



Course Unit Description

ELECTROMAGNETIC EXPLORATION SYSTEMS

Course 2020-21



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

CENTRO UNIVERSITARIO DE LA DEFENSA

Universidad Politécnica de Cartagena

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1. Subject data

Name	ELECTROMAGNETIC EXPLORATION SYSTEMS
Code	511103011
Type	Elective
ECTS	7.5
Length of subject	Per term
Length of subject	4th Year - Second term
Speciality	
Language	English
Mode of study	In person

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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	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 de investigación
CV	
Head of groups	G1, G2
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	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	1
Number of six-year periods	0

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CV

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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

Al finalizar la asignatura el estudiante debe ser capaz de: Explicar los principios de la propagación de ondas electromagnéticas y la radiodeterminación. Enumerar y describir los elementos básicos de los sistemas radar. Explicar el funcionamiento de los distintos subsistemas que componen un sistema radar complejo y la influencia de factores externos Identificar la problemática asociada al diseño de sistemas radar. Distinguir entre los distintos tipos y aplicaciones de los radares modernos y identificar sus capacidades y limitaciones. Explicar los métodos de posicionamiento utilizados en radionavegación. Explicar los principios básicos de los diferentes sistemas de radionavegación terrestre. Explicar los principios básicos de los sistemas de navegación por satélite. Describir razonadamente las capacidades y limitaciones de los sistemas de radionavegación terrestre y de los sistemas de navegación global por satélite.

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4. Contents

4.1 Curricular contents related to the subject

Radio determinación. Ayudas a la navegación aérea. Equipos en tierra, Equipos embarcados. Radar.

4.2. Theory syllabus

Teaching modules and 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

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4.2. Theory syllabus

Teaching modules and units

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 Orbiting Navigation Satellite System (GLONASS), Galileo, Compass

4.3. Practice syllabus

Name and 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: Pulsed Wave Radar.

Different experiments will be carried out in a Pulsed Radar to study the different characteristics and functionalities of this radar.

Practical 3: 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 of the basic principles and goals of the Universidad Politécnica de Cartagena. Such commitment to prevention and the responsibilities

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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

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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 subsystems 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 of 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 beamwidth, 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

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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.

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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.	6	0
Completion of formative and summative evaluation activities	Attending and taking the partial exam.	4	100
Conducting official exams	Attending the final examination.	3	100
Presentation of assignments/reports	Presentation of Laboratory work	2	100
Problem class in the classroom	Solving problems in the classroom and/or presenting case studies. In-class: Active attendance. Questions and problem solving.	5	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.	15	100
Tutorials	Resolving student questions and doubts related to the course. In-class: Actively participating in resolution of their questions/doubts.	4	100



Name	Description	Hours	In-class %
Visits to Companies and Facilities	Visit to the Air Traffic Control Tower and Radionavigation aids (VORTAC, ILS) in the San Javier Air Force Base.	2	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.	91.5	0

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6. Assessment method

6.1. Continuous assessment system		
Name	Description and criteria	Percentage %
Written tests	<p>This component of continuous assessment is composed of 3 evaluation activities as follows.</p> <p>Evaluation Activity 1: Partial Examination PEI_B1. A written exam consisting of theoretical and theoretical-practical questions and problems covering Topics 1-6 (30%). Minimum grade to pass: 3.0</p> <p>Evaluation Activity 2: Partial Examination PEI_B2. A written exam consisting of theoretical and theoretical-practical questions and problems covering Topics 7-12 (30%). Minimum grade to pass: 3.0</p> <p>Evaluation Activity 3: Partial Examination PEI_B3. A written exam consisting of theoretical and theoretical-practical questions and problems covering Topics 13-17 (20%). Minimum grade to pass: 3.0</p>	80 %
<p>Formative and summative evaluation activities for the assessment of competence performance:</p> <ul style="list-style-type: none"> - Evaluation by the teacher, Self-assessment and Co-assessment (peer evaluation) through quality criteria developed (rubrics) from laboratory reports, proposed problems, 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. 	<p>This component of continuous assessment is composed of 1 compulsory evaluation activity as follows:</p> <p>Laboratory work (LAB): Evaluation based on participation, oral questioning, presentation and/or lab reports. This activity is compulsory and there is no minimum grade to pass.</p>	20 %

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6.1. Continuous assessment system

Name	Description and criteria	Percentage %
- Completion of authentic tasks: simulations, case studies and / or real applied problems, etc.		

6.2. Final assesment system

Name	Description and criteria	Percentage %
Written tests	<p>Final Examination:</p> <p>The final examination will consist of 3 parts corresponding to the 3 partial examinations. 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 (30%). Minimum grade to pass: 3.0</p> <p>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 (30%). Minimum grade to pass: 3.0</p> <p>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 (20%)</p> <p>Minimum grade to pass: 3.0</p>	80 %
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, Cooperative Learning Activities, etc.	Laboratory work (LAB): Evaluation based on participation, oral questioning, presentation and/or lab reports. This grade is maintained from the continuous assessment grade as it is a compulsory evaluation activity.	20 %

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6.2. Final assesment system

Name	Description and criteria	Percentage %
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- 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.

6.3. Formative assesment

Description

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

The final grade for the course is calculated as: $\text{Final Grade} = 30\%(\text{PEI_B1}) + 30\%(\text{PEI_B2}) + 20\%(\text{PEI_B3}) + 20\%\text{LAB}$ To pass the course, the student must obtain a Final Grade ≥ 5.0 , such that PEI_B1 grade ≥ 3.0 , PEI_B2 grade ≥ 3.0 and PEI_B3 grade ≥ 3.0

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7. Bibliography and resources

7.1. Basic bibliography

Forsell, 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

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