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230259 - DERR - Design of Radio Emitters and Receivers

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering

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

Academic year: 2019

Degree: BACHELOR'S DEGREE IN TELECOMMUNICATIONS SCIENCE AND TECHNOLOGY (Syllabus 2010). (Teaching unit Optional)
BACHELOR'S DEGREE IN AUDIOVISUAL SYSTEMS ENGINEERING (Syllabus 2009). (Teaching unit Optional)
BACHELOR'S DEGREE IN ELECTRONIC SYSTEMS ENGINEERING (Syllabus 2009). (Teaching unit Optional)
BACHELOR'S DEGREE IN TELECOMMUNICATIONS SYSTEMS ENGINEERING (Syllabus 2010). (Teaching unit Optional)
BACHELOR'S DEGREE IN NETWORK ENGINEERING (Syllabus 2010). (Teaching unit Optional)
BACHELOR'S DEGREE IN TELECOMMUNICATIONS TECHNOLOGIES AND SERVICES ENGINEERING (Syllabus 2015). (Teaching unit Optional)

ECTS credits: 6 Teaching languages: Catalan

Teaching staff

Coordinator: Mas Casals, Orestes Miquel

Others: Aguasca Solé, Albert

Prior skills

Previously acquired knowledge about telecommunications systems, electronics and linear circuits and systems.

Teaching methodology

- Practical work in laboratory around four projects, of progressive difficulty, where emitter and receiver radio systems will be developed.

- Periodically proposed assignments, to be done at home individually or in group, consisting of the study, design and/or simulation of several circuits and systems.

- Seminars in which the specific concepts used later in the laboratory are introduced.

Learning objectives of the subject

This course aims to achieve the following teaching objectives:
· To deepen the knowledge of radio systems through experimentality.
· Become competent with the basic techniques of design and measurement of radio systems.
· Understand SDR (Software Defined Radio) systems, their characteristics, advantages and drawbacks with respect to conventional radio architectures, and learn how to use and design them.
· To make a review of the historical evolution of radio, from its inception to present days.

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Study load

Total learning time: 150h	Hours small group:	52h	34.67%
	Self study:	98h	65.33%

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Content

Project 1: Radio signals and measurements

Learning time: 20h

Laboratory classes: 8h
Self study : 12h

Description:
In this project the basic concepts of propagation and reception of radio signals are covered, as well as the instrumentation necessary to visualize and measure these signals. It also allows to unify student's knowledges before tackling the rest of the syllabus.

Contents:
- The radio spectrum. Applications.
- Radio signals. Type of modulations. Visualization of spectra, bandwidth, etc.
- Generation and capture of the signal. Type of antennas.
- Propagation of signals. Transmission equation.

Project 2: Basic circuits and techniques. The Tuned Radio Frequency (TRF) Receiver.

Learning time: 36h

Laboratory classes: 12h
Self study : 24h

Description:
The project's goal is to build an AM receiver based on a tuned design, while studying and designing the circuits and functional blocks that form it.

Contents:
- Historical background: "crystal set" radio. Passive reception.
- The LC tuned circuit. Quality factor. Amplification. Measurements.
- Study, design, construction and measurement of a ferrite antenna for the MW band.
- RF amplification. Choosing the active device. Design of the polarization network. Small signal analysis. Frequency response. Simulation. Measurements.
- Detection. Difference between coherent and incoherent techniques.
- Techniques for improving selectivity and / or amplification: Regeneration.
- LF amplification. Structures based on transistors and Operational Amplifiers.

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Project 3: Superheterodyne Radio	Learning time: 60h Laboratory classes: 20h Self study : 40h

Description:
This project presents the concepts and circuits that are used in modern radio systems, excluding software-defined radio. This is done by the design and construction of a emitter-receiver pair, of modular superheterodyne architecture.

Contents:
- Block diagram and operating principle.
- The local oscillator. Types of oscillators. VCO, Frequency Synthesizer.
- Types of mixers. Insertion loss, isolation, harmonics, etc.
- IF processing. Filters: topologies and technologies. Limitations, simulations and construction.
- Detectors: Foster-Seeley discriminator, Quadrature, etc.
- Automatic Gain and Frequency Control (CAF).
- The transmitter. Modulators. Power amplification at RF.

Project 4: Software Defined Radio (SDR)	Learning time: 36h Laboratory classes: 12h Self study : 24h

Description:
The goal of the project is to understand the basic concepts and peculiarities of software-defined radios, to build a simple SDR front-end and to learn how to program specific applications of increasing complexity.

Contents:
- Basic concepts and structure of SDR solutions.
- Sampling applied to SDR.
- Hardware Front-End. Tayloe Detector: design and implementation.
- Free software for SDR. Programming of radio applications in GnuRadio. Basic analog radios. Basic digital communications.
- Analysis of free and / or economical solutions: HackSDR, LimeSDR, RTL-SDR.

Qualification system

- Degree of accomplishment of laboratory tasks, evaluated continuously throughout the course (40%)
- Project summary report (30%)
- Grade of proposed activities (problem solving, design challenges, simulations, etc.) (30%)

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Bibliography

Basic:

Rutledge, David B. The Electronics of radio. New York: Cambridge University Press, 1999. ISBN 0521641365.

Rogers, John W.M.; Plett, Calvin; Marsland, Ian. Radio Frequency System Architecture and Design [on line]. Boston, USA: Artech House, 2013 [Consultation: 14/07/2017]. Available on: <http://site.ebrary.com/lib/upcatalunya/detail.action?docID=11069364>. ISBN 9781608075379.

Laufer, Carl. The Hobbyist's Guide to the RTL-SDR: Really Cheap Software Defined Radio [on line]. 3rd. ed. Createspace Independent Publishing Platform, 2015 [Consultation: 14/07/2017]. Available on: <https://www.amazon.es/Hobbyists-Guide-RTL-SDR-Software-Defined-ebook/dp/B00KCDF1QI/ref=tmm_kin_swatch_0?_encoding=UTF8&qid=1500022526&sr=1-1>. ISBN 9781514716694.

American Radio Relay League. The ARRL Handbook for Radio Communications 2017. 94th ed. USA: American Radio Relay League, 2017.

Complementary:

Penfold, R.A.. Simple short-wave receiver construction. UK: Bernard Babani (publishing) Ltd., 1990. ISBN 9780859342209.

Bowick, Christopher. RF Circuit design. 2nd ed. Amsterdam ; London: Elsevier ; Newnes, 2008. ISBN 9780750685184.

Others resources:

Hyperlink

http://www.rtl-sdr.com/

Reference website for SDR applications of RTL2832U chipset

https://greatscottgadgets.com/hackrf/

Website of «HackRF» free SDR platform

https://myriadrf.org/projects/limesdr/

Website of «LimeSDR» free SDR platform