STUDY MODULE DESCRIPTION FORM

Name of the module/subject		Code
Advanced Coding Techniques		**1010802121010812904**

Field of study	Profile of study (general academic, practical)	Year /Semester
Electronics and Telecommunications	**general academic**	**1 / 2**

Elective path/specialty	Subject offered in:	Course (compulsory, elective)
Information and Communication	**English**	**elective**

Cycle of study:	Form of study (full-time,part-time)
Second-cycle studies	**full-time**

No. of hours					No. of credits
Lecture: **2**	Classes: **1**	Laboratory: **1**	Project/seminars:	**-**	**4**

Status of the course in the study program (Basic, major, other)	(university-wide, from another field)
major	**from field**

Education areas and fields of science and art	ECTS distribution (number and %**)**
technical sciences	**4 100%**
Technical sciences	**4 100%**

Responsible for subject / lecturer:

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Prerequisites in terms of knowledge, skills and social competencies:

1	**Knowledge**	[K1_W01] [K1_W06] [K1_W15] [K1_W19] [K2_W05]
2	**Skills**	[K1_U1] [K1_U7]
3	**Social competencies**	[K1_K01]

Assumptions and objectives of the course:

Presentation of various coding techniques used in telecommunication systems. Passing knowledge about encoding and decoding methods used historically and in current times. Analysis of the code?s properties and comparison of the algorithms complexity and code?s properties and performance.

Study outcomes and reference to the educational results for a field of study

Knowledge:

1. Has knowledge about parameters and properties of the error detection and correction codes,about soft and hard decision decoding - [K2_W05]

2. Has knowledge about block codes, cyclic codes, BCH and RS and convolutional codes encoding and decoding methods, parameters and properties, about modification of block codes, RM, CRC, product and concatenated codes - [K2_W05]

3. Has knowledge about turbo codes, LDPC, encoding and decoding methods, parameters and properties, knows about TCM, fountain codes, space-time codes and network coding - [K2_W05]

4. Has basic knowledge about finite field algebra - [K2_W00]

5. Has knowledge about interleavers, ARQ techniques, STC and techniques used in moder telecommunication systems - [K2_W06]

Skills:

1. Can encode and decode soft- and hard-decision block, cyclic, convolutional codes turbo and LDPC codes. Can   - [K2_U09]

2. Can apply knowledge about interleavers, ARQ and STC - [K2_U16]

3. Can analyze coding scheme and compare different coding schemes - [K2_U14]

Social competencies:
1. Can see and analyze development of coding techniques, their prevalence, limits and costs - [K2_K04]

Assessment methods of study outcomes

Laboratory exercises are performed individually and consists of implementation and testing of selected techniques and algorithms.

Test rating classes rely on solving paper exercises.

Written test rating lectures consisting of test and open questions.

Course description

Lecture

Introduction, results from Information Theory

Block codes: generating codewords, systematic form, Hamminga distance, soft and hard decision ecoding, standard decoding array, generating and parity chech matrix, Hamming and Singleton bound, equivalent codes, dual codes, decoding with syndrome, decoding erasures, weight enumerator, properties of codes, burst errors and Reiger bound, bounds on minimum distance

Cyrylic codes: polynomial codes, generating codewords in systematic form, cyclic property, finite field algebra, minimal polynomials, polynomial factorization, properties of cyclic codes, syndrome polynomial, decoding, Meggitt decoder, codes described by roots, BCH bound, majority logic decoder, decoding using information sets

BCH and RS codes: definition, properties, methods of algebraic decoding: Petersom, Berlekamp-Massey and Rother, decoding of nonbinary codes, analysis in the transform domain

Modifications of block codes, RM codes, shortened cyclic codes and CRC codes, Fire codes and Kasami and error-trapping dekoder, Golay codes, produkt and concatenated codes, softdecison decoding of block codes

Convolutional codes: description in different domains, as a filter, as a FSSM, parameters, equivalent encoder, catastrophic encoder, state diagram and analysis of the encoder?s transfer function, ML decoding and Viterbi algorithm, error analysis, suboptimum decoding algorithms, decoding on trees, puncturing, basic, minimal, systematic encoder, RSCC

Trellis of the block codes, idea of TCM, interleaving and hybrid ARQ techniques

Codes decoded iteratively: turbo codes: PCCC, encoder, role of interleaver, performance, decoding: BCJR algorithm, EXIT charts, algorithm SOVA, SCCC and BTC, idea of message-passing algorithm, Tanner and factor graphs, LDPC codes: regular, irregular, ?, cycles in graphs, soft and hard-decision decoding of LDPC codes, complexiy of encoding

RA codes, codes for channels with erasures, idea of fountain codes, diversity, idea of space-time codes and BLAST architecture, idea of network coding

Classes

ML decoding rule, block codes, Block codes cont., syndrome, Finite field algebra and cyclic codes, BCH and RS codes, Convolutional codes, Viterbi algorithm, Turbo codes

Laboratories

Repetition code and simple transmission system, Block codes, Examination of cyclic codes, Examination of RS codes, Examination of convolutional codes, Examination of turbo codes, Examination ofLDPC codes

Basic bibliography:

1. Moon, ?Error Correction Coding, Mathematical Methods and Algorithms?, Wiley 2005

Additional bibliography:

1. Wicker, ?Error Control Systems for Digital Communication and Storage?, Prentice 1994

2. Huffman, Pless, ?Fundamentals Of Error-Correcting Codes?, Cambridge 2003

3. Lin, Costello, ?Error Control Coding Fundamentals and Applications?, 2ed Prentice 2004

4. Kabatiansky, ?Error Correcting Coding and Security for Data Networks?, Wiley 2005

5. MacKay, ?Information Theory, Inference, and Learning Algorithms?, Cambridge 2003

6. Moreira, Farell, ?Essentials of Error-Control Coding?, Wiley 2006

7. Morelos-Zaragoza, ?The Art of Error Correcting Coding?, 2ed Wiley 2006

Result of average student's workload

Activity	Time (working hours)

1. Lectures with examples illustrating given topic	30
2. Classes	15
3. Laboratories	15
4. Solving numerical examples at home	15
5. Preparation to laboratories	15
6. Preparation to test and final test	15

Student's workload		
Source of workload	**hours**	**ECTS**
Total workload	105	4
Contact hours	65	3
Practical activities	45	2