State doctoral exam topics

ELECTRICAL ENGINEERING AND COMMUNICATIONS

Section Electronics a Measuring Techniques

1. Electron Devices

1.1 The crystal structure of the solid state, the energy band structure of semiconductor, the statistics of electron and holes, transport properties of semiconductors. The PN junction, the contact metal-semiconductor (MS), the heterojunction, the metal-oxide-semiconductor (MOS), 2D, 1D and 0D structures, applications in modern electronic and optoelectronic devices.

1.2 Application important discrete semiconductor devices for low and high power processing. Devices and structures for high-frequency applications. Power semiconductor devices. Principles, parameters and characteristics.

2. Integrated Circuits

2.1 Integrated circuit (IC) technologies. IC manufacturing processes and materials. Lithography, diffusion and ion implantation, thin film deposition, etching, passivation, packaging, nanotechnology. Unipolar and bipolar integrated structures. Rules and methodology for layout and interconnection, design rules; device models and model libraries. Parameter extraction for IC device model.

2.2 Synthesis of integrated systems, Digital ICs architectures and macroblocks. Application-specific and reconfigurable ICs, systems on a chip. Integrated analog blocks: amplifiers, voltage and current references, operational amplifiers – circuit optimization, topologies, design principles, noise.

2.3 Synthesis and realization of analog electronic circuits and filters. Filter synthesis and implementation using transconductance amplifiers, blocks operating in the current mode and discrete systems, methods of electronic circuit analysis and optimization.

3. Microsystems

3.1 Microsystems. Physical, chemical and biochemical principles of the operation. MEMS structures and similar ones (micro-electro-optical, micro-electro-opto-mechanical). Technologies. Signal processing. Design methods.

3.2 Microactuators. Physical principles of the operation, materials, structures, signal processing. Micro realization, design.

3.3 Microsensors and sensor systems. Physical, chemical and biochemical principles of the structure operation. Sensor signal processing. Smart sensors and systems. Application of sensors and microactuators in electronic systems and devices, EMC.

4. Optoelectronics

4.1 Principles used in integrated optics, photonics, and optoelectronics. Physical principles, specific properties, materials a technologies used in optoelectronics. Passive and dynamic optoelectronic components: coupling and connection elements, optical modulators and switches, optical multi/demultiplexers, microresonators, etc. Principles of light sources, light-emitting diodes, laser diodes and lasers.

4.2 Optical fiber waveguides. Principles of optical amplifiers: planar, fiber, solid-state (dielectric), semiconductor. Detectors of optical radiation: photoresistors, PIN photodetectors, avalanche photodetectors, photomultipliers, phototransistors.

5. Theory of Measurement

5.1 Basic concepts of representation and information theory of measurement: measurement scales and their types, expected measurement information, entropy value of the measurement error. Measurement errors: systematic and random errors, procedures for eliminating systematic errors, ways of reducing random errors, errors of dynamic measurements and possibilities of their correction, errors of digital measurements. Evaluation of measurement uncertainties: Type A and Type B standard uncertainties, combined and expanded uncertainties.

5.2 Physical principles utilized in realization of primary standards of electrical quantities. Experiment planning, analysis of influencing phenomena.

6. Measurement and Instrumentation

6.1 Digitization and reconstruction of signal: basic notions and phenomena - sampling theorem, statistical properties, quantization errors, spectrum aliasing and its elimination, signal reconstruction. Sampling circuits, A/D and D/A converters, improvement of A/D converters metrological parameters by an additional signal. Signal processing in the measuring technique.

6.2 Measuring instruments: digital multimeters; resistance and impedance measurement; measurement of time intervals, frequency and phase; digital oscilloscopes, signal generators; reference sources; lock-in amplifiers. Electronic circuits of measuring instruments.

7. Sensors and Transducers

7.1 Sensors and transducers for thermal quantities measurement, perspective measuring circuits. Methods and sensors for pressure, flow and level measurement. Sensors and transducers for measurement of mechanical and geometrical quantities, vibration and force, position and dimensions measurement. Sensors of linear and angular velocity and acceleration; sensors for force and torque measurement. Sensors for material analysis and nuclear radiation measurement.

7.2 Sensors for electrical and magnetic quantities, contactless current and voltage measurement. Sensor technologies and applications: new materials and technologies in sensor technology, intelligent sensors.

8. Systems for Data Measurement, Acquisition and Processing

8.1 Laboratory systems composed of individual instruments - basic properties and parameters; principle of communication; ways of programming. Measurement systems based on PC, their properties and programming. Industrial modular systems: used standard busses, programming of industrial modular systems. EMC of data acquisition systems.

8.2 Distributed measurement systems: basic division of industrial busses; physical layer - the used transfer media; measured data transfer: transfer channel - type, transfer capacity, coding, security.

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.