2SC6210 – High energy performance communications

Instructors: Yves Louet
Department: CAMPUS DE RENNES
Language of instruction: FRANCAIS
Campus: CAMPUS DE RENNES
Workload (HEE): 60
On-site hours (HPE): 34,50

Description

ICT (Information and Communication Technologies including base stations, data centers, user equipment's, etc.) field is responsible of 6 to 10% of the worldwide electrical consumption what corresponds to 4% of the greenhouse gases emissions. With an early growth of 7% especially with the coming 5G and the expected increase of billions of connected "things", it is urgent to reduce this footprint by finding new ways of transmitting, processing and saving data. That is to say spectral efficiency (ie transmit the maximum data in a given bandwidth) have to be joined with the objectives to increasing the energy efficiency of the links.
To do so the milestones of this courses are:

- Make the audience aware of the ICT footprint
- Explain with is power consuming in ICT and where are the potential gains
- Draw the communications chain (transmitter, channel, receiver) with the key parameters which come into play (bandwidth, data bit rate, power, link budget, etc.). Explain the role of the key components (coding, modulation, filtering, etc.).
- Put in light one of the most dimensional factor : constant or no-constant envelope signal Continuous Phase Modulation (CPM) modulation format with constant envelope (MSK, GMSK, FSK, OQPSK, ….) and their associated receivers
- The associated standards (mobile communications, Bluetooth, IoT, aeronautical communications, etc.).
- compare the linear and non linear modulations

Quarter number

ST5

Prerequisites (in terms of CS courses)

Most of the prerequisites of this course fit with the topics covered in the 1A course entitled "Signal Processing" (1CC4000). In particular :

- deterministic modelisation of signals

- power, energy, correlation
- Fourier transform and spectral representation of signals
- spectral analysis
- filtering and convolution
- sampling of signals and aliasing
- Discrete Fourier Transform

Syllabus

1. Introduction : ICT footprint

a. The networks
b. The user equipment's

2. Linear modulations

a. Bit to symbol coding
b. Symbol to signal coding : waveform filtering : intersymbol interferences
c. Spectrum density
d. Examples of standards

3. Linear modulations

a. CPM (FSK, MSK, GMSK, OQPSK, etc.)
b. Receivers architectures
c. Examples of standards

4. Comparison between linear / non linear modulations

a. Spectrum sefficiency
b. Energy efficiency
c. Bit error rate performance on AWGN channel

Class components (lecture, labs, etc.)
Regarding the HPE (Heures Présentiel Elèves), the course is divided into three part:

- 18 hours of lectures
- 4,5 hours of tutorials classes
- 10,5 hours of laboratory classes

Furthermore, 25,5 hours of personnal works are scheduled. This course will be evaluated by a 1,5 hours exam. The Professors are Yves Louët (head of the course), Haïfa Fares and Georgios Ropokis.

All lectures will be given in french with specificities for students who have a low level in french : all documents will be in english and tutorial classes, laboratory classes and the "enseignement d'intégration" will be given in english. Additional hours as tutoring in english will be scheduled.

Grading

This course will be evaluated by :a score related to laboratory classes reports (weighted 0.2) and a score of a 1h30 exam duration (weighted 0.8)

Competencies 1 and 2 will be evaluated in the introduction (stakes and context) and in the specific course
Competencies 4, 6 and 7 will be evaluated during the final defense related to the integrated courses.

Course support, bibliography

[1] J. B. Anderson, T. Aulin, and C.-E. Sundberg, Digital Phase Modulation. New York: Plenum Press, 1986.
[2] L. H. J. Lampe, R. Tzschoppe, J. B. Huber, and R. Schober, "Noncoherent Continuous- Phase Modulation for DS-CDMA," in Communications, 2003. ICC '03. IEEE International Conference on, vol. 5, pp. 3282–3286 vol.5, May 2003.
[3] M. Mouly and M.-B. Pautet, The GSM System for Mobile Comm.. Telecom Publishing, 1992.
[4] M. K. Simon, Bandwidth-Efficient Digital Modulation with Application to Deep-SpaceCommunications. John Wiley & Sons, 2005.
[5] Reducing the Energy Consumption of Photonics Hardware in Data Center Networks Authors: Richard Penty, Jonathan Ingham, Adrian Wonfor, Kai Wang, Ian White Richard Penty, Core Switching and Routing Working Group Adrian Wonfor, Green Touch, 2012

Resources

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Learning outcomes covered on the course

At the end of this course, the student will be able to:

- evaluate the carbon footprint of the ICT (Information and Communication Technology) domain

- identify the most energy consuming processings and devices to transmit information
- argue about the most appropriate choice of parameters for a transmission according to the needs
- simulate a high energy efficiency radio transmission and establish its performance
- evaluate the trade-off between spectral efficiency (for high bit rate) and energy efficiency (energy saving) for a given transmission
- justify the use of high energy efficiency waveforms in some contexts (Internet of Things, low bit rate transmissions, autonomy, ...)

Description of the skills acquired at the end of the course

C1 : Analyze, design, and build complex systems with scientific, technological, human, and economic components

C2 : Develop in-depth skills in an engineering field and a family of professions

C4 : Have a sense of value creation for his caompany and his customers

C6 : Be operational, responsible, and innovative in the digital world

C7 : Know how to convince