# COURSE DESCRIPTION CARD - SYLLABUS

Course name
Advanced coding techniques [S2EiT2E-TIT>ZSK]

## Course

Field of study
Electronics and Telecommunications

Year/Semester
2/3

Area of study (specialization)
Information and Communication Technologies

Profile of study
general academic

Level of study
second-cycle

Course offered in
English

Form of study
full-time

Requirements
elective

## Number of hours

Lecture
30

Laboratory classes
15

Other
0

Tutorials
15

Projects/seminars
0

## Number of credit points

4,00

## Coordinators

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## Lecturers

## Prerequisites

Has systematic knowledge of algebra, probability theory, and one-dimensional signal theory necessary to understand the representation and analysis of signals in the time and frequency domains. The student knows the principles of operation of digital telecommunications systems, including baseband transmission, digital modulations, and methods of receiving signals, and has detailed knowledge of the basic methods of digital signal processing. The student can solve basic problems in the field of electronics and telecommunications using mathematical apparatus in the field of mathematical analysis, algebra and probability theory.

## Course objective

Presentation of the idea of correction and detection coding and coding techniques used in telecommunications systems. To familiarize the student with coding and decoding methods, in particular block, cyclic and convolutional codes. Presentation of the principle of operation of turbo codes and LDPC codes. Overview of ARQ/H-ARQ procedures.

## Course-related learning outcomes

Knowledge:

1. Has knowledge of: the characteristics, parameters and properties of correction and detection codes, hard and soft decision decoding,
2. Has knowledge of: block, cyclic, BCH, RS and other codes, convolutional codes, coding and decoding methods, parameters as well as properties of the codes, modification of block codes, CRC codes, iteratively decoded and cascade codes,
3. Has knowledge of: modern graph-based codes: turbo codes, LDPC codes, Polar codes: is able to elaborate on parameters, properties, coding and decoding methods. Knows TCM, fountain codes, and STC and network codes,
4. Has basic knowledge of finite body algebra,
5. Has knowledge of interleaving, ARQ, STC and techniques used in modern telecommunications systems.

Skills:
1. Is able to discuss / present the process of data encoding for block, cyclic, convolutional codes. Can define the basic parameters of codes,
2. Is able to implement the hard and soft decision decoding process for block, cyclic and convolutional codes,
3. Can analyze and compare different coding schemes,
4. Is able to apply knowledge of ARQ / H-ARQ techniques.

Social competences:
1. Can see and analyze the development of coding techniques and the need for their use,
2. Understands that the knowledge and skills of coding techniques can quickly become obsolete.

## Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

The knowledge and skills acquired during lectures are verified during the exam. It has written and/or oral form. It consists of 4-6 open questions that do not have to be scored equally. The passing threshold for the written exam is 50% of possible points. The oral exam consists of 2-3 open questions that are assessed taking into account the student's understanding of the issue and the detail of the answers. The passing threshold for the oral exam is 50% of possible points.
The skills acquired during practical classes are assessed on the basis of a colloquium. The colloquium is in written form and consists of 4-6 open questions. The passing threshold is 50% of possible points.

## Programme content

The lecture on encoding covers a range of topics related to code classification, encoding gain, block codes and Hamming codes, polynomial codes, cyclic codes, and decoding. Also discussed are modifications of block codes, CRC codes, iterated codes, cascade codes, soft-decision decoding algorithms, and convolutional codes with the Viterbi algorithm. In the practical exercises, students will have the opportunity to familiarize themselves with generating and decoding different types of codes, creating decoding tables, developing encoder/decoder schematics, and determining parameters for specific codes.

## Course topics

The lecture covers the following topics: code classifications, coding gain, block codes (codeword generation, systematic form, Hamming distance, hard and soft-decision decoding, standard table, generating and parity matrices), Hamming codes, decoding using the syndrome, properties of codes, polynomial codes, cyclic codes (the concept of cyclicity, properties of cyclic codes, generating words in a systematic form), polynomial syndrome, idea of decoding, Meggitt decoder, majority decoder, decoding using information sets, BCH and RS codes (definitions, properties, idea of algebraic code decoding), modifications of block codes, CRC codes, iterated codes, cascade codes, soft-decision algorithms for decoding block codes, convolutional codes (description in various fields, as a filter, as an automaton, properties, encoder state diagram, Viterbi algorithm, exclusion, systematic encoder, RSCC encoders, ARQ / H-ARQ techniques, iteratively decoded codes (turbo-codes, LDPC codes, the role of interleaving, achieved results, decoding).
The exercises cover the following topics: block codes (generating codewords, determining code parameters, creating a decoding table), syndrome (determining, decoding with determining the syndrome)), cyclic codes (developing an encoder/decoder operation scheme, determining code parameters, creating

codewords) , BCH and RS codes (determining code parameters based on the given initial assumptions), convolutional codes (creating an encoder scheme, generating codewords, decoding using Viterbi algorithm).

## Teaching methods

Lecture: multimedia presentation, illustrated with examples given on the board. Exercises: practical exercises - realization of tasks given by the teacher.

## Bibliography

Basic
1. K. Deergha Rao, Channel Coding Techniques for Wireless Communication, 2015
2. Wolfowitz Jacob., Coding Theorems of Information Theory, 1978
Additional
1. Todd K. Moon, "Error Correction Coding, Mathematical Methods and Algorithms", Wiley 2005
2. Daniel J. Costello, Shu Lin, "Error Control Coding Fundamentals and Applications", 2ed Prentice 2004
3. David MacKay, "Information Theory, Inference, and Learning Algorithms", Cambridge 2003
4. Robert H. Morelos-Zaragoza, "The Art of Error Correcting Coding", 2ed Wiley 2006

## Breakdown of average student's workload

| | Hours | ECTS |
|---|---|---|
| Total workload | 100 | 4,00 |
| Classes requiring direct contact with the teacher | 70 | 3,00 |
| Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation) | 30 | 1,00 |