Quarter number
SG8

Prerequisites (in terms of CS courses)

- Notions of probabilities
- Digital Signal Processing (Fourier Transform, Spectral Analysis)
- Basic programming skills

These presrequisites correspond to signal processing (1CC4000),modelisation (1CC3000) and programming (1CC1000) courses.

Syllabus

Part 1: Fundamentals of Wireless transmission

- Physical modelling of wireless channel
- Detection in a fading channel
- Digital Single Carrier and Multicarrier modulation
- Diversity techniques

Part 2: Multiple Access Schemes and Standards : (Multiple Access Schemes for 2G, 3G, 4G, 5G and Beyond 5G networks).

- TDMA, FDMA, CDMA, SDMA
- FDD, TDD, half duplex and full duplex
- Interference management
- Applications in GSM/UMTS/4G/5G network standards
- Other wirless access standards: WLAN, WPAN and LPWAN
- IoT standards and connected objects

Part 3: Computing architectures for wireless communications

- Adaptable wireless communications architecture: the Software-Defined Radio (SDR)
- Analog/Digital front-ends and ADC/DAC data converters
- Embedded computing architectures: from mobile ARM processors to DSPs, FPGAs and GPUs
- Embedded computing platforms for wireless communications

Part 4: Hardware implementation fon wireless systems using GNU Radio and USRP platforms

- Tutorial on GNU Radio
- Implementation of a simple FM receiver
- Implementing a file transfer application on GNU Radio and USRP with QPSK based modulation and demodulation

Class components (lecture, labs, etc.)

Course layout, course organization (CM, TD, EL / TP sequencing) in hours:
Fundamentals of Wireless Communications Lectures: 4.5h
Multiple Access Schemes and Standards Lectures: 6h
Practical work on Fundamentals of Wireless Communications and Multiple Access Schemes: 3h
Computing Architectures for Wireless Communications CM: 9h
GNU Radio tutorial CM: 1.5h
Experimentation/Practical work using GNU Radio and USRPs : 9h
Exam: 2h
Total (HPE): 35h

Grading

Final (written or oral) exam and evaluation of practical/laboratory work

Course support, bibliography

- Handout provided to students
- Tse, D., & Viswanath, P., “Fundamentals of Wireless Communication”. Cambridge: Cambridge University Press, 2005.
- Holma H., & Toskala A., “LTE for UMTS: OFDMA and SC-FDMA Based Radio Access”, Wiley Publishing, 2009.
- Vaezi M., Ding Z., & Poor H. V., “Multiple Access Techniques for 5G Wireless Networks and Beyond”, Springer 2018.
- Yannick Bouguen, Eric Hardouin, François-Xavier Wolff, “LTE et les réseaux 4G”, Eyrolles, 2012
- A. Elnashar, M. A. El-saidny, M. Sherif, K. Abdulla, “Design, deployment and performance of 4G networks”, Wiley-Blackwell 2014,
- Fattah Hossam, “5G LTE narrowband Internet of Things (NB-IoT)”, CRC Press in 2019.
- A. Pacaud, “Électronique radiofréquence”, Ellipses, 2000,B. Razavi
- “RF microelectronics, communication electronics”, Prentice Hall, 1997
- P.L.D. Abrie, “Design of RF and microwave amplifiers and oscillators”, Artech House, 1999,
- S.C. Cripps, “RF power amplifiers for wireless communications”, Artech House, 2006,
- Gernot Hueber, Robert Bogdan Staszewski “Multi-Mode/Multi-Band RF Transceivers for Wireless Communications: Advanced Techniques, Architectures, and Trends” , John Wiley & Sons, Inc, 2010

- Peter B. Kenington, ” RF and Baseband Techniques for Software Defined Radio ", Artech House, 2005.
- Collins, T.F.; Getz, R.; Pu, D.; Wyglinski, A.M. Software-Defined Radio for Engineers; Artech House: Norwood, MA, USA, 2018.

Resources

- Teaching staff (nales of professors delivering lectures): Haïfa Farès, Amor Nafkha, Georgios Ropokis, Ruben Salvador
- Size of TD (by default 35 students): 20
- Software tools and number of required licences: MATLAB and GNU radio for practical and personal work
- Practice rooms (deparment and capacity):

Learning outcomes covered on the course

At the end of the course, the students should be able to:

- understand the basics of digital transmission and multiple access schemes used in existing standards
- understand how a complete wireless communications RF chain works (Radio, Analog and Digital domains)
- become familiar with several different digital processing platforms available for building wireless communications systems and their impact on system requirements (cost, performance, lifetime, energy efficiency etc)
- understand the terminology, structure and characteristics of modern wireless and mobile communications standards
- experiment on building a real wireless communication system

Description of the skills acquired at the end of the course

The course addresses the folowing skills

- C1.2 skill "Develop and use appropriate models, choosing the correct modelling scale and simplifying assumptions when addressing a problem"
- Tutorals and practical work address:
    - The C1.4 skill "Design, detail and corroborate a whole or part of a complex system"
    - Core Skills "C3.1-Be proactive and involved" and "C8.1-Work collaboratively in a team"