1EL1010 – Radiation and propagation

Instructors: Dominique Lecointe
Department: DÉPARTEMENT ÉLECTRONIQUE ET ÉLECTROMAGNÉTISME
Language of instruction: FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 35,00

Description

Maxwell's theory has been a source of innovation and technological progress for more than a century and it is remarkable to note the extent of the industrial sectors impacted by the applications of this theory :
- the telecommunications sector at the heart of the information society,
- the aeronautics, automobile and transport sector,
- the electrical energy sector,
- the defense and security sector,
- the health and environment sector,
- the building and public works sector,
- the internet and connected objects sector.

For the 21st century engineer, the mastery of electromagnetic theory can not be ignored. But in an environment where the technological challenges are more and more complex, how does the engineer deal with the problems, what are the means at his disposal to solve them? This approach will be the thread of this course of electromagnetism. Starting from varied and concrete applications, this course presents the approach of an engineer to move from a real scene to the equation setting in the form of an electromagnetic problem, then the transition to resolution by use most often of specialized digital tools. The presented problems and their theoretical formulations will cover a broad spectrum of frequencies: from the continuous, via radio frequencies and microwaves to optics. The focus will be on the different types of problems, in particular, free and guided propagation and radiation. The small classes will allow a practical application on a wide variety of problems: free propagation and interference, guided propagation and optical fiber, radiation and antennas... The rise of digital tools has radically transformed the methodology for solving electromagnetic problems. Several small classes will use industrial electromagnetic software to illustrate the current approach of an engineer for solving electromagnetic problems.
All these technological advances, the use of electronic and electromagnetic systems in more and more extensive industrial fields, are not without

counterpart : electromagnetic pollution. this course does not ignore this societal issue and will address the 2 aspects of this problem : electromagnetic compatibility and exposure of people to electromagnetic waves.

Quarter number
SG1 and SG3

Prerequisites (in terms of CS courses)
None

Syllabus
1. Introduction

presence of electromagnetism in many industrial sectors
diversity of applications of electromagnetism
importance of digital simulation - state of the art for digital tools
course content and links between parties - course situation throughout the course

2. Equations of an electromagnetic problem: the 3 pillars

from the real scene to the setting in equation: phase of modeling study in temporal or in harmonic regime
first pillar: Maxwell's equations general case
second pillar: constitutive equations of media - most classical models - linearity, homogeneity, isotropy, dispersion
third pillar: equations of passage from one medium to another - writing according to the choice of medium models
link with digital tools (CST example)
Application: Digital TD: CST Presentation and Getting Started

3. Synthesis : the different types of problems: objective, associated hypotheses and simplification, iconic applications
quasi-stationary states
spread
influence
diffraction

4. Free propagation
plane wave
polarization of a plane wave
example of another solution - Gaussian bundles
propagation in a conductive medium - skin thickness
transmission of a wave from one medium to another
continuous monitoring of knowledge: MCQ

application: TD: duplexer
application: TD: polarimetry

5. Guided Propagation : Theory of Guides
physical approach of the modes through the parallel blade guide
theoretical development - TE, TM, TEM mode
example of the rectangular guide
example of the coaxial guide
application: TD: optical fiber
Application: Digital TD: Coaxial Line Transition - Rectangular Guide

6. Guided Propagation : Line Theory
from the TEM mode to the line theory
line theory
adaptation
application: TD: realization of an adaptation circuit for micro-ribbon line

7. Radiation and antennas
radiated field - far field
electromagnetic correlation
Huygens theorem
antenna technology
antenna characteristics (experimental approach) - gain and directivity
radiation pattern - input impedance
link budget
continuous monitoring of MCQ knowledge
application: TD: antenna
application: TD digital: realization of a Yagi antenna

8. Societal and Environmental Issue : Electromagnetic Pollution
electromagnetic compatibility
exposure of people to electromagnetic waves
application: digital TD: penetration of waves through an opening - equivalent dipole method

9. Visit of the test facilities used in electromagnetism
anechoic chamber
reverberation chamber
dosimetric base

Class components (lecture, labs, etc.)
12 lessons of 1h30, 6 TD of 1h30, 4 Digital TD of 1h30, and 1 final exam written of 2h00.
All occurrences are presented in French.

Grading
1 final exam written without documents of 2h00.

The skills acquired will be validated during the final check. Identified questions will validate milestones 1 of competences C1 and C2. At least two questions per skill. The student who obtained the average on the questions associated with the competency assessed will validate milestone 1.

Course support, bibliography

Course and Exercises books.

Slides projected during the course (EDUNAO)

Techniques micro-ondes de Marc Hélier, édition Ellipses

Resources

• Teaching staff (instructor(s) names): Dominique Lecointe, Dominique Picard

• Maximum enrollment (default 25 students): In general, 2 groups in digital TD will alternate with 2 groups in traditional TD.

• Software, number of licenses required: MWS software.

• Workroom (department and capacity): Computer rooms (2 computer rooms with 25 workstations) for digital TD

Learning outcomes covered on the course

At the end of this lesson, the student will be able to:

- put in equations a realistic problem by the choice of more or less complex models.
- to judge the relevance of the models and their limitations.
- choose a resolution methodology that includes modern simulation tools.
- to master, from theory to practice, the structures of electromagnetic waves propagating in a given medium.
- to master, from theory to practice, the systems allowing the propagation of an electromagnetic signal.
- to master, from theory to practice, systems radiating an electromagnetic signal.

These different learning outcomes validate milestone 1 of competency C1.2 (Knowing how to use a model presented in class in a relevant way (model describing a phenomenon, without couplings) Choosing simplifying hypotheses adapted to the studied problem .).

Description of the skills acquired at the end of the course

The different learning outcomes validate milestone 1 of skill C1.2 (Knowing how to use a model presented in class in a relevant way (model describing a phenomenon, without any coupling) Choosing simplifying hypotheses adapted to the studied problem .).

Also, the different learning outcomes make it possible to validate milestone 1 of competency C2.1 (knowing how to define the notion of a scientific field)