COURSE DESCRIPTION CARD - SYLLABUS

Course name
Advanced coding techniques

Course

Field of study
Electronics and Telecommunications

Year/Semester
I/II

Area of study (specialization)
Mobile Radio Technologies

Profile of study
general academic

Level of study
Second-cycle studies

Course offered in
Polish

Form of study
full-time

Requirements
elective

Number of hours

Lecture
30

Laboratory classes
15

Other (e.g. online)

Tutorials
15

Projects/seminars
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 systematized knowledge of algebra, probability theory, and the theory of one-dimensional signals necessary to understand the representation and analysis of signals in the time and frequency domain. Student knows the principles of operation of digital telecommunications systems, including baseband transmission, digital modulation, and methods of receiving signals. Can solve basic problems in the field of electronics and telecommunications with the use of a mathematical apparatus in the field of mathematical analysis, algebra and probability. Has ordered, mathematically based, detailed knowledge of basic methods of digital signal processing. Can obtain information from literature, databases and other sources in Polish or English; is able to integrate the 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 students with the methods of encoding and decoding, in particular block, cyclic and convolutional codes as well as methods used in modern telecommunication systems (turbocodes, LDPC codes, polarization codes).

Course-related learning outcomes

Knowledge

1. Has knowledge of the features, parameters and properties of correction and detection codes, hard and soft decoding.

2. Has knowledge of block and cyclic codes, BCH, RS and others, convolutional codes, coding and decoding methods, parameters, as well as properties, modification of block codes, RM, CRC, iterated and cascading codes.

3. Have knowledge of modern codes: turbo codes, LDPC codes, polarization codes including their parameters, properties, methods of coding and decoding. Knows about TCM, fountain codes and network codes.

4. Has basic knowledge of finite field algebra.

5. Has knowledge of interleaving, ARQ, STC and techniques used in modern telecommunications systems

Skills

1. Can discuss / present the data encoding process for block, cyclic and convolutional codes. Can determine the basic parameters of codes.

2. Can realize the process of hard and soft-decision decoding for block, cyclic and convolutional codes.

3. Can analyze and compare different coding schemes.

4. Can apply knowledge of ARQ / H-ARQ techniques.

Social competences

1. Can perceive and analyze the development of coding techniques and the need for their application.

2. Understand that knowledge and skills in 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 the lectures are verified during the exam. The exam is in a written and / or oral form. It consists of 4-6 open-ended questions that do not have to be scored equally. The pass mark for the written exam is 50% of the available points. The oral exam consists of 2-3 open questions, which are assessed together with the understanding of the issue by the student, as well as the detailed answers. The pass mark for the oral exam is 50% of possible points.

The skills acquired during the classes are assessed on the basis of a test. The test is written and consists of 4-6 open-ended questions. The pass mark is 50% of possible points.

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

Programme content

The lecture covers the following topics:

Block codes: codeword generation, systematic form, Hamming distance, hard and soft decoding, standard table, parity generator and parity matrices, Hamming and Singleton limit, Hamming codes, equivalent codes, dual codes, decoding using syndrom, erasure decoding, decomposition code weights, code properties, package errors.

Cyclic codes: polynomial codes, generating words in systematic form, the concept of cyclicity, finite field algebra, minimal polynomials, factorization of polynomials, properties of cyclic codes, syndrome polynomial, idea of decoding, Meggitt decoder, root-defined codes, majority decoder, decoding with the use of information sets.

BCH and RS codes: definitions, properties, methods of algebraic codes decoding: Berlekamp-Massey algorithm, decoding non-binary codes, transform domain.

Modifications of block codes, shortened cyclic codes, Golay codes, iterated codes, cascade codes, soft-decision block code decoding algorithms.

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

Block code lattice, TCM idea, interleaving process and hybrid ARQ techniques.

Iterative decoded codes: turbo-codes: obtained 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-decision decoding of LDPC codes, the problem of coding complexity , polarization codes, decoding of polarization codes.

The exercises cover the following topics: block codes (generating code words, determining code parameters, creating a decoding table), syndrome (determination, decoding with syndrome determination), finite body algebra, cyclic codes (developing an encoder / decoder operation scheme, determining code parameters, codewords), BCH and RS codes (determining code parameters based on the given preliminary assumptions), convolutional codes (creating an encoder scheme, creating a lattice, generating code words, decoding using Viterbi algorithms), turbocodes, LDPC codes, polarization codes.

The laboratories cover the following topics: block codes (generating code words, determining code parameters, creating a decoding table), syndrome (determination, decoding with syndrome determination), finite body algebra, cyclic codes (development of an encoder / decoder operation scheme, determination of code parameters, code words), BCH and RS codes (determining code parameters based on the given preliminary assumptions), convolutional codes (creating an encoder scheme, creating a lattice, generating code words, decoding using Viterbi algorithms), turbocodes, LDPC codes, polarization codes.

Teaching methods

Lecture: multimedia presentation, illustrated with examples given on the blackboard.

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

Laboratories: practical exercises, performed independently, consisting in the implementation and testing of selected techniques or algorithms.

Bibliography

Basic

Krzysztof Wesołowski, Podstawy cyfrowych systemów telekomunikacyjnych, 2006

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