

# **Master of Science in Electrical Engineering**

## **RENEWABLE ENERGY SYSTEMS**

### **List of questions for the Final Examination**

**In effect since 01.10.2015**

#### **1. Numerical and optimisation methods:**

- a) one-dimensional search methods, golden section search,
- b) unconstrained minimization techniques, the steepest descent method,
- c) nonlinear constrained optimisation, Kuhn-Tucker conditions, Lagrangian function & duality,
- d) penalty methods, linear programming.

#### **2. Power system faults:**

- a) identification of faults – basic algorithms for fault detection, fault classification and direction discrimination,
- b) analysis of single phase-to-ground faults in high voltage networks,
- c) characteristic of different methods of neutral earthing in MV networks,
- d) digital fault locators – basics of application, fault location versus protection, application of different input data measurements.

#### **3. Dynamics and control of AC/DC drives:**

- a) torque and speed control structures of electrical drives,
- b) speed control methods of converter-fed DC motor drives,
- c) frequency controlled induction motor drives,
- d) artificial intelligence methods in electrical drive.

#### **4. Circuits and systems:**

- a) circuits synthesis, positive rational function, immittance function of driving point impedances, Foster synthesis for LC (inductance-capacitance) subclass,
- b) nonlinear circuit analysis, examples of nonlinear characteristic of nonlinear elements, graphical method, series or parallel connection of nonlinear elements,
- c) state variable, definition of state variable, method of system description using state variable, transfer matrix, excitation matrix, output matrix, application of eigen values for stability criterion,
- d) selected issues of continuous representation of deterministic signals, Fourier transform, relation of two-sided Laplace transform, signal parameters in time and frequency domain.

#### **5. Analog and digital measurement systems:**

- a) types of sensors and transducers in measuring systems,
- b) structure, classification and organization of digital measuring systems; functional blocks and their tasks,

- c) A/D and D/A converters uses in signal processing from the renewable energy sources,
- d) digitals systems for wind speed, wave energy and noise measurement.

#### **6. Power quality assessment:**

- a) power quality disturbances in relations to electromagnetic compatibility, review and classification of power quality disturbances,
- b) voltage fluctuations, definition of the phenomena, method of measurement and algorithm for parameters describing voltage fluctuations, possible origin of the phenomena, potential impact on the operation of electrical power system,
- c) voltage harmonics, definition of the phenomena, method of measurement and algorithm for parameters describing voltage harmonics, possible origin of the phenomena, potential impact on the operation of electrical power system,
- d) power quality report, standards and national regulations for the limits, aggregation time, measurement evaluation.

#### **7. Power electronics:**

- a) 2-, 3- and 6-pulse rectifiers, commutation, output characteristics, advantages and disadvantages of particular solutions,
- b) AC voltage controllers and cycloconverters control systems, common applications,
- c) transistor and thyristor DC-DC switch mode converters,
- d) PWM techniques and their applications.

#### **8. Advanced technology in electrical power generation:**

- a) cogeneration systems in energy production,
- b) clean energy production system from fossil fuels – oxyfuel, capture of carbon dioxide,
- c) environmental impact of energy production systems,
- d) nuclear fuel cycle, nuclear fission principles, types of reactors.

#### **9. Protection and control of distributed energy sources:**

- a) distribution networks and generators protection: applied criteria and solution schemes; network earthing issues,
- b) methods for islanding detection: characterization of different criteria used,
- c) protection of photovoltaic sources,
- d) voltage control and stability of distributed generation.

#### **10. Water power plants:**

- a) types and characteristics of the SHP: Basic types of turbines, turbine technology and parameters,
- b) types and energy parameters of the turbines: Pelton, Banki-Michell, Kaplan, Francis, Kinetic turbines; electrical diagrams,
- c) voltage control in hydro power stations,
- d) project analysis of hydro power stations: analysis of hydrological potential of the site, turbine choice, selection of generator, automation and protection.

**11. Renewable energy sources:**

- a) wind energy productions systems, technical aspects, wind energy markets, future of wind energy,
- b) interconnecting photovoltaic systems to the utility grid,
- c) hydro energy: small and large hydro applications, environmental aspects of small and large hydro,
- d) biomass energy: advantages and disadvantages, European biomass policy.

**12. Integration of distributed resources in power systems:**

- a) technical requisites for dispersed generators connection to the public electric power grids,
- b) dispersed generator contribution to voltage and frequency regulation in electrical power system,
- c) impact of dispersed generation on transient processes in electrical power system,
- d) the effect of dispersed generators on power quality and reliability of electrical power network.

**13. Electromechanical systems in renewable energy:**

- a) generators driven by high speed and low speed turbines,
- b) asynchronous generators with squirrel cage and slip-ring rotors,
- c) cylindrical generators with permanent magnet and wounded excitation,
- d) disc rotor synchronous generators.

**14. Simulation and analysis of power system transients:**

- a) digital models of linear elements (R, L, C) of an electric network,
- b) line model with distributed parameters,
- c) single phase saturable transformer model,
- d) numerical stability of digital models - numerical oscillations, suppression/elimination of numerical oscillations.

**15. Photovoltaic cells:**

- a) description of the photovoltaic effect, I-V characteristics, cells based on the Schottky barrier,
- b) thin film, polycrystalline photovoltaic cells, photovoltaic cells in cadmium telluride,
- c) photovoltaic modules, their parameters and characteristics; effect of various factors of the conversion efficiency in photovoltaic cells,
- d) photovoltaic power plants; accumulation of electrical energy from photovoltaic modules, concentrating solar power systems.

**16. Electromagnetic compatibility:**

- a) sources and parameters of electromagnetic interferences,
- b) electrical equipment and system protection against overvoltages, nonlinear protection elements: gas spark gaps, varistors, diodes, thyristors,
- c) lightning discharges as source of electromagnetic stress,
- d) electromagnetic shielding, effectiveness of shielding from electric and magnetic interference sources in near and far field, low frequency magnetic field shielding,
- e) voltage quality indices and parameters, disturbances influence on power supply system.

**17. Energy storage systems:**

- a) classification and main characteristics of different kinds of electrical energy storage in power systems,
- b) pumped hydro energy storage,
- c) compresses air systems (CAES) and flywheel systems,
- d) superconducting Magnetic Energy Storage (SMES), ultra capacitors.

**18. Artificial intelligence techniques:**

- a) expert systems: definitions, knowledge base, data base, inference mechanisms,
- b) ANN architectures and design problems,
- c) fuzzy logic in power system protection: fuzzy criteria signals, fuzzy settings, fuzzy comparison,
- d) genetic algorithms: genetic modifications of individuals, genetic optimisation rules, application examples.