ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

93000921 - Radiofrequency Optimization Techniques

DEGREE PROGRAMME

09AT - Master Universitario En Teoria De La Señal Y Comunicaciones

ACADEMIC YEAR & SEMESTER

2021/22 - Semester 1

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	93000921 - Radiofrequency Optimization Techniques
No of credits	3 ECTS
Type	Optional
Academic year ot the programme	First year
Semester of tuition	Semester 1
Tuition period	September-January
Tuition languages	English
Degree programme	09AT - Master Universitario en Teoria de la Señal y Comunicaciones
Centre	09 - Escuela Tecnica Superior De Ingenieros De Telecomunicacion
Academic year	2021-22

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Jaime Esteban Marzo (Subject coordinator)	B-420	jaime.esteban@upm.es	Sin horario. Booked appointment by e-mail is encouraged.

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

- Fundamentos De OptimizaciÓn

3.2. Other recommended learning outcomes

- Circuit Theory, Matrix representation of multiports, Transmission lines.

- Linear systems, Fourier transform and FFT.

- A working knowledge of MATLAB.

- Fundamentals of microwave passive and active circuits.

4. Skills and learning outcomes *

4.1. Skills to be learned

CB06 - Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación

CB07 - Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio

CB08 - Que los estudiantes sean capaces de integrar conocimientos y enfrentarse a la complejidad de formular juicios a partir de una información que, siendo incompleta o limitada, incluya reflexiones sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos y juicios

CB09 - Que los estudiantes sepan comunicar sus conclusiones y los conocimientos y razones últimas que las sustentan a públicos especializados y no especializados de un modo claro y sin ambigüedades

CB10 - Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo

CE01 - Analizar y aplicar técnicas para el diseño y desarrollo avanzado de equipos y sistemas, basándose en la teoría de la señal y las comunicaciones, en un entorno internacional

CE02 - Evaluar y sintetizar los resultados de un trabajo en equipo en proyectos relacionados con la teoría de la señal y las comunicaciones, en un entorno internacional.

CE03 - Valorar y contrastar la utilización de las diferentes técnicas disponibles para la resolución de problemas reales dentro del área de teoría de la señal y comunicaciones.

CT01 - Capacidad para comprender los contenidos de clases magistrales, conferencias y seminarios en lengua inglesa

CT03 - Capacidad para adoptar soluciones creativas que satisfagan adecuadamente las diferentes necesidades planteadas

CT04 - Capacidad para trabajar de forma efectiva como individuo, organizando y planificando su propio trabajo, de forma independiente o como miembro de un equipo

CT05 - Capacidad para gestionar la información, identificando las fuentes necesarias, los principales tipos de documentos técnicos y científicos, de una manera adecuada y eficiente

CT06 - Capacidad para emitir juicios sobre implicaciones económicas, administrativas, sociales, éticas y medioambientales ligadas a la aplicación de sus conocimientos

4.2. Learning outcomes

RA3 - Conocer técnicas avanzadas de optimización para equipos y dispositivos de RF.

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

The analysis and design of radiofrequency circuits and subsystems by means of electromagnetic and circuit simulators requires solving global optimization problems, often of noisy and costly functions. We will review the better-known heuristic methods, such as simulated annealing, genetic algorithms and evolution strategies. The use of surrogate models will be also dealt with, by reviewing the Space Mapping technique.

Because of the eminently practical character of the course, all these topics will be illustrated by practical projects, where students will optimize different radiofrequency subsystems and components.

5.2. Syllabus

1. Introduction
   1.1. Optimization software. Matlab, toolboxes and functions.
   1.2. Examples and exercises.
2. RF and microwave network optimization
   2.1. Modelling. Definition of the optimization problem. The search space.
   2.2. Objective functions. Constraints.
   2.3. Yield optimization. Monte Carlo analysis. Latin hypercube.
   2.4. Examples and exercises.
3. Nonlinear microwave network analysis
   3.1. Linear and nonlinear subnetworks. Parametric description of nonlinear devices.
   3.2. Harmonic Balance method.
   3.3. Balance equation. Solution by optimization. The use of the Jacobian.
   3.4. Autonomous circuits.
   3.5. Examples and exercises.
4. Global optimization. Noisy and costly functions.
   4.1. Computational effort and numerical error in electromagnetic simulators.

4.2. Simulated annealing.

4.3. Genetic algorithms and evolution programs.

4.4. Other heuristic techniques.

4.5. Examples and exercises.

5. Surrogate models and the Space Mapping technique

5.1. Introduction to surrogate models.

5.2. Space mapping for the optimization of microwave circuits.

5.3. Examples and exercises.

6. Schedule

6.1. Subject schedule*

Week	Face-to-face classroom activities	Face-to-face laboratory activities	Distant / On-line	Assessment activities
1				
2				
3				
4				
5				
6				
7				
8	**Optimization software. Matlab, toolboxes and functions.** Duration: 01:00 Lecture **RF and microwave network optimization. Modelling. Definition of the problem. The search space. Objective functions. Constraints.** Duration: 01:00 Lecture	**1.2. Examples and exercises** Duration: 00:30 Problem-solving class **2.4. Examples and exercises** Duration: 01:30 Problem-solving class		
9	**Yield optimization. Monte Carlo analysis. Latin hypercube.** Duration: 01:00 Lecture **Nonlinear Network Analisis. Linear and nonlinear subnetworks. Parametric description of non-linear devices. Harmonic Balance method.** Duration: 01:00 Lecture	**2.4. Examples and exercises** Duration: 01:00 Problem-solving class **3.5. Examples and exercises** Duration: 01:00 Problem-solving class		
10	**Balance equation. Solution by optimization. Use of the Jacobian.** Duration: 01:00 Lecture	**3.5. Examples and exercises** Duration: 01:30 Problem-solving class		**Presentations** Individual presentation Continuous assessment Presential Duration: 01:30
11	**Global optimization. Noisy and costly functions. Computational effort and numerical error in electromagnetic simulators. Global optimization.** Duration: 00:30 Lecture **Simulatead annealing.** Duration: 01:00 Lecture	**3.5. Examples and exercises** Duration: 01:30 Problem-solving class **4.5. Examples and exercises** Duration: 00:45 Problem-solving class		**Short quizzes and exercises** Written test Continuous assessment Presential Duration: 00:15

12	**Genetic algorithms and evolution programs.** Duration: 01:30 Lecture	**4.5. Examples and exercises** Duration: 01:30 Problem-solving class		**Presentations** Group presentation Continuous assessment Presential Duration: 01:00
13	**Other heuristic techniques.** Duration: 00:30 Lecture **Surrogate models and the Space Mapping Technique. Introduction to surrogate models. Space mapping for microwave circuits.** Duration: 02:00 Lecture	**4.5. Examples and exercises** Duration: 01:15 Problem-solving class		**Short quizzes and exercises** Written test Continuous assessment Presential Duration: 00:15
14		**5.3. Examples and exercises** Duration: 01:00 Problem-solving class		**Presentations** Individual presentation Continuous assessment Presential Duration: 01:00
15				
16				
17				**Final exam** Written test Final examination Presential Duration: 02:00

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

* The schedule is based on an a priori planning of the subject; it might be modified during the academic year, especially considering the COVID19 evolution.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Continuous assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
10	Presentations	Individual presentation	Face-to-face	01:30	20%	3 / 10	CB08 CB09 CT01 CB07 CB06 CT04 CE01 CT06 CE03 CB10
11	Short quizzes and exercises	Written test	Face-to-face	00:15	15%	3 / 10	CT01 CB07 CB06 CE01 CE03
12	Presentations	Group presentation	Face-to-face	01:00	25%	3 / 10	CB08 CB09 CT01 CB07 CT03 CB06 CE02 CT04 CE01 CT06 CE03 CT05 CB10
13	Short quizzes and exercises	Written test	Face-to-face	00:15	15%	3 / 10	CT01 CB07 CB06 CE01 CE03

14	Presentations	Individual presentation	Face-to-face	01:00	25%	3 / 10	CB08 CB09 CT01 CB07 CT04 CE01 CT06 CE03 CB10

7.1.2. Final examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
17	Final exam	Written test	Face-to-face	02:00	100%	5 / 10	CB08 CB09 CT01 CB07 CT03 CB06 CE02 CT04 CE01 CT06 CE03 CT05 CB10

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Final exam	Written test	Face-to-face	02:00	100%	5 / 10	CB08 CB09 CT01 CB07 CT03 CB06 CE02 CT04 CE01

						CT06 CE03 CT05 CB10

7.2. Assessment criteria

Students will be qualified through continuous evaluation by default. According to the Normativa de Evaluación del Aprendizaje de la Universidad Politécnica de Madrid, students willing to renounce to continuous evaluation must complete the Moodle task entitled "Renounce to continuous evaluation", at least two weeks before the end of the semester (deadline will be announced in Moodle).

Evaluation will assess if students have acquired all the competences of the subject. Thus, evaluation through final assessment will be carried out considering all the evaluation techniques used in continuous evaluation (EX, ET, TG, etc.), and will be celebrated in the exam period approved by Junta de Escuela for the current academic semester and year. Evaluation activities that assess learning outcomes that cannot be evaluated through a single exam can be carried out along the semester.

Extraordinary examination will be carried out exclusively by the final assessment method.

Continuous assessment:
A series of short projects will be assigned throughout the semester (to groups or individuals) that involve the development of Matlab computer code to simulate and optimize basic RF circuits or subsystems. Besides, some short quizzes and exercises will be proposed, to be solved individually.

Final examination:
Short questions and exercises, which will include the development of some Matlab code or pseudocode, and would also involve a short presentation of results.

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Maas, Stephen A. Nonlinear microwave and RF circuits. Artech House, 2003, Chap 3.	Bibliography	
Dréo, Johann, et al. Metaheuristics for hard optimization: methods and case studies. Springer Science & Business Media, 2006.	Bibliography	
Michalewicz, Zbigniew. Genetic algorithms+ data structures= evolution programs. Springer Science & Business Media, 1996.	Bibliography	
Michalewicz, Zbigniew, and David B. Fogel. How to solve it: modern heuristics. Springer Science & Business Media, 2000.	Bibliography	
Bandler, John W., and Shao Hua Chen. "Circuit optimization: the state of the art," IEEE Transactions on Microwave Theory and Techniques, vol. 36, No. 2, 1988, pp. 424-443.	Bibliography	
Bakr, Mohamed H. "Advances in space mapping optimization of microwave circuits," PhD. Thesis, 2000. https://macsphere.mcmaster.ca/handle/11375/7119	Bibliography	