COURSE DESCRIPTION CARD - SYLLABUS

Course name
Advanced coding techniques [S2EiT1-TMiB>ZTK]

Course

Field of study
Electronics and Telecommunications

Year/Semester
1/2

Area of study (specialization)
Mobile and Wireless Technologies

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

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 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 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. Todd K. Moon, "Error Correction Coding, Mathematical Methods and Algorithms", Wiley 2005
Supplementary
1. Daniel J. Costello, Shu Lin, "Error Control Coding Fundamentals and Applications", 2ed Prentice 2004
2. David MacKay, "Information Theory, Inference, and Learning Algorithms", Cambridge 2003
3. 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