Course Unit Description

ELECTROMAGNETIC EXPLORATION SYSTEMS

Course 2021-22

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

CENTRO UNIVERSITARIO DE LA DEFENSA

Universidad Politécnica de Cartagena

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

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. Máster Universitario en Tecnologías de la Información y Comunicaciones. Acreditación ANECA Profesor Titular de Universidad, Área de Teoría de la Señal 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	1 de investigación
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: LO1. Explain the principles of electromagnetic wave propagation and radio detection LO2. Enumerate the basic elements of radar systems LO3. Explain the workings of radar subsystems and the influence of external factors LO4. Identify the problematics associated with radar system design LO5. Distinguish between different types of radar and modern radar applications and identify their capabilities and limitations LO6. Explain positioning methods used in radionavigation LO7. Explain the basic principles of operation of terrestrial navigation systems LO8. Explain the basic principles of satellite navigation systems LO9. 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 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

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)

BLOCK 2. RADIONAVIGATION SYSTEMS
Unit 6: Satellite Systems

Lecture 17: Satellite Systems: Global Navigation Satellite Systems (GNSS)

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 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.	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

6. Assessment method

6.1. Continuous assessment system

Name	Description and criteria	Percentage %
Written tests	This component of continuous assessment is composed of 3 evaluation activities as follows. Evaluation Activity 1: Partial Examination PEI_B1. A written exam consisting of theoretical and theoretical-practical questions and problems covering Topics 1-6 (30%), corresponding to learning outcomes LO1-LO4. Minimum grade to pass: 3.5 Evaluation Activity 2: Partial Examination PEI_B2. A written exam consisting of theoretical and theoretical-practical questions and problems covering Topics 7-12 (30%), corresponding to learning outcomes LO3-LO5. Minimum grade to pass: 3.5 Evaluation Activity 3: Partial Examination PEI_B3. A written exam consisting of theoretical and theoretical-practical questions and problems covering Topics 13-17 (20%), corresponding to learning outcomes LO6-LO9. Minimum grade to pass: 3.0	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. - Observation charts (check-list, scales,	This component of continuous assessment is composed of an evaluation activity as follows: Laboratory work grade (LAB): Evaluation based on problem resolution, presentation and/or lab reports, corresponding to learning outcomes LO1-LO5. There is no mimumum grade to pass.	20 %

6.1. Continuous assessment system

Name	Description and criteria	Percentage %
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. Final assesment system

Name	Description and criteria	Percentage %
Written tests	Final Examination: The final examination will consist of 3 parts corresponding to the 3 partial examinations. Evaluation Activity 1: Partial Examination PEI_B1. A written exam consisting of theoretical and theoretical-practical questions and problems covering Topics 1-6 (30%), corresponding to learning outcomes LO1-LO4. Minimum grade to pass: 3.5 Evaluation Activity 2: Partial Examination PEI_B2. A written exam consisting of theoretical and theoretical-practical questions and problems covering Topics 7-12 (30%), corresponding to learning outcomes LO3-LO5. Minimum grade to pass: 3.5 Evaluation Activity 3: Partial Examination PEI_B3. A written exam consisting of theoretical and theoretical-practical questions and problems covering Topics 13-17 (20%), corresponding to learning outcomes LO6-LO9. Minimum grade to pass: 3.0	80 %
Formative and summative evaluation activities for the assessment of competence	This component of final assessment is composed of an evaluation activity as follows: Laboratory work grade (LAB): Evaluation based on problem resolution, presentation and/or lab reports,	20 %

6.2. Final assesment system

Name	Description and criteria	Percentage %
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. - 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.	corresponding to learning outcomes LO1-LO5. There is no mimumum grade to pass.	

6.3. Formative assesment

Description

Information

Comments

The final grade for the course is calculated as: Final Grade= 30%(PEI_B1) +30%(PEI_B2)+20%(PEI_B3)+20%LAB To pass the course, the student must obtain a Final Grade >=5.0, such that PEI_B1 grade >= 3.5, PEI_B2 grade >= 3.5 and PEI_B3 grade >= 3.0 Attendance at laboratory sessions is compulsory. The temporal planning of the course activities will be coordinated with the aeronautical and military activities carried out at the Spanish Air Force Academy (AGA). Students can re-take any or all evaluation activities in the Final Assessment System. Students who pass an evaluation activity in the Continuous Assesment System but opt to re-take it in the Final Assesment System,

must renounce the grade received for the corresponding evaluation activity in the Continuous Assesment System in the corresponding exam call, irrespective of the result they obtain in the final exam.

7. Bibliography and resources

7.1. Basic bibliography

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

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

Habibur Rahman Fundamental Principles of Radar 1st Edition. CRC Press. 2019. 978-1138387799

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

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

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