Postgraduate Course
Design of Digital Communication Equipment (MSc)

Instructor Information

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Course Information

Course Description

This course is focused on those elements and techniques that are needed in order to built communication equipment based on digital technology. From the point of view of both the digital hardware and the signal processing software required for their full implementation.

The starting point is a review of digital communications fundamentals. New advanced topics are then added that cover performance degradation due to: subsystems impairments, channel time-variability or non-linearity. Digital signal processing techniques are introduced so as to reduce real-world system degradation to acceptable levels.

Additional topics present technology and architectures intended to interface all-digital equipment to the physical world, for both wired or wireless communication channels.

Moreover, there is also an analysis of digital technology available for implementation on actual equipment of signal processing and interface functionality. This includes programmable logic (FPGAs, for instance) and general purpose processors. To this, a description of development methodology for these technologies is added; including

signal processing techniques specifically intended for each of them.

Prerequisites

Digital Communication fundamentals.

Radio Communications

Probability and Stochastic Processes for Engineers

In addition, a working knowledge of a computation environment (MATLAB, Octave, Python,…) is required.

Course Goal

To develop a deep understanding of advanced signal processing as applied to communication equipments and to attain the capability of fully designing them.

Summary of intended course outcomes

The students should acquire a full grasp of the fundamentals and theoretical basis of communications equipment in real world. With this background they will be able to design a fully detailed real equipment at the signal and block diagram level. The students should also be able to quantitatively predict and evaluate its performance. The work developed within the course should also enable them to carry out an implementation of the equipment in actual hardware.

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

- Design and analyse communication equipment at the system, signal and function level.
- Evaluate the performance of equipment against design especifications.
- Carry out a full implementation of equipment on digital hardware.

Syllabus

1. Communication equipment concepts
   1.1. Modulation
   1.2. Degradation
   1.3. Digital processing
2. Implementation issues

2.1. The analog front-end
2.2. Receiver front-end architectures
2.2.1. Bandwidth
2.2.2. Dynamic range
2.3. Transmitter front-end topology
2.4. Distortion and noise
2.5. Analog-to-digital and digital-to-analog impairments

3. Signal processing
3.1. Sampling
3.2. Filter banks
3.3. Feedback loops
3.4. Adaptive systems
3.5. Synchronization
3.5.1. Timing
3.5.2. Carrier recovery

4. Signal generation
4.1. Direct synthesis in RF
4.2. Spurious signals
4.3. Bandpass generation

5. Digital hardware
5.1. Digital Signal Processing processors
5.2. Field Programmable Gate Arrays
5.3. Signal processing architectures.

Textbook:
C. Richard Johnson et al, *Software Receiver Design*, Cambridge University Press 2011.

Recommended reading material:

1. Jacques Palicot, *Radio Engineering: From Software Radio to Cognitive Radio*, Wiley 2011.
2. Edward A. Lee and David G. Messerschmidt, *Digital Communication*, Kluwer 2003.
3. Heinrich Meyr et al., *Digital Communication Receivers: Synchronization, Channel Estimation and Signal Processing*, Wiley 1997.

Student Assessment Criteria

Test exercises	10 %
Final Exam	60 %
Design Project	30 %

Test exercises are assigned in lectures as homework. The design project is an additional assignment involving the in-depth design of a realistic equipment for digital communications starting for specifications provided on an individual basis.