COURSE DESCRIPTION CARD - SYLLABUS

Course name
Advanced Coding Techniques

Course

Field of study
Electronics and Telecommunication

Year/Semester
II/III

Area of study (specialization)

Profile of study
general academic

Level of study
Second-cycle studies

Course offered in
english

Form of study
full-time

Requirements
elective

Number of hours

Lecture	Laboratory classes	Other (e.g. online)
30	15	
Tutorials	Projects/seminars	
15	0	

Number of credit points

4

Lecturers

Responsible for the course/lecturer:
dr inż. Michał Sybis, michal.sybis@put.poznan.pl

Responsible for the course/lecturer:

Prerequisites

Has a knowledge in the field of algebra, probability theory, theory of one-dimensional signals necessary to understand the representation and analysis of signals in the time and frequency domains. Knows the principles of operation of digital telecommunications systems, including baseband transmission, digital modulation, and signal reception methods. Is able to solve basic problems in the field of electronics and telecommunications using a mathematical apparatus in the field of mathematical analysis, algebra and probability theory. Has mathematically based detailed knowledge of the basic methods of digital signal processing. Is able to obtain information from literature and databases as well as other sources in English; is able to integrate obtained information, interpret it, draw conclusions and justify opinions

Course objective

Presentation of the idea of correction and detection coding and coding techniques used in telecommunications systems. To acquaint the student with the methods of coding and decoding, in particular of block, cyclic and convolutional codes, as well as methods used in modern telecommunications systems (Turbo codes, LDPC codes, Polar codes)

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:

Knowledge and skills acquired during Lecture are verified during the exam. The exam has a written and / or oral form. There are 4-6 open questions that can be scored differently. The pass mark for the written exam is 50% of the points you can get. The oral exam consists of 2-3 open questions which are assessed together, including the student's understanding of the issue, as well as the detail of the answers. The pass mark for the oral exam is 50% of the points student can earn.

Skills acquired during Tutorial are assessed on the basis of the test. The test has a written form and consists of 4-6 open questions. The pass threshold is 50% of the points student can get.

Skills acquired during Laboratory classes are assessed on the basis of written reports. The final grade is determined as the average grade from all reports prepared by the student.

Programme content

Lecture covers the following issues: Block codes: codeword generation, systematic form, Hamming distance, hard and soft decision decoding, standard table, parity and generation matrices, Hamming and Singleton limit, Hamming codes, equivalent codes, dual codes, decoding with the use of syndrome, code weights distribution, code properties, package errors,

Cyclic codes: polynomial codes, generating words in a systematic form, the concept of cyclicality, finite algebra, minimal polynomials, factorization of polynomials, properties of cyclic codes, syndrome polynomial, decoding idea, Meggitt decoder, codes determined by elements, majority decoder, decoding using information sets

BCH and RS codes: definitions, properties, methods of algebraic decoding of codes: Berlekamp-Massey algorithm, decoding of non-binary codes in the transform field,

Block code modifications, shortened cyclic codes, Golay codes, iteratively decoded codes, cascade codes,

Convolutional codes: description in various fields, as a filter, as an automaton, properties, state diagram and encoder transmittance analysis, Viterbi algorithm, error analysis, suboptimal decoding algorithms, tree decoding, puncturing,

Block code: lattice, TCM idea, interleavers and hybrid ARQ techniques

Iterative decoded codes: turbo codes: achieved results, decoding: BCJR algorithm, SOVA algorithm, LDPC codes, the idea of the message-passing algorithm, Tanner graphs and others, LDPC codes: cycles in graphs, soft and hard-coding LDPC code decoding, coding complexity problem , Polar codes, decoding of Polar codes.

Tutorials include the following topics: block codes (generating codewords, setting code parameters, creating a decoding table), syndrome (determining, decoding with a syndrome)), finite field algebra, cyclic codes (developing of an encoder / decoder working scheme, determining code parameters, creation of codewords), BCH and RS codes (determination of code parameters based on the given initial assumptions), convolutional codes (creation of a encoder scheme, creating a lattice, generating codewords, decoding using Viterbi algorithm), Turbocodes, LDPC codes.

Laboratory classes cover the following issues: block codes (generating codewords, setting code parameters, creating a decoding table), syndrome (determining, decoding with a syndrome)), finite field algebra, cyclic codes (developing of an encoder / decoder working scheme, determining code parameters, creation of codewords), BCH and RS codes (determination of code parameters based on the given initial assumptions), convolutional codes (creation of a encoder scheme, creating a lattice, generating codewords, decoding using Viterbi algorithm), Turbocodes, LDPC codes.

Teaching methods

Lecture: multimedia presentation, illustrated with examples on the board.

Tutorials: practical exercises - implementation of tasks given by the teacher.

Laboratory classes: practical exercises, performed independently, implementation and testing of selected techniques or algorithms.

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	4,0
Classes requiring direct contact with the teacher	70	3,0
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam) [1]	30	1,0

[1] delete or add other activities as appropriate