COURSE DESCRIPTION CARD - SYLLABUS

Course name
MODELLING OF COUPLED PHENOMENA IN ELECTRICAL ENGINEERING [S5AEEITK>MZSSE]

Course

Proposed by Discipline
–

Year/Semester
2/4

Level of study
Doctoral School

Course offered in
English

Form of study
full-time

Requirements
elective

Number of hours

Lecture
4

Laboratory classes
0

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

1,00

Coordinators

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Lecturers

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Prerequisites

Knowledge: Knowledge on the key developmental trends in electrical engineering software and elementary knowledge of partial differential equations, electromagnetic systems and electrical machines. Skills: use the knowledge of elementary numerical methods and basic skills in computational research environments and computational techniques. Social competencies: acknowledge the importance of new computational methods and modern physics understanding in the development of technical sciences.

Course objective

Getting knowledge of the modern field methods in the analysis and synthesis of electromagnetic systems machines and drives.

Course-related learning outcomes

Knowledge:

A PhD student who graduated from doctoral school knows and understands:
1) key developmental trends of the modern field methods in the analysis and synthesis of the systems with electric and magnetic field [P8S_WG/SzD_W02]
2) the methodology of 3D electromagnetic field calculation in systems of low frequency [P8S_WG/SzD_W03]

3) the new approaches in electromagnetic field calculation [P8S_WG/SzD_W04]

Skills:

A PhD student who graduated from doctoral school can:
1) developed the method of electromagnetic fields calculation and can create new software for design of electrical machines and drives [P8S_UW/SzD_U01]
2) critically analyze the results of numerical method application in the design of electromagnetic systems and coupled filed problems [P8S_UW/SzD_U02]
3) share results of electromagnetic field calculation in a popular form [P8S_UK/SzD_U05]
4) plan research project with the application of new 3D methods of electromagnetic field calculation[P8S_UO/SzD_U09]

Social competences:
A PhD student who graduated from doctoral school is ready to:
1) critically assess the achievements in the electromagnetic field calculation, including the achievements proposed by commercial software [P8S_KK/SzD_K01]
2) can think and act in an entrepreneurial manner as a designer of modern electrical machines and drives [P8S_KO/SzD_K06]
3) maintain the ethos of research in electromagnetism, including independent activity in the numerical methods of electric drive calculation and design [P8S_KR/SzD_K07]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Solving a Research Problem – Assessment of knowledge and skills based on the independent solution of a research problem in the field of electromagnetism. The assessment will involve the use of specialized software for numerical modeling and analysis of electromagnetic fields. The assessment will focus on the correctness of the adopted assumptions, the approach to solving the problem, the analysis of the obtained results, and the ability to formulate conclusions.

Programme content

1. Description of electromagnetic field (Differential equations, integral equations, constitutive equations, circuit representation of electromagnetic field equations, scalar and vector potentials).
2. New approach of finite element method for magnetic and electric field (Nodal, elements, edge elements, facet elements and volume elements, circuit representation of finite element equations, edge and facet magnetic and electric network, coupled network in the analysis of electromagnetic field, time step method, method of complex variables).
3. Description of winding in finite element space (Multiply connected conductors in the edge element and facet element space, potential T0 in the coupled field-circuit models).
4. Movement simulation and electromagnetic torque and force calculation in the finite element method (Methods of movement simulation: (a) fixed grid method, (b) moving grid method. Virtual work principle for discrete models, network representation of stress tensor method and Lorentz formula).
5. Transformation of 3D models into the 2D network (Symmetry of magnetic and electric field in electrical machines and actuators. Plane and axisymmetric magnetic field, Equivalence of nodal and edge element finite element equations for 3D and 2D field).
6. Software for electromagnetic field calculation (Pre-processor, solver, post processor and the components of these three groups of software. Formulation of input date. Mapping of electric and magnetic field).

Course topics

1. Description of electromagnetic field.
2. New approach of finite element method for magnetic and electric field.
3. Description of winding in finite element space.
4. Movement simulation and electromagnetic torque and force calculation in the finite element method.
5. Transformation of 3D models into the 2D network.
6. Software for electromagnetic field calculation.

Teaching methods

Lecture: multimedia presentation including illustrations and examples.

Bibliography

Basic:
1. Silvester Peter P., Ferrari Ronald L., Finite elements for electrical engineers, Cambridge University Press; 3 edition, 1996
2. Demenko A., Obwodowe modele układów z polem elektromagnetycznym, Wyd. Pol. Poznańskiej, 2004, (in Polish)
3. Meunier G., The finite element method for electromagnetic modeling, John Wiley & Sons, 2008
4. Bastos João Pedro A., Sadowski Nelson, Magnetic materials and 3D finite element modeling, CRC Press, 2013
5. Dolezel I., Karban P., Solin P., Integral methods in low-frequency electromagnetics, Wiley and Son, New Jersey, 2009

Additional:
1. Bianchi Nicola, Electrical machine analysis using finite elements, CRC Press (2005)
2. Salon Sheppard J., Finite elements analysis of electrical machines, SPRINGER (SIE), (2006)
3. Hameyer Kay, Belmans Ronnie, Numerical modelling and design of electrical machines and devices, WIT Press (1999)
4. Demenko A., Symulacja dynamicznych stanów pracy maszyn elektrycznych w ujęciu polowym, Wyd. Pol. Poznańskiej, 1997 (in Polish)
5. Demenko A., J, Sykulski J., Network equivalents of nodal and edge elements in electromagnetics, IEEE Trans. on Magnetics, Vol. 38, March, 2002,
6. Demenko A., Representation of windings in the 3d finite element description of electromagnetic converters, IEE Proceedings Science, Measurement and Technology, Vol. 149, September 2002,
7. Demenko A., Wojciechowski R., Sykulski J., 2-D versus 3-D electromagnetic field modeling in electromechanical energy converters, IEEE Trans. on Magnetics, Vol. 50, No.2, 2014

Breakdown of average student's workload

	Hours	ECTS
Total workload	25	1,00
Classes requiring direct contact with the teacher	4	0,00
Doctoral student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation)	21	1,00