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19398 - SCP - Satellite Communications Systems

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: MASTER'S DEGREE IN AEROSPACE SCIENCE AND TECHNOLOGY (Syllabus 2015). (Teaching unit Optional)

ECTS credits: 5 Teaching languages: English

Teaching staff

Coordinator: Defined in the course webpage at the EETAC website

Requirements

The course aims at providing a solid knowledge of the fundamentals of satellite communications to students with different profiles. Advanced knowledge in communication is not required, only basic engineering knowledge. Ability to perform application programs in Matlab / Octave or similar is expected.

Degree competences to which the subject contributes

Basic:

CB6. (ENG) CB6 - Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación.

CB7. (ENG) CB7 - Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio.

CB8. (ENG) CB8 - Que los estudiantes sean capaces de integrar conocimientos y enfrentarse a la complejidad de formular juicios a partir de una información que, siendo incompleta o limitada, incluya reflexiones sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos y juicios.

CB10. (ENG) CB10 - Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

Specific:

CE2 MAST. (ENG) CE2: Utilizar las herramientas, dispositivos, y sistemas que permiten realizar el acondicionamiento tanto analógico como digital de señal.

CE5 MAST. (ENG) CE5: Aplicar la ingeniería de sistemas en el entorno aeroespacial para el diseño y la gestión de los distintos aspectos tecnológicos asociados a una misión.

Generical:

CG2 MAST. (ENG) CG2: Identificar y aplicar los análisis teóricos, experimentales y numéricos fundamentales de uso actual en ingeniería aeroespacial.

Transversal:

CT2. SUSTAINABILITY AND SOCIAL COMMITMENT: Being aware of and understanding the complexity of the economic and social phenomena typical of a welfare society, and being able to relate social welfare to globalisation and sustainability and to use technique, technology, economics and sustainability in a balanced and compatible manner.

CT5. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

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Teaching methodology

Expositive classes based on a set of slides that students will have before classes. To complement the theoretical knowledge some exercises and case studies will be proposed. Moreover students will implement some concepts in a simulator based on MATLAB. Theoretical and practical classes will be interlaced.
In particular, the teaching methodologies applied during the course will be:
MD1: Master class
MD3: Practical class
MD4: Problem / project based learning
MD5: Autonomous work

Learning objectives of the subject

This course aims at providing students with a solid knowledge of the fundamentals of the design techniques used in satellite communication. Basic contents of the course are: Principal orbits (and characteristics) used in satellite communications. Description of a space radio link and its power balance, satellite and ground station equipment. Architecture and development of modern satellite networks. Multiple access and packet radio techniques. Mobile services, Internet services via satellite, VSAT systems and other satellite services.

Study load

Total learning time: 125h	Hours large group:	45h	36.00%
	Hours medium group:	0h	0.00%
	Hours small group:	0h	0.00%
	Guided activities:	0h	0.00%
	Self study:	80h	64.00%

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Content

Introduction	Learning time: 2h Theory classes: 2h

Description:
Introduction to space communications

Related activities:
A01: Exposition of theoretical contents through lectures.

The space segment	Learning time: 10h Theory classes: 10h

Description:
The space segment:
Orbits, eclipses and sun interference,
Characteristics of GEO and non-GEO satellites and constellations,
Advantages/disadvantages of various orbital schemes and their impact on coverage, coordination zones and quality of service.

Basic satellite system design:
Satellite subsystems, ground station/VSAT,
Electromagnetic compatibility between different systems.
Frequency spectrum and bandwidth: L and S band mobile links; C band, telecommunications services; X band, government applications; Ku and Ka band, telecommunications and broadcasting; millimetre wave and optical applications

Related activities:
A01: Exposition of theoretical contents through lectures.
A03: Problem solving, with student participation.
A04: Practical laboratory sessions individually or as a team.

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Payload	Learning time: 2h Theory classes: 2h

Description:
Introduction to the satellite subsystems
Payload description
i) Transponder
ii) High Power Amplifier (non-linear HPA)
iii) Antenna subsystem

Related activities:
A01: Exposition of theoretical contents through lectures.

Link budget	Learning time: 12h Theory classes: 12h

Description:
Radio wave propagation on earth to space paths:
Clear air attenuation, sky noise, ionospheric scintillation, rain attenuation and rain models
Free space propagation: free space loss, use of decibels, antenna gain.
Noise and interference:
noise considerations at the receiver end (antenna, transmission line and receiver)
Interference and C/I estimation (cross-polarization, adjacent satellite interference analysis, adjacent channel interference).
Intermodulation products and satellite amplifier backoff.
UL and DL elements: definitions, transponder saturation, power budget calculations, signal and noise bandwidth, C/N, Eb/No, BER, satellite footprints (EIRP, G/T and SFD).

Basic link budgets for a single carrier:

DL and UL link budget, and combined link budget,

optimization: maximizing throughput, minimizing transmit power, receiver antenna size, required transponder capacity.

Related activities:
A01: Exposition of theoretical contents through lectures.
A03: Problem solving, with student participation.
A04: Practical laboratory sessions individually or as a team.

Specific objectives:
Link budget is the standard tool for designing and assessing the RF and other physical layer aspects of fixed and mobile satellite systems. At the end of this lesson students will practice using different link budget calculators to perform the link budget of a real satellite system.

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PHY and MAC Layer	Learning time: 4h Theory classes: 4h

Description:
Digital modulations:
with almost constant envelopes: QPSK, OQPSK and MSK,
bandwidth efficient modulation: APSKs;
Forward error correction (FEC).
Medium access techniques (MAC).

Related activities:
A01: Exposition of theoretical contents through lectures.
A03: Problem solving, with student participation.

Networks and digital satellite servicies.	Learning time: 10h Theory classes: 10h

Description:
Broadcast Satellite Services.
VSAT networks.
Mobile Satellite Services (MSS).
IP satellite services.
Other satellite services.

Related activities:
A01: Exposition of theoretical contents through lectures.
A03: Problem solving, with student participation.
A04: Practical laboratory sessions individually or as a team.
A05: Discussion in the classroom of problems or articles, made by the students and moderated by the teacher.
A11: Realization of projects proposed by teachers outside the classroom, individually or in groups.

Qualification system

Defined in the course webpage at the EETAC website

Regulations for carrying out activities

All the evaluation activities proposed are mandatory and will be evaluated with a zero qualification if they are not done. The exam has to be done individually (additional instructions will be given in class). The work and activities done in class must be done individually but cooperation and collaboration is welcome although the deliverables must be done individually.

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Bibliography

Basic:

Maral, Gérard; Bousquet, Michel. Satellite communications systems : systems, techniques and technology. 4th ed. London: John Wiley & Sons, cop. 2002. ISBN 0471496545.

Maini, Anil Kumar; Agrawal, Varsha. Satellite technology : principles and applications. 3rd ed. Chichester [etc.]: John Wiley & Sons, 2014. ISBN 9781118636473.

Complementary:

Ha, Tri T. Digital satellite communications. 2nd ed. New York: Macmillan, cop. 1990. ISBN 0070253897.