Module Description

Applied Electromagnetics

General Information

Number of ECTS Credits

3

Abbreviation

TSM_AppElm

Version

24.02.2016

Responsible of module

Prof. Dr. Jasmin Smajic, FHO

Language

	Lausanne	Bern	Zurich
Instruction	☐ E ☐ F	☐ D ☒ E ☐ F	☐ D ☐ E
Documentation	☐ E ☐ F	☐ D ☒ E ☐ F	☐ D ☐ E
Examination	☐ E ☐ F	☐ D ☒ E ☐ F	☐ D ☐ E

Module category

☐ Fundamental theoretical principles - FTP
☒ Technical/scientific specialization module - TSM
☐ Context module - CM

Lessons

☒ 2 lecture periods and 1 tutorial period per week

Brief course description of module objectives and content

This module offers a comprehensive introduction into electromagnetic field theory and its relevant applications, modern numerical methods for solving the field equations, and state-of-the-art simulation techniques.

Aims, content, methods

Learning objectives and acquired competencies

After successfully completing this course the student possesses the fundamental knowledge of the electromagnetic field theory that is sufficient for its successful application in daily design and product development. Additionally, the student has become acquainted with the finite difference time domain (FDTD) method and the finite element method (FEM) for electromagnetic simulations in the low- and high-frequency range. He has also gained experience with at least one modern simulation tool (available at his university, open source or freeware, etc.) and can efficiently use the simulation software in order to solve practical design problems.

Contents of module with emphasis on teaching content

1. Fundamental equations of the electromagnetic field theory (3 weeks)
    a. Maxwell equations
    b. Static und quasi-static analysis (dielectric design, computation of the electric capacitance and magnetic inductance, eddy currents, skin effect, proximity effect, and magnetic force)
    c. Emission, propagation and reception of electromagnetic waves
    d. Eigenvalue problems (waveguide, antenna, resonator, and optical fiber)
2. Finite difference time domain (FDTD) (3 weeks)
    a. 2-D and 3-D FDTD theory (Cartesian grid, discretization of Maxwell equations, stability criterion, etc.) and practical experience using Matlab
    b. FDTD simulations (wave propagation, antenna, etc.)
3. Finite element method (FEM) for electromagnetic simulations (3 weeks)
    a. Scalar FEM (electrostatic, magnetostatic, eddy currents, etc.)
    b. Vector FEM (3-D eddy currents, wave propagation, eigenvalue problems, etc.)

4. Practical applications (5 weeks)
    a. Dielectric simulations of high voltage devices
    b. Eddy-current analysis
    c. Electromagnetic simulations of electrical machines
    d. Eigenvalue analysis of filters and waveguides
    e. Electromagnetic simulations of RF-antennas
    f. Electromagnetic analysis of microstrip structures
    g. Electromagnetic compatibility (EMC and EMI)
    h. MRI-applications
    i. Electromagnetic meta-materials

Teaching and learning methods

Ex cathedra, practical exercises and case studies.

Prerequisites, previous knowledge, entrance competencies

Knowledge of vectors, multivariable functions, ordinary- and partial differential equations.

Own laptop computer is also necessary.

Literature

J. Smajic, “How to Perform Electromagnetic FE Analysis”, NAFEMS books, Hamilton, Scotland, January 2016

Assessment

Certification requirements for final examinations (conditions for attestation)

Successfully completed own simulation project.

Written module examination

Duration of exam:	120 minutes
Permissible aids:	Lecture notes