NATIONAL TECHNICAL UNIVERSITY OF UKRAINE
"Igor Sikorsky Kyiv Polytechnic Institute"

Approved by

Head of the Admission Committee
Rector

Signature

Mykhailo ZGUROVSKY

2.05.2023
Date

PROGRAM
of entrance examination

for admission to the educational and scientific program of study for the doctor of philosophy "Electrical Power Engineering, Electrotechnics and Electromechanics"

in specialty 141 Electric Power Engineering, Electrotechnics and Electromechanics

Program is adopted by:
Scientific and methodical commission on specialty 141 Electric Power Engineering, Electrotechnics and Electromechanics
Protocol No. 4
from «27» 04 2023
Head of the SMC

Olexandr YANDULSKY

Kyiv – 2023

I. GENERAL INFORMATION

The entrance exam for admission to study for the doctor of philosophy in the specialty 141 "Electric power engineering, electrotechnics and electromechanics" is conducted for those entrants who have a master's degree *.

The educational program " Electric power engineering, electrotechnics and electromechanics " corresponds to the mission and strategy of Igor Sikorsky KPI, according to which the strategic priority of the university is the fundamentalization of training. Features of the educational program are taken into account by selecting the appropriate sections of the entrance exam program. Conducting an entrance examination should reveal the level of preparation of the entrant in the chosen specialty for admission.

Theoretical questions of the entrance exam can be divided into nine sections:

1. Theoretical electrical engineering.
2. Technique of high electric and magnetic fields.
3. Electric power plants
4. Electrical systems and networks
5. Control, protection and automation of electric power systems
6. Electromechanical automation systems and electric drive
7. Electric machines and apparatus
8. Alternative and renewable energy sources
9. Systems of providing consumers with electric energy, electrotechnical complexes, electromechanical systems, automation of electrotechnical and electrotechnological complexes, energy management and energy efficiency.

The task for the entrance exam consists of three theoretical questions. The exam ticket includes consiquently: the first question from the first section, the second and third questions from the second to ninth sections.

Entrance exam in the specialty is conducted in the form of an oral exam.

The duration of the entrant's preparation for the answer is 2 academic hours.

The next section of the program lists only those topics from these sections that relate to the tasks of the entrance examinations.

Information on the rules of admission and requirements for entrants to the educational program "Electric Power Engineering, Electrotechnics and Electromechanics " is provided in the section "Admission to postgraduate program" on the website of graduate school and doctoral study at Igor Sikorsky Kyiv Polytechnic Institute, available at the link https://aspirantura.kpi.ua/

* According to appendix 2 of Section XV of the Law on Higher Education higher education at the educational and qualification level of a specialist is equated to higher education with a master's degree

II. TOPICS SUBMITTED FOR THE ENTRANCE EXAMINATION

Section 1. Theoretical electrical engineering

Topic 1.1. Basic concepts of electromagnetic field and electric circuits

General characteristics of the problems of the theory of the electromagnetic field and the theory of electric and magnetic circuits. Basic equations of the electromagnetic field in integral form. Energy, forces and mechanical manifestations of electric and magnetic fields. The main parameters of electric and magnetic fields in integral form. Statement of problems of automated design of electrical devices.

Topic 1.2. Theory of linear electric circuits

Electrical and electronic circuits in energy and information transmission and conversion systems. Classification of circles and their elements. Bipolar and multipolar. Managed sources. Inductively coupled elements. Graphs and topological matrices of electrical circuits, topological equations. Ohm's law for the generalized branch, matrix component equations. Nodal and extended nodal equations, contour equations. Numerical methods for solving the equations of circles at steady states. Accurate and iterative methods. Gaussian method; decomposition of matrices into triangular factors; numerical methods of matrix rotation. Conditions of convergence of iterative methods. Calculation of input and transfer functions in symbolic form. Topological methods of analysis. Signal graphs and their application to the analysis of electrical circuits.

Multiphase circuits. Calculation of symmetric and asymmetric three-phase circuits. Method of symmetrical components.

Multipoles; matrix of multipoles. Basic equations of regular quadrupoles. Characteristic supports and transmission ratio. Substitute schemes of mutual and non-reciprocal quadrupoles. Connection of four-poles. Four-pole feedback. Features of formation of equations of circles with multipolar components. Hybrid equations. Resistor gyrators and converters.

Electrical circuits with inharmonic voltages and currents. Harmonic analysis of periodic functions. Current value and power. Signals and their spectra. Spectral density. Signal conversion by linear systems. Elements of filter theory. Reactive filters. Induction filters. Frequency characteristics and methods of their calculation.

Transients in linear circles. Analysis of dynamic processes in the time domain. The classic method. Features of calculation in the presence of capacitive circuits and inductive sections. Compilation and numerical methods for solving state equations. Discrete circuit models of circuit components and their application for numerical solution of state equations. Analysis of dynamic processes in the frequency domain. Application of Laplace and Fourier transforms to calculate transients. Approximate and numerical methods of spectral analysis. Relationship between transient and frequency characteristics.

Elements of synthesis of linear circles. Properties of functions and methods of realization of bipolar and quadrupole passive electric circuits. Synthesis of inductive quadrupoles with active and non-reciprocal elements.

Circles with distributed parameters. Basic equations of long lines and their transportations for steady-state sinusoidal oscillations. Transients in circles with distributed parameters.

Topic 1.3. Theory of nonlinear electric circuits

Steady processes in nonlinear circles. Methods for calculating nonlinear electric and magnetic circuits at constant currents and voltages. Features of nonlinear alternating current circuits and methods of their calculation. Analysis of steady-state processes in nonlinear alternating current circuits. Formation and numerical methods for solving algebraic equations of nonlinear resistive electric circuits. Small parameter method.

Transients in nonlinear circles. Basic methods of analysis. Asymptotic methods. Perturbation method. Harmonic balance method and frequency properties of nonlinear circuits. Phase plane. State variable method. Numerical methods for solving nonlinear equations of state. Methods of implicit integration. Discrete models of nonlinear reactive elements and their application for calculation of dynamic processes.

Self-oscillation. Almost harmonic oscillations. Relaxation oscillations. Stability. Energy ratios. Machine method for calculating periodic and self-oscillating modes.

Basic vectors and basic equations of the electromagnetic field. Systems of Maxwell's equations. Electrodynamic potentials. Boundary conditions. Energy. Condition-Pointing Theorem. Gauss's theorem.

Static fields. Basic equations of electric and magnetic static field. Boundary value problems and methods of their solution, Method of conformal transformations and method of separation of variables. Numerical methods for solving boundary value problems: grid method, finite element method. Method of integral equations of potential theory and its numerical realization. Capacity, capacitance and potential coefficients.

Stationary electric and magnetic fields. Basic field equations. Differential form of the laws of Ohm, Lenz-Joule, Kirchhoff. Similarity of static and stationary fields. Vector magnetic potential. Flow inoculation. Own and mutual inductance. Application of the method of integral equations.

Alternating electromagnetic field in a conductive medium. Waves in conductive media. Surface effect. Penetration of the magnetic field into the ferromagnet array for the rectangular magnetization characteristic. Modeling of variable fields in conducting environments.

Electromagnetic waves and radiation. Wave equation and its solution. Harmonic waves in an ideal dielectric. Reflection of electromagnetic waves. Waves in space bounded by leading boundaries. Waveguides and resonators. Types of waves. Phase and group speed. D'Alembert's equation. Radiation of

quantum generators. Electromagnetic fields in real dielectrics, ferromagnets and anisotropic media. Complex parameters of the environment.

Numerical methods for calculating nonstationary fields. Electromagnetic fields in moving media. Basic equations of magnetic hydrodynamics.

References to Section 1

1. Boyko V.S. Teoretychni osnovy elektrotekhniky: V 3-kh t. Pidruchn. dlya stud. elektrotekhn. spetsial′n. vyshchykh zakl. osv. Tom 1 / V.S. Boyko, V.V. Boyko, YU.F. Vydolob [ta in.]; za zah. red. I.M. Chyzhenka, V.S. Boyka.– K.: IVTS «Politekhnika», 2004. – 272 s.

2. Boyko V.S. Teoretychni osnovy elektrotekhniky: V 3-kh t. Pidruchn. dlya stud. elektrotekhn. spetsial′n. vyshchykh zakl. osv. Tom 2 / V.S. Boyko, V.V. Boyko, YU.F. Vydolob [ta in.]; za zah. red. I.M. Chyzhenka, V.S. Boyka. – K.: IVTS «Politekhnika», 2008. – 224 s.

3. Boyko V.S. Teoretychni osnovy elektrotekhniky: V 3-kh t. Pidruchn. dlya stud. elektrotekhn. spetsial′n. vyshchykh zakl. osv. Tom 3 / V.S. Boyko, V.V. Boyko, YU.F. Vydolob [ta in.]; za zah. red. I.M. Chyzhenka, V.S. Boyka. – K.: IVTS «Politekhnika», 2013. – 244 s.

4. Teoretychni osnovy elektrotekhniky-3. Neliniyni kola. Osnovy teoriyi elektromahnitnoho polya. Konspekt lektsiy [Elektronnyy resurs] : navch. posib. dlya stud. cpetsial′nosti 141 «Elektroenerhetyka, elektrotekhnika ta elektromekhanika» / KPI im. Ihorya Sikors′koho ; uklad.: L. YU. Spinul, M. P. Buryk. –Kyyiv : KPI im. Ihorya Sikors′koho, 2021. – 192 s.

5. Osnovy teoriyi elektromahnitnoho polya. Kurs lektsiy [Elektronnyy resurs] : navch. posib. dlya stud. cpetsial′nosti 141 «Elektroenerhetyka, elektrotekhnika ta elektromekhanika», spetsializatsiyi «Elektromekhanichni systemy avtomatyzatsiyi ta elektropryvod, elektromobil′nist′» / KPI im. Ihorya Sikors′koho, uklad. L. YU. Spinul. – Kyyiv : KPI im. Ihorya Sikors′koho, 2020. – 102 s.

Section 2. Technique of high electric and magnetic fields

Topic 2.1. Electrophysical foundations of high electric and magnetic fields

Formation and neutralization of charged particles in the gas. The motion of charged particles in a gas. Condition of discharge independence in gas. Initial voltages of intervals with homogeneous and inhomogeneous electric field. Avalanche breakdown theory of Townsend-Rogovsky. Pashen's law. Streamer breakdown theory. Features of breakdown of long air gaps, leadership process. Characteristics and features of SF6 application. Overlapping solid insulation in the air. Ways to increase the floor voltage of insulating structures. DC corona discharge. Crown losses on the power line. Radio interference from corona discharge. Electrical conductivity of liquids in strong electric fields. Pre-discharge processes in liquids. Ignition discharge. Dynamics of pulse discharge in liquids. Breakdown of liquid dielectrics with impurities. Theory of thermal breakdown of

solid dielectrics. Theory of electric breakdown of solid dielectrics. Breakdown of inhomogeneous solid dielectrics. Partial discharges. Aging insulation. Discharge on the contaminated and moistened surface of the insulator.

Topic 2.2. Lightning surges and lightning protection of electrical installations

Characteristics and parameters of lightning discharges. Lightning protection grounding. Methods of calculation and modeling. Induced overvoltages on overhead lines. Overvoltages of direct lightning strike in power lines. Protection against direct lightning strikes. Lightning protection zones. Methods for determining the probability of lightning breakthrough. Wave propagation in a line. Refraction and reflection of waves in power lines. Influence of pulse corona on wave processes in power lines. Lightning protection of substations. Tubular and valve arresters. Nonlinear surge arresters. Number of thunderstorms of overhead power lines, APV. Indicator of lightning resistance of substations. Lightning protection of overhead power lines.

Topic 2.3. Internal overvoltages in electrical systems and their limitations

Internal overvoltages in networks with isolated neutral. The role of arc suppressors. Overvoltages when unloaded lines are switched off. Overvoltages when unloaded transformers are switched off. Resonant overvoltages in power lines. Limitation of internal overvoltages. Statistical characteristics of internal overvoltages. Estimated multiplicity of internal overvoltages.

Topic 2.4. Insulation of high voltage installations and high voltage test installations

Methods of electric field regulation in insulating structures. Insulation of overhead power lines. The main types of internal insulation. Short-term and long-term electrical strength. Isolation of power transformers. Insulation of power cables. Isolation of power capacitors. Insulation of rotating electric machines. High voltage inputs. External insulation tests. Internal insulation tests. Diagnosing internal insulation. Transformer installations for insulation testing. Test high-voltage direct current installations. Pulse voltage generators. Methods of generating switching pulses.

Topic 2.5. Technique of high voltages and high currents

Measurement of high voltage pulses. Voltage dividers. Measurement of high direct current (DC) and alternating (AC) voltage. Measurement of large pulse currents. Measurement of capacitance and angle of dielectric losses. High-precision pulse discharges and their application. Charging of macroscopic particles and their motion in an electric field. Electrostatic precipitators and electroseparators. Ecological factors of ultra-high voltage overhead and cable lines.

References to Section 2

1. Brzhezyts′kyy V.O., Isakova A.V., Rudakov V.V. ta in. Tekhnika i elektrofizyka vysokykh napruh: Navch. posibnyk / Za red. V.O. Brzhezyts′koho ta V.M. Mykhaylova. – Kharkiv: NTU «KHPI» – Tornado, 2005. 930 s.
2. Sobchuk V.S. Tekhnika ta elektrofizyka vysokykh napruh: navchal′nyy posibnyk– Vinnytsya, VNTU, 2003. – 85 s.
3. Tekhnika vysokykh napruh: navchal′nyy posibnyk / MON MS Ukrayiny; Maystruk E. V., uklad. – Chernivtsi: Chernivets′kyy natsional′nyy universytet, 2012. – 128 s.
4. Tekhnika vysokykh napruh: Kurs lektsiy [Elektronnyy resurs] : navch. posib. dlya stud. spetsial′nosti 141 «Elektroenerhetyka, elektrotekhnika ta elektromekhanika» / KPI im. Ihorya Sikors′koho ; uklad.: V. B. Abramov, V. O. Brzhezyts′kyy, YA. O. Haran, O. R. Protsenko – Kyyiv : KPI im. Ihorya Sikors′koho, 2021. – 345 s.
5. Elektrotekhnolohichni ustanovky ta systemy. Kurs lektsiy [Elektronnyy resurs] : navchal′nyy posibnyk dlya studentiv spetsial′nosti 141 «Elektroenerhetyka, elektrotekhnika ta elektromekhanika», osvitn′oyi prohramy «Elektrotekhnichni prystroyi ta elektrotekhnolohichni kompleksy» / KPI im. Ihorya Sikors′koho ; uklad.: V. O. Brzhezyts′kyy, YA. O. Haran, M. YU. Laposha, YE. O. Trotsenko. – Kyyiv : KPI im. Ihorya Sikors′koho, 2020. – 136 s. – Nazva z ekrana.

Section 3. Electric power plants

Topic 3.1. General information about power stations and power systems

The structure of generating capacities of modern electric power systems of Ukraine. Ensuring power balance in power systems. Types, technological schemes of power plants and their characteristics. The participation of various power plants in the production of electricity. Load schedules of electrical installations. Power quality indicators. Operating modes of neutrals in electrical installations. Features of the main schemes of electrical connections of power plants of various types.

Topic 3.2. Main electrical equipment of power plants and substations

Characteristics, design features of the cooling and excitation system of modern synchronous generators (SG) and synchronous compensators (SC). Systems of automatic regulation of excitation of SG and SC. Automatic extinguishing of the field, synchronization of SG and SC with the network. Normal and permissible operating modes of synchronous generators. Modes of operation when changing the active load and excitation current. Diagram of permissible generator loads. The effect of changing the network voltage and frequency on the operation of synchronous generators. Abnormal operating modes of turbogenerators. Overloading of turbogenerators with stator and rotor currents. Asynchronous and asymmetric modes of operation of synchronous generators.

Main operating parameters, design elements and cooling systems of power transformers (PT) and autotransformers (AT). Surge limiting properties and application of transformers with split windings. Modes of operation of three-winding autotransformers. Criteria for admissibility of JSC work modes. Overvoltages in the AT caused by short circuits on the lines. Load capacity, thermal characteristics and thermal regimes of transformers.

Topic 3.3. Systems of own needs of power plants and substations

Power sources of consumers of the system of own needs (ON). Categories of ON consumers. Electric circuits of combined heat and power plants (CHP), thermal power plants (TPP), hydraulic power plants (HPP), substations. Principles of power backup for consumers of ON power plants of various types. The main types of ON working machines at power plants and their features. Working and mechanical characteristics of ON mechanisms. The effect of changing the rotation frequency on the operating characteristics of the ON mechanisms. Regulation of the productivity of ON mechanisms.

Electric motors for own needs of power plants. Mechanical characteristics of asynchronous and synchronous electric motors, ON direct current motors. Abnormal operating modes of ON electric motors. The effect of changing the network frequency, voltage, and load on the operating modes of electric motors of the ON. Asymmetric modes of operation of ON electric motors. Coasting and self-starting of ON electric motors. Individual and group coasting of electric motors. Characteristics of run-out. Self-starting of ON electric motors. Practical methods and algorithms for calculating self-starting. Features of electrical equipment and mechanisms of nuclear power plants (NPP). Connection of technological and electrical parts. Categories of consumers of NPP ON. Requirements for emergency cooling systems. Principles of construction of electric power supply schemes of VP NPP. Schemes of electricity supply to consumers of the NPP ON of normal operation and reliable power supply.

Topic 3.4. Conditions of operation and operation of modern power systems from nuclear power plants

Features of the nuclear power plant as an object of energy generation in the power system. Factors that determine the reliability and survivability of nuclear power plants. Climatic influences on the elements of the power output system from nuclear power plants. Causes of extreme regimes of power systems from nuclear power plants. The main factors and reasons for de-energizing the nuclear power plant. Processes in the NPP ON system during de-energization of sections of normal operation. Tasks and ways to ensure the reliability of the external power supply systems of the NPP.

Topic 3.5. Short circuits, asymmetric and incomplete phase modes of electrical installations

Calculation conditions of short circuits: electrical installation scheme, type of short circuit, point and time of short circuit. Parameters of elements of substitute circuits in short-circuit (short-circuit) calculations. Calculation of the initial value of the periodic component of the three-phase short-circuit current. Transient

processes in synchronous machines with three-phase short-circuits. Practical methods of calculating the effective value of the short-circuit current. Thermal and electrodynamic effect of short-circuit currents on conductors and electrical devices. Methods of testing conductors and electrical devices for thermal and electrodynamic stability. The method of compiling substitute schemes of various sequences. Unsymmetrical short circuits. Calculation of currents and voltages with longitudinal asymmetry and complex asymmetric damage. Methods and means of limiting short-circuit currents.

Calculation conditions for the selection of electrical equipment under the conditions of long-term operating conditions. Checking electrical equipment for thermal and electrodynamic stability in the event of a short circuit.

Topic 3.6. Transient electromechanical processes and stability of electric power systems

Power characteristics of the simplest unregulated system and a system with generator excitation regulators. Sustainability categories. The concept of static stability of the power system. Method of small oscillations for analysis of static stability. Practical criteria of static stability and their use. Effective power limit. Static stability of the two-machine power system. Modern theory of stability. The concept of the first and second (direct) Lyapunov methods. Transient processes during large disturbances. Dynamic stability of the system. Methods of studying dynamic stability. Dynamic stability of the electrical system in the emergency, post-emergency mode and in the mode after automatic reactivation (AR). Asynchronous modes in electric power systems. Determination of system parameters in asynchronous mode, resynchronization and resulting stability.

Static and dynamic load characteristics. Criteria of static stability of asynchronous motors and complex load. Transient processes in load nodes during large disturbances.

Anti-emergency automation of energy systems. Types of control influences to ensure static and dynamic stability: disconnection of generators, impulse unloading of turbines, long-term unloading of turbines, forcing excitation of generators, disconnection of load. Measures to improve the stability and quality of transient processes of electrical systems.

References to Section 3

1. Bardyk YE. I., Lukash M. P. Elektrychna chastyna stantsiy ta pidstantsiy. Osnovne elektroobladnannya (navch. pos.) / K.: "Politekhnika", NTUU "KPI", 2011. – 218 s.

2. Ekspluatatsiya ta rezhymy roboty elektrostantsiy: normal′ni, dopustymi i anormal′ni rezhymy synkhronnykh heneratoriv [Elektronnyy resurs] : navchal′nyy posibnyk dlya studentiv spetsial′nosti 141 «Elektroenerhetyka, elektrotekhnika ta elektromekhanika» / KPI im. Ihorya Sikors′koho; uklad.: YE. I. Bardyk. – Elektronni tekstovi dani (1 fayl: 2,69 Mbayt). – Kyyiv: KPI im. Ihorya Sikors′koho, 2022. – 107 s.

3. Perekhidni protsesy v systemakh elektropostachannya: pidruchnyk dlya VNZ / H.H. Pivnyak, I.V. Zhezhelenko, YU.A. Papayika, L.I. Nesen, za red. H.H. Pivnyaka ; M-vo osvity i nauky Ukrayiny, Nats. hirn. un-t. – 5-te vyd., dooprats. ta dopov. – Dnipro : NHU, 2016. – 600 s.

4. Perekhidni protsesy v systemakh elektropostachannya: pidruch. [dlya stud. vyshch. navch. zakl.] / M. M. Cheremisin, O. M. Moroz, O. B. Yehorov, S. V. Shvets′. – Kharkiv: TOV «V spravi», 2016. – 260 s.

5. Kiameh P. Power plant equipment operation and maintenance guide, 1st Edition / P. Kiameh – New York City: McGraw-Hill Professional Publishing, 2012. – 770 pages.

6. Dr. Juan A. Martinez-Velasco, "Transient Analysis of Power Systems: A Practical Approach". - Wiley-IEEE Press; 1st edition, 2020. – 624 pages.

Chapter 4. Electrical systems and networks

Topic 4.1. Electrical networks

Technical and economic advantages of creating energy systems and their associations. Electrical networks. Classification of electrical networks. Main and distribution electric networks. Power system load schedule and its coverage. Schedules of loads of power stations of power systems. Modes of operation of the neutral of electrical networks.

Physical processes and phenomena that occur during the transmission of electrical energy along power lines. Alternative schemes of overhead and cable power transmission lines. Determining the parameters of the alternate circuits of power lines.

Physical processes and phenomena that occur in power transformers during the transmission of electrical energy. Replacement schemes of two- and three-winding transformers and autotransformers. Transformers with split windings. Power transformers with shortened windings. Determination of the parameters of substitute schemes of transformers according to catalog data.

Losses of power and energy in elements of electrical networks. Load schedules of electric power system nodes. The number of hours of use of the maximum and set power. Coefficients of participation in the maximum load, simultaneity coefficient, utilization coefficient of installed capacity. Power losses in power lines. Power losses in transformers of various types. Energy losses in lines and transformers and their determination according to load schedules. RMS load power and time of maximum energy loss. Vector diagram of power line currents and voltages. Drop and loss of voltage in the elements of the electrical network.

Topic 4.2. Calculation and analysis of modes of electrical systems

Characteristics of problems of calculating the parameters of steady-state modes of electric power systems. Calculation schemes of electrical systems of different classes of nominal voltage. Combined and estimated load. Voltage

reference and balancing point of the calculation scheme of the electrical network. Static load characteristics by voltage

Iterative calculation of the mode of the electric network. Convergence criteria of iterative calculation. Calculation of lines with two-way power supply. Method of contour equations. Contour cutting method. Nodal stress equations and their modification. Iterative methods of implementing the nodal model: linearization, Seidel, Newton-Raphson method. Heterogeneity of electrical networks. Means of compensation of heterogeneity.

Features of calculation of asymmetric modes of electrical systems. Incomplete phase modes of power transmission lines. Ways and means of balancing the mode of the electrical system. Causes and consequences of non-sinusoidal current and voltage curves. Means of compensation of higher harmonics in electrical systems.

Topic 4.3. Regulating modes of electrical systems

Quality of electrical energy and its characteristics. Voltage deviations and fluctuations, their causes, limit values, their influence on the operation of electrical receivers. The concept of permissible voltage loss in the electrical network.

Means and methods of voltage regulation in electrical networks of energy systems. Regulation of voltage in the network by changing the voltage on the busbars of generators, active and reactive resistance of lines, redistribution of reactive power flows in the system network. Advantages and disadvantages of synchronous compensators and batteries of static capacitors (BSC). Transverse compensation as a means of voltage regulation in the network. An avalanche of tension. Calculation of parameters of compensating devices of transverse compensation. Longitudinal compensation (LC) as a means of voltage regulation in the network. Selection of the place of installation in the network of compensating devices of longitudinal and transverse compensation.

Transformer means of voltage regulation in electrical networks of the power system. The concept of reverse voltage regulation. Schemes of voltage regulation using autotransformers in direct and reverse modes. The use of booster transformer (BT) for voltage regulation in electrical networks. Longitudinal and transverse tension adjustment using BT.

Balance of active and reactive power and quality of electricity in systems. Static load characteristics as a function of frequency. Turbine speed regulators. Static and astatic characteristics of speed controllers. Regulatory effect of load by frequency. Primary and secondary frequency regulation. Frequency regulation in the system using a non-regulating unit and a frequency-regulating station. Frequency regulation in emergency modes. Automatic frequency discharge and frequency automatic reconnection system.

Topic 4.4. Regulation of long-distance power transmission modes

Wave parameters of long-distance power transmissions (LDPT). Charging power and natural power of LDPT. Voltage distribution along the LDPT. Basic equations of LDPT. Modeling the LDPT mode using a quadrupole device.

Compensation of charging capacity of LDPT. Arrangement of shunt reactors along the LDPT. Ensuring the balance of reactive power at the final substations of LDPT.

Bandwidth of LDPT. Characteristics of power transmission and its throughput. Artificial measures to increase the carrying capacity and range of electrical energy transmission by alternating current. Quarter-wave to half-wave energy transfer. Compensation of parameters and adjustment of LDPT. Calculation of the parameters of compensation devices and tuning to increase the bandwidth of the DEP.

References to Section 4

1. Kyryk, V. V. Elektrychni merezhi ta systemy. Rezhymy roboty rozimknenykh merezh = Electrical power networks and systems. Operation modes of open networks [Elektronnyy resurs] : navchal′nyy posibnyk dlya studentiv usikh form navchannya ta studentiv-inozemtsiv spetsial′nosti 141 “Enerhetyka, elektrotekhnika ta elektromekhanika” / V. V. Kyryk, T. B. Maslova ; NTUU «KPI». – Kyyiv : Politekhnika, 2015. – 256 s.
2. Kyryk V. V. Elektrychni merezhi ta systemy : pidruchnyk / V. V. Kyryk. – Kyyiv : KPI im. Ihorya Sikors′koho, Vyd-vo «Politekhnika», 2021. – 324 s.– ISBN 978-966-990-031-9
3. Katsadze T. L. Elektrychni systemy i merezhi. Rozrakhunok ta analiz ustalenykh rezhymiv elektroenerhetychnykh system: Navchal′nyy posibnyk / T. L. Katsadze, V. V. Kyryk.-K.: KPI im. Ihorya Sikors′koho, 2018.-212 s.
4. Elektrychni systemy i merezhi. Chastyna 1 [Elektronnyy resurs] : navchal′nyy posibnyk / YU. V. Malohulko, O. B. Burykin, T. L. Katsadze, V. V. Netrebs′kyy ; Vinnyts′kyy natsional′nyy tekhnichnyy universytet ; za red. P. D. Lezhnyuka. – Vinnytsya : VNTU, 2020. – 200 s.
5. Analiz ta syntez system peredachi elektrychnoyi enerhiyi postiynoho strumu [Elektronnyy resurs] : navchal′nyy posibnyk dlya studentiv spetsial′nosti 141 «Elektroenerhetyka, elektrotekhnika ta elektromekhanika», osvitn′oyi prohramy «Elektrychni systemy i merezhi» / KPI im. Ihorya Sikors′koho; uklad. V. V. Kyryk. – Kyyiv : KPI im. Ihorya Sikors′koho, 2021. – 59 s.
6. Suleymanov V. M. Elektrychni merezhi ta systemy: pidruchn. / V. M. Suleymanov, T. L. Katsadze. – Kyyiv: NTUU «KPI», 2008. – 456 s. – ISBN 978-966-622-300-8.
7. Katsadze T. L. Osnovy mekhanichnykh rozrakhunkiv povitryanykh liniy elektroperedavannya: Pidruchnyk / T. L. Katsadze. – Kyyiv: KPI im. Ihorya Sikors′koho, 2019 – 333 s.
8. Seheda M. S. Elektrychni merezhi ta systemy: Pidruchnyk / M. S. Seheda. – L′viv: Vydavnytstvo Natsional′noho universytetu «L′vivs′ka politekhnika», 2007. – 488 s.
9. Suleymanov V. M. Rozrakhunok i rehulyuvannya ustalenykh rezhymiv roboty elektrychnykh merezh enerhosystem / V. M. Suleymanov. – Kyyiv: NMK VO, 1992. – 208 s.

10. Anderson P. M. Power System Control and Stability / P. M. Anderson, A. A. Fouad. – Wiley-IEEE Press, 2002. – 672 pp.
11. Bayliss C. Transmission and Distribution Electrical Engineering / Colin Bayliss, Brian Hardy. – Elsevier, 2006. – 1040 pp.
12. Glover J. D. Power System Analysis and Design / J. Duncan Glover, Mulukutla S. Sarma, Thomas Overbye. – Cengage Learning, 2012. – 782 pp.
13. Grigsby L. L. Power System Stability and Control / Leonard L. Grigs-by. – CRC Press, 2012. – 450 pp.
14. Grigsby L. L. Power Systems / Leonard L. Grigsby. – CRC Press, 2012. – 556 pp.
15. Sarma M. S. Power Quality: VAR Compensation in Power Systems / S. R . Vedam, M. S. Sarma. – CRC Press, 2008. – 304 pp.

Section 5. Control, protection and automation of electric power systems

Topic 5.1. Theory of automatic control

General information about management systems. Management principles. The principle of compensation (principle of control by disturbance). The principle of open management. The principle of feedback (principle of deviation control). The principle of combined management. Mathematical description of control elements and systems. Linearization of differential equations. Forms of writing linearized equations.

Characteristics of linear links. Transitional link function. Frequency characteristics of the link. Amplitude-phase frequency characteristic. Amplitude-frequency characteristic. Logarithmic frequency characteristics. Mathematical modeling of automatic systems. Transformation of structural schemes of regulation objects. Basic linear regulation laws. Typical regulators and their characteristics.

Stability of linear systems. Lyapunov's theorem. Stability analysis by root method. Limit of stability in the root plane. Stability criteria. Algebraic criteria of Raus, Hurwitz,. Frequency criteria: Mykhailo, D-distribution, Nyquist. Analysis using logarithmic characteristics. Finding the critical values of the parameters and determining the margin of stability using various criteria.

Assessment of the quality of automatic control systems (ACS). Basic criteria for static and astatic systems.

Characteristics of nonlinear elements. Analysis of nonlinear systems by the method of harmonic balance. Analysis of nonlinear systems by phase trajectories.

Mathematical foundations of the theory of discrete ACS. Impulse element. Discrete signals. Lattice function. Digital regulators. Discrete signal conversion channel. Analog-digital converter. Delta pulse modulator. Digital-analog converter. Demodulator. Structural diagram of a discrete ACS with a digital regulator. Quality criteria of discrete ACSs with digital regulators. Stability of impulse

systems. Conditions for using the Hurvits and Mykhaylov criteria for stability assessment.

Topic 5.2 Automatic regulation in energy systems

Active power balance and alternating current frequency. Types of frequency and active power regulation. Primary frequency adjustment. Turbine speed regulators. Static frequency characteristics of the generating part of the power system. Static frequency characteristic of consumption. Combined static frequency characteristics of the generating part of the power system and consumption. The regulating effect of the load. Secondary regulation of frequency and active power. Organization of automatic regulation of frequency and power (ARFP) in the power association. System part of ARFP. Modes of operation of the system ARFP. Frequency and active power regulation methods. The mode-leading station method.

Regulation of voltage and reactive power in power systems. Means of voltage regulation in power systems. Flexible AC transmission systems (FACTS systems). Asynchronous mode in power systems. Signs of asynchronous mode. Ways to eliminate asynchronous mode.

Topic 5.3 Relay protection of electrical systems

Maximum current directional and non-directional protections. Primary measuring transducers in protection and automation systems. Relay protection of electrical systems, requirements and principles of operation. Functional and logical elements of automatic devices. Information sensors in relay protection and automation systems. Redundancy of action of relay protection and switches. Measuring bodies and the logical part of relay protection systems.

Protection of electric motors. Protection of transformers of power plants and substations. Protection of synchronous generators. Protection of the generator-transformer unit. Relay protection of buses of stations and substations. Automatic frequency unloading (AFU), purpose and principle of action. Automatic reactivation (AR), purpose and principle of action. Automatic switching on of backup power (ABP), purpose and principle of action.

References to Section 5

1. Yandul′s′kyy, O. S. Matematychne modelyuvannya system ta protsesiv. Matematychne zabezpechennya mikroprotsesornykh prystroyiv releynoho zakhystu i avtomatyky elektroenerhetychnykh system [Elektronnyy resurs] : navchal′nyy posibnyk / O. S. Yandul′s′kyy, O. O. Dmytrenko; pid zah. red. O. S. Yandul′s′koho ; NTUU «KPI». – Kyyiv : NTUU «KPI», 2016. – 60 s.

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Section 6. Electromechanical automation systems and electric drive

Topic 6.1. Electromechanical systems of automation and electric drive

Classification of automation devices, their main features. Automatic control systems (ACS), functional scheme of the ACS and its elements. Stabilization, software control, tracking systems. Open ACSs: compensatory and software control. Combined control. General information about ACS elements. Feedback in ACS. Feedback and gain.

Conditions of the equilibrium state of the automatic regulation system (ARS). Static characteristics with serial and parallel connection of links. Characteristics of links with feedback. Static error and gain. Contradiction of the requirements of statics and dynamics. Static error in combined control. Forms of writing equations of statics.

Compilation of equations of link dynamics. The method of drawing up equations. The principle of detection. Vyshnegradsky's hypothesis of small deviations. Linearization methods. Forms of recording dynamics equations. Operating form, etc. Typical sections of ARS. Equations and time characteristics of links.

Transfer functions, frequency characteristics of links. Assignment of transfer functions and frequency characteristics. Transfer functions and amplitude-phase frequency response (APFR) in series and parallel connection of links, for links with feedback. Logarithmic frequency characteristics, their features and purpose, construction of logarithmic characteristics. AFC and logarithmic characteristics of typical links.

Equations, transfer functions and APFR regulation systems. The equation of the open CAP, its transfer functions and APFR. The equation of a single-loop closed stabilization system. Obtaining the equation of a closed ACS with the help of Kramer's theorem. Equation of program (tracking) ARS. Obtaining the ARS statics equation. Transfer functions and AFCHH ARS for task and perturbation. Transformation of complex structural schemes of closed ACSs. Circuits with simple and cross feedback connections.

Concept of stability of linear systems. Lyapunov theorems. Analysis of stability by the type of roots of the characteristic equation. Limit of stability in the root plane. Stability criteria. Algebraic criteria of Raus-Hurwitz, Vyshnegradskyi. Frequency criteria: Mykhailov, D-breakdown, Mykhailov-Nyquist. Stability

analysis using amplitude and phase-frequency characteristics. Analysis using logarithmic characteristics. Finding the critical values of the parameters and determining the margin of stability using various criteria.

Study of stability of systems with transport delay. Structurally unstable ARS. Examples. Serial and parallel corrective links. Examples of adjustment of structurally unstable ARS.

ARS quality indicators. Features of quality analysis in linear systems. Quality analysis by type of roots of the characteristic equation. Degree of damping of transient processes. Problems of synthesis. Methods of synthesis of serial and parallel correcting devices. Use of logarithmic characteristics. General information about invariance. The invariance of the SAC relative to the disturbing influence. Implementation of invariance requirements.

The main types of nonlinearities. Methods and research of nonlinear systems. Method of phase trajectories. Concept of phase plane. Special points. Phase trajectories of stable and unstable systems. Research methodology. Stability according to Lyapunov. Concept of limit cycles. Harmonic linearization method. Relay ARS. Using the method of phase trajectories for the analysis of relay systems.

Discrete systems, their classification. Differential equations, transformations, transfer functions of impulse systems. Frequency characteristics of discrete systems. Methods of investigating the stability of impulse systems (criterion of Hurvits, Mikhailov, Nyquist, etc.) Synthesis of discrete corrective devices by the method of logarithmic pseudo-frequency characteristics.

Extreme ACS. Features and limits of application. Concept of utility function and optimal control.

General information about the electric drive. Purpose, features, tasks. Types of electric drives. Functional scheme of the electric drive.

The mechanical part of the electric drive. Kinematic and calculation schemes. Static loads. Accounting for losses. Equations of motion.

Direct current electric motors. Electromechanical characteristics. Natural characteristic. Types of artificial characteristics. Braking modes. Dynamic properties. Characteristics of direct current motors with series, mixed or combined excitation.

Asynchronous electric motors. Obtaining mechanical characteristics. Slip. Natural mechanical characteristics. Types of artificial characteristics. Braking modes. Construction of artificial characteristics. Dynamic properties.

Synchronous electric motors. The principle of action. Angular characteristic. Braking modes. Dynamic properties. Advantages and disadvantages.

Electromechanical system. Equations and structural diagram. Dynamic properties.

Optimal transient processes: speed, power consumption with moment limitation, acceleration or jerk. Working out stepwise control and disturbing influence. Smooth start. Reverse. Features of transient processes for alternating current electric motors.

Thermal transient processes. Nominal modes of electric motors. Methods of equivalent current, moment, power. Choice of engine power.
Adjusting the coordinates of the electric drive. Types of control and main functions of the electric drive. Frequency converter-asynchronous motor system. Precision. Adjustment range. Electric drive with subordinate adjustment of coordinates. Regulation of torque, current, speed.

References to Section 6

1. Popovych M. H., Koval′chuk O. V., Teoriya avtomatychnoho keruvannya: Pidruchnyk. – K.: Lybid′, 1997.
2. Teoriya elektropryvoda: Pidruchnyk / Za red. M. H. Popovycha. – K.: Vyshcha shkola, 1993.
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9. Sharuda V.H. Praktykum z teoriyi avtomatychnoho upravlinnya: Navchal′nyy posibnyk.- Dnipropetrovs′k: Natsional′na hirnycha akademiya Ukrayiny, 2002. 414s.
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11. Leonhard W. Control of Electrical Drives. (3rd edition) // Berlin: Springer-Verlag, 2001. – 460 p.
12. Bose B. K. Power Electronics and Variable Frequency Drives // IEEE Press, 1997. – 639 p.

Section 7. Electric machines and apparatus

Topic 7.1. Direct current machines

Design and principle of operation of a direct current machine (DC). Switching processes in the DC machines. Ways to improve switching: additional poles, brush offset, etc. Compensation winding. Expressions for electromotive force (EMF) and electromagnetic moment of the DC machines. The phenomenon of the anchor reaction and its effect on the magnetic flux of excitation. Traction DC machines. Performance characteristics of the traffic police with sequential excitation.

Topic 7.2. Transformers

Structure and principle of operation of the transformer. Classification of transformers. Transformation coefficient. Design of windings and magnetic circuit of three-phase transformers. Higher harmonics in the curve of magnetizing current, magnetic flux and phase EMF of three-phase transformers with different ways of connecting primary and secondary windings. Modes of non-working (idling) and short circuit of transformers. Short-circuit voltage and idling current. Losses in idling and short circuit modes. Experimental determination of parameters of the substitution scheme. Operation of transformers under load. Fundamentals of mathematical equations. Transformer replacement schemes. Vector and energy charts. Determination of transformer efficiency.

Topic 7.3. General questions of the theory of alternating current machines

Design of alternating current machines. Insulation of windings. Conditions for obtaining a rotating magnetic field in AC machines. Magnetic field of alternating current machines and its calculation. Inductance and mutual inductance of windings. Magnetic fluxes of mutual induction and scattering of windings. Electromotive forces of the coil, coil, phase of the AC winding. Winding coefficients. Ways to reduce higher harmonics in EMF. Bevel grooves. Magnetomotive forces of AC windings of machines. Higher harmonics of MRS.

Topic 7.4. Asynchronous machines

Equation of electrical circuits of stator and rotor windings. Bringing the rotor winding to the stator winding. Asynchronous machine replacement scheme. Operating modes of asynchronous machine: motor, generator, electromagnetic brake. Vector and energy charts. Methods of speed control of induction motors. Autonomous asynchronous generator. Conditions of self-excitation. Asymmetric modes of operation of asynchronous machines. Influence of power voltage asymmetry and winding parameters on mechanical characteristics of induction motors.

Topic 7.5. Synchronous machines

Synchronous machine in idle mode. Requirements for the distribution of the magnetic field in the air gap. The phenomenon of the anchor reaction in a synchronous machine and the factors that affect it. Parallel operation of a synchronous generator with the network. Conditions and methods of switching on a synchronous generator for parallel operation, V - similar characteristics,

regulation of active and reactive power of synchronous machine. Angular characteristics of a synchronous machine. Static and dynamic stability of the synchronous machine. Synchronous motor and synchronous compensator. Ways to start. Vector charts. Working and V - similar characteristics. Transient, asynchronous and asymmetric modes of operation of a synchronous machine. Inductive impedances of a synchronous machine in transient and asymmetric modes of operation.

Topic 7.6. Electrical appliances

Electrodynamic forces in electrical devices. Thermal processes in electrical appliances. Electrical contacts: definition and classification, their resistance, materials, contact heating, electrodynamic forces in contacts. Designs of low-voltage and high-voltage switching contacts. Electric arc and methods of its extinguishing. The selection of switching devices: general conditions for the selection of electrical devices. Protective devices: fuses and their choice, protective switching device, surge arresters and limiters, current-limiting reactors.

References to Section 7

1. Zahirnyak M. V., Nevzlin B.I. Elektrychni mashyny: Pidruchnyk. — 2-he vyd., pererob. i dop. – K.:Znannya, 2009. — 400 s. — ISBN 978-966-346-644-6
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Section 8. Alternative and renewable energy sources

Topic 8.1. Wind energy

The main parameters of wind flow and means of their description in time and space. Types of wind turbines and wind turbines. Their advantages and disadvantages. The main provisions of aeromechanical calculation of wind turbines. Features of electrical circuits of direct current (DC) wind turbines and their use. Features of electrical circuits of alternating current (AC) wind turbines and their use. Typical modes of operation of wind turbines (start, nominal mode,

stop) and algorithms for their implementation. Methods and technical means of stabilizing the speed of wind turbines.

Topic 8.2. Solar energy

The main parameters that characterize the flow of solar energy. Electrodynamic approaches to the description of the interaction of solar radiation with the atmosphere and structural elements of solar collectors and photovoltaics. Basic designs of solar collectors and photovoltaics. Models of electromotive force generation in photoelectric converters. Models of heat generation during the interaction of solar radiation with the elements of solar collectors and photovoltaics. Models of the thermal state of solar collectors and photovoltaics. Structures and schemes of active and passive systems of solar heat supply of buildings and constructions. Features of solar energy systems using concentrated solar radiation.

Topic 8.3. Conversion and accumulation of energy from renewable sources

The principle of operation of chemical current sources. Schemes of use of electric accumulators in power supply systems. The main types of electrochemical batteries of electric energy. Schemes of use of heat accumulators in heat supply systems. Principles of calculation of thermal and electric energy accumulators.

Topic 8.4. Integrated use of renewable energy sources

Energy technology units. Methods of optimization of parameters of combined heat supply systems. requirements for combined energy supply systems. Principles of construction of combined power supply systems.

Topic 8.5. Use of geothermal resources

Basic parameters of geothermal energy. Methods of modeling geothermal reservoirs and wells. Variants of geothermal energy use schemes for power supply needs. Typical schemes of geothermal resources extraction.

Topic 8.6. Use of other types of renewable energy sources

The principle of operation of power plants that use energy for small years. The principle of operation of wave power plants. The principle of operation of bioenergy plants. The principle of operation of power plants that use temperature and concentration gradients in seawater. The principle of operation of magnetohydrodynamic generators. The principle of operation of heat emission generators. The principle of operation of thermoelectric generators and thermal refrigerators. The principle of operation of compressor and absorption heat pumping units.

References to Section 8

1. Vstup do spetsial′nosti. Netradytsiyni ta vidnovlyuvani dzherela enerhiyi : elektronnyy kurs lektsiy / S.O. Kudrya, V.I. Bud′ko – Kyyiv: Natsional′nyy tekhnichnyy universytet Ukrayiny («KPI»), 2013. – 360 s.

2. Netradytsiyni ta vidnovlyuvani dzherela enerhiyi: pidruchn. / S. O. Kudrya. – K. : NTUU «KPI», 2012. – 492 s.

3. Osnovy konstruyuvannya enerhoustanovok z vidnovlyuvanymy dzherelamy enerhiyi : navch. posib. / S. O. Kudrya, V. M. Holovko. – K. : NTUU «KPI», 2011. – 184 s.

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Section 9. Systems of providing consumers with electric energy, electrotechnical complexes, electromechanical systems, automation of electrotechnical and electrotechnological complexes, energy management and energy efficiency

Topic 9.1. Electrotechnological and electrotechnical complexes

The efficiency of the use of electrical energy and its transformation into other types of energy in the implementation of electrotechnological processes.

Features of construction and operation of electromechanical and electrotechnical installations.

Automated control systems of electrotechnological and electrotechnical complexes.Diagnostic systems (systems of technical diagnostics), control and protection of electrotechnological and electrotechnical complexes.

Digital and analogandautomation systems of electrotechnical and electrotechnological complexes. Typical structures of analog and digital control systems. Conversion of analog and digital signals. Analog and digital filtering. Analog and digital PID controllers. Programmable logic controllers

Classification of electrotechnological installations as consumers of electricity.

Modern systems and means of energy and resource saving in electrotechnological installations. Increasing the energy efficiency of electrotechnological and electrotechnical complexes.

Topic 9.2. Elements of electrical engineering complexes

Electric machine converters. Uncontrolled AC rectifiers. Controlled thyristor rectifiers of single- and three-phase current. Current and voltage inverters. Resonant inverters. Thyristor and transistor AC frequency converters.

Semiconductor converters of alternating voltage. Voltage and current stabilizers. Pulse width converters. Pulse-phase control systems. Active filters. Filter-compensating devices. Electromechanical devices of automated electric drives. Sensors and setters of electric drive coordinates. Accumulators and energy accumulators for power supply (electrochemical, electrical, electromechanical): construction, principle of operation and main indicators.

Switching elements and their characteristics. Disconnectors and high-voltage switches. Commutators of impulse current sources. Semiconductor and superconductor current switches. Integrated modules and microprocessors.

Topic 9.3. Electromechanical systems

General functional scheme of the electromechanical system. Characteristics of typical loads of regulated electric drives. Calculation schemes and mathematical models of the mechanical part of electric drives. Equations of motion. Operating modes of electric drives. Modes of operation of mechatronic pulse systems.

Structural diagrams, control properties, dynamics quality indicators and statics of typical structures of electromechanical systems based on direct and alternating current electric drives according to the "controlled converter-motor" scheme.

Stability of linear and nonlinear systems. Algebraic criteria, frequency criteria, Lyapunov function, Popov criterion. Numerical methods of identification of nonlinear systems.

Microprocessor control of electrotechnical and electromechanical systems. Microcontrollers. Programmable logic controllers. Signal processors.

Topic 9.4. Power supply systems of technological and technical complexes

Structure and general characteristics of power supply systems. Theoretical justification of the estimated load. Practical methods of determining the calculated load. Requirements for reliability of power supply. Determination of parameters of elements of power supply systems (power transformers, networks with a voltage of up to and over 1000 V). Methods of calculating electrical energy losses in the elements of power supply systems, their scope of application. Organizational and technical measures to reduce electrical energy losses. The essence of the reactive power compensation problem. Compensation of reactive power in power supply systems. Indicators of the quality of electric energy and their standardization. Electromagnetic compatibility of electrotechnical and electrotechnological installations in load nodes of electrical networks.

Autonomous power supply systems. Characteristics of energy sources, types and main parameters of primary converters of electrical energy for autonomous power supply systems of stationary and mobile objects. Types of electric generators and structures of automatic control systems of electric generator installations with thermal energy, wind and water propulsion.

Hybridization of power sources. Autonomous power supply systems with renewable energy sources. Non-traditional and renewable energy sources.

Topic 9.5. Energy management and energy saving in energy systems and complexes

Main directions of energy saving policy. Main directions and reserves of energy saving.

Directions and tasks of energy management. Assessment and monitoring of energy consumption.

Economic and mathematical modeling of energy systems and complexes. Losses from shortages of energy resources and environmental pollution. Consideration of reliability in the optimization of energy systems, assessment of technical risks of innovative developments.

Topic 9.6. Theory of electric and magnetic circuits

Linear electric circuits of direct current (basic laws of electrical engineering). Features of calculation and methods of calculation of electric circuits.

Linear electrical circuits of alternating current. Single-phase and three-phase circuits. General characteristics.

Transient processes in linear circles. Features and methods of calculating transient processes (classical and operator method).

Nonlinear DC circuits. Methods of calculating non-linear electric circuits at constant currents and voltages in series, parallel and mixed connection).

General characteristics of direct current and alternating current magnetic circuits.

Energy characteristics and indicators of non-sinusoidal (non-linear) circuits.

Monitoring and diagnostics of nonlinear and magnetic circuit parameters. Computer modeling of nonlinear and magnetic circuits.

References to Section 9

1. Systemy elektropostachannya z aktyvnym spozhyvachem: modeli ta rezhymy [Elektronnyy resurs] : monohrafiya / S. P. Denysyuk, T. M. Bazyuk, M. M. Fedosenko, O. S. Yarmolyuk ; KPI im. Ihorya Sikors′koho. – Kyyiv : Avers, 2017. – 182 s.

2. Denysyuk, S. P. Otsinyuvannya yakosti elektropostachannya u lokal′nykh systemakh z dzherelamy rozoseredzhenoyi heneratsiyi [Elektronnyy resurs] : monohrafiya / S. P. Denysyuk, D. H. Derev″yanko ; KPI im. Ihorya Sikors′koho. – Kyyiv : KPI im. Ihorya Sikors′koho, 2019. – 166 s.

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zabezpechennya spozhyvachiv elektrychnoyu enerhiyeyu» ta «Enerhetychnyy menedzhment ta enerhoefektyvni tekhnolohiyi» / V. A. Popov, V. V. Tkachenko, O. S. Yarmolyuk ; KPI im. Ihorya Sikors′koho. – Kyyiv : KPI im. Ihorya Sikors′koho, 2021. – 163 s.

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III. RATING SYSTEM FOR EVALUATION OF THE ADMISSION TEST

1. The initial rating of the entrant for the exam is calculated based on a 100-point scale. When determining the overall rating of the entrant, the initial rating for the exam is converted into a 200-point scale according to the relevant table (paragraph 4).

2. At the exam, entrants prepare for an oral answer to the task of the exam ticket.

Each task of the complex professional entrance test contains three theoretical questions. The first two questions are common in the field of information technology. The last question is focused on special training of the entrant.

Each of the first two questions is evaluated with 30 points according to the following criteria:
- "excellent", complete answer, not less than 90% of the required information - 27-30 points;
- "good", a fairly complete answer, not less than 75% of the required information (minor inaccuracies are allowed) - 23-26 points;
- "satisfactory", incomplete answer, not less than 60% of the required information (the answer contains certain shortcomings) - 18-22 points;
- "unsatisfactory", the answer does not meet the conditions for "satisfactory" - 0 points.

The third question is evaluated with 40 points according to the following criteria:
- "excellent", complete answer, not less than 90% of the required information - 36-40 points;
- "good", a fairly complete answer, at least 75% of the required information (minor inaccuracies are allowed) - 30-35 points;
- "satisfactory", incomplete answer, not less than 60% of the required information (the answer contains certain shortcomings) - 24-29 points;
- "unsatisfactory", the answer does not meet the conditions for "satisfactory" - 0 points.

3. The sum of points for answers to the exam is transferred to the examination score according to the table:

Points	**Rating**
100… 95	Perfectly
94… 85	Very good
84… 75	Good
74… 65	Satisfactorily
64… 60	Enough
Less than 60	Unsatisfactorily

4. The sum of points for answers to the exam is transferred to a 200-point scale according to the table:

The table of correspondence of estimations of a rating system of estimation (RSE 60…100) to points of a 200-point scale (100…200)

Rate RSE	Points 100...200	Rate RSE	Points 100...200	Rate RSE	Points 100...200	Rate RSE	Points 100...200
60	100.0	70	125.0	80	150.0	90	175.0
61	102.5	71	127.5	81	152.5	91	177.5
62	105.0	72	130.0	82	155.0	92	180.0
6л	107.5	71	132.5	83	157.5	93	182.5
64	110.0	74	135.0	84	160.0	94	185.0
65	112.5	75	137.5	85	162.5	95	187.5
66	115.0	76	140.0	86	165.0	46	190.0
67	117.5	77	142.5	87	167.5	97	192.5
68	120.0	78	145.0	88	170.0	98	195.0
69	122.5	79	147.5	89	172.5	99	197.5
						100	200.0

IV. EXAMPLE OF EXAMINATION TICKET

National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute"

(full name of the higher educational institution)

Educational degree *doctor of philosophy*

Specialty *141 Electric power engineering, electrotechnics and electromechanics*

(name)

Academic discipline *Entrance examination*

PAPER ____ ____

1. Question 1

2. Question 2

3. Question 3

Approved

Guarantor of the educational program _____ Oleksandr YANDULSKY

The translation of the program of entrance examination into English performed by:

Associate Professor of
the Department of Theoretical Electrical Engineering _____ Yevhenii TROTSENKO

The program of the entrance examination for admission to the educational-scientific program of study for the doctor of philosophy in "Electric Power Engineering, Electrotechnics and Electromechanics" in the specialty 141 "Electric Power Engineering, Electrotechnics and Electromechanics" is recommended by:

Academic Council of the Faculty of Electric Power Engineering and Automatics
Chairman of the Academic Council _____ Olexandr YANDULSKY
protocol # 10 from "24" 04 2023

Academic Council of the Educational and Scientific Institute of Energy Saving and Energy Management
Chairman of the Academic Council _____ Serhii DENYSIUK
protocol # 9 from "26" 04 2023