Universida de Vigo

IDENTIFYING DATA				
Naval sensors				
Subject	Naval sensors			
Code	P52G381V01502			
Study programme	(*)Grao en Enxeñaría Mecánica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	5th	1st
Teaching language	Spanish			
Department				
Coordinator	Gómez Pérez, Paula			
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General description	This subject gets framed into the Intensification in Naval Technology, and its goal is to provide the student with a theoretical and practical training over the basic operation of radar, sonar and optoelectronic sensors in naval and terrestrial environments. Along this subject, students learn the concept of naval sensor and will acknowledge the most usual sensors in their operative environment. The main concepts for all remote sensing system will be provided, so the student understand the multidisciplinary character of this subject, applying different knowledge from previous subjects, such as radiocommunication systems, electronic circuits and filters, automatic control, electrotechnics of physics (electromagnetic fields). It will be mainly focused on radar sensors, both continuous and pulsed wave systems, analysing the parameters that limit the radar range, the probability of detection and of false alarm, the concept of radar cross section, clutter, etc. We will also analyse the basic and most common techniques for radar signal processing, most of them used in other remote sensing systems (such as sonar), emphasizing the multidisciplinary nature of the subject. The student will be able to understand the proper acoustic characterisation of the underwater environment, and the propagation issues associated, such as noise and reverberation. The architecture and characterisation of the active and passive sonar systems will also be studied, along with their acoustics tranducers. Lastly, the optical spectrum and the classification of the existing emitting sources will be analysed, understanding the operation of the distinct types of optoelectronic sensors and their main characteristics.			

Competencies	
Code	
B3	Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations.
C30	To understand the principles that govern the operation of communications systems and naval sensors.
D1	Analysis and synthesis
D2	Problems resolution.
D5	Information Management.
D8	Decision making.
D9	Apply knowledge.
D10	Self learning and work.
D16	Critical thinking.

Learning outcomes	
Expected results from this subject	Training and Learning Results

To know the technological basis supporting naval sensors.	B3	C30	D1 D5 D10
To understand the basic operation of naval sensors.	B3	C30	D1 D2 D8 D9 D10 D16
ENAEE LEARNING OUTCOME: KNOWLEDGE AND UNDERSTANDING LO 1.2 Knowledge and understanding of the engineering disciplines of their specialty, at the proper level to acquire the rest of the competences of the degree, including notions of the latest advances. (level of development of this sub-learning outcome: Medium (2))	B3		
ENAEE LEARNING OUTCOME: KNOWLEDGE AND UNDERSTANDING LO 1.3 Be aware of the multidisciplinary context of engineering. (Medium (2))		C30	
ENAEE LEARNING OUTCOME: ENGINEERING ANALYSIS LO 2.2 Ability to identify, formulate and solve engineering problems within an specialty; choose and apply properly analytical methodologies; recognize the importance of social, health and safety, environmental, economic and industrial restrictions. (Medium (2))			D1 D2 D8 D9 D16
ENAEE LEARNING OUTCOME: ENGINEERING PRACTICAL APPLICATION LO 5.15.1 Understanding the applicable techniques and methods for analysis, planning and research and their limitations in the field of their specialty. (Medium (2))			D9
ENAEE LEARNING OUTCOME: ENGINEERING PRACTICAL APPLICATION LO 5.3 Application knowledge on materials, equipment and tools, technology and engineering processes and their limitations within the field of their specialty. (Medium (2))		C30	D8 D9
ENAEE LEARNING OUTCOME: CONTINUOUS EDUCATION LO 8.1 Ability to realize the need for continuous training and undertake this activity throughout their professional life on their own. (Basic (1))			D8 D10

Contents

Topic	
Chapter 1. Introduction to Naval Sensors	1.1 Basic concepts of naval sensors. 1.2 Frequency bands. 1.3 Introduction to radar systems. 1.4 Fundamental parameters of radar systems: PRF/PRI, range resolution, angular resolution, maximum non-ambiguous range, time of observation, ... 1.5 Monostatic, bistatic and multistatic radar systems 1.6 Pulsed wave and continuous wave radar systems. 1.7 Radar cross section (RCS) and simplified radar range equation. 1.8 Simplified block diagram of a radar system.
Chapter 2. Pulsed wave radar systems	2.1 Introduction 2.2 Signal-to-noise ratio and probability of detection. 2.3 Pulse integration techniques. 2.4 Attenuation losses in radar range equation: 2.4.1 Fluctuating targets. 2.4.2 Propagation losses. 2.4.3 Atmospherical losses. 2.4.4 Interferences: clutter, jamming, ... 2.5 Radar Cross Section (RCS) and stealth technologies.
Chapter 3. Continuous wave radar systems	3.1 Introduction: 3.1.1 Doppler effect. 3.1.2 Pulsed wave (PW) radar vs. continuous wave (CW) radar systems. 3.2 CW radars modulated in frequency (CWFM). 3.2.1 With sawtooth modulation (CHIRP). 3.2.2 With triangular modulation. 3.3 Radar range equation for CW radar systems. 3.4 Advantages and disadvantages of CW radar systems.

Chapter 4. Digital signal processing	4.1 Pulse compression techniques. 4.1.1 Frequency pulse compression. 4.1.2 Phase pulse compression. 4.2 MTI systems and pulse-Doppler systems. 4.3 PRF Staggering
Chapter 5. Optoelectronical sensors	5.1 Optical spectrum. 5.2 Infrared sensors (thermal, medium-IR) 5.3 Night-vision sensors (near-IR). 5.4 Optoelectronic emitters: Laser vs. LED. 5.5 Optoelectronic sensors: photodetectors. 5.6 Other sensors and applications: laser telemeter, luxometer, etc.
Chapter 6. Acoustic sensors and sonar systems	6.1 Introduction. 6.2 Acoustic oceanography. 6.3 Underwater signal propagation. 6.4 Active and passive sonar systems. 6.5 Noise and reverberation.
Chapter 7. Specific purpose radar systems	7.1 Multifunction radars. 7.2 Secondary radar (IFF). 7.3 LPI radars. 7.4 Sinthetic aperture radars (SAR).
Practice 1: Introduction to remote sensing and radar systems	The goal of this practice is introducing the basic concepts of remote sensing and radar systems analysed in the theoretical classes. By means of short Matlab scripts, the influence of each one of the parameters in the simplified radar range equation will be illustrated. The relationship between resolution and pulse spreading for a target conformed by several primary scatterers will be analysed. Students will be able to check whether some common techniques (such as pulse integration) effectively improve the probability of detection.
Practice 2: Pulsed wave radars (PW radars)	This practice enhances the comprehension of the operative differences between PW and CW radars, as well as their different applications and limitations. Radar simulators will be used instead real radar systems, because, on the one hand, it is neither operative nor safe to activate several of such systems within a short range, and in the second hand, simulators allow to create different tactical scenarios which could not be possible in a real environment. An overview of radar cross section concepts explained in theory will also be analysed. The dependence on the geometry of the radar cross section and radar response will be studied, as well as Swerling models for fluctuating targets.
Practice 3: Movement detector radar	This practice describes a simple CW radar system works, by means of a movement sensor. The student will set up a basic CW radar system within the Laboratory, where the ability of the student to handle instrumentation equipment will also be evaluated.
Practice 4: Digital signal processing	The goal of this practice is to help the comprehension of the digital signal processing techniques used in radar systems nowadays. It will include: MTI systems, filter banks and pulse compression techniques.
Practice 7: Electronic warfare systems and antimissile defence	The goal of this practice is to understand in depth the existing methodologies for electronic warfare regarding the antimissile defence for surface platforms.
Practice 6: Underwater acoustics	This practice focuses on recognizing and differentiating the underwater noises that might affect a sonar system. The student should be able to extract the parameters of interest in each of the cases under studio, in order to be able to differentiate the analyzed sound.

Practice 5: Optoelectronic systems	The goal of this practice is to get the student to know about optoelectronic sensors operating either in visible or in non-visible spectrum. Hence, in the Laboratory they will learn to operate different optoelectronic equipment, such as thermal cameras, night-vision cameras, telemeters, They will also learn about the primary light-emitting devices, such as LEDs or LASER.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	28	42	70
Laboratory practical	14	7	21
Seminars	21	5	26
Problem and/or exercise solving	9	12	21
Problem and/or exercise solving	2	4	6
Objective questions exam	1	1	2
Essay	1	3	4

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Lectures. These sessions will be used to explain in detail the theoretical contents of the syllabus. Whiteboard and slides will be used as the basic methodology. Whenever slides are used, a copy in paper will be provided beforehand. However, slides should not be considered as a replacement for lectures, since they are only complementary material.
Laboratory practical	Lectures If necessary, a prior explanation of some particular concepts will be performed beforehand, in order to optimize the practical sessions. Laboratory practices: Students will be working in groups and the professor will take care of their work. The goal of these sessions is to strengthen the theoretical concepts studied in theoretical lectures. Practical sessions have a series of rules that the student must abide: - Practical sessions are compulsory and in-person classes. - Lost sessions cannot be recovered, unless justified absences.
Seminars	Some weekly hours will be dedicated to solve problems, where small groups will be encouraged. This section includes the intensive course designed for preparing the extraordinary exam.

Personalized assistance

Methodologies	**Description**
Seminars	Two types of tutorial actions might be distinguished: the academic tutoring and the personalized tutoring. In the academic tutoring, office hours will be at the student disposition where they can consult any doubt related with the contents, organisation and/or schedule of the subject. Tutorials can be individualized, encouraging group sessions for problem-solving hours. In the personalized tutoring, each student, individually, will be able to comment with the professor any problem with the subject, with the goal of finding a proper solution. Combining both types of tutorial actions, the different paces of learning will be attended through attention to diversity. Lectures will properly assist the students through the learning process, both in-person and/or online formats (email, VTC, FAITIC forums,...), and always under prior appointment.

Assessment

	Description	Qualification	Training and Learning Results

Problem and/or exercise solving	Midterm exam: It will evaluate 30% of the theoretical knowledge of the subject. Individual, of about approximately 1 hour. Over 10 points. Can have the form of test, short questions, problems or a combination of all of them. No minimum required.	30	B3	C30	D1 D2 D5 D8 D9 D10 D16
Problem and/or exercise solving	Final term exam: It will evaluate the 40% of the theoretical knowledge of the subject. Individual, about 2-3 hours. Over 10 points. Can have the form of test, short questions, problems or a combination of all of them. A minimum of 4.0 points over 10 is required in each of the parts to be able to pass the subject.	40	B3	C30	D1 D2 D5 D8 D9 D10 D16
Objective questions exam	Laboratory exams: It will evaluate 20% of the practical knowledge of the subject, divided in 2 test of a 10%. Individual, of about 10-20 min. Over 10 points. Can have the form of test, short questions, problems or a combination of all of them. A minimum of 4.0 over 10 is required in the 20% assigned to laboratory training.	20		C30	D1 D2 D5 D8 D9 D16
Essay	Multimedia video: It will evaluate 10% of the full knowledge of the subject (theoretical and practical). Video recorded by the students, performing an easy subject-related experiment. Maximum length: 3 min. Individual, or in groups of two students. Over 10 points.	10	B3	C30	D1 D2 D9 D10

Other comments on the Evaluation

Ordinary exam:

The weight of the distinct parts in the final note of the ordinary exam (*NEO*) gets distributed as follows:

- Theory (*T*): 80%
- Practices (*L*): 20%

Theory:

Consists of:

- A single exam, of approximately 2-3 hours, to be performed within the course calendar.

- Ranked over 10 points (*T*).
- Individual.
- It can include tests, short questions and/or problems or a combination of them.

Laboratory:

Consists of:

- A single exam, of approximately 20-30 min., regarding the contents of the practical sessions.
- Ranked over 10 points (*L*).
- Individual.
- It can include tests, short questions and/or problems or a combination of them.

Final mark and minimum requirements to pass the subject:

The final mark (*NEO*) will be computed following the next equation:

NEO = 0.8 * T + 0.2 * L

A minimum of 4.0 points over 10 is required for both the L exam and the T exam. Once obtained these minimums, a minimum of 5.0 points over 10 in the total computation of *NEO* is mandatory to pass the subject.

Extraordinary exam:

The students that did not pass the subject on first convocatory must attend the second convocatory (or extraordinary exam), that will have the same structure, exam duration, percentages and minimum points required thant in the ordinary exam.

Code of Honor:

During exams, the use of non-allowed electronic devices, notes or books is forbidden.

Exams lacking some of the sheets will not be graded.

Results obtained must be properly justified in all cases, in any of the exams or activities. None of the numerical results will be considered if no explanation is given about the methodoly used to obtain them.

It is expected that all the students abide to these considerations. If a non-ethical behaviour is detected, the student will automatically be graded with a 0.0 at the current examination.

Sources of information

Basic Bibliography

Curry, G. Richard, **Radar Essentials. A concise handbook for radar design and performance analysis**, 1ª ed., Scitech Publishing Inc., 2012

Complementary Bibliography

Denny M., **Blip, Ping & Buzz. Making sense of radar and sonar**, 1ª ed., The Johns Hopkins University Press, 2007

Skolnik, Merril I., **Introduction to Radar Systems**, 3ª ed., McGraw□Hill, 2003

Eaves J., Reedy E., **Principles of Modern Radar**, 2ª ed., Springer, 2011

Marage J., Mori Y.,, **Sonars and Underwater acoustics**, 1ª ed., Wiley, 2010

Mahafza B. R., **Radar systems analysis and design using Matlab**, 3ª ed., CRC Press, 2010

Recommendations

Subjects that it is recommended to have taken before

Physics: Physics II/P52G381V01106
Fundamentals of electrical engineering/P52G381V01205
Electronic technology/P52G381V01301
Radio-communication systems/P52G381V01408

Contingency plan

Description

=== EXCEPTIONAL PLANNING ===
Given the uncertain and unpredictable evolution of the health alert caused by COVID-19, the University of Vigo establishes an extraordinary planning that will be activated when the administrations and the institution itself determine it, considering safety, health and responsibility criteria both in distance and blended learning. These already planned measures guarantee, at the required time, the development of teaching in a more agile and effective way, as it is known in advance (or well in advance) by the students and teachers through the standardized tool.

=== ADAPTATION INTO A DISTANCE-LEARNING ENVIRONMENT ===

If a new lockdown situation might appear, leading to a non-presential and online scenario, the following modifications might apply:

=== CONTENTS ADAPTATION ===

3.1 Theoretical contents

Theoretical classes and contents should not be affected by an online scenario. In case the schedules are tighten, contents will be adapted to the new situation, in order to guarantee the proper achievement of the competences and learning outcomes of the subject.

3.2 Laboratory sessions

Since it will not be possible to provide laboratory classes, those practices will be replaced by their equivalents in an online environment.

In particular, the next changes will be applied:

Practice 3: Movement detector radar
The contents of this laboratory class will be replaced by experimentation with a continuous-wave radar simulator. In the maximum extent possible, similar scenarios will be replicated, so that the student might be seeing similar effects to a real environment.

Practice 5: Optoelectronic systems
The loss of this practical class might have an important impact in the learning outcomes (specially LO 5.3). In this case, real equipment will be replace by the demonstrative videos (or similar multimedia resources) to explain how these devices work.

Practice 6: Underwater acoustics
This practice will be replaced by underwater acoustic simulators, in order to provide similar or equivalent results.

The rest of the laboratory sessions should not be affected by an online situation.

=== METHODOLOGIES ADAPTATION ===

A new lecturing methodology should be added:

Virtual session:
Classes will be provided by means of videoteleconference (VTC) within a virtual room. Resources will depend on the platform used, but will include virtual blackboards/whiteboards, chats, file sharing, audio and video transmission, polls,

=== ASSESSMENT ADAPTATION ===

Assessment methodologies regarding weights, minimums, and number of tests will be the same in any scenario (in-person or online classes).
In an online environment, the difference might be the format of the assessment test, that will take place within the platform FAITIC-MOODLE and Campus Remoto from the University of Vigo (and/or similar platforms).