GENERAL INFORMATION

Course information	
Name	Telecommunications for Smart Grids
Code	DEAC-MSG-515
Degree	Master in Smart Grids
Year	1st
Semester	1st (Fall)
ECTS credits	7.5 ECTS
Type	Compulsory
Department	Electronics, Control and Communications
Area	Communications
Coordinator	Javier Matanza Domingo

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DETAILED INFORMATION

Contextualization of the course

Contribution to the professional profile of the degree

The aim of this course is to provide the student with knowledge about the main technologies and standards used for digital communications. More precisely, the course is focused in technologies that are or could be useful in present and future Smart Grids, respectively. Contents will vary from a mathematical model of the signal transmission to a higher-level view of the network architecture for Smart Grid Networks.

This course assumes certain knowledge in communications, therefore, the students with no basic knowledge is highly encouraged to take the subject "Fundamentals of Telecommunications" prior enrolling this course.

By the end of this course, the student will know a variety of digital transmission techniques and will be able to assess their suitability depending on the application, requirements and scenarios. Moreover, students will have a general knowledge of the network topology of Smart Grids' communication networks.

Prerequisites

Students willing to take this course should be familiar with linear algebra, basic probability and statistics, some fundamental knowledge in telecommunications and undergraduate-level programming. Previous experience with MATLAB is desired although not strictly required. All these prerequisites can be acquire taking the course on "Fundamentals of Telecommunications".

CONTENTS

Contents
Theory
Unit 1. Introduction
1.1 Telecommunication Challenges in Smart Grids 1.2 Smart Grids' main services: AMI, Distributed Automation, Distributed Generation, Demand Response, Security
Unit 2. Digital Transmission Technologies
2.1 Digital Modulation: M-PSK, M-QAM, Coherent-Incoherent transmissions, Charrier-Phase Estimation 2.2 Orthogonal Frequency Division Multiplexing: OFDM's Principle, Effective Implementation, FFT Vs. Wavelet OFDM, PAPR, Common Applications 2.3 Channel Coding: Linear Codes, Convolutional Codes, Interleaving, Trellis Code Modulation 2.4 Multiple Access Techniques: CDMA, Spread Spectrum 2.5 Fundamentals of Digital Optical Communications: Light Propagation, Digital Transmission using Light, Limitations of Optical Communication Systems.
Unit 3. Transport Technologies
3.1 TDM: PDH, SDH, SONET 3.2 WDM Systems 3.3 Radio-frequency technologies: Physics for Radio Transmissions, Antenna's Parameters, Wireless Propagation
Unit 4. Switching Technologies
4.1 Routing Basics 4.2 Legacy example: Distance Vector 4.3 MPLS: MPLS – TP, Carrier Ethernet.
Unit 5. Distribution Technologies
5.1 Wired: PLC (NB and BB), xDSL, FTTx, GPON 5.2 Wireless: WiMAX, Bluetooth, Zigbee, Cellular Communications
Unit 6. Application-layer Technologies
6.1 DLMS/COSEM 6.2 OpenADR 6.3 CIM 6.4 IEC61850
Unit 7. Telecommunication Architecture for the Smart Grid
7.1 Network Architecture 7.2 Access Network 7.3 Core Network 7.4 Reliability and Security
Unit 8. Technologies Enabling the Smart Grid
8.1 PRIME: PHY, MAC and LLC 8.2 Analysis of other standards: G3-PLC, IEEE1901, M&M, G.hnem.
Unit 9. Practical examples
9.1 Telecommunication design case. 9.2 Testbed Practical sessions
Laboratory
Lab 1. Phase Shift Keying and Phase Carrier Estimation
This first session will deal with a common digital modulation technique: Phase Shift Keying. Students will implement a modulator and demodulator for the coherent (PSK) and incoherent version (PSK). Additionally,

they will implement a simple Phase Carrier Estimation algorithm to deal with unknown phase in transmissions.
Lab 2. OFDM-based transmission systems
In this laboratory students will simulate the transmission of a signal using an efficient implementation of OFDM based on FFT.
Lab 3. Channel coding
In this laboratory students will experience with the codification and decodification of both linear block codes and convolutional codes.
Lab 4. Code Division Multiple Access
In this laboratory students will evaluate how Code Division Multiple Access is able to extract all the individual messages that are transmitted together in the multiplex thanks to orthogonal codes.
Lab 5. Digital transmission using Plastic Optic Fibers
In this session students will have a hands-on experience on how digital signals can be transmitted using Plastic Optic Fibers and visible light.
Lab 6. Multipath propagation
In this session, students will build a model for the transfer function of a multipath scenario. They will also apply this channel's transfer function to the previously built model for OFDM transmission and will try to build a simple equalizer.
Lab 7. Prime Transceiver Modeling
Using most of the concepts developed in previous laboratory sessions, students will build a model for the transceiver of one popular NB-PLC technologies: PRIME.
Lab 8. PLC Transceiver Modeling
Based on previous experience, students will make groups and choose a different NB-PLC standard and will build a model for the transceiver. Results will be presented to the classroom to see how different standards address the difficult task of transmitting through the power lines.
Lab 9. AMI Test bed
Students will have the opportunity to see in detail how an AMI system based on PRIME and DLMS/COSEM technology works.

Competences and learning outcomes

Competences

C1.	Have acquired demonstrated knowledge on the mathematical model, and simulations of the performance in advanced communication techniques.
C2.	Have the capacity to apply information theory, modulation and channel coding methods to telecommunication systems.
C3.	Have the capacity to design a telecommunication solution based on a set of requirements. Additionally, have the capacity to assess if a design would meet the required specifications.

Learning outcomes

By the end of the course students should:

LO1. Demonstrate advance knowledge of signal processing for digital communications.

LO2. Demonstrate advance knowledge of how optical communication networks works.

LO3. Be able to design and evaluate a telecommunication infrastructure given a set of requirements.

LO4. Have acquire a wide spectrum of the telecommunications alternatives suitable to be used in the Smart Grids.

TEACHING METHODOLOGY

General methodological aspects	
	Competences
▪ **Lectures**: The lecturer will introduce the fundamental concepts of each chapter, along with some practical recommendations, and will go through worked examples to support the explanation. Active participation will be encouraged by raising open questions to foster discussion and by proposing short application exercises to be solved in class either on paper or using a software package	C1, C2, C3
▪ **Lab sessions:** Under the instructor's supervision, students, divided in small groups, will apply the concepts and techniques covered in the lectures.	C1, C2, C3
Out-of-class activities	**Competences**
▪ Personal study of the course material and resolution of the proposed exercises.	C1, C2, C3
▪ Lab session preparation to make the most of in-class time.	C1, C2, C3
▪ Lab results analysis and report writing.	C1, C2, C3

ASSESSMENT AND GRADING CRITERIA

Assessment activities	Grading criteria	Weight
Quizzes	▪ Understanding of the theoretical concepts.	20%
Final exam	▪ Understanding of the theoretical concepts. ▪ Application of these concepts to problem-solving.	40%
Lab assignments	▪ Application of theoretical concepts to real problem-solving. ▪ Written communication skills.	40%

GRADING AND COURSE RULES

Grading

Regular assessment

- **Theory** will account for 60%, of which:
  - Quizzes: 20%
  - Final exam: 40%
- **Lab** will account for the remaining 40%

In order to pass the course, the mark of the final exam must be greater or equal to 4 out of 10 points and the laboratory mark must be at least 5 out of 10 points. Otherwise, the final grade will be the lower of the two marks.

Retake

If laboratory grade is below 5 points out of 10, a new lab session could be issued to the student or a witting exam with lab content will take place.

If the final exam grade is below 4 points out of 10, a new exam will be issued to the students.

The resulting grade will be computed as follows:

- **Theory** will account for 70%, of which:
  - Final retake exam: 70%
- **Lab** will account for the remaining 30%, of which:

As in the regular assessment period, in order to pass the course, the mark of the final exam must be greater or equal to 4 out of 10 points and the mark of the laboratory must be at least 5 out of 10 points. Otherwise, the final grade will be the lower of the two marks.

Course rules

- Class attendance is mandatory according to Article 93 of the General Regulations (Reglamento General) of Comillas Pontifical University and Article 6 of the Academic Rules (Normas Académicas) of the ICAI School of Engineering. Not complying with this requirement may have the following consequences:
  - Students who fail to attend more than 15% of the lectures may be denied the right to take the final exam during the regular assessment period.
  - Regarding laboratory, absence to more than 15% of the sessions can result in losing the right to take the final exam of the regular assessment period and the retake. Missed sessions must be made up for credit.
- Students who commit an irregularity in any graded activity will receive a mark of zero in the activity and disciplinary procedure will follow (cf. Article 168 of the General Regulations (Reglamento General) of Comillas Pontifical University).

WORK PLAN AND SCHEDULE

The work plan and schedule will be presented the first day of lessons.

BIBLIOGRAPHY

Basic bibliography

- Slides prepared by the lecturer (available in Moodle).
- Proakis, J. G., & Salehi, M. (2008). Digital Communications. McGraw-Hill Higher Education.
- Haykin, S. S. (2013). Digital Communication Systems. Wiley.
- Concepts in Systems and Signals, J. D. Sherrick. Prentice-Hall 2001.
- Agrawal, G. P. (2010). Fiber-optic communication systems (4th ed.). Wiley.

Complementary bibliography

- J. D. Sherrick. Concepts in Systems and Signals, Prentice-Hall
- Saleh, B. E. A., & Teich, M. C. (2007). Fundamentals of Photonics. Wiley.