Course Unit Description

SISTEMAS DE EXPLORACIÓN ELECTROMAGNÉTICA

Course 2019-20

GRADO EN INGENIERÍA EN ORGANIZACIÓN INDUSTRIAL (BOE 21-12-2012)

CENTRO UNIVERSITARIO DE LA DEFENSA

Universidad Politécnica de Cartagena

1. Subject data

Name	SISTEMAS DE EXPLORACIÓN ELECTROMAGNÉTICA
Code	511103011
Type	Optativa
ECTS	7.5
Length of subject	Cuatrimestral
Semester and course	Curso 4º - Segundo cuatrimestre
Speciality	
Language	Inglés
Mode of study	Presencial

2. Lecturer data

Lecturer data	Skorin-Kapov, Nina
Knowledge area	Ingeniería Telemática
Department	Ingeniería y Técnicas Aplicadas (CUD)
Telephone	968189923
email	nina.skorinkapov@cud.upct.es
Office hours and location	Despacho nº 24. Martes y Jueves 12:50-14:35 Como criterio general, el alumno que desee realizar una tutoría deberá previamente (al menos con un día de antelación) enviar un e-mail al profesor solicitando una cita previa con el fin de poder organizar debidamente la atención de todo el alumnado
Qualifcation/Degree	Licenciatura en telecomunicaciones por la Universidad de Zagreb, Croacia; Doctora por la Universidad de Zagreb, Croacia (homologado por la UPCT) Acreditación ANECA Profesor Titular de Universidad
Academic rank in UPCT	Profesor/a Contratado/a Doctor/a de Facultades y Escuelas Superiores
Number of five-year periods	3
Number of six-year periods	2
CV	

Lecturer data	Martínez Inglés, María Teresa
Knowledge area	Teoría de la Señal y Comunicaciones
Department	Ingeniería y Técnicas Aplicadas (CUD)
Telephone	968189916
email	mteresa.martinez@cud.upct.es
Office hours and location	Despacho nº 2. Martes y Jueves 12:50-14:35 Como criterio general, el alumno que desee realizar una tutoría deberá previamente (al menos con un día de antelación) enviar un e-mail al profesor solicitando una cita previa con el fin de poder organizar debidamente la atención de todo el alumnado
Qualifcation/Degree	Doctora Ingeniera de Telecomunicación. Área de Tecnologías de la Información y Comunicaciones. Acreditación Profesor Contratado Doctor.
Academic rank in UPCT	Profesor/a Contratado/a Doctor/a de Facultades y Escuelas Superiores
Number of five-year periods	

Number of six-year periods
CV

3. Competencies and learning outcomes

3.1. Basic curricular competences related to the subject

[CB3]. Students are required to have the ability to gather and interpret relevant data (usually within their area of study) to make judgments that include a reflection on relevant issues of a social, scientific or ethical nature.

3.2. General curricular competences related to the subject

[CG2]. Application of general technologies and fundamental subjects in the industrial domain for the solving of engineering problems

3.3. Specific curricular competences related to the subject

[CE30]. Analyze topics applied to engineering and aircraft systems operations

Specific topic competences (for elective topics which have them)

3.4. Transversal curricular competences related to the subject

[CT4]. Using information resources responsibly

3.5. Subject learning outcomes

The main objective of the course is to understand the underlying principles of operation and capabilities of modern radar and radionavigation systems. Specifically, the student should be able to:

1. Explain the principles of electromagnetic wave propagation and radio detection
2. Enumerate the basic elements of radar systems
3. Explain the workings of radar subsystems and the influence of external factors
4. Identify the problematics associated with radar system design
5. Distinguish between different types of radar and modern radar applications and identify their capabilities and limitations
6. Explain positioning methods used in radionavigation
7. Explain the basic principles of operation of terrestrial navigation systems (point¿source systems and aircraft landing systems)
8. Explain the basic principles of satellite navigation systems
9. Describe the capabilities and limitations of terrestrial radionavigation systems and global satellite navigation systems

4. Contents

4.1 Curricular contents related to the subject

Radio determination. Air navigation aids. Ground equipment. Onboard equipment. Radar.

4.2. Theory syllabus

Teaching modules	Units
BLOCK I. RADAR SYSTEMS Unit 1: Introduction to radar systems	Lecture 1: Introduction and Basic Concepts Lecture 2: The Radar Range Equation
BLOCK I. RADAR SYSTEMS Unit 2: Radar Subsystems and External factors	Lecture 3: Propagation effects Lecture 4: Radar Cross Section Lecture 5: Detection of Signals in Noise Lecture 6: Pulse Compression Lecture 7: Radar antennas Lecture 8: Clutter Lecture 9: Signal Processing - MTI and Pulse Doppler Techniques Lecture 10: Tracking and Parameter Estimation Lecture 11: Transmitters and Receivers
BLOCK I. RADAR SYSTEMS Unit 3: Selected Radar Applications	Lecture 12: Air Traffic Control Radars
BLOCK 2. RADIONAVIGATION SYSTEMS Unit 4: Introduction to radionavigation systems	Lecture 13: Introduction and Basic Concepts
BLOCK 2. RADIONAVIGATION SYSTEMS Unit 5: Terrestrial systems	Lecture 14: Direction Finding: Nondirectional Beacons (NDB), Automatic Direction Finding (ADF), VHF Direction Finding (VDF) Lecture 15: VHF Omnidirectional Range (VOR), Distance Measuring Equipment (DME), Tactical Air Navigation (Tacan) Lecture 16: Aircraft Landing Systems: Instrument Landing System (ILS), Microwave Landing System (MLS)
BLOCK 2. RADIONAVIGATION SYSTEMS Unit 6: Satellite Systems	Lecture 17: Satellite Systems: Global Navigation Satellite Systems (GNSS); fundamentals of satellite navigation; Global Positioning System (GPS); Global

4.2. Theory syllabus	
Teaching modules	**Units**
	Orbiting Navigation Satellite System (GLONASS), Galileo, Compass

4.3. Practice syllabus	
Name	**Description**
Practical 1: Radar Range Equation	In this practical, students will become familiar with the radar range equation which describes the response of radar systems and involves the main design parameters.
Practical 2: Signal Analysis in a Continuous Wave Radar.	The different signals involved in the transmission and reception of this type of Radar will be analyzed.
Practical 3: Signal Analysis in a Pulsed Radar.	In this practical, the signals corresponding to the transmission, reception and processing processes of a pulsed radar will be simulated.
Practical 4: Pulsed Wave Radar.	Different experiments will be carried out in a Pulsed Radar to study the different characteristics and functionalities of this radar.
Practical 5: Characterization of pulsed radars.	In this practical, the students will analyze the different characteristics and benefits of the most relevant radars, both civilian and military.
Comments	

Risks prevention

Promoting the continuous improvement of working and study conditions of the entire university community is one the basic principles and goals of the Universidad Politécnica de Cartagena. Such commitment to prevention and the responsibilities arising from it concern all realms of the university: governing bodies, management team, teaching and research staff, administrative and service staff and students.
The UPCT Service of Occupational Hazards (Servicio de Prevención de Riesgos Laborales de la UPCT) has published a "Risk Prevention Manual for new students" (Manual de acogida al estudiante en materia de prevención de riesgos), which may be downloaded from the e-learning platform ("Aula Virtual"), with instructions and recommendations on how to act properly, from the point of view of prevention (safety, ergonomics, etc.), when developing any type of activity at the University. You will also find

recommendations on how to proceed in an emergency or if an incident occurs.
Particularly when carrying out training practices in laboratories, workshops or field work, you must follow all your teacher's instructions, because he/she is the person responsible for your safety and health during practice performance. Feel free to ask any questions you may have and do not put your safety or that of your classmates at risk.

4.4. Comments

GENERAL DESCRIPTION:

The course "Electromagnetic Exploration Systems (EES)" is an elective course in the 4th year of the undergraduate program in Industrial Organization offered at the University Centre of Defence (CUD) as part of the formation of future Air Force officers at the Spanish Air Force Academy (AGA). Specifically, the main objective is for students to learn the basic theoretical and practical concepts of radar and radionavigation systems, and thus, develop the skills needed to apply them in their future professional practice.

Radar systems apply the concepts of electromagnetic wave propagation to detect objects (targets) and determine their distance (range). Modern radar systems can be used to track, identify, and image targets, and have numerous military and civilian applications, such as aircraft and missile detection and tracking, fire control, weather radar, and airport surveillance. The first part of this course covers the basic elements of radar systems, their underlying principles of operation, design issues and applications. It develops upon the basic concepts on radar systems introduced in course Security and Defense Technology.

In addition to the aforementioned radar applications, exploiting the properties of electromagnetic wave propagation is widely used in navigation systems to determine the position of moving objects with respect to a reference, referred to as radionavigation. The second part of this course covers a wide range of air radionavigation aids, including both terrestrial systems (point source systems, aircraft landing systems, and hyperbolic systems) and satellite systems.

The complex and practical character of the course will also be aimed at developing skills such as teamwork, independent learning, quality concern and critical thinking.

HOW THE SUBJECT CONTRIBUTES TO A PROFESSIONAL CAREER:

Radar systems have extensive military applications, including target tracking, surveillance, and reconnaissance missions, as well as military and civilian applications in air traffic control and weather detection. Thus, knowledge of the underlying principles of operation of radar systems is critical for military officers with direct responsibilities in the areas mentioned. Furthermore, understanding the foundations of various radionavigation systems, specifically air navigation aids, including both terrestrial and

satellite systems, form an integral part of the formation of future Air Force officers. This course is meant to provide the fundamental knowledge needed to understand the theoretical workings and design of radar and radionavigation systems, and thus prepare the students with a solid theoretical background to face their practical training within the Spanish Air Force.

DETAILED DESCRIPTION OF LEARNING GOALS FOR EVERY TEACHING MODULE:

BLOCK 1: Radar Systems
Unit 1: Introduction to Radar Systems
TOPIC 1 (BLOCK 1, UNIT 1): RADAR SYSTEMS: INTRODUCTION AND BASIC CONCEPTS
The objective is to introduce the students to radar systems, outlining the basic concepts and design issues of modern radar.
TOPIC 2 (BLOCK 1, UNIT 1): THE RADAR RANGE EQUATION
The objective is to teach the students to interpret and calculate Radar Range Equation (RRE) which one of the basic and most important topics in radar systems, tying together all the radar subsytems and external factors.

Unit 2: Radar Subsystems and External factors
TOPIC 3 (BLOCK 1, UNIT 2): PROPAGATION EFFECTS
The objective is to teach the students the individual propagation effects affecting electromagnetic radar signals as they travel to and from the target.
TOPIC 4 (BLOCK 1, UNIT 2): RADAR CROSS SECTION
The objective is to familiarize the students with the basic concepts of the The Radar Cross Section (RCS) which is a measure of power scattered in a given spatial direction when a target is illuminated by an incident wave
TOPIC 5 (BLOCK 1, UNIT 2): DETECTION OF SIGNALS IN NOISE
The objective is to teach the students the basic concepts of detection of a target, a detection threshold, and the probabilities of false alarm and detection. These concepts will then be tied together in a description if the radar detection problem.
TOPIC 6 (BLOCK 1, UNIT 2): PULSE COMPRESSION
The objective is to teach the students the basic concepts and motivation behind Pulse Compression, including a discussion on range resolution, bandwidth and pulsewidth.
TOPIC 7 (BLOCK 1, UNIT 2): RADAR ANTENNAS
The objective is to familiarize the students with the fundamentals of radar antennas, such as field regions, radiation patterns (with a main focus on beamwith, gain and sidelobes), and polarization.
TOPIC 8 (BLOCK 1, UNIT 2): CLUTTER
The objective is to familiarize the students with the concepts of radar clutter, the differences between clutter and noise, and the main measure used for clutter backscatter (called the scattering coefficient).
TOPIC 9 (BLOCK 1, UNIT 2): SIGNAL PROCESSING - MTI (MOVING TARGET INDICATOR) AND PULSE DOPPLER TECHNIQUES
The objective is to teach the students the basics of radar signal processing, i.e. Moving Target Indicator (MTI) and Pulse Doppler Techniques, beginning with a review of clutter characteristics from the previous topic, a review of the Doppler effect, techniques for measuring Doppler shifts in pulsed waveforms, Doppler velocity ambiguity, and finally the differences between MTI and Pulse Doppler Techniques.
TOPIC 10 (BLOCK 1, UNIT 2): TRACKING AND PARAMETER ESTIMATION
The objective is to familiarize the students with radar tracking, including Single Target Tracking and Multiple Target Tracking in Track-while-Scan (Automatic Detection and Tracking) and Phased Array Tracking radars.
TOPIC 11 (BLOCK 1, UNIT 2): TRANSMITTERS AND RECEIVERS
The objective is to familiarize the students with aspects relating to radar transmitter

and receivers and transmitter/receiver architectures used in radar systems.

Unit 3: Selected Radar Applications
TOPIC 12 (BLOCK 1, UNIT 3): AIR TRAFFIC CONTROL RADARS
The objective is to familiarize the students with Air Traffic Control (ATC) radars such as Primary Surveillance Radars (En-route and Airport Surveillance Radars) and Secondary Surveillance Radars (SSR).

BLOCK 2: Radionavigation Systems
Unit 4: Introduction to Radionavigation Systems
TOPIC 13 (BLOCK 2, UNIT 4): INTRODUCTION AND BASIC CONCEPTS
The objective is to give a general introduction to radionavigation systems and associated
Term. Common position fixing methods will be covered, as well as overview of the main navigation system performance parameters.

Unit 5: Terrestrial Systems
TOPIC 14 (BLOCK 2, UNIT 5): POINT SOURCE SYSTEMS I (DIRECTION FINDING)
The objective is to teach the students the basic principles of operation of point source systems based on direction finding (NDB, ADF, VDF), as well as their capabilities and limitations.
TOPIC 15 (BLOCK 2, UNIT 5): POINT SOURCE SYSTEMS II (VOR, DME, TACAN)
The objective is to teach the students the basic principles of operation of point source systems DME, VOR, and TACAN, as well as their capabilities and limitations.
TOPIC 16 (BLOCK 2, UNIT 5): AIRCRAFT LANDING SYSTEMS
The objective is to teach the students the basic principles of aircraft landing systems, as well as their capabilities and limitations.

Unit 6: Satellite Systems
TOPIC 17 (BLOCK 2, UNIT 6): SATELLITE SYSTEMS
The objective is to teach the students the basic principles of satellite systems, as well as the characteristics, capabilities and limitations of different global satellite navigation systems.

5. Teaching method

Name	Description	Hours	In-class
Theory classes in the classroom	Presentation and explanation of the course material. Resolving doubts. Special emphasis will be made on the fundamental and more complex theoretical aspects of the course. In-class: Active attendance and class participation. Taking notes. Questions.	55	100
Preparation of assignments / reports	Preparation of laboratory reports. Self-study: Personal or group work where the results of the work made in the laboratory will be described.	20	0
Completion of formative and summative evaluation activities	Preparing the individual written examinations In-class: Attending and taking the midterms and final exam.	4	100
Problem class in the classroom	Solving problems in the classroom and/or presenting case studies. In-class: Active attendance. Questions and problem solving.	10	100
Practical Laboratory Sessions	Explaining the laboratory exercises. Supervising and leading the laboratory classes. Evaluating student knowledge and participation. In-class: Individual and/or cooperative work in the laboratory under lecturer supervision. Active participation.	10	100
Tutorials	Resolving student questions and doubts related to the course. In-class: Actively participating in resolution of their questions/doubts.	4.5	100
Individual work / study	Lecture notes covering all course topics will be made available to the students to ease individual study. Self-study: Individual study. Problem solving.	84	0

6. Assessment method

6.1. Assesment system		
Name	**Description and criteria**	**Percentage**
Official written tests	Partial Exam PEI_B1: A written exam consisting of theoretical and theoretical-practical questions and problems covering Topics 1-6 (32%) Partial Exam PEI_B2: A written exam consisting of theoretical and theoretical-practical questions and problems covering Topics 7-12 (32%) Partial Exam PEI_B13 A written exam consisting of theoretical and theoretical-practical questions and problems covering Topics 13-17 (26%) Final Exam (90%): The final exam is divided in 3 parts: PEI_B1 of the final written exam will consist of theoretical and/or practical questions aimed at evaluating the acquired knowledge of Topics 1-6 (32%) PEI_B2 of the final written exam will consist of theoretical and/or practical questions aimed at evaluating the acquired knowledge of Topics 7-12 (32%) PEI_B3 of the final written exam will consist of theoretical and/or practical questions aimed at evaluating the acquired knowledge of the material covered in Topics 13-17 (26%) (*) See comments below	90 %
Formative and summative evaluation activities for the assessment of competence performance: - Evaluation by the teacher, Self-assessment and Co-assessment (peer evaluation) through quality criteria developed (rubrics) from laboratory reports, proposed problems,	Laboratory work: Evaluation based on participation, oral questioning and/or lab reports.	10 %

6.1. Assesment system

Name	Description and criteria	Percentage
Cooperative Learning Activities, etc. - Observation charts (check-list, scales, rubrics) to evaluate performance. - Student portfolio and / or diary to assess self-reflection ability and dedication. - Completion of authentic tasks: simulations, case studies and / or real applied problems, etc.		

6.2. Formative assesment

Description

Laboratory work: Evaluation based on participation, oral questioning and/or lab reports.

Information

As set forth in article 5.4 of the Reglamento de las pruebas de evaluación de los títulos oficiales de grado y de máster con atribuciones profesionales (UPCT), students in the special circumstances listed in the article 5.4 are entitled to a comprehensive assessment test, upon justified request which must be granted by the Department. This does not exempt them from carrying out compulsory tasks included in the teacher's guide of the subject (official syllabus).

Comments

(*) There will be 3 individual written partial examinations during the semester: PEI_B1 will cover topics 1-6, PEI_B2 will cover topics 7-12, and PEI_B3 will cover topics 13-17. For each partial exam, students who obtain a grade greater than or equal to 4.5 out of 10 have the option to skip that corresponding part of the final exam.

The Final examination will consist of three parts: Part PEI_B1 covering Topics 1-6, Part PEI_B2 covering Topics 7-12 and Part PEI_B3 covering Topics 13-17 (Block 2: Radionavigation Systems) each carrying a maximum of 10 points. Each part will be taken by those students who did not pass the corresponding partial exam (received a grade <4.5) or by students who wish to try to improve upon their partial grades. Note: Students who decide to try to improve upon their partial grade(s) in the final exam, permanently renounce the grade received on the corresponding partial exam, irrespective of the result they obtain on the final exam.

The final grade is based on the grades received for each part (PEI_B1, PEI_B2 and PEI_B3). To pass the course it is necessary to obtain a minimum score of 4.5 out of 10 for each part an overall minimum score of 5 out of 10 for the Final Grade. The grade for parts PEI_B1, PEI_B2 and PEI_B3 can be obtained either though the partial exams or the Final Exam as outlined above.

Laboratory work grade (LAB) has no minimum grade and has a weight of 10%

The final grade will then be calculated as:

Final grade= 32%(PEI_B1 grade) +32%(PEI_B2 grade)+26%(PEI_B3 grade)+10%LAB
To pass the course the student must obtain a Final grade >=5.0,
such that PEI_B1 grade >= 4.5, PEI_B2 grade >= 4.5 and PEI_B3 grade >= 4.5

The grades received for each part (either from the partial exams or the final exam in June) which are >= 4.5, and the laboratory work grade LAB, will remain valid for the exam call in August.

7. Bibliography and resources

7.1. Basic bibliography

Forssell, Bèorje Radionavigation systems. Artech House. 2008. 9781596933545

Merrill Skolnik Introduction to Radar Systems, 3 edition. McGraw-Hill Education; . 2002. 0072881380

Mark A. Richards (Editor), James A. Scheer (Editor), William A. Holm (Editor) Principles of Modern Radar: Basic Principles 1st Edition. Scitech Publishing. 2010. 978-1891121524

George W. Stimson Introduction to Airborne Radar, 3rd Edition. Scitech Publishing. 2014. 1613530226

7.2. Supplementary bibliography

Kayton, Myron Avionics navigation systems. John Wiley and Sons,. 1997. 0471547956

. Radio Navigation, JAA ATPL Training Edition 2. Jeppesen Sanderson Inc. 2007. 0884874532

J. C. Toomay, Paul J. Hannen Radar Principles for the Non-Specialist, 3rd Edition. SciTech Publishing. 2004. 1891121286

B. Hofmann-Wellenhof (Author), K. Legat (Author), M. Wieser (Author), H. Lichtenegger (Contributor) Navigation, Principles of Positioning and Guidance. Springer. 2011. B0014TI5JE

Peña Moran, L.c. Ayudas a la Navegación Aérea.. DIEGO MARIN LIBRERO EDITOR. 2000. 9788484250531

7.3. On-line resources and others

-All material used during the development of this course will be available online in the Virtual Classroom

-O'Donnell, Robert M. RES.LL-001 Introduction to Radar Systems, Spring 2007. (Massachusetts Institute of Technology: MIT OpenCourseWare), http://ocw.mit.edu License: Creative Commons BY-NC-SA