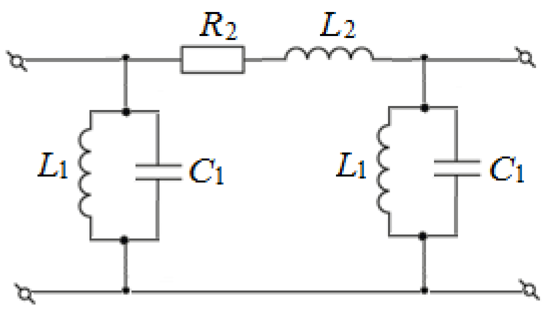


Figure 3.8

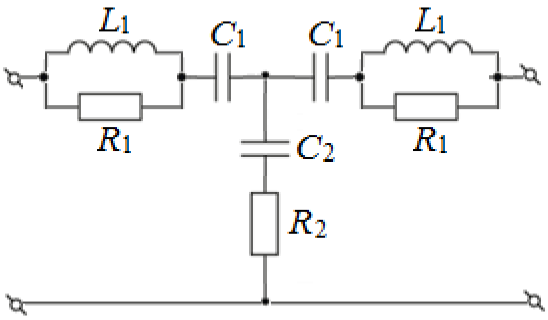


Figure 3.9

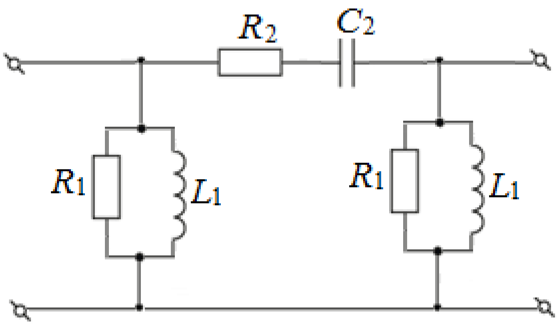


Figure 3.10

3.2 Methodological guidelines for performing of calculation-graphical work № 3

The method of determining the A-parameters will show the example of an L-shaped two-port network. We define the A-parameters of the L-shaped two-port network (figure 3.11), using equations compiled according to the Kirchhoff’s laws.

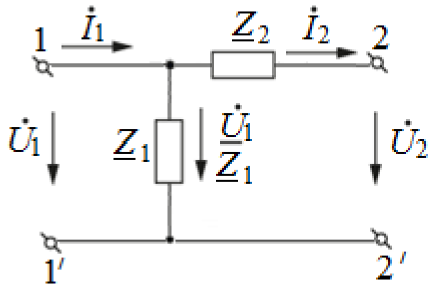


Figure 3.11 – L-shaped two-port network.

We write the equation according to the Kirchhoff's laws for the two-port network (figure 3.11).

$$\begin{cases} \dot{U}_1 = \dot{U}_2 + \underline{Z}_2 \dot{I}_2 \\ \dot{I}_1 = \dot{U}_1 / \underline{Z}_1 + \dot{I}_2 \end{cases}. \tag{3.1}$$

Substitute the expression for $\dot{U}_1$ into the second equation of the system:

$$\dot{I}_1 = (\dot{U}_2 + \underline{Z}_2 \dot{I}_2) / \underline{Z}_1 + \dot{I}_2 = \dot{U}_2 / \underline{Z}_1 + (1 + \underline{Z}_2 / \underline{Z}_1) \dot{I}_2. \tag{3.2}$$

We represent the solutions of equations (3.1, 3.2) in the form of equations of the transmission of the two-port network in A-parameters:

$$\begin{cases} \dot{U}_1 = \dot{U}_2 + \underline{Z}_2 \dot{I}_2 \\ \dot{I}_1 = \dot{U}_2 / \underline{Z}_1 + (1 + \underline{Z}_2 / \underline{Z}_1) \dot{I}_2 \end{cases}. \tag{3.3}$$

Let we compare the system of equations (3.3) with the transmission equation in A-parameters:

$$\begin{cases} \dot{U}_1 = \underline{A}_{11} \dot{U}_2 + \underline{A}_{12} \dot{I}_2 \\ \dot{I}_1 = \underline{A}_{21} \dot{U}_2 + \underline{A}_{22} \dot{I}_2 \end{cases} \tag{3.4}$$

and get the A-parameters of the L-shaped two-port network (figure 3.1):

$$\underline{A}_{11} = 1; \quad \underline{A}_{12} = \underline{Z}_2; \quad \underline{A}_{21} = \frac{1}{\underline{Z}_1}; \quad \underline{A}_{22} = 1 + \frac{\underline{Z}_2}{\underline{Z}_1}. \tag{3.6}$$

Determine the A-parameters of the two-port network according to the values of voltages and currents in the modes of idling and short circuit.

Parameters $\underline{A}_{11}$ and $\underline{A}_{21}$ can be determined using voltages $\dot{U}_1$, $\dot{U}_2$ and current $\dot{I}_1$ in idle mode at the port *2 - 2*′:

$$\underline{A}_{11} = (\dot{U}_1 / \dot{U}_2)_{I_2 = 0}; \quad \underline{A}_{21} = (\dot{I}_1 / \dot{U}_2)_{I_2 = 0}. \tag{3.7}$$

Current $\dot{I}_1$ and voltage $\dot{U}_2$ for the circuit (figure 3.11) in idle mode at the port 2 -2' we find by the formulas:

$$\dot{I}_1 = \dot{U}_1 / \underline{Z}_1; \quad \dot{U}_2 = \dot{U}_1. \tag{3.8}$$

We substitute the current $\dot{I}_1$ and the voltage $\dot{U}_2$ (3.8) into formulas (3.7), we obtain the parameters $\underline{A}_{11}$ and $\underline{A}_{21}$:

$$\underline{A}_{11} = 1; \quad \underline{A}_{21} = \frac{1}{\underline{Z}_1}. \tag{3.9}$$

Parameters $\underline{A}_{12}$ and $\underline{A}_{22}$ can be determined through the voltage $\dot{U}_1$, and the currents $\dot{I}_1$, $\dot{I}_2$ in the short circuit mode at port 2 - 2' (figure 3.12):

$$\underline{A}_{12} = (\dot{U}_1 / \dot{I}_2)_{U_2=0}; \quad \underline{A}_{22} = (\dot{I}_1 / \dot{I}_2)_{U_2=0}. \tag{3.10}$$

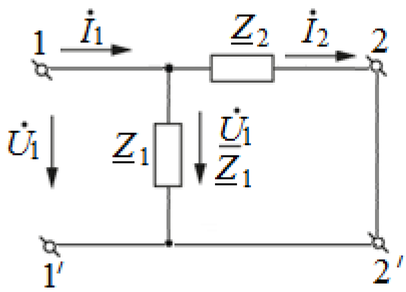


Figure 3.12 – Short circuit across the port 2 - 2'

Current $\dot{I}_2$ for the circuit (figure 3.12) in the short circuit mode at the port 2 - 2' we will find by the formulas:

$$\dot{I}_2 = \frac{\dot{U}_1}{\underline{Z}_2} = \dot{I}_1 \frac{\underline{Z}_1}{\underline{Z}_1 + \underline{Z}_2}. \tag{3.11}$$

Substitute the currents $\dot{I}_1$, $\dot{I}_2$ (3.11) into formulas (3.10), we obtain the parameters $\underline{A}_{12}$ and $\underline{A}_{22}$:

$$\underline{A}_{12} = \underline{Z}_2; \quad \underline{A}_{22} = 1 + \frac{\underline{Z}_2}{\underline{Z}_1}. \tag{3.12}$$

All systems of parameters – coefficients describe the same two-port network and there is a one-to-one relationship between them. Let us show how to express, for example, Y-parameters through A-parameters. Let us write the equations of the transmission of the two-port network in the *A*-parameters and solve it with respect to the currents I_1, I_2:

$$\begin{cases} \dot{U}_1 = \underline{A}_{11}\dot{U}_2 + \underline{A}_{12}\dot{I}_2 \\ \dot{I}_1 = \underline{A}_{21}\dot{U}_2 + \underline{A}_{22}\dot{I}_2 \end{cases} \Rightarrow \begin{cases} \dot{I}_1 = \dfrac{\underline{A}_{22}}{\underline{A}_{12}}\dot{U}_1 + \dfrac{-(A_{11}A_{22} - A_{12}A_{21})}{A_{12}}\dot{U}_2 \\ \dot{I}_2 = \dfrac{\dot{U}_1}{\underline{A}_{12}} - \dfrac{\underline{A}_{11}}{\underline{A}_{12}}\dot{U}_2 \end{cases}. \quad (3.13)$$

Compare the system of equations of transmission in the form of Y:

$$\begin{cases} \dot{I}_1 = \underline{Y}_{11}\dot{U}_1 + \underline{Y}_{12}\dot{U}_2 \\ \dot{I}_2 = \underline{Y}_{21}\dot{U}_1 + \underline{Y}_{22}\dot{U}_2 \end{cases} \quad (3.14)$$

and the system of equations (3.13), we get the Y-parameters:

$$\underline{Y}_{11} = \frac{\underline{A}_{22}}{\underline{A}_{12}}; \quad \underline{Y}_{12} = -\frac{\Delta A}{\underline{A}_{12}}; \quad \underline{Y}_{21} = \frac{1}{\underline{A}_{12}}; \quad \underline{Y}_{22} = -\frac{\underline{A}_{11}}{\underline{A}_{12}}. \quad (3.15)$$

For a symmetric T-or π-shaped two-port network $\underline{A}_{11} = \underline{A}_{22}$.

The characteristic impedance of a symmetrical two-port network is determined by the formulas:

$$\underline{Z}_C = \sqrt{\frac{\underline{A}_{12}}{\underline{A}_{21}}}; \quad \underline{Z}_C = \sqrt{\underline{Z}_{oc}\underline{Z}_{sc}}, \quad (3.16)$$

where $\underline{Z}_{oc}$, $\underline{Z}_{sc}$ are the parameters of idling and short circuit.

The characteristic constant of transmission symmetric two-port network is determined by the formula:

$$\underline{\Gamma}_C = A_C + jB_C = \ln\left(\sqrt{\underline{A}_{11}\underline{A}_{22}} + \sqrt{\underline{A}_{12}\underline{A}_{21}}\right). \quad (3.17)$$

Appendix A

Requirements for the content and design of calculation-graphical works

Each of the calculation-graphical work should be included next sections:

a) title page (a sample of the title page is represented on the next page);

b) contents;

c) introduction;

d) assignment;

e) main section (procedure of calculation and graphical results presentation);

f) conclusion (make conclusion about the obtained results and using methods);

g) list of references;

h) appendices (if it is necessary).

Academic group code, credit book number, surname and initials of the student should be written down on the title page (see sample of the title page on the next page).

Choose the original assignment data according to your variant. Assignments text should be rewritten to the explanatory note completely unabridged.

Each stage of the CGW should be named. All tasks are carried out on only one side of a white paper sheet (sheet size A4 with margins: top of 20 mm, bottom of 25 mm, left of 25 mm, right of 18 mm).

An explanatory note should be handwritten or by using Microsoft Word (font size 14 points, line spacing 1…1.5 line).

In an explanatory note are to be presented not only calculation formulas and final results, but also text with explanations, needed intermediate calculations, which allow understanding and verifying your actions.

It is necessary to write appropriate units for the parameters, having a particular of dimensions.

The graphs of instantaneous and r.m.s. values should be performed on the inserted sheets of graph or checkered paper, or by using computer applications.

It is necessary to sign coordinate axes and variable names of on the graph, also choose a scale to make it convenient to use the graph or diagram.

The circuit diagrams should be numbered and done in pencil neatly by using a ruler, or by using computer applications.

All pages should be numbered, starting from the title page. The page number should be located in the middle of the sheet bottom.

The works, which do not satisfy above requirements, will not be allowed to defense and will be returned for revision.

In the introduction to justify the need to study transients and methods for their calculation.

Calculation-graphical work must be submitted for check on the date specified by the teacher in the syllabus. In case of violation the term of delivery the work by the student, the total score for the work decreases.

Appendix B

Sample of the title page

MINISTRY OF EDUCATION AND SCIENCE REPUBLIC OF KAZAKHSTAN
Non-commercial Joint Stock Company
ALMATY UNIVERSITY OF POWER ENGINEERING AND TELECOMMUNICATIONS

Department of Electrical Engineering

CALCULATION-GRAPHICAL WORK № __

Theory of electrical circuits (TEC) discipline

____
(Title of the calculation-graphical work)

____

5B071600 – Instrumentation baccalaureate specialty

Done by ___________________________ student of the ______________ group
(Student’s Surname and Initials) (Academic group code)

Checked by ____
(Teacher’s academic degree, academic rank, Surname and Initials)

___________ __________________ “_____” “_____________” 20___ y.
(Score) (Teacher’s signature) (Date)

Almaty 20___ y.

List of references

Main

1 Fundamentals of Electric Circuits / Charles K. Alexander, Matthew N. O. Sadiku. – 5th edition 2013. – 995 p.

2 John Bird. Electrical Circuit Theory and Technology. – Third edition, 2007. – 694 p.

3 Introductory Circuit Analysis / Robert L. Boylestad. – 13th edition 2015. – 1224 p.

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6 Денисенко В. И., Зуслина Е. Х. ТОЭ. Учебное пособие. – Алматы: АИЭС, 2000. – 83 с.

7 Жолдыбаева З. И., Зуслина Е. Х. ТЭЦ2. Примеры расчета установившихся и переходных режимов в линейных электрических цепях с сосредоточенными и распределенными параметрами: Учебное пособие. – Алматы, 2010. – 80 с.

8 Жолдыбаева З. И., Зуслина Е. Х. Применение Mathcad в теории электрических цепей: Учебной пособие. – Алматы: АУЭС, 2012. – 83 с.

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