POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name

Electromagnetic compatibility and environmental exposure [S1Eltech2>PO10-KEiNS]

Course

Field of study
Electrical Engineering

Year/Semester
4/7

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
elective

Number of hours

Lecture
15

Laboratory classes
15

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

2,00

Coordinators

dr hab. inż. Rafał Wojciechowski prof. PP
rafal.wojciechowski@put.poznan.pl

dr inż. Milena Kurzawa
milena.kurzawa@put.poznan.pl

dr hab. inż. Paweł Idziak
pawel.idziak@put.poznan.pl

Lecturers

Prerequisites

A student commencing the course should possess basic knowledge of electrical engineering, electric circuit theory, and the fundamentals of electromagnetic field theory, as well as knowledge related to the generation, transmission, and processing of electrical energy. The student should be able to analyze simple electrical circuits and solve basic engineering problems typical of an electrical engineering program, as well as demonstrate the ability to independently supplement and update their knowledge. The student should be aware of the necessity for continuous development of their own competencies, be prepared to work in a team, and comply with the rules applicable during lectures and laboratory classes, including occupational health and safety regulations.

Course objective

The aim of the course is to familiarize students with the fundamentals of electromagnetic compatibility (EMC) of electrical devices and systems, as well as with issues related to human and environmental exposure to low- and high-frequency electromagnetic fields. The course also aims to provide knowledge on the sources and mechanisms of electromagnetic interference, methods for its mitigation, and the principles of measurement and assessment of compliance with normative and legal requirements. As part of laboratory classes, students acquire practical skills in identifying electromagnetic interference, performing basic EMC measurements, and assessing levels of exposure to electromagnetic fields, with due consideration given to safety principles and engineering responsibility.

Course-related learning outcomes

Knowledge:
1. Has advanced knowledge and understanding of the laws and phenomena of electrical engineering, particularly in the field of electric circuit theory and electromagnetic field theory.
2. Has advanced knowledge and understanding of issues related to electrical and electronic metrology; possesses knowledge of the properties and operation of measuring equipment used in electrical engineering.
3. Has knowledge enabling an understanding of the fundamental dilemmas of contemporary civilization related to the generation, processing, storage, and distribution of electrical energy.
4. Possesses the knowledge necessary to understand non-technical determinants (including economic, legal, and ethical aspects) of the professional activity of an electrical engineer; is familiar with basic principles of occupational health and safety and ergonomics, as well as hazards related to electrical engineering.

Skills:
1. Is able to perform a critical analysis and evaluation of the operation of existing electrical devices, circuits, and systems using appropriately selected methods and tools.
2. Is able to plan and conduct simulation-based and physical experiments, including performing measurements, testing, and diagnosing simple electrical circuits and devices.
3. Is able to assess the suitability of, select, and apply basic methods and tools used to solve practical engineering problems typical of electrical engineering.

Social competences:
1. Is ready to make use of scientific achievements and to consult experts in the field of electrical engineering in order to effectively solve engineering problems that go beyond his or her own competencies.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture:
Verification of learning outcomes is carried out through a written problem-based assessment test evaluating the level of mastery of theoretical knowledge and the ability to apply it to the analysis of issues related to electromagnetic compatibility and exposure to electromagnetic fields. In addition, continuous assessment is applied, consisting of rewarding student activity during lectures as well as the substantive quality of their contributions and participation in discussions.
Laboratory:
Verification of learning outcomes is conducted through entry tests covering the knowledge necessary to perform individual laboratory exercises, continuous assessment of student activity during classes, and evaluation of practical skills related to performing measurements, analyzing results, and completing laboratory tasks. The quality and completeness of laboratory reports are also assessed, including their substantive correctness, the manner of presenting results, and the formulation of conclusions. Social competences are verified through the assessment of teamwork, compliance with organizational and safety rules, and a responsible approach to assigned tasks.

Programme content

Lecture:
Concepts of electromagnetic compatibility (EMC) and environmental interference - definitions, scope,

and significance in electrical engineering; sources of electromagnetic interference in electrical and electronic devices and systems; mechanisms and coupling paths for electromagnetic disturbances: conducted and radiated; standards and legal regulations related to EMC; electromagnetic emission and immunity of electrical and electronic devices, permissible levels of exposure to electromagnetic fields - normative and legal requirements; methods for measuring and assessing exposure to electromagnetic fields; occupational health and safety principles related to exposure to electromagnetic fields; fundamentals of EMC measurements - methods, equipment, and measurement setups; effects of electromagnetic fields on living organisms and the environment.
Laboratory:
Implementation of laboratory exercises on EMC disturbance measurements, investigation of the influence of shielding and grounding on electromagnetic disturbance levels, testing the effectiveness of interference suppression filters, measurement of electromagnetic field levels around selected electrical devices, assessment of measurement results’compliance with normative requirements, and simulation of EMC processes using the specialized CST Studio Suite software.

Course topics

Lecture:
1. Introduction to EMC
Basic definitions: compatibility, emission, immunity, disturbance margin.
Decibels in EMC - review and applications.
Classification of disturbances: natural vs. artificial, continuous vs. impulsive.
Signal spectrum and interference potential.
2. Mechanisms of Disturbance Generation and Coupling
Sources of interference in power and electronic systems (converters, switching, discharges).
Galvanic coupling (through common impedance).
Capacitive (electric) and inductive (magnetic) coupling.
Coupling via electromagnetic waves (radiated).
3. Legal Aspects and Standardization
EMC Directive and CE marking - conformity assessment procedure.
Key standards families (PN-EN 61000, ISO, CISPR, FC, product standards, general standards).
Distinction of requirements for industrial and residential environments (ICNIRP, IEEE C95).
Device classes and permissible emission levels.
4. EMC Measurement Methodology
Measurement equipment: spectrum analyzer, measuring receiver, LISN (Line Impedance Stabilization Network).
Measurement setups: OATS (Open Area Test Site), anechoic chambers (SAC/FAR), GTEM chambers.
Detectors (peak, quasi-peak, average) - differences and applications.
5. Methods for Reducing Disturbances
Filtering: line filters, current-compensated chokes, ferrite beads.
Shielding: shielding effectiveness, materials, influence of openings and gaps.
Grounding and signal/mass routing: ground loops, multipoint vs. single-point grounding.
6. Environmental Hazards and Effects on Living Organisms
Thermal and non-thermal effects of EM fields on biological tissues.
SAR (Specific Absorption Rate) - definition and significance.
Effects of low-frequency fields (high-voltage lines) vs. high-frequency fields (telecommunication).
7. Field Strength Measurements and Occupational Safety
Regulations concerning environmental protection (EMF exposure) and worker safety (OHS).
Protection zones (intermediate, hazard, danger).
Methods for determining zones and assessing occupational exposure.
Laboratory:
1. Introduction to Measurements and Equipment Handling
Laboratory safety (OHS).
Operation of spectrum analyzer: Wavecontrol.
Measurement of RLC parameters.
2. Conducted Disturbance Measurements and Filter Effectiveness
Measurement of conducted emissions (e.g., from a switching power supply using LISN).
Comparison of raw spectrum vs. spectrum after application of commercial line filters.
Analysis of common-mode and differential-mode components.
3. Shielding Effectiveness and Grounding Influence

Measurement of attenuation for different shielding materials (solid sheet, mesh, composite materials).
Investigation of shield continuity (gap simulation).
Demonstration of ground loop influence on disturbance levels in signal paths.
4. Field Strength Measurements Around Devices - Environmental Hazards
Use of broadband field probes (E- and H-field).
Mapping field distribution around selected sources (e.g., microwave oven, transformer, Wi-Fi transmitter).
Evaluation of results (protection zones).
5. EMC Simulation in CST Studio Suite - Part 1
Introduction to CST environment: interface, solvers, material definitions.
Modeling a simple interference source (e.g., dipole, PCB trace).
Visualization of E- and H-field distribution in space (near-field).
6. EMC Simulation in CST Studio Suite - Part 2
Simulation of shielding effectiveness in CST.
Modeling an enclosure with a ventilation hole - analysis of wave penetration.
7. Assessment and Case Study Analysis
Compliance check: students are provided with measurement results for a hypothetical device and must determine whether it meets the given standard (Pass/Fail).

Teaching methods

Lectures - presentations with personal participation, illustrated examples, and discussion topics;
Laboratory - simulation and laboratory testing of selected electronic and electrical systems.

Bibliography

Basic:
[1] Steve Roberts, Jose ne Lametschwandtner, EMC BOOK OF KNOWLEDGE, 2023, RECOM Engineering
GmbH & Co.KG, Austria.
[2] Borecki M., Sroka J., Kompatybilność elektromagnetyczna: pomiary i badania, Oficyna Wydawnicza Politechniki Warszawskiej, 2021
[3] Brejwo W., Wybrane zagadnienia kompatybilności elektromagnetycznej, Wojskowa Akademia techniczna, 2009
[4] Machczyński W., Wprowadzenie do kompatybilności elektromagnetycznej, Wydawnictwo Politechniki Poznańskiej, 2010

Additional:
[1] Wojciechowski R. M., Kurzawa M., Idziak P., Kowalski K, Elektromagnetyczne zagrożenia środowiskowe: silniki elektryczne zasilane z przekształtników energoelektronicznych vs. wytyczne standardu ICNIRP, PEMINE: problemy eksploatacji maszyn i napędów elektrycznych: materiały konferencyjne, 2025: Sieć Badawcza Łukasiewicz - Górnośląski Instytut Technologiczny, 2025 - s. 141-143

Breakdown of average student's workload

	Hours	ECTS
Total workload	55	2,00
Classes requiring direct contact with the teacher	30	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	25	1,00