

State doctoral exam topics

ELECTRICAL ENGINEERING AND COMMUNICATIONS

Section Electrical Power Engineering

1. Modeling and Analysis of Electrical Machines

Mathematical models of electrical machines, conditions of their validity and application in solving steady and transient states. Real and complex linear transformations of quantities of electrical machines, their meaning, definition, context, advantages and disadvantages. Effect of space and time higher harmonic voltages and currents on the behavior of AC electrical machines. Use of permanent magnets in electrical machines, their properties.

2. Compatibility and Influence of Semiconductor Converters on the Supply Network

Fundamental and higher harmonic currents and voltages in the power grid and in converters. Methods for reducing the content of higher harmonics in the network. Active, reactive and deformation power of semiconductor converters, converter as a source of high-frequency interference. High frequency filters. Methods of experimental detection of feedback effects of converters on the network, active devices with high compatibility.

3. Inverters and Frequency Converters

Principle of operation of voltage and current type inverters, principle of operation of two or multi level inverters. Typical topology diagrams of transistor and thyristor inverters. Methods of output voltage, current and frequency control. Principle of operation and connection of direct and indirect frequency converter. Principles of dimensioning and control methods of semiconductor converters.

4. Regulated Drives and Their Control

Synchronous and asynchronous motor powered by an inverter, topology, principles of dimensioning, mechanical characteristics, block diagrams of used control methods. Control schemes in general: methods of description, stability criteria, optimization criteria, types of used controllers and methods of their synthesis. Linearization of discrete systems, algorithms of used digital controllers, implementation using microprocessors.

5. Electric Drives for Traction and Their Control Parts

Specific requirements for traction operation. Types of drives used on dependent and independent traction vehicles. Used control strategies. Energy balance of operating modes. Components of HV and LV circuits of vehicles dependent and independent traction. Principles of design of main and auxiliary drives. Architecture of control systems used on vehicles and means of their implementation (analog and digital).

6. Technology of Electrical Energy Production

Classic and alternative electrical energy sources. Balance equations in devices for energy transformation, environmental impact. Dynamic characteristics of energy sources. Regulation programs, circuits and dynamic models. Operational modes of electrical parts in power stations. Systems of heat supply.

7. Control and Operation of Electrical Power Systems

Power systems dynamics, extraordinary states in electrical power systems. Optimization methods in electrical power engineering. Covering of load diagrams, prediction of energy consumption. Control of power balance, frequency and voltage. Cooperation of electrical power systems. Energy savings. Cogeneration processes.

8. Reliability and Safety in Electrical Power Systems

Power reserve in electrical power systems. Failure rate and operating lifetime of devices. Methods and conditions of electrical power systems interconnection. Liberalization in electrical power engineering, control methods of electrical energy supplies.

9. Transmissions and Distributions Systems

Methods of transmission and distribution systems design and operation. Technical devices for transmission and distribution of electrical energy. Power quality. Harmonics and subharmonics. Steady states and their solving methods.

10. Transient States in Electrical Power Systems

Modal analysis of electrical power systems and classification of transient states according to modes. Long-term and short-term dynamics. Longitudinal and cross faults and their combinations in complex systems, unbalance. Static and dynamic stability. Wave processes.

11. High Voltage Technique

Dielectric strength of electrical machines and devices insulation. Electrical discharges in insulation systems. Overvoltage, insulation coordination. Methods of insulation systems diagnostics.

12. Electrical Heat Devices

Modelling of heat and mass transfer and electromagnetic fields in electrical heat technology. Conception and construction of electrical heat devices. Control and environmental aspects of electrical heat devices.

13. Lighting Systems of Indoor and Outdoor Spaces

Light field. Spatial characteristics of lighting. Solving of illuminance, luminance and luminous flux distribution. Light sources and luminaires. Conception of lighting systems.

14. Materials

Internal structure of the basic group of materials (metals, polymers, ceramics, glass, composite materials) and the influence of the structure on the electrical, mechanical and other properties of these material groups. Progressive, new materials, constructions and technologies, their application in electrical engineering.

15. Characterization of Materials

Characterization of materials, diagnostic methods. Basic methods of chemical and structural analysis, overview of methods for material properties determination, microscopic methods, measuring methods of electrical conductivity, dielectric properties of materials.

16. Electrically Conductive Composites

Composites with electrical conductivity, matrix types, types and arrangement of used conductive fillers, percolation threshold. Conduction principles of Electrically Conductive Adhesives (ECA), basic ingredients (binder and filler) in ECAs and their influence on the properties of adhesive bonds, degradation of joints formed of electrically conductive adhesives. Electrically conductive adhesives with isotropic and anisotropic conductivity, the principle of electrical anisotropy, ECAs applications.

17. Degradation Processes

Mechanisms materials aging in electrical and electronic applications. Chemical and electrochemical corrosion, thermo-oxidative degradation and photo-degradation, electromigration and diffusion. Ergonomic and ecological aspects of electronic devices production. Cleanliness of the environment. Protection of components and equipment from the effects of static electricity.

18. Special Methods for Determining the Quality of Components

Diagnostics of electronic components. Measurement of electrical current noise and residual parameters in a wide frequency range. Measurement of non-linearity of volt-ampere characteristics. Measurement of small non-linearities of passive electronic components. Detection of non-linearity and intermodulation distortion.

19. Layer Deposition

Production technology with the use of plasma, high and low pressure sputtering, ion and plasma etching, plasma spraying. Beam technologies - electron beam, ion beam, molecular beam. Technology, deposition of thick layers. Thin film technologies - PVD and CVD and their modifications. Application and characterization of layers.

20. Photovoltaics

Solar energy and basic principles of conversion. Photovoltaic effect, photovoltaic cells, perspective materials in photovoltaics. Optimization of cell structure in terms of optical and electrical properties of individual layers. V-A characteristics of photovoltaic cells. Technological processes of production of basic types of photovoltaic cells and modules. Characterization and diagnostic methods, analysis of failure types, influence on durability. Photovoltaic systems (autonomous, connected to the grid). Components of photovoltaic systems.

21. Assembly Technology and Materials

Substrates for printed circuit boards, diversification of surface finishes, techniques for conductive patterns creation. Special techniques for the printed circuit boards manufacturing. Testing equipment for measurement and control of printed circuit boards. Chip encapsulation, chip contacting technology. Soldering in electrical engineering. Types of soldering technologies; materials used. Description of the issues and the causes of their occurrence. Testing, control, and diagnostic methods.

22. Quality Management Systems

Quality of technological processes. Quality management systems. Accelerated reliability tests. Processing and analysis of experimental data. Eligibility of the production equipment and manufacturing process; assessment techniques. Six Sigma quality management system and its implementation. Basic tools of the Six Sigma system. Reliability as a subset of quality. Mathematical distributions used in the field of reliability. Process control charts for measurement evaluation and comparison of their interpretation. Sampling procedures for inspection by measurement or evaluation, sampling plans, the risk of supplier and customer, acceptance characteristic.

23. Batteries and electrochemical sources

Structure, material composition, types of battery cells, and their production. Battery testing and their characteristics. Battery modeling, including electrical, thermal, electrochemical, and lifetime aspects. Battery management systems. Battery applications. Battery diagnostics and prognostics including state estimation. Battery waste treatment and second life, recycling - pyrometallurgy, hydrometallurgy. Economic and environmental aspects of battery technology (Life Cycle Assessment, ecodesign).

Elective Thematic Area (all sections)

Selection of a specific area should be based on the supervisor's recommendation, it should be related to the dissertation topic and concern the problems having been studied by the student from current scientific literature. The topic should be quoted in the application for the State Doctoral Examination.