EQ2411 Advanced Digital Communications 7.5 credits

Avancerad digital kommunikation

This is a translation of the Swedish, legally binding, course syllabus.

Establishment

Course syllabus for EQ2411 valid from Spring 2019

Grading scale

A, B, C, D, E, FX, F

Education cycle

Second cycle

Main field of study

Electrical Engineering

Specific prerequisites

For single course students: 180 credits and documented proficiency in English B or equivalen

Language of instruction

The language of instruction is specified in the course offering information in the course catalogue.

Intended learning outcomes

Students are required to show the following skills to pass the course:

- Identify and describe properties and limiting effects of wireless communication channels.

- Identify and describe modern digital communication techniques with applications to wireless transmission like multi-carrier transmission and OFDM, spread-spectrum techniques, modern coding techniques, CDMA and multiuser systems, multiple-antenna systems, diversity, and receiver architectures (e.g., equalization, iterative processing, multi-user processing).

- Identify and describe standardized technologies in the field, in particular 3G, 4G and different WLAN standards.

- Motivate the fact that the implementation and development of modern communication technology, in particular in wireless communications, requires mathematical modeling and problem solving.

- Apply mathematical modeling to problems in wireless digital communications, and explain how this is used to analyze and synthesize methods and algorithms within the field.

- Formulate a mathematical model which is applicable and relevant in the case of a given problem.

- Use a mathematical model to solve a given engineering problem in the field, and analyze the result and its validity.

To acquire a higher grade, the student is in addition required to show the following skills:

- Compare different digital commnuication techniques and judge their applicability and performance in different application scenarios.

- Formulate advanced mathematical models which are applicable and relevant in the case of a given problem. When explicit assumptions are missing, the student should be able to judge and compare different possibilities and make own relevant assumptions.

- Use a mathematical model to solve a given demanding engineering problem in the field, and analyze the result and its validity.

Course contents

This course aims at introducing advanced topics in digital communications and providing students with up-to-date knowledge of the techniques used in modern communication systems and the principles underlying their design. The course covers three main areas: digital communication over bandlimited channels, modern channel coding techniques, and wireless communication techniques.

Bandlimited Channels and Equalization

Most practical communications channels have a limited bandwidth, and therefore distort the transmitted signal. In particular, intersymbol interference (ISI) will generally occur. In many applications, notably involving radio channels, this has to be taken into account in the system design.

The course studies: Bandlimited baseband channels with Gaussian noise, optimal signal design, intersymbol interference, linear and non-linear equalization.

Modern Channel Coding

Forward-error correction coding or channel coding in general is an important component of digital communication systems. In order to protect transmitted data from transmission errors, channel coding introduces redundancy in a structured way to the transmitted data. This redundancy is utilized by the receiver to detect transmission errors and correct them. In this field, so called Turbo and low-density parity-check (LDPC) codes have attracted a lot of attention during recent years. They have now become standard components of numerous digital communication standards.

In this course, we will discuss the fundamental principles behind LDPC and Turbo coding and iterative decoding using so-called soft-input/soft-output decoding algorithms based on a-posteriori probabilities.

Wireless Communications

One of the most important application of digital communications in today's society is wireless mobile communications. The radio channel is a quite demanding transmission medium, and several phenomena occur that have to be dealt with. Multicarrier systems (e.g., OFDM) and CDMA systems mitigate effectively effects of frequency-selective channels and utilize effectively the diversity offered from multi-path propagation. They are used in radio communication standards of the third and fourth generation. Spread-spectrum techniques use high bandwidths to "spread" the information-carrying signal over the entire available spectrum. Traditionally these techniques were used in military applications, but are now common in wireless multiuser communication systems, e.g. in the UMTS/WCDMA system.

The course studies: Basic models for radio channels, frequency selective/flat fading, fast/slow fading, Rayleigh and Rice fading, performance in fading, diversity, block coding, interleaving, channel capacity, and multiple antenna systems. Furthermore, the course will cover the basic principles of multicarrier systems, spread-spectrum communications, and introduce CDMA as a popular multiple access technique. Topics include: OFDM, direct-sequence and frequency hopped spread-spectrum, interference avoidance, CDMA, multiuser communications.

Course literature

Announced on the course homepage.

Preliminary: U. Madhow: "Fundamentals of Digital Communications"

Examination

- TEN1 - Exam, 7.5 credits, grading scale: A, B, C, D, E, FX, F

Based on recommendation from KTH's coordinator for disabilities, the examiner will decide how to adapt an examination for students with documented disability.

The examiner may apply another examination format when re-examining individual students.

If the course is discontinued, students may request to be examined during the following two academic years.

Other requirements for final grade

Written examination, 7.5 credits, grade scale: A-F

Ethical approach

- All members of a group are responsible for the group's work.
- In any assessment, every student shall honestly disclose any help received and sources used.
- In an oral assessment, every student shall be able to present and answer questions about the entire assignment and solution.