Subject Description Form

Subject Code	EIE579
Subject Title	Advanced Telecommunication Systems
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	The students are expected to have some basic knowledge about digital communication and signal processing. Extra materials will be provided for self-learning before the commencement of the course on request for those who do not have the necessary background. Exclusion: EIE566-Wireless Communciation
Objectives	Modern wireless communication is a field in which theoretical ideas have had an unusually powerful impact on system design and practice. The basis of the theory was developed in 1948 by Claude Shannon, and is called information theory. Amazingly and surprisingly, Shannon theory stated that reliable communication without any error is possible over a noisy channel. By the mid 1970's, mainstream systems using information theoretic ideas began to be widely implemented because of the increasing number of engineers who understood both information theory and communication system practice. Since then, wireless communication technologies have been more and more powerful. For example, in the first-generation (1G) cellular systems, the phones can only be used for a call with very poor quality. Now, the fifth-generation (5G) cellular systems can even support 4K live streaming in virtual reality (VR). It is thus important to understand how the connection between communication theory and engineering design leads to the success of the current communication systems. The objectives of this course are two-fold. First, this course will equip the students with the classic digital communication theory, which is the basis of the current communication systems. Second, this course will provide specific 5G applications in broadband communication and Internet of Things (IoT) such that the students can understand how to utilize the communication theory in modern communication systems.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: **(1) Professional/academic knowledge and skills** a. Understand the basic principle for sending information reliably over the noisy channels. b. Understand the basic modules of transmitters in digital communication, e.g., coding, modulation, etc. c. Understand the basic modules of receivers in digital communication, e.g., decoding, demodulation, etc. d. Understand the application of digital communication in 5G broadband communication. e. Understand the application of digital communication in 5G-assisted IoT. **(2) Attributes for all-roundedness** f. Communicate effectively. g. Think critically and creatively. h. Learn the skill of teamwork. i. Assimilate new technological development in related field.

Subject Synopsis/ Indicative Syllabus

1. Basis of digital communication
   - 1.1 Ways to measure information and Huffman code
   - 1.2 A brief introduction to Shannon capacity
   - 1.3 Geometric representation of signals
2. Uncoded communication systems
   - 2.1 Decoding strategies at the receiver
   - 2.2 Error probability analysis
   - 2.3 Digital modulation principles
3. Coded communication systems
   - 3.1 Introduction of codes
   - 3.2 Decoding strategies at the receiver
   - 3.3 Error probability analysis
   - 3.4 Convolutional codes
4. Case study 1: Broadband communication in 5G
   - 4.1 Massive MIMO (multiple-input multiple-output)
   - 4.2 Cloud RAN (radio access network)
5. Case study 2: IoT in 5G
   - 5.1 Ultra-reliable low-latency communication and its applications
   - 5.2 Massive machine-type communication and its applications

Teaching/Learning Methodology

The basic principles of modern communication systems for reliable communications over noise channels will be described and explained in lectures. Key communication modules, e.g., modulation/demodulation, coding/decoding, etc., will be introduced. Performance of a digital communication system under the studied modulation/demodulation schemes and coding/decoding schemes will be simulated with Matlab or other programs. Students will also be required to study one digital communication technique and its application in modern systems, share their findings with other classmates through presentations and write a report summarizing their findings.

Teaching/Learning Methodology	Intended Subject Learning Outcomes								
	a	b	c	d	e	f	g	h	i
Lecture	✓	✓	✓	✓	✓		✓		✓
Workshop	✓	✓	✓	✓	✓		✓		
Project	✓					✓	✓	✓	✓

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	Weighting	Intended Subject Learning Outcomes to be assessed								
		a	b	c	d	e	f	g	h	i
Workshop	30%	✓	✓	✓	✓	✓		✓		
Quizzes	10%	✓	✓	✓	✓	✓		✓		
Mid-Term Test	30%	✓	✓	✓	✓	✓		✓		
Final-Project	30%	✓					✓	✓	✓	✓
Total	100%									

	Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes: Quizzes and tests let students review the taught materials, do further reading for deeper learning and apply the learnt materials to modern communication systems. Workshop requires the students to design matlab codes for implementing what they have learnt in lectures to solve real problems in wireless communication Final-project requires the students to do further reading, search for information, keep abreast of current development, run simulations, give presentations and write a report.	
Student Study Effort Expected	Class contact:	
	▪ Lecture/Tutorial/Tests	30 Hrs.
	▪ Workshop	6 hours
	▪ Presentation	3 Hrs.
	Other student study effort:	
	▪ Lecture: further reading, doing homework/ Assignment	30 Hrs.
	▪ Final-project: studying, writing a report, giving presentations	40 Hrs.
	Total student study effort	109 Hrs.
Reading List and References	1. S. Haykin, *Communication Systems* (5th Edition), John Wiley & Sons, 2009. 2. J. G. Proakis and M. Salehi, *Digital communications* (5nd Edition), McGraw-Hill Education, 2007. 3. Robert G. Gallager, *Principles of Digital Communication*, Cambridge University Press, 2008. 4. E. Dahlman, S. Parkvall, and J. Skold, *5G NR: The Next Generation Wireless Access Technology*, New York, NY, USA: Academic, 2018. 5. O. Liberg, *et al.*, *Cellular Internet of Things: From Massive Deployments to Critical 5G Applications* (2nd edition), Academic Press, 2019.	