FACULTY OF ELECTRICAL
ENGINEERING
UNIVERSITY OF WEST BOHEMIA

Topics of questions for the doctoral study interview, study program **Electrical Engineering and Informatics** the field of study **Electrical Engineering**

1) The integral form of Maxwell equations, distribution of symmetric stationary fields, calculation of capacitance, inductance and resistance for typical configurations, mutual inductance. Differential form of Maxwell equations, electromagnetic field potentials, boundary value problems for potentials.
2) Induced voltage (Faraday's law of induction, motion and transformation voltage). Physical nature of the skin effect (skin depth, the influence of skin effect on conductor parameters and Joule losses, ways of limitation, using possibilities of skin effect).
3) Nonlinear passive elements, static and dynamic parameters, linearization at a working point, analysis of simple nonlinear circuits in steady-state and transient processes. Transient processes in electrical circuits - initial conditions, steady-state, time responses in first and second-order circuits, method of state variables.
4) Transformers. Mechanical design of transformers. Principle of function. Transformer winding connection, vector group of transformer. Short-circuit voltage, parallel operation of transformers. Conversion ratio, relative quantities, surrogate diagram, phasor diagram. Unsymmetrical modes of transformers. Autotransformer and three-winding transformer. Transformation power and type-power of an autotransformer, properties, connections. Equivalent circuit of a three-winding transformer, determination of parameters, connection, type power, use.
5) Synchronous machines. Mechanical design of synchronous machines. Principle of operation. Magnetic anisotropy of synchronous machines (Ld/Lq ration). Synchronous machines with permanent magnets. Characteristics of synchronous machines. Equivalent circuit , phasor diagram, circular diagram. Induction machines. Mechanical design of Induction machines. Principle of operation. Wound rotor and squirrel-cage machines. Special types of cages of induction machines. Characteristics of induction machines. Equivalent circuit, phasor diagram, circle diagram.
6) DC machines. Mechanical design of DC machines. Principle of operation. Ways of connection of field windings of DC machines. Characteristics of DC machines depending on wiring. Equivalent circuit.
7) Parasitic phenomena in electrical machines. Unidirectional transformer magnetization. Time and space harmonics in an electric machine. One-sided magnetic pull. The third harmonic and its multiples in the magnetizing current.
8) Circular diagram of synchronous machine. Construction of circle diagram of synchronous machine, circle diagram with neglect and consideration of armature resistance. Synchronous machines on a hard network, V-curves. Active and reactive power control. Unsymmetrical modes of synchronous machines. Circle diagram of the asynchronous machine. Creation of circle diagram by means of circular inversion. Construction of a circle diagram based on measurements. Scope of validity.
9) Transient states on electric machines. Switching on an unloaded transformer, a sudden short circuit on the transformer. Sudden short circuit on the synchronous machine. Coil stress at short circuit. Dynamic behavior of the synchronous machine.
10) Constructive parts of electrical machines. Bearings of electric machines, ways of fixing individual components of the electric machine and their stress. Securing of stator and rotor beam. Shafts, shaft deflection, and critical speeds.

11) Thermal circuits. Heat sources in electric machines and their location. An analogy of thermal circuits with electrical circuits. Methods of solution of steady-state and transient states. Ways of heat dissipation. Methods of cooling of electric machines. Direct cooling, dual-circuit cooling, cooling of closed machines. Use of water and hydrogen cooling. Ventilation circuits. Sources of pressure in electrical machines. Assembly of ventilation circuits. Atkinson law and method of solution of ventilation circuits.

12) Engineering methods of drive analysis and synthesis (DC motor with external excitation). Frequency characteristics (ALFCH and FLFCH) of the open current (or speed) loop. Nyquist criterion. Influence of controller settings changes on phase safety and influence on system time response. Relation to zeros and poles of closed-loop.

13) Negative effects of drives with frequency converter to distribution grid. Power circuit (single-phase or three-phase bridge diode rectifier supplying voltage-type DC link). Input current and voltage waveforms for different inductance variants at the input and DC link. Negative effects of thyristor rectifier drives to distribution grid. Possibilities of reducing negative impacts.

14) Drive with rectifier and DC motor (with external excitation). Power circuit for the reversible variant in the rotor circuit and for the reversible variant in the excitation circuit. Function description of the blocks for all 4 drive quadrants. Description of the torque reversal on the torque characteristics (for the specified motor speed). Current regulator for DC drives with external excitation. Current loop as a sub-loop of the speed controller.

15) PMSM synchronous machine powered from the voltage inverter. Phase diagram for motor and generator mode for low speed ($i_{sd} = 0$) and high speed ($i_{sd} < 0$). Simplified power and control scheme. Regulators for controlling i_{sdw} and i_{sqw} currents. Examples of realization of the position sensor.

16) Wound induction (or squirrel-cage) machine as a generator. Mechanical power and power applied to the stator and rotor (wound rotor) for sub-synchronous and above-synchronous speeds. Examples of drives with DFIM dual-feed induction machine (description of used converters and directions of power flow in individual operating states). Squirrel-cage motor in generator mode - description of the function of individual blocks of the frequency converter with the possibility of recovery.

17) Basic approaches in electrical equipment diagnostics, comparison of testing and functional diagnostics, diagnostics of objects with sudden and successive failures, failure prediction, absorption characteristics, their recording and quantities determined from them - polarization indices, insulation resistance, internal and surface resistivity, dielectric losses and their measurement, aspects and parameters of the applied voltage test.

18) Gaseous and liquid electro-insulating materials (classification, characteristics, typical representatives and examples of their use), properties and use of magnetic materials in magnetic circuits.

19) Basic prerequisites for application of structural analyzes in the characterization of materials and material systems in electrical engineering, infrared spectroscopy, broadband dielectric spectroscopy, thermal analyzes - principles of selected methods.

20) Operating diagnostics of transformers, its off-and on-line methods, methods for checking the function of oils, regeneration of insulating oils, operational diagnostics of small and medium rotating electrical machines, workplaces for this diagnostics, principles, methods , methods of on-line diagnostics of large rotating electric machines, parameters characterizing discharge activity, methods of off- and on-line recording of discharge activity.

21) Connection structures in electronics (soldering, bonding, bonding, principles, procedures). Substrates for electronics (printed circuits, ceramics, microvia - principles, procedures), Composites in electrical engineering - types, applications

22) Process management and production management (principle, attributes, modeling, optimization, modern management principles)

23) Quality management and risk management (principles, standards, methods, and tools for management, implementation)

24) Thick- and thin-film technology, selective and non-selective deposition of functional layers, nanotechnology, functional printing materials, flexible and printed electronics

25) Acoustic quantities and their level expression. Sound propagation in space, basic types of acoustic fields. Basic acoustic sources in terms of their emission. Measurement of sound pressure, intensity, and sound power.

26) Measurement of electrical and non-electrical quantities: measurement of DC and AC active quantities (U, I, P - overview of methods, possibilities of instruments, their principles, and properties). Measurement of resistances and impedances (methods of measurement R, L, C, M, Z). Liquid flow measurement, volumetric and mass flowmeters, level measurement, Speed sensors, angular velocity, acceleration, accelerometers, vials, Force, pressure, torque sensors - types, properties and design of sensors, Temperature sensors - contact, non-contact. Problems of temperature measurement in industry.

27) Passive electronic components (principles, properties, parameters, construction), semiconductor electronic components (diodes, transistors, switching components - principles, construction, properties, parameters), optoelectronic and electro-optical elements (principles, properties, parameters, construction).

28) Description of material degradation due to an environmental, technological and operational environment. Reverse negative effects of individual elements on the environment and human organism. Problems of recycling and possible disposal of wastes of electrotechnical production.

29) Computer modeling of physical fields. Basic numerical methods and their computer implementation. Partial differential equations for the description of electromagnetic and temperature fields. Accuracy of the solution.

30) Advanced methods of physical field solution. Sensitivity analysis. Optimization techniques. Shape and topological optimization. Identification of material parameters. Formulation of substitute models and methods of system order reduction.

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Topics of questions for the doctoral study interview, study program **Electrical Engineering and Informatics** field of study **Electronics**

1) Characteristics of conductors, semiconductors and insulators, basic properties and principles of semiconductors, mathematical description of PN junction, physical characteristics of more complex semiconductor structures, LED, Laser.

2) Feedback in electronic circuits. Stability. Influence on frequency response, gain, input and output impedance. Operational amplifiers. Basic parts - differential amplifier, current mirror, etc. Correction of frequency response. Analysis of real amplifier characteristics, discussion of possible inaccuracies. Current feedback amplifiers, instrumentation amplifiers, isolation amplifiers.

3) Functional circuits: precision limiters, multipliers, logarithmic and exponential amplifiers, oscillation generators, relaxation and harmonic. LC and crystal oscillators. Generators of rectangular, saw and triangular oscillations. U/f and f/U conversion. Circuits with precision switches. Multiplexers, sampling circuits, switched capacitor circuits and Op-amp.

4) Linear and pulse regulators, a basic configuration of power circuits of linear regulators, pre-regulators, DC/DC impulse power supplies, and mains impulse power supplies, use, properties, reference voltage, and current sources.

5) A/D, D/A converters. Principles, errors. Sampling circuits. Frequency filters. Filter transfer functions, types of filters (types of approximations - Bessel, Butterworth, Chebyshev, technical parameters, practical implementation of filters). Digital filters, FIR, IIR, FFT. Topology, design, properties, transfer functions of filters. Implementation of filters - Salen-Key, universal filter, synthetic components, filters with switched capacitors. Transformation 1 / p. Impedance converters.

6) Basic interference couplings. The concept of symmetric and asymmetric noise source. Interference suppressors, filter insertion loss, interference suppression capacitor (ideal, real, class X, Y), noise suppression inductor (ideal, real, compensated, ferrite bead), suppression LC filters (power line, data), Measurement of electromagnetic interference. Classification of basic measurement methods according to interference. Electromagnetic immunity testing.

7) Microcomputers. Address, data, and control bus. Bus controller, bus timing, internal and external buses. Peripheral circuits of microcomputers, parallel, and serial I/O. DMA. Counters and timers. Diagnostic timers and other diagnostic tools. Memory circuits and systems. Static and dynamic RAM. EEPROM and FLASH memories, special memory types - FIFO, two-port memory. Analog inputs and outputs, PWM outputs, interrupts. Vectors. Sources of interruption internal and external, maskable and non-maskable.

8) Noise and interference in analog systems. Noise voltages of components - resistors, semiconductors. Modeling of noise sources in analog circuits. Noise analysis supported by Spice circuit simulators. Influence of signal source impedance on circuit noise ratios. Noise number, noise factor, Friis relation, equivalent noise temperature, passive element noise, active element noise, antenna noise temperature.

9) Extended two-port theory, scatter parameters, Smith diagram, analysis of two-port using scatter parameters, stability, and gain, impedance matching. Microwave components with lumped and distributed parameters, planar lines and its properties, planar microwave circuits.

10) Architecture and function of CPLD, FPGA programmable devices, realization of combinational and sequential devices in VHDL.

11) Description of LTI systems in the frequency domain, system frequency response, system function, time-frequency-time transition, Z-transform, description, and properties of discrete LTI systems, description of LTI systems in the time domain.

12) Sampling, sampling theorem, aliasing, quantization, coding, computer representation, rounding and trimming effect on calculation, distribution, properties and design methods of digital filters NRDF and RDF, use and influence of windowing method on properties of NRDF filters, filter structures, DFT, FFT, properties, applications, time decimation, frequency decimation, spectral analysis.

13) Measurement of electrical and non-electrical quantities: measurement of DC and AC active quantities (U, I, P - overview of methods, possibilities of instruments, their principles, and properties). Measurement of resistances and impedances (methods of measurement R, L, C, M, Z). Liquid flow measurement, volumetric and mass flowmeters, level measurement, Speed sensors, angular velocity, acceleration, accelerometers, vials, force, pressure, torque sensors - types, properties and design of sensors, temperature sensors - contact, non-contact. Problems of temperature measurement in industry.

14) Serial transmitter, synchronous and asynchronous transmission, principles, RS232 interface, RS485, CAN bus, basic features, coding methods, way of accessing the bus, frame types, frame formats, LIN bus, basic features, LIN network structure, data transfer method, LIN message format, USB - basic features, data transfer method, packet format and types.

15) Analog to digital conversion, sampling, quantization. Modulation, time and frequency domain. Constellation diagram. Baseband digital modulation (e.g. DM, PCM, DPCM, ADPCM). Digital modulation (ASK, FSK, PSK), M-ary modulation. Advanced digital modulations with carrier (GMSK, OFDM, QAM,…).

16) Radio signal processing. A radio receiver, receiver topology. Fading channel elimination, diversity systems, MIMO, SIMO, MISO, SISO. Radio broadcast systems FM, DAB, DRM.

17) Cellular networks. GSM, UMTS, LTE, 5G systems. Private networks PMR and PAMR (MPT 1327, TETRA, TETRAPOL,…). Voice and data services. VoIP. QoS. Optical networks. Types of fibers, their parameters, and use. Sources and receivers of optical radiation. Methods of sharing - WDM.

18) Channel capacity, symbol rate and bit rate, bandwidth. Electromagnetic wave propagation. Radio link budget, free space loss, Fresnel zones, design of communication system. Satellite communication systems, signal propagation delay, orbits for satellite communication systems. Global navigation satellite systems, GPS, Galileo,… Problems of sensitivity of electronic systems to ionizing radiation.

19) Display systems. PDP, LCD, DLP, OLED, ..., large-area display systems, 3D display systems. Physiology of image perception. Measurement of basic parameters of display systems. Methods of image signal processing (resolution interpolation, impulse noise suppression), measurement of image processing and reproduction quality (subjective, objective methods, reference, non-reference methods). Television broadcast systems. DVB-T, DVB-C, DVB-C. Video codecs (MPEG-2, MPEG-4, HEVC). IPTV.

20) Audio source coding methods - lossy, lossless. Structure of lossy codec, psychoacoustic model and its importance, errors arising from lossless and lossy audio coding - comparison. Application areas of lossy and lossless audio coding. Measurement of technical parameters of audio equipment, linear and non-linear distortion, noise voltages, dynamic range, examples of measurement parameters of analog and digital devices. Measurement of devices using lossy audio coding technique - objective measurement methods. The acoustics of listening room. Sound propagation. Electroacoustic converters.

21) Basic connection of rectifiers - comparison of basic types, inverter and rectifier operation, control and load characteristics, use of zero diodes, real commutation, interrupted and uninterrupted current of rectifiers - the ripple of uninterrupted current, interrupted current with a (i) DC motor and (ii) RC load, dynamic behavior of rectifier at interrupted and uninterrupted current, influence on load characteristics.

22) Voltage inverter with rectangular control - single-phase and three-phase connection, switching diagram, a control range of switching angle Ψ, load voltage and load current at $\Psi = \pi$, switching of reverse diodes. Voltage inverters with PWM - principle of a coincidence of carrier and modulation signal, comparison with rectangular control, the possibility of increasing the fundamental harmonic. Vector

modulation - transformation to space vector, creation of fundamental voltage vectors, improvisation of any voltage vector.

23) Indirect converters with voltage inverter and current inverter - variants of the power circuit, principle of operation, operating modes (motor, generator). Direct frequency converters with external commutation and self-commutation scheme, the principle of operation. Current inverters - thyristor with commutation circuits (two functions of commutation circuit), circuit solution with switchable components, PWM (embedded commutation, vector control).

24) Harmonic currents on the AC side of rectifiers - idealized waveforms, amplitude law, the influence of commutation angle, simultaneous operation of multiple converters. Influence of indirect frequency converters to the distribution grid - conditions of the converter with voltage inverter, generalized amplitude law, the influence of DC bus capacitance and inductance, real power factor. Ways of minimizing harmonics and power factor compensation in the distribution grid - without the help of additional devices, with the help of additional devices - network filters, dynamic power factor compensation.

25) Power circuits of DC drives powered from DC catenary - power circuits, operating modes (i) drive, (ii) regenerative braking, (iii) braking to resistance, control circuits. Current and voltage waveforms at the inverter output. Power circuits of drives with asynchronous motor - frequency converter with voltage inverter and diode or voltage-source rectifier. Operating mode drive, braking. Phase diagrams for the input and output side of the drive (for both modes), description of operation, evaluation.

26) Multi-level converters with clamping diodes - three-level variant power circuit, the principle of multi-level phase voltage of the inverter, switching diagram. PWM and polar control principle for this type of inverter. Multilevel converter with cascaded H-bridges - single-cell power circuit, cascading multiple cells. Principle of output voltage generation. Principle of PWM control. Multi-level converters with floating capacitors - three-level variant power circuit, the principle of multi-level phase voltage generation of the inverter, switching diagram. Principle of voltage balancing on floating capacitors. Principle of increasing the number of converter levels.

27) Thick- and thin-film technology, selective and non-selective deposition of functional layers, nanotechnology, functional printing materials, flexible and printed electronics.

28) Interconnection structures in electronics (soldering, bonding, principles, procedures). Substrates for electronics (printed circuits, ceramics, microvia - principles, procedures), Composites in electrical engineering - types, applications.

29) Acoustic quantities and their level expression. Sound propagation in space, basic types of acoustic fields. Basic acoustic sources in terms of their emission. Measurement of sound pressure, intensity, and sound power.

30) Passive electronic components (principles, properties, parameters, construction), semiconductor electronic components (diodes, transistors, switching components - principles, construction, properties, parameters), optoelectronic and electro-optical elements (principles, properties, parameters, construction).

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Topics of questions for the doctoral study interview, study program **Electrical Engineering and Informatics** field of study **Electrical Power Engineering**

1) Heat cycle of thermal power stations (technologic scheme diagram, h-s, T-s diagram of working medium). Comparison of heat efficiency in individual stages of steam production in a thermal power plants. Calculation of thermal power plant efficiency and possibilities of its increase. Calculation of thermal scheme of a power plant. Determination of the amount of heat required for transformation into electricity and the number of operating substances needed for production quantity, quality requirements and methods of treatment of operating substances.
2) Combined power production cycles (CC - combined cycle), cogeneration – combined heat power cycles (CHP), efficiency determination.
3) Nuclear power plants, thermal block diagrams of 1, 2 and 3 circuit NPP. Method of heat production in a nuclear reactor. Basic types and arrangement of nuclear reactors. Nuclear reactor design elements, fuel, moderator, coolant. Nuclear reactor physics, fundamentals of nuclear physics - atomic nucleus structure, basic forces, mass loss, binding energy, radioactivity, ionizing radiation, neutron interactions, chain fission reaction, neutron balance in the reactor, equation of four coefficients, neutron deceleration, xenon poisoning).
4) Measurement of reactor power - principles of measurement, neutron flux detectors, measurement ranges, measurement processing and evaluation, measurement errors. Reactor power control - principle, control elements and their characteristics, effect of control at individual reactor states.
5) Operating states of a nuclear reactor - physical and energetic starting, nominal load operation, nuclear reactor shutdown and nuclear reactor emergency shutdown; assessment of basic dynamic characteristics of a nuclear reactor.
6) NPP technology using pressurized water reactors (I.C. – II. C.) - safety systems, support systems, operating modes, nuclear safety criteria, in-depth protection, barriers, redundancy, diversity, independence).
7) Nuclear safety - classification of nuclear safety, in-depth protection system, analysis of emergency situations, project resources, enhancement of safety of nuclear power plants, control - STRESS tests.
8) Metrology of measurement in nuclear power plants - terminology, types of uncertainties, determination of measurement uncertainty, measurement range intervals. Basic parts of the measuring chain, reproducibility, repeatability, calibration, special tests, tests.
9) Renewable energy sources - overview, basic usage principles. Deployment of these sources when covering the daily load diagram, influence on power system control. Hydropower plants, hydroelectric power sets, types of turbines. Theoretical output of hydropower plants. Photovoltaic power plants, principle, connection, determination of their output.
10) The electrical part of power plants: electric schemes of plants, self-consumption of power plants, secured power supply. Sources of self-consumption and check of their output. Characteristics of drives of technological equipment in the plant's self-consumption. Voltage and current conditions during start-up, operation, and self-starting of electric motors in the self-consumption power supply system. Determination and check of the output of self-consumption power sources.

11) Characteristics of electric power networks. Voltage levels, transformer concept, network topology (use, operation, properties), way of transformer neutral connection (advantages, disadvantages, use, limit criteria for the choice of distribution system operation).

12) Equivalent circuits of network elements. Passive parameters of network elements (power line, transformer, inductor, capacitor, alternator, consumption) and their using in calculations.

13) Voltage, current and power conditions on the power line in symmetrical steady state. Methods of solution. Use of power line equivalent circuits, phasor diagrams. Special operating states (natural power, short-circuit, no-load state - Ferranti effect). Transmission capacity of lines.

14) Electric network under steady-state conditions - load flow solution. Method of nodal voltages. Nodal admittance and impedance matrix - the way of assembly, advantages, and disadvantages of use in load flow calculations. Load flow solution using iterative methods (Newton-Raphson, Gauss-Seidl).

15) Solving unbalanced failures using the symmetrical component method. Decomposition of an unbalanced system into symmetrical components. Series and shunt unbalance. Short-circuit calculation, detailed analysis of short-circuit current components for near-from-generator and far-from-generator faults. Characteristic parameters of short-circuit currents, limitation of short-circuit currents and their effects.

16) Transient phenomena in power systems, classification according to physical causes of their origin, duration, methods of their solution. Transient electromagnetic phenomena on the synchronous alternator, equivalent circuits, time behavior of near-from-generator short-circuit.

17) Static and dynamic stability of power transmissions - in the alternator system operating in the transmission system. Angular and voltage stability in ES. Means and methods for increasing the stability of the electric power system.

18) Electric power system control and regulation. Dispatching control. Regulation of frequency and transferred power, regulation of voltage and reactive power (methods, means). Basic concepts and means for voltage regulation in the distribution system, the influence of distributed generation on voltage conditions and voltage regulation.

19) Electric substations, their function in the electric power system. Substation layouts, structural design, devices, types and equipment of branches. Control of electric substations operation, operational manipulation in electric substations.

20) Dimensioning of electrical distribution equipment and devices - current carrying capacity and short-circuit conditions. Principles of dimensioning, thermal and mechanical stress of electrical equipment, check of the breaking capacity of switching devices. Design of electrical power lines - of mechanical and electrical properties. Basic criteria for sizing of conductor cross-section, selection of suitable conductor cross-section with respect to operational losses.

21) Electrical protection - principle, use, setting. Main and backup protections. Protection of network elements. Earth fault detection and localization. Voltage and current conditions in the network during an earth fault. Principle of single-line-to-ground fault detection in networks with directly, indirectly grounded or isolated neutral.

22) Industrial distribution systems, the basic concept of power supply, requirements for the availability of supply, expected power demand. Choice of transformers and their operation. Power factor correction in industrial plants, determination of necessary compensation power, compensation devices and their use.

23) Power quality, basic characteristics of the supply voltage (voltage magnitude and variations, voltage fluctuations, voltage unbalance, voltage dips, harmonics) and their influence on the operation of the network and connected devices, the feedback effects of the equipment on the distribution network and ways of their elimination.

24) Discharges on high voltage equipment. Gas discharges. Discharges along a solid insulator. Mechanisms of solid dielectric breakdown, electrical breakdown, partial discharges, thermal breakdown.

25) Voltage tests of high voltage equipment. Principles of tests with high alternating voltages and with high lightning and switching impulse voltages. Basic principles of insulation coordination. Lightning impulse overvoltage and protection against it, surge arresters.

26) Types of circuit-breakers (design, operating characteristics). Switching off small inductive and capacitive currents.

27) Switching process in DC and AC circuits - time intervals and spatial zones.

28) Testing of electromagnetic immunity of electrical equipment - principles, evaluation. Measurement of electromagnetic interference - principles, measuring equipment, evaluation, units. Reduction of disturbances in electrical circuits, elimination of over-voltages in low voltage networks.

29) Transformation of electric energy into useful heat, principles, advantages, importance. Application of thermal effects of the electromagnetic field. Heat generation and its propagation mechanisms. Mathematical description and definition of basic relations. Direct, inductive and dielectric heating - theory and applications. Use of electrothermal processes in practice.

30) Application of physical laws of heat transfer. Thermal quantities and their measurement. Increasing the efficiency of electrothermal devices.