SCOPE OF QUESTIONS FOR THE FINAL EXAM - MSc. CONTROL, ELECTRONIC AND INFORMATION ENGINEERING

I. COMMON COURSES FOR ALL SPECIALIZATIONS

Advanced Optimization Methods

1. Duality in linear programming
2. Integer linear programming
3. Kuhn-Tucker conditions
4. Linear-Quadratic problem
5. Maximum principle

II. COMMON COURSE FOR SPECIALIZATION - AUTOMATIC CONTROL

Advanced Topics in Numerical Methods

1. List and compare the methods of solving systems of linear equations known to you
2. What is the Linear Discriminant Analysis and to which purpose it can be used?
3. What is the Principal Component Analysis and to which purpose it can be used?
4. Compare methods of crisp and fuzzy clustering
5. Compare methods of calculation of eigenvalues and eigen vectors known to you

Advanced Control

1. Phase plane analysis. Equations of phase trajectories, phase portrait. Properties of phase trajectories. Singular points and trajectories
2. Lyapunov definition of stability and asymptotic stability. Local stability, indirect Lyapunov method. Determination of equilibrium points. Global stability, direct Lyapunov method
3. Describing function method
4. Relay control systems analysis in phase plane. Stabilization of relay systems. Sliding modes
5. On-off relay control - time domain analysis
6. Extremal control systems. System with derivative sign examination. System with external modulating signal, synchronic detection, approximate system description and stability analysis
7. State observers. LQ observer based regulator

System Identification

1. Least squares method
2. How to identify a time-varying system?
3. How to identify the frequency response function?
4. Parametric and non-parametric models
5. How to validate a model?

Expert Systems

1. Give an operational definition of the artificial intelligence system. What is the aim of artificial intelligence as engineering idea?
2. Define expert system and describe its informatics' structure
3. Enumerate methods of the knowledge gathering and knowledge representation. Describe one chosen
4. Give aims of the forward (backward) chaining inference and present its basic ideas
5. What are the methods of uncertainty modelling? Describe one chosen

Modeling and Simulation of Industrial Systems

1. Modelling of lumped systems based on mass and energy conservation laws
2. Modelling of distributed parameter systems based on mass and energy conservation laws
3. Simulation of lumped and distributed parameter systems - methods for numerical integration
4. Model-based control - basic concept and example applications
5. Virtual commissioning of control systems - basic concept and example applications

Biotechnical Systems

1. Ecological problems with wastewater
2. Measurements in wastewater treatment
3. Processed for the removal of carbon, nitrogen and phosphorous compounds from wastewater
4. Control of activated sludge processes for wastewater treatment
5. Modelling of activated sludge processes

Programmable Controllers

1. Main features of programmable controllers
2. The principle of operation of programmable controllers
3. Plant-controller interface
4. Programming languages
5. Configuration of the controller

Sensors and Actuators

1. Sensors, smart transducers and HART protocol
2. Contact and non-contact temperature measurements and sensors/devices
3. Strain and pressure measurements, sensors and transducers
4. Acceleration sensors
5. Actuators

III. COMMON COURSE FOR SPECIALIZATION – DATA SCIENCE

Markov Models

1. Idea of Metropolis-Hastings algorithm
2. Types of Markov Chain (irreducible etc.)
3. Forward and backward algorithm
4. Properties of time reverse Markov Chains

Classifiers

1. Machine learning (main idea; basic concepts: supervised learning, unsupervised learning, reinforcement learning)
2. Feedforward neural networks and their learning algorithms
3. Assessing the quality of recognition systems; performance measures and testing/validation scenarios

Cloud Platforms

1. Cloud computing concept, properties, and models
2. Cloud resources and services for IaaS and PaaS models
3. Construction of a Datacenter
4. Scalability, availability, durability, and fault tolerance
5. Cloud security, economy, and pricing

Evolutionary Algorithms

1. Genetic algorithms, evolution strategies, memetic algorithms: chromosome coding, variation operators, population management
2. Ant system
3. Particle swarm optimization
4. Artificial immune systems
5. Simulated annealing

Formal Languages

1. Alphabet, formal language, classification of formal languages
2. Kleene's theorem and pumping lemma for regular languages
3. Automata for regular languages
4. Top-down analysis of context-free languages
5. Bottom-up analysis of context-free languages

Fuzzy Data Analysis

1. Define the fuzzy set and explain to which kinds of uncertainty representation it can be used
2. Explain the difference between the fuzzy set and the intuitionistic fuzzy set and provide examples of their use
3. What is the extension principle and in which way it is used in fuzzy control
4. What are similarities and differences in fuzzy analysis of data and analysis of fuzzy data
5. Define the two uncertainty measures in the Dempster-Shafer theory of evidence

Statistical Learning

1. Model selection approaches and selection criteria
2. Logistic regression as classifier
3. Correlation coefficient and its types
4. Unsupervised learning techniques
5. Feature dimensionality reduction methods (selection and extraction)

Knowledge Discovery

1. Principles of sequential covering approach to classification rule induction
2. Frequent itemset mining – A priori approach
3. Rule quality measures - precision, coverage, support, lift (definitions and applications)
4. Feature Selection – Rough Set based approach (reducts and relative (decision) reduct)
5. General outline of decision tree induction

Hadoop Ecosystem

1. V model, motivations, and usage scenarios of Big Data
2. Data models, scalable databases, their properties and comparison
3. Tools and frameworks of Hadoop ecosystem
4. Hadoop construction, MR processing, job execution
5. Big Data and Cloud complementarity

Data Mining in Practice

1. Performance evaluation of classifiers and regression models
2. Methods of splitting the data into train and test sets for models performance evaluation
3. Analysis of the actor role in social networks
4. Community identification in social networks
5. Visualisation of a social network

Applied Statistics

1. Multiple testing correction
2. Confidence intervals for population means
3. Statistical inference procedure (from hypothesis to conclusion)
4. Analysis of Variance (ANOVA)
5. Types of error in statistical testing

IV. COMMON COURSE FOR SPECIALIZATION - ELECTRONICS

Advanced Topics in Numerical Methods

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Programmable Logic Devices

1. General classification of Programmable Logic Devices: SPLD-s, CPLD-s, FPGA-s, architectures, programming technologies
2. CPLD-s: the general concept, architecture (Function Blocks, macrocells, expanders), routing, programming technologies, logic capacity, speed
3. FPGA-s: the general concept, architecture (CLB-s, specific elements like fast-carry logic, Block RAM-s, DSP Blocks, DCM-s), routing, programming technologies, logic capacity, speed
4. Electrical properties of advanced PLD-s: logic standards, and other I/O configuration options, power consumption, packages, programming
5. Design flow for advanced PLD-s, in particular (logic) synthesis, (physical) implementation, simulation, static timing analysis, power estimation

Electromagnetic Compatibility

1. Typical noise sources and coupling path for electromagnetic noise
2. Nonideal behavior of typical circuits components
3. Conducted emissions and EMI filters
4. Radiated emission and shielding against electromagnetic fields
5. Testing for EMC compliance (typical emission and immunity tests)

Optoelectronics

1. Optical transmitters – direct modulation (single transistor, logic gate, emitter coupled transmitters), indirect (external) modulation (phase, Mach-Zender, eletro-absorption, acousto-optic modulators)
2. Black-body radiation
3. Light and matter interactions – absorption, spontaneous emission, stimulated emission
4. Photodiodes (p-n, p-i-n, APD) – current-voltage characteristics, electrical model, spectral response, junction capacitance, solar cell
5. Optical receivers

Microelectronics

1. Technology of semiconductor single crystals as typical substrates
2. Technology and control of an ultrahigh vacuum for semiconductor microelectronics
3. Preparation and characterization of surface properties of semiconductor substrates
4. Technology of selected semiconductor electronic materials in the form of low dimensional structures
5. Surface analytical methods for control of surface properties of low dimensional electronic nanomaterials and structures

Sensor Networks

1. Sensor network protocol stack – layers and management planes
2. Wireless Sensor Networks topologies
3. Routing protocols in Wireless Sensor Networks – network structure-based protocols
4. IEEE 802.15.4 standard – frame types
5. MEMS – manufacturing technologies

Power Electronics

1. The Budeanu definitions of reactive and distortion power in circuits with non-sinusoidal current waveforms. Draw a power tetrahedron. Define Power Factor in the circuit with non-sinusoidal current waveforms (Budeanu theory)
2. What are 3 basic DC/DC converters – a short description and figures
3. Describe (the figure and the description) Clarke transform for the balanced 3-phase system. Draw 2 figures for the different sequence of abc phases. Where is the β axis
4. What is a general idea of the single phase Shunt Active Power Filter
5. Draw and describe the characteristics (the I-V curve) of a PV cell. Describe the idea of the Maximum Power Point Tracking method based on the analysis of dPPV/dVPV

Design for Testability

1. Defects, faults and errors in digital circuits
2. Automatic test pattern generation for digital circuits
3. Built-in self-test
4. Scan path and boundary scan path
5. Fault-tolerant digital circuits

Telemedicine

1. Principles of telemedicine – description
2. Basic characteristics of selected biomedical signals
3. Requirements for sensor networks in telemedicine
4. Characteristics of personal devices in single WBAN
5. Safety of biomedical telemetry

Verification of Digital Systems

1. Hardware description language – principles of description of parallel systems and description execution principles
2. Synthesizable construct requirements - hardware mapping limitation. Modelling and verifying timing properties of digital components and systems
3. Complex behavioral system modelling – Bus Functional Models, event driven modelling, transactors
4. Universal Verification Methodology (UVM) - concepts and methods, random testing
5. Programmable Language Interface – accessing the simulator structures from C. Principles of interacting with simulator using PLI/VPI or VHPI

Radiocommunication

1. Budget of a radio link
2. Comparison of the free-space and two-ray propagation models
3. Antennas. Parameters and constructions
4. Basic parameters of the receivers and transmitters
5. Noise in receiving systems. Noise figure of a transducer, noise floor, noise figure of the cascaded transducers - Friis equation

Systems on Chip

1. Language, grammar, context free language, BNF notation
2. Syntax diagram construction and application for analyzer building
3. Data flow graph – intermediate representation of statements semantics, optimizing the representation
4. Mapping the data flow graph to instructions – managing variables and optimizing generated instruction sequence
5. Mapping the data flow graph to hardware components using unlimited and limited resources. Scheduling concepts, resource sharing concepts and registers management