Subject Description Form

Subject Code	EIE587
Subject Title	Channel Coding
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	The students are expected to have some basic knowledge about digital communications. Extra materials will be provided for self-learning before the commencement of the course on request for those who do not have the appropriate knowledge. Please contact the subject lecturer for details.
Objectives	The subject aims to introduce (i) the constraints in the design of channel codes (ii) the characteristics of block codes and convolutional codes (iii) capacity-approaching channel codes including turbo codes and low-density parity-check codes (iv) some applications of channel codes
Intended Learning Outcomes	Upon completion of the subject, students will be able to: **(1) Professional/academic knowledge and skills** a. select, design and evaluate channel codes. **(2) Attributes for all-roundedness** b. Communicate effectively. c. Think critically and creatively. d. Assimilate new technological development in a related field.
Subject Synopsis/ Indicative Syllabus	1. <u>Introduction</u> 1.1 Elements of a typical digital communication system 1.2 Types of channels Additive-white-Gaussian-noise channel, binary erasure channel, binary symmetric channel, power-limited channel, bandwidth-limited channel 1.3 Channel capacity and Shannon's coding theorem 1.4 Error detection and error correction Forward error correction 1.5 Selection of coding schemes Power and bandwidth, error performance, code rate, coding gain, data structure, data rate, hardware complexity/cost, latency 1.6 Galois Field arithmetic and vector spaces 2. <u>Linear Block Codes</u> 2.1 Parity checks 2.2 Systematic codes and generator matrices 2.3 Parity-check matrix, parity-check equations and graphical representation 3. <u>Convolutional Codes</u> 3.1 Encoder Constraint length, memory, generator matrix, state diagram, code tree and trellis 4. <u>Decoder</u> 4.1 Maximum-likelihood (ML) decoding, maximum a posteriori (MAP) decoding 4.2 Hard decision decoder and soft decision decoder 5. <u>Turbo Codes</u> 5.1 Encoder 5.2 Decoder

Iterative MAP decoder, extrinsic information transfer chart (EXIT chart)

5.3 Error floor

6. Low-Density Parity-Check (LDPC) Codes

6.1 LDPC block codes and LDPC convolutional codes
Random codes, structured codes and quasi-cyclic LDPC (QC-LDPC) codes

6.2 Iterative decoding algorithms and implementation design
Sum-product algorithm (SPA), min-sum algorithm (MSA), quantized SPA and quantized MSA

6.3 Cycles, girth, trapping sets and error floor

7. Applications

7.1 Deep space communications

7.2 5G wireless communications

7.3 Wifi

7.4 Case studies

Teaching/Learning Methodology

The theories, working principles and examples of channel coding will be described and explained in lectures. Applications and case studies will help the students to learn not only the theoretical material but also to understand the practical issues.
Computer simulations will allow student to evaluate and compare the performance of different channel coding schemes.

Teaching/Learning Methodology	Intended Subject Learning Outcomes			
	a	b	c	d
Lectures	✓		✓	✓
Tutorials	✓		✓	
Simulation	✓	✓	✓	
Case study	✓	✓	✓	✓

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed (Please tick as appropriate)			
		a	b	c	d
1. Assignments	15%	✓	✓	✓	
2. Test	10%	✓	✓		
3. Simulation	15%	✓	✓	✓	
4. Case study	10%	✓	✓		✓
5. Final examination	50%	✓	✓	✓	
Total	100%				

Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes:

Assignments and test and final examination let students review the taught materials, do further reading for deeper learning and apply the learnt materials to solving channel coding problems.

The simulation experiment provides a deeper understanding of the channel encoding/decoding algorithms.

Case study requires the student to do further reading, search for information, keep abreast of current development, and give a presentation.

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial	30 Hrs.

	▪ Simulation/Case study	9 Hrs.
	Other student study effort:	
	▪ Lecture: further reading, doing homework/ assignment	18 Hrs.
	▪ Simulation: further studying and writing a report	18 Hrs.
	▪ Case study: studying and giving one presentation	32 Hrs.
	Total student study effort	107 Hrs.
Reading List and References	1. William Ryan and Shu Lin, *Channel Codes: Classical and Modern*, Cambridge University Press, 2009. 2. Bernard Sklar, *Digital Communications: Fundamentals and Applications*, second edition, Prentice Hall, 2004. 3. Shu Lin and Daniel J. Costello Jr., *Error Control Coding*, second edition, Prentice Hall, 2004. 4. Peter Sweeney, *Error Control Coding*, John Wiley & Sons, 2002. 5. Andre Neubaue, Jurgen Freudenberger and Volker Kuhn, *Coding Theory: Algorithms, Architectures and Applications*, John Wiley & Sons, 2007. 6. Tom Richardson and Ruediger Urbanke, *Modern Coding Theory*, Cambridge University Press, 2008. 7. Yuan Jiang, A Practical Guide to Error-control Coding Using Matlab, Artech House, 2010. 8. Nicholas L. Pappas, Error Correction Code Design, CreateSpace Independent Publishing Platform, 2015. 9. IEEE publications: http://ieeexplore.ieee.org/, ieee802.org/16/tge/	

July 2023