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300227 - RL-MN8 - Radiolocation

Coordinating unit: 300 - EETAC - Castelldefels School of Telecommunications and Aerospace Engineering

Teaching unit: 739 - TSC - Department of Signal Theory and Communications

Academic year: 2018

Degree: BACHELOR'S DEGREE IN AIR NAVIGATION ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
BACHELOR'S DEGREE IN TELECOMMUNICATIONS SYSTEMS ENGINEERING (Syllabus 2009). (Teaching unit Optional)
BACHELOR'S DEGREE IN NETWORK ENGINEERING (Syllabus 2009). (Teaching unit Optional)
BACHELOR'S DEGREE IN AEROSPACE SYSTEMS ENGINEERING (Syllabus 2015). (Teaching unit Optional)
BACHELOR'S DEGREE IN AEROSPACE SYSTEMS ENGINEERING/BACHELOR'S DEGREE IN TELECOMMUNICATIONS SYSTEMS ENGINEERING (Syllabus 2015). (Teaching unit Optional)
BACHELOR'S DEGREE IN AEROSPACE SYSTEMS ENGINEERING/BACHELOR'S DEGREE IN NETWORK ENGINEERING (Syllabus 2015). (Teaching unit Optional)

ECTS credits: 6 Teaching languages: Catalan, Spanish, English

Teaching staff

Coordinator: Definit a la infoweb de l'assignatura.

Others: Definit a la infoweb de l'assignatura.

Prior skills

Operability with complex numbers. Product and sum of complex numbers, rationalization, calculation of module and phase of a complex number.
Operability in linear and logarithmic scale
Operability with trigonometric functions.
Operability with signals and systems in the frequency domain by means of Fourier series and transforms, and apply the main properties of these.
Knowledge of analog communication systems and digital

Requirements

Aeronautical Communications 1

Degree competences to which the subject contributes

Specific:

5. CE 24 AERON. Conocimiento adecuado y aplicado a la Ingeniería de: Los métodos de cálculo y de desarrollo de la navegación aérea; el cálculo de los sistemas específicos de la aeronavegación y sus infraestructuras; las actuaciones, maniobras y control de las aeronaves; la normativa aplicable; el funcionamiento y la gestión del transporte aéreo; los sistemas de navegación y circulación aérea; los sistemas de comunicación y vigilancia aérea. (CIN/308/2009, BOE 18.2.2009)
6. CE 25 AERON. Conocimiento aplicado de: Transmisores y receptores; Líneas de transmisión y sistemas radiantes de señales para la navegación aérea; Sistemas de navegación; Instalaciones eléctricas en el sector tierra y sector aire; Mecánica del Vuelo; Cartografía; Cosmografía; Meteorología; Distribución, gestión y economía del transporte aéreo. (CIN/308/2009, BOE 18.2.2009)

Transversal:

1. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.

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2. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 3. Communicating clearly and efficiently in oral and written presentations. Adapting to audiences and communication aims by using suitable strategies and means.
3. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
4. TEAMWORK - Level 3. Managing and making work groups effective. Resolving possible conflicts, valuing working with others, assessing the effectiveness of a team and presenting the final results.

Teaching methodology

It is a subject with great theoretical content, which means that often the show and extracting mathematical expressions, so the lectures are held on board with the necessary support transparencies. Classes and laboratory problems should consolidate the concepts presented in lectures by conducting drills and exercises, on paper or by using simulation tools, MATLAB. In classes of problems and laboratory students work in groups of two people.

Learning objectives of the subject

The overall objective of the course is to provide knowledge of aeronautical surveillance systems within the CNS/ATM concept defined by ICAO. Students will learn the techniques used in primary and secondary surveillance radar for air traffic control, deepening the theory of pulsed Radar to explain the primary and the secondary Radar. The course is completed with new trends Dependent Surveillance ADS (Automatic Dependent Surveillance) and Mode S interrogation techniques and other aeronautical radar based Applications such radio altimeters, dead reckoning navigation, weather radar, and anti-collision warning Systems..

In more detail, the completion of the course will enable students to:
· Identify the principal air navigation systems
· Analyse the different subsystems of a Radar system.
· Design some parameters of a Radar system to meet specifications.
· Analyse specific regulations defined surveillance equipment ICAO.
· Calculate Time and frequency-domain signals involved in surveillance systems.
· Check with computer simulations the theoretical results.

Study load

Total learning time: 150h	Hours large group:	36h	24.00%
	Hours small group:	24h	16.00%
	Guided activities:	6h	4.00%
	Self study:	84h	56.00%

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Content

1.- Introduction to Air Navigation

Learning time: 7h

Theory classes: 1h
Laboratory classes: 2h
Guided activities: 1h
Self study : 3h

Description:
Functions of Air Navigation. Surveillance. Overview of surveillance Systems. Organizations.

Related activities:
Lab Session no. 0.- Introduction to MATLAB.

Specific objectives:
To know the different surveillance systems and to evaluate their restrictions and performances.

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2.- Pulsed Radar

Learning time: 92h 20m

Theory classes: 17h
Laboratory classes: 20h
Guided activities: 2h
Self study : 53h 20m

Description:

The Pulsed Radar: Principle of operation. Signals type. Range determination: blind range and maximum unambiguous range. Pulse width and range resolution. Pulse repetition frequency. Peak and average power; duty cycle. Radar block diagram.

Radar Equation. Minimum detectable signal.

Noise at the receiver. Types. Thermal noise. Noise equivalent temperature. Noise figure. Noise in passive devices. Friis formula. Signal to noise ratio.

False alarm probability and time of false alarms. Probability of Detection.

Integration of pulses. Observation time. Numbers of hits per scan. Coherent and no coherent pulse integration. Efficiency of integration. Improvement factor. Loss of integration. Number of false alarms.

Transmitters. Type: magnetrons and klystrons. Duplexers. Distortion and intermodulation. Compression point. Third order intercept point.

Antennas. Parameters and basic concepts. Polarization. Gain and radiation pattern. Beam width. Angular resolution and volume of uncertainty. Aperture Antennas: horns and reflectors. 2D and 3D radars.

Matched filter.

Radar Cross Section (RCS). RCS of simple objects: Sphere. Depending on frequency. Cylinder and cone / sphere. Form factor. RCS of complex objects. RCS of fluctuating targets: Swerling cases.

Other considerations of Radar System: Power and energy. Mechanisms and effects of radio electric propagation. Devices and system losses. Cumulative probability of detection. M of N criterion. Staggering techniques. CFAR techniques.

Pulse compression. Linear FM pulse compression (chirp). Binary phase code pulses. Barker codes.

Related activities:

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First exercises's short test.
First lab's short test.
Second lab's short test.
Midterm exam.
Final exam.
Lab Session no. 1.- Pulsed Radar.
Lab Session no. 2.- The Radar equation.
Lab Session no. 3.- The matched filter.
Lab Session no. 4.- The Radar antennas.
Lab Session no. 5.- The Radar Cross Section
Lab Session no. 6.- CFAR

Specific objectives:

The Pulsed Radar: Principle of operation. Signals type. Range determination: blind range and maximum unambiguous range. Pulse width and range resolution. Pulse repetition frequency. Peak and average power; duty cycle. Radar block diagram.

Radar Equation. Minimum detectable signal.

Noise at the receiver. Types. Thermal noise. Noise equivalent temperature. Noise figure. Noise in passive devices. Friis formula. Signal to noise ratio.

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Antennas. Parameters and basic concepts. Polarization. Gain and radiation pattern. Beam width. Angular resolution and volume of uncertainty. Aperture Antennas: horns and reflectors. 2D and 3D radars.

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3.- Radar Clutter

Learning time: 2h 55m

Theory classes: 1h 20m
Guided activities: 0h 15m
Self study : 1h 20m

Description:
Analysis of the unwanted signal inside my range, which can mask the wanted target.
Typologies: surface, volume, and angel.
Typical radar cross sections.
Signal to Clutter ratio (S/C).

Related activities:
Second exercices's short test.
Final exam.

Specific objectives:
To know the unwanted echoes which can mask the targets of interest.
To analyse the effect of the clutter power on the desired signal power.

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4.- Doppler based Radars

Learning time: 23h 50m

Theory classes: 7h
Laboratory classes: 2h
Guided activities: 1h
Self study : 13h 50m

Description:

The Doppler Effect. Continuous-wave radar (CW): principle of operation; homodyne and heterodyne structures. Pulsed Doppler Radar. Speed?s measurement system.

MTI (Moving Target Indicator) Radar: block diagram; Canceller circuits for static targets; Transfer function of cancellers; Blind speeds; Staggered PRF; Clutter attenuation; two stages canceller; Improvement Factor; N pulses canceller; Transversal filter; Doppler filter banks; MTI Digital processing; Blind phases; I/Q channel.

Pulsed Doppler Radar: AWACS System (Airborne Warning and Control System).

FM-CW Radar: Principles of operation; range and speed measurements; application as a radio altimeter; modulation types; techniques for improving isolation.

Other Radar applications in aerospace engineering: Radar Doppler Navigation (dead reckoning); Surface Movement Radar (SMR); Radio altimeter (pulsed).

Radar Ambiguity function. Properties. Ambiguity functions of several radar waveforms.

Related activities:

Session Lab 7.- MTI
Second exercices's short test.
Second lab's short test.
Final exam.

Specific objectives:

Know and apply the Doppler effect to the measurement of the speed of moving targets.
Understand the fundamentals, characteristics and performance of the MTI radars.
To know the applications in aeronautical engineering of the different types of continuous wave radars.

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5.- Tracking Radars

Learning time: 3h 15m

Theory classes: 1h 20m
Guided activities: 0h 15m
Self study : 1h 40m

Description:
Fundamentals. Typologies.
Angle-Tracking Radar: Amplitude Comparison Monopulse Radar; Phase comparison Monopulse Radar; Sequential Lobing Radar; Conical Scan Radar.
Limitations factors to tracking accuracy: Noise angle (Glint); amplitude fluctuations.
Low-Angle Tracking.

Related activities:
Second exercices's short test.
Final exam.

Specific objectives:
To know the systems and techniques of targeting and tracking of mobile targets with Radar systems.

6.- Secondary Surveillance Radar

Learning time: 10h 20m

Theory classes: 4h
Guided activities: 0h 30m
Self study : 5h 50m

Description:
Fundamentals of the Secondary Surveillance Radar (SSR). Radio links (interrogation and replies). Frequency bands. Mode A (identity). Mode C (altitude). Interrogator Side Lobe Suppression system. Limitations of SSR: FRUIT and Garbling. SSR Antennas types. Multi Radar Processing multi. Mode S Interrogation system. Wide Area Multilateration Systems.

Related activities:
Second exercices's short test.
Final exam.

Specific objectives:
Know the purpose, characteristics and operation of the secondary surveillance radar.

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7.- Automatic Dependence Surveillance (ADS-B)

Learning time: 2h 30m

Theory classes: 1h 05m
Guided activities: 0h 15m
Self study : 1h 10m

Description:
The ADS system: Fundamentals. ADS types: ADS-B (Broadcast); ADS-C (Contract). System block diagram. Squitter Mode S. Services and compatibility.

Related activities:
Final exam.

Specific objectives:
To know the operation, the benefits and the limitations of the automatic systems of dependent surveillance.

8.- Airborne Collision Avoidance System (ACAS)

Learning time: 2h 30m

Theory classes: 1h 05m
Guided activities: 0h 15m
Self study : 1h 10m

Description:
Theory of operation. Traffic Advisories (TA). Resolution Advisories (RA). Current standards: TCAS II version 7.1. Volume of protection. Block diagram. Antennas.

Related activities:
Final exam.

Specific objectives:
Know the operation of anti-collision systems and their integration with radiolocation systems.

9.- Enhanced Ground Proximity Warning System (EGPWS)

Learning time: 2h 30m

Theory classes: 1h 05m
Guided activities: 0h 15m
Self study : 1h 10m

Description:
Theory of operation. Block diagram. Warnings typology. Enhanced mode.

Related activities:
Final exam.

Specific objectives:
To know the operation of the alarm and warning systems by collision against the ground, and its integration with the radiolocation and radionavigation systems.

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10. - Weather Radar	Learning time: 2h 50m Theory classes: 1h 05m Guided activities: 0h 15m Self study : 1h 30m

Description:
Theory of operation. Frequency bands. Wheater Reflectivity. Raindrop modelling. Reflectivity Factor. Precipitation rate. Airborne Weather Radars: Block Diagram. Wind Shear detection.

Related activities:
Final exam.

Specific objectives:
Know the theory of operation, characteristics and applications in aeronautics of weather radars.

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Planning of activities

Lab Session no. 0.- Introduction to MATLAB.

Hours: 4h
Laboratory classes: 2h
Self study: 2h

Description:
This practice session will introduce the main tools of MATLAB: creating files .m, using vectors and matrices, representation of results and show common commands.

Support materials:
MATLAB.

Descriptions of the assignments due and their relation to the assessment:
No deliverable.

Specific objectives:
Knowledge of the software to be used during the course.

Lab Session no. 1.- Pulsed Radar.

Hours: 4h
Laboratory classes: 2h
Self study: 2h

Description:
Matlab routines will be created to represent RADAR pulsed signals, identified the effect of the basic parameters: carrier frequency, pulse repetition frequency, and time repetition pulses. Displayed and represent the concepts of distance through the signal delay and the concept of maximum unambiguous distance.

Support materials:
MATLAB

Descriptions of the assignments due and their relation to the assessment:
Report the results of the activity.

Specific objectives:
Consolidate and extend the concept learnt in theoretical lectures.

Lab Session no. 2.- The Radar equation.

Hours: 4h
Laboratory classes: 2h
Self study: 2h

Description:
RADAR equation will be programmed in MATLAB to represent the relationship between the different parameters involved, such as the ratio of received power and range, signal to noise ratio and range, transmitted power etc.

Support materials:
MATLAB.

Descriptions of the assignments due and their relation to the assessment:
Report the results of the activity.

Specific objectives:
Consolidate and extend the concept learnt in theoretical lectures.

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Lab Session no. 3.- The matched filter.	Hours: 8h Laboratory classes: 4h Self study: 4h

Description:
In this lab session will be plotted the baseband complex signal and the output of the matched filter for a given code and a given signal to noise ratio.

Support materials:
MATLAB

Descriptions of the assignments due and their relation to the assessment:
Report the results of the activity.

Specific objectives:
Consolidate and extend the concept learnt in theoretical lectures.

Lab Session no. 4.- The Radar antennas.	Hours: 4h Laboratory classes: 2h Self study: 2h

Description:
Create MATLAB routines and represent the radiation patterns of several antennas by current distribution. It will identify the basic parameters of the antennas, such as gain, beamwidth, main lobe and secondary relationship, and relationship with Radar systemic parameters such as angular resolution volume uncertainty, observation time and number of observed pulse.

Support materials:
MATLAB

Descriptions of the assignments due and their relation to the assessment:
Report the results of the activity.

Specific objectives:
Consolidate and extend the concept learnt in theoretical lectures.

Lab Session no. 5.- The Radar Cross Section.	Hours: 8h Laboratory classes: 4h Self study: 4h

Description:
This practice will be held in two sessions. Although it is not necessary to differentiate between the two sessions, the first session is to study the radar cross section of simple objects, seeing their frequency dependence and aspect ratio, while the second session will explore the radar cross section of complex objects based on the composition of simple objects.

Support materials:
MATLAB

Descriptions of the assignments due and their relation to the assessment:
Report the results of the activity.

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Specific objectives:
Consolidate and extend the concept learnt in theoretical lectures.

Lab Session no. 6.- CFAR.	Hours: 4h Laboratory classes: 2h Self study: 2h

Description:
In this lab session we will make a very simple analysis of a typical CFAR technique named Cell-Averaging CFAR, or CA-CFAR.

Support materials:
MATLAB

Descriptions of the assignments due and their relation to the assessment:
Report the results of the activity.

Specific objectives:
Consolidate and extend the concept learnt in theoretical lectures.

Lab Session no. 7.- MTI.	Hours: 8h Laboratory classes: 4h Self study: 4h

Description:
In this session we will analyze in the time domain two MTI's.

Support materials:
MATLAB

Descriptions of the assignments due and their relation to the assessment:
Report the results of the activity.

Specific objectives:
Consolidate and extend the concept learnt in theoretical lectures.

First exercises's short test.	Hours: 1h Theory classes: 1h

Description:
Short test on exercises about pulsed radar

Specific objectives:
Verify that learning objectives are achieved.

Second exercises's short test.	Hours: 1h Theory classes: 1h

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Description:
Short test on exercises about the Doppler based Radars and the tracking Radars.

Specific objectives:
Verify that learning objectives are achieved.

First lab's short test.	Hours: 1h Laboratory classes: 1h

Description:
Lab short test about the lab sessions on Matlab exercises.

Support materials:
Matlab

Specific objectives:
Verify that successful practices have been performed.

Second lab's short test.	Hours: 1h Laboratory classes: 1h

Description:
Lab short test about the lab sessions on Matlab exercises.

Support materials:
Matlab

Specific objectives:
Verify that successful practices have been performed.

Midterm exam.	Hours: 1h 30m Guided activities: 1h 30m

Description:
Exam about the theoretical and practical aspects of the Pulsed Radar.

Specific objectives:
Verify that learning objectives are achieved.

Final exam.	Hours: 1h 30m Guided activities: 1h 30m

Description:
Synthesis course exam, with theoretical and practical content, but focused towards the contents studied in the second half of the course.

Specific objectives:
Verify that learning objectives are achieved.

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Qualification system

The ones defined in the course infoweb.

Regulations for carrying out activities

The first and second exercices control will be done during the fifth and tenth week of the course. They will be one-hour exams that will be done in theory hours. The first and second laboratory tests will last for one hour and will be held in laboratory hours, preferably during the sixth and twelfth week of the course. The mid-term exam will be held in the middle of the semester during the week dedicated especially for them, and will evaluate all the content of the subject taught until then, without this entailing the release of material for the next examinations. At the end of the semester a final exam will be done which will evaluate all the material presented in class.

Bibliography

Basic:

Skolnik, Merrill I. Introduction to radar systems. 3rd. ed. Boston (Mass.) [etc.]: McGraw-Hill, 2001. ISBN 0072909803.

Complementary:

Mahafza, Bassem R. Radar systems analysis and design using MATLAB. Boca Raton (Fla.) [etc.]: Chapman & Hall, 2000. ISBN 1584881828.

Levanon, Nadav. Radar principles. New York [etc.]: John Wiley & Sons, 1988. ISBN 0471858811.