RTU Course "Simulation of Electrical Processes"

11103 Industriālās elektronikas un elektrotehnol.katedra

General data

Code	EEP585
Course title	Simulation of Electrical Processes
Course status in the programme	Compulsory/Courses of Limited Choice
Course level	Post-graduate Studies
Course type	Academic
Field of study	Power and Electrical Engineering
Responsible instructor	Iļja Galkins
Academic staff	Maksims Vorobjovs
Volume of the course: parts and credits points	1 part, 5.0 Credit Points, 7.5 ECTS credits
Language of instruction	LV, EN, RU
Possibility of distance learning	Not planned
Abstract	The subject is devoted to simulation of electrical circuits. Principles of composing of differential equation systems for electrical equipment, of their numerical calculation, and its features in MATLAB are given in the first significant part of the course. The second part is devoted to PSPICE circuit description language and to the features of its practical utilization. The theoretical part of the course deals with solutions of ordinary differential equation systems and basics principles of PSPICE. The practical (most important) part of the course includes various examples of simulation of electrical equipment.
Goals and objectives of the course in terms of competences and skills	Teach a student to compose mathematical models for electrical equipment and to use it in the design, analysis and optimization of the equipment. Teach the student to solve numerically ordinary differential equation systems ant to estimate the accuracy of the calculations. Teach the student to use practically for the mentioned purposes the programs MATLAB, its graphical environment SIMULINK, circuit description language PSPICE, as well as schematic editors that allow this languages for purpose of simulation.
Structure and tasks of independent studies	Unassisted work of the students is concluded of various simulation exercises with MATLAB, SIMULINK programs, PSPICE circuit description language, as well as compatible schematic editors. The practical exercises may be performed during the class practice (laboratories) or at home.
Recommended literature	1. Brian R. Hunt, Ronald L. Lipsman, Jonathan M. Rosenberg, A Guide to MATLAB – for Beginners and Expirienced Users (Second Edition), Cambridge University Press, 2007, ISBN-13 978-0-521-61565-5. 2. John H. Mathews, Kurtis D. Fink, Numerical Methods Using MATLAB (Third Edition), Prentice Hall, Williams, 2001, ISBN 0-13-270042-5. 3. Raymond Ramshaw, Derek Schuurman, PSpice Simulation of Power Electronic Circuits – An Introductory Guide, Chapman&Hall, 1997, ISBN 0-412-75140-2. 4. Franz J. Monssen, OrCAD PSpice with Circuit Analysis (Third Edition), Prentice Hall, 2001, ISBN 0-13-017035-6.
Course prerequisites	Theory of Electrical Engineering, Higher Mathematics.

Course outline

Theme	Hours
(L) General information. MATLAB command window. MATLAB data types. Variables in MATLAB: numbers, vectors and matrices.	1
(L) Simple arithmetical operations with numbers, vectors and matrices. Solving of systems of linear algebraic equations.	1
(P) Entering variables and operations with data in the MATLAB command window. Saving/reading workspace data to files.	1
(L) Drawing of 2-dimensional and 3-dimensional diagrams. Adjusting of graphical parameters (colors, grids, titles etc.)	1
(L) Graphical user interface: windows, menus, pop-up menus, lists, push buttons, etc. Use of PC keyboard and mouse.	1
(L) Hierarchy of graphical objects. Properties of the most important objects and commands for their modification.	1
(P) Defining data for graphics. Drawing 2D and drawing the 3D diagrams. Modification of their graphical properties.	2
(L) Introduction to MATLAB executables. M-scripts. MATLAB tools for elaboration and debugging. Data import and export.	1
(P) Writing the commands from the previous exercise as M-script. Executing and debugging the M-script.	1
(P) Import data in MATLAB from real measurement equipment. Graphical representation of the imported data.	1
(L) MATLAB arithmetical, logical and relationship operators. Use of operators of relationship in together with logical.	1
(L) Control operators (conditions, switches and cycles) and their utilization to form complete programs.	1
(P) Defining a piece-monotonous function and drawing its 2D graphics from an M-script.	2
(L) Utilization of M-functions – input and output variables. Some useful MATLAB functions.	1
(L) Composing of M-functions: placement in M-files, transfer of the variables, global and local variables of MATLAB.	1
(P) Development of an approximation function with Fourier series. Its utilization to achieve specified accuracy.	3
(P) Harmonic (and other) analysis of experimentally measured data utilizing embedded MATLAB functions.	1

(L) Ordinary differential equations (ODE) and systems. ODE formulation for electric and electronic circuits.	2
(L) Numerical solution (integration) of ODE systems. Development of an original MATLAB function for ODE integration.	2
(P) Formulation of ODE system for a particular electrical circuit and its solution. Comparison of integration methods.	5
(L) Embedded MATLAB functions (solvers) for ODE integration. Its input and output parameters. Service functions.	1
(P) Development of MATLAB compatible ODE solver. Integration with embedded and original solvers. Comparison of results.	5
(L) SIMULINK: functional blocks, sources, sinks, connection of blocks, defining parameters, analysis and visualisation.	1
(L) Relationship between SIMULINK and MATLAB command window. Utilisation of M-functions in SIMULINK. S-functions.	2
(P) Development of models and simulation of power electronic converters in SIMILINK.	1
(L) Basics of PSPICE circuit description language. Description of R, V, I and D elements. DC analysis with PSPICE.	1
(P) Investigation of volt-ampere characteristics of a semiconductor switch utilizing DC analysis of PSPICE.	3
(L) Description of C, L, K, D, Q, M, B and Z elements. PSPICE models and their description. AC analysis with PSPICE.	1
(P) Investigation of resonant circuits (finding frequency an type of the resonance) utilizing AC analysis of PSPICE.	3
(L) Analysis of transient processes. Independent (V, I) and controllable sources (E, F, G, H) and their specifications.	3
(P) Analysis of transient process in particular electrical circuit with PSPICE. Comparison of MATLAB and PSPICE results.	3
(L) Setup of subcircuits: commands, parameters, formal connection and internal nets. Elasticity of subcircuits.	2
(L) Utilization of subcircuits: X element representing the subcircuit, real connection points, adjustment of parameters.	2
(P) Simulation of electronic circuits with operational amplifiers in PSPICE utilizing subcircuits.	3
(P) Simulation of power electronic converters with PSPICE utilizing subcircuits.	2
(L) PSPICE elements for analysis of digital circuits: U (logic), N (inputs), O (outputs). Specifications of U element.	2
(P) Simulation of digital circuits containing combinatorial and feedback digital components with PSPICE.	4
(L) PSPICE schematic editor. Getting symbols from libraries. Defining electrical connections. Setup of analysis.	1
(P) Simulation of power electronic converters with PSPICE schematic editor.	2
(L) PSPICE symbolic libraries: defining graphics, defining text models, attachment the models to the symbols.	2
(P) Design of the library element for an electronic component. Utilization of the element in PSPICE schematic editor.	6

Learning outcomes and assessment

Learning outcomes	Assessment methods
Ability to compose mathematical models, use them for numerical calculations and estimate the accuracy of the calculations.	The final quiz with 100% result provides 3 (of 9) points to the final mark.
Skills of practical utilization of the program MATLAB for simulation of electrical equipment.	Practical exercises solved in time provide 3 more points of 9.
Ability to identify basic constructions of the PSPICE language.	The final quiz with 100% result provides 2 (of 9) points to the final mark.
Skills of practical utilization of PSPICE language for simulation of electrical equipment.	Practical exercises solved in time provide 1 more points of 9.
Skills of practical utilization of the program SIMULINK and PSPICE compatible schematic editors.	There is an opportunity to gain up to 2 extra points for simulation (on the contest basis) of increased difficulty auxiliary exercises.

Study subject structure

Part	CP	ECTS	Hours per Week			Tests		
			Lectures	Practical	Lab.	Test	Exam	Work
1.	5.0	7.5	2.0	0.0	3.0		*	